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BERMUDA TESTBED MOORING DATA REPORT

Deployment #17 September 3, 2002 - May 4, 2003

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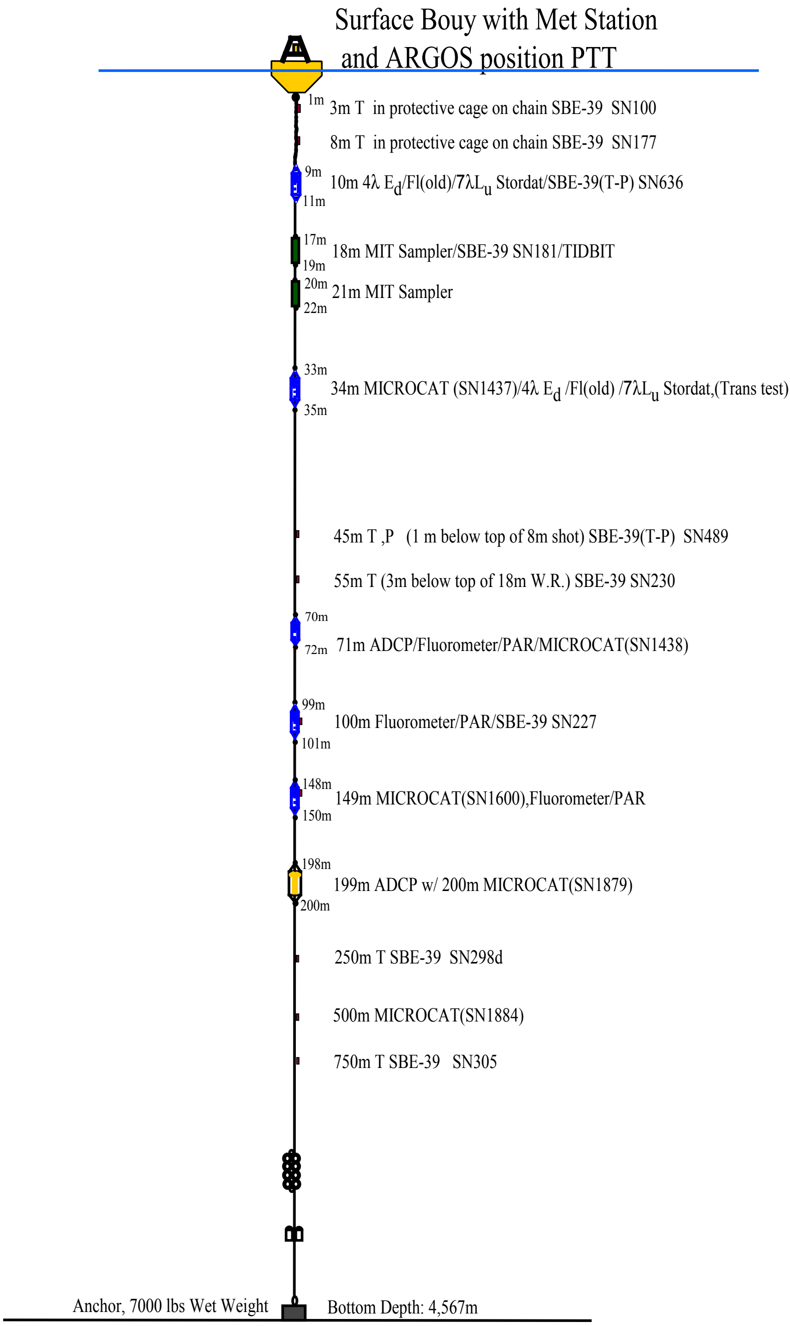

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Abstract

The Bermuda Testbed Mooring (BTM) has been deployed since June 1994 and provides the oceanographic community with a deep-water platform for testing new instrumentation, *in situ* comparisons for satellite ocean color imagers, and scientific studies. The mooring is located at approximately 31°44'N, 64°10'W or about 80 km southeast of Bermuda. There have been 17 deployments during the period from June 1994 to May 2003. The duration of each deployment is about 3 to 8 months. Meteorological and surface spectral radiometric measurements were made from a buoy tower. Measurements at depth included: currents, temperature, conductivity, and optical properties including spectral irradiance and radiance, PCO_2, and trace element concentrations. The high temporal resolution, long-term data collected from the mooring capture a broad dynamic range of oceanic variability and provide important information concerning episodic and periodic processes ranging in scale from minutes to years. Evaluation of undersampling and aliasing effects characteristic of infrequent sampling is also enabled with these data sets. The primary purposes of this report are to describe instrumentation, calibrations, and data collected during Deployment #17 (September 3 , 2002 – May 4, 2003). More detailed descriptions of the BTM program, instrumentation, and examples of previous results are presented in this report's reference section and the UCSB Ocean Physics Laboratory (OPL) web site (http://www.opl.ucsb.edu).

Introduction

The Bermuda Testbed Mooring (BTM), a deep-sea mooring which is available for long-term testing of interdisciplinary oceanographic sensors and systems, has been in operation since June 1994 (Dickey, 1995; Dickey et al., 1997, 1998a, 2001a). The BTM program was stimulated in part by the need for autonomous, interdisciplinary measurements in remote oceanic regions. This need is underscored by the initiation of several recent and planned national and international oceanographic programs (e.g., Joint Global Ocean Flux Study, JGOFS; Global Ocean Ecosystems Dynamics, GLOBEC; Global Ocean Observing System, GOOS) over the past decade. These programs concern the environmental and ecological causes and effects of global changes. The success of these programs depends on the development and application of relevant technologies that are crucial for improved observational databases (Dickey, 1993; Dickey, 2001a). The technological development has been sponsored through funding from: the National Science Foundation (NSF), the Office of Naval Research (ONR), the National Aeronautical and Space Administration (NASA), the National Oceanic Partnership Program (NOPP), the University of California, Santa Barbara (UCSB), the Monteray Bay Aquarium for Research (MBARI), other collaboratory institutions, two private foundations, and the National Oceanic and Atmospheric Administration (NOAA). A summary of BTM deployment #17 users is provided in Table 1.

New sensors, instrumentation and telemetry systems have greatly expanded observable scales and the number of variables pertinent to programs such as those mentioned above (e.g., Dickey, 1991, 2001a, b; Dickey et al., 1993, 1998a, 2001). Observationalists, as well as numerical modelers who wish to form collaborations with technologists, test and evaluate these sensors and systems using the BTM.

