National Data Buoy Center

The National Data Buoy Center

Introduction, Overview, and the OceanSITES Global Data Assembly Center

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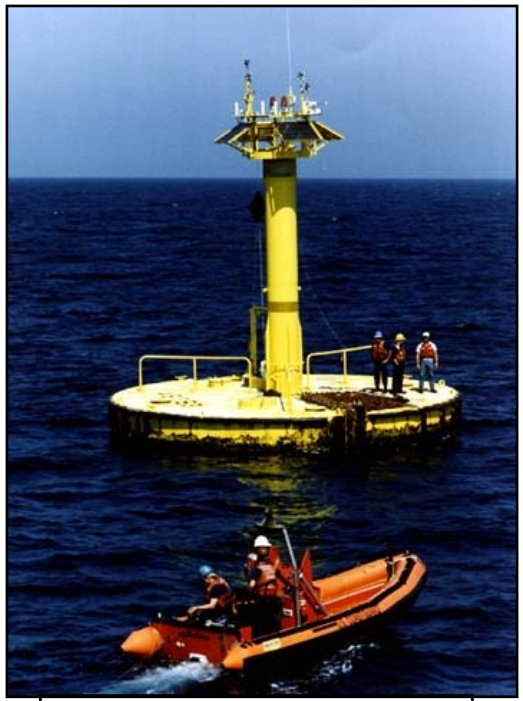
National Data Buoy Center
Data Management and Communications
Branch Chief

10 April 2008 – OceanSITES Meeting – Vienna, Austria

National Data Buoy Center

There has been a need for a DAC from the very beginning of NDBC:



NDBC's platforms (buoys and coastal stations) are placed in harsh and hard to reach environments.

Failing anemometers, inaccurate barometer readings, low power levels, and irregular wave spectrums all contribute to poor marine weather/ocean observations, and the need for trained eyes to stop the data before they are released to the public.

Once a buoy is placed on station, NDBC personnel usually have to wait a few years before visiting the station. Therefore, all platforms and instruments must be in excellent condition before deployment – and the data carefully monitored during station operations.

1960s - 2005

National Data Buoy Center

- Established in 1967 as the National Data Buoy Development Programs as part of the US Coast Guard.
- After NOAA formed in 1970 became the National Data Buoy Office under the National Ocean Service.
- In 1982, renamed the National Data Buoy Center and placed under the National Weather Service.
- The first buoys deployed by NDBC were large 12-m discus hulls, constructed of steel, and deployed in the deep waters off the U.S. East Coast and in the Gulf of Mexico.
- By 1979, NDBC maintained 26 stations – 16 in the Pacific, seven in the Atlantic and three in the Gulf of Mexico. NDBC deployed eight more stations in the Great Lakes during the 1980s.

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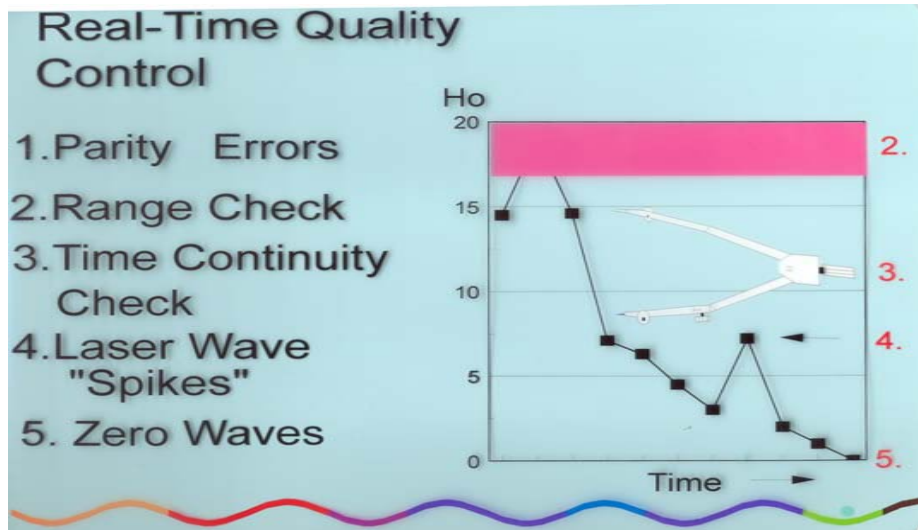
NDBC's Quality Control

- Started with NDBC in 1970s
  - Focus on "Top Five"
  - Wind Direction, Wind Speed, Atmospheric Surface Pressure, Wave Height and Dominant Period
- Algorithms perform check at NWS Gateway
- Quality Assurance Group at NDBC provided daily check of marine observations – usually 8 hours to two days after dissemination
- Approx. 110 platforms



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NDBC Today

- One Hundred and six (106) meteorological buoys moored off East, West, Gulf, Alaska, and Hawaiian coasts and Great Lakes.
- Fifty-five (55) oceanographic buoys located in the tropical Pacific [TAO].
- Fifty-six (56) meteorological stations located on East, West, Gulf and Alaskan coasts, Lake St. Clair and St. Lawrence Seaway.
- Thirty-nine (39) Deep-ocean Assessment and Reporting of Tsunami (DART) stations in Pacific and Atlantic Oceans, Caribbean Sea, and Gulf of Mexico.
- Four hundred plus (400+) vessels routinely reporting meteorological observations worldwide.
- Collect, QC and distribute data from ~400 partner stations.

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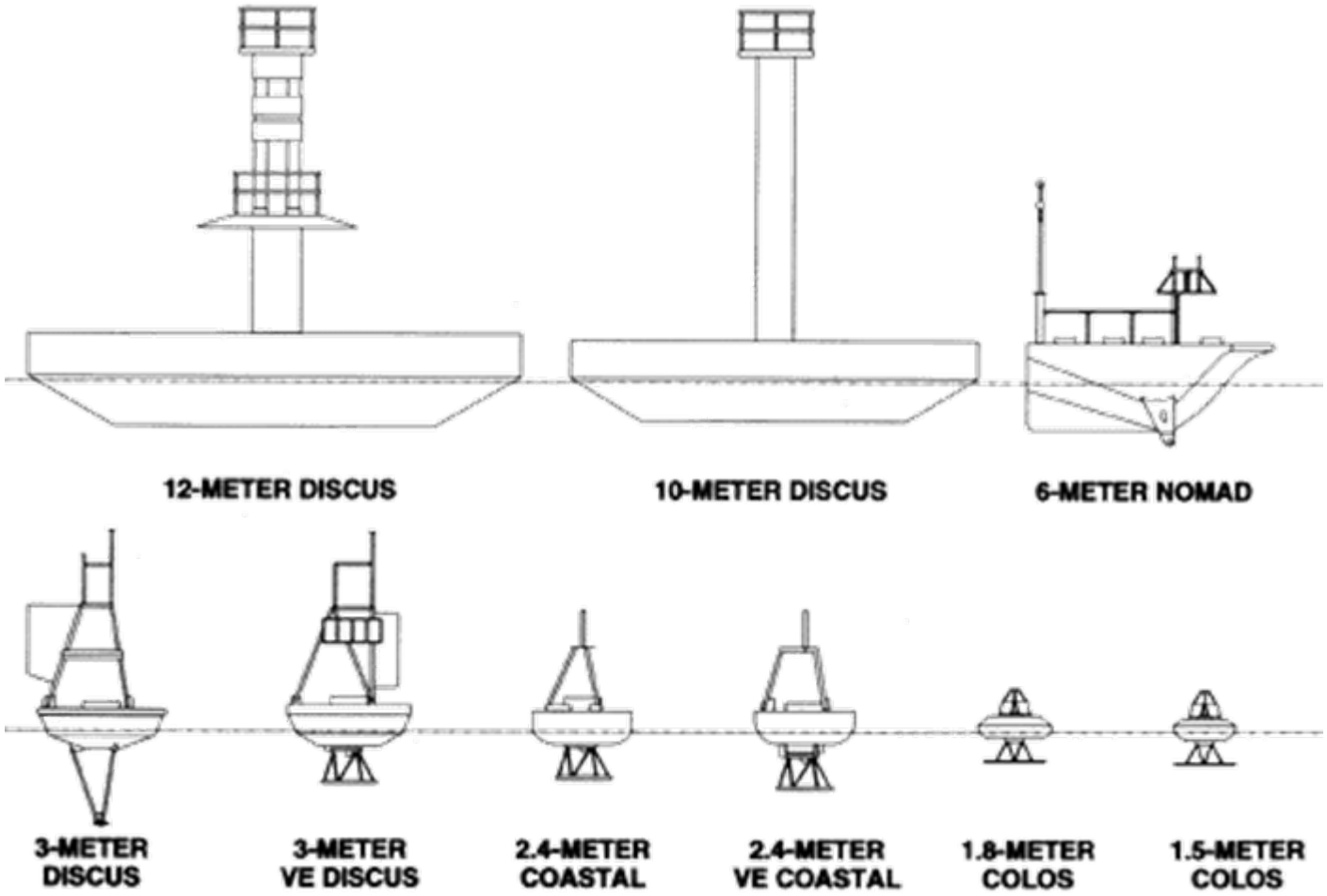
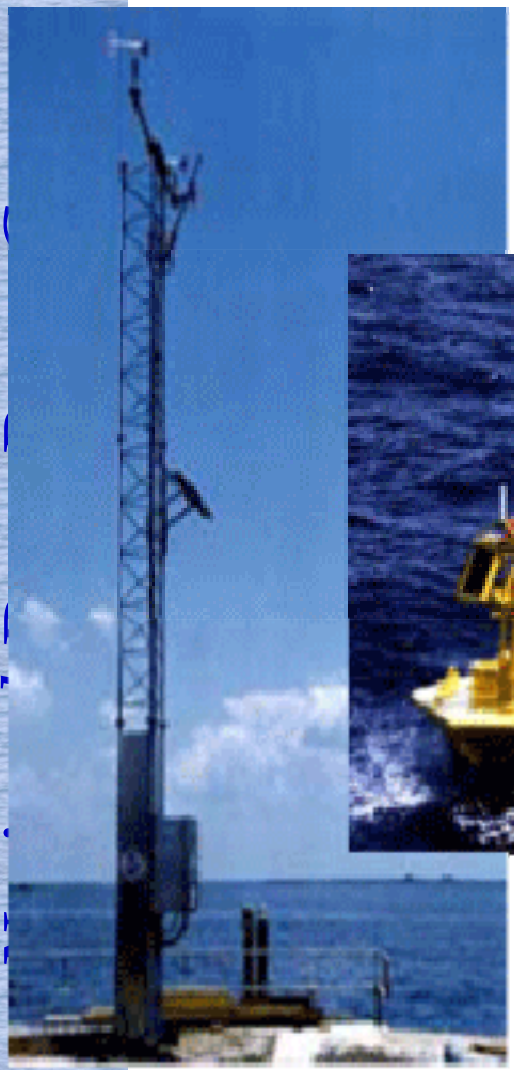
Observing System Platform Types



