NOAA Pacific Marine Environmental Laboratory
Ocean Climate Stations Project

DATA ACQUISITION AND PROCESSING REPORT FOR KE015

Site Name:	Kuroshio Extension Observatory (KEO)
Deployment Number:	**KE015**
Year Established:	2004

Nominal Location:	32.3°N 144.6°E
Anchor Position:	32 23.19 N 144 32.44 E (triangulated)
	32 16.60 N 144 35.27 E (redeployed)

Deployment Date:	July 15th, 2017
Mooring Failure, Buoy Adrift:	October 18th, 2017
Buoy Redeployment Date:	December 23rd, 2017
Recovery Date:	July 4th, 2018

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Date of Report:	November 14, 2022
Revision History:	March 11, 2022

Special Notes: On October 18th, 2017 the buoy broke free and drifted for over 2 months before being recovered and redeployed on December 23rd, 2017.

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Data Acquisition and Processing Report for OCS Mooring KE015

1.0 Mooring Summary

The NOAA Ocean Climate Stations reference mooring at the Kuroshio Extension Observatory (KEO) site was established with the deployment of the KE001 mooring in June 2004. The 2004 deployment was part of the first year of the two-year Kuroshio Extension System Study (KESS). At the conclusion of KESS, a partnership with the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) was formed.

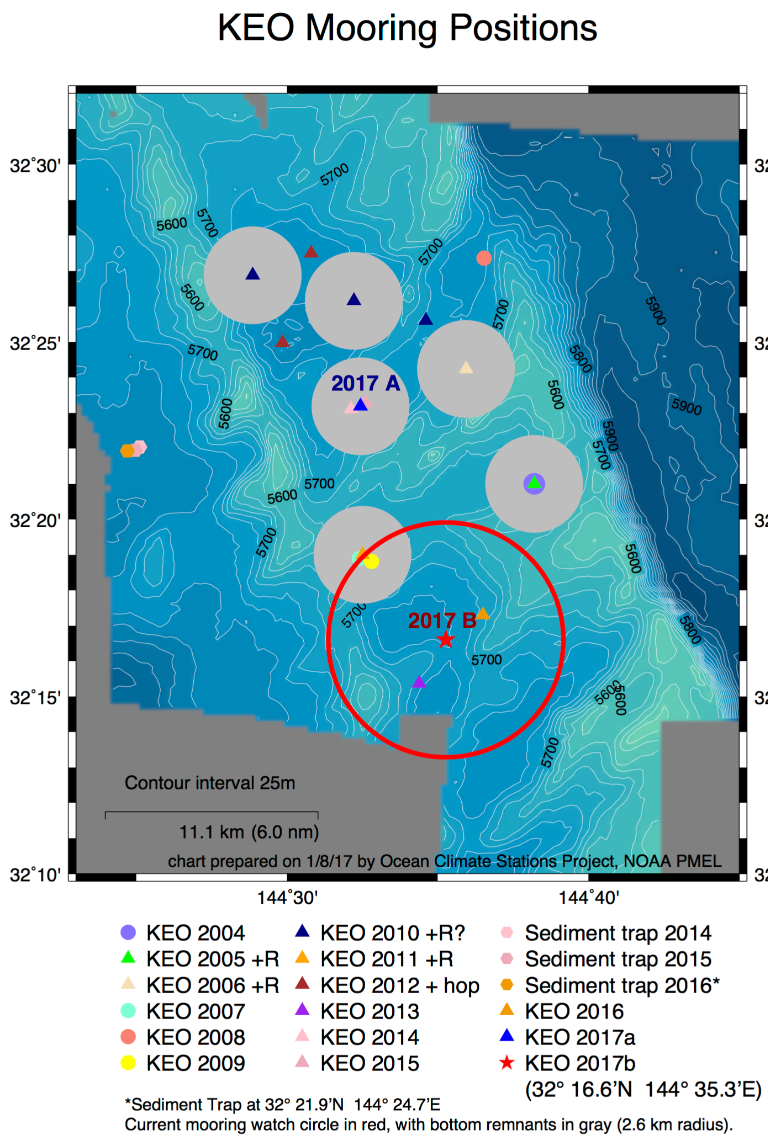

Figure 1: KEO regional map, with the KE015 positions and JAMSTEC sediment trap.

KE015 was the 14th deployment at the KEO site (the KE004 name was given to a buoy deployed at the nearby JKEO site, maintained by JAMSTEC). KE015 was deployed on July 15th, 2017 by the M/V BLUEFIN. On October 18th, KE015 broke free of its mooring line 425m below the surface, setting the buoy adrift. The drifting buoy was recovered and redeployed on December 23rd, 2017 by the JAMSTEC vessel R/V YAKASUKA. This second deployment as well as the remnant of the original KEO15 mooring were ultimately recovered on July 4th, 2018 by the M/V BLUEFIN. The captain and crew of the BLUEFIN and the YAKASUKA are gratefully acknowledged for their contributions toward maintaining the KEO climatological reference station. Many thanks are extended to PMEL's partners at JAMSTEC as well for efforts in arranging the rescue and redeployment of the KEO buoy.

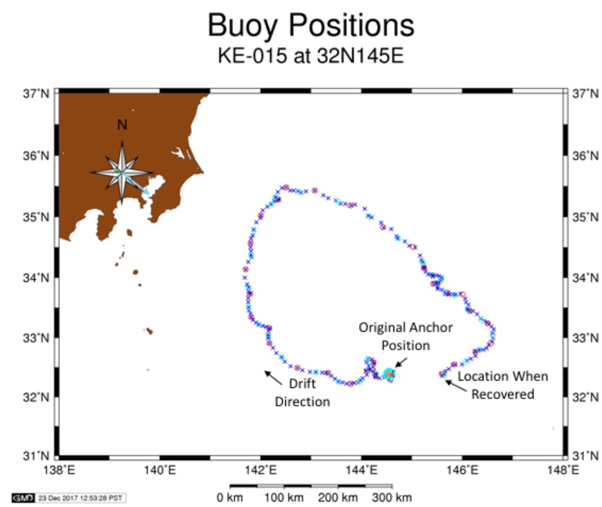

Figure 2: Path of drifting KEO15 buoy.

Several interesting weather events impacted the KE015 deployment, with tropical storm and typhoon passage observed by instrumentation on the mooring. Of note, typhoon Sanvu (category 2, August 26 – September 3, 2017), typhoon Lan or "Paolo" (category 4, October 15 – 23, 2017), and tropical storm Maliksi or "Domeng" (70mph winds, June 3 – 11, 2018) all tracked near KEO, and are particularly evident in the atmospheric pressure, wind, and current measurements.

1.1 Mooring Description

The KE015 mooring was a slack-line mooring, with a nominal scope of 1.4. Non-rotating 7/16" (1.11cm) diameter wire rope, jacketed to 1/2" (1.27cm), was used in the upper 700m of the mooring line. Plastic fairings were installed on the wire rope from 1m – 150m and 240m – 350m. The remainder of the mooring line consisted of plaited 8-strand nylon line, spliced to buoyant polyolefin, as shown in Figure 4. There were 18 glass balls in line above the acoustic release. The 8,240lb (3,738kg) anchor was fabricated from scrap railroad wheels.

The upper portion of the mooring was kept fairly vertical by using a reverse catenary design, but less so than with taut-line moorings. Since instrument depths change on a slack line mooring, most KEO instruments measure pressure. Interpolated pressures are used in salinity calculations where no pressure measurements exist.

The surface buoy was a 2.6m fiberglass-over-foam discus buoy, with a central instrument well. It had an aluminum tower and a stainless steel bridle.

In addition to OCS equipment, partner groups also provide mooring instrumentation. The PMEL carbon group contributed an SBE16 package (with attached oxygen sensor, fluorometer, and UW-owned Gas Tension Device) and a SAMI pH sensor, both mounted on the buoy bridle, along with their primary CO_2 flux monitoring system housed in the buoy well. Collaborators at JAMSTEC provided 2x backscatter sensors deployed at 23m and 103m. Previous KEO moorings have included a University of Washington Passive Acoustic Listening (PAL) device mounted at 200m, but after 2 years of losing the instrument from its bracket, no PAL was deployed in 2017. A more robust mount is being designed to hold these passive acoustic devices on future deployments. OCS is not responsible for the acquisition or processing of partner data, and no further discussion of these systems is included in this report. All OCS and partner systems with corresponding instrumentation are shown in the mooring diagram (Figure 4).

Figure 3: KE015 during the redeployment cruise.

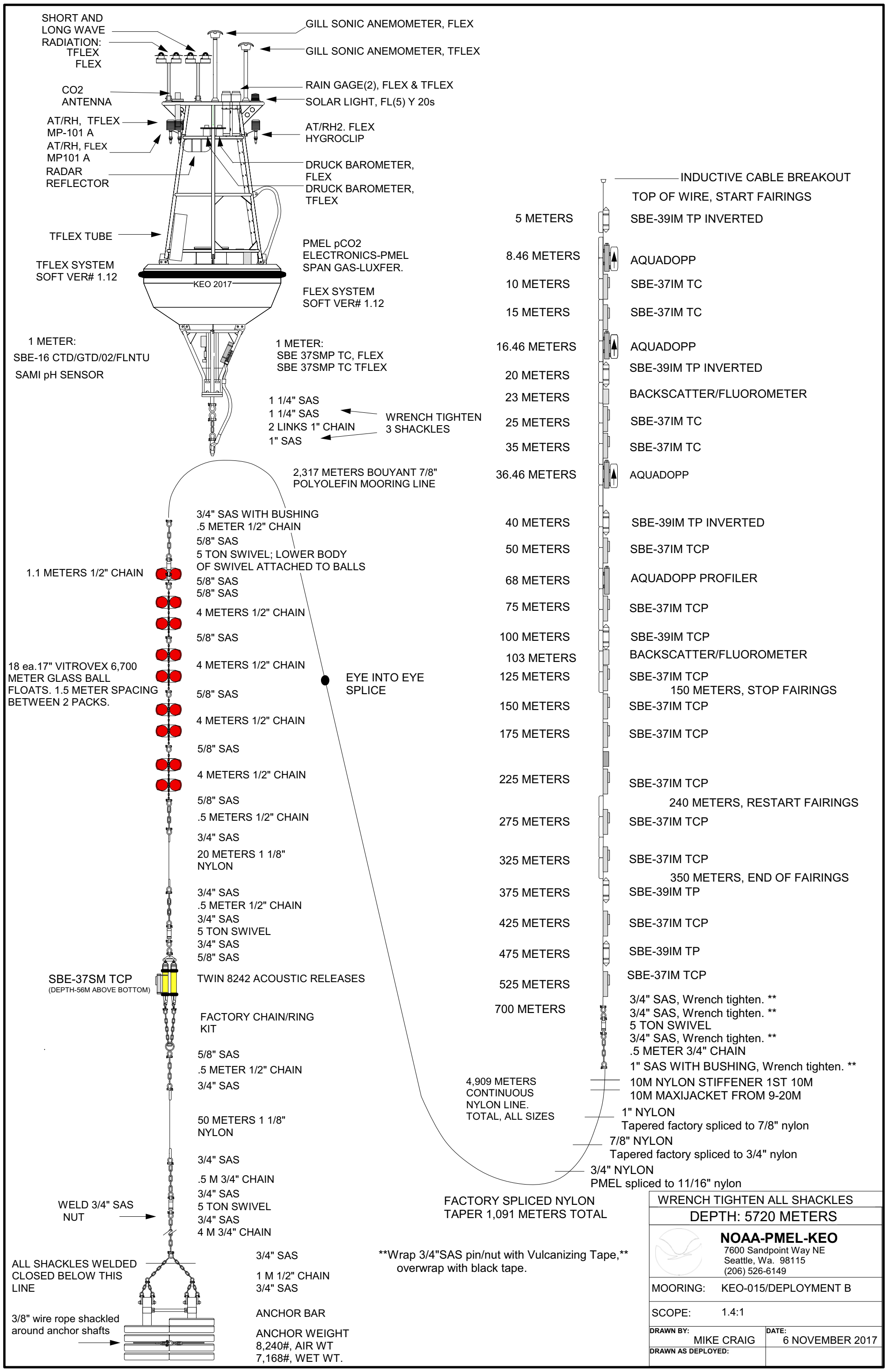

Figure 4: KE015 mooring diagram. This diagram is of the redeployed buoy (KE015B), which is identical to the original buoy aside from mooring length. No deep SBE37TCP was redeployed on KE015B.

1.2 Instrumentation on KE015

The following instrumentation was deployed on KE015. Redundant data acquisition systems were used, Flex and TFlex. Flex meteorological sensors are generally considered primary. Any substitutions are noted in the relevant section of this report.

Deployment:		**KE015**			
Met Sensors		**Model**	**Serial #**		**Notes**
Height	Acquisition	**FLEX**	0008	7/8	
2.6m	ATRH	Rotronics MP-101A	133390		
2.6m	ATRH2	Rotronics HygroClip	20044582		
4.2m	Wind	Gill	10510080		
2.5m	BP	Druck	2153676		
3.1m	Rain	RM Young	1674		
3.6m	SWR	Eppley PSP	38475		
3.6m	LWR	Eppley PIR	38486		
	Acquisition	**TFLEX**	2002		
2.6m	ATRH	Rotronics MP-101A	51042		
3.8m	Wind	Gill	051415		
2.5m	BP	Druck	4249223		
3.1m	Rain	RM Young	1642		
3.6m	SWR	Eppley PSP	38484		
3.6m	LWR	Eppley PIR	38487		
CO2	Electronics	PMEL	0145		
	Span Gas	Luxfer	JB03894		
Subsurface Instrumentation					
Bridle		**Model**	**Serial #**		**Notes**
1m	SST/C	SBE37SMP - TC	11554		Flex, AA
1m	SST/C	SBE37SMP - TC	3802		TFLEX
1m	pH	Sami	P0201		CO2
1m	SST/C	SBE16+V2	6838		CO2
1m	Oxygen	Optode			Attached to CO2 SBE16+
1m	Fluorescence	ECO FLNTUS			Attached to CO2 SBE16+
1m	Gas Tension	GTD			Attached to CO2 SBE16+ (owned by UW)

Table 1: Surface and buoy bridle instruments deployed on KE015.

Depth		Model	Serial #	IM ID	Notes
5m	TP	SBE39IM-TP	4377	01	Inverted
8.46m	ADCM	AquaDopp	12690	02	
10m	TC	SBE37IM - TC	6076	03	
15m	TC	SBE37IM - TC	6077	04	
16.46m	ADCM	AquaDopp	9980	05	
20m	TP	SBE39IM-TP	4358	06	Inverted
23m		Backscatter	891		JAMSTEC
25m	TC	SBE37IM - TC	6078	07	
35m	TC	SBE37IM - TC	6079	08	
36.46m	ADCM	AquaDopp	5952	09	
40m	TP	SBE39IM-TP	4359	10	Inverted
50m	TCP	SBE37IM - TCP	12519	11	AA
68m	ADCP	Aquadopp Profiler	13317		New. Logging internally.
75m	TCP	SBE37IM - TCP	7093	12	KE015b: 16293 (TC) - 7093 moved to 425m
100m	TCP	SBE37IM - TCP	7094	13	
103m		Backscatter	905		JAMSTEC
125m	TCP	SBE37IM - TCP	7095	14	
150m	TCP	SBE37IM - TCP	7096	15	
175m	TCP	SBE37IM - TCP	7097	16	
225m	TCP	SBE37IM - TCP	7098	17	
275m	TCP	SBE37IM - TCP	7099	18	
325m	TCP	SBE37IM - TCP	7100	19	
375m	TP	SBE39IM-TP	4379	20	
425m	TCP	SBE37IM - TCP	7780	21	KE015b: 7093, S/N 7780 missing guard.
475m	TP	SBE39IM-TP	4859	22	KE015b: 4361, S/N 4859 recovered flooded.
525m	TCP	SBE37IM - TCP	7101	23	KE015b: 7785, S/N 7101 was lost (sunk).
700m	End of Wire				
Release	TCP	SBE37SM - TCP	10504	-	AA

Table 2: Subsurface instruments deployed on KE015. Yellow highlights indicate changes during the redeployment of the adrift buoy (KE015b) starting 12/23/2017.