Another primary objective is to provide nearly continuous optical time series data for calibration, validation, and algorithm development for ocean color satellites including SeaWiFS, as part of the NASA SIMBIOS project (Esaias et al., 1995). For example, satellite-derived color data are confined to the uppermost ocean layer and the number of viewing days are severely limited by cloud obscuration (e.g., Smith et al., 1991). Bio-optical measurements made from moorings can provide critical complementary and virtually continuous information at a variety of depths (Dickey, 2001b; Dickey and Falkowski, 2001). One important use of our data is to develop new methodologies and capabilities for obtaining and synthesizing data derived from *in situ* and several satellite ocean color sensors (Esaias et al., 1995). Nearly continuous moored observations are especially attractive as they optimize the number of "match-up" data (e.g., spectral water-leaving radiance) with satellite measurements (e.g., Mueller and Austin, 1992). Large dynamic ranges are observed because of variations in solar elevation, cloud type, wave and surface conditions, and amount and types of pigmented biomass. The UCSB BTM data have been provided to the NSF U.S. JGOFS and NASA SeaBASS data management systems.

The third major objective of the BTM program concerns time series oceanic measurements for scientific studies (e.g., Deep-Sea Research II, Volume 43, Nos. 2-3, 1996, eds. D. Karl and A. Michaels and Deep Sea Research II, Volume 48, Nos. 8-9, 2001, eds. D. Siegel, D. Karl and A. Michaels). The BTM mooring site nearly coincides with the U.S. JGOFS sponsored Bermuda Atlantic Time-Series Study (BATS) site, the Bermuda BioOptics Program (BBOP) site (Siegel et al., 1996), and the Ocean Flux Program (OFP) site (e.g., Conte et al., 2001) (Figure 1). Some of the mutual objectives of the BTM and BATS programs are: 1) to observe and interpret the annual and interannual variability of the biology and chemistry of the upper ocean; 2) to understand the interrelationships among the biological, chemical, and physical characteristics of the water column; and 3) to provide data on global trends of selected oceanic properties over decadal time scales.

Some of the specific goals of the BTM program are:

1. To concurrently collect interdisciplinary data sets that may be used to improve interpretation of measurements made with new *in situ* sensors and systems.
2. To provide nearly continuous measurements enabling study and modeling of seasonal and interannual as well as high frequency, episodic, and mesoscale variability in physical and bio-optical properties and primary productivity.
3. To determine the most appropriate suite of sensors (efficacy and cost) for use on moorings, drifters, floats, and autonomous underwater vehicles (AUVs) for future interdisciplinary global ocean observing systems applications in harsh (e.g., Southern Ocean, Arctic Ocean, etc.) as well as temperate oceanic regions. This objective is similar to that of the Oceanographic-Systems for Chemical, Optical, and Physical Experiments (O-SCOPE) project, funded by the National Ocean Partnership Program (NOPP) (see Dickey et al., 2000).
4. To provide data which may be used for analyzing and modeling biogeochemical cycling (e.g., phytoplankton biomass, productivity, and carbon fluxes) and intense forcing events including hurricanes (see Table 1).
5. To provide necessary links between data from remotely sensed observations (e.g., ocean color, sea surface temperature, and currents) and those collected from the BTM. Effects of long-term sensor drift, solar elevation, etc. are being examined as well. Several OPL reports on this aspect are available (see references).

Description of the BTM Program and Its Site Selection

1. The Bermuda Testbed Mooring

The BTM has been introduced to the oceanographic community through articles in Sea Technology, EOS, the Bulletin of the American Meteorological Society, Deep-Sea Research, the Journal of Geophysical Research, the Journal of Atmospheric and Oceanic Technology, Monthly Weather Review, and other publications (see references), announcements and presentations at major oceanographic society meetings, through mass emails, and our web site (http://www.opl.ucsb.edu). The BTM program was initiated through collaboration between the UCSB OPL (Dickey) and WHOI (Dan Frye). The collaborative effort has continued throughout the program. WHOI is responsible for the preparation and deployment of the mooring platform and related engineering studies including some data telemetry experiments. The UCSB OPL manages the BTM program, sampling strategies, baseline scientific instrumentation, new optical and telemetry technologies, and user organization and facilitation. Mooring redeployments take place approximately every 4 months. The first deployment in June 1994 included 9 instrument systems with no spectral (optical) capabilities. At present, there are more than twice as many systems and several instruments are much more sophisticated than the initial equipment. The mooring design used for the BTM program is based on a mooring used previously as part of the Atlantic Long-Term Oceanographic Mooring (ALTOMOOR) engineering program near Bermuda (Bocconcelli et al., 1991; Frye et al., 1996).

The surface expression of the mooring (Figure 2) is a 2.5-m diameter buoy fabricated of surlyn foam. Surface recording systems, controllers, and batteries are housed inside the buoy. The buoy tower supports an Argos transmitter to provide position of the buoy and data transmission, meteorological instruments, and a radiometer package. The meteorological package includes sensors for measuring winds, air temperature, shortwave radiation, relative humidity, and barometric pressure. These variables are sampled every minute, recording 5 min averaged data. The peak wind gust (highest value every 1 min) is also recorded during this 5 min sampling period. This measurement is important particularly under high wind, high sea conditions, such as those experienced during the passage of Hurricane Felix in August 1995 (Dickey et al., 1998c; Zedler, 1999). The anemometer and radiometer are located 4.4 m above the ocean surface. Commonly used estimates of wind speed at 10 m above the surface, U_{10}, are computed using a formula presented by Large et al. (1995).

Subsurface instruments and their sampling rates and sequences are shown in Table 2. Depths of the various subsurface sensors and systems are shown in Figure 2 and Table 3 for Deployment #17. Several different types of sensors are used to measure physical parameters from the BTM. Temperature is measured with self-recording temperature systems (e.g., SBE39, MICROCAT and Tidbit). Conductivity is measured with MICROCAT. In addition, an uplooking Broadband Acoustic Doppler Current Profiler (ADCP; RDI 150 KHz) measures currents every 15 minutes at multiple vertical bin depths (3 m bins) deployed at 199 m depth, and an uplooking Workhorse ADCP (RDI 300 KHz) measures currents every 15 minutes at multiple vertical bin depths (2 m bins) deployed at 71 m depth.

The BTM is also equipped with several types of optical sensors: Fluorometer (Sea Tech; Bartz et al., 1988) for measuring stimulated chlorophyll fluorescence, PAR sensor (Biospherical QSP-200; Booth, 1976), transmissometers (Wetlabs, C-Star), radiometers for measuring downwelling spectral irradiance, E_d, (Satlantic, OCR-504) at wavelengths of $\lambda = 412, 443, 490,$ and 555 nm, and nadir upwelling spectral radiance, L_u, (Satlantic, Stordat) at wavelengths of $\lambda = 412, 443, 490, 510, 555, 665$ and 683 nm.

A moored *in situ* trace element serial sampler (MITESS) developed by Ed Boyle of MIT and collaborators (Bell et al., 2001) has also been deployed. The purpose of the MITESS is to examine the temporal variability of trace metals in the upper ocean. Details concerning the design and development of the MITESS are presented elsewhere (e.g., Dickey et al., 1998a; Bell et al., 2001).

