

## **COAMPS User Support**

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### **LONG-TERM GOALS**

The long-term goal of this project is to continue to provide support (e.g., consultation, code updates, training, data transfer, etc.) for those users who obtain the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS<sup>®1</sup>) through the release of the code as determined by release guidelines. The active distribution of COAMPS to the general scientific community cannot be accomplished without strong support from NRL-Monterey. To fully realize the development potential of the COAMPS system, the Navy must leverage research being performed in the community at large. Through increased usage of COAMPS by the broader community, NRL has been able to leverage discoveries, leading to advances in COAMPS capabilities, including model physics, numerical methods, and coupled modeling.

### **OBJECTIVES**

One of the primary objectives of this project is to develop and improve our comprehensive technical support capability for the COAMPS users, particularly those who have projects supported by ONR. Components in the support structure include, but are not limited to: providing guidance on model code structure and result interpretation, improving/updating to the COAMPS web site, updating versions of the code as necessary, updating the COAMPS documentation, providing user feedback to COAMPS developers, providing users with tools to obtain NOGAPS/NAVGEN data for COAMPS initial and boundary conditions, observations data (both atmospheric and ocean) for historical cases, and maintaining/updating all of the supporting databases.

### **APPROACH**

We have been providing support and consultation services to users through email communications and occasionally hosting on-site visitors who need to have more in-depth knowledge about the COAMPS system. One example is the successful idealized tropical cyclone simulations using COAMPS-TC by the scientists at University of Rhode Island (URI). We made a site visit to the University of Oklahoma to help port COAMPS-TC to their computer platform and shared our experience in subsequent testing. New development and updates to the COAMPS code have been achieved through leveraging recent research conducted by external collaborators (see examples in the results section).

### **WORK COMPLETED**

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<sup>1</sup> COAMPS is the registered trademark of the Naval Research Laboratory.

The following work was completed in FY13 (milestones are italicized):

*1. Continue to provide routine user support*

We spent considerable time providing in-depth consultation to users, especially those with ONR funded projects. In the past year we had **538** email communications with our users, and numerous telephone calls and tele-conferences, over a wide range of questions and requests for software and data. We received 102 registration requests for using COAMPS from both the US and international institutions (e.g. Britain, Greece, India, New Zealand, Singapore, South Korea, Sweden, and Vietnam), of which **39** were approved by NRL.

*2. Facilitate user-developer communication*

We continued to provide routine user support. While doing this, we connected users with developers for more detailed knowledge of the code and to share the developers' expertise. New features developed by external users have been incorporated back into COAMPS. For example, the OU group developed software that enables COAMPS to use initial conditions prepared using ARPS Data Analysis System. This software has been provided to NRL.

*3. Continue to develop and improve COAMPS functional interoperability with the WRF physics parameterization suite. Continue to work as a liaison between the COAMPS developers, the scientific community at large, and the DTC.*

Leveraging efforts under the HFIP and COAMPS 6.4 projects, we continue to improve COAMPS functional interoperability with physics in other models (e.g., WRF, ARPS). The Thompson microphysics has been examined further in the COAMPS-TC system and several updates and bug fixes have been committed. The Milbrandt-Yau multi-moment microphysics schemes have been implemented in COAMPS-TC through our collaboration with the OU group. The Tiedtke cumulus scheme has been implemented and improvement has been obtained using this scheme for TC track and intensity prediction for a small sample size. We have made substantial progress investigating and implementing the University of Washington shallow cumulus scheme. These new capabilities enable us to better understand the physical processes and provide additional reference points for COAMPS performance evaluation.

*4. Advance COAMPS capability by leveraging research being performed in the community at large.*

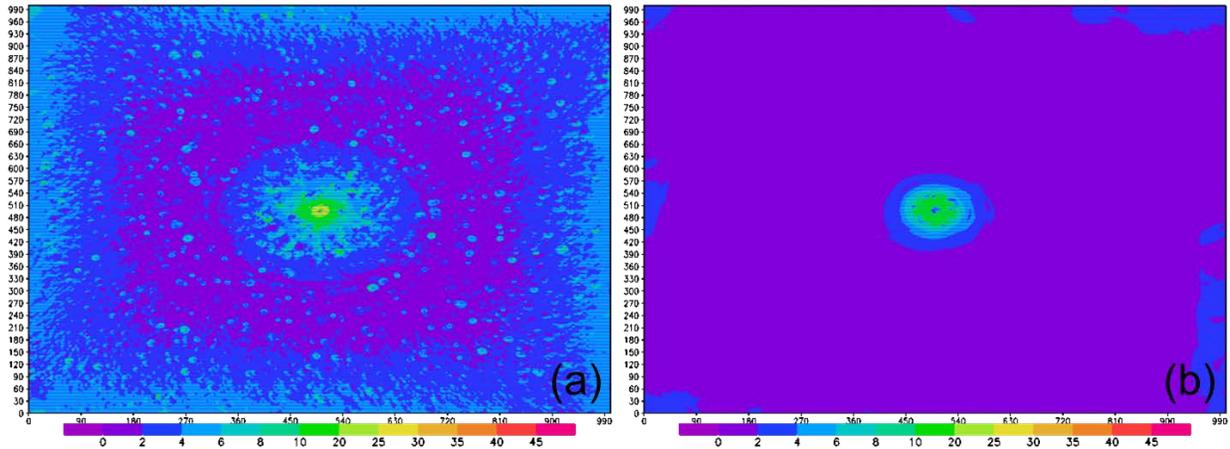
We continued our successful collaboration with CIRA (Cooperative Institute for Research in the Atmosphere) at the Colorado State University in satellite synthetic imagery. We have obtained the software package and ported it to NRL computers. Dr. Grasso at CIRA also provided 3-year GOES satellite data that have already been decoded and ready to use. This collaboration equipped us with the state-of-science cloud verification system and significantly enhanced NRL capability for model evaluation, especially for vast areas over the ocean.

