2019 SAMOS Data Quality Report

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REVISION HISTORY

- Originally published 17 April 2020
- Quality report for ship Kilo Moana (see section 3c.) and notifications of unflagged data for ship Kilo Moana (see Annex A) modified due to receipt of new information; new Report version published 22 April 2020
- 2019 quality across-system (i.e. section 3b.) plots (Figures 4-25) and text (as needed) modified due to emergence of a bug in plot creation software; new Report version published 20 May 2020

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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 2019 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 <u>not</u> 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 enhancement, 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 (http://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 2019, out of 36 active recruits, a total of 30 research vessels routinely provided SAMOS observations to the DAC (Table 1). SAMOS data providers included the National Oceanographic and Atmospheric Administration (NOAA, 14 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 University of Hawaii (UH, 1 vessel), the University of Washington

(UW, 1 vessel), Scripps Institution of Oceanography (SIO, 3 vessels), the Schmidt Ocean Institute (SOI, 1 vessel), the Australian Integrated Marine Observing System (IMOS, 3 vessels), the Louisiana Universities Marine Consortium (LUMCON, 1 vessel), and the University of Alaska (UA, 1 vessel). Two additional NOAA vessels – the *Ferdinand Hassler* and *Hi'ialakai*– one additional USCG vessel – the *Polar Sea* – the Bermuda Institute of Ocean Sciences (BIOS) vessel – the *Atlantic Explorer* – the University of Rhode Island (URI) vessel – the *Endeavor* – and one additional vessel formerly with WHOI and transferred to Oregon State University in March 2012 – *Oceanus* – 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 2019.

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.

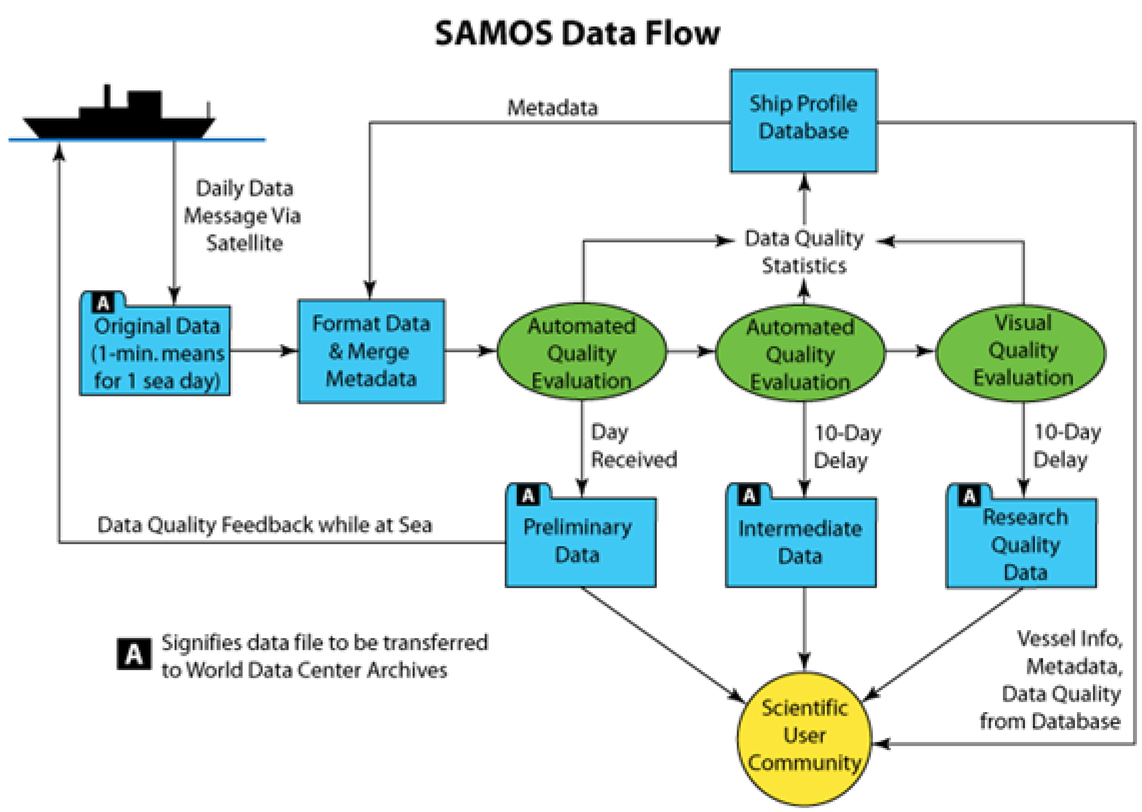

Figure 1: Diagram of operational data flow for the SAMOS initiative in 2019.

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 2019, 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), sensor failures (many vessels), sensors or equipment that remained problematic or missing for extended periods (namely, the air temperature sensor on the *Pelican*, the secondary thermosalinograph on the *Roger Revelle*, the secondary air temperature sensor and the photosynthetically active radiation sensor on the *Sally Ride*, and the long wave radiation sensor on the *Thomas G. Thompson*), erroneously characterized data units (*Oregon II*), problematic parameter designators (*Rainier* and *Pelican*), and data transmission oversights or issues.

This report begins with an overview of the vessels contributing SAMOS observations to the DAC in 2019 (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 2020. 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 2019, a total of 36 research vessels were under active recruitment to the SAMOS initiative; 30 of those vessels routinely provided SAMOS observations to the DAC (Table 1). The *Hi'ialakai* did not sail in 2019, hence no data from her, and we learned that NOAA has plans for her decommissioning. A combination of a new data acquisition system and turnover in technical personnel resulted in no data from the *Atlantic Explorer* in 2019. 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 2019, but despite attempts to reestablish transmission SAMOS data were not received from her in either 2018 or 2019. In March 2012, stewardship of the *Oceanus* was transferred from WHOI to OSU and she underwent a major refit. *Oceanus* planned to return to SAMOS using the 2.0 data protocol, but this transition never occurred and, with changes to technical personnel and the new OSU Regional Class Research Vessel (RCRV) under construction, we do not anticipate the *Oceanus* returning to SAMOS. Real-time data were not received in 2019 from the *Endeavor* because they have not been able to transition back to SAMOS 1.0 format (FSU is no longer developing SAMOS 2.0) and they too are expecting to be operating one of the RCRVs in a few years. In 2019, we implemented an "inactive" ship status for vessels recruited to SAMOS at one point in the past, but which have not sent data in over a year. The *Hi'ialakai, Atlantic Explorer, Polar Sea, Oceanus*, and *Endeavor* have been assigned inactive status (the *Hassler* began transmitting again in 2020).

In total, 5,321 ship days were received by the DAC for the January 1 to December 31, 2019 period, resulting in 7,145,734 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 7,145,734 records received in 2019, a total of 160,157,629 distinct measurements were logged. Of those, 7,796,078 were assigned A-Y quality control flags – about 5 percent – by the SAMOS DAC (see section 3a for descriptions of the QC flags). This is about the same as in 2018. 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, Kilo Moana, Thomas G. Thompson, Sikuliaq, Pelican, 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
TOTAL	-	5,321	663	7,145,734	7,796,078	160,157,629
ROGER REVELLE	KAOU	67	24	88,733	140,813	2,129,592
ATLANTIS	KAQP	295	29	409,925	272,234	11,887,825
T.G. THOMPSON	KTDQ	213	20	279,743	293,351	5,512,515
HEALY	NEPP	71	30	92,972	159,796	2,716,776
INVESTIGATOR	VLMJ	283	31	390,757	440,389	11,899,338
AURORA AUSTRALIS	VNAA	152	28	213,544	173,796	5,881,494
NEIL ARMSTRONG	WARL	291	31	406,532	272,595	12,602,492
NATHANIEL B. PALMER	WBP3210	313	23	448,140	766,943	10,079,217
LAURENCE M. GOULD	WCX7445	289	23	407,046	488,408	8,578,669
KILO MOANA	WDA7827	251	22	332,301	87,747	6,665,408
PELICAN	WDD6114	42	16	47,460	95,687	759,360
SIKULIAQ	WDG7520	355	21	510,665	579,268	10,227,366
SALLY RIDE	WSAF	250	22	319,810	564,433	6,975,122
ROBERT GORDON SPROUL	WSQ2674	166	23	197,190	72,503	4,191,325
HENRY B. BIGELOW	WTDF	162	29	209,980	331,843	5,198,851
OKEANOS EXPLORER	WTDH	151	21	192,980	121,402	3,582,329
PISCES	WTDL	143	18	183,688	318,029	3,290,696
OREGON II	WTDO	156	16	203,440	182,756	3,234,676
THOMAS JEFFERSON	WTEA	32	16	40,755	82,898	650,940
FAIRWEATHER	WTEB	137	16	180,222	178,964	2,880,606
RON BROWN	WTEC	99	20	129,072	111,510	2,477,540
BELL M. SHIMADA	WTED	152	20	198,461	165,065	3,960,622
OSCAR ELTON SETTE	WTEE	145	16	191,966	156,625	3,059,336
RAINIER	WTEF	78	13	107,305	31,362	1,394,965
REUBEN LASKER	WTEG	172	20	223,176	305,632	4,322,724
GORDON GUNTER	WTEO	154	16	208,555	226,780	3,299,768
OSCAR DYSON	WTEP	159	31	206,371	244,587	6,244,815
NANCY FOSTER	WTER	80	16	101,320	33,645	1,592,668
FALKOR	ZCYL5	188	35	246,556	314,895	8,467,695
TANGAROA	ZMFR	275	17	377,069	582,122	6,392,899

Table 1: CY2019 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.

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. 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 (http://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) and the results of the automated quality control on these files (Preliminary Quality). 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 and blue) to final 2019 ship schedules provided by each vessel's institution. A “blue” day denotes that the data file was received past the 10-day delayed-mode window (or otherwise entered the SAMOS processing system well past the window) and thus missed timely processing and visual quality control, although processing (and visual QC where applicable) was eventually applied. (It must be noted, though, that “late” data always incurs the risk of not being visually quality controlled, based on any time or funding constraints.) A quick review of Figure 2 reveals that most data received by the DAC in 2019 arrived in a timely manner (green vs. blue). 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" and a “P” indicates a vessel was known to be in port. 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 2019, 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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FEBRUARY	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			
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Figure 2: 2019 calendar of ship days received by DAC within (green) or after (blue) the 10-day window 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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ZCYL5																															
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AUGUST	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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WDG7520																															
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(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	
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WDC9417							S	S	S	S	S	S				S	S									S	S	S	S	S	
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ZCYL5																															
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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
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WDC9417	S	S	S	S	S	S	S	S	S	S		S	S	S	S	S	S			S	S	S	S	S	S				S	S	S
WDD6114	S	S	S	S					S	S			S	S	S	S	S		S	S	S	S	S	S	S	S	S	S			
WDG7520																															
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(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	
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WDD6114				S	S	S	S	S	S	S	S					S	S	S	S	S	S	S	S								
WDG7520																															
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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																															
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WDC9417									S	S	S	S	S	S				S													
WDD6114																															
WDG7520																															
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ZCYL5																															
ZMFR																															

(Figure 2: cont'd)

NOAA								
Ship Name	**Bell M. Shimada**	**Fairweather**	**Ferdinand Hassler**	**Gordon Gunter**	**Henry Bigelow**	**Nancy Foster**	**Okeanos Explorer**	**Oregon II**
Call Sign/ Ship Code	**WTED/SH**	**WTEB/FA**	**WTEK/FH**	**WTEO/GU**	**WTDF/HB**	**WTER/NF**	**WTDH/EX**	**WTDO/OT**
# scheduled at-sea days	151	147	56	134	168	82	159	153
# matching SAMOS days	146	127	0	117	155	71	147	152
→% received	97%	86%	0%	87%	92%	87%	92%	99%

NOAA (cont'd)							
Ship Name	**Oscar Dyson**	**Oscar E. Sette**	**Pisces**	**Rainier**	**Reuben Lasker**	**Ronald Brown**	**Thomas Jefferson**
Call Sign/ Ship Code	**WTEP/OD**	**WTEE/OS**	**WTDL/PI**	**WTEF/RA**	**WTEG/RL**	**WTEC/RB**	**WTEA/TJ**
# scheduled at-sea days	159	155	140	113	172	103	37
# matching SAMOS days	153	142	130	62	164	96	31
→% received	96%	92%	93%	55%	95%	93%	84%

TOTAL scheduled at-sea days:	1929
TOTAL matching SAMOS days:	1693
OVERALL RATIO:	**88%**

Table 2: 2019 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	152	283	262
# matching SAMOS days	152	282	262
→% received	100%	100%	100%
TOTAL scheduled at-sea days:	697		
TOTAL matching SAMOS days:	696		
OVERALL RATIO:	100%		

OPP		
Ship Name	Laurence M. Gould	Nathaniel B. Palmer
Call Sign	WCX7445	WBP3210
# scheduled at-sea days	234	148
# matching SAMOS days	221	148
→% received	94%	100%
TOTAL scheduled days:	382	
TOTAL matching SAMOS days:	369	
OVERALL RATIO:	97%	

SIO			
Ship Name	Robert G. Sproul	Roger Revelle	Sally Ride
Call Sign	WSQ2674	KAOU	WSAF
# scheduled at-sea days	56	59	251
# matching SAMOS days	35	59	195
→% received	63%	100%	78%
TOTAL scheduled at-sea days:	366		
TOTAL matching SAMOS days:	289		
OVERALL RATIO:	79%		

WHOI		
Ship Name	R/V Atlantis	R/V Neil Armstrong
Call Sign	KAQP	WARL
# scheduled at-sea days	237	183
# matching SAMOS days	237	180
→% received	100%	98%
TOTAL scheduled at-sea days:	420	
TOTAL matching SAMOS days:	417	
OVERALL RATIO:	99%	

	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	154	185	181	241	262	102	270
TOTAL matching SAMOS days	0	37	162	241	243	62	208
OVERALL RATIO:	0%	20%	90%	100%	93%	61%	77%

(Table 2: cont'd)

b. Spatial coverage

Geographically, SAMOS data coverage continues to be noteworthy in 2019, with both the typical exposures and several trips outside traditional mapping/shipping lanes. Cruise coverage for the January 1, 2019 to December 31, 2019 period is shown in Figure 3. It includes a sampling of the North Atlantic provided by the *Ronald Brown*, *Thomas G. Thompson*, *Henry B. Bigelow*, and *Neil Armstrong*, with a brushing of Cape Verde by *Ron Brown* and additional exposures around Greenland and Iceland by the *Armstrong*, as well as numerous lengthy swaths of the Pacific and heavy coverage in and around Hawaii provided by the *Kilo Moana*, *Falkor*, *Oscar Elton Sette*, and *Sally Ride* (among others). The Antarctic and the Southern Ocean were again frequented by both the IMOS vessels (*Aurora Australis*, *Tangaroa*, *Investigator*) and the OPP vessels (*Laurence M. Gould* and *Nathaniel B. Palmer*), with the *Palmer* and *Gould* both additionally providing data partway up along the Argentine coastline. Australia and New Zealand saw coverage via the *Tangaroa*, *Investigator*, and *Roger Revelle*. Natively, the entire East coast U.S. was densely sampled by the *Henry Bigelow*, *Gordon Gunter*, and *Okeanos Explorer* (among others), including a concentration around Delmarva and the Chesapeake Bay by the *Thomas Jefferson*. Similar coverage of the West coast, from Vancouver Island all the way down through Baja California Sur and beyond, was provided by the *Bell M. Shimada*, *Rainier*, *Fairweather*, *Reuben Lasker*, and *Atlantis* (among others). A focus in and around the Channel Islands of California was contributed by the *Robert Gordon Sproul*. Substantial coverage of Alaska, including some north of the Arctic Circle, was furnished by the *Sikuliaq*, *Healy*, *Oscar Dyson*, and *Fairweather*. Comprehensive coverage of the northern Gulf of Mexico and the Florida coastline was again provided by the *Oregon II*, *Gordon Gunter*, and *Pisces* (among others), with a concentrated effort south of the Mississippi River Delta area of Louisiana supplied by the *Pelican*. A brief foray in the northern Bahamas and east down through the Caribbean islands was given by the *Ron Brown*, while some additional tropical exposure extending out through the northern coastlines of Cuba and Hispaniola was provided by *Nancy Foster*. Finally, the well-traveled *Thomas G. Thompson* approached no less than five continental coastlines in 2019 (North and South America, Africa, Australia, and Antarctica).

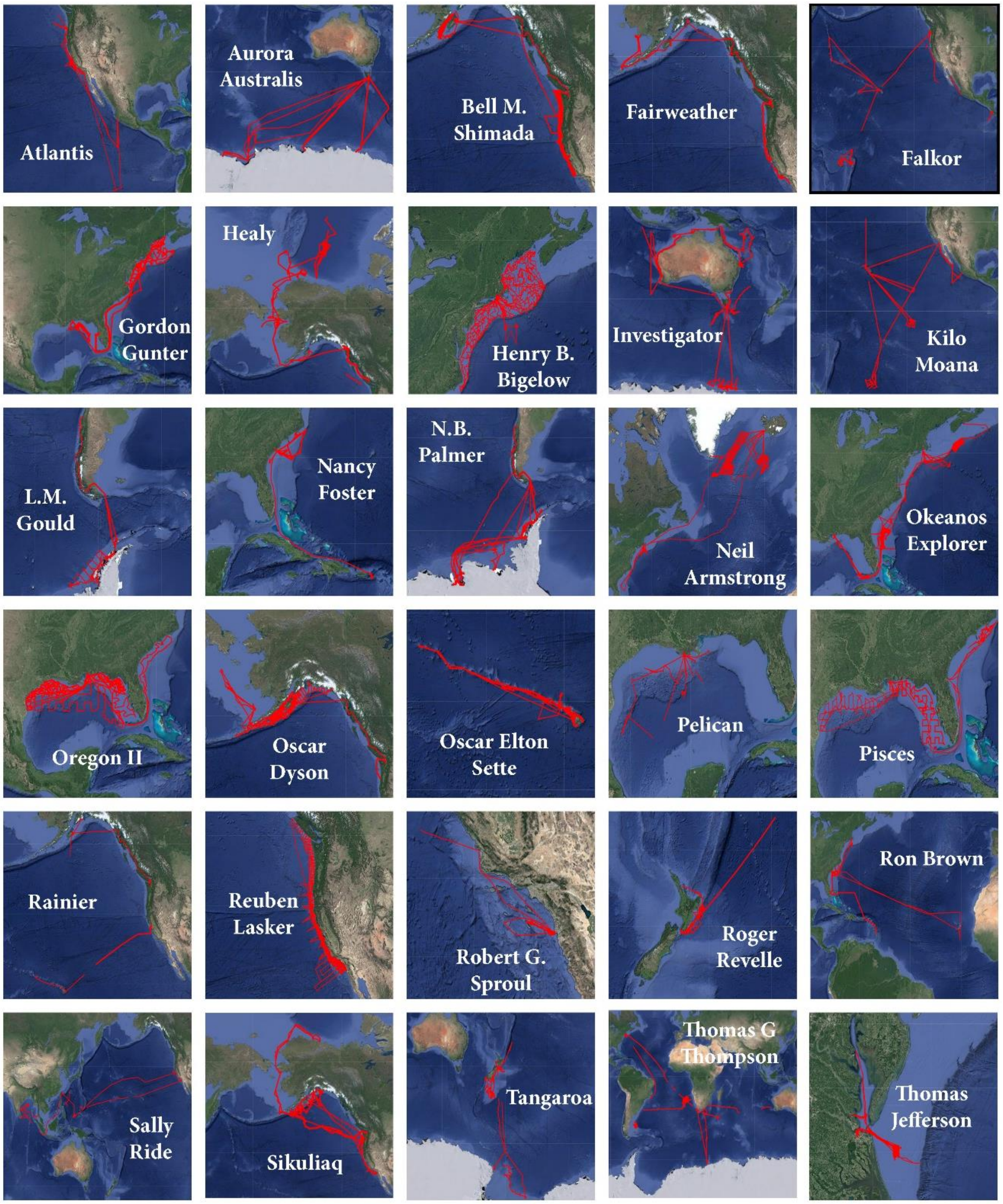


Figure 3: Cruise maps plotted for each vessel in 2019.

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 *Roger Revelle*, *Sally Ride*, *Okeanos Explorer*, and *Thomas Jefferson* are all capable of providing dew point temperature, although only the *Okeanos Explorer* and *Thomas Jefferson* did so in 2019. The *Jefferson* and *Okeanos Explorer* are also the only vessels set up to provide wet bulb temperature and both did so in 2019. 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 2019/2020; 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 2019 (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. 2019 quality across-system

This section presents the overall quality from the system of ships providing observations to the SAMOS data center in 2019. 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 quality of SAMOS atmospheric pressure data is generally good (Figure 4). 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. The origins of most a-y flagging seen in P and P2 are not clearly attributable to any specific vessel(s) but are likely due to several vessels simultaneously experiencing the common sensor issues we mention here. We note the uptick in flagging in January seen in both P and P2 looks to have come from the *Sally Ride*. The details in that case are not known. 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.

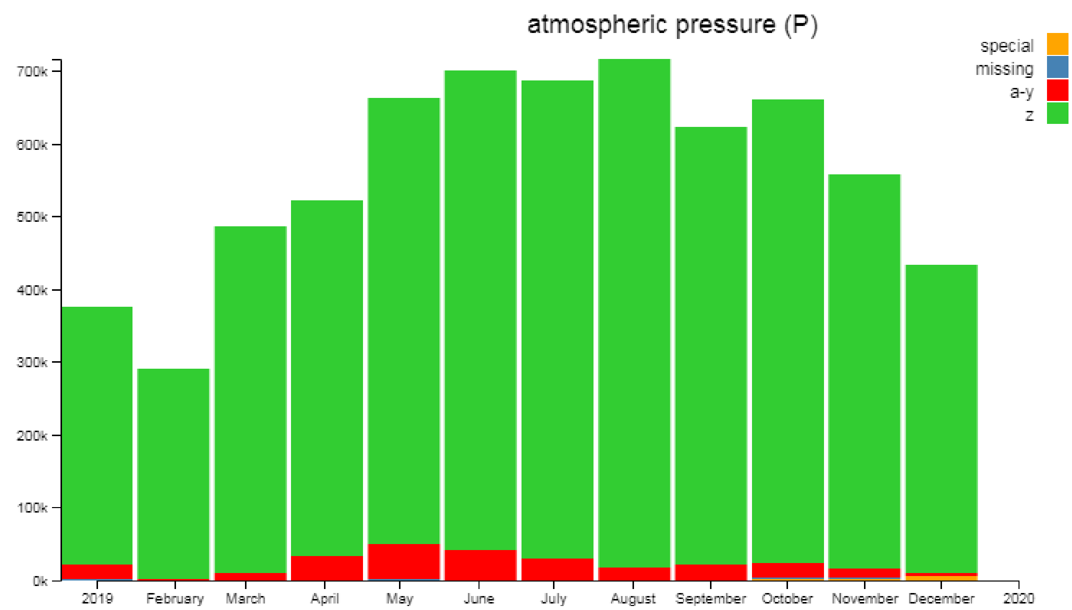
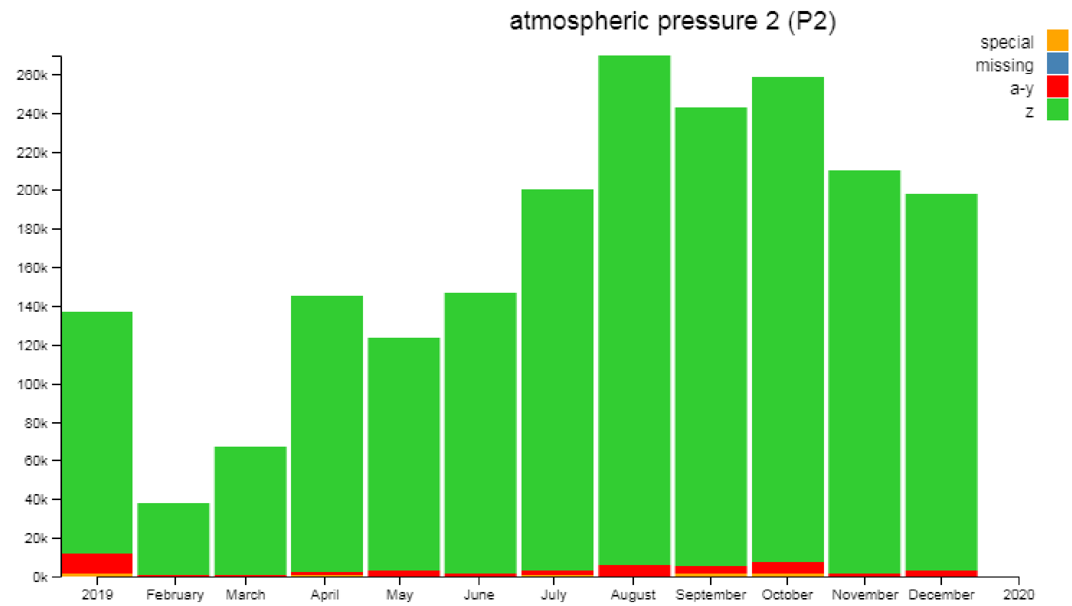
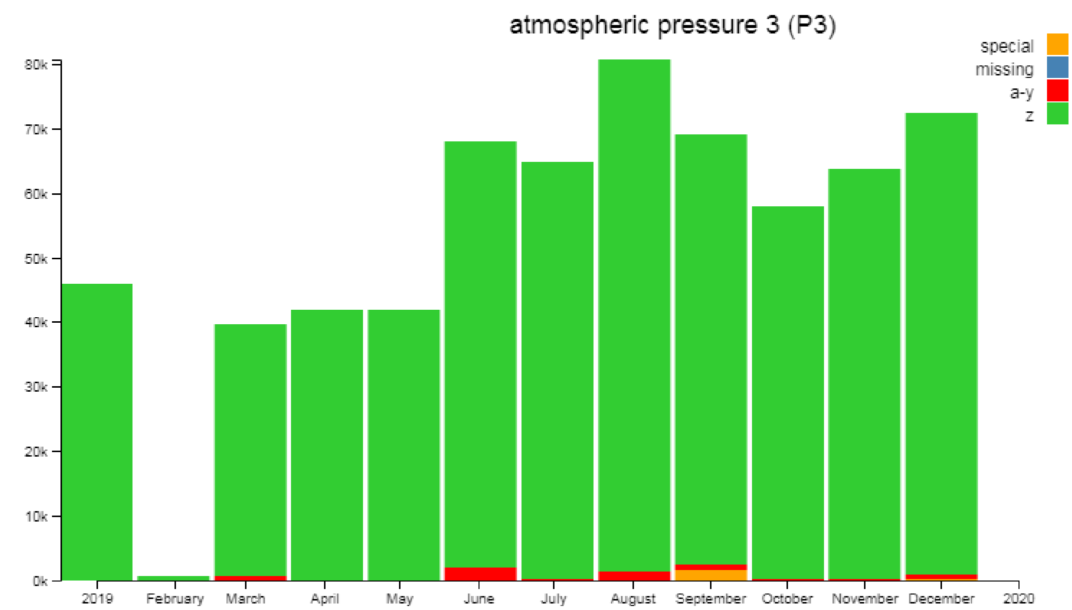


Figure 4: Total number of (this page) atmospheric pressure – P – (next page, top) atmospheric pressure 2 – P2 – and (next page, bottom) atmospheric pressure 3 – P3 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that 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)

Air temperature was also of decent quality (Figure 5). 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 in March seen in T was likely caused by *Pelican* and *Kilo Moana* experiencing simultaneous issues in data translation (documented; see individual vessel description in section 3c for details), while that seen in March and April in T2 was likely the *Sally Ride*, where damaged power cabling was found (documented; see individual vessel description in section 3c for details). The upticks seen April and May in T were likely caused by another two vessels experiencing issues simultaneously, in this case the *Oscar Elton Sette* with a sensor gone bad and the *Oscar Dyson* with an erroneous data offset (documented; see individual vessel description in section 3c for details). The upticks seen June through August in both T and T2 were again mainly *Sally Ride*, for an issue of unknown origin (documented; see individual vessel description in section 3c for details). The origins of any of the other major upticks are not clearly attributable to any specific vessel(s) but are likely due to several vessels simultaneously experiencing common sensor issues. We 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.

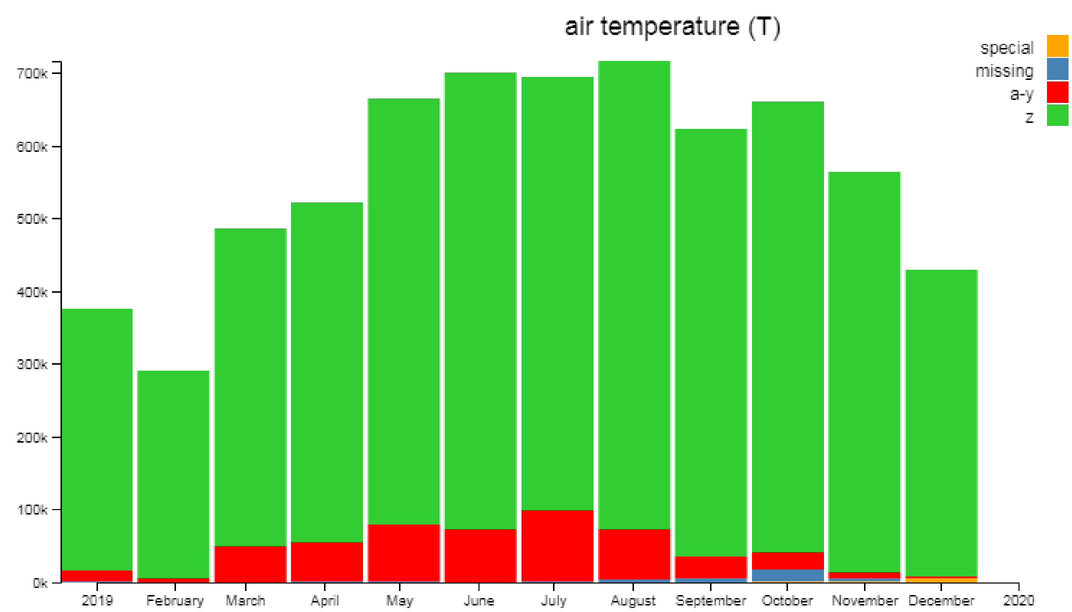
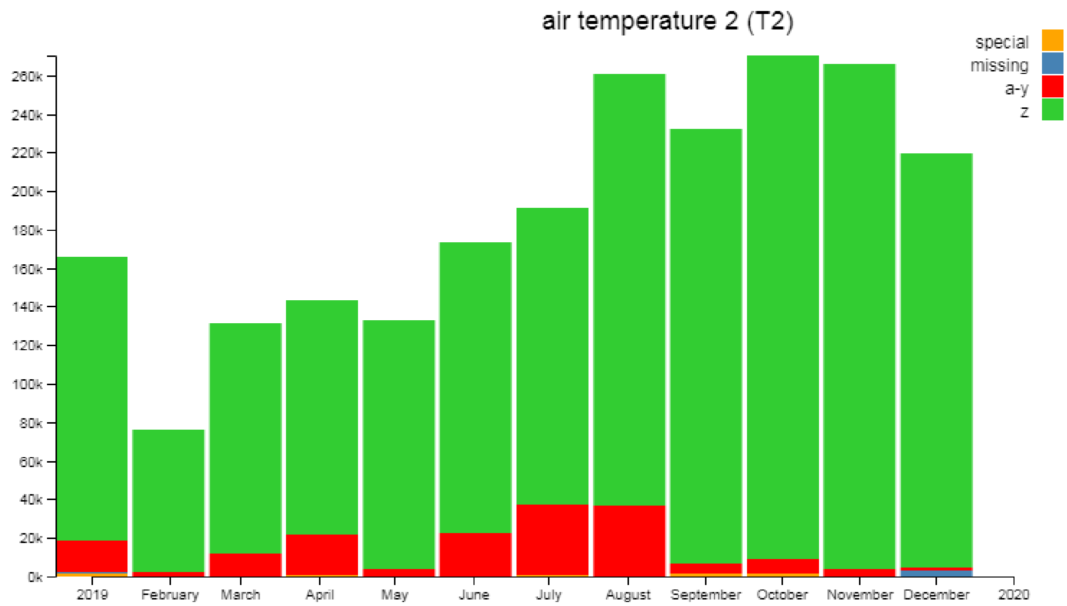
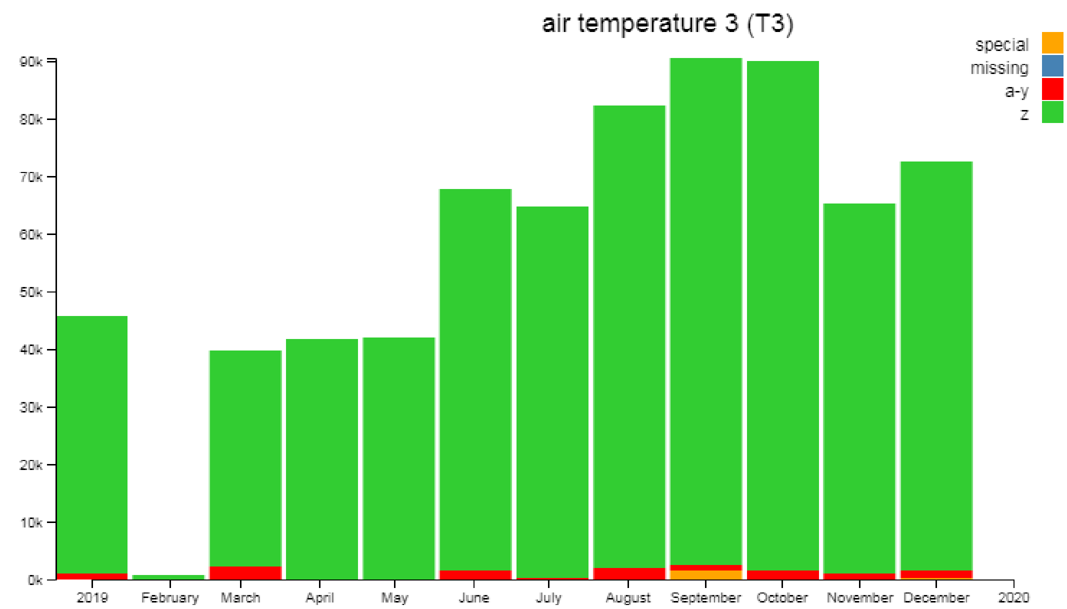


Figure 5: Total number of (this page) air temperature – T – (next page, top) air temperature 2 – T2 – and (next page, bottom) air temperature 3 – T3 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of 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)

Wet bulb temperature (Figure 6) was reported by only two vessels in 2019; 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 2019. Most flags were the result of flow obstruction and/or ship heating.

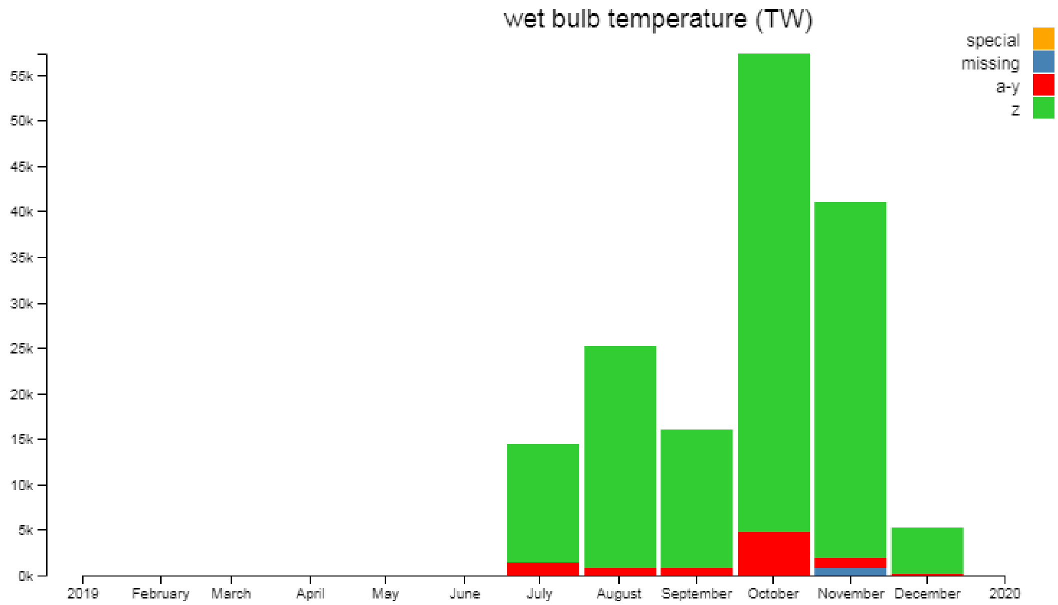


Figure 6: Total number of wet bulb temperature – TW – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

Dew point temperature (Figure 7) was also only reported by two vessels in 2019; again, the *Thomas Jefferson* and the *Okeanos Explorer*, although three additional vessels are currently set up to report dew point if they wish. (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 2019. Most flags were the result of flow obstruction and/or ship heating.

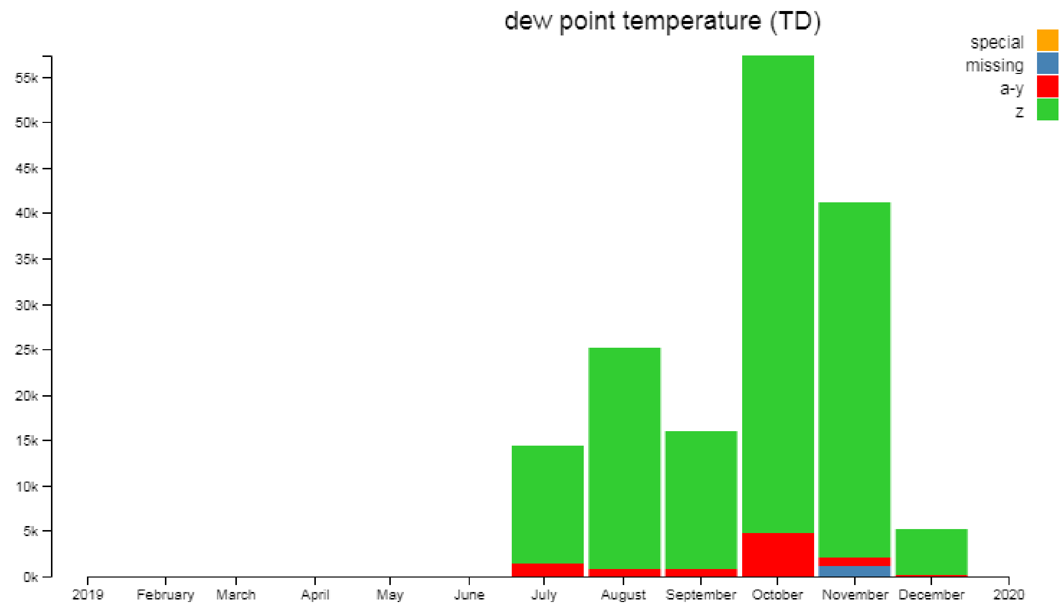
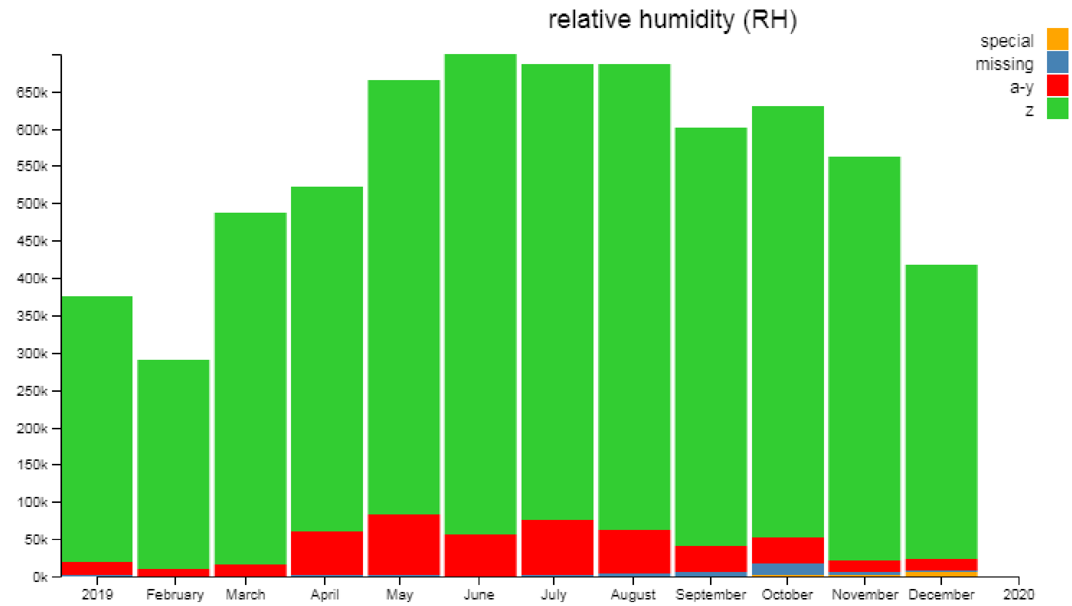


Figure 7: Total number of dew point temperature – TD – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are 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. 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 8.

The upticks in flagging in April and May seen in RH were likely caused by the *Oscar Elton Sette*, with a sensor gone bad, and the *Oscar Dyson*, with an erroneous data offset (documented; see individual vessel description in section 3c for details). The upticks in flagging in June through August seen in RH were due to the *Sally Ride* experiencing data issues of unknown origin (documented; see individual vessel description in section 3c for details). The uptick in October in RH was the *Reuben Lasker*, with another issue of unknown origin (documented; see individual vessel description in section 3c for details). The upticks in February, March, and December seen in RH2 look to have come from the *Investigator* and *Aurora Australis*. The details are not known. 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. We note only the *Falkor* reports RH3, so 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.



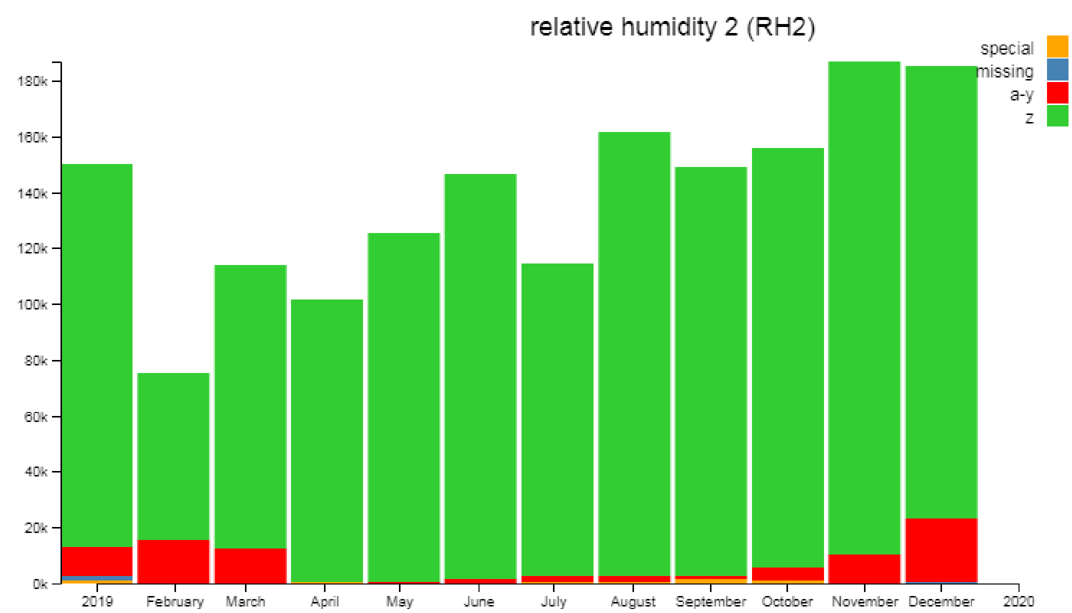
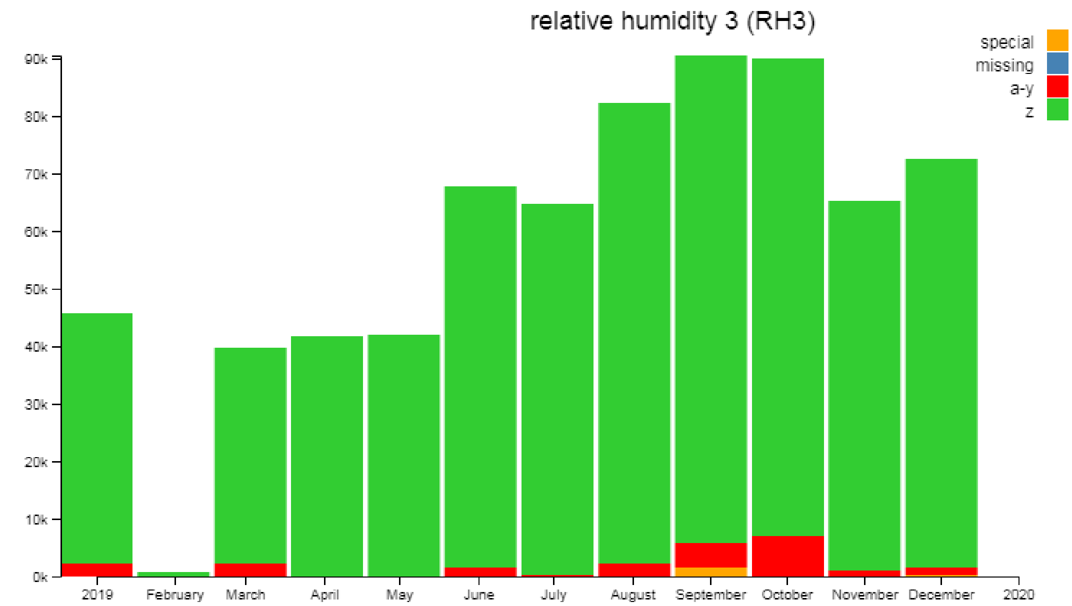


Figure 8: Total number of (this page, top) relative humidity – RH – (this page, bottom) relative humidity 2 – RH2 – and (next page) relative humidity 3 – RH3 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed 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.



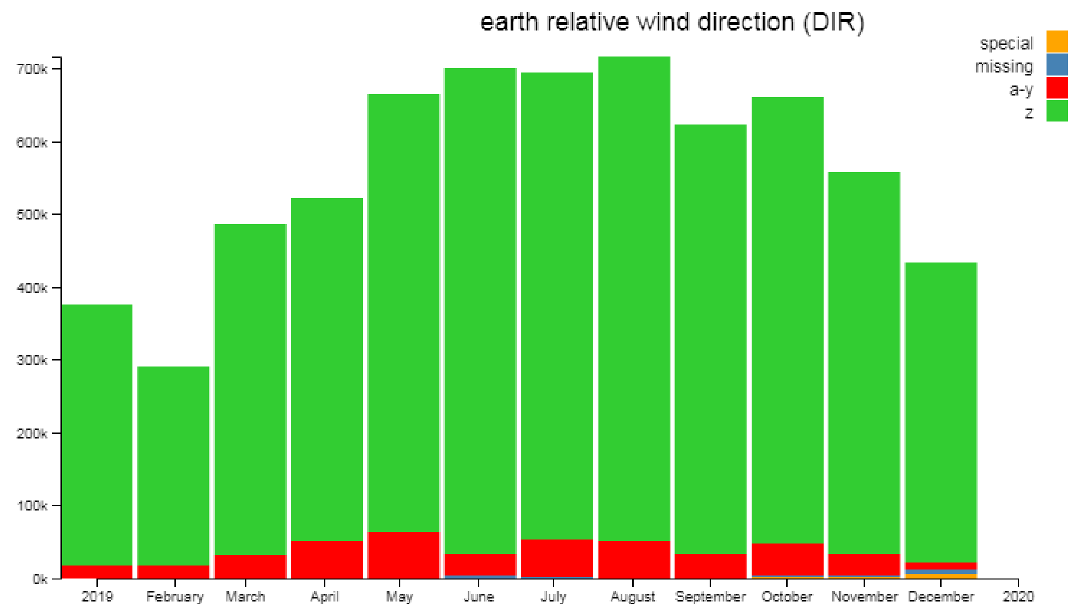
(Figure 8: cont'd)

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 2019. 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.

A number of vessels experienced issues with their primary wind sensors and/or data over the course of the year – the *Brown* in February through April, the *Pelican* in February through May, the *Bigelow* in March through May, the *Dyson* in April, the *Healy* in September through October, and the *Thomas Jefferson* in November (all documented;

see individual vessel description in section 3c for details). The origins of any of the other major upticks are not clearly attributable to any specific vessel(s) but are likely due to several vessels simultaneously experiencing common sensor issues.



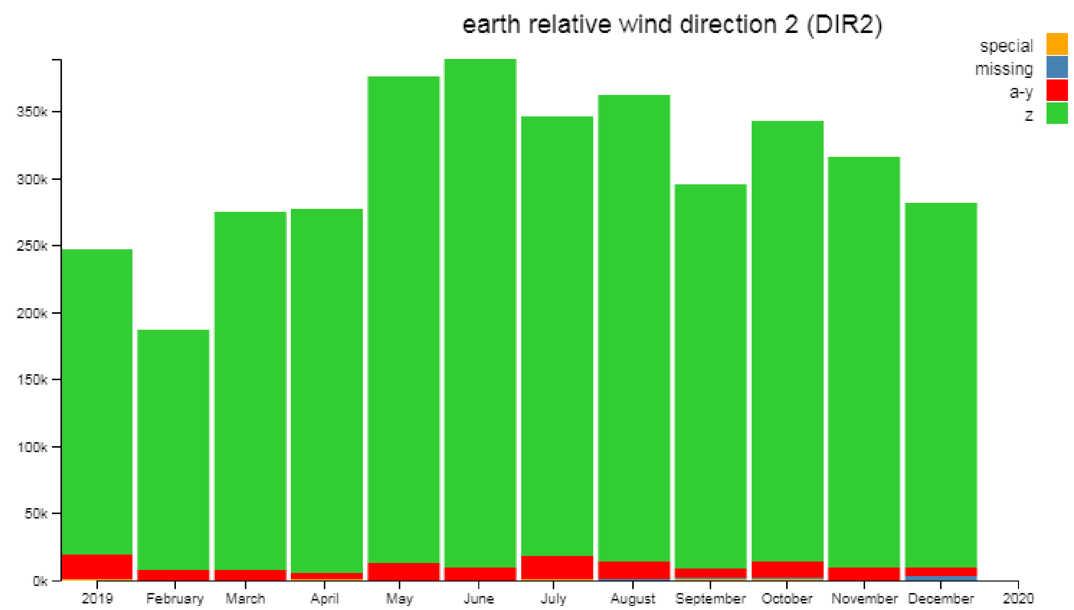
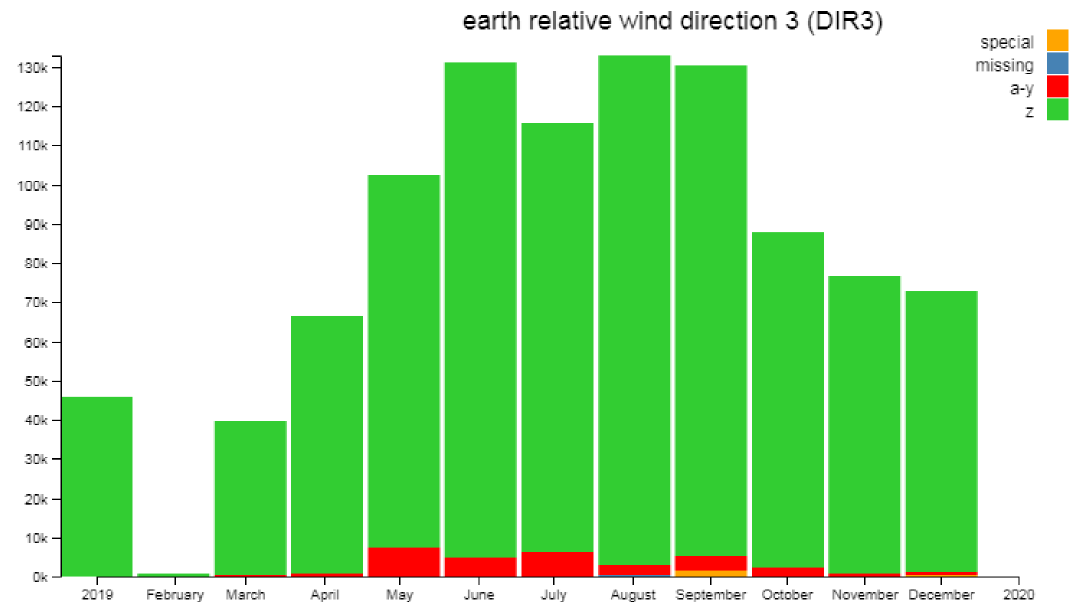


Figure 9: Total number of (this page, top) earth relative wind direction – DIR – (this page, bottom) earth relative wind direction 2 – DIR2 – and (next page) earth relative wind direction 3 – DIR3 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) 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)

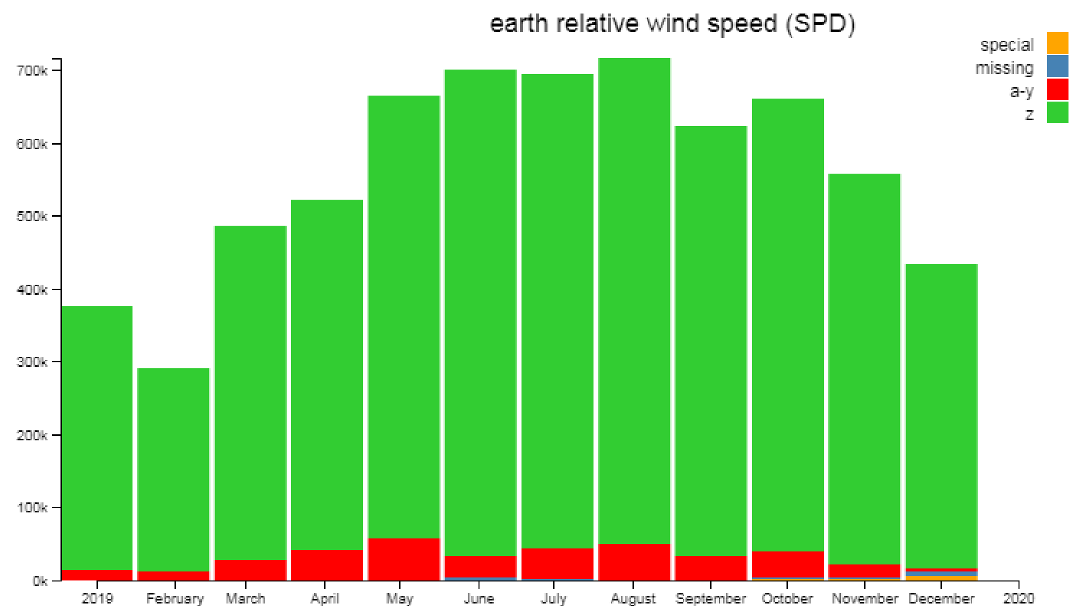
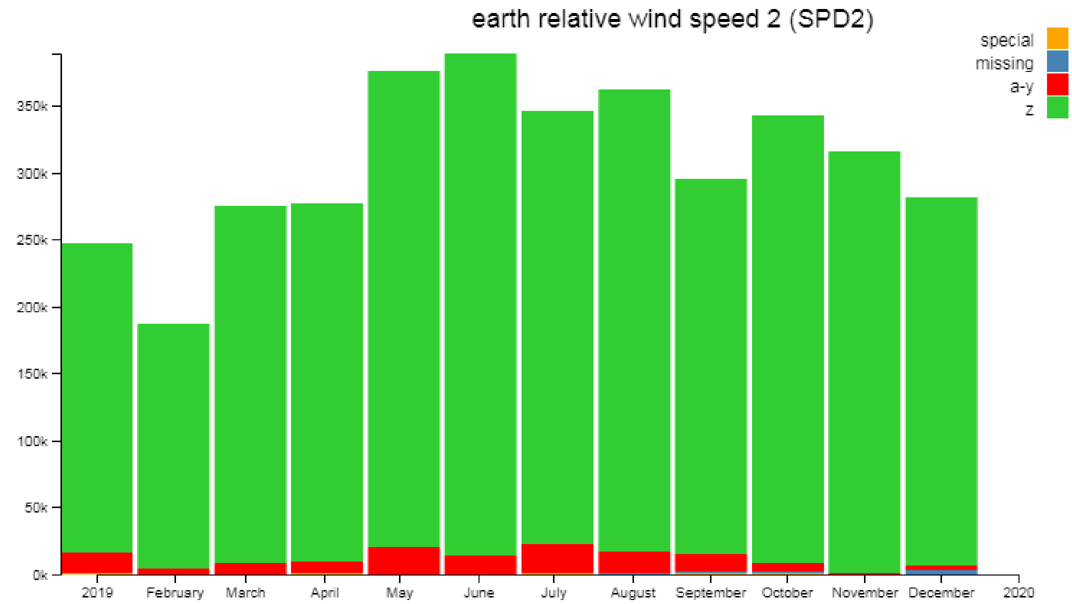
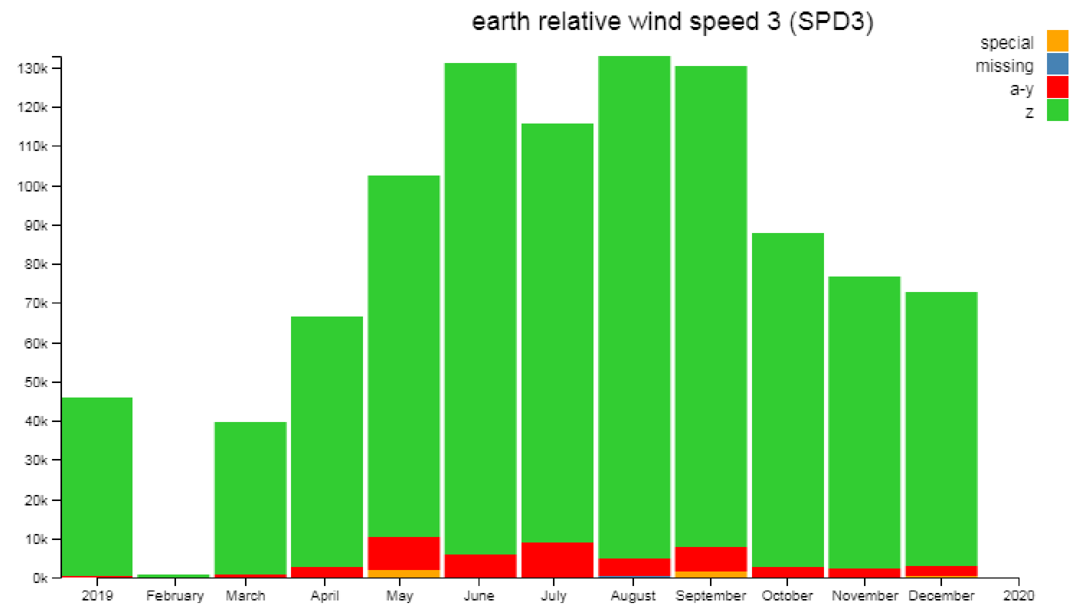


Figure 10: Total number of (this page) earth relative wind speed – SPD – (next page, top) earth relative wind speed 2 – SPD2 – and (next page, bottom) earth relative wind speed 3 – SPD3 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values 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)

Most of the flags applied to the radiation parameters were assigned by the auto flagger, primarily to short wave radiation (Figure 11). 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 12).

