Takle, E.S.; Roads, J.; Rockel, B.; Gutowski, W.J.; Arritt, R.W.; Meinke, I.;
Jones, C.G.; Zadra, A.:

Transferability intercomparison: An opportunity for new insight on the global water cycle and energy budget

In: Bulletin of the American Meteorological Society (2007) AMS

DOI: 10.1175/BAMS-88-3-375

TRANSFERABILITY INTERCOMPARISON

An Opportunity for New Insight on the Global Water Cycle and Energy Budget

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Transferability intercomparisons provide a new approach for advancing the science of modeling the water cycle and energy budget on regional to global scales by using multiple limited-area models applied to multiple domains.

The water and associated energy cycles introduce exponential, episodic, and other nonlinear processes that create difficulties for observing, simulating, and predicting climate variations. The water cycle both creates and responds to spatial heterogeneities that feed back strongly on the energy budget and circulation system. These feedback processes represent some of the largest uncertainties in our ability to simulate future scenarios of Earth's climate, especially scenarios that suggest warming beyond the temperature bounds of recent interglacial conditions and hence for which we have no previous observations for comparison. Water cycle processes also occur on a wide range of spatial and temporal scales, many being far too small to either be globally observed and or simulated by global climate and weather forecast models.

Transferability intercomparions represent a new approach for understanding the water cycle and energy budget on regional to global scales. This new class of intercomparisons applies multiple regional climate models to a prescribed collection of domains where enhanced observations are conducted and results are archived in a coordinated manner. The primary goals of the transferability intercomparisons are to understand the complex interactions forming the water cycle and evaluate our ability to simulate these processes. The transferability framework goes

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A supplement to this article is available online (DOI:10.1175/BAMS-88-3-Takle)

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The abstract for this article can be found in this issue, following the table of contents.

DOI:10.1175/BAMS-88-3-375

In final form 7 July 2006

beyond previous regional climate model (RCM) intercomparisons to provide a global method for testing and improving model parameterizations by constraining the simulations within analyzed boundaries for several domains. Transferability intercomparisons expose the limits of our current regional modeling capacity by examining model accuracy on a wide range of climate conditions and realizations.

Transferability intercomparisons draw heavily on the infrastructure, research capabilities, and datasets of the Global Energy and Water Cycle Experiment (GEWEX; information available online at www.gewex.org) and contribute to the overall goals thereof. GEWEX was initiated by the World Climate Research Programme (WCRP) to observe, understand, and model the hydrologic cycle and energy fluxes in the atmosphere and land surface in order to develop "the fundamental scientific understanding of the physical climate system and climate processes needed to determine to what extent climate can be predicted and the extent of [human] influence on climate." As described by Sorooshian et al. (2005), GEWEX research phase I objectives called for development of "the ability to predict the variations of global and regional hydrological processes and water resources and their response to environmental change." Phase II GEWEX science questions further ask the following: Are the Earth's energy budget and water cycle changing? How do processes contribute to feedback and causes of natural variability? Can we predict these changes on seasonal to interannual scales? What are the impacts of these changes on water resources?

The GEWEX Hydrometerology Panel (GHP) was established (Lawford et al. 2004) to globally coordinate intrinsically regional continental-scale experiments (CSEs) (Iowa State University 2005a) to address these questions. This article discusses activities of the Transferability Working Group (TWG) established by the GHP to develop a global framework for answering scientific questions on predicting variations of regional and global hydrological processes and water resources and their response to environmental change (Iowa State University 2005b). The mission of TWG is as follows: to understand the physical processes underpinning the global water and energy cycles and their predictability through systematic intercomparisons of regional simulations of unique climates and to compare these simulated regional climates with coordinated continental-scale observations and analyses.

Numerical models used for simulating climate processes at both global and regional scales are constructed from fundamental conservation laws. However, parameterizations required to account for subgrid-scale nonlinear processes introduce an empiricism that reduces generality. Uncertainties arising from these parameterizations feed back strongly on the energy budget and circulation system. Mountains, coastal areas, and heterogeneous patterns of land use and natural vegetation provide regional-scale influences that are not appropriately modeled with current coarse-scale climate models. A key tool of GHP CSE activities, therefore, has been the coupled land–atmosphere regional models.

