2010 SAMOS Data Quality Report

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

Table of Contents

1. Introduction

This report describes the quantity and quality of observations collected in 2010 by research vessels participating in the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative. 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. Measurements are recorded at high-temporal sampling rates (typically 1 minute or less). A SAMOS comprises scientific instrumentation deployed by the RV operator and typically differ from instruments provided by national meteorological services for routine marine weather reports. The instruments are not provided by the SAMOS initiative.

Data management at the SAMOS data assembly center (DAC) provides a ship-to-shore-to-user data pathway (Figure 1). Daily packages of one-minute interval SAMOS data are sent to the DAC at the Florida State University via e-mail attachment. Broadband satellite communication facilitates this transfer as near as possible to 0000 UTC daily. A preliminary version of the SAMOS data is made available via web services within five minutes of receipt. The 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. 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://www.coaps.fsu.edu/RVSMDC/html/data.shtml) and long-term archiving occurs at the US National Oceanographic Data Center (NODC).

In 2010, out of 28 active recruits, a total of 26 research vessels routinely provided SAMOS observations to the DAC (Table 1). SAMOS data providers included the National Oceanographic and Atmospheric Administration (NOAA, 17 vessels), the Woods Hole Oceanographic Institution (WHOI, 3 vessels), the United States Coast Guard (USCG, 2 vessels), Raytheon Polar Services (RPS, 2 vessels from the National Science Foundation's Antarctic Program), University of Hawaii (UH, 1 vessel), Bermuda Institute of Ocean Sciences (BIOS, 1 vessel), and the Australian Integrated Marine Observing System (IMOS, 2 vessels). Two additional NOAA vessels – the *Rainier* and the *David Starr Jordan* – were active in the SAMOS system but their data stewards opted not to participate in 2010. Additionally, the *Jordan* was decommissioned in August 2010, hence no future SAMOS data transmission will be expected.

IMOS is an initiative to observe the oceans around Australia (see 2008 reference). 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 two Australian RVs. In addition to running a parallel system to SAMOS, IMOS also contributes to SAMOS the first observations from vessels not operated by the United States (US).

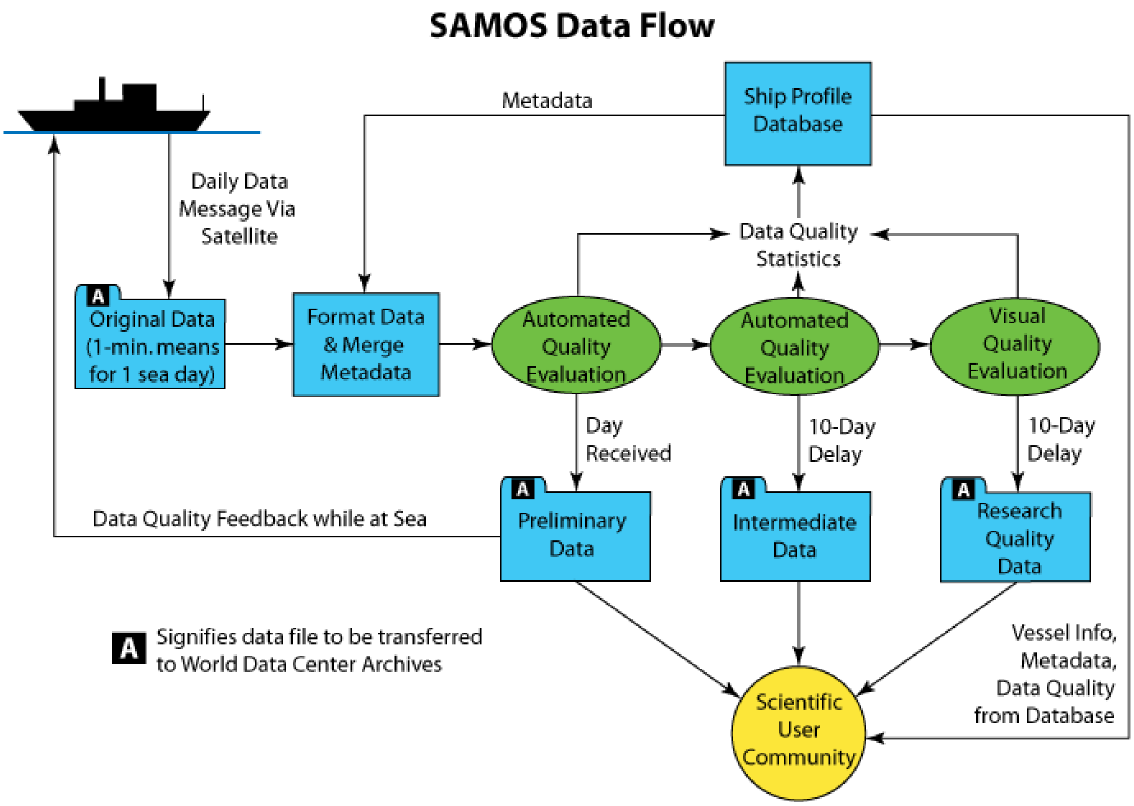


Figure 1: Diagram of operational data flow for the SAMOS initiative in 2009.

The quality results presented herein are from the research quality products, with the exception of data from the *Southern Surveyor*, *Aurora Australis*, *Kilo Moana*, *Atlantic Explorer*, and the USCGC *Polar Sea*. In the case of the *Southern Surveyor* and *Aurora Australis*, the IMOS project conducts their visual QC (only automated QC for these vessels occur at the SAMOS DAC). For the *Polar Sea*, *Kilo Moana*, and *Atlantic Explorer*, current funding does not extend to cover visual QC of their data. During 2010, 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), sensors that remained problematic for the duration of 2010 (namely, the relative humidity sensor onboard the *Nancy Foster*, the atmospheric pressure sensor onboard the *Hi'ialakai*, and the sea temperature sensor onboard the *Delaware II*), unmonitored transmission of erroneous data during the *Knorr* and *Oceanus* dry dock periods, and a catastrophic failure of the air temperature and relative humidity sensors from 17 November through 19 December 2010 onboard the *Fairweather*. On a positive note, the long-standing issue with the atmospheric pressure sensor onboard the *Okeanos Explorer* was finally fixed on

26 March. There was also a productive teleconference between Shawn Smith (lead investigator on the SAMOS project), two SAMOS data analysts, and core NOAA personnel in November 2010 that led to plans to address other major vessel issues.

This report begins with an overview of the vessels contributing SAMOS observations to the DAC in 2010 (section 2). The overview treats the individual vessels as part of a surface 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. A 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 2011. Annexes include web interface instructions for accessing SAMOS observations (Annex A, part 1) and metadata submission by vessel operators (Annex A, part2), as well as examples of at sea feedback to technicians from the SAMOS data analyst (Annex B).

2. System review

In 2010, a total of 28 research vessels were under active recruitment to the SAMOS initiative; 26 of those vessels routinely provided SAMOS observations to the DAC (Table 1). SCS personnel for the NOAA ship *Rainier* chose not to submit data for 2010. In their opinion, the scientific equipment onboard the *Rainier* was not of sufficiently high grade as to provide quality data. Likewise, the *David Starr Jordan* (decommissioned as of August 2010) did not submit data for 2010. In total, 4,526 ship days were received by the DAC for the January 1 to December 31 2010 period, resulting in 6,072,327 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 6,072,327 records received in 2010, a total of 122,348,865 distinct measurements were logged. Of those, 8,184,734 were assigned A-Y quality control flags – roughly six and a half percent, as opposed to 2009's roughly eight percent – by the SAMOS DAC (see section 3a for descriptions of the QC flags). Measurements deemed "good data," through both automated and visual QC inspection, are assigned Z flags. The authors wish to note that 2010 was the second full year during which data analysts regularly performed visual QC. The data analyst's quality control methods thus improved in 2010 as they gained more experience. This may partially explain the apparent overall data quality improvement. Additionally, recall that five of the SAMOS vessels (the *Southern Surveyor, Aurora Australis, Kilo Moana, Atlantic Explorer*, and the USCGC *Polar Sea*) only underwent automated QC. None of these vessel's data was assigned any additional flags, nor were any automatically assigned flags removed via visual QC, which may also contribute to the lower system-wide percentage of A-Y quality control flags.

SHIP NAME	CALL SIGN	Days at Sea	Tot. Days Afloat	# of Days	# of Vars	# of Records	# of A-Y Flags	# of All Flags
TOTAL	-	-	-	4,526	526	6,072,327	8,184,734	122,348,865
ATLANTIS	KAQP	289	352	353	35	505,811	493,332	14,004,925
KNORR	KCEJ	274	314	324	33	460,441	501,114	13,238,268
DELAWARE II	KNBD	-	-	131	14	176,015	321,972	2,414,305
HEALY	NEPP	146	167	131	29	180,617	605,217	5,237,122
POLAR SEA	NRUO	-	-	42	18	55,757	98,637	962,028
SOUTHERN SURVEYOR	VLHJ	183	311	180	29	219,283	271,838	5,922,533
AURORA AUSTRALIS	VNAA	134	210	170	30	233,622	261,333	6,054,982
NATHANIEL B. PALMER	WBP3210	-	204	149	17	211,552	194,160	3,596,384
LAURENCE M. GOULD	WCX7445	-	186	246	23	353,360	813,201	7,808,984
KILO MOANA	WDA7827	282	316	66	22	90,422	690	1,982,084
ATLANTIC EXPLORER	WDC9417	156	221	73	21	78,100	48,534	1,640,046
HENRY B. BIGELOW	WTDF	-	-	143	18	181,027	198,468	3,164,751
OKEANOS EXPLORER	WTDH	-	-	97	16	129,671	168,506	2,013,119
DAVID STARR JORDAN	WTDK	-	-	0	14	-	-	-
PISCES	WTDL	-	-	195	15	261,657	414,806	3,627,141
MILLER FREEMAN	WTDM	-	-	135	16	175,422	84,217	2,792,922
OREGON II	WTDO	-	-	99	14	131,185	106,534	1,836,590
FAIRWEATHER	WTEB	-	-	221	13	305,753	460,535	3,917,340
RONALD H. BROWN	WTEC	-	-	151	17	209,003	120,090	3,321,855
OSCAR ELTON SETTE	WTEE	-	-	170	16	231,177	253,399	3,587,377
RAINIER	WTEF	-	-	0	13	-	-	-
MCARTHUR II	WTEJ	-	-	157	16	215,777	134,518	3,391,451
GORDON GUNTER	WTEO	-	-	158	16	214,352	152,726	3,215,211
OSCAR DYSON	WTEP	-	-	177	16	234,987	249,374	3,666,587
NANCY FOSTER	WTER	-	-	158	17	211,541	417,688	3,461,137
KA'IMIMOANA	WTEU	-	-	225	16	308,669	218,017	4,590,977
HI'IALAKAI	WTEY	-	-	200	16	280,745	451,373	4,265,193
OCEANUS	WXAQ	252	265	294	33	414,855	1,291,506	12,557,749

Table 1: CY2010 summary table showing (column three) number of vessel days reported specifically at sea by institution, (column four) total number of vessel days reported afloat in general by institution, (column five) number of vessel days received by the DAC, (column six) number of variables reported per vessel, (column seven) number of records received by DAC per vessel, (column eight) total incidences of A-Y flags per vessel, (column nine) total incidences of A-Z flags per vessel. A "–" denotes information not available.

a. Temporal coverage

As shown in Table 1, the number of files received by the DAC from each vessel is rarely equal to the number of days reportedly at sea or even merely afloat. (*Note that complete CY2010 schedule information was not obtainable for the enrolled NOAA vessels prior to this report distribution.) Days "afloat" include days spent at port, which are assumedly of less interest to the scientific community than those spent at sea. We are therefore not intensely concerned when we do not receive data during port stays, although if a vessel chooses to transmit port data we are pleased to apply automated and visual QC and archive it. However, when a vessel is reportedly "at sea" and we have not received underway data, we endeavor to reclaim any available data, usually via email communication with vessel technicians and/or lead contact personnel. (Annex B offers examples of operator/analyst interaction and demonstrates the extreme usefulness of ongoing communication.) 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.

In Figure 2, we compare the data we've received (green and blue) to final 2010 ship schedules provided by each vessel's institution. (*Note again that the schedules obtained for NOAA vessels were incomplete; no schedule information after September 2010 was available.) A “blue” day denotes that the data file was received well past the 10 day delayed-mode window and thus missed timely processing and visual qc. Because the amount of these “blue” days was not overwhelming, these files were processed and received both automated and visual qc when they were discovered to be in the system (in early 2011). It should be noted, however, that current funding for the SAMOS initiative would 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. Days identified on the vessel institutions 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." It should be noted that the *Atlantic Explorer* (WDC9417) was not recruited and made active in the SAMOS system until late July 2010, such that any preceding "at sea" days would not be anticipated to be in the SAMOS data system. Through agreement with IMOS, we receive data for the *Southern Surveyor* and the *Aurora Australis* and for both vessels perform automated QC only. IMOS data is visually evaluated in Australia and 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
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KCEJ										S	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KNBD																		S	S	S	S										
NEPP																															
NRUO																															
VLHJ	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	S									
VNAA																							P								
WBP3210				S	S	S	A	A	A	A	A	A	A	S	A	S	A	A	A	S	A	S	A	S	S	A	A	A	A	A	A
WCX7445	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WDA7827																													S	S	S
WDC9417																											S	S	S	S	P
WTDF																															
WTDH																															
WTDK																															
WTDL																												A	A	A	A
WTDM																															
WTDO																															
WTEB																					S										
WTEC		A	A	A	S	S	S	S	S	S	S	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S	
WTEE													S							S	S	S	S	S	S	S	S	S	S	S	S
WTEF																															
WTEJ																															
WTEO																															
WTEP																			S				S							S	S
WTER																															
WTEU					A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A				A	A	A	A	A	A	S
WTEY													S								S	A	A	A	A	A	A	A	A	A	A
WXAQ	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A	A	A	A	A

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			
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			
KCEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			
KNBD		A	A	A	A	A	A	A	A	A	A	A	A			A	A	S								A	A	A			
NEPP																															
NRUO																															
VLHJ																P	P	P	P	P	P	P	P	P	P	P	P	P			
VNAA																															
WBP3210	S	A	A	A	S	A	A	A	A	A	S	A	A	A	A	A	S	A	A	A	A	A	A	A	A	A	A	A			
WCX7445	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			
WDA7827	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	S	S	S			
WDC9417	P	S	S	S	S	S	P								P	S	P				P	S	S	S	S	S	P				
WTDF																						A	A	A	S		A	A			
WTDH						S		S	S	S	A	A	A	A	A	A	A	A	S				S	S	S	S		S			
WTDK																															
WTDL	A	A	A	A	A	A	A	A	A	A							A	A	A	A	A	A	A	A	A	A	A	A			
WTDM																															
WTDO																															
WTEB																															
WTEC						S	S	S	S	S	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S				
WTEE	S	S	S	S	S	S				A	A	A	A	A	A	A	A	A	A	A	A	A	A	S	S			A			
WTEF																															
WTEJ																															
WTEO																															
WTEP	S								S						S	S	A	A	A	A	A	A	A	A	A	A	A	A			
WTER																A	A	A	A	A	A		A	A	A	A	A	A			
WTEU	A	A	A	A	A	A	A	A	A	A	A		A	A	A	A			A	A	A	A	A	A	A	A	A	A			
WTEY	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			
WXAQ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	P	P			

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
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KCEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KNBD	A	A	A	A	A						S																				
NEPP																			S	S	S										
NRUO																															
VLHJ	P	P	P	P	P	P	P	P	P	P	P	P	P	P										S	P	P	P	P	P		
VNAA	P	P	P	P	P	P	P																								
WBP3210	S															S	S	S	S	S	A	A	A	S	S	S	A	A	S	A	A
WCX7445	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WDA7827	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	P
WDC9417	P	S	P				P	S	S	S	P											P	S	S	S	S	S	P			
WTDF	A	A	A	A	A	A	A	A	A	A	A					A	A	A	A	A	A	A	A	A							A
WTDH	S	S	S	S	S	S	S	A	A	A	S					A	A	A	A	A	S	A	A	A	A	A	S				
WTDK																															
WTDL	A	A							A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A							
WTDM																									S	S	A	A	A	A	A
WTDO																															
WTEB																															
WTEC								A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEE	A	A	A	A	A	A	A	A	A	A	A	A	S	S					A	A	A	A	A	A	A	A	A	A	A	A	A
WTEF																															
WTEJ																															
WTEO																															
WTEP	A	A	A	A	A	A	A	A	A								A	A	A	A	A	A	A	A	A	A	A	A	A	A	
WTER	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEU	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S												A	A
WTEY	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			S	A	S	A	A	A	A
WXAQ	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Figure 2: 2010 calendar showing (green and blue) ship days received by DAC and (grey) additional days reported afloat by vessels; "A" denotes data has been archived, "*S*" denotes vessel reportedly at sea, "P" denotes vessel reportedly at port. Vessels are listed by call sign (see Table 1).

APRIL	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
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KCEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KNBD																														
NEPP							S	S	S	S	S	S	S	S	S	S			S	S	S	S	P	S						
NRUO																														
VLHJ							S																							
VNAA																														
WBP3210	A	A	A	A	A	A	A	A	A	A	S	A	A	A	S	A	S	A	A	S	A	A	S	A	S	A	A	S	A	A
WCX7445	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WDA7827	S	S	S	S	S	S	S	S	S	S	S	S	S	S	P	S	S	S	S	S	S	S	S	S	S	S	P	S	S	S
WDC9417					P	S	S	S	P			P	S	S	S	S	P		P	S	S	S	S	S	P					
WTDF	A	A	A	A	A	A	A	S					A	A	A	A	A	A	A	A	A	A	S			A	A	A	A	A
WTDH																														A
WTDK																														
WTDL						A	A	A	A	A	A	A	A								A	A	A	A	A	A	A	A	A	A
WTDM	S	S	A	A	A	A	A	A	S		S	A	A	A	A	A	A	A	A	A	A	S				A	A	A	A	A
WTDO																														
WTEB							S	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEC	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S	S	S	S	S	S	S	S	S	A	A	A	A	A
WTEE	A	A	A	A	A	A	A	A	A	A	A	S							A	A	A	A	A	A	A	A	A	A	A	A
WTEF																														
WTEJ		S																	S	A	S	S	A	A	A	A	A	A	A	A
WTEO			S	S	S	A	A	A	A	A	A	A	A	A	S	S	S	S		A	A	A	A	A	A	A	A	A	A	A
WTEP																							S	A	A	A	A	A	A	A
WTER	A	A	A	A	A	A	A	A	A	A	A	A	S																	
WTEU	A	A	A	A	A	S	S	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEY	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S						
WXAQ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

MAY	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
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KCEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KNBD			A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A							A	A	A	A
NEPP																A	A	A	A	A	A	A	A	P	P	P	P	P	P	P	A
NRUO																															
VLHJ						P	P															S					S	P	P	P	P
VNAA																			P	P	P	S	S	S	S	P	P	P	P	P	P
WBP3210	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	S
WCX7445	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WDA7827	S	S	S	S	S	S	S	S	P	S	S	S	S	S	P	P	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
WDC9417		P	S	P	P	S	S	S	S	P	P	S	S	S	S	S	S	P			S	S	S	S							
WTDF	A	A	S																												
WTDH	A	A	A	A	A			A	A	A	A	S							S	A	A	A	A	A	A	A	A	A	A	A	A
WTDK																															
WTDL	A	A	A	A	A	A																									
WTDM	A	A	A	A	A	A	A						A	A	A	A	A	A	A					A	A	A	A	A	A	A	A
WTDO																															
WTEB	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEC	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S									
WTEE	A	A	A	A									A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEF																															
WTEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S	A	A	A	A	A
WTEO	A	A	A	A	A					A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S	S	S
WTEP	A	A			S	A	A	A	A	A	A	A	A	A	A	A	A	A			A	A	A	A	A	A	A	A	A	A	A
WTER																	A	A	A	A	A	A	A	A	A	A	A				
WTEU	S																														
WTEY										S	S	S	S	S	S	S	S	A	A	A	A	A	A	A	A	A	A	A	A	S	S
WXAQ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

JUNE	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
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KCEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KNBD	A	A	A	A	A	A	A	A	A									S	S	A	A	A	A	A		A	A	A	A	A
NEPP	A	A	A	A	A	A	A	A	A	A	A	A	P	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
NRUO																														
VLHJ	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
VNAA	P	S	S	S	S	S																								
WBP3210	S	A	A	A	A	A	A	A	A	A	S								S	S										
WCX7445	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			
WDA7827	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	S	S	S	S	S	S	S	P	P	S	S
WDC9417														S	S	S	S	S	P	P	S	S	S	S	S	P	P	S	S	P
WTDF																														
WTDH	A	S	S	S				A	A	A	A	A	A	S	S	S	S	S	S	S	S	S	S	A	A	A	A	A	A	A
WTDK																														
WTDL														A	A	A	A	A	A	A	A	A	A	A	A	A	A			
WTDM	A	A	A	A	A	A			A	A	A	A	A	A	S	A	A	A	A	A	S									
WTDO															A								A	A	A	A	A	A	A	A
WTEB	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A				A	A	A	A	A	A	A
WTEC	S	S	S																											
WTEE	A	A	A	S																			S							
WTEF																														
WTEJ	A	A	A							S	S	S	S	S	S		S	S	S	S	S	S	S	S	S	S	S	S	S	S
WTEO	S	S	S	S									A	A	A	A	A	A	A	A	S			A	S					A
WTEP	A			A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A					A	A
WTER	S	S																								A	A	A		A
WTEU																													A	A
WTEY	S	S	S						S	A	A	A	A	A			A	A	A	A	A	A	A	A	A	A	A	A		
WXAQ	A	A	A	A	A	A	A	A	A	A				A	A	A	A	A	A	A	S	A	A	A	A	A	A	A	A	A

(Figure 2: cont'd)

JULY	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
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KCEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KNBD	A	A	A	A	A	A	A											A	A	A	A	A	S	A						S	S
NEPP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S	A	A	A
NRUO																															
VLHJ	P	P	P	P																							S	P			
VNAA																															
WBP3210																															
WCX7445																															
WDA7827	S	S	S	S		P	S	S	S	S	S	P	S	S	S	S	S	S	S	S	S	S	S		P	P	S	S	S	S	S
WDC9417					P	S	P					P	S	S	S	S	S	P			P	S						P			
WTDF																A		A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTDH	A	A	A	A	A	A	A	A	A	A	A	A	S	S								A	A	A	A	A	A	A	A	A	A
WTDK																															
WTDL							A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			A						
WTDM				S	A	A	A	A	A			A	A	A	A	A	A	A	A	A	A	A	A		A	A					
WTDO	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A										A	A	A	A	A	A
WTEB	A						S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEC																															
WTEE							A	A	A	A	A	A	A	A	A	A	A														
WTEF																															
WTEJ	S	S	S	S								S	S	S	S	A	A	A	A	A	A	S	A	A	A	A	A	A	A	A	A
WTEO	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S				A	A	A	A	A	A	A	A	A	A	A	A
WTEP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A				A	A	A	A	A	A	A	A	A	A	A	A
WTER	A	A	A	A	A	A	A	A	A	A	A	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEU	A								A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEY																						A	A	A	A	A	A	A	A	A	A
WXAQ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

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
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KCEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A									A	A	A	A
KNBD																		A	A	A	A	A	A	A	A	A	A	A	A	A	A
NEPP	A	A	A	A	A	A	A	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S	S	S	S	S	S	A	A	A
NRUO																															
VLHJ									S											S	P	P	P	P	P	P	P	P	P	P	P
VNAA		P	S	S	S	S	P	S	S	S	S																				
WBP3210																															
WCX7445																															
WDA7827	S	S	S	S	P	S	S	S	S	S								P	P	S	S	S	S	S	S	S	S	S	S	S	
WDC9417			P						P	P		P						P						P							
WTDF	A	A	A	A	A	A	A	A	A	S			A	A	A	A	S	S	S	A	A	A		A	A	A	A	S			
WTDH	A	A	A	A	A	S	S							S	S	S	S	A	S	S			A	A	S	S	S	S	S	S	S
WTDK																															
WTDL					A	A	A	A	A	A	A	A	A	A	A	A	A	A						A	A	A	A	A	A	A	A
WTDM			A	A	A	A	A	A	A	A	A	S																	A	A	A
WTDO	A	A	A																						A	A				A	A
WTEB	A	A	A	A	A	A	S	S	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEC																															
WTEE				A	A	A	A	A	A	A	A	S	A	A	A	A	A	A	A	A	S										
WTEF																															
WTEJ				A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEO	A	A	A	A	A	A	A	S											A					A	A	A	A	A	A	A	A
WTEP	A	A	A	A	A	A	A										S	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTER	A	A	A	A	A	A	A	S					A	A	A	A	A	A	A	A	A		A	A	A	A	S				
WTEU	A	A	A	A	A	A	A	A	A		S	S	S	A	A	A	A	A	A	S	S										
WTEY	A	A	A	A	S	S	S	A	A	A	A	A	A	A	A	A	A	A	A	S			S								
WXAQ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

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	
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
KCEJ	A	A	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
KNBD										A	A	A	A	A	A	A	A					A	A	A	A	A	A	A	A	A	
NEPP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
NRUO																															
VLHJ	P	P	P	P	P							S			S	P					S										
VNAA																															
WBP3210															S	S															
WCX7445					S	S							S	S	S	S	S	S	S			S	S	S		S	S	S	S	S	
WDA7827	P	S	S	S	S	S						S	S	P	P	S	S	S	S	S	S	S	S				P	P	S	S	
WDC9417							S	P	P	P							S	S	S	S	S					P	P		S	P	
WTDF							A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A				A	A	A		
WTDH	S	S	S	S	S																										
WTDK																															
WTDL	A									A	A	A	A	A	A	A								A	A	A	A	A	A	A	
WTDM	A	A	A			A	A	A	A	A	A	A	A	A	A	A	A	A	A			A	A	A	A	A	A	A	A	A	
WTDO	A	A	A	A	A	A	A	A	A				A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			
WTEB	A	A	A	A	A	A	A	A	A					A	A	A	A	A	A	A		A	A	A	A	A	A	A	A	A	
WTEC																															
WTEE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
WTEF																															
WTEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		A	A					
WTEO	A	A	A	A	A	A	A	A	A	A					A	A	A	A	A	A	A	A	A	A	A	A					
WTEP	A	A	A				A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
WTER				A	A	A	A	A	A					A	A	A	A	A	A	A	A	A	A	A	S			A	A	A	
WTEU	S	S	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
WTEY				A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
WXAQ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	

(Figure 2: cont'd)

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
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KCEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
KNBD	A	A	A								A	A	A	A	A	A	A	A	A	A	A										
NEPP	A	A	A	A	A	A	A	A	A	A	A	S																			
NRUO																															
VLHJ					S	P	P	P	P	P	P	P	P											S	S						
VNAA													P	S	S	S	P	S	S	P											
WBP3210																							S	S	A	A	A	A	S	A	A
WCX7445	S					S	S	S	S	S	S	S				S	S	S	S	S						A	A	A	A	A	A
WDA7827	P	S	S	S	S	S	P	P	S	S	S	S	S	S			S														
WDC9417			P	P						P							P														
WTDF		A	A	A	A	A						A	A	A			A	A	A	A	A					A	A	A	A	A	A
WTDH																			A	A	A	A	A	A	A	A	A	A			
WTDK																															
WTDL	A	A										A	A	A	A	A	A	A		A	A	A	A	A	A	A	A	A			
WTDM	A	A	A	A	A	A	A	A	A	A	A	A	A																		
WTDO							A	A	A	A	A	A	A	A	A	A	A	A			A	A	A	A	A	A	A	A	A	A	A
WTEB	A	A	A	A			A	A	A	A	A	A	A	A	A	A	A	A													
WTEC																		A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEE					A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			
WTEF																															
WTEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A				
WTEO						A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A					
WTEP					A	A	A	A	A	A	A	A	A																		
WTER	A	A	A	A	A	A	A	A					A	A	A	A	A	A	A	A	A	A									
WTEU					A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WTEY	A							A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WXAQ		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

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	
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
KCEJ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	A	
KNBD																															
NEPP																															
NRUO																															
VLHJ	P							P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
VNAA																															
WBP3210	A	A	A	A	S	A	A	A	A	A	A	A	A	A	S											S	A	A	A	A	
WCX7445	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
WDA7827																						P									
WDC9417				P					P	S			S	P	P							P		S	S			P	P		
WTDF	A	A	A	A								A	A	A	A	A	A	A												A	
WTDH																															
WTDK																															
WTDL	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A											
WTDM																															
WTDO	A	A							A	A	A	A	A	A	A	A	A	A	A												
WTEB		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
WTEC	A	A	A						A	A	A	A	A	A	A	A	A	A	A	A	A	A						A	A	A	
WTEE																															
WTEF																															
WTEJ																														A	
WTEO					A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A									
WTEP																															
WTER																															
WTEU	A	A													A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
WTEY	A	A	A	A	A																										
WXAQ	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	

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
KAQP	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A											
KCEJ	A	A	A	A	A	A	A	A	A	A	A					S	S	S	S												
KNBD																															
NEPP																															
NRUO																															
VLHJ	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
VNAA																															
WBP3210	S	A	A	A	S	A	A	A	S	A	A	S	S	S	A	A	A	A	A	A	S	A	A	A	A	S	A	A	A	A	S
WCX7445	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
WDA7827																															
WDC9417	S	P			P						S	P	P	S					S	P											
WTDF	A	A	A						A	A	A	A																			
WTDH																															
WTDK																															
WTDL	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A												
WTDM																															
WTDO																															
WTEB	A	A	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A												
WTEC	A	A	A		A	A		A	A	A	A	A		A	A	A	A	A	A												
WTEE																															
WTEF																															
WTEJ	A	A	A	A	A	A	A	A	A	A		A		A	A	A															
WTEO																															
WTEP																															
WTER																															
WTEU	A	A	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A												
WTEY																															
WXAQ	A	A	A	A	A																					A	A	A	A	A	A

(Figure 2: cont'd)

b. Spatial coverage

Geographically, SAMOS data for 2010 is fairly comprehensive. Cruise coverage for the January 1, 2010 to December 31, 2010 period (Figure 3) includes occurrences poleward of both the Arctic (*Fairweather*, *Healy*, and *Polar Sea*) and Antarctic (*Aurora Australis, Palmer,* and *Gould*) circles, additional exposure in Alaskan waters (*Oscar Dyson*, *Miller Freeman*, and *McArthur II*), a few occurrences off Cape Horn, Africa (*Knorr* and *Ron Brown*), and a sizable area in the South Pacific (*Southern Surveyor*). The *Knorr* also provided data from the Labrador Sea region and waters north. Natively, the western coastal United States is well-covered by the *Atlantis* and *Miller Freeman*, among others, and the eastern coastal United States is comparably covered by the *Delaware II* and *Henry Bigelow*, among others. *Nancy Foster* rounds the southeast coastline from Louisiana to the Carolinas, while the northern Gulf of Mexico is virtually covered by the *Gordon Gunter* and *Pisces*. Following the Deepwater Horizon oil spill, a number of NOAA vessels were assigned to the Gulf of Mexico (outside of their normal operating regions), resulting in a notable increase in data coverage over the latter half of 2010. Hawai'ian waters are well-sampled by the *Oscar Elton Sette*, the *Okeanos Explorer*, the *Kilo Moana,* and the *McArthur,* as well as the *Ka'imimoana* and *Hi'ialakai*, both of which routinely cruise to the Hawai'ian waters from their home port in Seattle.

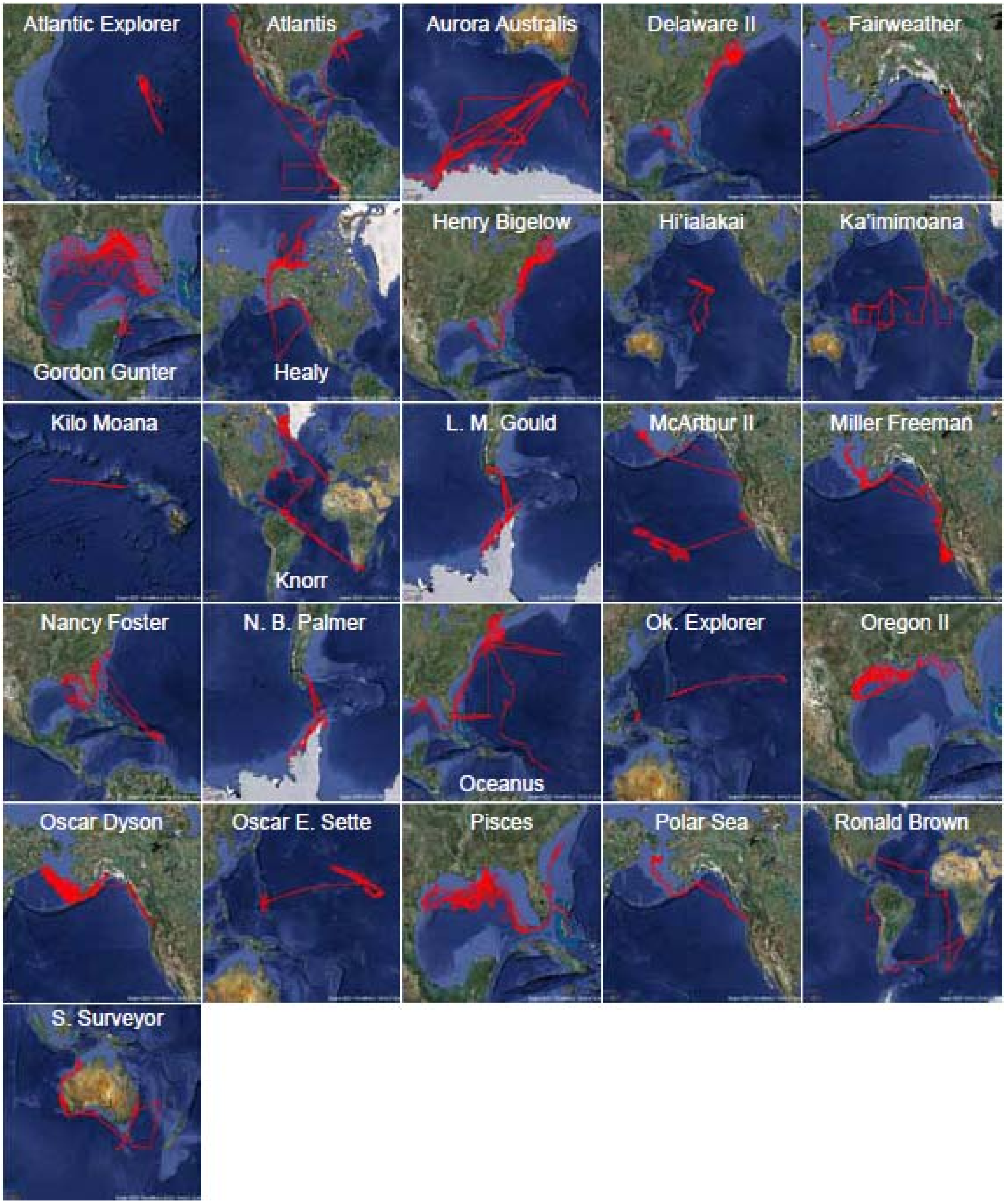


Figure 3: Cruise maps plotted for each vessel in 2010.

c. Available parameter coverage

The core meteorological parameters – earth relative wind speed and direction, atmospheric pressure, and air temperature and relative humidity – and the oceanographic parameter sea temperature are reported by all ships. Many SAMOS vessels also report precipitation accumulation, rain rate, longwave, shortwave, net, and photosynthetically active radiations, along with sea water conductivity and salinity. A quick glance at Table 3 (located in Section 4) shows which parameters are reported by each vessel: those boxes in columns 6 through 26 with an entry indicate a parameter was reported and processed in 2010. (Further detail on Table 3 is discussed in Section 4.) Some vessels furnish redundant sensors, which can be extremely helpful for visually assessing data quality. Again referring to Table 3, those boxes in columns 6 through 26 with multiple entries indicate the number of redundant sensors reported and processed in 2010; 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 2. It should be noted that no secondary automated QC was active in 2010 (SASSI), so quality control flags U-Y were not in use. If a coded variable does not contain an integer pointer to the flag attribute it is assigned a "special value" (set equal to -8888). A special value may also be set for any overflow value that 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 don't necessarily imply a problem. The port flag is applied to indicate the vessel is in port and may be combined with flags on other parameters to note questionable data that are likely attributable to dockside structural interference or, as in the case of sea temperature, the fact that some apparatus are habitually turned off while a vessel is in port. 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 >20degrees 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 then 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.

Table 2: Definitions of SAMOS quality control flags

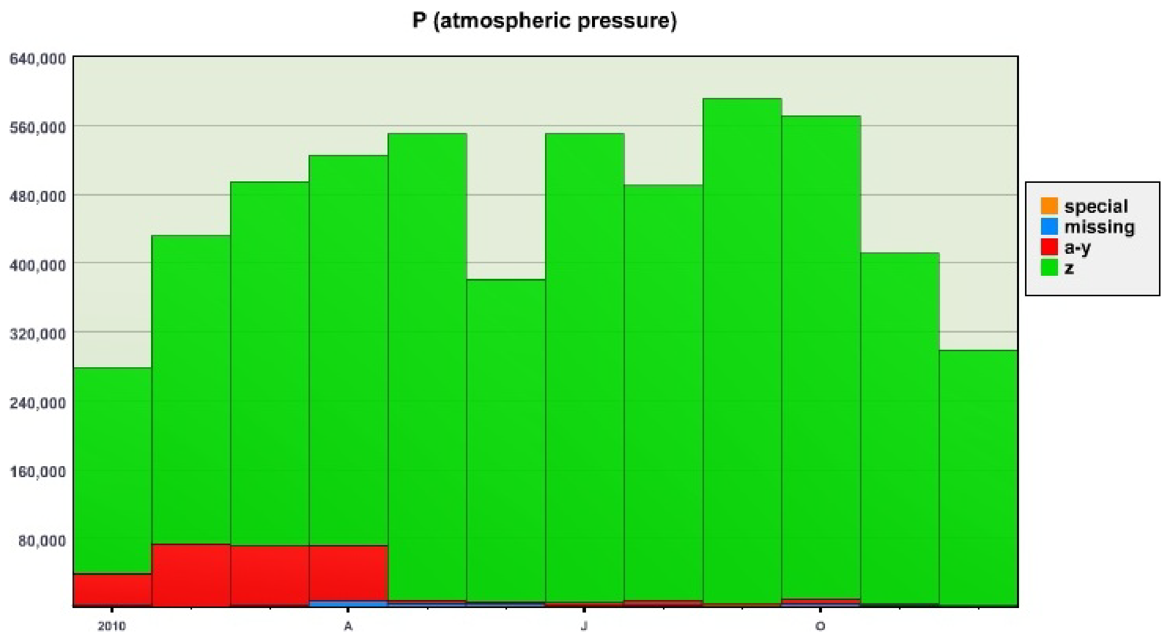
N	Signifies that the data were collected while the vessel was in port. Typically these data, though realistic, are significantly different from open ocean conditions.
O	Original units differ from those listed in the *original_units* variable attribute. See quality control report for details.
P	Position of platform or its movement are 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 occur 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 2: cont'd)

b. 2010 quality across-system

This section presents the overall quality from the system of ships providing observations to the SAMOS data center in 2010. 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 good, overall (Figure 4), with the exception of P during the period from January through April. This was due mostly to *Okeanos Explorer*, whose pressure sensor was problematic and thus always flagged until it was finally fixed in May (see discussion in *Okeanos Explorer* section of 3c). 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. In Figure 5, obvious steps in the pressure data occur when the platform speed increases onboard the *Miller Freeman*. Each of these incidences will result in the application of either caution/suspect (K) or poor quality (J) flags. Two vessels, *Okeanos Explorer* and *Hi'ialakai* received a large quantity of K, J, and out of bounds (B) flags due to habitual readings that were out of range for the region of operation (see individual vessel descriptions in section 3c for details).



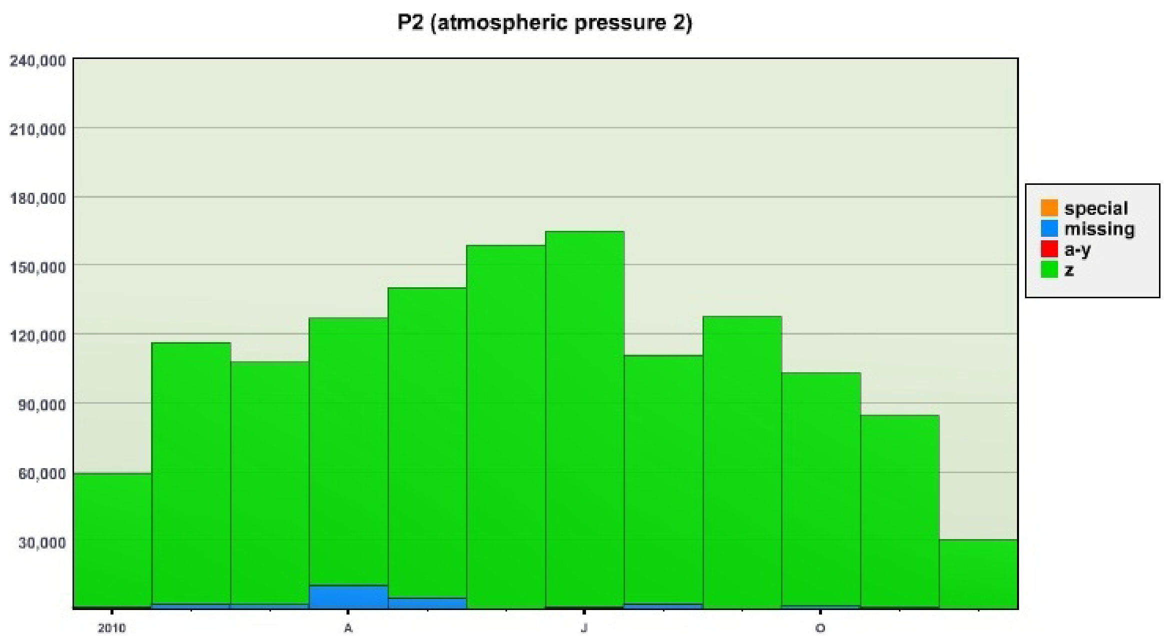
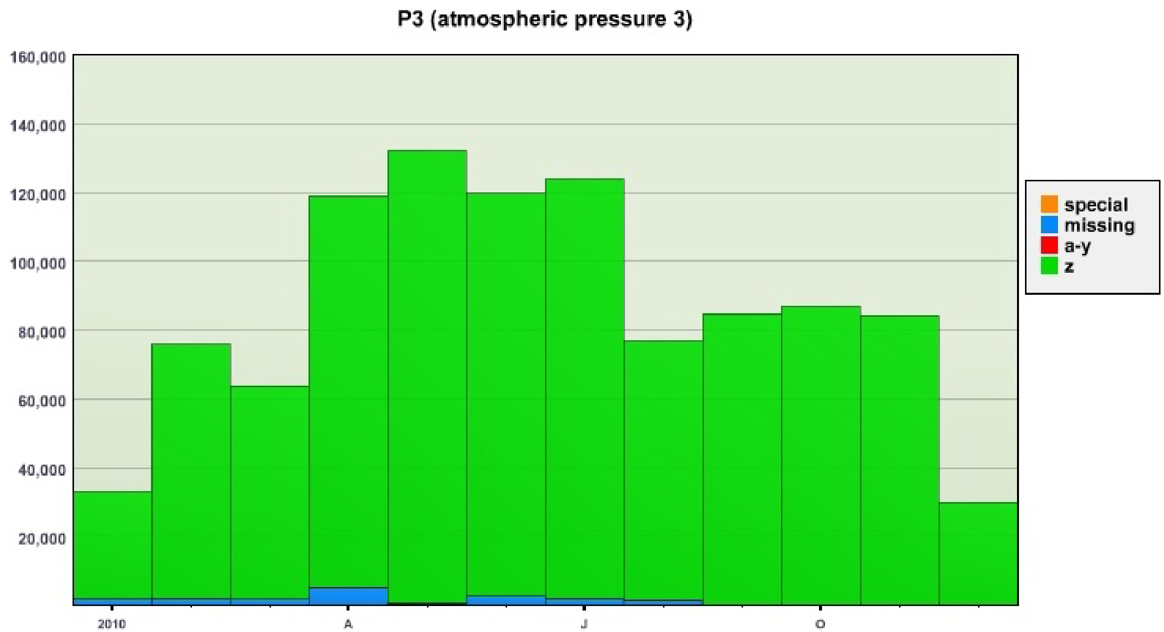


Figure 4: Total number of (top) atmospheric pressure – P – (bottom) atmospheric pressure 2 – P2 – and (next page) atmospheric pressure 3 – P3 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS 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)

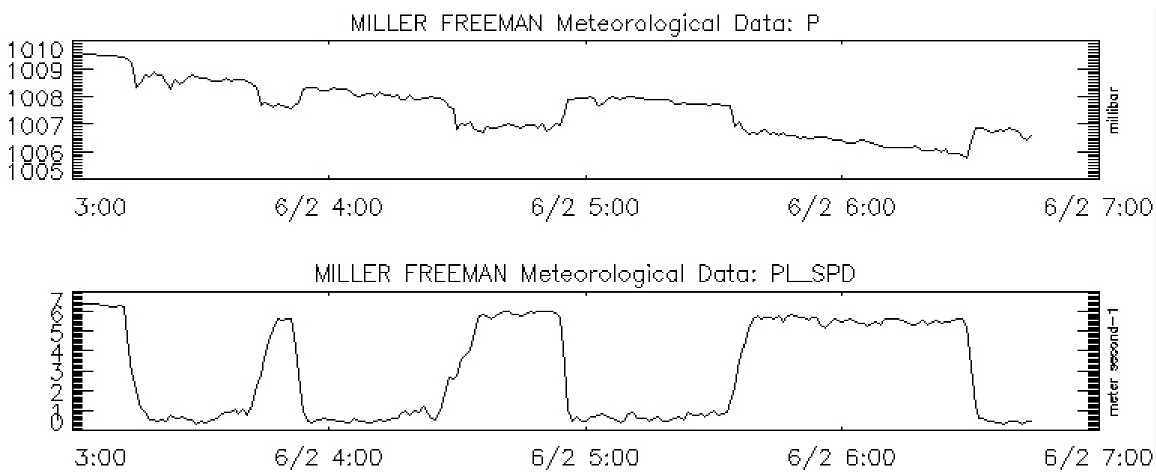
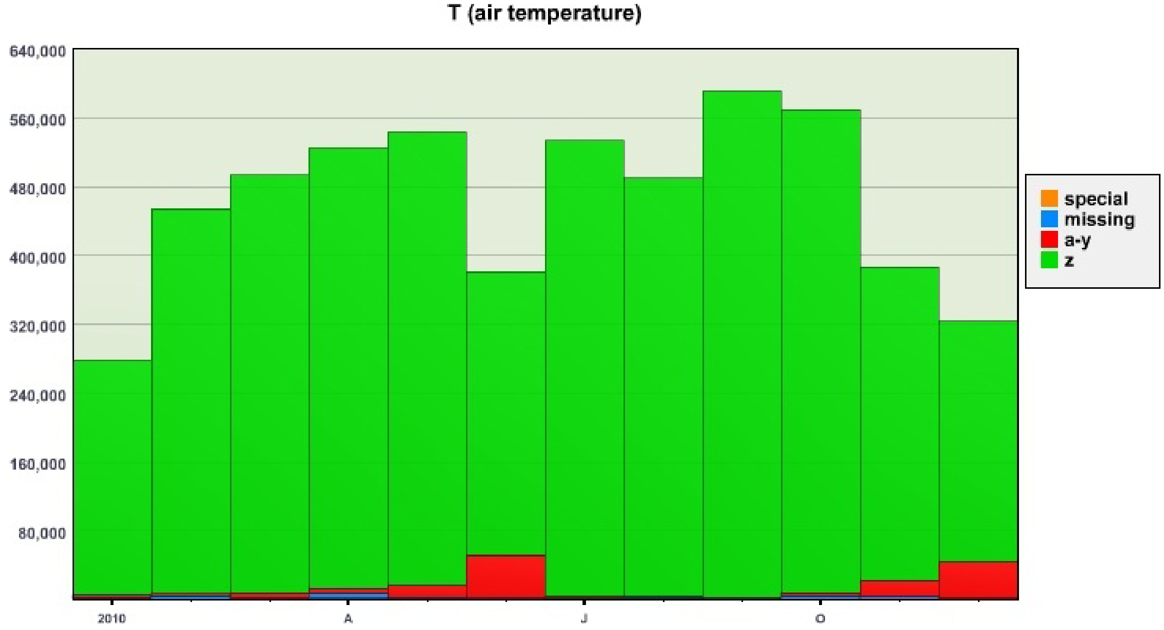


Figure 5: *Miller Freeman* SAMOS data for 2 June 2010; from top: atmospheric pressure – P – and platform speed – PL_SPD.

Air temperature was also of decent quality (Figure 6). However, a slight increase of flagging of T in June is likely due to a 3-day T sensor failure onboard the *Gould*. Similarly, a slight increase of flagging of T in December is likely due to a T sensor failure onboard the *Fairweather* that persisted for about a month. With the air temperature sensors, again flow obstruction was 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. Deck heating 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. Each of these incidences will result in the application of either caution/suspect

(K) or poor quality (J) flags. 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.



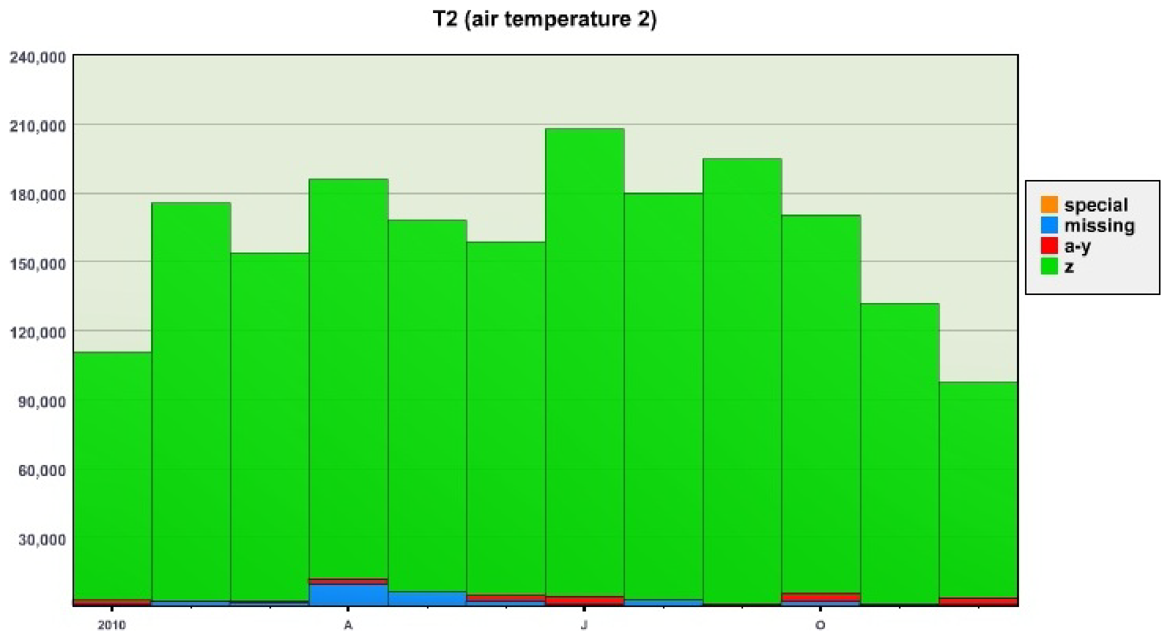
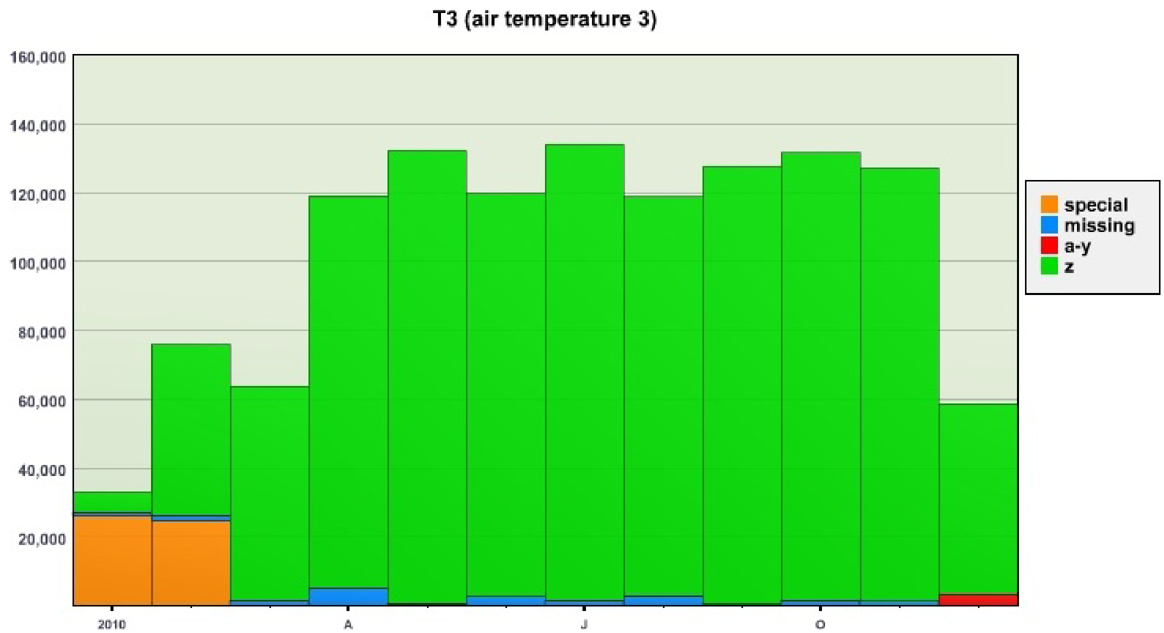
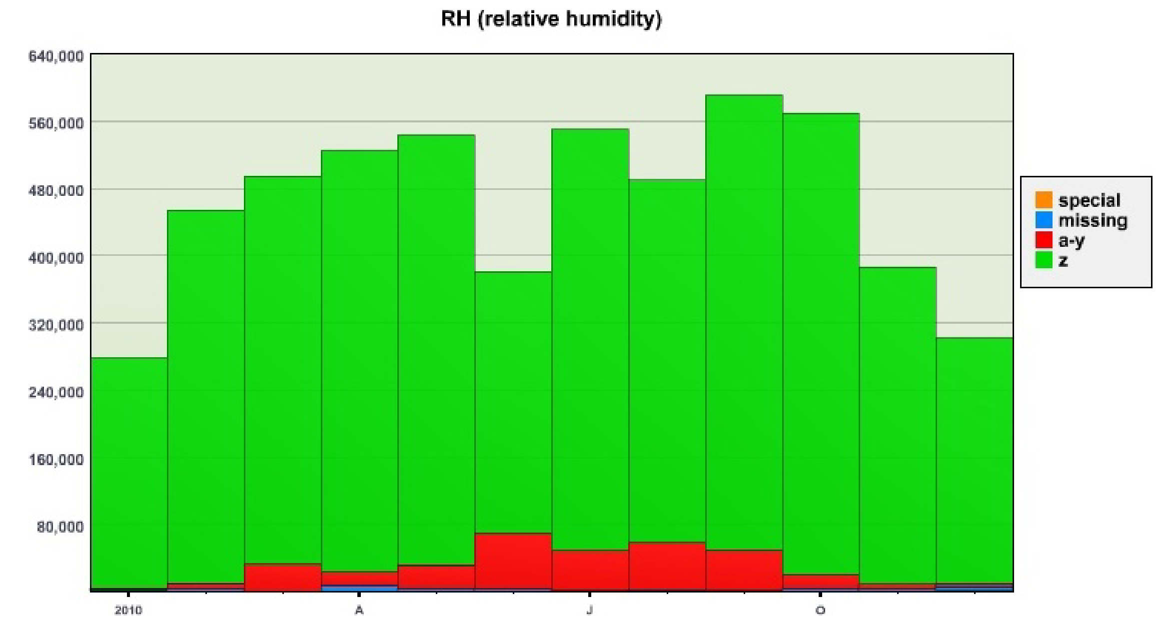


Figure 6: Total number of (top) air temperature – T – (bottom) air temperature 2 – T2 – and (next page) air temperature 3 – T3 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 6: cont'd).

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 7. It is interesting to note in Figure 7, as in other similar Figures, what appears to be a seasonal component to relative humidity performance (in this case the A-Y flag tallies applied to RH appear to peak from June through September). The authors suggest that on the whole it would actually be risky to draw any conclusions of seasonality where sensor performance is concerned, except perhaps in extreme climates where for example sustained periods of icing might occur. Rather, this likely arises due to ship scheduling, whereby a number of certain vessels whose sensors are particularly problematic routinely perform the bulk of their operations over the period in question. Of special note, this misidentified "seasonality" is far more drawn out than it appeared in 2009, when it appeared to peak quite sharply in July, August, and September, lending strength to the argument that this is not likely to be actual seasonality.



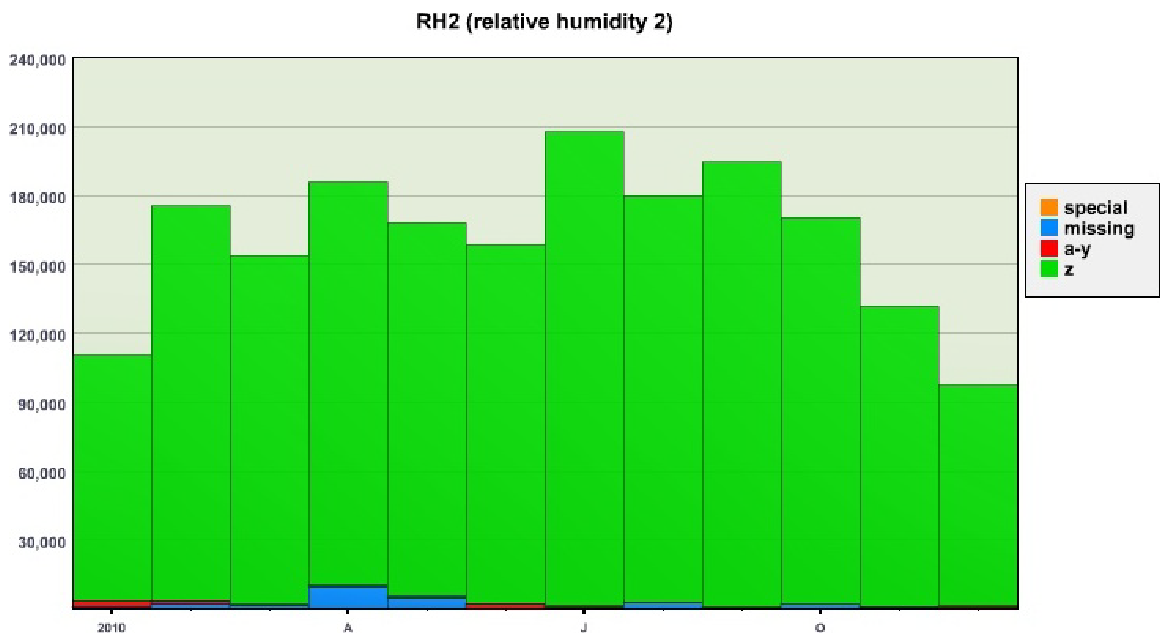
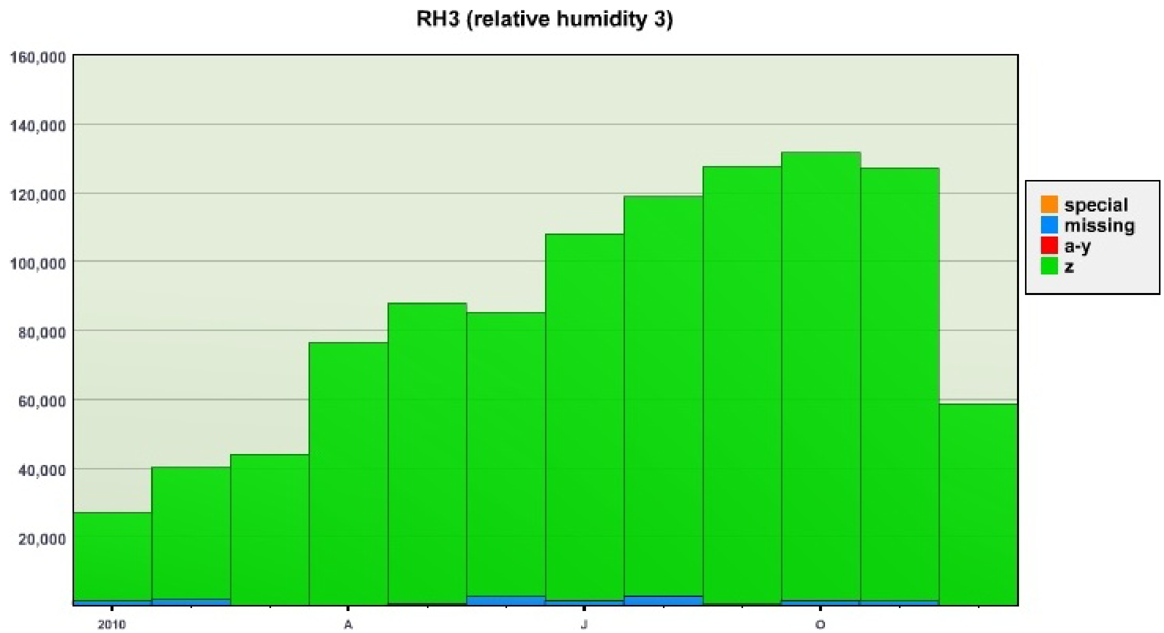


Figure 7: Total number of (top) relative humidity – RH – (bottom) relative humidity 2 – RH2 – and (next page) relative humidity 3 – RH3 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 7: cont'd)

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-atmospheric circulation. 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 readily incorporated into wind measurements. These flow-obstructed and platform speed-affected wind data were the most common problems across SAMOS vessels in 2010.

