M Daniel Schwarzkopf[3] (1-609-452-6521; ds@gfdl.noaa.gov)

[1]Department of Environmental Sciences, Rutgers University, 14 College Farm Road, New Brunswick, NJ 08901, United States

[2]International Pacific Research Center, University of Hawaii, Honolulu, HI 96822, United States

[3]NOAA Geophysical Fluid Dynamics Laboratory, P.O. Box 308, Princeton, NJ 08542, United States

A number of recent studies have suggested an important role for stratospheric dynamics in the intraseasonal, interannual and longer-term variations of extratropical surface circulation and climate. A particular focus has been on how the stratosphere affects variations of the Arctic Oscillation (AO). To understand atmospheric processes that cause the AO variability we studied the impact of the 1991 Mount Pinatubo eruption, which produced the largest global volcanic aerosol cloud in the 20th Century and caused an anomalously positive AO index in the next two winters. A series of control and perturbation experiments were conducted with the GFDL SKYHI general circulation model to examine the evolution of the circulation in the two years following the Pinatubo eruption. Forced by volcanic aerosols, SKYHI produces a statistically significant positive phase of the AO in winter, as observed. Ozone depletion causes a positive phase of the AO in late winter and early spring by cooling the lower stratosphere in high latitudes, strengthening the polar night jet, and delaying the final warming. A positive phase of the AO was also produced in the experiment with only the tropospheric effect of aerosols showing that aerosol heating in the lower tropical stratosphere is not necessary to force positive AO response, as was previously assumed. We also used long-term stratospheric wind observations at Singapore station to implement a quasi-biennial oscillation (QBO) in our simulations. Using this setup we showed that the phase of the QBO modulates climate system sensitivity to an external forcing. The QBO in its westerly phase strengthens the Arctic Oscillation response. Because of nonlinear interactions, aerosols and the QBO together produce a stronger response than a linear superposition of responses to each of these forcings. Improved quantification of the aerosol, ozone, and QBO effect helps to better understand mechanisms of the stratospheric contribution to natural and externally forced climate variability.

A14A-05 1630h

The Influence of the QBO and Solar Variability on the North Annular Mode.

Alexander Ruzmaikin[1] (818-393-3953; aruzmaik@pop.jpl.nasa.gov)

Joan Feynman[1] (Joan.Feynman@jpl.nasa.gov)

Xun Jiang[2] (xun@gps.caltech.edu)

Charles D. Camp[2] (cdc@gps.caltech.edu)

Yuk Yung[2] (ylu@gps.caltech.edu)

[1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, United States

[2]Department of Geology and Planetary Sciences, California Institute of Technology, California Blvd, Pasadena, CA 91125, United States

The Quasi-Biennial Oscillations (QBO) and solar variability are two natural stratospheric forcings affecting atmospheric dynamics and possibly climate. We study how these forcings affect the major mode of the wintertime atmospheric variability in the Northern Hemisphere, the North Annular Mode (NAM). This mode extends from the top of the stratosphere through the troposphere to sea level accounting for 22% of the variance in geopotential heights at sea level and more in the stratosphere (Thompson and Wallace, 1998; Baldwin and Dunkerton, 1999). It has been found (Ruzmaikin and Feynman, 2002) that the NAM of the coupled troposphere-stratosphere is influenced by decadal solar variability. But the influence depends on the phase of the QBO and phase of the winter season. Thus, in early (late) winter for the West (East) QBO, the NAM is more positive for low UV than for high UV fluxes. The effect was shown to be statistically significant. Here we present the results of our search for a physical mechanism by which the QBO and solar variability combined with seasonality affect the NAM. Because the NAM is excited in the interplay between the planetary waves and mean zonal wind (see for example Limpasuvan and Hartmann, 2000), we investigate the latitudinal, vertical and time distributions of the wave (EP) fluxes employing the NCEP Reanalysis Data and the ECMWF Data. We also investigate the possible effect of the QBO associated circulation on the NAM. References: Baldwin, M. P. and T. J. Dunkerton, J. Geophys. Res. 104, 30,937, 1999; Limpasuvan, V., and D. L. Hartmann, J. of Climate, 4414, 2000; Ruzmaikin, A., J, Feynman, J. Geophys. Res., 107, D14, 10.1029/2001JD001239, 2002; Thompson, D. W. J. and J. M. Wallace, Geophys. Res. Lett., 25, 1297, 1998.

