10.0 NUMERICAL MODELING OF A THERMAL INVERSION IN THE UINTA BASIN, UTAH, JANUARY 26-30 2013

Trang Tran, Marc Mansfield, Seth Lyman

Bingham Research Center, Utah State University, Vernal, Utah 84048

WRF simulations have been performed to provide the meteorological conditions for photochemical grid calculations of the role of major emission sources (e.g., oil and gas extraction, the Bonanza power plant, vehicles) on winter ozone pollution in the Uinta Basin. The CAMx platform, which has been developed for studying ozone photochemistry (Yarwood et al., 2010; Emery et al. 2011; Shen et al., 2011) will be used as the chemistry model in our study. The high-ozone period occurring during January to March 2013 was selected as the study episode.

WRF model configurations were adapted from the report (AECOM, 2013) of the Utah Air Resource Management Strategy Modeling Project (Utah ARMS), performed by AECOM under contract with the Bureau of Land Management (BLM). Most of AECOM's winter-month setups were retained, although some changes were applied with the goal of improving both model performance and computational efficiency. (We increased vertical and horizontal resolutions, we employed one-way nesting, and we omitted sea surface temperature updating.) We examined model performance at different horizontal resolutions (1300 m versus 800 m) and will test different initial snow conditions to determine the optimum configurations for WRF simulations of winter inversions in the basin.

Primary evaluation of our WRF simulations was conducted using the episode of January 26-30, 2013 as a reference case (hereafter referred as REF). We focused on the capability of the model to simulate inversions and snow cover within the basin since they are the two major meteorological conditions triggering ozone pollution in the basin. In REF, 1-way nested domains were set at 36-12-4-1.3 km resolution with the finest domain extending from the Great Salt Lake in the northwest to the Uncompaghre Plateau in the southeast, covering much of eastern Utah and adjoining parts of Wyoming and Colorado (Fig. 10-1). The Pleim-Xiu scheme was selected for the LSM and no snow modification was applied for the initial condition. Other configurations can be found in AECOM (2013).

In general, WRF captured the timing and basic structure of the inversion at a number of observational sites within the basin (Roosevelt, Ouray, and Horsepool). The inversion conditions on a high ozone day, January 26, were reproduced (Fig. 10-2a,b). WRF also modeled the inversion breakup on January 28 that was caused by a storm (Fig. 10-2c,d). Snow depths within the basin were also represented reasonably in REF simulations. Within the basin, modeled snow depths ranged between 5 and 50 cm, which coincide with the 10-50 cm range of the NOAA snow analysis data for the basin (Fig. 10-3). Further evaluation of snow depths should be conducted for individual snow monitoring sites to strengthen this conclusion. WRF eventually overestimated wind speed in near-surface layer with large bias up to 4m/s.

Increasing grid resolution from 1300m to 800m did not improve model performance on simulating wind speed (Fig. 10.4) and other meteorological quantities at near-surface layer (e.g., temperature, sea-level pressure, precipitation; not shown).

For future work, besides doing further model evaluation of REF (e.g, skill-scores calculation), we will test the impact of modifying the snow initial conditions on model performance in simulating snow and albedo, which are important factors affecting ozone formation in the basin. Once these steps are finished, we will proceed with preparing emissions data and running CAMx to investigate ozone pollution in the Uinta Basin.

