16C.4 USE OF NUMERICAL WEATHER PREDICTION TECHNOLOGY FOR SIMULATIONS OF HISTORIC TROPICAL CYCLONES

Michael Dickinson*, George D. Rowe, Raymond Richardson,
Isaac Ginis, and Lewis A. Rothstein

Accurate Environmental Forecasting, Inc.
Narragansett, RI 02852

1. Introduction

Detailed surface wind information after tropical cyclone landfall is of vital importance, not only to meteorologists studying and forecasting the storm, but to state and local risk managers and to members of the insurance industry who want to assess damages and financial losses to the landfall regions. However, highly detailed surface wind information is not available given the sparse nature of the observation network. Further, instrument failure in high wind conditions during tropical cyclone landfall can further reduce the already sparse number of observations.

One way to produce high-resolution surface wind information is through the use of numerical weather prediction (NWP) technology. High resolution information about the terrain and land use characteristics can be incorporated in this framework to produce high resolution (in space and time), realistic surface wind fields. This is the approach taken by Accurate Environmental Forecasting (AEF).

2. Methodology

The AEF RealTrack™ model is based on the operational Geophysical Fluid Dynamics Laboratory (GFDL) hurricane forecast model (Kurihara et al., 1998) that has been extensively modified to permit simulations of the wind field produced by a hurricane with a prescribed track and intensity. RealTrack™ is a dynamical model that utilizes the physical balances in the dynamic equations to determine how a hurricane will respond to local variability in the surface conditions (primarily topography and surface roughness). The RealTrack™ hurricane model incorporates a high-resolution boundary layer (eight vertical levels below 1000 meters) combined with high-resolution information about topography and land use.

The model is run on a domain which moves with the tropical cyclone. Movement of the domain is directable and is designed to force the storm to follow a predefined track**.** The upper level winds (1000 m and above) are forced toward a predefined “target” storm structure in a manner that will be described below whereby storm intensity and gross spatial characteristics are imposed. The boundary layer (below 1000 m), however, is free and is capable of representing complex three dimensional atmospheric processes such as interactions with topographic features and decoupling of the wind fields between the surface and the top of the atmospheric boundary layer.

The target storm structure at heights above 1000 m is generated from hurricane data containing information regarding the storm maximum wind and the radius of maximum, 50 knot and 34 knot winds at 6 hour intervals. It is derived from an integration of a simplified version of the hurricane model that creates an axisymmetric vortex with the desired intensity and size. A target axisymmetric vortex is created for each 6 hour set of parameters in the storm record. These target axisymmetric vortices are then modified to account for the asymmetric nature of real hurricanes. The storm radii in four spatial quadrants are used to create asymmetry fields that are superimposed on the target axisymmetric vortices.

The RealTrack™ system is designed to run after the storm has made landfall using known hurricane track and intensity characteristics. It can also be run in forecast mode from a National Hurricane Center (NHC) or any other available forecast. Once the storm footprint has been produced, the maximum surface winds affecting each state or county can be readily determined.

3. Applications

The AEF RealTrack™ system can be applied to storms in near real-time. Figure 1 shows an example of the AEF RealTrack™ system applied for a post-landfall analysis for Hurricane Isabel (2003). This image shows the details in the surface wind field due to variations in surface roughness (land use) and terrain. This footprint was generated based on the observed location, maximum wind speed, and storm radii for the period 0600 UTC 18 September to 1200 UTC 19 September. The footprint shows the winds enhanced on the right side of the track due to the storm motion. Inland, the wind speeds quickly weaken though winds in excess of 50 mph are found over the higher elevations of the Appalachian Mountains in northern Virginia. In forecast mode, this footprint provides a measure of where the strongest winds are expected to be for the given forecast track. However, the quality of the wind footprint is strongly dependent on the quality of the tropical cyclone intensity and track forecast.

Table 1 provides a comparison between observed winds and winds from the AEF footprint at corresponding points. Wind speeds from the footprint compare favorably to the direct observations.