We have also obtained from NOAA Hurricane Research Division air-borne Doppler radar composite for TCs. We were able to produce for the first time a direct comparison between COAMPS simulations and observed composite structure of azimuthally averaged TC inner core.

## 5. Release updates and bug fixes

We started to work on the next release of the COAMPS system. The current funding level, however, does not provide enough man power for us to progress quickly with this substantial effort.

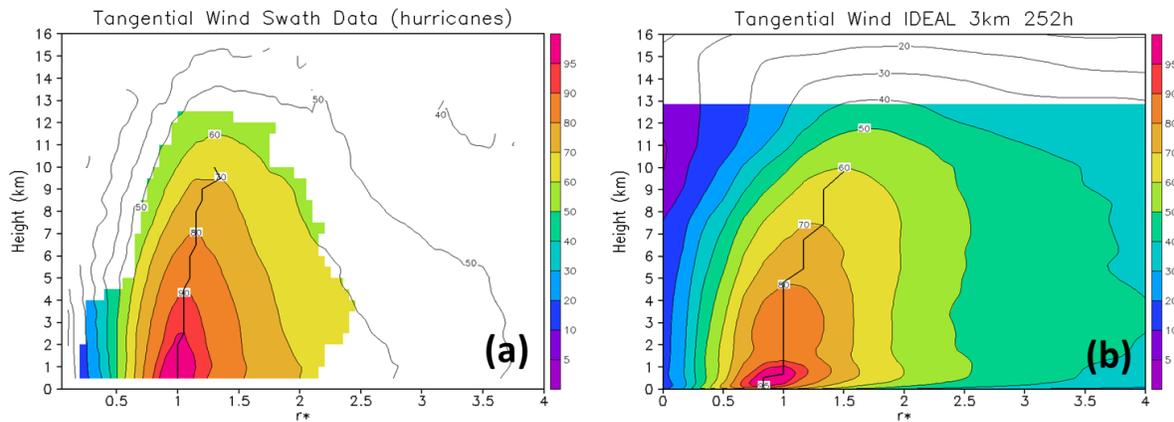
## RESULTS



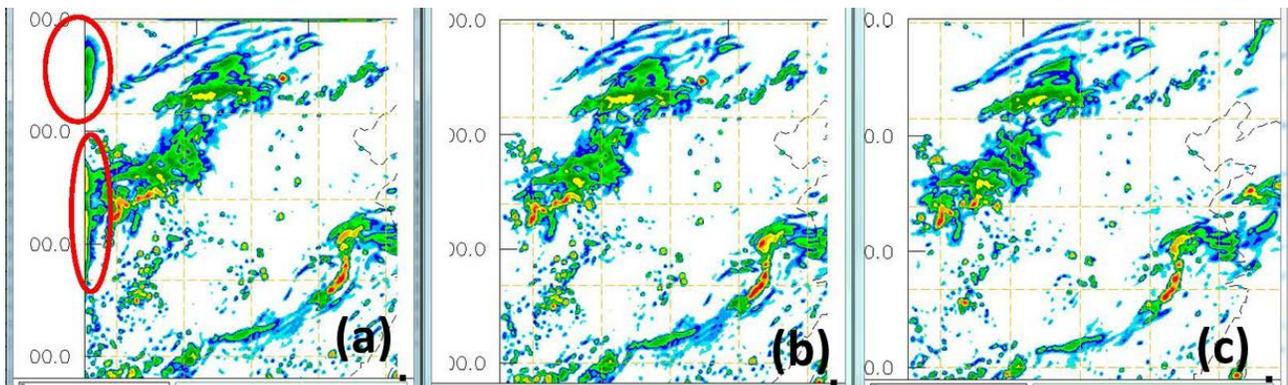
**Fig. 1.** Surface wind speed ( $m\ s^{-1}$ ) simulated at 48 h from idealized COAMPS-TC with grid spacing of 3 km and time steps of 10 s (a) and 2 s (b).

One problem that the URI group encountered while using COAMPS-TC for idealized TC simulations is the noise developed in the domain, especially near the lateral boundary (Fig. 1a). They asked us to help solve this problem. We performed a series of sensitivity tests to examine contribution from model physics schemes, domain size, and grid spacing. Noise of  $2\Delta$ -wave type was still present even in the dry dynamic simulation, which suggested computational instability. Therefore, further tests were performed by reducing the time steps. The noise was successfully removed (Fig. 1b) after the time step was reduced down to 20% of their original time step. Our help enabled the URI group to continue with their research effort using COAMPS-TC profiles to study boundary layer rolls.