A14A-06 1645h

Influence of the Southern Annular Mode on the circumpolar ocean circulation on timescales from subseasonal to interannual

Michael P. Meredith[1] (+44 151 653 8633; mmm@pol.ac.uk)

Chris W. Hughes[1] (+44 151 653 8633; cwh@pol.ac.uk)

Philip L. Woodworth[1] (+44 151 653 8633; plw@pol.ac.uk)

[1]Proudman Oceanographic Laboratory, Bidston Observatory, Prenton, Wirral CH43 7RA, United Kingdom

The Southern Ocean surrounding Antarctica is unique in being zonally unbounded, and forms a link between the Atlantic, Pacific and Indian Oceans that is important to the global oceanic thermohaline circulation and hence climate. Consequently there is great interest in measuring and understanding changes in ocean transport around Antarctica, although conventional techniques such as hydrographic sections and current meter arrays have limitations due to the complexity of the current systems. We will demonstrate that data from coastal tide gauges and Bottom Pressure Recorders (BPRs) deployed around Antarctica have great utility in monitoring the genuine circumpolar transport variability. The primary driving mechanism for the transport changes is variability in circumpolar eastward winds associated with the Southern Annular Mode (SAM, also called the Antarctic Oscillation). High levels of coherence are observed in the sea level data from around Antarctica at subseasonal frequencies, testifying to the circumpolar response to the forcing. At these frequencies, the transport changes are highly barotropic (depth independent), thus the signal of the SAM is seen to extend completely to the deep ocean floor around Antarctica. The SAM has been observed to be undergoing significant changes in the past 30 years, manifested via changes in its seasonality. These changes to the seasonal signal are also present in BPR data collected near Antarctica, and suggest a possible mechanism whereby large-scale atmospheric climate variability can directly influence ocean circulation. At interannual timescales, significant correlation is observed between the SAM and Antarctic sea level measured at Faraday (Vernadsky), despite the transport variability presumably having a significant baroclinic (depth dependent) component at these frequencies. This further suggests sensitivity of the ocean circulation to large-scale high-latitude climate variability, and presents a possible low-cost method for monitoring interannual variability in circumpolar transport. It is essential that the Antarctic tide gauge network is maintained so that continued monitoring covering longer-period signals can be pursued.

A21A CC: 220 C-E Tuesday 0830h

Magnitude and Causes of Decreasing Surface Solar Radiation Posters *(joint with B, H, GC)*

Presiding: **V R Ramanathan,** Scripps Institution of Oceanography**; H C Power,** University of South Carolina

A21A-01 0830h POSTER

Global Dimming, Diffuse Light and Photosynthesis

Michael L. Roderick[1] (+61 2 61254020; Michael.Roderick@anu.edu.au)

Graham D. Farquhar[1] (+61 2 61253743; farquhar@rsbs.anu.edu.au)

Sandra L. Berry[1] (+61 2 61254020; berry@rsbs.anu.edu.au)

Ian R. Noble[1] (+61 2 61254020; noble@rsbs.anu.edu.au)

[1]The Australian National University, CRC for Greenhouse Accounting Research School of Biological Sciences, Canberra, ACT 0200, Australia

Global dimming means that the transmission of sunlight through the atmosphere is decreasing. What effect would this have on photosynthesis? The simplest assumption would be that if there is less light then there should be less photosynthesis. In this talk we show that this assumption is wrong because; (1) canopy scale photosynthesis is very sensitive to, and usually increases with, diffuse light, and because (2) global dimming means a higher proportion of diffuse light will be incident at the surface. These two conclusions follow from two well established facts; (a) leaf scale photosynthesis saturates with light, and (b) that as the transmission of sunlight declines, the diffuse fraction of the incident sunlight increases. Both relations are remarkably invariant. Volcanic eruptions are an ideal global test of the hypothesised relations and we show why we expect that the decline in atmospheric CO2 following the eruption of Mt Pinatubo (July 1991) was due to an increase in photosynthesis.

A21A-02 0830h POSTER

Seasonal and Climatic Correlations with Surface Solar Forcing at Bet Dagan, Israel

Shabtai Cohen[1] (972-3-9683701; vwshep@agri.gov.il)

Amiran Ianetz[2] (972-3-9682173; amirani@ims.gov.il)

Gerald Stanhill[1] (972-8-9472874; gerald@agri.gov.il)

[1]Institute of Soil, Water and Environmental Sciences, ARO Volcani Center POB 6, Bet Dagan 50250, Israel

[2]Israel Meteorological Service, Research and Development Division, POB 25, Bet Dagan 50250, Israel

This study targeted the correlations between global dimming and seasonal and diurnal climatic conditions. Global, diffuse, and direct radiation measured during the last 40 years at the Israel Meteorological Service observatory at Bet Dagan, on the eastern coast of the Mediterranean Sea, where large decreases in annual global radiation have been observed and extensive climate data is available, were examined in order to determine the climatic conditions most correlated with these changes. Israel's Mediterranean climate enables clear differentiation between the cool, wet, rainy season, occurring between November and March, and the hot dry summer season between June and September. Examination of the seasonality in trends of radiative forcing shows that the largest mid-day decreases in global radiation occurred at the height of the rainy season in February, while in June, the least cloudy time of the year with zero mean cloudiness, no change has occurred. However, diffuse and direct radiation at noon and early afternoon in June have decreased and increased, respectively, during the past 10 years. Decreases in global radiation are significant at low sun angles in the mornings and evenings during most of the year, reflecting increasing haziness at these times. The significant seasonal-diurnal changes are highly correlated with wind azimuth, with the largest decreases in global radiation occurring when westerly, off-sea winds prevail. Regression of monthly average global radiation on sunshine duration for five year periods shows that there has been a gradual decrease in the extrapolated value of global radiation when sunshine duration is zero. These and other changes will be discussed with relation to their implications for solar dimming climate interactions.

