P4.3 ASSIMILATION OF GOES RAPID-SCAN WINDS INTO AN EXPERIMENTAL ETA MODEL DURING HURRICANE KEITH

Howard I. Berger* and Chris Velden
University of Wisconsin-CIMSS

1. Introduction:

The lack of in-situ data in the tropics makes it difficult to properly initialize tropical cyclones in Numerical Weather Prediction (NWP) models. Remotely sensed data from satellites offer an alternative source of information for this initialization problem.

To examine this, experiments are performed that are designed to optimize the assimilation of winds derived from GOES rapid-scan data into the National Centers for Environmental Prediction's (NCEP) Eta model. The wind data are assimilated into the 48 km Eta model through the Eta Data Assimilation System (EDAS). The case study evaluated in this paper is Atlantic Hurricane Keith (Sept/Oct 2000). The satellite-derived winds will more accurately describe the initial upper-level environment over Keith. Various assimilation strategies will be explored in order to optimize the influence of these wind data on the model initialization and resulting analyses. Model forecasts of track and intensity will be used to evaluate the various imposed assimilation strategies.

2. Methodology, Data and Case study

2.1 Eta Model

The Eta model version used in this study has 48 km resolution and 45 vertical levels. The model is being run on a Silicon Graphics Origin workstation at the University of Wisconsin-CIMSS. The Eta was chosen for this experiment because it is one of NCEP's primary operational regional models and it has a well-established assimilation system.

This assimilation system, the EDAS, uses a regional 3-d variational analysis (Rogers 1996). The EDAS creates its analysis by minimizing a cost function at observation locations .It is designed to use high-resolution mesoscale data types, making it an ideal system to test assimilating rapid scan winds (Rogers 1996). Experiments were performed on the 00Z Oct 02, 2000 Eta run. The operational run is used as the control run for this study.

* Corresponding author address: Howard Ian Berger
1225 West Dayton St. Madison, WI 53706
Email: howardb@ssec.wisc.edu

2.2 Rapid-scan (RS) winds from GOES

During selected hurricane events in 2000, the GOES-8 satellite was operated in a special scanning mode that allowed multi-spectral images of the storm at 1-minute intervals over several hour periods. Winds are derived from successive images using automated feature (cloud) tracking techniques developed at CIMSS (Velden et al. 1998). It has been shown that the quantity and quality of cloud-motion winds can be greatly enhanced by more frequent sampling strategies. The normal operational sampling interval for GOES wind determinations is 15-30 minutes.

In this study, the GOES RS data set was sub-sampled so that the winds were derived from successive 3-5 minute scans (to minimize the effects of image-to-image registration errors). Winds were produced from both visible and IR imagery. An example of the coverage obtainable over the cloud canopy of Hurricane Keith is shown in Figure 1.

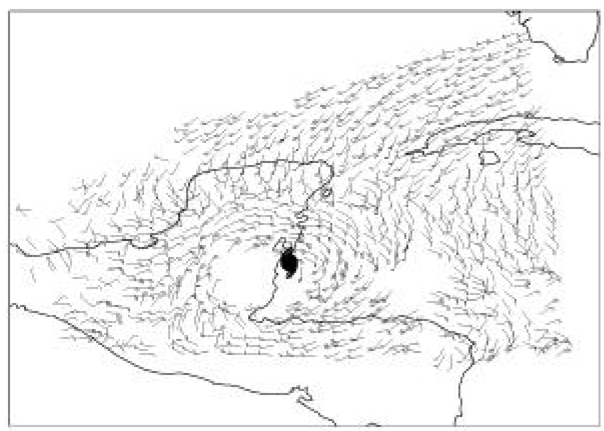

Fig. 1: Plot of GOES RS winds over the 100-400 hPa range during Hurricane Keith on 02 October 2000. The hurricane symbol represents the storm's center at the time the winds are valid.

2.3 Hurricane Keith

Keith was an intense tropical cyclone in the Northwest Caribbean Sea and the Gulf of Mexico during the fall of 2000. It was a Category 3 hurricane when it made landfall over Belize with maximum winds near 120 kts (Beven 2001).

