with OH the overall rate constant reflects the number of available hydrogen atoms and the strengths of C-H bonds, therefore the effect of one 13C atom in a molecule of NMHC will change the rate constant. The rate constants of NMH13C reactions with the OH-radical were determined from recent and on going laboratory measurements of KIE (Proffessor Rudolph's Group York University). The model used for this study was the MC2AQ model. The model includes on-line gas phase chemistry, and covers part of Eastern US and Canada on a 21km grid scale. The model was modified to include isotope information for Propene, Toluene, Propane, Benzene, Xylenes, and Isoprene. These compounds (both ^{12}C and ^{13}C were included as tracers reacting only with OH, with no feedback on the main chemistry in the model. This will help to test and verify the OH-radical concentration predicted by the chemistry model. The changes in ($\delta^{13}C$) of less reactive (or more reactive) NMHC due to the mixing of air masses is studied from the output of the model.

A61B-0082 0830h POSTER

Carbon Kinetic Isotope Effects in the Reactions of Atmospheric Non-methane Hydrocarbons with Hydroxyl Radicals, Chlorine Atoms and Ozone

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Recently it has been shown that stable carbon isotope measurements are extremely useful for better understanding of atmospheric processes involving NMHC. Interpretation of these measurements requires both the knowledge of the isotopic composition of hydrocarbon emissions as well as of the isotopic fractionation associated with the removal of NMHC from the atmosphere. Oxidation by OH-radicals is by far the most important atmospheric removal process of NMHC. To some extent oxidation by chlorine atoms and ozone also contribute to the removal of NMHC from the atmosphere. KIEs for the reactions of C2-C9 NMHC with atmospheric oxidants hydroxyl radicals, chlorine atoms and ozone will be presented and discussed with respect to studying atmospheric processes.

A61B-0083 0830h POSTER

The Carbon and Hydrogen Kinetic Isotope Effects of Non-methane Hydrocarbons in Their Reactions with OH Radicals, Cl Atoms and Ozone

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A quantitative understanding of atmospheric oxidation processes can be attained through studies of the isotopic composition of non-methane hydrocarbons (NMHCs). Rudolph and Czuba (2000) have demonstrated that such isotopic studies can be used to determine the average photochemical age of an air mass. One of the prerequisites is the knowledge of the kinetic isotope effects associated with the removal processes for NMHCs in the atmosphere. We have measured the carbon and hydrogen kinetic isotope effects (KIEs) of NMHCs in reaction with species of atmospheric relevance (OH and Cl radicals, ozone) using continuous flow-isotope ratio mass spectrometry (CF-IRMS). The NMHCs studied include alkanes, alkenes, and aromatics such as toluene and p-xylene. This presentation will focus on the results of these experiments and will explain their significance and utility in atmospheric chemistry.

A61B-0084 0830h POSTER

Trends of Formate, Acetate, and Oxalate in Alpine Ice Cores over the Twentieth Century: Implications for their Natural and Anthropogenic Budgets in the Atmosphere over Europe

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A continuous high-resolution record from a Col du Dome (Mt Blanc, 4250 m a.s.l., French Alps) ice core in addition to discontinuous samples from a Colle Gnifetti (Monte Rosa, 4450 m a.s.l., Swiss Alps) ice core were used to investigate the partitioning between natural and anthropogenic sources of mono- and di-carboxylates in the European atmosphere. It is found that with a mean summer level close to 100 ppb formate dominates other monocarboxylates such as acetate (∼15 ppb) and lactate (∼8 ppb). With levels close to 15 ppb, oxalate and succinate are the two most important di-carboxylates of the present-day Alpine precipitation. Together, these 4 species represent on average 30% of the DOC level, which ranges between 100 and 300 ppb C.

The long term trends of formate and acetate show an increase by a factor of two after 1950 and a re-decrease after 1980. At present more than 80% of formate and acetate present in Alpine precipitation is of natural origin (likely continental biogenic emissions). The changes of formate and acetate after 1950 follow rather well the course of expected change of COV emissions related to vehicular traffic. The absence of a temporal trend for oxalate suggests an insignificant impact of anthropogenic emissions for this species. Likewise it is shown that the oxalate produced in biogenic soils and emitted during biomass burning events does not dominate the atmospheric budget of this species. A comparison of the Alpine oxalate levels with those obtained at sites located at lower elevation, suggests that a secondary production of this species takes place in the troposphere. Finally, in contrast to oxalate, succinate whose atmospheric budget is poorly understood exhibits a well marked anthropogenic trend (a factor of 10 between the pre-industrial era and present).