2. *Site selection for the BTM*

The BTM site is located at 31° 42'N, 64° 11'W (Figure 1) and within a half day's steam of Bermuda, so minimal time is spent in transit. This site was chosen for the BTM program for the following reasons:

1) It is within a representative oligotrophic gyre and in deep waters (~4570 m), yet is easily accessible;
2) There are rich historical data sets available near this site (e.g., Hydrostation S, BATS, OFP and BBOP). These data are useful for setting up and calibrating new instruments and facilitating intercomparisons and interpretations;
3) High resolution remote sensing data are collected for the Bermuda area (e.g., Nelson, 1998), thus providing complementary measurements for our study and vice versa; and
4) There is a reasonably high probability of passages of intense storms and hurricanes (Dickey et al., 1998b; Zedler, 1999).

Among the programs located near the BTM site, the BATS and its associated programs are particularly valuable for the BTM program (see review by Michaels and Knap, 1996 and other papers in Deep-Sea Research volume 43, Nos. 2 and 3, 1996; and Deep Sea Research II, Volume 48, Nos. 8-9, 2001). The primary BATS site is located at 31° 50'N, 64°10'W (Figure 1). The BATS site has been sampled as part of the BATS program since October 1988. Research cruises are made monthly (bi-monthly cruises in springtime) to the BATS site. Core measurements include: 1) profiles of temperature, salinity, beam attenuation coefficient or c660, stimulated chlorophyll fluorescence, PAR, dissolved oxygen, nutrients, particulate organic carbon and nitrogen, primary productivity, phytoplankton pigments, dissolved organic carbon, nitrogen, and phosphorus; 2) net tow and video sampling of zooplankton; 3) bacteria assays; and 4) sediment trap determined sinking carbon flux. Bio-optical profile data are also being obtained during these cruises as part of the Bermuda Bio-optics Project (BBOP, Siegel and Michaels, 1996a,b; Siegel et al., 1995, 1996). The profile data provide excellent vertical resolution (~1 m from the surface to ~200 m), but relatively poor temporal resolution, whereas the mooring data provide excellent temporal resolution (order of minutes to an hour), but relatively poor vertical resolution (~10 m or greater). The profiling system includes several bio-optical sensors that are compatible with the BTM sensors to be described later. Clearly, both sampling modes are necessary for detailed optical studies. Intercomparisons of BTM, BBOP, and SeaWiFS water-leaving radiance data are presented in Dickey (2001b).

The Bermuda Biological Station for Research (BBSR) program is also equipped with an HRPT satellite receiver system (TeraScan: SeaSpace, Inc.) for acquiring and processing AVHRR and SeaWiFS image data. Typically, four satellite images are captured per day. Using these images, basin scale and local mesoscale features can be resolved, thus providing spatial context for time series observations. The retrievals are validated with monthly or bi-weekly shipboard CTD/optics casts at the BATS site and underway data collected during R/V Weatherbird II cruises in the region. An interesting example of AVHRR imagery obtained during Hurricane Felix's passage in August 1995 near the mooring site is presented in Nelson (1996a). TOPEX/Poseidon and ERS-2 altimetry are also being examined (personal communication, Erik Fields and David Siegel (UCSB) and Dennis McGillicuddy (WHOI)). These complementary remote sensing measurements are valuable for the BTM work and vice versa.

Progress Over the Past 9 Years

Over the past nine years, we have established the BTM as a viable international testbed facility along with an active user group (Table 1), and developed and tested several bio-optical systems (Dickey et al., 1998a; Dickey 2001b). These systems measure inherent and apparent optical properties on time scales of minutes. Additionally, we used our data to groundtruth SeaWiFS satellite data. Comparisons are excellent (e.g., see Dickey, 2001b). We have also made inter-comparisons of ocean currents among a VMCM, an ADCP, and a new acoustic current meter (FSI 3D-ACM; Gilboy et al. 2000). Meteorological, physical, and optical data collected from the mooring are used to evaluate several new systems and to interpret the BTM users' collective data sets (Dickey et al., 1998a, 2001a). The mooring was also used to obtain data during hurricanes—it is well known that the data of hurricanes are extremely difficult to collect (e.g., Nelson, 1996, 1998; Dickey et al., 1998b; Zedler, 1999). We have also successfully transitioned the BIOPS design to other scientific programs such as the ONR-sponsored Coastal Mixing and Optics (CMO) and HyCODE for capturing sediment resuspension events associated with hurricanes (Dickey et al., 1998d; Chang and Dickey, 1999, 2001; Chang et al., 2001). New telemetry systems were also developed (Frye et al., 1996; Dickey et al., 1998a, 2001). The telemetry work is important in the long-term scheme of utilizing moored, drifter, float, and AUV instrumentation for remote sites as part of global ocean/climate observing networks (e.g., Dickey, 2000a).

BTM investigators have deployed several other emerging measurement systems such as high-resolution optical systems (UCSB OPL) and nitrate analyzers, among which OsmoAnalyzer was developed by Hans Jannasch of MBARI. Ed Boyle of MIT developed moored *in situ* trace element serial sampler systems MITESS I (Bell et al., 2001) and other groups have developed pCO_2 measurement systems (Merlivat and Brault, 1995; Tabacco et al., 1999; Bates et al., 2001). In addition, a serial ^{14}C analyzer for primary productivity, a newly developed acoustic current meter ACM and near real-time inductive telemetry systems were developed by Craig Taylor of WHOI, Al Fougere of Falmouth Scientific Instruments, and Dan Frye of WHOI and the UCSB OPL, respectively.

In addition to technology development and testing, the data collected from the BTM program are used for scientific studies. Publications resulting from BTM activities are indicated in the references. A summary of the various deployments, a guide to data reports and papers, recent data highlights, and information for potential BTM users may be found on our worldwide web site (http://www.opl.ucsb.edu/btm.html).

Description of Deployment #17

The duration of Deployment #17 was from September 3, 2002 througth May 4, 2003. The major purpose of this long deployment was to continue development and testing of anti-biofouling methods for a variety of optical instruments. Our goal is to reduce the effects of biofouling to the point where 6-month deployments are routine (power and data storage are no longer major obstacles). Data quality for physical variables is not affected by the long-term operation, while measurements of optical variables show some deterioration in quality. This quality deterioration suggests that biofouling techniques need further improvement. In fact, one focus of the O-SCOPE program concerns development of new anti-biofouling systems and methods (Dickey et al., 1998a, 2000).

This deployment documented the seasonal shift from late summer, to fall, to winter, and to spring. Surface air temperature decreases about 5 ^{o}C from JD 291 to JD 325 (Figure 4). Good air temperature data ended on JD 339 with unknown reason. On average, surface wind was stronger in late fall and early winter than spring and summer. Seasonal trends in barometric pressure is not strong compared with synoptic changes, while shortwave radiation seasonal changed significantly from late summer, to fall and winter, and to spring (Figure 5). Wind speed and barometric pressure indicate the passages of synoptic scale pressure system every few days. Winds were quite variable with speeds occasionally reaching values as high as 20 m/sec. Shortwave insolation decreased until JD 350 after which it began to increase again.

