Advanced Satellite-Derived Wind Observations, Assimilation, and Targeting Strategies During TCS-08 for Developing Improved Operational Analysis and Prediction of Western Pacific Tropical Cyclones

PI: Christopher Velden
University of Wisconsin – SSEC
1225 W. Dayton St., Rm 229
Madison, WI 53706
Phone: (608) 262-9168 Fax: (608) 262-5974 Email: chrisv@ssec.wisc.edu

CO-PI: Sharanya J. Majumdar
RSMAS/MPO, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149
Phone: (305) 421 4779 Fax: (305) 421 4696 Email: smajumdar@rsmas.miami.edu

Award Number: N00014-08-1-0251
http://cimss.ssec.wisc.edu/tropic2/tparc

LONG-TERM GOALS

Forecasts of tropical cyclone (TC) formation and intensity change in the north-western Pacific basin are often lacking in skill, in part due to the paucity of conventional oceanic observations that are assimilated into the operational models. This lack of observations has also constrained our understanding of how TC formation is governed by environmental processes. Recently, remotely-sensed observations from satellites have become a routine and important input to the global data assimilation systems. These data can provide critical environmental data for the testing of hypotheses of TC formation and development, and improving our understanding of how environmental influences on TC structure evolve up to landfall or extratropical transition. In particular, winds derived from geostationary satellites have been shown to be an important component of the observing system in reducing TC model track forecasts. However, in regards to TC formation, intensity change, and extratropical transition, it is clear that a dedicated research effort is needed to optimize the satellite data processing strategies, assimilation, and applications to better understand the behavior of the near-storm environmental flow fields during these evolutionary TC stages. To our knowledge, this proposal represents the first time anyone has tried to evaluate the impact of targeted *satellite* data on TC forecasts using an automated dynamic targeted observing strategy. TCS-08 will afford us the opportunity to employ specially-processed satellite data along with observations collected in situ by the NAVY P-3, and other platforms, to investigate these objectives as they apply in the western north Pacific TC basin. The development of successful real-time strategies to optimally assimilate wind data from satellites will ultimately lead to the provision of improved initial and boundary conditions for the Navy's envisioned mesoscale coupled ocean-wave-atmosphere forecast model.

OBJECTIVES

The ultimate objective of this project is the development and refinement of a capability to supplement the contemporary atmospheric observation network with advanced satellite wind observations to improve high-resolution operational analyses and medium-range forecasts of western North Pacific typhoons.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2008	**Annual**	**00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE
Advanced Satellite-Derived Wind Observations, Assimilation, And Targeting Strategies During TCS-08 For Developing Improved Operational Analysis And Prediction Of Western Pacific Tropical Cyclones

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Wisconsin ? SSEC,1225 W. Dayton St., Rm 229,Madison,WI,53706

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT

Forecasts of tropical cyclone (TC) formation and intensity change in the north-western Pacific basin are often lacking in skill, in part due to the paucity of conventional oceanic observations that are assimilated into the operational models. This lack of observations has also constrained our understanding of how TC formation is governed by environmental processes. Recently, remotelysensed observations from satellites have become a routine and important input to the global data assimilation systems. These data can provide critical environmental data for the testing of hypotheses of TC formation and development, and improving our understanding of how environmental influences on TC structure evolve up to landfall or extratropical transition. In particular, winds derived from geostationary satellites have been shown to be an important component of the observing system in reducing TC model track forecasts. However, in regards to TC formation, intensity change, and extratropical transition, it is clear that a dedicated research effort is needed to optimize the satellite data processing strategies, assimilation, and applications to better understand the behavior of the near-storm environmental flow fields during these evolutionary TC stages. To our knowledge, this proposal represents the first time anyone has tried to evaluate the impact of targeted satellite data on TC forecasts using an automated dynamic targeted observing strategy. TCS-08 will afford us the opportunity to employ specially-processed satellite data along with observations collected in situ by the NAVY P-3, and other platforms, to investigate these objectives as they apply in the western north Pacific TC basin. The development of successful real-time strategies to optimally assimilate wind data from satellites will ultimately lead to the provision of improved initial and boundary conditions for the Navy?s envisioned mesoscale coupled ocean-wave-atmosphere forecast model.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

One primary research goal will be to evaluate and diagnose the impact of assimilating the advanced satellite wind observations on global Navy model forecasts, and high-resolution forecasts of structure change. We aim to better understand how to utilize the satellite wind data in the context of numerical model assimilation and forecast impact. Optimizing the assimilation of the experimental satellite winds will involve a continued investigation of the satellite data quality control indicators, prescribing improved observational error covariances, and utilizing 4DVAR approaches.

