2020 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 2020 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 2020, out of 33 active recruits, a total of 29 research vessels routinely provided SAMOS observations to the DAC (Table 1). SAMOS data providers included the National Oceanographic and Atmospheric Administration (NOAA, 13 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, 3 vessels). Two additional NOAA vessels – the *Ferdinand Hassler* and *Pisces* – one additional USCG vessel – the *Polar Sea* – and the Louisiana Universities Marine Consortium (LUMCON) vessel *Pelican* were 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.) were unable to contribute data in 2020.

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 two vessels (*Investigator* and *Aurora Australis*) operated by Australia. In 2015 code was developed at the SAMOS DAC (updated in 2018) which allows for harvesting *Tangaroa*, *Investigator*, and *Aurora Australis* 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.

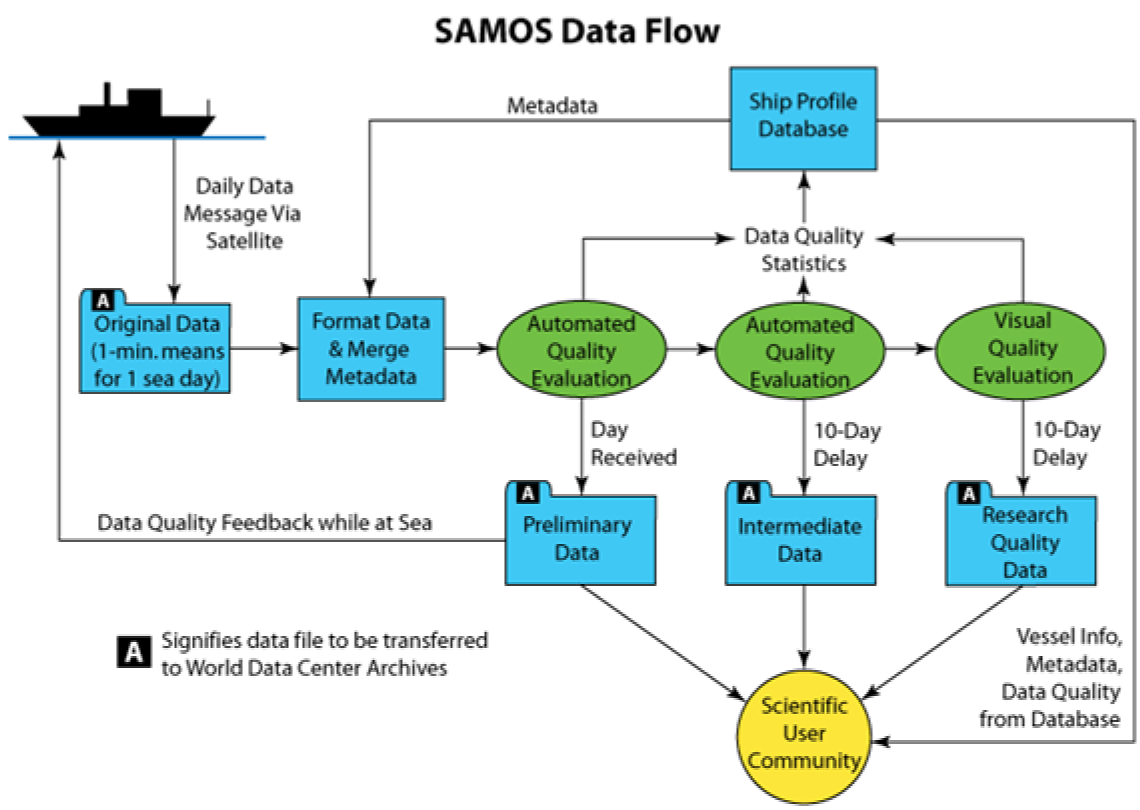

Figure 1: Diagram of operational data flow for the SAMOS initiative in 2020.

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 *Aurora Australis* and *Tangaroa*, the IMOS project conducted their own visual QC until a personnel change there in June 2013. Only automated QC for the *Investigator, Aurora Australis,* 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 2020, the overall quality of data received varied widely between different vessels and the individual sensors on the vessels. Major problems included poor sensor placement that enhanced flow distortion (nearly all vessels experience some degree of flow distortion), sea water plumbing issues (*Ron Brown*, for one), sensor failures/sensors or equipment that remained problematic or missing for extended periods (e.g. anemometers on the *Rainier*, *Henry Bigelow*, *Thomas Jefferson*, and *Atlantic Explorer*, the relative humidity sensors on the *Kilo Moana*, the radiometers on the *Henry Bigelow*, barometer tubing on the *Thomas Jefferson*, and sea temperature sensor cabling on the *Oregon II*, among others), erroneously characterized data units (*Investigator*), sensors that were dirty or in need of recalibration (relative humidity sensors on the *Aurora Australis*, *Sally Ride*, and *Sikuliaq*, and the short wave radiometer on the *Sikuliaq*), and data transmission oversights or issues (many vessels). But perhaps the most notable problem in 2020 was the reduction in operations that resulted from COVID-19 restrictions. In fact, a large portion of SAMOS observations in 2020 were collected by vessels dockside in their home ports.

This report begins with an overview of the vessels contributing SAMOS observations to the DAC in 2020 (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 2021. 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) and web interface instructions for accessing SAMOS observations (Annex B, part 1) and metadata submission by vessel operators (Annex B, part2).

2. System review

In 2020, a total of 33 research vessels were under active recruitment to the SAMOS initiative; 29 of those vessels routinely provided SAMOS observations to the DAC (Table 1). The *Pisces* did not sail in 2020, hence no data from her. The *Polar Sea* was designated a "parts donor" to sister ship USCGC *Polar Star* in 2017, so naturally there was no data from her, either. The *Ferdinand Hassler* did sail in 2020. But she was the flagship test case in 2020 for NOAA/OMAO's latest major release (v5) of their Scientific Computer System (SCS) data acquisition software, and processing code to parse the new SCS v5 data packages did not yet exist at SAMOS. Hence, no SAMOS netCDF data files were created for her in 2020. The *Pelican* also sailed in 2020, 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 2020 despite repeated efforts to work with the LUMCON team, meaning no SAMOS data from her, either.

In total, 3,811 ship days were received by the DAC for the January 1 to December 31, 2020 period, resulting in 5,210,502 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 5,210,502 records received in 2020, a total of 124,530,958 distinct measurements were logged. Of those, 6,860,355 were assigned A-Y quality control flags – about 5.5 percent – by the SAMOS DAC (see section 3a for descriptions of the QC flags). This is about the same as in 2019. Measurements deemed "good data," through both automated and visual QC inspection, are assigned Z flags. In total, fifteen of the SAMOS vessels (the *Tangaroa, Investigator, Aurora Australis*, *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	-	3,811	698	5,210,502	6,860,355	124,530,958	5.51
ROGER REVELLE	KAOU	70	27	90,910	55,872	2,402,289	2.33
ATLANTIS	KAQP	82	29	116,092	57,495	3,366,668	1.71
T.G. THOMPSON	KTDQ	86	20	112,043	46,405	2,225,416	2.09
HEALY	NEPP	35	34	44,487	117,786	1,395,553	8.44
INVESTIGATOR	VLMJ	169	32	232,100	255,575	7,083,732	3.61
AURORA AUSTRALIS	VNAA	81	28	112,886	82,244	3,140,648	2.62
NEIL ARMSTRONG	WARL	362	31	505,942	446,138	15,421,934	2.89
NATHANIEL B. PALMER	WBP3210	301	23	432,851	353,337	9,355,558	3.78
LAURENCE M. GOULD	WCX7445	301	23	432,255	819,997	8,924,289	9.19
KILO MOANA	WDA7827	129	23	165,399	123,044	3,417,441	3.60
ATLANTIC EXPLORER	WDC9417	82	29	98,898	116,147	2,762,298	4.20
SIKULIAQ	WDG7520	344	39	495,287	978,589	12,339,159	7.93
SALLY RIDE	WSAF	257	25	348,210	546,467	8,523,710	6.41
ROBERT GORDON SPROUL	WSQ2674	261	23	347,956	627,518	7,773,717	8.07
HENRY B. BIGELOW	WTDF	46	29	60,497	134,407	1,711,772	7.85
OKEANOS EXPLORER	WTDH	26	21	30,830	22,322	637,296	3.50
OREGON II	WTDO	47	16	59,616	54,470	953,056	5.72
THOMAS JEFFERSON	WTEA	93	19	123,279	145,950	2,175,774	6.71
FAIRWEATHER	WTEB	40	16	50,181	40,290	802,891	5.02
RON BROWN	WTEC	132	28	177,329	199,644	3,790,892	5.27
BELL M. SHIMADA	WTED	19	20	18,817	22,653	350,042	6.47
OSCAR ELTON SETTE	WTEE	58	16	77,667	117,830	1,241,349	9.49
RAINIER	WTEF	78	13	106,651	155,009	1,092,747	14.19
REUBEN LASKER	WTEG	23	20	32,049	21,610	622,399	3.47
GORDON GUNTER	WTEO	2	14	2,135	18	29,890	0.06
OSCAR DYSON	WTEP	95	31	122,490	60,970	3,790,878	1.61
NANCY FOSTER	WTER	44	17	57,162	39,160	941,646	4.16
FALKOR	ZCYL5	240	35	327,676	646,818	10,991,224	5.88
TANGAROA	ZMFR	308	17	428,807	572,590	7,266,690	7.88

Table 1: CY2020 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 (denoted with a "P" in Figure 2 where applicable), 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. As noted above, COVID-19 resulted in a number of ships laying up at their home port for much of 2020; however, many continued to transmit mostly meteorological observations during these periods, which were processed and archived by SAMOS. 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 2020 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 2020, with the exceptions of *Tangaroa*, *Aurora Australis* and *Investigator,* has been archived at the NCEI. Through agreement with IMOS, we receive data for the *Tangaroa*, the *Investigator*, and the *Aurora Australis* and for these vessels perform automated QC only. IMOS data is archived within the IMOS DAC-eMarine Information Infrastructure (eMII).

JANUARY	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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Figure 2: 2020 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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WSQ2674																															
WTDF																															
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WTDL																															
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WTEB				S																											
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WTEF			S	S	S	S																									
WTEG				S	S	S	S																								
WTEK																														S	S
WTEO																															
WTEP																															
WTER																S															
ZCYL5																															
ZMFR																															

(Figure 2: cont'd)

SEPTEMBER	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																															
KAQP																															
KTDQ	S																								S				S	S	
NEPP																															
VLMJ																															
VNAA																															
WARL																															
WBP3210																			S	S			S	S	S						
WCX7445																															
WDA7827				S																					S					S	
WDC9417																															
WDD6114																								S	S	S	S	S	S	S	
WDG7520																															
WSAF																															
WSQ2674																															
WTDF																															
WTDH																															
WTDL																															
WTDO							S																								
WTEA																															
WTEB														S	S	S	S														
WTEC																					S	S									
WTED																											S				
WTEE																							S								
WTEF			S	S																											
WTEG						S	S	S	S	S	S																				
WTEK	S	S	S	S	S	S	S	S	S					S	S	S	S	S					S	S	S	S	S	S	S		
WTEO									S																						
WTEP	S																											S	S	S	
WTER																S		S													
ZCYL5																															
ZMFR																															

OCTOBER	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																	S	S													
KAQP																															
KTDQ	S																														
NEPP											S	S	S	S	S	S	S														
VLMJ																															
VNAA																															
WARL																															
WBP3210																				S	S	S	S	S	S	S	S	S	S	S	S
WCX7445																															
WDA7827																															
WDC9417																															
WDD6114	S	S	S	S	S	S							S	S	S	S	S	S	S	S	S	S		S	S						
WDG7520																															
WSAF																															
WSQ2674																															
WTDF																															
WTDH																															S
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WTEF										S				S																	
WTEG																															
WTEK																															
WTEO																															
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																															
NEPP																															
VLMJ																															
VNAA																															
WARL																															
WBP3210	S	S																													
WCX7445																															
WDA7827													S																		
WDC9417																															
WDD6114		S	S	S												S	S	S	S												
WDG7520																															
WSAF																															
WSQ2674																															
WTDF																															
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WTDL																															
WTDO																								S							
WTEA																															
WTEB										S											S	S									
WTEC																															
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WTEK						S	S	S	S																						
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												
NEPP																															
VLMJ																															
VNAA																															
WARL																															
WBP3210																															
WCX7445																															
WDA7827																															
WDC9417																															
WDD6114						S	S	S	S	S	S	S	S	S																	
WDG7520																															
WSAF																															
WSQ2674																															
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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
Call Sign/ Ship Code	WTED/SH	WTEB/FA	WTEK/FH	WTEO/GU	WTDF/HB	WTER/NF	WTDH/EX
# scheduled at-sea days	21	44	42	4	47	49	26
# matching SAMOS days	17	36	0	2	46	42	25
→% received	81%	82%	0%	50%	98%	86%	96%

NOAA (cont'd)							
Ship Name	Oregon II	Oscar Dyson	Oscar E. Sette	Rainier	Reuben Lasker	Ronald Brown	Thomas Jefferson
Call Sign/ Ship Code	WTDO/OT	WTEP/OD	WTEE/OS	WTEF/RA	WTEG/RL	WTEC/RB	WTEA/TJ
# scheduled at-sea days	47	97	60	76	35	130	90
# matching SAMOS days	43	90	57	50	23	126	90
→% received	91%	93%	95%	66%	66%	97%	100%

TOTAL scheduled at-sea days:	768
TOTAL matching SAMOS days:	647
OVERALL RATIO:	84%

Table 2: 2020 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	Aurora Australis	Investigator	Tangaroa
Call Sign	VNAA	VLMJ	ZMFR
# scheduled at-sea days	81	131	275
# matching SAMOS days	81	131	275
→% received	100%	100%	100%
TOTAL scheduled at-sea days:	487		
TOTAL matching SAMOS days:	487		
OVERALL RATIO:	100%		

OPP		
Ship Name	Laurence M. Gould	Nathaniel B. Palmer
Call Sign	WCX7445	WBP3210
# scheduled at-sea days	53	182
# matching SAMOS days	53	163
→% received	100%	90%
TOTAL scheduled days:	235	
TOTAL matching SAMOS days:	216	
OVERALL RATIO:	92%	

SIO			
Ship Name	Robert G. Sproul	Roger Revelle	Sally Ride
Call Sign	WSQ2674	KAOU	WSAF
# scheduled at-sea days	27	63	125
# matching SAMOS days	27	60	124
→% received	100%	95%	99%
TOTAL scheduled at-sea days:	215		
TOTAL matching SAMOS days:	211		
OVERALL RATIO:	98%		

WHOI		
Ship Name	R/V Atlantis	R/V Neil Armstrong
Call Sign	KAQP	WARL
# scheduled at-sea days	62	165
# matching SAMOS days	62	165
→% received	100%	100%
TOTAL scheduled at-sea days:	227	
TOTAL matching SAMOS days:	227	
OVERALL RATIO:	100%	

	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	104	100	215	134	122	69	172
TOTAL matching SAMOS days	78	0	200	132	102	29	75
OVERALL RATIO:	75%	0%	93%	99%	84%	42%	44%

(Table 2: cont'd)

b. Spatial coverage

Geographically, SAMOS data coverage continues to be noteworthy in 2020, with both the typical exposures and several trips outside traditional mapping/shipping lanes. Cruise coverage for the January 1, 2020 to December 31, 2020 period is shown in Figure 3. It includes hits in the Indian Ocean by the *Investigator* and *Thomas G. Thompson*, plenty of coverage in the Southern Ocean and along the Antarctic shelf provided by the *Aurora Australis* and the two OPP vessels *Nathaniel B. Palmer* and *Laurence M. Gould*, and multiple swaths of the Pacific Ocean (North and South) contributed by the *Kilo Moana*, *Rainier*, *Roger Revelle*, and others. The *Atlantis* made a transit through the Panama Canal, while the Gulf of Alaska saw exposure from the *Healy*, Oscar *Dyson*, and *Sikuliaq*, with the *Dyson* and *Sikuliaq* contributing additional coverage in the Bering and Chukchi Seas. Several long-haul voyages occurred: the *Neil Armstrong* made a trip all the way up the U.S. east coast, around Newfoundland and through the Gulf of St. Lawrence, on into the Labrador Sea and off the southern tip of Greenland; meanwhile, the *Ronald H. Brown* left the mid-Atlantic U.S. coast and crossed the Atlantic, north to south, all the way to offshore Cape Town, South Africa and back; not to be outdone, the *Nathaniel B. Palmer* left a trail stretching from the coastal Pacific northwest all the way down to Chile and the Strait of Magellan, and beyond; and finally, the *Thomas G. Thompson* went trans-Pacific, rounding southern Australia before crossing into the Indian Ocean, and eventually finding its way to the waters off South Africa. Some of these long cruise tracks were likely the result of COVID-19, when the U.S. fleet had to return to home ports early in the pandemic. Additionally, most U.S. vessels were required to sail from and return to U.S. ports after every cruise as part of COVID protocols once cruise activity restarted in mid-2020. The result is some unexpected long cruises with likely very unique datasets. 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 *Henry Bigelow*, *Neil Armstrong*, *Nancy Foster*, *Okeanos Explorer*, *Thomas Jefferson*, and others. Comparable coverage of British Columbia and the West coast was effected by the *Bell M. Shimada*, *Sikuliaq*, *Rainier*, and *Fairweather*, 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 *Oregon II*, *Thomas Jefferson*, *Okeanos Explorer*, and others. We must again note that while many vessels were able to operate partial schedules in 2020, covering many ocean regions, there was a significant drop in overall at sea observations during the year. Many vessels continued to report SAMOS observations dockside at their home ports and all these data are included in the 2020 dataset.

Figure 3: Cruise maps plotted for each vessel in 2020.

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 *Okeanos Explorer* and *Thomas Jefferson* provided dew point temperature and wet bulb temperature in 2020. 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 2020/2021; 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 2020 (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. 2020 quality across-system

This section presents the overall quality from the system of ships providing observations to the SAMOS data center in 2020. 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. The COVID-19 pandemic significantly impacted research vessel operations from April-July 2020, which is exhibited by a notable decrease in SAMOS data receive for all parameters in April 2020 as compared to May 2020. A slow return to “normal” data receipts continued through August 2020 when COVID operational protocols allowed more vessels to return to operations.

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 land error flags, which 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). 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 2020.

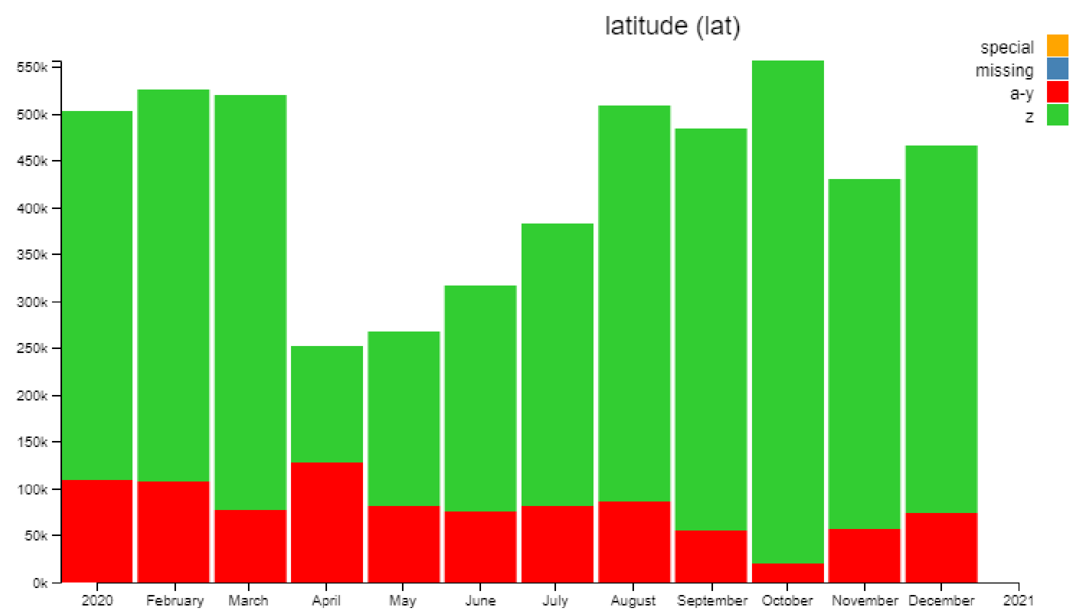


Figure 4: Total number of (this page) latitude – LAT – and (next page) longitude – LON – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

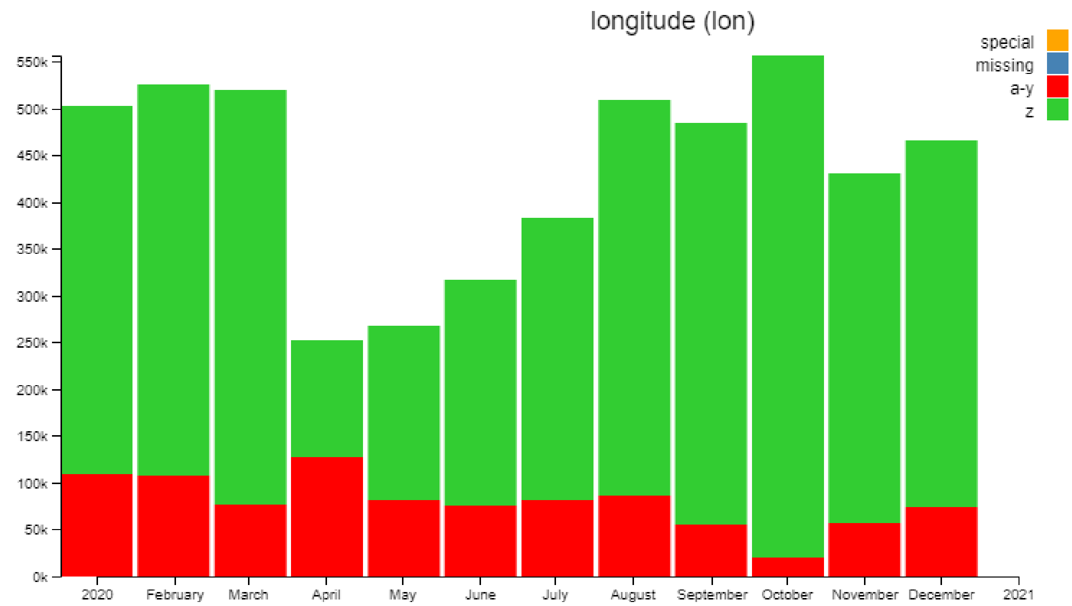
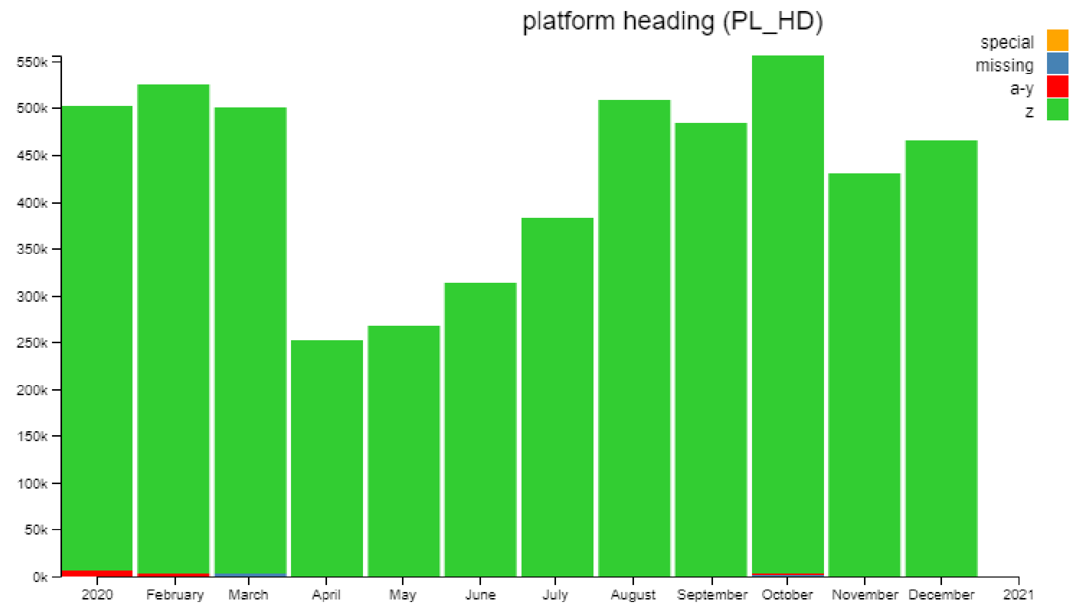


Figure 4: cont'd.

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).

All the special values seen in PL_SOW appear to have come from the *Neil Armstrong*. The full details are not known, but historically both the WHOI vessels (*Neil Armstrong* and *Atlantis*) have tended to send NaN values for many sensors when they are in port. We add, though, *Atlantis* did not transmit any data in May 2020 as she had started her mid-life refit on 25 March, so none of the May "special values" would have been from her. *Neil Armstrong*, on the other hand, was dockside in May and transmitting NaNs for most MET/TSG data. Note that prior to late May 2020, NaNs were set to "special values" (-8888) by the SAMOS data ingestion code. At the end of May 2020, the SAMOS team modified our data ingestion code to read the non-numeric NaN values and properly assign them with the "missing" (-9999) value instead. For this reason, the occurrences of special values dropped dramatically after May 2020 for PL_SOW (and other) parameters.



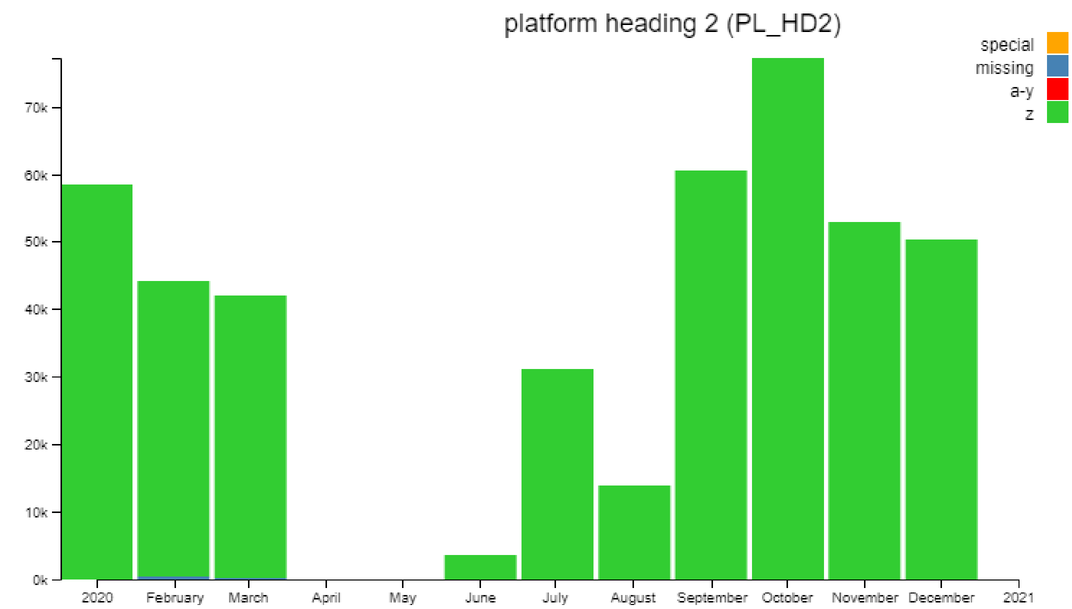


Figure 5: Total number of (this page, top) platform heading – PL_HD – (this page, bottom) platform heading 2 – PL_HD2 – and (next page) platform heading 3 – PL_HD3 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that 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.

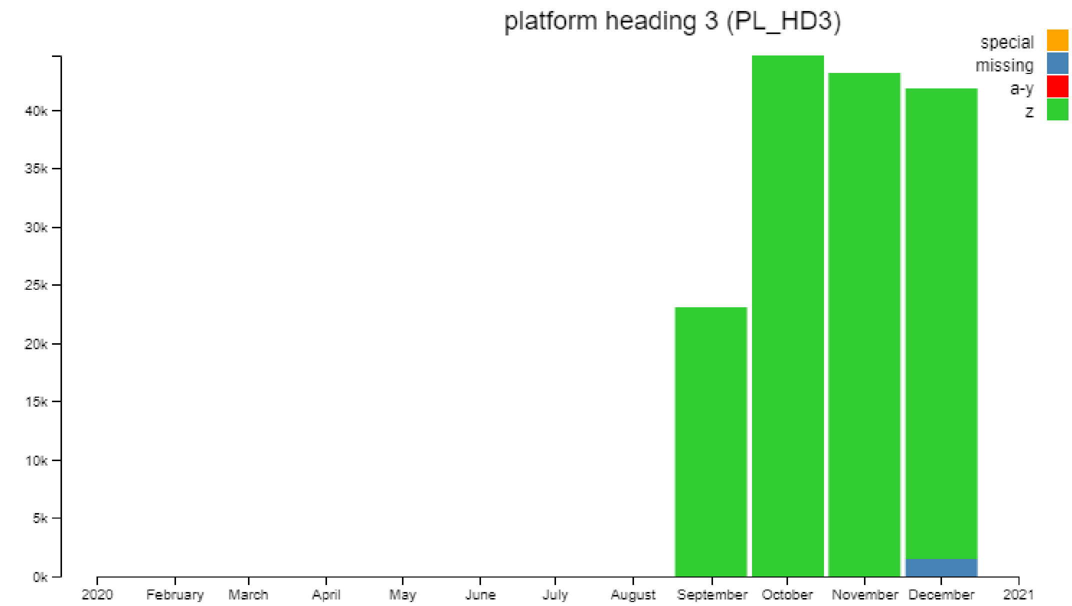


Figure 5: cont'd.

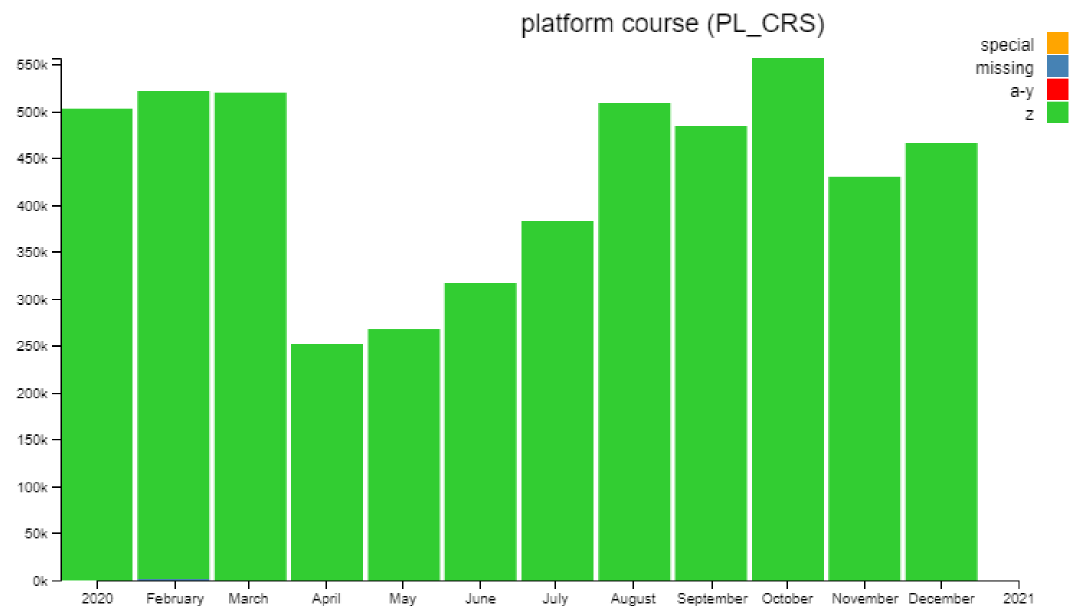


Figure 6: Total number of platform course – PL_CRS –observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

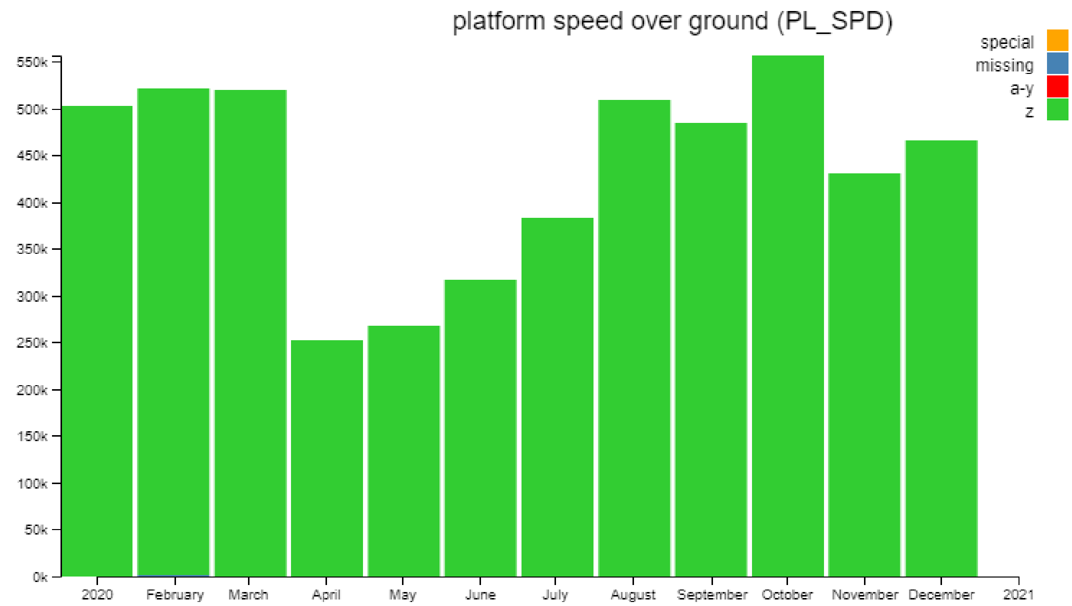


Figure 7: Total number of platform speed over ground – PL_SPD –observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

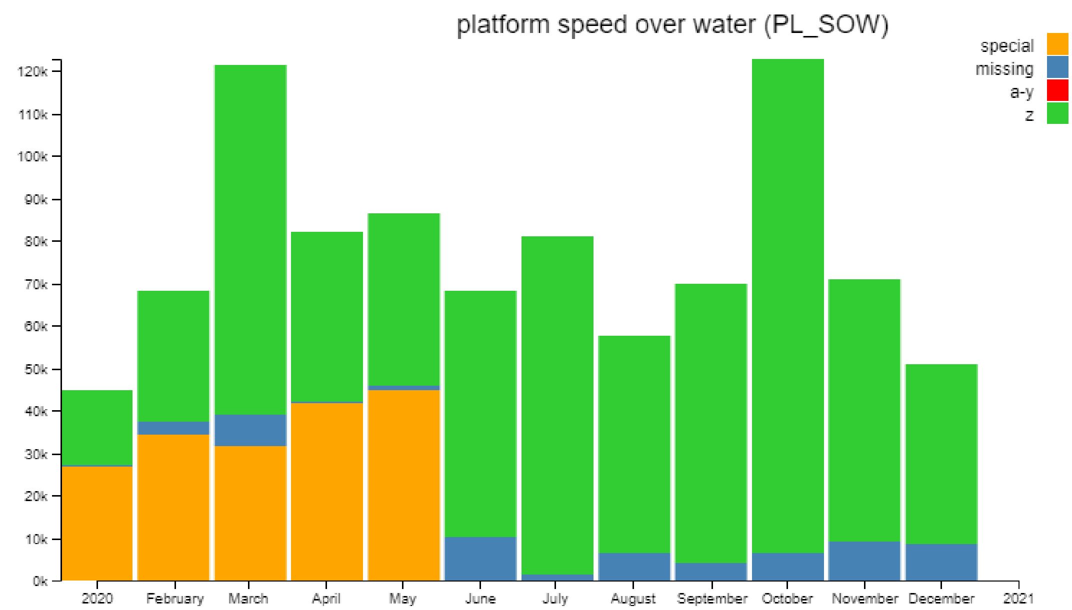


Figure 8: Total number of (this page) platform speed over water – PL_SOW – and (next page) platform speed over water 2 – PL_SOW2 observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

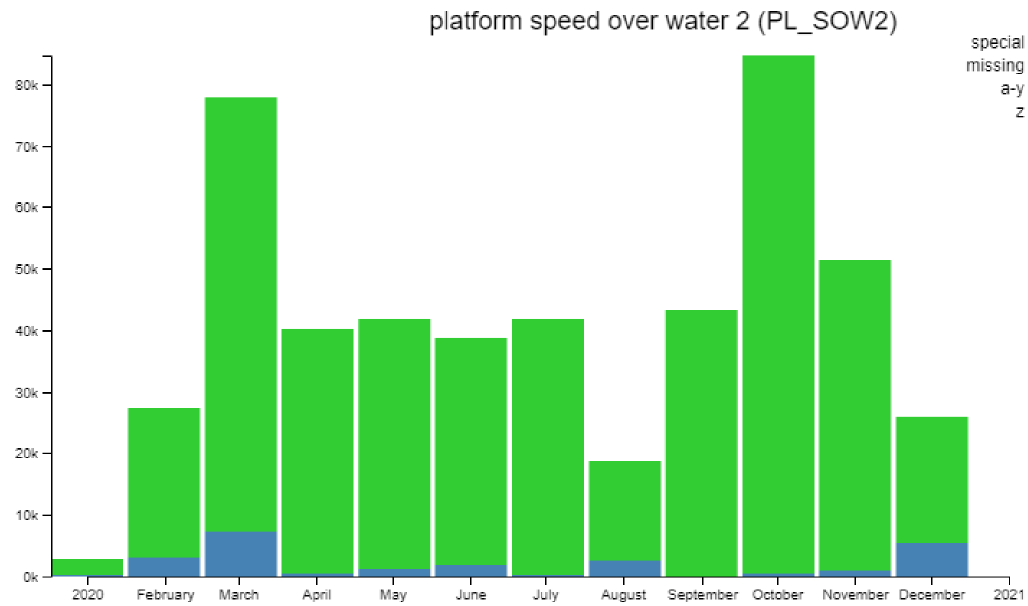
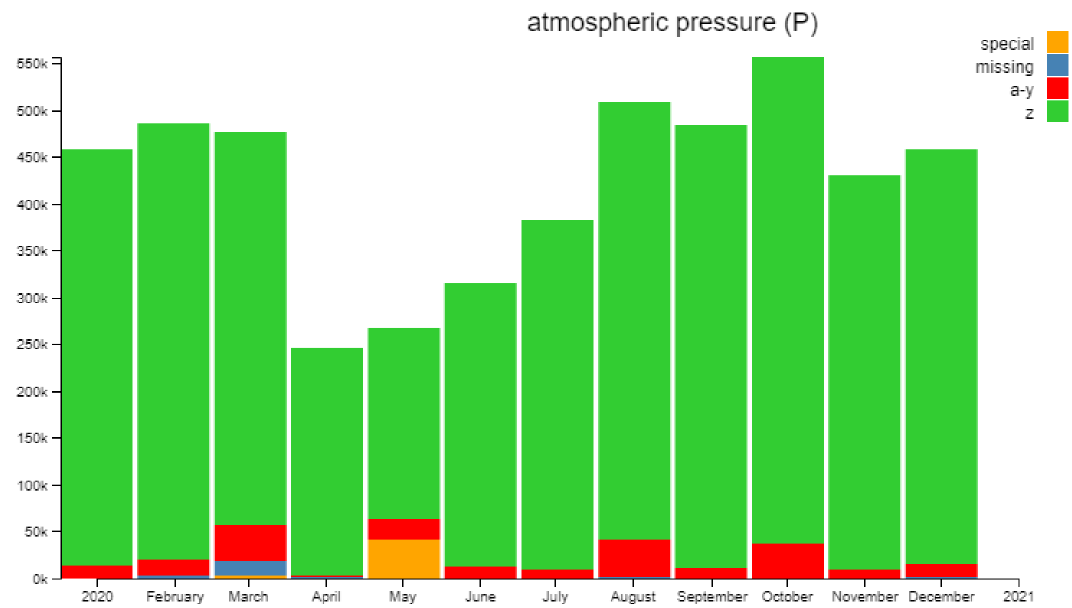


Figure 8: cont'd.

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 (and seen in many other parameters) in March looks to have come mainly from the *Sally Ride* (details unknown). The increase in flagging seen in P in October may have come from the *Thomas Jefferson*, where there was a protracted issue with barometer tubing (documented; see individual vessel description in section 3c for details). The origins of any other increases in a-y flagging seen in P, P2, and P3 are not clearly identified as belonging to any specific vessel(s). Rather, these were likely due to several vessels simultaneously experiencing the common sensor issues we mention here. We note the "special values" seen here and in numerous other parameters, particularly in May, look to have come mostly from the *Neil Armstrong*. The full details are not known, but historically both the WHOI vessels (*Neil Armstrong* and *Atlantis*) have tended to send NaN values for many sensors when they are in port. We add, though, *Atlantis* did not transmit any data in May 2020 as she had started her mid-life refit on 25 March, so none of the May "special values" would have been from her. *Neil Armstrong*, on the other hand, was dockside in May and transmitting NaNs for most MET/TSG data. Note that prior to late May 2020, NaNs were set to "special values" (-8888) by the SAMOS data ingestion code. At the end of May 2020, the SAMOS team modified our data ingestion code to read the non-numeric NaN values and properly assign them with the "missing" (-9999) value instead. For this reason, the occurrences of special values dropped dramatically after May 2020. P3 is only furnished by the *Falkor* so all flags seen there in all months are hers. 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.



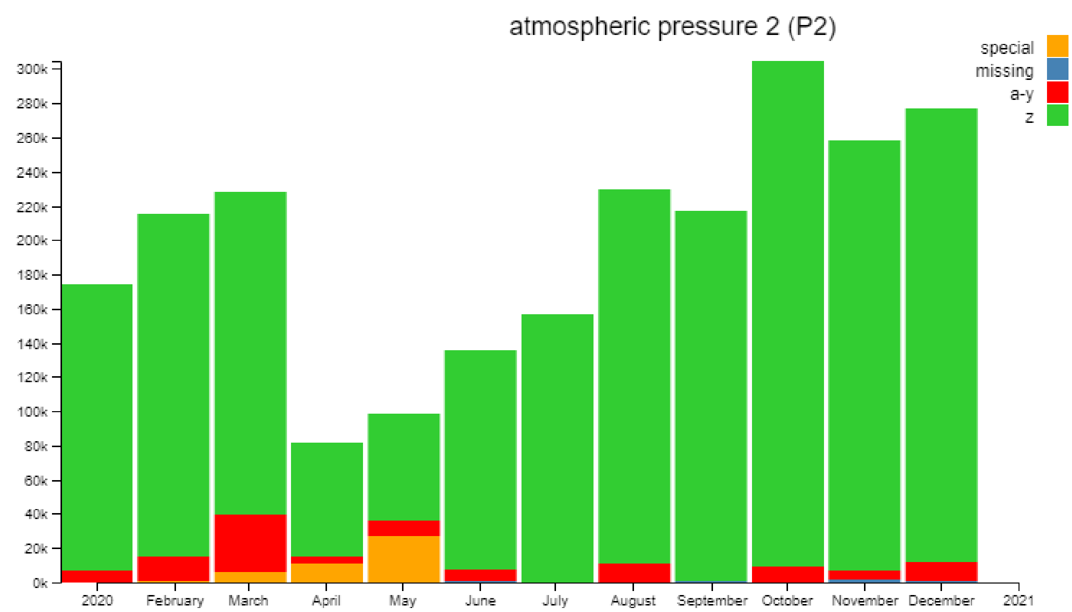
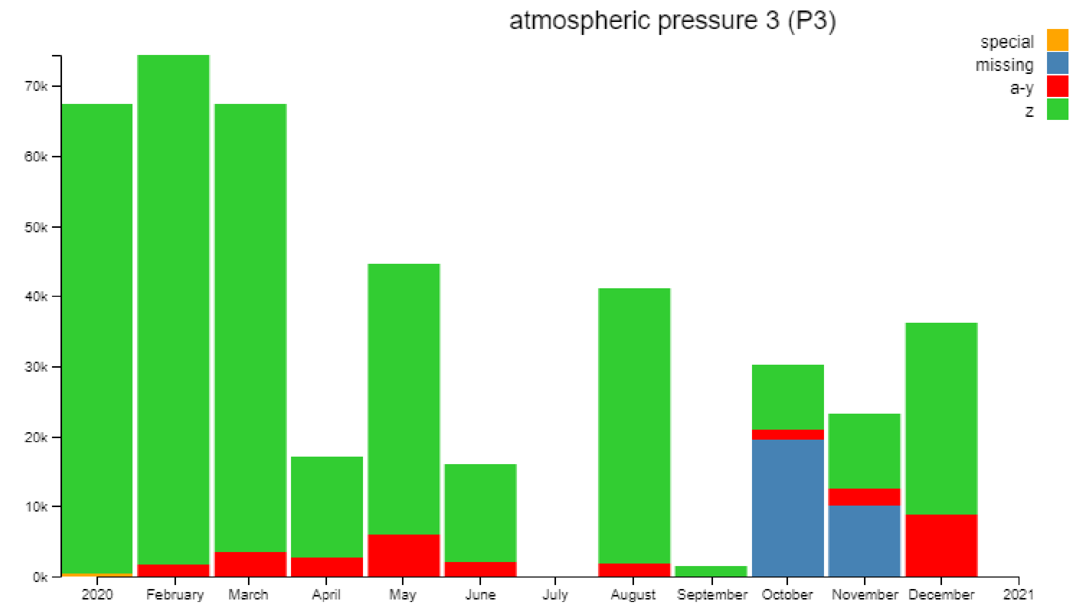


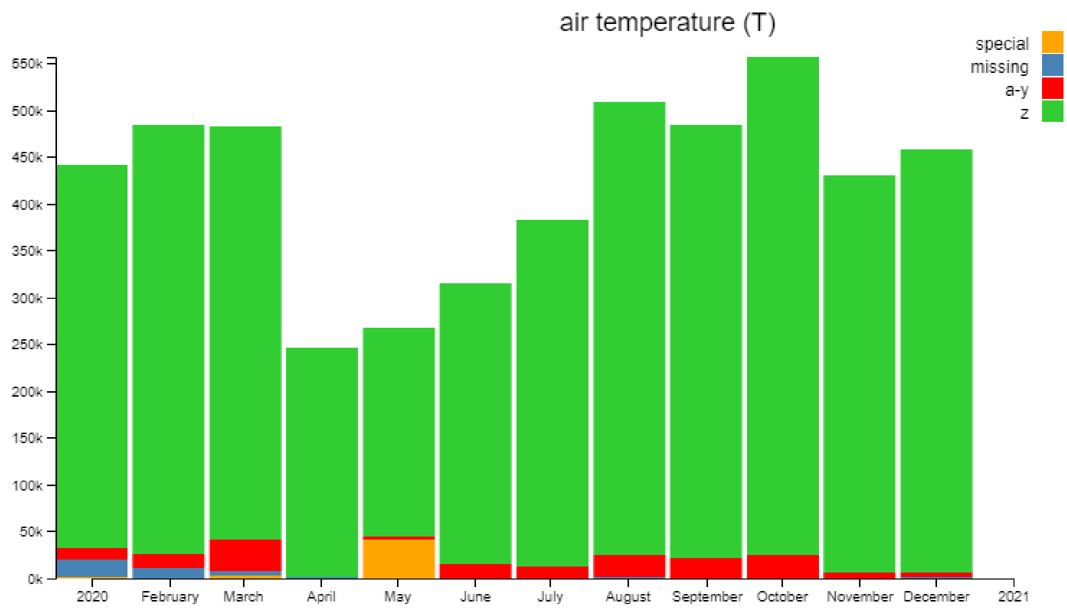
Figure 9: Total number of (this page, top) atmospheric pressure – P – (this page, bottom) atmospheric pressure 2 – P2 – and (next page) atmospheric pressure 3 – P3 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that 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 uptick in flagging seen here in T and T2 (and seen in many other parameters) in March looks to have come mainly from the *Sally Ride* (details unknown). Once again, the origins of any of the other major upticks are not clearly identified as belonging to any specific vessel(s) but are likely due to several vessels simultaneously experiencing common sensor issues. We note the "special values" seen here and in numerous other parameters, particularly in May, look to have come mostly from the *Neil Armstrong*. The full details are not known, but historically both the WHOI vessels (*Neil Armstrong* and *Atlantis*) have tended to send NaN values for many sensors when they are in port. We add, though, *Atlantis* did not transmit any data in May 2020 as she had started her mid-life refit on 25 March, so none of the May "special values" would have been from her. *Neil Armstrong*, on the other hand, was dockside in May and transmitting NaNs for most MET/TSG data. Note that prior to late May 2020, NaNs were set to "special values" (-8888) by the SAMOS data ingestion code. At the end of May 2020, the SAMOS team modified our data ingestion code to read the non-numeric NaN values and properly assign them with the “missing” (-9999) value instead. For this reason, the occurrences of special values dropped dramatically after May 2020. We also note the overwhelming majority of T3 data was provided by the *Falkor*, so most of the flagging seen there is hers. But we again stress the *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” seen in T3 in October/November are likely hers, as well.



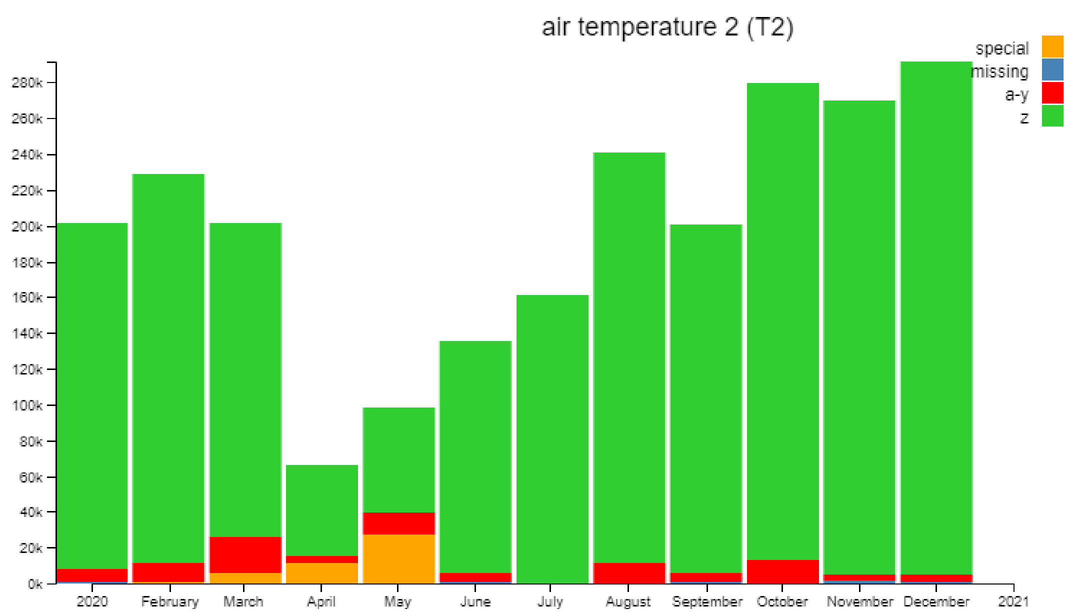
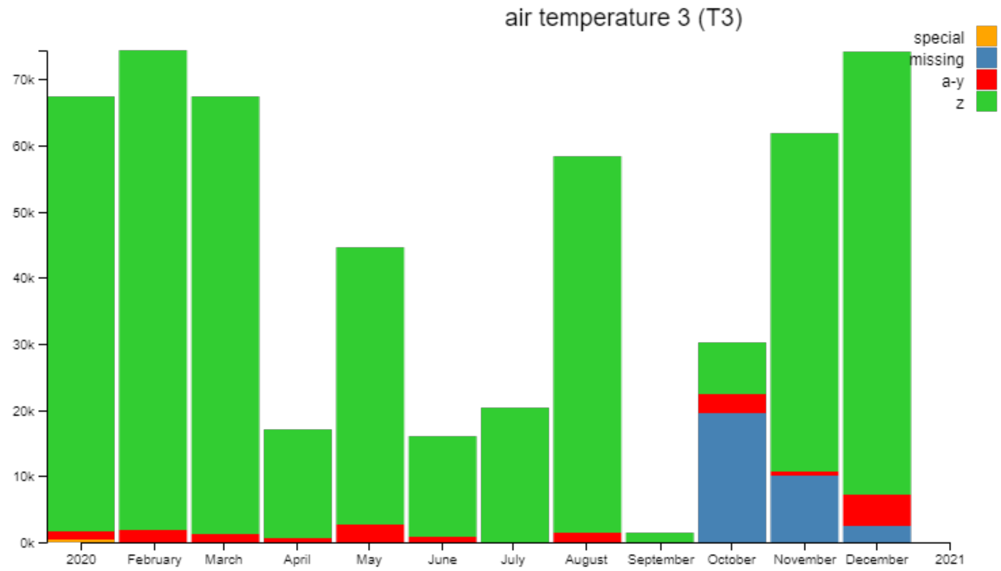


Figure 10: Total number of (this page, top) air temperature – T – (this page, bottom) air temperature 2 – T2 – and (next page) air temperature 3 – T3 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of 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 only two vessels in 2020; namely, the *Thomas Jefferson* and the *Okeanos Explorer*, which are also the only vessels currently set up to report wet bulb. (We note TW from both the *Jefferson* and the *Okeanos Explorer* is a calculated value, rather than being directly measured.) There were no notable issues with TW in 2020. Most flags were the result of flow obstruction and/or ship heating.

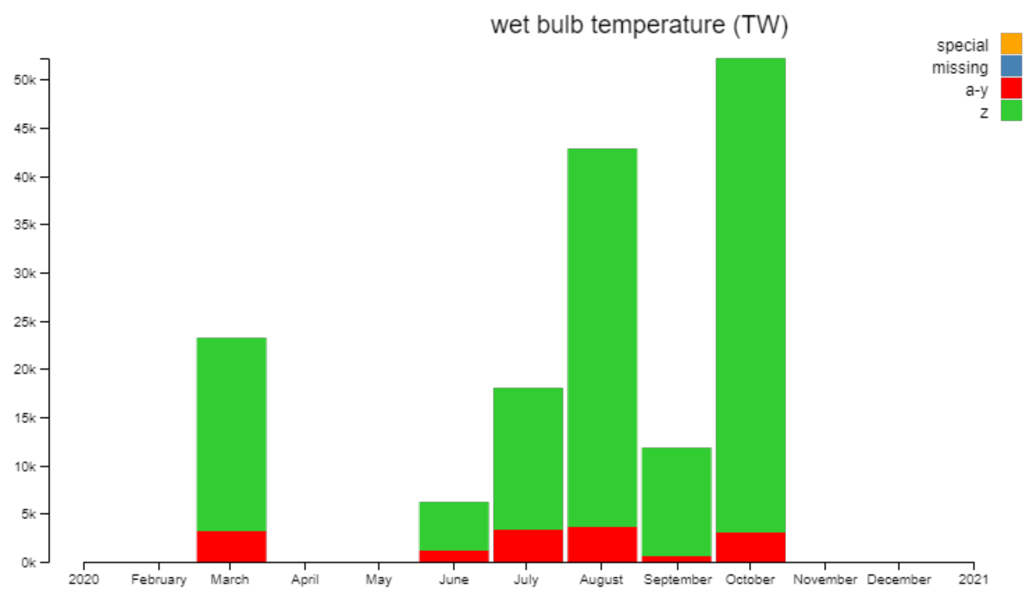


Figure 11: Total number of wet bulb temperature – TW – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

Dew point temperature (Figure 12) was also only reported by two vessels in 2020: again, the *Thomas Jefferson* and the *Okeanos Explorer*. (Again, we note TD from both the *Jefferson* and *Okeanos Explorer* is a calculated value, rather than being directly measured.) As with TW, there were no notable issues with TD in 2020. Most flags were the result of flow obstruction and/or ship heating.

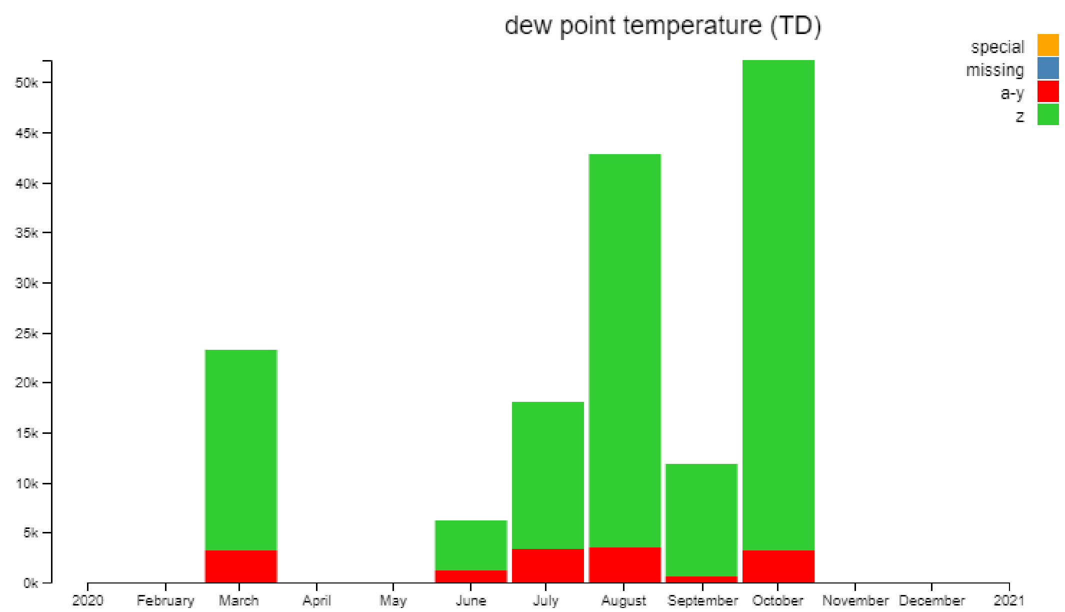


Figure 12: Total number of dew point temperature – TD – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are 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 RH (and seen in many other parameters) in March looks to have come mainly from the *Sally Ride* (details unknown). The origins of any other upticks are not clearly attributable to any specific vessel(s) but are likely due to several vessels simultaneously experiencing common sensor issues and/or common high-humidity weather patterns. Additionally, RH from three vessels (*Aurora Australis*, *Sally Ride*, *Sikuliaq*) were noted at various times throughout the year to be producing humidity values several percentage points over 100% (a B-flagging scenario) in saturated conditions, likely because the sensors were dirty and/or out of calibration (documented; see individual vessel description in section 3c for details). We note only the *Falkor* reports RH3, so once again all flags seen in all months there are hers. But we again stress the *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" seen in T3 in October/November are likely hers, as well. We note the "special values" seen here and in numerous other parameters, particularly in May, look to have come mostly from the *Neil Armstrong*. The full details are not known, but historically both the WHOI vessels (*Neil Armstrong* and *Atlantis*) have tended to send NaN values for many sensors when they are in port. We add, though, *Atlantis* did not transmit any data in May 2020 as she had started her mid-life refit on 25 March, so none of the May "special values" would have been from her. *Neil Armstrong*, on the other hand, was dockside in May and transmitting NaNs for most MET/TSG data. Note that prior to late May 2020, NaNs were set to "special values" (-8888) by the SAMOS data ingestion code. At the end of May 2020, the SAMOS team modified our data ingestion code to read the non-numeric NaN values and properly assign them with the "missing" (-9999) value instead. For this reason, the occurrences of special values dropped dramatically after May 2020.

