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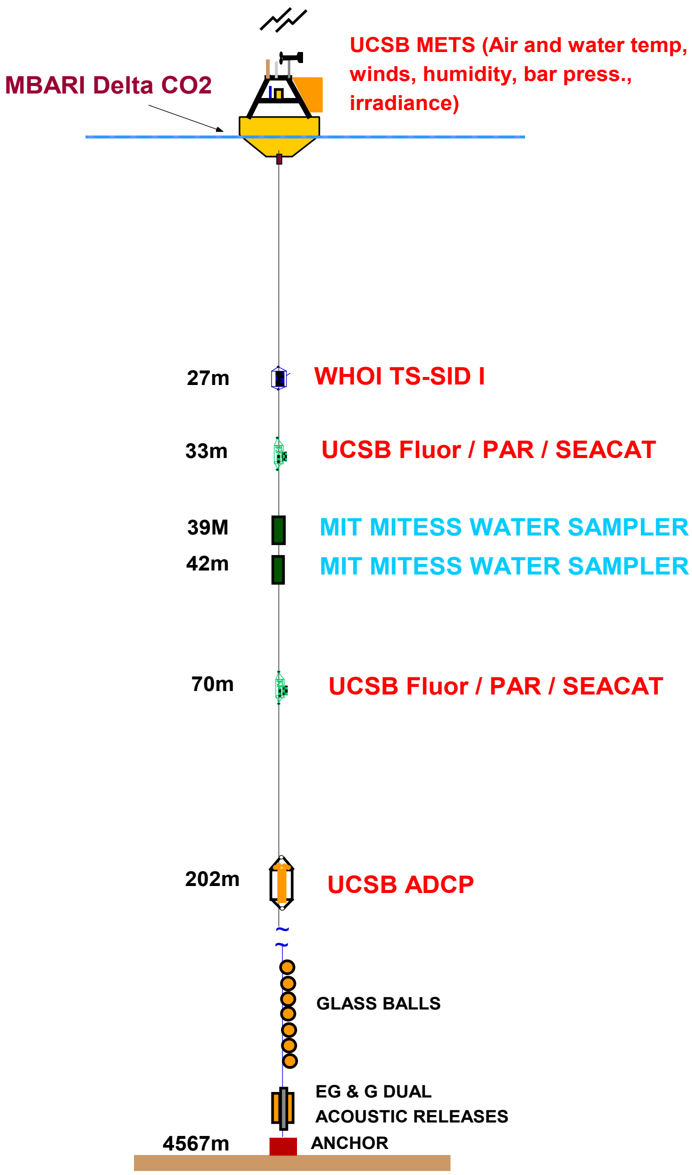
BERMUDA TESTBED MOORING DATA REPORT

Deployment #15 March 16 - November 4, 2001



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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°42'N, 64°11'W or about 80 km southeast of Bermuda. There have been 15 deployments during the period from June 1994 to November 2001. The duration of each deployment is about 3 to 7 months. Meteorological and surface spectral radiometric measurements were made from a buoy tower. Measurements at depth included: currents, temperature, conductivity, and optical properties, 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 #15 (March 16 – November 4, 2001). 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 #15 users is provided in Table 1.

New sensors, and 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, an RF antenna for short-range 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 #15. 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, SEACAT and Tidbit). Conductivity is measured with SEACAT. In addition, an uplooking Acoustic Doppler Current Profiler (ADCP; RDI 150 KHz) measures currents every 15 minutes at multiple vertical bin depths (3 m bins).

The BTM is also equipped with several types of optical sensors: Fluorometer (Sea Tech; Bartz et al., 1988) for measuring stimulated chlorophyll fluorescence and PAR sensor (Biospherical QSP-200; Booth, 1976).

A new 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).

A time-series sampler incubation devices (TS-SID; Taylor and Doherty, 1990) has been deployed to periodically and remotely measure the incorporation of ^{14}C and ^{3}H as measures of primary production and bacterial production.

