

A31B-05 0900h

On the Remarkable Cooling of the Tropical Lower Stratosphere Since 1990

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Radiosonde measurements of temperature and geopotential height from several island stations in the tropical western Pacific have been used to look for long-term trends in the tropopause region and the lower stratosphere. The time period studied was up to 43 years in length, beginning in 1960 and extending through 2002 in some cases. Trends prior to about 1990 were small, in agreement with previous results and with model predictions of the effects of long-term ozone depletion and greenhouse-gas enhancements, but a steep cooling trend has taken place throughout the decade of the 1990s and appears to be continuing unabated to the present. The cooling appears to maximize between pressures of 80 and 30 hPa, and is small at the tropopause level, indicating a decrease in the stability of the lowermost stratosphere. The cooling trend is steepest in the northern-hemisphere winter and early spring, and weakest in the northern early summer months, suggesting that it is dynamical in origin, and related to the meridional Brewer-Dobson circulation of the lower stratosphere. The results and their interpretation will be discussed.

A31B-06 0915h

POAM III Ozone and Water Vapor in the Upper Troposphere and Lower Stratosphere

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We present Upper Troposphere/Lower Stratosphere (UT/LS) observations from the Polar Ozone and Aerosol Measurement (POAM) III instrument. POAM is a remote sensing instrument that uses the solar occultation technique to measure trace gas species and aerosol extinction at high latitudes. POAM began measurements in April 1998 and is still operational. Ozone and water vapor observations on potential temperature and potential vorticity surfaces will be presented, in order to study seasonal and interannual variability in the abundance of these species in the UT/LS. Isentropic stratosphere-troposphere exchange is examined by means of ozone/water vapor correlations. We find evidence of isentropic exchange from the upper troposphere at lower latitudes to the lower stratosphere at high latitudes during summer and fall. We also use POAM observations in conjunction with isentropic advection calculations of ozone, water vapor, and tracer-derived equivalent length to study seasonal variability in isentropic transport in the lowermost stratosphere.

A31B-07 0930h

Warming of the Arctic Lower Stratosphere by Light Absorbing Particle

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Light absorption by particles such as soot and dust change the thermodynamic structure of the atmosphere and contribute to regional and global climate change. The lower stratosphere is particularly sensitive to the presence of light absorbing particles (LAP) since particles in this region can reside from months to years, in contrast to upper tropospheric lifetimes of days to

weeks. The source of particles in the lower stratosphere may be aircraft, meteorites or transport from tropospheric sources. There is a serious deficiency of accurate and quantitative measurements of these particles that limits our understanding of the origin and lifetime of aerosols in this region of the atmosphere and how their presence alters radiative fluxes that lead to climate change. Here we present measurements in the Arctic lower stratosphere with a new, single particle soot photometer (SP2) that has detected black carbon (BC) mass concentrations of 20-1000 ng m⁻³. These concentrations are 10-1000 times larger than those reported in previous experimental studies and are at least 30 times larger than predictions based on fuel consumption by commercial aircraft. The comparison of the measurements of BC with published 3D model predictions suggests that particles transported from the troposphere are the likely source of LAP in the Arctic lower stratosphere. Radiative transfer calculations that include the presence of a layer of LAP between 9 and 12 km, indicate an increase in the localized heating of this layer by approximately 25%.

A31B-08 0945h

Nitric acid depressions in and near midlatitude cirrus clouds during TRACE-P

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Cirrus cloud ice particles have been implicated in scavenging a wide variety of soluble and semisoluble species. Species removed by an ice surface can undergo a number of significant processes including heterogeneous reactions with other adsorbed species, vertical redistribution in the troposphere from sedimenting particles, or modifying the microphysical properties of the ice particle. Nitric acid (HNO₃) has been shown in the laboratory to readily adsorb onto ice surfaces, and modeling studies suggest significant perturbations to its distribution can result. Unfortunately, field observations of HNO₃ within and near cirrus clouds have shown mixed and sometimes contradictory results. The NASA P-3B aircraft sampled numerous upper tropospheric, mid-latitude ice clouds during Flight 24 of the NASA TRACE-P field experiment. In contrast to tropical cirrus clouds, the cirrus ice clouds sampled by the P-3B were at warmer temperatures of -17 to -32 degrees Celsius and at pressures of 365-436 mb. The clouds' origins ranged from jet stream induced cirrostratus clouds to convectively-induced cirrus anvils. Nitric acid levels decreased 60-70 pptv (35-60%) within the clouds compared to areas just outside of it. Slight asymmetries in the HNO₃ profiles around the cloud were noted, with the lee or downwind sides of clouds containing more gradual returns from inside cloud levels to "background" levels, potentially due to greater mixing as the cloud evaporated. If HNO₃ removed inside the cloud were distributed evenly onto ice surfaces, approximately one tenth of a monolayer of HNO₃ was adsorbed onto ice (based on estimates of ice surface area density of 5000 microns squared per cubic centimeter). The incorporation of HNO₃ into existing liquid quaternary NH₃/H₂SO₄/HNO₃/H₂O aerosols within the cloud could also be important due to the sampling location over central North America where elevated NH₃ emissions exist. The midlatitude HNO₃/cirrus cases observed on the P-3B will be contrasted to liquid water clouds sampled elsewhere during TRACE-P (only slight depressions observed), recent field results of tropical cirrus clouds, and laboratory and modeling studies.