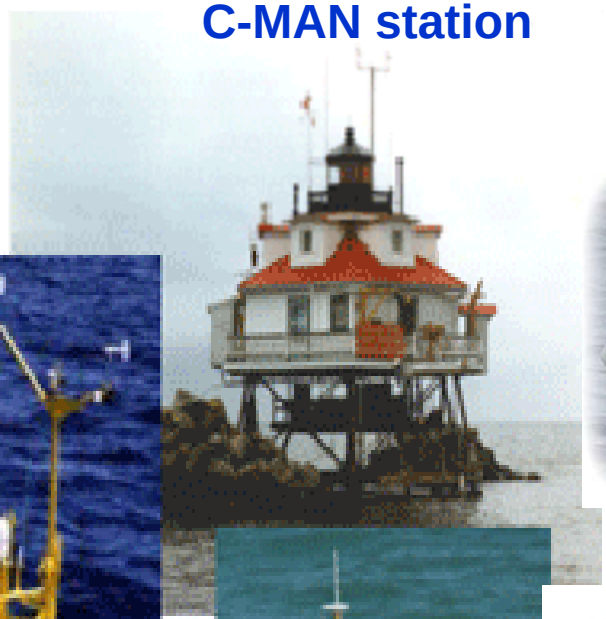
Observing System Platform Types



C-MAN station

6-meter NOMAD

C-MAN station



3-meter discus

DART II

TAO

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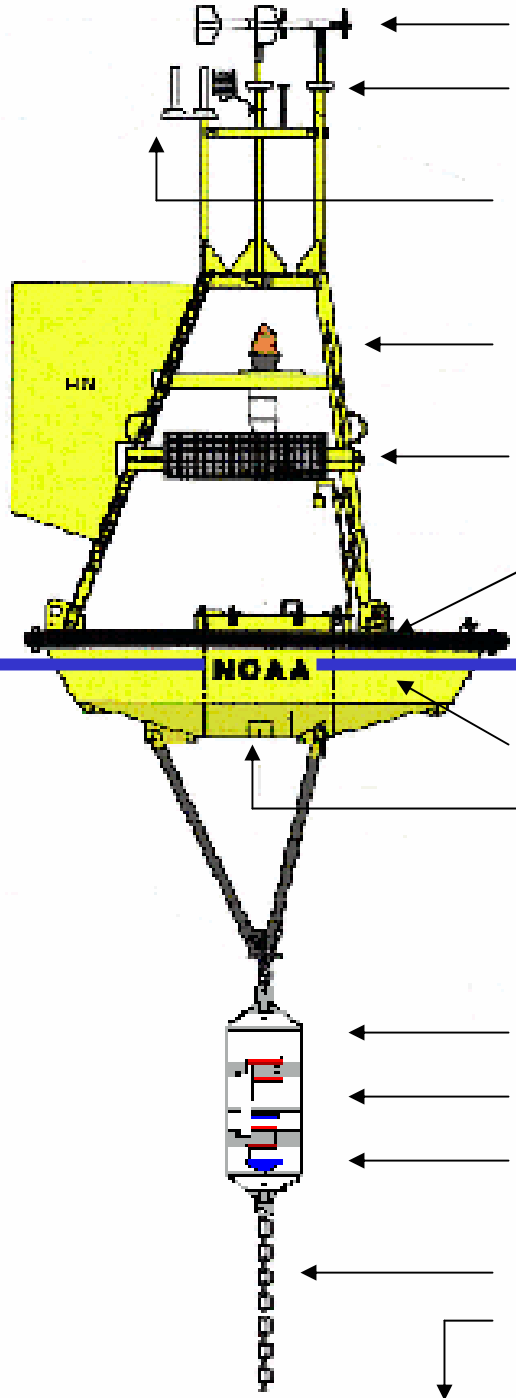

Air

Water

Wind speed / direction

Air temp / humidity / pressure

Tracking / communications

Navigational beacon

Solar panels

Magnetometer, compass, computer, batteries, position tracking

Wave height, period, direction*

Ocean temperature

Surface currents

Surface salinity

Current profiler

Mooring

Bottom tsunami pressure sensors*

* Not on all buoys

NDBC Data Assembly Center

National Data Buoy Center

- 24/7/365 support of
  - Data Quality Control
  - Communications
  - Operations
- Daily Operations Brief
- More than 600 stations currently supported
  - NDBC Buoys
  - NDBC C-MAN Stations
  - NOS Stations
  - DART
  - TAO
  - VOS
  - Partner Stations
    - OOSs
    - MMS ADCP

Data Assembly Center Capabilities

National Data Buoy Center

- Reevaluates the data collected and ensures that monthly archive data sets contain only accurate data.
- Analyzes data acquired during integration, test and deployment activities to ensure proper operation of all systems.
- Forecasts weather and sea-state prior to and during these field missions. These five day forecasts assign a “Go,” “No Go,” or “Marginal” status for each deployment or service operation to be used for guidance only.
- Support integration and testing of buoy payloads. Once a payload has been refurbished, the buoy is thoroughly tested before deployment.
- Maintain a centralized library of current parameter load files using interactive configuration management applications for all operations.
- For newer payloads, DAC personnel work with software engineering and Combined Operations, Maintenance, Engineering, Technicians personnel on the development and testing of their parameter load files.
- Monitor battery voltages and input (charging) currents for each operational NDBC station as well as those in integration or staged for development.
- Finally, on a monthly basis, the DAC group sends data to the National Environmental Satellite, Data, and Information Service (NESDIS) for archival at the National Climatic Data Center (NCDC) or the National Oceanographic Data Center (NODC) based on data type.

Growth of Platforms

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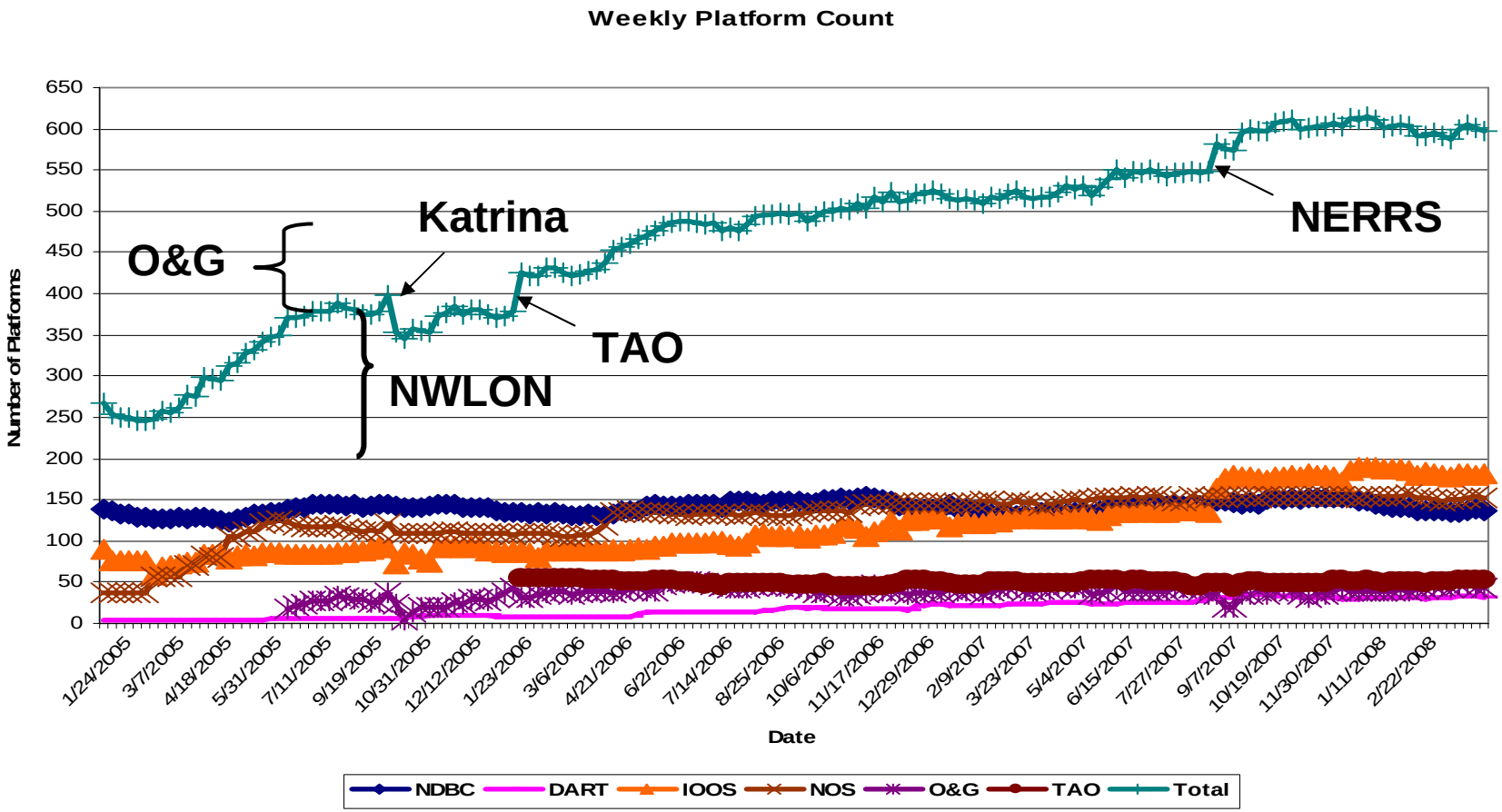

Platform Availability Variance

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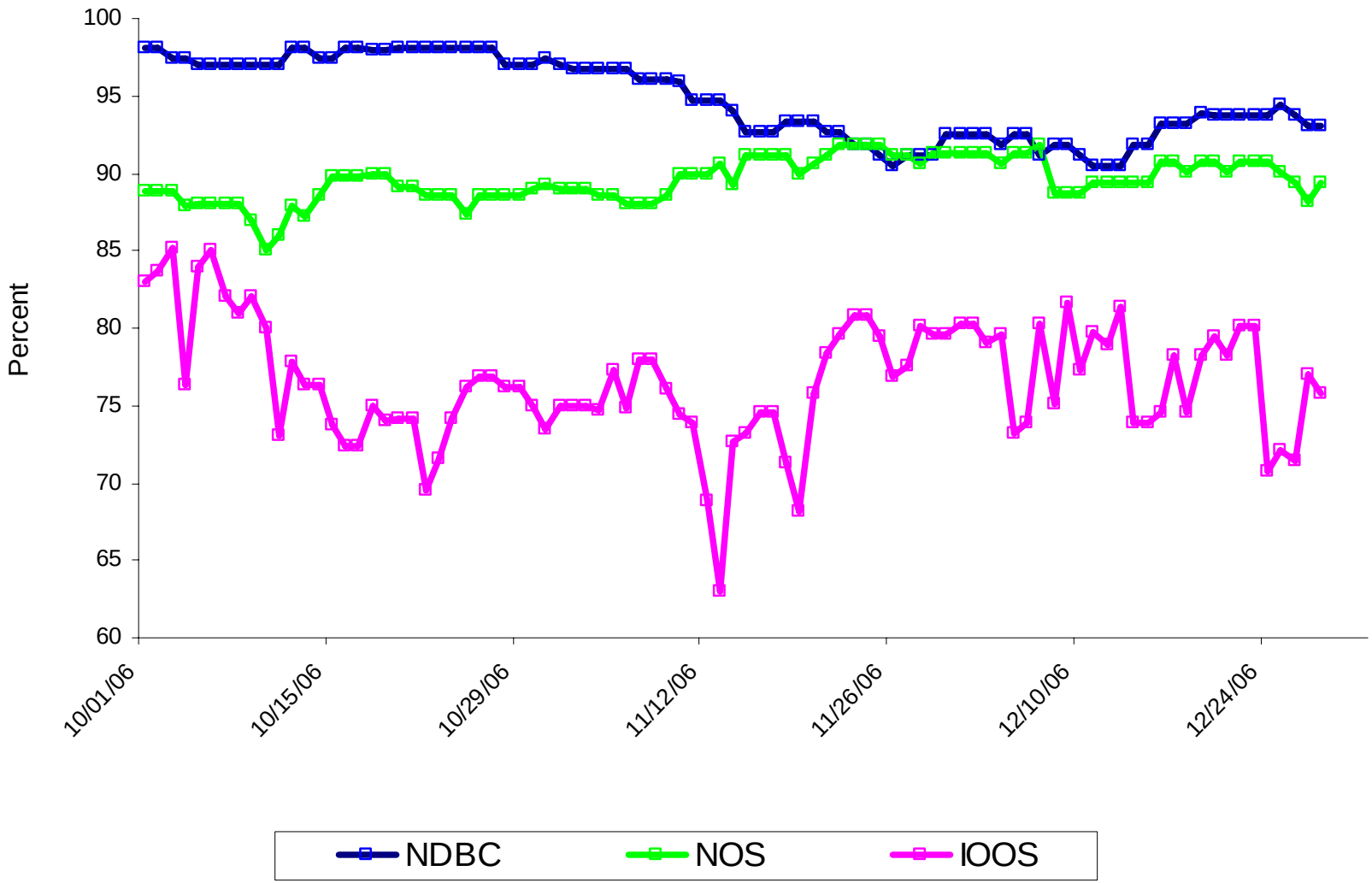