Much of the flagging seen in RAD_LW in March through April was likely due to the *Aurora Australis*, which experienced a sensor malfunction of unknown origin (documented; see individual vessel description in section 3c for details). Likewise, much of the flagging seen in RAD_LW in May through November was probably due to the *Thomas G. Thompson*, where there was an extended issue of unknown origin (documented; see individual vessel description in section 3c for details). The uptick in flagging in July seen in RAD_LW2 looks to have come from the *Investigator*, but the details there are not known. Any perceived upticks in flagging seen in RAD_SW or RAD_SW2 are not known to be attributable to any single vessel, but again these sensors often read negative at night so flagging is bound to be shared across multiple vessels in any given month. The uptick in flagging in January see in RAD_PAR looks to come from the *Roger Revelle* and the *Sally Ride*, and once again the details are not known. The uptick in December looks to come from the *Sikuliaq* and the *Neil Armstrong*; the details are not known there, either. Any other perceived upticks in flagging in the two PAR parameters are likely to be, again, shared across multiple vessels and, more than likely, for benign reasons. We note most of the missing and/or special values seen in RAD_PAR2 were from the *Falkor*. It is not known why.

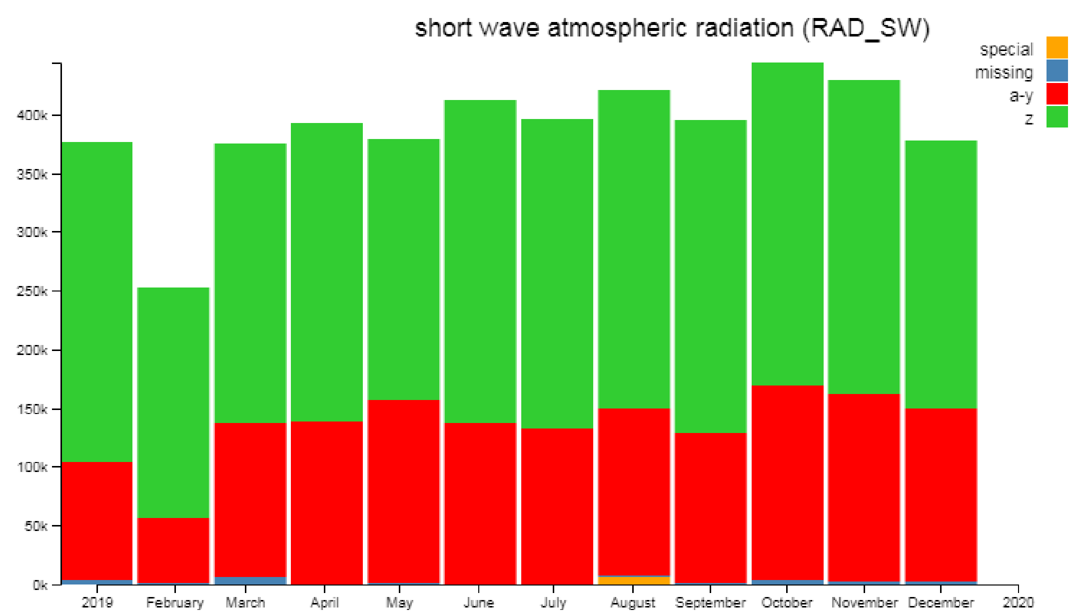
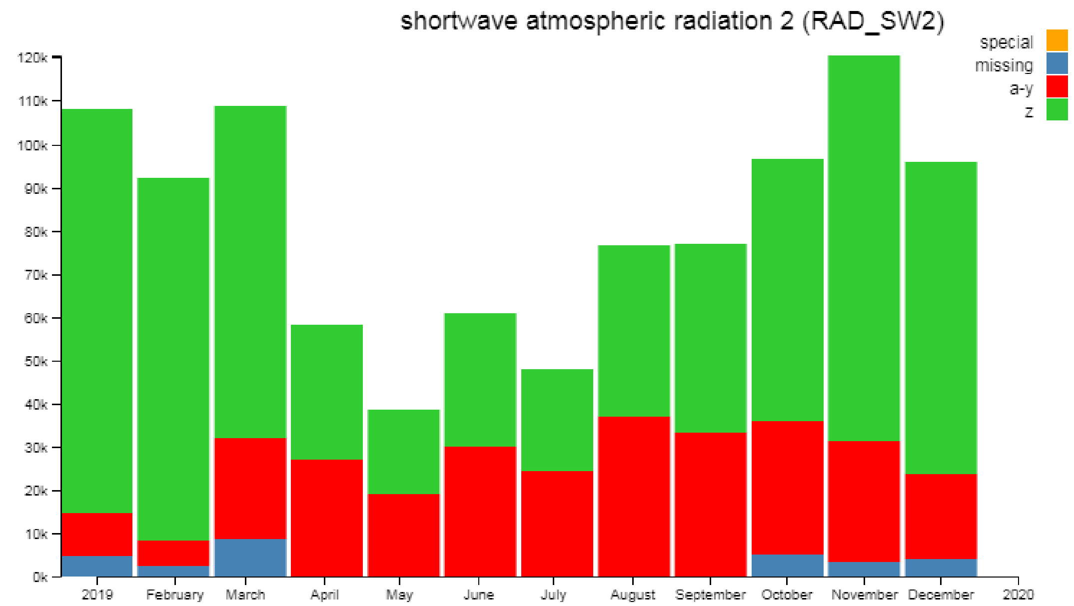


Figure 11: Total number of (this page) shortwave atmospheric radiation – RAD_SW – and (next page) shortwave atmospheric radiation 2 – RAD_SW2 –observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 11: cont'd)

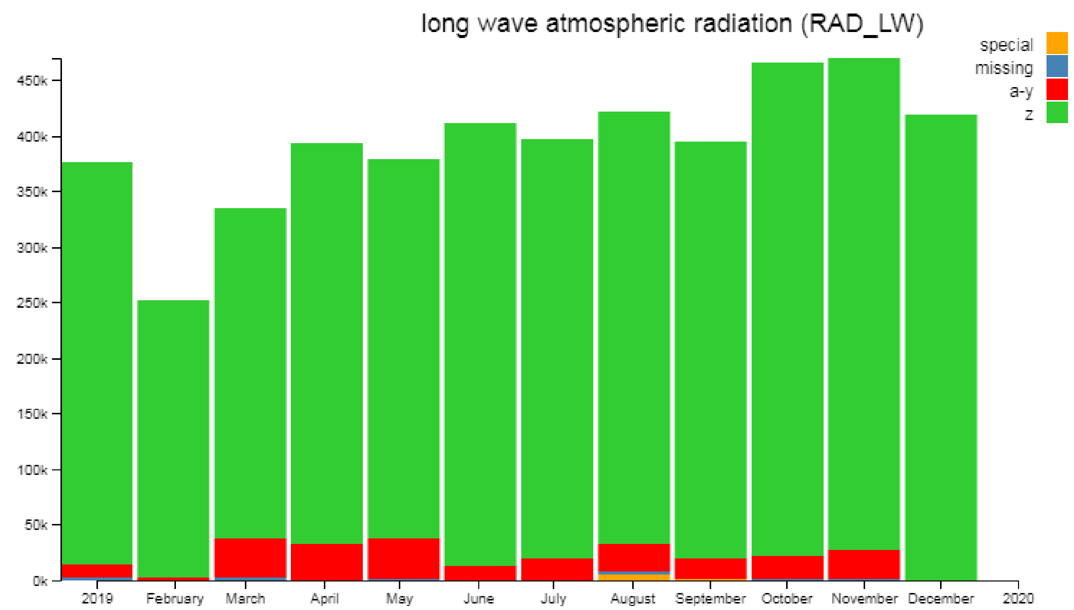
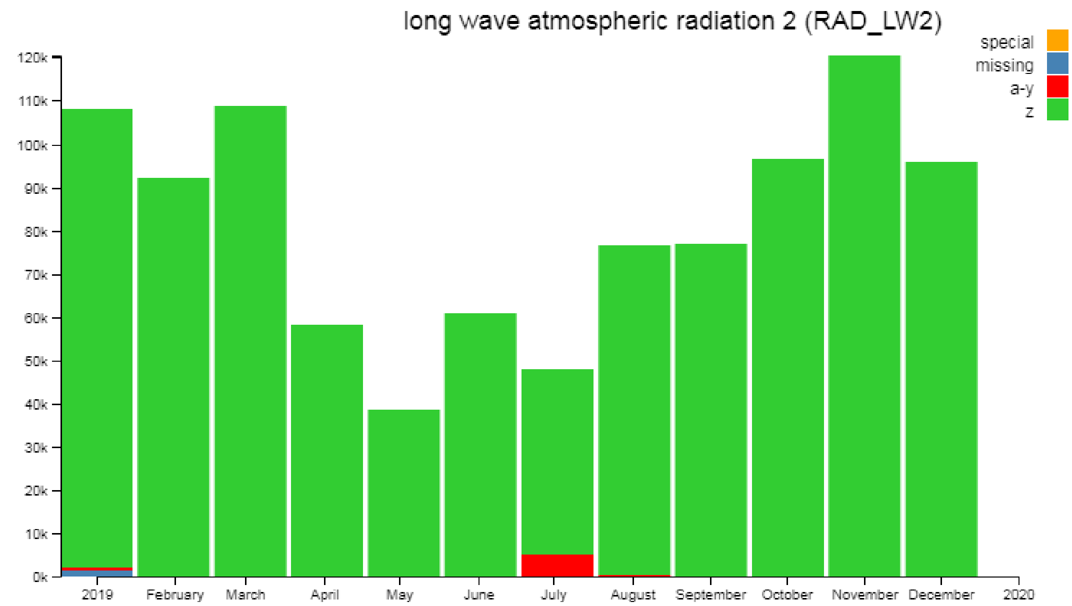


Figure 12: Total number of (this page) long wave atmospheric radiation – RAD_LW – and (next page) long wave atmospheric radiation 2 – RAD_LW2 –observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 12: cont'd)

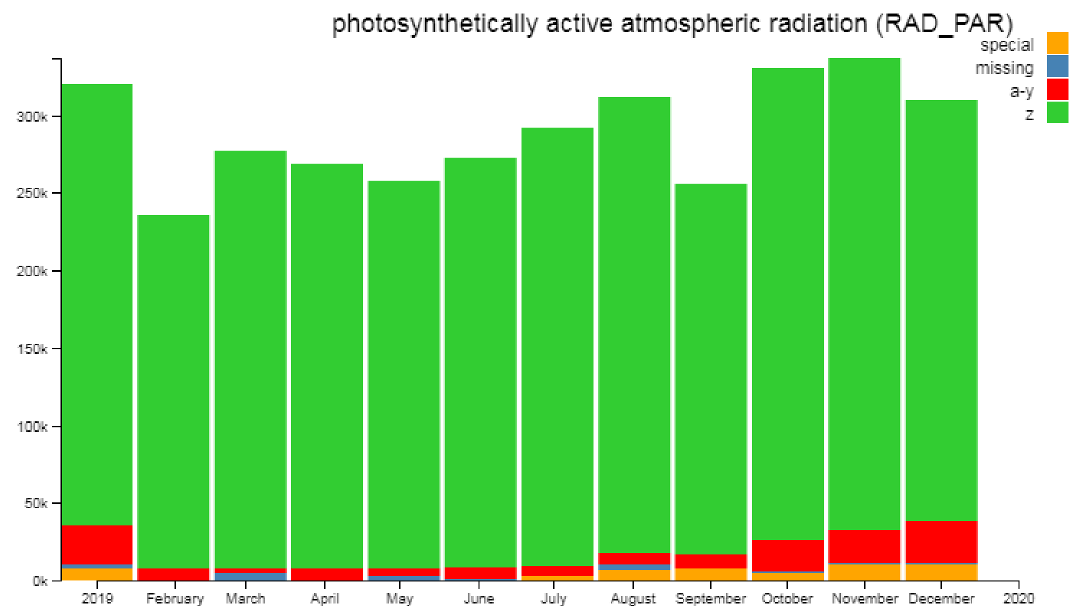
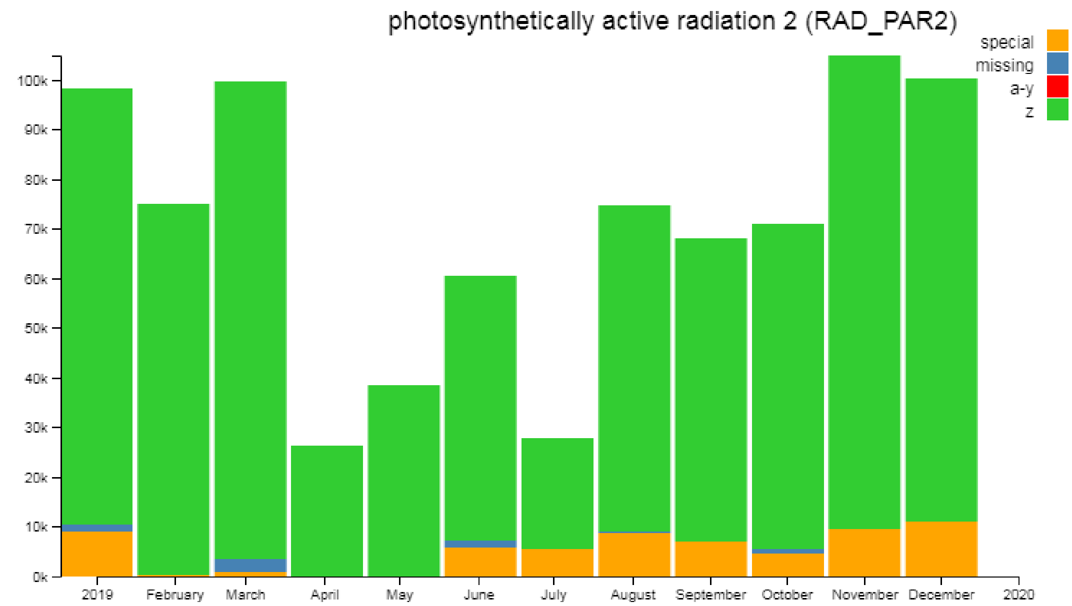


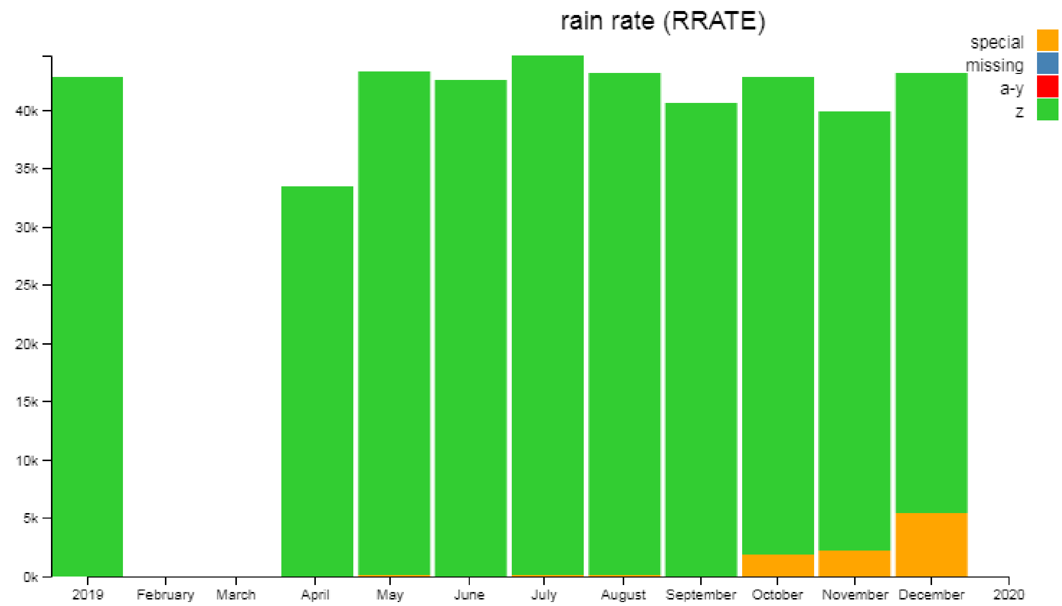
Figure 13: Total number of (this page) photosynthetically active atmospheric radiation – RAD_PAR – and (next page) photosynthetically active atmospheric radiation 2 – RAD_PAR2 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the 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)

There were no major problems of note with either the rain rate (Figure 14) or precipitation accumulation (Figure 15) parameters. It should be noted 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. Likewise, only the *Atlantis* provides PRECIP3, so the special values seen in September there are all hers. No details are known about any of these special value situations, although we note both *Atlantis* and *Neil Armstrong* commonly transmit port data, which could be a contributing factor.



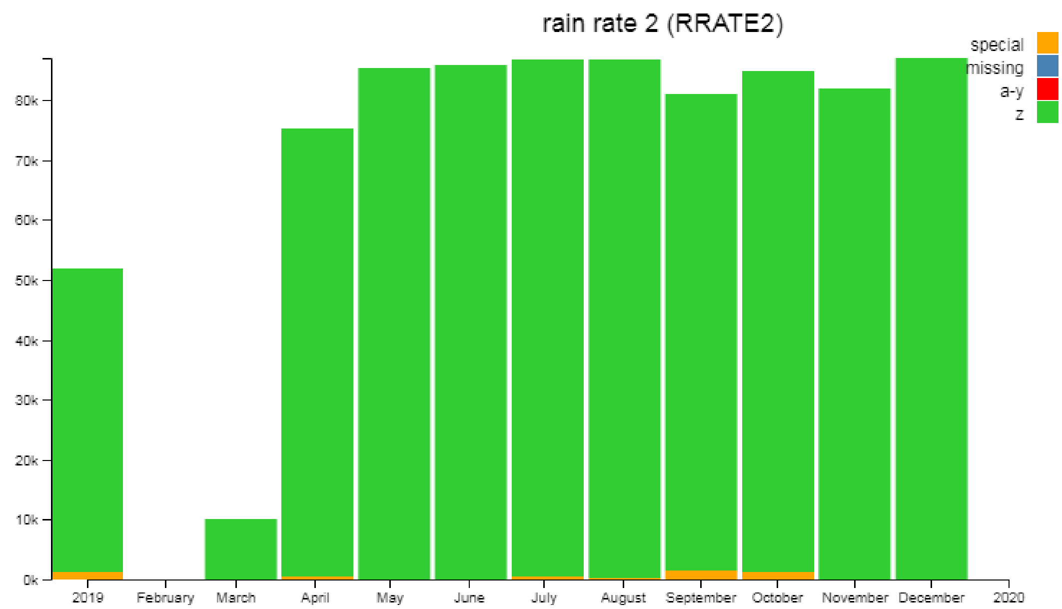
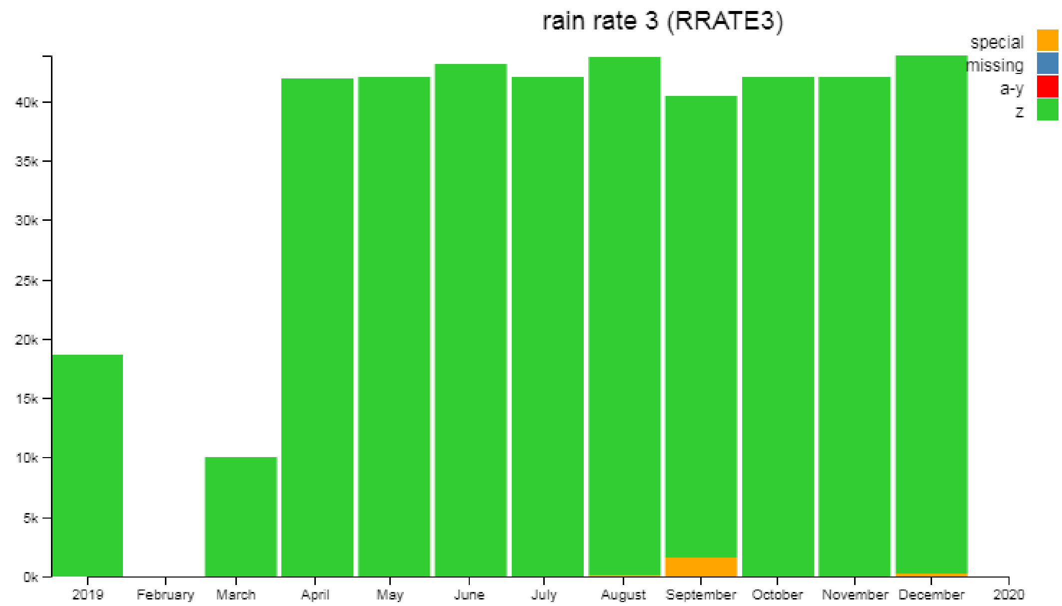


Figure 14: Total number of (this page, top) rain rate – RRATE – (this page, bottom) rain rate 2 – RRATE2 – and (next page) rain rate 3 – RRATE3 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the 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)

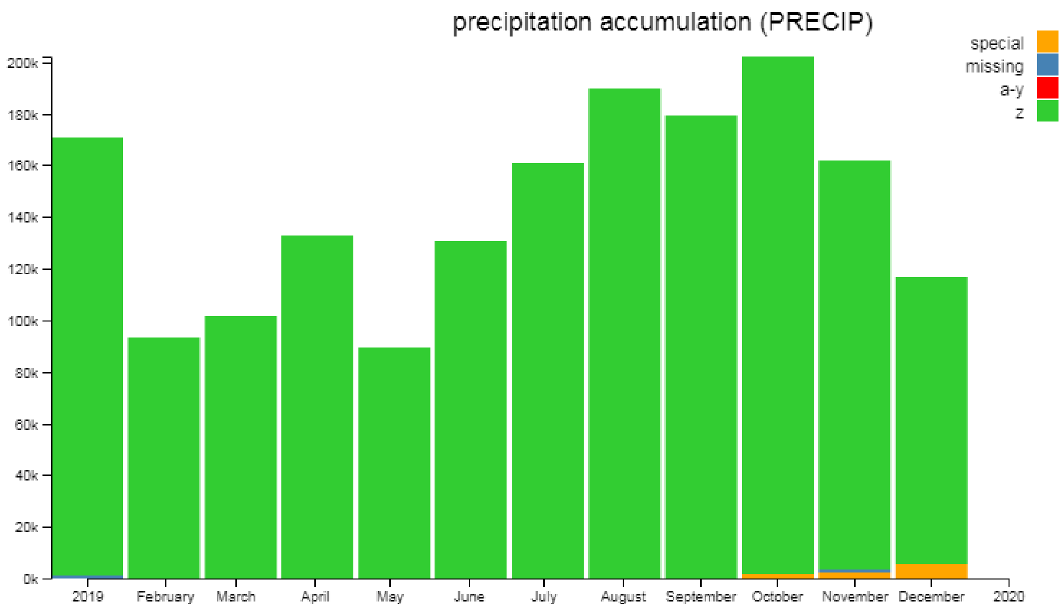
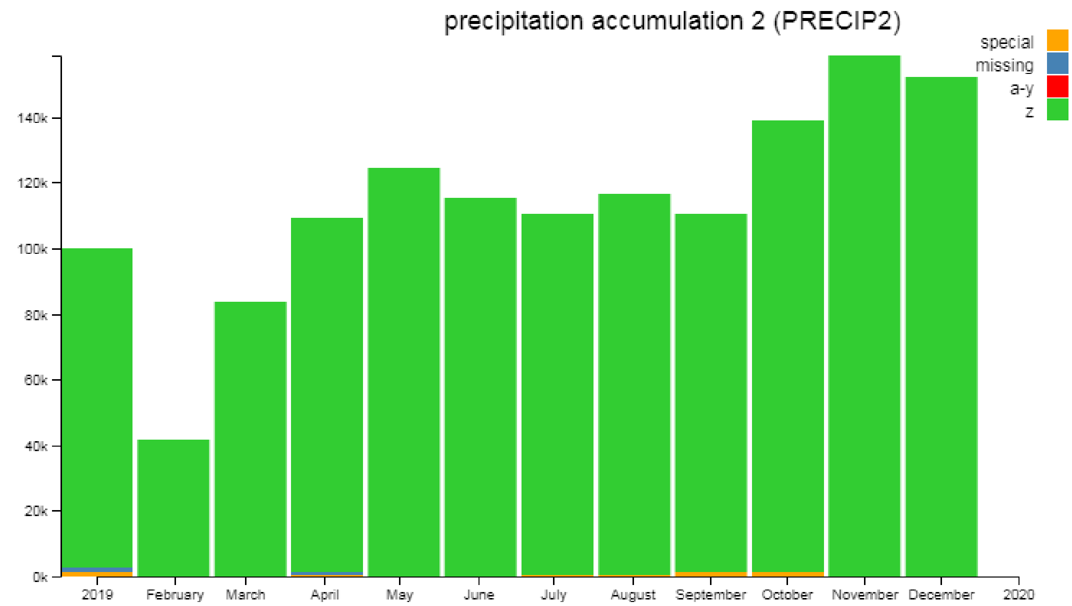
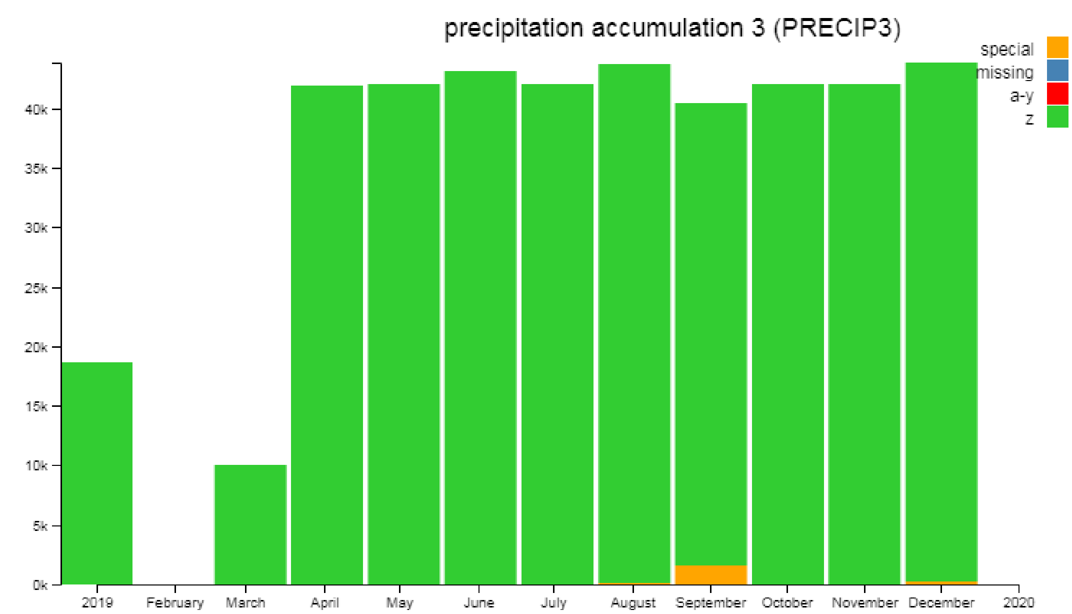


Figure 15: Total number of (this page) precipitation accumulation – PRECIP – (next page, top) precipitation accumulation 2 – PRECIP2 – and (next page, bottom) precipitation accumulation 3 – PRECIP3 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) 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 main problem identified with the sea temperature parameter (Figure 16) occurs when the sensor is denied a continuous supply of seawater. In these situations, 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 2019. We will note, however, that it's become clear intermittent air bubbling/pocketing in a sea chest or within the internal sea water channel is not an uncommon problem.

The *Oregon II* experienced a documented issue with TS in October/November (see individual vessel description in section 3c for details), and the *Ronald Brown* experienced the aforementioned air pocketing issue with TS2 in early March, so any associated upticks in flagging seen in Figure 16 are at least partly due to each of those vessels. But the origins of any of the other flagging in TS and TS2 are not clearly attributable to any specific vessel(s) thus are likely due to several vessels simultaneously experiencing common sensor issues. Only the *Roger Revelle*, *Healy*, and *Oscar Dyson* provide TS3, and only the *Dyson* provides TS4 and TS5, so any flagging seen in those parameters is limited to those three vessels. However, it isn't clear any of the upticks are specific to any one vessel. We note, again, most flags applied to sea temperature parameters are incurred for benign in-port reasons.

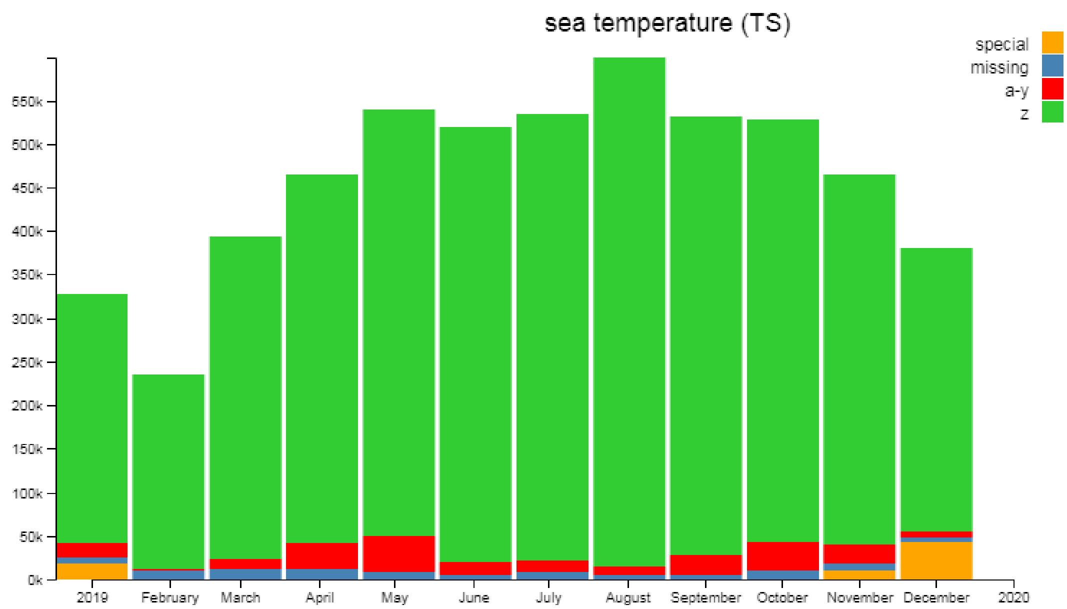
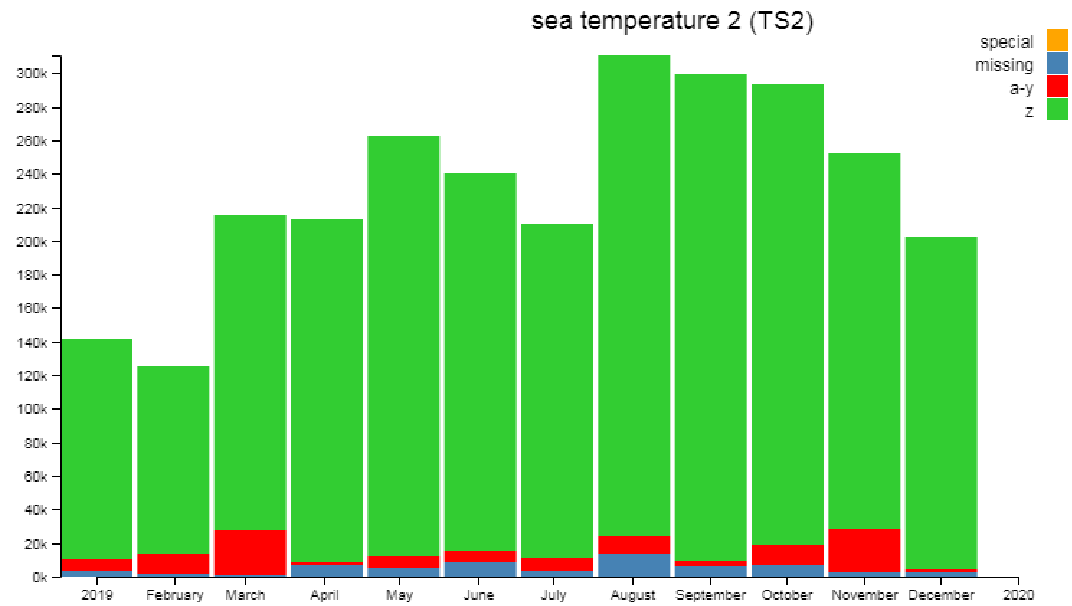
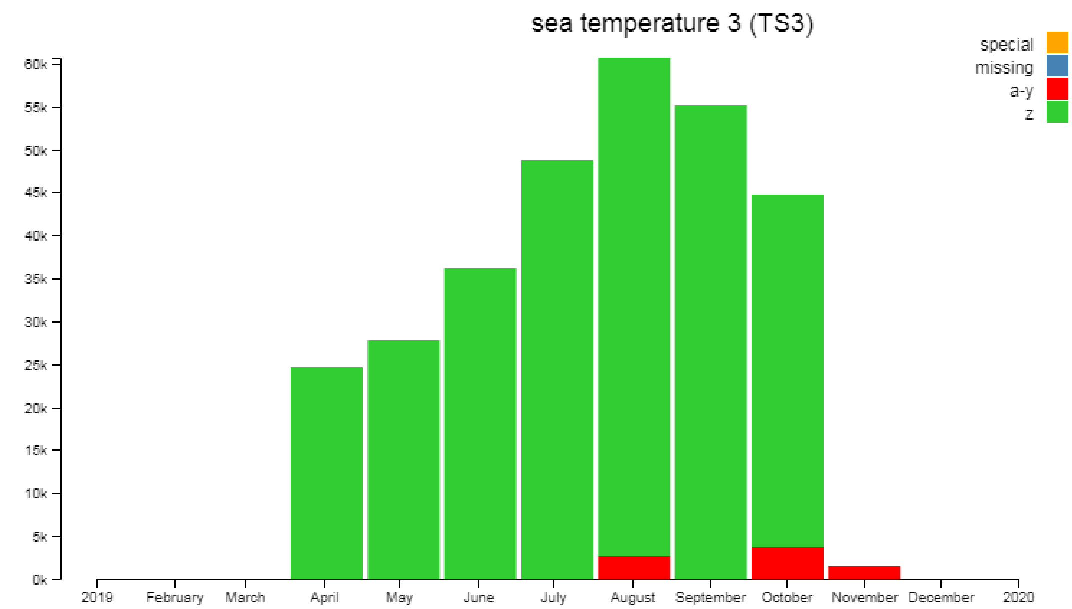
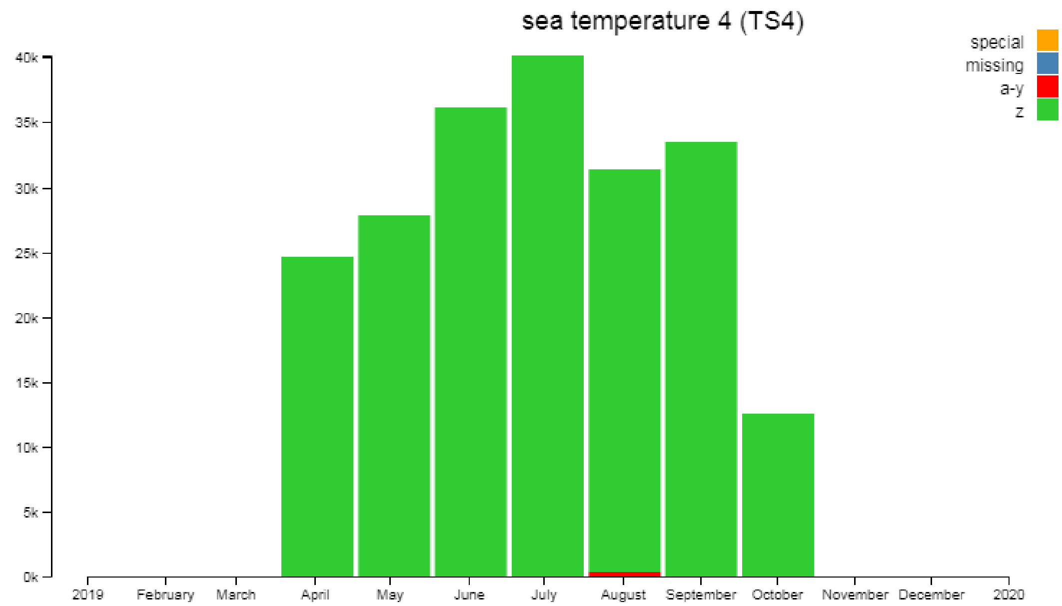


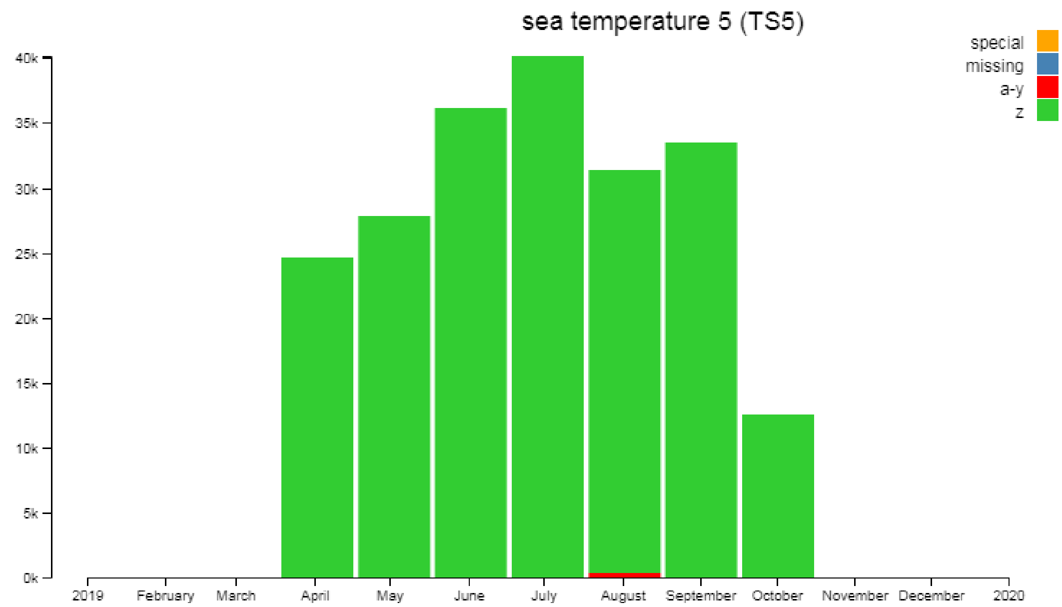
Figure 16: Total number of (this page) sea temperature – TS – (next page, top) sea temperature 2 – TS2 – (next page, bottom) sea temperature 3 – TS3 – (third page, top) sea temperature 4 – TS4 – (third page, bottom) and sea temperature 5 – TS5 – observations provided by all ships for each month in 2019. 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 16: cont'd.)

Salinity and conductivity (Figures 17 and 18, 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. Similar to 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. Despite these issues, though, salinity and conductivity data in 2019 were still reasonably good.

The flagging in April seen in CNDC is likely heavily influenced by the *Oregon* reporting CNDC in unexpected data units for a short while (documented; see individual vessel description in section 3c for details). The origins of any other flagging seen in SSPS and CNDC are not clearly attributable to any specific vessel(s) but are likely due to several vessels simultaneously experiencing common sensor issues as laid out above. There was a known issue of unknown origin for CNDC2 lasting January through March on the *Roger Revelle* (documented; see individual vessel description in section 3c for details), which entirely captures the a-y flagging for that parameter seen in those months. The flagging seen in SSPS2 in March is also entirely due to the *Revelle*, and while the details here are not known it is surmised there was a connection with the CNDC2 issue. Only the *Healy* provided SSPS2 and CNDC2 in July through November. As such, all the associated flagging is hers, although the source(s) in this case is/are not known.

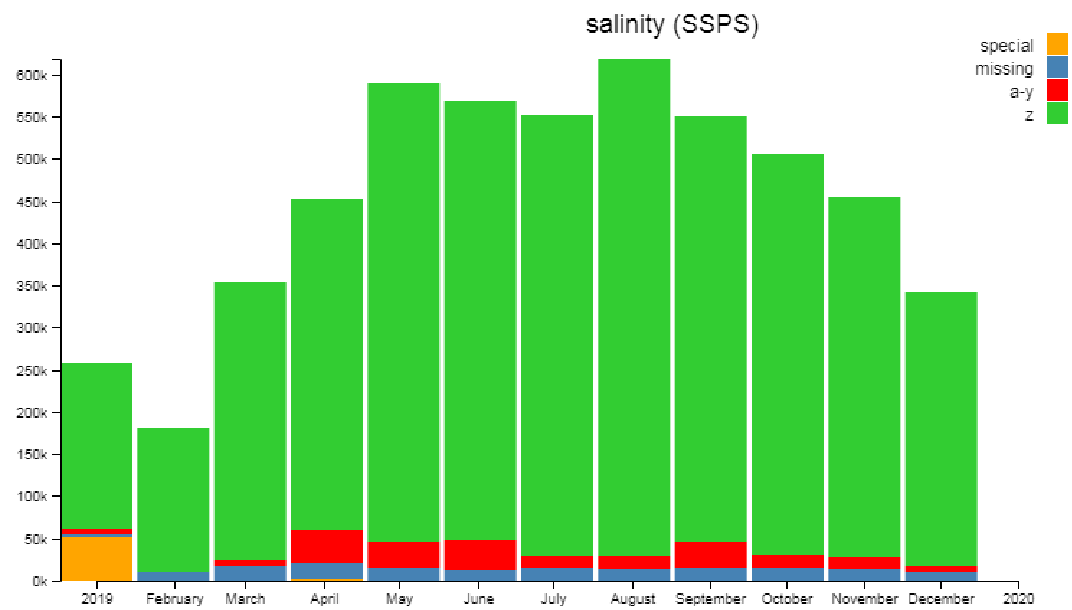
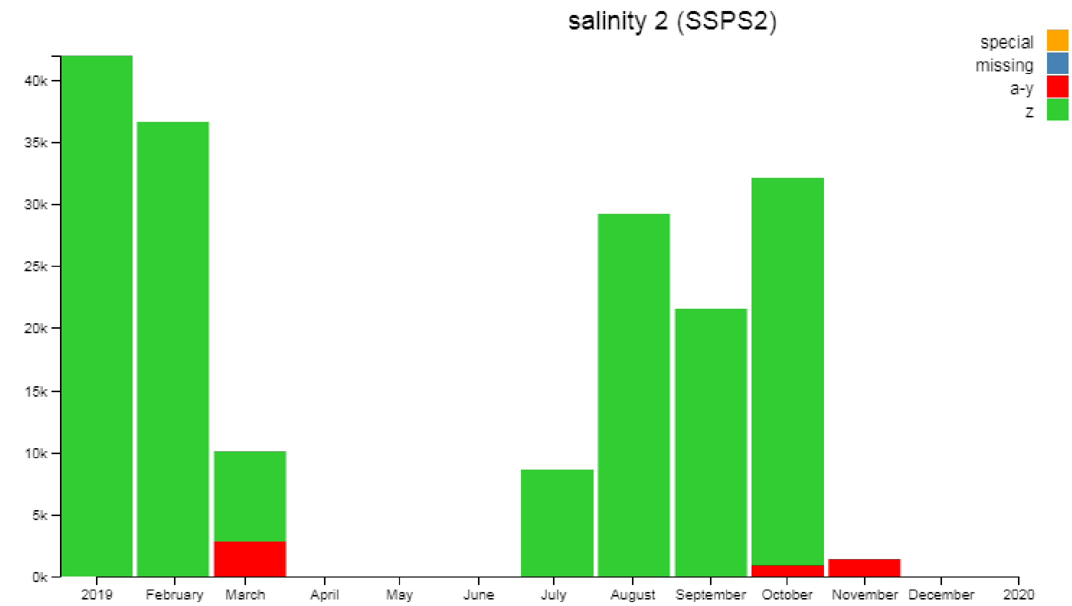


Figure 17: Total number of (this page) salinity – SSPS – and (next page) salinity 2 – SSPS2 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 17: cont'd.)

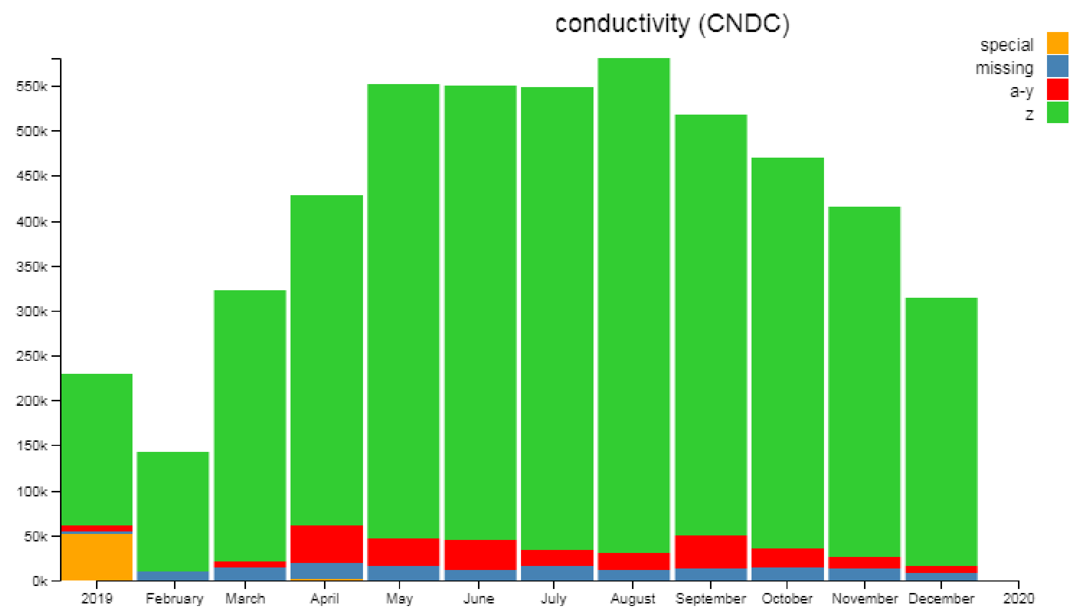
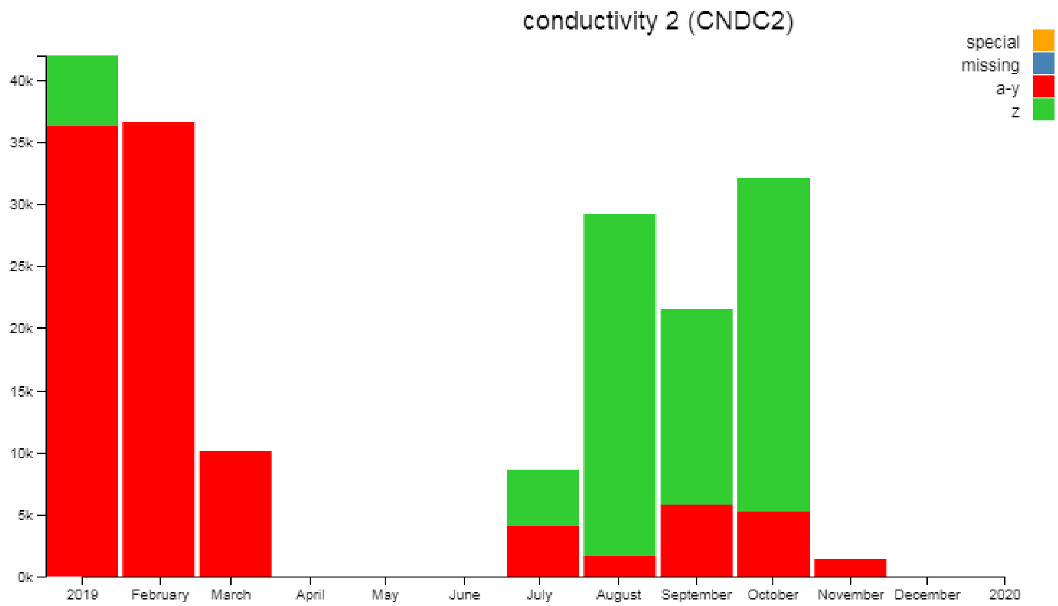
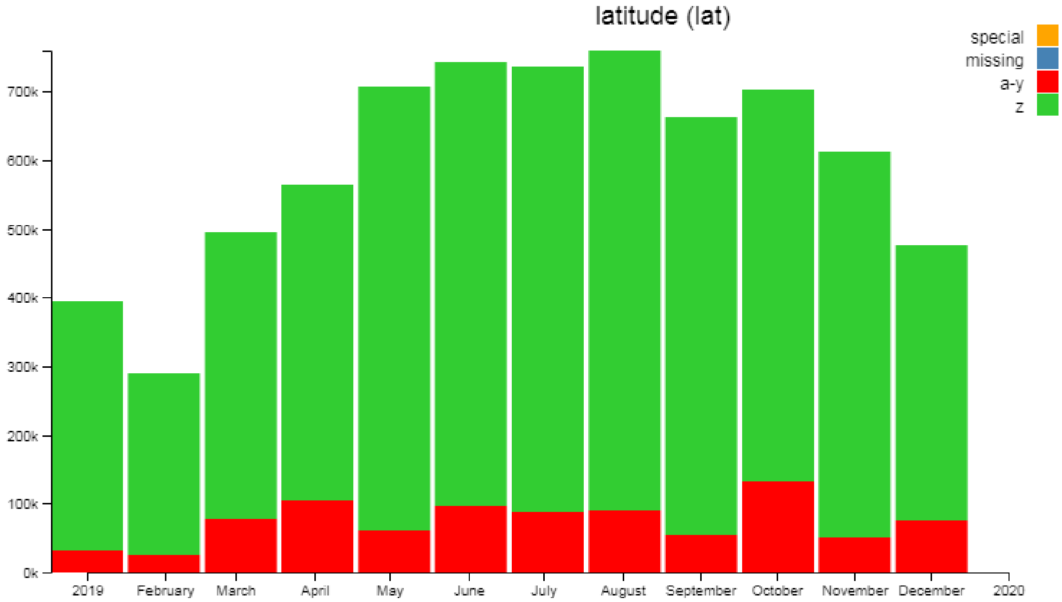


Figure 18: Total number of (this page) conductivity – CNDC – and (next page) conductivity 2 – CNDC2 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 18: cont'd.)

Latitude and longitude (Figure 19) 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 (although for non-visual QC ships this step is not taken). 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 2019.



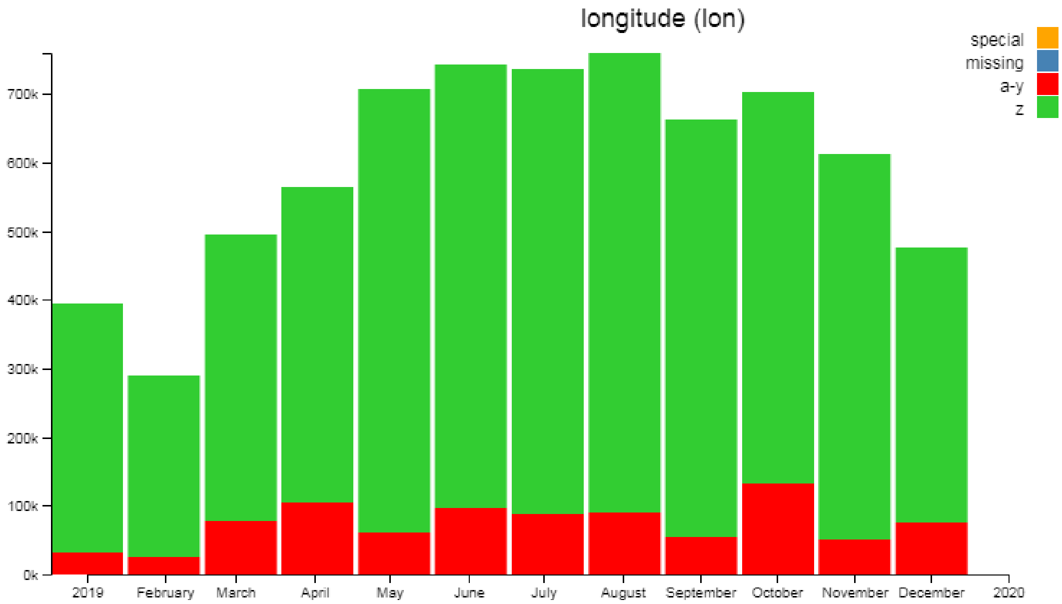


Figure 19: Total number of (top) latitude – LAT – and (bottom) longitude – LON – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

The remainder of the navigational parameters exhibited no real problems of note. They are nevertheless included for completeness: platform heading (Figure 20), platform course (Figure 21), platform speed over ground (Figure 22), and platform speed over water (Figure 23).

All the special values seen in PL_SOW appear to have come from the *Neil Armstrong*, though it is not known why. Only the *Sikuliaq*, *Henry Bigelow*, and *Okeanos Explorer* report PL_SOW2, and the special and missing values seen for that parameter seem to be spread across all three vessels.