Since 2007, the measurement point for bridle sensors, including the SST/C, is known to have varied between 1.0 - 1.3m depth. Uncertainties in actual measurement depth are introduced by changes in buoy waterlines, variation between instrument mounting locations, and alteration of measurement points with different instrument versions. For these reasons, the nominal depth for all bridle sensors is stated as 1m.

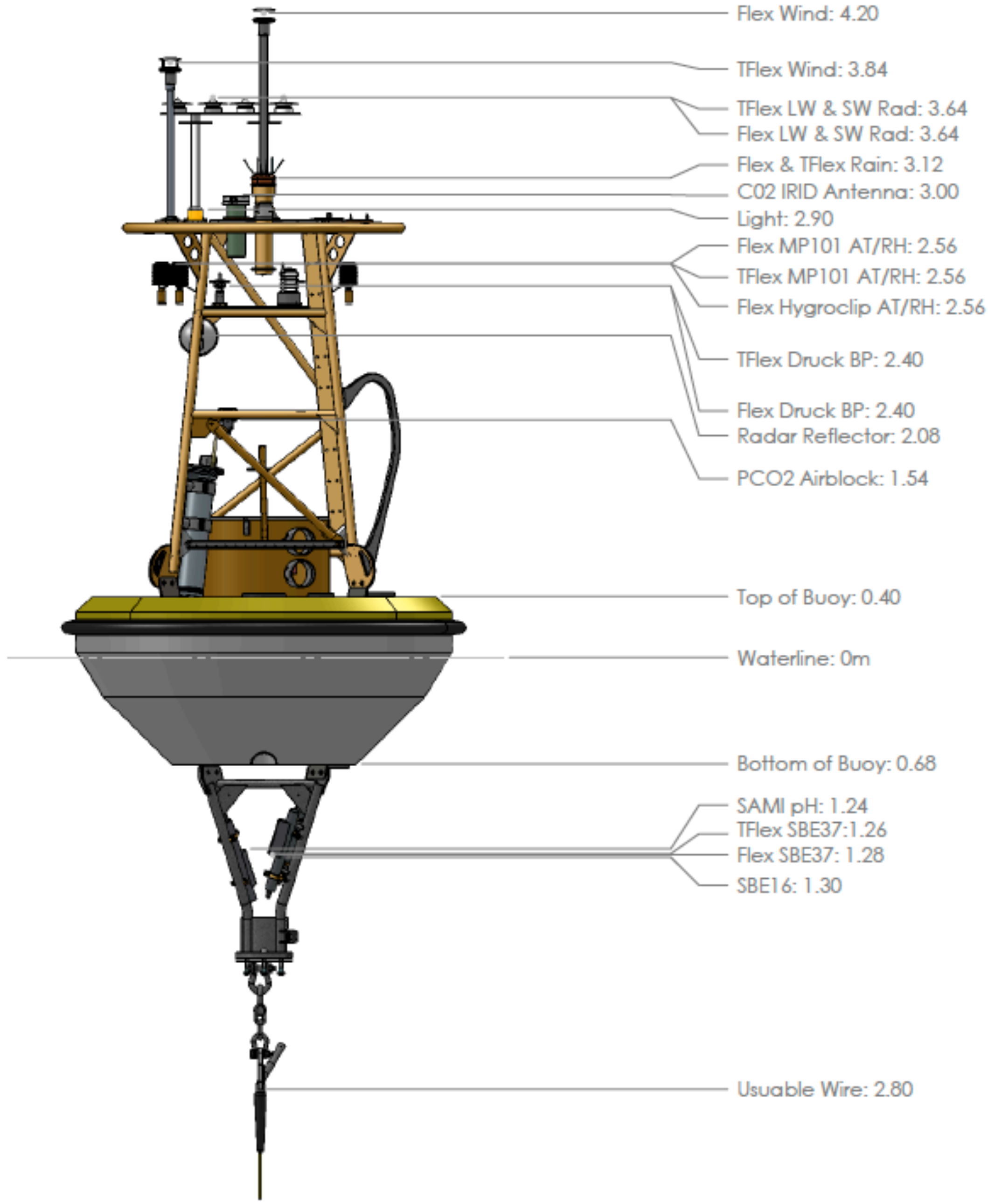

Figure 5: Buoy diagram showing bridle arrangement. The SBE16 package contains a suite of sensors.

2.0 Data Acquisition

Two independent data acquisition systems were deployed on KE015, Flex and TFlex. Both systems telemetered hourly averaged surface data via Iridium satellite, with Flex also transmitting hourly data from the subsurface instruments. High-resolution data are logged internally throughout the deployment in subsurface instruments, and downloaded upon recovery of the mooring. KE015 was the fourth KEO mooring to have phased out the ATLAS system and implemented the newer TFlex.

Position information associated with real-time data comes through the Iridium satellite network. Buoy latitude and longitude are transmitted to shore via three GPS devices on the Flex, TFlex, and CO_2 systems. The Flex GPS measurements are hourly and TFlex GPS measurements occur every six hours. Occasional position errors were spotted and removed during quality control operations.

The KEO mooring site is nominally located at 32.3°N, 144.6°E. The actual anchor position is different for each deployment, and the slack line mooring has a watch circle radius greater than 5km. For users performing intercomparisons, it may be important to use the actual position of the buoy from the GPS data. Also, depths of the subsurface measurements will change over time on a slack mooring. Depths shown in the delivered KEO files represent the nominal location of the sensors on the mooring line. To determine the true depth of the measurement, use the accompanying pressure time series data.

2.1 Sampling Specifications

The following tables describe the high-resolution sampling schemes for the KE015 mooring, for both the primary and secondary systems. Observation times in data files are assigned to the center of the averaging interval. The Flex system sensors are usually considered primary, and the reasoning behind any substitution is described in the relevant sections that follow.

PRIMARY SENSORS

Measurement	Sample Rate	Sample Period	Sample Times	Recorded Resolution	Acquisition System
Wind Speed/Direction	2 Hz	2 min	2359-0001, 0009-0011…	10 min	FLEX
Air Temperature + Relative Humidity	1 Hz	2 min	2359-0001, 0009-0011…	10 min	TFLEX
Barometric Pressure	1 Hz	2 min	2359-0001, 0009-0011…	10 min	FLEX
Rain Rate	1 Hz	1 min	0000-0001, 0001-0002…	1 min	FLEX
Shortwave Radiation	1 Hz	1 min	0000-0001, 0001-0002…	1 min	FLEX
Longwave Radiation (Thermopile, Case & Dome Temperatures)	1 Hz	1 min	0000-0001, 0001-0002…	1 min	FLEX
Seawater Temperature, Pressure & Conductivity	1 per 10 min	Instant.	0000, 0010,…	10 min	Internal
Ocean Currents (Point)	1 Hz	2 min	2359-0001, 0009-0011…	10 min	Internal
Ocean Currents (Profile)	1 Hz	2 min	0059-0101,…	1 hr	Internal
GPS Position	1 per hr	Instant.	0000, 0100, …	1 hr	FLEX

Table 3: Sampling parameters of the primary sensors on KE015.

SECONDARY SENSORS

Measurement	Sample Rate	Sample Period	Sample Times	Recorded Resolution	Acquisition System
Wind Speed/Direction	2 Hz	2 min	2359-0001, 0009-0011…	10 min	TFLEX
Air Temperature + Relative Humidity	1 Hz	2 min	2359-0001, 0009-0011…	10 min	FLEX
Barometric Pressure	1 Hz	2 min	2359-0001, 0009-0011…	10 min	TFLEX
Rain Rate	1 Hz	1 min	0000-0001, 0001-0002…	1 min	TFLEX
Shortwave Radiation	1 Hz	1 min	0000-0001, 0001-0002…	1 min	TFLEX
Longwave Radiation (Thermopile, Case & Dome Temperatures)	1 Hz	1 min	0000-0001, 0001-0002…	1 min	TFLEX
SSTC	1 per 10 min	Instant.	0000, 0010,…	10 min	Internal
GPS Position	1 per 6 hrs	Instant.	0000, 0600, …	6 hr	TFLEX

Table 4: Sampling parameters for the secondary sensors on KE015.

2.2 Data Returns

Data returns are calculated from the highest-resolution data, comparing the number of records available to the total amount of records expected for the period. The following list shows the data returns from the surface and subsurface measurements from both acquisition systems.

In the tables below, pre-adrift statistics will be presented, with a second set of statistics for the post-adrift period displayed in parentheses. Most notably, the 10m sensor was lost in the post-adrift period, so no delayed-mode data were recovered, and the lower instruments (425, 475, and 525m) were damaged or lost from the pre-adrift period, but new instruments were attached at those depths in the post-adrift redeployment, whose statistics are presented below in parentheses.