A31C MCC: Level 1 Wednesday 0830h

Atmospheric Dynamics and Transport Posters (joint with SA, AE)

Presiding: E Ray, NOAA Aeronomy Laboratory; E Richard, NOAA Aeronomy Laboratory and CIRES

A31C-0036 0830h POSTER

The Equations of Motion in PV-coordinates

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The importance of potential vorticity (PV) for the global circulation of the atmosphere is now well recognized. This quantity captures all relevant information about balanced flows in a single scalar field, and therefore many aspects of the general circulation can be described compactly in terms of potential-vorticity dynamics. The dynamical equations governing the atmospheric flow can be transformed into a system of coordinates that uses PV as the meridional coordinate. We are exploring the utility of this coordinate for modeling the zonal-mean flow. The technique relies on the fact that PV is materially conserved in adiabatic, frictionless flow. We have constructed a shallow-water model on a sphere in which the meridional coordinate is the potential vorticity. In this model, (i) the mass flows in only one direction, parallel to the latitudinal circle on a surface of constant potential vorticity, (ii) the zonally averaged mass-weighted angular momentum changes only in response to the net form drag acting on a PV contour, (iii) in a time average or steady state the form drag is the same on all PV contours. We have also generalized the model to three dimensions, using potential temperature coordinates.

A31C-0037 0830h POSTER

Statistical Characterization of Stably Stratified Atmospheric Boundary Layer Turbulence

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In comparison with convective and neutral boundary layers, stable boundary layer (SBL) turbulence has not received much attention despite its scientifically intriguing nature and practical significance (e.g., numerical weather prediction and pollutant transport). This might be attributed to the lack of adequate field or laboratory measurements, to the inevitable difficulties arising from small scales of motion due to stratification - in numerical simulations and to the intrinsic complexity of its dynamics (e.g., intermittency). Fortunately, the contemporary literature is witnessing a brisk surge in the SBL research. Field campaigns like SABLES 98, CASES-99 and high-quality wind-tunnel experiments geared towards comprehensive investigation of SBL are being carried out. In the case of numerical modeling, a handful of partially successful Large-Eddy Simulations (LES) and a few Direct Numerical Simulations (DNS) were also attempted. Despite all these synergistic efforts in understanding the SBL, several outstanding issues still remain. It is the purpose of this paper to address some of these (seemingly controversial) issues, such as the validity of Monin-Obukhov similarity under very stable stratified condition, existence of local scaling in non-traditional top-down boundary layers and the characteristics of probability density functions of turbulence in SBL. This is accomplished through extensive analysis of turbulence data from several field experiments. Wherever possible, support of our claims is provided by further analysis of wind-tunnel data and also by comparison with reported LES and DNS results.

A31C-0038 0830h POSTER

Turbulence Modeling of GABLS Stable Atmospheric Boundary Layer Intercomparison Case

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The GABLS arctic stable boundary layer intercomparison case is simulated using the One-Dimensional Turbulence (ODT) model. ODT is a single-column simulation in which vertical turbulent transport is represented by an unsteady, stochastic advective process, rather than the customary representation by a diffusive process. Unlike conventional single-column models, ODT resolves small-scale, unsteady motions and transport processes in the stable atmospheric boundary layer. In the GABLS intercomparison case, it captures small sporadic turbulent bursts that are not resolved by conventional single-column models or by large-eddy simulations. Strong property gradients in the shear-dominated near-surface boundary layer are resolved to the roughness scale, so a Monin-Obukhov-type near-surface parameterization is not needed. Results presented here include instantaneous and time-averaged vertical profiles of velocity components and

potential temperature, and fluctuation statistics of turbulent fluxes and terms of the turbulent kinetic energy budget. The ODT approach is intermediate in cost between conventional single-column models and large-eddy simulations. ODT has been tested against experimental data for a number of different convective, stably-stratified, sheared, and reacting flow configurations. It has proven to be an efficient tool for studying parameter dependencies in various flows. With further development, ODT could be implemented in global circulation models to provide improved representation of vertical transport and mixing at a modest increase in computational cost.

A31C-0039 0830h POSTER

PIV Measurements of Atmospheric Turbulence and Pollen Dispersal Above a Corn Canopy

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Dispersal of pollen grains by wind and gravity (Anemophilous) is one of the oldest means of plant fertilization available in nature. Recently, the growth of genetically modified foods has raised questions on the range of pollen dispersal in order to limit cross-fertilization between organically grown and transgenic crops. The distance that a pollen grain can travel once released from the anther is determined, among others, by the aerodynamic parameters of the pollen and the characteristics of turbulence in the atmosphere in which it is released. Turbulence characteristics of the flow above a pollinating corn field were measured using Particle Image Velocimetry (PIV). The measurements were performed on the eastern shore of the Chesapeake Bay, in Maryland, during July 2003. Two PIV systems were used simultaneously, each with an overall sample area of 18x18 cm. The spacing between samples was about equal to the field of view. The PIV instrumentation, including CCD cameras, power supply and laser sheets forming optics were mounted on a measurement platform, consisting of a hydraulic telescopic arm that could be extended up to 10m. The whole system could be rotated in order to align it with the flow. The flow was seeded with smoke generated about 30m upstream of the sample areas. Measurements were carried out at several elevations, from just below canopy height up to 1m above canopy. The local meteorological conditions around the test site were monitored by other sensors including sonic anemometers, Rotorod pollen counters and temperature sensors. Each processed PIV image provides an instantaneous velocity distribution containing 64x64 vectors with a vector spacing of 3mm. The pollen grains (100µm) can be clearly distinguished from the smoke particles (1µm) based on their size difference. The acquired PIV data enables calculation of the mean flow and turbulence characteristics including Reynolds stresses, spectra, turbulent kinetic energy and dissipation rate. Data analysis is currently in progress and results, focusing on the flow very near to the canopy will be presented. This research is funded by the National Science Foundation (NSF).