The overall quality of the 2010 SAMOS wind data was nonetheless good, as shown in Figures 8 (earth relative wind direction) and 9 (earth relative wind speed). In SAMOS visual quality control, compromised wind data is addressed with caution/suspect (K), visual spike (S), and sometimes poor quality (J) flags. 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 suggestions can be made as to improved sensor locations. Another diagnostic tool available to SAMOS data analysts is a polar plotting routine, which can look at a single variable and identify the ratio of flagged observations to total observations in one degree (platform relative wind direction) bins. In this way, platform relative wind bands that interfere with sensor readings may be identified. For example, the polar plot for the *Okeanos Explorer*'s earth relative wind speed (SPD) data for all of 2010 is shown in Figure 10. A pink line on the plot indicates that the ratio of flagged SPD data to total SPD data in that one degree (platform relative wind direction) bin equals or exceeds 7.5%, the threshold chosen to indicate a potential problem. Where several of these lines are clustered together, it is a good indication that flow obstruction is occurring. In Figure10 there is a noticeable cluster of pink lines near 90°. Looking at digital imagery of the *Explorer* (Figure 11), the possible culprits are the multiple instruments seated just behind and to the right of the SCS Wind bird, which may be disrupting the flow to the Wind bird. Currently the polar plot program is configured to accept air temperature, humidity, and true wind speed and direction data with corresponding platform relative wind data. The polar plotting program is not currently in regular use by SAMOS data analysts because it is a time consuming process and the routines need more tuning, but its attributes could be improved and its benefits further explored in the future.

The other major problem with earth relative wind data is errors caused by changes in platform speed. Figure 12 shows the spikes that can occur in SPD when the platform speed changes, while Figure 13 shows spikes in earth relative wind direction (DIR) caused by platform speed changes. Occasionally, a wind direction sensor is also suspected of being "off" by a number of degrees. Historically, SAMOS data analysts had access to global gridded wind data from the space-based QuikSCAT scatterometer with which to compare true wind speed and direction measurements. However, the QuikSCAT product terminated in late 2009 when the satellite failed in orbit. In general, if a technician suspects a wind direction bias it is critical they communicate that suspicion to SAMOS personnel, as otherwise the data analysts often will have no reliable means of discovering the problem themselves. Suspected wind direction biases are typically flagged with K flags, or J flags if the case is extreme and/or verifiable.

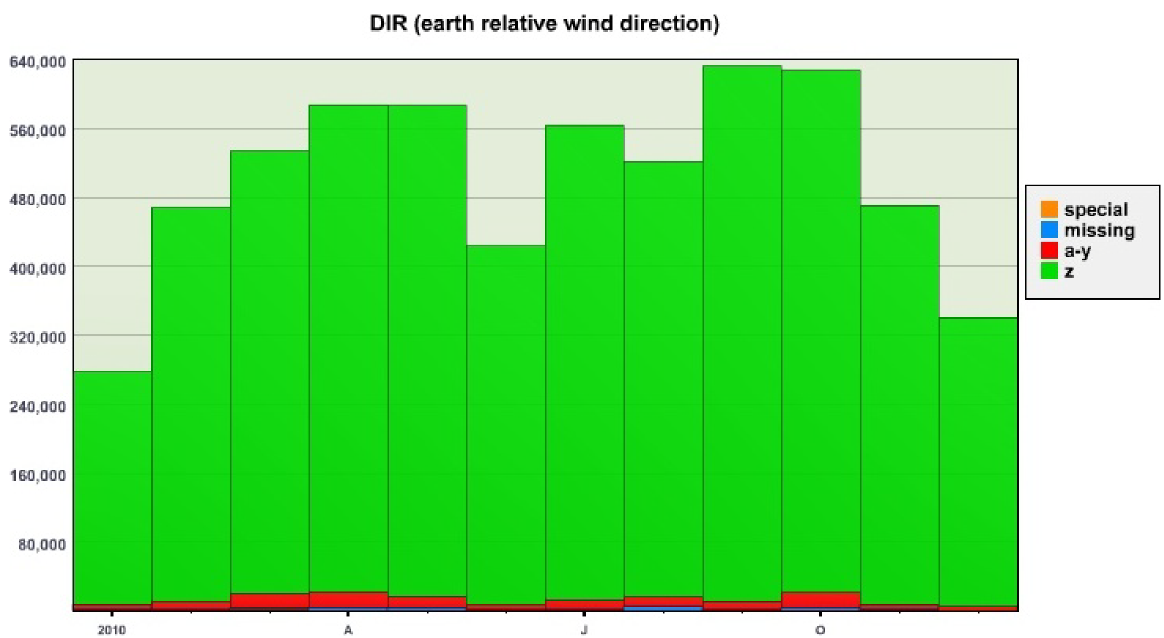
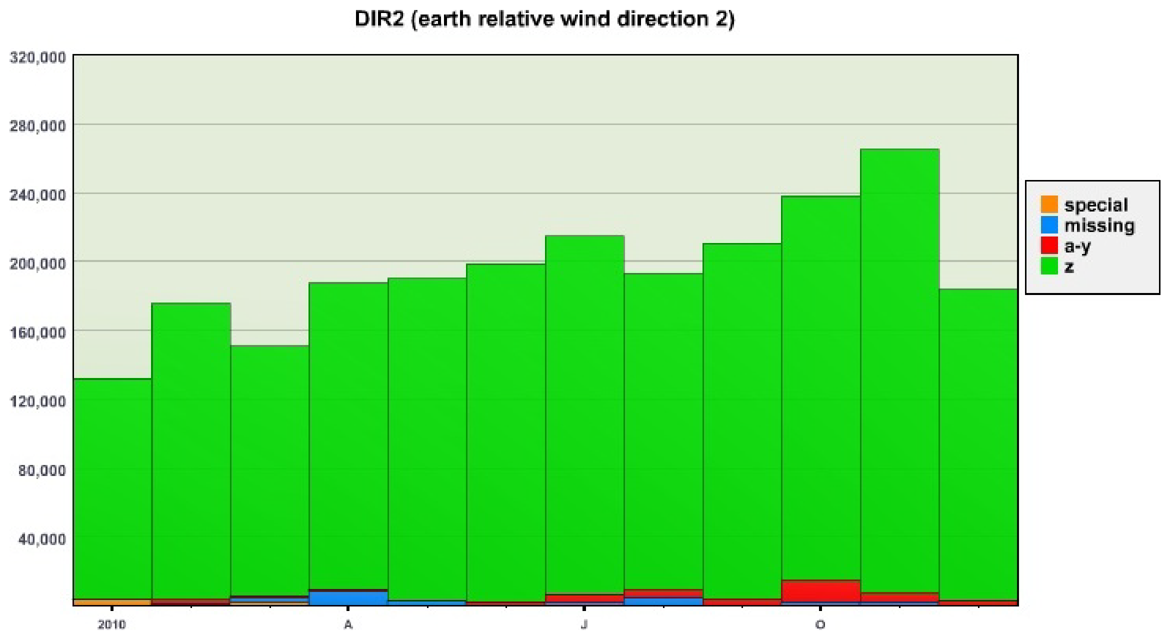
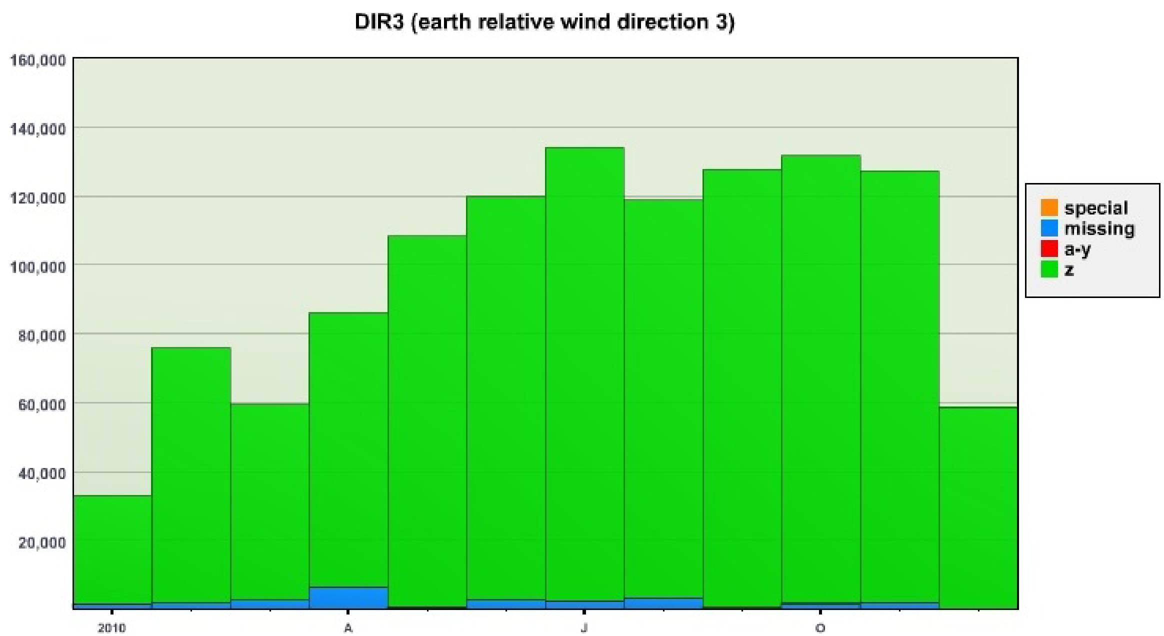
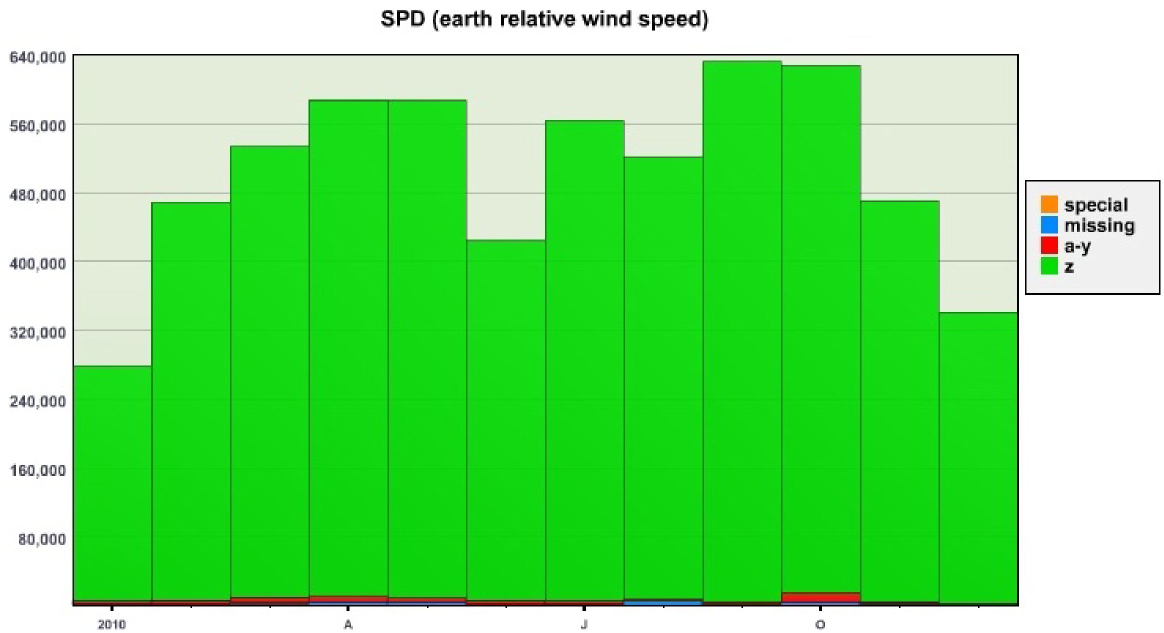


Figure 8: Total number of (this page) earth relative wind direction – DIR – (next page, top) earth relative wind direction 2 – DIR2 – and (next page, bottom) earth relative wind direction 3 – DIR3 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) 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)



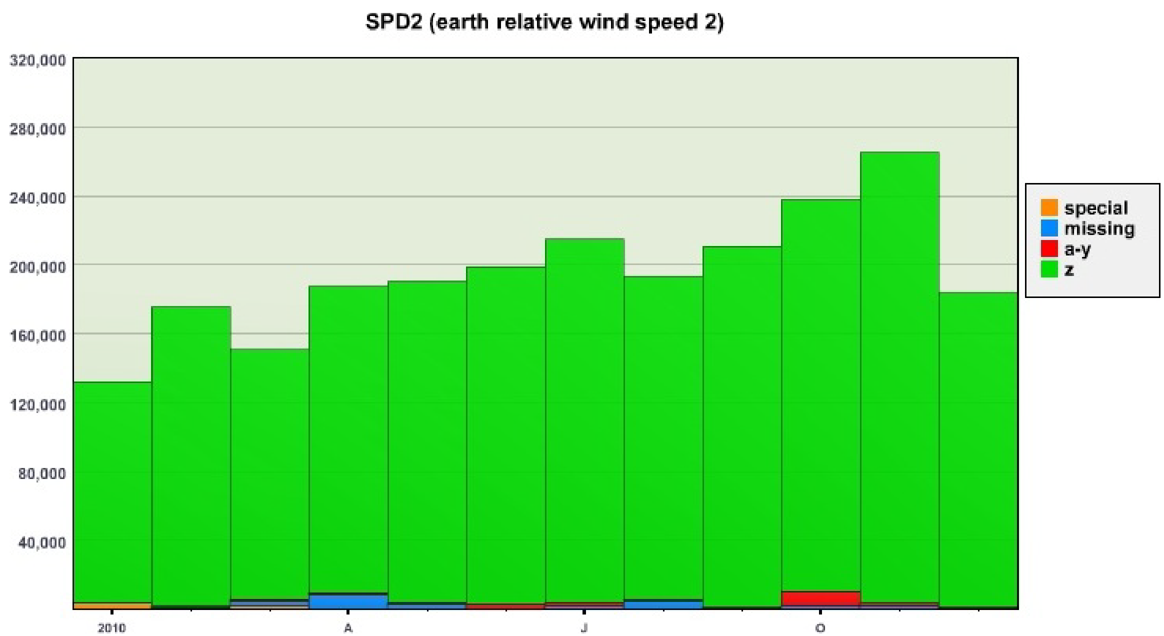
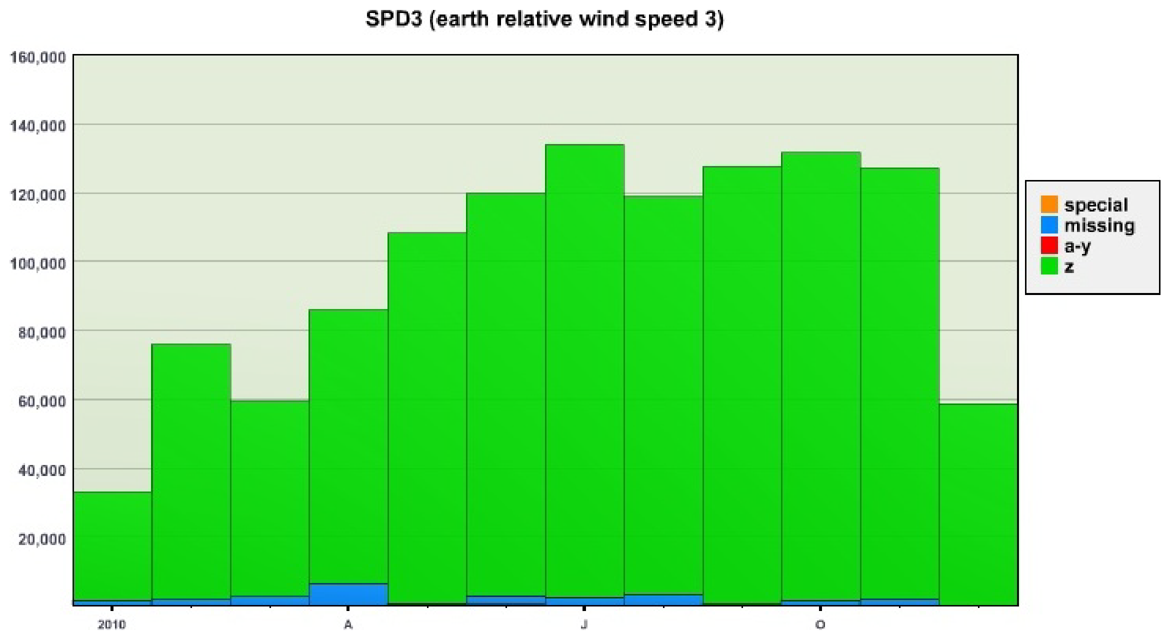


Figure 9: Total number of (top) earth relative wind speed – SPD – (bottom) earth relative wind speed 2 – SPD2 – and (next page) earth relative wind speed 3 – SPD3 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that 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)

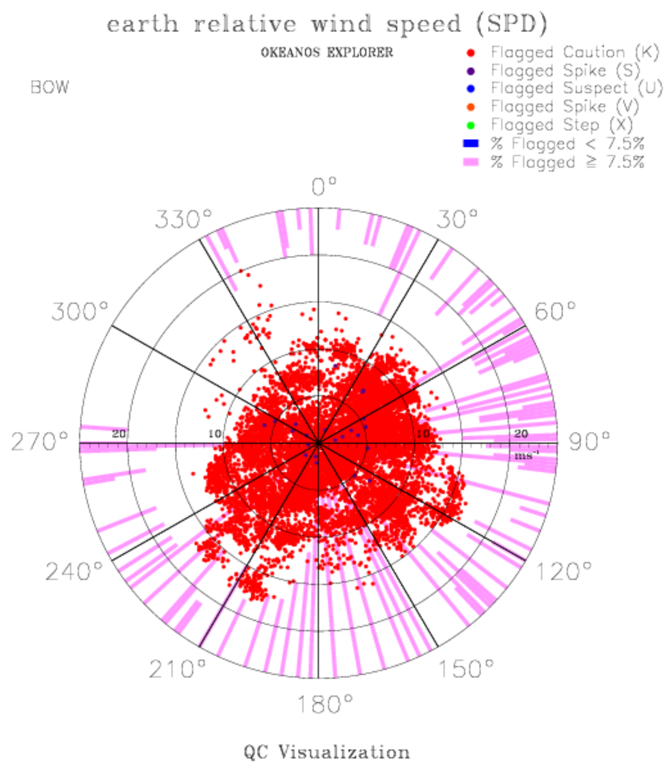


Figure 10: Polar plot of 2010 *Okeanos Explorer* earth relative wind speed – SPD – data. The existence of a pink line indicates the ratio of flagged SPD data to total SPD data in the corresponding one degree platform relative wind direction bin (designated around the perimeter) equals or exceeds 7.5%. Caution – K – flags (red dots) and spike – S – flags (purple dots) are plotted by ship relative wind speed and direction. (Note: Suspect – U – Spike – V – and Step – X – flags were not plotted in this example.)

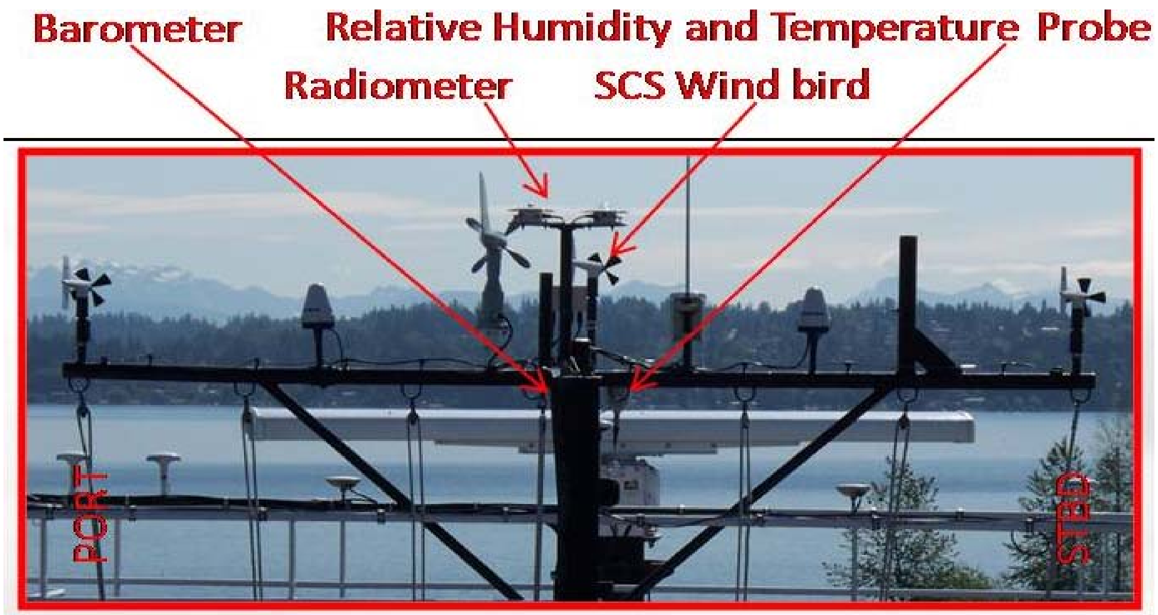


Figure 11: Digital imagery provided by *Okeanos Explorer* of their MET instrument mast.

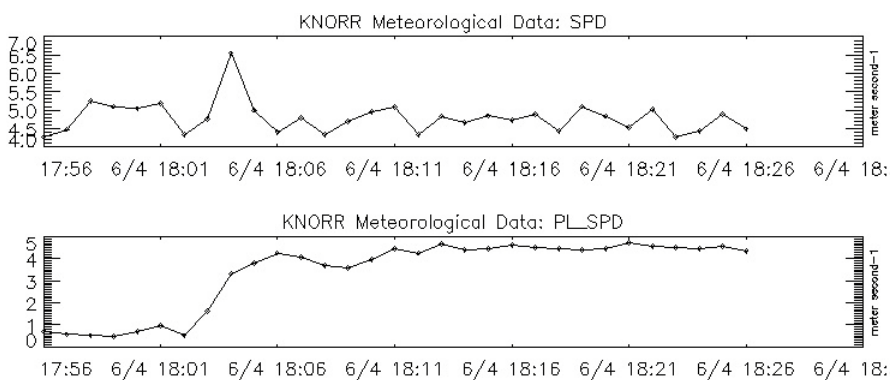


Figure 12: *R/V Knorr* SAMOS data for 4 June 2010; (top) earth relative wind speed – SPD – and (bottom) platform speed – PL_SPD. Note spike in SPD at moment of PL_SPD acceleration.

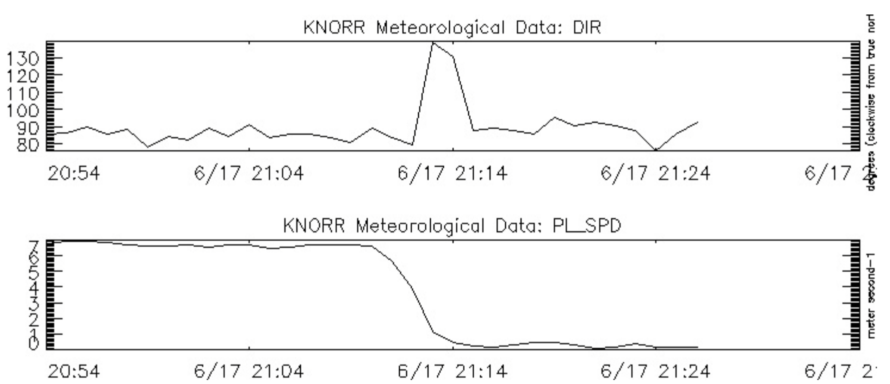


Figure 13: *R/V Knorr* SAMOS data for 17 June 2010; (top) earth relative wind direction – DIR – and (bottom) platform speed – PL_SPD. Note spike in DIR at moment of PL_SPD deceleration.

Most of the flags applied to the radiation parameters were assigned by the autoflagger, primarily to short wave radiation (Figure 14). 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, shortwave sensors are typically tuned to permit greater accuracy at large radiation values. Consequently, shortwave 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. Regarding long wave atmospheric radiation, the excessive flagging of RAD_LW and RAD_LW2 through April 2010 (Figure 15) was due primarily to erroneous data from the *Aurora Australis* (discussed in section 3c). Overall quality for photosynthetically active atmospheric radiation and net atmospheric radiation, on the other hand, appears quite good (Figures 16, and 17, respectively), although in June there were a number of special values assigned in the case of RAD_NET and RAD_NET2 (see preceding section a for details). The LW, PAR, and NET radiation sensors are also provided by a very limited subset of SAMOS vessels (Table 3).

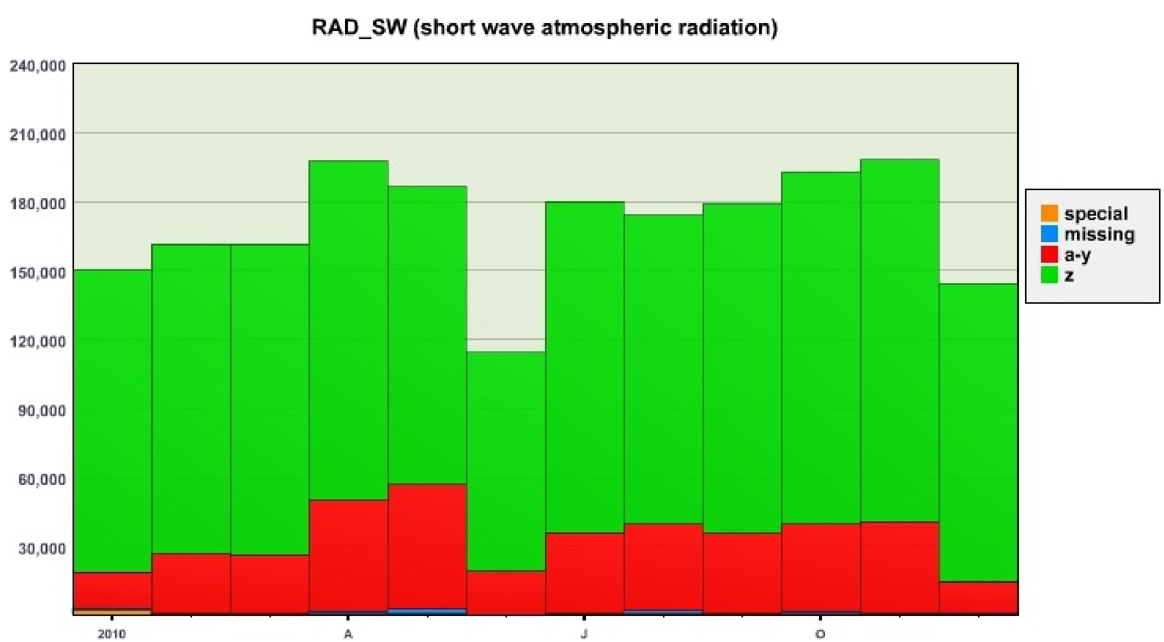
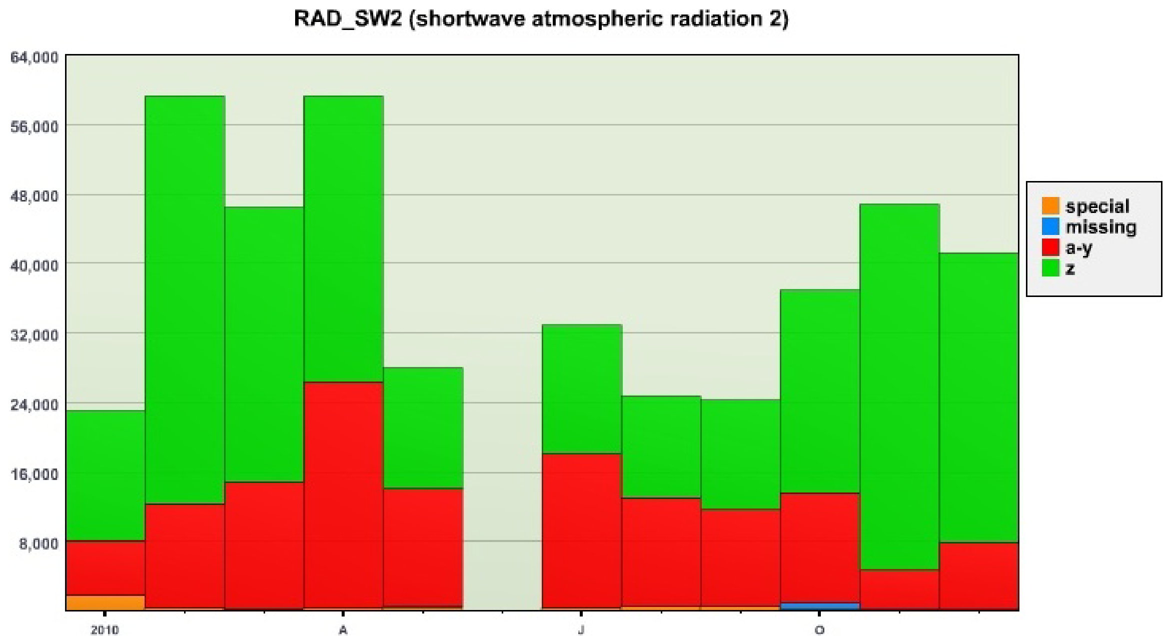


Figure 14: Total number of (this page) shortwave atmospheric radiation – RAD_SW – and (next page) shortwave atmospheric radiation 2 – RAD_SW2 –observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS 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)

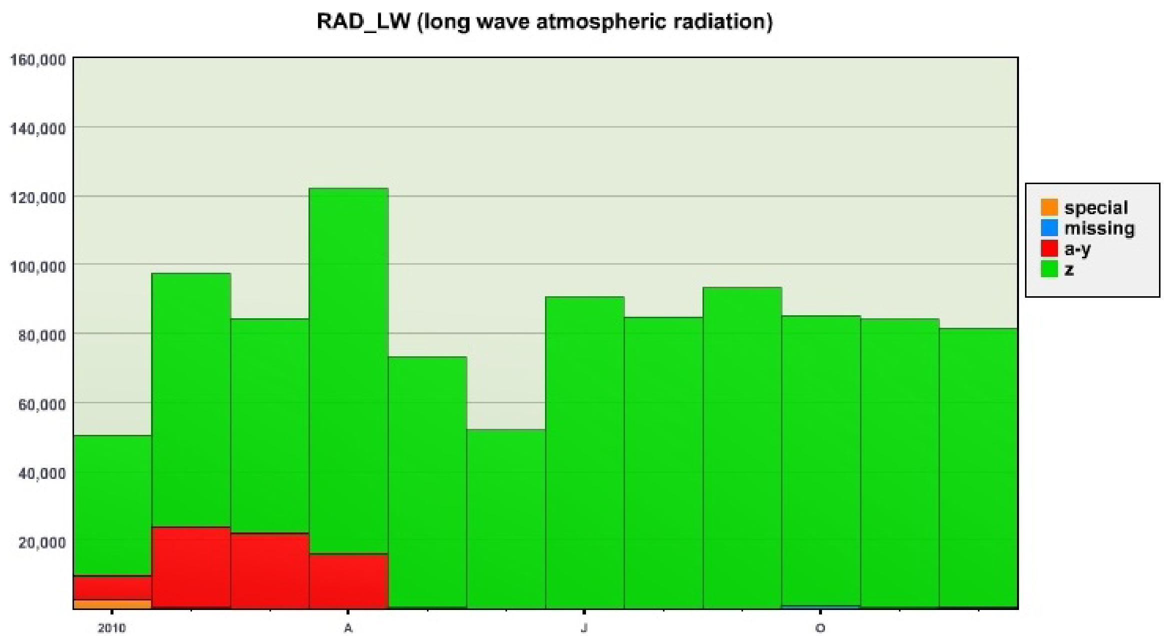
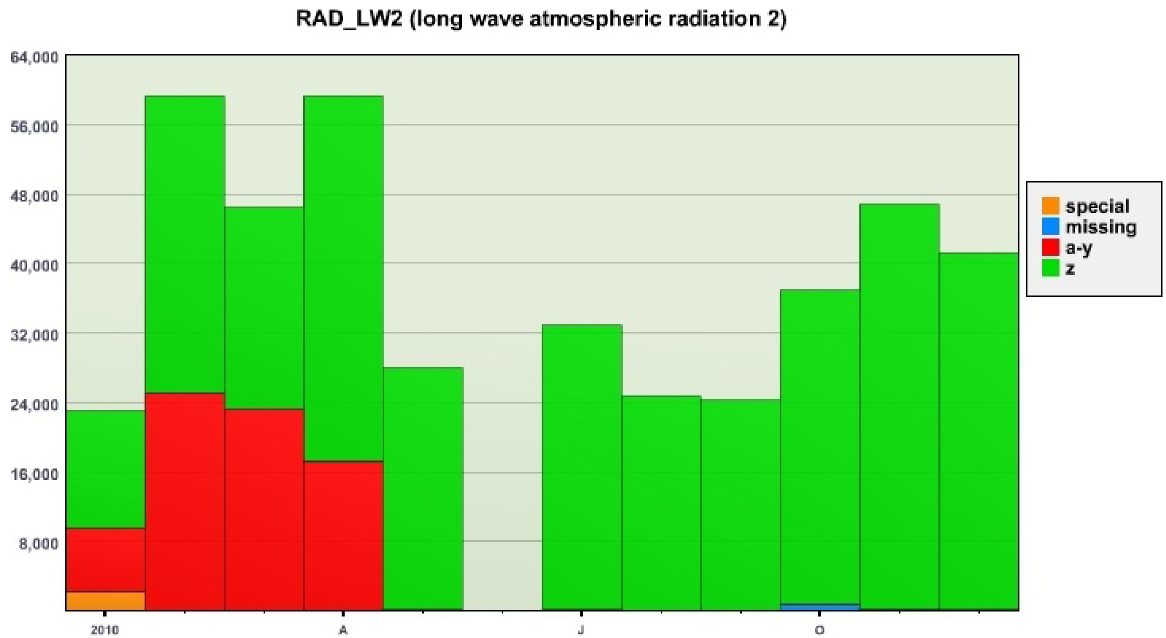


Figure 15: Total number of (this page) long wave atmospheric radiation – RAD_LW – and (next page) long wave atmospheric radiation 2 – RAD_LW2 –observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS 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)

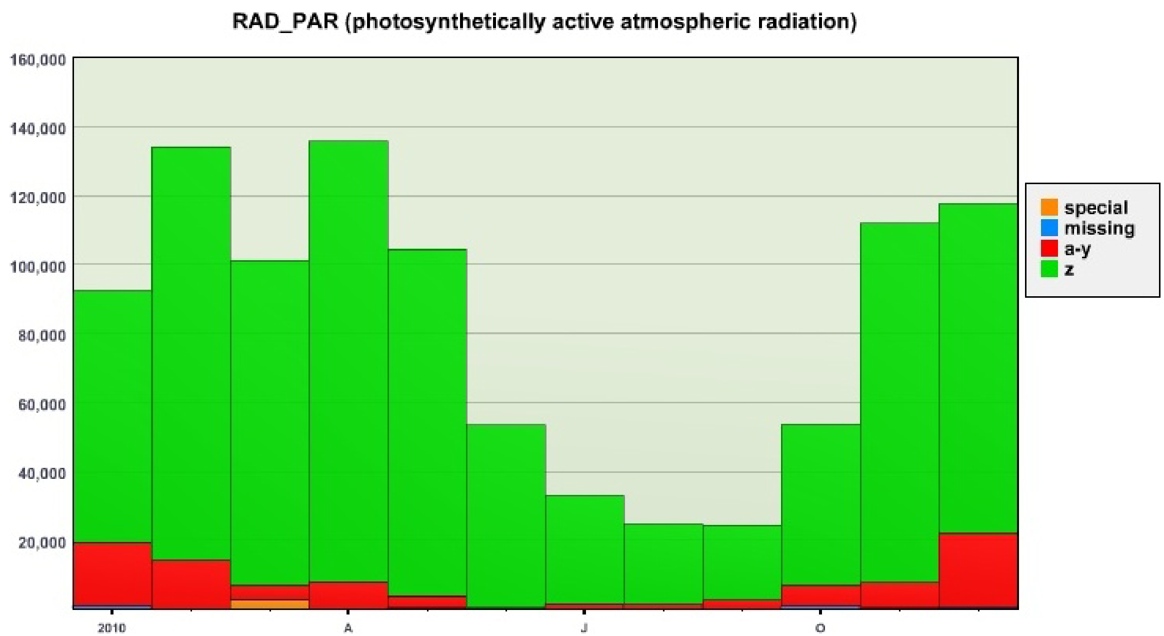
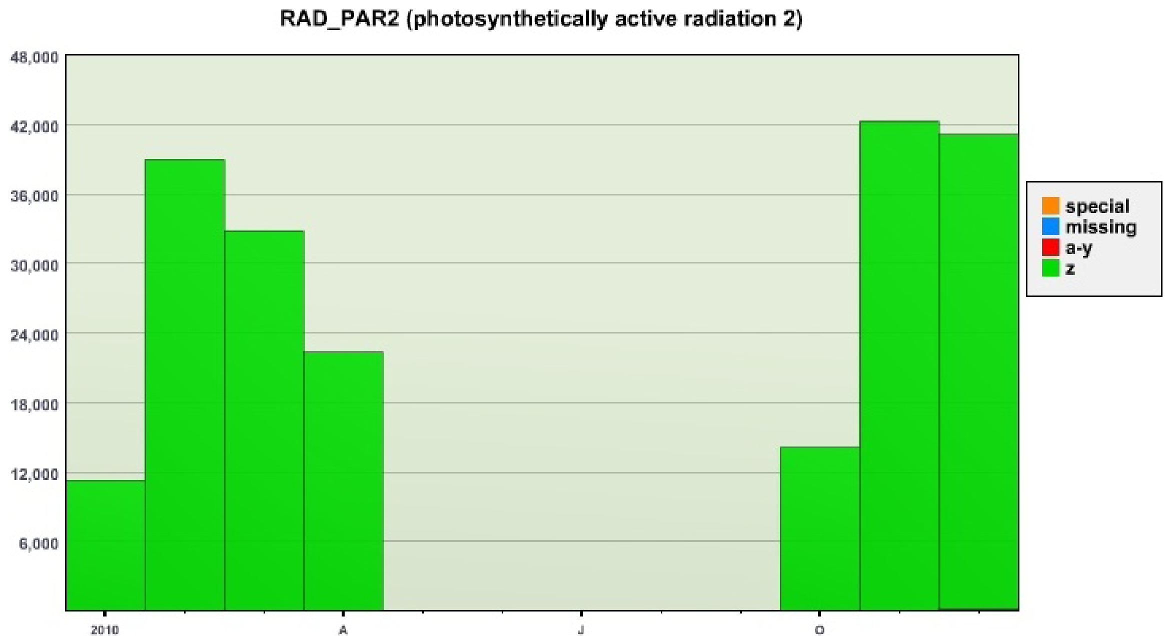


Figure 16: Total number of (this page) photosynthetically active atmospheric radiation – RAD_PAR – and (next page) photosynthetically active atmospheric radiation 2 – RAD_PAR2 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 16: cont'd)

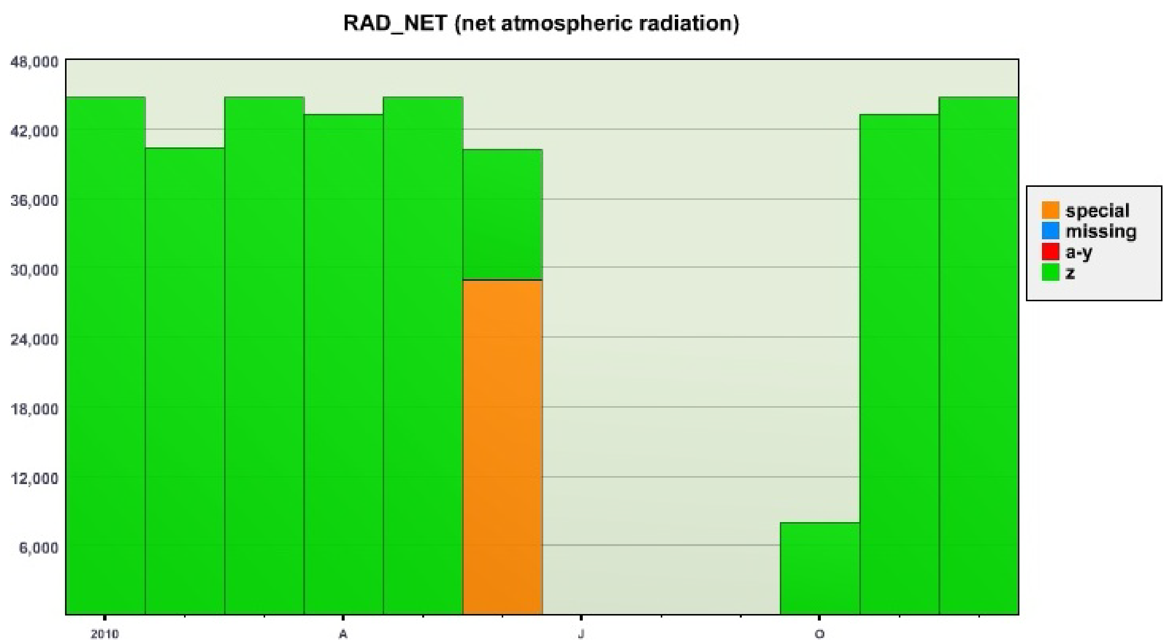
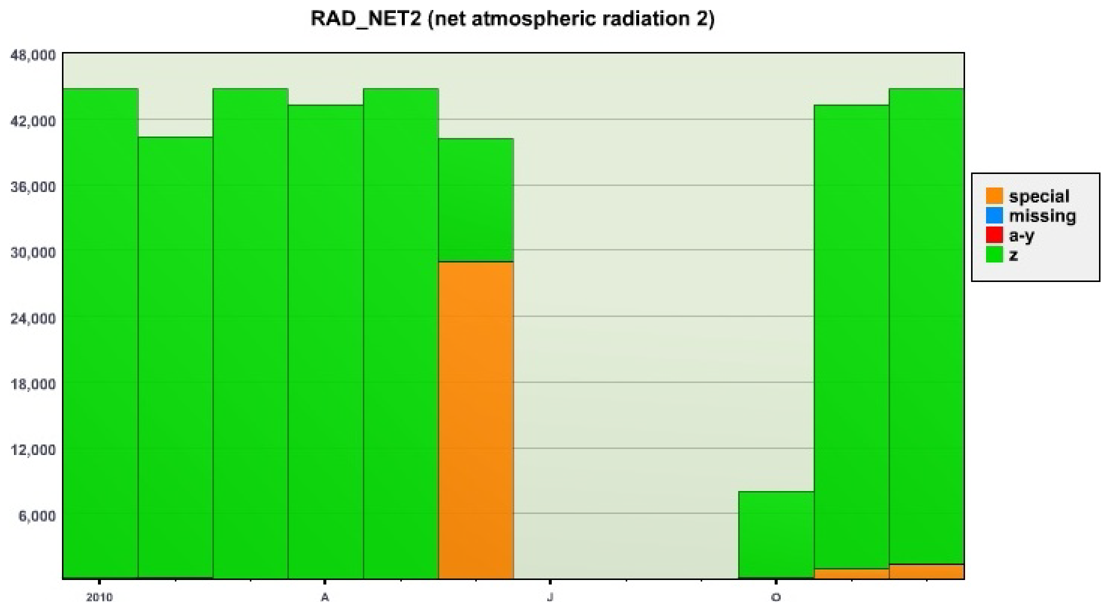


Figure 17: Total number of (this page) net atmospheric radiation – RAD_NET – and (next page) net atmospheric radiation 2 – RAD_NET2 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 17: cont'd)

There were no major problems of note with either the rain rate (Figure 18) or precipitation accumulation (Figure 19) parameters, although it should be noted that some accumulation sensors will occasionally exhibit slow leaks and/or evaporation. These data are not typically flagged; nevertheless, frequent emptying of precipitation accumulation sensors is always advisable.

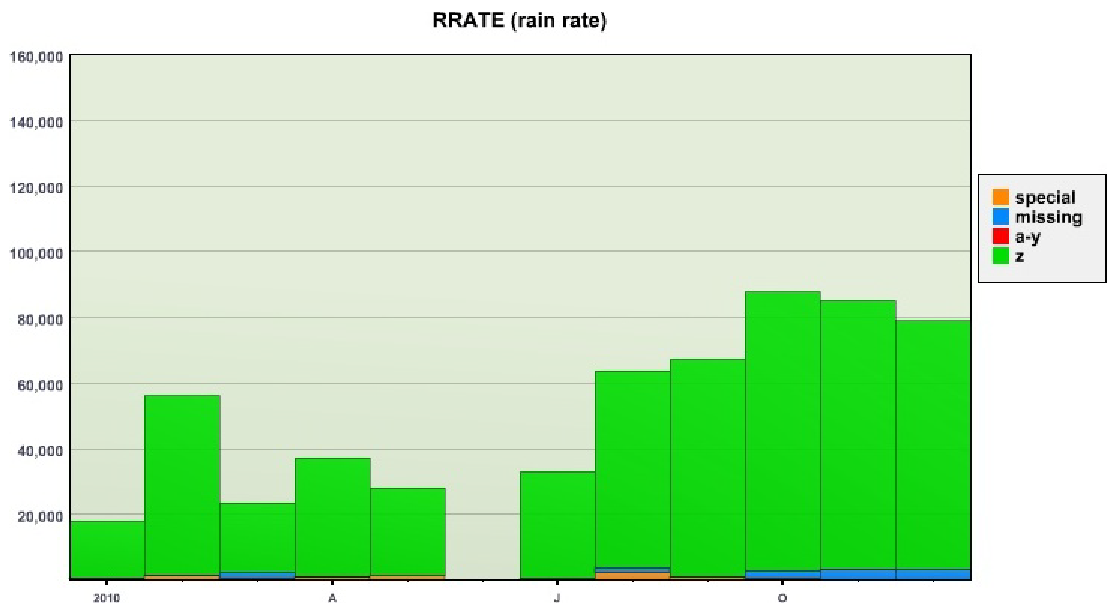
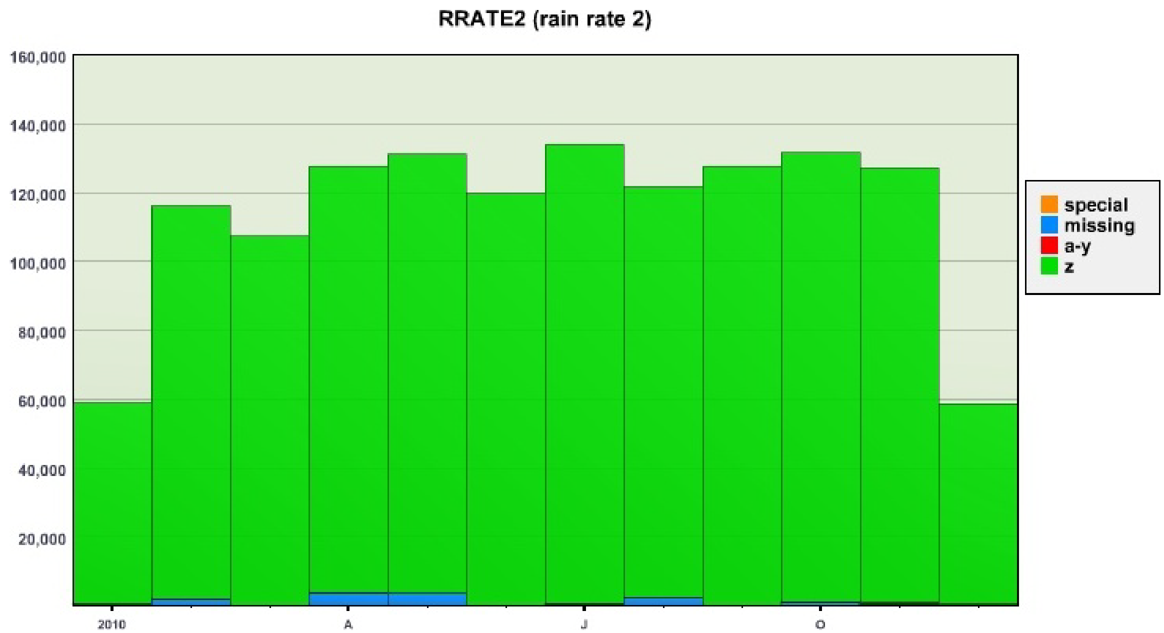
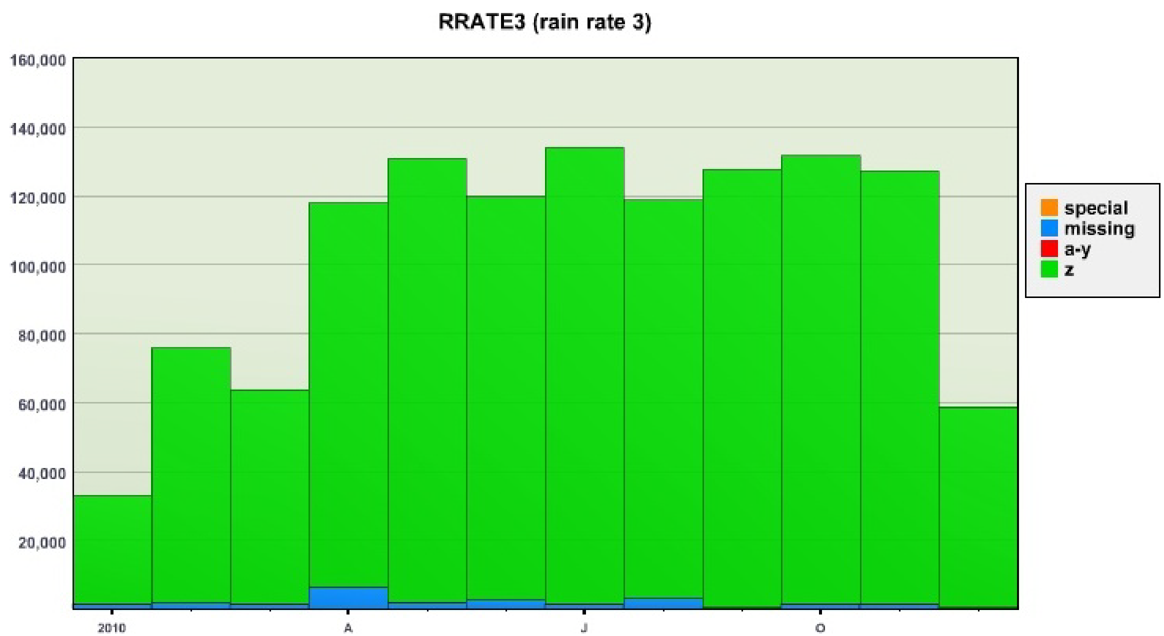
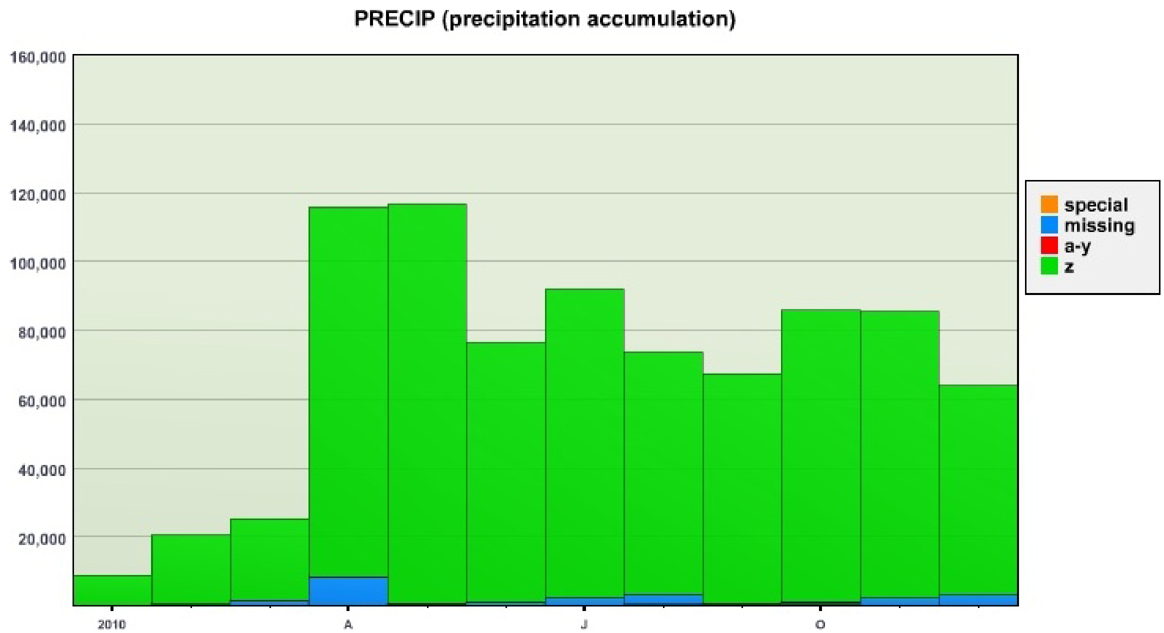


Figure 18: Same as Figure 17, except for (this page) rain rate –RRATE – (next page, top) rain rate 2 – RRATE2 – and (next page, bottom) rain rate 3 – RRATE3.





(Figure 18: cont'd)



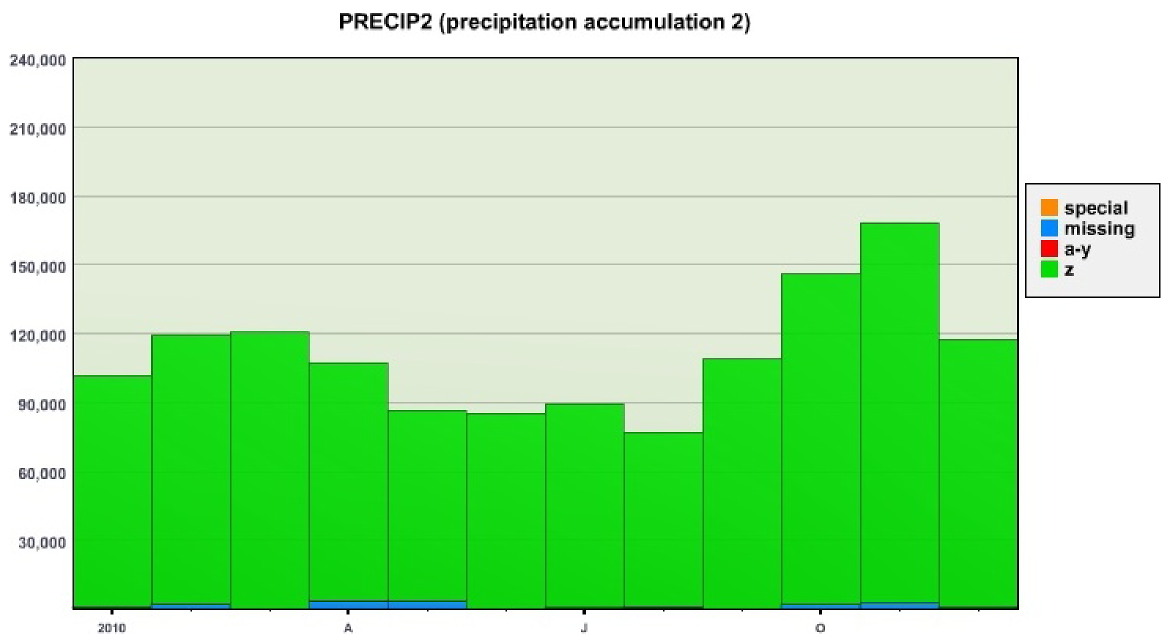
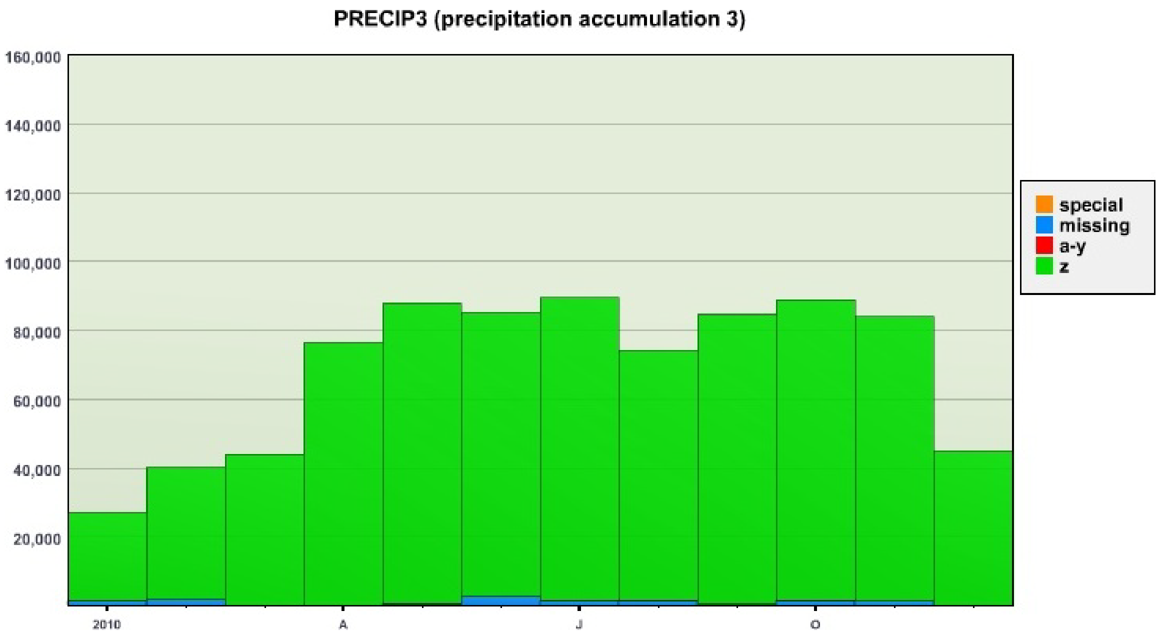
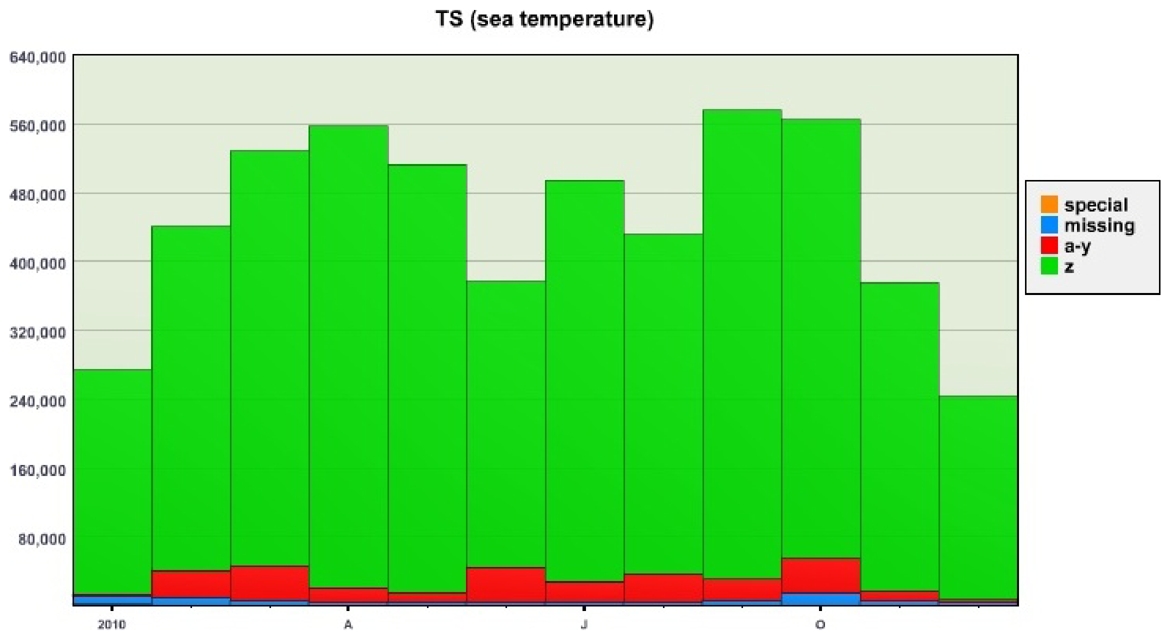


Figure 19: Total number of (top) precipitation accumulation – PRECIP – (bottom) precipitation accumulation 2 – PRECIP2 – and (next page) precipitation accumulation 3 – PRECIP3 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 19: cont'd)

The main problem identified with the sea temperature parameter (Figure 20) occurred when the sensor was denied a continuous supply of fresh seawater. In these situations, either the resultant sea temperature values were deemed inappropriate for the region of operation (using gridded SST fields as a guide), in which case they were flagged with suspect/caution (K) flags or occasionally poor quality (J) flags if the readings were extraordinarily high or low, or else the sensor reported a constant value for an extended period of time, in which case they were unanimously J-flagged. The authors note that this usually occurred while a vessel was in port, which is rather anticipated as the normal ship operation practice by SAMOS data analysts. The *Delaware II* also experienced erroneous TS data throughout 2010 (see discussion in *Delaware II* section of 3c), contributing to the flag totals depicted in Figure 20.