IOOS Partners

National Data Buoy Center

- Carolina - COOPS
- Chesapeake Bay Interpretive
- Chesapeake Biological Lab
- CICORE
- U.S. Army Corps of Engineers
- COMPS
- CORIE
- CORMPS
- Delaware Coastal Programs
- Dauphin Island Sea Lab
- WFO Green Bay
- Great Lakes ERL
- NWS Great Lakes Central Region
- NWS Great Lakes Eastern Region
- Gulf of Maine - GOMOOS
- LSU WAVCIS
- LUMCON
- MBARI
- MMS Gulf of Mexico
- MYSOUND
- North Carolina - NCCOOS
- NERRS Water Quality
- National Estuarine Research
- National Ocean Service
- NWS Alaska
- NWS Columbia, SC
- NWS Detroit
- OR-COOS
- SCCOOS
- Scripps
- Skidaway
- Stevens Institute
- TCOON
- Univ. of Californina at Davis
- Univ. of Michigan
- Univ. of So. Carolina Nearshore
- Univ. of So. Mississippi
- Woods Hole Oceanographic Instit

Data Assembly Center Partner Support

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NDBC - NDBC Partner Status - Central Stations - Mozilla Firefox

http://www.ndbc.noaa.gov/pstat_central.shtml

Eastern Western Report Legend

Wednesday, 2/28/2007

Central			Daily Evaluation		Ob Freq	Status by Sensor Groups													New item	Data Reporting and Data Quality Comments			
									Winds			Waves								Summary of Current Issues/Actions		Effective Date	Verified on their Web Site	
Exp	Station	Pgm	WED	NWS Met Status		BA	AT	DP	WD	WS	GT	WV	PD	WT	TD	VS	CR	OC		Issue/Action	Reason for Change			Init
Y	SHPF1	COM	--	Release				m	D	D	D	-	-	-		-	-	-		No Data Reports Wind data failed		01/12/07 01/07/07	na	TJB RB2
Y	HSSF1	COM		Release				m	D	D	D	-	-			-	-	-		Wind data failed	Suspect lightning strike	02/02/07	Y	RB1
Y	ARPF1	COM		Release		D		m	D	D	D	-	-			-	-	-		Baro failed Wind data failed	baro too low numerous drops to zero	2/27/07 2/22/2007		IS TJB
Y	PTRF1	COM		Release				m				-	-			-	-	-						
Y	ANCF1	COM		Release				m				-	-	-		-	-	m						
Y	FHPF1	COM		Release				m				-	-	-		-	-	-						
Y	TARF1	COM		Release		D		m				-	-	-		-	-	-		Baro failed	Baro too low	02/27/07		IS
Y	EGKF1	COM		Release		-	-	-				-	-	-		-	-	-						
Y	ANMF1	COM		Release				m				-	-	-		-	-	-						
N	SEAF1	COM																						
Y	BGCF1	COM		Re																				
Y	NFBF1	COM																						
Y	42014	COM		Re																				
Y	42023	COM		Re																				
Y	42013	COM	--																					
Y	42022	COM		Re																				
Y	42021	COM		Re																				
Y	42024	COM																						
Y	VCAF1	NOS		Re																				
Y	KYWF1	NOS		Re																				
Y	NPSF1	NOS		Re																				
Y	FMRF1	NOS																						
Y	PMAF1	NOS		Re																				
Y	OPTF1	NOS		Re																				
Y	SAPF1	NOS		Re																				
N	ERTF1	NOS		Re																				
Y	MCYF1	NOS		Re																				
Y	CWBF1	NOS	i	Re																				
N	CKYF1	NOS																						
Y	APCF1	NOS		Re																				
Y	PCBF1	NOS		Re																				
Y	PCLF1	NOS		Re																				
Y	WAVM6	NOS																						
Y	LABL1	NOS		Re																				

NDBC - NDBC Partner Status - Central Stations - Mozilla Firefox

http://www.ndbc.noaa.gov/pstat_central.shtml

Y	SPAL1	LUM	--						D	D	D	-	-	D	D	-	-	-		Not Activated - BURL1 WTMP/WINDS failed Tide data failed No data reports	-- WSPD>GUSTS; WSPDs 2m/s low WTMP = -22 --	-- 11/21/06 11/12/06 12/08/06		-- RB2 IS RB1
Y	LKPL1	LUM		Release																				
Y	TRBL1	LUM		NR																				
Y	LUML1	LUM		Release																				
Y	TAML1	LUM		Release										D	D	-	-	-		WTMP data failed TIDE data failed	WTMP = -data Tide = -9.8	11/12/06 11/12/06	N	IS IS
Y	SIPM6	LSU		NR	2hr																			
Y	SPLL1	LSU		Release				D				**	D							WTMP data failed DEWPT data failed	erratic DEWPT = ATMP	01/24/07 11/26/05	Y	RB2 RB1
Y	ILDL1	LSU	i	Release	2hr			m				**		D						Data intermittent TIDE data failed		02/26/07 4/5/2006	IS Y	IS RB1
Y	SLPL1	LSU		NR	2hr									D										
Y	MRSL1	LSU	i	Release				D				**								Data intermittent DEWPT failed	DEWPT = ATMP	02/22/07 11/09/04	Y	TJB RB1
Y	42067	USM		NR																				
Y	FGBL1	FOR		NR										m						No data reports		10/21/06	Y	TJB
Y	PCNT2	TCO		NR																TCOON not providing data to NDBC				
Y	RTOT2	TCO		NR																				
Y	BABT2	TCO		NR																				
Y	RSJT2	TCO		NR																				
Y	42047	TAB	X	NR	30m	D	D	D	D	D	D	-	-	D						All data bad				
Y	42046	TAB	X	NR	30m	D	D	D	D	D	D	-	-	D						All data bad				
Y	42045	TAB	--	Release	30m	D			D	D	D	-	-	D						No data reports BARO failed WINDS failed Intermittent data WTMP failed	 Erratically reports 0 WSPDS stuck on 0 WTMP too low	02/07/07 02/06/07 02/04/07 04/04/07 4/7/05	 Y Y N Y	TJB RB2 RB2 RB2 RB1
Y	42044	TAB	i	Release																Ocean current data only	Ocean data missing aft 05z	02/24/07		TJB
Y	42043	TAB	i	Release	30m		D	D				-	-	D						Intermittent data reports DEWPT/ATMP failed WTMP failed	 Both reading less than -35C WTMP too low	02/26/07 02/22/07 03/05/03	 Y	IS TJB RB1
Y	42048	TAB	i	Release																Ocean current data only **Use Webcheck to verify**				
Y	42049	TAB	i	Release																Ocean current data only	Ocean data missing aft 03z	02/24/07		TJB
Y	42050	TAB	--	Release																no data reports Ocean current data only		02/18/07		RB2
N	42051	TAB																		Planned Station				
Y	CAPL1	NOS		Release	6m							-	-	m										
Y	SBPT2	NOS		Release																				
Y	GNJT2	NOS	i	Release	6m							-	-							Intermittent data		02/26/07	Y	IS
Y	GPST2	NOS		Release	6m							-	-											
Y	GTOT2	NOS		Release	6m							-	-											
Y	EPTT2	NOS	I	Release	6m							-	-						*	Intermittent data		02/27/07	Y	IS
Y	MGPT2	NOS		Release	6m							-	-	D						WTMP failed	Data spikes	12/03/06		RB2

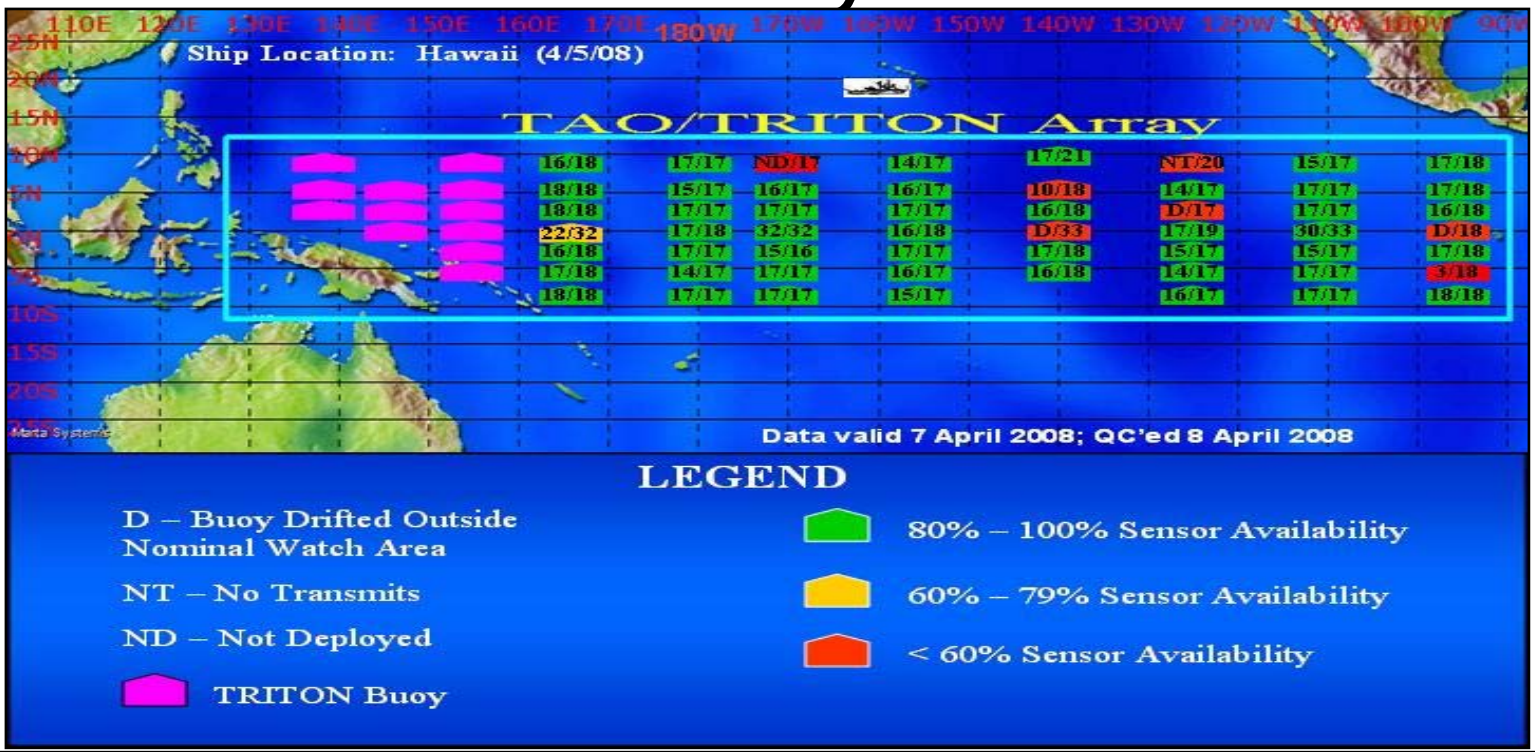
Data Assembly Center Capabilities

National Data Buoy Center

- 10 Gigabit Ethernet technology that delivers multi-gigabit bandwidth to all of their resources while maintaining a 100% uptime status.
- Designed around high-end enterprise class systems. Their minimum standards include Dual-Core 1.8Ghz systems, 4GB RAM, redundant Gigabit network interface cards, and redundant power.
- Firewalls deliver multi-gigabit wire-speed security at the perimeter of the network protecting resources from compromise attempts. Intrusion detection systems provide wire-speed in-line inspection of all network traffic. This provides an additional layer of security that coupled with firewalls ensures the NDBC network is well-defended and is capable of staying online even in the event of compromise attempts.