APPROACH

During the field phase of TCS-08, experimental satellite-derived wind observations were produced by UW-CIMSS using state-of-the-art automated methods. Hourly datasets were routinely derived from operational images provided from the Japan Meteorological Agency (JMA) MTSAT geostationary satellite. In addition, special rapid-scan (r/s) images from MTSAT-2 were provided by JMA for extended periods (24-48hrs) over specific regions, and including parts of selected typhoon life cycles. UW-CIMSS also processed these images into wind fields (higher resolution). These special satellite-derived wind observations will complement those data collected by the NRL P-3 aircraft during TCS-08, by providing unique time-continuous environmental data in locations that are deemed important to tropical cyclone formation and development.

The project will begin with the current versions of NAVDAS and NOGAPS, the Navy's current operational data assimilation and global forecast model systems, so that the research results may be easily transitioned to improve the Navy's operational predictions. The DA approaches will be extended to the new NAVDAS 4DVAR system that is expected to be ready for use very soon. We expect that the 4DVAR assimilation will provide an improved analysis, since its temporal continuity better exploits the asynoptic satellite winds than 3DVAR, in which the observations are assimilated at discrete 6-hour intervals. Upon completion of the experiments, the resulting global analyses and forecasts will be made available to investigators involved in developing and testing the Navy's coupled ocean-wave-atmosphere model.

Finally, existing adaptive observing strategies such as the Ensemble Transform Kalman Filter (ETKF) and NOGAPS Singular Vectors will be used to identify regions in which numerical forecasts are most likely to benefit from the assimilation of additional satellite wind data. A new 'synthetic observation ensemble' will also be devised to answer this question more directly. Via the observation sensitivity method (for forecasts up to 24h) and data denial in the Navy forecast system (for forecasts up to 5 days), the impact of assimilating targeted high-density (hourly and rapid-scan) satellite winds on global model forecasts of tropical cyclone track and high-resolution forecasts of tropical cyclone structure will be evaluated and analyzed.

WORK COMPLETED

The tasks in Year 1 are primarily focussed on support for the TCS-08 field program, which was conducted in August-September. Specifically, completed tasks at UW-CIMSS include the real-time processing and display of MTSAT data and derived analysis during TCS-08 (Fig. 1). CIMSS also provided key real-time satellite products and analyses for critical mission planning support during the field phase. The products are archived locally at CIMSS, as well as in the EOL catalog. PI Velden participated in the daily planning meetings, including two on-site stints at the Monterey Operations Center.

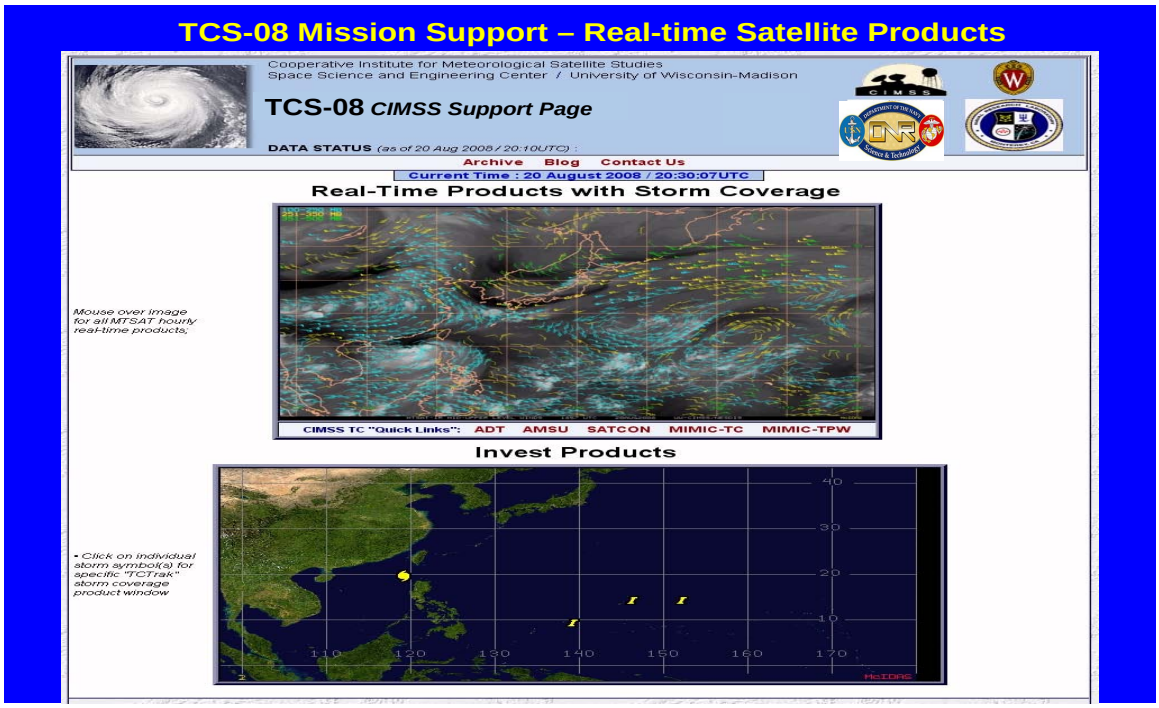

Fig. 1. Lead page of UW-CIMSS satellite-derived products site, used extensively in mission planning and support of TCS-08 events.