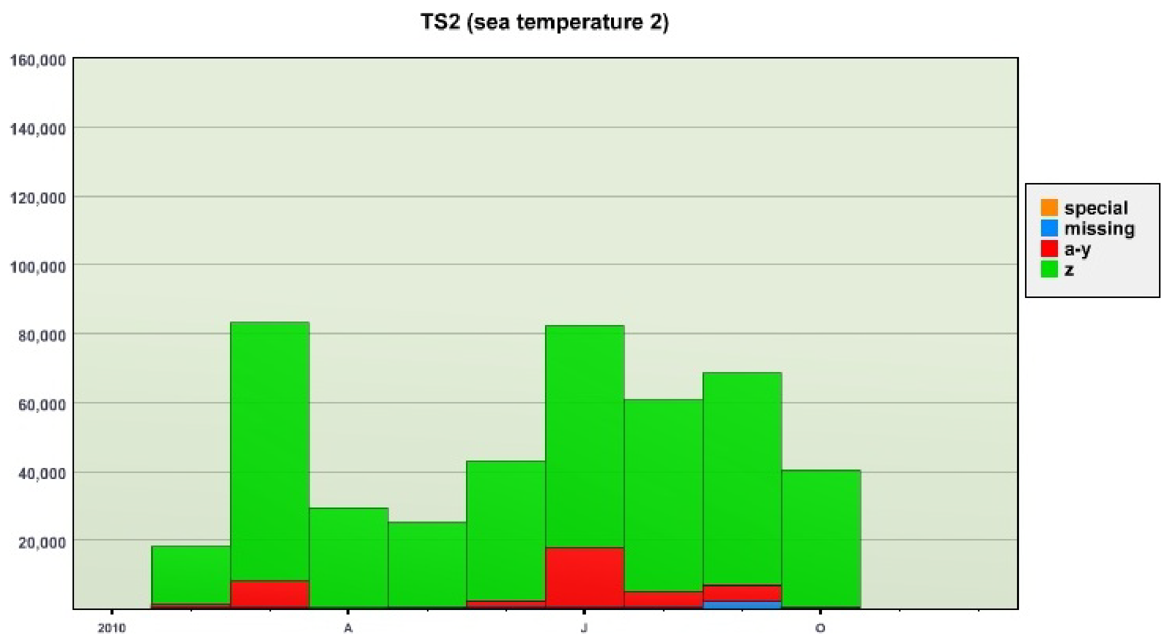


Figure 20: Total number of (top) sea temperature – TS – and (bottom) sea temperature 2 – TS2 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

Salinity and conductivity (Figures 21 and 22, respectively) experienced the same major issue as sea temperature; namely, when a vessel was in port the flow water system that feeds the probes was usually shut off, resulting in either inappropriate or static values. *Gordon Gunter* also experienced conductivity (and resulting salinity) sensor issues in 2010 (details in 3c). In spite of these issues, though, salinity and conductivity data was still rather good. The authors do note that all the salinity values are relative and no effort was made to benchmark the values to water calibration samples. Calibration of salinity data is beyond the scope of SAMOS.

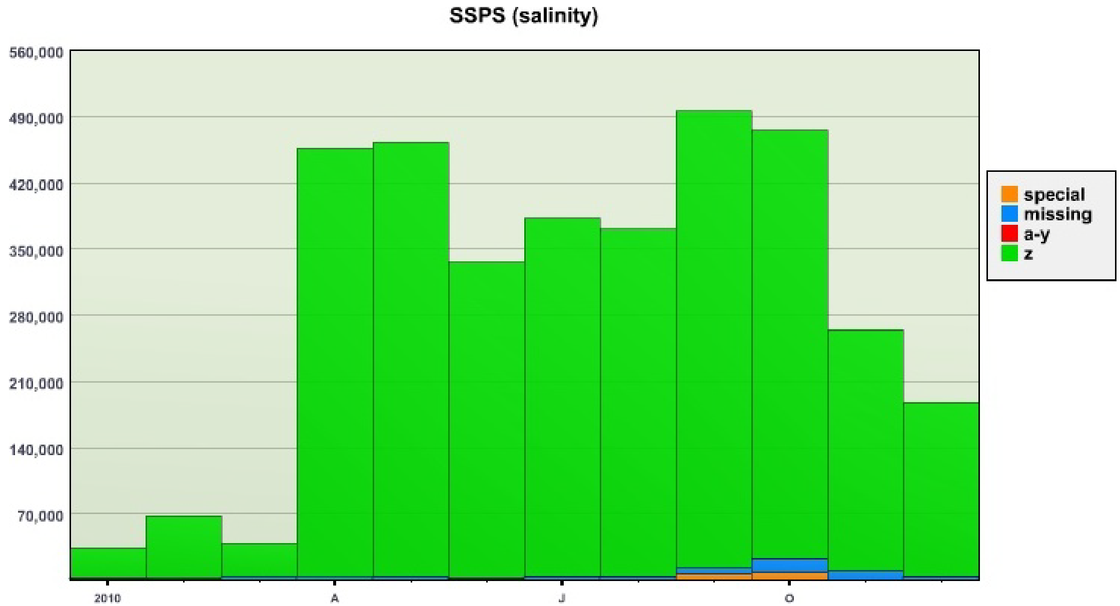


Figure 21: Total number of salinity – SSPS – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

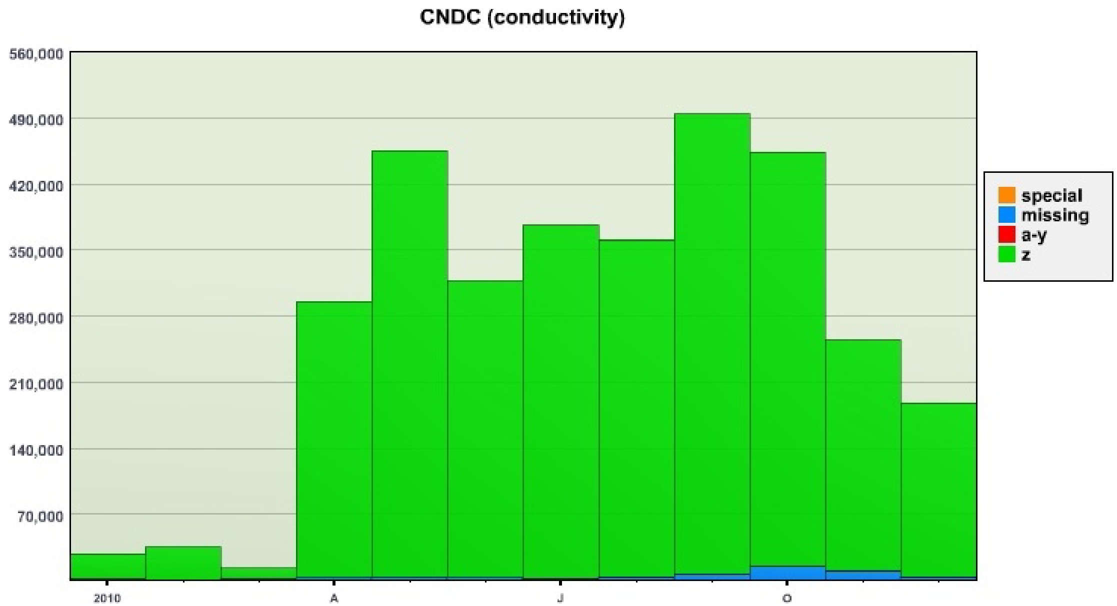


Figure 22: Total number of conductivity – CNDC – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.

Latitude and longitude (Figure 23) primarily only receive flags via the autoflagger, 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. The geographic land/water mask in use for determining land positions in 2010 was a two-minute grid. The land/water mask will be transitioned to a finer one-minute grid, which will likely reduce the number of land error flags applied by the autoflagger, in 2011. Additionally, both the *Knorr* (in November) and the *Oceanus* (in December) transmitted SAMOS data while in dry dock periods; hence, they received port (N) flags, which drove up the November/December a-y flag totals.

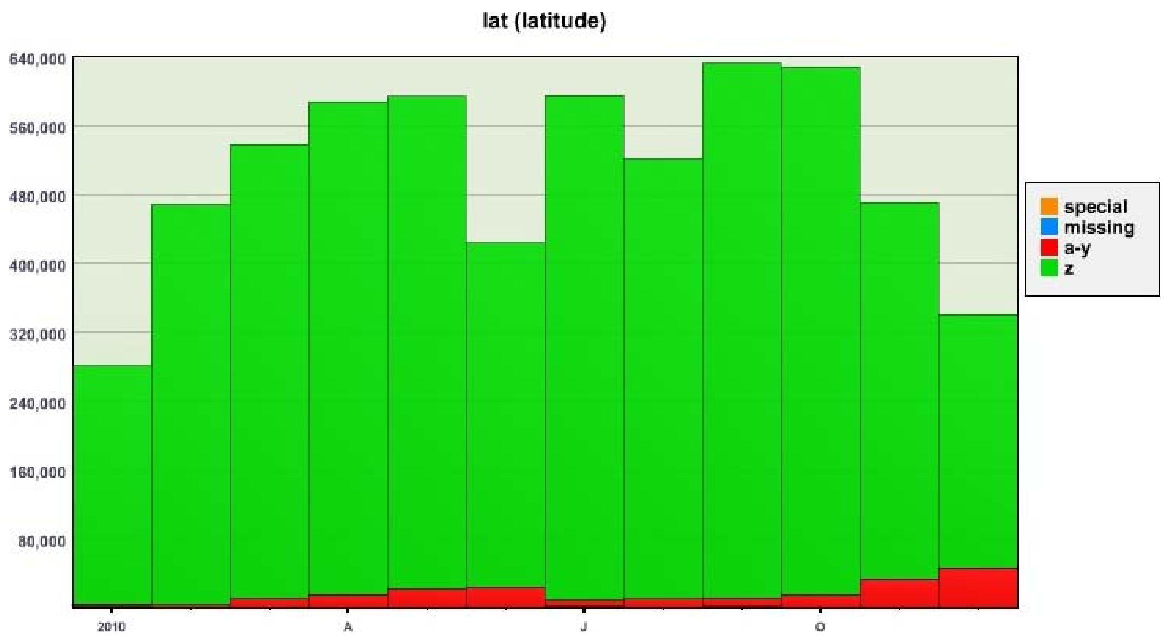
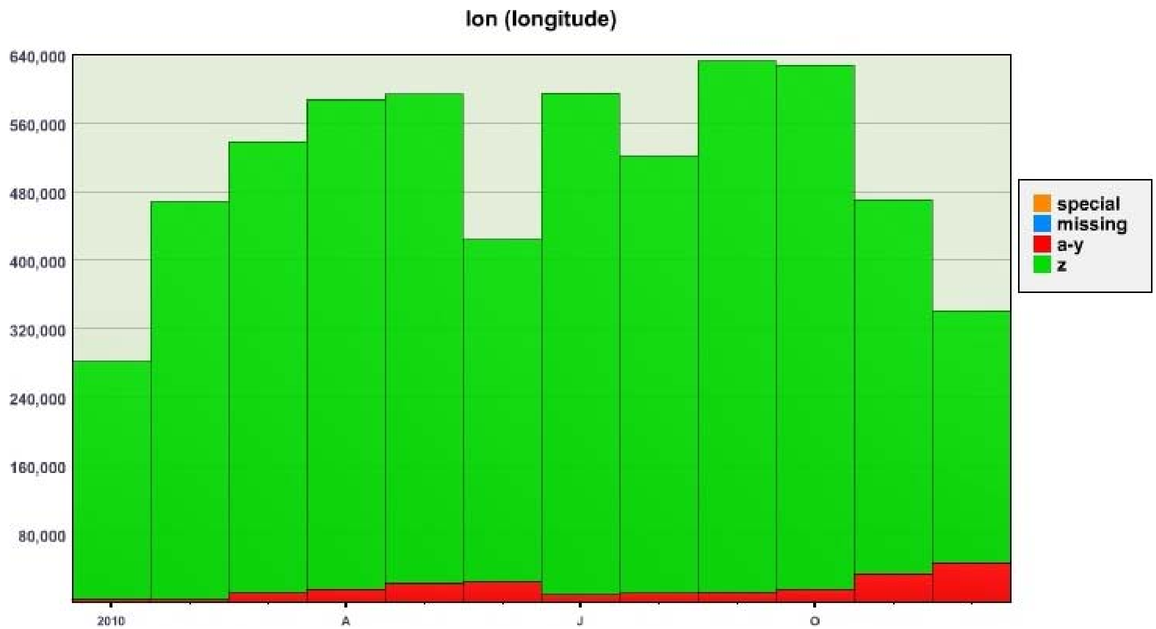


Figure 23: Total number of (this page) latitude – LAT – and (next page) longitude – LON – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 23: cont'd)

The remainder of the navigational parameters exhibited no problems of note. They are nevertheless included for completeness: platform heading (Figure 24), platform course (Figure 25), platform speed over ground (Figure 26), and platform speed over water (Figure 27). Note that secondary values for these parameters are only provided by a limited number of vessels, thus resulting in incomplete reporting over the year.

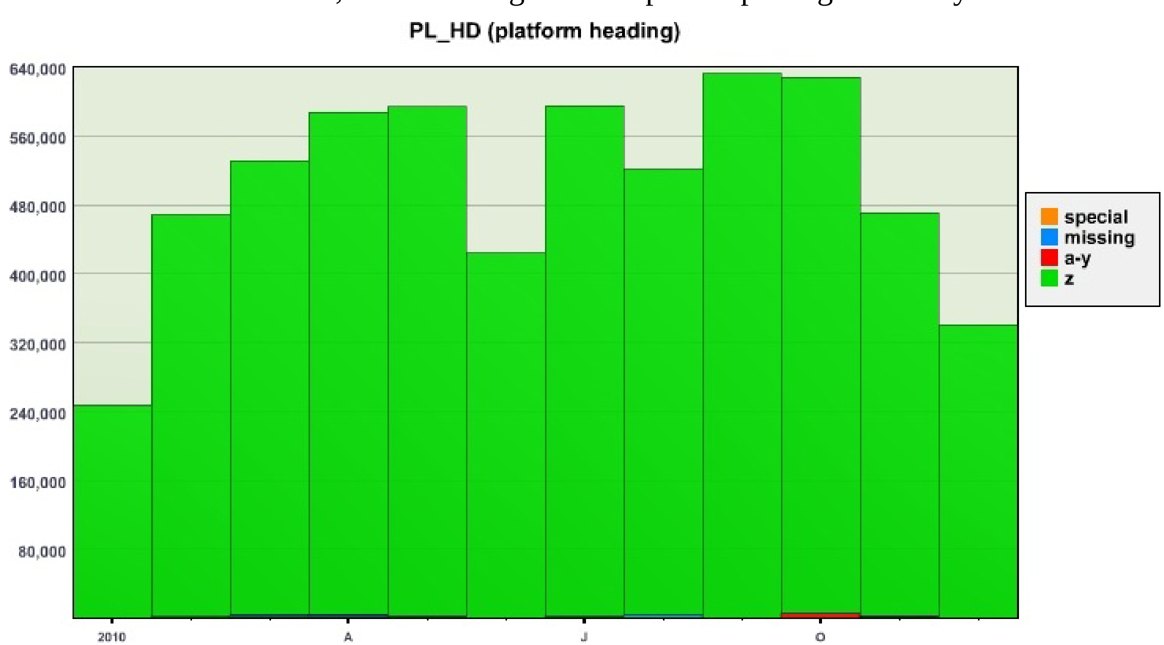
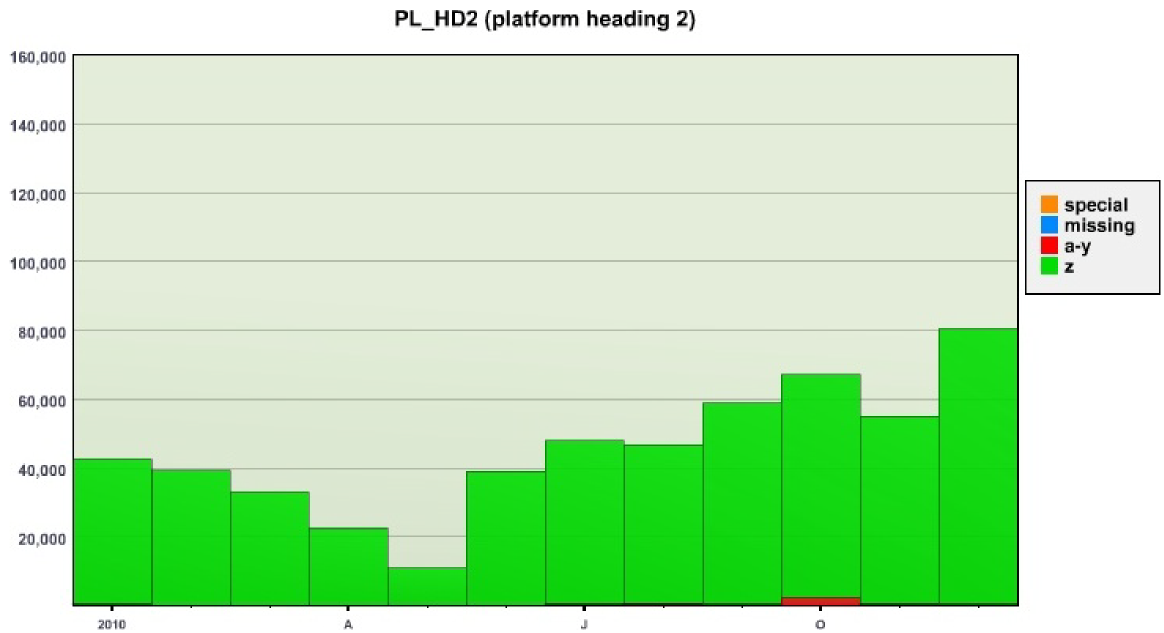


Figure 24: Same as Figure 23, except for (this page) platform heading – PL_HD – and (next page) platform heading 2 – PL_HD2.



(Figure 24: cont'd)

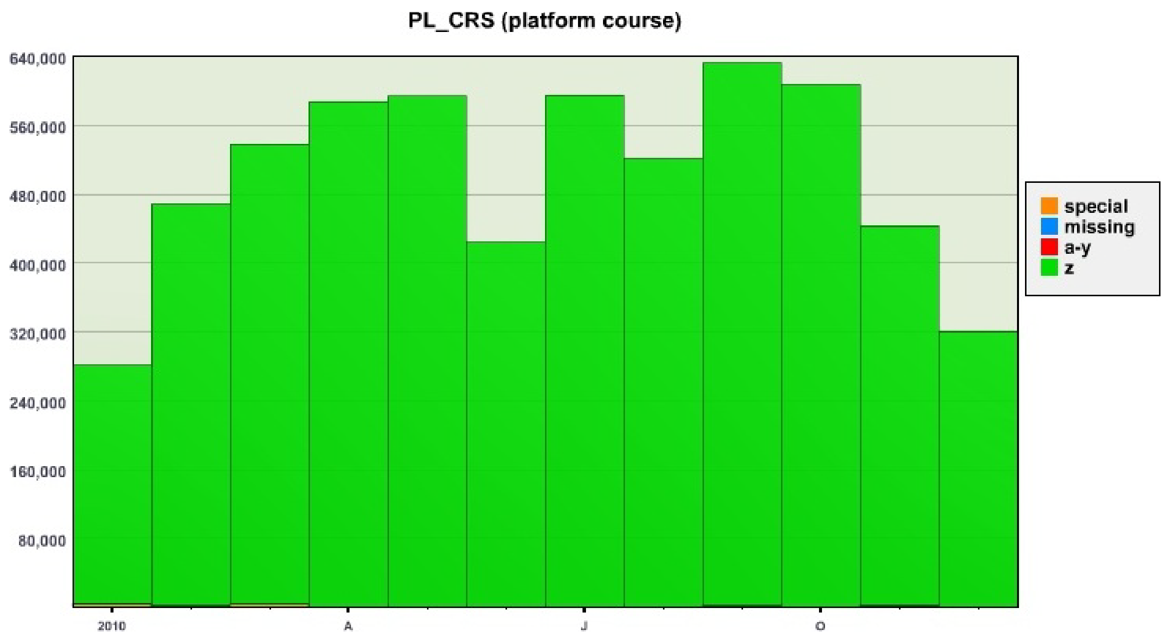
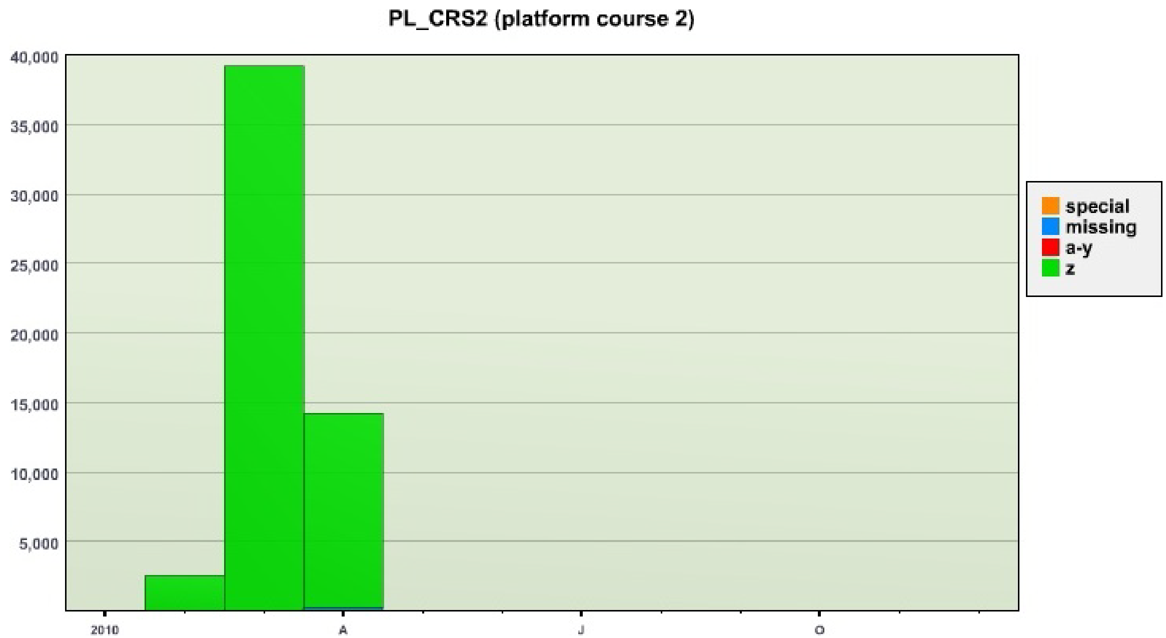


Figure 25: Total number of (this page) platform course – PL_CRS – and (next page) platform course 2 – PL_CRS2 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 25: cont'd)

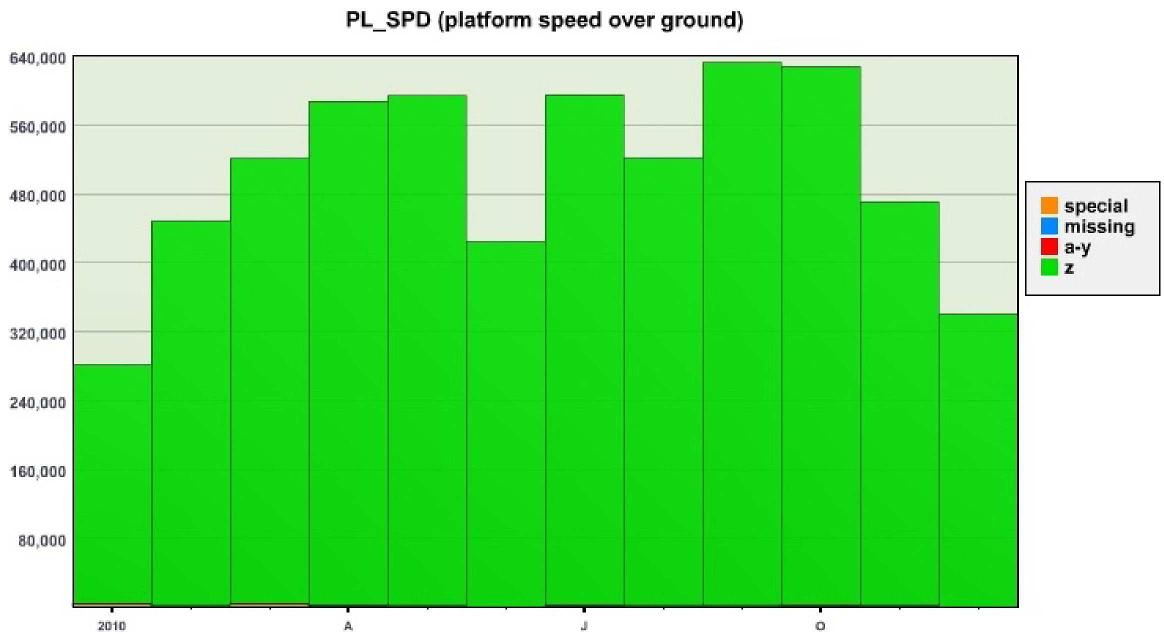
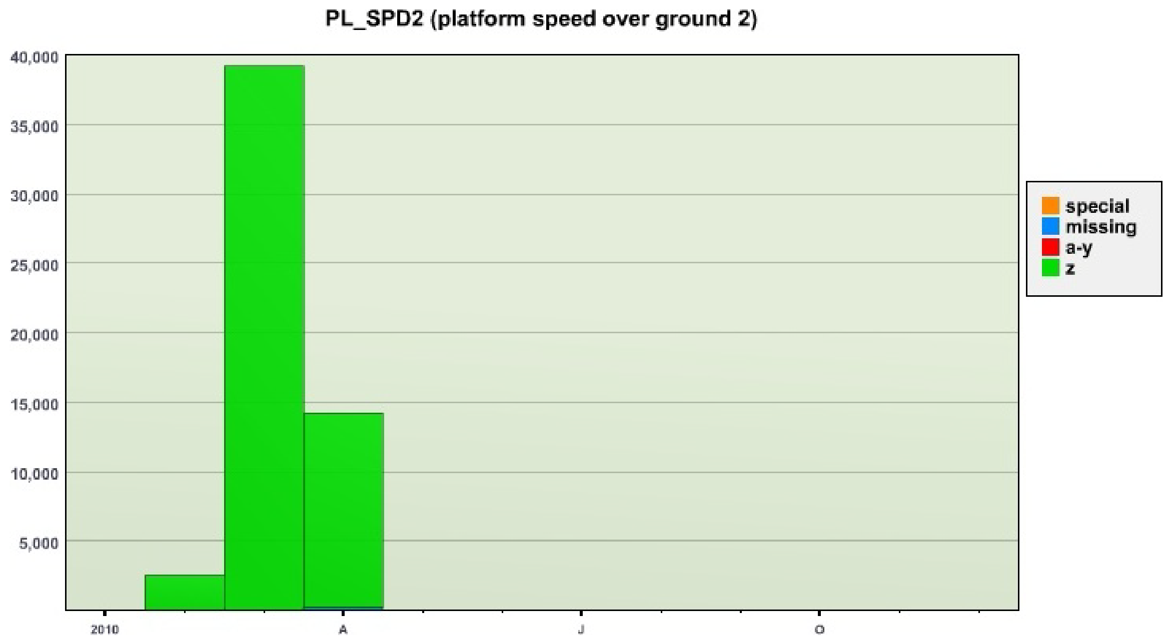


Figure 26: Total number of (this page) platform speed over ground – PL_SPD – and (next page) platform speed over ground 2 – PL_SPD2 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 26: cont'd)

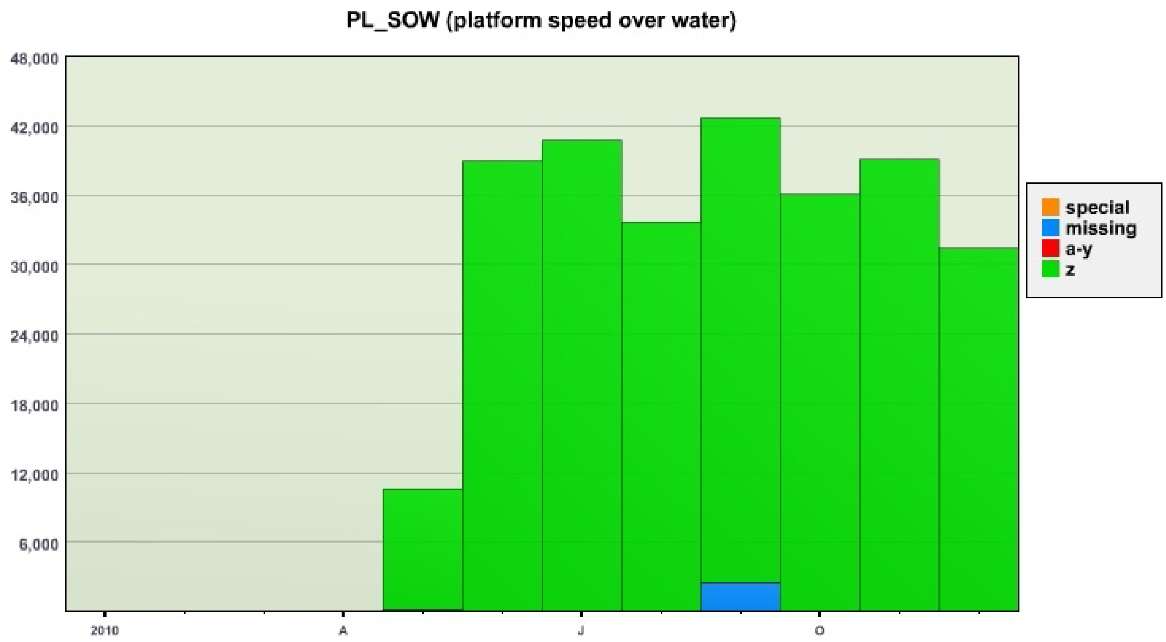
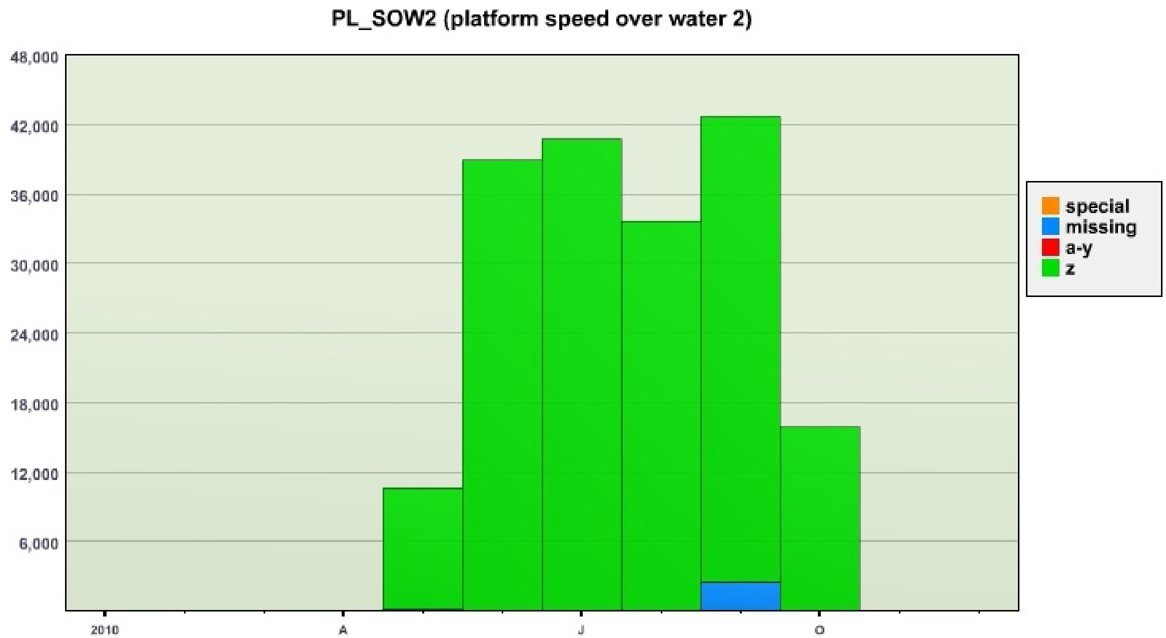


Figure 27: Total number of (this page) platform speed over water – PL_SOW – and (next page) platform speed over water 2 – PL_SOW2 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.



(Figure 27: cont'd)

The platform relative wind parameters, both direction (Figure 28) and speed (Figure 26), also exhibited no problems of note, save that a few rare sensor and/or connectivity failures occurred. These sparse cases were treated with J and M flags.

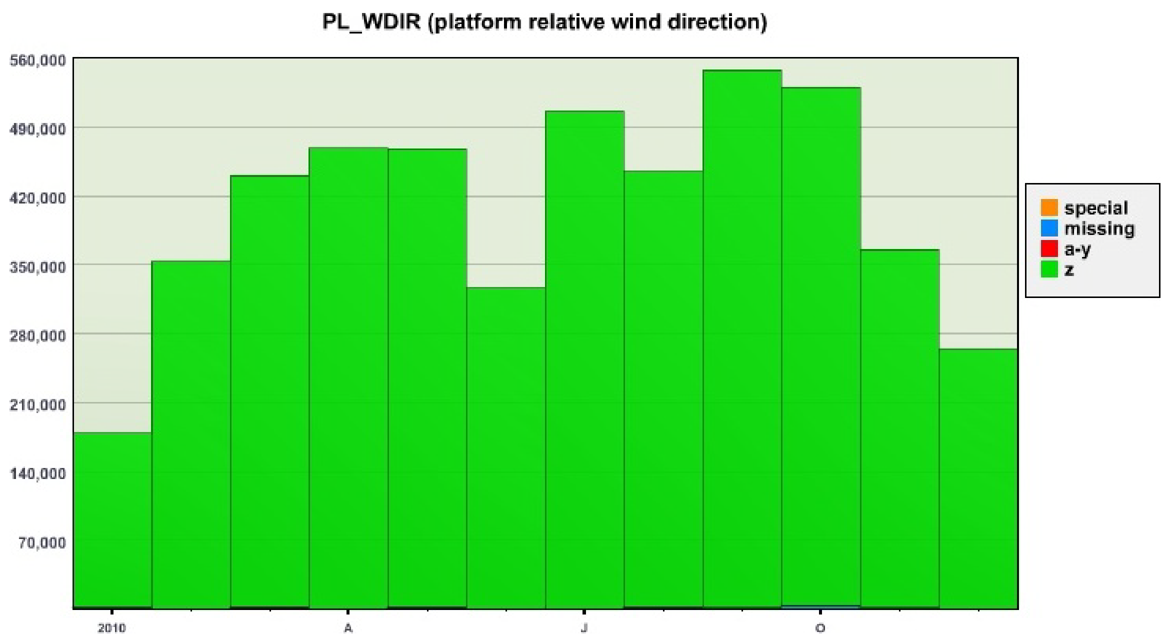
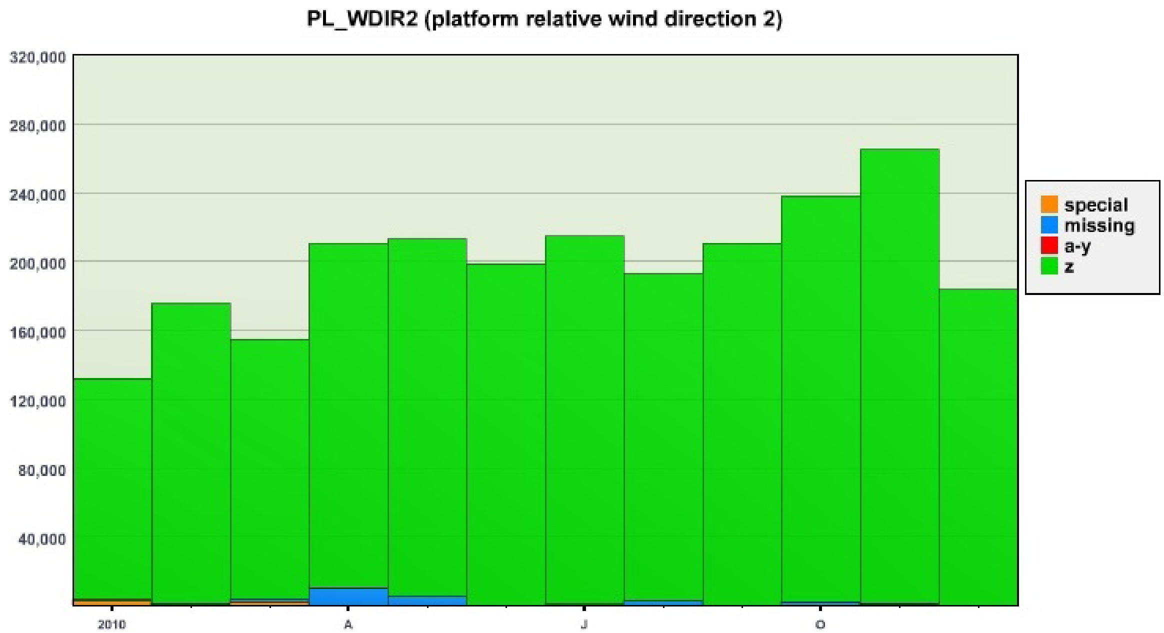
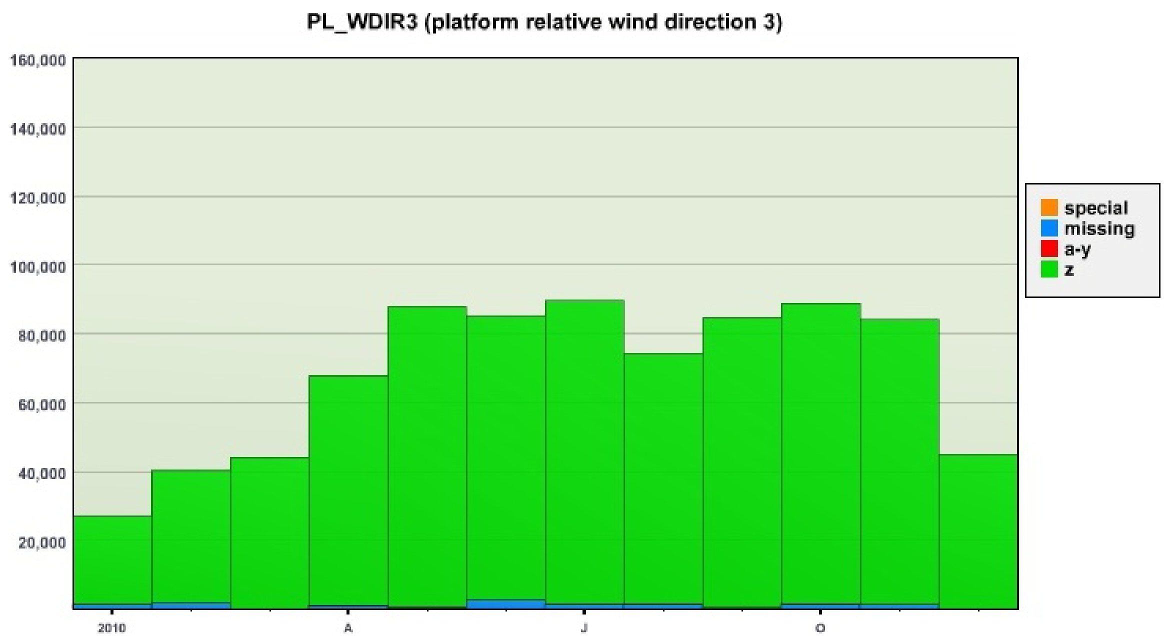
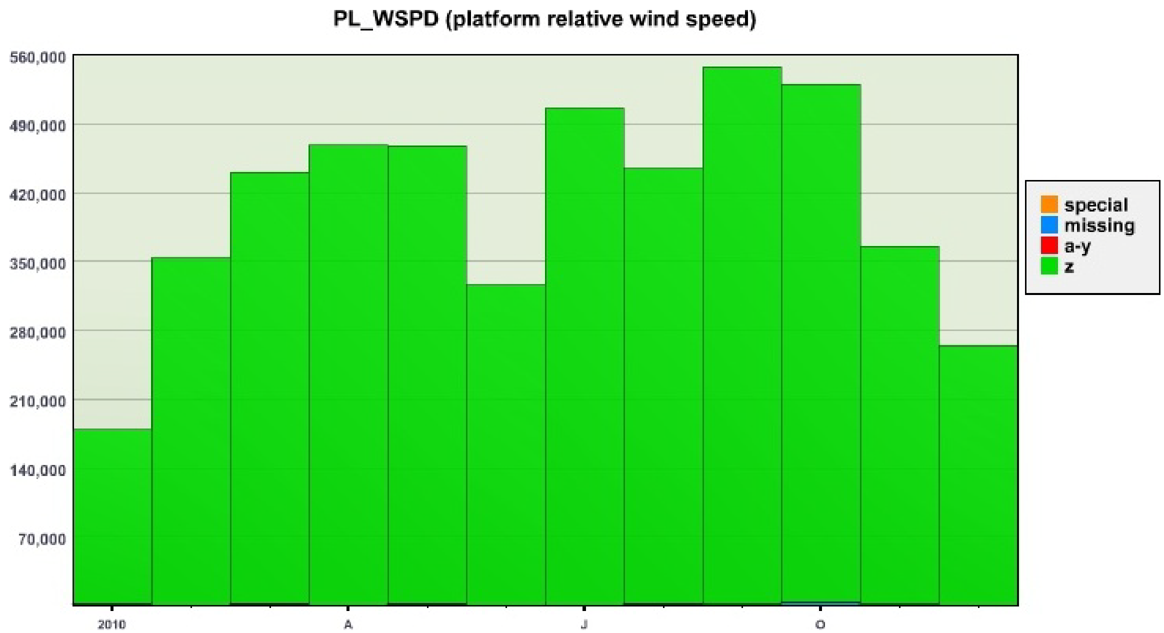


Figure 28: Total number of (this page) platform relative wind direction – PL_WDIR –(next page, top) platform relative wind direction 2 – PL_WDIR2 – and (next page, bottom) platform relative wind direction 3 – PL_WDIR3 – observations provided by all ships for each month in 2010. The colors represent the 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 28: cont'd)



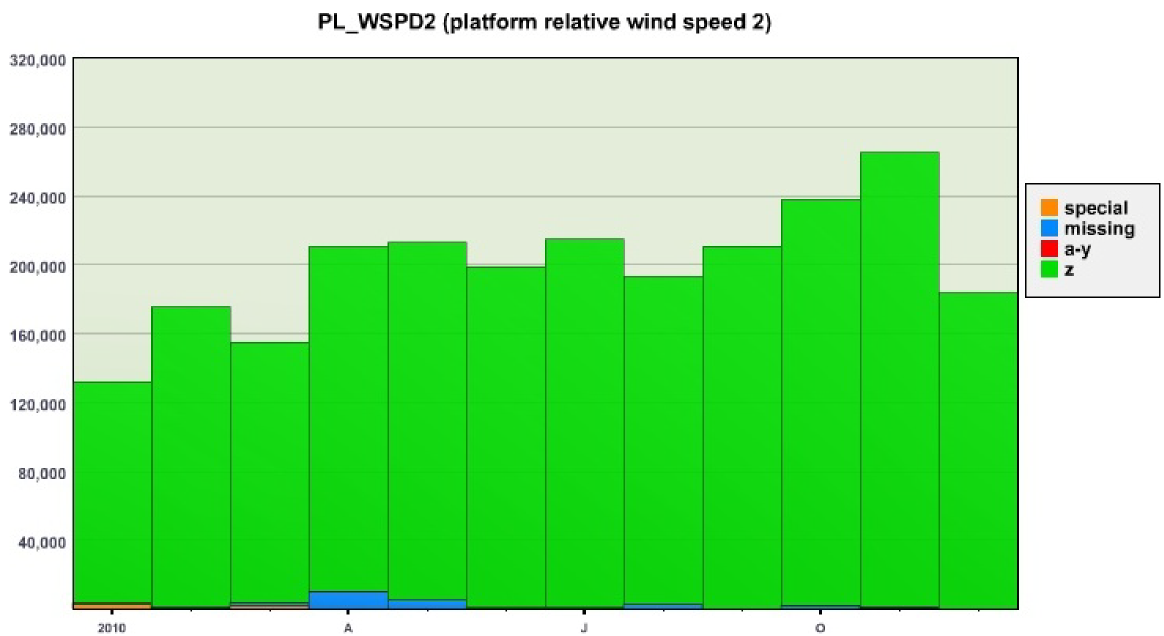
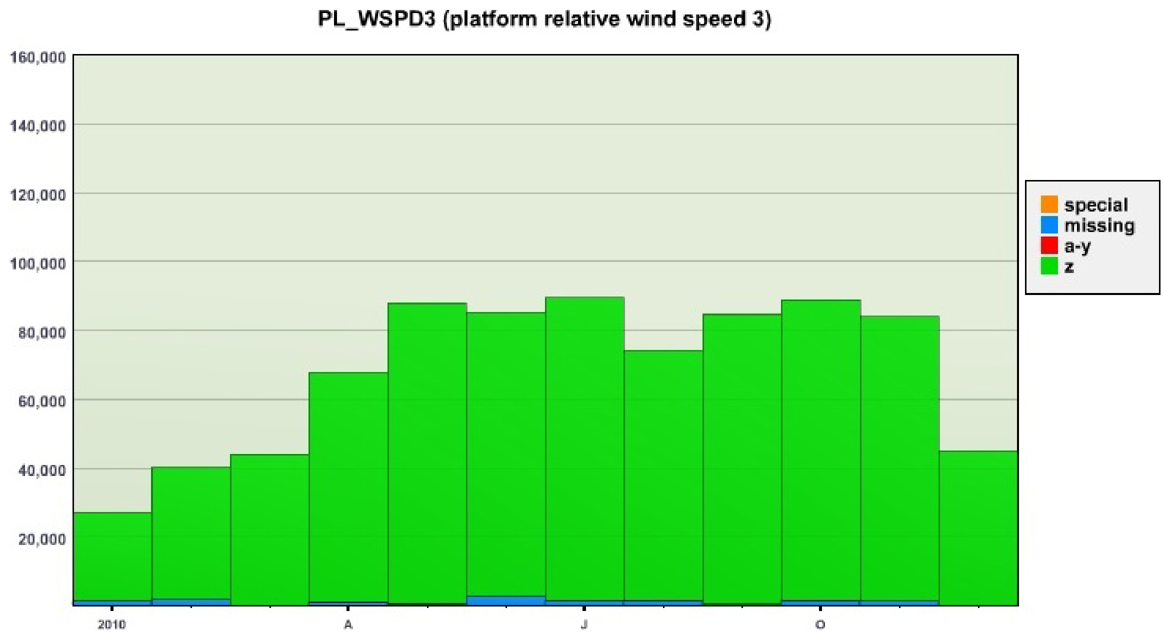


Figure 29: Total number of (top) platform relative wind speed – PL_WSPD – (bottom) platform relative wind speed 2 – PL_WSPD2 – and (next page) platform relative wind speed 3 – PL_WSPD3 – observations provided by all ships for each month in 2010. The colors represent the number of good (green) values 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 29: cont'd)

c. 2010 quality by ship

R/V Atlantis

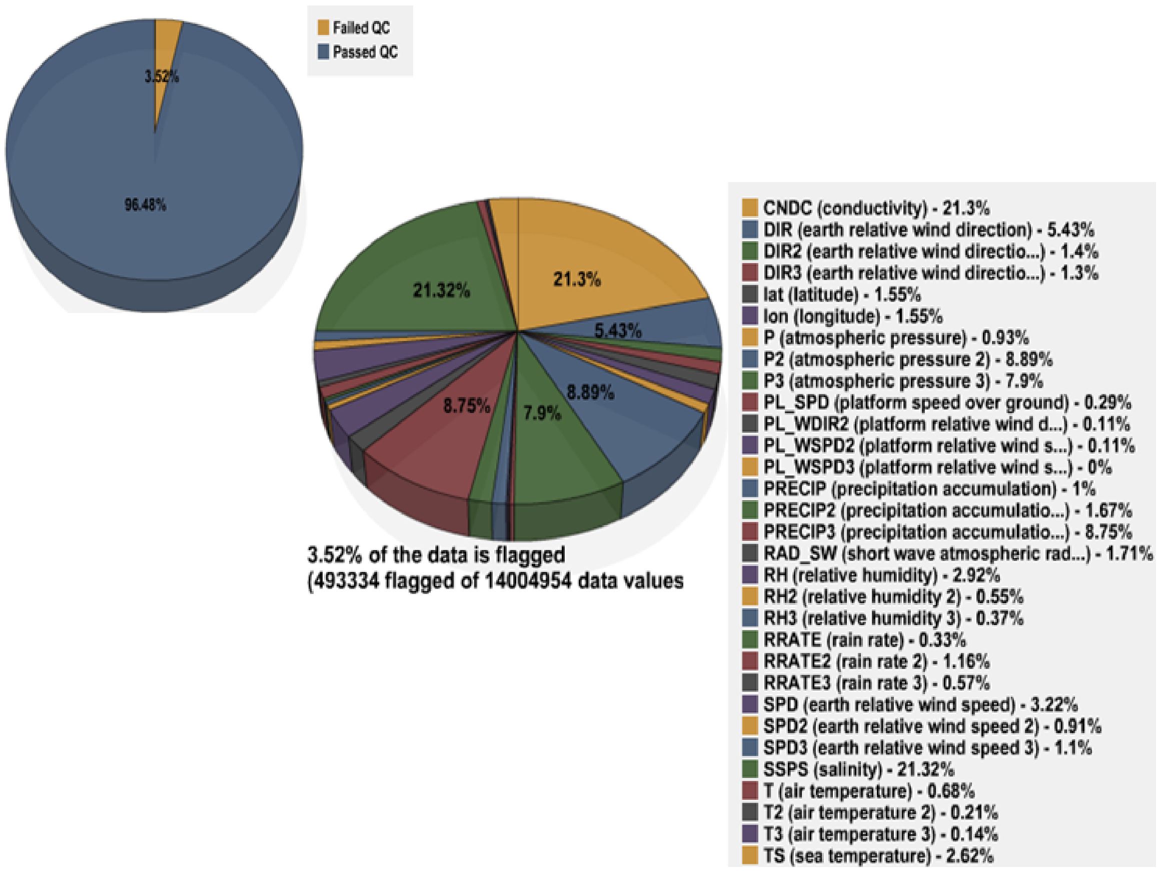


Figure 30: For the *R/V Atlantis* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *R/V Atlantis* provided SAMOS data for 353 ship days, resulting in 14,004,954 distinct data values. After both automated and visual QC, 3.52% of the data was flagged using A-Y flags (Figure 30). This is a change of -1.91% from 2009 (5.43% flagged) – a change that pushed *Atlantis* into second place for lowest flag percentage among all vessels receiving visual QC.

About two-fifths of the flagged values were sea surface salinity (SSPS, 21.32%) and conductivity (CNDC, 21.3%), with caution/suspect (K) flags being the dominant flags (Figure 32, bottom row). In most cases, the data analyst applied these flags as a result of sudden, unexpected sensor behavior that vessel geographical location and/or sea surface temperature behavior did not seem to support. For example, in Figure 31 we can see that although there is no change in sea surface temperature and although the vessel is not located in a region where a sudden supply of fresher water might be expected, the conductivity and salinity parameters experience sudden up and down steps after 22:09 UTC. While these particular steps were not very extreme in magnitude, the author notes that sometimes the decreases were more severe to the point where the analyst considered applying poor quality (J) flags or spike (S) flags as opposed to K but refrained simply because of limited oceanographic understanding. The author also notes that the preceding drop in platform speed may suggest water supply to the SSPS and CNDC sensors was actually cut off at the time of the first step. While the *Atlantis's* SSPS and CNDC parameters do not look visually similar to other vessels' SSPS and CNDC data when their water supply is presumed cut off, it's important to stress that 2010 marks the first year that SAMOS data analysts performed visual QC for the SSPS and CNDC parameters system-wide. As such, the analysts have limited experience with the different makes and models of thermosalinographs (and other conductivity/salinity meters) and the ways they behave in a no-flow situation versus a non-optimal performance situation. However, SAMOS data analysts plan to broaden their understanding of these instruments and of conductivity/salinity in general when time permits.

Precipitation accumulation 3 (PRECIP3) received another 8.75% of all A-Y flags, overwhelmingly of the K variety (Figure 32, middle row). These flags were applied when rain rate (RRATE) and rain rate 2 (RRATE2) sensors as well as PRECIP and PRECIP2 reported rain but PRECIP3 reported none. Rain rate 3 (RRATE3) also did not report rain in these instances, but because only the portions where rain was reported by other sensors were flagged this resulted in a smaller percentage of flags for RRATE3 overall. Because PRECIP3 measures accumulation, all values after the first occurrence of unexpected non-rain were flagged, up until at minimum the end of the 24-hour data period. As the precipitation accumulation time series are rarely reset on board the *Atlantis*, realistically the analysts could have K flagged all PRECIP3 values after the first occurrence of unexpected non-rain in 2010 (and any subsequent first occurrences, if the gauge was never reset). However, the analyst chose not to do so in the spirit of not dragging down a vessel's overall performance based on a parameter that is notoriously unreliable to begin with. It's important for vessel operators to note, though, that when precipitation accumulation gauges are not routinely zeroed out the resulting data traces become virtually meaningless. As to the cause of the suspected under-performance of RRATE3/PRECIP3, data analysts suspect poor sensor placement that results in the gauge being blocked whenever the rain comes from a certain platform-relative direction. However, sensor location metadata is missing for these sensors and analysts are unable to confirm their suspicion. As a separate note on RRATE and RRATE2, in 2010 these sensors often reported values well out of the realistic range (in excess of 10 mm/min). These values were always flagged with K and J flags and, later when a proper range was inserted into the bounds checker, out of bounds (B) flags by the auto flagger. But because non-zero rain rate values only occur during rain events, the proportion of flagging as compared to other variables results in the deceptively low flag percentages for RRATE and RRATE2.

A further 8.89% and 7.9% of flags, respectively, were applied to the atmospheric pressure 2 (P2) and atmospheric pressure 3 (P3) parameters. Again, these were overwhelmingly K flags. These flags were usually applied when either P2 or P3 appeared too low, as compared to the first atmospheric pressure (P) parameter. *Atlantis* metadata states that all three sensors are located at the same height (although distances from the bow and centerline are not given for P2 and P3), with P being adjusted to sea level, P2 being reported at sensor height, and P3 adjustment or non-adjustment unknown. Recalling the barometric formula, whereby pressure decreases with height, analysts would expect a small difference between P and P2 (with unknown expectation regarding

P3); however, flags were applied to P2/P3 when the differences appeared too large for physics alone to account for them. As precise sensor location is not given for P2 and P3 in the metadata, analysts are unable to conjecture what might cause these excessive differences. The author notes that when possible the value of P was often verified against buoys and nearby land-based stations and was deemed a reliable sensor.

As a final note on flagged parameters, in the 2009 SAMOS Data Quality Report the largest portion of flags on board the *Atlantis* were applied to the wind parameters. This year, while earth relative wind direction (DIR) did still receive 5.43% of all flags, the addition of two more wind sensors in April 2010 resulted in improved wind parameter performance overall on board the *Atlantis*. Again, as was stated in the 2009 report, it should be stressed that, overall, *Atlantis* offers very good data.

On 15 February 2010 *Atlantis* stopped reporting the SOG (platform speed over ground) parameter. On 12 March SAMOS data analysts brought the missing parameter to the attention of *Atlantis* technicians via email. We received word back from the tech a day later that they had found and eliminated a bug as a result of our communication. Consequently, SOG reporting resumed on 13 March. This is an excellent demonstration of well-established and mutually beneficial operator/analyst interaction.

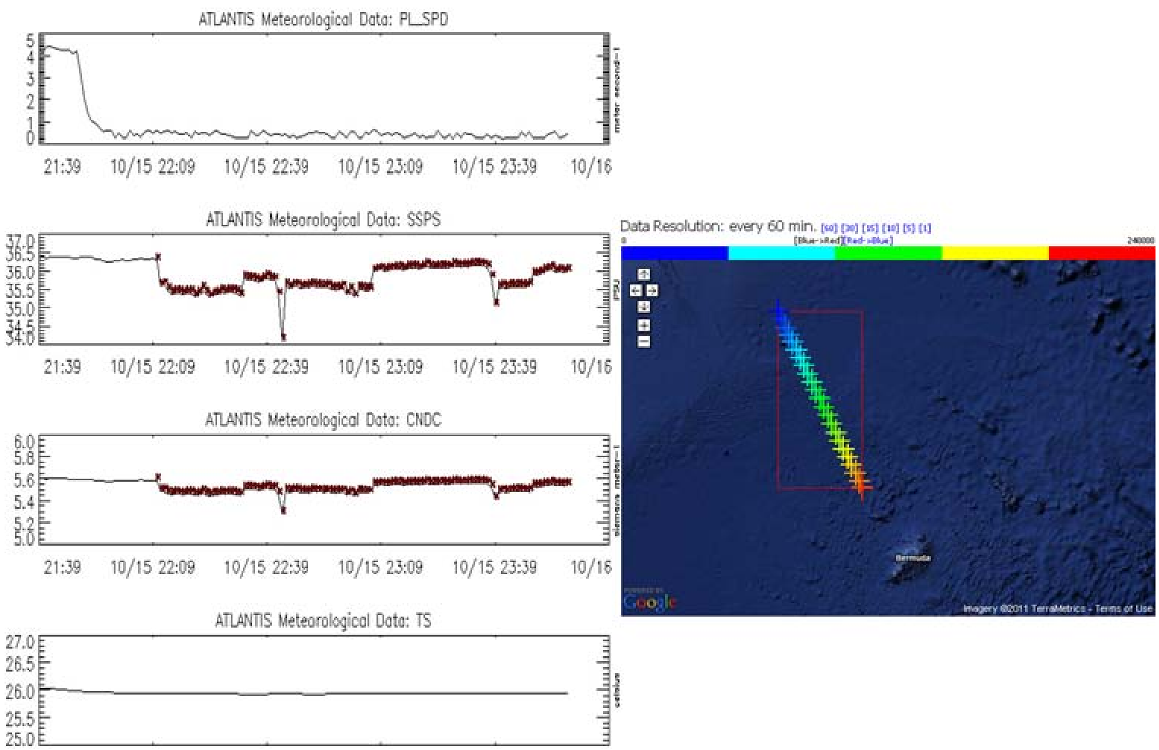


Figure 31: left, *R/V Atlantis* SAMOS data for 15 October 2010; from top: platform speed – PL_SPD – sea surface salinity – SSPS – conductivity – CNDC – and sea surface temperature – TS; right, data map for the *Atlantis's* track on 15 October 2010.

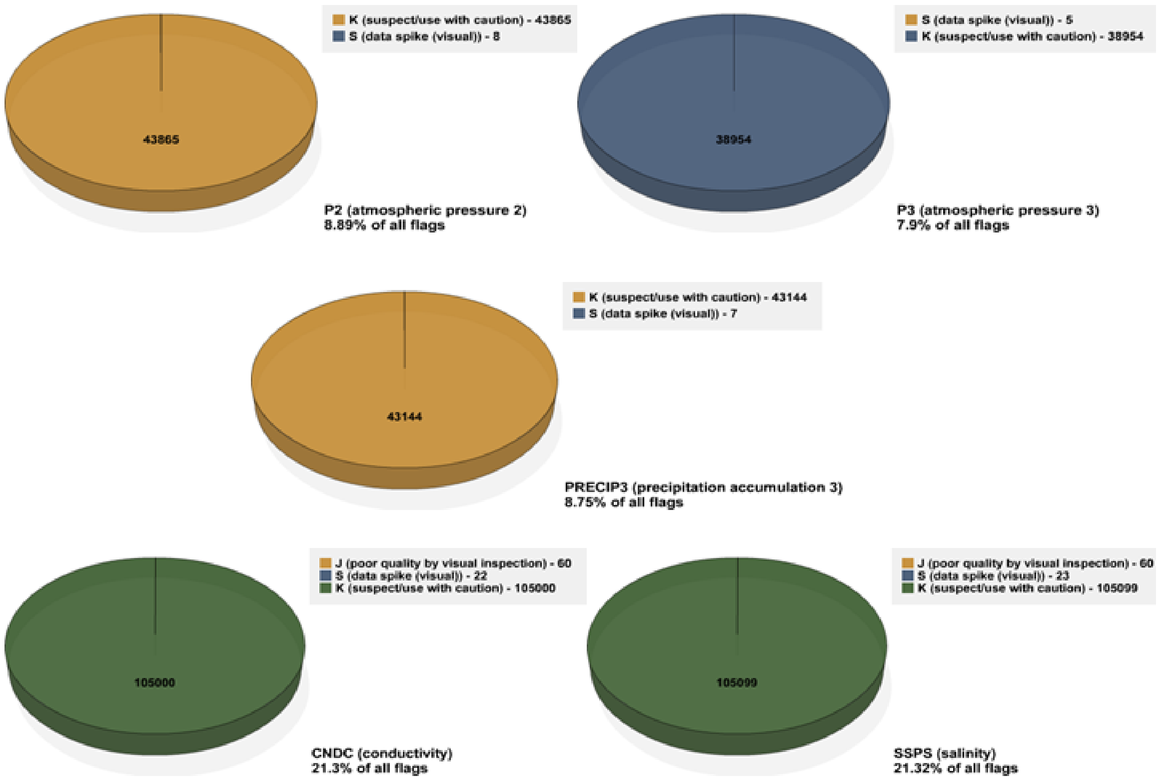


Figure 32: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – and atmospheric pressure 2 – P2 – (middle) precipitation accumulation 3 – PRECIP3 – and (bottom) conductivity – CNDC – and salinity – SSPS – for the *R/V Atlantis* in 2010.