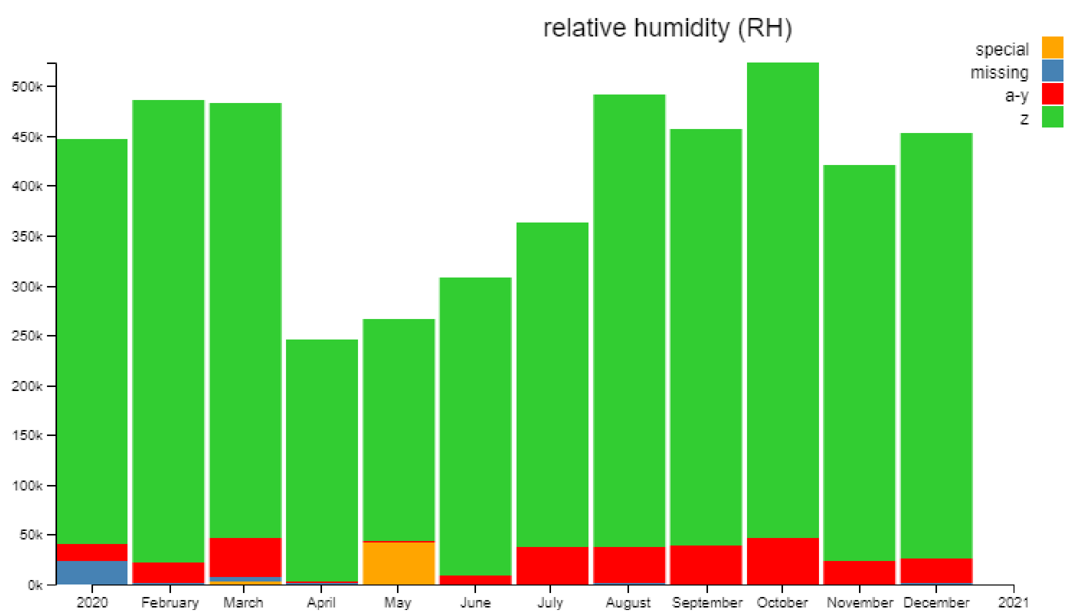
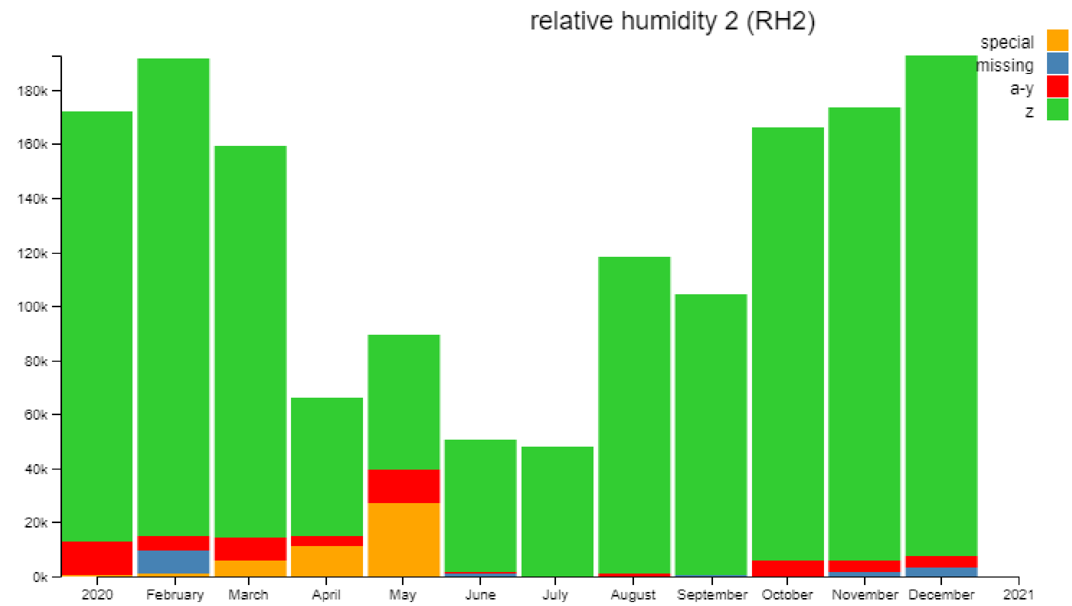
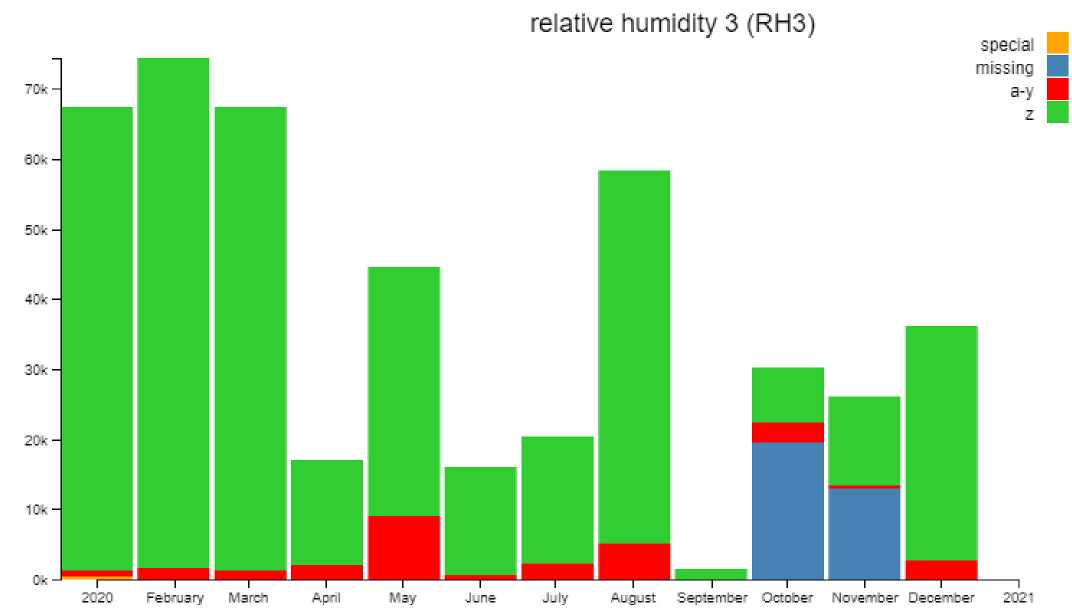


Figure 13: Total number of (this page) relative humidity – RH – (next page, top) relative humidity 2 – RH2 – and (next page, bottom) relative humidity 3 – RH3 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed 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.



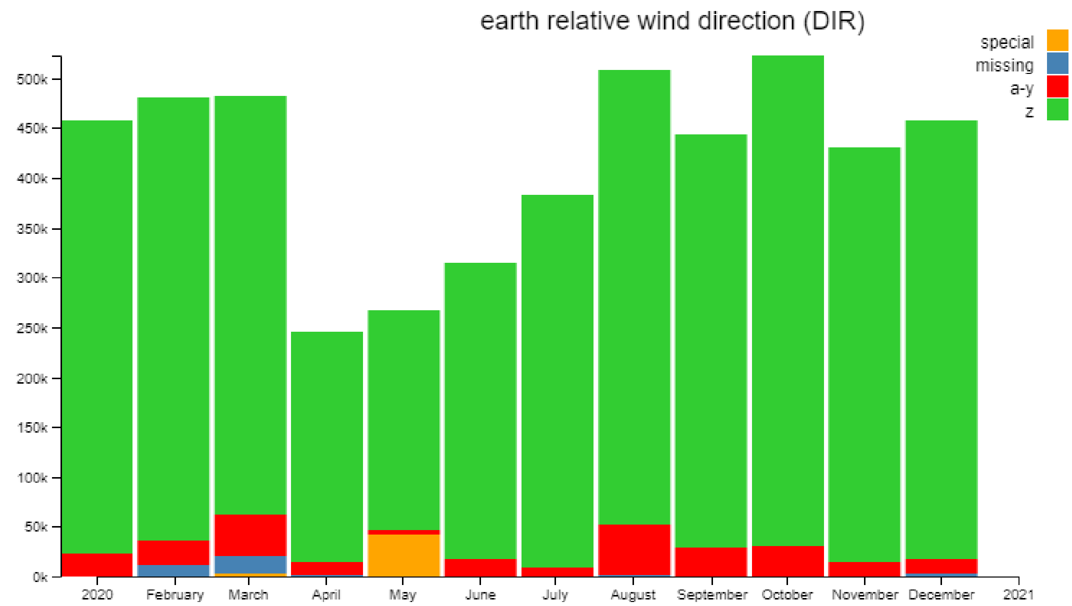


(Figure 13: cont'd)

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 2020. 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.

Several vessels experienced issues with their wind sensors and/or data over the course of the year – most notably the *Falkor* in March through April, the *Rainier* in August, and the *Bigelow* in October (all documented; see individual vessel description in section 3c for details). These issues likely played into some of the upticks in flagging seen across the various earth relative wind direction and speed parameters, in Figures 14 and 15. And we note the upticks in flagging seen here in DIR and SPD (and seen in many other parameters) in March look to have come mainly from the *Sally Ride* (details unknown). In most cases, though, upticks in flagging are not clearly attributable to any specific vessel(s) but are likely due to several vessels simultaneously experiencing common sensor issues. Again, any "special values" seen here and in numerous other parameters, particularly in May, look to have come mostly from the *Neil Armstrong*. The full details are not known, but historically both the WHOI vessels (*Neil Armstrong* and *Atlantis*) have tended to send NaN values for many sensors when they are in port. We add, though, *Atlantis* did not transmit any data in May 2020 as she had started her mid-life refit on 25 March, so none of the May "special values" would have been from her. *Neil Armstrong*, on the other hand, was dockside in May and transmitting NaNs for most MET/TSG data. Note that prior to late May 2020, NaNs were set to "special values" (-8888) by the SAMOS data ingestion code. At the end of May 2020, the SAMOS team modified our data ingestion code to read the non-numeric NaN values and properly assign them with the "missing" (-9999) value instead. For this reason, the occurrences of special values dropped dramatically after May 2020. The "missing values" seen in DIR3/SPD3 in October/November likely belong to the *Falkor*.



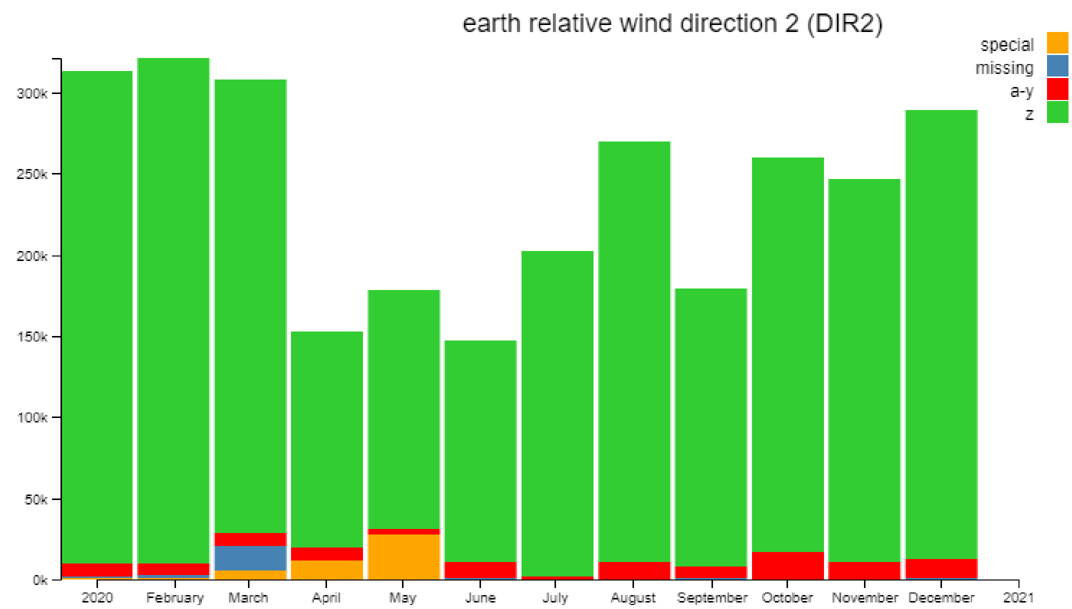
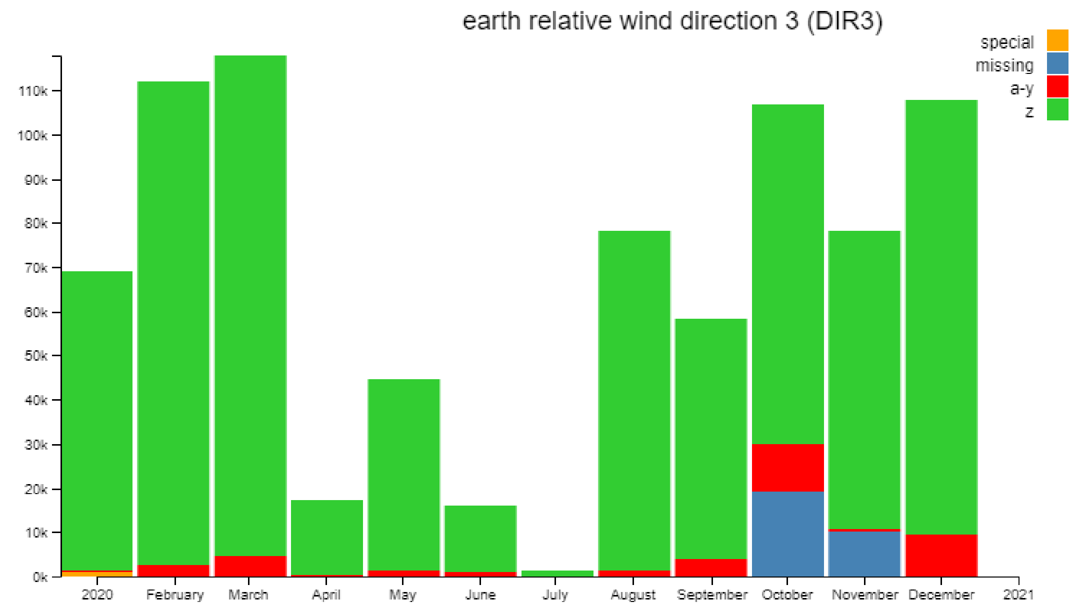


Figure 14: Total number of (this page, top) earth relative wind direction – DIR – (this page, bottom) earth relative wind direction 2 – DIR2 – and (next page) earth relative wind direction 3 – DIR3 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) 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)

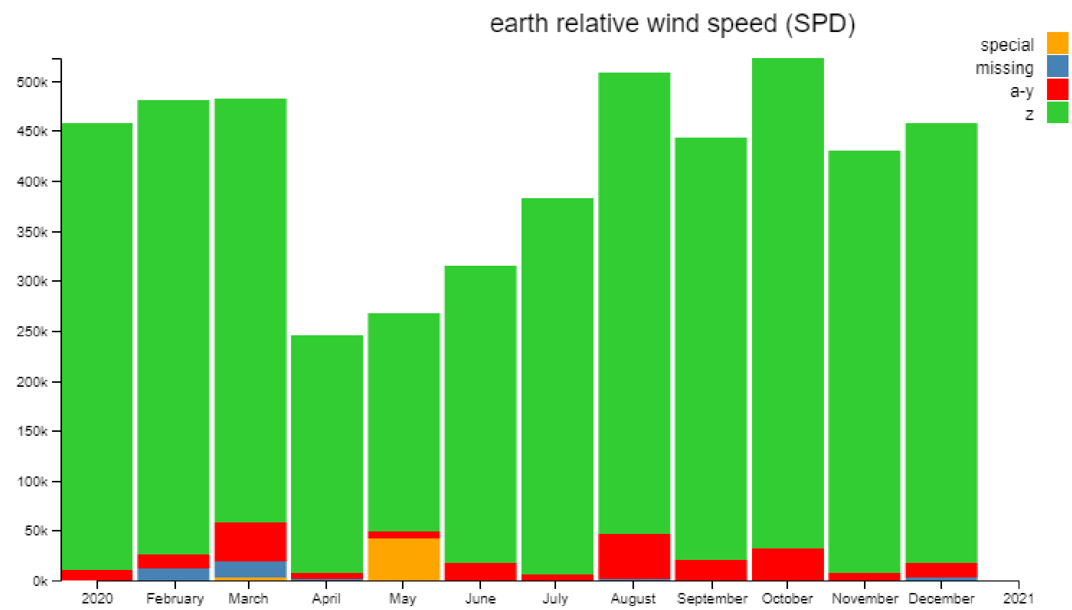
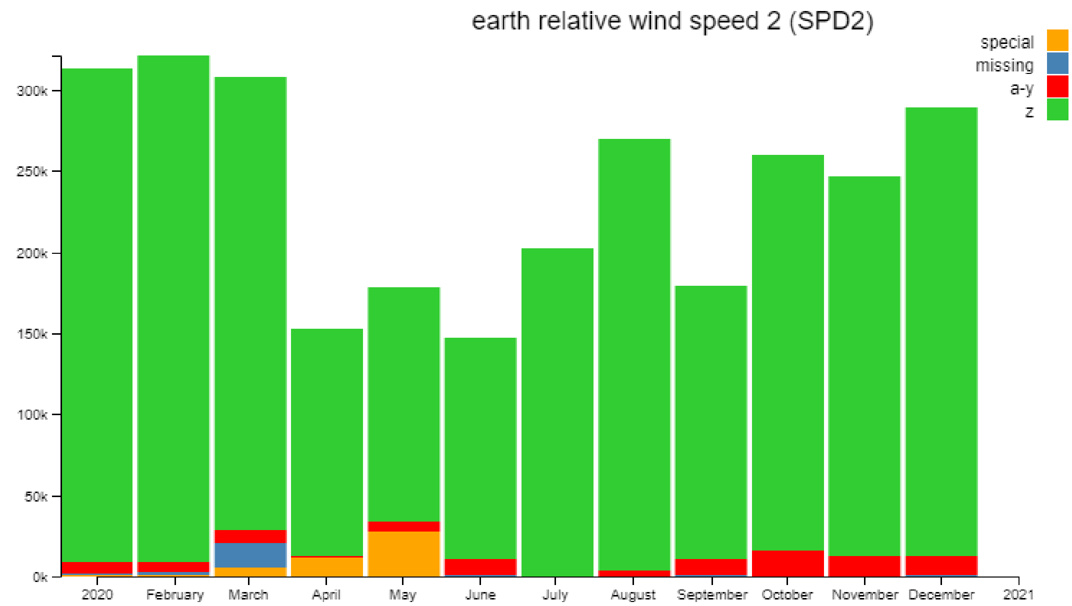
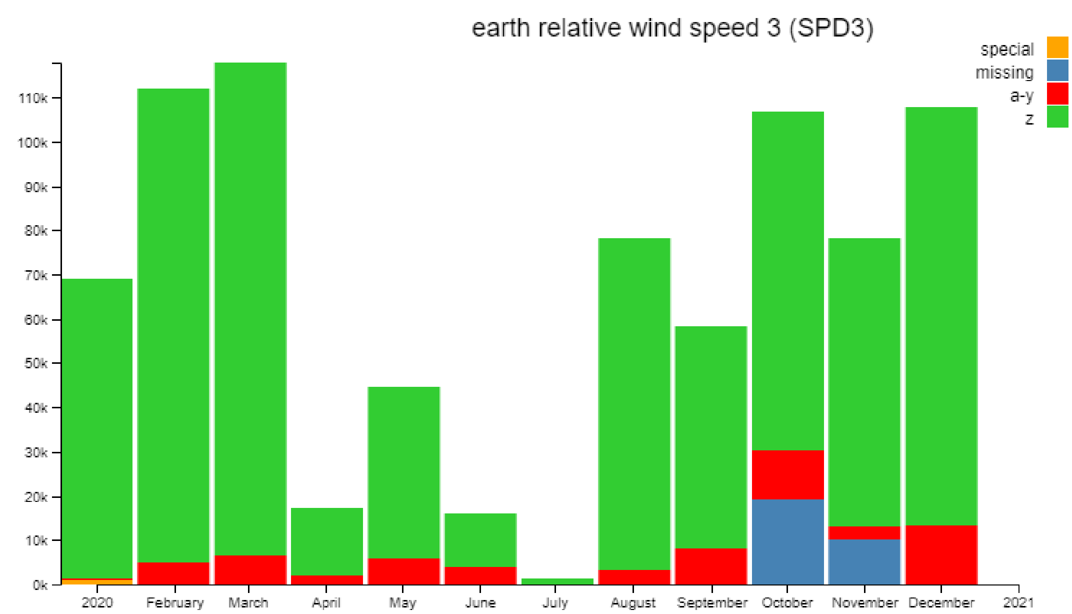


Figure 15: Total number of (this page) earth relative wind speed – SPD – (next page, top) earth relative wind speed 2 – SPD2 – and (next page, bottom) earth relative wind speed 3 – SPD3 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values 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), exhibited no major problems of note, save that a few rare sensor and/or connectivity failures occurred – specifically, the *Falkor* in March, the *Rainier* in August, and the *Henry Bigelow* in October (all documented; see individual vessel description in section 3c for details). These and any other sparse cases were treated with J and 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. We note the "special values" seen here and in numerous other parameters, particularly noteworthy in May, look to have come mostly from the *Neil Armstrong*. The full details are not known, but historically both the

WHOI vessels (*Neil Armstrong* and *Atlantis*) have tended to send NaN values for many sensors when they are in port. We add, though, *Atlantis* did not transmit any data in May 2020 as she had started her mid-life refit on 25 March, so none of the May "special values" would have been from her. *Neil Armstrong*, on the other hand, was dockside in May and transmitting NaNs for most MET/TSG data. Note that prior to late May 2020, NaNs were set to "special values" (-8888) by the SAMOS data ingestion code. At the end of May 2020, the SAMOS team modified our data ingestion code to read the non-numeric NaN values and properly assign them with the "missing" (-9999) value instead. For this reason, the occurrences of special values dropped dramatically after May 2020. And again, here we'll note the "missing values" seen in PL_WDIR3 and PL_WSPD3 in October/November are likely from the *Falkor*.

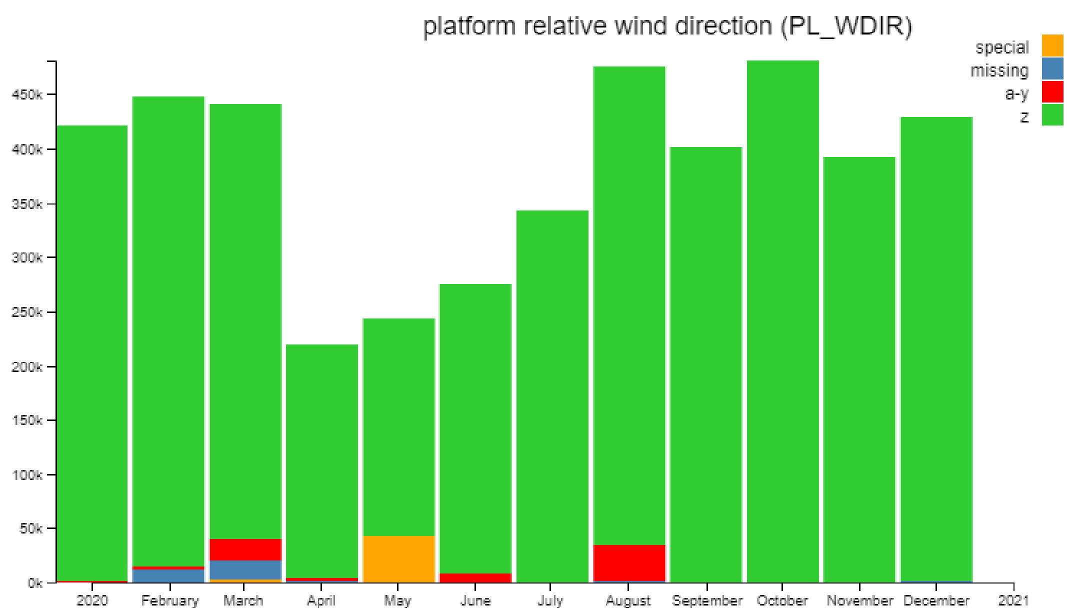
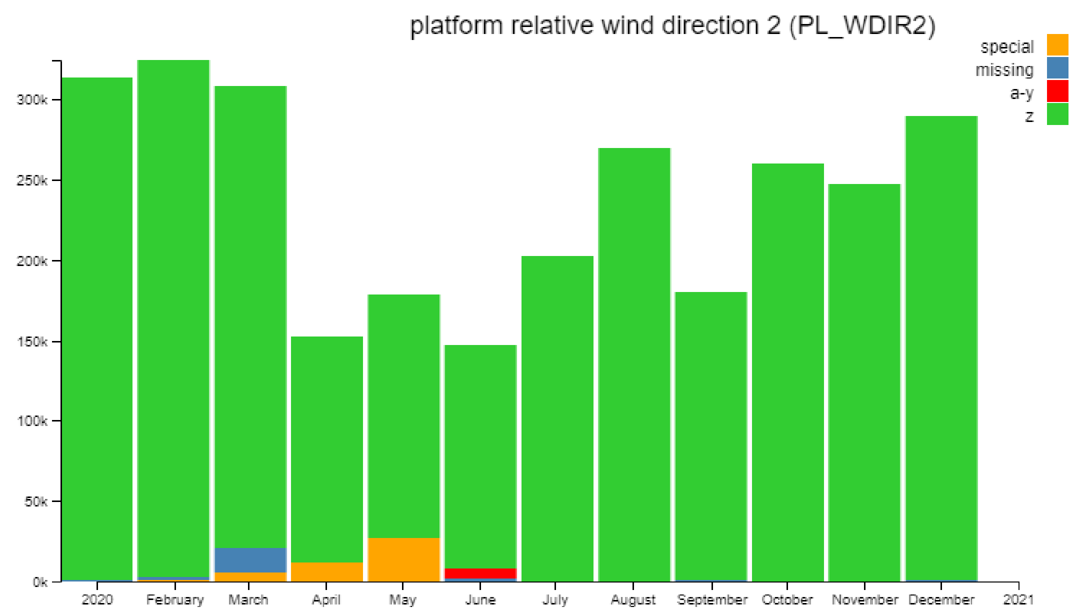
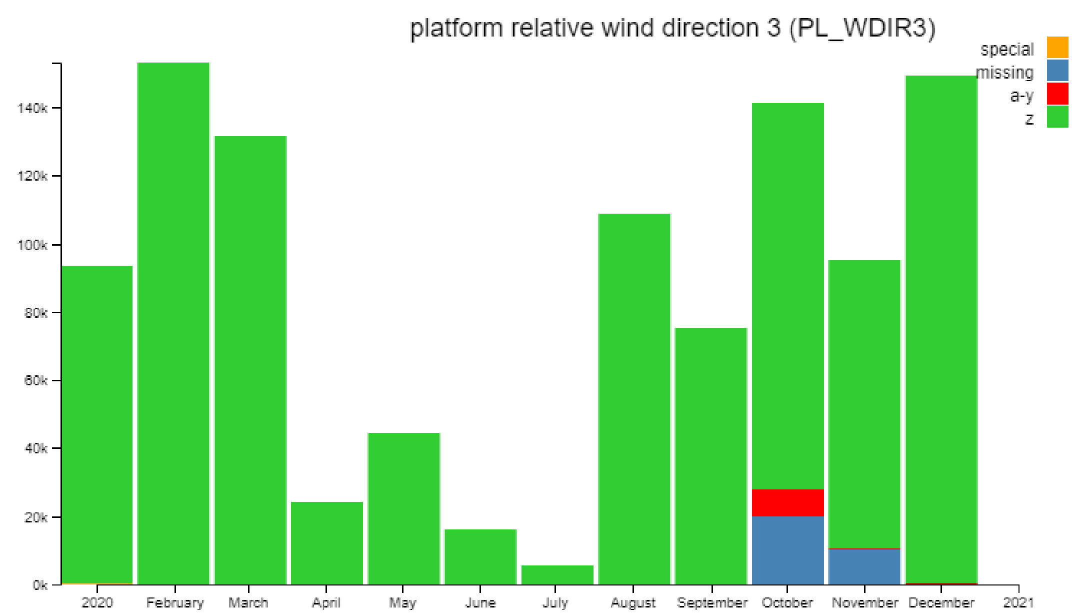
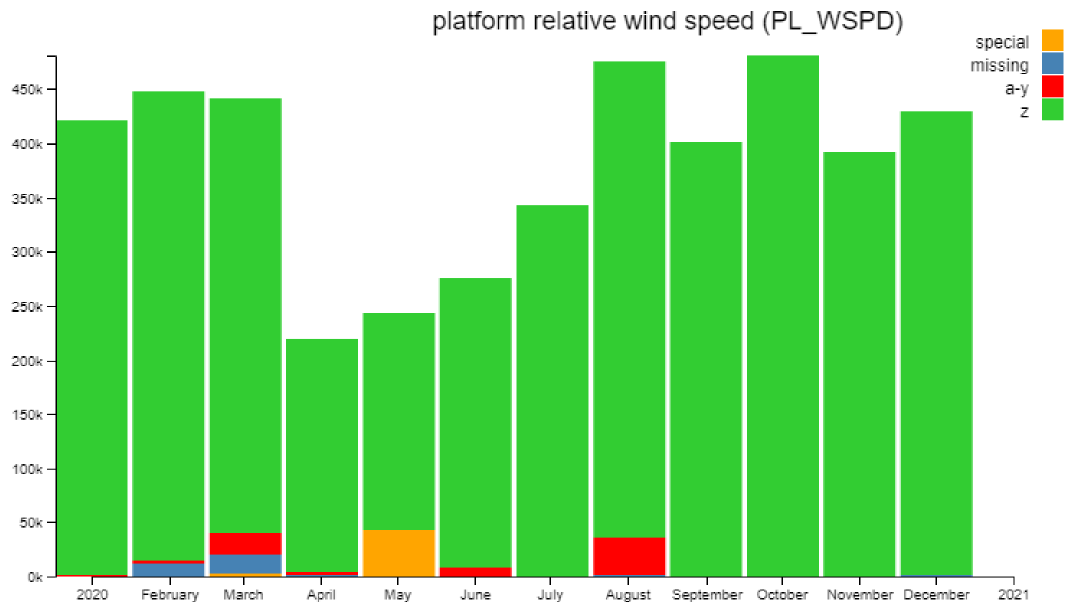


Figure 16: Total number of (this page) platform relative wind direction – PL_WDIR – (next page, top) platform relative wind direction 2 – PL_WDIR2 – and (next page, bottom) platform relative wind direction 3 – PL_WDIR3 – observations provided by all ships for each month in 2020. The colors represent 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)



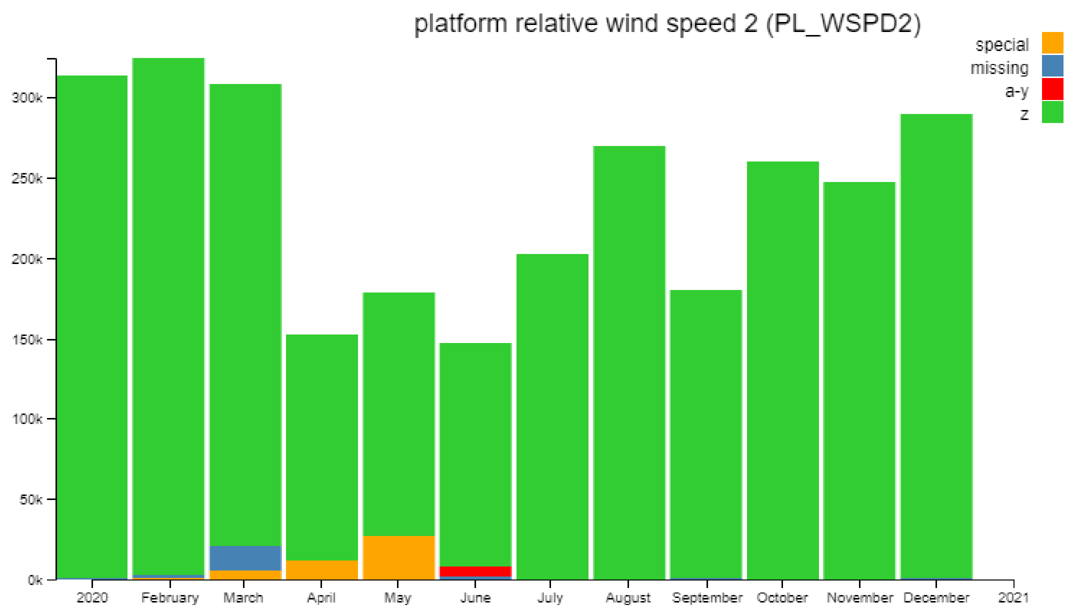
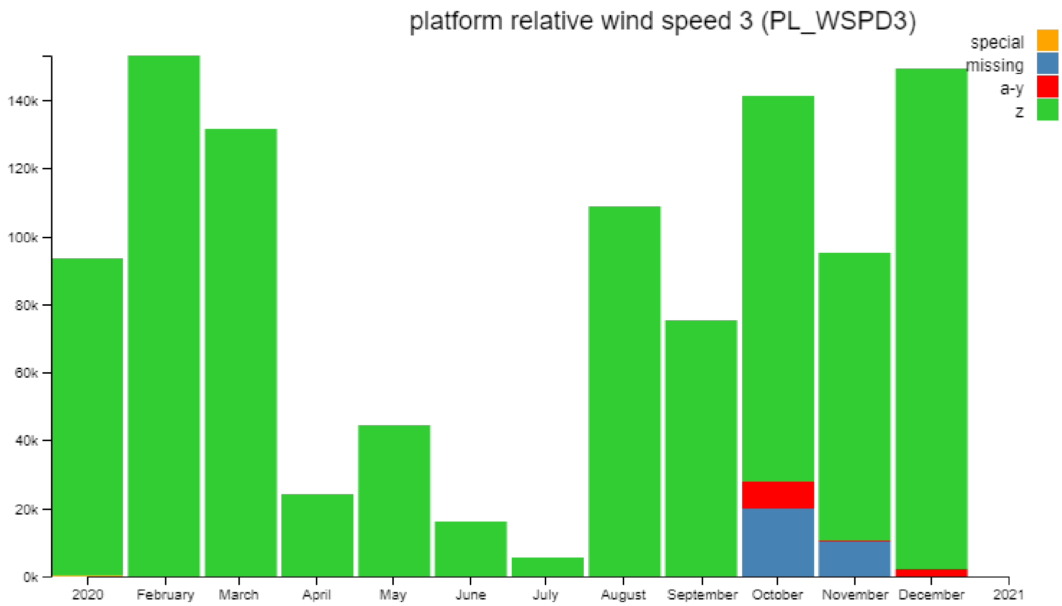


Figure 17: Total number of (this page, top) platform relative wind speed – PL_WSPD – (this page, bottom) platform relative wind speed 2 – PL_WSPD2 – and (next page) platform relative wind speed 3 – PL_WSPD3 – observations provided by all ships for each month in 2020. The colors represent the number of 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) 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_SW and RAD_LW (and seen in many other parameters) in March look to have come mainly from the *Sally Ride* (details unknown). The increase in flagging seen in RAD_SW in August may also have come from the *Sally Ride*, where there was an issue with the j-box for that sensor (documented; see individual vessel description in section 3c for details). The upticks in flagging in RAD_PAR (Figure 20) seen in February through June were likely due the *Robert Gordon Sproul*, as the sensor was probably not actually installed during that period (documented; see individual vessel description in section 3c for details). Meanwhile, *Falkor* was responsible for the increased flagging seen in RAD_PAR2 in October and November, likely owing to corrosion (documented; see individual vessel description in section 3c for details). We note the “special values” seen here and in numerous other parameters, particularly in May, look to have come mostly from the *Neil Armstrong*. The full details are not known, but historically both the WHOI vessels (*Neil Armstrong* and *Atlantis*) have tended to send NaN values for many sensors when they are in port. We add, though, *Atlantis* did not transmit any data in May 2020 as she had started her mid-life refit on 25 March, so none of the May "special values" would have been from her. *Neil Armstrong*, on the other hand, was dockside in May and transmitting NaNs for most MET/TSG data. Note that prior to late May 2020, NaNs were set to "special values" (-8888) by the SAMOS data ingestion code. At the end of May 2020, the SAMOS team modified our data ingestion code to read the non-numeric NaN values and properly assign them with the "missing" (-9999) value instead. For this reason, the occurrences of special values dropped dramatically after May 2020. We further note most of the missing and/or special values seen in RAD_PAR2 were from the *Falkor*. It is not specifically known why.

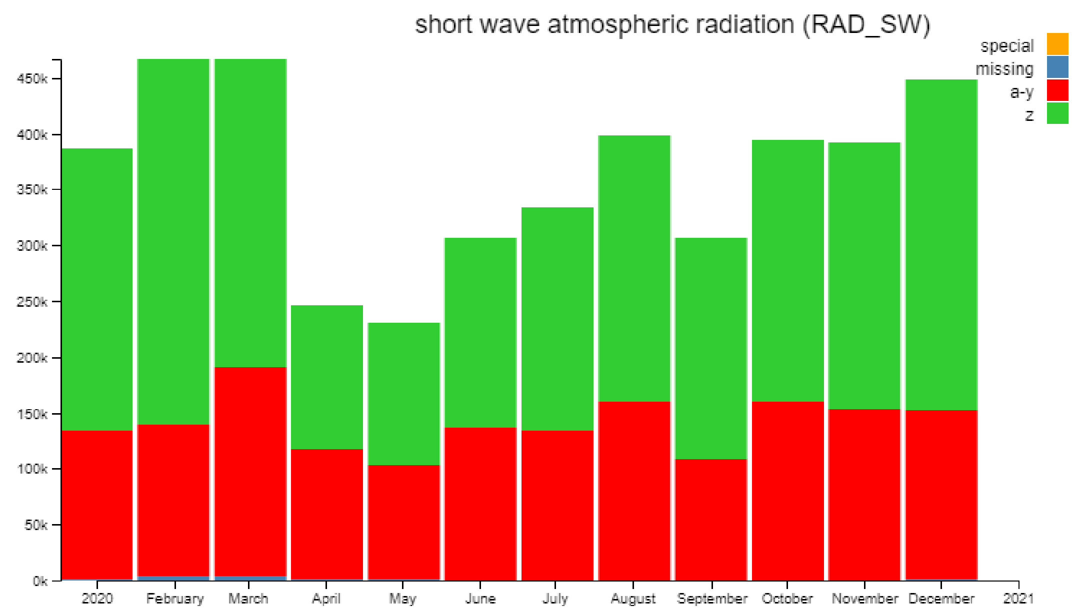
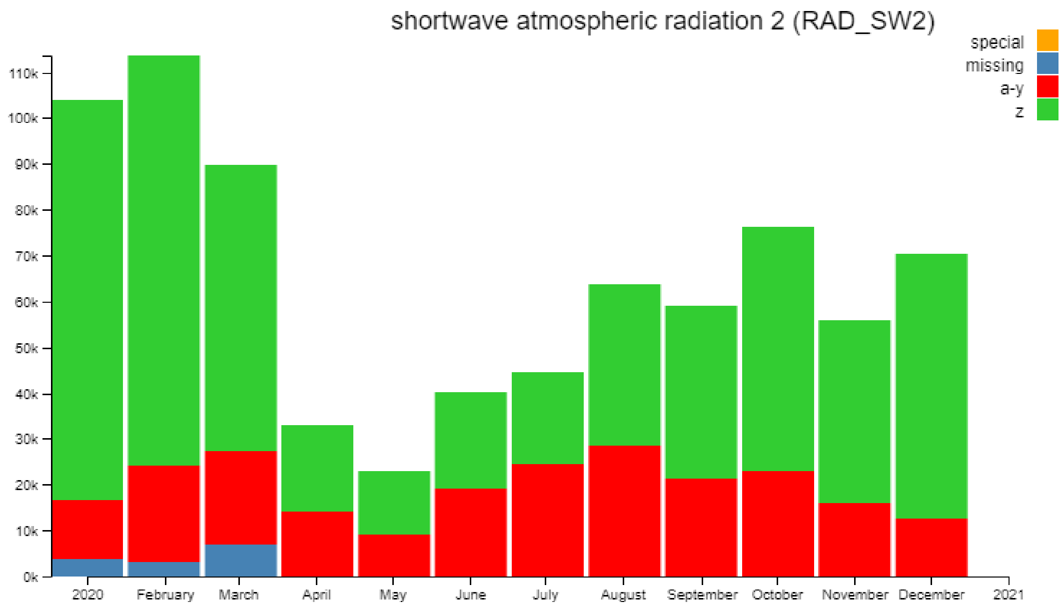


Figure 18: Total number of (this page) shortwave atmospheric radiation – RAD_SW – and (next page) shortwave atmospheric radiation 2 – RAD_SW2 –observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS 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)

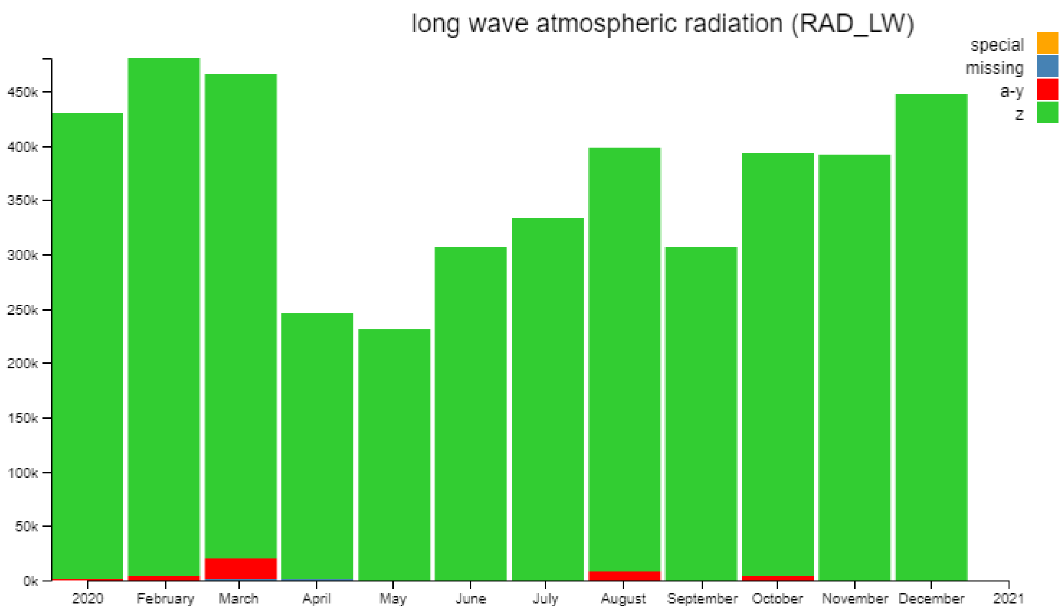
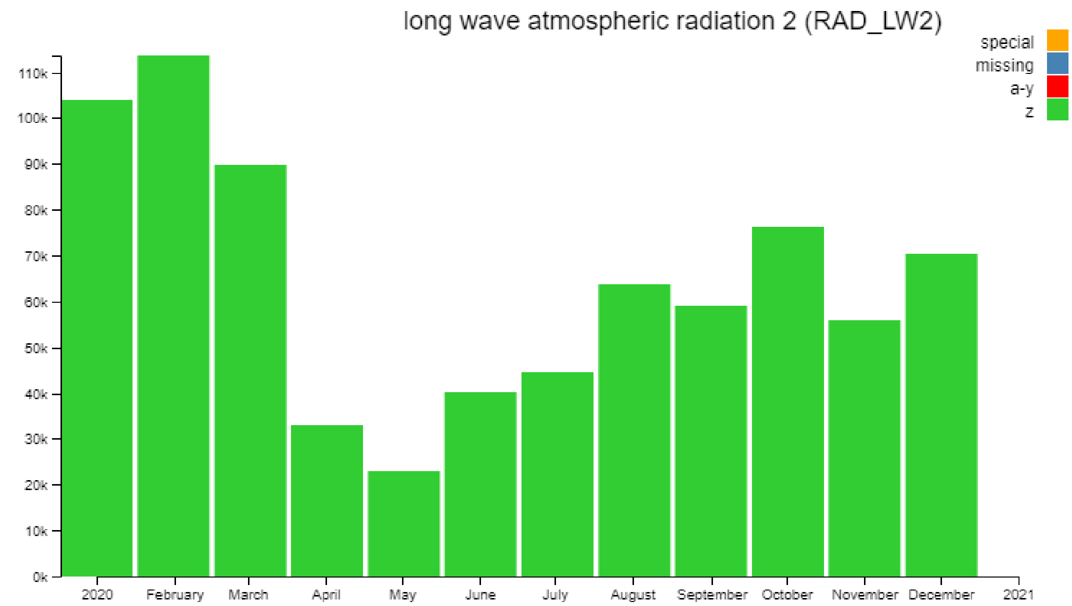


Figure 19: Total number of (this page) long wave atmospheric radiation – RAD_LW – and (next page) long wave atmospheric radiation 2 – RAD_LW2 –observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 19: cont'd)

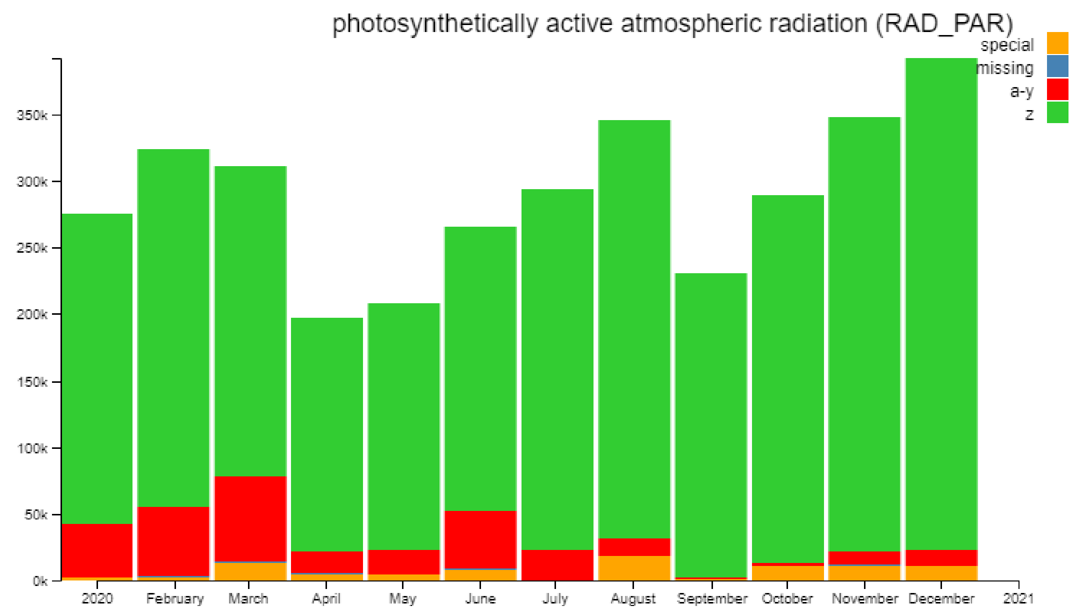
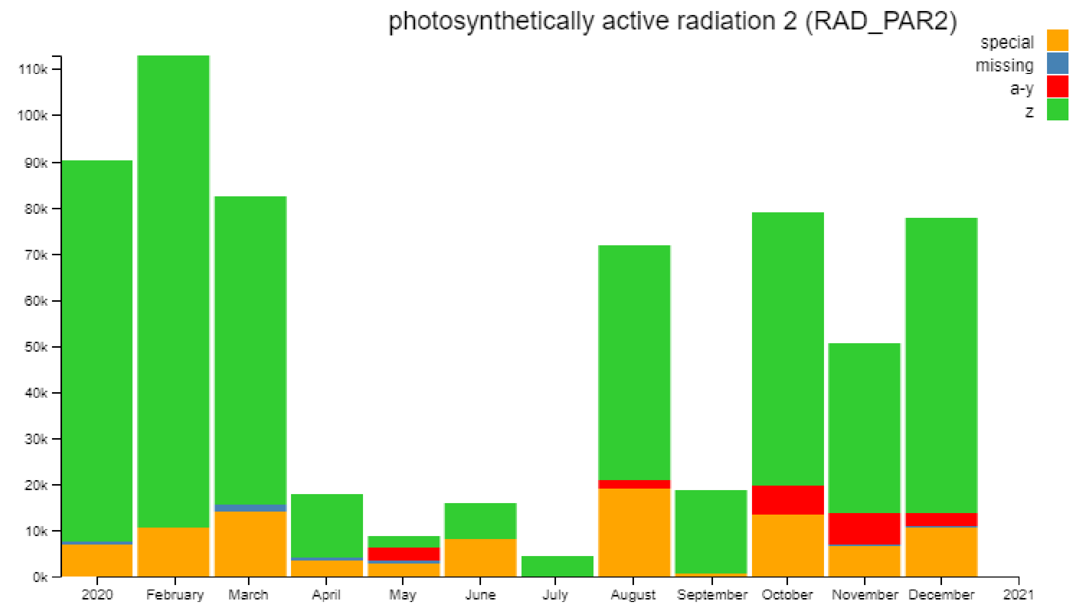


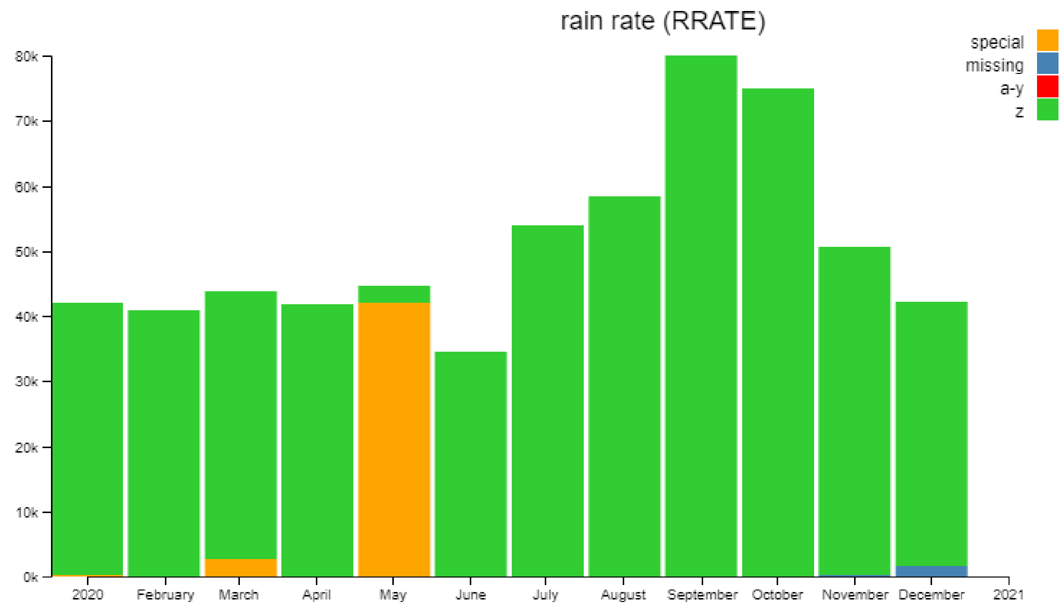
Figure 20: Total number of (this page) photosynthetically active atmospheric radiation – RAD_PAR – and (next page) photosynthetically active atmospheric radiation 2 – RAD_PAR2 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the 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.

We note only the *Atlantis*, *Neil Armstrong*, and *Aurora Australis* provide RRATE, only *Atlantis* and *Armstrong* RRATE2, and only *Atlantis* RRATE3, so special values seen in any of the RRATE parameters are only attributable to those select ships (excepting the *Atlantis* after 25 March, since she was entered her mid-life refit on that date and stopped transmitting any data thereafter). No details are known about any of these special value situations, but again we stress both *Atlantis* and *Neil Armstrong* commonly transmit port data, which could be a contributing factor.



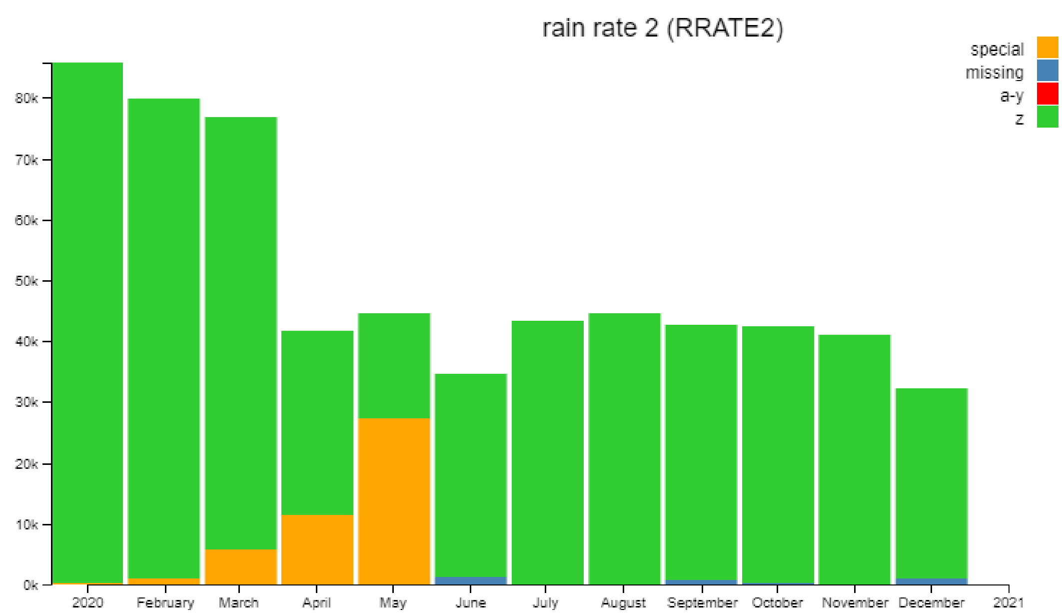
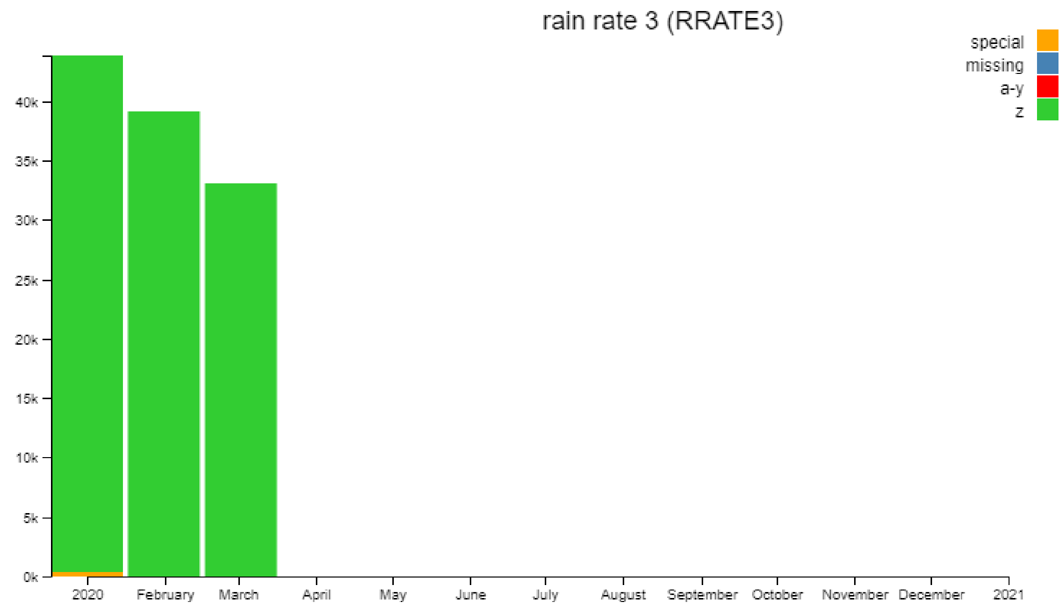


Figure 21: Total number of (this page, top) rain rate – RRATE – (this page, bottom) rain rate 2 – RRATE2 – and (next page) rain rate 3 – RRATE3 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the 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)

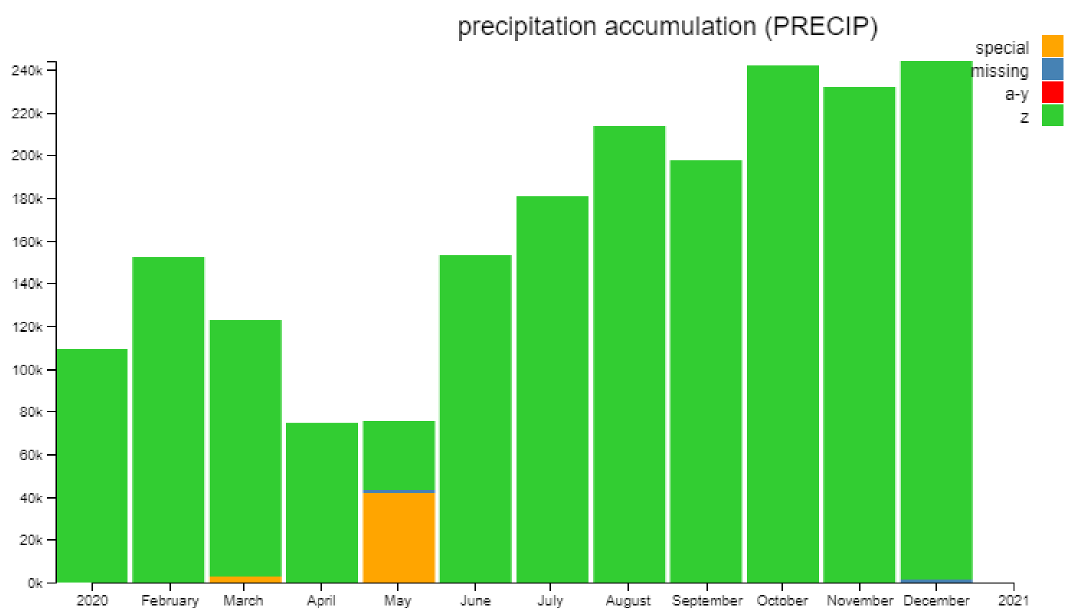
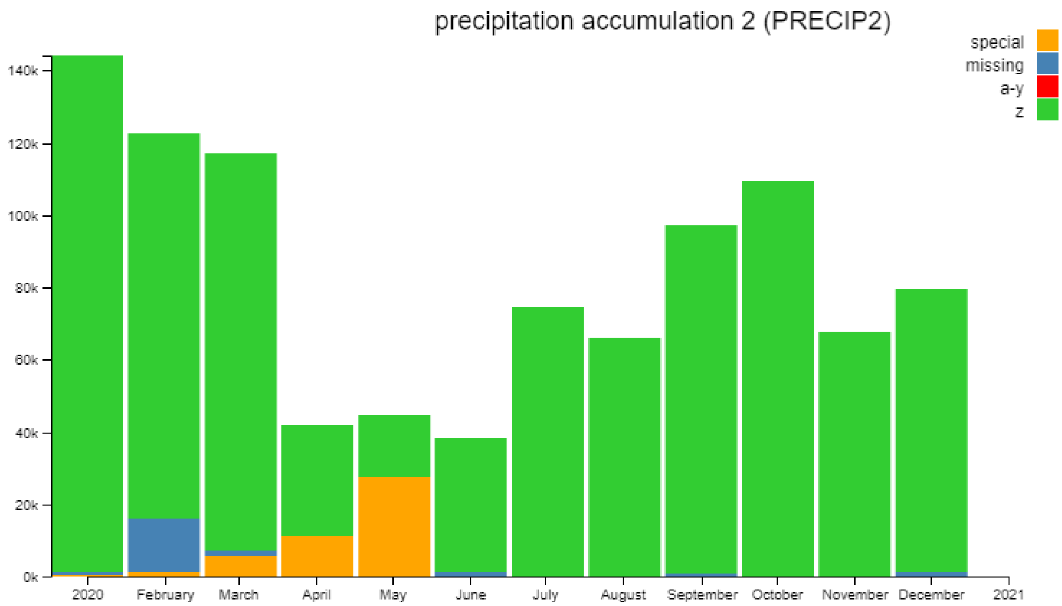
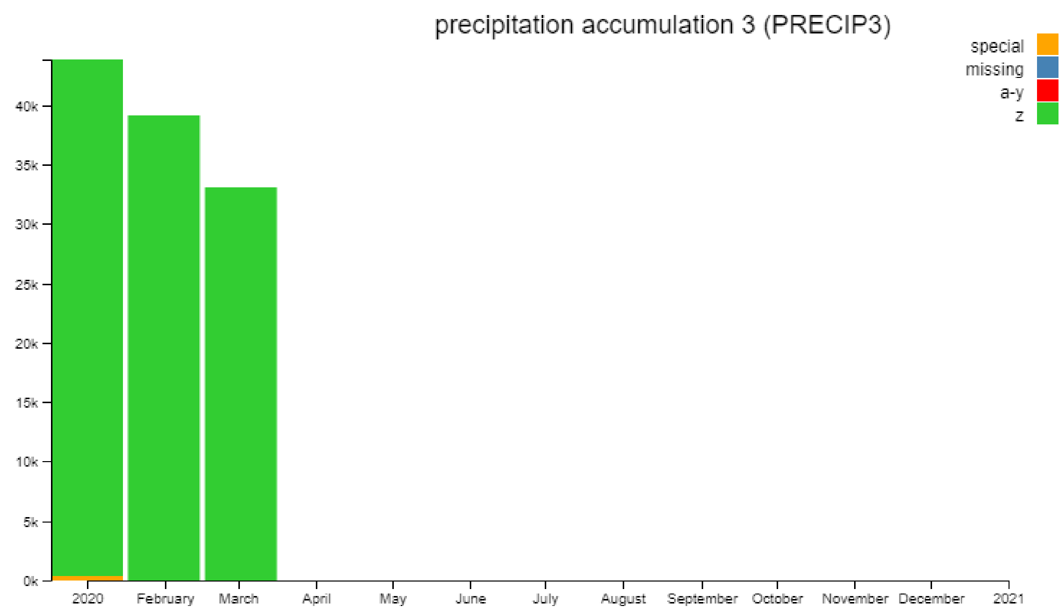


Figure 22: Total number of (this page) precipitation accumulation – PRECIP – (next page, top) precipitation accumulation 2 – PRECIP2 – and (next page, bottom) precipitation accumulation 3 – PRECIP3 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) 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 2020. 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 origins of any increases in 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 here. Once again, we note the "special values" seen here and in numerous other parameters, particularly in May, look to have come mostly from the *Neil Armstrong*. The full details are not known, but historically both the WHOI vessels (*Neil Armstrong* and *Atlantis*) have tended to send NaN values for many sensors when they are in port. We add, though, *Atlantis* did not transmit any data in May 2020 as she had started her mid-life refit on 25 March, so none of the May "special values" would have been from her. *Neil Armstrong*, on the other hand, was dockside in May and transmitting NaNs for most MET/TSG data. Note that prior to late May 2020, NaNs were set to "special values" (-8888) by the SAMOS data ingestion code. At the end of May 2020, the SAMOS team modified our data ingestion code to read the non-numeric NaN values and properly assign them with the "missing" (-9999) value instead. For this reason, the occurrences of special values dropped dramatically after May 2020.

