nuclei leads to a slightly enhanced ice crystal number densities and, thus, to a slight reduction in the average ice particle size and sedimentation speed in the upper tropical troposphere. Therefore, on the average a larger fraction of these particles may be carried through the cold point tropopause by the rising motion of air, increasing the overall transport of water into the stratosphere. At the same time, an enhanced particle formation in the troposphere followed by some sedimentation decreases also to some extent the overall input of sulphur into the stratosphere. Since biomass burning is known to be a source of HOx, the long-term increase in the tropical burning activity could lead to increasing stratospheric humidity and a decreasing level of sulphur in the stratosphere.

A11D MCC: 3020 Monday 0800h

Climate I: Models *(joint with GC)*

Presiding: **M Herzog,** University of Michigan**; M J Prather,** University of California, Irvine

A11D-01 0800h

Adaptive Grids in Climate Modeling: Concept and First Results

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One of the most important advances needed in global climate models is the development of models that can reliably treat convection. This project will result in a climate model that self-adjusts the grid resolution and the complexity of the physics model to the atmospheric flow conditions. Adaptive grid techniques are being applied to a parallel version of NASA's next generation climate model, the NASA/NCAR Finite-Volume Community Climate Model, which has been developed at the NASA Goddard Space Flight Center (GSFC, Data Assimilation Office). This global hydrostatic model is based on NCAR physics and the so-called Lin-Rood finite volume dynamical core that provides highly efficient algorithms for high performance computing. The non-hydrostatic model will be based on an extension of the Lin-Rood finite volume dynamical core. It will keep the concept of a Langrangian vertical coordinate. Special considerations are made to ensure conservation of total mass and heat. The adaptive model design utilizes a spherical grid library that is based on a computationally efficient block-structured data layout. This communication library for parallel processors will also enable a reduced grid design near polar regions. We will discuss the basic model concept with the focus on the adaptive grid design and the formulation of the non-hydrostatic model. We will present first results from runs with the block-structured code.

A11D-02 0815h

Adaptive Grids in Climate Modeling: Tests of the Dynamical Core

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Adaptive grids in climate modeling offer unique opportunities for future climate model predictions. They allow the use of static and dynamic refinements depending on terrain features or flow characteristics. For the first time, an adaptive hydrostatic dynamical core for global atmospheric General Circulation Models has been built. It is based on the NASA/NCAR finite volume dynamical core and utilizes a parallel, spherical adaptive grid library with a block-structured data layout. The model can adapt its resolution statically and dynamically during a model run. Static adaptations resolve predetermined regions of interests, like mountain ranges, at high resolutions and allow the efficient use of reduced grids in polar regions. Dynamic adaptations are guided by user defined refinement/coarsening criteria and are capable of tracking a wide variety of features of interest. Examples include vorticity and pressure-based adaptation criteria that track a cyclone path. The presentation shows the highlights of the adaptive dynamical core experiments using both 2D shallow water tests and idealized 3D test cases. The results emphasize the pros and cons of different refinement criteria and suggest that adaptive grids can be considered an alternative to today's nested grid approaches.

A11D-03 0830h

Impacts of numerical approximation in atmospheric tracer transport: examples from the Global Modeling Initiative

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Improved numerical methods for transport of trace species in the atmosphere and ocean continue to be developed. Typically, these algorithms are evaluated against existing methods using analytic or idealized test cases, but the NASA Global Modeling Initiative now provides a realistic framework for evaluating their accuracy in full chemistry-transport models (CTM). GMI's modular approach is combined with parallel simulations in the UCI CTM to quantify the differences between two relatively accurate tracer transport algorithms (Lin-Rood, Prather 2nd-order moments), including the impact of forcing a positive-definite, ripple-free tracer abundance. We use a range of simplified atmospheric chemical tracers (radon-lead, fossil-fuel CO2, industrial and biomass CO) with the meteorology from the Goddard Institute for Space Studies global climate model (4 deg by 5 deg with 23 layers) that includes three-hourly integrated winds, boundary-layer physics, entraining and non-entraining convection, large-scale and convective precipitation, updrafts and downdrafts. The relative accuracy of the different methods is considered in terms of forward and inverse calculations. We thank the entire GMI team, especially the researchers at LLNL and GSFC who have built and maintained the GMI modeling capability.