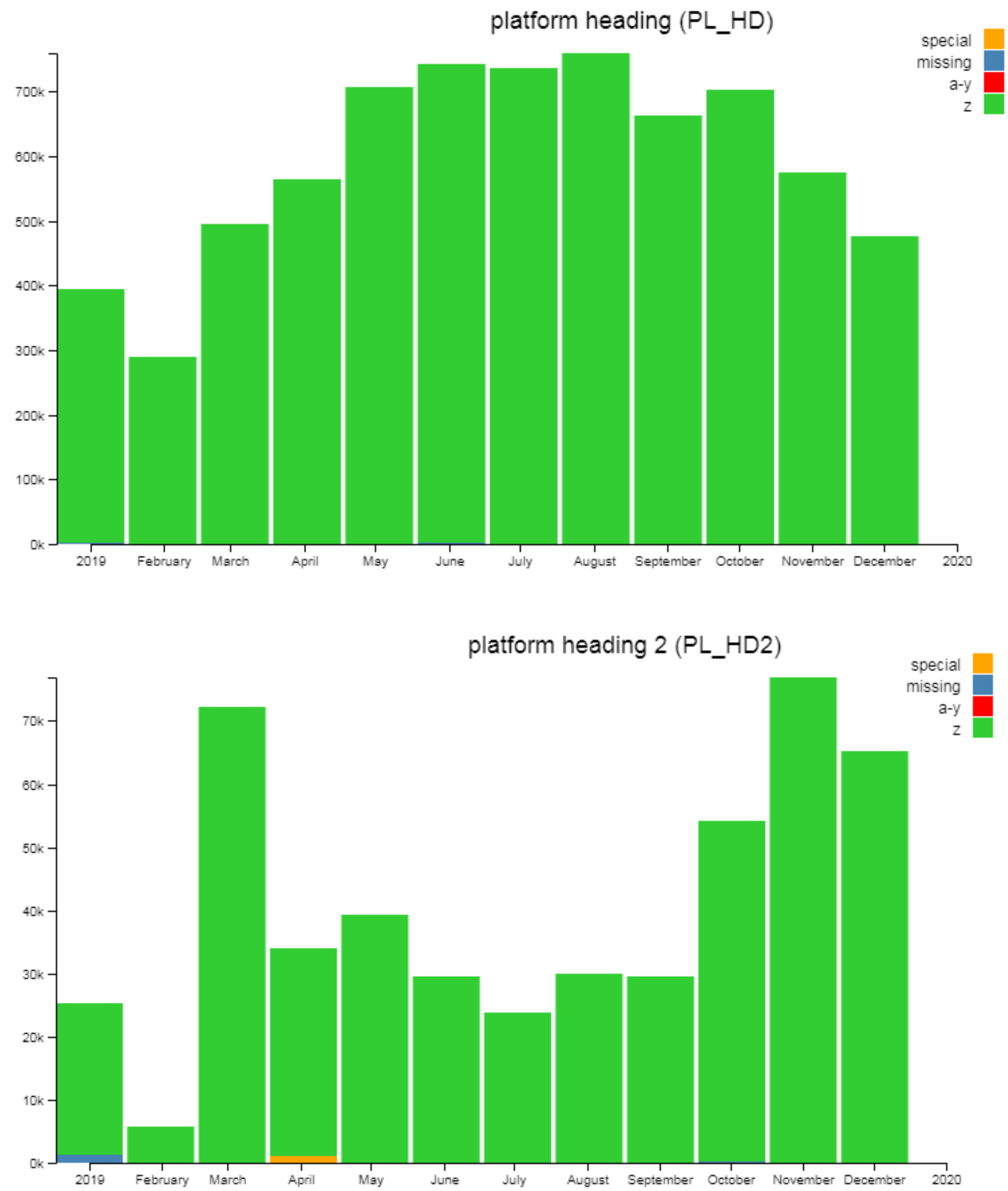


Figure 20: Total number of (top) platform heading – PL_HD – and (bottom) platform heading 2 – PL_HD2 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

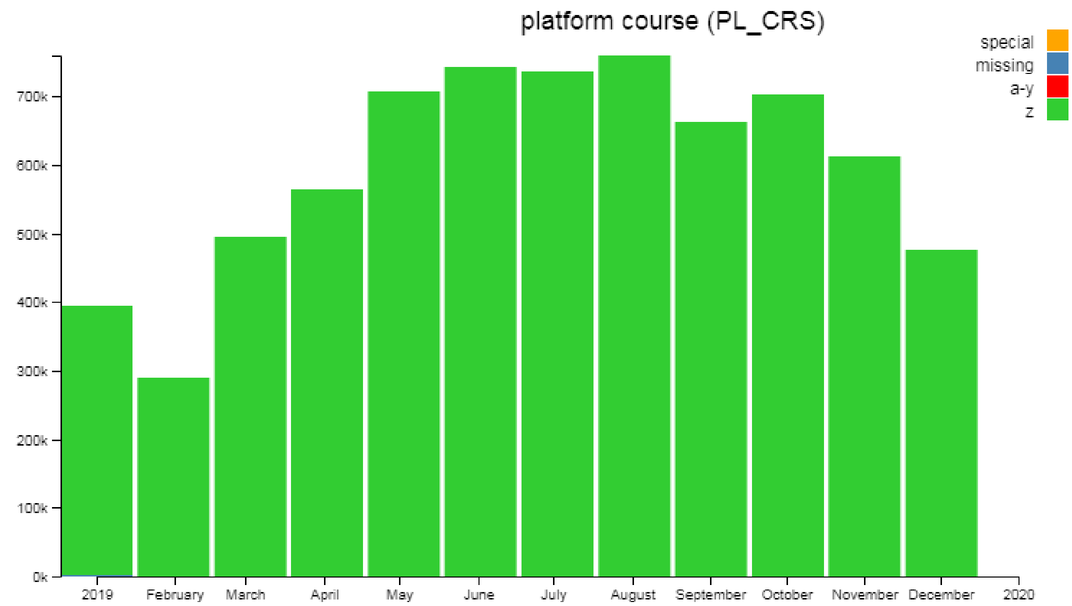


Figure 21: Total number of platform course – PL_CRS –observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

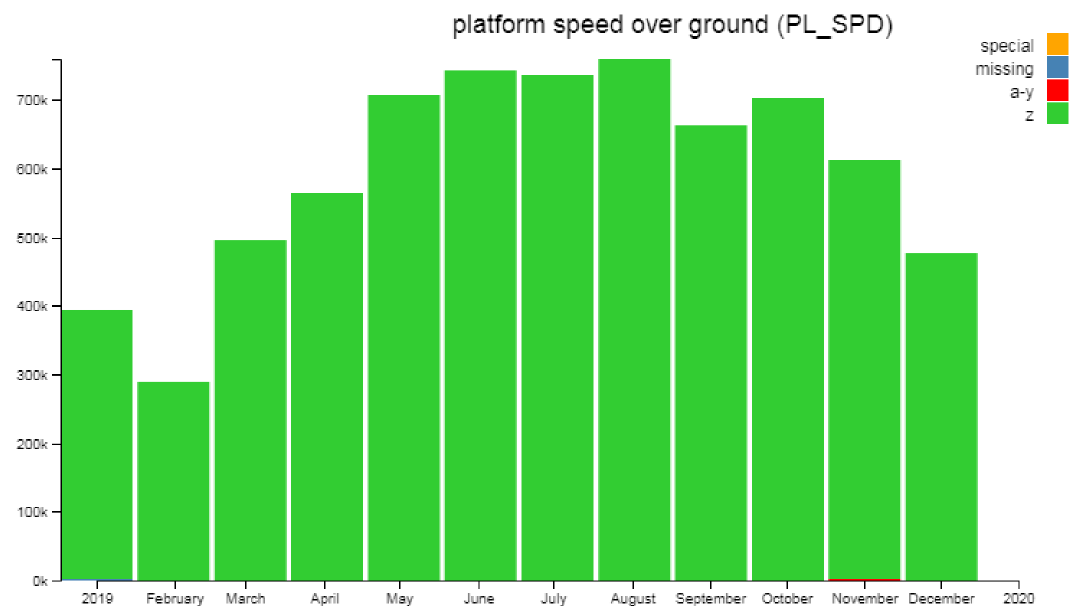
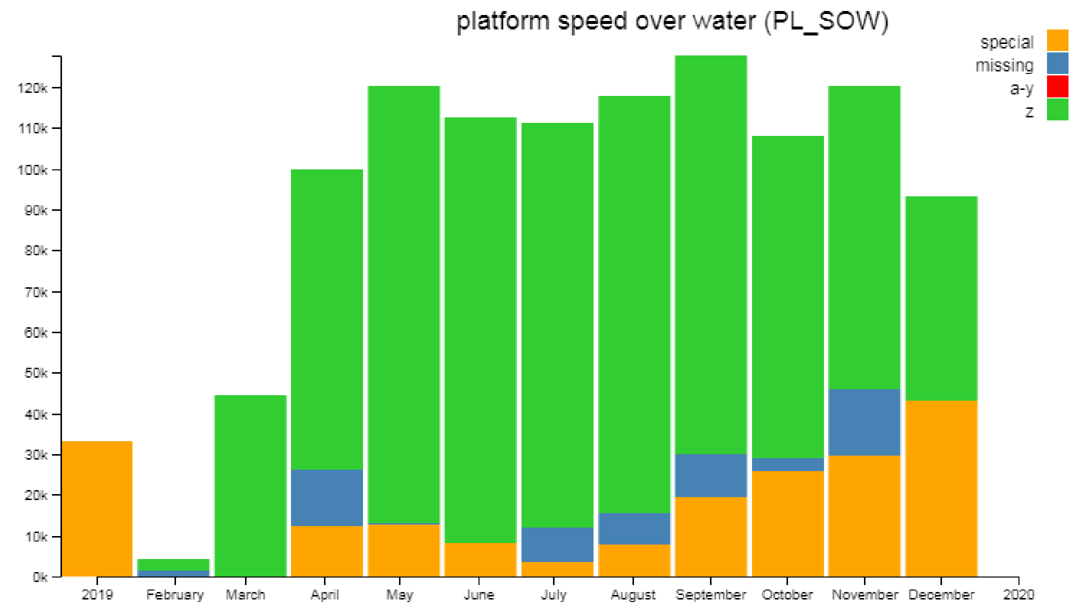


Figure 22: Total number of platform speed over ground – PL_SPD –observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



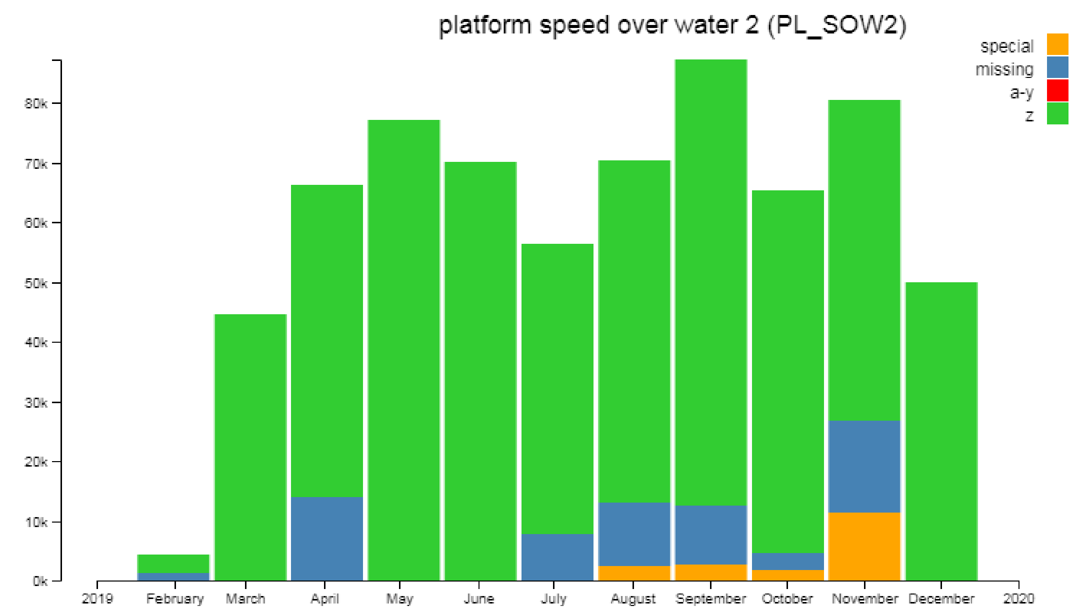
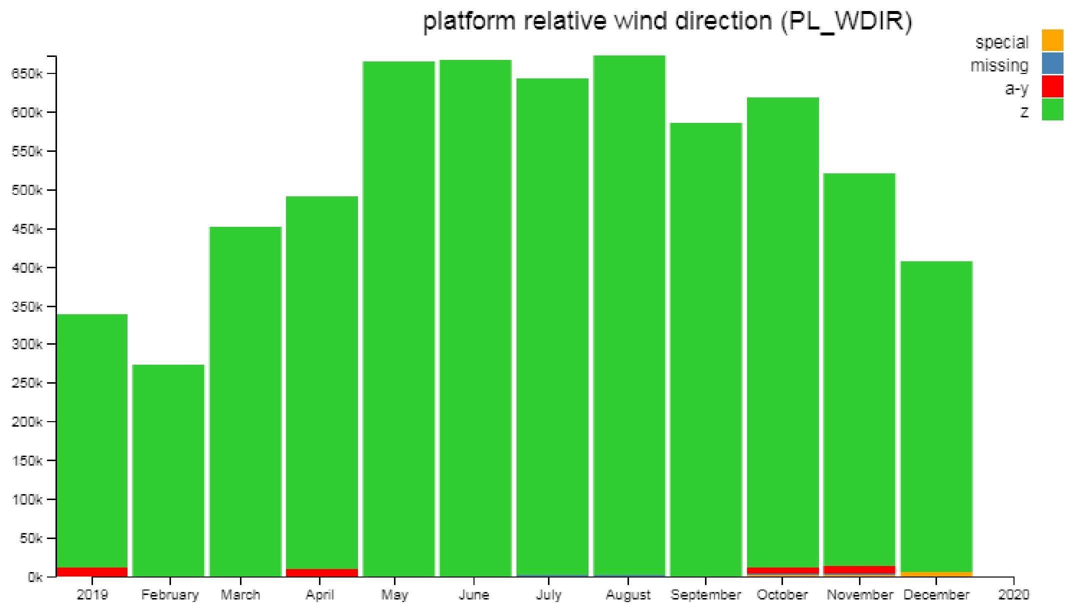


Figure 23: Total number of (top) platform speed over water – PL_SOW – and (bottom) platform speed over water 2 – PL_SOW2 observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

The platform relative wind parameters, both direction (Figure 24) and speed (Figure 25), also exhibited no major problems of note, save that a few rare sensor and/or connectivity failures occurred. These 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.



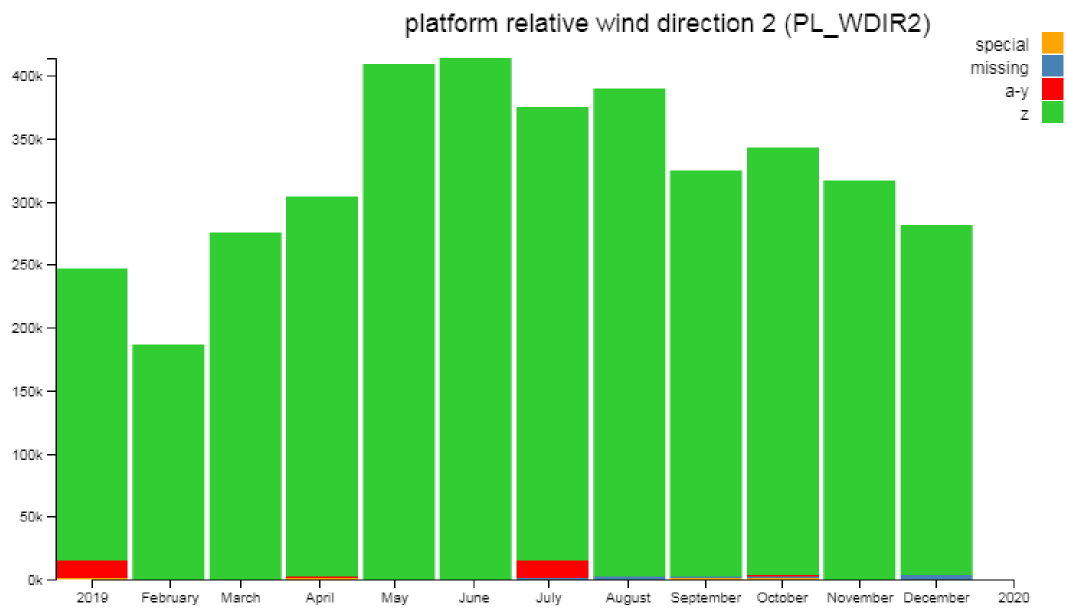
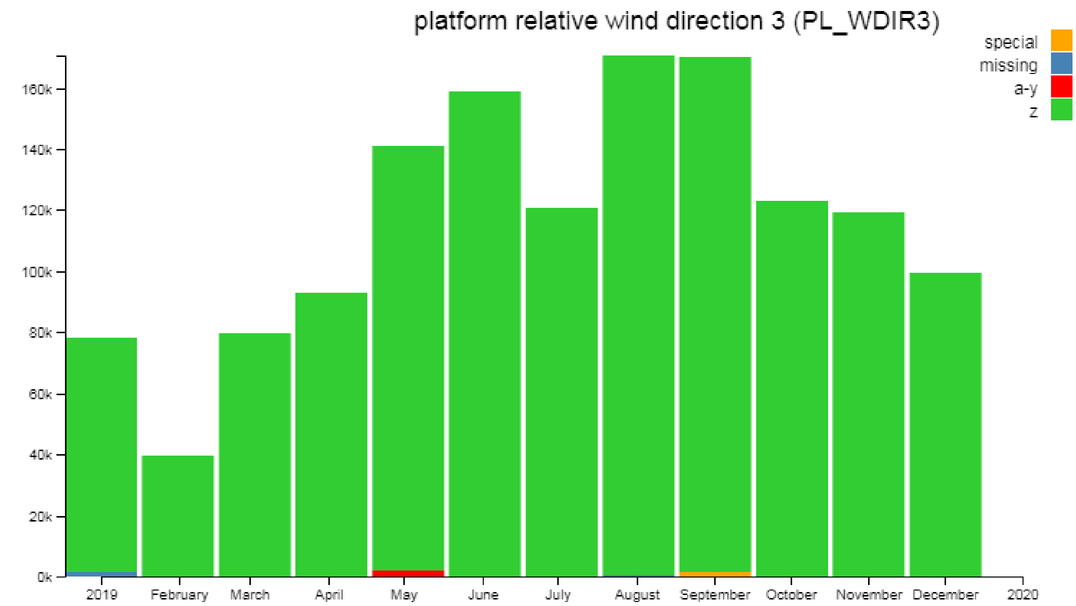


Figure 24: Total number of (this page, top) platform relative wind direction – PL_WDIR – (this page, bottom) platform relative wind direction 2 – PL_WDIR2 – and (next page) platform relative wind direction 3 – PL_WDIR3 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 24: cont'd)

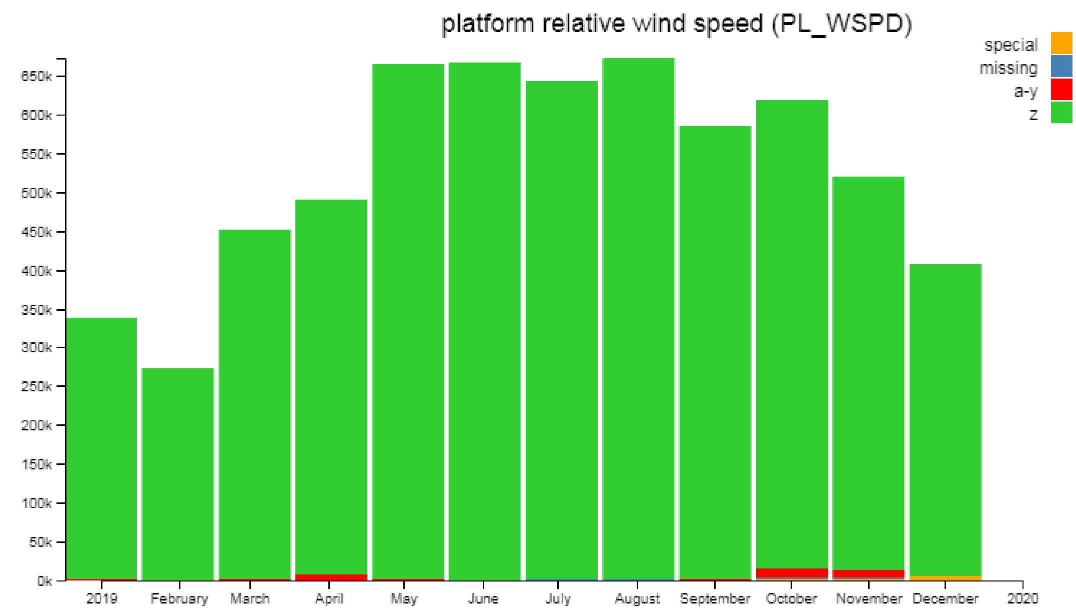
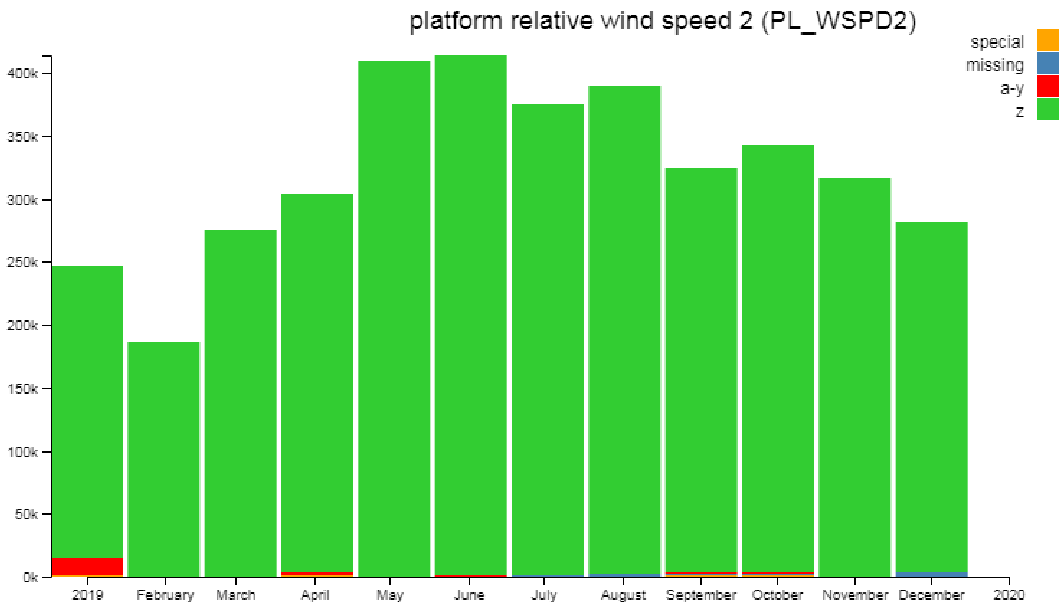
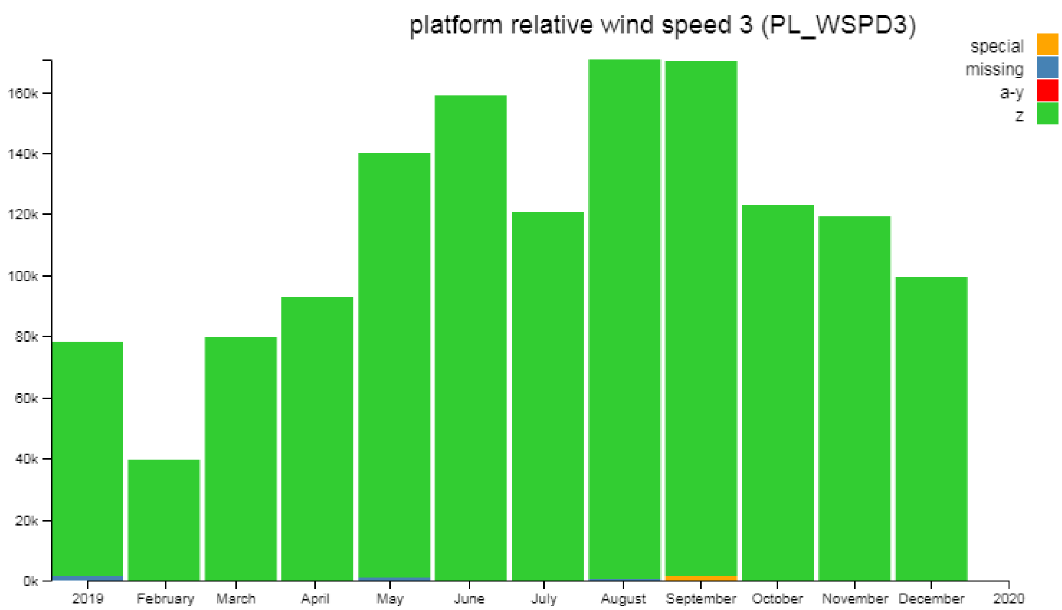


Figure 25: Total number of (this page) platform relative wind speed – PL_WSPD – (next page, top) platform relative wind speed 2 – PL_WSPD2 – and (next page, bottom) platform relative wind speed 3 – PL_WSPD3 – observations provided by all ships for each month in 2019. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.





(Figure 25: cont'd)

c. 2019 quality by ship

Aurora Australis

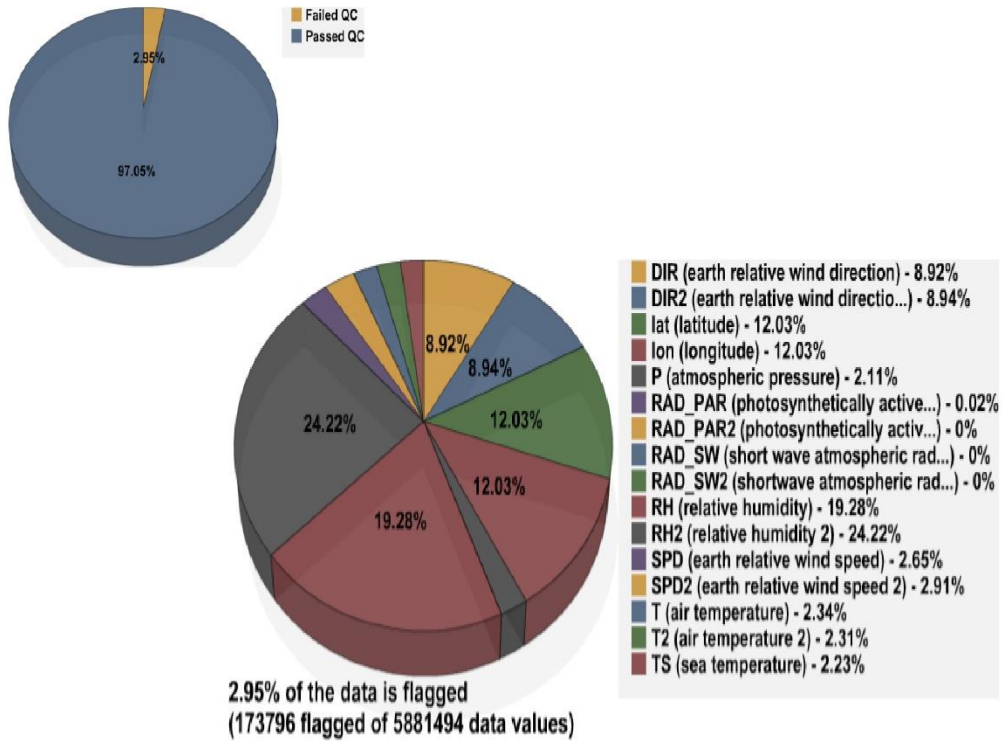


Figure 26: For the *Aurora Australis* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Aurora Australis* provided SAMOS data for 152 ship days, resulting in 5,881,494 distinct data values. After automated QC, 2.95% of the data were flagged using A-Y flags (Figure 26). This is about a percentage point higher than in 2018 (1.82%) 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*).

There were no specific issues noted for the *Aurora Australis* in 2019. Looking at the flag percentages in Figure 26, around 44% 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 27), appear to have been applied mainly to values slightly over 100% such as occur when a sensor commonly tuned for better accuracy at lower readings (see 3b.) is exposed to a saturated environment (e.g. rain, fog). A further ~24% of the total flags were applied to the latitude (LAT) and longitude (LON) parameters (Figure 26). In this case the flags are unanimously “platform position over land” (L) flags (Figure 27) 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.

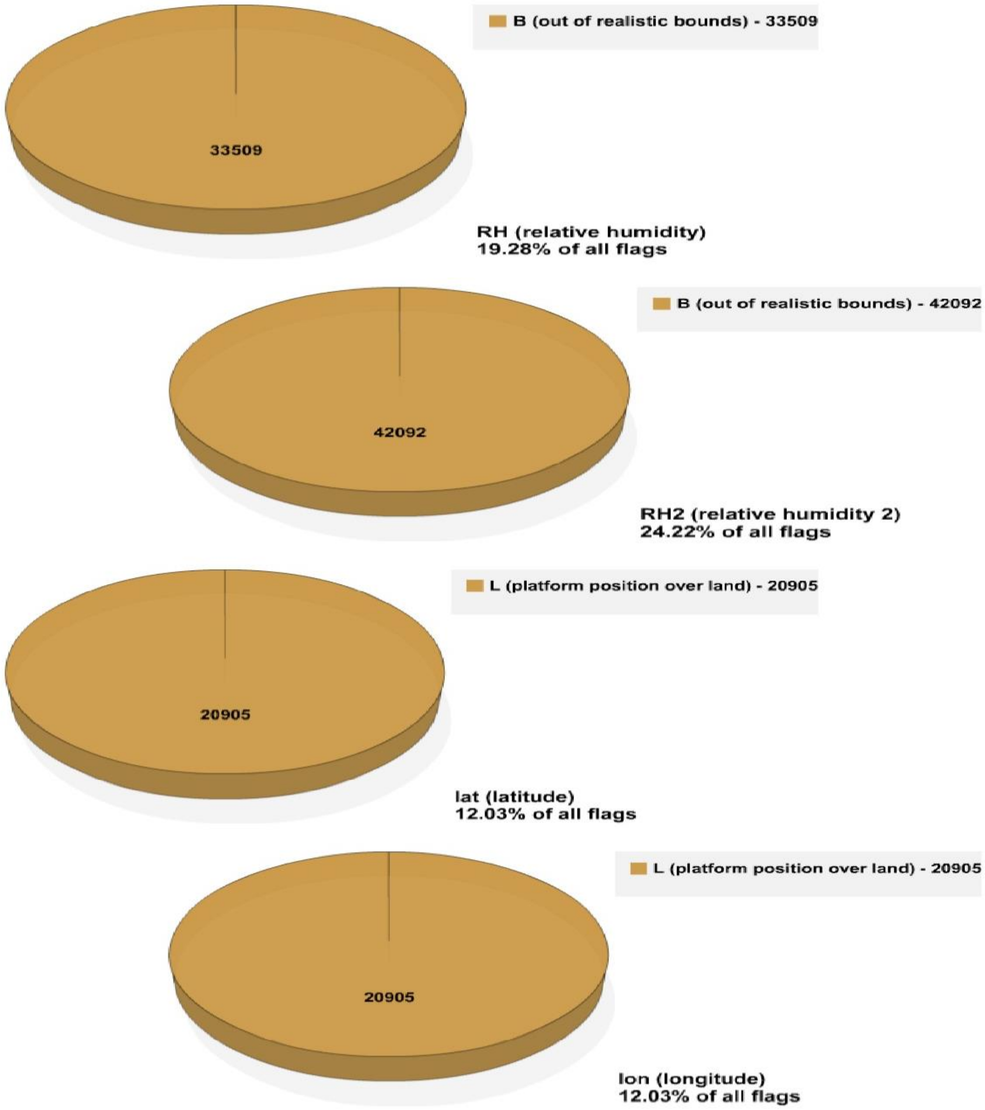


Figure 27: Distribution of SAMOS quality control flags for (first) relative humidity – RH – (second) relative humidity 2 – RH2 – (third) latitude – LAT – and (last) longitude – LON – for the *Aurora Australis* in 2019.

Investigator

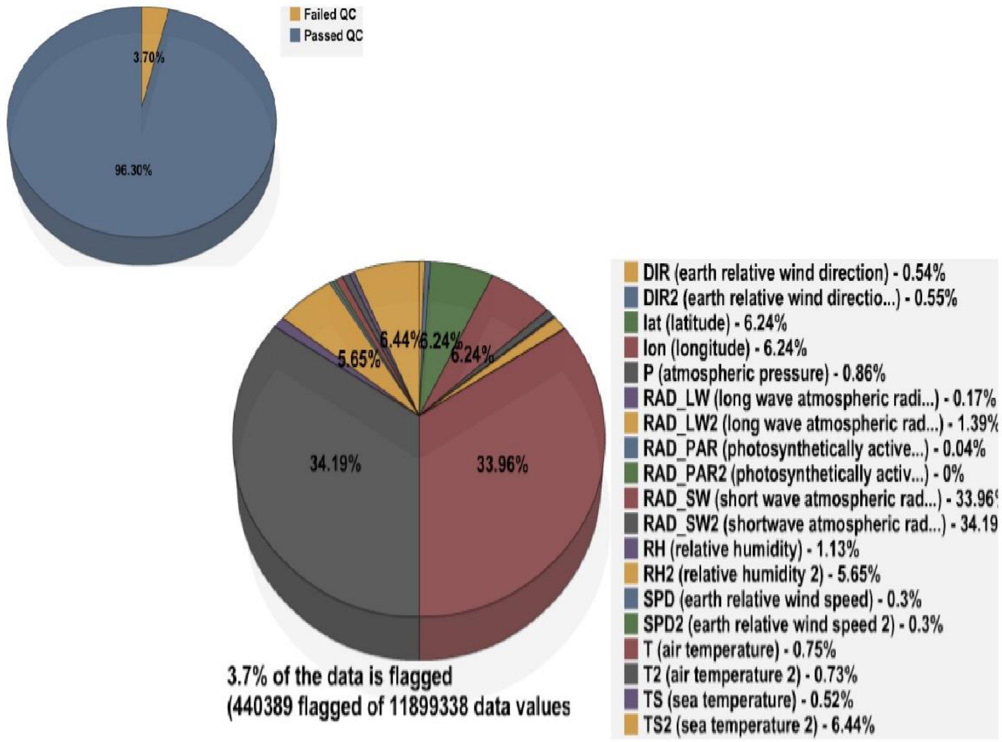


Figure 28: For the *Investigator* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Investigator* provided SAMOS data for 283 ship days, resulting in 11,899,338 distinct data values. After automated QC, 3.7% of the data were flagged using A-Y flags (Figure 28). This is virtually unchanged from 2018 (3.52%) 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*).

There were no specific issues noted for the *Investigator* in 2019. Looking at the flag percentages in Figure 28, about 68% of the total flags were applied to the redundant shortwave atmospheric radiation parameters (RAD_SW and RAD_SW2). Upon inspection the flags, which are unanimously “out of bounds” (B) flags (Figure 29), 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.)

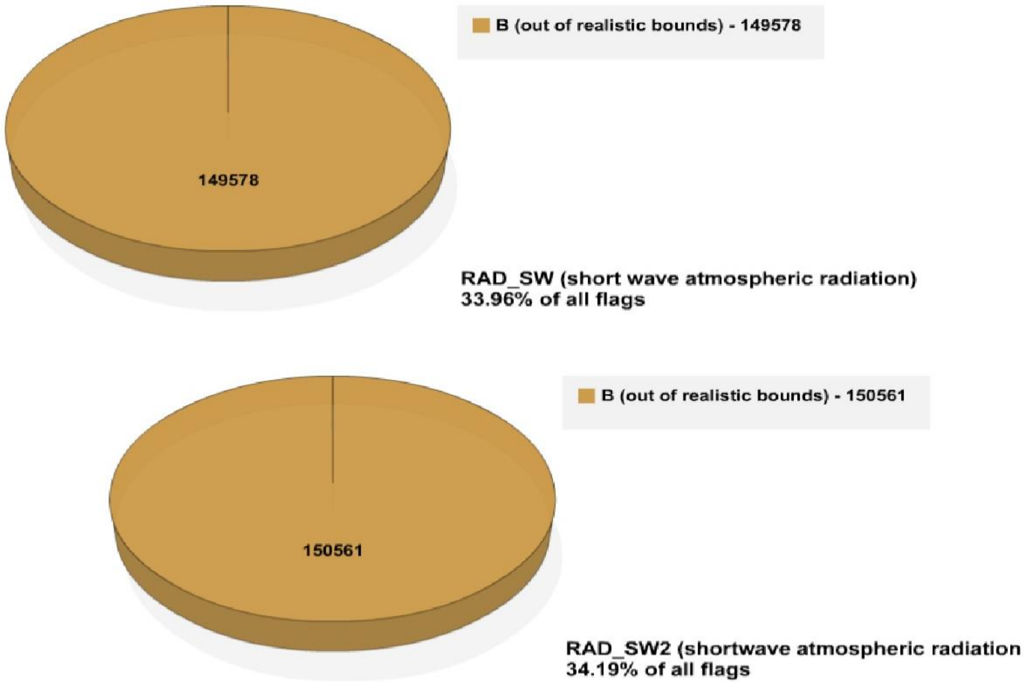
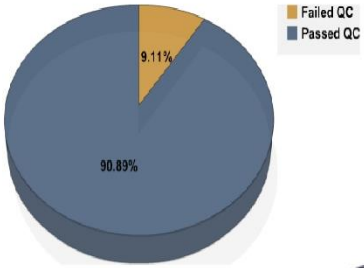


Figure 29: Distribution of SAMOS quality control flags for (top) shortwave atmospheric radiation – RAD_SW – and (bottom) shortwave atmospheric radiation 2 – RAD_SW2 – for the *Investigator* in 2019.

Tangaroa



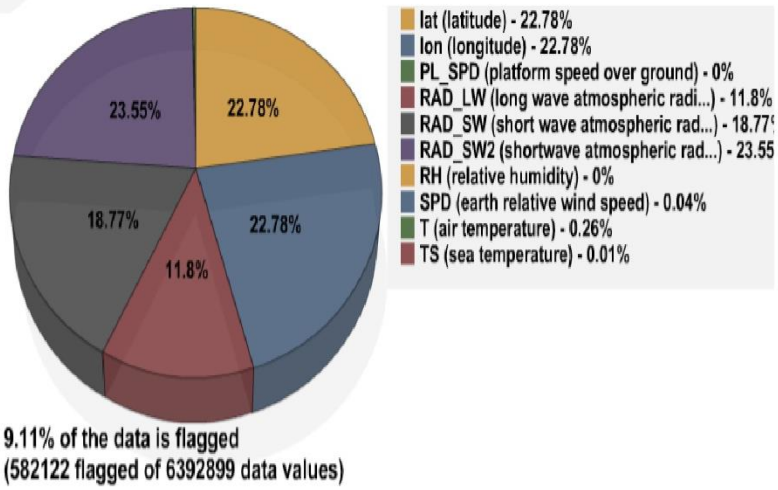


Figure 30: For the *Tangaroa* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Tangaroa* provided SAMOS data for 275 ship days, resulting in 6,392,899 distinct data values. After automated QC, 9.11% of the data were flagged using A-Y flags (Figure 30). This is about one and a half percentage points higher than in 2018 (7.8%). NOTE: the *Tangaroa* does not receive visual quality control by the SAMOS DAC, so all flags are the result of automated QC (no research-level files exist at the SAMOS DAC for the *Tangaroa*).

It was noted on 11 March and confirmed a day later by the lead contact for *Tangaroa* that the starboard short and long wave radiation sensors (RAD_SW and RAD_LW, respectively) had flat lined as of 11 February (see Figure 31). The contact further advised that the rain gauge (PRECIP, not shown) was also problematic. For their part, in their own data files IMOS flagged RAD_SW, RAD_LW, and PRECIP with "malfunction" (M) flags beginning 5 March, and they anticipated sensor repairs in early April. (It is not known precisely if/when such repairs took place.) However, as the SAMOS DAC does not conduct visual quality control for IMOS vessels, and as the affected data values for both RAD_SW and PRECIP were still within realistic bounds, no flags were applied to either of those parameters. Only RAD_LW received "out of bounds" (B) flags (Figure 32), likely comprising the bulk of the ~12% of the total flags assigned that parameter (Figure 30).

Aside from this malfunction episode, as in previous years RAD_SW and RAD_SW2 acquired a sizable portion of the total flags, roughly 42% taken together (Figure 30). These were exclusively out of bounds (B) flags (Figure 32). Once again, it appears most or all the B flags applied to RAD_SW and RAD_SW2 were the result of the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.)

Latitude (LAT) and longitude (LON) flags together further comprised roughly 46% of the total (Figure 30). A quick inspection reveals these were unanimously "platform position over land" (L) flags (Figure 32) 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.

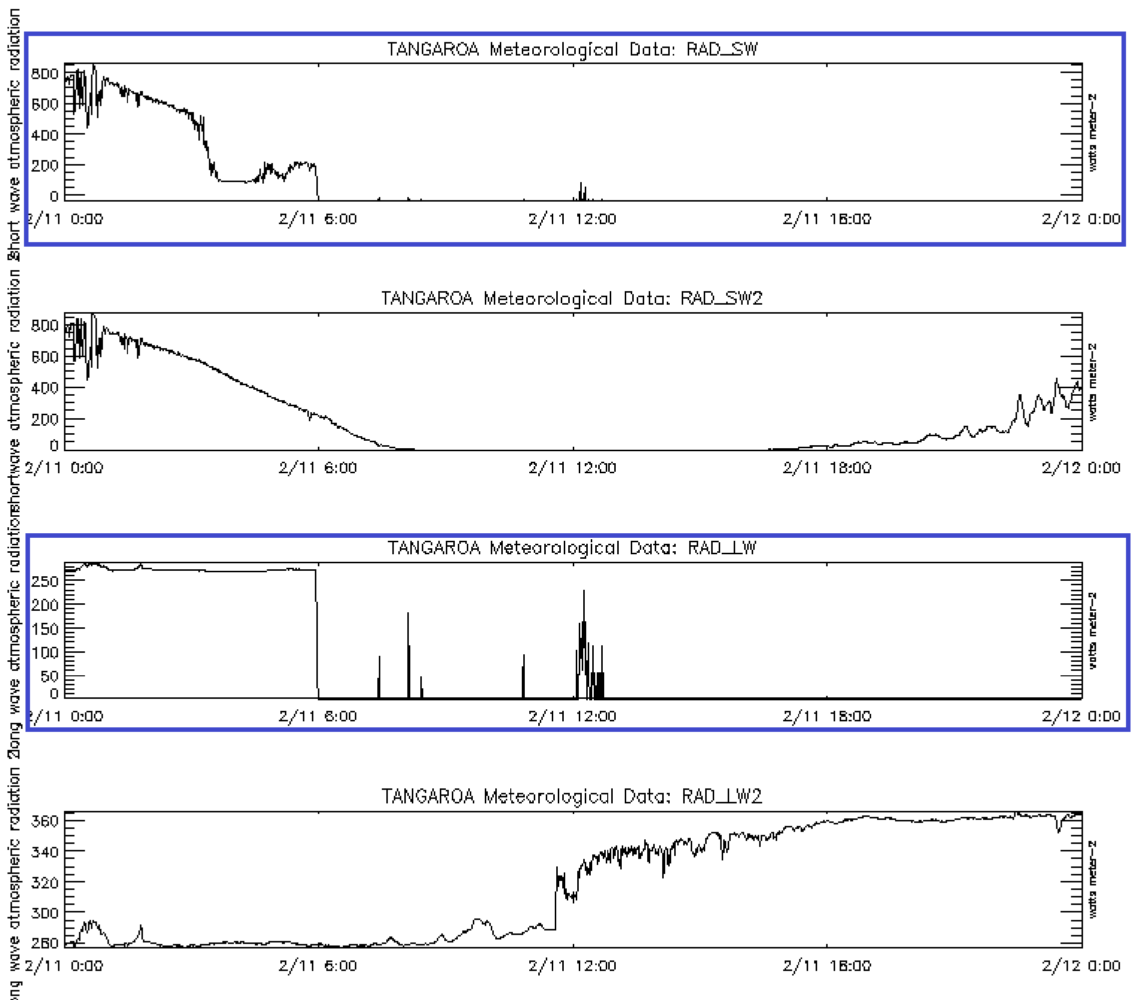


Figure 31: *Tangaroa* SAMOS (first) short wave radiation – RAD_SW – (second) short wave radiation 2 – RAD_SW2 – (third) long wave radiation – RAD_LW – and (last) long wave radiation 2 – RAD_LW2 – data for 11 February 2019. Note the flat lining of both RAD_SW and RAD_LW (blue boxes) as compared with RAD_SW2 and RAD_LW2, respectively.

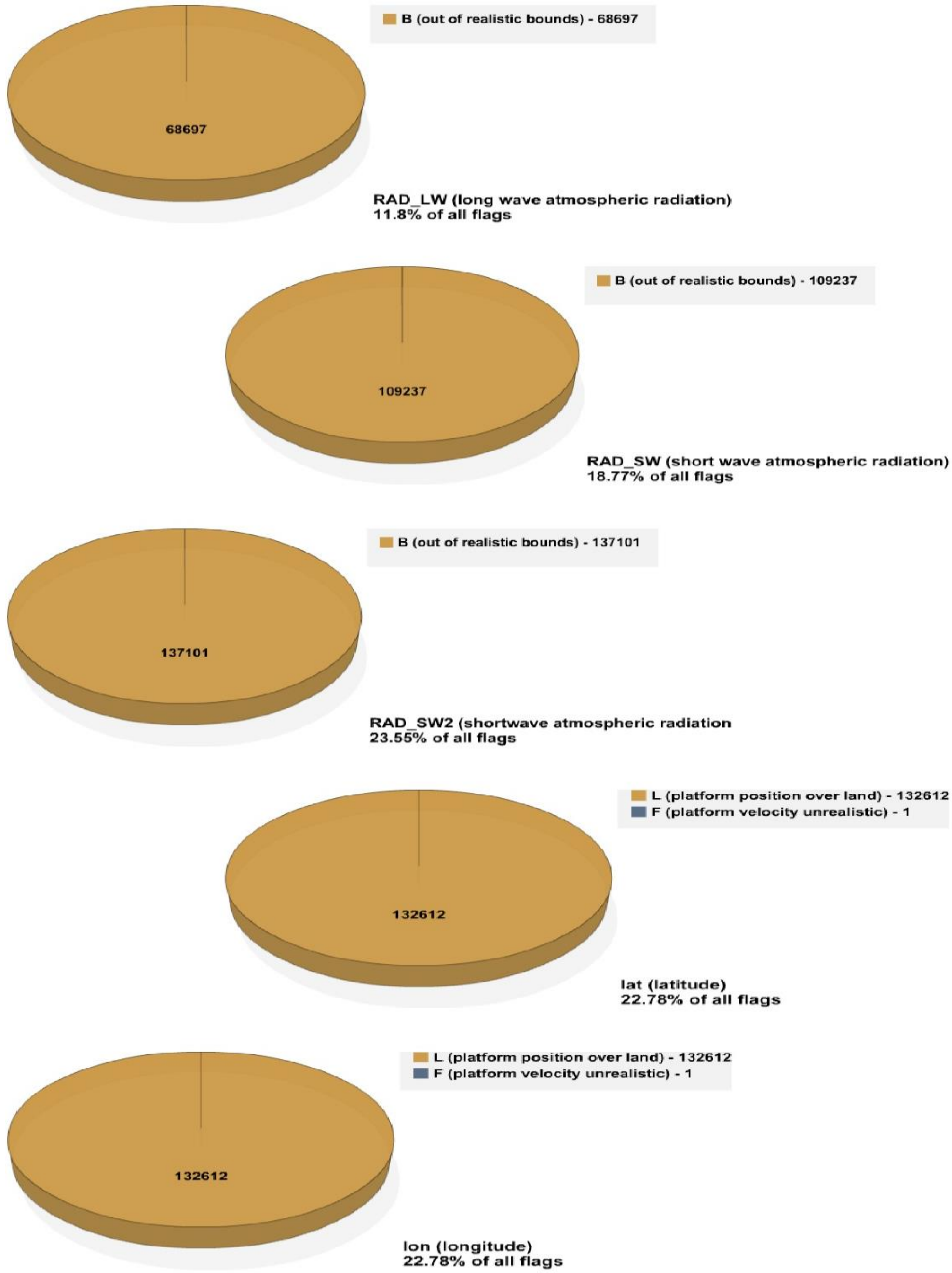
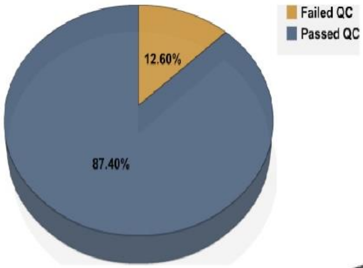


Figure 32: Distribution of SAMOS quality control flags for (first) long wave radiation – RAD_LW – (second) short wave radiation – RAD_SW – (third) short wave radiation 2 – RAD_SW2 – (fourth) latitude – LAT – and (last) longitude – LON – for the *Tangaroa* in 2019.

Pelican



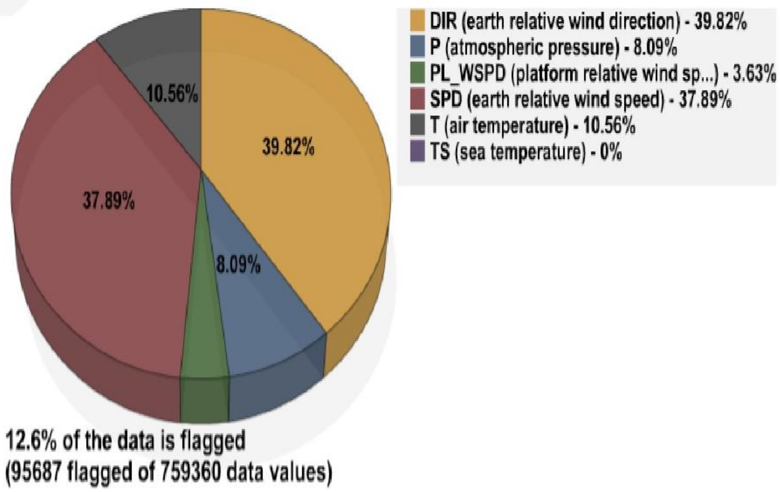


Figure 33: For the *Pelican* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Pelican* provided SAMOS data for 42 ship days, resulting in 759,360 distinct data values. After automated QC, 12.6% of the data were flagged using A-Y flags (Figure 33). This is significantly higher than in 2018 (1.46%) and moves *Pelican* outside the “under 5% total flagged” bracket regarded by SAMOS to represent "very good" data. It should be noted the *Pelican* 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 *Pelican*). We also note *Pelican’s* 2019 SAMOS data transmission rate was 20% (see Table 2). It would be desirable to recover any data not received by us, if possible (see Figure 2).

It was noted on 9 January (at the start of the season) and immediately confirmed by *Pelican’s* lead contact that the platform relative wind direction (PL_WDIR) and atmospheric pressure (P) were flat lined at 0° and 1100 mb, respectively. While the affected PL_WDIR data were not technically out of realistic bounds and thus not flagged, P received “out of bounds” (B) flags for about six days (Figure 35) until the vessel reached port. A new all-in-one weather system was then installed as a remedy.

Nearly 80% of the total flags were allotted to Pelican’s earth relative wind parameters, meaning speed (SPD) and direction (DIR) (Figure 33). In actuality, the issue here was with the platform relative wind speed and direction (PL_WSPD and PL_WDIR, respectively). On 25 February, as soon as *Pelican’s* new weather system was transmitting to SAMOS, it was noted and immediately confirmed by a vessel technician that the PL_WDIR and PL_WSPD fields appeared to be "swapped," with PL_WDIR reading between about 0 - 20 "degrees" and PL_WSPD reading between about 0 - 200 "meters per second" (see Figure 34). Most of these data were nevertheless within realistic bounds and thus not flagged, excepting PL_WSPD values greater than 50 "m/s," which were B-flagged (Figure 35). However, because DIR and SPD, which did not appear to be "swapped" in this case, were recalculated by the SAMOS QC software using the vessel's faulty platform relative wind values they were both assigned a good deal of "failed the true wind test" (E) flags (Figure 35). The vessel technician planned to investigate the issue as soon as time allowed. On 1 March it was additionally noted that air temperature (T) had begun reading about 10 °C too low for the area of operation. This resulted in both B and "greater than four standard deviations from climatology" (G) flags (Figure 35). A vessel technician immediately provided confirmation and noted a redundant sensor on board the *Pelican* was, by comparison, reading in a more realistic range. Various joint troubleshooting efforts were undertaken to solve the wind and temperature issues through early May, but these were ultimately unsuccessful, and all wind and temperature flagging continued for the remainder of *Pelican's* 2019 SAMOS transmission.

We note in mid-May SAMOS data transmission from *Pelican* stopped due to a suspected problem with SMTP protocol in the ship's data acquisition system. Again, despite ongoing efforts, this problem persisted for the remainder of 2019.

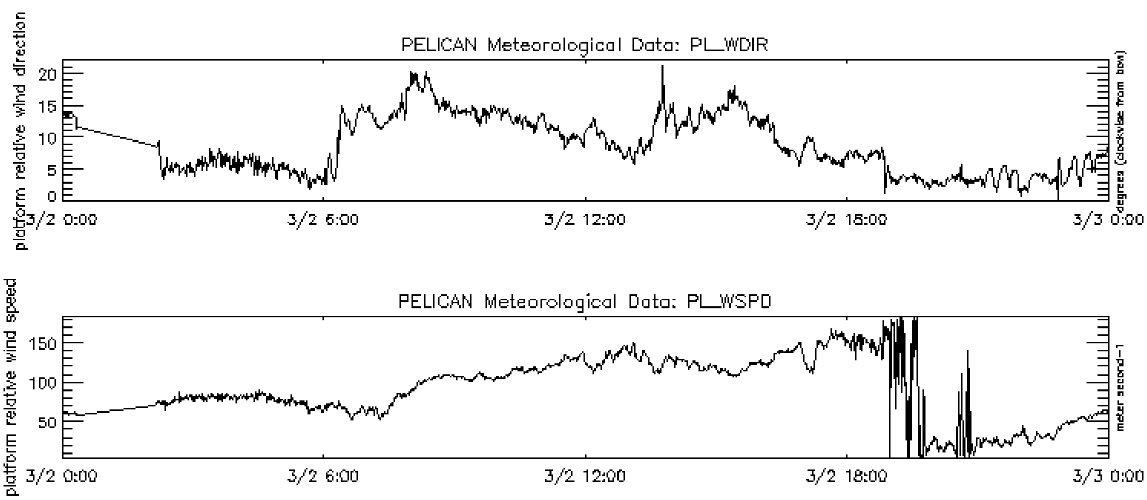


Figure 34: *Pelican* SAMOS (top) platform relative wind direction – PL_WDIR – and (bottom) platform relative wind speed – PL_WSPD – data for 2 March 2019. Note the questionable data ranges ~ 0 - 20 °C (PL_WDIR) and ~ 0 - 200 m/s (PL_WSPD).

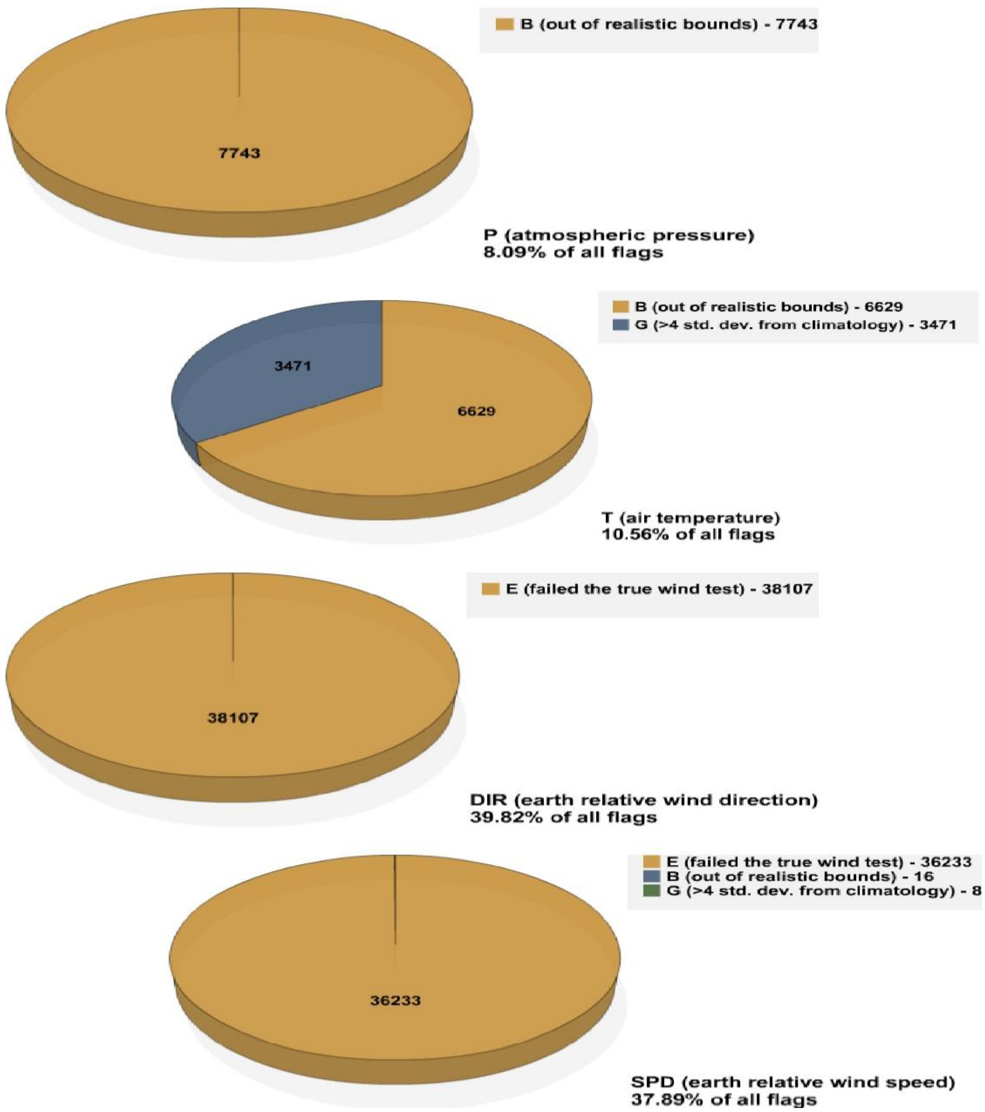


Figure35: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – for the *Pelican* in 2019.

Bell M. Shimada

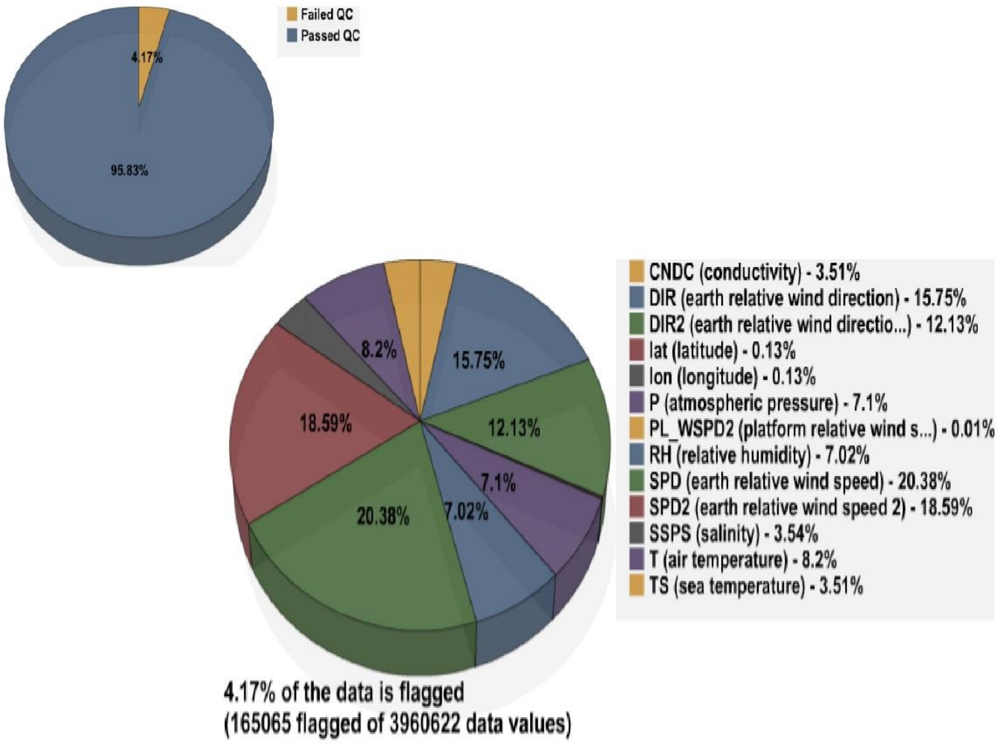


Figure 36: For the *Bell M. Shimada* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Bell M. Shimada* provided SAMOS data for 152 ship days, resulting in 3,960,622 distinct data values. After both automated and visual QC, 4.17% of the data were flagged using A-Y flags (Figure 36). This is about the same as in 2018 (3.72% total flagged) and maintains *Shimada's* standing under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

There were no specific issues noted for the *Shimada* in 2019. *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 appears affected, it is generally flagged with “caution/suspect” (K) flags. As is suggested by Figure 36, this is a bit more prevalent in the true winds. About 39% of the total flags were applied to the two earth relative wind speeds (SPD and SPD2) and a further ~28% were applied to the two earth relative wind directions (DIR and DIR2), these primarily being K flags (Figure 37). We note, though, that while it can be a challenge to site sensors ideally on a ship, with an overall flagged percentage below 5% these sensor location issues are not terribly consequential.

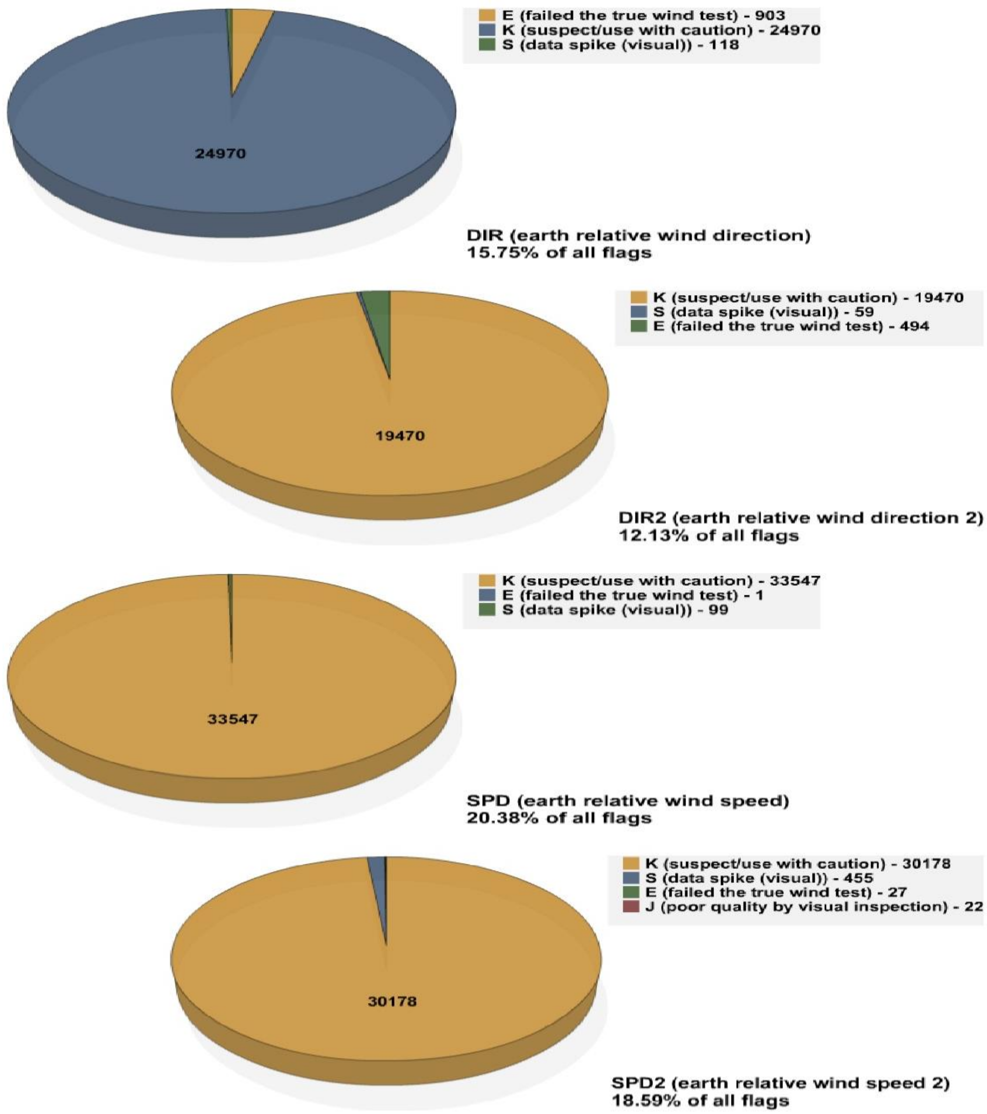


Figure 37: Distribution of SAMOS quality control flags for (first) earth relative wind direction – DIR – (second) earth relative wind direction 2 – DIR2 – (third) earth relative wind speed – SPD – and (last) earth relative wind speed 2 – SPD2 – for the *Bell M. Shimada* in 2019.

