2021 SAMOS Data Quality Report

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The authors wish to thank the technicians working onboard participating research vessels. You are the backbone to the data system, which makes the SAMOS Initiative possible and successful. We also thank the operators, captains, and crews of these vessels.

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1. Introduction

This report describes the quantity and quality of observations collected in 2021 by research vessels participating in the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative (Smith et al. 2018). The SAMOS initiative focuses on improving the quality of, and access to, surface marine meteorological and oceanographic data collected *in-situ* by automated instrumentation on research vessels (RVs). A SAMOS is typically a computerized data logging system that continuously records navigational (ship position, course, speed, and heading), meteorological (winds, air temperature, pressure, moisture, rainfall, and radiation), and near-surface oceanographic (sea temperature, conductivity, and salinity) parameters while the RV is underway. Original measurements from installed instrumentation are recorded at high-temporal sampling rates (typically 1 minute or less). A SAMOS comprises scientific instrumentation deployed by the RV operator and typically differs from instruments provided by national meteorological services for routine marine weather reports. The instruments are not provided by the SAMOS initiative.

Data management at the DAC focuses on a ship-to-shore-to-user data pathway (Figure 1). SAMOS version 1.0 relies on daily packages of one-minute interval SAMOS data being sent to the DAC at the Florida State University via e-mail attachment. Data reduction from original measurements down to 1-minute averages is completed onboard each ship using their respective data acquisition software. Broadband satellite communication facilitates transferal of SAMOS data to the DAC as near as possible to 0000 UTC daily. For SAMOS 1.0, a preliminary version of the SAMOS data is made available via web services within five minutes of receipt. All preliminary data undergo common formatting, metadata conjoining, and automated quality control (QC). A data quality analyst examines each preliminary file to identify any major problems (e.g., sensor failures). When necessary, the analyst will notify the responsible shipboard technician via email while the vessel is at sea. On a 10-day delay, all preliminary data received for each ship and calendar day are merged to create daily intermediate files. The merge considers and removes temporal duplicates. For all NOAA vessels and the *Falkor,* visual QC is conducted on the intermediate files by a qualified marine meteorologist, resulting in research-quality SAMOS products that are nominally distributed with a 10-day delay from the original data collection date. All data and metadata are version controlled and tracked using a structured query language (SQL) database. All data are distributed free of charge and proprietary holds through the web (https://samos.coaps.fsu.edu/html/) under “Data Access” and long-term archiving occurs at the US National Centers for Environmental Information (NCEI). SAMOS data at NCEI are accessible in monthly packages sorted by ship and have been assigned a collection-level reference and digital object identifier (Smith et al. 2009) to facilitate referencing the SAMOS data in publications.

In 2021, out of 31 active recruits, a total of 30 research vessels routinely provided SAMOS observations to the DAC (Table 1). SAMOS data providers included the National Oceanographic and Atmospheric Administration (NOAA, 15 vessels), the Woods Hole Oceanographic Institution (WHOI, 2 vessels), the National Science Foundation Office of Polar Programs (OPP, 2 vessels), the United States Coast Guard (USCG, 1 vessel), the Bermuda Institute of Ocean Sciences (BIOS, 1 vessel), the

University of Hawaii (UH, 1 vessel), the University of Washington (UW, 1 vessel), the University of Alaska (UA, 1 vessel), Scripps Institution of Oceanography (SIO, 3 vessels), the Schmidt Ocean Institute (SOI, 1 vessel), and the Australian Integrated Marine Observing System (IMOS, 2 vessels). The Louisiana Universities Marine Consortium (LUMCON) vessel *Pelican* was active in the SAMOS system, but for reasons beyond the control of the SAMOS DAC (e.g., caretaker status, mid-life refit, changes to shipboard acquisition or delivery systems, satellite communication problems, etc.) was unable to contribute data in 2021. We learned early in 2021 that the USCG vessel *Polar Sea* would not be returning to active service, so we decommissioned this vessel in SAMOS as of 1 January 2021.

IMOS is an initiative to observe the oceans around Australia (Hill et al. 2010). One component of the system, the "IMOS underway ship flux project" (hereafter referred to as IMOS), is modelled on SAMOS and obtains routine meteorological and surface-ocean observations from one vessel (*Tangaroa)* operated by New Zealand and one vessel (*Investigator*) operated by Australia. (A second IMOS vessel operated by Australia, *Aurora Australis*, was officially retired in 2020.) In 2015 code was developed at the SAMOS DAC (updated in 2018) which allows for harvesting *Tangaroa* and *Investigator* SAMOS data directly from the IMOS THREDDS catalogue. In addition to running a parallel system to SAMOS in Australia, IMOS is the only international data contributor to SAMOS.

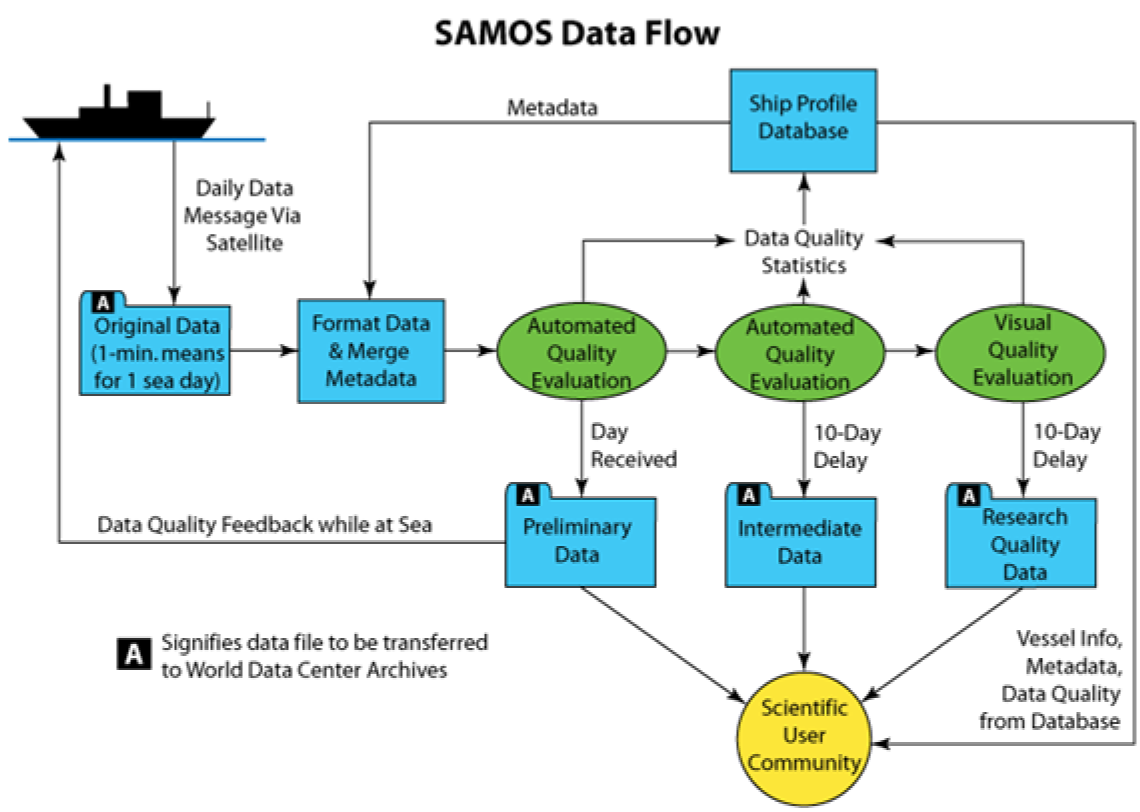

Figure 1: Diagram of operational data flow for the SAMOS initiative in 2021.

Beginning in 2013, funding did not allow for visual quality control procedures for any non-NOAA vessels except the *Falkor*, which is separately supported via a contract with SOI. As such, visual QC for all remaining vessels was discontinued, until such time as funding is extended to cover them. It should be noted that in the case of the *Tangaroa*, the IMOS project conducted their own visual QC until a personnel change there in June 2013. Only automated QC for the *Investigator* and *Tangaroa* occurs at the SAMOS DAC. The quality results presented herein are from the research quality products for all NOAA vessels and the *Falkor*, and automated-only quality control-level, daily-merged (intermediate) products for all remaining vessels. During 2021, the overall quality of data received varied widely between different vessels and the individual sensors on the vessels. Major problems included non-ideal sensor placement that enhanced flow distortion (nearly all vessels experience some degree of flow distortion) or that otherwise impeded normal sensor operation (*Lasker's* short wave radiometer proximity to a brightly lit night-time area), sea water plumbing issues or failures (*Fairweather*, among others), sensor failures/sensors or equipment that remained problematic or missing for extended periods (e.g. a bow thruster issue preventing sea water collection on the *Rainier*, a likely voltage issue during saturation in *Sally Ride's* relative humidity*,* radiometers on the *Bigelow* and *Atlantis*, temperature/humidity sensors on the *Sikuliaq*, *Sproul*, *Revelle*, *Healy*, *Lasker,* and *Sette*, as well as *Sette's* anemometer, and others), sensors that were in likely need of recalibration (radiation sensors on the *Gould* , *Palmer*, and *Thomas G. Thompson*), various sensor configuration errors such as erroneously entered calibration information (*Healy*) or other unknown improprieties (*Hassler* winds and *Shimada* longwave radiation), improper data averaging (*Thomas G. Thompson*), and data transmission oversights or issues (many vessels).

This report begins with an overview of the vessels contributing SAMOS observations to the DAC in 2021 (section 2). The overview treats the individual vessels as part of a global ocean observing system, considering the parameters measured by each vessel and the completeness of data and metadata received by the DAC. Section 3 discusses the quality of the SAMOS observations. Statistics are provided for each vessel and major problems are discussed. An overview status of vessel and instrumental metadata for each vessel is provided in section 4. Recommendations for improving metadata records are discussed. The report is concluded with the plans for the SAMOS project in 2022. Annexes include a listing of vessel notifications and vessel data identified as suspect but not flagged or only partially flagged by quality control procedures (Annex A), as well as web interface instructions for accessing SAMOS observations (Annex B, part 1) and metadata submission by vessel operators (Annex B, part2).

2. System review

In 2021, a total of 31 research vessels were under active recruitment to the SAMOS initiative; 30 of those vessels routinely provided SAMOS observations to the DAC (Table 1). The *Polar Sea* was decommissioned from SAMOS at the start of the year. The *Pelican* also sailed in 2021, but in her case proper configuration of the SAMOS file template and mail server (for the purposes of transmitting SAMOS data) could not be established in 2021 despite efforts to work with the LUMCON team, meaning no SAMOS data from her, either.

In total, 5,988 ship days were received by the DAC for the January 1 to December 31, 2021 period, resulting in 8,125,470 records. Each record represents a single (one minute) collection of measurements. Records often will not contain the same quantity of information from vessel to vessel, as each vessel hosts its own suite of instrumentation. Even within the same vessel system, the quantity of information can vary from record to record because of occasional missing or otherwise unusable data. From the 8,125,470 records received in 2021, a total of 194,633,823 distinct measurements were logged. Of those, 10,325,535 were assigned A-Y quality control flags – about 5.3 percent – by the SAMOS DAC (see section 3a for descriptions of the QC flags). This is about the same as in 2020. Measurements deemed "good data," through both automated and visual QC inspection, are assigned Z flags. In total, fourteen of the SAMOS vessels (the *Tangaroa, Investigator, Atlantis, Neil Armstrong, Laurence M. Gould, Nathaniel B. Palmer, Healy*, *Atlantic Explorer*, *Kilo Moana, Thomas G. Thompson, Sikuliaq*, *Roger Revelle, Sally Ride*, and the *Robert Gordon Sproul*) only underwent automated QC. None of these vessels' data were assigned any additional flags, nor were any automatically assigned flags removed via visual QC.

SHIP NAME	CALL SIGN	# of Days	# of Vars	# of Records	# of A-Y Flags	# of All Flags	% Flagged
TOTAL	-	5,988	753	8,125,470	10,325,535	194,633,823	5.31
ROGER REVELLE	KAOU	344	27	483,547	245,071	13,039,989	1.88
ATLANTIS	KAQP	102	30	143,576	122,774	3,902,654	3.15
T.G. THOMPSON	KTDQ	211	20	277,852	187,248	5,479,767	3.42
HEALY	NEPP	118	35	160,594	107,127	5,208,797	2.06
INVESTIGATOR	VLMJ	222	34	294,705	340,837	9,621,712	3.54
NEIL ARMSTRONG	WARL	349	31	480,024	343,862	13,996,463	2.46
NATHANIEL B. PALMER	WBP3210	358	23	513,624	1,149,757	10,730,208	10.72
LAURENCE M. GOULD	WCX7445	360	23	517,195	1,097,176	10,533,040	10.42
KILO MOANA	WDA7827	178	21	227,429	5,949	4,772,046	0.12
ATLANTIC EXPLORER	WDC9417	150	31	187,316	197,378	5,605,908	3.52
SIKULIAQ	WDG7520	346	37	493,897	904,284	16,086,071	5.62
SALLY RIDE	WSAF	248	27	337,120	172,736	8,579,864	2.01
ROBERT GORDON SPROUL	WSQ2674	363	23	501,573	427,574	10,799,482	3.96
HENRY B. BIGELOW	WTDF	164	27	220,271	340,668	5,919,395	5.76
OKEANOS EXPLORER	WTDH	158	22	210,202	248,228	4,391,399	5.65
PISCES	WTDL	151	18	195,641	587,664	3,471,266	16.93
OREGON II	WTDO	132	16	178,314	177,852	2,802,510	6.35
THOMAS JEFFERSON	WTEA	137	26	153,974	217,028	2,817,666	7.70
FAIRWEATHER	WTEB	150	16	199,582	272,077	3,167,029	8.59
RON BROWN	WTEC	196	28	273,777	615,848	7,664,688	8.03
BELL M. SHIMADA	WTED	152	41	201,437	327,151	7,711,309	4.24
OSCAR ELTON SETTE	WTEE	212	26	281,693	565,552	4,317,485	13.10
RAINIER	WTEF	90	16	125,632	82,750	1,541,847	5.37
REUBEN LASKER	WTEG	142	24	191,828	253,319	4,219,288	6.00
FERDINAND HASSLER	WTEK	118	14	163,383	140,543	1,863,769	7.54
GORDON GUNTER	WTEO	119	16	155,980	85,721	2,492,800	3.44
OSCAR DYSON	WTEP	137	32	178,235	117,154	5,572,836	2.10
NANCY FOSTER	WTER	81	17	102,761	84,940	1,714,066	4.96
FALKOR	ZCYL5	224	35	305,806	448,315	10,364,652	4.33
TANGAROA	ZMFR	276	17	368,502	458,952	6,245,817	7.35

Table 1: CY2021 summary table showing (column three) number of vessel days received by the DAC, (column four) number of variables reported per vessel, (column five) number of one-minute records received by DAC per vessel, (column six) total incidences of A-Y flags per vessel, (column seven) total incidences of A-Z flags per vessel, (column eight) percentage flagged A-Y.

a. Temporal coverage

As demonstrated in Figure 2, the files received by the DAC from each vessel are not often equally matched to the scheduled days reported by each institution. Scheduled days may sometimes include days spent at port, which are assumedly of less interest to the scientific community than those spent at sea. We are therefore not intensely concerned when we do not receive data during port stays, although if a vessel chooses to transmit port data we are pleased to apply automated and visual QC and archive it. Occasionally vessel technicians may be under orders not to transmit data due to vessel location (e.g., within an exclusive economic zone, marine protected area, underwater cultural heritage site, etc., denoted with a "*" in Figure 2, when known). However, when a vessel is reportedly "at sea" (denoted with an "***S***" in Figure 2, when possible) and we have not received expected underway data, we endeavor to reclaim any available data, usually via email communication with vessel technicians and/or lead contact personnel. For this reason, we perform visual QC on a 10-day delay. SAMOS data analysts strive to follow each vessel's time at sea by focusing on continuity between daily files and utilizing online resources (when available), but as ship scheduling is subject to change and in some cases is unavailable in real time, we may be unaware a vessel is at sea until well after the 10-day delay period. The DAC provides JSON web services (https://samos.coaps.fsu.edu/html/webservices.php) to allow interested parties to track the date data was last received by the DAC for each vessel (Preliminary File), the results of the automated quality control on these files (Preliminary Quality), and to search for available SAMOS data by cruise identifier for those vessels cataloged by the Rolling Deck to Repository (R2R) project. This allows operators and the DAC to track the completeness of SAMOS data for each vessel and to identify when data are not received within the 10-day limit for visual quality control. When data are received after the 10-day limit, current funding for the SAMOS initiative does not permit the visual quality control of a large number of "late" files, so it is important that vessel operators and SAMOS data analysts do their best to ensure files are received within the 10-day delayed-mode window.

In Figure 2, we directly compare the data we've received (green) to final 2021 ship schedules provided by each vessel's institution. Days identified on the vessel institution's schedule for which no data was received by the DAC are shown in grey. Within the grey boxes an italicized "***S***" indicates a day reportedly "at sea." As an added metric, Table 2 attempts to measure each vessel's actual submission performance by matching scheduled at-sea (or assumed at-sea) days to the availability of SAMOS data files for those days. All data received for 2021, with the exceptions of *Tangaroa* and *Investigator,* has been archived at the NCEI. Through agreement with IMOS, we receive data for the *Tangaroa* and the *Investigator* and for these vessels perform automated QC only. IMOS data is archived within the IMOS DAC-eMarine Information Infrastructure (eMII).

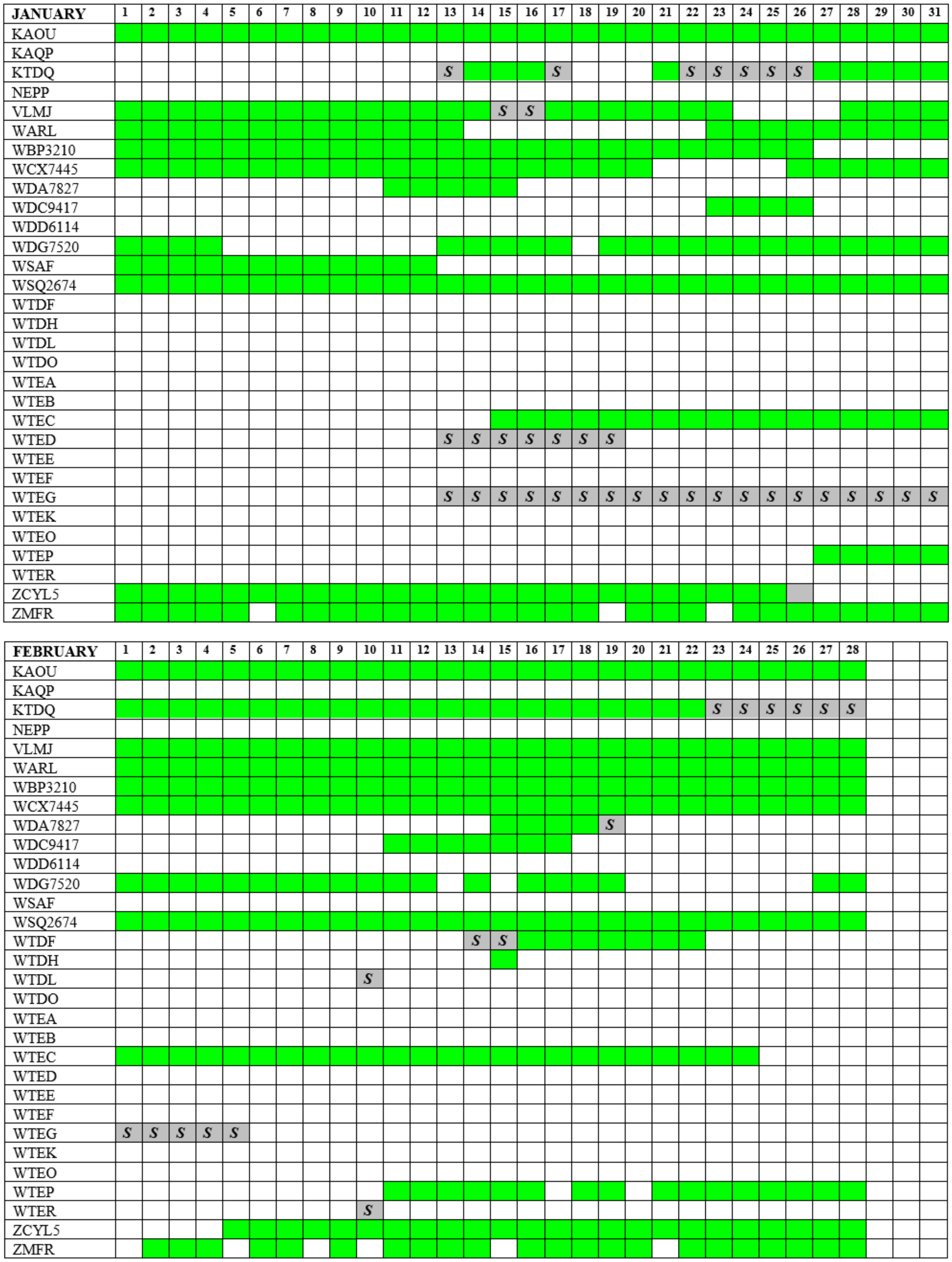

Figure 2: 2021 calendar of ship days received by DAC (green) and (grey) additional days reported afloat by vessels; "***S***" denotes vessel reportedly at sea, "P" denotes vessel in port, "*" denotes a known "restricted data" situation (e.g., a maritime EEZ, underwater cultural heritage 'UCH' protocol, etc.) with no expectation of data. Vessels are listed by call sign (see Table 1).

MARCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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WDC9417																															
WDD6114	S											S		S	S						S	S	S	S	S	S				S	S
WDG7520																															
WSAF																															
WSQ2674																															
WTDF																															
WTDH																															
WTDL																	S	S		S	S					S					
WTDO																															
WTEA																															
WTEB																S															
WTEC																															
WTED																															
WTEE																															
WTEF																															
WTEG															S																
WTEK																															
WTEO				S																											
WTEP																															
WTER																															
ZCYL5																															
ZMFR																															

(Figure 2: cont'd)

NOVEMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
KAOU														S																	
KAQP																															
KTDQ											S	S						S													
NEPP	*	*	*	*	*	*	*	*	*	*	*	*																			
VLMJ																															
WARL																															
WBP3210												S																			
WCX7445																															
WDA7827																															
WDC9417																															
WDD6114	S	S	S	S	S	S	S																								
WDG7520																															
WSAF																															
WSQ2674																															
WTDF																															
WTDH																		S	S												
WTDL														S	S	S									S	S					
WTDO																															
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WTEK																															
WTEO																															
WTEP																															
WTER																															
ZCYL5																															
ZMFR																															

DECEMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
KAOU																															
KAQP																															
KTDQ															S															S	
NEPP																															
VLMJ								S																							
WARL																															
WBP3210																															
WCX7445																															
WDA7827										S									S	S	S										
WDC9417																															
WDD6114						S	S							S		S	S	S	S	S											S
WDG7520																															
WSAF																															
WSQ2674																															
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WTEF																															
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WTEK																															
WTEO																															
WTEP																															
WTER																															
ZCYL5																															
ZMFR																															

(Figure 2: cont'd)

NOAA								
Ship Name	Bell M. Shimada	Fairweather	Ferdinand Hassler	Gordon Gunter	Henry Bigelow	Nancy Foster	Okeanos Explorer	Oregon II
Call Sign/ Ship Code	WTED/SH	WTEB/FA	WTEK/FH	WTEO/GU	WTDF/HB	WTER/NF	WTDH/EX	WTDO/OT
# scheduled at-sea days	116	153	105	116	157	79	158	131
# matching SAMOS days	105	127	103	105	154	74	155	127
→% received	91%	83%	98%	91%	98%	94%	98%	97%

NOAA (cont'd)							
Ship Name	Oscar Dyson	Oscar E. Sette	Pisces	Rainier	Reuben Lasker	Ronald Brown	Thomas Jefferson
Call Sign/ Ship Code	WTEP/OD	WTEE/OS	WTDL/PI	WTEF/RA	WTEG/RL	WTEC/RB	WTEA/TJ
# scheduled at-sea days	132	139	157	88	168	198	110
# matching SAMOS days	132	129	139	78	139	194	107
→% received	100%	93%	89%	89%	83%	98%	97%

TOTAL scheduled at-sea days:	2007
TOTAL matching SAMOS days:	1868
OVERALL RATIO:	93%

Table 2: 2021 data submission performance metrics listed by institution and ship. Note where official schedules specify "at sea" days only those days are counted. In all other cases "at sea" is assumed and scheduled days are counted as-is. Note also while SAMOS days follow GMT, ship schedules may not. This leaves room for some small margin of error. Lastly, note any transit through an exclusive economic zone, marine protected area, etc. may preclude data transmission. All schedule resources are listed in the References.

IMOS		
Ship Name	Investigator	Tangaroa
Call Sign	VLMJ	ZMFR
# scheduled at-sea days	188	255
# matching SAMOS days	175	255
→% received	93%	100%
TOTAL scheduled at-sea days:	443	
TOTAL matching SAMOS days:	430	
OVERALL RATIO:	97%	

OPP		
Ship Name	Laurence M. Gould	Nathaniel B. Palmer
Call Sign	WCX7445	WBP3210
# scheduled at-sea days	44	52
# matching SAMOS days	44	51
→% received	100%	98%
TOTAL scheduled days:	96	
TOTAL matching SAMOS days:	95	
OVERALL RATIO:	99%	

SIO			
Ship Name	Robert G. Sproul	Roger Revelle	Sally Ride
Call Sign	WSQ2674	KAOU	WSAF
# scheduled at-sea days	44	255	176
# matching SAMOS days	44	252	175
→% received	100%	99%	99%
TOTAL scheduled at-sea days:	475		
TOTAL matching SAMOS days:	471		
OVERALL RATIO:	99%		

WHOI		
Ship Name	R/V Atlantis	R/V Neil Armstrong
Call Sign	KAQP	WARL
# scheduled at-sea days	48	194
# matching SAMOS days	43	193
→% received	90%	99%
TOTAL scheduled at-sea days:	242	
TOTAL matching SAMOS days:	236	
OVERALL RATIO:	98%	

	BIOS	LUMCON	SOI	UAF	UHI	USCG	UW
Ship Name	Atlantic Explorer	Pelican	Falkor	Sikuliaq	Kilo Moana	Healy	Thomas G. Thompson
Call Sign	WDC9417	WDD6114	ZCYL5	WDG7520	WDA7827	NEPP	KTDQ
TOTAL scheduled at-sea days	151	154	219	209	187	127	258
TOTAL matching SAMOS days	149	0	209	208	176	93	203
OVERALL RATIO:	99%	0%	95%	100%	94%	73%	79%

(Table 2: cont'd)

b. Spatial coverage

Geographically, SAMOS data coverage continues to be noteworthy in 2021, with both the typical exposures and a few trips outside traditional mapping/shipping lanes. Cruise coverage for the January 1, 2021 to December 31, 2021 period is shown in Figure 3. It includes some good coverage in the Southern Ocean and along the Antarctic shelf provided by the *Investigator*, the *Tangaroa*, and the two OPP vessels *Nathaniel B. Palmer* and *Laurence M. Gould*, broad exposure in the Atlantic Ocean provided by the *Atlantic Explorer*, *Neil Armstrong*, *Okeanos Explorer*, *Pisces*, and *Thomas G. Thompson* (among others), with notable north Atlantic visits made by *Armstrong*, *Thompson*, and the *Healy*, plus multiple swaths of the Pacific Ocean (North and South) contributed by the *Falkor*, *Kilo Moana*, *Roger Revelle*, *Thomas G. Thompson* and others. The *Ron Brown* and *Atlantis* both made transits through the Panama Canal (two, for the *Brown*), while the Gulf of Alaska saw extensive exposure from the *Healy*, *Oscar Dyson*, and *Sikuliaq*, with the *Healy* and *Sikuliaq* contributing additional coverage in the Bering, Beaufort, and Chukchi Seas. Further, and quite unusually, the *Healy* spent some time in Northern Canada and the Arctic Circle as she completed a circumnavigation of North America in 2021. The waters around Australia were substantially explored by the *Falkor* and *Investigator*, and the waters east of New Zealand received heavy coverage from the *Tangaroa*. The *Atlantic Explorer* naturally spent a lot of time cruising around Bermuda. Natively, the entire East coast was sampled by the *Gordon Gunter*, *Henry Bigelow*, *Neil Armstrong*, *Nancy Foster*, *Okeanos Explorer*, *Pisces* and others. Comparable coverage of British Columbia and the West coast was effected by the *Bell M. Shimada*, *Fairweather, Oscar Dyson, Rainier*, *Reuben Lasker*, *Ron Brown*, and *Thomas G. Thompson*, among others, with particular emphasis on the southern coastline from San Francisco down through the Baja peninsula provided by the *Robert Gordon Sproul*, *Reuben Lasker*, and *Sally Ride*. The Hawai'ian archipelago was comprehensively explored by the *Oscar Elton Sette* and *Kilo Moana*. There was also the fairly typical coverage in the Gulf of Mexico, as contributed by the *Gordon Gunter*, *Pisces*, *Oregon II*, and others.

Figure 3: Cruise maps plotted for each vessel in 2021.

c. Available parameter coverage

The core meteorological parameters – earth relative wind speed and direction, atmospheric pressure, and air temperature and relative humidity – are reported by all ships. Most ships also report the oceanographic parameter sea temperature. Many SAMOS vessels additionally report precipitation accumulation; rain rate; and longwave, shortwave, net, and photosynthetically active radiations; along with seawater conductivity and salinity. Additionally, the *Bell M. Shimada*, *Okeanos Explorer*, *Rainier*, and *Thomas Jefferson* provided dew point temperature and wet bulb temperature in 2021. A quick glance at Table 4 (located in Section 4) shows which parameters are reported by each vessel: those boxes in columns 6 through 13 on the first page and columns 2 through 16 on the second page with an entry indicate a parameter was enabled for reporting and processing at the writing of this publication. (Further detail on Table 4 is discussed in Section 4.) Some vessels furnish redundant sensors, which can be extremely helpful for visually assessing data quality, and those boxes in columns 6 through 13 on the first page and columns 2 through 16 on the second page in Table 4 with multiple entries indicate the number of redundant sensors available for reporting and processing in 2021/2022; boxes with a single entry indicate the existence of a single sensor.

3. Data quality

a. SAMOS quality control

Definitions of A-Z SAMOS quality control flags are listed in Table 3 and detailed descriptions of the quality tests are provided in Smith et al. (2018). It should be noted that no secondary automated QC was active in 2021 (SASSI), so quality control flags U-Y were not in use. A “special value” (set equal to -8888) may exist in any variable when a value received does not fit the memory space allocated by the internal SAMOS format (e.g., character data value received when numeric value was expected). A "missing value" (set equal to -9999) is assigned for any missing data across all variables except time, latitude, and longitude, which must always be present. In general, visual QC will only involve the application of quality control flags H, I, J, K, M, N and S. Quality control flags J, K, and S are the most commonly applied by visual inspection, with K being the catchall for the various issues common to most vessels, such as (among others) steps in data due to platform speed changes or obstructed platform relative wind directions, data from sensors affected by stack exhaust contamination, or data that appears out of range for the vessel's region of operation. M flags are primarily assigned when there has been communication with vessel personnel in which they have dictated or confirmed there was an actual sensor malfunction. Port (N) flags are reserved for the latitude and longitude parameters and, in an effort to minimize over-flagging, are rarely used. The primary application of the port flag occurs when a vessel is known to be in dry dock. The port flag may also be applied, often in conjunction with flags on other parameters, to indicate that the vessel is confirmed (visually or via operator) in port and any questionable data are likely attributable to dockside structural interference, although this practice is traditionally only used in extreme cases. (We note that, owing to a timeworn visual flagging platform, the H flag is not routinely used, in order to achieve expeditious flagging.) SAMOS data analysts may also apply Z flags to data, in effect removing flags that were applied by automated QC. For example, B flagging is dependent on latitude and occasionally a realistic value is assigned a B flag simply because it occurred very close to a latitude boundary. This happens with sea temperature from time to time in the extreme northern Gulf of Mexico – TS values of 32˚C or 33ºC are not unusual there in the summer, but portions of the coastline are north of 30 degrees latitude and thus fall into a region where such high temperature are coded as "out of bounds." In this case the B flags would be removed by the data analyst and replaced with good data (Z) flags.

Flag	Description
A	Original data had unknown units. The units shown were determined using a climatology or some other method.
B	Original data were out of a physically realistic range bounds outlined.
C	Time data are not sequential or date/time not valid.
D	Data failed the T>=Tw>=Td test. In the free atmosphere, the value of the temperature is always greater than or equal to the wet-bulb temperature, which in turn is always greater than or equal to the dew point temperature.
E	Data failed the resultant wind re-computation check. When the data set includes the platform's heading, course, and speed along with platform relative wind speed and direction, a program re-computes the earth relative wind speed and direction. A failed test occurs when the wind direction difference is >20 or the wind speed difference is >2.5 m/s.
F	Platform velocity unrealistic. Determined by analyzing latitude and longitude positions as well as reported platform speed data.
G	Data are greater than 4 standard deviations from the ICOADS climatological means (da Silva et al. 1994). The test is only applied to pressure, temperature, sea temperature, relative humidity, and wind speed data.
H	Discontinuity found in the data.
I	Interesting feature found in the data. More specific information on the feature is contained in the data reports. Examples include: hurricanes passing stations, sharp seawater temperature gradients, strong convective events, etc.
J	Data are of poor quality by visual inspection, DO NOT USE.
K	Data suspect/use with caution – this flag applies when the data look to have obvious errors, but no specific reason for the error can be determined.
L	Oceanographic platform passes over land or fixed platform moves dramatically.
M	Known instrument malfunction.
N	Signifies that the data were collected while the vessel was in port. Typically these data, though realistic, are significantly different from open ocean conditions.
O	Original units differ from those listed in the *original_units* variable attribute. See quality control report for details.
P	Position of platform or its movement is uncertain. Data should be used with caution.
Q	Questionable – data arrived at DAC already flagged as questionable/uncertain.
R	Replaced with an interpolated value. Done prior to arrival at the DAC. Flag is used to note condition. Method of interpolation is often poorly documented.
S	Spike in the data. Usually one or two sequential data values (sometimes up to 4 values) that are drastically out of the current data trend. Spikes for many reasons including power surges, typos, data logging problems, lightning strikes, etc.
T	Time duplicate.
U	Data failed statistical threshold test in comparison to temporal neighbors. This flag is output by automated Spike and Stair-step Indicator (SASSI) procedure developed by the DAC.
V	Data spike as determined by SASSI.
X	Step/discontinuity in data as determined by SASSI.
Y	Suspect values between X-flagged data (from SASSI).
Z	Data passed evaluation.

Table 3: Definitions of SAMOS quality control flags

b. 2021 quality across-system

This section presents the overall quality from the system of ships providing observations to the SAMOS data center in 2021. The results are presented for each variable type for which we receive data and are broken down by month. The number of individual 1-minute observations varies by parameter and month due to changes in the number of vessels at sea and transmitting data.

Latitude and longitude (Figure 4) primarily only receive flags via the auto flagger, although occasionally the data analyst will apply port (N) flags as prescribed in the preceding section 3a, and in the rare cases of system-wide failure they can each be assigned malfunction (M) flags by the data analyst. Other than these few cases, LAT and LON each primarily receive either land error flags (L) or platform velocity unrealistic (F) flags. L flags are often removed by the data analyst when it is determined that the vessel was simply very close to land, but still over water and the flag is simply a result of using a 1 arc-minute land mask that cannot resolve the smaller near coastal waters (see Smith et al. 2018, land flag removal is not possible for non-visual QC ships). Otherwise, L and F flags are commonly assigned to spikes in LAT and LON data. It should be noted that *Atlantis*, *Neil Armstrong*, *Sikuliaq*, *Palmer*, and *Gould* in particular are known to transmit a good deal of port data and since they do not receive visual QC, some amount of erroneous L (position over land) auto flagging would be expected for 2021. It might also be noted some visual QC ships that were upgraded to the newest version of NOAA's Scientific Computing System (SCSv5) in 2021 saw an increase in L and F flags, particularly in port, which were not always able to be removed (mainly *Oscar Elton Sette* and *Thomas Jefferson*).

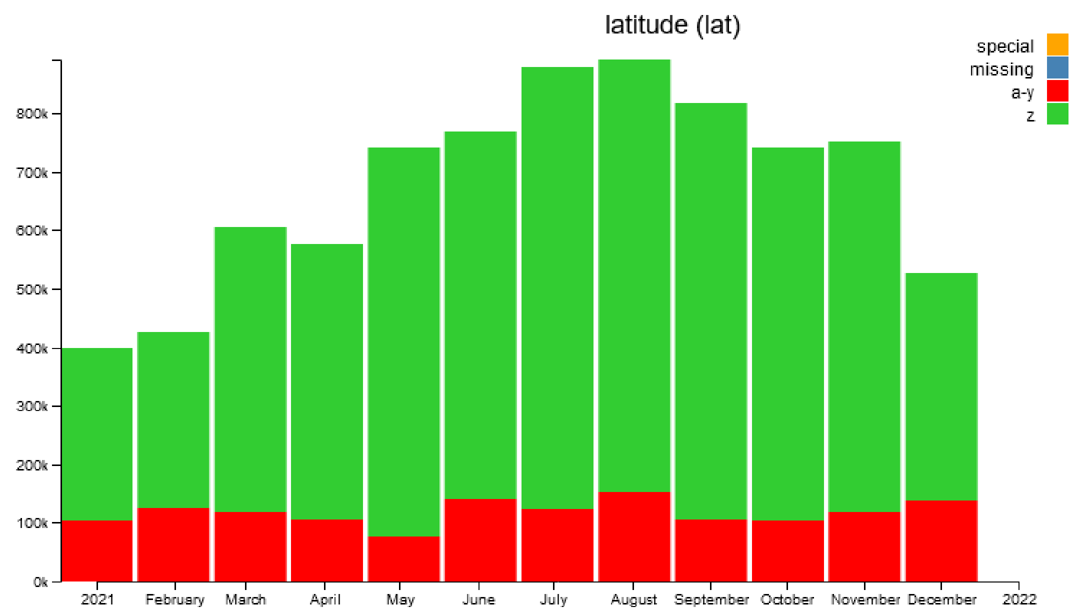


Figure 4: Total number of (this page) latitude – LAT – and (next page) longitude – LON – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

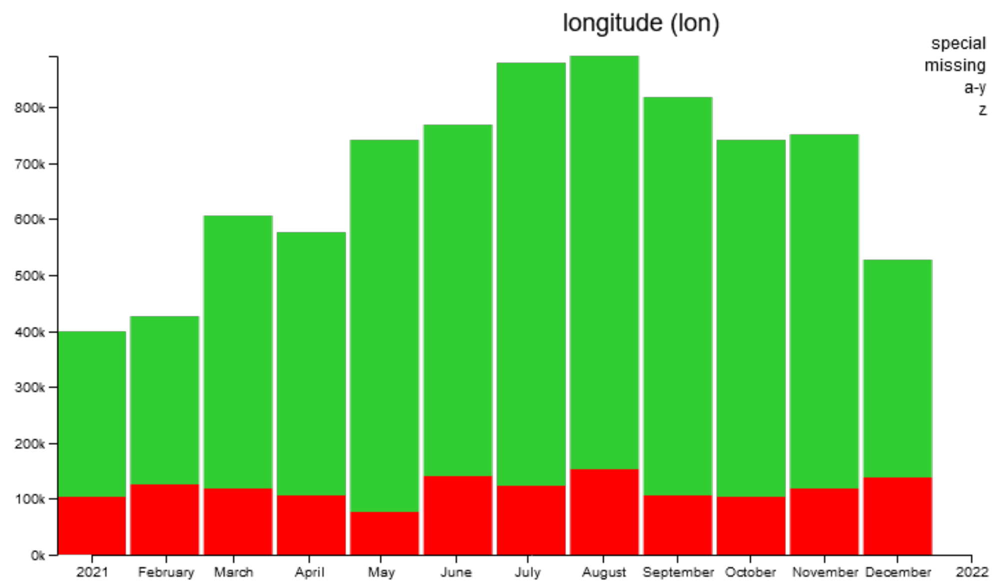


Figure 4: cont'd.

The remainder of the navigational parameters exhibited no real problems of note. They are nevertheless included for completeness: platform heading (Figure 5), platform course (Figure 6), platform speed over ground (Figure 7), and platform speed over water (Figure 8). We note, regarding PL_SOW and PL_SOW2 it is common for these sensors only to transmit data when underway. As such, frequent missing values are rather the norm for those two.

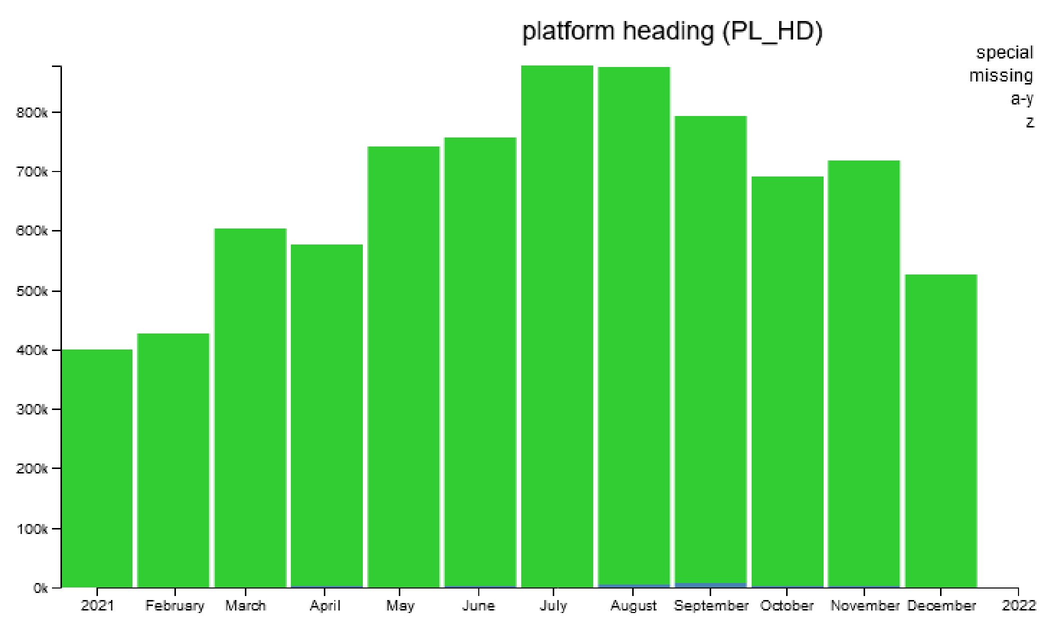
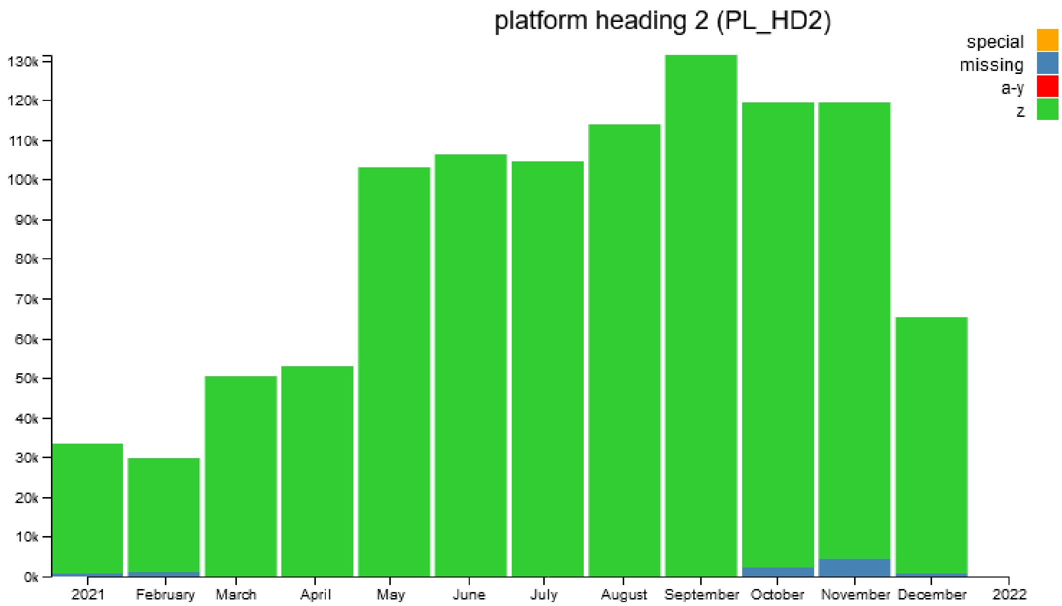


Figure 5: Total number of (this page) platform heading – PL_HD – (next page, top) platform heading 2 – PL_HD2 – and (next page, bottom) platform heading 3 – PL_HD3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



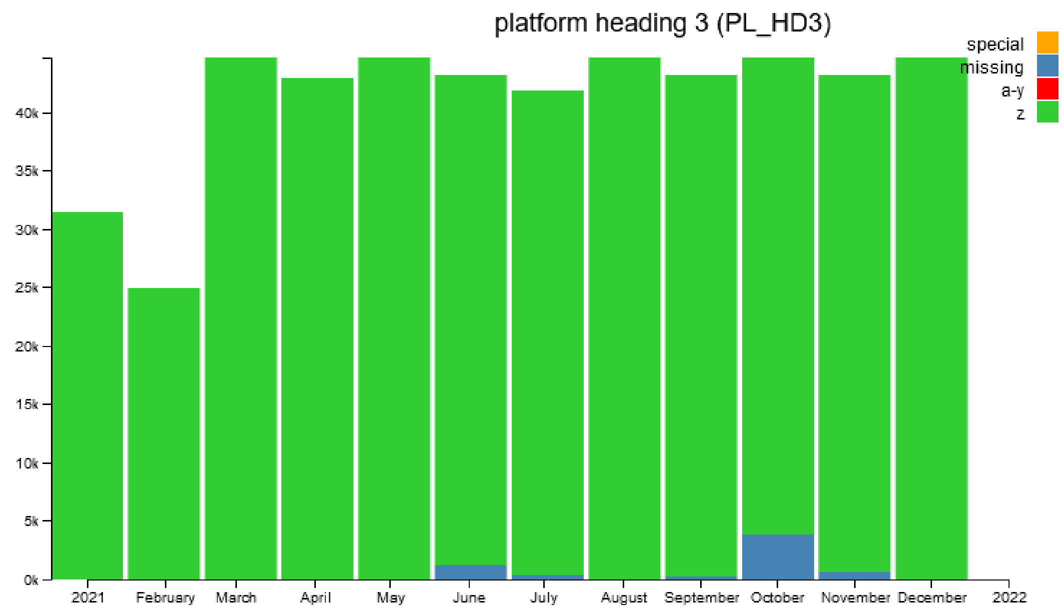
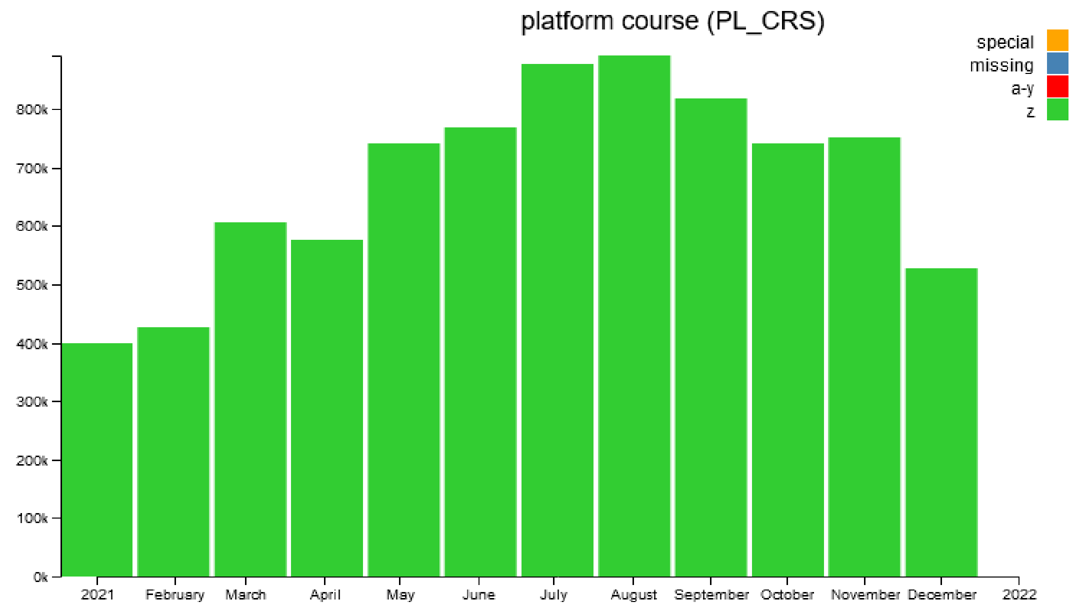


Figure 5: cont'd.



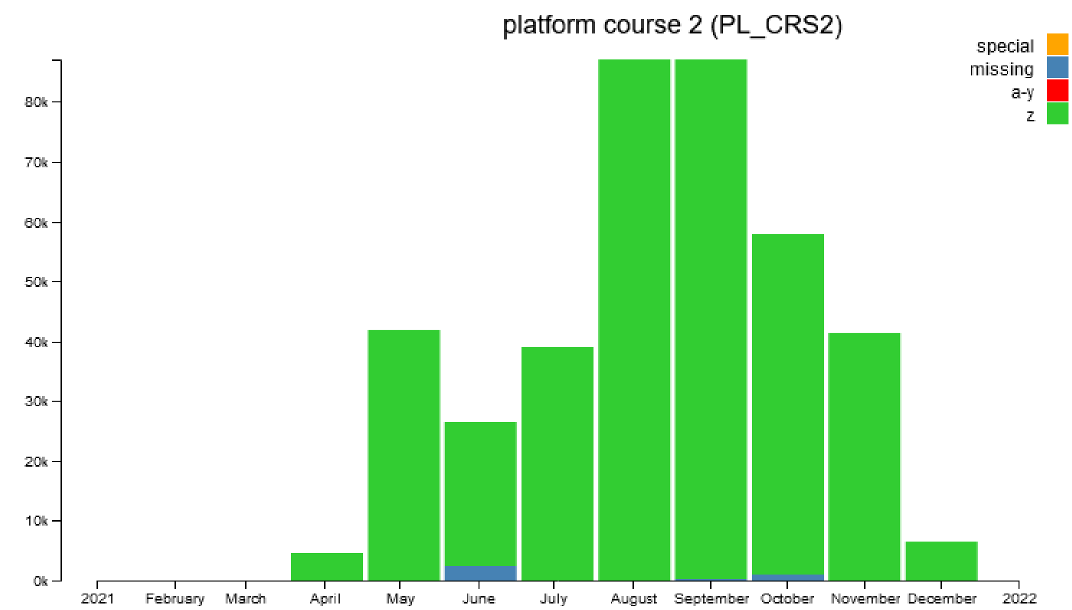


Figure 6: Total number of (this page, top) platform course – PL_CRS – (this page, bottom) platform course 2 – PL_CRS2 – and (next page) platform course 3 – PL_CRS3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

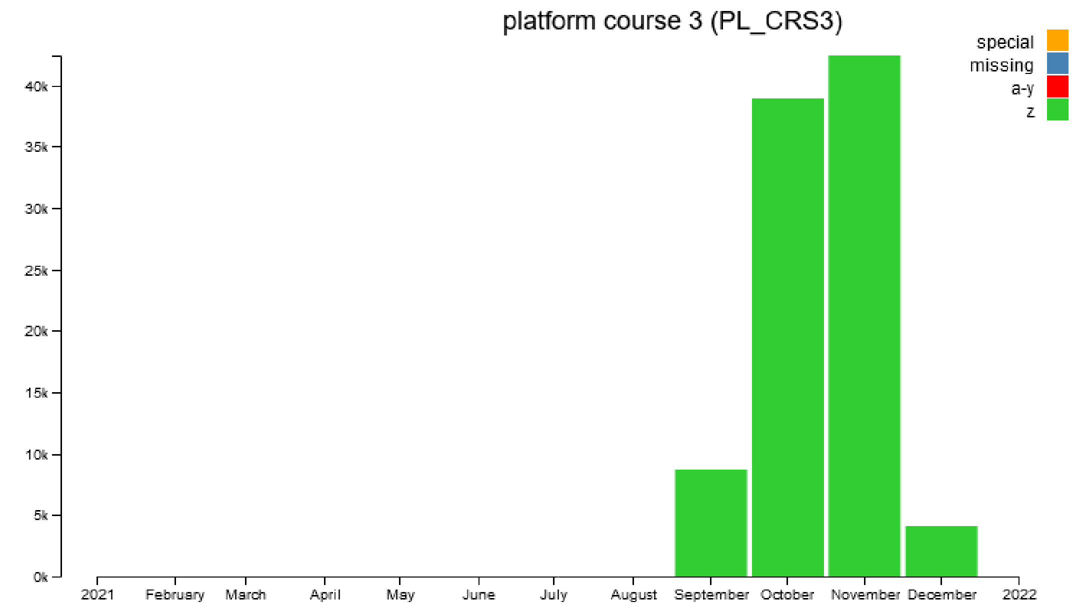


Figure 6: cont'd.

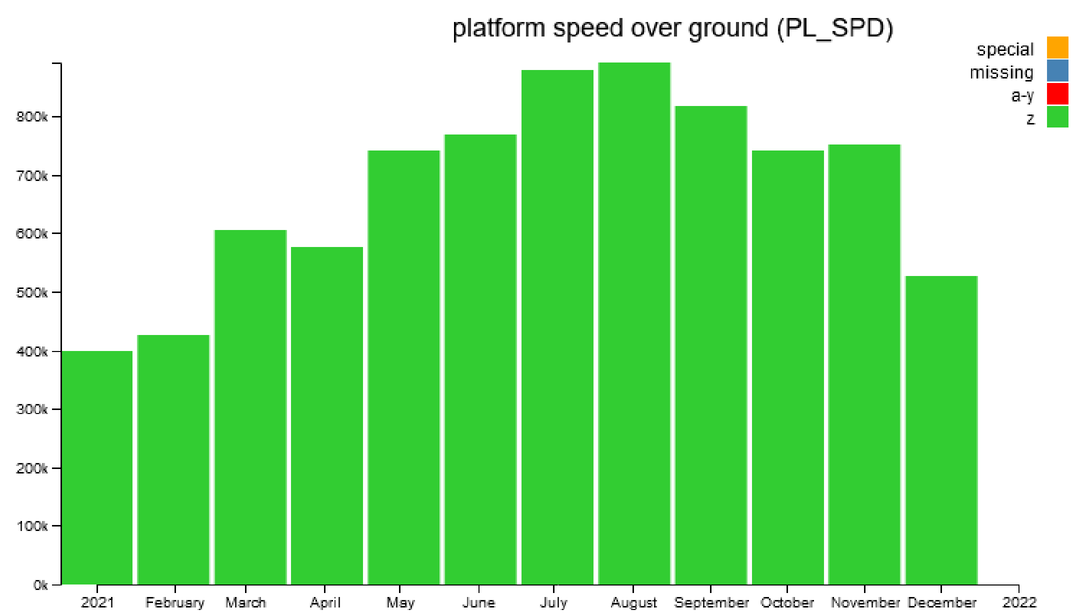


Figure 7: Total number of (this page) platform speed over ground – PL_SPD – and (next page) platform speed over ground 2 – PL_SPD2 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

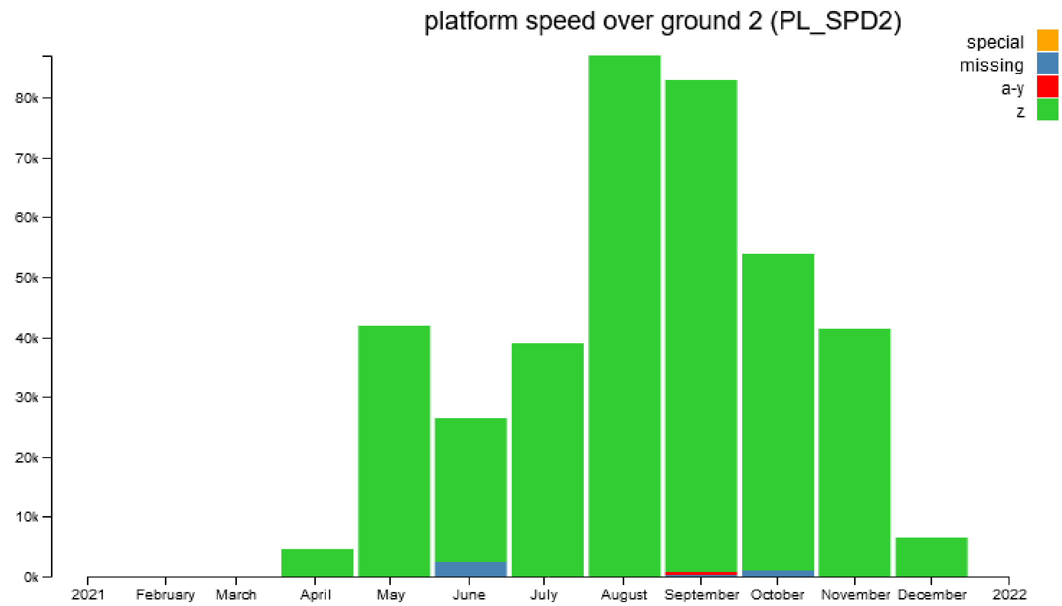


Figure 7: cont'd.

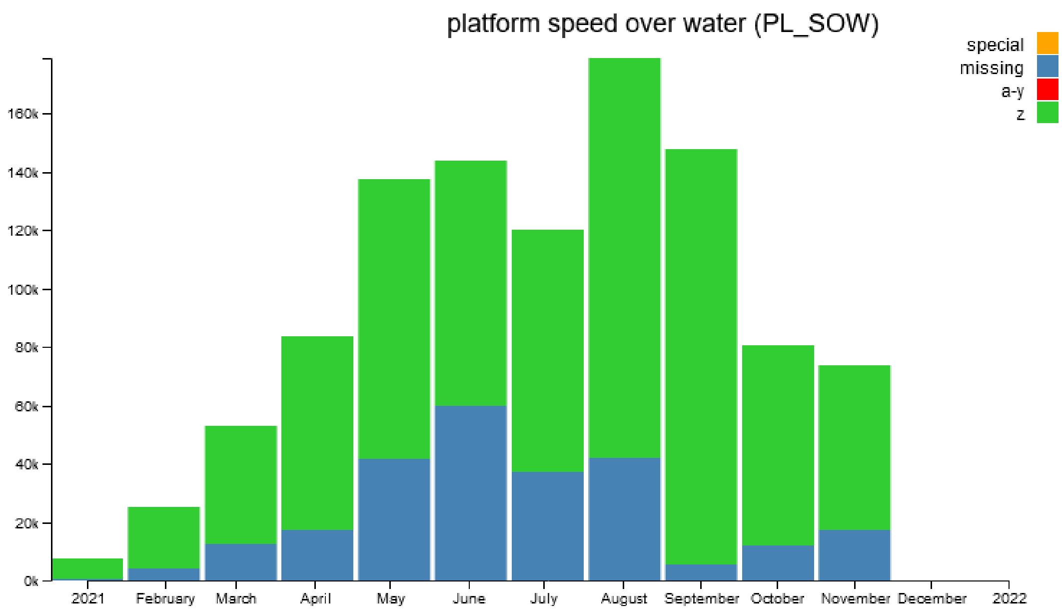


Figure 8: Total number of (this page) platform speed over water – PL_SOW – and (next page) platform speed over water 2 – PL_SOW2 observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

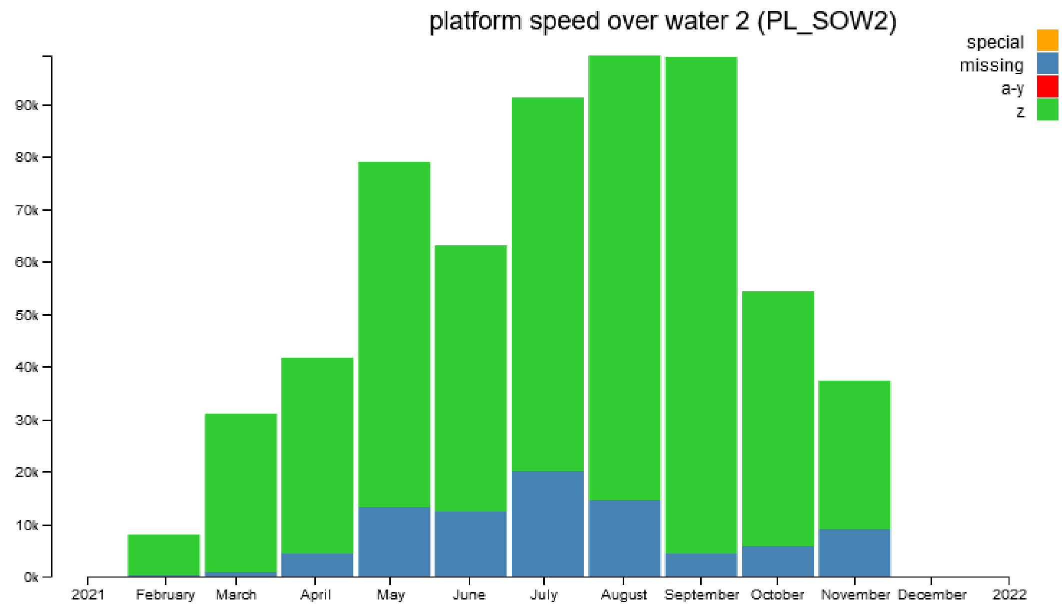
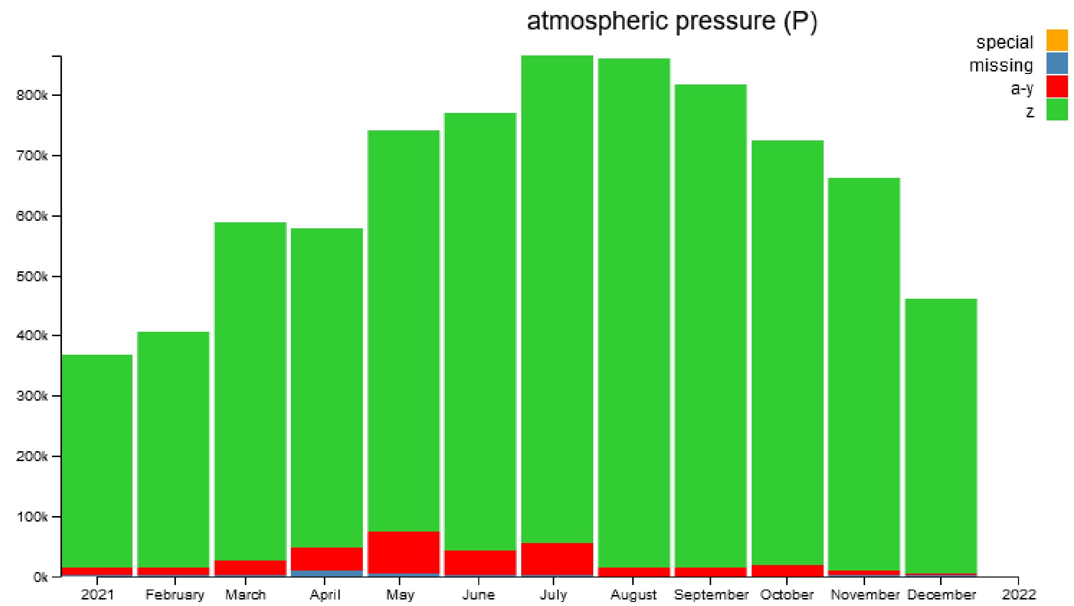


Figure 8: cont'd.

The quality of SAMOS atmospheric pressure data is generally good (Figure 9). The most common problems with the pressure sensors are flow obstruction and barometer response to changes in platform speed. Unwanted pressure response to vessel motion can be avoided by ensuring good exposure of the pressure port to the atmosphere (not in a lab, bridge, or under an overhanging deck) and by using a Gill-type pressure port. We note it is also fairly common to see water collection in cracked pressure port tubing, which affects the pressure data and can contribute to pressure flags during visual QC.

The uptick in flagging seen here in P and P2 in April through July are likely mainly due to sensor or data issues with those parameters throughout the period on board the *Bigelow* and *Okeanos Explorer* (documented; see individual vessel description in section 3c for details). The origins of any increases in a-y flagging seen in P3 are not clearly identified as belonging to any specific vessel(s); however, it is known only the *Atlantis*, *Falkor*, and *Bell M. Shimada* provided P3 data in 2021. We note *Falkor* is known to periodically encounter high seas underway that regularly wash all her meteorological sensors with spray, which tends to be a main contributor to her quality flags. The missing values noted in July and August in P3 look to have come from the *Atlantis*. This was likely due to their starboard Vaisala WXT520 unit spontaneously stopping data logging, a known issue with both their WXTs (documented; see individual vessel description in section 3c for details).



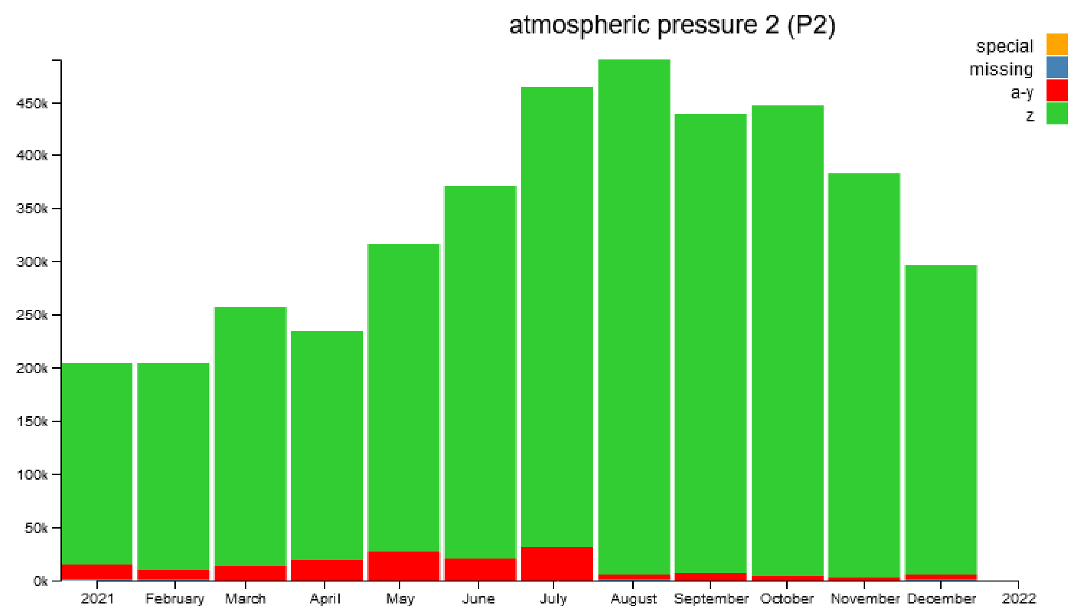
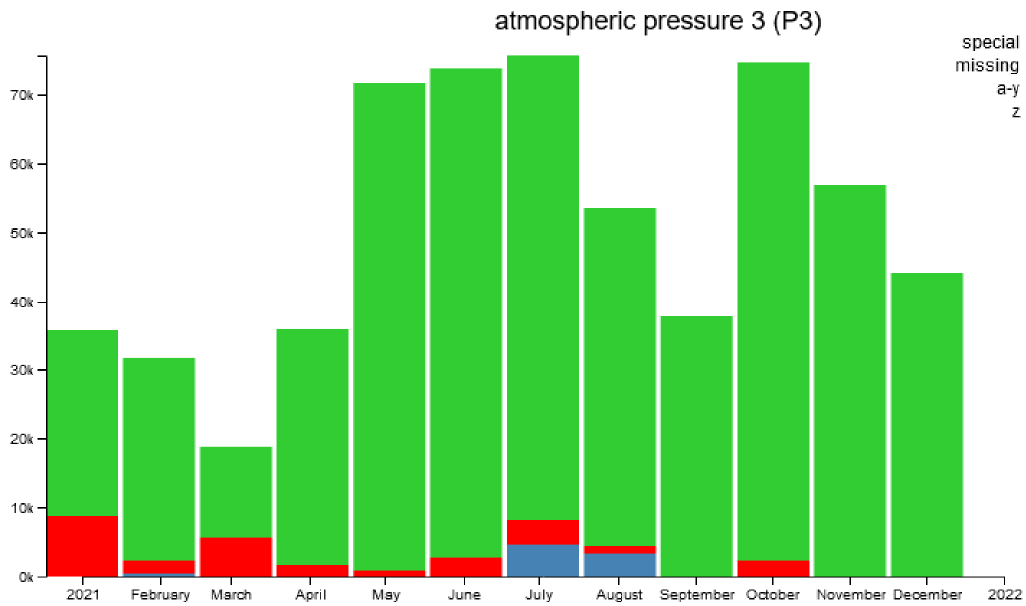


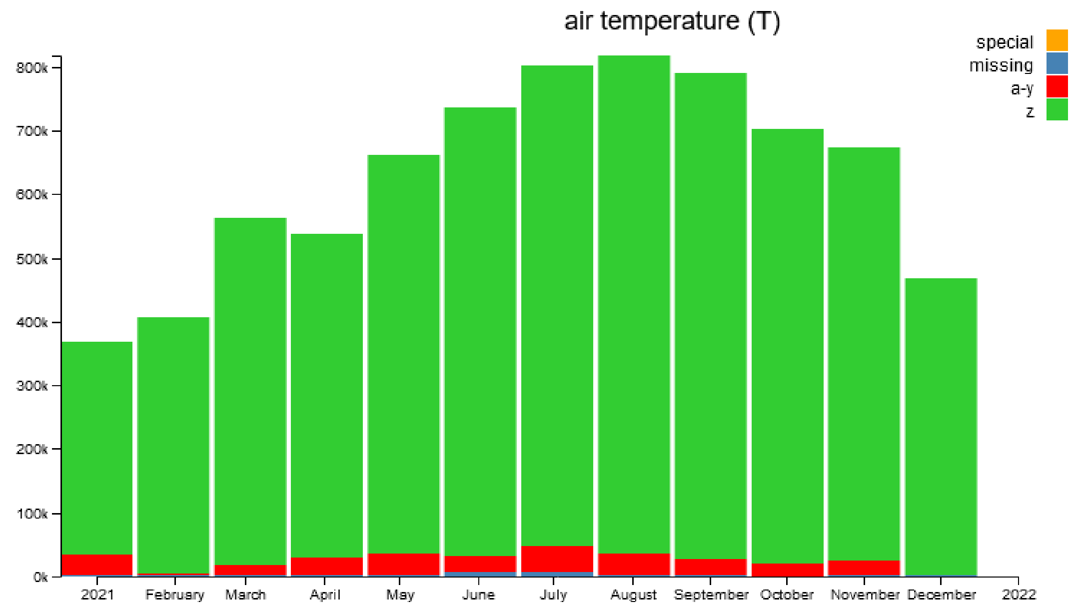
Figure 9: Total number of (this page, top) atmospheric pressure – P – (this page, bottom) atmospheric pressure 2 – P2 – and (next page) atmospheric pressure 3 – P3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 9: cont'd)

Air temperature was also of decent quality (Figure 10). With the air temperature sensors, again flow obstruction is a primary problem. In this case, when the platform relative wind direction is such that regular flow to the sensor is blocked, unnatural heating of the sensor location can occur. Thermal contamination can also occur simply when winds are light, and the sensor is mounted on or near a large structure that easily retains heat (usually metal). Contamination from stack exhaust was also a common problem. In the case of stack exhaust, the authors wish to stress that adequate digital imagery, when used in combination with platform relative wind data, can facilitate the identification of exhaust contamination and subsequent recommendations to operators to change the exposure of their thermometer.

The greater proportion of flagging seen here in T in January looks to have come from *Laurence M. Gould* as a result of damage to their hygrometer at the end of 2020. The sensor was replaced on 26 January 2021. The increases in a-y flagging seen in T3 in July through October are mainly due to ongoing sensor problems on board the *Healy* and the *Roger Revelle* (documented; see individual vessel description in section 3c for details). Generally speaking, the origins of any upticks in flagging in air temperature are often not clearly identified as belonging to any specific vessel(s) but tend to be due to several vessels simultaneously experiencing common sensor issues. The missing values noted in July and August in T3 look to have come from the *Atlantis*. This was likely due to their starboard Vaisala WXT520 unit spontaneously stopping data logging, a known issue with both their WXTs (documented; see individual vessel description in section 3c for details).



