

A21A-04 0830h POSTER

23 Years of Cloud Statistics Using HIRS Over Australia

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Clouds are an integral factor in the Earth's water and radiation budgets. Observations and improvements to the accuracy of measurements of cloud properties are crucial in supporting global climate change studies. Regional studies are also of interest and analysis of regional climate variability provides an insight into local weather systems. HIRS is the High-Resolution Infrared Radiation Sounder aboard polar orbiting satellites operated by NOAA (National Oceanographic and Atmospheric Administration). An archive of HIRS data obtained between 1979 (NOAA-5) through to 2001 (NOAA-16) was made available by CIMSS (Cooperative Institute for Meteorological Satellite Studies) at the University of Wisconsin-Madison. The data is obtained from near nadir and frequencies of observations are converted into percentages based on total number of observations for each 1 by 1 degree cell. An assessment of cloud frequency percentages for a region including areas of the Indian Ocean and Australia (0° - 60°S; 80°E - 170°E) will be presented. Climate variability and possible associations with future work to be conducted into cloud frequency and rainfall of North West Cloud Bands using MODIS data will also be covered.

A21A-05 0830h POSTER

Automated Algorithm for Analysis of Long-Term MFRSR Datasets

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A substantial upgrade of our previously developed MFRSR data analysis algorithm (Alexandrov et al. 2002) is presented. The new version features an automated cloud screening procedure based on optical thickness variability analysis. The technique is objective, computationally efficient and is able to detect short clear-sky intervals under broken cloud cover conditions. A bimodal gamma distribution is adopted as aerosol particle size model. A size of the fine mode particles and a ratio between optical thicknesses of the two modes are retrievable, the coarse mode has a fixed particle size. The aerosol optical thicknesses (total, fine, and coarse) obtained from our analysis were successfully compared with the corresponding AERONET aluminant retrievals from a CIMEL sunphotometer collocated with MFRSR. Besides the aerosol optical thicknesses and the fine mode size, the products of our analysis include time series of column amounts of ozone and nitrogen dioxide. Our algorithm is applied simultaneously to a set of daily MFRSR records covering at least a month of measurements and runs level by level: first all days are cloud screened, then all 870 nm records are calibrated using compatibility between the direct and diffuse measurements, etc. This approach allows for stabilization of the daily calibration constants on each level using a robust smoothing technique. Our preliminary results for September 2000 dataset from the MFRSR network at the Southern Great Plains (U.S. DOE Atmospheric Radiation Measurement (ARM) Program site) showed differences in aerosol fine mode size between the measurement locations. The fine particles appeared to be smaller in the South than in the North with notable anti-correlation observed between the daily mean aerosol fine mode size and the ground temperatures in the data from the northern part of the site.

A21A-06 0830h POSTER

Variability of Aerosol Optical Depth and its Relation with Natural and Man Made Hazards

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Aerosols have direct influence in global climatology and play adverse effect on human health, and the study of spatial and temporal variations of aerosol optical depth (AOD) is important. The Moderate Resolution Imaging Spectroradiometer (MODIS) instrument onboard the Terra satellite is providing spatial and temporal information about the continental and oceanic aerosols. The present study is based on the analysis of aerosol optical depth retrieved from MODIS data from March 2000 to December 2003. Several maxima values are found to be associated with the occurrence of various natural and man made hazards such as: forest, coal mine and oil well fires, volcanic activities and large blasts. The study shows dynamics of AOD concentrations with seasonal wind patterns over the eas

A21A-07 0830h POSTER

Evaluating Surface Measured vs. Satellite-Retrieved Long-term Surface SW fluxes by Surface Climatological Type.

