JP3.5 QUANTITATIVE PRECIPITATION FORECAST (QPF) SKILL FOR SELECTED TROPICAL CYCLONE FORECAST MODELS DURING HURRICANE IRENE (1999)

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1. INTRODUCTION

Over half of the deaths associated with tropical cyclones in the United States in the past 30 years have been associated with fresh-water flooding (Rappaport 2000). Even relatively weak tropical systems, such as Tropical Storm Allison (2001) have the potential to produce copious amounts of rainfall: Allison caused extensive flooding from eastern Texas through North Carolina and resulted in 41 deaths. To date, however, most model validation studies of tropical cyclone forecasts have focused on track and intensity. The purpose of this study is to investigate quantitative precipitation forecast (QPF) skill for operational models routinely used for tropical cyclone forecasting. The case of Hurricane Irene (1999) is explored using both the NOGAPS and GFDL model forecasts.

Irene formed as a tropical depression in the northwestern Caribbean on 13 October, 1999, and attained tropical storm status within 6-hours. The storm moved north across western Cuba and reached hurricane strength over the Florida Straits. Irene made landfall in southwest Florida on 15 October, and continued on a north-northeastward track, emerging back over water north of West Palm Beach. The system dumped up to 20 inches of rain on south Florida.

2. DATA AND METHODOLOGY

In this study, 24 hour QPF totals from the National Weather Service GFDL (Geophysical Fluid Dynamics Laboratory) operational hurricane forecast model are compared against rain gauge observations, a rainfall "CLIPER" and TRMM rainfall rate retrievals.

Rain gauge measurements are from COOP sites across Florida, and were obtained from the National Climatic Data Center. Florida observations from 1200UTC on 15 October to 1200UTC on 16 October, 1999 were plotted and hand-analyzed in order to obtain areal precipitation coverage (Fig.1). The GFDL 12–36 hour QPF from the 1999101500 model run was used in order to avoid errors resulting from model spin-up in the first 12 hours, and track dependent errors beyond 48 hours. Model-forecasted rainfall patterns were qualitatively compared to observed rainfall patterns, and differences in 24-hour forecasted and observed precipitation maximums were determined.

Over ocean areas, GFDL QPF was compared to data from the Tropical Rainfall Measuring Mission (TRMM) satellite. This data is an average 24-hour rain rate (mm/h) at 1°X 1° resolution and was obtained courtesy of NASA's Goddard Space Flight Center. Because the model data was valid from 15/1200UTC to 16/1200UTC and the TRMM data was a daily average, it was necessary to use an average of the 15 October and 16 October TRMM data in order to obtain an representative comparison. Again, forecasted and observed rainfall patterns and maxima were compared.

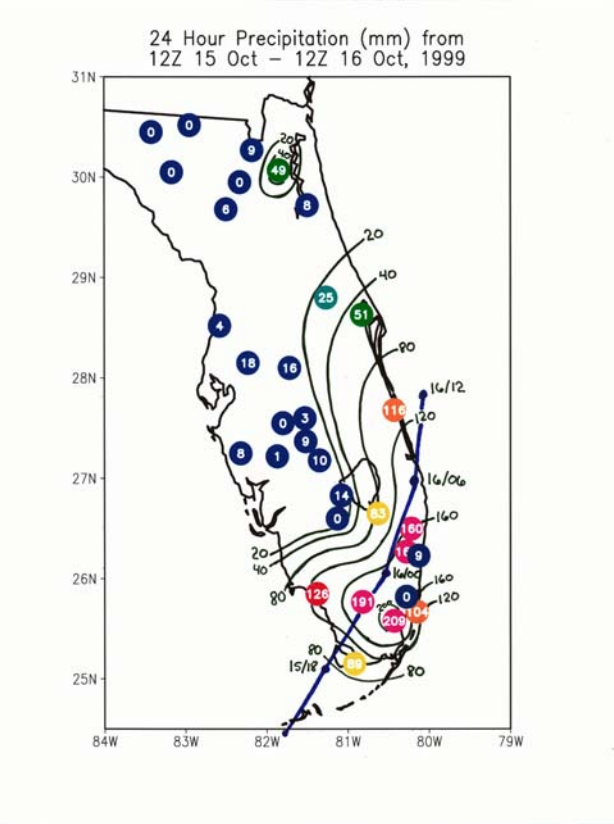

Fig. 1. Rain gauge totals for 1200UTC 15 Oct. to 1200UTC 16 Oct., 1999 reported at COOP observing sites. Dots represent the observation sites, color coded by rainfall; numbers inside the dots are the rainfall amounts (mm). The blue line represents the NHC best track of Hurricane Irene.

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Model-forecasted precipitation was then evaluated relative to the Rainfall Climatology and Persistence (R-CLIPER) model developed by Marks et al. (2002). This comparison was made to determine the skill of the GFDL rainfall forecast. Finally, the model's errors and skill were scrutinized in light of the track forecast error.

3. RESULTS

3.1 GFDL vs. Rain Gauge Observations

The GFDL-forecasted precipitation had a westward bias of about 1° of latitude (Fig.2). The observed area of maximum rainfall occurred over southeastern Florida, in Broward and Miami-Dade counties, whereas the QPF maximum was located off the southwest coast. Rainfall amounts were under-forecast by 20–30 mm. The peak observed rainfall over the 24-hour period was 209 mm, while the maximum forecast was just over 180 mm.