Flex 0008:

```
Data Return Summary
 2017-07-15 13:46:00 to 2017-10-18 18:00:00
(2017-12-23 07:30:00 to 2018-07-03 23:15:00)

Sensor        Deployed        Obs            Return
=========================================================
AT1          13705(27743)    13705(27729)    100.0(99.9)%
AT2          13705(27743)    13705(27729)    100.0(99.9)%
RH1          13705(27743)    13705(27729)    100.0(99.9)%
RH2          13705(27743)    13705(27729)    100.0(99.9)%
WIND1        13705(27743)    13705(27712)    100.0(99.9)%
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BP1	13705(27743)	13705(27729)	100.0(99.9)%
RAIN1	137055(277426)	131610(260517)	96.0(93.9)%
SWR1	137055(277426)	131679(262119)	96.1(94.5)%
LWR1	137055(277426)	131728(263780)	96.1(95.1)%

Subsurface Temperature Profile

1m	13705(27743)	13705(27743)	100.0(100.0)%
5m	13705(27743)	13705(27743)	100.0(100.0)%
10m	13705(27743)	0 (0)	0.0(0.0)%
15m	13705(27743)	13705(27743)	100.0(100.0)%
20m	13705(27743)	13705(27743)	100.0(100.0)%
25m	13705(27743)	13705(27743)	100.0(100.0)%
35m	13705(27743)	13705(27743)	100.0(100.0)%
40m	13705(27743)	13705(27743)	100.0(100.0)%
50m	13705(27743)	13705(27743)	100.0(100.0)%
75m	13705(27743)	13705(27731)	100.0(100.0)%
100m	13705(27743)	13705(27743)	100.0(100.0)%
125m	13705(27743)	13705(27743)	100.0(100.0)%
150m	13705(27743)	13705(27743)	100.0(100.0)%
175m	13705(27743)	13705(27743)	100.0(100.0)%
225m	13705(27743)	13705(27743)	100.0(100.0)%
275m	13705(27743)	13705(27743)	100.0(100.0)%
325m	13705(27743)	13705(27743)	100.0(100.0)%
375m	13705(27743)	13705(27743)	100.0(100.0)%
425m	13705(27743)	0(27731)	0.0(100.0)%
475m	13705(27743)	0(27731)	0.0(100.0)%
525m	13705(27743)	0(27731)	0.0(100.0)%

Subsurface Pressure Profile

5m	13705(27743)	13705(27743)	100.0(100.0)%
20m	13705(27743)	13705(27743)	100.0(100.0)%
40m	13705(27743)	13705(27743)	100.0(100.0)%
50m	13705(27743)	13705(27743)	100.0(100.0)%
75m	13705(27743)	13705(27731)	100.0(100.0)%
100m	13705(27743)	13705(27743)	100.0(100.0)%
125m	13705(27743)	13705(27743)	100.0(100.0)%
150m	13705(27743)	13705(27743)	100.0(100.0)%
175m	13705(27743)	13705(27743)	100.0(100.0)%
225m	13705(27743)	13705(27743)	100.0(100.0)%
275m	13705(27743)	13705(27743)	100.0(100.0)%
325m	13705(27743)	13705(27743)	100.0(100.0)%
375m	13705(27743)	13705(27743)	100.0(100.0)%
425m	13705(27743)	0(27731)	0.0(100.0)%
475m	13705(27743)	0(27731)	0.0(100.0)%
525m	13705(27743)	0(27731)	0.0(100.0)%

Subsurface Salinity Profile

1m	13705(27743)	13705(27743)	100.0(100.0)%
10m	13705(27743)	0 (0)	0.0(0.0)%
15m	13705(27743)	13705(27743)	100.0(100.0)%
25m	13705(27743)	13705(27743)	100.0(100.0)%
35m	13705(27743)	13705(27743)	100.0(100.0)%
50m	13705(27743)	13705(27743)	100.0(100.0)%

75m	13705(27743)	13705(25171)	100.0(90.7)%
100m	13705(27743)	13705(27743)	100.0(100.0)%
125m	13705(27743)	13705(27743)	100.0(100.0)%
150m	13705(27743)	13705(27743)	100.0(100.0)%
175m	13705(27743)	13705(27743)	100.0(100.0)%
225m	13705(27743)	13705(27743)	100.0(100.0)%
275m	13705(27743)	13705(27743)	100.0(100.0)%
325m	13705(27743)	13705(27743)	100.0(100.0)%
425m	13705(27743)	0(27731)	0.0(100.0)%
525m	13705(27743)	0(27731)	0.0(100.0)%

AQD Current Velocity

8m	13705(27743)	13705(27743)	100.0(100.0)%
16m	13705(27743)	13705(27743)	100.0(100.0)%
36m	13705(27743)	13705(27743)	100.0(100.0)%

TFlex 2002:

Data Return Summary
2017-07-15 13:46:00 to 2017-10-18 18:00:00
(2017-12-23 07:30:00 to 2018-07-03 23:15:00)

Sensor	Deployed	Obs	Return
AT1	13705(27743)	13549(24908)	98.9(89.8)%
RH1	13705(27743)	13549(24908)	98.9(89.8)%
WIND1	13705(27743)	13547(24908)	98.8(89.8)%
BP1	13705(27743)	13543(24908)	98.8(89.8)%
RAIN1	137055(277426)	133959(239768)	97.7(86.4)%
SWR1	137055(277426)	134083(241557)	97.8(87.1)%
LWR1	137055(277426)	134833(247792)	98.4(89.3)%
SST1	13705(27743)	13705(20570)	100.0(74.1)%
SSC1	13705(27743)	13705(16490)	100.0(59.4)%
SSS1	13705(27743)	13705(16490)	100.0(59.4)%

2.3 Known Sensor Issues

Thousands of TFlex resets occurred starting on May 4, 2018, quickly increasing by May 20, 2018. The cause is unknown. Real time transmissions from the primary Flex system were intermittent in April and May of 2018, including an extended period from April 13th to 24th. On May 22nd, the Flex system stopped transmitting all together, but high-resolution data were recorded and recovered through the end of the deployment.

Rain data were quite noisy on both the Flex and TFlex systems. The rain gauges reported gaps around siphons, and some interpolation or setting of data values was required to cause to automated programs to trigger siphon events when accumulations clearly decreased. Toward the end of the TFlex record, large gaps existed. When gaps were relatively short (hours or less) and accumulations were the same on each end of the gap, interpolation was used to fill the gap. However, when accumulation occurred, interpolation was not performed, as it would result in a time-averaged rainfall rate smeared across the gap. Rain accumulations frequently plateaued around 600 mL on KE015. This is higher than the gauge should read (0 – 50 mm precipitation = 0 – 250 mm in the gauge's chamber, which corresponds to 0 – 500 mL of accumulation), but this phenomenon has been observed before, and could be a result of saltwater spray affecting the measured capacitance.

Longwave radiation again became noisy and anomalously high during the peak of summer heating on this deployment. A similar anomaly was recently discovered on a GTMBA mooring (ATLAS acquisition system) at 8°S 67°E. As witnessed in the previous few years at KEO, the following evidence supports the hypothesis that these signals are false:

- Substantially different measurements (>50 W/m^2) between Flex and TFlex LWR, despite both passing calibrations
- The Stefan-Boltzmann equation suggests a maximum of 478.9 W/m^2 based on a maximum air temperature of 30°C.
- The anomaly is worse during the day, but occasionally persists at night, when the sun would not contribute to blackbody irradiance.
- A single spike to ~500 W/m^2 is infrequently seen on GTMBA moorings.
- Eppley has stated that Net LWR should range from -100 to 0 W/m^2. The anomaly occurs when net LWR is near 0, and up to +100 W/m^2.

As with previous years, post-processing assigned Q5 to LWR data that exceeded a LWRnet of 0 W/m^2 or downwelling LWR above 475 W/m^2. These thresholds should be reevaluated if maximum summertime temperatures inch upward.

When the KE015 nilspin broke in October 2017, the surface buoy and instruments down to 425m went adrift. The Seabird instrument at 525m (SBE37TCP) was permanently lost, and unfortunately hadn't reported realtime data. One hypothesis is that the nilspin line became loosely knotted/looped during deployment, but allowed data above 475m to report up the line. Then, either during or shortly after deployment, the knot tightened, cutting off inductive transmissions from 525m. The instrument at 475m (SBE39TP) was recovered off the seafloor with the remnant line in July 2018, but exceeded its depth limit and flooded. The 425m (SBE37TCP) was damaged and returned to PMEL, but no data were recoverable. Only realtime data are available from the 425m and 475m sensors.

Figure 6: Nilspin break below S/N 7780 (left) and knot (right) on KE015a discovered during the redeployment cruise.

