A FEW REGIONAL MODEL INTERCOMPARISON STUDIES

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PROJECT TO INTERCOMPARE REGIONAL CLIMATE SIMULATIONS. The Project to Intercompare Regional Climate Simulations (PIRCS; information online at www.pircs.iastate.edu) is a community-based project that seeks to evaluate the strengths and weaknesses of regional climate models and their component procedures through systematic comparative simulations. Initial intercomparisons focused on the upper Mississippi River basin where summertime precipitation is created by both large-scale processes and mesoscale (nonorographic) convection, augmented by moisture transport by a low-level jet. The first series of PIRCS experiments examined extreme events of 2–3-month duration (1988 drought and 1993 flood) over the same limited region in brief periods. The drought period allowed simulation of a period with minimal contribution to the surface energy budget from latent heat, whereas the second investigated the same region during a period of intense rainfall and saturated surface conditions. All models captured the sequence of wet and dry days when the flow is driven by the large-scale motion, but varied much more randomly for strong summertime convectively driven cases. Most regional climate models (RCMs) were able to simulate the unique nocturnal precipitation maximum in the U.S. Midwest, even though this feature was absent in the climatology of the driving reanalysis. Most RCMs simulated the precipitation maximum during a flood event to be northeast of its actual location and of a lower total rainfall amount than that observed.

PIRCS is now transitioning to become a key component of the North American Climate Change Application Project (NARCCAP; information online at www.narccap.ucar.edu). NARCCAP is an international program that will provide high-resolution climate scenarios for impact studies for both the United States and Canada, using regional climate models, coupled global climate models, and time-slice experiments. The fundamental scientific motivation for NARCCAP is to understand and quantify the combined uncertainty in future climate projections resulting from these of different atmosphere–ocean general circulation models providing boundary conditions for different regional climate models.

ARCTIC REGIONAL CLIMATE MODEL INTERCOMPARISON PROJECT. An international intercomparison of regional model simulations in the Arctic has been organized under the auspices of the World Climate Research Programme (WCRP) Global Energy and Water Cycle Experiment

(GEWEX) Cloud System Studies Working Group on Polar Clouds and the Arctic Climate System Study (ACSYS) Numerical Experimentation. This domain offers extreme low temperatures, strong low-level stability, permanently frozen soils, and migrating sea ice. From the Arctic Regional Climate Model Intercomparison Project (ARCMIP), Tjernström et al. (2005) report that biases in near-surface wind speed, perhaps created for correct representation of large-scale pressure fields in forecast models, give incorrect sea ice drift. Simulated turbulent heat flux has little similarity to observations. Long-term errors in sensible and latent heat flux tend to compensate, perhaps resulting from tuning of wind stress. Simulated downward shortwave radiation suggested that cloud simulations were reasonably accurate, but a positive correlation between cloud water and bias in specific moisture suggests inconsistencies. Rinke et al. (2005) report that the seven-member ensemble mean reproduces the driving reanalysis very realistically (constrained by a rather small domain), but that the largest intermodel scatter is in 2-m temperature over land, surface radiation fluxes, and cloud cover, all of which are likely attributable to different land surface and radiation cloud schemes. Both performance bias and intermodel differences are largest at low levels and near the surface. No single model stands out as being superior in all simulations. Modeling studies are continuing under the Global Implications of Arctic Climate Processes and Feedbacks (GLIMPSE; information online at www.aui-potsdam.de/www-pot/atmo/glimpse/index.html).

IRI/ARC. Tropical climates have been examined through an intercomparison of simulations by four models over South America (Roads et al. 2003). This region offers examination of influences of Atlantic SSTs, ENSO events, the South American monsoon system, and steep topographic features. All models captured the seasonal cycle of precipitation, including the precipitation maximum associated with the South American monsoon, although precipitation totals were less than those observed. All models had excessive variability in the vicinity of the Andes, with better predictability on the windward than the leeward side. Predictability in summer and winter was better than in the transition seasons.

NEWBALTIC I AND II. Within the Baltic Sea Experiment (BALTEX) continental-scale experiment of GEWEX and its intensive observing period BRIDGE, the Numerical Studies of the Energy and Water Cycle in the Baltic Region (NEWBALTIC) I and II have intercompared simulations of components of the hydrological cycle produced by regional models applied to the Baltic Sea area. Northern Europe provides strong seasonal changes characteristic of midlatitude and sub-Arctic climates. A wide variety of marine influences (ocean, inland sea, shallow lakes) and topographic features with various orientations to the predominant flow direction offer a range of surface forcing. From a study of meteorological versus hydrological models, Graham and Bergström (2000, 2001) concluded that meteorological models should keep their multilayered approach for modeling soil temperature, but add a simpler, yet physically consistent, hydrological approach for modeling snow processes and water transport in the soil. One result is that compensating errors are evident in the snow routines of the atmospheric models studied. Most regional models were consistent in producing too many high clouds and not enough low clouds. Hamelbeck et al. (2001) conclude that total convective heat flux is a useful subgrid-scale quantity for making model physics comparable across limited-area models. Jacob et al. (2001) compared results from eight models for a 3-month period and found significant disagreement in cloud cover, radiative properties, average precipitation, and runoff even though synoptic events were well captured. Van Meijaard et al. (2001) further explored the characteristics of RCM cloud simulation by comparison with measurements by ceilometers, IR radiometers, and satellite observations. They found that RCMs systematically predicted too much cloud amount below 900 hPa and compensated by simulating less than that observed around 800 mb and attributed this behavior to the underestimate of planetary boundary layer height. The models differed substantially in their cloud radiative fluxes, even though they were reasonably alike in cloud parameters.

