Ocean Climate Observation Program
FY 2009 Progress Report

Spring 2009

Project Initiation Year: 2000

Project Summary:

NOAA's Ocean Climate Observation program is the core of the ocean sub-capability of NOAA's Climate Observations and Monitoring Program. The Ocean Climate Observation program also constitutes the backbone of the Global Component of the U.S. Integrated Ocean Observing System (IOOS). IOOS is the U.S. contribution to the international Global Ocean Observing System (GOOS), which is the ocean baseline of the Global Earth Observation System of Systems (GEOSS).

In 2003 the Project Office for Climate Observation (OCO) was established under the auspices of the Climate Program Office (CPO) to manage the Ocean Climate Observation program. It is the job of OCO to advance its multi-year *Program Plan for Building a Sustained Ocean Observing System for Climate*, which is updated annually. The intended outcome is a sustained global system of complementary *in situ*, satellite, data, and modeling subsystems adequate to accurately document the state of the ocean and to force climate models. The observing system is being put in place to meet climate requirements but it also supports weather prediction, global and coastal ocean prediction, marine hazard warning systems (e.g., tsunami warning), transportation, marine environment and ecosystem monitoring, and naval applications. Many non-climate users also depend on the baseline composite system that is nominally referred to as the Sustained Ocean Observing System for Climate.

The Sustained Ocean Observing System for Climate is a composite system-of-systems comprised of ten complementary sub-systems or networks (illustrated in Figure 1). The networks are managed by 22 distributed centers of expertise at NOAA laboratories, centers, joint institutes, universities and business partners. The "System" is centrally managed at the Office of Climate Observation. Specifically, OCO's tasks are to:

- Monitor the status of the globally distributed networks; report system statistics and metrics routinely and on demand;
- Evaluate the effectiveness of the system; take action to implement improvements through directed funding;
- Advance the multi-year program plan; evolve the *in situ* networks through directed funding;
- Focus intra-agency, interagency, and international coordination;
- Organize external review and user feedback; and
- Produce annual reports on the state of the ocean and the adequacy of the observing system for climate.