A61B-0085 0830h POSTER

Development of Laser Induced Fluoorescence Sensor for Measurements of Atmospheric HCHO

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Formaldehyde has been identified as a source of free radicals that ultimatley leads to the formation of pollutants, particularly ozone. Formaldehyde is formed from the oxidation of both anthropogenic and biogenic oganics; it is also directly emitted by anthropogenic sources such as maotor vehicles. Currently, there are pronounced discepancies between measured formaldhyde and model predictions, especially within the upper troposphere. In order to understand the atmospheric oxidation capacity and the ozone formation/destruction cycle more fully, it is essential for formaldehyde measurments to be accurate and precise. We present results from the ongoing deveopment of field-deployable LIF (laser induced fluorescence) based on a real-time sensor for formaldehyde with one-minute signal integration time. Its projected limits of detection in the free troposphere and boundry layer are 5 pptv and 30 pptv respective

URL: http://lif.gtri.gatech.edu/web/experiments/hcho

A61B-0086 0830h POSTER

The Role of Organic Compounds in Precipitation Development Using an Explicit Microphysical Model

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In order to estimate the anthropogenic influence of gas and aerosol emissions from the Petroleum Industry in maritime zones with clouds of small vertical extent, a numerical 1D Eulerian cloud-chemical model with detailed microphysics (Alfonso and Raga 2002) is used to simulate the influence of water soluble organic compounds (WSOC) and organic+inorganic gas emissions on cloud development. Following Mircea et al. (2002), we tested the sensitivity of the cloud and precipitation development in the classical inorganic case (CIC) and the inorganic+organic case (IOC) with respect to CCN compositions. The results indicate an increase in the droplet concentration for the IOC, and a delay in the development of precipitation. The pH spectral evolution was studied during both the development and precipitation stages. The influence of the diffusion of formic acid and its generation by oxidation of hydrated formaldehyde in the aqueous phase result in a reduction in the acidity of precipitation in the range between 0.05 and 0.15 pH units (from 1 to 3%) for the high ambient SO_2 concentration (20 ppb) and between 0.8-1.6 pH units for the low ambient SO_2 concentration (1ppb) case.

A61C MCC: Hall D Saturday 0830h

Recent Advances in Global Climate Modeling I Posters *(joint with NG, B, H, OS, GC)*

Presiding: **D Stephenson-Hawk,** The Stephenson Group

A61C-0087 0830h POSTER

Simulations of Global Climate With a High Resolution Model of the Atmosphere

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One factor limiting the realism of global climate simulations is lack of spatial resolution. We have performed simulations of global climate at spectral truncations of T170 and T239 (resolutions of 75 km and 50 km, respectively) using the NCAR CCM3 atmospheric climate model. We performed simulations of the present climate and of the effects of increased greenhouse gases. We performed a first-order "retuning" of the model physics at T170. We will discuss how the model's ability to simulate the present climate, and its response to increased greenhouse gases, depend on horizontal resolution.

A61C-0088 0830h POSTER

Development of a High-Resolution Climate Model for Future Climate Change Projection on the Earth Simulator

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The fastest supercomputer of the world, the Earth Simulator (total peak performance 40TFLOPS) has recently been available for climate researches in Yokohama, Japan. We are planning to conduct a series of future climate change projection experiments on the Earth Simulator with a high-resolution coupled ocean-atmosphere climate model.

The main scientific aims for the experiments are to investigate 1) the change in global ocean circulation with an eddy-permitting ocean model, 2) the regional details of the climate change including Asian monsoon rainfall pattern, tropical cyclones and so on, and 3) the change in natural climate variability with a high-resolution model of the coupled ocean-atmosphere system.

To meet these aims, an atmospheric GCM, CCSR/NIES AGCM, with T106($\sim$1.1°) horizontal resolution and 56 vertical layers is to be coupled with an oceanic GCM, COCO, with $\sim 0.28^\circ \times 0.19^\circ$ horizontal resolution and 48 vertical layers. This coupled ocean-atmosphere climate model, named MIROC, also includes a land-surface model, a dynamic-thermodynamic seaice model, and a river routing model. The poles of the oceanic model grid system are rotated from the geographic poles so that they are placed in Greenland and Antarctic land masses to avoid the singularity of the grid system.

Each of the atmospheric and the oceanic parts of the model is parallelized with the Message Passing Interface (MPI) technique. The coupling of the two is to be done with a Multi Program Multi Data (MPMD) fashion. A 100-model-year integration will be possible in one actual month with 720 vector processors (which is only 14% of the full resources of the Earth Simulator).

A61C-0089 0830h POSTER

Thermodynamic Efficiency of a General Circulation Model

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The thermodynamic efficiency is a fundamental number that allows us to compare numerical models of the general circulation. In this study, we use the heat engine framework to evaluate the atmospheric circulations, both global and regional, generated in the idealized GCM from GFDL (Held and Suarez 1994). We will demonstrate that this theoretical framework can be applied to both closed systems (the general circulation) and open systems (the Hadley circulation). We have calculated the thermodynamic efficiency in 3 different ways for the closed system. One is based on mechanical dissipation of energy, the other based on net heating, and the third is the Carnot efficiency. For the open system, we calculate the the thermodynamic efficiency in 2 ways, the first based on mechanical dissipation of energy and the second based net heating. For the closed system, the efficiencies are calculated in the tradition manner. However, for open systems such as the Hadley circulation, it is necessary to take into account the energy fluxes that enter or leave the control volume. We will present the mathematical description of these efficiencies.

In a numerical model without error or irreversible processes, the efficiencies based on dissipation of mechanical energy and net heating are identical, while the Carnot efficiency is the maximum possible. Therefore, by comparing these efficiencies, we can ascertain the irreversibilities present in the model. The results for various experiments demonstrate that the efficiencies based on dissipation and net heating are sensitive to model resolution. T42 appears to be an adequate resolution. Model experiments give efficiencies based on dissipation, net heating and Carnot of 9.5%, 11.2% and 12.5%, respectively for the general circulation. Although the model is reversible in terms of its parameterization, they are irreversibilities associated with the numerics. For the Hadley cell, the efficiency based on mechanical dissipation of energy is 6.2%, while that based on net heating is 7.4%. The decrease in efficiency compared to the global values results for the fact that the Hadley cell exports thermal energy to higher latitudes.