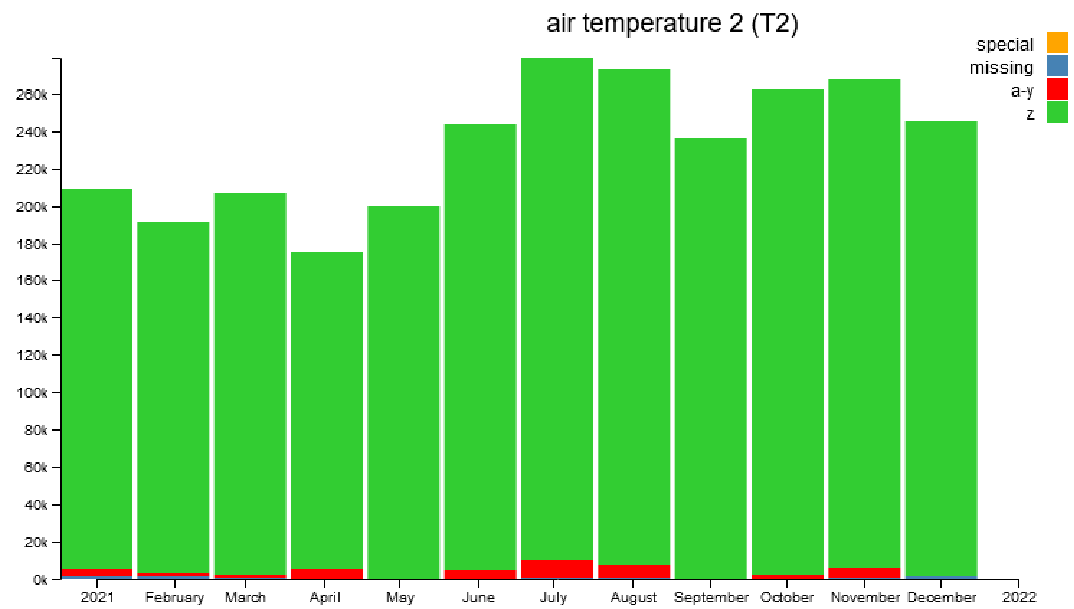
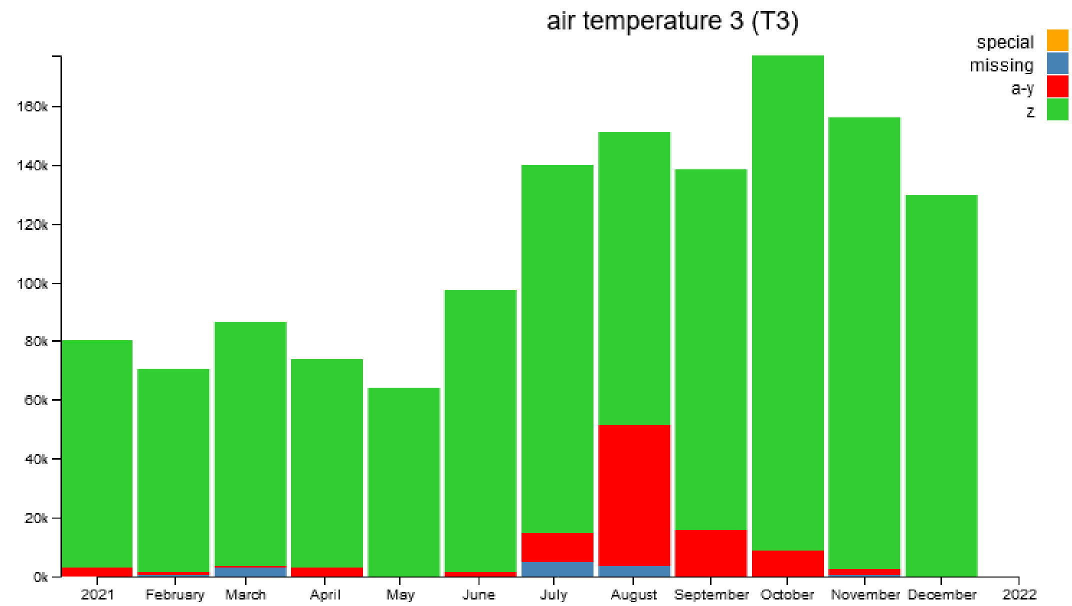


Figure 10: Total number of (this page, top) air temperature – T – (this page, bottom) air temperature 2 – T2 – and (next page) air temperature 3 – T3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 10: cont'd)

Wet bulb temperature (Figure 11) was reported by four vessels in 2021; namely, the *Thomas Jefferson*, the *Bell M. Shimada*, the *Rainier*, and the *Okeanos Explorer*, which are also the only vessels currently set up to report wet bulb. We note TW from all four vessels is a calculated value, rather than being directly measured. In the case of both *Rainier* and *Jefferson*, because their relative humidity parameters often top out at just over 100% in saturation (common, see relative humidity topic below) the calculated TW (and TD, below) parameters are often unrealistic, meaning they receive "failed the T>=Tw>=Td test" (D) flags (documented; see individual vessel description in section 3c for details). Other than these, most flags seen here were the result of flow obstruction and/or ship heating.

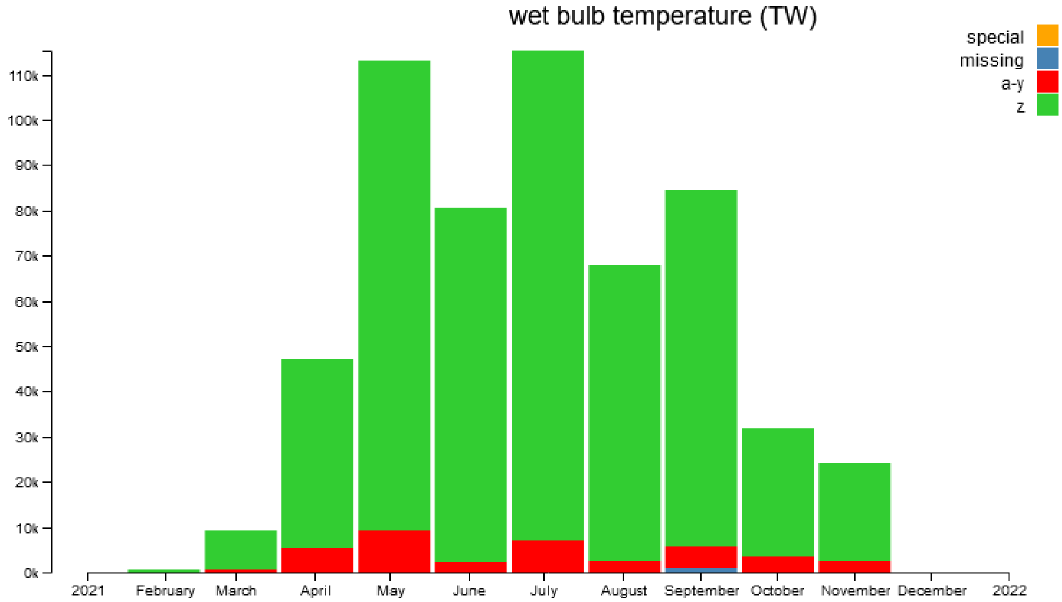


Figure 11: Total number of wet bulb temperature – TW – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

Dew point temperature (Figure 12) was also reported by just these four vessels in 2021 (again, *Thomas Jefferson, Bell M. Shimada*, the *Rainier*, and the *Okeanos Explorer*. We reiterate, TD from all four vessels is a calculated value, rather than being directly measured. And again, in the case of both *Rainier* and *Jefferson*, because their relative humidity parameters often top out at just over 100% in saturation (common, see relative humidity topic below) the calculated TD (and TW, above) parameters are often unrealistic, meaning they receive "failed the T>=Tw>=Td test" (D) flags (documented; see individual vessel description in section 3c for details). Other than these, most flags seen here were the result of flow obstruction and/or ship heating.

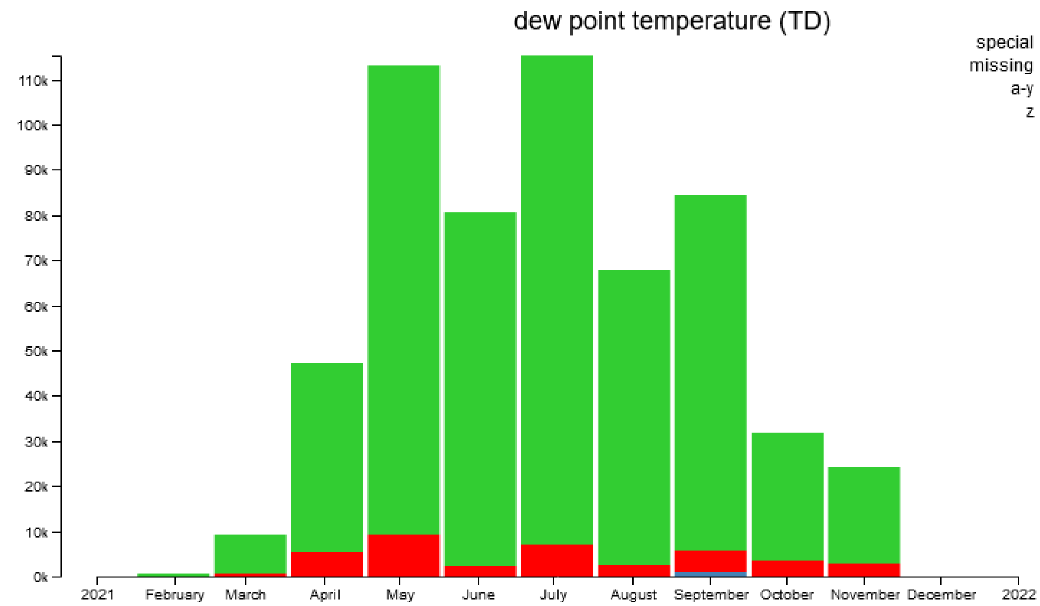
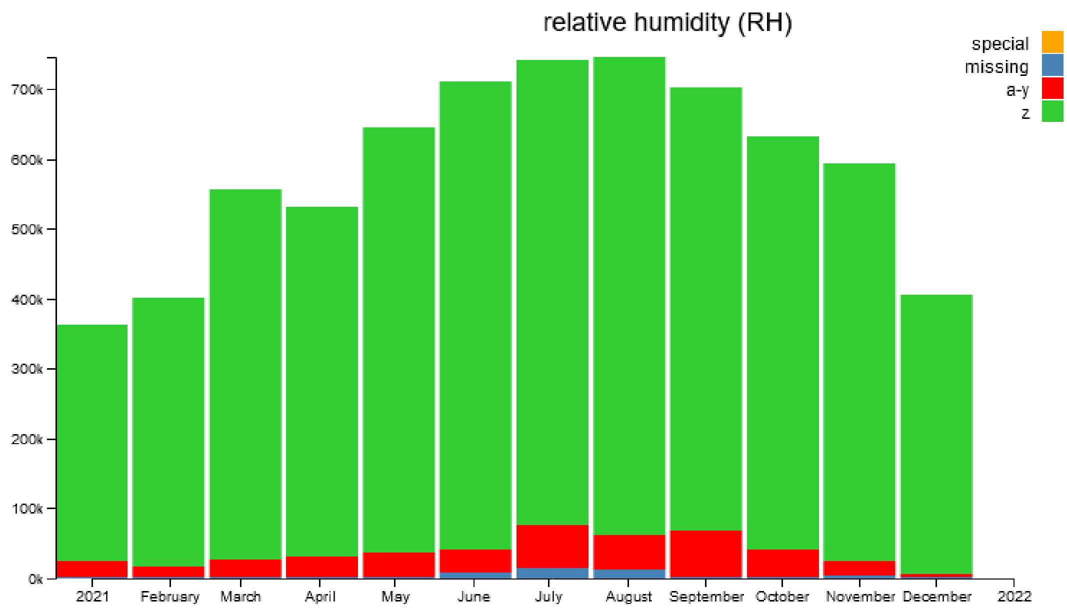


Figure 12: Total number of dew point temperature – TD – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

With relative humidity, the most common issue is readings slightly greater than 100%. If these measurements were sound, they would imply supersaturated conditions, but in fact that scenario is quite rare near the surface of the ocean. When it comes to relative humidity, the mechanics of most types of sensors is such that it is easier to obtain high accuracy over a narrow range than over a broader range, say from 10% to 100% (Wiederhold, 2010). It is often desirable to tune these sensors for the greatest accuracy within ranges much less than 100%. The offshoot of such tuning, of course, is that when conditions are at or near saturation (e.g., rainy or foggy conditions) the sensor performs with less accuracy and readings over 100% commonly occur. While these readings are not really in grave error, they are nonetheless physically implausible and should not be used, or, as desired by the user, simply set to a value of 100%. Thus, they are B flagged by the automated QC flagger. These B flags likely account for a large portion of the A-Y flagged portions depicted in Figure 13.

The uptick in flagging seen here in RH2 in January looks to have come mainly from the *Roger Revelle*. Onboard technicians confirmed the *Revelle* was operating in a particularly saturated environment (fog, rain) in late January and early February resulting in many RH2 data slightly over 100%, as is known to occur with *Revelle's* humidity sensors (and as described above). But for the most part, the origins of any upticks in flagging in relative humidity (as with air temperature) are often not clearly identified as belonging to any specific vessel(s) but tend to be due to several vessels simultaneously experiencing common sensor issues. The missing values noted in July and August in RH3 look to have come from the *Atlantis*. This was likely due to their starboard Vaisala WXT520 unit spontaneously stopping data logging, a known issue with both their WXTs (documented; see individual vessel description in section 3c for details). Possibly the missing values in RH2 could be from the *Sally Ride*, whose sensor has a suspected voltage issue wherein it frequently puts out NaN when in saturation (documented; see individual vessel description in section 3c for details).



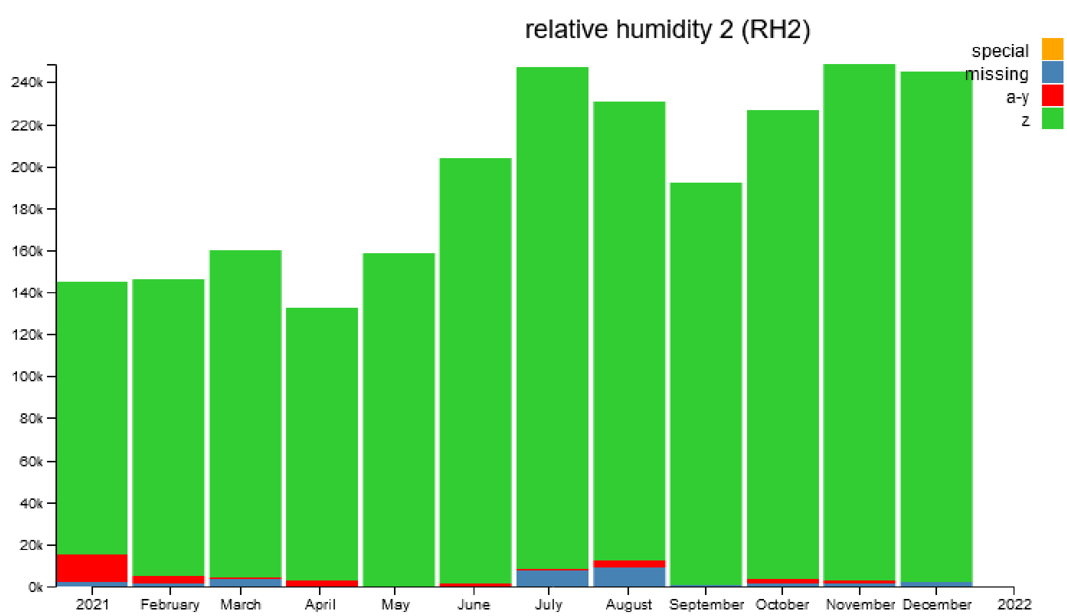
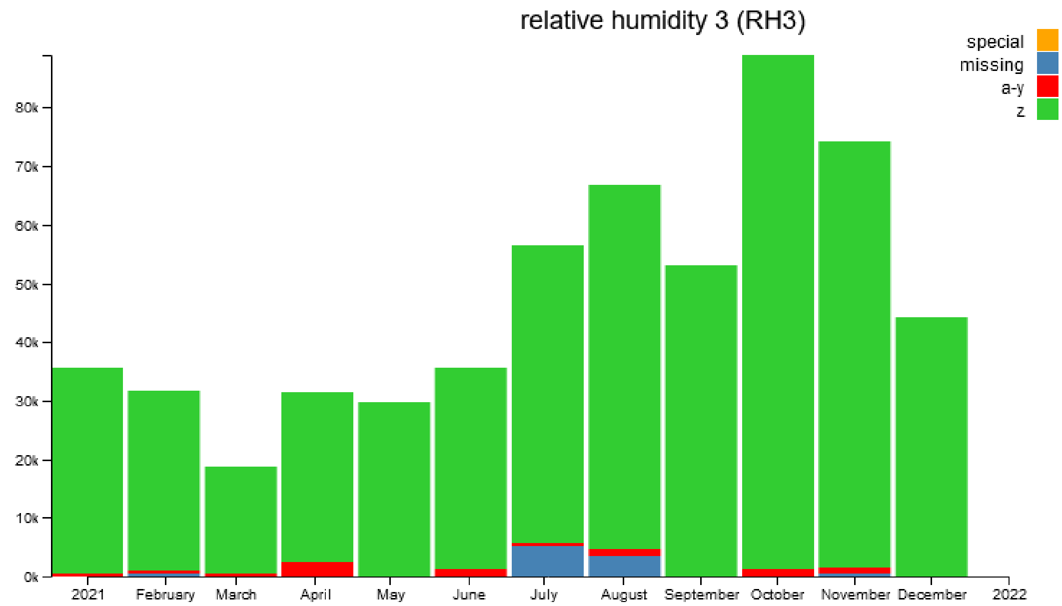


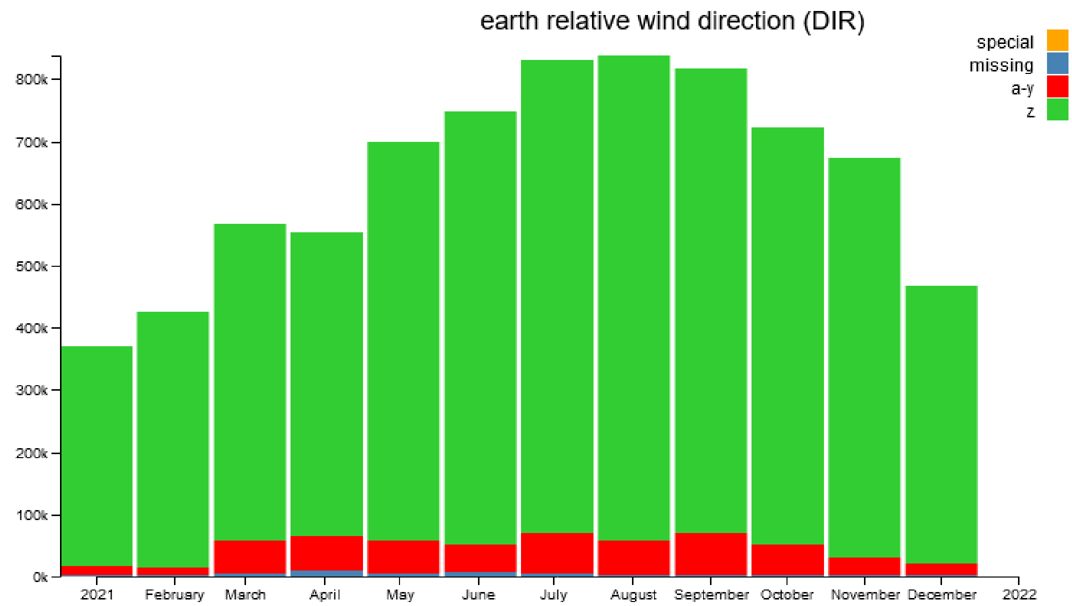
Figure 13: Total number of (this page, top) relative humidity – RH – (this page, bottom) relative humidity 2 – RH2 – and (next page) relative humidity 3 – RH3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 13: cont'd)

Wind sensors, both direction and speed, are arguably the instruments most affected by flow obstruction and changes in platform speed. Because research vessels traditionally carry bulky scientific equipment and typically have multi-level superstructures, it is a challenge to find locations on a research vessel where the sensors will capture the free-circulating atmosphere. Unlike other met sensors such as air temperature and relative humidity that are designed to function more or less independent of the micro scale nuances in airflow surrounding them, nuances in flow are the very thing that wind sensors are intended to measure. This is why obstructed flow is so readily incorporated into wind measurements. These flow-obstructed and platform speed-affected wind data were a common problem across SAMOS vessels in 2021. Where comprehensive metadata and digital imagery exist, flow obstructed platform relative wind bands can often be diagnosed based on the structural configuration of the vessel and recommendations can be made to the vessel operator to improve sensor locations.

The other major problem with earth relative wind data is errors caused by changes in platform speed. Occasionally, a wind direction sensor is also suspected of being "off" by several degrees. Satellite wind products and in-situ data (buoys, pier-based stations, etc.) can sometimes clue data analysts in to such a bias, particularly if the bias is very large. But in general, if a technician suspects a wind direction bias it is critical they communicate that suspicion to SAMOS personnel, as otherwise the data analysts often will have no reliable means of discovering the problem themselves.   Suspected wind direction biases are typically flagged with K flags, or J flags if the case is extreme and/or verifiable.



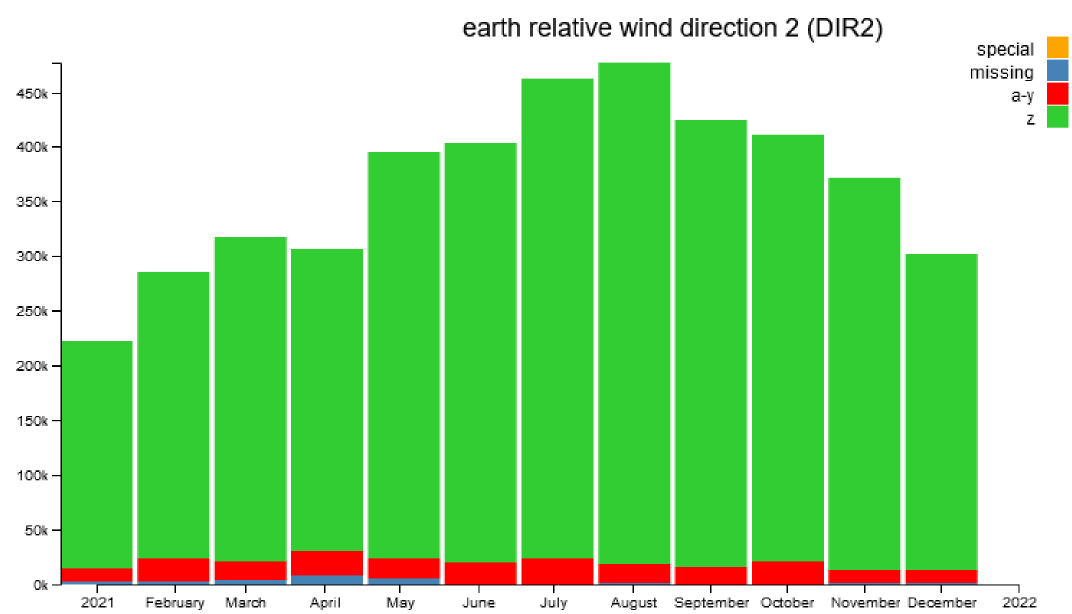
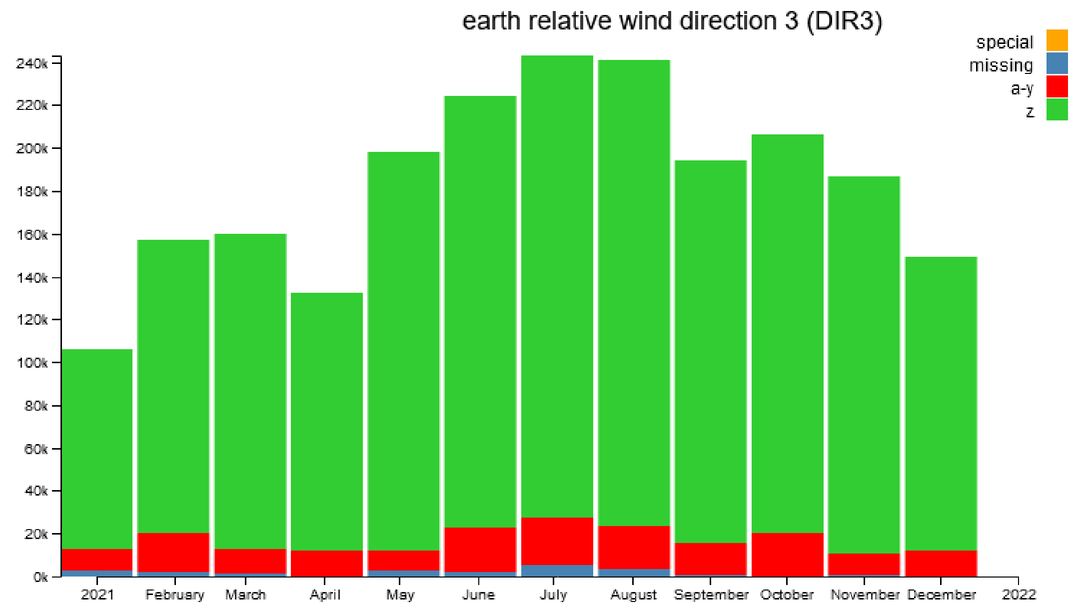


Figure 14: Total number of (this page, top) earth relative wind direction – DIR – (this page, bottom) earth relative wind direction 2 – DIR2 – and (next page) earth relative wind direction 3 – DIR3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 14: cont'd)

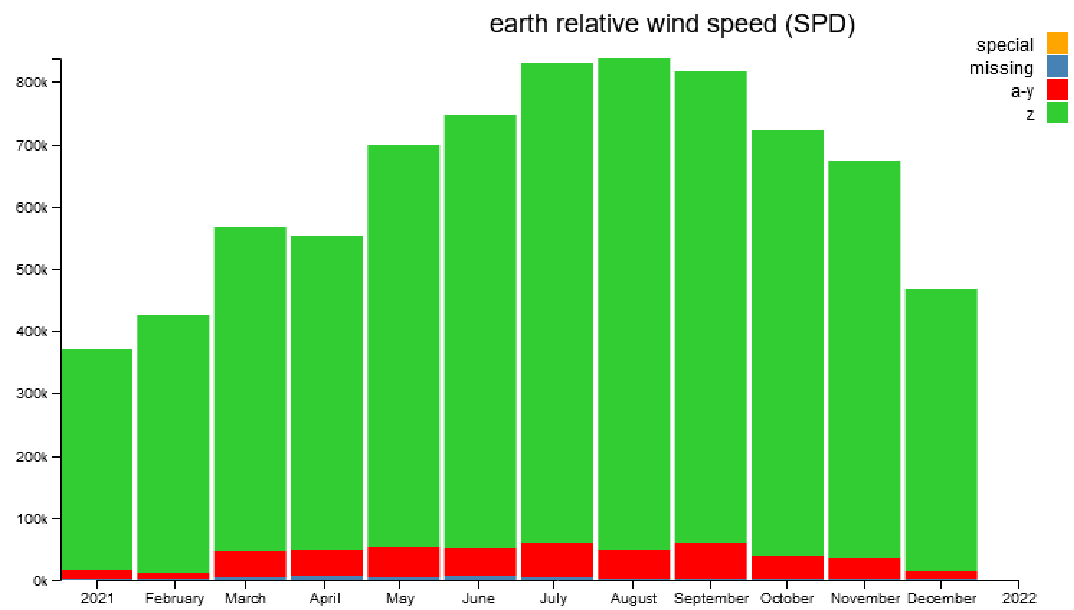
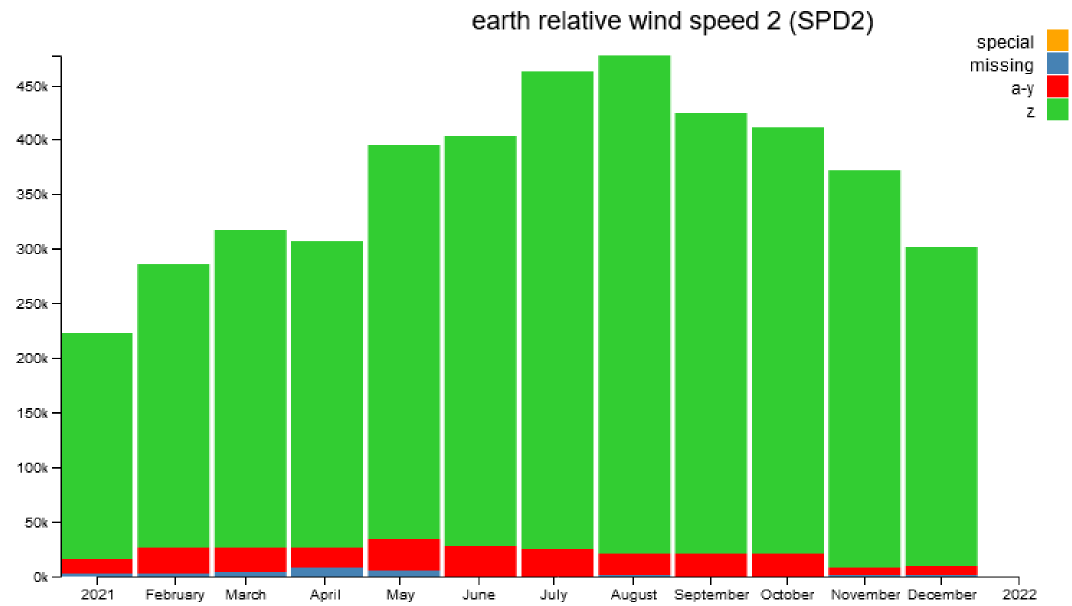
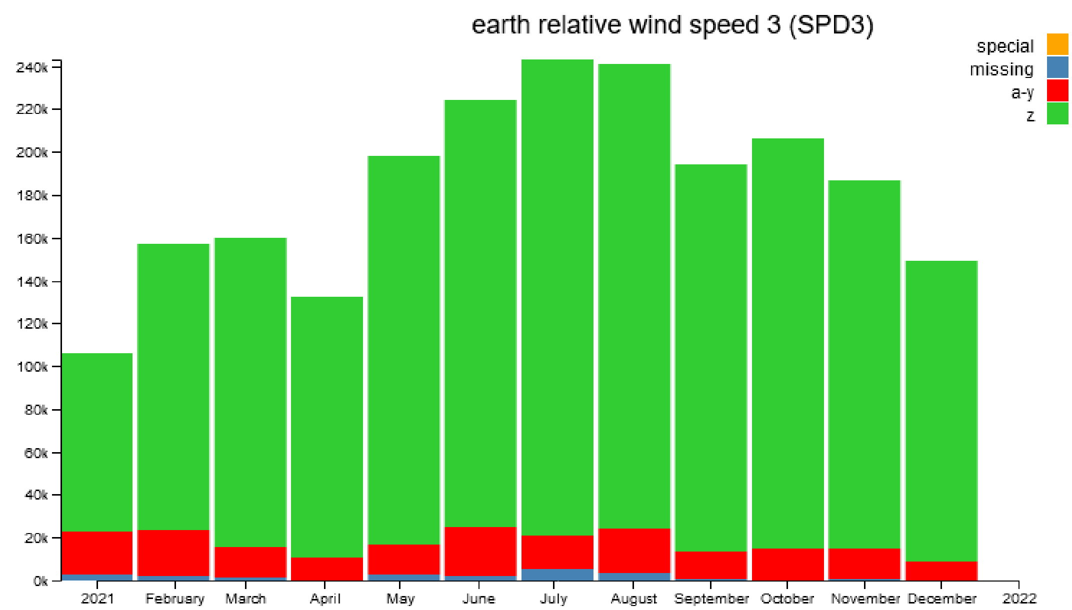


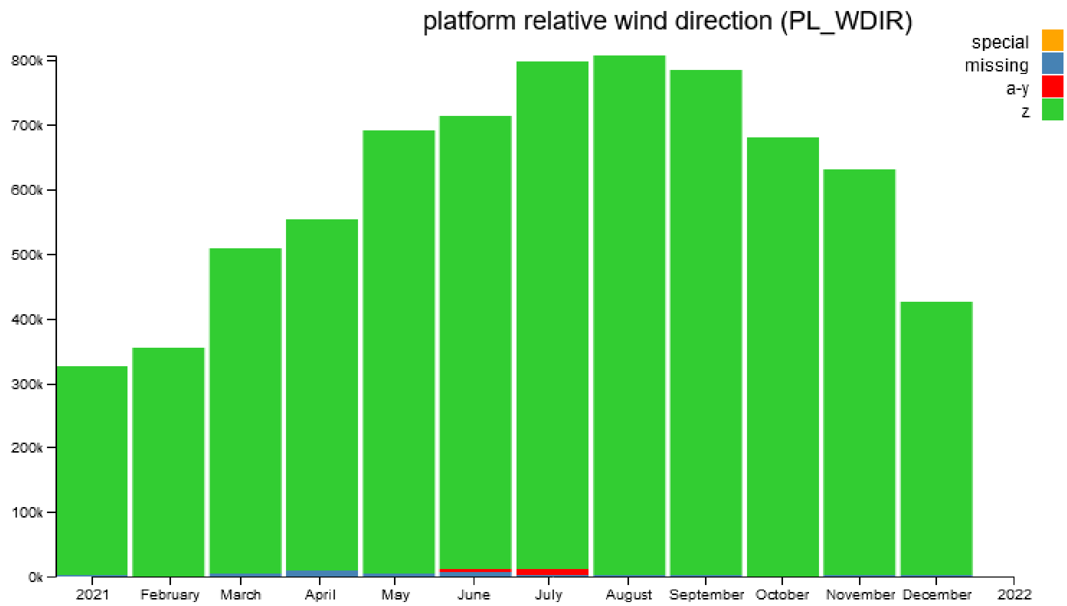
Figure 15: Total number of (this page) earth relative wind speed – SPD – (next page, top) earth relative wind speed 2 – SPD2 – and (next page, bottom) earth relative wind speed 3 – SPD3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.





(Figure 15: cont'd)

The platform relative wind parameters, both direction (Figure 16) and speed (Figure 17), mostly exhibited no major problems of note, with a few exceptions: namely, an unknown (suspected) PL_WDIR2 configuration error that lasted all year on the *Pisces* and a spate of mistaken PL_WSPD2 data adjustment on the *Reuben Lasker* in March (both documented; see individual vessel description in section 3c for details). These and any other sparse cases were treated with J, K, or M flags in those vessels that receive visual quality control but left alone (and more than likely unflagged by the auto flagger) for the remaining vessels.



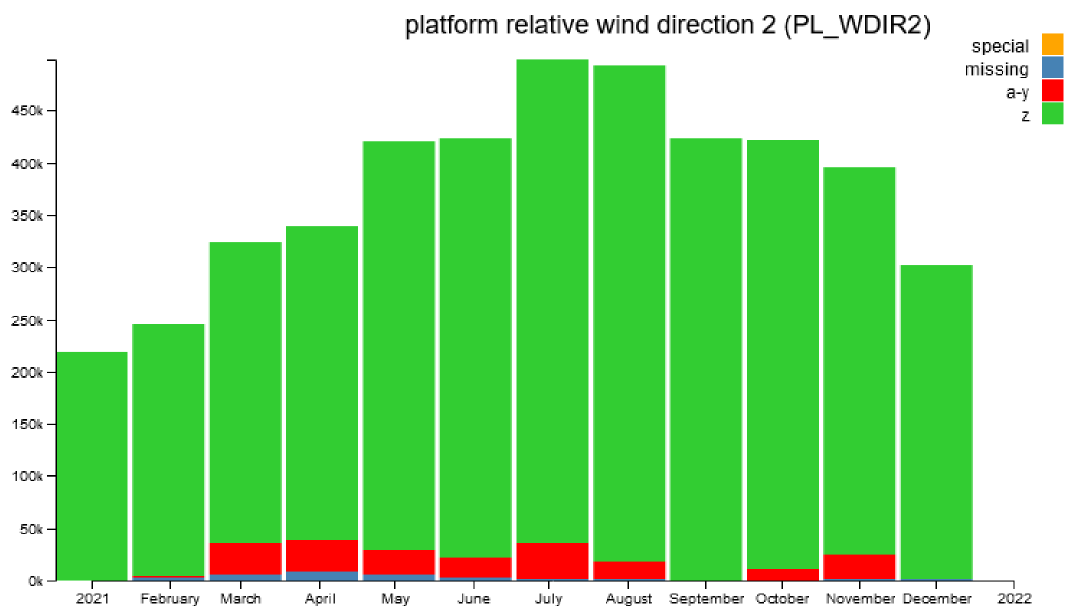
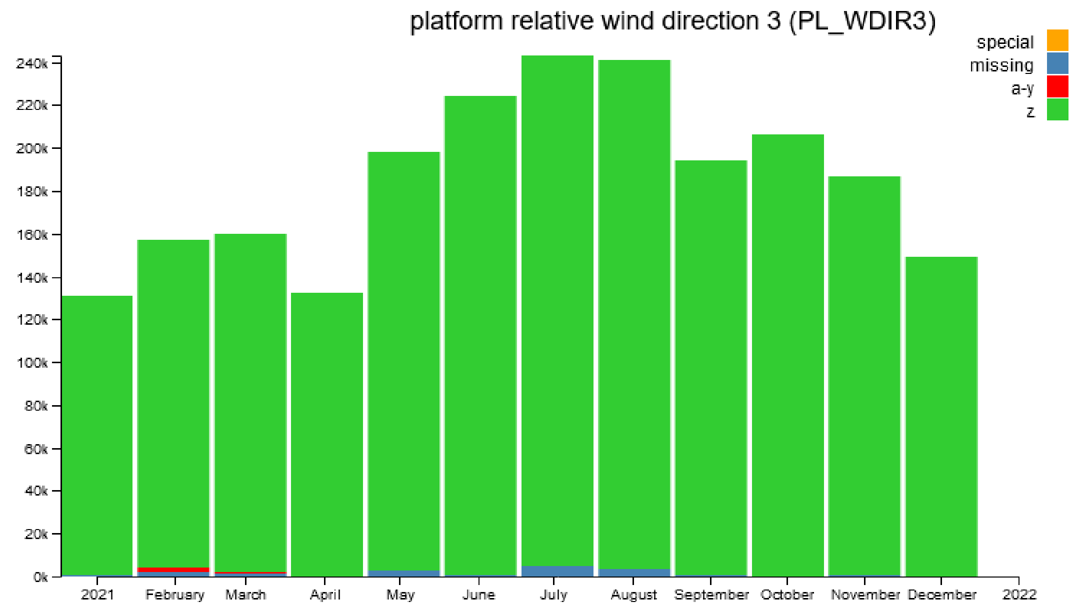


Figure 16: Total number of (this page, top) platform relative wind direction – PL_WDIR – (this page, bottom) platform relative wind direction 2 – PL_WDIR2 – and (next page) platform relative wind direction 3 – PL_WDIR3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 16: cont'd)

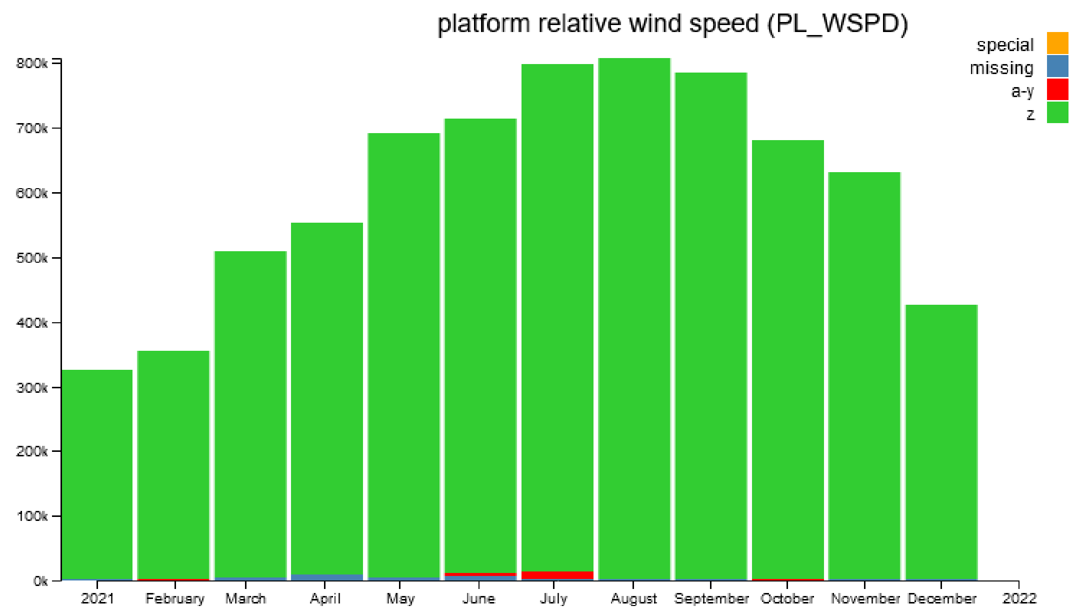
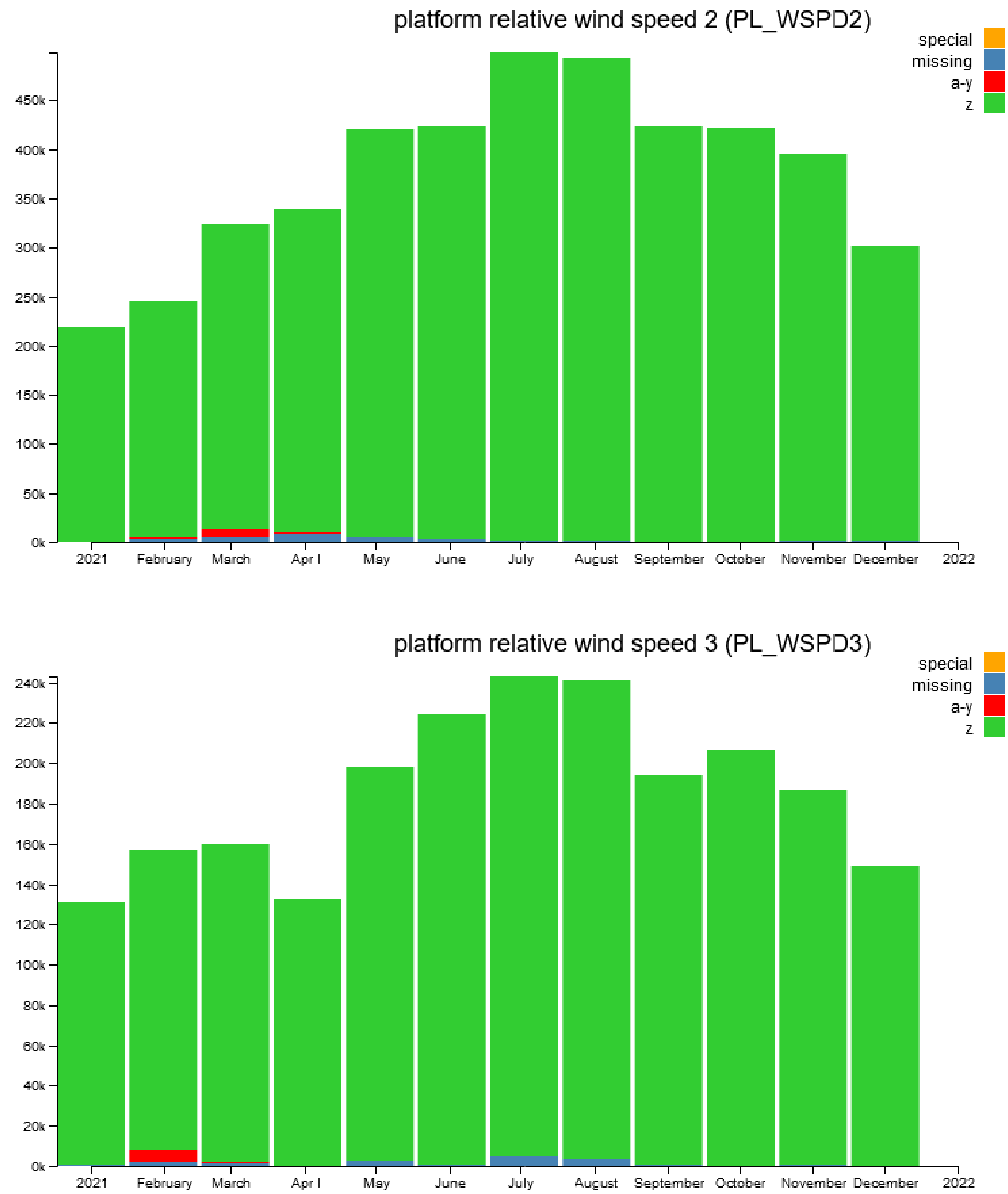


Figure 17: Total number of (this page) platform relative wind speed – PL_WSPD – (next page, top) platform relative wind speed 2 – PL_WSPD2 – and (next page, bottom) platform relative wind speed 3 – PL_WSPD3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 17: cont'd)

Most of the flags applied to the radiation parameters were assigned by the auto flagger, primarily to short wave radiation (Figure 18). Short wave radiation tends to have the largest percentage of data flagged for parameters submitted to SAMOS. Out of bounds (B) flags dominate in this case. Like the relative humidity sensors, this is again a situation where a high degree of accuracy is impossible over a large range of values. As such, short wave (and, similarly, photosynthetically active aka PAR) radiation sensors are typically tuned to permit greater accuracy at large radiation values. Consequently, short wave and photosynthetically active radiation values near zero (i.e., measured at night) often read slightly below zero. Once again, while these values are not a significant error, they are nonetheless invalid and unsuitable for use as is and should be set to zero by any user of these data. Long wave atmospheric radiation, on the other hand, usually has the smallest percentage of data flagged among the radiation parameters submitted to SAMOS (Figure 19).

The upticks in flagging seen in RAD_LW in June through October were mainly due to a problem with that sensor on the *Atlantis* (July – Oct) and another case of an unknown (suspected) RAD_LW configuration error that lasted June through the end of the season on *Bell M. Shimada* (both documented; see individual vessel description in section 3c for details). Most of the special values in RAD_PAR and RAD_PAR2 appear to have come from the *Falkor*, whose PAR sensors at night often reported their very smallest nighttime values in E notation, which is not an accepted data value format in SAMOS processing (hence being assigned the "special" values). Incredibly, this fact was not noted until the writing of this report. However, as nighttime PAR is by definition always zero at night anyway, it's expected the impact of the special values here is limited or nonexistent. Moreover, as *Falkor* is now retired, the issue no longer exists. (However, it will be on our radar for other and future installations of PAR.)

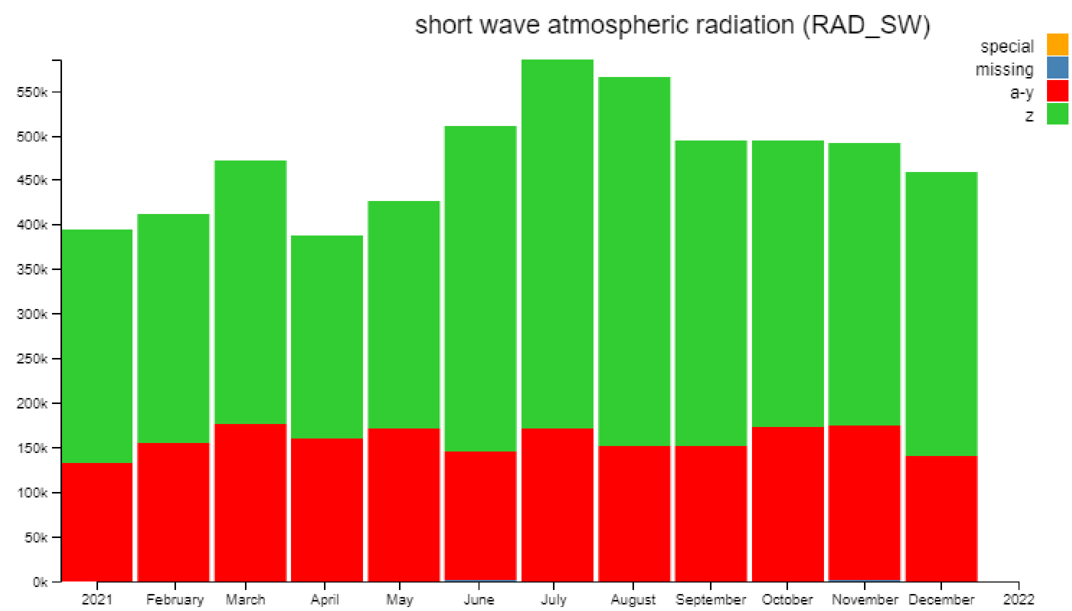
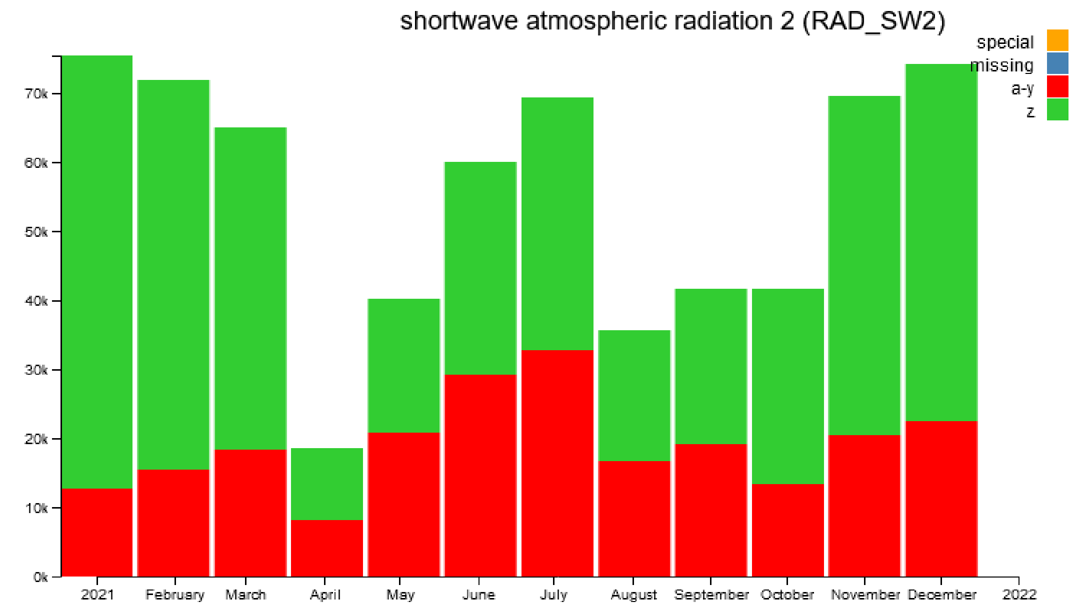


Figure 18: Total number of (this page) shortwave atmospheric radiation – RAD_SW – and (next page) shortwave atmospheric radiation 2 – RAD_SW2 –observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 18: cont'd)

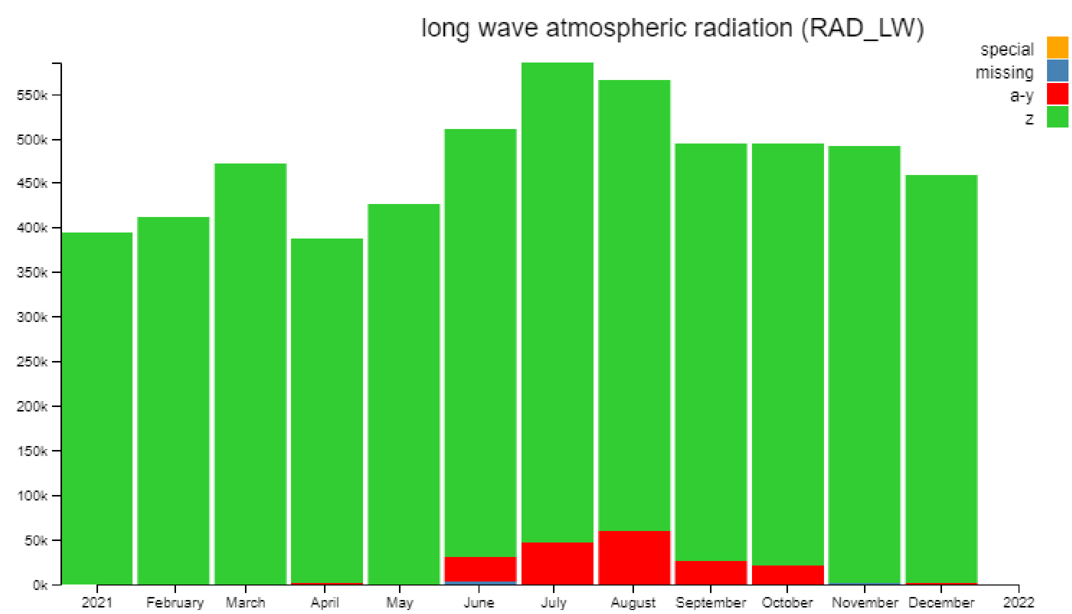
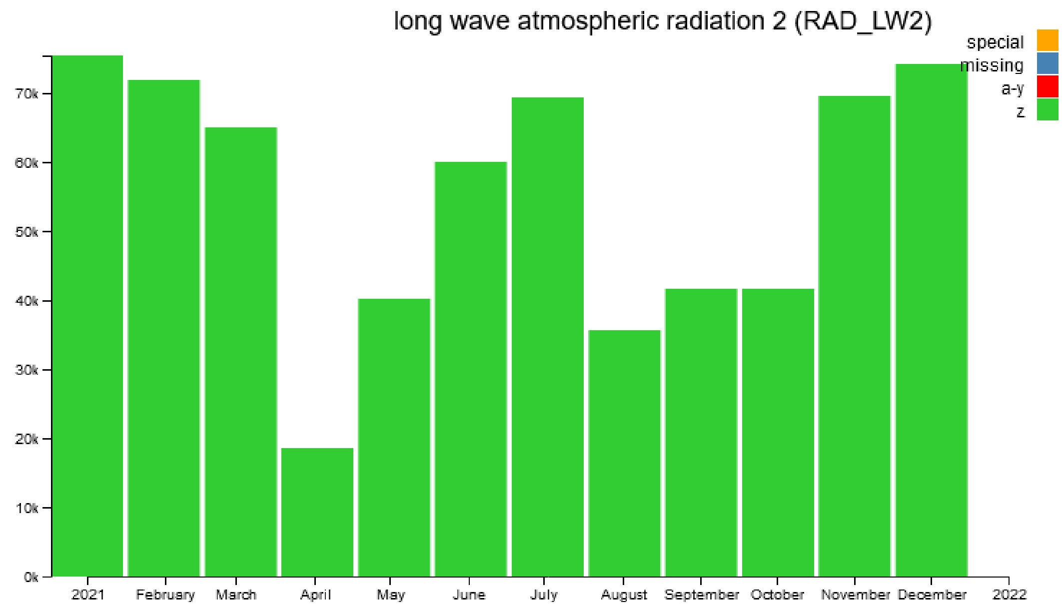


Figure 19: Total number of (this page) long wave atmospheric radiation – RAD_LW – and (next page) long wave atmospheric radiation 2 – RAD_LW2 –observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



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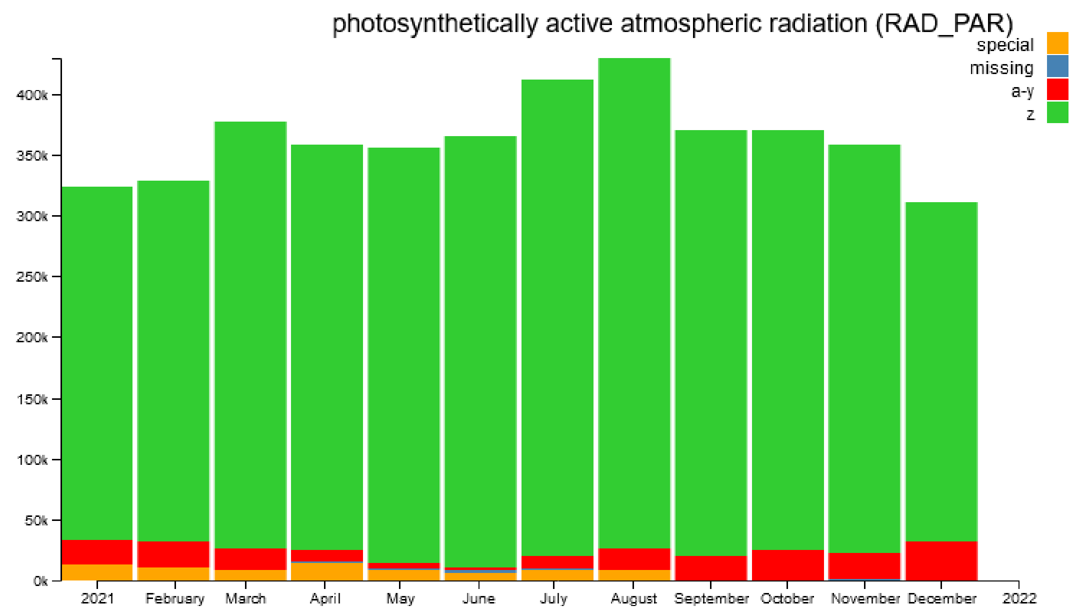
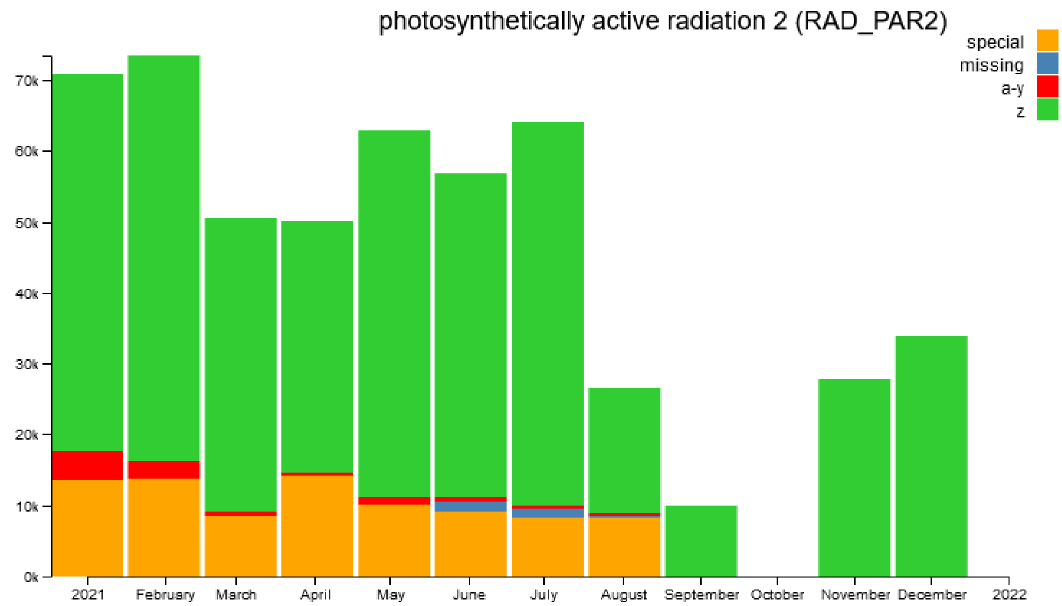


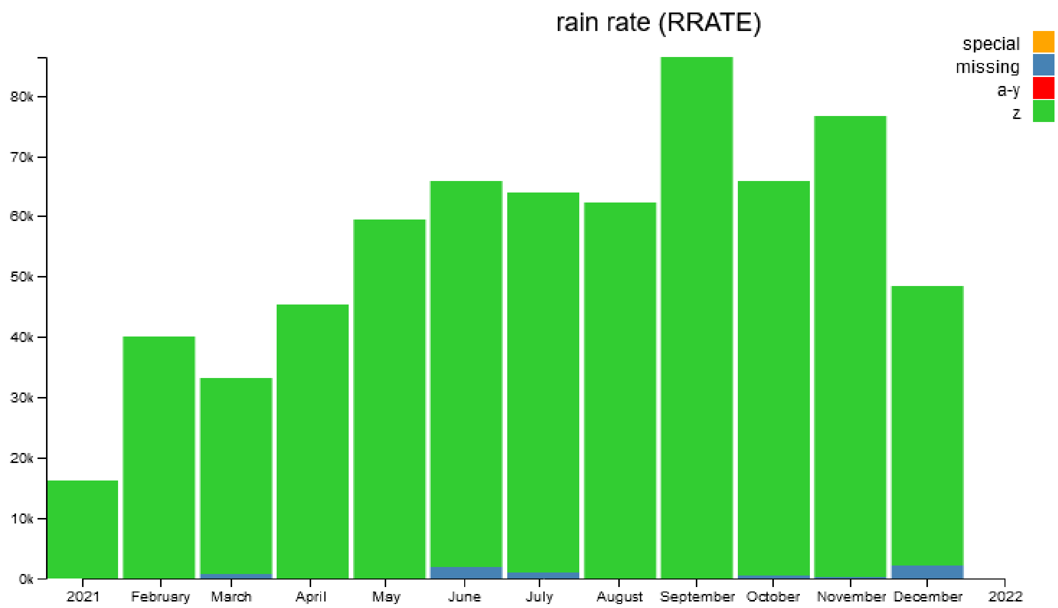
Figure 20: Total number of (this page) photosynthetically active atmospheric radiation – RAD_PAR – and (next page) photosynthetically active atmospheric radiation 2 – RAD_PAR2 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 20: cont'd)

There were no major problems noted for either the rain rate (Figure 21) or precipitation accumulation (Figure 22) parameters. It should be mentioned that some accumulation sensors occasionally exhibit slow leaks and/or evaporation. These data are not typically flagged; nevertheless, frequent emptying of precipitation accumulation sensors is always advisable.

The conspicuous missing values noted in July and August in RRATE3 and PRECP3 look to have come from the *Atlantis*. This was likely due to their starboard Vaisala WXT520 unit spontaneously stopping data logging, a known issue with both their WXTs (documented; see individual vessel description in section 3c for details).



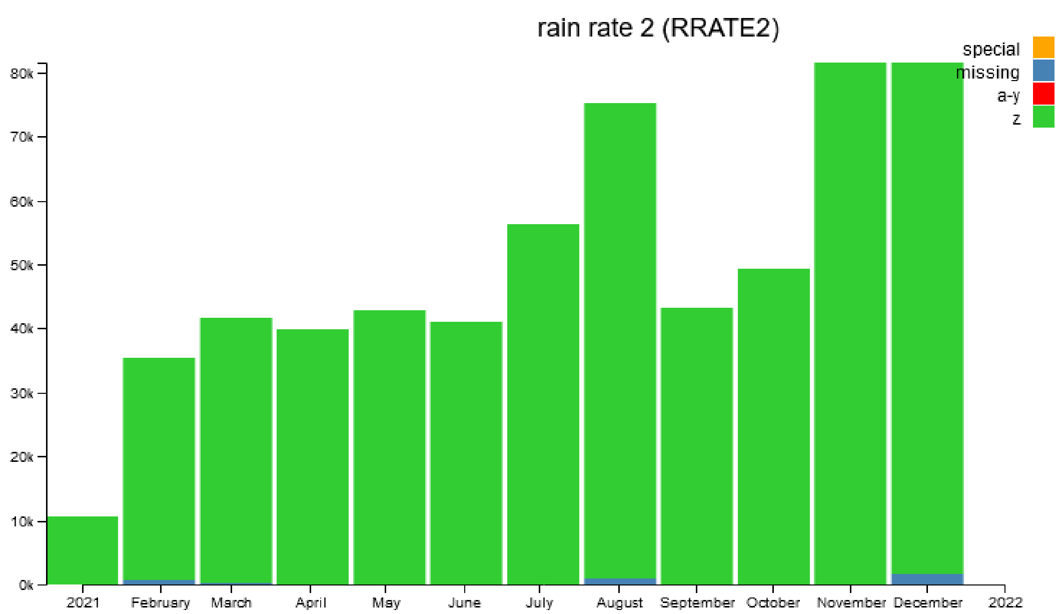
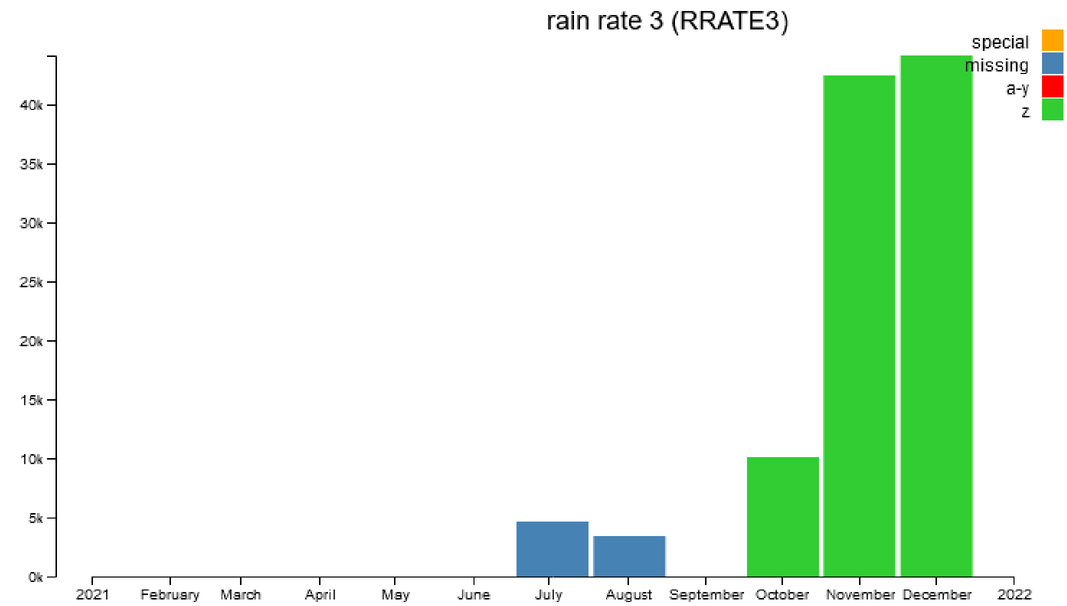


Figure 21: Total number of (this page, top) rain rate – RRATE – (this page, bottom) rain rate 2 – RRATE2 – and (next page) rain rate 3 – RRATE3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 21: cont'd)

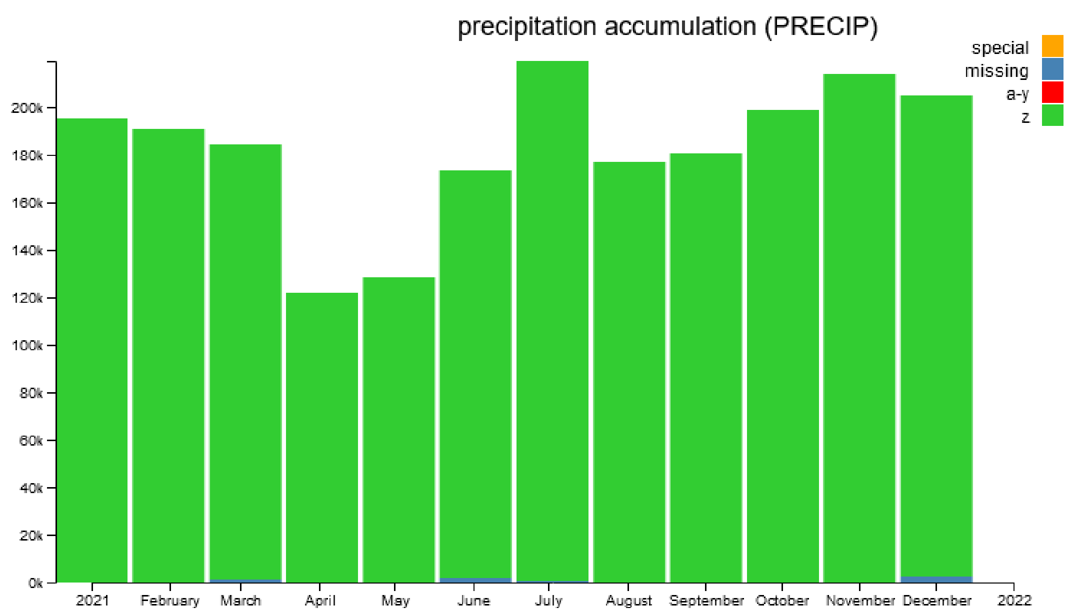
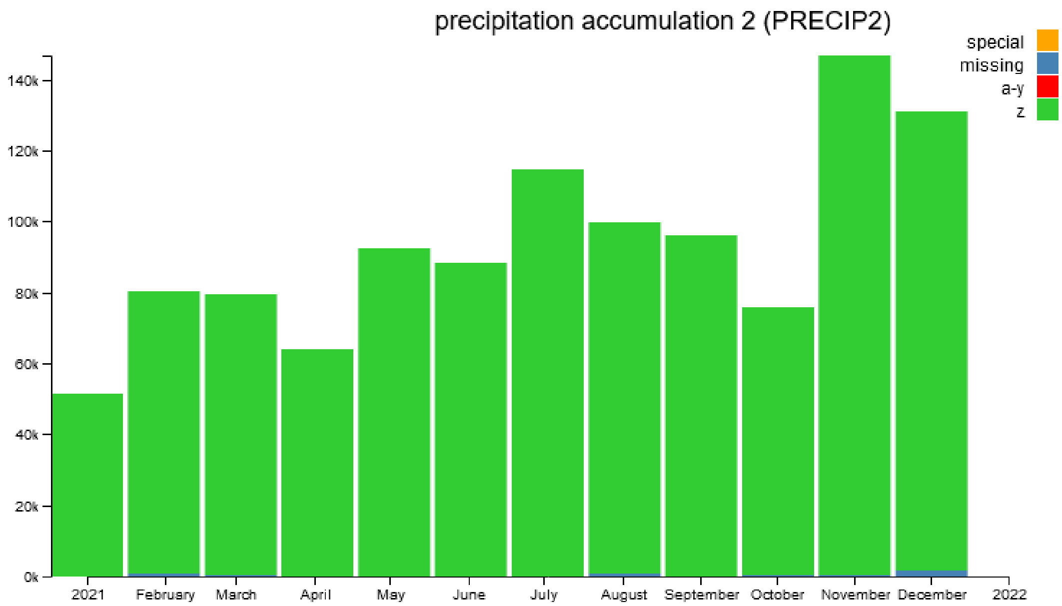
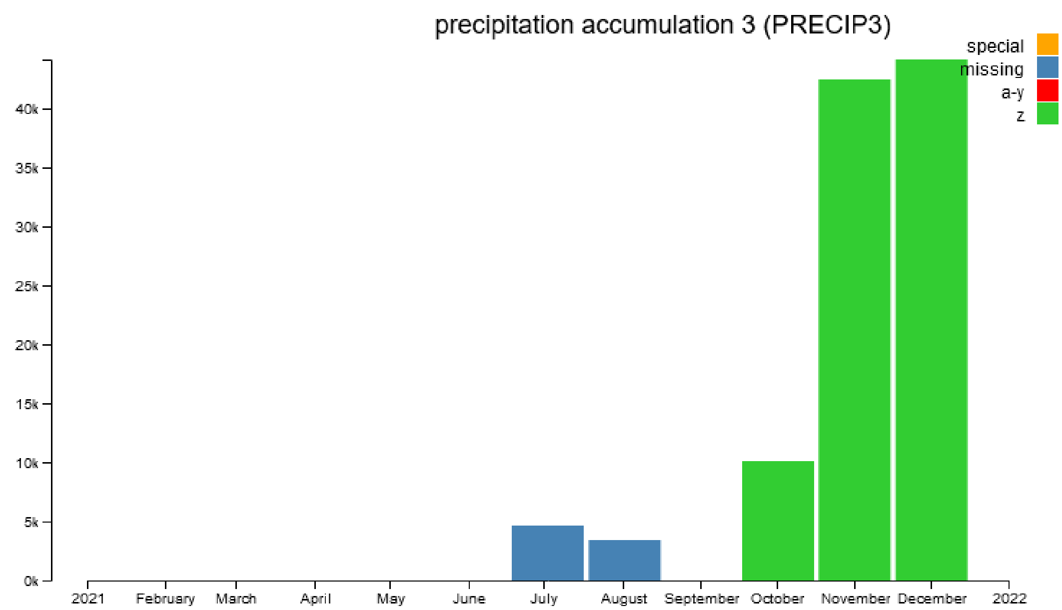


Figure 22: Total number of (this page) precipitation accumulation – PRECIP – (next page, top) precipitation accumulation 2 – PRECIP2 – and (next page, bottom) precipitation accumulation 3 – PRECIP3 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.