R/V Knorr

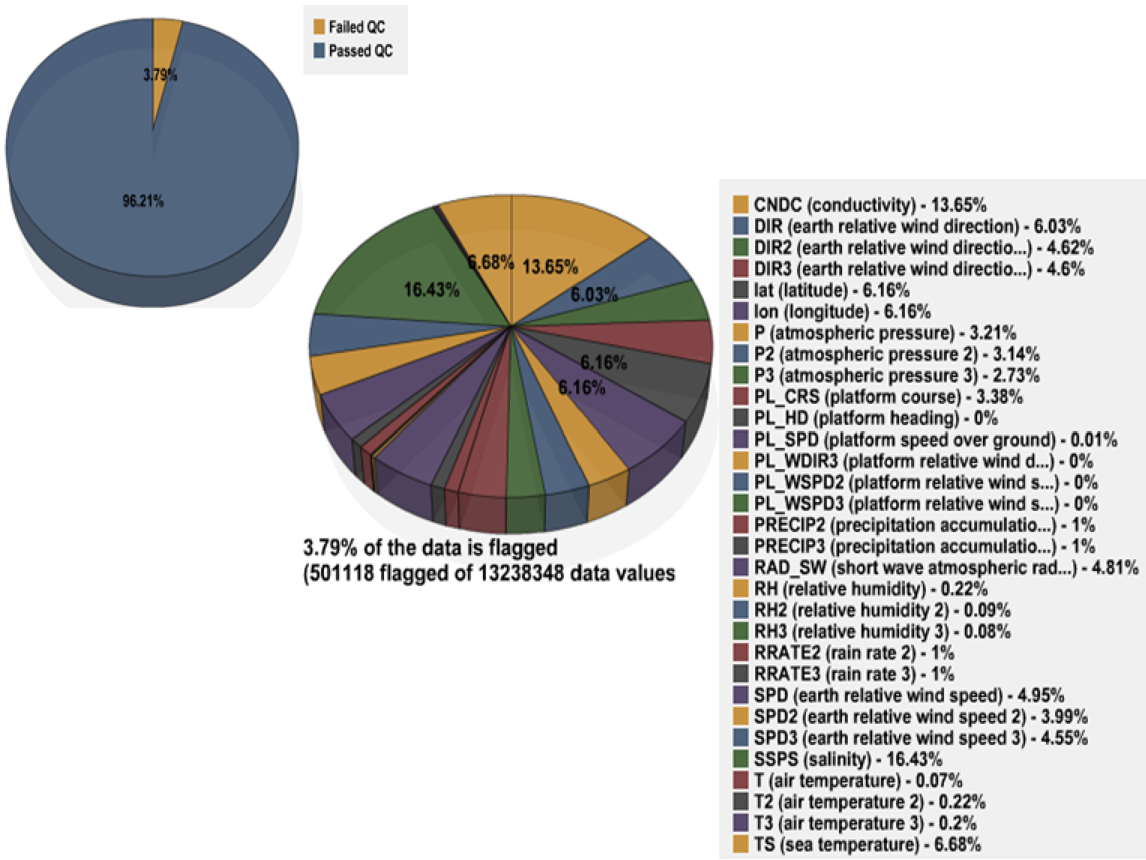


Figure 33: For the *R/V Knorr* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *R/V Knorr* provided SAMOS data for 324 ship days, resulting in 13,238,248 distinct data values. After both automated and visual QC, 3.79% of the data was flagged using A-Y flags (Figure 33). This is a change of -0.41% from 2009 (4.2% flagged). In 2010, the *Knorr* took fourth place for lowest flag percentage among all vessels receiving visual QC. However, the authors suspect the improvement to the *Knorr's* data quality over that of 2009 is greater than implied by the -0.41% change. With the addition of a second wind sensor in late August 2009 and a third in January 2010, the *Knorr's* wind data is now of much better quality overall, in contrast to the true wind parameters claiming over 30% of the flagged values in 2009. This wind data improvement was unfortunately counter-balanced by the volume of flags applied to the latitude (LAT), longitude (LON), sea surface salinity (SSPS), conductivity (CNDC), and sea temperature (TS) parameters during a dry dock period, lasting from 26 November through 13 December, throughout which the data acquisition system was still active. This was an unscheduled dry docking, which became necessary when the *Knorr* experienced a sheared gear-shaft in one of her 2 main propulsion thruster gearboxes. Normally during a dry dock SAMOS data transmission is halted, but such was not the case this time. Since the vessel was not in the water, all of the TS, SSPS, and CNDC data were flagged with bad data (J) flags and LAT and LON were flagged with port (N) flags to add detail to the TS, SSPS, CNDC problem (Figure 35).

On other cruises, CNDC and SSPS were assigned caution (K) flags whenever it appeared the flow water system that supplied fresh sea water to the sensors was shut off, usually while the vessel was in port. TS was also assigned a portion of K flags, most of them while the *Knorr* was off the coast of Cape Town, South Africa (refer to Figure 34). At this location, TS from the *Knorr* read around 11 degrees Celsius, while microwave and infrared SST data in the location appeared to be around 19 degrees Celsius. Although the *Knorr* is equipped with a hull contact thermometer – typically among the most reliable of sea temperature gauges – the analyst felt the 8+ degree difference was too large not to question, hence the K flags. Again, though, the authors stress that with a total flag percentage below 5%, the *Knorr* offers one of the best data sets in 2010.

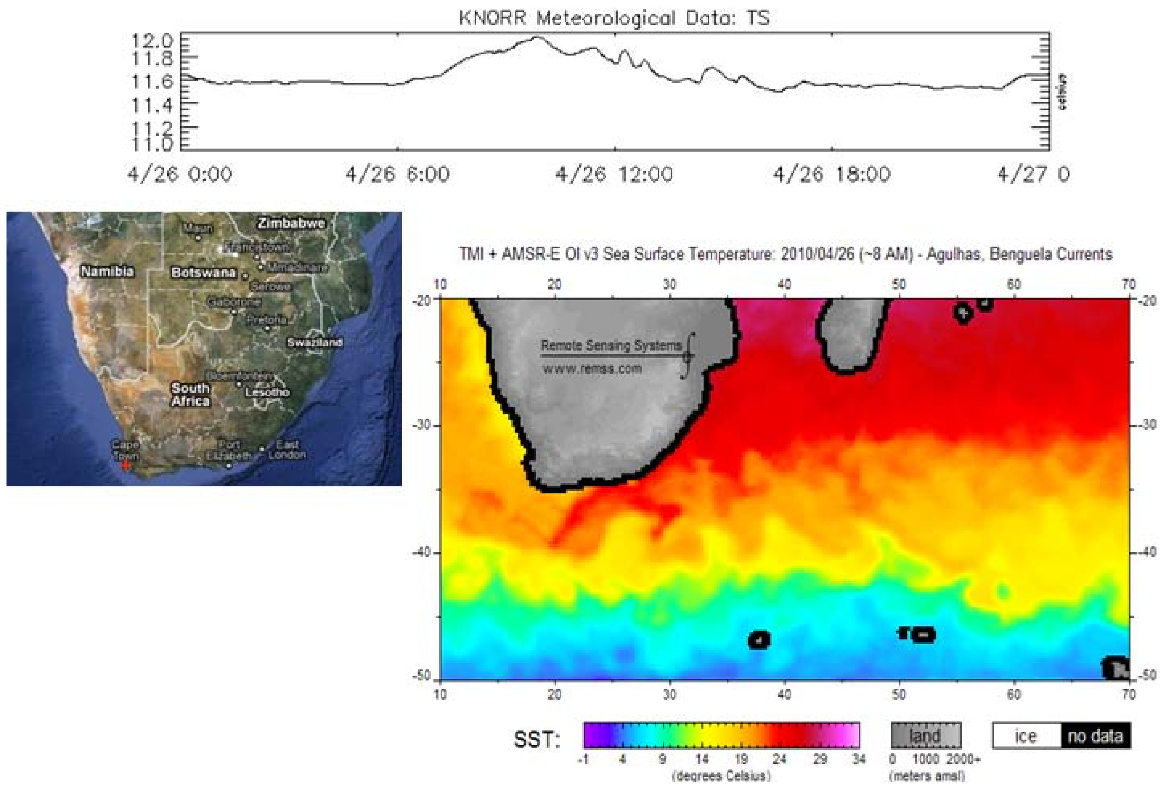


Figure 34: clockwise, from top: *R/V Knorr* SAMOS sea temperature – TS – data for 26 April 2010; archived microwave/infrared sea surface temperature data for 26 April 2010; the *Knorr's* location on 26 April 2010.

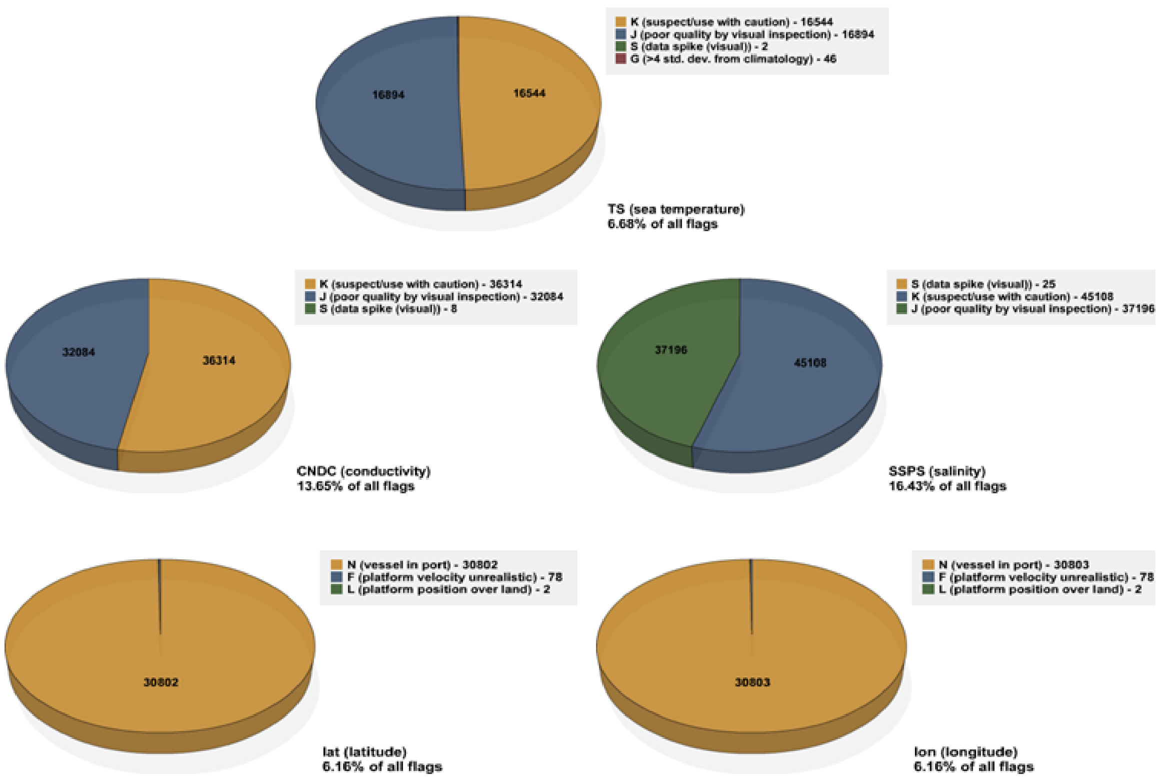


Figure 35: Distribution of SAMOS quality control flags for (top) sea temperature – TS – (middle) conductivity – CNDC – and salinity – SSPS – and (bottom) latitude – LAT – and longitude – LON – for the *R/V Knorr* in 2010.

Delaware II

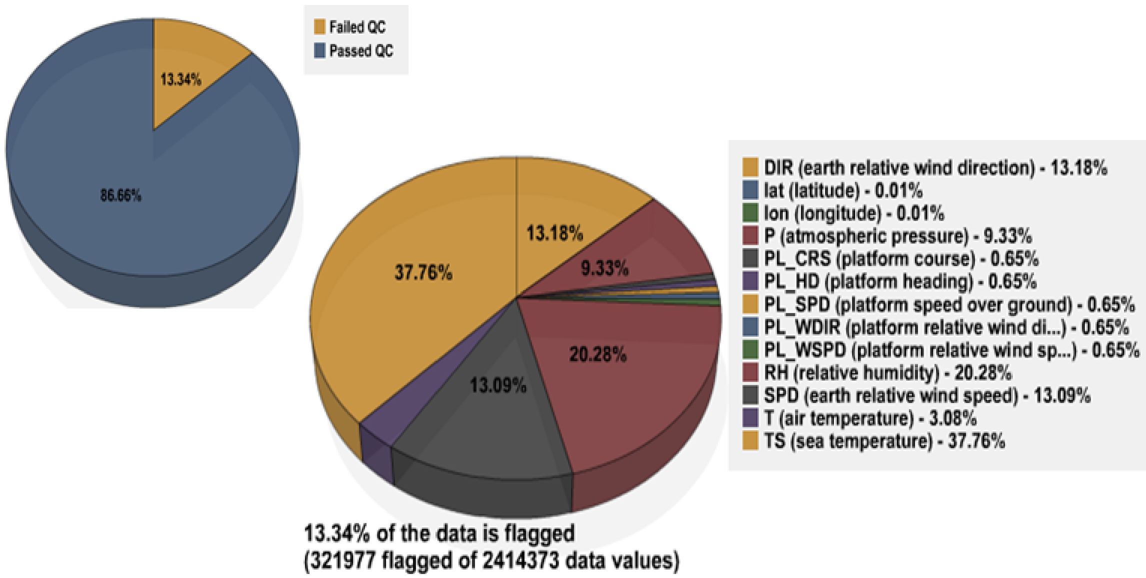


Figure 36: For the *Delaware II* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Delaware II* provided SAMOS data for 131 ship days, resulting in 2,414,373 distinct data values. After both automated and visual QC, 13.34% of the data was flagged using A-Y flags (Figure 36). This is a scant change of -0.02% from 2009 (13.36% flagged), and at 13.34% the *Delaware II* performed the least reliably overall among all vessels receiving visual QC in 2010. *Delaware II* reported unrealistic sea temperature (TS) values for the duration of 2010 (example Figure 37). On 11 February *Delaware II's* technicians were contacted via email by SAMOS data analysts concerning the TS issue. A response was received from a technician stating they'd had an issue with the sensor earlier in the year but that they thought it had been resolved. The technician requested that we let them know if the SAMOS TS data was still erroneous so they could look into it, which we did. The issue was not resolved at that time, however. Later, on 11May TS transmission stopped entirely. The technicians were again contacted by the SAMOS group, and this time we were told (by a second technician) that the TSG computer had suffered a motherboard casualty and was out of commission. Parts were reportedly on order and repairs would take place before the next cruise. Nevertheless, when *Delaware II* began reporting data again the TS data was still showing the same error. Technicians were contacted a third and final time on 15 September, and a third tech responded, stating that he had forgotten to restart the water pump. But once again, there was no improvement to the data. As a result, the parameter was always flagged with out of bounds (B) flags by the auto flagger. Initially, the data analyst replaced these B flags with poor quality (J) flags but eventually let the B flags stand, reasoning that either flag would signal to an end user that the data were unrealistic. Hence, the applied flags are divided between the B and J varieties (Figure 39, bottom row).

In 2009, relative humidity was a problematic sensor on the *Delaware II*, with over half of the flags applied to RH being out of bounds (B) flags, reflecting the common occurrence of RH readings slightly over 100% due to instrument tuning, described in section 3b. This scenario repeated in 2010, resulting in RH receiving the second highest amount of flags (20.28%), the majority being B flags.

Atmospheric pressure (Figure 39, top left) and earth relative wind speed and direction (Figure 39, middle row) also received sizable flag percentages. In the case of atmospheric pressure, the problem appeared to be related to changes in platform speed (PL_SPD), as demonstrated in Figure 38. Platform relative wind direction did not appear to factor in, although it could not be ruled out as a factor since accurate metadata for the pressure sensor does not exist. It should be especially noted that pressure data on board the *Delaware II* has nevertheless improved since 2009, when although the readings were appropriate in terms of range, they tended to hold at a specific value for an extended period of time. (Since the sensor was declared accurate to two decimal places in the metadata, these static readings indicated a problem and led to copious poor quality (J) flagging.)

In the case of the true winds, the majority of the flags were again, as in 2009, caution/suspect (K) flags. The problem was likely flow obstruction, although digital imagery for the *Delaware II* was once again unavailable to use as verification.

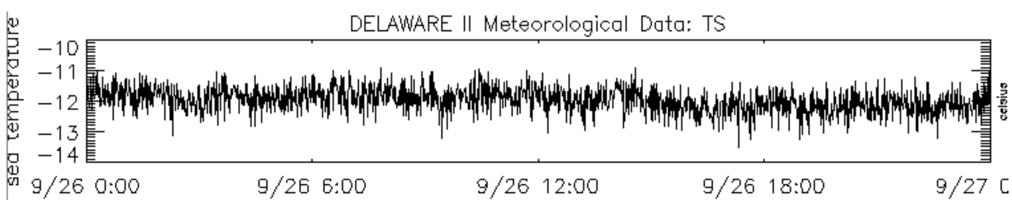


Figure 37: *Delaware II* SAMOS sea temperature data – TS – for 26 September 2010.

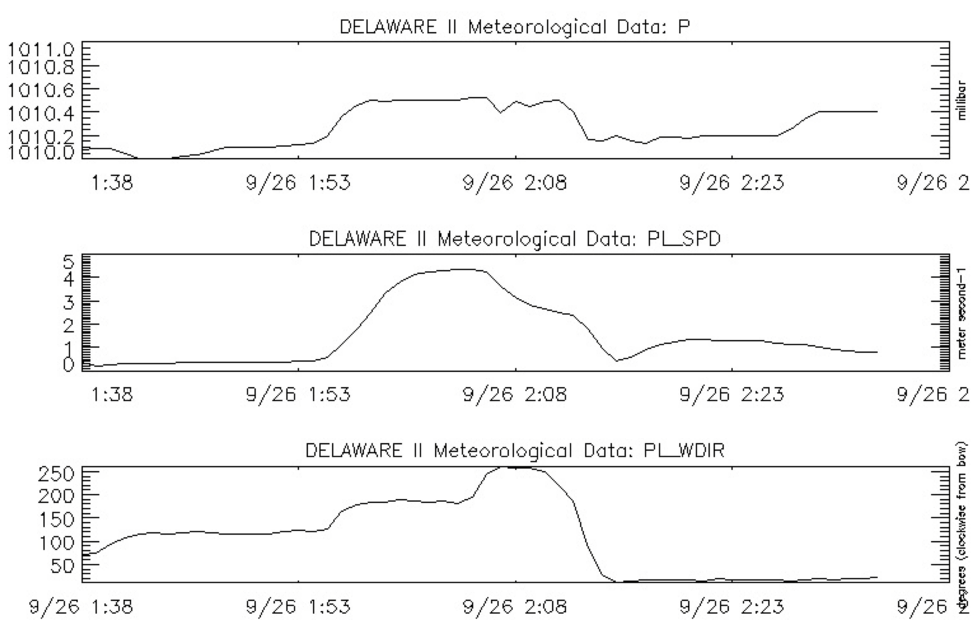


Figure 38: *Delaware II* SAMOS data for 26 September 2010: from top: atmospheric pressure – P – platform speed – PL_SPD – platform relative wind direction – PL_WDIR.

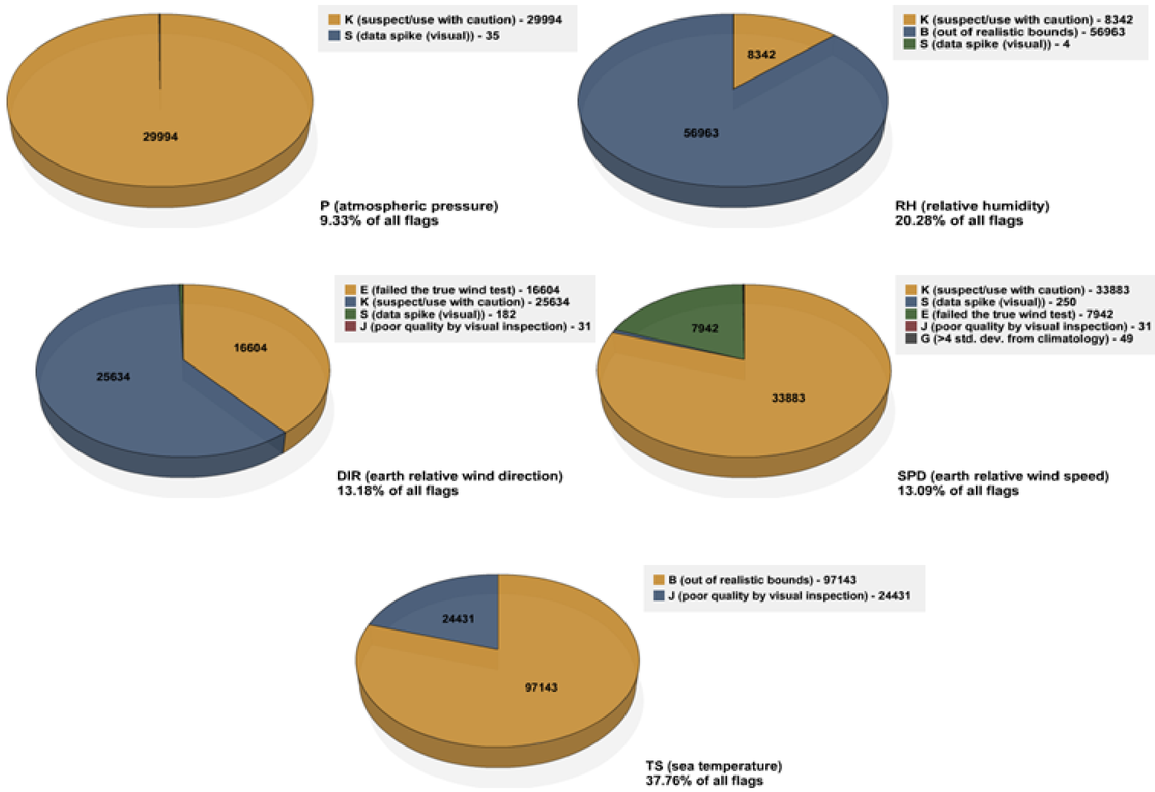


Figure 39: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – and relative humidity – RH – (middle) earth relative wind direction – DIR – and speed – SPD – and (bottom) sea temperature – TS – for the *R/V Delaware II* in 2010.

Healy

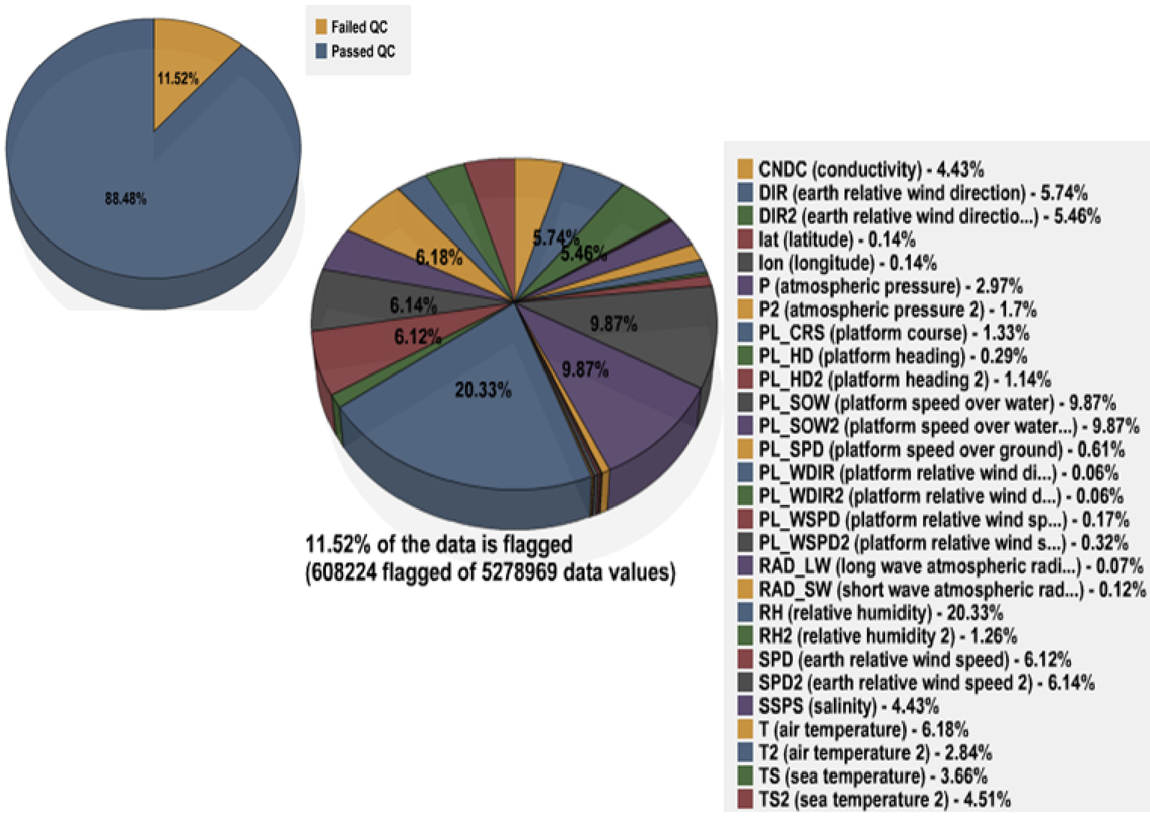


Figure 40: For the *Healy* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Healy* provided SAMOS data for 131 ship days, resulting in 5,278,969 distinct data values. After both automated and visual QC, 11.52% of the data was flagged using A-Y flags (Figure 40). This is a vast improvement (-11.01%) over 2009's 22.53% flagged. The authors stress, as they did in the 2009 report, that the block-house shape of the superstructure on the *Healy* makes flow obstruction nearly unavoidable and provides few good locations for meteorological sensors. As such, the majority of the flagging in most of the MET parameters was likely due to airflow obstruction. Once again, the many redundant sensors on board the *Healy* are clear evidence of that fact, as redundant sensors commonly differed from each other appreciably. However, as stated in 2009, no definitive statement can be made regarding airflow obstruction without detailed airflow modeling of the *Healy*.

A small portion of the flags applied to the relative humidity (RH), air temperature 2 (T2), and atmospheric pressure (P) sensors occurred between 6 July and 8 July, when there was a confirmed problem with the interface for those three sensors. But it is significant that the problems with calibration coefficients so prevalent in 2009 were not repeated in 2010, resulting in the much-improved overall flag percentage. The most noteworthy flagged parameter in 2010 was the primary relative humidity sensor (RH). This sensor often read as much as 10% higher than relative humidity 2 (RH2), with this increase frequently putting the reading well over 100%. This behavior resulted in copious out of bounds (B) flagging by the auto flagger and, when the elevated reading was under 100%, suspect/caution (K) flagging by the data analyst (Figure 41, top). Given that the RH sensor is located much closer to the stacks than the RH2 sensor, the analysts felt confident the problem was usually exhaust contamination, sometimes compounded by the common occurrence of RH readings over 100% in saturation conditions due to sensor tuning (described in Section 3b). It was also common in 2010, as in 2009, for the platform speed over water parameters (PL_SOW and PL_SOW2) to hold at one value for an extended period, either due to ice under the hull or because the sensors were switched off while the vessel was in ice. This scenario resulted in frequent poor quality (J) flagging, as seen in Figure 41, bottom row.

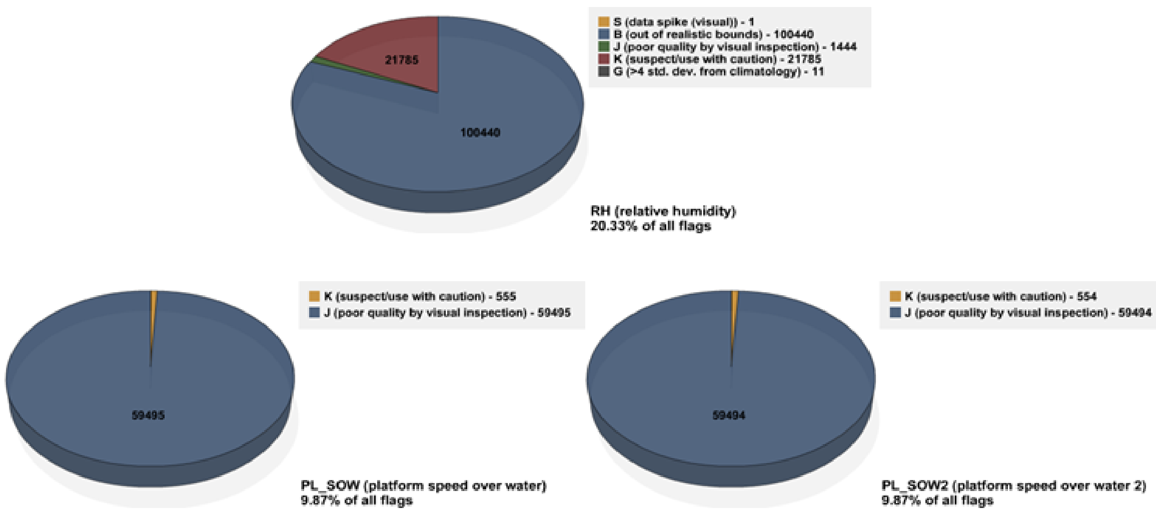


Figure 37: Distribution of SAMOS quality control flags for (top) relative humidity – RH – and (bottom) platform speed over water – PL_SOW – and platform speed over water 2 – PL_SOW2 – for the *R/V Healy* in 2010.

Polar Sea

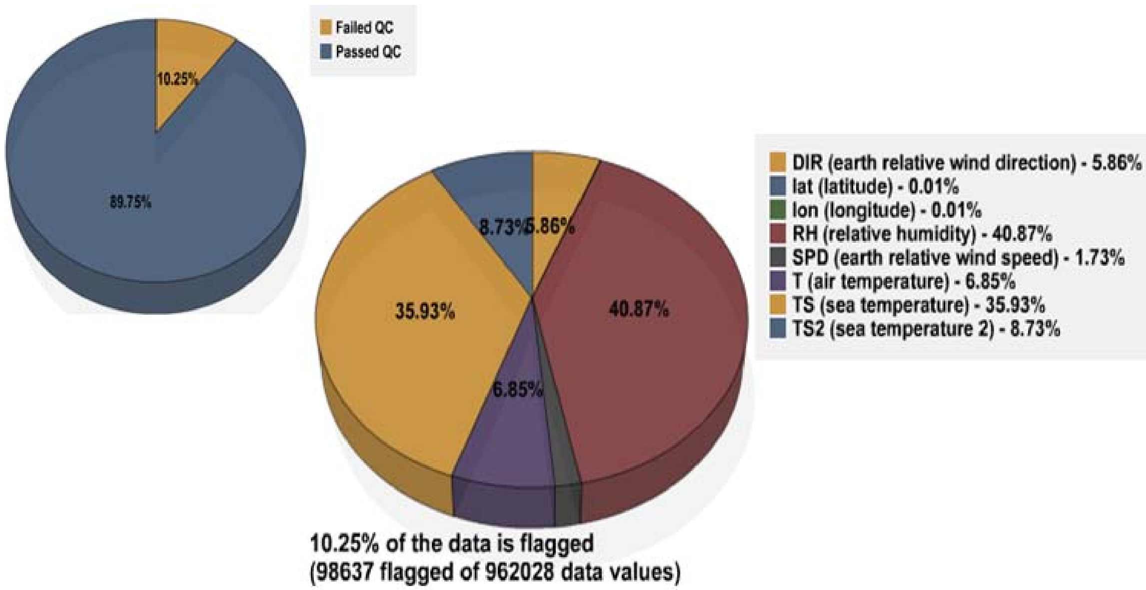


Figure 42: For the *Polar Sea* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Polar Sea* provided SAMOS data for 42 ship days, resulting in 962,028 distinct data values. After automated QC, 10.25% of the data was flagged using A-Y flags (Figure 42). This is a fairly large deviation (+3.68%) from 2009's 6.57% flagged. NOTE: the *Polar Sea* does not receive visual quality control, so all of the applied flags are the result of automated QC (no research-level files exist for the *Polar Sea*).

The highest percentage of flags was applied to relative humidity (RH). Most of those flags were out of bounds (B) flags (Figure 45, top). It is likely these were due to the common occurrence of RH readings over 100% in near-saturation conditions, owing to sensor tuning (see Section 3b for details). The example shown in Figure 43 supports this theory; with sea temperatures several degrees higher than the air temperature, it is quite conceivable that the actual relative humidity would be very near 100%.

In addition to relative humidity, sea temperature (TS) once again received the a very large portion of flags, notably out of bounds (B) flags and greater than 4 standard deviations (G) flags (Figure 45, bottom). In this case, as in 2009, the readings were often much too high for the vessel's region of operation. *Polar Sea* SAMOS metadata specifies that TS was a wet lab sea temperature sensor, strongly supporting the continuing theory that the sensor simply was not being supplied fresh seawater but was rather measuring "room temperature" water. A good example in support of this theory is demonstrated in Figure 44, where it seems clear the flow water control was shut off around 0300 UTC (at which time the behavior of the data abruptly changes and begins a steady climb to an eventual unrealistic range). Visual QC, if it were applied to this data, would probably result in further suspect/caution (K) or perhaps poor quality (J) flagging of the portion of steadily rising data prior to the B-flagged section. Similarly, G flags would likely have been converted to K or J flags. The authors do note, though, that it is not uncommon for vessel operators to leave sea water pumps off in icy conditions.

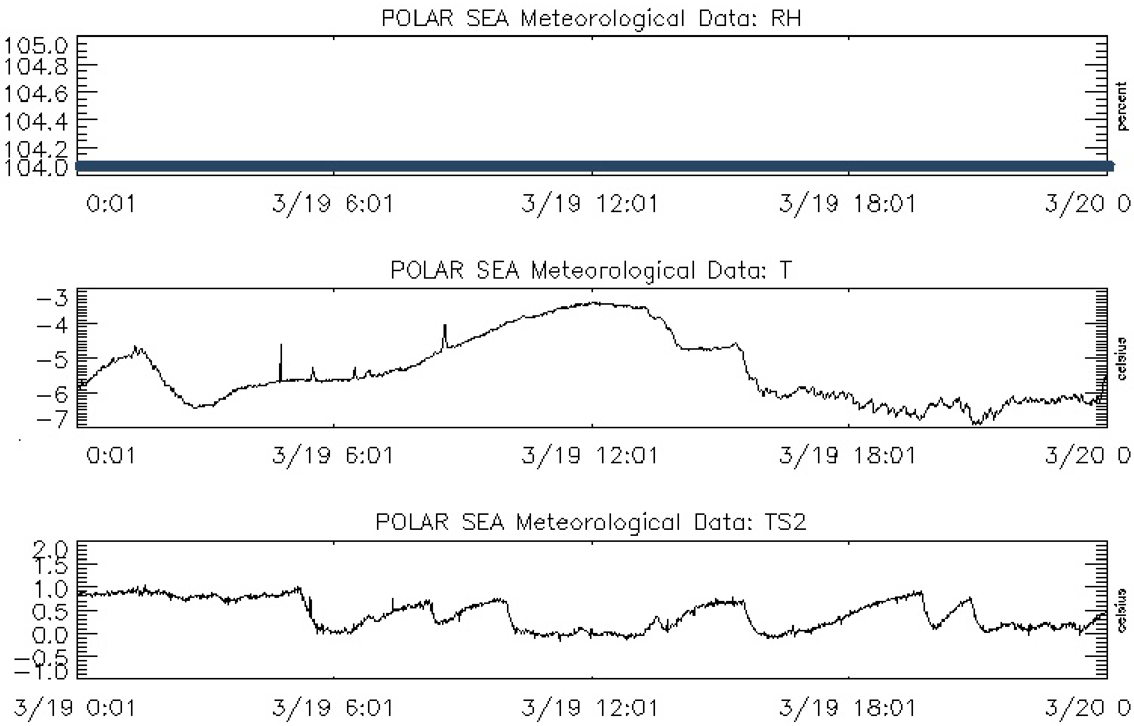


Figure 43: *Polar Sea* SAMOS data for 15 March 2010, from top: relative humidity (with out of bounds "B" flags applied by automated QC) – RH – air temperature – T – and sea temperature 2 – TS2.

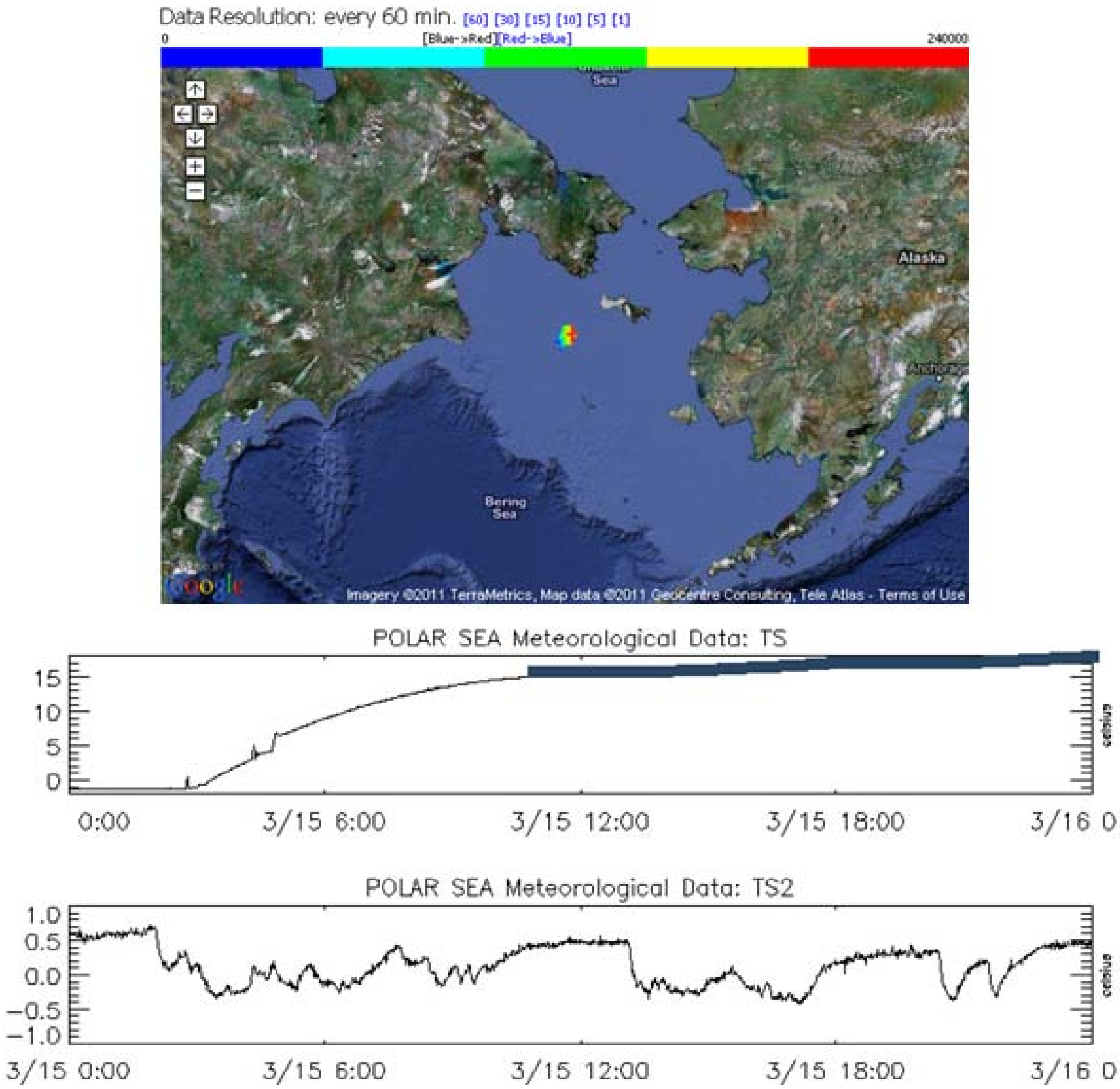


Figure 44: top: *Polar Sea* ship track for 15 March 2010, bottom: *Polar Sea* SAMOS data for 15 March 2010; sea temperature (with out of bounds "B" flags applied by automated QC) – TS – and sea temperature 2 – TS2.

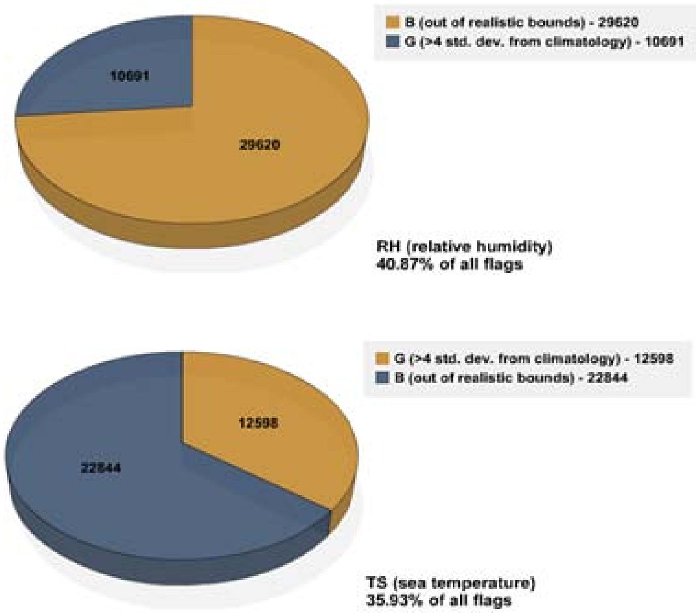


Figure 45: Distribution of SAMOS quality control flags for (top) relative humidity – RH – and (bottom) sea temperature – TS for the *R/V Polar Sea* in 2010.

Southern Surveyor

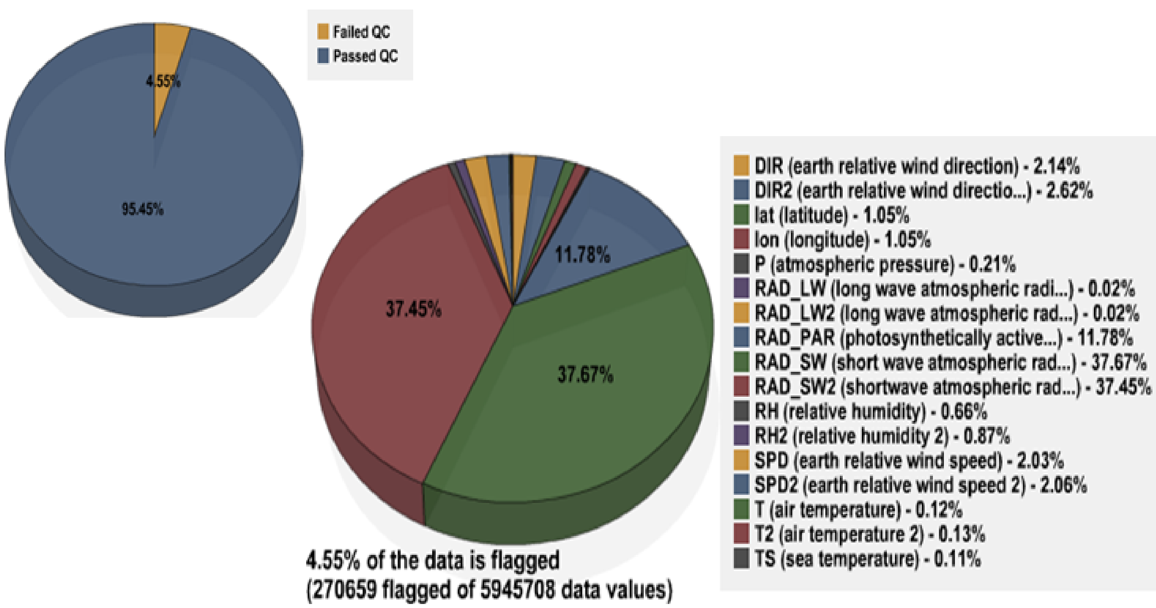


Figure 46: For the *Southern Surveyor* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Southern Surveyor* provided SAMOS data for 180 ship days, resulting in 5,922,533 distinct data values. After automated QC, 4.55% of the data was flagged using A-Y flags (Figure 46). This is a change of +0.32% from 2009 (4.23% flagged). NOTE: the *Southern Surveyor* does not receive visual quality control by the SAMOS DAC, so all of the flags are the result of automated QC (no research-level files exist at the SAMOS DAC for the *Southern Surveyor*).

Almost three quarters of the flags applied belong to the two short wave radiation parameters, and those are overwhelmingly of the out of bounds (B) variety (Figure 47). Interestingly, this is the exact statement that was made for the *Surveyor* in the 2009 SAMOS Data Quality Report, with very similar distribution of flag percentage between the two parameters. Upon inspection, though, it is apparent the B flags were once again applied to short wave radiation values slightly below zero. This is a common situation wherein the sensors are tuned for greater accuracy at much higher readings (see section 3b), and as such it is not surprising after all that the flag situation did not change much from 2009 to 2010. NOTE: The IMOS group at the Australian Bureau of Meteorology does conduct visual quality control and makes research quality data files for the *Southern Surveyor*.

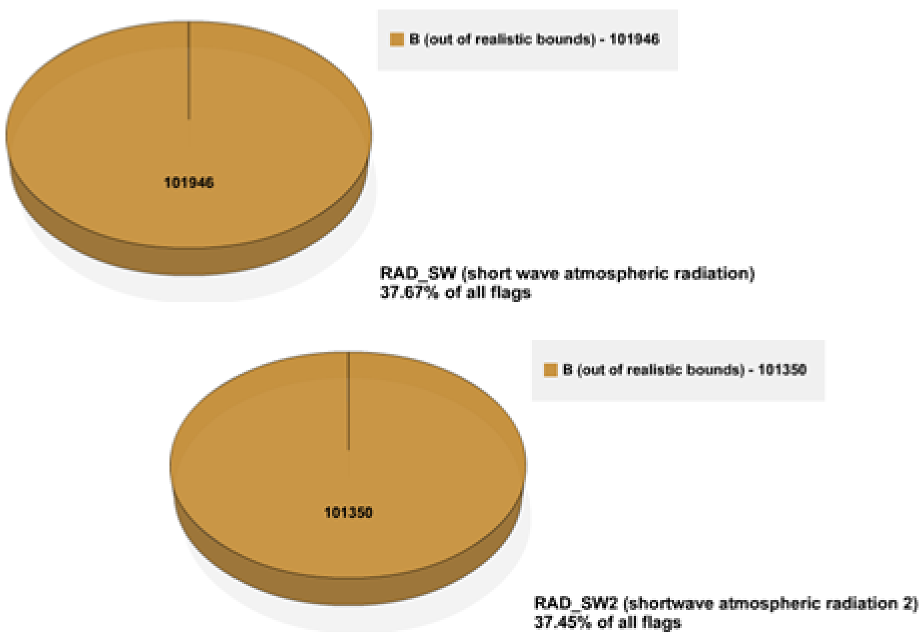


Figure 47: Distribution of SAMOS quality control flags for (top) shortwave atmospheric radiation – RAD_SW – and (bottom) short wave atmospheric radiation 2 – RAD_SW2 for the *R/V Southern Surveyor* in 2010.

Aurora Australis

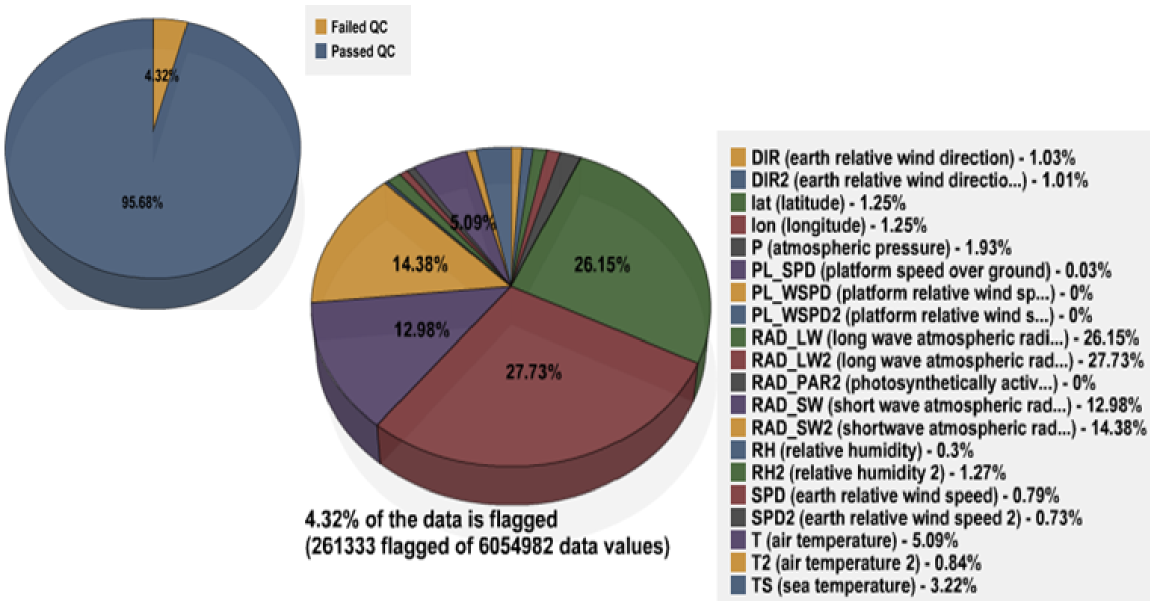


Figure 48: For the *Aurora Australis* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Aurora Australis* provided SAMOS data for 170 ship days, resulting in 6,054,982 distinct data values. After automated QC, 4.32% of the data was flagged using A-Y flags (Figure 48). 2010 is the first year in which SAMOS received data from the *Aurora Australis*. NOTE: the *Aurora Australis* does not receive visual quality control by the SAMOS DAC, so all of the flags are the result of automated QC (no research-level files exist at the SAMOS DAC for the *Aurora Australis*).

Roughly 80% of the flags applied belong to the two short wave (RAD_SW and RAD_SW2) and two long wave (RAD_LW and RAD_LW2) radiation parameters, and those are overwhelmingly of the out of bounds (B) variety (Figure 51). Upon inspection, it is apparent the short wave radiation B flags were applied to short wave radiation values slightly below zero (Figure 49, top two). This is a common situation wherein the sensors are tuned for greater accuracy at much higher readings (see section 3b). In the case of the long wave radiation parameters, the B flags were mainly applied to very small long wave radiation values (Figure 49, bottom two). However, the very small long wave radiation values and subsequent B flagging appears to have occurred exclusively prior to the *Australis's* layup period from 17 April to 20 October (Figure 50). This suggests to the author that there was some malfunction, or perhaps a unit conversion error, which was fixed during the layup period. NOTE: The IMOS group at the Australian Bureau of Meteorology does conduct visual quality control and makes research quality data files for the *Aurora Australis*.

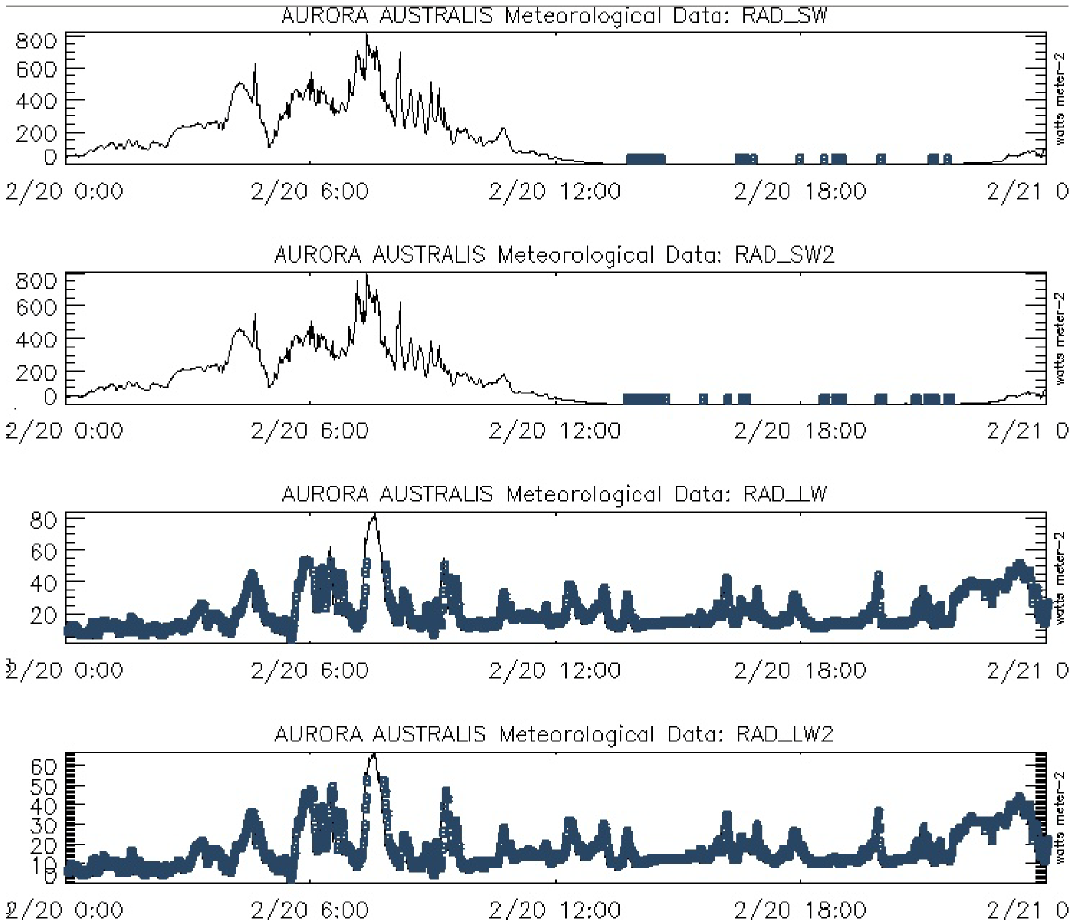


Figure 49: *Aurora Australis* SAMOS data for 20 February 2010: from top: short wave atmospheric radiation – RAD_SW – short wave atmospheric radiation 2 – RAD_SW2 – long wave atmospheric radiation – RAD_LW – and long wave atmospheric radiation 2 – RAD_LW2 (all with out of bounds "B" flags applied by automated QC).

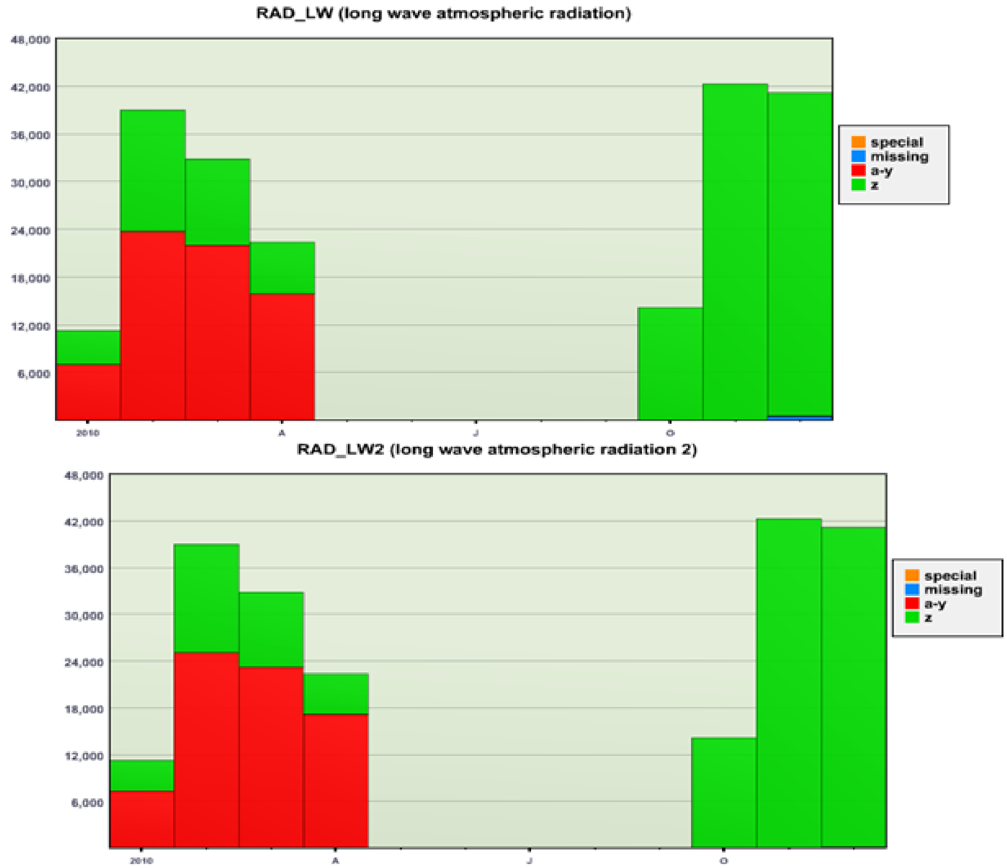


Figure 50: Total number of (top) long wave atmospheric radiation – RAD_LW – and (bottom) long wave atmospheric radiation 2 – RAD_LW2 – observations provided by *Aurora Australis* for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red).

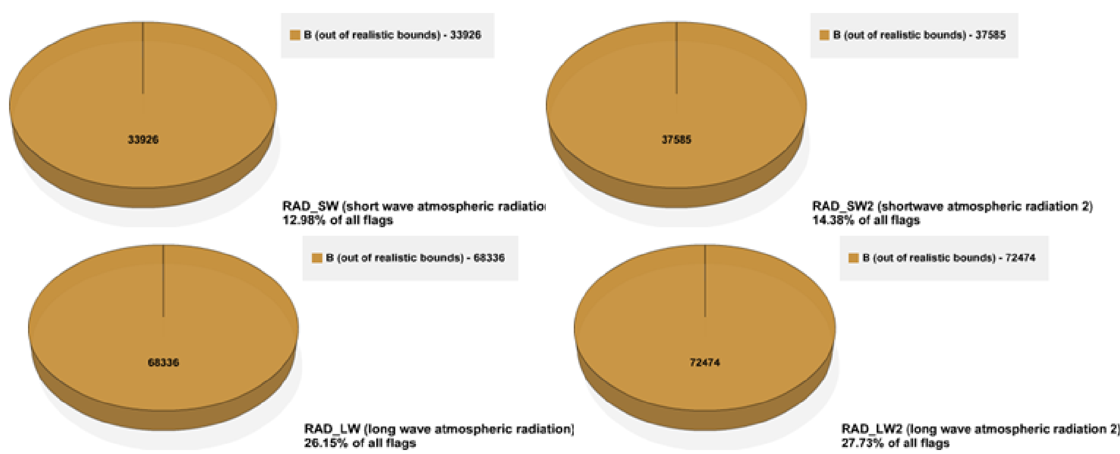


Figure 51: Distribution of SAMOS quality control flags for (top) shortwave atmospheric radiation – RAD_SW – and shortwave atmospheric radiation 2 – RAD_SW2 – and (bottom) long wave atmospheric radiation – RAD_LW – and long wave atmospheric radiation 2 – RAD_LW2 – for the *Aurora Australis* in 2010.