Upon redeployment (in the post-adrift period), the sensor originally deployed at 75m (SBE37TCP) was relocated to 425m because of its higher depth rating, replacing the original, damaged 425m sensor. A new sensor (SBE37TC) with a lower depth rating was mounted at 75m for the KE015 redeployment. The newly deployed 75m sensor experienced an unrealistic drop in salinity on June 16, 2018 and was flagged Q5 through the end of the deployment. The 10m sensor (SBE37TC) failed after the redeployment, having stopped reporting in realtime on April 13th, 2018. The instrument likely fell to the seafloor at this time, as it was not attached to the line upon recovery. The overall result of these failures was the creation of a special-case file to include realtime data from 10m, 425m, and 475m.

The 75m instrument (S/N 16293) and the 475m instrument (S/N 4361) from the redeployment had a 12-hour time offset in the recovered, post-adrift data. The data were shifted to align with surrounding time-series. The error likely came from an incorrectly programmed time in the laptop used for setup during the redeployment process.

KE015 was split into parts A (pre-adrift), B (adrift), and C (post-adrift) for the purposes of OceanSITES. The adrift period is not distributed on the OCS webpage (appears as missing values), as the mooring was not near the nominal KEO position at that time. Users interested in adrift data can find the data on OceanSITES or in the special periods section of the OCS webpages.

KE015 went adrift 10/18/2017 around 18:00 UTC, with the last GPS fix inside the watch circle at 17:06:18 UTC, and the first position clearly outside of the watch circle at 18:06:05 UTC. The mooring was redeployed 12/23/2017 at 07:30 UTC. Interestingly, the watch circle diameter on the redeployed mooring was approximately 75% of the size of the initial KE015a deployment. When the final mooring recovery occurred, a large wuzzle of knotted/tangled line was found between the poly and the nylon, which could explain the tighter scope and smaller watch circle in the post-adrift KE015c deployment.

GPS positions outside the watch circle were discarded during KE015a and KE015c, but positions were allowed to vary during the adrift period in order to keep accurate records. Rather than customizing a tight threshold box around the buoy while adrift, individual outlying positions were manually flagged when they did not fit into context.

3.0 Data Processing

Processing of data from OCS moorings is performed after the data are returned to PMEL. There are some differences between OCS data and data from GTMBA moorings, but standard methods described below are applied whenever possible. The process includes assignment of quality flags for each observation, which are described in Appendix A. Any issues or deviations from standard methods are noted in processing logs and in this report.

Raw data recovered from the internal memory of the data acquisition system are first processed using computer programs. Instrumentation recovered in working condition is returned to PMEL for post-recovery calibration before being reused on future deployments. These post-recovery calibration coefficients are compared to the pre-deployment coefficients. If the comparison indicates a drift larger than the expected instrument accuracy, the quality flag is lowered for the measurement. If post-recovery calibrations indicate that sensor drift was within expected limits, the quality flag is raised. Post-recovery calibrations are not generally applied to the data, except for seawater salinity, or as otherwise noted in this report. Failed post-recovery calibrations are noted, along with mode of failure, and quality flags are left unchanged to indicate that pre-deployment calibrations were applied and sensor drift was not estimated.

The automated programs also search for missing data, and perform gross error checks for data that fall outside physically realistic ranges. A computer log of potential data problems is automatically generated as a result of these procedures.

Time series plots, difference plots, and comparison plots are generated for all data. Plots of differences between adjacent subsurface temperature measurements are also generated. Statistics, including the mean, median, standard deviation, variance, minimum and maximum are calculated for each time series.

Trained analysts examine individual time series and statistical summaries. Data that have passed gross error checks, but which are unusual relative to neighboring data in the time series, or which are statistical outliers, are examined on a case-by-case basis. Mooring deployment and recovery logs are searched for corroborating information such as battery failures, vandalism, damaged sensors, or incorrect clocks. Consistency with other variables is also checked. Data points that are ultimately judged to be erroneous are flagged, and in some cases, values are replaced with “out of range” markers. For a full description of quality flags, refer to Appendix A.

For some variables, additional post-processing after recovery is required to ensure maximum quality. These variable-specific procedures are described below.

3.1 Buoy Positions

Since KEO is a slack-line mooring with a long scope, the buoy has a watch circle radius of more than 5km. When using KEO data in scientific analyses, it may be appropriate to consider the actual GPS position of the buoy rather than its nominal position. Gross error checking was performed to eliminate values outside the watch circle. The positions were used to determine buoy velocities for processing ocean current data.

3.2 Meteorological Data

All primary meteorological sensors on KE015 remained functional at or near 100% throughout the deployment.

No data from secondary sensors are included in the final data files, except when included in OceanSITES files as secondary data. The OceanSITES data repository can be found here: http://dods.ndbc.noaa.gov/thredds/catalog/oceansites/DATA/KEO/catalog.html

The KE015 buoy had secondary air temperature, relative humidity, wind, rain, air pressure, and radiation sensors. The only tertiary sensor deployed was a Rotronic HygroClip attached to the Flex system, measuring air temperature and relative humidity. These tertiary data were not distributed in any format.

3.2.1 Winds

Both wind sensors passed their post-calibration routines, with a maximum speed error of 3.8% at low speeds with the Flex system and 2.0% at high speeds for the TFlex system during the post-cruise wind tunnel evaluation. Both wind sensors lasted throughout the deployment, adrift period, and post-adrift redeployment, and automated routines indicated a good data record with a minimal number of points detected and flagged by the gross error thresholds. Manual review confirmed good wind sensor performance, outside of some brief gaps in the secondary TFlex data (see May 2018 in Figure 7).

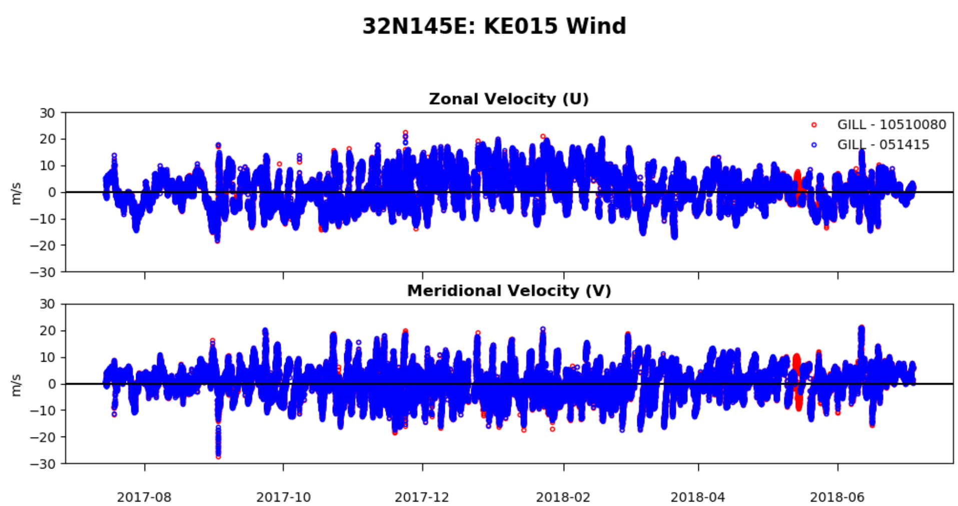


Figure 7: KE015 wind measurements.

3.2.2 Air Temperature

The air temperature sensors performed well on KE015, and all returned instruments passed their post-calibration procedures for air temperature. The TFlex air temperature data were distributed as primary data due to the failed calibration of the Flex relative humidity sensor described in the next section. Since air temperature and relative humidity share the same instrument housing, and a failed calibration in one component can indicate a sensor issue in the other (e.g. internal moisture, instrument damage, etc.), so it is standard practice to select the instrument that passes calibrations 100%.