Time series of surface spectral downwelling irradiance [Es~Ed(0^{+})] for 4 wavelengths are shown in Figure 6. There is evidence for a seasonal signal (decrease in irradiance into early fall and began to increase in irradiance on JD 350), as well as synoptic variability. These behaviors are common to all of the surface light sensors.

The seasonal progression of the upper ocean from late summer, to fall and winter, and to spring is well characterized by the vertical temperature structure evolution (Figure 7 and 8). Stratification was significant in late summer (JD 247 to JD 320), but convection and wind mixing caused cooling at the sea surface, and the upper 200 m of water were well mixed by JD 426. Sea surface temperature dropped from 29^{o}C to 19.7^{o}C from JD 247 to JD 426, while temperature at 200 m depth varied few of a degree during the same time period. Sea surface temperatures began to increase around early-March. Stratification was re-established.

Time series of salinity from the MicroCat at 34, 71, 149, 200 and 500 m appear to be of good quality (Figures 9). Time series of pressure from the SBE-39 at 10 and 45 m appear to be of good quality (Figures 10). The fluorometer at 10 and 34 m began to biofoul at JD 335 (Figure 11).

Figures 12-15 show a trend of decreasing subsurface spectral irradiance and radiance at 10 and 34 m, consistent with the trends in decreasing light intensity at the surface until JD 350. Although the spectral radiometers for irradiance at 10 and 34 m depth were operational during the entire deployment, there might be biofouling after JD 385 at 10 m and after JD 350 at 34 m. There might be biofouling after JD 350 for radiance measurement with wavelength 412-510 at 34 m. The existence of biofouling indicates that anti-biofouling techniques need further improvement in order to have good-quality optical data from 6-month long mooring deployments.

Figure 16 show fluorescence and PAR at 71 m depth. There was biofouling after JD 430 for fluorescence measurement.

Time series of beam c measured with COPPER and without COPPER are shown in Figure 17. Improvement for anti-biofouling with COPPER is evident.

Figures 18-20 show currents from the BB ADCP for a subset of measurement depths. The currents show large variability on both near-inertial and synoptic time scales. The inertial component is stronger in the surface layer than at depth. The inertial signal in the upper 131 m is strongest for about 10 days. Currents from the WH ADCP deployed at 71 are consistent with the result from the BB ADCP, while the WH ADCP provided horizontal current with more shallower and higher vertical resolution compared with the BB ADCP.

Summary

This report provides a preliminary description of the data collected during Deployment #17 of the Bermuda Testbed Mooring (September 3, 2002 - May 4, 2003). The data show typical seasonal changes. Water temperatures in the upper ocean decreased significantly from late summer to fall, and to winter. Cooling and mixed layer deepening trends are evident by` JD 426. Sea surface temperatures began to increase around early-March. Time series show that photosynthetically available radiation (PAR), downwelling irradiance and upwelling radiance generally decrease since late summer. Due to the passage of synoptic scale weather patterns, air temperature, wind speed and other atmospheric parameters are variable on these time scale, resulting in similar variations in oceanic parameters such as PAR, irradiance and radiance.

Horizontal currents show strong vertical coherence after JD 385, when the seasonal thermocline disappeared. In the upper 126m, very strong near-inertial motion occurred from JD 365 to JD 378.

The data from this deployment will be made available to the oceanographic community in the near future. The data are being submitted to the U.S. JGOFS database. A summary of the various deployments, a guide to data reports (with calibration information) and papers, recent data highlights, and information for potential BTM users may be found on the following worldwide web site (http://www.opl.ucsb.edu).

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OCE-9730471, OCE-9819477, OCE-9987884), NASA (TD: NAS5-97127), the ONR Ocean Engineering and Marine Systems Program (DF: N00014-96-1-0028 and N00014-94-1-0346), the University of California, Santa Barbara (to T. Dickey, UCSB. Special thanks are extended to John Kemp for his dedication to the mooring activity and to the Captain and crew of the R/V Weatherbird II for their assistance at-sea.

Pertinent References

Publications resulting from the BTM activity are indicated with asterisks. A summary of the various deployments, a guide to data reports and papers, recent data highlights, and information for potential BTM users may be found on our worldwide web site (http://www.opl.ucsb.edu). Note that we have listed the technical reports sequentially (by deployment number) at the end of the Bibliography.

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Table 1: List of BTM Users for Deployment # 17

Instrument	**Measurement**	**P. I.**	**Institution**
METS	Wind speed and direction, air temp, barometric pressure, humidity	Dickey	UCSB OPL
Radiometers	4 λ's $E_{d,}$ 7 λ's L_u	Dickey	UCSB OPL
Wetstar Fluorometers	Fluorescence	Dickey	UCSB OPL
DFLS Fluorometers	Fluorescence	Dickey	UCSB OPL
PAR	PAR	Dickey	UCSB OPL
C-Star Transmissometers	Transmission	Dickey	UCSB OPL
MicroCat	Temperature, Conductivity	Dickey	UCSB OPL
SBE39	Temperature, Pressure	Dickey	UCSB OPL
TidBit	Temperature	Dickey	UCSB OPL
ADCPs	Current profile measurements	Dickey	UCSB OPL, Penn State
Mooring design	Mooring design	Frye	WHOI
TS-SID I	Incorporation of ^{14}C and ^{3}H	Taylor	WHOI
MITESS I	Trace metals i.e. Pb, Fe, Al	Boyle	MIT
MITESS II	Phase II trace metal sampler	Boyle	MIT

Table 1 (continued)