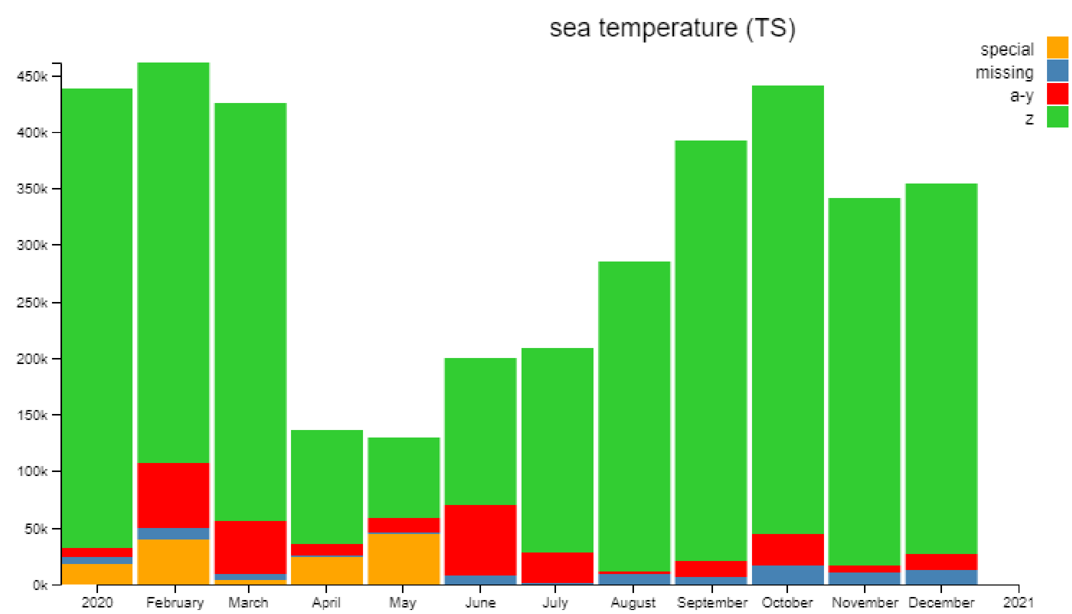
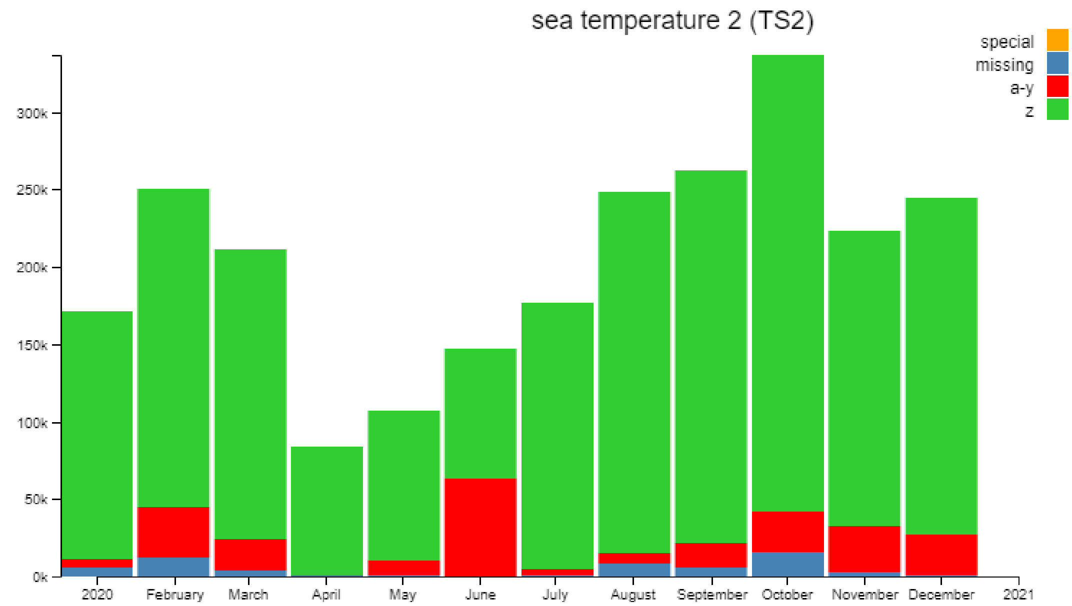
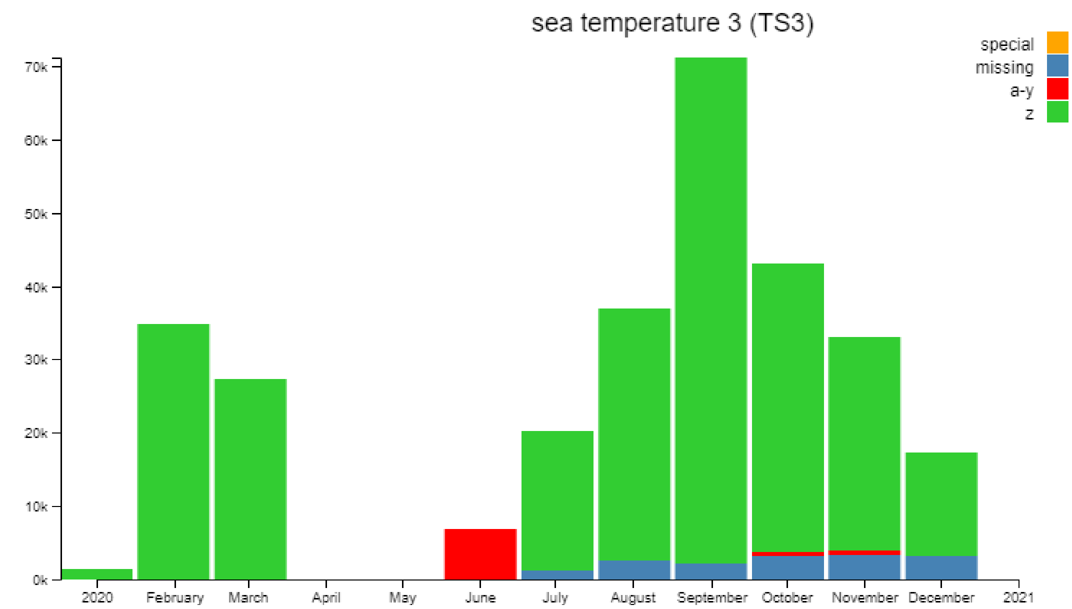
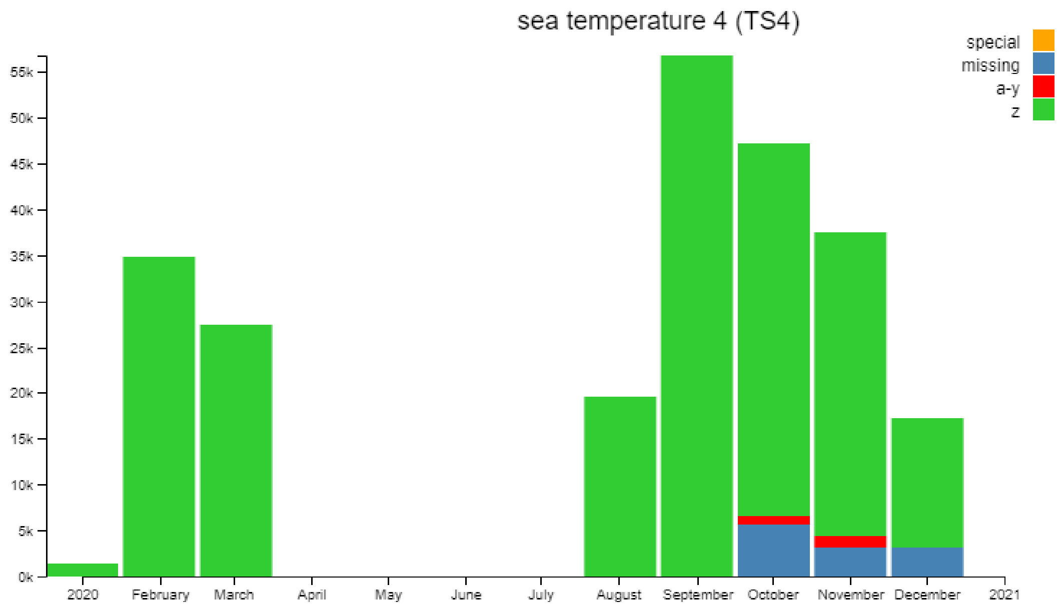


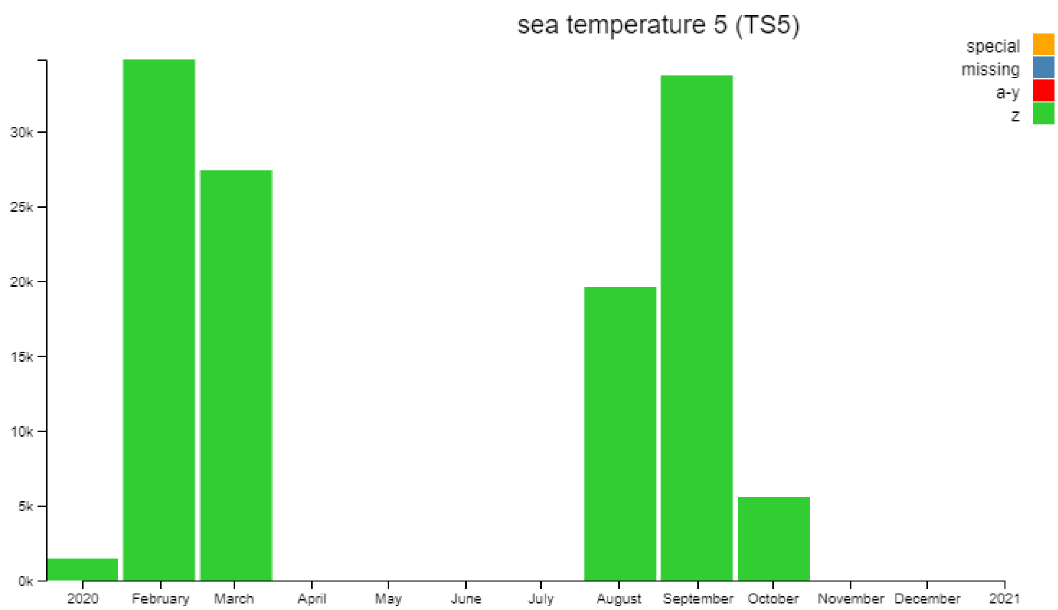
Figure 23: Total number of (this page) sea temperature – TS – (next page, top) sea temperature 2 – TS2 – (next page, bottom) sea temperature 3 – TS3 – (third page, top) sea temperature 4 – TS4 – (third page, bottom) and sea temperature 5 – TS5 – observations provided by all ships for each month in 2020. 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 23: cont'd.)

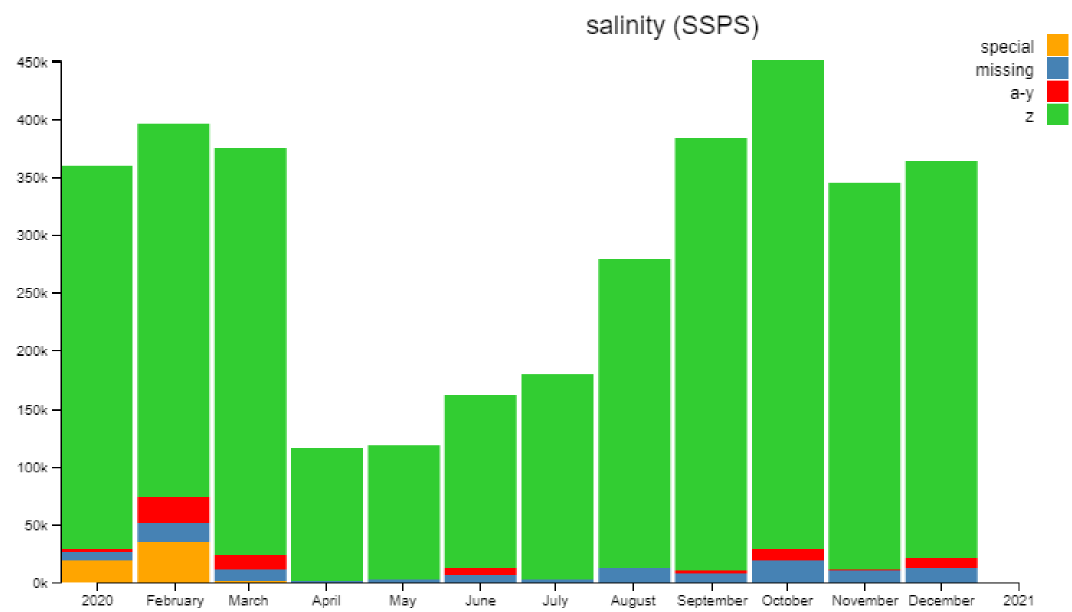




(Figure 23: cont'd.)

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 2020 was still well within reason.

The origins of any increases in a-y flagging seen in the conductivity and salinity have not been 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 here.



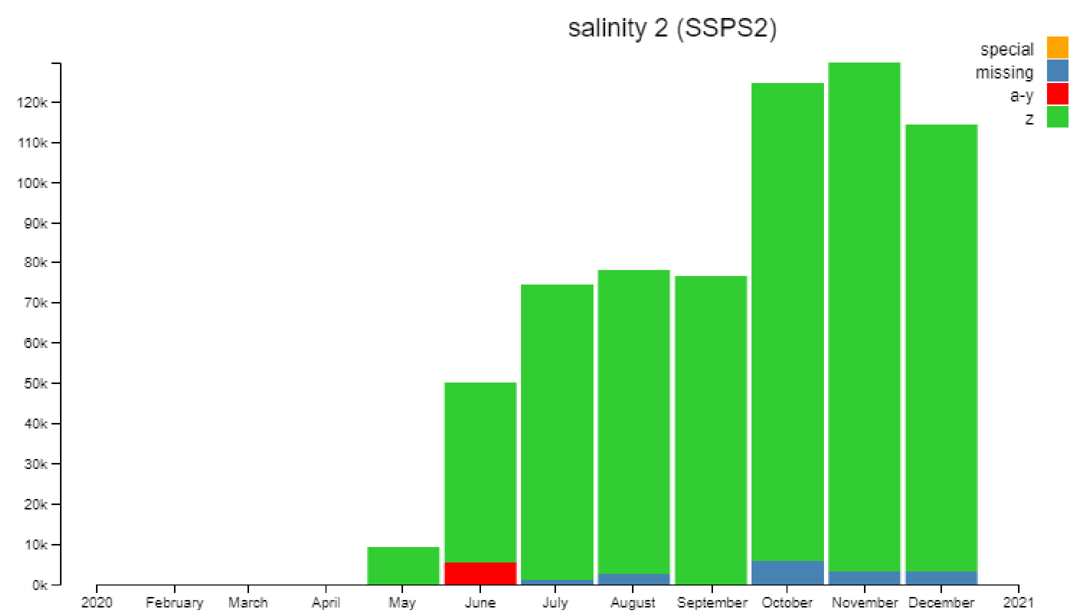


Figure 24: Total number of (top) salinity – SSPS – and (bottom) salinity 2 – SSPS2 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

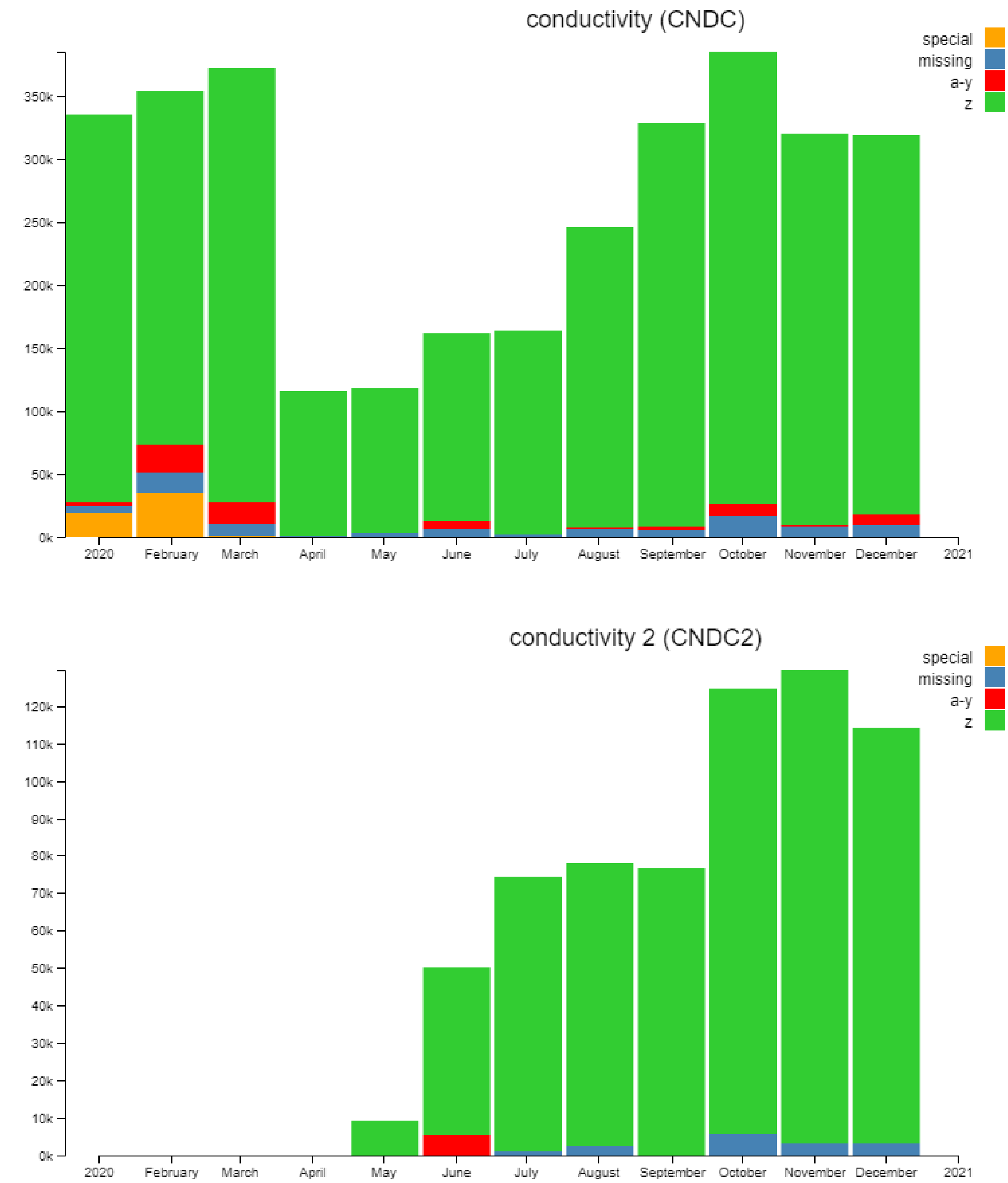


Figure 25: Total number of (top) conductivity – CNDC – and (bottom) conductivity 2 – CNDC2 – observations provided by all ships for each month in 2020. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

c. 2020 quality by ship

Atlantic Explorer

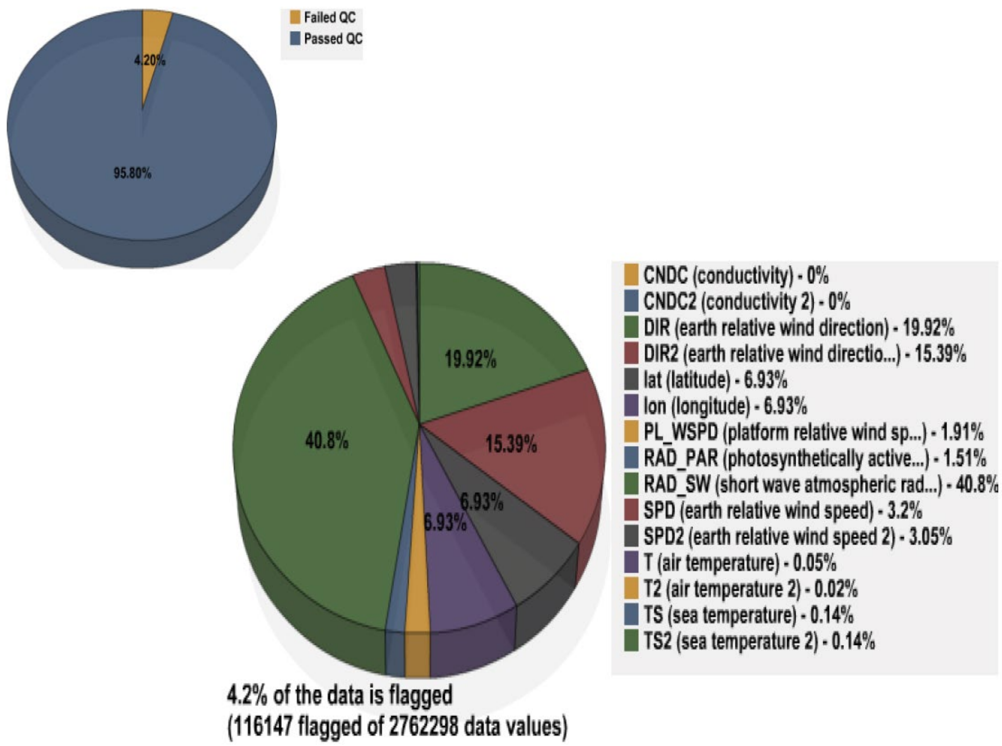


Figure 26: For the *Atlantic Explorer* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Atlantic Explorer* provided SAMOS data for 82 ship days, resulting in 2,762,298 distinct data values. After automated QC, 4.2% of the data were flagged using A-Y flags (Figure 26), which 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 12 August as SAMOS data quality evaluator (DQE) observed periodic slightly negative platform relative wind speed (PL_WSPD) values in very light wind regimes from the *Atlantic Explorer's* primary RM Young mechanical anemometer. Noting the issue was not present in the secondary anemometer, the DQE suspected a sensor or translator issue and contacted the vessel. After receiving no response, the DQE notified the vessel again on 27 August and received an immediate reply. A ship operator confirmed receipt of the problem and stated she would look into it at their next port call. On 1 October we were advised the primary anemometer had been replaced and the problem should be solved. In the meantime, any negative PL_WSPD values from 7 August through at least the end of September received “out of bounds” (B) flags (Figure 28) during automated quality control procedures. It is unknown if the negative

PL_WSPD observations adversely affected the associated true wind speeds (SPD), but users may want to treat both observations as suspect when PL_WSPD is B-flagged.

On 29 October a ship technician got in touch to inform us their underway sea water system was turned off between 16:33:52 UTC 28 October and 12:00:34 UTC 29 October for a quick port stop. Consequently, all the Explorer's sea water data – meaning sea temperatures (TS and TS2), salinity (SSPS and SSPS2), and conductivity (CNDC and CNDC2) – for this period should not be used. We also note that around 7 October 2020, we asked the operator to increase the precision for all conductivity and salinity measurements to three decimal places. This was completed and was a big improvement to their thermosalinograph observations, especially in tropical regions with slowly varying conductivity and salinity values.

Looking to the flag percentages in Figure 26, about 40% of the total flags were applied to the short wave atmospheric radiation parameter (RAD_SW). Upon inspection the flags, which are unanimously "out of bounds" (B) flags (Figure 28), 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 ~35% 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 28), 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.

An interesting note, on 14 September *Atlantic Explorer* was tied up at the dock collecting some excellent data when the eye of hurricane Paulette passed over Bermuda (see Figure 27).

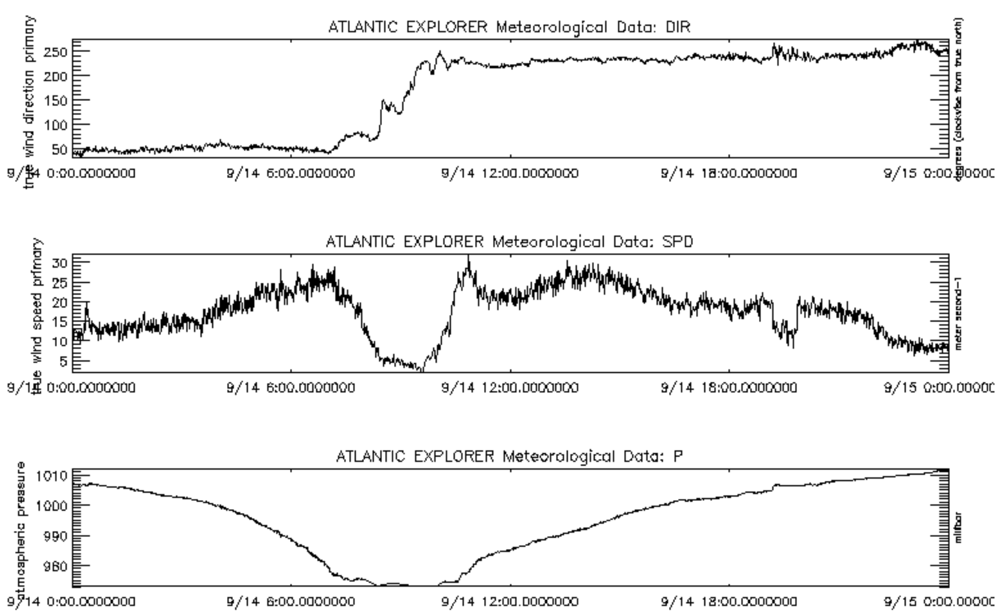


Figure 27: *Atlantic Explorer* SAMOS (top) earth relative wind direction – DIR – (middle) earth relative wind speed – SPD – and (bottom) atmospheric pressure – P – data for 14 September 2020. Note hurricane Paulette eye passage signature in all three parameters between ~7:00 and 10:30 UTC.

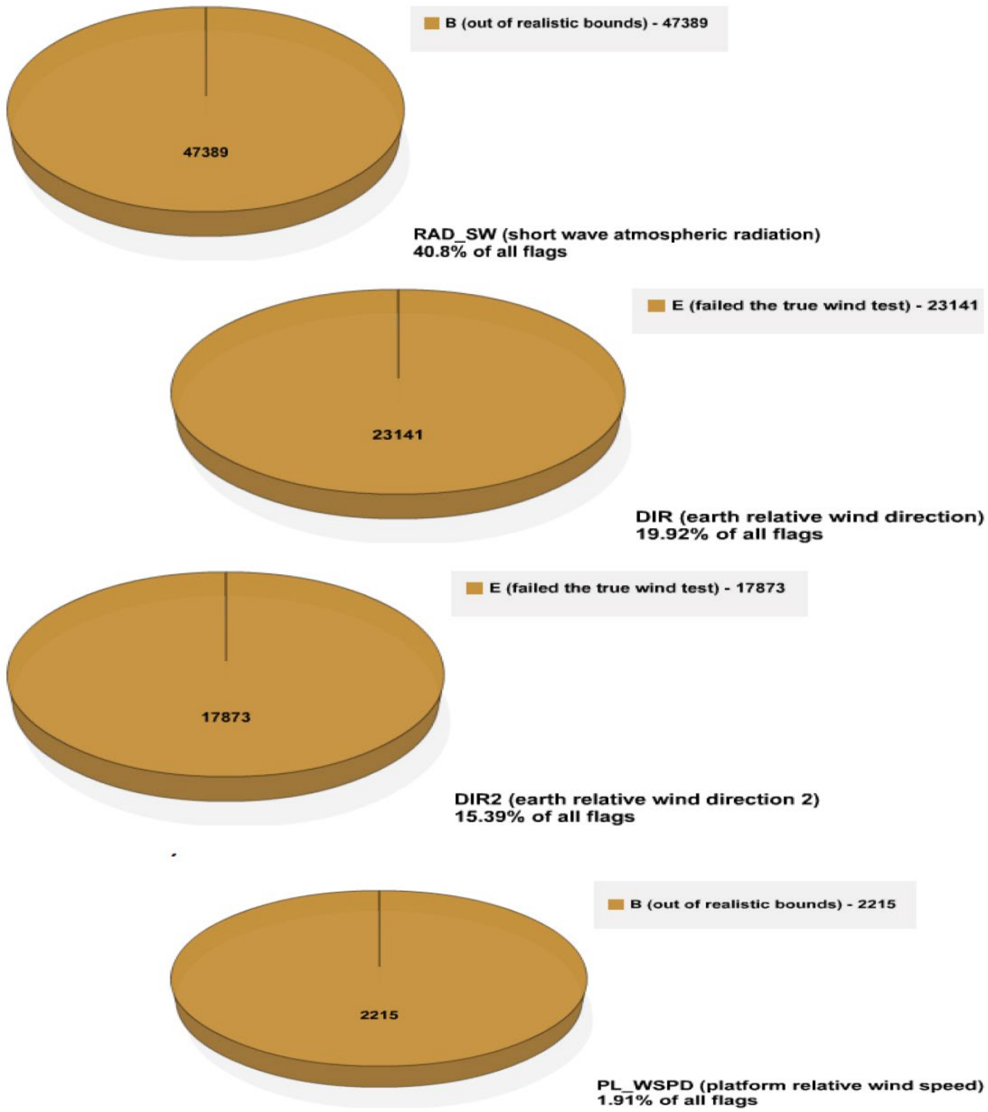


Figure 28: Distribution of SAMOS quality control flags for (first) short wave atmospheric radiation – RAD_SW – (second) earth relative wind direction – DIR – (third) earth relative wind direction 2 – DIR2 – and (last) platform relative wind speed – PL_WSPD – for the *Atlantic Explorer* in 2020.

Aurora Australis

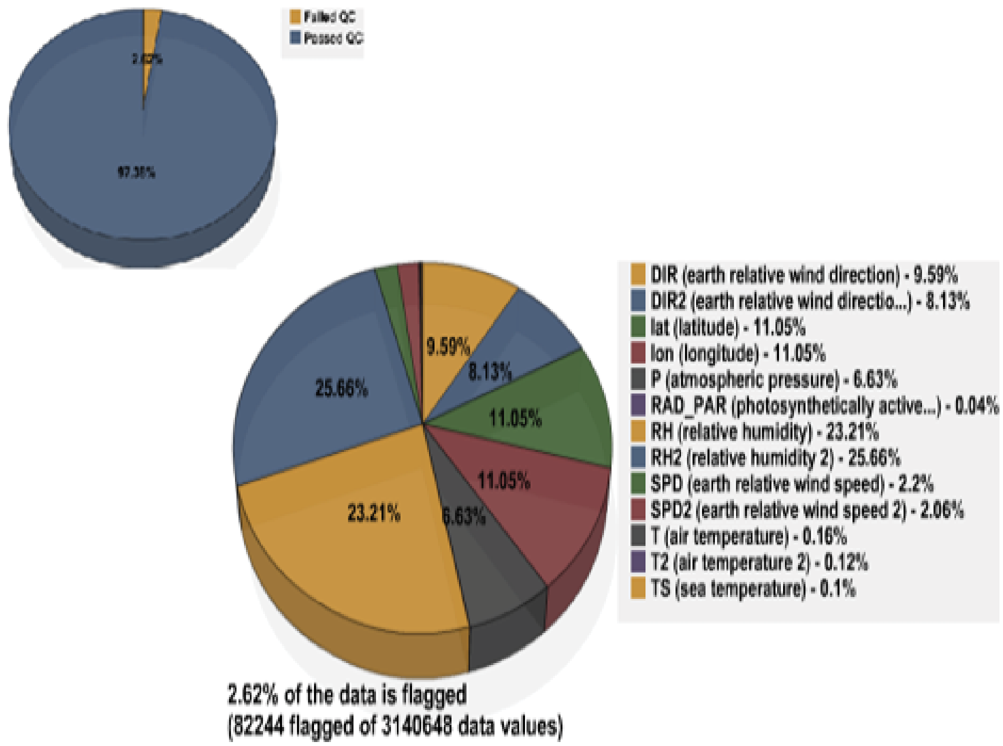


Figure 29: For the *Aurora Australis* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Aurora Australis* provided SAMOS data for 81 ship days, resulting in 3,140,648 distinct data values. After automated QC, 2.62% of the data were flagged using A-Y flags (Figure 29). This is essentially the same as in 2019 (2.95%) and is under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. NOTE: The *Aurora Australis* 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 *Aurora Australis*). NOTE: The *Aurora Australis* was retired from the SAMOS initiative as of 1 April 2020 and we thank her crew and technicians for her many years of contributions to the SAMOS initiative.

There are no specific issues on record for the *Aurora Australis* in 2020. Looking at the flag percentages in Figure 29, about half of the total flags were applied to the two relative humidity parameters (RH and RH2). Upon inspection the flags, which are unanimously “out of bounds” (B) flags (Figure 31), appear to have generally been applied to measurements taken under saturated conditions (e.g., snow, fog). Because hygrometers are commonly tuned for better accuracy at lower readings (see 3b.), it is not unusual to see relative humidity values slightly over 100% when the sensor is exposed to a saturated environment. However, in the case of the *Australis* these saturation readings tended to be a bit higher (~110%, see Figure 30) than would be expected based on tuning alone, suggesting the sensors may also have drifted off calibration and/or required clearing of dirt/salt encrustation. (As the vessel routinely sailed the harsh Southern

Ocean, it seems likely instrumentation on board regularly took a beating.) We also note that RH is very difficult to measure in the polar oceans with some sensors types often resulting in more high RH values (a lesson learned from other polar vessels in SAMOS). A further ~22% of the total flags were applied to the latitude (LAT) and longitude (LON) parameters (Figure 29). In this case the flags are unanimously "platform position over land" (L) flags (Figure 31) that appear generally to have been applied when the vessel was 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.

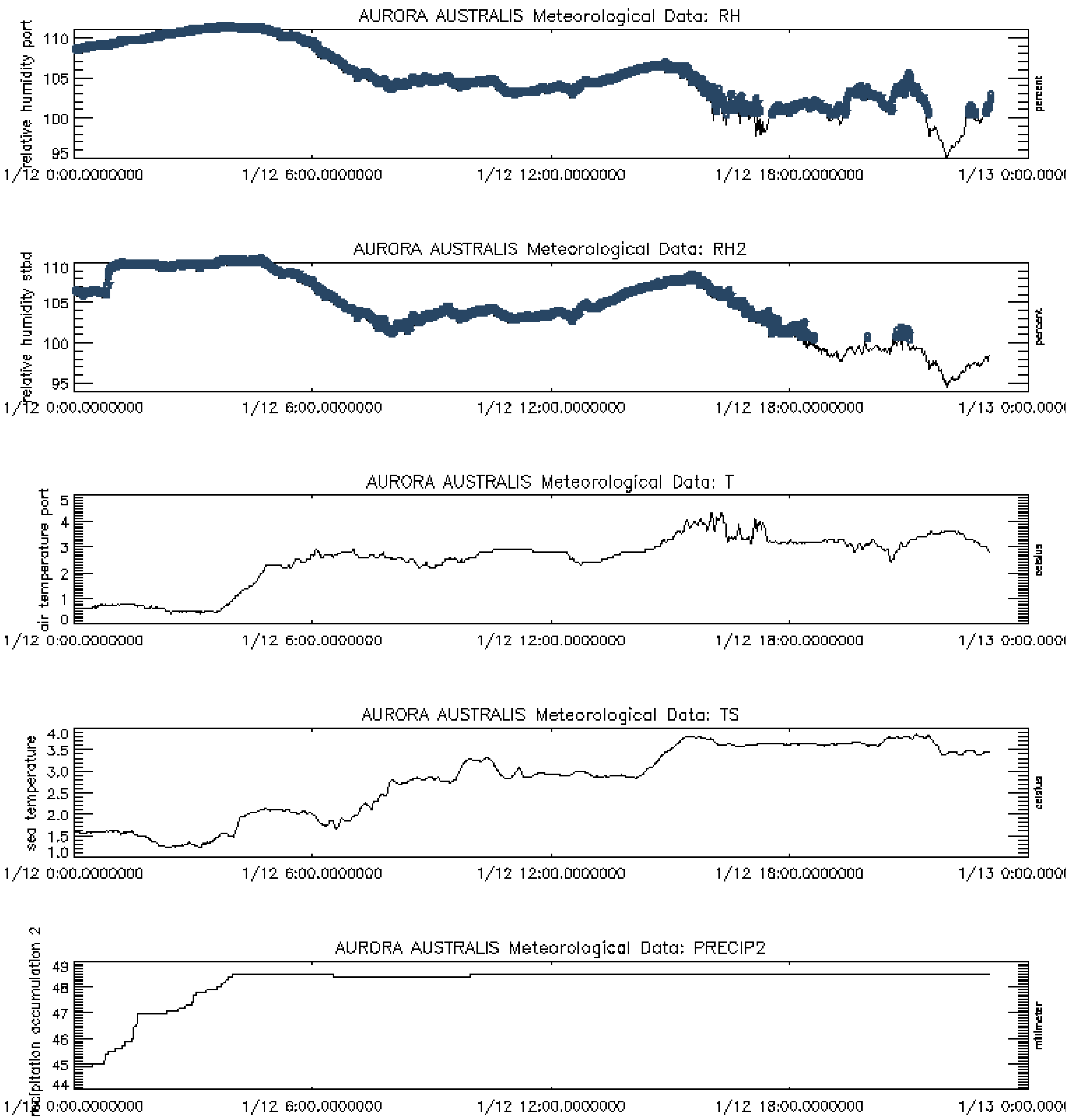


Figure 30: *Aurora Australis* SAMOS (first) relative humidity – RH – (second) relative humidity 2 – RH2 – (third) air temperature – T – (fourth) sea surface temperature – TS – and (last) precipitation accumulation 2 – PRECIP2 – data for 12 January 2020. Note physically unrealistic RH/RH2 values > 100% (flagged in grey), as well as strong suggestion of a saturated environment (i.e., early PRECIP2 accumulation, and very similar air and sea temperatures with occasional TS > T).

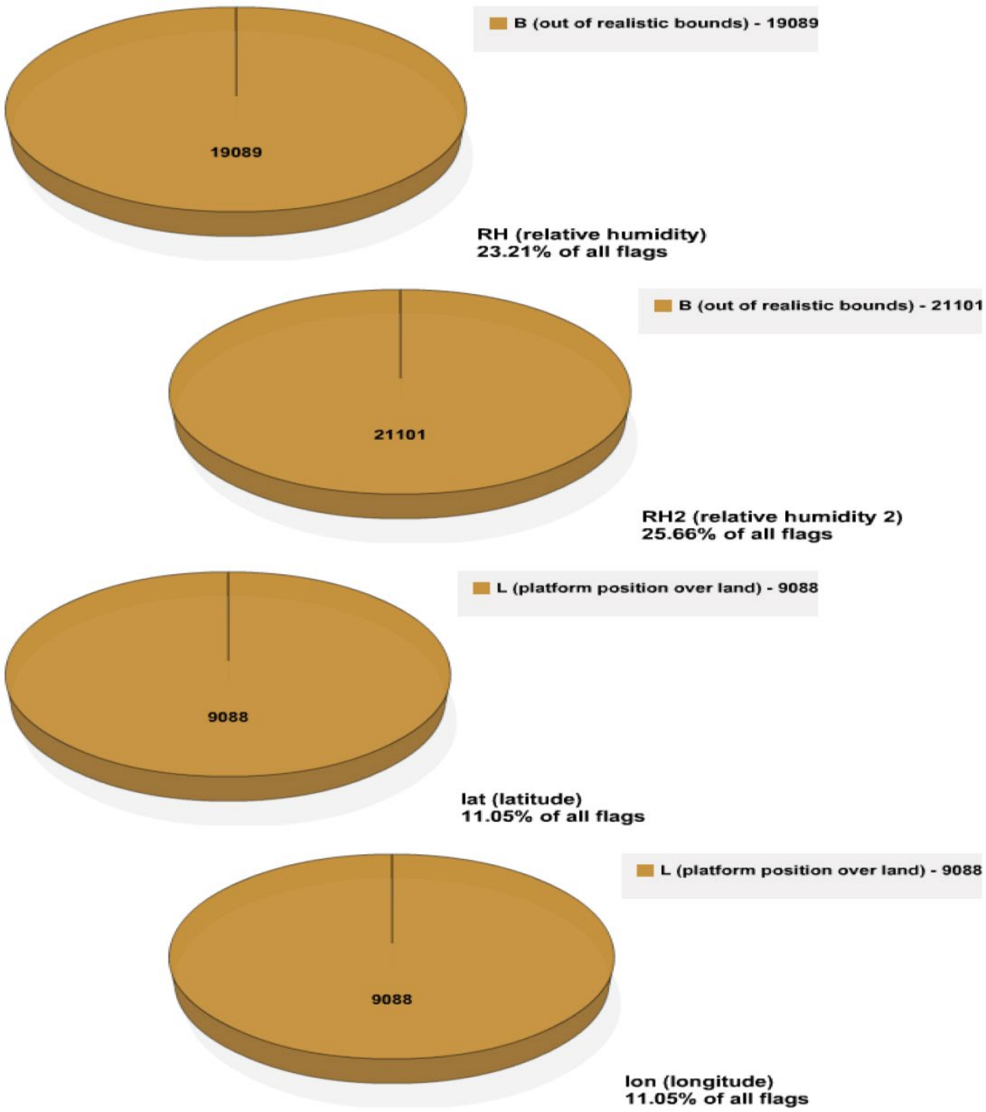
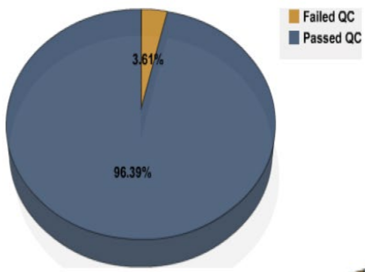


Figure 31: Distribution of SAMOS quality control flags for (first) relative humidity – RH – (second) relative humidity 2 – RH2 – (third) latitude – LAT – and (last) longitude – LON – for the *Aurora Australis* in 2020.

Investigator



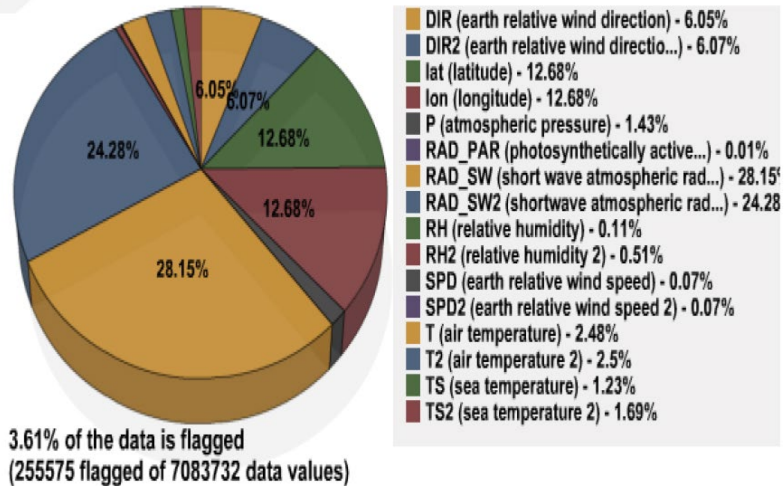


Figure 32: For the *Investigator* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Investigator* provided SAMOS data for 169 ship days, resulting in 7,083,732 distinct data values. After automated QC, 3.61% of the data were flagged using A-Y flags (Figure 32). This is virtually unchanged from 2019 (3.7%) 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*).

On 9 September a SAMOS data quality evaluator (DQE) observed the automated SAMOS true wind recomputation procedure had been flagging much of the true wind speeds (SPD and SPD2) with "failed the true wind recomputation" (E) flags. When the vessel was contacted about the situation an operator noted *Investigator* on their most recent cruise had been experiencing issues with the calculation of true wind whenever their Kongsberg Seapath navigation was offline, owing to a failure in software meant to choose an alternative heading source for true wind computation in the Seapath's absence. The operator stated they would aim to fix the bug in the port period before their next voyage. However, E flagging of SAMOS SPD and SPD2 continued. When emailed again, another vessel contact confirmed their own IMOS software was not flagging the true winds. It was subsequently determined since *Investigator's* recruitment to SAMOS the original units for SPD, SPD2, the platform relative wind speeds (PL_WSPD and PL_WSPD2) and platform speed over ground (PL_SPD) had been incorrectly identified as knots instead of the correct units m/s. The original units have now been corrected in the SAMOS database and there are plans in place to reprocess all *Investigator* SAMOS data from 24 March 2016 through 24 August 2020. The reprocessed files will be released with new versions, but until such time the SPD, SPD2, PL_WSPD, PL_WSPD2, and PL_SPD should be understood to have the wrong units/values.

Looking to the flag percentages in Figure 32, about 52% 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 33), 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 ~25% of the total flags were applied to latitude (LAT) and longitude (LON). Upon inspection these were entirely “platform position over land” (L) flags (Figure 33) 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.

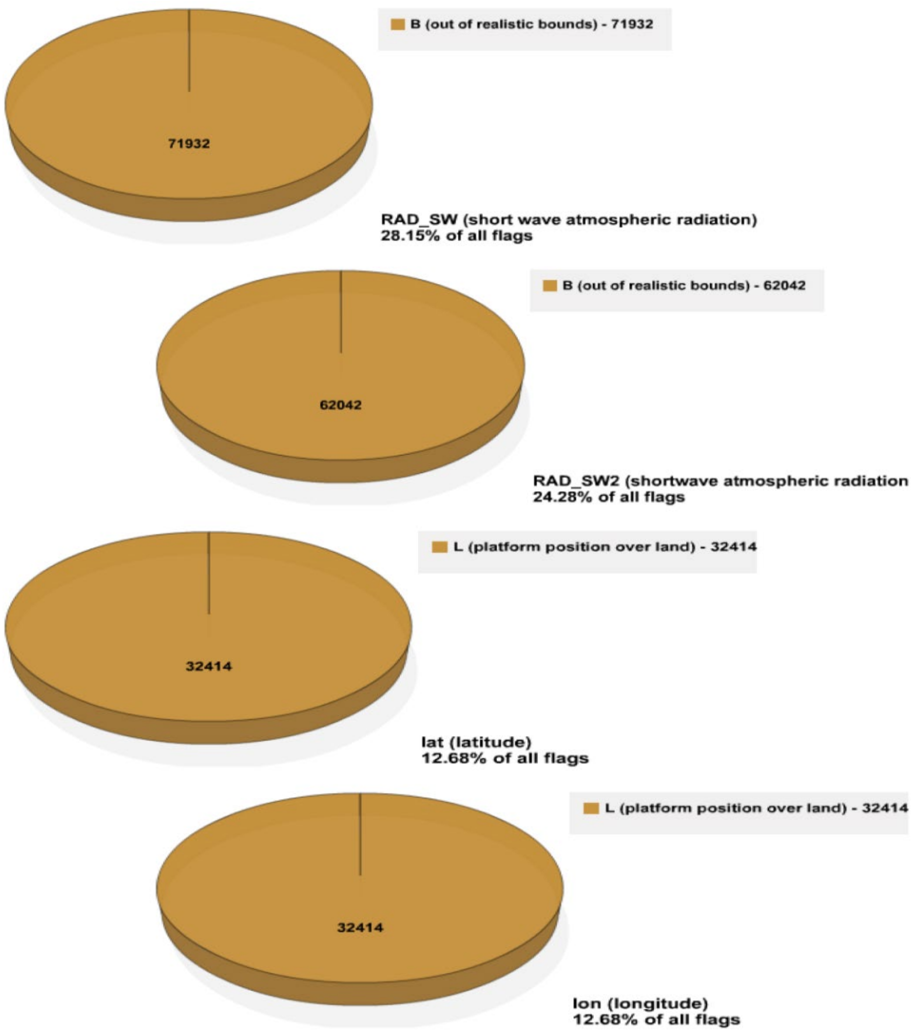


Figure 33: Distribution of SAMOS quality control flags for (first) shortwave atmospheric radiation – RAD_SW – (second) shortwave atmospheric radiation 2 – RAD_SW2 – (third) latitude – LAT – and (last) longitude – LON – for the *Investigator* in 2020.

Tangaroa

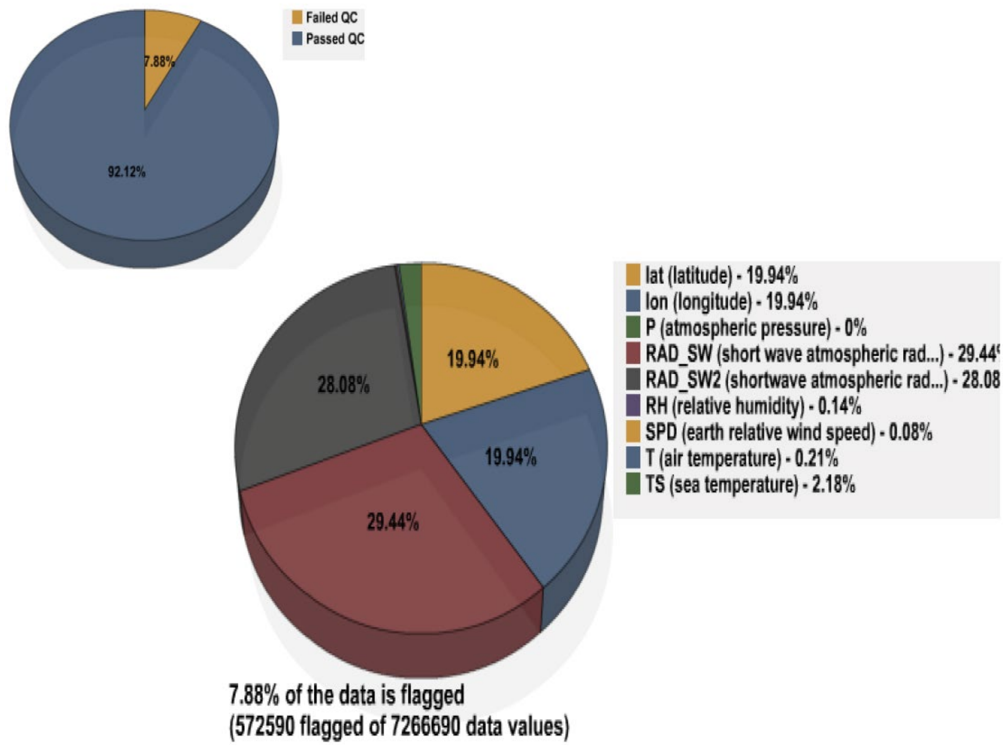


Figure 34: For the *Tangaroa* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Tangaroa* provided SAMOS data for 308 ship days, resulting in 7,266,690 distinct data values. After automated QC, 7.8% of the data were flagged using A-Y flags (Figure 34). This is about two percentage points lower than in 2019 (9.11%). 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*).

On 22 September a *Tangaroa* contact informed SAMOS personnel that as of 31 August ~12:00 UTC their sea temperature (TS) was bad, owing to the main pump providing flow to their sea water thermometer being turned off. (This pump was stated to not perform well in rough sailing conditions.) It is not clear when the main pump was able to be turned back on. Affected TS data were not flagged by SAMOS quality control; however, they were "malfunction" (M) flagged by IMOS in their own files.

Looking to the flag percentages in Figure 34, 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 35), 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 35) 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.

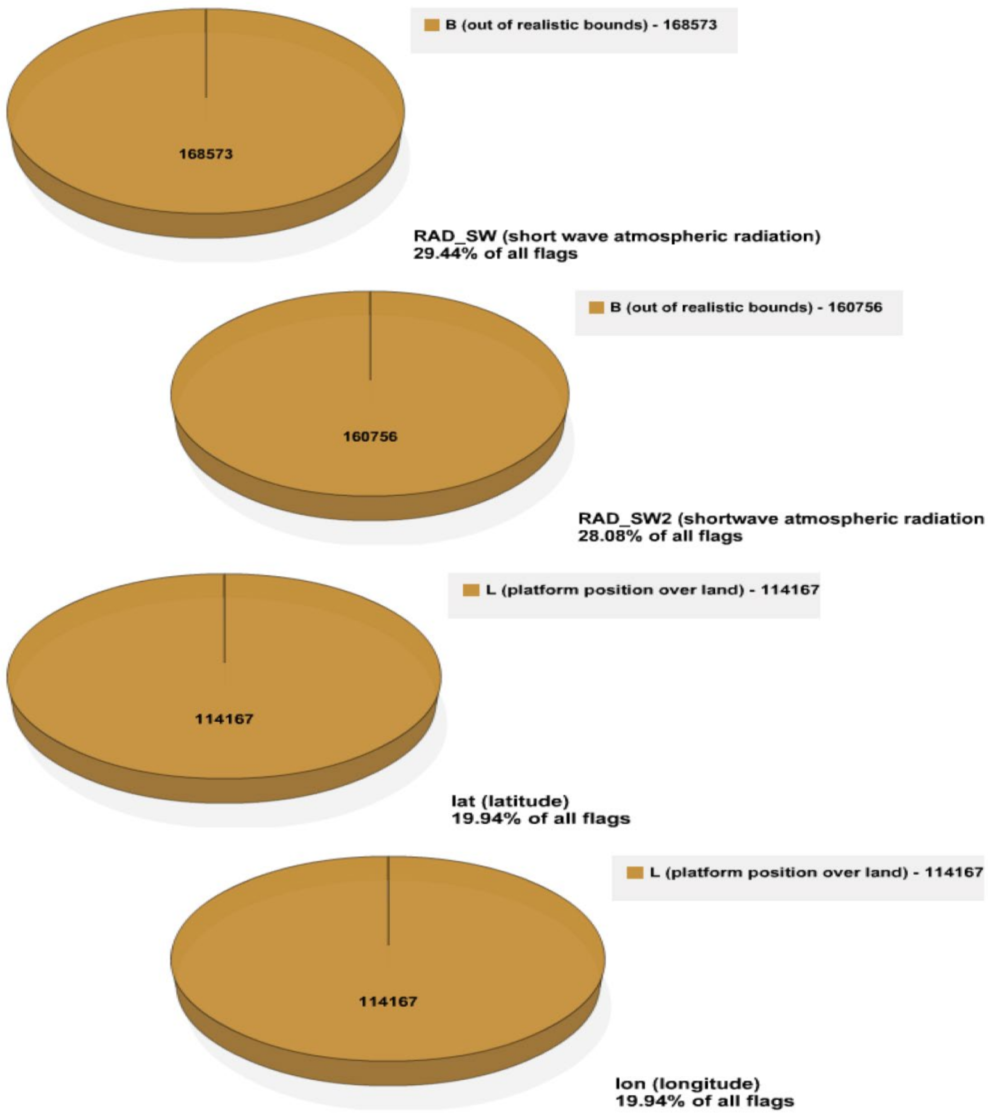


Figure 35: Distribution of SAMOS quality control flags for (first) short wave radiation – RAD_SW – (second) short wave radiation 2 – RAD_SW2 – (third) latitude – LAT – and (last) longitude – LON – for the *Tangaroa* in 2020.

Bell M. Shimada

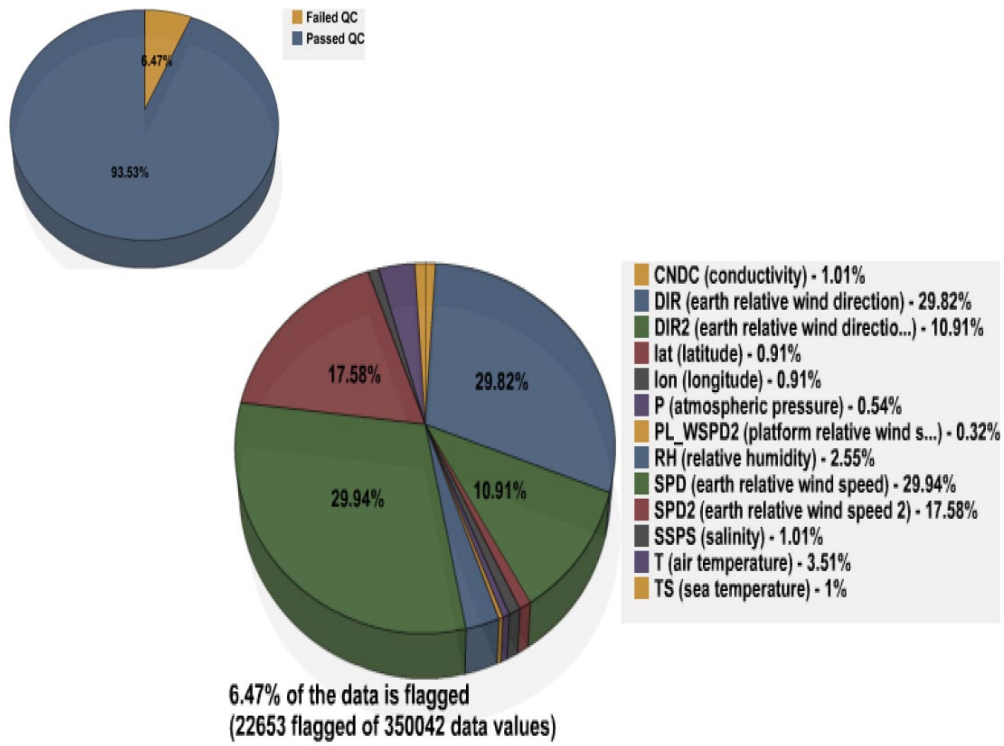


Figure 36: For the *Bell M. Shimada* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Bell M. Shimada* provided SAMOS data for 19 ship days, resulting in 350,042 distinct data values. After both automated and visual QC, 6.47% of the data were flagged using A-Y flags (Figure 36). This is about two percentage points higher than in 2019 (4.17% total flagged) and places *Shimada* outside the < 5% total flagged bracket regarded by SAMOS to represent "very good" data.

There were no specific issues noted for the *Shimada* in 2020. *Shimada's* various meteorological sensors do 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. As is suggested by Figure 36, this is a bit more prevalent in the true winds. About 48% of the total flags were applied to the two earth relative wind speeds (SPD and SPD2) and a further ~41% were applied to the two earth relative wind directions (DIR and DIR2), these primarily being K flags (Figure 37). As is also suggested by the flag percentages, between the two anemometers the ultrasonic RM Young 86004 amidships (DIR2, SPD2) appeared to perform a bit better than the forward RM Young 05103 propeller vane (DIR, SPD) in 2020. Although whether this was due mainly to instrument superiority or superior placement aboard the vessel is not entirely clear, especially given the short duration.