NORTH AMERICAN MONSOON MODEL ASSESSMENT PROJECT. Although this project did not have the tightly constrained protocol on lateral boundary conditions common to most intercomparisons, its assessment of the monsoon of the southwest United States and northwest Mexico with four regional models and two global models provides insights on model behavior for an important climatic feature (Gutzler et al. 2005). The North American monsoon, with its strong interaction with coastal terrain, offers both latitudinal and orographic contrasts for comparison with other continental monsoon systems. All regional models in the North American Monsoon Model Assessment Project (NAMAP) reproduced the observed July maximum precipitation, whereas both global models simulated an August maximum. All four regional models retained their diurnal cycle phase before, during, and after the monsoon peak (June, July, August), and three had their hourly amplitudes proportionally decreased after the July peak. However, one model partitioned all of the difference between July and August rain to be in the nocturnal component. The models did not agree on the interaction of convection with topography, particularly for intense convection in regions of extremely complicated terrain. A second phase, NAMAP2 (which is currently underway), will simulate the North American monsoon for 2004, when a wealth of observed data were obtained in the North American Monsoon Experiment (NAME) field campaign (NAME Project Science Team 2004)

PREDICTION OF REGIONAL SCENARIOS AND UNCERTAINTIES FOR DEFINING EUROPEAN CLIMATE CHANGE RISKS AND EFFECTS. Europe offers regions from the lower midlatitudes to the sub-Arctic, with a dominant mountain range oriented parallel to the predominant flow direction, thereby providing a constraint on longitudinal flow over some subregions. The Prediction of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects (PRUDENCE; Christensen 2005) is a European Union project that focuses on improving projections of future climate change. PRUDENCE provides high-resolution climate change scenarios for 2071–2100 for Europe using dynamical downscaling methods (regional climate modeling) performed at numerous European climate modeling institutes. These scenarios are being used to explore changes in the frequency and magnitude of extreme weather events. The variability and level of confidence in these scenarios is furthermore being analyzed as a function of uncertainties in model formulation, natural/internal climate variability, and alternative scenarios of future atmospheric composition. With a combination of climate models, impact models, and expert judgment, quantification of the uncertainties in predictions of future climate will be provided to European decision makers.

From PRUDENCE, Déqué et al. (2005) find that individual RCMs present a larger spread than the difference between global climate models (GCMs) and RCMs. The systematic error in temperature is less than half the climate change for a future scenario (A2, end of the twenty-first century) climate. Sources of uncertainty for global models, in decreasing order, are from model to scenario (B2 versus A2), SST forcing, and sampling. For RCMs, the order is from scenario to boundary forcing, model, and sampling. For precipitation for GCMs systematic error is large with diverse patterns and is larger than climate change. Major sources of uncertainty in precipitation for both GCMs and RCMs are SST forcing and model-to-model variability, followed by scenario and sampling error.

REGIONAL CLIMATE MODEL INTERCOMPARISON PROJECT FOR ASIA. East Asia offers a monsoonal climate with high terrain to the west and ocean to the south and east, in contrast with other monsoonal climates. The Regional Climate Model Intercomparison Project (RMIP) for Asia has been established since 1999 to evaluate and improve RCM simulations of monsoonal climate. RMIP operates under joint support of the Asia–Pacific Network for Global Change Research (APN). Fu et al. (2005) report that models tended to have a cool bias, more so over arid regions in northern China, with individual model biases ranging from ± 1° to ± 6°C and generally exceeding the ensemble average. The annual cycle of precipitation was reproduced except in western arid and semiarid regions of China. Ensemble averages outperformed individual models for precipitation as well as temperature. Precipitation at high latitudes was excessive for most models. Most models captured wet and dry extreme events, including a belt of heavy rain and its associated low-level jet.

OTHER MIPS. Emerging model intercomparison projects (MIPs) include the La Plata Basin Project (PLATIN; information online at www.eol.ucar.edu/projects/lpb) in the de La Plata basin in Argentina/Uruguay, the African Monsoon Multidisciplinary Analysis (AMMA; online at http://amma.mediasfrance.org/index) in West Africa, the Quantification of Uncertainties in Regional Climate Change and Climate Change Simulations (QUIRCS; information online at www.pa.op/dlr/climate/dek/im.html) in central Europe, and Assessments of Inputs and Adaptations to Climate Change (AIACC; online at www.aiaccproject.org/) in southern Africa. The Structured Grid Model Intercomparison Project (SGMIP; information online at www.essic.umd.edu/~foxrab/sgmip.html) compares results of stretched grid models, which offer advantages for simulating regional climates by allowing full interaction with coarsely resolved regions outside the region of interest. SGMIP results so far have focused on overall accuracy of the method and have not intercompared model validity on specific climate features.

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