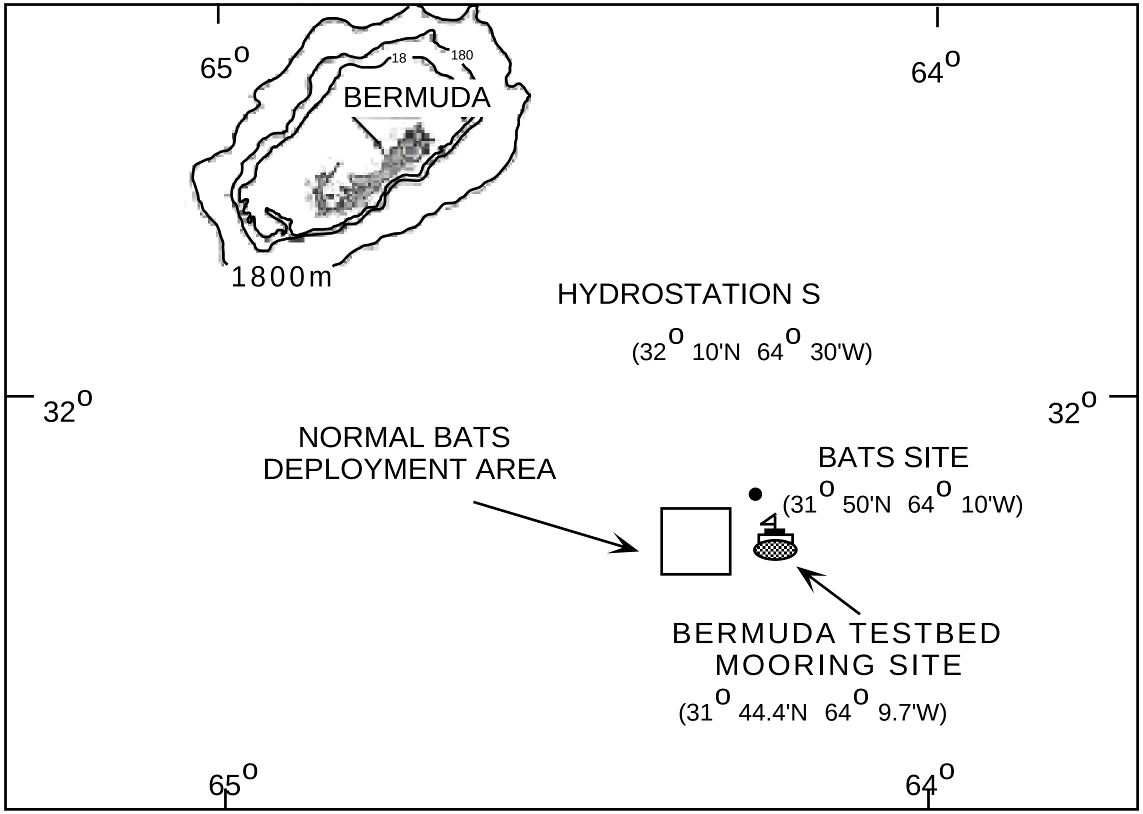
MODELING / OBSERVATIONS		
General Area of Interest	**P. I.**	**Institution**
Biogeochemical modeling	Doney	NCAR
Biogeochemical modeling	Bissett	NRL
Biogeochemical modeling	Gnanadesikan	Princeton
Biogeochemical modeling	Porthun	A.-Wegener (Germany)
Biogeochemical modeling	McNames	Stanford
Biogeochemical modeling	McGillicuddy	WHOI
Biogeochemical modeling	Mahadevan	Univ. Paris-VI
Biogeochemical modeling	Archer	Univ. Chicago
Chemical sampling with new systems	Feely	PMEL
Chemical sampling with new systems	Wanninkhof	AOML
Chemical sampling with new systems	Dickson	Scripps
Chemical sampling with new systems	Chavez et al.	MBARI
Chemical sampling with new systems	Byrne	U. So. Florida
Chemical sampling with new systems	Bates	BBSR
Optical sensors	Moore	WET Labs
Bio-optics (Laboratory vs. *in situ* response of fluorometers to varying chlorophyll levels)/Satellites)	Nelson	BBSR
Observations and modeling of photochemistry, biogeochemical cycling, and physics	Zafiriou/Taylor	WHOI
Carbon fluxes	Conte	WHOI
Carbon fluxes	Schulz-Bull	IfM-M (Kiel, Ger)
Hurricane modeling	Ginis	URI
Hurricane modeling	Price/Dickey	WHOI/UCSB

Table 3. Sensor Functionality Summary

Deployment 17 start date: September 3, 2002 end date: May 4, 2003 (JD 246-489 ref. 2002)

Surface METS	**Serial Number**	**Last day of operation**	**Reason for failure or comments**	
Temperature and Relative Humidity	2020003	Temp. 339, R. H. 251	Unknow	
Licor Pyranometer (400-1100nm)	31163	FULL DEPLOYMENT		
Barometric Pressure	4910019	FULL DEPLOYMENT		
Wind	WM23259	FULL DEPLOYMENT		
Surface OCR-504	52	FULL DEPLOYMENT		
11m				
OCR-504	50	FULL DEPLOYMENT		
STOR DAT	036/085	390	Unknow	
Fluorometer	173P	FULL DEPLOYMENT		
Pressure (SBE-39)	636	FULL DEPLOYMENT		
35m				
OCR-504	51	FULL DEPLOYMENT		
STOR DAT	037/086	390	Unknow	
Fluorometer	170	FULL DEPLOYMENT		
Transmissometer with no copper	329	458		
Transmissometer with copper	325	457		
45m				
Pressure (SBE-39)	489	FULL DEPLOYMENT		
71m				
ADCP		FULL DEPLOYMENT		
PAR	4332	460		
Fluorometer	91	459		
100m				
PAR	4396	354	record every 10 days	
Fluorometer	27	355	record every 10 days	
150m				
PAR	4398	FULL DEPLOYMENT	record every 10 days	
Fluorometer	90	FULL DEPLOYMENT	record every 10 days	
199m				
ADCP	2513	FULL DEPLOYMENT		
Conductivity Sensors				
35m Microcat	1437	FULL DEPLOYMENT		
71m MicroCat	1438	FULL DEPLOYMENT		
150m MicroCat	1600	FULL DEPLOYMENT		
200m MicroCat	1879	FULL DEPLOYMENT		
500m MicroCat	1884	FULL DEPLOYMENT		
Temperature Sensors				
2m Tidbit	526497			
3m SBE39	100			
8m SBE39	177			
11m Tidbit	526498			
11m SBE39	636			
18m SBE39	181	NO DATA		
35m Tidbit	526499			
35m Microcat	1437			
40m Tidbit	520802			
43m Tidbit	520804			
45m SBE39	489			
55m SBE39	230			
71m Tidbit	526500			
71m MicroCat	1438			
100m Tidbit	526500			
100m SBE39	227			
150m Tidbit	526502			
150m MicroCat	1600			
200m Tidbit	520801			
200m MicroCat	1879			
250m SBE39	298			
500m MicroCat	1884			
750m SBE39	305	NO DATA	Battery dead	

Figure 1: Bermuda Testbed Mooring Site Map



BERMUDA TESTBED MOORING

Deployment #17

Sept. 3, 2002 -
May 4, 2003

31° 44.382' N
64° 9.720' W

Temperature Measurements

TidBit	2m
SBE-39	3m
SBE-39	8m
TidBit	10m
SBE-39	10m
SBE-39	18m
TidBit	34m
MICROCAT	34m
TidBit	40m
TidBit	43m
SBE-39	45m
SBE-39	55m
TidBit	71m
MICROCAT	71m
TidBit	100m
SBE-39	100m
TidBit	149m
MICROCAT	149m
TidBit	200m
MICROCAT	200m
SBE-39	250m
MICROCAT	500m
SBE-39	750m