URL: <http://pegasus.me.jhu.edu/~lefd/BioComp/FieldExperiment/FieldExperiment.htm>

A31C-0040 0830h POSTER

Nocturnal Katabatic Air Flow in a Forested Watershed: Measurements and Modeling

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Many productive forest ecosystems are in mountainous regions where their carbon and energy exchange with the atmosphere cannot be readily studied using micrometeorological methods. At night, katabatic air

drainage flow commonly develops in sloping forested watersheds. Such flow is maintained by a three-way balance between gravitational forcing, turbulent mixing and non-linear advection. The carbon dioxide concentration and carbon isotope composition in nocturnal drainage flows may provide information about recent ecosystem productivity, but to interpret these data it is necessary to understand how the properties of the flow are influenced by forest structure and turbulence. We report measurements from a tower erected near the base of an incised watershed in the H.J. Andrews Experimental Forest in the Oregon Cascade Range, and include early results from a numerical modeling program. The watershed is forested with Douglas-fir about 45 years old and 25m high. The tower, 28m high, carries sonic and cup anemometers and thermistor temperature sensors at eight levels. Katabatic drainage flow occurs almost every night and persists for up to 18 hours. The depth of the flow is at least 28m on occasions, and the windspeed often peaks in mid-canopy. The in-canopy flow is well-mixed, with very small vertical gradients of carbon dioxide concentration and temperature. There are some indications that radiative cooling at the canopy top may encourage additional uncoupled drainage flow above the canopy. A numerical model of katabatic flow on slopes is being modified to include roughness elements to simulate a forest canopy. Comparisons between observations and the model will be reported.

A31C-0041 0830h POSTER

The Effect of Lake Michigan on the Sustainance of Mesoscale Convective Systems. Part I: Short-Term Climatology

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The primary aim of this research is to investigate the influence of Lake Michigan on the intensity of mesoscale convective systems (MCSs). One of the greatest nowcast challenges during the warm season is anticipating the impact of the Great Lakes on severe convection, particularly MCSs capable of producing damaging widespread windstorms known as derechos. Specific objectives of the research include: 1) The development of a short-term climatology of MCS events that have impacted the Great Lakes region over the past seven years (1996-2002); 2) An analysis of radar, satellite, surface (including buoy and lighthouse observations), and lake surface temperature data to determine the environmental conditions impacting the evolution of MCSs passing over a Lake Michigan; 3) An examination of MCS initiation times and seasonal frequencies of occurrence to delineate temporal consistencies in MCS evolution due to changing lake surface temperatures; and 4) The development of conceptual and forecast models to help anticipate MCS intensity and morphology as these systems interact with the Great Lakes environment.

A31C-0042 0830h POSTER

Surface flux processes and evolution of characteristic eddy scales above a young Middle Rio Grande forest

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The extended drought throughout the Southwest has brought water budgets and policy decisions into public purview. It is often presumed that riparian restoration, i.e. removal of non-native species, presents a water salvage panacea. The cost of such operations can be prohibitive, making reliable estimates of

phreatophytic ET a crucial piece of information. This study has taken a long-term approach to monitoring ET water flux from a variety of these forests. ET monitoring towers have been established at 5 sites along the Middle Rio Grande - 2 over mature cottonwood forests, 2 over mature saltcedar forests, and 1 over a young mixed stand of Russian olive and willow. Because there is yet no infallible method for determining ET fluxes, eddy covariance technology provides the best method for evaluating those processes in the surface layer by provided data directly into surface flux similarity relationships. ET, energy, and carbon flux were measured during the 2003 growing season from towers using the 3-dimensional sonic eddy covariance (3SEC) method. Scalar flux sensors included a 3-D sonic anemometer, Krypton hygrometer, 12.7 µm type E fine wire thermocouple (Campbell Scientific, Inc), and LI-7500 open-path IRGA (Licor, Inc). An averaging period of 30 min was chosen based as a period of low cospectral density. The following corrections were applied to these fluxes: coordinate rotation; correction of frequency-specific signal attenuation due to instrument separation, instrument line averaging, and signal path length (Massman 2000 & 2001); krypton hygrometer calibration as a function of humidity; oxygen contribution to the krypton hygrometer signal; and flux effects on measured densities (Webb et al 1980). These corrections reduced the closure error by 5 percent. Closure was then forced using the measured Bowen Ratio as the weighting factor. Measured ET, along with leaf area index, was reduced as much as 35 percent during the prolonged drought in the southwestern U.S. At the end of the season, younger cottonwood, willow, and Russian olive forests were developing severe chlorosis (< 100 mg m⁻² at some locations), and ET rates fell from 8.5 mm day⁻¹ to 4.4 mm day⁻¹ due to a record-breaking hot July. Evaluation of the 10-Hz raw data from the 3SEC system was performed using cospectral and wavelet time series analyses. Of particular interest are the low frequency harmonics between the turbulent scales and the spectral gap. Correlation of intermittent flux variations with variations in net radiation preceding summer monsoon precipitation illustrates the relative roles of vegetative homeostasis and advection in explaining remaining closure error following turbulence corrections. This time series analysis of physical turbulent Monin-Obukhov scales and surface fluxes illustrates the frequency-temporal relationships between surface processes, stomatal control, and mesoscale forcing events.