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This study compares an analysis of monthly average surface shortwave (SW) radiation measurements from 1983 through 1995 to SW fluxes from the newly released NASA/GEWEX Surface Radiation Budget Project (SRB). The NASA/GEWEX SRB dataset provides a twelve-year-plus (July 1983 to October 1995) global dataset of surface shortwave (SW) and longwave (LW) radiative parameters on a 1x1 grid. The SW fluxes were computed with two algorithms: a primary algorithm (modified version of Pinker and Laszlo, 1992) and a SW quality-check algorithm (modified version of Darnell et al., 1992). Cloud properties were derived on a 1-resolution using International Satellite Cloud Climatology Project (ISCCP) pixel-level (DX) datasets. Other meteorological inputs, namely the temperature and humidity profiles, were taken from the GEOS-1 reanalysis product of the Global Modeling and Assimilation Office at NASA/GSFC. Ozone data were obtained from TOMS archives. Daily and monthly surface measurements were obtained from the World Radiation Data Center in St. Petersburg, Russia. Sites of high quality containing a continuous long-time series were selected and were clustered in areas of similar climatological surface type as proposed by Smith et al. (2002, J. Clim). Long-term estimates of the fluxes as inferred by the SRB dataset were compared to flux measurements. Comparisons were made in regards to the seasonal and interannual variability within the region as compared to the variability estimated by the SW SRB. In general, most regions showed high correlation between the estimates and the measurements. A few regions showed long-term changes consistent with a downward trend. One exception was a region in Egypt where surface measurements showed downward change over most the time period that was not captured in the SRB record. The reasons for this are explored. Lastly, long-term changes over the 12 year period are computed on a 1 degree basis.

A21B CC: 220 C-E Tuesday 0830h

Forcing of the High-Latitude Climate System by the Stratosphere III Posters (joint with OS, GC)

Presiding: V Ramaswamy, NOAA Geophysical Fluid Dynamics Laboratory; M P Baldwin, Northwest Research Associates

A21B-01 0830h POSTER

Stratospheric Influence on Baroclinic Lifecycles

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The possibility that the stratosphere might exert significant influence on the troposphere has recently attracted much attention. In this work, we focus our attention on how stratospheric conditions might alter the development of baroclinic instability in the troposphere, using an idealized primitive equation model with a substantial number of levels located throughout the middle atmosphere. We perform 20 day integrations, starting with an unstable tropospheric jet, similar to that prescribed by Thorncroft et al., and a number of different stratospheric jets, representative of different states of the polar night vortex. When the stratospheric winds extend sufficiently into the upper troposphere, significant departures from the LC1 paradigm are observed: the eddy kinetic energy (EKE) is suppressed, and the meridional extent of the source of upward propagating EP flux is restricted to the poleward side of the jet. This results in a meridional restriction of upper level wave breaking and the consequent incomplete barotropization of the zonal wind in the lower half of the tropospheric jet. The remaining baroclinic shear may then engender a secondary lifecycle that completes the barotropization, in which the EKE-maximum is a non-monotonic function of the strength of the stratospheric jet. The strength and time of primary and secondary lifecycles is related to parameters defining the stratospheric jet. Results are related to observed stratospheric conditions with particular reference to recently observed trends in the NAM index.

A21B-02 0830h POSTER

Nonlinear extratropical response to tropical forcing

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Using the NCEP/NCAR global reanalysis data for 51 boreal winters, a convective index (CI) for the tropical Pacific is constructed. It is found that the extreme positive and negative events of the CI are connected to the positive phases of the two dominant modes of the extratropical atmospheric variability, i.e., the PNA and the NAO, respectively. A primitive equations dry atmospheric model is used to investigate the atmospheric response to a tropical diabatic forcing pattern and explore how the atmospheric response changes as a function of the amplitude of the forcing. The forcing anomaly represents a linear fit of the model forcing to the CI. The time-averaged 500 hPa geopotential height anomaly responses of two long integrations with forcing anomalies of equal amplitudes but opposite signs show an asymmetric feature that is similar to observations. A set of linear experiments with forcing perturbations and eddy flux anomalies associated with the positive and negative amplitudes of forcing conditions indicates that the nonlinearity of the extratropical response primarily results from the modification of the "basic state" caused by the large-amplitude forcing and the subsequent sensitivity of the response to that modified basic flow.