A11D-04 0845h

Effect of Convective Parameterization Closure on Climate Simulation in the NCAR Model

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This paper investigates the role of convective parameterization closures in the NCAR CCM3 climate simulation. Several recent observational studies using both tropical and midlatitude data suggest that the conventional convective instability-based closures for convective parameterization can deviate considerably from reality, particularly at sub-daily timescales. Based on these studies, a new closure for convective parameterization is devised. It is implemented and tested in the NCAR GCM. Results from the test simulations show that there is significant improvement in the simulated model climate. For example, the seasonal variation of tropical precipitation is in better agreement with the observations. Many GCMs including the NCAR model and the ECMWF model have difficulties in simulating the diurnal cycle of convection correctly. Particularly over land, the simulated convection occurs too early compared to observations. We will show that with the new closure, the simulated diurnal cycle of convection over land is much closer to what is observed.

A11D-05 0900h

Modeling Intra-seasonal to Interannual Variability of Precipitation Over Central America

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A devastating Central American drought occurred during the summer of 2001. This drought ravaged much of northern Central America (C.A.) but was not predicted or anticipated; nor is a cause for it immediately apparent. The catastrophe caused by this drought points out how little is known about precipitation and its variability over this region. Some of the seasonal controls are qualitatively known (e.g., trade winds, orographic effects, seasonal march of the ITCZ) but much less is known about intraseasonal to interannual variability. For example, on intraseasonal timescales, the midsummer drought (MSD) on the Pacific side of C.A. is well known and documented, but little is known about why it occurs. Almost nothing is known about the interactions between precipitation in C.A. and the rest of the Americas. Because of its location, C.A. is key in linking monsoon variability in both North and South America. C.A. is affected by monsoonal processes, large-scale ocean circulation and related cold tongue-ITCZ (CTIC) features, and quasi-cyclical ENSO events. Because of the importance of small-scale orography and land use issues, large-scale models and reanalyses by themselves are insufficient to fully understand and model precipitation variability over C.A. Regional modeling capabilities are critical as a means to examine how large-scale forcing gets downscaled by orographic effects, and to explore the impact of land surface state. We are making runs with the regional climate version of MM5 with the OSU (NOAH) land surface scheme. We have focused on three key interrelated issues regarding high resolution mesoscale modeling: (i) improving the simulated distribution of precipitation and cloudiness through high resolution simulation of topographical forcing acting on anomalous large scale flows, (ii) evaluating the relative roles of C.A. land surface / east Pacific Warm Pool in controlling convective triggering; and (iii) determining is the ensemble effect of these processes on the diurnal cycle of cloudiness.

A11D-06 0915h

A less dusty future?

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Atmospheric desert dust is potentially highly sensitive to changes in climate, carbon dioxide and human land use. In this study we use 6 different scenarios of the processes responsible for changes in source areas and explore changes in desert dust loading in pre-industrial and future climates, although all the scenario results are likely to be sensitive to the climate model simulations used for this study. Comparisons between model results and available pre-industrial ice cores are not able to constrain which scenario is most likely to be correct. Simulations suggest that future dust may be 20 to 60 percent lower than current dust loadings. The anthropogenic portion of the current dust loading may be as large as 60 percent, or humans may have caused a 24 percent decrease in desert dust, depending on the relative importance of land use, carbon dioxide and human induced climate change. These results suggest there may be a high sensitivity of natural aerosols' to human intervention, which has enormous implications for climate and biogeochemistry in the future.

A11D-07 0930h

A new Type of Idealized Global Climate Model and its Application to Dust-Climate Interactions