A61C-0090 0830h POSTER

Using Clustering to Establish Climate Regimes from PCM Output

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A multivariate statistical clustering technique–based on the k-means algorithm of Hartigan–has been used to extract patterns of climatological significance from 200 years of general circulation model (GCM) output. Originally developed and implemented on a Beowulf-style parallel computer constructed by Hoffman and Hargrove from surplus commodity desktop PCs, the high performance parallel clustering algorithm was previously applied to the derivation of ecoregions from map stacks of 9 and 25 geophysical conditions or variables for the conterminous U.S. at a resolution of 1 sq km. Now applied both across space and through time, the clustering technique yields temporally-varying climate regimes predicted by transient runs of the Parallel Climate Model (PCM). Using a business-as-usual (BAU) scenario and clustering four fields of significance to the global water cycle (surface temperature, precipitation, soil moisture, and snow depth) from 1871 through 2098, the authors' analysis shows an increase in spatial area occupied by the cluster or climate regime which typifies desert regions (i.e., an increase in desertification) and a decrease in the spatial area occupied by the climate regime typifying winter-time high latitude perma-frost regions. The patterns of cluster changes have been analyzed to understand the predicted variability in the water cycle on global and continental scales. In addition, representative climate regimes were determined by taking three 10-year averages of the fields 100 years apart for northern hemisphere winter (December, January, and February) and summer (June, July, and August). The result is global maps of typical seasonal climate regimes for 100 years in the past, for the present, and for 100 years into the future.

Using three-dimensional data or phase space representations of these climate regimes (i.e., the cluster centroids), the authors demonstrate the portion of this phase space occupied by the land surface at all points in space and time. Any single spot on the globe will exist in one of these climate regimes at any single point in time. By incrementing time, that same spot will trace out a trajectory or orbit between and among these climate regimes (or atmospheric states) in phase (or state) space. When a geographic region enters a state it never previously visited, a climatic change is said to have occurred. Tracing out the entire trajectory of a single spot on the globe yields a "manifold" in state space representing the shape of its predicted climate occupancy. This sort of analysis enables a researcher to more easily grasp the multivariate behavior of the climate system.

URL: http://climate.esd.ornl.gov/

A61C-0091 0830h POSTER

Uncertainty Propagation in Earth System Models

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One of the major challenges of climate prediction is the estimation of uncertainty related to the modeling results. Various assumptions about the model structure and different settings of parameters and initial conditions can alter the model output crucially - especially in the case of model inherent thresholds and other consequences of non-linearities within the model equations.

General Circulation Models (GCMs) - used for climate prediction- are not suited for a sufficient uncertainty analysis because the computational costs are too demanding through the highly complex model structure. The model class of EMICs (Earth System Models of Intermediate Complexity) can serve as a tool to investigate different aspects of model performance by realizing Multi-Run experiments (e.g. for scanning the phase space of possible solutions for different input parameter settings). We use a model of this class (CLIMBER-2) for the propagation of probability densitiy functions (PDFs) of the uncertain model input parameters by applying a Latin-Hypercube-Sampling scheme.

Our aim is to restrict the parameter space, and hence the space of possible solutions. We compare model simulations with observational data to reject model input parameters, which will result in simulation of climate states inconsistent with climatologies.

Enlarging the number of uncertain model parameters or rerunning the experiment in different modes (e.g. with interactive vegetation module) would be too time demanding. This problem can be circumvented if the comprehensive original climate model can be emulated by a fit model. The low variability and the smooth model response of CLIMBER with respect to parameter changes might allow to construct a reduced form model using an approximation procedure by orthogonal polynomials. This model will be very time effective (compared to the original climate model) if the order for the approximation will be low and if the dimensionality of the problem (i.e. the number of uncertain parameters) will be mathematically tractable. Having constructed such a computationally efficient polynomial model, extensive uncertainty analyses are feasible for various parameters of interest.

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A61C-0092 0830h POSTER

The Role of Ocean General Circulation in Climate Assessed With Coupled Climate Models

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Integrations of coupled climate models with fixed ocean currents are used to explore the climatic response to varying magnitude of ocean circulation. A trio of 100 year integrations are made with control currents from a GFDL R30 ocean simulation, same currents reduced by half, and same currents increased by half. This suite is performed with two coupled models employing different atmospheric components, the new GFDL AM2 atmospheric model and the GFDL Manabe Climate Model atmosphere (MCM), for a total of six experiments. Both models show a large sensitivity of the sea ice extent to the magnitude of currents with increased currents reducing the extent and warming the high latitudes. Cloud short wave forcing over the ocean also responds to circulation changes in both models but in the opposite sense. In the AM2-based model, low cloudiness decreases as ocean circulation increases, reinforcing the sea ice changes in reducing the planetary reflectivity, and warming the climate. This cloudiness change is associated with a reduction in lower atmospheric stability over the ocean. The MCM-based model has a smaller sensitivity of lower atmospheric stability with the same sign but the cloud cover becomes more reflective as the circulation is increased, offsetting the changes due to sea ice cover and reducing the change in global mean temperature.