Fairweather

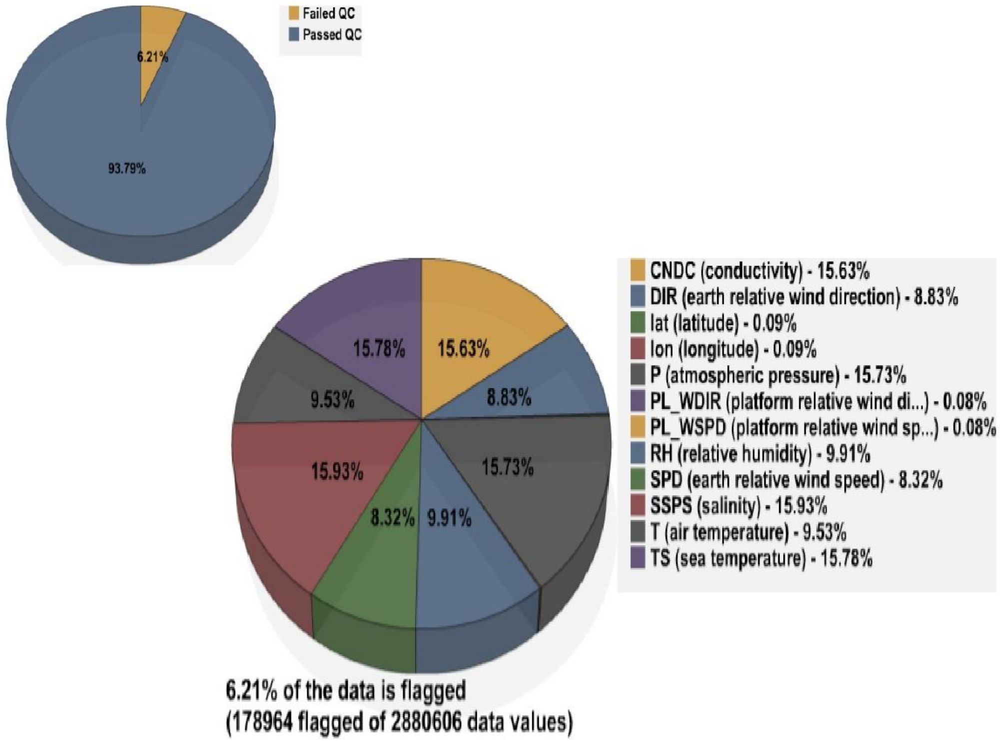


Figure 38: For the *Fairweather* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Fairweather* provided SAMOS data for 137 ship days, resulting in 2,880,606 distinct data values. After both automated and visual QC, 6.21% of the data were flagged using A-Y flags (Figure 38). This is about the same as in 2018 (6.68% total flagged).

There were no considerable unique issues noted for the *Fairweather* in 2019. 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 subject to problematic sensor location, as indicated by the total flagged percentage and the distribution of flag percentages (Figure 38). SAMOS metadata for the sensors are incomplete and outdated, and digital imagery does not exist for this vessel (see Table 4), all of which precludes a meaningful diagnosis of sensor placement. All five of the meteorological parameters offered by *Fairweather* regularly demonstrate a considerable amount of flow obstruction and/or interference from stack exhaust or ship heating (see Figure 39), resulting mainly in "caution/suspect" (K) flags (Figure 41, not all shown).

The highest flag percentages, however, were allotted to the sea water parameters – sea temperature (TS), conductivity (CNDC), and salinity (SSPS) – about 16% each (Figure 38). These were primarily K flags (Figure 41, not all shown) 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 being common practices on other vessels. A small portion of the K flags (Figure 41, not all shown) was applied when underway sea water data exhibited short bursts of anomalous behavior characterized by a gradual rise and a sudden “snapping back” (see Figure 40) inconsistent with global gridded microwave sea temperature data. The cause here is unknown, but possible candidates include poor plumbing and/or a thermosalinograph that is mounted too high inside a sea chest prone to air pocketing.

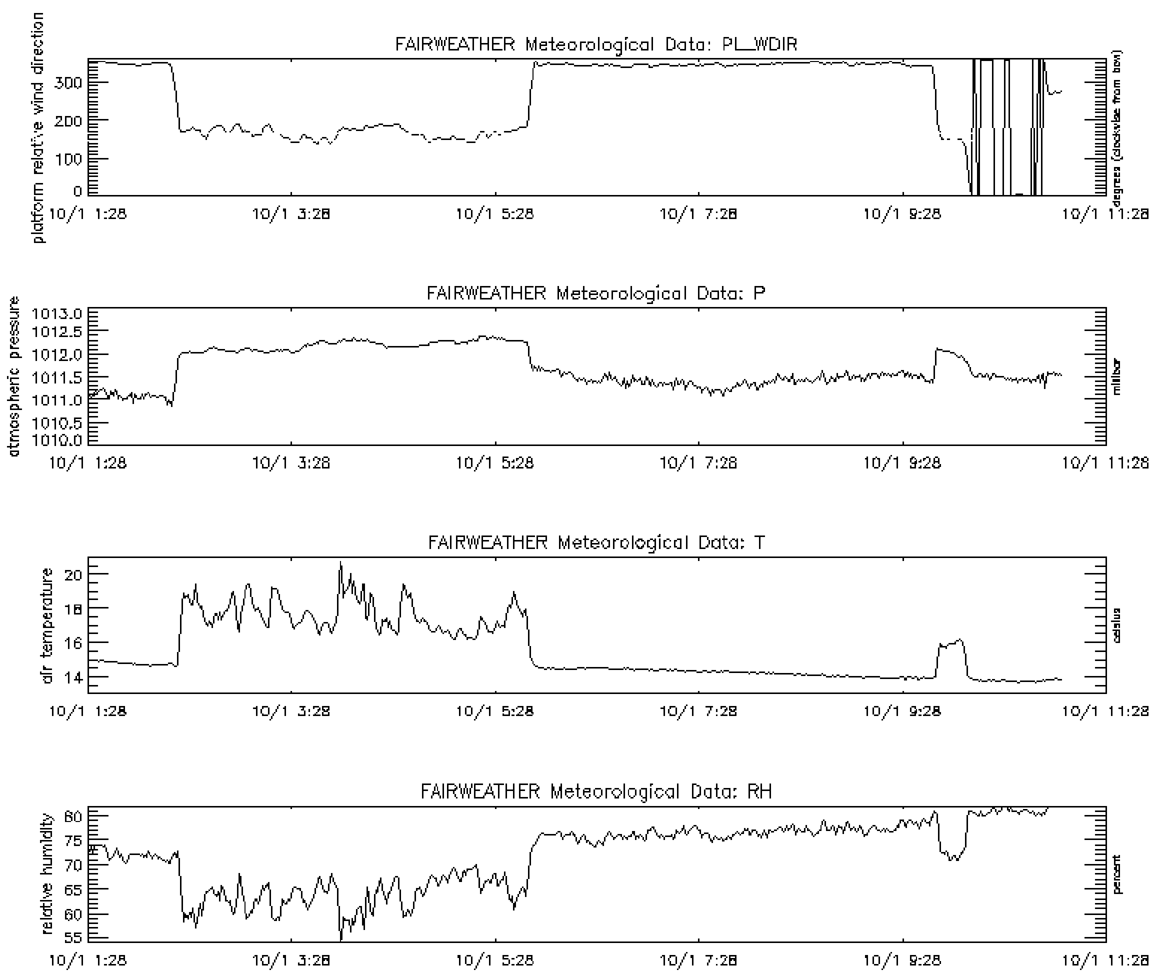


Figure 39: *Fairweather* SAMOS (first) platform relative wind direction – PL_WDIR – (second) atmospheric pressure – P – (third) air temperature – T – and (last) relative humidity –RH – data for 1 October 2019. Note the steps in P, T, and RH when the relative wind is from ~ 150° - 200°.

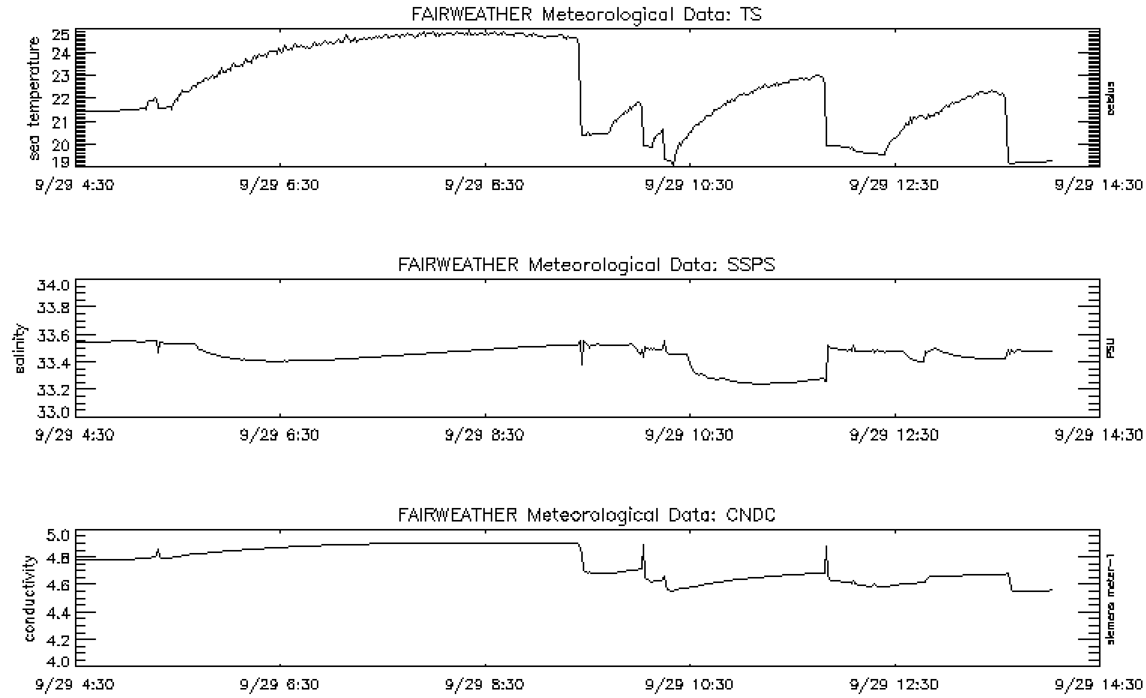


Figure 40: *Fairweather* SAMOS (top) sea temperature – TS – (middle) salinity – SSPS – and (bottom) conductivity – CNDC – data for 29 September 2019. Note the multiple instances of anomalous rises in TS/CNDC and falls in SSPS terminated by an abrupt return to the overall trend.

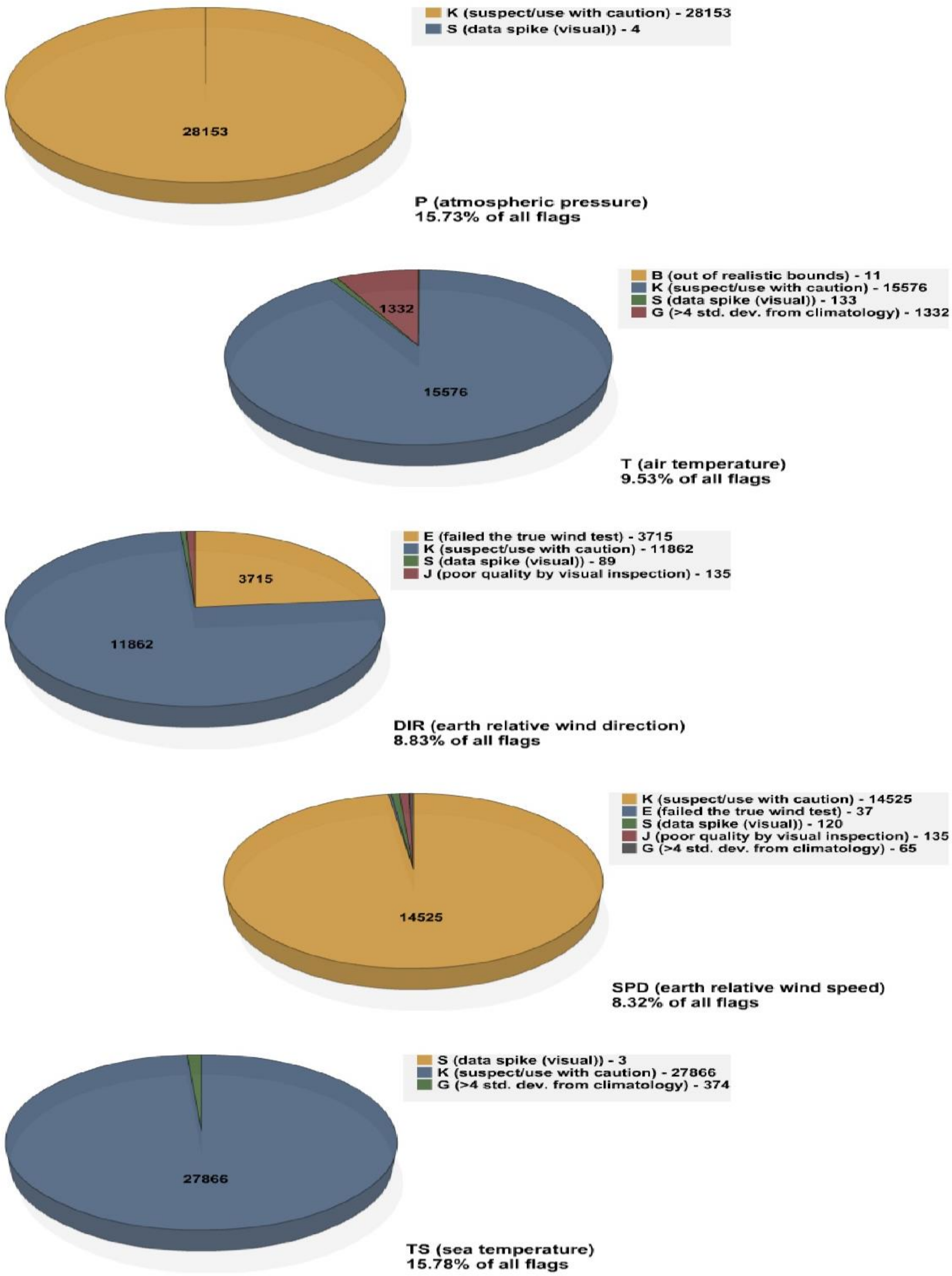


Figure 41: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) earth relative wind direction – DIR – (fourth) earth relative wind speed – SPD – and (last) sea temperature – TS – for the *Fairweather* in 2019.

Gordon Gunter

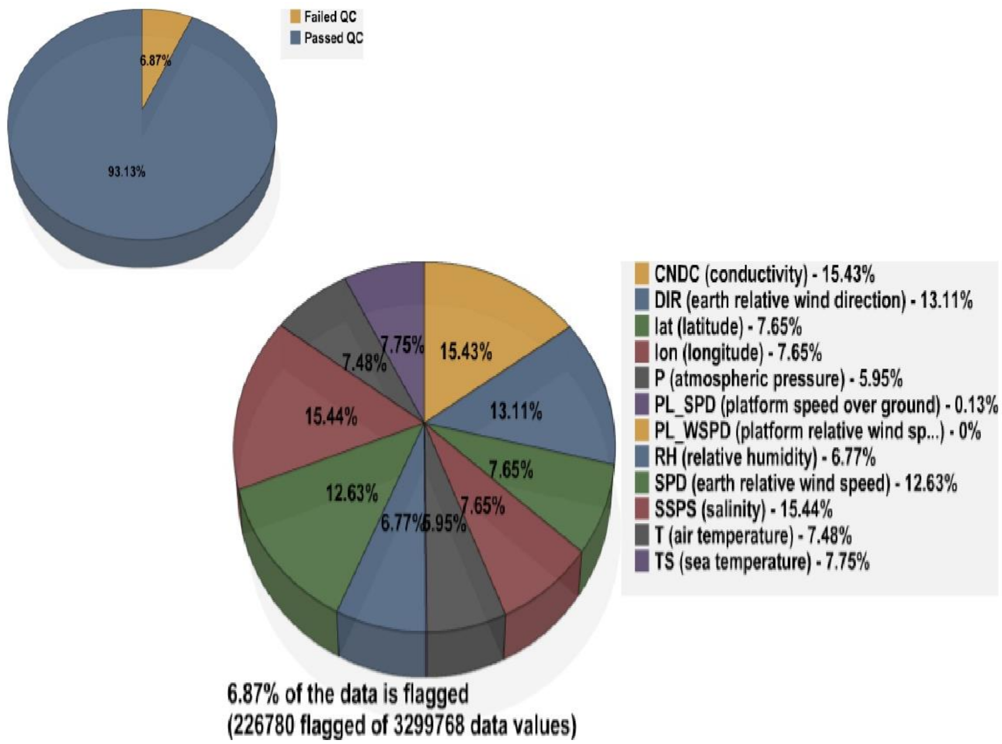


Figure 42: For the *Gordon Gunter* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Gordon Gunter* provided SAMOS data for 154 ship days, resulting in 3,299,768 distinct data values. After both automated and visual QC, 6.87% of the data were flagged using A-Y flags (Figure 42). This is almost two percentage points higher than in 2018 (5.04%).

In general, *Gunter'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, which oftentimes results in "caution/suspect" (K) flags for each of those parameters (Figure 44, not all shown). This is common to most vessels, as it is difficult to site instruments ideally on a moving ship. In addition to the general flow distortion issue, DIR and SPD sometimes appeared particularly sensitive to variations in platform speed, exhibiting suspicious steps closely echoing platform speed patterns (see Figure 43). These steps also received K flags (Figure 44). The cause of these steps isn't clear, but it's known, for example, that science parties occasionally request the instrument mast be lowered during their cruise. Some type of similar temporary condition is suspected here.

Additionally, towards the end of the year Gunter's latitude (LAT) and longitude (LON) data began exhibiting frequent spikes, which resulted in the application of "platform velocity unrealistic" (F) and "platform position over land" (L) flags to those parameters (Figure 44, only LAT shown). The cause of the spikes is not known.

The highest flag percentages were allotted to conductivity (CNDC) and salinity (SSPS), about 15% each (Figure 42). These were primarily “poor quality” (J) flags (Figure 44, only SSPS shown) applied when the thermosalinograph was clearly off, generally when the vessel was in port. Often at these times it also appeared the sea water flow-through system was off, and as a result sea temperature (TS) data were K flagged as well (Figure 44).

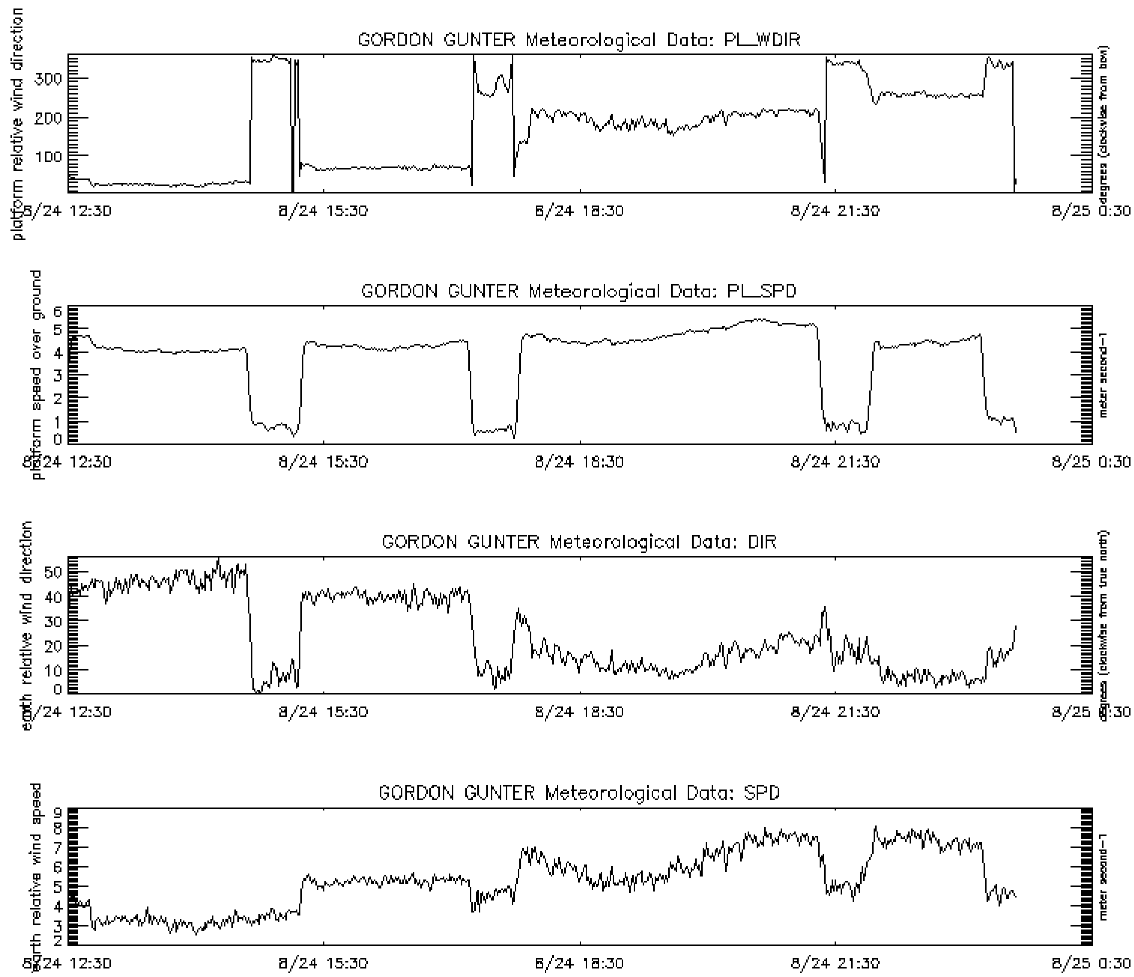


Figure 43: *Gordon Gunter* SAMOS (first) platform relative wind direction – PL_WDIR – (second) platform speed – PL_SPD – (third) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – data for 24 August 2019. Note multiple suspicious steps in both DIR and SPD that appear to mirror PL_SPD patterns. Note also these steps appear irrespective of PL_WDIR.

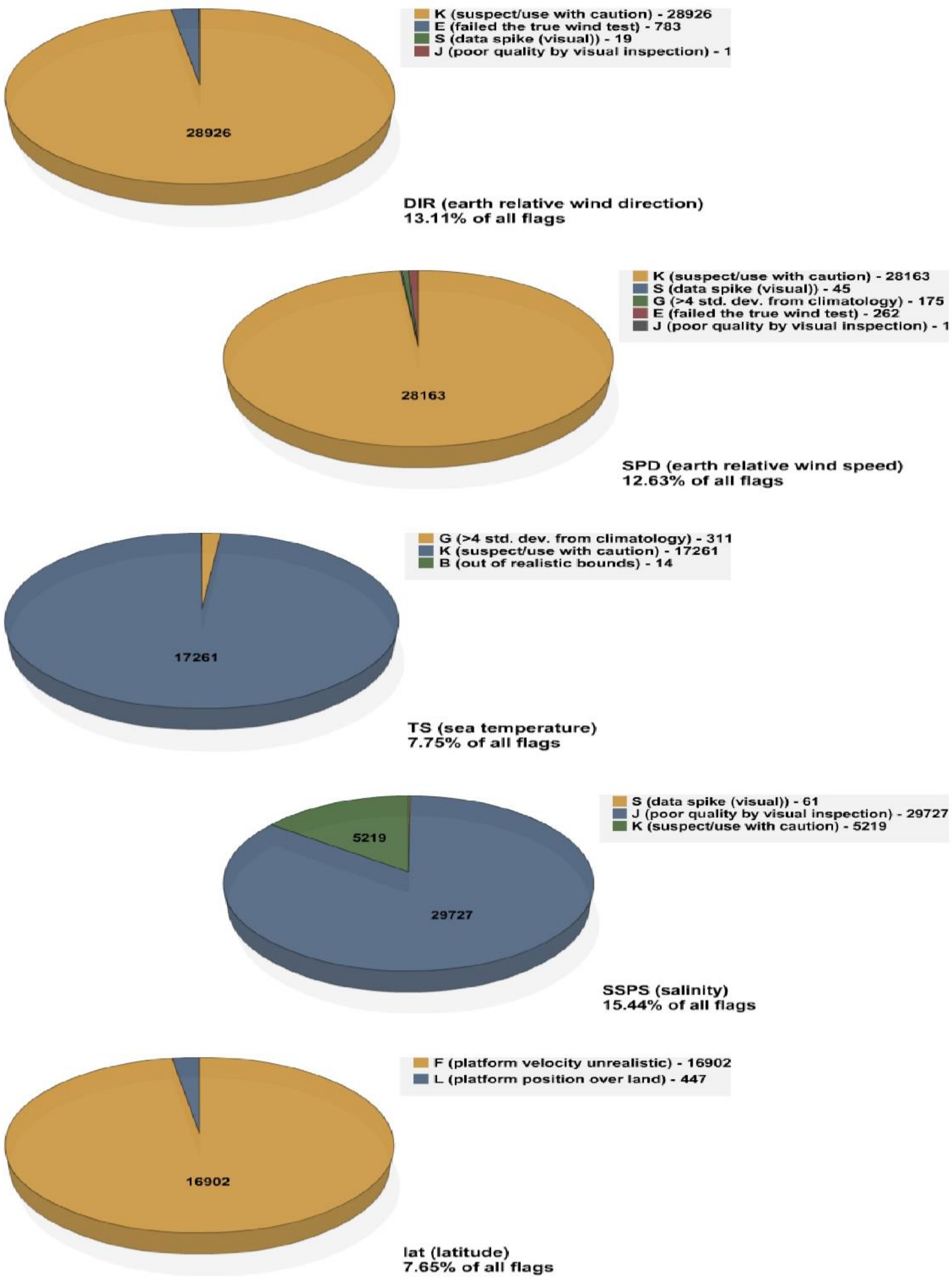


Figure 44: Distribution of SAMOS quality control flags for (first) earth relative wind direction – DIR – (second) earth relative wind speed – SPD – (third) sea temperature – TS – (fourth) salinity – SSPS – and (last) latitude – LAT – for the *Gordon Gunter* in 2019.

Henry B. Bigelow

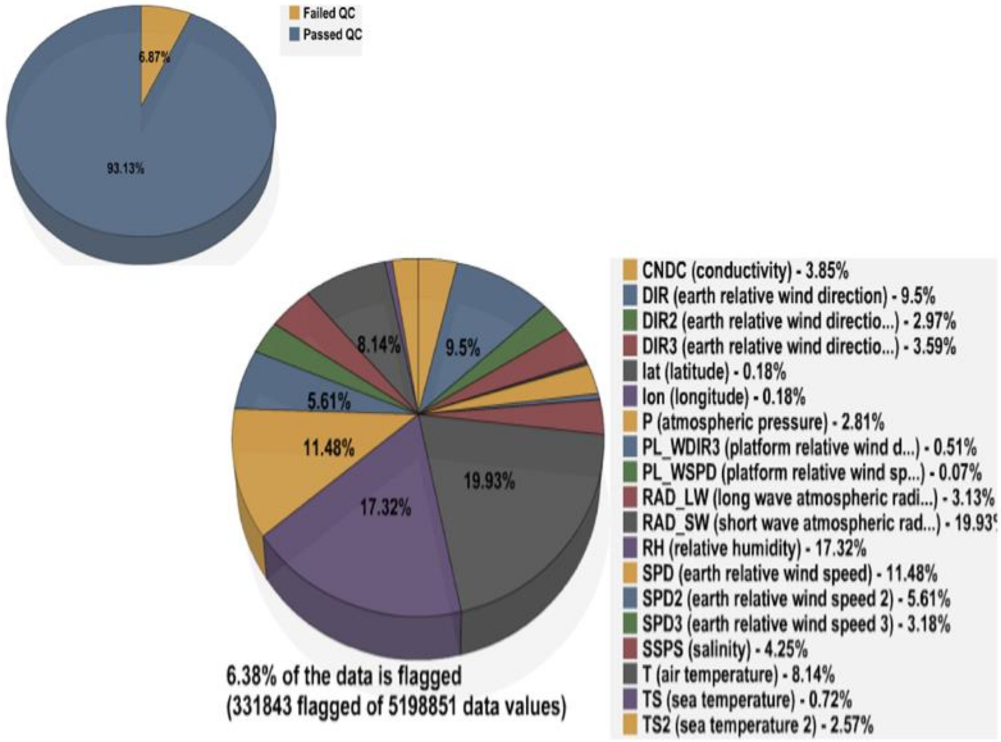


Figure 45: For the *Henry B. Bigelow* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Henry Bigelow* provided SAMOS data for 162 ship days, resulting in 5,198,851 distinct data values. After both automated and visual QC, 6.38% of the data were flagged using A-Y flags (Figure 45). This is about the same as in 2018 (5.79%).

A combined ~21% of the total flags was applied to the earth relative wind speed and direction (SPD and DIR, respectively) (Figure 45). In early May, an augmenting senior survey technician determined *Bigelow's* platform relative wind speed and direction (PL_WSPD and PL_WDIR, respectively) were being provided by a different anemometer than the one reporting SPD and DIR. Consequently, SPD and DIR were regularly receiving "failed the true wind test" (E) flags, since they were being tested against the wrong sensor's relative wind data (Figure 46). To rectify the mismatch, the technician added relative and true wind speed and direction data from *Bigelow's* two other anemometers to the vessel's SAMOS files and made clear which data came from which instruments, thus ensuring a representative true wind computation test for each.

The visiting technician also added short and long wave radiations (RAD_SW and RAD_LW, respectively) to *Bigelow's* SAMOS files. Shortly after the various new parameter additions there was a small hiccup in the data acquisition software that caused RAD_SW, SPD, and PL_WDIR to output static, unrealistic values, effecting application of "out of bounds" (B) and "poor quality" (J) flags to those parameters (Figure 46, not all shown). A system reboot a few days later solved the issue, except for RAD_SW, which was determined to need servicing. The faulty sensor was swapped out on 6 June. In the meantime, as is suggested by Figure 45, RAD_SW accrued a sizable portion of "malfunction" (M) flags (Figure 46).

Relative humidity (RH) also received a sizable (~17%) portion of the total flags (Figure 45). The majority of those flags, however, were B flags (Figure 46) applied to values slightly over 100% such as occur when a sensor commonly tuned for better accuracy at lower readings (see 3b.) is exposed to a saturated environment. For the better part of the cruise days in April the vessel was in a constant dense fog.

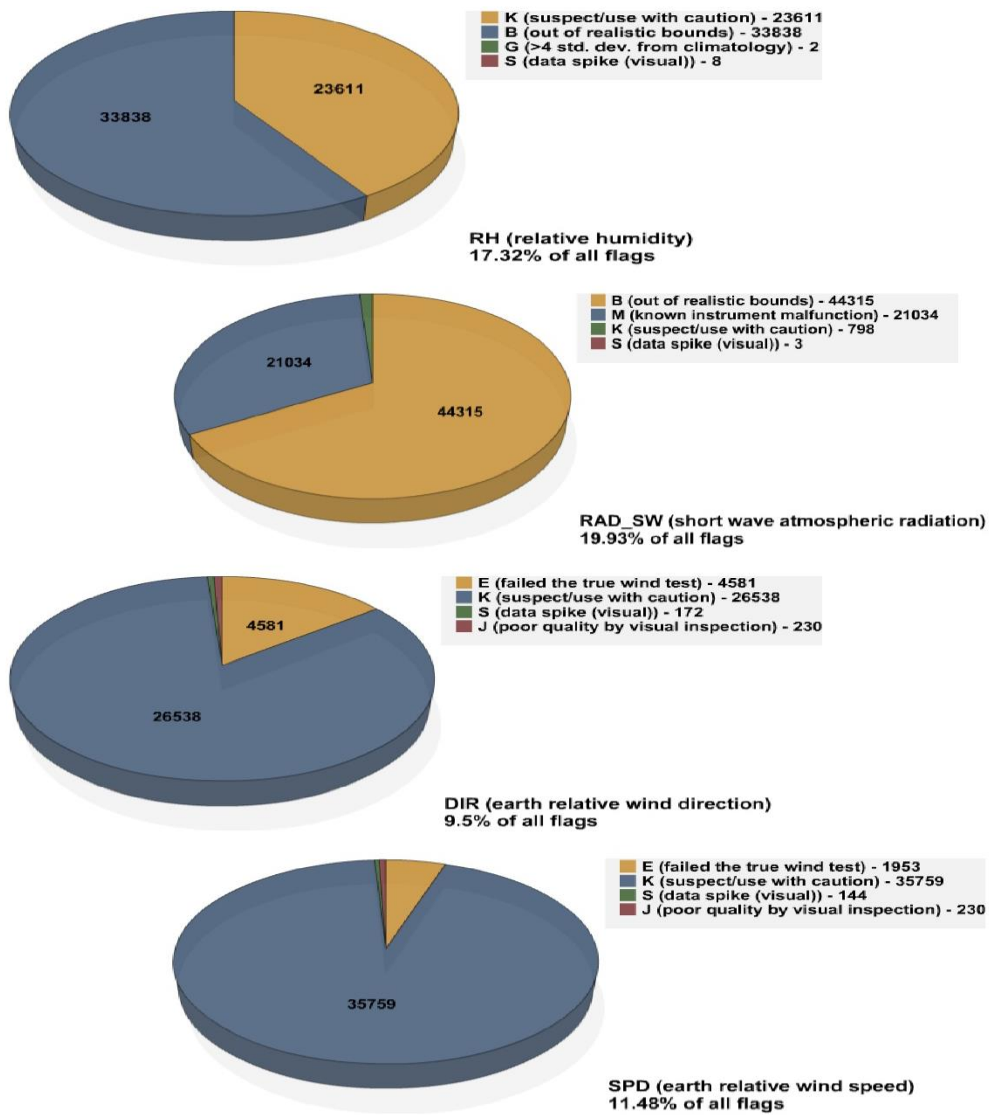


Figure 46: Distribution of SAMOS quality control flags for (first) relative humidity – RH – (second) short wave radiation – RAD_SW – (third) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – for the *Henry B. Bigelow* in 2019.

Nancy Foster

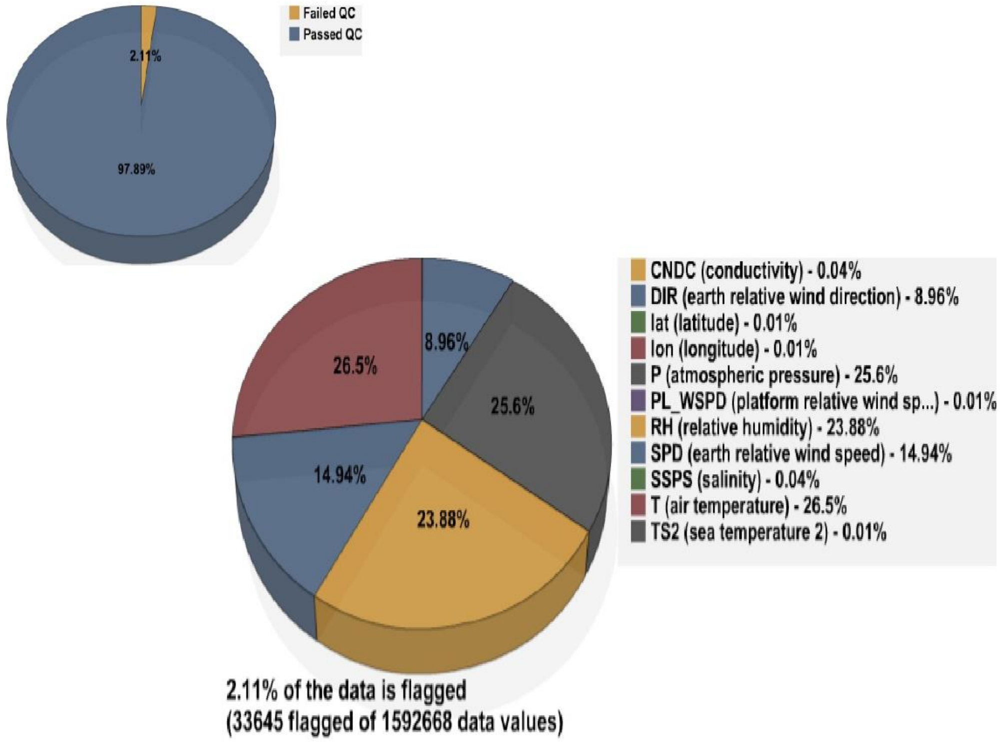


Figure 47: For the *Nancy Foster* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Nancy Foster* provided SAMOS data for 80 ship days, resulting in 1,592,668 distinct data values. After both automated and visual QC, 2.11% of the data were flagged using A-Y flags (Figure 48). This is almost a percentage point lower than in 2018 (2.86%) and maintains *Foster's* standing well under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

Air temperature (T), pressure (P), relative humidity (RH), and to a lesser extent platform- and earth-relative wind speeds (PL_WSPD and SPD, respectively) and (only occasionally) earth relative wind direction (DIR) continue to be prone to exhibiting spikes (see Figure 48) at various times in the sailing season, to which mainly “spike” (S) flags are assigned (Figure 49). It is not certain whether these spikes are tied to a particular platform relative wind direction, although it is suspected not. The cause remains unknown.

As a general note, in addition to the spike issue *Foster’s* various meteorological sensors occasionally exhibit data distortion that is dependent on the vessel relative wind direction, which sometimes results in the application of “caution/suspect” (K) flags (Figure 49). This is common to most vessels, as it is difficult to site instruments ideally on a moving ship. *Foster’s* SAMOS metadata are known to be outdated, precluding a meaningful diagnosis, but with an overall flag percentage well under 5% any sensor location issues on the *Foster* should not be considered terribly consequential anyway.

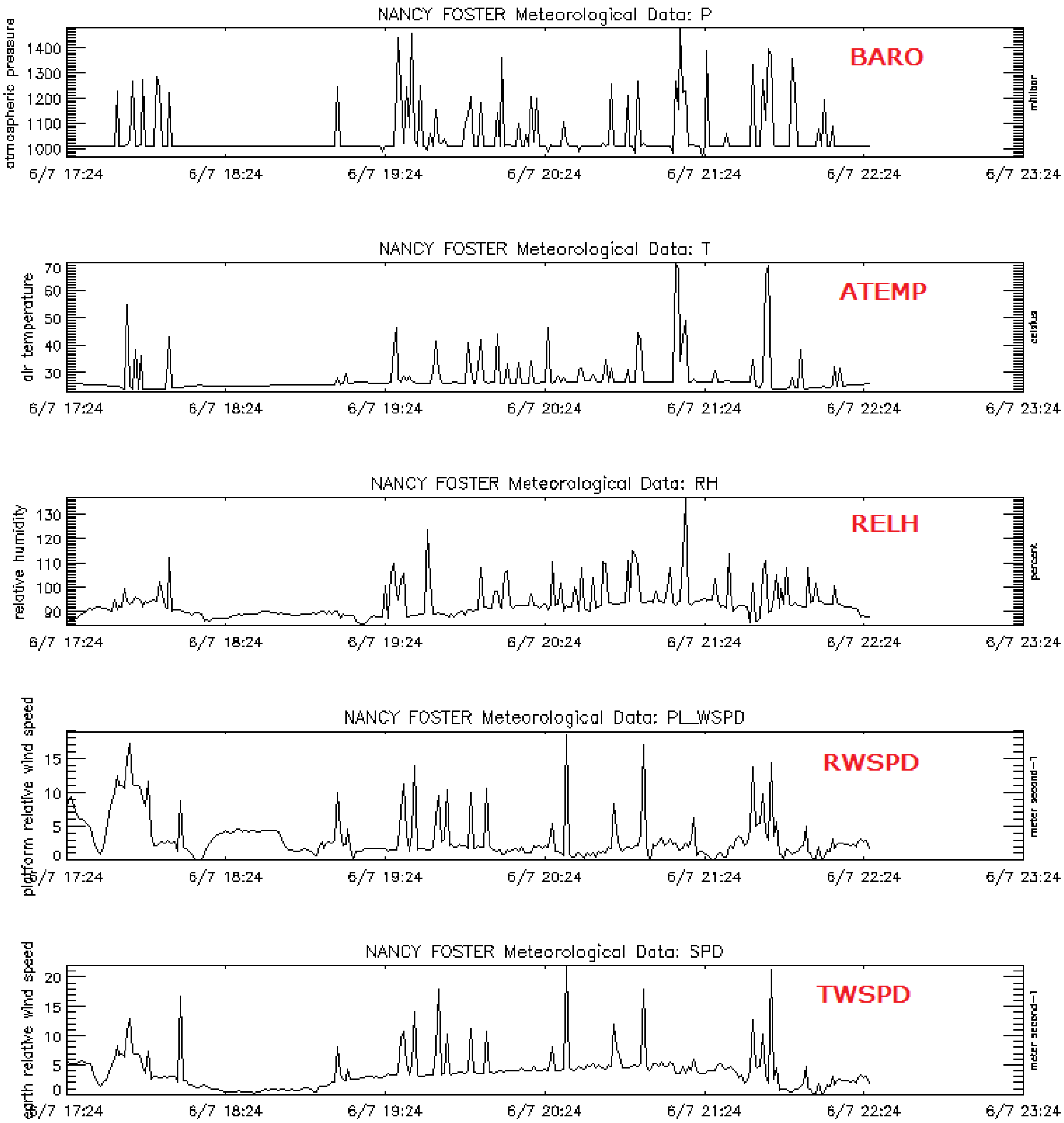


Figure 48: *Nancy Foster* SAMOS (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) platform relative wind speed – PL_WSPD – and (last) earth relative wind speed – SPD – data for 7 June 2019. Note anomalous spikes in all variables.

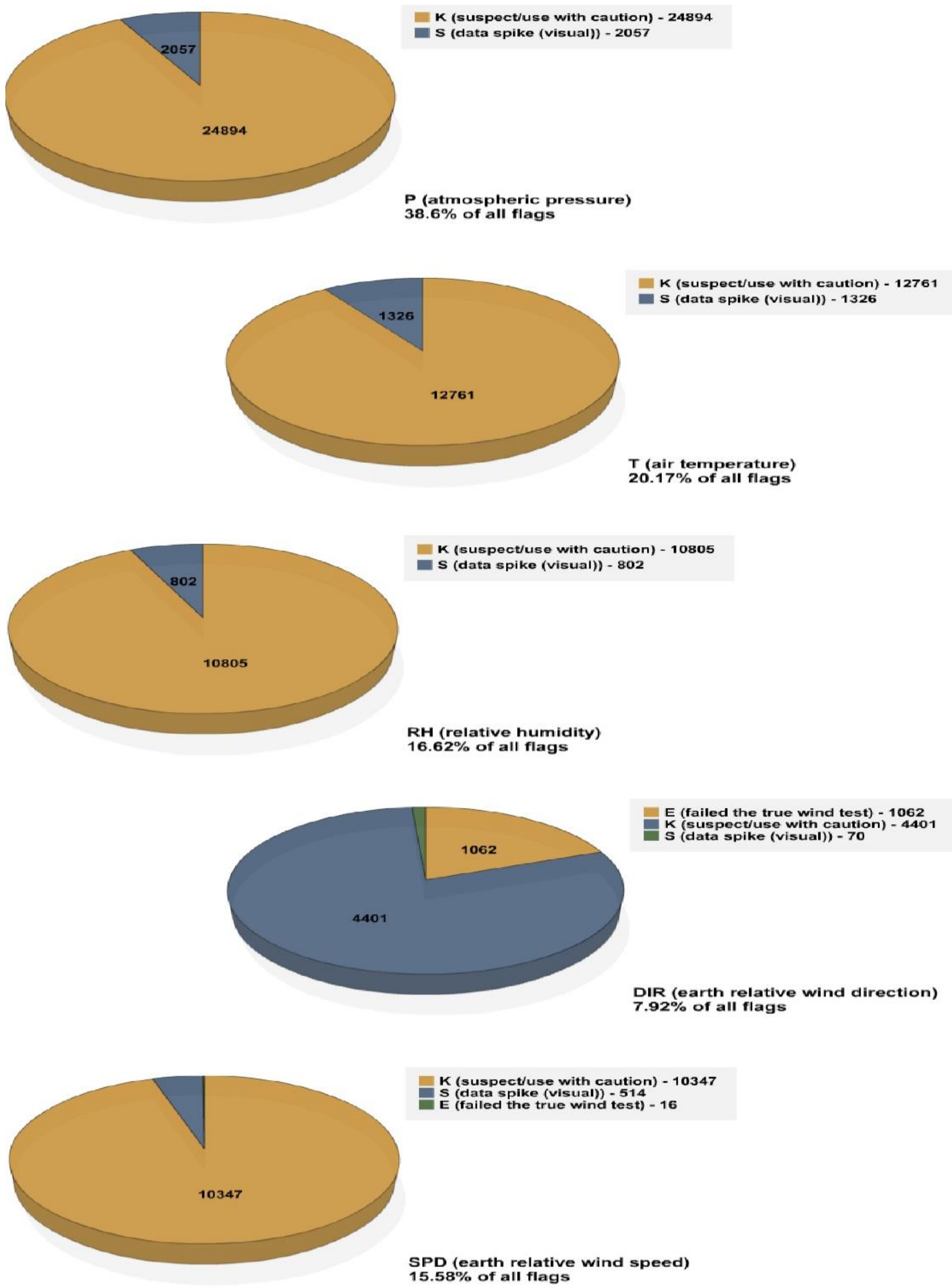


Figure 49: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – for the *Nancy Foster* in 2019.

Okeanos Explorer

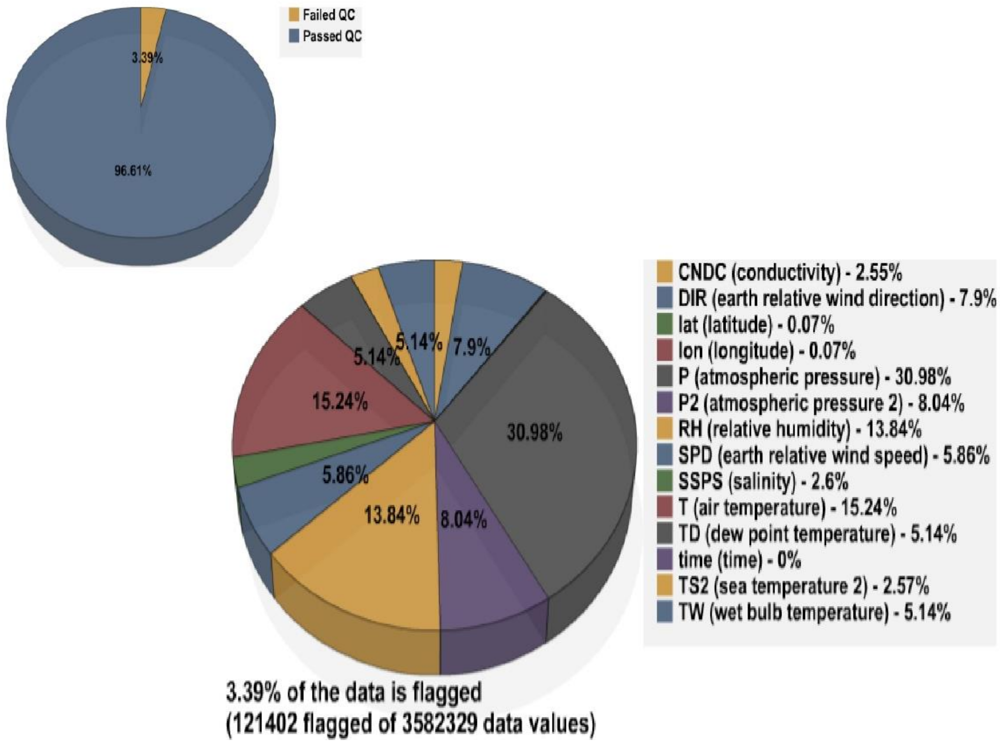


Figure 50: For the *Okeanos Explorer* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Okeanos Explorer* provided SAMOS data for 151 ship days, resulting in 3,582,329 distinct data values. After both automated and visual QC, 3.39% of the data were flagged using A-Y flags (Figure 51). This is about a percentage point lower than in 2018 (4.62%) and maintains *Explorer's* standing under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

There were no specific issues noted for the *Explorer* in 2019. *Okeanos Explorer'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/relative humidity, likely ship heating. Where the data appears affected, it is generally flagged with “caution/suspect” (K) flags. As is suggested by Figure 50, these effects are a bit more prevalent in the atmospheric pressure (P), air temperature (T), and relative humidity (RH). About 31% of the total flags were applied to P and a further combined ~29% were applied to T and RH, these all primarily being K flags (Figure 51). The T/RH and P sensors are known to be located just a few feet over the pilot house, with numerous metal structures nearby, such that T and RH are particularly susceptible to ship heating. In addition, the pressure sensor is situated just beside a small metal plate that, together with the other nearby structures, causes this sensor to be particularly sensitive to changes in the platform relative wind direction and speed. It should be noted that parameters wet bulb temperature (TW) and dew point temperature (TD), both calculated from T/RH, and the secondary atmospheric pressure (P2) parameter, which is an unadjusted version of P, were newly added to the SAMOS files halfway through the year. This means there was a lesser volume of TW/TD/P2 data overall, which would seem to explain why the flagged percentages for those are lower than the percentages for P, T, and RH (Figure 50). We add, though, that while it can be a challenge to site sensors ideally on a ship, with an overall flagged percentage below 5% *Explorer's* sensor location issues are not terribly grave.

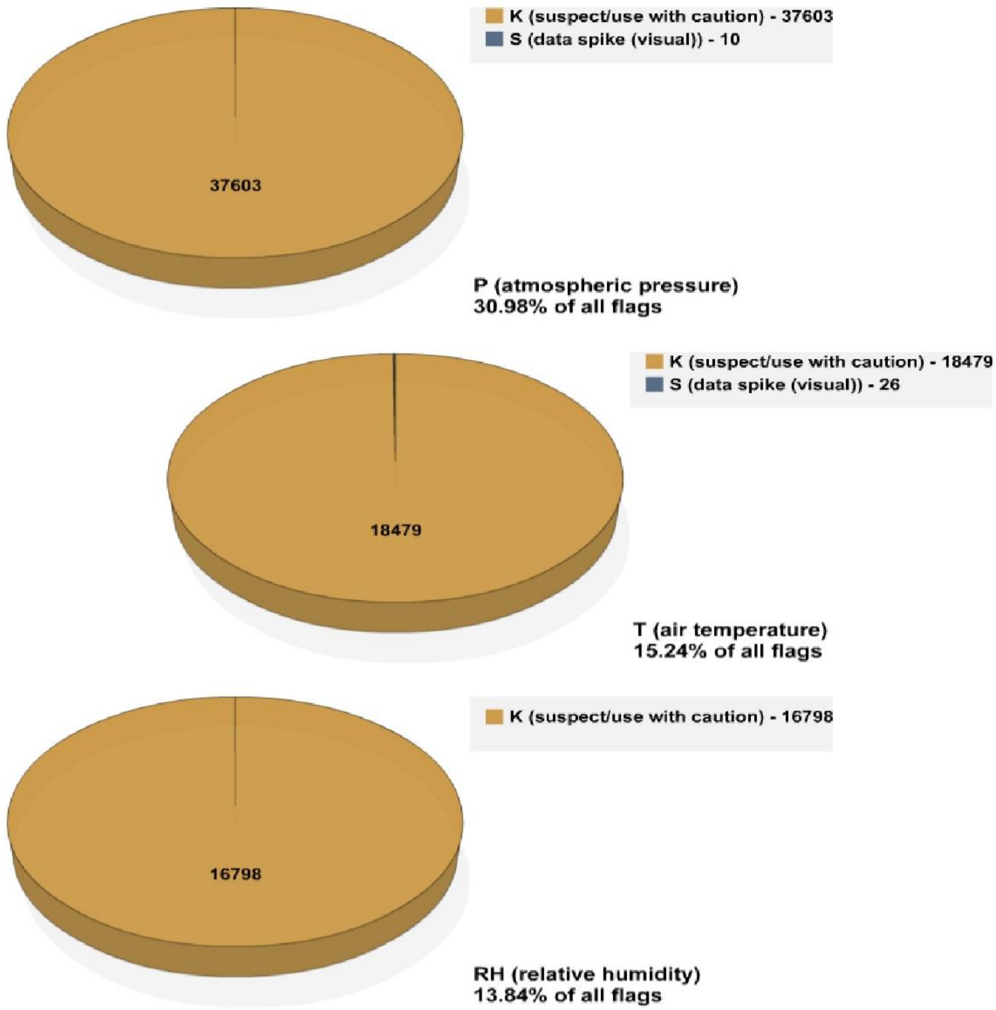
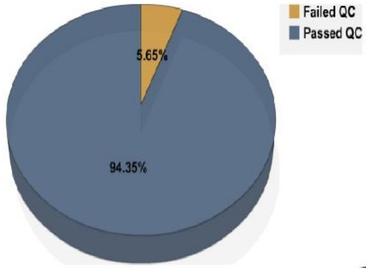


Figure 51: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – (middle) air temperature – T – and (bottom) relative humidity – RH – for the *Okeanos Explorer* in 2019.

Oregon II



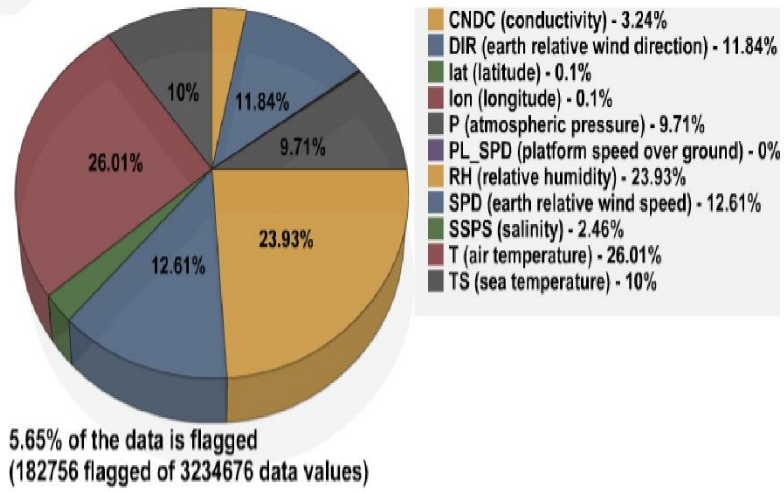


Figure 52: For the *Oregon II* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oregon II* provided SAMOS data for 156 ship days, resulting in 3,234,676 distinct data values. After both automated and visual QC, 5.65% of the data were flagged using A-Y flags (Figure 52). This is about a percentage point higher than in 2018 (4.33%) and moves the *Oregon II* just outside the "under 5% total flagged" bracket regarded by SAMOS to represent "very good" data.

Near the start of the season, on 20 April, it was noted and immediately confirmed by a vessel technician that conductivity (CNDC) appeared to be reporting different units than what was expected, causing the data values to be an order of magnitude too low. The units were subsequently fixed in the data acquisition system. In the meantime, CNDC accrued about 10 days-worth of "caution/suspect" (K) flags (Figure 53). We note that salinity (SSPS) is independently calculated onboard the vessel and these values do not appear affected by the CNDC units reporting issue.

Towards the end of the season, between 26 October and 7 November, sea temperature (TS) reported constant values that were mostly out of bounds for the region of operation. This effected the application of mainly "out of bounds" (B) and some small portion of "poor quality" (J) flags to that parameter (Figure 53). It is not known what caused the erroneous values, but by the following cruise (and lasting through the end of the year) the sensor was no longer reporting any data.

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 53, 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.

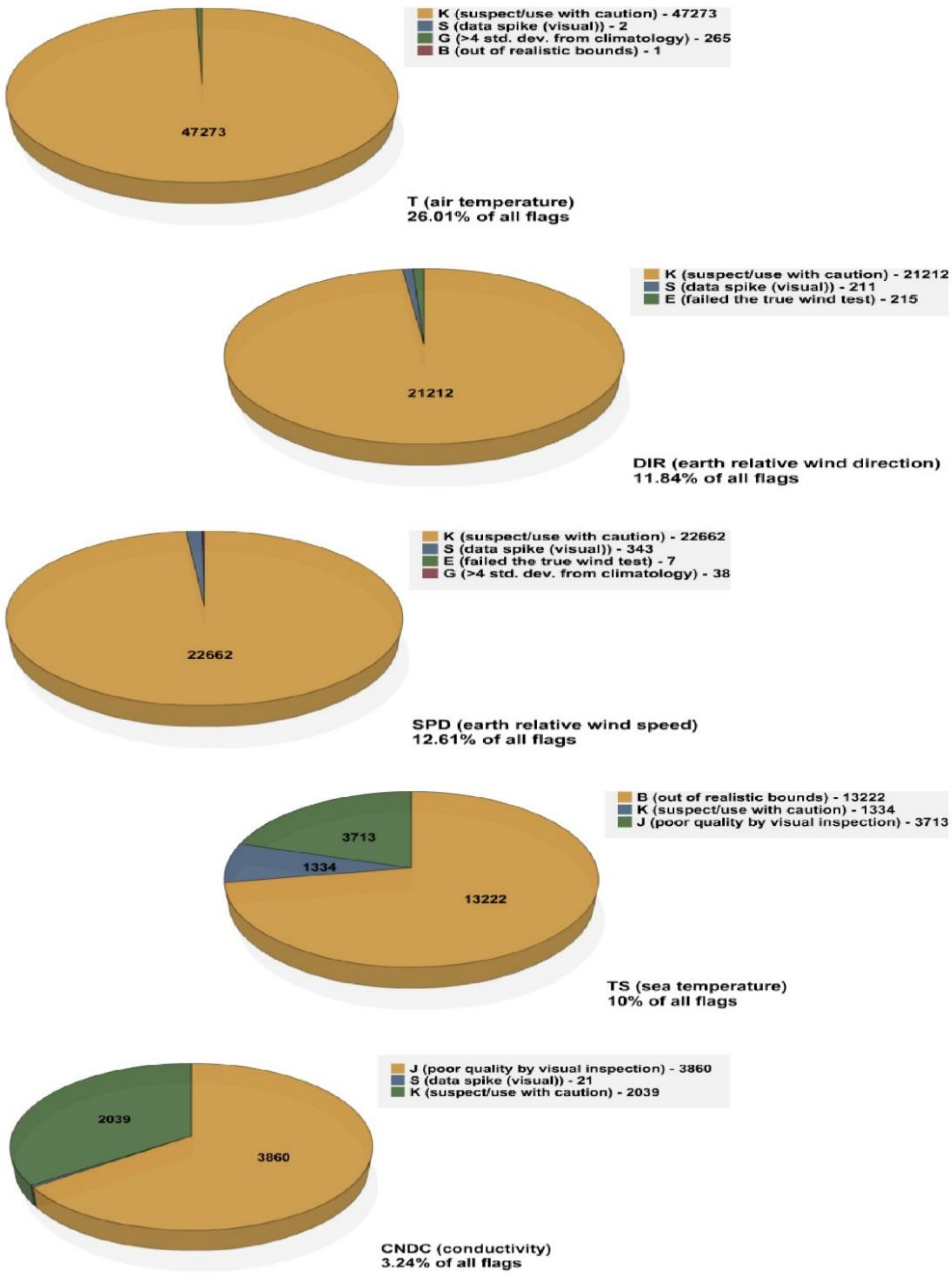
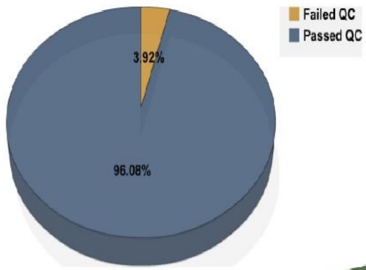


Figure 53: Distribution of SAMOS quality control flags for (first) air temperature – T – (second) earth relative wind direction – DIR – (third) earth relative wind speed – SPD – (fourth) sea temperature – TS – and (last) conductivity – CNDC – for the *Oregon II* in 2019.