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 6 Years

Over the past six 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 #15

Deployment 15 took place between March 16 - November 4, 2001. The duration of this deployment is about seven and half months. 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 early spring, to summer, and to fall. Surface air temperature rose by about 11°C from March 16 to around July 30, and then kept 27°C toward the end of meteorological measurements (Figure 4). On average, surface wind was stronger in early spring than summer. Seasonal trends in barometric pressure, surface relative humidity and shortwave radiation are not strong compared with synoptic changes (Figure 5). High-frequency variability is also apparent in the meteorological data. The air temperature varied with magnitudes of 11°C and surface wind speed changed between 0 and about 17m/s (Figure 4). Weather systems passed over the BTM site on time scales of about 4-5 days. Most days were cloudy, with a few days of very low light. Relative humidity fluctuated between 42% and 100%.

Ocean temperature in the surface layer shows a strong seasonal trend (Figure 6a). Temperature at 2m increased from ~18°C mid-March to ~28°C in mid-August, and then cooled to about 25°C toward mid-October. Below the surface layer, however, the seasonal trend was not very strong relative to the surface layer. Stratification was high in late fall, but convection and wind mixing caused cooling at the sea surface and the upper 250 m of water were well mixed before May (Figures 6a and b).

Figure 7 shows pressure data at 44 and 251 m respectively. The data are generally of good quality.

Time series of temperature and salinity from the SEACAT at 33 and 70 m are good quality (Figures 8a, b and 9a, b).

The two fluorometer/PAR sensors data logger's pressure case leaked causing loss of data. The ADCP failed to start due to an operational programming error.

Summary

This report provides a preliminary description of the data collected during Deployment #15 of the Bermuda Testbed Mooring (March 16 - November 4, 2001). The data show typical seasonal changes. Water temperatures in the upper ocean increased significantly from spring to summer, and then decreased from summer to late fall. Stratification was high in late fall, but convection and wind mixing caused cooling at the sea surface and the upper 250 m of water were well mixed before May.

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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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 # 15

Instrument	Measurement	P. I.	Institution
METS	Wind speed and direction, air temp, barometric pressure, humidity	Dickey	UCSB OPL
ADCP	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

