OPERATIONAL OCEANOGRAPHY AT THE NAVAL OCEANOGRAPHIC OFFICE: REAL-TIME OCEANOGRAPHIC MEASUREMENTS

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Abstract

The Naval Oceanographic Office (NAVOCEANO) currently collects data from a variety of real-time satellite and in situ sensors that are processed into tailored fleet products within hours. Satellite sea surface temperature (SST) data are generated from a variety of polar-orbiting and geostationary satellites including NOAA-18/19, METOP, GOES, and MSG. These data are directly assimilated into operational ocean models in near-real-time and are also used to generate regional fleet support products. Satellite altimeter data are received from Jason-1, Jason-2, and ENVISAT altimeters to maintain continuous sea surface height observations that are assimilated into operational ocean models. Significant wave height and marine wind speed products are also generated to support operational maritime activities. Satellite ocean color data are received from sensors aboard two polar-orbiting satellites, SeaWiFS and MODIS. These data are processed into visibility, chlorophyll, and K532 products for a broad range of fleet support. Each data set described here is routinely checked for accuracy, coverage, and timeliness requirements. In addition, NAVOCEANO deploys profiling floats, drifting buoys, and ocean gliders throughout the world to measure surface and subsurface oceanographic parameters such as temperature, salinity, currents, and optics. These tools enable NAVOCEANO to persistently sample areas of naval interest and, coupled with performance models, provide characterization of the operational environment.

1. INTRODUCTION

Maritime activities, numerical weather prediction, and ocean forecasting depend upon accurate depiction of the ocean environment. Proper ocean characterization, forecasting, and at-sea operations support have been historically challenged by the relative sparseness of real-time ocean data. Compared to atmospheric prediction, ocean forecasting has lacked the persistent sampling networks and timely data flow necessary to forecast and validate ocean conditions. However, recent advancements in ocean data collection and processing have allowed the naval oceanography community to establish an effective real-time ocean characterization and forecast capability. Numerous satellite and in situ data sources are now providing surface and sub-surface data that are directly assimilated into operational ocean models and other products supporting the fleet. This paper details these oceanographic measurement advances made at NAVOCEANO during the past decade.

2. OCEAN OBSERVING CAPABILITIES PROVIDING NEAR REAL-TIME DATA

2.1 Satellite Sea Surface Temperature

Satellite SST data provide timely synoptic coverage of the global ocean surface needed for ocean model data assimilation and fleet support products. NAVOCEANO began operational production of satellite SST retrievals in 1993 from the NOAA-11 satellite [1]. The processing is fully automated and monitored 24/7 to meet timeliness, accuracy, and spatial coverage requirements. SST processing was limited to global 4km AVHRR GAC data and a single satellite until 1999, when modified to include both NOAA-14 and NOAA-15 into operations.

A significant improvement to SST processing occurred in 2002 with the implementation of a high resolution 1km land mask, allowing operational production from 1km AVHRR LAC data sets that provides high resolution data close to coastal areas. NAVOCEANO also implemented GOES-East and GOES-West SST processing into operational production in 2002. Together, these enhancements provided better regional data coverage and improved mesoscale feature depiction.

Beginning in 2004, NAVOCEANO's participation in the GODAE High Resolution SST Pilot Project [2] provided access to multiple international satellite SST data sets. These new data sets were individually evaluated, and many are now routinely assimilated into our operational analyses and forecast models. In the past decade, NAVOCEANO's satellite SST data capability has improved from 200 thousand retrievals per day with 12 hour spatial refresh to 20 million retrievals per day with hourly refresh.

2.2 Satellite Altimetry

NAVOCEANO's Altimeter Data Fusion Center (ADFC) began processing satellite altimeter data for assimilation into operational ocean models and ocean products in 1992 [3]. Processing began with ERS-1 and TOPEX/Poseidon. A third altimeter (GFO) was launched by the Navy in 1998 and added to operations.

Today, the ADFC generates sea surface height (SSH) and significant wave height (SWH) data from Jason-1, Jason-2, and ENVISAT altimeters. SSH products are vital inputs to ocean circulation models, while also providing primary input into upper-ocean heat content analysis and hurricane intensity models utilized by the Tropical Prediction Center. In addition, wave products are generated and delivered to operational centers for maritime support.

Sustainment of three or more altimeters is important for meeting the data assimilation requirements of operational ocean models. Several international agencies have successfully cooperated to provide this capability during the past decade. Unfortunately, it is a high probability that data from three or more altimeters will not be publicly available during the next 4 to 5 years unless new collaborative agreements are successful.