Nathaniel B. Palmer

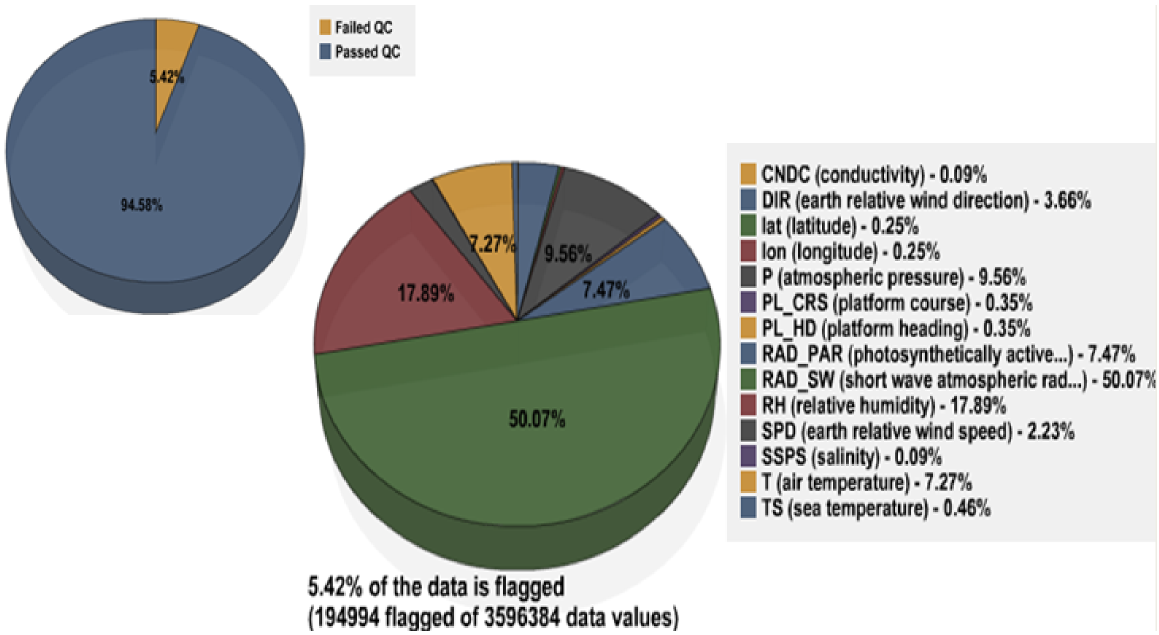


Figure 52: For the *Nathaniel B. Palmer* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Nathaniel Palmer* provided SAMOS data for 149 ship days, resulting in 3,596,384 distinct data values. After both automated and visual QC, 5.42% of the data was flagged using A-Y flags (Figure 52). This is a change of +2.87% from 2009 (2.55% flagged); however, as the *Palmer* did not receive visual QC in 2009 this number isn't very meaningful in diagnosing improved/diminished data quality.

By far, the largest portion of flags applied (~50%) were to short wave radiation (RAD_SW). This was the case in 2009 as well, and the issue was the same for both years – namely, out of bounds (B) flagging of short wave radiation values slightly below zero. This is a common consequence of tuning radiation sensors for better accuracy at much higher values (see Section 3b).

Another notable portion (18%) was given to relative humidity (RH), which was also very similar to the 2009 analysis. Both parameters received primarily out of bounds (B) flags. Upon inspection, the issue in both cases was primarily the incidental (and common) result of the sensors being tuned for greater accuracy within the more significant ranges (see Section 3b). However, RH also received caution/suspect (K) flags, as did air temperature (T) and atmospheric pressure (P) (Figure 53). Airflow obstruction is suspected in most cases, as the *Palmer* is an ice-capable research vessel that houses a large superstructure with the primary instrument mast located amidships. Accurate metadata and a detailed flow analysis of the *Palmer* would go a long way towards verifying this conjecture, but the data analyst did note that both T and RH in particular showed signs of airflow obstruction whenever the platform relative wind direction was approximately 180 degrees (i.e. a tail wind).

Regarding the photosynthetically active radiation (RAD_PAR) parameter, the applied flags were exclusively B flags. This was a direct result of incorrect metadata that caused the application of incorrect unit conversion. Through extensive email communication between ship personnel and SAMOS data analysts, the problem was finally identified and corrected as of 15 February 2010.

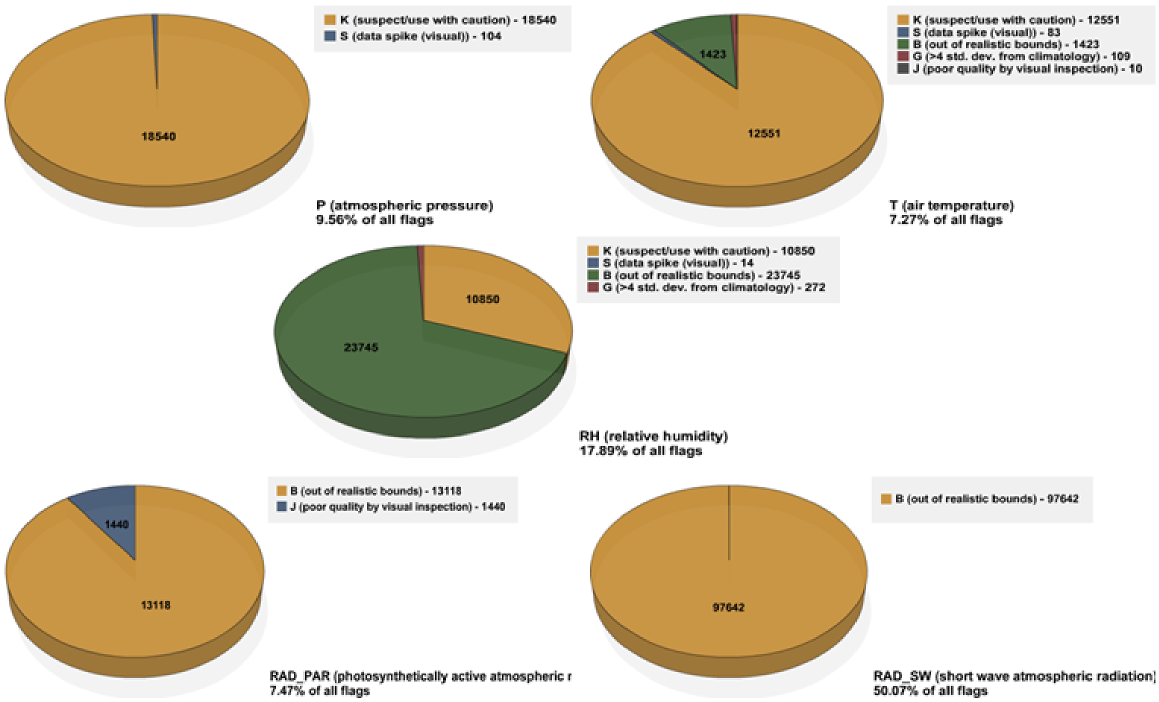


Figure 53: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – and air temperature – T – (middle) relative humidity – RH – and (bottom) photosynthetically active atmospheric radiation – RAD_PAR – and short wave atmospheric radiation – RAD_SW for the *R/V Nathaniel B. Palmer* in 2010.

Laurence M. Gould

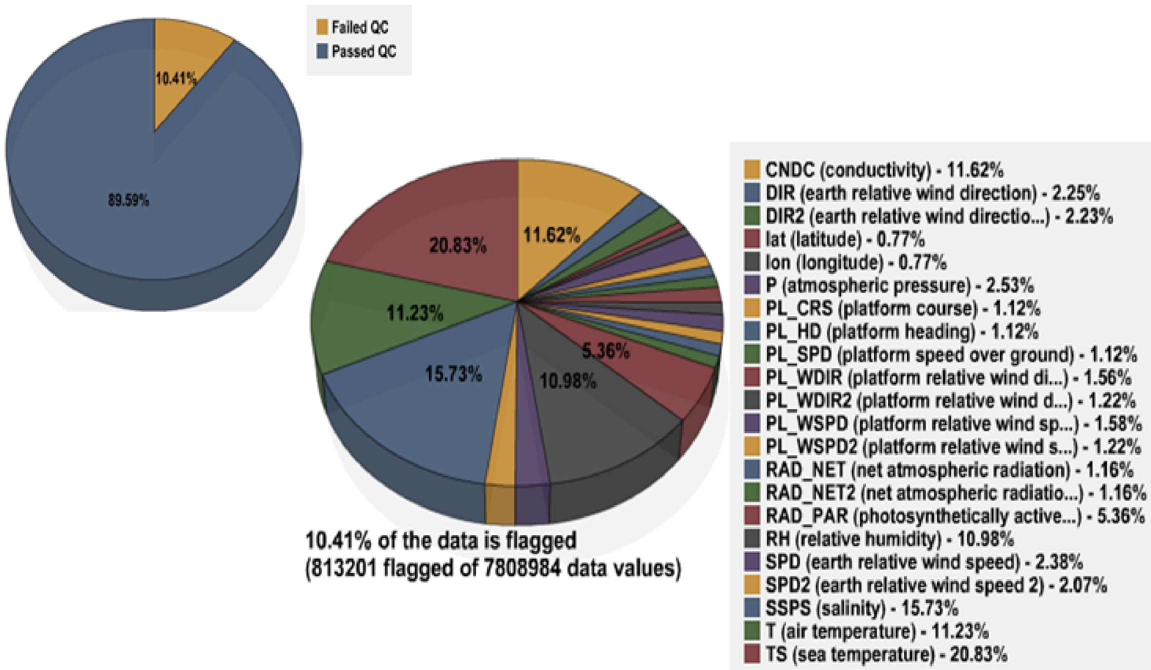


Figure 54: For the *Laurence M. Gould* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Laurence M. Gould* provided SAMOS data for 246 ship days, resulting in 7,808,984 distinct data values. After both automated and visual QC, 10.41% of the data was flagged using A-Y flags (Figure 54). This is a change of +1.82% from 2009 (8.59% flagged). This increase may simply be due to the addition of the sea surface salinity (SSPS) and conductivity (CNDC) parameters in 2010, which earned flag percentages of ~16% and ~12%, respectively.

The logic behind the air temperature (T) and relative humidity (RH) flag percentages remains largely unchanged from 2010: namely, that the location and exposure of the instruments on the *Gould* contribute to problems with the atmospheric observations. This is once again evident in the temperature and relative humidity parameters, which each received approximately 11% of the flags – mainly caution/suspect (K) flags (Figure 55, top row). The T/RH sensor is located low on the mid-ship instrument mast, which is located aft of the vessel stack and main superstructure. In addition to being poorly exposed to the free atmosphere when the winds are from the forward portion of the vessel, some ship relative wind angles will contaminate the T/RH sensor with the ship's exhaust (typically resulting in increased T and RH values). However, T and RH each also received a number of poor quality (J) flags. These were mainly applied between 9 June and 11 June, when the sensors reported static values (cause undetermined).

Exactly as noted in 2009, sea temperature (TS) received the largest portion of the flags (~21%) in 2010, mostly poor quality (J) flags (Figure 55, middle); however, the authors note once again that the *Gould* often reports SAMOS data while they are in port. Because *Gould*'s sea temperature sensor is commonly switched off while in port (resulting in a static value), this accounts for a very large portion of those J flags. This is also the case for SSPS and CNDC, each of which received almost exclusively J flags (Figure 55, bottom row).

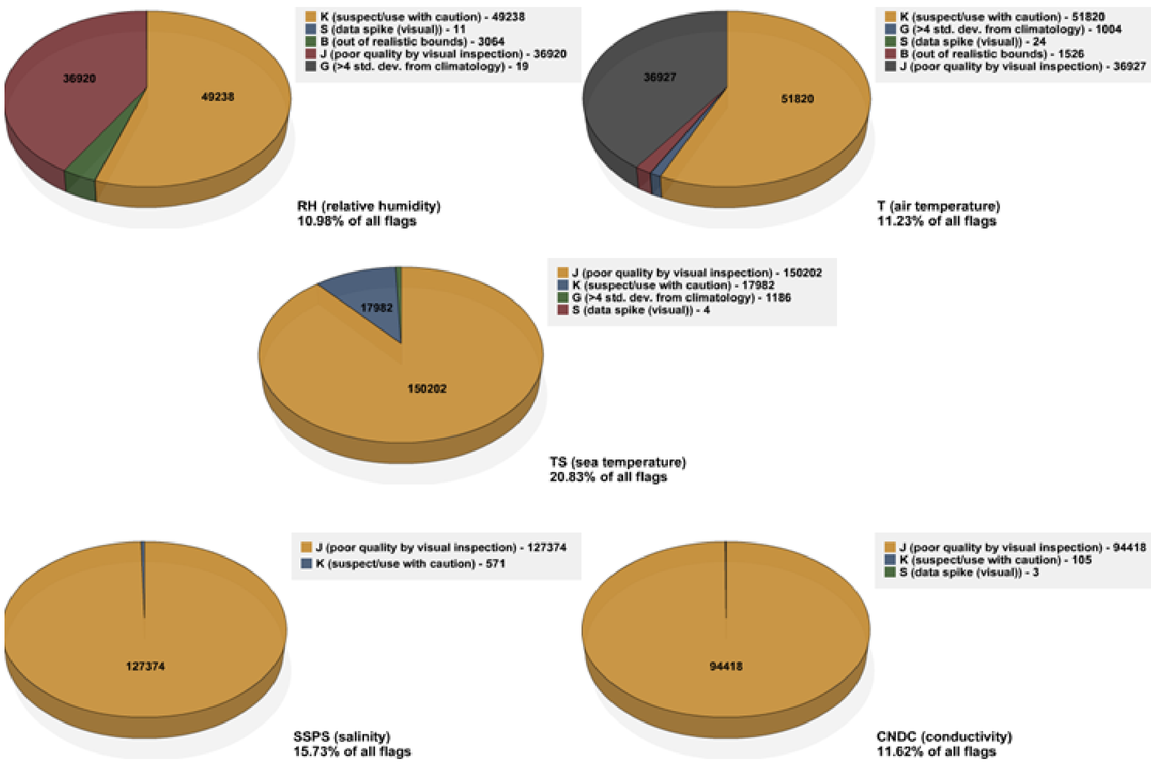


Figure 55: Distribution of SAMOS quality control flags for (top) relative humidity – RH – and air temperature – T – (middle) sea temperature – TS – and (bottom) salinity – SSPS – and conductivity – CNDC – for the *R/V Lawrence M. Gould* in 2010.

Kilo Moana

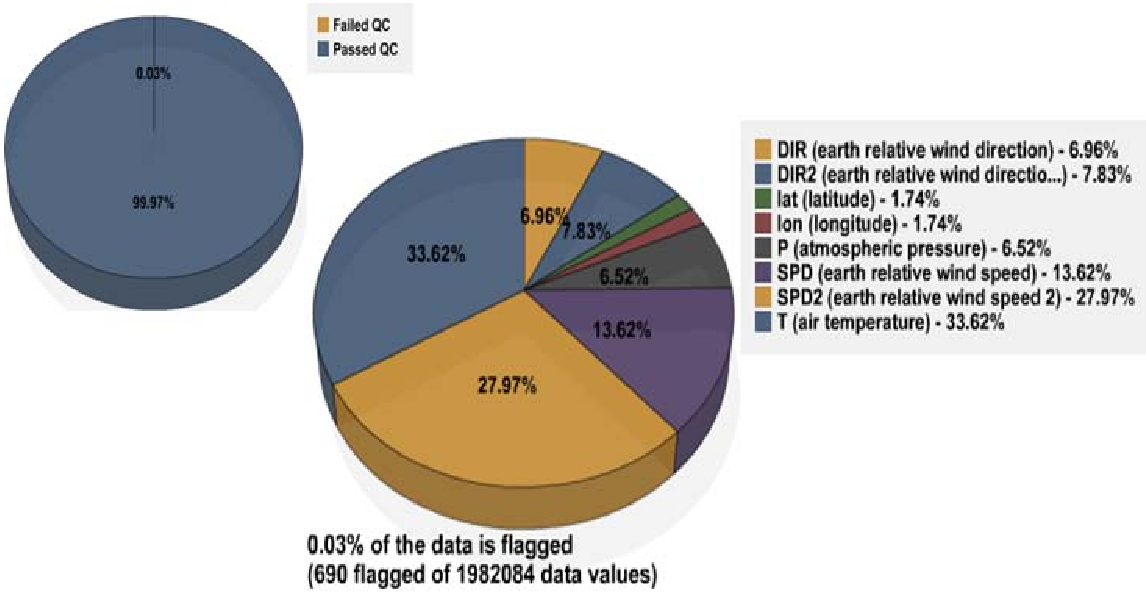


Figure 56: For the *Kilo Moana* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Kilo Moana* provided SAMOS data for 66 ship days, resulting in 1,982,084 distinct data values. After automated QC, 0.03% of the data was flagged using A-Y flags (Figure 56), far and away the lowest flag percentage among all SAMOS vessels. However, due to funding constraints, the *Kilo Moana* does not receive visual QC, which is when the bulk of quality control flags are usually applied. As such, the authors cannot determine the cause of limited number (690) of flagged data values. Hopefully resources can be secured in the future for visual QC.

Atlantic Explorer

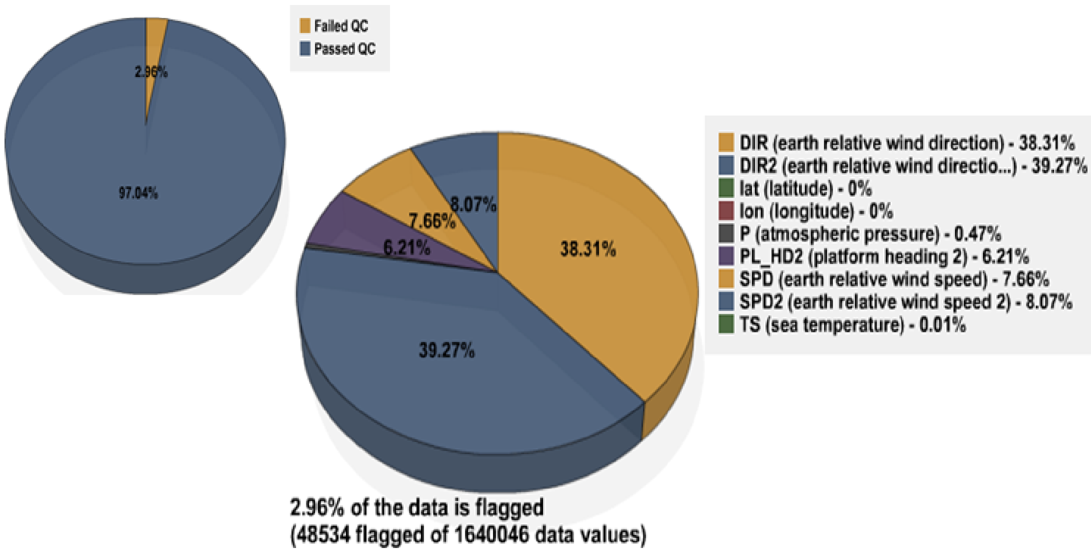


Figure 57: For the *Atlantic Explorer* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Atlantic Explorer* provided SAMOS data for 73 ship days, resulting in 1,640,046 distinct data values. After automated QC, 2.96% of the data was flagged using A-Y flags (Figure 57). This is a notably low percentage of flagged values, but it is important to note that the *Atlantic Explorer*, like the *Kilo Moana*, does not receive visual QC (due to a lack of funding), which is when the bulk of flags are usually applied. Perhaps more telling of the *Atlantic Explorer's* actual data quality is the fact that the majority of the flags (nearly 80%, combined) were applied to the two earth relative wind direction parameters (DIR and DIR2). The flags applied were exclusively failing the true wind test (E) flags (Figure 58).

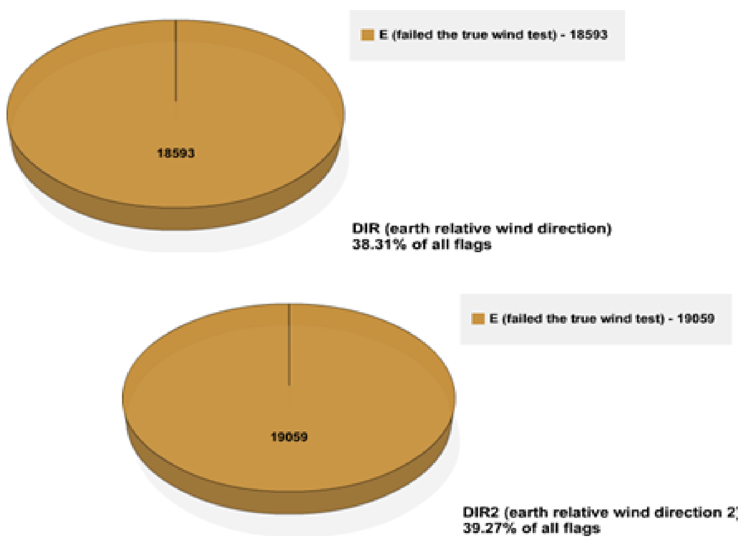


Figure 58: Distribution of SAMOS quality control flags for (top) earth relative wind direction – DIR – and (bottom) earth relative wind direction 2 – DIR2 –for the *Atlantic Explorer* in 2010.

Henry B. Bigelow

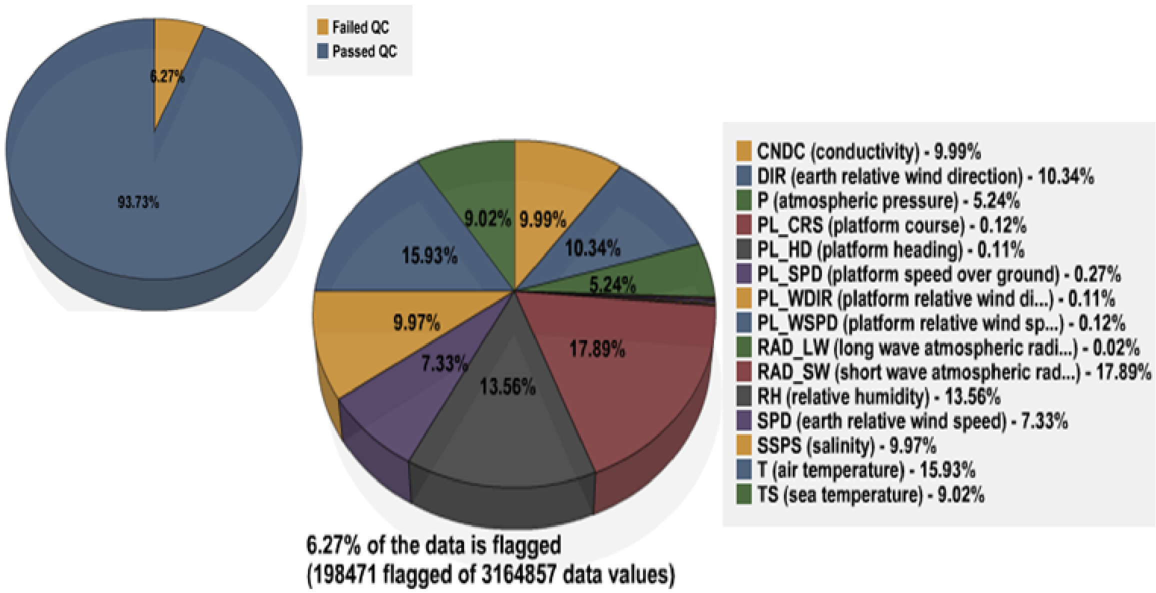


Figure 59: For the *Henry B. Bigelow* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Henry Bigelow* provided SAMOS data for 143 ship days, resulting in 3,164,857 distinct data values. After both automated and visual QC, 6.27% of the data was flagged using A-Y flags (Figure 59). This is a change of -1.97% from 2009 (8.24% flagged), suggesting modest improvement. Indeed, the problem of frequent aberrant behavior of the atmospheric pressure (P) sensor present in 2009 appears to have been corrected, or at least greatly reduced, in 2010; the flag percentage for P dropped to a scant 5.24%. Upon inspection, the flagged P values (mostly caution/suspect (K), not shown in Figure 60) appear to have been caused by the more typical airflow obstruction and/or platform speed change related issues. Again, digital imagery of the sensor's location and more complete metadata for the sensor would help in diagnosing the issue.

Air temperature (T) and relative humidity (RH) also showed signs of a fair amount of airflow obstruction, which resulted in primarily K flagging to the tune of ~16% (T) and ~13.5% (RH) of the total flags (Figure 60, top row). The remainder of the flags applied to the MET and oceanographic sensors are fairly evenly distributed, suggesting no major problems with those sensors. However, the greatest remaining percentage of flags was applied to the short wave radiation (RAD_SW) parameter. Being primarily out of bounds (B) flags, though, this percentage (~18%) is not particularly troublesome (Figure 60, bottom); the B flags, similarly to many other SAMOS vessels, are applied mainly to the slightly negative short wave values that result from tuning the sensor for optimal performance at much higher values (see Section 3b).

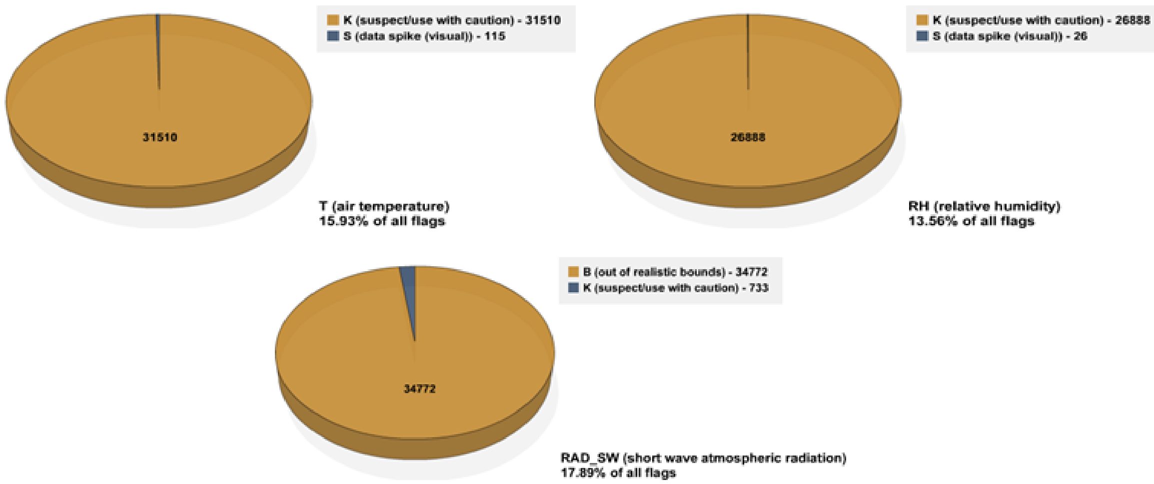


Figure 60: Distribution of SAMOS quality control flags for (top) air temperature – T – and relative humidity – RH – and (bottom) short wave atmospheric radiation – RAD_SW – for the *Henry B. Bigelow* in 2010.

Okeanos Explorer

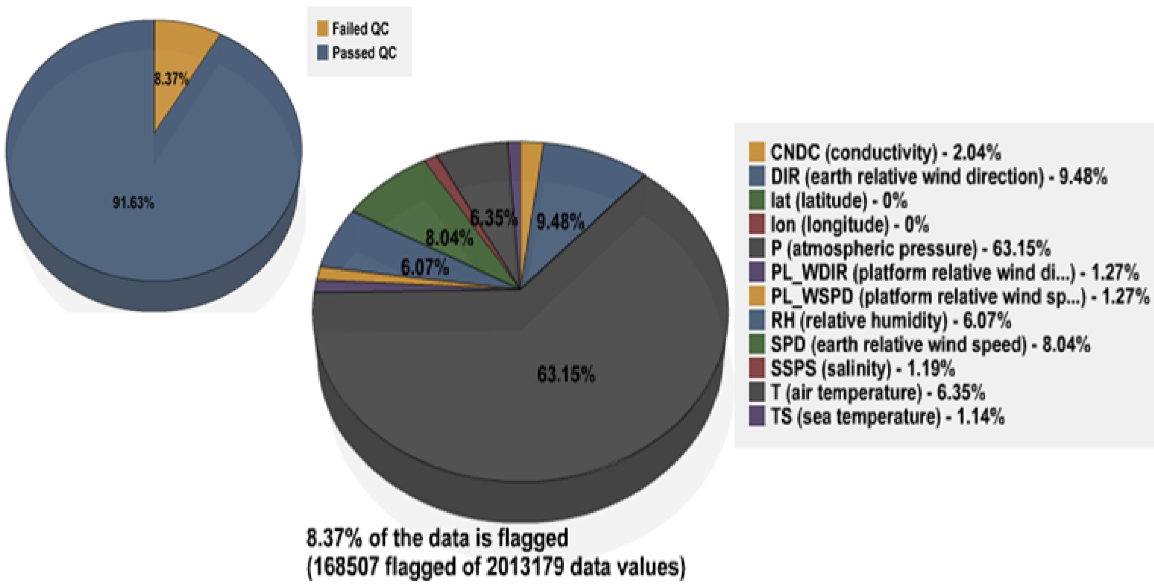


Figure 61: For the *Okeanos Explorer* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Okeanos Explorer* provided SAMOS data for 97 ship days, resulting in 2,013,179 distinct data values. After both automated and visual QC, 8.37% of the data was flagged using A-Y flags (Figure 61). This is a deviation of -3.89% from 2009 (12.26% flagged), a fairly substantial improvement.

Overwhelmingly, the *Explorer's* largest data quality problem occurred with the atmospheric pressure (Figure 64), holding ~63% of the total flags (as compared to ~52% in 2009). Pressure readings were again consistently and unquestionably too high for their geographic location (refer to Figure62), resulting in habitual poor quality (J) and, less frequently, suspect/caution (K) flagging. Wherever possible, this assumption of bias continued to be verified by comparing the pressure reading from the *Explorer* to any nearby buoy or land-based pressure readings or available gridded SLP fields. Additionally, the SAMOS auto flagger frequently assigned G flags denoting pressure values greater than four standard deviation from the local climatology, which in most cases were changed to the more appropriate J and K flags during visual QC. However, this problem appears to have been addressed on 26 May 2010 at which time there was an abrupt shift in the data (refer to Figure 62), and after which time P values were consistently much more meteorologically appropriate (as evidenced by Figure 63). As metadata for the sensor was not modified and no word was received from ship personnel, the authors can only assume the technicians physically addressed the issue (it's extremely unlikely the sensor somehow corrected itself!). It's also noteworthy that *Okeanos Explorer* personnel provided new metadata for most sensors a year later in March 2011. The pressure sensor, in particular, was reported in an entirely new vessel location. The authors noted in 2009 that the problem with the pressure data may have been associated with what looked to be a very poor exposure of the pressure port, so this relocation may also have contributed to the improved P data, depending on when the relocation actually took place.

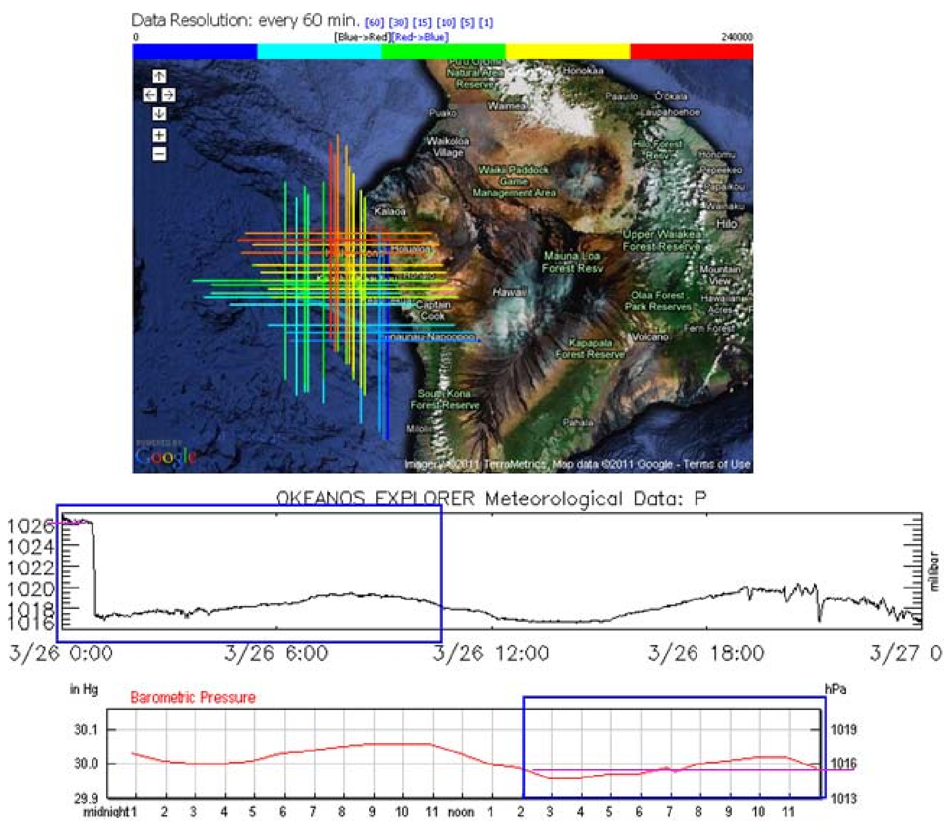


Figure 62: (top) *Okeanos Explorer*'s ship track for 26 March 2010; (middle) *Okeanos Explorer* SAMOS pressure data for 26 March 2010, as compared to (bottom) historical pressure data for 26 March 2010 at nearby Kona International Airport (photo courtesy http://www.wunderground.com/history/airportfrompws/PHKO/2010/3/25/DailyHistory.html), matching time frames boxed in blue. Note the initial 10+ mb discrepancy (denoted at pink lines) prior to the drop at approximately 0100 UTC into a reasonable range.

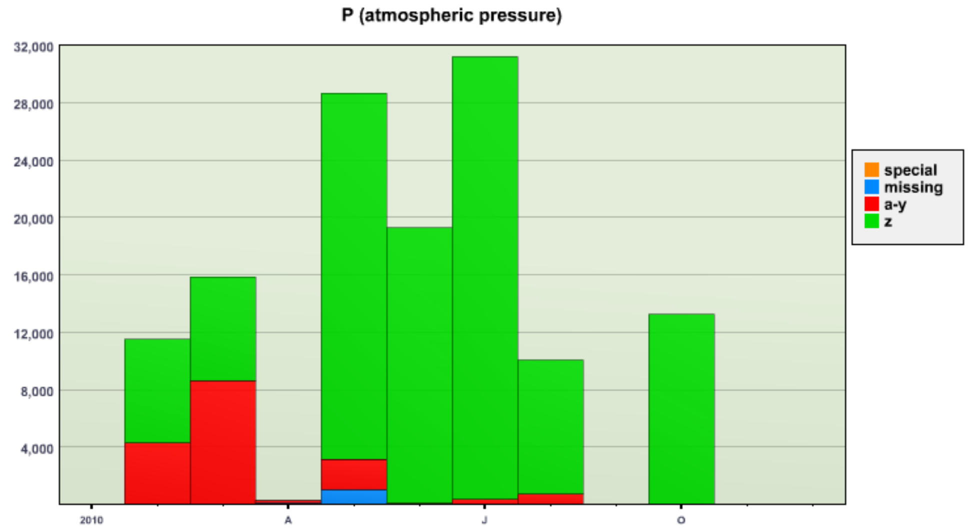


Figure 63: Total number of atmospheric pressure – P – observations provided by *Okeanos Explorer* for each month in 2010. The colors represent the number of good (green) values versus the values that failed one of the SAMOS QC tests (red). (Values noted as missing or special values by the SAMOS processing are also marked in blue and orange, respectively.)

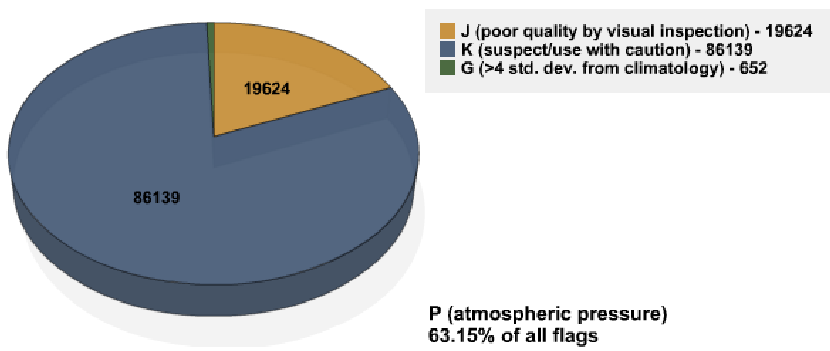


Figure 64: Distribution of SAMOS quality control flags for atmospheric pressure – P for the *R/V Okeanos Explorer* in 2010.

Pisces

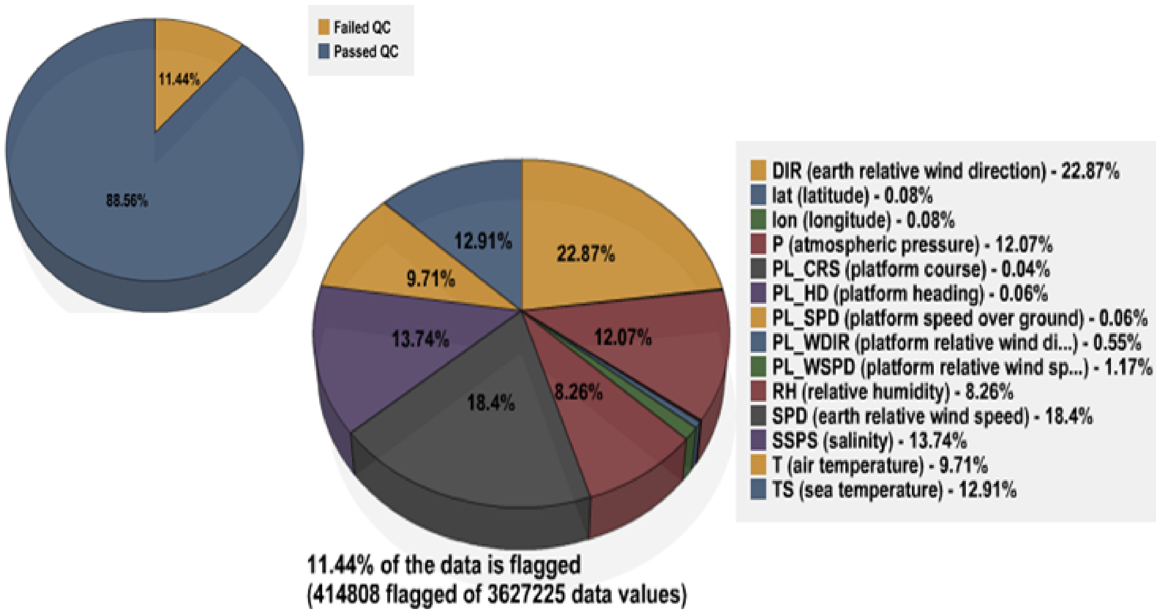


Figure 65: For the *Pisces* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Pisces* provided SAMOS data for 195 ship days, resulting in 3,627,225 distinct data values. After both automated and visual QC, 11.44% of the data was flagged using A-Y flags (Figure 65). 2010 marks the first year in which SAMOS fully processed and applied visual QC to *Pisces* data, although there were a very small number of files received for dates in October/November 2009. The 2009 files, however, were not received until May of 2010, which is why they were never fully processed.

Pisces wind data was among the least reliable of vessels reporting to SAMOS. Indeed, earth relative wind speed and direction received the highest percentage of flags for the *Pisces*, totaling a combined ~40% of all flags. Most of the flags applied to earth relative wind data were caution/suspect (K) flags (Figure 68, middle row). Upon inspection, the causes varied: most notably airflow-obstruction occurred for multiple platform relative wind directions (e.g., Figure 66) as well as suspected problems related to the performance of the platform relative wind direction sensor itself (as seen in Figure 67), from which sensor the earth relative wind parameters are partially derived. However, without adequate metadata or digital imagery of the vessel, it is difficult to adequately diagnose any of these problems. It should be noted, though, that these wind issues were specifically communicated to NOAA personnel in November 2010 during a SAMOS/NOAA teleconference. It is expected that the issues will be addressed or at least investigated sometime in 2011.

Atmospheric pressure (P) also received a substantial portion of the total flags, mostly of the K variety (Figure 68, top). Upon inspection, it appears that the atmospheric pressure sensor also suffers from airflow obstruction, although again more detailed metadata are needed to accurately diagnose the condition.

Finally, sea temperature and sea surface salinity appear to share the common situation wherein a fresh supply of sea water is frequently cut off from the thermosalinograph while the vessel is in port or otherwise not moving, resulting in a number of K and J flags (Figure 68, bottom row). The authors also would like to stress that conductivity is not reported from the *Pisces*, although it is presumably available from the same thermosalinograph that provides the salinity data. Adding the conductivity parameter to the *Pisces* data set would be highly desirable in 2011.

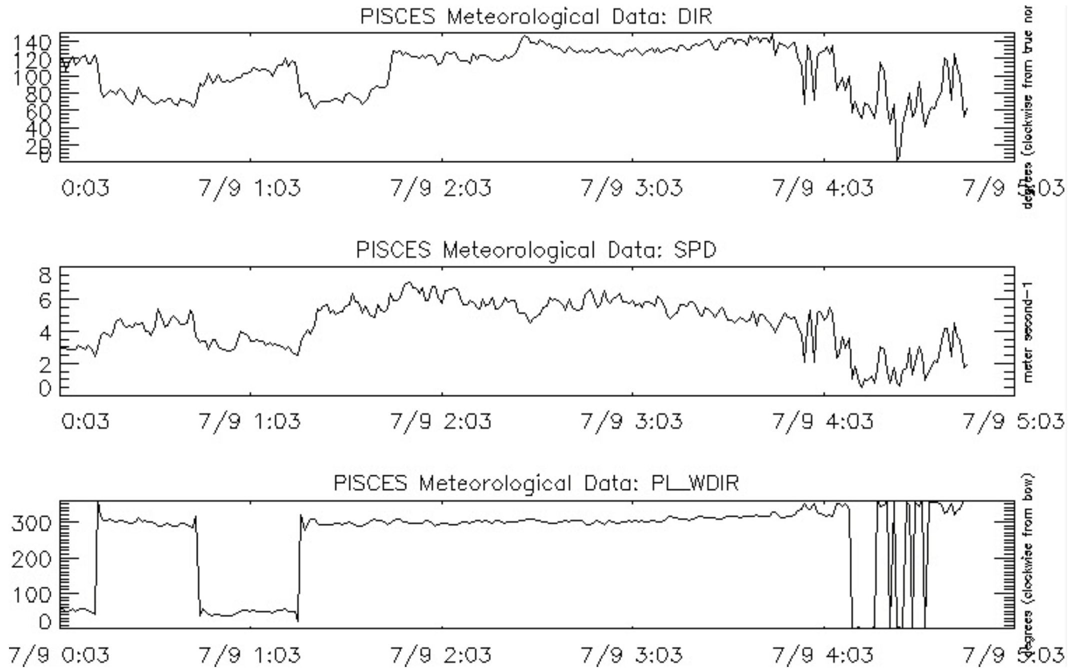


Figure 66: *Pisces* SAMOS data for 9 July 2010: from top: earth relative wind direction – DIR – earth relative wind speed – SPD – and platform relative wind direction – PL_WDIR.

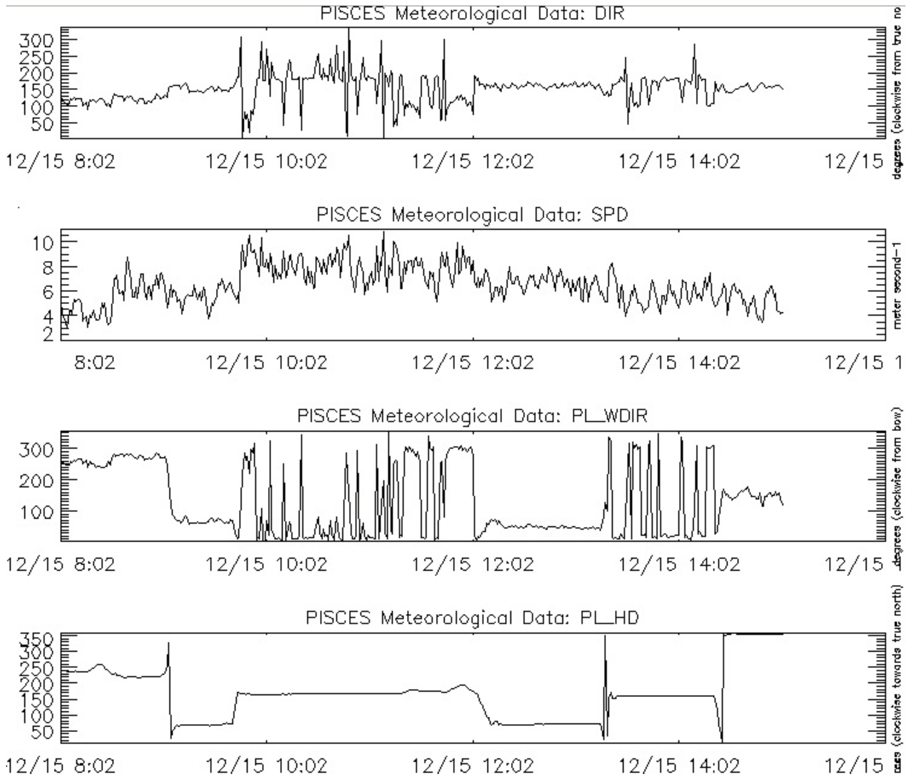


Figure 67: *Pisces* SAMOS data for 15 December 2010, from top: earth relative wind direction – DIR – earth relative wind speed – SPD – platform relative wind direction – PL_WDIR – and platform heading – PL_HD.

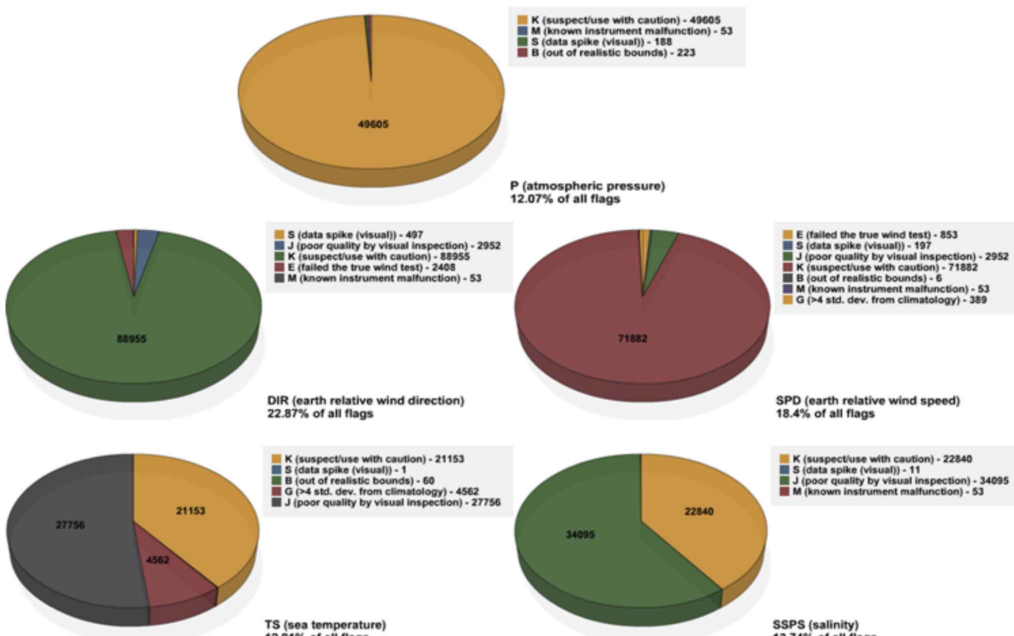


Figure 68: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – (middle) earth relative wind direction – DIR – and earth relative wind speed – SPD – and (bottom) sea temperature – TS – and salinity – SSPS – for the *Pisces* in 2010.

Miller Freeman

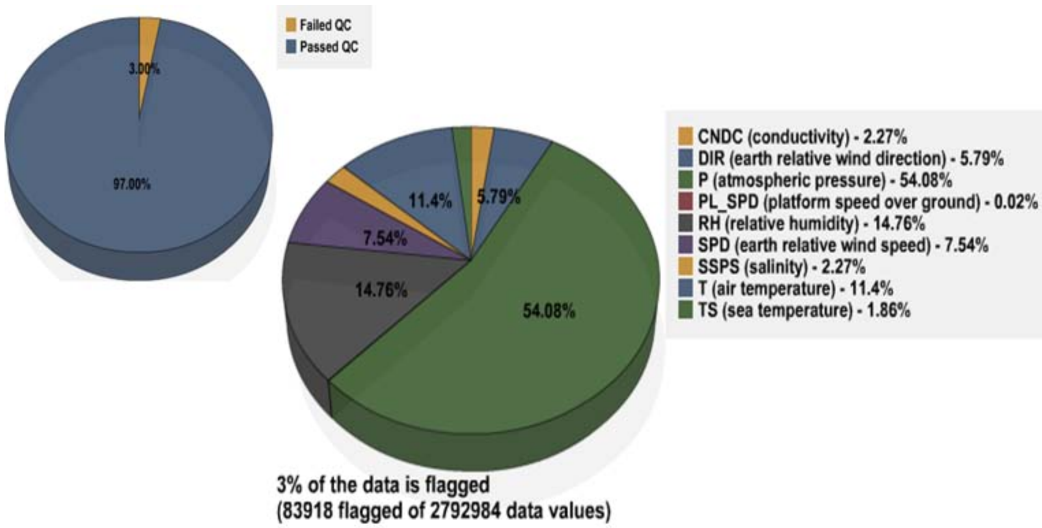


Figure 69: For the *Miller Freeman* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Miller Freeman* provided SAMOS data for 135 ship days, resulting in 2,792,984 distinct data values. After both automated and visual QC, 3% of the data was flagged using A-Y flags (Figure 69). This is a deviation of -0.04% from 2009 (3.04% flagged). It is well worth noting the *Freeman* has the lowest flag percentage of all vessels receiving visual QC in 2010. (In 2009, the *Freeman* was surpassed in terms of perceived data quality only by the vessel *Nathaniel B. Palmer*, which did not receive visual QC in 2009, and the vessel *Fairweather*, which contributed only one ship day of data in 2009.)

Overwhelmingly, the largest portion of the *Freeman's* flagged data is held by the atmospheric pressure parameter, with mostly suspect/caution (K) flags (Figure 70). As that sensor is still located inside the bridge with a window reportedly always left open, the pressure readings are likely usually affected by the platform speed, probably in a Bernoulli-type action within the cabin. This problem could be easily solved by adding an exterior pressure port connected to the barometer by flexible tubing (a common arrangement on other research vessels). This possible solution was re-iterated to NOAA personnel during a SAMOS/NOAA teleconference held in November 2010.

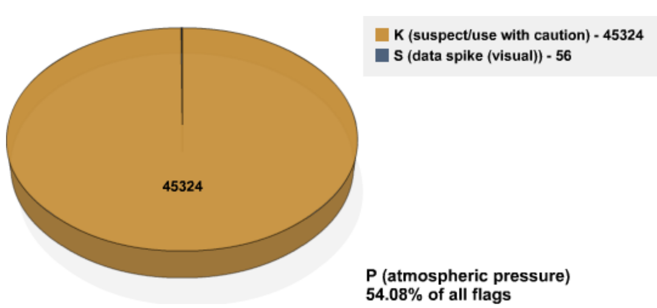


Figure 70: Distribution of SAMOS quality control flags for atmospheric pressure – P –for the *R/V Miller Freeman* in 2010.

Oregon II

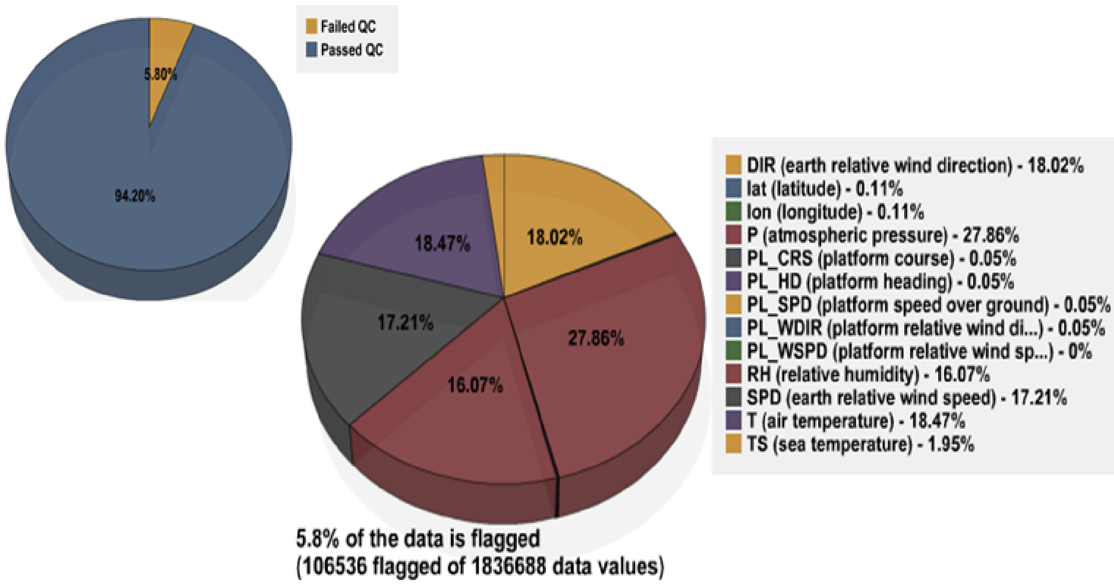


Figure 71: For the *Oregon II* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oregon II* provided SAMOS data for 99 ship days, resulting in 1,836,688 distinct data values. After both automated and visual QC, 5.8% of the data was flagged using A-Y flags (Figure 71). This is a deviation of -0.37% from 2009 (6.17% flagged), inching the *Oregon II* closer to the < 5% flagged threshold regarded by SAMOS to represent "very good" data.

Atmospheric pressure (P) received the largest percentage of flags (~28%). Most of these flags were caution/suspect (K) flags (Figure 72), with no specific issues overtly recognizable in the data. Regarding the remaining MET parameters, once again, as was pointed out in the 2009 report, when combined with the relatively low total flag percentage and the fact that most of the flags are K flags (not shown) one intriguing possibility exists regarding the fairly even distribution of these flags: the authors can surmise that no severe flow obstruction and/or stack exhaust contamination issues exist with the *Oregon II*. Again, if this conjecture is accurate, it might imply the *Oregon II* is a model vessel for ideal sensor placement. However, no digital imagery exists in the SAMOS database for the *Oregon II* and location metadata for all meteorological parameters is unavailable. Further, as the metadata for the pressure sensor did not change in 2010, it is suspected that the slightly larger percentage of flags is merely coincidence or perhaps evidence that a routine re-calibration is needed.

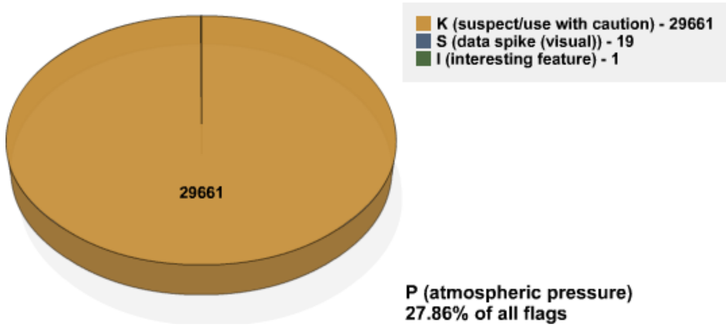


Figure 72: Distribution of SAMOS quality control flags for atmospheric pressure – P –for the *R/V Oregon II* in 2010.

Fairweather

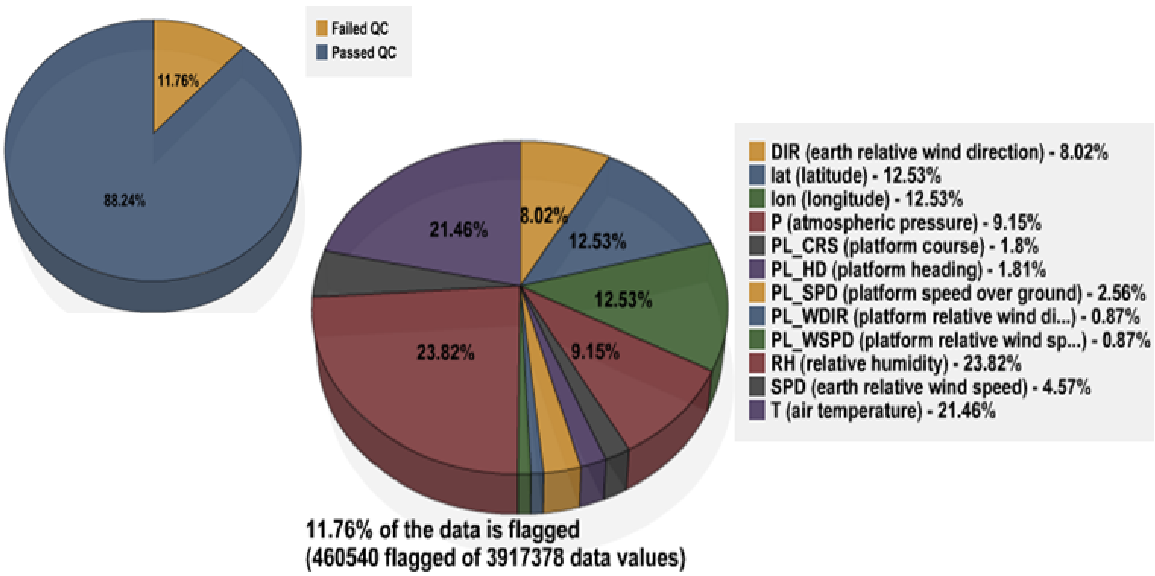


Figure 73: For the *Fairweather* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Fairweather* provided SAMOS data for 221 ship days, resulting in 3,917,378 distinct data values. After both automated and visual QC, 11.76% of the data was flagged using A-Y flags (Figure 73). This is a deviation of +9.34% from 2009 (2.42% flagged). While this is a very large change, the authors remind the reader that the *Fairweather* provided data for only one ship day in 2009 and, thus, the comparison to 2009 is not a fair one.

The *Fairweather* exhibited problematic air temperature (T) and relative humidity (RH) readings, as evidenced by their ~21.5% and ~24% flag percentages, respectively. One problem appeared to be a multitude of airflow-obstructed platform relative wind directions; characteristic "steps" (usually flagged with caution/suspect (K) flags) correlating to specific platform relative wind directions were frequently seen in the T/RH data. In fact, this airflow obstruction issue is also seen in the other MET parameters, likely being the major contributor to those flag percentages. Another larger problem with T/RH, however, was a catastrophic failure of the T and RH sensors. As seen in Figure 74, on 17 November at around 1900 UTC the values of T and RH dropped suddenly into meteorologically unrealistic ranges and remained there for the duration of *Fairweather's* 2010 SAMOS data transmission, which terminated after 19 December. As a result, out of bounds (B) flags were automatically applied to T by the auto flagger, and primarily poor quality (J) flags were applied to RH by the data analyst. As the vessel was most likely in port during this time, it's probable the failure was a result of either sensor testing or actual sensor removal, which often causes very irregular behavior if the sensor interfaces are not properly disconnected. But the reason a port stay isn't quite confirmed is that the latitude (LAT) and longitude (LON) parameters actually experienced a problem of their own, reporting values that were over land This resulted in the volume of land error (L) flags applied to each (Figure 76, bottom row). Often in narrow waterways LAT and LON will erroneously be assigned L flags by the auto flagger simply because the SAMOS land mask was too coarse to resolve the area, but in this case even Google maps (which has a much finer resolution) shows the position as being on land (Figure 75). This strongly suggests these navigational sensors require calibration or perhaps a software update.

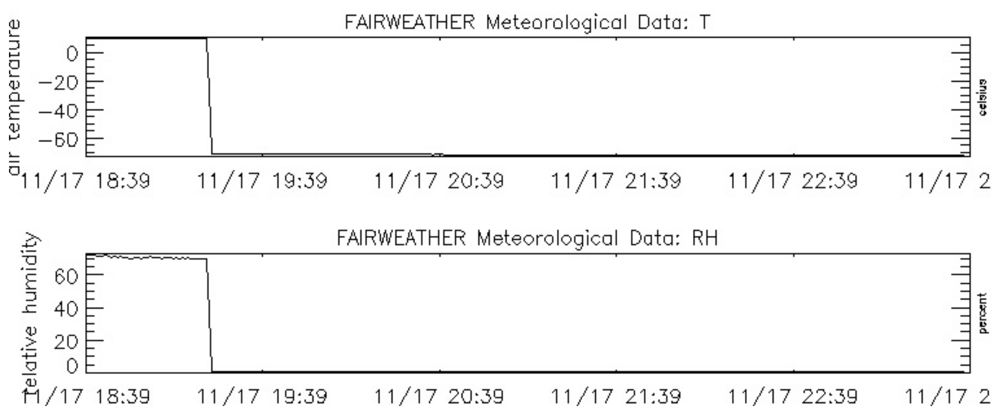


Figure 74: *Fairweather* SAMOS data for 17 November 2010, from top: air temperature – T – and relative humidity – RH.

Figure 75: *Fairweather's* reported location (at red crosshatch) on 17 November 2010.

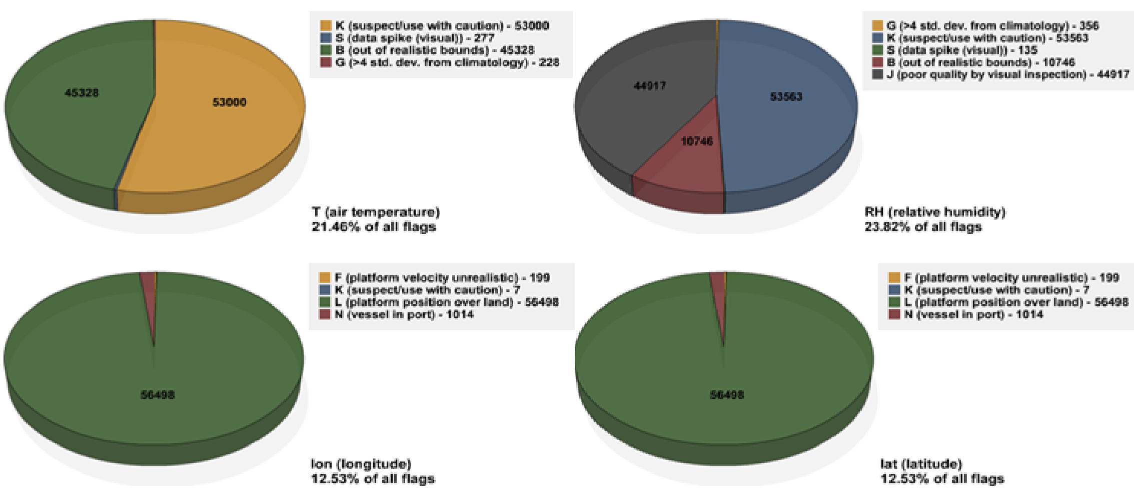


Figure 76: Distribution of SAMOS quality control flags for (top) air temperature – T – and relative humidity – RH – and (bottom) longitude – LON – and latitude – LAT – for *Fairweather* in 2010.

