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OPERATIONAL SATELLITE-DERIVED TROPOSPHERIC WINDS FOR DOD MODELS AND APPLICATIONS

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1. INTRODUCTION

Feature Tracked Winds (FTWinds), derived by tracking cloud and water vapor motions from geostationary satellite imagery, have proven to be an important source of data for the U.S. Department of Defense (DoD) global weather prediction model, the Navy Operational Global Atmospheric Prediction System (NOGAPS). Fleet Numerical Meteorology and Oceanography Center (FNMOC) and Air Force Weather Agency (AFWA) also run high-resolution regional forecast models for remote areas of interest to DoD, where *in-situ* data may be absent and FTWinds become a particularly important data type. In addition, the Navy and Air Force jointly forecast for tropical cyclones over vast regions of the oceans, and FTWinds are an important source of observations for these operations. Because of the diverse and global scope of these responsibilities, a robust FTWinds processing algorithm commensurate with currently utilized algorithms at other data processing centers (e.g., NESDIS) is highly desirable for DoD. Therefore, the Navy and Air Force have teamed with the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin and the Naval Research Lab (NRL) in Monterey to transition state-of-the-art FTWinds software into the DoD operational processing environment. An AFWA, FNMOC, and CIMSS integration team installed the software on hardware at AFWA, and the system became operational in the summer of 2001.

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2. CONCEPT OF OPERATIONS (CONOPS)

Under the CONOPS, AFWA receives GMS-5, METEOSAT-5, and METEOSAT-7 telemetry data in near-real-time from its satellite communications links, and NOGAPS model fields from FNMOC over Asynchronous Transfer Mode (ATM) communication networks. Processed FTWinds are returned to FNMOC for assimilation into NOGAPS, and distributed within AFWA. Below, we describe some unique elements of this operational system.

2.1 C-Portable FTWinds Algorithm

A C-portable version of the CIMSS FTWinds software was developed, which employs all the algorithms of its parent MCIDAS version, but allows for software builds on any ANSII standard C compiler. See Olander (2001) for more details.

2.2 Satellite Data Handling System (SDHS)

AFWA's SDHS handles all incoming satellite data traffic for AFWA. The data is output in "SIMPLE" format, which retain the calibrations, navigation, and radiance data of the original satellite transmission in separate files (Sterling Software Inc., 2000). The format was developed for satellite data shared among the operational processing centers in the US (AFWA, FNMOC, and NESDIS), but the format is not widely used outside of these centers. A case in point is the CIMSS FTWinds algorithm code, which accepts only MCIDAS Area format. Rather than build unique versions for SIMPLE data, we have

elected to build stand-alone SIMPLE to MCIDAS converters to interface to a standardized version of the CIMSS FTWinds algorithm source code. Fortunately, the processing costs for these conversions are minimal.

2.3 FTWinds Control and Monitor Scripts

Korn shell scripts were developed at FNMOC to handle data conversion, data set grouping into "triplets", retrieval of background model fields, dynamic configuration of input parameters, execution of the CIMSS FTWinds algorithms, error handling, and logging. The system was designed to be event-driven, rather than schedule-driven. This allows for calculation of FTWinds at the earliest possible opportunity following ingest of a geostationary data set. The system also allows for parallel processing of different telemetry types on the same platform.

2.4 Output Distribution

FNMOC receives all AFWA output, in both ASCII text and WMO BUFR format, from AFWA's Weather Products Management and Distribution System (WPMDS) over an ATM circuit. WPMDS insures delivery of products through monitoring and logging. Internal AFWA customers access the data using an NCR Teradata database.

3. MODELS AND APPLICATONS

FTWinds are used for atmospheric model data assimilation and graphical forecast aids by the Navy and Air Force. Some examples follow.

3.1 FNMOC

Data assimilation experiments using the CIMSS operational wind algorithms been have shown to improve the NOGAPS model accuracy at FNMOC (Velden et al., 1997). In particular, the use of water vapor winds in the tropics has increased the accuracy of tropical cyclone track forecasting (Goerss et al., 1997). A motivating factor for the AFWA-FNMOC FTWinds collaboration was the choice of the model background fields used in the algorithms. The Goerss et al. (1997) data assimilation experiments used NOGAPS background fields, and therefore the project requirements specify the use of NOGAPS background whenever possible.

Prior to assimilation, FTWinds undergo quality control (QC) checks at several processing stages. As part of the CIMSS FTWinds algorithm processing, winds are screened for a wide variety of known speed or height biases. See Olander (2001) for more detail. Additionally, the background enters the QC process through "QI" thresholding (50%), and the 3-dimensional recursive filter, termed "autoeditor". The autoeditor adjusts measurement heights to minimize departures from the background, and rejects outliers.

Feature tracking winds are treated as conventional observations in the NRL Atmospheric Variational Data Assimilation System (NAVDAS), where further QC is performed. Thinning is performed prior to assimilation. Innovations (observation minus background) within latitude-dependent volumes are screened against height dependent thresholds, and then spatially averaged. The data assimilation uses a 3 dimensional variational method in observation space. As with most 3DVAR methods, observations are removed during the iteration process, based on their background/observation error scaled departures from the solution.