Tropical Atmosphere Ocean Data Assembly Center

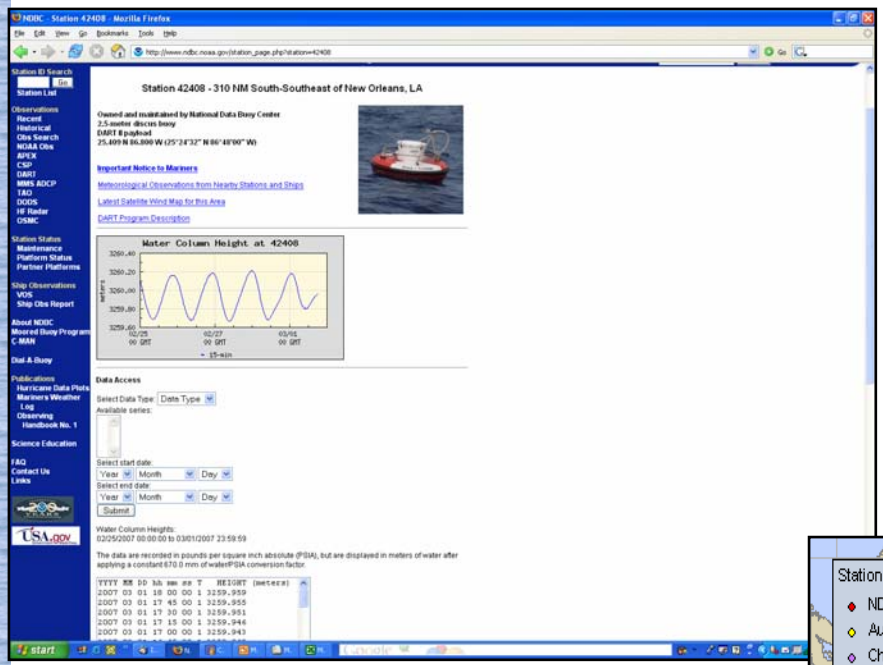
National Data Buoy Center



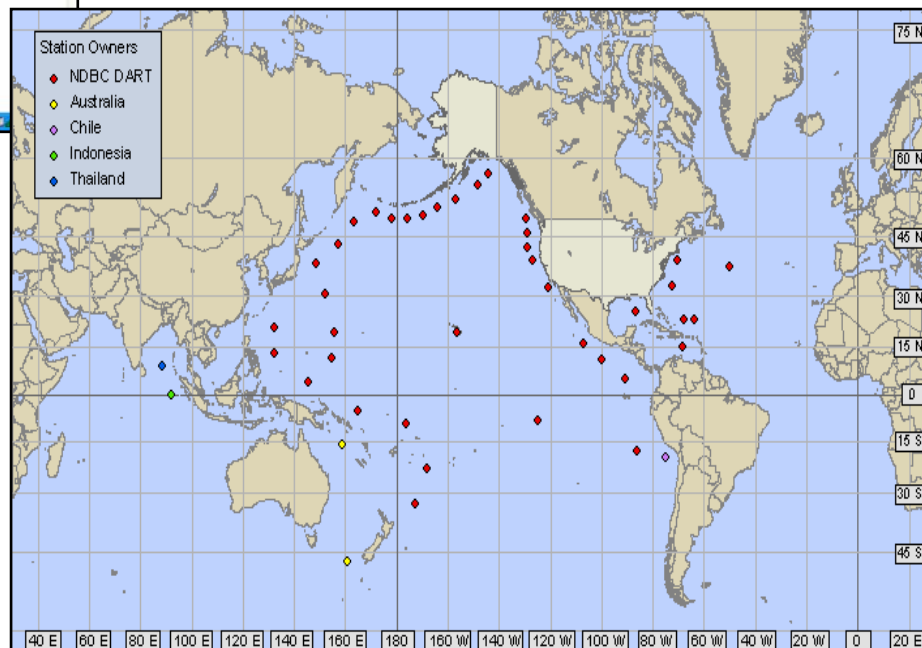
- Processing of Automated Distribution Service messages from Service Argos. It uses both the TAO calibration database and calibration files to convert raw data to engineering units and also calculates buoy positions. An automated real-time QC is performed for gross error checking and then the TAO database is updated with the corrected data.
- The TAO Real-time Data Monitoring Subsystem supports daily, weekly, and monthly QA/QC activities by providing on-demand data checking functionality to the DAC. In addition to the automated gross error checking, the real-time data monitoring subsystem provides on-demand reports for once-daily, thorough examination of all current buoy data and detailed review of the real-time data.
- The reports cover daily QC, platform transmissions, deployment, present positions, Argos positions, latitude/longitude time series, data plots, etc. The TAO DAC may request any data checking reports through the subsystem's web interface and make decisions to flag or not to flag the real-time data according to the analysis.

Tsunameter Data Assembly Center

National Data Buoy Center



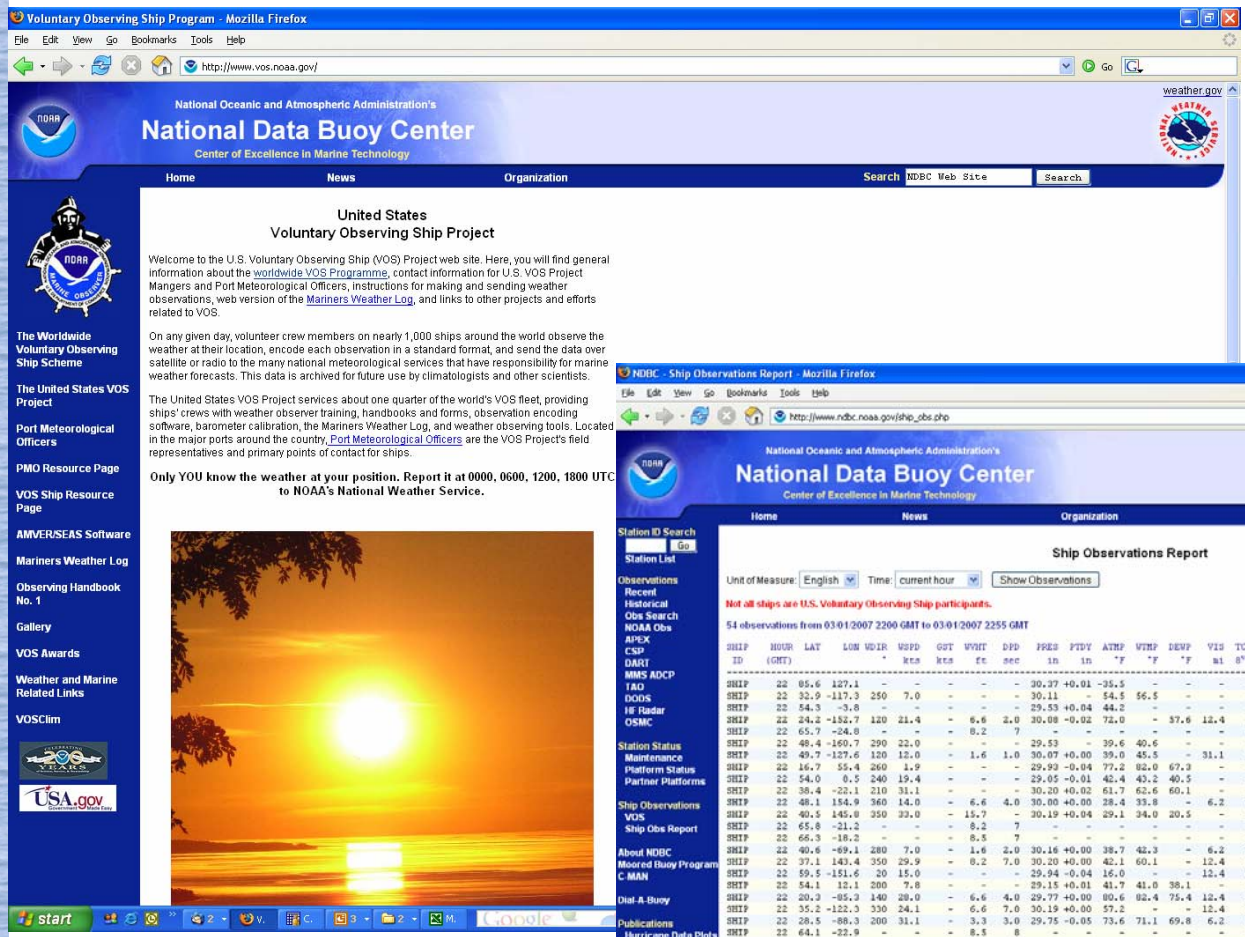
The worldwide tsunami observation network also requires a real-time, data assembly center to provide continual monitoring and quality control of Deep-ocean Assessment and Reporting of Tsunamis (DART®) water pressure/height observations. The DART Data Assembly Center monitors the various real-time transmission of DART messages depending on the operating mode of the bottom pressure recorder.

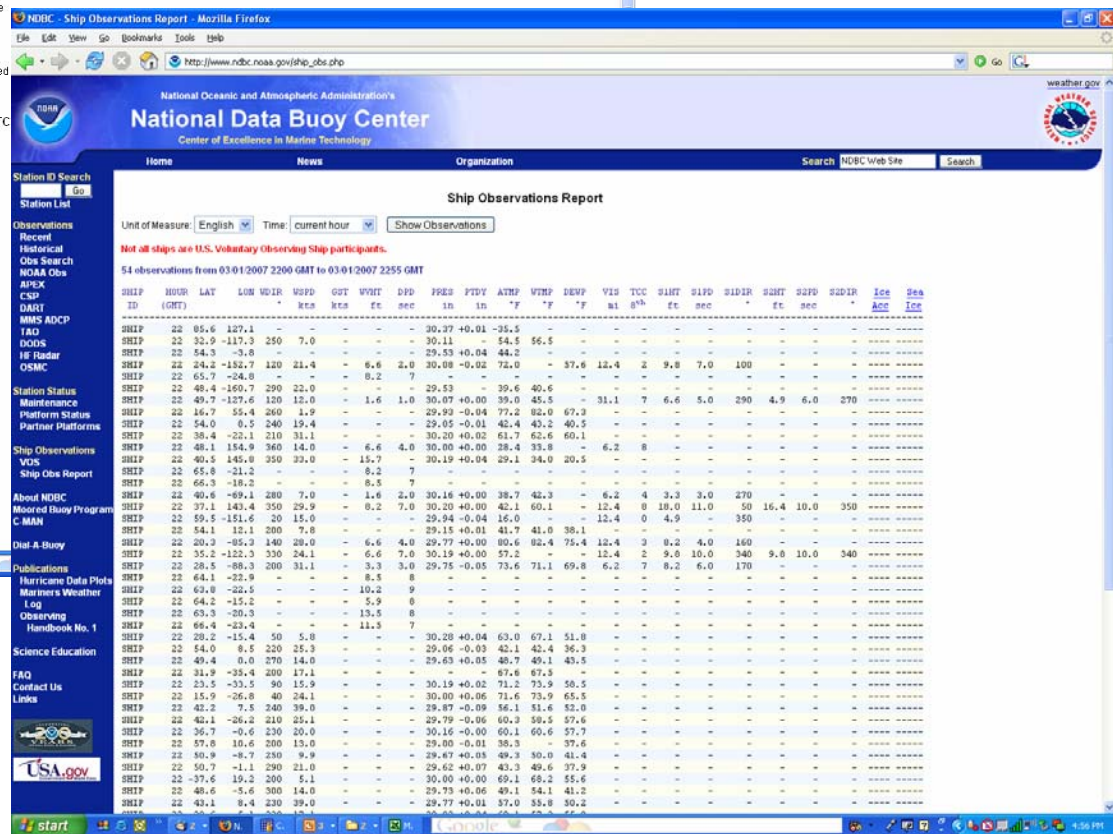


Transmission of real-time water level heights occurs when the tsunami detection algorithm is triggered by a seismic event, when interrogated by the NOAA Tsunami Warning Centers (TWCs) or NDBC, or at pre-scheduled intervals. The bottom unit transmits the messages to the surface buoy via underwater acoustics systems. The surface buoy is equipped with duplicate and independent communications systems to transmit data to the Iridium satellite and then on to the Iridium Gateway in Arizona, U.S., where the data to routed to the NDBC server.

