The Observing System Monitoring Center (OSMC)

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1. Abstract

The Observing System Monitoring Center (OSMC) is an information gathering, decision support, and display system for NOAA's Climate Observations and Monitoring Division (COMD). The OSMC helps COMD to ensure that NOAA meets the long-term observational requirements of forecast and modeling centers, international research programs, major scientific assessments, and decision-makers. To monitor the full suite of ocean sensors the OSMC ingests real time ocean observations carried on the GTS as well as (increasingly) real time and delayed mode observations carried on Internet protocols such as OPeNDAP, SOS and FTP. The OSMC permits the many "networks" of *in situ* ocean observing platforms -- ships, surface floats, profiling floats, tide gauges, etc. -- to be viewed as a single system. It provides tools to help managers to assess the contributions of different countries and programs. It provides tools to help scientists track the effectiveness of *in situ* observations for assessing the state of measured parameters – temperature, salinity, etc. The OSMC is also a key component in emerging ocean/climate data integration strategies. It integrates US coastal (IOOS) and global (GOOS) observations. It integrates indices of climate change with observations. Increasingly it integrates *in situ* observations with gridded climate analysis products – climatologies, state estimations and model forecasts – and is positioned to play a key role in the fusion and intercomparison of observations and models in support of such activities as IPCC AR5/CMIP5.

2. Project Summary

The Observing System Monitoring Center (OSMC) is an information gathering, decision support, and display system for NOAA's Climate Observations and Monitoring Division (COMD). The OSMC helps COMD to ensure that NOAA meets the long-term observational requirements of forecast and modeling centers, international research programs, major scientific assessments, and decision-makers. To monitor the full suite of ocean sensors the OSMC ingests real time ocean observations carried on the GTS as well as (increasingly) real time and delayed mode observations carried on Internet protocols such as OPeNDAP, SOS and FTP or in dedicated data management systems. The OSMC permits the many "networks" of *in situ* ocean observing platforms -- ships, surface floats, profiling floats, tide gauges, etc. -- to be viewed as a single system. It provides tools to help managers to assess the contributions of different countries and programs. It provides tools to help scientists track the effectiveness of *in situ* observations for assessing the state of measured parameters – temperature, salinity, etc. The OSMC is also a key component in emerging data integration strategies. It integrates US coastal (IOOS) and global (GOOS) observations. It integrates time-series indices of climate change with observations. Increasingly it integrates *in situ* observations with gridded climate products – climatologies, state estimations and model forecasts – and is positioned to play a key role in the fusion of observations, products and climate forecast models in support of such activities as IPCC AR5/CMIP5.

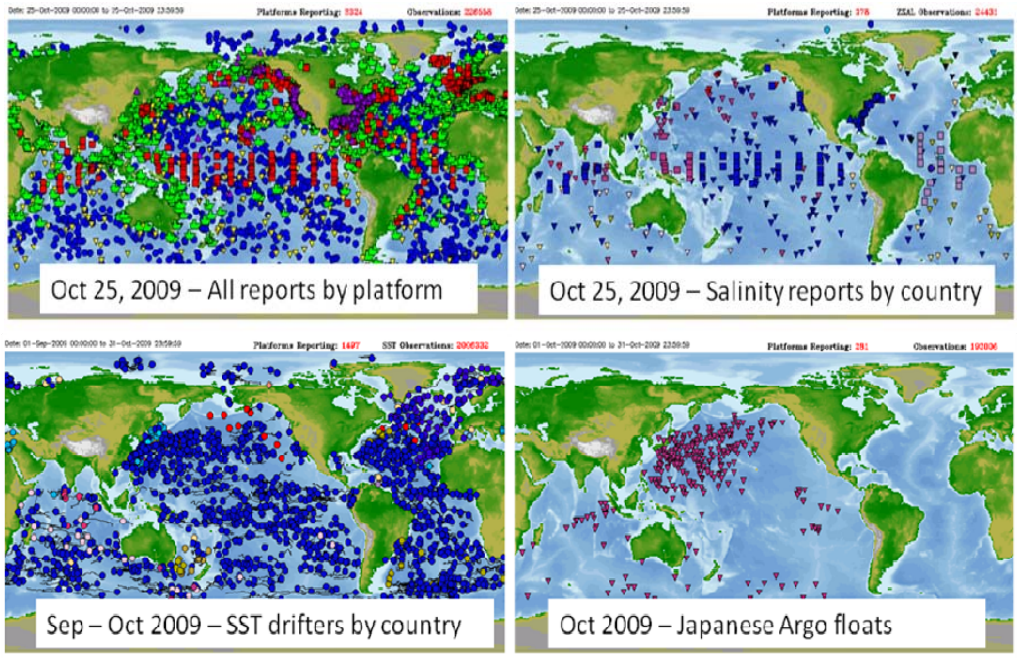

Figure 1. Several examples of maps generated by the OSMC

Figures 1 illustrates how the OSMC maps display the status of the global observing system for *in situ* ocean surface meteorological and oceanographic measurements.

