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OSSEs FOR REALISTIC DWL CONCEPTS: IMPACTS ON HURRICANE TRACK FORECASTS

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1. INTRODUCTION

Observing System Simulation Experiments (OSSEs) are used to evaluate the potential impact of proposed new observing systems, most often space-based sensors. Furthermore, past experience has shown significant time lags between instrument deployment and eventual operational NWP use. Thus, we employ OSSEs to obtain quantitative information on observing system impacts for

- new instruments
- alternative mix of current instruments
- data assimilation system diagnosis and improvement

OSSEs have been ongoing at numerous location including NCEP and NASA GSFC. Masutani et al., 2005 (these proceedings) summarizes the work ongoing at NCEP while this paper focuses on the work at GSFC dealing with OSSEs and the impact of space-based Doppler lidar winds on hurricane track forecasts.

2. DESCRIPTION OF OSSEs

The primary components of an OSSE are shown in Figure 1. In OSSEs, a "Nature Run" (NR) is a free run of a forecast model and is a proxy for real nature. The goal is to have the NR contain realistic phenomenology and variability. The model used to produce the NR should be as independent as possible from the data assimilation system model since correlated biases introduce inappropriate optimism.

The NR is used to simulate observations from both existing and planned observing systems. For the existing systems, simulated observations should exhibit the same system impact as real observations and contain the same kinds of errors as real observations (e.g., systematic errors, representativeness). It is critical to remember that the NR is truncated spectrally in space and time while nature, of course, is not.

As shown in Figure 1, in Step 1 of the OSSE both current observing systems and proposed systems are simulated using forward models. In Step 2, the statistics of the simulated current observations are compared with those developed over years of data quality assessment. In Step 3, the simulated data are assimilated and an analyses generated that can be compared (Step 4) with the Nature Run (Truth) at initialization times. In Step 5, the analyses are used to initialize a model different from the Nature Run model and forecasts are generated. In Step 6, the forecasts are compared with the Nature Run to assess the relative impacts of the various observing systems.

At GSFC, OSSEs have been used over the past decade to:

- Evaluate the relative impact of temperature, wind and moisture data. These experiments showed wind data to be more effective than mass data in correcting analysis errors and indicated significant potential for space-based wind profile data to improve weather prediction.
- Evaluate the relative importance of upper and lower level wind data. These experiments showed that the wind profile data from 500hpa and higher provided most of the impact on numerical forecasting.

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- Evaluate different orbital configurations and the effect of reduced power for a space-based laser wind sounder. These experiments showed the quantitative reduction in impact that would result from proposed degradation of the LAWS instrument.
- Determine draft data requirements of space-based lidar winds. These experiments evaluated different coverages, resolutions, and accuracies for lidar wind measurements to estimate both research and operational requirements for the Global Tropospheric Wind Sounder (GTWS) Mission.
- Determine if the impact of space-based wind profiles would be substantially reduced in the presence of advanced sounders or with more accurate forecast models.

Most recently, a 90 day Nature Run was generated using the FVCCM. Some of the features of the Nature Run and associated simulation experiments are:

- Summer time Nature run (4 month) including hurricanes
- NR by NASA FVCCM model with 0.5 deg
- Use NASA DAO GEOS-3 data assimilation with 1-1.5 deg
- 1999 data distribution
- Use interpolated temperature for radiance data
- Use U and V wind for DWL data
- Impact on hurricane forecast
- Evaluate cyclone tracks and Jet streak locations

3. DWL OSSEs

Space-based wind profiles were simulated first in a very idealized way, with the same coverage as TOVS, 1m/s accuracy at all levels and no degradation due to cloud effects; in later experiments somewhat more realistic lidar winds with attenuation due to clouds, but still 1m/s accuracy were assimilated. The OSSE system was calibrated through comparison with real data impact experiments. The results of the OSSE were evaluated in terms of standard metrics (RMS, anomaly correlation) and new metrics (cyclones, jet streaks, hydrologic cycle).

While there are several ways to express the forecast impacts, we have chosen hurricane track forecast improvement as a phenomenological metric. In the 1999 NR there were numerous tropical cyclones and two that became hurricanes. The track prediction for Hurricane 1 (similar to hurricane Floyd) was improved at all time steps for all forecast lengths (Figure 2). Plots of the tracks with and without DWL data for two hurricanes are shown in Figure 3. The lidar simulated was a full tropospheric sounder.

4. SUMMARY

Observing System Simulation Experiments (OSSEs) provide an effective means to:

- Evaluate the potential impact of proposed observing systems
- Determine tradeoffs in their design
- Evaluate new data assimilation methodology

Previous OSSEs conducted with 4 different data assimilation systems (from 1985-1999) all showed significant potential for space-based lidar wind profiles to improve atmospheric analyses and weather predictions. Results from the current NCEP and NASA OSSEs indicate that there would be a substantial impact of space-based lidar winds on weather prediction, if sufficient coverage and accuracy can be achieved from space.

New metrics, which are more directly relevant to local weather and earth system science, are being developed. Several of these metrics were applied for the first time in the NASA/GSFC OSSE. The impact on hurricane track prediction is significant in terms of reduced costs of coastal evacuation.

Additional OSSEs by both NASA and NOAA will be required to evaluate the impact of specific lidar systems that may be proposed to meet the need for wind profile measurement.

