by =20%. A mean atmospheric residence time of 5.9 months for HCN and 5.1 months for CH3CN is calculated. A global budget analysis shows that the sources and sinks of HCN and CH3CN are roughly in balance but many uncertainties remain.

## A61E MCC: 125 Saturday 0830h

### Regional Climate Modeling I *(joint with NG, B, H, OS, GC)*

***Presiding:*** **A Robock,** Rutgers University**; G Stenchikov,** Rutgers University

#### A61E-01 0840h INVITED

### Comparison of Inter- and Intra-Model Variability of Precipitation in Nested Regional Climate Models

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Variability of simulated precipitation among a suite of regional climate models (inter-model variability) is compared with variability among realizations performed using a single model (inter-model variability). Inter-model variability is evaluated from the PIRCS 1b suite of simulations for the 1993 summer flood over the north-central United States. Intra-model variability is evaluated in simulations using the MM5 model for the same domain and period. Various approaches are explored for establishing intra-model variability, such as lagged ensemble forecasts and perturbations to the physical parameterizations. It is found that inter-model variability is larger than all measures of intra-model variability. Simulations with differing physical parameterizations in MM5 is the only method that produces intra-model variability that begins to approach that of inter-model variability.

URL: http://www.mesoscale.iastate.edu

#### A61E-02 0855h INVITED

### Mesoscale Diagnosis and Simulation of the South American Monsoon System

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We employ a multiyear data set of Eta model short-term forecasts as a proxy of analyses to investigate the mesoscale processes contributing to the development of the South American monsoon system. Several studies have identified the subtropical summer circulation as a monsoon phenomenon, and this has served as a framework to explain the more important components of the warm season climate system. The onset of the monsoon is associated with a quick development of precipitation over southern Brazil, which can be viewed as the southernmost extension of the tropical precipitation during its annual march over the Americas.

The Low-level Jet (LLJ) east of the Andes has been identified as a key part of the monsoon system, but unlike other LLJs, and in particular the United States Great Plains LLJ, it is present throughout the year. In fact, during the cold season it can be as intense as the summer case, but somewhat more elevated and with a weaker diurnal cycle. Therefore, the monsoon?s onset is not so much associated with a spring development of the LLJ, but rather with its changes in structure, and lateral shifts.

The higher frequency variability of the monsoon precipitation has an out-of-phase relationship with precipitation in the central La Plata basin (at about 25o S), so that increases in monsoon precipitation imply decreases to the south, and vice versa. The LLJ has a significant role in this pattern as it experiments lateral shifts during the warm season. When the LLJ has an eastward shift, it can supply moisture directly to the monsoon region, where increased precipitation is detected. Meanwhile, the moisture supply to the La Plata basin becomes weaker and a simultaneous decrease of precipitation is found over Southern Brazil/Northern Argentina/ Uruguay. When the jet shifts west, its core acquires a southward direction, effectively reducing the moisture supply to the monsoon but increasing it to the La Plata basin with the corresponding changes in precipitation. Understanding this dipole pattern, its seasonality, its linkage to local and remote forcings, and its functioning in general, should help identify the mechanisms that favor the monsoon precipitation and its variability. Longer-term simulations of the Eta model are being employed to address these issues.

#### A61E-03 0910h

### Modeling diurnal rainfall in northwestern South America

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Nested-grid simulation of convective weather of northwestern South America has been performed with the MM5 model. After optimization of the deep convection scheme for the coarser grids, the model produces reasonable rainfall simulations. Of special interest is the night-morning rainfall peak associated with convection offshore in the Panama Bight. This night-morning rainfall is seen to result from destabilizing effects of a gravity wave radiated from the diurnally varying heat source of the mixed layer over the Andes mountains.

URL: http://www.cdc.noaa.gov/~bem/publications.shtml

#### A61E-04 0925h

### The Climatology of African Wave Disturbances in a Regional Model

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Our understanding of the structure and behavior of African wave disturbances (AWD) has been derived from brief empirical studies or analyses/simulations using general circulation models. In each case the spatial resolution of the observational network or the computational grid has been an issue in the interpretation of results. The current effort studies the structure and behavior of AWD based on the results of a regional climate model (RCM) run on a grid with 0.5 deg spacing over a limited domain covering West Africa. The model is driven by four times daily synchronous NCEP reanalysis data at the lateral boundaries from June 1-September 30. Thus far, seven summers have been completed. Diagnostics from this system provide distinct advantages over those from coarser resolution global models and from previous results based on sparse networks of observations. The presentation will show composites of mid-tropospheric AWD circulation, associated precipitation patterns and near-surface divergence. Spectra and wavelets of the meridional wind at selected locations will highlight favored periodicities of AWD and intraseasonal variability. Trajectories of AWD during different seasons will be mapped by spatial distributions of the vorticity variance at 700 mb. Interannual variability of AWD characteristics will be related to the interannual variability of summer monsoon precipitation over West Africa. Sensitivity of AWD characteristics to land surface influences will be examined. RCM characteristics of AWD will also be compared to previous descriptions in the literature.