The U. Miami team provided real-time guidance for targeting in support of the field program. The ETKF guidance was computed at U. Miami/NCEP and uploaded to the ECMWF PREVIEW system (see Figure 2 for an example plot). Dr Majumdar spent 3 weeks in the Monterey Operations Center. Both locally and remotely, he led Elluminate conference sessions on targeted observing strategies adjacent to the Daily Planning Meetings, in order to make decisions on deployment specific to targeted observations. Among the discussions in these meetings were whether or not to activate MTSAT rapid-scan mode, and recommendations were made to JMA. Other decisions included the coordination of structure missions by the NRL P-3 and USAF C-130 aircraft with targeting missions conducted by the DOTSTAR and Falcon groups. The accompanying summaries are archived in .pdf format in the "Weather Targeting Blog" section on the EOL Catalog: http://catalog.eol.ucar.edu/cgi-bin/tparc_2008/report/index

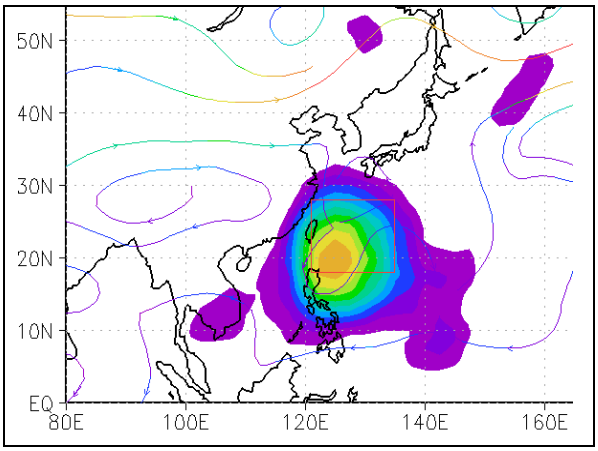

Fig. 2: Ensemble Transform Kalman Filter (ETKF) guidance for targeted observations around Typhoon Sinlaku on 00 UTC, September 11th, 2008, in order to improve a 2-day forecast of the wind field associated with the typhoon. The MTSAT-2 rapid-scan mode was activated during this period.

Another task has been completed by the U. Miami team. A 2-km resolution version of the Weather Research and Forecasting (WRF) model, including a bogus vortex initialization, was configured to be nested within NOGAPS output. This high-resolution model offers the new flexibility to answer questions about the modification to numerical predictions of tropical cyclone *structure* (and not just track) by assimilating targeted satellite wind data. Preliminary simulations have been performed for Typhoon Sinlaku. The WRF infrastructure will be made available to other TCS-08 PIs upon request for their hypothesis testing. A new graduate student has joined the TCS-08 team on this project. He spent 2 weeks in the TCS-08 Operations Center learning about the experiment, assisting with weather briefings and conducting verifications of the global models' abilities to predict tropical cyclone formation. He and another student funded on a different TCS-08 grant (N000140810250) are being trained to use the WRF model infrastructure for the purposes of our investigations in this proposal.

RESULTS

A unique satellite-derived dataset was produced during TCS-08 consisting of hourly wind fields (important for testing 4DVAR assimilation methods), and occasionally enhanced with higher-resolution rapid-scan winds (important for resolving details of tropical cyclone circulations and interacting targeted features).

Diagnostic analyses of the hourly wind data were made available for operational support, and will also be a valuable asset in post experiment studies (see Fig. 2 for an example).