2.3 Satellite Ocean Color

NAVOCEANO began its operational production of satellite ocean color products in 2001 from the SeaWiFS sensor on Orbview-2. SeaWiFS ocean color imagery is presently obtained by direct High Resolution Picture Transmission (HRPT) reception at Naval Meteorology and Oceanography Command centers in Rota, Bahrain and Yokosuka. The 1.1 km data are forwarded to NAVOCEANO in near real-time for processing and distribution of resultant products [4]. Additionally, NAVOCEANO produces daily optical products from ocean color imagery received from MODIS Aqua. MODIS Aqua provides global coverage at 250 m and 1.1 km resolution. NAVOCEANO has a subscription service to receive data from selected regions, based on fleet requirements, from NOAA/NASA. Optical products are distributed on the Naval Oceanography Portal, both classified and unclassified (www.usno.navy.mil) for strategic and operational fleet support, and can include diver visibility for fleet and diver guidance, vertical visibility for diver or asset vulnerability, attenuation fields for electro-optical system performance assessments, and chlorophyll biomass for circulation model evaluations.

2.4 Ocean Gliders

NAVOCEANO has utilized a growing fleet of ocean gliders since 2007 to observe oceanographic conditions in regions of high interest. Total observations to date are in excess of 25,000 ocean profiles. Our current inventory includes twelve Seagliders (iRobot), four Slocum gliders (Teledyne Webb Research), and two Spray gliders (Scripps Institution of Oceanography). However, NAVOCEANO expects to receive approximately 150 Littoral Battlespace Sensing-Glider (LBS-G) systems from the Space and Naval Warfare Systems Command over the next five years. These LBS-G systems are based on the Slocum glider, which is an unmanned underwater vehicle that uses changes in its buoyancy, a rudder in the tail section, and wings to move through the water at a forward speed of approximately 0.5 knots. These systems are capable of diving to a depth of 1000 meters while measuring temperature, salinity, sound speed, and a range of optical parameters, depending on the sensor configuration [5]. Data collected from these systems are critical to NAVOCEANO's efforts to provide relevant oceanographic knowledge to the fleet during Anti-Submarine Warfare, Mine Warfare, and Naval Special Warfare exercises and operations.

2.5 Profiling Floats and Drifting Buoys

NAVOCEANO has actively deployed drifting buoys since the 1980s to support operational requirements. Buoys are manufactured to meet specifications for either ship or air deployment. Original deployments were primarily intended to meet tropical storm warning and ocean circulation model validation requirements. By 1999, more than 200 drifting buoys were being deployed each year to support these requirements. In 2009, buoy deployment requirements have significantly changed to focus on regional ocean circulation model validation requirements. Approximately 70 are deployed each year in specific regions of the world.

NAVOCEANO began purchasing profiling floats in 1998. Fifteen floats were deployed that year to provide accurate three-dimensional temperature and salinity data for assimilation into operational ocean models. In 2009, NAVOCEANO is routinely deploying 30 floats per year and typically has 50+ floats active in the water each month. Together with the 3000+ international Argo profiling float program assets [6], these data have significantly enhanced the volume and accuracy of in situ data available for assimilation into operational ocean models.

2.6 Public Ocean Data on GTS

NAVOCEANO routinely obtains numerous ocean observations via the public GTS communications network. A decade ago, these observations included XBTs, CTDs, profiling floats, ship reports, fixed buoy reports, and drifting buoys reports. Each day about 16,000 surface and 115 sub-surface observations were assimilated into operational ocean models within 6 hours of data acquisition.

The quantity of real-time ocean in situ data has significantly increased during the past decade and now includes profiles taken by ocean gliders and marine mammals. Each day about 50,000 surface and 1,070 sub-surface observations are assimilated into models within 2 hours of data acquisition. These enhancements provide better data coverage and improved ocean model accuracy.

3. SUMMARY

The advancements in ocean data collection and processing during the last ten years have significantly improved our ability to characterize and forecast the ocean environment. The quantity of in situ and satellite ocean data has expanded by an order of magnitude. In addition, improvements to communications and data processing have made it possible to assimilate the data into analyses and models within a few hours of sensor measurement. Access to these various data sets has made it possible to move from climate planning products into the realm of persistent sampling and forecasting.

4. REFERENCES

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