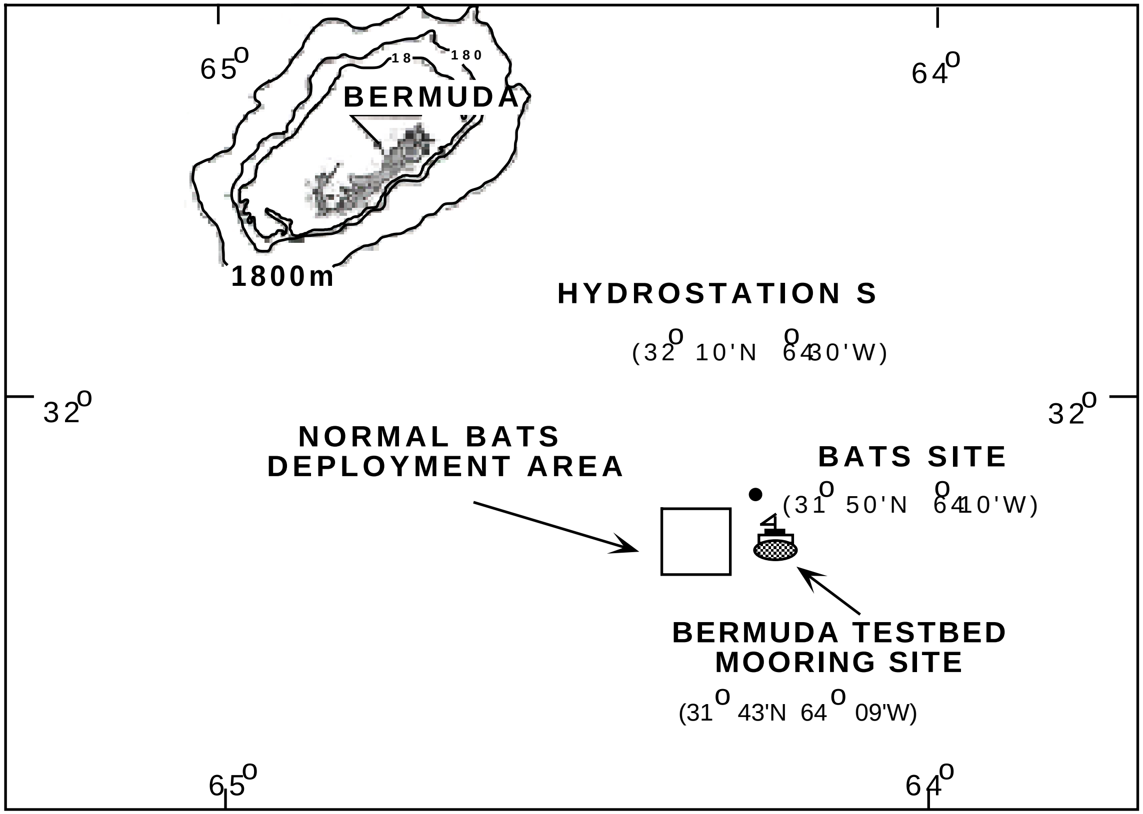
<u>Table 1 (continued)</u>

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/Zedler/ Dickey	WHOI/UCSB

	Table 2: Instrument Sampling Regimen Chart		
Instrument Package	**Instrument**	**Sampling Regimen**	**Type of Data stored**
SURFACE			
METS	Campbell Scientific Relative Humidity and Temperature Probe	averages over 5 minutes	average
	RM Young Wind Speed Sensor	averages over 5 minutes	average
	RM Young Wind Gust	max value during 5 minutes	raw
	Campbell Scientific Vaisala Barometric Pressure	averages over 5 minutes	average
	Li-COR Silicon Pyranometer (SW, 400-1100nm)	averages over 5 minutes	average
Compass	KVH Compass	1 sample per minute	raw
Telemetry	ARGOS Transmitter	90 sec and 200 sec	raw
SUBSURFACE			
SEACAT	Sea-Bird Electronics, Inc. Conductivity (Temperature) sensor	1 sample/3.75 minutes	raw
	Biospherical Instruments, Inc., PAR sensor	1 sample/3.75 minutes	raw
	Sea Tech Inc. Fluorometer	1 sample/3.75 minutes	raw
SBE39	Sea-Bird Electronics, Inc. Pressure sensor	1 sample/3.75 minutes	raw
	Sea-Bird Electronics, Inc. Temperature sensor	1 sample/3.75 minutes	raw
TidBit	Onset	10 minutes	raw
ADCP	Acoustic Doppler Current Profiler	sampling rate= 15 min, bin depth = 3m	average

Table 3. Sensor Functionality Summary			
Deployment 15 start date: March 16; end date: November 4, 2001 (JD 75-308 ref. 2001)			
Surface METS	**Serial Number**	**Last day of operation**	**Reason for failure or comments**
Temperature and Relative Humidity	2020003	248	battery low
Licor Pyranometer (400-1100nm)	31163	248	battery low
Barometric Pressure	4910019	248	battery low
Wind	WM23259	248	battery low
33m			
PAR	4332	No data	data logger's pressure case leaked
Fluorometer	27	No data	data logger's pressure case leaked
Conductivity (SEACAT)	2083	261	battery low
70m			
PAR	4398	No data	data logger's pressure case leaked
Fluorometer	28	No data	data logger's pressure case leaked
Conductivity (SEACAT)	2084	FULL DEPLOYMENT	N/A
Current Sensors			
202m ADCP	2513	No data	failed to start due to an operational programming
			error
Temperature Sensors			
2m Tidbit	317714	294	battery low
3m SBE39	100	FULL DEPLOYMENT	N/A
8m SBE39	177	233	battery low
13m Tidbit	317715	294	battery low
33m Tidbit	317718	294	battery low
33m SEACAT	2083	261	battery low
39m Tidbit	317720	294	battery low
42m Tidbit	317721	294	battery low
44m SBE39	250	246	battery low
54m SBE39	178	FULL DEPLOYMENT	N/A
70m Tidbit	317719	294	battery low
70m SEACAT	2084	FULL DEPLOYMENT	N/A
99m SBE39	181	FULL DEPLOYMENT	N/A
150m SBE39	230	FULL DEPLOYMENT	N/A
203m SBE39	227	FULL DEPLOYMENT	N/A
251m SBE39	251	FULL DEPLOYMENT	N/A
501m SBE39	298	FULL DEPLOYMENT	N/A
751m SBE39	305	FULL DEPLOYMENT	N/A

Figure 1: Bermuda Testbed Mooring Site Map



BERMUDA TESTBED MOORING

Deployment #15
March 16, 2000 - Nov. 4, 2001

31° 41.768' N
64° 10.523' W

Temperature Measurments

TidBit	2m
SBE-39	3m
SBE-39	8m
TidBit	13m
TidBit & SEACAT	33m
TidBit	39m
TidBit	42m
SBE-39	44m
SBE-39	54m
TidBit & SEACAT	70m
SBE-39	99m
SBE-39	150m
SBE-39	203m
SBE-39	251m
SBE-39	501m
SBE-39	751m