A31C-0043 0830h POSTER

Seasonal Dependency of Diurnal and Semidiurnal Surface Wind Variations Over the Tropical Pacific Ocean

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To advance our understanding of the behavior of the large-scale atmospheric circulation, the daily cycle of the near-surface wind field over the tropical Pacific Ocean was examined. Hourly wind measurements collected from 53 moored buoys in the Tropical Atmosphere Ocean array (9°N-8°S, 165°E-180°W) from 1993 through 2002 were used to document seasonal changes of the diurnal and semidiurnal harmonics of surface wind variability. The zonal wind component was dominated by a semidiurnal variation, with a near-uniform amplitude (~0.14 m/s) and phase (~0300 and 1500 local time) across the tropical Pacific. The semidiurnal cycle showed no apparent seasonal differences and was generally well explained by atmospheric thermal tidal theory. The meridional wind component, on the other hand, exhibited primarily diurnal variability (amplitudes ~0.17 m/s) with opposite phase on either side of the equator, particularly in the western Pacific (~0600-0900 local time in the Northern Hemisphere, 1800-2100 local time in the Southern Hemisphere). This induced a diurnal cycle of wind divergence near the equator, with enhanced convergence in the late evening. This diurnal cycle of surface wind divergence may contribute to the diurnal cycle in convection and rainfall observed near the equator. Some seasonal dependence was found in the diurnal meridional wind variations in the eastern equatorial Pacific, with stronger amplitudes during boreal summer and autumn.

A31C-0044 0830h POSTER

Relationships Between Polar Highs Activity and Air Temperature Anomalies in the North Pacific Region

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Because of thermal deficit in the Arctic Basin region which reign throughout the year and especially during the winter season, polar air masses break out from the North Pole equatorward as polar highs. Polar highs which circulate across the North Pacific region descend from North Eastern Siberia. They travel the Pacific Ocean by Bering, Okhotsk, Japan and East China seas, then adopt zonal trajectories with a meridional component. Around 40 percent of them continue their trajectories to North Western America. Along their paths, polar highs affect atmospheric characteristics and especially air temperature. This study establishes relationships between space-time variability of polar highs and air temperature at 2 meters in North Pacific aerological space. Initially, from daily sea level pressure data for the region 80°E to 110°W and 90°N to 0°, we have developed an automated method to track the paths and record features for each polar high track during the period 1950-1999. Next, we have analyzed the seasonal cycle of these features: frequency, maximum pressure, velocity and type of trajectory. With this information we have computed an index which characterizes the inter-annual variability of polar highs activity. Finally we have calculated temporal correlations between the polar highs activity index and air temperature anomalies at 2 meters for each season. The strongest correlations are found in winter with positive correlations in the inter-tropical zone and negative correlations in North Eastern Siberia and Central North Pacific. The large-scale physics governing these relationships will be elucidated.

A31C-0045 0830h POSTER

Multiple Planetary Flow Regimes and the Eddy Forcing in Northern Hemisphere Wintertime Variability

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A cluster algorithm is applied to the zonal mean zonal wind from winter monthly means of the reanalyses of NCEP/NCAR. Four reproducible and robust clusters are found: two regimes represent the opposite phases the Northern Hemisphere Annular mode (NAM), and two regimes represent the opposite phases of a pattern which can be identified with the Cold Ocean-Warm Land (COWL) pattern. This identification is accomplished by regressing the zonal-mean zonal wind on the COWL-index derived from 500 hPa height data by Wu and Straus [2002]. Transformed Eulerian (or Eliassen-Palm) eddy forcing analysis is used to examine the maintenance of these clusters. The results show that barotropic forcing by the eddy momentum fluxes appears to maintain the wind anomalies in the upper troposphere and balances the Coriolis acceleration associated with the anomalous transformed mean meridional circulation, while the Coriolis acceleration maintains the wind anomalies against friction in the lower troposphere. This mechanism holds for both NAM-like and COWL-like regimes.

A31C-0046 0830h POSTER

Yearly 24-hour Lidar Observations: Diurnal and Semi-diurnal Tides of Sodium Density, Temperature, and Wind

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The Colorado State sodium wind/temperature lidar measurements are used to characterize the bi-monthly behaviour of tide in the mesopause region (80-105 km). Total 936 hour data were taken throughout the diurnal and annual cycles at Fort Collins, CO from May 2002 through April 2003. This paper will present the monthly mean as well as diurnal and semi-diurnal tides of sodium density, temperature and zonal wind profiles in the mesopause region based on this data set.

A31C-0047 0830h POSTER

Gravity Wave Parameters Derived from High Vertical Resolution U.S. Radiosonde Data

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Five years of high vertical resolution U.S. radiosonde data have been analyzed to derive important gravity wave parameters such as intrinsic frequency, vertical wavelength, and vertical and horizontal directions of gravity wave energy propagation. It is found that all these parameters display distinctive latitudinal and seasonal variations. Most dominant gravity wave intrinsic frequencies divided by the Coriolis parameter are around 3.9 in the troposphere, and 2.4-3 in the lower stratosphere. In the lower stratosphere, this ratio generally decreases with increasing latitude and is higher in NH winter than summer at mid- and high latitudes. Most dominant gravity wave vertical wavelengths decrease with increasing latitude in the lower stratosphere, and they maximize at mid-latitudes in the troposphere. In both the troposphere and lower stratosphere, the vertical wavelengths are longer in winter and shorter in summer. Approximately 50% of the tropospheric gravity waves show upward energy propagation, whereas there is about 75% upward propagation in the lower stratosphere. The lower stratospheric percentage is smaller in winter and bigger in summer. In the lower stratosphere, the dominant horizontal wave propagation direction is eastward south of 25 N and westward north of 25 N. Waves are relatively more isotropic in the troposphere. Moreover, lower stratospheric waves are found to be more anisotropic in winter. Interpretations are given to explain the derived latitudinal and seasonal variations of these parameters.

