P2.16 REGIONAL SCALE MODELING FOR THE 2002 OLYMPIC WINTER GAMES

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1. INTRODUCTION

In February 2002, the Olympic Winter Games were held in the Salt Lake City (SLC) metropolitan area and the nearby Wasatch Mountains. With over 100,000 spectators and athletes attending and competing daily at various weather-sensitive venues, accurate weather forecasts proved critical for games logistics. The NOAA-CIRP MM5 modeling system was a key component of the forecasting system implemented for the games.

The computer hardware necessary was extremely low-cost. The system ran on fourteen 1333 Mhz AMD processors of the University of Utah Center for High Performance Computing Beowulf-class PC cluster, utilizing Giganet VIA networking equipment. The total hardware cost was $30,000. Expansion of the modeling system is also inexpensive and can be accomplished by purchasing low-cost personal computers and optional additional networking hardware to improve performance.

2. MODEL DESCRIPTION

The NOAA-CIRP real-time modeling system is based on the Penn State/NCAR MM5 Version 3 (Grell et al. 1995), a non-hydrostatic finite-difference atmospheric model employing a terrain-following sigma coordinate. The model was run with a 36-km grid spacing outer nest covering the western United States and eastern Pacific, a 2-way interactive nested grid at 12-km grid spacing covering Utah and parts of adjacent states, and a 1-way nest at 4-km grid spacing over northern Utah (Fig. 1). The model is run with 27 vertical levels. Model parameterizations include a microphysical scheme that allows for simple ice-phase processes below 0 ˚C, a radiation parameterization allowing for long- and short-wave interactions with the atmosphere, clouds, precipitation, and surface, the Kain-Fritsch cumulus parameterization, and the MRF planetary boundary layer scheme.

Initial and lateral boundary conditions for the modeling system are provided by the NCEP Eta Model (MM5-Eta). These 36-h forecasts require 65 minutes to integrate on the PC cluster. Forecasts and post-processing are typically completed by 4 hours after the initialization time (0000, 0600, 1200, and 1800 UTC). An additional NCEP Aviation-model-initialized version (MM5-AVN) was also run. Forecasters feel this version adds important mesoscale detail when they determine that the AVN is the large-scale “model of the day” rather than the Eta.

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Improvements to the model initial conditions incorporated observations from 2300 surface stations, which are collected by the MesoWest network (www.met.utah.edu/mesowest), and assimilated into a near-surface analysis using the ARPS Data Assimilation System (ADAS). ADAS has been modified for use in the complex terrain of the Intermountain West, resulting in improved utilization of the heterogeneous mix of high- and low-elevation observations provided by the MesoWest network. The Great Salt Lake temperature, important for local scale wind circulations and lake-effect snows, was specified using AVHRR-derived temperatures provided by the NOAA CoastWatch program. When AVHRR data was not available, MesoWest lake temperature probes were used.

3. MODEL PRODUCTS AND AVAILABILITY

After the model integration is completed, 3-d hourly model output is ingested into the National Weather Service (NWS) AWIPS system and used by meteorologists at the SLC, Elko, and Pocatello forecast offices, as well as by the 2002 Winter Olympics Venue Forecast Team. Forecasters at the SLC forecast office and Olympic Venue Forecasters had up to two winter seasons to gain familiarity with the model and it’s strengths and biases.

Forecasts are also available to the public via the Internet (www.met.utah.edu/jimsteen/mm5). Products include time-height sections, soundings, station time-series, various horizontal plots, gridded data files in GEMPAK, Vis5d, NetCDF, and Grib formats, and model-output-statistics (MOS) time-series (Siffert 2001; Fig. 2). Sites for MOS time-series included major regional cities, transportation corridors, and all outdoor Olympic venue sites for the 2002 Winter Games. This hourly MM5 MOS guidance was the only objective site-specific forecast product available at most locations, and was found to be helpful by many Olympic forecasters.