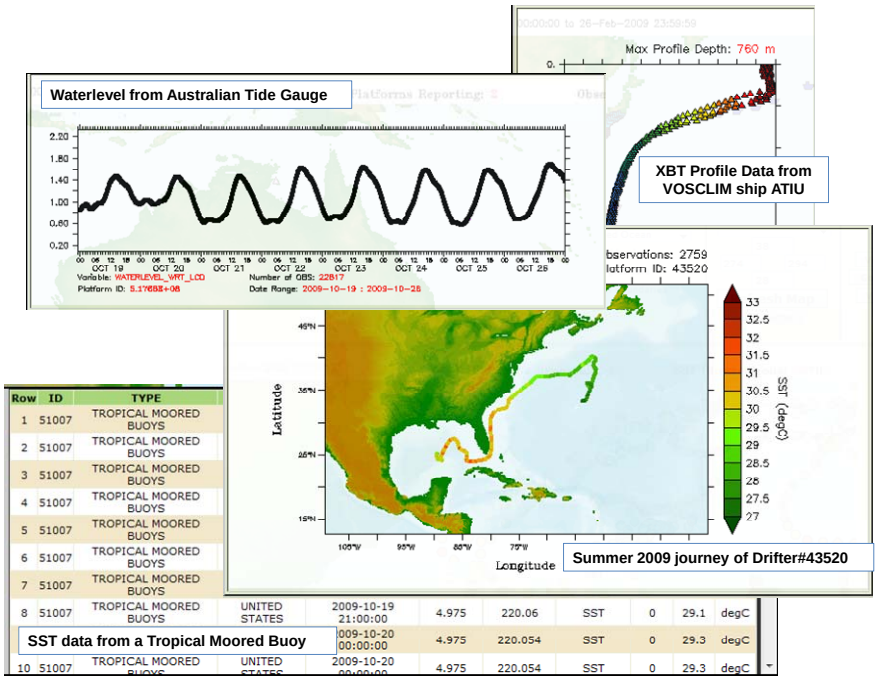

Figure 2. A sample of the drill down products available from the OSMC

OSMC users may constrain their selections of observations by factors such as the observing platform type, the programs associated with platforms, parameter (temperature, sea level height, etc.), contributing nation and instrument ID. Maps may be requested for arbitrary time intervals – daily, weekly, etc. With a click the user can "drill down" to read details of a particular platform and the measurements it has made as shown in Figure 2.

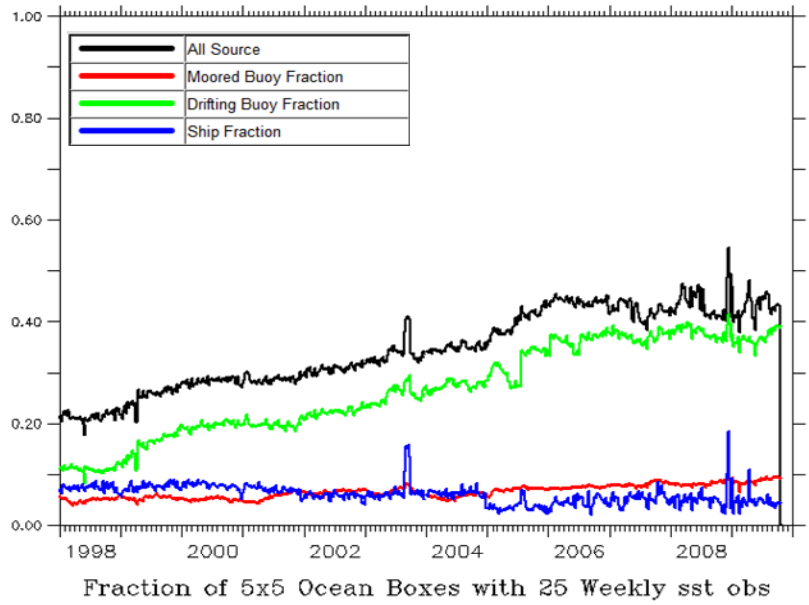

Figure 3. Time series showing progress implementing the ocean observing system

The OSMC can generate time series plots to show long term trends in observing system coverage (Figure 3). Tabulated summaries generated by the OSMC show the counts of platforms by ocean basin and platform type and contributing nation for any selected time contained in the OSMC database (Figure 4).