A31C-0048 0830h POSTER

Hydraulic Jumps, Waves and Other Flow Features Found by Modeling Stably-Stratified Flows in the Salt Lake Valley

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The Advanced Regional Prediction System (ARPS) was used to simulate weak synoptic wind conditions with stable stratification and pronounced drainage flow at night in the vicinity of the Jordan Narrows at the south end of Salt Lake Valley. The simulations showed the flow to be quite complex with hydraulic jumps and internal waves that make it essential to use a complete treatment of the fluid dynamics. Six one-way nested grids were used to resolve the topography; they ranged from 20-km grid spacing, initialized by ETA 40-km operational analyses down to 250-m horizontal resolution and 200 vertically stretched levels to a height of 20 km, beginning with a 10-m cell at the surface. Most of the features of interest resulted from interactions with local terrain features, so that little was lost by using one-way nesting. Canyon, gap, and over-terrain flows have a large effect on mixing and vertical transport, especially in the regions where hydraulic jumps are likely. Our results also showed that the effect of spatial resolution on simulation performance is profound. The horizontal resolution must be such that the smallest features that are likely to have important impact on the flow are spanned by at least a few grid points. Thus, the 250 m minimum resolution of this study is appropriate for treating the effects of features of about 1 km or greater extent. To be consistent, the vertical cell dimension must resolve the same terrain features resolved by the horizontal grid. These simulations show that many of the interesting flow features produce observable wind and temperature gradients at or near the surface. Accordingly, some relatively simple field measurements might be made to confirm that the mixing phenomena that were simulated actually take place in the real atmosphere, which would be very valuable for planning large, expensive field campaigns. The work was supported by the Atmospheric Sciences Program, Office of Biological and Environmental Research, U.S. Department of Energy. The National Energy Research

Scientific Computing Center (NERSC) provided computational time. We thank Professor Ming Xue and others at the University of Oklahoma for their help.

A31C-0049 0830h POSTER

Numerical Study of Moist Baroclinic Cyclones: Environment and Development Characteristics

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A mean state of the atmosphere (wind and thermal structure) designed to maximize diabatic heating feedback on synoptic scale circulations is studied numerically with respect to stability to baroclinic perturbations. Simulations are presented that follow the evolution of cyclonic vortices at finite amplitude. Results include a faster evolution and a spatial structure modified at all levels, and the appearance of mesoscale features within the synoptic cyclone. The meridional eddy fluxes associated with the moist baroclinic cyclone are able to regenerate a baroclinically unstable belt, to the North of the original one, which is newly unstable to short scale perturbations. The initial mean state is designed by imposing zero equivalent potential vorticity, and can be generated by short scale instabilities in a saturated environment.

A31C-0050 0830h POSTER

Cyclone Activity associated with the Summer Precipitation Dipole Pattern over Northern Eurasia

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An east-west seesaw-like oscillation of dry and wet extremes is a marked characteristic of interannual variability of summer (June-August) precipitation in Siberia (Fukutomi et al. 2003a, JHM). They found an out-of-phase relationship in the temporal and spatial signature of basin-scale precipitation between eastern and western Siberia (ES and WS), which is characterized by an east-west dipole pattern across northern Eurasia. This interannual seesaw with about 6-8-yr timescale has been pronounced in recent 30 years. The formation of the Siberian precipitation dipole anomalies may be related to interannual changes in extratropical cyclone activity. From this viewpoint, this study examines mid-tropospheric cyclone activity and cyclone tracks involved in two opposite phases of the precipitation dipole that are out-of-phase with each other (ES-wet-WS-dry and WS-wet-ES-dry). To accomplish this, the global cyclone climatology data for the period 1957-1997 (Key and Chan 1999, GRL) was employed. Additionally, the NCEP-CPC global land precipitation (PREC/L) data, and the NCEP/NCAR reanalysis data were used. First, we selected four ES-wet-WS-dry summers (1974, 1981, 1988, and 1989) and four WS-wet-ES-dry summers (1979, 1986, 1992, and 1996 - based on the Siberian precipitation seesaw index (Fukutomi et al. 2003b, submitted)). Then a composite analysis is performed on the 500mb cyclone frequency and cyclone tracks for these phases. The results present a coherent picture of cyclone behavior with the east-west contrastive structure of the summer precipitation distribution over northern Eurasia. Composite field of anomalous cyclone frequency exhibits quite similar east-west dipole pattern across northern Eurasia with that of precipitation. The number of cyclones increases (decreases) in the vicinity of above (below) normal precipitation region. Tracks of cyclones moving into the Siberian domain for the ES-wet-WS-dry phases pass through central Siberia (CS), and mainly originate in the WS region and Kara Sea. On the other hand, those for the WS-wet-ES-dry phases cross predominantly over WS, and these systems come from European Russia and Barents Sea. In this situation, the cyclone track density is quite low over ES. The interannual variability of the summer cyclone frequency in the WS (CS-ES) box significantly correlates with that of the basin-averaged summer precipitation for WS (ES). In summary, our results suggest that the appearance of the Siberian precipitation dipole pattern strongly depends on the high-latitude cyclone activity.