This technology can also be utilized to examine historical events. The NHC Atlantic best track dataset (Jarvinen et al. 1984) is used by the scientific community as well as the private sector to determine hurricane climatologies from the Gulf of Mexico to New England. This best track dataset contains two pieces of information: (1) storm center positions and maximum wind speed (vitals) and (2) for land-affecting hurricanes, a Saffir-Simpson Hurricane Scale (SSHS) category based on the maximum winds observed in each affected state. The best track dataset is currently undergoing a reanalysis by the Hurricane Research Division.

For a number of storms in the NHC best track dataset, the wind distribution implied by the vitals can not support the state-based SSHS measurement in the affected state. Using our storm footprint technology, we can determine the maximum wind each region, state, or county experiences for the prescribed track and intensity record (the vitals) for the entire best-track.

4. Summary

The AEF RealTrack™ hurricane system is designed to produce high resolution wind speed estimates for a given tropical cyclone using NWP technology and detailed land use and topographic information. This technology can be utilized to augment the official National Hurricane Center forecasts during hurricane landfall and to deliver more accurate and detailed forecasts of hurricane winds to the public. This will result in a more informed community and better overall community preparedness prior to a hurricane making landfall.

5. References

Jarvinen, B. R., C. J. Neumann, and M. A. S. Davis, 1984: A tropical cyclone data tape for the North Atlantic Basin, 1886-1983: Contents, limitations, and uses. *NOAA Technical Memorandum* NWS NHC 22, Coral Gables, Florida, **21 pp**.

Kurihara, Y., R.E. Tuleya, and M.A. Bender, 1998: The GFDL hurricane prediction system and its performance in the 1995 hurricane season. *Mon. Wea. Rev.*, **126**, 1306-1322.

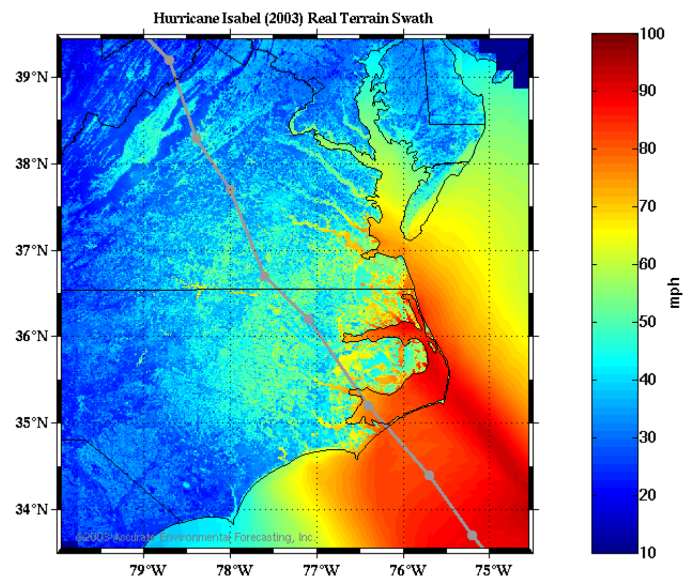

***Figure 1**: AEF RealTrack™ wind footprint for Hurricane Isabel (2003) created from observed track and intensity. Shading represents maximum 1-min sustained winds at 10 meters in mph for the period of storm passage at 1 km resolution.*

***Table 1**: Comparisons with observations (1-min sustained wind). Both model and observational data are adjusted to 10 cm roughness length for this comparison.*

Station	City	State	Date	Latitude	Anemometer ht. (m)	Obs. Wind (MPH)	Model (MPH)
IAD	Washington	DC	9/18/2003	38.93	33	37	37
ILM	Wilmington	NC	9/18/2003	34.27	33	45	40
MRH	Beaufort	NC	9/19/2003	34.73	26	50	58
OXB	Ocean City	MD	9/18/2003	38.32	33	41	46
PHF	Newport News	VA	9/18/2003	37.13	33	51	66
RIC	Richmond	VA	9/18/2003	37.52	33	46	51
WAL	Wallops Island	VA	9/18/2003	37.93	33	49	47
BUY	Burlington	NC	9/18/2003	36.05	33	38	38
DAN	Danville	VA	9/18/2003	36.56	33	39	39
LBT	Lumberton	NC	9/18/2003	34.62	33	37	34