Wang et al. (2004) provide a recent review of regional climate modeling, so we present only a few features relevant to transferability intercomparisons discussed herein. The increased resolution of RCMs provides better representation of regional circulation, improved representation of orographic forcing, and increasingly realistic physics parameterizations according to Giorgi and Marinucci (1996). They found that decreasing model grid spacing from 200 to 50 km in simulations over Europe generally improved model representation of synoptic system structure, precipitation intensity distributions, precipitation threat scores, and cloudiness. They suggested an additional source of resolution dependency of simulated precipitation, namely, improved resolution of scales of motion involved in such processes, although they found no evidence for this in their results. Leung et al. (2003) and Leung and Qian (2003) have demonstrated that higher resolution improves precipitation forecasts in regions of complex terrain. The "Big Brother Experiments" of Denis et al. (2002) demonstrated the ability of regional models to successfully reproduce finescale features over regions where small-scale surface forcings are strong. However, the results of Pan et al. (2004) demonstrate that improved resolution of dynamical processes can have a significant impact on the ability to simulate climate *even in regions where orographic forcing is minimal.* Jones et al. (1995) find that higher vertical velocity and altered precipitation can also result from higher resolution. Regional models have further demonstrated capabilities for resolving key mesoscale features of the hydrological cycle such as the diurnal cycle and spatial dynamics that resemble mesoscale convective systems (MCSs) (Anderson et al. 2003). The resolution of spatial variations of low-level jet characteristics is needed in the U.S. Great Plains, for instance, for the simulation of extreme precipitation events and high spatial variability of precipitation, which can trigger long-term memory into the climate system resulting from soil moisture recharge (Koster et al. 2004).

A number of RCM simulations previously have been coordinated to explore the strengths and weaknesses of numerical simulation of specific regional climates at subcontinental scales, following the successful global Atmospheric Model Intercomparison Project (AMIP; Gates et al. 1998). Regional climate model intercomparison projects (MIPs) have been conducted for the following regions (more information can be found online at http://dx.doi.org/10.1175/BAMS-88-3-Takle): 1) the Arctic [the Arctic Regional Climate Model Intercomparison (ArcMIP)], 2) Asia [the Regional Climate Model Intercomparison Project for Asia (RMIP)], 3) Europe [the Baltic Sea Experiment (BALTEX) and the Numerical Studies of the Energy and Water Cycle of the Baltic Region (NEWBALTIC) I and II for northern Europe and the Prediction of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects (PRUDENCE) for all of Europe], 4) North America [the North American Monsoon Experiment (NAME) Model Assessment Project (NAMAP) for the monsoon region of the Southwest U.S. and northwest Mexico; the Project to Intercompare Regional Climate Simulations (PIRCS) for all the United States], 5) and South American International Research Institute/Applied Research Centers (IRI/ARC). Other regional model intercomparisons are just beginning and have yet to contribute to the body of information on regional model intercomparisons (see additional information online at http://dx.doi.org/10.1175/BAMS-88-3-Takle). Sequels to PRUDENCE and PIRCS [ENSEMBLES; information available online at www.ensembles-eu.org/; and the North American Regional Climate Change Assessment Program (NARCCAP); (available online at www.narccap.ucar.edu), respectively], designed to more fully address GEWEX phase II objectives of improving the predictability of climate on seasonal to interdecadal scales, currently engage ensembles of RCMs for the simulation of regional climates consistent with future scenarios generated by global climate models.

Unlike the previously mentioned global model comparisons, which have been fostered in part by the Working Group on Numerical Experimentation (WGNE), there has not been a global organization to nurture these intrinsically regional model intercomparisons. However, RCM simulations on domains well constrained by analyzed boundary conditions provide an opportunity for improving parameterizations for higher-resolution models (both global and regional). Analyzed boundaries allow parameterizations to be developed in the absence of error propagation from remote regions. Regional models can be constrained to the degree needed or required to allow three-dimensional interactions while keeping the large-scale flow synchronized with analyses, thereby allowing a more direct comparison of simulation details with observations. Because the GHP was particularly interested in fostering RCM research globally, TWG was established to summarize the lessons learned from previous RCM intercomparisons; to partner with the Coordinated Enhanced Observing Period (CEOP) Water and Energy Simulation and Prediction (WESP) Working Group to develop a global regional model intercomparison project, the Inter-CSE Transferability Experiment; and to encourage representatives of current regional model intercomparisons to become part of future TWG efforts. By participating in TWG regional climate model groups will not only reap the expected benefits from participating in an MIP, but will further contribute to the basic understanding of global energy and water cycle processes.