Volunteer Observing Ship

National Data Buoy Center





High Frequency Radar

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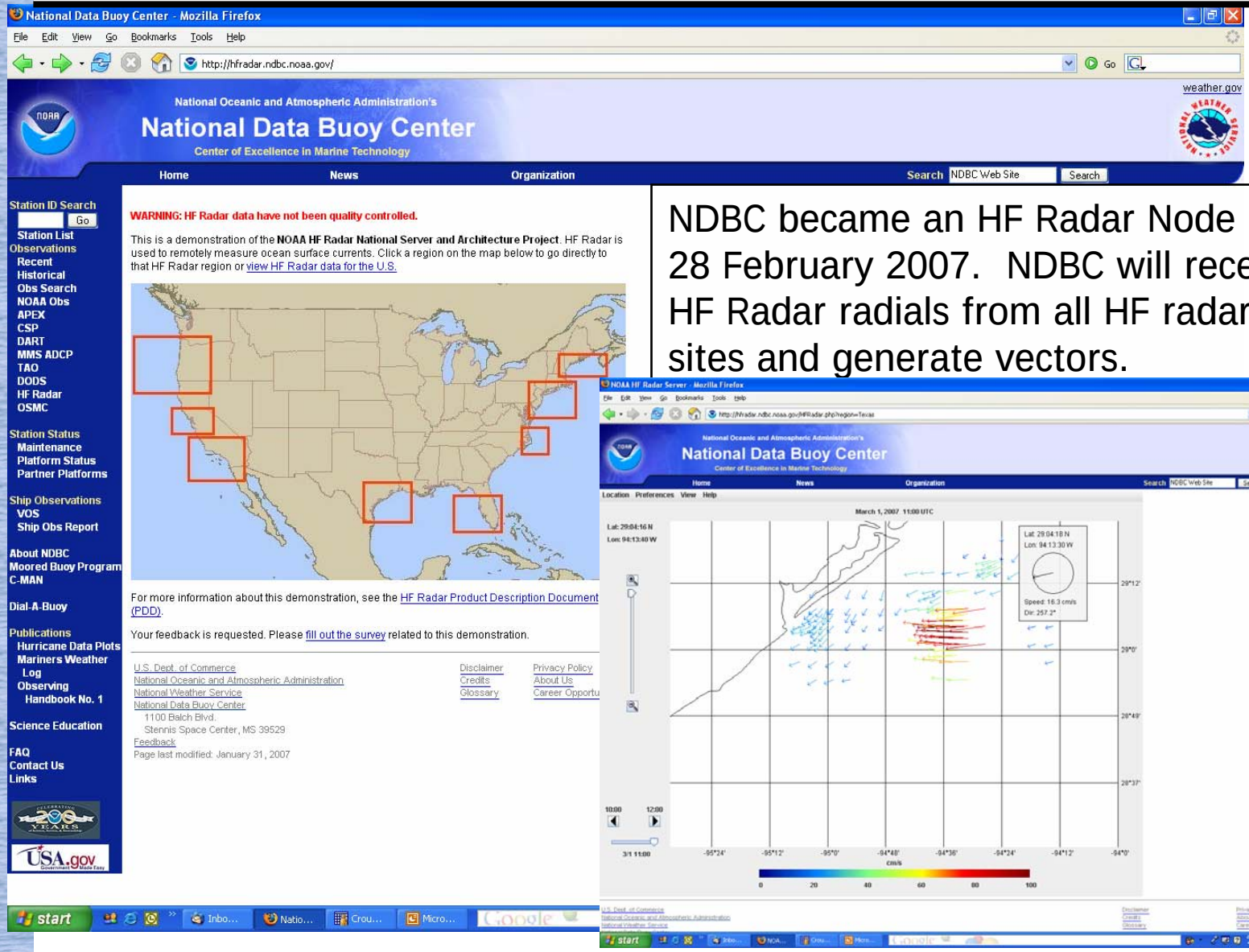

NDBC became an HF Radar Node on 28 February 2007. NDBC will receive HF Radar radials from all HF radar sites and generate vectors.

Oil and Gas Ocean Vectors

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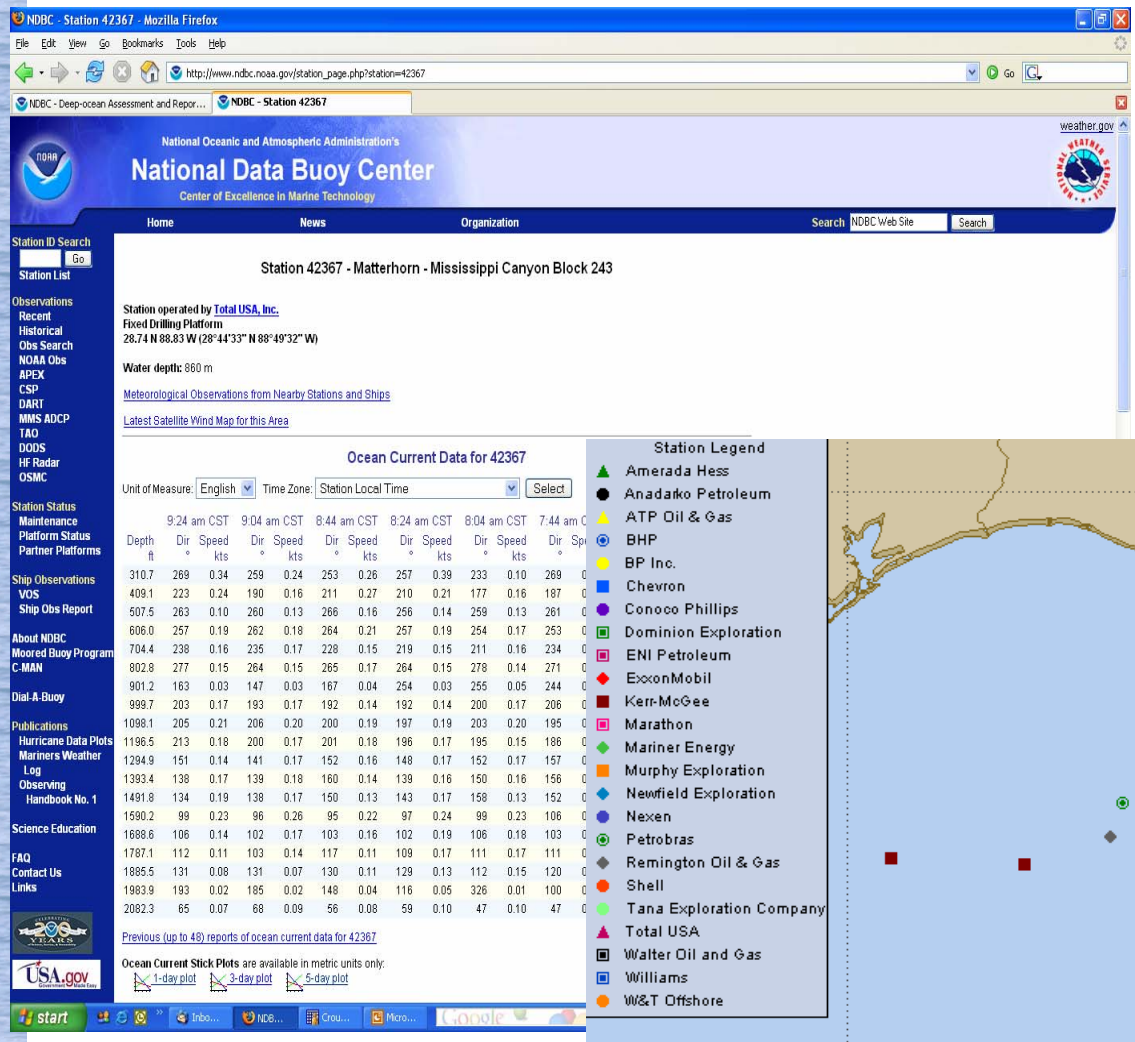

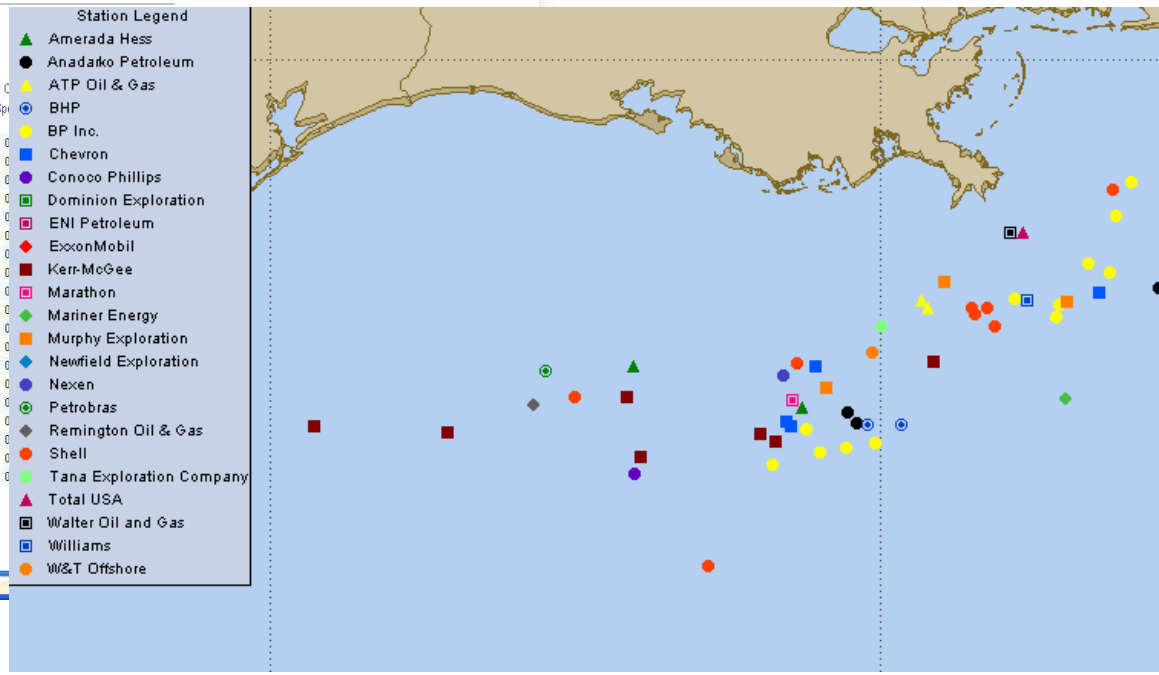

Apply quality control to real-time ADCP data from deep-water oil platforms and rigs