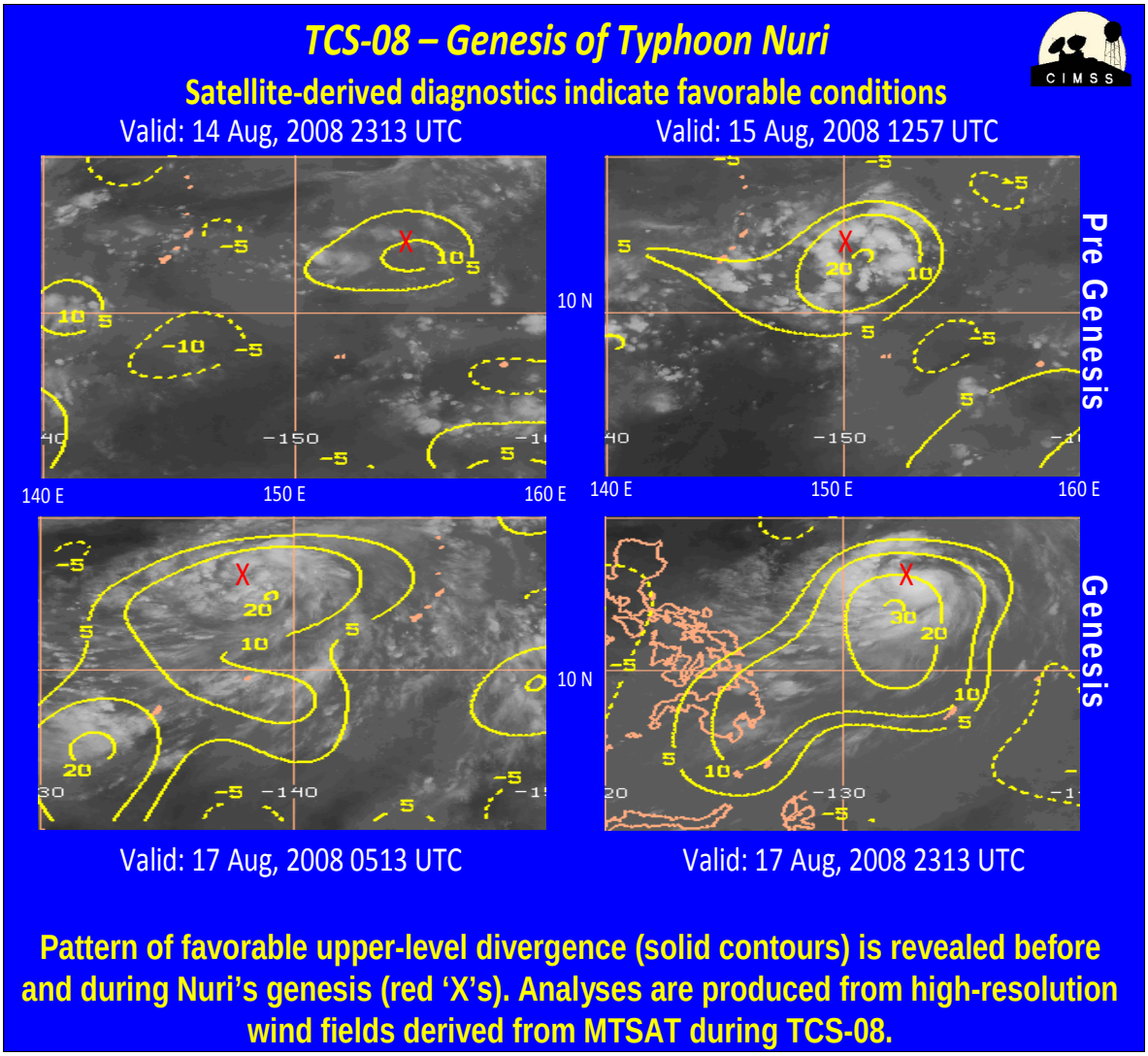

Fig. 3. Example of a diagnostic analysis derived from high-resolution satellite winds during the genesis of Typhoon Nuri showing favorable (divergent) upper-level conditions.

A real-time capability for targeted observations with the ETKF has been established, including the ability to select specific variables (such as upper-tropospheric winds) for targeting.

A new high-resolution modeling capability has been established to examine detailed tropical cyclone structure that is not possible with global models.

IMPACT/APPLICATIONS

A quantitative understanding of the influence of improved representations of the synoptic environment and outflow should lead to new scientific conclusions on environmental interactions and resulting forecasts of tropical cyclone track and structure.

The results of this study should benefit operational forecasting of western North Pacific typhoons. Principally, this benefit will be realized by superior numerical forecasts provided by improved assimilation of satellite data in key (targeted) areas.

RELATED PROJECTS

This project is related to that funded by the TCS-08 grant N000140810250: "Using NOGAPS Singular Vectors to Diagnose Large-Scales on Tropical Cyclogenesis" (PI Majumdar; Co-PIs Peng and Reynolds of NRL Monterey). NOGAPS Singular Vectors are another type of guidance that can be used to identify where satellite wind data are most necessary for assimilation into the NOGAPS system.

This project is also related to that funded by the NSF grant ATM-0735892: "Extratropical transition of tropical cyclones over the western North Pacific: Physical characteristics, downstream impacts, and predictability" (PI Velden, Co-PIs Harr and Elsberry of NPG).

HONORS/AWARDS/PRIZES

PI Velden (UW-CIMSS) was elected Fellow of the American Meteorological Society.

Collaborating student Will Komaromi has received a RSMAS/U. Miami Graduate Student Fellowship, in which the School provides 8 months of funding that would otherwise have been covered by this TCS-08 grant. These TCS-08 funds are now being used to fund assistant scientist Dr. Eric Rappin to prepare the WRF system.