3.2.3 Relative Humidity

The Flex relative humidity sensor (Rotronic MP101) failed its post-calibration at PMEL, and data quality was downgraded to Q4. For this reason, data from the TFlex ATRH was selected for distribution as the primary dataset. After passing gross error checks, manual flagging was applied toward the end of the TFlex relative humidity record, where spikes over 100% were flagged for removal (Q5) on 6/12/2018 and 6/29/2018.

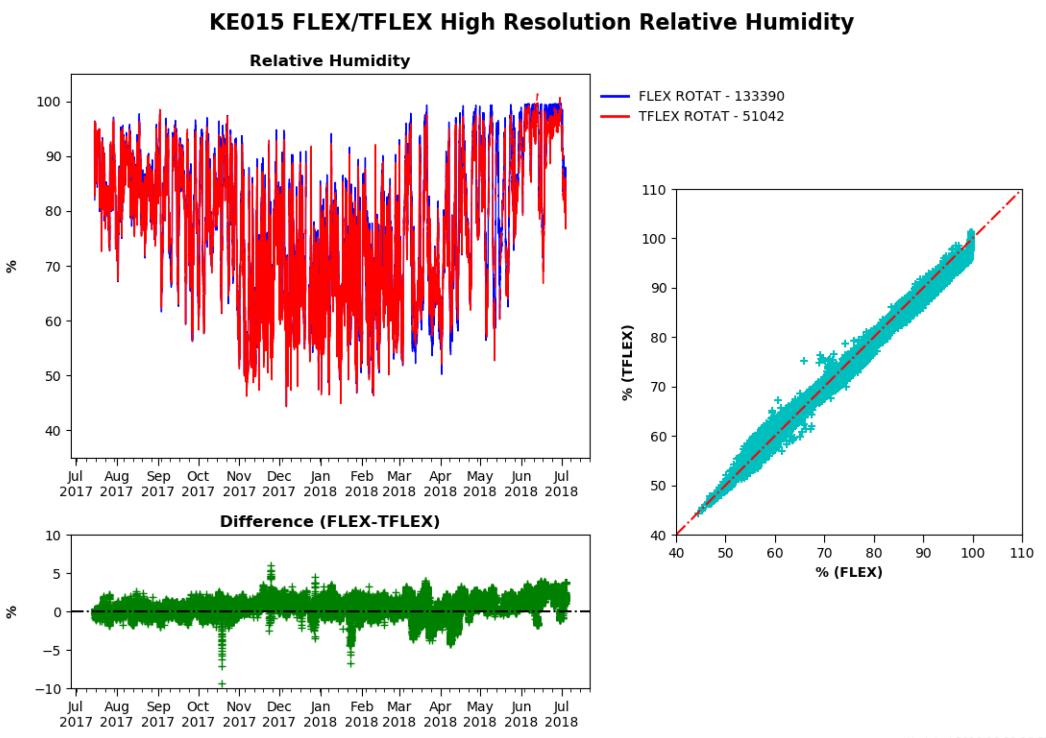


Figure 8: KE015 relative humidity measurements prior to the application of quality control measures.

3.2.4 Barometric Pressure

Atmospheric pressure was measured by two Druck RPT350 sensors on the KE015 buoy tower. Both sensors were stable throughout the deployment, and after review, no manual quality control was required for barometric pressure data, aside from the assignment of standard quality (Q2) flags. The TFlex resets mentioned in the Known Sensor Issues section of this report did cause some data gaps in the TFlex records, which appear in the time series plot below, and resulted in the Flex data being distributed as the primary and more complete barometric pressure record.

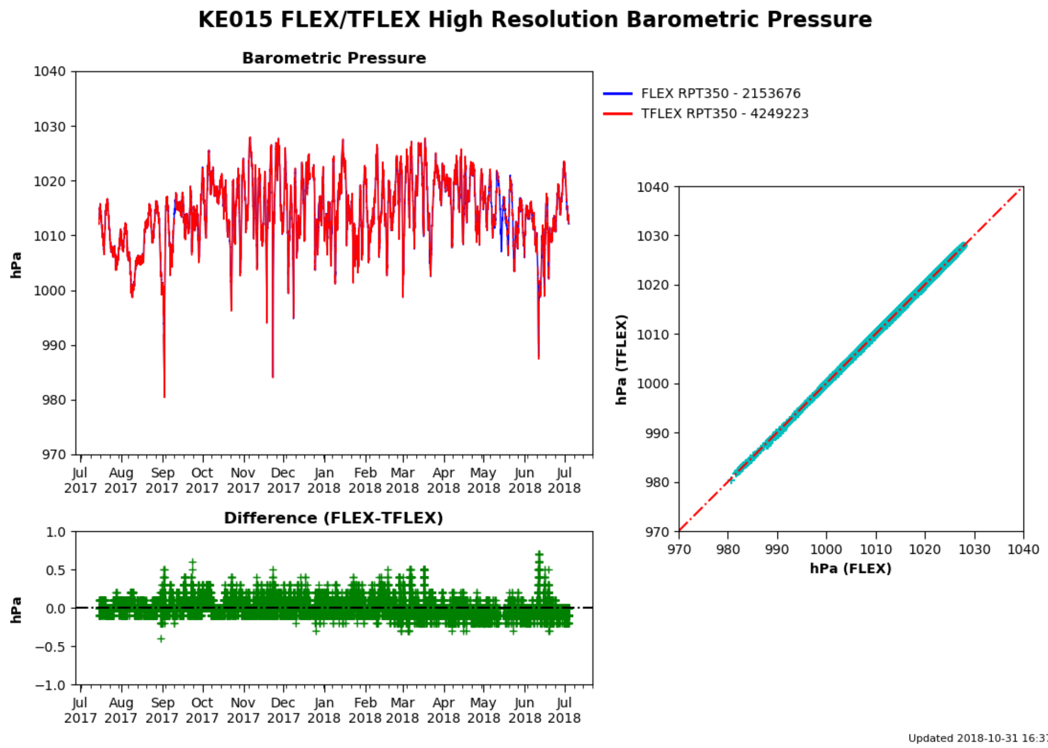


Figure 9: KE015 barometric pressure measurements.

3.2.5 Rain

Rain data are acquired as accumulation values, and then converted to rain rates during processing. Rainfall data are collected using an RM Young rain gauge, and recorded internally at a 1-min sample rate. The gauge consists of a 500mL catchment cylinder which, when full, empties automatically via a siphon tube. Data from a three minute period centered near siphon events are ignored. Occasional random spikes in the accumulation data, which typically occur during periods of rapid rain accumulation, or immediately preceding or following siphon events, are eliminated manually.

To reduce instrumental noise, internally recorded 1-minute rain accumulation values are smoothed with a 16-minute Hanning filter upon recovery. These smoothed data are then differenced at 10-minute intervals and converted to rain rates in mm/hr. The resultant rain rate values are centered at times coincident with other 10-minute data (0000, 0010, 0020...).

Residual noise in the filtered data may include occasional false negative rain rates, but these rarely exceed a few mm/hr. No wind correction is applied, as this is expected to be done by the user. The wind effect can be large. According to the Serra, et al. (2001) correction scheme, at wind speeds of 5 m/s the rain rates should be multiplied by a factor of 1.09, while at wind speeds of 10 m/s, the factor is 1.3. As winds are high at KEO, the user is strongly encouraged to apply an appropriate wind correction.

3.2.6 Shortwave Radiation

The primary shortwave radiation sensor was chosen based on a system developed by Kelly Balmes during the summer of 2014, using the following criteria:

- Use the sensor with the higher shortwave daily average (if difference is > 1%)
- Use the FLEX system if all else is similar
- Use the sensor that maximizes the time period of available data

Based on these criteria, the KE015 Flex shortwave radiometer was designated primary. The Flex sensor had slightly lower data returns in the pre-adrift period, but better returns in the post-adrift period. Mean daily Flex and TFlex shortwave radiation values were compared, and found to differ by 0.91%, further validating the choice of Flex SWR as primary.

Shortwave radiation is processed into hourly and daily averaged values differently than other measurements. Because SWR goes to 0 at night, any substantial number of missing values during the night (day) will bias the data high (low). In keeping with GTMBA processing, the percentage of good high-resolution data for SWR must be at least 87.5% in order to generate an hourly or daily averaged data point. Most other instruments use a 50% threshold for high-resolution data needed to generate hourly and daily averages.

3.2.7 Longwave Radiation

The downwelling longwave radiation is computed from thermopile voltage, dome temperature, and instrument case temperature measurements, using the method described by Fairall et al. (1998).

Kelly Balmes also developed a set of criteria for determining the primary LWR sensor:

- Use the LWR data from the sensor on the data system that was chosen for SWR
- If LWR data from the first criteria is not available, use the remaining instrument

These criteria were created to maximize data returns and account for bent radiation masts, which are usually detectable by comparing SWR measurements. Although LWR is much less sensitive to orientation, a bent mast can affect either sensor. Clear sky conditions will have a lower LWR than clouds, which are warm due to water content (high LWR). With one LWR and one SWR sensor mounted to each mast, the goal of the criteria is to obtain data from the most vertical mast to avoid a mean tilt when samples are averaged over 1 minute. Based on these criteria, the KE015 Flex LWR was designated primary.

Regions of unrealistically high, noisy LWR data were seen during the hottest part of the year on KE015. This issue has been observed before, but no discernable pattern links it to a particular instrument or acquisition system. During summertime maximum temperatures, LWR values exceeded climatological norms. The instrument manufacturer

(Eppley) suggested the cause was bad thermopile readings. In the absence of an inversion, net LWR should not exceed 0 W/m^2, which would indicate heat transfer from the atmosphere to the ocean, which is rare during warm summer days in the KEO region. Both sensors frequently had net LWR greater than 0 in this time window, but the data were noisy (the magnitudes nor timing of the positive net LWR from the independent sensors aligned).

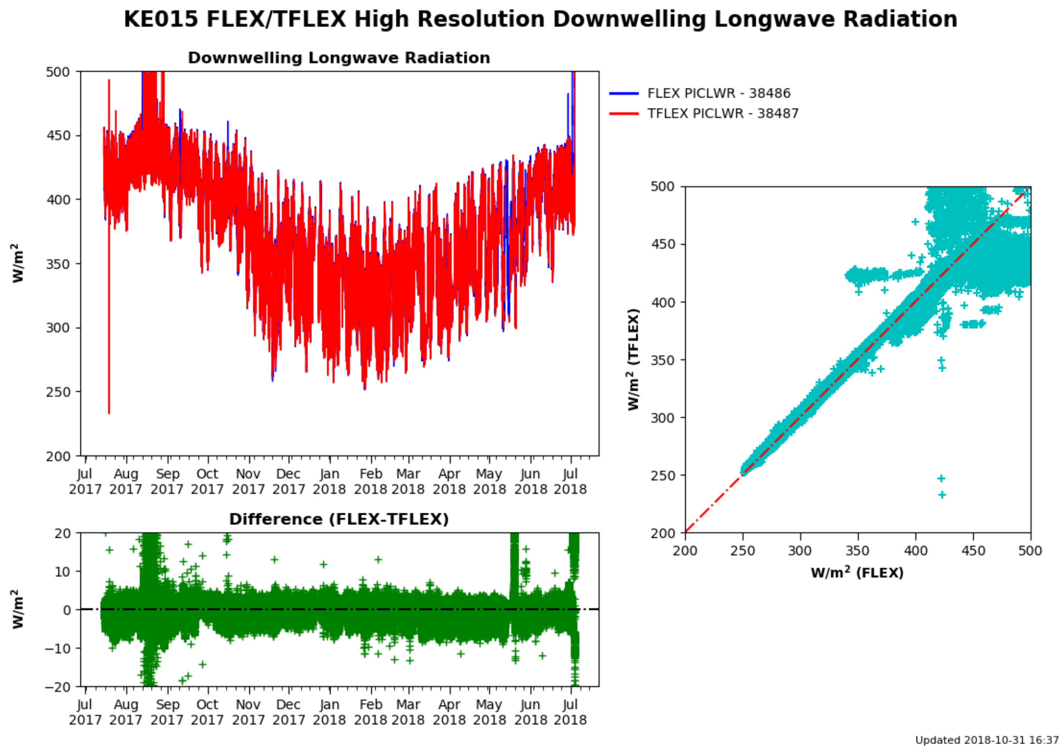


Figure 10: Entire (pre-adrift, adrift, and post-adrift) LWR records prior to quality control. Spikes early in the record, during the mid-summer anomaly, and late in the record were flagged and removed.

Backing up Eppley's hypothesis, SST exceeded air temperature during the anomaly, indicated sensible heat transfer from ocean to atmosphere. Unless other heat transfers (e.g. latent heat) are downward and of greater magnitude, this observation is inconsistent with a positive net LWR. The Stefan Boltzmann equation suggests a downwelling LWR limit of 478.9 W/m^2, given the approximate maximum air temperature of 30°C. However, these do not necessarily prove that net LWR is incorrect, because LWR is a product of the entire overlying atmosphere.

If this hypothesis is correct, the explanation could reside in the gain that is applied to the thermopile voltage before being interpreted by the acquisition system. Q5 flags (removed) were applied to downwelling LWR when net LWR was greater than 0 or where downwelling exceeded 475 W/m^2. Without conclusive evidence of additional bad data, both LWR sensors were otherwise distributed with standard quality flags.

3.3 Subsurface Data

There were two sea surface temperature and conductivity (SSTC) instruments deployed on the bridle. One was wired to the Flex system, and the other to the TFlex system. Both also logged data internally.