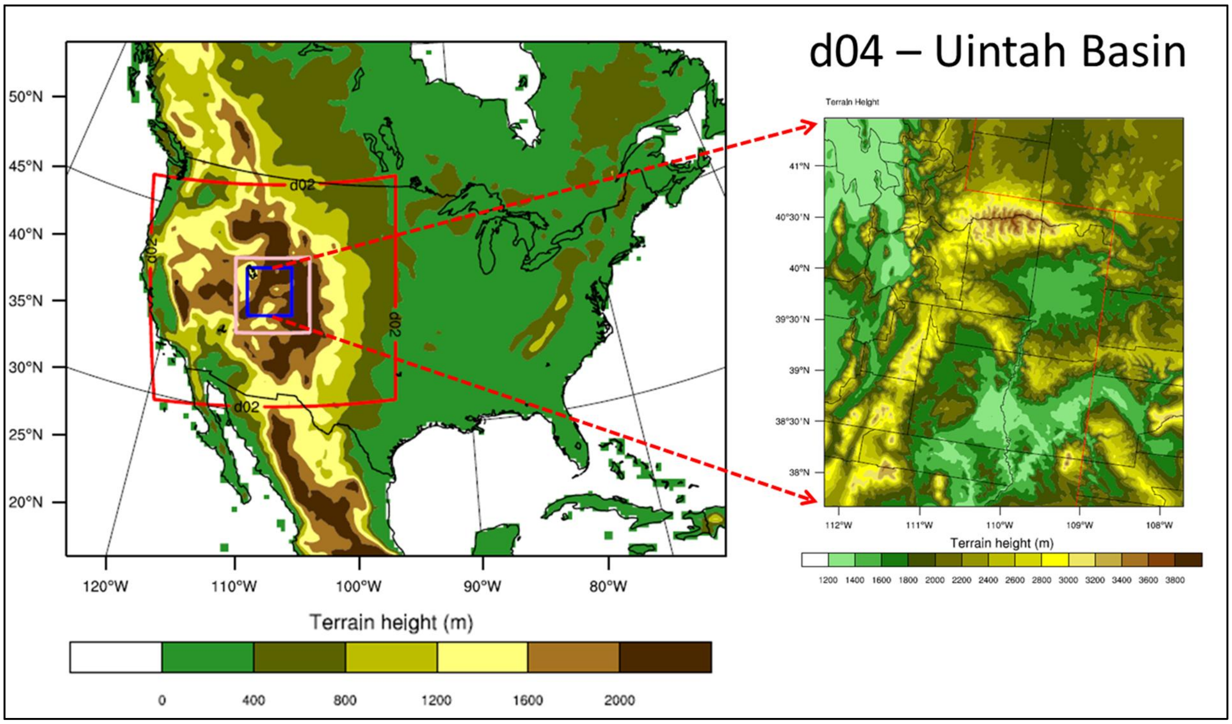

Figure 10-1. Nested domains with horizontal resolution of 36, 12, 4 and 1.3 km, respectively (left). Domain 4 (right). The Uinta Basin is the low terrain centered at about 109.5°W longitude and 40°N latitude.