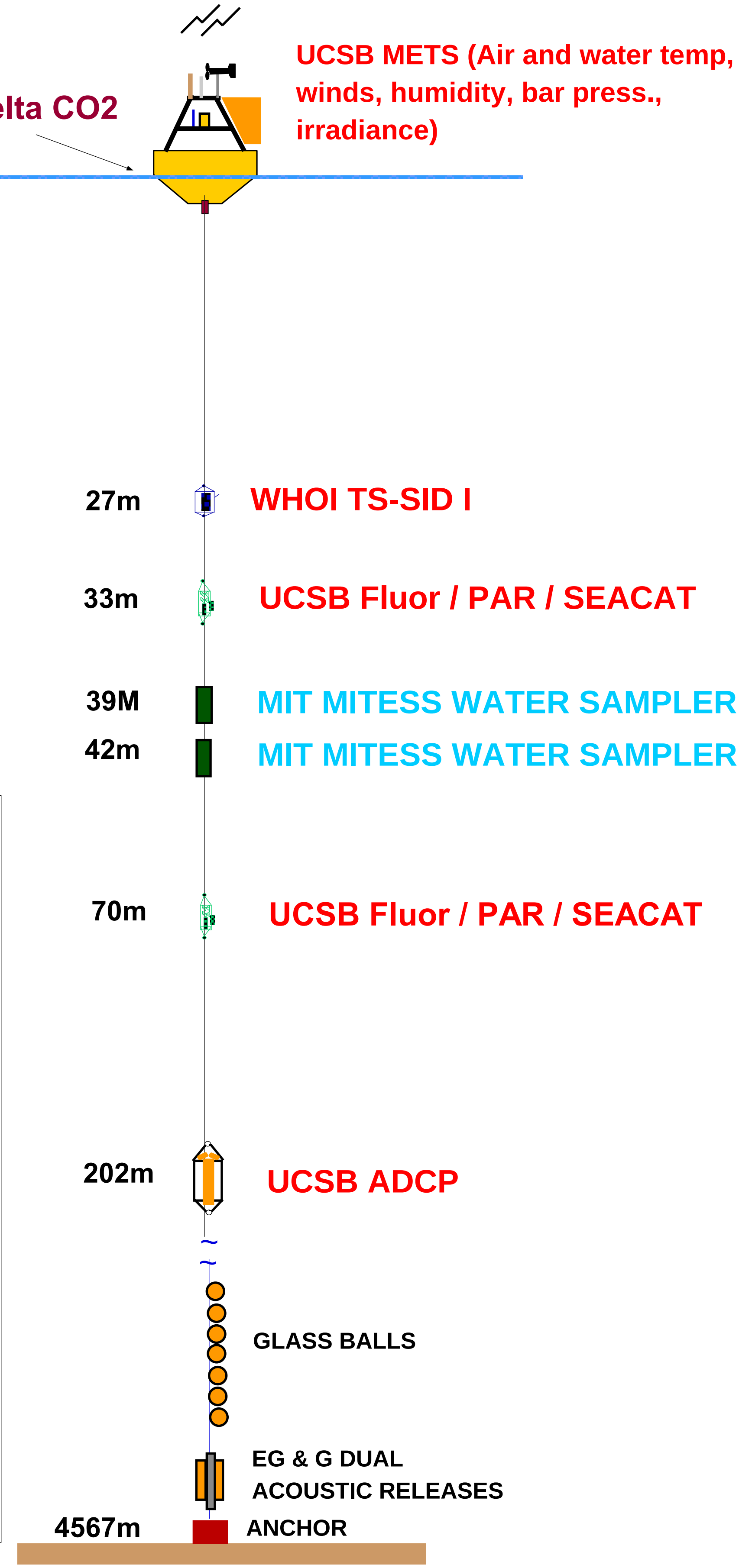