All remaining subsurface instrumentation was connected inductively to the Flex system, except for the instrument attached to the acoustic release. General comments and clock errors from each recovered subsurface instrument are summarized in a snapshot of the recovery log (Figure 11). Two instruments had a 12-hour offset in their timestamps (likely a setup error) but were adjusted without further issue. Since no other clock errors exceeded half the sampling interval, measurements were mapped to the nearest 10-minute time increment.

Clock Errors Are the clock dates all okay? (type yes/no or comment): yes

	Sensor Type	S/N	Actual Time (GMT)	Instr. Time	Clock Error	File Name	Bat. Voltage from Status	Comments	# of Records
0	SBE37-	11554	00:24:50	00:25:04	0:00:14				
1	SBE37-	3802	00:34:15	00:34:01	-0:00:14				
2	SAMI pH	P0201							
3	SBE16+	6838							
4	O2								
5	ECO								
6									
7	SBE39-	4377	6:35:10	6:36:03	0:00:53				51271
8	Aquadop	12690							
9	SBE37-	6076	08:17:35	08:17:29	-0:00:06				
10	SBE37-	6077	07:59:40	07:59:37	-0:00:03				
11	Aquadop	9980							
12	SBE39-	4358	6:10:45	6:11:45	0:01:00				
13	Backscatt	891							
14	SBE37-	6078	09:08:05	09:07:56	-0:00:09				
15	SBE37-	6079							
16	Aquadop	5952							
17	SBE39-T-	4359	6:49:40	6:50:43	0:01:03				
18	SBE37-	12519	6:03:25	6:03:14	-0:00:11				
19	SBE37-	16293	5:54:15	17:52:15	11:58:00				
20	SBE37-	7094	3:50:20	3:50:45	0:00:25				
21	Backscatt	905							
22	SBE37-	7095	4:16:35	4:16:46	0:00:11				
23	SBE37-	7096	5:35:45	5:36:00	0:00:15				
24	SBE37-	7097	4:24:40	4:24:52	0:00:12				
25									
26	SBE37-	7098	5:19:38	5:19:35	-0:00:03				
27	SBE37-	7099	4:08:50	4:08:50	0:00:00				
28	SBE37-	7100	5:29:30	5:29:48	0:00:18				
29	SBE39-	4379	6:42:50	6:43:45	0:00:55				
30	SBE37-	7093	4:38:55	4:39:07	0:00:12				
31	SBE39-	4361	6:30:50	18:29:28	11:58:38				28107
32	SBE37-	7785	5:45:55	5:46:11	0:00:16				
33									
34									
35									

Figure 11: Recovery log displaying all instrument clock errors.

3.3.1 Temperature

Subsurface temperature instruments were set to 10-minute sampling increments. The data are also provided at hourly and daily resolutions. Temperatures are rarely corrected based on post-calibrations, and there was no evidence of drifting temperature measurements.

3.3.2 Pressure

Since this was a slack mooring, none of the sensors can be assumed to have been recording measurements at their nominal depths. Users are reminded that the depths of subsurface sensors must be computed from the observed and interpolated pressures contained in the data files.

Pressure measurements were recorded by most of the subsurface instruments. In processing for salinity, interpolated pressures were used if an instrument's pressure sensor failed. In the case of complete instrument failure, where no temperature or conductivity data exists, interpolated pressures were truncated to the time of failure.

A few spikes in pressure were observed in the KE015 record, but occurred across many instruments, indicative of a real event tilting the line and drawing deeper instruments toward the surface. This can occur during typhoon or eddy passage, but surprisingly, line tilt was prominently observed twice while the mooring was adrift, indicative of strong shear between the surface and the line break near 425m. According to the realtime data, the 425m instrument was drawn up to a minima of 371.8 dbar on 11/23/2017, likely as the adrift buoy entered the Kuroshio Extension current. The other tilting event occurred on 10/22/2017, when the 425m realtime data reported a minima of 380.0 dbar just days after the mooring line had parted.

The collective pressure deviations can also be seen in the delayed-mode data in Figure 12. In August 2017, a cold core eddy passed the KEO mooring, resulting in gradual pressure decreases as the buoy was thrust to the east and the mooring line tightened, pulling instruments toward the surface. Two prominent line-tilt events while adrift can also be seen, along with a few minor events once the mooring was redeployed. The June 2018 spike is attributed to the passage of tropical storm Maliksi (or "Domeng"), with coincident increases in rainfall and winds alongside decreased barometric pressure readings.

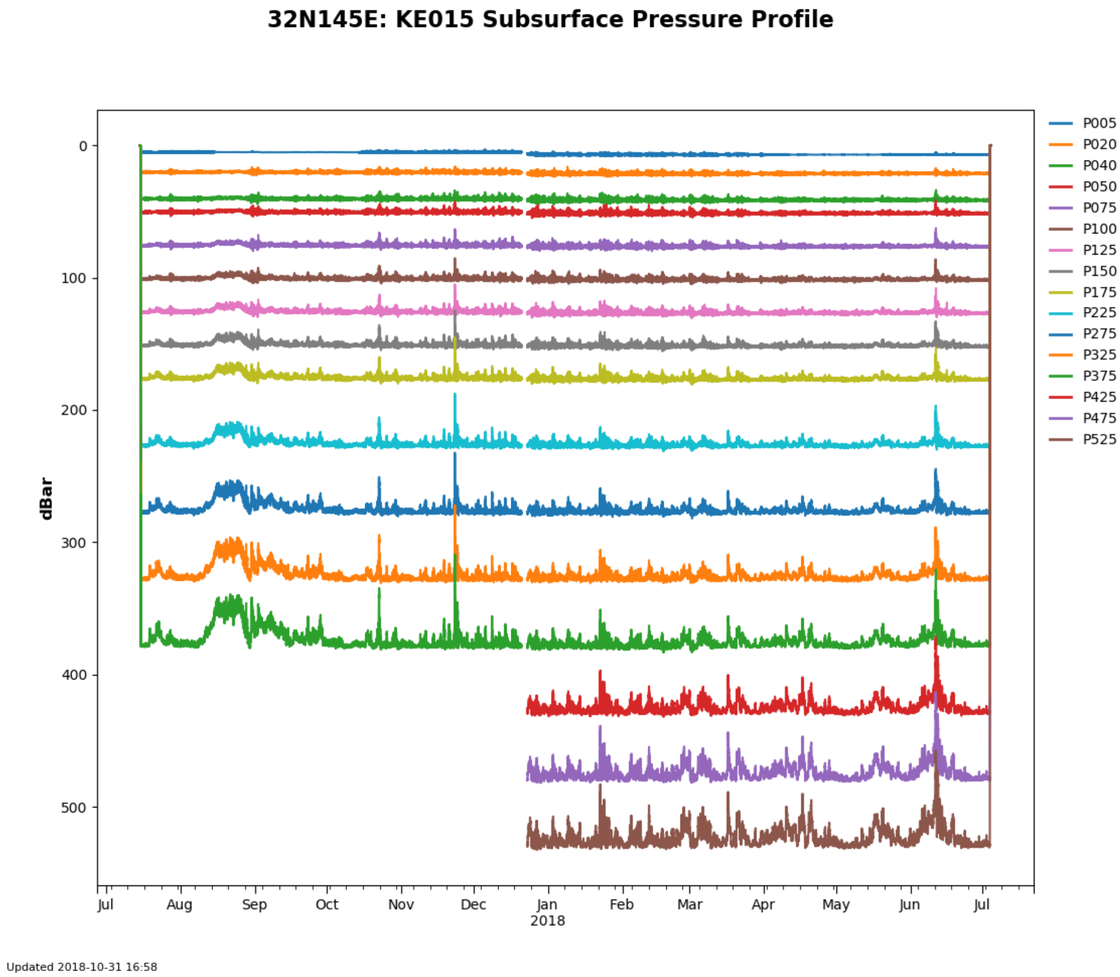


Figure 12: Subsurface pressure measurements, showing several pressure deviation events.

3.3.3 Salinity

Salinity values were calculated from measured conductivity and temperature data using the method of Fofonoff and Millard (1983). Conductivity values from all depths were adjusted for sensor calibration drift by linearly interpolating over time between values calculated from the pre-deployment calibration coefficients and those derived from the post-deployment calibration coefficients. Salinities were calculated from both the pre and post conductivity values, to determine the drift in the salinity measurement.

<u>Salinity Drifts in PSU (post - pre), totals for the pre-adrift + adrift period:</u>

Depth:	**Drift:**
1m (TFlex)	-0.0517
1m (Flex)	-0.0248
10m	N/A (instrument lost in post-adrift period)
15m	N/A (postcal invalid, performed after SBE repaired damage)

25m	N/A (postcal invalid, performed after SBE repaired damage)
35m	N/A (postcal invalid, performed after SBE repaired damage)
50m	-0.0248
75m	-0.0468
100m	-0.0408
125m	-0.0221
150m	-0.0290
175m	-0.0332
225m	-0.0301
275m	-0.0249
325m	-0.0168
425m	N/A (instrument returned to SBE, no data recovered)
525m	N/A (instrument was lost)

<u>Salinity Drifts in PSU (post - pre), totals for the post-adrift period:</u>

Depth:	**Drift:**
1m (TFlex)	-0.0451
1m (Flex)	-0.0251
10m	N/A (instrument lost in post-adrift period)
15m	N/A (postcal invalid, performed after SBE repaired damage)
25m	N/A (postcal invalid, performed after SBE repaired damage)
35m	N/A (postcal invalid, performed after SBE repaired damage)
50m	-0.0245
75m	N/A (postcal discarded, salinity low 6/16/2018, postcal reflected bad data)
100m	-0.0409
125m	-0.0223
150m	-0.0292
175m	-0.0335
225m	-0.0303
275m	-0.0250
325m	-0.0167
425m	-0.0468
525m	-0.0082

The values above indicate the change in data values when post-recovery calibrations are applied vs. when pre-deployment calibrations are applied. Negative differences suggest that the instrument drifted towards higher values while deployed, and indicate expansion of the conductivity cell effective cross-sectional area. This expansion is possibly due to scouring of the cell wall by abrasive material in the sea water. Positive values indicate decrease in the cell effective cross-sectional area, presumably due to fouling, and secondarily due to fouling or loss of material on the cell electrodes.

A thirteen point Hanning filter was applied to the high-resolution (ten minute interval) conductivity and temperature data. A filtered value was calculated at any point for which seven of the thirteen input points were available. The missing points were handled by dropping their weights from the calculation, rather than by adjusting the length of the filter. Salinity values were then recalculated from the filtered data.

KE015's special-case data