#### A61E-05 0940h INVITED

### Regional Climate Simulation and Data Assimilation With Variable-Resolution GCMs

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Variable resolution GCMs using a global stretched grid (SG) with enhanced regional resolution over one or multiple areas of interest represents a viable new approach to regional climate/climate change and data assimilation studies and applications. The multiple areas of interest, at least one within each global quadrant, include the major global mountains and major global monsoonal circulations over North America, South America, India-China, and Australia. The SG-approach provides an efficient regional downscaling to mesoscales, and it is an ideal tool for representing consistent interactions of global/large- and regional/mesoscales while preserving the high quality of global circulation. Basically, the SG-GCM simulations are no different from those of the traditional uniform-grid GCM simulations besides using a variable-resolution grid.

Several existing SG-GCMs developed by major centers and groups are briefly described. The major discussion is based on the GEOS (Goddard Earth Observing System) SG-GCM regional climate simulations.

The global variable resolution SG-version of the GEOS DAS (Data Assimilation System) or SG-DAS incorporating the GEOS SG-GCM, has been developed and tested as an efficient tool for producing regional analyses and diagnostics with enhanced mesoscale resolution. Both the SG-GCM and SG-DAS include the entire tropospheric and stratospheric domains from the surface to 0.1 hPa. The prognostic and diagnostic fields are produced for all model and mandatory pressure levels.

The annual (November 1997 to December 1998) GEOS SG-GCM simulation and SG-DAS data assimilation, with 50 km regional resolution over large areas of interest, have been performed simultaneously and analyzed in terms of producing anomalous events over four areas of interest and their vicinities. They include the North and South American Monsoon Systems (NAMS and SAMS); the anomalous U.S. summer events; the summer flood in China; the spring-summer Mexican drought; the Indian and Australian monsoons; and other extreme precipitation events.

The 12-year (1987-1998) GEOS SG-GCM simulations with 60 km and 100km regional resolution over the U.S. have been performed in a limited ensemble integration mode. The preliminary analysis of the ensemble means has shown a promising potential of the SG-approach for long-term regional climate simulation at mesoscale resolution.

Brief information on development of the new SG-GCM is provided. It is the SG-version of the new NASA/NCAR FV-GCM (with the finite-volume (FV) Lin-Rood dynamics), and the NCAR CAM2 physics. Using the advanced numerical technique provides an increased computational efficiency for the new SG-GCM that will allow us to use finer regional resolution.

The international SGMIP (Stretched-Grid Model Intercomparison Project), with participation of NASA/GSFC and UMD, RPN/Canadian Meteorological Centre, Meteo-France, and Australian CSIRO, has been initiated. It has a potential connection to AMIP-II as a regional project.

#### A61E-06 0955h INVITED

### Seasonal Climate Predictability in an AGCM and a Nested Regional Model

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The potential for enhancing the predictability inherent in seasonal climate predictions with a global general circulation model by the use of a nested regional model is investigated by analyzing seasonal ensembles over North America and India. For the summer season, 9-member ensembles of June-July-August-September (JJAS) climate over North America and India are analyzed for five different years. For the winter season, 5-member ensembles of December-January-February-March (DJFM) climate are analyzed for 8 different years. The global models used are versions of the Center for Ocean-Land-Atmosphere Studies (COLA) atmospheric general circulation model (AGCM). The regional models used are versions of the National Centers for Environmental Prediction (NCEP) Eta model.

The results are compared to the observations with particular emphasis on the precipitation simulations. An analysis of variance is conducted to evaluate the relative abilities of the global and nested regional models in simulating the interannual signal versus the intra-ensemble noise. These merits are contrasted for the two regional domains considered.

#### A61E-07 1030h

### The Sensitivity of Simulated Central U.S. Summer Precipitation and Atmospheric Moisture Budget to Both the Spatial Distribution and the Amount of Initial Soil Moisture

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We quantify the relative influences of initial soil moisture amount and initial soil moisture spatial distribution on future simulated precipitation, and the other components of the atmospheric water vapor budget, over the central U.S. A series of Regional Atmospheric Modeling System (RAMS) simulations have been made for a domain covering the U.S. Great Plains and southwest for July 1995, 1996, and 1997. Control simulations are initialized with soil moisture and temperature from the NCEP reanalysis, as well as with soil texture and soil hydraulic properties from the LDAS database, and are validated against various datasets including precipitation observations from the Arkansas-Red Basin River Forecast Center(ABRFC). 10 additional RAMS simulations for each of the three Julys investigate the relative sensitivity of simulated evaporation, precipitation, horizontal atmospheric moisture flux and flux divergence, and atmospheric storage during that month to both the initial domain-average soil moisture amount and the spatial distribution of that initial soil moisture. Lastly, we investigate the further sensitivity to the choice of two convective parameterizations.