REGIONAL MODEL INTERCOMPARISON PROJECTS—HISTORY AND LESSONS LEARNED. As more and different regional climate model intercomparisons are being reported, some common features have emerged among the results. Perhaps the most common theme emerging from these studies (which follows the general experience of the global climate modeling community as well) is that no single model dominates others in accuracy in all variables being simulated. Occasionally, remarkable accuracy is demonstrated in one variable by one model for one region, but the same model may be very inaccurate for other variables or in other domains. Most model intercomparisons have helped individual modelers identify and overcome major shortcomings of their models. One outcome of the comparisons is that regional model ensemble means frequently are closer to observations than any individual model (Takle et al. 1999; Fu et al. 2005). Such ensemble means, however, fail to capture the magnitude of extreme events (Fig. 1).

Regional models driven by reanalysis data at the lateral boundaries create their climates from sequences of actual events (as opposed to collections of *plausible but not real* events) when there is strong coupling to the large-scale flow, such as stratiform precipitation relating to synoptic-scale flow. Most models tend to produce too many high-level clouds, too few midlevel clouds, and too many low-level clouds (Van Meijgaard et al. 2001). Almost all models tend to produce too many light rain events and not enough intense rain events, although presumably these regional models show some improvement over

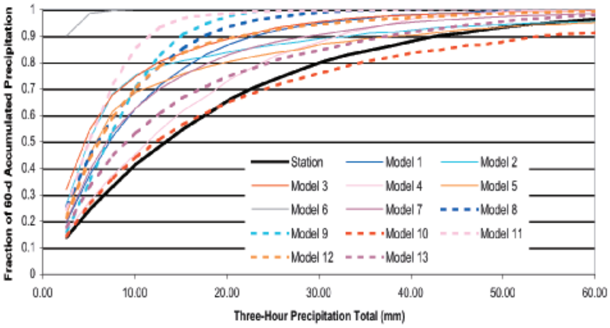

Fig. 1. Intensity of precipitation events over the upper Mississippi River basin as simulated by 13 RCMs with essentially identical domains over the continental United States driven by reanalysis boundary conditions from summer of 1993 (Anderson et al. 2003).

the even coarser-scale global models. All models (with 50-km resolution) fail to capture the timing between maximum and minimum 3-hourly precipitation accumulation from MCSs. Some, but not all, models run at this resolution are able to capture circulation features resembling MCSs and recognize the nocturnal maximum in precipitation associated with MCS events, but even these models do not get the timing correct within the diurnal cycle (Anderson et al. 2003). Seasonal cycles of precipitation are captured quite well over a wide range of climates, even in California where the seasonal cycle at the coast may differ from that inland. Rainfall generally is underestimated in very wet climates. Models generally capture the diurnal and seasonal cycles of temperature well, although with larger error under extreme cold and stably stratified conditions.

Several intercomparisons have concluded that model physics (convection scheme, surface layer physics) contributed more than the numerical solution method (spectral versus grid point) or heritage [a derivative of the fifth-generation Pennsylvania State University (PSU)–National Center for Atmospheric Research (NCAR) Mesoscale Model (MM5) versus another gridpoint model] to differences among model results and between model results and observations. Furthermore, model features, such as frontal position and rainfall generation in relation to frontal position, are more important than boundary data (a source of reanalysis data) in accuracy of precipitation amount and placement. Unique signatures in specific regions offer opportunities to explore model processes in more detail. One such set of signatures is the diurnal pattern of components of the hydrological cycle. The nocturnal summer precipitation maximum in the U.S. Midwest allows inspection of how models organize the moisture supply to feed these nighttime storms. Diurnal cycles of hydrological components produced by regional models evaluated in PIRCS 1b produced nocturnal maxima of moisture convergence and precipitation (Fig. 2), including both convective and stratiform precipitation. It is noteworthy that these (physically correct) attributes were absent in the driving reanalysis, thereby confirming the value added by at least one group of RCMs for the season simulated. The timing of convective precipitation in models (although not directly verifiable by observations) further allows diagnosis of whether precipitation is driven by moisture flux convergence or destabilization resulting from surface heat fluxes.