Because KE015 had a pre-adrift, adrift, and post-adrift period, each portion of data was processed separately. Splitting the data was necessary in order to accurately document metadata changes (swapped instruments, the mooring's departure from its nominal position, etc.). However, this complicated the application of post-calibration coefficients. Because the pre-adrift + adrift segments constituted a combined 45.3% of the deployment, interpolation from a pre-cal/post-cal ratio of 100/0 to 0/100 would not be appropriate, since post-cals were performed after the post-adrift period (and many instruments were reused/relocated or left in place). Processing steps were added to fractionally interpolate the data (e.g. starting at 100% precal and ending at 54.7%/45.3% precal/postcal ratios at the time of redeployment).

Similar issues occurred in the post-adrift period, where newly deployed instruments required the standard precal-to-postcal interpolation, while redeployed (existing) instruments picked up their post-adrift records with a 54.7%/45.3% precal/postcal ratio and ended at a 0%/100% ratio. When applied in this manner, the data aligned nicely, and few adjustments were needed during density intercomparisons against neighboring-sensors.

Manual Salinity Adjustments

The drift-corrected salinities were checked for continuity across deployments. The range and magnitude of variation matched well with prior and subsequent deployments.

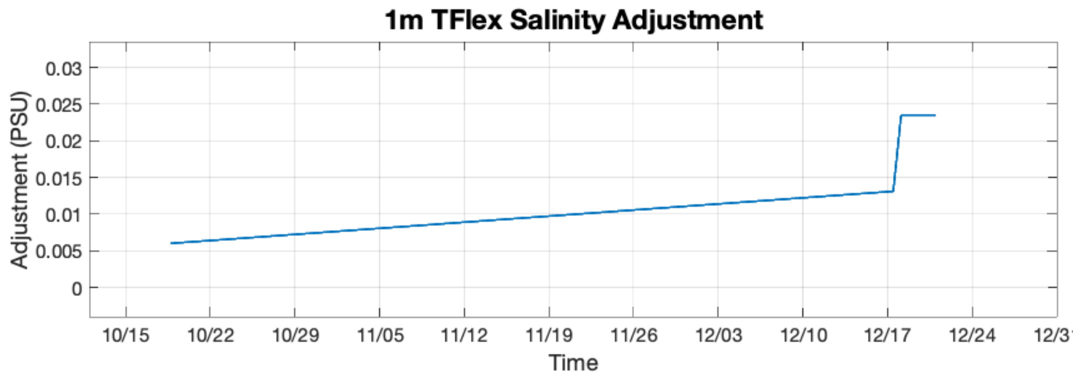
Additional linear corrections were also applied to the salinity data in time segments, as noted below. These corrections were based on comparisons with neighboring sensors on the mooring line. If an unrealistic prolonged, unstable density inversion was found, an attempt was made to identify the sensor at fault and adjust its data based on differences with data from adjacent depths during unstratified conditions (e.g. within the mixed layer during nighttime). These *in situ* calibration procedures are described by Freitag et al. (1999).

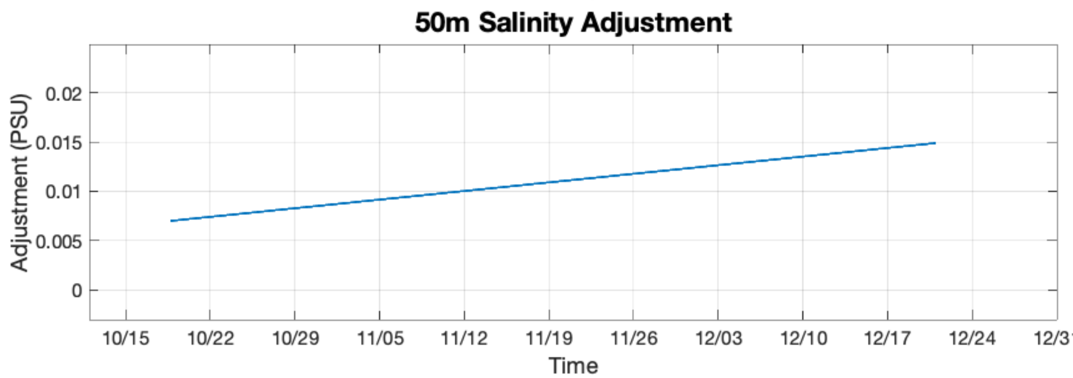
Based on manual review of the data against neighboring instruments, the following adjustments were made in the pre-adrift, adrift, and post-adrift periods:

Pre-adrift:
None – no instruments went out of spec within the short pre-adrift timeframe

Adrift:

2017-10-18 07:23:22 to 2017-12-21 10:47:24 at 50 m adjusted 0.0070 to 0.0149
2017-10-18 05:38:45 to 2017-12-17 11:18:40 at -1 m adjusted 0.0060 to 0.0131
2017-12-17 11:18:40 to 2017-12-18 02:56:24 at -1 m adjusted 0.0131 to 0.0235
2017-12-18 02:56:24 to 2017-12-21 15:20:08 at -1 m adjusted 0.0235 to 0.0235

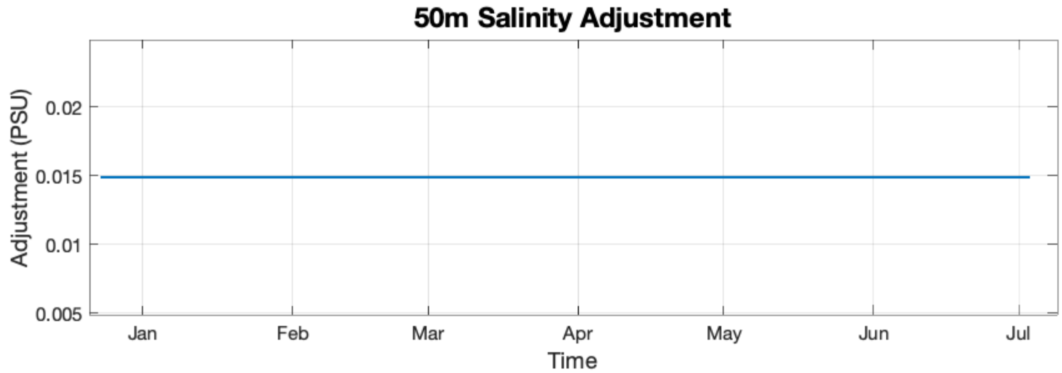


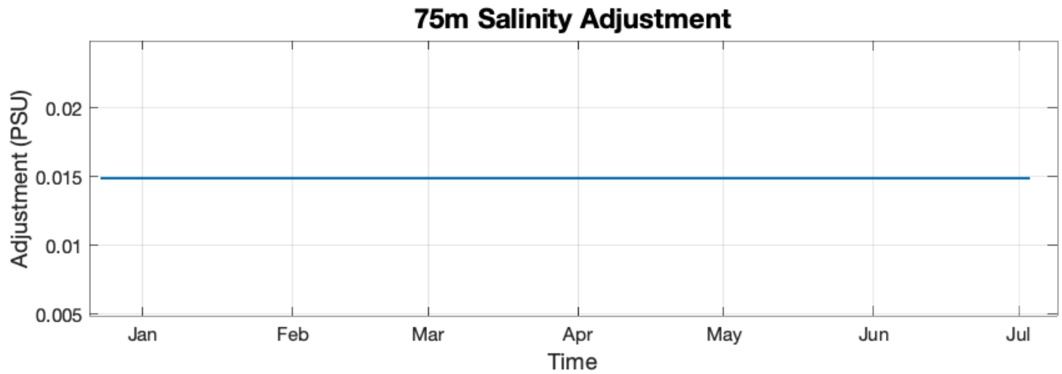


Post-adrift:

2017-12-21 10:47:24 to 2018-07-03 23:10:00 at 50 m adjusted 0.0149 to 0.0149
2017-12-21 10:47:24 to 2018-07-03 23:10:00 at 75 m adjusted 0.0149 to 0.0149

The 50m adjustment picks up from the adjustment applied at the end of the adrift period, continuing into the post-adrift period. The 75m instrument was replaced with a new instrument during the redeployment, so the post-adrift correction is independent from the pre-adrift 75m record, which did not require any corrections. The correction required for the TFlex SSTC while the buoy was adrift did not appear to be necessary in the post-adrift period (where no sustained inversions were observed). This change is attributed to the bridle instruments being cleaned of biofouling before the redeployment.





CTDs were performed before and after the KE015 deployment. The casts matched the data well, or were within the natural variability of the time-series at each depth.

Dr. Eitarou Oka performed 4 additional CTD casts (January 19 - 20, 2018) in a 50km square around KEO, and the CTD records are retained by OCS. There was general agreement between these casts and the moored records, but given their distance from the KEO mooring, these casts were not used to correct KEO data.

3.3.4 Deep SBE Data

From PA006-present and KE010-present, an SBE37S has been mounted on the acoustic release near the anchor. Retrieval rates have been high, and several years of data at each site are now available.

On KE015, the deep SBE was not influenced by the surface buoy having drifted, but upon recovery of the remnant (performed on the same cruise that redeployed the mooring), the instrument was found to have no internal records. The lab test and at-sea setup files showed the instrument was functional at the time of deployment, so no cause of failure has been established.

3.3.5 Currents (Nortek Aquadopp)

The deployed current meters calculate the speed of sound, and internally apply sound velocity corrections to current measurements. During post processing, a correction for magnetic declination (-5.0°) is applied. A thirteen-point Hanning filter is applied to the 10-minute resolution data to get hourly data, and a boxcar filter produces daily averaged values.

Upward facing point current meters were deployed at three depths on the KE015 mooring. The stated head depth differs from the actual current measurement depth, because the instruments require a blanking distance. Currents from the instruments deployed at 8.46, 16.46 and 36.46m measured velocities at 8, 16 and 36m, respectively. All current meters deployed on KE015 were Nortek Aquadopps.

The 8.46m instrument slipped down approximately 1m when the mooring was redeployed after being adrift. No flags were changed due to this small displacement, and all Aquadopp data were recovered and downloaded successfully.

Since the KEO buoy could move about its watch circle, the current meters did not measure true currents. Using time-stamped data from aggregated Flex + TFlex GPS system data, buoy velocity averages were generated. True currents were determined by adding calculated buoy motion to the measured current meter data.

Buoy motion was determined by first interpolating the acquired GPS positions onto a 10-minute grid (:05, :15, :25, etc.). Ten-minute mooring velocities (:00, :10, :20, etc.) were then calculated using the haversine formula, to equate change in position over time to a mooring velocity. The calculated U and V mooring velocities corresponding to the 10-minute measurement intervals were then added to the measured current meter data.

No flags were provided by the GPS systems, so manual flagging was applied to remove any acquired positions which placed the buoy outside its nominal watch circle while the buoy was moored. Positions and calculated velocities from within the watch circle were otherwise trusted. Note that mean buoy velocities increase greatly when the buoy breaks free from October – December 2017. Positions outside the watch circle were allowed during the adrift period, but the trackline was manually reviewed for outliers. A few buoy-motion spikes occur when GPS timestamps are closely spaced, but short periods of high velocities are possible, so were not flagged.

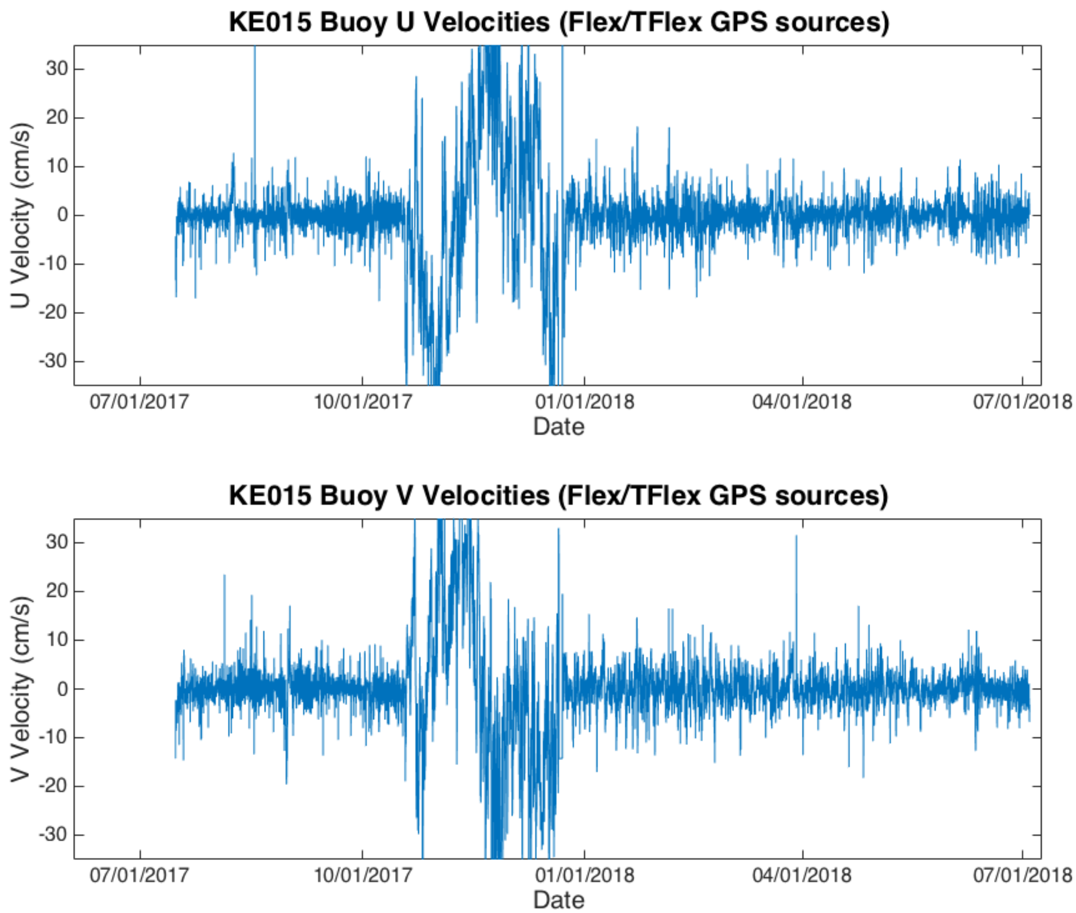


Figure 13: KE015 buoy velocities used to correct currents. The adrift period is apparent in the October to December 2017 timeframe.

3.3.6 Acoustic Doppler Current Profiler (Aquadopp Profiler)

An upward-looking Aquadopp Profiler was deployed at 68m for the first time on the KE015 mooring. The profiler was downloaded and redeployed, resulting in a split data file, with pre-adrift and adrift data in 1 file, and post-adrift data in another.