URL: http://www.agri.gov.il/People/ShabtaiCohen.html

A21A-03 0830h POSTER

Role of Dust and Black Carbon on Dimming of the Arabian Sea

Igor A Podgorny[1] (858-822-1663; igor@fiji.ucsd.edu)

V. Ramanathan[1]

[1]Scripps Institution of Oceanography, CAS/SIO/UCSD, 9500 Gilman Drive, La Jolla, CA 92093-0221

Satellite aerosol and cloud data (MODIS, AVHHR, ISCCP) have been integrated with a comprehensive 3D Monte Carlo radiative transfer model to quantify the aerosol impacts on the surface solar radiation over the Arabian Sea and to generate the regional maps of aerosol radiative forcing. During winter monsoon, the haze reduces the diurnal mean solar flux at the surface by 20 W/m2 and increases all-sky solar absorption in the atmosphere by nearly the same amount. Black carbon (BC) accounts for about 60% of the aerosol induced solar absorption. During summer monsoon, the large particles (sea salt, dust) contribute up to 50% to the aerosol optical depth, but relatively low values of aerosol single scattering albedo (SSA) suggest a strong interaction between anthropogenic BC and mineral dust. While the magnitude of the surface forcing during summer monsoon is estimated to be in the range from 15 to 30 W/m2, it is a subject to a larger uncertainty due to the lack of comprehensive SSA measurements over the Arabian Sea in summer. Also the decrease in the surface solar radiation during summer monsoon is partly offset by the positive mineral dust radiative forcing in the long-wave domain. While the absorbing aerosols over the Northern Indian Ocean have been shown to affect the winter monsoon circulation in a substantial way, further research is needed to understand if the aerosol impacts during summer monsoon can be equally important for the regional climate and hydrological cycle.

A

A21A-04 0830h POSTER

23 Years of Cloud Statistics Using HIRS Over Australia

Helen C Chedzey[1] (61-8-9266-3524; helen.chedzey@student.curtin.edu.au)

W Paul Menzel[2] (paul.menzel@ssec.wisc.edu)

Mervyn J Lynch[1] (m.lynch@curtin.edu.au)

Brendan T McGann[1] (b.mcgann@curtin.edu.au)

[1]Remote Sensing and Satellite Research Group, Curtin University of Technology, Kent Street, Bentley, WA 6102, Australia

[2]Space Science and Engineering Center, University of Wisconsin-Madison, 1225 West Dayton Street, Madison, WI 53706, United States

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

Mikhail Alexandrov[1,2] (1-212-678-5548; malexandrov@giss.nasa.gov)

Andrew Lacis[2]

Barbara Carlson[2]

Brian Cairns[1,2]

Alexander Marshak[3]

[1]Columbia University, 2880 Broadway, New York, NY 10025, United States

[2]NASA Goddard Institute for Space Studies, 2880 Broadway, New York, NY 10025

[3]NASA Goddard Space Flight Center, Code 913, Greenbelt, MD 20771, United States

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 almucantar retrievals from a CIMEL sunphotometer colocated 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

Guido Cervone[1] (703-968-6573; gcervone@gmu.edu)

Roongroj Chokngamwong (rchokngа@gmu.edu)

Ramesh P. Singh (rsingh3@gmu.edu)

Menas Kafatos (mkafatos@gmu.edu)

[1]Center for Earth Observing and Space Research, 4400 University Drive, Fairfax, VA 22030, United States

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.

Marc Chiacchio[1] (757-827-4893; m.chiacchio@larc.nasa.gov)

Paul W. Stackhouse[2] (757-864-5368; Paul.W.Stackhouse@nasa.gov)

Stephen J. Cox[1] (s.j.cox@larc.nasa.gov)

Shashi K. Gupta[1] (s.k.gupta@larc.nasa.gov)

Colleen J. Mikovitz[1] (j.c.mikovitz@larc.nasa.gov)

[1]AS&M, 1 Enterprise Parkway, Hampton, VA 23666, United States

[2]NASA Langley Research Center, 21 Langley Boulevard, Hampton, VA 23681, United States

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

Matthew AH Wittman[1] (maw2006@columbia.edu)

Lorenzo M Polvani[1] (lmp@columbia.edu)

Richard K Scott[2] (richard@mcs.st-andrews.ac.uk)

[1]Columbia University, Department of Applied Physics and Applied Mathematics, 500 west 120th street, New York, NY 10027, United States

[2]Northwestern Research Associates, Inc., 14508 NE 20th Street,, Bellevue, WA 98007-3713, United States

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

Hai Lin[1] ((514)398-3164; hai.lin@mcgill.ca)

Jacques Derome[1] (jacques.derome@mcgill.ca)

[1]McGill University, 805 Sherbrooke Street West, Montreal, QC H3A 2K6, Canada

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.