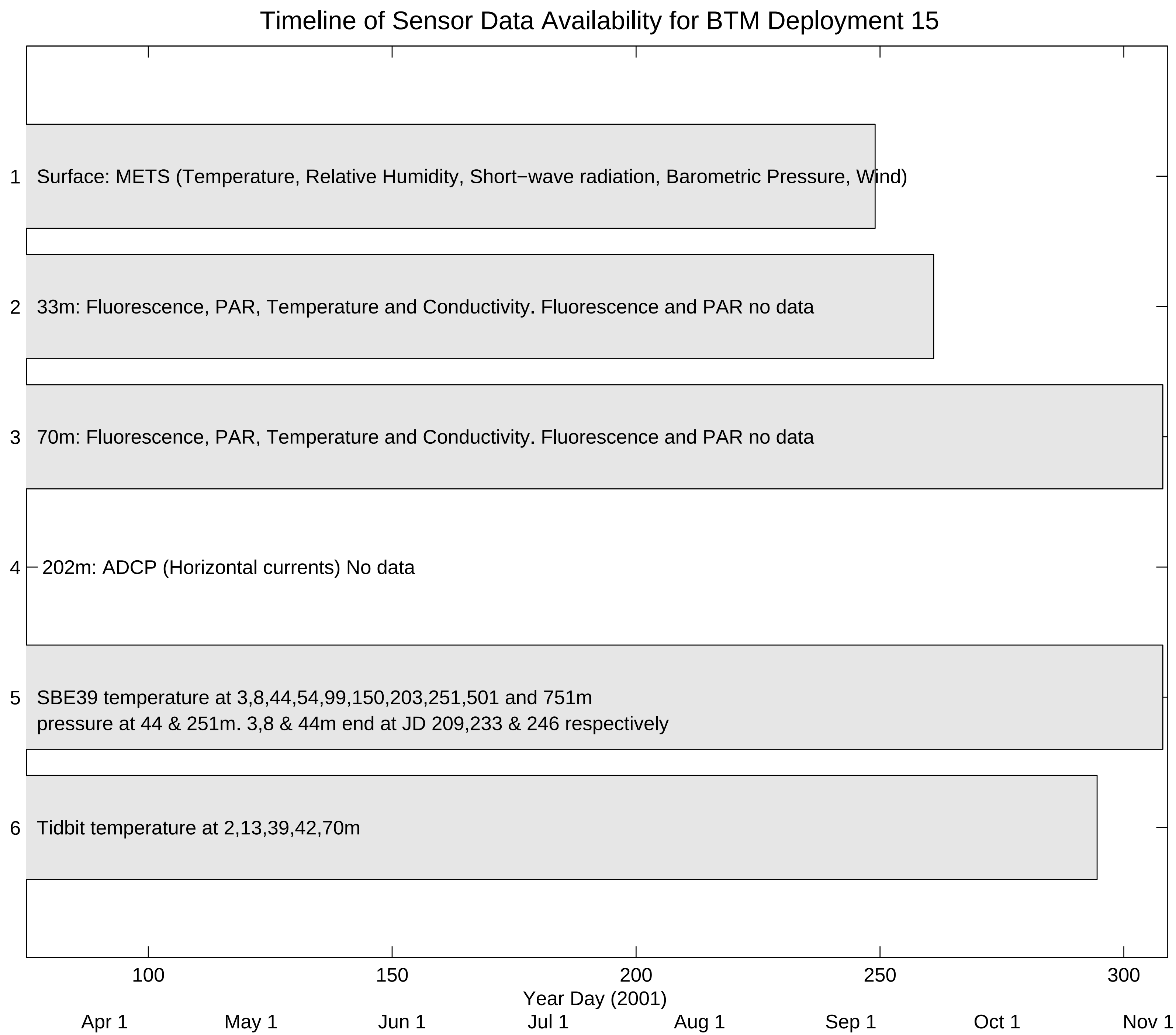
