

# Relocatable Shipboard Coastal Modeling System

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## LONG-TERM GOAL

The development of limited-area, open-boundary, nowcast/forecast systems that have a stand-alone, shipboard capability and which can be applied around the globe, especially in shallow coastal waters.

## OBJECTIVES

The transition of a scalable (workstation through high-performance computing platform) system for producing optimal regional and tactical scale ocean nowcasts and forecasts to related 6.4 projects.

## APPROACH

Adapt, develop, and evaluate the components necessary for a limited-area, coastal nowcast/forecast system and integrate these components into a demonstration system for evaluation, comparison, and transition. This system is called NOMADS, for NRL Ocean Models and Assimilation Demonstration System, and is outlined below. The key modules in the present version of NOMADS are the Modular Ocean Data Assimilation System (MODAS), a set of programs and scripts for performing optimum interpolation using a first-guess derived from satellite measured altimetry (SSH) and sea surface temperatures (SST), plus a relocatable version of the Princeton Ocean Model (POM). Future versions will include tide, wave, and surf modules. The entire system is constructed using a “modular” philosophy, permitting rapid prototyping and testing of new algorithms and capabilities.

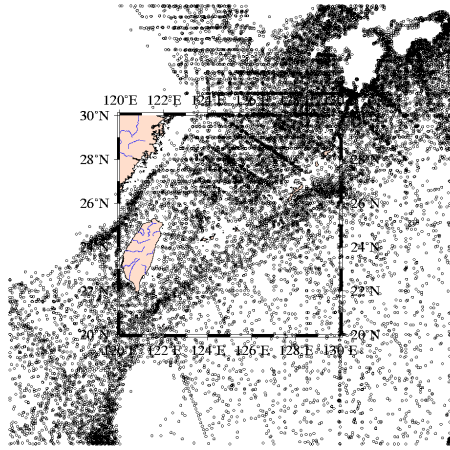
The figures below and on the following pages outline the process of using satellite altimetry and temperature measurements to form a “synthetic profile”. NAVOCEANO uses a subset of MODAS modules to produce daily 1/8 degree analyses of SSH and SST which are used by the full version of MODAS to generate a full 3-dimensional grid of temperature and salinity, into which in situ BT's and CTD's are assimilated. The synthetic BT algorithms are based on a re-analysis of approximately 100 years of MOODS data, totaling nearly 2 million profiles. Figure 1a displays the locations of data used to derive regressions in the vicinity of Korea, for example. Regression relationships are derived to relate surface height and temperature to subsurface temperature and a companion set of coefficients is derived to estimate salinity from temperature. These relationships are stored on a variable-resolution grid (illustrated in figure 1b below) with sampling of 1 degree in deep water (and in data-sparse areas) and decreasing to 1/8 degree in the littoral.

# Report Documentation Page

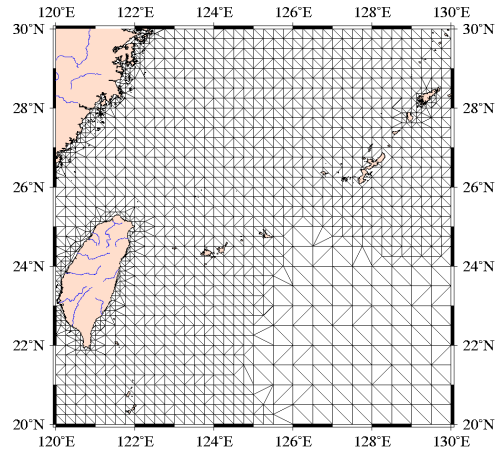
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**Figure 1a: Historical data locations**



**Figure 1b: Variable resolution grid**

## WORK COMPLETED

An initial version of MODAS2 was beta tested during the NATO Rapid Response / Strong Resolve '98 exercise off Sierra de Retin in southwestern Spain. As a result, significant improvements were made and the overall database structure revised to support the variable resolution grid. The changes were significant enough that this version is referred to as MODAS2.1.

The NOMADS interface is being replaced by a system-independent, web-based version. The old version was hard-coded in the C++ computer language, which made rapid updates difficult. The new version is written as Javascript components which run inside the user's web browser plus Perl CGI scripts which run on a webserver. This permits the user to run MODAS (and POM and other modules as they are added) on a Unix server system while sitting at any computer that supports a web browser (such as their Windows '95 or NT systems, or a TAC-IV). Some limitations have been encountered in the present Perl/Javascript approach and we are investigating switching to a full Java-based interface.

## RESULTS

The figures below show an example of the MODAS synthetic BT algorithms off the northeast US. In the first figure, all three pictures show the temperature at 200 meters. The left displays climatology, the middle after a MODAS synthetics based on surface temperatures only, and the right displays the full MODAS synthetics including both surface temperature and satellite altimetry. Clearly in this example, the altimeters "saw" a cold core eddy which was not represented in the surface temperature.

In the second figure, vertical sections display climatology (left), the actual in situ XBT survey (middle), and the MODAS synthetics (right). It is important to note that no in situ BT data was used in any of the MODAS analyses shown. The "buried" eddy revealed here was reproduced solely from satellite measured quantities applied to the MODAS synthetic profile algorithms.

