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MM5 SIMULATIONS OF SUB-TROPICAL STORM ALLISON OVER SOUTHERN MISSISSIPPI VALLEY

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1. INTRODUCTION[1]

Allison was a long-lived, early-season tropical storm that affected a widespread area from Texas eastward to Florida then up the eastern seaboard of the United States in June of 2001. During its two-week life span, Allison underwent various stages of structural evolution. One such notable evolution occurred in the morning of 11 June 2001 as the circulation center of the "remnants" of Allison moved onshore over Louisiana and into southern Mississippi. A burst of convection was seen on infrared images just east of where Allison made landfall. Shortly thereafter, Doppler radar images showed the formation of a squall line on the southeast flank of Allison as an eye-like feature emerged around its cyclonic center. Meanwhile, the central pressure was falling, and a cirrus cloud shield was seen emanating outward following the convection outbreak (Kong, 2002). Overall, these signified a strengthening cyclone, but in an unusual manner. Allison was a hybrid storm throughout much of its life span—it exhibited both the characteristics of tropical and extratropical cyclones. The National Hurricane Center classified the cyclone as sub-tropical storm Allison while it was located over Louisiana and Mississippi (Beven et al., 2003). Formation of "sub-tropical" cyclones occurs more often in the open ocean where few surface observations is available. However, Allison passed through regions where there was a good coverage of land stations, especially Doppler radars. Figure 1 shows a Doppler reflectivity image from Slidell, LA when the eye-like feature and the squall line were very distinct.

2. MM5 SETUPS

Given the above observations, numerical experiments using the NCAR/Penn State MM5 were carried out to see how well the model could simulate Allison. The model was set up with two nested domains at 81km and 27km grid spacing with 23 vertical levels. It was initialized at 12 UTC 10 Jun 2001 using the NCEP's 2.5° gridded analyses, and was integrated for 60 hours. Various combinations of microphysics, cumulus parameterizations, and boundary-layer (PBL) options were run. Table 1 lists the available MM5 physics options.

Table 1

Microphysics	Cumulus	PBL
Warm rain	Anthes-Kuo	Blackadar
Simple ice	Grell	Burk-Thompson
Mixed-phase	[Arakawa-Schubert]	Eta
Goddard	Fritsch-Chappell	MRF
Reisner-graupel	Kain-Fritsch (KF)	Gayno-Seaman (GS)
Schultz	Betts-Miller	[Pleim-Chang]

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We did not exhaustively perform every possible combination of physics options. Rather, our strategy was to use either "simple ice" or "mixed-phase" as microphysics. We then coupled the default MM5 cumulus scheme (Grell) with all the available PBL schemes and executed the model. After examining the results from each run, we then selected the best-performed PBL and coupled it with the rest of the cumulus schemes.

3. DISCUSSION OF PRELIMINARY RESULTS

It was found that when the Grell cumulus scheme was coupled with the MRF PBL scheme, many salient observed features were successfully simulated. Figure 2a shows the simulated sea-level pressure and rain mixing ratio patterns at 26 h for domain two using the Grell+MRF combination. A hook-shaped line of rain resembling a squall line is seen on the east flank of the cyclone. Although the timing of the squall line is delayed by three hours, and it does not wrap completely around the cyclone center, its similarity to the Doppler radar image of Figure 1 is evident. By contrast, convective activity developed by all other runs forms both later and further south and east of the cyclone and does not wrap around the center at all. In addition, the vertically integrated convergence of water vapor is much larger for the Grell+MRF run than for the other runs (not shown). Finally, the pressure pattern, central pressure, and the track of the simulated cyclone using Grell+MRF also agree better with observations than using all other cumulus+PBL combinations.

Recently, Davis and Bosart (2002) conducted a sensitivity study of model physics on the simulated structure of Hurricane Diana. Different combinations of MM5 physics options, including the Grell+MRF and KF+MRF were tested. They found that the cyclone intensity obtained from the Grell+MRF scheme was weaker, whereas the cyclone track was closer to the observed. Nevertheless, results obtained from KF+MRF were considered to be more realistic based on the viewpoint that the Grell+MRF scheme produced more perturbed pressure and wind fields than the KF+MRF scheme did in the 9km domain.

By contrast, this MM5 study of Allison shows that the overall result using the Grell+MRF combination clearly out-performs the rest. The key feature related to the intensification that only the Grell+MRF run captured appears to be its ability to organize the burst of convection east of the storm center into a squall line, which, in turn, induces adequate pressure fall to deepen the surface cyclone. The close coincidence of the appearance of a convective burst near Allison's center with its intensification in both observation and the MM5 Grell+MRF simulation provides further support for the existence of a strong linkage between convective bursts and intensification of tropical cyclones.

