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A TEST OF TWO MESOSCALE METEOROLOGICAL MODELS IN JASPER NATIONAL PARK

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1. INTRODUCTION

The fire management program within Jasper National Park and, to some extent, all parks in the mountain district would be enhanced with a means of forecasting fire behaviour conditions over complex terrain. This will require an improved understanding of weather conditions as well as a weather network capable of providing reliable weather observations over a large mountainous area.

The problem of predicting fire weather and potential fire behaviour conditions occurs at the mesoscale. The mesoscale is described by Hunschke (1959) as "the state of the atmosphere as it exists between meteorological stations." Following Orlanski (1975), it denotes the range of atmospheric scales 200-2 km, subdivided itself into α, β, and γ ranges. Forest fires occur and interact with the atmosphere on the mesoscale. Having models that predict mesoscale meteorology would greatly enhance the ability to model fire growth and micro-site fuel moisture conditions — especially in complex terrain.

Two mesoscale meteorological models were used to predict meteorological conditions for Jasper National Park. The Regional Atmospheric Modelling System (RAMS) is a mesoscale model produced by the University of Colorado. This model is a combination of a dynamic numerical model by R.A. Pielke (1984) and a detailed cloud physics model by W.R. Cotton (Cotton and Anthes 1989). The RAMS model is currently being used by the Canadian Forest Service to forecast fire danger conditions in Alberta.

The second model is the Mesoscale Compressible Community (MC2) model produced by Cooperative Centre for Research in Meteorology (Bergeron et al. 1994). Similar in scope and complexity to RAMS, the MC2 model is currently supported by Recherche en prévision numérique (RPN), Environment Canada (Benoit et al., 1997).

The goal of this project is to test the ability to forecast fire weather and fire behaviour conditions within the complex terrain that exists in Jasper National Park. A mesoscale observation network will be used to verify the accuracy of these models in different watersheds. Results of this study will determine the appropriateness of using these models for fire growth modelling on an operational basis.

1.1 *Jasper National Park*

Jasper National Park lies within the Rocky mountains just east of the continental divide, which defines the border between Alberta and British Columbia. The region is mountainous with great diversity in topography and elevation. It comprises glacially created terrain with river valleys separated by mountain ranges. Active glaciers are present and several large icefields, including the Columbia Icefields, are a significant factor on the landscape.

Climate is defined primarily by its variability (Janz and Storr 1977). The park is in a transitional zone between pacific dominated weather patterns and continental weather patterns. The prominent north to south strike of the majority of the river valleys alters the precipitation, temperature, and wind regimes that are determined by larger-scale controls. The influence of topographic factors is significant and can outweigh the larger-scale controls.

2. METHODOLOGY

2.1 *RAMS*

The RAMS model was set up to predict meteorological conditions on a 4-kilometre resolution grid over Jasper National Park with 1-kilometre resolution sub-grids first for the Athabasca and then the Chaba watersheds. To achieve this, the model was run with four grids at 64-, 16-, 4-, and 1-kilometre resolutions.

The model was run with 21 atmospheric levels to an altitude of 17 kilometres using a stretched vertical spacing of 75 metres near the surface to 2 kilometres at the top. Seven soil levels were used down to a depth of one-half a metre.

Geophysical databases were developed for each grid based on existing Park biophysical information

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representing topographic, vegetation, water, and soils.

Initial meteorological conditions for the model were derived from upper air soundings and surface observations. These data were collected off the Anikom satellite dish and values were then interpolated to the model grids using an isentropic analysis scheme provided with the model.

Horizontally homogeneous initial soil temperature and moisture profiles were used, with the default moisture profile supplied with the RAMS model, and the temperature profile estimated from Great Plains Field Program plots (Arya 1988).

The model was run continually for the test period with nudging every twelve hours from upper air data and every four hours from surface data. These nudging times were reduced to every five minutes towards the boundaries following an e-folding scheme to prevent the reflection of gravity waves into the interior of the model domain.

The model was run non-hydrostatically with full microphysical handling of precipitation. The radiation package included longitudinal variation and effects of atmospheric moisture. The model provided a convective parameterization for the coarse (64 km) grid alone, while convection was modelled with vertical motions and cloud physics on the finer (1, 4 and 16 km) grids.