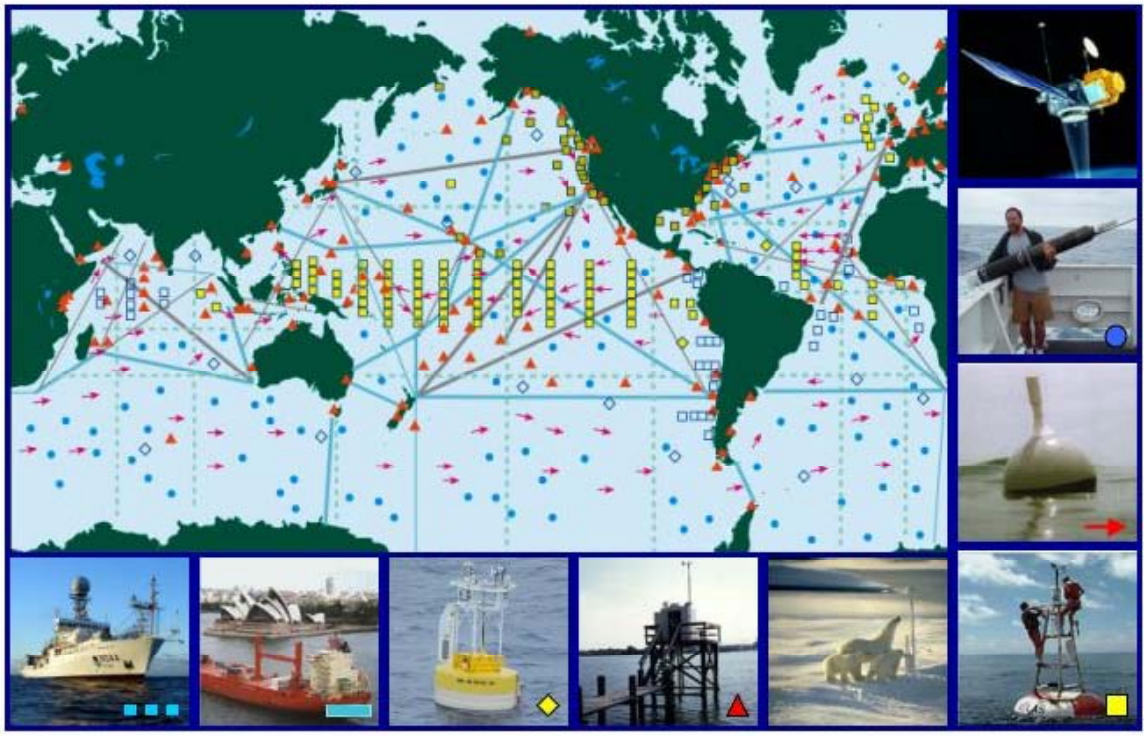

Figure 1. The Networks that make up the Sustained Ocean Observing System for Climate are (from lower left to upper right): Dedicated Ships, Ships of Opportunity, Ocean Reference Stations, Tide Gauge Stations, Arctic Observing Systems, Tropical Moored Buoys, Surface Drifting Buoys, Argo Profiling Floats, and Continuous Satellite Missions for sea surface temperature, sea surface height, surface vector winds, ocean color, and sea ice. Not illustrated are the Data & Assimilation Subsystems and Analysis Products.

The 22 distributed centers of expertise that are implementing NOAA's contributions to the system are at AOML, PMEL, ESRL, GFDL, JIMAR (University of Hawaii), JIMO (Scripps Institution of Oceanography), CICOR (Woods Hole Oceanographic Institution), JISAO (University of Washington), CIMAS (University of Miami), CICAR (Columbia University), CIFAR (University of Alaska), NCDC, NODC, NGDC, CO-OPS, OMAO, NDBC, NCEP, FSU (Florida State University), LSA, CLS America, and OCO. The contributions of these centers are summarized by the project managers in their individual reports, which are published each year in OCO's *Annual Report on the Ocean Observing System for Climate.*

Across the United States there are 46 Federal employees, and 81 non-Federal employees working to implement NOAA's contribution to the global ocean observing system. Within the OCO project office there are seven Federal employees, and two non-Federal employees.

Partnerships are central: A global observing system by definition crosses international boundaries, with potential for both benefits and responsibilities to be shared by many nations. All of the Ocean Climate Observation program contributions to global observation are managed internationally in cooperation with the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). The

Ocean Climate Observation program sponsors nearly half of the observing system platforms in the global ocean, and provides approximately half of the funding needed to support JCOMM's technical infrastructure. OCO employees provide international leadership through active service in the JCOMM Management Committee, Expert Teams, and the Implementation Panels, and have held the office of JCOMM Observations Program Area Coordinator since 2002.

OCO also works cooperatively with other U.S. agencies, especially the National Science Foundation (NSF). The ongoing NSF-NOAA cooperative project for CLIVAR-ocean carbon surveys has proved to be an interagency-international-interdisciplinary success. NSF has initiated the Ocean Observatories Initiative (OOI), which will provide significant infrastructure in support of ocean climate observation; OCO is committed to working with NSF to jointly maintain climate reference stations at the OOI global ocean observatory sites.

Mission and Requirements: The mission of the OCO is to build and sustain a global climate observing system that will respond to the long term observational requirements of the operational forecast centers, international research programs, and major scientific assessments. The focus is on building the *in situ* ocean component. The top-level requirements are to:

- Document long term trends in sea level change;
- Document ocean carbon sources and sinks;
- Document the ocean's storage and global transport of heat and fresh water; and
- Document ocean-atmosphere exchange of heat and fresh water.

Deliverables: The ocean climate observing system must have the capability to deliver continuous instrumental records and analyses accurately documenting:

- Sea level to identify changes resulting from climate variability;
- Ocean carbon content every ten years and the air-sea exchange seasonally;
- Sea surface temperature and surface currents to identify significant patterns of climate variability;
- Sea surface pressure and air-sea exchanges of heat, momentum, and fresh water to identify changes in the forcing function driving ocean conditions and atmospheric conditions;
- Ocean heat and fresh water content and transports to: 1) identify changes in the global water cycle; 2) identify changes in thermohaline circulation and monitor for indications of possible abrupt climate change; and 3) identify where anomalies enter the ocean, how they move and are transformed, and where they re-emerge to interact with the atmosphere; and
- Sea ice thickness and concentrations to identify changes resulting from, and contributing to, climate variability and change.

Present ocean observations are not adequate to deliver these products with confidence. The fundamental deficiency is lack of global coverage by the *in situ* networks. Present international efforts constitute only about 61% of what is needed. The *Second Report on the Adequacy of the Global Observing System for Climate in Support of the UNFCCC* concludes that "the ocean networks lack global coverage and commitment to sustained

operations…Without urgent action to address these findings, the Parties will lack the information necessary to effectively plan for and manage their response to climate change."