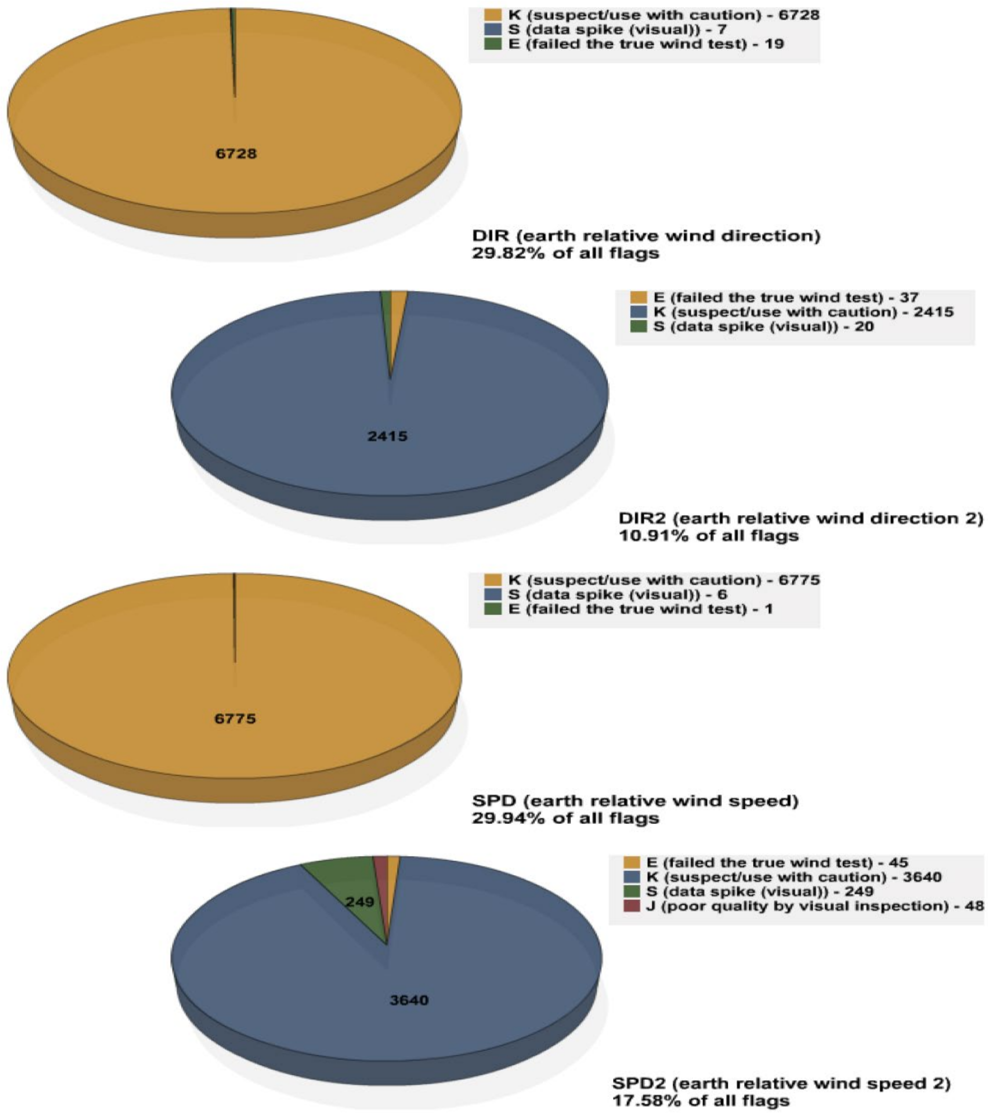


Figure 37: Distribution of SAMOS quality control flags for (first) earth relative wind direction – DIR – (second) earth relative wind direction 2 – DIR2 – (third) earth relative wind speed – SPD – and (last) earth relative wind speed 2 – SPD2 – for the *Bell M. Shimada* in 2020.

Fairweather

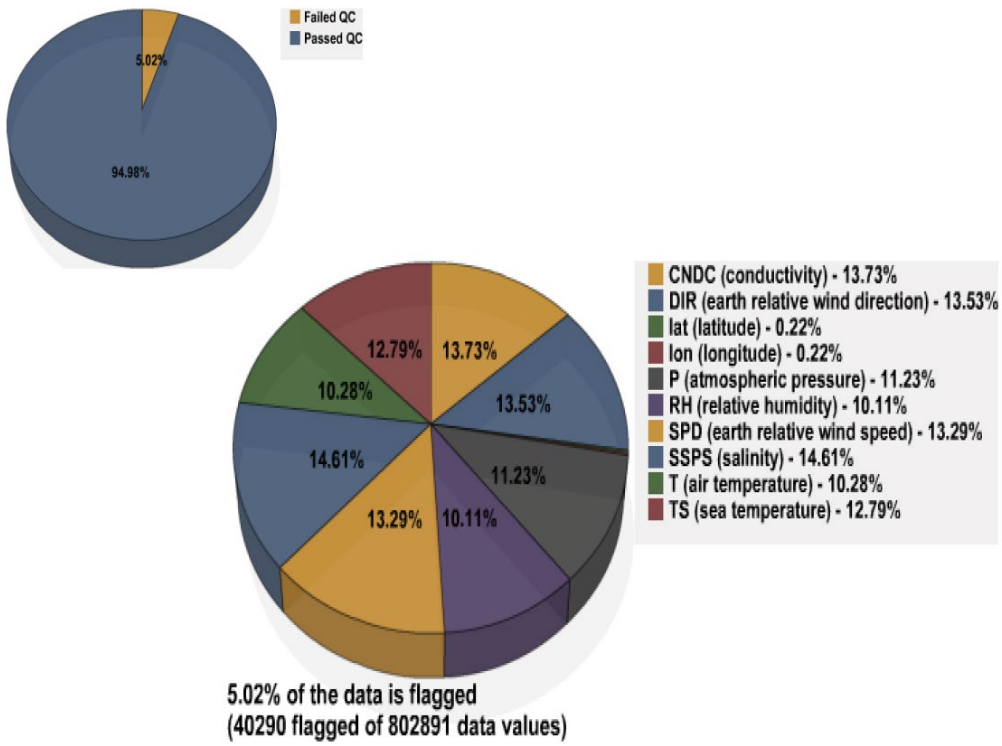


Figure 38: For the *Fairweather* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Fairweather* provided SAMOS data for 40 ship days, resulting in 802,891 distinct data values. After both automated and visual QC, 5.02% of the data were flagged using A-Y flags (Figure 38). This is about a percentage point lower than in 2019 (6.21% total flagged) and places *Fairweather* squarely at the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

There were no specific issues noted for the *Fairweather* in 2020. In general, *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) – continue to be exhibit some amount of data distortion that is dependent on the vessel relative wind direction, as indicated by the total flagged percentage (Figure 38), although the even spread among the flag percentages for these parameters suggests no one instrument suffers worse than any of the others (or perhaps they are all in the same location). SAMOS metadata for the sensors are incomplete and outdated, though, and digital imagery does not exist for this vessel (see Table 4), all of which precludes a meaningful diagnosis of sensor placement. Regardless, where the data appear affected, they are generally flagged with "caution/suspect" (K) flags (Figure 39, not all shown).

In addition to the meteorological parameters, the sea water parameters – sea temperature (TS), conductivity (CNDC), and salinity (SSPS) – also took an even slice each of the overall flagging pie (Figure 38). These were also primarily K flags (Figure 39, not all shown), in this case primarily applied when the sea water flow-through system appeared to be shut down (secured), either because the vessel was in or near port or else was underway in rough seas. Both these shut-down practices are common on other vessels.

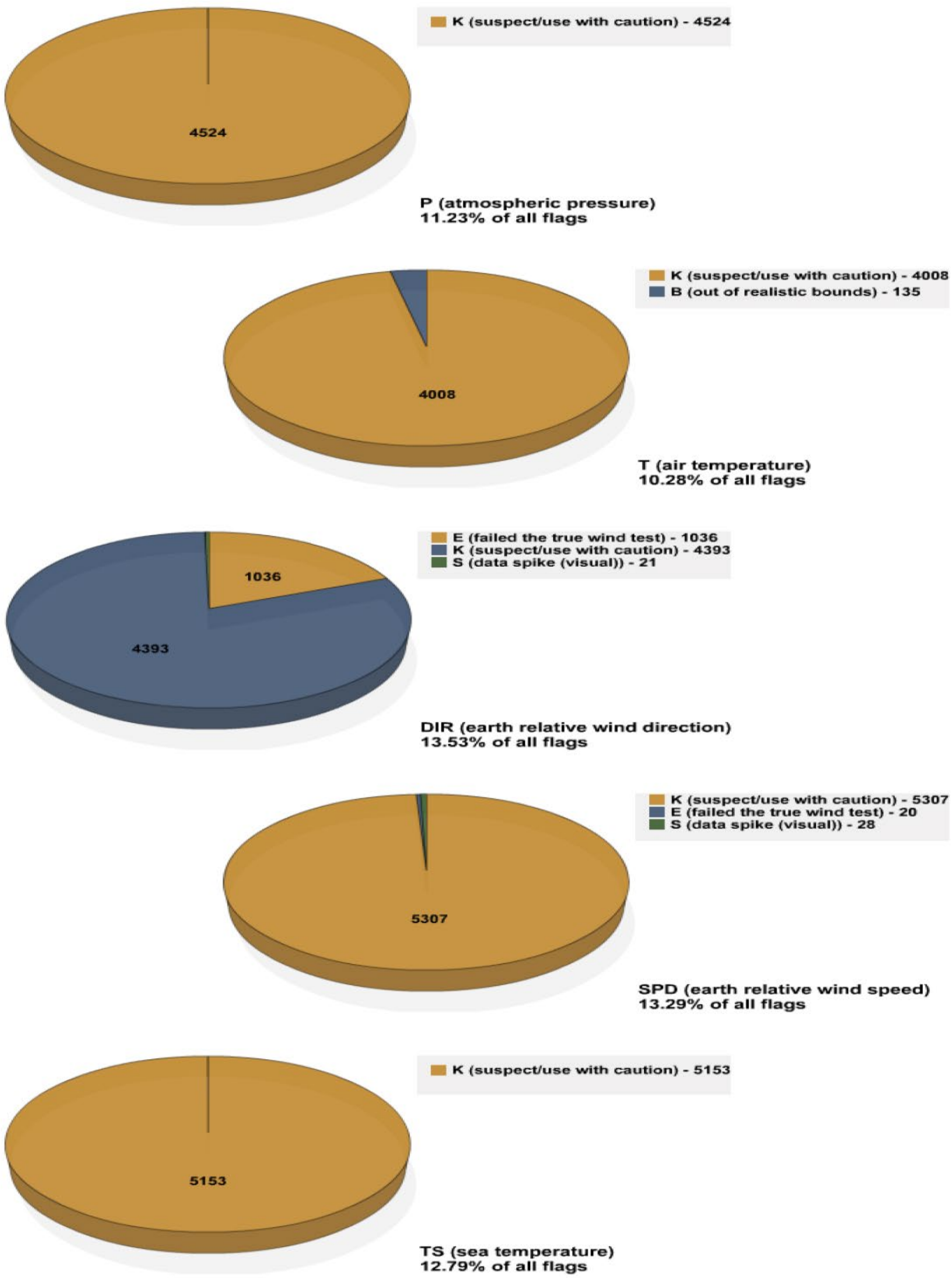


Figure 39: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) earth relative wind direction – DIR – (fourth) earth relative wind speed – SPD – and (last) sea temperature – TS – for the *Fairweather* in 2020.

Gordon Gunter

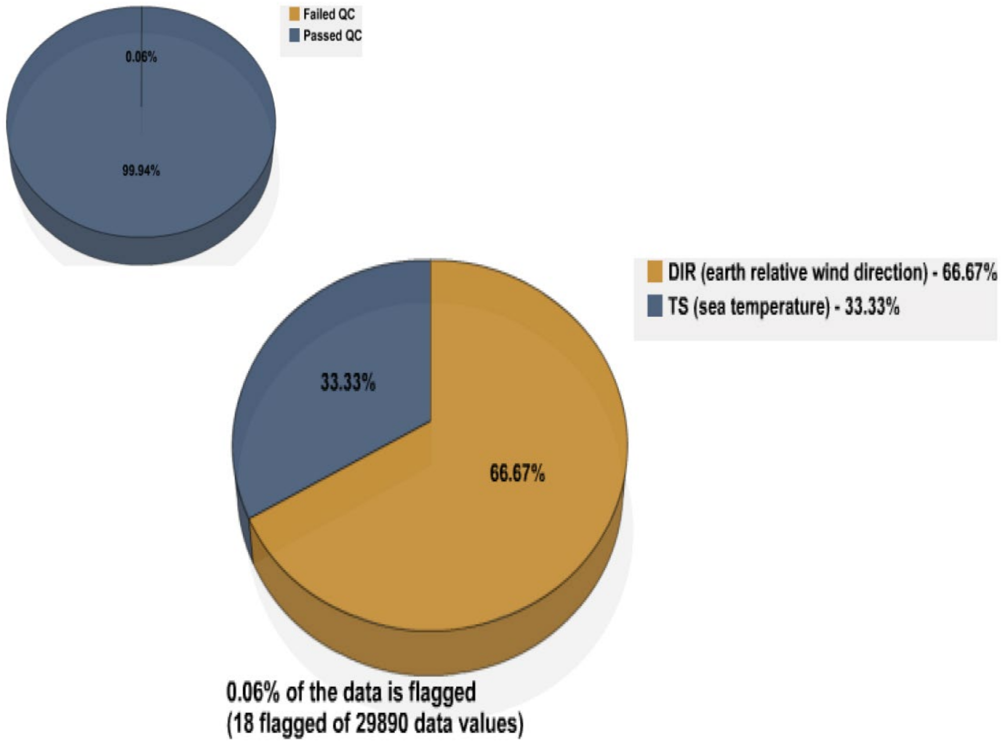


Figure 40: For the *Gordon Gunter* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Gordon Gunter* provided SAMOS data for 2 ship days, resulting in 29,890 distinct data values. After both automated and visual QC, 0.06% of the data were flagged using A-Y flags (Figure 40). This is of course just about the lowest possible flagged percentage and is 6.81 percentage points lower than in 2019 (6.87%). Although with just 2 days' worth of data it would be foolish to try to draw any real conclusions about data quality or improvements therein.

Additionally, there were no specific issues noted for the *Gunter* in 2020.

Henry B. Bigelow

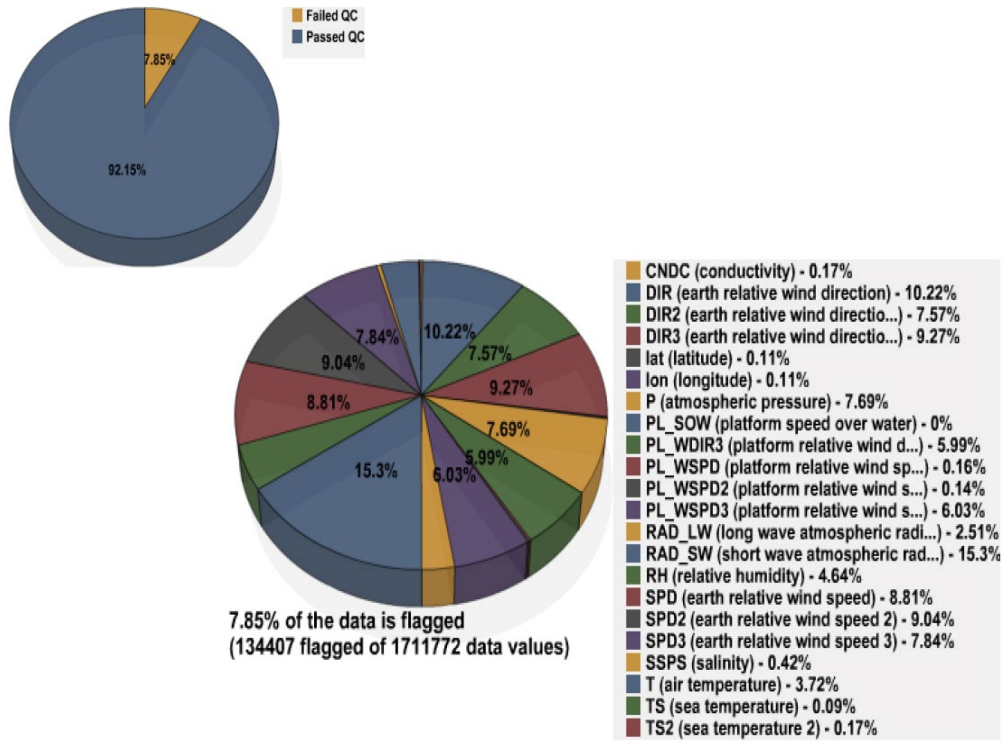


Figure 41: For the *Henry B. Bigelow* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Henry Bigelow* provided SAMOS data for 46 ship days, resulting in 1,711,772 distinct data values. After both automated and visual QC, 7.85% of the data were flagged using A-Y flags (Figure 41). This is about 1.5 percentage points higher than in 2019 (6.38%).

On 5 October a SAMOS data quality evaluator (DQE) observed the jackstaff platform relative wind direction values (PL_WDIR3) seemed to be getting "stuck" at ~10° (Figure 42), which was in turn causing the jackstaff earth relative wind direction (DIR3) data to look erroneous. The vessel was immediately contacted about the situation, and after some troubleshooting ship technicians deemed it likely the attaching collar for the wind bird had come loose. However, to play it safe, the entire wind bird was simply replaced ~19:45 UTC on 7 October. After the instrument replacement the jackstaff wind data was once again in favorable agreement with the other two wind birds. As a result of this episode, though, during the period of about 4 October through ~19:45 UTC on 7 October DIR3, PL_WDIR3, and the jackstaff earth relative wind speed (SPD3) data were all assigned "poor quality" (J) flags while the jackstaff platform relative wind speed data (PL_WSPD3) were assigned "caution/suspect" (K) flags (Figure 43).

On 3 November a SAMOS DQE noted both the long wave radiation (RAD_LW) and the short wave radiation (RAD_SW) had stopped reporting after a weekend of incurring "out of bounds" (B) flags (Figure 43, only RAD_LW shown) while RAD_LW was flatlined at ~955 W/m^2 and RAD_SW was waffling between -2000 W/m^2 and +2000 W/m^2. The vessel was contacted with a request for information, but no response was received, and *Bigelow's* sailing season ended soon after. It was learned in 2021 both radiation sensors had fallen off during a storm the previous season, though whether that is the explanation for the behavior in early November is not immediately clear.

Aside from the above recounted incidences, 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 K flags (Figure 43, not all shown) to all the earth relative wind directions (DIR, DIR2, DIR3) and speeds (SPD, SPD2, SPD3).

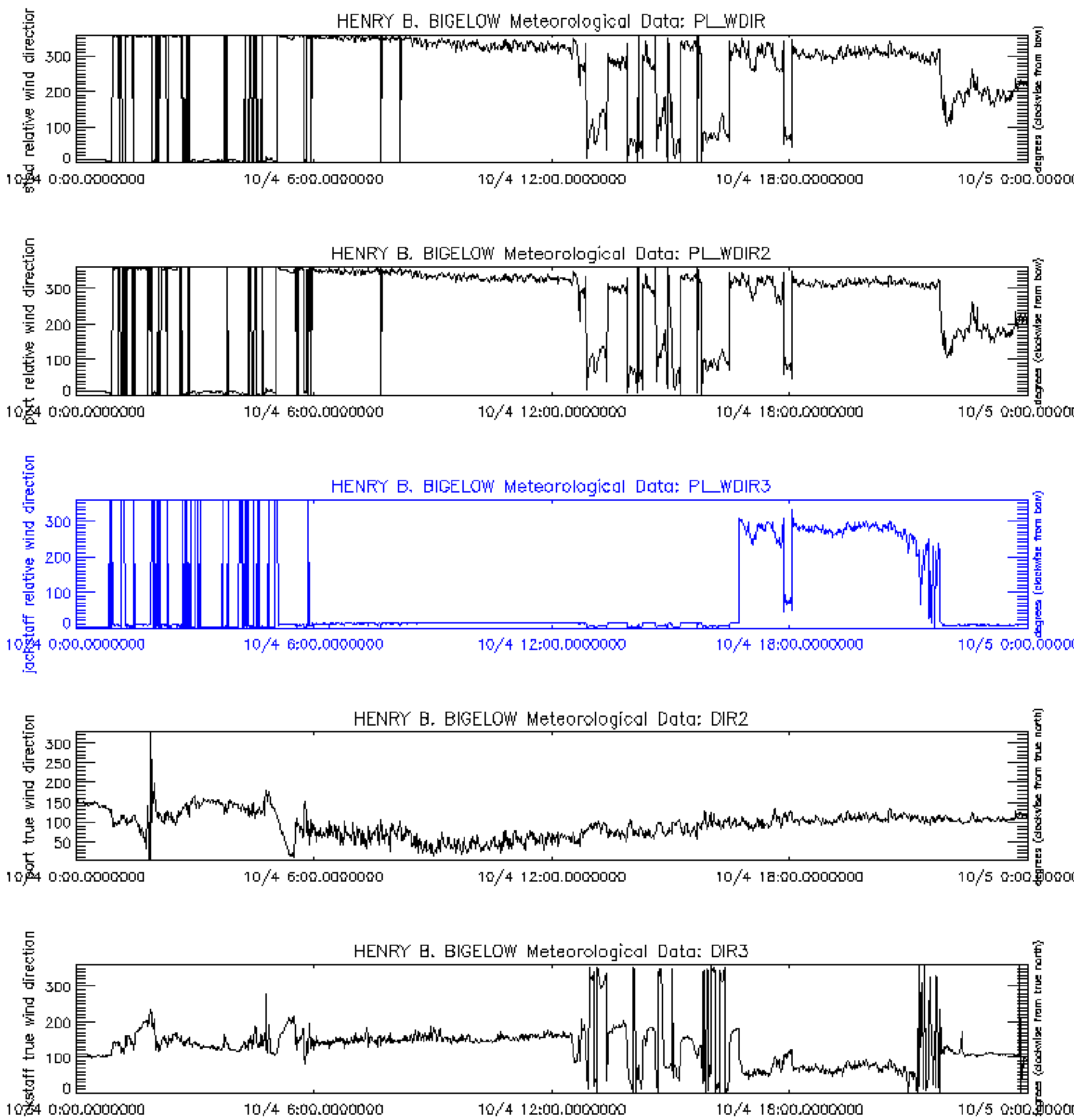


Figure 42: *Henry B. Bigelow* SAMOS (first) platform relative wind direction – PL_WDIR – (second) platform relative wind direction 2 – PL_WDIR2 – (third) platform relative wind direction 3 – PL_WDIR3 – (fourth) earth relative wind direction 2 – DIR2 – and (last) earth relative wind direction 3 – DIR3 – data for 4 October 2020. Note PL_WDIR3 (in blue) disagreement with both PL_WDIR and PL_WDIR2 especially between ~6:00 UTC and ~17:00 UTC as well as after ~22:00 UTC. Also note DIR3 disagreement with DIR2 around these time frames.

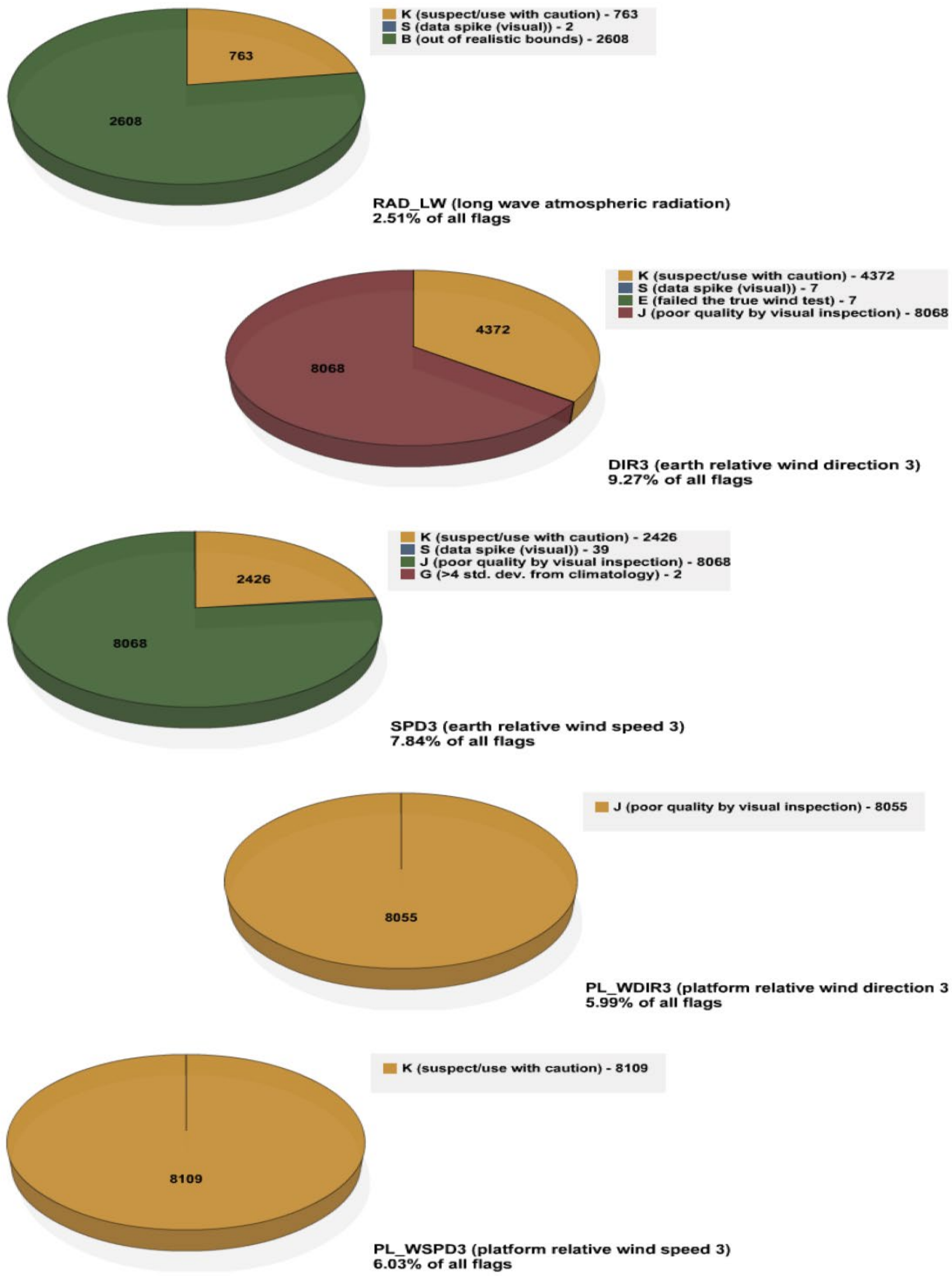
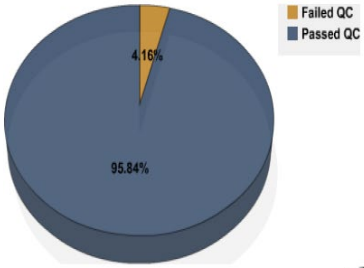


Figure 43: Distribution of SAMOS quality control flags for (first) long wave atmospheric radiation – RAD_LW – (second) earth relative wind direction 3 – DIR3 – (third) earth relative wind speed 3 – SPD3 – (fourth) platform relative wind direction 3 – PL_WDIR3 – and (last) platform relative wind speed 3 – PL_WSPD3 – for the *Henry B. Bigelow* in 2020.

Nancy Foster



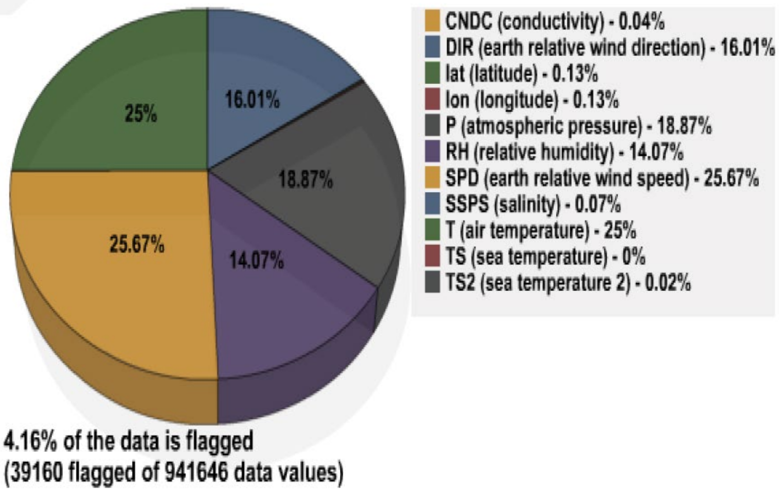


Figure 44: For the *Nancy Foster* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Nancy Foster* provided SAMOS data for 44 ship days, resulting in 941,646 distinct data values. After both automated and visual QC, 4.16% of the data were flagged using A-Y flags (Figure 44). This is about two percentage points higher than in 2019 (2.11%) and maintains *Foster's* standing under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

There were no specific issues noted for the *Nancy Foster* in 2020. On a positive note, *Foster* technicians added their Sea-Bird SBE 21 thermosalinograph (TSG) water temperature parameter (TS2) to their SAMOS roster in August. Having this internal TSG temperature is useful for the verification of recorded TSG salinity values.

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). Where the data appear affected, they are typically flagged with "caution/suspect" (K) flags (Figure 45).

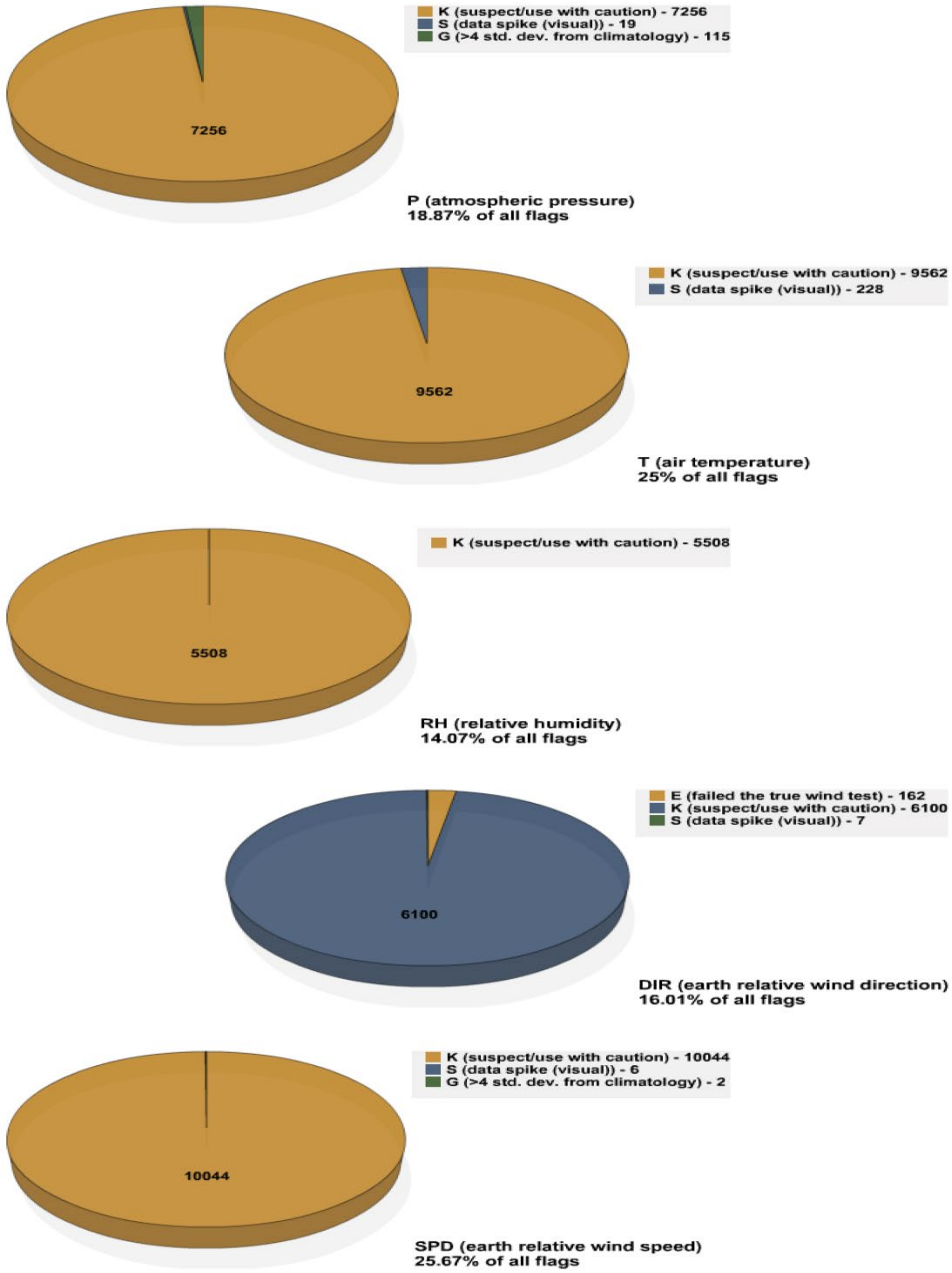
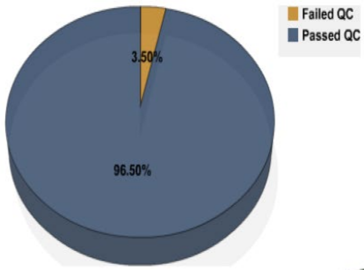


Figure 45: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – for the *Nancy Foster* in 2020.

Okeanos Explorer



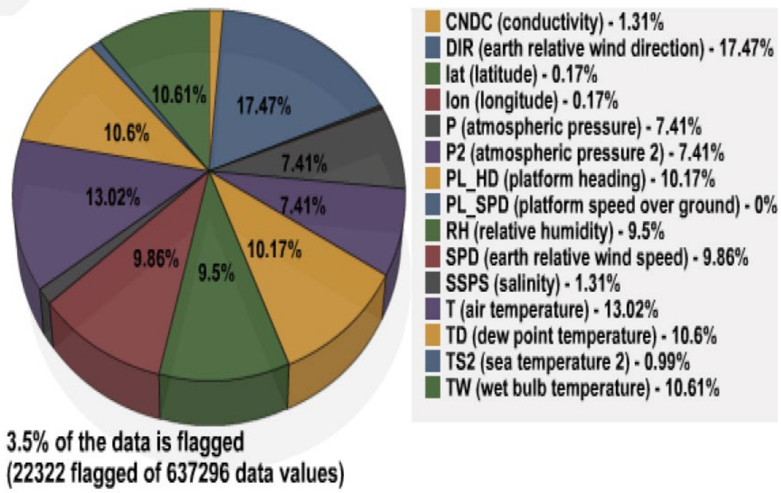


Figure 46: For the *Okeanos Explorer* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Okeanos Explorer* provided SAMOS data for 26 ship days, resulting in 637,296 distinct data values. After both automated and visual QC, 3.5% of the data were flagged using A-Y flags (Figure 46). This is about the same as in 2019 (3.39%) and maintains *Explorer's* standing under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

On 26 October a SAMOS data quality evaluator (DQE) observed that *Okeanos Explorer's* platform heading (PL_HD) values had been improbably spiking to a value of 45° with high frequency (see Figure 47) for several days. When the vessel was contacted a technician immediately confirmed they had noticed the same thing and expressed their suspicion the spikes were due to an issue with their gyrocompass serial interface. Within a few hours (~18:00 UTC) the same technician reported he had found and addressed two issues (details unknown), with the favorable result being a cease in the PL_HD data spikes. During the period of these spikes – approximately 21-26 October – much of the PL_HD data were assigned "poor quality" (J) flags (Figure 48). Additionally, because of the faulty heading data, the SAMOS automated true wind recalculation procedure contributed to some volume of "failed the true wind recalculation test" (E) flags being applied to the earth relative wind direction (DIR) and speed (SPD) (Figure 48). The DIR and SPD E flags during this time, however, may be taken with a grain of salt.

In general, *Okeanos Explorer's* various meteorological sensors – DIR, SPD, air temperature (T), wet bulb temperature (TW), dew point temperature (TD), relative humidity (RH), and atmospheric pressure (P and P2) – do occasionally exhibit data distortion that is dependent on the vessel relative wind direction and, in the case of T/TW/TD/RH, likely vessel heating (all common to most vessels). Where the data appear affected, they are typically flagged with "caution/suspect" (K) flags (Figure 48, not all shown).

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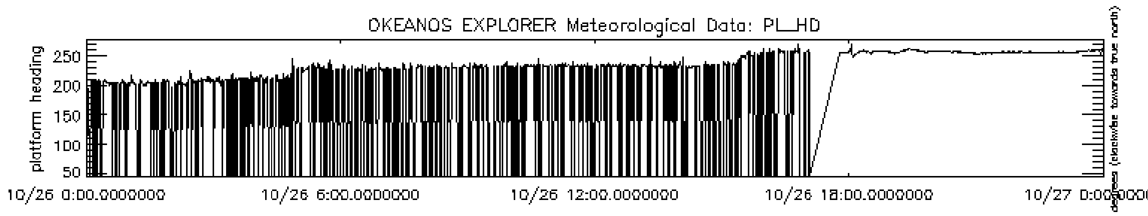


Figure 47: *Okeanos Explorer* SAMOS platform heading – PL_HD – data for 26 October 2020. Note excessive negative spikes to ~45°. Note also spikes cease after ~18:00 UTC.

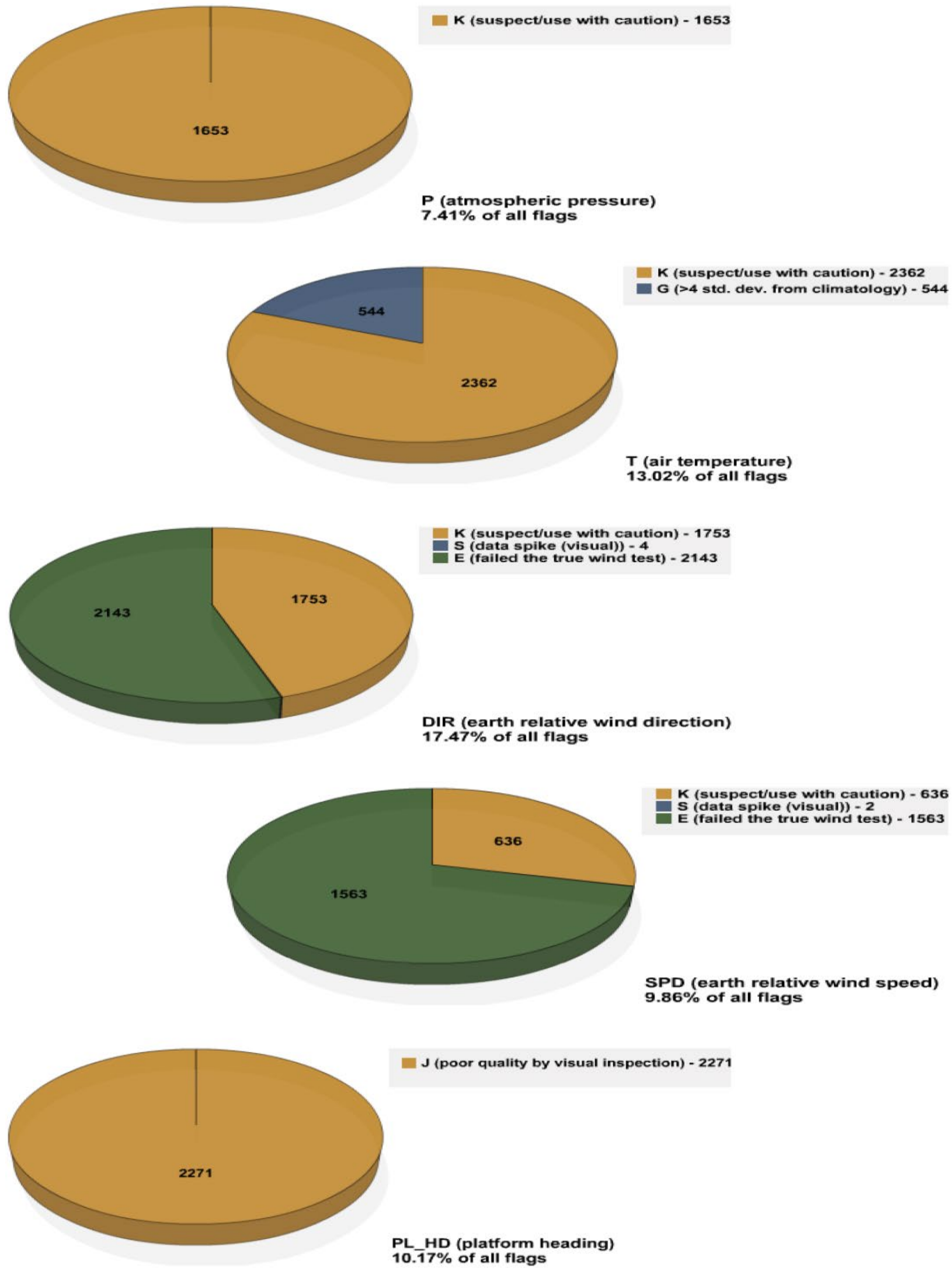


Figure 48: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) earth relative wind direction – DIR – (fourth) earth relative wind speed – SPD – and (last) platform heading – PL_HD – for the *Okeanos Explorer* in 2020.

Oregon II

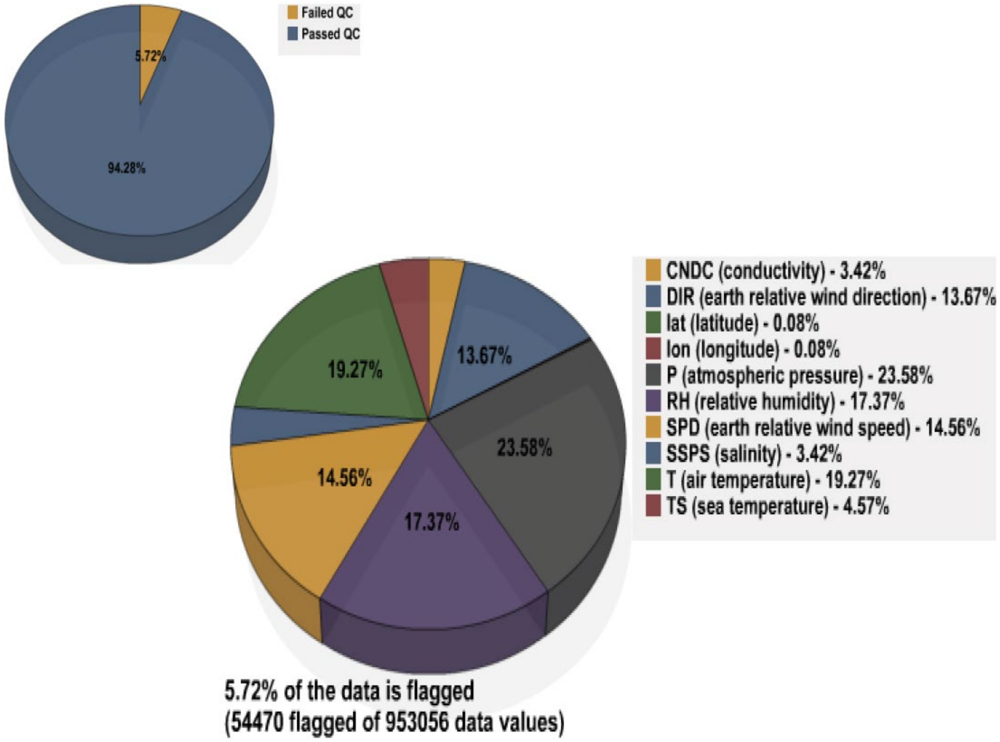


Figure 49: For the *Oregon II* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oregon II* provided SAMOS data for 47 ship days, resulting in 953,056 distinct data values. After both automated and visual QC, 5.72% of the data were flagged using A-Y flags (Figure 49). This is about the same as in 2019 (5.65%) and maintains the *Oregon II* just outside the "under 5% total flagged" bracket regarded by SAMOS to represent "very good" data.

As *Oregon II* got underway again in the fall, a SAMOS data quality evaluator (DQE) touched base with the vessel and noted their sea temperature (TS) seemed like it possibly read a little high sometimes in comparison with gridded microwave and buoy sea surface temperature data. She cautioned, however, without recent detailed metadata defining the type or placement of TS sensor (e.g., a hull contact thermometer perhaps somewhere near the vessel load line, a thermosalinograph in a wet lab at the end of a long pipe run, etc.) there was not much to go on. About two weeks later, on 15 October, a vessel operator responded and echoed the DQE's concerns about TS. (At this time, the vessel was not transmitting SAMOS data). He stated the original temperature probe in the instrument had malfunctioned late the previous year and was substituted with another probe that had a longer cable and thus increased cable resistance, which was not being accounted for. Two weeks after that the operator emailed again to say he had made some offset adjustments to the TS unit and believed it was now reporting accurately. In the period 3-24 September TS received some occasional "caution/suspect" (K) flags (Figure 50).

In general, *Oregon II'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) – all show signs of moderate flow distortion or contamination (e.g., from ship heating, or stack exhaust), which oftentimes results in "caution/suspect" (K) flags for each of those parameters (Figure 50, not all shown). This is common to most vessels, as it is difficult to site instruments ideally on a moving ship. We note, though, SAMOS metadata for these sensors are outdated, precluding a meaningful diagnosis.

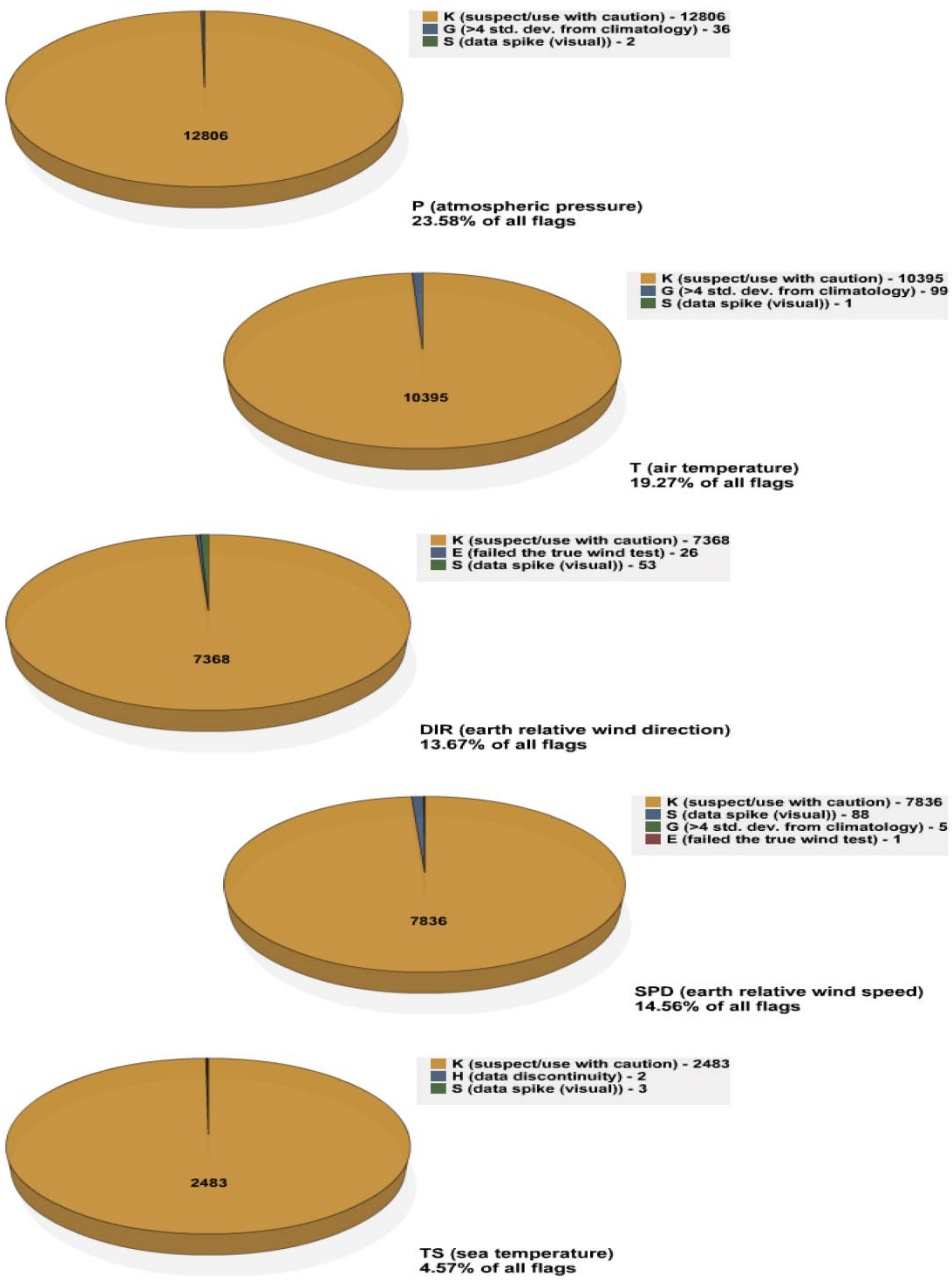


Figure 50: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) earth relative wind direction – DIR – (fourth) earth relative wind speed – SPD – and (last) sea temperature – TS – for the *Oregon II* in 2020.

Oscar Dyson

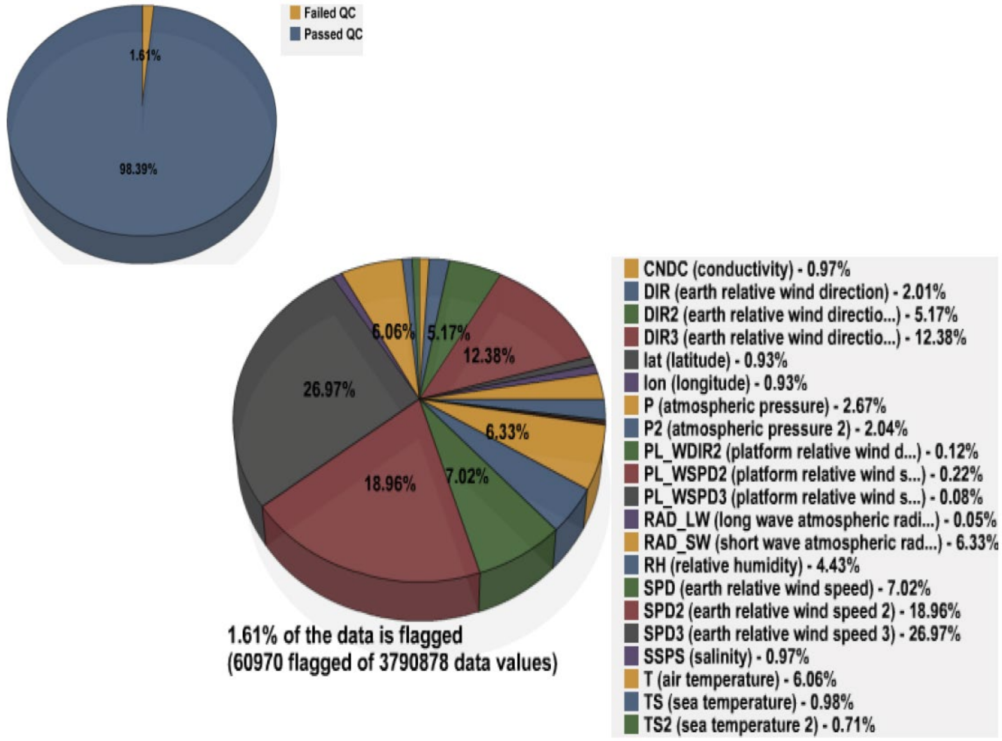


Figure 51: For the *Oscar Dyson* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oscar Dyson* provided SAMOS data for 95 ship days, resulting in 3,790,878 distinct data values. After both automated and visual QC, 1.61% of the data were flagged using A-Y flags (Figure 51). This is about two and a half percentage points lower than in 2019 (3.92%) 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 2020. On a positive note, after a bit of troubleshooting in *Dyson's* data acquisition system (DAS) configuration someone from OMAO was able to add the fore/aft water speed data (PL_SOW, not shown here) from *Dyson's* Litton Marine Doppler to her SAMOS files. The fore/aft water speed parameter designator had been initiated in *Dyson's* SAMOS files in 2019 but for reasons unknown the data values never made it into the files. In October of 2020, however, the OMAO personnel in question discovered that changing the data field name for the fore/aft water speed in *Dyson's* DAS inexplicably (in her own assessment) solved the problem. (We note, though, that even though PL_SOW was made functional in *Dyson's* SAMOS data file setup in 2020 she did not sail again afterwards until 2021. As such, there are no actual Dyson SAMOS PL_SOW data until 11 February 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). Where any of the meteorological data appear affected by flow distortion, exhaust, or ship heating they are typically flagged with "caution/suspect" (K) flags (Figure 52, not all shown).

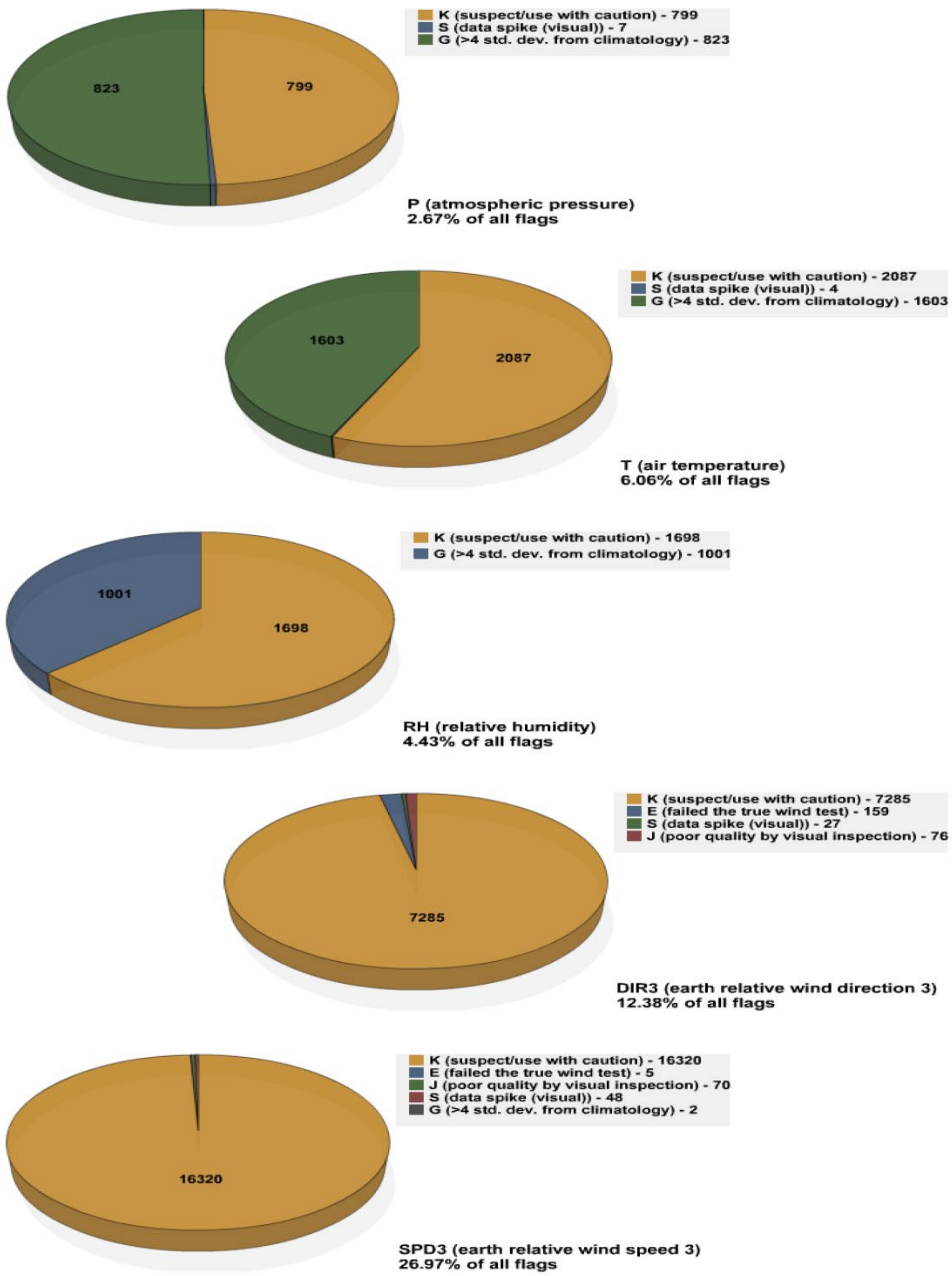
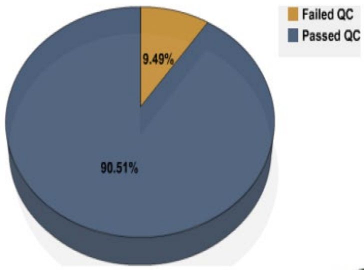


Figure 52: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) earth relative wind direction 3 – DIR3 – and (last) earth relative wind speed 3 – SPD3 – for the *Oscar Dyson* in 2020.

Oscar Elton Sette



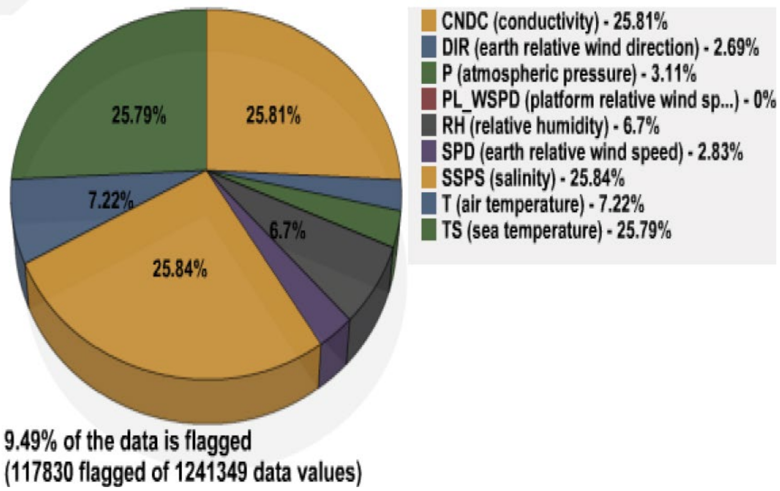


Figure 53: For the *Oscar Elton Sette* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oscar Elton Sette* provided SAMOS data for 58 ship days, resulting in 1,241,349 distinct data values. After both automated and visual QC, 9.49% of the data were flagged using A-Y flags (Figure 53). This is about four percentage points higher than in 2019 and is over the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

There were no specific issues noted for *Oscar Elton Sette* in 2020. As seen in Figure 53, over 75% of the total flags were assigned to the three sea parameters – sea temperature (TS), salinity (SSPS), and conductivity (CNDC). However, the vast majority of these were “caution/suspect” (K) flags (Figure 54) assigned when the sea water flow-through system was known to be or appeared to be shut down (secured), mainly during the February-March time period as the vessel cruised around the Hawai’ian archipelago (details unknown).

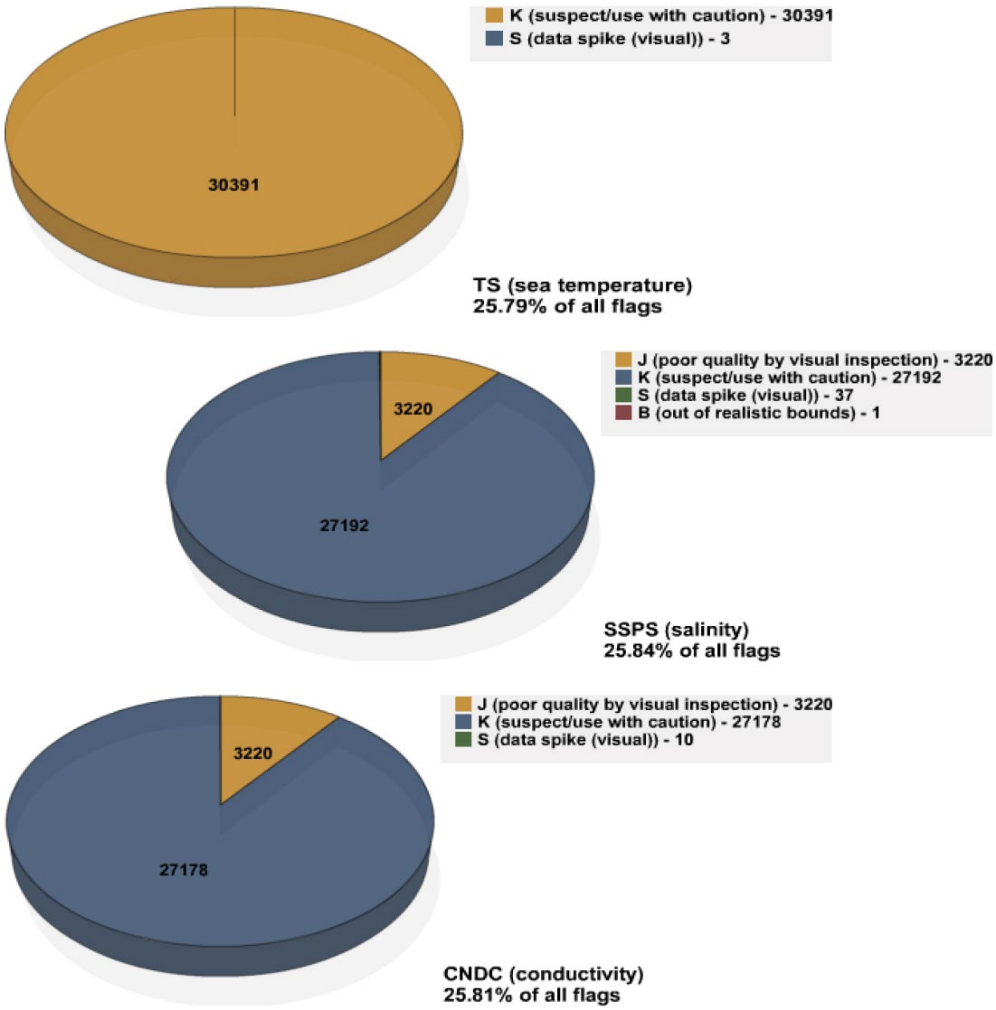


Figure 54: Distribution of SAMOS quality control flags for (top) sea temperature – TS – (middle) salinity – SSPS – and (bottom) conductivity – CNDC – for the *Oscar Elton Sette* in 2020.