2.2 _MC2_

The MC2 model was set up on a sequence of 3 grids (35-, 10-, and 2-km), with the final 2 km grid placed first over Athabasca (July) and then Chaba (August) On the finest grid, the domain size was 320x320 km^2. To further avoid errors caused by the lateral nesting over the central region of interest, two 6-hour integrations were performed in sequence for the 2-km.

The model was run with 20 variably spaced Gal-Chen levels stretching from 50 m to a 20-km top. Geophysical surface properties were extracted from existing climatological and topographical databases at the Canadian Meteorological Centre (CMC). Soil properties are taken as horizontally homogeneous.

Initial and lateral boundary conditions (only for the coarser 35-km grid) are obtained from the 35-km RFE model (Environment Canada Operational Regional Model) at 00 UTC; the lateral time variation is sampled every 3 hours.

The following time strategy is then applied to cascade MC2 towards the final prognostic: first integrate from 0 to 18 h on the 35-km grid; then integrate from 3 to 18 h on the 10-km grid; last, integrate from 6 to 12 h and 12 to 18 h on the 2-km grid.

The MC2 model, being a fully compressible hydrodynamics code, was run in non-hydrostatic mode, which becomes of importance for the 2-km grid. Physics package is similar to that in the RFE, with a full radiation computation, non-cloudy boundary layer turbulence, Kuo-type convective closure and simple explicit condensation based on Kessler equations and a gravity wave drag (GWD) scheme; at the 2-km resolution, both the GWD and the convective parameterizations are removed, being treated directly by the model's dynamics. Soil temperature is computed with a force-restore scheme and no subsurface grid.

2.3 _Site Locations_

To validate the mesoscale models, a network of five Forestry Technology Systems (FTS) were used to collect hourly observations. These stations recorded the temperature, humidity, precipitation, wind speed and direction. The network was deployed in the Athabasca basin for June and July 1996 and for August and September 1996 in the Chaba.

The FTS stations consisted of four model WR-62 data loggers and one FTS-11. The stations were equipped with temperature and humidity sensors stored in a non-ventilated Stevenson screen, a tipping bucket rain gauge and an anemometer atop a 10-m mast. Hourly measurements were made of dry-bulb temperature, relative humidity, wind speed and direction and precipitation. One minute averages of each were made in estimating the hourly value with the exception of precipitation. The station sites followed WMO standards and were situated in openings typically 100-m wide.

During July and August, upper air data was collected for the study. At 1200 UTC, a radiosonde was released from the Warden's Office in Jasper. This data was not used by the models but was used to verify upper air conditions during the model runs.

3. RESULTS

So far, the validation study has focused on the Athabasca for a seven day period from July 23 to 29. There was no appreciable amount of rain detected during this period.

Figures 1 shows six scatter plots of predicted versus observed data for the Snaring (A2) station. The solid line appearing on each graph shows where predicted equals observed, while the dashed line is a best-fit with the correlation coefficient, r^2, printed beside.

Table 1 summarizes the correlations for 4 stations within the Athabasca. Henry House (A3) is missing as the station failed to properly record the data.

Table 1. Correlation coefficients for model predictions versus observed data for four stations in the Athabasca.

	RAMS			MC2		
	Temp	Hum	Wind	Temp	Hum	Wind
A1	0.858	0.749	-0.30	0.884	0.765	0.109
A2	0.764	0.721	-0.02	0.931	0.821	0.357
A4	0.607	0.499	-0.33	0.712	0.575	0.205
A5	0.828	0.770	0.026	0.900	0.823	0.239

4. DISCUSSION

The best correlations for both models were with temperature though both models consistently under-predicted maximum temperatures by as much as 10°C while correctly predicting overnight lows. This occurred at all four stations to varying degrees. A likely explanation for this would be that both models use forest as the predominant vegetation type around the observation sites while the sites themselves are 100-metre clearings with a grassy/sandy surface. One would expect the heat balances to be different in the afternoon with a greater amount of sensible heat being emitted from the grassy/sandy surface. Likewise, nighttime inversions would minimize such differences.

The RAMS model did well at predicting humidity on a whole while the MC2 model consistently and significantly over predicted humidity. This is likely an error in the model parameterization that was not accounted for in time for this paper or a faulty (too wet) soil moisture distribution, leading to excessive evaporation/moistening of the boundary layer.

