19.1 THE NAVY'S ON-SCENE WEATHER PREDICTION SYSTEM, COAMPS-OS™

Daniel A. Geiszler *, John Kent, AND Jennifer L. S. Strahl
Science Applications International Corporation, Monterey, California

John Cook, Gary Love, Larry Phegley, Jerome Schmidt, AND Quiqyun Zhao
Marine Meteorology Division, Naval Research Laboratory, Monterey, California

Francisco Franco, Linda Frost, Michael Frost, Daren Grant,
Steve Lowder, AND Daniel Martinez
Computer Sciences Corporation, Monterey, California

Lari M. McDermid
Neptune Science Inc., Slidell, LA

1. INTRODUCTION

COAMPS-OS™ originated in the mid-1990's as an X11-based interface to configure and run the Naval Research Laboratory's operational numerical weather prediction (NWP) model, COAMPS™ (Hodur 1996, Chen et. al, 2002). The interface was designated as the On-Scene Tactical Atmospheric Forecast Capability (STAFC, Cook et. al, 1998) and demonstrated in the SHip Antisubmarine Warfare Readiness / Effectiveness Measuring (SHAREM) exercises in 1995 and 1996 and aboard the USS Nimitz in 1997. In 1998, STAFC was deployed with the Navy's operational environmental database, TEDS, and renamed as the Tactical Atmospheric Modeling System / Real-Time (TAMS/RT). With the addition of TEDS to provide near real-time atmospheric and oceanographic observations to initialize COAMPS, TAMS/RT represented the Navy's first effort to field a forward deployed NWP system at regional meteorology and oceanography centers.

By 2000, the Fleet Numerical Meteorology and Oceanography Center (FNMOC) assumed management of TAMS/RT as an operational platform called DAMPS (Distributed Atmospheric Modeling and Prediction System). DAMPS included systems located at Navy centers in San Diego (California), Yokosuka (Japan), Pearl Harbor (Hawaii), Manama (Bahrain), Norfolk (Virginia), and Rota (Spain). NRL continued to maintain TAMS/RT for other government and academic organizations that used the model to support operational weather forecasting and initialize models requiring atmospheric input.

In the past three years, TAMS/RT has undergone changes to comply with the Defense Information Infrastructure's Common Operating Environment (DII-COE), leveraged scientific and engineering enhancements to COAMPS™, and integrated advancements in computer technology. Compliancy to the DII-COE represented a major restructuring of the original TAMS/RT directory hierarchy and required a port of TAMS/RT software to Sun hardware. Following compliancy to the DII-COE, the Navy renamed TAMS/RT as COAMPS-OS™ to acknowledge the centerpiece of the system, COAMPS™. COAMPS-OS™ includes enhancements to COAMPS™ including improvements to the physics and tropical cyclone tracking, and modifications to model aerosol transport. NRL replaced the shared memory model of COAMPS™ with the Message Passing Interface (MPI) protocols that permit the model to be distributed across multiple computational nodes. With the advent of MPI-based protocols in COAMPS™, the model can be scaled across clusters of low cost, high performance PC-based workstations and servers. With cost and performance considerations, NRL chose to port COAMPS-OS™ to linux-based servers.

In mid-2003, the Naval Meteorology and Oceanography Command (CNMOC) chose to replace all DAMPS software and hardware at Navy regional centers with a centralized capability located at FNMOC. Unlike DAMPS, CAAPS (Centralized Atmospheric Analysis and Prediction System) will be operated on clusters of linux servers to support the modeling, visualization, and database capabilities available with COAMPS-OS™. With NRL's support, FNMOC expects to field CAAPS in early 2004 to support all regional centers formerly supported by DAMPS. By the end FY2004, all support for COAMPS-OS™ running on the IRIX operating system will cease.