(Figure 22: cont'd)

The main problem identified with the sea temperature parameter (Figure 23) occurs when the sensor is denied a continuous supply of seawater. In these situations (in the case of ships that receive visual QC), either the resultant sea temperature values are deemed inappropriate for the region of operation (using gridded SST fields as a guide), in which case they are flagged with suspect/caution (K) flags or occasionally poor quality (J) flags if the readings are extraordinarily high or low, or else the sensor reports a constant value for an extended period, in which case they are unanimously J-flagged. The events are also frequently extreme enough for the auto flagger to catch them and assign greater than four standard deviations from climatology (G) or out of bounds (B) flags. The authors note that this stagnant seawater scenario often occurs while a vessel is in port, which is rather anticipated as the normal ship operation practice by SAMOS data analysts. Other than this expected performance, the TS data were generally good in 2021. We will note, however, that it has become clear intermittent air bubbling/pocketing in a sea chest or within the internal sea water channel is not an uncommon problem. The SAMOS team has begun development of new QC methods that will use the flow-meter data from the seawater systems to better document when the pumps are off or flow rates are insufficient (see section 5).

A number of issues with sea temperature data were noted and flagged over the course of 2021, which would contribute to some of the flagging seen here: These were *Investigator's* TS2 in January and February, *Thomas Jefferson's* TS2 (also SSPS, CNDC) in April through May, *Fairweather's* TS (also SSPS, CNDC) in May through July and also November, and *Oscar Elton Sette's* TS in March and April (all documented; see individual vessel description in section 3c for details).   But the origins of any other a-y flagging seen in the sea temperature and in fact all the sea water parameters are not clearly identified as belonging to any specific vessel(s). Rather, they were likely due to several vessels simultaneously experiencing the common sensor issues we have mentioned above. We also note it's not uncommon for sea water data transmission to cease when a vessel is nearing or in port (even while other types of data continue to be transmitted), meaning missing values in these sea water parameters are not unexpected.

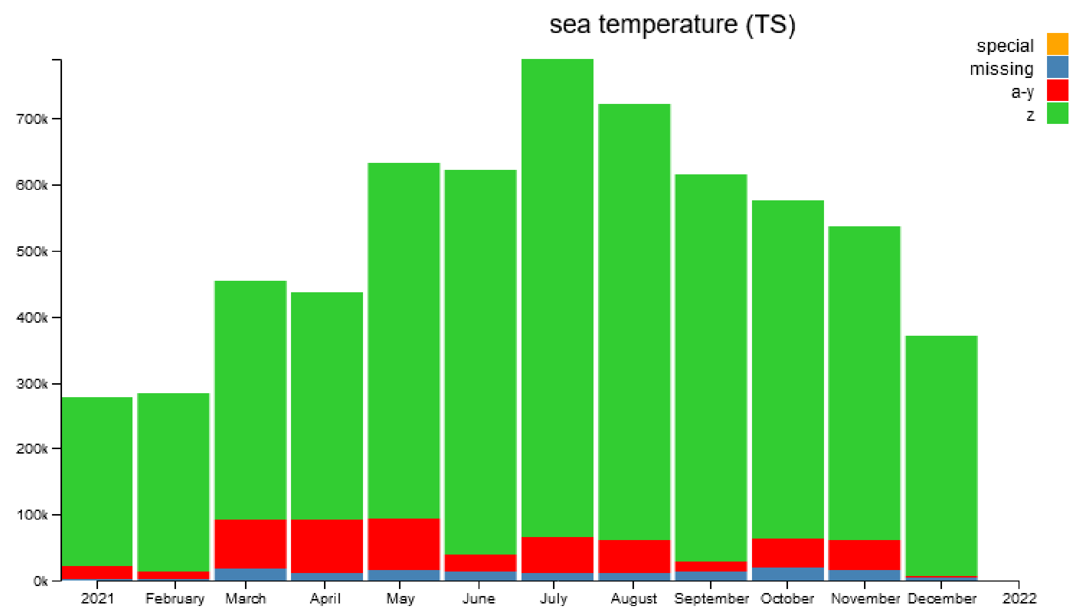
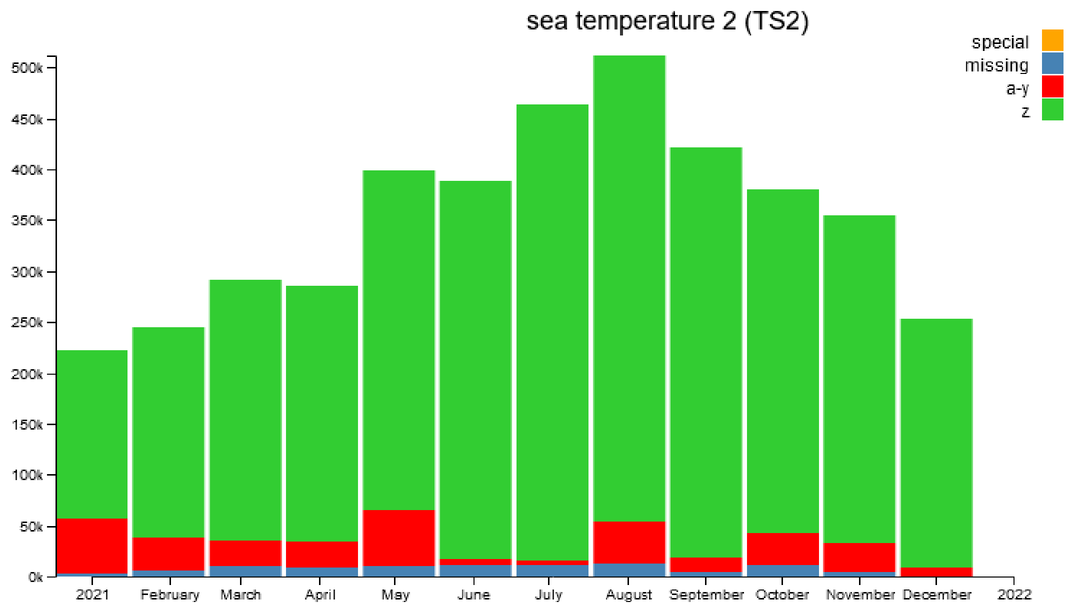
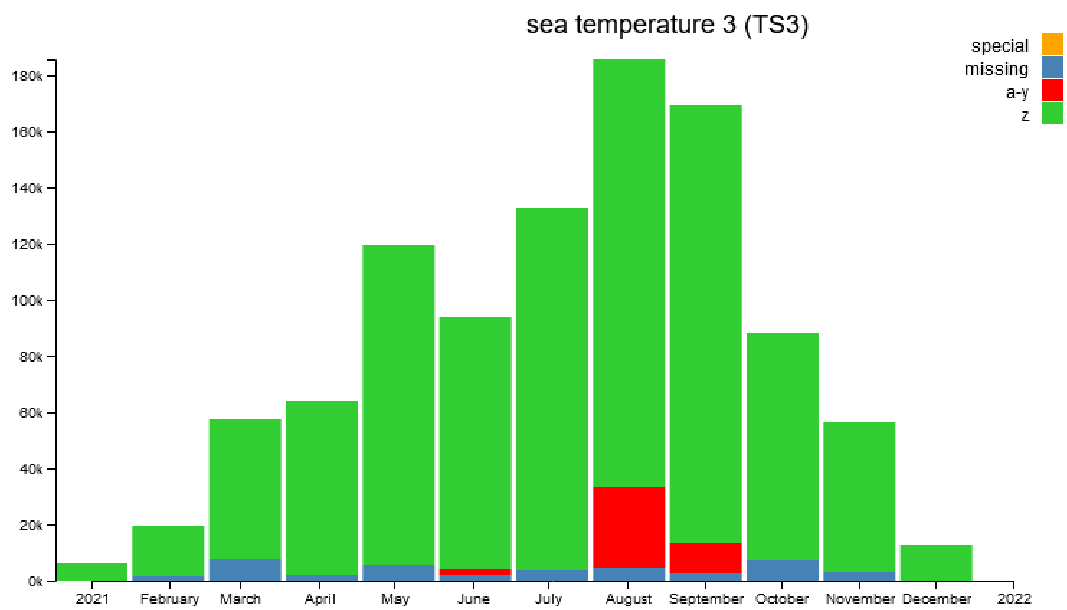


Figure 23: Total number of (this page) sea temperature – TS – (next page, top) sea temperature 2 – TS2 – (next page, bottom) sea temperature 3 – TS3 – (third page, top) sea temperature 4 – TS4 – (third page, bottom) and sea temperature 5 – TS5 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.





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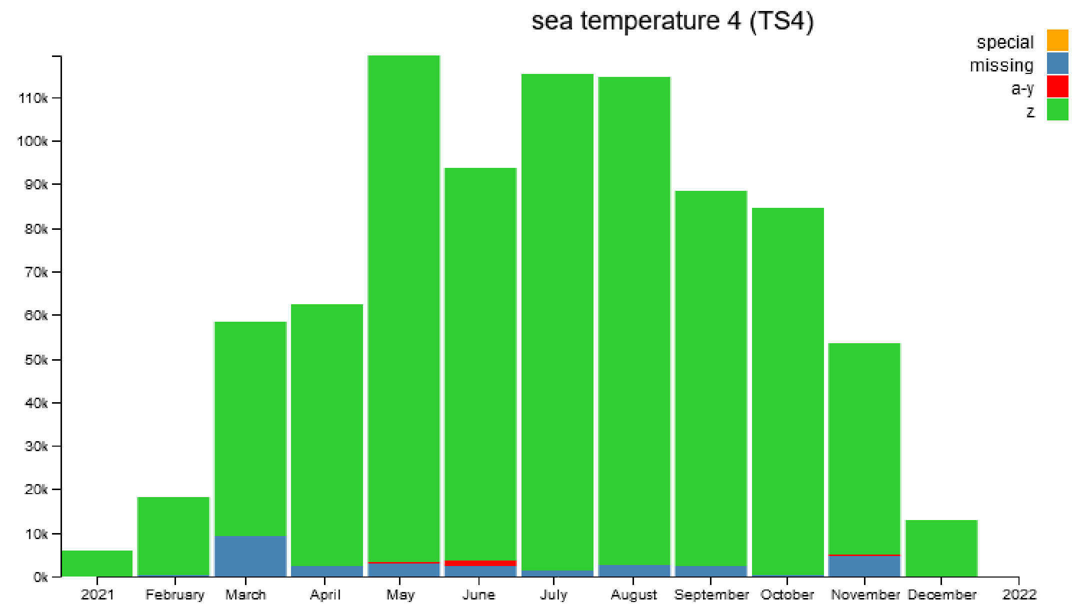

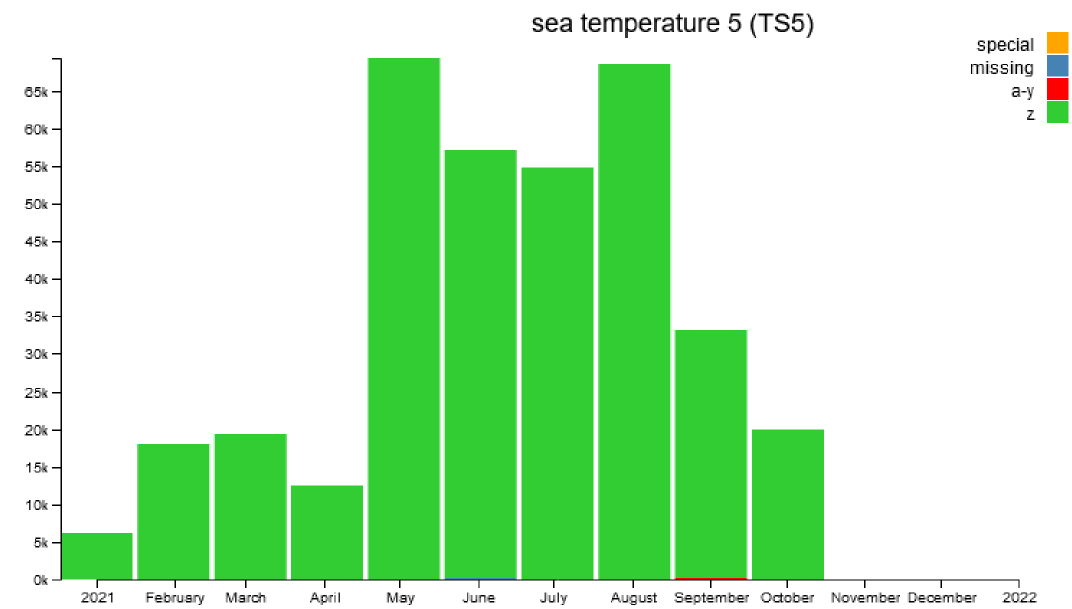

(Figure 23: cont'd.)

Salinity and conductivity (Figures 24 and 25, respectively) experienced the same major issue as sea temperature; namely, when a vessel was in port or ice or rough seas the flow water system that feeds the probes was usually shut off, resulting in either inappropriate or static values. Like sea temperature, air intrusion is another fairly common issue with salinity and conductivity. When this occurs, the data can be fraught with spikes. Data such as this is typically flagged with either spike (S), suspicious quality (K), or occasionally even poor quality (J) flags during visual quality control, for those vessels that receive it. Despite these issues, though, the quality of salinity and conductivity data in 2021 was still well within reason.

Two of the known cases of (flagged) issues with sea temperature data listed above apply here as well: namely, those with *Thomas Jefferson's* SSPS, CNDC (also TS2) in April through May and *Fairweather's* SSPS, CNDC (also TS) in May through July (both documented; see individual vessel description in section 3c for details). But once again the origins of any other a-y flagging seen in all the sea water parameters (including conductivity and salinity) are not clearly identified as belonging to any specific vessel(s). Rather, they were likely due to several vessels simultaneously experiencing the common sensor issues we have mentioned above. We also reiterate it's not uncommon for sea water data transmission to cease when a vessel is nearing or in port (even while other types of data continue to be transmitted), meaning missing values in these sea water parameters are not unexpected.

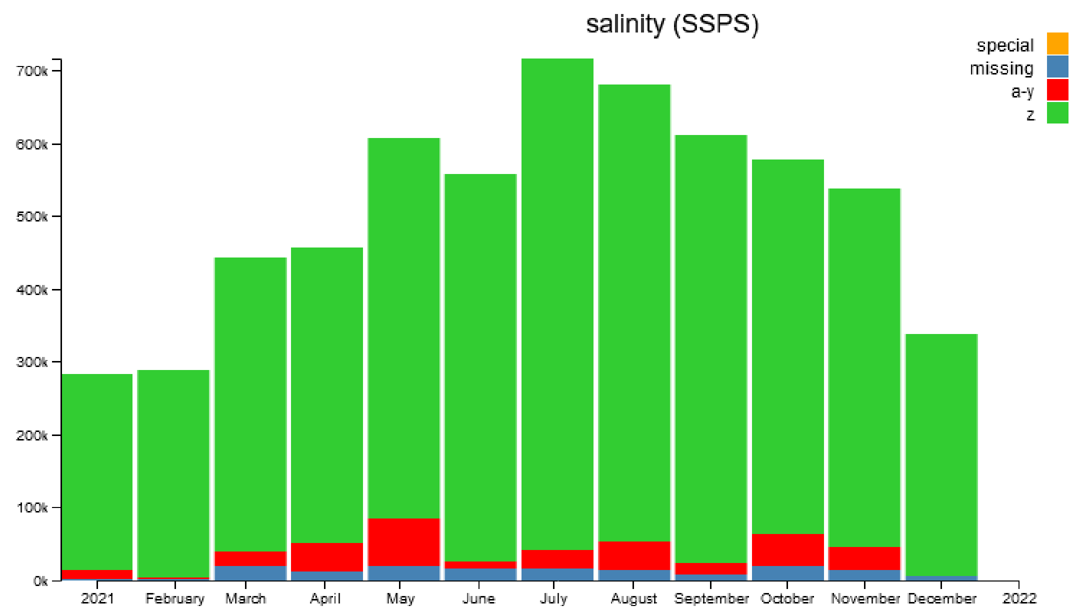

Figure 24: Total number of (this page) salinity – SSPS – and (next page) salinity 2 – SSPS2 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

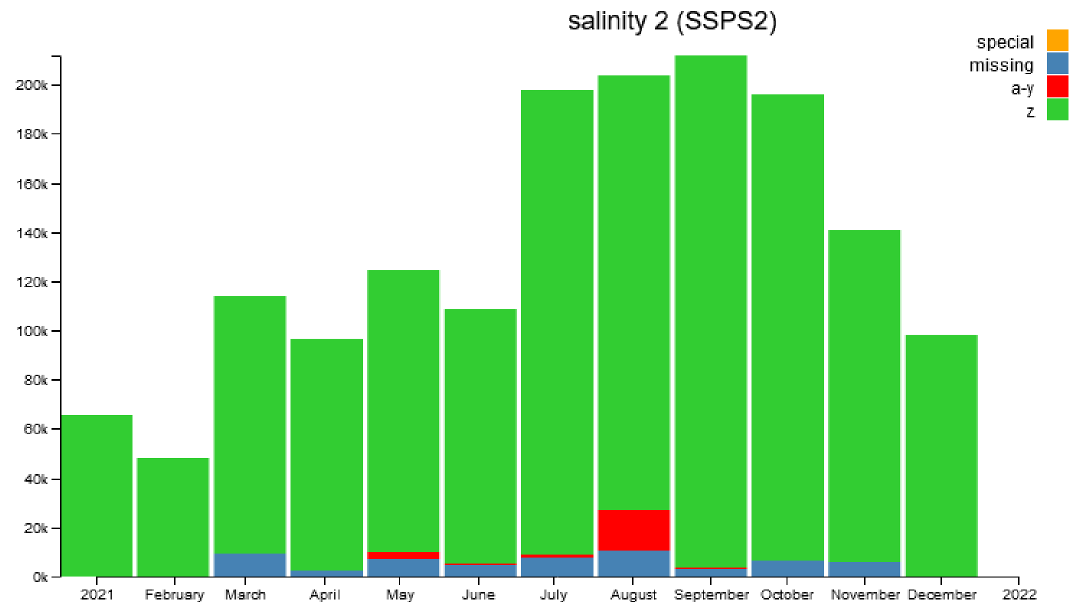

Figure 24: cont'd.

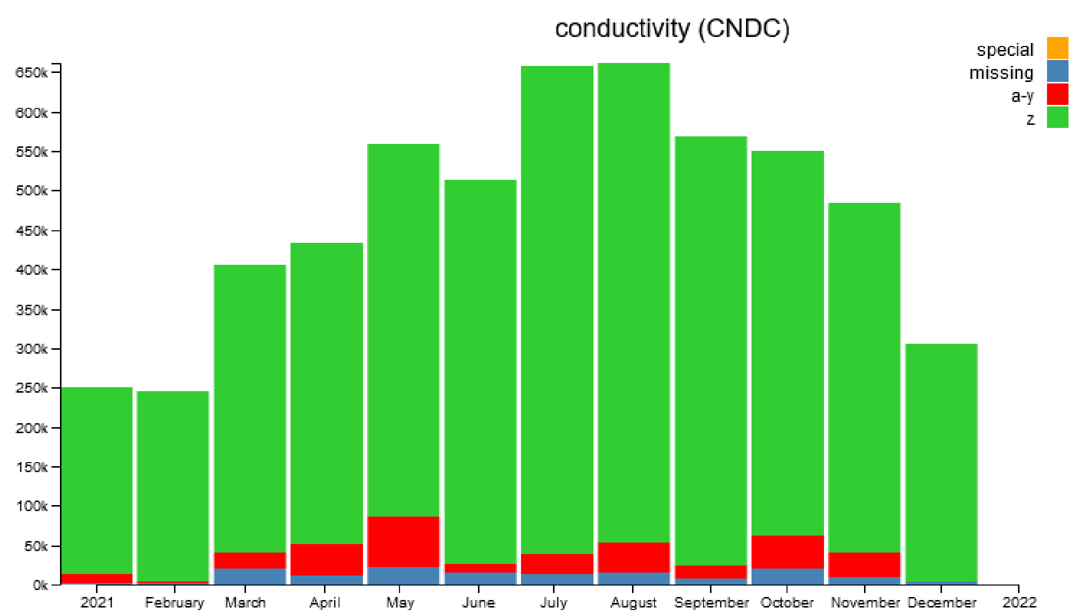

Figure 25: Total number of (this page) conductivity – CNDC – and (next page) conductivity 2 – CNDC2 – observations provided by all ships for each month in 2021. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

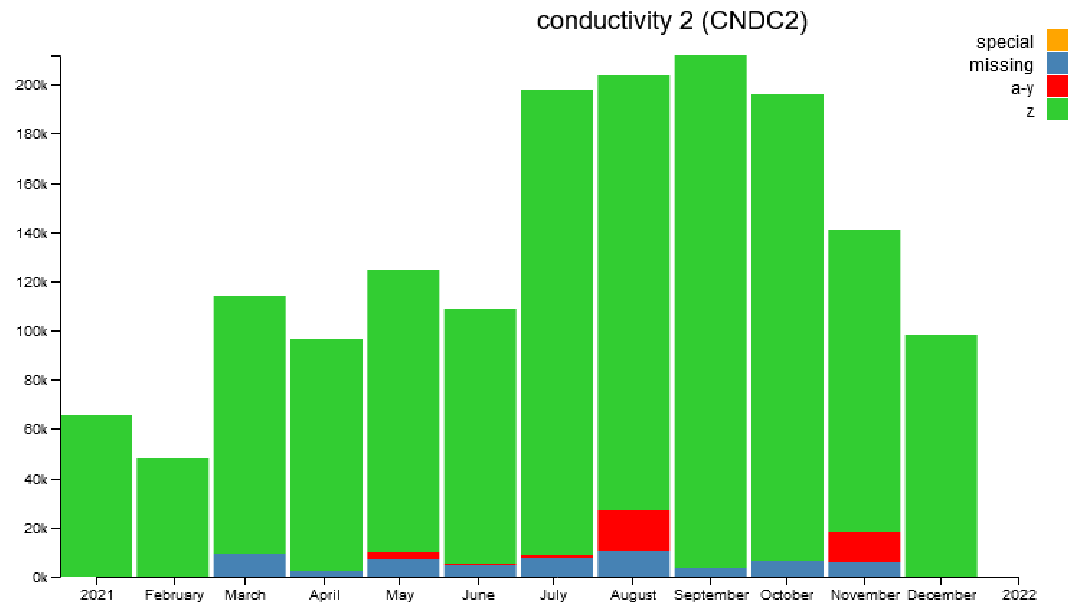

Figure 25: cont'd.

c. 2021 quality by ship

Atlantic Explorer

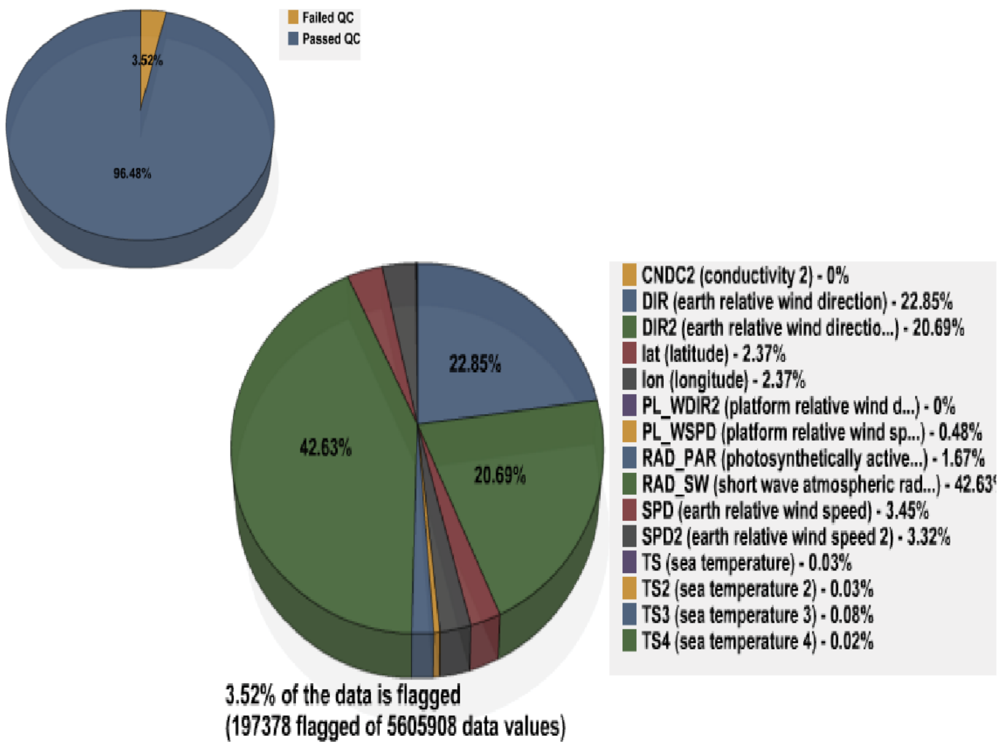

Figure 26: For the *Atlantic Explorer* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Atlantic Explorer* provided SAMOS data for 150 ship days, resulting in 5,605,908 distinct data values. After automated QC, 3.52% of the data were flagged using A-Y flags (Figure 26). This is a bit lower than in 2020 (4.2%) and is under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. NOTE: The *Atlantic Explorer* does not receive visual quality control by the SAMOS DAC, so all the flags are the result of automated QC (no research-level files exist at the SAMOS DAC for the *Atlantic Explorer*).

On 7 and 13 July, isolated pockets of slightly negative vessel relative wind speed values were observed in *Explorer's* primary main mast anemometer data. These non-physical values resulted in accrual of a small amount of “out of bounds” (B) flags on platform relative wind speed (PL_WSPD) during automated quality control procedures (Figure 27). Ship personnel were notified of these negative wind speeds on 19 July. There is no response on record. However, we note sporadic negative relative wind speed behavior was also observed in 2020 in the primary main mast anemometer. In that case it was assumed an anemometer replacement (completed ~October 2020) would see resolution of the issue. The recurrence of negative values in 2021 may suggest the culprit and solution lie elsewhere. It is unknown if the negative PL_WSPD observations adversely affected the associated true wind speeds (SPD), though they did look to be in line with surrounding data. Nevertheless, users may want to treat both observations as suspect when PL_WSPD is B-flagged.

There were no other issues of note in 2021. Looking to the flag percentages in Figure 26, about 43% of the total flags were applied to the short-wave atmospheric radiation parameter (RAD_SW). Upon inspection the flags, which are unanimously B flags (Figure 27), appear to have been applied mainly to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.) A further ~44% of the total flags were applied to the two earth relative wind direction (DIR and DIR2) parameters, combined. These were entirely "failed the true wind recalculation" (E) flags (Figure 27), which may be indicative of the *Explorer* reporting to SAMOS a different vessel heading than what is used in their true wind calculations, or possibly a practice of mixing averaged values and spot values across the parameters used in true wind calculation.

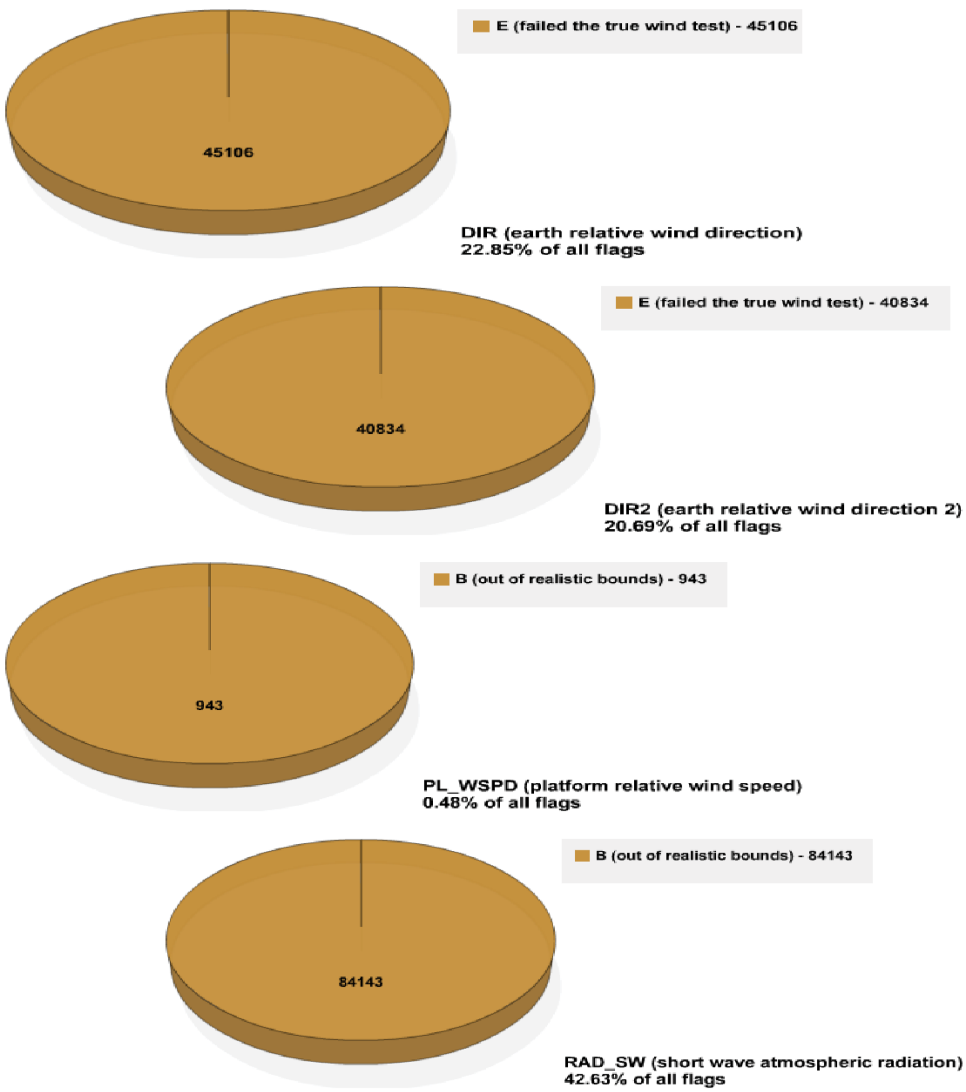

Figure 27: Distribution of SAMOS quality control flags for (first) earth relative wind direction – DIR – (second) earth relative wind direction 2 – DIR2 – (third) platform relative wind speed – PL_WSPD – and (last) short wave atmospheric radiation – RAD_SW – for the *Atlantic Explorer* in 2021.

Investigator

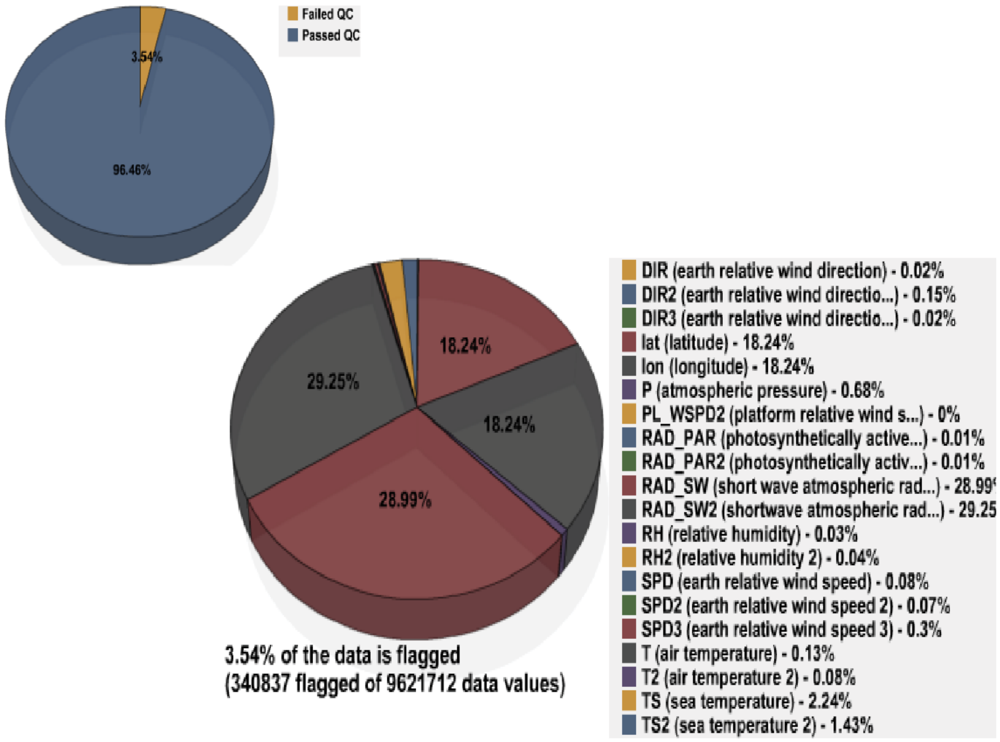

Figure 28: For the *Investigator* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Investigator* provided SAMOS data for 222 ship days, resulting in 9,621,712 distinct data values. After automated QC, 3.54% of the data were flagged using A-Y flags (Figure 28). This is virtually unchanged from 2020 (3.61%) and is under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. NOTE: The *Investigator* does not receive visual quality control by the SAMOS DAC, so all the flags are the result of automated QC (no research-level files exist at the SAMOS DAC for the *Investigator*).

From 28 January through 9 February *Investigator's* infrared (IR) sea temperature sensor data (TS2) were not tracking well with the data from her digital oceanographic thermometer (TS). TS2 data were often observed to be blocky (or missing) in this period and were mostly well below TS values (see Figure 29). It was suspected the sensor was experiencing issues in the severe weather conditions present around Antarctica, a common characteristic of IR sea temperature sensors. When emailed about this suspicion on 9 February, an IMOS contact confirmed the IR sensor had not been operating correctly for the entirety of the voyage and concurred the cause may have been rough seas. She advised the instrument had been switched off for the remainder of the voyage and that existing data in the 28 January – 9 February period should be considered faulty. We note that a good deal of the TS2 data in this period did receive automated "out of bounds" (B) or "greater than four standard deviations from climatology" (G) flags (Figure 30). However, in keeping with IMOS recommendations (and their own data QC flag plan), the end user is best advised to avoid **all** TS2 data from 28 January through 9 February.

In the course of the conversation with our IMOS contact about TS2, it came to light TS should also be considered suspect for the voyage beginning 28 January through the time the ship reached its destination in Antarctic waters (date unclear) due to the ship's drop keel being flush with the hull (i.e., drop keel depth = 0 m). We were advised when *Investigator's* drop keel is not extended the flow of water into the intake pipe used for the TS sensor is affected. Notably, in the IMOS data QC system these sea water temperature data are automatically flagged as suspect any time the drop keel is not extended; however, analogous SAMOS TS data are likely unflagged in most or all cases (but are nonetheless suspect, as per IMOS).

From ~0300 UTC on 24 February through ~1500 UTC on 25 February it was noted the vessel relative and earth relative wind speed data (PL_WSPD and SPD, respectively) from *Investigator's* starboard side RM Young anemometer were stuck near zero and differed substantially from her other two anemometers. When emailed on 26 February, ship personnel confirmed the anemometer had stopped for the identified period. It was noted ship engineers initially planned to replace the affected sensor. But before the okay to climb the foremast could be obtained the anemometer spontaneously came back to life and began tracking well again so the plan to replace was abandoned. PL_WSPD and SPD data in the affected period are likely not flagged but should nevertheless not be used.

As a general advisory, it's been noted all of *Investigator's* earth relative winds, meaning both directions and speeds (i.e., DIR, DIR2, DIR3, SPD, SPD2, SPD3), sometimes show steps in the data in association with changes in the ship speed. Upon inspection our determination is there's likely a flow distortion issue whereby all wind sensors are being obstructed when the vessel relative wind direction is from the stern. In all cases, users should take care to choose the true winds from the best exposed anemometer based on the ship-relative wind direction.

Looking to the flag percentages in Figure 28, about 58% of the total flags were applied to the shortwave atmospheric radiation parameters (RAD_SW and RAD_SW2). Upon inspection the flags, which are unanimously "out of bounds" (B) flags (Figure 30), appear to have been applied mainly to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.) A further ~36% of the total flags were applied to latitude (LAT) and longitude (LON). Upon inspection these were entirely "platform position over land" (L) flags (Figure 30) that appear generally to have been applied when the vessel was either in port or very close to land. This is not uncommon, as the land mask in use for the land check routine is often incapable of resolving the very fine detail of a coastline or an inland port.

One interesting episode for *Investigator* in 2021: An email was sent to ship personnel inquiring about missing port RM Young anemometer earth relative and vessel relative wind speed and direction data (DIR2, SPD2, PL_WDIR2, PL_WSPD2), observed beginning ~2000 UTC on 15 March. In the email response we learned their port anemometer propellor had been hit by a wave, came loose, and then fell off at precisely 2021-03-13T08:45:11Z, with the whole event having been captured on their CCTV. (A screen capture of the suspect wave just before it hit the anemometer and the CCTV camera was charmingly included.)

For anyone interested in working with reprocessed, post-cruise data from the *Investigator*, you can access both flux and meteorological observations from the IMOS THREDDS server via http://thredds.aodn.org.au/thredds/catalog/IMOS/SOOP/SOOP-ASF/VLMJ_Investigator/catalog.html. For additional information see Beggs et al. (2017).

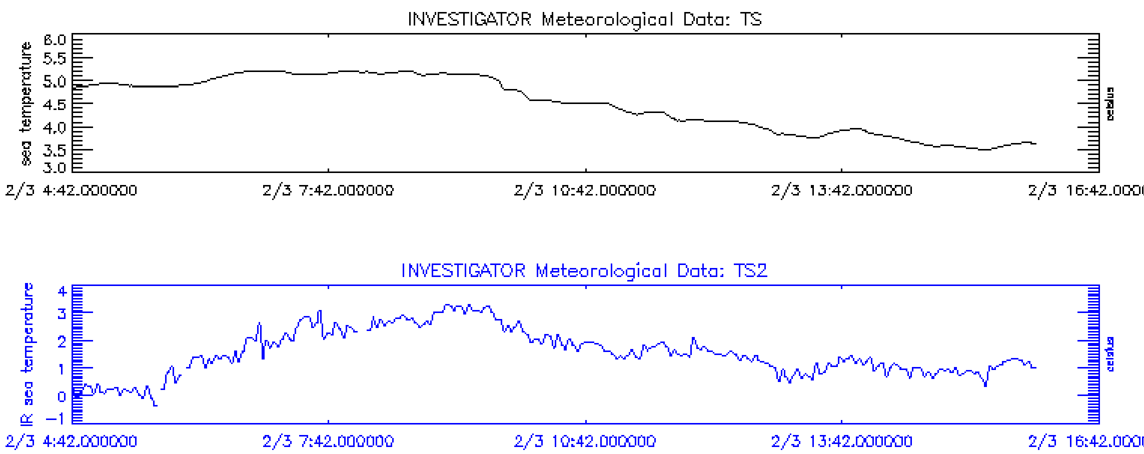

Figure 29: *Investigator* SAMOS (top) sea temperature – TS – and (bottom) sea temperature 2 – TS2 – data for 3 February 2021. Note blocky appearance of TS2 (as opposed to smooth, as in TS), as well as lower range of values in TS2 as compared to TS.

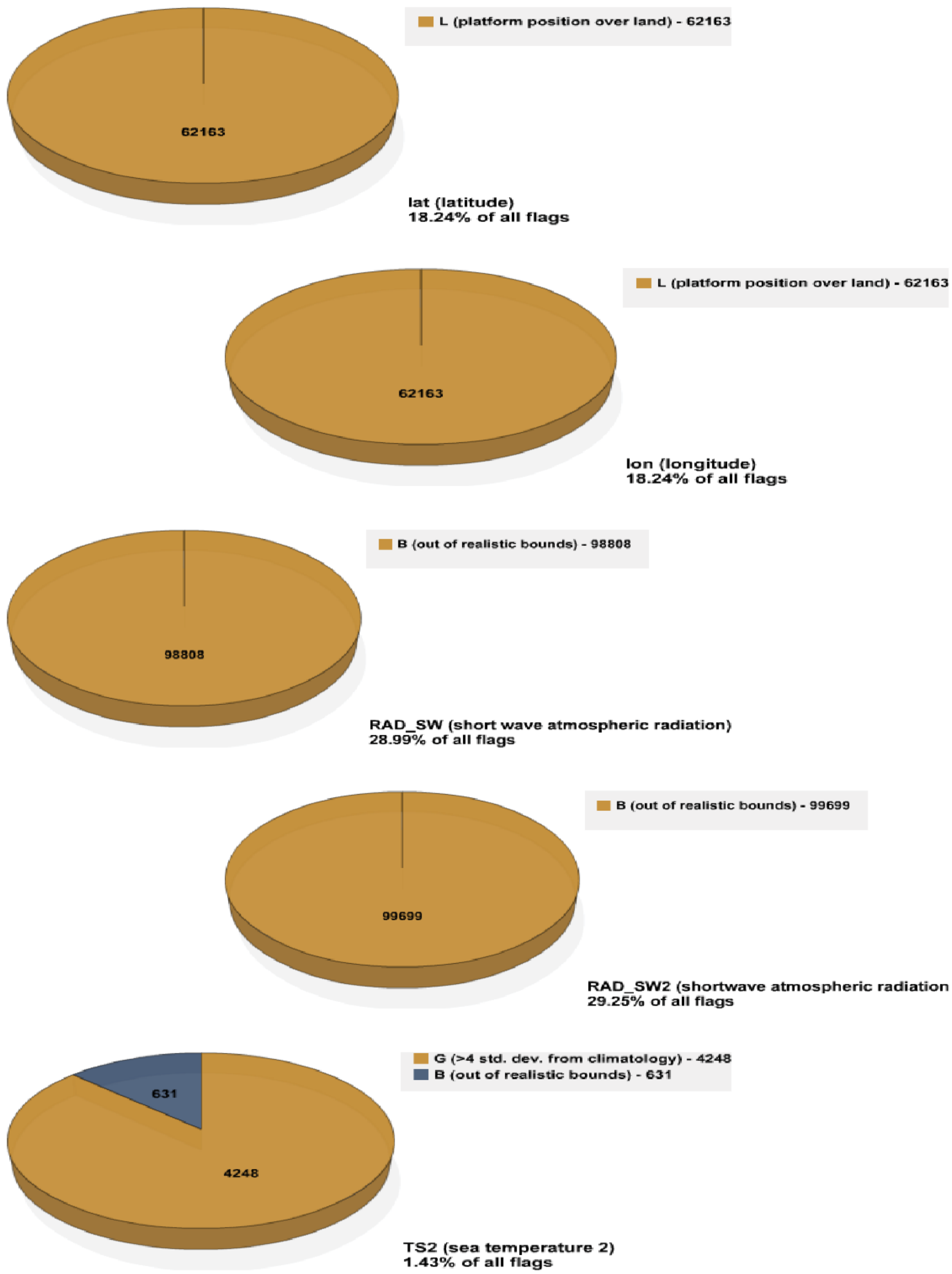

Figure 30: Distribution of SAMOS quality control flags for (first) latitude – LAT – (second) longitude – LON – (third) shortwave atmospheric radiation – RAD_SW – (fourth) shortwave atmospheric radiation 2 – RAD_SW2 –and (last) sea temperature 2 – TS2 – for the *Investigator* in 2021.

Tangaroa

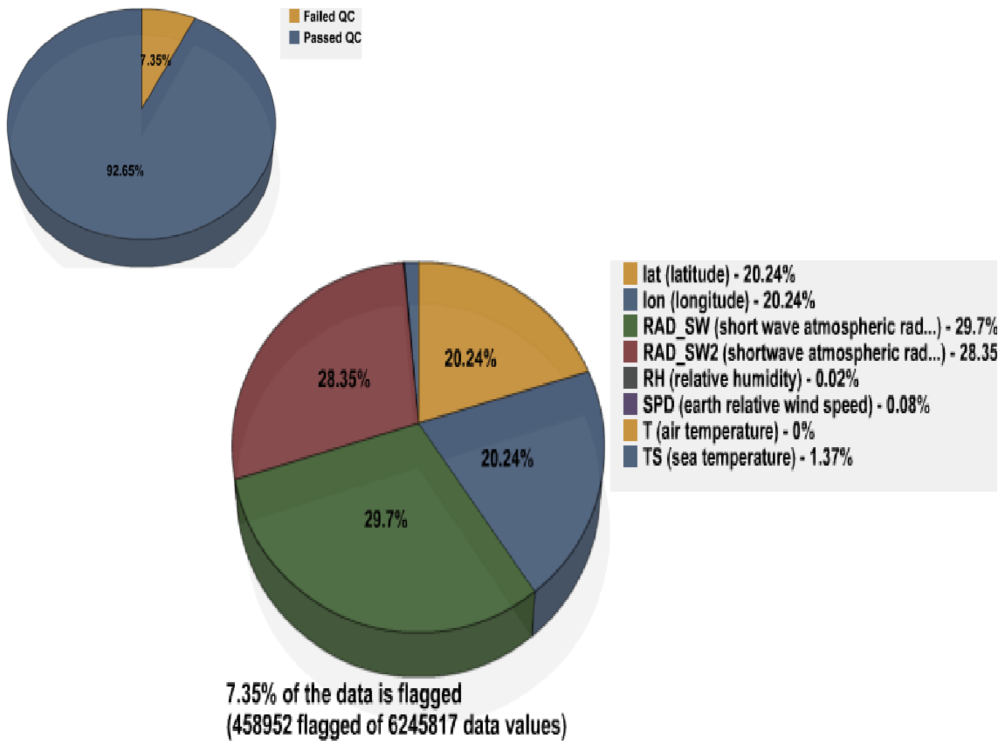

Figure 31: For the *Tangaroa* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Tangaroa* provided SAMOS data for 276 ship days, resulting in 6,245,817 distinct data values. After automated QC, 7.35% of the data were flagged using A-Y flags (Figure 31). This is about the same as in 2020 (7.8%). NOTE: the *Tangaroa* does not receive visual quality control by the SAMOS DAC, so all flags are the result of automated QC (no research-level files exist at the SAMOS DAC for the *Tangaroa*).

There were no specific data issues of record for *Tangaroa* in 2021. Looking to the flag percentages in Figure 31, about 58% of the total flags were applied to the shortwave atmospheric radiation parameters (RAD_SW and RAD_SW2). Upon inspection the flags, which are unanimously "out of bounds" (B) flags (Figure 32), appear to have been applied mainly to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.) A further ~40% of the total flags were applied to latitude (LAT) and longitude (LON). Upon inspection these were entirely "platform position over land" (L) flags (Figure 31) that appear generally to have been applied when the vessel was either in port or very close to land. This is not uncommon, as the land mask in use for the land check routine is often incapable of resolving the very fine detail of a coastline or an inland port. *Tangaroa* is also known to frequently transmit data from port.

For anyone interested in working with reprocessed, post-cruise data from the *Tangaroa*, you can access both flux and meteorological observations from the IMOS

THREDDS server via http://thredds.aodn.org.au/thredds/catalog/IMOS/SOOP/SOOP-ASF/ZMFR_Tangaroa/catalog.html. For additional information see Beggs et al. (2017).

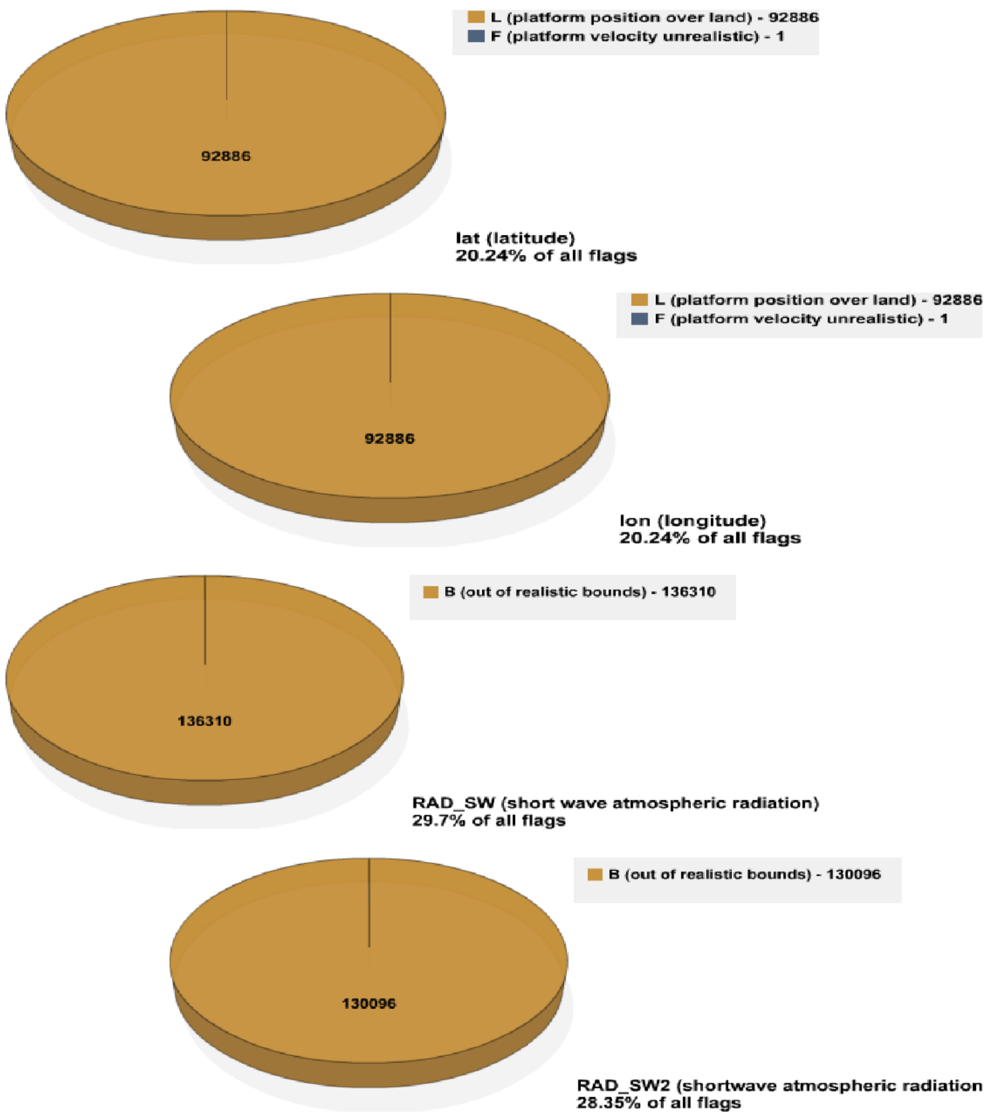

Figure 32: Distribution of SAMOS quality control flags for (first) latitude – LAT – (second) longitude – LON – (third) short wave radiation – RAD_SW – and (last) short wave radiation 2 – RAD_SW2 – for the *Tangaroa* in 2021.

Bell M. Shimada

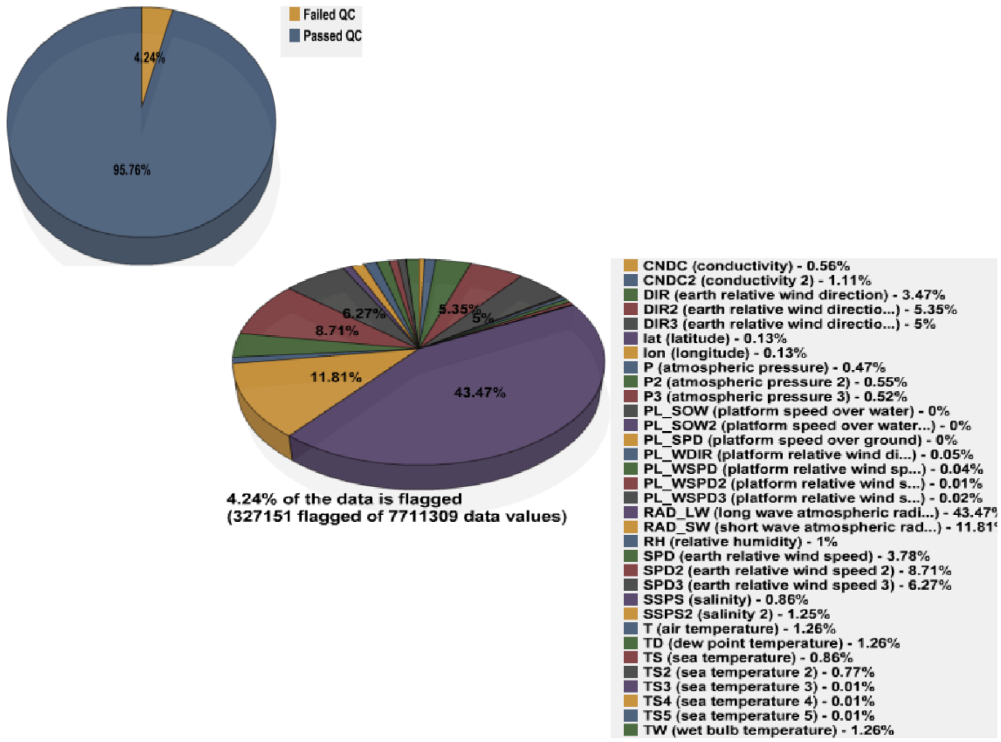

Figure 33: For the *Bell M. Shimada* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Bell M. Shimada* provided SAMOS data for 152 ship days, resulting in 7,711,309 distinct data values. After both automated and visual QC, 4.24% of the data were flagged using A-Y flags (Figure 33). This is about two percentage points lower than in 2020 (6.47% total flagged) and drops *Shimada* inside the < 5% total flagged bracket regarded by SAMOS to represent "very good" data.

As seen in Figure 33, almost half *Bell M. Shimada's* total flags in 2021 were assigned to her long wave atmospheric radiation (RAD_LW) parameter. In June the *Shimada's* data acquisition system software (NOAA Scientific Computer System, "SCS") was upgraded to the next major release version (v5), one of the first two SCS ships to do so. Immediately following the transition, RAD_LW data were largely well out of range (~1200-1800 W/m^2). Additionally, the RAD_LW data trace appeared dissimilar to the typical long wave trace seen on many other vessels. It was suspected the device may have been configured incorrectly during the v5 upgrade. Several email communications about the questionable/bad RAD_LW went back and forth over the course of the rest of the year, while the issue persisted. We stress *Shimada* having been one of the first adopters of the new (and admittedly a bit buggy) software meant there was not a lot of informed familiarity on either side of the fence as everyone strove to troubleshoot. In the end, a large application of "out of bounds" (B) flags, as well as some "poor quality" (J) and "caution/suspect" (K) flags were applied to RAD_LW (Figure 35) during the second half of the year.

There were no other specific issues noted for the *Shimada* in 2021, other than to say that when she upgraded to SCSv5 there were naturally a few initial data misfires that resulted in short-term ill effects observable (and thus flagged) in many of her parameters. But, otherwise, in general *Shimada's* various meteorological sensors are known (like most vessels) to occasionally exhibit data distortion that is dependent on the vessel relative wind direction and, in the case of air temperature, likely ship heating. Where the data appear affected, they are generally flagged with "caution/suspect" (K) flags (not shown). As is suggested by Figure 33, this is a bit more prevalent in the true winds, both directions (DIR, DIR2, DIR3) and speeds (SPD, SPD2, SPD3). Altogether, around a third of the total flags were applied to DIR, DIR2, DIR3 and SPD, SPD2, SPD3, these being mostly K and "failed the wind recomputation check" (E) flags (Figure 35, not all shown). Short wave atmospheric radiation garnered a further ~11% of the total flags in 2021 (Figure 33), although in this case they were primarily B flags (Figure 35) such as are applied to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.)

In a general advisement, we learned (in 2022, from an experienced NOAA fleet source) that in 2021 the installation alignment of the *Shimada's* starboard ultrasonic anemometer was visually observed to be a few degrees clockwise of the port alignment. What effect(s) this may have had on the data from either of the anemometers is not known. We further caution that after the SCS upgrade it is not even totally clear which of the SAMOS wind variables represent these two instruments. Nevertheless, we are mentioning the noted discrepancy here.

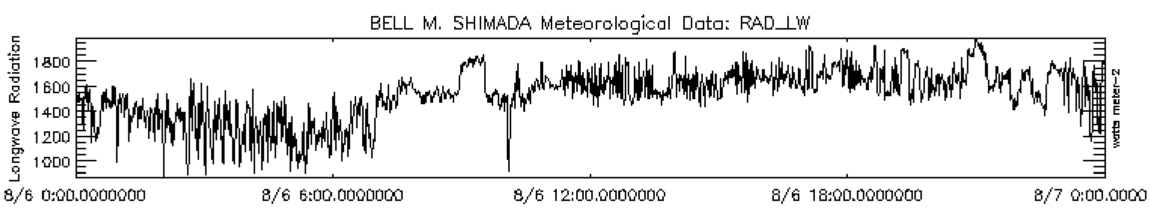

Figure 34: *Bell M. Shimada* SAMOS longwave atmospheric radiation – RAD_LW – data for 6 August 2021.

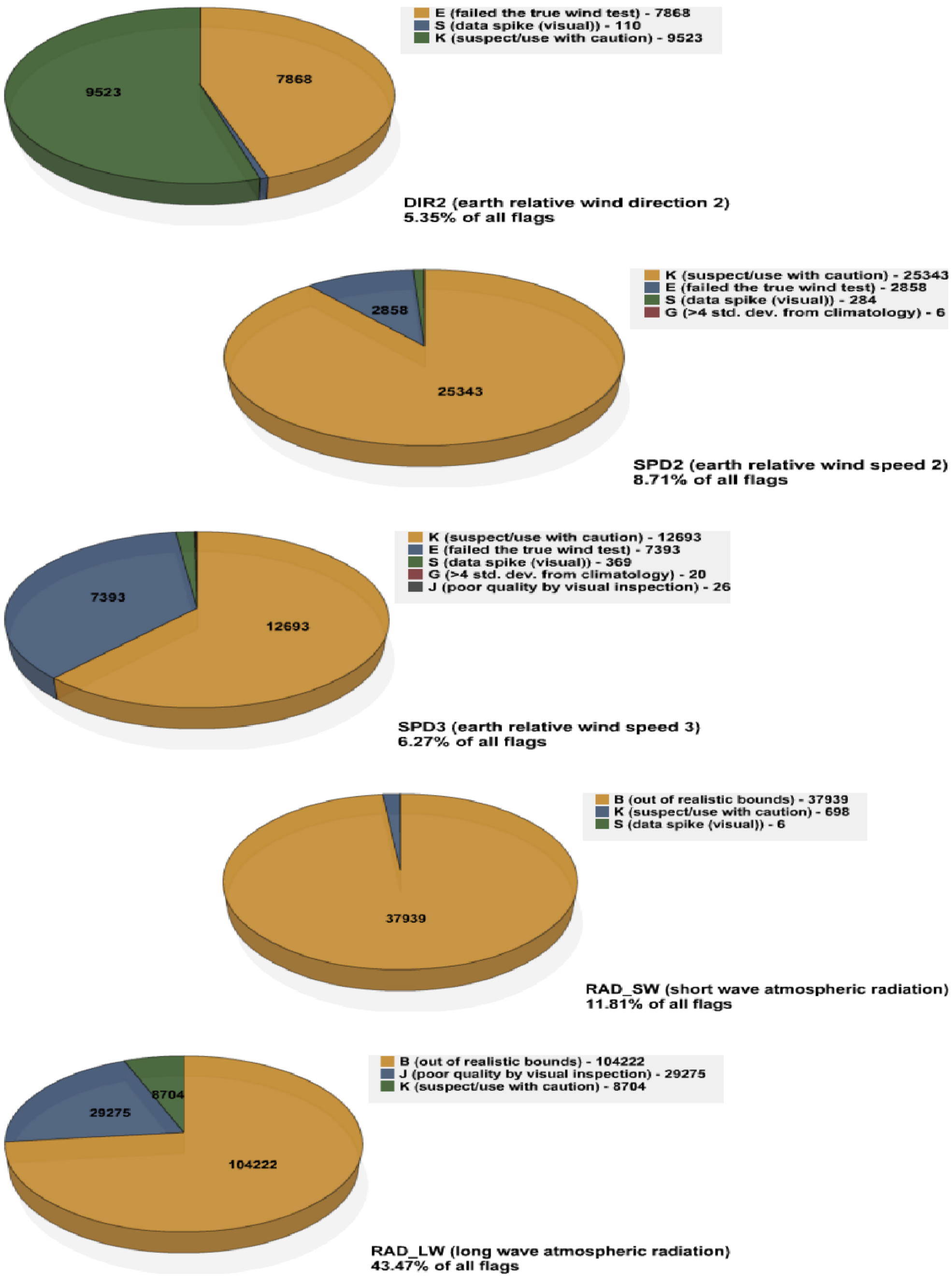

Figure 35: Distribution of SAMOS quality control flags for (first) earth relative wind direction 2 – DIR2 – (second) earth relative wind speed 2 – SPD2 – (third) earth relative wind speed 3 – SPD3 – (fourth) shortwave atmospheric radiation – RAD_SW – and (last) longwave atmospheric radiation – RAD_LW – for the *Bell M. Shimada* in 2021.

Fairweather

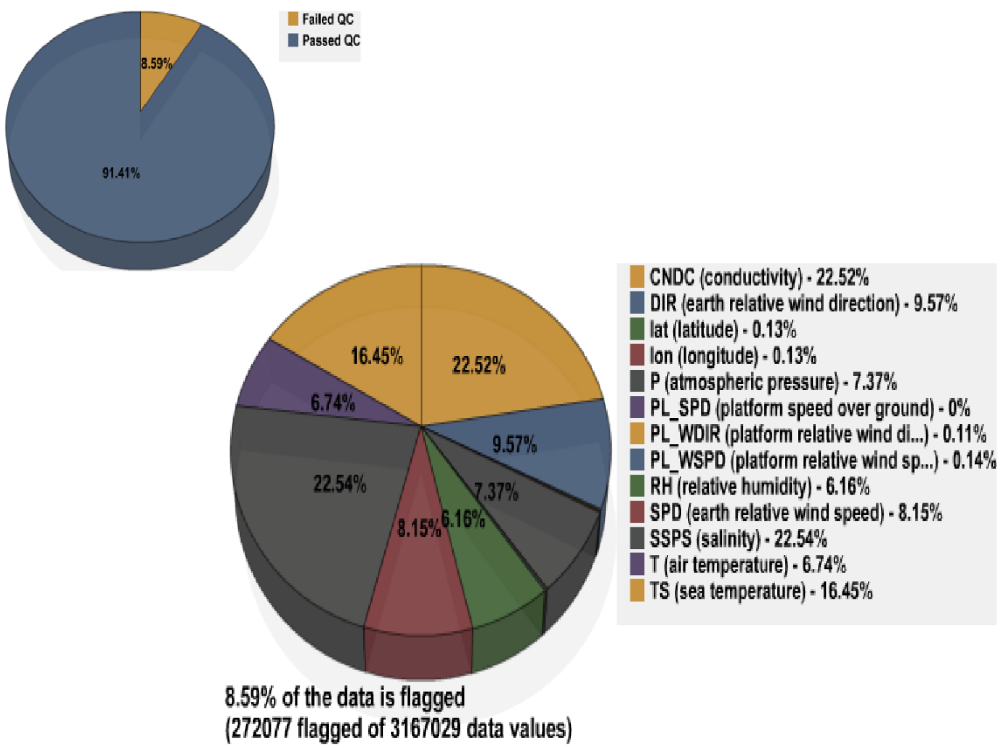

Figure 36: For the *Fairweather* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Fairweather* provided SAMOS data for 150 ship days, resulting in 3,167,029 distinct data values. After both automated and visual QC, 8.59% of the data were flagged using A-Y flags (Figure 36). This is a few percentage points higher than in 2020 (5.02% total flagged).

On 10 May one of *Fairweather's* technicians reached out to inform us a leak in their thermosalinograph (TSG) plumbing had been discovered on 9 May and the science sea water system had been subsequently secured to fix the leak. We were contacted again on 15 May with an update that the pump had just been turned back on. Consequently, the sea temperature (TS), salinity (SSPS), and conductivity (CNDC) data were assigned "poor quality" (J) flags (Figure 37) for the period 9-15 May. Then on 13 June we received another communication stating the TSG pump had been discovered to be leaking again and had been removed from service as of 13:26 UTC 12 June. We were advised the pump would remain offline until a new seal could be acquired. The result being that from the onset of the pump disablement on 12 June through 9 July, at which point the pump appeared to be fixed, TS, SSPS, and CNDC were again assigned J flags (Figure 37).

Unrelated to the previous leak issue, on 7 November we were advised the TSG pump had been secured around 3:00 UTC 4 November due to heavy weather. Once again TS, SSPS, and CNDC data were J-flagged, from 3:00 UTC 7 November through 15 November, when it appeared pump operation had been restored.

There are no other issues on record for *Fairweather* in 2021. In general, similar to most vessels, *Fairweather's* meteorological data – earth relative wind speed and direction (SPD and DIR, respectively), air temperature and relative humidity (T and RH, respectively) and atmospheric pressure (P) – habitually exhibit some amount of data distortion that is dependent on the vessel relative wind direction, as indicated by the total flagged percentage (Figure 36). Where the data appear affected, they are generally flagged with "caution/suspect" (K) flags (Figure 37, not all shown).

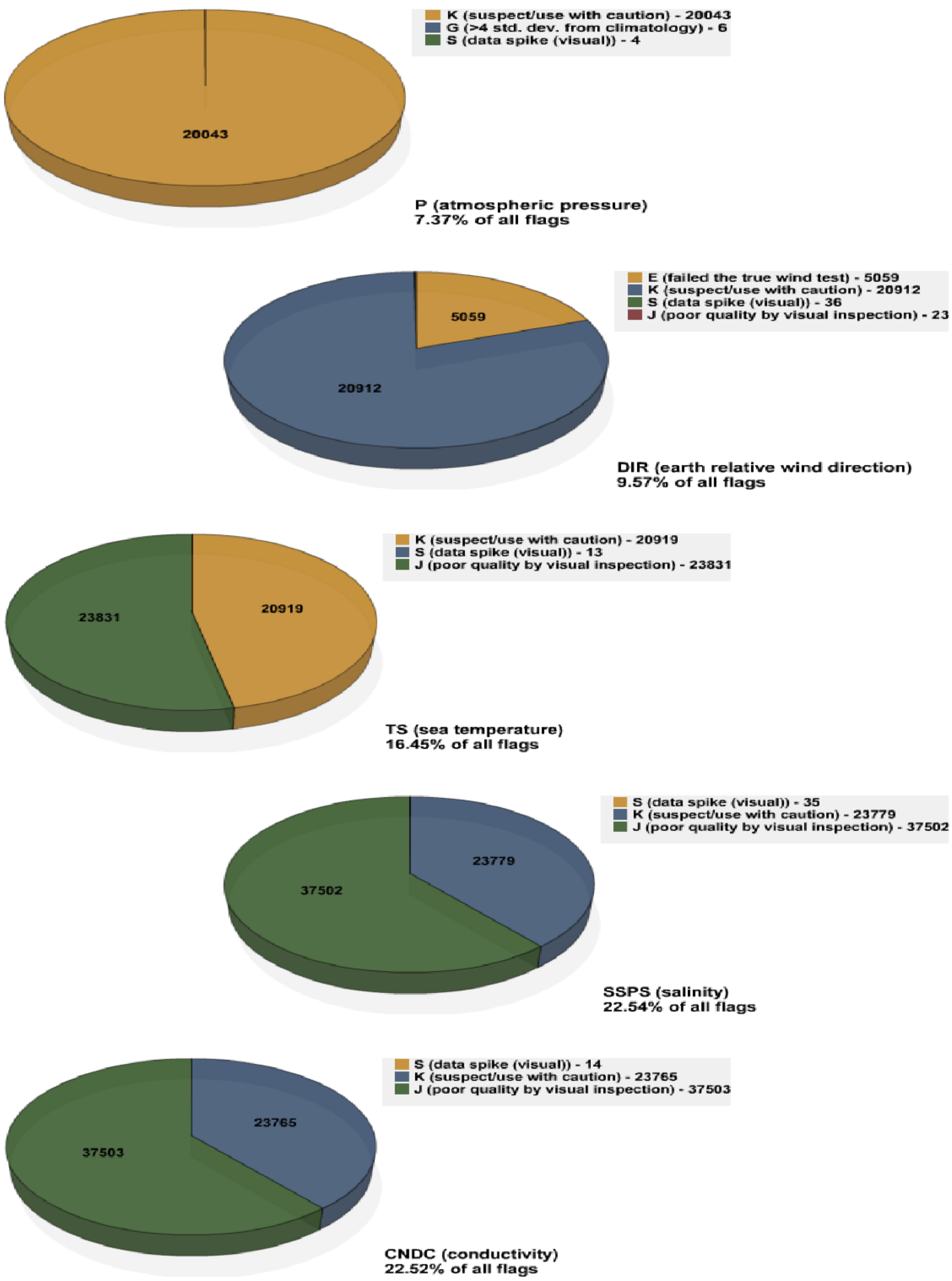

Figure 37: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) earth relative wind direction – DIR – (third) sea temperature – TS – (fourth) salinity – SSPS – and (last) conductivity – CNDC – for the *Fairweather* in 2021.

Ferdinand Hassler

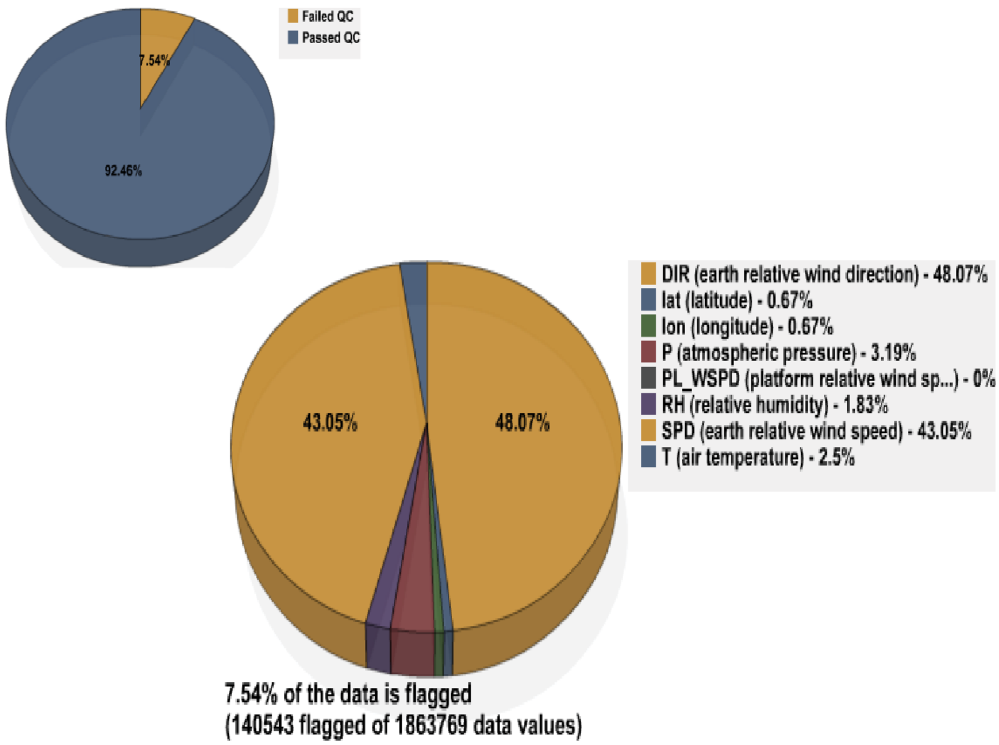

Figure 38: For the *Ferdinand Hassler* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Ferdinand Hassler* provided SAMOS data for 118 ship days, resulting in 1,863,769 distinct data values. After both automated and visual QC, 7.54% of the data were flagged using A-Y flags (Figure 38).

Hassler was the first ship to have her data acquisition system software (NOAA Scientific Computer System, "SCS") upgraded to the next major release version (v5); she served as a test ship initially, really. Incidentally, she also served as our (SAMOS) own test ship for our newly designed metadata harvesting software. It was a bit of bumpy ride, with several software issues identified during testing on both sides of the fence. Operational processing (and visual QC) of *Hassler* SAMOS data did not begin until 1 August, although data dating back to 22 May were eventually processed through the intermediate level (no visual QC).

Almost all (~91%) of the total flags in 2021 were applied to the earth relative wind direction and speed parameters (DIR and SPD, respectively). These were mostly "caution/suspect" (K) flags (Figure 40). From the onset of operational processing of the *Hassler's* data, DIR and SPD in particular were highly suspect, most of the time exhibiting steps distinctly reminiscent of the platform relative wind direction (PL_WDIR). Perhaps conspicuously, the platform heading (PL_HD) purportedly associated with the true wind calculation was missing most of the time. Further, when able to be compared to station reports and satellite wind products DIR and SPD did not compare well. This all lasted until mid-October, at which point PL_HD began reliably appearing in the files. Thereafter DIR and SPD appeared to have improve drastically and much of the data flagging ceased. (We note there is frequently no lead technician resident on this ship.)