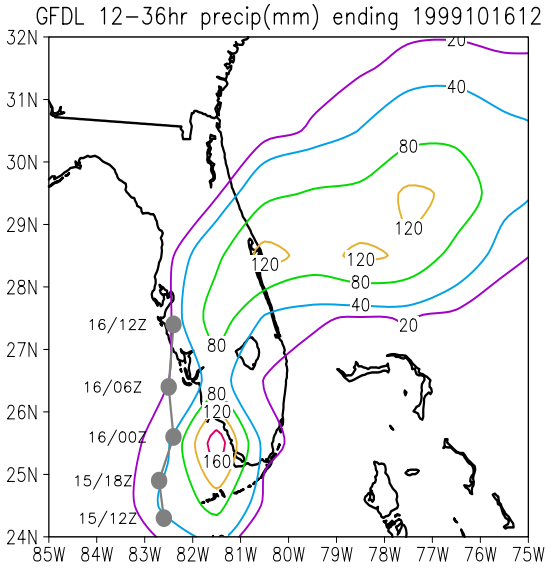

Fig. 2. GFDL 12-36 hour QPF from the 1999101512 model run (mm). Grey dots and line represent GFDL track forecast for Hurricane Irene.

3.2 GFDL vs. TRMM

GFDL QPF tended to be over-forecast along the southwest coast of Florida; in comparison to TRMM measurements (Fig. 3), GFDL QPF in the Florida Straits and off the eastern coast was under-forecast. Forecast precipitation amounts along the west-coast were ~ 160–180mm, while TRMM observations were ~ 100–110mm. In the Florida Straits, GFDL forecasted ~40–80mm, and 80–100 mm were observed. Precipitation was under-forecasted off Florida's east coast by ~20–40mm. The model QPF once again demonstrated a westward bias. This bias appears to be the culprit in the over-forecast of rainfall along Florida's southwest coast. If the maximum were shifted to the east, it would be over southeast Florida where it actually occurred. However, the coarse resolution of the TRMM data could cause some ambiguity in the comparison.

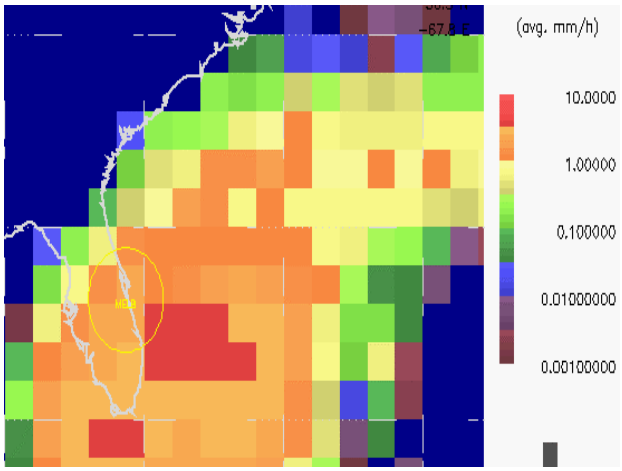

Fig. 3. TRMM average daily rainfall (mm/hr), 1°X 1° resolution for 16 Oct., 1999.

3.3 GFDL vs. R-CLIPER

Output from the R-CLIPER model tends to compare well with observed rainfall amounts and patterns, with the exception of the area encompassing Miami-Dade and Broward counties, where rainfall amounts were under-forecasted by 40–60 mm (Fig. 4). Even so, the GFDL rainfall forecast does not display skill with respect to the R-CLIPER for this particular case. However, it should be noted that the R-CLIPER forecast was obtained using Irene's best-track, not a track forecast produced by the model itself. This R-CLIPER analysis is currently being repeated using the model-forecast track to determine the R-CLIPER rainfall distribution.

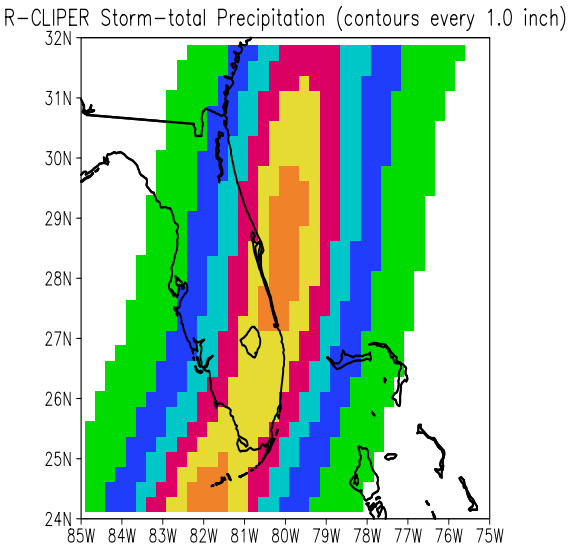

Fig. 4. R-CRILPER storm-total precipitation (contours every inch) for Hurricane Irene.

4. SUMMARY AND CONCLUSIONS

The GFDL QPF forecast was shown to have a westward bias, consistent with a westward bias in the GFDL track forecast. The model captured the broad asymmetry of the rainfall pattern with respect to the storm's track. The heaviest precipitation associated with Irene over south Florida was to the right of the storm's track. Even though the GFDL forecast track differed from best-track, the Highest QPF values were located to the right of the forecast track. Overall, the GFDL was found to under-forecast precipitation amounts for this case.

Results will be presented for U.S. Navy NOGAPS model as well as GFDL in the poster presentation. Further work will encompass analyzing model QPF for Irene in North Carolina and the Canadian Maritimes.

Acknowledgements: The authors thank Dr Frank Marks (HRD) for providing the R-CLIPER data. Thanks to the Hydrology Data Support Team for producing the TRMM data and the Distributed Active Archive Center, (Code 902) at the Goddard Space Flight Center, [Greenbelt, MD, 20771] for distributing them; Goddard's contribution to this activity was sponsored by NASA's Earth Science Enterprise. Thanks to Dr Robert Hart for assistance with the data acquisition and graphics.

4. REFERENCES

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