Merging a high-resolution meteorological distribution model (MicroMet) with a detailed snow-evolution model (SnowModel)

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A snow evolution modeling system (SnowModel; Liston and Elder 2006a) was used to simulate seasonal snow evolution across three, 30-km by 30-km, simulation domains that included the Cold Land Processes Field Experiment (CLPX) meso-cell study areas (MSAs) in Colorado, U.S.A. These three MSAs have distinctly different topography, vegetation, meteorological, and snow-related characteristics. The simulations were performed using a 30-m grid increment and a 3-hour time step, and spanned the period 1 October 2002 through 1 April 2003; generally the snow accumulation season for this region. Meteorological forcing was provided by 27 meteorological stations and 75 atmospheric analysis grid points that were distributed across the model simulation domains using a micrometeorological distribution model (MicroMet; Liston and Elder 2006b). The simulations included a data assimilation sub-model (DataAssim; Liston and Hiemstra 2006) that forced the simulated snow water equivalent (SWE) distributions towards a collection of ground-based and airborne SWE observations. The observations consisted of area-averaged SWE over three, 1-km by 1-km intensive study areas (ISAs) for each MSA, and a collection of NOAA airborne observations that each integrated an area covering a length of approximately 10 km and a width of 300 m.

The simulated SWE distributions displayed considerably more spatial variability than that available from the observations alone. This is the result of SnowModel's relatively fine-scale representations of orographic precipitation, low-elevation melt, wind redistribution (snow drifts above treeline), and snow-vegetation interactions. Intuitively, the general distribution patterns simulated by the model were considerably more realistic than those defined solely by the observations. The combined modeling and data assimilation system produced high-resolution SWE distributions that closely fit both our understanding of snow evolution processes and the magnitude of the snow observations.

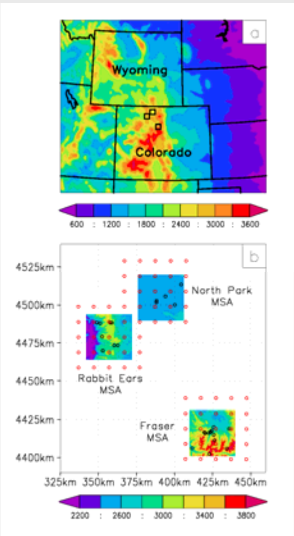

Fig. 1. (a) Locations of the three Cold Land Processes Field Experiment (CLPX) meso-cell study areas (MSAs) (shown by the small open squares in north-central Colorado, U.S.A.), and the topography (m) of the surrounding states. (b) Details of the Fraser, North Park, and Rabbit Ears MSAs, showing the topography (m) in each 30-km by 30-km MSA simulation domain, and the meteorological stations (black circles) and LAPS atmospheric analysis model grid cells (red circles) used to provide the atmospheric forcing for the snow simulations.

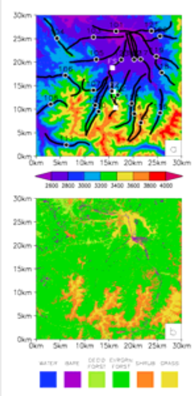

Fig. 2. Fraser MSA (a) topography (m), and (b) vegetation. Also shown in (a) are the intensive study areas (ISAs) (white squares), and the Gamma Radiation Detection System (GAMMA) flight lines (black lines with black and white markers and ID numbers in the center of each line) for this MSA.

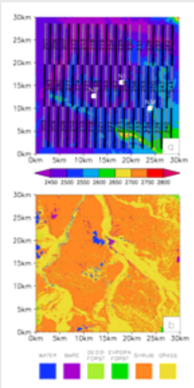

Fig. 3. Same as Fig. 2, but for North Park MSA.

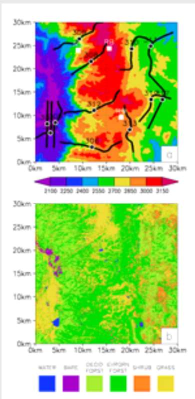

Fig. 4. Same as Fig. 2, but for Rabbit Ears MSA.

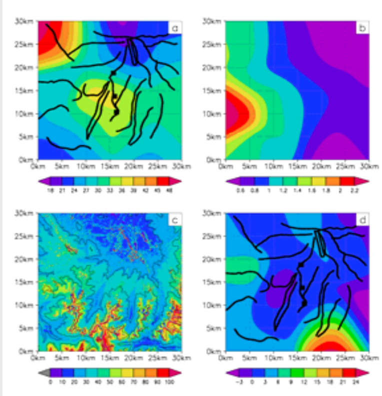

Fig. 5. The Fraser MSA on 25 March 2003, during IOP 4. (a) ISA and GAMMA SWE observations gridded to the simulation domain (cm). Also shown are the ISA and GAMMA observation masks for this date. (b) The average of the two data assimilation precipitation correction factor distributions (IOP 3 and 4) used in the simulations (non-dimensional). (c) Model simulated SWE (cm). (d) SWE differences (modeled – observed) calculated over the ISAs and GAMMA flight lines and interpolated over the simulation domain (cm).

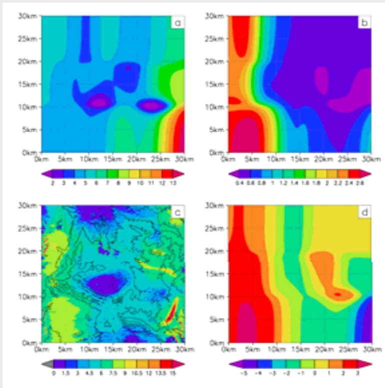

Fig. 6. Same as Fig. 5, but for the North Park MSA on 28 March 2003.

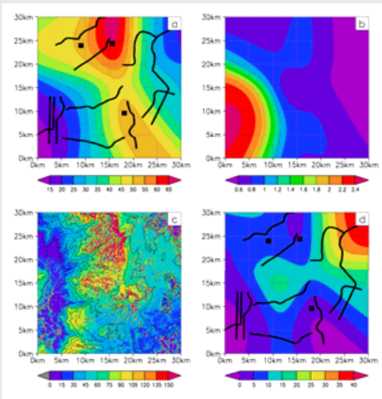

Fig. 7. Same as Fig. 5, but for the Rabbit Ears MSA on 30 March 2003.

(Snowflake photos courtesy of Kenneth G. Libbrecht and Patricia Rasmussen)

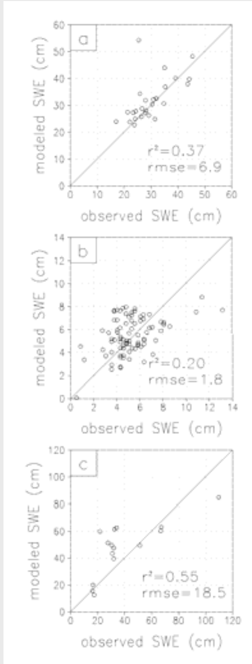

Fig. 8. Comparison of modeled and observed SWE, over the ISA and GAMMA observation masks for (a) Fraser, (b) North Park, and (c) Rabbit Ears MSAs; included are the square of the linear correlation coefficient, r2, and rmse.

Liston, G. E., and K. Elder, 2006a: A distributed snow-evolution modeling system (SnowModel). *J. Hydrometeorology*, in press. A preprint of this can be obtained from ftp://ftp.cira.colostate.edu/liston/papers/first_author/2006.inpress.liston.JHM.pdf.

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