Shipboard Data Assimilation System/Doppler Radar

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LONG-TERM GOAL

Develop a high-resolution data assimilation system that can provide an analysis of the atmosphere with sufficient details and accuracy that it can be used to support the Navy mission in threat detection, weapons, and weather safe operations. The system will utilize all available weather information, such as Doppler radar, in situ, and remotely sensed observations, to generate a detailed analysis of the atmosphere with sufficient accuracy to predict EM/EO propagation and potential weather target conditions. This information can then be fed back to the SPY-1 radar and other weather systems, to give them lower threshold detection capability.

OBJECTIVES

Build a data assimilation suite around the Coupled Ocean/Atmospheric Mesoscale Prediction System (COAMPS). This data assimilation system will be able to analyze mesoscale weather by applying sophisticated analysis procedures capable of ingesting the information from Doppler radar, mesonet, and remote sensors. The primary focus of this effort will be to design a system that optimally utilizes the available weather information such as SPY-1 Doppler radar for COAMPS.

APPROACH

A mesoscale data assimilation system will be developed which uses the background fields provided by the atmospheric component of COAMPS predictions on non-synoptic time levels and by the newly developed NRL 3DVAR (NAVDAS) on the synoptic time levels. This new and complementary variational assimilation system (3.5DVAR) will use simplified adjoint methods to achieve the high computational efficiency needed to assimilate high resolution data from Doppler radars (including SPY-1) and satellites in four dimensions (space and time). The analysis increment fields will be expressed by B-spline expansions to optimally filter noise while the analysis is performed directly on the COAMPS grid. The assimilation time window will be synchronized with COAMPS integration time steps and radar volumetric scans to enhance the coupling of the model with the data.

Since Doppler radar measurements are limited to reflectivity and radial-component wind in stormy areas and/or boundary layer within the range of radar observations, using radar information alone may not be sufficient for the proposed high-resolution data assimilation. It is then necessary to combine the radar observations with other high-resolution observations (such as the GOES cloud imageries and sounders, and lightning data). A cloud analysis package using GOES (and other remotely sensed)

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observations is being developed in collaboration with the University of Oklahoma and will be incorporated into the 3.5DVAR data assimilation system.

WORK COMPLETED

Basic parameters, based on our numerical experiments, have been furnished for the SPY-1 scan and data acquisition strategy planed for At-Sea Demo in 1999. The quality control code (velocity alias correction & etc.) for Doppler wind data has been improved. The SPY-1 wind retrieval package was successfully tested against a dual-Doppler analysis using NEXRAD data. A variational data assimilation system (3.5DVAR version 1) is being assembled for COAMPS-SPY-1 data assimilation. The core code and adjoint routines have been completed and the code will be applied to SPY-1 data as soon as declassified At-Sea Demo data become available.

The GOES IR forward code was completed for COAMPS. The core subroutines of the GOES cloud analysis have been extracted from the University of Oklahoma ARPS Data Analysis System (ADAS v2.3) and adapted for COAMPS. A variational wind adjustment package is being developed for use with the cloud analysis. However, due to large errors found in the surface properties predicted by COAMPS, and which are needed for the cloud analysis package, critical improvements were required in the land surface parameterization used in COAMPS. The ARPS soil-vegetation model package and database (1 km with processing subroutines) has therefore been adapted to COAMPS. Further testing with real data cases is being carried out and the prologues are being written. Based on the results of real data testing, an upgraded version will be implemented in COAMPS.

Much effort has been spent in the past year in improving the predictive capability of COAMPS for generating better surface properties for the simulation of GOES cloud imagery, which will be used as background information by the 3.5DVAR assimilation system. A large number of the basic building blocks of the 3.5DVAR assimilation system, needed for assimilating SPY-1 radar data in COAMPS, have been completed in the past year.

RESULTS

The previous quality control code (velocity alias correction & etc.) for Doppler wind data, developed at University of Oklahoma, is not an independent package and the background field used by the code is restricted to a uniform Cartesian grid. The code was modified and upgraded, so that the COAMPS background can be used. During testing with NEXRAD data, the code was further improved as some bugs in the original were fixed and these bugs caused some good data to be rejected. The newly developed 3.5DVAR (version-1) code was tested with NEXRAD data for the 7 May 95 squall line case. The results showed positive impact on short-term COAMPS forecast of clouds and precipitation. Although similar results and impact were previously obtained from COAMPS initialized with ADAS-assimilated NEXRAD data, the previous assimilation runs were not performed within the COAMPS configuration. With the newly developed 3.5DVAR, the Doppler radar data assimilation was performed, for the first time, within the COAMPS configuration.