We find that regional hydrometeorology is sensitive to both the spatial pattern and the amount of initial soil moisture, because changes in spatial variability produce changes in, and feedbacks on, large-scale dynamical factors such as zonal and meridional moisture transport. These three-dimensional dynamical effects interact with the one-dimensional (vertical thermodynamic) convective feedbacks. This sensitivity is greatest in relatively drier initial soil moisture regimes. In addition, the results are significantly sensitive to the choice of convective parameterization.

## A61E-08 1045h

### Seasonal Precipitation Simulations and Predictions over North America with the Eta Regional Climate Model

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To examine seasonal climate predictability using regional models, in this study we developed and tested a high resolution Regional Climate Model (RCM). The model was based on the NCEP operational Eta model (as of 24 July, 2001, and also the version in the NCEP 25-year Regional Reanalysis), with changes made to make the model run over a longer time period and to update the Sea Surface Temperature (SST), sea ice, greenness fraction, and albedo fields on the daily basis. The model was run on the same large domain as does the operational Eta model with a resolution of 32 km and 45 levels, as used in the Regional Reanalysis. Presently, the model can be executed off of analyzed lateral boundary conditions of the NCEP Global Reanalysis I and II and predicted lateral boundary conditions from the NCEP global Seasonal Forecast Model (SFM).

To test the skill of the Eta RCM in predicting warm season precipitation anomalies, two summertime cases (1999 and 2000) were chosen, representative of both wet and dry soil moisture anormalies in the southwest United States. Most previous studies of RCM seasonal simulation driven by analysis lateral boundary conditions and observed SST employed only "1-member" executions from one single initial condition date. In contrast, we executed 6 members whose initial conditions vary by one and a half day. The study period is from June to September and the executions were started from late May and continued to early October. In both cases, we use lateral boundary conditions from both the NCEP Global Reanalysis II and global SFM, ensemble mean of total precipitation for each month and 200 mb and 500 mb heights were examined , where the monthly mean precipitation was compared to the CPC unified daily precipitation data, and the 200 and 500 mb geopotential heights were compared to the NCEP Reanalysis data, respectively. As part of this study, we also tested the impact of initial land states and Sea Surface Temperature (SST) on seasonal precipitation predictions. To do this, we use a suite of combinations of climatological land states and SST versus their realtime fields with different sources of lateral boundary conditions.

The resulting ensemble mean shows that the Eta RCM successfully simulates and predicts the wet and dry bias in soil moisture over the southwest U.S. and has substantial member-to-member variability of seasonal precipitation. This suggests that previous RCM studies that employed only one member may be misleading by failing to represent the inherent internal variability. Comparison of results obtained from using different sources of land states and SST indicates that the Eta RCM is sensitive to the initial land surface conditions and the choice of SST and shows a great variability in the simulated monthly and total precipitation, suggesting that a careful initialization of land states as well as an accurate source of SST are important to seasonal predictions.

## A61E-09 1100h

### Modeling the Present Climate and Future Climate Anomalies Over North America Using RAMS

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We employ the Regional Atmospheric Modeling System (RAMS) to perform summertime climate simulations over North America focusing on the Mid-Atlantic States. First, to improve the model's ability to simulate the current climate while being driven by the NCEP/NCAR reanalysis, we made several modifications. By including soil types from the Land Data Assimilation System project at 1/8° resolution, with 11 layers to a depth of 2.5 m; using initial soil moisture and temperatures from the NCEP/NCAR reanalysis; implementing high resolution sea surface temperatures; using spectral nudging with large-scale patterns; and adjusting surface evaporation we were able to produce quite accurate simulations. We will describe the relative importance of these changes, and the effects of the choice of convective parameterization (Kain-Fritsch or Kuo). Then, we perform experiments to downscale future climate change scenarios produced by a general circulation model (GCM). In the experiments, we added climate anomalies produced by GCM experiments for future climate change scenarios to the boundary conditions from the reanalysis for several summer seasons of the present climate. We analyzed the downscaled anomalies by taking the difference between the experiments with perturbed and unperturbed boundary conditions. This strategy is intended to minimize errors produced by incompatibilities between the RCM and GCM, which we estimate to be comparable to errors produced by the RCM itself throughout the climate simulations. In our approach, the errors from the RCM can be estimated directly in the control simulations for the present climate, since the model is driven by reanalysis and there are high-resolution observations available.