Wind speeds and direction (not shown) were disappointing. The RAMS model failed at predicting wind showing little to no correlation. The MC2 model did significantly better than RAMS, clearly showing the advantage of initializing the model with gridded data coming from a complete data assimilation system, over surface and upper air reports alone. Yet, for the purposes of this study, to drive a possible fire growth model, the increased accurracy is of little benefit given the MC2 model explaining 36% of the variation at best. The likely explanation for this is simply that the topography within the Athabasca valley is too complex for this exercise. The 1- and 2-km grids cannot capture the variability and its effects on the wind flow to a reasonable degree of confidence. This problem is not new and has been experienced in other contexts (such as with the 3-km model operated by Meteo-France over the French Alps during the Albertville Olympics). It is very difficult to match the actual exposure and that of a surrounding model grid point.

The timeliness of the data is another issue. The RAMS model was run on a DEC Alpha 3000 and generally was taking 16 to 20 hours to produce a 12-hour forecast for four grids. This may not be a problem though, given the rate at which the power desktop workstations increases from year to year. The MC2 model runs, which were conducted on the NEC computer at the CMC, in Dorval (Quebec), were taking 3 to 6 hours to produce a 24-hour forecast, which is reasonable for an operational stand point.

5. CONCLUSIONS

One goal of this project was to validate fire weather forecasts produced by mesoscale models for Jasper National Park. Forecasts of temperature and humidity appear acceptable while wind forecasts are poor. As winds are a principal driving force in fire growth, the use of these models in fire growth modelling in complex terrain is questionable and requires further evaluation to go beyond difficult point-wise error calculations; it could be that fires respond more to the patterns generated than to local values.

A second goal was to determine the appropriateness of using these models on an operational basis. In this regard, the timeliness of model output is a concern. Modelling weather conditions down to these levels still appears to be out of reach of most desktop workstations. Though this will change in time, those who wish to use such mesoscale models must rely on meteorological agencies with sufficient computing power. Another possible avenue is to run the expensive fine grids over just a limited number of timesteps, compatible with available power, to obtain an adaptation of the cheaper coarse grid wind forecasts to the fine scale terrain.

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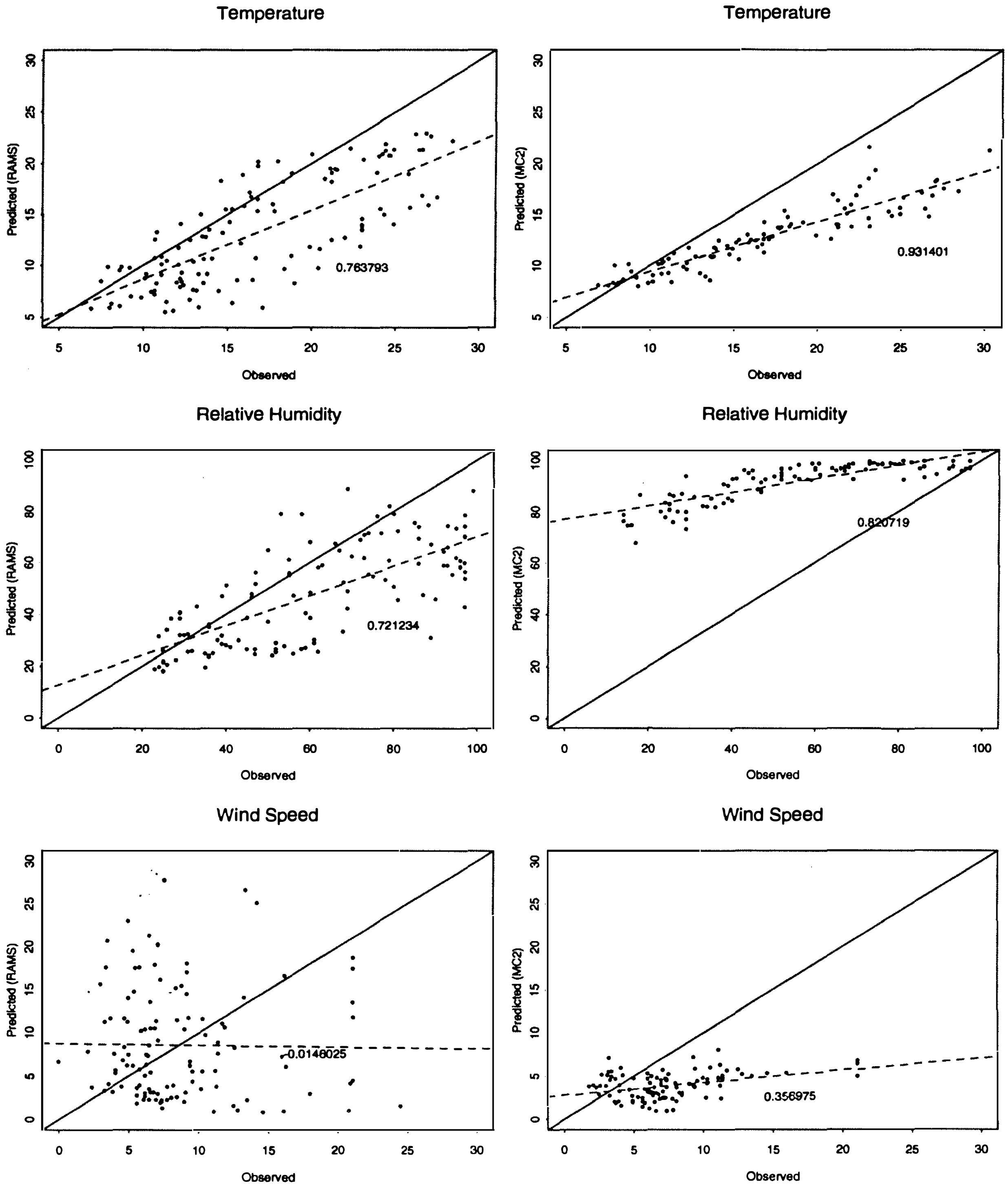