Rainier

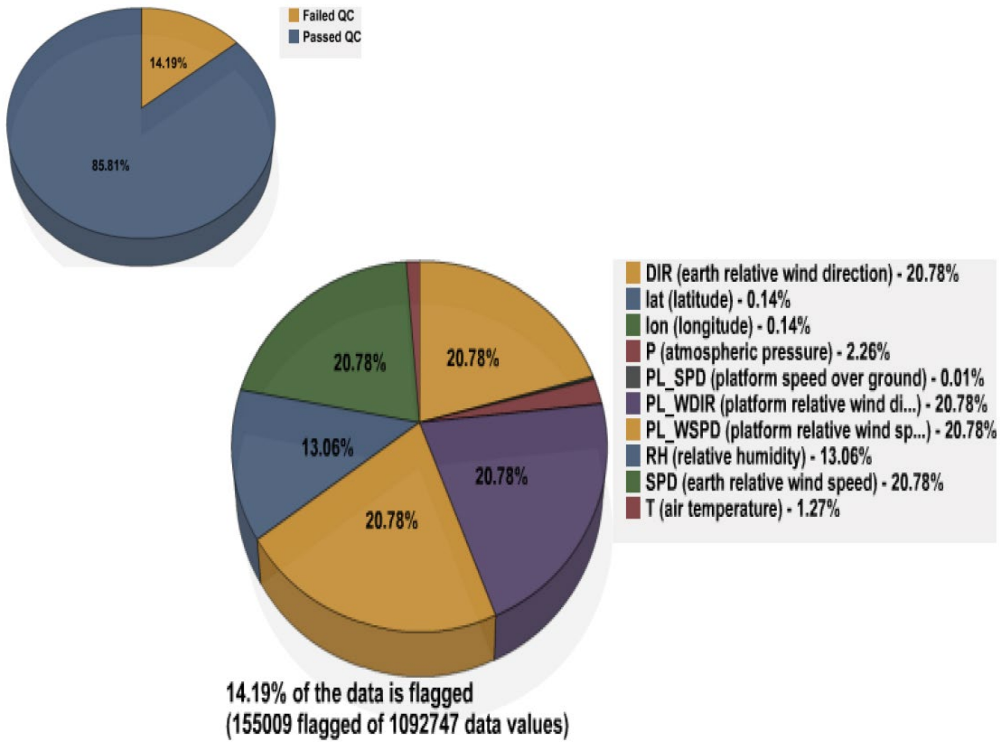


Figure 55: For the *Rainier* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Rainier* provided SAMOS data for 78 ship days, resulting in 1,092,747 distinct data values. After both automated and visual QC, 14.19% of the data were flagged using A-Y flags (Figure 55). This is a substantial increase over 2019 (2.25%) and is well outside the “under 5% total flagged” bracket regarded by SAMOS to represent "very good" data.

On 7 August a SAMOS data quality evaluator (DQE) contacted *Rainier* to inquire about a lack of SAMOS data transmission despite the vessel’s apparent underway status. In the technician’s immediate response – in addition to committing to restarting transmission – he mentioned the ship’s anemometer had been broken by scaffolding in their recent shipyard period. He noted all wind data would be bad and should not be used, but stated he hoped to service the anemometer when *Rainier* would next be in port on 21 August. However, as soon as the following cruise began it was clear the anemometer was not yet fixed. When the DQE emailed the vessel again on 31 August to check in the technician confirmed a crane was needed and he would therefore not be able to service the instrument before the season ended. Consequently, SAMOS processing of the earth relative wind direction and speed (DIR and SPD, respectively) and platform relative wind direction and speed (PL_WDIR and PL_WSPD, respectively) was halted as of 1 September 2020 and was not resumed that year. In the end, all the DIR, SPD, PL_WDIR, and PL_WSPD data received from *Rainier* in 2020 were flagged with “malfunction” (M) flags (Figure 56).

Looking to Figure 55, the relative humidity parameter received a further ~13% of the total flags. These were, however, primarily "out of bounds" (B) flags (Figure 56) applied to humidity readings slightly over 100% such as commonly occur with these instruments in a saturated environment, owing to instrument tuning (see 3b).

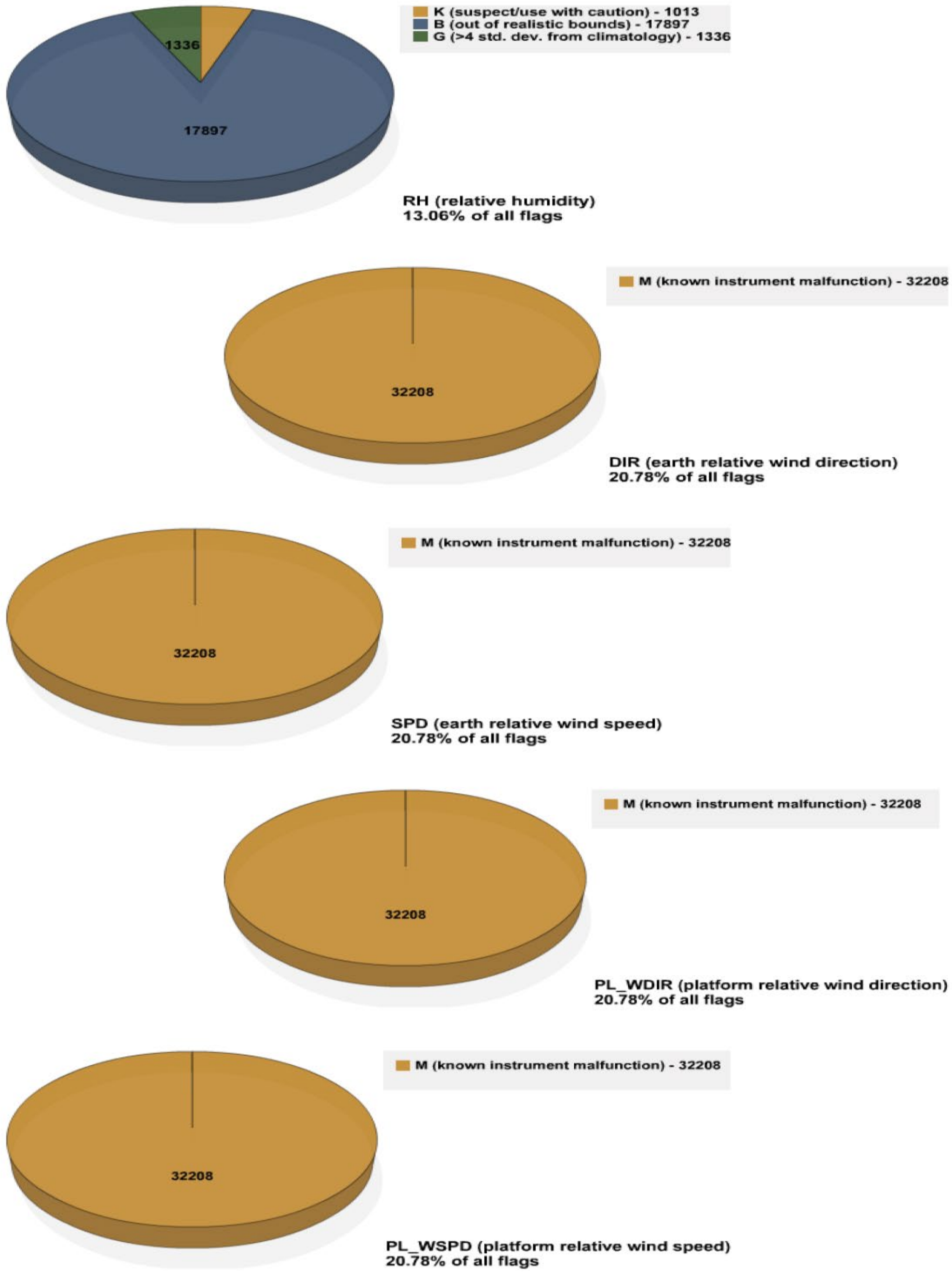
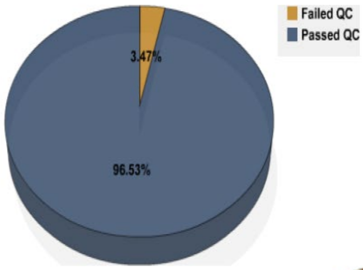


Figure 56: Distribution of SAMOS quality control flags for (first) relative humidity – RH – (second) earth relative wind direction – DIR – (third) earth relative wind speed – SPD – (fourth) platform relative wind direction – PL_WDIR – and (last) platform relative wind speed – PL_WSPD – for the *Rainier* in 2020.

Reuben Lasker



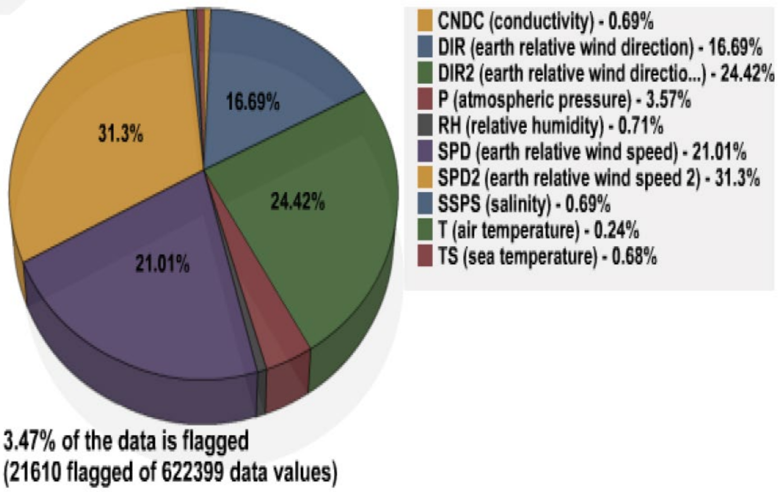


Figure 57: For the *Reuben Lasker* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Reuben Lasker* provided SAMOS data for 23 ship days, resulting in 622,399 distinct data values. After both automated and visual QC, 3.47% of the data were flagged using A-Y flags (Figure 57). This is about three and a half percentage points lower than in 2019 (7.07%).

On 7 and 8 September SAMOS files were received from Reuben Lasker that had latitude and longitude data = 0,0, which would put the ship in the Gulf of Guinea. However, MarineTraffic.com had shown the vessel to be in San Diego, CA just days before, making the 0,0 latitude and longitude position especially suspicious. A SAMOS data quality evaluator (DQE) contacted the vessel to confirm their location and to advise them of the latitude and longitude values being included in their SAMOS files, but no response was received. Nevertheless, with confidence being high the latitude and longitude data were in error, and because the data would be useless without valid latitude and longitude, the decision was made to delete the 7-8 September files from the SAMOS data server. We note it was later determined, in 2021, there was in fact an issue with Lasker's latitude and longitude parameters (corrected in 2021).

In general, *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 58).

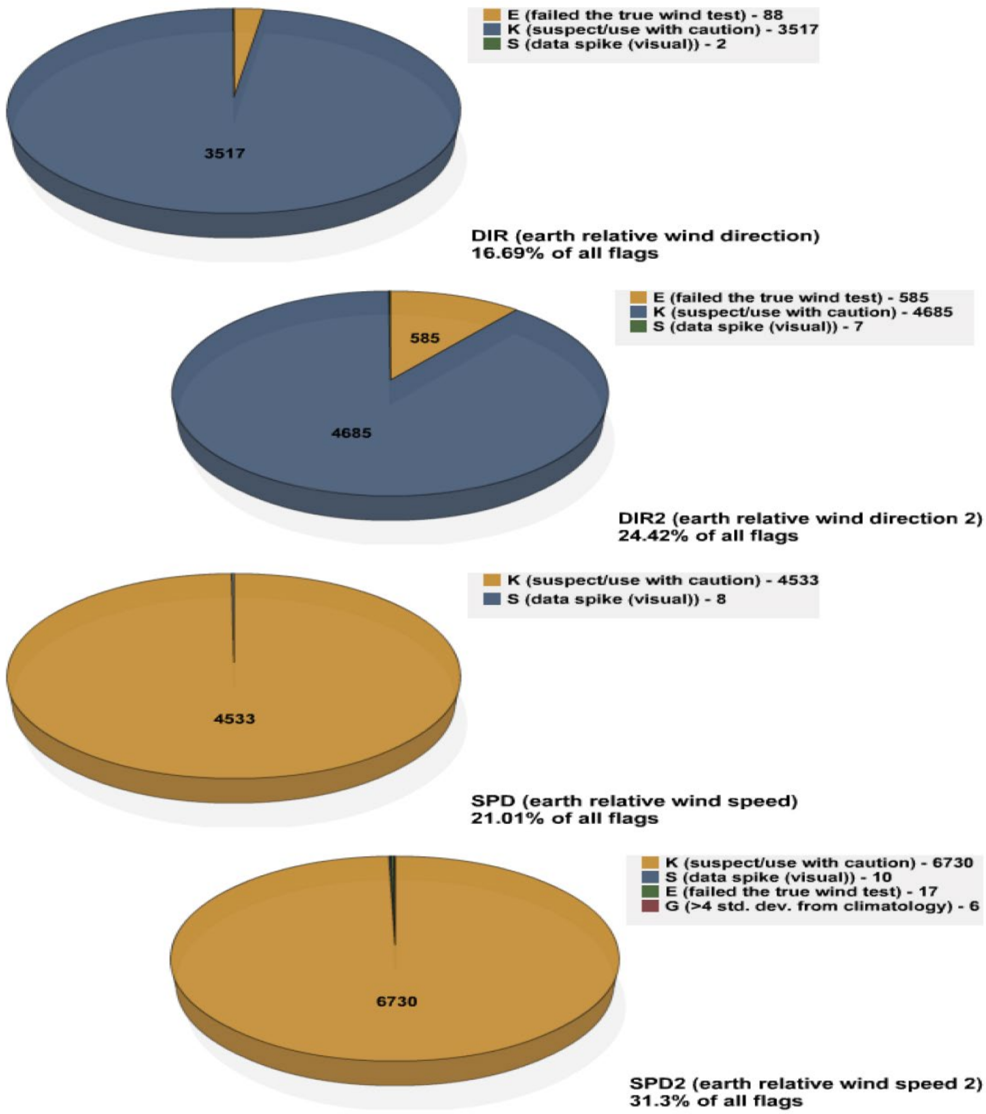


Figure 58: Distribution of SAMOS quality control flags for (first) earth relative wind direction – DIR – (second) earth relative wind direction 2 – DIR2 – (third) earth relative wind speed – SPD – and (last) earth relative wind speed 2 – SPD2 – for the *Reuben Lasker* in 2020.

Ronald H. Brown

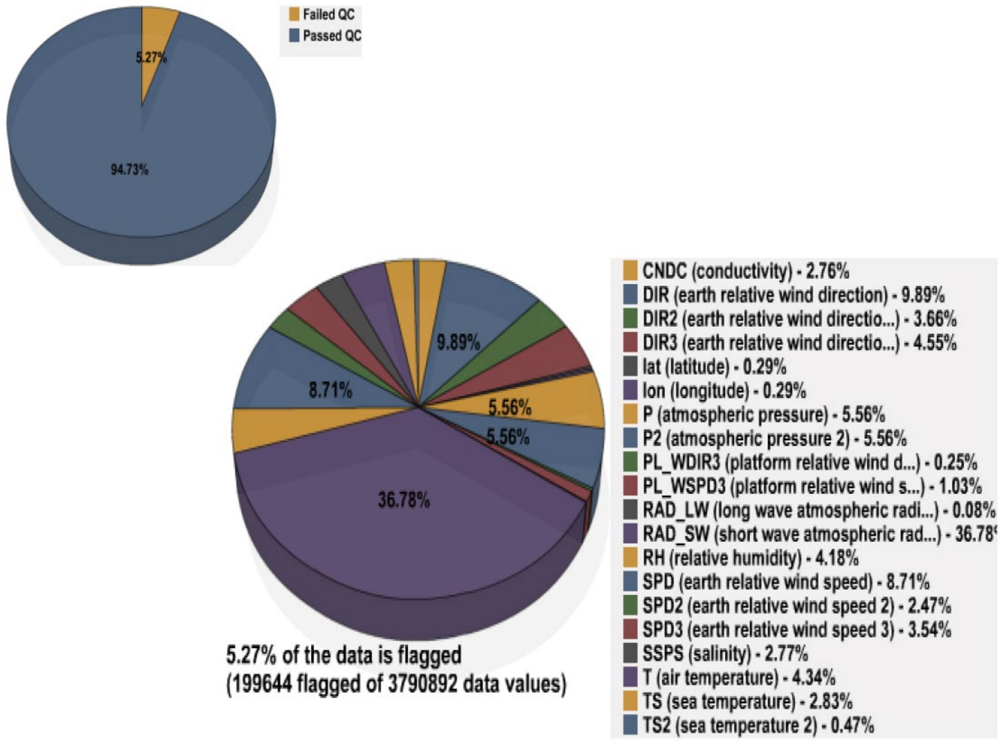


Figure 59: For the *Ronald H. Brown* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Ronald H. Brown* provided SAMOS data for 132 ship days, resulting in 3,790,892 distinct data values. After both automated and visual QC, 5.27% of the data were flagged using A-Y flags (Figure 59). This is about a percentage point higher than in 2019 (4.5%) and moves *Brown* outside the "under 5% total flagged" bracket regarded by SAMOS to represent "very good" data.

As *Ron Brown* got underway again in the fall a SAMOS data quality evaluator (DQE) noted some suspicious behavior in their internal thermosalinograph sea temperature (TS) and the salinity (SSPS) and conductivity. As demonstrated in Figure 60, she observed occasional negative steps or drifts in the data (notably not seen in the external sea temperature, TS) that were always followed by an abrupt return to the prevailing trend. When the DQE contacted the vessel for confirmation on 26 October a technician immediately replied and advised there was a known plumbing issue he was working to resolve. He stated that essentially the water flow rate was dropping too low. He expected to have the problem solved shortly, and indeed within a day it appeared things had improved. In the meantime, between about 19-26 October TS, SSPS, and CNDC all received some amount of "caution/suspect" (K) flags (Figure 61).

Looking to Figure 59, the short wave atmospheric radiation (RAD_SW) parameter, with ~37% of the total flags, would appear to have been especially problematic for the *Brown*. However, these were almost exclusively "out of bounds" (B) flags (Figure 61), which have been applied mainly to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.) This does not indicate a data issue, just a cautionary note for users of the RAD_SW data.

As a general note, *Ronald Brown's* various meteorological sensors do occasionally exhibit data distortion that is dependent on the vessel relative wind direction (common to many vessels). Where the data appears affected, it is typically K-flagged (not shown).

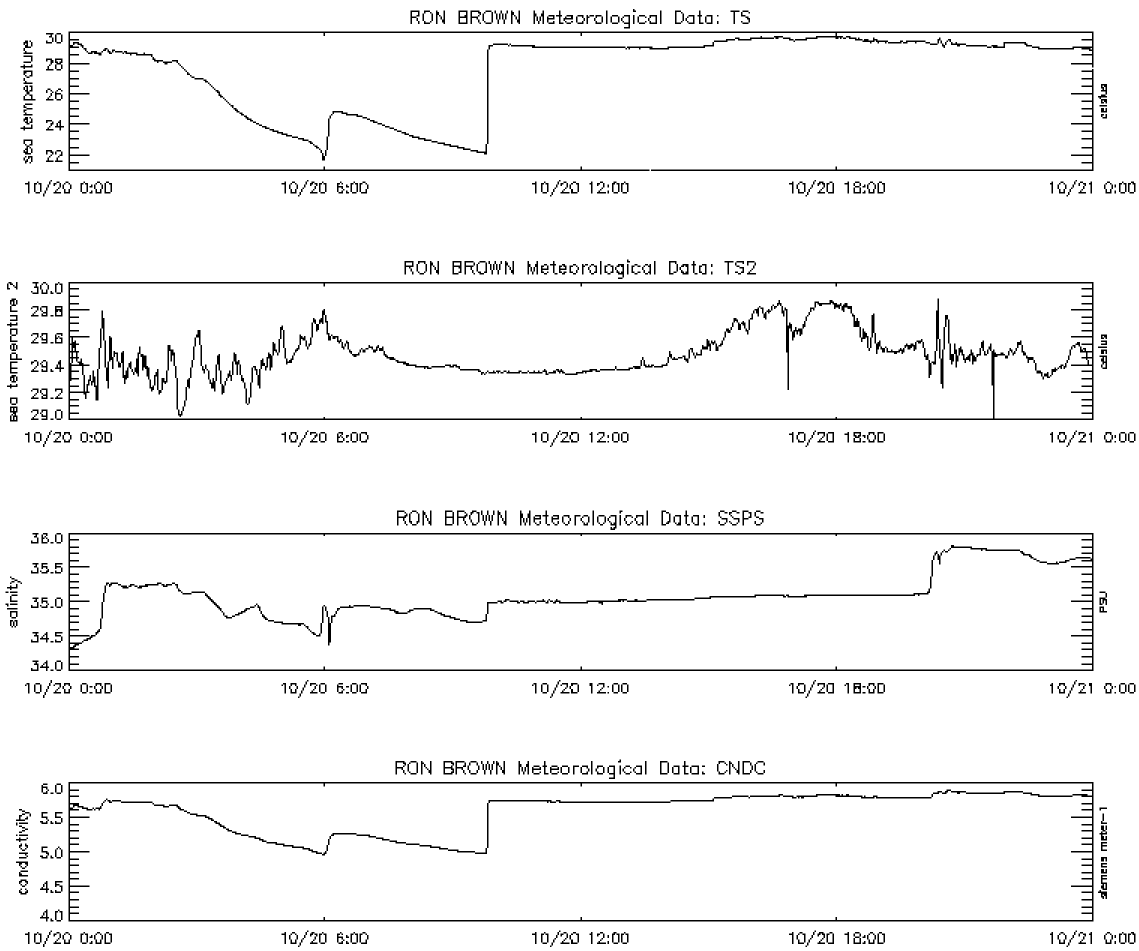


Figure 60: *Ronald H. Brown* SAMOS (first) sea temperature – TS – (second) sea temperature 2 – TS2 – (third) salinity – SSPS – and (fourth) conductivity – CNDC – data for 20 October 2020. Note negative drift behavior in TS/SSPS/CNDC (not mirrored in TS2), particularly between ~2:30 and 9:30 UTC.

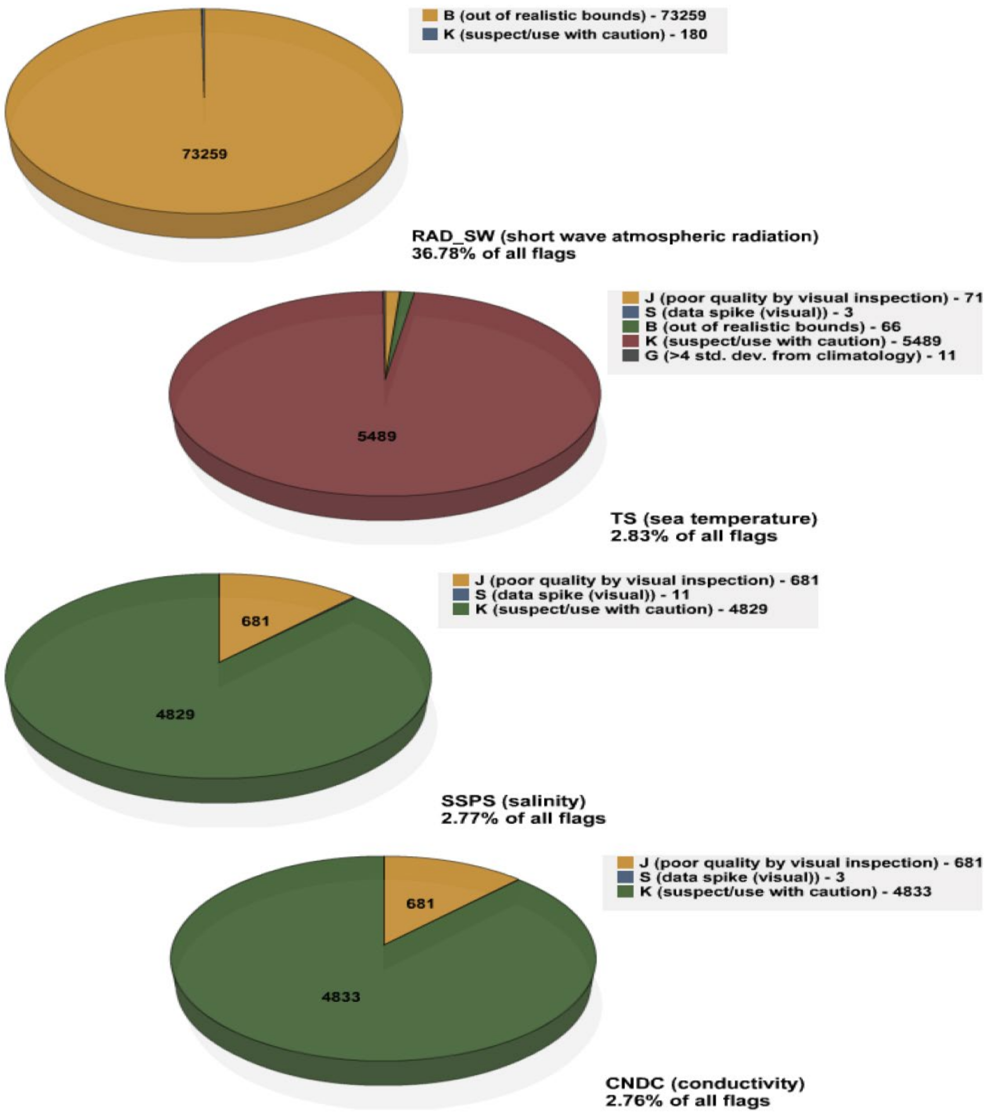


Figure 61: Distribution of SAMOS quality control flags for (first) short wave atmospheric radiation – RAD_SW – (second) sea temperature – TS – (third) salinity – SSPS – and (last) conductivity – CNDC – for the *Ronald H. Brown* in 2020.

Thomas Jefferson

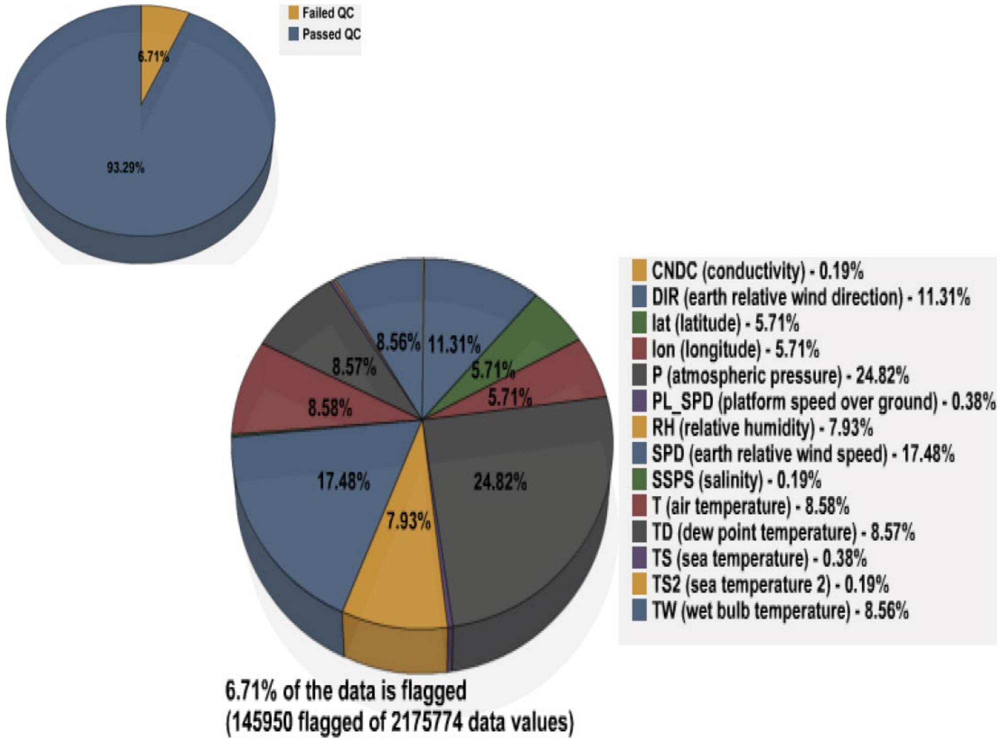


Figure 62: For the *Thomas Jefferson* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Thomas Jefferson* provided SAMOS data for 93 ship days, resulting in 2,175,774 distinct data values. After both automated and visual QC, 6.71% of the data were flagged using A-Y flags (Figure 62). This is significantly lower than in 2019 (12.74%) and brings *Jefferson* closer to the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

On 10 June a SAMOS data quality evaluator (DQE) observed *Thomas Jefferson's* earth relative wind speed and direction (SPD and DIR, respectively) were suspiciously changing in lockstep with the ship's speed and heading, respectively (see Figure 63). The DQE emailed the vessel, noting the stepping behavior in DIR and SPD would normally be a pretty typical product of static/erroneous values in the relative wind parameters (direction and/or speed) but that in this case the relative winds being received by SAMOS were not displaying any obvious problems. She stressed, however, that Jefferson's metadata did not make clear which of the ship's multiple anemometers was the input source for either the relative or the true winds and wondered if the relative and true might be coming from different instruments. A technician immediately confirmed the suspicious appearance of SPD and DIR and noted, too, their starboard anemometer was not giving complete data. Because he was not very familiar with their data acquisition system, however, he was not in a position at that time to make any changes. More than a month later, on 21 July, the DQE, noting DIR and SPD still appeared compromised, emailed the vessel again for an update. A second technician got in touch a day later to inform they had just switched the input for DIR and SPD to their starboard wind bird, after which DIR and SPD did appear greatly improved (see Figure 63). Meanwhile, between 8 June and 22 July all DIR and SPD data were flagged with “poor quality” (J) flags (Figure 65).

On 2 October a DQE detected suspicious behavior in Jefferson’s atmospheric pressure (P) data. She noted a discontinuous ~ +1 mb step in P ~14:00 UTC on 1 October with what looked like potential vibrational noise in the data afterwards (Figure 64). She emailed the vessel the details and a technician replied he had noticed some of the sensor’s tubing had deteriorated, likely causing the noise. He was able to locate and install replacement tubing later that day, after which P improved. Then on 19 October the DQE noted the odd noise behavior in P had resurfaced and she once again emailed the vessel. This time the technician advised he had found water in some of the tubing, drained it, and attached hose clamps over the connections to prevent further water intrusion. Nevertheless, the noise continued, and so did email discussions. The technician expressed he had changed the tubing type to a more rigid vinyl, and he felt it was possible the way he had attached it to the ship to was causing deformation in the hose, resulting in rapid pressure changes as the ship vibrated. He noted he had done what he could to mechanically decouple the hose from the ship. With just a few days of sailing left for the year, it was expected any lingering P data issues would have to wait for winter inport sensor calibrations. In the meantime, from 1-28 October, P was frequently flagged with “caution/suspect” (K), J, and a small portion of “malfunction” (M) flags (Figure 65).

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 (Figure 65, not all shown).

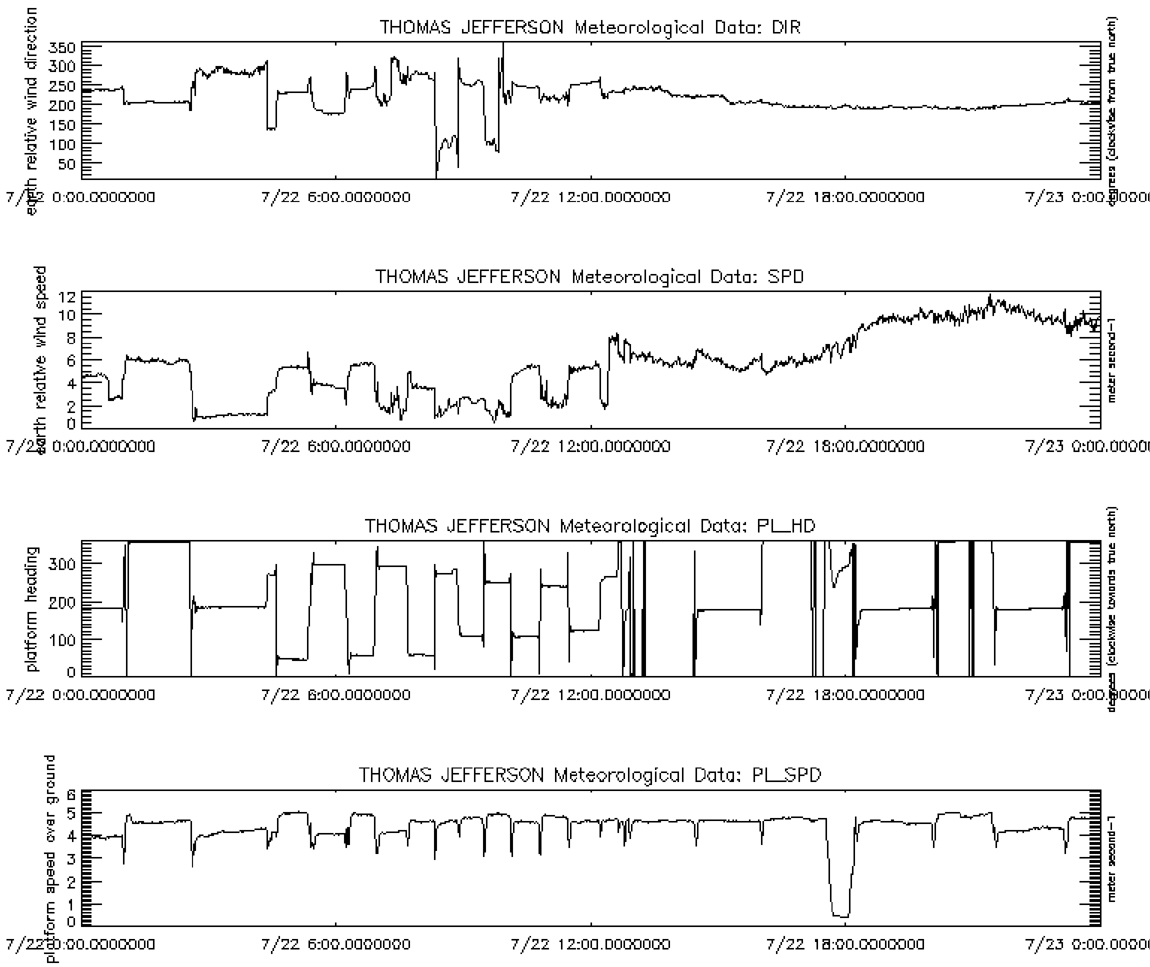


Figure 63: *Thomas Jefferson* SAMOS (first) earth relative wind direction – DIR – (second) earth relative wind speed – SPD – (third) platform heading – PL_HD – and (last) platform speed over ground – PL_SPD – data for 22 July 2020. Note how DIR and SPD essentially mirror PL_HD and PL_SPD, respectively, prior to the true wind input being switched to *Jefferson's* starboard wind bird, ~13:00 UTC.

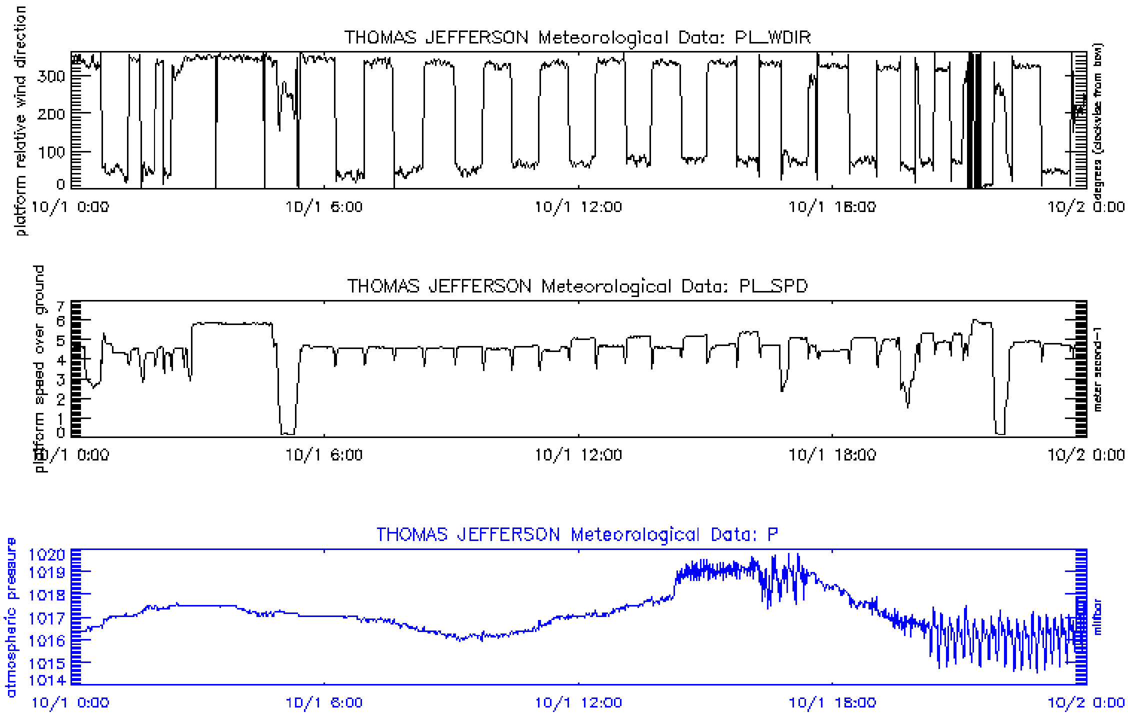


Figure 64: *Thomas Jefferson* SAMOS (top) platform relative wind direction – PL_WDIR – (middle) platform speed over ground – PL_SPD – and (bottom) atmospheric pressure – P – data for 1 October 2020. Note discontinuity in P ~14:00 UTC as well as periods of sinusoidal noise that follows.

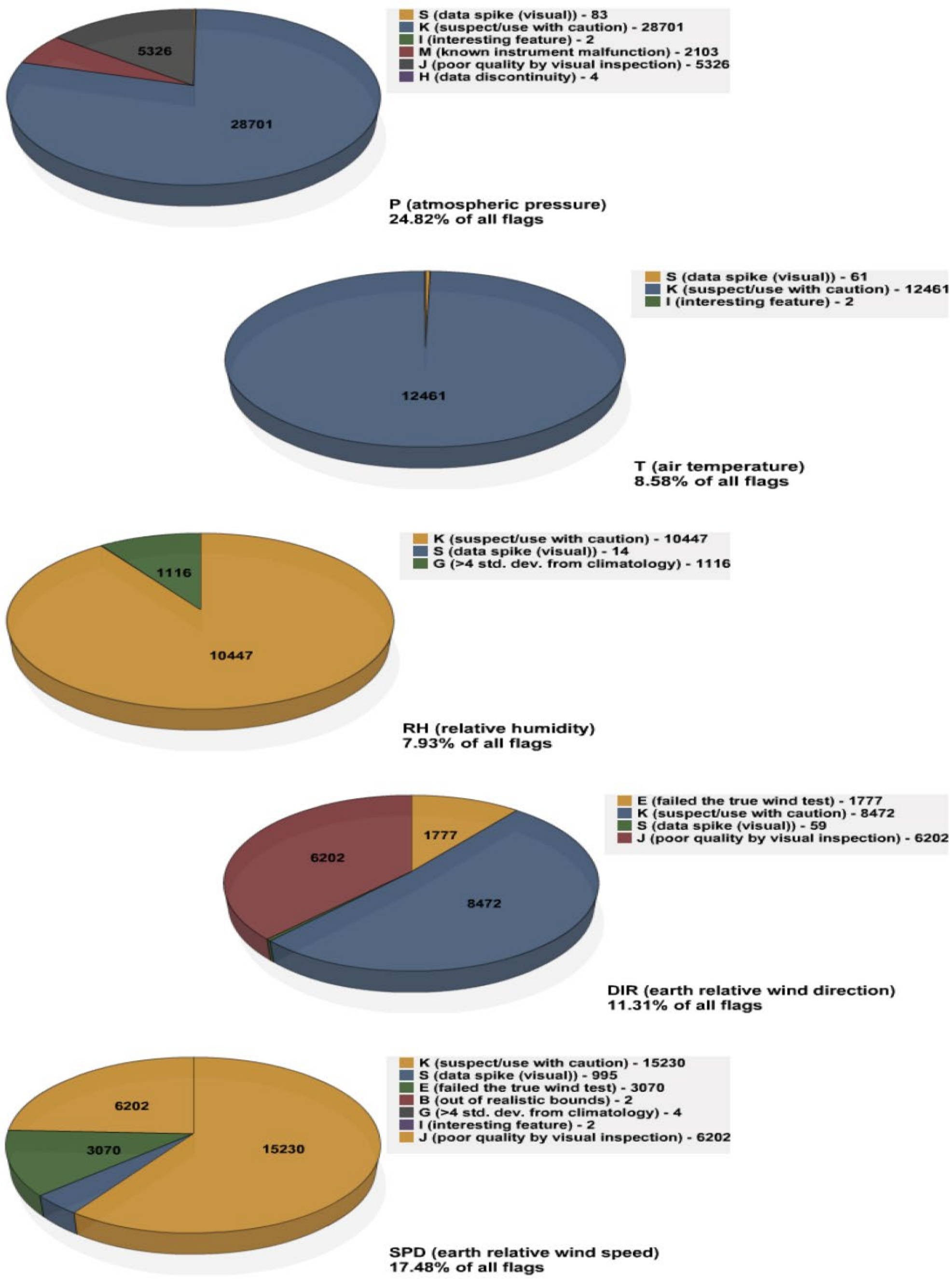


Figure 65: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) earth relative wind direction – DIR – and (last) earth relative wind speed –SPD – for the *Thomas Jefferson* in 2020.

Laurence M. Gould

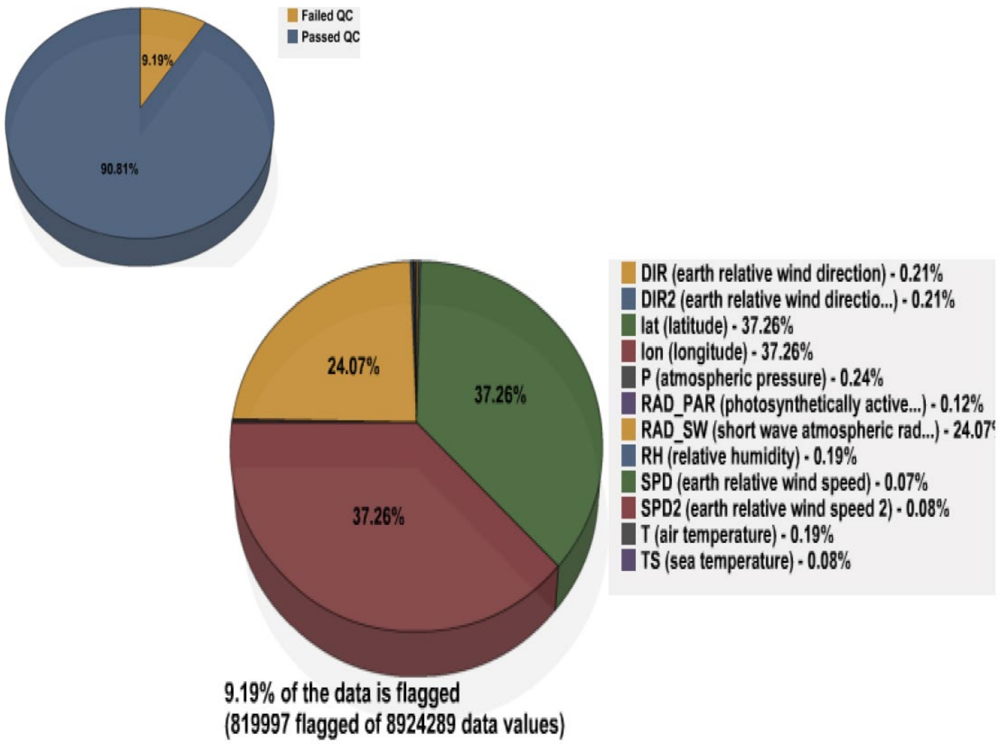


Figure 66: For the *Laurence M. Gould* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Laurence M. Gould* provided SAMOS data for 301 ship days, resulting in 8,924,289 distinct data values. After automated QC, 9.19% of the data were flagged using A-Y flags (Figure 66). This is three and a half percentage points higher than in 2019 (5.69%) and maintains *Gould* outside the "under 5% total flagged" bracket regarded by SAMOS to represent "very good" data. 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, the majority of the 2020 SAMOS data from the *Gould* were sent while the vessel was dockside in Chile, resulting in the large number of land (L) flags.

On 18 December a technician on the *Laurence M. Gould* emailed to advise they had had their meteorology data turned off from 19:38 to 20:31 UTC the previous day for instrument cleaning and maintenance. It was cautioned that data in this period should not be used and previous data should be considered suspect (inception date indeterminate). A SAMOS data quality evaluator (DQE) observed that relative humidity (RH) and air temperature (T) had dropped a few percent/degrees during the cleaning period, and afterwards T was notably a bit lower than before and RH notably a bit higher.

Later, on 28 December, the DQE noticed periodic big spikes and steps in both T and RH, starting on 27 December around 1:15 UTC (see Figure 67). He emailed the vessel about the spikes and steps, wondering if the instrument was experiencing icing. The technician immediately responded stating she had noticed the T/RH probe had fallen out of its housing and was bouncing around. She expressed her belief that this was the probable cause of the jumpy T data. She also noted humidity was now reporting at zero, which she suspected meant the instrument was damaged and would need repairing/replacing in port. The instrument was repaired early in 2021.

There were no other issues noted in 2020 for the *Gould*. Looking to the flag percentages in Figure 66, nearly all the flags applied were assigned to latitude (LAT), longitude (LON), and short wave atmospheric radiation (RAD_SW). These were almost exclusively "platform position over land" (L) flags in the case of LAT and LON (Figure 68) 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 68) 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 66.

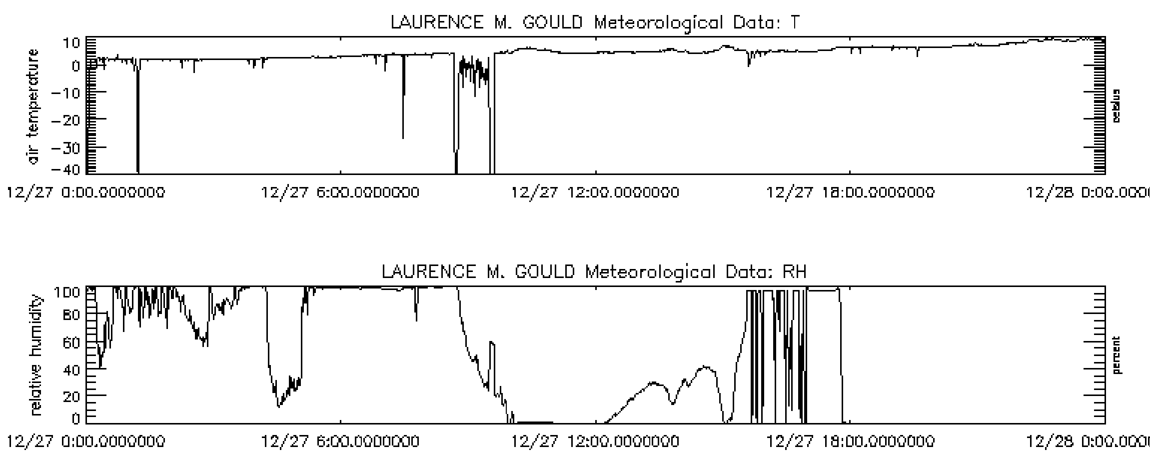


Figure 67: *Laurence M. Gould SAMOS* (top) air temperature – T – and (bottom) relative humidity – RH – data for 27 December 2020. Note large spikes/steps in T and RH after ~1:15 UTC.

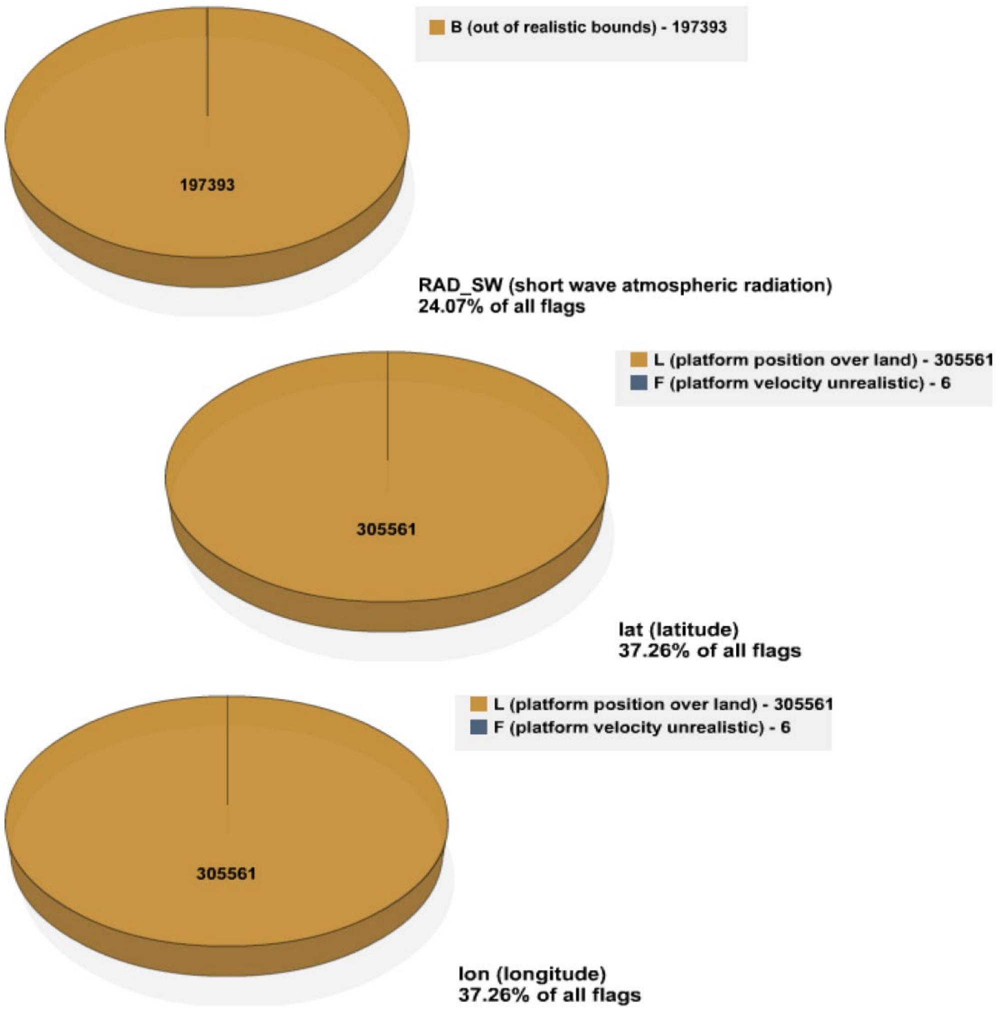


Figure 68: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – (middle) latitude – LAT – and (bottom) longitude – LON – for the *Laurence M. Gould* in 2020.

Nathaniel B. Palmer

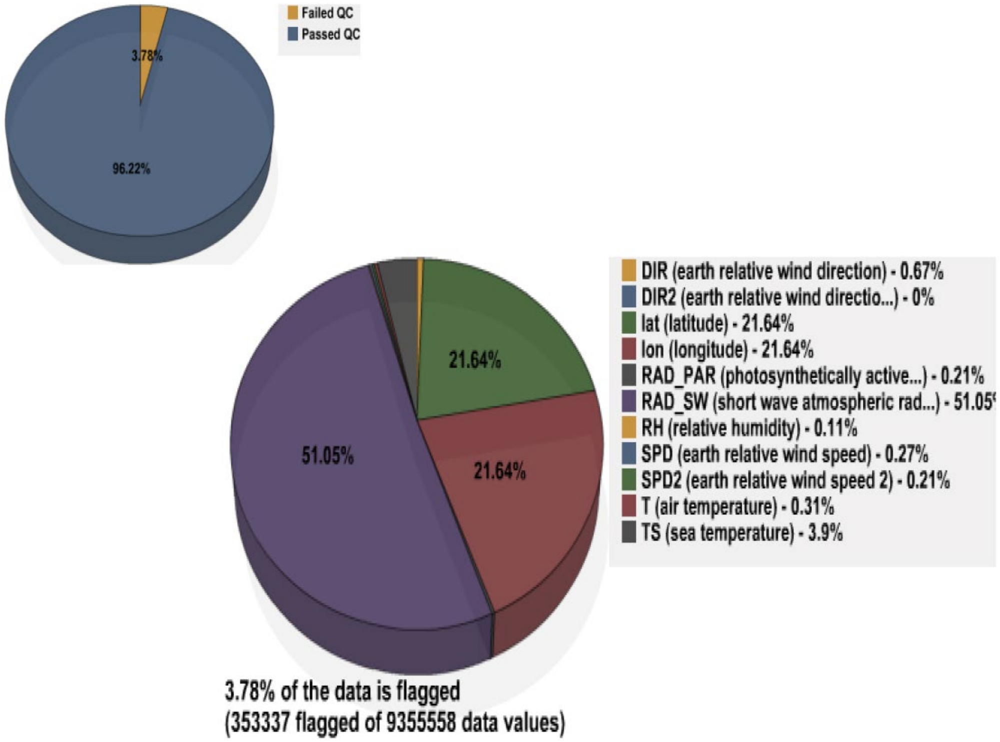


Figure 69: For the *Nathaniel B. Palmer* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Nathaniel Palmer* provided SAMOS data for 301 ship days, resulting in 9,355,558 distinct data values. After automated QC, 3.78% of the data were flagged using A-Y flags (Figure 69). This is about four percentage points lower than in 2019 (7.61%) and moves *Palmer* inside 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, the majority of the 2020 SAMOS data from the *Palmer* were sent while the vessel was dockside in Chile, resulting in the large number of land (L) flags.

On 12 December a SAMOS data quality analyst (DQE) noted static values in the *Palmer's* sea temperature (TS), salinity (SSPS), and conductivity (CNDC) beginning the previous day. He suspected the pumps were off and emailed the vessel to confirm. A technician responded two days later, affirming they had shut down their seawater flow through system and stopped logging all sea water data when they crossed into an EEZ at 19:05 UTC on 11 December.

There were no other issues noted in 2020 for the *Palmer*. Looking to the flag percentages in Figure 69, nearly all the flags applied were assigned to latitude (LAT), longitude (LON), and short wave atmospheric radiation (RAD_SW). These were almost exclusively "platform position over land" (L) flags in the case of LAT and LON (Figure

70) 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 70) 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 *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 69.

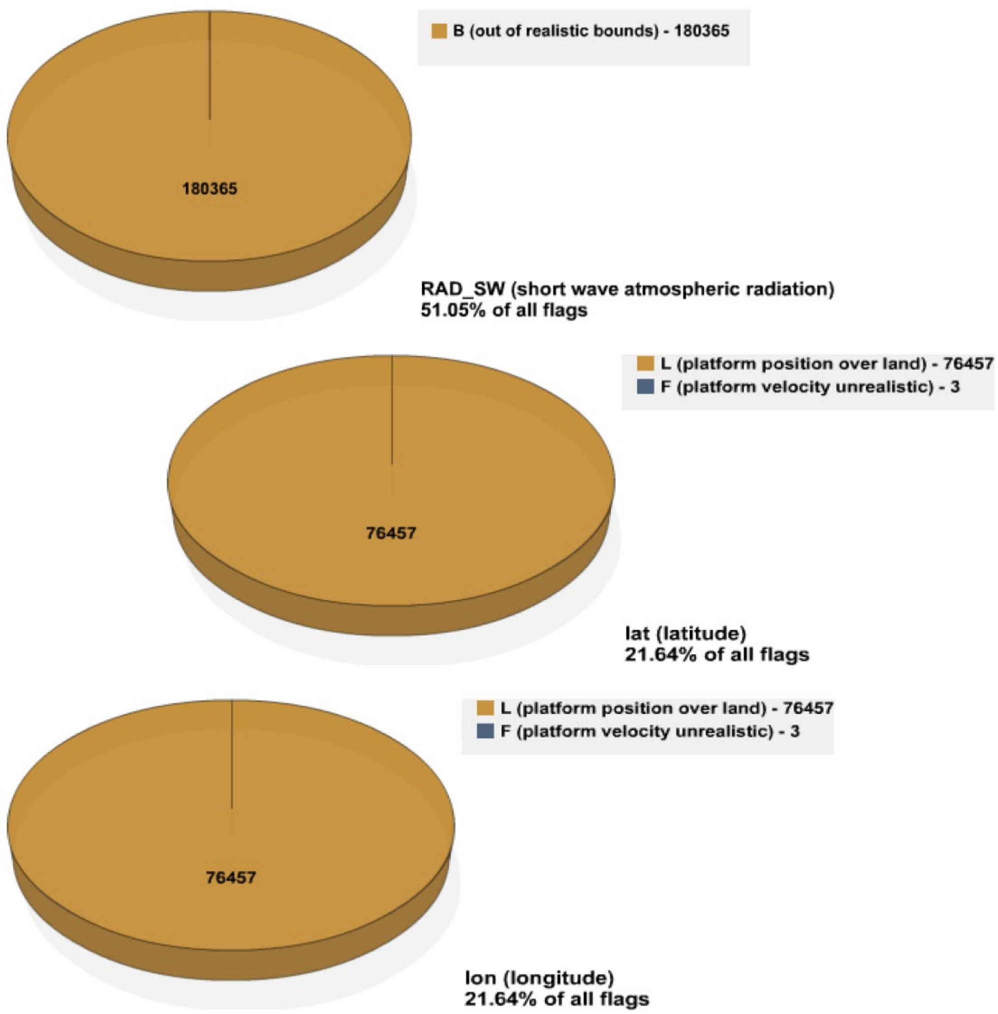


Figure 70: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – (middle) latitude – LAT – and (bottom) longitude – LON – for the *Nathaniel B. Palmer* in 2020.

Robert Gordon Sproul

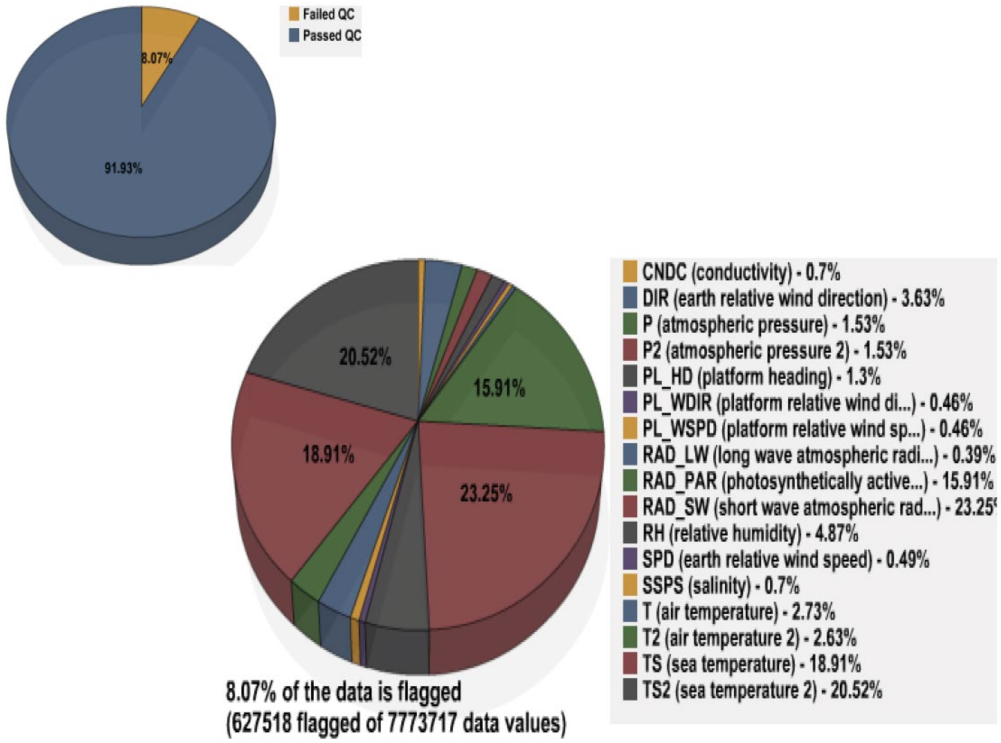


Figure 71: For the *Robert Gordon Sproul* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Robert Gordon Sproul* provided SAMOS data for 261 ship days, resulting in 7,773,717 distinct data values. After automated QC, 8.07% of the data were flagged using A-Y flags (Figure 71). This is significantly higher than in 2019 (1.73%) and bumps *Sproul* over 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*).