Number of Observing System Platforms Reporting

	Argo Floats	CMAN	Drifting Buoys	Moored Buoys	Ships	Unknown	Sum
11-18-2009	265	382	1335	442	650	276	3350
11-17-2009	267	382	1328	437	654	296	3364
11-16-2009	267	386	1326	438	666	291	3374
11-15-2009	244	382	1334	438	680	290	3368

*A count is defined as a platform reporting any type of observation on a particular day.

Figure 4. One of many OSMC table-based summaries

The OSMC also displays observing system metrics, incorporated into the system as they are developed by NOAA observing system scientists and others. These analysis capabilities help managers and scientists to assess the adequacy of the observations for inference of critical ocean state fields, such as sea surface temperature. Figure 5 shows a 5x5 degree gridded analysis of a simple metric for the adequacy of the sampling for SST: the percentage of weeks in which at least 25 observations are made in a grid box (during an arbitrarily selected 9 month period beginning Jan. 1, 2009).

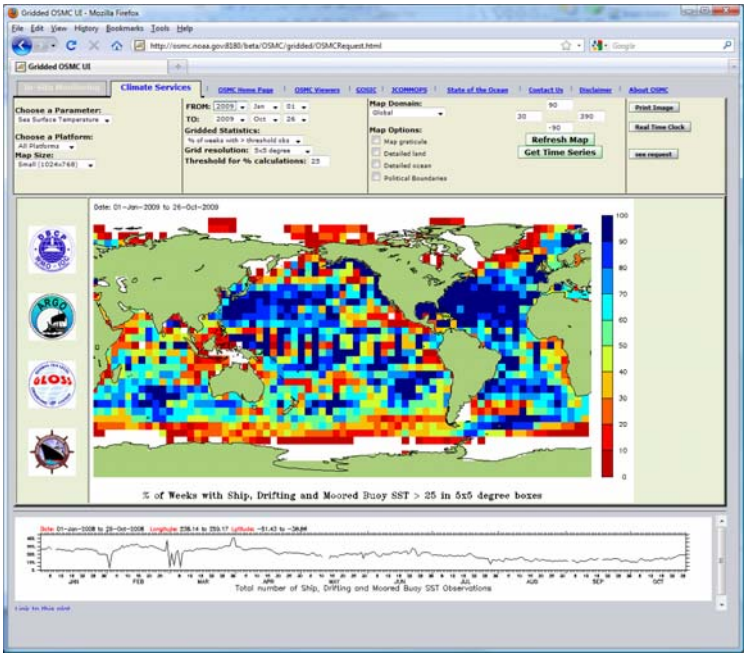

Figure 5. 5x5˚ SST sampling metric

It is widely understood that one of the great challenges in earth science data integration that must be addressed during the coming decade is the integration of observations and products. The OSMC is a platform for climate product integration as well as climate observations monitoring. Some illustrations of current capabilities are shown below in figure 6 -- the integration of OSMC observation records with SST bias errors computed by Dick Reynolds at NCDC and served by OPeNDAP (left); and

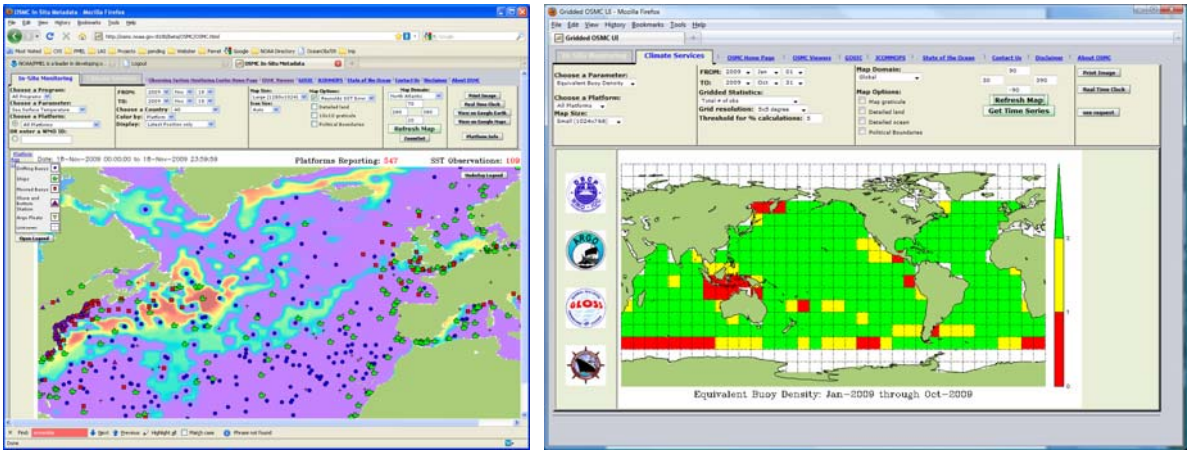

Figure 6. Observations over Reynold's SST bias errors (left); EBD for Jan–Oct, 2009 (right)

the Equivalent Buoy Density (EBD) product on a 10x10º grid (right), which shows where additional drifting buoys should be added in order to improve satellite bias corrections for SST – also hosted remotely at NCDC and served to the OSMC via OPeNDAP. The "State of the Ocean" indices of which we see an example in Figure 7 represent a first step in the OSMC as a site where various indices can be visualized and inter-compared (see further discussion under PMEL 2009 Accomplishments).