Oscar Dyson



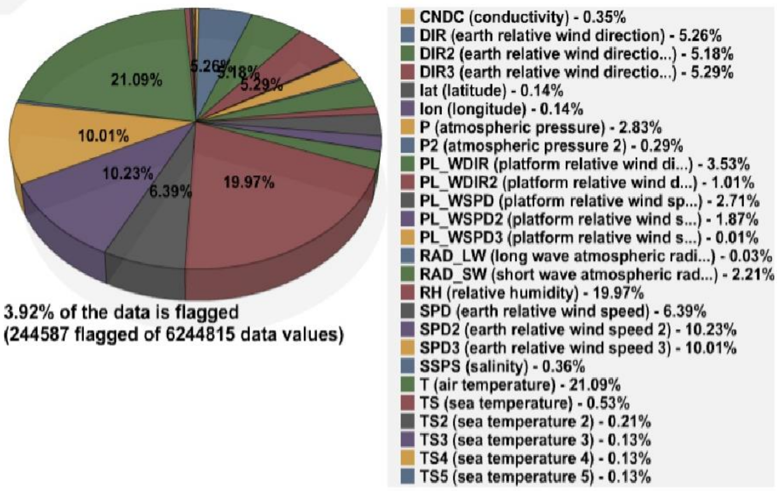


Figure 54: For the *Oscar Dyson* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oscar Dyson* provided SAMOS data for 159 ship days, resulting in 6,244,815 distinct data values. After both automated and visual QC, 3.92% of the data were flagged using A-Y flags (Figure 54). This is significantly lower than in 2018 (8.77%) and brings *Dyson* under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

As seen in Figure 54, air temperature (T) and relative humidity (RH) together amassed ~ 40% of *Dyson's* total flags. In mid-April, just after the start of the season, *Dyson's* chief survey technician advised they'd discovered a problematic offset value in the translator for T/RH that effectuated inaccurate output for both those parameters. The technician had attempted to address the offset, which afforded some improvement, but further instructed that although the data now appeared more reasonable they still should not be used until the issue was definitively fixed. Consequently, both T and RH were assigned "malfunction" (M) flags from 8 through 15 April, before the first attempt at fixing, and "poor quality" (J) flags thereafter, at the technician's directive (Figure 55). Several subsequent attempts were made to confirm the date the data should be considered "good," and in late May we received word the data had likely been "fixed" as of 5 May. Unfortunately, J-flagging had already continued through 20 May. It was stopped thereafter.

Also, at the beginning of *Dyson's* season, it was noted the primary wind direction differed by about 100° from the vessel's other two anemometers. We were immediately informed by a vessel technician the mount for the affected anemometer had been bent by a crane lift during their shipyard period. The issue was fixed as of 20 April, but from 8 through 19 April all of platform relative wind direction (PL_WDIR), earth relative wind direction (DIR), and earth relative wind speed (SPD) were assigned M flags (Figure 55, not all shown). During this period platform relative wind speed (PL_WSPD) data additionally were assigned "caution/suspect" (K) flags (not shown). Shortly afterwards, on 3 May, a visiting chief survey technician for the NOAA fleet advised that the primary wind sensor showed an apparent approximate bias of -11° (this would affect PL_WDIR and DIR), which he and other vessel technicians were attempting to address within the sensor's translator code. It is not known whether this fix was accomplished, but in any case, no flags were applied based on this note. We publish the information here as an advisory only.

As a general note, *Dyson's* various meteorological sensors do occasionally exhibit data distortion that is dependent on the vessel relative wind direction, which sometimes results in the application of K flags (Figure 55, not all shown). This is common to most vessels, as it is difficult to site instruments ideally on a moving ship. But with an overall flag percentage under 5% any sensor location issues on the *Dyson* should not be considered terribly consequential.

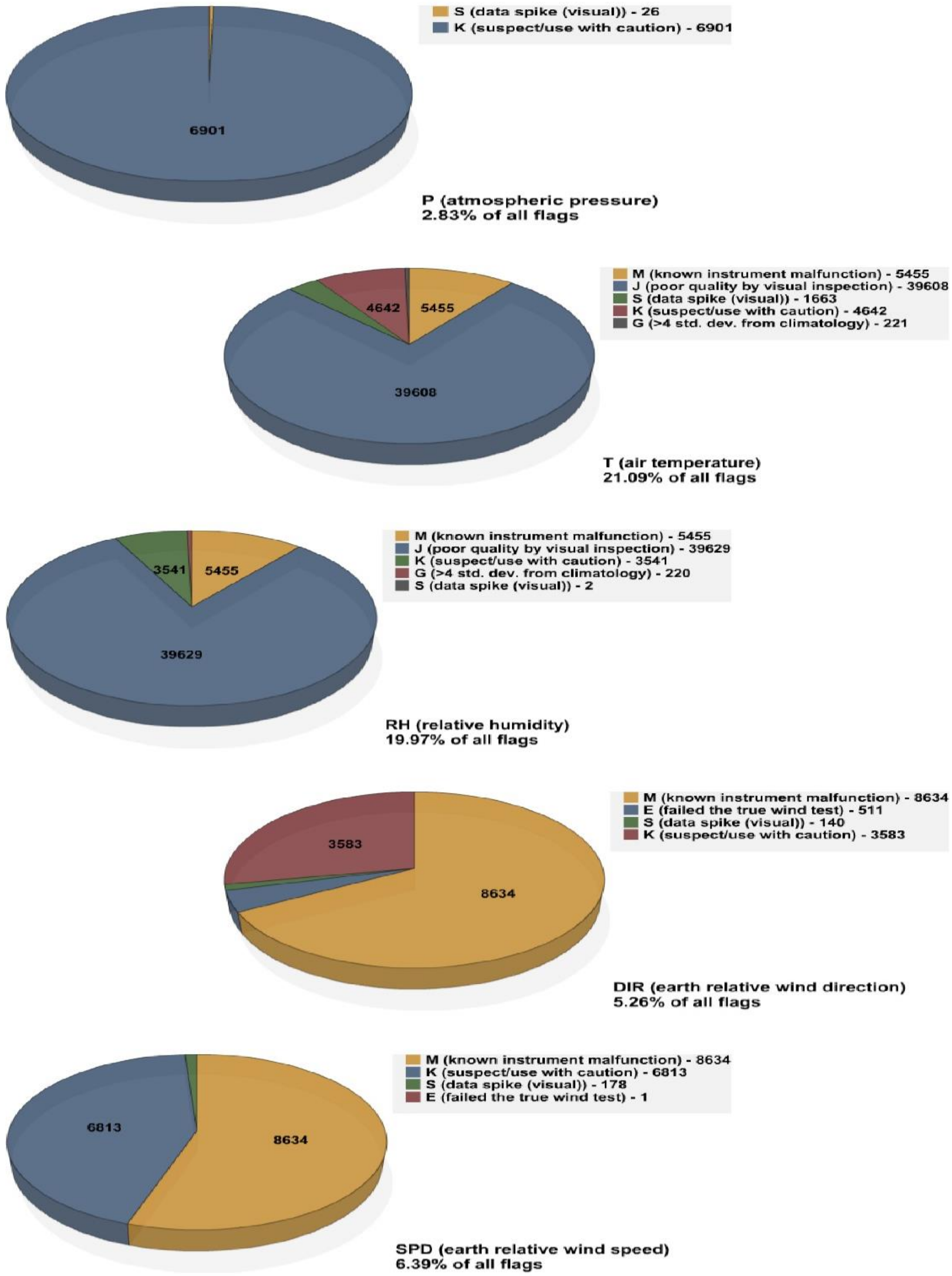


Figure 55: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – for the *Oscar Dyson* in 2019.

Oscar Elton Sette

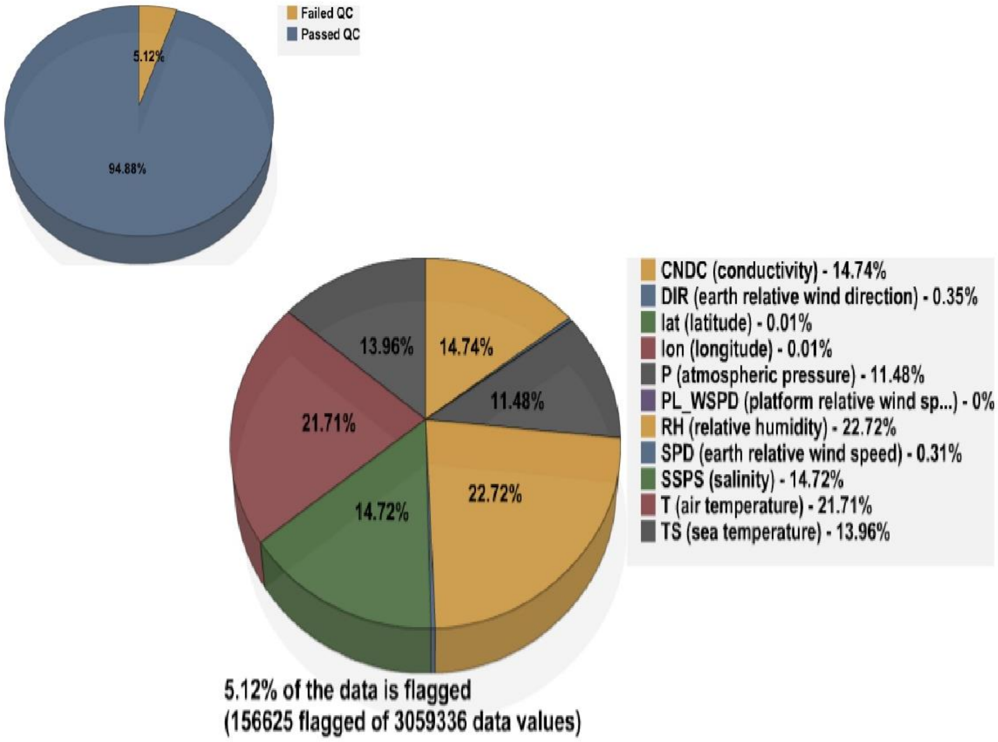


Figure 56: For the *Oscar Elton Sette* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oscar Elton Sette* provided SAMOS data for 145 ship days, resulting in 3,059,336 distinct data values. After both automated and visual QC, 5.12% of the data were flagged using A-Y flags (Figure 56). This is only a tiny bit higher than in 2018 (4.99%) but moves *Sette* just outside the "under 5% total flagged" bracket regarded by SAMOS to represent "very good" data.

As seen in Figure 56, air temperature (T) and relative humidity (RH) together amassed ~ 44% of *Oscar Elton Sette's* total flags. Beginning around 20 April RH became "stuck" right around 100%. On 1 May this was communicated to the vessel and one of the technicians immediately confirmed that RH appeared to be broken. Consequently, RH was flagged with "caution/suspect" (K) flags from 20 through 30 April and "malfunction" (M) flags beginning 1 May (Figure 57). As this was an integrated unit, and the actual extent of the problem was indeterminate, air temperature (T) was also K-flagged for the duration (Figure 57). The affected T/RH instrument was replaced while the vessel was in port in mid-May and the data were thereafter markedly improved. As such, associated flagging of T and RH ceased as of 15 May.

Each of the three sea parameters – sea temperature (TS), salinity (SSPS), and conductivity (CNDC) – received about 14% of the total flags (Figure 56). However, the vast majority were K and "poor quality" (J) flags (Figure 57) assigned when the sea water flow-through system was known to be or appeared to be shut down (secured), either because the vessel was in or near port or else was underway in rough seas, both being common practices on other vessels.

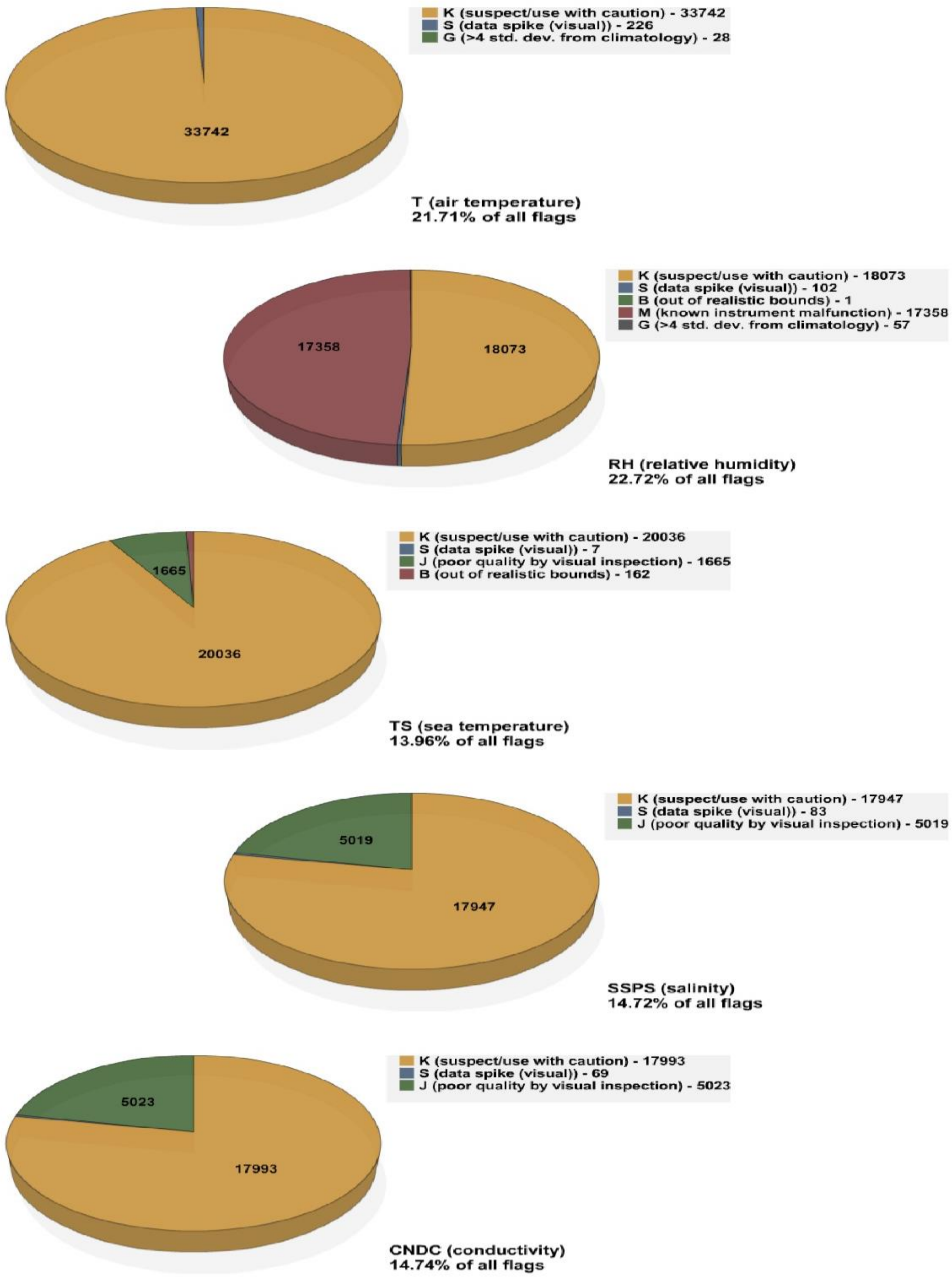
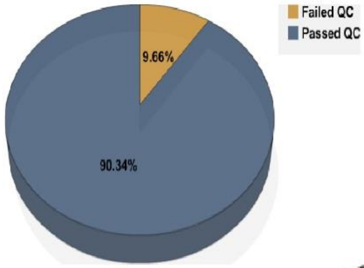


Figure 57: Distribution of SAMOS quality control flags for (first) air temperature – T – (second) relative humidity – RH – (third) sea temperature – TS – (fourth) salinity – SSPS – and (last) conductivity – CNDC – for the *Oscar Elton Sette* in 2019.

Pisces



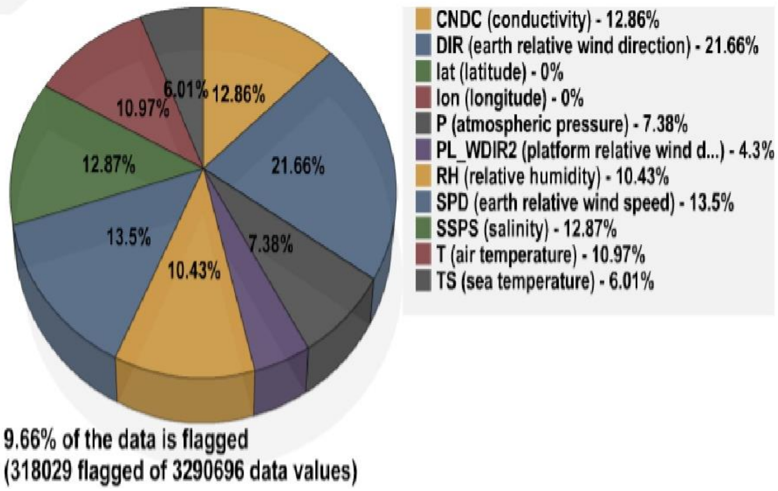


Figure 58: For the *Pisces* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Pisces* provided SAMOS data for 143 ship days, resulting in 3,290,696 distinct data values. After both automated and visual QC, 9.66% of the data were flagged using A-Y flags (Figure 58). This is about one and a half percentage points lower than in 2018 (11.13%).

In mid-July it was noted and immediately confirmed by both the vessel's commanding officer and the chief electronics technician that the secondary platform relative wind direction (PL_WDIR2) sensor's data had been stuck at a constant 94° since 4 July. Recalling there had been a power outage on the ship around the 4th, the technician tried a power reset on the sensor and this indeed cleared the issue. In the meantime, PL_WDIR2 received some "poor quality" (J) and "malfunction" (M) flags between 4 and 17 July (Figure 60). We note the secondary anemometer does not supply analogous earth relative wind speed or direction to SAMOS, hence no extra flagging was needed here.

In general, *Pisces'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 flow distortion, which oftentimes results in "caution/suspect" (K) flags for each of those parameters (Figure 60, not all shown). This is common to most vessels, as it is difficult to site instruments ideally on a moving ship, though it is notably more pronounced on the *Pisces* than others. As is suggested by Figure 58, the effects of flow distortion are a bit more prevalent in the true winds. About 35% of the total flags were applied to SPD and DIR, these primarily being K flags (Figure 60).

Additionally, as has long been known, there is poor sea water piping on the *Pisces*. This often causes spurious noise and steps in the sea water data (see Figure 59). The effect is a bit more evident in the thermosalinograph data, meaning salinity (SSPS) and conductivity (CNDC), than it is in the remote thermometer data, meaning sea temperature (TS). Where noise appears in TS, SSPS, or CNDC, K flags are typically applied (Figure 60, not all shown). This mode of flagging likely explains the bulk of the ~32% combined total flagged percentage assigned to TS, SSPS, and CNDC (Figure 58).

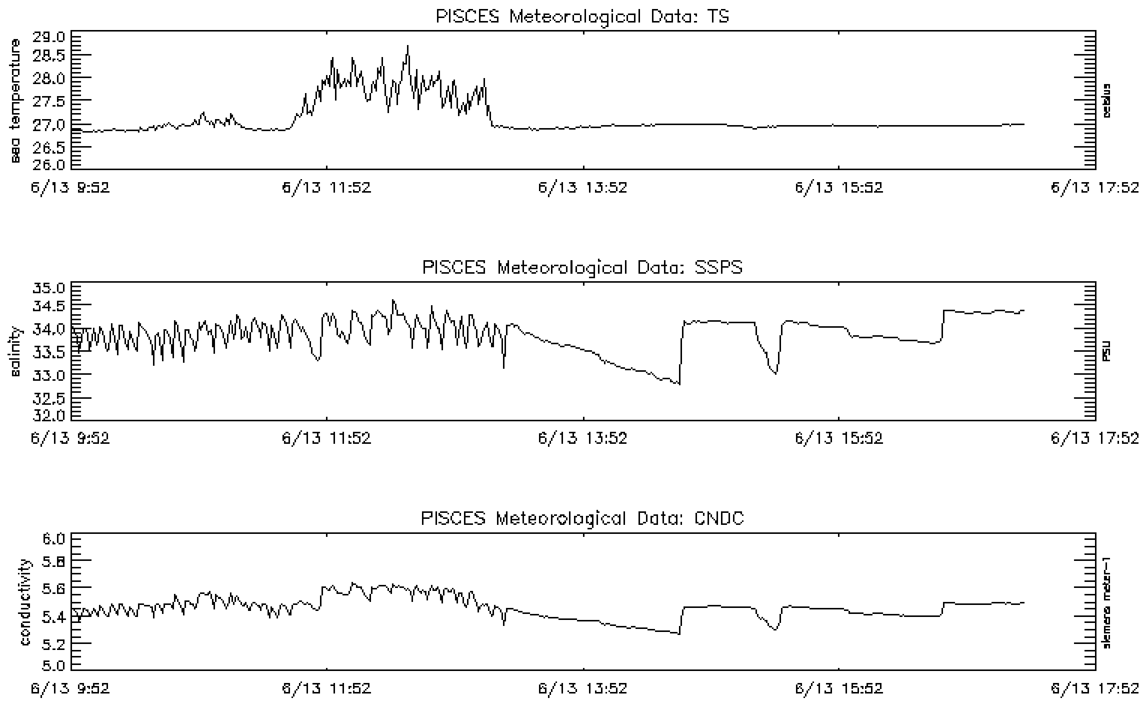


Figure 59: *Pisces* SAMOS (top) sea temperature – TS – (middle) salinity – SSPS – and (bottom) conductivity – CNDC – data for 13 June 2019. Note some gritty noise in all data as well as spurious wedge-shaped downward steps in SSPS and CNDC.

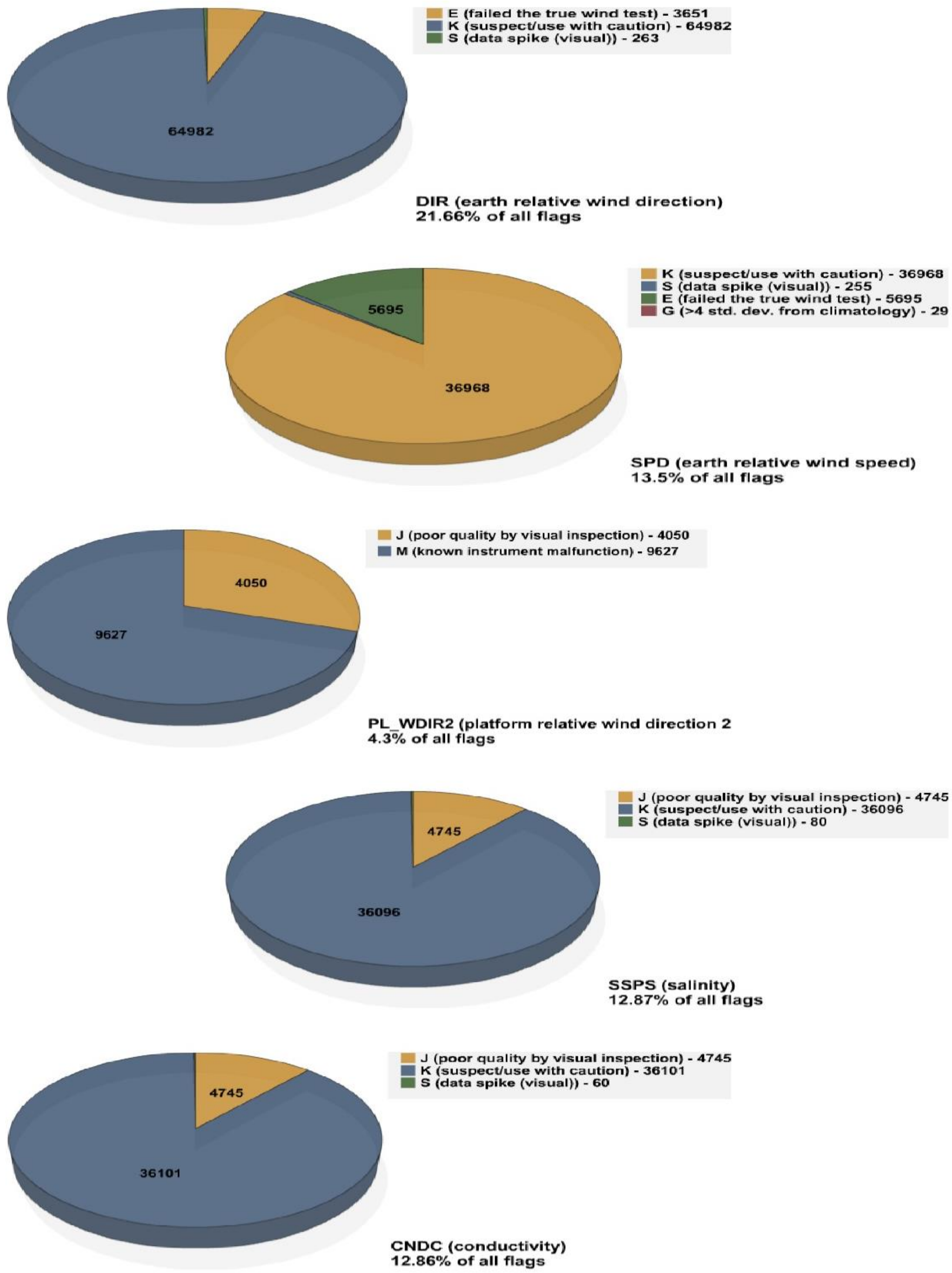
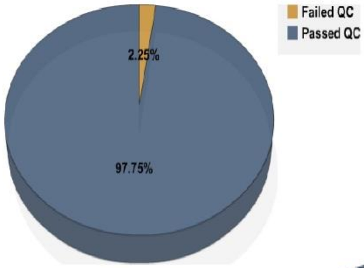


Figure 60: Distribution of SAMOS quality control flags for (first) earth relative wind direction – DIR – (second) earth relative wind speed – SPD – (third) platform relative wind direction 2 – PL_WDIR2 – (fourth) salinity – SSPS – and (last) conductivity –CNDC – for the *Pisces* in 2019.

Rainier



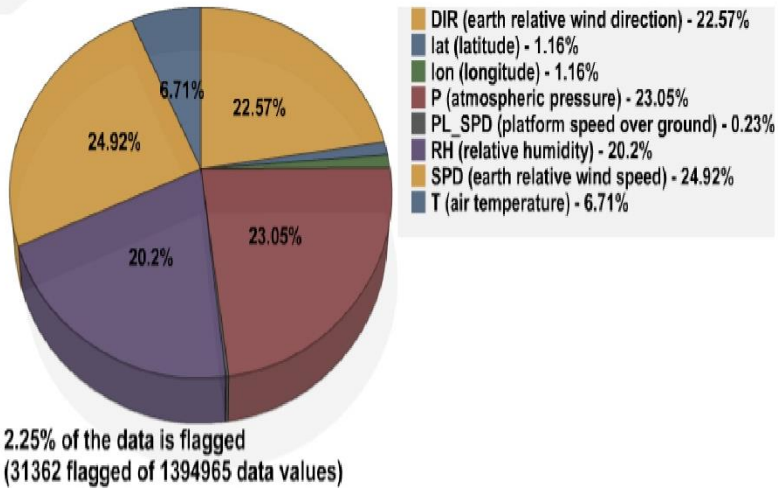


Figure 61: For the *Rainier* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Rainier* provided SAMOS data for 78 ship days, resulting in 1,394,965 distinct data values. After both automated and visual QC, 2.25% of the data were flagged using A-Y flags (Figure 61). This is about a percentage point lower than in 2018 (3.56%) and maintains *Rainier's* standing well under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. We note *Rainier's* 2019 SAMOS data transmission rate was 55% (see Table 2). It would be desirable to recover any data not received by us, if possible (see Figure 2).

There were no specific data issues noted for *Rainier* in 2019. There was, however, a recurrence of a problematic "key:value" data pair in *Rainier's* SAMOS files beginning around mid-June. The designator "Cruise / Leg" was supplied in the files, which causes errors when the National Centers for Environmental Information (NCEI) attempts to archive the data set. The problem here is blank spaces in the designator. Vessel technicians were unable in 2019 to correct the problematic designator. As such, we routinely manually altered the designators in the affected data files before archiving with NCEI. We note in our SAMOS recruitment materials that all SAMOS designators must be alphanumeric without any blank spaces.

In general, *Rainier's* various meteorological sensors – atmospheric pressure (P), air temperature (T), relative humidity (RH), and earth relative wind speed and direction (SPD and DIR, respectively) – do occasionally exhibit data distortion that is dependent on the vessel relative wind direction. Where the data appears affected, it is generally flagged with "caution/suspect" (K) flags (Figure 62). We note, though, that while it can be a challenge to site sensors ideally on a ship, with an overall flagged percentage well below 5% these sensor location issues are not terribly consequential.

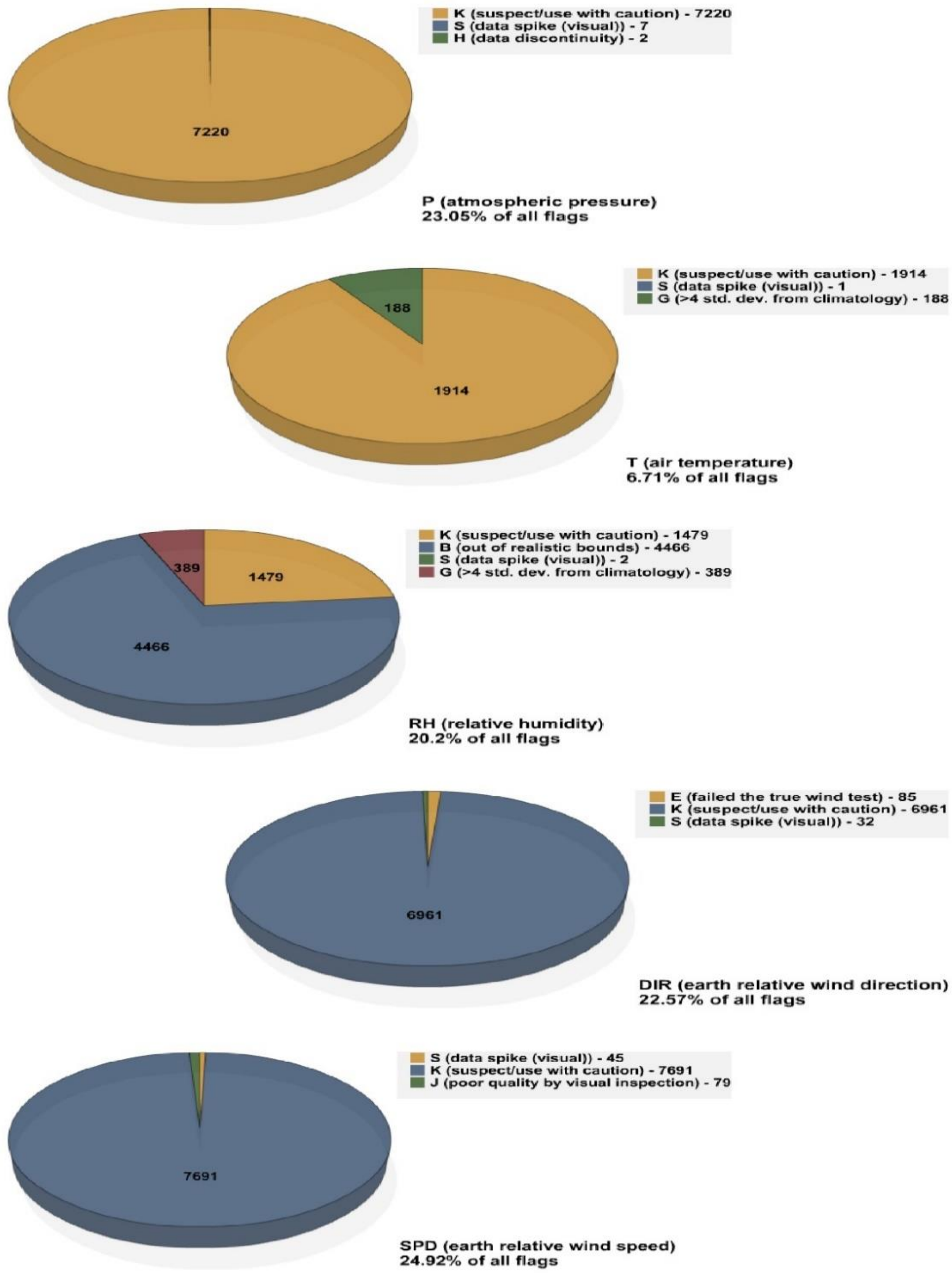


Figure 62: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) air temperature – T – (third) relative humidity – RH – (fourth) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – for the *Rainier* in 2019.

Reuben Lasker

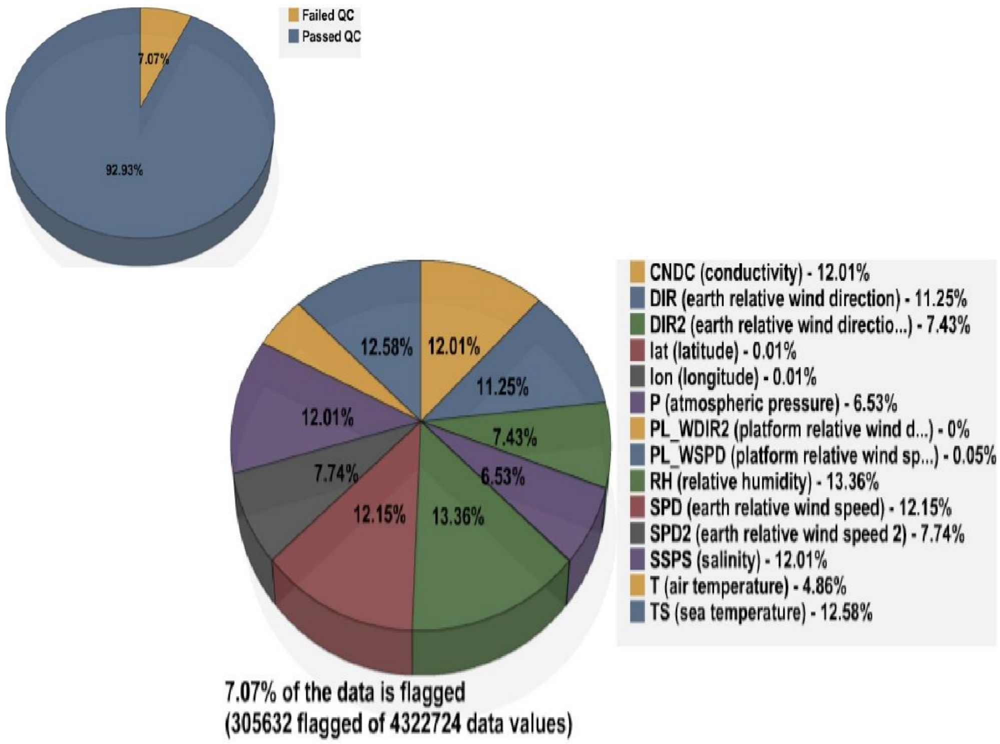


Figure 63: For the *Reuben Lasker* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Reuben Lasker* provided SAMOS data for 172 ship days, resulting in 4,322,724 distinct data values. After both automated and visual QC, 7.07% of the data were flagged using A-Y flags (Figure 63). This is significantly lower than in 2018 (12.09%).

In October, near the end of the season, *Reuben Lasker's* air temperature (T) and relative humidity (RH) began exhibiting sporadic data dropouts and occasional spikes or steps to unreasonable (and sometimes constant) values (see Figure 64). In the final days T and RH data quickly degraded to the point of being mostly unrealistic values or else entirely missing. During this entire episode, T and RH were variously flagged with "caution/suspect" (K), "spike" (S), and "out of bounds" (B) flags, depending on the severity of the presentation (Figure 65). It was confirmed in early 2020, at the start of the new season, that vessel technicians had been and still were struggling to identify the problem with the T/RH sensor and to put things in order. It's been suggested the sensor may need replacing if/when possible, or that perhaps there is a problem with the wiring.

In general, *Reuben Lasker's* meteorological data – earth relative wind speeds and directions (SPD, SPD2 and DIR, DIR2, respectively), T and RH, and atmospheric pressure (P) – all show signs of moderate flow distortion, which oftentimes results in K flags for each of those parameters (Figure 65, not all shown). This is common to most vessels (though a bit more pronounced on the *Lasker*), as it is difficult to site instruments ideally on a moving ship.

As seen in Figure 63, a combined ~ 36% of the total flags were amassed by the sea temperature (TS), salinity (SSPS), and conductivity (CNDC). These were primarily K flags applied when the sea water flow-through system appeared to be shut down (secured) and J flags applied when the thermosalinograph itself appeared to be off (Figure 65, not all shown), generally because the vessel was either in or near a port or else was underway in rough seas. These practices are all common on other vessels.

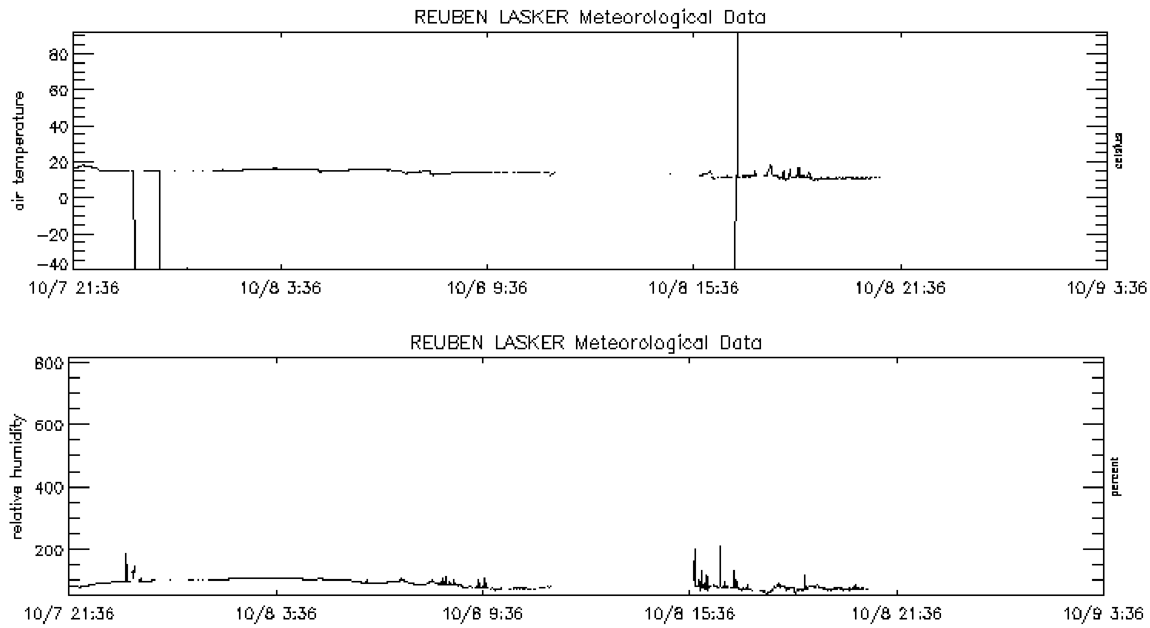


Figure 64: *Reuben Lasker* SAMOS (top) air temperature – T – and (bottom) relative humidity – RH – data for 7-8 October 2019. Note data dropouts and unreasonable spikes.

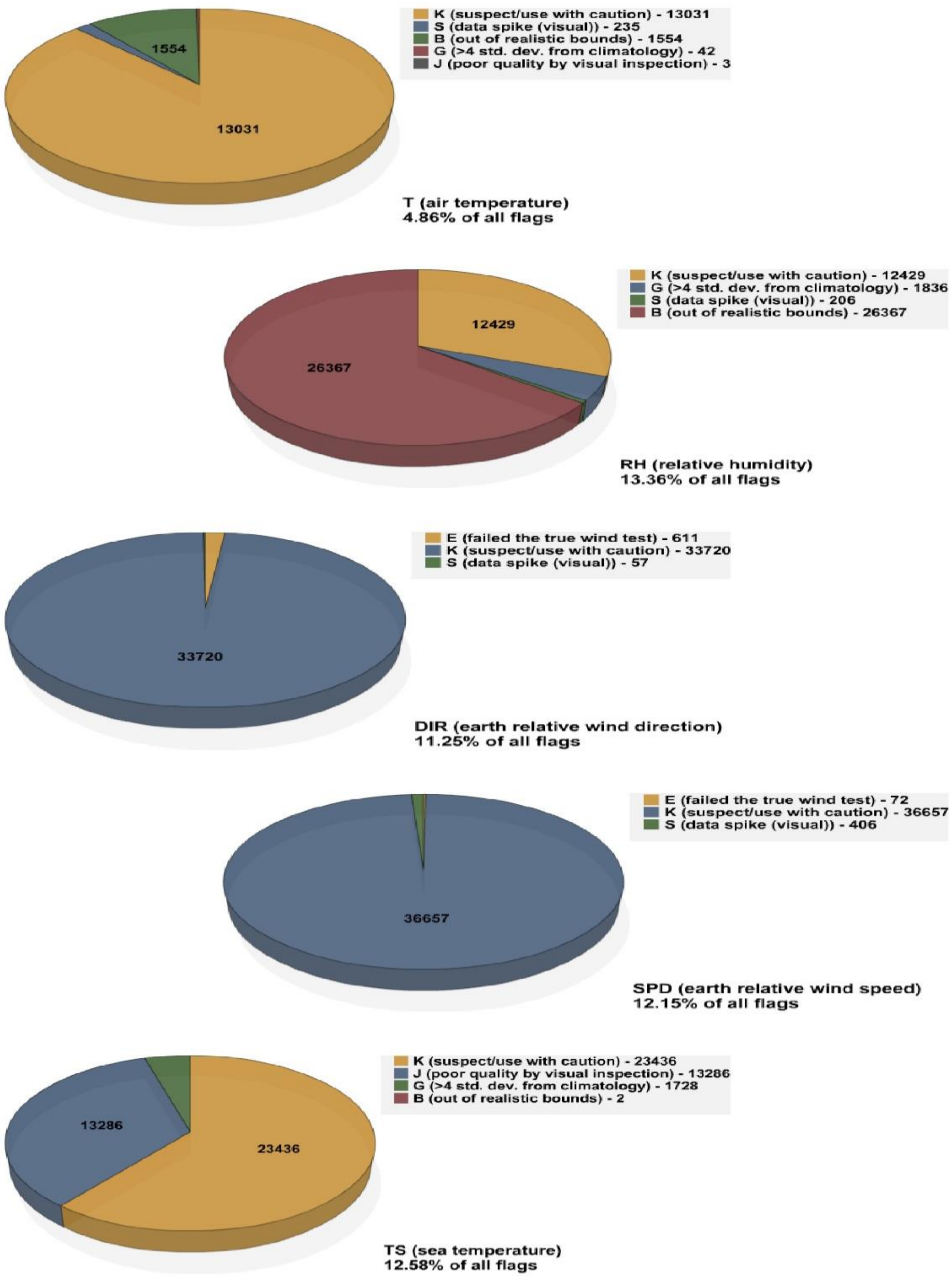


Figure 65: Distribution of SAMOS quality control flags for (first) air temperature – T – (second) relative humidity – RH – (third) earth relative wind direction – DIR – (fourth) earth relative wind speed – SPD – and (last) sea temperature – TS – for the *Reuben Lasker* in 2019.

Ronald H. Brown

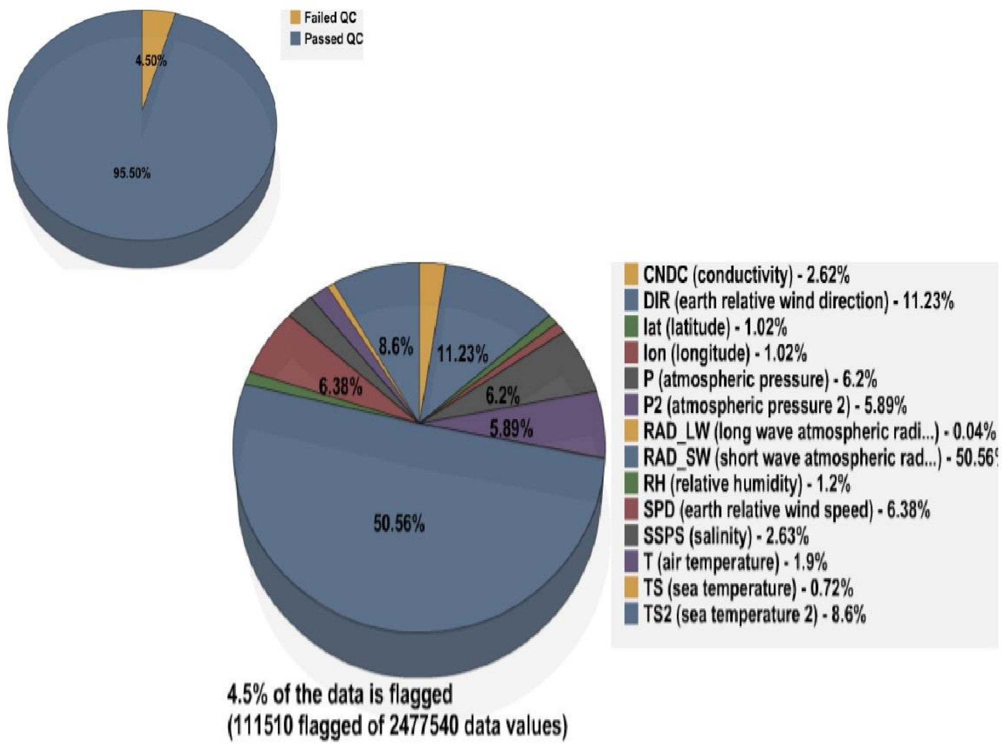


Figure 66: For the *Ronald H. Brown* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Ronald H. Brown* provided SAMOS data for 99 ship days, resulting in 2,477,540 distinct data values. After both automated and visual QC, 4.5% of the data were flagged using A-Y flags (Figure 66). This is about a percentage point lower than in 2018 (5.38%) and brings *Brown* under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

It was discovered in early 2019 that, due to sensor installation and water draw issues, a pocket of air occasionally formed at the top of the *Brown's* thermosalinograph sea chest and left the secondary sea temperature sensor (TS2) taking measurements from above the water level. TS2 data were smoothed and appeared less responsive to sea changes as a result. Affected data were first flagged with “caution/suspect” (K) flags and later, after the issue was defined, “malfunction” (M) flags (Figure 67). On or around 9 March a technician modified the TS2 housing inside the chest so that the sensor would sit below the level of any air pockets and the issue was permanently eliminated.

In early April an augmenting senior survey technician determined *Brown's* platform relative wind direction (PL_WDIR) was being provided by a different anemometer than the one providing the earth relative wind speed and direction (SPD and DIR, respectively). Consequently, SPD and DIR were regularly receiving “failed the true wind test” (E) flags (Figure 67), since they were being tested against the wrong instrument's relative wind direction data. The technician subsequently rectified the mismatch in the vessel's data acquisition system and as a result DIR and SPD E-flagging was significantly reduced.

At first glance the short wave radiation (RAD_SW) parameter, holding half of all flags (Figure 66), would appear to have been especially problematic for the *Brown*. However, these were almost exclusively "out of bounds" (B) flags (Figure 67), 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. Where the data appears affected, it is generally K-flagged (Figure 67, not all shown). We note, though, that while it can be a challenge to site sensors ideally on a ship, with an overall flagged percentage below 5% these sensor location issues are not terribly consequential.

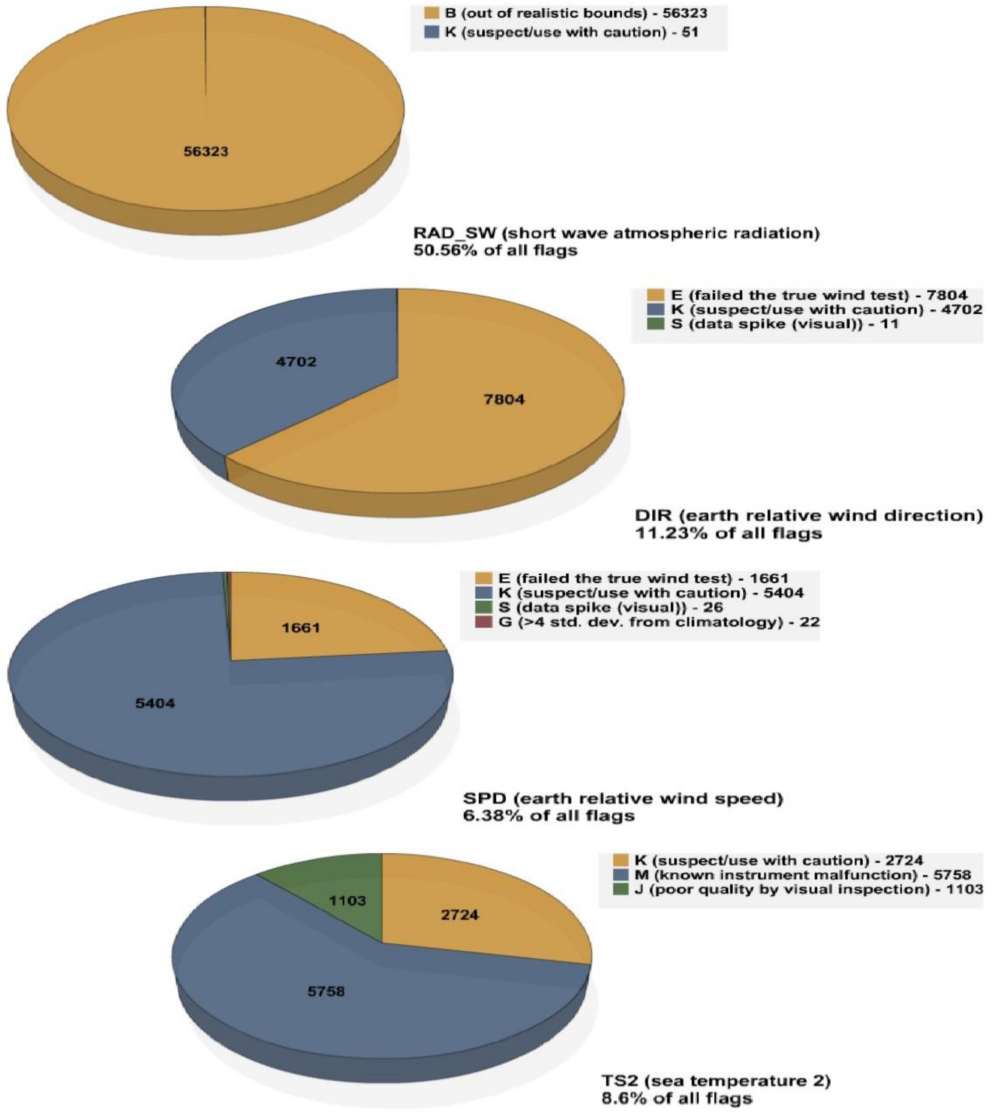
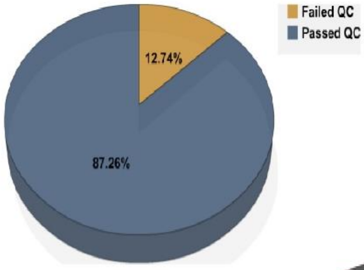


Figure 67: Distribution of SAMOS quality control flags for (first) short wave atmospheric radiation – RAD_SW – (second) earth relative wind direction – DIR – (third) earth relative wind speed – SPD – and (last) sea temperature 2 – TS2 – for the *Ronald Brown* in 2019.

Thomas Jefferson



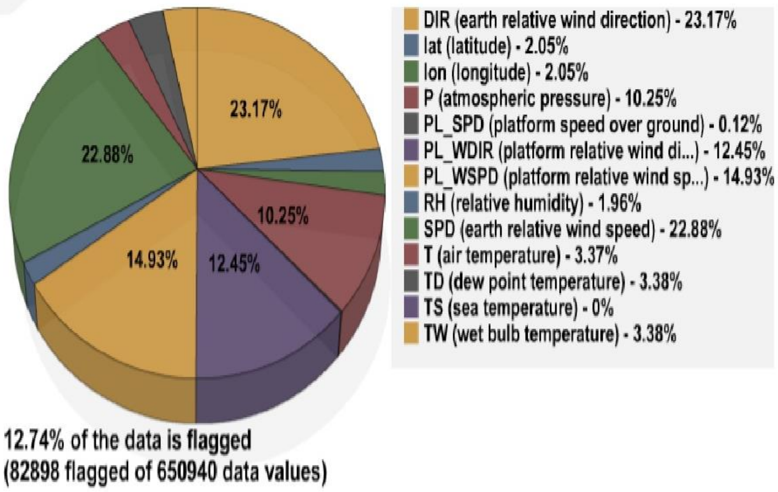


Figure 68: For the *Thomas Jefferson* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Thomas Jefferson* provided SAMOS data for 32 ship days, resulting in 650,940 distinct data values. After both automated and visual QC, 12.74% of the data were flagged using A-Y flags (Figure 68). This is significantly higher than in 2018 (4.18%) and moves *Jefferson* outside the “under 5% total flagged” bracket regarded by SAMOS to represent "very good" data.

We note *Thomas Jefferson* was in the shipyard until early October, meaning a very late start for her in 2019.

On 20 November it was noted that since 10 November *Jefferson's* platform relative wind speed and direction (PL_WSPD and PL_WDIR, respectively) had remained pretty static over the course of each day. This, in turn, had caused the earth relative wind speed and direction (SPD and DIR, respectively) to echo the ship's speed (PL_SPD) and heading (PL_HD), respectively (see Figure 69). This was immediately confirmed by a vessel technician, who advised that their port anemometer had failed at the beginning of the cruise leg, and modifications to the data acquisition system to pull wind data from their other sensor had been inadvertently overlooked. The technician immediately made these modifications and the wind issue was resolved. In the meantime, PL_WDIR, PL_WSPD, DIR, and SPD were assigned mainly “malfunction” (M) flags from 10 through 20 November (Figure 71).

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 71, not all shown). As is suggested by Figure 68, this is more pronounced in the atmospheric pressure (P). Steps in the P data are frequently seen (see Figure 70), suggesting an exposure issue for the pressure port. However, digital imagery does not exist for this vessel (see Table 4), making diagnosis difficult.

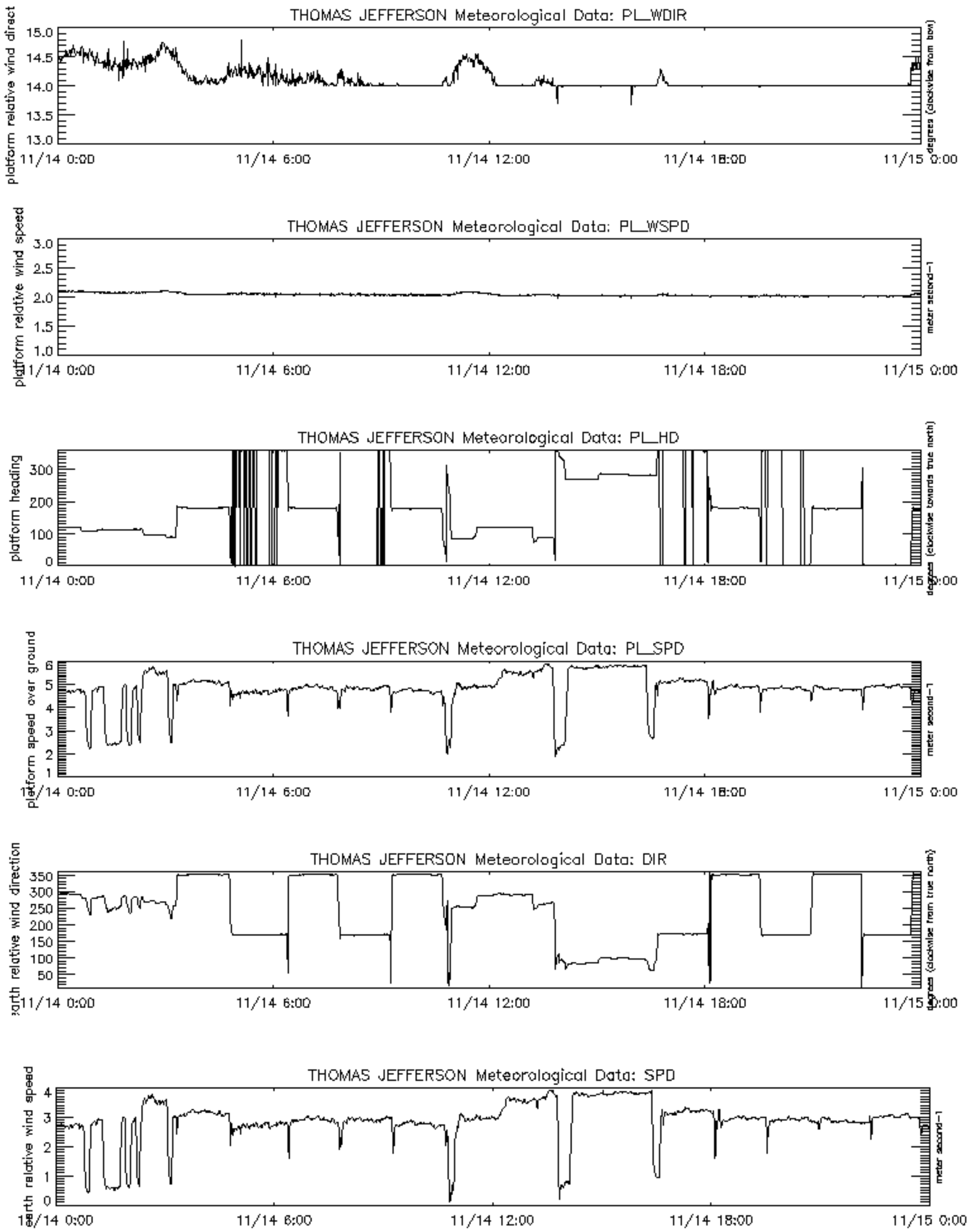


Figure 69: *Thomas Jefferson* SAMOS (first) platform relative wind direction – PL_WDIR – (second) platform relative wind speed – PL_WSPD – (third) platform heading – PL_HD – (fourth) platform speed over ground – PL_SPD – (fifth) earth relative wind direction – DIR – and (last) earth relative wind speed – SPD – data for 14 November 2019. Note nearly static PL_WDIR and PL_WSPD, and note how DIR and SPD essentially mirror PL_HD and PL_SPD, respectively.