OSMC / OPeNDAP

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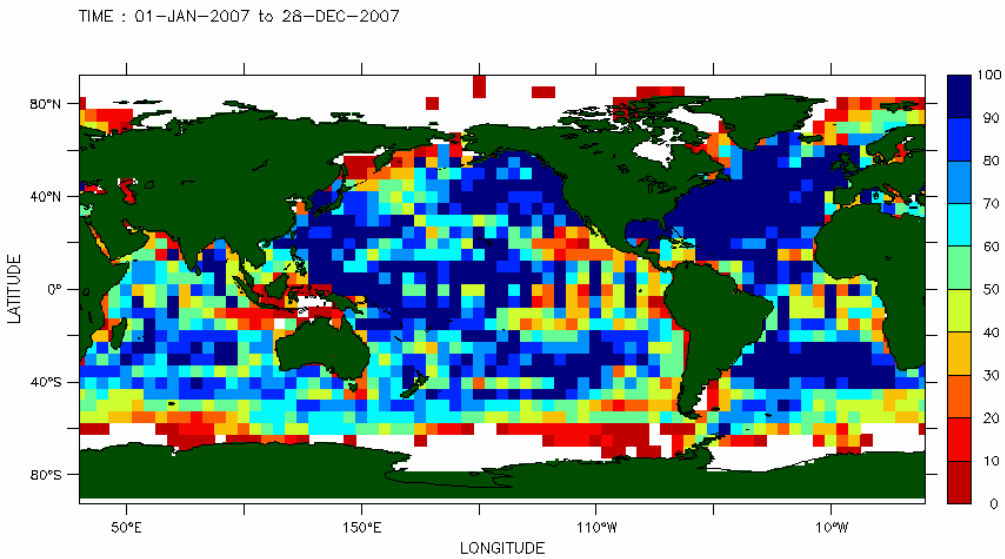
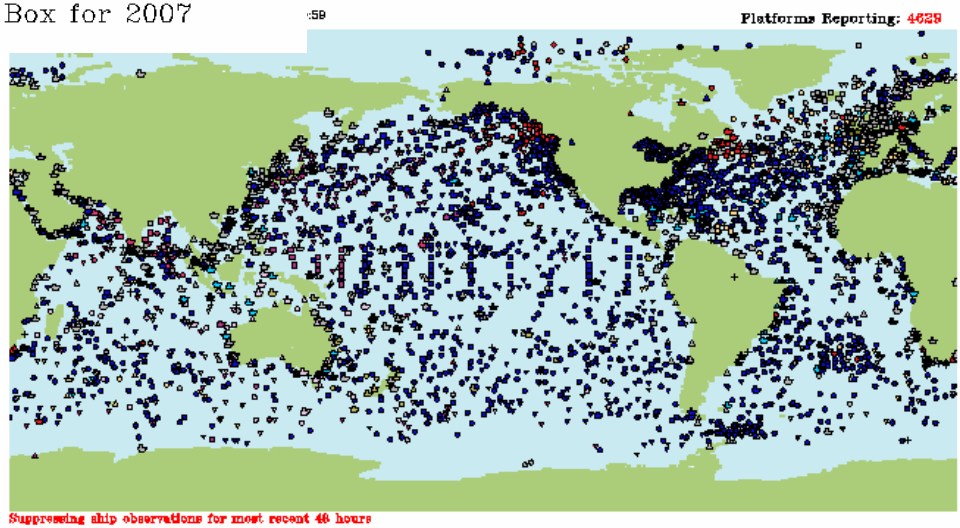


Percent of Weeks with 10 sst obs in 5x5 Box for 2007

Will serve as the backbone of the NDBC's OceanSITES GDAC



Other NDBC Collaborations

National Data Buoy Center

- Quality Assurance of Real-Time Ocean Data (QARTOD) – Collaborative effort between a number of U.S. organizations to standardize QA/QC procedures for “real-time” data
- Q20 – QARTOD to OGC Open Geospatial Consortium (OGC) Sensor Web Enablement (SWE)
- NOAA IOOS Data Integration Framework – standardize all marine observations using web services
- META-T – Metadata for Ocean Temperature – standardize ocean temperature metadata that are included within the observations using BUFR – joint server with NMDIS China

Maintaining OceanSITES

National Data Buoy Center

Appendix No. 1 (Obtaining Your OceanSITES ID)

The OceanSITES Global Data Assembly Centers (GDAC) will store and post the reported OceanSITES data on their OceanSITES ftp / websites. You should contact XXXXX via e-mail at XXXXX and provide the following information for each of your locations. After you have submitted this information, the selected GDAC will issue an FTP Account ID, a Station ID, and GTS Routing Identifiers (anything else?)

1. **OceanSITES Information**

OceanSITES Name	
OceanSITES URL (Optional, will be hyperlinked from website to Owner)	
Name of OceanSITES Contact	
Phone Number of OceanSITES Contact	
E-mail address for future notification of outages and for contact	
IP address of FTP delivery server	

2. **Unique Station Information** **XXXXX**

Station Type (e.g., SPAR, TLP, SEMI, MODU, Mooring)	
Platform/MODU/Project Name	
OCS-G Block and Area (e.g., High Island - HI-334B)	
OCS-G Lease Number	
Latitude (deg min sec)	
Longitude (deg min sec)	
Datum used for Lat/Long	
Water depth (ft)	

3. **Instrument Information (for *each* unit at the site)**

Instrument ID or Serial Number	
Instrument model (e.g., RDI 75 kHz BB)	
Recovery time (real-time; recovered bi-annually, etc.)	
Transducer depth (meters – if ocean acoustic modem is used)	
Coordinate system of data (beam, inst or earth)	
Compass reference (True required)	
Specify if the heading of the instrument is fixed. If fixed, specify if the actual compass value is used for orientation or if it is manually set.	
Vertical Datum Reference – Degrees from vertical looking down (i.e., 0 degrees = downward, 90 degrees = horizontal, 180 degrees = upward)	
Specify if the angle of the instrument is fixed and the tilt value is calculated when installed or if the tilt sensor value is used for orientation.	
Number of bins or levels	
Bin size (meters) – Doppler current profiler only	
Specify first bin depth (meters). Bin depth is assumed to represent center of bin. Indicate if otherwise (top or bottom). Doppler current profiler only	
Time data reference (GMT required)	
Number of sampling periods per hour	
Specify sampling period (minutes).	
Specify if clock time represents middle, beginning, or end of period.	
List any obstructions such as risers, moorings, tendons, or umbilicals that may affect the instrument information.	
Specify any instrument parts that have been taken out of service to accommodate obstructions.	

NDBC Sea State QC Table

http://cdip.ucsd.edu/documents/index/product_docs/qc_summaries/waves/waves_table.php

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TIME SERIES VALUES	DIR BUOY	NON-DIR
RANGE CHECK (TS): verify that values fall within established ranges.	✓	✓
SPECTRAL VALUES	**DIR BUOY**	**NON-DIR**
MESSAGE CHECK: verify checksums, parity of transmission.	✓	✓
RANGE CHECK (SP): check range of spectral wave density values.	✓	✓
TIME CONTINUITY (SP): check continuity of spectral values over 1 hour.	✓	✓
PARAMETER VALUES	**DIR BUOY**	**NON-DIR**
RANGE CHECK (PM): check range of primary and ancillary parameters.	✓	✓
TIME CONTINUITY (PM): check continuity of parameter values over time.	✓	✓
LOW ENERGY: set parameters to zero for very low energy readings.	✓	✓
HEIGHT VS. PERIOD: check that Hs does not exceed limits for the given Ta.	✓	✓
WIND/WAVE ENERGY: checks that wave energy corresponds to measured wind.	✓	✓
WIND/WAVE DIRECTION: checks that wave, wind directions correspond.	✓	
SWELL DIRECTION: verifies that swell comes from non-sheltered directions.	✓	
CHECK FACTORS: range test of directional wave check factors.	✓	
VISUAL INSPECTION: data analyst reviews data.	✓	✓

Quality Control Parameters

Parameter	Reporting Range	Reporting Resolution	Sample Interval	Sample Period	Total System Accuracy
Wind Speed	0 to 62 m/s	0.1 m/s	1 s	8 min[1]	±1 m/s or 10%
Wind Direction	0 to 360°	1°	1 s	8 min[1]	±10°
Peak Wind	0 to 82 m/s	1 m/s	1 s	5 s	±1 m/s or 10%
Air Temperature	-40 to 50 °C	0.1 °C	90 s	8 min	±1 °C
Atmospheric Pressure	800 to 1100 hPa	0.1 hPa	4 s	8 min	±1 hPa
Sea Surface Temperature	-7 to 41 °C	0.1 °C	1 s	8 min	±1 °C
Significant Wave Height	0 to 35 m	0.1 m	0.39 s	20 min	±0.2 m or 5%
Wave Period	3 to 30 s	0.1 s	0.39 s	20 min	±1 s
Nondirectional Wave Spectra	0.03 to 0.40 Hz	0.01 Hz	0.39 s	20 min	—
Dew Point Temperature[2]	-35 to 30 °C	0.1 °C	1 s	8 min	±1 °C
Solar Radiation[2]	0 to 2150 W/m^2	0.5 W/m^2	1 s	8 min	±5%
Precipitation Rate[2]	1 to 1600 mm/hr	1 mm	1 s	15 min	±5%
Directional Waves[2]	0 to 360°	1.0°	0.5 s	20 min[3]	±5°
Ocean Currents (ADCP)[2]	0 to 1000 cm/s	0.5 cm/s	1.5 s	20 min	±2 cm/s

[1]For continuous winds, successive 10-min samples
[2]Parameter reported on selected buoys
[3]Wave sampling period 40 min on some systems

Becoming More Standard

Quality Control of Observations

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- No QC Done Onboard the Buoy or C-MAN
- *Handbook of Automated Quality Control Checks and Procedures of the National Data Buoy Center*

  http://www.ndbc.noaa.gov/handbook.pdf
- Automated QC Done in Real-Time at NWSTG
- Hard-flags:
  - Stop the Release and Archive of Data unless Analyst Overrides.
    - Override in advance – Storm Limits, or
    - Remove before archive
  - Hierarchical: Order of Precedence, Fail One and Stop
- Soft-flags: Climatology-based, Advisory

Quality Control Process Flow

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- Real-Time:
  - System Parameters (e.g., power)
  - Message Integrity
  - Automated Hard-Flag
  - Automated Soft-Flag
- Post-Release, Pre-Archive: Data Analyst

Hard-Flags

by hierarchy - highest to lowest:

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- **T** Transmission parity error
- **M** Missing sensor data
- **W** **W**ave message is short, checksum or parity errors.
- **E** Spectral Density are exceeded or are in error
- **D** Delete measurement (“permanent failure”)
- **S** Invalid statistical parameter (e.g., mean > max)
- **V** Failed time continuity.
- **L** Failed range (climatological) limits
- **R** Related measurement has failed a hard QC check (e.g., WVHGT fails → Periods failed).

Soft Flags for Waves

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- **a:** Measurement is above monthly, regional limit.
- **b:** Measurement is below monthly, regional limit.
- **c:** Measurement has been adjusted, or corrected.
- **f:** Measurement failed hourly time continuity.
- **m:** High frequency spikes detected in the wave spectrum.
- **p:** Failed wave height to wave period comparison test.
- **q:** Swell direction is from an improbable direction.
- **w:** Failed wind direction verses wave direction check.
- **x:** Wind wave energy is too high for prevailing wind speed.
- **y:** Wind wave energy is too low for prevailing wind speed.