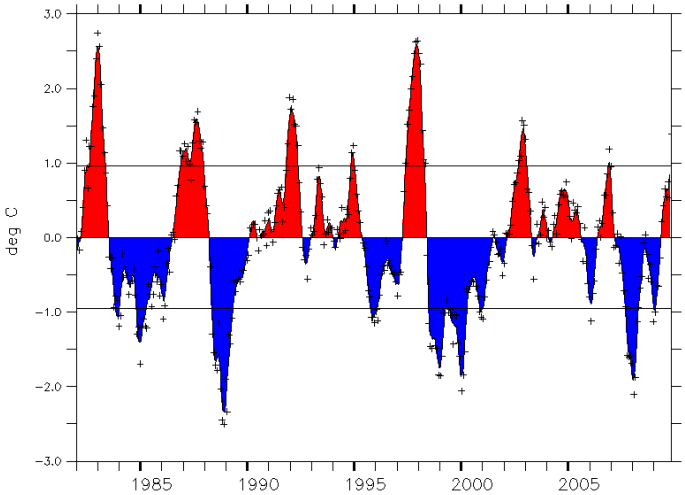

Figure 7. Niño3.4 SST anomaly index of central tropical Pacific El Niño conditions

Users may optionally elect to view OSMC maps on a virtual globe with Google Earth® (Figure 8, left) or on Google Maps® (figure 8, right).

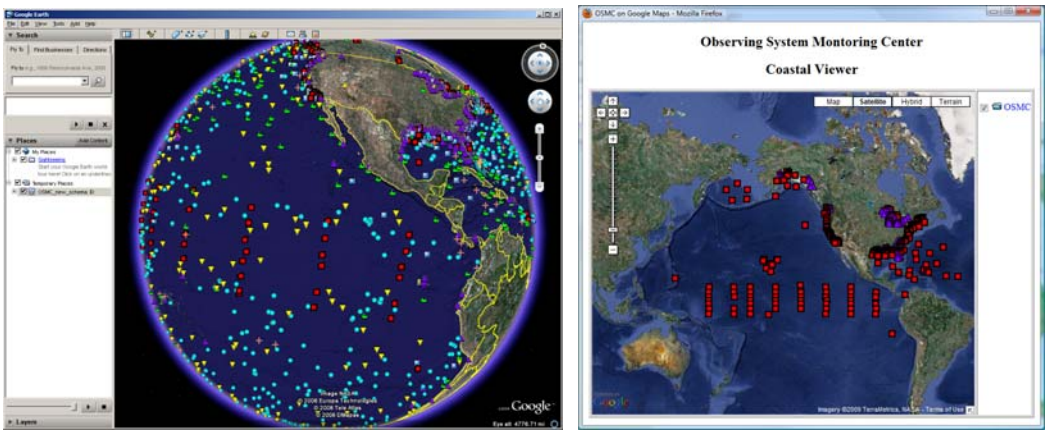

Figure 8. OSMC observations on Google Earth® (left) and on Google Maps® (right)

The OSMC system is available on-line at http://www.osmc.noaa.gov. It is provided as a resource to other NOAA centers, national research partners, and international partners. The project is a joint development effort between the Pacific Marine Environmental Laboratory (OAR/PMEL) in Seattle, Washington; the National Data Buoy Center (NWS/NDBC) at Stennis Space Center in Mississippi; and the National Geophysical Data Center (NESDIS/NGDC) in Boulder, Colorado. The project is aligned to take advantage of the strengths of each organization. PMEL (an ocean/climate research laboratory) is responsible for the analysis, graphics and user interface tools; NDBC (an operational organization) is responsible for the managing the OSMC data base; and NGDC (a data center) provides technical consulting and development services on the use of metadata, data bases and standard services. The OSMC project is a close partner with the JCOMM in situ Observing Platform Support Centre (JCOMMOPS) with JCOMMOPS focusing on the deployment of and operations for platforms whereas OSMC focuses on the return and integration of quality data and the performance of the observing system as a whole including the production of climate products.