A61C-0093 0830h POSTER

Analysis of the Polar Amplification Pattern of Global Warming in an Atmospheric GCM Coupled to an Oceanic Mixed Layer

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The sensitivity of an idealized climate system model consisting of an atmospheric GCM coupled to an oceanic upper mixed layer on an aquaplanet is analyzed. There is no seasonal cycle and the solar radiation is taken to be symmetric about the equator. The system is integrated with the observed CO_2 (330 ppm) until it reaches a quasi-equilibrium climate. To study the sensitivity we double the CO_2 and again integrate until the system reaches a new equilibrium climate. To simplify the linear analysis we assume that the atmosphere is always in quasi-equilibrium (typical atmospheric adjustment times being much shorter than that of the oceanic upper mixed layer). We introduce a linear surface energy budget sensitivity (or response) operator consisting of a Jacobian matrix of the surface budget with respect to the surface temperature. The operator is used to construct a linear estimate of the surface temperature change that results from the CO_2 doubling. It is found that the temperature response obtained from the linear extimate compares well with the results of the full 3D run. The shape of the response looks very similar to that of the least stable mode of the linear surface budget sensitivity operator. The importance of different components of the initial forcing at the surface is discussed. The role of individual components of the system in determining the typical polar amplification pattern is studied.

A61C-0094 0830h POSTER

The effects of using ocean color to parameterize penetration of shortwave radiation in ocean GCMs

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The impact of two parameterizations using ocean color for penetrating shortwave radiation on the ocean circulation is studied using the GFDL Modular Ocean Model. We find that parameterizations which increase the penetration of shortwave radiation increases the mixed layer depths, and decreases the export of heat from the tropics. We show that within deeper mixed layers a larger fraction of the Ekman transport is compensated by geostrophic transport. We demonstrate that the distribution of heat within the upper part of the mixed layer, rather than the penetration of heat below the mixed layer, is most important in changing the heat transport.

A61C-0095 0830h POSTER

Parameterizations of Cloud-Radiation Interactions Based on Detailed Cloud Microphysics

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Cloud-radiation effects still account for much of the variation among leading global climate models in sensitivity to greenhouse gases. A single-column model (SCM) allows results of different cloud-radiation parameterizations to be compared directly with measurements. The relevant fields include cloud altitude, cloud amount, liquid and ice content, particle size spectra, and radiative fluxes at the surface and the top of the atmosphere. Comparisons with data from the Atmospheric Radiation Measurement (ARM) Program show conclusively that prognostic cloud algorithms with detailed microphysics are far more realistic than simpler approaches. Long-term comparisons of SCM quantities strongly modulated by clouds, such as monthly mean downwelling surface shortwave radiation, clearly demonstrate the superiority of parameterizations based on comprehensive treatments of cloud microphysics and radiative interactions. The single-column model was run at the ARM Southern Great Plains, Tropical Western Pacific, and North Slope of Alaska sites using forcing data derived from operational numerical weather prediction models. Our results indicate that atmospheric radiative fluxes are sensitive to the scheme used to specify the ice particle effective radius by up to 30 W m-2 on a daily time scale and up to 5 W m-2 on a seasonal time scale. Differing treatments of ice particle fallout have a significant effect on the amount and location of high cirrus clouds. An unexpected finding was that the variance of the modeled ice particle effective radius at a given level is considerably smaller than that suggested by ARM cloud radar measurements. Our results indicate that this theoretical underestimate of the ice particle effective radius variance can have effects on modeled radiative fluxes comparable in magnitude to those cited above for sensitivity to the mean values of ice particle effective radius.

A61C-0096 0830h POSTER

The Statistical Characteristics of the Outgoing Spectra: Inter-Comparison Between Models and Comparison Between Models and Observations

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Using MODTRAN (MODerate resolution TRANsmittance code), we calculate synthetic outgoing spectra based on the outputs of the UCLA GCM and the NCAR CCM3 control runs. These two GCMs are chosen for comparative study because of their many fundamental differences. Then we apply EOF analysis to the synthetic spectra. We limit our study to tropical and mid-latitude Pacific regions. For both GCMs, the first Principal Component (PC1) is associated with tropospheric variations while the second Principal Component (PC2) is related to stratospheric variations. The variance explained by each PC, as well as the magnitude of PC1, differs substantially between the two GCMs in the tropical Pacific. A high-order statistical moment analysis discloses additional differences between the two GCMs.

The synthetic spectra are compared with InfraRed Interferometer Spectrometer (IRIS; Hanel et al., 1971) observations. For both GCMs, PC2s in the tropical Pacific and mid-latitude Pacific are related to stratospheric variations. On the other hand, IRIS observations indicate that PC2 in the tropical Pacific is not related to the stratospheric variations, while there is a stratospheric influence on PC2 at mid-latitudes. This suggests that both GCMs overestimate the stratospheric variability in the tropical Pacific. Based on another UCLA GCM run with realistic SST forcing over the IRIS period, we show that in the mid-latitude Pacific the amplitude of PC1 from IRIS is smaller than that derived from the GCM. In the tropical Pacific, however, PC1 from IRIS is 2-6 times larger than the model results.

The statistical characteristics of outgoing spectra could be a potentially powerful tool for testing the variability of climate models. The 10-month long IRIS data were obtained about 30 years ago. With the incoming AIRS data, we will have a new and potentially longer dataset to be used for model validation and development.