5. REFERENCES

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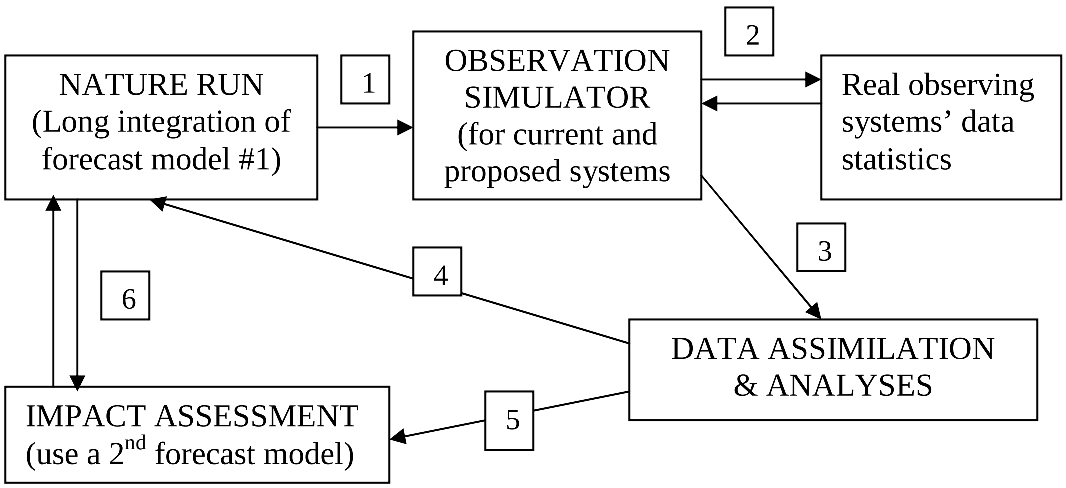

FIGURE 1: Observing System Simulation Experiment diagram.

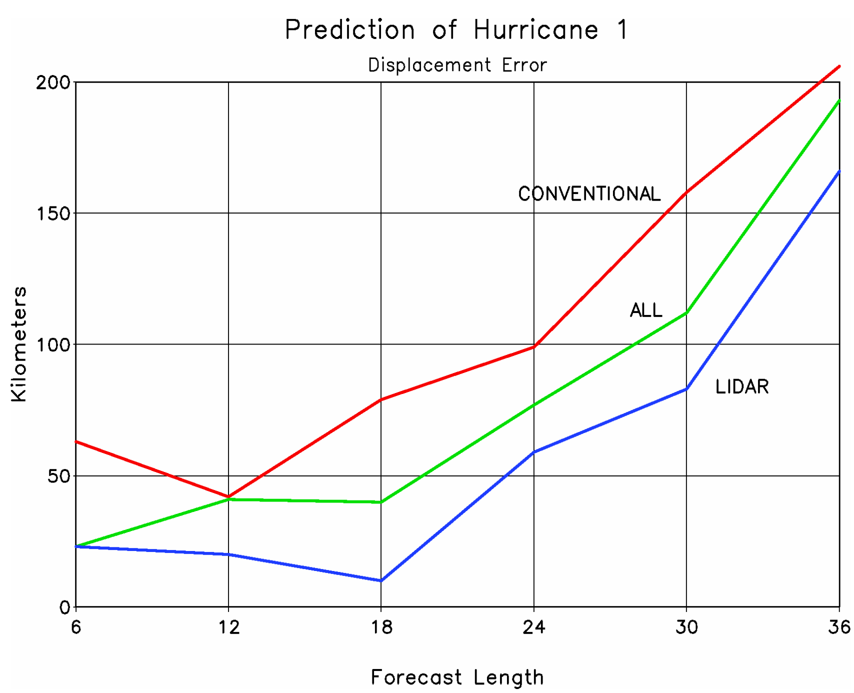

FIGURE 2: Predicted track error as a function of forecast time. See Table 1 for further explanation of labels.

Potential Impact of new space-based observations on Hurricane Track Prediction

Based on OSSEs at NASA Laboratory for Atmospheres

- Tracks
  - Green: actual track
  - Red: forecast beginning 63 hours before landfall with current data
  - Blue: improved forecast for same time period with simulated wind lidar
- Lidar in case 1
  - Reduces landfall prediction error by 66%

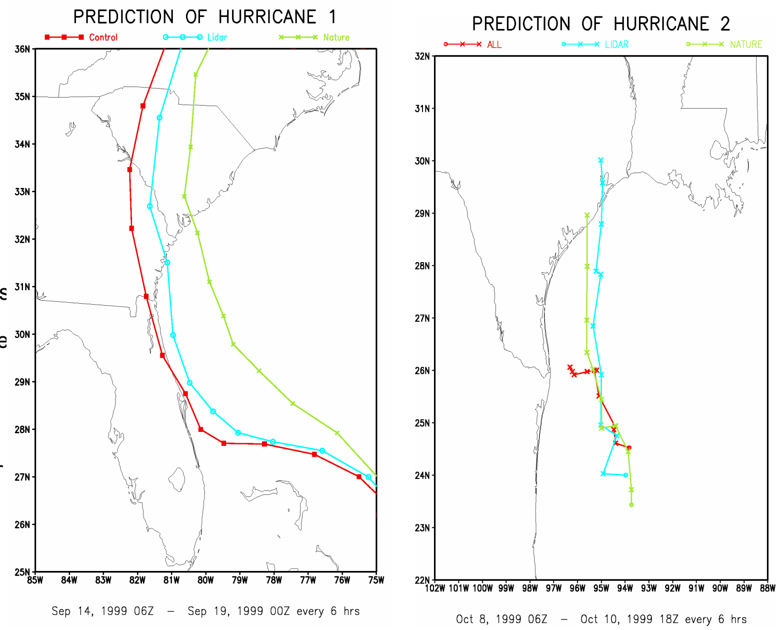

FIGURE 3 Two hurricane tracking impact cases from the GSFC's 90 day Nature Run.