## A61E-10 1115h

### Seasonal Simulations over the Baltic Sea Region: Sensitivity to Convective and Boundary Layer Parameterizations.

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A recently revised version of the Canadian Regional Climate Model (CRCM), developed at l'Université du Quèbec à M ontréal, has been used to carry out seasonal simulations over the Baltic Sea region. The Physical processes package i ncluded in the version of the CRCM presented was originally developed for the third generation of the atmospheric gene ral circulation model of the Canadian Centre for Climate Modelling and Analysis (CCCma). National Centers for Environmental Prediction (NCEP) reanalyses are used to provide lateral forcing.

Comparison of model results with the Baltic Sea Experiment (BALTEX) observational data and precipitation analysis show that the model underestimates the convective precipitation in summer, but overestimates total precipitation in winter. As well, cooler than observed screen temperatures are typic al for winter simulations. While such biases may in part be associated with inadequacies in lateral forcing data, it is probable that a more significant factor is deficiencies in the representation of key physical processs in terms of parameterizations that were developed for a GCM whose operational horizontal resolution is much coarser that that of the CRCM.

This study examines the sensitivity of CRCM simulation biases to convective and boundary layer processes, specifically in regard to alternative closure conditions for the parameterization of moist convection and representations of nonlocal mixing and entrainment in the boundary layer scheme.

## A61E-11 1130h INVITED

### Simulation of Anomalous Precipitation Episodes Using a Regional Climate Model

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A regional climate model (RCM) was used to produce a simulation of the period 1982-1995 for the United States. The RCM was developed based on the MM5 version 3.3. To extend the MM5 capability for applications on climate time-scales, we have incorporated several key improvements, including [1] an optimal buffer zone treatment that integrates realistic energy and mass fluxes across the boundaries between the GCM and RCM domains, [2] a realistic ocean interface where daily SSTs evolve as observed, [3] an accurate convection-cloud-radiation representation that enables multi-scale interactions between hydrologic and thermodynamic processes, and [4] a time-varying vegetation distribution following observations. The horizontal resolution is 30 km. There are 35 vertical layers with the top at 35 km. The buffer zones are located across 14 grid points on all 4 edges. This RCM simulation used the NCEP/DOE reanalysis fields as lateral boundary conditions, updated every 6 hours. There was no data nudging within the RCM domain.

A diagnostic analysis is investigating the accuracy of simulation of anomalous precipitation episodes on time scales of 1 day to a season. Preliminary results, concentrating on seasonal anomalies in the central U.S. and the Pacific Northwest, indicate that the RCM produces an accurate simulation of the interannual precipitation variability on seasonal timescales in both regions. In the central U.S., very wet episodes in autumn 1986 and summer 1993 and the drought of spring-summer 1988 are simulated accurately. Within-season fluctuations are also well-represented, such as the wetness in early summer 1983 following by dryness in midlate summer. The warm season diurnal cycle in the central U.S., strongly influenced by mesoscale convective systems, is accurately reproduced in the wet summer of 1993. In the Pacific Northwest, wet cold seasons in 1982-1983 and 1983-1984 and dry cold seasons in 1984-1985 and 1986-1987 are reproduced. An ongoing analysis is investigating the RCMs ability to simulate heavy precipitation episodes of 1 day to 1 week duration.

## A61E-12 1145h

### Internal Variability in RCM Simulations over an Annual Cycle

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Three one-year simulations generated with the Canadian RCM (CRCM) are compared to study internal variability in nested regional climate models and to evaluate the control exerted by the lateral boundaries information supplied by the nesting procedure. All simulations are generated over large domains and over an annual cycle. The simulations use different combinations of surface and atmospheric initial conditions but all of them share the same set of time-dependent lateral boundary condition taken from a simulation of the Canadian GCM. A first simulation is used as control, the second simulation is launched with different atmospheric and surface IC and finally the third simulation is launched taking its surface IC from the control simulation. Comparison of the root-mean-square differences (RMSD) between each pair of simulations shows distinct seasonal behaviour in the time series of the RMSD. In winter all simulations are almost identical to each other resulting in very low RMSD values while in summer large discrepancies develop between simulations. For water vapour related fields such as precipitation or specific humidity, these discrepancies are sometimes as large as the monthly-averaged variability. Analysis of the climate statistics however shows that, even though the evolution of the various simulations is different in summer, their climates are similar.