A61C-0097 0830h POSTER

Introduction to an Online Coupled Ocean-Atmosphere Radiative Transfer (COART) Model

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A web site (http://snowdog.larc.nasa.gov/jin/rtset.html) has been established recently at NASA Langley Research Center for online simulations of radiative transfer in the atmosphere and ocean. Simulations are based on COART (Coupled Ocean-Atmosphere Radiative Transfer), a model we developed recently. COART is, in turn, founded on the Coupled DIScrete Ordinate Radiative Transfer (CDISORT) or the Coupled DISORT. CDISORT is distinguished from DISORT, in that CDISORT accounts for the refractive index change of the media (e.g., at the air-water interface). COART considers the ocean just as additional "atmospheric layers" but with significantly different optical properties. The online model calculates radiances (including water-leaving radiances) and irradiances at individual wavelengths or in spectral bands specified by the user; and at selected altitudes in the atmosphere and depths in the ocean. With the online setup menu, users simply specify the atmosphere (atmospheric profile, aerosol type, aerosol optical depth and precipitable water, etc.) and the ocean (ocean depth, wind speed, Chl, CDOM, and scattering phase function etc.), and then select calculation type and output levels.

Radiometric observations from aircraft and from a rigid sea platform (the Chesapeake lighthouse) are used to validate COART. Examples of application of the model, which including but not limited to ocean surface albedo, bidirectional reflectance, effects of atmospheric and oceanic properties on the light transport in the air and water, and solar heating in the upper ocean, will be presented. COART simulations are used to specify the ocean spectral albedo for retrievals of the Surface and Atmospheric Radiation Budget (SARB) in the global, multi-satellite CERES EOS experiment.

A61C-0098 0830h POSTER

The Climatic Impact of 11-Year Solar Irradiance Changes Simulated With the Berlin Climate Middle Atmosphere Model (FUB CMAM)

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The impact of 11-year solar cycle variations on the stratosphere and troposphere is studied in simulations with the new Freie Universität Berlin Climate Middle Atmosphere Model (FUB CMAM) using interactive chemistry. Wavelength-dependent changes in solar insolation between solar maximum and solar minimum conditions were prescribed, while the response of the ozone concentration to the irradiance changes was calculated by the model's chemistry module. Possible feedback processes of dynamical changes on the ozone distribution were accounted for by a Semi-Lagrangian transport module.

The model results will be compared with observations as well as with recent General Circulation Model (GCM) studies of the GRIPS (GCM-Reality Intercomparison Project for SPARC) initiative where identical irradiance changes, but uniform pre-calculated ozone responses were prescribed. The discussion will focus on the ability of the GCMs to reproduce the observed solar signal and on the impact of the different model configurations on the simulated signal.

A61C-0099 0830h POSTER

A Parameterization of Solar Energy Disposition in a Climate Model Using an EBM

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During the past decade, a class of climate models of reduced complexity (also termed EMICs: Earth system Models of Intermediate Complexity), which employs an energy balance model as the atmospheric component, has been developed. However, the solar energy disposition in the subcomponents in these climate models has never been rigorously parameterized. In this study, an atmospheric radiative-convective model is used to parameterize the integrated reflectivity and transmissivity of an atmospheric column in terms of precipitable water, cloud properties and aerosols. Then, for a prescribed surface albedo, the solar energy disposition can be calculated using the parameterized reflectivity and transmissivity. In this calculation, we use climatology data from ISCCP (International Satelite Cloud Climatology Project), ERA-15 (ECMWF 15-year Renalysis) and PATMOS (Pathfinder Atmosphere). This solar energy disposition calculated using these parameterized reflectivity and transmissivity is tested against that observed in the Earth Radiation Budget Experiment.

A61C-0100 0830h POSTER

Effect of Climate Model Resolution on Simulated Response to Increased Greenhouse Gases

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The scientists of the Atmospheric Science Division at the Lawrence Livermore National Laboratory recently performed high-resolution global climate simulations, in order to determine the possible effects of increased greenhouse gases on global and regional climate.

The simulations use the NCAR CCM3 atmospheric model. Simulations of present and doubled CO2 concentrations were performed. For both the current climate and the future climate, the simulations were performed at two spatial resolutions: 2.8 degrees by 2.8 degrees (T42 truncation) and 0.7 degrees, 0.7 degrees (T170 truncation).

These simulations show some interesting features: As expected, the climate warms up with the increase in greenhouse gases. Also as expected, the temperature responses differ from region to region. The response of high latitudes, for example, tends to differ from the global response (with even some cooling in some months for several regions). Moreover, the two simulations corresponding to the two different resolutions present some statistically significant differences, for several regions of the world. This resolution-sensitivity to the models response to increased greenhouse gases is in general due to differing feedbacks at the two resolutions. We will discuss how the models response to increased greenhouse gases depends on resolution and the mechanisms responsible for these differences. A close look at variables such as cloudiness and radiation fluxes gives an explanation to these differences.

Such an analysis of the climate simulation results is important to assess the performances of the model at the two resolutions but mostly to evaluate the changes that are going to take place in our climate due to the increase in greenhouse gases.