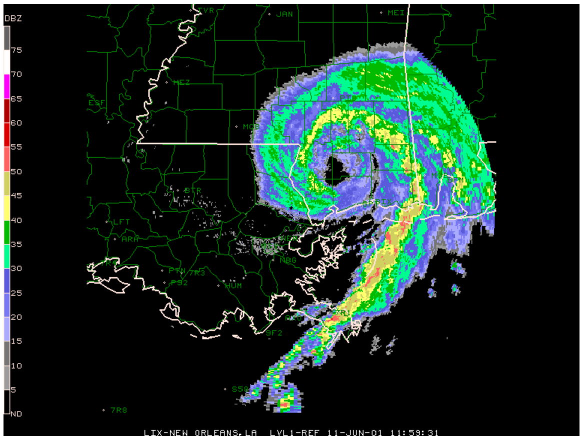

Figure 1. Doppler reflectivity image from Slidell, LA at 11:59 UTC 11 June 2001

4. REFERENCES

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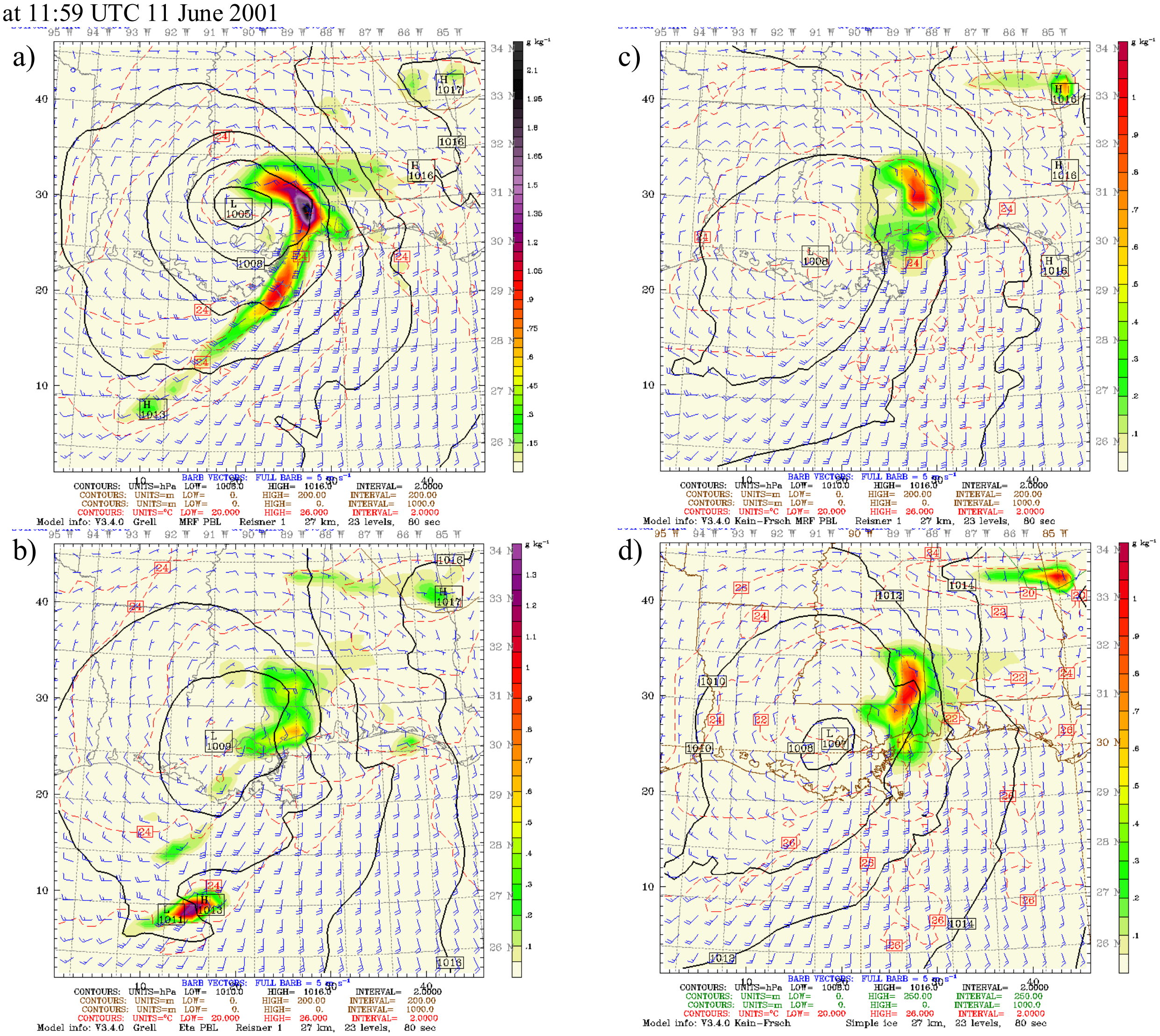

Figure 2. Plots of sea-level pressure, near-surface temperature, winds, and rain water mixing ratio (color shadings) of domain 2 (27km) at forecast hour 26 (14 UTC 11 Jun 2001) for four different cumulus and boundary layer parameterization combinations—(a) Grell plus MRF, (b) Grell plus Eta, (c) Kain-Fritsch plus MRF, and (d) Kain-Fritsch plus Gayno-Seaman schemes.