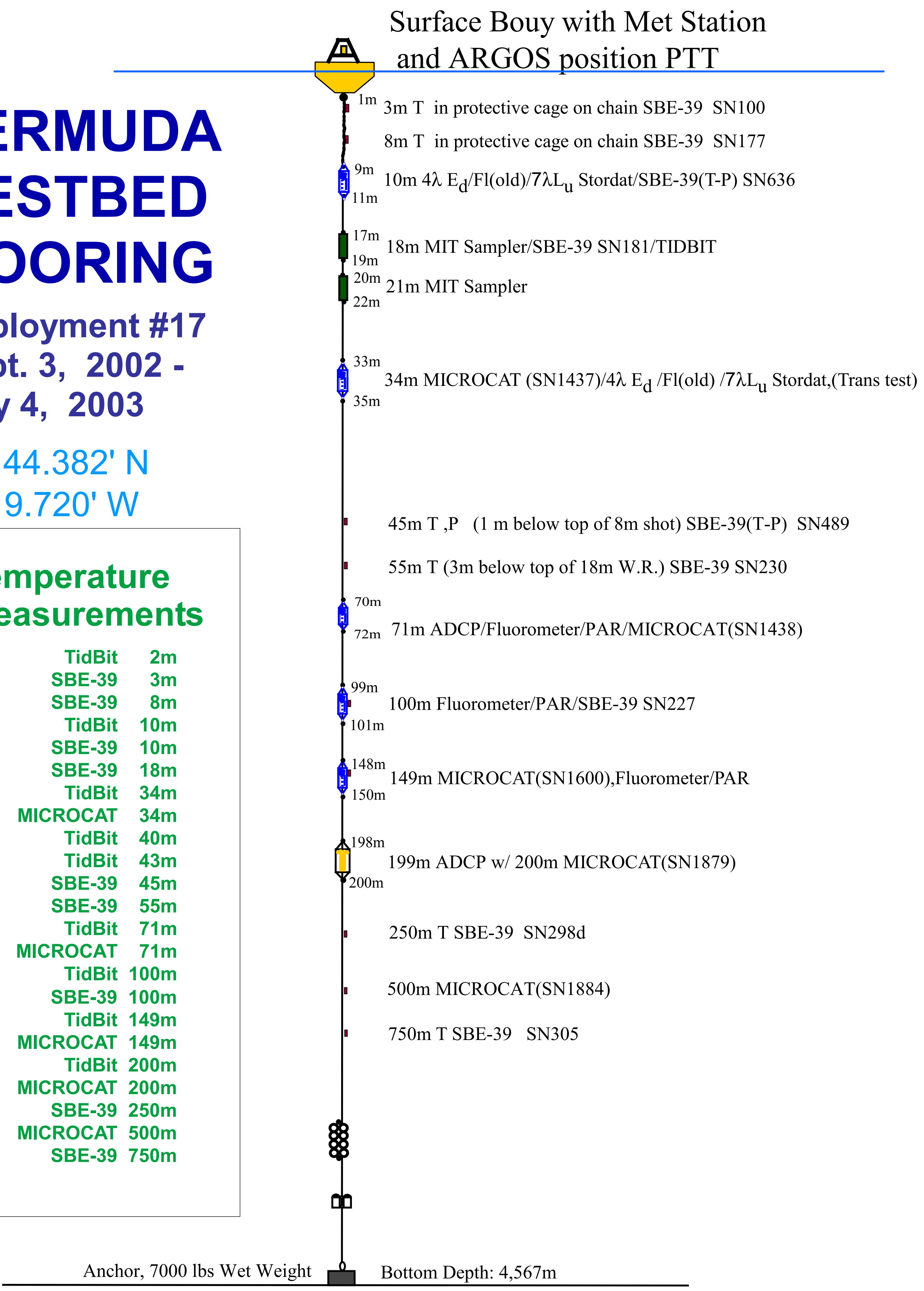


Figure 2

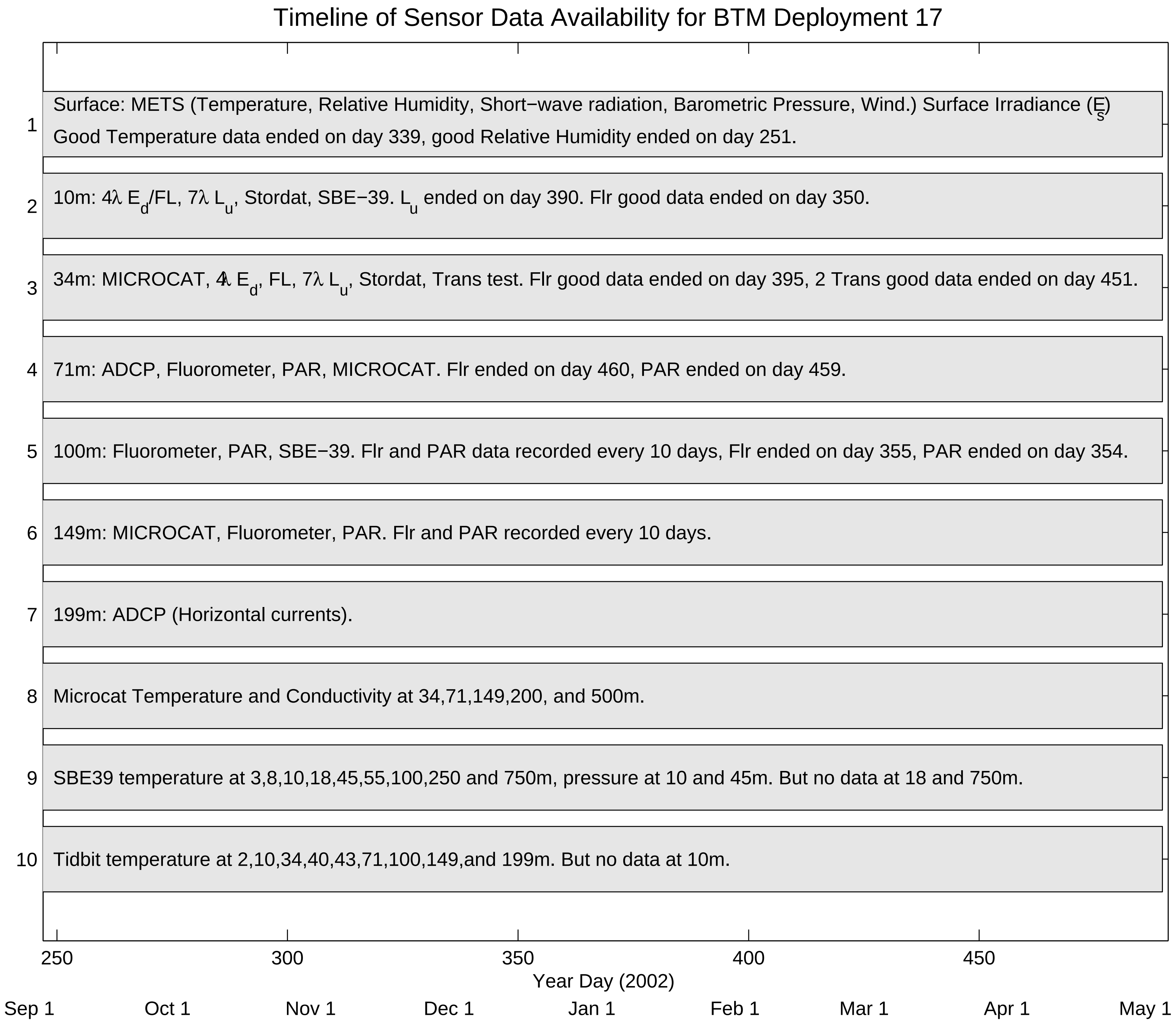

Timeline of Sensor Data Availability for BTM Deployment 17
1
Surface: METS (Temperature, Relative Humidity, Short−wave radiation, Barometric Pressure, Wind.) Surface Irradiance (E_s)
Good Temperature data ended on day 339, good Relative Humidity ended on day 251.
2
10m: 4λ E_d/FL, 7λ L_u, Stordat, SBE−39. L_u ended on day 390. Flr good data ended on day 350.
3
34m: MICROCAT, 4λ E_d, FL, 7λ L_u, Stordat, Trans test. Flr good data ended on day 395, 2 Trans good data ended on day 451.
4
71m: ADCP, Fluorometer, PAR, MICROCAT. Flr ended on day 460, PAR ended on day 459.
5
100m: Fluorometer, PAR, SBE−39. Flr and PAR data recorded every 10 days, Flr ended on day 355, PAR ended on day 354.
6
149m: MICROCAT, Fluorometer, PAR. Flr and PAR recorded every 10 days.