2. COMPONENTS

Although COAMPS-OS™ has been transitioned completely to a linux environment, the software distribution will continue to be maintained and enhanced. The modeling components of

* *Corresponding author address*: Daniel A. Geiszler, NPMOC, BLDG 14, Sauffley Rd., San Diego, CA 92135; email: daniel.geiszler@saic.com

COAMPS-OS™ include the multivariate optimum interpolation (MVOI) analysis, the COAMPS Ocean Data Assimilation (CODA) analysis, and the COAMPS™ forecast model. In addition to the modeling components, COAMPS-OS™ capabilities include web-based interfaces to configure COAMPS™ and access COAMPS™ data, automated graphical processing, and software to interface with the Navy's environmental database, TEDS. Each capability is briefly described in the following sections.

Web-Based Applications

Unique features of COAMPS-OS™ are the web-based GUI's that permit users to remotely configure the model and interface with the data produced by the model. The interfaces are java-based and, unlike X11-based applications, the java applets represent an efficient means to communicate between a remote server and local client. Three primary applications in COAMPS-OS™ include: the COAMPS-OS™ GUI, the HPAC/VLSTrack Interface, and the Station GUI.

a. COAMPS-OS™ GUI

The COAMPS-OS™ GUI is the most important interface between a forecaster and COAMPS™. The GUI permits users to select a region of the world and configure the resolution, duration, and length of a model forecast. The GUI allows users to select output fields and schedule model runs. The scheduler represents an interface to a computer's cron facilities and is particularly useful in cases where a model forecast is required over the same area and the same time everyday.

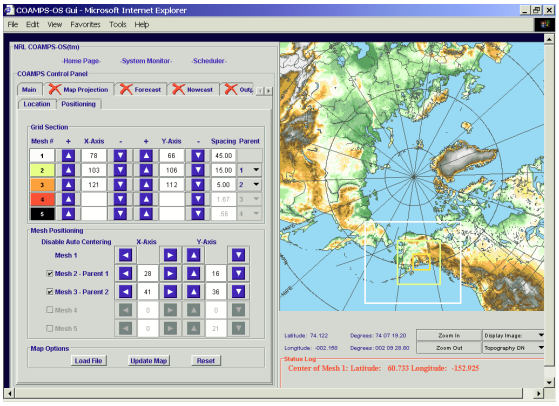

FIG 1. The COAMPS-OS™ GUI permits users to remotely configure a model domain and forecast within a web browser. COAMPS™ domains are globally relocatable.

b. HPAC and VLSTrack GUI

The HPAC and VLSTrack GUI's allow users to select sub-regions and profiles from the COAMPS™ forecast domain and format the data to run the Hazardous Prediction Assessment Capability (HPAC) and VLSTrack. HPAC and VLSTrack are transport and dispersion models developed to monitor the effects of hazardous releases.

c. Station GUI

The Station GUI permits users to graphically select WMO station locations stored in TEDS or add user-defined point locations. The station locations are used to generate point products including meteograms and Skew-T's. COAMPS-OS™ graphical products are described in more detail in the Section 3.

3. PRODUCTS

COAMPS™ computational grids may vary in resolution and duration with domains covering regions potentially requiring six to eight hours to complete a forecast. COAMPS-OS™ performs both visualization and database processing as each forecast hour completes. This parallel processing permits users to review products and data prior to the completion of a model run. Visualization products generated during each model run are described below.

Visualization

COAMPS-OS™ produces graphical products and publishes the products to a web page during each forecast. Graphical products include horizontal weather depictions of common weather elements such as sea level pressure, low-level winds, precipitation, and relative humidity. Products also include vertical profiles as Skew-T's and meteograms. Locations for single point, station products are estimated using the nearest grid point on the computational grid. Examples of COAMPS-OS™ meteogram and Skew-T products are shown in Figures 2 and 3.