Ronald H. Brown

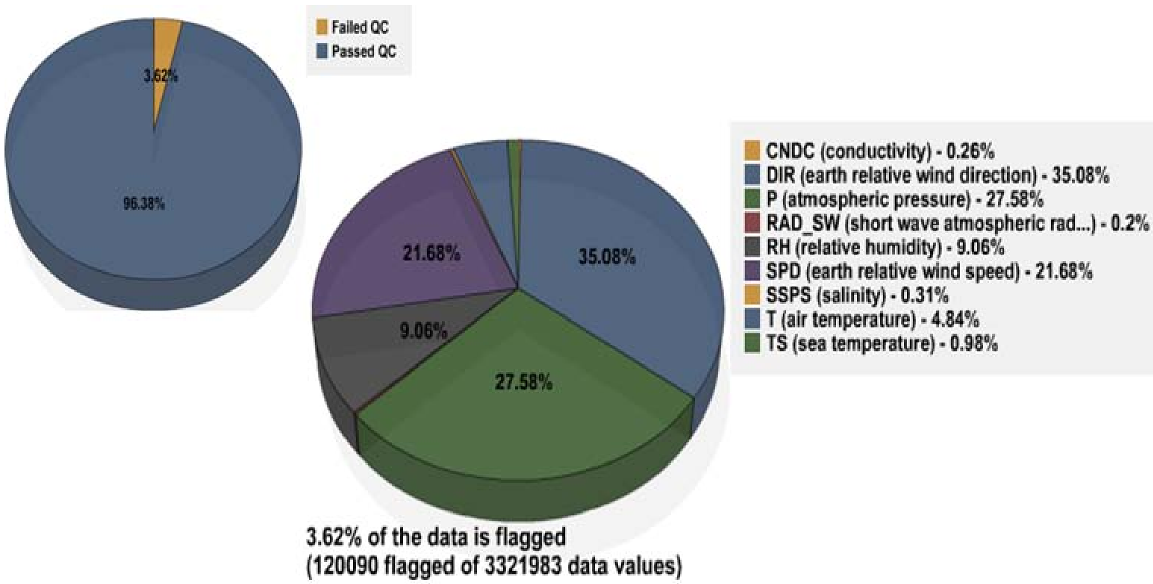


Figure 77: For the *Ronald H. Brown* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The SAMOS data center has a long history of evaluating the data quality for the *Ron Brown*. A number of previous discussions with the vessel technicians had resulted in great improvements to the vessel's data quality. In 2010 the *Ron Brown* provided SAMOS data for 151 ship days, resulting in 3,321,983 distinct data values. After both automated and visual QC, 3.62% of the data was flagged using A-Y flags (Figure 77). This is a deviation of a scant +0.28% from 2009 (3.34% flagged). The *Ron Brown* remains in third place for lowest flag percentage of all SAMOS vessels receiving visual QC in 2010.

Quite similar to 2009, the three variables most frequently failing SAMOS QC in 2010 (Figure 78) were the earth relative wind direction (DIR), earth relative wind speed (SPD), and atmospheric pressure (P). The authors suspect again for 2010 that flow obstruction is the most likely cause of the problems. Since recruitment into SAMOS, the metadata for most all sensors is incomplete for the *Ron Brown* and no recent digital imagery exists in the database to ascertain the current location of the sensors. Therefore, the authors cannot confirm our suspicions as to the source of the QC flags during 2010.

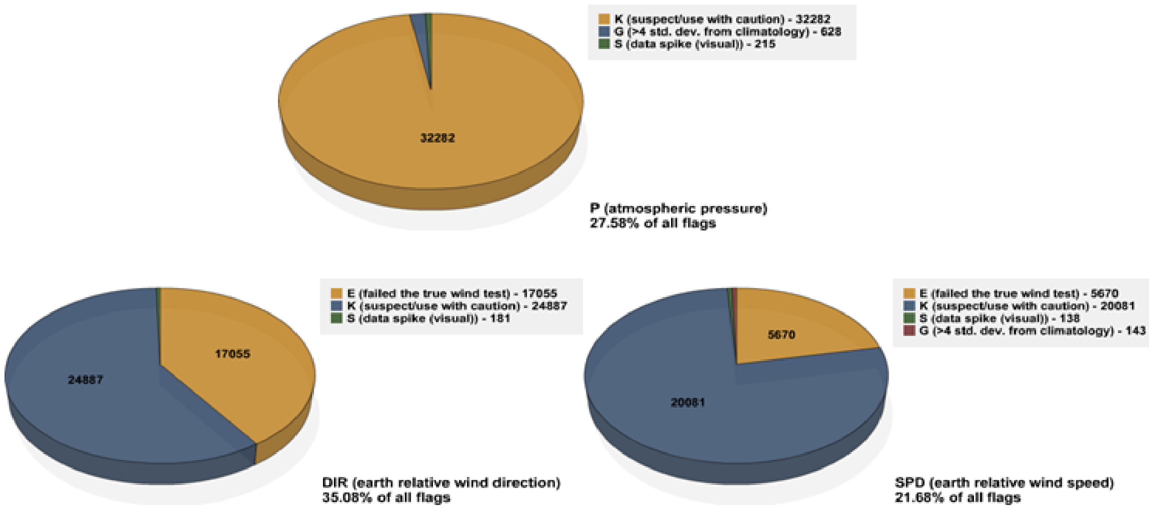


Figure 78: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – and (bottom) earth relative wind direction – DIR – and speed – SPD for the *R/V Ronald H. Brown* in 2010.

Oscar Elton Sette

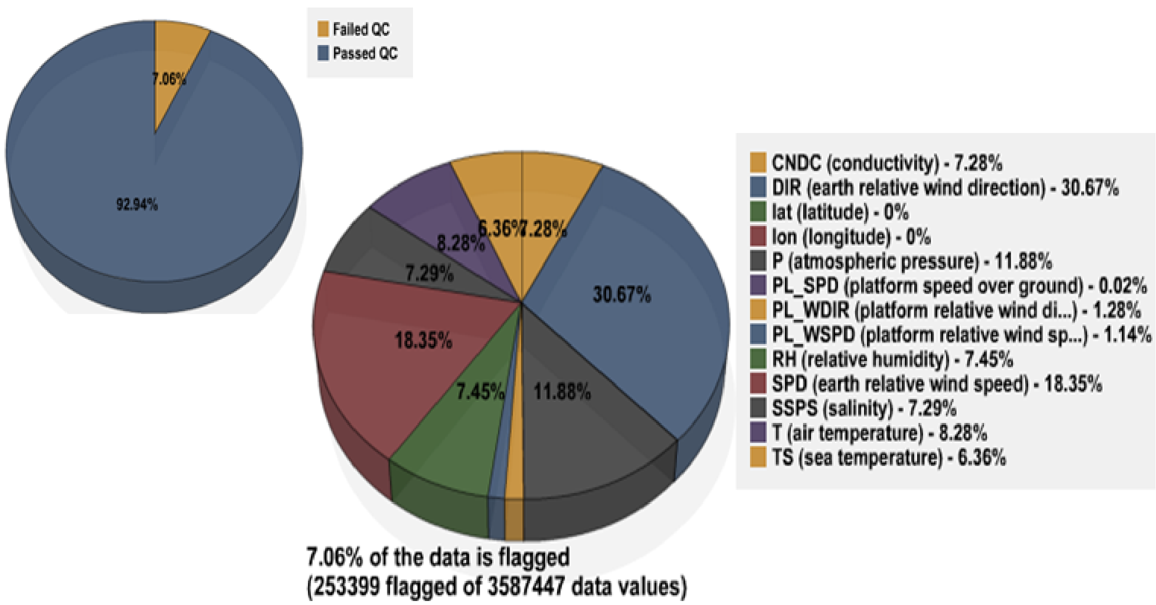


Figure 79: For the *Oscar Elton Sette* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oscar Elton Sette* provided SAMOS data for 170 ship days, resulting in 3,587,447 distinct data values. After both automated and visual QC, 7.06% of the data was flagged using A-Y flags (Figure 79). This is a deviation of +1.75% from 2009 (5.31% flagged).

Nearly half of the flagged data is comprised of earth relative wind direction and earth relative wind speed (~31% and ~18%, respectively). This is very similar to the *Sette's* performance in 2009 (although with a somewhat lowered percentage for SPD – ~18%

vs. ~31% in 2009); however, the issue is not the same. In 2009, the *Sette* experienced an extended duration where the algorithm used to calculate the true winds was incorrectly removing the vessel's motion. In 2010, the culprit for the mostly caution/suspect (K) and failed true wind recomputation test (E) flags appeared to be none other than the ubiquitous airflow-obstructed platform relative wind directions. This problem is easily picked out visually in the data by the appearance of "steps," such as those depicted in Figure 80. However, it should be stressed that the *Sette* appears to have a particularly comprehensive set of "bad" relative wind directions, which are extremely difficult to nail down and diagnose since there is no sensor location metadata or digital imagery available.

Another nearly 12% of the total flags were assigned to atmospheric pressure (P). These mostly K flags also appeared to be mainly due to airflow obstruction, with some evidence towards platform speed-related causes as well. As with many other vessels, more comprehensive sensor metadata and the addition of digital imagery would be extremely helpful in diagnosing these problems.

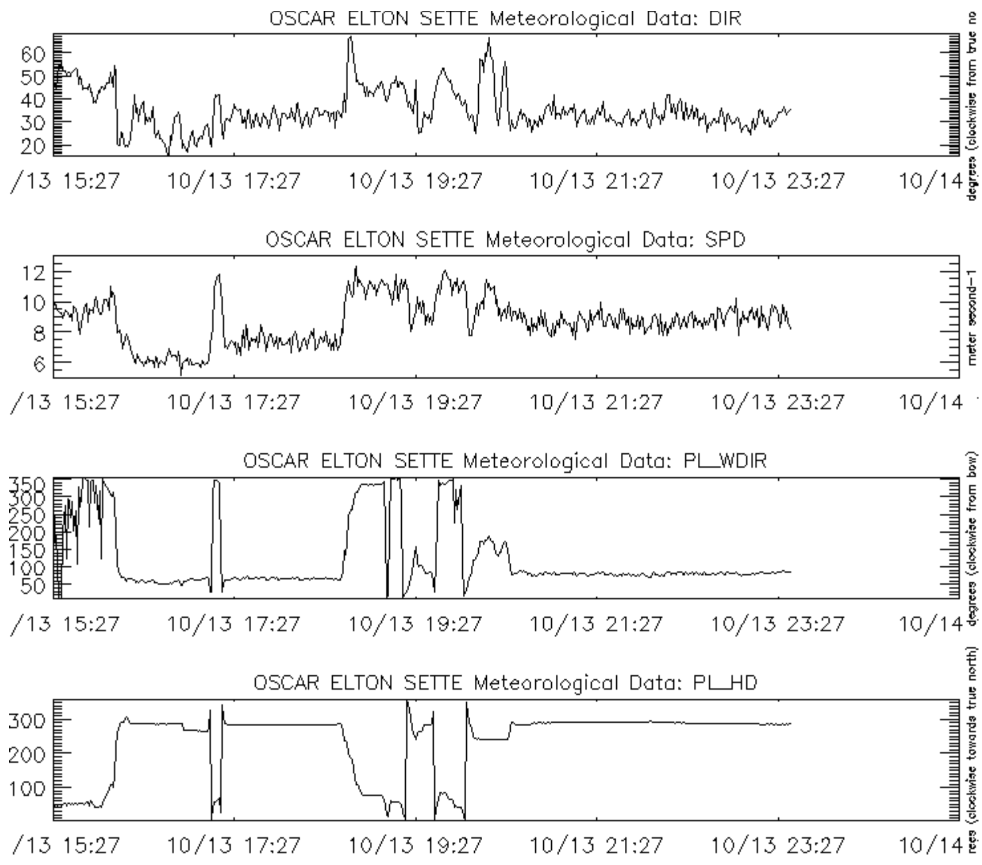


Figure 80: *Oscar Elton Sette* SAMOS data for 13 October 2010, from top: earth relative wind direction – DIR – earth relative wind speed – SPD – platform relative wind direction – PL_WDIR – and platform heading – PL_HD.

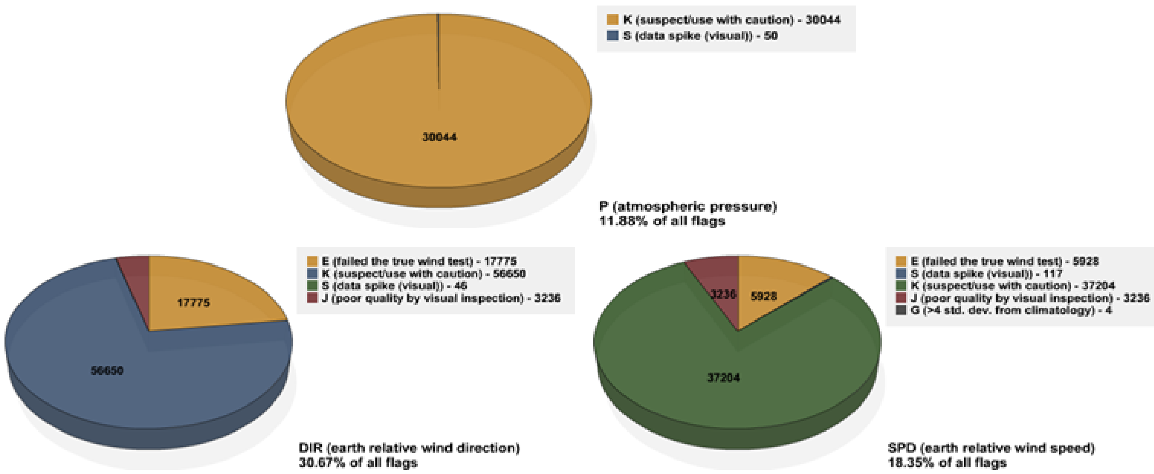


Figure 81: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – and (bottom) earth relative wind direction – DIR – and earth relative wind speed – SPD for the *R/V Oscar Elton Sette* in 2010.

McArthurII

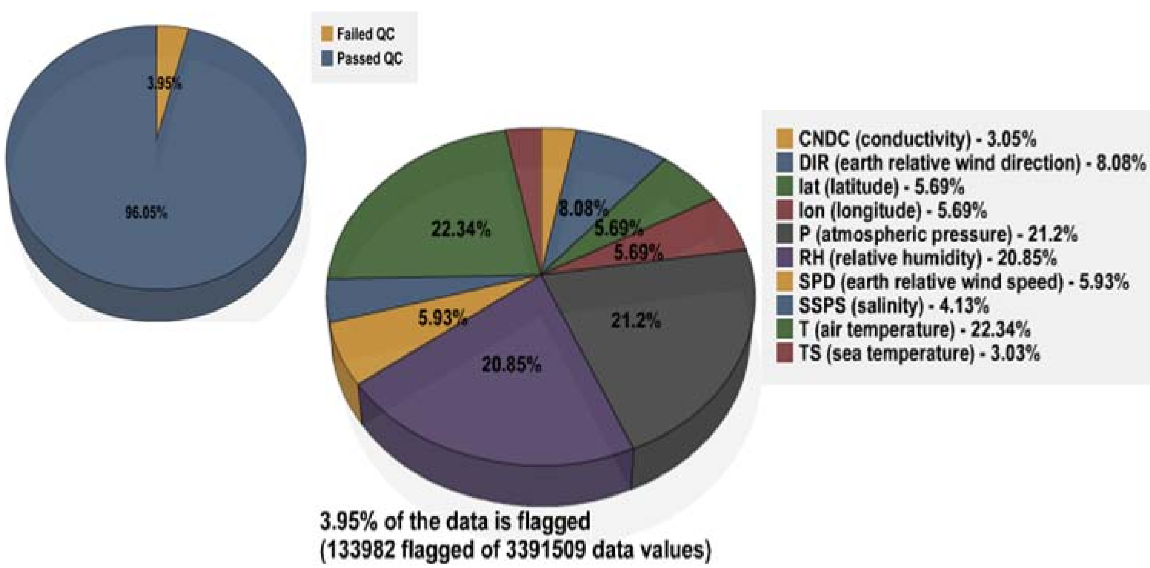


Figure 82: For the *McArthur II* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *McArthur II* provided SAMOS data for 157 ship days, resulting in 3,391,509 distinct data values. After both automated and visual QC, 3.95% of the data was flagged using A-Y flags (Figure 82). This places the *McArthur II* in fifth place for lowest flag percentage among SAMOS vessels receiving visual QC, and well within the < 5% flagged bracket denoting "very good" data. NOTE: Although the *McArthur II* was recruited to the SAMOS initiative in March 2009, 2010 marks the first year SAMOS data were received and visually QC'd. There was some confusion regarding this scenario, as some NOAA personnel were under the impression SAMOS data was being sent by the *McArthur II* in 2009.

Air temperature (T), relative humidity (RH), and atmospheric pressure (P) together made up over 60% of all flags (Figure 83), but as these were mainly caution/suspect (K) flags and no clear patterns were identified in the flagged data – compounded with the low overall flag percentage – these sensors were not considered particularly problematic for 2010.

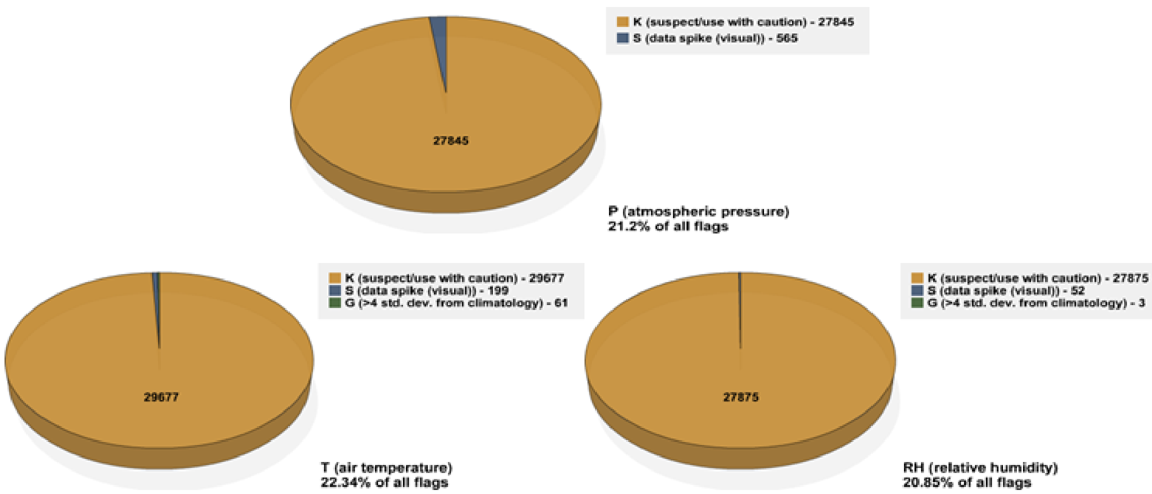


Figure 83: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – and (bottom) air temperature – T – and relative humidity – RH for the *R/V McArthur II* in 2010.

Gordon Gunter

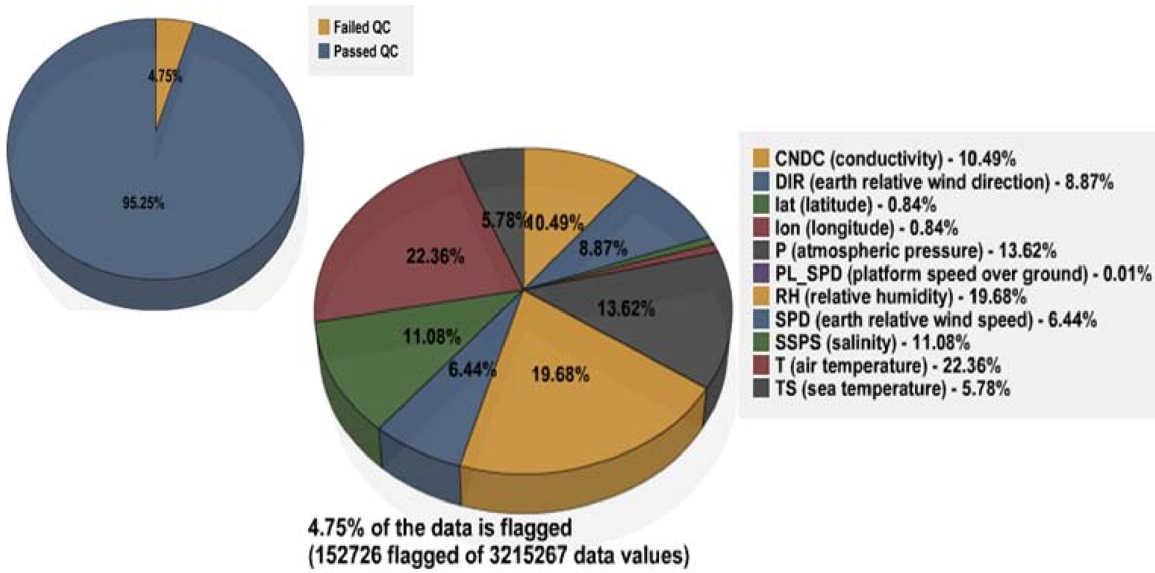


Figure 84: For the *Gordon Gunter* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Gordon Gunter* provided SAMOS data for 158 ship days, resulting in 3,215,267 distinct data values. After both automated and visual QC, 4.75% of the data was flagged using A-Y flags (Figure 84). This is a deviation of -1.88% from 2009 (6.63% flagged), a modest improvement that moved the *Gunter* within the coveted < 5% flagged bracket for 2010.

Air temperature and relative humidity each represent over one quarter of the total flagged values (~29% and ~27%, respectively). The unidentified problem with air temperature (T) and relative humidity (RH) from 2009 appears to have persisted in 2010, though perhaps with decreased severity. The issue once again did not appear to be flow obstruction or stack contamination (although again incomplete metadata and a lack of digital imagery prohibited verification), but rather still may have had something to do with ship heating. While wind speeds in Figure 85 appear rather high to allow 5+ degree C radiational heating, the analyst notes that platform relative wind speeds actually drop quite low at the same time as the suspected T/RH behavior. Platform relative wind direction assessment during this event was inconclusive, but more details (including more comprehensive metadata and better digital imagery) are needed to confirm. The author also notes again that the suspect data from the T and RH sensors occurred mainly during daylight hours. Another possibility would be intermittent exhaust from an auxiliary system that operates periodically during the day.

Flagged percentages for earth relative wind speed and direction were noticeably smaller in 2010, strongly suggesting improved wind data. In 2009 it appeared to the analyst that, rather than the usual sensitivity to platform speed changes, earth relative wind parameters aboard the *Gunter* were actually sensitive to combinations of deck motions such as sway, heave, pitch, and roll such as would occur in choppy waters. In 2010 this apparent effect was not routinely observed, suggesting either mechanically improved sensor data (i.e. by ship technicians) or, perhaps, cruising in generally calmer waters. The observed suspect/caution (K) flagged wind data in 2010 instead showed some evidence of airflow obstruction, as did atmospheric pressure (P). Again improved sensor metadata and digital imagery would aid in any diagnosis.

Sea surface salinity (SSPS) and conductivity (CNDC) also occasionally exhibited erratic behavior (example Figure 86), which resulted in a fair amount of poor quality (J) flagging. The cause of this behavior was undetermined.

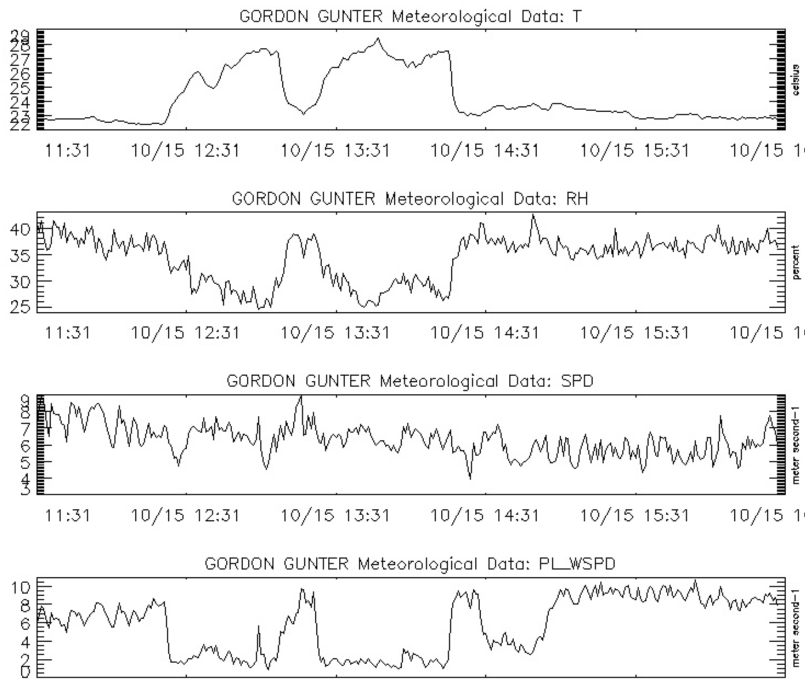


Figure 85: *Gordon Gunter* SAMOS data for 15 October 2010; from top: air temperature – T – relative humidity – RH – earth relative wind speed – SPD – and platform relative wind speed – PL_WSPD.

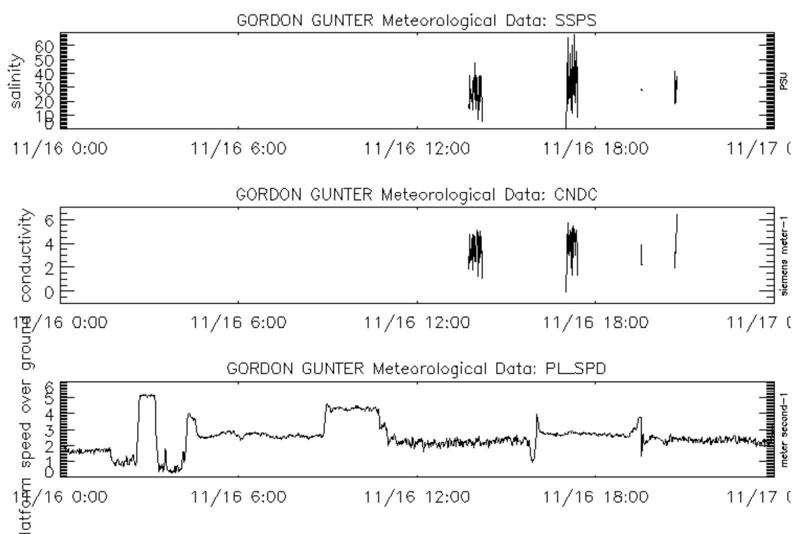


Figure 86: *Gordon Gunter* SAMOS data for 16 November 2010; from top: salinity – SSPS –conductivity – CNDC –and platform speed – PL_SPD.

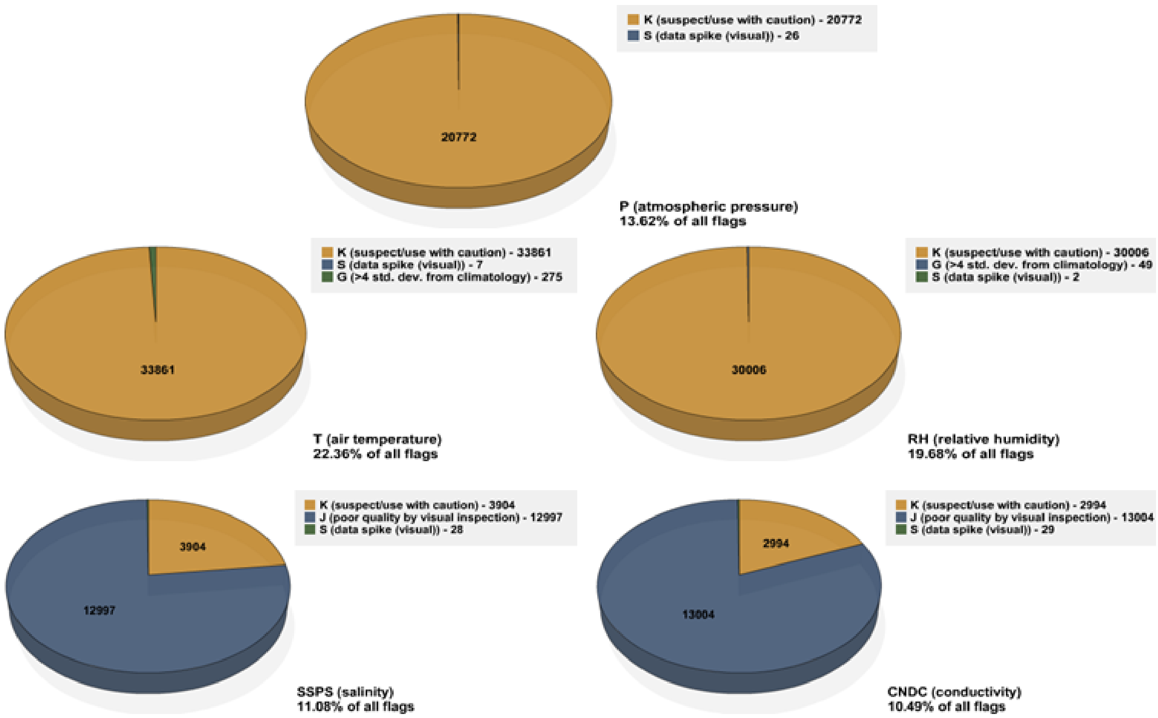


Figure 87: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – (middle) air temperature – T – and relative humidity – RH – and (bottom) salinity – SSPS – and conductivity – CNDC – for the *R/V Gordon Gunter* in 2010.

Oscar Dyson

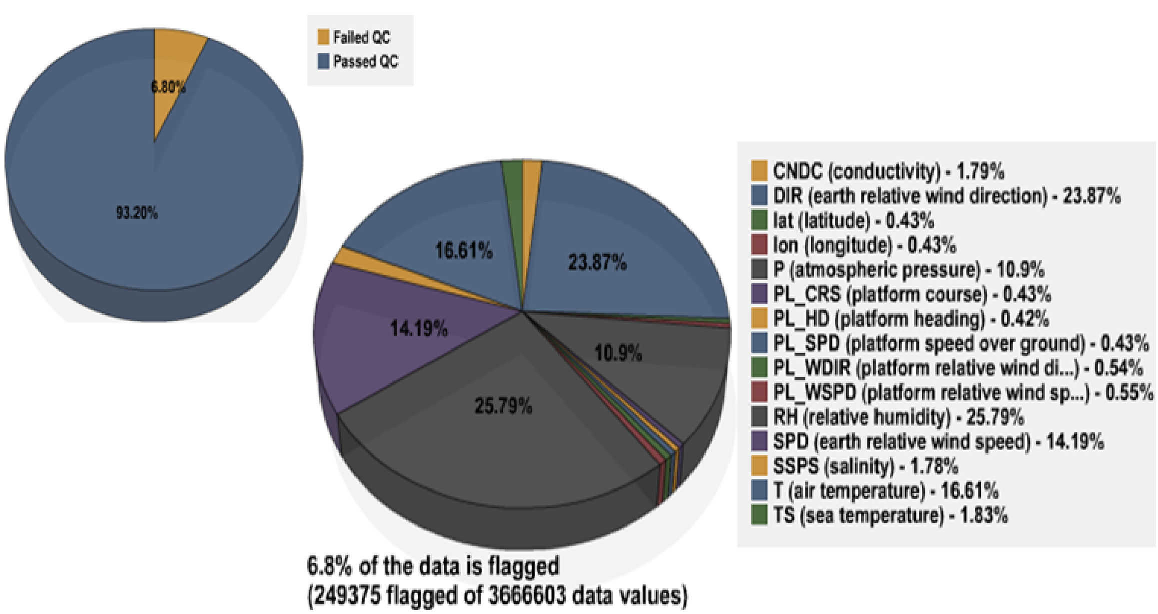


Figure 88: For the *Oscar Dyson* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oscar Dyson* provided SAMOS data for 177 ship days, resulting in 3,666,603 distinct data values. After both automated and visual QC, 6.8% of the data was flagged using A-Y flags (Figure 88). This is a deviation of +0.83% from 2009 (5.97% flagged).

Flag percentages among the MET parameters and the logic behind the flagging remains essentially unchanged from the 2009 analysis. With some vessels, the *Dyson* among them, SAMOS data analysts can attempt to compile a list of platform-relative wind direction bands that routinely produce compromised readings from the various MET sensors. The *Dyson* retains one of the longest lists of suspicious wind bands. This suggests the *Oscar Dyson* experiences a multitude of platform-relative wind directions where the airflow to the sensors is obstructed. It is worth mentioning that the *Dyson* spends a lot of time in fjord regions and rounding the many mountainous island of Alaska, with the result that the vessel often travels through erratic winds. But while this complicates the data analysts attempts to identify obstructed platform relative wind directions, several bands of platform relative wind directions have nevertheless been identified with a fair amount of confidence. The vessel's cruise activity commonly requires repeated turns, passing the various MET sensors back and forth through these wind bands. The result is frequent caution/suspect (K) flags on atmospheric pressure, air temperature, relative humidity, and both earth relative wind parameters (Figure 89).

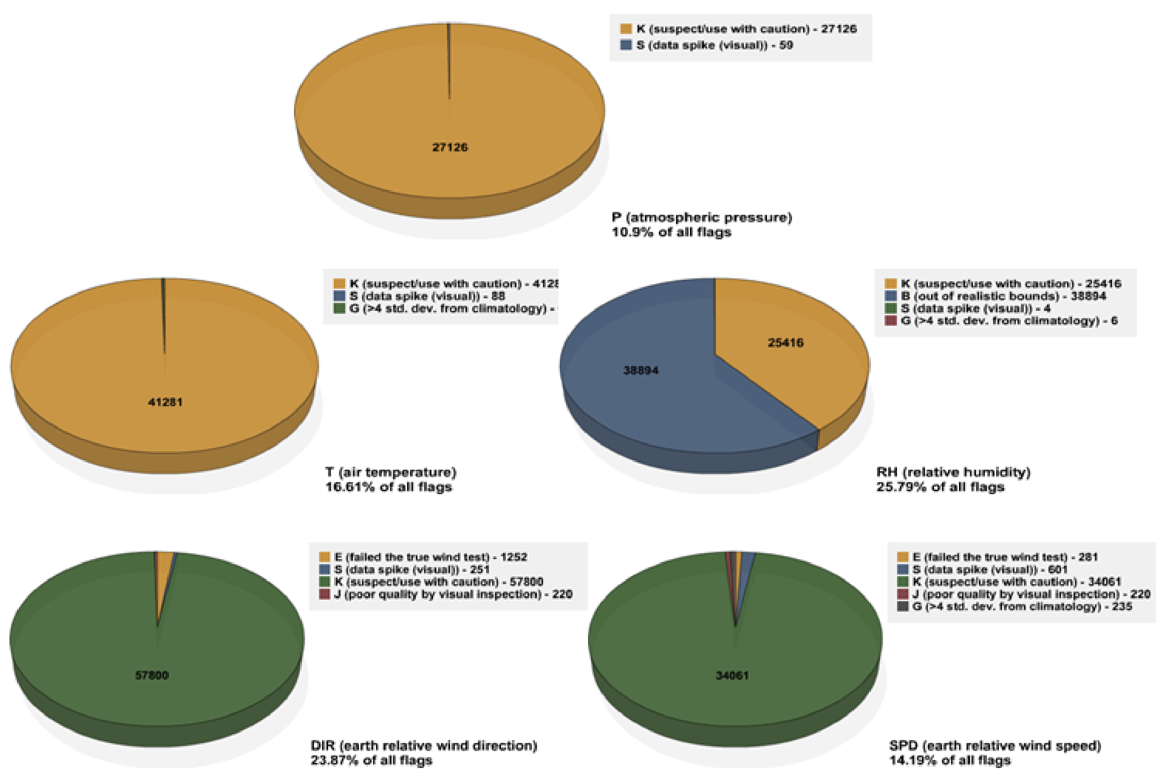


Figure 89: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – (middle) air temperature – T – and relative humidity – RH – and (bottom) earth relative wind direction – DIR – and earth relative wind speed – SPD – for the *R/V Oscar Dyson* in 2010.

Nancy Foster

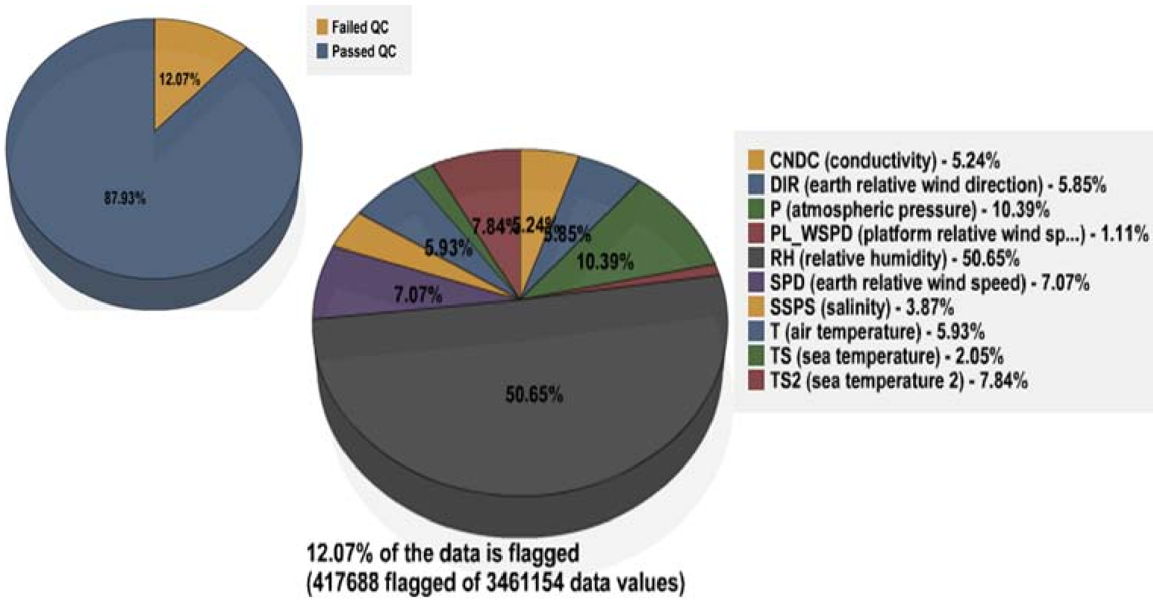


Figure 90: For the *Nancy Foster* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Nancy Foster* provided SAMOS data for 158 ship days, resulting in 3,461,154 distinct data values. After both automated and visual QC, 12.07% of the data was flagged using A-Y flags (Figure 90). This is a deviation of -1.55% from 2009 (13.62% flagged). While this likely signifies a slight improvement over 2009 data quality, it must be stressed that *Nancy Foster* nevertheless holds second-to-last place for least percentage flagged among all SAMOS vessels (not just those receiving visual QC).

The overwhelming problem with *Nancy Foster's* data in 2010 continued to be the known malfunction of the relative humidity parameter. The problem was three-fold (refer to Figure 91, an extremely clear example taken from 2009 data): First, the readings displayed an improbably minimal amount of variability. Operating along the eastern seaboard and the Gulf of Mexico out of Norfolk, VA the *Foster* would likely have experienced cold fronts, fog, convective storms etc. at some point, but these natural variations never occurred in the RH data. Second, the data did not appear to adhere to the equation of state $p = \rho RT$ (where p is pressure, ρ is air density, T is air temperature, and R is a constant value); meteorologically speaking, this equation means that for the most part when the air temperature increases relative humidity should decrease, except in special situations such as a convective storm. Contrary to this rule of general behavior, however, the shape of the *Foster*'s relative humidity traces always mimicked exactly the shape of the air temperature trace. Third, the number of decimal places being returned in the data was inconsistent. The readings normally came out in whole percents but would sporadically go into finer (~.01%) resolution. With roughly 60 samples per minute, it seemed highly unlikely the average value would almost always come out to a whole number. Both SAMOS personnel and *Foster* personnel were aware of the issues and had a lot of discussion in 2009, as well as heavy reiteration during a SAMOS/NOAA teleconference in November 2010, but to date the issues still appear to SAMOS data analysts to be unresolved. As a consequence of these problems, RH was flagged with malfunction (M) flags for the duration of 2010 (Figure 92).

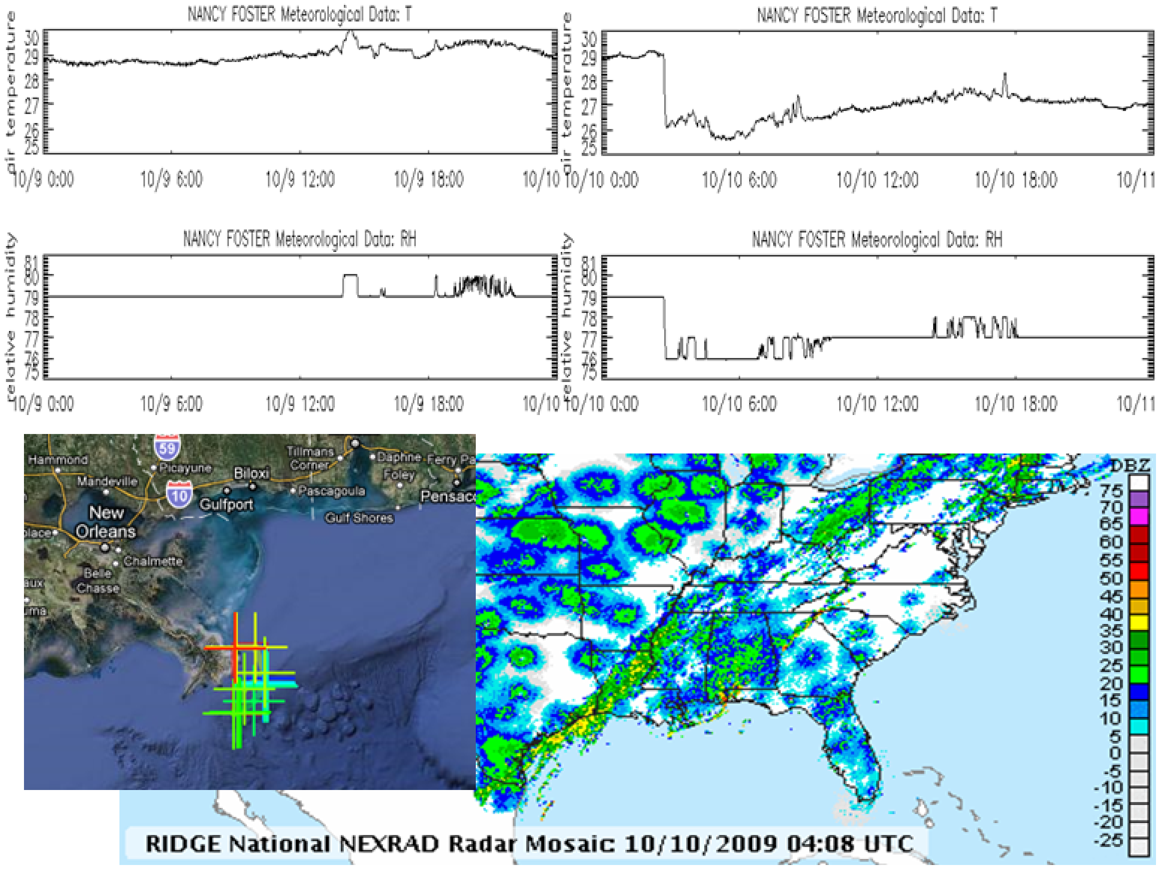


Figure 91: (top) *Nancy Foster* SAMOS air temperature (°C) – T – and relative humidity (%) – RH – data for 9 October through 10 October 2009; (bottom) archived NEXRAD radar image for 10 October 2009 at approximately 04:00 UTC (photo courtesy http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwNexrad~SelectedImage ~20091010~0400) with (inset) 9 October 2009 ship track for the *Foster* shown. Nearby Boothville, LA reported a maximum humidity of 94% and rain around 10pm local (03:00 UTC), and the radar image suggests rain at the vessel location around 04:00 UTC. RH data for the *Foster*, however, gives no evidence of saturation and rain, even around the frontal passage evident in the SAMOS RH trace around 03:00 UTC. The RH traces exhibit all 3 problems mentioned in the text: minimal variability, constant mirroring of T behavior, and apparent inconsistency of decimal accuracy.

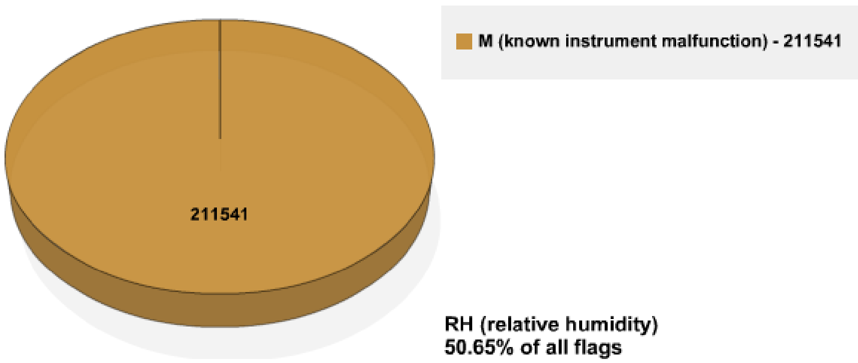


Figure 92: Distribution of SAMOS quality control flags for relative humidity – RH –for the *R/V Nancy Foster* in 2010.

Ka'imimoana

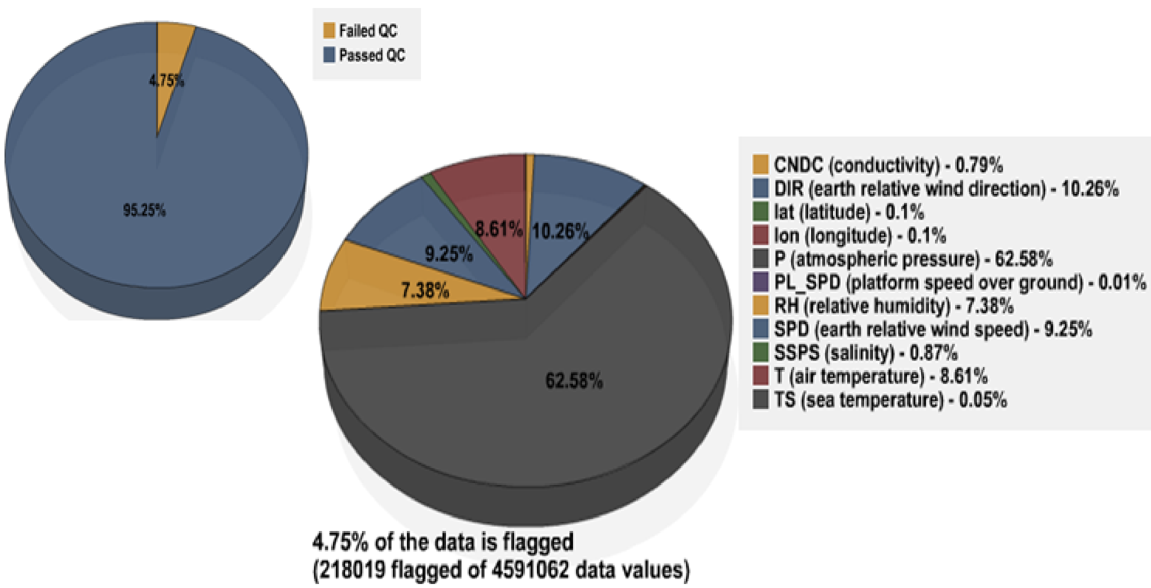


Figure 93: For the *Ka'imimoana* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Ka'imimoana* provided SAMOS data for 225 ship days, resulting in 4,591,062 distinct data values. After both automated and visual QC, 4.75% of the data was flagged using A-Y flags (Figure 93). This is a slight increase of 1.23% over the 2009 percentage (3.52% flagged), but *Ka'imimoana* nevertheless remains in the highly desirable < 5% flagged bracket, denoting "very good" data overall.

There was a long-standing issue aboard the *Ka'imimoana* with the units in which atmospheric pressure was reported, which was finally fixed mid-way through 2010. As a result, though, over 60% of *Ka'imimoana*'s flagged values in 2010 were atmospheric pressure (Figure 94). It is worth mentioning, however, that communication between the shipboard technician and SAMOS personnel continued to be abundant in 2010, so flagging of the parameter was anticipated. It should again be stressed, as it was in 2009, that *Ka'imimoana* both provided one of the best data sets (with the atmospheric pressure exception) and represents one of the best instances of open communication between ship technicians and data analysts.

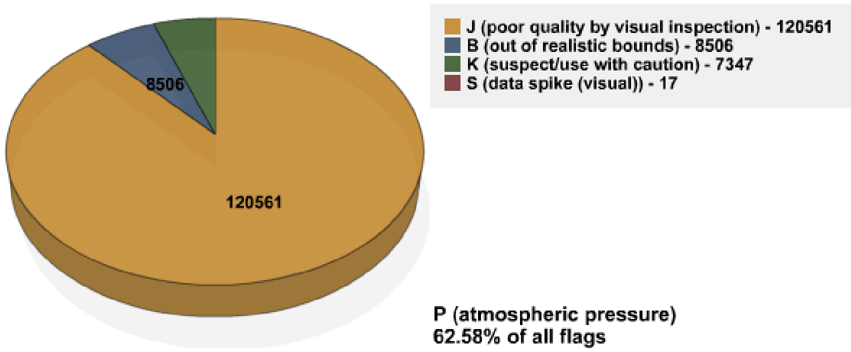


Figure 94: Distribution of SAMOS quality control flags for atmospheric pressure – P on the *R/V Ka'imimoana* in 2010.

Hi'ialakai

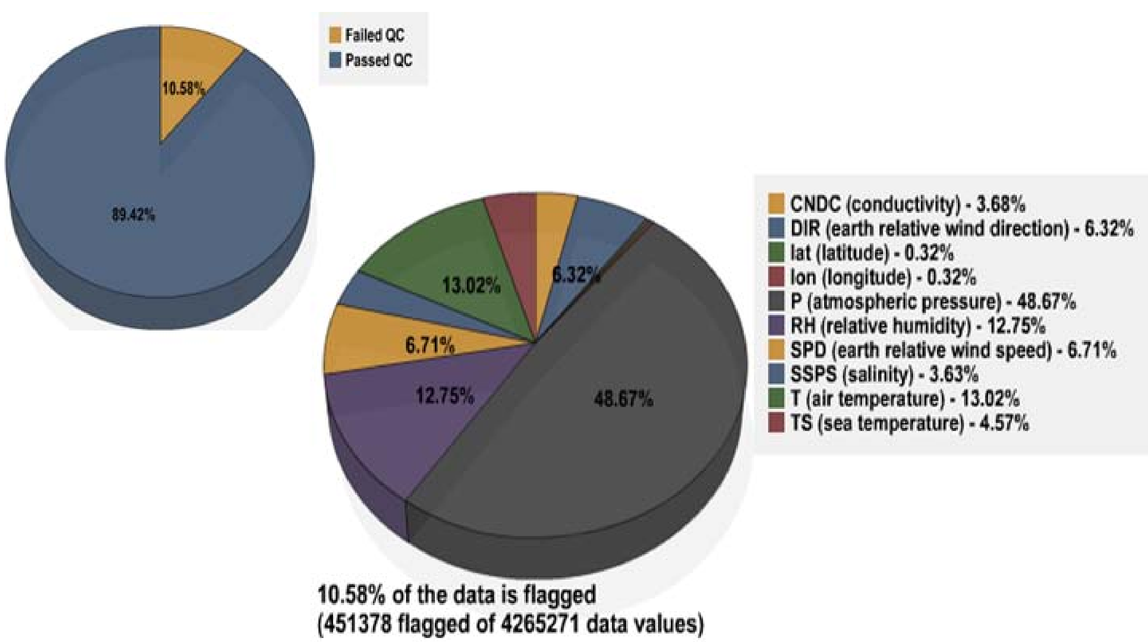


Figure 95: For the *Hi'ialakai* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Hi'ialakai* provided SAMOS data for 200 ship days, resulting in 4,265,271 distinct data values. After both automated and visual QC, 10.58% of the data was flagged using A-Y flags (Figure 95). This is a deviation of -0.83% from 2009 (11.41% flagged).

The *Hi'ialakai* experienced an ongoing problem of atmospheric pressure (P) reading too low throughout 2010, as in 2009. *Hi'ialakai's* pressure data was frequently initially assigned greater than four standard deviations (G) flags by the autoflagger, which are intended to highlight unusual but valid readings. However, through extensive and repeated cross-checking of the pressure values sent to SAMOS against pressure values reported by nearby land stations and/or ocean buoys (example Figure 96), it was always concluded that the SAMOS-reported values were too low. Hence, any pressure values that were not G flagged by the auto flagger were assigned caution/suspect (K) and occasionally poor quality (J) flags, and the G-flags on pressure values were almost always exchanged by the data analyst for K and J flags (Figure 97, top). This flag scheme continued throughout 2010 *Hi'ialakai* SAMOS data transmission. However, communication between SAMOS personnel and the *Hi'ialakai* dramatically improved in 2010. Consequently, and with the added efforts from core NOAA personnel, much discussion occurred regarding the sensor, resulting in *Hi'ialakai* advising the SAMOS group of an impending sensor location change. (NOTE as of February 2011, the sensor has finally been relocated.)

In addition to the issue of low pressure readings, the *Hi'ialakai* experiences an appreciable amount of flow obstruction, which resulted in air temperature (T) and relative humidity (RH) both garnering a fairly substantial percentage (~25%, combined) of flags, primarily K flags (Figure 97, bottom row). However, it should be noted that the T/RH probe was also relocated in February 2011 so data analysts anticipate improved data for those sensors in 2011, as well.

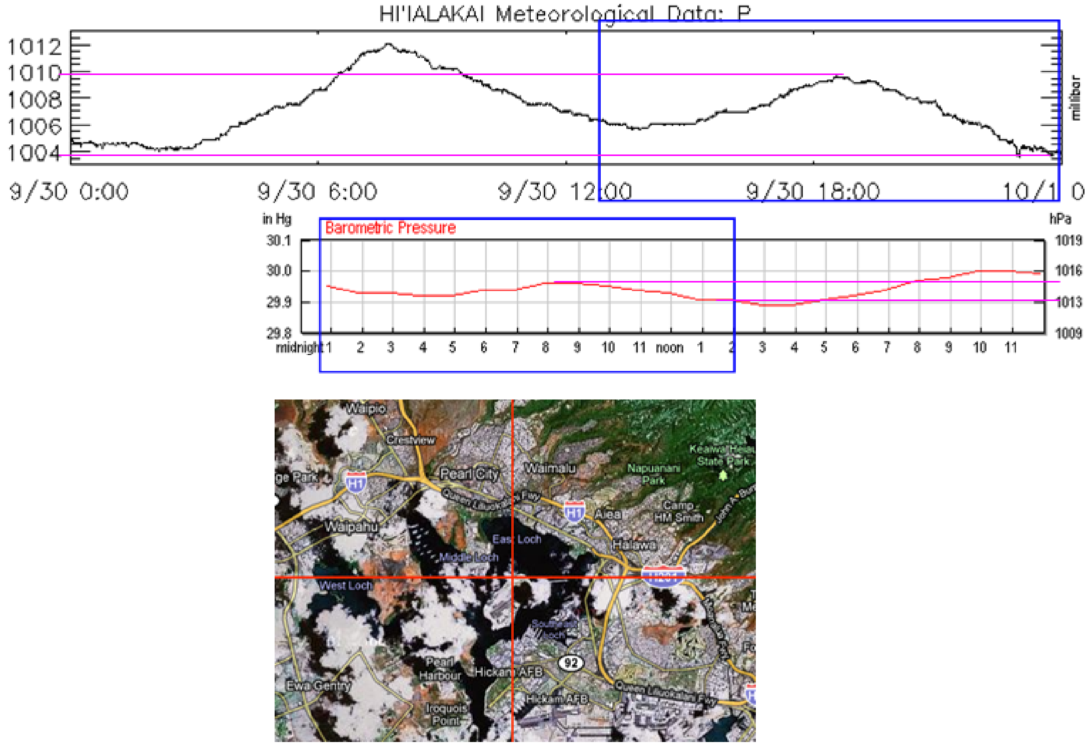


Figure 96: (top) *Hi'ialakai* SAMOS pressure data for 30 September 2010, as compared to (middle) historical pressure data for 30 September 2010 at Hickam Airforce Base (photo courtesy http://www.wunderground.com/history/airportfrompws/PHNL/2010/9/30/DailyHistory.html?req_city=NA&req_state=NA&req_statename=NA), matching time frames boxed in blue. Note the discrepancies (denoted at pink lines) range between ~5 mb at the max value and ~9mb at the min value; (bottom) *Hi'ialakai*'s location for 30 September, at center of red crosshatch.

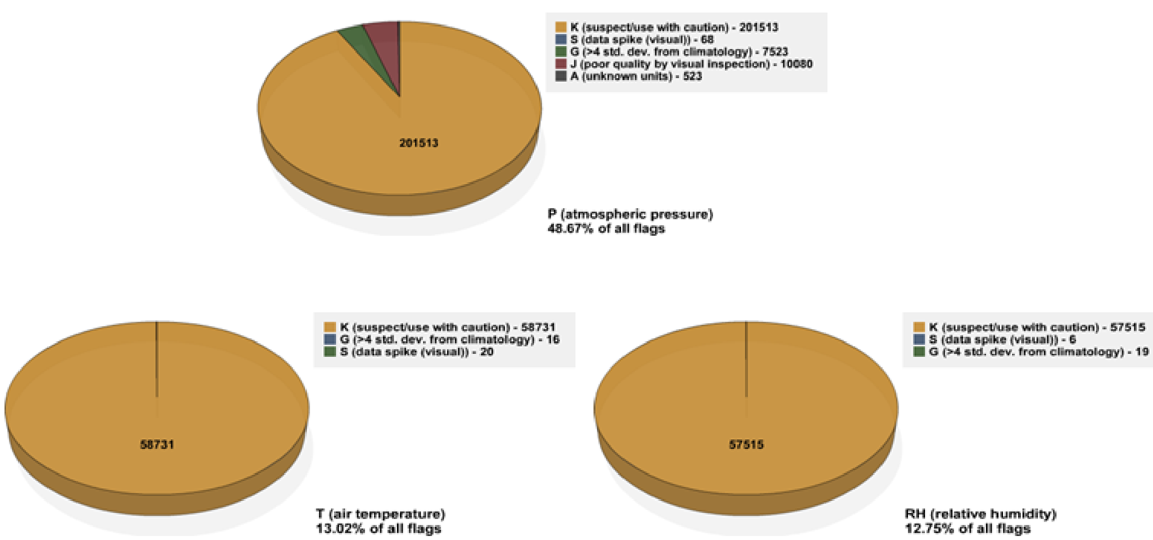


Figure 97: Distribution of SAMOS quality control flags for (top) atmospheric pressure – P – and (bottom) air temperature – T – and relative humidity – RH – for the *R/V Hi'ialakai* in 2010.