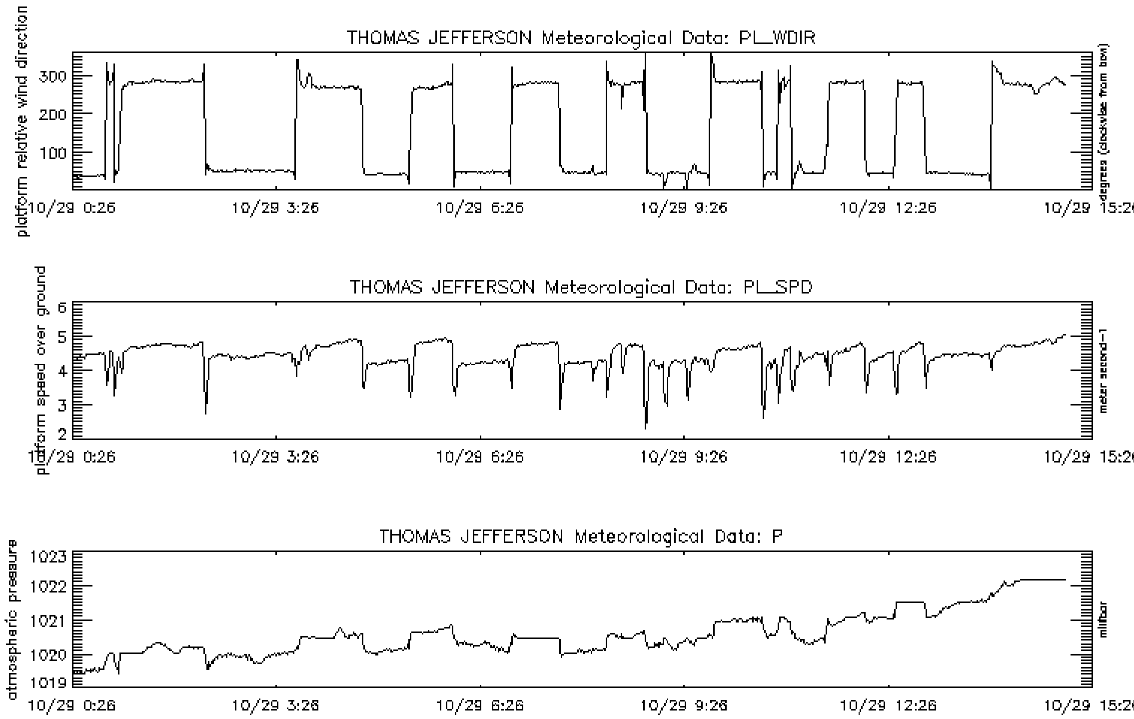


Figure 70: *Thomas Jefferson* SAMOS (top) platform relative wind direction – PL_WDIR – (middle) platform speed over ground – PL_SPD – and (bottom) atmospheric pressure – P – data for 29 October 2019. Note the many steps in P as PL_WDIR/PL_SPD change.

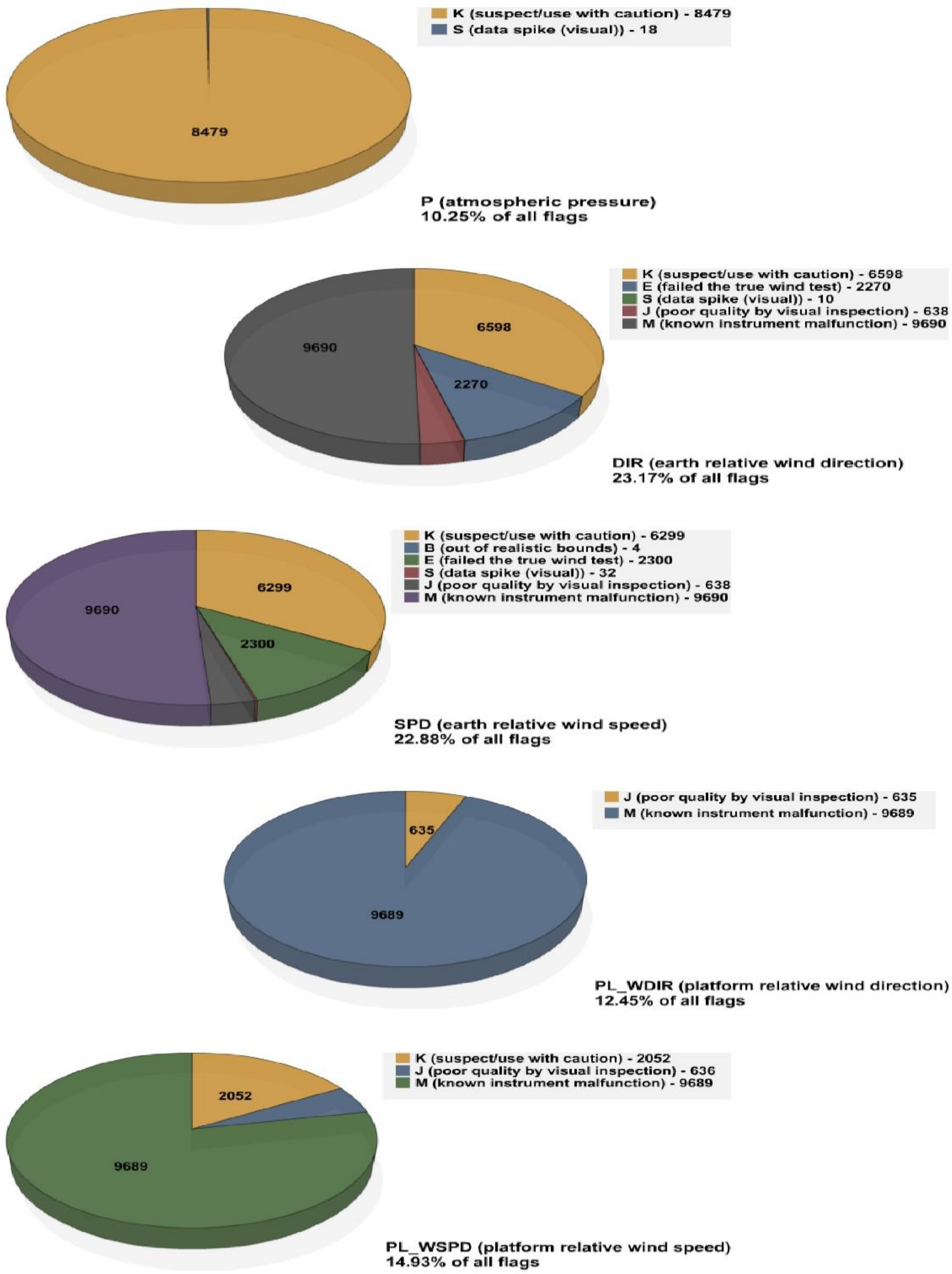


Figure 71: Distribution of SAMOS quality control flags for (first) atmospheric pressure – P – (second) earth relative wind direction – DIR – (third) earth relative wind speed –SPD – (fourth) platform relative wind direction – PL_WDIR – and (last) platform relative wind speed – PL_WSPD – for the *Thomas Jefferson* in 2019.

Laurence M. Gould

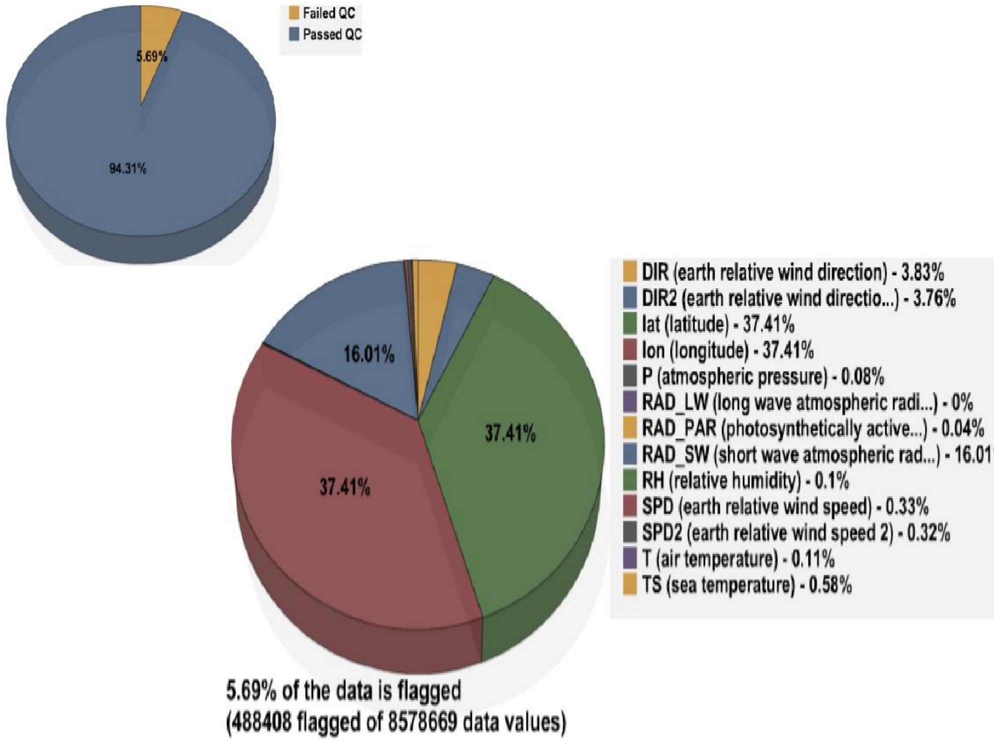


Figure 72: For the *Laurence M. Gould* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Laurence M. Gould* provided SAMOS data for 289 ship days, resulting in 8,578,669 distinct data values. After automated QC, 5.69% of the data were flagged using A-Y flags (Figure 72). This is about one and a half percentage points lower than in 2018 (7.01%) and brings *Gould* under the 5% total flagged cutoff 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.

We were informed by a technician on the *Laurence M. Gould* that they cleaned their air temperature and relative humidity probe at 2005 GMT on 29 November 2019. We record the information here for posterity.

There were no specific issues noted in 2019 for the *Gould*. Looking at the flag percentages in Figure 72, 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 73) 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 73) 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 72.

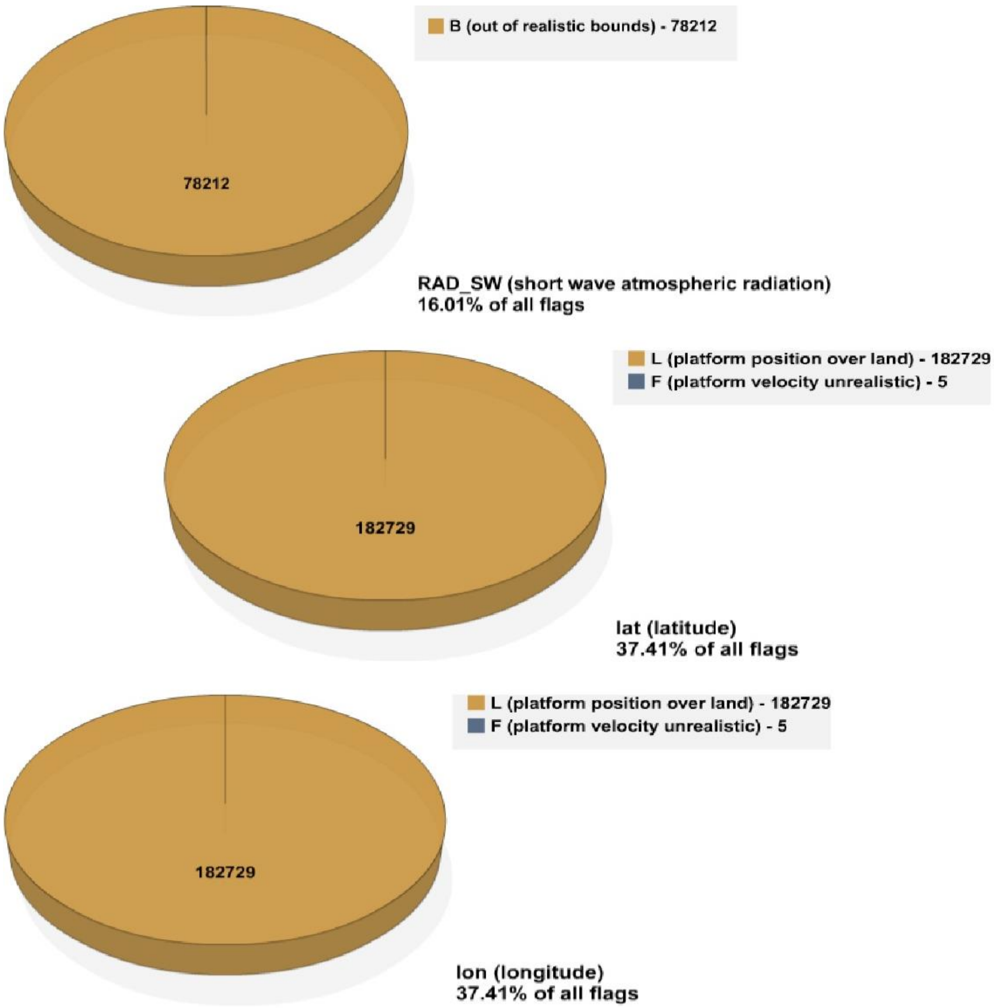
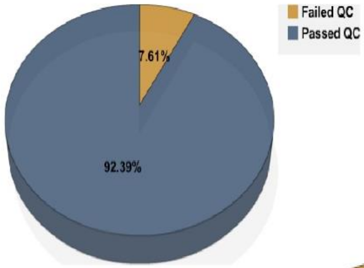


Figure 73: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – (middle) latitude – LAT – and (bottom) longitude – LON – for the *Laurence M. Gould* in 2019.

Nathaniel B. Palmer



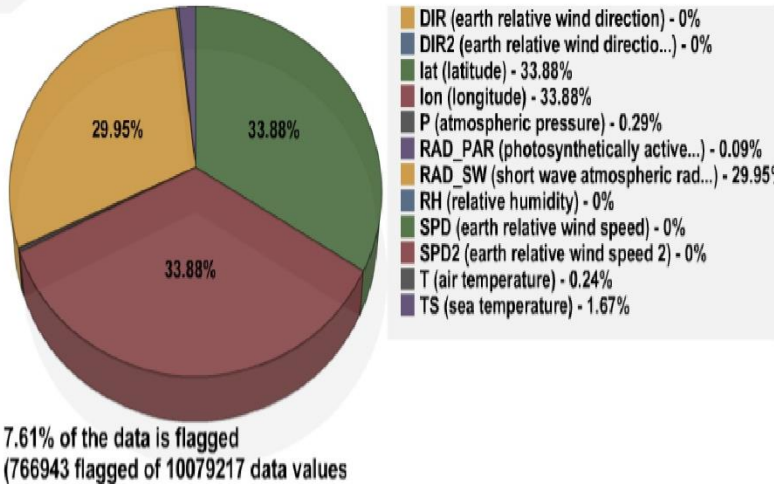


Figure 74: For the *Nathaniel B. Palmer* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Nathaniel Palmer* provided SAMOS data for 313 ship days, resulting in 10,079,217 distinct data values. After automated QC, 7.61% of the data were flagged using A-Y flags (Figure 74). This is about four percentage points higher than in 2018 (3.85%) and moves *Palmer* outside the “under 5% total flagged” bracket regarded by SAMOS to represent "very good" data. It should be noted the *Palmer* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only.

There were no specific issues noted in 2019 for the *Palmer*. Looking at the flag percentages in Figure 74, 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 75) 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 75) 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 74.

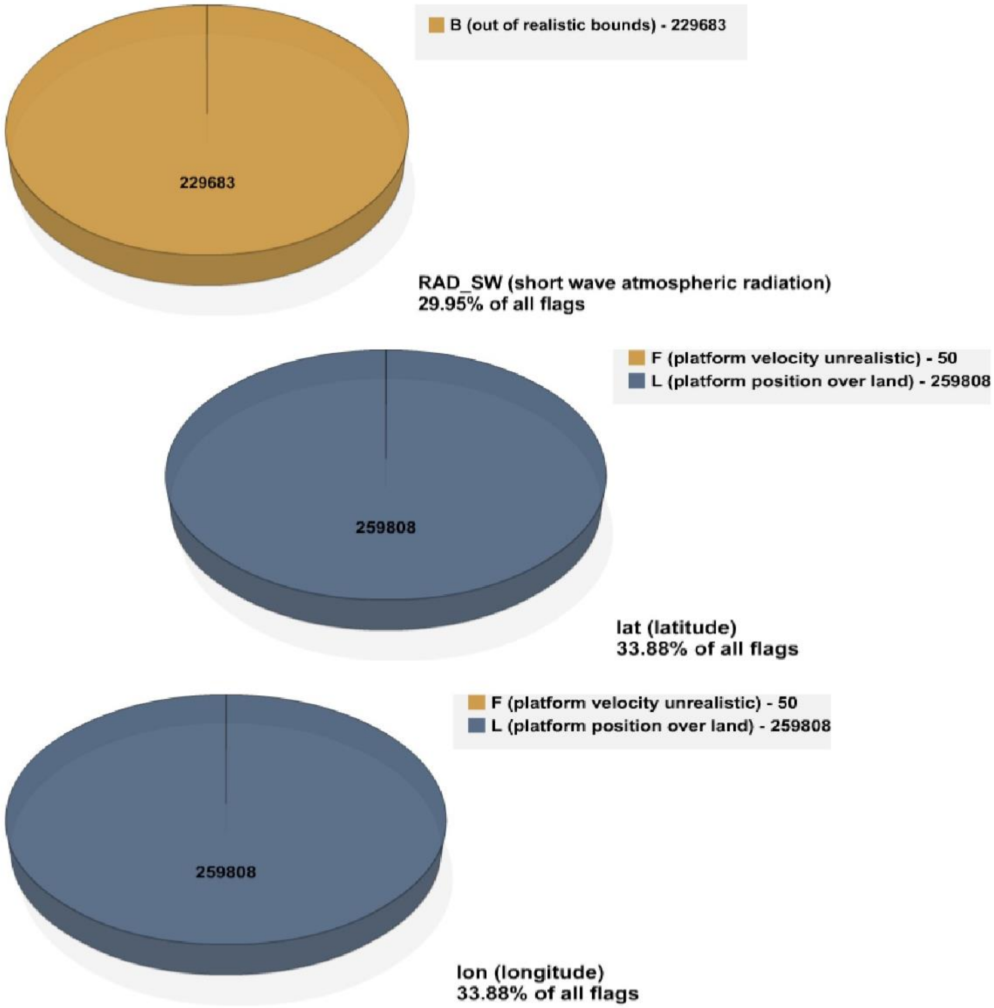


Figure 75: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – (middle) latitude – LAT – and (bottom) longitude – LON – for the *Nathaniel B. Palmer* in 2019.

Robert Gordon Sproul

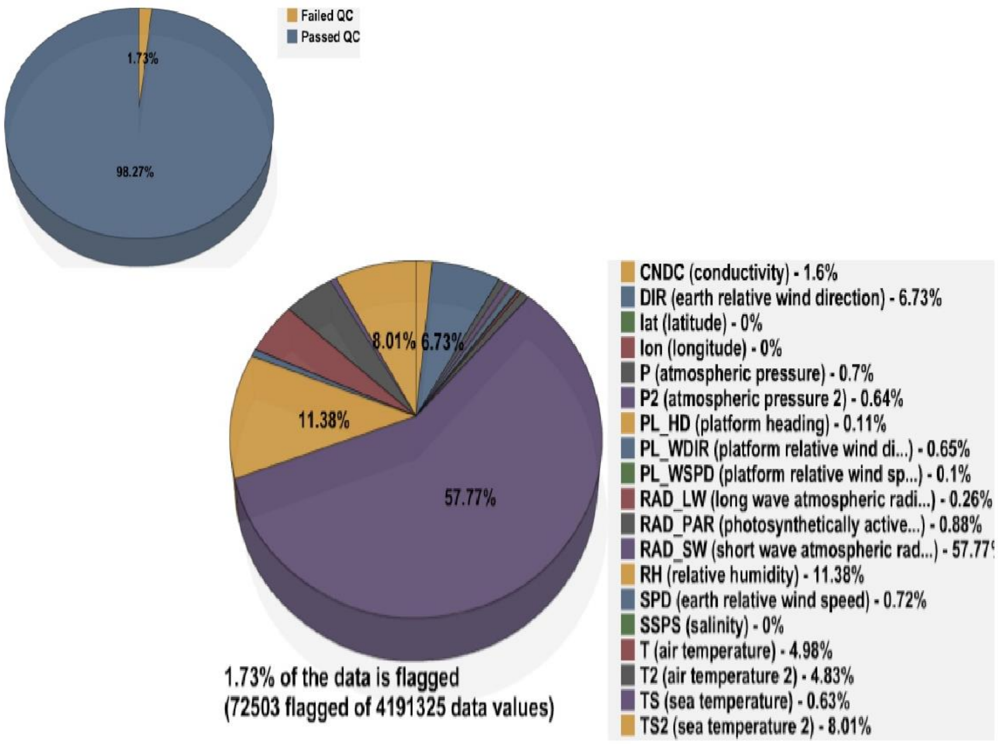


Figure 76: For the *Robert Gordon Sproul* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Robert Gordon Sproul* provided SAMOS data for 166 ship days, resulting in 4,191,325 distinct data values. After automated QC, 1.73% of the data were flagged using A-Y flags (Figure 76). This is about three percentage points lower than in 2018 (5.19%) and brings *Sproul* well under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. It should be noted the *Sproul* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only (no research-level files exist at the SAMOS DAC for the *Robert Gordon Sproul*). We also note *Sproul's* 2019 SAMOS data transmission rate was 63% (see Table 2). It would be desirable to recover any data not received by us, if possible (see Figure 2).

On 2 September it was noted that *Sproul's* photosynthetically active radiation (RAD_PAR) data had oddly been mirroring the relative humidity (RH) data pattern, only with a different magnitude. (It is not known when the issue began.) It was proposed RAD_PAR may be erroneously reporting RH data with a RAD_PAR calibration coefficient tacked on. A SCRIPPS fleet technician confirmed a few days later and advised they'd corrected the error in their data acquisition system on 3 September. Looking at the flag percentage for RAD_PAR in Figure 76, it's likely this episode was entirely missed by automated processing, as the data were still within physically realistic bounds.

There were no other issues noted for the *Sproul* in 2019. Looking at the flag percentages in Figure 76, over half of the total flags were applied to short wave radiation (RAD_SW). Upon inspection the flags, which are unanimously out of bounds (B) flags (Figure 77), 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.)

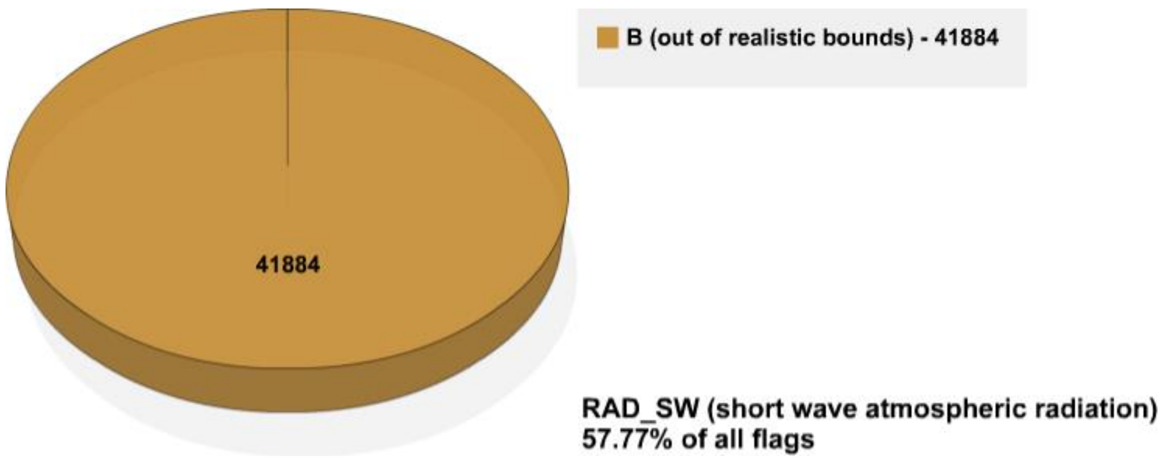
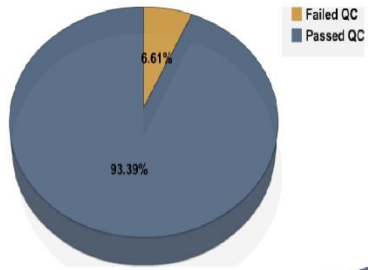


Figure 77: Distribution of SAMOS quality control flags for short wave atmospheric radiation – RAD_SW – for the *Robert Gordon Sproul* in 2019.

Roger Revelle



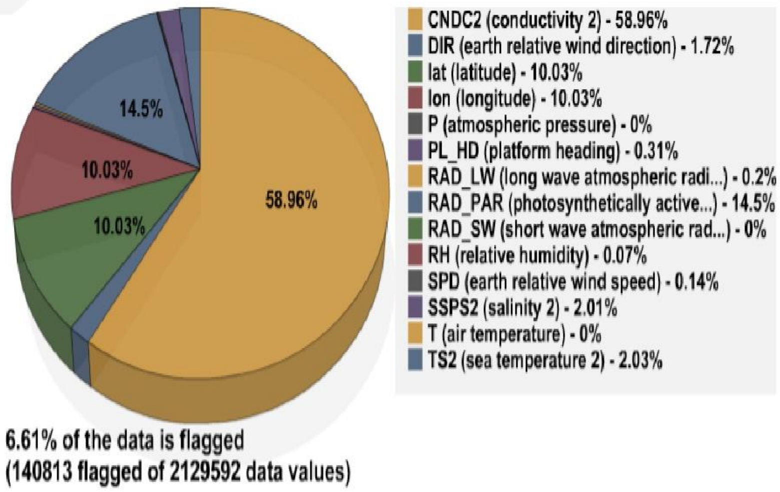


Figure 78: For the *Roger Revelle* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Roger Revelle* provided SAMOS data for 67 ship days, resulting in 2,129,592 distinct data values. After automated QC, 6.61% of the data were flagged using A-Y flags (Figure 78). This is about the same as in 2018 (6.45%). 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*).

We note *Roger Revelle* began her mid-life refit around March, meaning a very short season for her in 2019.

There are no specific issues on record for the *Revelle* in 2019. Looking at the flag percentages in Figure 78, the secondary conductivity (CNDC2) amassed almost 60% of the total flags. These were exclusively "out of bounds" (B) flags (Figure 80). Upon inspection, it appears for virtually all *Revelle's* short 2019 season CNDC2 reported values around -0.001 S/m. We note one of the instrument's other data outputs, a secondary salinity (SSPS2), also featured very low values throughout the season (about 0.011 PSU). However, these SSPS2 values were not actually out of bounds and thus not flagged. The cause of the low/out of bounds readings is not known, but it's possible the instrument was simply not in use for the 2019 season.

Looking again the total flag percentages in Figure 78, around 15% of the total flags were applied to photosynthetically active radiation (RAD_PAR). These were exclusively

B flags (Figure 80). Upon inspection, it appears *Revelle's* daytime RAD_PAR values routinely overshot expected maximums for this type of data (see Figure 79). This likely indicates either a sensor out of calibration or else perhaps calibration coefficients used for data calculation were incorrectly applied. Alternatively, the RAD_PAR may have been provided with the incorrect units, thus exceeding the expected range.

A further combined ~20% of the total flags applied were assigned to latitude (LAT) and longitude (LON). These were exclusively "platform position over land" (L) flags (Figure 80) 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.

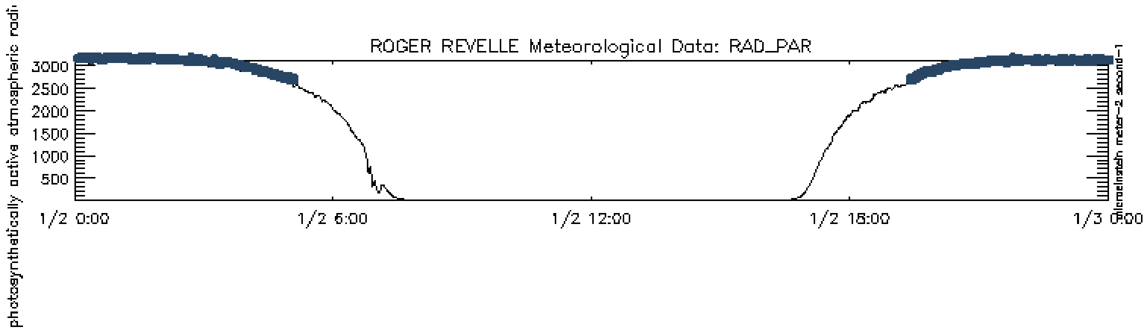


Figure 79: *Roger Revelle* SAMOS photosynthetically active radiation – RAD_PAR – data for 2 January 2019. Note flagged daytime values exceeding the expected maximum for RAD_PAR.

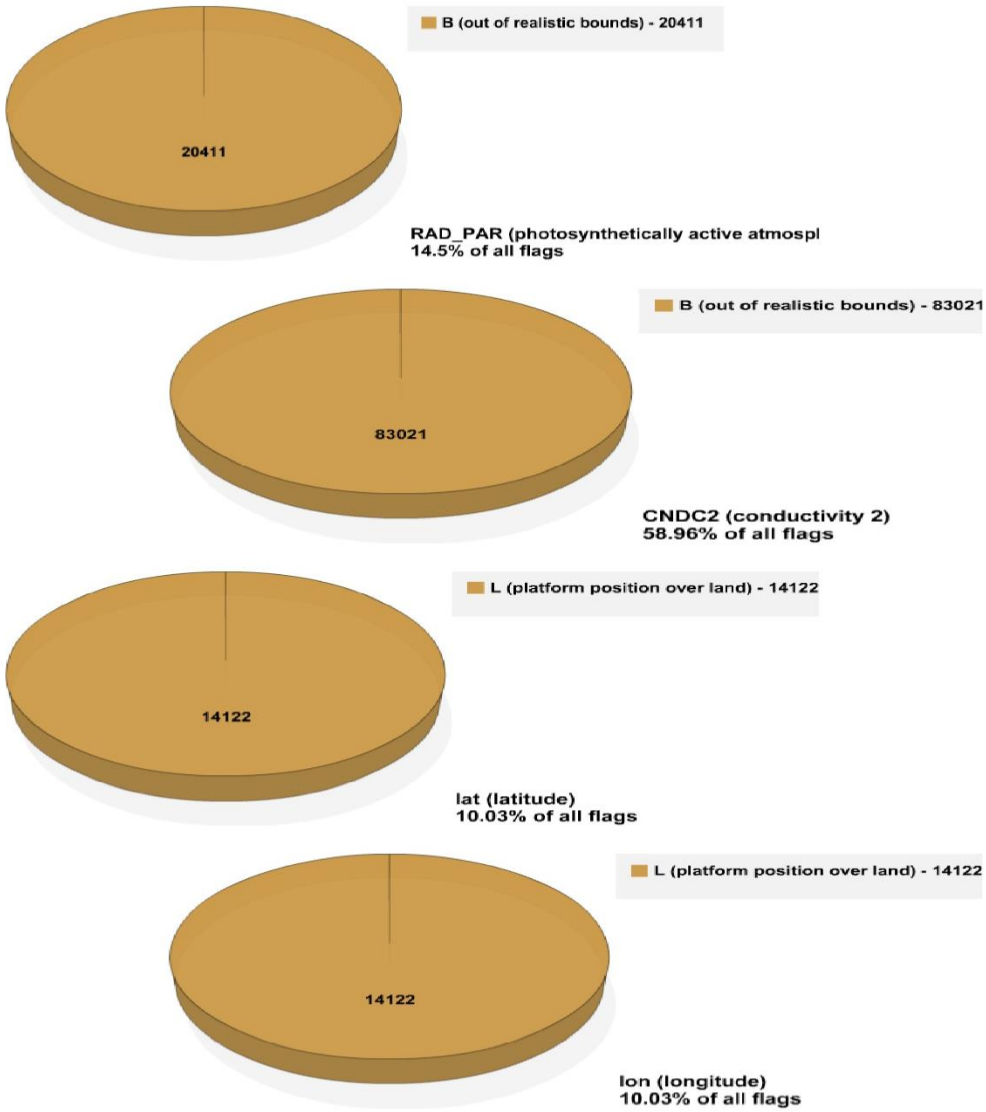


Figure 80: Distribution of SAMOS quality control flags for (first) photosynthetically active atmospheric radiation – RAD_PAR – (second) – conductivity 2 – CNDC2 – (third) latitude – LAT – and (last) longitude – LON – for the *Roger Revelle* in 2019.

Sally Ride

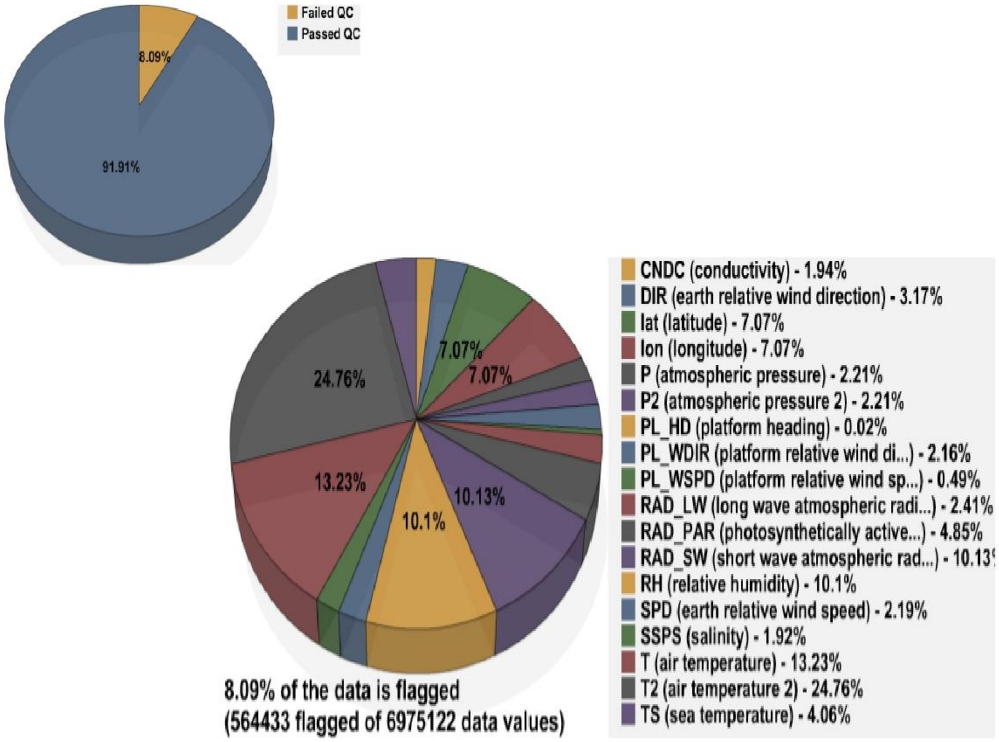


Figure 81: For the *Sally Ride* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Sally Ride* provided SAMOS data for 250 ship days, resulting in 6,975,122 distinct data values. After automated QC, 8.09% of the data were flagged using A-Y flags (Figure 81). This is about three and a half percentage points higher than in 2018 (4.63%) and moves *Sally Ride* 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*).

It was noted on 26 March and immediately confirmed by a vessel technician that *Sally Ride’s* secondary air temperature (T2) had been fluctuating unrealistically between about -15 ° C and 17 ° C. The technician stated they could not get to the sensor until bad weather and a huge swell abated. An update on the sensor was requested on 15 April and a SCRIPPS fleet technician again responded, advising they’d discovered salt encrustation on the sensor and had cleaned it off. Until that point, T2 amassed a good deal of “greater than 4 standard deviation from climatology” (G) and “out of bounds” (B) flags (Figure 82). On 30 April it was noted T2 was again reading unreasonably low (with additional G- and B-flagging, Figure 82). This was again immediately confirmed by a vessel technician and it was suspected that spray or salt had gotten on the sensor again. Two days later we were advised that while cleaning the sensor once again vessel technicians had found a gash in one of the associated power cables on the mast. This gash was patched, and a conclusion was drawn that the cable was probably the more likely culprit of the low T2 readings.

On 14 June it was noted both T2 and the primary air temperature (T) were recording unrealistic values. We were immediately advised it was known all of T, T2, relative humidity (RH), and dew point temperature (not received by SAMOS in 2019) were reporting erroneous values but, because of an engineering issue, technicians would have to wait to address the data fault. In the meantime, T, T2, and RH all received additional G and B flags (Figure 82). It appears from a decrease in flagging that the fix occurred mid- to late-August.

On 4 November we were informed by a SCRIPPS fleet technician that *Sally Ride's* photosynthetically active radiation (RAD_PAR) had been largely stuck around 200 $\mu E\ m^{-2}\ s^{-1}$ from about 18 July until a sensor swap in late September, and afterwards stuck around 20 $\mu E\ m^{-2}\ s^{-1}$. On 5 November we were further informed the issue was fixed. It is not known precisely what the issue or its repair entailed. We note, though, that as most or all the affected readings would still have been within realistic bounds this episode was probably virtually missed by automated processing.

Looking at the other flag percentages in Figure 81, about 14% of the total flags were assigned to latitude (LAT) and longitude (LON) combined, and another ~10% were assigned to short wave atmospheric radiation (RAD_SW). These were exclusively "platform position over land" (L) flags in the case of LAT and LON (Figure 82, only LAT shown) 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 82) 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.)

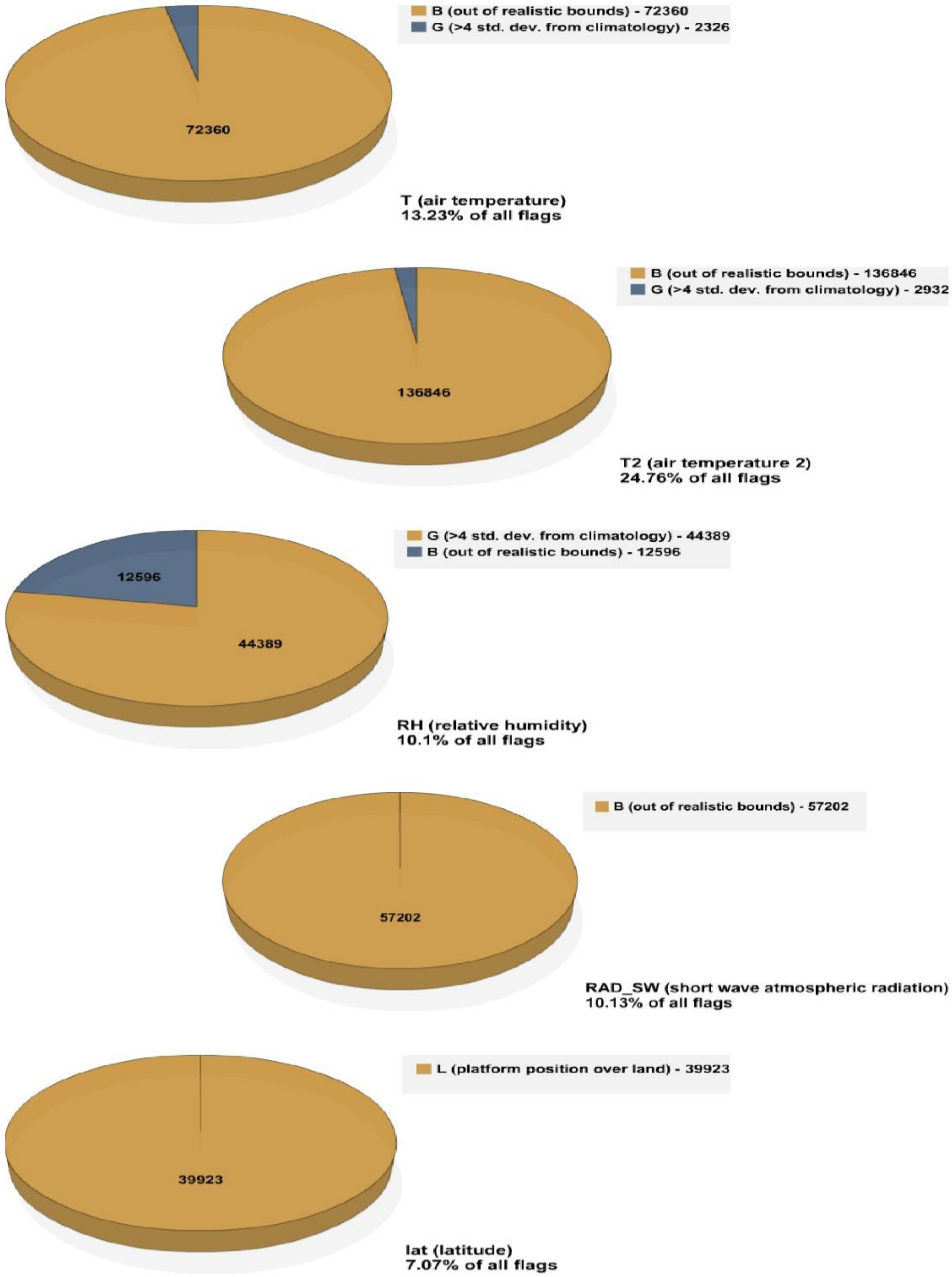


Figure 82: Distribution of SAMOS quality control flags for (first) air temperature – T – (second) air temperature 2 – T2 – (third) relative humidity – RH – (fourth) short wave atmospheric radiation – RAD_SW – and (last) latitude – LAT – for the *Sally Ride* in 2019.

Falkor

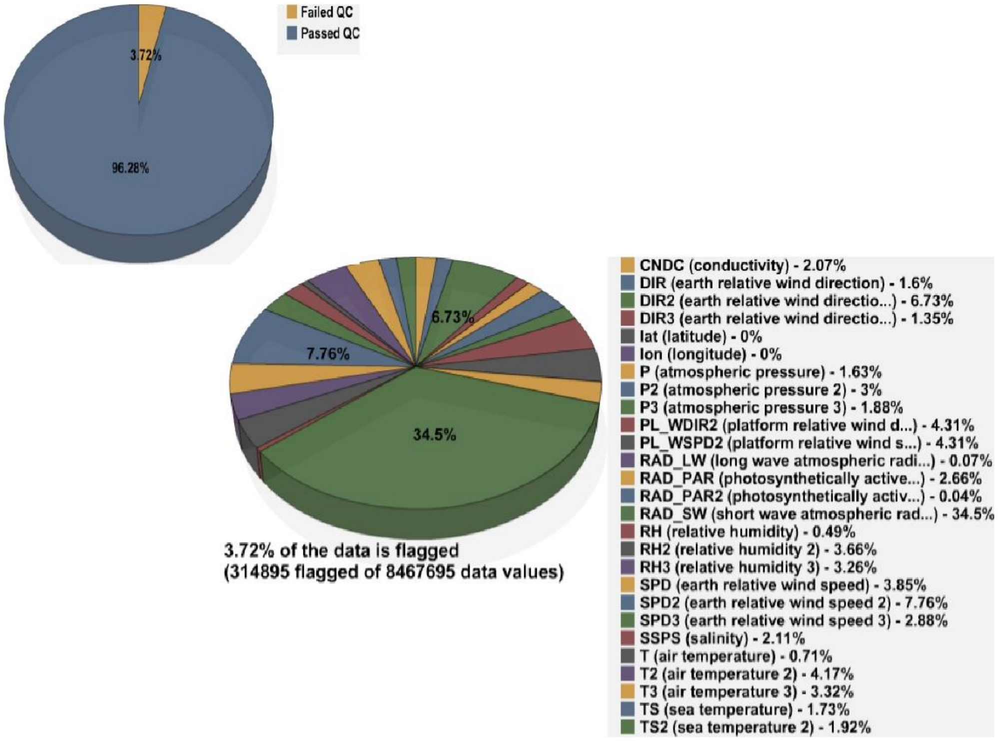


Figure 83: For the *Falkor* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Falkor* provided SAMOS data for 188 ship days, resulting in 8,467,695 distinct data values. After both automated and visual QC, 3.72% of the data were flagged using A-Y flags (Figure 83). This is virtually unchanged from 2018 (3.7%) and maintains the *Falkor's* standing under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data.

On 19 January a *Falkor* technician reported their port weather system had been knocked 90° off its mount by large birds. The technician advised that, while the secondary air temperature (T2), secondary relative humidity (RH), and secondary atmospheric pressure (P2) from the instrument should not be affected, the secondary platform relative wind speed and direction (PL_WSPD2 and PL_WDIR2, respectively) and secondary earth relative wind speed and direction (SPD2 and DIR2, respectively) should not be used until technicians were able to fix the instrument mount. Consequently, all of DIR2, SPD2, PL_WDIR2, and PL_WSPD2 were assigned "malfunction" (M) flags (Figure 84) from17 January through the repair date, 25 January.

There were no other issues noted for *Falkor* in 2019. Looking at Figure 83, it would seem like the short wave radiation (RAD_SW) parameter, holding about 35% of all flags (Figure 83), was especially problematic for the *Falkor*. However, these were almost exclusively "out of bounds" (B) flags (Figure 84), 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.

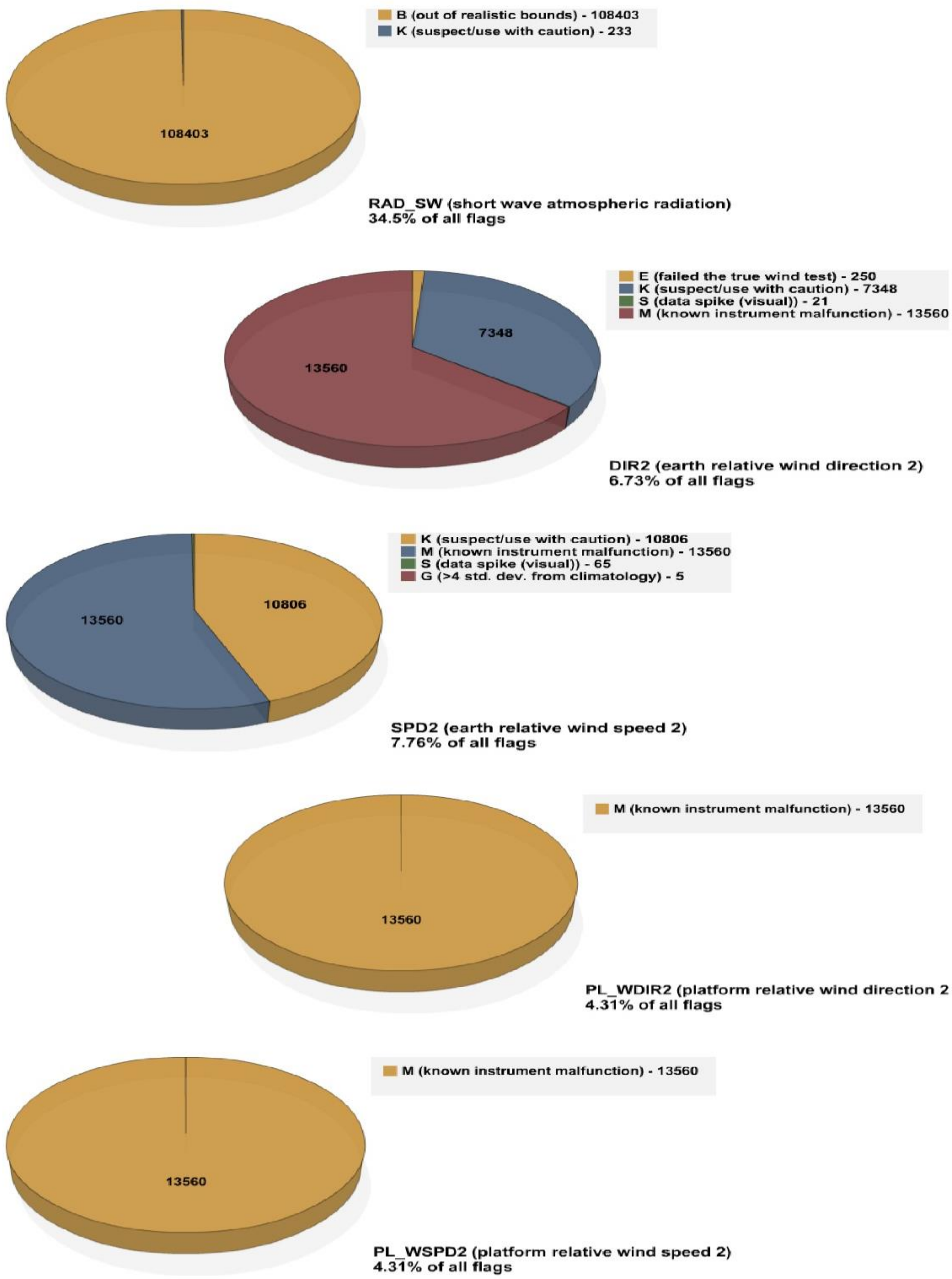
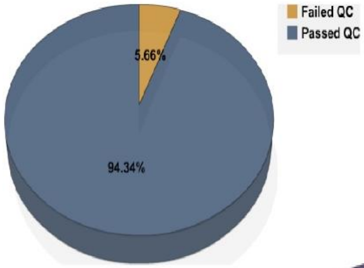


Figure 84: Distribution of SAMOS quality control flags for (first) short wave atmospheric radiation – RAD_SW – (second) earth relative wind direction 2 – DIR2 – (third) earth relative wind speed 2 – SPD2 – (fourth) platform relative wind direction 2 – PL_WDIR2 – and (last) platform relative wind speed 2 – PL_WSPD2 – for the *Falkor* in 2019.

Sikuliaq



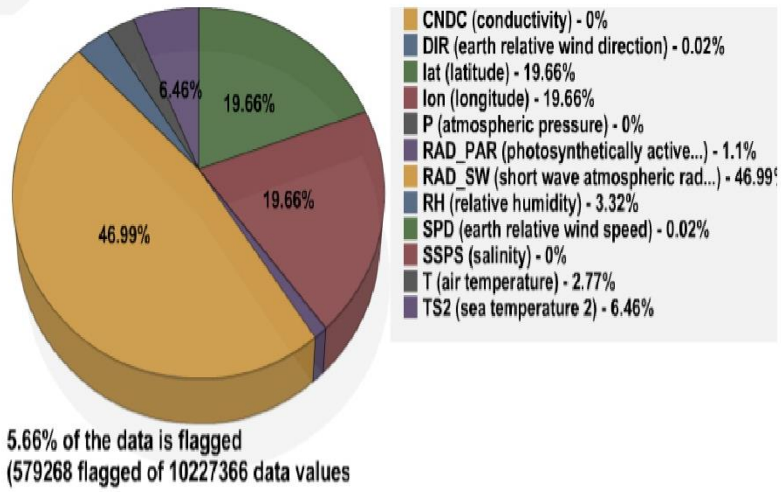


Figure 85: For the *Sikuliaq* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Sikuliaq* provided SAMOS data for 355 ship days, resulting in 10,227,366 distinct data values. After automated QC, 5.66% of the data were flagged using A-Y flags (Figure 85). This is about the same as in 2018 (5.86%). 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*).

There are no specific issues on record for *Sikuliaq* in 2019. Looking at the flag percentages in Figure 85, almost half of the total flags were assigned to short wave radiation (RAD_SW). Upon inspection the flags, which are unanimously “out of bounds” (B) flags (Figure 86), 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 combined ~40% of the total flags was amassed by latitude (LAT) and longitude (LON) (Figure 85). These were exclusively “platform position over land” (L) flags (Figure 86) 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.

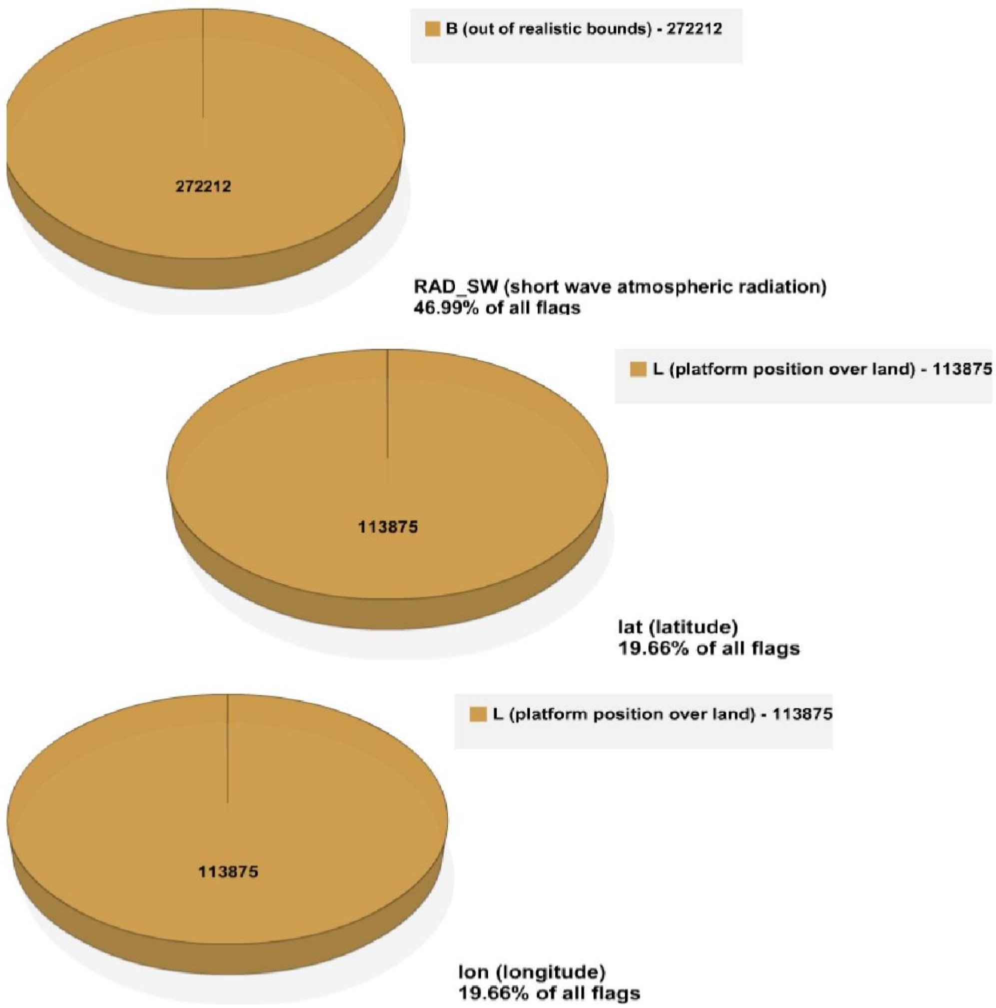


Figure 86: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – (middle) latitude – LAT – and (bottom) longitude – LON – for the *Sikuliaq* in 2019.

Kilo Moana

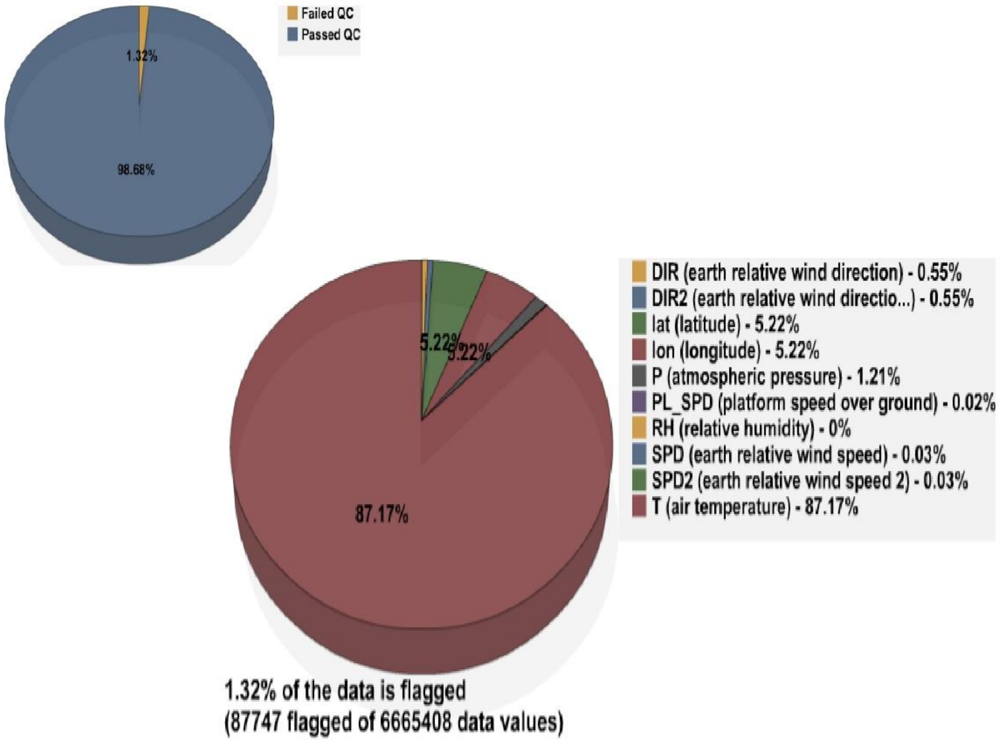


Figure 87: For the *Kilo Moana* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Kilo Moana* provided SAMOS data for 251 ship days, resulting in 6,665,408 distinct data values. After automated QC, 1.32% of the data were flagged using A-Y flags (Figure 87). This is about a percentage point higher than in 2018 (0.18%) and maintains *Kilo Moana's* standing well under the 5% total flagged cutoff regarded by SAMOS to represent "very good" data. It should be noted the *Kilo Moana* receives only automated QC, and visual QC is when the bulk of flags are typically applied. All the flags are the result of automated QC only (no research-level files exist at the SAMOS DAC for the *Kilo Moana*).