3. Scientific Accomplishments

The following milestones track the progress made by the OSMC project during fiscal year 2009. "Group" lists those accomplishments or events that involved all three partners in the collaborative effort.

Group Accomplishments (PMEL, NDBC, NGDC)

- The publicly accessible OSMC Web site at http://osmc.noaa.gov/Monitor/OSMC/OSMC.html was upgraded to version 3.2.0 in August 2009. (See details under PMEL Accomplishments.) On-going continuing advancements were provided via the BETA version of the site at http://osmc.noaa.gov:8180/beta/OSMC/OSMC.html Outputs from the OSMC were featured in several plenary presentations at the OceanObs09 Symposium.

- Outreach efforts to the community informing them of the capabilities of the OSMC and the role of the community as participants in the OSMC occurred at multiple venues including:
    - AGU annual Fall meeting, December, 2008, "*Moving Toward Climate Data Integration: The Observing System Monitoring Center*" presentation by Kevin O'Brien
    - AGU annual Fall meeting, December, 2008, "*Extensible Database Designs for Marine Observations*" presentation by Kevin O'Brien
    - 89th AMS Annual meeting, January, 2009, "*Using THREDDS to 'sew' observational data into the Observing System Monitoring Center*" presentation by Kevin O'Brien
- The OSMC supported Office of Climate Observations (OCO) needs in FY09 for presentation materials and information needed for numerous initiatives, briefings, and ad-hoc requirements.

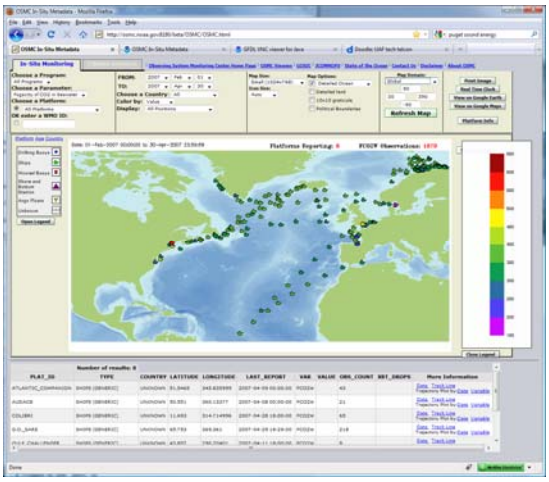

Figure 9. Underway ship observations of CO_2 in the North Atlantic, Feb.-April, 2007

- The OSMC group held two technical meetings – February and July – including Mike Johnson from OCO Headquarters and Hester Viola from JCOMMOPS at the July meeting. These meetings complement the weekly technical telcons held by the group. Among the many outcomes of these meeting were specific work plans for the addition of new data types (DART buoys, Tide Gauge data from GTS) and an implementation plan for daily summary tables in the OSMC database that has lead to significantly improved performance.
- PMEL, NGDC and NDBC worked together to refine the transfer of carbon underway observations into the OSMC database (see Figure 9). A streamlined process to ingest the data from the Surface Ocean Carbon Atlas (SOCAT) database was created using the Climate System Markup Language (CSML) conventions for XML to encode underway **carbon** cruise tracks.. The larger goal behind creating this procedure is that it is sufficiently general to be applied to the ingestion of most non-GTS observation records into the OSMC database.

- Two new methods of downloading data from the OSMC were added in 2009 -- arbitrary subsets of observations downloadable 1) as netCDF; and as CSML that is requested via the Open Geospatial Consortium (OGC) standard Sensor Observation Services (SOS).
- Gridded summaries of OSMC data continue to be compiled and made available as virtual lat-lon-time grids through the publicly available OSMC THREDDS server.
- Work was completed on the tasks identified as joint IOOS-OSMC developments. IOOS was added as a new "program" type in the OSMC database making it possible to identify and monitor IOOS-relevant observations. (Note that the concept of a "program" had to be generalized to allow for platform may belong to more than one program. Figure 8 (right panel) shows IOOS platforms displayed on Google Maps.