A61C-0101 0830h POSTER

Interannual Variability (IAV) of Passive Tracer Interhemispheric Transport (IHT) in the GISS-UCB AGCM

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Possible sources of passive tracer IHT IAV are explored over the period spanning 1979-1994 using an ensemble of model runs produced with the GISS-UCB AGCM. The index of IHT considered, a 2-box model exchange time, represents a global measure of the timescale for interhemispheric mixing. While the exchange time is observed to exhibit some El Niño/Southern Oscillation (ENSO)-like variability, the phase relationship between ENSO and exchange time anomalies is weak and varies significantly over different members in the ensemble. Moreover, comparison of exchange time IAV with axisymmetric circulation statistics such as the intensity of the Hadley circulation or the anomalous displacement and/or intensity of the zonally-averaged ITCZ yields no significant relationships. The poor agreement between axisymmetric circulation variability and exchange time anomalies implicates nonaxisymmetric circulation variability as the more important determinant of exchange time IAV, as is in fact confirmed by a simple quantitative partitioning of the total mass transport in the tropics.

Indian Ocean sector (40E-120E) variability, on the other hand, is observed to exert significant influence over the IAV of passive tracer IHT in a global sense. The Indian Ocean region is dominated by seasonally-reversing monsoon circulations, and it is hypothesized that year-to-year variations in late NH summertime monsoon intensity play an especially important role in regulating IHT IAV, both during the NH monsoon active season (June-September) as well as in an annual-mean sense. Indeed, statistically-significant correlations between exchange time variability and various measures of monsoon intensity (e.g. precipitation averaged over South Asia and cross-equatorial wind averaged over western Indian Ocean lower troposphere) are noted: exchange times are found to be anomalously negative-corresponding to faster IHT-during strong monsoon years. It is argued that stronger monsoons enhance cross-equatorial, stationary-eddy transports and thereby diminish the timescale for interhemispheric mixing.

A61C-0102 0830h POSTER

A Trajectory Study of the Tropical Troposphere-Stratosphere Exchange based on ECMWF Re-analysis Data

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A significant increase in stratospheric water vapor mixing ratios has been observed over the past 50 years. This increase cannot be explained by oxidation of increasing stratospheric methane concentrations alone. Hence, troposphere-stratosphere exchange processes at the tropical tropopause have been considered to be responsible for the increase.

Here, we present an analysis of trajectory calculations based on re-analysis data of the European Centre for Medium-range Weather Forecasts (ECMWF). Forward and backward trajectory calculations are used to analyze: (a) the water mixing ratio of air entering the stratosphere, assuming that the mixing ratio is determined by the lowest saturation vapor pressure over ice during the ascent; (b) the geographical regions of troposphere-stratosphere exchange.

Assuming thermodynamic equilibrium between the ice phase and the gas phase, the water mixing ratio of air entering the stratosphere is determined from the coldest temperature of the air during its ascent (the so-called 'cold trap'). It has been argued that tropical tropopause temperatures are on average too high to explain stratospheric water vapor, and that troposphere-stratosphere exchange must occur predominantly at locations where tropopause temperatures are lower than average (the 'stratospheric fountain' hypothesis, considered to be located over the western tropical Pacific, northern Australia, Indonesia and India). However, several other studies conclude that average tropical tropopause temperatures are sufficiently low to explain the stratospheric water mixing ratio and/or that the suggested stratospheric fountain region is actually a region of descending rather than ascending air.

Our preliminary results indicate that average tropical tropopause temperatures in the ECMWF re-analysis data are indeed sufficiently low to explain stratospheric water mixing ratios, but also that the exchange occurs predominantly in regions with lower than average temperatures. The results might be affected by the way tropical deep convection is parameterized in the ECMWF data set. Consequently, in order to asses the quality of our study the results are discussed in context with measurements and other modelling studies.

A61C-0103 0830h POSTER

On the Diurnal Variation of Globally Averaged Temperature and Surface Heat Fluxes by Using ECMWF Re-analysis Data

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Though it is what everyone experiences, the temperature rises when the sun rises and the temperature drops in the night under the condition of weak wind. This phenomenon is known generally, and called a diurnal variation of surface temperature. Such diurnal variation of temperature takes place in a certain specific point, however the question arises whether such diurnal variation of temperature occurs in the entire earth or not. Since the earth has a spherical surface and the incident solar radiation at the top of the atmosphere has no such diurnal variation, it is expected that the large diurnal variation of temperature does not happen in the whole earth. To answer this simple question, we need observational data of four times or more a day and was impossible until now. The traditional method of examining the diurnal variation of temperature or other variables at local time in each observatory will be called "local diurnal variation of temperature". On the other hand, submitting here is "global diurnal variation of temperature" by which the diurnal variation of temperature in the entire earth is examined at universal time (UTC). ECMWF Re-analysis Data (ERA: 1979-1993) sampled at every six hours first made it possible to estimate reliable global diurnal variations of various fields. On the earth, the area where the diurnal variation of temperature is strong is in dry area of Africa and the Middle East, and it is realized that global diurnal variation of temperature is brought by the local diurnal variation of temperature over these area. The globally averaged temperature is the highest at 12 UTC and the lowest at 00UTC through entire ERA data (1979-1993) when the sun is above these regions or not. The surface sensible heat flux also has large diurnal variations over dry area of Africa and the Middle East. The globally averaged surface sensible flux is the largest between 06 and 12 UTC and the lowest between 18 and 24 UTC on the whole earth and entire ERA data, which is brought by the local diurnal variation of sensible heat flux over above regions. On the contrast the diurnal variation of surface latent heat flux is the largest over South America where the surface condition is very wet and high temperature especially above Amazon basin. Therefore the globally averaged surface latent heat flux is the largest between 12 and 18 UTC on the whole earth when the sun has passed South America.