7
199m: ADCP (Horizontal currents).
8
Microcat Temperature and Conductivity at 34,71,149,200, and 500m.
9
SBE39 temperature at 3,8,10,18,45,55,100,250 and 750m, pressure at 10 and 45m. But no data at 18 and 750m.
10
Tidbit temperature at 2,10,34,40,43,71,100,149,and 199m. But no data at 10m.
250
300
350
400
450
Year Day (2002)
Sep 1
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1

Figure 3

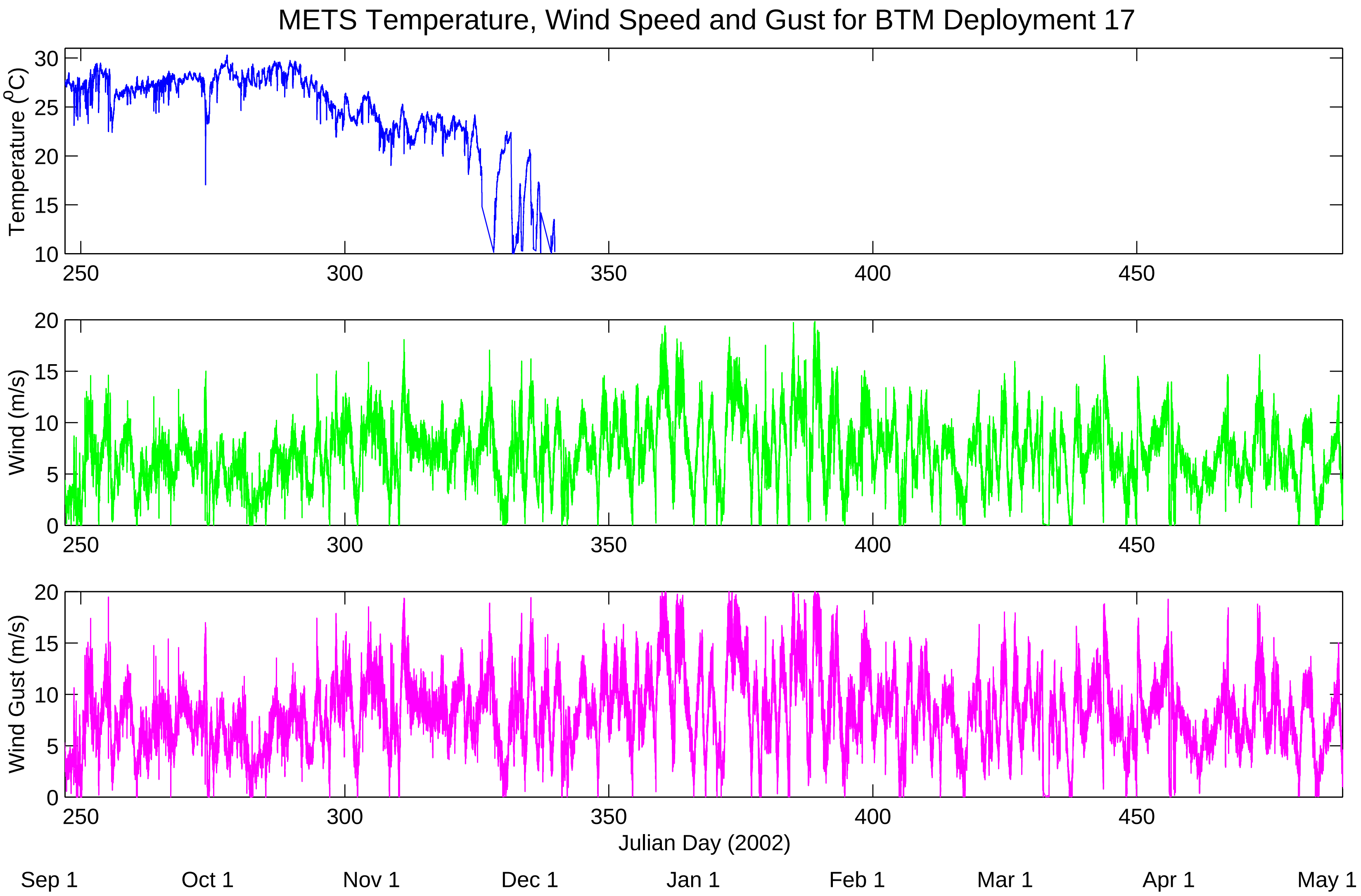

METS Temperature, Wind Speed and Gust for BTM Deployment 17
Temperature (°C)
30
25
20
15
10
250
300
350
400
450
Wind (m/s)
20
15
10
5
0
250
300
350
400
450
Wind Gust (m/s)
20
15
10
5
0
250
300
350
400
450
Julian Day (2002)
Sep 1
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1

Figure 4

BTM Deployment 17: Barometric Pressure, Relative Humidity, and Shortwave Radiation