TRANSFERABILITY INTERCOMPARISONS. Regional climate MIPs typically apply multiple models on a single domain. Although much has been learned from individual regional MIPs, a lack of uniformity across projects, such as implementation of boundary conditions and use of observed data, has limited our ability to draw more general conclusions regarding new understanding of *global* water and energy cycles. A next step in RCM development is the application of a single model to multiple domains, which we refer to as a *transferability experiment.* In a transferability experiment, the model options are kept fixed for all domains to assess model skill outside its "home" domain (domain of development and testing), that is, the generality of the model. Transferability *intercomparison,* as promoted by TWG, consist of intercomparisons of coordinated transferability *experiments* from several models where, insofar as possible, all experiments use the same domain geometries, lateral boundary conditions, and resolution on a prescribed collection of domains where enhanced observations are available and results are archived in a coordinated manner.

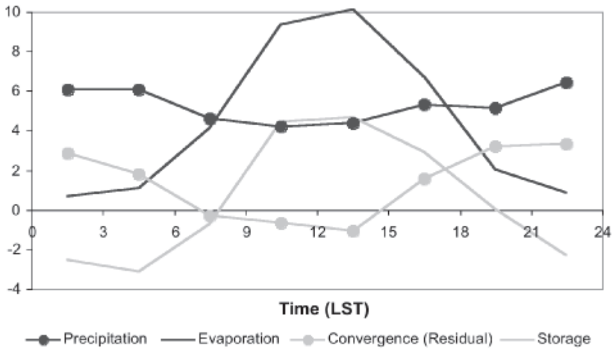

Fig. 2. Diurnal patterns of hydrological components for a subset of models shown in Fig. 1 showing nocturnal maximum in precipitation (Anderson et al. 2003).

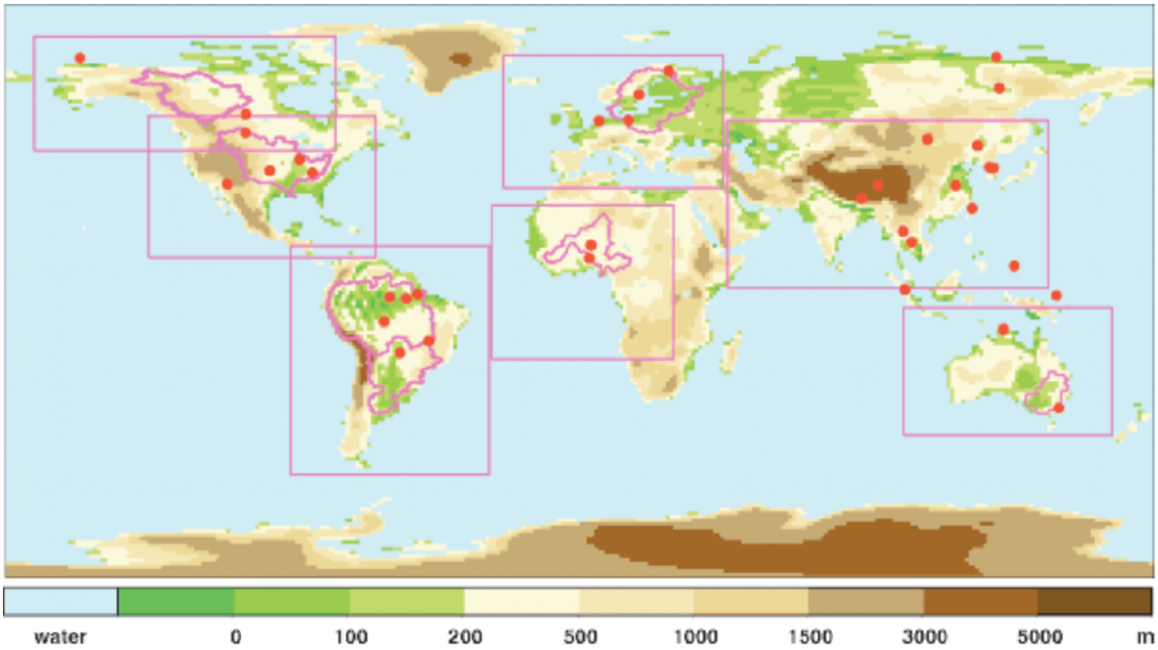

Fig. 3. Domains used for ICTS simulations and for transferability study reported herein. Red dots denote CEOP reference sites.