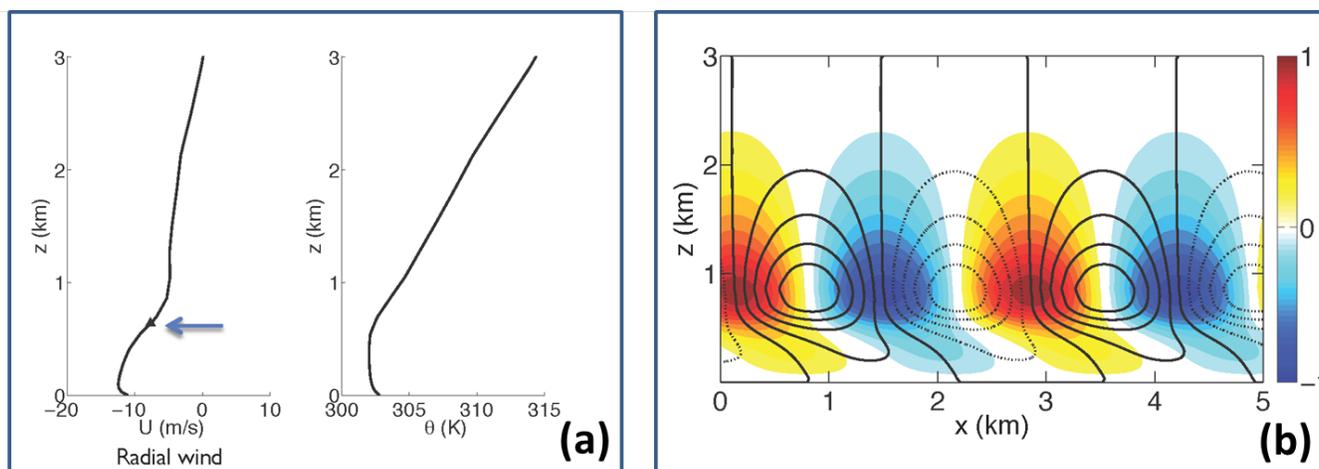
Leveraging the effort under HFIP and COAMPS 6.4, we constructed a direct comparison between the composite TC inner-core structure derived from air-borne Doppler radar observations and the structure from high-resolution idealized COAMPS-TC simulation. The azimuthally averaged TC structure is normalized against the maximum values in the analysis domain. The radius is normalized against the radius of maximum wind at the 2-km level. The normalized method facilitates comparisons for storms of different intensity and structure. COAMPS-TC captures quite well the tangential winds with 85 percentile winds located within the eyewall (i.e. 1.5 normalized radius) (Fig. 2). The strong tangential flow in the simulated TC eyewall, however, is limited to levels lower than the composite data. For example, the 90% tangential wind contour extends to  $\sim 4$  km in the composite data, but it is limited to below  $\sim 1.5$  km in the simulation. The radial extension of the tangential wind at low levels in the simulation is narrower than the composite structure, as indicated by the nearly vertical orientation of the contours in the simulation (Fig. 2b) compared to the slanted contours (Fig. 2a). These differences suggest that further studies are needed to better represent TC structure using COAMPS-TC.



**Figure 2.** Distribution of azimuthally averaged tangential wind speed (%) normalized against the maximum tangential wind speed in the radius-height plane. The x-axis is the normalized radius against the radius of the maximum wind (RMW) at the 2-km height. The thick black line indicates the location of RMW at each level. Panel (a) shows the structure from the composite data, whereas panel (b) from the COAMS-TC simulation at 10.5 day.



**Figure 3.** Composite radar reflectivity (dBZ) simulated by COAMPS-TC at 6 h using (a) the IC/BC prepared by CAPS original code, (b) the IC/BC prepared using modified CAPS code, and (c) the COAMPS IC/BC (by Xue et al).



**Figure 4.** (a) vertical profiles of radial wind speed (left) and potential temperature (right) from the COAMPS-TC idealized TC simulation; (b) the normalized vertical velocity (shaded) and streamlines (contoured) simulated by a 2-D LES boundary layer roll model (Gao and Ginis) with the COAMPS vertical profiles.

We helped the URI group resolve various issues related to running COAMPS-TC idealized TC simulations. With the successful COAMPS simulations, they were able to extract vertical profiles (Fig. 4a) from COAMPS simulation and used them to drive their 2-D LES roll models, which generated boundary structures that bear distinct features of hurricane boundary layer rolls (Fig. 4b).

## IMPACT/APPLICATIONS

Several long term benefits from this project can be identified: 1) improved opportunities for the next generation of atmospheric researchers to contribute to COAMPS development, 2) increased awareness and visibility of COAMPS in the broader scientific community, and 3) accrued credit to NRL and the Navy from academic research performed using COAMPS.

## RELATED PROJECTS

This project is closely coordinated with the HFIP and COAMPS 6.4 projects.