A61C-0104 0830h POSTER

Evaluation of NCEP Re-analysis Radiation and Cloud Products in the Arctic Based on Comparison With Ground-based and Space-borne Measurements.

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We have evaluated the performance of the NCEP re-analysis in the Arctic by comparing the re-analysis radiation fields with ground-based radiation measurements obtained at the Department of Energy (DOE) Atmospheric Measurement Program (ARM) sites on the North Slope of Alaska and space-borne retrievals based on the MODIS dataset. The DOE ARM program operates two Cloud And Radiation Testbed (CART) facilities on the North Slope of Alaska. The main measurement facility located in Barrow (71 deg 19' N; 156 deg 37' W) has been in operation since 1998 and the second facility located in Atqasuk (70 deg 28' N; 157 deg 24' W) in operation since spring 2000. Barrow is located on the Arctic Coast while Atqasuk is about 100 km inland (south) and approximately one third of the way to the Brooks Range from the coast. We have evaluated how well the re-analysis model calculates the surface radiation fluxes during different atmospheric conditions. In particular we compare modeled and measured solar and terrestrial irradiances for clear, cloudy and patchy skies in different seasons. The composition of the frequently observed low arctic stratus changes from pure liquid water phase in the summer to mixed-phase in the transition between summer and winter to almost pure ice phase in the middle of winter. The purpose of this work is to identify weaknesses in model parameterizations. The ultimate goal is to improve climate model performance by correcting these problems.

A61C-0105 0830h POSTER

The NCEP Nonhydrostatic Meso Model and First Experiences With Its Applications

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Considerable experience with nonhydrostatic models has been accumulated on the scales of convective clouds and storms. However, numerical weather prediction (NWP) deals with motions on a much wider range of temporal and spatial scales. Difficulties that may not be significant on the small scales, may become important in NWP applications. Based on these considerations, a new approach has been applied in developing the NCEP Nonhydrostatic Meso Model (NMM) within the WRF effort. Namely, instead of extending the cloud models to synoptic scales, the hydrostatic approximation is relaxed in a hydrostatic model formulation. In this way the model validity is extended to nonhydrostatic motions, the number of prognostic equations does not increase, and at the same time the favorable features of the hydrostatic formulation are preserved. This approach does not require any additional approximation.

In the model, isotropic horizontal finite differencing is employed that conserves a variety of basic and derived dynamical and quadratic quantities. Among these, the conservation of energy and enstrophy improves the accuracy of nonlinear dynamics of the model. The hybrid pressure-sigma vertical coordinate has been chosen as the primary option. The forward-backward scheme is used for horizontally propagating fast waves, and an implicit scheme is used for vertically propagating sound waves. The Adams-Bashforth scheme is applied for horizontal advection of the basic dynamical variables and for the Coriolis terms. In real data runs the nonhydrostatic dynamics does not require extra computational boundary conditions at the top.

Since recently, the NMM has been applied operationally at NCEP. The efficiency of the computational algorithm of the model far exceeds the efficiency of algorithms of most state-of-the-art nonhydrostatic models. In high resolution NWP applications, the model has been highly competitive with other nonhydrostatic and mature hydrostatic models. Several examples of model forecasts are presented.

A61C-0106 0830h POSTER

A new numerical approach on groundwater dynamics study for land surface models

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Interactions between surface and groundwater play a significant role in re-distributing soil moisture in the vadose zone which impacts the partitions among water and energy budgets. However, a reasonable representation of the dynamic behavior of groundwater table would require numerically a large number of vertical soil layers under the framework based on Richard equations in general. The computational expense could thus limit the applications of incorporating surface and groundwater interactions into the land surface and atmosphere interaction studies. In this paper, a new approach is presented where the requirement of a large number of layers is relaxed. Specifically, the dynamic behavior of groundwater table represented as a moving boundary problem in the previous study by Liang and Xie [2002] is now described by a fixed boundary problem through certain mathematical transformations. With the new numerical framework, one can use significantly less number of vertical layers to obtain results that are comparable to the ones obtained with the original approach applied to a moving boundary problem. Therefore, the computation expense could be significantly reduced. The new approach was applied to two sites with encouraging results.

Reference

Liang, X., and Z. Xie, Important factors in land-atmosphere interactions: surface runoff generations and interactions between surface and groundwater, Global and Planetary Change, accepted, 2002.

A61C-0107 0830h POSTER

Impact of lakes and wetlands on present and future boreal climate

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Impact of lakes and wetlands on present and future boreal climate

The role of lakes and wetlands in present-day high latitude climate is quantified using a general circulation model of the atmosphere. The atmospheric model includes a lake module which is presented and validated. Seasonal and spatial wetland distribution is calculated as a function of the hydrological budget of the wetlands themselves and of continental soil whose runoff feeds them. Wetland extent is simulated and discussed both in simulations forced by observed climate and in general circulation model simulations. In off-line simulations, forced by ECMWF reanalyses, the lake model simulates correctly observed lake ice durations, while the wetland extent is somewhat underestimated in the boreal regions. Coupled to the general circulation model, the lake model yields satisfying ice durations, although the climate model biases have impacts on the modeled lake ice conditions. Boreal wetland extents are overestimated in the general circulation model as simulated precipitation is too high. The impact of inundated surfaces on the simulated climate is strongest in summer when these surfaces are ice-free. Wetlands seem to play a more important role than lakes in cooling the boreal regions in summer and in humidifying the atmosphere.