A31C-0051 0830h POSTER

Tracer Transport in the Atmosphere

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Atmospheric tracer transport governed by large scale weather systems in the troposphere and the stratosphere determines global distribution of chemical tracers, ozone and water vapour. Identification of barriers to transport such as tropopause is important to enable understanding of different concentrations of such tracers in different parts of the atmosphere. Understanding the exchange of fluid and transport of fluid particles across oceanic eddies on the other hand is essential for an assessment of distribution of fluid properties such as temperature and salinity. Intergyre transport is dominated by coherent eddies which trap fluid and carry it along with them. The effect of such atmospheric eddies on transport of tracers can be analyzed from geometric point of view offered by dynamical systems theory to study Lagrangian particle dynamics. Point vortex system on a sphere appears as finite dimensional approximation to vorticity evolution, equations of motion of which are derived by substituting delta functions into the vorticity equation. This Hamiltonian system acts as a dynamical model for the motion of concentrated regions of vorticity on a sphere. Stable and unstable manifolds of hyperbolic points are obtained from numerical simulations and KAM tori representing barriers to fluid transport can be identified. We will investigate sharing of fluid by vortex rings and effect of coherent vortices in mesoscale transport in such a three-dimensional geometry and show that transport in this vortex model depends on topology of streamlines. Topology of the advected boundary is governed by time-dependence of advecting flow which is distinguished by isolated regions of closed streamlines bounded by separatrices.

A31C-0052 0830h POSTER

Tracer Dispersion Within an Urban Environment.

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The transport and dispersion of pollutants has extremely important implications for the environment on urban, regional and global scales. At the urban level localised emissions of both biogenic and anthropogenic pollutants can directly impact the health of the inhabitants. The DAPPLE (Dispersion of Air Pollutants and their Penetration into the Local Environment) project is a consortium of six universities, which involves a multidisciplinary approach to characterise relatively small-scale urban atmospheric dispersion including wind tunnel modelling, computer simulations, fieldwork and analysis. This work describes the tracer technology used to characterise atmospheric dispersion as well as preliminary results from the first tracer release experiment in Central London. A steady state finite duration release of both perfluoromethylcyclohexane (PMCH) and Sulfur Hexafluoride (SF₆) was performed as part of the first DAPPLE campaign. These compounds were released over a fifteen-minute integrated time period with the SF₆ release staggered one and a half minutes behind the PMCH. The low background concentrations of PMCH (5 x 10⁻³ pptv) and SF₆ (5 pptv) along with non-depositing and non-reactive characteristics allow for the implementation of near ideal fluid dynamic experiments. Sampling consists of a multipoint ladder fitting with solenoid valves onto which a succession of sampling bags is attached. These are electrically actuated in sequential order with an integrated sampling time of three minutes. The samplers are placed at various receptor positions in the DAPPLE zone in predefined positions designed to best validate these model simulated meteorological dispersion processes. Analysis of PMCH is carried out using sample enrichment on carbon based adsorbents, separation by capillary Gas Chromatography and Negative Ion Chemical Ionisation Mass Spectrometry detection (GC-MS-NICI). SF₆ concentrations are determined using fixed volume loop injections with Gas Chromatography with an Electron Capture Detector (ECD). Preliminary results from the first field campaign in London are presented. These results compare well with those obtained from an advanced operational dispersion model and simple analytical models run at Cambridge University, UK as well as wind tunnel tracer simulation experiments carried out at the University of Surrey, UK.

A31C-0053 0830h POSTER

A Survey of Lidar Data for the Joint Urban Disperion 2003 Experiment

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During July of 2003, the U.S. DOD, DOE, and Army Research offices sponsored a field experiment (JU2003) in Oklahoma City to better understand and model atmospheric releases in urban environments. As part of this study, Arizona State University deployed a coherent Doppler lidar. The ASU lidar was deployed approximately 4 kilometers south of the central business district with the purpose of characterizing the inflow region. Typical winds during July in Oklahoma are from the south. The ASU lidar employed a variety of scanning strategies to obtain radial velocity and aerosol backscatter fields. A sampling of the data gathered will be presented. A unique aspect of the lidar data at JU2003 was that another lidar (with the same type of laser and software acquisition systems) was simultaneously deployed by the Army Research Laboratory. During portions of the experiment, the two lidars scanned similar volumes and planes from two different locations. Therefore, retrieval of vectors from the radial velocity fields is possible. Early retrievals of vectors from co-scanned volumes will be presented. General operation of the ASU lidar and data availability will be discussed.

A31C-0054 0830h POSTER

Characterization and Transport of Aerosols in the El Paso- Juarez Airshed

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Aerosol optical depth measurements, in conjunction with novel inversion techniques, are used to determine the size distribution of airborne particulates in the El Paso, TX-Juarez, MX region (El Paso-Juarez Airshed). The inversion method was developed using Twomey's regularization method as a foundation. In our methodology novel algorithms are developed to determine the constraint coefficient and the regularization matrices. The extinction coefficient of the airborne particulates is calculated utilizing the T-matrix code. SEM images of regional airborne particulates are analyzed to determine aerosol physical characteristics for input into the T-matrix. Subsequently, the Mesoscale Model 5 in combination with trajectory analysis is implemented to study the transport of particulates in the El Paso-Juarez Airshed. The impact of an urban area on the concentration of aerosols on the surrounding rural and pastoral areas is analyzed for the El Paso-Juarez Airshed.