## A21B-03 0830h POSTER

## Measuring the Forcing Function of Global Warming

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The earth's climate system is warmed by 35 C due to the emission of downward infrared radiation by greenhouse gases in the atmosphere (surface radiative forcing) or by the absorption of upward infrared radiation (radiative trapping). Increases in this emission/absorption are the driving force behind global warming. Climate models predict that the release of greenhouse gases into the atmosphere has altered the radiative energy balance at the earth's surface by several percent by increasing the greenhouse radiation from the atmosphere. With measurements at high spectral resolution, this increase can be quantitatively attributed to each of several anthropogenic gases. Calibrated radiance spectra of the greenhouse radiation from the atmosphere have been measured at ground level from Peterborough and Mirabel using FTIR spectroscopy at high resolution. This long wave radiation consists of thermal emission from naturally occurring gases such as CO<sub>2</sub>, H<sub>2</sub>O and O<sub>3</sub> as well as from many trace gases such as CH<sub>4</sub>, CFC11, CFC12, CFC22 and HNO<sub>3</sub>. The forcing radiative fluxes from CFC11, CFC12, CCl<sub>4</sub>, HNO<sub>3</sub>, O<sub>3</sub>, N<sub>2</sub>O, CH<sub>4</sub>, CO and CO<sub>2</sub> have been quantitatively measured over a range of seasons. The contributions from stratospheric ozone and tropospheric ozone are separated by our measurement techniques. A comparison between our measurements of surface forcing emission and measurements of radiative trapping absorption from the IMG satellite instrument shows reasonable agreement. The experimental fluxes are simulated well by the FASCOD3 radiation code. This code has been used to calculate the increase in surface radiative forcing since 1850 to be 2.55 W/m<sup>2</sup>. An ensemble summary of our measurements indicates that an energy flux imbalance of 3.5 W/m<sup>2</sup> has been created by anthropogenic emissions of greenhouse gases since 1850. This should effectively end the argument by skeptics that no experimental evidence exists for the connection between greenhouse gas increases in the atmosphere and global warming.

## A21B-04 0830h POSTER

## Impact on Climate due to Changes in Radiative Forcing from Stratospheric Aircraft Emissions

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Aircraft emissions can affect climate both directly and indirectly. The 1999 Intergovernmental Panel on Climate Change report on Aviation and The Global Atmosphere estimated that emissions from a fleet of one thousand High Speed Civil Transport aircraft (flying at Mach 2.4) could produce a non-negligible impact on the radiative forcing driving changes in climate. In this study we reexamine the radiative forcing from fleets of aircraft flying at stratospheric altitudes and predominantly in the northern hemisphere mid-latitude regions. We use our narrowband radiative transfer model in these studies, along with model calculations of calculated changes in ozone and water vapor from our zonally-averaged model of atmospheric chemical and physical processes. The radiative transfer model has higher resolution in the tropopause and lower stratosphere region than the models used in the 1999 IPCC assessment. Our results suggest that the radiative forcing for the water vapor emissions from aircraft was overestimated previously.

## A21B-05 0830h POSTER

## Prognostic Greenhouse Tracers in the CCCma Atmospheric GCM

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Improvements to the Canadian Centre for Climate Modelling (CCCma) atmospheric GCM, as part of ongoing work within the Canadian Global Coupled Carbon Climate Modelling (CGC<sup>3</sup>M) project, are described. Specifically, a prognostic tracer scheme has been introduced for methane and nitrous oxide, including parameterized chemical loss of both species and methane oxidation as a source of water vapour in the stratosphere. Results and sensitivity tests of ten-year climate simulations forced with climatological SSTs, sea ice, ozone, and specified surface concentration distributions of the tracers are presented. Zonally-averaged distributions are compared with UARS (HALOE/CLAES) climatology for the years 1992 to present. The model is able to reproduce the observed latitude-height distributions and seasonal variations of these radiatively important species with an accuracy sufficient for long-term transient climate simulations.