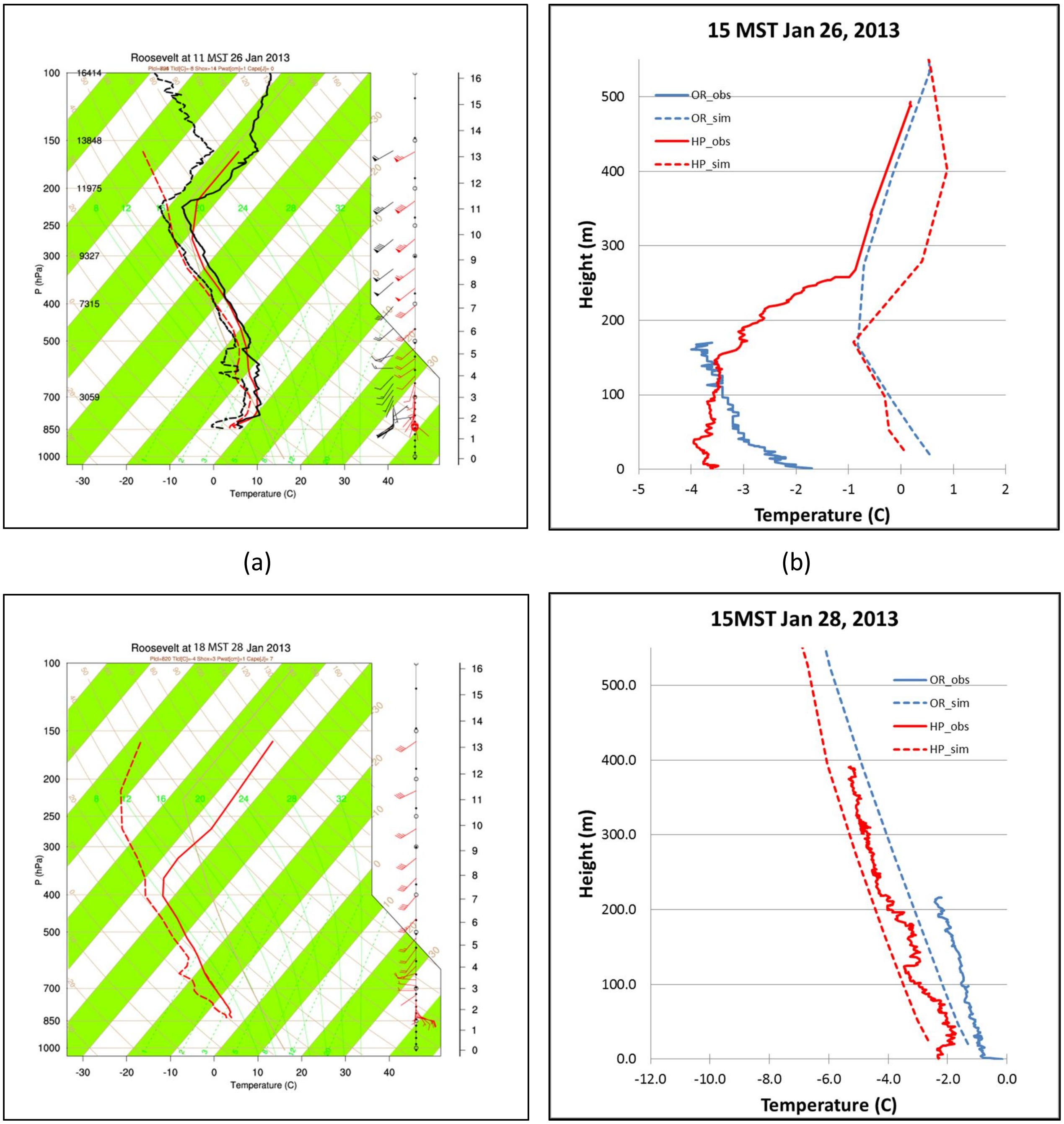

Figure 10-2. Observed (black) and simulated (red) temperature vertical profiles at Roosevelt (a, c) and observed (solid) and simulated (dash) temperature vertical profiles at Ouray (blue) and HorsePool (red) (b,d). Observational data for Roosevelt and Ouray/Horsepool sites were collected from rawinsonde measurements conducted by the University of Utah and from ozonesonde measurements conducted by NOAA, respectively.

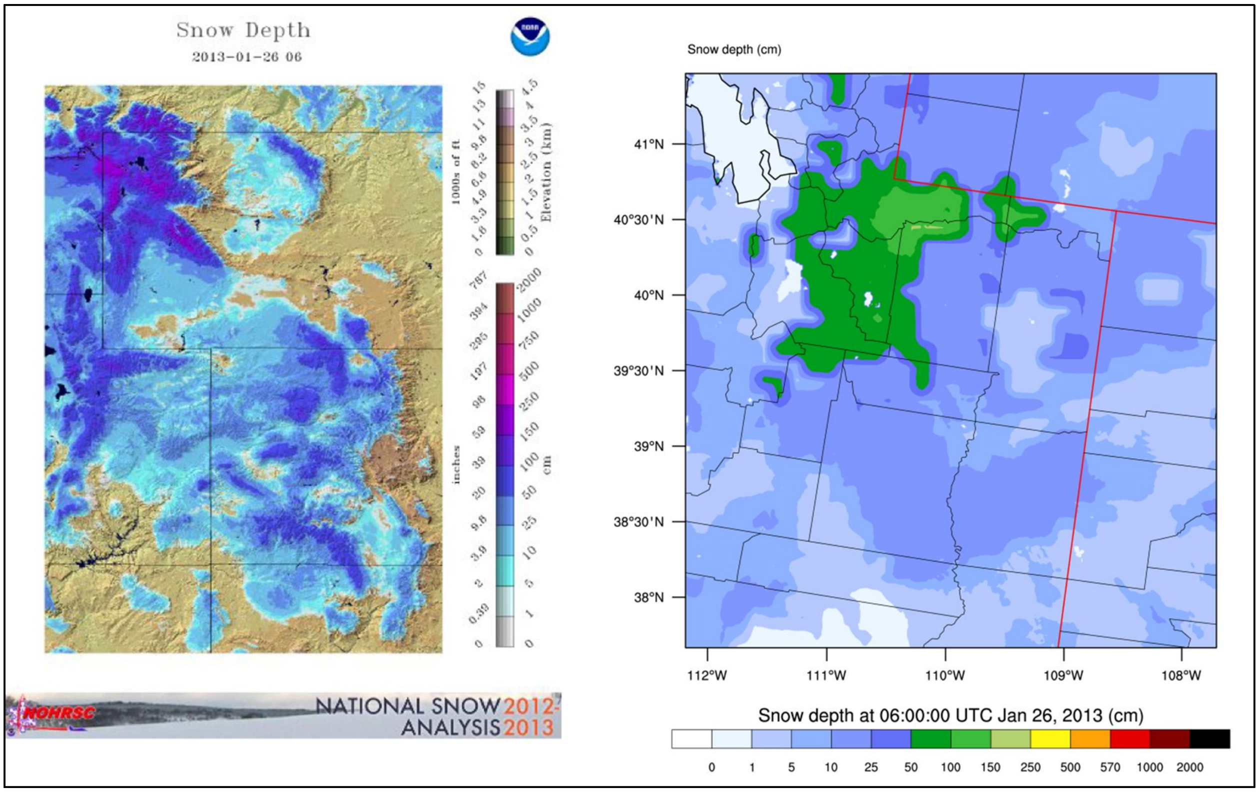

Figure 10-3. Comparison of simulated (right) and NOAA analysis (left) snow depths.