Real-Time and Automated QC

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- Purpose: Remove gross errors
- Data rejected: Virtually certain to be degraded
- Typical causes: Transmission errors, power degradations, broken cables
- Limitations: Won't detect minor errors, biases

Manual Quality Control

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- Sensor Evaluations
- Individual Sensor Calibrations
- Payload Software Testing
- Burn-In
- Data Evaluation at Deployment
- Real-time Q.C. Algorithms

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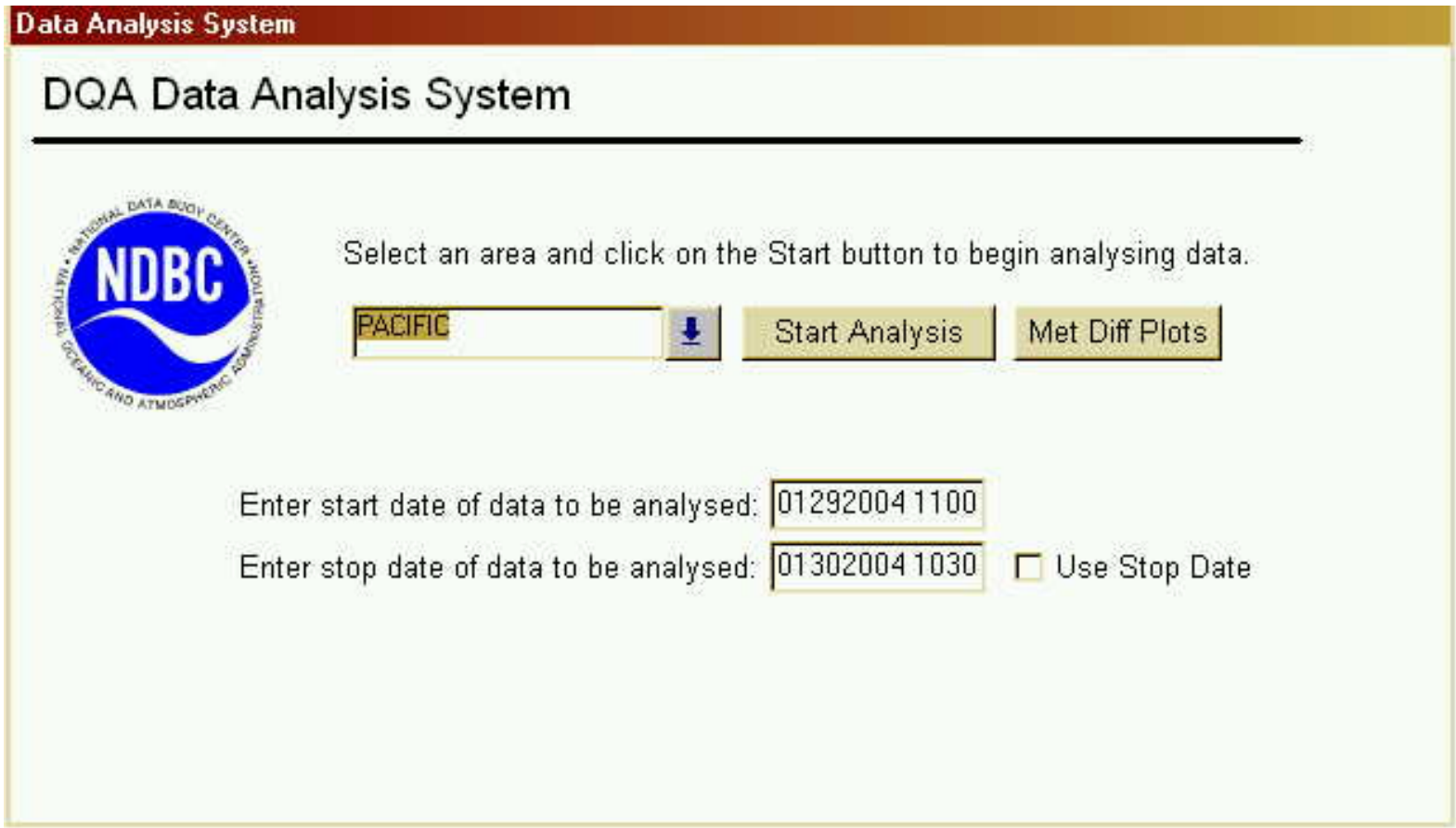
Quality Control Interface



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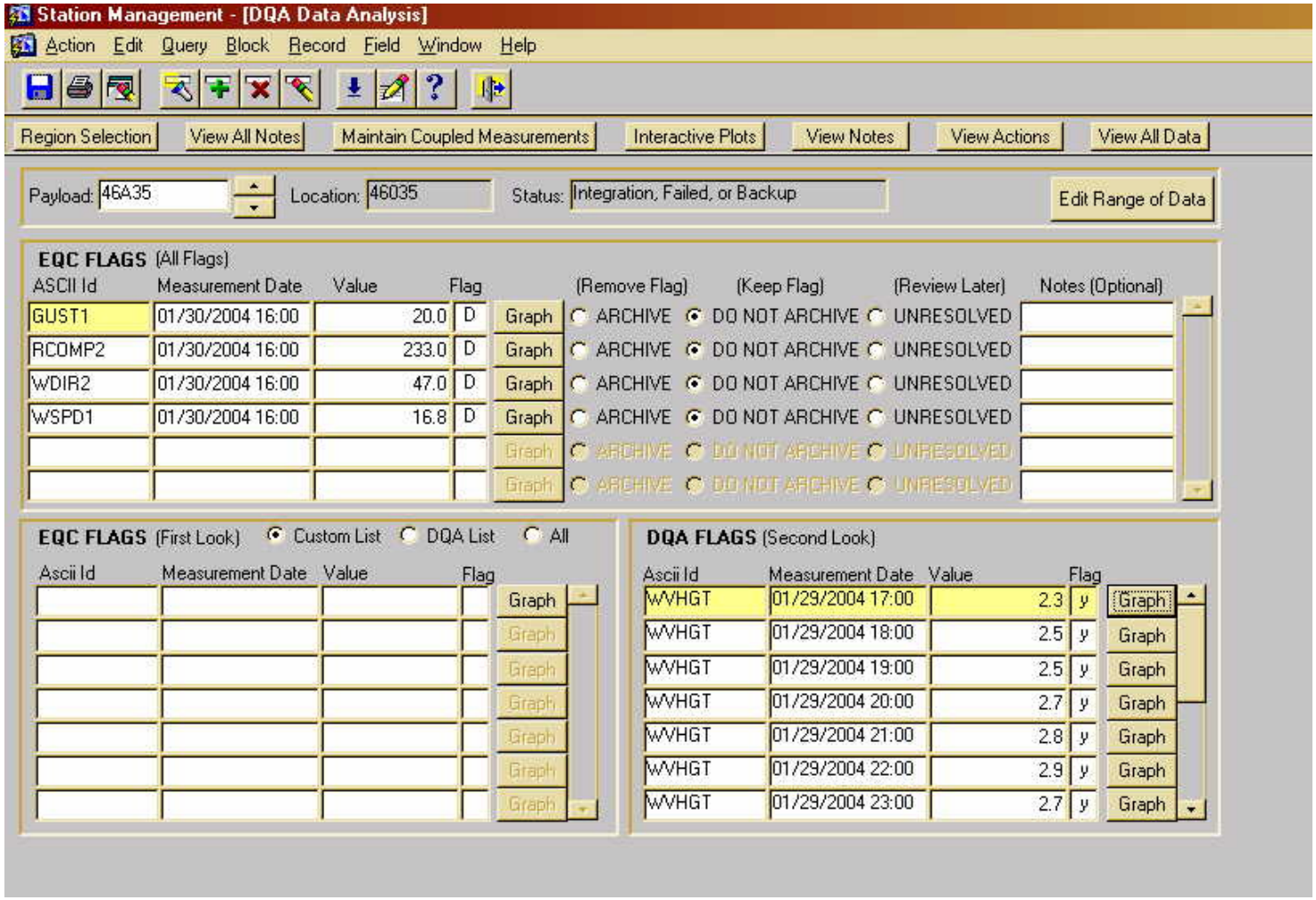
QC Flag Monitoring



Wind Plots

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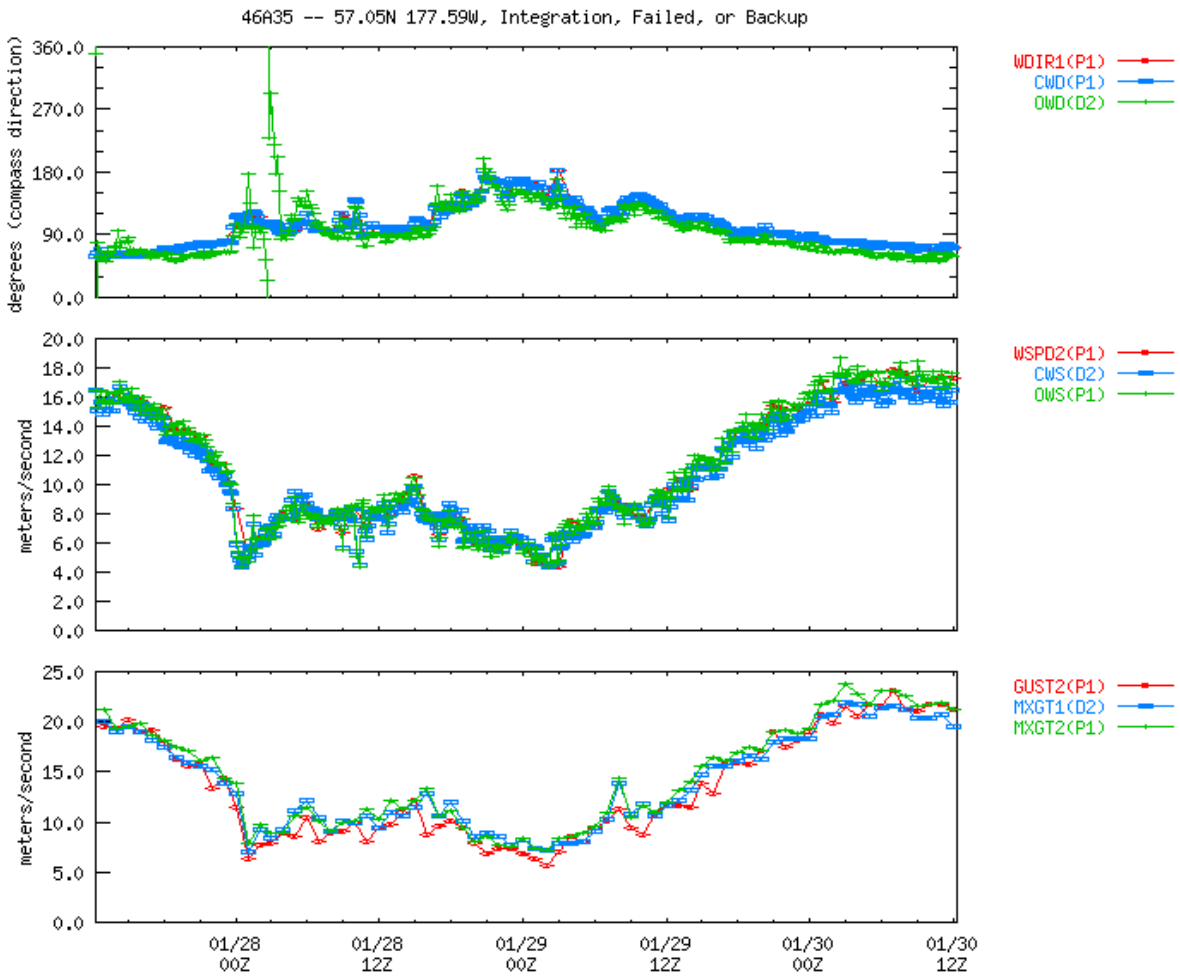