The role of lakes and wetlands in future climate change is evaluated by analyzing simulations of present and future climate with and without prescribed inland water bodies.

A61C-0108 0830h POSTER

Nonlinear principal component analysis with applications to the atmosphere and ocean

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Nonlinear principal component analysis (NLPCA) by auto-associative feed-forward neural networks with 3 hidden layers of neurons has recently been applied to analyze a number of meteorological/oceanographic datasets. However, many of these datasets, especially climate datasets, tend to be relatively short and noisy. Under these conditions, the 3-hidden-layer NLPCA exhibits serious overfitting and non-uniqueness problems and is found to be an under-determined model. We also found that the overfitting and non-uniqueness problems are greatly alleviated by trimming the NLPCA network from 3 to 2 hidden layers and eliminating the bias parameters from the bottleneck and output layers, a simpler NLPCA model result. This new model is applied to several datasets – the Lorenz (1963) chaotic system, the tropical Pacific sea surface temperatures anomaly, and the tropical stratospheric zonal winds (with the quasi-biennial oscillation phenomenon).

URL: http://www.agu.org/blu

A61C-0109 0830h POSTER

Development of a Stochastic Cloud-Radiation Parameterization

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A parameterization of the stochastic approach to modeling cloud-radiation interactions is being developed using archived data from the Atmospheric Radiation Measurement (ARM) Programs Clouds And Radiation Testbed sites. Initially, long time-series data from the ARM Southern Great Plains site will be used to characterize the cloud base height, cloud top height, cloud size, cloud spacing, and cloud optical properties during the year 2000. These observations will be analyzed to be input to a shortwave stochastic radiative transfer model. Subsequent analysis will include data from the Tropical Western Pacific site and the North Slopes of Alaska site. The output domain-averaged radiation fields will be evaluated using independent observations. One benefit of the stochastic approach is the ability to calculate more realistic heating rates. The impact of these heating rates on model dynamics will be investigated using a single-column model.

A61C-0110 0830h POSTER

Understanding Tropospheric Temperature Changes: Challenges for Observational and Model Studies

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One of the outstanding challenges in climate science today is to explain the discrepancies between near-surface temperature changes, satellite-based (Microwave Sounding Unit - MSU) temperature changes in the low-to-mid troposphere, and model estimates of these tropospheric temperature changes. Observed near-surface temperature changes show a marked warming over the period of MSU data availability (0.183oC/decade over Jan. 1979 through Dec. 1999). The standard Spencer and Christy MSU data show a much smaller warming trend over this period (0.032oC/decade for MSU channel 2). Model estimates of these trends vary depending on the assumed forcing and the model's sensitivity. Few model simulations have been run with the full complement of known forcings. For the NCAR Parallel Climate Model, a model with relatively low sensitivity, ensemble-mean trends over the above interval are 0.148oC/decade for the surface and 0.068oC/decade for equivalent MSU2. Some of these differences may be explained by differences in data coverage, uncertainties in or neglected forcings for model results, and different responses to ENSO in the different data sets. Even so, when these effects are accounted for, discrepancies still remain. Possible reasons for the remaining discrepancies include: errors in either the surface and/or tropospheric data; and/or model errors. The implications of model errors would be profound. The MSU data, if correct, would imply that all models are overestimating the climate sensitivity. If so, then projected future climate changes would also be overestimated. If we are to have confidence in current projections of global warming, the above discrepancies must be resolved.

The purpose of this talk is to review the surface/tropospheric temperature discrepancy issue. A new MSU-based tropospheric temperature data set will be evaluated relative to other observational data sets and to new model results. The new MSU data show better agreement with both the surface data and models. This raises important questions about the reliability of observational data sets in general, quantification of radiative forcing and climate sensitivity, the issue of model validation using imperfect observational data, and the statistical tools available to quantify model uncertainties with such data. The scientific challenges are far-reaching and of considerable importance, requiring cross-disciplinary collaborations between modelers, observational data producers and analysts, and statisticians.

A61D MCC: 102 Saturday 0830h

Transport and Effects of Anthropogenic Pollutants: Trace-P II

(joint with GC)

Presiding: **J Crawford,** NASA Langley Research Center**; D Jacob,** Harvard University

A61D-01 0830h

Chemical Characterization of Biomass Burning Aerosols over the Western Pacific as part of TRACE P

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Aircraft measurements of ambient aerosol inorganic chemical composition and a variety of gases were made over the western Pacific Ocean from late February to early April 2001 during NASAs Transport and Chemical Evolution over Pacific (TRACE-P) experiment. The chemical composition of ambient water-soluble fine particles was measured from the NASA P3-B research aircraft by a Particle-Into-Liquid Sampler coupled to an Ion Chromatograph (PILS-IC). For particles smaller than 1.3 mm diameter, 5 cations (sodium, ammonium, potassium, magnesium, and calcium) and 3 anions