On 17 July a SAMOS data quality evaluator (DQE) noted *RG Sproul's* photosynthetically active radiation (RAD_PAR) data the previous day appeared way too high, averaging around 4450 microeinsteins meter-2 sec-1 for the entire day. The DQE contacted the vessel, wondering if the sensor was experiencing a problem or whether perhaps the data being provided were not using the microeinsteins meter-2 sec-1 units that were documented in *Sproul's* metadata. A technician immediately responded, stating the reason RAD_PAR values were so high was because the sensor was not installed and there was nothing connected to that A/D channel. He noted they took the sensor off earlier in the year to send to Biospherical for calibration and had not gotten it back until recently. The RAD_PAR sensor was re-installed later that day, 17 July. Looking back, it appears likely the sensor was removed on or around 14 February. RAD_PAR data from ~14 February through 17 July were assigned "out of bounds" (B) flags by automated quality control procedures (Figure 73).

All day on 14 December and after 21:00 UTC on 15 December the DQE observed *Sproul's* sea temperature 2 (TS2), salinity (SSPS), and conductivity (CNDC) exhibited unrealistic, smooth data curves (see Figure 72) indicative of the sea water system being off. As the vessel was near or in port at these times they were not notified, but we note the data should not be used. Some of the affected TS2 data exceeded automated climatology checks by greater than four standard deviations and were thus assigned "greater than four standard deviations from climatological mean" (G) flags (Figure 73); however, again, they simply should not be used.

There were no other issues noted for the *Sproul* in 2020. Looking to the flag percentages in Figure 71, ~20% of the total flags were applied to each of the two sea temperatures (TS and TS2). Upon inspection, it appears likely TS was reporting a static, unrealistic value (-99) from the start of the 2021 season until it ceased reporting at all after 17 June. The details here are not known but given the conspicuous -99 value (a common "missing value" indicator) it is suspected the instrument may not actually have been installed. All affected data were assigned "out of bounds" (B) flags (Figure 73) during automated quality control procedures. A quick look at TS2 reveals additional instances of the sea water system being off over the course of the year, which resulted in additional G and possibly B flags (Figure 73). Short wave radiation (RAD_SW) additionally received ~23% of the total flags (Figure 71). Upon inspection the flags, which are unanimously out of bounds (B) flags (Figure 73), 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.)

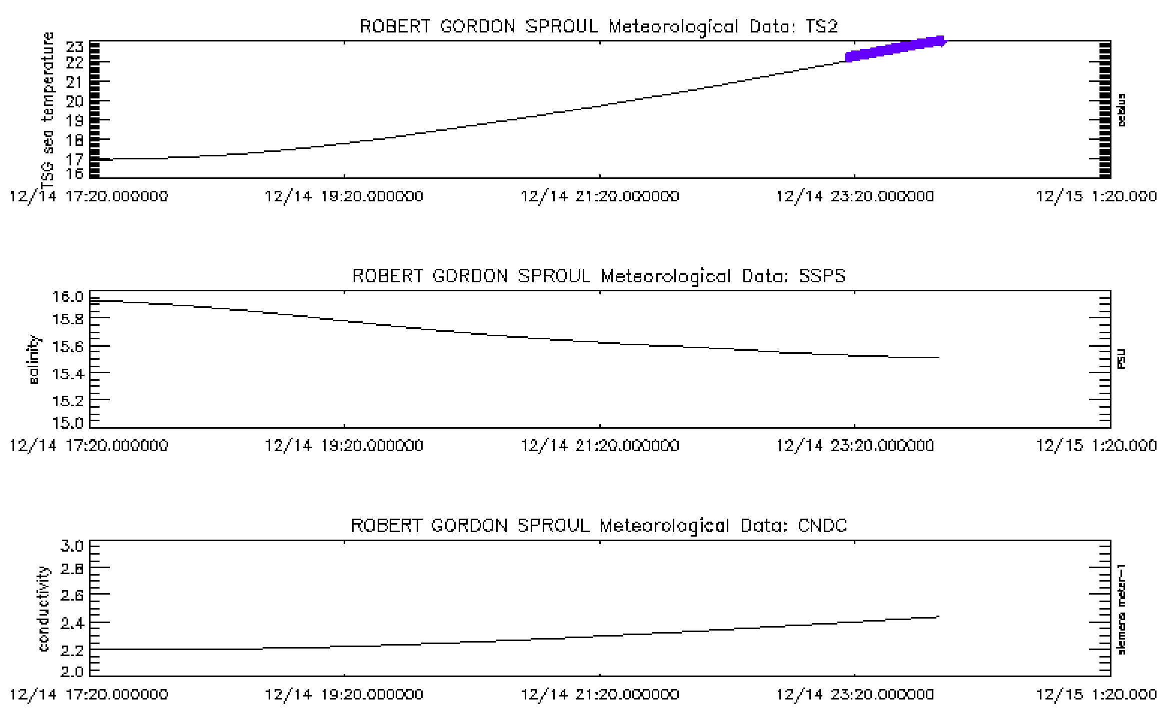


Figure 72: *Robert Gordon Sproul SAMOS* (top) sea temperature 2 – TS2 – (middle) salinity – SSPS – and (bottom) conductivity – CNDC – data for 14 December 2020. Note smoothed data appearance and "greater than four standard deviations from climatological mean" (G) flags (in purple) on TS2.

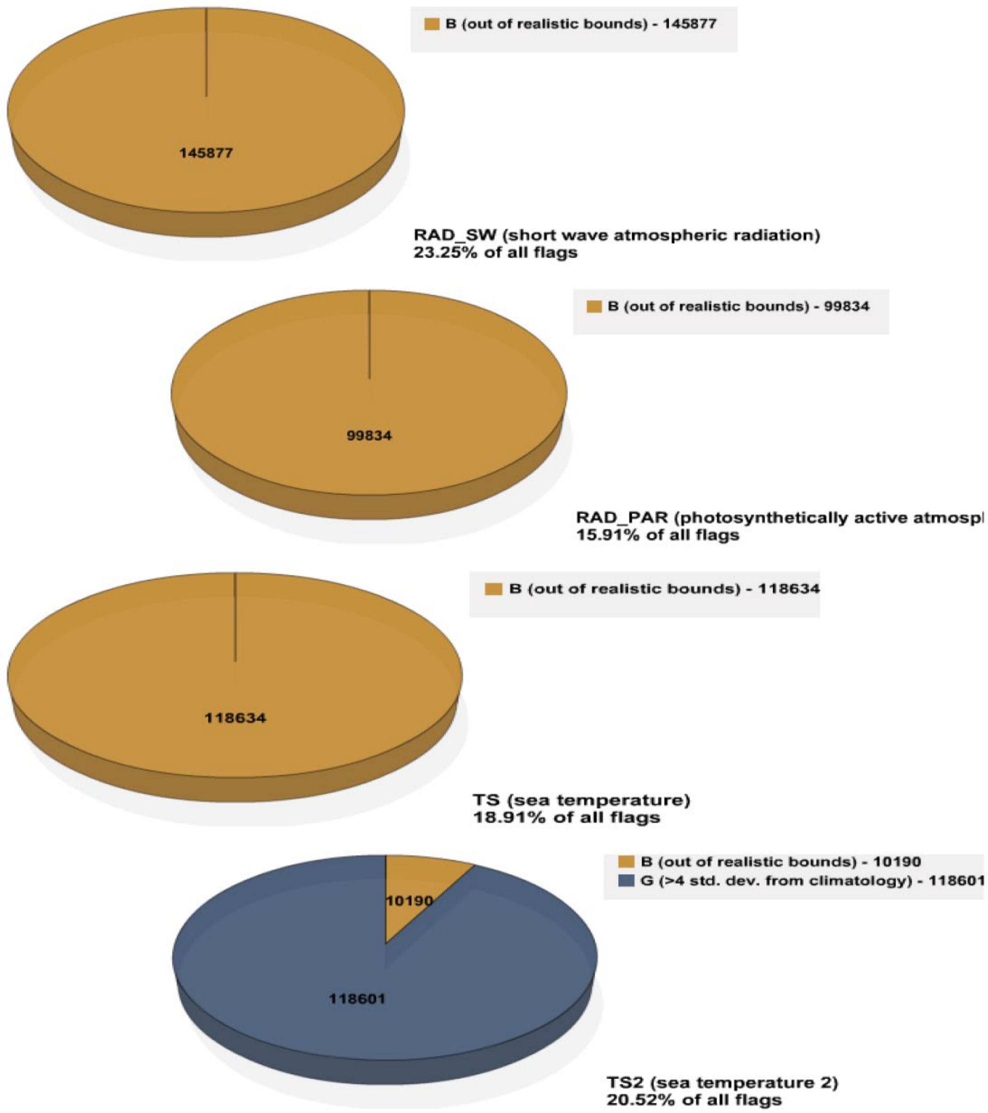


Figure 73: Distribution of SAMOS quality control flags for (first) short wave atmospheric radiation – RAD_SW – (second) photosynthetically active radiation – RAD_PAR – (third) sea temperature – TS – and (last) sea temperature 2 – TS2 – for the *Robert Gordon Sproul* in 2020.

Roger Revelle

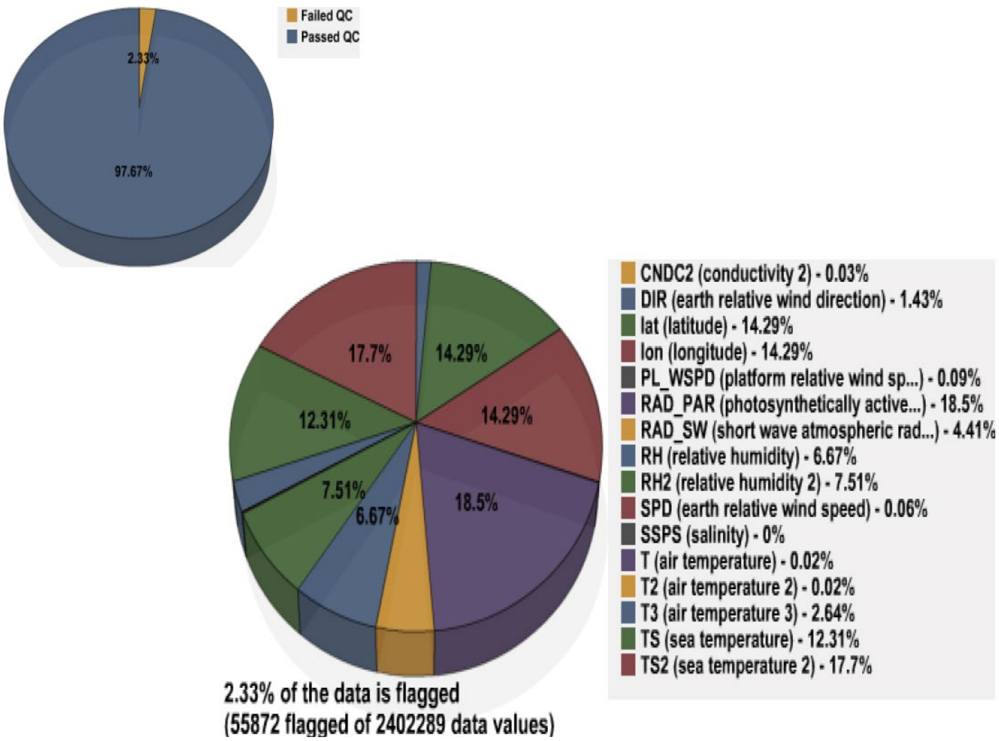


Figure 74: For the *Roger Revelle* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Roger Revelle* provided SAMOS data for 70 ship days, resulting in 2,402,289 distinct data values. After automated QC, 2.33% of the data were flagged using A-Y flags (Figure 74). This is about four percentage points lower than in 2019 (6.61%) and brings *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*). Also, the *Revelle*, was only operational from mid-October 2020 onward as she had just returned from her mid-life refit.

On 16 November a SAMOS data quality evaluator (DQE) noted *Roger Revelle's* sea temperature (TS), salinity (SSPS), and conductivity (CNDC) for several days had been exhibiting values that were out of range and had unrealistic, smooth data curves. The DQE contacted the vessel for information and an operator responded immediately advising their pumps were currently off and would be until ~11/18 as they traversed EEZs for which they did not have clearances. TS, SSPS, and CNDC data for ~13 November through 18 November should not be used. The DQE also observed the pumps were off 16 December from ~5:00 to 11:30 UTC and again on 7-9 December. Both sea temperatures (TS and TS2), SSPS, and CNDC should not be used for these time periods, either.

On 7 December the DQE observed air temperature 3 (T3) and relative humidity 2 (RH2) had begun exhibiting a lot of steps in the data two days earlier, after ~7:30 UTC. He noted some of these "steppy" data appeared very unrealistic (typically lower than truth). The vessel was emailed for details about the suspicious T3/RH2. Several days later an operator responded to say it looked as if the instrument in question had been giving spurious readings (which translated to 120% humidity and 50 degrees C) after a heavy rain, and that the sensor had subsequently dried out on its own. Much of the affected T3 and RH2 data was flagged with "greater than four standard deviations from climatological mean" (G) and "out of bounds" (B) flags (Figure 75).

In general, a DQE has noted steps in the earth relative wind speed (SPD) appear when the vessel turns the bow directly into the wind. This suspected flow distortion may mean a sensor relocation needs to be considered in the future.

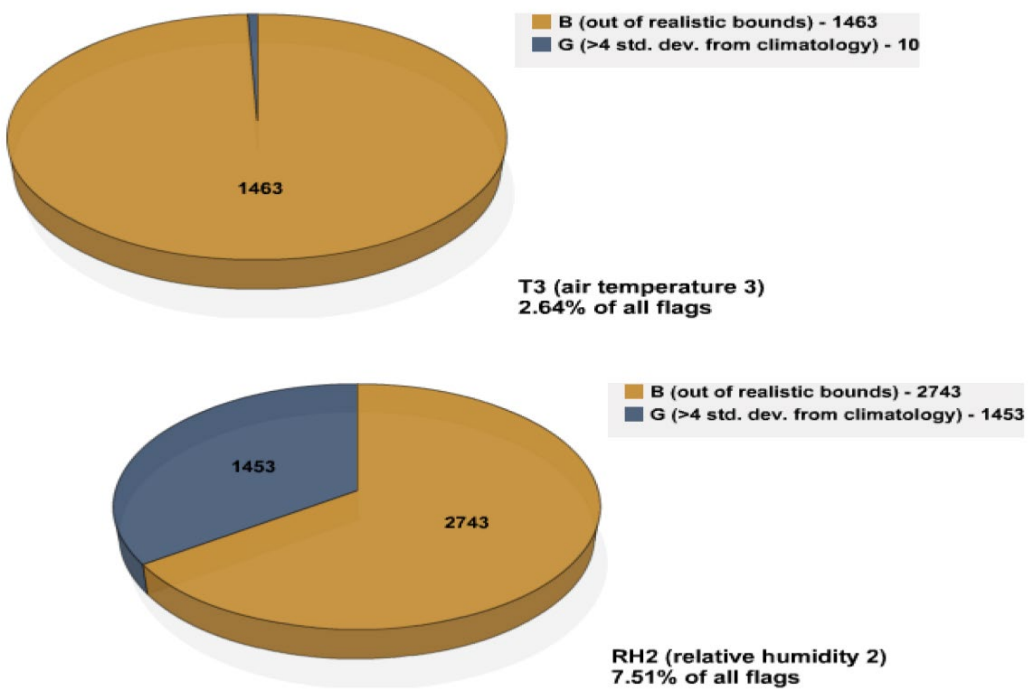


Figure 75: Distribution of SAMOS quality control flags for (top) air temperature 3 – T3 – and (bottom) relative humidity 2 – RH2 – for the *Roger Revelle* in 2020.

Sally Ride

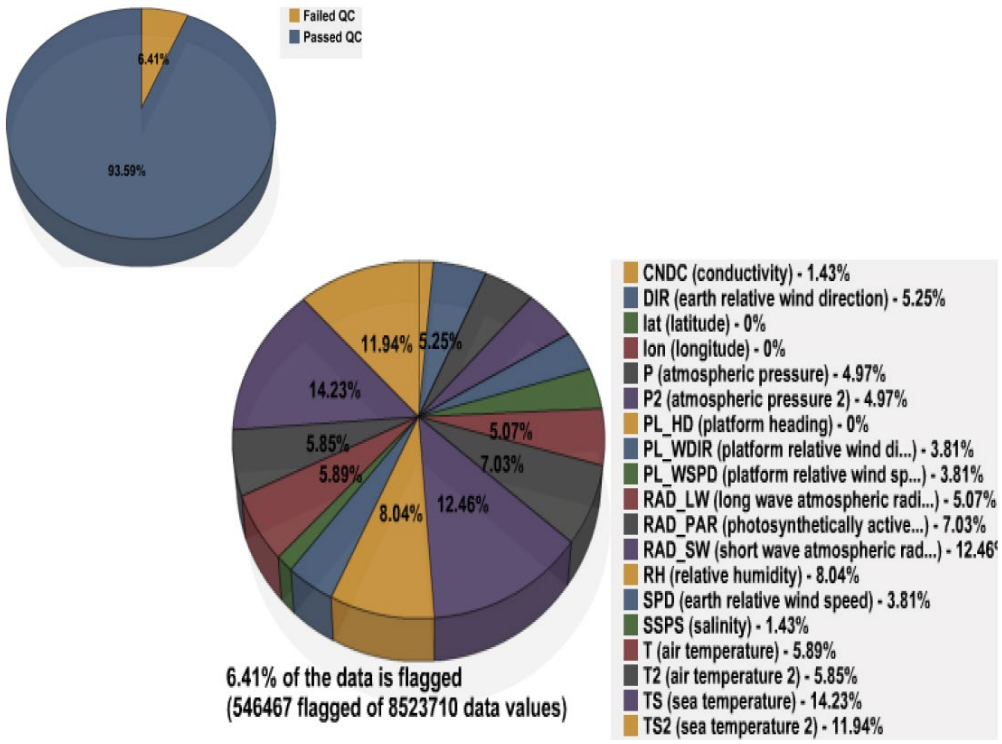


Figure 76: For the *Sally Ride* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Sally Ride* provided SAMOS data for 257 ship days, resulting in 8,523,710 distinct data values. After automated QC, 6.41% of the data were flagged using A-Y flags (Figure 76). This is about one and a half percentage points lower than in 2019 (8.09%) and *Sally Ride* remains outside 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 2 August a ship operator emailed to advise Sally Ride's meteorological sensor j-box was down and they likely would not be able to service it until the 7th. As a result, for the 2-8 August period, all the following data should not be used: both atmospheric pressure parameters (P and P2), both air temperature parameters (T and T2), relative humidity (RH), and short wave, long wave, and photosynthetically active atmospheric radiation (RAD_SW, RAD_LW, and RAD_PAR, respectively). We note some or all this data was likely flagged with "greater than four standard deviations from climatological mean" (G) and/or "out of bounds" (B) flags, as suggested by Figure 77.

On 14 October a SAMOS data quality analyst (DQE) observed sea temperature (TS) was reading about 5-6 degrees C higher than sea temperature 2 (TS2), while the salinity (SSPS) and conductivity (CNDC) were showing little variability, all since the beginning of the ongoing cruise. The DQE emailed the vessel with suspicions the bow intake thermosalinograph, a Sea-Bird SBE45, was either not running or experiencing a problem. Technicians responded immediately, stating the bow SBE45 pump had been switched off because of high seas. It is not immediately clear when the pump was turned back on, but TS/SSPS/CNDC cruise data beginning 12 October should not be used.

Sea water systems for both the bow intake and main lab SBE 45s were also suspected of being off from 7 December through at least ~22:30 UTC 16 December. TS, SSPS, and CNDC (the bow SBE45 parameters) exhibited unrealistic, smooth curves while sea temperature 2 (TS2), salinity 2 (SSPS2), and conductivity 2 (CNDC2), aka the main lab SBE45 parameters, all displayed unrealistic values. After ~22:30 the data effects seemed more or less swapped (also more critical in the case of TS/SSPS/CNDC), with the bow intake parameters now all exhibiting unrealistic static negative numbers and the main lab parameters exhibiting unrealistic, smooth curves. The DQE contacted the vessel on 18 December requesting details, but it appears no response was received. Some of these affected data received G and/or B flags (not shown), but all sea water data from 7 December through end date unknown should not be used.

At the end of the year, 29-30 December, the DQE noted upper values of RAD_PAR were unrealistically high, exceeding 3000 microeinsteins meter-2 second-1. It is wondered whether that sensor was drifting off calibration. These data received B flags during automated quality control (Figure 77).

In general, an air flow issue was noted in 2021 for Sally Ride’s wind data. Prominent, severe steps had been observed in the earth relative wind direction and speed (DIR and SPD, respectively) whenever the relative wind was from abeam (i.e., vessel heading 90 degrees to the true wind). After conferring with technicians a few times over the summer it was determined that any fix was unlikely in the near term, mainly because of COVID-19 restrictions.

Also noted in the summer, and persisting throughout the remainder of the year, the *Ride’s* RH values often reach as high as 105% in nocturnal saturation conditions. This may indicate a calibration or sensor salting/cleaning issue. Any RH values over 100% are B-flagged during automated quality control (not shown).

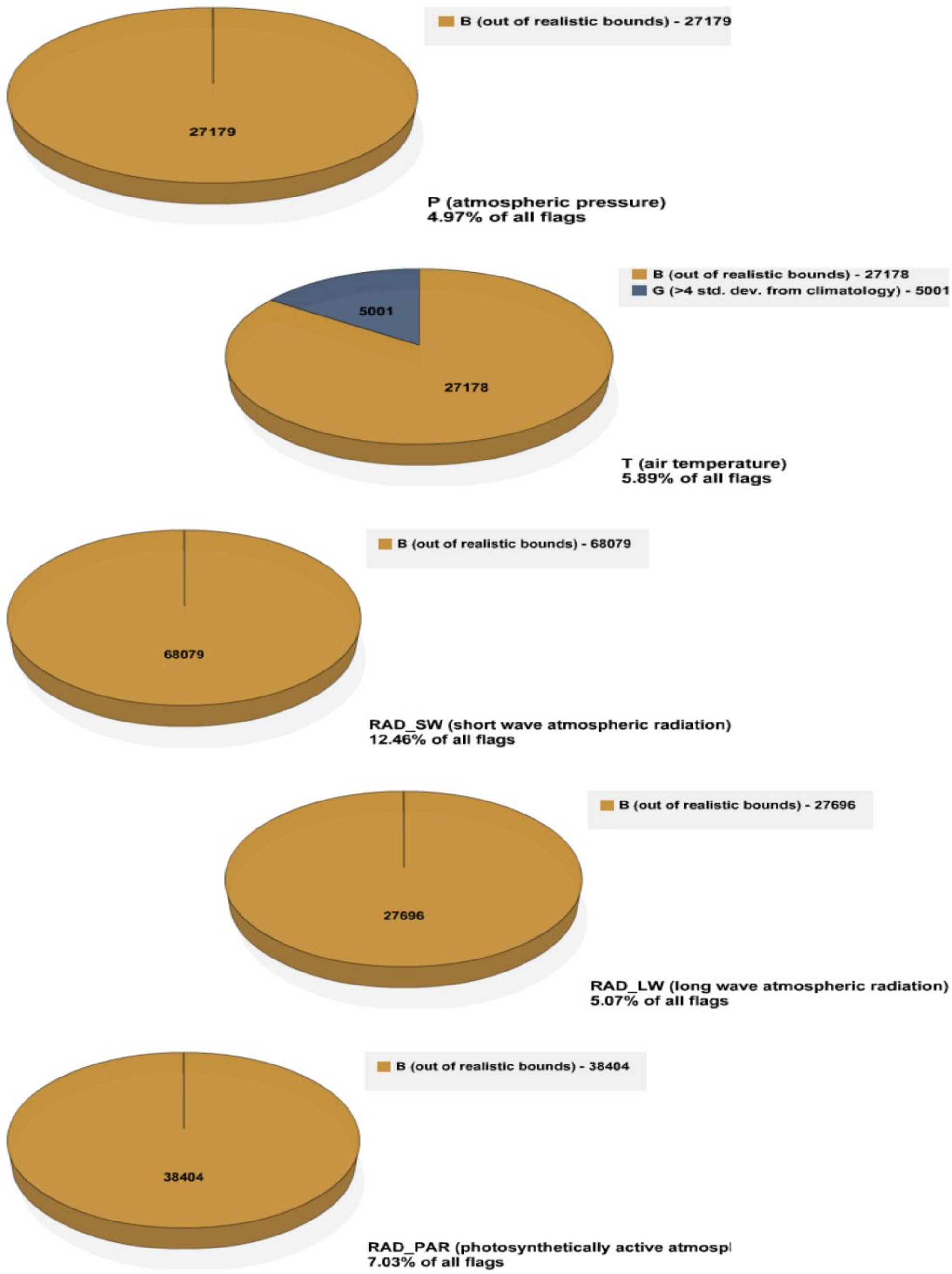


Figure 77: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) short wave atmospheric radiation – RAD_SW – (fourth) long wave atmospheric radiation – RAD_LW – and (last) photosynthetically active atmospheric radiation – RAD_PAR – for the *Sally Ride* in 2020.

Falkor

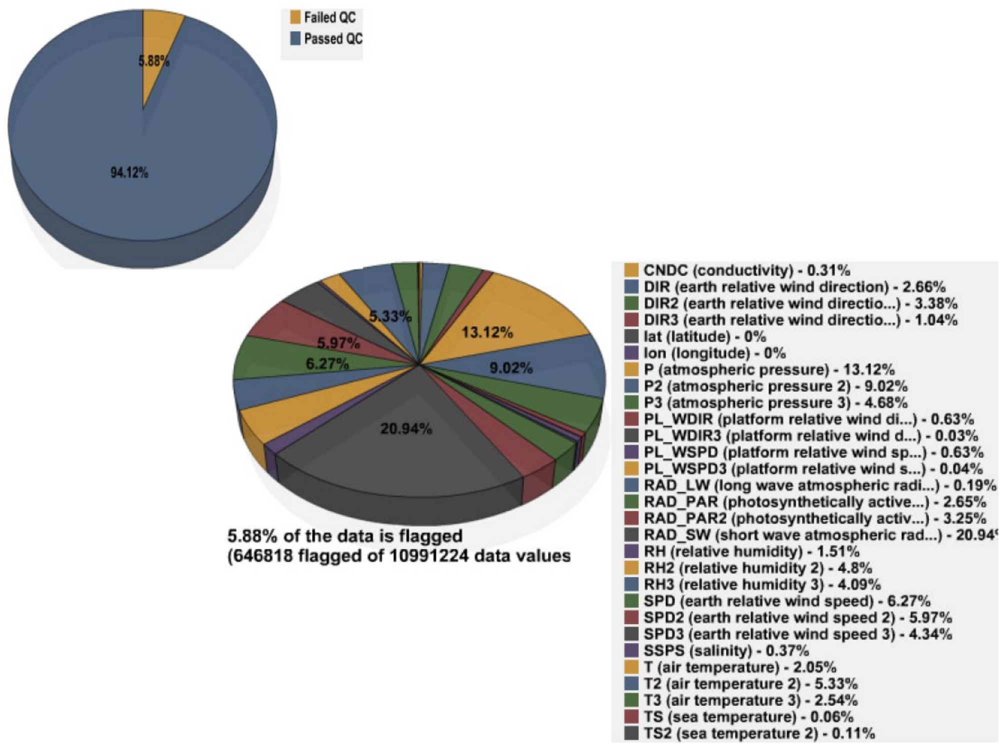


Figure 78: For the *Falkor* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Falkor* provided SAMOS data for 240 ship days, resulting in 10,991,224 distinct data values. After both automated and visual QC, 5.88% of the data were flagged using A-Y flags (Figure 78). This is about two percentage points higher than in 2019 (3.72%) and bumps the *Falkor's* just outside the "under 5% total flagged" bracket regarded by SAMOS to represent "very good" data.

On 14 April Falkor personnel advised they had just removed both of their photosynthetically active atmospheric radiation (RAD_PAR and RAD_PAR2) sensors as well as their long wave (RAD_LW) and short wave (RAD_SW) radiation sensors, owing to extensive corrosion damage. The contact person additionally advised they had just replaced their foremast MetPakPro unit, which had been experiencing wind data outages off and on since the original installation on 15 February, and they had further fitted the new MetPakPro unit with a new hygroclip sensor and new junction box. As the contact noted the wind from the original unit failed around ~0:48 UTC 29 March, any sporadic earth relative wind direction and speed (DIR and SPD, respectively) and platform relative wind direction and speed (PL_WDIR and PL_WSPD, respectively) data that showed up between 29 March and ~5:42 UTC 12 April was assigned "malfunction" (M) flags (Figure 80, not all shown).

On 12 May a SAMOS data quality evaluator (DQE) noted air temperature and relative humidity from the port MetPakPro unit (T2 and RH2, respectively) appeared to be suffering effects of artificial heating during the day. When contacted for details a technician confirmed the issue, stating they had noticed the hygroclip for the port unit had slipped out of its screen and was hanging down unshielded. The technician noted they would not be able to get up the mast to address the problem until they were at anchor on 17 May, which they subsequently did. Meanwhile, between 12 and 17 May, T2 and RH2 each received a fair amount of "caution/suspect" (K) flags (Figure 80).

On 27 May RAD_PAR, RAD_PAR2, RAD_SW, and RAD_LW were all reinstalled and data resumed. However, it was noted by the DQE RAD_PAR2 (the starboard unit) was experiencing issues out of the gate, with nighttime values not reaching anywhere near zero as would be expected and daytime valued seeming very low, especially as compared to the values from the port unit. The DQE informed the vessel of her observations and a technician initially advised they had identified a connector problem with the starboard unit, prompting the application of some "malfunction" (M) flags to RAD_PAR2 (Figure 80). A day later he emailed again to say the problem had been fixed and further advised they had discovered the port sensor had been erroneously plugged into the terminal blocks for the starboard unit and vice versa, such that the calibration coefficients for the two units had been applied backwards. He asserted this cross-wiring had also been fixed. (It is unclear for how long the cross-wiring had been an issue, but possibly as far back as 2019.)

Much later, on 15 October, the DQE noted RAD_PAR2 had begun exhibiting what looked like overly frequent shadowing (see Figure 79). She contacted the vessel and wondered if the unit might be dirty. The following day a technician responded they were stretched a bit thin in terms of staff and they had only been able to give the unit a brief visual check and a water rinse. The RAD_PAR2 data did not improve, however. Additional troubleshooting occurred over the several days, as time allowed, but to no avail. On 20 October the technician expressed their plan to swap both PAR units with a brand-new set, likely sometime in mid-November. On 23 October we were advised a technician had noticed corrosion again at the RAD_PAR2 connector, which he cleaned and resealed, but again there was no improvement to the data. The planned RAD_PAR and RAD_PAR2 sensor swaps were completed around 21 November and afterwards all data appeared good again. In the meantime, between ~15 October and 21 November, RAD_PAR2 received a good deal of K flags (Figure 80).

As a general note, all three of *Falkor's* MetPakPro units (foremast, port main mast, and starboard main mast) are known to get hit with sea spray (the foremast more so than the other two) whenever the vessel is in particularly rough waters, which happens fairly often. Effects from water inundation are 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, DIR2/SPD2/P2/T2/RH2, and DIR3/SPD3/P3/T3/RH3 all receive an appreciable amount of K flagging throughout the year (Figure 80, not all shown). It has been noted these MetPakPro units were not originally designed for offshore installation.

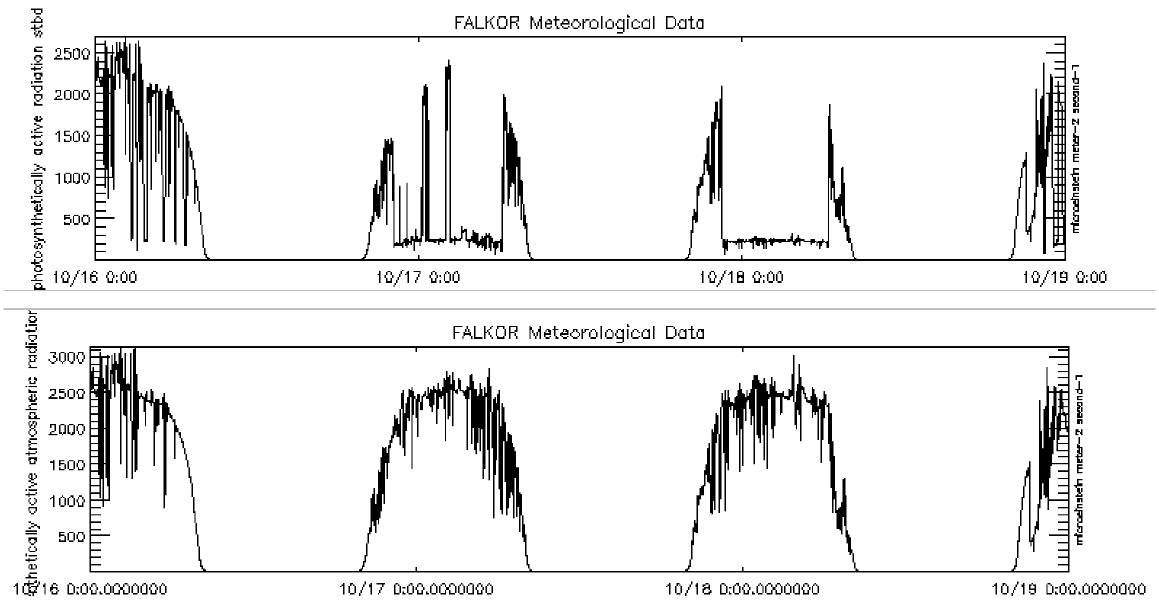


Figure 79: *Falkor SAMOS* (top) photosynthetically active atmospheric radiation – RAD_PAR – and (bottom) photosynthetically active atmospheric radiation 2 – RAD_PAR2 – data for 16-18 October 2020. Note pronounced daytime differences between RAD_PAR and RAD_PAR2 particularly on the 17^{th} and 18^{th}.

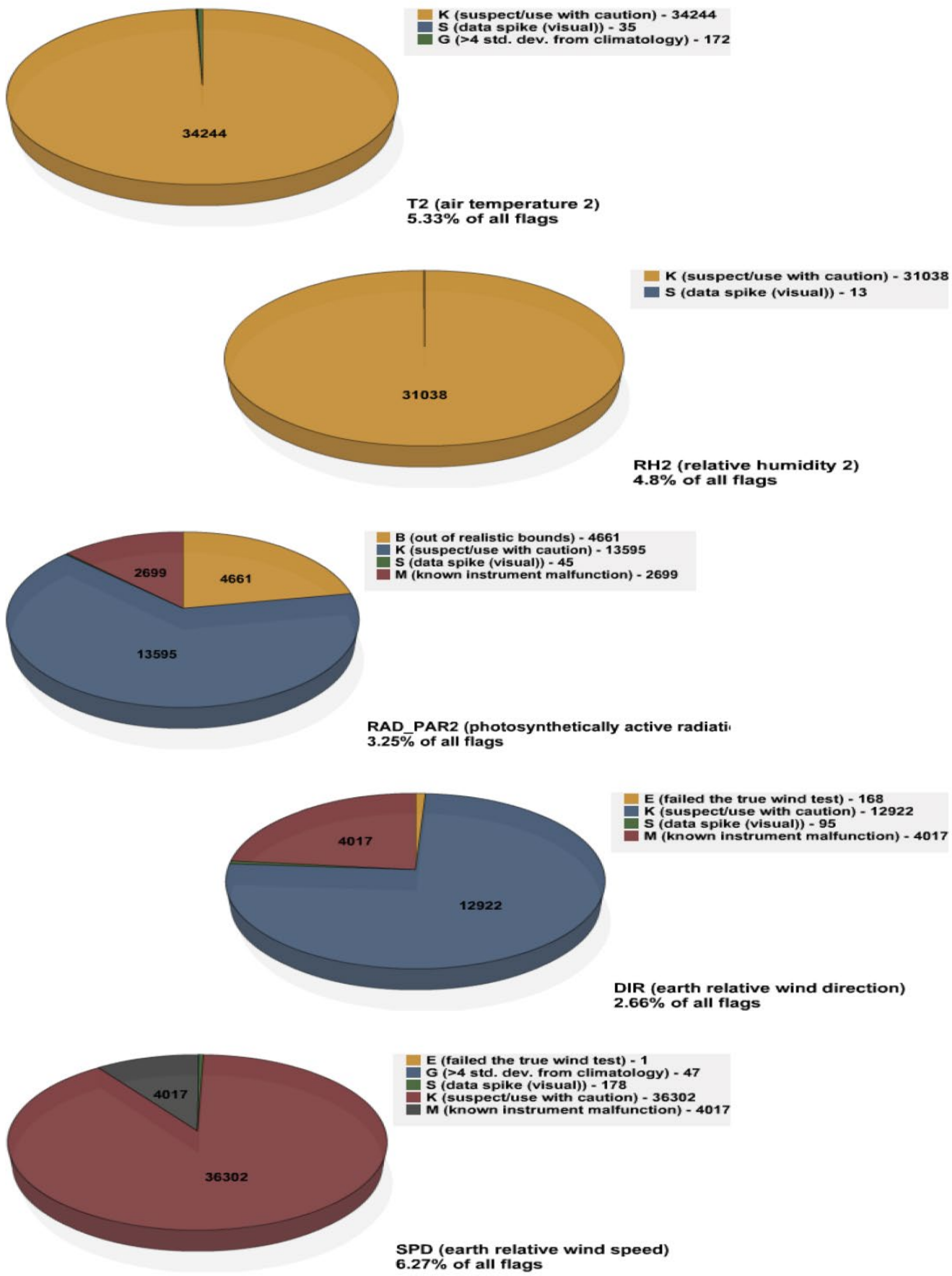


Figure 80: Distribution of SAMOS quality control flags for (first) air temperature 2 – T2 – (second) relative humidity – RH – (third) photosynthetically active atmospheric radiation 2 – RAD_PAR2 – (fourth) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – for the *Falkor* in 2020.

Sikuliaq

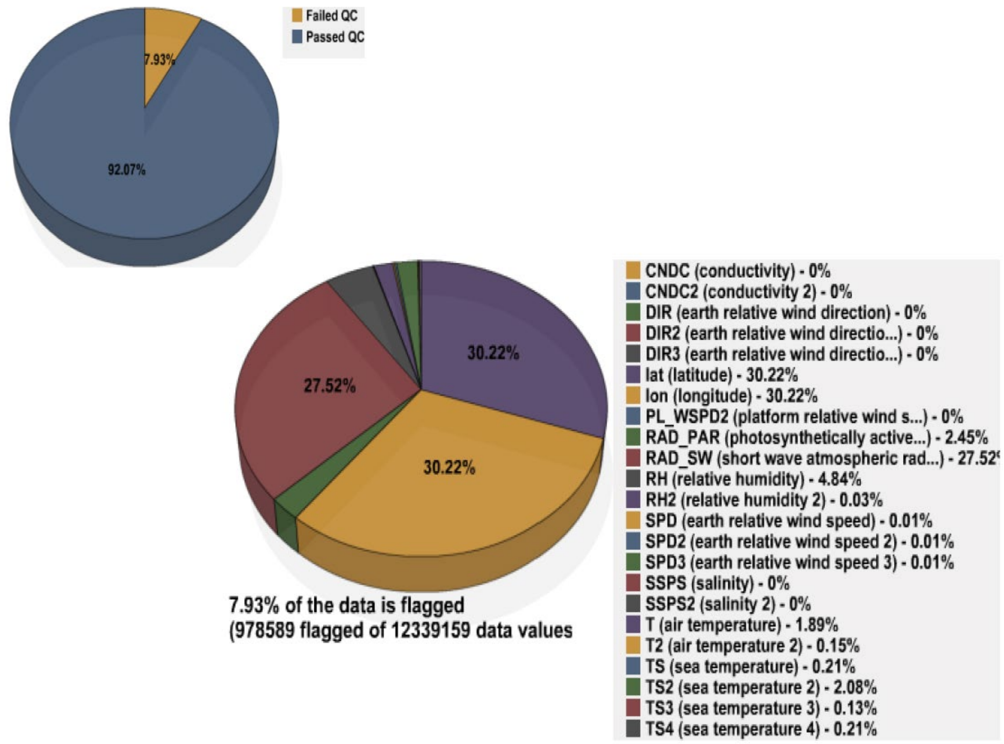


Figure 81: For the *Sikuliaq* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Sikuliaq* provided SAMOS data for 344 ship days, resulting in 12,339,159 distinct data values. After automated QC, 7.93% of the data were flagged using A-Y flags (Figure 81). This is about two percentage points higher than in 2018 (5.66%) and maintains *Sikuliaq* outside the "under 5% total flagged" bracket regarded by SAMOS to represent "very good" data. 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 7 September a SAMOS DQE noted *Sikuliaq's* relative humidity (RH) from their Vaisala PTU was performing more poorly than the relative humidity (RH2) from their Paroscientific instrument, with RH values generally reading higher than RH2 and tending to exceed 100%, which resulted in application of "out of bounds" (B) flags by automated quality control (Figure 82). The DQE contacted the vessel for confirmation and several days later a technician responded in the affirmative. The technician stated they may at some point discontinue the Vaisala, but presently they were running both as the Vaisala was preferred overall for low latitude work. He stressed, though, they would eventually move away from the Vaisala PTU's entirely, since the Paroscientific hygrometer performs much better in high latitude/Arctic conditions. In the meantime, RH data from 31 August through the end of the year should be used with caution.

On 3 November the DQE noted starting around 29 October short wave atmospheric radiation (RAD_SW) values had been reading below -20 W/m^2 and were receiving B flags (Figure 82) via automated quality control. He thought the low readings were possibly an indication of frost/icing on the sensor. The vessel was contacted for confirmation and a technician immediately replied, stating he had been cleaning the radiometers regularly so they would not accumulate frost. The technician advised the units were basically out of calibration and should have been replaced a while ago. He described a plan to replace them with Kipp & Zonnen radiometers, which should do better in polar conditions, in 2021. In the meantime, B-flagging of RAD_SW appears to have continued through 19 November.

Near the end of the season a DQE noted the vessel, while in port, appeared to have briefly turned on their sea water flow through system such that there was a brief transmission of sea temperature (TS), sea temperature 4 (TS4), salinity (SSPS), salinity 2 (SSPS2), conductivity (CNDC), and conductivity 2 (CNDC2) data that did not appear to ever reach equilibrium. As such, these data for 16 December between about 17:30 and 18:00 UTC should not be used.

There are no other issues on record for *Sikuliaq* in 2020. Looking to the flag percentages in Figure 81, more than 60% of the total flags were applied to latitude (LAT) and longitude (LON). These were exclusively "platform position over land" (L) flags (Figure 82) 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. Like many other vessels, in 2020 the *Sikuliaq* spent a lot of time dockside in Alaska, Washington, and Oregon and most of these ports have complex coastlines that are not resolved by our land check test.

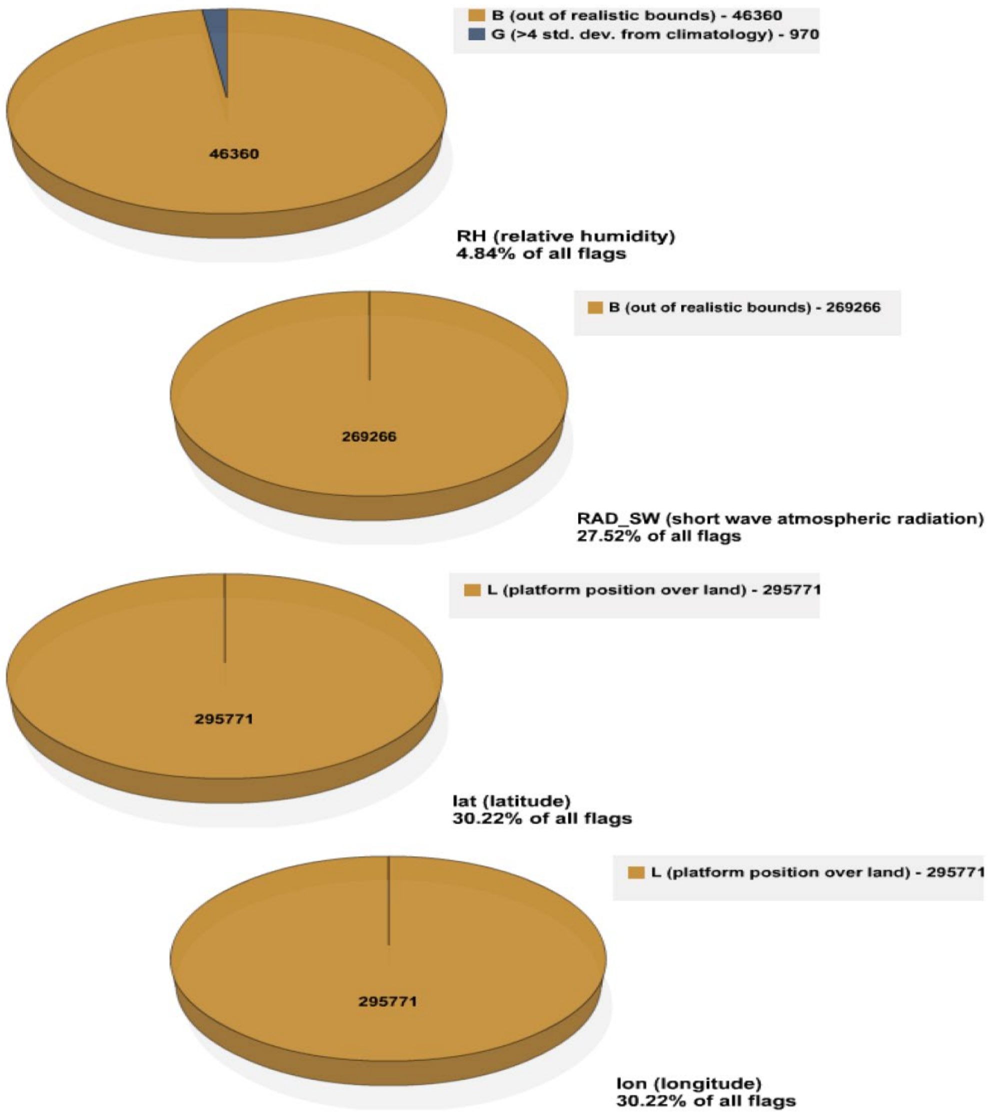


Figure 82: Distribution of SAMOS quality control flags for (first) relative humidity – RH – (second) short wave atmospheric radiation – RAD_SW – (third) latitude – LAT – and (last) longitude – LON – for the *Sikuliaq* in 2020.

Kilo Moana

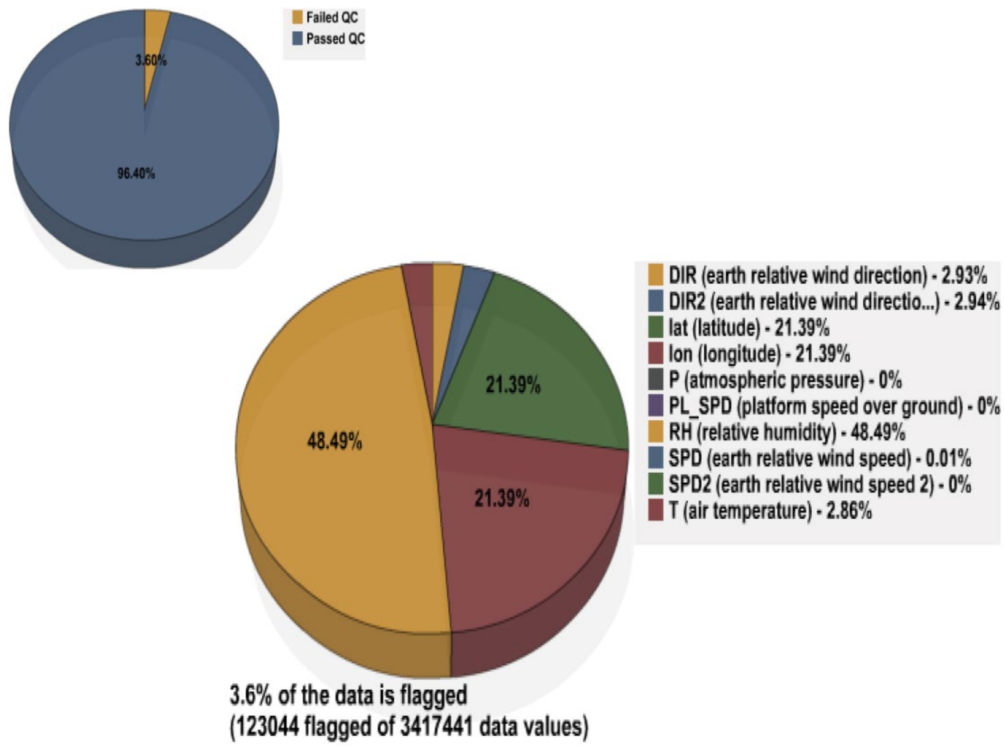


Figure 83: For the *Kilo Moana* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Kilo Moana* provided SAMOS data for 129 ship days, resulting in 3,417,441 distinct data values. After automated QC, 3.6% of the data were flagged using A-Y flags (Figure 83). This is about two percentage points higher than in 2019 (1.32%) and maintains *Kilo Moana's* standing 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*).

On 6 July a SAMOS data quality evaluator (DQE) observed *Kilo Moana's* relative humidity (RH) had been as of three days earlier ranging only from 30-38%. Suspecting the sensor was likely out of calibration, the DQE contacted the vessel to confirm. A vessel operator replied the next day and advised the sensor was damaged in the shipyard, but he thought technicians had addressed it. He stated he would follow up, which he did on 5 August. At that time, the operator informed he had changed the sensor but found the issue was actually likely with the acquisition module instead. Because of COVID-19 restrictions, however, technicians were unable to address the faulty equipment at that time. On 8 September the decision was made to halt RH SAMOS processing until such time the problem was solved. Meanwhile, RH received a sizable volume of “greater than four standard deviations from climatological mean” (G) flags via automated quality control (Figure 84). To date the RH sensor problem has not been resolved.

In general, it has been noted *Kilo Moana's* thermometer is subject to artificial heating from stack exhaust when the relative wind is at ~160 degrees. Air temperature (T) increases by 2-4 degrees C when affected.

Looking to the flag percentages in Figure 83, over 40% of the total flags applied were assigned to latitude (LAT), longitude (LON). These were almost exclusively "platform position over land" (L) flags in the case of LAT and LON (Figure 84) 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. Like many other vessels, in 2020 the *Kilo Moana* spent a lot of time dockside in Honolulu, HI, a port with complex coastlines that are not resolved by our land check test.

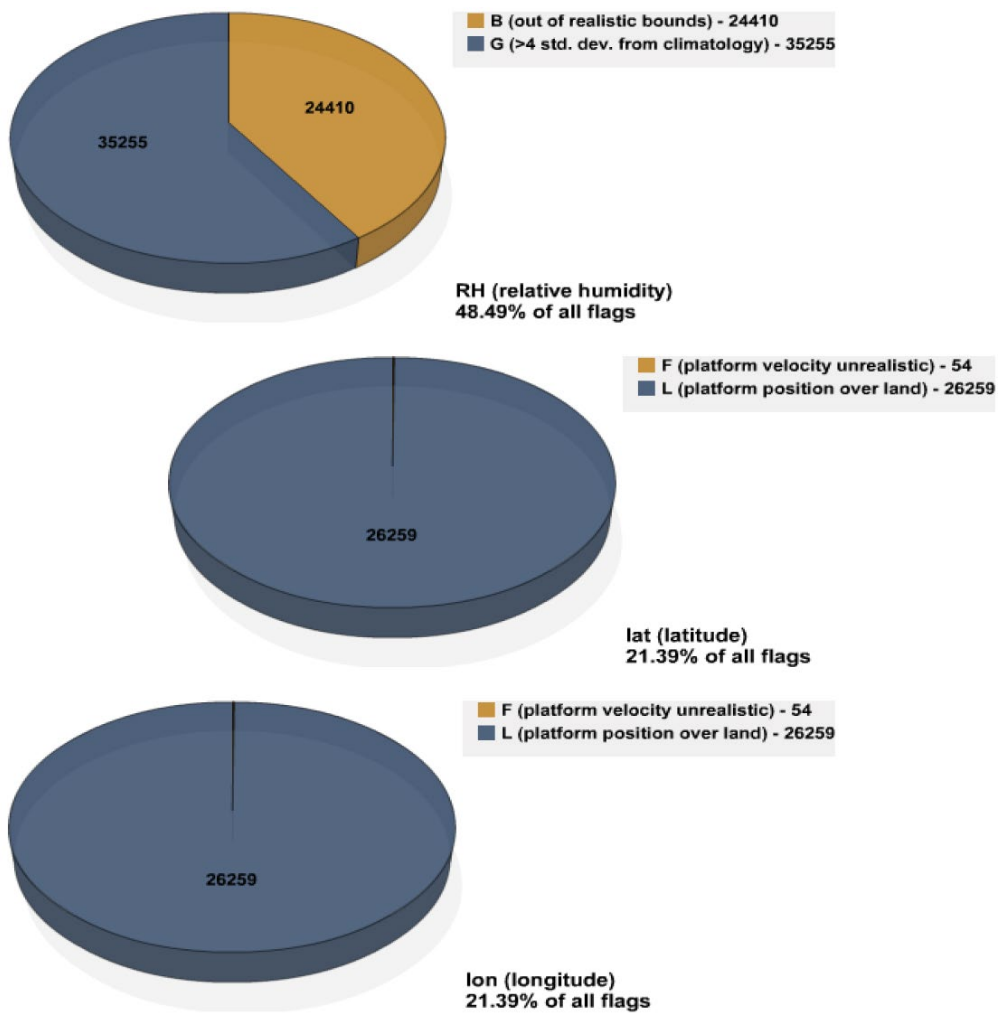
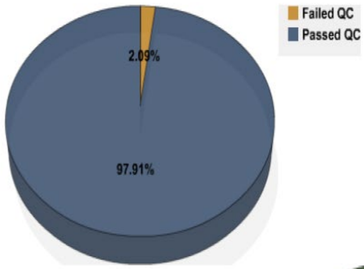


Figure 84: Distribution of SAMOS quality control flags for (top) relative humidity – RH – (middle) latitude – LAT – and (bottom) longitude – LON – for the *Kilo Moana* in 2020.

Thomas G. Thompson



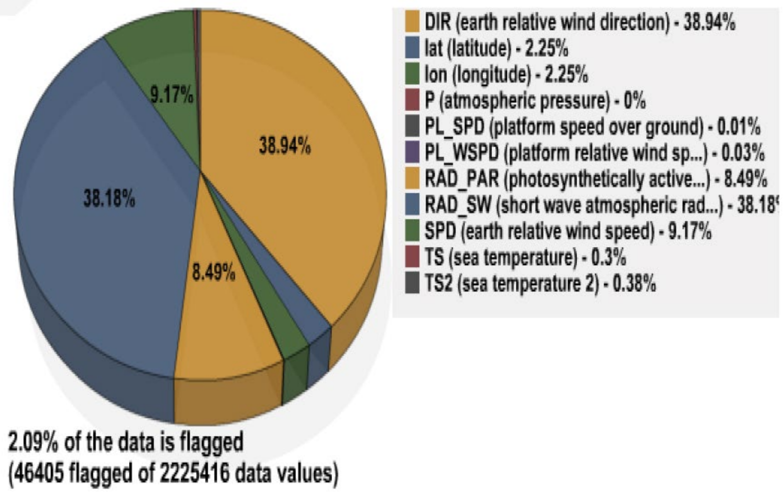


Figure 85: For the *Thomas G. Thompson* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Thomas G. Thompson* provided SAMOS data for 86 ship days, resulting in 2,225,416 distinct data values. After automated QC, 2.09% of the data were flagged using A-Y flags (Figure 85). This is about three percentage points lower than in 2019 (5.32%) and brings *Thompson* well 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*).

There are no specific issues on record for *Thomas G. Thompson* in 2020. Looking to the flag percentages in Figure 82, almost 39% of the total flags were applied to earth relative wind direction (DIR). These are exclusively "failed the true wind" test (E) flags (Figure 86), which may be indicative of the *Thompson* 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. A further ~38% of the total flags were applied to short wave atmospheric radiation (RAD_SW). Upon inspection the flags, which are unanimously B flags (Figure 86), appear to have been applied mainly to negative values that can occur with these sensors at night (often a consequence of instrument tuning, see 3b.)

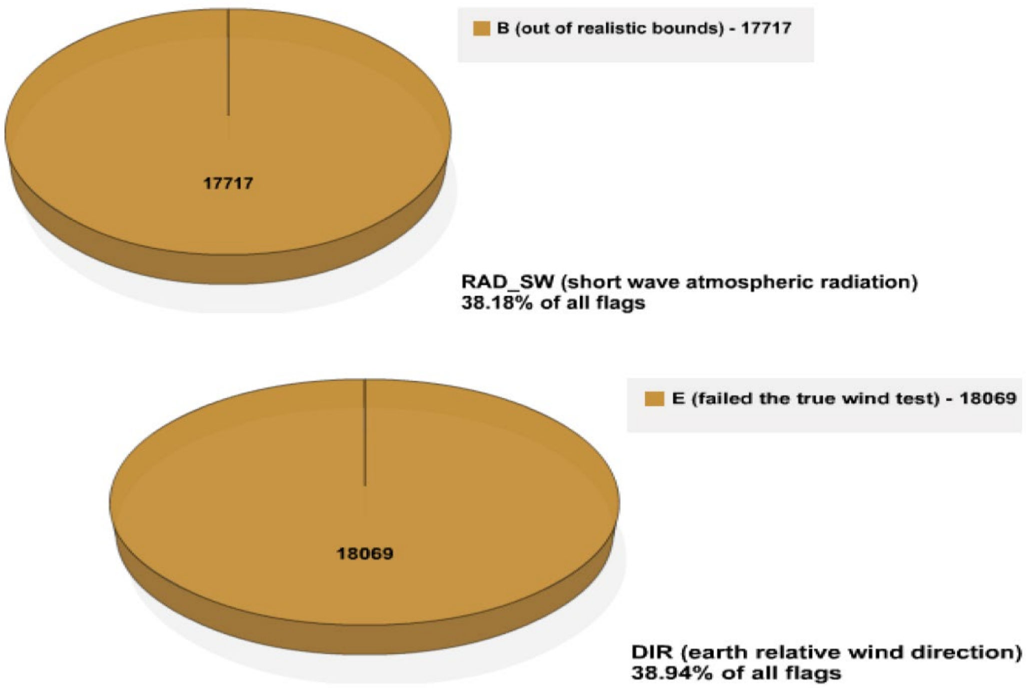


Figure 86: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – and (bottom) earth relative wind direction – DIR – for the *Thomas G. Thompson* in 2020.