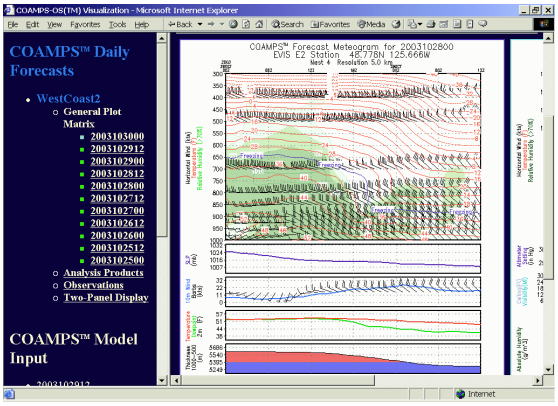

FIG 2. COAMPS-OS™ meteograms show multiple weather variables (y-axis) at user-defined stations as a function of time (x-axis).

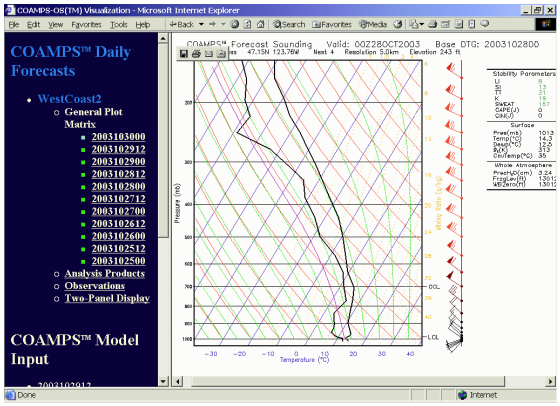

FIG 3. COAMPS-OS™ Skew-T products depict vertical profiles of temperature, dew point, and wind at user-defined stations every forecast hour.

COAMPS-OS™ completely automates several visualization processes with each model run. To customize graphics shown on the web pages, COAMPS-OS™ provides an X11-based application called IPVS-Charts. IPVS-Charts is based on a non-commercial, freely distributed graphics package called GrADS. IPVS-Charts can be used to create cross sections, vertical profiles, and horizontal charts of any output field generated by COAMPS™. Products created by IPVS-Charts can be updated to a web page interactively or created automatically with each model run.

Database

The Tactical Environmental Database Server (TEDS) represents the Navy's effort to manage the multiple environmental data types required by the Navy's diverse applications. In addition to COAMPS™, applications that utilize data from TEDS include the Joint METOC Viewer (JMV), Metcast, and the Naval Integrated Tactical Environmental System (NITES). During each COAMPS™ forecast, COAMPS-OS™ copies model output to TEDS, so recent data is available to the other applications. COAMPS-OS™ also utilizes TEDS as a resource for NOGAPS (Navy's Operational Global Atmospheric Prediction System, Hogan and Rosmond, 1992) grids, atmospheric observations, and ocean observations. Although TEDS is not required to run COAMPS-OS™, the database provides an efficient mechanism to obtain input data for COAMPS™ and disseminate COAMPS™ output to Navy applications.

4. METRICS

COAMPS-OS™ includes a web-based application called the Remote Monitor to diagnose the state of COAMPS-OS™ processing and hardware. The Remote Monitor utilizes a stoplight display to highlight the status of each process or application. By selecting the link associated with each status, a user can interactively view log files, check model completion times, and monitor the state of the system on the web. The Remote Monitor allows system technicians to diagnose problems without requiring local access to the system. An example of the Remote Monitor is shown is Figure 4.

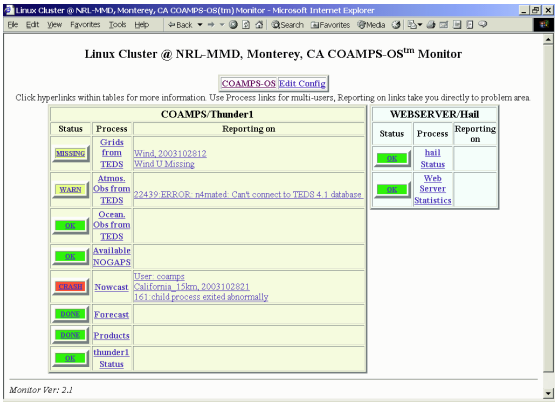

FIG 4. The Remote Monitor uses a web-based stoplight display to highlight potential problems with COAMPS-OS™ software and hardware.