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Paleoclimatic evidence suggests that airborne mineral dust can be a climatically important atmospheric aerosol, but little is known quantitatively about the mechanisms of dust-climate interactions. We have developed an idealized global model with which to study processes and feedbacks within the dust-climate system. The model is a generalization of the energy balance approach to climate modeling. We solve numerically for equilibrium climate states defined by zonal average temperature as a function of latitude for both an atmosphere and a surface. We parameterize the effects of radiative, latent, and sensible heating, ocean heat transport, the Hadley circulation, and midlatitude atmospheric eddies. The model reproduces the mean variation of temperature with latitude and the global average heat budget within the uncertainty of observations. Dust concentrations can influence the climate system by altering the radiative properties of the atmosphere. We determine the longwave and shortwave forcing due to dust based on specified dust distribution

and optical properties. The dust forcing is comparable to that obtained in more complicated models, such as general circulation models. Since the atmospheric dust properties are not well known, we use our model to explore the response of the climate to a range of dust concentrations, distributions, and optical properties in order to determine the dust sensitivity and highlight important feedbacks within the system. The dust alters the model climate, resulting in a surface temperature decrease. However, the primary effect of dust is the reduction in latent and sensible heat transferred from the surface to the atmosphere. The latent heating changes may result in further feedbacks through changes in water vapor and precipitation.

A11D-08 0945h

Future Changes in Stratosphere-Troposphere Exchange and Those Impacts on Future Tropospheric Ozone

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We assess future climate change impacts on stratosphere-troposphere exchange (STE) and those influences on tropospheric O_3, using a chemistry coupled climate model. This study employs the coupled tropospheric chemistry climate model CHASER which has been developed in the framework of the Center for Climate System Research/National Institute for Environment Studies (CCSR/NIES) GCM. Tropospheric O_3 distribution and budget were predicted decadally for 1990 to 2100 with emission changes (for O_3 precursors) and climate change specified by the IPCC SRES-A2 scenario. Our simulations show increases in stratospheric O_3 transport to the troposphere as a result of enhancement in the tropospheric (the Hadley) and stratospheric (the Brewer-Dobson) circulation with climate change in the model. With emission changes only, net stratospheric O_3 input to the troposphere were simulated to decrease by ~20% during 1990-2100 in response to the simulated tropospheric O_3 increases, but to increase by more than 80% with including climate change also (600TgO_3/yr in 1990 to ~1100TgO_3/yr in 2100). The enhanced STE with climate change has larger impacts on tropospheric O_3 distribution in the southern hemisphere than in the northern hemisphere, because of shorter chemical lifetime of O_3 and larger water vapor increases in the northern hemisphere. Simulated increases in net cross-tropopause O_3 transport are most significant particularly after 2050 reflecting the climate sensitivity of the CCSR/NIES GCM. Our simulations of atmospheric radon also suggest enhancement in stratosphere-troposphere mixing with future climate change.

A11E MCC: Level 1 Monday 0830h

Integrating Aerosol Measurements and Models I Posters *(joint with OS, GC)*

Presiding: **K A Prather,** University of California, San Diego; **G R Carmichael,** University of Iowa

A11E-0011 0830h POSTER

The Effect of Non-sphericity on GOES-8 Dust Aerosol Retrievals During PRIDE

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This paper examines the effect of non-spherical phase functions on satellite aerosol retrievals by using a variety of data collected during the Puerto Rico Dust Experiment (PRIDE). Scanning electron micrograph (SEM) analysis was used to build a statistical model to describe dust morphologies [Reid et al., 2003]. By assuming that dust particles are oblate spheroids, the statistical model together with measured size distribution are then used to compute the dust phase function and dust scattering properties through T-matrix calculations. Comparison shows that modeled and measured scattering coefficients, although highly correlated, have 20% discrepancies that cannot be simply ascribed to the uncertainties (10%) of light scattering measurements. Such discrepancy could either from size distribution measurements or the lack of full consideration of dust irregular shapes. The modeled non-spherical function however favorably agrees the synthetic non-spherical phase function [Liu et al., 2003]. The non-spherical phase function is then used to replace the spherical phase function for the GOES8 aerosol retrievals. New dust AOT retrievals however only show slightly improvement at certain scattering angles. Further analysis shows that using composite phase function by considering both spherical and non-spherical particles can greatly improve the retrievals. This research underscores the practical difficulties in applying non-spherical phase function into the satellite retrieval algorithms because current remote sensing retrievals cannot determine the ratios between spherical and non-spherical particles. Further studies are also needed on how to better quantify aerosol morphologies and thus better model the phase function of irregular sharp-edge particles.

A11E-0012 0830h POSTER

Retrieving mineral dust composition, size and shape (CSS) properties from multi-angle remote sensing observations.