To process the data, 4 corrections were applied: declination (-5 degrees), tilt correction, head depth adjustment, and buoy-motion corrections. Aquadopps do not have an internal setting for declination, so this correction to true heading is applied first in post-processing. Tilt correction, also called "bin-mapping," is then computed using a conversion between Earth and Beam coordinates, taking samples along each beam where it most nearly pierces defined horizontal slices of the water column. Tilts over 20 degrees are eliminated (Q5 flags), as the manufacturer considers data beyond this threshold unusable. A head depth adjustment is needed for the profiler, as its vertical position varies slightly, unlike the downward-looking Sentinel ADCP. The data are then regridded using linear interpolation, and buoy-motion is added to U/V currents.

4.0 References

Freitag, H.P., M.E. McCarty, C. Nosse, R. Lukas, M.J. McPhaden, and M.F. Cronin, 1999: COARE Seacat data: Calibrations and quality control procedures. NOAA Tech. Memo. ERL PMEL-115, 89 pp.

Fairall, C.W., P.O.G. Persson, E.F. Bradley, R.E. Payne, and S.P. Anderson, 1998: A new look at calibration and use of Eppley Precision Infrared Radiometers. Part I: Theory and Application. J. Atmos. Ocean. Tech., 15, 1229-1242.

Fofonoff, P., and R. C. Millard Jr., 1983: Algorithms for computation of fundamental properties of seawater, Tech. Pap. Mar. Sci., 44, 53 pp., Unesco, Paris.

Serra, Y.L., P.A'Hearn, H.P. Freitag, and M.J. McPhaden, 2001: ATLAS self-siphoning rain gauge error estimates. J. Atmos. Ocean. Tech., 18, 1989-2002.

5.0 Acknowledgements

N. Anderson (UW CICOES) processed the Flex/TFlex data, with initial assistance from C. Fey (UW CICOES) in developing scripts to handle the Flex/TFlex data. D. Dougherty (UW CICOES) is recognized for designing and generating the initial python files from which processing begins, and for the quality control of real-time data.

The OCS project office is grateful to the captain and crew of the M/V BLUEFIN, who made the deployment and recovery operations possible. P. Berk (UW CICOES) and T. Nesseth (NOAA/PMEL Engineering) participated in both the deployment and final recovery cruises. Our gratitude extends to D. Kester, R. Wells (both of UW CICOES) and the captain and crew of the R/V YOKOSUKA, who recovered the drifting buoy and redeployed KE015 for its “post-adrift” segment.

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6.0 Contact Information

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APPENDIX A: Description of Data Quality Flags

Instrumentation recovered in working condition is returned to PMEL for post-recovery calibration before being reused on future deployments. The resultant calibration coefficients are compared to the pre-deployment coefficients, and measurements are assigned quality indices based on drift, using the following criteria:

Q0 - No Sensor, or Datum Missing.

Q1 - Highest Quality. Pre/post-deployment calibrations agree to within sensor specifications. In most cases, only pre-deployment calibrations have been applied.

Q2 - Default Quality. Pre-deployment calibrations only or post-recovery calibrations only applied. Default value for sensors presently deployed and for sensors which were not recovered or not calibratable when recovered, or for which pre-deployment calibrations have been determined to be invalid.

Q3 - Adjusted Data. Pre/post calibrations differ, or original data do not agree with other data sources (e.g., other in situ data or climatology), or original data are noisy. Data have been adjusted in an attempt to reduce the error.

Q4 - Lower Quality. Pre/post calibrations differ, or data do not agree with other data sources (e.g., other in situ data or climatology), or data are noisy. Data could not be confidently adjusted to correct for error.

Q5 - Sensor, Instrument or Data System Failed.

For data provided in OceanSITES format, the standard GTMBA quality flags described above are mapped to the different OceanSITES quality flags shown below:

Q0 -	No QC Performed.	
Q1 -	Good Data.	(GTMBA Q1, Q2)
Q2 -	Probably Good Data.	(GTMBA Q3, Q4)
Q3 -	Bad Data that are Potentially Correctable.	
Q4 -	Bad Data.	(GTMBA Q5)
Q5 -	Value Changed.	
Q6 -	Not Used.	
Q7 -	Nominal Value.	
Q8 -	Interpolated Value.	
Q9 -	Missing Value.	(GTMBA Q0)

APPENDIX B: Primary Instrument High Resolution Data Plots

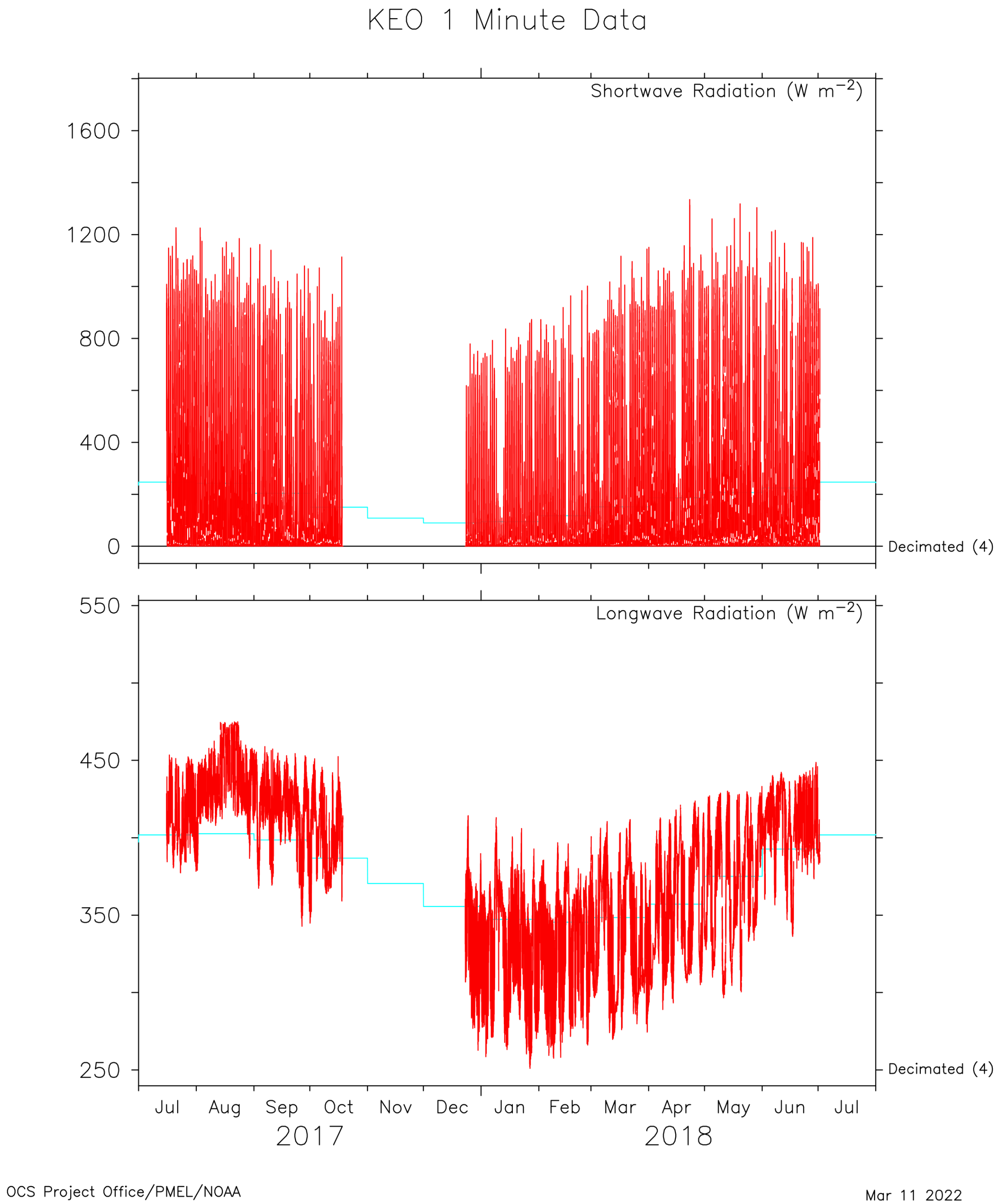

Figure B 1: KE015 primary shortwave and longwave radiation data at 1-min resolution (TFlex). Gap indicates the adrift period.

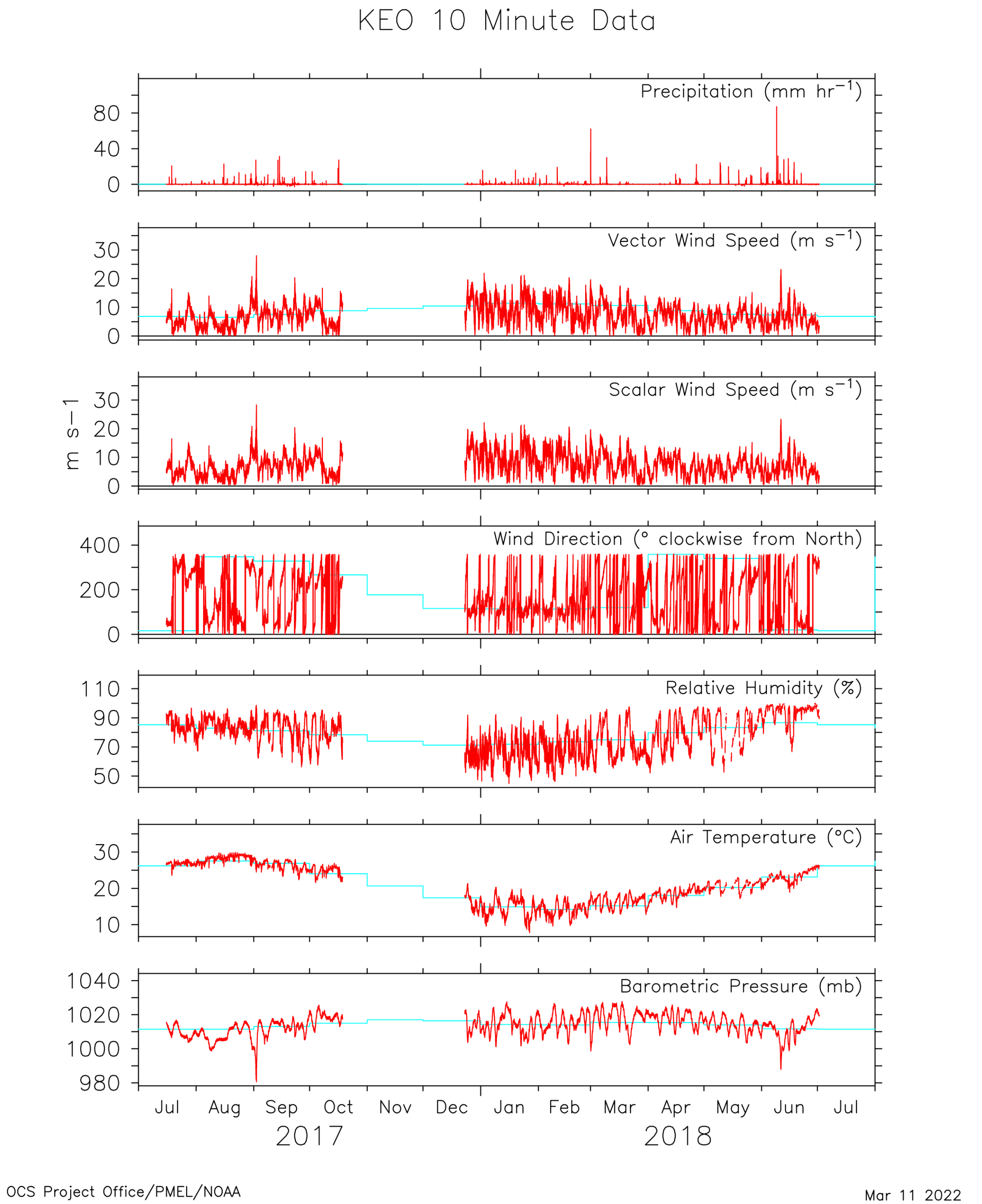

Figure B 2: KE015 primary meteorological data at 10-min resolution. All data are from Flex, except ATRH. Gap indicates the adrift period.

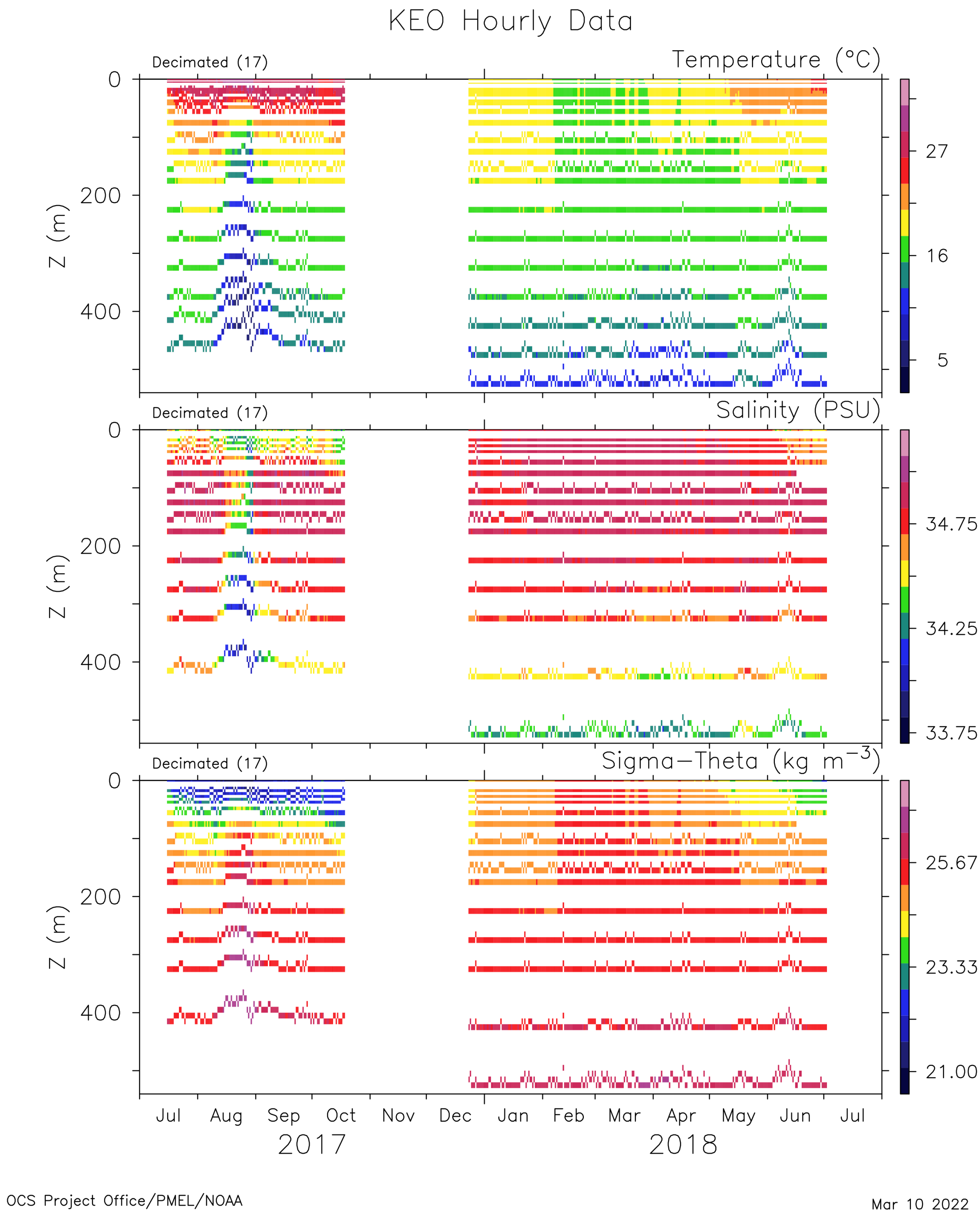

Figure B 3: KE015 subsurface temperature, salinity, and density at hourly resolution (decimated).

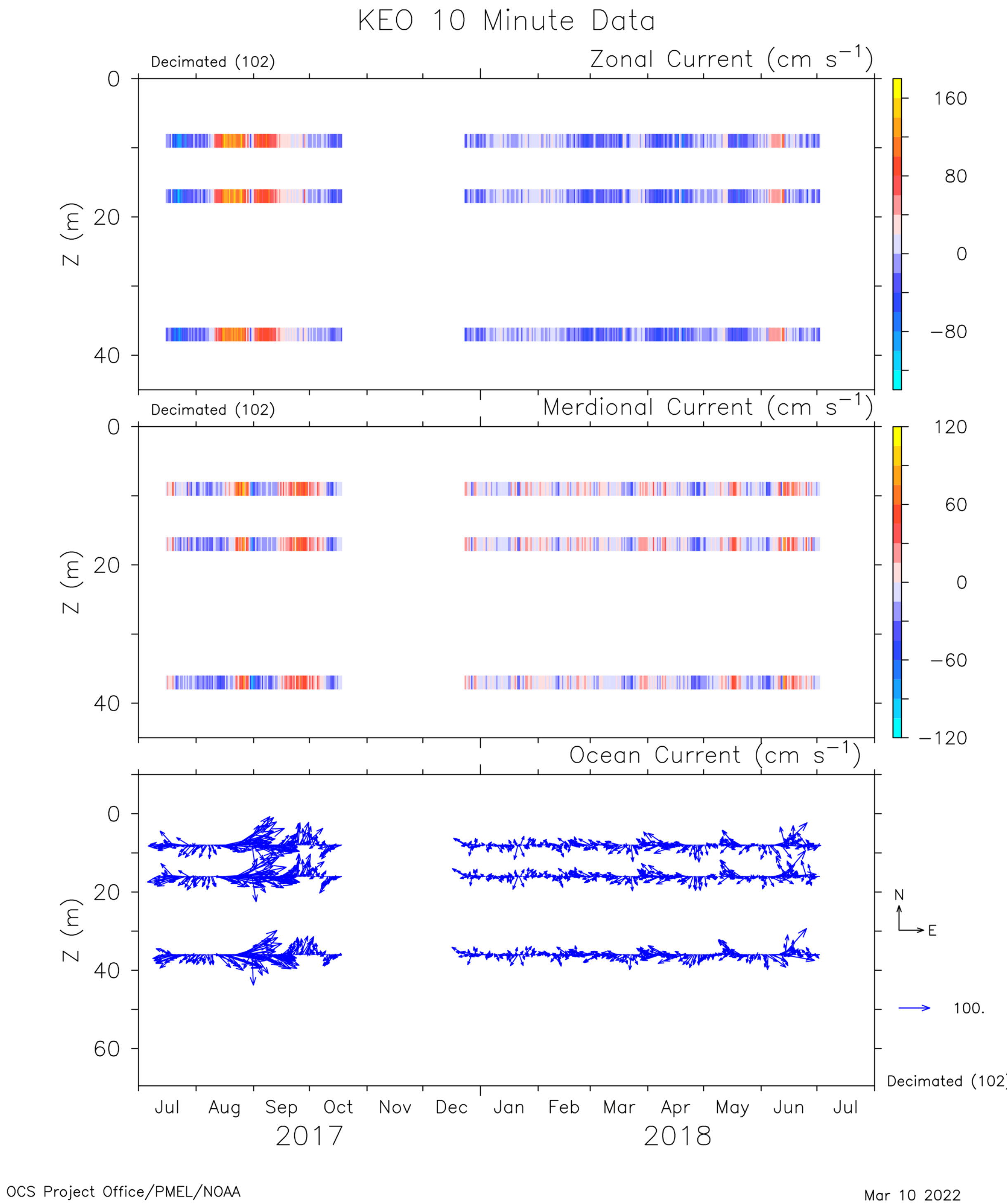

Figure B 4: Zonal and meridional current meter data (decimated) from KE015. Data during the adrift period are available through OceanSITES, but not the OCS webpage, as it did not represent the standard KEO location.

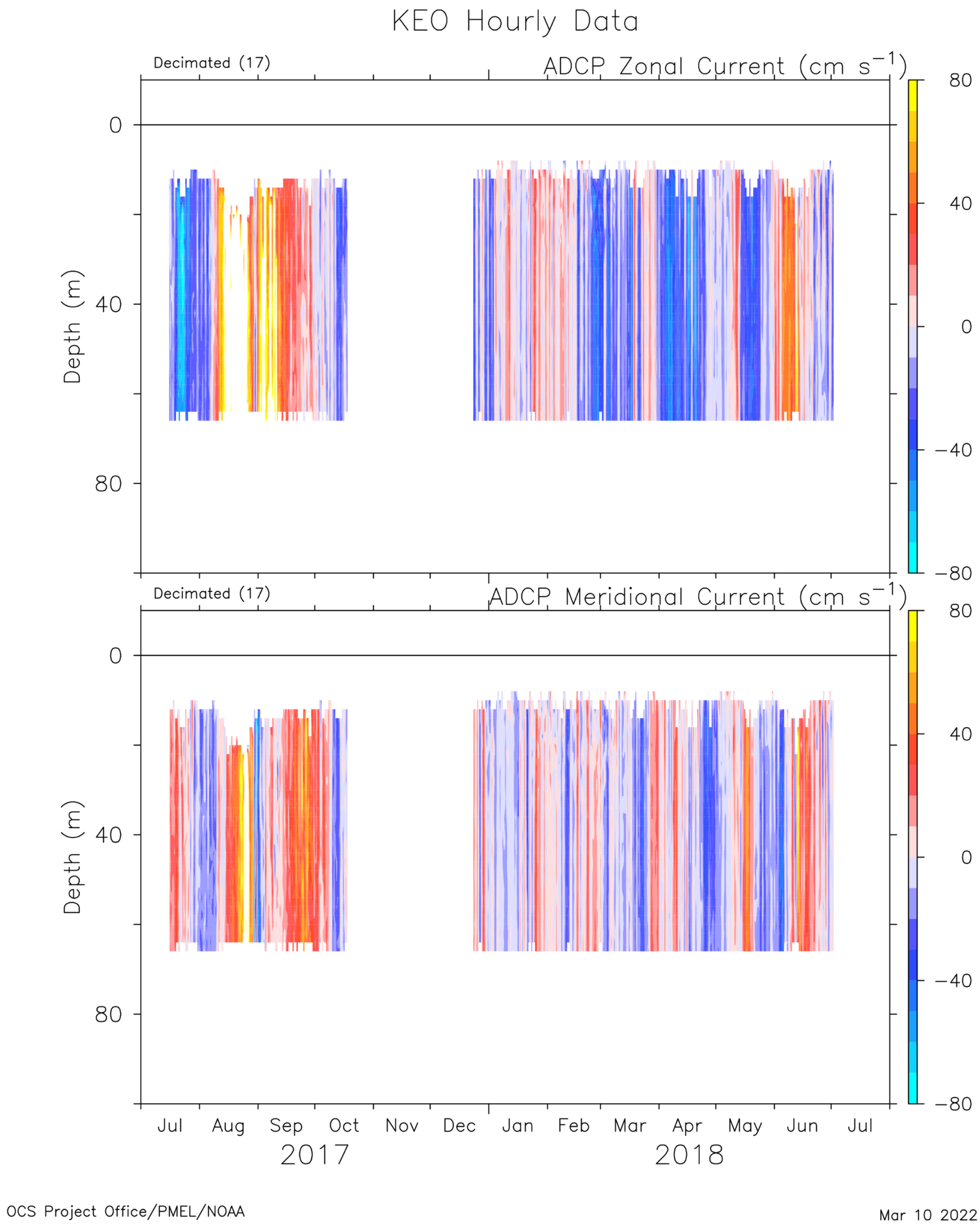

Figure B 5: Data from the upward-looking Nortek Aquadopp Profiler at 68m. This profiler was deployed for the first time on KE015.

APPENDIX C: Secondary Instrument High Resolution Data Plots

Note: Secondary data are provided through OceanSITES, split into pre-adrift (ke015a), adrift (ke015b), and post-adrift (ke015c) data. The entire deployment is shown here, but the surface mooring and subsurface instruments down to 425m were adrift October 18 – December 23, 2017.

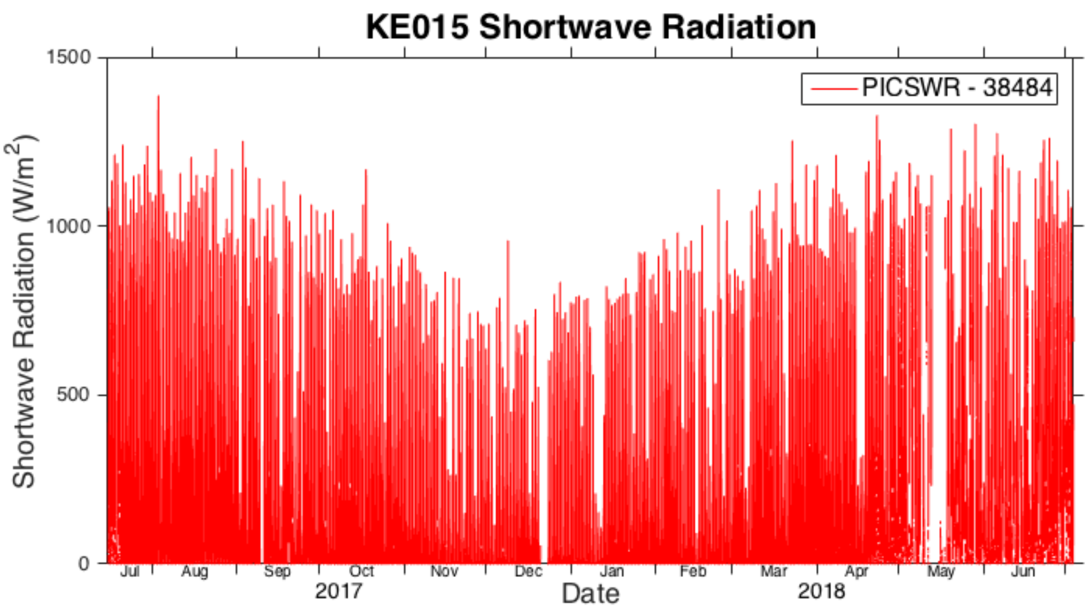

Figure C 1: Secondary (TFlex Eppley PSP) shortwave radiation sensor. The high resolution data were affected by TFlex system resets toward the deployment's end.

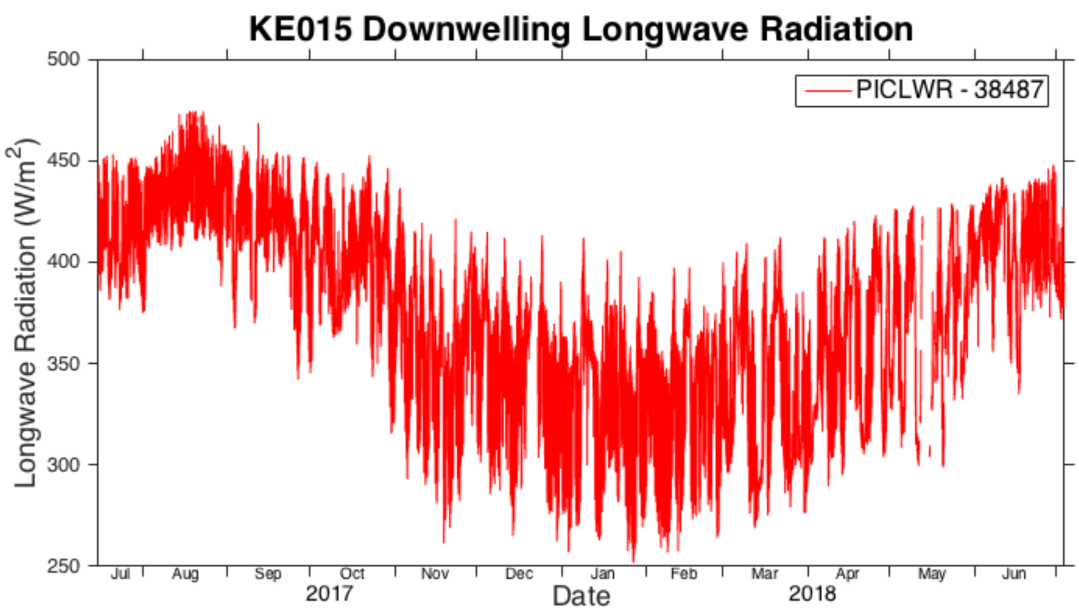

Figure C 2: Secondary (TFlex Eppley PIR) longwave radiation sensor. Q5 (removed) flags were assigned where net LWR exceeded 0 W/m^2 and where values exceeded 475 W/m^2, especially during a noisy period in August where the two LWR sensors disagreed. The high resolution data were affected by TFlex system resets toward the deployment's end.

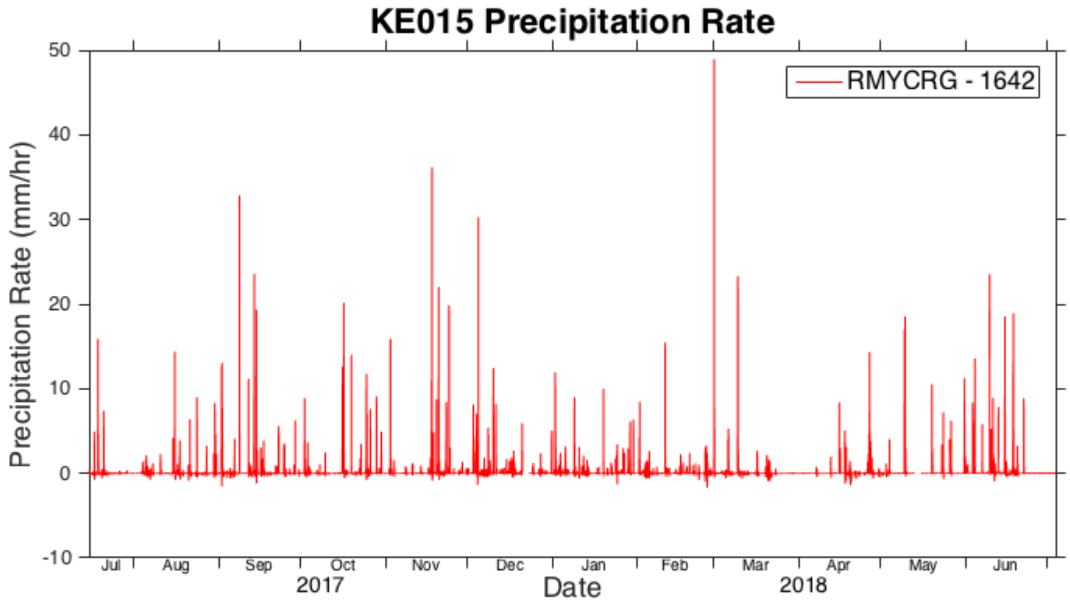

Figure C 3: Secondary (TFlex RM Young) rain sensor.

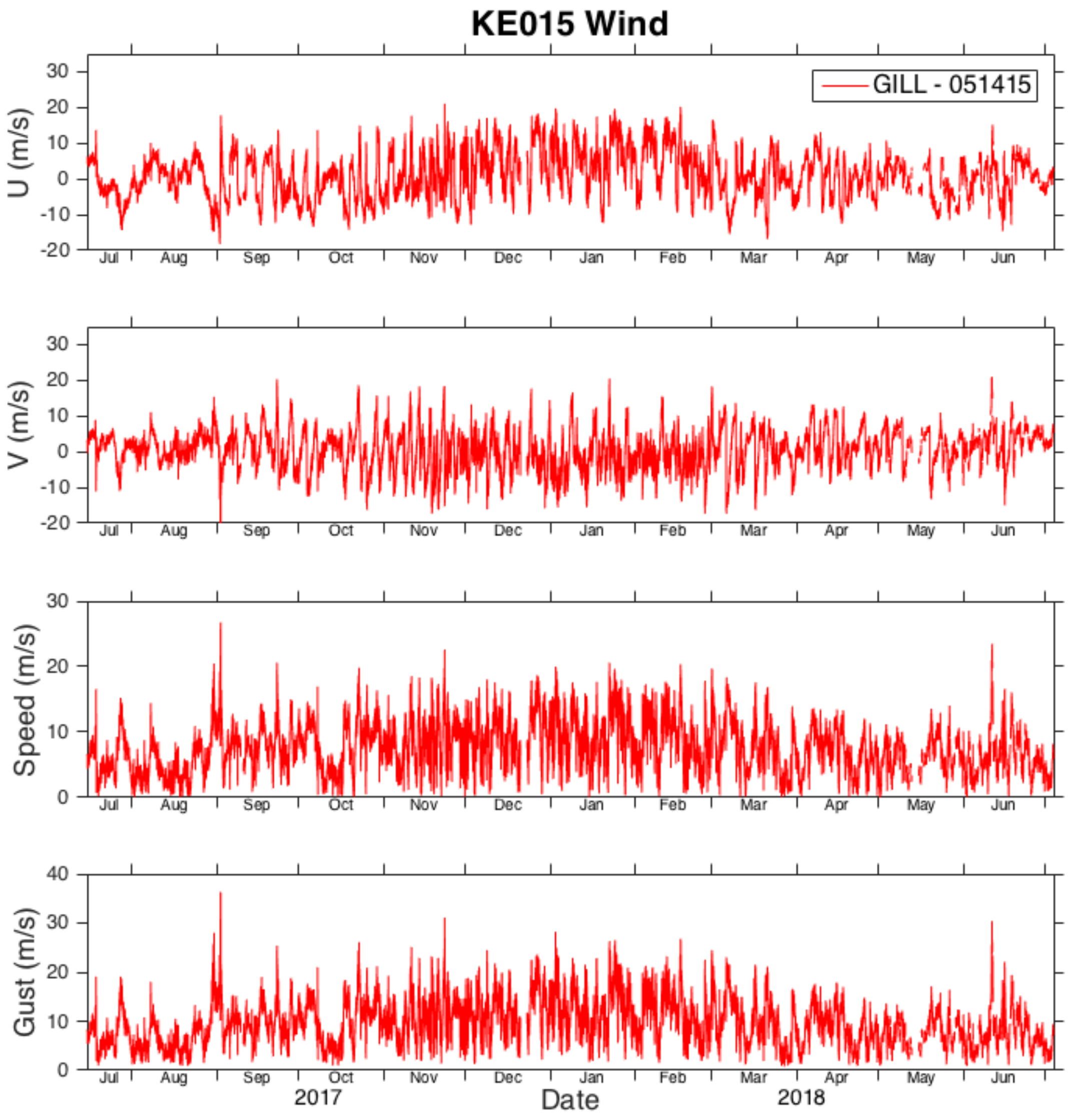

Figure C 4: Secondary (TFlex Gill) wind sensor.

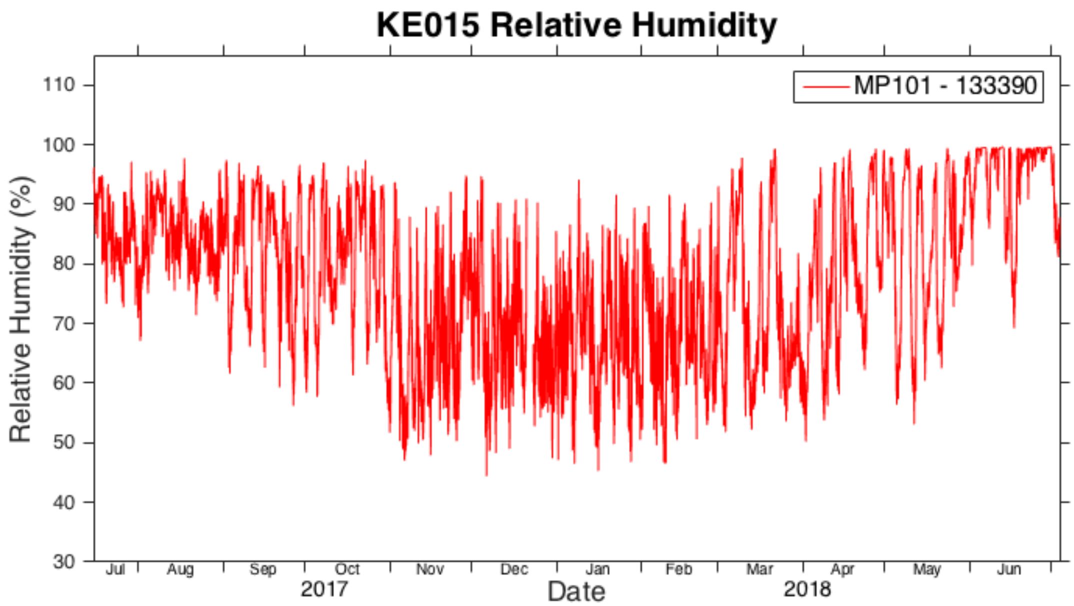

Figure C 5: Secondary (Flex MP101) relative humidity sensor. This sensor failed post-calibration, and was flagged as lower quality (Q4).

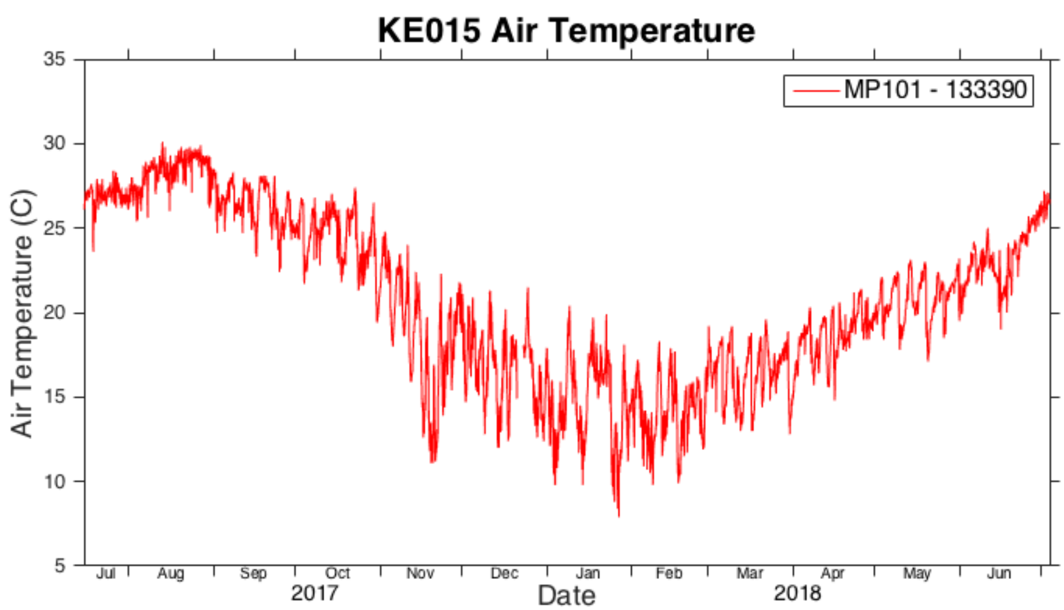

Figure C 6: Secondary (Flex MP101) air temperature sensor.

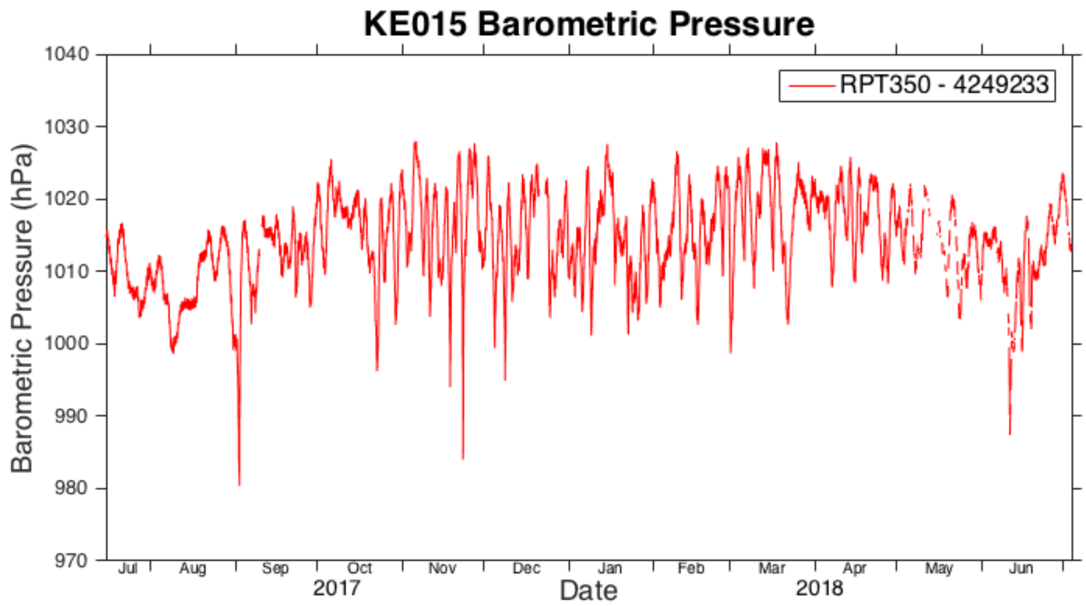

Figure C 7: Secondary (TFlex Druck) barometric pressure sensor.

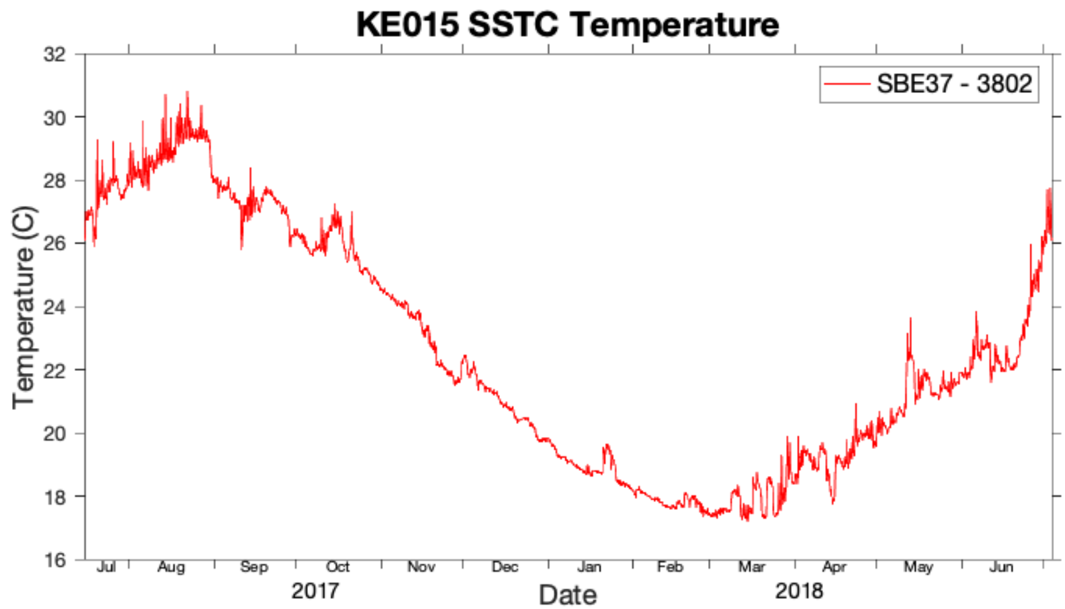

Figure C 8: Secondary (KE015 TFlex) SSTC temperature.

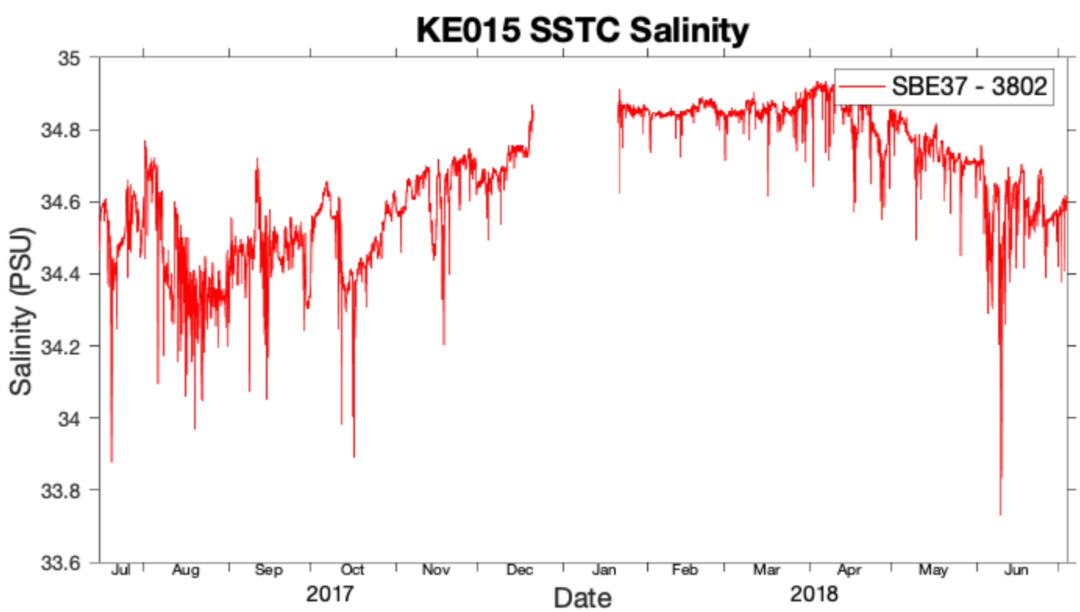

Figure C 9: Secondary (KE015 TFlex) SSTC Salinity. When KE015 was redeployed December 23, 2017, the secondary SSTC's conductivity/salinity/density went to 0, likely a result of bubbles caught in the conductivity cell as a result of redeployment. These data were flagged Q5 and removed. Functionality was restored mid-January.

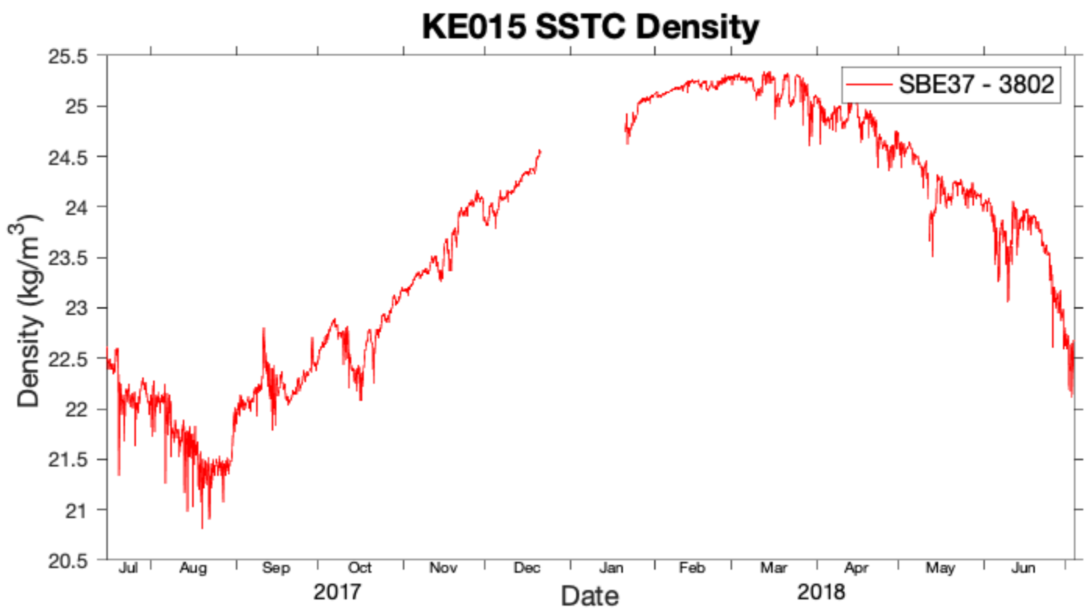

Figure C 10: Secondary (KE015 TFlex) SSTC Density. For the same reason as in Figure C 9, the secondary SSTC's conductivity/salinity/density went to 0, and data were temporarily flagged Q5 until functionality was restored.