Transferability is a means of exposing the limits of our current regional modeling capacity by examining model accuracy on a wide range of climate conditions and realizations. The framework for the transferability intercomparisons described herein builds on the experiences, analysis methods, and collaboration infrastructure of the model intercomparisons to expand our understanding of regional climate at global scales by evaluating RCM performance and the capabilities of the underlying parameterizations across many climatic regions. For some variables we now have a first opportunity to compare model results with observations across a wide spectrum of variables (including surface fluxes). These comparisons will help modelers identify and repair failures, especially those not common to all models. And, once a regionally specific failure is fixed, the updated RCM will be reevaluated on a wide range of climates to ensure that the improvement is globally applicable.

The first international Inter-CSE Transferability Study (ICTS; information available online at http://icts.gkss.de/) is a project under both the TWG and the CEOP WESP that is simulating a 5-yr period (2000–04), which includes all of the CEOP phase I observations (July–August–September 2001) for the CSE regions shown in Fig. 3. ICTS (Rockel et al. 2005a) began as an activity of the GKSS Research Centre, the Experimental Climate Prediction Center (ECPC) at the Scripps Institution of Oceanography, and the Iowa State University Regional Climate Modeling Laboratory, but seeks to expand by incorporating additional models. Domains defined for transferability experiments take into account the locations of the CEOP reference sites of the CSEs. Models performing transferability experiments will have all model parameters and parameterizations documented in detail, and simulations will be made on all domains without changing model parameters. Furthermore, initial and boundary data will be the same for all models and all domains. Model data to be saved will be carefully coordinated and follow strict protocols for formatting to ensure accuracy for common analysis.

Models are typically developed and tested against data close to home: U.S. models are compared mostly with U.S. climates, and European models are compared mostly with observed European climate. Careful attention usually is paid to climate processes important to simulating these datasets; however, it is possible that less attention is paid to climate processes that either do not occur or are rather unimportant in the "home domain." For instance, a model developed and used in tropical or midlatitude climates might not have a well-tested sea ice submodel or frozen soils submodel. Another example is small (subgrid scale) lakes, marshes, or swamps, which may be treated more carefully by modelers from home domains where these features make important contributions to regional climate. In addition, some degree of "tuning" usually is done on parameterizations like convection schemes that are important in the home domain. The results of many models developed on different domains (and presumably somewhat different climates) will reveal the dependence of global generality on the domain of model origin. A model that demonstrates high accuracy on the home domain (presumably achieved by the model developer's attention to validation on the home domain) but also shows high skill (compared to other models) on nonnative domains would inspire more confidence for simulating future (perhaps unseen anywhere) climate. A null hypothesis guiding this transferability intercomparison is as follows: models show no superior performance on their domains of origin as evaluated by their accuracy in reproducing diurnal cycles of key surface hydrometeorological variables.

As a preliminary test of this hypothesis, we have evaluated the diurnal cycles of sensible and latent heat flux for three domains using five models (Table 1) for the CEOP enhanced observing period (1 July 2001–30 September 2001). Land use characteristics at the model grid points nearest the CSE reference sites

Table 1. Models and domains used in preliminary transferability intercomparison.

Model	Native continent	Native domain	Nonnative CSE domains	Reference
Regional Spectral Model (RSM)	North America	GEWEX Americas Prediction Project (GAPP)	BALTEX, Large-Scale Biosphere–Atmosphere Experiment in Amazonia (LBA)	Roads et al. (2003)
Regional Climate Model, version 3 (RegCM3)	Europe	BALTEX	GAPP, LBA	Giorgi and Mearns (1999)
Community Land Model (CLM)*	Europe	BALTEX	GAPP, LBA	Steppeler et al. (2003)
Rossby Centre Atmosphere Model, version 3 (RCA3)	Europe	BALTEX	GAPP, LBA	Jones et al. (2004)
Global Environmental Multiscale (GEM)-Limited Area Model (LAM)**	North America	GAPP**	BALTEX, LBA	Côté et al. (1998)

*Model output currently only available at 6-h intervals.

