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TRANSIENT CLIMATE CHANGE SCENARIOS FOR HIGH RESOLUTION ASSESSMENT OF IMPACTS ON CANADA'S FOREST ECOSYSTEMS

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Executive Summary

Production of national climate change scenarios for Canada

The major effort of this study was devoted to developing the tools and techniques needed to create high resolution scenarios of projected transient changes in climate for Canada, derived from General Circulation Model (GCM) simulations. The initial effort was focused on the Canadian Centre for Climate Modelling and Analysis (CCCma) CGCMII (second generation coupled GCM). For various reasons we selected the IPCC IS92A greenhouse gas plus aerosol emissions scenario, and used the data from the second ensemble simulation of this emissions scenario. Data were downloaded from the CCCma website for eight climate variables, and used to generate time series of simulated monthly anomalies (relative to 1961-90 means) covering the 121-year period 1950 to 2070.

Observed monthly Normals data obtained from Meteorological Service of Canada (MSC) climate stations across the country and from neighbouring stations in Alaska and the US States south of the border were used to create high resolution (0.0833 ° latitude/longitude) grids for each climate variable of interest. Data were interpolated as functions of latitude, longitude and station elevations using ANUSPLIN software developed by Hutchinson and coworkers (see Hutchinson 2000). The resulting spline functions were then applied to a national digital elevation model to create maps for each monthly mean variable. These were: daily maximum and minimum screen temperatures, total precipitation, solar radiation incident at the surface, vapour pressure and wind velocity.

The anomaly data obtained from the CGCMII simulation were similarly interpolated for each month (i.e., 121 years times 12 months = 1432 separate interpolations per variable) using ANUSPLIN. The data were then all converted to the UCAR NetCDF binary format for storage and data transmission purposes. Software tools were developed to facilitate all the data manipulations required both to create these files and to access them. Further documentation on these tools and their use is provided in Appendix I of this report.

The software tools were then used to create seasonal summary maps showing changes in Canada's climate as projected by CGCMII under the IS92A emissions scenario for two 30 year periods: 2001-2030 and 2041-2070. While it is inappropriate to consider these projections as forecasts of Canada's climate, they are nevertheless of interest both for indicating what may happen and the general spatial distribution of trends in several climate variables. The greater value of such datasets, however, lies in their use as drivers of models of climate impacts on Canada's infrastructure, agriculture and natural ecosystems. The data are currently being used to carry out large-scale simulations of climate change on Canada's forest ecosystems, but it is fully intended that they also be made generally available to the modelling community as soon as possible.

Comparison of scenarios derived from CRCM2 and CGCMII

The second part of this project attempted a formal comparison of scenarios derived as above from observed data and the CGCMII simulation with similar data derived from the Canadian Regional Climate Model, CRCM2. A series of diagnostics were applied to a 10-year CRCM2 simulation and to two scenarios derived from a combination of observed data interpolated using ANUSPLIN and simulation data generated by CRCM2 and CGCMII (using an approach recently developed by Boer and Lambert 2001). The analysis was performed for four monthly variables: daily minimum and maximum screen temperature, mean precipitation and mean incident solar flux received at the surface. Two sets of diagnostics were considered: the first dealing with the spatio-

temporal decomposition of the Mean Square Difference (MSDs), and the second dealing with spatial decomposition of the variance.

This analysis showed that the scenarios are still affected by the biases of the model upon which they are built—which can make interpretation of the scenarios very difficult. The problem appears only in those variables for which the scenario is built from an anomaly calculated as a ratio instead of a difference (e.g., precipitation and incident solar flux received at the surface).

In the second part of the analysis, we found that the dominant contribution of the spatio-temporal variance (90-98%, depending on the variable and the season considered) results from the spatial variance of the climate-mean fields (stationary eddies). The approach used to build the scenarios (with the simulated stationary eddies being replaced by observed data) resulted in the spatio-temporal variance being dominated by the observations. The differences between the two scenarios (i.e., as derived from CGCMII and CRCM2) was associated with the interannual anomalies.

Further work

The overall analysis suggests that the climate scenarios created in this study were closely tied to the observations and therefore could not be considered independent datasets. It would be interesting to downscale the GCMII simulations using ANUSPLIN and to compare the results to the CRCM2 simulation to assess the improvement obtained by using a sophisticated interpolator (i.e., CRCM2) instead of a simpler statistical approach (i.e., ANUSPLIN).

Elevation effects were deliberately ignored in our initial construction of the CGCMII scenarios because preliminary tests suggested that there was no elevation signal for the selected variables, and because accounting for elevation would require considerably more computing time. Results from the CRCM2/CGCMII comparison suggested that the quality of the CGCMII scenario might be improved, however, by including effects of model orography on each climate variable. This suggests a slight change to the data manipulation sequence, where the source data would first be interpolated to the final resolution (using elevation as an independent variable), and the anomalies then determined from the interpolated data.