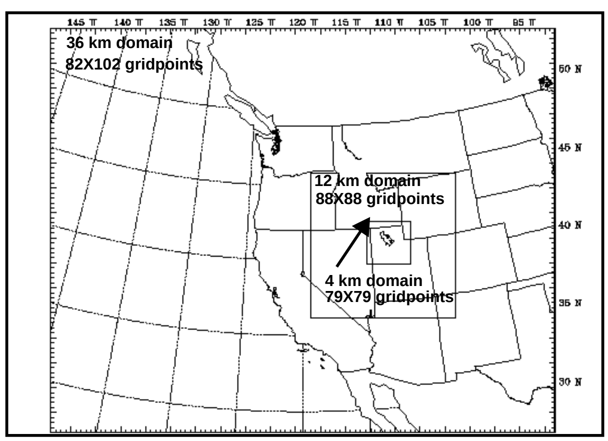


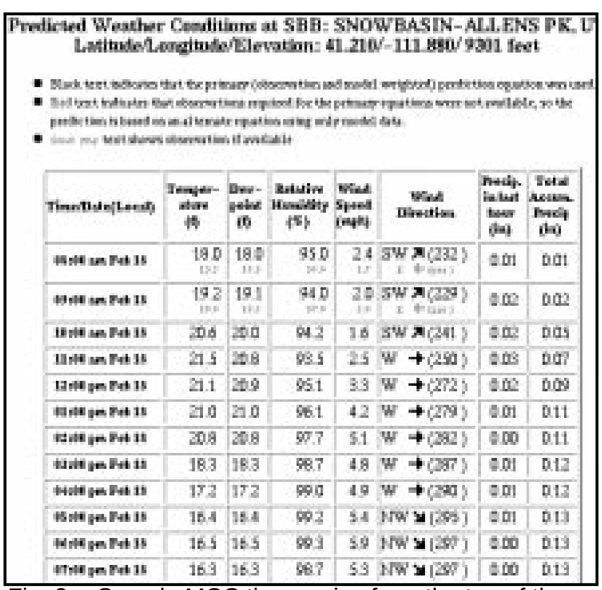
Fig. 1 Domains of NOAA-CIRP Real-time MM5

4. EVALUATION DURING THE OLYMPIC PERIOD

Olympic forecasters filled out a subjective model evaluation form when possible, rating both model utility, or how useful the model was in their forecast, and model performance, or how well the model verified. Models evaluated included the AVN, Eta, MM5-AVN, and MM5-Eta (Table 1). Forecasters tended to rate the utility of the MM5 models higher, although forecasters with less local forecasting experience found it the most helpful. This was likely due to the ability of the higher-resolution MM5 models' ability to represent terrain driven mesoscale features which experienced local forecasters were already familiar with. Forecasters rated the performance of the AVN model slightly higher than that of the MM5-AVN, although they determined that the MM5-Eta added value over the Eta model. This apparent discrepancy could be a reflection of the smaller sample size of performance evaluations compared to utility evaluations. Additional objective verification work is currently in progress.

5. EVALUATION DURING IPEX FIELD PROGRAM

The Intermountain Precipitation Experiment (IPEX) was held near SLC during February 2000 to improve understanding of orographic and lake-effect precipitation, to evaluate model performance, to improve radar estimates of quantitative precipitation, and to study electric fields in winter storms. As part of the IPEX project, the performance of precipitation forecasts by the 12-km MM5-Eta was studied (Cheng 2001). It was found that the MM5 often outperformed the Eta and AVN models over regions of higher terrain, primarily due to better terrain resolution of these features. However, in locations with fine scale terrain features not resolved by the MM5, forecasts performed badly in many cases. An objective technique based on the Students-t test for the difference of two means was used to contrast the observed vs. MM5



Predicted Weather Conditions at SBB: SNOWBASIN–ALLENS PK, UT
Latitude/Longitude/Elevation: 41.210/-111.880/ 9301 feet

- Black text indicates that the primary (observation and model weighted) prediction equation was used.
- Red text indicates that observations required for the primary equations were not available, so the prediction is based on an alternate equation using only model data.
- [illegible] text shows observation if available