PMEL Accomplishments

- PMEL met its on-going project leadership responsibilities for the OSMC collaboration: organizing meetings and telcons; overseeing the tracking of bug fixes, milestones, and deliverables; coordinating plans of high level strategy; helping to ensure that group-wide communications continue to flow smoothly. PMEL also continued to provide the primary (though by no means sole) point for coordination of OSMC developments and outreach with projects such the Integrated Ocean Observing System (IOOS); the NOAA Data Management Committee (DMC/EDMC); the NOAA "GEO-IDE" data integration framework; and NOAA science programs.
- Adopting graphical techniques prototyped by NGDC, the Google Earth® displays of OSMC metadata were improved as shown in Figure 8. Using Google's "placemarks" to represent each platform means that the platform icons on Google Earth® are clickable to retrieve metadata and data plots. We believe that Google Earth® can provide an excellent interface for those who wish to use the OSMC to monitor polar observations.
- In August 2009 OSMC version 3.2 was officially announced and made available from NDBC in an operational capacity. It contains the following new features that PMEL developed or contributed to:
    - Enhanced "drill down" abilities for individual platforms to include data listings, profile plots and track line and trajectory visualizations, as illustrated in Figure 2.
    - Added ability for user to download the data viewed on maps in NetCDF format. (Currently available only in the "executive" OSMC interface. Public availability to follow after testing.)
    - Expanded ability to view "tails" for all platforms. This is a useful way to track moored buoys that have broken free, as shown in figure 10.

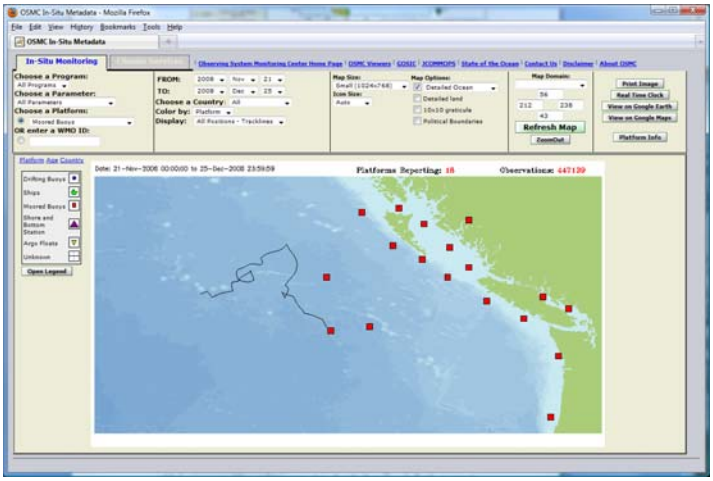

Figure 10. Trackline of Ocean Station Papa after it broke free in Winter, 2008

- Expanded the menu of predefined OSMC regions to include IOOS-relevant US coastal regions.
- Added ability to terminate requests before completion.

- Much of the technical development in 2009 has focused on shifting to a more powerful database schema – V4, operating in BETA mode since summer, 2009. PMEL has had the role of testing and developing queries on that database schema.
- The OSMC V4 LAS viewer has been built for the V4 database, including the follow enhancements:
  - Google Maps viewer (see IOOS bullet below)
  - Expanded metadata outputs available from Google Earth and Google Map balloons as shown in Figure 11
  - Access to OSMC visualizations (profiles, track lines, etc.) from Google Earth

Figure 11. Metadata "drill-down" through Google Earth with links to OSMC products.

- Ability to track XBT drops, including implementing special queries to visualize XBTs as shown in figure 12.
- Add real time GTS Tide Gauges reports.
- Added animations displayed on Google Earth. (Note: The creation of Google Earth animations is sufficiently resource intensive that the OSMC group is

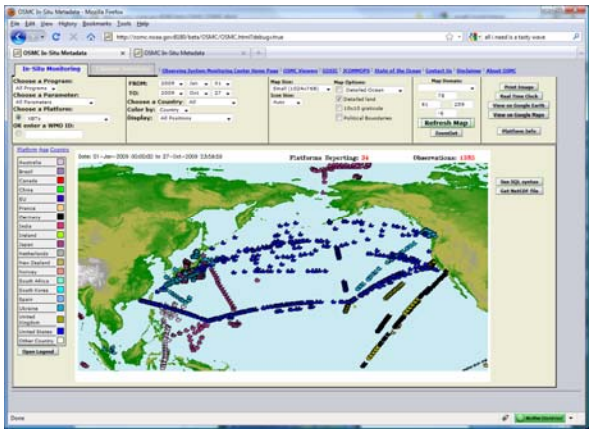

Figure 12. North Pacfic XBT's for 2009

- PMEL added the Equivalent Buoy Density (EBD) product to the OSMC Climate Services offerings. The EBD product is designed to show where additional drifting buoys should be added in order to improve satellite bias corrections for SST. See Figure 6 (right).
- Completed enhancements to the OSMC as required for initial IOOS purposes. Figure 8 (right) shows the OSMC "Coastal Viewer" -- a Google Maps-based interface to interact with platforms belonging to the IOOS group.
- PMEL has revised and simplified the OSMC home page, hosted at the Climate Program Office. This is a continuing task. Current plans include using the Google Web Toolkit to integrate all aspects of OSMC interaction into one page, including monitoring, evaluation and data access services. See Figure 13 for a current snapshot of the OSMC prototype home page and more detail in the FY10 work plan.