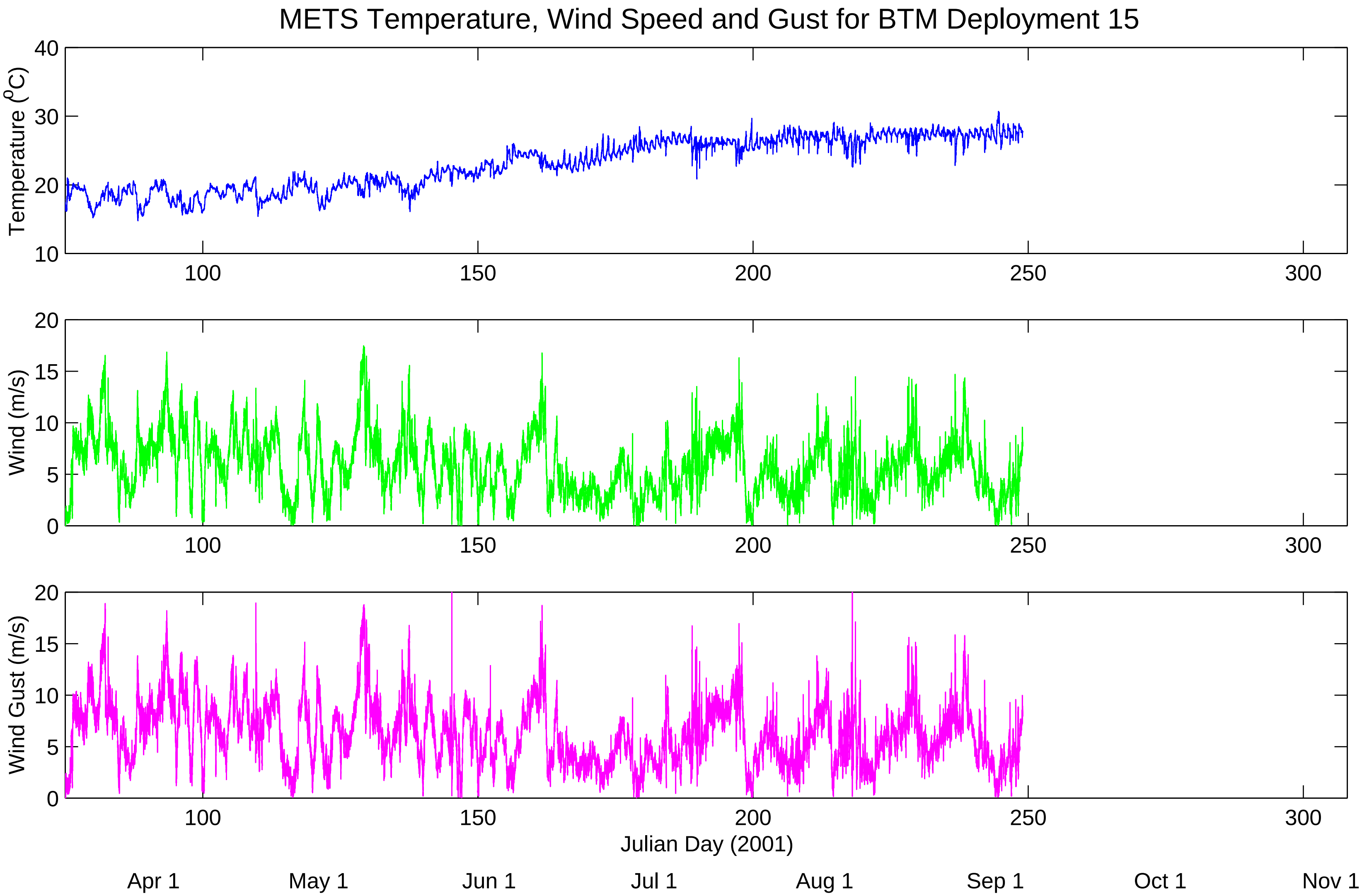


