Introduction

During the warm season, the Carolinas are particularly prone to tropical cyclone (TC) activity and can be impacted in many different ways depending on storm track. The coasts of the Carolinas are the most vulnerable areas, but particular situations (Frances and Ivan 2004) affected communities far from the coasts (Prat and Nelson 2013). Regardless of where landfall occurs, TCs are often associated with intense precipitation and strong winds triggering a variety of natural hazards (storm surge, flooding, landslides). The assessment of societal and environmental impacts of TCs requires a suite of observations. The scarcity of station coverage, sensor limitations, and rainfall retrieval uncertainties are issues limiting the ability to assess accurately the impact of extreme precipitation events. Therefore, numerical models, such as the Weather Research and Forecasting model (WRF), can be valuable tools to investigate those impacts at regional and local scales and bridge the gap between observations.

The goal of this study is to investigate the impact of TCs across the Carolinas using both observational and modeling technologies, and explore the usefulness of numerical methods. To fully assess TC impacts, the Carolinas inhabitants, storms impacting both coastal and inner communities (Fig. 1) were selected and high-resolution WRF ensemble simulations generated from a suite of physical schemes for each TC to further investigate their impact at finer scales (see comparison poster of Leeper et al.).

The ensemble member performance was evaluated with respect to satellite (TMPA 3B42) and ground-based (PRISM daily) observations.

Comparisons WRF Modeling Results with Observations

When compared to observations (Fig. 2), the differences observed (precipitation field, maximum location and intensity) are dependent upon the storm characteristic (track, area impacted). Results indicated an important model sensitivity to microphysical parameterization (Fig. 3). For the TCs considered, the simulated precipitation fields display important differences with regards to the WRF physical scheme. Differences ranged from (0.91<R²=0.99) for Hurricane Isabel to (0.43<R²<0.87) for Hurricane Frances.

Fig 2. WRF simulated rainfall accumulation (ensemble: 1st column; selected physic option: 2nd column) and observations (TMPA 3B42: 3rd column; PRISM: 4th column) for (from top to bottom): a) Hurricane Floyd (1999), b) Hurricane Isabel (2002), c) Hurricane Frances (2004), and d) Hurricane Irene (2011). Event accumulation derived from surface stations (5th column) is provided for comparison. Locations of the reported (red triangle), modeled (black/white squares), remotely sensed (pink diamond), and ground based (green diamond) maxima.

Preliminary Results

The total accumulated rainfall displays important differences from storm to storm (Fig. 4). Hurricane Isabel (Fig. 4b) presents the best overall agreement between models (-7%<Acc.<+8%) and observations (-11%<Acc.<+11%).

For Hurricane Frances (Fig. 4c), the best agreement with observations is found for the Morrison scheme (H). In addition to a better timing (see poster of Leeper et al.), the model captured the higher rainfall accumulation along the mountain slopes in better agreement with surface observations (PRISM) when compared to satellite rainfall estimates (TMPA 3B42) (Fig. 2).

Ongoing Work

- Evaluate the fitness of WRF simulations by including more observations such as the Climate Reference Network (CRN) stations, COOP rain gauge stations, satellite precipitation estimates (CMORPH, PERSIANN), TRMM Precipitation Radar (TPR 2A25), and rainfall estimates from the National Mosaic and Multi-sensor QPE (NM2/Q2) among others for a better timing of precipitation.
- More broadly, this work aims to provide an assessment of the various types of impacts TCs can have based on their track and other characteristics.

References:

Huffman, G.J., et al. (2007), The TRMM multisatellite precipitation analysis (TMPA) quasi-global, multiyear, combined-sensor precipitation estimates at fine scales, J. Hydrometeorol., 8, 38-55.


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