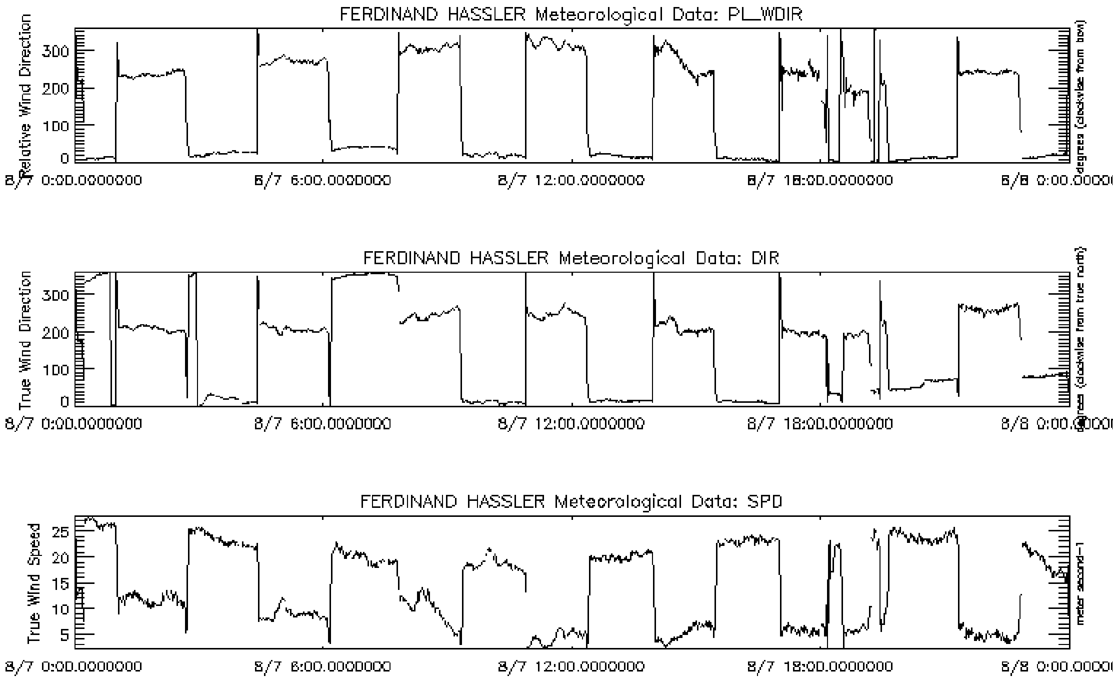

Figure 39: *Ferdinand Hassler* SAMOS (top) platform relative wind direction – PL_WDIR – (middle) earth relative wind direction – DIR – and (bottom) earth relative wind speed – SPD – data for 7 August 2021.

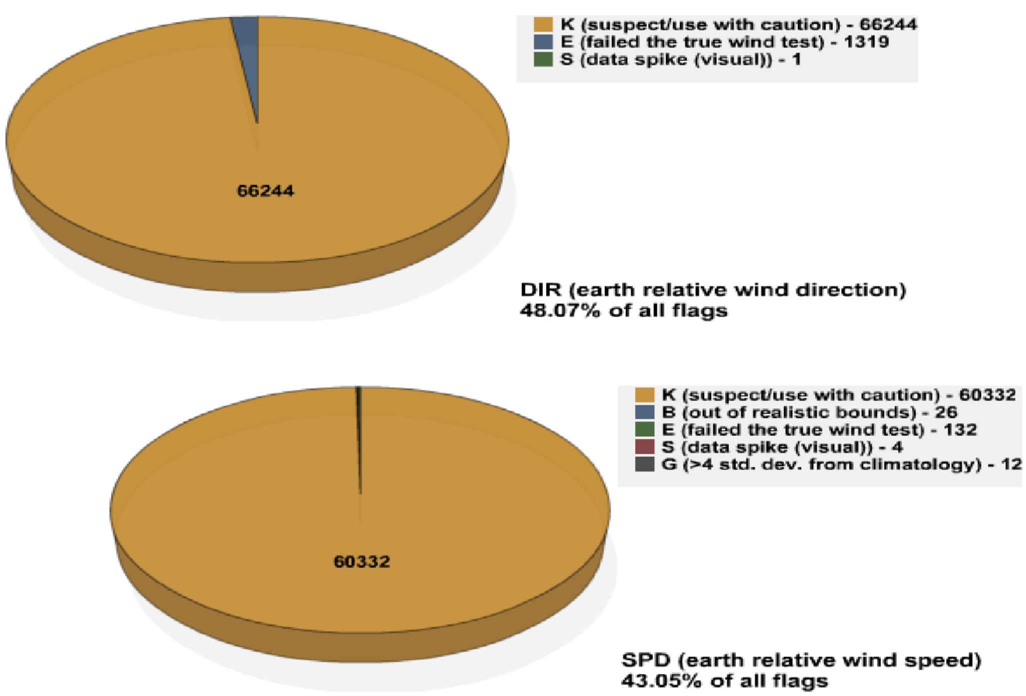

Figure 40: Distribution of SAMOS quality control flags for (top) earth relative wind direction – DIR – and (bottom) earth relative wind speed – SPD – for the *Ferdinand Hassler* in 2021.

Gordon Gunter

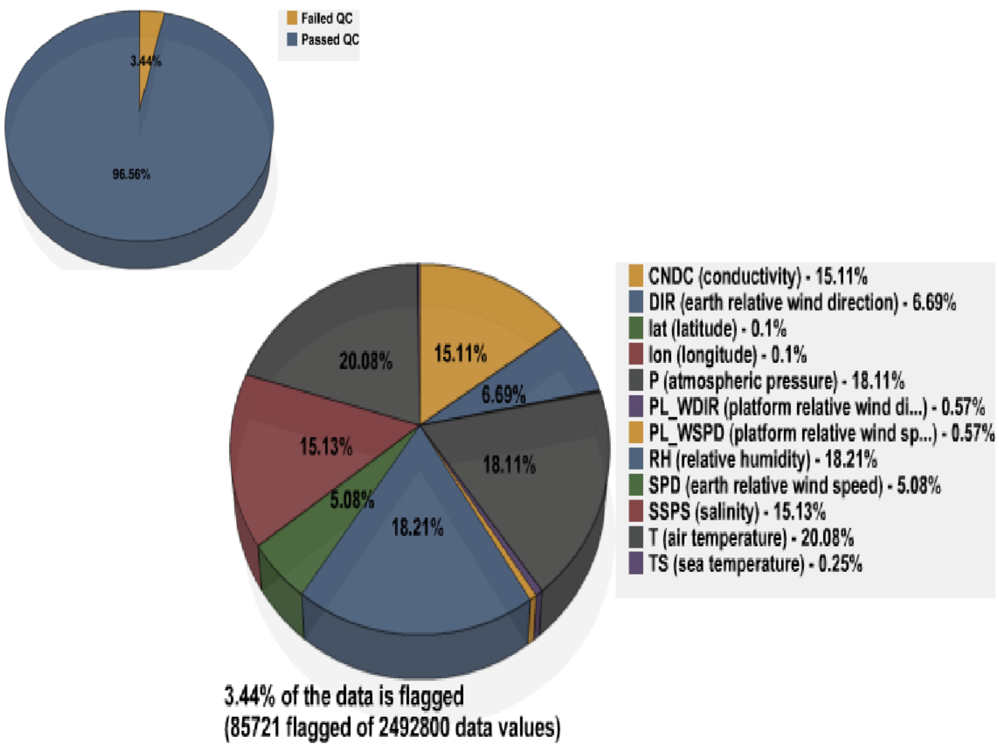

Figure 41: For the *Gordon Gunter* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Gordon Gunter* provided SAMOS data for 119 ship days, resulting in 2,492,800 distinct data values. After both automated and visual QC, 3.44% of the data were flagged using A-Y flags (Figure 41). This is a few percentage points higher than in 2020 (0.06%), although notably there were only 2 days of data in 2020. In any case, 3.44% is comfortably below the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

There were no specific issues noted for the *Gordon Gunter* in 2021. In general, *Gunter's* meteorological data – atmospheric pressure (P), air temperature and relative humidity (T and RH, respectively), and perhaps less noticeably earth relative wind speed and direction (SPD and DIR, respectively) – all show signs of moderate flow distortion and/or ship heating effects, which sometimes results in "caution/suspect" (K) flag application for each of those parameters (Figure 42, not all shown). This is common to most vessels, as it is difficult to site instruments ideally on a moving ship. Still, with an overall flagged percentage under 5% there's not much cause for concern. After the meteorological parameters, conductivity (CNDC) and salinity (SSPS) garnered most of the remaining flags, about 15% each (Figure 41). These were primarily "poor quality" (J) flags (Figure 42, only SSPS shown) applied when the thermosalinograph was clearly off, generally when the vessel was in port.

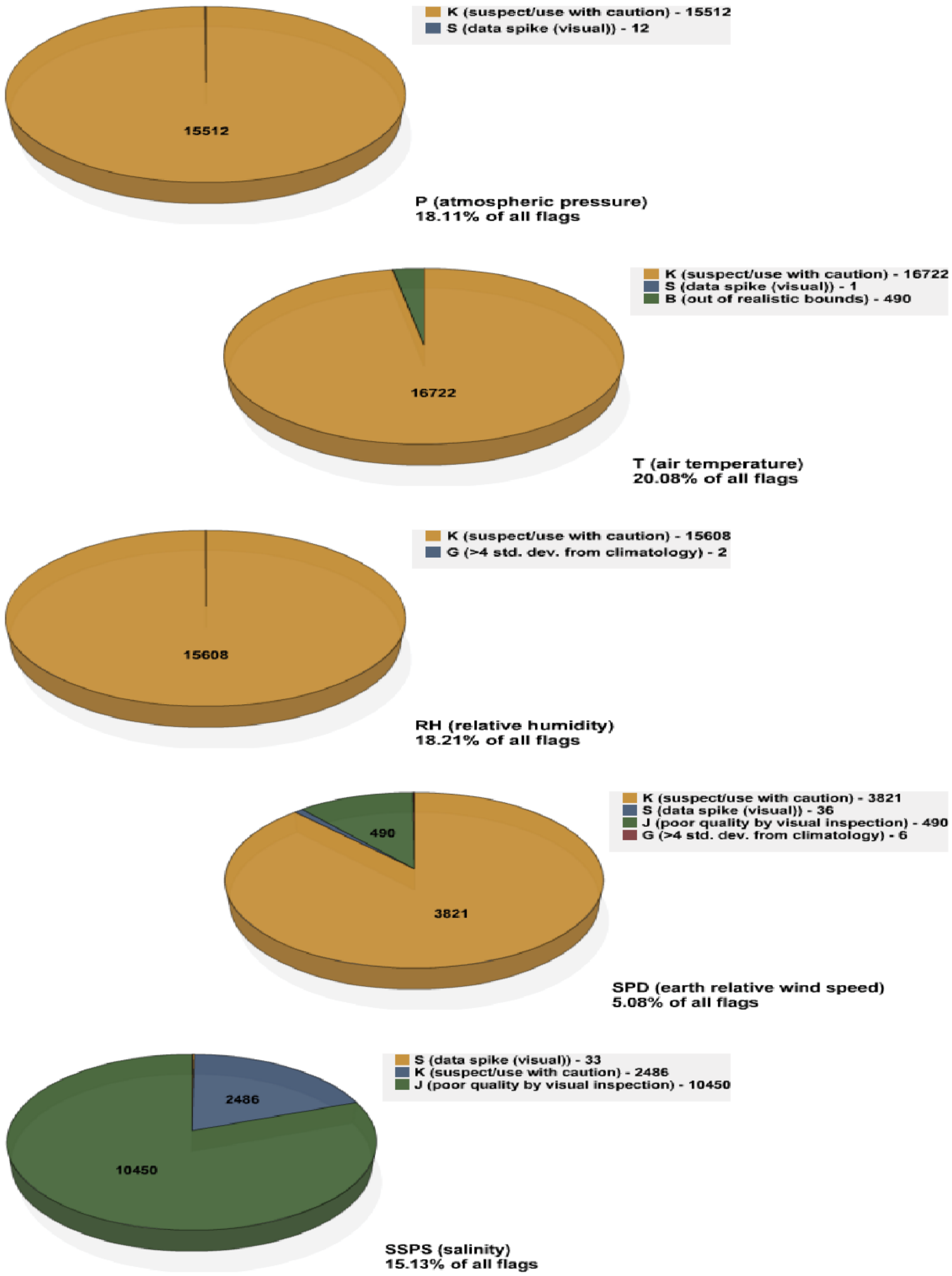

Figure 42: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) earth relative wind speed – SPD – and (last) salinity – SSPS – for the *Gordon Gunter* in 2021.

Henry B. Bigelow

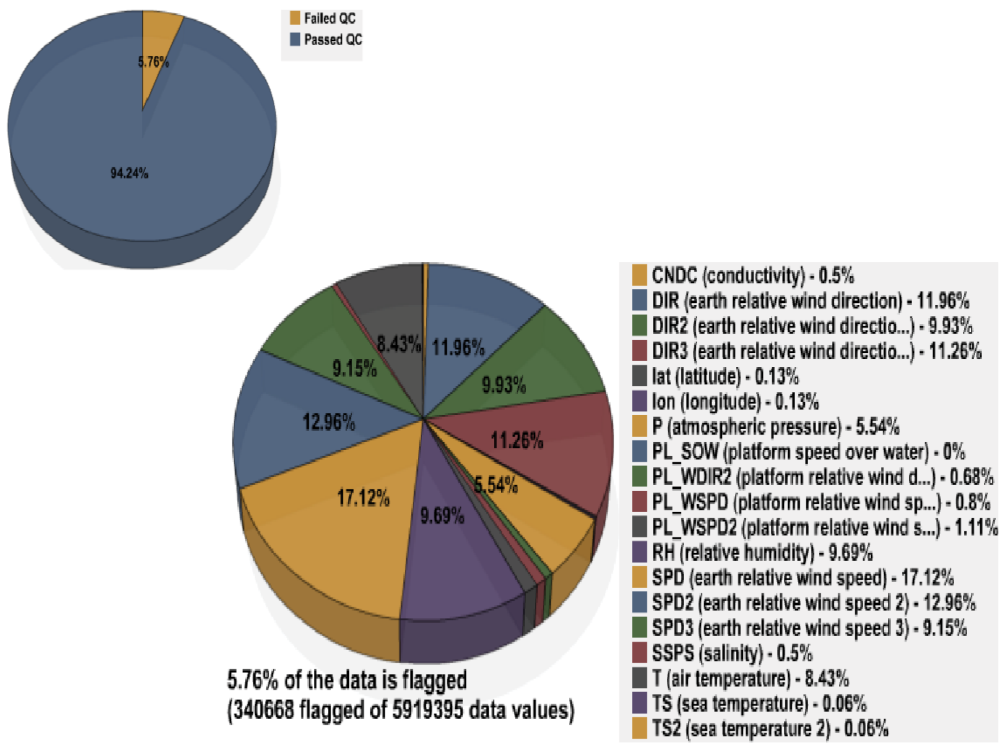

Figure 43: For the *Henry B. Bigelow* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Henry Bigelow* provided SAMOS data for 164 ship days, resulting in 5,919,395 distinct data values. After both automated and visual QC, 5.76% of the data were flagged using A-Y flags (Figure 43). This is about two percentage points lower than in 2020 (7.85%).

Early in the cruise season it was noted latitude (LAT) and longitude (LON) were being provided with only 0.01 precision, which was causing some automated application of "platform velocity unrealistic" (F) flags to both parameters (not shown). However, as technical specs for *Bigelow's* GPS (a Leica MX420) indicate accuracy to within about 1-3 meters (typical of many modern-day GPSs), a precision increase to 0.00001 was requested. This change was made effective on 3 March, after which automated application of F flags was greatly reduced.

From ~2200 on 16 February through 1430 on 19 February the port relative wind direction (PL_WDIR2) exhibited a very limited range of values (~5-20 degrees), as did the port relative wind speed (PL_WSPD2) (~2-3 m/s), neither behavior of which agreed well with data from *Bigelow's* other two anemometers (see Figure 44). This in turn affected the port true wind speed and direction (SPD2 and DIR2, respectively). All of PL_WDIR2, PL_WSPD2, DIR2, and SPD2 received mostly "poor quality" (J) and "out of bounds" (B) flags throughout the period (Figure 46, not all shown). The vessel was contacted about the issue on 18 February and word came back the technicians were working on it, but it's not specifically known what the cause or solution were.

About a month later, *Bigelow's* atmospheric pressure (P) data began exhibiting spikes and brief episodes of missing data. When contacted for information on 13 April, the senior survey technician noted she was aware of an issue and another technician was currently investigating. For about a month, during the suspected troubleshoot period, P was routinely erratic and too high (see Figure 45), resulting in application of mainly B, J, and "spike" (S) flags (Figure 46). The cause of the issue and the solution are again not known, but in any case, P drastically improved after 15 May.

Aside from the above recounted port anemometer incidence, all three of *Bigelow's* anemometers are known to exhibit a good deal of data distortion that is dependent on the vessel relative wind direction, with the result being various applications of "caution/suspect" (K) flags (Figure 46, not all shown) to all the earth relative wind directions (DIR, DIR2, DIR3) and speeds (SPD, SPD2, SPD3).

In addition to the winds, *Bigelow's* other meteorological data – atmospheric pressure (P), air temperature and relative humidity (T and RH, respectively) – also show signs of moderate flow distortion and/or ship heating effects (in the case of T/RH), which sometimes results in K flag application for each of those parameters (Figure 46, not all shown). This is common to most vessels, as it is difficult to site instruments ideally on a moving ship.

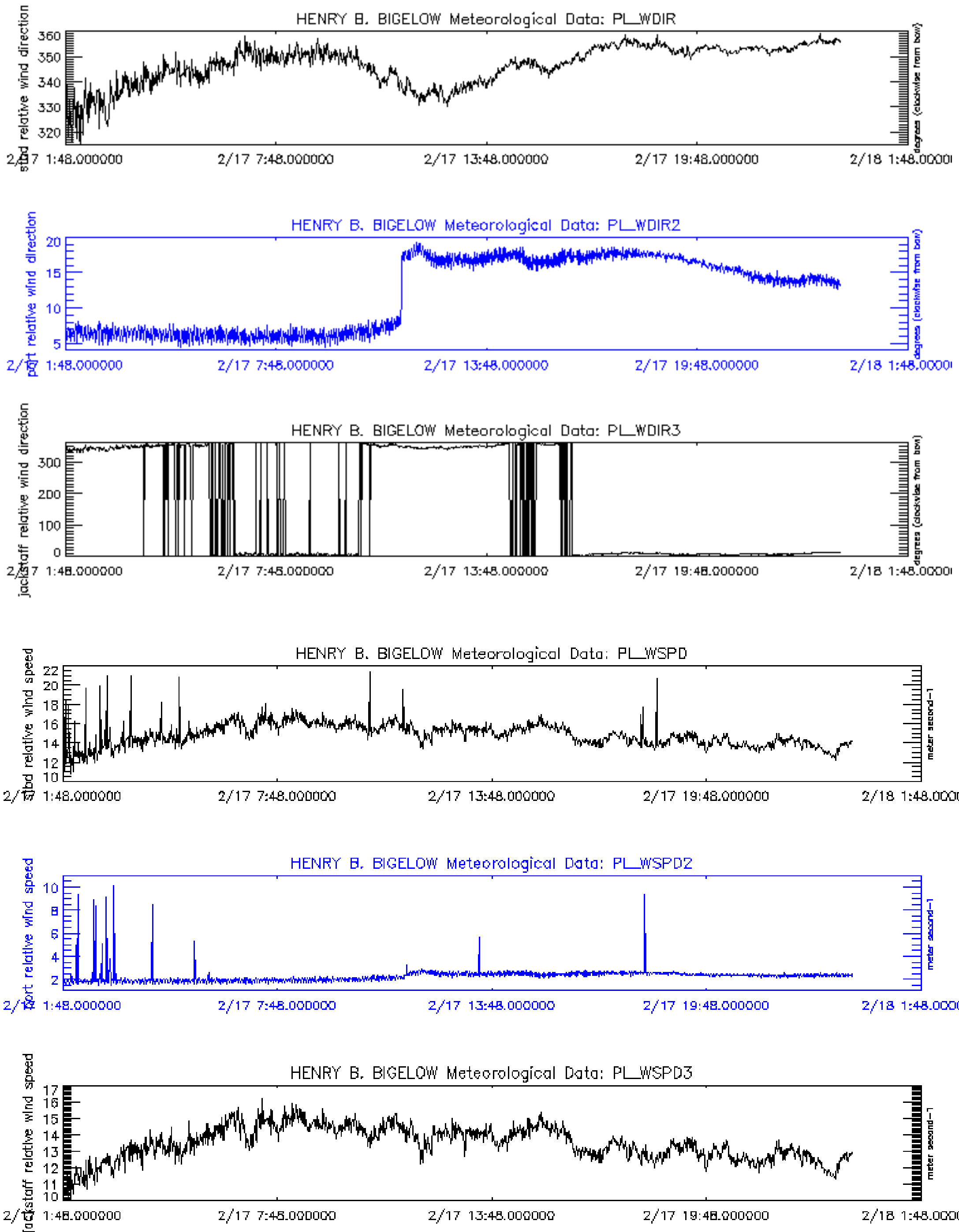

Figure 44: *Henry B. Bigelow* SAMOS (first) platform relative wind direction – PL_WDIR – (second) platform relative wind direction 2 – PL_WDIR2 – (third) platform relative wind direction 3 – PL_WDIR3 – (fourth) platform relative wind speed –PL_WSPD – (fifth) platform relative wind speed 2 – PL_WSPD2 – and (last) platform relative wind speed 3 – PL_WSPD3 – data for 17 February 2021. Note PL_WDIR2 (in blue) limited range and general disagreement with both PL_WDIR and PL_WDIR3. Similarly for PL_WSPD2 (also in blue) when compared to both PL_WSPD and PL_WSPD3.

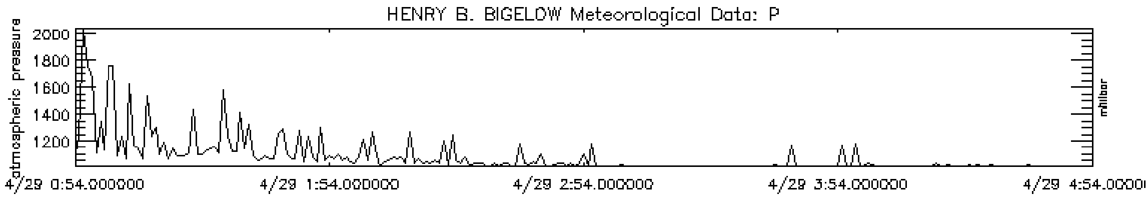

Figure 45: *Henry B. Bigelow* SAMOS atmospheric pressure – P – data for 29 April 2021. Note unrealistically high (~1200-2000 mb) spikes/noise.

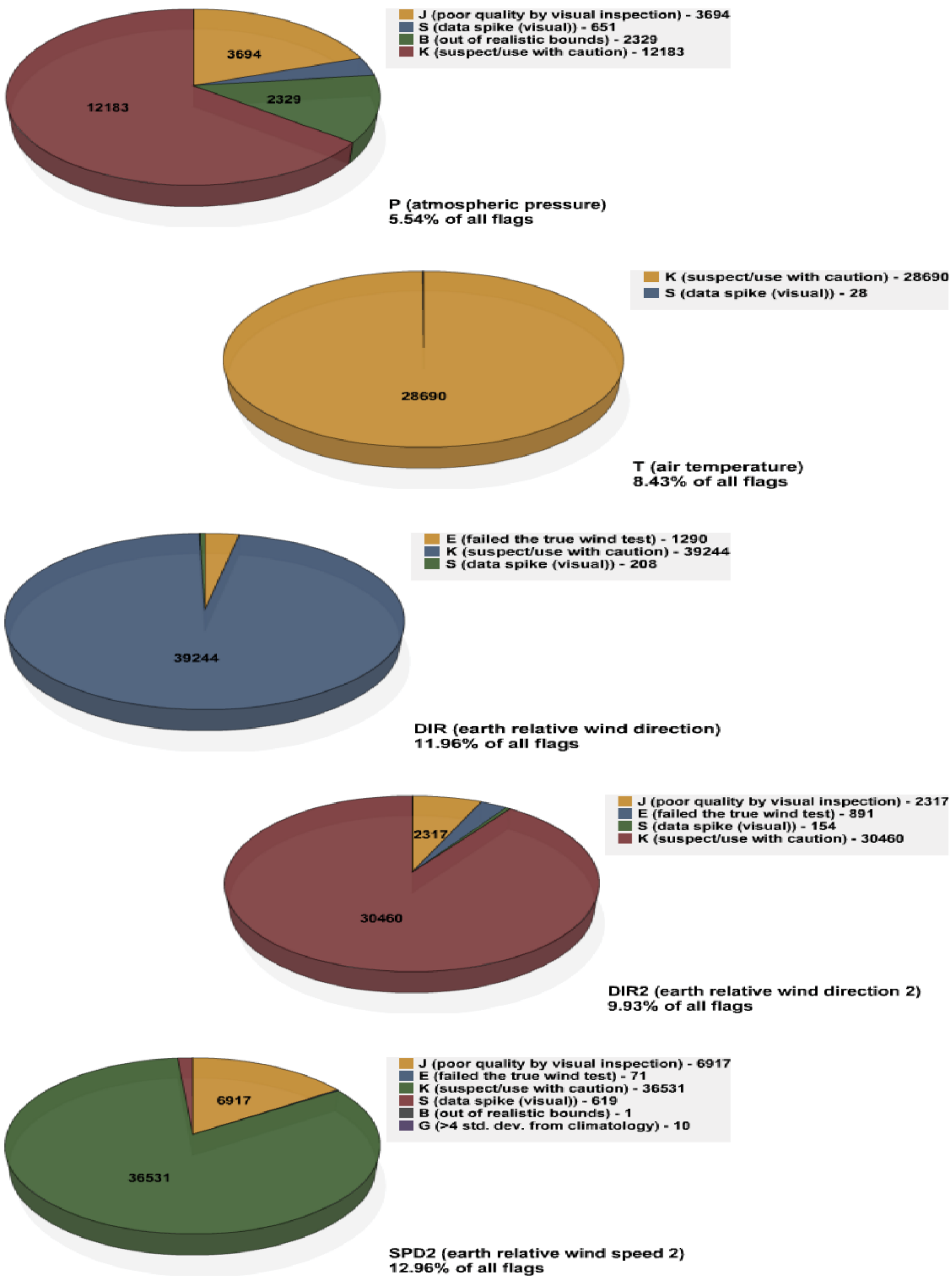

Figure 46: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) earth relative wind direction – DIR – (fourth) earth relative wind direction 2 –DIR3 – and (last) earth relative wind speed 2 –SPD2 – for the *Henry B. Bigelow* in 2021.

Nancy Foster

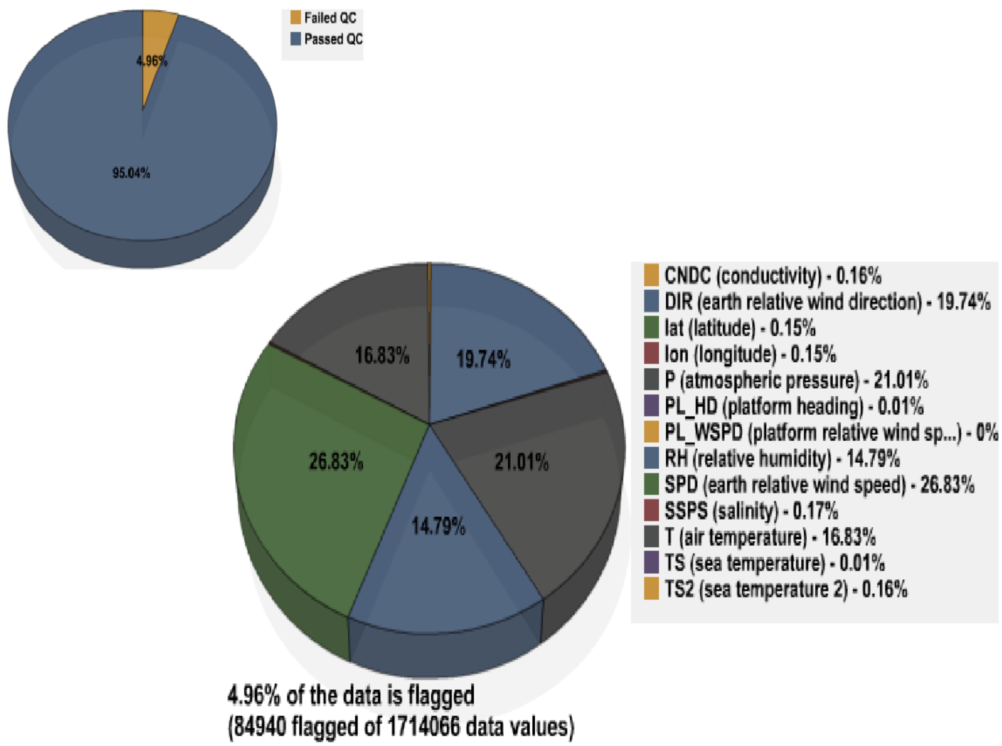

Figure 47: For the *Nancy Foster* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Nancy Foster* provided SAMOS data for 81 ship days, resulting in 941,646 distinct data values. After both automated and visual QC, 4.96% of the data were flagged using A-Y flags (Figure 47). This is only slightly higher than 2020 (4.16%) and maintains *Foster's* standing just under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

There were no specific issues of note for the *Nancy Foster* in 2021. In general, *Foster's* various meteorological sensors – earth relative wind direction (DIR), earth relative wind speed (SPD), air temperature (T), relative humidity (RH), and atmospheric pressure (P) – do occasionally exhibit data distortion that is dependent on the vessel relative wind direction (common to most vessels). The fairly even spread of flagging across these five parameters (Figure 47) suggests none of the instruments supplying the data is in a particularly compromised location. Where any of these data appear affected, they are typically flagged with "caution/suspect" (K) flags (Figure 48).

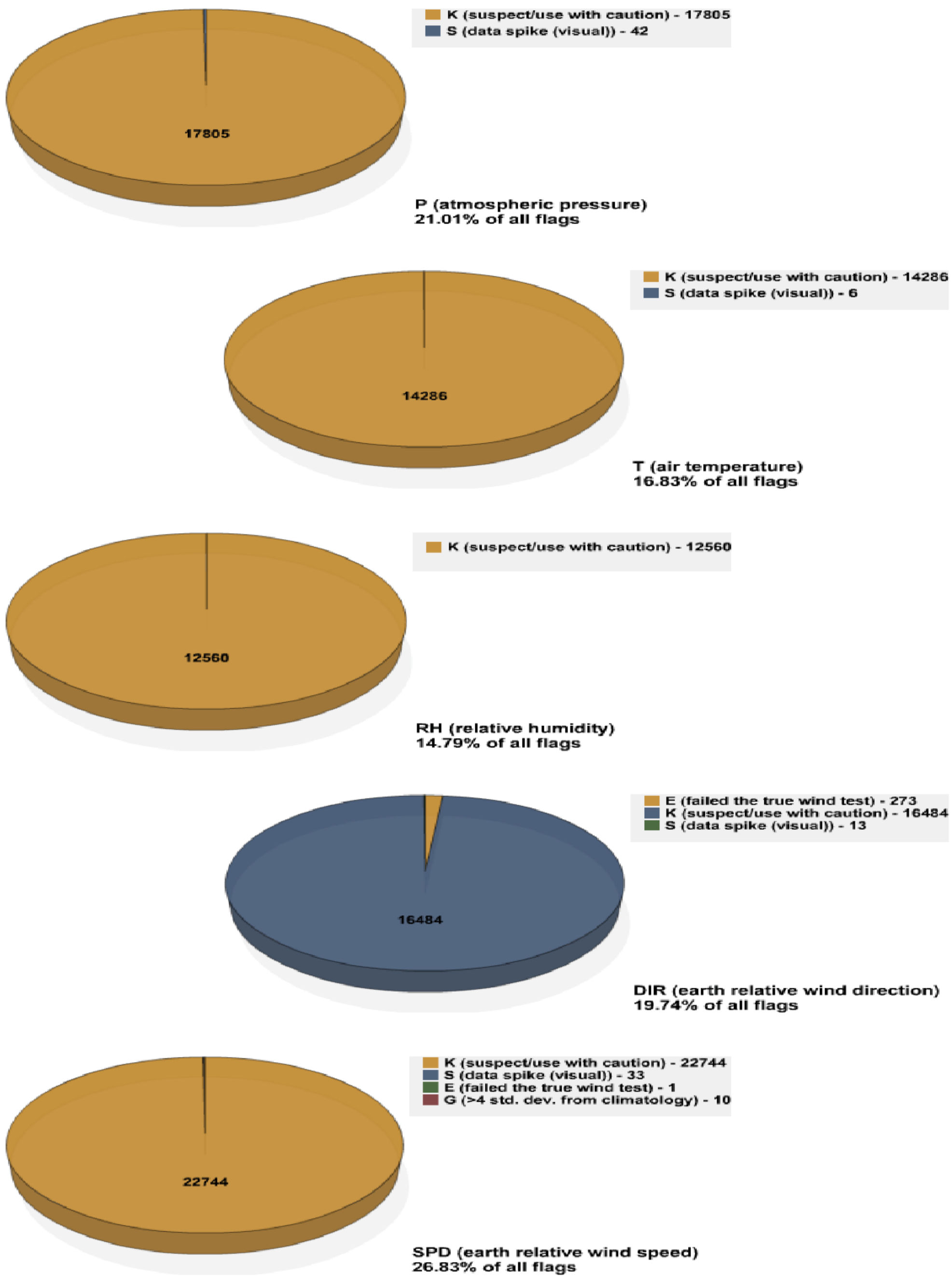

Figure 48: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – for the *Nancy Foster* in 2021.

Okeanos Explorer

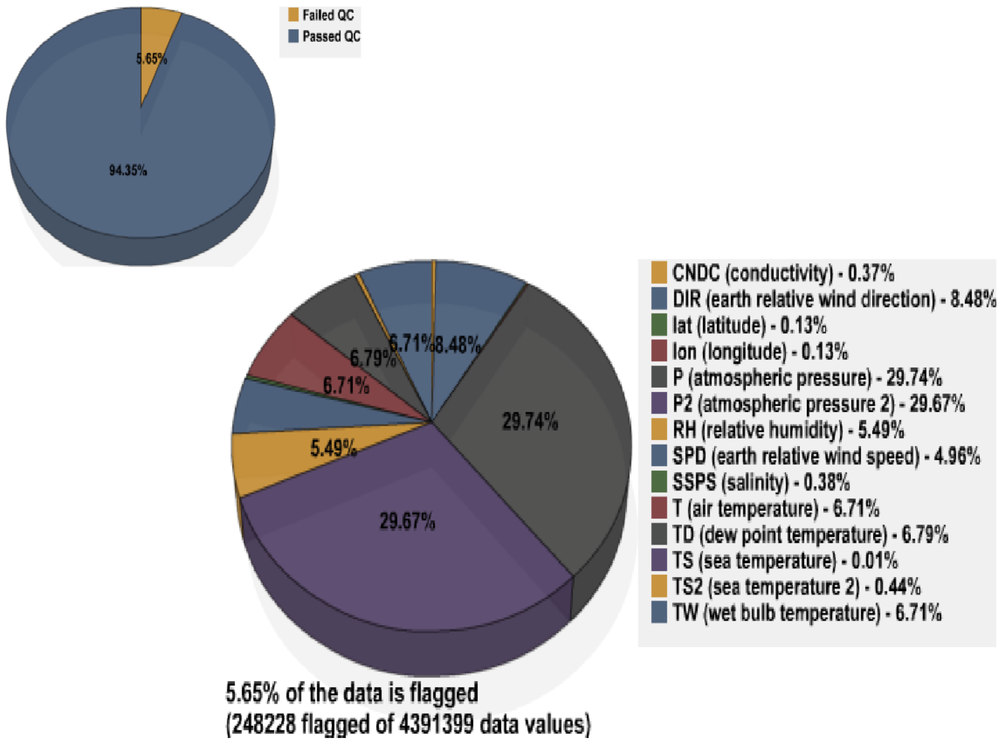

Figure 49: For the *Okeanos Explorer* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Okeanos Explorer* provided SAMOS data for 158 ship days, resulting in 4,391,399 distinct data values. After both automated and visual QC, 5.65% of the data were flagged using A-Y flags (Figure 49). This is about two percentage points higher than 2020 (3.5%) and moves *Explorer* just outside the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

At the onset of the 2021 field season the senior survey technician onboard *Okeanos Explorer* sent email notification the *Explorer's* thermosalinograph had spontaneously failed upon activation. He conferred that the failed instrument had been swapped with another unit of the same make and model (originally intended for 2022 use) the day after the initial failure. As a result of the failure, the TSG internal sea temperature (TS2) was auto-flagged with "out of bounds" (B) flags while salinity (SSPS) and conductivity (CNDC) data were assigned "poor quality" (J) flags (Figure 51) for the period 19:00 UTC 9 March through 9:00 UTC 10 March, although in retrospect all three of these parameters should probably have just received "malfunction" (M) flags.

Historically, the sensor supplying *Explorer's* atmospheric pressure (P) and surface adjusted atmospheric pressure (P2) data was known to suffer from some weird flow distortion and/or localized pressure effects due to a somewhat compromised installation location on the vessel's pilot house roof railing. In mid-summer 2021 it was noted P and P2 had been showing signs of worsening contamination during daylight hours, with many unrealistic 1-2+ mb swings in pressure over short (5-10 min) time periods (see Figure

50). The daytime aspect seemed significant, and it was suggested via email on 29 July, at the end of a cruise, that *Explorer's* senior survey tech might want to check the pressure tubing for moisture infiltration (also cracks or kinks). It was suspected water in the tubing could be heating up while the sun was out (either directly or indirectly, i.e., from nearby heat sources), causing the pressure readings to swing. When the next cruise began about two weeks later the technician reported good news: they had replaced the barometer tubing (though no moisture had been noted) and had also added a slight outward extension (about 3") to the bracket holding the sensor, creating a bit of extra space between the sensor and the railing mount. Both P and P2 data performance were markedly improved after these changes were made. In the meantime, both P and P2 received "caution/suspect" (K) flags (Figure 51) fairly frequently throughout the first half of the year wherever the data appeared compromised, with a greater concentration of flagging occurring over the summer up until the end of July. As noted, K flagging of P and P2 was then much reduced in the second half of the year.

In general, *Okeanos Explorer's* other meteorological sensors – earth relative wind direction (DIR), earth relative wind speed (SPD), air temperature (T), wet bulb temperature (TW), dew point temperature (TD), and relative humidity (RH) – do also occasionally exhibit data distortion that is dependent on the vessel relative wind direction and, in the case of T/TW/TD/RH, which share the P/P2 installation location, likely vessel heating (all common to most vessels). Where the data appear affected, they are typically flagged with "caution/suspect" (K) flags (not shown).

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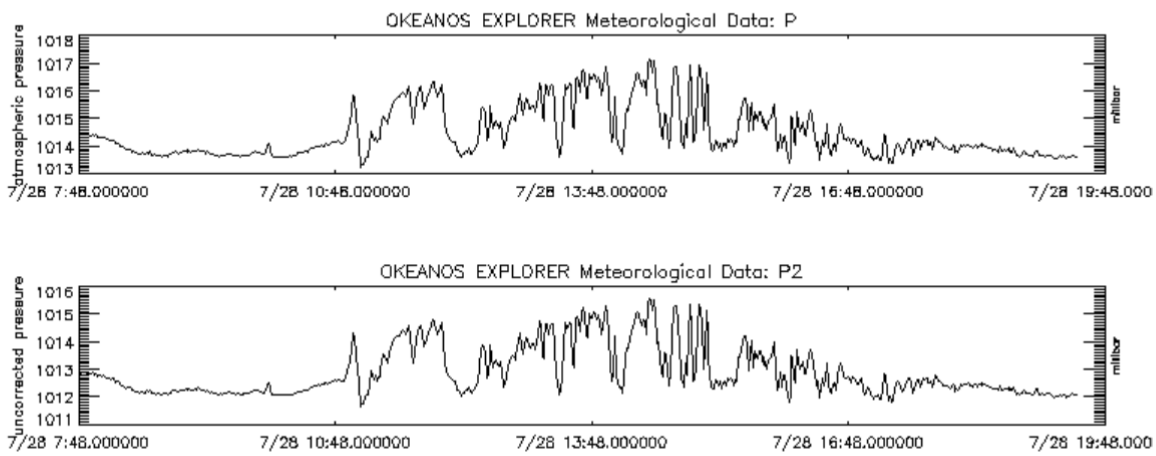

Figure 50: *Okeanos Explorer* SAMOS atmospheric pressure – P – and atmospheric pressure 2 – P2 – data for 28 July 2021. Note short-period (5-10 min.) > 2 mb swings in pressure particularly during prime insolation hours (~11:00 - 15:00 UTC).

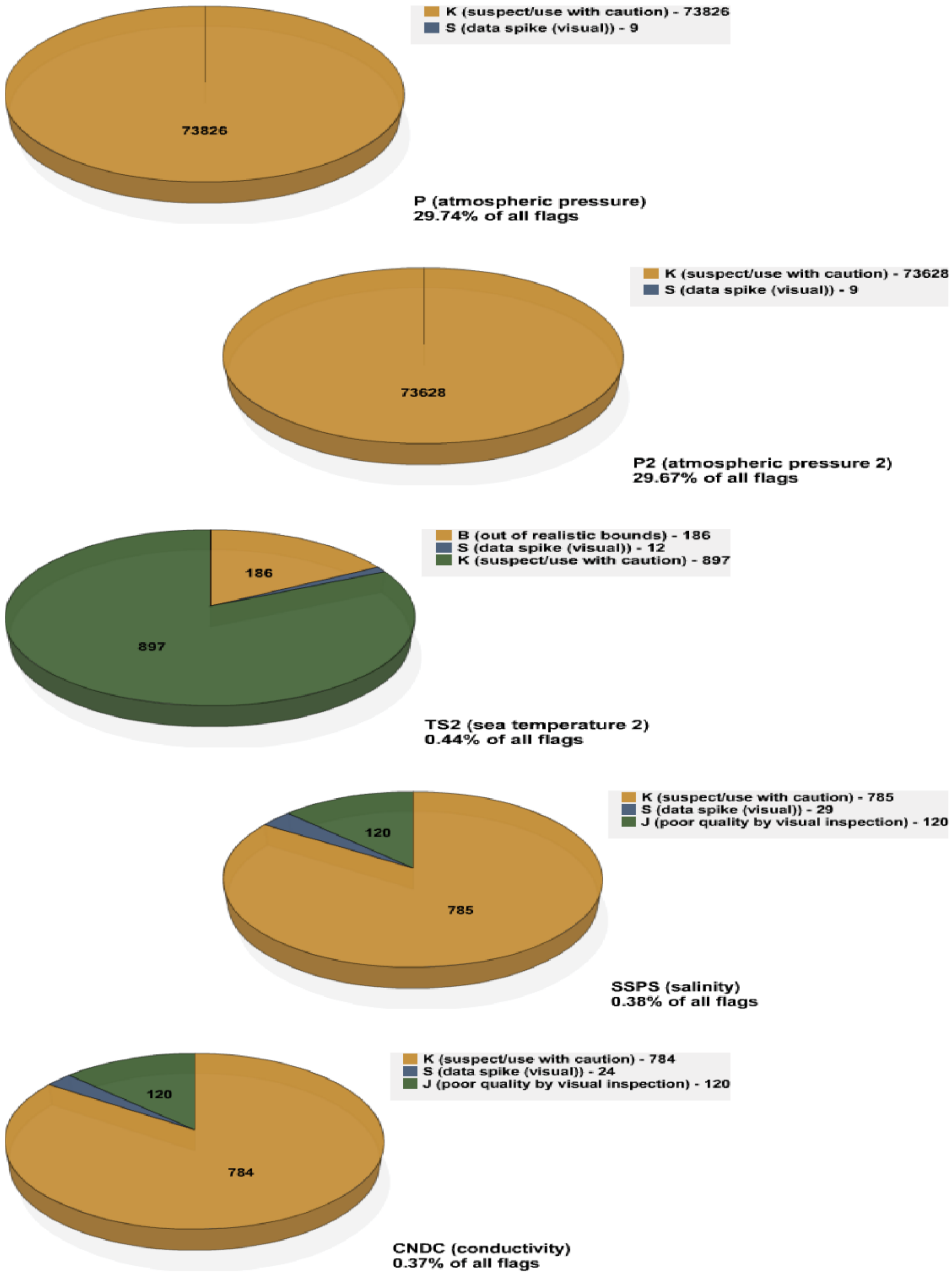

Figure 51: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) atmospheric pressure 2 – P2 – (third) sea temperature 2 – T2 – (fourth) salinity – SSPS – and (last) conductivity – CNDC – for the *Okeanos Explorer* in 2021.

Oregon II

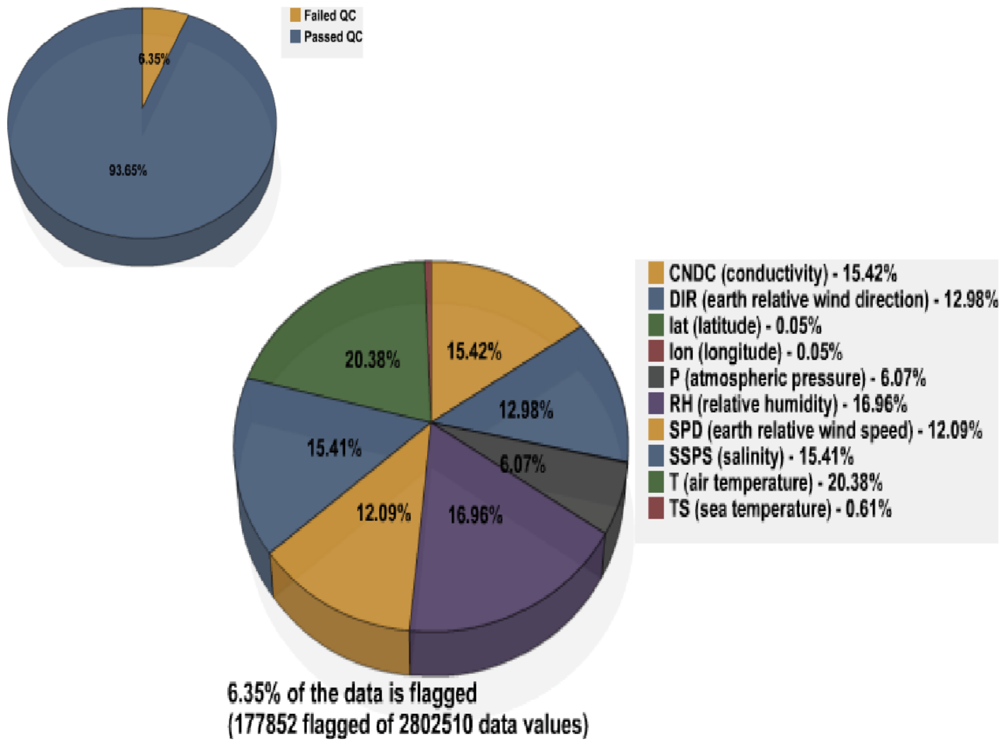

Figure 52: For the *Oregon II* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oregon II* provided SAMOS data for 132 ship days, resulting in 2,802,510 distinct data values. After both automated and visual QC, 6.35% of the data were flagged using A-Y flags (Figure 52). This is only slightly higher than in 2020 (5.72%).

There were no specific issues noted for the *Oregon II* in 2021. As a general note, air temperature (T), relative humidity (RH), earth relative wind direction and speed (DIR and SPD, respectively), and atmospheric pressure (P) on the *Oregon* all suffer the myriad effects of less-than-ideal sensor placement (e.g., flow distortion, stack exhaust contamination, ship heating), which oftentimes results in "caution/suspect" (K) flags for each of those parameters (Figure 54, not all shown). What looks to be the effect of localized ship heating seems particularly evident in T and RH on sunny days when the relative wind is from broadly port to astern (Figure 53). All these effects are common among sea-faring vessels, where instrument siting can be tricky, although the effects are perhaps a little more pronounced on the *Oregon II* than on the average SAMOS ship. We note *Oregon II* metadata is almost certainly well out of date and digital imagery/schematics of the vessel are unavailable, so accurately diagnosing flow issues isn't possible. (Renewed efforts to achieve metadata accuracy will be undertaken in 2022.) In any case, the resulting flags make up most percentages seen in Figure 52 for each parameter.

Looking again to the flag percentages in Figure 52, about 30% of the total flags were assigned to the sea parameters salinity (SSPS) and conductivity (CNDC). These were overwhelmingly K flags (Figure 54), applied mainly when it appeared the flow-through sea water system that feeds the thermosalinograph was disengaged, such as routinely occurs when a vessel is near/at port or in rough seas.

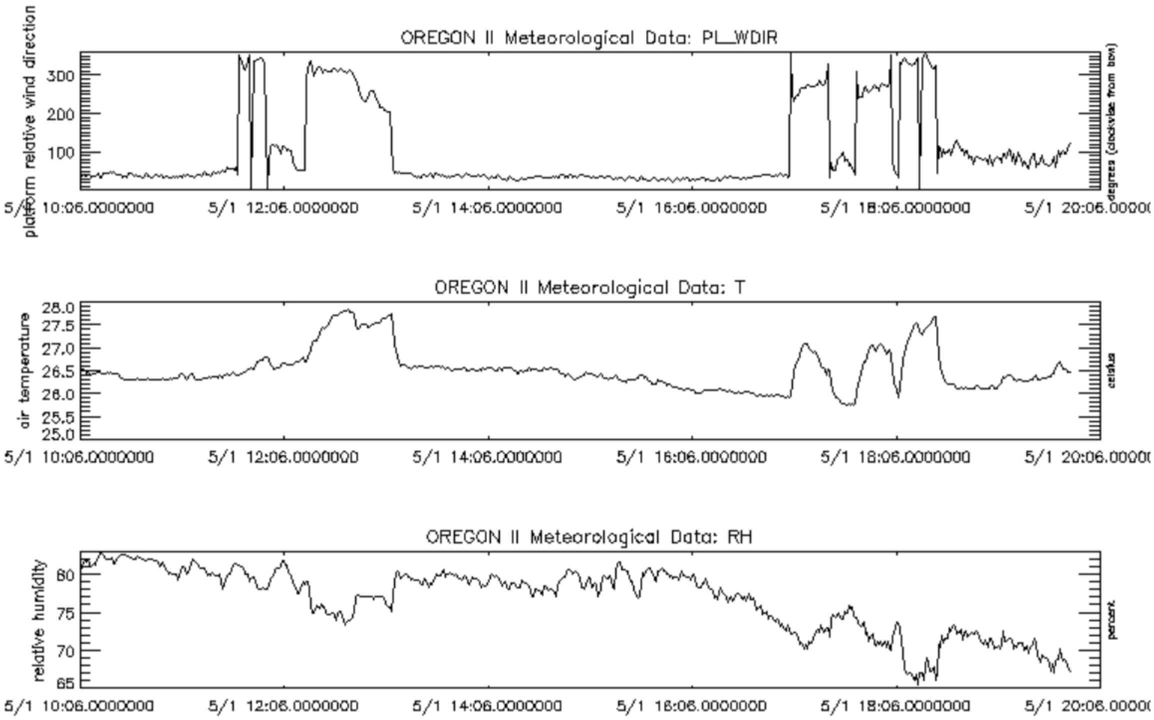

Figure 53: *Oregon II* SAMOS (top) platform relative wind direction – PL_WDIR – (middle) air temperature – T – and (bottom) relative humidity – RH – data for 1 May 2021. Note daytime steps in T/RH when the platform relative wind is from roughly > 180° to 359° (i.e., port side). Note sunrise occurred at approximately 11:00 UTC.

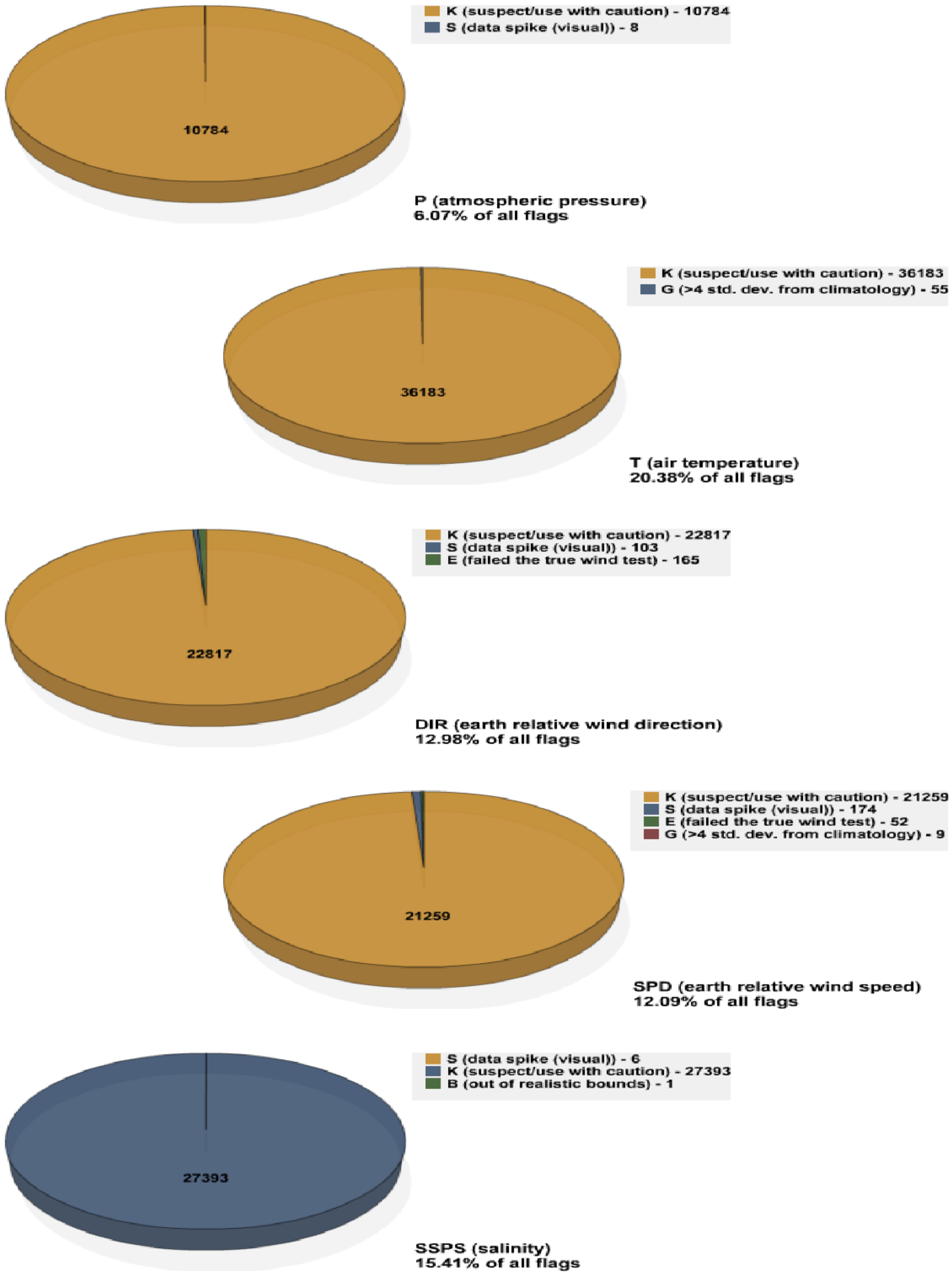

Figure 54: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) earth relative wind direction – DIR – (fourth) earth relative wind speed – SPD – and (last) salinity – SSPS – for the *Oregon II* in 2021.

Oscar Dyson

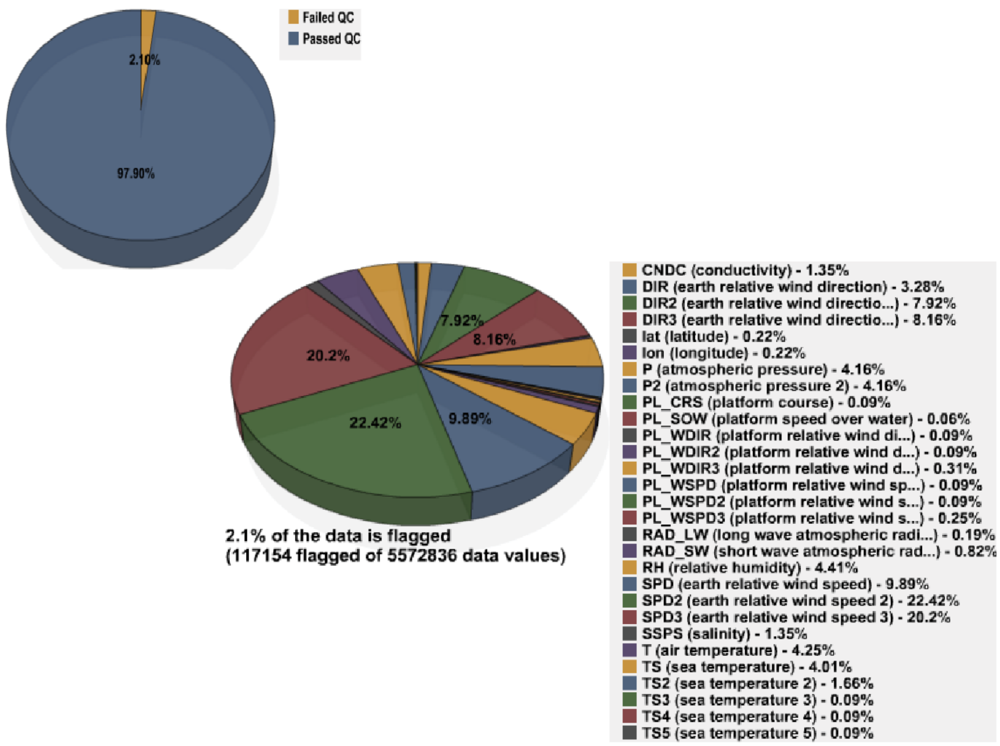

Figure 55: For the *Oscar Dyson* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oscar Dyson* provided SAMOS data for 137 ship days, resulting in 5,572,836 distinct data values. After both automated and visual QC, 2.1% of the data were flagged using A-Y flags (Figure 51). This is only half a percentage points higher than in 2020 (1.61%) and maintains *Dyson's* standing well under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

There were no specific issues noted for the *Oscar Dyson* in 2021. As a general note, *Dyson's* various meteorological sensors do occasionally exhibit data distortion that is dependent on the vessel relative wind direction and/or stack exhaust contamination and/or, in the case of air temperature (T) and relative humidity (RH), likely ship heating (all common to most vessels). As suggested by the percentages in Figure 51, issues of flow distortion are a bit more pronounced in the two ultrasonic wind sensors amidships – earth relative wind directions 2 and 3 (DIR2 and DIR3) and earth relative wind speeds 2 and 3 (SPD2 and SPD3). (In 2022 *Dyson* personnel voiced a sneaking suspicion the problem with these ultrasonics – both RM Young 85004's – lies primarily in the cabling, which is hard to come by, besides. We note that may hold some influence in the 2021 flagging of DIR2/DIR3/SPD2/SPD3.) Where any of the meteorological data appear affected by flow distortion, exhaust, or ship heating, or appear otherwise compromised as may be the case with the ultrasonic wind parameters, they are typically flagged with "caution/suspect" (K) flags (Figure 56, not all shown).

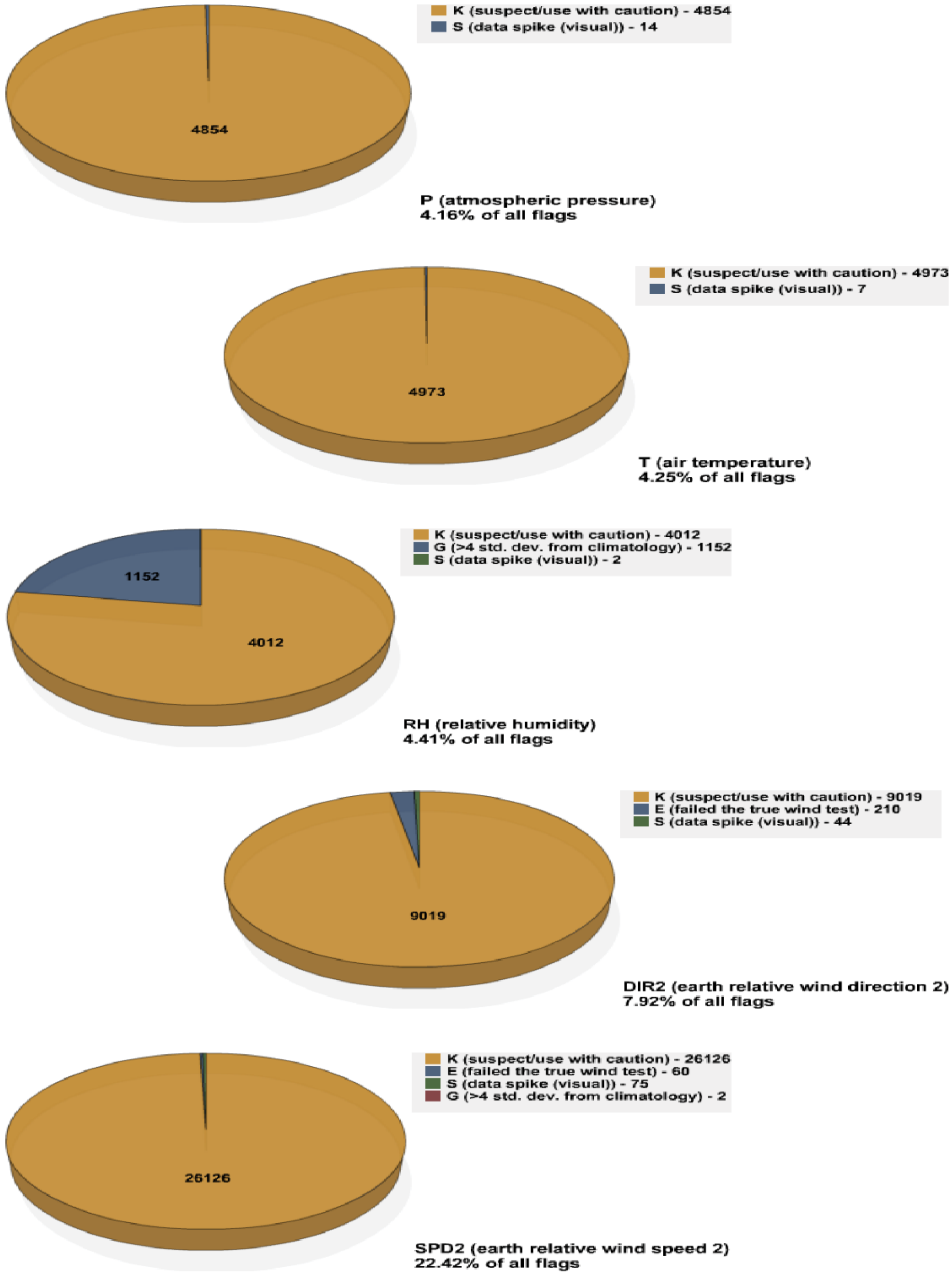

Figure 56: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) earth relative wind direction 2 – DIR2 – and (last) earth relative wind speed 2 – SPD2 – for the *Oscar Dyson* in 2021.

Oscar Elton Sette

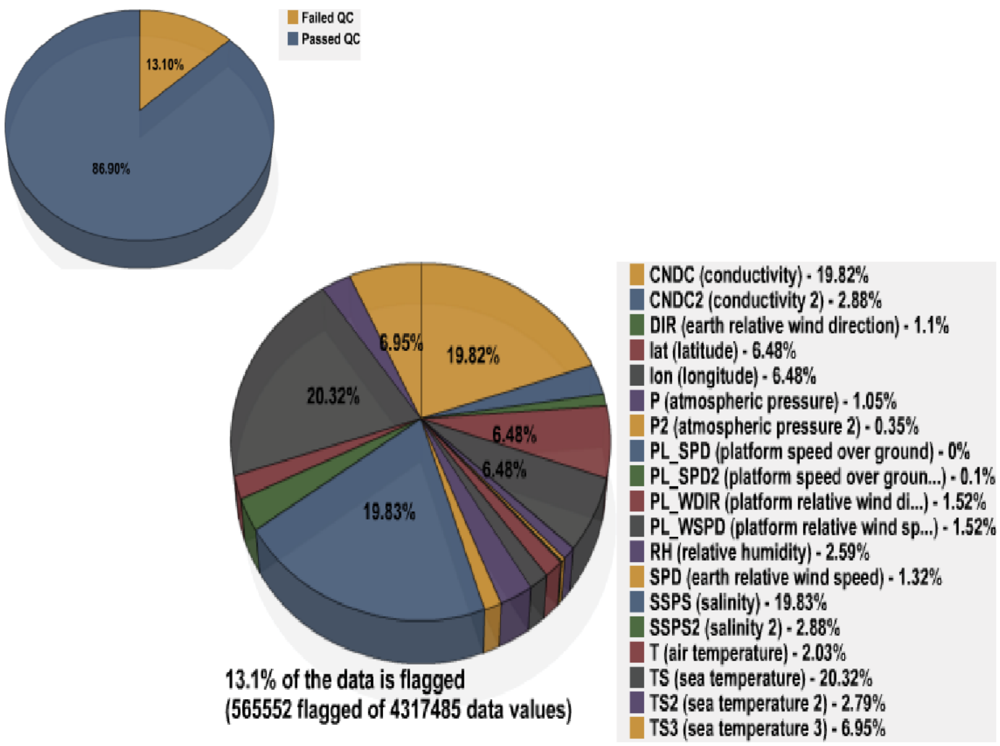

Figure 57: For the *Oscar Elton Sette* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oscar Elton Sette* provided SAMOS data for 212 ship days, resulting in 4,317,485 distinct data values. After both automated and visual QC, 13.1% of the data were flagged using A-Y flags (Figure 57). This is about three and a half percentage points higher than in 2020 (9.49%) and is over the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

At the start of the season, *Oscar Elton Sette's* intake sea temperature (TS) appeared to be bad (mostly ~0° Celsius, with numerous high-valued spikes) while salinity (SSPS) and conductivity (CNDC) both seemed in range but suspicious (atypical trace) nonetheless. Additionally, their initial SAMOS files were missing most of their meteorological data -- namely, the true wind speed and direction (SPD and DIR) and the associated vessel relative wind speed and direction (PL_WSPD and PL_WDIR), as well as the air temperature (T) and relative humidity (RH). An email was sent to the vessel on 26 March requesting information about the various issues. A technician immediately responded, informing us that, firstly, the TS sensor was off due to lack of a necessary converter (currently on order). In the second place, their RM Young T/RH and anemometer were not producing any output due to a suspected wiring installation issue, which would have to wait to be addressed until they had someone available to troubleshoot who was climb certified. Based on this information, TS was assigned "poor quality" (J) flags and SSPS/CNDC were assigned "caution/suspect" (K) flags (Figure 59) for the period 24 March through 15 April, at which point TS ceased transmitting while simultaneously the SSPS and CNDC traces shifted to resemble more normal patterns.

The remaining issues were confirmed to be ongoing on 22 April, with the same technician now informing that they were awaiting some translator program information from RM Young for the winds and T/RH. As for the intake TS (now missing), he emailed again a day later to inform that he'd discovered a bad cable at some point in the path of the TS, which he was planning to rewire. As of 28 April, TS data resumed and were looking good. When contacted for confirmation of a fix, the technician shared that in an unlikely twist it had actually turned out to be not one but two bad TS sensors that were the problem (oof!).

Not long after, in early May, the technician contacted us yet again to advise that they'd lost suction in their seawater pump the first day out of the cruise (see Figure 58) and seas had only gotten rougher, meaning the pump would remain off for the time being. (This episode resulted in additional J flags on CNDC/SSPS/TS, for the 3-23 May period (Figure 59, not all shown). It also brought an understanding that *Sette's* seawater pump would habitually lose suction from time to time, in rougher seas.)

Also shared with us in the early May conversation was that the technician was still unfortunately playing "telephone tag" with RM Young regarding the winds and T/RH. Evidently the RMY rep had tried to email out the needed translator programs, but they kept getting rejected from the NOAA servers. In the end, PL_WDIR, PL_WSPD, DIR, SPD, and T/RH did not resume in *Sette's* SAMOS data stream until the ship was upgraded to the newest version (v5) of her data acquisition system, NOAA's Scientific Computing System (SCS) at the beginning of August. Although we note there had been occasional brief stints (a few to several days, generally) of all these data within the prior cruise months as the technician was testing. But most of these sporadic data were obviously bad and J-flagged (Figure 59, not all shown). Once the winds and T/RH began showing up, after the upgrade, everything basically looked good.

Notably, the *Sette's* upgrade to SCSv5 constituted a major update to the SCS platform, one consequence of which seems to have been that for vessels running the software in 2021 SAMOS data transmission was almost always "on," regardless of whether the ship was underway or not (and in some cases even whether she was crewed or not). When vessels transmit from port, it is not uncommon for the latitude and longitude to receive automated "land error" (L) flags, as the land mask in use for the SAMOS land check routine is often incapable of resolving the very fine detail of a coastline or an inland port. Such was often the case for the *Sette* in the latter half of 2021. In a further twist, *Oscar Elton Sette's* LAT and LON data while in port tended to have a lot of data spikes, which generally result in "platform velocity unrealistic" (F) flags to both the spike value and the second value after the spike (the flagging scheme is not capable of determining which of these values is likely in error, it only sees the outsized disparity between the two). Taken all together, *Sette's* port-based LAT and LON data were usually heavily laden with L and F flags (Figure 59, only LAT shown). Generally speaking, these flags can be winnowed quite a bit during visual quality control. However, due to the frequency of the spikes and because the visual editing software for use in changing SAMOS data flags is rather ancient and clunky, time often did not permit for a laborious combing through of the LAT/LON data to remove any unnecessary flags.

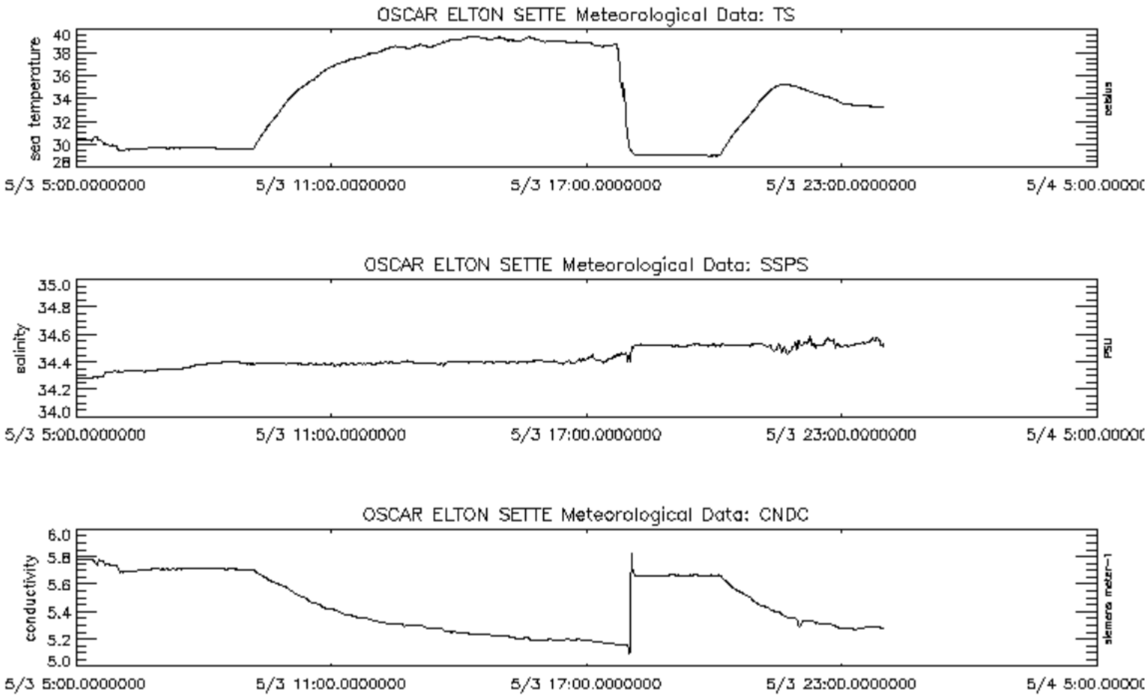

Figure 58: *Oscar Elton Sette* SAMOS (top) sea temperature – TS – (middle) salinity – SSPS – and (bottom) conductivity – CNDC – data for 3 May 2021. Note pronounced "shark fin" curves, most evident in TS/CNDC, that result from the seawater pump losing suction.

