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AN INVESTIGATION OF THE SENSITIVITY OF MODEL PREDICTIONS OF PRECIPITATION TO VERTICAL GRID SPACING

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1. INTRODUCTION

With limited supplies and increasing demands for water resources, it is becoming increasingly important to understand the hydrologic cycle within river basins. A thorough understanding of typical precipitation and runoff and the nature of their variability is vital for planning the best use of these water resources. In the long term, all aspects of the hydrologic cycle affect the availability of water and it is therefore important to explore the entire cycle in order to understand the potential effects of increased water use, land use modifications, and changes in the regional climate.

To simulate water resources, we are coupling a series of existing and previously tested models that address the multitude of physical processes and temporal and spatial scales that are important (Bossert, et al., 1999, Costigan, et al., 2001). The modeling system includes the Regional Atmospheric Modeling System (RAMS) (Pielke et al., 1992), which simulates regional climate and provides meteorological variables and precipitation to the Los Alamos Distributed Hydrologic System (LADHS), a land-surface hydrology model. The Finite Element Heat and Mass (FEHM) model (Zyvoloski et al., 1997) is being added to the system to include ground water in the simulations.

The modeling system is being applied to the Walnut River Watershed (WRW) in southern Kansas, as part of a pilot study to investigate if the predictability of the regional water balance can be improved using high resolution model simulations. The WRW is located in southeastern Kansas, just east of Wichita, and has an area of about 75 km by 100 km. The Atmospheric Boundary Layer Experiments (ABLE) observations are located within the basin, which is also within DOE's Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site.

This paper examines the atmospheric component of the coupled modeling system. Miller, et al. (2003) present an evaluation of precipitation predictions from two atmospheric models as compared to radar estimates for March 2000, in the ARM SGP site. This paper looks at the sensitivity of one of those models (the RAMS model that is regional atmospheric model of the coupled modeling system) to the vertical grid spacing that is employed. Relatively fine vertical grid spacing can allow for better resolution of the vertical structure of the moisture and wind fields, but leads to higher computational costs due to the smaller timestep required to satisfy the CFL condition. Two simulations are presented that employ different vertical resolutions to investigate the effect of vertical grid spacing on predicted moisture fluxes and precipitation.

2. MODEL SETUP

The RAMS simulations require the use of two-way interactive nested grids. The largest grid is necessary to simulate the synoptic-scale flow features in the region. Grid 1 covers the United States, some of the eastern Pacific and Western Atlantic Oceans, as well as parts of Canada and Mexico. Horizontal grid spacing on grid 1 is 48 km. Grid 2 includes the great plains and parts of the midwest, with horizontal grid spacing of 12 km. Grid 3 (Figure 1) covers most of Kansas and Oklahoma and parts of their surrounding states and includes the ARM SGP site. Grid 3 uses 4 km horizontal grid spacing. The fourth grid (Figure 2) uses 1 km grid spacing over the WRW. All of the runs used NCEP/DOE Reanalysis II gridded data to initialize and nudge the model.

In the first simulation, all grids employ 50 m vertical grid spacing in the lowest 300 m. Above 300 m, the grid spacing gradually stretches and a total of 46 grid cells are used. In the second simulation, the vertical grid spacing starts at 200 m, up to 400 m. It then stretches and uses a total of 35 grid cells. In both simulations the maximum vertical grid spacing is 750 m and the model top extends above 20 km.

3. DISCUSSION

In early March 2000, two precipitation events took place within the WRW. Both events involved a surface area of low pressure that was associated with a low aloft. For the event of 2-3 March, the surface low passed to the south of the WRW, along the Texas and Oklahoma border. A trough of low pressure extended north from the low and passed over the WRW, as the low traveled from west to east. On 8 March, the surface low passed just to the northwest of the WRW. The occluded and cold fronts