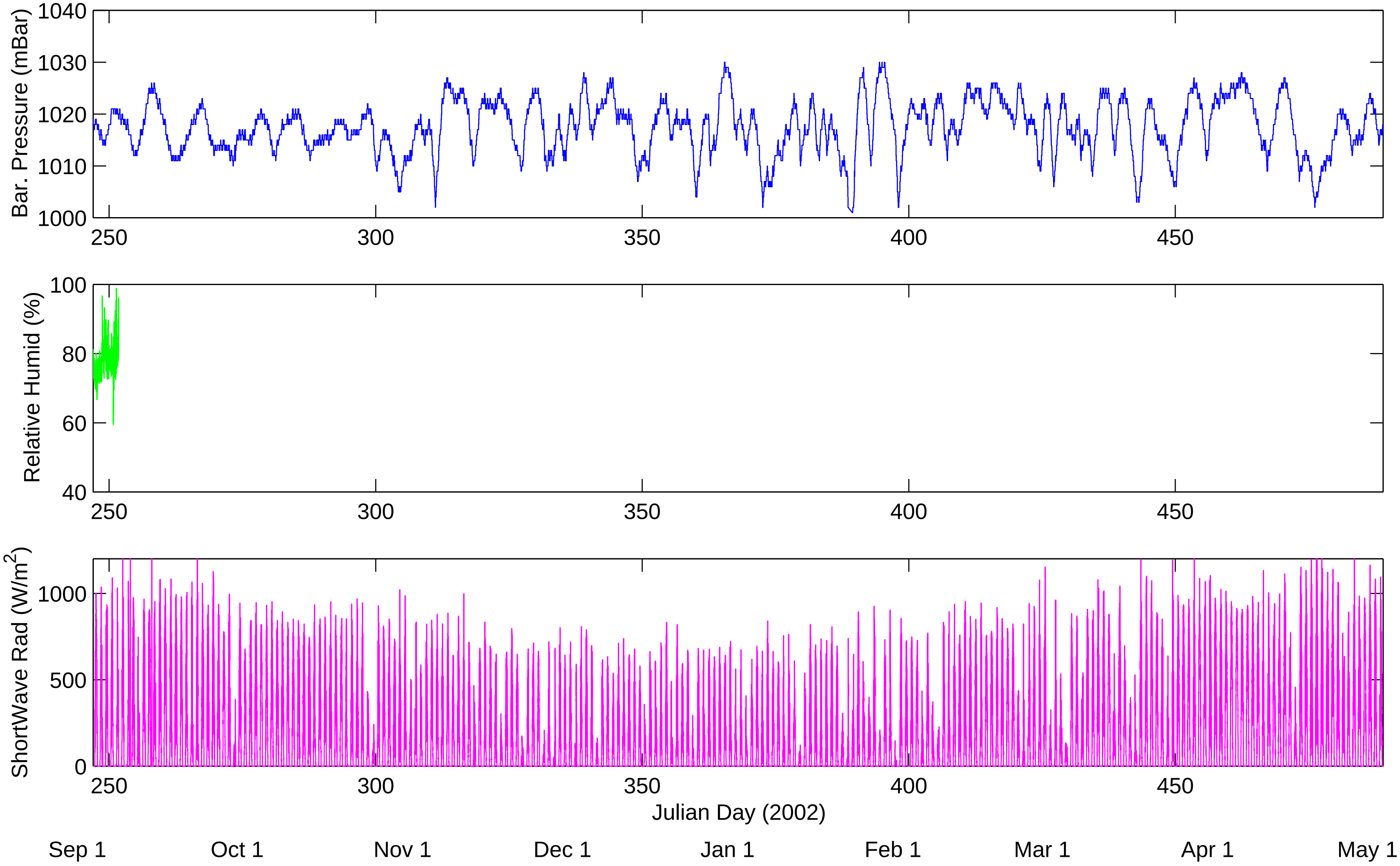


Figure 5

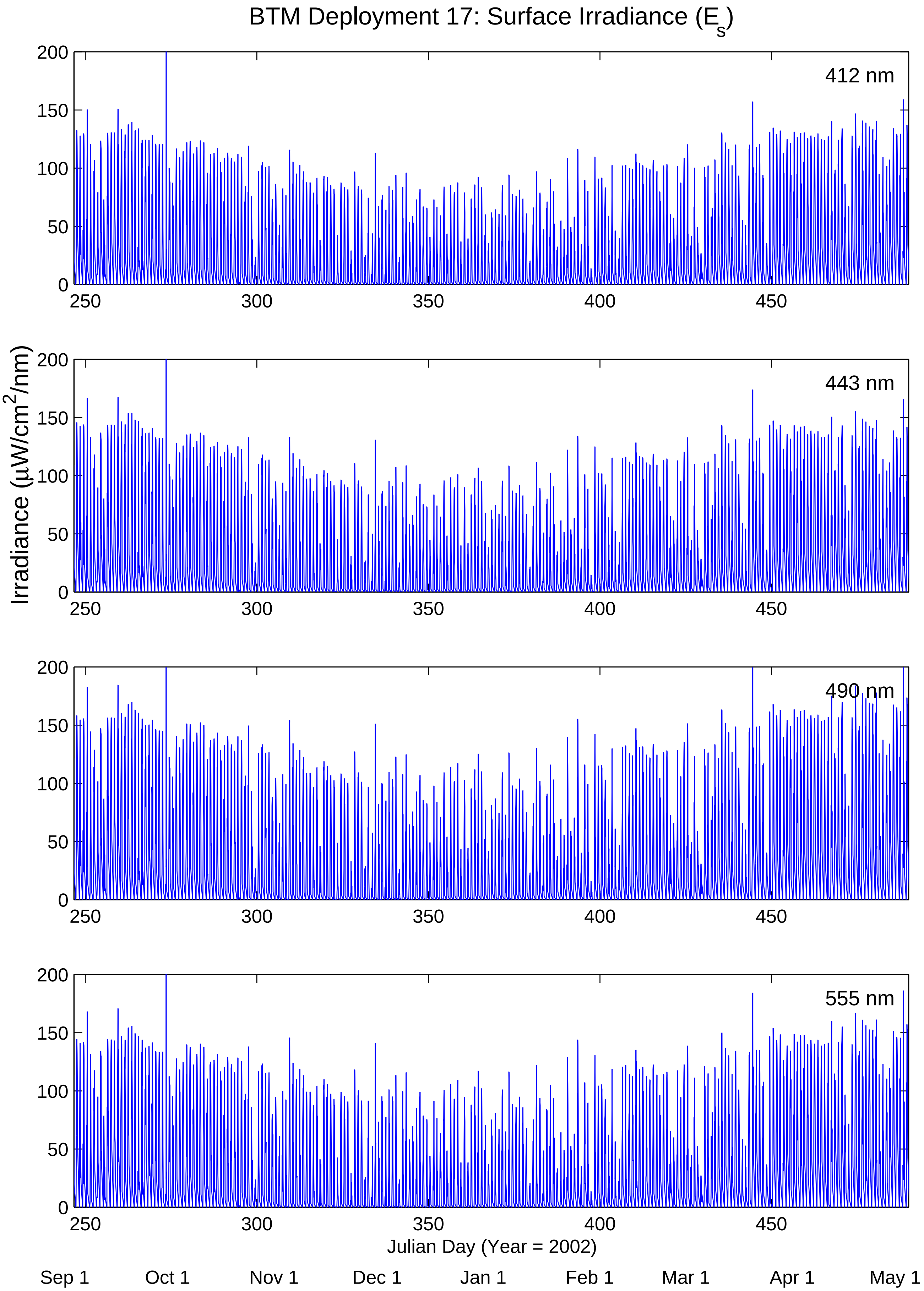

BTM Deployment 17: Surface Irradiance (E_s)
Irradiance (µW/cm^2/nm)
412 nm
443 nm
490 nm
555 nm
0
50
100
150
200
250
300
350
400
450
Julian Day (Year = 2002)
Sep 1
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1

Figure 6