A31C-0055 0830h POSTER

Analysis of the Transport of Volcanic Ash from the July, 2003 Eruption of the Soufrière Hills Volcano on Montserrat to Puerto Rico

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The Soufrière Hills Volcano is located on the southern half of the Caribbean island of Montserrat. Montserrat is situated in the northern part of the Lesser Antilles, which is a volcanic island arc formed along the junction of the Atlantic tectonic plate and the Caribbean plate. The Soufrière Hills Volcano began erupting in 1995. On July 12, 2003, a lava-dome of the volcano collapsed and led to several days of explosions that rocked the island and injected ash into the atmosphere. This presentation will focus of the transport mechanism of the volcanic ash from the island of Montserrat to the southwest coast of Puerto Rico. Trajectory models will be used to show the air mass history and movement of the ash during transport. This data will be supported with In situ measurements of

aerosol particle size and mass distributions taken on the southwest coast of Puerto Rico in the days before, during, and after the lava-dome collapse.

A31C-0056 0830h POSTER

Evaluation of Tephra Found in the Law Dome Ice Core, East Antarctica

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The presence of tephra in several sections of the Law Dome ice core, collected in East Antarctica, has enabled us to expand on the glaciochemical record of volcanic events detected in that core (Palmer et al., JGR, 2001). High snow accumulation, low summer temperatures that inhibit melting and relatively moderate winds that limit the amount of post-depositional mixing of snow at the coring site has helped produce a well-dated, and highly-resolved chronology of past volcanic activity. We expanded on this chronology by filtering continuous meltwater samples covering the last 700 years and by analyzing volcanic glass shards found in these sections with an electron microprobe with the objective of identifying the volcanic sources. We found rhyolitic glass in 15 different layers and are presently working on identification of the source volcanoes. The lack of significant populations of shards at many of these depths make the interpretation of these shards as time-stratigraphic makers equivocal. However, the compositions are not known to occur in Antarctica volcanic systems, thus we believe that they represent either southern hemisphere mid-latitude or equatorial eruptions. Several potential sources include rhyolitic volcanoes in New Zealand or South America. These results, in combination with the tephra analyses that we performed on the Antarctica Siple Dome and Taylor Dome ice cores, suggest that in addition to the stratospheric transport of volcanic debris from South America and New Zealand to Antarctica, tropospherically transported material may be another source of tephra particles found in Antarctica ice cores. Large particle sizes as well as thickness of the several tephra layers combined with results of satellite observations on propagation of volcanic clouds from recent eruptions of South American volcanoes allowed us to suspect this tropospheric mode of transport. This work provides interesting new evidence on past circulation patterns in the Southern Hemisphere and on the climatic-forcing capabilities of volcanic eruptions.

A31C-0057 0830h POSTER

Water vapor transport to the Tibetan Plateau revealed with stable isotopes of precipitation: a new hypothesis for unusual isotope signals

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Spatial and temporal variations of oxygen and hydrogen stable isotopes in precipitation were observed on the Tibetan Plateau and in Nepal during the

GAME/Tibet field campaign in 1998. Different spatial patterns in delta-18O were found between active and break phases of Indian monsoon activity. During a break phase, low delta-18O with relatively low d-excess (<15) values were observed at all observational sites south of Tanggula mountain on the plateau, indicating that water vapor directly transported from the south over the Himalaya reached the central region of the plateau. Decrease in delta-18O from south to north on the plateau was insignificant, which indicates a high contribution of recycled water. During an active phase, low delta-18O with relatively low d-excess was observed in the region between the Himalaya and Nyainqentanghla mountain, indicating direct transport of water vapor from the south to this region, while high delta-18O with high d-excess value was observed in the region between Nyainqentanghla and Tanggula mountains. High delta-18O and high d-excess values were observed when water vapor was transported from the west or north. Water vapor with unusually high delta-18O and high d-excess may be formed by dynamic fractionation of water with low delta-18O in convective clouds in the ITCZ.

A31C-0058 0830h POSTER

Pollution Sources Over the Grand Canyon and Canyonlands National Parks

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To investigate pollution sources that are degrading the visibility of two national parks, Grand Canyon National Park, AZ, and Canyonlands National Park, UT, daily samples of total suspended particulates (TSP), PM_{2.5}, trace gases, and organic compounds were collected in the two parks in the summer (July) of 2001 and winter (December-January) of 2001-2002. Factor analysis results show a number of anthropogenic signals (e.g., smelters) in the summer air over the Grand Canyon. In winter, the Grand Canyon samples revealed an aged pollution signal, which was probably transported from long distance, and a local source. In contrast, Canyonlands has less distinctive pollution signals in summer compared with winter. Summer air there shows an aged pollution source, evidence for smelter impacts on the concentrations of rare-earth elements and other metals, and a titanium source. More individual pollution signals were identified from the winter samples at Canyonlands (e.g., coal combustion and smelters). Our chemical and meteorological data clearly indicate that the main long-range transport pathway for pollution in summer is via southwesterly winds at both national parks; this implicates western Arizona as a likely source region. In winter pollution comes from the Salt Lake area via northerlies or northwesterlies.

A31C-0059 0830h POSTER

Can Large Windfarms Affect Local Meteorology?

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A numerical model was used to explore the possible impacts of large windfarms in the Great Plains region on the local meteorology over synoptic timescales under typical summertime conditions. Wind turbines were approximated as sinks of energy and sources of turbulence. A virtual windfarm was created using an array of such turbines. Results show that windfarms significantly slow down the wind at the turbine hub-height level. Additionally, the turbulence generated by rotors create small-scale eddies that enhance vertical mixing of momentum, heat and scalars usually leading

to a warming and drying of the near-surface air and reduced surface sensible heat flux. This effect is most intense in the early morning hours when the hub-height level wind speed is the strongest due to the nocturnal low-level jet. The impact on evapotranspiration is small.