Figure 1. Predicted versus observed values of temperature, humidity and wind speed for Snaring station (A2).

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Front Cover: The Eta 10 km run is shown with 0.1x0.1 degree resolution including topography in grey. An iso-surface of Vertical Motion is shown in blue for upward motion greater than 0.1m/s. 6-hr total accumulated precipitation is shown every 0.5 mm and shaded for amounts in excess of 3 mm. Red arrows show the low-level wind at 2.3 km.

Of interest is the alignment of the blue "blobs" of vertical motion and associated precipitation along the mountain ridge at the Wyoming-Idaho border trailing west through southern Idaho from the center right to the lower left corner of the figure.

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FOREWORD

The 12th Conference on Numerical Weather Prediction and 16th Conference on Weather Analysis and Forecasting were limited to topics related to smaller scale, high frequency events and short-range prediction problems. We hoped such a narrow range of topics would limit the number of abstracts and allow us to keep parallel sessions to a minimum. We even entertained the notion that we might be able to intersperse sessions on NWP among the sessions on WAF giving the conferences the feel of one conference. We received over 350 abstracts forcing us to abandon our plans and to break WAF and NWP apart into two separate conferences with their own preprint volumes. We have attempted to integrate both conferences as much as possible but because of the shear volume of papers were prevented from a truly integrated program. We decided to allow as many oral presentations as possible feeling that severely limiting the number of oral presentations would be unfair to the authors because of the large number of quality abstracts. Hopefully, the resulting parallel sessions will not cause too many aggravations.

The growing cooperation between universities, the NWS field offices, the military and the NOAA Atmospheric Research Labs is exciting. The use of high resolution, local models in NWS forecast offices is an outgrowth of this cooperation. The resulting interaction between the research and operational communities is healthy and is needed to identify and solve forecast problems. A number of exciting developments have taken place in the field of NWP during the past couple of years. The GFDL Hurricane Model has been implemented at NCEP resulting in a significant decrease in track errors. Data Assimilation methods continue to improve and now utilize data from a wide variety of observing systems. For example, during the Olympics in Atlanta, a 10-km resolution Eta-coordinate model and version of 3D-VAR assimilation that used radial wind velocities from the NEXRAD network were tested. Ensemble forecasting techniques are now being explored for short-range prediction problems. We hope this year's NWP program encompasses and reflects the exciting developments that are taking place in the field. Papers are being presented on a wide range of topics including: data analysis, quality control, initialization, data assimilation, local and mesoscale modeling, modeling of physical processes including convective, radiative, boundary-layer processes, orographic effects, model verification, and predictability.

We also hope participants at the meetings are able to obtain a comprehensive view of the current state of knowledge regarding short-range forecasting of mesoscale systems and stimulates participants to continue to work to advance Numerical Weather Prediction.

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