The transplanted ARPS soil-vegetation model package and database (1 km with processing subroutines) were installed in COAMPS. Test runs were performed at OU and NRL, and problems were identified (such as lack of soil moisture increase in response to precipitation at grid points of high vegetation coverage) and fixed (by correcting some unphysical settings in the original scheme). An example of the impact of the soil-vegetation package on COAMPS forecasts of surface brightness temperature is shown in Fig. 1. During the morning of July 24, the sky was mostly clear at this grid point and the predicted brightness temperatures closely match the observed brightness temperatures. After about noon, the sky was slightly cloudy, as shown by the decrease of brightness temperature from 18 to 21Z. These light cloudy conditions in the afternoon were not reproduced in COAMPS.

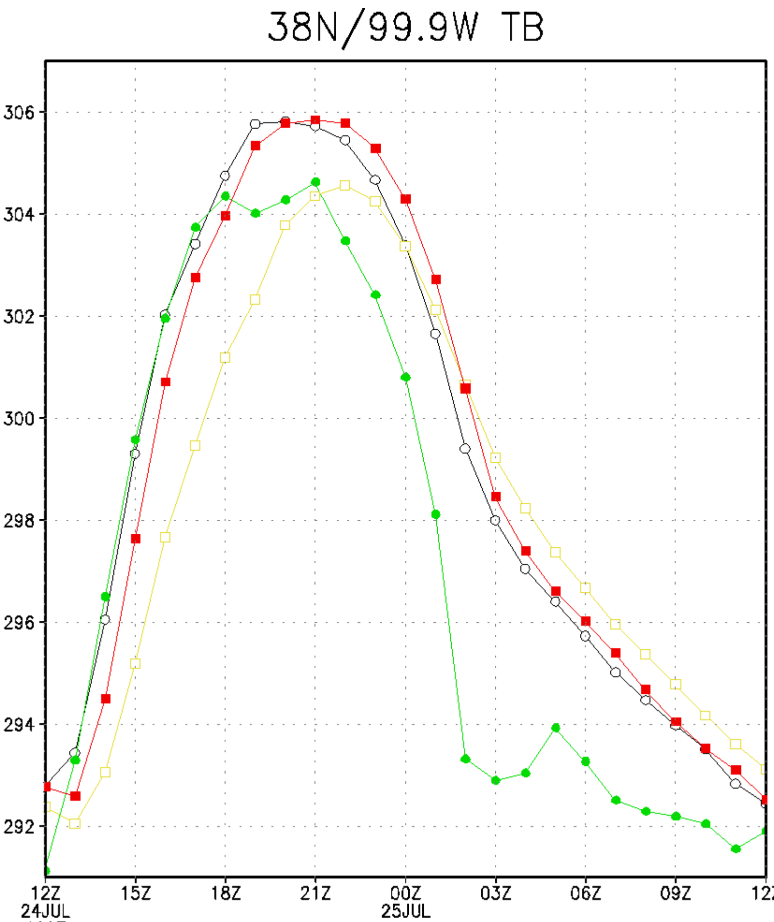

Fig. 1. Variations of surface brightness temperature (10.7 um) at 8N 99.9W on 24 July 97: the black curve is from the COAMPS run with the new soil-vegetation package and every 10 min radiation computation, the red curve is the COAMPS run with the new soil-vegetation package but every 60 min (default) radiation computation, the yellow curve is the COAMPS run without the new soil-vegetation package, and the green curve is the GOES observation.

After the GOES IR forward code was completed and installed in COAMPS, many test runs were performed. The test results show that the code is useful for direct comparisons and verifications of COAMPS radiance forecasts against GOES observations. The core subroutines of GOES cloud analysis package were extracted from ADAS (v2.3) and adapted to COAMPS. The code was tested with GOES data for Feb. 98 case, and then was further improved in resolving fine cloud structures (by reducing the extraneous smoothing in the original code). An example showing the improvement in the initial clouds in COAMPS is shown in Fig. 2. A 3DVAR wind adjustment package is currently being developed for the cloud analysis. The package uses B-spline basis functions to filter noise and to generate wind increment field, which is consistent with the thermodynamic increment field within the COAMPS configuration.