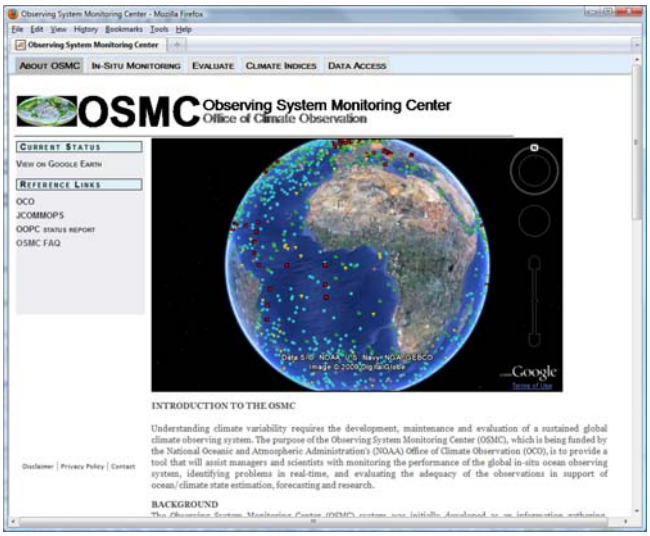

Figure 13. Prototype of new OSMC home page being designed at PMEL.

- Several platform types and parameters were made selectable in the LAS viewer: IOOS program; CORIOLIS program; Fugacity of Carbon in Sea Water; Tidal Elevation with respect to Local Chart Datum; and Meteorological Residual Tidal Elevation
- PMEL worked with Dr. Andy Chiodi to integrate the Ocean Observations Panel for Climate's (OOPC) State of the Ocean website into the OSMC. The state of the ocean site calculates and displays the status of various ocean indices, such as Nino3.4, the Tropical Northern Atlantic Index (TNA), etc. See Figures 7 and 14.

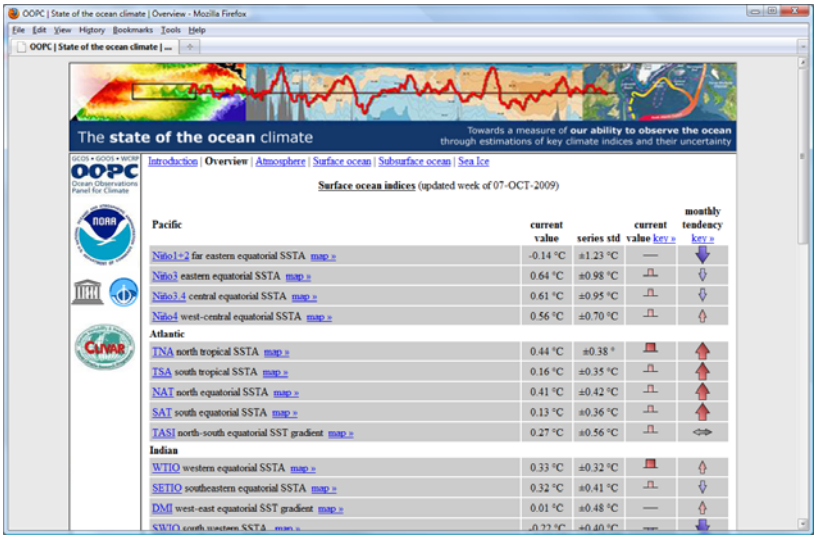

Figure 14. State of the Oceans overview, summarizing ocean-climate indices.

NDBC Accomplishments

- Continued to update the OSMC Oracle database and NetCDF files with data from the following sources:
    - GODAE data files (Met and Profiles)
    - GTS feed from NWSTG
    - WMO Allocation table (Country info)
    - WMO Pub 47 data (meta-data)
    - JCOMOPS WMO Platform Cross-Reference (meta-data)
    - NDBC Platform Data
    - NDBC IOOS Platforms
    - VOS Clim Ships

  We are currently managing the data update for 3 separate schemas:
    - Version 1 – Supports gridded summary generation
    - Version 3 – current production database
    - Version 4 – target production database
- During fiscal year 2009 NDBC processed and ingested approximately 198 million observation records into the OSMC database.
- During fiscal year 2009 added 2,698 new platforms to the OSMC database.
- Acquired and installed new database server hardware (Dell PowerEdge 2950 server and PowerVault MD300 disk array) to improve database performance.

