10A.3 Recent results on landfalling hurricanes with the GFDL hurricane-land-ocean coupled system at NCEP

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1. INTRODUCTION

The current operational GFDL hurricane prediction system at NCEP uses a slab land surface model (LSM) for hurricane-land interactions. Under the current framework, the model only predicts soil temperature with land heat capacity and moisture fixed. This certainly limits the model capability of predicting land surface temperature and heat exchanges. Also, the land moisture is derived from surface vegetation. This is obviously incorrect since initial land moisture depends on the previous rainfall typically in the timescale of several days and land moisture changes during its interaction with a hurricane. However, land surface heat fluxes are minor compared to those over oceans and may no longer be important. So the question is whether accurate representation of land surface exchanges is required for accurate landfalling hurricane prediction. The GFDL hurricane-Noah LSM coupled system was used to answer how and to what extent land surface exchanges can affect landfalling hurricanes.

2. MODEL USED FOR THE STUDY

The model used is the operational Geophysical Fluid Dynamics Laboratory (GFDL) hurricane model at NCEP but with the slab LSM being replaced by the Noah LSM (Ek et al. 2003). The Noah LSM is a comprehensive LSM which is currently used in the operational global and regional forecast system (or GFS and Eta for short). The Noah LSM uses four soil layers with a canopy cover. Surface skin temperature, evaporation and sensible heat fluxes are predicted from the LSM and passed to the atmospheric model. The coupled system was tested for 25 historical landfall hurricanes and a significant number of hurricane cases (for both landfall and non-landfall hurricanes) for the season of 2005. For the historical hurricanes, the operational version for the season of 2003 was used for the ocean and atmosphere. NCEP's North American Land Data Assimilation System, NLDAS (Mitchell et al. 2004), data were used to provide the initial land conditions for these cases. For the season of 2005, our experiments were conducted with initial land conditions from the Eta-based 4-Data Assimilation System (EDAS), which is only slightly different from the NLDAS. Compared to the version of 2003, two major upgrades including a new nest of resolution of 1/12 degree and larger domain of ocean coupling were made.

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3. RESULTS

A 3-day forecast for each of the 25 historical landfall hurricanes was run for both slab (operational) and Noah LSM couplings. For the chosen cases, all hurricanes made landfall in less than a day. The model results for hurricane track, intensity and (accumulated) precipitation over land were compared to the observations from the rain gauge data and the National Hurricane Center best track reanalysis. It was found (not shown) that the impact of the Noah LSM coupling on track and intensity are insignificant. For example, the track difference is smaller than 50 km for most of the cases. Appreciable differences are found in the precipitation particularly in local accumulation. The hurricane-Noah LSM coupled system in general improves the precipitation forecast (such as in total rainfall, equitable threat score and QPF bias score). Fig. 1 shows the QPF bias score values for different rainfall thresholds.

For the season of 2005, the system with minor physics upgrades and resolution increase was used to investigate all the major hurricanes in the Gulf of Mexico and western Atlantic oceans (defined by the domain of ocean coupling in the GFDL system). 5-day predictions were made for totally 50 cases (see Fig. 2 a). It was found that the impact of land surface exchanges can be profound after about 3 days depending on such

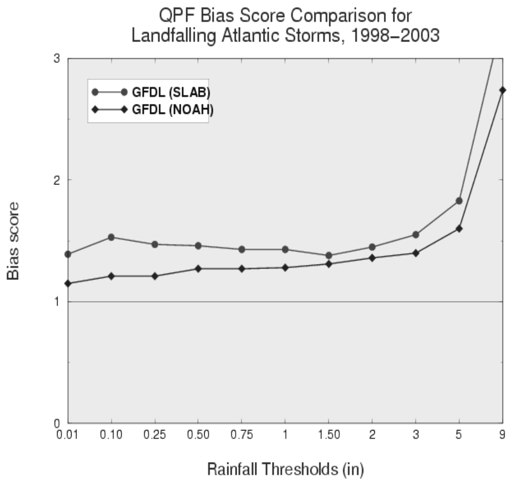

Figure 1. Rainfall bias statistics for 25 historical landfall hurricanes over the Gulf of Mexico and western Atlantic basins from 1998 to 2003.

as storm translation speed and location. For example, the track differences due to land surface coupling change are quite large for the hurricanes Ophelia and Wilma during their early stages of stalling and slow movement. However, for most of the cases, the impact of Noah LSM coupling on the hurricane track are small and gradually increases with time. It is quite encouraging that the overall track is improved with the Noah LSM coupling (see Fig. 2 b), while the impact on hurricane intensity is rather minor (not shown).

The hurricane-Noah LSM coupled system was also tested for several major landfalling hurricanes for the season of 2004 such as hurricanes Jeanne, Ivan, and Frances. Relatively large track differences were also found after 3 days but the Noah LSM coupling led to an overall degradation in the track prediction. This is probably due to the fact that the operational GFDL hurricane system appreciably under-predicted the 500mb high or ridge to the north of the hurricanes. Somehow, the high is further weakened by the Noah LSM coupling although it remains quite similar to that by the operational model (with slab LSM coupling). For understanding of the hurricane-land interface exchanges, detailed analysis were performed for the Jeanne and Ivan cases. It was found that the major impact of hurricane-land interface exchanges by the Noah LSM is strongly confined to the lower troposphere. However, a long-term (i.e. 5 days) effect can cause an appreciable change in the large-scale circulation. We also compared our results to those by the NCEP's Eta system which used the same Noah LSM and provided the initial land conditions for the hurricane-Noah LSM coupled system. We found that they are in good agreement about the surface fluxes and temperatures over land and outperform the operational (slab LSM) model. We, thus, suspect that the track degradation for the hurricanes for the season of 2004 may be due to the biased large-circulations in the GFDL model prediction.

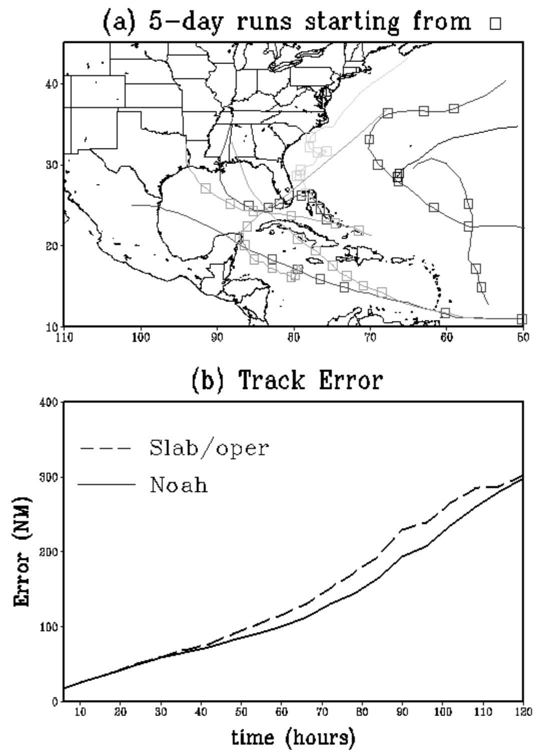

Figure 2. (a) A summary of the hurricane cases for investigation. The solid lines are the observed tracks. 5 days run starts at □
(b) Track error as a function of forecast time (Noah vs Slab).

4. REFERENCES

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