1. INTRODUCTION

That the model initialization procedure can affect model performance has been a well-known fact. This is particularly true for the short-term mesoscale numerical forecast. Although several model initialization schemes/packages, such as WRF static initialization (SI) and WRF 3DVAR are under rapid development within the WRF community, there is no research tool, at present, which permits us to incorporate all available synoptic and asynoptic observations, and generate four-dimensional dynamically and physically consistent analysis to initialize the WRF forecasts.

In this paper, the analysis from a MM5-based real-time four-dimensional data assimilation system (RTFDDA) were interfaced to the WRF model initialization. Two sensitivity experiments, using different initialization techniques, were conducted to display the impacts of the advanced model initialization approach. The first experiment was initialized from the NCEP/ETA model data, re-analyzed with observations at around the model initial time. This experiment, called "cold-start" run in the rest of the paper, is similar to the traditional mesoscale model initialization approach. In the second experiment, the WRF model was initialized with the dynamically and physically consistent analysis of a MM5-based real-time four-dimensional data assimilation system (RTFDDA), which incorporate all observations at and before the model initial time during an analysis period. This experiment is called "warm-start" run hereafter.

2. EXPERIMENT DESIGN

The RTFDDA system was built upon the PSU/NCAR MM5 version 3. The data assimilation technology is essentially based on the continuous Newtonian nudging method initially developed by Stauffer and Seaman (1994). Some modifications and adjustments were made by NCAR/RAP RTFDDA group in past 2 years (Cram et al., 2001 and Liu et al. 2002a). Liu et al. (2002b) introduced the development and performance of an RTFDDA system that supported the Year-2002 Winter Olympics at SLC. The WRF sensitivity tests were conducted on a snow storm event occurred over western states on March 13, 2002, which was selected from during the Olympic period. Both the "cold-start" and "warm-start" WRF initializations are from the real-time model data of the SLC Olympic RTFDDA system. Readers are recommended to refer to Liu et al. (2002b) for more detail about this RTFDDA system. In brief, the "observation nudging" was employed to assimilate all observations collected in real-time. Proper space and time weights are allowed to strengthen and spread the observation information from the observation time and location. To balance the data cutoff and real-time requirements, the system ran in a three-hourly cycling mode. The data incorporated include all observations obtained at varying time and locations.

The WRF forecasts started at 00Z, March 13, 2002. The RTFDDA analyses had been continuously running into 84 hours from the cold-start. The 84th hour analysis was used to initialize the "warm-start" WRF forecasts. In contrast, the "cold-start" WRF was initialized with 00Z, March 13, ETA. The re-analysis takes the conventional observations around 00Z. The WRF forecasts were configured to the same domain configuration as the coarse mesh (Domain 1) of the RTFDDA system. There are 82x70 horizontal grids, with a grid spacing of 36 km. The model had 36 vertical layer, with dense grid in the lowest 1 km AGL. In order to appropriately compare the WRF forecasts with the real-time RTFDDA (MM5) forecasts, the WRF model physics were switched to be close to
those of the RTFDDA during the operation.

3. PRELIMINARY RESULTS

On March 13, a large-scale precipitation system developed in many areas over the western states. At 0145 UTC, satellite infrared image (Fig. 1c) indicated a cold front along the Washington coast. In front of this cold front, there are three major rainbands: Rainband A along the U.S.-Canada border, Rainband B over the southern Montana, and Rainband C over the area bordered by Idaho, Oregon, Nevada and California. Both the Rainband B and C were also observed from radar image (Fig. 1e). The whole system had synoptic scale in nature as it traversed eastward from the Pacific.

Fig. 1a and 1b depict hourly precipitation distribution at 03Z March 13 from the "cold-start" WRF forecast and the "warm-start" WRF forecast, respectively. Fig. 1d shows the same numerical result but from the operational RT-FDDA forecast. In general, the "cold-start" WRF forecast significantly underestimated the precipitation from all three rainbands identified by both satellite and radar images. In contrast, the "warm-start" WRF forecasts picked up these three bands reasonably well. Comparing Fig.1 (b) and (d), one sees remarkable similarity of the overall precipitation patterns between the "warm-start" WRF forecast and the "warm-start" RTFDDA forecast. As found by many previous comparison studies, the WRF model tends to generate more concentrated rain cores due to its reduced implicit diffusion effect.

With the forecast proceeding, the solutions of the "cold-start" and "warm-start" WRF forecasts tend to converge (not shown), as the "cold-start" model "span up". Nevertheless, the exact locations and timing of the individual rain cores are still displaced from each other. Similar evolution can be seen between the "warm-start" WRF forecast and the RTFDDA MM5 forecasts.

4. SUMMARY AND FUTURE PLAN

The WRF model was interfaced to the NCAR/RAP real-time RTFDDA system for a "warm-start" initialization. Case studies show significant discrepancies in the precipitation patterns between the short-term forecasts of the "cold-start" and the "warm-start" WRF and indicate evident benefits of the "warm-start" from the analysis of continuous four-dimensional data assimilation. The "warm-start" WRF forecasts are very close to the RTFDDA (MM5) forecasts in the first few hours, indicating the overall dynamical and physical consistency between the MM5 and WRF model. This suggests that the "warm-start" WRF can be benefited from the mitigation of the "spin-up problem" by the MM5 FDDA processes.

More detailed comparison between the sensitivity tests is needed. Verification against various observations are required to properly evaluated the models. In addition, works are now carried out to ingest the RTFDDA cloud/precipitation analyses into the WRF, besides those of the standard initialization variables. More importantly, long-term parallel tests in operational mode of "warm-start" WRF and RTFDDA MM5 forecasts will be implemented so that we can compare the two models in a more generalized sense.

REFERENCES


Liu, Y. and co-authors, 2002a: Performance and enhancements of the NCAR/ATEC Mesoscale FDDA and forecasting system. Preprints 15th NWP Confs., San Antonio, AMS, Boston, MA.


Fig. 1 The 1 hour accumulated surface precipitation (mm) of the 3rd
hour forecast, ended at 03Z, March 13, 2002, of the “cold-
started” WRF forecast (a), “warm-started” WRF forecast
(b) and the “warm-started” real-time FDDA forecast (c).
The satellite IR image (c) and Utah local composite radar
reflectivities (d) close to 03Z are also shown for comparison
purposes. The letter “A”, “B”, and “C” marked areas of
three major precipitation bands of interest (see text for more
detailed description).