Figure 2



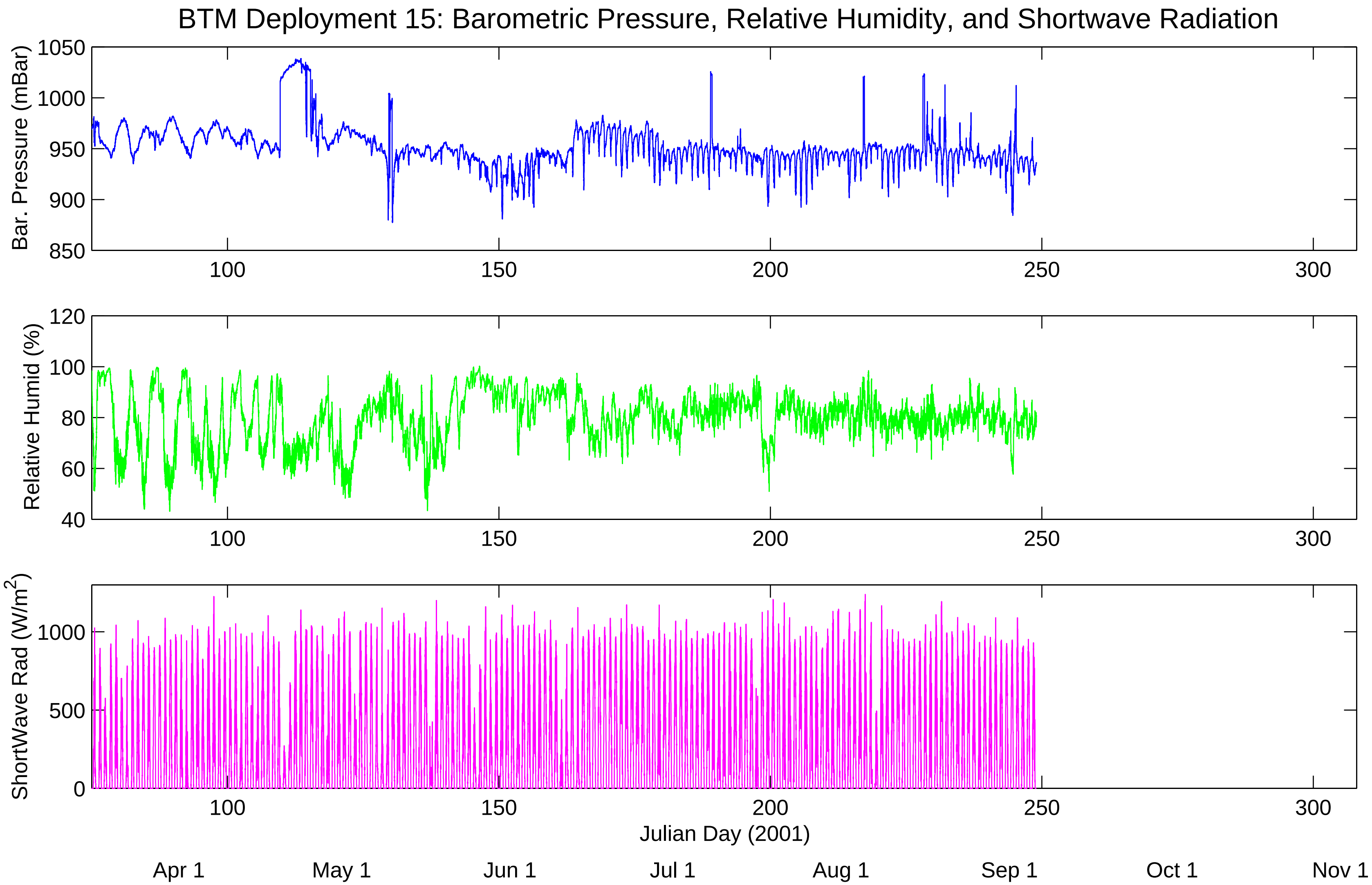
Timeline of Sensor Data Availability for BTM Deployment 15
1 Surface: METS (Temperature, Relative Humidity, Short−wave radiation, Barometric Pressure, Wind)
2 33m: Fluorescence, PAR, Temperature and Conductivity. Fluorescence and PAR no data
3 70m: Fluorescence, PAR, Temperature and Conductivity. Fluorescence and PAR no data
4 202m: ADCP (Horizontal currents) No data
5 SBE39 temperature at 3,8,44,54,99,150,203,251,501 and 751m
pressure at 44 & 251m. 3,8 & 44m end at JD 209,233 & 246 respectively
6 Tidbit temperature at 2,13,39,42,70m
100
150
200
250
300
Year Day (2001)
Apr 1
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
Nov 1

Figure 3



METS Temperature, Wind Speed and Gust for BTM Deployment 15
Temperature (°C)
40
30
20
10
100
150
200
250
300
Wind (m/s)
20
15
10
5
0
Wind Gust (m/s)
Julian Day (2001)
Apr 1
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
Nov 1

Figure 4



BTM Deployment 15: Barometric Pressure, Relative Humidity, and Shortwave Radiation
Bar. Pressure (mBar)
1050
1000
950
900
850
100
150
200
250
300
Relative Humid (%)
120
100
80
60
40
100
150
200
250
300
ShortWave Rad (W/m2)
1000
500
0
100
150
200
250
300
Julian Day (2001)
Apr 1
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
Nov 1

Figure 5