Healy

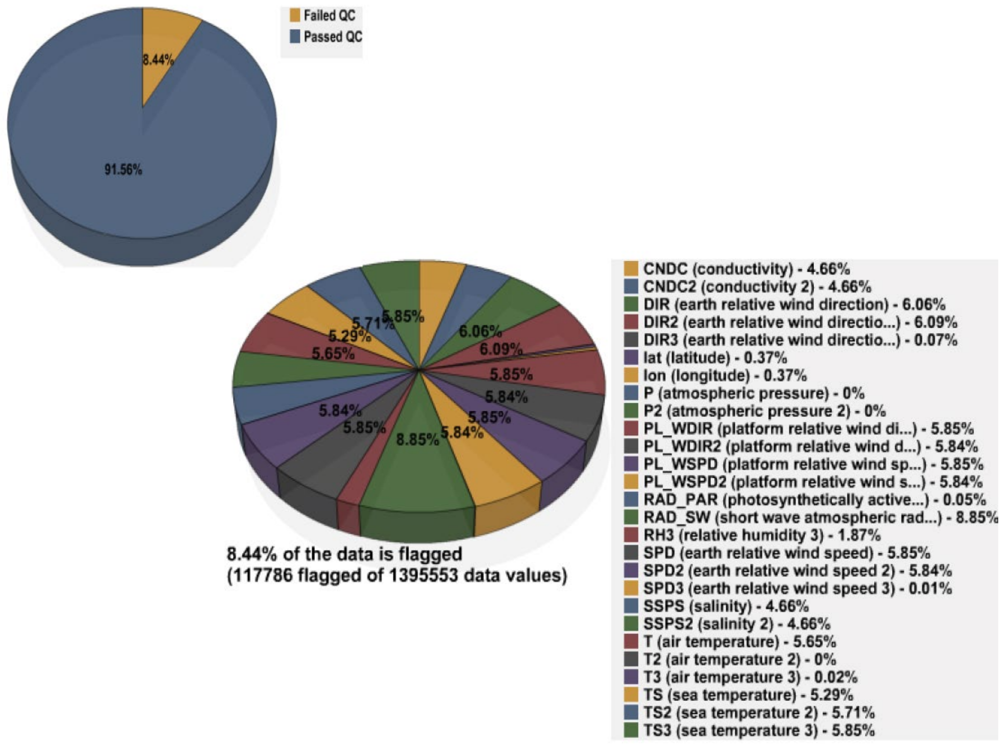


Figure 87: For the *Healy* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Healy* provided SAMOS data for 35 ship days, resulting in 1,395,553 distinct data values. After automated QC, 8.44% of the data were flagged using A-Y flags (Figure 87). This is about three percentage points higher than in 2018 (5.88%). 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 22 June a SAMOS data quality evaluator (DQE) observed most of Healy's meteorological (MET) parameters had flat lined at a constant value from about 22:00 UTC 20 June to 2:00 UTC 21 June. The DQE suspected the data logging system was off during this period, perhaps due to an EEZ issue, and he contacted the vessel to confirm. A vessel contact replied immediately that, yes, they had crossed into an EEZ around 19:00 UTC 19 June and all logging had been stopped. He stated he had restored MET without recording later that day, leading to the flat lined values for most *Healy* parameters. In this same email conversation, the DQE noted from 00:00 to 22:00 UTC 19 June Healy's relative humidity (RH) had read 100% while the air temperature (T) was at or below freezing. He suspected some type of freezing fog condition and wondered if the 100% readings were indicative of the sensor icing up. The vessel contact confirmed they had indeed been in foggy, freezing conditions at the time.

On 6 July a DQE noted the relative humidity 3 (RH3) data were all either above 100% or near zero all day, even while the associated air temperature 3 (T3) looked reasonable.

When emailed for details, a vessel contact replied, acknowledging the problem and stating a plan to explore a solution during sea trials. Any RH3 data on 6 July that were above 100% were assigned “out of bounds” (B) flags via automated quality control while those that were near 0% were assigned “greater than four standard deviations from climatological mean” (G) flags (Figure 88). Also on 6 July (and communicated in the email) the DQE observed the earth relative wind speed (SPD) and platform speed (PL_SPD) both featured some data values of -99.0, which he expected were likely “missing” fill values. The vessel contact confirmed these -99.0 values indicated bad or no data and stated he would plan on changing them to NaNs in the future, since SAMOS processing does not distinguish -99.0 values as “missing”, but as of May 2020 can correctly set NaN values to missing.

There are no other specific issues on record for *Healy* in 2020. Looking to the flag percentages in Figure 87, there are no real standouts among the various parameters, suggesting no other unique problems. As a general note, it is known that *Healy's* sensors are frequently affected by airflow being deflected over and around her super structure.

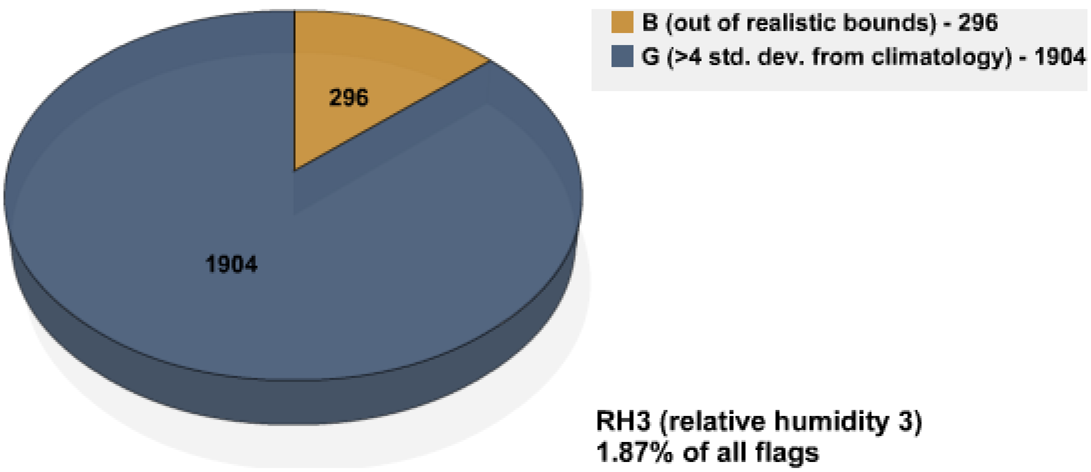


Figure 88: Distribution of SAMOS quality control flags for relative humidity 3 – RH3 – for the *Healy* in 2020.

R/V Atlantis

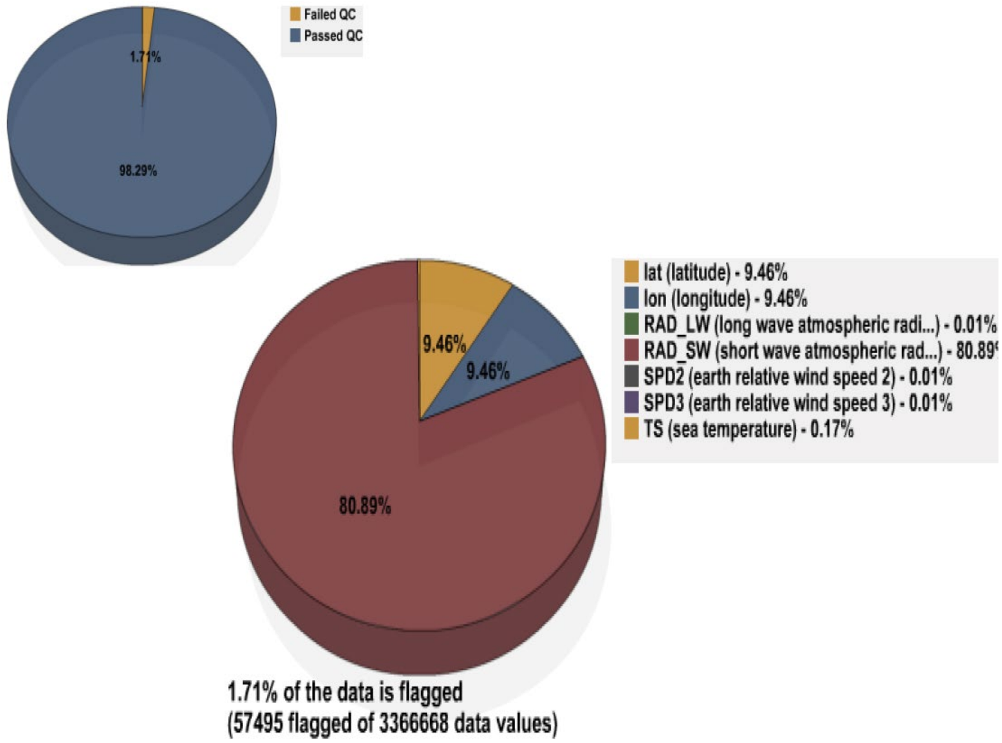


Figure 89: For the *R/V Atlantis* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *R/V Atlantis* provided SAMOS data for 82 ship days, resulting in 3,366,668 distinct data values. After automated QC, 1.71% of the data were flagged using A-Y flags (Figure 89). This is about a half percentage point lower than in 2019 (2.29%) 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. It is worth noting the low number of ship days for the *Atlantis* are in part because she entered mid-life refit in late March 2020.

There were no specific issues noted in 2020 for the *Atlantis*. Looking to the flag percentages in Figure 89, the overwhelming majority of all flags applied were assigned to short wave atmospheric radiation (RAD_SW). These were exclusively "out of bounds" (B) flags (Figure 90) 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.)

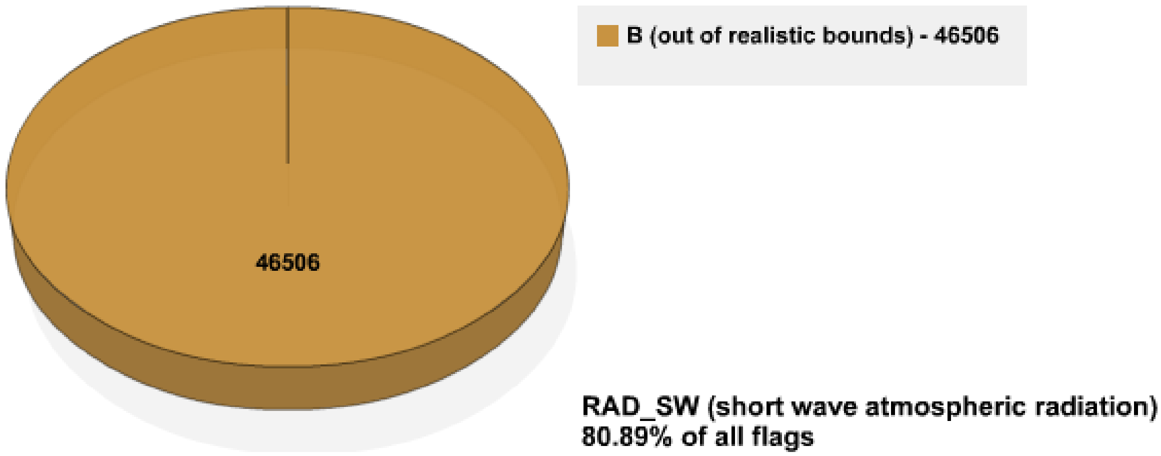


Figure 90: Distribution of SAMOS quality control flags for short wave atmospheric radiation – RAD_SW – for the *R/V Atlantis* in 2020.

R/V Neil Armstrong

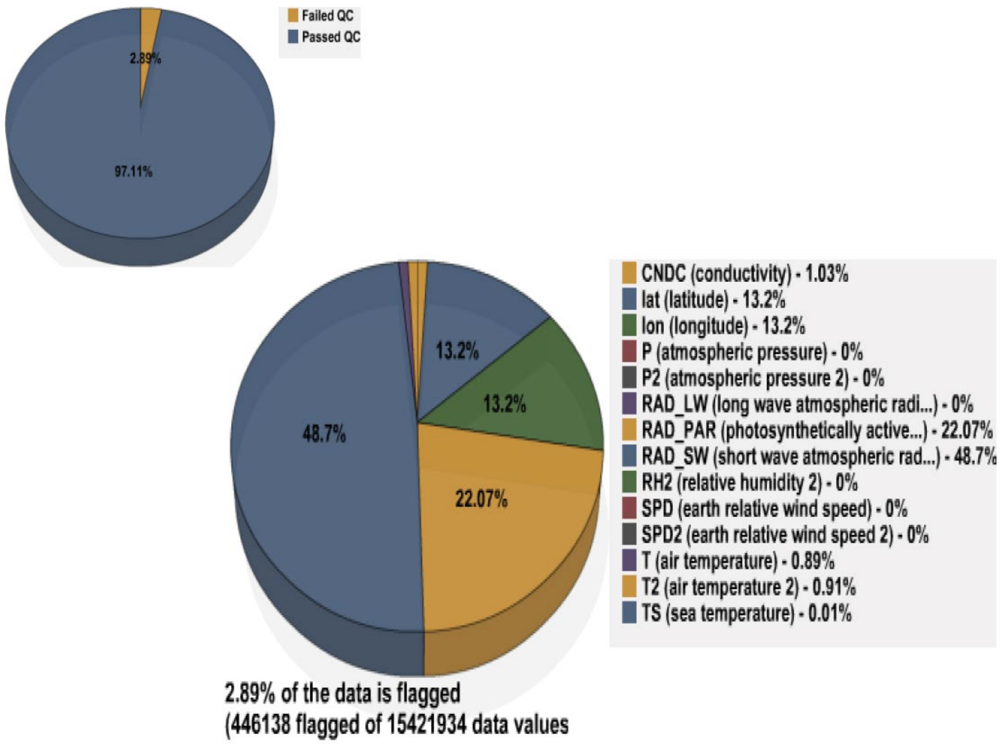


Figure 91: For the *R/V Neil Armstrong* from 1/1/20 through 12/31/20, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *R/V Neil Armstrong* provided SAMOS data for 362 ship days, resulting in 15,421,934 distinct data values. After automated QC, 2.89% of the data were flagged using A-Y flags (Figure 91). This is a little less than a percentage point higher than in 2019 (2.16%) 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*).

There were no specific issues noted in 2020 for the *Neil Armstrong*. Looking to the flag percentages in Figure 91, about 70% 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 92) 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.) A further ~13% of the total flags were applied to each of latitude (LAT) and longitude (LON). These were exclusively "platform position over land" (L) flags (Figure 92) that appear generally to have been applied when the vessel was in port. 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. It is known *Neil Armstrong* spent much of 2020 transmitting from the dock, owing to COVID-19 restrictions.

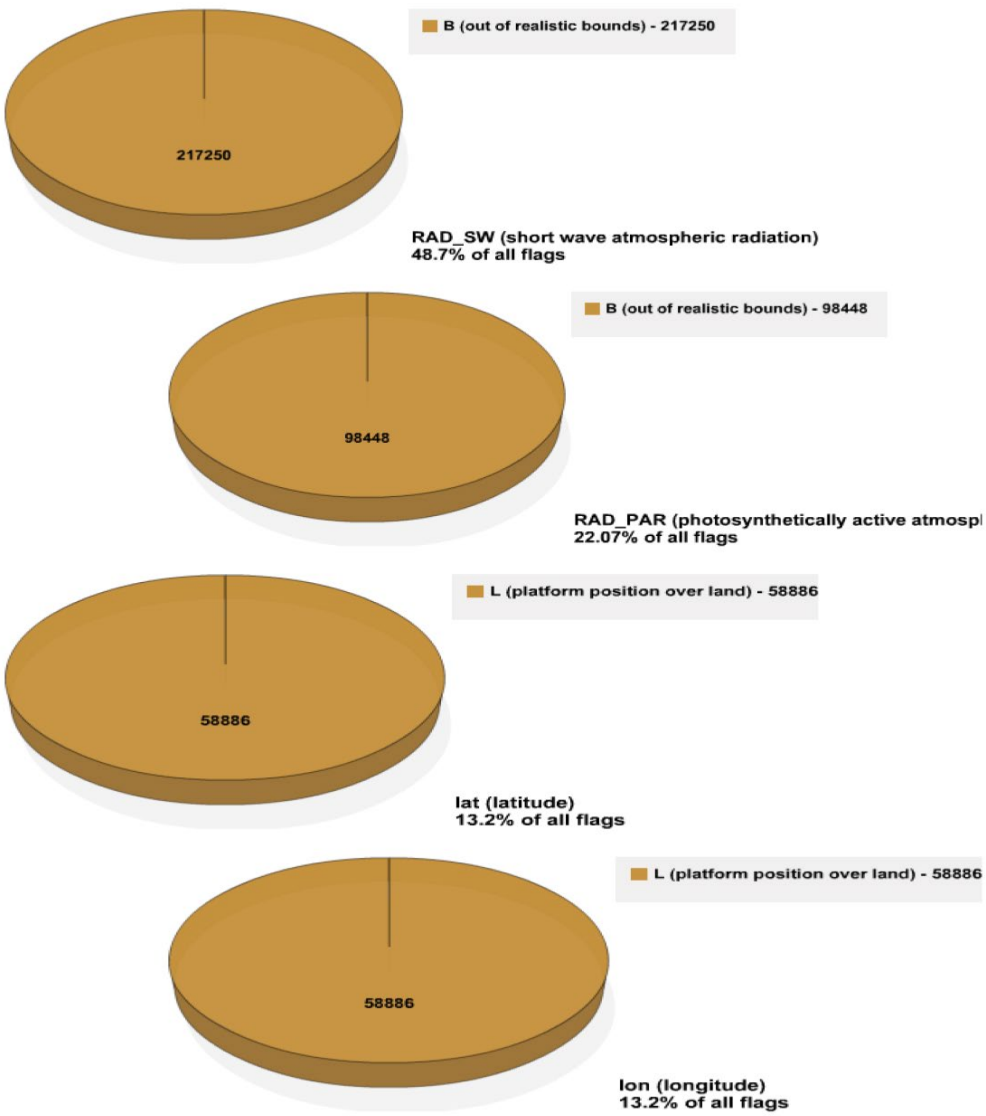


Figure 92: Distribution of SAMOS quality control flags for (first) short wave atmospheric radiation – RAD_SW – (second) photosynthetically active radiation – RAD_PAR – (third) latitude – LAT – and (last) longitude – LON – for the *R/V Neil Armstrong* in 2020.

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 93 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 94. (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 94 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.

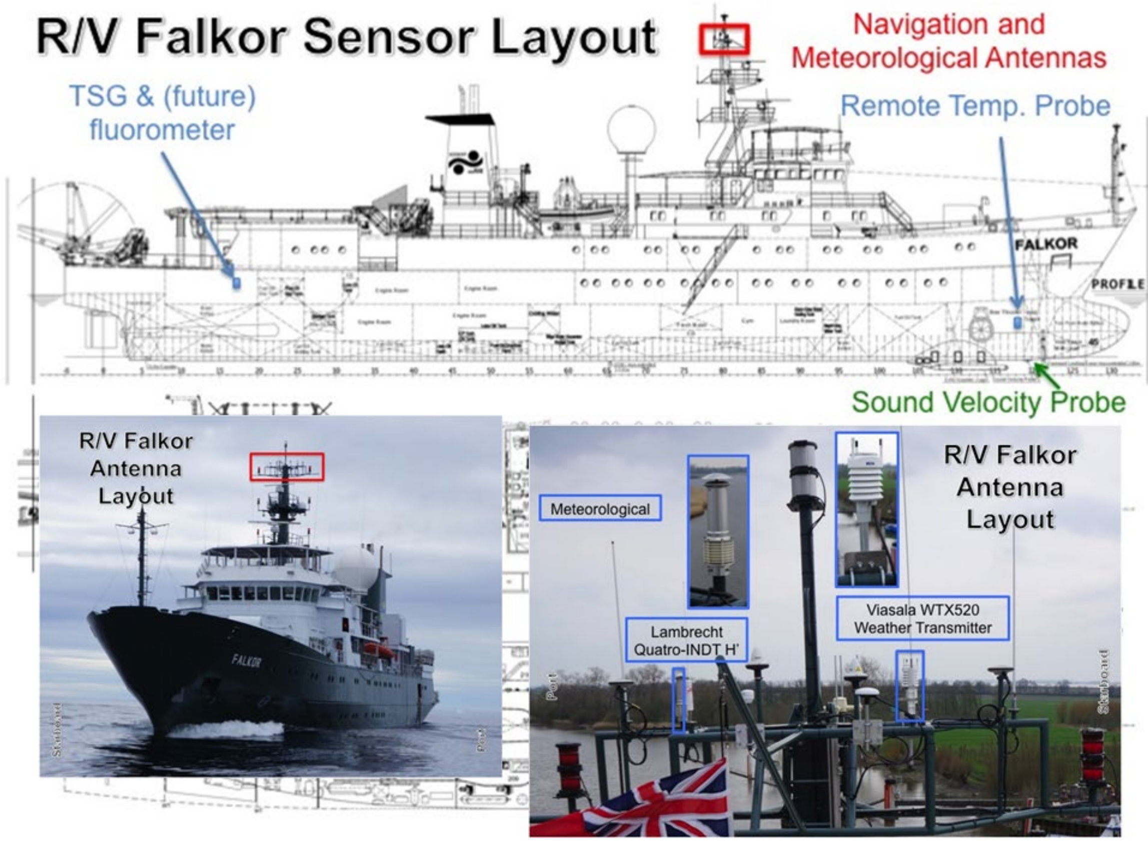


Figure 93: Examples of detailed vessel instrument imagery from the *R/V Falkor*.

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 94: 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	No	C	C	C	C	C	C,C	C,C	C,C
KAQP	C	C	C	Yes	I	I	I	I	I	C	I	I
KTDQ	C	C	C	Yes	I	I	I	I	I	I,I	I	I
NEPP	C	C	C	Yes	I	I	I	I	I	I,I,I	I,I	I,I
NRUO	C	I	I	No	I	I	I	I,I	I,I	I,I		I
VLMJ	C	C	I	No	I	I	I	I	I	I,I		I
VNAA	C	C	C	No	I	I	I,I	I	I	I		
WARL	C	C	I	Yes	I	I	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
WDC9417	C	C	C	Yes	C	C	C	C	I	I,C,C,I	C,I	C,I
WDD6114	C	C	I	Yes	I	I	I	I	I	I	I	I
WDG7520	C	C	C	Yes	I	I	I,I,I	I	I,I,I	I,C,I,I	I,I	I,I
WSAF	C	C	I	Yes	I	I	I	I	I	I,I	I,I	I,I
WSQ2674	C	C	I	Yes	I	I	I	I	I	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	C,C	C	C
WTDL	C	I	C	Yes	I	I	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
WTEB	I	I	C	No	I	I	I	I	I	I	I	I
WTEC	C	C	C	Yes	I	I	I	I	I	I,C	C	C
WTED	C	C	C	Yes	I	I	I	I	I	I	I	I
WTEE	C	C	C	No	I	I	I	I	I	I	I	I
WTEF	I	I	C	No	I	I	I	I	I	I	I	I
WTEG	C	C	C	Yes	C	C	I	C	C	I,I	I	I
WTEK	I	I	C	No	I	I	I	I	I			
WTEO	C	I	C	Yes	I	I	I	I	I	I	I	I
WTEP	C	C	C	Yes	I	I	C	I	I,I	C,C,I,I,I	C	C
WTER	C	I	I	Yes	I	I	I	I	I	I,I	I	I
ZCYL5	C	C	C	Yes	C	C	C	C	C	I,I	I	I
ZMFR	C	I	C	No	I	I	I	I	I	I		

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.

	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,C	C,C	C,C	I,C,C	I	I		
KTDQ	C	C	C	C	C			I	I			I	I		I
NEPP	I,I,I	I,I,I	C,I,I	C,I,I	I,I,I			I,I	I			I	I		I
NRUO	I,I	I,I	I,I	I,I	I			I	I						
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
VNAA	I,I	I,I	I,I	I,I	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			
WDC9417	I,I	I,I	I,I	I,I	I			I,C	I	C		I	I		I
WDD6114	I	I	I	I	I			I	I						
WDG7520	C,I,I	C,I,I	C,I,I	C,I,I	C,I			C,I	C,I			C	C		C
WSAF	I	I	I	I	I,I,I			I,I	I,I	I		I	I		I
WSQ2674	I	I	I	I	I,I			I,I	I	I		I	I		I
WTDF	I,I,I	I,I,I	I,I,I	I,I,I	I			I	I			I	I		
WTDH	C	C	C	C	C	C	C	C,C	C						
WTDL	I,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						
WTEB	I	I	I	I	I			I	I						
WTEC	C,I,I	I,I,I	C,I,I	I,C,I	C			C,C	C			C	C		
WTED	I,I	I,I	I,I	I,I	I			I	I			I	I		
WTEE	I	I	I	I	I			I	I						
WTEF					I			I	I						
WTEG	C,C	I,I	C,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						
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
ZMFR			C	C	C			C	C	I		I,I	I,I		

(Table 4: cont'd)

5. Plans for 2021

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. Throughout the crazy year that was 2020, you all continued to strive 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. During 2020, 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, so we will be incorporating the OSU XML into our metadata updating software as well.

The primary challenge that faced SAMOS and the RV community in 2020 was the COVID-19 pandemic. This global event resulted in the lay-up of most of the U.S. and international RV fleets, particularly from April-July 2020. As a result, the underlying supply of "at sea" SAMOS observations was severely curtailed in 2020. A significant portion of the observations received were "in port" data, which do have some practical application for the meteorological community.

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

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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 (*Aurora Australis*, *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:

- 16:34 UTC 28 October – 12:01 UTC 29 October: sea water system off, TS, TS2, SSPS, SSPS2, CNDC, CNDC2 should not be used.

Atlantis: no notes. Presently in mid-life refit.

Healy:

- ~22:00 UTC 20 June – 2:00 UTC 21 June: logging system off and most MET data flat lined at a constant value, do not use.
- ~14:30 UTC 6 July: -99.0 values appear in SPD and PL_SPD, vessel's "missing or bad" fill value, do not use.

Investigator:

- 24 March 2016 - 24 August 2020: PL_SPD, PL_WSPD, PL_WSPD2, SPD, SPD2 all subjected to erroneous kt to m/s units conversion (original data units were actually m/s)

Kilo Moana: 3 July 2020 – termination of processing in 2020: RH sensor providing unrealistically high (>140%) values. All RH data in this period are erroneous and should not be used.

Laurence M. Gould:

- Inception date indeterminate – 17 December 22:30 UTC: meteorology data instrumentation cleaned on 17 December, T and RH between ~20:30 and 22:30 UTC on 17 December should not be used, T and RH prior to 20:30 on 17 December should be considered suspect.
- 27 December – (early 2021): temp/humidity probe slipped out of its housing ~ 1:15 UTC 27 December, T and RH should be considered suspect/bad.

Nathaniel B. Palmer:

- 11 December – end date unknown (likely to in port period at end of 2020): seawater flow-through system shut down and all sea water data logging stopped at 1905 UTC on 11 December, TS, SSPS, and CNDC should not be used.

Neil Armstrong:

- 8 July 2020, ~1230-1550 UTC: Met mast lowered to repair ice light, so all MET data should be treated as unrepresentative and not used.
- 28 July – 2 August: Met mast lowered for maintenance, so in port MET data for this period should not be used.
- 5-9 September: Met mast lowered for maintenance, so in port MET data for this period should not be used.

Robert Gordon Sproul:

- 14 December - ~16:00 UTC 15 December: sea water system assumed off, TS2, SSPS, CNDC data should not be used.
- ~21:00 UTC 15 December - end date unknown: sea water system assumed off, TS2, SSPS, CNDC data should not be used.

Roger Revelle:

- 13 - 18 November: intake pump off (ship in EEZ without clearance), TS, SSPS, CNDC should not be used.
- 5:00-11:30 UTC 16 December: intake pump likely off, TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.
- 7 - 9 December: intake pump suspected off, TS, TS2, SSPS, SSPS2, CNDC, CNDC2 should be considered suspect.

Sally Ride:

- 2 - 7 August: j-box for met system down, P, P2, T, T2, RH, RAD_SW, RAD_LW, RAD_PAR data should not be used.
- 12 October - end date unknown: bow intake sea water pump off due to high seas, TS, SSPS, CNDC data should not be used.
- 7 December - end date unknown: bow intake and main lab sea water systems suspected off, TS, TS2, SSPS, SSPS2, CNDC, CNDC2 data should not be used.
- 29 - 30 December: RAD_PAR upper values out of range, suspected sensor drifting off calibration, data should be considered suspect.

Sikuliaq:

- 31 August - end of 2021: RH performance suspect, use with caution.
- 29 October – end of 2020 (ongoing): RAD_SW looks to have drifted off calibration (very low negative nocturnal values), use with caution.
- ~17:30-18:00 UTC 16 December: quick cycling of flowthrough system suspected, TS, TS4, SSPS, SSPS2, CNDC, CNDC2 should not be used.

Tangaroa:

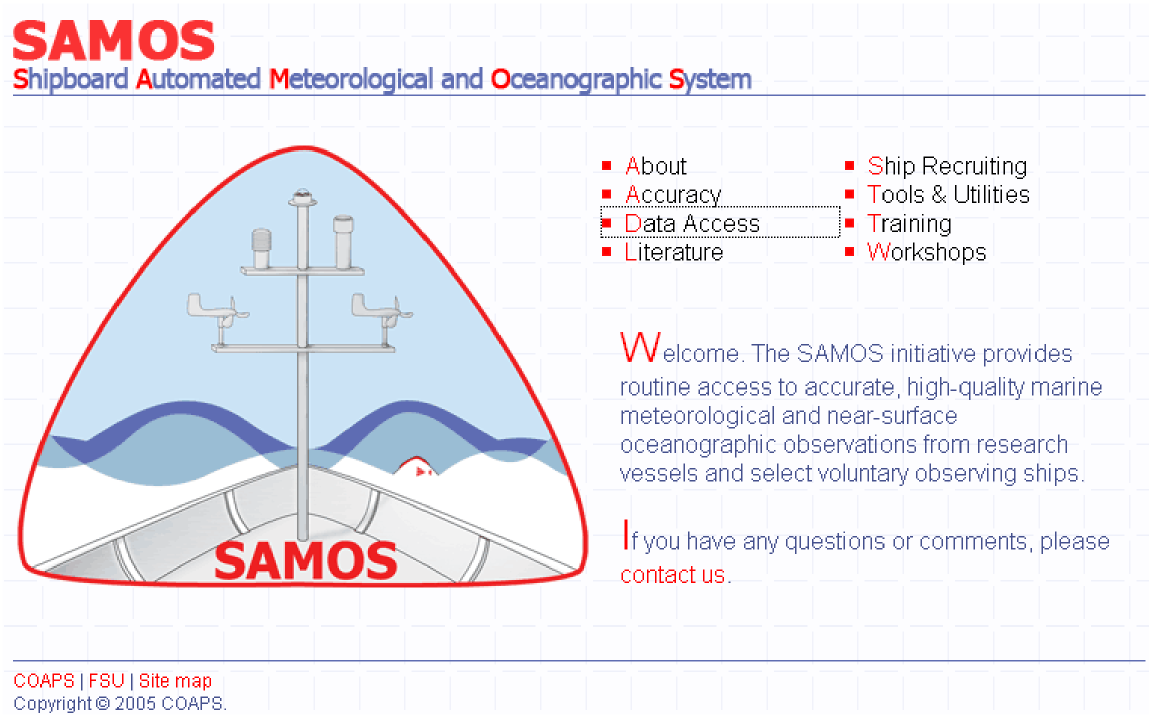
- 31 August (~12:00 UTC) - end date unknown, but possibly late September when returned to port: TS bad (flow pump off), data should not be used.

T.G. Thompson: no notes.

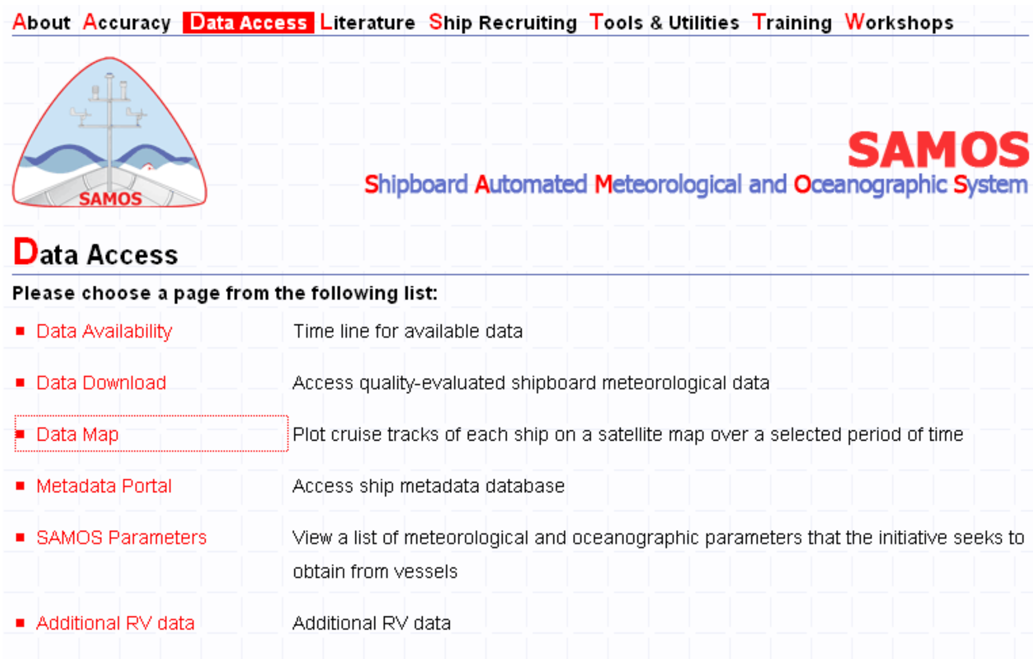
Annex B: SAMOS Online Metadata System Walk-through Tutorial

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:



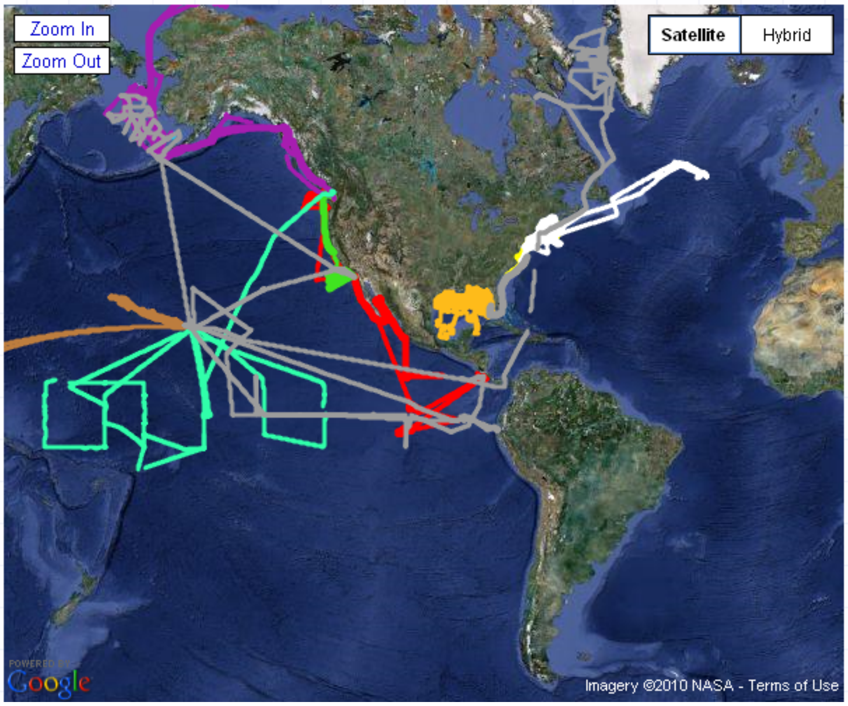
The user highlights a set of ships from the available list (10 ships may be chosen at a time):

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:

Metadata Portal

HEALY

Expand each of the ship's variables for a detailed view

[Show All] [Hide All]

Order: [Alphabetically] [netCDF order]

Download PDF

- time
- latitude
- longitude
- platform heading
- platform heading 2
- platform course
- earth relative wind direction
- earth relative wind direction 2
- platform relative wind direction
- platform relative wind direction 2
- platform speed over ground
- platform speed over water
- platform speed over water 2
- earth relative wind speed
- earth relative wind speed 2

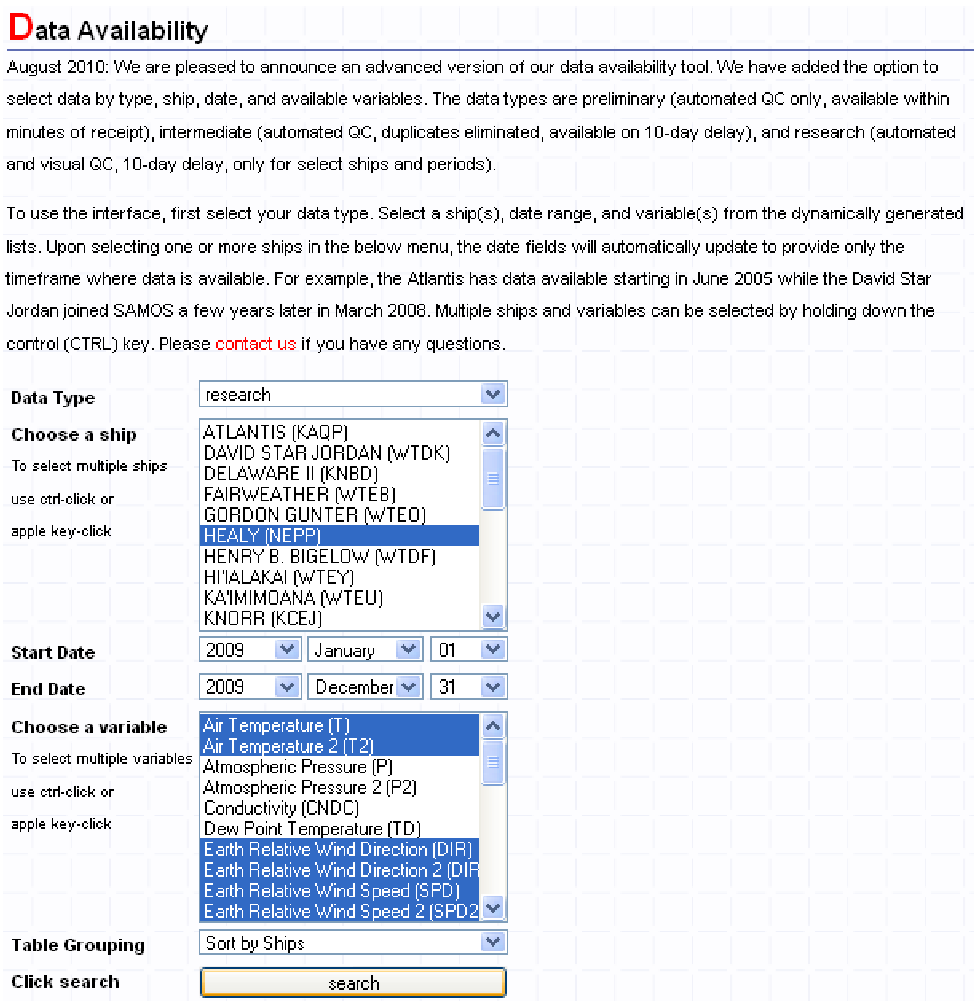
A thorough investigation of the list (note: image is truncated) tells the user the *Healy* did in fact provide both wind and temperature data in 2009. (Throughout the online SAMOS system, clicking on a "+" will yield further information; in this case the result would be metadata for the individual parameters.) 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:

Data Access

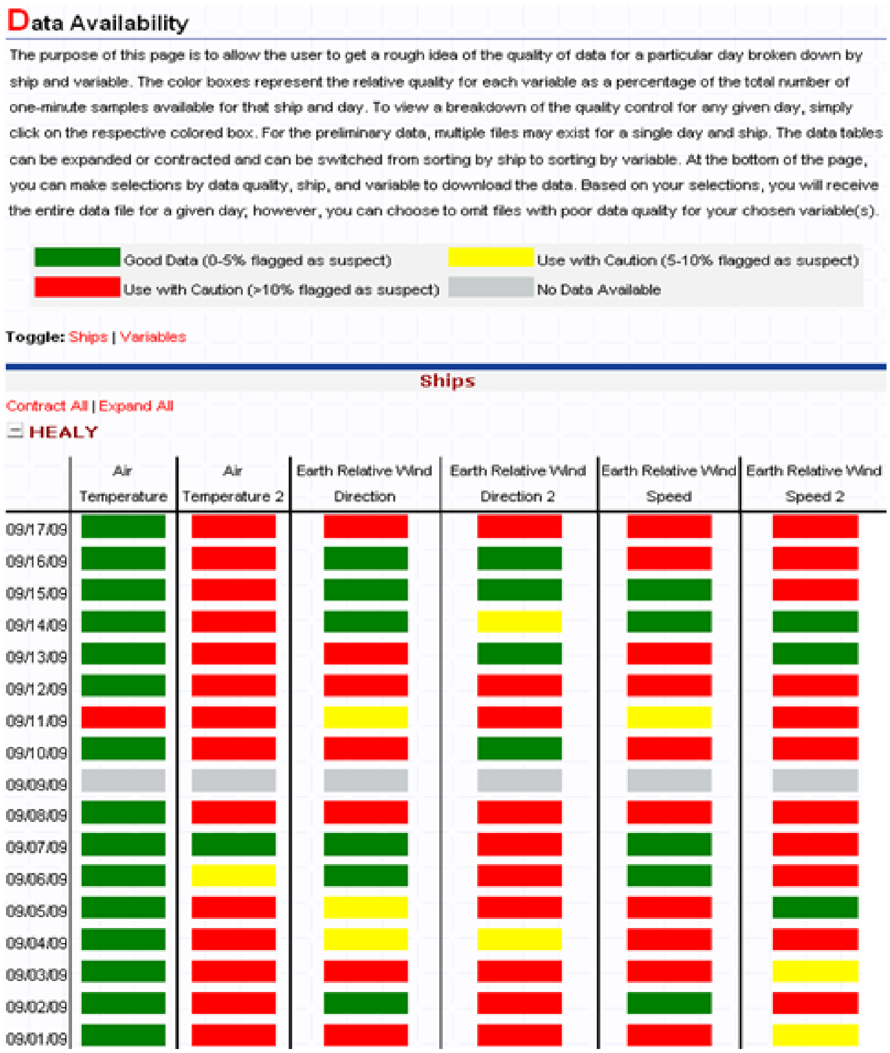
Please choose a page from the following list:

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

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.

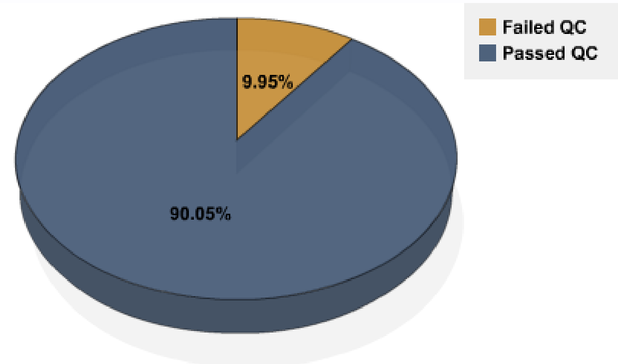
09-07-2009

HEALY

☐ select all

☐ File download | view file

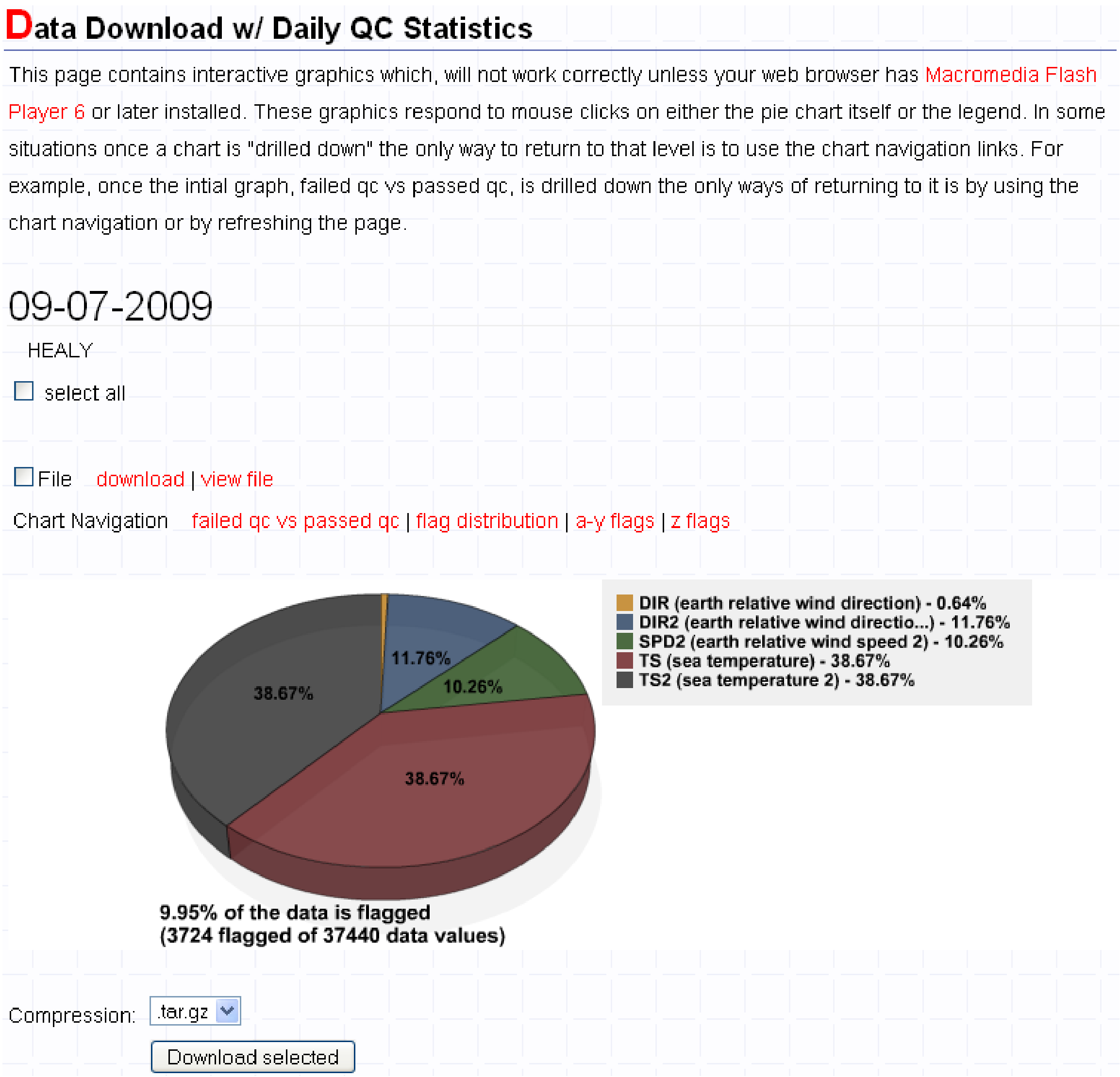
Chart Navigation failed qc vs passed qc | flag distribution | a-y flags | z flags



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:



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.

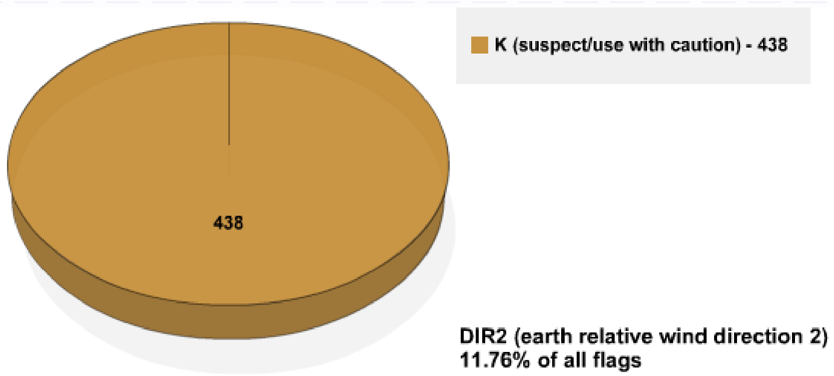
09-07-2009

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:

Data Access

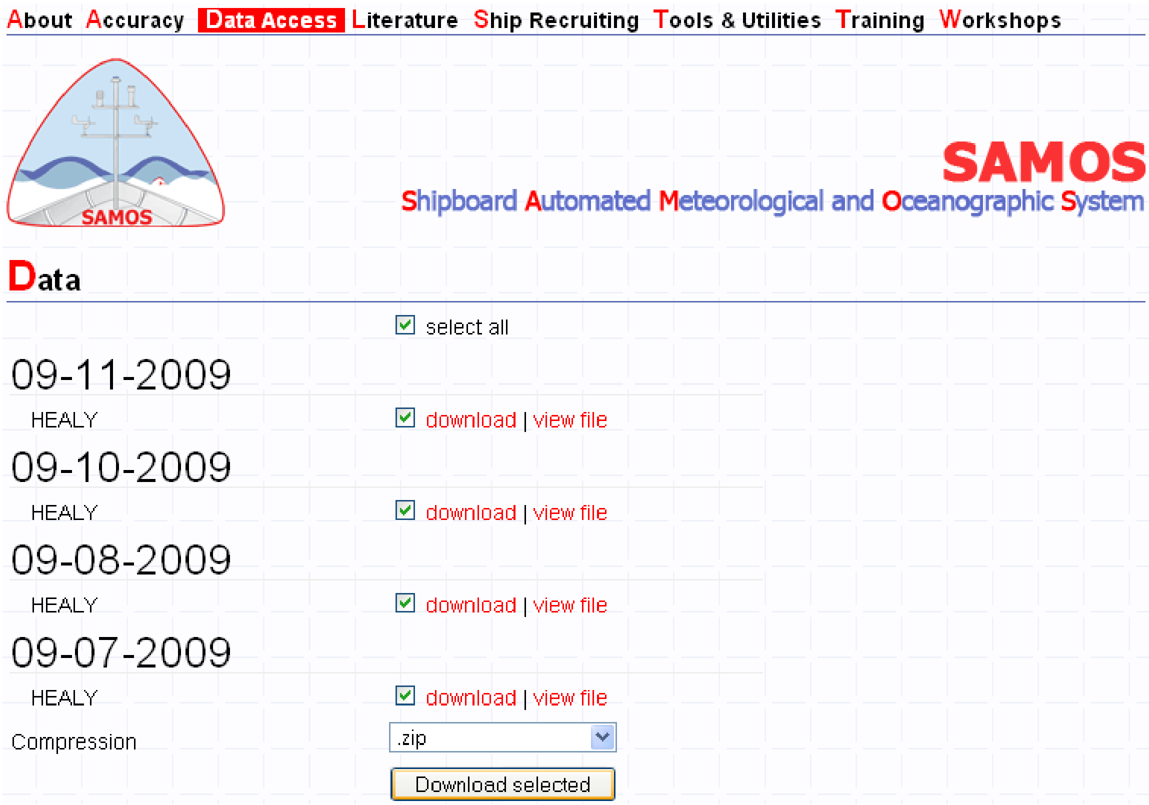
Please choose a page from the following list:

▪ 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

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:

Choose a ship or multiple ships (ctrl-click or apple key-click), or no ships	ATLANTIS (KAQP) DAVID STAR JORDAN (WTD DELAWARE II (KNBD) FAIRWEATHER (WTEB) GORDON GUNTER (WTEO) HEALY (NEPP) HENRY B. BIGELOW (WTDF) HI'IALAKAI (WTEY) KA'IMIMOANA (WTEU) KNORR (KCEJ) LAURENCE M. GOULD (WCX MCARTHUR II (WTEJ) MILLER FREEMAN (WTDM) NANCY FOSTER (WTER) NATHANIEL PALMER (WBP3 OCEANUS (WXAQ) OKEANOS EXPLORER (WTD OREGON II (WTDO) OSCAR DYSON (WTEP) OSCAR ELTON SETTE (WTE
Type a date	9/7/09-9/11/09 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". if nothing is entered, everything is returned (this will take some time)
Sorted by	date collected
Data	research
Click search	search

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



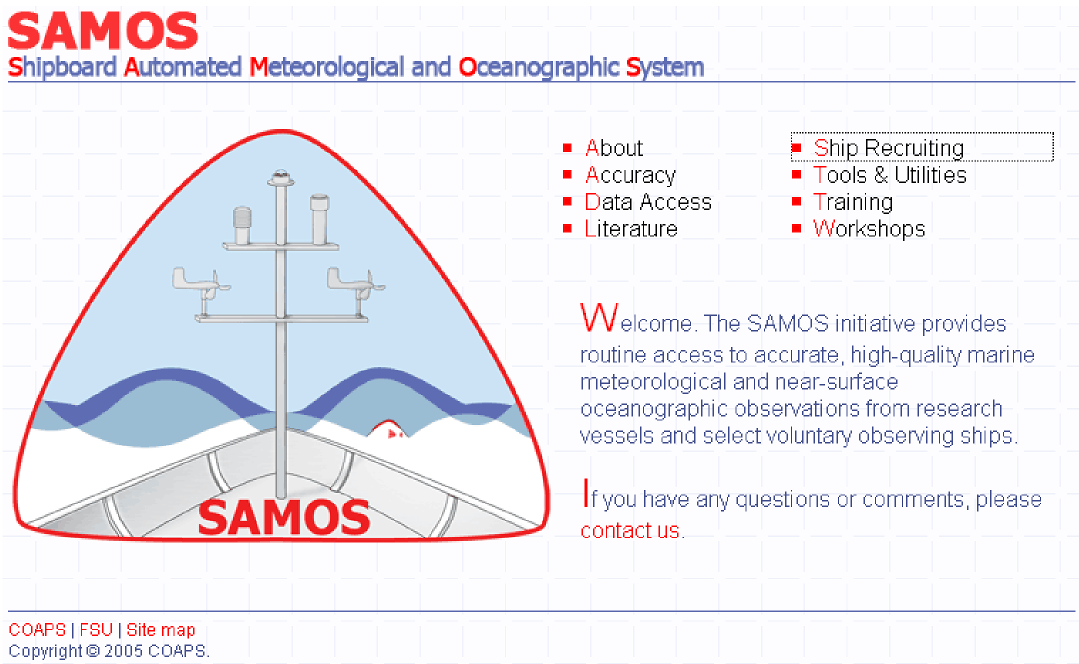
PART 2: the SAMOS operator

(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)

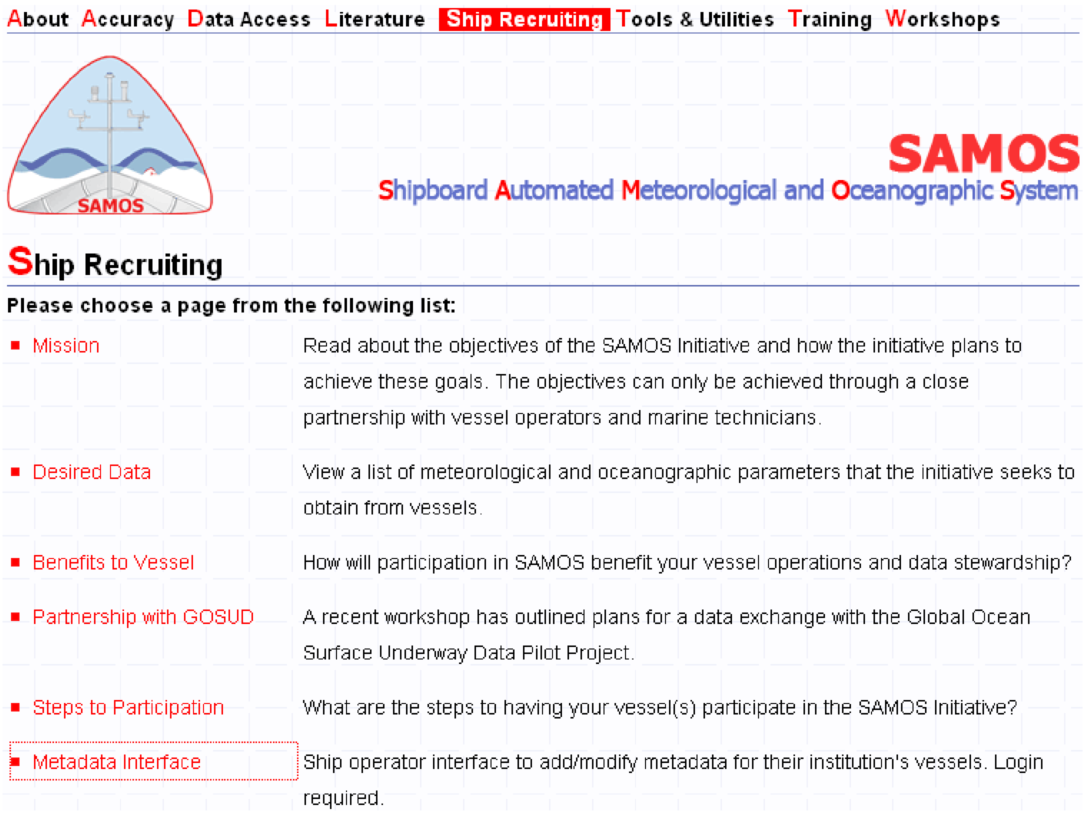
A SAMOS operator might choose to follow the steps outlined in part one as a simple way to keep tabs on the performance of his instruments. When problems are observed, vessel and instrument metadata are important tools for diagnosing a problem and finding a solution. For this reason, we strongly emphasize 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.