On 6 February a lead contact for *Kilo Moana* advised that their optical rain gauge, which provided us with both precipitation accumulation and rain rate data, was outputting erroneous data and determined to be broken beyond repair. As such, we discontinued further SAMOS processing of any data from that instrument after 26 January, our most recent day of precipitation/rain rate data for the *Kilo*. However, in April 2020 it came to light the optical rain gauge had been evaluated by someone familiar with the instrument in mid-2019 and the rain rate (aka R_RATE) data were found to be without fault. This very likely means only the 2019 preciptation accumulation (aka PRECIP) data were unreliable. We caution that, as is evident in Figure 87, no faulty precipitation data were flagged by SAMOS, as the data must still have been within realistic bounds. We nevertheless advise that no 2019 SAMOS PRECIP data from the *Kilo Moana* should be used.

On 11 March it was noted the air temperature (T) was unrealistically fluctuating between about -50 °C and 65°C and bearing somewhat of a resemblance to a typical short wave radiation signature rather than that of an air temperature (see Figure 88). A lead contact for the vessel immediately confirmed and advised that as the sensor had been swapped in around 4 March it could possibly be a calibration issue. Time did not immediately allow for an inspection, but the issue appears to have been addressed in early April. In the meantime, T received a good deal of "out of bounds" (B) and "greater than four standard deviations from climatology" (G) flags (Figure 89).

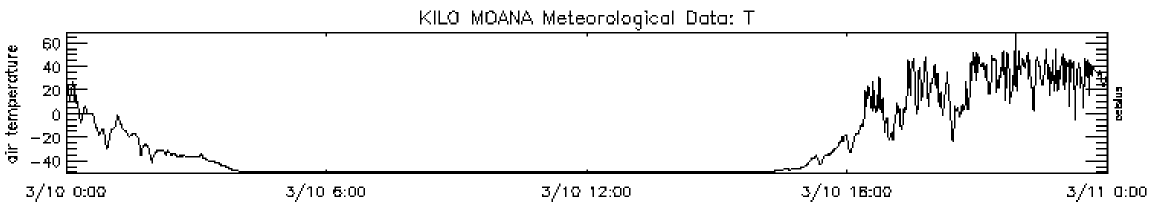


Figure 88: *Kilo Moana* SAMOS air temperature – T – data for 10March 2019. Note unrealistic range of values. Also note resemblance to an incoming short wave radiation signature.

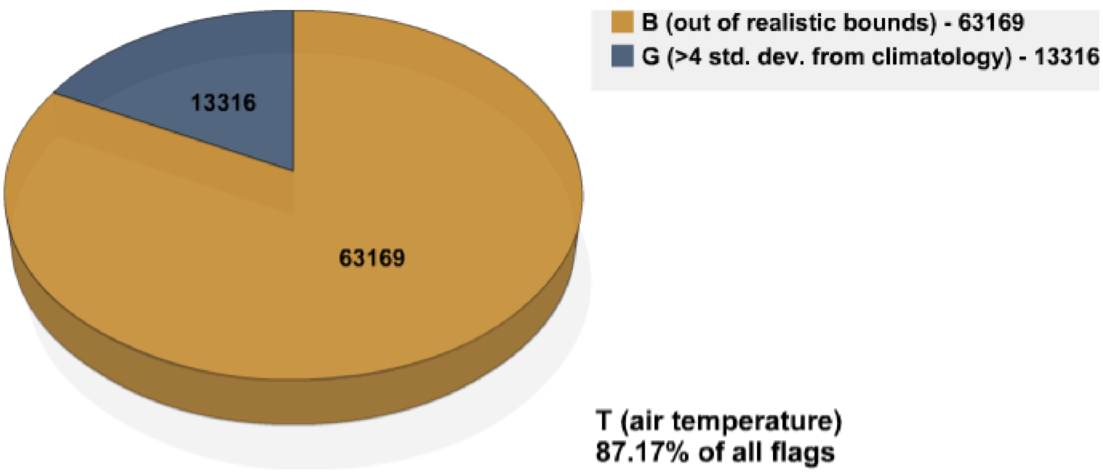


Figure 89: Distribution of SAMOS quality control flags for air temperature – T – for the *Kilo Moana* in 2019.

Thomas G. Thompson

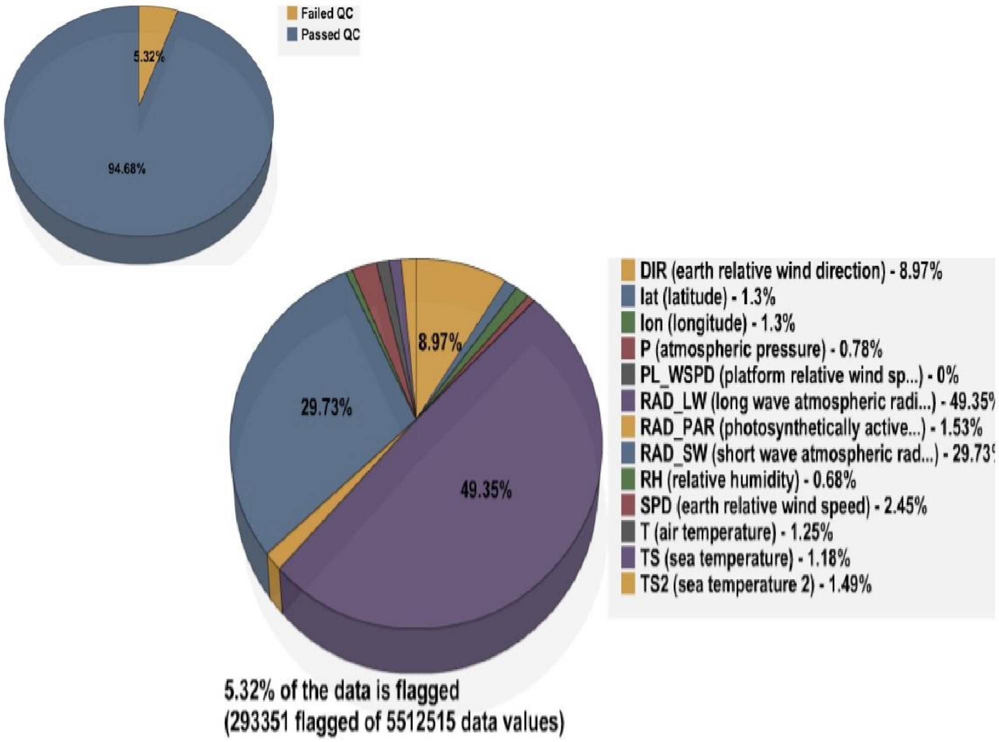


Figure 90: For the *Thomas G. Thompson* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Thomas G. Thompson* provided SAMOS data for 213 ship days, resulting in 5,512,515 distinct data values. After automated QC, 5.32% of the data were flagged using A-Y flags (Figure 90). This is about two and a half percentage points higher than in 2018 (2.85%) and moves *Thompson* outside 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 2019. Looking at the flag percentages in Figure 90, almost half the total flags were assigned to long wave radiation (RAD_LW). Upon inspection it appears the sensor may have experienced a problem or failure on 4 May that persisted for the rest of 2019 (see Figure 91). Beginning on 4 May and continuing through the end of the season RAD_LW reported values that were almost entirely out of realistic bounds. Consequently, RAD_LW amassed a very large volume of “out of bounds” (B) flags over the course of the year (Figure 92). It is not known what caused the erroneous data.

Looking again at Figure 90, short wave radiation (RAD_SW) was assigned a further ~30% of the total flags. Upon inspection the flags, which are unanimously B flags (Figure 92), 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.) However, it should be noted *Thompson's* nighttime RAD_SW values were typically around -100 W/m^2 rather than very close to zero, as is most common, possibly suggesting the instrument needs servicing (e.g. calibration, or tuning).

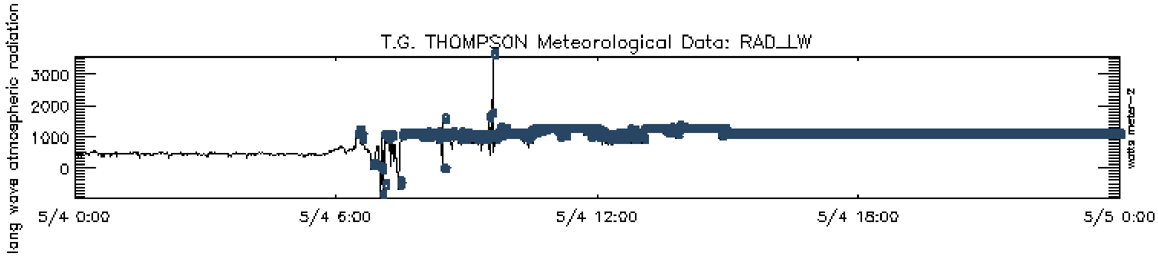


Figure 91: *Thomas G. Thompson* SAMOS long wave radiation – RAD_LW – data for 4 May 2019. Note quick transition to unrealistic values (flagged) after 0600 GMT.

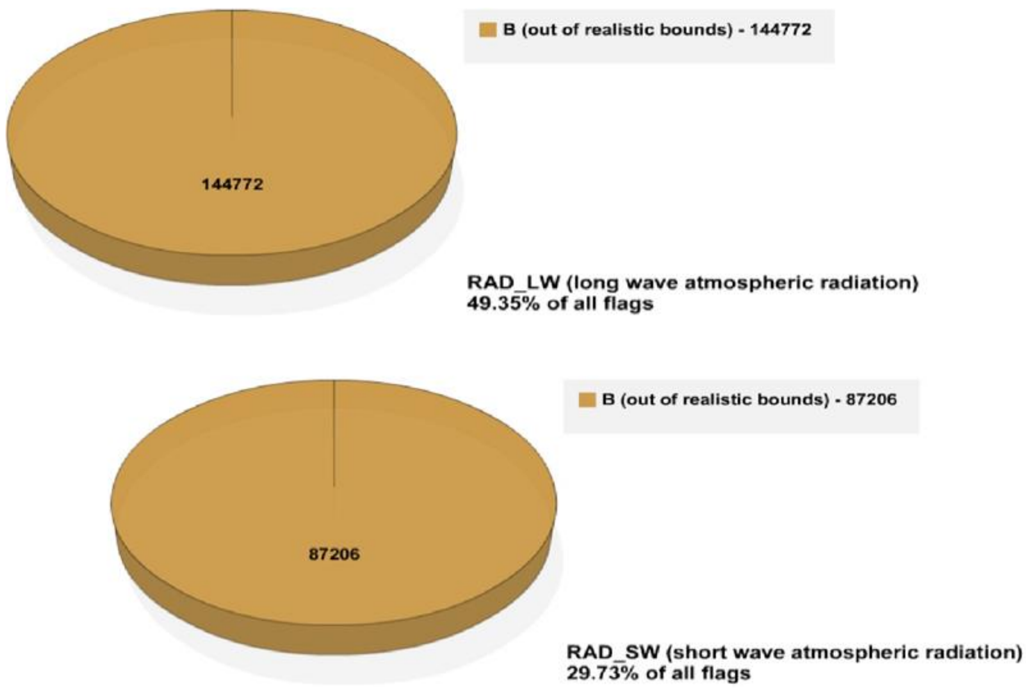


Figure 92: Distribution of SAMOS quality control flags for (top) long wave atmospheric radiation – RAD_LW – and (bottom) short wave atmospheric radiation – RAD_SW – for the *Thomas G. Thompson* in 2019.

Healy

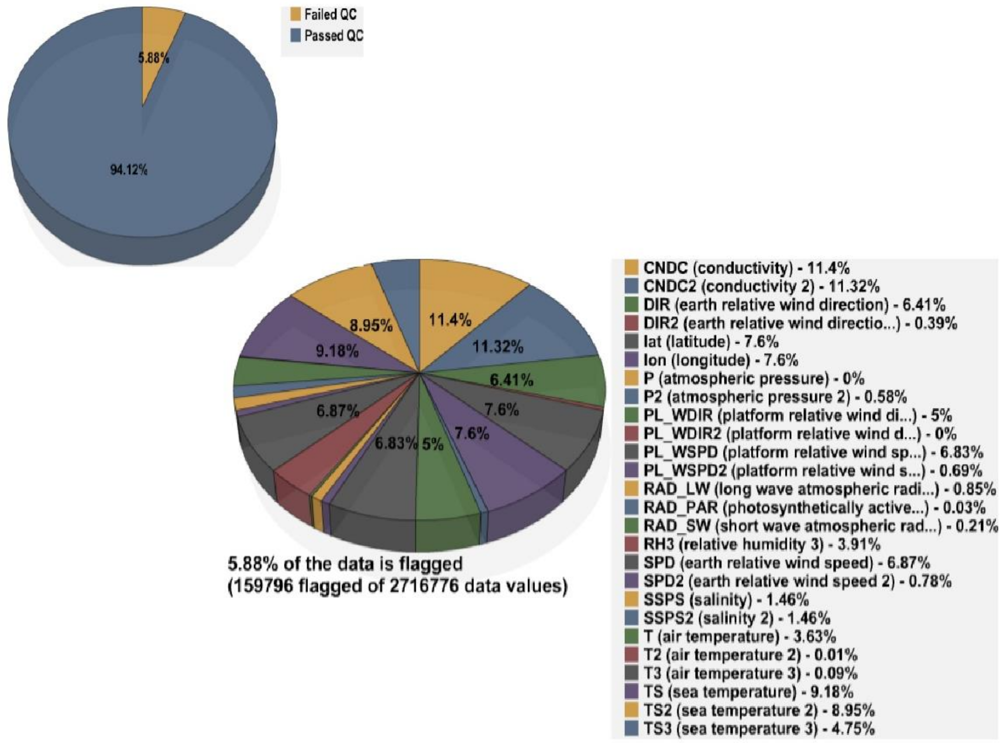


Figure 93: For the *Healy* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Healy* provided SAMOS data for 71 ship days, resulting in 2,716,776 distinct data values. After automated QC, 5.88% of the data were flagged using A-Y flags (Figure 93). This is about the same as in 2018 (6.31%). 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. We also note *Healy's* 2019 SAMOS data transmission rate was 61% (see Table 2). It would be desirable to recover any data not received by us, if possible (see Figure 2).

On 19 September a *Healy* technician advised that their wind sensors were reporting inaccurate data due to being iced over. The vessel was expected to remain in extreme cold through mid-October, and it was cautioned the sensors likely would not thaw on their own before then. The technician also explained that any efforts to manually de-ice would likely be infrequent, due to safety concerns, and any relief anyway short-lived. Looking at the flag percentages in Figure 93, it seems probable at least some of the erroneous data was caught by automated processing, at least for the primary wind sensor. Platform relative wind speed and direction (PL_WSPD and PL_WDIR, respectively) and earth relative wind speed and direction (SPD and DIR, respectively) each amassed roughly 6% of the total flags (Figure 93). For PL_WDIR and PL_WSPD these were exclusively "out of bounds" (B) flags and for DIR and SPD they were mainly "failed the true wind test" (E) flags with the addition of some B flags (Figure 94). Nevertheless, we strongly advise that any *Healy* wind data from 19 September running through at least mid-October should only be used with the most extreme caution.

The primary and secondary conductivity parameters (CNDC and CNDC2, respectively) were each assigned a further ~11% of the total flags (Figure 93). Upon inspection these exclusively B flags (Figure 94, only CNDC shown) appear to have been applied mainly to very slightly negative values (~ -0.001) reported while the vessel was in port, possibly indicating the sensors were turned off, which would not be unexpected in port. We note the two salinity parameters (SSPS and SSPS2) additionally appear to have reported very slightly positive values at these times, although these values were not considered out of bounds and thus not flagged.

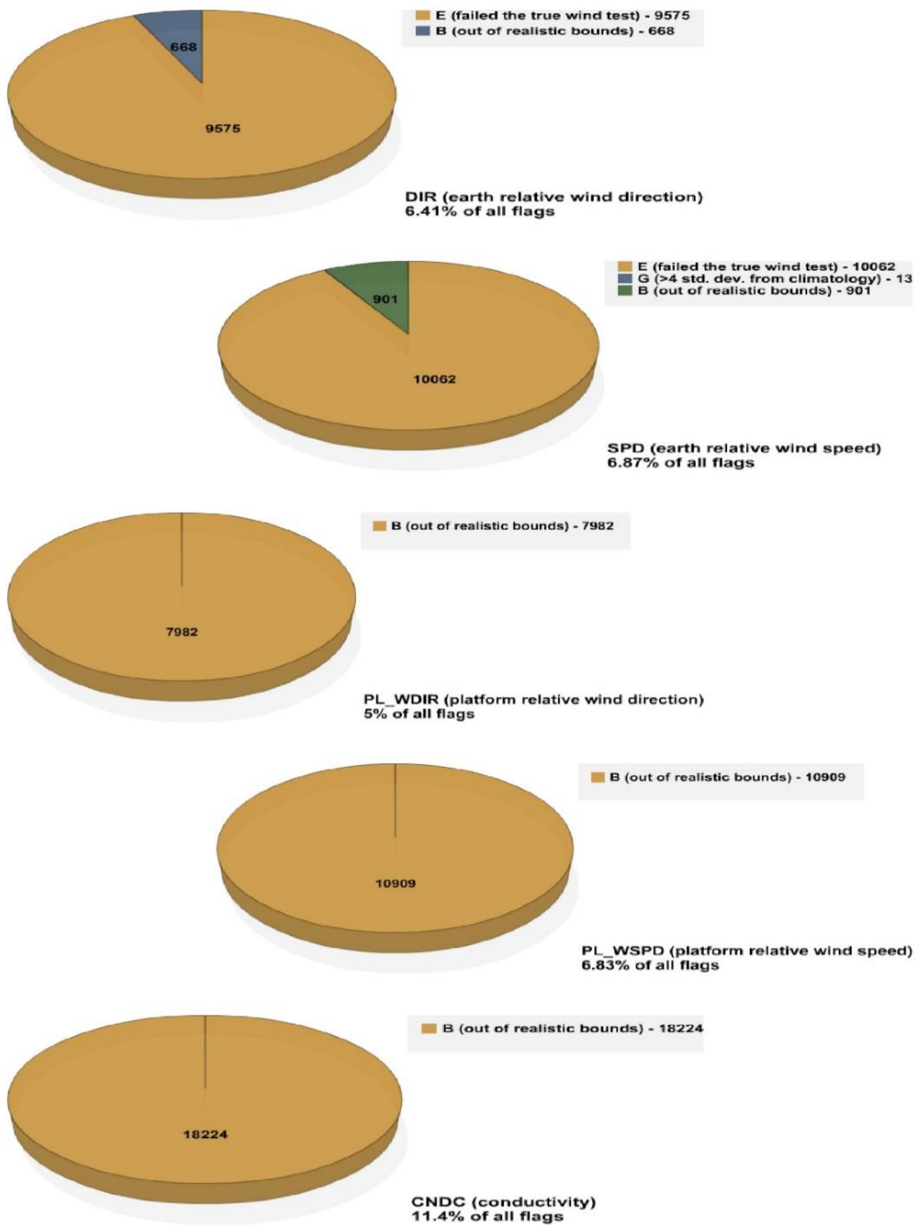
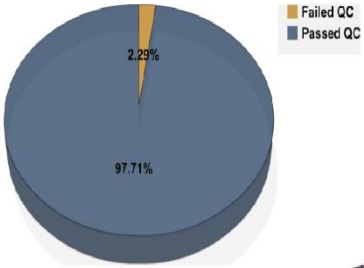


Figure 94: Distribution of SAMOS quality control flags for (first) earth relative wind direction – DIR – (second) earth relative wind speed – SPD – (third) platform relative wind direction – PL_WDIR – (fourth) platform relative wind speed – PL_WSPD – and (last) conductivity – CNDC – for the *Healy* in 2019.

R/V Atlantis



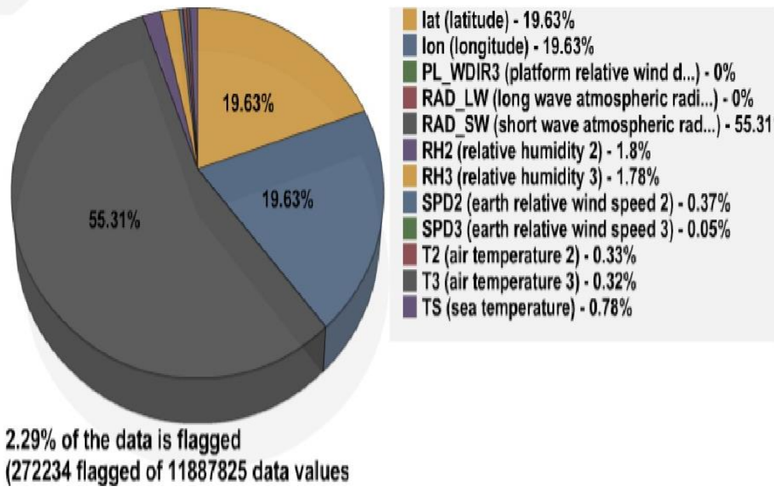


Figure 95: For the *R/V Atlantis* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *R/V Atlantis* provided SAMOS data for 295 ship days, resulting in 11,887,825 distinct data values. After automated QC, 2.29% of the data were flagged using A-Y flags (Figure 95). This is about the same as in 2018 (1.93%) 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.

There were no specific issues noted in 2019 for the *Atlantis*. Looking at the flag percentages in Figure 95, nearly all the flags applied were assigned to latitude (LAT), longitude (LON), and short wave atmospheric radiation (RAD_SW). These were exclusively "platform position over land" (L) flags in the case of LAT and LON (Figure 96) 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 96) and appear to have been applied mainly to the slightly negative values that can occur with these sensors at night (a consequence of instrument tuning, see 3b.)

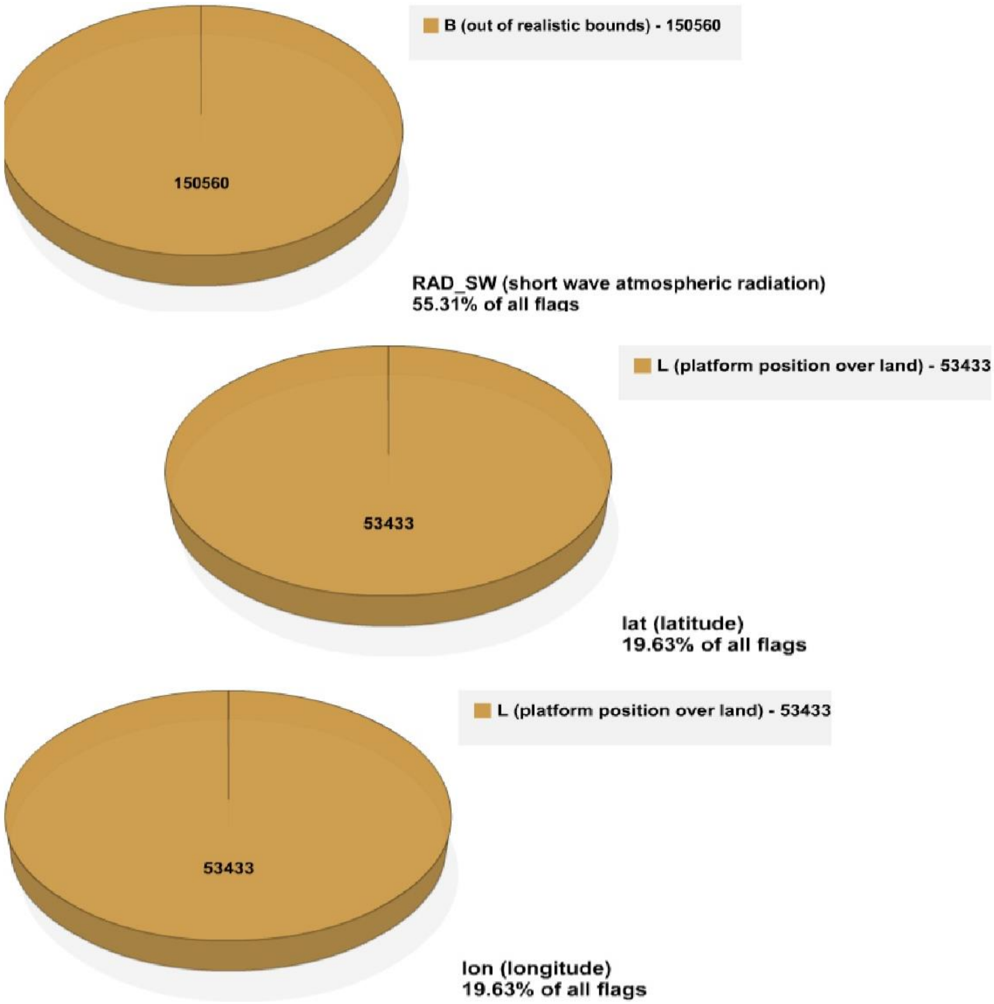


Figure 96: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – (middle) latitude – LAT – and (bottom) longitude – LON – for the *R/V Atlantis* in 2019.

R/V Neil Armstrong

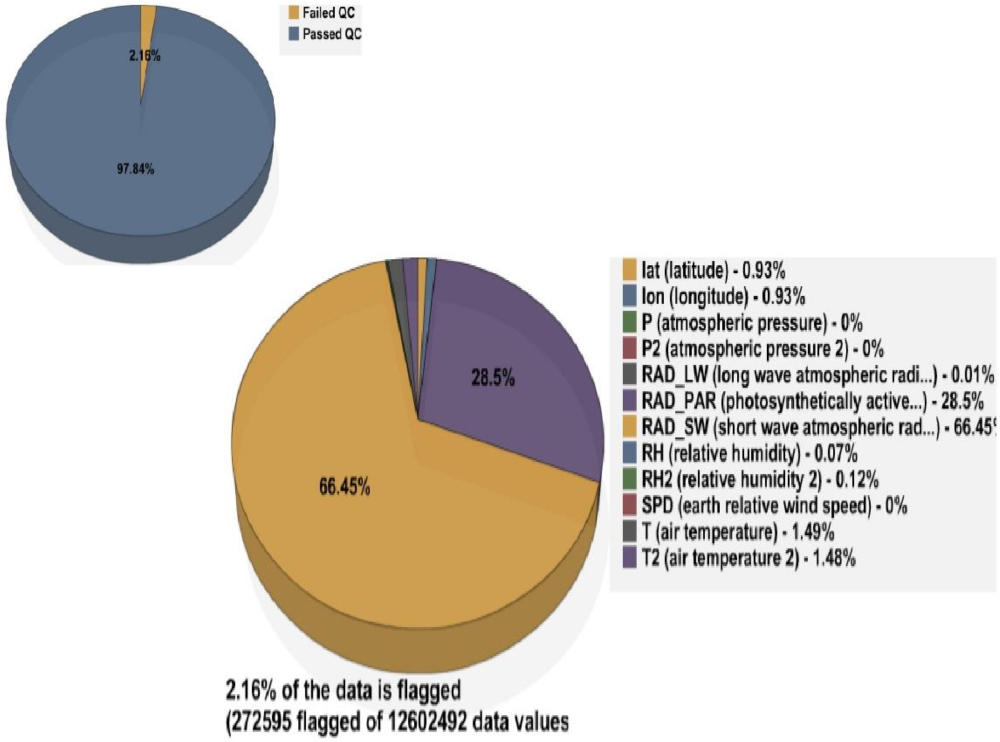


Figure 97: For the *R/V Neil Armstrong* from 1/1/19 through 12/31/19, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *R/V Neil Armstrong* provided SAMOS data for 291 ship days, resulting in 12,602,492 distinct data values. After automated QC, 2.16% of the data were flagged using A-Y flags (Figure 97). This is virtually unchanged from 2018 (2.07%) 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 2019 for the *Neil Armstrong*. Looking at the flag percentages in Figure 97, nearly all the 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 96) that appear to have been applied mainly to the slightly negative values that can occur with these types of sensors at night (a consequence of instrument tuning, see 3b.)

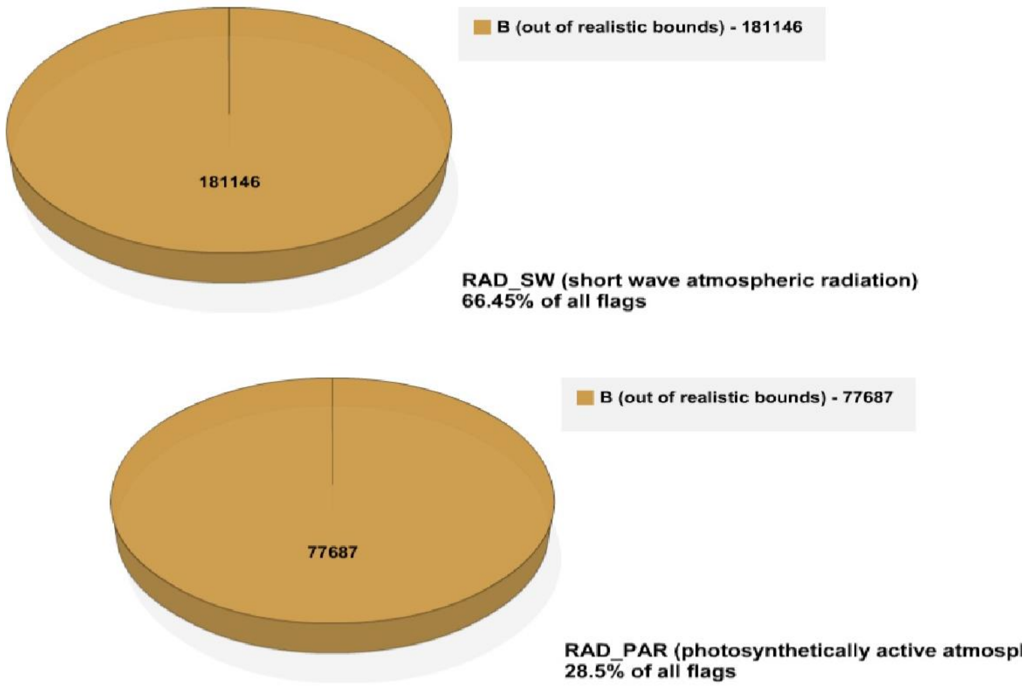


Figure 98: Distribution of SAMOS quality control flags for (top) short wave atmospheric radiation – RAD_SW – and (bottom) photosynthetically active radiation – RAD_PAR – for the *R/V Neil Armstrong* in 2019.

4. Metadata summary

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

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

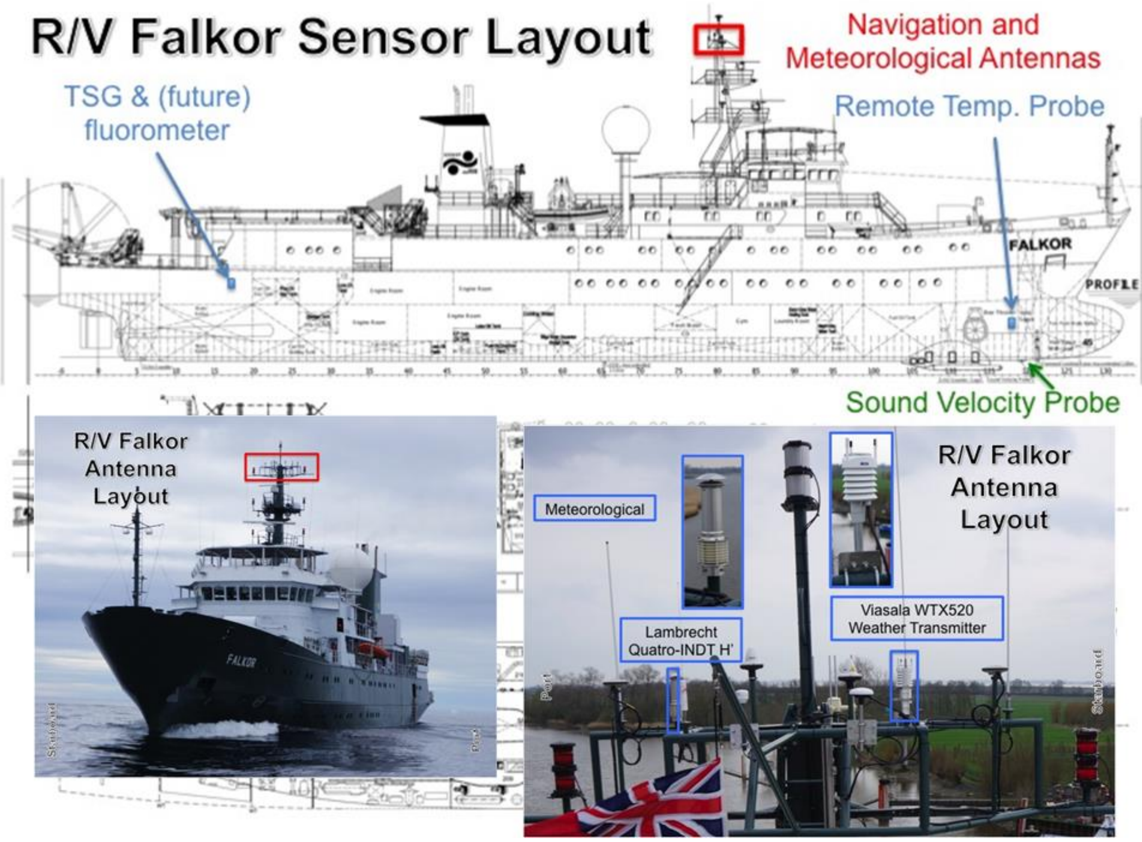


Figure 99: Examples of detailed vessel instrument imagery from the *R/V Falkor*.

a.

sea temperature

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

b.

sea temperature

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

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

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

	Vessel Info	Contact Info	Vessel Layout	Digital Imagery	LATITUDE	LONGITUDE	PLATFORM HEADING	PLATFORM COURSE	PLATFORM SPEED	SEA TEMPERATURE	CONDUCTIVITY	SALINITY
KAOU	C	C	C	No	I	I	I	I	I	I,I,I	I,I	I,I
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	C	C
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	I	C	No	I	I	I,I	I	I	I		
WARL	C	C	I	Yes	I	I	I	I	I,C	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								
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	C	C	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	I	C	Yes	I	I	I	I	I	C,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	I	I	I	I	I	C,C	C	C
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
WTEY	C	I	C	Yes	I	I	I,I,I	I	I	I,I	I	I
ZCYL5	C	C	C	Yes	C	C	C	C	C	C,C	C	C
ZMFR	C	I	C	No	I	I	I	I	I	I		

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	I	I	I	I	I	I		I,I	I	I		I	I		I
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			C	C			C	I		I
NEPP	I,C	I,C	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	I,I	I,I	I,I	I,I	I,I			I,I	I,I	C,C	C,C	I	I		I
WBP3210	I,I	I,I	I,I	I,I	I			I	I			I	I		I
WCX7445	C,C	I,I	C,C	C,C	I			C	I			I	I		I
WDA7827	I,I	I,I	I,I	I,I	I			I	I	I		I			
WDC9417															
WDD6114	I	I	I	I	I			I	I						
WDG7520	C	I	I	I	C			C	C			I	I		I
WSAF	C	C	C	C	C,C	I		C,C	C	C		I	I		I
WSQ2674	C	C	I	I	C,C			C,C	C	C		C	C	C	I
WTDF	I,I,I	I,I,I	I,I,I	I,I,I	I			I	I			I	I		
WTDH	C	I	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	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	I	I			I	I						
WTEG	C,C	I,I	C,C	C,C	C,C			C,C	C			I	I		
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						
WTEY	I	I	I	I	I			I	C						
ZCYL5	C,C,C	C,C,C	C,C,C	C,C,C	C,C,C			I,I,I	C,C,C			I	I		C,C
ZMFR			C	C	C			C	C	I		I,I	I,I		

(Table 4: cont'd)

5. Plans for 2020

As the SAMOS initiative continues its second decade following the workshop where the concept was born (http://coaps.fsu.edu/RVSMDC/marine_workshop/Workshop.html), the SAMOS chairman would like to personally thank all of the technicians, operators, captains, and crew of the SAMOS research vessels for their dedication to the project. The DAC team would also like to thank personnel within our funding agencies, 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; http://www.rvdata.us/overview) 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 2019, the university-operated vessels contributing to the SAMOS DAC were those operated by WHOI, SIO, UA, UH, UW, and LUMCON. 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. In 2020, we are collaborating with R2R and the team at Oregon State University leading the build of the RCRVs to ensure that the instrumentation that will provide SAMOS observations from the RCRVs are well-exposed to the marine environment. We are also collaborating on establishing SAMOS data and metadata flow from the RCRVs and on best practices for underway optical flow-water sensors. We are also working with R2R and the UHDAS project at UH to synchronize device metadata from vessels recruited for SAMOS and these other projects.

The primary challenge facing SAMOS and the RV community in 2020 is the COVID-19 pandemic. This global event resulted in the lay-up of most of the U.S. and international RV fleets, with little expectation that the U.S. fleet will return to normal operations before mid-summer 2020. As a result, the underlying supply of SAMOS observations will be severely curtailed for an unknown period in 2020. Although this was an unexpected occurrence in 2020, the SAMOS team plans to take advantage of the limited data flow to update our operational data processing codes. We will work to fix known issues both with our processing software and web-based data services/tools. We also anticipate using this time to develop software to support SAMOS data received using NOAA's Scientific Computing System version 5 (SCS5) as part of an ongoing collaboration with NOAA OMAO. Via SCS5 we plan to begin automated instrumental metadata harvesting and linking these metadata to the underway observations. We may also explore expanding our quality control processes to monitor the metadata received from each vessel using SCS5.

6. References

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Pieter R. Wiederhold, cited 2010: True Accuracy of Humidity Measurement. [Available online at http://archives.sensorsmag.com/articles/0997/humidity/index.htm.]

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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

Freeman, E., S. D. Woodruff, S. J. Worley, S. J. Lubker, E. C. Kent, W. E. Angel, D. I. Berry, P. Brohan, R. Eastman, L. Gates, W. Gloeden, Z. Ji, J. Lawrimore, N. A. Rayner, G. Rosenhagen, and S. R. Smith, 2016: ICOADS Release 3.0: a major update to the historical marine climate record. Int. J. Climatol. doi:10.1002/joc.4775

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 http://strs.unols.org/public/search/diu_all_schedules.aspx?ship_id=0&year=2018 (all other non-NOAA vessels)

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

Excepting the *Okeanos Explorer*, 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.

Atlantis: no notes.

Healy:

- 19 September - mid October: wind sensors generally iced over, DIR, SPD, PL_WDIR, PL_WSPD, DIR2, SPD2, PL_WDIR2, PL_WSPD2 data should not be considered reliable

Investigator: no notes.

Kilo Moana: 14 January - 26 January: optical rain gauge partially broken, PRECIP data should not be used (PRECIP2 is ok).

Laurence M. Gould:

- 29 November: T/RH probe cleaned 20:05 UTC

Nathaniel B. Palmer: no notes.

Neil Armstrong: no notes.

Okeanos Explorer:

- 6 - 19 August: both barometers reported same value, unknown whether it was the raw or height-corrected value, use data with caution

Pelican: no notes.

Robert Gordon Sproul:

- start date unknown - 2 September: RAD_PAR erroneous (issue unclear), data should not be used

Roger Revelle: no notes.

Sally Ride:

- start date unknown - 15 April: T2 unreliable (salt encrustation and/or cabling rip), data should not be used
- ~30 April - 2 May: T2 unreliable (salt encrustation and/or cabling rip), data should not be used
- ~14 June - mid to late August: T, T2, RH erroneous (cause unknown), data should not be used

- 18 July - 5 November: RAD_PAR erroneous/constant values (cause unknown), data should not be used

Sikuliaq: no notes.

Tangaroa:

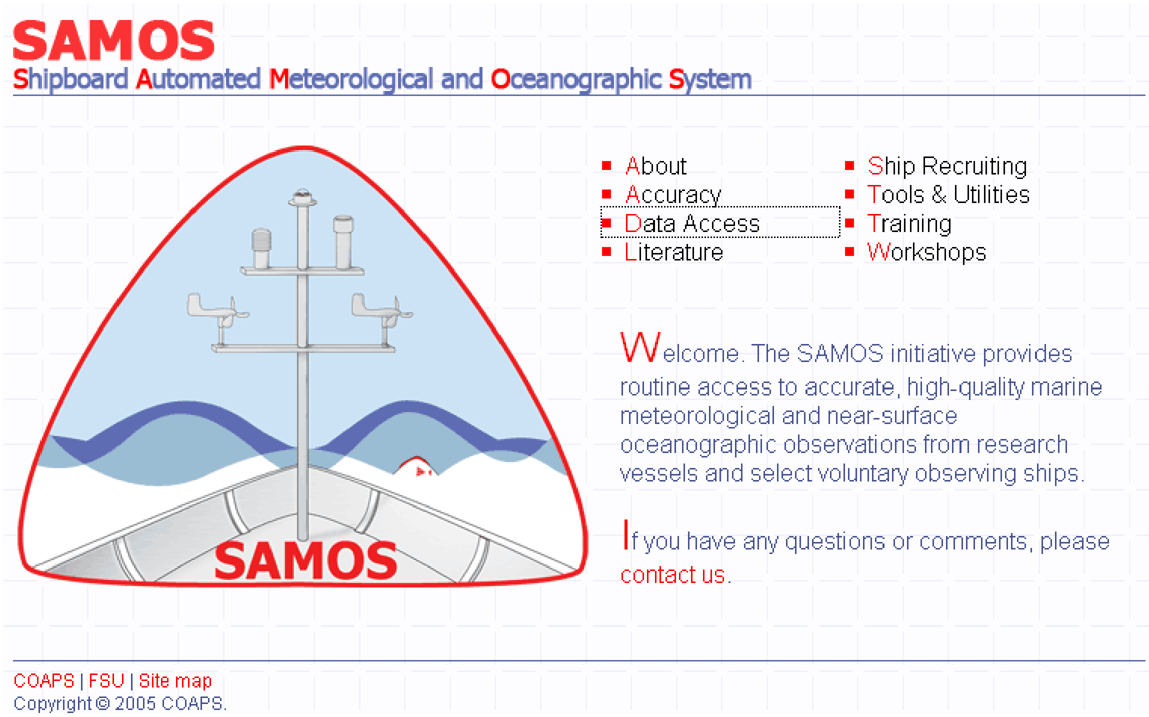
- 21 February - end date unknown, but possibly early April: RAD_LW, RAD_SW, PRECIP malfunction (details unknown), data should not be used

T.G. Thompson: no notes.

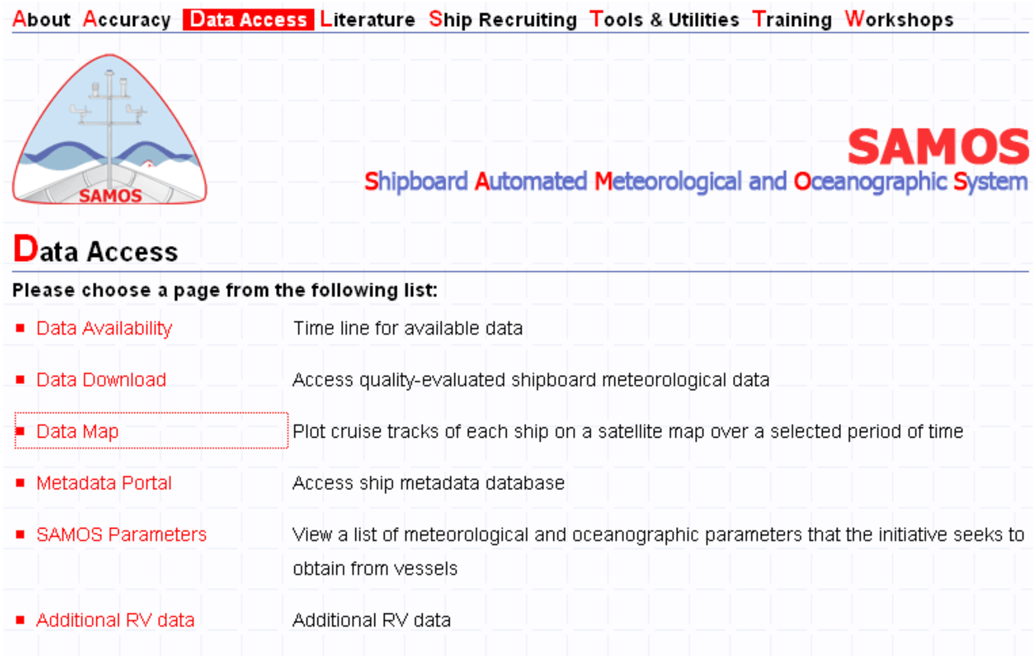
Annex B: SAMOS Online Metadata System Walk-through Tutorial

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:



About Accuracy Data Access Literature Ship Recruiting Tools & Utilities Training Workshops

SAMOS
Shipboard Automated Meteorological and Oceanographic System

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

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

Data Map

To use the data map, select one or more ships from the menu. Then, using either the calendar or the drop-down menus, select a date range. To access the calendar, click the icon next to the start or end selection menus. Since the data takes 10 days to process, please keep this in mind when selecting your end date range. A maximum of 16 ships can be displayed on the map at a single time. Please contact us if you have any questions.

Choose a Ship
or Multiple Ships
(ctrl-click or apple key-click)

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

Select a Date
Start: January 1 , 2009
End: December 31 , 2009

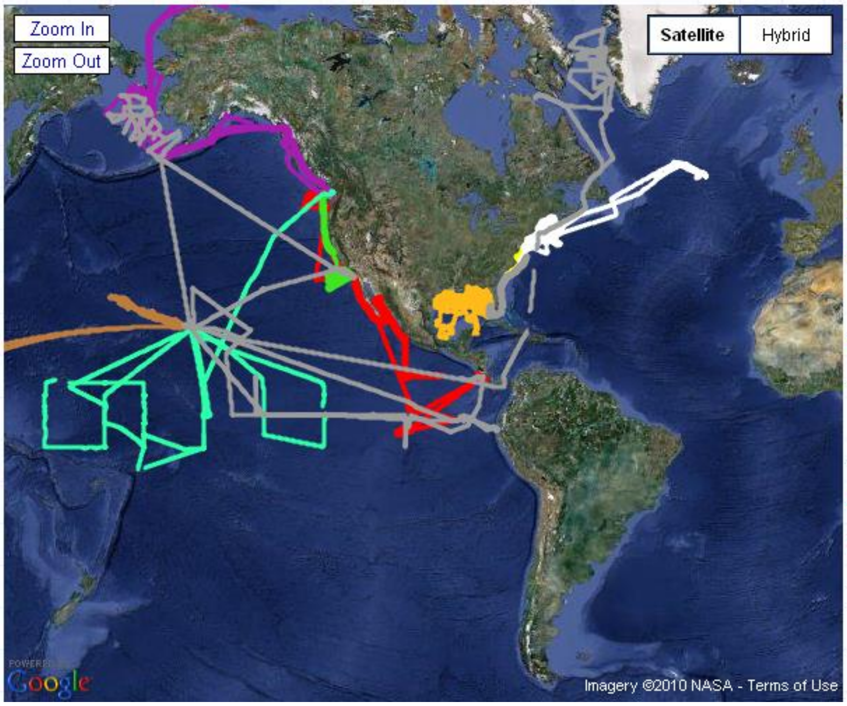
Search

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

Data Map

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

January 1, 2009 - December 31, 2009



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

Map Controls	
On / Off	☑

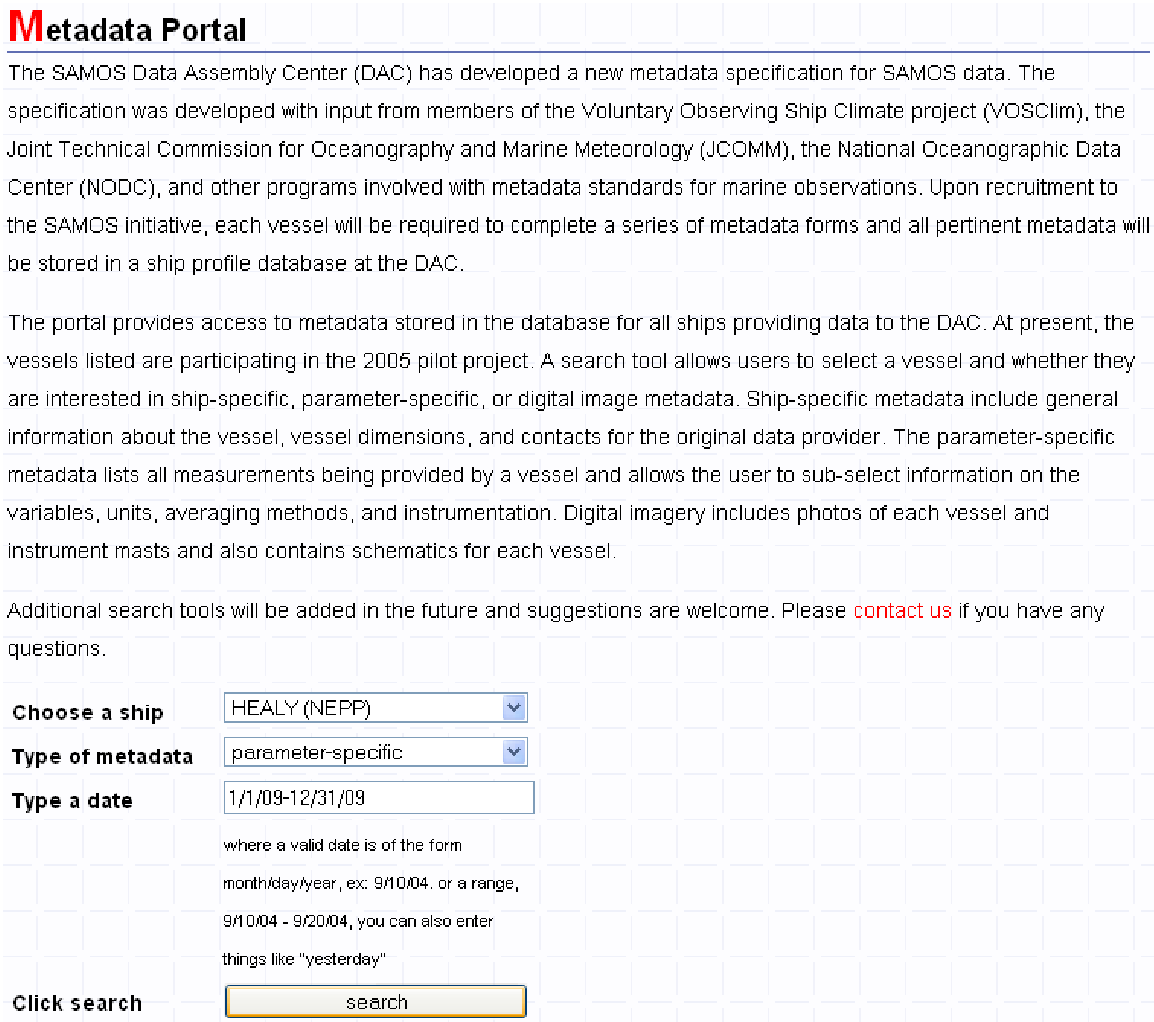
Now the user can see that both the *Healy* and the *Knorr* cruised in the north-polar region in 2009. The next step might be to see what parameters are available on each ship. Returning to the Data Access page, the user this time selects the Metadata Portal:

Data Access

Please choose a page from the following list:

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

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


Metadata Portal

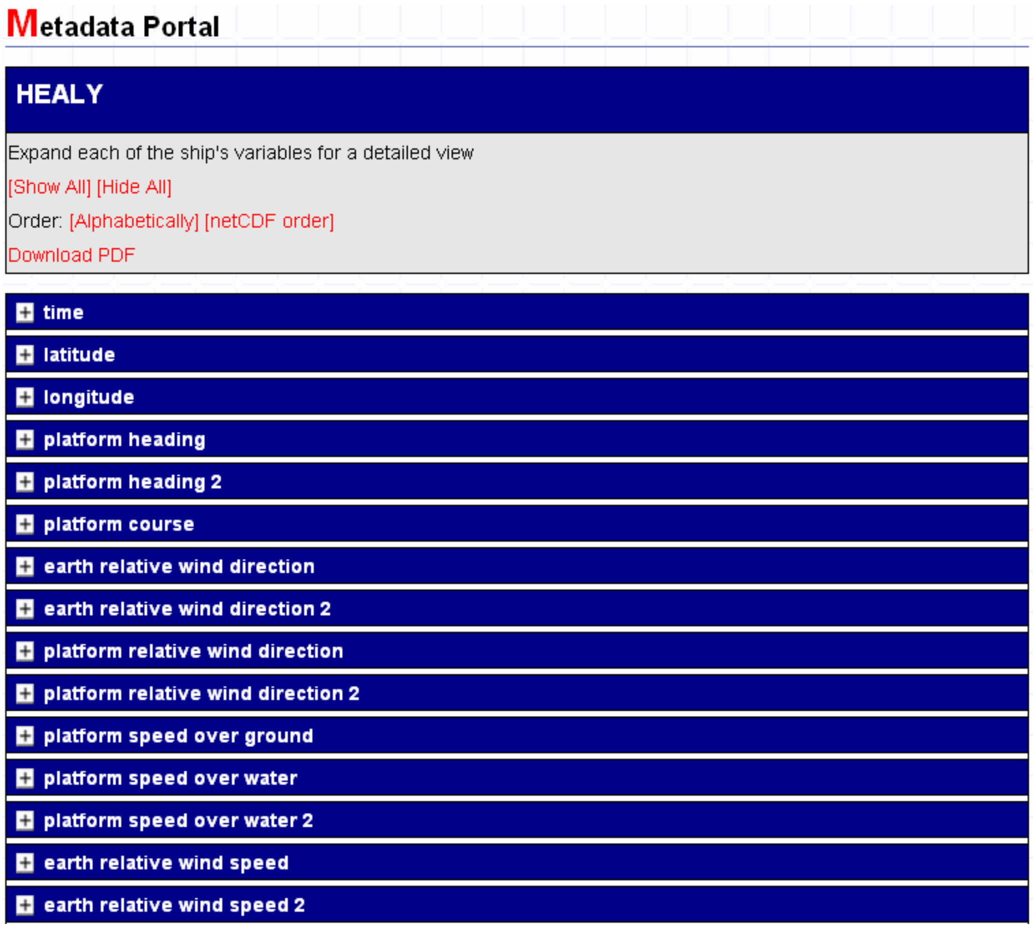
The SAMOS Data Assembly Center (DAC) has developed a new metadata specification for SAMOS data. The specification was developed with input from members of the Voluntary Observing Ship Climate project (VOSClim), the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), the National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

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

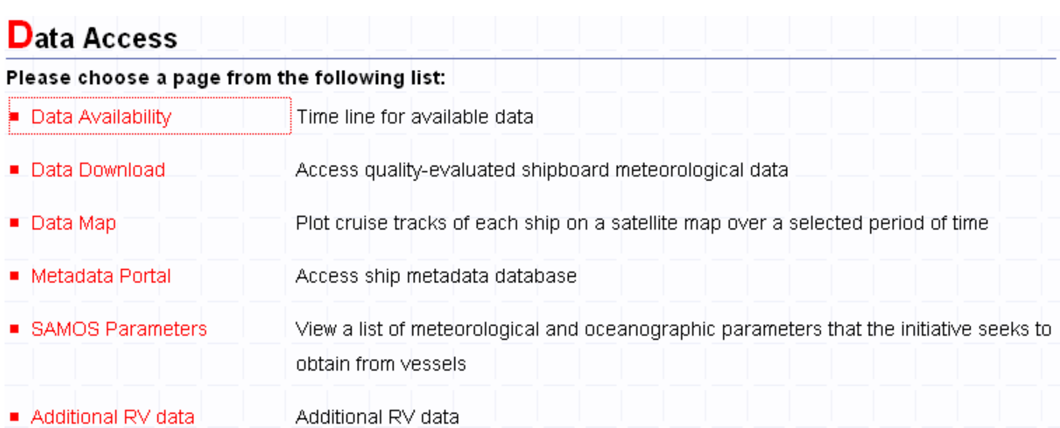
Additional search tools will be added in the future and suggestions are welcome. Please contact us if you have any questions.