## A21B-06 0830h POSTER

## Climate Variability of Free Atmosphere in the Polar Regions

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Preliminary investigations of free atmosphere above the Arctic Ocean filled with sounding data of the drifting stations "North Pole" show that in 70% of the soundings the inversion base was on the surface; boundary layer height did not exceed 200 m; mean air temperature gradient in the inversion layer was 0.5-1.0 C/100 m. Low-level jets were found in 30% of the soundings. During the investigated period (1955-1991) the boundary layer height and surface inversion depth tended to decrease, and the temperature change through the inversion tended to increase. Longest time series of soundings, executed at the polar station Dickson, shows the maximal inversion height in late 1940s - early 1950s, minimal - in 1980s - early 1990s, and gradual increase in the last years of 20th century. Long-term variations of the monthly mean air temperature and humidity in the free atmosphere above the North Polar Region (60-90 N) were investigated with the original database, created in the Arctic and Antarctic Institute, Russia by V. Maistrova. This database combines the results of soundings executed on 116 aerological stations, ship observations and observations on the drifting stations "North Pole". The analysis of temperature trends for 1959-2003 shows that the annual mean air temperature in the North Polar Region increased in the low and middle troposphere (850-400 hPa) and decreased in the upper troposphere and in the low stratosphere. The total energy of the Arctic atmosphere attributed to the so-called "mean energetic level" shows weak positive trend with strong long-term variations. Preliminary estimates of temporal variability of mean specific humidity at 850, 700, 500, 400 and 300 hPa show pronounced increase from surface to 850 hPa and decrease above 850 hPa. The spatial distributions of air temperature and humidity trends demonstrate strong inhomogeneity of relevant meteorological fields. Comparison the trends of the annual mean air temperature and humidity for 1959-2003 in the North and South Polar Regions shows strong differences, especially in the low stratosphere, where negative trends in the Arctic much more pronounced. In total the data demonstrate the increase of local instability in the polar upper troposphere and low stratosphere, which could be explain as due to direct greenhouse effect, as well as due to changes in global circulation, originated by the increase of global or tropical ocean temperature.

## A21C CC: 520 D Tuesday 0830h

## Tropical Water Vapor: New Understanding and New Challenges I (joint with H, OS, GC)

Presiding: I Folkins, Dalhousie University; A Gettelman, National Center for Atmospheric Research

## A21C-01 0830h INVITED

## Free-tropospheric Water Vapor in the Tropics

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In the deep Tropics, convective detrainment and evaporation of precipitation falling from convective clouds are the only sources of the free-tropospheric moisture. It is thus not surprising that the observed large-scale fluctuations of the free-tropospheric humidity are closely tied to convection, with large-scale regions featuring deep convection being more humid than regions void of deep convection. Tropical convection is organized on a large range of spatial and temporal scales, and involves individual convective clouds, mesoscale convective systems, convectively-coupled equatorially-trapped waves, and intraseasonal oscillations. Coping with this range of convective phenomena in the Tropics is challenging for temporary climate models. This has important implications not only from the point of view of climate variability in the tropics, but also for the stratospheric physics and chemistry. This paper will review the role of the water vapor in the tropical dynamics and climate. In particular, it will be argued that free-tropospheric humidity is not a passive constituent, but it has a significant role in organizing convection on intraseasonal time scales. A comparison between tropical climate simulations using a traditional climate model and a model featuring a novel representation of convective processes, the superparameterization, will highlight key processes relevant to the tropical free-tropospheric water vapor.

## A21C-02 0900h

## Predicted and observed histograms of free-tropospheric water vapor

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The simplest conceptual model of free-tropospheric water vapor is that initial water vapor amounts are nearly saturated in air that is introduced from the boundary layer into the free troposphere, and are subsequently unchanged as air slowly descends to lower potential temperatures while circulating horizontally. This may be combined with stochastic models of convective lofting to predict water vapor histograms; a broad distribution of relative humidity is predicted. If cloud effects are qualitatively included, and if the sinking rate is sufficiently rapid, this distribution becomes bimodal. We present these results and test the idea using GPS and MLS (Microwave Limb Sounder) satellite observations.

## A21C-03 0915h

## Bimodality in Tropical Water Vapor

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Probability distribution functions of tropospheric water vapor in the tropics are shown to be commonly