FTWinds have utility to several other FNMOC applications and customers. FTWinds are assimilated into FNMOC's Coupled Ocean/Atmosphere Mesoscale Predictions System (COAMPS®) for regional forecasting. FTWinds support near-real-time forecasts for Navy operations. Wind vector and imagery composites, such as those shown in fig. 1, are produced for routine and special areas of interest, and made available to users on the FNMOC secure Internet Web site. FTWinds are also distributed to remote databases and client applications, for on-site display, modeling and analysis.

3.2 AFWA

One of the main uses of the FTWinds data is to supplement conventional observations for military weather forecasting. This additional wind information can be an important aid when

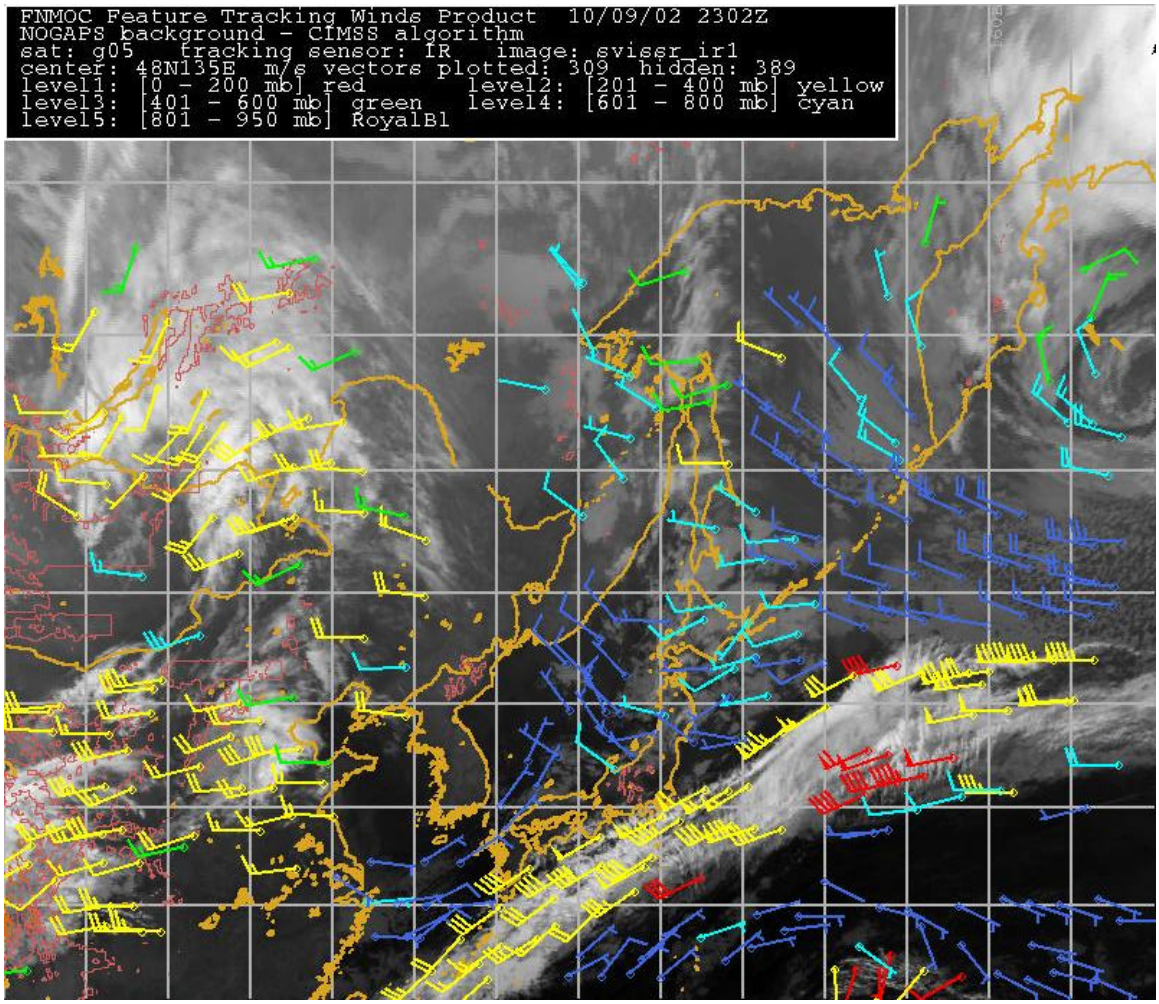

Figure 1. Example of FTWinds in the western Pacific

preparing an enroute weather forecast for aviation. While FTWinds do not completely replace conventional upper-air observations, they can be an important supplement. This is especially true in areas of the world where traditional upper-air observations are sparse or non-existent.

FTWinds are also provided to the Joint Typhoon Warning Center at Pearl Harbor, Hawaii. Forecasters use the wind vectors to help diagnose potential areas of low-level convergence and upper-level divergence that aid the formation of tropical systems. As the data distribution portion of the system matures, the wind vectors will be provided to more field units for their local analysis and forecast programs.

AFWA will soon incorporate FTWinds into its mesoscale numerical weather prediction models through a 3-dimensional variational data assimilation scheme. These wind vectors are an important source of data for model initialization when they are run for areas of the world with few or no conventional observations.

4. SUMMARY

A cooperative software development effort between AFWA, FNMOC, NRL, and CIMSS has successfully implemented the CIMSS FTWinds algorithms in DOD operational weather facilities, insuring a high quality, timely, and consistent FTWinds product is available for models and forecasters worldwide.

5. REFERENCES

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