Intercomparison of Forecasts from Very-High Resolution MM5 and WRF Physics-Based Ensembles: The Dryline/Pacific Frontal Merger During STORM-FEST IOP 17

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1. Introduction

During Intensive Observing Period (IOP) 17 of the Stormscale Operational and Research Meteorology-Fronts Experiment Systems Test (STORM-FEST), an extratropical cyclone produced widespread severe weather throughout the southern United States. The severe weather occurring over the 2-day period (8-10 March 1992) included 13 tornadoes and substantial flash flooding. We refer the reader to Neiman et. al (1998) for a thorough discussion of observed synoptic and mesoscale structure and evolution during this event.

A goal of STORM-FEST was to better understand the limits of mesoscale predictability, and several observational and modeling studies (e.g., Locatelli et al 1995; Neiman et al 1998) have been conducted towards that end. Since the time of the program, however, computational resources have expanded greatly, allowing for routine operational numerical weather prediction to be conducted at the meso-β scale (20-200 km), much finer than was possible during STORM-FEST.

In this paper we re-examine the period leading up to the Dryline/Pacific Frontal Merger during STORM-FEST IOP17 via 10-member MM5 and WRF ensemble forecasts at 1 km resolution, with members constructed by varying the model physics. We will comment on the relative forecast performance of the MM5 and WRF ensembles (members and means) as well as on the predictability of the meso-β scale phenomena that developed and meso-γ scale features in the forecasts not considered in previous studies of the event.

2. Experiment Design: Domain and Data

Though our main ensembling focus considers very fine spatial scales, proper simulation of the frontal and dryline mergers which led to the severe weather outbreak during IOP 17 requires consideration of the synoptic and upper mesoscales in order to appropriately evolve precursory factors in the mergers. In addition, given that the most complete large scale analysis available for model initialization during this period is the NCAR/NCEP Reanalysis (e.g., Kistler et. al 2001), a nesting approach is thereby called for.

Typically, nesting ratios of 3:1 are common for regional models such as MM5 and WRF. However, given the size required at the 1-km resolution, as well as the fact that our intended MM5 and WRF ensembles will ultimately include 18 members each, the 3:1 nesting ratio convention (leading to domains at 1, 3, 9, 27 and 81 km, the latter initialized from the ~120 km resolution reanalysis fields) is time and cost prohibitive with respect to the overall project objectives. Thus, for this case we are experimenting with economization strategies for the nesting. In particular, for this paper we consider a 15 km domain on the larger scales, with a 1 km domain covering the target area one-way nested within this 15 km domain. The area covered by each domain, as well as the landuse categories utilized, is illustrated graphically in Figure 1 on the following page.

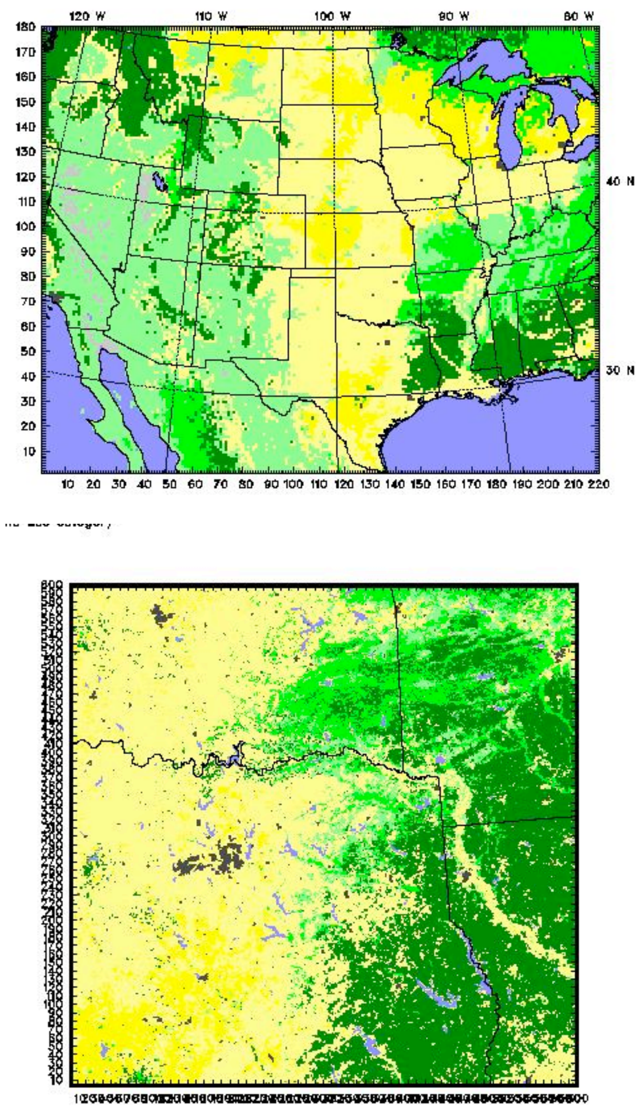

Figure 1. Domains used in the ensembling experiments. Top: Sub-continental scale domain with 15 km horizontal resolution; Bottom: 1 km domain covering eastern Texas and Oklahoma. Land use categories utilized for the domains are also indicated.

3. Ensemble Members

Our overall research goals include examining the relative value of MM5, WRF and combined MM5/WRF ensembles, constructed in such a manner as to provide maximum diversity, at very high resolutions (~ 1 km grid scales). The work presented here represents only a part of this effort; the complete effort, in addition to considering model physics and dynamics uncertainty (dynamics via the use of both MM5 and WRF), will also address initial condition and analysis/data assimilation uncertainties.