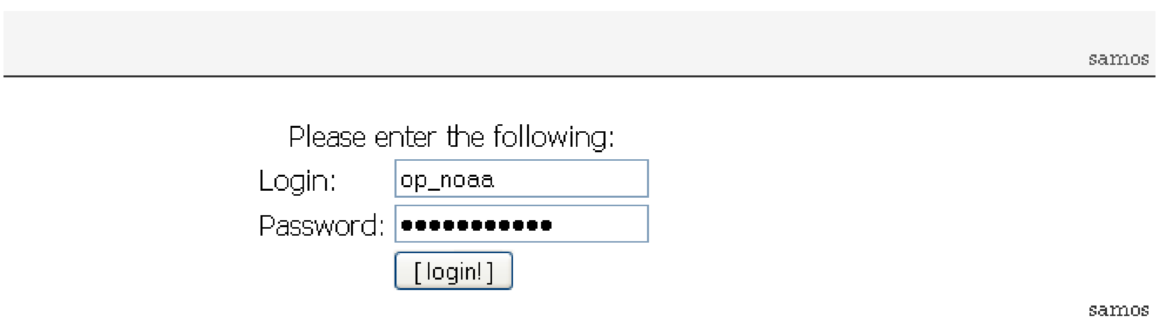
The database can be accessed by visiting the main page and choosing Ship Recruiting:



(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]

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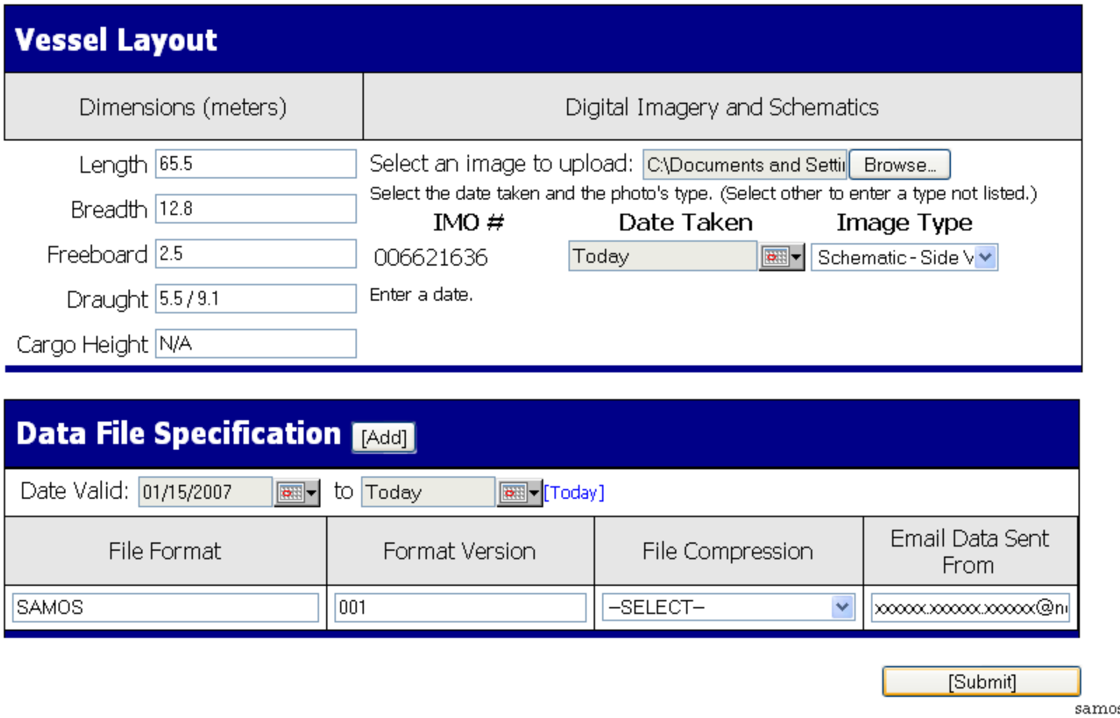
This metadata form provides Vessel Information (such as call sign and home port location), Contact Information for the home institution and shipboard technicians (as well as any other important persons), Vessel Layout, which details ship dimensions and allows for the uploading of digital imagery, and 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]

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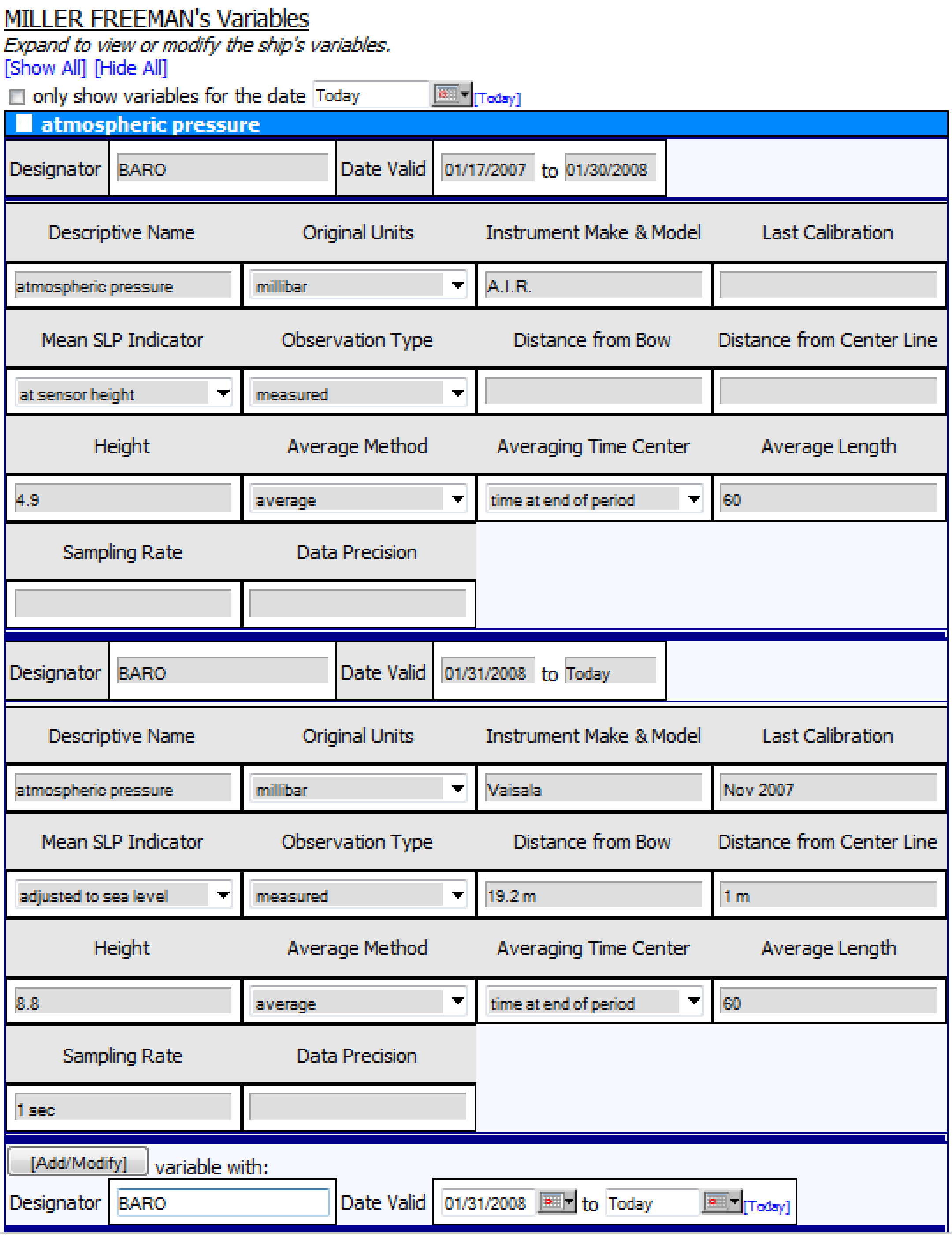
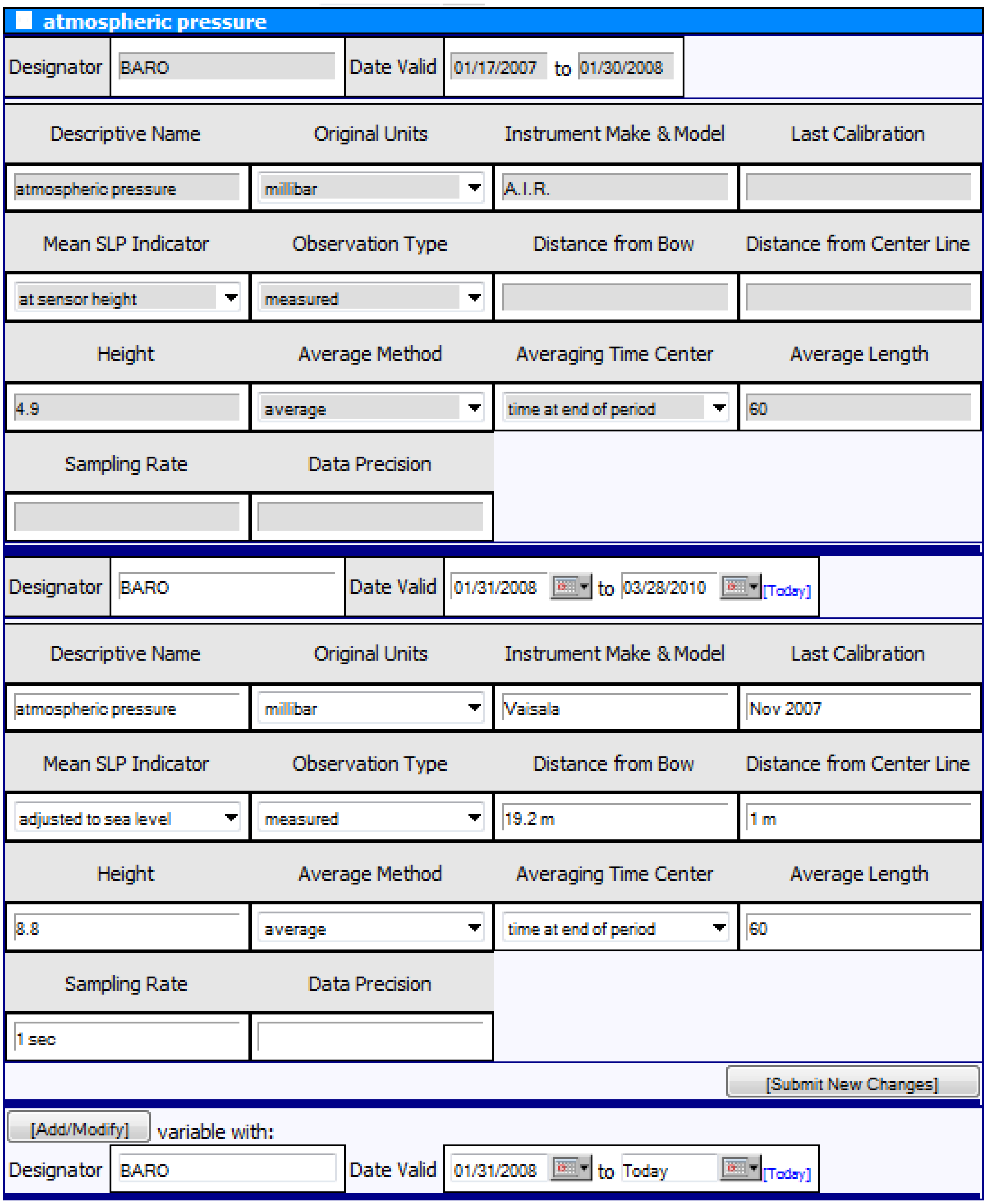
Adding and editing instrument (or parameter) metadata follow a slightly different procedure. The first step for the SAMOS operator is to identify which parameter he wishes to add or modify. Let us first consider the case of modifying a parameter already in use. Let us assume that a pressure sensor has 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:

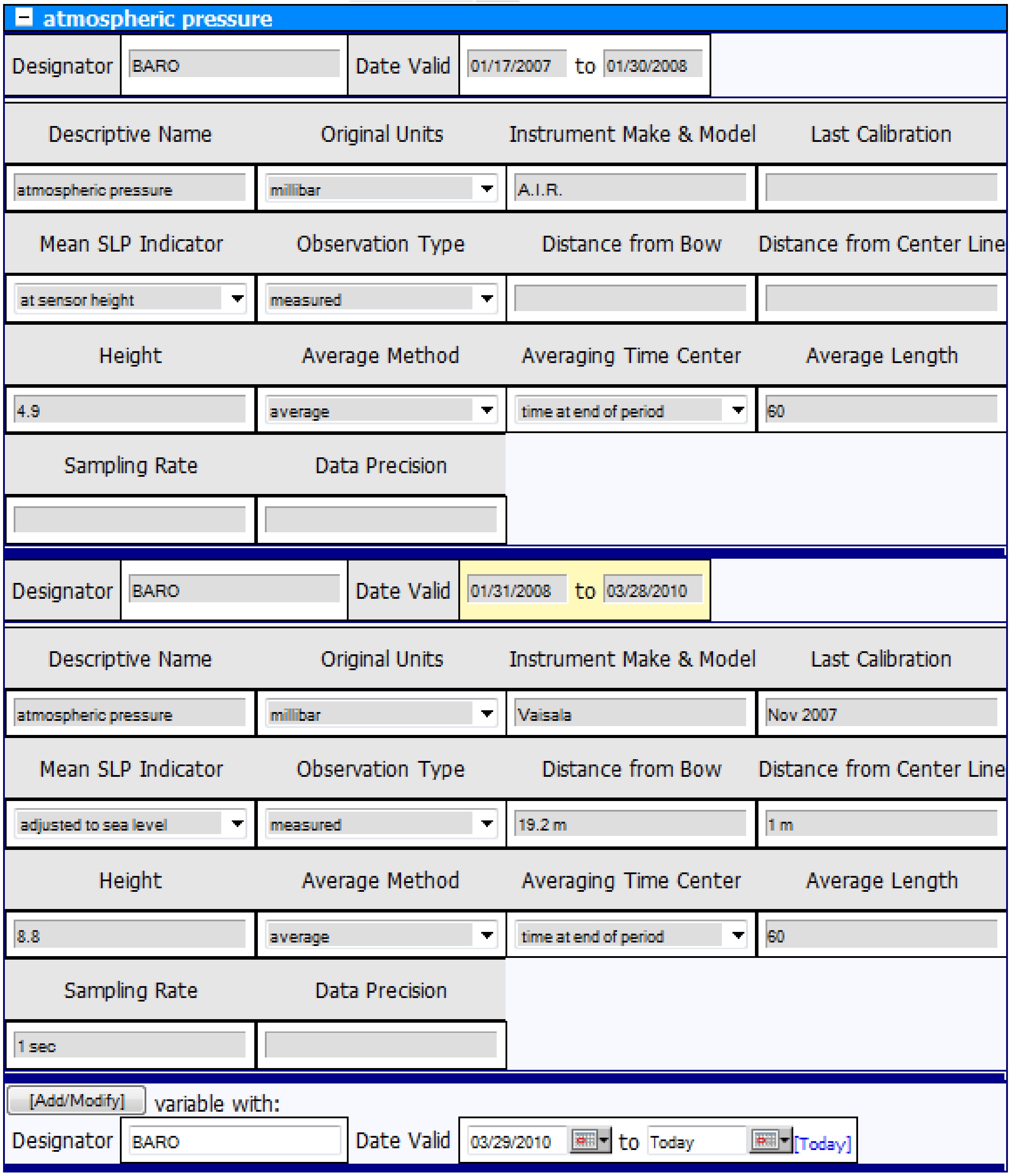
Clicking over the "+" for atmospheric pressure opens the list of metadata fields associated with that parameter. The first step is to identify to the system which version (i.e. range of dates for which the listed metadata values are valid for the instrument) of the parameter metadata is being modified. (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:



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):

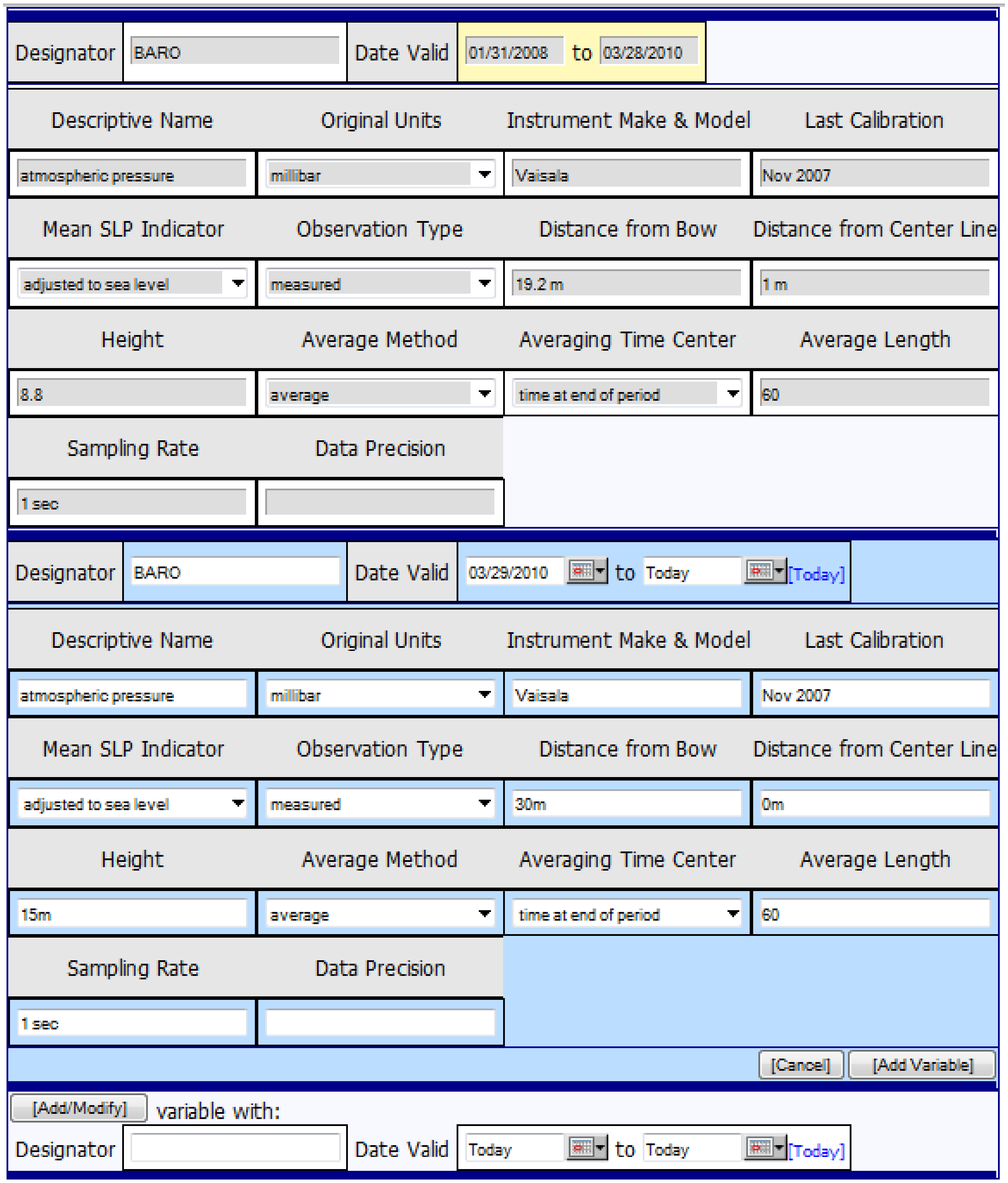


The user then initiates a new version by filling in the sequestered set of Designator and Date Valid fields to reflect the new period for the new or altered metadata, beginning at the date the instrument was relocated, and once again clicking "Add/Modify":

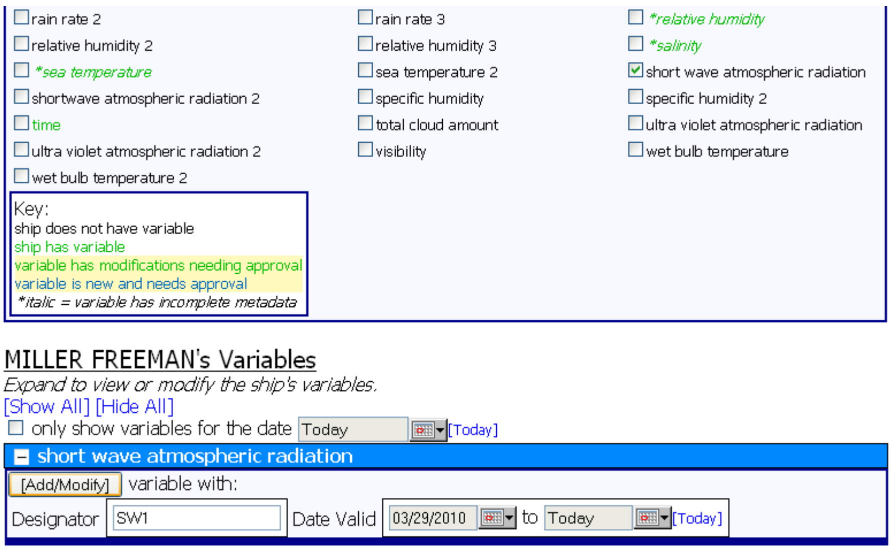


*It is crucial to note that Valid Dates cannot overlap for a single Designator, so if an instrument is moved in the middle of the day (and the Designator is not to be changed), the SAMOS user must decide which day is to be considered the "last" day at the old location, i.e. the day of the change or the 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:



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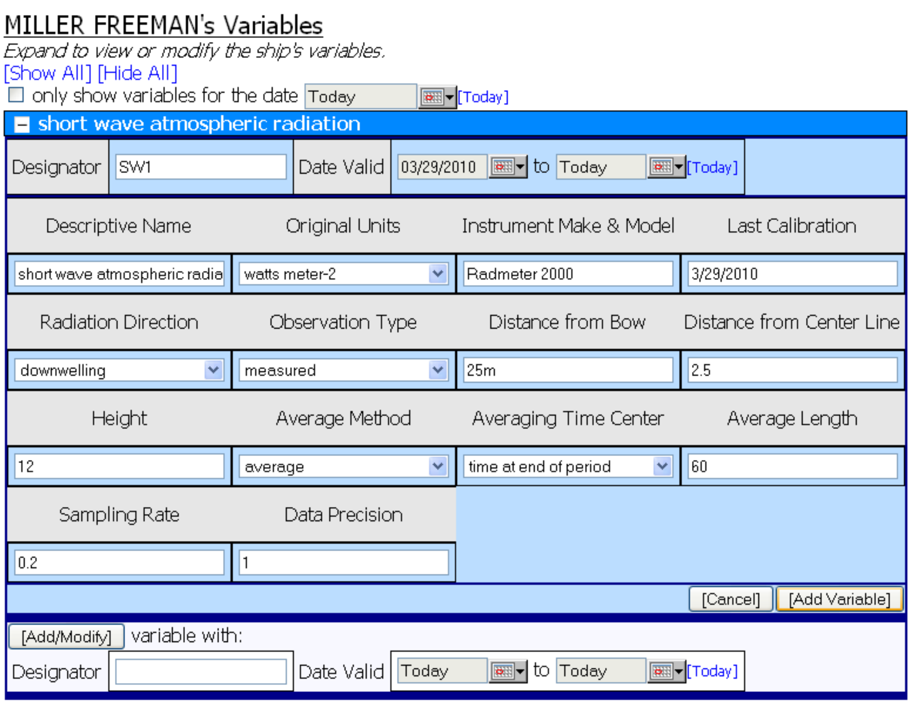
the user is immediately given the new set of fields, to be filled in as desired:



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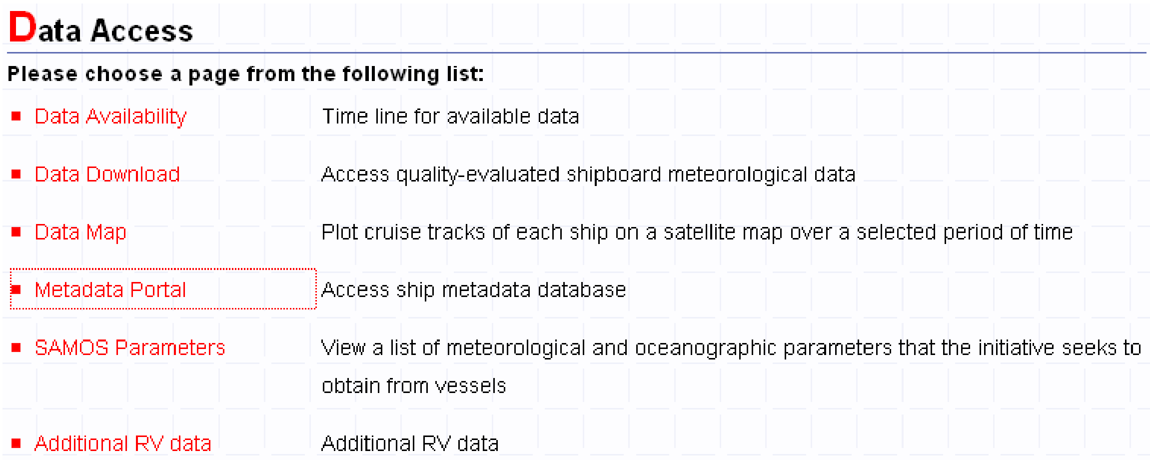
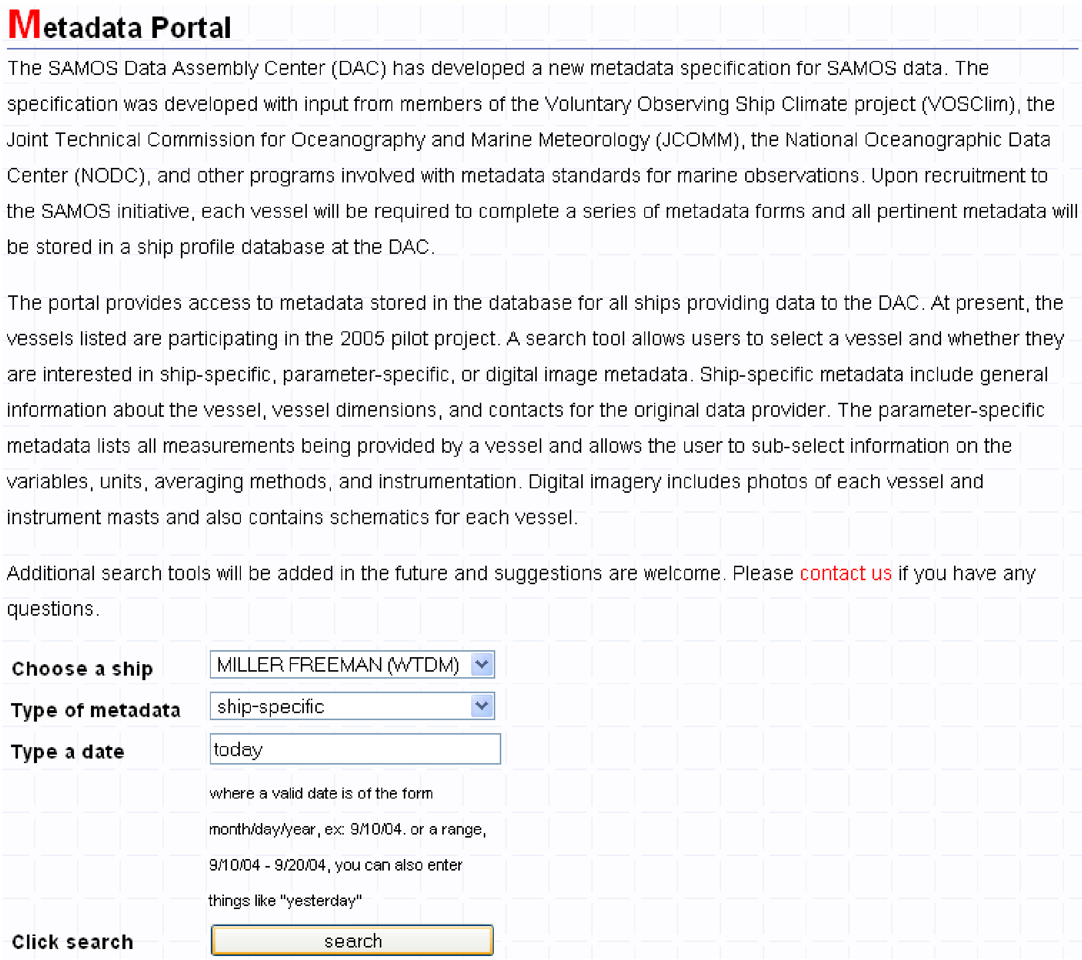
Once an addition or modification to metadata has been submitted, a SAMOS associate at COAPS is automatically notified that approval is needed. Once approved, the new information will be visible to the public, via the Metadata Portal, accessed from the Data Access page as outlined in part one:



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

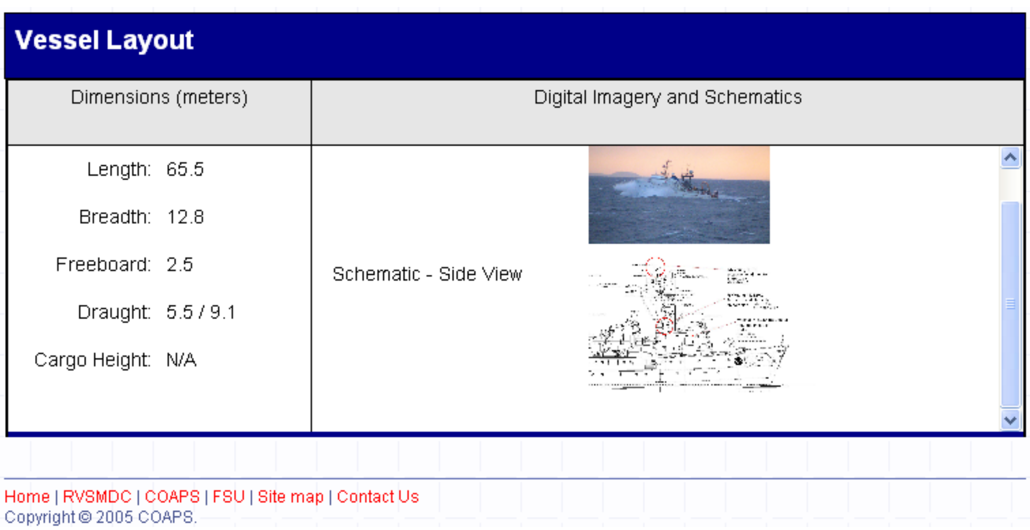
The SAMOS Data Assembly Center (DAC) has developed a new metadata specification for SAMOS data. The specification was developed with input from members of the Voluntary Observing Ship Climate project (VOSClim), the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), the National 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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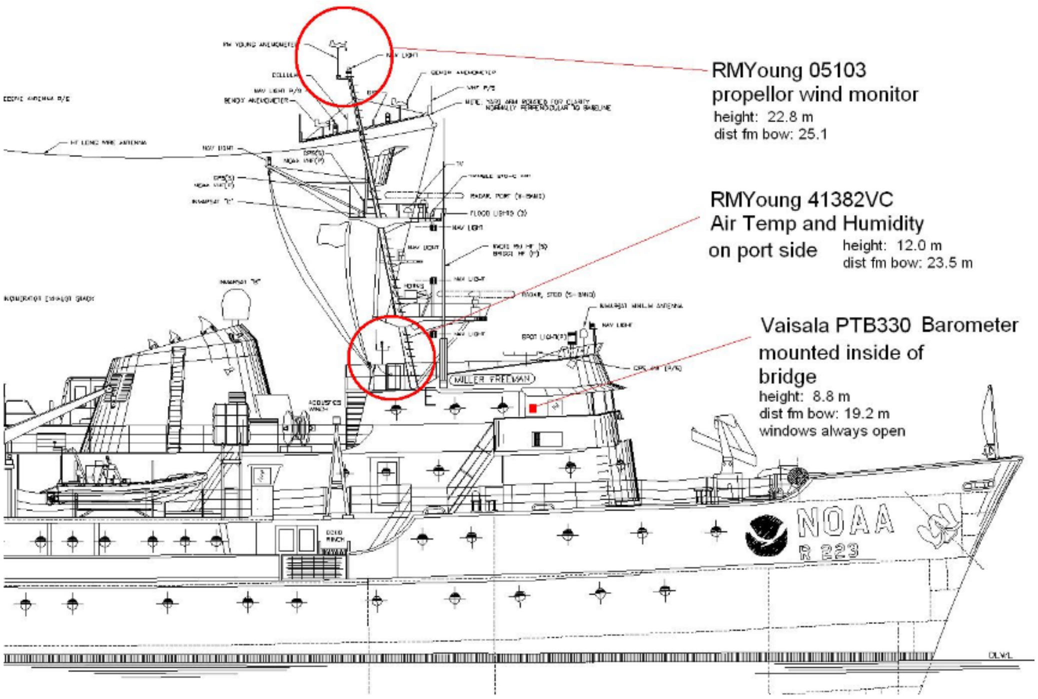
Clicking on the image itself would give us an enlarged view. In this case, the photo provides details about the locations of three MET sensors:



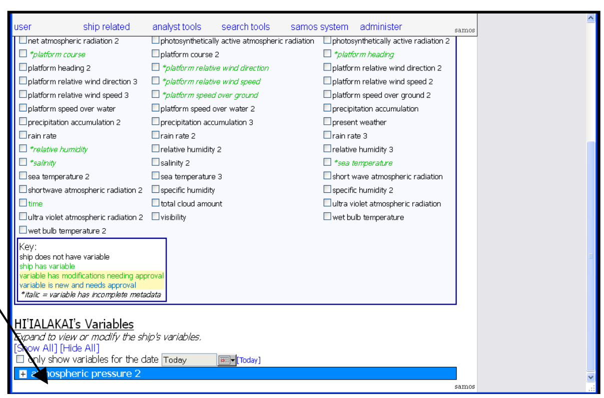
As a SAMOS user becomes familiar with following the metadata modification steps outlined in this section, chores such as adding duplicate sensors, logging sensor relocations, and keeping calibrations up-to-date become straightforward tasks. Naturally, complete and accurate metadata make for better scientific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

UPDATING SAMOS METADATA: STEP BY STEP EXAMPLE

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

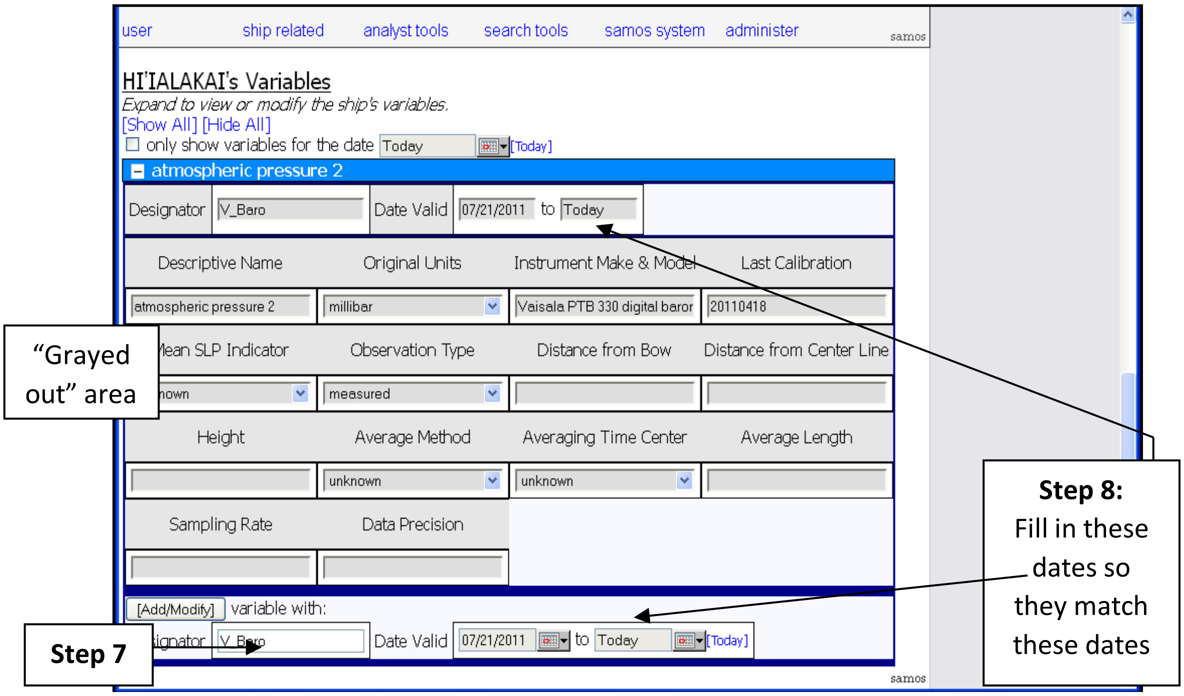
1. Go to: http://samos.coaps.fsu.edu/html/
    a. Click "Ship Recruiting"
    b. Click "Metadata Interface"
2. Enter login ID and password (case sensitive)
3. You can choose to modify Vessel or Instrument Metadata; you will likely choose Instrument. Vessel Metadata does not often change, other than the 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.



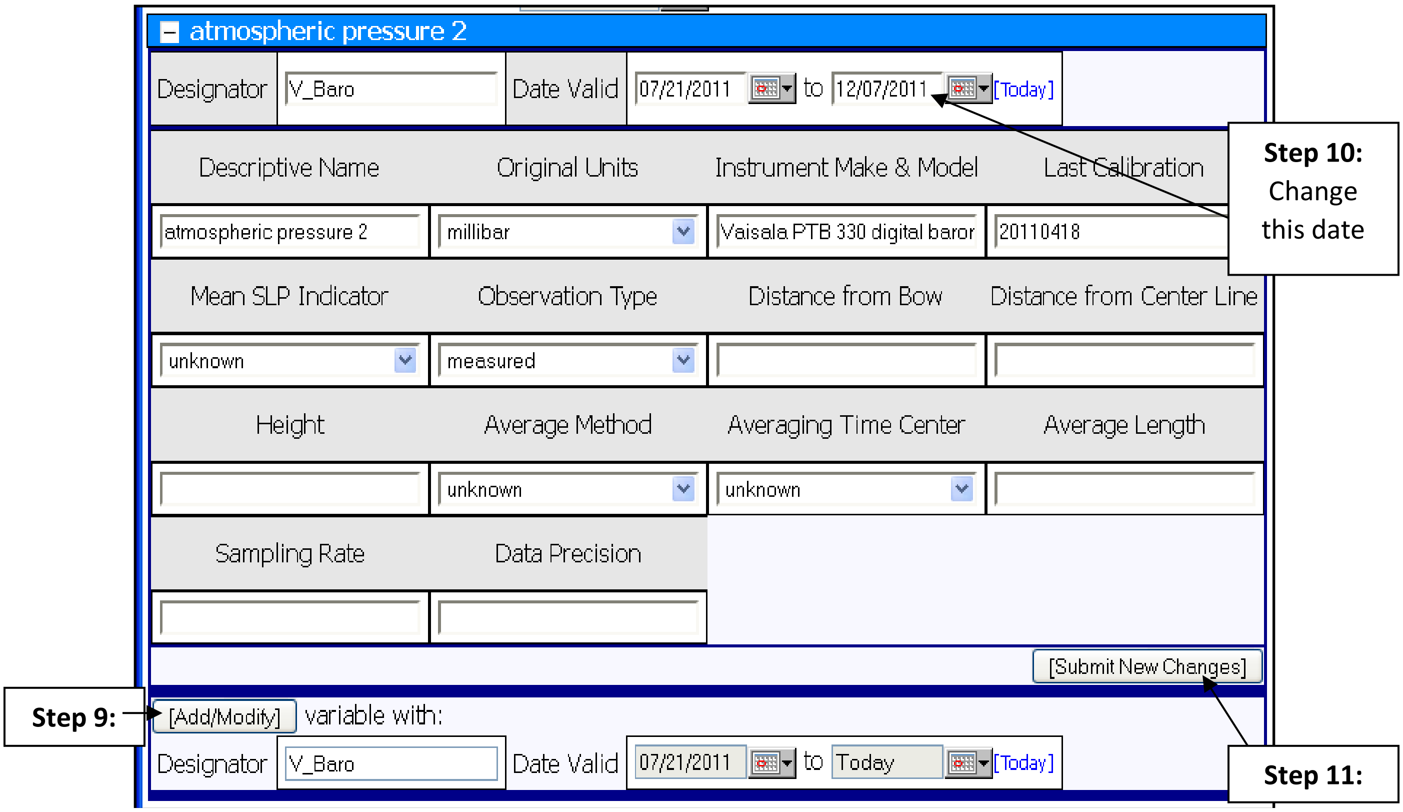
7. You first need to let the system know for which sensor you want to change information. In the box that appears at the very bottom (see image above), enter the name of the designator just at it appears in the box next to 'Designator' in the grayed out area.
    a. For the example above you would enter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

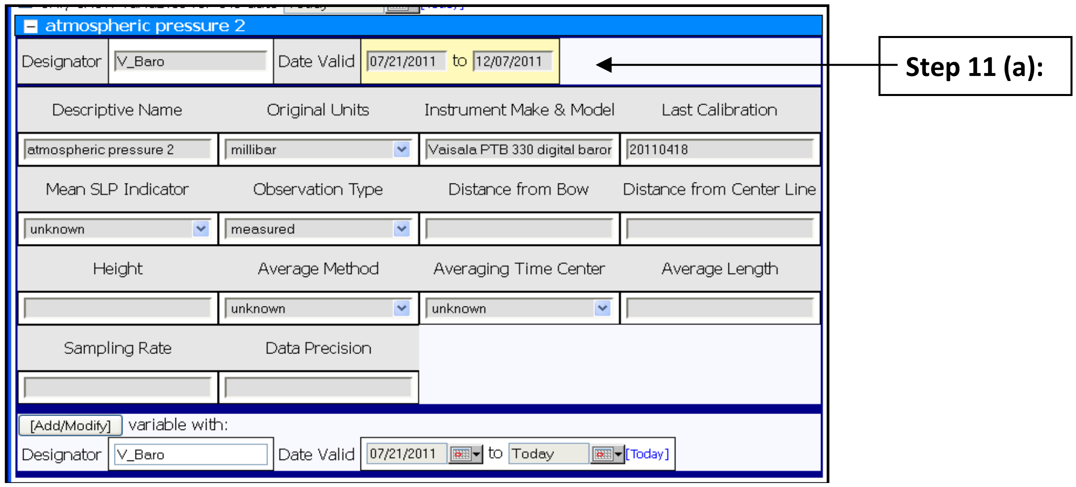
d. Year is changed by clicking on the year (it will now be highlighted) and then typing in the year you want.

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.

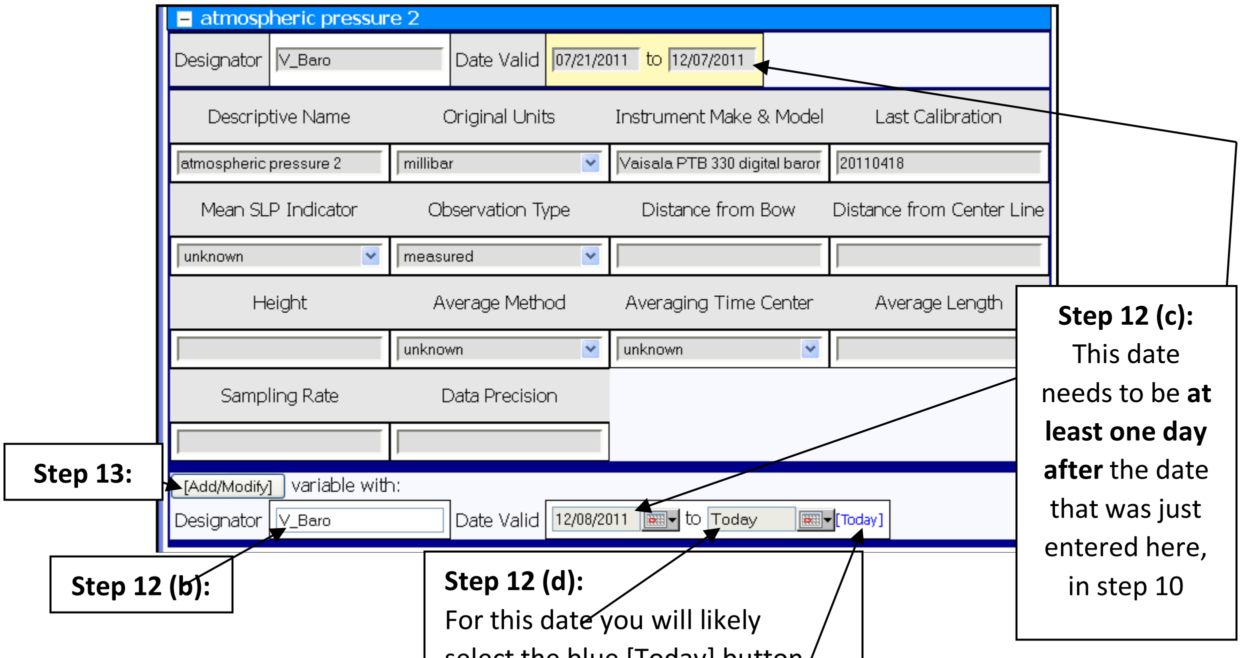


10. You now want to change the "Date Valid" info in this data box. The "Date Valid" start date (on the left) in this now edit-able area will likely stay the same unless you want to correct a previously entered erroneous start date. More than likely you will only be changing the end date, on the right.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

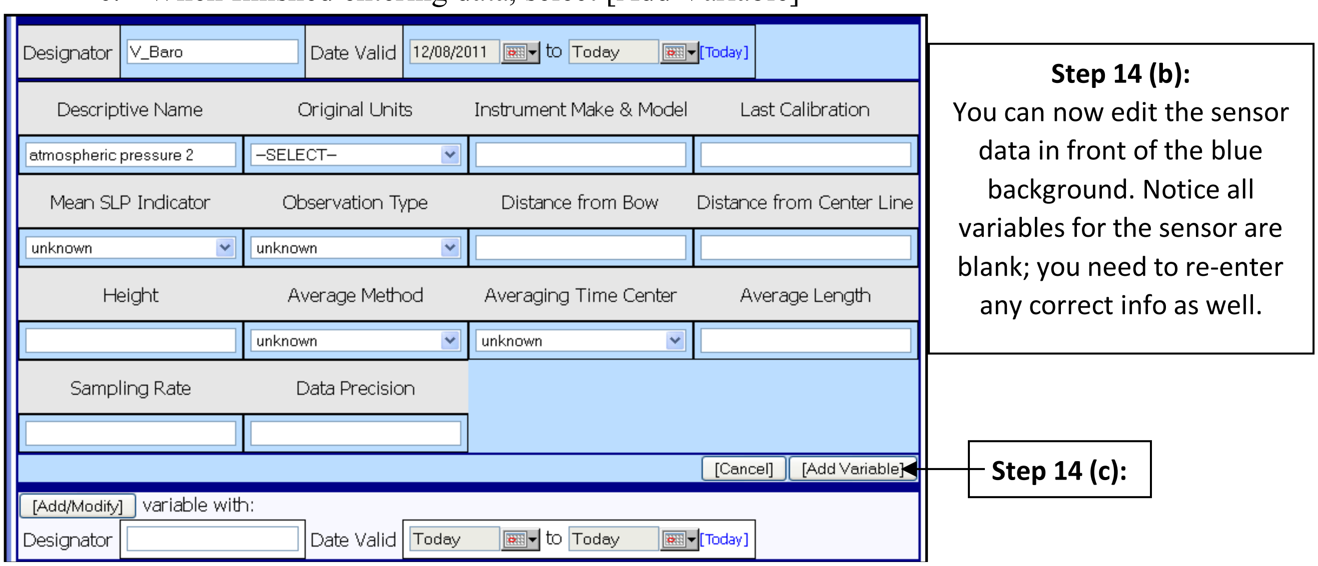
11. Click "Submit New Changes" on the bottom right of the data box (see image above)
    a. The text boxes in the data entry area should be grayed out again. The background of the dates that you just edited will be yellow (see image below).



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.

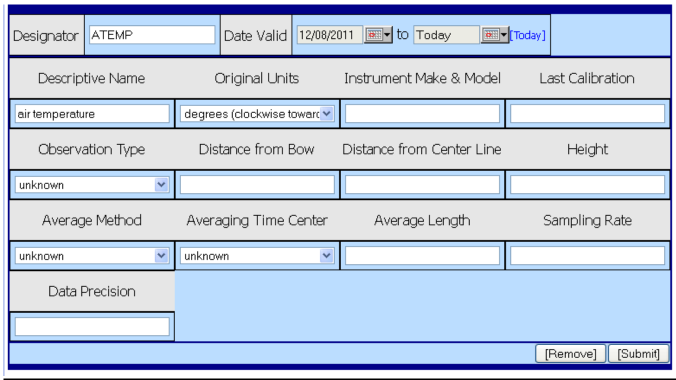


13. Click the [Add/Modify] button again (see image above)
14. You will now see a new, editable data box at the bottom of the screen that has blue around the sensor info instead of gray.
    a. Leave the Date Valid area the same
    b. You can now change the sensor data to reflect updates and add new 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

Annex C: SAMOS PAR PROJECT SUMMARY:

(Credit: Olivia Graff, meteorology undergraduate, Department of Earth, Ocean, and Atmospheric Science, the Florida State University)

Purpose:

The goal of this analysis was to better understand the distribution of Photosynthetically Active Radiation (PAR) over the ocean, and establish the validity of the current upper limit in the database used in the SAMOS range (or bounds) quality control test. PAR is the amount of light available for photosynthesis to occur (400-700 nm wavelength range). PAR varies seasonally depending on latitude and time of day, with greatest levels being mid-day over the summer months. Monitoring PAR is important to ensure agriculture is receiving enough light for photosynthesis to occur.

The current upper and lower limits of PAR [microensteins m-2 s-1] are 0.0 – 2600.0.

DATA USED/METHOD:

SHIP NAME	YEAR	# OBS	% EXCEEDENCE	99TH PERCENTILE
VLMJ	2016	403,840	0.09	2077.46
VLMJ	2017	531,610	0.0	1986.54
VLMJ	2018	625,628	0.0	1830.77
VLMJ	2019	792,792	0.0	1981.92
VLMJ	2020	464,200	0.0	1841.151
VNAA	2009	2,862	0.0	1142.79
VNAA	2010	404,886	0.003	1865.713
VNAA	2011	516,626	0.005	1722.547
VNAA	2012	605,571	0.008	1911.027
VNAA	2013	184,956	0.0	1807.543
VNAA	2017	302,188	0.0	1733.907
VNAA	2018	359,795	0.001	1766.208

VNAA	2019	427,088	0.004	1903.1
KAOU	2011	281,209	10.176	2964.158
KAOU	2012	493,891	9.035	2977.189
KAOU	2013	312,041	2.606	2831.056
KAOU	2014	324,063	1.958	2954.809
KAOU	2015	416,436	9.531	3146.21
KAOU	2016	345,211	9.119	3209.18
KAOU	2017	442,516	8.648	3102.52
KAOU	2019	88,733	23.002	3361.568
KAOU	2020	90,910	11.371	3258.68
WBP3210	2011	265,285	0.165	2249.895
WBP3210	2012	477,873	0.061	2162.09
WBP3210	2013	500,980	0.175	2281.735
WBP3210	2014	506,982	0.038	2086.744
WBP3210	2015	486,645	0.207	2153.176
WBP3210	2016	515,007	0.251	2364.958
WBP3210	2017	408,215	0.295	2359.426
WBP3210	2018	325,123	0.153	2282.875
WBP3210	2019	448,140	0.145	2250.78
WBP3210	2020	432,851	0.143	2061.295
WCX7445	2017	439,319	0.174	2300.0
WCX7445	2018	514,129	0.506	2500.0
WCX7445	2019	303,374	0.069	2100.0
WCX7445	2020	373,215	0.253	2300.0
WKWB	2012	197,438	0.28	2377.272
WKWB	2013	426,422	1.59	2673.213
WKWB	2014	374,705	0.522	2470.17
WKWB	2015	155,096	0.014	2059.351

WSAF	2017	166,120	0.016	2020.484
WSAF	2018	435,986	0.18	2301.846
WSAF	2019	319,810	4.896	3200.081
ZCYL5	2020	570,574	5.643	3012.314
ZCYL5	2021	186,648	6.967	3027.554
WECB	2011	57,093	2.435	2766.41
WECB	2012	427,591	0.886	2576.682
WECB	2013	360,355	1.964	2771.893
WECB	2014	279,749	0.63	2516.674
WECB	2015	509,842	1.735	2690.802
WECB	2016	33,295	0.333	2427.771
KTDQ	2012	49,741	0.0	1511.567
KTDQ	2013	90,970	5.323	2841.933
KTDQ	2014	373,501	0.531	2485.89
KTDQ	2015	334,537	1.885	2706.838
KTDQ	2016	127,886	2.295	2741.373
KTDQ	2018	111,528	2.743	2789.47
KTDQ	2019	272,544	1.591	2683.243
KTDQ	2020	112,043	1.731	2702.532
WDG7520	2015	217,192	0.039	2130.117
WDG7520	2016	460,672	0.353	2411.123
WDG7520	2018	441,744	0.301	2387.364
WDG7520	2019	496,276	0.098	2279.842
WDG7520	2020	495,287	0.018	2101.226
WSQ2674	2012	51,126	0.756	2484.718
WSQ2674	2013	211,444	0.979	2596.473
WSQ2674	2014	217,805	0.307	2428.026
WSQ2674	2015	411,485	0.309	2411.512

WSQ2674	2016	480,678	0.515	2478.752
WSQ2674	2018	386,912	1.141	2558.2
WSQ2674	2019	197,190	0.091	2320.027
WDC9417	2020	98,898	1.772	2714.104
NEPP	2011	300,628	0.127	2091.963
NEPP	2012	159,187	0.0	1431.143
NEPP	2013	125,690	0.002	1832.272
NEPP	2018	148,606	0.073	2181.139
NEPP	2019	92,972	0.027	2005.743
NEPP	2020	44,487	0.142	2148.662
WARL	2017	398,217	0.974	2512.207
WARL	2018	428,182	0.506	2457.552
WARL	2019	406,532	1.492	2641.093
WARL	2020	505,942	0.737	2514.005
VLHJ	2011	195,571	0.043	2211.43
VLHJ	2013	205,103	0.001	2008.50

Table 1: displays all ships and all years used

Mean of Percent of PAR greater than Upper Limit (2600.0)	1.459%
Standard Deviation of PAR greater than Upper Limit (2600.0)	3.256
Mean value of 98th Percentile	2140.214
Standard Deviation of 98th Percentile	494.387
Mean value of 99th Percentile	2277.903
Standard Deviation of 99th Percentile	504.611
Mean value of 99.5th Percentile	2402.814

Standard Deviation of 99.5th Percentile	532.331

Table 2: Using the data of all ships and years in Table 1, overall values are calculated

Each ship and year used to analyze the data (Table 1) was imported and filtered based on validity of the data (B-Flag, Z-flag). After importing the data, the individual readings of PAR were stored and the percent exceeding the upper limit of 2600.0 was calculated, along with the 98th percentile, 99th percentile, and 99.5th percentile and the standard deviation of each (Table 2).

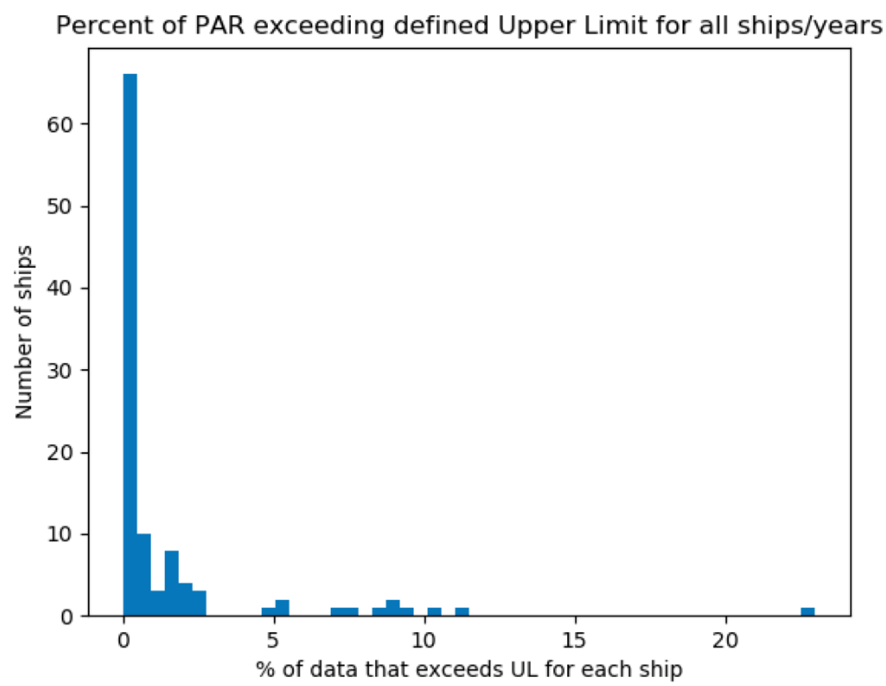


Figure 1: Using all ship and year platforms in Table 1, this histogram displays the distribution of the percent of PAR exceeding the upper limit of 2600.0

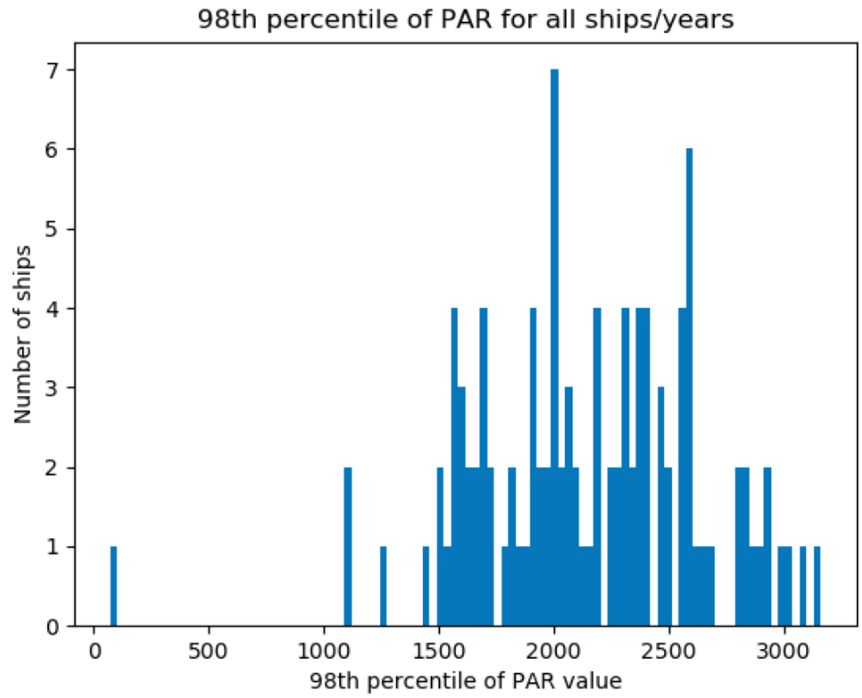


Figure 2: Using all ship and year platforms in Table 1, this histograms displays the distribution of the 98th percentile of data used

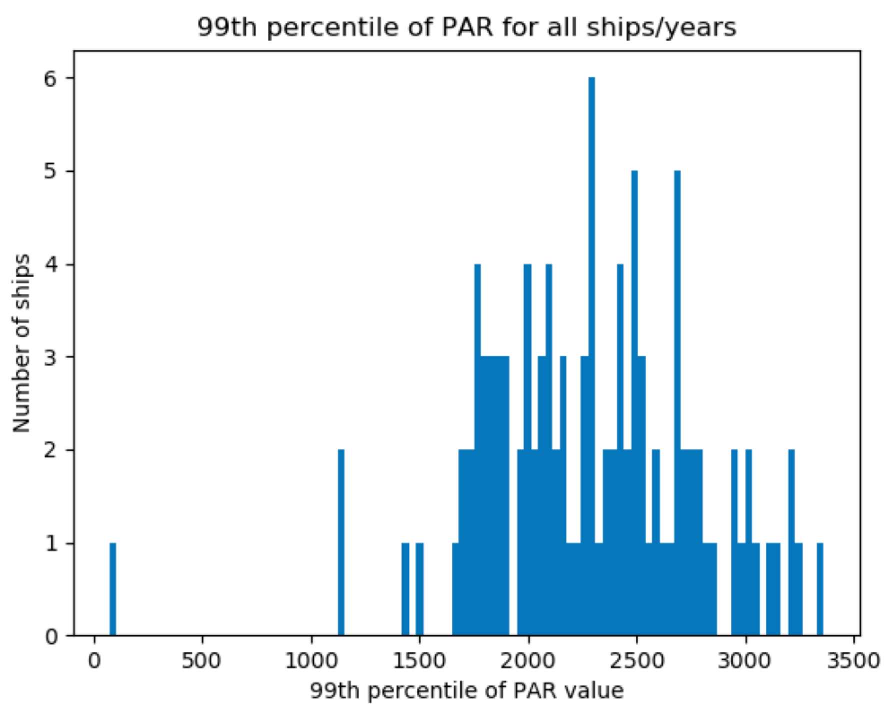


Figure 3: Using all ship and year platforms in Table 1, this histograms displays the distribution of the 99th percentile of data used

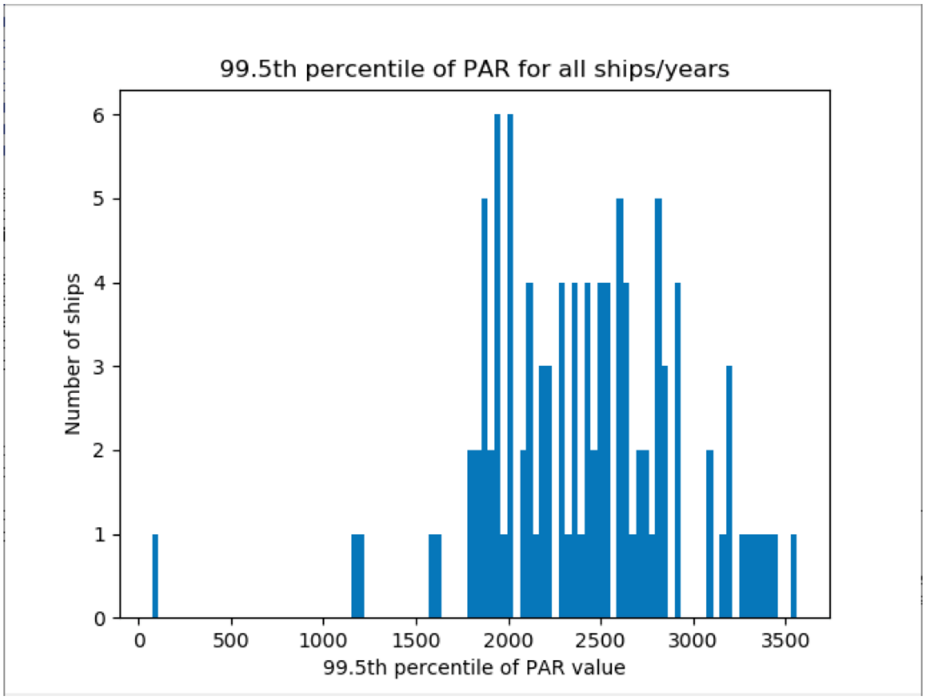


Figure 4: Using all ship and year platforms in Table 1, this histograms displays the distribution of the 99.5th percentile of data used

There were various ships and years excluded from calculations that are not listed in Table 1, and do not contribute to calculations or plots in Table 2, Figure 1, Figure 2, or Figure 3.

The excluded data includes:

VNAA: 2008 (too few PAR readings), 2014, 2015, 2016 (No file found in the database)

KAOU: 2018 (extremely high PAR values due to a units error)

WXC7445: 2007, 2008, 2009 (extremely low values of PAR, due to a units error), and 2014, 2015, 2016 (error in the database)

VLHJ: 2008, 2009 (units error), 2010 (No file found in the database)

NEPP: 2015 (too few PAR readings due to an error with the device), 2016 (too few PAR readings, and units error)

WARL: 2016 (extremely high values of PAR, due to a units error)

WBP3210: 2006, 2007 (units error)

WSAF: 2020 (data error, extremely high values of PAR)

Summary:

All ships and all years were processed, filtering out any missing or special values, before assessing the percentage of B-flag (observations that exceeded the upper limit) occurrences. In instances of increasingly high PAR values as the year's progress (such as the KAOU ship, or and the WSAF ship) it is speculated that the high values are due to device malfunction over time. The overall percentage of PAR that exceeded the upper limit of 2600 microensteins m-2 s-1 was 1.459%, which therefore led to a conclusion that the current upper limit was sufficient.