R/V Oceanus

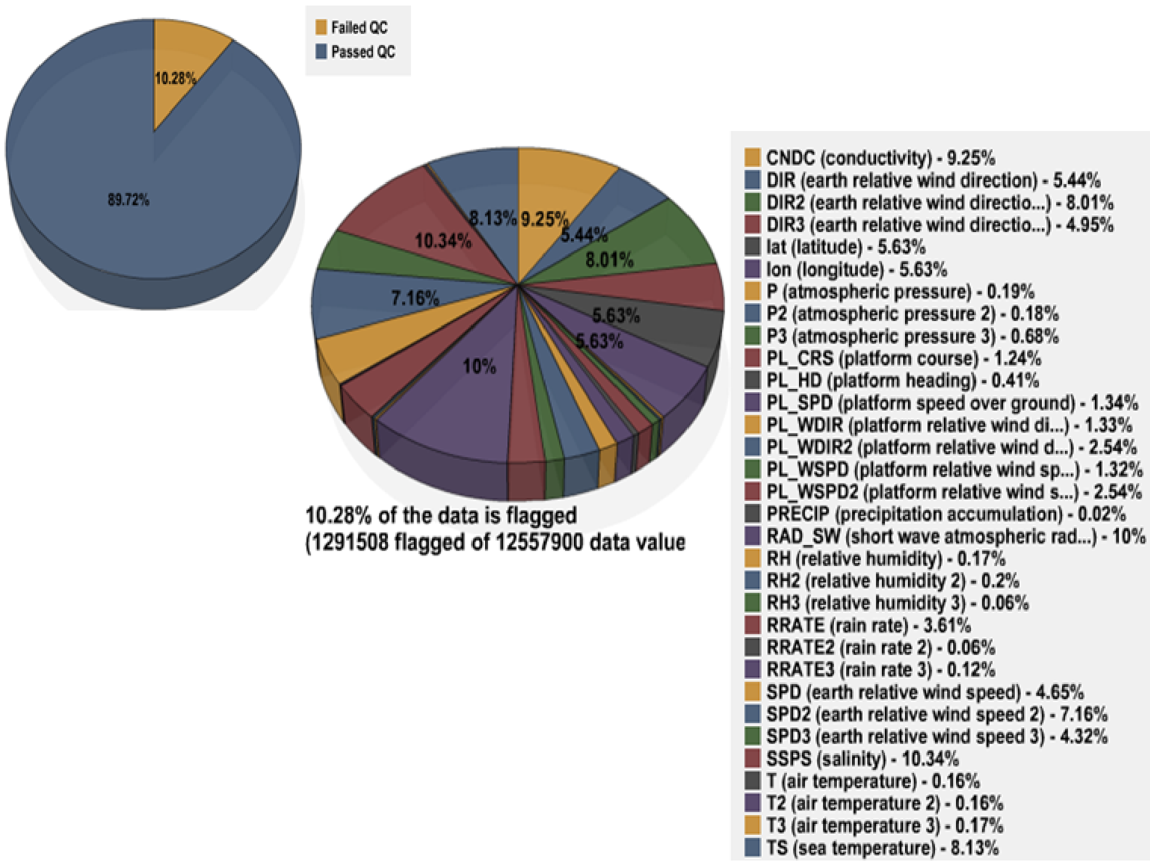


Figure 98: For the *R/V Oceanus* from 1/1/10 through 12/31/10, (left) the percentage of all observations that passed vs. failed SAMOS quality control tests and (right) the percentage of the overall failed observations broken down by parameter.

The *Oceanus* provided SAMOS data for 294 ship days, resulting in 12,557,900 distinct data values. After both automated and visual QC, 10.28% of the data was flagged using A-Y flags (Figure 98). This is a deviation of -1.71% from 2009 (11.99% flagged). However the high flag percentage is somewhat misleading, as it was in 2009, and for the same reason: The *Oceanus* often transmits port data. In the first place, this practice results in occasional port (N) flagging of the lat/lon parameters (not shown) whenever other parameters are flagged while in port as well. The sea water parameters fell into this category most often, since the flow water systems that fed the sea temperature (TS), conductivity (CNDC), and salinity (SSPS) probes were usually shut off while *Oceanus* was in port. When this occurred it was easily recognized by the data analysts who then flagged the parameters with suspect/caution (K) and, more rarely, poor quality (J) flags (Figure 100, middle row and bottom left). Additionally, a portion of the moderate flagging of the earth relative wind parameters occurred while the vessel was in port, and was likely due to land-based structures complicating airflow in the immediate vicinity of the vessel's mooring, as opposed to being a vessel-based issue. However, in the case of the earth relative wind speed 2 (SPD2) and direction 2 (DIR2), there was a period of questionable behavior between 15 May and10 June when DIR2/SPD2 often did not agree with the values being reported from the other two wind sensors (Figure 99) and were thus given a fair amount of K and J flags (Figure 100, top row). Furthermore, beginning on 2 December all of *Oceanus's* wind parameters appeared quite suspicious and were flagged with K. Then on 15 December it was communicated to the SAMOS group that the *Oceanus* went into dry dock in the beginning of December, with the mast supporting the wind sensors being lowered into a horizontal position. At that point, the data analyst went back into the data files and changed all K flags to J flags. During this dry dock period, the sea water parameters were also J flagged, since they naturally were not being fed fresh sea water. Finally, the shortwave radiation (RAD_SW) was often assigned out of bounds (B) flags by the autoflagger (Figure 100, bottom right). This was once again merely an issue of sensor tuning, whereby very small values are inaccurately reported as slightly negative values.

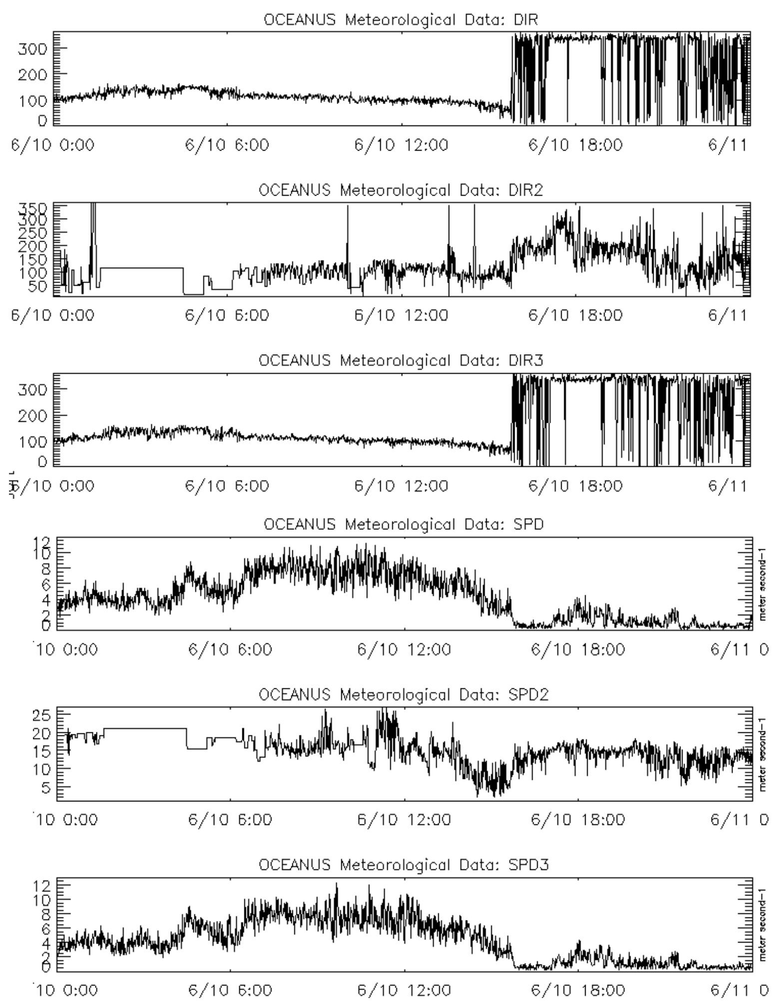


Figure 99: *Oceanus* SAMOS data for 10 June 2010; from top: earth relative wind direction – DIR – earth relative wind direction 2 – DIR2 – earth relative wind direction 3 – DIR3 – earth relative wind speed – SPD – earth relative wind speed 2 – SPD2 – and earth relative wind speed 3 – SPD3. Note DIR2 and SPD2 differences from DIR/DIR3 and SPD/SPD3.

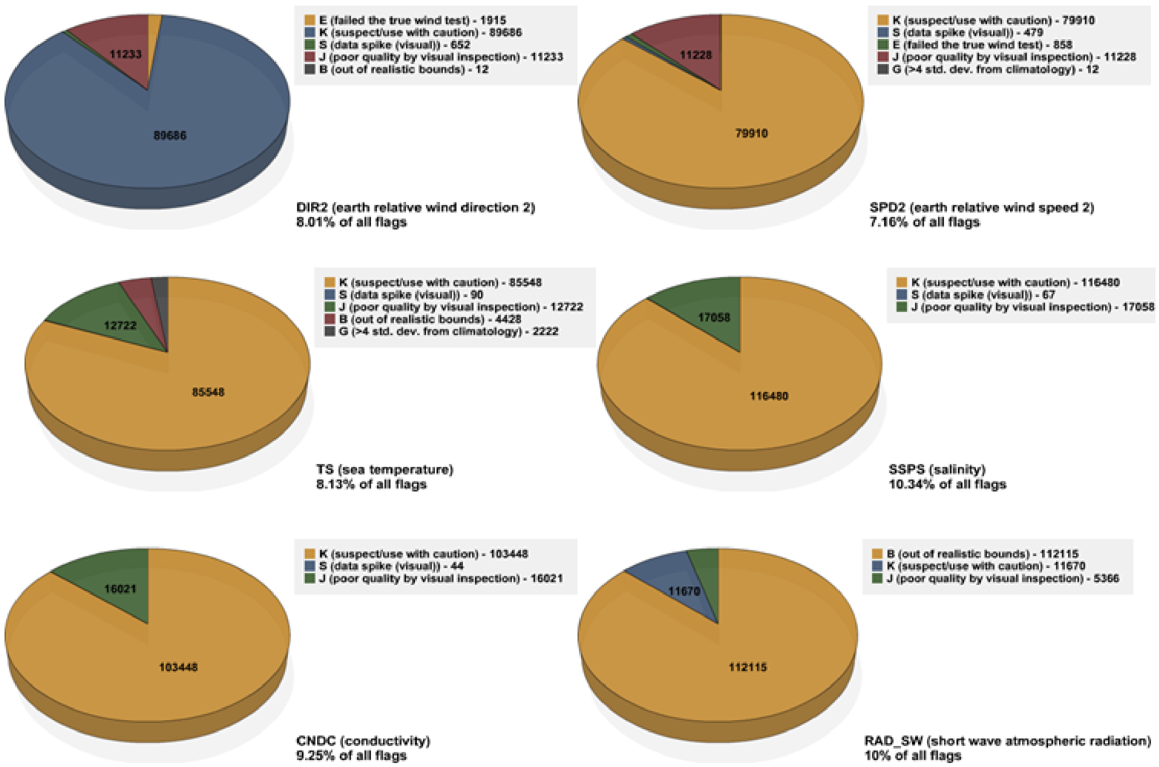


Figure 100: Distribution of SAMOS quality control flags for (top) earth relative wind direction 2 – DIR2 – and earth relative wind speed 2 – SPD2 – (middle) sea temperature – TS – and salinity – SSPS – and (bottom) conductivity – CNDC – and short wave atmospheric radiation – RAD_SW – for the *R/V Oceanus* in 2010.

4. Metadata summary

Adequate metadata is the backbone of good visual QC. As such, vessel operators are strongly advised to keep vessel and parameter metadata complete and up to date. Annex A, 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. Note that for the IMOS ships *Aurora Australis* and *Southern Surveyor*, while Vessel contact information is considered "incomplete" in Table 3, there is intentionally no onboard contact information, at the discretion of the Australian Bureau of Meteorology. Vessel metadata should also include vessel imagery (highly desirable, see Figure 101 for examples) and a web address for a vessel's home page.

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 102. (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 102 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. The authors wish to point out that the field "Data Reporting Interval" erroneously appears in several of the parameters. This field is actually only applicable to the time parameter and the Vessel information metadata. The erroneous field will be removed in 2011 and was not considered for completeness of any parameter in Table 3. To access and download (in PDF format) any participating vessel's metadata forms, visit the SAMOS Metadata Portal at http://samos.coaps.fsu.edu/html/meta.php. Detailed instructions for this feature are also covered in Annex A, Part 1: the end user.

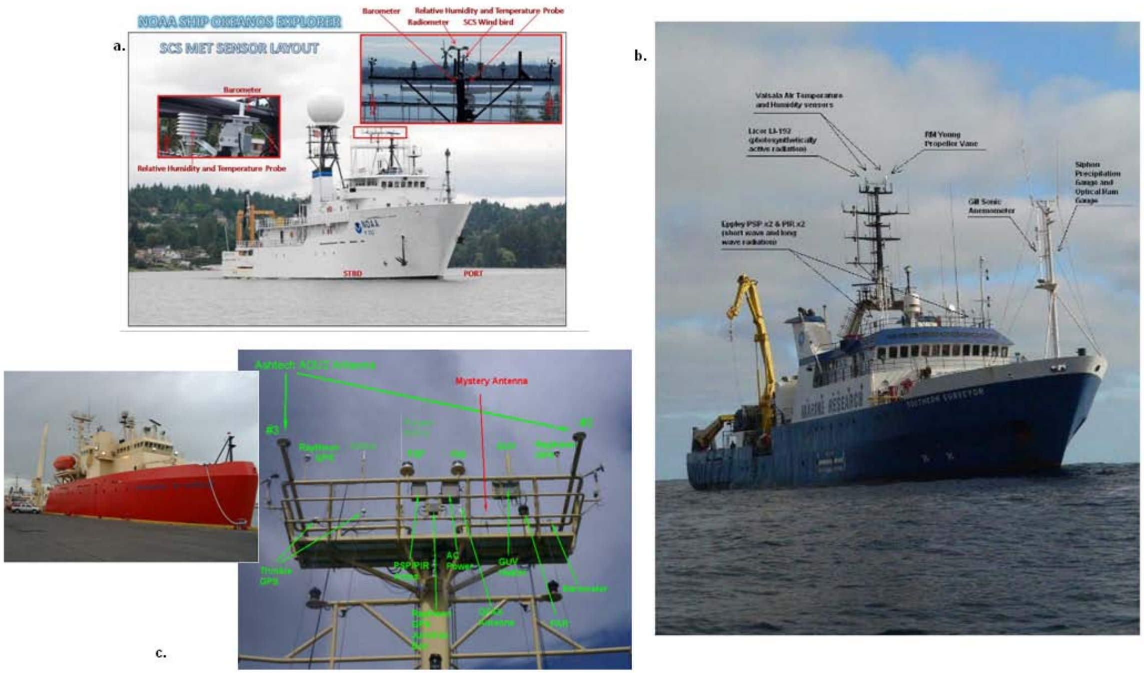


Figure 101: Examples of detailed vessel instrument imagery from (a) *Okeanos Explorer*, (b) *Southern Surveyor*, and (c) *Laurence M. Gould*

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 102: 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 3 summarizes the current state of all SAMOS vessel and parameter metadata.

	Vessel Info	Contact Info	Vessel Layout	Digital Imagery	LAT	LON	HD	CRS	PL SPD	PL WSPD	PL WDIR	SPD	DIR	T	P	RH	PRECIP	RRATE	LW	SW	NET RAD	PAR	TS	CON	SAL
KAQP	C	C	C	Yes	I	I	I	I	I	C,I,I	C,I,I	C,I,I	C,I,I	C,I,I	C,I,I	C,I,I	C,I,I	I,I,I		C			C	I	C
KCEJ	C	C	C	Yes	I	I	I	I	I	C,I,I	C,I,I	C,I,I	C,I,I	C,I,I	C,I,I	C,I,I	I,I	C,I,I		C			I	I	I
KNBD	C	C	C	No	I	I	I	I	I	I	I	C	C	I	I	I							I		
NEPP	C	C	I	Yes	I	I	I,I	I	I,I,I	C,C	C,C	C,C	C,C	C,C	C,I	C,C	C		C	C			C,C	C	C
NRUO	I	I	I	No	I	I	I	I,I	I,I	I,I	I,I	I,I	I,I	I	I	I							I,I		I
VLHJ	C	I	I	Yes	I	I	I,I	I	I	C,C	C,C	I,I	I,I	C,C	I	C,C	C,C	C	C,C	C,C		C	I		
VNAA	C	I	I	No	I	I	I,I	I	I	I,I	I,I	I,I	I,I	I,I	I	I,I	I,I	I	I,I	I,I		I,I	I		
WBP3210	C	I	I	Yes	I	I	I	I	I			I	I	I	I	I			I	I		I	I	I	I
WCX7445	C	C	C	Yes	I	I	I	I	I	I,I	I,I	I,I	I,I	I	I	I					I,I	I	I,I	I	I
WDA7827	C	C	C	No	I	I	I,I	I	I,I	I,I	I,I	I,I	I,I	I	I	I	I,I	I	I				I		I
WDC9417	I	I	I	No	I	I	I,I	I	I	C,C	C,C	C,C	C,C	C	C	C							I,I	I	I
WTDF	C	C	I	No	I	I	I	I	I,I,I	I	I	I	I	I	I	I			I	I			I	I	I
WTDH	C	C	I	Yes	I	I	I	I	I	I	I	I	I	I	C	I							I,I	I	I
WTDK	I	I	I	Yes	I	I	I	I	I	I	I	I	I	I	I	I							I		
WTDL	I	I	I	No	I	I	I	I	I	I	I	I	I	I	I	I							I		I
WTDM	C	C	C	Yes	I	I	I	I	I	I	I	I	I	I	I	I							I	I	I
WTDO	I	I	I	No	I	I	I	I	I	I	I	I	I	I	I	I							I		
WTEB	I	I	I	No	I	I	I	I	I	I	I	I	I	I	I	I							I		
WTEC	C	C	I	No	I	I	I	I	I	I	I	I	I	I	I	I				I			I	I	I
WTEE	C	C	C	No	I	I	I	I	I	I	I	I	I	I	I	I							I	I	I
WTEF	I	I	I	No	I	I	I	I	I	I	I	I	I	I	I	I							I		
WTEJ	I	I	I	No	I	I	I	I	I	I	I	I	I	I	I	I							I	I	I
WTEO	I	I	I	Yes	I	I	I	I	I	I	I	I	I	I	I	I							I	I	I
WTEP	C	C	I	Yes	I	I	I	I	I	I	I	I	I	I	I	I							I	I	I
WTER	C	C	I	No	I	I	I	I	I	I	I	I	I	I	I	I							I,I	I	I
WTEU	C	C	I	No	I	I	I	I	I	I	I	I	I	I	I	I							I	I	I
WTEY	C	C	I	Yes	I	I	I	I	I	I	I	I	I	I	I	I							I	I	I
WXAQ	C	C	C	Yes	I	I	I	I	I	I,I	I,I	I,I,I	I,I,I	I,I,I	I,I,I	I,I,I	I,I,I	I,I,I		I			I	I	C

Table 3: Vessel and parameter metadata overview. "C" indicates complete metadata; "I" indicates incomplete metadata. Under "Digital Imagery," "Yes" indicates the existence of vessel/instrument imagery in the SAMOS database, "No" indicates non-existence. Empty boxes indicate non-existence of a parameter; multiple entries in any box indicate multiple sensors for that parameter and vessel.

5. Plans for 2011

The SAMOS DAC is partnering with the Rolling deck To Repository (R2R; http://www.rvdata.us/overview) project. Funded by the National Science Foundation, R2R is developing a protocol 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 2010, the UNOLS vessels contributing to the SAMOS DAC were those operated by WHOI, UH, and BIOS. The focus of the R2R is capturing all these data at the end of each planned cruise; however, the SAMOS DAC is developing a real-time component to transfer a subset of meteorological and surface-oceanographic data from ship to shore. The data will be transferred at the full observational resolution for the specified sensor (in some cases up to 1Hz samples) on a yet to be determined transfer schedule. The transfer protocol will take full advantage of the evolving broadband satellite communication technology. Draft comma-separated value (CSV) and extensible mark-up language (XML) formats have been developed in consultation with UNOLS operators and Oregon State University and the University of Rhode Island. In 2011, the SAMOS DAC will update our process to ingest the full resolution data in these formats and develop quality controlled preliminary and intermediate data that conform to existing SAMOS products.

In addition to new data transfer and processing protocols related to the R2R, we will be implementing a new automated statistical QC procedure to identify spikes, steps, and highly variable data. This routine is being modified after initial testing in 2010 to allow objective determination of thresholds for marking suspect values. The original design required labor-intensive tuning for each vessel, which the DAC simply can not support at current resource levels. A phased implementation should commence in late-2011. The objectively derived tuning parameters will be stored in the SAMOS ship profile SQL database.

Finally, in an effort to improve communication with our data providers, vessel operators, and shipboard technicians, we plan to establish a subscription service for routine data reports. We plan to create daily, weekly, and/or monthly reports regarding data flow (what have we received) and data quality. Several of those reports will be based on the information provided in this annual report. We are open to suggestions and ask operators and technicians to feel free to contact us at samos@coaps.fsu.edu.

6. References

The Australian Integrated Marine Observing System, 2008: *J. Ocean Technology* **3**(3), 80-81.

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

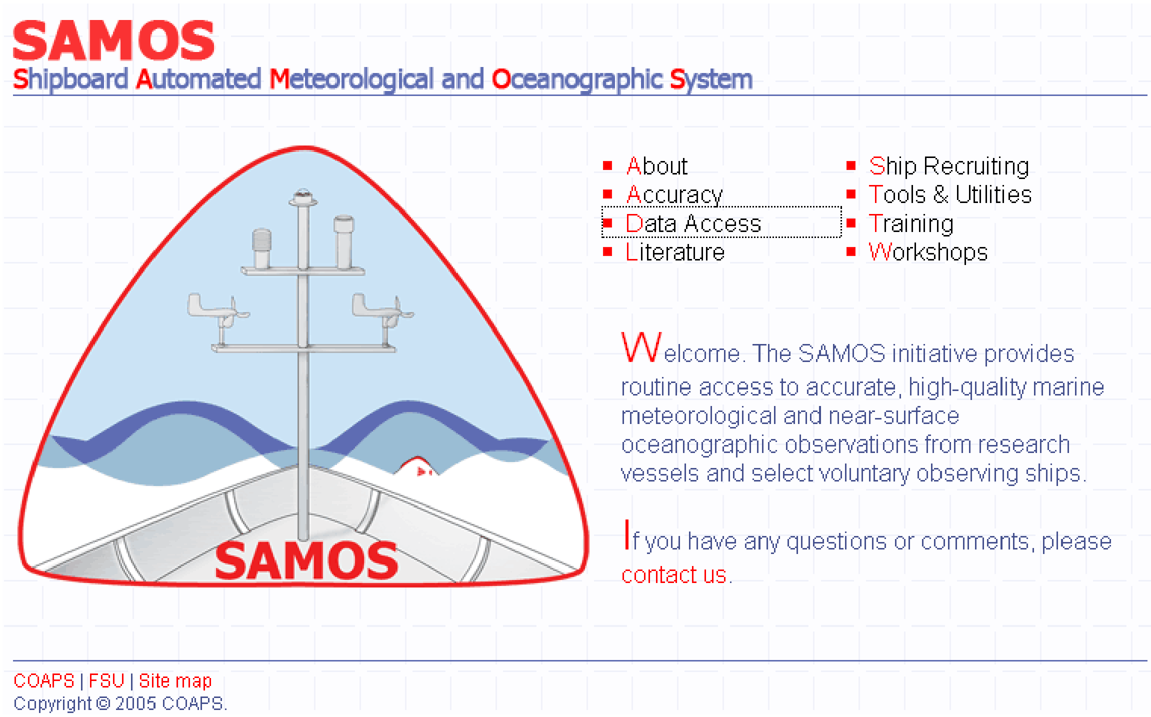
Weather Underground, cited 2010: History for Faleolo, Samoa. [Available online at http://www.wunderground.com/history/airport/NSFA/2009/3/1/ DailyHistory.html?req_city=NA&req_state=NA&req_statename=NA.]

Weather Underground, cited 2010: History for Keahole Point, HI. [Available online at http://www.wunderground.com/history/airport/ PHKO/2009/3/9/ DailyHistory.html?req_city=NA&req_state=NA&req_statename=NA.]

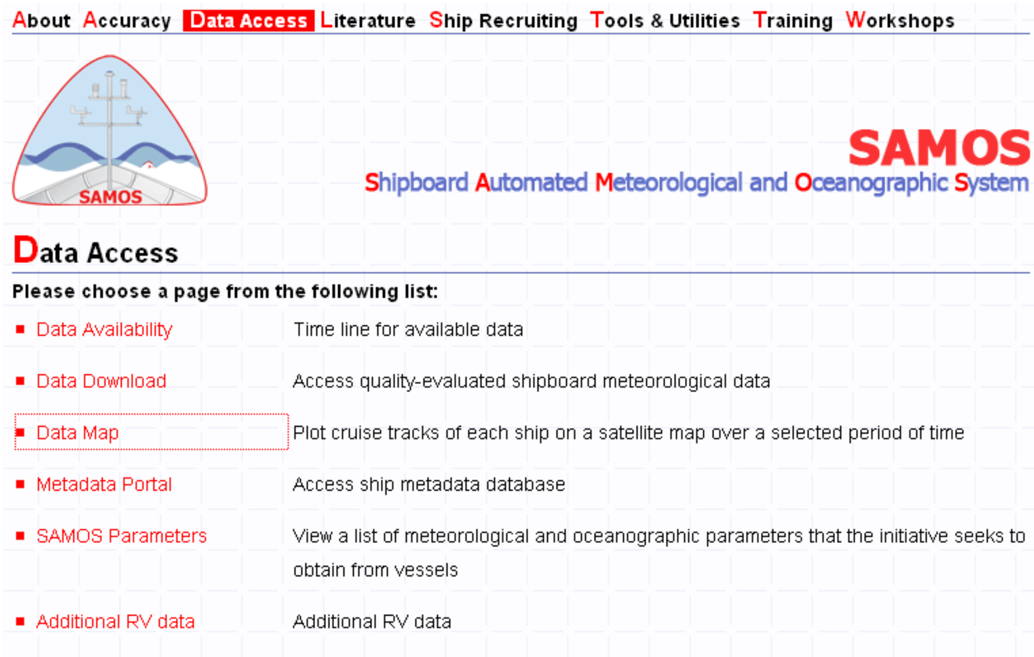
Annex A: SAMOS Online Metadata System Walk-through Tutorial

PART 1: the end user

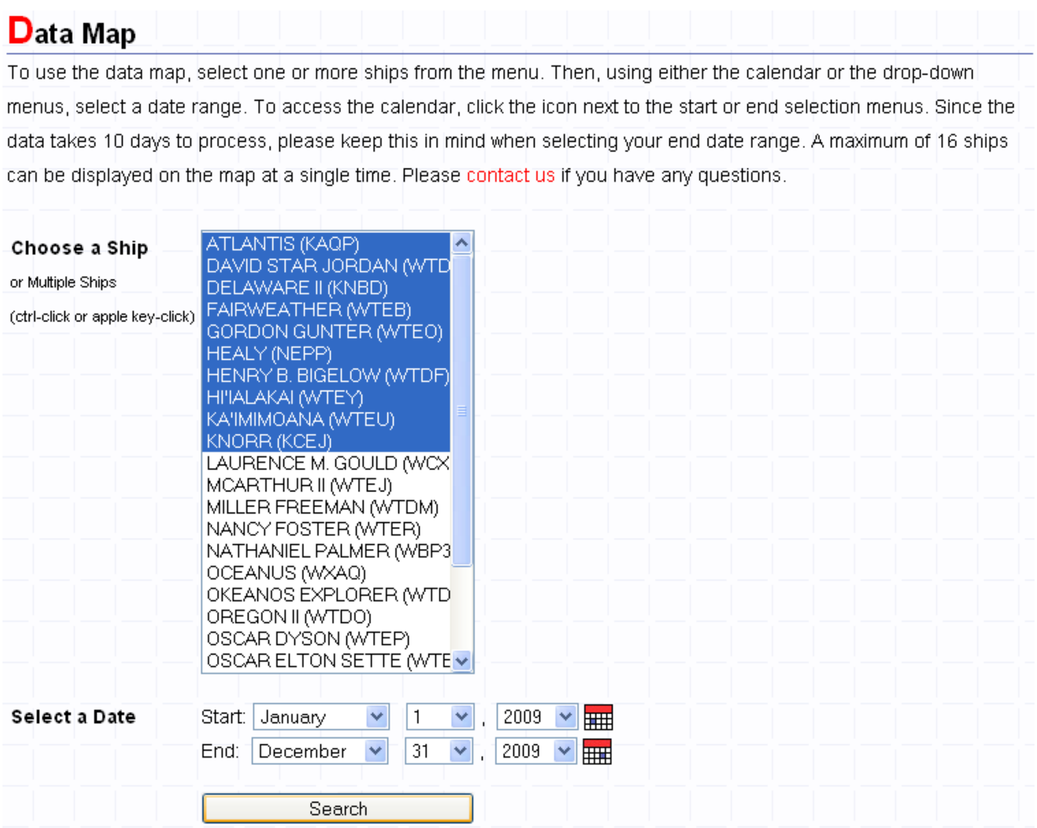
The SAMOS public website can be entered via the main page at http://samos.coaps.fsu.edu/html/



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



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

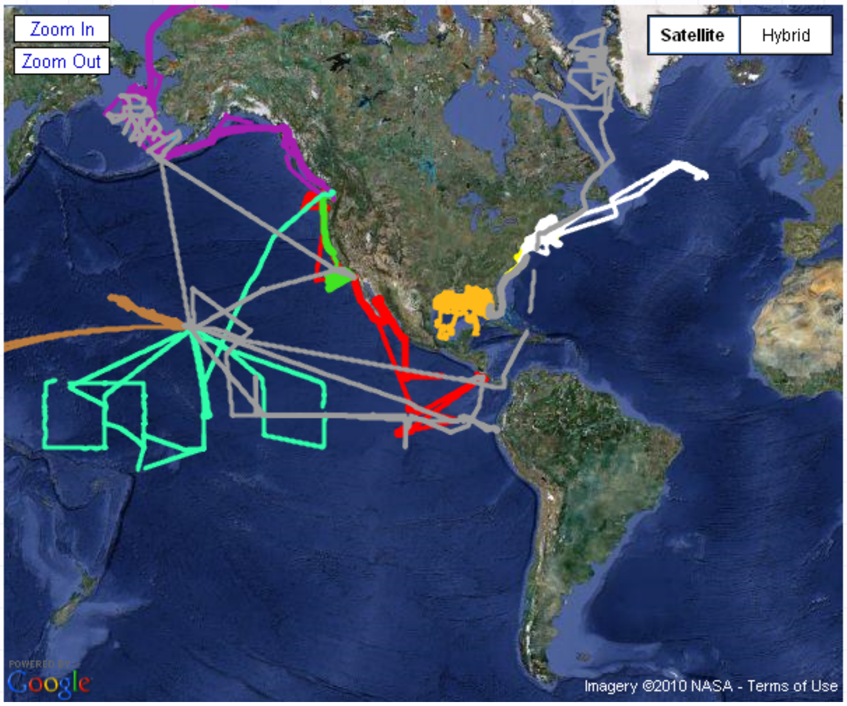


By entering a date range of January 1, 2009 to December 31, 2009 and clicking "search," a map is displayed showing all of the selected ship's tracks for the year 2009:

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	☑

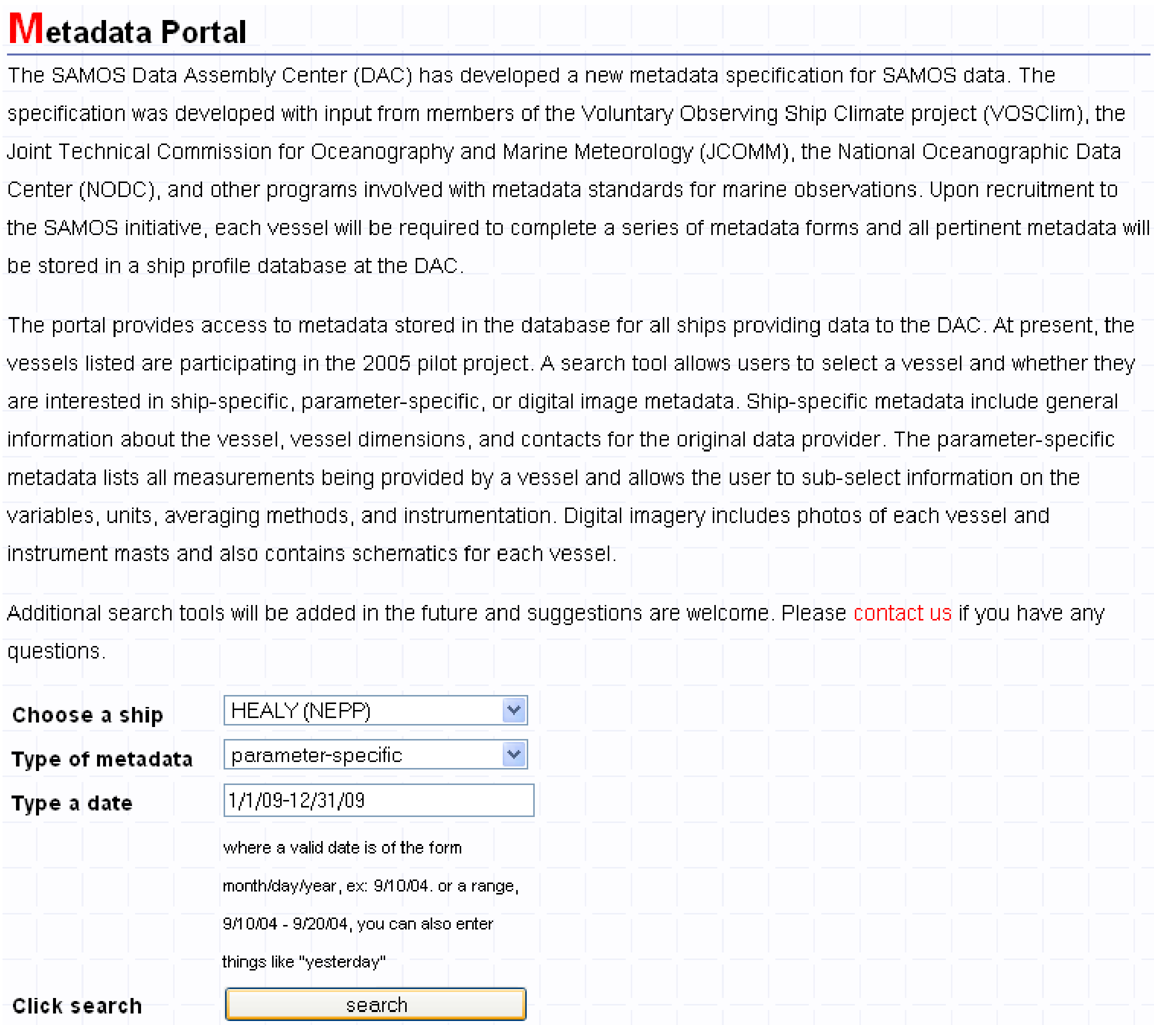
Now the user can see that both the *Healy* and the *Knorr* cruised in the north-polar region in 2009. The next step might be to see what parameters are available on each ship. Returning to the Data Access page, the user this time selects the Metadata Portal:

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.

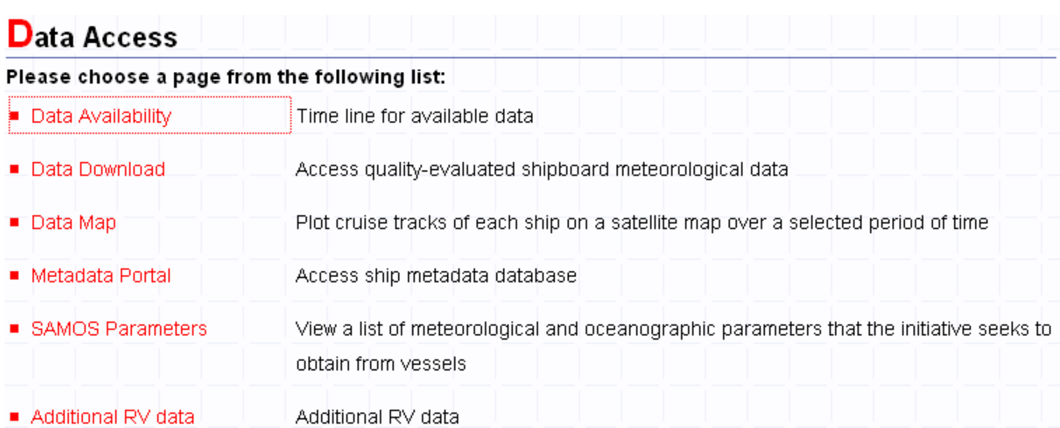
The portal provides access to metadata stored in the database for all ships providing data to the DAC. At present, the vessels listed are participating in the 2005 pilot project. A search tool allows users to select a vessel and whether they are interested in ship-specific, parameter-specific, or digital 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.

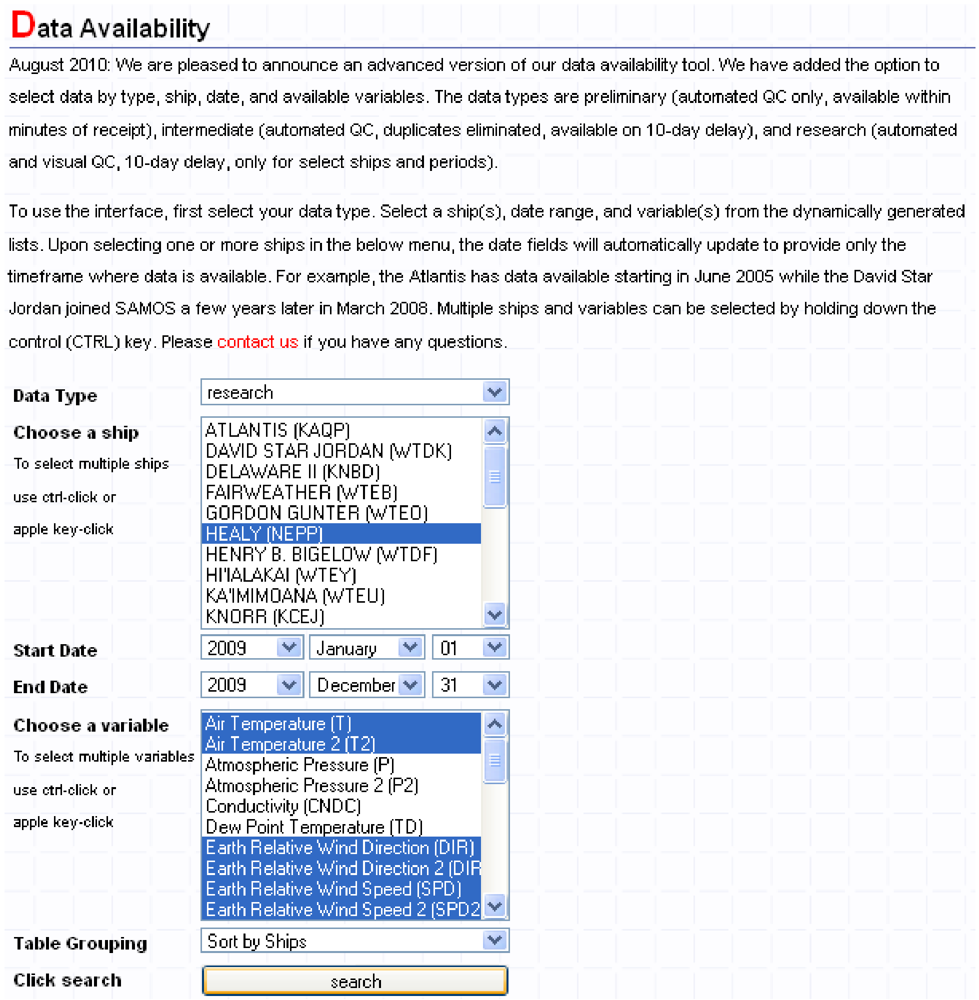
Choose a ship	HEALY (NEPP)
Type of metadata	parameter-specific
Type a date	1/1/09-12/31/09
	where a valid date is of the form month/day/year, ex: 9/10/04. or a range, 9/10/04 - 9/20/04, you can also enter things like "yesterday"
Click search	search

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

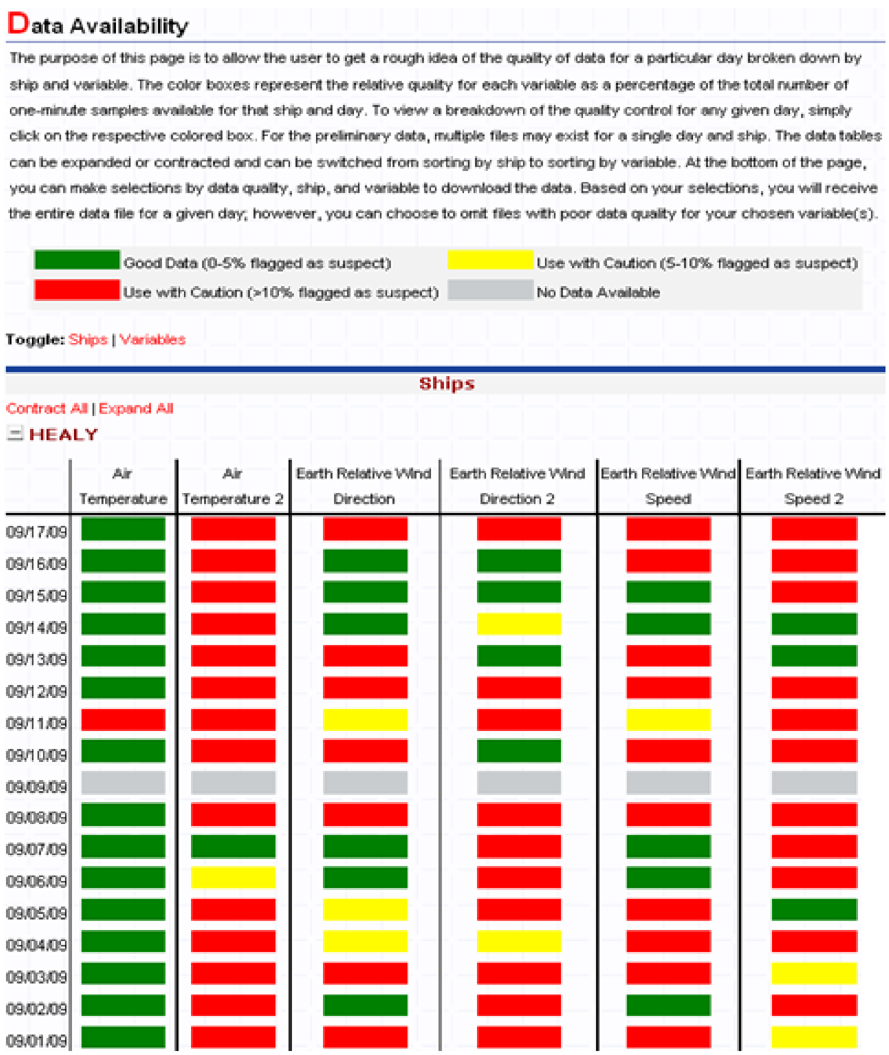
A thorough investigation of the list (note: image is truncated) tells the user the *Healy* did in fact provide both wind and temperature data in 2009. (Throughout the online SAMOS system, clicking on a "+" will yield further information; in this case the result would be metadata for the individual parameters.)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



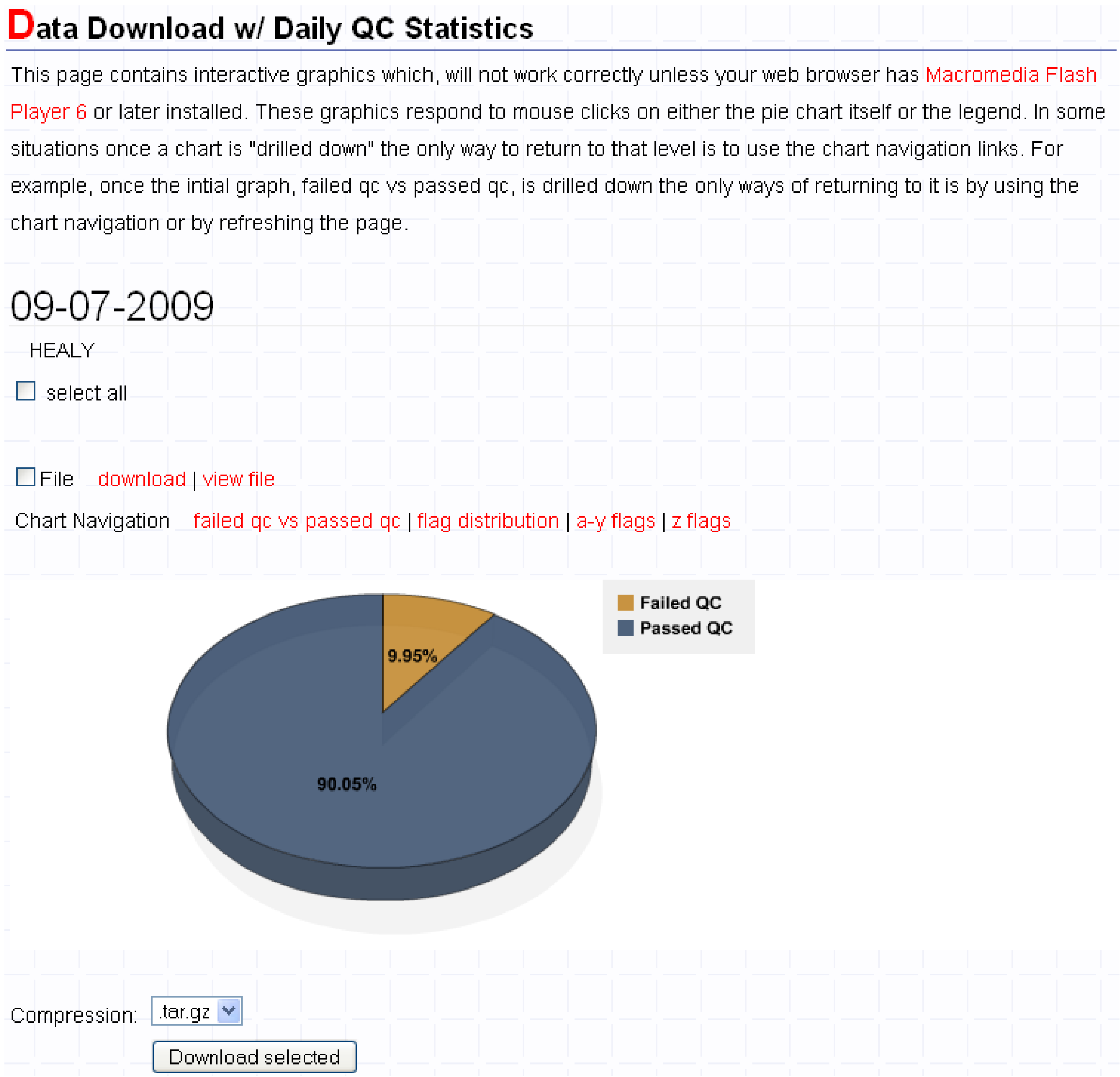
After selecting the *Healy* along with the desired parameter(s), date range, and data version (preliminary, intermediate, or research), noting that the default date range and available parameters will change once a vessel and data version are selected, and then clicking "search":



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 of 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:



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.

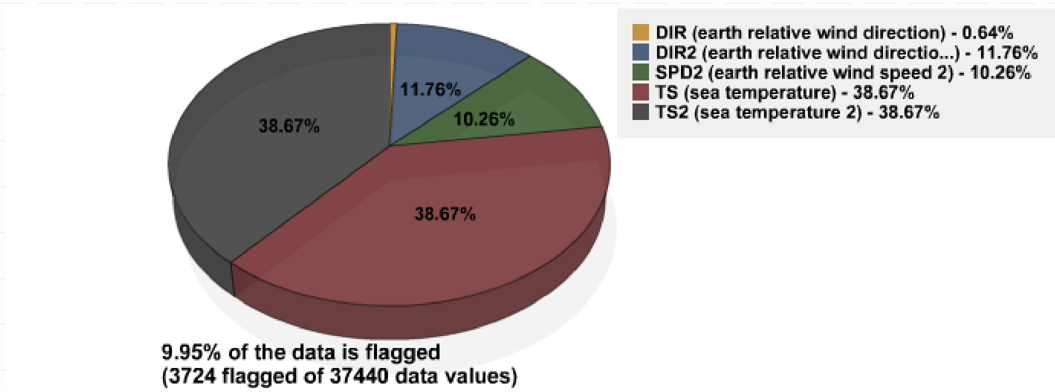
09-07-2009

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.

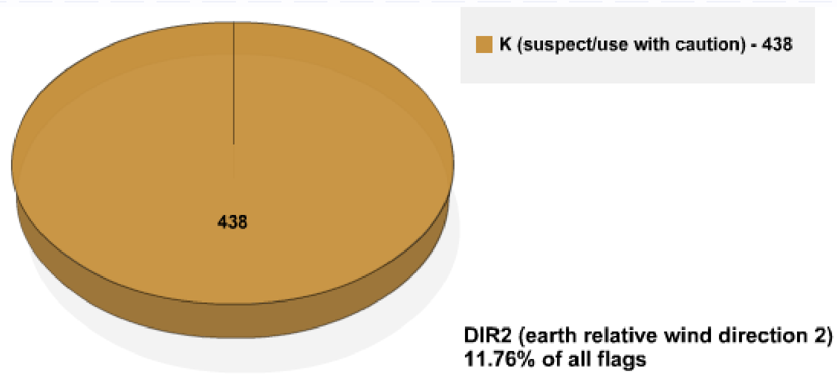
09-07-2009

HEALY

☐ select all

☑ File download | view file

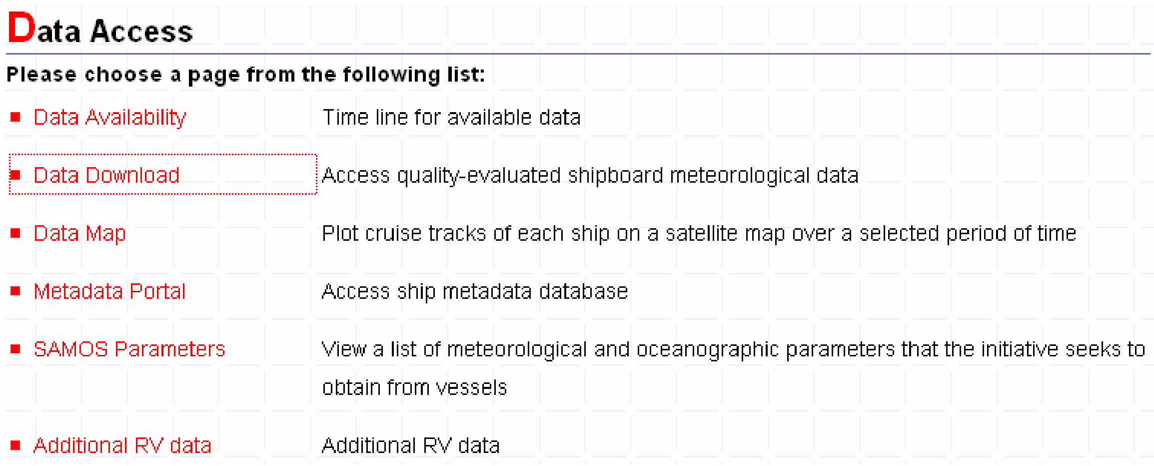
Chart Navigation failed qc vs passed qc | flag distribution | a-y flags | z flags



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:

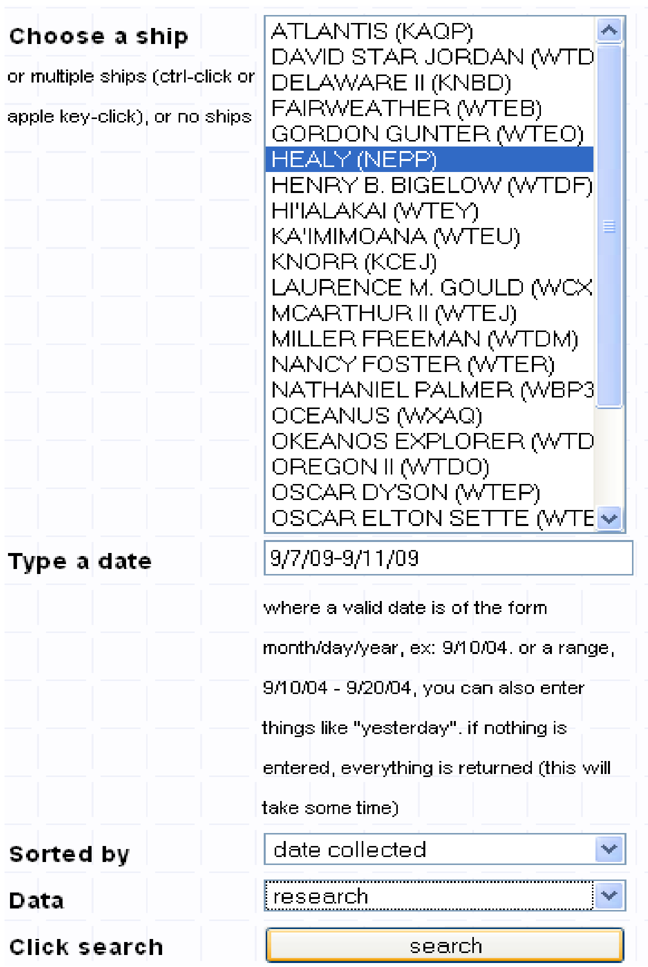


Data Access

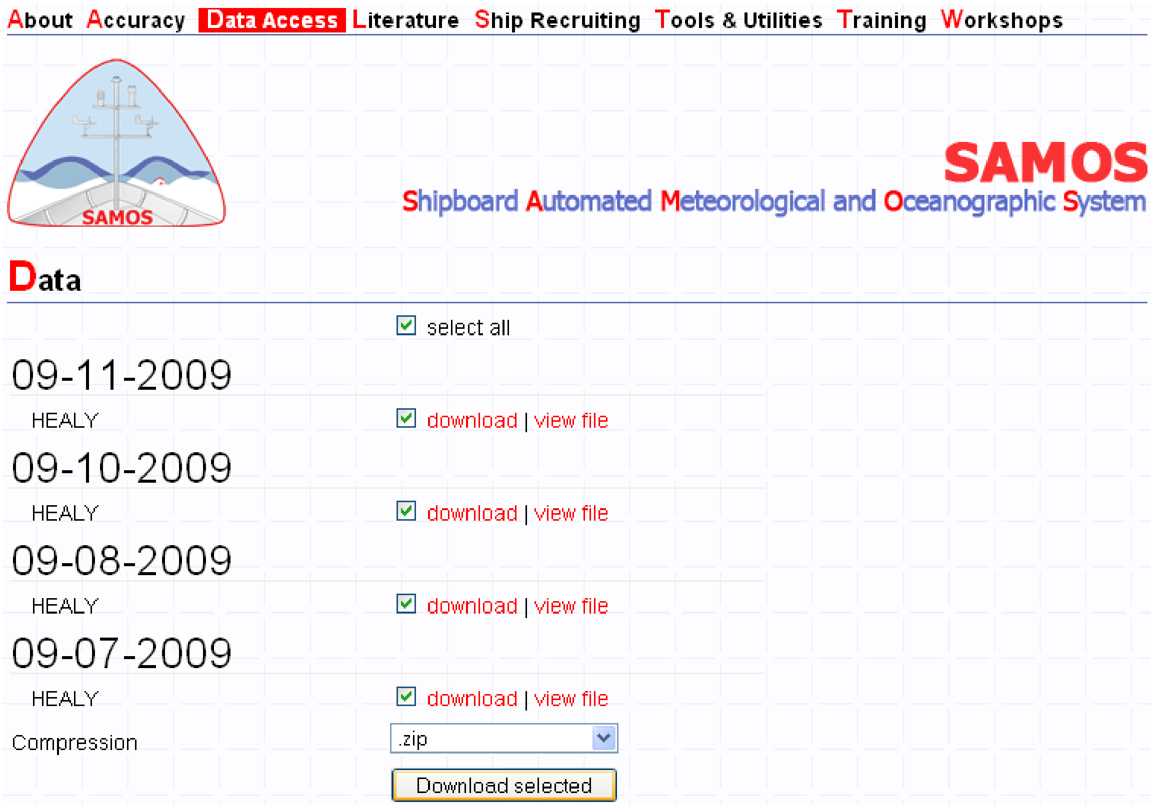
Please choose a page from the following list:

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

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



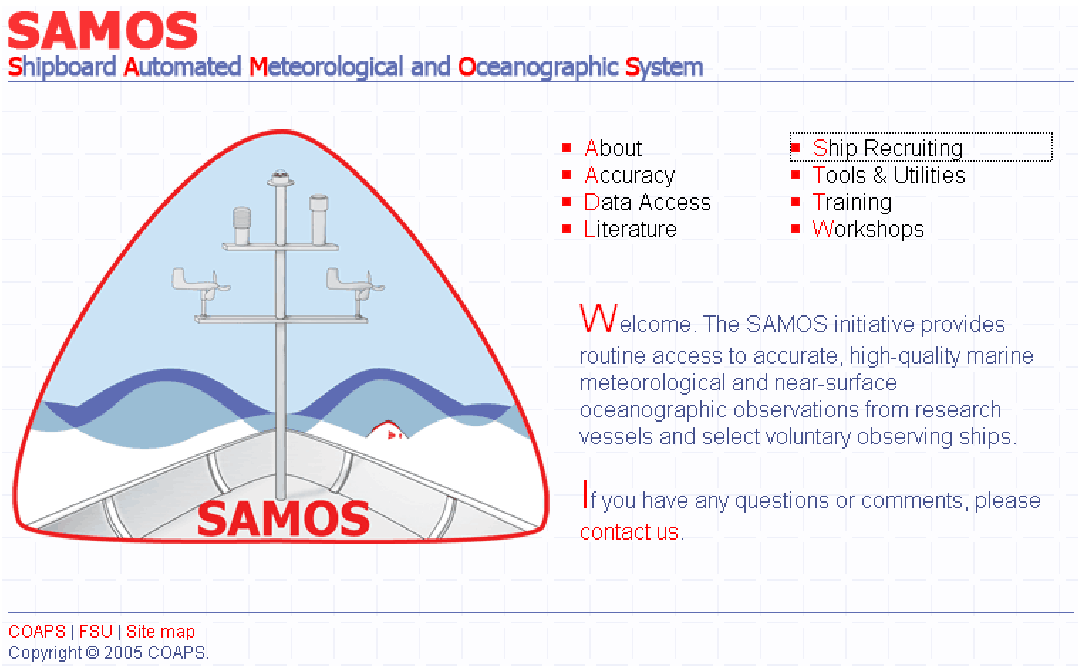
the user can choose "select all," along with a file compression format, and click "Download selected" to begin the download:



PART 2: the SAMOS operator

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 are also highly desirable, as they are often beneficial in diagnosing flow obstruction issues. 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:



SAMOS
Shipboard Automated Meteorological and Oceanographic System

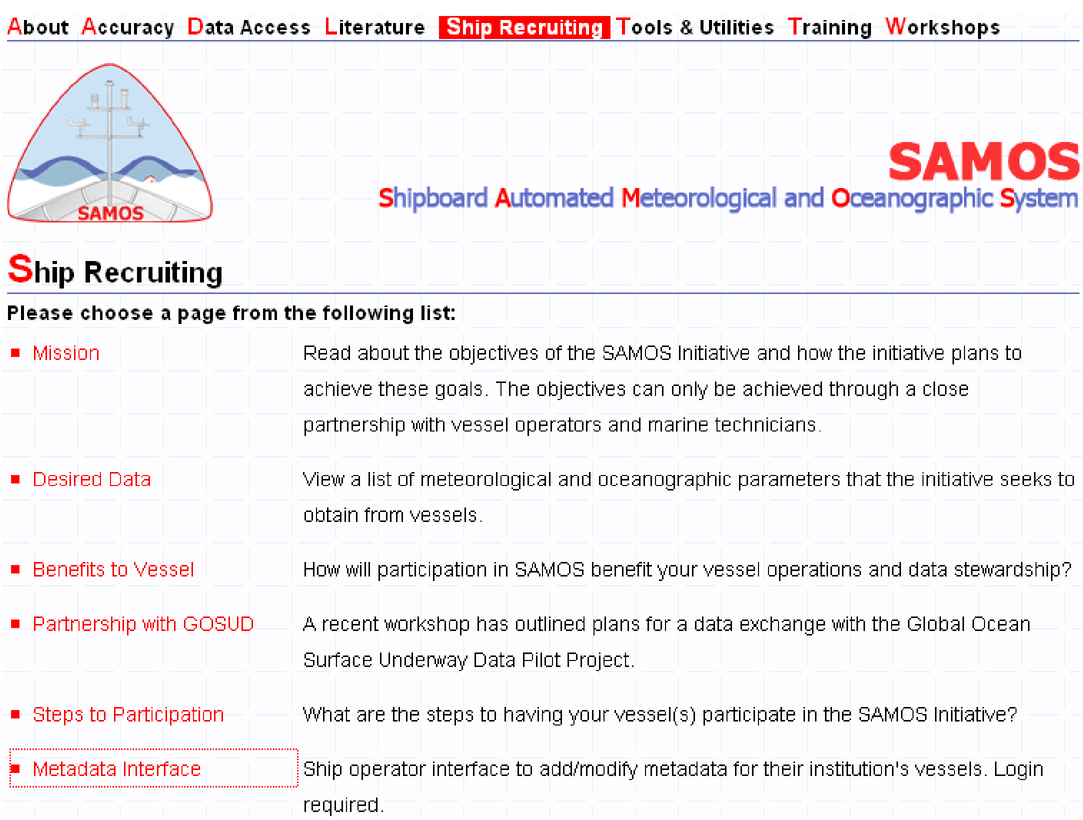
- About
- Accuracy
- Data Access
- Literature
- Ship Recruiting
- Tools & Utilities
- Training
- Workshops

Welcome. The SAMOS initiative provides routine access to accurate, high-quality marine meteorological and near-surface oceanographic observations from research vessels and select voluntary observing ships.

If you have any questions or comments, please contact us.

COAPS | FSU | Site map
Copyright © 2005 COAPS.