Details of the different physics configurations utilized to construct the various MM5 and WRF 1 km ensemble members are provided in Tables 1 and 2 on the following page. As can be seen readily by inspection of the Tables, we have incorporated significant physical uncertainties into the two ensembles, including the use of cumulus parameterization schemes at such high resolutions. This choice runs counter to conventional thinking since at such scales many cumulus scale processes should be explicitly simulated on the model grid. However, optimal results have not always been obtained with the use of only the explicit (bulk) microphysical schemes and grid-scale dynamics in mesoscale model simulations at such high resolutions, clearly suggesting some uncertainty in how to best formulate cumulus cloud processes at such scales. As such, we include several members utilizing cumulus schemes as an attempt to a) account for these uncertainties and b) provide added diversity to both the MM5 and WRF ensembles.

Due to compatibility restrictions with respect to boundary layer, surface layer and land surface schemes when nesting with MM5, not all 1-km runs in that ensemble are initialized from the same 15-km fields. We found it necessary to perform parallel 15-km simulations utilizing the NOAH and 5-layer land surface models, respectively, to properly initialize the corresponding 1-km runs utilizing those land surface schemes. This is actually beneficial for the ensemble as it adds in a degree of initial condition uncertainty based on the fact that the 15-km simulations with the different land surface schemes will not generally evolve identically.

MM5 Member	Cumulus	PBL	Microphysics	Radiation	Land Surface
Control	None	Eta	Reisner 2	RRTM	NOAH
Blackadar	None	Blackadar	Reisner 2	RRTM	5 Layer
Gayno-Seaman	None	Gayno-Seaman	Reisner 2	RRTM	5 Layer
Grell	Grell + Shallow	Eta	Goddard	RRTM	NOAH
Fritsch-Chappell	Fritsch-Chappell	Eta	Reisner 2	RRTM	NOAH
Goddard	None	Eta	Goddard	RRTM	NOAH
Reisner 1	None	Eta	Reisner 1	RRTM	NOAH
Schultz	None	Eta	Schultz	RRTM	NOAH
Cloud	None	Eta	Reisner 2	Cloud	NOAH
CCM2	None	Eta	Reisner 2	CCM2	NOAH
5 Layer	Shallow only	Eta	Reisner 2	RRTM	5 Layer
5 Layer/ MRF	None	MRF	Reisner 2	RRTM	5 Layer
Slab/GaynoSeaman	None	Gayno-Seaman	Reisner 2	RRTM	Slab

Table 1. Description of MM5 ensemble members examined in this study. Documentation on individual options can be found in the References or online at http://www.mmm.ucar.edu/mm5/mm5-home.html.

WRF Member	Cumulus	PBL	Surface Layer	Microphysics	Longwave Radiation	Shortwave Radiation	Land Surface
Control	None	MYJ	Monin -Obukov (M-O) -Janjic	Ferrier	RRTM	Goddard	NOAH
YSU/M-O	None	YSU	M-O	Ferrier	RRTM	Goddard	NOAH
Grell	Grell	MYJ	M-O -Janjic	Ferrier	RRTM	Goddard	NOAH
BMJ/YSU	BMJ	YSU	M-O	Ferrier	RRTM	Goddard	NOAH
5 Class	BMJ	MYJ	M-O -Janjic	WSM 5-Class	RRTM	Goddard	NOAH
3 Class	None	MYJ	M-O -Janjic	WSM 3-Class	RRTM	Goddard	NOAH
6 Class	Grell	MYJ	M-O -Janjic	WSM 6-Class	RRTM	Goddard	NOAH
RRTM/Dudhia	None	MYJ	M-O- Janjic	Ferrier	RRTM	Dudhia	NOAH
GFDL	None	MYJ	M-O -Janjic	Ferrier	GFDL	GFDL	NOAH
5 Layer	None	MYJ	M-O -Janjic	Ferrier	RRTM	Goddard	5 Layer
RUC	None	MYJ	M-O- Janjic	Ferrier	RRTM	Goddard	RUC
Call Times	None	MYJ	M-O -Janjic	Ferrier	RRTM	Goddard	NOAH
Lin/ Kain-Fritsch	Kain-Fritsch	MYJ	M-O -Janjic	Lin	RRTM	Goddard	NOAH

Table 2. Description of WRF ensemble members. Documentation on schemes can be found in the References. Call Times run involves changes to the frequency the radiation (10 vs 5 min), PBL (3 sec vs 5 min), and cumulus (5 vs 8 min) schemes are called. MYJ: Mellor-Yamada-Janjic scheme; YSU: Yonsei State University scheme. WSM: WRF Single Moment.

4. Project Status and Preliminary Results

Simulations for the 20 MM5 and WRF members listed in Tables 1 and 2 have been completed; analysis of the simulation results is currently in progress. Due to space limitations, preliminary results are not presented in this preprint article. We have noted, however, some overrunning of the solution in the western portions of the 1 km domain by the 15 km parent fields by the end of the simulation period. Such a result is not entirely unexpected with our 15:1 nesting ratio and the size of the 1 km domain. The effect is more of a problem with the WRF ensemble, which, thus far, shows a tendency to be slower in its merger of the dryline and Pacific front associated with STORM-FEST IOP 17.

Key results and a preliminary evaluation of the ensembles will be presented at the workshop.

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