**Model developed and tuned for global numerical weather prediction of the GEM model.

Table 2. Land use at model grid points corresponding to observation sites. Land surface file was corrupted by RegCM3 over the U.S. domain. South American domain was not simulated by the GEM-LAM model. Land-use scheme given in parenthesis below model name. (Veg = vegetative fraction, Forest = forest fraction)

Model	Cabauw	Bondville	Pantanal
RSM (Noah)	Sandy loam Veg 0.65 Cultivated, ground cover	Silty clay loam Veg 0.83 Cultivated, ground cover	Light clay Veg 0.44 Broadleaf trees, ground cover
RegCM3 [Biosphere–Atmosphere Transfer Scheme 1e (BATS1e)]	Soil porosity 0.48 Veg 0.85, Leaf area index (LAI) 6.0 Crop/mixed farming		Soil porosity 0.50 Veg 0.81, LAI 6.0 Tall grass/forest
CLM (BATS/*Terra*)	Sandy loam Veg 0.62, LAI 2.0 Roughness 0.34 m	Sandy loam Veg 0.71, LAI 3.0 Roughness 0.27 m	Sandy loam Veg 0.87, LAI 2.4 Roughness 1.00 m
RCA3 (new)	Sand/sandy loam Veg 0.85 Forest 0.045 Roughness 0.23 m	Loam Veg 0.90 Forest 0.04 Roughness 0.21 m	Clay Veg 0.75 Forest 0.25 Roughness 0.41 m
GEM-LAM [Interactive Soil–Biosphere–Atmosphere (ISBA)]	Sand 48%, silt 30%, clay 22% Crops 18% Roughness 0.081 m	Silt 69%, sand 16%, clay 15% Crops 96% Roughness 0.082 m	

are given in Table 2. Observed sensible and latent heat fluxes at three CSE reference sites compared to the results of models for which 3-hourly fluxes were available are shown in Fig. 4. Observational data were obtained from the CEOP archive maintained at Joint Office of Science Support (JOSS) of the University Corporation for Atmospheric Research (UCAR) (see UCAR/JOSS; information available online at http://data.eol.ucar.edu/codiac/). Preliminary conclusions, drawn from these results and from comparisons of quartiles and extremes from box-and-whisker plots (not shown), suggest a weak "home domain advantage" for RCMs. Most models do well in determining the time of peak daytime sensible and latent heat flux, even though the observation sites have different peak times. The variability of latent heat flux seems overestimated for the warmer climate site and underestimated for the cooler climate site, whereas the variability of sensible heat seem overestimated for the cooler climate site and underestimated for the warmer climate site. We note that the Pantanal site, with its tropical wet and dry climate and tropical vegetation, has the least model–observation agreement and also is the most "foreign" of all three sites to these models whose development and past applications have been primarily at middle and high latitudes. Although there may be other factors, such as weaker coupling with lateral boundary conditions at this latitude (20°S), that agreement between the models and observations is lowest at this site adds credibility to our assertion of a home domain advantage.

Preliminary results of the ICTS (Rockel et al. 2005b) indicate that precipitation totals for reference sites surrounded by shallow orography have the lowest variations for both observations and model output, whereas the opposite is