(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:



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

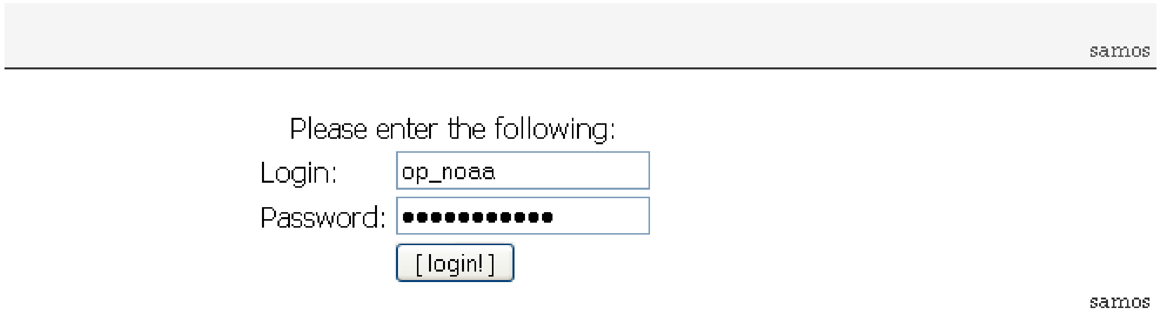
SAMOS
Shipboard Automated Meteorological and Oceanographic System

Ship Recruiting

Please choose a page from the following list:

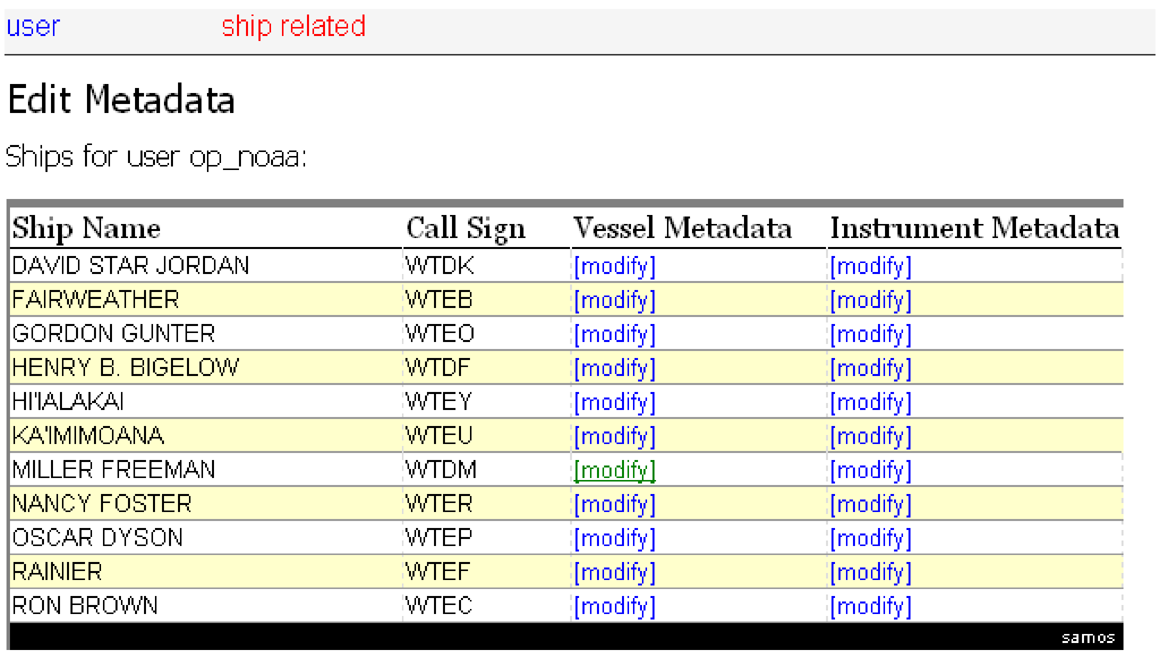
Mission	Read about the objectives of the SAMOS Initiative and how the initiative plans to achieve these goals. The objectives can only be achieved through a close partnership with vessel operators and marine technicians.
Desired Data	View a list of meteorological and oceanographic parameters that the initiative seeks to obtain from vessels.
Benefits to Vessel	How will participation in SAMOS benefit your vessel operations and data stewardship?
Partnership with GOSUD	A recent workshop has outlined plans for a data exchange with the Global Ocean Surface Underway Data Pilot Project.
Steps to Participation	What are the steps to having your vessel(s) participate in the SAMOS Initiative?
Metadata Interface	Ship operator interface to add/modify metadata for their institution's vessels. Login required.

The user will then be directed to log in, using their group's username and password:



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

a. Select Vessel Metadata


user ship related

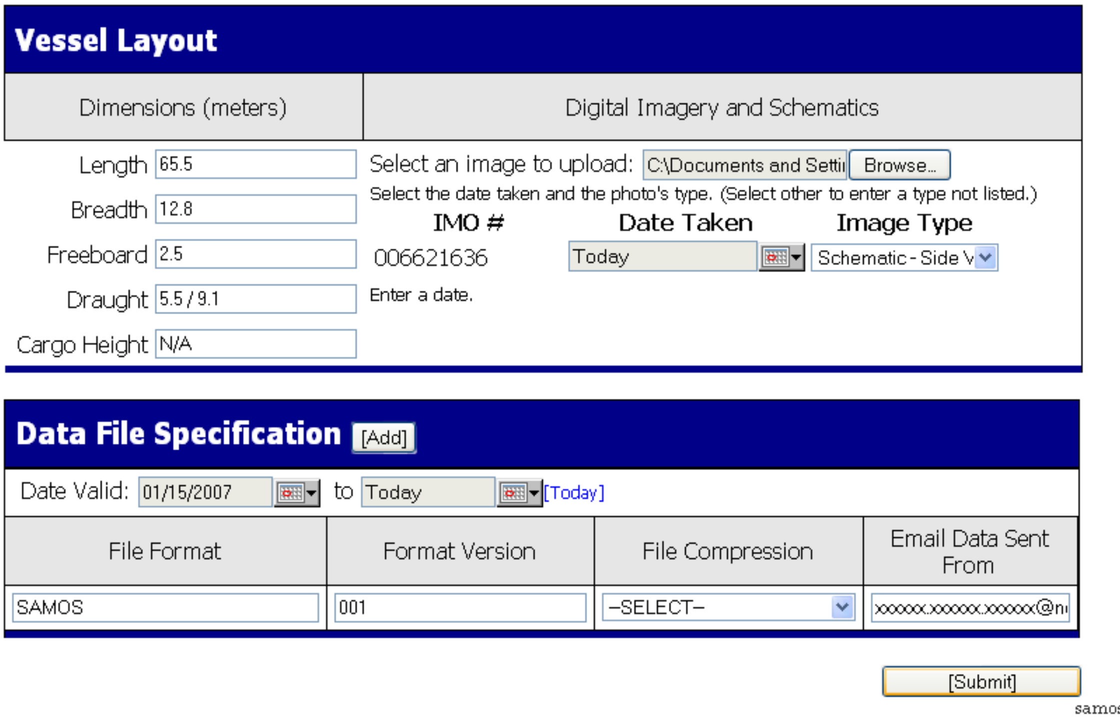
Edit Metadata

Ships for user op_noaa:

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

samos

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



When editing Vessel Metadata, it is important to remember that submitting any new information will overwrite any existing information. The user should therefore take special care not to accidentally overwrite a valid field, for example the vessel Draught field. However, adding an image, as demonstrated previously, 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. 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

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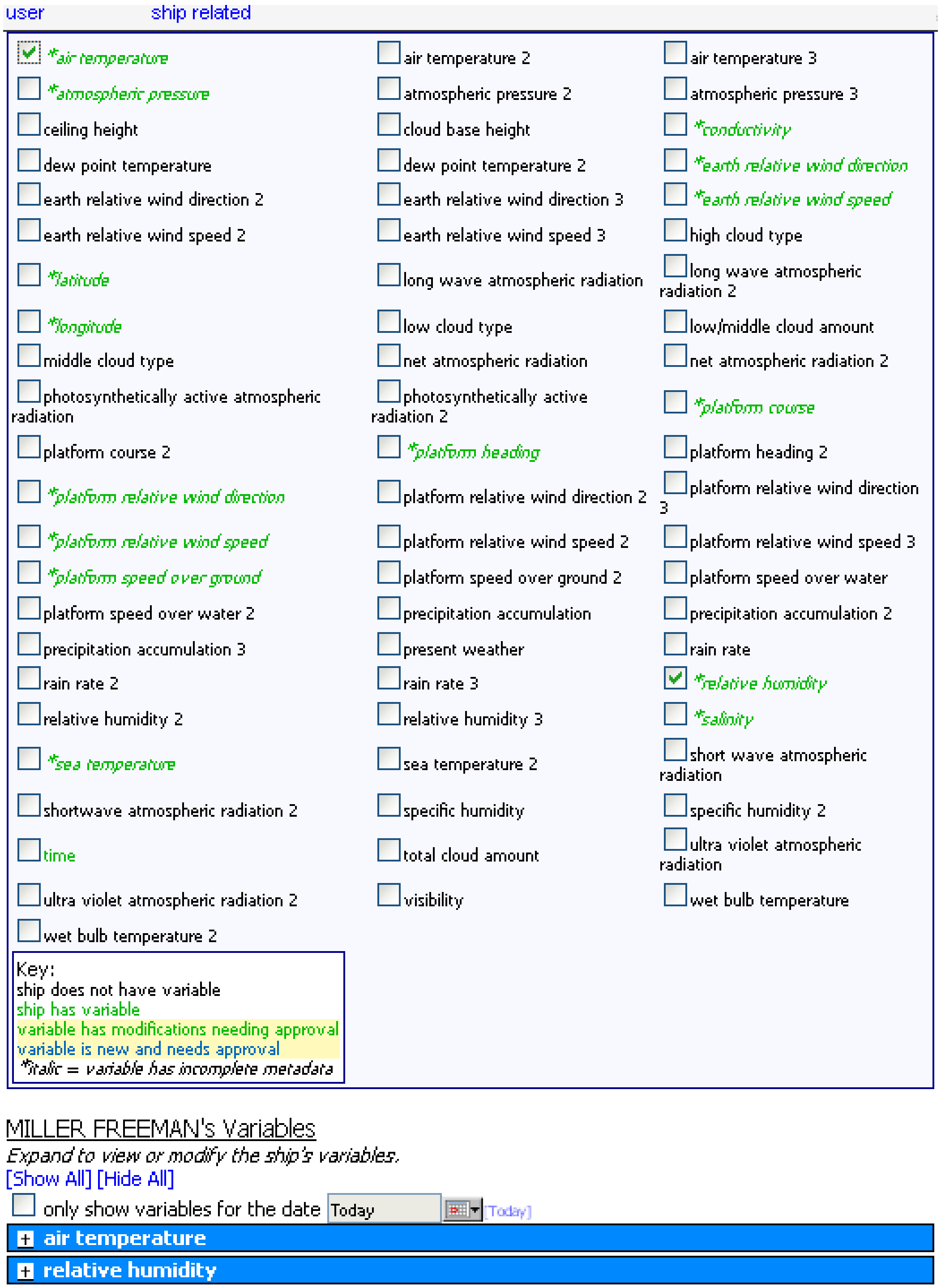
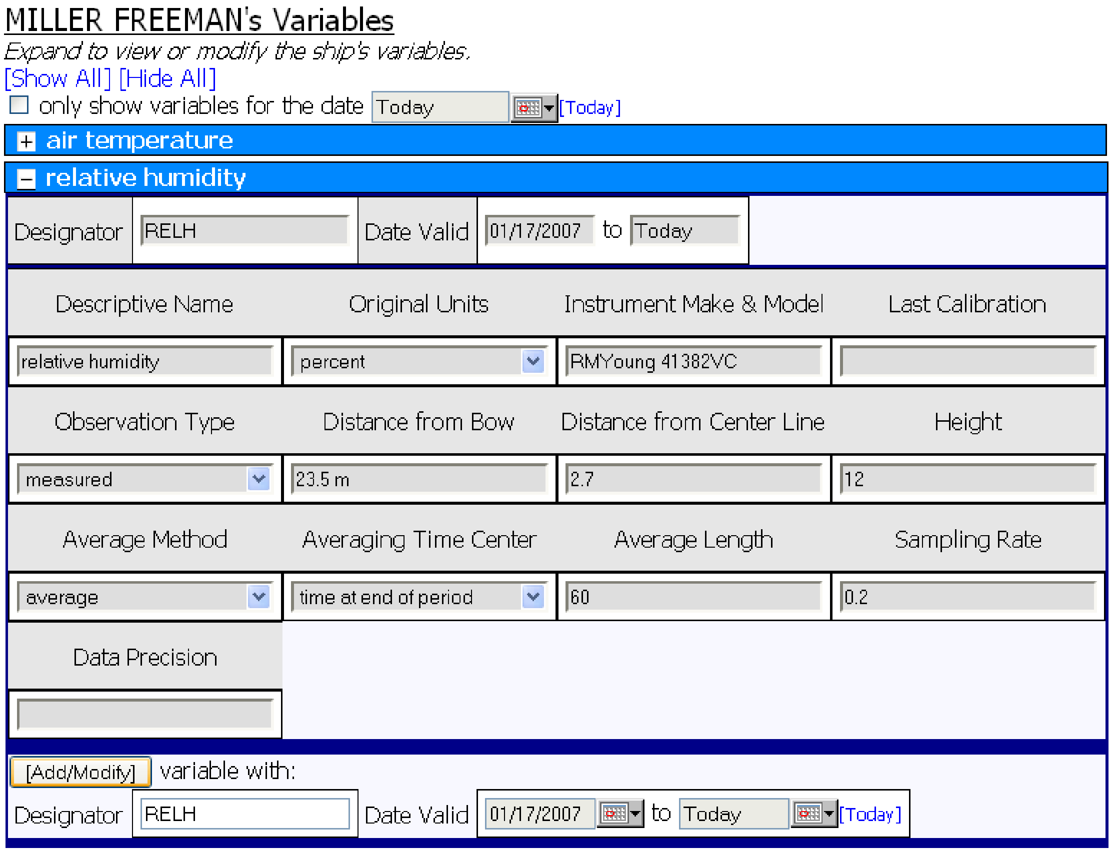
Adding and editing instrument (or parameter) metadata follow a slightly different procedure. The first step for the SAMOS operator is to identify which parameter he wishes to add or modify. Let us first consider the case of modifying a parameter already in use. Let us assume that a humidity/temperature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

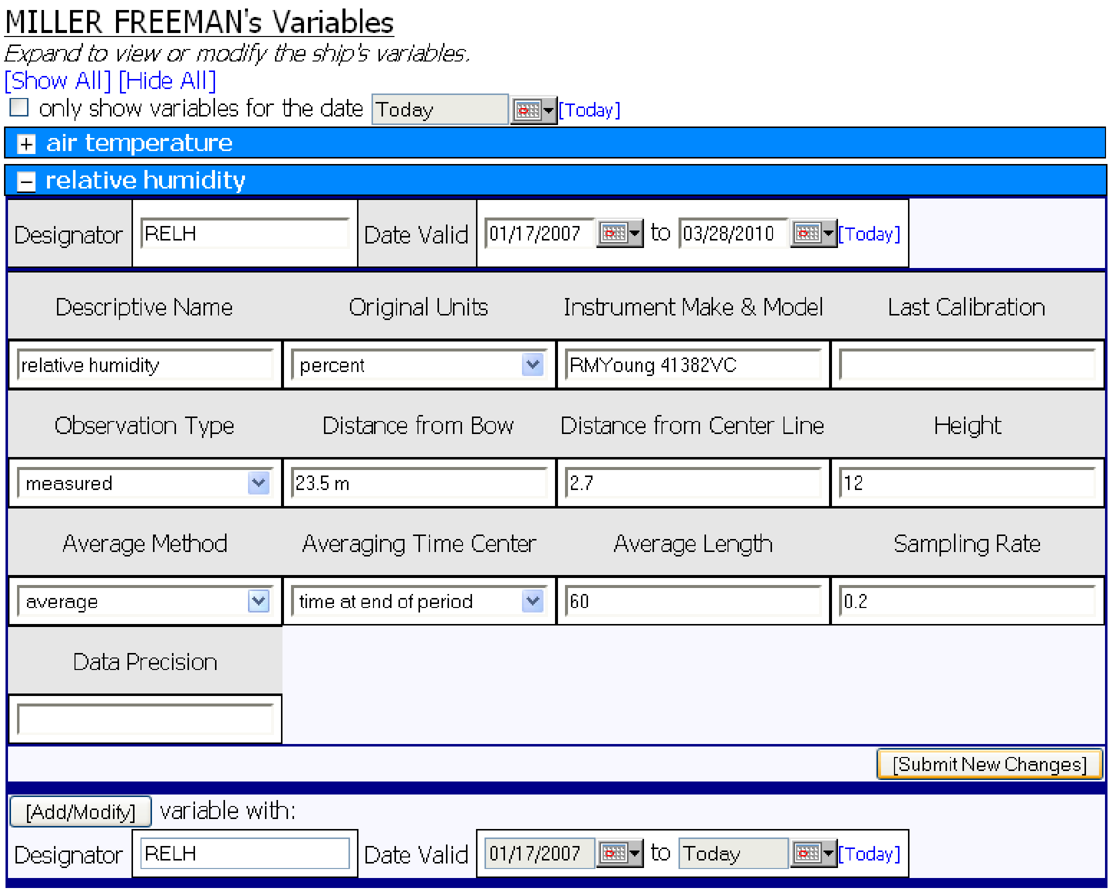


Clicking over the "+" for relative humidity opens the list of metadata fields associated with that parameter. The first step is to identify to the system which version of the parameter metadata is being modified. (In most cases that will be the current version; however, it should be noted that occasionally there are multiple versions listed and a previous version needs to be edited retrospectively.) This identification is accomplished by filling in the sequestered set of Designator and Date Valid fields (located below the metadata info) to exactly match those of the desired version metadata and then clicking "Add/Modify":



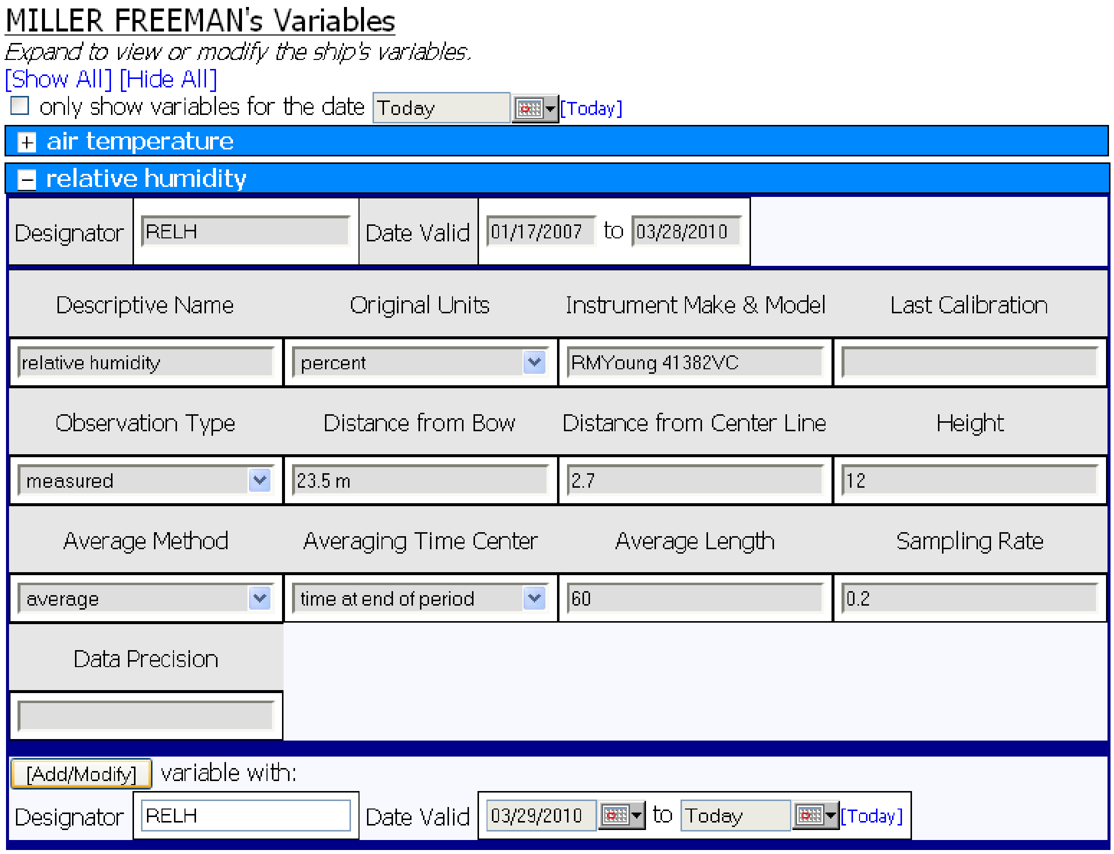
samos

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, he would change the Date Valid field in the metadata area to reflect the last date the instrument was oriented at the old location and then click "Submit New Changes":



samos

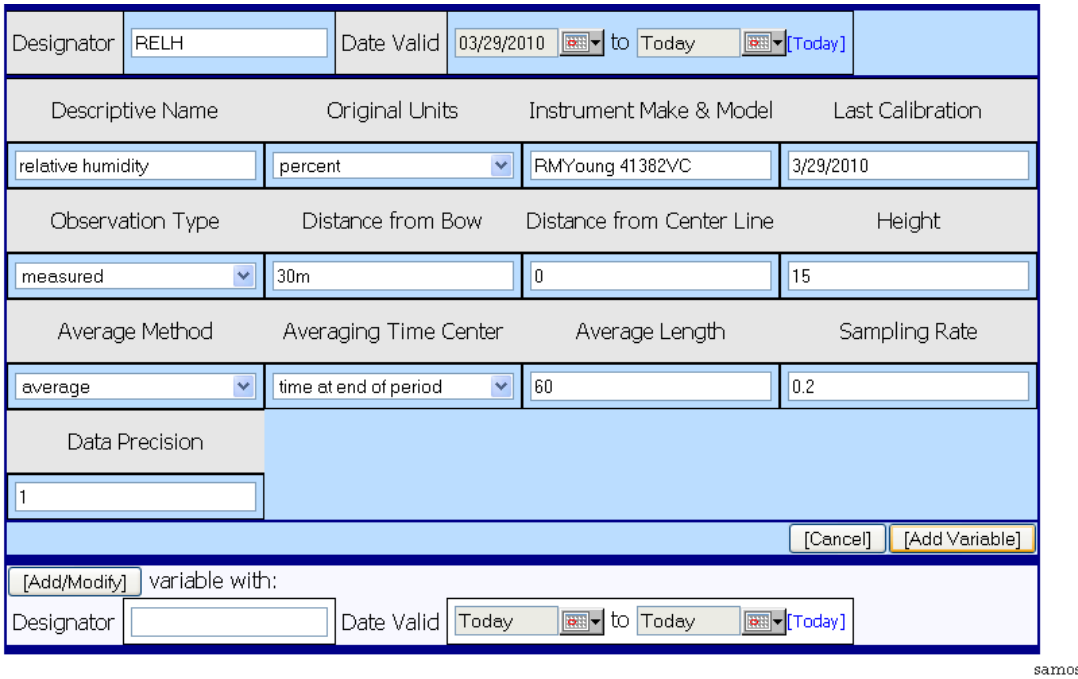
He then initiates a new version by filling in the sequestered set of Designator and Date Valid fields to reflect the new current period, beginning at the date the instrument was relocated, and once again clicking "Add/Modify":



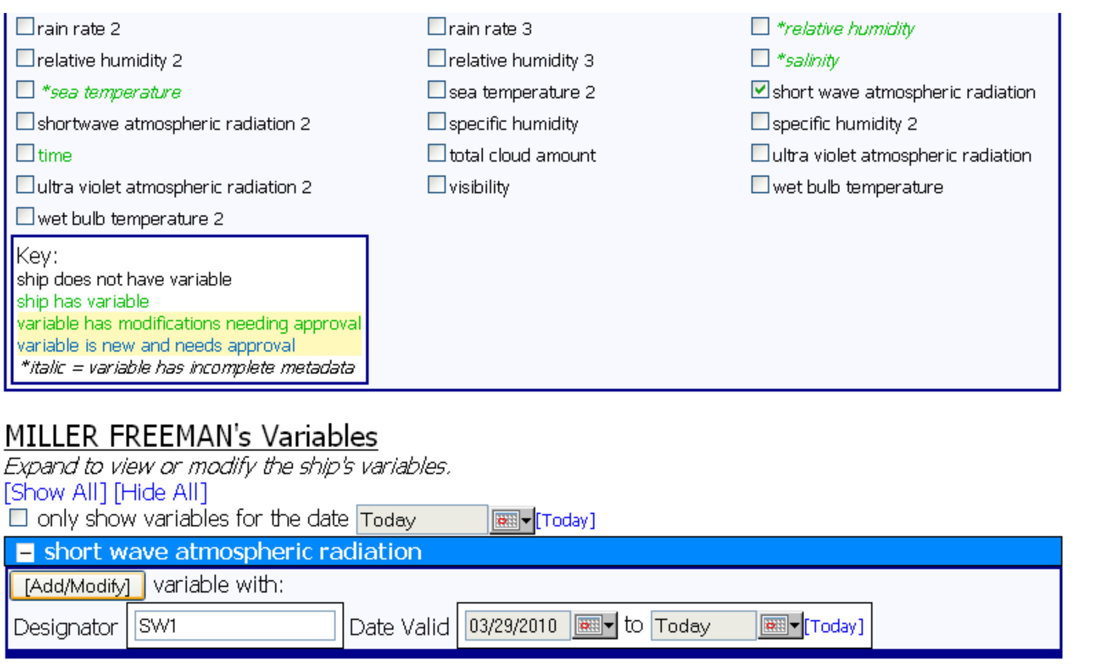
samos

*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.

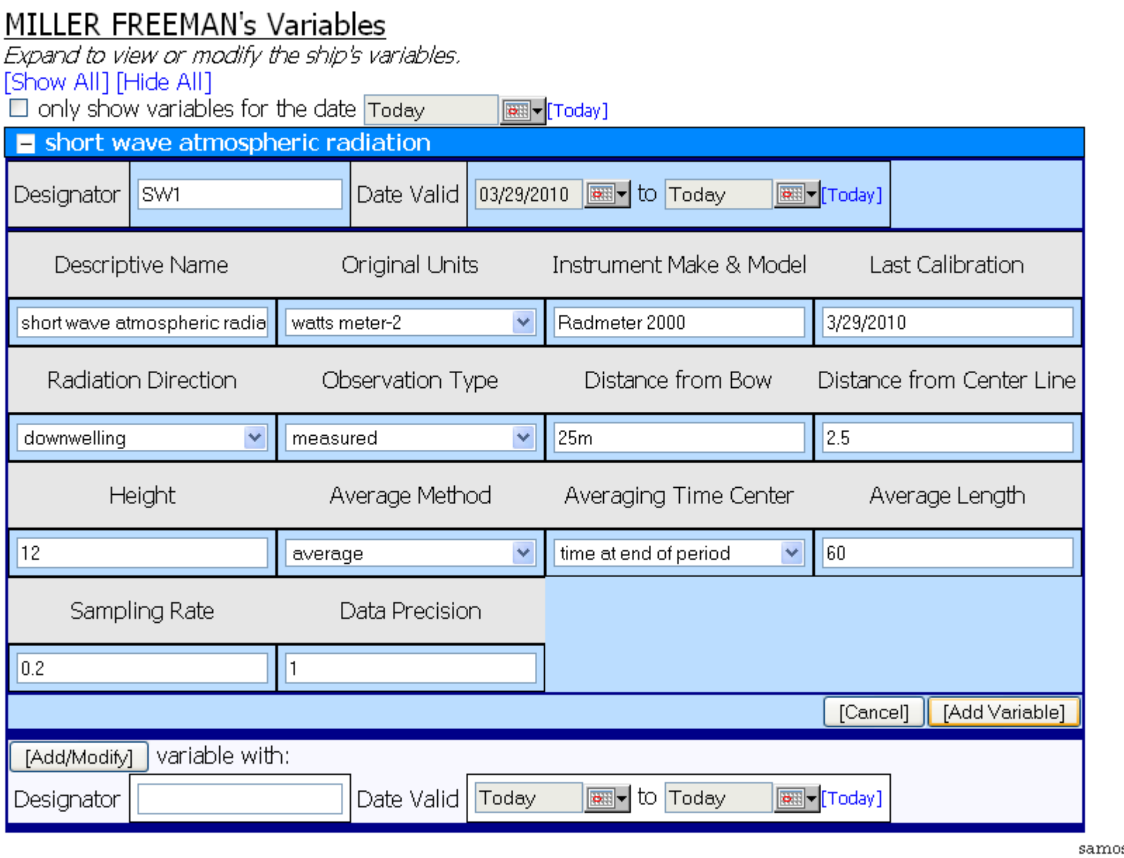
Once "Add/Modify" is clicked, a new set of fields opens up for the RELH parameter. All op_noaa need do at this point is recreate the parameter metadata entry, of course taking care to fill in the new location information, and click "Add Variable":



User op_noaa would then need to repeat the process for the air temperature parameter, since it too is measured by the relocated sensor. 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.


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]

⊟ short wave atmospheric radiation

Designator	SW1	Date Valid	03/29/2010 to Today [Today]

Descriptive Name	Original Units	Instrument Make & Model	Last Calibration
short wave atmospheric radia	watts meter-2	Radmeter 2000	3/29/2010
Radiation Direction	**Observation Type**	**Distance from Bow**	**Distance from Center Line**
downwelling	measured	25m	2.5
Height	**Average Method**	**Averaging Time Center**	**Average Length**
12	average	time at end of period	60
Sampling Rate	**Data Precision**		
0.2	1		

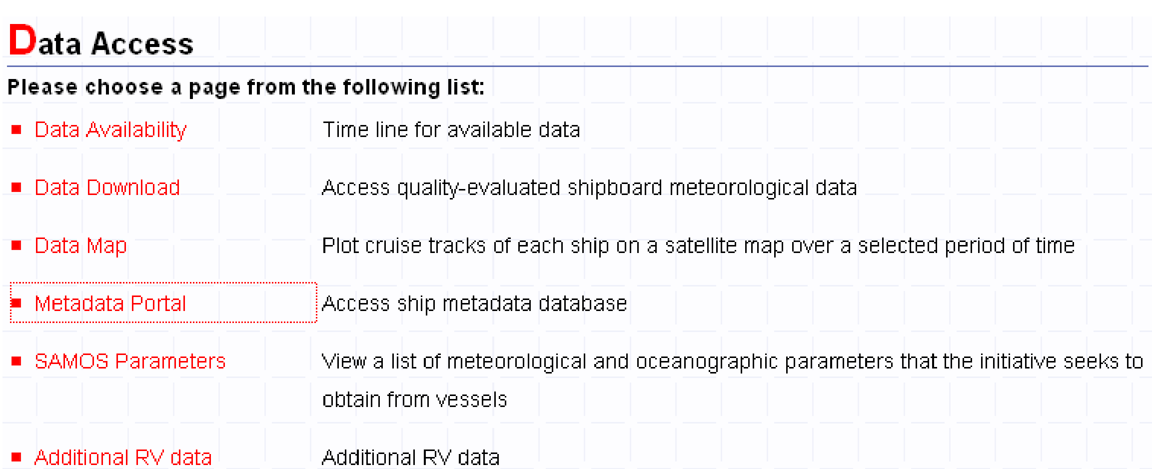
[Cancel] [Add Variable]

[Add/Modify] variable with:

Designator		Date Valid	Today to Today [Today]

samos

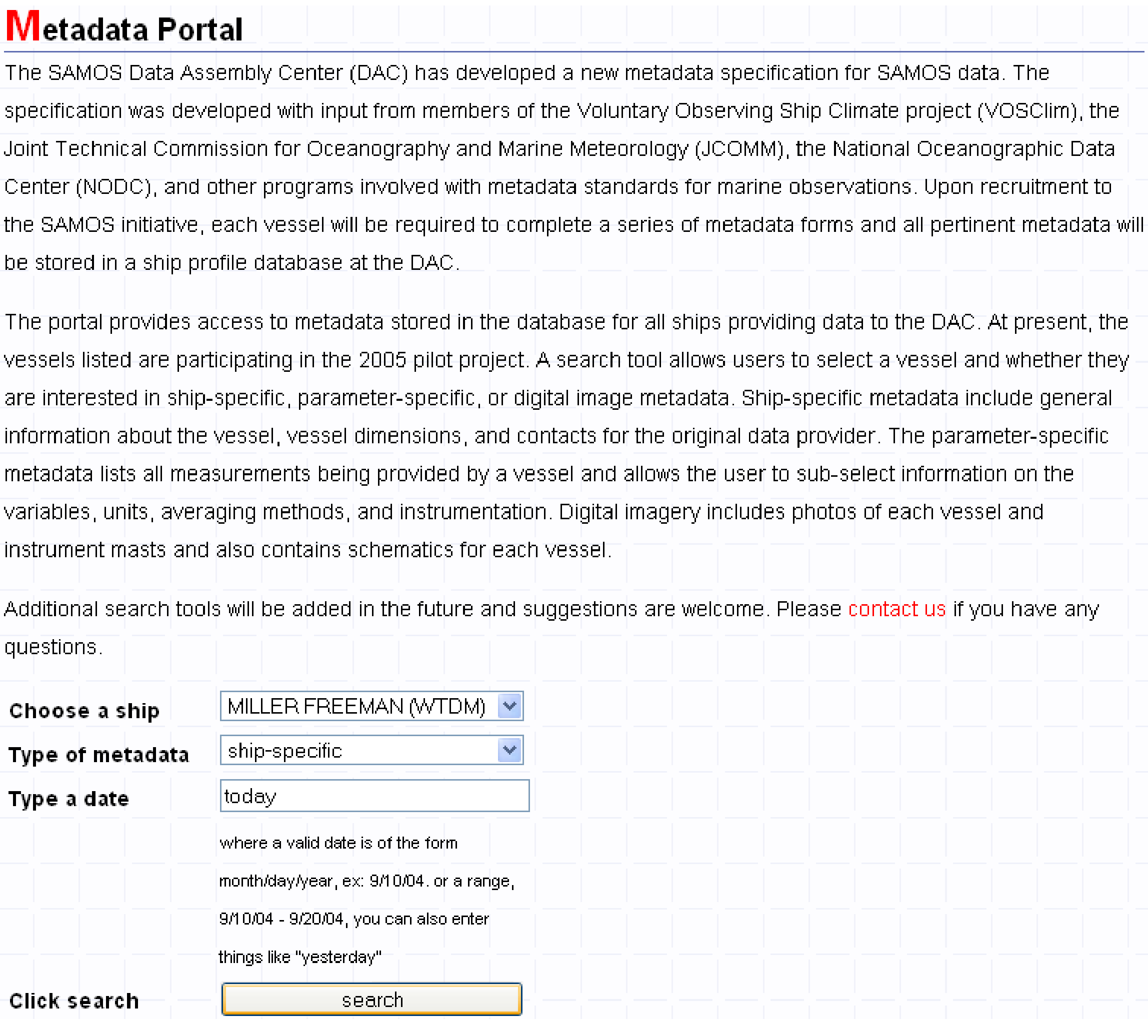
Once an addition or modification to metadata has been submitted, a SAMOS associate at COAPS is automatically notified that approval is needed. Once approved, the new information will be visible to the public, via the Metadata Portal, accessed from the Data Access page as outlined in part one:


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

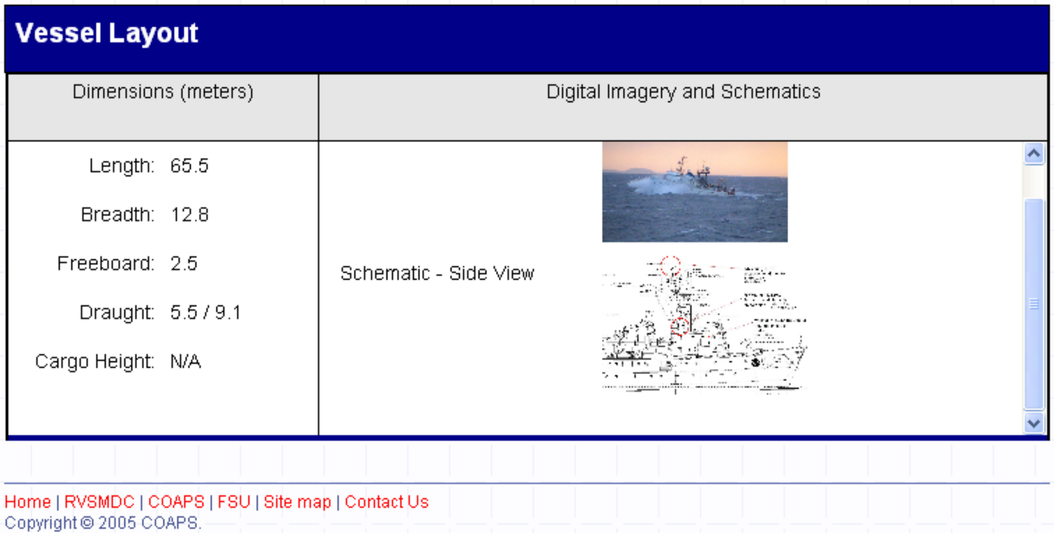
The SAMOS Data Assembly Center (DAC) has developed a new metadata specification for SAMOS data. The specification was developed with input from members of the Voluntary Observing Ship Climate project (VOSClim), the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), the National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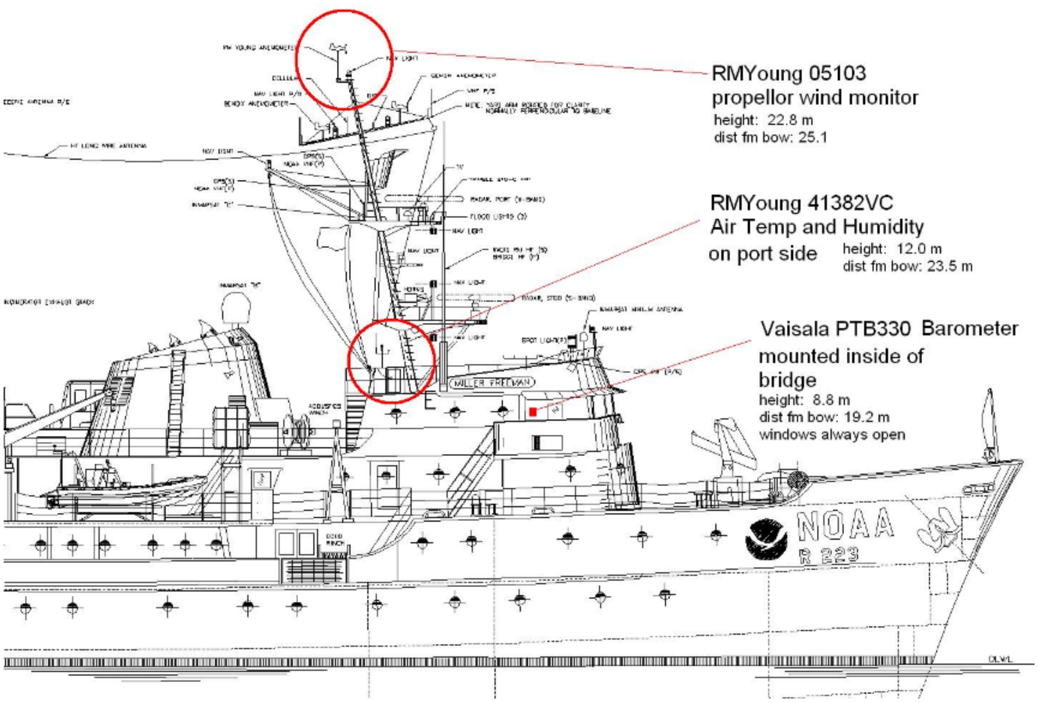
Clicking on the image itself would give us an enlarged view. In this case, the photo provides details about the locations of three MET sensors:



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!)

Annex B: **Importance of SAMOS Operator/Analyst Interaction: A Case Study**

SAMOS operator/analyst interaction is vital to the ongoing integrity of the SAMOS data. When there is a problem with the SAMOS data, the ship's technicians are often unaware and it is up to the data analysts to notify the ship so attempts can be made to correct the issue as soon as possible. There are several common occurrences that easily stand out and warrant operator notification. These include: sea temperature apparatus being left switched off while the vessel is at sea (Figure B1) or, similarly, intake pumps that feed near-surface seawater to sea temp indicators being left off while the vessel is at sea; pressure sensors that routinely read too high or too low (Figure B2); and other obvious sensor failures (Figure B3). Another common occurrence is missing sensor data for parameters that a specific vessel has indicated would be included in routine transmissions. The following excerpts from recent email communications with the *R/V Atlantis* demonstrate the notification/resolution process:

In an email from data analyst Kristen Briggs, dated 12 March 2010, to technicians onboard the *R/V Atlantis*:

> ..."I recently noticed we are no longer receiving any data for the SAMOS SOG parameter (platform speed). Upon investigation, it looks like 2/14/10 was the last date the parameter was included in the daily SAMOS files. Is there currently an issue with that sensor?"

Response from Woods' Hole Institute contact Dave Sims, dated 13 March 2010:

> ..."Please take a look now. I believe we have the bug eliminated.
> aloha,
> Dave Sims"

In general, these common types of issues are given a few days' grace period before operator notification, as the SAMOS operators sometimes clear them up of their own accord within a day or two. Occasionally, though, an analyst will come across a more unusual problem. As the following case study demonstrates, communication between the SAMOS operators and the SAMOS data analysts is crucial in identifying, investigating, and resolving these kinds of issues.

Case Study

The *R/V Oscar Elton Sette* routinely operates in tropical west Pacific waters. On 10 February 2010, the *Sette* resumed SAMOS data transmission after their lay-up period for the 2009/10 winter season. When SAMOS data are received, daily monitoring of data occurs (via a "quick look") to catch any large issues, with visual quality control occurring approximately 10 days later. (This lag ensures that SAMOS operators have time to send or resend any data files that failed during original ship-to-shore transfer.) On 21

February 2010, a SAMOS data analyst noticed a huge spike in the platform speed, which caused an equally unrealistic spike in the true wind speed, and repeated around the same time every day (Figure B4). The following was sent to SAMOS points-of-contact for the *Sette* on 21 February 2010:

"Hello All,
I've been monitoring the 2010 Sette SAMOS data and I've noticed a peculiarity I'm hoping someone can shed some light on. In every dataset we've received so far this year (excluding the very first, which was a truncated set), there has been an unrealistic spike in both the platform speed and, consequently, the true wind speed just before local midnight (see attached). Each successive day, the spike occurs a few minutes earlier than the previous one (except 2/21). From 2/11 through 2/21 the times, in UTC, are: 13:23, 13:21, 13:17, 13:10, 13:08, 13:02, 12:58, 12:53, 12:50, 12:45, and lastly 12:46 to 12:47 on 2/21. The spikes don't seem to coincide with any particular ship maneuver, as we sometimes see, nor do they occur at a specific lat/long coordinate. So I can only guess that either a sensor is malfunctioning with surprising regularity, or else there is some regular activity that occurs on the ship just before midnight which briefly affects the sensor. (It is really only affecting the platform speed reading, but we see it in true wind speed as well because the pl_spd is incorporated into the true wind speed calculation.) Do these times suggest any ideas to anyone as to what might be causing the spikes?
Sincerely,
Kristen Briggs
SAMOS FSU/COAPS"

Operator response was immediate, with the following email being circulated the same day (SAMOS data analysts and the SAMOS project leader were cc'd):

"Chief ET,
Could you check the raw files for this sensor and time period and determine if the Raw message is normal or reflect the spike.
This will allow us to isolate the anomaly more quickly.
It is either an averaging error(SCS Software problem) or a sensor error (GPS) as best as I can figure.
Thanks,
Dennis "

Roughly three weeks later, the following email was received by all involved parties:

"Greetings,
Sorry for taking so long to reply to this, but the good news is; we have a breakthrough. Pete Langlois noticed on the ship's Nobeltec computer that there was a spike in the ship's route that coincided with your data spike. Evidently our GPS is what's causing the problem. The GPS keeps "throwing" the ship about 2 miles to the Northwest and back every night around midnight. You can see it plain as day on the Nobeltec display. So I can only assume that as such, the "movement" as fed from the GPS is affecting the platform speed and true wind speed by saying we travel at something like the speed of light for 1 second for 2 miles and back again every night around midnight. Anyhow, I don't have a real fix for this other than to

replace the Northstar GPS unit on the Bridge that gives the location feed to both the Nobeltec computer and the SCS. We don't have a spare Northstar on-hand at the moment. We do have another Northstar Model 952X in the Aft Lab that I can swap out with the Bridge unit. Kim, is it "safe" for me to do that? I understand the Aft Lab unit provides a feed for the ADCP.

Hope this at least offers some plausible insight...

V/r

Ricardo Guevara
ET, NOAAS Oscar E Sette"

From this example, it is clear how important operator/analyst interaction is to both the ship-side and shore-side ends of the SAMOS spectrum. The ship technicians were apparently unaware there was anything odd going on. By the SAMOS team making them aware of the issue, it enabled other people who might be of help to be brought into the discussion and an investigation ensued. The problem is now known to all and is awaiting resolution.

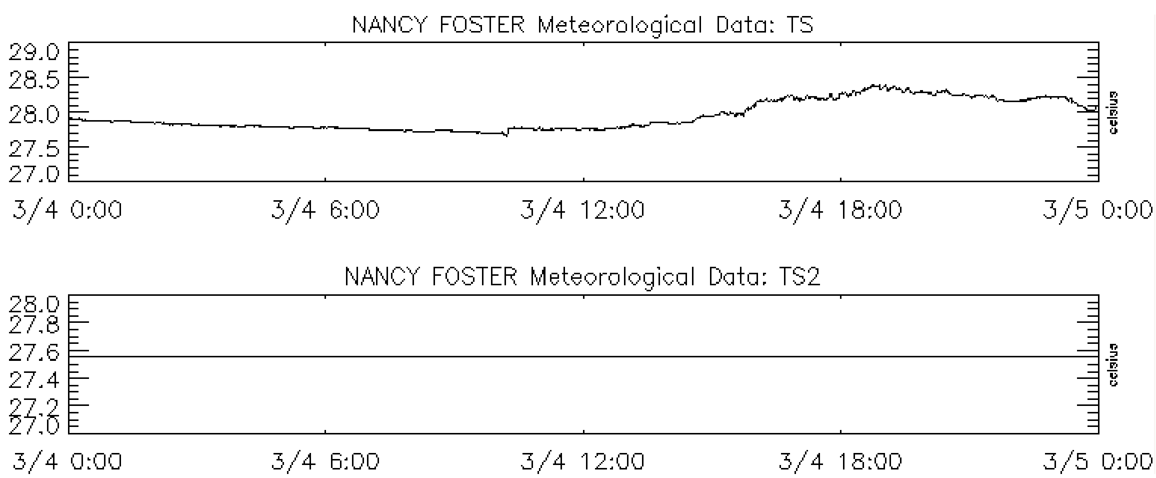
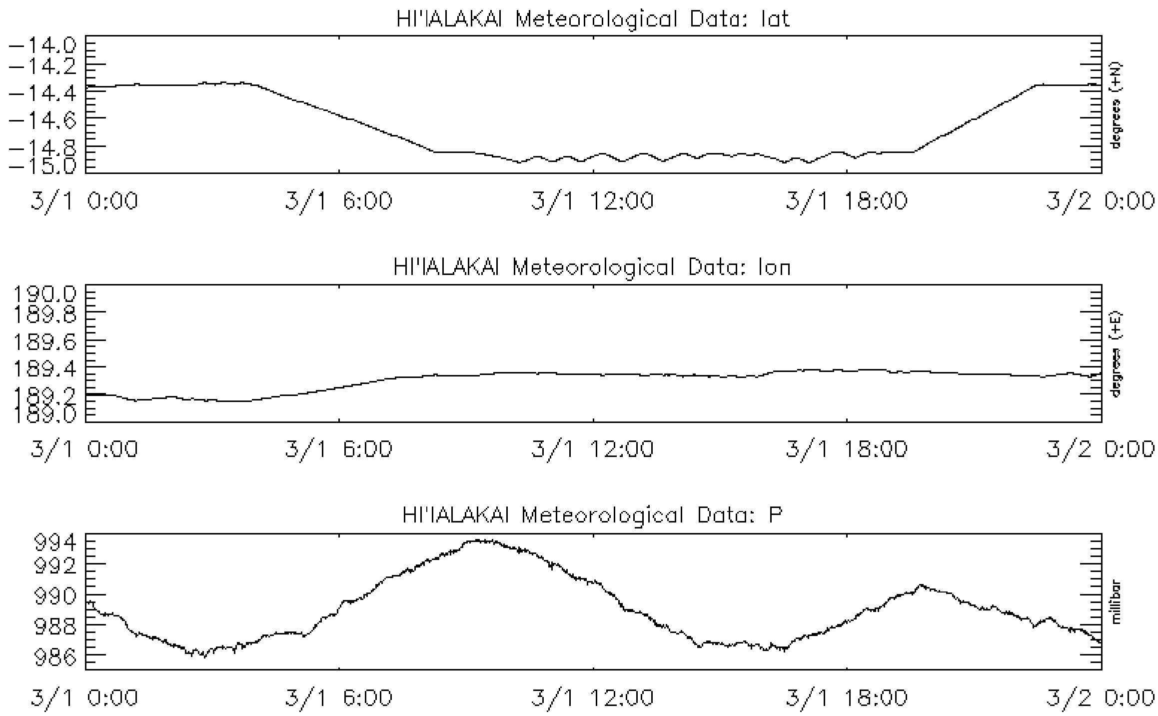


Fig B1: sensor for sea temperature 2 switched off onboard the *Nancy Foster* (note figure is for demonstration purposes only; vessel was actually in port at the time) a.


HI'IALAKAI Meteorological Data: lat
−14.0
−14.2
−14.4
−14.6
−14.8
−15.0
degrees (+N)
3/1 0:00
3/1 6:00
3/1 12:00
3/1 18:00
3/2 0:00
HI'IALAKAI Meteorological Data: lon
190.0
189.8
189.6
189.4
189.2
189.0
degrees (+E)
3/1 0:00
3/1 6:00
3/1 12:00
3/1 18:00
3/2 0:00
HI'IALAKAI Meteorological Data: P
994
992
990
988
986
millibar
3/1 0:00
3/1 6:00
3/1 12:00
3/1 18:00
3/2 0:00

b.

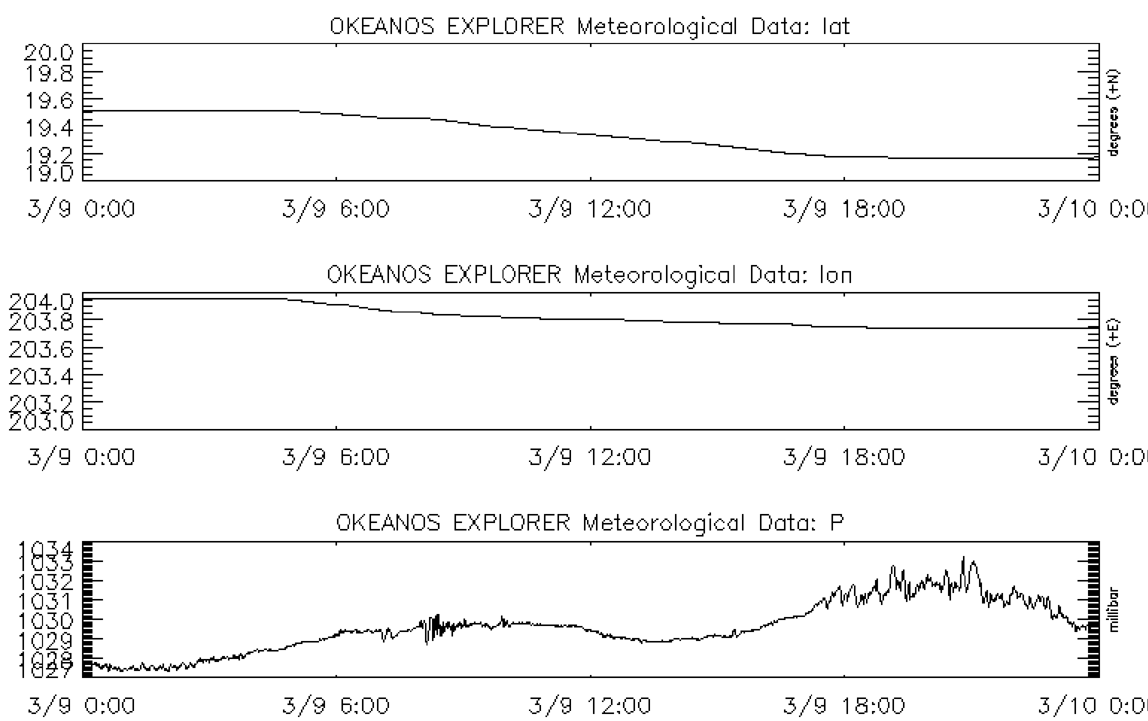

OKEANOS EXPLORER Meteorological Data: lat
20.0
19.8
19.6
19.4
19.2
19.0
degrees (+N)
3/9 0:00
3/9 6:00
3/9 12:00
3/9 18:00
OKEANOS EXPLORER Meteorological Data: lon
204.0
203.8
203.6
203.4
203.2
203.0
degrees (+E)
3/9 0:00
3/9 6:00
3/9 12:00
3/9 18:00
OKEANOS EXPLORER Meteorological Data: P
1032
1031
1030
1029
millibar
3/9 0:00
3/9 6:00
3/9 12:00
3/9 18:00

Figure B2: (a) pressure too low onboard the *Hi'ialakai*; pressure reading at nearby Faleolo, Samoa ranged between 1003 and 1007 mb (Weather Underground (1), 2010), (b) pressure too high onboard the *Okeanos Explorer*; pressure reading at nearby Keahole Point, HI ranged between 1017 and 1021 mb (Weather Underground (2), 2010)

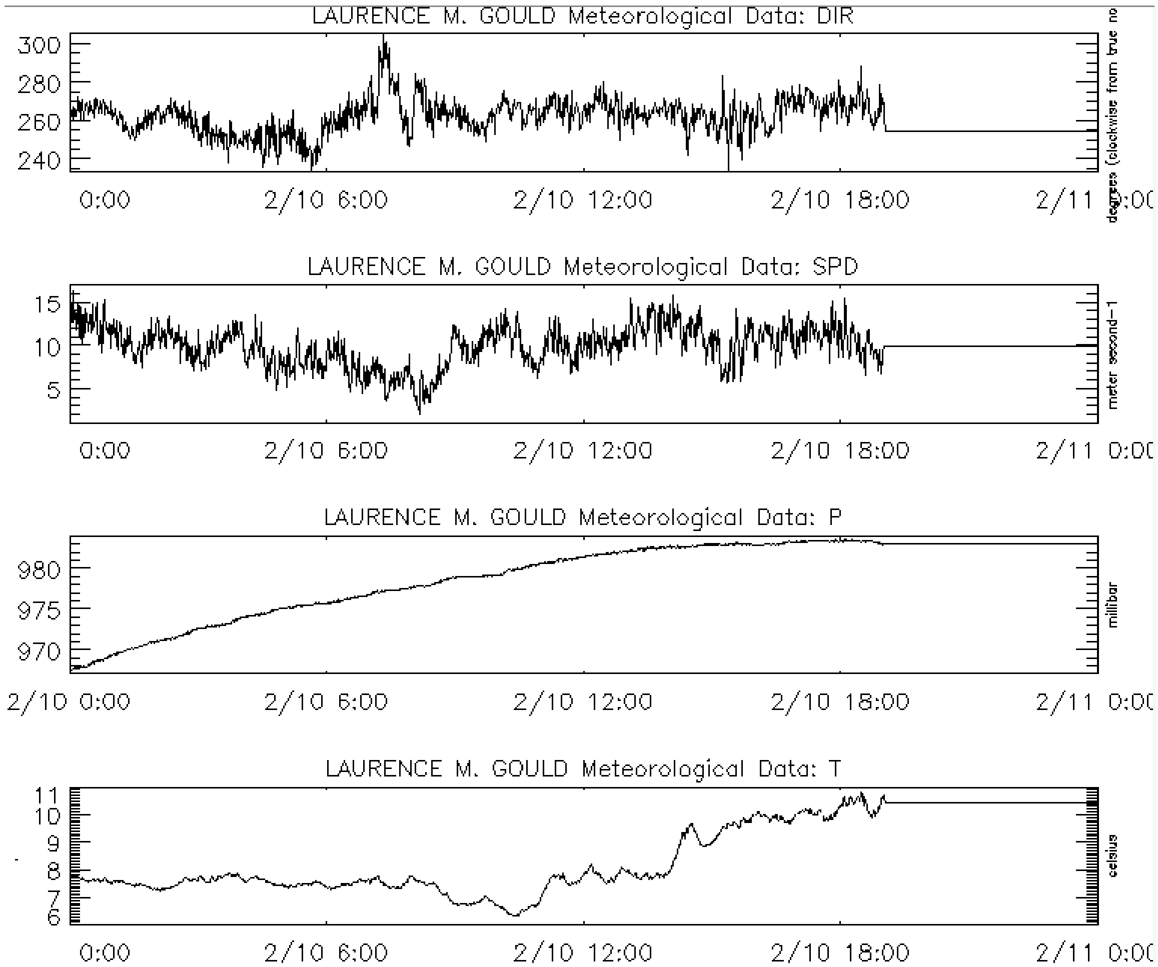


Figure B3: system-wide sensor failure at 1903 UTC on 10 February 2010 onboard the *R/V Laurence M. Gould*; issue persisted for ~5 days

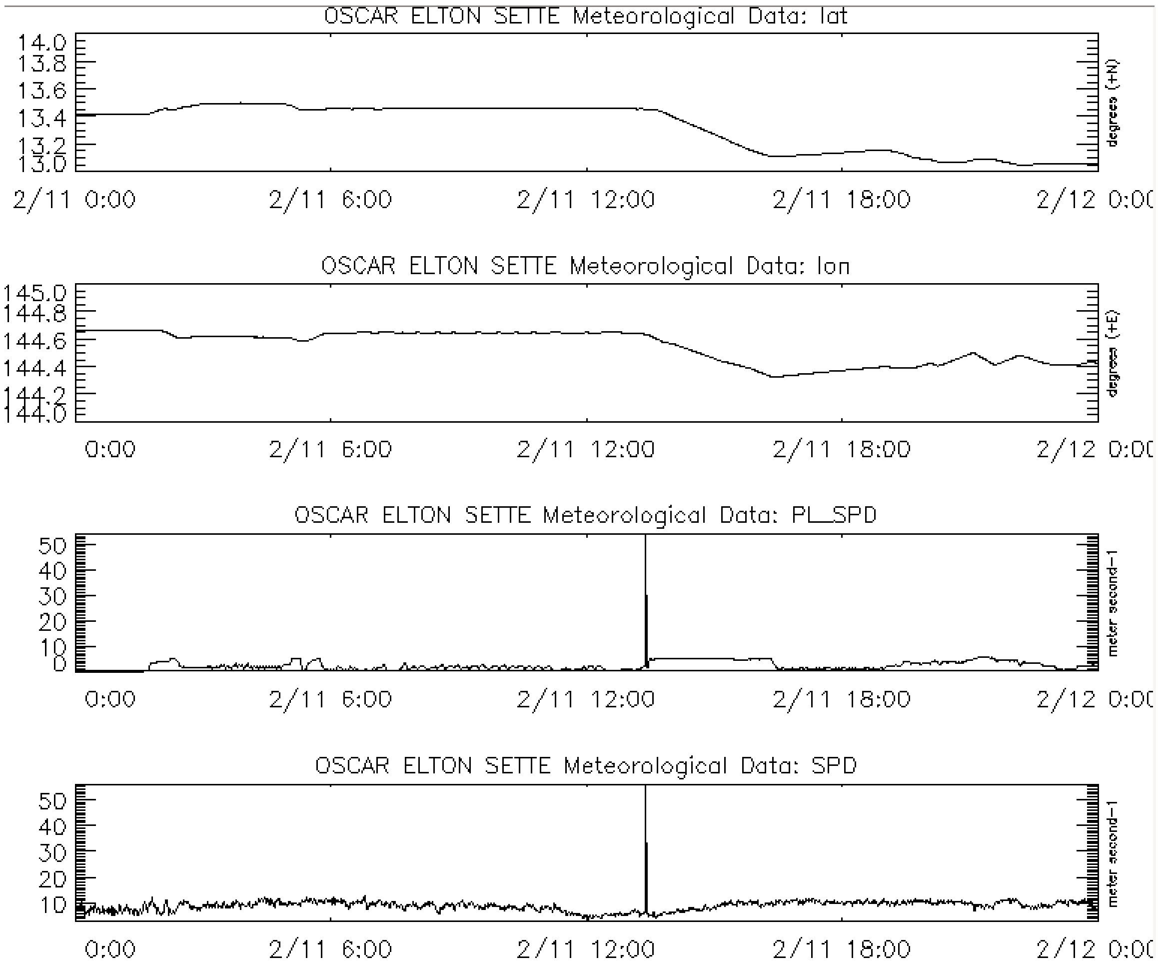


Figure B4: data for 11 February 2010 from the *R/V Oscar Elton Sette* showing anomalous spike in PLSPD and SPD parameters at 1323 UTC