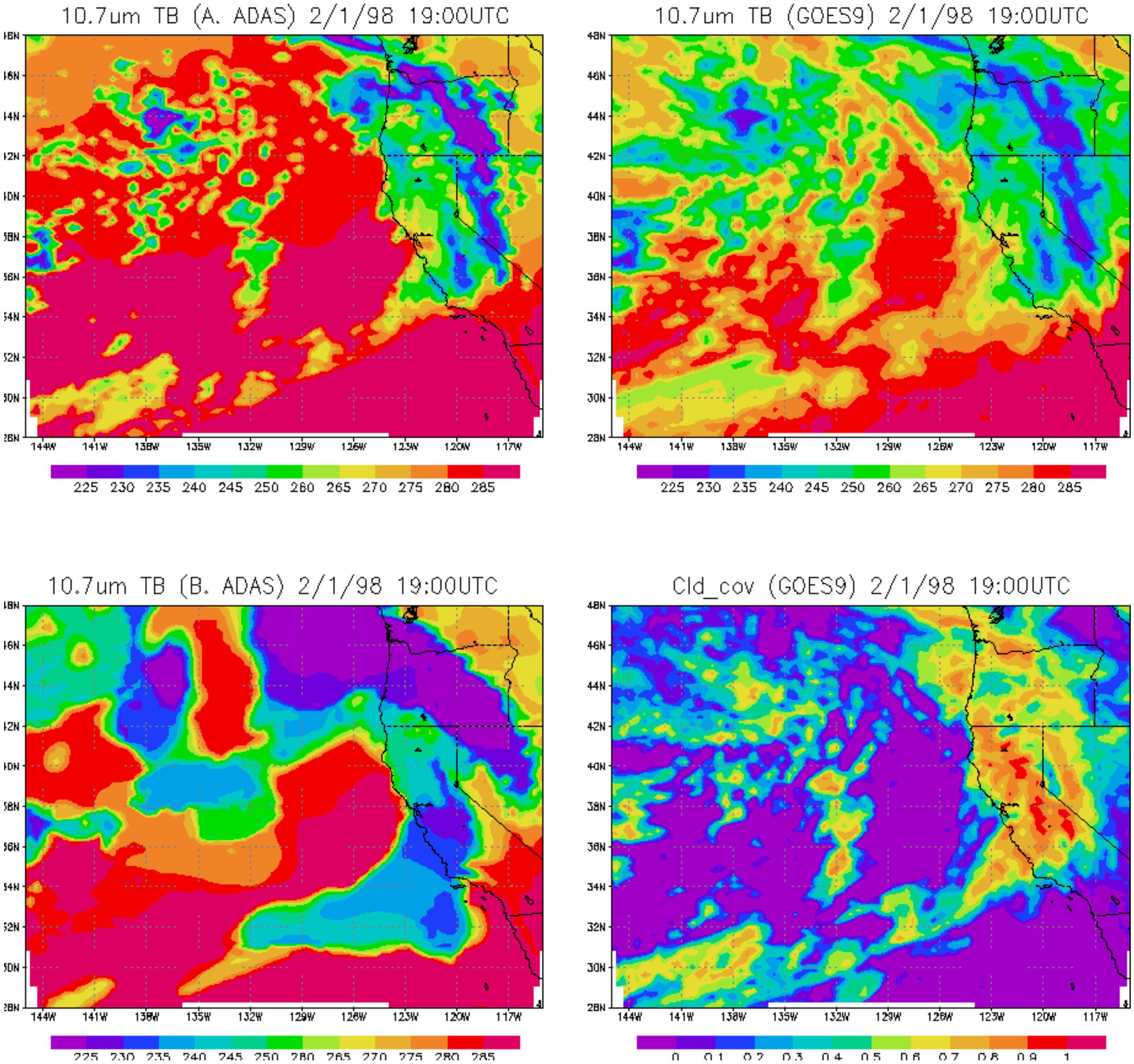

Fig. 2. Comparison of analyzed, predicted and observed GOES brightness temperatures at 10.7 um, as seen from space on February 1, 1998 at 1900 UTC. Upper-left panel is the COAMPS radiance after cloud analysis with GOES data, lower-left panel is the predicted COAMPS radiance (before cloud analysis), upper-right panel is the GOES9 radiance and lower-right panel is the GOES9 product of cloud coverage (based on visible channel).

IMPACT

The completed GOES IR forward code has been installed in COAMPS and provides a useful tool for direct comparisons and verifications of COAMPS radiance forecasts against GOES observations, therefore accomplishing the first step toward a full GOES data assimilation system.

The transplanted ARPS soil-vegetation model package and database has been installed in COAMPS. This package upgraded the COAMPS land-surface physics so that the model can use the high-resolution soil-vegetation data, setting the stage for a land-surface data assimilation capability for COAMPS.

The newly developed assimilation of the high resolution Doppler radar data (3.5DVAR) in combination with all other available weather information is expected to lead to a significant improvement in the quality of the COAMPS on-scene atmospheric environment analysis and forecast. Improvements in Shipboard COAMPS translate to improved mission support and cost savings for the Navy.

TRANSITIONS

The ARPS soil-vegetation model and the GOES IR forward model computer codes, adapted under this project, have been integrated into COAMPS. The new codes will be used in 6.4 programs (PE 0603207N) for applications within TESS/NC and, via the TESS/NC - JMCIS link, with the tactical applications supporting on-scene decision-makers.

RELATED PROJECTS

Related 6.2 projects within PE 0602435N are BE-35-02-09, Data Assimilation and Analysis, BE-35-2-19, Data Assimilation Techniques and Quality Control for On-scene Analysis/Prediction System, and BE-35-02-18, for the development of Atmospheric Mesoscale Models. The related 6.4 project under PE 0603207N is X2343-10, which focuses on the transition of the 6.2 development to the STAFC demonstration project.

PUBLICATIONS

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