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

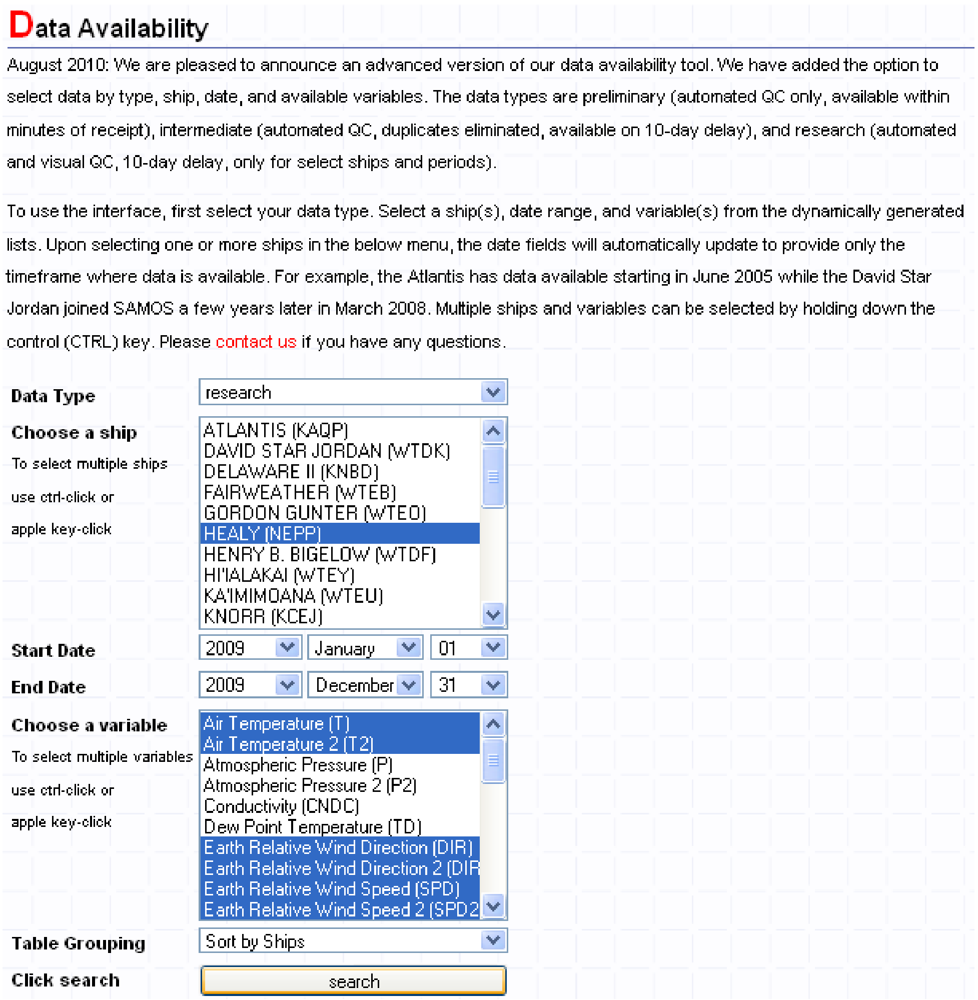
The result, once "search" is clicked, is an exhaustive list of all parameters available from the *Healy* in 2009:



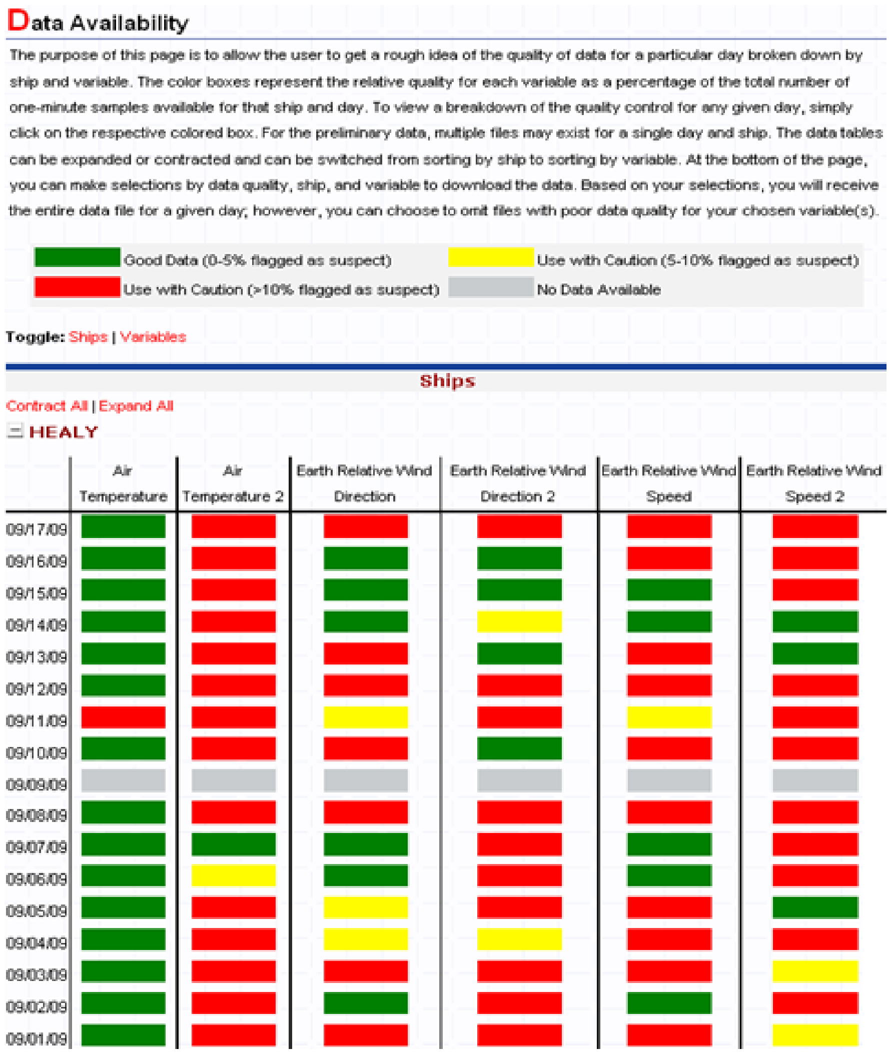
A thorough investigation of the list (note: image is truncated) tells the user the *Healy* did in fact provide both wind and temperature data in 2009. (Throughout the online SAMOS system, clicking on a "+" will yield further information; in this case the result would be metadata for the individual parameters.)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



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



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



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

Data Download w/ Daily QC Statistics

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

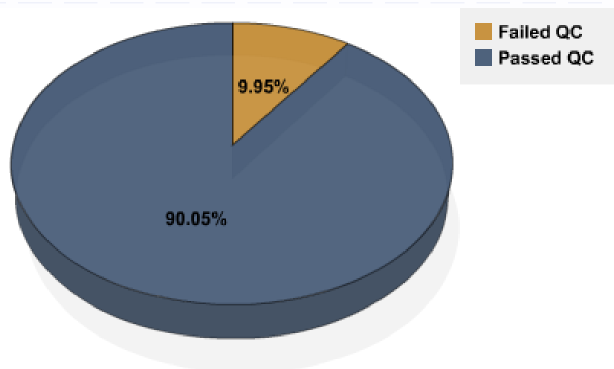
09-07-2009

HEALY

☐ select all

☐ File download | view file

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



Compression: .tar.gz

Download selected

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

Data Download w/ Daily QC Statistics

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

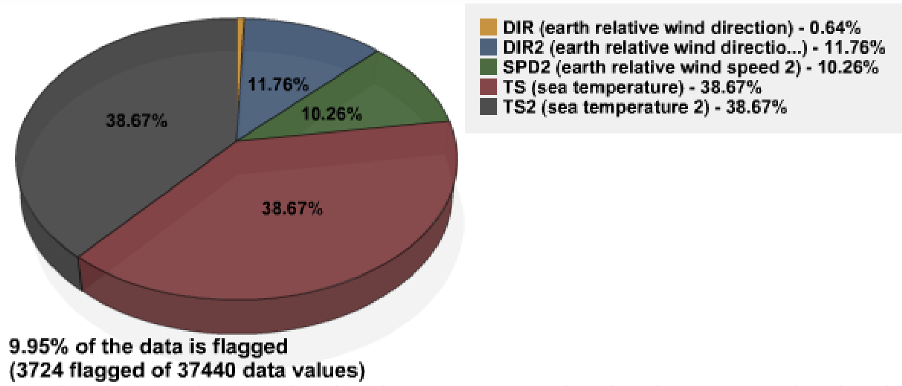
09-07-2009

HEALY

☐ select all

☐ File download | view file

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



Compression: .tar.gz

Download selected

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

Data Download w/ Daily QC Statistics

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

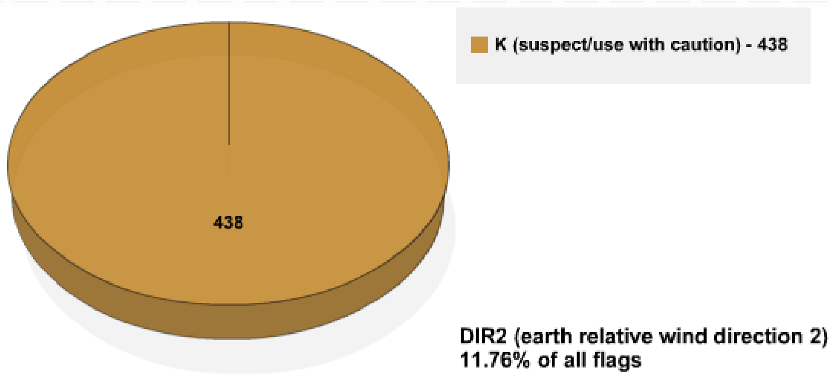
09-07-2009

HEALY

☐ select all

☑ File download | view file

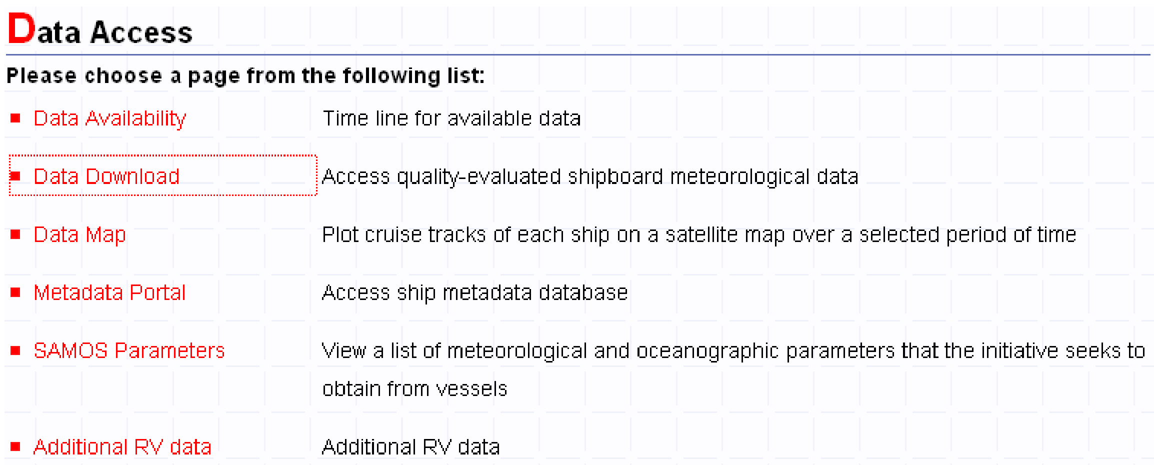
Chart Navigation failed qc vs passed qc | flag distribution | a-y flags | z flags



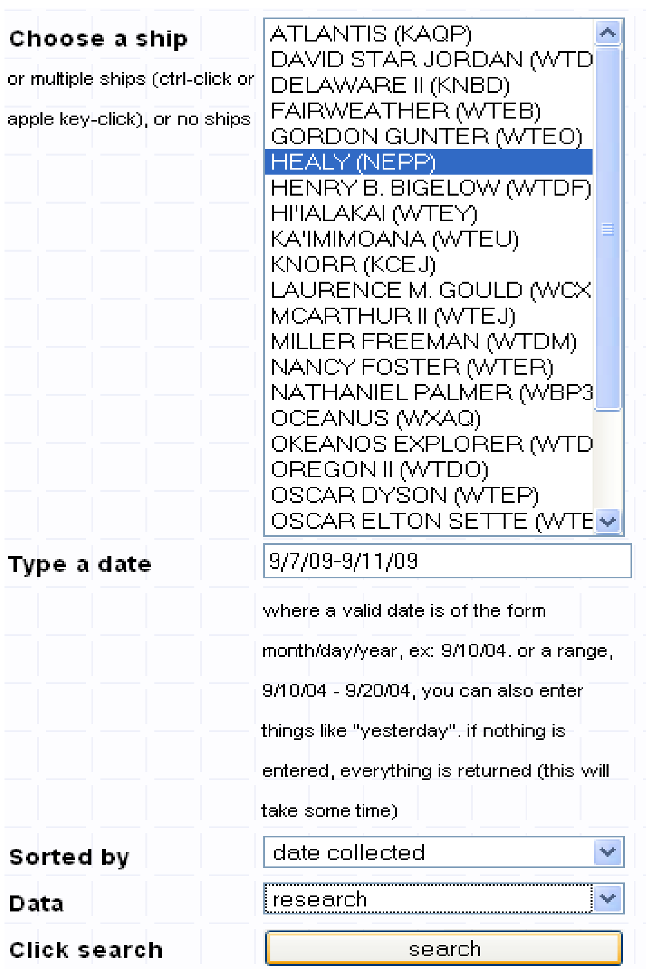
Compression: .zip

Download selected

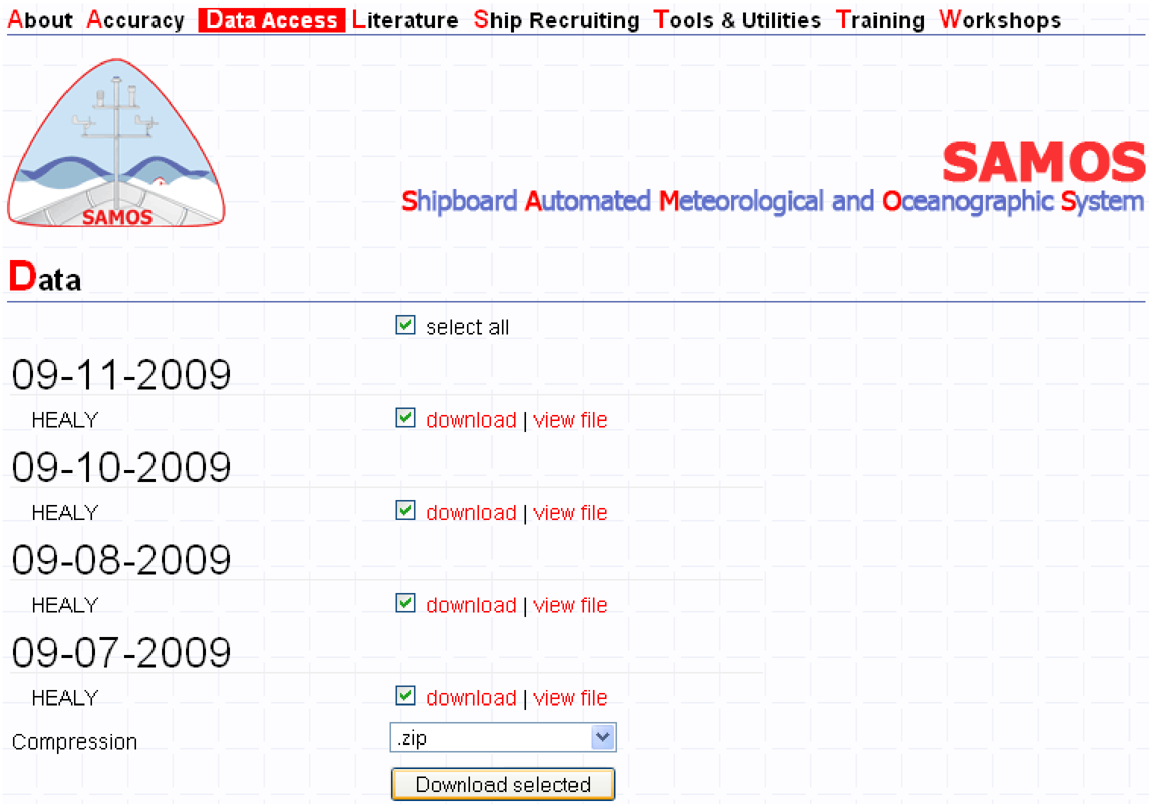
In this example, the user might repeat these steps to evaluate the quality of "SPD2" for 09/07/09. In the end, perhaps he decides the second wind sensor data will also be useful to him and now he would like to download the data. There are a couple of ways to accomplish this: By toggling a check mark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



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



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



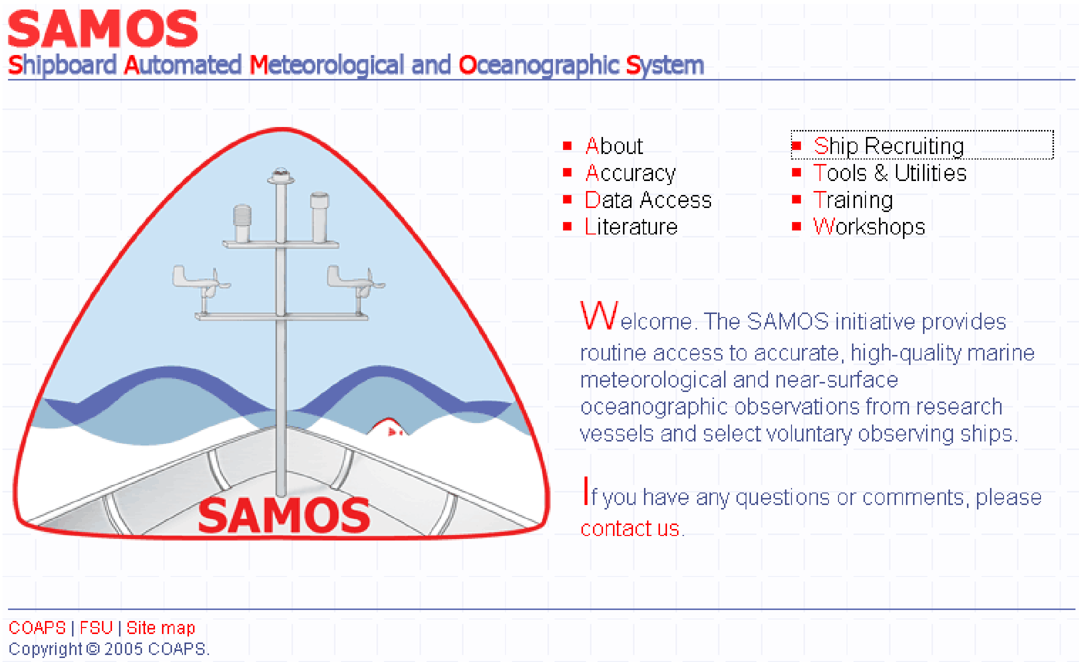
PART 2: the SAMOS operator

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

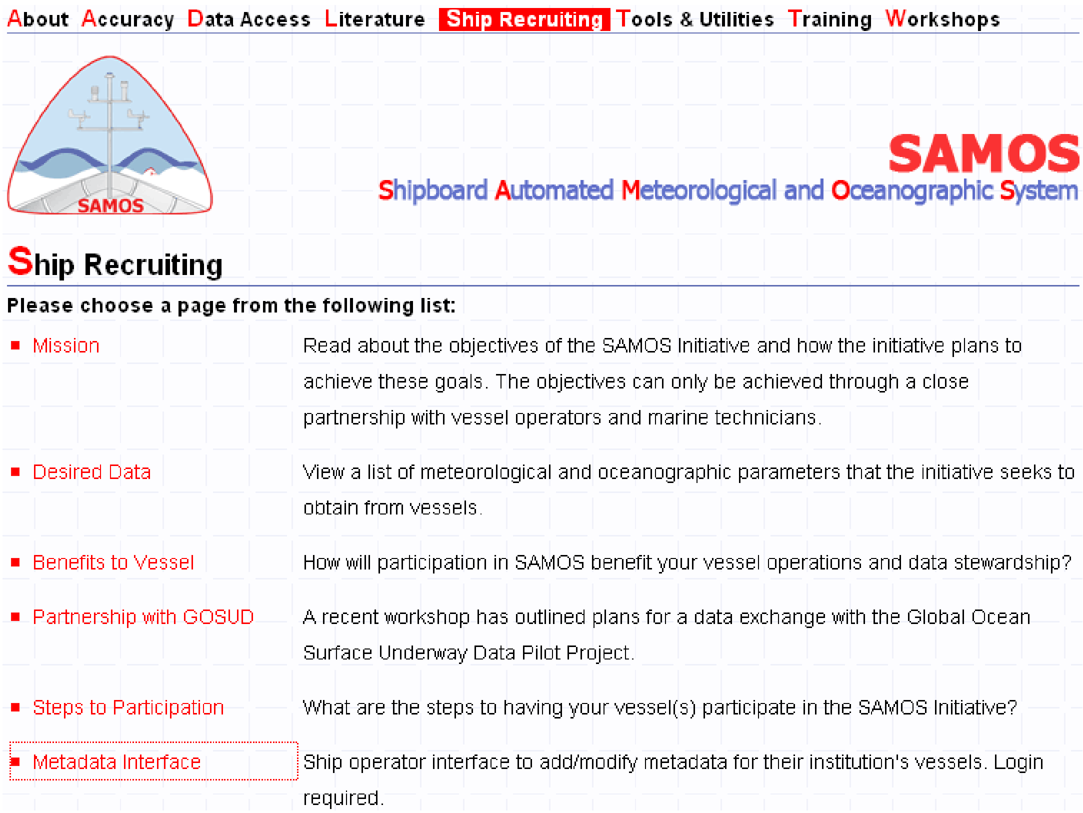
A SAMOS operator might choose to follow the steps outlined in part one as a simple way to keep tabs on the performance of his instruments. When problems are observed, vessel and instrument metadata are important tools for diagnosing a problem and finding a solution. For this reason, we strongly emphasize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

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

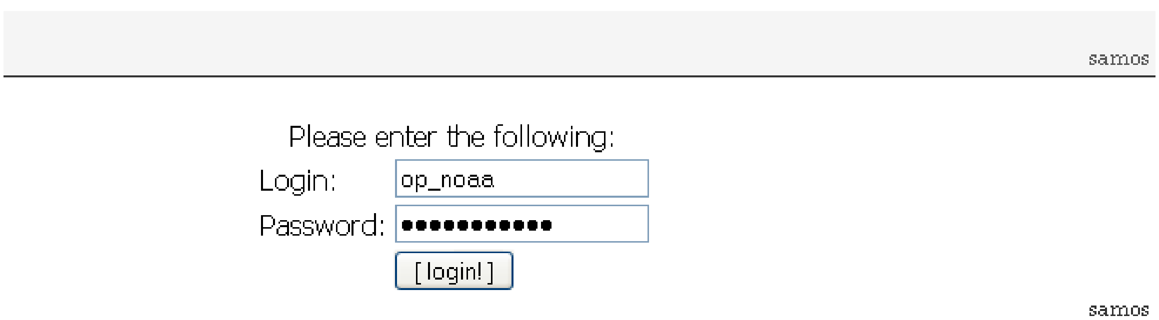
The database can be accessed by visiting the main page and choosing Ship Recruiting:



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



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



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

a. Select Vessel Metadata

user ship related

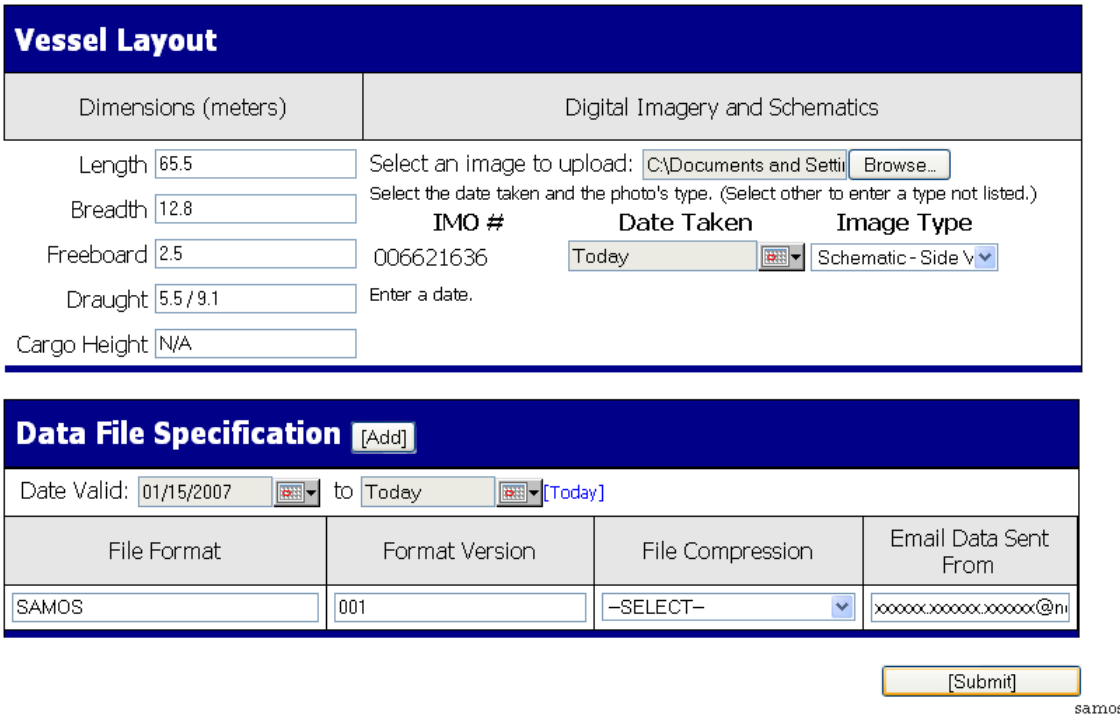
Edit Metadata

Ships for user op_noaa:

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

samos

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



Vessel Layout

Dimensions (meters)		Digital Imagery and Schematics
Length	65.5	Select an image to upload: C:\Documents and Setti Browse...
Breadth	12.8	Select the date taken and the photo's type. (Select other to enter a type not listed.)
Freeboard	2.5	IMO # 006621636 · Date Taken: Today · Image Type: Schematic - Side V
Draught	5.5 / 9.1	Enter a date.
Cargo Height	N/A	

Data File Specification [Add]

Date Valid: 01/15/2007 to Today [Today]

File Format	Format Version	File Compression	Email Data Sent From
SAMOS	001	–SELECT–	xxxxxx.xxxxxx.xxxxxx@n

[Submit]

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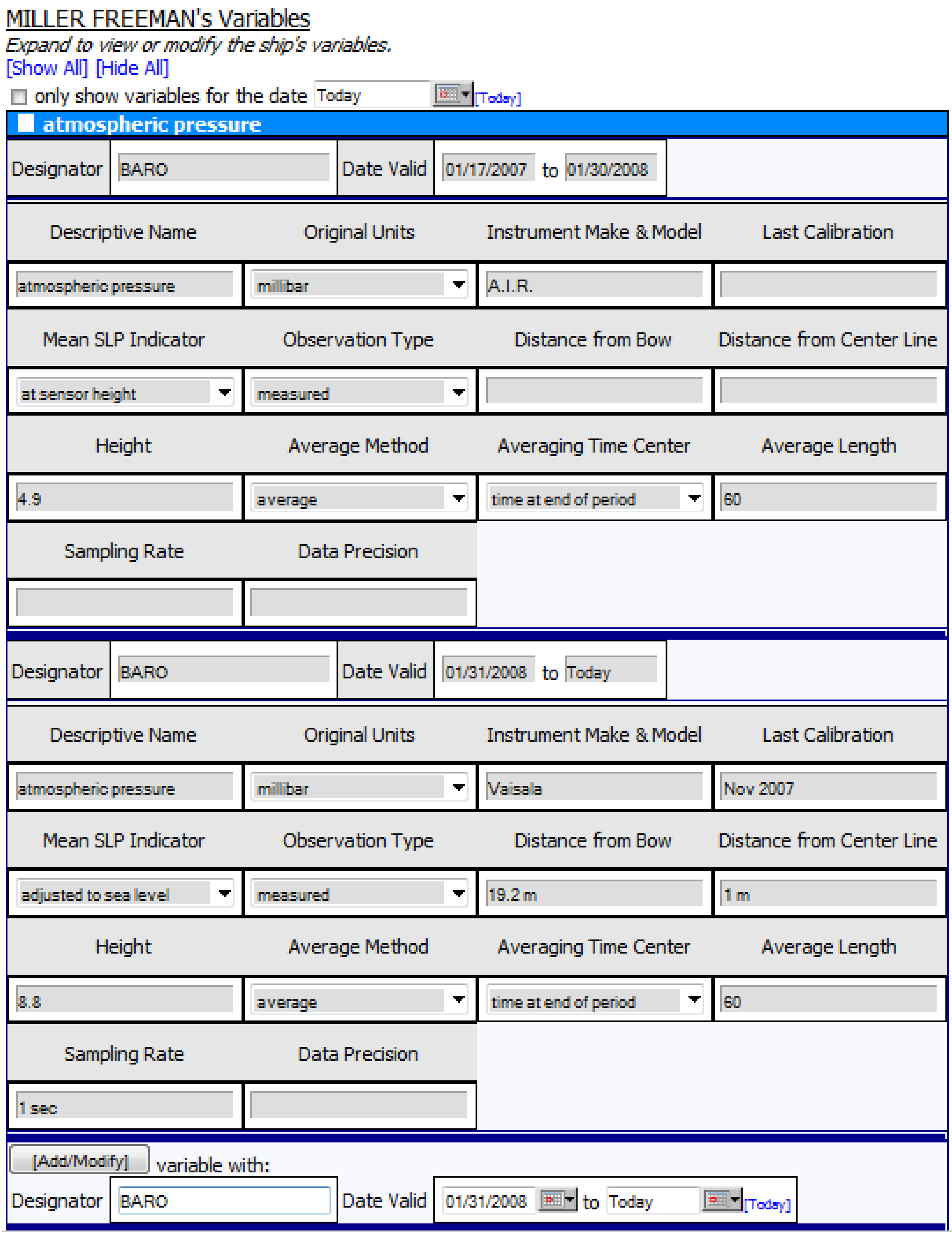
Adding and editing instrument (or parameter) metadata follow a slightly different procedure. The first step for the SAMOS operator is to identify which parameter he wishes to add or modify. Let us first consider the case of modifying a parameter already in use. Let us assume that a pressure sensor has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



MILLER FREEMAN's Variables

Expand to view or modify the ship's variables.

[Show All] [Hide All]

only show variables for the date Today [Today]

atmospheric pressure

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

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

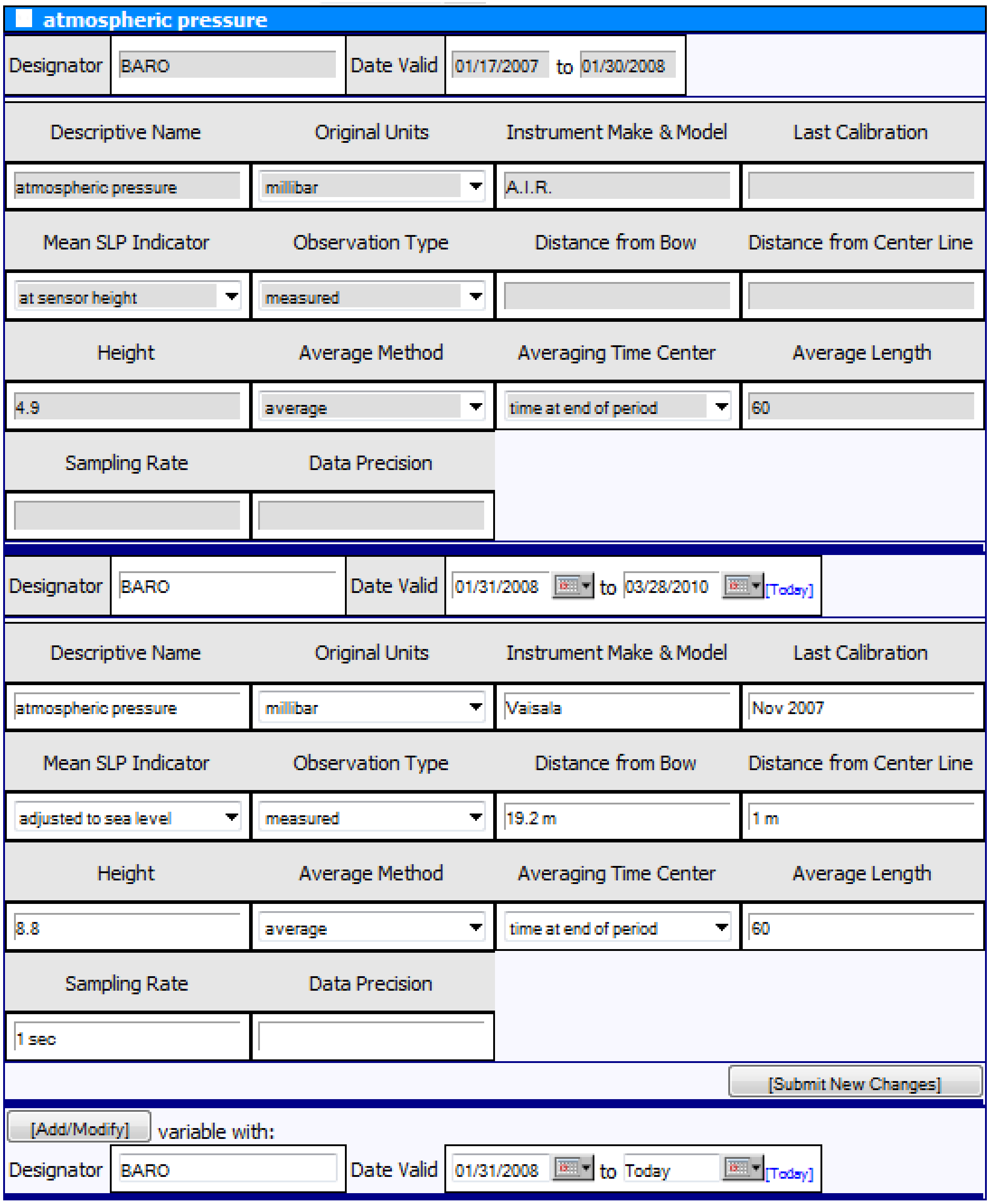
Designator	BARO	Date Valid	01/31/2008 to Today

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

[Add/Modify] variable with:

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

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



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

atmospheric pressure

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

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

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

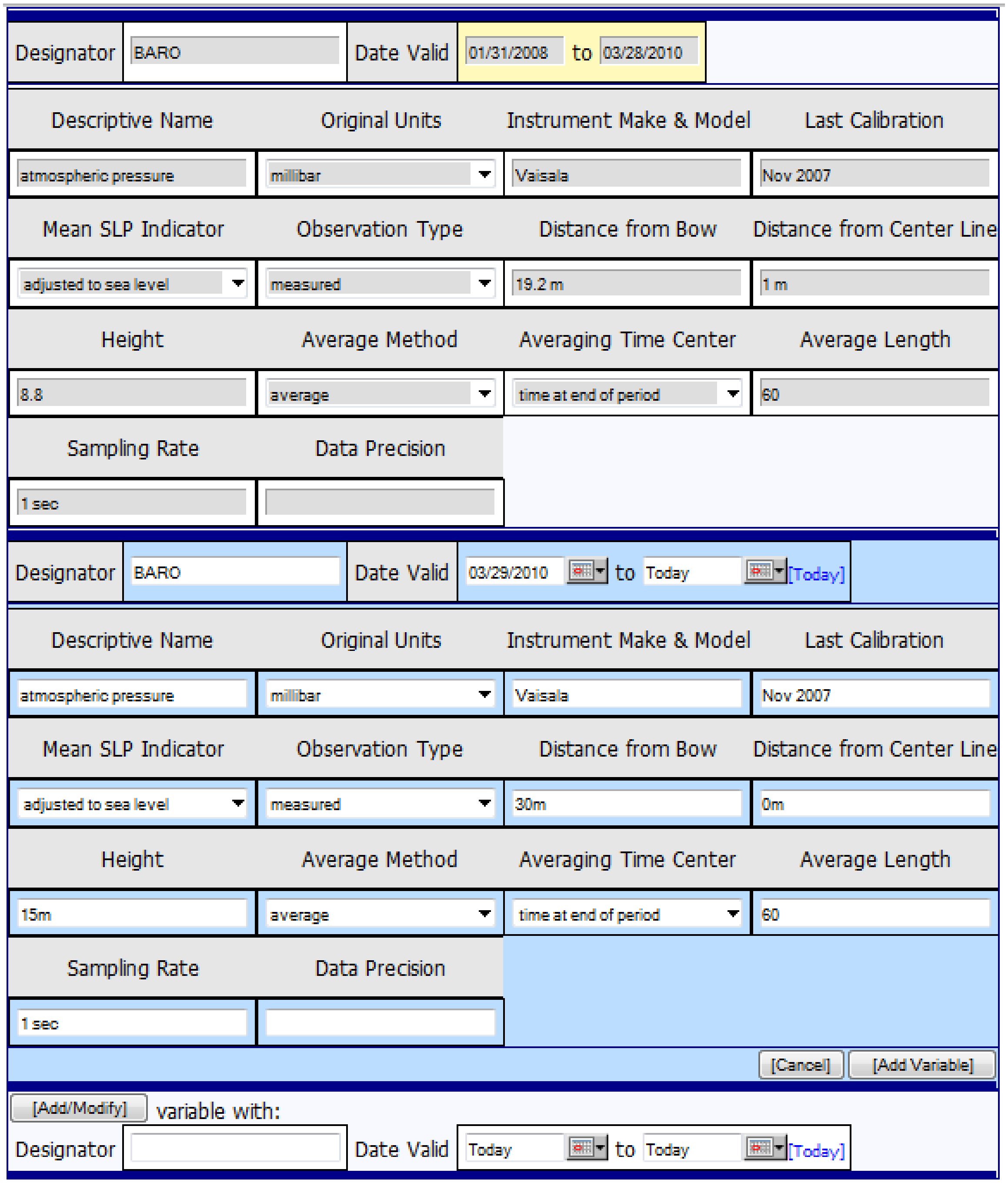
Descriptive Name	Original Units	Instrument Make & Model	Last Calibration
atmospheric pressure	millibar	Vaisala	Nov 2007
Mean SLP Indicator	**Observation Type**	**Distance from Bow**	**Distance from Center Line**
adjusted to sea level	measured	19.2 m	1 m
Height	**Average Method**	**Averaging Time Center**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

[Add/Modify] variable with:

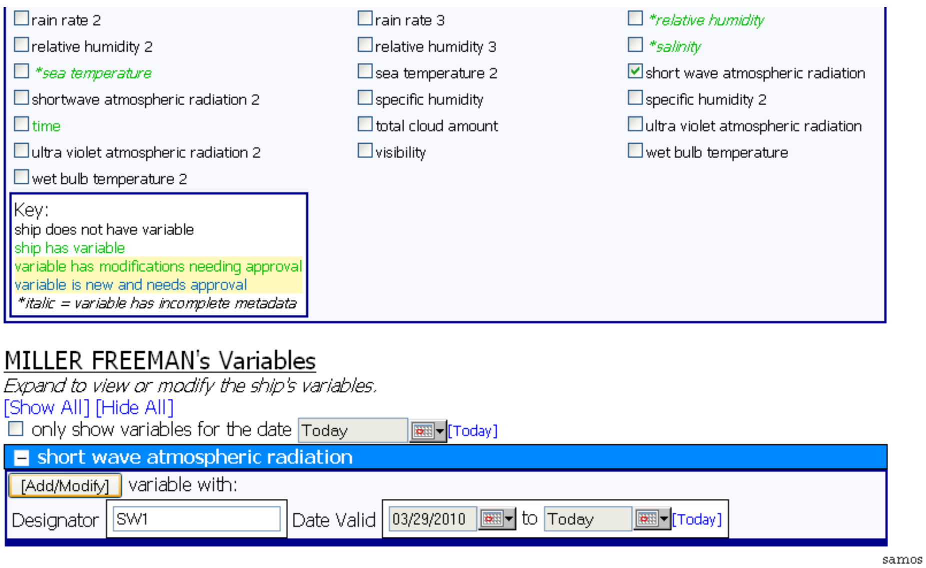
Designator	BARO	Date Valid	03/29/2010 to Today [Today]

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

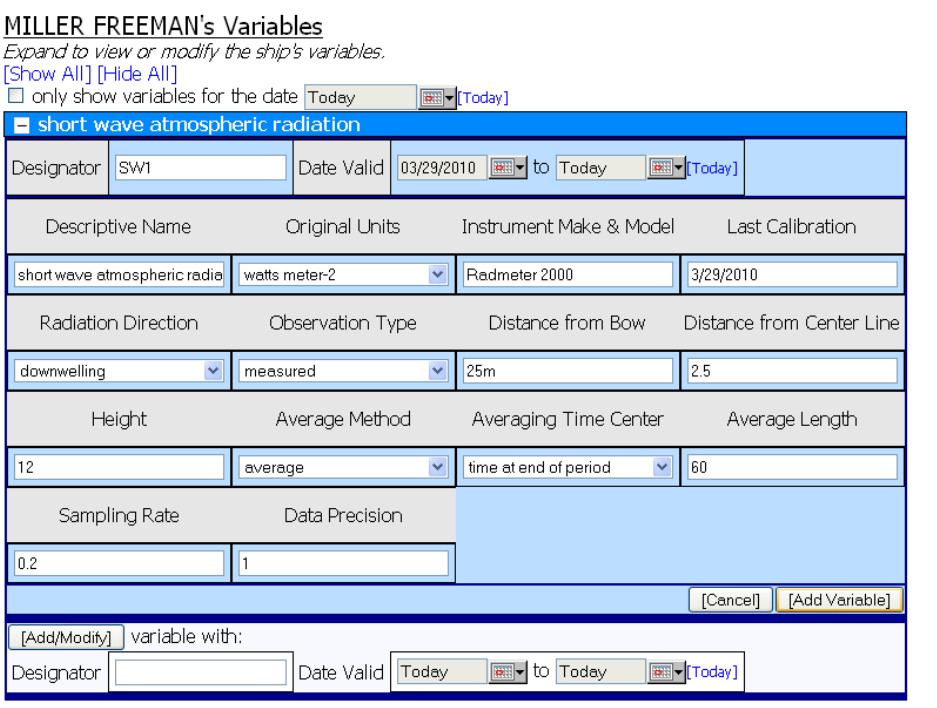
Once "Add/Modify" is clicked, a new set of fields opens up for the BARO parameter. All op_noaa need do at this point is recreate the parameter metadata entry, of course taking care to fill in the new location information, and click "Add Variable":



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



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



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

Data Access

Please choose a page from the following list:

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

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

Metadata Portal

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

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

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

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

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

Vessel Layout

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

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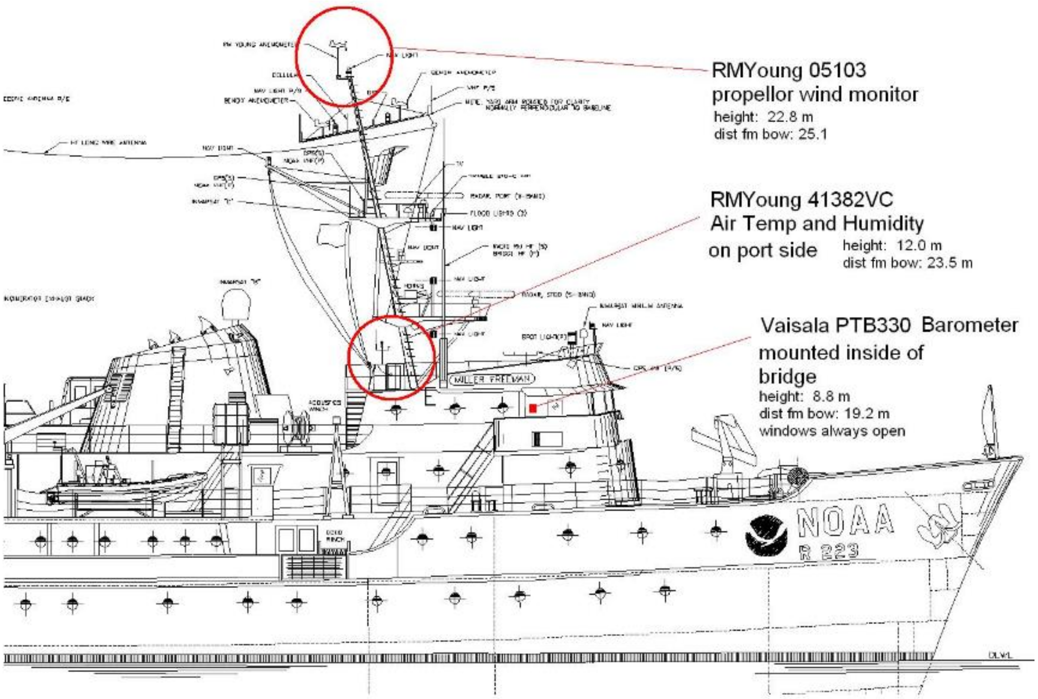
Clicking on the image itself would give us an enlarged view. In this case, the photo provides details about the locations of three MET sensors:



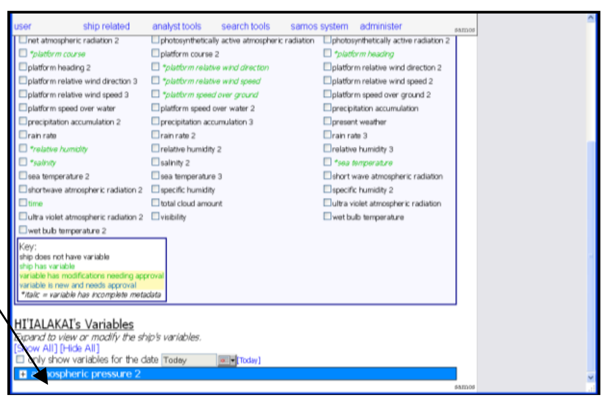
As a SAMOS user becomes familiar with following the metadata modification steps outlined in this section, chores such as adding duplicate sensors, logging sensor relocations, and keeping calibrations up-to-date become straightforward tasks. Naturally, complete and accurate metadata make for better scientific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

UPDATING SAMOS METADATA: STEP BY STEP EXAMPLE

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

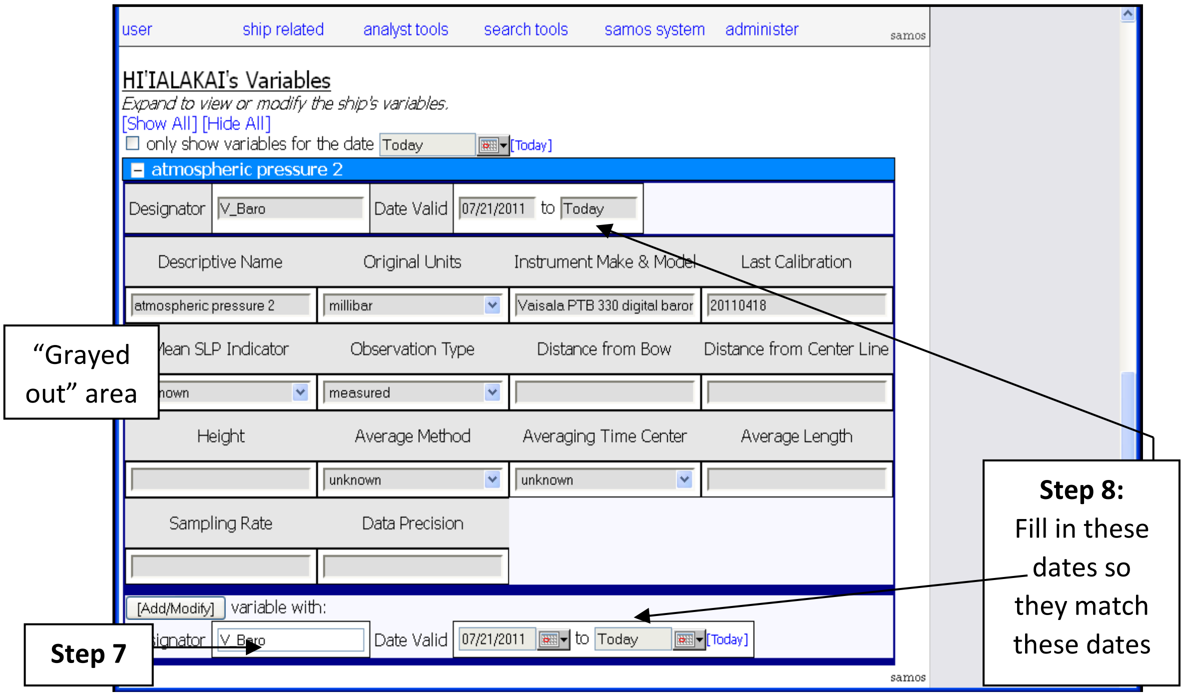
1. Go to: http://samos.coaps.fsu.edu/html/
   a. Click "Ship Recruiting"
   b. Click "Metadata Interface"
2. Enter login ID and password (case sensitive)
3. You can choose to modify Vessel or Instrument Metadata; you will likely choose Instrument. Vessel Metadata does not often change, other than the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

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



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

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

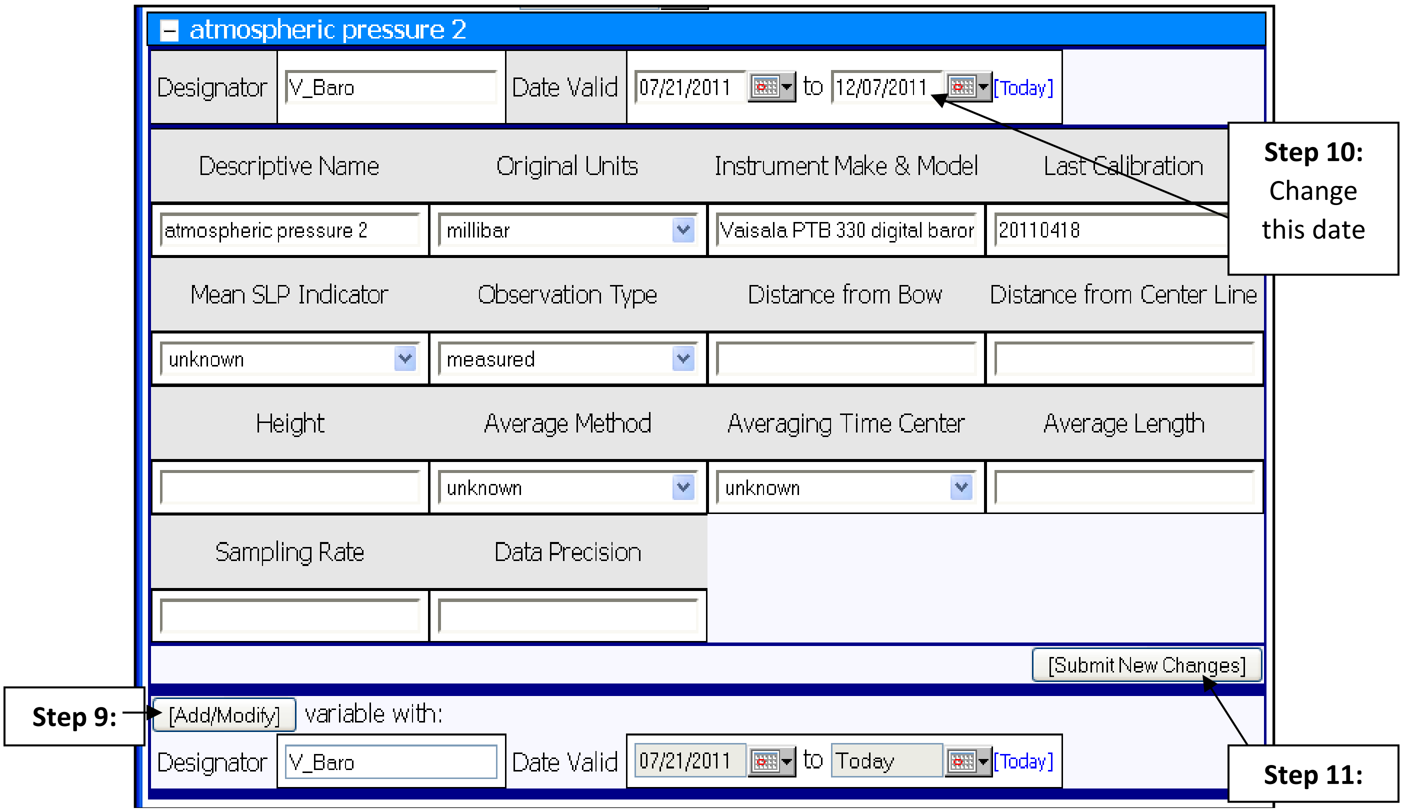


7. You first need to let the system know for which sensor you want to change information. In the box that appears at the very bottom (see image above), enter the name of the designator just at it appears in the box next to 'Designator' in the grayed out area.
   a. For the example above you would enter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

   * Note that before an updated version of sensor information can be entered, you must first "close out" the existing version. This is accomplished via steps 8 through 11. (The updated information will be entered in steps 12 through 15.)
8. In the bottom "Date Valid" boxes, make the dates match what you see above for the "Date Valid" dates in the grayed out area
   a. For the example above you would enter 02/01/2011 in the left box and you would click the blue [Today] button to make the right box read Today
   b. The right box will probably say 'TODAY' by default, and that is likely what you want.
      i. **NOTE:** The word 'Today' in any "Date Valid" entry is a floating date that implies the sensor is currently valid, no matter what day it is. The actual calendar dates mean the sensor starts & stops on the actual dates shown.
   c. Months are changed using the arrows

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

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



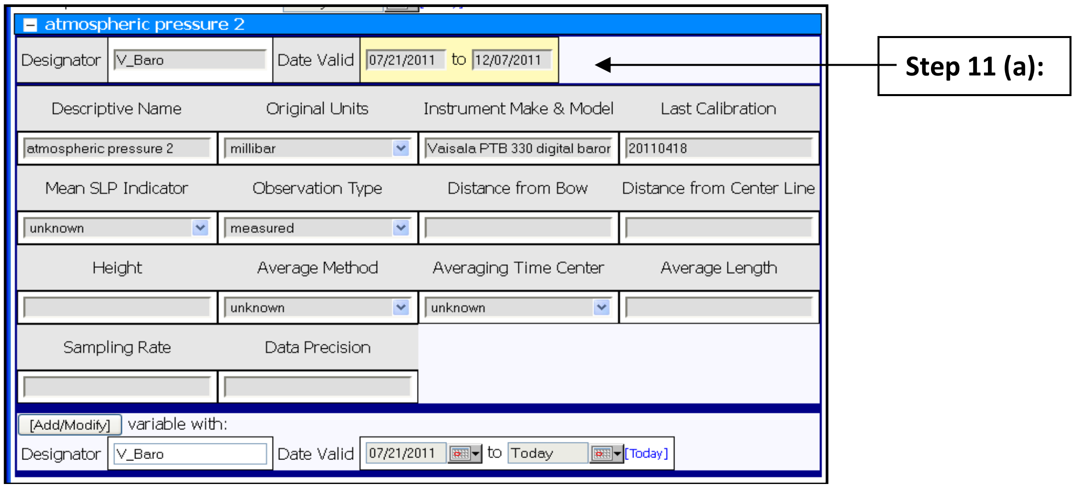
10. You now want to change the "Date Valid" info in this data box. The "Date Valid" start date (on the left) in this now edit-able area will likely stay the same unless you want to correct a previously entered erroneous start date. More than likely you will only be changing the end date, on the right.

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

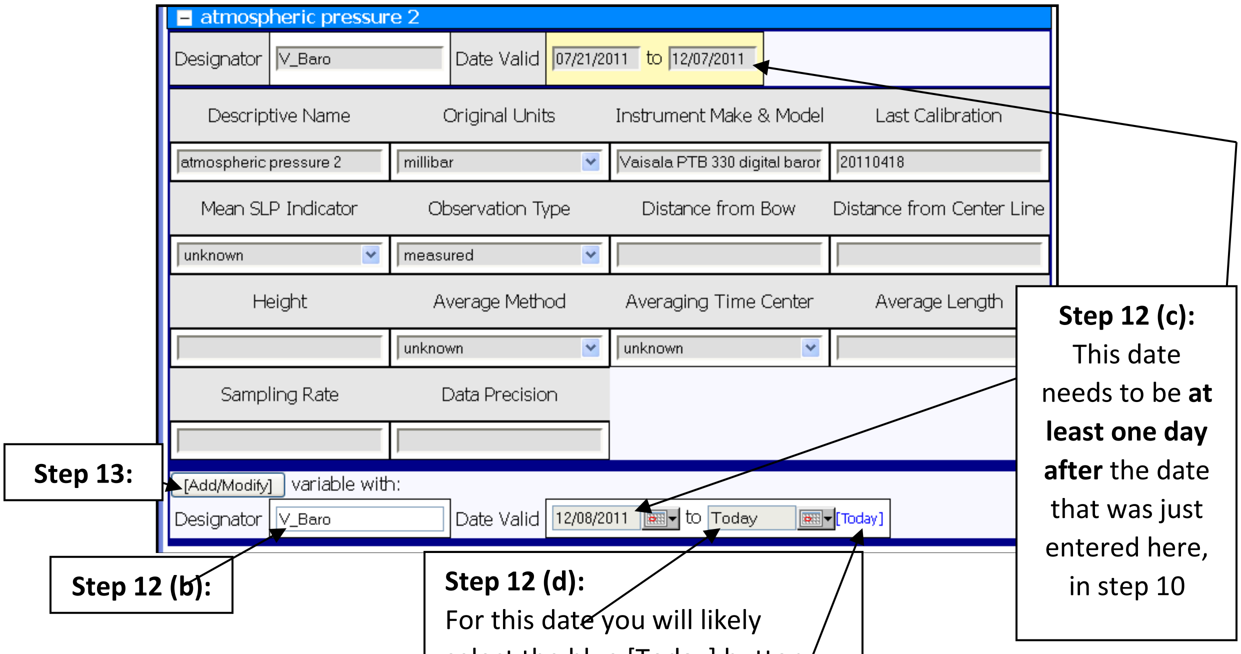
b. You will most likely be entering a calendar date in the right hand "Date Valid" box to close out the existing data for the sensor.

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

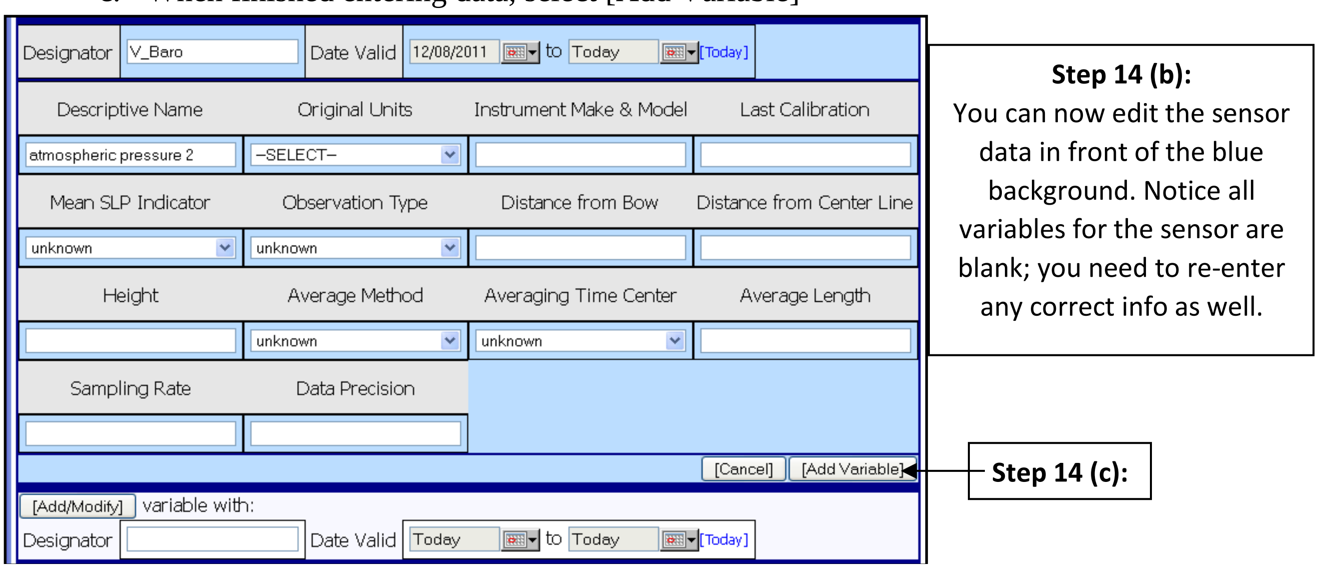
a. The text boxes in the data entry area should be grayed out again. The background of the dates that you just edited will be yellow (see image below).



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

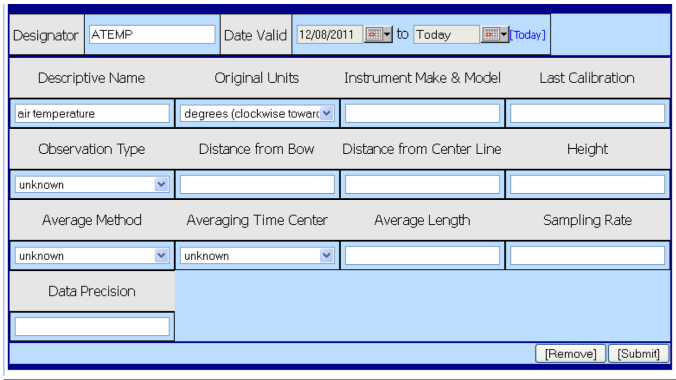


13. Click the [Add/Modify] button again (see image above)
14. You will now see a new, editable data box at the bottom of the screen that has blue around the sensor info instead of gray.
    a. Leave the Date Valid area the same
    b. You can now change the sensor data to reflect updates and add new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



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

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



Step 15:

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