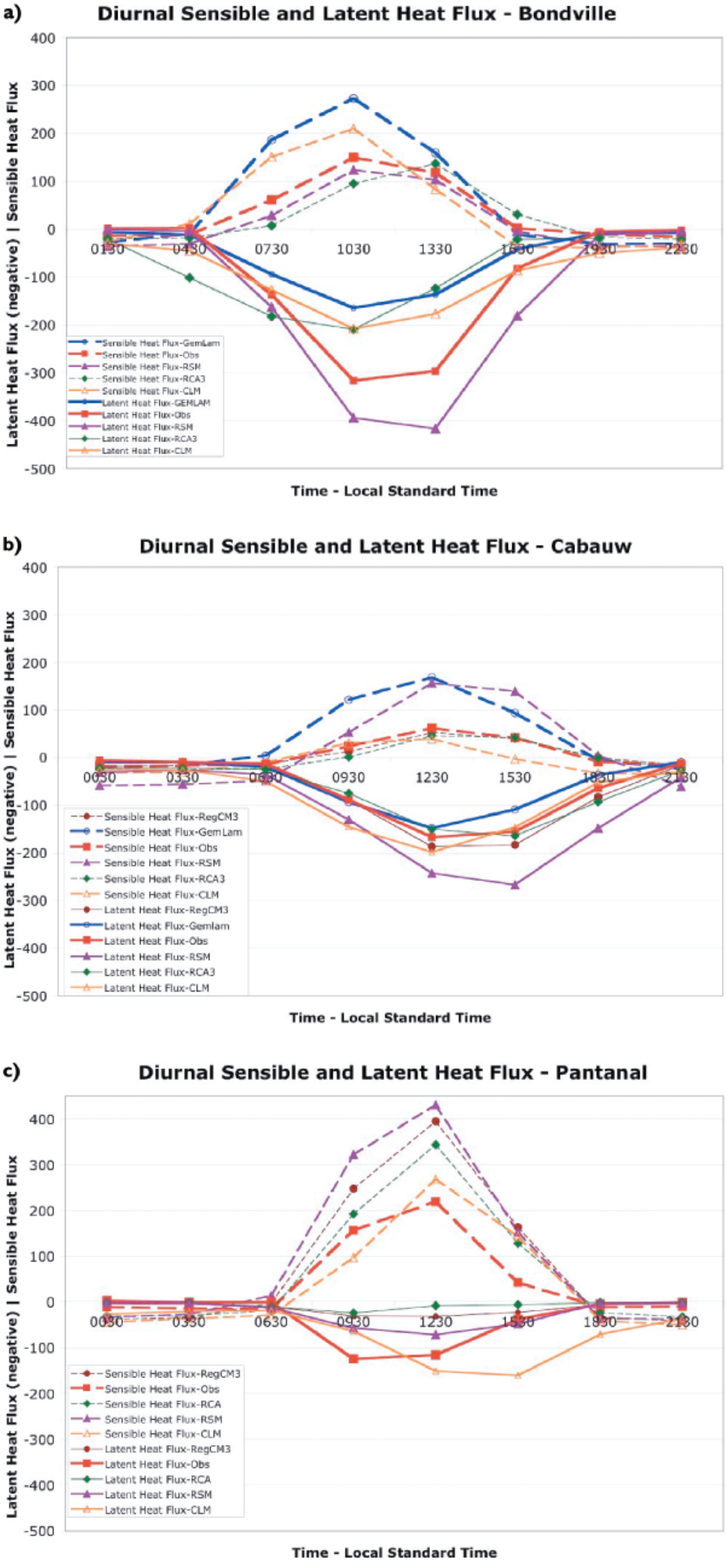

FIG. 4. Simulated and observed diurnal sensible and latent heat flux for three of the CSE reference sites: (a) Bondville, Illinois; (b) Cabauw, Netherlands; and (c) Pantanal, Brazil.

true in regions of high orography or heterogeneous surfaces.

These examples are shown only to illustrate the method; by engaging more models and comparing data from other CSE reference sites within these and other domains and by evaluating other hydrometeorological parameters, we will be able to draw more definitive and general conclusions. However, this limited example illustrates how transferability intercomparisons can be used, not only to detect biases in parameterization schemes widely used in regional models (and global models), but to develop and improve parameterizations that are robust across a wide range of climatic conditions.

FUTURE DEVELOPMENTS. Additional regional experiments are needed to improve our capacity to simulate the water and energy cycles as well as explore their fundamental characteristics. These experiments are designed to test specific hypotheses relating to water cycle and energy budget processes on selected domains during specific time periods. For instance, nocturnal convective precipitation may be caused by orographic lifting, mesoscale convective systems, or monsoonal dynamics. All of these processes occur on more than one continent. Transferability intercomparisons might focus on nocturnal orographic precipitation in many climate zones, or they may search for commonalities in all manifestations of a given precipitation regime. Following the latter approach, we might improve our capacity to simulate precipitation by testing the following hypothesis: for all climatic regions and periods having convective precipitation during both day and night, alternative parameter settings in convective schemes at a specific resolution result in changes of intensity and diurnal phasing of precipitation that are correlated.

Testing the validity of this hypothesis by using several models, each simulating MCSs in the central United States and South America, monsoon precipitation in the southwest United States, South America, and east Asia, and orographic precipitation in the vicinity of the Andes Mountains, Rocky Mountains, and Sierra Nevada would increase both our understanding of the diurnal cycle of precipitation and our ability to model this feature more realistically.

Additional hypotheses to be tested under the transferability intercomparison framework include the following: no single domain provides climatic conditions for developing and tuning a regional climate model that results in measurably better regional climate model performance on all climate domains in the transferability domain ensemble.

If this hypothesis is proven false then the single domain so identified should be used for model development and tuning.

Hypothesis 4 is as follows: for all nonmonsoon climatic regions experiencing weak large-scale forcing, daytime surface fluxes are correlated with the height of cloud base.