5. FUTURE

Validation

Model validation represents the most important component of a regional weather forecasting system that is not completely addressed by COAMPS-OS™. A major hurdle to developing a comprehensive validation and verification system is the diversity of the users. Navy regional meteorology and oceanography centers support aviation and sea-based operations, amphibious and near-shore missions, and weapons targeting and deployment. Traditional statistics cannot quantify or qualify model performance in a perspective representative of all Navy users.

Improvements to model validation require a greater understanding of the forecasting process at the regional centers. To reconcile the void between R&D and operational forecasting, a unit of COAMPS-OS™ R&D has been transitioned to the Navy's regional meteorology and oceanography center in San Diego. The relationship is synergistic, benefiting the development of COAMPS-OS™ while providing an on-site resource to the center for training and consultation. Since September 2002, the relationship has contributed to the development a cloud verification product for COAMPS-OS™ using the Naval Research Laboratory's satellite server (NRLSAT, Geiszler et. al, 2003)

Model Initialization

Specification of the initial conditions in NWP models heavily influence the quality of weather forecasts produced by the models. Two efforts to improve the initial conditions of COAMPS™ include the NRL Atmospheric Variational Data Assimilation System (NAVDAS, Daley and Barker 2001) and the ARPS Data Assimilation System (ADAS). NAVDAS will replace the multivariate optimum interpolation (MVOI) analysis currently used for COAMPS™. A recent three month operational test of NAVDAS at FNMOC has demonstrated an improvement upon the MVOI analysis used for NOGAPS.

The MVOI analysis used in COAMPS-OS™ does not consider moisture, clouds, or precipitation. ADAS adds a capability to analyze clouds and moisture, and tests with ADAS suggest the analysis will improve the COAMPS™ initialization. The NAVDAS and ADAS analysis systems will be transitioned to COAMPS-OS™ in 2004.

6. REFERENCES

Chen, S., J.A. Cummings, J.D. Doyle, T.R. Holt, R.M. Hodur, C.S. Liou, M. Liu, A. Mirin, J. A. Ridout, J.M. Schmidt, G. Sugiyama, and W.T. Thompson, 2002: COAMPS Version 3 model description. [Available from the Naval Research Laboratory, Monterey, CA, 93943-5502] 143 pp.

Cook, B. J., J. Schmidt, R.M. Hodur, P. Tsai, S. Chen and L.D. Phegley, 1998: The On Scene Tactical Atmospheric Forecast Capability (STAFC). *Battlespace Atmospheric Conference, NRAD*, San Diego, CA, 283-289. [Available from SPAWAR Systems Center San Diego, CA, Technical Document 2989, March 1998]

Daley, R., and E. Barker, 2001: *NAVDAS Source Book 2001*. NRL/PU/7530-01-441. Available from the Naval Research Laboratory, Monterey, CA., 93943-5502, 163 pp.

Geiszler, D., R. Wade, and J. Cook, 2003: The Naval Research Laboratory's Satellite Server (NRLSAT): An automated cloud verification system for COAMPS-OS™. Battlespace Atmospheric and Cloud Impacts on Military Operations [BACIMO] Conference, Monterey, CA, 2003.

Hodur, R. M., 1997: The Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). *Mon. Wea. Rev*., **125**, 1414-1430.

Hogan, T., and T. Rosmond, 1991. The description of the Navy Operational Global Atmospheric Prediction System's spectral forecast model. *Mon. Wea. Rev.*, **119**, 1786-1815.

7. ACKNOWLEDGEMENTS

COAMPS-OS™ is sponsored by the Oceanographer of the Navy through the Space and Naval Warfare Systems Command (SPAWAR PMW 150) Program Element 0603207N, Project X-2342.