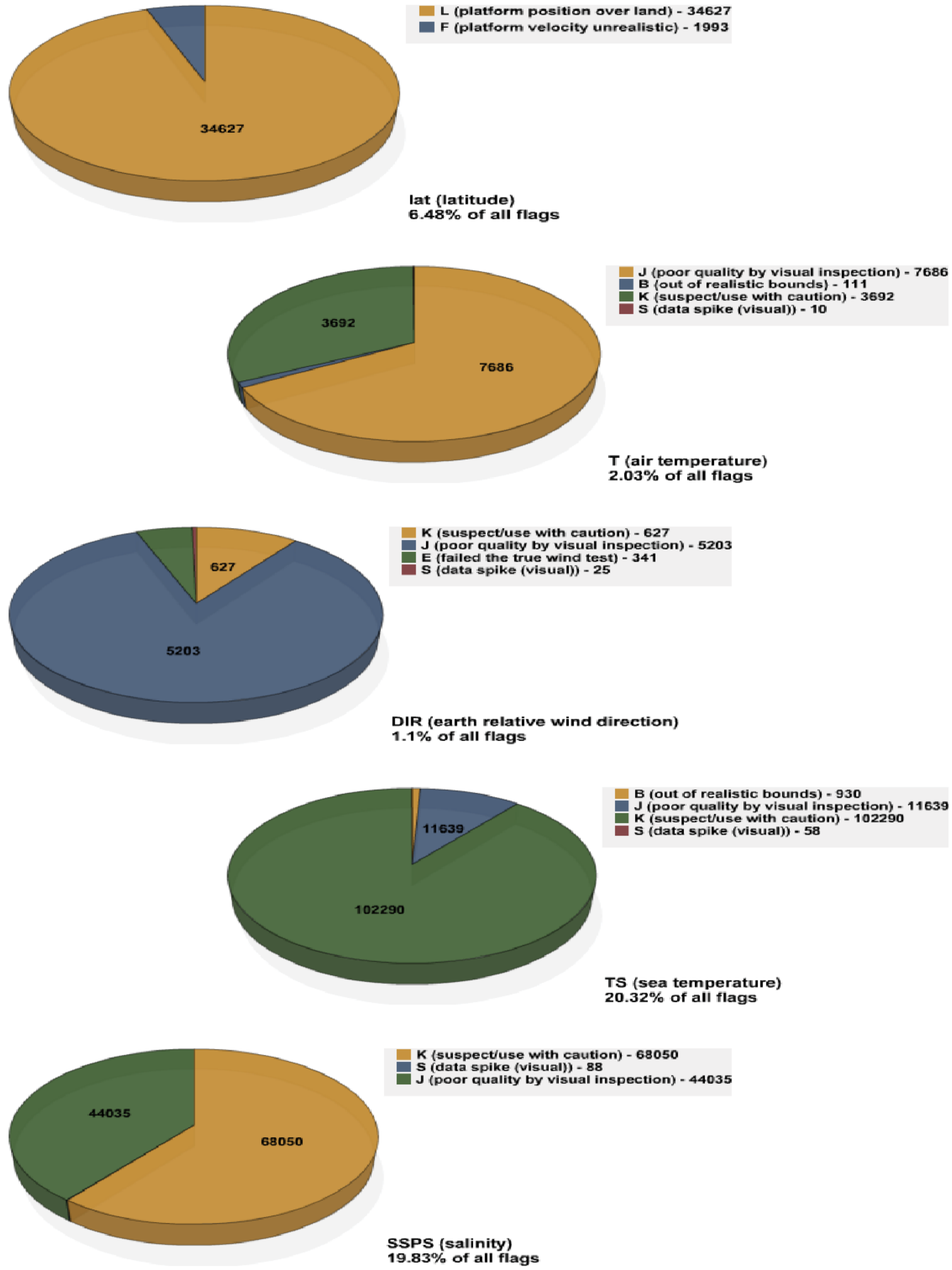

Figure 59: Distribution of SAMOS quality control flags for (first) latitude – LAT – (second) air temperature – T – (third) earth relative wind direction – DIR – (fourth) sea temperature – TS – and (last) salinity – SSPS – for the *Oscar Elton Sette* in 2021.

Pisces

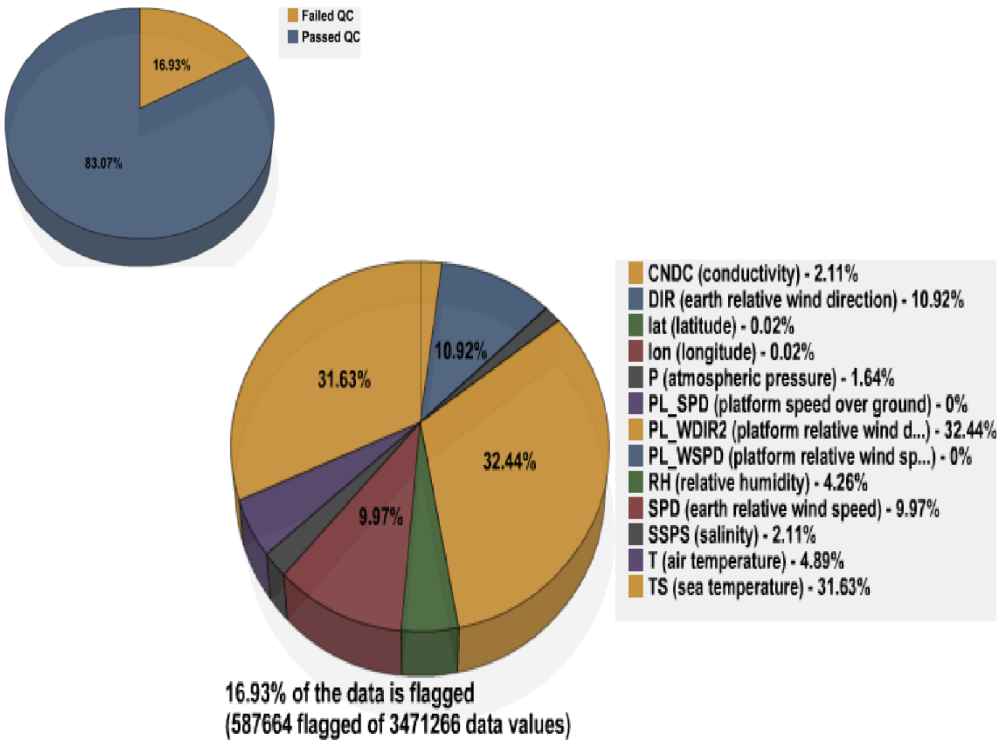

Figure 60: For the *Pisces* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Pisces* provided SAMOS data for 151 ship days, resulting in 3,471,266 distinct data values. After both automated and visual QC, 16.93% of the data were flagged using A-Y flags (Figure 60). This is over the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

Pisces did not sail in 2020, so when she began transmitting in early March 2021 it had been well over a year since her last SAMOS submission. Not surprisingly, there were a few issues with her data from the start. Unfortunately, two major issues persisted throughout 2021, significantly contributing to an almost 17% total flagged percentage for the year (Figure 60). The first of these two issues concerned her secondary platform relative wind direction parameter (PL_WDIR2). Here, PL_WDIR2 values constantly waffled between ~359° and 1° ("north"), without end (see Figure 61). The second issue concerned her external sea temperature (TS). In this case, the data exhibited an unrealistic range of values, from about 0 to 90 degrees Celsius (see Figure 61). Ongoing email conversations throughout March and April with *Pisces's* senior survey technician revealed the data sources for PL_WDIR2 and TS were undetermined. Notably, all sensor definitions had been set up in *Pisces's* data acquisition system (NOAA Scientific Computing System, "SCS") several years prior by a previous technician. *Pisces's* current lead technician had difficulty following the previous technician's sensor labeling logic in SCS and could not discover which of the vessel's five anemometers was supposedly flowing into the PL_WDIR2 variable nor could he ascertain the origination of TS. He noted, too, there were a number of disconnected sensors on the ship and that it was slow work trying to get things rewired amidst an overfull to-do list. As a last resort, it was expected the *Pisces* would be upgrading to the newest release of SCS (v5) in late spring or early summer, at which point sensor configuration would be completely revamped and reinitiated anyway. This upgrade did not take place as planned, however. The issues of PL_WDIR2 and TS were revisited for the last time in mid-November, at which time the lead technician confirmed an SCS upgrade would not take place in 2021 and stated he would likely have to sit down and redo everything, going port to port and testing/labeling everything in the *Pisces* data stream. He further noted he now understood there was a definite "disconnect" between what he was seeing and what SAMOS was receiving. In the meantime, both PL_WDIR2 and TS data ended up being flagged throughout the entirety of 2021, each receiving about 32% of the total flags for the year (Figure 60). These were almost exclusively "poor quality" (J) flags (Figure 62). In retrospect, it may have been better to simply suspend SAMOS processing of PL_WDIR2 and TS at some point in 2021. We do note, though, that in the case of PL_WDIR2 there was at least no associated true wind value being collected so the impact of the flagging of PL_WDIR2 was limited. Additionally, the salinity and conductivity values being submitted to SAMOS appeared unaffected by the issue with TS.

In general, *Pisces's* various other meteorological sensors – earth relative wind direction (DIR), earth relative wind speed (SPD), and to a lesser extent air temperature (T), relative humidity (RH), and atmospheric pressure (P) – do occasionally exhibit data distortion that is dependent on the vessel relative wind direction, as well as occasional effects of ship heating on T/RH (all common to most vessels). Where any of these data appear affected, they are typically flagged with "caution/suspect" (K) flags (Figure 62, not all shown).

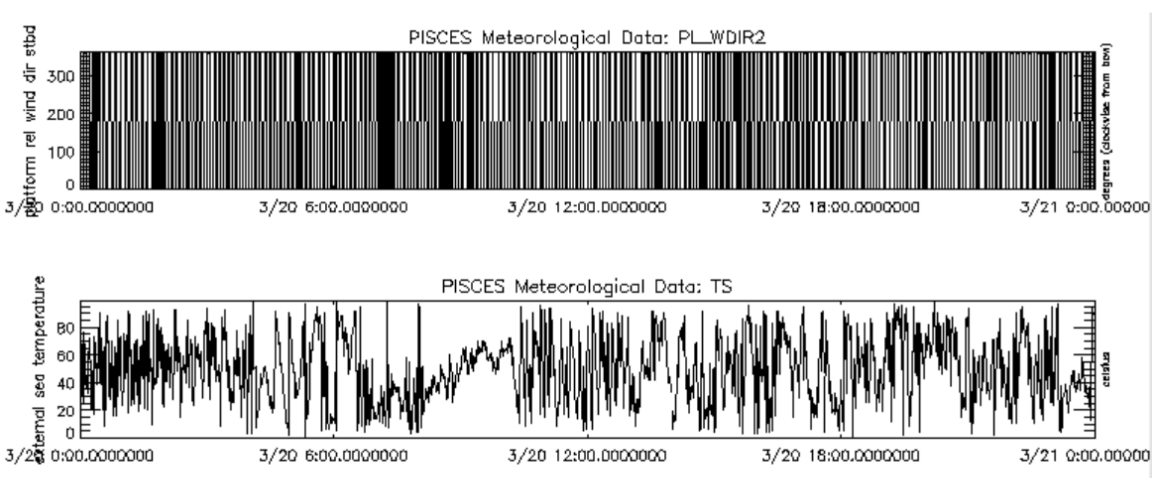

Figure 61: *Pisces* SAMOS (top) platform relative wind direction 2 – PL_WDIR2 – and (bottom) sea temperature – TS – data for 20 March 2021.

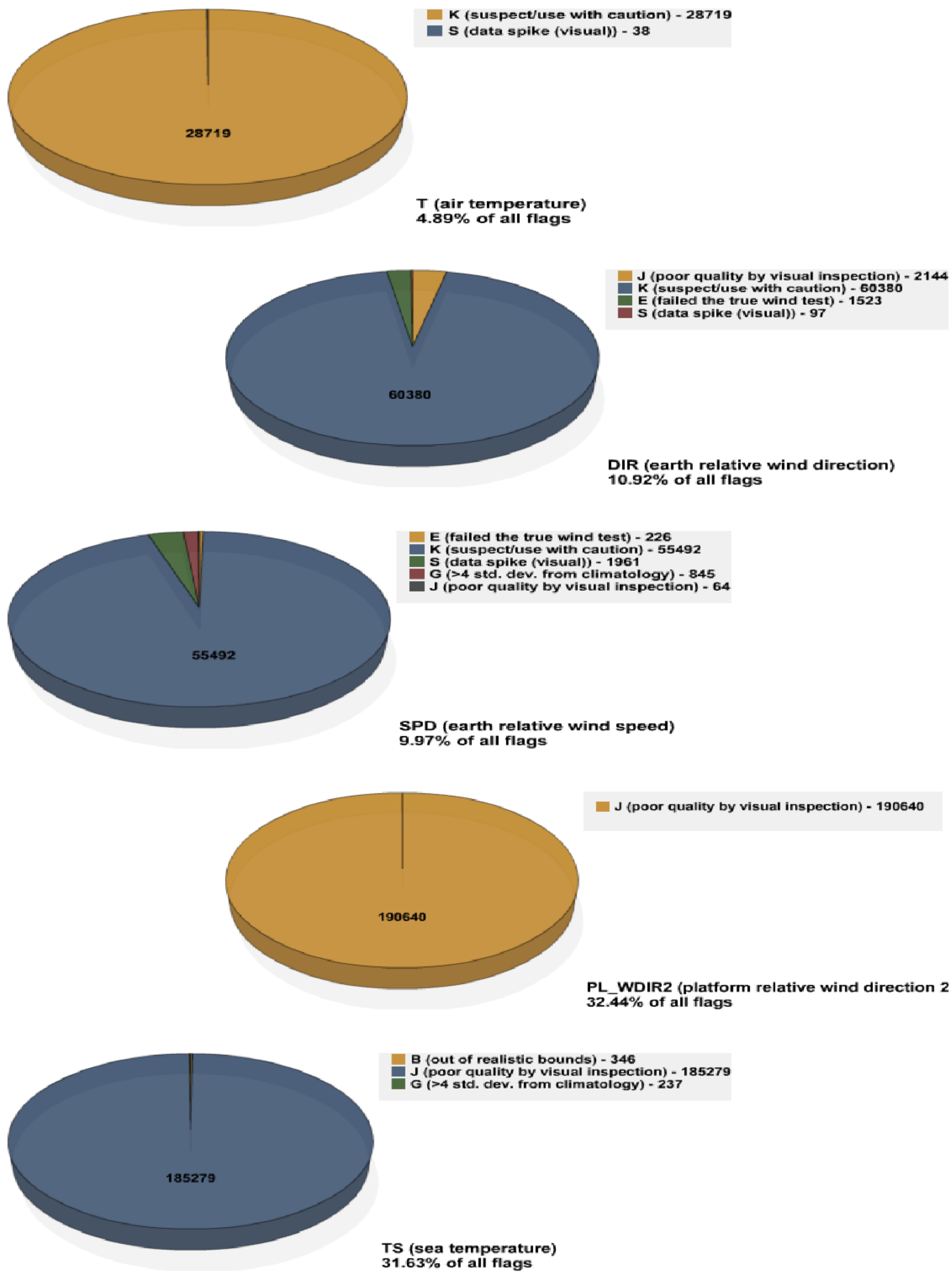

Figure 62: Distribution of SAMOS quality control flags for (first) air temperature – T – (second) earth relative wind direction – DIR – (third) earth relative wind speed – SPD – (fourth) platform relative wind direction 2 – PL_WDIR2 – and (last) sea temperature – TS – for the *Pisces* in 2021.

Rainier

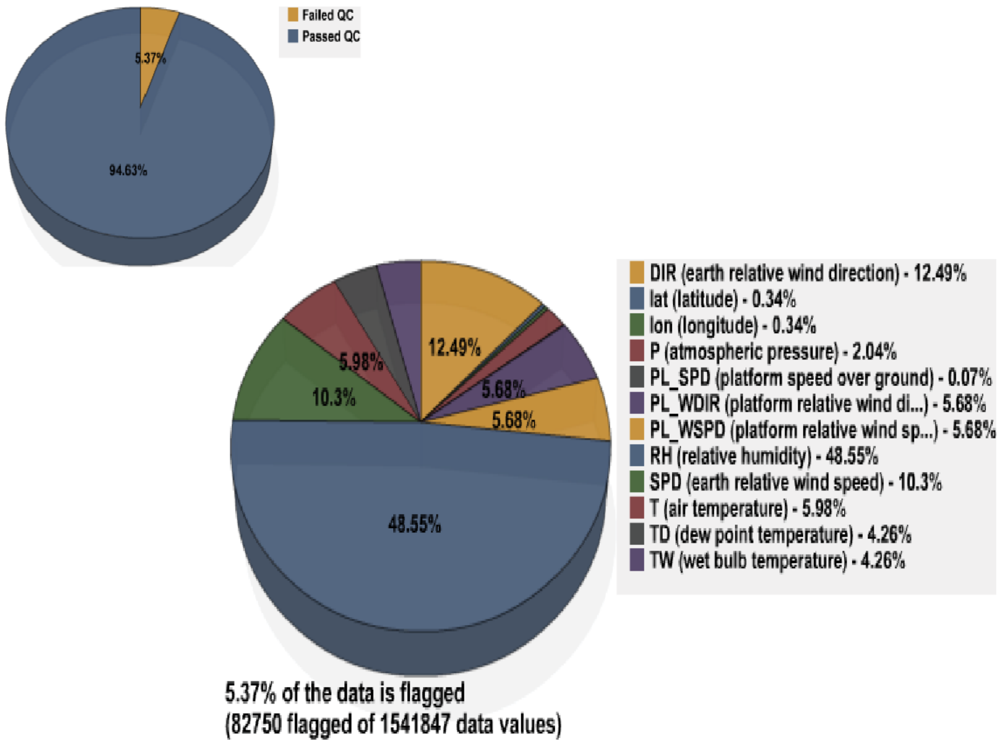

Figure 63: For the *Rainier* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Rainier* provided SAMOS data for 90 ship days, resulting in 1,541,847 distinct data values. After both automated and visual QC, 5.37% of the data were flagged using A-Y flags (Figure 63). This represents a substantial decrease from 2020 (14.19%) and is quite close to the “under 5% total flagged” cutoff regarded by SAMOS to represent "very good" data.

At the onset of the 2021 cruise season, in a carryover from 2020, vessel and earth relative wind direction and speed (PL_WDIR/PL_WSPD and DIR/ SPD) data were not getting included in *Rainier's* SAMOS transmissions. The issue had been a broken anemometer out on her yardarm and a temporary substitute anemometer that could not be properly integrated into her data acquisition system. When contacted for an update a technician confirmed the issue still had not been resolved. He stated he had the means with him to correct it, but that he needed some crane service, which would not be immediate. Then in early June PL_WDIR, PL_WSPD, DIR, and SPD were restored to *Rainier's* SAMOS files. Upon reaching out to the vessel it was learned, while crane service had not ultimately been secured, the technician had managed to find a new anemometer and had installed it. The wind data thereafter were mostly reasonable, with one exception. It was observed that on random days there would be a period (usually ~1-2 hours) during which PL_WDIR and PL_WSPD were constant-valued. These flatline periods did not occur at regular times during the day and did not have any apparent dependency on a particular relative wind direction or vessel speed, either. When this information was conveyed to the vessel technician, he could not put it down to a specific cause and shared his suspicion the anemometer was not ideally located. However, as was communicated back to the technician, it would be unusual for compromised siting to result in prolonged static values, except in perhaps some very extreme cases. Plus, the lack of a consistent vessel relative wind direction during flatline activity further argues against a location cause. At the time it was supposed the anemometer installation was going to be temporary anyway. But we note the odd behavior continues to the present day, from time to time, though it has never worsened. Possibly there is some semi-regular, unrelated activity (human or machine) that occurs in the vicinity of the anemometer that somehow causes the static wind data. In any case, whenever PL_WDIR and PL_WSPD flatline they are assigned "poor quality" (J) flags (Figure 65). DIR and SPD, being calculated from PL_WDIR and PL_WSPD, overtly mirror changes in the platform heading and platform speed during these occurrences. Thus, DIR and SPD are also J-flagged when the relative winds flatline (Figure 65).

Looking to Figure 63, the greatest percentage of flags (almost 50%) was allocated to the relative humidity (RH) parameter. During saturation conditions *Rainier's* RH sensor tends to read just slightly over 100%, which results in automatic application of "out of bounds" (B) flags to those values (Figure 65). This is not an uncommon occurrence, as these sensors are often tuned for better accuracy at lower relative humidities (see 3b.) Interestingly, however, when *Rainier's* RH exceeds 100% her wet bulb (TW) and dew point (TD) temperatures exceed her reported air temperature (T) and consequently acquire "failed the T>=Tw>=Td test" (D) flags (not shown). It's assumed *Rainier's* TW and TD are calculated values, thus the unrealistic numbers resulting from unrealistic RH. (We note TD and TW were added to *Rainier's* suite of SAMOS variables when she upgraded to the newest version of her data acquisition software, i.e., NOAA Scientific Computing System, or SCS, in late September.)

One final note, no sea water data (sea temperature, salinity, conductivity) were received from *Rainier* in 2021. As a technician explained early in the cruise season, their seawater system always locks up as soon as they use their bow thrusters, and it's an ongoing problem that has been on their mission engineers list to correct. Several subsequent check-ins revealed the same – the bow thruster issue had not yet been corrected.

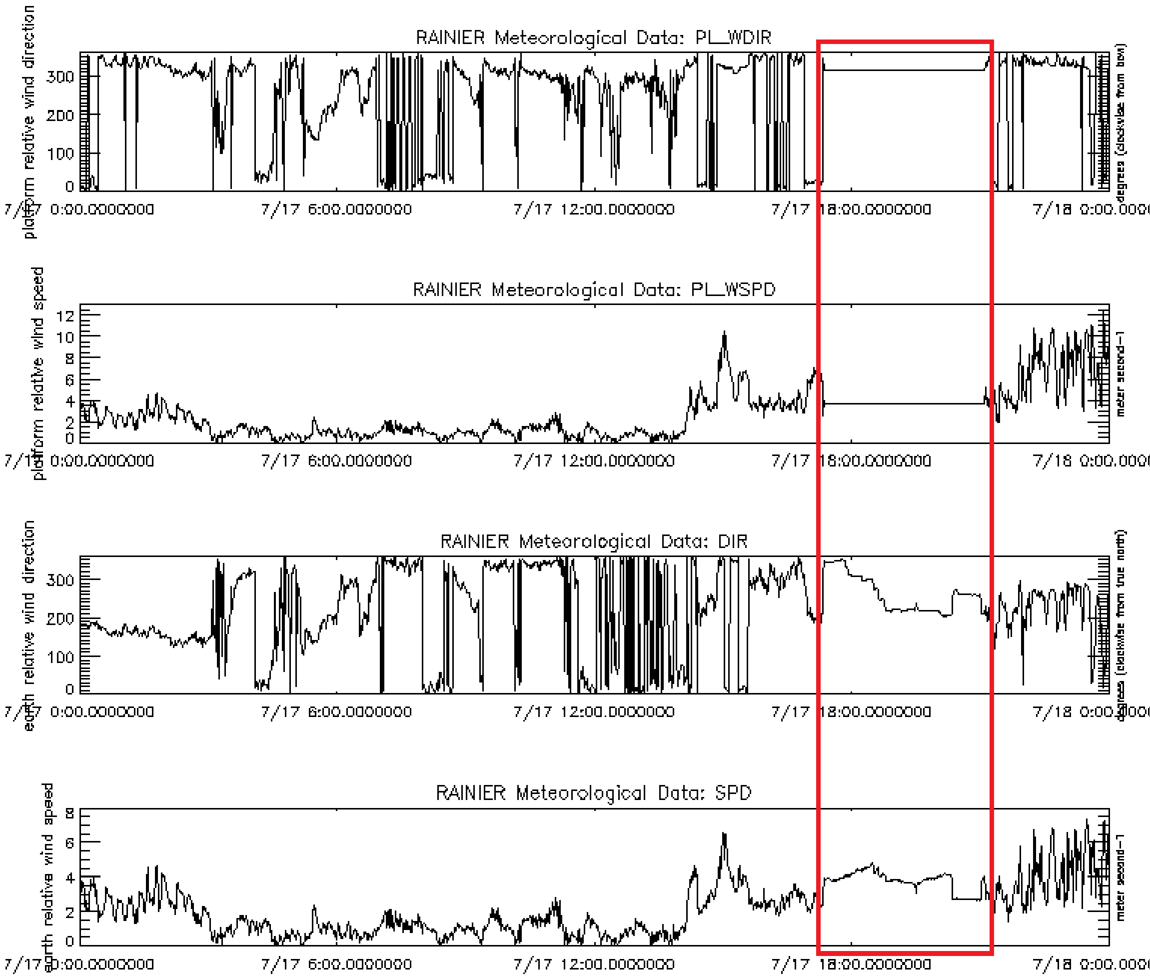

Figure 64: *Rainier* SAMOS (first) platform relative wind direction – PL_WDIR – (second) platform relative wind speed – PL_WSPD – (third) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – data for 17 July 2021. Note constant-valued platform relative wind data inside red box, with corresponding shift in behavior observed in DIR and SPD (more steppy and reminiscent of changes in platform heading and platform speed, not here shown).

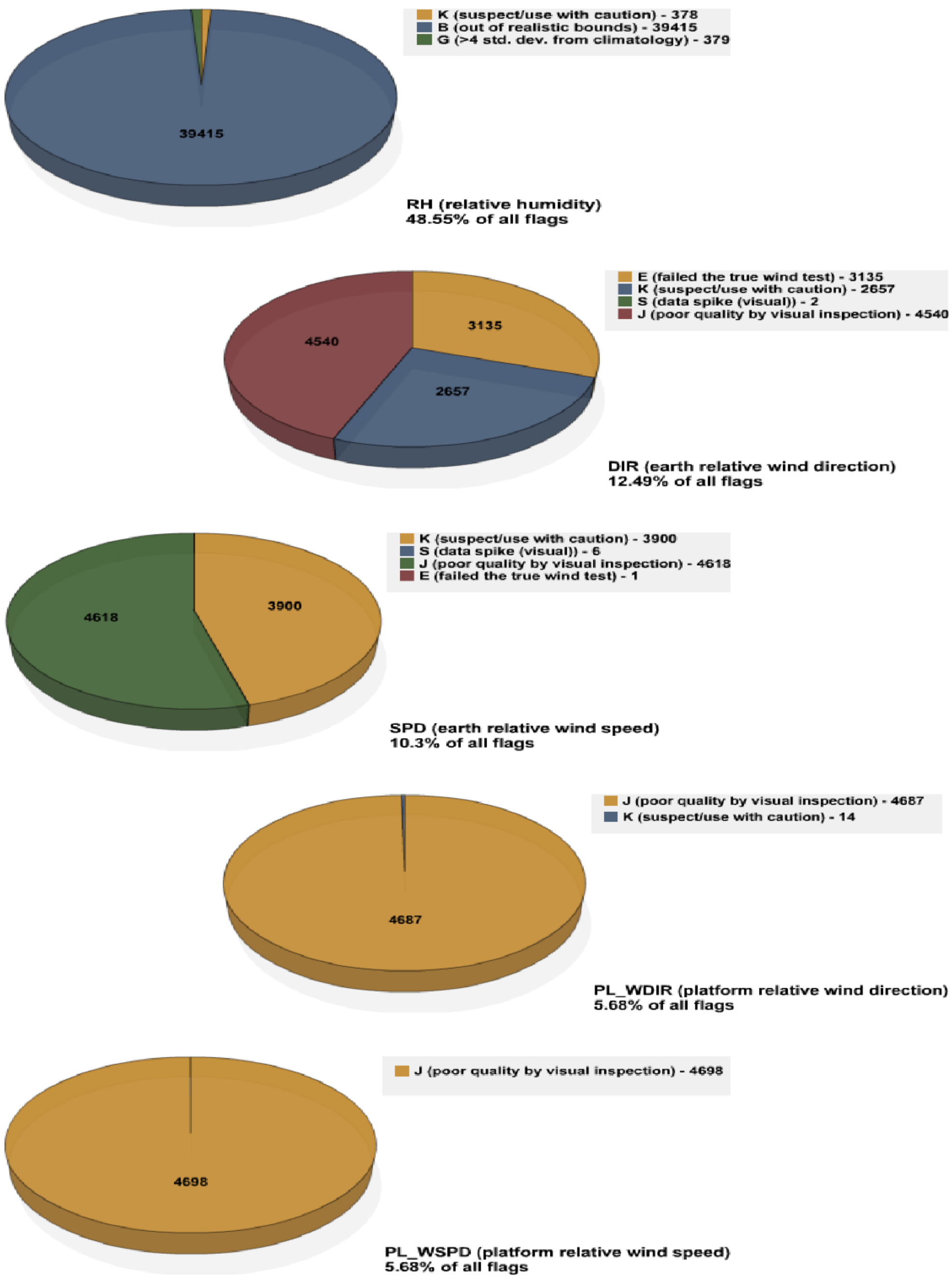

Figure 65: Distribution of SAMOS quality control flags for (first) relative humidity – RH – (second) earth relative wind direction – DIR – (third) earth relative wind speed – SPD – (fourth) platform relative wind direction – PL_WDIR – and (last) platform relative wind speed – PL_WSPD – for the *Rainier* in 2021.

Reuben Lasker

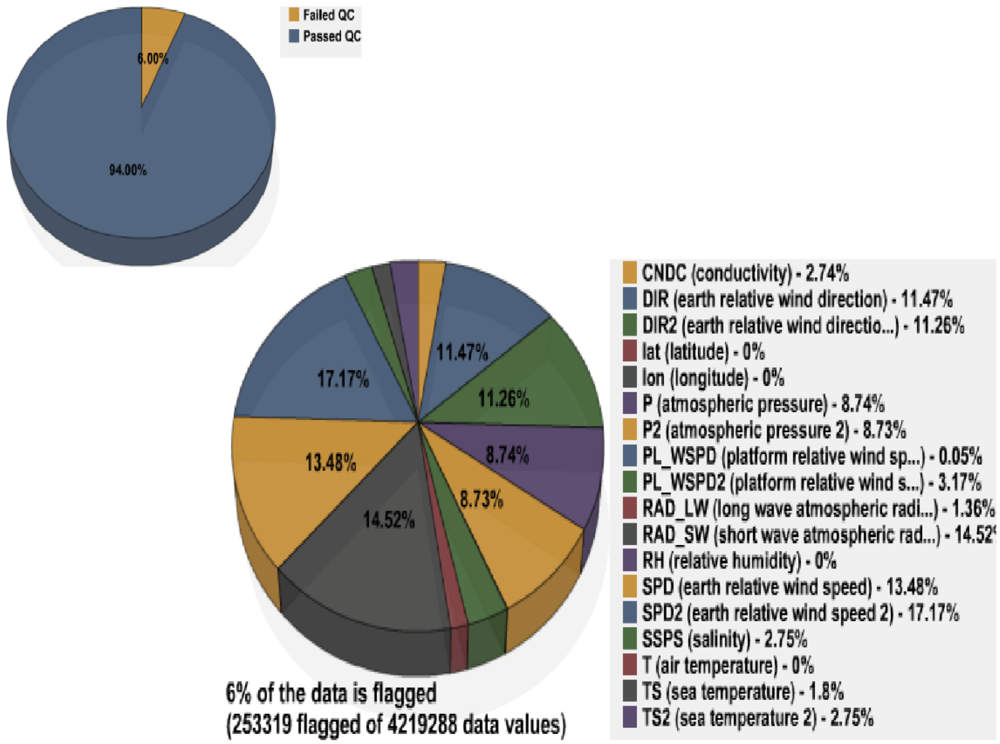

Figure 66: For the *Reuben Lasker* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Reuben Lasker* provided SAMOS data for 142 ship days, resulting in 4,219,288 distinct data values. After both automated and visual QC, 6% of the data were flagged using A-Y flags (Figure 66). This is about two and a half percentage points higher than in 2020 (3.47%) and moves Lasker outside the < 5% total flagged bracket regarded by SAMOS to represent "very good" data.

The first few SAMOS files received from *Reuben Lasker* in January, at the start of her cruise season, contained faulty latitude (LAT) and longitude (LON) data. Each of these variables was reporting a static 0.0000 decimal degrees. However, when contacted, *Lasker's* senior survey technician noted the values she was seeing in their SAMOS event appeared to be correct, i.e., not 0.0000. A programmer for the NOAA Scientific Computing System (SCS) was subsequently consulted for her expertise. After working directly with the technician and remotely logging into *Lasker's* data acquisition server the programmer was able to verify that, while the SAMOS position data in the event view were not in error, the SAMOS LAT and LON values actually being logged by the event were indeed all 0.0000. The programmer ultimately determined the issue was an incorrect data "decoding type" in the SAMOS LAT and LON sensor configurations. At this time, it was decided to halt SAMOS transmission from the *Lasker* until the technician had a chance to correct the faulty sensor configurations, since any transmissions with the incorrect LAT and LON would need to be deleted from the

SAMOS servers. As soon as the "decode type" issue was fixed, in mid-February, SAMOS data transmission resumed as normal.

Once SAMOS data were flowing again, a few data issues were noted. The first of these involved the air temperature (T) and relative humidity (RH). Here, values for T and RH were discovered to be mostly missing from the SAMOS files and what very little data existed was well out of realistic ranges for both. Communication with the senior survey tech revealed their T/RH sensors, with which they'd had ongoing problems, were now completely defunct and needed rewiring. Subsequent check-ins over the course of the year revealed the issue remained unfixed, and transmission of T/RH did not resume in 2021 (after the few, initial bad values).

The second issue discovered involved the vessel relative wind speed from *Lasker's* secondary anemometer (PL_WSPD2), an ultrasonic RM Young 81000. In this case PL_WSPD2 data were twice as large as the relative wind speed values coming from their primary anemometer. (The true wind speed appeared unaffected.) It was suspected there might be an issue with the reported units on PL_WSPD2. In an email discussion on 23 March, it was learned there'd been perhaps a miscommunication about sensor output units and a questionable directive to create a supplemental derived sensor feed for the ultrasonic (effecting a units conversion). It was decided to switch the PL_WSPD2 source to the original, i.e., non-derived, data feed and PL_WSPD2 subsequently came in line with the primary anemometer. Nevertheless, based on our discussion PL_WSPD2 data from 17 through 23 March were assigned "poor quality" (J) flags (Figure 68).

The third issue that came to light in the early season involved *Lasker's* short wave radiation (RAD_SW) parameter. It was noted RAD_SW nighttime data were generally not getting quite down to 0 W/m^2, as would be expected, falling instead usually somewhere in the vicinity of 10-20 W/m^2. There were also often mysterious positive steps in the nighttime RAD_SW data (see Figure 67). When this was communicated to the vessel lead tech, it came to light (no pun intended) their short wave sensor was installed on their back deck, which was lit up very bright at night. Further, the radiation sensors were located right next to the area where they trawl, and they often trawled at night. The nighttime steps in the RAD_SW seemed to correspond to when they did a trawl. The technician understandably did not foresee the placement of the radiation sensors changing as it would require extensive new wiring. As such, nighttime RAD_SW are routinely flagged as either "caution/suspect" (K) or "poor quality" (J) at night (Figure 68).

As a general note, *Reuben Lasker's* earth relative wind parameters, both speed (SPD, SPD2) and direction (DIR, DIR2), exhibit a fair amount of data distortion that is dependent on the vessel relative wind direction. Where data appear affected, they are generally flagged with "caution/suspect" (K) flags (Figure 68, not all shown).

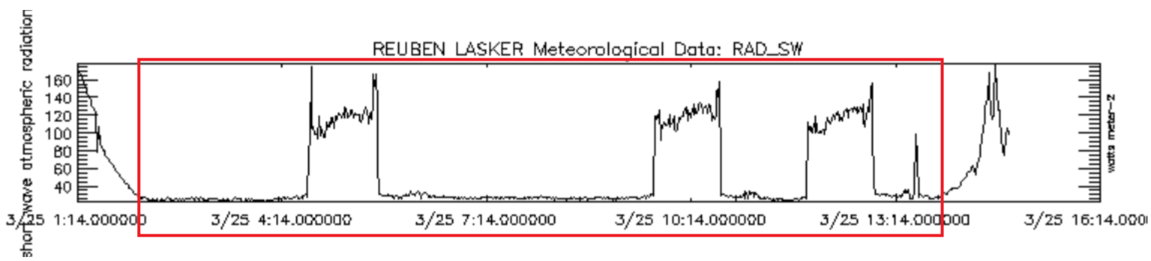

Figure 67: *Reuben Lasker* SAMOS short wave atmospheric radiation – RAD_SW – data for 25 March 2021. Note non-zero nighttime baseline values as well as three large (> 100 W/m^2) steps at night (night hours denoted by red box).

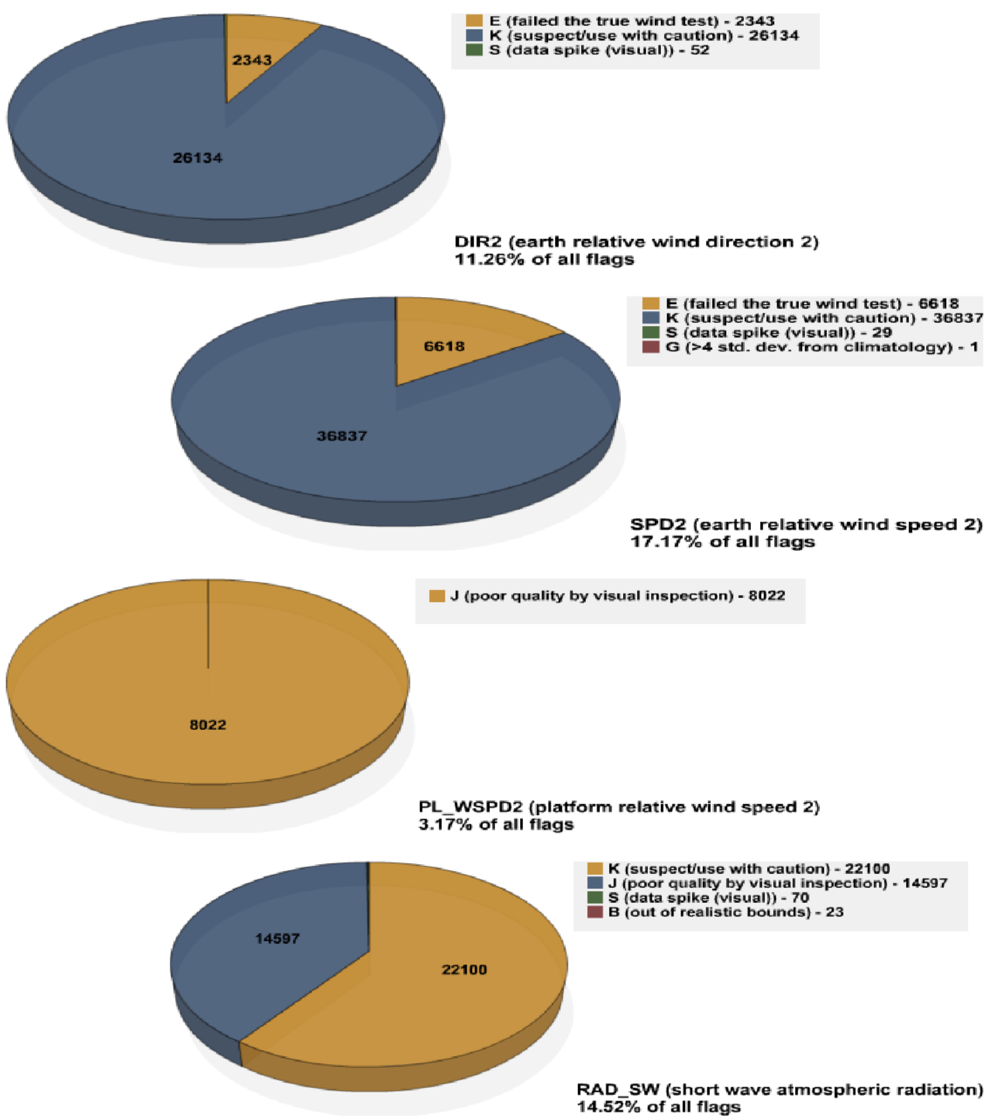

Figure 68: Distribution of SAMOS quality control flags for (first) earth relative wind direction 2 – DIR2 – (second) earth relative wind speed 2 – SPD2 – (third) platform relative wind speed 2 – PL_WSPD2 – and (last) short wave atmospheric radiation – RAD_SW – for the *Reuben Lasker* in 2021.

Ronald H. Brown

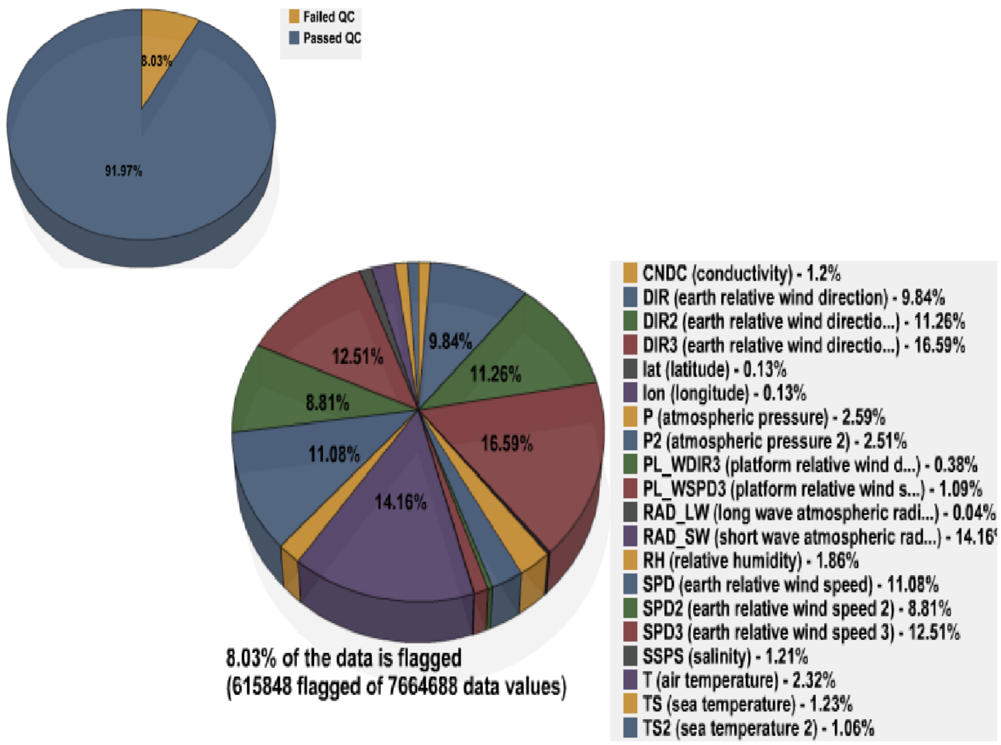

Figure 69: For the *Ronald H. Brown* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Ronald H. Brown* provided SAMOS data for 196 ship days, resulting in 7,664,688 distinct data values. After both automated and visual QC, 8.03% of the data were flagged using A-Y flags (Figure 69). This is a few percentage points higher than in 2020 (5.27%).

In late March *Ron Brown* made passage through the Panama Canal. Initially all her latitude (LAT) and longitude (LON) data from the passage received "land error" (L) flags from SAMOS automated processing. This is actually pretty typical of so narrow a waterway as the Canal, since the land mask in use for the SAMOS land check routine is often incapable of resolving such very fine detail. During visual quality control these L flags are able to be removed manually after visually verifying the data against a mapping routine with finer spatial resolution, such as Google maps (previously used in SAMOS web plotting), and they were indeed removed in this case. However, in the exercise of verifying the data it was discovered *Ron Brown's* LAT and LON were only being reported to two decimal places, which is much coarser a value than a typical modern-day GPS is capable of resolving. Consequently, based on the listed accuracy of the *Brown's* GPS instrument, we requested on 23 March the reporting precision be increased from two to four decimal places. This request was enforced about a week later when *Brown* made port and the data acquisition system was able to be restarted for the changes to take effect.

There were no other items of record for *Ron Brown* in 2021. As a general note, all three of *Brown's* anemometers are known to exhibit a good deal of data distortion that is dependent on the vessel relative wind direction, with the result being various applications of mostly "caution/suspect" (K) flags (Figure 70, not all shown) to all the earth relative wind directions (DIR, DIR2, DIR3) and speeds (SPD, SPD2, SPD3). Additionally, often when the vessel was heading roughly due north the platform course (PL_CRS) data was noisy, for undetermined reasons (perhaps sea state). This ultimately caused automated application of a lot of "failed the wind re-computation check" (E) flags to all six earth relative wind parameters (Figure 70, again not all shown).

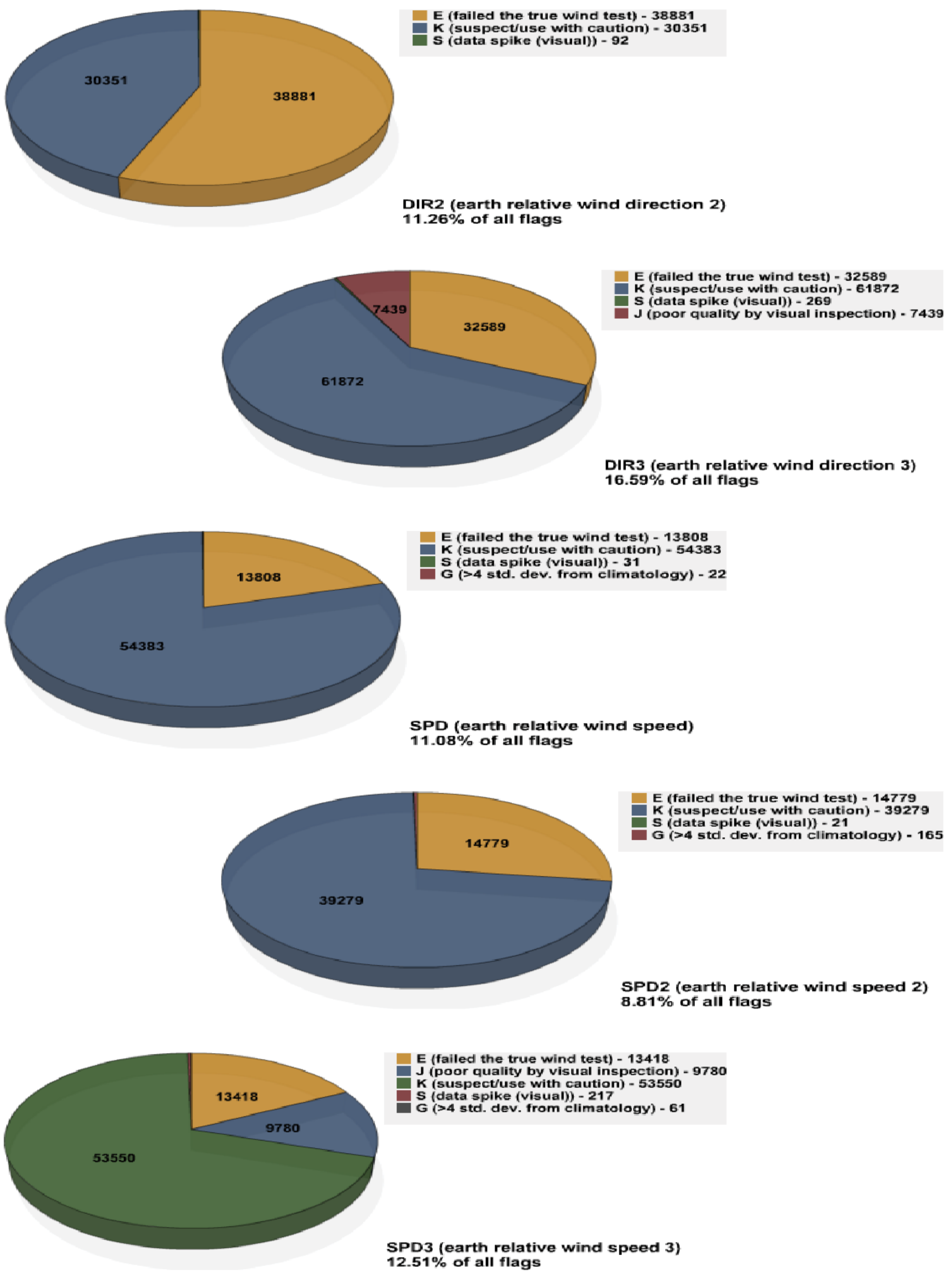

Figure 70: Distribution of SAMOS quality control flags for (first) earth relative wind direction 2 – DIR2 – (second) earth relative wind direction 3 – DIR3 – (third) earth relative wind speed – SPD – (fourth) earth relative wind speed 2 – SPD2 – and (last) earth relative wind speed 3 – SPD3 – for the *Ronald H. Brown* in 2021.

Thomas Jefferson

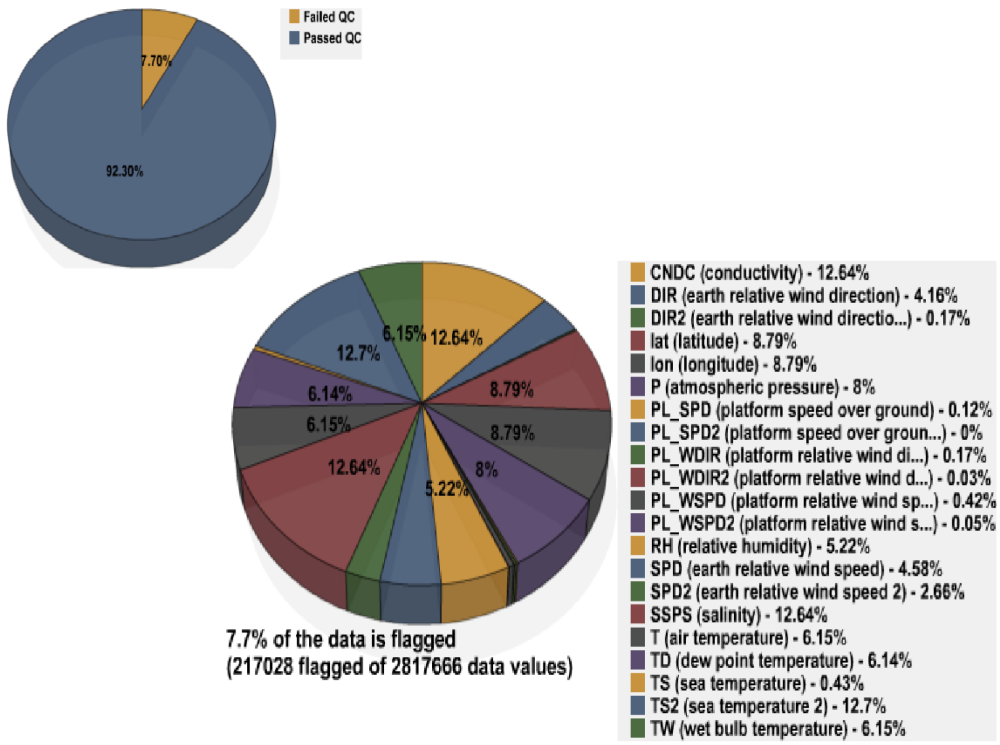

Figure 71: For the *Thomas Jefferson* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Thomas Jefferson* provided SAMOS data for 137 ship days, resulting in 2,817,666 distinct data values. After both automated and visual QC, 7.7% of the data were flagged using A-Y flags (Figure 71). This is one percentage point higher than in 2020 (6.71%).

At the onset of *Thomas Jefferson's* cruise season the sea temperature (TS2) data from her thermosalinograph was clearly erroneous, ranging around 290° Celsius. The conductivity (CNDC) and salinity (SSPS) values from the same thermosalinograph were also suspicious, reading somewhat lower than expected in the case of CNDC and extremely low in the case of SSPS. When the vessel was initially contacted about these issues, on 22 April, the chief electronics technician stated he may need to do a flush of the unit, as the flow gauge looked to have grown something in the sight glass over the winter. On 1 May the tech communicated they'd finally had a chance to do the flush, however the thermosalinograph still appeared to be reporting unreliable data. At this point, because we really do not have any experience with troubleshooting a TSG, we reached out to the Oregon State RCRV team on the *Jefferson's* behalf, as it was expected they may have some best practice docs for underway TSGs that could help. A few suggestions – most notably confirming the calibration coefficients used in internal transformations – were obtained from the OSU group and passed along to *Thomas Jefferson.* However, these ultimately proved unfruitful, and after 7 May *Jefferson* ceased transmitting all TSG data, for the remainder of the year. Stemming from the discussions with the *Jefferson's* chief technician during the event, it was decided to assign "malfunction" (M) flags to all of the TS2, SSPS, and CNDC (Figure 72) for the duration, from 16 April through 7 May.

Looking to the flag percentages in Figure 71, latitude (LON) and longitude (LON) also accrued a sizable portion of the total flags, about 9% each. Notably, the *Jefferson* was upgraded to the newest version (v5) of her data acquisition system, NOAA's Scientific Computing System (SCS) at the end of July. This v5 constituted a major update to the SCS platform, one consequence of which seems to have been that for vessels running the software in 2021 SAMOS data transmission was almost always "on," regardless of whether the ship was underway or not (and in some cases even whether she was crewed or not). When vessels transmit from port, it is not uncommon for the latitude and longitude to receive automated "land error" (L) flags, as the land mask in use for the SAMOS land check routine is often incapable of resolving the very fine detail of a coastline or an inland port. Such was often the case for the *Jefferson* in the latter half of 2021. In a further twist, *Thomas Jefferson's* LAT and LON data while in port tended to have a lot of data spikes, which generally result in "platform velocity unrealistic" (F) flags to both the spike value and the second value after the spike (the flagging scheme is not capable of determining which of these values is likely in error, it only sees the outsized disparity between the two). Taken all together, *Jefferson's* port-based LAT and LON data were usually heavily laden with L and F flags (Figure 72). Generally speaking, these flags can be winnowed quite a bit during visual quality control. However, due to the frequency of the spikes and because the visual editing software for use in changing SAMOS data flags is rather ancient and clunky, time often did not permit for a laborious combing through of the LAT/LON data to remove any unnecessary flags.

As a general note, *Thomas Jefferson's* various meteorological sensors do occasionally exhibit data distortion that is dependent on the vessel relative wind direction and potentially, in the case of atmospheric pressure (P), the vessel speed. Where the data appears affected, it is generally flagged with "caution/suspect" (K) flags (not shown). Additionally, during saturation conditions *Jefferson's* relative humidity (RH) sensor tends to read just slightly over 100%, which results in automatic application of "out of bounds" (B) flags to those values (Figure 65). This is not an uncommon occurrence, as these sensors are often tuned for better accuracy at lower relative humidities (see 3b.) Interestingly, however, when *Jefferson's* RH exceeds 100% her wet bulb (TW) and dew point (TD) temperatures exceed her reported air temperature (T) and consequently acquire "failed the T>=Tw>=Td test" (D) flags (not shown). It's assumed *Jefferson's* TW and TD are calculated values, thus the unrealistic numbers resulting from unrealistic RH. (We note TD and TW were added to *Jefferson's* suite of SAMOS variables when she upgraded SCSv5.)

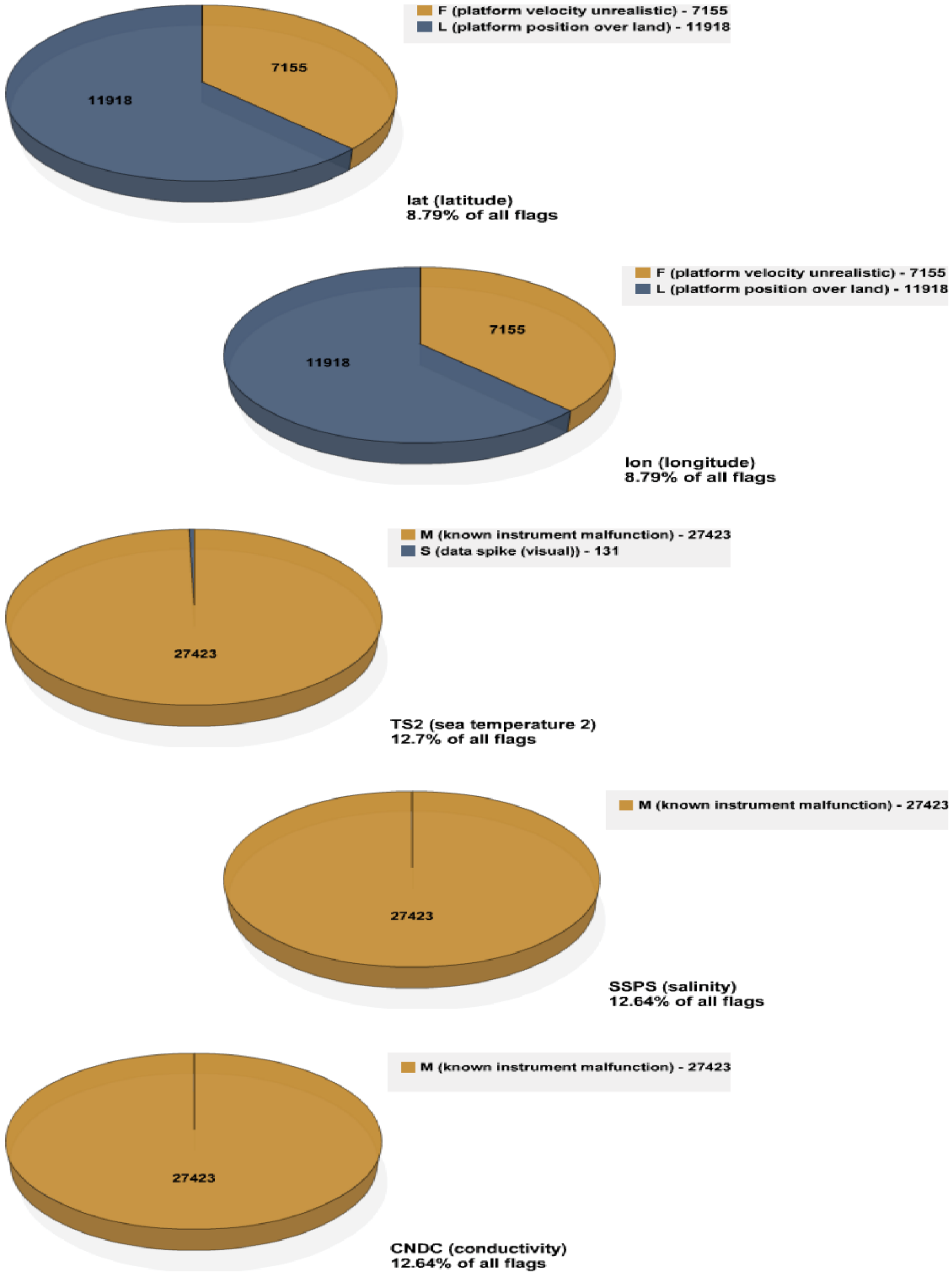

Figure 72: Distribution of SAMOS quality control flags for (first) latitude – LAT – (second) longitude – LON – (third) sea temperature 2 – TS2 – (fourth) salinity – SSPS – and (last) conductivity – CNDC – for the *Thomas Jefferson* in 2021.

Laurence M. Gould

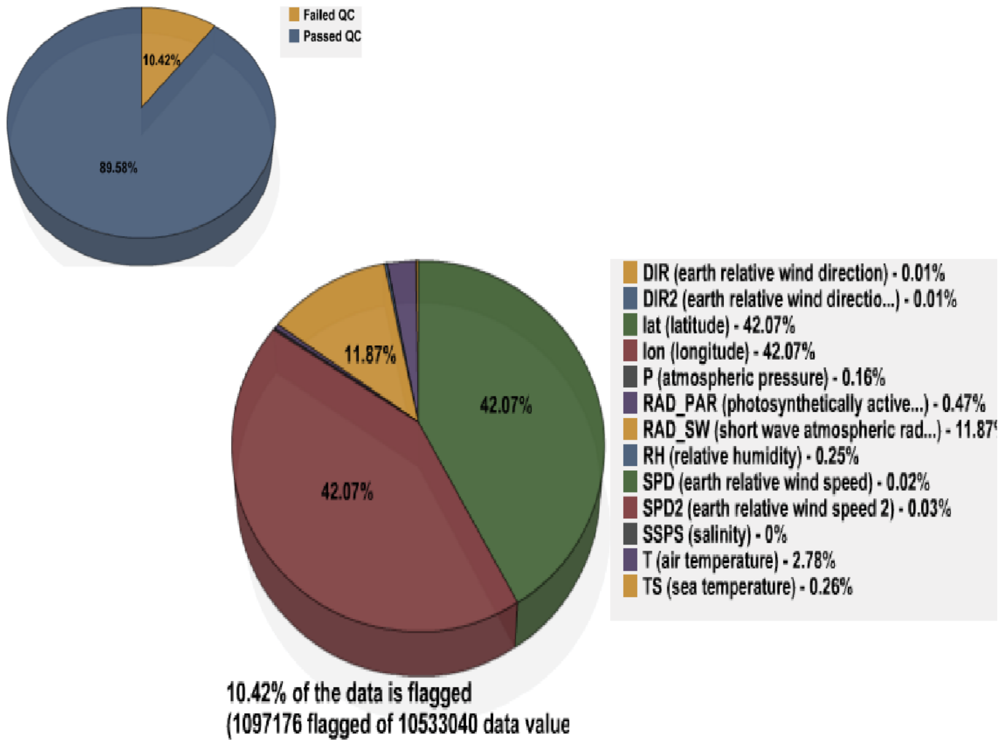

Figure 73: For the *Laurence M. Gould* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Laurence M. Gould* provided SAMOS data for 360 ship days, resulting in 10,533,040 distinct data values. After automated QC, 10.42% of the data were flagged using A-Y flags (Figure 73). This is about a percentage point higher than in 2020 (9.19%). It should be noted the *Gould* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only. Also, much of the 2021 SAMOS data from the *Gould* were sent while the vessel was dockside in Chile, resulting in the large number of land (L) flags.

On 4 May it was noted the atmospheric pressure (P) from *Laurence M. Gould* had recently been showing minute to minute swings in the data that were several millibars in size, which is exceedingly large for a one-minute average pressure. It was suspected *Gould* had encountered rough seas or very gusty wind conditions once they reached the open South Pacific, but this scenario still should not have affected the pressure to such a degree. The vessel was contacted with an inquiry about whether the Gill pressure port on the tube running to the barometer may be damaged or possibly had water in the pressure tubing, either of which may cause large minute to minute changes. There was no recorded response at the time, but the effects ceased after the *Gould* made port in Chile on or around 14 June. Nevertheless, any of these large swings in P between about 2 May through 14 June should be considered highly suspicious. Notably in 2022 we learned that, after having independently observed similar large swings in the pressure data on an October 2021 cruise (the first cruise since June), a vessel technician on the *Gould* did in fact discover water collected in the barometer tubing. The issue was addressed at their next port call. (Note, any large swings in P noted in the ~October 2021 cruise should also be considered highly suspicious.) Given this new information, it seems likely water infiltration was indeed the cause of the May-June episode with P.

In late May there was also some concern *Gould's* photosynthetically active radiation (RAD_PAR) sensor might be reading inaccurate (high). On 6/1 while *Gould* was at the dock in Chile in close proximity to the *Nathaniel B. Palmer,* we were able to compare RAD_PAR from the two vessels. This comparison confirmed *Gould's* RAD_PAR was indeed reading quite a bit higher than *Palmer's*, although it was indeterminate which of the two ships might have the "wrong" data. Email notification of this analysis was sent to the OPP and it was suggested the RAD_PAR discrepancy should be investigated before the next cruise by either vessel. (No response on record.)

In late December *Gould's* RAD_PAR was again noted to be reading suspiciously high. This time, RAD_PAR values were apparently maximized when the short wave radiation (RAD_SW) was at a minimum, a definite impossibility. It was suspected there'd been a sensor failure, and email notification was again sent to the vessel. In her response a vessel technician confirmed there'd been a failure and stated the sensor had been replaced. As such, *Gould* RAD_PAR data from ~8:45 UTC 23 December through ~13:00 UTC 27 December should not be used. Considering the eventual failure of this sensor, it may also be advisable to consider the *Gould's* (as opposed to the *Palmer's*) RAD_PAR suspicious from at least late May through the time of the reported sensor failure.

There were no other issues noted in 2021 for the *Gould*. Looking to the flag percentages in Figure 73, nearly all the flags applied were assigned to latitude (LAT), longitude (LON), and RAD_SW. These were exclusively "platform position over land" (L) flags in the case of LAT and LON (Figure 74) that appear generally to have been applied when the vessel was either in port or very close to land. This is not uncommon, as the land mask in use for the land check routine is often incapable of resolving the very fine detail of a coastline or an inland port. In the case of RAD_SW, all the flags were "out of bounds" (B) flags (Figure 74 and appear to have been applied mainly to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.)

As a general note, it is known that Gould's sensors are frequently affected by airflow being deflected around the super structure, as well as stack exhaust contamination, although, being a vessel that does not receive visual QC, none of this is evident in the flag percentages seen in Figure 73.

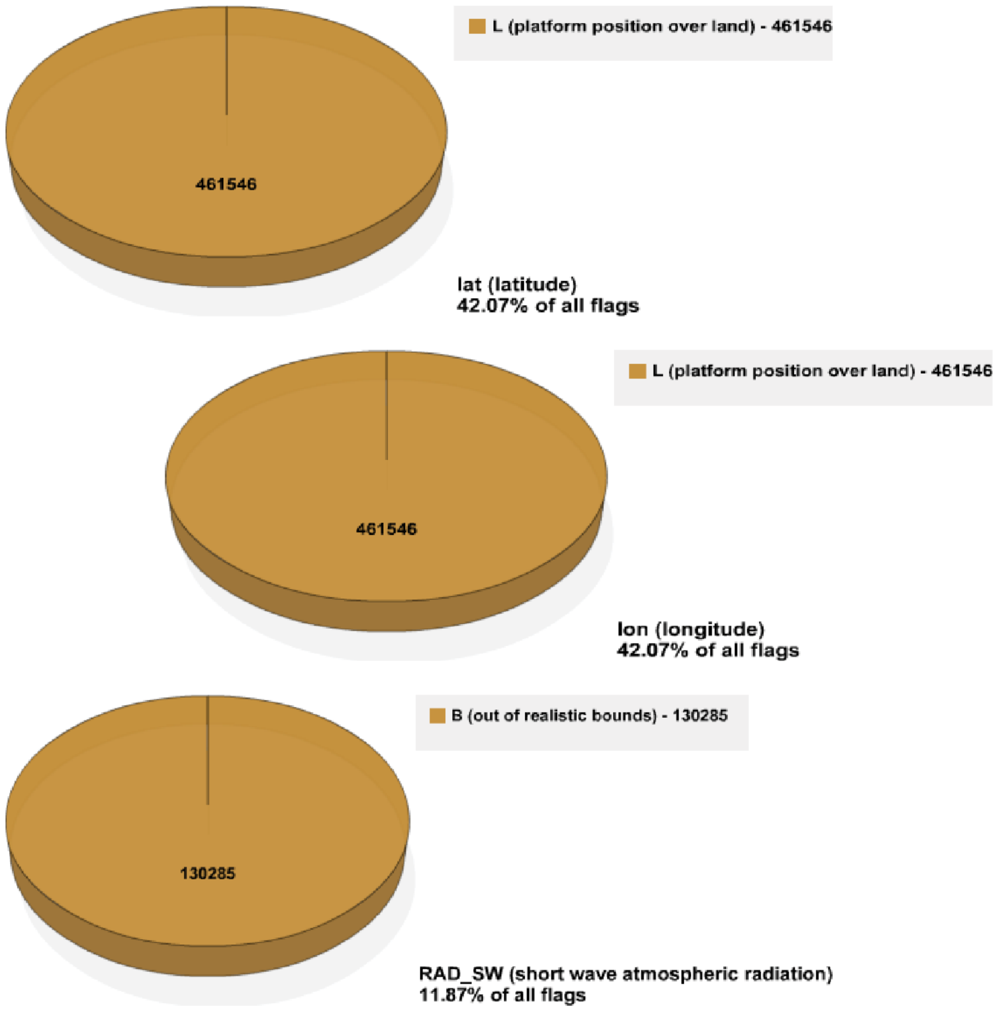

Figure 74: Distribution of SAMOS quality control flags for (top) latitude – LAT – (middle) longitude – LON – and (bottom) short wave atmospheric radiation – RAD_SW – for the *Laurence M. Gould* in 2021.

__Nathaniel B. Palmer__

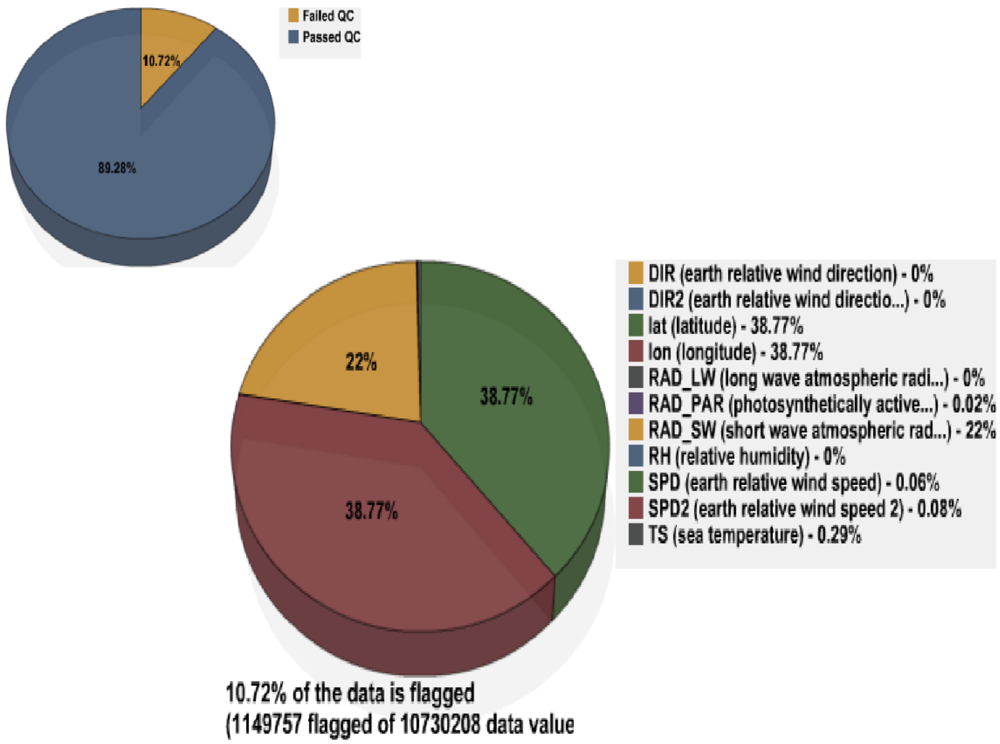

Figure 75: For the *Nathaniel B. Palmer* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Nathaniel Palmer* provided SAMOS data for 358 ship days, resulting in 10,730,208 distinct data values. After automated QC, 10.72% of the data were flagged using A-Y flags (Figure 75). This is seven percentage points higher than in 2020 (3.78%) and moves *Palmer* well outside the "under 5% total flagged" bracket regarded by SAMOS to represent "very good" data. It should be noted the *Palmer* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only. Also, much of the 2021 SAMOS data from the *Palmer* were sent while the vessel was dockside in Chile, resulting in the large number of land (L) flags.

In mid-June it was noted *Nathaniel B. Palmer's* short wave atmospheric radiation parameter (RAD_SW) had been reporting progressively lower nighttime values for at least a few weeks (e.g., -9.8 W/m^2 on 1 June, down to -12.2 W/m^2 by 17 June). While it is not uncommon for RAD_SW to read slightly below zero at night generally (a consequence of instrument tuning, see 3b.), the negative drift in values suggested the sensor could be decaying out of calibration. Email notification of this analysis was sent to the vessel on 18 June, and the response indicated they were in the process of looking to update or replace their radiation sensors.

From about 16:00 UTC on 3 July through about 18:30 UTC on 6 July all of the *Palmer's* data variables were observed to be constant-valued. It was suspected this event may have been the result of maintenance or testing, as the vessel was in port at the time, and an email was sent, notifying any crew. There was no response recorded, but none of the *Palmer's* SAMOS data for this period should be used.

There were no other issues noted in 2021 for the *Palmer*. Looking to the flag percentages in Figure 75, nearly all the flags applied were assigned to latitude (LAT), longitude (LON), and RAD_SW. These were almost exclusively "platform position over land" (L) flags in the case of LAT and LON (Figure 76) that appear generally to have been applied when the vessel was either in port or very close to land. This is not uncommon, as the land mask in use for the land check routine is often incapable of resolving the very fine detail of a coastline or an inland port. In the case of RAD_SW, all the flags were "out of bounds" (B) flags (Figure 76) and appear to have been applied mainly to negative nighttime values. Once again, slightly negative values commonly occur with these sensors at night; however, the negative drift observed in the nighttime values in late spring suggest the sensor may have been falling out of calibration.

As a general note, it is known that *Palmer's* sensors are frequently affected by airflow being deflected around the super structure, as well as stack exhaust contamination, although, being a vessel that does not receive visual QC, none of this is evident in the flag percentages seen in Figure 75.