Time/Date(Local)	Temperature (f)	Dewpoint (f)	Relative Humidity (%)	Wind Speed (mph)	Wind Direction	Precip. in last hour (in)	Total Accum. Precip (in)
08:00 am Feb 15	18.0	18.0	95.0	2.4	SW (232)	0.01	0.01
09:00 am Feb 15	19.2	19.1	94.0	2.0	SW (229)	0.02	0.02
10:00 am Feb 15	20.6	20.0	94.2	1.6	SW (241)	0.02	0.05
11:00 am Feb 15	21.5	20.8	93.5	2.5	W (250)	0.03	0.07
12:00 pm Feb 15	21.1	20.9	95.1	3.3	W (272)	0.02	0.09
01:00 pm Feb 15	21.0	21.0	96.1	4.2	W (279)	0.01	0.11
02:00 pm Feb 15	20.8	20.8	97.7	5.1	W (282)	0.00	0.11
03:00 pm Feb 15	18.3	18.3	98.7	4.8	W (287)	0.01	0.12
04:00 pm Feb 15	17.2	17.2	99.0	4.9	W (290)	0.01	0.12
05:00 pm Feb 15	16.4	16.4	99.2	5.4	NW (295)	0.01	0.13
06:00 pm Feb 15	16.5	16.5	99.3	5.9	NW (297)	0.00	0.13
07:00 pm Feb 15	16.3	16.3	98.7	5.3	NW (297)	0.00	0.13

Fig. 2 Sample MOS time-series from the top of the Olympic Men's Downhill.

Table 1 Summary of Olympic forecaster subjective evaluation scores, ranging from 1 (lowest)–10 (highest). Model Utility reflects how useful they found the model. Model Performance reflects how well the model verified overall. Average 1 was the average of all ratings given to that particular model. Average 2 included only evaluation forms in which all 4 models were rated.

Model	Average 1	Average 2	Highest	Lowest
Model Utility				
MM5-Eta	7.8	7.7	10	3
MM5-AVN	8.0	8.0	10	5
Eta	6.3	6.0	9	1
AVN	6.6	6.2	8	3
Model Performance				
MM5-Eta	6.3	6.0	10	2
MM5-AVN	6.9	6.7	10	4
Eta	5.0	4.8	9	1
AVN	7.3	7.3	10	5

precipitation in selected NWS northern Utah zones. A summary of the results (Table 2) shows that the MM5 provided skillful forecasts in most zones much of the time, however, the Wasatch Mountain Valleys zone had a bias toward too much precipitation due to a lack of terrain resolution. The model error statistics in the Great Salt Lake Desert and Mountains zone were inconclusive because most observations were located in mountains, although most of the region is lowland desert.

6. REFERENCES

Cheng, L., 2001: Validation of quantitative precipitation forecasts during the Intermountain Precipitation Experiment. M.S. thesis, Dept. of Meteorology, University of Utah, 137 pp. [Available from Dept. of Meteorology, University of Utah, 145 South 1460 East Room 209, Salt Lake City, UT 84112-0110].

Grell, G. A., J. Dudhia, and D. R. Stauffer, 1995: A description of the fifth-generation Penn State/NCAR Mesoscale Model (MM5). NCAR Tech. Note NCAR/TN-398+STR, 122 pp. [Available from UCAR Communications, P.O. Box 3000, Boulder, CO 80307].

Siffert, A. J., 2001: Point-specific MOS forecasts for the 2002 Winter Games. M.S. thesis, Dept. of Meteorology, University of Utah, 51 pp. [Available from Dept. of Meteorology, University of Utah, 145 South 1460 East Room 209, Salt Lake City, UT 84112-0110]

Table 1 Summary of MM5 precipitation performance for northern Utah zones for 23 forecasts during IPEX. Performance during precipitation events in columns 2-4. Column 5 presents the number of forecasts where the model produced precipitation when none was observed and the number of days with no observed precipitation (i.e. false alarm rate). Mean bias and observed precipitation in columns 6 and 7. Adapted from Cheng (2001).

Zone	Under Forecast	Skillful	Over Forecast	False Alarms/ No Obs. Precip	Mean Bias (mm)	Mean Observed Precip (mm)
Wasatch Front[a]	4	7	5	2/7	0.2	2.6
Wasatch Mountains[b]	1	9	6	2/7	1.2	5.3
GSL Desert and Mts	6	5	3	3/9	-1.4	3.1
SL and Tooele Valley	4	8	3	2/8	-0.3	2.6
N Wasatch Front	3	6	5	2/9	0.3	3.0
S Wasatch Front	1	10	5	2/7	0.6	2.6
N Wasatch Mts	5	9	2	1/7	-1.2	6.6
S Wasatch Mts	3	8	5	2/7	1.1	6.4
Wasatch Mtn Valleys	0	5	10	2/8	4.8	2.6

a. Includes SL and Tooele Valley, N Wasatch Front, and S Wasatch Front.
b. Includes N Wasatch Mts, S Wasatch Mts, and Wasatch Mtn Valleys.