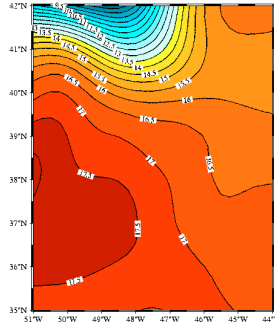
## MODAS Validation Example: Using SSH and SST



6-Aug-1995

**200 m temperature  
Climatology**

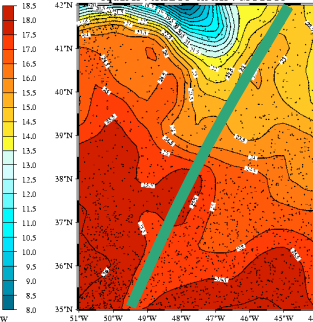
Climatological Temperature (Degs C)  
200 m 1995/08/06



**MODAS including MCSST  
does not significantly alter  
climatology**

Temperature (Degs C) from OI Analysis  
0 m 1995/08/06

squares -> AXBTs circles -> MCSSTs



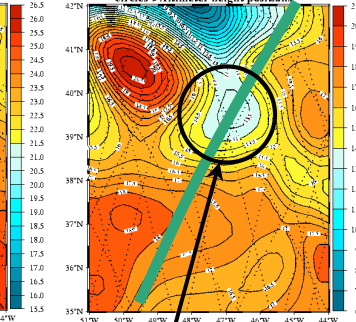
AXBT Line

Points:  
MCSST

**SSH reveals  
concealed ocean  
environment**

Climatological-SSH Temperature (Degs C)  
200 m 1995/08/06

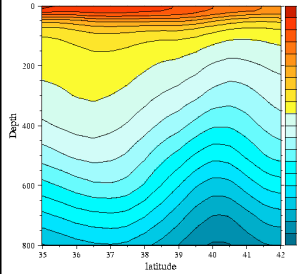
circles -> Altimeter height positions



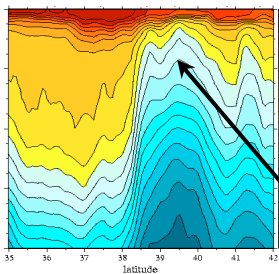
Cold core eddy

## MODAS Validation Example: AXBT Survey

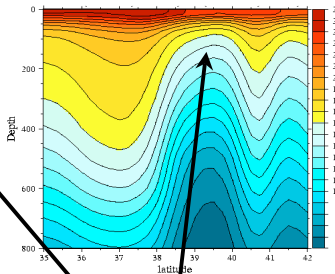
**Climatological Temp**



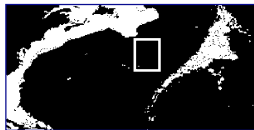
**AXBT Temp**



**MODAS results  
SSH + SST + Clim**

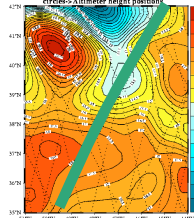


Cold core eddy



Climatological-SSH Temperature (Degs C)  
200 m 1995/08/06

circles -> Altimeter height positions



**MODAS  
Temperature  
at 200m**

## **IMPACT/APPLICATION**

The present version of the MODAS climatology and synthetic profile algorithms represent a significant advance in operational oceanography. It is now possible to generate nowcasts which are significantly better than climatogoy virtually anywhere in the world's oceans, from deep water through the littoral, based solely on satellite remote sensed properties. These nowcasts provide an accurate estimate of the temperature and salinity structure which can be further refined by including in situ BT and CTD data, where available.

## **TRANSITIONS**

The initial version of MODAS2.0 was transitioned to the 6.4 Rapid Response project, where it was used to provide the oceanography and currents during the NATO Rapid Response '98 rapid environmental assessment (REA) and the related Strong Resolve '98 NATO naval exercise.

After significant improvements, MODAS2.1 was transitioned to the 6.4 ROAMER project, which delivered it to NAVOCEANO where it is now producing nowcasts for over 30 regions and relocatable POM forecasts for about 15 of those. These analyses vary from special support areas to large regional areas which are sent to the regional METOC centers where they are used to initialize their existing MODAS1.6 systems.

## **RELATED PROJECTS**

This project works closely with the 6.4 On-Scene Tactical Ocean Forecast Capability, which this year delivered a special "light" version of MODAS to the NITES-I AFLOAT project (formerly TESS-NC) and is now working on delivering a full version of MODAS for the NITES-I ASHORE system where it will co-exist with TAMS-RT (COAMPS) on large SGI computers at selected regional centers.

The project also works closely with the 6.4 ROAMER project, which handles transitions of NOMADS modules to NAVOCEANO. It also provided the MODAS modules which the NRL Altimeter Support Group is using to transition the altimetry processing system to the NAVO Altimeter Data Fusion Center.

This project relies on other 6.1 and 6.2 projects to do the initial R&D of the models and assimilation methods it will use. The relocatable coastal ocean model is being developed in the 6.2 Model Evaluation and Performance Project; techniques for nesting this model in regional and global large scale models are being developed in the 6.2 Ocean Data Assimilation Project (formerly DART); wave models are being developed in the 6.4 Surf Model Upgrade project.

## **PUBLICATIONS**

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Smedstad, O.M., D.N. Fox, H.E. Hurlburt, G. Jacobs, E.J. Metzger, J.L. Mitchell, 1997: Altimeter Data Assimilation into an 1/8 degree eddy resolving model of the Pacific Ocean, in "Data Assimilation in Meteorology and Oceanography: Theory and Practice", edited by Michael Ghil, M. Kimito, and others, published by the Japan Meteorology Society.

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