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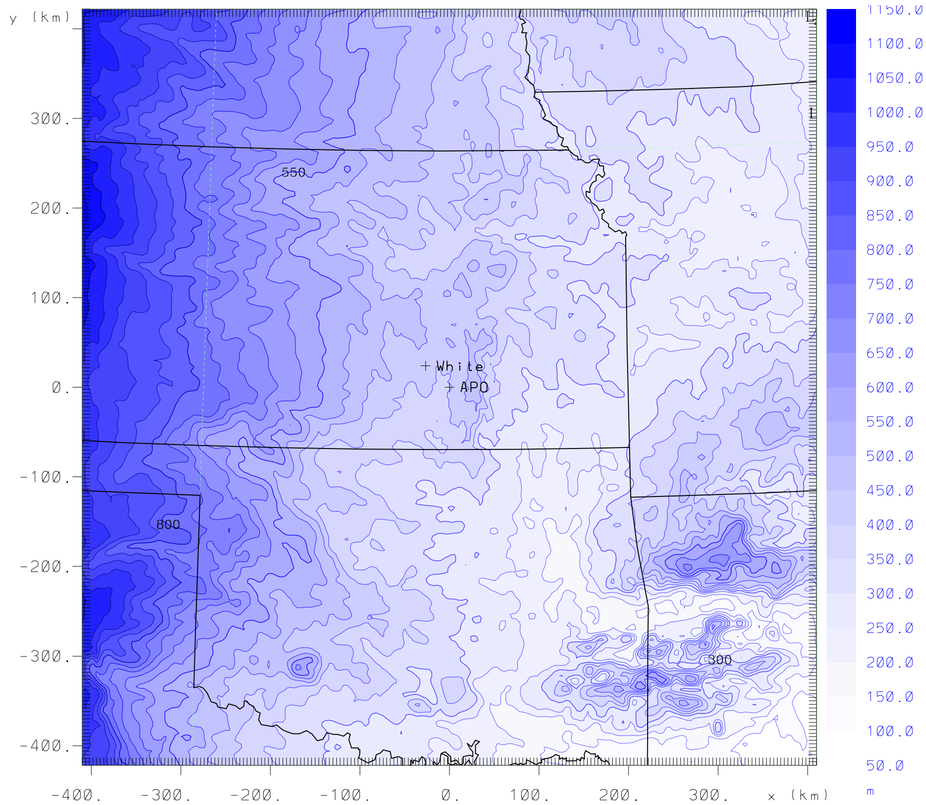

Figure 1. Topography represented on Grid 3 of the RAMS simulations. Contour interval is 50 m.

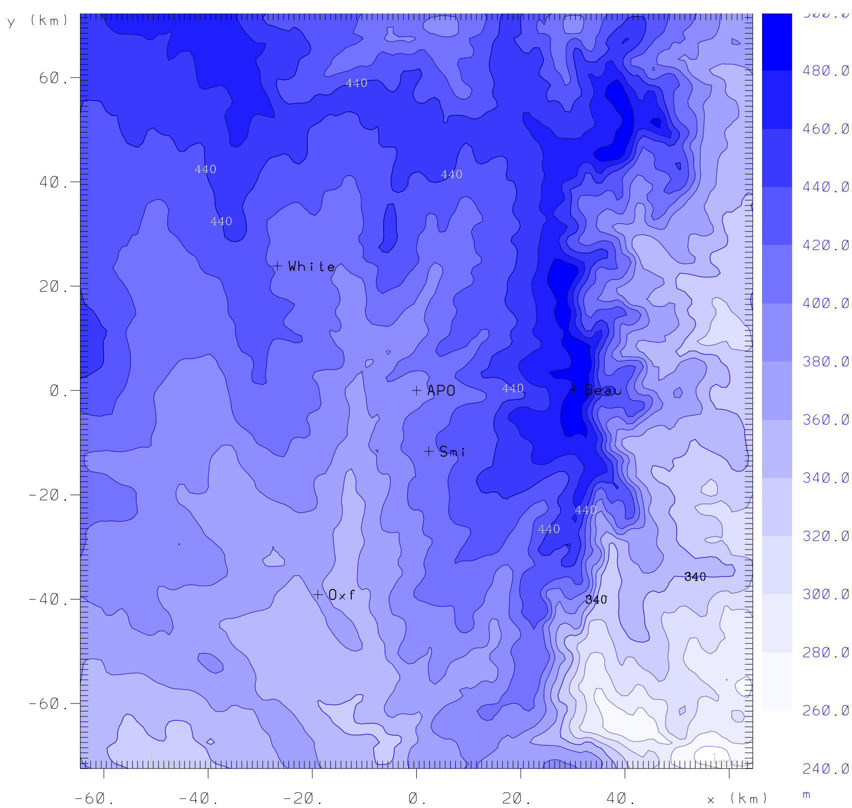

Figure 2. Topography represented on grid 4 of the RAMS simulations. Contour intervals are 20 m.

that extended to the east and south of the low passed over the WRW.

Figures 3 and 4 give the model predicted total accumulated precipitation at 0800 UTC on 3 March, at the end of the first precipitation event. Figure 3 presents the precipitation on grid 4, for the first simulation with the relatively fine vertical resolution. Figure 4 shows the total precipitation on grid 4 for the second simulation with coarser vertical grid spacing. The precipitation pattern is similar between the two runs. One difference is the somewhat smaller totals for the simulation with coarser vertical resolution, in the southern part of grid 4. In contrast, totals are slightly higher in the northern sections of the grid, with coarser vertical resolution. This difference only amounts to one or two mm, but is noticeable because of the generally light precipitation overall. Similar results are found on grid 3 (not shown). Local maximums are slightly higher in the run with finer vertical resolution, especially in the southern part of the grid.