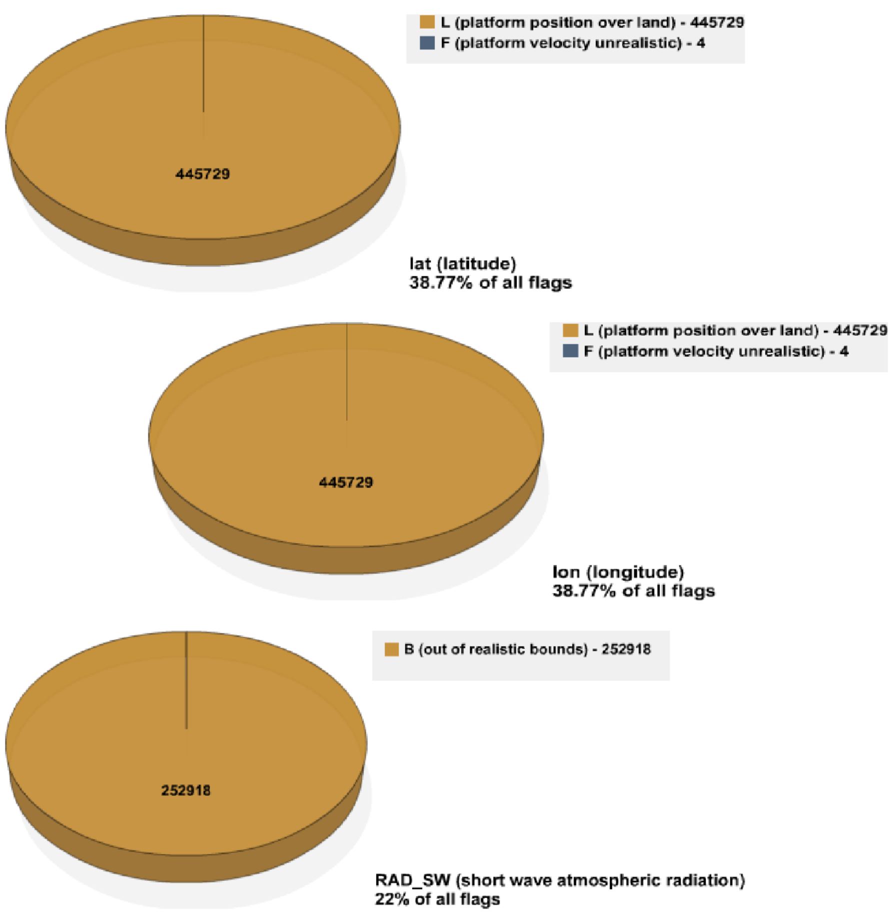

Figure 76: Distribution of SAMOS quality control flags for (top) latitude – LAT – (middle) longitude – LON – and (bottom) short wave atmospheric radiation – RAD_SW – for the *Nathaniel B. Palmer* in 2021.

Robert Gordon Sproul

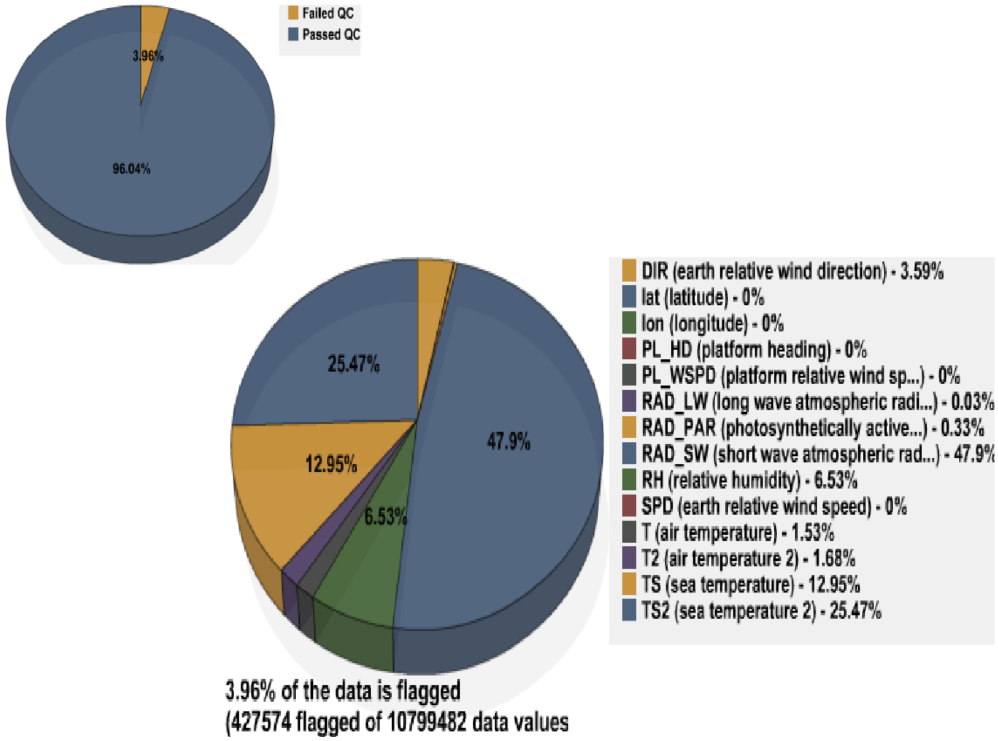

Figure 77: For the *Robert Gordon Sproul* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Robert Gordon Sproul* provided SAMOS data for 363 ship days, resulting in 10,799,482 distinct data values. After automated QC, 3.96% of the data were flagged using A-Y flags (Figure 77). This is about four percentage points lower than in 2020 (8.07%) and bumps *Sproul* back under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. It should be noted the *Sproul* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only (no research-level files exist at the SAMOS DAC for the *Robert Gordon Sproul*).

In early March it was noted *Robert Gordon Sproul's* air temperature (T2) and relative humidity (RH) data had flatlined as of ~15:00 UTC on 23 February. The vessel was notified about a suspected sensor failure via email on 2 March. The issue appeared resolved as of ~22:00 UTC on 2 March, and two days later a technician reported the T2/RH instrument had been swapped out. Because the constant value observed in RH during this period was out of realistic bounds all RH data were flagged "out of bounds" (B) (Figure 78) by SAMOS automated quality control. Constant-valued T2 data for the period were technically within reason and thus not flagged, but they should nevertheless also not be used.

There were no other issues of note for the *Sproul* in 2021. Looking to the flag percentages in Figure 77, nearly 40% of the total flags were applied to the two sea temperatures (TS and TS2). These were mostly "greater than four standard deviations from climatology" (G) flags plus a small portion of B flags and were mainly due to instances of the sea water system being off over the course of the year, generally when the vessel was in port (common) but also occasionally during a cruise in which the resident science party did not want the thermosalinograph running (common for this vessel). Short wave radiation (RAD_SW) also received almost half the total flags (Figure 77). Upon inspection the flags, which are unanimously B flags (Figure 78), appear to have been applied mainly to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.)

One further note of perhaps some passing interest: It was discovered incidentally (and well after the fact) that on 30 August, for several minutes during the day, the *Sproul* provided latitude (LAT) and longitude (LON) from a different navigation system than usual using unknown SAMOS designators. The associated data records for these several minutes were correctly ignored by the SAMOS processing; however, in somewhat of a surprise turn these "not expected" designators did not appear in the internal quality analysis files produced by our metadata QA monitoring module. When the unintended omission from monitoring was discovered, we reviewed our QA code but found no real solution exists, as we simply cannot handle multiple navigation designators. The moral of the story is, perhaps, just a note that we are unlikely to realize it if occasional data records get missed because of unexpected LAT and LON designators in transmitted SAMOS files. In these cases, the original data records from the missed minutes will be included in the original data file received from the vessel and archived at NCEI within the vessel's monthly archive packages.

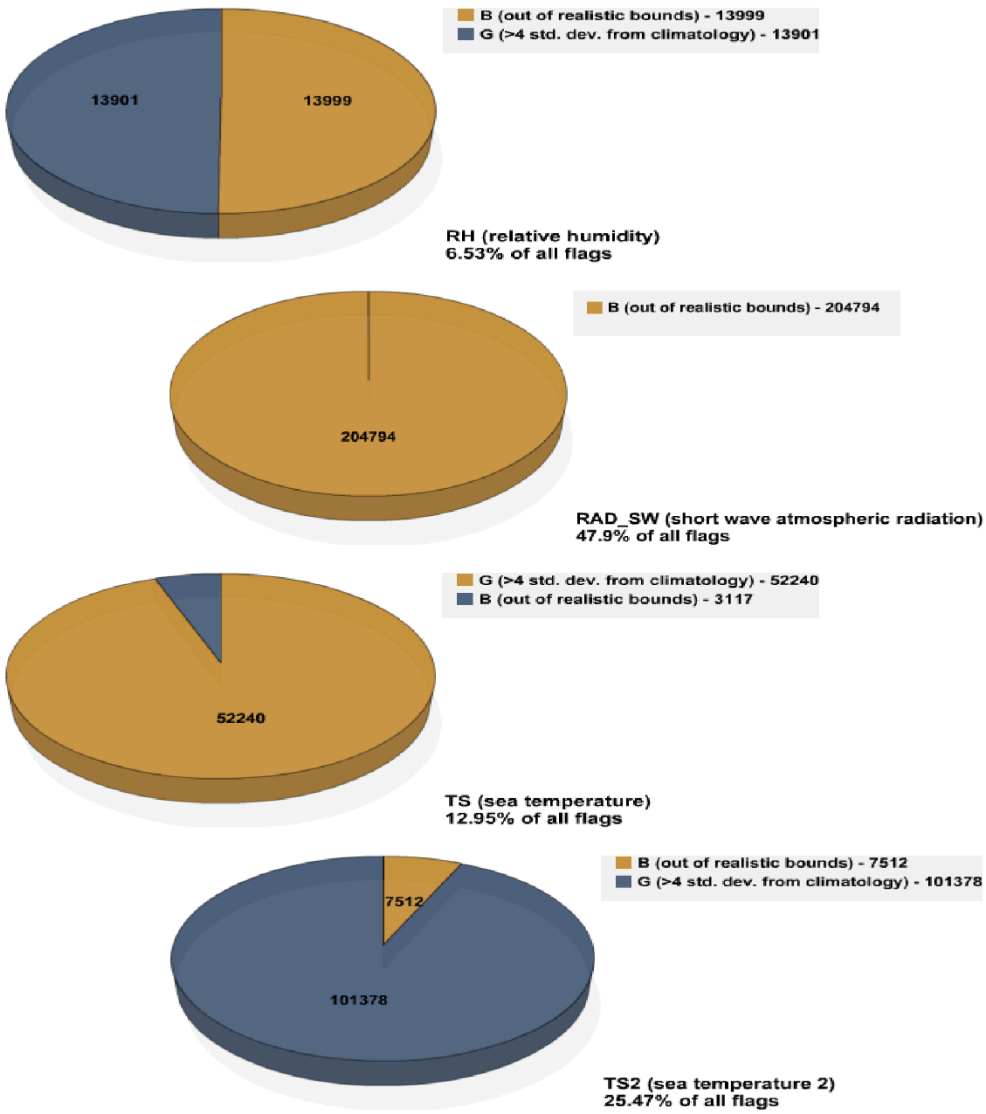

Figure 78: Distribution of SAMOS quality control flags for (first) relative humidity – RH – (second) short wave atmospheric radiation – RAD_SW – (third) sea temperature – TS – and (last) sea temperature 2 – TS2 – for the *Robert Gordon Sproul* in 2021.

Roger Revelle

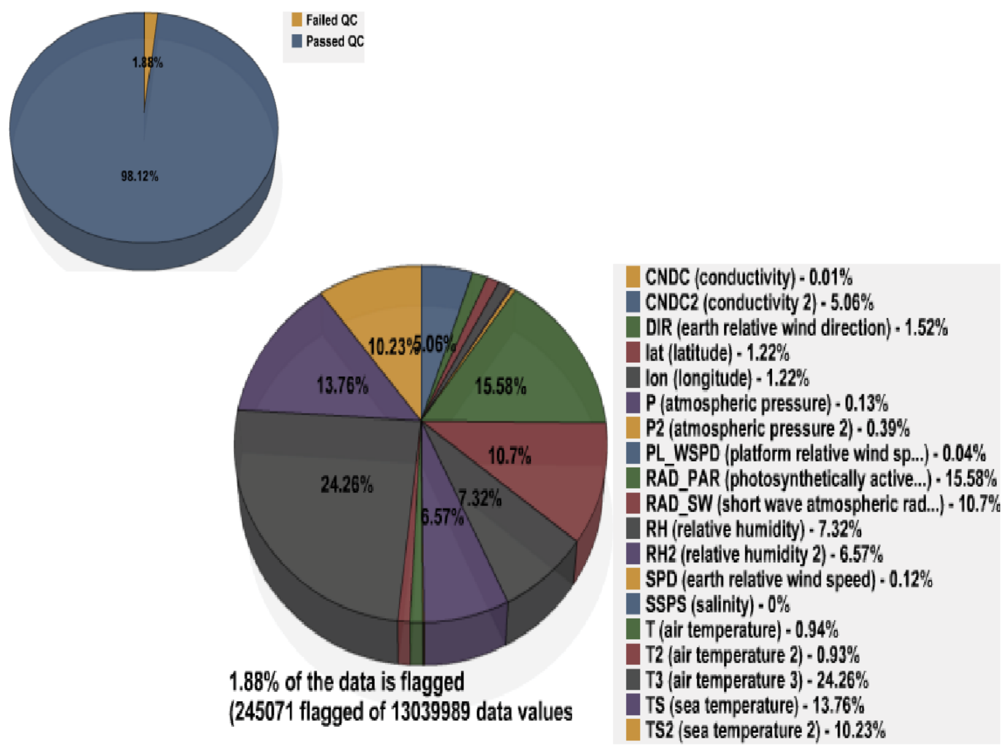

Figure 79: For the *Roger Revelle* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Roger Revelle* provided SAMOS data for 344 ship days, resulting in 13,039,989 distinct data values. After automated QC, 1.88% of the data were flagged using A-Y flags (Figure 79). This is about a half percentage point lower than in 2020 (2.33%) and maintains *Revelle* well under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. It should be noted the *Revelle* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only (no research-level files exist at the SAMOS DAC for the *Roger Revelle*).

Over a three-day period, from 21-23 May while the *Roger Revelle* was on station, the sea temperature (TS), salinity (SSPS), and conductivity (CNDC) parameters exhibited a large amount of data spikes. When contacted for any information regarding the spikes one of Revelle's technicians explained they'd been experiencing heavy sea states that likely resulted in the spikes. He noted operation of their new bow thruster could be influencing the bow TSG intake, as well, as the thruster was likely heavily in use at the time. No flags were applied to the spikes evident in TS, SSPS, or CNDC but we note these data will likely need to be filtered prior to science application, for the noted period.

On 17 July around 8:00 UTC, a very sharp jump in the air temperature (T3) from *Revelle's* EE260 occurred, after which T3 continuously read about 3° Celsius higher than her other two air temperature sensors. The jump was also seen in the EE260 relative humidity (RH), though in this case the subsequent RH data was not that different from their other humidity sensor (RH2). The SIO group were first made aware of the issue via email on 20 July. Initially technicians thought the T3 issue might be weather related (saturated atmosphere) but considered it may also be a J-box issue and planned to investigate. In late August word came from SIO that while the problem with T3 persisted they would be unable to address it during their present port stop. Ultimately, on 6 November, they reported the sensor had been completely replaced, after which time T3 data were greatly improved. We note that over the course of this event T3 was often flagged by automated processing, generally with "greater than four standard deviations from climatology" (G) flags (Figure 80). However, we stress none of the T3 or RH data between 17 July and 6 November should be used.

In general, it might also be noted both RH and RH2 are known to read a few percent over 100 in saturated conditions (rain, fog). It's not uncommon for relative humidity to read slightly over 100% in saturation, as these sensors are often tuned for better accuracy at lower relative humidities (see 3b.) In the *Revelle's* case the overshoot seems to be a little atypical in its size; however, on subsequent clear days when the sensors dry out RH/RH2 always drop back down under 100% to expected values, so there likely is no problem indicated. Nevertheless, wherever RH and RH2 exceed 100% they are assigned "out of bounds" (B) flags (not shown) by automated quality control procedures.

On 24 September it was observed that the salinity from *Revelle's* bow thermosalinograph (SSPS) read ~1.5 PSU lower than salinity from the TSG in her main lab (SSPS2), while the bow conductivity (CNDC) was ~0.2 S/m lower than the main lab conductivity (CNDC2). Meanwhile, sea temperatures from the bow and main lab TSGs (TS and TS2, respectively) were nearly identical. The implication seemed to be that the TSGs located at the bow and in the lab were drifting apart. These details were communicated via email and in response SIO acknowledged the discrepancies and requested further notification if the drift intensified. It was also projected they may be able to swap their TSGs when *Revelle* returned to port. A little later, on 6 November, we were notified they had indeed changed out both TSGs for newly calibrated units. In the meantime, SSPS, SSPS2, CNDC, and CNDC2 data for around 24 September through 6 November should probably only be used with caution.

There were no other issues of note for the *Revelle* in 2021. Looking to the flag percentages in Figure 79, about a quarter of the total flags were applied to TS and TS2. These were almost exclusively G flags (Figure 80) that were mainly due to instances of the sea water system being off over the course of the year, either when the vessel was in port (common) or during transit through an exclusive economic zone (also common). Short wave radiation (RAD_SW) and photosynthetically active radiation (RAD_PAR) together also received about a quarter of the total flags (Figure 79). These flags, which are unanimously B flags (Figure 80), appear to have been applied mainly to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.)

One final note of perhaps some passing interest: It was discovered incidentally (and well after the fact) that on 25 August, for several minutes during the day, the *Revelle* provided latitude (LAT) and longitude (LON) from a different navigation system than usual using unknown SAMOS designators. The associated data records for these several minutes were correctly ignored by the SAMOS processing; however, in somewhat of a surprise turn these "not expected" designators did not appear in the internal quality analysis files produced by our metadata QA monitoring module. When the unintended omission from monitoring was discovered, we reviewed our QA code but found no real solution exists, as we simply cannot handle multiple navigation designators. The moral of the story is, perhaps, just a note that we are unlikely to realize it if occasional data records get missed because of unexpected LAT and LON designators in transmitted SAMOS files. In these cases, the original data records from the missed minutes will be included in the original data file received from the vessel and archived at NCEI within the vessel's monthly archive packages.

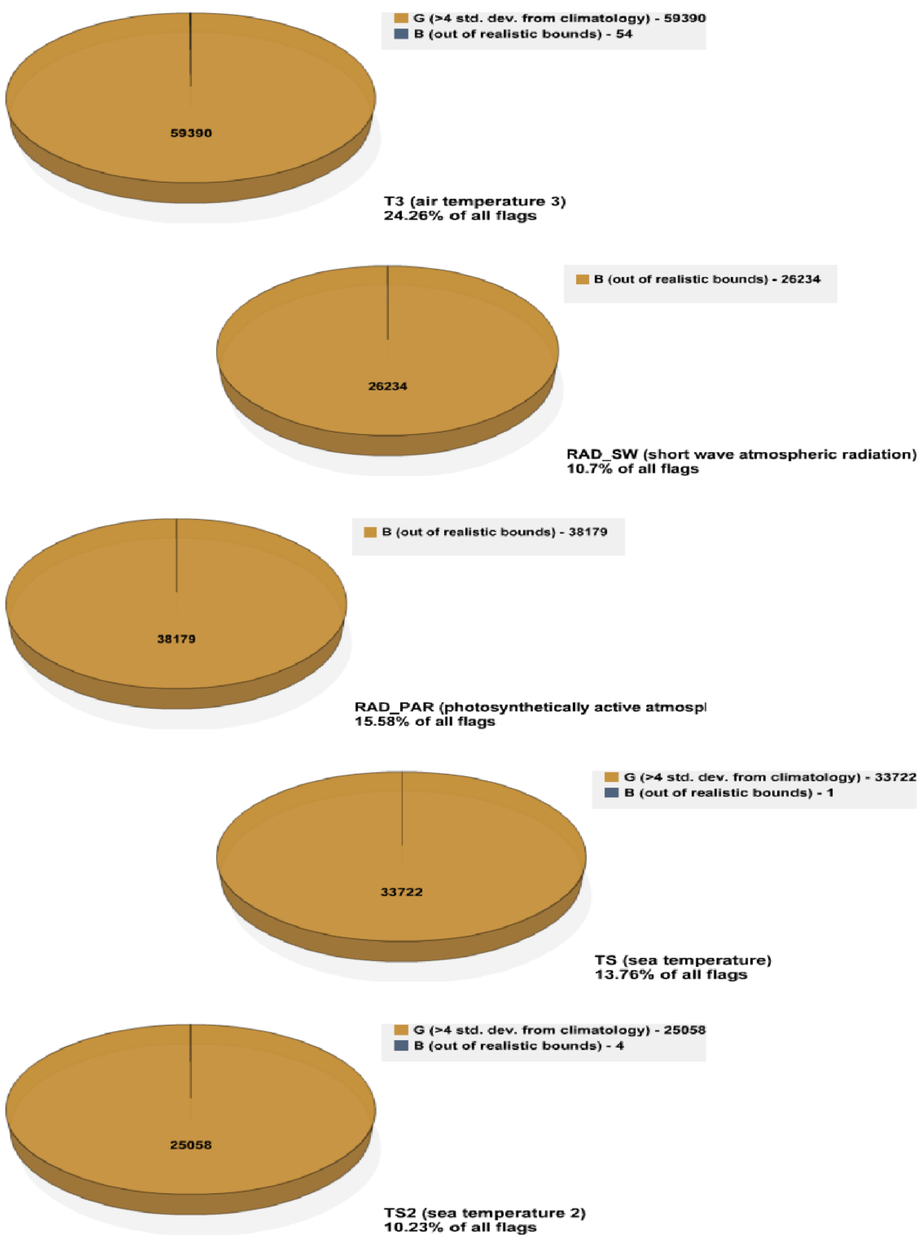

Figure 80: Distribution of SAMOS quality control flags for (first) air temperature 3 – T3 – (second) shortwave atmospheric radiation – RAD_SW – (third) photosynthetically active radiation – RAD_PAR – (fourth) sea temperature – TS – and (last) sea temperature 2 – TS2 – for the *Roger Revelle* in 2021.

Sally Ride

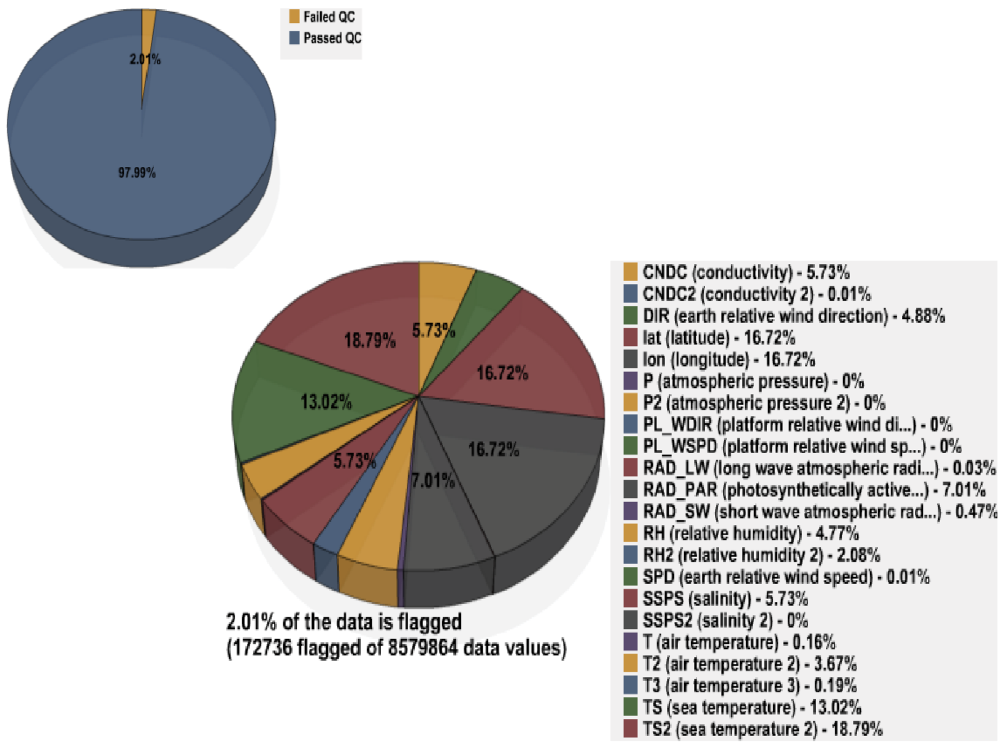

Figure 81: For the *Sally Ride* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Sally Ride* provided SAMOS data for 248 ship days, resulting in 8,579,864 distinct data values. After automated QC, 2.01% of the data were flagged using A-Y flags (Figure 81). This is more than four percentage points lower than in 2020 (6.41%) and places *Sally Ride* inside the “under 5% total flagged” bracket regarded by SAMOS to represent "very good" data. It should be noted the *Sally Ride* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only (no research-level files exist at the SAMOS DAC for the *Sally Ride*).

On 22 June, at multiple times during the day, the air temperature (T2) from Sally Ride’s EE60 rose very high (> 30° Celsius) and did not compare well with air temperature from her other two sensors (see Figure 82). The vessel was contacted via email, but vessel personnel suspected it might have been just a fluke. Then on several subsequent days in early July the pattern of transiently too-high T2 reemerged. After 3 July the relative humidity (RH) from the same instrument also seemed to be affected, with values falling into a range much lower than their other humidity sensor. The vessel was contacted again, and this time personnel confirmed the EE60 most likely needed to be inspected and/or cleaned once the *Ride* returned to port. An update from the Ride on 9 July noted the problem appeared to be with the j-box position, and not the sensor itself. Unfortunately, there was no spare box available, so for the time being T2 and RH were being commented out of the *Ride’s* module and thus no further T2/RH data would be received. Meanwhile, throughout the period 22 June through 9 July both T2 and RH received some amount of "greater than four standard deviations" (G) flags, with some additional "out of bounds" (B) flags applied to T2 (Figure 83), as well. But we caution that all T2/RH data within the noted period, whether G-flagged or unflagged, should probably be treated as suspect/highly suspect, and anything B-flagged should obviously not be used.

In a note of interest, one quirk with the relative humidity (RH2) from *Sally Ride's* other humidity sensor came to light late in the year. It was observed that when *Ride* was operating in saturated conditions (e.g., fog) her RH2 would often report NaNs for a while, after first hitting 100%, until such time as conditions dried out. When this information was conveyed to the ship, shoreside personnel proposed a technical source, to be investigated at some future time when he was on the ship. His suspicion was that the NaN values resulted from a 0-1V A-D module receiving a > 1V signal in saturated conditions, exceeding its limit. He guessed there was probably a bit of voltage drop on the ground line from the mast box to the RH2 sensor, shifting the sensor output voltage a bit high compared to the mast box ground. He stated he had a few ideas for addressing/fixing the NaN's, but it was not known which option(s) would be tried, or when.

There were no other issues of note for Sally Ride in 2021. Looking to the flag percentages in Figure 81, over 35 percent of the total flags were applied to the latitude (LAT) and longitude (LON) parameters. These were virtually all "vessel over land" (L) flags (Figure 83, only LAT shown), likely all incurred when the vessel was either in port or very close to land. This is not uncommon, as the land mask in use for the land check routine is often incapable of resolving the very fine detail of a coastline or an inland port. A further ~32% combined of the total flags was assigned to the two sea temperature parameters (TS and TS2). In this case there was a mix of G and B flags (Figure 83), mainly due to instances of the sea water system being off but the sensors still providing a data value over the course of the year, either when the vessel was in port (common) or during transit through an exclusive economic zone (also common).

As a general note, steps in *Sally Ride's* earth relative wind speed (SPD) and both her atmospheric pressure parameters (P and P2) have frequently been observed when the platform relative wind direction is from the port (270°) or starboard (90°) beam, indicating likely flow distortion. (Similar behavior has been noted with the *Revelle's* weather data, as well.) As SIO was informed in an email dated 15 November, the only solution would be to relocate these affected sensors on the bow mast and/or add redundant sensors elsewhere on the vessel.

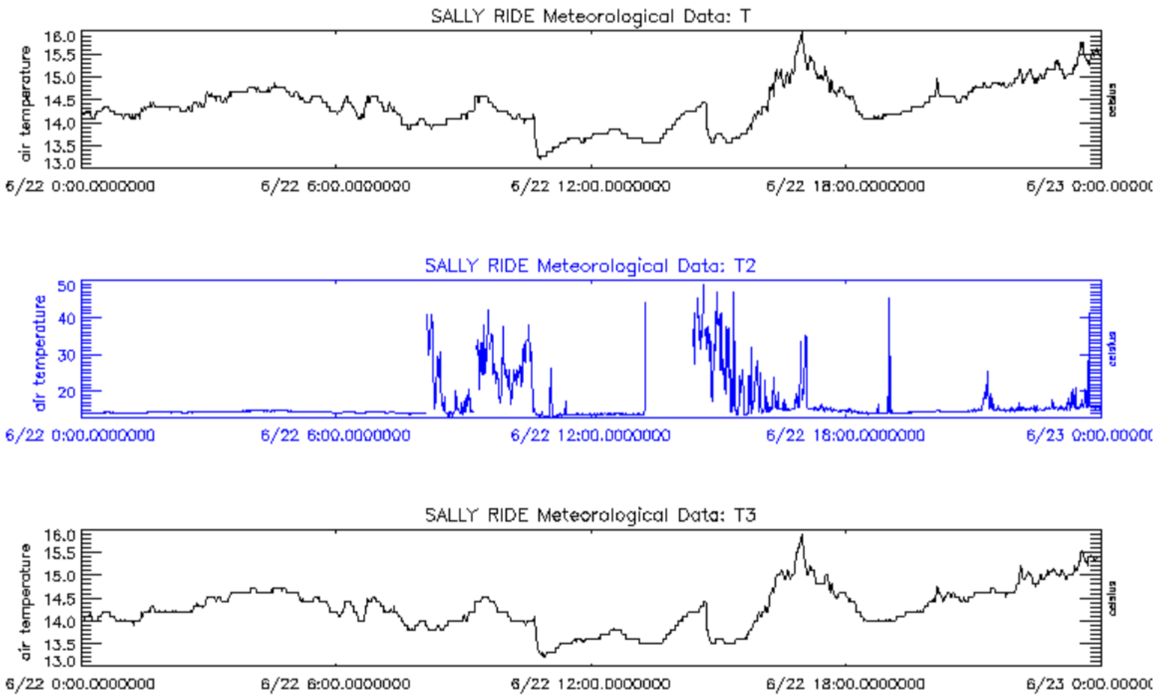

Figure 82: *Sally Ride* SAMOS (top) air temperature – T – (middle) air temperature 2 – T2 – and (bottom) air temperature 3 – T3 – data for 22 June 2021. Note large increases in T2 as compared to T and T3.

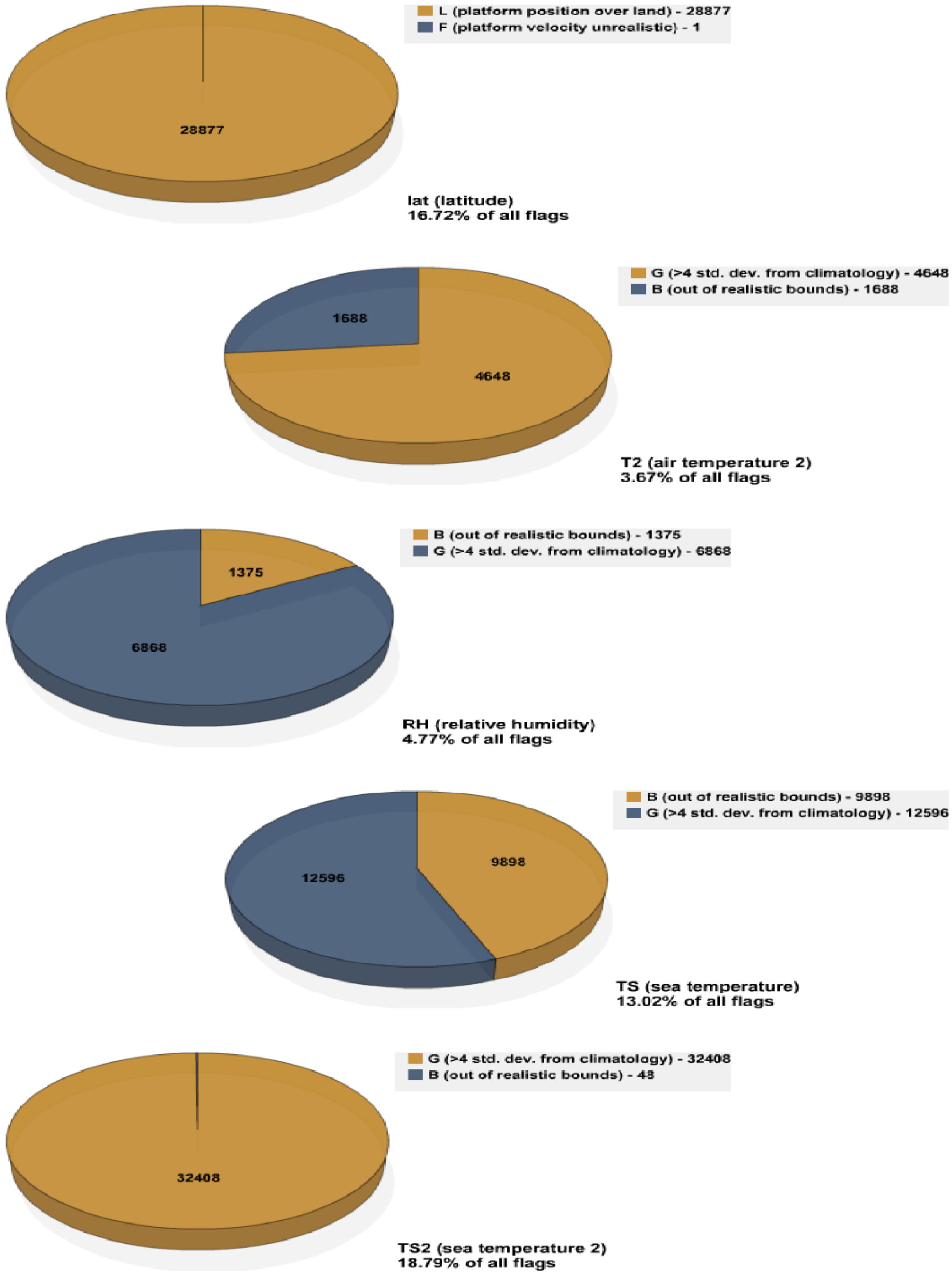

Figure 83: Distribution of SAMOS quality control flags for (first) latitude – LAT – (second) air temperature 2 – T2 – (third) relative humidity – RH – (fourth) sea temperature – TS – and (last) sea temperature 2 – TS2 – for the *Sally Ride* in 2021.

Falkor

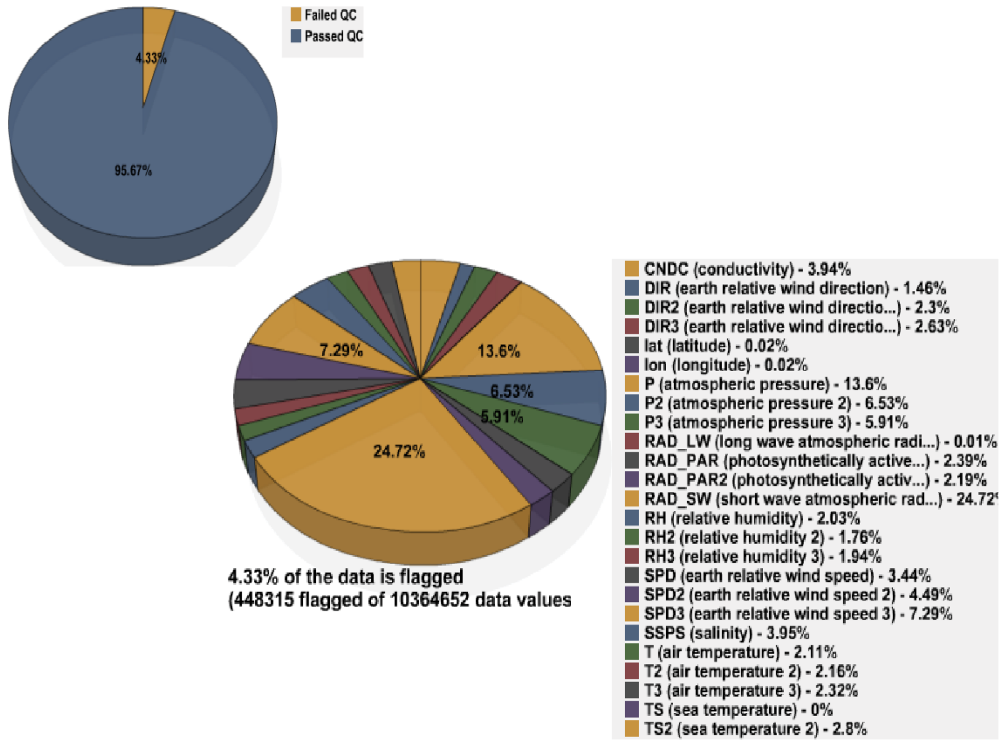

Figure 84: For the *Falkor* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Falkor* provided SAMOS data for 224 ship days, resulting in 10,364,652distinct data values. After both automated and visual QC, 4.33% of the data were flagged using A-Y flags (Figure 84). This is about one and a half percentage points lower than in 2020 (5.88%) and returns the *Falkor* within the "under 5% total flagged" bracket regarded by SAMOS to represent "very good" data for her final year of service. (*Falkor* was officially retired in late 2021 and will be replaced by the new vessel *Falkor(too)* sometime in 2022. We thank the *Falkor* crew for their many years of dedicated service with the *Falkor* and look forward to rejoining them with the *Falkor(too)*!)

Very early on in the cruise season the *Falkor's* port photosynthetically active radiation (RAD_PAR) data suddenly appeared to be too small, by approximately a factor of 10, as compared to her starboard sensor (RAD_PAR2). The vessel technician group was notified of this suspicious activity on 23 March via email. A tech confirmed the discrepancy the same day and stated plans to inspect the sensor and do some tests. The next day she reported back that the plastic Switchcraft bulkhead connector on RAD_PAR had evidently cracked and as a result the cable must have slowly come undone in a recent spate of bad weather. She humbly shared her opinion that the connectors on their PAR units (both Biospherical QSR-2200s) are not fit for the job, being easily prone to damage. (In fact, these connectors are identified as being the most vulnerable part of the system directly in the QSR-2200 manual.) In any event, RAD_PAR data for 22 March through ~5:30 UTC 24 March were assigned "malfunction" (M) flags (Figure 85).

Falkor crew also reported a couple of unplanned Rotronic Hygroclip filter changes in two of their MetPakPro sensor packages in 2021. In the first case, on or around 17 March, technicians observed erratic relative humidity (RH2) data in the port main mast unit (as compared to the other two units) and subsequently switched out the filter, at which point RH2 immediately improved. (Any erratic data in RH2 prior to the swap was assigned "caution/suspect" (K) data during SAMOS visual quality control.) In the second case, ~22:00 UTC 30 September the filter was changed in the foremast unit due to there being wildfire ash in the area. A brief spike each in the air temperature (T) and relative humidity (RH) data from the foremast unit was noted at the time of the change, but otherwise there were no obvious differences detected in the data pre- and post-swap.

No other issues of note exist for *Falkor* in 2021. Looking to the flag percentages in Figure 84, about a quarter of the total flags was assigned to the shortwave atmospheric radiation (RAD_SW). However, these were almost exclusively "out of bounds" (B) flags (Figure 85) applied to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.) As a general note, all three of *Falkor's* MetPakPro units (foremast, port main mast, and starboard main mast) were habitually known to get hit with sea spray (the foremast more so than the other two) whenever the vessel was in particularly rough waters, which happened fairly often. Effects from water inundation were fairly marked in meteorological data (wind direction and speed, and more notably atmospheric pressure, air temperature, and relative humidity) from all three of these units, meaning DIR/SPD/P/T/RH (foremast), DIR2/SPD2/P2/T2/RH2 (port main mast), and DIR3/SPD3/P3/T3/RH3 (starboard main mast) all routinely received an appreciable amount of K flagging throughout the year (Figure 85, not all shown). It has been noted these MetPakPro units were not originally designed for offshore installation and tend to struggle in harsh conditions. It has also been noted that as the original sensor pack junction boxes are made from aluminum they tend to corrode heavily in the marine (i.e., salt) environment.

One final note, just before *Falkor's* 2021 cruise season had gotten underway one of their technicians reached out to us with some retrospective information. Evidently during routine maintenance prior to 2021 departure they'd noticed their starboard main mast MetPakPro sensor package was misaligned. They'd consequently rotated it between 5-10 degrees horizontally to port to align with the vessel heading. The misalignment was believed to have existed from no earlier than 23 November 2020. While this revelation has no bearing on 2021 data quality, it may be of note for users of *Falkor's* P3, T3, RH3, and especially DIR3 and SPD3 data from very late 2020.

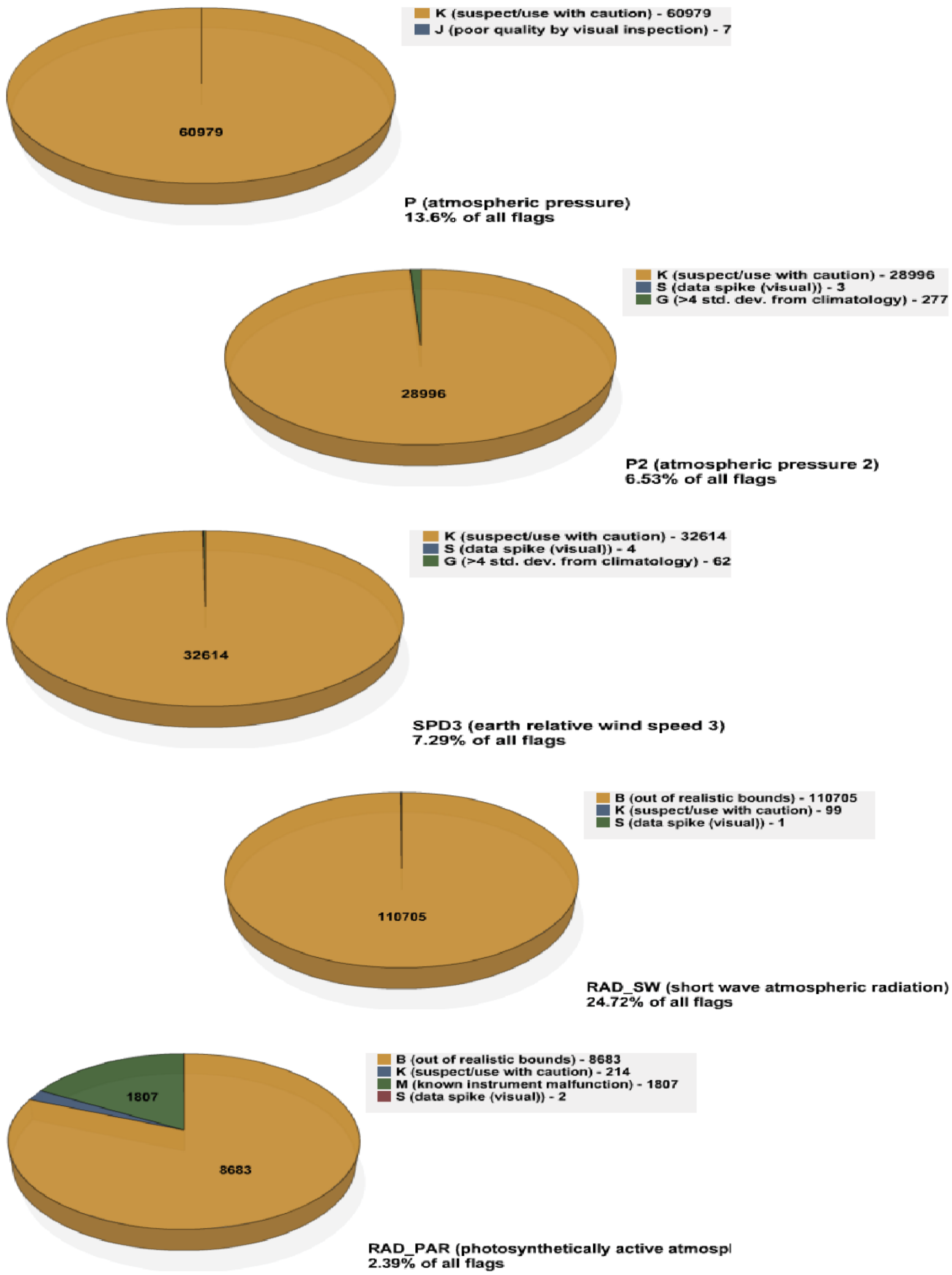

Figure 85: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) atmospheric pressure 2 – P2 – (third) earth relative wind speed 3 – SPD3 – (fourth) short wave atmospheric radiation – RAD_SW – and (last) photosynthetically active atmospheric radiation – RAD_PAR – for the *Falkor* in 2021.

Sikuliaq

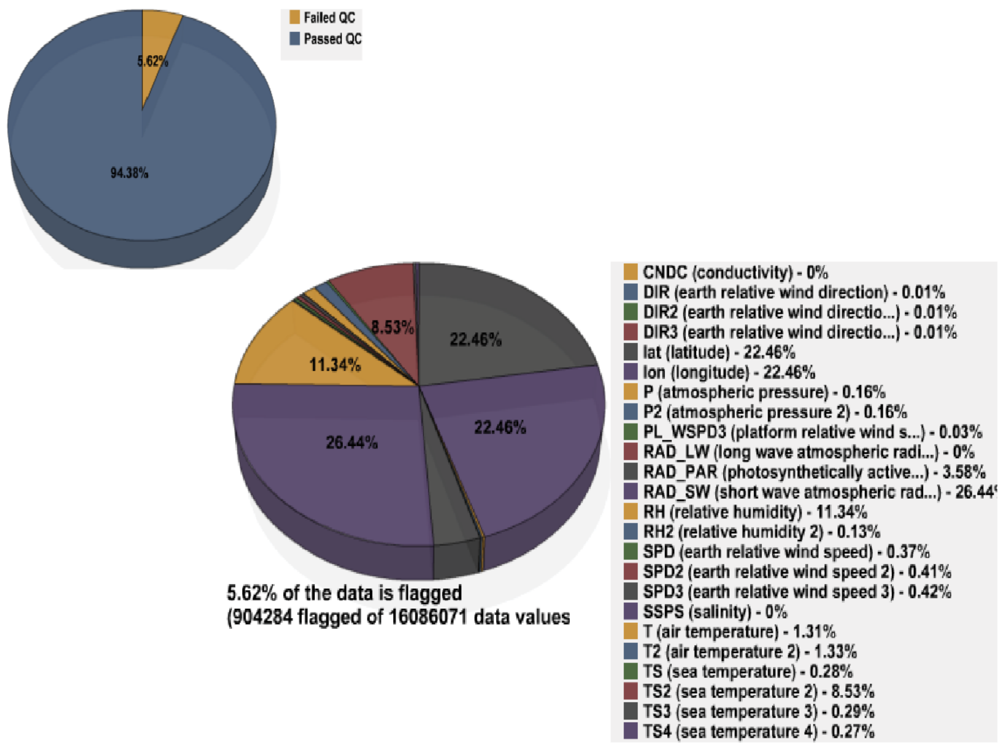

Figure 86: For the *Sikuliaq* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Sikuliaq* provided SAMOS data for 346 ship days, resulting in 16,086,071 distinct data values. After automated QC, 5.62% of the data were flagged using A-Y flags (Figure 86). This is a little over two percentage points lower than in 2020 (7.93%). It should be noted the *Sikuliaq* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only (no research-level files exist at the SAMOS DAC for the *Sikuliaq*).

On 12-13 September some very high relative wind speed values were observed coming from *Sikuliaq's* starboard RM Young 85004 on the bridge. It was expected the sensor had probably iced up, and an email request was sent out to confirm. The technician who responded noted that, in fact, both the starboard and port RM Young wind sensors were severely iced over. He expressed surprised that the port sensor would still be working, and instead urged not to trust its data. Some of the relative/true wind direction and speed (PL_WDIR3/PL_WSPD3, DIR3/SPD3) data from the starboard unit did receive "out of bounds" (B) flags from automated quality control (not shown), but we stress that, based on the technician's information, no PL_WDIR3, PL_WSPD3, DIR3, or SPD3 data from 12-13 September should be used. Nor should the relative/true wind direction and speed (PL_WDIR2/PL_WSPD2, DIR2/SPD2) from the port unit for this period be used.

It was noted again in 2021, as it had been in prior years, that *Sikuliaq's* relative humidity (RH) from their Vaisala PTU307 unit generally performed more poorly than the relative humidity (RH2) from their Paroscientific MET4A instrument. RH values in 2021 often read higher than RH2 and in humid conditions tended to exceed 100%, which resulted in application of B flags to RH by automated quality control procedures (Figure 87). Notably, in a 6 July email communication about RH, *Sikuliaq* personnel explained that the feedback loop for the PTU307's heated humidity probe tends to get "pegged" in more humid conditions, resulting in a temperature correction that is way off (and thus inaccurate RH). He stated that past efforts to work with Vaisala to correct the problem had never seen any success. For these reasons the stated plan was to eventually phase out *Sikuliaq*'s PTU307s entirely, replacing them instead with all MET4As, which use a fan-aspirated humidity sensor and perform demonstrably much better in the cold and humid conditions *Sikuliaq* frequently encounters. In the meantime, we suggest that RH2 should generally be given precedence over RH wherever possible, for all of 2021.

There were no other data issues of note for *Sikuliaq* in 2021. Looking to the flag percentages in Figure 86, about half of the total flags were applied to latitude (LAT) and longitude (LON). These were exclusively "platform position over land" (L) flags (Figure 87) that appear generally to have been applied when the vessel was either in port or very close to land. This is not uncommon, as the land mask in use for the land check routine is often incapable of resolving the very fine detail of a coastline or an inland port. A further ~26% of the total flags were applied to shortwave atmospheric radiation (RAD_SW), in this case exclusively B flags (Figure 87) such as are applied to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.) Finally, a little under 10% of the total flags were applied to *Sikuliaq's* radiometric sea surface temperature (TS2), aka "skin" temperature. These were mostly B flags with a few "greater than four deviations from climatology" (G) flags, as well (Figure 87). In this case the flagged data mainly resulted from the infrared thermometer pointing at the dock or at pack ice, meaning it was not actually measuring the sea temperature. We note this does not indicate a problem with the sensor.

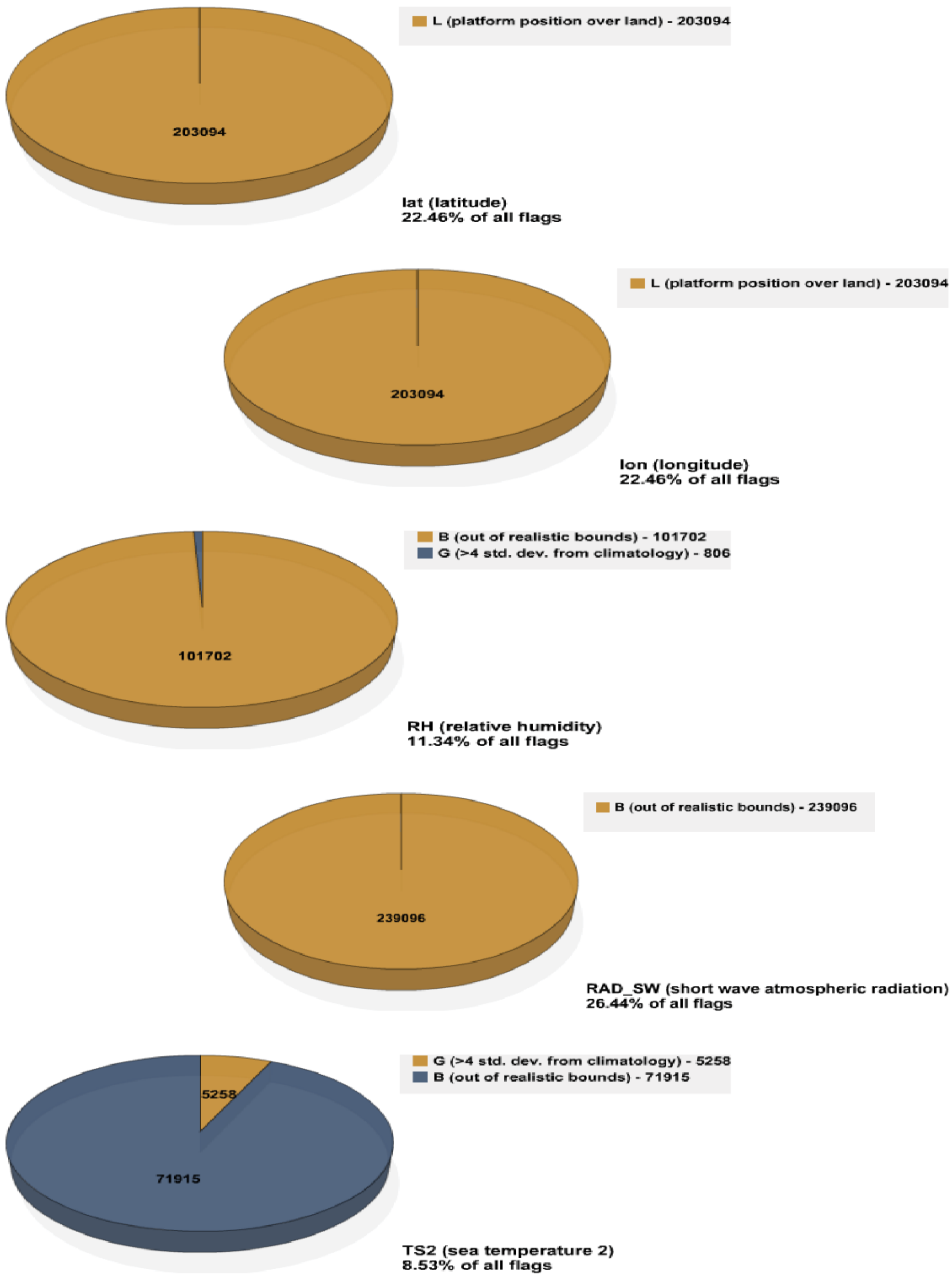

Figure 87: Distribution of SAMOS quality control flags for (first) latitude – LAT – (second) longitude – LON – (third) relative humidity – RH – (fourth) short wave atmospheric radiation – RAD_SW – and (last) sea temperature 2 – TS2 – for the *Sikuliaq* in 2021.

Kilo Moana

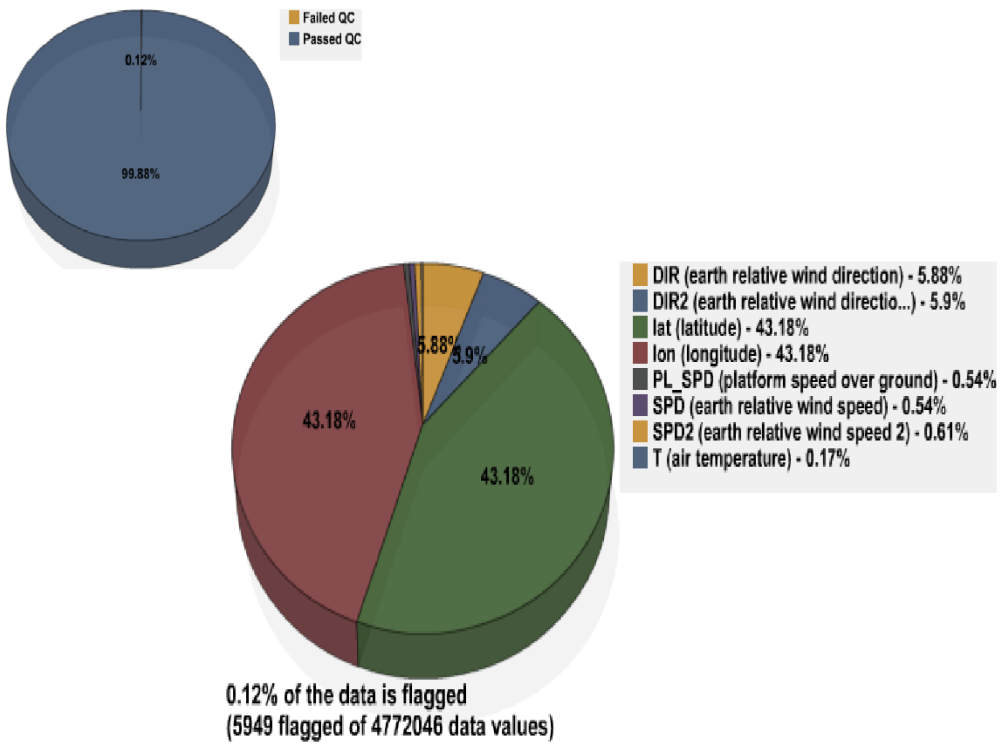

Figure 88: For the *Kilo Moana* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Kilo Moana* provided SAMOS data for 178 ship days, resulting in 4,772,046 distinct data values. After automated QC, just 0.12% of the data were flagged using A-Y flags (Figure 83). This is a little over three percentage points lower than in 2020 (3.6%) and obviously maintains *Kilo Moana's* standing well under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. It should be noted the *Kilo Moana* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only (no research-level files exist at the SAMOS DAC for the *Kilo Moana*). Still, a total flagged percentage of 0.12% is exceedingly low.

In mid-April it was noted *Kilo Moana's* precipitation accumulation (PRECIP2) data often did not agree with her rain rate (RRATE) data. Beginning on at least 12 April, in many cases when PRECIP2 showed rainfall no positive RRATE existed. PRECIP2 also had a peculiar habit of gaining volume and then losing volume soon afterward, but not in a quick drop like is typical of a siphon. RM Young and ORG sensors clearly not operating correctly. The vessel was notified of these facts on 19 April. There is no response on record, but we stress the sensors were clearly not operating correctly, at least at the time and possibly longer.

On both 19 and 20 September *Kilo Moana* crossed the international date line. At the moment of crossing a spike was observed in both latitude (LAT) and longitude (LON).

Upon investigating, it became clear that the *Kilo Moana's* averaging code was not properly handling the longitude transition across the date line from -180 to 180 degrees (and vice versa). This analysis was relayed to the vessel via email on 21 September. A technician responded with their acknowledgement and stated they needed to recode their SAMOS data averaging scripts (timeline TBD). We note the spikes in LAT and LON were assigned "platform velocity unrealistic" (F) flags by automated quality control procedures.

On 27 September an email was sent to the vessel informing that over the past few weeks a very small magnitude (+/- 0.01PSU) sawtooth pattern was being noted in the *Kilo Moana's* salinity (SSPS) parameter (see Figure 89). Although not of much concern, given the small magnitude, it was wondered if there was any explanation for the pattern (e.g., variation in the water flow rate through the thermosalinograph). A technician responded, stating they had a known flow issue with their underway system wherein their metering valves clogged easily. He further noted they often have to go down to clear them out and advised that they were investigating solutions. We note that the SSPS data from 21 August through at least 27 September (and likely much later) may need some smoothing by users.

There were no other issues of note for *Kilo Moana* in 2021. Additionally, considering the very low total flagged percentage it is not worth drilling down into the individual parameter flag percentages.

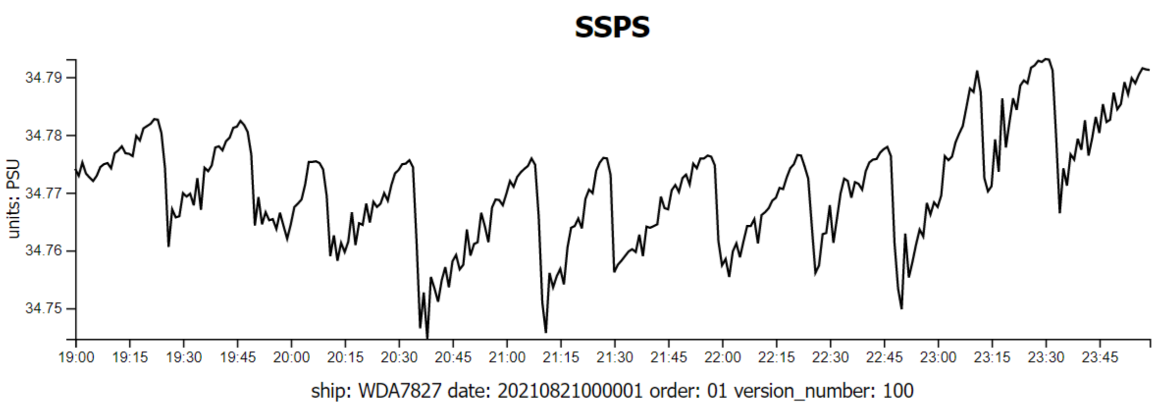

Figure 89: *Kilo Moana* SAMOS salinity – SSPS – data for 21 August 2021. Note small-amplitude sawtooth pattern.

Thomas G. Thompson

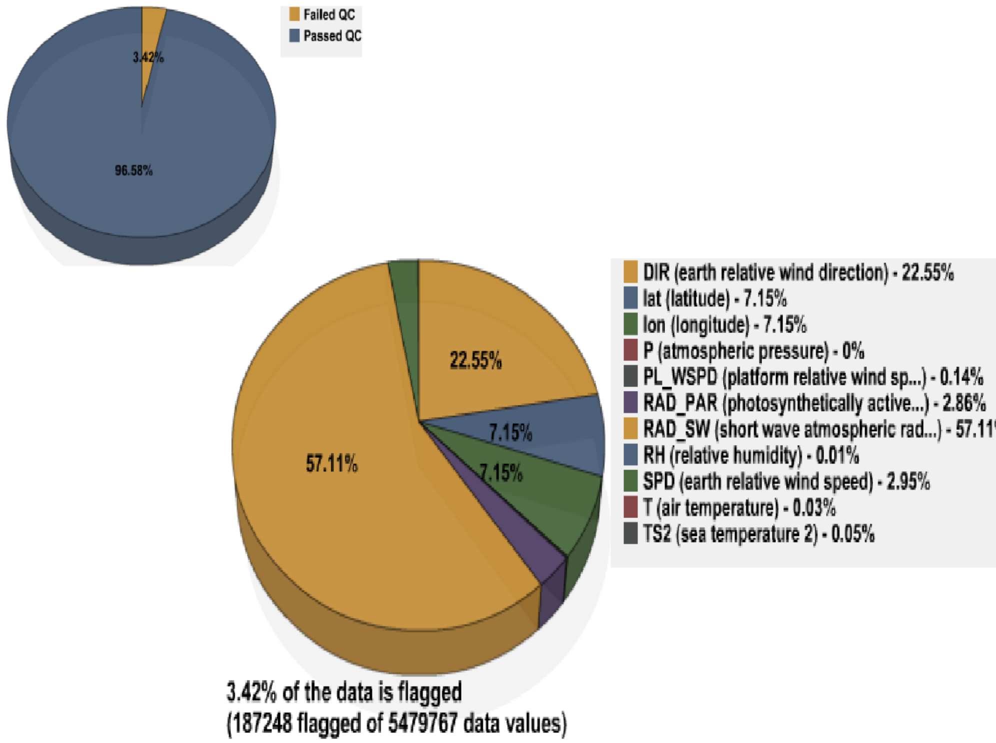

Figure 90: For the *Thomas G. Thompson* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Thomas G. Thompson* provided SAMOS data for 211 ship days, resulting in 5,479,767 distinct data values. After automated QC, 3.42% of the data were flagged using A-Y flags (Figure 90). This is a little over a percentage point higher than in 2020 (2.09%) and maintains *Thompson's* standing inside the “under 5% total flagged” bracket regarded by SAMOS to represent "very good" data. It should be noted the *T. G. Thompson* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only (no research-level files exist at the SAMOS DAC for the *T. G. Thompson*).

On 22 February numerous very large spikes (up to 80 m/s) were observable in *Thomas G. Thompson's* platform relative and earth relative wind speeds (PL_WSPD and SPD, respectively). When contacted for details, ship technicians confirmed the wind sensor was working fine and shared that the anomalous readings were due to boobies roosting on the instrument mast (Fig. 91). The bird “infestation” and resultant anomalously high wind speeds recurred on 11 June, and possibly again 29-30 November. (This booby scenario further continues to recur at sparse odd times through to the present day.) When these such data spikes occur in the *Thompson's* wind speed data, they are usually assigned either “out of bounds” (B), “greater than four standard deviations from climatology” (G), or “failed the wind recomputation check” (E) flags by automated quality control procedures (Figure 92, only SPD shown).

In mid-April it was noted the nighttime shortwave radiation (RAD_SW) from *Thompson's* Eppley SPP had been reading excessively low (-60 W/m^2). (While it's not uncommon for an SPP to read slightly negative at night (see 3b.) the typical nighttime reading is in the -1 to -5 W/m^2 range.) The vessel was notified of the issue and several weeks later one of the technicians alerted us of plans to swap the shortwave radiometer. This swap occurred on 8 July, after which all RAD_SW data looked reasonable again. The negative nighttime RAD_SW values in the period of note – 4 April through 7 July – all received automated B flags (Figure 92), but we caution that all unflagged RAD_SW data in the period may be suspect, as well.

On 12 July, stemming from an inquiry the previous day into some noted true wind direction (DIR) errors, it was learned that the *Thompson's* SAMOS averaging had been set to 20 samples in their data acquisition system, not the standard 60 seconds, for some indeterminate period (likely long-term). Once this fact became known to all parties it was immediately remedied (averaging changed to 60 seconds). However, we note that the prior metadata we had in the SAMOS database (for a long time back) listed *Thompson's* averaging as 60 seconds, which has turned out to be incorrect. Further, there is no way to reflect an average of 20 samples in the SAMOS database, so we cannot go back and correct the metadata. All this to say, from some indeterminate start date through 12 July 2021 the averaging info included in *T.G. Thompson's* SAMOS data files is incorrect. There also may be a correlation between the odd 20-sample averaging and the volume of "failed the wind recomputation check" (E) flags habitually seen on *Thompson's* DIR parameter (Figure 92).

In early August sporadic "platform velocity unrealistic" (F) flags were observed in *Thompson's* latitude (LAT) and longitude (LON) parameters, which led to the discovery their LAT and LON data precision seemed to have mysteriously reverted to two decimal places (much coarser than their GPS is capable of resolving). Upon further investigation and communication with one of the *Thompson's* technicians it became suspected a previous fix switching the precision to six decimal places had never actually migrated down to the level of the SAMOS data. Certainly, all LAT/LON data from January through August 2021 were two-decimal precision, which sometimes resulted in F flags to those parameters and may also have contributed heavily to the volume of "land error" (L) flags seen in those parameters (Figure 92). (It's not uncommon for even high-precision SAMOS latitude/longitude data to receive L flags in port, for example, as the land mask in use for the land check routine is often incapable of resolving the very fine detail of a coastline or an inland port.) In September *Thompson's* SAMOS LAT/LON precision was successfully increased to four decimal places.

On 26 November unrealistic multi-minute (~10-15) spikes were observed in *Thompson's* SPD data. However, in this case no corresponding changes were observed in the true wind direction (DIR) data or PL_WSPD, as might be expected if the SPD spikes were due to birds. Nor were there any indications evident in the other parameters associated with the true wind, namely the vessel heading (PL_HD), course (PL_CRS), and speed (PL_SPD). Some type of configuration or calculation error in the data acquisition system was suspected, although never confirmed. In any case it appears to have been an isolated incident, and the spikes in SPD received automated G and B flags (Figure 92).

Figure 91: Photo from shipboard technician showing birds roosting on the sonic anemometer and meteorological mast on the *Thomas G. Thompson*. Photo courtesy Adam Stenseth, University of Washington.

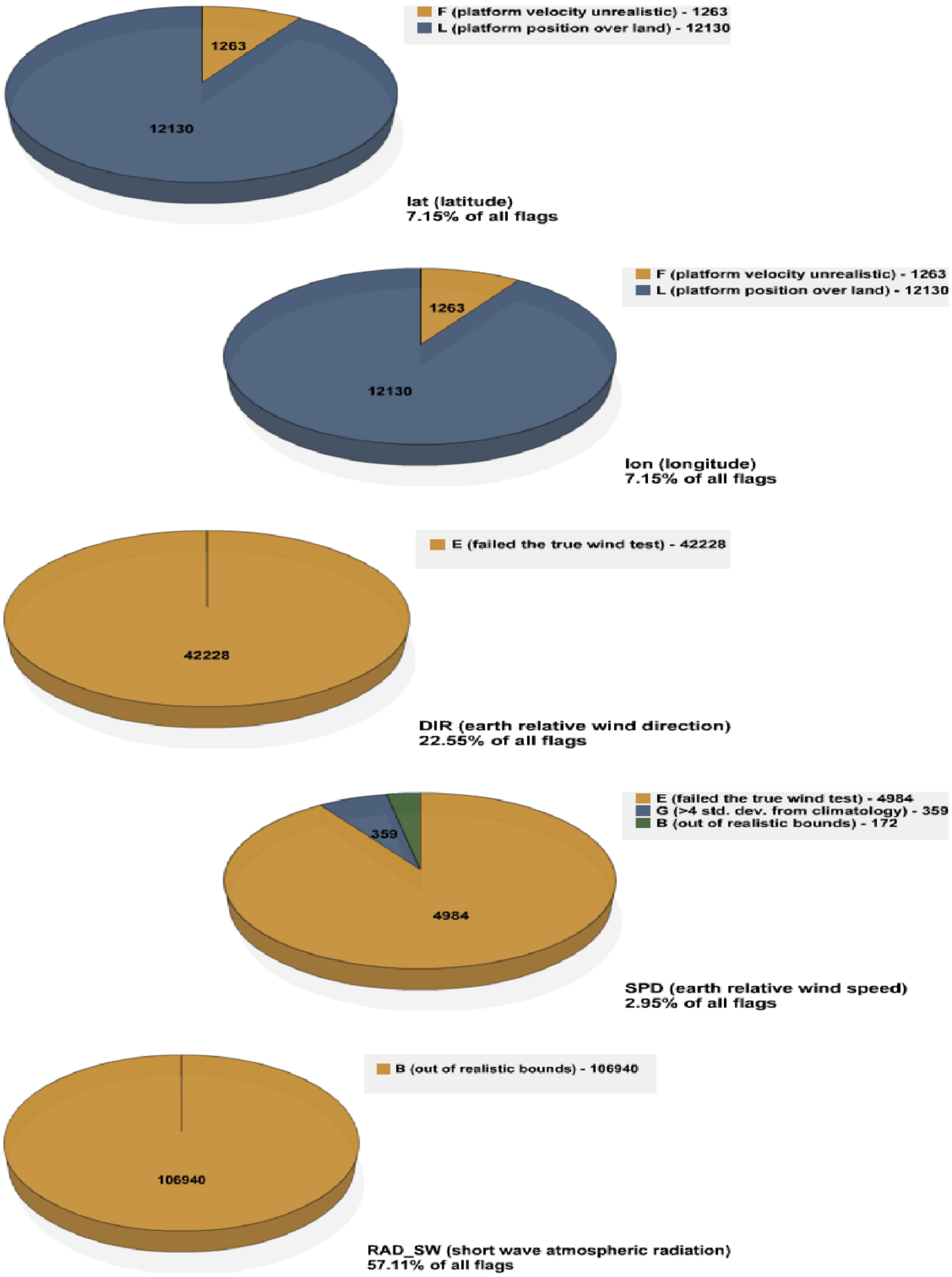

Figure 92: Distribution of SAMOS quality control flags for (first) latitude – LAT – (second) longitude – LON – (third) earth relative wind direction – DIR – (fourth) earth relative wind speed – SPD – and (last) short wave atmospheric radiation – RAD_SW – for the *Thomas G. Thompson* in 2021.