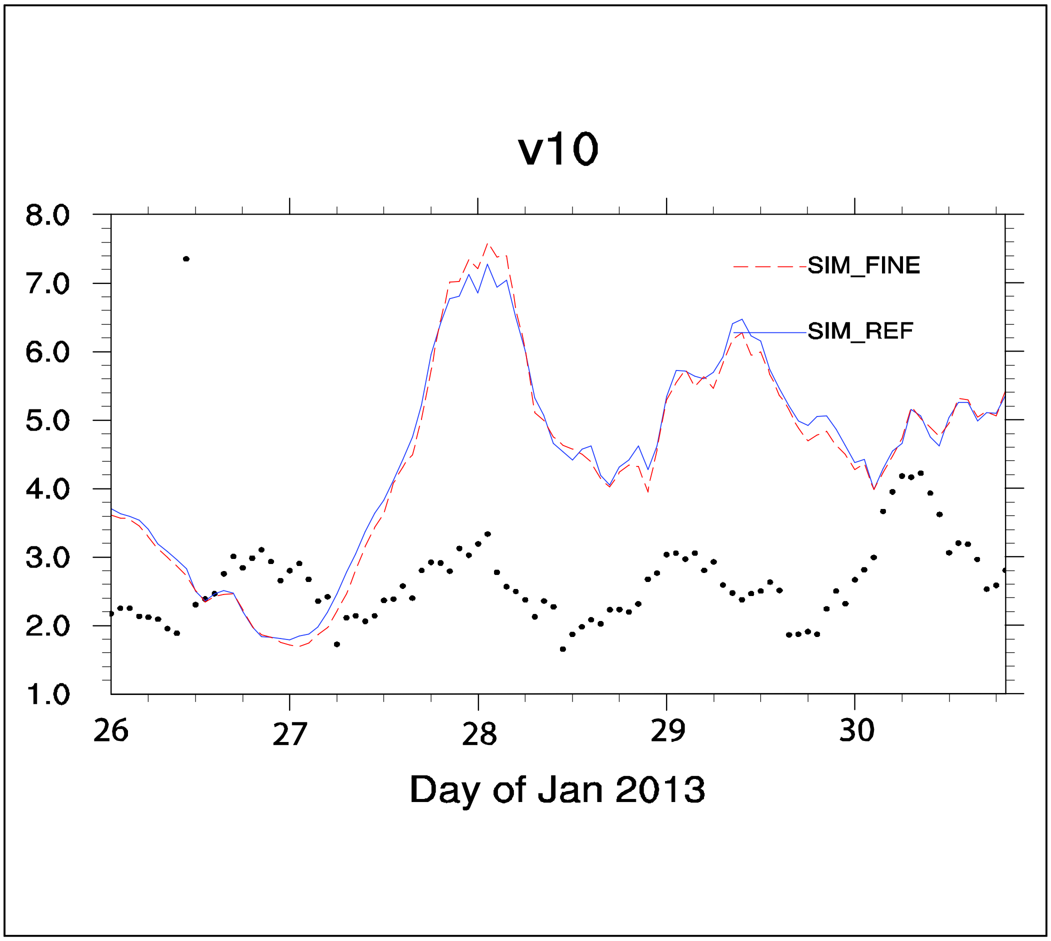

Figure 10 4. Temporal evolution of hourly simulated (line) and observed (dot) near-surface wind speed (m/s) averaged over 61 monitoring sites within domain. Observational data were obtained from Western Regional Climate Center. SIM_REF and SIM_FINE stands for reference and fine resolution simulation, respectively.

10.1 References

AECOM, 2013. Utah Air Resource Management Strategy Modeling Project: meteorological model performance evaluation. Report prepared for Bureau of Land Management – Utah State Office.

Emery, C., Jung, J., Downey, N., Johnson, J., Jumenez, M., Yarwood, G., Morris, R., 2011. Regional and global modeling estimates of policy relevant background ozone over the United States. Atm. Environ., doi:10.1016/j.atmosenv.2011.11.012

Shen, J., Wang, X.S., Li, J.P., Zhang, Y.H., 2011. Evaluation and intercomparison of ozone simulations by Models-3/CMAQ and CAMx over the Pearl River Delta. Sci. Chin., 11, 1789-1800.

Yarwood, G., Kemball-Cook, S., Koo, B., Johnson, J., 2010. Ozone transport analysis using back-trajectories and CAMx probing tools. 9th Annual CMAS conference, 2013.