The official National Hurricane Center (NHC) forecasts for Keith as a whole were worse than CLIPER (Climate-Persistence model) at the 12 and 24 hour forecast periods, and worse than the 10-year average at longer forecast intervals (Beven 2001). The NCEP Aviation (AVN) model in particular had a difficult job of predicting Keith's westward motion as well as being biased too far to the north. For the 12 UTC forecast on Oct. 02, the actual track that verified was outside of the entire envelope of numerical guidance. Thus, the models had significant problems forecasting the track of this storm.

The intensity forecasting was also difficult, being significantly worse than the ten-year average. This intensity error was tied both to the track forecast uncertainty (the storm remaining over water when it was predicted to go over land), and a lack of understanding about the storm's structural changes as it passed over changing surface types (Beven 2001).

3. Model Initialization Impact

Initially, traditional operational values for visible and infrared cloud-drift winds were used in the observation weighting. The winds were assimilated into the 00 UTC initialization of the Eta model on 02 Oct., which was close to the time of the rapid scan wind set.

Figure 2 is a plot of wind differences between the experimental and control run at 300 hPa. Although the wind impact is not dramatic, one can see that the experimental winds are adding a counterclockwise rotation around the center of the storm. The rapid scan winds are capturing an upper level cyclonic circulation that the operational model analyses did not resolve.

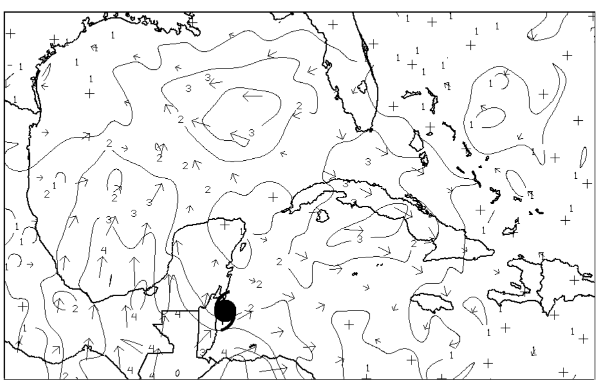

Fig. 2: 300 hPa wind differences between the experimental and control Eta analyses. The barbs show direction, while the isotachs show wind speed differences in ms^{-1}. The hurricane symbol represents the location of the storm's center at this time.

4. Future Work

This project will continue to explore ways to optimally assimilate the GOES RS wind observations in hurricane events to improve the initialization of the storm structure that should improve forecasts.

Two directions for future study are envisioned. The first involves the implementation of a vortex relocation algorithm within the Eta model. A similar relocation algorithm showed improvement during some tests in NCEP's Aviation model during the 1999 hurricane season (Liu, 2000). The algorithm, similar to that used in the GFDL hurricane model, involves relocating the model's initial vortex to the location determined by the NHC. It is hoped that by improving the initial vortex position, adding the satellite winds will be even more effective because the winds will be assimilated to a properly initialized storm center.

The second direction involves modifying the observation weights and correlation lengths in the assimilation system. Using the operational weights showed only minor impact. It is hoped that an optimal configuration will have a greater impact on the initial analyses and result in an improved forecast track and intensity. The results from these experiments will be presented.

5. References

Beven, J. 2001: Tropical Cyclone Report Hurricane Keith. Preliminary Report

Liu, Q.,T. Marchok, H. Pan, M. Bender, and S. Lord, 2000:Improvements in Hurricane Initialization and Forecasting at NCEP with Global and Regional (GFDL) Models, NOAA Technical Procedures Bulletin 472.

Rogers, E., D. Parrish, Y. Lin, and G.J. DiMego, 1996: The NCEP Eta Data Assimilation System: Test with a Regional 3-D Variational Analysis and Continuous Cycling. Preprints, 11th AMS Conference on Numerical Weather Prediction, 19-23 August 1996, Norfolk Virginia.

______, D. Parrish, G.J. DiMego, 1996: Data Assimilation Experiments with the Regional 3-D Variational Analysis at the National Centers for Environmental Prediction

Velden et al. 1998 The Impact of Multispectral GOES-8 Wind Information on Atlantic Tropical Cyclone Track Forecasts in 1995. Part I: Dataset Methodology, Description and Case Analysis. *Mon. Wea. Rev,* **126,**1202-1218

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