If this hypothesis is proven true and there is a correlation that matches the sign of the observations (Betts 2004), then models are simulating the direction of influence of surface fluxes and soil water variability on cloud processes and the subsequent modification to surface radiation and resulting surface fluxes induced by the cloud occurrences. The magnitude of influence offers an additional point for comparison.

An additional intercomparison to be undertaken by TWG has a goal of assessing the capability of regional models to simulate cloud systems across a range of cloud types. TWG will join the Pacific Cloud Transect Study in progress under the GEWEX Cloud System Study (GCSS; information online at www.gewex.org/gcss.html) by defining a domain over the Pacific Ocean that will allow for simulations of cloud systems ranging from tropical deep convection, through trade wind shallow cumulus, to subtropical stratocumulus. In this domain, 98% of the surface is water with prescribed SST, so cloud/convection and turbulence can be studied without the feedback of surface radiation and associated flux errors that can occur over terrestrial domains with strong surface interactions. For this intercomparison, individual model transferability experiments will be defined as simulating cloud systems of different origins, structures, and evolution within a single domain by a single model. From a comparison of the results of NWP and RCMs with measurements taken during an enhanced observational period of the BALTEX BRIDGE experiment, Crewell et al. (2004) observed that there are large discrepancies among the liquid water climatologies of models, and that a clear improvement in the simulation of clouds was achieved when 40 or more levels were used to resolve the fine structure of clouds. Simulations with regional models, some with enhanced vertical resolution, will be compared against intensive observations made during the Northern Hemisphere summer.

We recognize that a number of issues relating to regional climate modeling are yet to be resolved. Many of these can be addressed by the application of single models to single domains, multiple models to single domains, and single models to multiple domains, as opposed to applying multiple models to multiple domains, which is promoted by transferability intercomparisons. Fundamental questions, such as well posedness, need further clarification. Regional model domain size and boundary forcing procedures are known to influence results throughout the simulated domain. By analyzing kinetic energy spectra, Castro et al. (2005) concluded that their limited area model run in climate mode and driven by reanalysis at lateral boundaries gradually lost large-scale variability and drifted toward flow dominated by surface forcing. The WCRP Working Group on Numerical Experimentation has called for more research on and with regional climate models to more fully exploit their potential for advancing the science of numerical simulation.

SUMMARY. The GEWEX Hydrometeorology Panel (Lawford et al. 2004) has established TWG to promote regional climate simulations for advancing our understanding of global water and energy cycles. We herein briefly summarized some lessons learned from previous RCM intercomparison studies and how transferability intercomparisons represent the next step toward improved understanding of the global water cycle and energy budget.

We discussed ways in which regional climate MIPs have advanced the science of climate modeling for a variety of spatial scales and applications. However, transferability intercomparisons as we have defined them will go beyond current regional climate MIPs and single-model transferability *experiments* to provide new insight on the global energy budget and water cycle. Regional climate MIPs typically apply multiple models to a single domain, and individual modeling groups typically apply single models to multiple domains. Transferability intercomparisons, by contrast, apply multiple models to multiple domains, and thus provide a global framework for past and current MIPs. Such intercomparisons allow us to test the generality of the modeling community's understanding of key physics components of the hydrological cycle. A systematic intercomparison across models and domains more clearly exposes collective biases in the modeling process. By isolating particular regions and processes, regional model transferability intercomparisons can more effectively explore the spatial and temporal heterogeneity of predictability.

Testing specific hypotheses allows for rigorous evaluation of the generality of RCMs. Preliminary results of testing the first such hypothesis suggest that RCMs perform better in the domain in which they were developed and show reduced accuracy in simulating nonnative domains. Further variables will be tested to evaluate the range of conditions for which models tend to have a "home domain advantage."

Modeling groups are invited to participate and help to further develop TWG's global perspective on regional climate simulation experiments. Updated information on activities of the Transferability Working Group are posted online at http://rcmlab.agron.iastate.edu/twg/, which is also linked to the GHP Web site (http://ecpc.ucsd.edu/projects/ghp/).

ACKNOWLEDGMENTS. Chris Anderson of the RCM Laboratory is acknowledged for his contributions to stimulating discussions relating to this manuscript. Partial support for this work is provided by the National Science Foundation Grant ATM0450148 to Iowa State University. Heather Moser is acknowledged for designing the TWG Web site and performing the analysis of model and observed data.

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