Healy

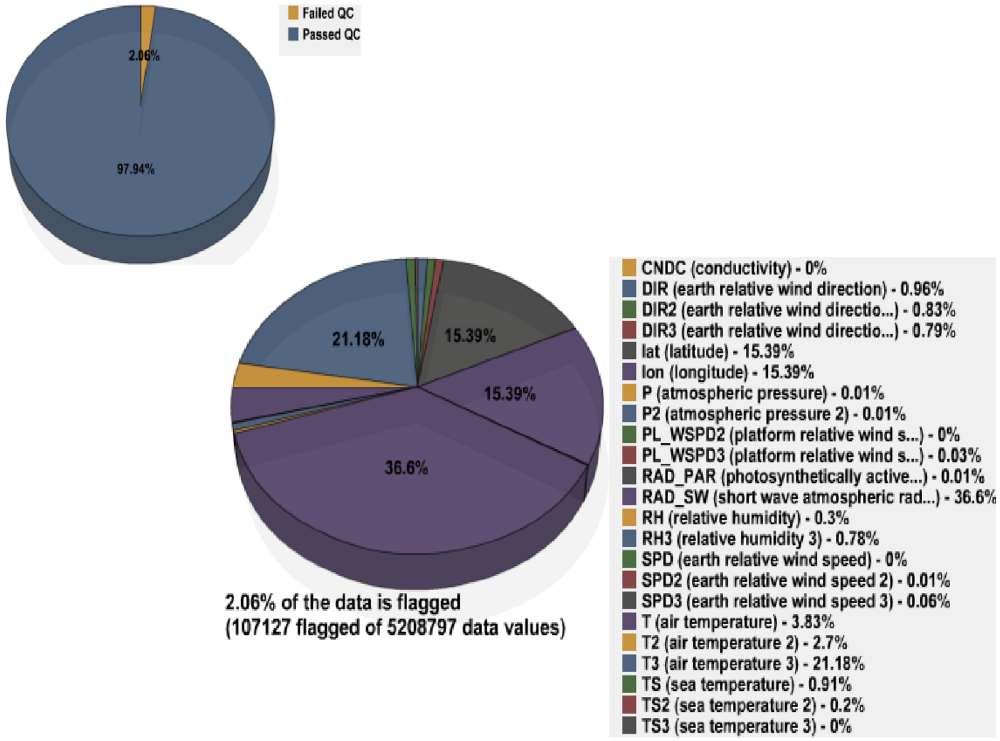

Figure 93: For the *Healy* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Healy* provided SAMOS data for 118 ship days, resulting in 5,208,797 distinct data values. After automated QC, 2.06% of the data were flagged using A-Y flags (Figure 93). This is over six percentage points lower than in 2020 (8.44%) and brings *Healy* under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. It should be noted *Healy* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only.

On 19 July a *Healy* technician alerted us that when their bow sonic anemometer was recently installed, it was off by 180 degrees. So, as he advised, all wind data from the sensor would be incorrect until the sensor was rotated. It was subsequently rotated, on 21 July. In the meantime, relative/true wind direction and speed from the instrument (PL_WDIR/PL_WSPD, DIR/SPD) for the period 17:19 UTC on 19 July through 16:15 UTC 21 July should be considered suspect.

A few days later, it was noted there had been regular (hourly) spikes occurring in *Healy's* sea temperature (TS), salinity (SSPS), and conductivity (CNDC) data since the 23rd. When contacted for any explanation, a tech noted they were beta testing an hourly standardization cycle on their water wall that involved switching the inlet from straight seawater to being filtered through a 20-micron element. He thought this was the likely source for the hourly spikes, with the pulse of warmer water trapped in the filter housing being the primary culprit. This seems likely, as testing was completed by the 25th and the spikes thereafter resolved.

From 10-17 August, numerous spikes were observable, at various times, in the data from all three of *Healy's* temperature (T, T2, T3) sensors, especially in T3. T3 also had some definite bad data (too high) off and on within the period, which resulted in a good deal of "out of bounds" (B) and "greater than four standard deviations from climatology" (G) flags (Figure 94). There were additionally a lot of missing data from the relative humidity (RH) sensor on *Healy's* bow mast. An email notification was sent out to the ship on 13 August. A responding technician's suspicion was interference from some radio frequency signals that would have occurred at 45-minute intervals, though he'd not been able to confirm this theory. However, beginning 26 August, in what was a possible recurrence of the above issue but observed in T3 only this time (reading 6-10° Celsius higher than T or T2), RF interference at regular, 45-minute intervals was clearly not indicated. One possible explanation here could be that there was a sensor heating (internal heater) issue, and the sensor was correcting for the heating thus providing realistic relative humidity (RH3) but unrealistic T3. Finally, on 4 September the values for T3 dropped from 10° Celsius down to -4 in about an hour, at which point T3 values were consistent with T and T2 (and remained so thereafter). It was inquired of the tech group whether they had modified anything, as cold temperatures should generally not fix a sensor. (No response on record.) We note the T3 data from 26 August through 4 September should not be trusted.

At the end of the season, we were informed by a *Healy* contact that a copy-paste error had been discovered in the calibration data entered for their bow mast RH, meaning the data had habitually read slightly higher (2-4%) than RH3 for all of 2021. We at SAMOS cannot do anything to correct this data, so we will leave an advisory here for users of *Healy's* 2021 SAMOS RH.

As a general note, steps from suspected flow distortion have been observed in *Healy's* atmospheric pressure (P and P2) and true wind speed (SPD, SPD2, SPD3) data when the relative wind is from abeam (either 90 or 270 degrees). In this case, given the blockhouse bridge/superstructure on *Healy*, there is probably no real solution without moving these sensors higher up on the main mast.

Looking to the flag percentages in Figure 93, about 37% of the total flags were applied to shortwave atmospheric radiation (RAD_SW), in this case exclusively B flags (Figure 94) such as are applied to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.) A further ~31% of the total flags were applied to latitude (LAT) and longitude (LON). These were virtually all "platform position over land" (L) flags (Figure 94) that were likely mainly to have been applied when the vessel was either in port or very close to land. This is not uncommon, as the land mask in use for the land check routine is often incapable of resolving the very fine detail of a coastline or an inland port.

One final note for 2021, we learned at the start of the 2022 field season that the time reported with the original and SAMOS data for all of 2021 are off by an order of a few minutes. This was a result of a network change and the data acquisition computers no longer having the correct path to find the time servers. There is no fix that can be made to the SAMOS data, but some of this can be corrected by correlating the in-data GPS time with the serial epoch timestamps for the serial instrument feeds. This would require a user to work with the raw data available for the *Healy* from the Rolling Deck to Repository project.

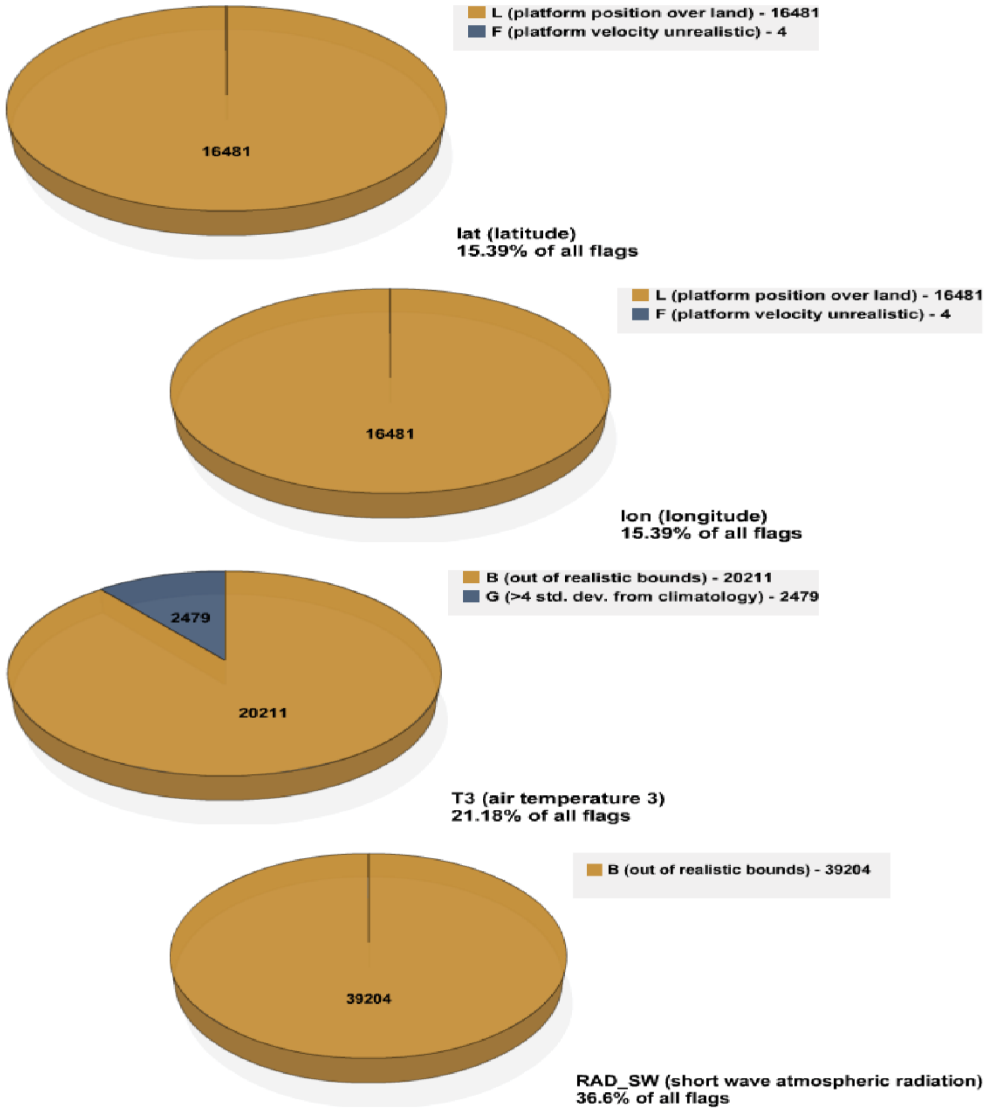

Figure 94: Distribution of SAMOS quality control flags for (first) latitude – LAT – (second) longitude – LON – (third) air temperature 3 – T3 – and (last) shortwave atmospheric radiation – RAD_SW – for the *Healy* in 2021.

R/V Atlantis

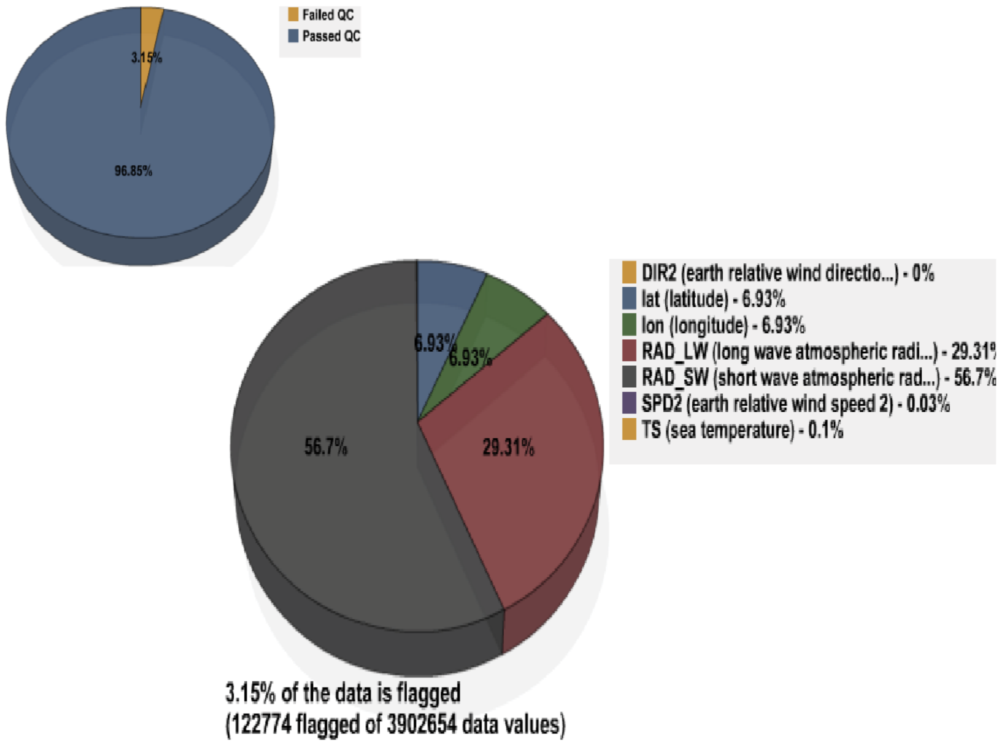

Figure 95: For the *R/V Atlantis* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *R/V Atlantis* provided SAMOS data for 102 ship days, resulting in 3,902,654 distinct data values. After automated QC, 3.15% of the data were flagged using A-Y flags (Figure 95). This is about one and a half percentage points higher than in 2020 (1.71%) and maintains *Atlantis's* standing well under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. It should be noted the *R/V Atlantis* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only.

During the period 20-23 July and the longer period 30 July – 24 October *Atlantis's* long wave radiometer (RAD_LW) reported unreasonable values, being consistently in the -5700 - -6000 W/m^2 range. The vessel was first notified of the unrealistic data on 21 July. A few days later a technician responded, noting the issue seemed to have fixed itself on the 23rd. After the 30 July recurrence a second notification received no response. However, on 24 October we were informed technicians believed they'd traced the problem to a bad cable. The cable was replaced before their next cruise began and subsequent RAD_LW were within normal bounds. In the meantime, for the entirety of both periods of note RAD_LW was assigned "out of bounds" (B) flags (Figure 96).

A while later, at the beginning of December, RAD_LW values were suspected of being a bit high, reaching upwards of 650 W/m^2 (very unusual). While *Atlantis* and her sister ship *Neil Armstrong* were both in port at WHOI we made a side-by-side comparison of their long wave radiation data and found they did not compare well at all.

Notification of this analysis was sent to Atlantis on 3 December. There is no response on record; however, because of the past issues with RAD_LW, a continued cable or other problem is suspected.

There were no other data issues of note for *Atlantis* in 2021. Looking to the flag percentages in Figure 94, over half the total flags were applied to short wave atmospheric radiation (RAD_SW). These were exclusively “out of bounds” (B) flags (Figure 96) and appear to have been applied mainly to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.)

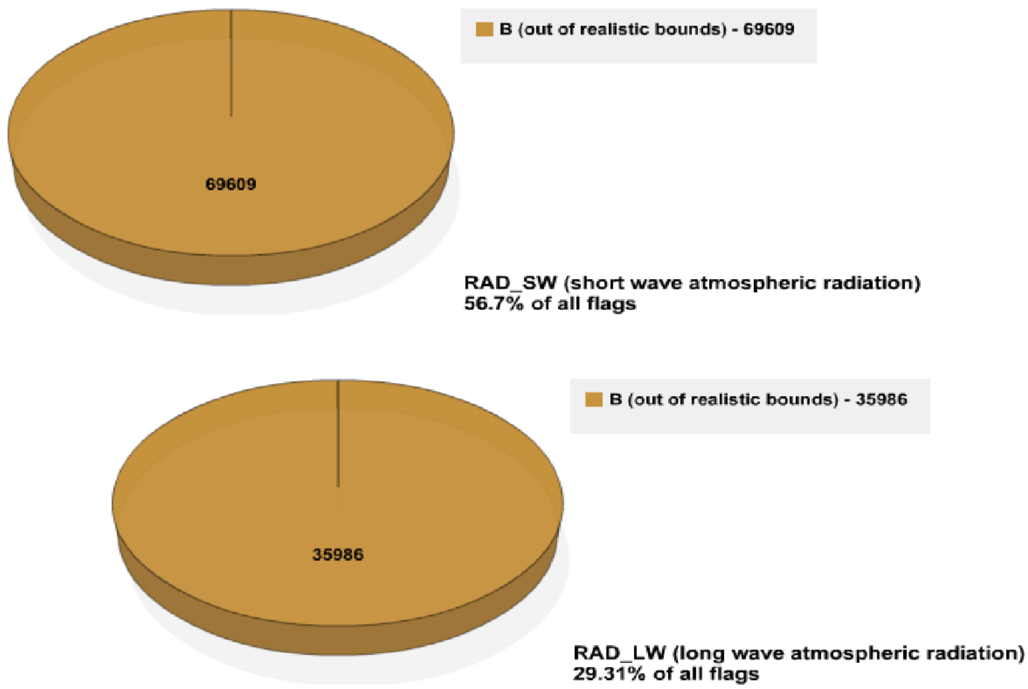

Figure 96: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – and (bottom) long wave atmospheric radiation – RAD_LW – for the *R/V Atlantis* in 2021.

R/V Neil Armstrong

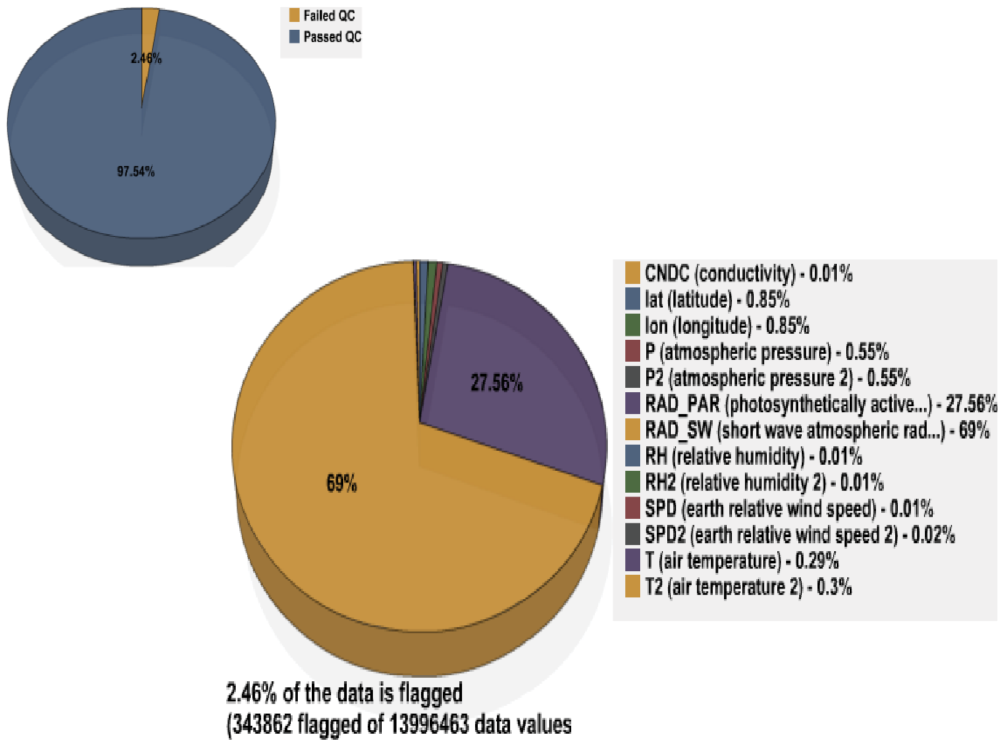

Figure 97: For the *R/V Neil Armstrong* from 1/1/21 through 12/31/21, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *R/V Neil Armstrong* provided SAMOS data for 349 ship days, resulting in 13,996,463 distinct data values. After automated QC, 2.46% of the data were flagged using A-Y flags (Figure 97). This is about the same as in 2020 (2.89%) and maintains the *Armstrong's* standing well under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. It should be noted the *R/V Neil Armstrong* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only (no research-level files exist at the SAMOS DAC for the *R/V Neil Armstrong*).

A single data spike was observed at 12:30 UTC on 24 May in most of *Neil Armstrong's* starboard Vaisala WXT parameters – namely, atmospheric pressure (P2), air temperature (T2), relative humidity (RH2), and earth relative wind direction and speed (DIR2 and SPD2, respectively) at the same time as the WXT's precipitation (PRECIP) value apparently reset to zero. Curious about the spikes and the reset, we contacted the *Armstrong* via email. At that point a technician responded that the starboard WXT had spontaneously stopped logging and the only solution was to power cycle all the met mast sensors. This spontaneous ceasing of data logging in *Armstrong's* WXT units and the need for a power cycling to restore eventually became a known issue, recurring several times throughout the year and often being preceded by an obvious gap (sometimes several days or more) in the data from the affected unit.

On 19 July we were notified by one of *Armstrong's* technicians that they'd lowered their MET tower beginning shortly after 1300 UTC to swap out some instrumentation. We received a subsequent email advising that the MET tower had been raised again around 14:00 UTC on 28 July. We caution that all meteorological data from *Armstrong* from 13:00 UTC 19 July through 14:00 UTC 28 July should be considered suspect.

There are no other data issues of note for *Neil Armstrong* for 2021. Looking to the flag percentages in Figure 97, almost all of the total flags applied were assigned to short wave atmospheric radiation (RAD_SW) and photosynthetically active radiation (RAD_PAR). In both cases these were exclusively "out of bounds" (B) flags (Figure 98) that appear to have been applied mainly to the slightly negative values that can occur with these types of sensors at night (a consequence of instrument tuning, see 3b.)

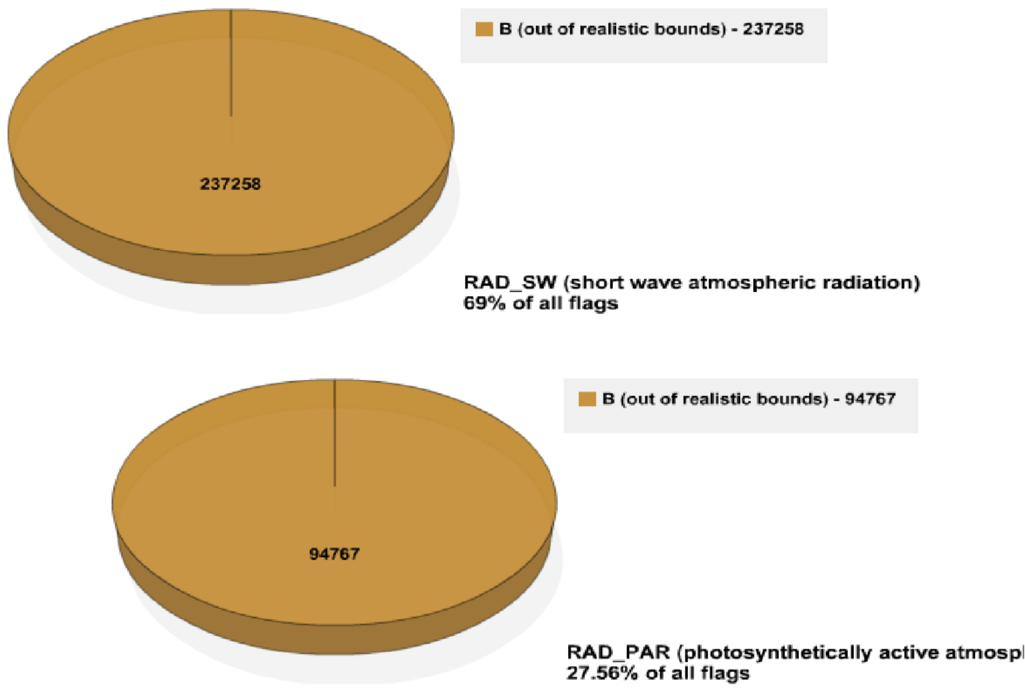

Figure 98: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – and (bottom) photosynthetically active radiation – RAD_PAR – for the *R/V Neil Armstrong* in 2021.

4. Metadata summary

Adequate metadata is the backbone of good visual QC. It also improves the utility of any data set. As such, vessel operators are strongly advised to keep vessel and parameter metadata complete and up to date. Annex B, Part Two walks SAMOS operators through editing metadata online, step by step, while Part One offers instructions for monitoring metadata and data performance. For vessel metadata, the following are the minimum required items in consideration for completeness: Vessel information requires vessel name, call sign, IMO number, vessel type, operating country, home port, date of recruitment to the SAMOS initiative, and data reporting interval. Vessel layout requires length, breadth, freeboard, and draught measurements. Vessel contact information requires the name and address of the home institution, a named contact person and either a corresponding email address or phone number, and at least one onboard technician email address. A technician name, while helpful, is not vital. Vessel metadata should also include vessel imagery (highly desirable, see Figure 99 for examples) and a web address for a vessel's home page, if available.

Parameter metadata requirements for completeness vary among the different parameters, but in all cases "completeness" is founded on filling in all available fields in the SAMOS metadata form for that parameter, as demonstrated in Figure 100. (Any questions regarding the various fields should be directed to samos@coaps.fsu.edu. Helpful information may also be found at https://samos.coaps.fsu.edu/html/docs/samos_metadata_tutorial_p2.pdf, which is the metadata instruction document located on the SAMOS web site.) In this example (Figure 100 b.), as is frequently the case, the only missing field is the date of the last instrument calibration. Calibration dates may be overlooked as important metadata, but there are several situations where knowing the last calibration date is helpful. For example, if a bias or trending is suspected in the data, knowing that a sensor was last calibrated several years prior may strongly support that suspicion. Alternatively, if multiple sensors give different readings, the sensor with a more recent last calibration date may be favored over one whose last calibration occurred years ago. (Note that for those sensors not routinely calibrated, such as GPS instruments, an installation date is alternately desired.)

We note here that as of summer 2020 we are now collecting additional flow water metadata elements, namely, intake location and pipe run length. Knowing these details can help establish a basis for any unnatural increase or decrease seen in sea water variable values away from what they would have been directly at the sea water intake. Typically, the further water has travelled inside the ship, the greater the warming/cooling effects of the ship/pipes on the water.

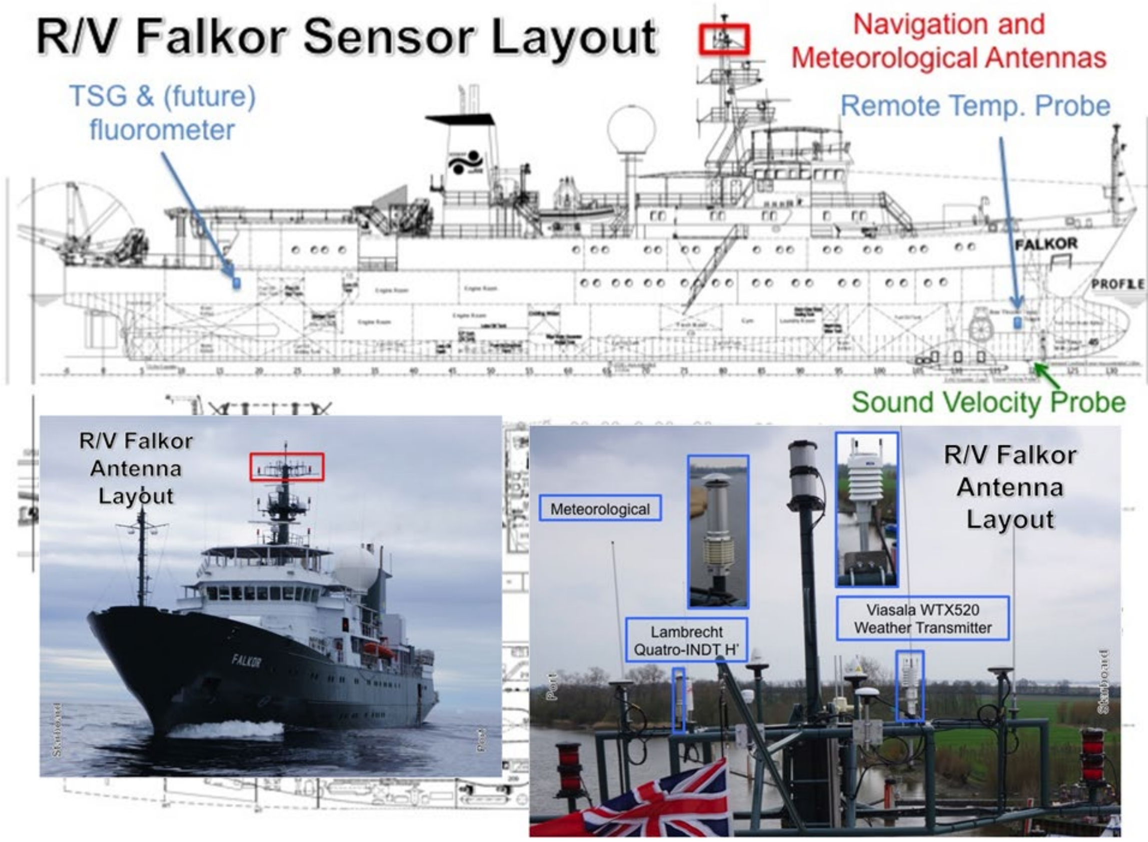

Figure 99: Examples of detailed vessel instrument imagery from the *R/V Falkor*.

a.

sea temperature			
Designator		Date Valid	
SST		06/01/2005 to Today	
Descriptive Name	Original Units	Instrument Make & Model	Last Calibration
sea temperature	celsius	Falmouth Science Inc. OTM-S-212 (OTM1378)	August 2004
TS Sensor Category	Observation Type	Distance from Bow	Distance from Center Line
12	measured	0	0
Height	Average Method	Averaging Time Center	Average Length
-5.4	average	time at end of period	1
Sampling Rate	Data Precision		
4	0.01		

b.

sea temperature			
Designator		Date Valid	
SST		05/09/2005 to Today	
Descriptive Name	Original Units	Instrument Make & Model	Last Calibration
sea temperature	celsius	Sea-bird SBE48 Hull Sensor	
TS Sensor Category	Observation Type	Distance from Bow	Distance from Center Line
hull contact sensor	measured	0	0
Height	Average Method	Averaging Time Center	Average Length
-5	average	time at end of period	1
Sampling Rate	Data Precision		
4	0.01		

Figure 100: Example showing parameter metadata completeness (a.) vs. incompleteness (b.). Note missing information in the "Last Calibration" field in (b.)

Following the above guidelines for completeness, Table 4 summarizes the current state of all SAMOS vessel and parameter metadata:

	Vessel Info	Contact Info	Vessel Layout	Digital Imagery	LATITUDE	LONGITUDE	PLATFORM HEADING	PLATFORM COURSE	PLATFORM SPEED	SEA TEMPERATURE	CONDUCTIVITY	SALINITY
KAOU	C	C	C	Yes	C	C	C	C	C	I,I,I	I,I	I,I
KAQP	C	C	C	Yes	I	I	I	I	I	I,I	I	I
KTDQ	C	C	C	Yes	I	I	I	I	I	C,C	C	C
NEPP	C	I	C	Yes	I	I	C	I	I	I,I,I,I	I,I	I,I
VLMJ	C	C	I	No	I	I	I	I	I	I,I		I
WARL	C	C	I	Yes	I	I	C	I	I,I	I,I	I	I
WBP3210	C	C	C	Yes	I	I	I	I	I	I	I	I
WCX7445	C	C	C	Yes	I	I	I	I	I	I	I	I
WDA7827	C	C	C	Yes	I	I	I,I	I	I	I,I	I	I
WDC9417	C	C	C	Yes	C	C	C	C	I	I,C,C,C	C,C	C,C
WDD6114	C	C	I	Yes	I	I	I	I	I	I	I	I
WDG7520	C	C	C	Yes	C	C	C,I,I	C	C	C,I,C,C	C,C	C,C
WSAF	C	C	I	Yes	C	C	C	C	C	I,I,I	I,I	I,I
WSQ2674	C	C	I	Yes	C	C	I	C	C	I,I	I	I
WTDF	C	C	C	Yes	I	I	I	I	I,I,I	I,I	I	I
WTDH	C	C	C	Yes	I	I	I	I	I,I,I	I,I	I	I
WTDL	C	I	C	Yes	C	C	I	I	I	I	I	I
WTDO	C	I	C	Yes	I	I	I	I	I	I	I	I
WTEA	C	C	C	No	I	I	I,I	I,I	I,I	I,I	I	I
WTEB	I	I	C	No	I	I	I	I,I	I,I	I,I	I	I
WTEC	C	C	C	Yes	I	I	I	I	I	C,C	C	C
WTED	C	C	C	Yes	I	I	I,I	I,I	I,I,I,I	I,I,I,I,I	I,I	I,I
WTEE	C	C	C	No	I	I	I,I	I,I	I,I,I,I	I,I,I	I,I	I,I
WTEF	I	I	C	No	I	I	I	I,I	I	I	I	I
WTEG	C	I	C	Yes	C	C	I	C	C	I,I	I	I
WTEK	I	I	C	No	I	I	I	I	I	I,I	I	I
WTEO	C	I	C	Yes	I	I	I	I	I	I	I	I
WTEP	C	C	C	Yes	C	C	C	C	C,C	I,I,I,I,I	I	I
WTER	C	I	I	Yes	I	I	I,I,I	I,I,I	I,I,I	I,I,I	I,I	I,I
ZCYL5	C	C	C	Yes	C	C	C	C	C	C,C	C	C
ZMFR	C	I	C	No	I	I	I	I	I	I		

	RELATIVE WIND SPEED	RELATIVE WIND DIRECTION	TRUE WIND SPEED	TRUE WIND DIRECTION	AIR TEMP	DEW POINT TEMP	WET BULB TEMP	PRESSURE	RELATIVE HUMIDITY	PRECIP	RAIN RATE	LONG WAVE RADIATION	SHORT WAVE RADIATION	NET RADIATION	PHOTOSYNTHETICALLY ACTIVE RADIATION (PAR)
KAOU	C	C	C	C	C,C,C			C,C	C,C	C		C	C		C
KAQP	C,C	I,I	C,C	C,C	C,C			C,I	I,C	I,I	C,C	I	I		
KTDQ	C	C	C	C	C			C	C			C	C		C
NEPP	I,I,I	C,C,C	C,C,C	C,C,C	C,I,C,C			C,C	C,I,C			C	C		C
VLMJ	I,I,I	I,I,I	C,C,C	C,C,C	I,I			I	I,I	I,I		I,I	I,I		I,I
WARL	C,C	C,C	C,C	C,C	C,C			C,C	C,C	C,C	C,C	C	C		C
WBP3210	I,I	I,I	I,I	I,I	I			I	I			I	I		I
WCX7445	I,I	I,I	I,I	I,I	I			I	I			I	I		I
WDA7827	I,I,I	I,I,I	I,I,I	I,I,I	I,I			I,I	I,I	I,I	I,I				
WDC9417	I,I	I,I	I,I	I,I	C,I			C,C	C,I	I		I	I		I
WDD6114	I	I	I	I	I			I	I						
WDG7520	C,I,I	C,I,I	C,C,C	C,C,C	C,C			C,C	C,C			C	C		C
WSAF	C	C	C	C	C,C,C			C,C	C,C	C		C	C		C
WSQ2674	C	C	C	C	C,C			C,C	C			C	C		C
WTDF	I,I,I	I,I,I	I,I,I	I,I,I	I			C	I			C	C		
WTDH	C	I	C	C	C	C	C	C,C	C						
WTDL	I,I	I	I	I	I			I	I						
WTDO	I	I	I	I	I			I	I						
WTEA	I,I	I,I	I,I	I,I	I	I	I	I	I						
WTEB	I	I	I	I	I	I	I	I	I						
WTEC	C,C,I	I,I,I	C,C,I	C,C,I	C			C,C	C			C	C		
WTED	I,I,I	I,I,I	I,I,I	I,I,I	I	I	I	I,I,I	I			I	I		
WTEE	I	I	I	I	I			I,I	I						
WTEF	I	I	I	I	I	I	I	I	I						
WTEG	C,C	I,I	C,C	C,C	C			C,C	C			C	C		
WTEK	I	I	I	I	I			I	I						
WTEO	I	I	I	I	I			I	I						
WTEP	C,C,C	C,C,C	C,C,C	C,C,C	C			C,C	C			C	C		
WTER	I,I,I	I,I,I	I,I,I	I,I,I	I	I	I	I	I						
ZCYL5	C,C,C	C,C,C	C,C,C	C,C,C	C,C,C			C,C,C	C,C,C			C	C		C,C

Table 4: Vessel and parameter metadata overview. Only metadata valid as of the writing of this report is shown. "C" indicates complete metadata; "I" indicates incomplete metadata. Under "Digital Imagery," "Yes" indicates the existence of vessel/instrument imagery in the SAMOS database, "No" indicates non-existence. Empty boxes indicate non-existence of a parameter; multiple entries in any box indicate multiple sensors for that parameter and vessel.

5. Plans for 2022

As the SAMOS initiative continues its second decade, the SAMOS chairman would like to personally thank all the technicians, operators, captains, and crew of the SAMOS research vessels for their dedication to the project. In 2022, we continue to see the dedication of the vessel operators to provide high-quality underway observations in the face of restrictions brought on by the pandemic. The DAC team would also like to thank personnel within our funding agencies (see page 3), NOAA OMAO, NOAA NCEI, NOAA ESRL, Australian IMOS project, and the Schmidt Ocean Institute for their continued support of the SAMOS initiative.

The SAMOS DAC also recognizes an ongoing partnership with the Rolling deck To Repository (R2R; https://www.rvdata.us/) project. Funded by the National Science Foundation, R2R has developed procedures for transferring all underway data (navigation, meteorology, oceanographic, seismic, bathymetry, etc.) collected on U. S. University-National Oceanographic Laboratory System (UNOLS) research vessels to a central onshore repository. So far in 2022, the university-operated vessels contributing to the SAMOS DAC were those operated by WHOI, SIO, UA, UH, UW, and BIOS. The focus of the R2R is collecting and archiving the full-sampling-level (e.g., sampling rates up to 1 Hz) underway data at the end of each planned cruise, which are the source data for the 1-min averages submitted to SAMOS in daily emails. Over the next year, we will continue to collaborate with R2R and the team at Oregon State University leading the build of the Regional Class Research Vessels (RCRVs) to ensure that meteorological instrumentation installed on the RCRVs are well-exposed to the marine environment and provide high-quality SAMOS observations. We are also collaborating on establishing SAMOS data and metadata flow from the RCRVs and general best practices for underway science flow-through systems. We also plan to work with R2R to update our procedural documentation and revise our metadata forms and instructions.

Over the next year, we also will continue to retool the SAMOS data ingestion and processing system to take full advantage of the 5th version of NOAA's Scientific Computer System (SCS) software. The big advancement is that we will be receiving daily device metadata XMLs in addition to the daily SAMOS data exchange files. This will allow the SAMOS team to automatically update our device metadata profile when changes are discovered and ensure the metadata are properly linked to the observations in the SAMOS netCDF files. As with any new software, there are ongoing "growing pains," and we are working with the NOAA technicians and developers to debug SCS5. We note that a similar daily device metadata XML is being used by OSU as part of the RCRV data acquisition system, and we plan to run a prototype SAMOS metadata ingestion process for the R/V *Taani*, the first RCRV currently being built.

We also plan to meet virtually with as many operators providing SAMOS observations in 2022 to review and update their respective instrumental metadata and to discuss any questions the operators may have regarding meteorological sensor selection, placement, etc. We found in 2021 that frequent dialog with the operators results in fewer data problems and the up-to-date metadata benefits both the SAMOS team for our quality evaluation and the downstream data users.

6. References

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Smith, S. R., and J. Elya: 2015. Procedure for placing hourly super-observations from the Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative into ICOADS**.** COAPS, Tallahassee, FL, USA, 34 pp. Available from Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, Florida, 32306-2840, USA and online at http://icoads.noaa.gov/e-doc/other/transpec/samos/SAMOS_RVtoIMMAprocedure_v2p1.pdf.

Smith, S. R., J. J. Rolph, K. Briggs, M. A. Bourassa, 2009: Quality-Controlled Underway Oceanographic and Meteorological Data from the Center for Ocean-Atmospheric Predictions Center (COAPS) - Shipboard Automated Meteorological and Oceanographic System (SAMOS). National Oceanographic Data Center, NOAA. Dataset. doi:10.7289/V5QJ7F8R

Ship schedule references, publicly available only:

IMOS data availability is found online at http://opendap.bom.gov.au:8080/thredds/catalog/imos_samos_archive/catalog.html (*Investigator* and *Tangaroa)*

R2R vessels are found online at http://www.rvdata.us/catalog (*Falkor*)

UNOLS vessels are found online at https://strs.unols.org/public/search/diu_all_schedules.aspx?ship_id=0&year=2020 (most other non-NOAA vessels)

Annex A: Notifications and Data Subsets with Verified Issues, Unflagged or Only Partially Flagged (listed by vessel)

The vessels listed here do not receive visual quality control. As such, this compilation relies almost entirely on notifications sent to the DAC by vessel operators or email exchanges initiated by the DAC; in many cases the exact cause of any issues and/or the exact date range under impact are unknown.

Atlantic Explorer:

- 13 July 2:00-6:00 UTC: when negative PL_WSPD (B-flagged) observed SPD may also be suspect; use SPD with caution.
- 15 July 2:30 UTC: negative PL_WSPD (B-flagged) observed, SPD may also be suspect; use SPD with caution.
- The following known dates/times, as reported by ship personnel, document flow water system pump operation activity; TS, TS2, TS3, TS4, SSPS, SSPS2, CNDC, CNDC2 should not be used during known periods when pump was off (all times GMT):
    - pump turned on: 1126 July 22nd
    - pump turned off: 1315 July 22nd, pump turned on: 1320 July 22nd
    - pump turned off: 1608 July 22nd, pump turned on: 1613 July 22nd
    - pump turned off: 1619 July 22nd, pump turned on: 1814 July 22nd
    - pump turned off: 1905 July 23rd, pump turned on: 1955 July 23rd
    - pump turned off: 1842 July 24th, pump turned on: 1946 July 24th
    - pump turned off: 1849 July 25th, pump turned on: 1937 July 25th
    - pump turned off: 1850 July 26th, pump turned on: 0213 July 27th
    - pump turned off: 0342 July 27th, pump turned on: 0606 July 27th
    - pump turned off: 1332 July 27th, pump turned on: 1338 July 27th
    - pump turned off: 1232 July 29th, pump turned on: 1235 July 29th
    - pump turned off: 1320 July 30th, pump turned on:1323 July 30th
    - pump turned off: 1302 July 31st, pump turned on: 1306 July 31st
    - pump turned off: 1756 August 1st
- 11 August ~12:00-13:45 UTC: flow water system assumed off while vessel in port; TS, TS2, TS3, TS4, SSPS, SSPS2, CNDC, CNDC2 should not be used.
- 15 August prior to ~12:00 UTC: flow water system assumed off while vessel in port; TS, TS2, TS3, TS4, SSPS, SSPS2, CNDC, CNDC2 should not be used.
- 18 August prior to ~11:30 UTC: flow water system assumed off while vessel in port; TS, TS2, TS3, TS4, SSPS, SSPS2, CNDC, CNDC2 should not be used.
- 4 October ~10:30-11:30 UTC: flow water system assumed off while vessel in port; TS, TS2, TS3, TS4, SSPS, SSPS2, CNDC, CNDC2 should not be used.

- 19 November ~12:00-17:00 UTC: flow water system assumed off while vessel in port; TS, TS2, TS3, TS4, SSPS, SSPS2, CNDC, CNDC2 should not be used.

Atlantis:

- ~1600 UTC 11 August – 19 August (probably later): flowthrough system assumed off while approaching/in port; TS2, CNDC, SSPS should not be used.
- ~1230-2359 UTC 14 November: flowthrough system assumed off while pulling into port; TS2, CNDC, SSPS should not be used.
- ~1330 UTC 26 November – end date unknown: flowthrough system assumed off while approaching/in port; TS2, CNDC, SSPS should not be used.

Healy:

- 1719 UTC 19 July – 1615 UTC 21 July: anemometer rotated 180 degrees out; DIR, SPD, PL_WDIR, PL_WSPD data all suspect.
- 23-24 July: water wall beta testing; hourly data spikes in TS, SSPS, CNDC should be filtered.
- 10-17 August: unknown issue, spikes in T, T2, T3 should not be used.
- 26 August – 4 September: unknown issue, T3 should be considered highly suspect (use T, T2 instead).
- Entire 2021 cruise season: slight calibration error, RH should only be used with caution.
- Entire 2021 cruise season: times received by SAMOS may be off by several minutes because of a server switch and loss of access to the time servers. Data should be used with caution if precise timing down to the minute is important to your application.

Investigator:

- 28 January - 9 February: ISAR radiometer instrument faulty; TS2 should not be used.
- 28 January - end date unknown (sometime after 9 February): Flow of water @ intake impacted by drop keel position (drop keel depth = 0 m); TS suspect.
- 24 February ~0300 UTC - 25 February ~1500 UTC: issue unknown, PL_WSPD and SPD should not be used.

Kilo Moana:

- 12 April - end date unknown: disagreement between PRECIP2 and RRATE frequently observed; data should be considered highly suspect.
- 21 August - 27 September (probably later): underway flow issue exists; SSPS data may require smoothing before use.

Laurence M. Gould:

- ~1200 UTC 2 May - ~16 June: large (2+ mb) minute-to-minute swings in P should be considered highly suspect.
- 31 May (possibly earlier) - ~0845 UTC 23 December: RAD_PAR may be suspect (high), use with caution.

- 16 June - 5 July (possibly later): flowthrough pump assumed off while vessel in port; SSPS, and CNDC should not be used.
- 10 August (likely earlier) - 19 August (possibly later): flowthrough system assumed off while vessel in port; SSPS and CNDC should not be used, TS should be considered suspect.
- ~October - (next port call, date unknown): water confirmed in barometer tubing; P should be considered suspect, especially any large (1-2+ mb) minute-to-minute swings.
- ~0845 UTC 23 December - ~1300 UTC 27 December: RAD_PAR sensor failure, data should not be used.

Nathaniel B. Palmer:

- ~1545 UTC 8 January - end date unknown: flowthrough system assumed turned off when vessel entered Chilean EEZ; TS, SSPS, CNDC should not be used.
- Unknown start date (probably in spring) - unknown end date: negative drift observed in nighttime RAD_SW data; data may be suspect, use with caution.
- ~1600 UTC 3 July - ~1830 6 July: all data static; no data should be used.
- ~2230 UTC 5 October - end date unknown: flowthrough system assumed turned off while vessel was in port; TS, SSPS, and CNDC should not be used.

Neil Armstrong:

- ~1430 UTC 21 April - ~1700 UTC 23 April: TSG data collection assumed halted while vessel in port; SSPS, CNDC should not be used.
- ~2230 UTC 25 April - ~2000 UTC 26 April: TSG data collection assumed halted while vessel in port; SSPS, CNDC should not be used.
- 16 June – 17 June (probably later): TSG data collection assumed halted while vessel in port; SSPS, CNDC should not be used.
- ~1315-2359 UTC 2 July: TSG data collection assumed halted while vessel in port; SSPS, CNDC should not be used.
- ~1300 UTC 19 July - ~1400 UTC 28 July: MET tower lowered; all variables suspect.
- ~2000 UTC 4 October – end date unknown (possibly 8 October): TSG data collection assumed halted while vessel in port; SSPS, CNDC should not be used.
- 0000-1330 UTC 8 October: TSG data collection assumed halted while vessel in port; SSPS, CNDC should not be used.

Robert Gordon Sproul:

- ~1500 UTC 23 February - ~1300 UTC: T/RH instrument failure; data should not be used.
- 20 April - end date unknown: flowthrough system assumed turned off while vessel was in port; TS, SSPS, and CNDC should not be used.
- 14-22 May: pump to thermosalinograph confirmed off; TS2, SSPS, and CNCD should not be used.
- 16 June - 5 July (possibly later): flowthrough system assumed turned off while vessel was in port; TS2, SSPS, and CNDC should not be used.

- 10 August (probably earlier) - 19 August (possibly later): flowthrough system assumed turned off while vessel was in port; TS2, SSPS, and CNDC should not be used.
- Unknown start date (but by 1 October) - ~1700 UTC 9 October: flowthrough system assumed turned off while vessel was in port; TS2, SSPS, and CNDC should not be used.
- ~2345 UTC 9 October - ~1515 UTC 10 October: flowthrough system assumed turned off while vessel was in port; TS2, SSPS, and CNDC should not be used.
- 17-21 December: pump to thermosalinograph suspected off while underway; TS2, SSPS, and CNCD should not be used.

Roger Revelle:

- 12-19 February: TSG pumps secured; TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.
- 24 March - ~1700 UTC 28 March: TSG pumps secured; TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.
- ~700 UTC 21 April - end date unknown: TSG pumps secured; TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.
- 5-20 May: bow intake pump off; TS, SSPS, CNDC data should not be used.
- 21-23 May: numerous spikes in data from bow TSG (cause indeterminate); TS, SSPS, CNDC data should be filtered before use.
- 1 July - 5 July (probably later): flowthrough system assumed off while vessel in port; TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.
- 17 July – 6 November: T3 confirmed erroneous, data should not be used.
- ~1700 UTC 13 August – 19 August (probably later): flowthrough system assumed off while vessel in port; TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.
- 18 September - ~1820 UTC 22 September: TSG pumps secured; TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.
- 23 September - 6 November: bias noted between thermosalinographs; SSPS, SSPS2, CNDC, CNDC2 should be treated as suspect (use only with extreme caution).

Sally Ride:

- ~100-1300 UTC 16 June: flowthrough pumps suspected cycled on/off multiple times during short transit; TS, TS2, SSPS, SSPS2, CNDC, CNDC considered suspect.
- ~1800 UTC 17 June - end date unknown: flowthrough pumps assumed off while in port; TS, TS2, SSPS, SSPS2, CNDC, CNDC should not be used.
- 22 June - 9 July: Likely protracted period of eventual instrument failure; any unflagged T2/RH should be considered suspect, any G-flagged T2/RH should be considered highly suspect or erroneous.
- ~1400 UTC 16 August - 18 August (possibly later): flowthrough pumps assumed off while in port; TS, TS2, SSPS, SSPS2, CNDC, CNDC should not be used.

- ~0445-1545 UTC 3 September: flowthrough pumps assumed off; TS, TS2, SSPS, SSPS2, CNDC, CNDC should not be used.
- ~0300-1600 UTC and ~0800-0930 20 September: flowthrough pumps assumed off; TS, TS2, SSPS, SSPS2, CNDC, CNDC should not be used.
- ~1400 UTC 30 September - ~2100 UTC 2 October: flowthrough pumps assumed off while in port; TS, TS2, SSPS, SSPS2, CNDC, CNDC should not be used.
- ~0500 UTC 4 October - 0100 UTC 5 October: flowthrough pumps assumed off while in port; TS, TS2, SSPS, SSPS2, CNDC, CNDC should not be used.
- ~0500 UTC 6 October - 0330 UTC 7 October: flowthrough pumps assumed off while in port; TS, TS2, SSPS, SSPS2, CNDC, CNDC should not be used.
- ~0500-2330 UTC 8 October: flowthrough pumps assumed off while in port; TS, TS2, SSPS, SSPS2, CNDC, CNDC should not be used.
- After ~0500 UTC on 10 October: flowthrough pumps assumed off while in port; TS, TS2, SSPS, SSPS2, CNDC, CNDC should not be used.
- 5, 7, 13, 21 October: steps noted in SPD, P, P2; step data should be considered suspect.
- 22-29 November: pumps likely secured for EEZ; TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.
- ~0600-0900 UTC 30 December: pumps secured for EEZ; TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.

Sikuliaq:

- 12-13 September: port and starboard anemometers iced over; PL_WSPD2, PL_WDIR2, SPD2, DIR2, PL_WSPD3, PL_WDIR3, SPD3, and DIR3 data should not be used.
- 1 October (probably earlier) - 8 October: radiometric SST likely pointed at the dock; TS2 data should be considered highly suspect.

Tangaroa:

- 13 November - end date unknown: “shark fin” curve observed in TS, flow water system assumed off; TS should not be used.

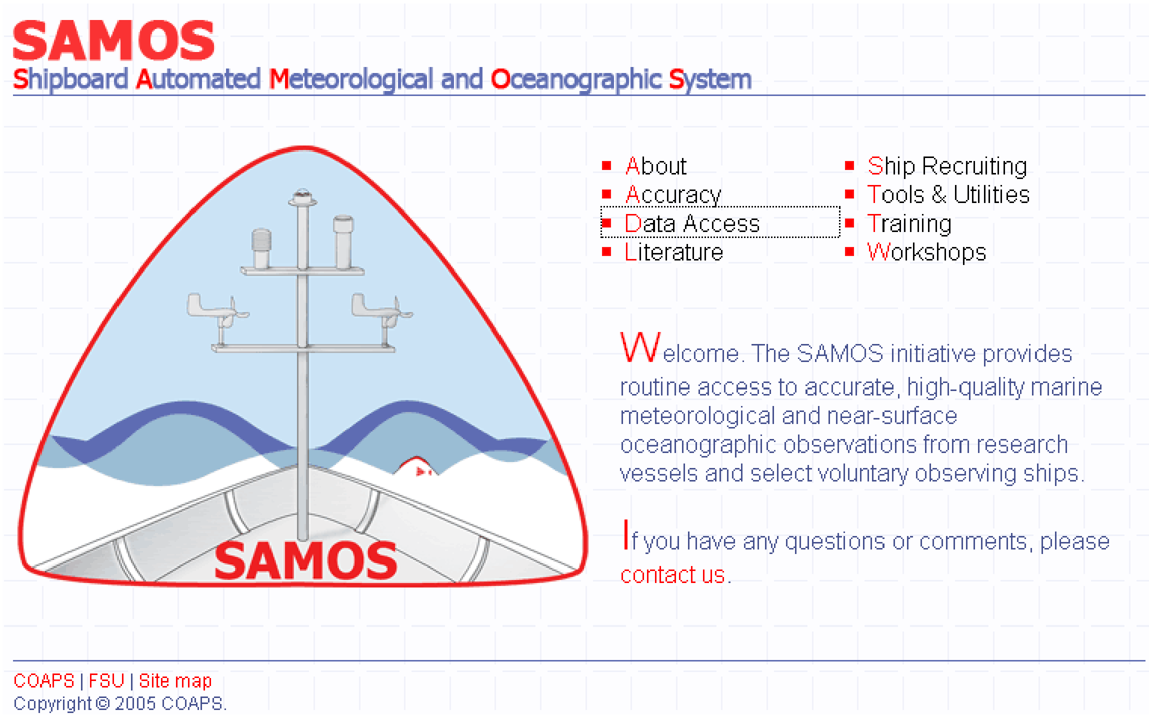
T.G. Thompson:

- 4 April - 8 July: SPP radiometer suspect; use RAD_SW with caution.
- Unknown start data - ~2230 UTC 10 August: flowthrough system assumed off while in port; TS, TS2, SSPS, CNDC should not be used.
- ~1330 UTC 16 August - ~1900 UTC 19 August: flowthrough system assumed off while in port; TS, TS2, SSPS, CNDC should not be used.

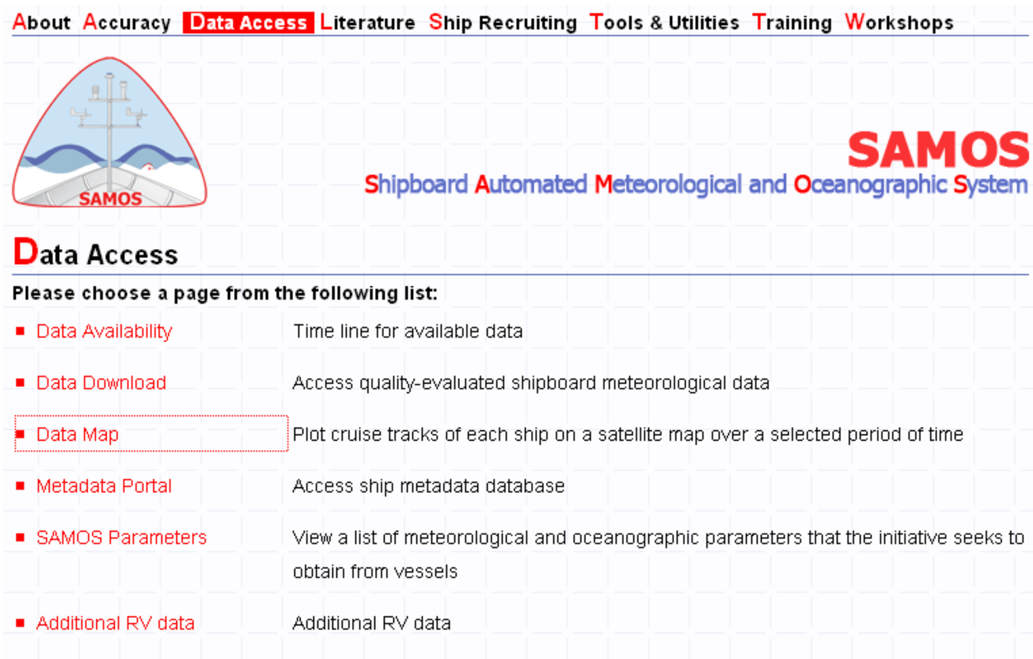
Annex B: SAMOS Online Metadata System Walk-through Tutorial

PART 1: the end user

The SAMOS public website can be entered via the main page at
http://samos.coaps.fsu.edu/html/



By choosing the Data Access link (boxed area), the user can access preliminary, intermediate, and research-quality data along with graphical representations of data availability and quality. As an example, consider the user who wants to find 2009 in situ wind and temperature data for the north-polar region. The first step would be to identify which ships frequented this area in 2009. To do so, choose Data Map on the Data Access page:



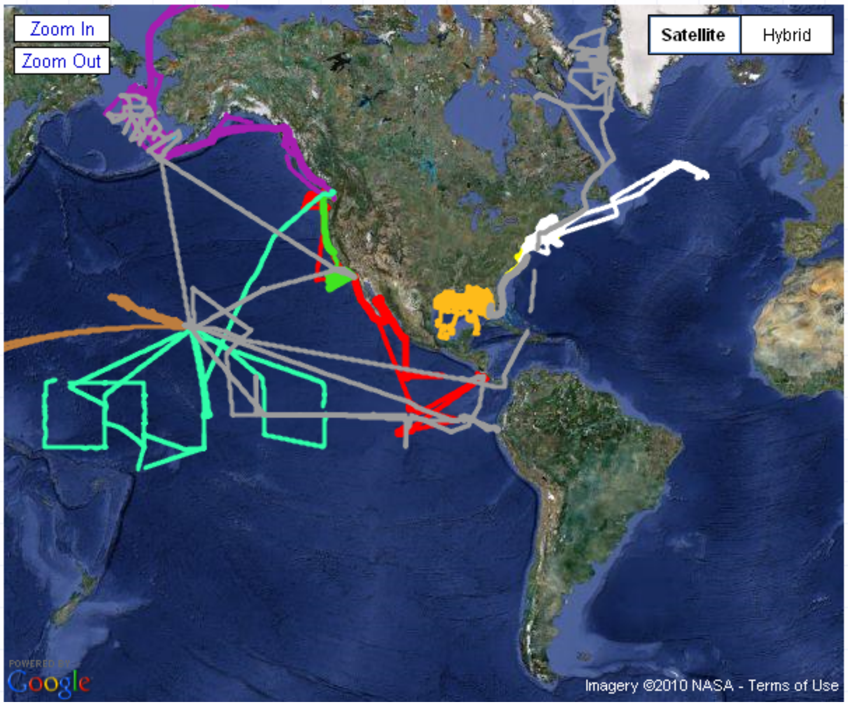
The user highlights a set of ships from the available list (10 ships may be chosen at a time):

By entering a date range of January 1, 2009 to December 31, 2009 and clicking "search," a map is displayed showing all the selected ship's tracks for the year 2009:

Data Map

The purpose of this page is for the user to select ships and date ranges. Then, using Google maps, a track of the ship(s) will be displayed for the selected dates. To view the tracks of other ships or dates, click here. To learn more about the map and ship tracks, please read the documentation.

January 1, 2009 - December 31, 2009



Ship Key	
Atlantis	☑
David Star Jordan	☑
Delaware Ii	☑
Fairweather	☑
Gordon Gunter	☑
Healy	☑
Henry B. Bigelow	☑
Hi'ialakai	☑
Ka'imimoana	☑
Knorr	☑

Map Controls	
On / Off	☑

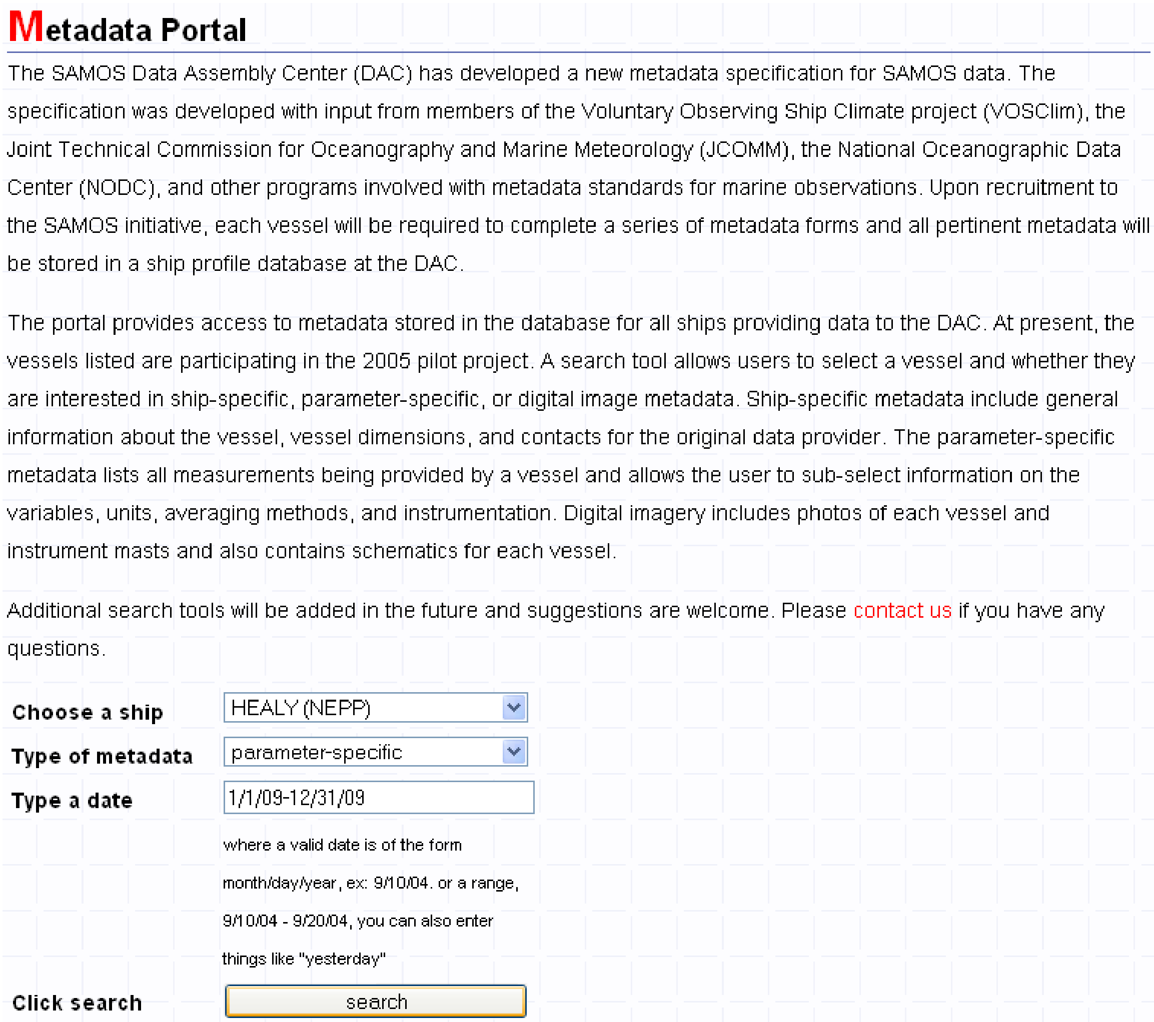
Now the user can see that both the *Healy* and the *Knorr* cruised in the north-polar region in 2009. The next step might be to see what parameters are available on each ship. Returning to the Data Access page, the user this time selects the Metadata Portal:

Data Access

Please choose a page from the following list:

▪ Data Availability	Time line for available data
▪ Data Download	Access quality-evaluated shipboard meteorological data
▪ Data Map	Plot cruise tracks of each ship on a satellite map over a selected period of time
▪ Metadata Portal	Access ship metadata database
▪ SAMOS Parameters	View a list of meteorological and oceanographic parameters that the initiative seeks to obtain from vessels
▪ Additional RV data	Additional RV data

and first inputs the proper information for the *Healy*:



Metadata Portal

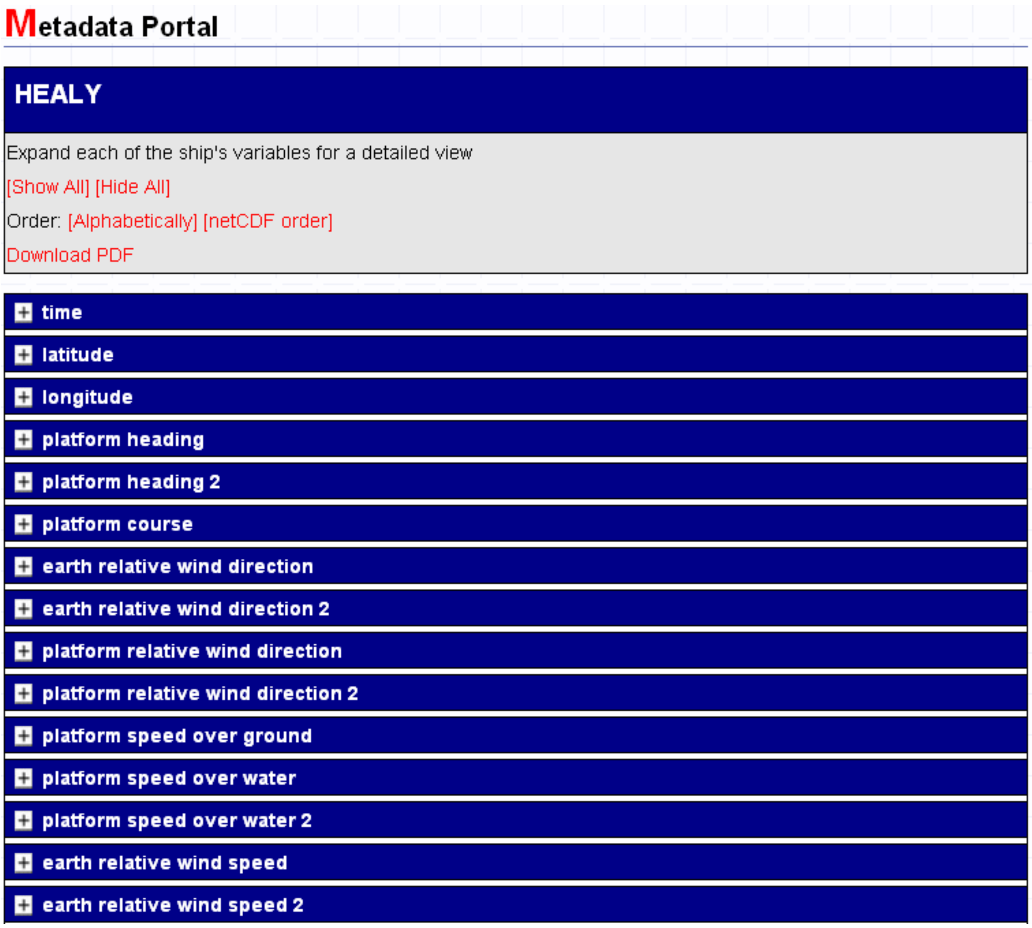
The SAMOS Data Assembly Center (DAC) has developed a new metadata specification for SAMOS data. The specification was developed with input from members of the Voluntary Observing Ship Climate project (VOSClim), the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), the National Oceanographic Data Center (NODC), and other programs involved with metadata standards for marine observations. Upon recruitment to the SAMOS initiative, each vessel will be required to complete a series of metadata forms and all pertinent metadata will be stored in a ship profile database at the DAC.

The portal provides access to metadata stored in the database for all ships providing data to the DAC. At present, the vessels listed are participating in the 2005 pilot project. A search tool allows users to select a vessel and whether they are interested in ship-specific, parameter-specific, or digital image metadata. Ship-specific metadata include general information about the vessel, vessel dimensions, and contacts for the original data provider. The parameter-specific metadata lists all measurements being provided by a vessel and allows the user to sub-select information on the variables, units, averaging methods, and instrumentation. Digital imagery includes photos of each vessel and instrument masts and also contains schematics for each vessel.

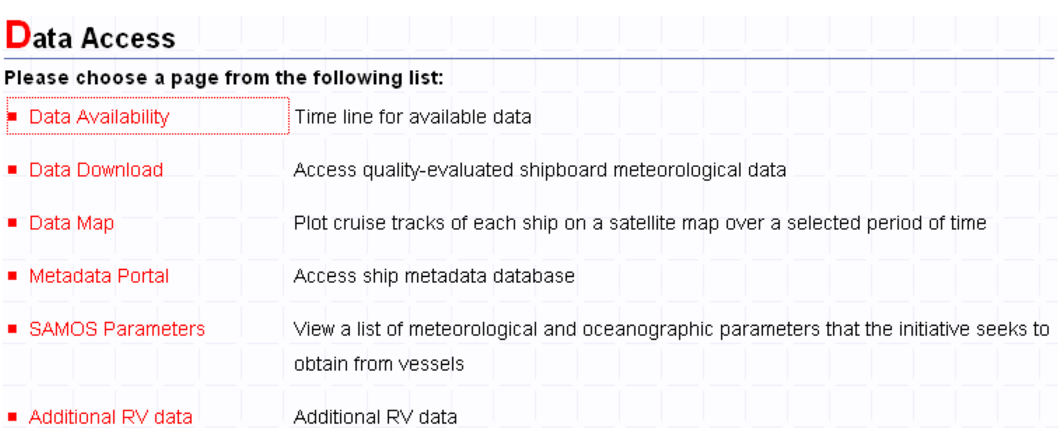
Additional search tools will be added in the future and suggestions are welcome. Please contact us if you have any questions.

Choose a ship	HEALY (NEPP)
Type of metadata	parameter-specific
Type a date	1/1/09-12/31/09
	where a valid date is of the form month/day/year, ex: 9/10/04. or a range, 9/10/04 - 9/20/04, you can also enter things like "yesterday"
Click search	search

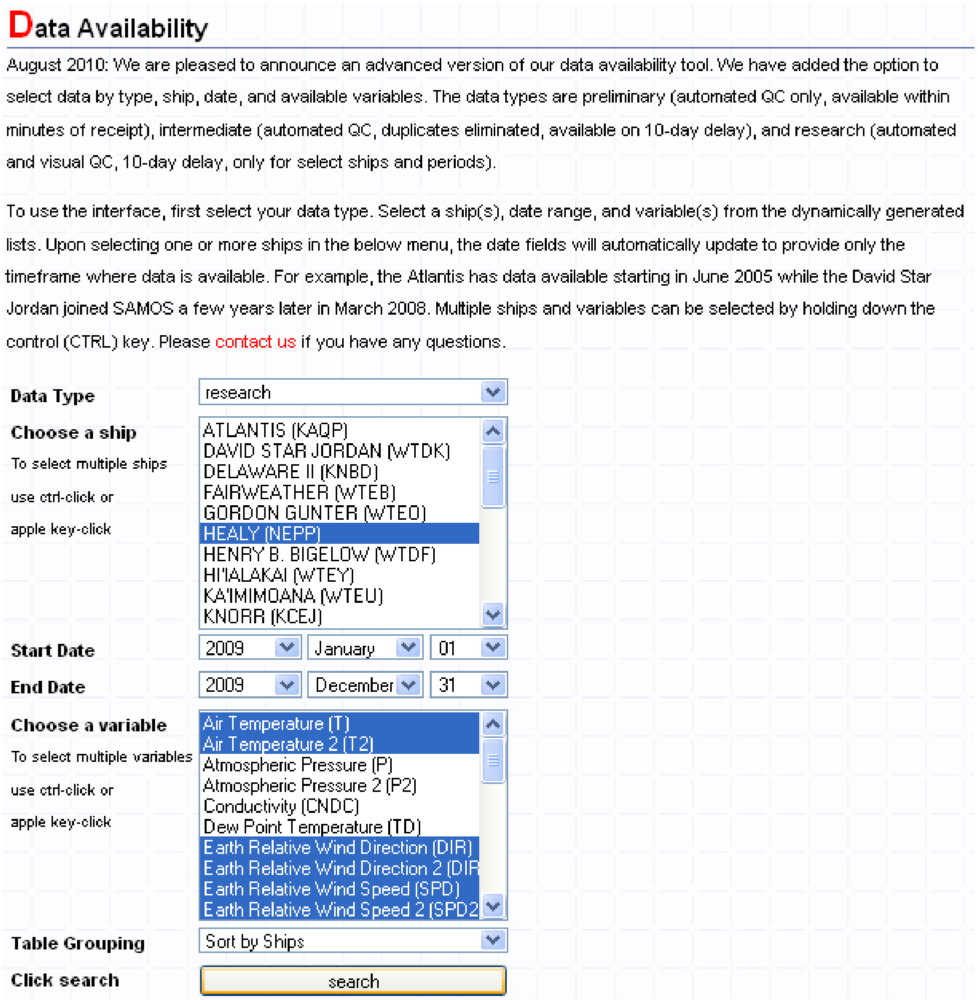
The result, once "search" is clicked, is an exhaustive list of all parameters available from the *Healy* in 2009:



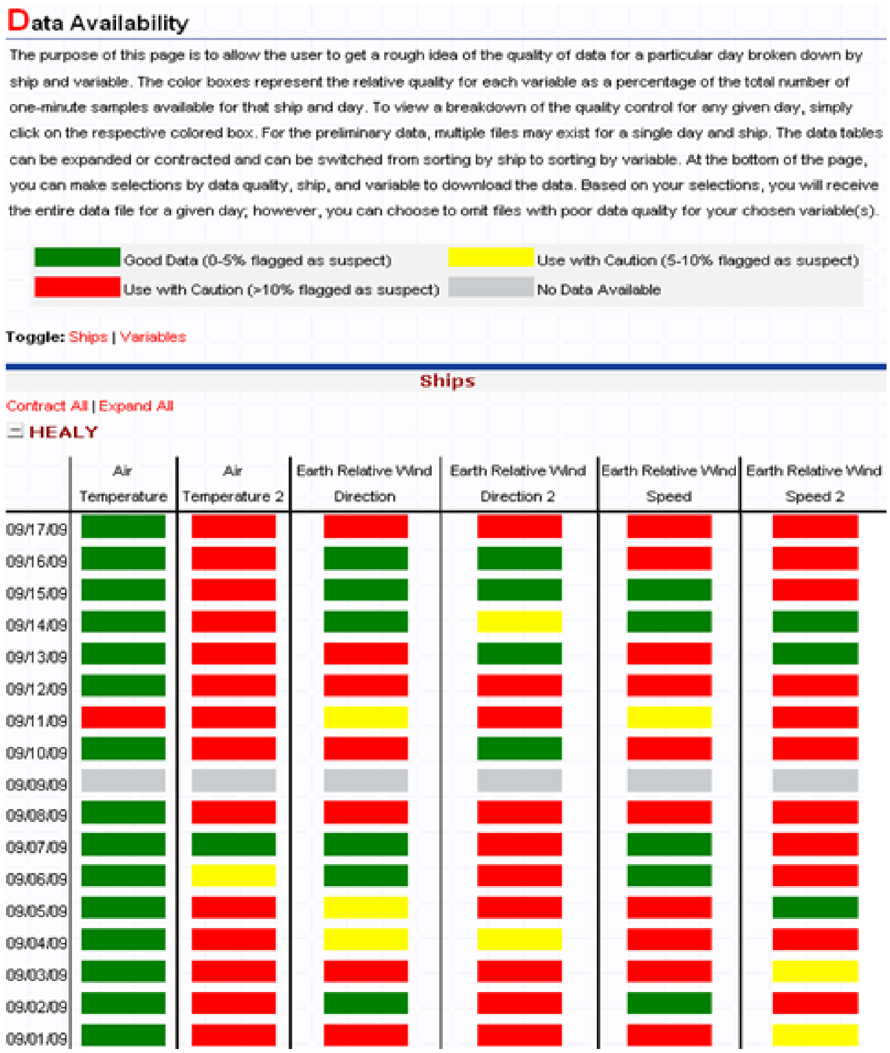
A thorough investigation of the list (note: image is truncated) tells the user the *Healy* did in fact provide both wind and temperature data in 2009. (Throughout the online SAMOS system, clicking on a "+" will yield further information; in this case the result would be metadata for the individual parameters.) Now the user will want to know the quality of the wind and temperature data. To find that, he returns once again to the Data Access page and this time chooses Data Availability:



After selecting the *Healy* along with the desired parameter(s), date range, and data version (preliminary, intermediate, or research), noting that the default date range and available parameters will change once a vessel and data version are selected, and then clicking "search":



the user arrives at a timeline showing on which days in 2009 the Healy provided data for the chosen parameter(s), as well as the quality of that data for each calendar day (note: image has been customized):



Color-coding alerts the user to the perceived quality of the data. As explained in the key at the top of the page, green indicates "Good Data" (with 0-5% flagged as suspect), yellow indicates "Use with Caution" (with 5-10% flagged as suspect), and red indicates a more emphatic "Use with Caution" (with >10% flagged as suspect). A grey box indicates that no data exists for that day and variable. In this case, the user can automatically see that on 09/07/09 all the *Healy's* temperature data and the winds from the first wind sensor are considered "Good Data." More detailed flag information, as well as information pertaining to all other available parameters, can be found by simply clicking on any colored box. As an example, by clicking over the red bar for DIR2 on the date 09/07/09 a user can find out more specific information about data quality to determine whether the wind data might also be useful. When the red bar is clicked, the user is first directed to a pie chart showing overall quality:

Data Download w/ Daily QC Statistics

This page contains interactive graphics which, will not work correctly unless your web browser has Macromedia Flash Player 6 or later installed. These graphics respond to mouse clicks on either the pie chart itself or the legend. In some situations once a chart is "drilled down" the only way to return to that level is to use the chart navigation links. For example, once the intial graph, failed qc vs passed qc, is drilled down the only ways of returning to it is by using the chart navigation or by refreshing the page.