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We present a systematic study of radiative properties of atmospheric wind-blown mineral dust, focusing on the implications for multi-angle and multi-spectral remote sensing. We investigate the impact of particle irregularity, composition, and size distribution on extinction coefficients, single scattering albedo and scattering phase functions for three visible-NIR channels of the Multi-angle Imaging SptectoRadiometer (MISR) instrument: 550, 672 and 866 nm, taking into account the spectral dependence of mineral dust refractive indices. We develop optical models of mineral dust for different composition-size-shape (CSS) types, and use them to test the ability of MISR to distinguish different mineral dust type and amount. Modeled radiancies are systematically compared with MISR measured radiancies for several optically thick dust cases, allowing us to verify the main features of Saharan and Asian dust to which the instrument is sensitive.

A11E-0013 0830h POSTER

Asian Dust from Vertical to Horizontal

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Abstract Seasonal variations of the Southeast Asia dust plumes are analyzed with NOAA PathFinder data (from 1981-2001) for the optical depths, and with SAGE II data for the vertical profiles. The effective radius distributions of the dust plumes are examined with the Terra MODIS data. The results show that the Asian dust eruptions persist in March, Apr and May of a year. The monthly mean aerosol optical depth (AOD) in the regional area (30N-50N,120E-150E) peaks in April with values of 0.3±0.05. Riding with seasonal atmospheric circulation the dust plumes loftily spread toward the North America. The vertical profile analysis indicates that the dust air mass could rush up to tropopause, higher than the currently realized range of 6 8km. 21-year AOD anomaly results show that the trend of difference from the yearly mean AOD (0.16) in the dust area basically follows the trend of global AOD anomaly, and therefore falls under volcano eruption influence. Characterization of those features will be a crucial step in the climate effect program.

A11E-0014 0830h POSTER

Aerosol Size Distribution, Composition, and Hygroscopicity Measurements During CSTRIPE Using an Aerosol Mass Spectrometer and a Dual Differential Mobility Analyzer

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During July 2003, the CIRPAS Twin Otter aircraft was deployed in the CSTRIPE (Coastal STRatocumulus Imposed Perturbation Experiment) field experiment in order to quantify the effects of aerosols on the microphysics and dynamics of marine stratocumulus clouds. In order to characterize the effects of different aerosol types on stratocumulus clouds, various air masses were sampled, including local fire plumes, pollution over the San Joaquin valley, unperturbed marine stratocumulus clouds, and stratocumulus clouds perturbed by seeding flares. Some research flights were also dedicated to characterize the seeding flares in the clear sky. Measurements of aerosol mass distribution and composition, using an Aerodyne Aerosol Mass Spectrometer (AMS), and size distribution and hygroscopic behavior, using a Dual Differential Mobility Analyzer (Dual DMA) with one column at dry conditions and another at a relative humidity of approximately 70 percent, will be presented here. During a number of in-cloud sampling periods, the Counter-flow Virtual Impactor (CVI) was used to select and dry cloud droplets, which were then analyzed by the AMS and the Dual DMA. The AMS composition measurements showed that sulfate and organics comprised most of the mass of the non-refractory components of the aerosol. The DMA showed a mixture of unimodal and bimodal size distributions in most types of air masses. The air mass over the San Joaquin valley, however, showed strong evidence of freshly nucleated particles, with aerosol number concentrations often above 80,000 cm-3.

A11E-0015 0830h POSTER

Galactic Cosmic Rays and Ion Induced Aerosol Production

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The effect of ions on the production of sulfate aerosol in the Earth's atmosphere has been a topic of a number of modeling studies in the recent past. These studies were able to explain new particle formation in the middle and lower troposphere, observed in field campaigns under conditions where classical binary nucleation theory does not allow for a substantial particle production. However, recent observations of massive charged clusters in the upper troposphere indicate that ions may play an important role for aerosol formation in higher atmospheric regions as well. A major source of ions in the lower and middle atmosphere are galactic cosmic rays (GCR). The ion production due to GCR and the subsequent formation of sulfuric aerosol, together with its variations in altitude and solar cycle phase, were another topic of modeling studies. However, these studies relied mainly on theoretical approaches to ion-induced nucleation, and on sparse data of ion production in the atmosphere due to GCR. We