In response to the Second Adequacy Report, international GCOS produced the *Implementation Plan for the Global Observing System for Climate in support of the UNFCCC* (GCOS-92). GCOS-92 was published in October 2004. It has been endorsed by the UNFCCC and by the Group on Earth Observation (GEO). In particular:

1. The UNFCCC, Decision CP.10, "Encourages Parties to strengthen their efforts to address the priorities identified in the [GCOS] implementation plan, and to implement the priority elements …"
2. The *Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan Reference Document* targets include: "Support implementation of actions called for in GCOS-92."

OCO's *Program Plan for Building a Sustained Ocean Observing System for Climate* is in complete accord with GCOS-92 and provides the framework for NOAA contributions to the international effort. In particular 21 of the specific actions listed in the GCOS-92 ocean chapter (pages 56-84) are being acted upon by the OCO program in cooperation with the implementation panels affiliated with JCOMM. These specific GCOS-92 actions provide the roadmap to guide annual work plans. GCOS-92 is accessible via link from the OCO web site: www.oco.noaa.gov -- click on "Reports & Products." The work supported by OCO is directed toward implementation of this international plan and the projects are being implemented in accordance with the GCOS Ten Climate Monitoring Principles. The OCO-supported projects contributed 48% of the total international effort in 2009.

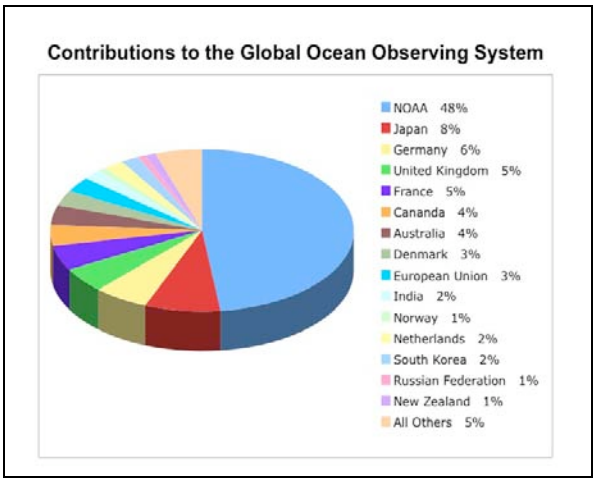

Figure 2: Relative contributions to the Global Ocean Observing System.

FY 2009 Accomplishments:

FY 2009 accomplishments are detailed in the individual Project Manager reports. Some highlights include:

- The international global ocean climate observing system overall advanced from 60% complete in 2008 to 61% complete in 2009. Some highlights for 2009 included:
    - The Global Drifting Buoy array was maintained at its design strength of 1250 data buoys in service for the fifth continuous year since 2005, which enabled NOAA to continue meeting its GPRA Performance Measure for reducing the error in global measurement of sea surface temperature.
    - The Argo profiling float array was maintained at its design strength of 3000 floats in sustained service for the third continuous year since 2007.
    - RAMA, the tropical moored buoy array in the Indian Ocean, progressed from 20 to 24 stations in operation.
    - Transition of the Weddell Sea ocean reference station from the NOAA Climate Variability and Predictability Program to OCO funding was completed.
    - An NOAA-NSF CLIVAR/Carbon survey line in the Indian Ocean was completed aboard the UNOLS ship Roger Revelle.
    - An improved methodology for determining seasonal air-sea fluxes of CO_2 was implemented, blending ocean surface measurements of pCO_2 from volunteer observing ships and buoys with remote sensing.

- The Ocean Climate Observation program made the following contributions to the GCOS initial implementation targets for sustained global ocean observing system operations:
    - Tide gauge stations: 16% (the 2009 total international effort was estimated to 62%)
    - Surface Drifting Buoys: 49% (the 2009 total international effort was estimated to be 79%)
    - Tropical Moored Buoys: 64% (the 2009 total international effort was estimated to be 79%)
    - Ships of Opportunity: 24% (the 2009 total international effort was estimated to be 67%)
    - Argo Profiling Floats: 58% (the 2009 total international effort was at 100%)
    - Ocean Reference Stations: 14% (the 2009 total international effort was estimated to be 36%)
    - Ocean Carbon Networks: 25% (the 2009 total international effort was estimated to 43%)

- The NOAA-NSF CLIVAR/Carbon survey made full-depth measurements of carbon, tracers, oxygen, nutrients, and physical oceanographic parameters. This international project conducts the only routine measurements sampled below the depth of the ARGO array. Recent findings contribute to ongoing analyses of anthropogenic carbon uptake in the global oceans, and demonstrate warming of abyssal waters.