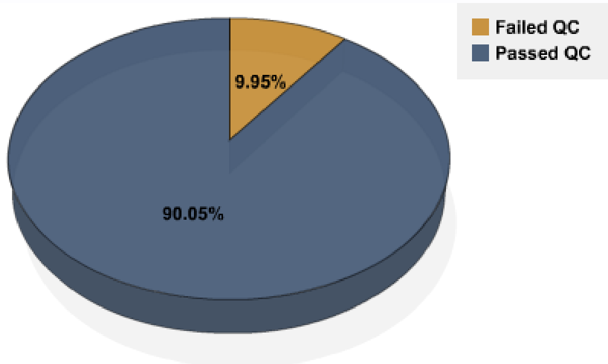
09-07-2009

HEALY

☐ select all

☐ File download | view file

Chart Navigation failed qc vs passed qc | flag distribution | a-y flags | z flags



Compression: .tar.gz

Download selected

Clicking over the yellow pie slice showing the percentage of data that failed quality control yields a more in-depth look:

Data Download w/ Daily QC Statistics

This page contains interactive graphics which, will not work correctly unless your web browser has Macromedia Flash Player 6 or later installed. These graphics respond to mouse clicks on either the pie chart itself or the legend. In some situations once a chart is "drilled down" the only way to return to that level is to use the chart navigation links. For example, once the intial graph, failed qc vs passed qc, is drilled down the only ways of returning to it is by using the chart navigation or by refreshing the page.

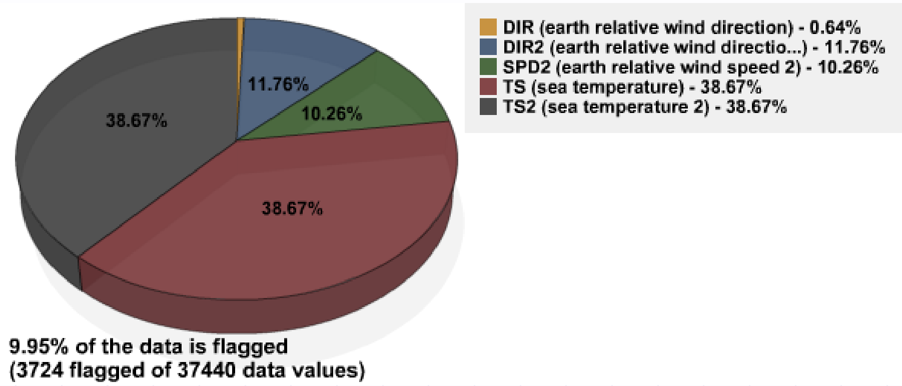
09-07-2009

HEALY

☐ select all

☐ File download | view file

Chart Navigation failed qc vs passed qc | flag distribution | a-y flags | z flags



Compression: .tar.gz

Download selected

The user can now check to see precisely what types of flags were applied to the second wind sensor data, as only a portion of the data were flagged and they may still be usable. By clicking on either the blue pie slice for "DIR2" or the "DIR2" line in the grey box, he determines that "caution" flags were applied to a portion of the data:

Data Download w/ Daily QC Statistics

This page contains interactive graphics which, will not work correctly unless your web browser has Macromedia Flash Player 6 or later installed. These graphics respond to mouse clicks on either the pie chart itself or the legend. In some situations once a chart is "drilled down" the only way to return to that level is to use the chart navigation links. For example, once the intial graph, failed qc vs passed qc, is drilled down the only ways of returning to it is by using the chart navigation or by refreshing the page.

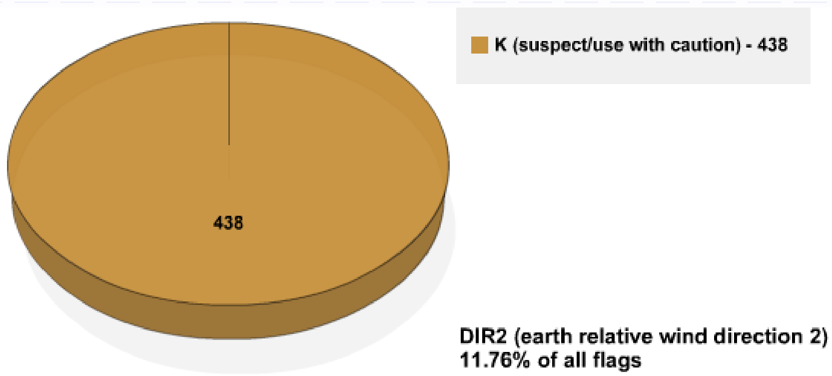
09-07-2009

HEALY

☐ select all

☑ File   download | view file

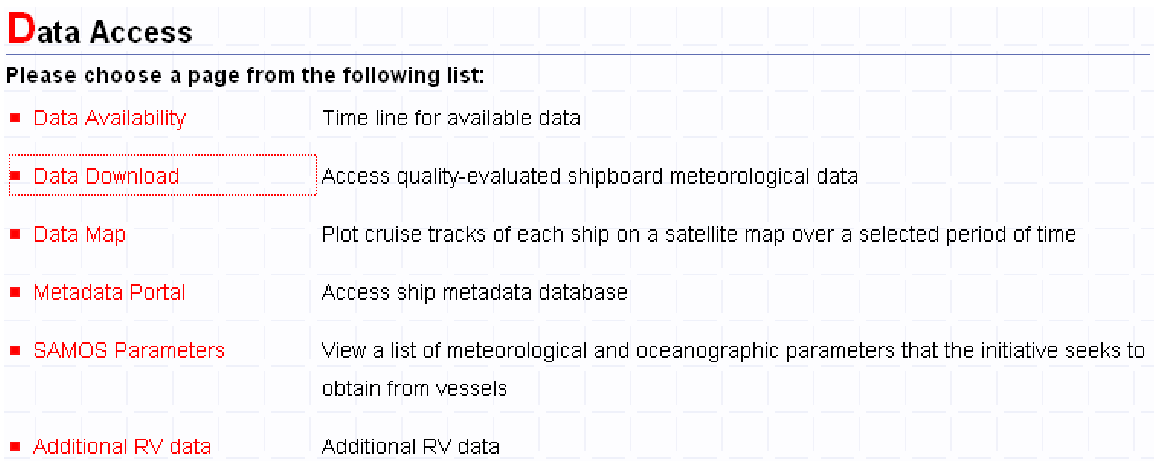
Chart Navigation   failed qc vs passed qc | flag distribution | a-y flags | z flags



Compression: .zip

Download selected

In this example, the user might repeat these steps to evaluate the quality of "SPD2" for 09/07/09. In the end, perhaps he decides the second wind sensor data will also be useful to him and now he would like to download the data. There are a couple of ways to accomplish this: By toggling a check mark in the "File" box (as shown above) and choosing the preferred file compression format (".zip" in this case) on this or any of the pie chart pages, the 09/07/09 file containing all available parameters for that date is downloaded once "Download selected" is clicked. (Note that the entire file must be downloaded; individual parameters are not available for singular download at this time.) Alternatively, the user can return to the Data Access page and choose Data Download, where he will have an opportunity to download multiple files at one time:



Let us assume that, after careful consideration of the quality of wind and temperature data from the *Healy* for the period from 09/07/09 to 09/11/09, the user decides he would like to download all available data from that period. By filling in the proper information on the Data Download page:

the user can choose "select all," along with a file compression format, and click "Download selected" to begin the download:

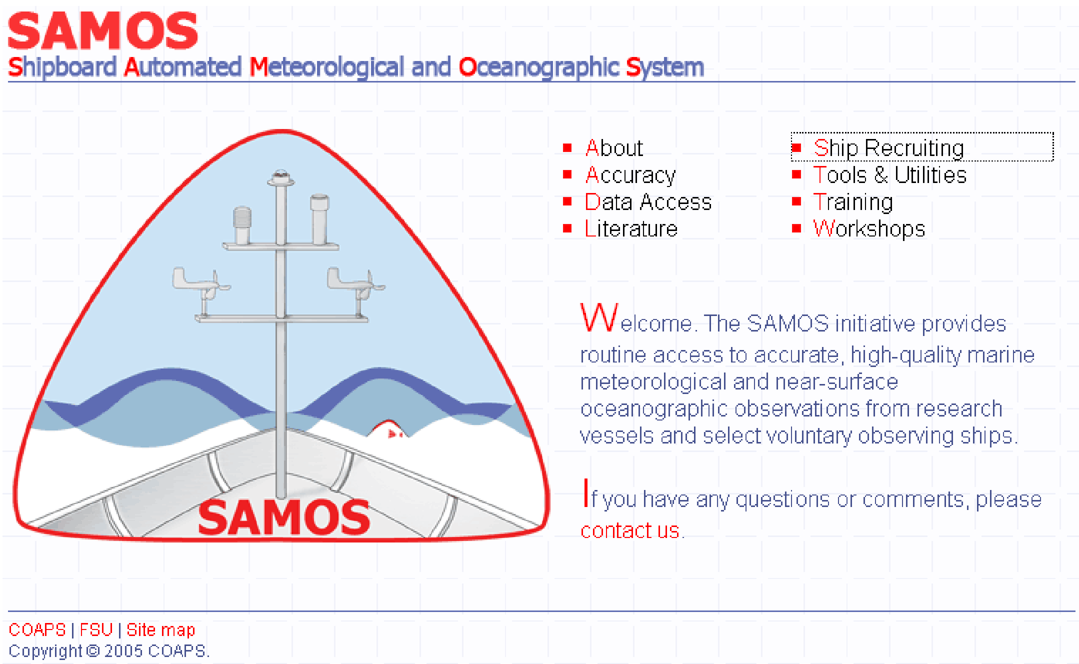
PART 2: the SAMOS operator

(NOTE: a step-by-step example created by a shipboard technician, suitable for saving and generalizing to any SAMOS instrument metadata change, follows this summary)

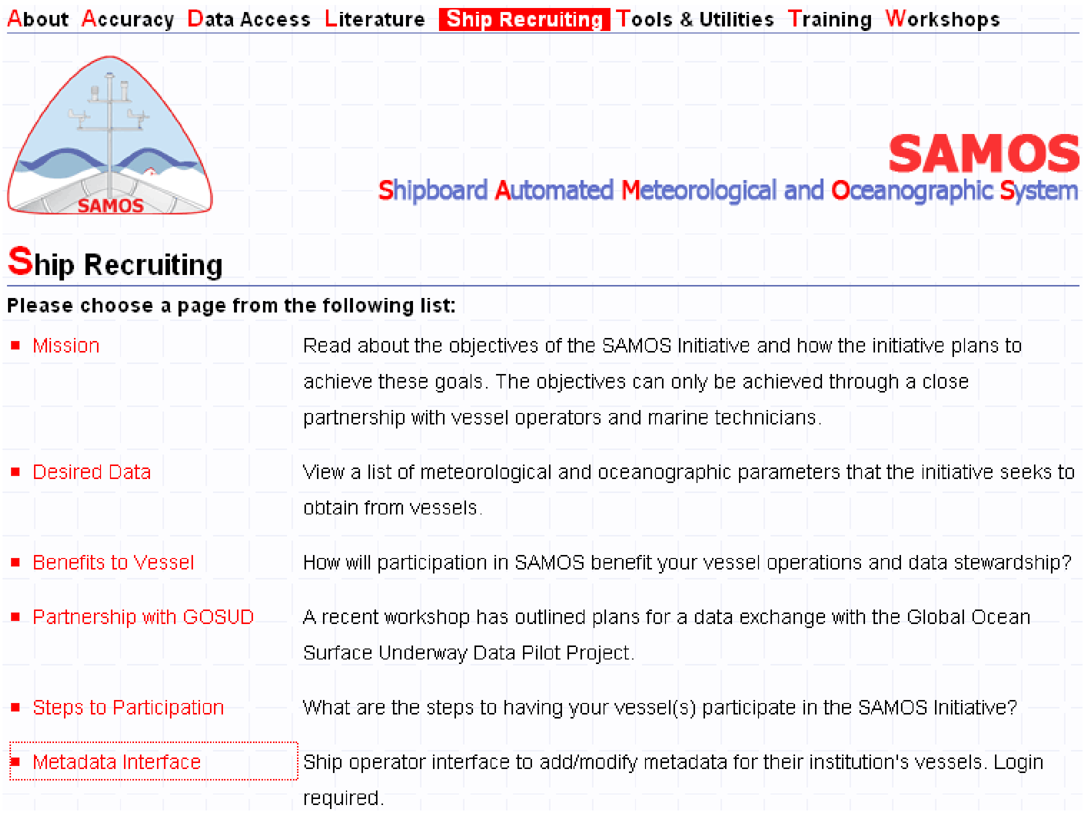
A SAMOS operator might choose to follow the steps outlined in part one as a simple way to keep tabs on the performance of his instruments. When problems are observed, vessel and instrument metadata are important tools for diagnosing a problem and finding a solution. For this reason, we strongly emphasize the need for complete, accurate, up-to-date information about the instruments in use. Digital imagery of the ship itself and of the locations of instruments on the ship is also highly desirable, as it is often beneficial in diagnosing flow obstruction issues. As a SAMOS operator, it is important to note that metadata (vessel and/or instrument) should be updated whenever new instruments are added or changes are made to existing instruments (for example moving an instrument or performing a calibration). Inputting and modifying both vessel and instrument metadata are easy tasks that the SAMOS operator can perform via the internet at any time, provided the ship exists in the database and has been assigned "original time units" by a

SAMOS associate at COAPS. In order to use the online system, the SAMOS operator will need to be assigned a unique login and password for his ship, which is obtained by contacting samos@coaps.fsu.edu. With a login and password in hand, the following steps outline the methods for inputting and updating metadata.

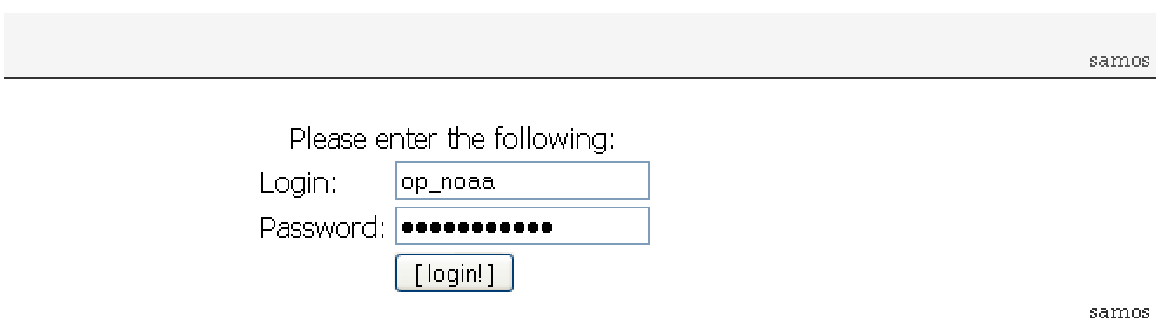
The database can be accessed by visiting the main page and choosing Ship Recruiting:



(or by navigating directly to the Ship Recruiting page, located at http://samos.coaps.fsu.edu/html/nav.php?s=4), and then choosing Metadata Interface:



The user will then be directed to log in, using their group's username and password (please contact samos@coaps.fsu.edu to obtain a username or for misplaced passwords):



Once logged in, the SAMOS operator chooses to modify either Vessel or Instrument Metadata..

a. Select Vessel Metadata

user ship related

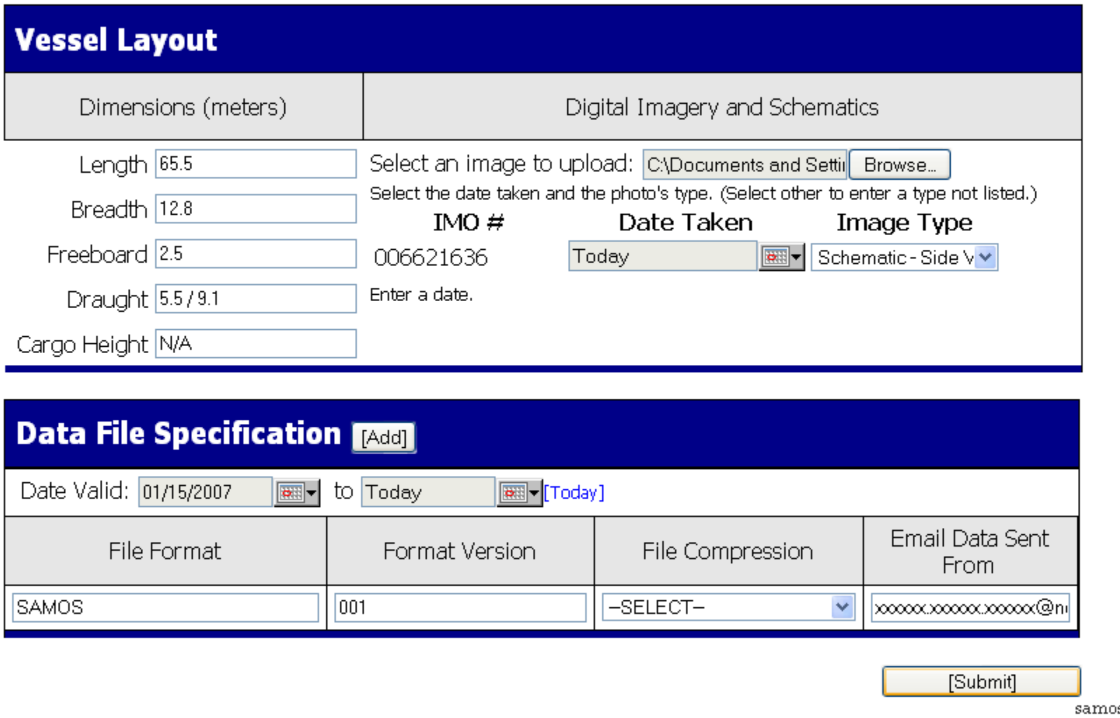
Edit Metadata

Ships for user op_noaa:

Ship Name	Call Sign	Vessel Metadata	Instrument Metadata
DAVID STAR JORDAN	WTDK	[modify]	[modify]
FAIRWEATHER	WTEB	[modify]	[modify]
GORDON GUNTER	WTEO	[modify]	[modify]
HENRY B. BIGELOW	WTDF	[modify]	[modify]
HI'IALAKAI	WTEY	[modify]	[modify]
KA'IMIMOANA	WTEU	[modify]	[modify]
MILLER FREEMAN	WTDM	[modify]	[modify]
NANCY FOSTER	WTER	[modify]	[modify]
OSCAR DYSON	WTEP	[modify]	[modify]
RAINIER	WTEF	[modify]	[modify]
RON BROWN	WTEC	[modify]	[modify]

samos

This metadata form provides Vessel Information (such as call sign and home port location), Contact Information for the home institution and shipboard technicians (as well as any other important persons), Vessel Layout, which details ship dimensions and allows for the uploading of digital imagery, and Data File Specification, which refers to the file format and file compression associated with SAMOS data transmission. On this page, all an operator would need to do is fill in the appropriate information and click "submit." For example, let us assume operator op_noaa desires to add a digital image to his vessel's metadata. Assuming the desired image is located on his native computer, he would merely need to click "Browse" to find the image he wants, fill in a Date Taken (if known) and choose an Image Type from the dropdown list, and then click "Submit" at the bottom of the page:



When editing Vessel Metadata, it is important to remember that submitting any new information will overwrite any existing information. The user should therefore take special care not to accidentally overwrite a valid field, for example the vessel Draught field. However, adding an image, as previously demonstrated, will not overwrite any existing images. This is true even if a duplicate Image Type is selected. The only way to remove an image is to contact SAMOS database personnel at COAPS. In any case, other than the addition of photos, Vessel Metadata does not often change. Additionally, except in the incidental case of Data File Specification (shown in image), changes are not date-tracked. Regarding the Date Valid field in the Data File Specification section, this date window maps to the File Format, Version, and Compression properties; it is not intended to capture the date Vessel Metadata changes were made by the SAMOS operator.

b. Select Instrument Metadata

(NOTE: a step-by-step example created by a shipboard technician, suitable for saving and generalizing to any SAMOS instrument metadata change, follows this summary)

user ship related

Edit Metadata

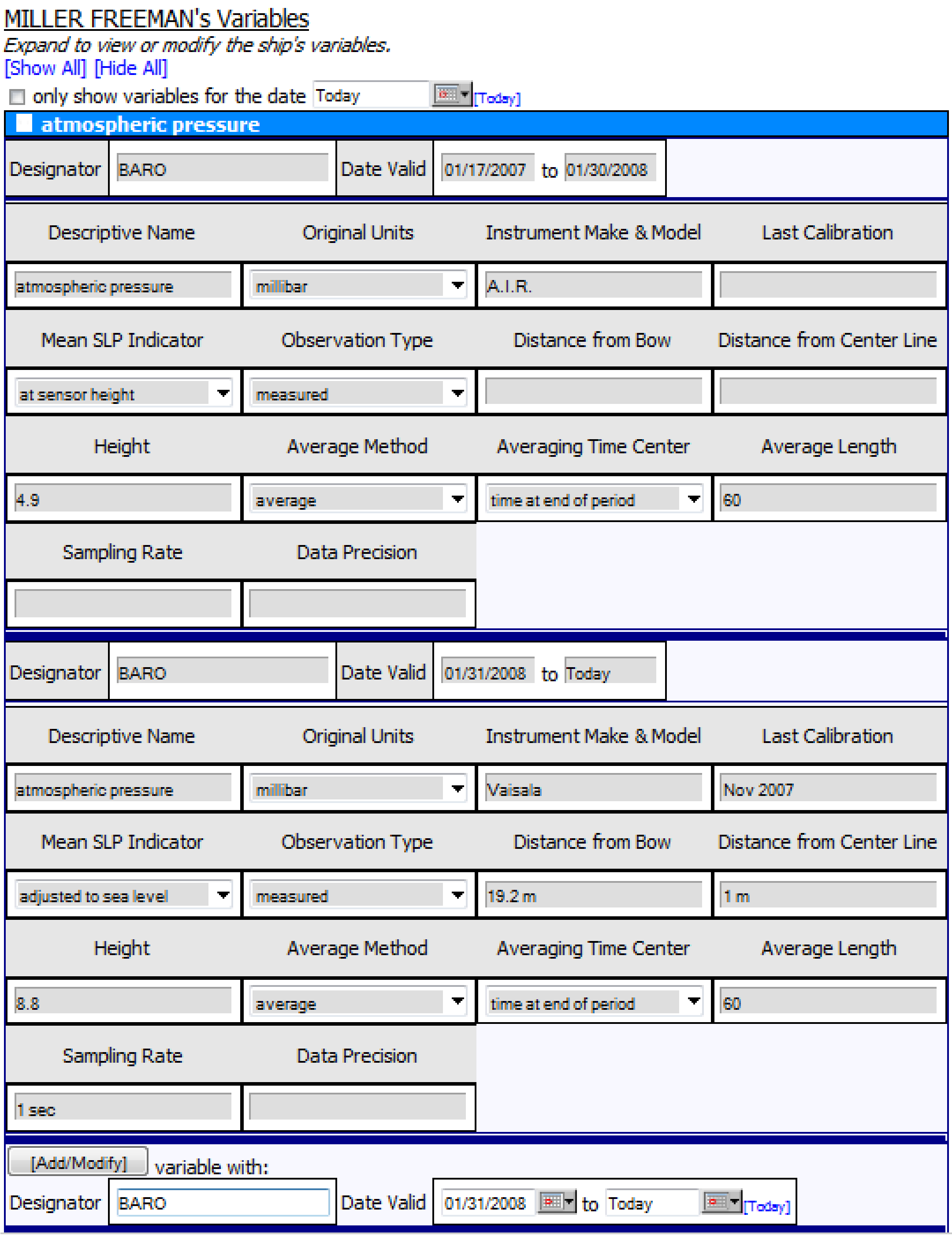
Ships for user op_noaa:

Ship Name	Call Sign	Vessel Metadata	Instrument Metadata
DAVID STAR JORDAN	WTDK	[modify]	[modify]
FAIRWEATHER	WTEB	[modify]	[modify]
GORDON GUNTER	WTEO	[modify]	[modify]
HENRY B. BIGELOW	WTDF	[modify]	[modify]
HI'IALAKAI	WTEY	[modify]	[modify]
KA'IMIMOANA	WTEU	[modify]	[modify]
MILLER FREEMAN	WTDM	[modify]	[modify]
NANCY FOSTER	WTER	[modify]	[modify]
OSCAR DYSON	WTEP	[modify]	[modify]
RAINIER	WTEF	[modify]	[modify]
RON BROWN	WTEC	[modify]	[modify]

samos

Adding and editing instrument (or parameter) metadata follow a slightly different procedure. The first step for the SAMOS operator is to identify which parameter he wishes to add or modify. Let us first consider the case of modifying a parameter already in use. Let us assume that a pressure sensor has been moved and user op_noaa wants to update the metadata for that parameter to reflect the new location. He would toggle a check in the box for *atmospheric pressure*, resulting in an expansion bar at the bottom of the screen:

Clicking over the "+" for atmospheric pressure opens the list of metadata fields associated with that parameter. The first step is to identify to the system which version (i.e. range of dates for which the listed metadata values are valid for the instrument) of the parameter metadata is being modified. (In most cases that will be the current version; however, it should be noted that occasionally there are multiple versions listed, as in this case, and a previous version needs to be edited retrospectively. For clarity, though, we will only be modifying the most recent in this example.) This identification is accomplished by filling in the sequestered set of Designator and Date Valid fields (located at the bottom below the metadata name, e.g., atmospheric pressure in the example below.) to exactly match those of the desired version metadata and then clicking "Add/Modify." Note that because we are modifying the most recent version, we choose our dates to match 01/31/2008 to today, instead of 01/17/2007 to 01/30/2008:



MILLER FREEMAN's Variables

Expand to view or modify the ship's variables.

[Show All] [Hide All]

only show variables for the date Today [Today]

atmospheric pressure

Designator	BARO	Date Valid	01/17/2007 to 01/30/2008

Descriptive Name	Original Units	Instrument Make & Model	Last Calibration
atmospheric pressure	millibar	A.I.R.	
Mean SLP Indicator	**Observation Type**	**Distance from Bow**	**Distance from Center Line**
at sensor height	measured		
Height	**Average Method**	**Averaging Time Center**	**Average Length**
4.9	average	time at end of period	60
Sampling Rate	**Data Precision**		

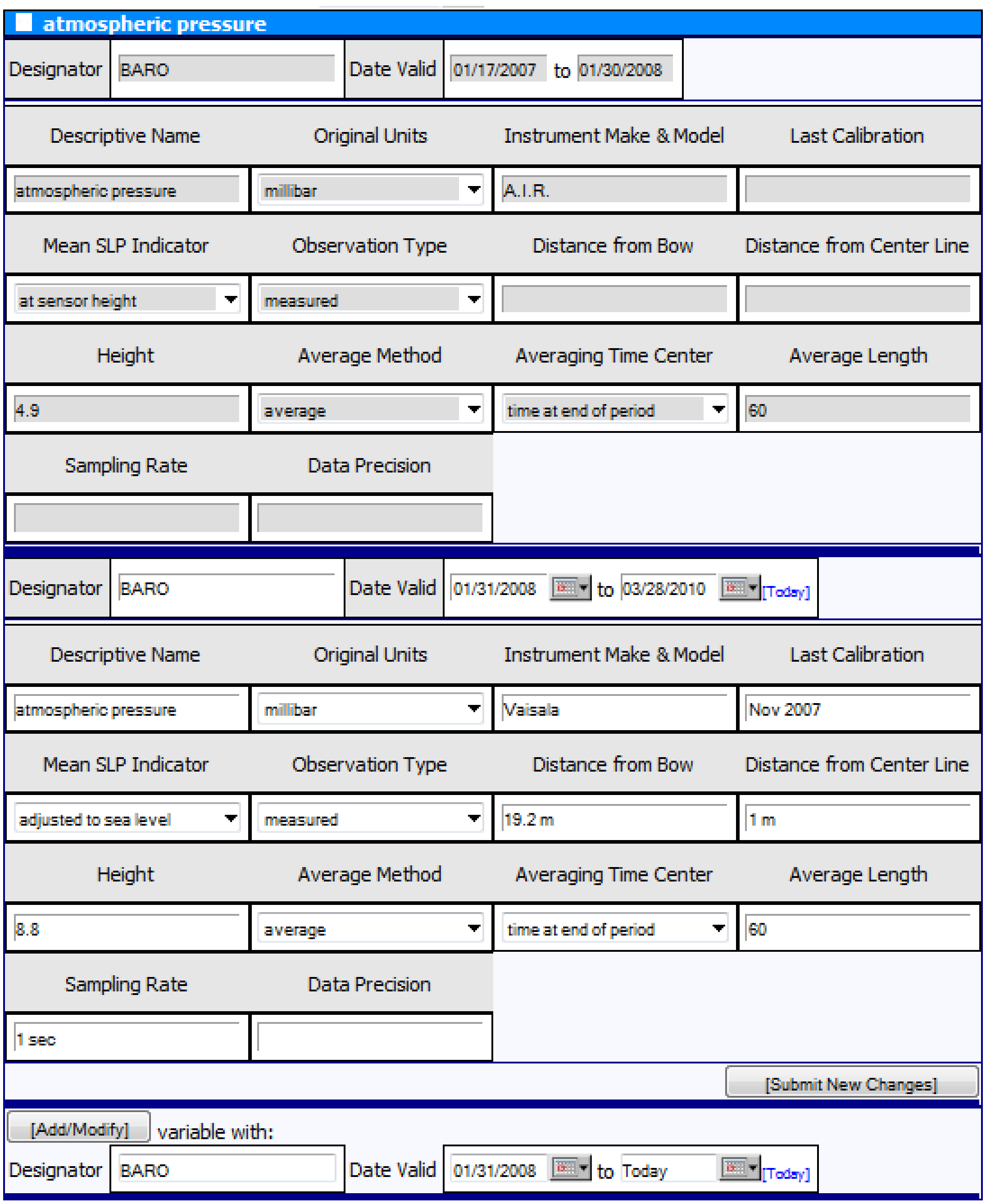
Designator	BARO	Date Valid	01/31/2008 to Today

Descriptive Name	Original Units	Instrument Make & Model	Last Calibration
atmospheric pressure	millibar	Vaisala	Nov 2007
Mean SLP Indicator	**Observation Type**	**Distance from Bow**	**Distance from Center Line**
adjusted to sea level	measured	19.2 m	1 m
Height	**Average Method**	**Averaging Time Center**	**Average Length**
8.8	average	time at end of period	60
Sampling Rate	**Data Precision**		
1 sec			

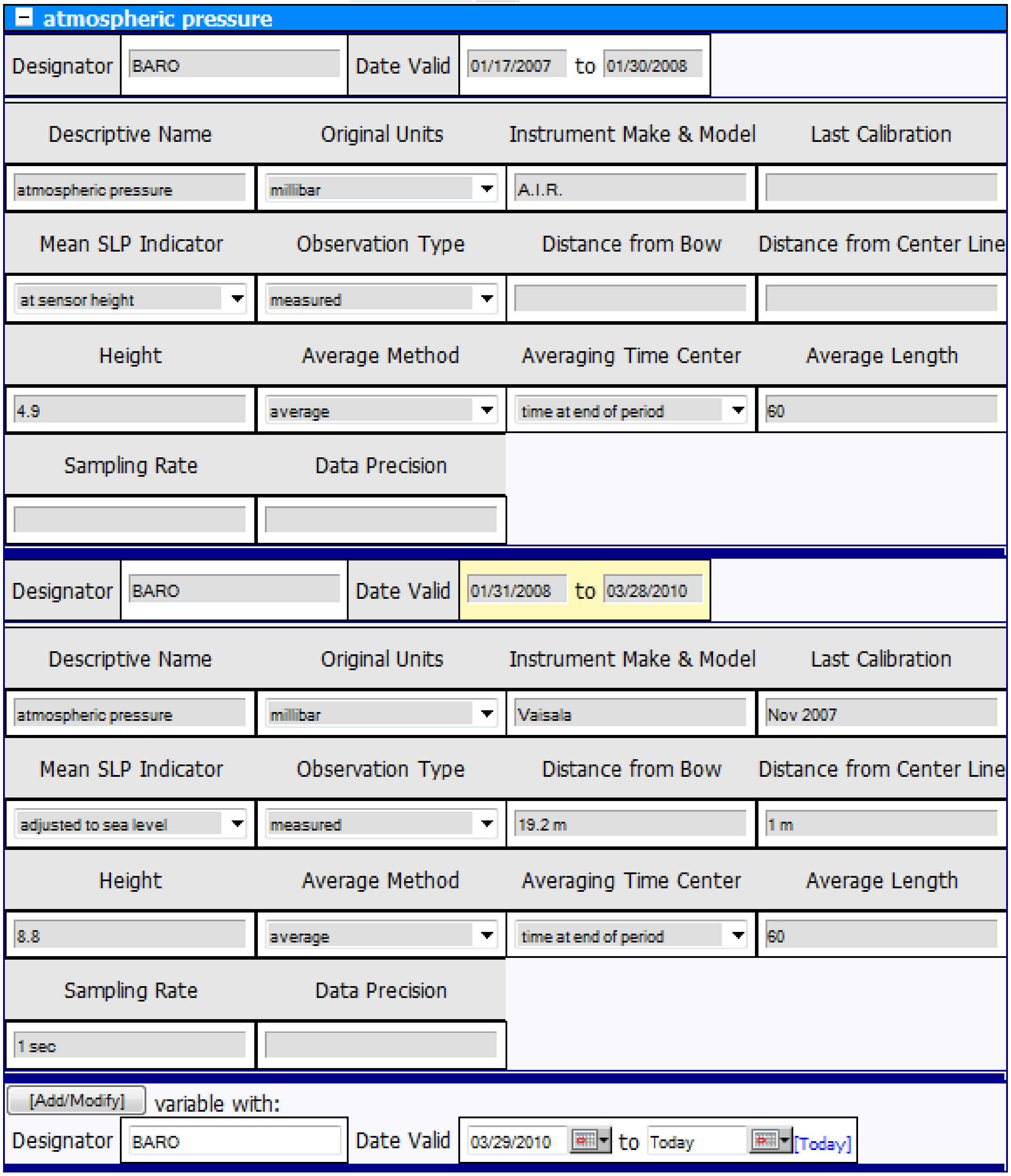
[Add/Modify] variable with:

Designator	BARO	Date Valid	01/31/2008 to Today [Today]

If the identification procedure is successful, there will be a "Submit New Changes" button visible in the desired version metadata area. User op_noaa must first close out the current metadata version (so the previous data is still associated with the correct information) and then initiate a new version. To close out the current version, the user would change the Date Valid field in the metadata area to reflect the last date the metadata displayed for an instrument was associated with at the old location and then click "Submit New Changes." (Note the first version, i.e. with Dates Valid 01/17/2007 to 01/30/2008, is left untouched):



The user then initiates a new version by filling in the sequestered set of Designator and Date Valid fields to reflect the new period for the new or altered metadata, beginning at the date the instrument was relocated, and once again clicking "Add/Modify":



atmospheric pressure

Designator	BARO	Date Valid	01/17/2007 to 01/30/2008

Descriptive Name	Original Units	Instrument Make & Model	Last Calibration
atmospheric pressure	millibar	A.I.R.	
Mean SLP Indicator	**Observation Type**	**Distance from Bow**	**Distance from Center Line**
at sensor height	measured		
Height	**Average Method**	**Averaging Time Center**	**Average Length**
4.9	average	time at end of period	60
Sampling Rate	**Data Precision**		

Designator	BARO	Date Valid	01/31/2008 to 03/28/2010

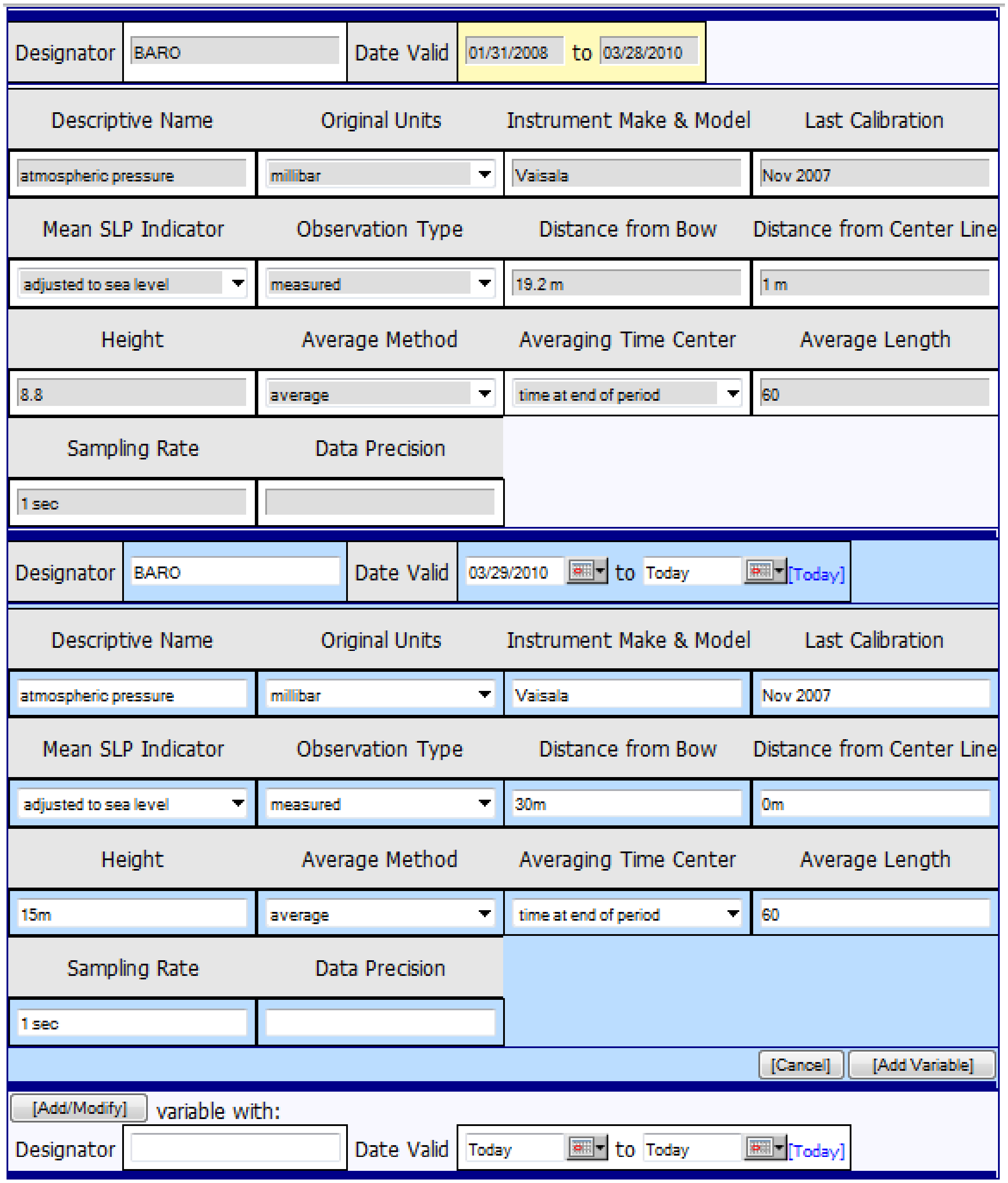
Descriptive Name	Original Units	Instrument Make & Model	Last Calibration
atmospheric pressure	millibar	Vaisala	Nov 2007
Mean SLP Indicator	**Observation Type**	**Distance from Bow**	**Distance from Center Line**
adjusted to sea level	measured	19.2 m	1 m
Height	**Average Method**	**Averaging Time Center**	**Average Length**
8.8	average	time at end of period	60
Sampling Rate	**Data Precision**		
1 sec			

[Add/Modify] variable with:

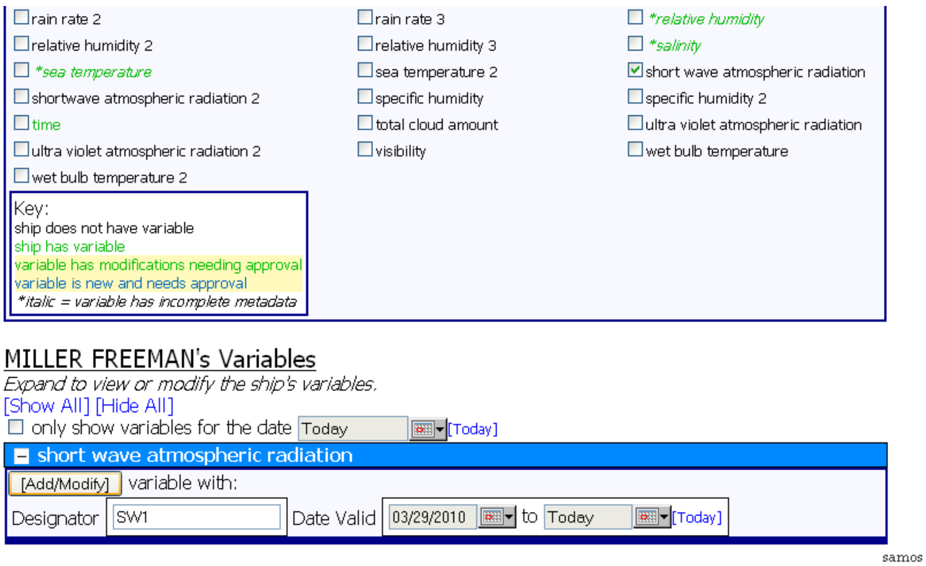
Designator	BARO	Date Valid	03/29/2010 to Today [Today]

*It is crucial to note that Valid Dates cannot overlap for a single Designator, so if an instrument is moved in the middle of the day (and the Designator is not to be changed), the SAMOS user must decide which day is to be considered the "last" day at the old location, i.e. the day of the change or the day before the change. If the day of the change is considered the last day, then the new version must be made effective as of the day after the change. Likewise, if the day before the change is considered the last day, then the new version becomes effective as of the day of change. Let us assume the technician moved the instrument on 03/28/2010 and user op_noaa chose to consider that the last valid date for the old information, as demonstrated in the preceding figure.

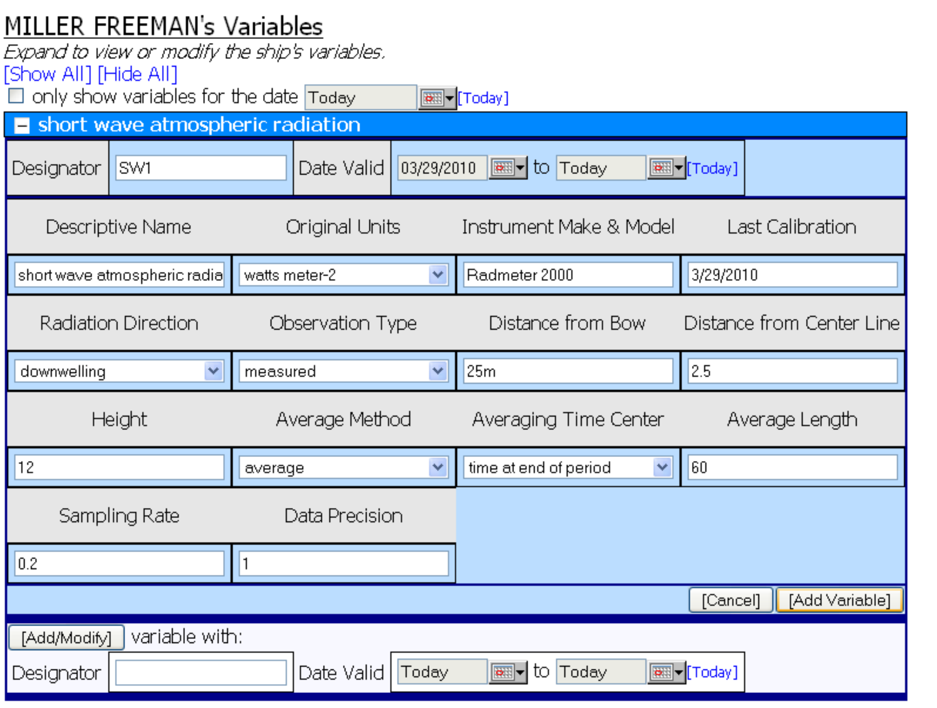
Once "Add/Modify" is clicked, a new set of fields opens up for the BARO parameter. All op_noaa need do at this point is recreate the parameter metadata entry, of course taking care to fill in the new location information, and click "Add Variable":



Adding an entirely new parameter follows only the latter part of these instructions: by simply choosing a parameter (for example short wave atmospheric radiation), clicking the "+" on the expansion bar, and entering either a new or not currently in use Designator and any Date Valid window:



the user is immediately given the new set of fields, to be filled in as desired:



Once an addition or modification to metadata has been submitted, a SAMOS associate at COAPS is automatically notified that approval is needed. Once approved, the new information will be visible to the public, via the Metadata Portal, accessed from the Data Access page as outlined in part one:

Data Access

Please choose a page from the following list:

Data Availability	Time line for available data
Data Download	Access quality-evaluated shipboard meteorological data
Data Map	Plot cruise tracks of each ship on a satellite map over a selected period of time
Metadata Portal	Access ship metadata database
SAMOS Parameters	View a list of meteorological and oceanographic parameters that the initiative seeks to obtain from vessels
Additional RV data	Additional RV data

For example, let's say we'd like to see the photo added by op_noaa for the *Miller Freeman*. We would simply choose the correct vessel from the dropdown list, choose "ship-specific" for the Type of metadata, and type in a date. (We choose "today" because we want the most up-to-date information.) Once we click "search,"

Metadata Portal

The SAMOS Data Assembly Center (DAC) has developed a new metadata specification for SAMOS data. The specification was developed with input from members of the Voluntary Observing Ship Climate project (VOSClim), the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), the National Oceanographic Data Center (NODC), and other programs involved with metadata standards for marine observations. Upon recruitment to the SAMOS initiative, each vessel will be required to complete a series of metadata forms and all pertinent metadata will be stored in a ship profile database at the DAC.

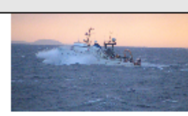
The portal provides access to metadata stored in the database for all ships providing data to the DAC. At present, the vessels listed are participating in the 2005 pilot project. A search tool allows users to select a vessel and whether they are interested in ship-specific, parameter-specific, or digital image metadata. Ship-specific metadata include general information about the vessel, vessel dimensions, and contacts for the original data provider. The parameter-specific metadata lists all measurements being provided by a vessel and allows the user to sub-select information on the variables, units, averaging methods, and instrumentation. Digital imagery includes photos of each vessel and instrument masts and also contains schematics for each vessel.

Additional search tools will be added in the future and suggestions are welcome. Please contact us if you have any questions.

Choose a ship	MILLER FREEMAN (WTDM)
Type of metadata	ship-specific
Type a date	today
	where a valid date is of the form month/day/year, ex: 9/10/04. or a range, 9/10/04 - 9/20/04, you can also enter things like "yesterday"
Click search	search

we are directed to a listing of all valid ship-specific information. At the bottom of the page we find the Vessel Layout items, including the newly added photo at the bottom of the Digital Imagery and Schematics scroll list:

Vessel Layout

Dimensions (meters)	Digital Imagery and Schematics
Length: 65.5 Breadth: 12.8 Freeboard: 2.5 Draught: 5.5 / 9.1 Cargo Height: N/A	 Schematic - Side View 

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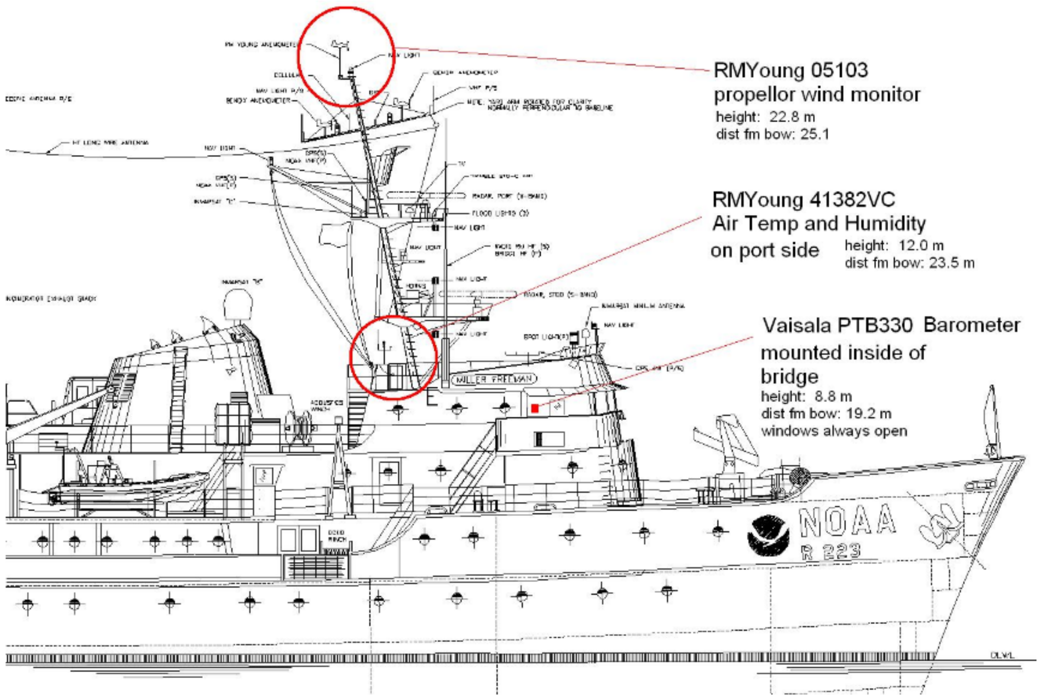
Clicking on the image itself would give us an enlarged view. In this case, the photo provides details about the locations of three MET sensors:



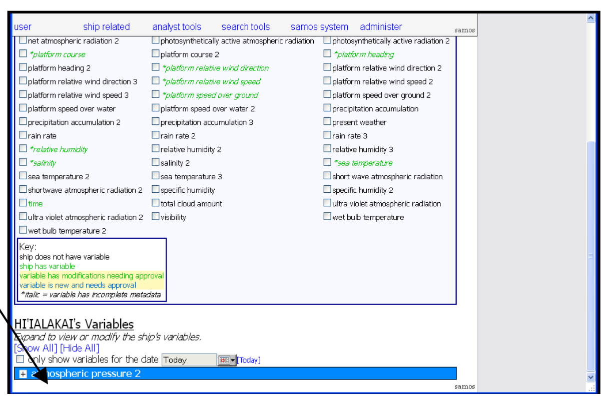
As a SAMOS user becomes familiar with following the metadata modification steps outlined in this section, chores such as adding duplicate sensors, logging sensor relocations, and keeping calibrations up-to-date become straightforward tasks. Naturally, complete and accurate metadata make for better scientific data. (and thus, happier end users!)

UPDATING SAMOS METADATA: STEP BY STEP EXAMPLE

(credit: Lauren Fuqua, chief technician for *Hi'ialakai*)

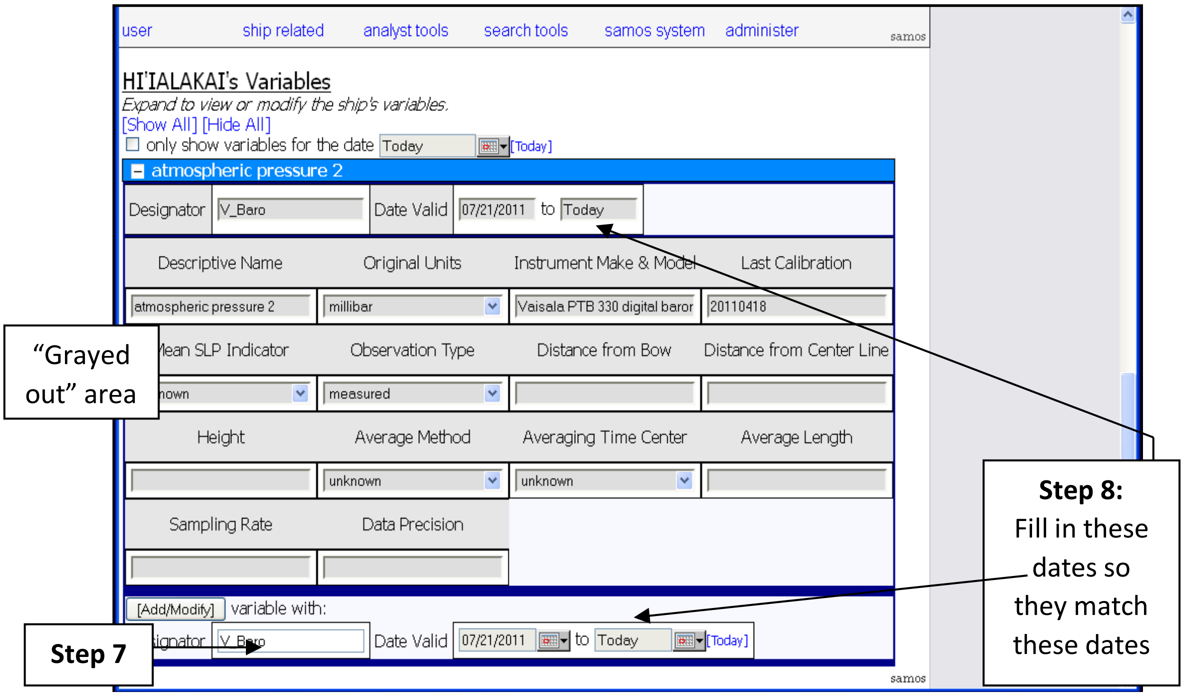
1. Go to: http://samos.coaps.fsu.edu/html/
    a. Click "Ship Recruiting"
    b. Click "Metadata Interface"
2. Enter login ID and password (case sensitive)
3. You can choose to modify Vessel or Instrument Metadata; you will likely choose Instrument. Vessel Metadata does not often change, other than the addition of photos.
4. Once "Instrument Metadata" is clicked, a box of sensors will appear. You will usually only be dealing with the Green ones (will look different if entering a new sensor).
    a. Select the sensor you want to Modify by clicking the box to the left of it

5. You will now see that sensor below, highlighted in Blue; click the plus sign to the left to expand the info about that sensor



6. You will now see the current data for that sensor, grayed out at the top (see image below). You are unable to make changes at this point in the grayed out sensor info area.
    a. If this is a brand new sensor you will only see Designator and Date Valid.

b. If changes have already been made to this sensor you will see several sets of data boxes; scroll to the bottom one.



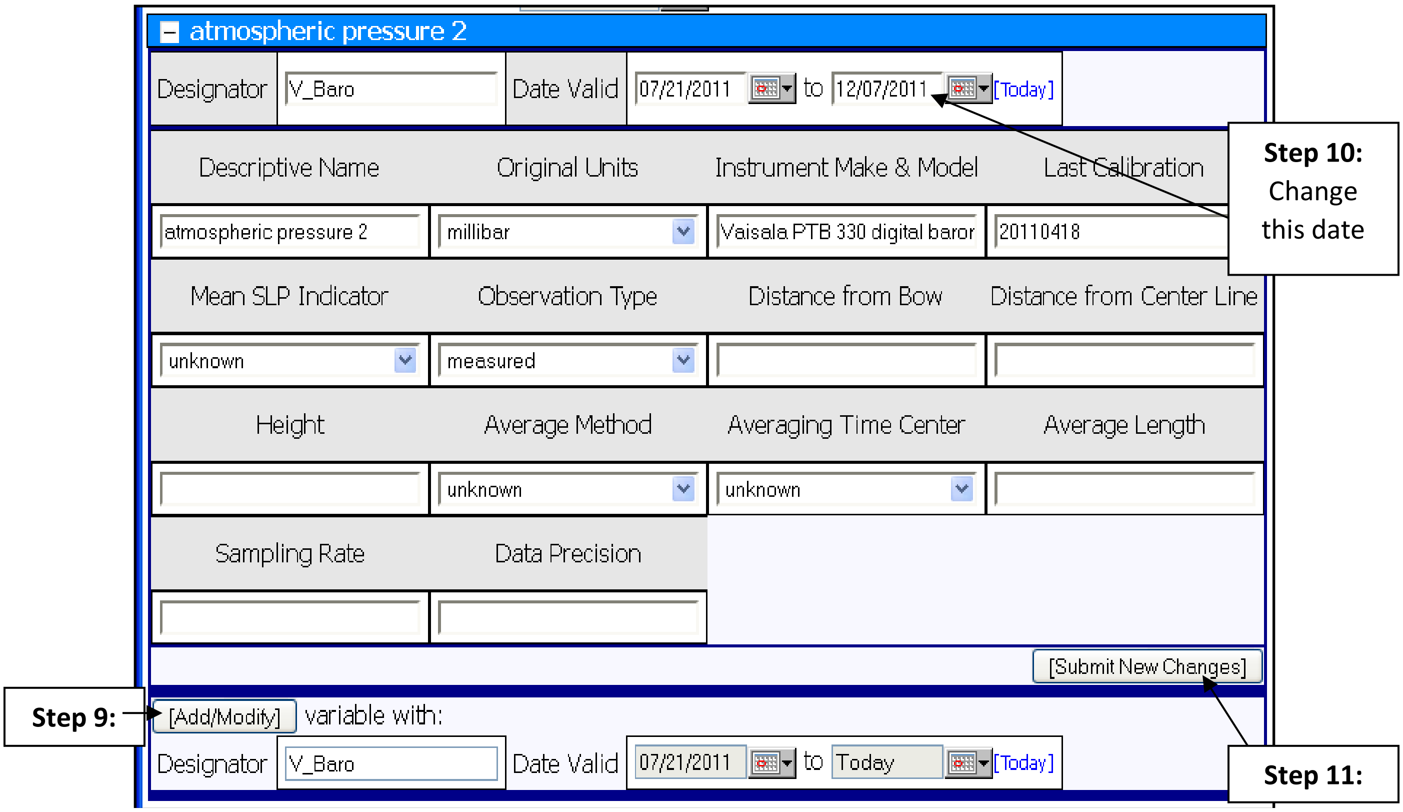
7. You first need to let the system know for which sensor you want to change information. In the box that appears at the very bottom (see image above), enter the name of the designator just at it appears in the box next to 'Designator' in the grayed out area.
    a. For the example above you would enter 'V_Baro' for atmospheric pressure 2

* Note that before an updated version of sensor information can be entered, you must first "close out" the existing version. This is accomplished via steps 8 through 11. (The updated information will be entered in steps 12 through 15.)

8. In the bottom "Date Valid" boxes, make the dates match what you see above for the "Date Valid" dates in the grayed out area
    a. For the example above you would enter 02/01/2011 in the left box and you would click the blue [Today] button to make the right box read Today
    b. The right box will probably say 'TODAY' by default, and that is likely what you want.
        i. **NOTE:** The word 'Today' in any "Date Valid" entry is a floating date that implies the sensor is currently valid, no matter what day it is. The actual calendar dates mean the sensor starts & stops on the actual dates shown.
    c. Months are changed using the arrows

d. Year is changed by clicking on the year (it will now be highlighted) and then typing in the year you want.

9. Click the [Add/Modify] button (see image below); this should change the text boxes in the data area from gray to white (as in the image below), so that you can now put your cursor in there. If you are unable to make changes in the data area, then the date valid dates and/or designator you entered are incorrect.



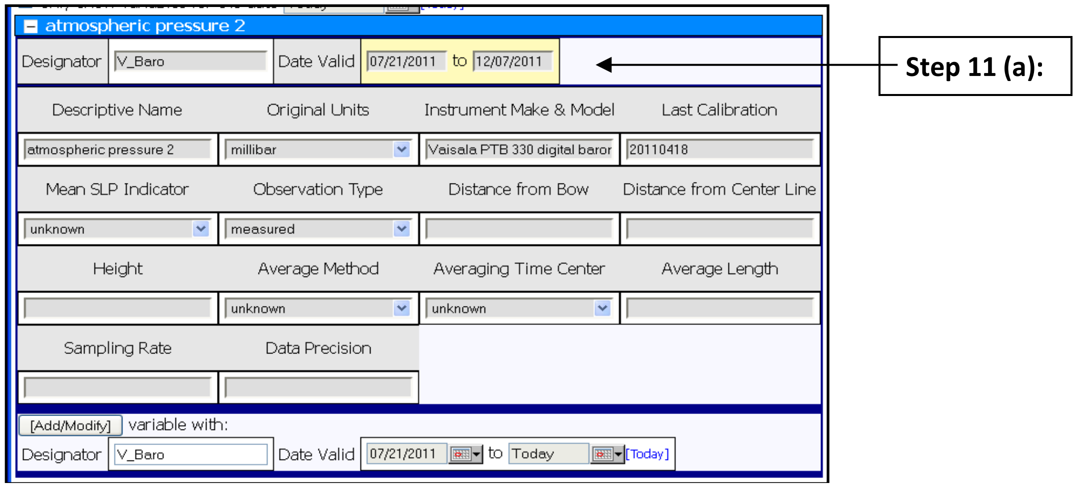
10. You now want to change the "Date Valid" info in this data box. The "Date Valid" start date (on the left) in this now edit-able area will likely stay the same unless you want to correct a previously entered erroneous start date. More than likely you will only be changing the end date, on the right.

   a. This step simply closes out the current data; letting the system know the start and end dates for which the data on the screen about that sensor are valid. You will probably not change any data here; only the end date.

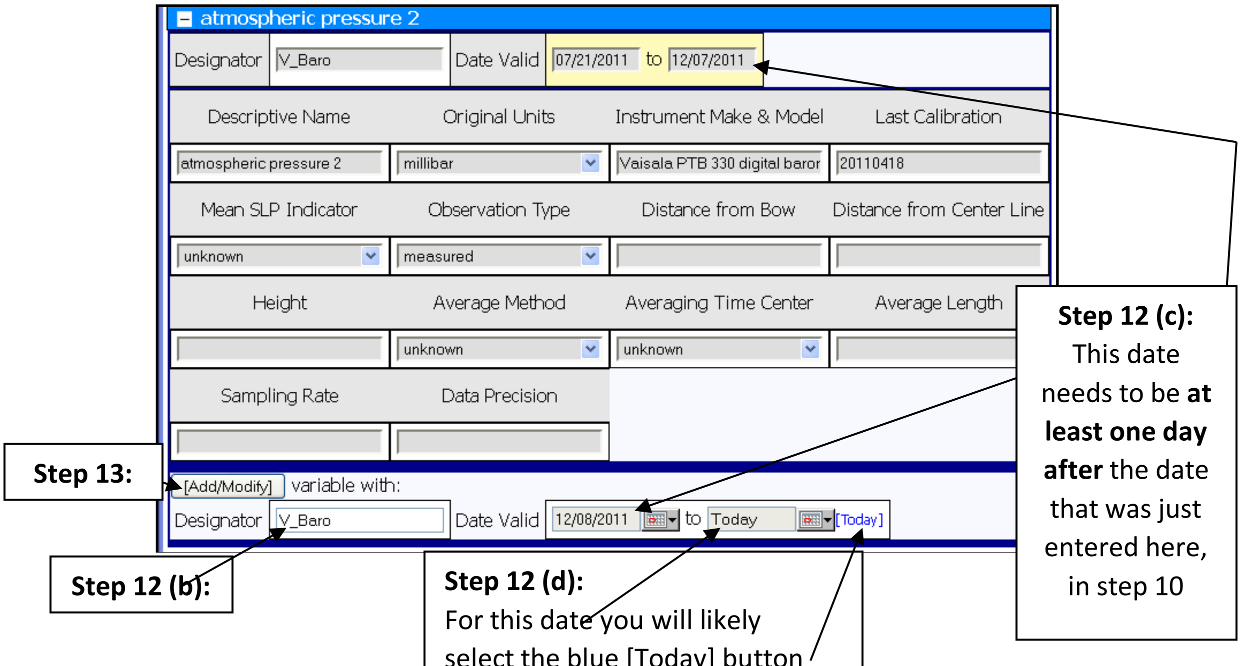
   b. You will most likely be entering a calendar date in the right hand "Date Valid" box to close out the existing data for the sensor.

11. Click "Submit New Changes" on the bottom right of the data box (see image above)

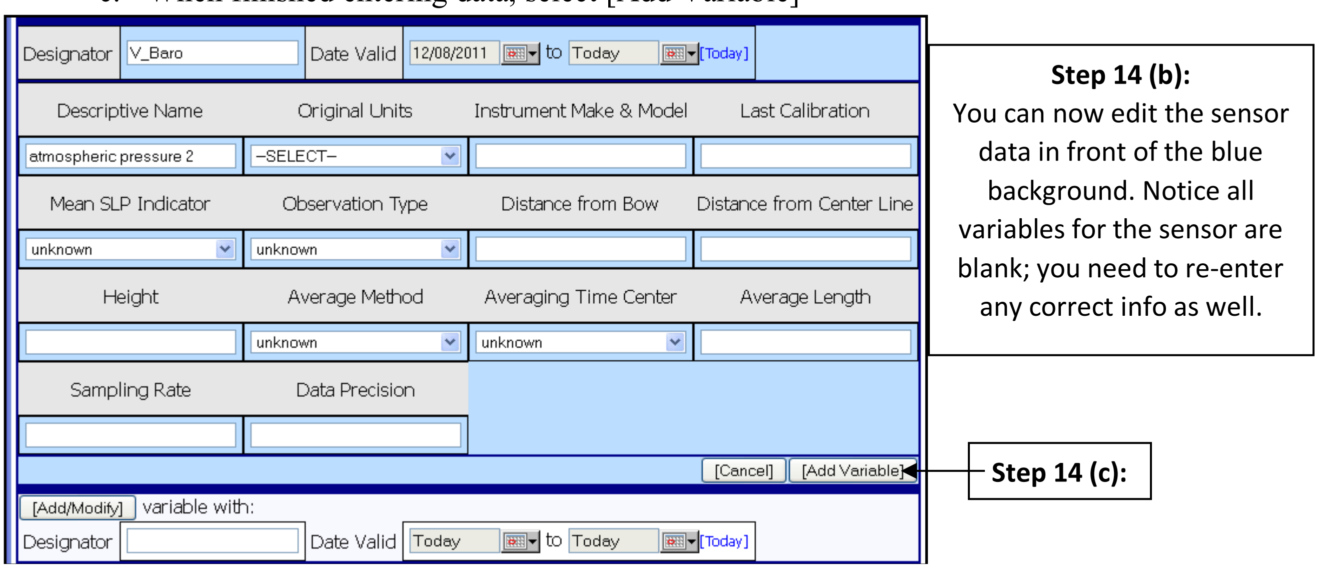
   a. The text boxes in the data entry area should be grayed out again. The background of the dates that you just edited will be yellow (see image below).



12. Now you need to choose new "Date Valid" info in the bottom window (see image below). *Note again that steps 12 through 15 should NOT be performed until the previous set of instrument metadata has been "closed out" for that instrument, via steps 8 through 11.
    a. This step lets the system know the new valid dates for the new information about this sensor (you will enter the new information in Step 14).
    b. Make sure the same designator name is in the 'Designator' box
    c. The left box in the Date Valid area will indicate the start date for which the new sensor info is valid. **That start date needs to be at least one day after the end date that was just entered above in Step 10; the valid dates cannot overlap.**
    d. The right "Date Valid" date will most likely be Today (again, do this by clicking the blue [Today] button to the right of the box; not by putting in today's date on the calendar).
    e. Note: If you are seeing X's over the calendar date you want to select on the left hand "Date Valid" box, change the right hand box to Today first, and you will now be able to change the left box to the date you want.

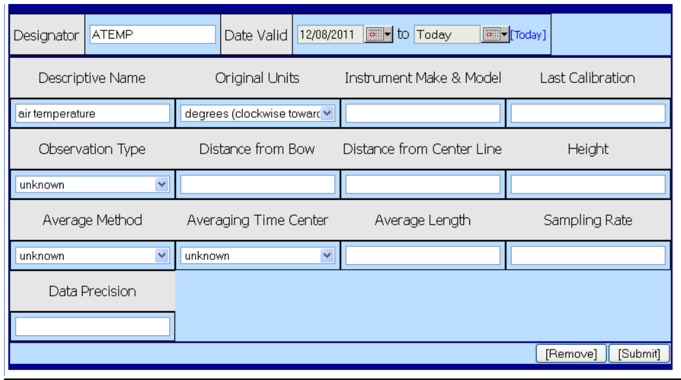


13. Click the [Add/Modify] button again (see image above)
14. You will now see a new, editable data box at the bottom of the screen that has blue around the sensor info instead of gray.
    a. Leave the Date Valid area the same
    b. You can now change the sensor data to reflect updates and add new information. Note that you need to re-enter any existing, correct info about the sensor.
    c. When finished entering data, select [Add Variable]



15. You do not need to click [Submit] on the new window that appears (see image below) unless you make any additional changes or corrections immediately after finishing step 11, for example if you realize you've entered incorrect info or you've accidentally left something out. Otherwise, your new data are now

waiting for approval from the SAMOS staff. To prevent anything being changed mistakenly from this point on, you should now close out that sensor window by going to the top window that has all of the sensors listed and un-checking the sensor you just edited. You can now either exit the website or select a new sensor



Step 15:

If all info entered is correct, **DO NOT** select the [Submit] button. Simply close out of SAMOS