4. ACKNOWLEDGMENTS

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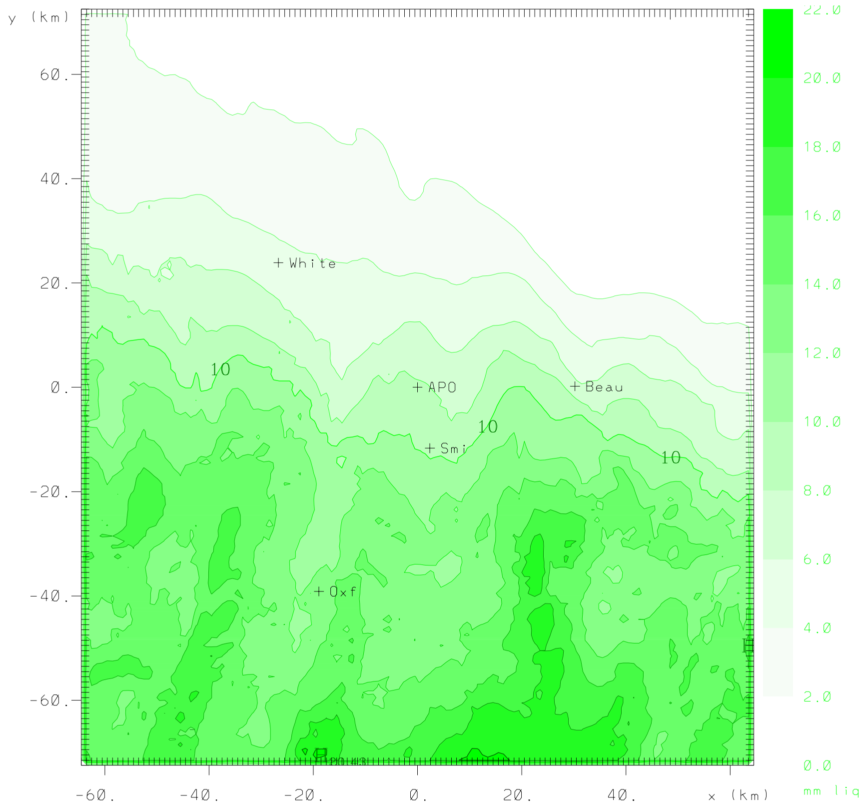

Figure 3. Total accumulated precipitation on grid 4 at 0800 UTC 3 March 2000. Vertical grid spacing is 50 m. Contour interval is 2 mm.

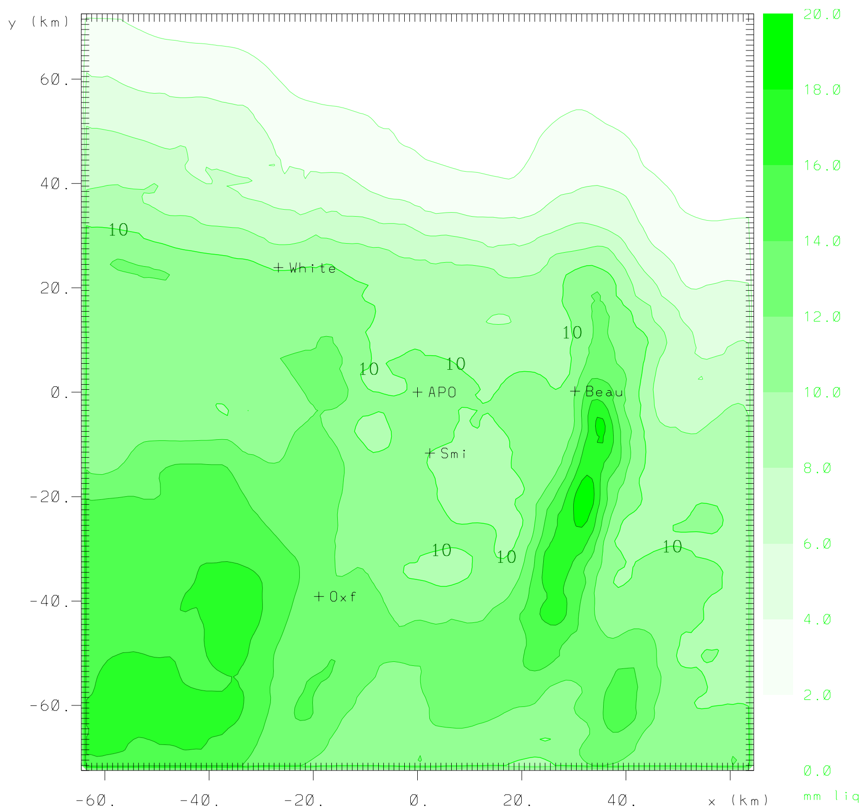

Figure 4. Total accumulated precipitation on grid 4 at 0800 UTC 3 March 2000. Vertical grid spacing is 200 m. Contour interval is 2 mm.