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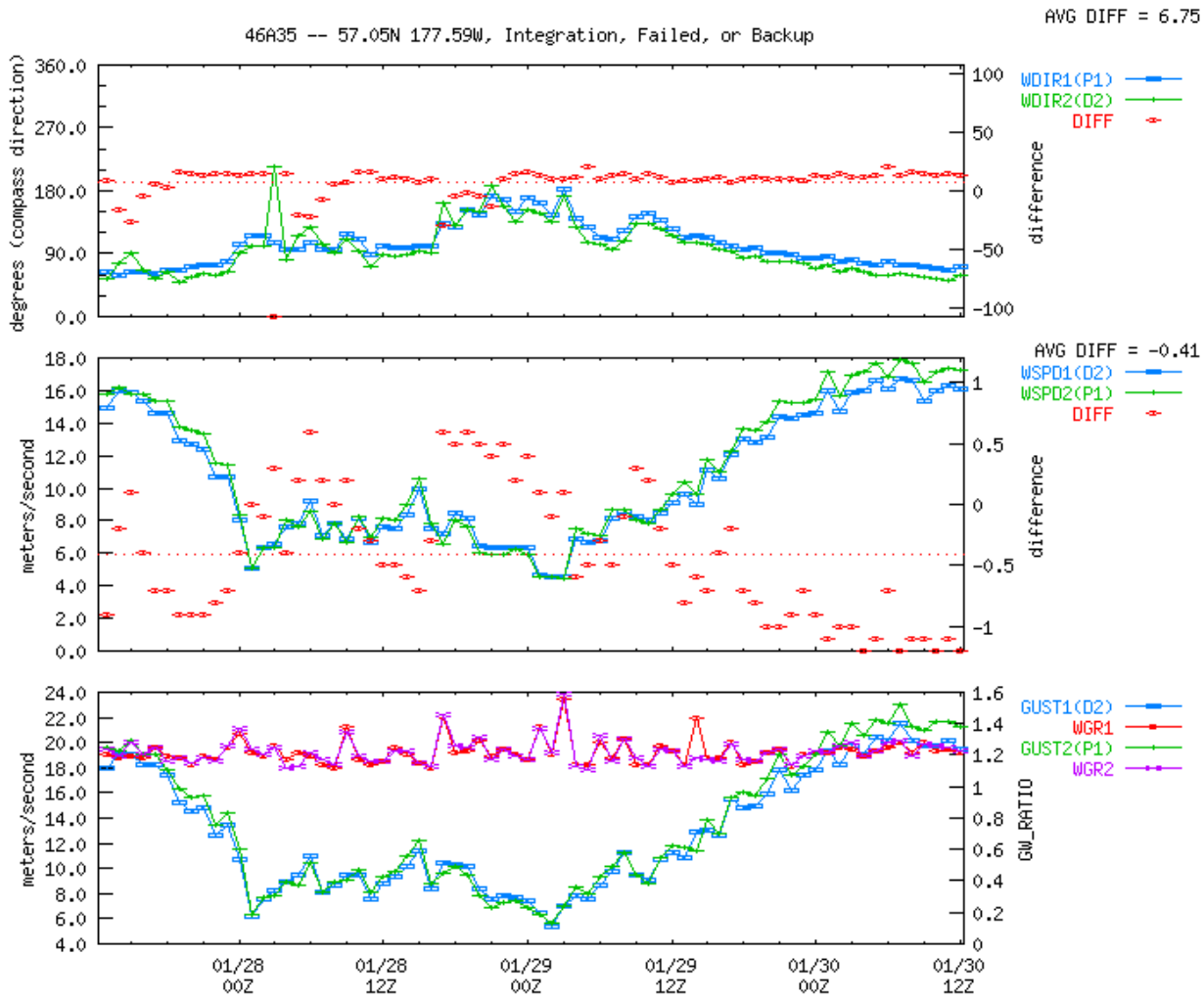
More Wind Plots



QC for Two Station Plots

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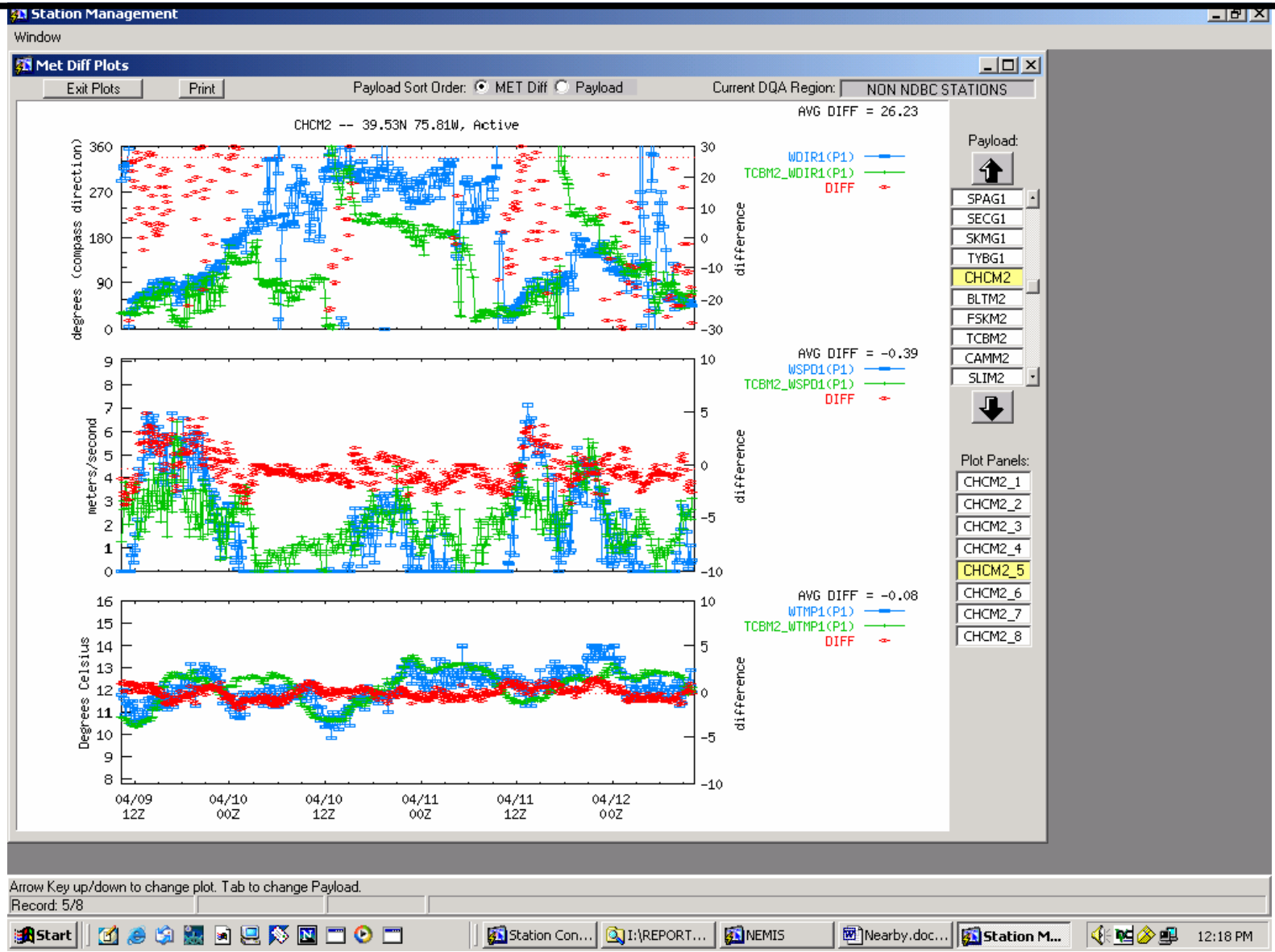

NDBC vs. University stations

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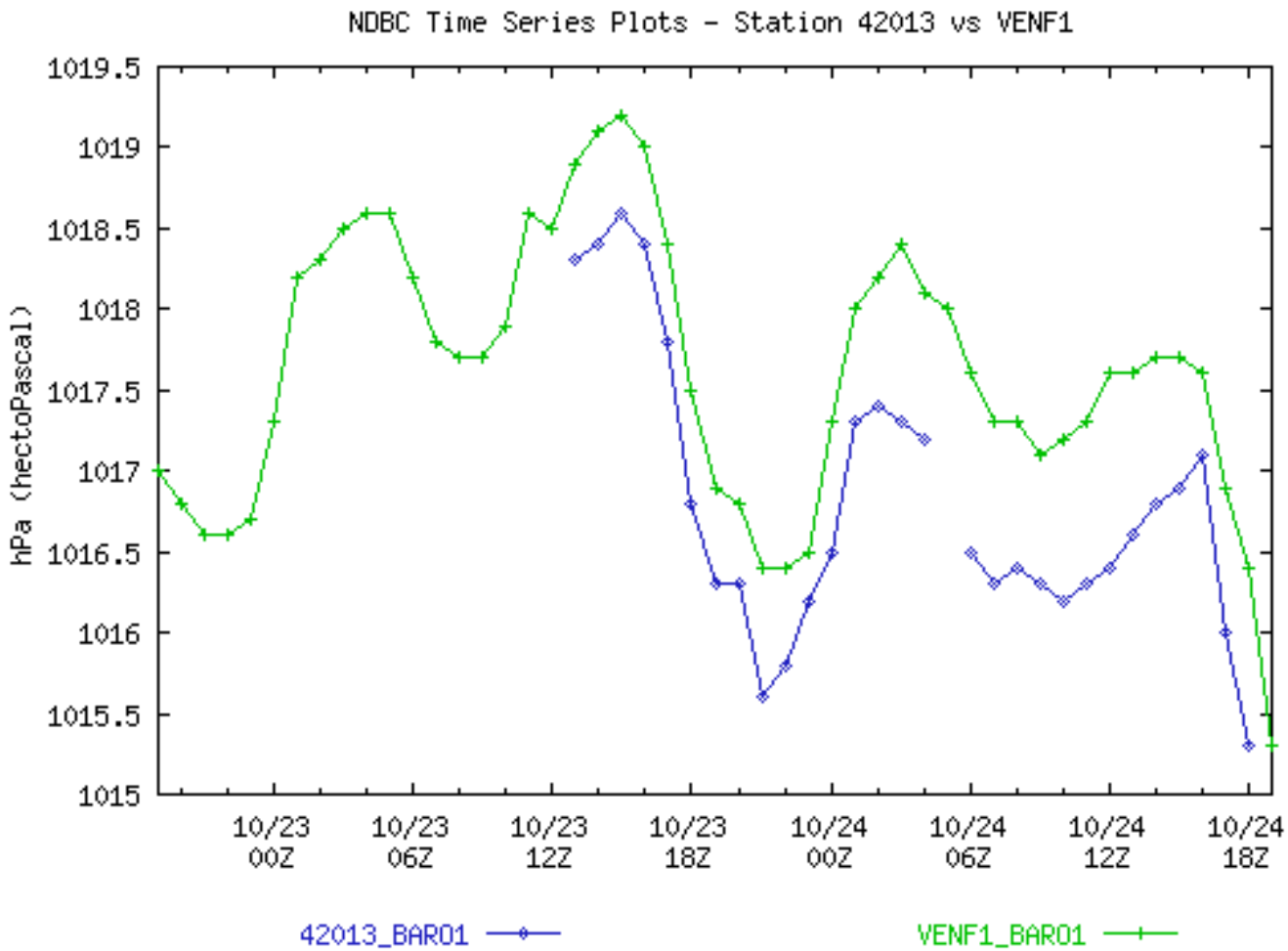

Output Formats

- FM-13 for moored buoys
- C-MAN code for coastal stations:
  - National code, but well-suited for coastal obs.
  - Contains water level & waves
  - Decoded by all (?) met. Workstations
- FM-64 TESAC (temp., salinity, current profiles)
- FM-65 WAVEOB (spectral wave data)

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Thank You!

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