- Migrated data from June 2004 through 2009 for both GTS and GODAE from version 3 schema to version 4 schema.
- Migrated data feeds, and meta-data feeds to the Version 4 database schema.
- Implemented NGDC scripts that build the daily summary tables in the V4 schema
- Data Enhancements:
    - Developed routine to ingest DART data from the NDBC web site
        - Ingested data from 13 Sept 2009 - present
    - Identified Ice Tethered profilers within the OSMC database
    - Use of JCOMMOPS to update program-platform relations table
    - Implemented VOS masking of ships
    - Properly identified XBTs in historical data
- Developed and implemented:
    - CREX decoder – Australian Tide Gauge data
    - FM62/TRACKOB Decoder
    - CSML Decoder – SOCAT carbon data
- OSMC operational environment:
    - Performed OSMC server upgrades and security patches as required
    - Provided network/administration support as required in support of OSMC
- Research Items:
    - Provided initial draft of GTS message flowchart
    - Provided initial draft of meta-data flowchart
    - Produced reports showing the mean, median, minimum, maximum, standard deviation of the report interval for each platform for drifting buoys, moored buoys and ARGO floats.
    - Continued investigations of differences between GODAE Server and NOAAport real-time feeds
    - Australian Tide Gauge station issues
    - Reused WMO ids (algorithms to disambiguate platforms)

NGDC Accomplishments

- Database Design and Implementation Services
    - Led the OSMC V4 redesign and migration to Version 4 of the OSMC database. Daily_Summary and Daily_Unique_Observations reporting table load process developed and delivered to NDBC for local operational implementation. (Reporting tables facilitate simpler queries and improve query performance for OSMC client applications as they eliminate duplicate records, and provide summary counts for XBT drops and observation counts.)
    - Developed Java tool to facilitate daily loads that also incorporates delayed mode data ingest into summary tables.
    - Performed validation of XBT identification and drop counts via the reporting tables and cross-walked results with information available from JCOMMOPS.
- Java Climate Science Modeling Language (CSML) libraries
    - Worked with partners from UK NERC and the Reading e-Science Centre (J. Blower, A. Woolf, D. Lowe) to test and improve Java CSML libraries. Incorporated libraries into products that use CSML in OSMC.
- Data Ingest into the OSMC database

- Provided Java class library and templates to PMEL that provided conversion of OceanSITES and SAMOS datasets (in NetCDF) into CSML. The CMSL format allows the design of a single decoder for loading into OSMC for a wide variety of non-GTS based data formats.

- Access to OSMC database contents via Web Services
  - Provided a web service that allows OSMC clients to access different OSMC platform types as logical CSML feature types with embedded data. CSML provides standards based way for accessing and downloading OSMC data.
  - Provided access to OSMC contents via the OGC's Sensor Observation Service (SOS) with output in a variety of formats including CSML, IOOS DIF, and KML.
  - Provided recommendations on how to handle ambiguous platform identifiers from WMO (explored the use of URIs).
  - For IOOS collaborations provided service access using the IOOS 'DIF' format via the Sensor Observations Services.

4. Education and Outreach

The OSMC is an education and outreach resource that is available to support NOAA managers, NOAA and non-NOAA scientists and the general public including classroom education. Output graphics from the OSMC are increasingly seen in science presentations from a variety of quarters and are used regularly in planning documents that refer to both NOAA and non-NOAA components of the ocean-climate observing system – in particular NOAA PPBES documents. Although the OSMC project has not to date been directly involved in the development of classroom curricula it is a resource that has great potential to support interactive classroom education and to increase public awareness about the scope of activities and the importance of our global *in situ* ocean observing system.

5. Publications and Reports

5.1. Presentations by Principal Investigators and project members

O'Brien,K.M., Hankin,S.C., Haberman,T., Kern,K., Schweitzer,R., Little, M. Snowden, D., Catrwright, J. Laroque, J., Li, J., Malczyk, J., and Manke, A., 2008: Moving Toward Climate Data Integration: The Observing System Monitoring Center, AGU Fall Meeting, 15-19 December, 2008, San Francisco, CA

Snowden, D., Habermann, T., Cartwright, J.C., Larocque, J., Kern, K., Little M. and O'Brien, K.M., S. HankinHabermann, T., and O'Brien, K.M., 2008: Extensible Database Designs for Marine Observations, AGU Fall Meeting, 15-19 December, 2008, San Francisco, CA

O'Brien, K.M., Hankin, S.C., Schweitzer, R., Habermann, T., Cartwright, J., Larocque, J., Kern, K., and Little, M., 2009: Using THREDDS to "sew" observational data into the Observing System Monitoring Center, 89th AMS Annual Meeting, 11-15 January 2009, Phoenix, AZ

Hankin, S.C., 2009: Ocean Data Management: The Way Forward, OceanObs'09 Conference, 21-25 Sept. 2009, Venice, Italy