- A joint OCO-National Marine Fisheries Service project, “Moored carbon, biogeochemical, and ecosystem observations in the Southern California Current,” was initiated to establish a mooring in the California Current for ecosystem monitoring to complement the flow and transport monitoring system that has been initiated under prior OCO funding, and to start building a comprehensive real-time monitoring system for this region.

- The Russian-American Long-term Census of the Arctic (RUSALCA) cruise extended 400 km farther north than ever before, with all objectives met.

- The World Ocean Heat Analysis conducted by the National Oceanic Data Center commenced quarterly updates.

- A Global Sea Level Index from tide gauges was developed for 1960-2009 by the University of Hawaii Sea Level Center.

- The U.S. has continued to maintain more than one-half of the global array of Argo floats (the U.S. commitment is one-half), presently deploying operational Argo floats. Approximately 90% of the profiles eligible for delayed-mode processing (i.e., greater than one year old) have been processed and submitted to the GDACs. This compares with slightly more than 60% a year ago and an average for the global array of approximately 60%. This reflects an increased effort in delayed-mode quality control in 2009 and will extend into 2010.

Program Funding Summary

Ocean Climate Observation Program Funding History								
Network			$ K					
Program Expenditures	**FY 02**	**FY 03**	**FY 04**	**FY 05**	**FY 06**	**FY07**	**FY08**	**FY09**
Tide Gauge Stations	670	710	970	1196	1177	1196	1196	1496
Drifting Buoys	1699	2077	2769	3130	3427	3130	3169	3400
Tropical Moored Buoys	3175	3175	3625	4360	3094	3329	2850	4323
Ships of Opportunity	1960	1903	2487	2907	2776	2804	2678	2224
Argo Profiling Floats	6749	9459	9835	9218	9108	9152	9201	9451
Ocean Reference Stations	1712	2082	2998	2995	3958	5071	5747	6379
Ocean Carbon Networks	1478	2204	2875	3521	3482	3181	3177	3344
Arctic Observing System	1937	4659	3988	5325	5237	4031	4096	5095
Dedicated Ship Time	0	626	523	92	542	378	1801	674
Data & Assimilation Subsystems	1286	1323	1487	1418	1331	1036	1229	1198
CLS Argos Data Processing	813	480	1525	1408	823	1143	1590	1672
Product Delivery, Analysis/Reanalysis	578	638	896	1982	2048	2572	2697	3016
Institutional Infrastructure	1126	1175	1791	1878	1084	1591	1371	993
Total	**23183**	**30511**	**35769**	**39430**	**38087**	**38614**	**40802**	**43265**
					38087	38614	40802	43265
Program Income								
Ocean Observation					17657	18490	20741	22266
Sustained Ocean Observations					5334	5389	5755	5640
Argo					9758	9758	9758	9776
Arctic					4927	3694	3995	5095
Other					411	1283	553	488
Total					**38087**	**38614**	**40802**	**43265**

Figure 4: System Funding Record

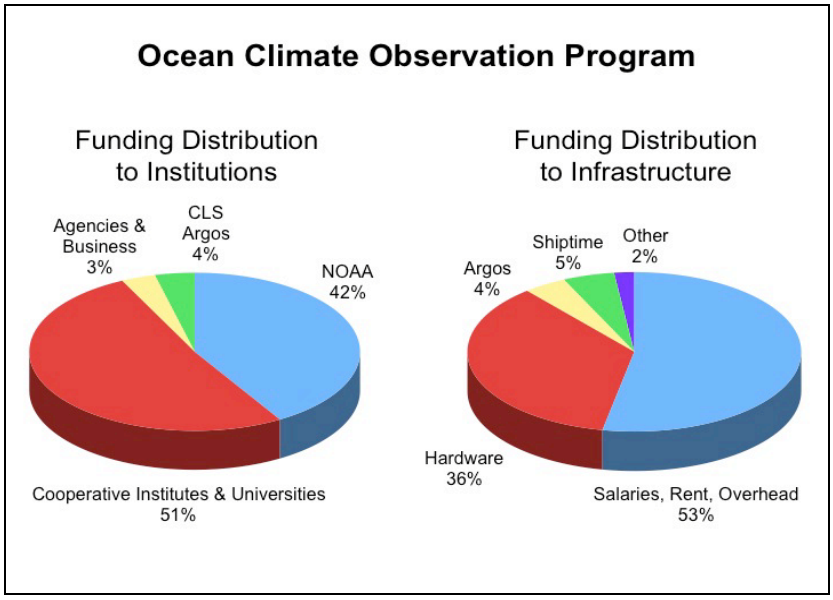

Figure 5: Program funding distribution.