A31C-0060 0830h POSTER

Solar cycle signals in northern hemisphere wave activity

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Although there have been many indications of solar cycle influence on the Earth's climate from observational and statistical studies, the physical mechanism of Sun-Climate connections is thus far still unclear. One generally agreed, but unproved theory suggests that solar UV variation affects stratospheric ozone, which in turn affects stratospheric temperature and circulations. The stratospheric changes then propagate downward to the troposphere through modulation of tropospheric wave propagation and wave-mean flow interactions. To examine to what extent this theory is valid, we search for atmospheric regions where dynamical quantities including wave fluxes show, if any, the strongest apparent solar cycle. Based on the NCEP/NCAR Reanalysis data since 1979, we find that during solar maxima the northern hemisphere waves tend to be refracted more equatorward near the subtropical jet region, and wave forcing tends to enhance polar westerly wind. The meridional eddy heat flux also shows signals of solar cycle modulation in subpolar stratosphere, but the phase is somewhat different. Statistical and composite techniques are used to distinguish solar cycle effects from other external forcings, and to determine significance levels of analyzed solar signal in the dynamical quantities.

A31C-0061 0830h POSTER

Synoptic Meteorology of U.S. Southwest-Great Plains Summer Precipitation

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In this study, daily synoptic weather patterns are examined for simultaneous precipitation characteristics of bioclimatic subregions of the Southwest U.S. and Great Plains. The bioclimatic regions take into account gradients caused by differences in topography, continentality, and diurnal precipitation characteristics; such gradients result in great differences in precipitation total that have ramifications for decision makers. Precipitation and synoptic patterns were analyzed for subregions with strong inverse precipitation correlations. Subregional precipitation characteristics (i.e., wetness or dryness) and associated synoptic patterns were defined based on the percent raininess from the raw regional precipitation data for the period from 1948 through 2002. Percent raininess is defined as the percent of stations in the region reporting measurable daily rainfall. Wet days are defined as those during which at least 60% of stations report daily rainfall; dry days are defined as those during which 0% of stations report daily rainfall. Midtropospheric synoptic meteorological patterns and atmospheric moisture (specific humidity) were examined for all days determined to be dry in a Southwest subregion of interest and dry in a corresponding Great Plains region of interest (dry-dry), and for all other possible combinations between these regions (i.e., wet-wet, wet-dry, dry-wet). Examination of the synoptic patterns associated with these combinations for subregions with strong inverse summer season precipitation correlations indicates that a wide variety of synoptic patterns can lead to simultaneous inverse precipitation in the subregions. In addition, a variety of synoptic patterns can lead to simultaneous wetness or dryness in these distant subregions. The findings of this research are at times dramatically different than past results reported in the literature. A number of examples and comparisons will be shown.

A31C-0062 0830h POSTER

Alternate Energy from the Desert

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Due to rapid growth of the world's population and more demands for energy, and due to limited amount of fossil fuels (which provide 95 % of the world's energy needs), harnessing of alternate energy sources such as solar and wind power should be considered. In addition to the mountain passes with usually high wind, vast and flat desert areas could be good candidates for harvesting both solar and wind power. We set up a weather station in the middle of a desert, approximately 65 km east-west by 130 km north-south, located at Dugway (40°08' N, 113°27' W, 1124 m above mean sea level) in northwestern Utah, USA, in 1999. This station measured the incoming (Rsi) and outgoing (Rso) solar or shortwave radiation using two CM21 Kipp & Zonen pyrrometers (one inverted), the incoming (Rli) or atmospheric) and outgoing (Rlo) or terrestrial) longwave radiation, using two CG1 Kipp & Zonen pyrrometers (one inverted), and the net (Rn) radiation using a Q*7 net radiometer (Radiation Energy Balance System, REBS). We also measured the 3-m wind speed (U3) and direction (R.M. Young wind monitor) and precipitation (Campbell Sci., Inc.) and some other weather parameters. The measurements were taken every two seconds, and averaged into 20-min, continuously, throughout the year. The two-year (January 2000 - December 2001) period comparisons of global or solar radiation and windiness with two other stations in central (Hunter) and northern (Logan) Utah, indicate higher average solar radiation [Rsi, Dugway = 601 MJ / (m²-month) vs. Rsi, Hunter = 5371 MJ / (m²-month) and Rsi, Logan = 516 MJ / (m²-month)] and much higher 10-m average wind (UDugway = 478 km/d vs. UHunter = 323 km/d and ULogan = 275 km/d) throughout the period over the desert. These data reveal the possibility of simultaneously harvesting these two sources of clean energies at this vast and uniform desert area. Keywords: Desert, energy, radiation balance, solar and wind energies, windiness.

A31D MCC: Level 1 Wednesday 0830h

Chemistry and Composition of the Troposphere I Posters (joint with B, GC)

Presiding: A H Goldstein, University of California; P Novelli, NOAA Climate Modeling and Diagnostics Laboratory

A31D-0063 0830h POSTER

Development of an in situ gas chromatograph - mass selective detector for the purpose of studying long-range pollution transport from Asia

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In September 2002, we began work on the development and construction of an automated, 3 channel gas chromatograph (GC) with a mass selective detector (MSD) and two electron capture detectors (ECDs). The instrument will be placed at a Pacific CMDL station (Mauna Loa or Trinidad Head), and will make continuous measurements of a variety of chemical species with a wide range of lifetimes, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), methyl halides, non-methane hydrocarbons (NMHCs), peroxyacetyl nitrate (PAN), nitrous oxide, and sulfur hexafluoride. The primary goal