iron and its control on export production and macronutrient distributions. We formulate parameterizations of iron cycling in the deep ocean based on current understanding of possibly important mechanisms and constrained by the observed oceanic distribution of dissolved and particulate iron.

We first examine these parameterizations in the framework of a highly idealized six-box ocean biogeochemistry model incorporating coupled phosphorous and iron cycles and a prescribed aeolian deposition of iron. Export production is parameterized simply,limited by light, phosphate, and iron availability in the surface ocean. We compare parameterizations of the deep water, geochemical processes affecting iron based on scavenging and redissolution of iron, analogous to the inferred properties of thorium; and complexation, the binding of iron to organic ligands.When complexation is not represented the scavenging-redissolution model can reproduce the observed, basin to basin, deep water gradients of iron when scavenging and redissolution rate constants are in a ratio of approximately 1:100. The introduction of a strong ligand into the box model changes the balance, reducing the significance of redissolution. The observed deep water gradients are again reproducible when an appropriate and plausible ligand binding strength is applied. In agreement with observations, the model suggests that over 95% of the "dissolved" iron is organically bound and predicts the presence of excess, uncomplexed ligand. Deep water Fe gradients in the model are sensitive to the scavenging rate and total ligand concentration but the observed iron distribution can be reproduced with a broad range of plausible parameter values.

We use the results from the box model study to guide parameter choices and apply the iron biogeochemistry model in the more complex setting of an ocean general circulation and biogeochemistry model. Again, the surface phosphate distribution and export production are actively controlled by the availability of iron. The model can reproduce the broad characteristics of the known oceanic iron distribution and maintains high surface phosphate concentrations in known "High Nutrient Low Chlorophyll" regions. More extensive observations of the oceanic iron distribution and greater understanding of the nature and role of the organic ligands are needed in order to better constrain and verify such models.

### A71C-0124 0830h POSTER

## Does the Pacific Equatorial Undercurrent bring Iron into the HNLC region?

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The enrichment of iron in the Pacific Equatorial Undercurrent (EUC) has often been attributed to the submarine volcanic activity in the region around New Guinea and to the Sepik river discharge laden with iron rich sediments. A fully coupled biological ocean general circulation model (BOGCM) is employed to study the effects of iron injection from these two sources. The volcanic source is modeled as a continuous injection at 145E of 8 micromoles/m2/d at various depths. The most efficient place to enrich the euphotic zone in the central eastern Pacific is found to be around 125m near the core of the EUC. An increase in annual mean net community production of 15-25% is acheived with an increase of nitrate uptake by nearly 1 mmol/m3. The Sepik river discharge is modeled as an estuarine flow with mass flow into the ocean in one layer and an equal outflow in the layer below with specified salinity and iron concentrations. Details of the shelf flow are neglected for this idealized study. The near surface flow off Sepik river is northwestward which then joins the eastward flow near the equator. Similar to the volcanic iron injection, the riverine iron input also appears to be more efficiently transported eastward and upwelled in the euphotic zone of the HNLC region when the input is near depths of 125m. The Sepik river outflow is greatly reduced during warm ENSO events. However, due to a lack of interannual time-series of the discharge data, we employ climatological river inputs. The details of the interannual simulations from are discussed including the effect of the western Pacific iron sources on decadal variability of the tropical Pacific ecosystem.

# A71D MCC: Hall D Sunday 0830h

## Fine-Scale Vertical Structures in the Upper Troposphere/Lower Stratosphere and Their Roles in Climate and Weather Processes: Hypotheses, Observations, and Models I Posters

*Presiding:* **M de la Torre Jurez,** Jet Propulsion Laboratory

### A71D-0125 0830h POSTER

## The tropopause region revealed by lidar and dropsonde observations

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A composite of different observational tools are applied to explore the fine-scale structure of the tropopause region under a variety of meteorological conditions. Differential absorption lidar (DIAL) observations along extended flight tracks above the Atlantic Ocean reveal complex structures in the measured water vapor field. Mesoscale features like deep tropopause folds close to cyclones as well as stratospheric intrusions of much smaller horizontal and vertical scale are studied. In order to identify their origin and to understand their relationship with synoptic-scale meteorological systems numerical simulations with the NCAR weather prediction model MM5 are performed. Dropsonde measurements of the temperature and wind field in the vicinity of intense cyclones above the Pacific Ocean during NORPEX98 reveal wave-like structure below and above the core of the subtropical jet stream. The dropsonde data are compared with mesoscale numerical simulations and the source of these wavelike structures is discussed. The observations presented in this paper are restricted to altitudes below 12 km. Future field campaigns will be designed to investigate also the height range above this altitude.

### A71D-0126 0830h POSTER

## Breaking Gravity Waves Over Large-Scale Topography

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The importance of mountain waves is underscored by the numerous studies that document the impact on the atmospheric momentum balance, turbulence generation, and the creation of severe downslope winds. As stably stratified air is forced to rise over topography, large amplitude internal gravity waves may be generated that propagate vertically, amplify and breakdown in the upper troposphere and lower stratosphere. Many of the numerical studies reported on in the literature have used two- and three-dimensional models with simple, idealized initial states to examine gravity wave breaking. In spite of the extensive previous work, many questions remain regarding gravity wave breaking in the real atmosphere. Outstanding issues that are potentially important include: turbulent mixing and wave overturning processes, mountain wave drag, downstream effects, and the mesoscale predictability of wave breaking.

The current limit in our knowledge of gravity wave breaking can be partially attributed to lack of observations. During the Fronts and Atlantic Storm-Track Experiment (FASTEX), a large amplitude gravity wave was observed in the lee of Greenland on 29 January 1997. Observations taken collected during FASTEX presented a unique opportunity to study topographically forced gravity wave breaking and to assess the ability of high-resolution numerical models to predict the structure and evolution of such phenomena. Measurements from the NOAA G-4 research aircraft and high-resolution numerical simulations are used to study the evolution and dynamics of the large-amplitude gravity wave event that took place during the FASTEX. Vertical cross section analysis of dropwindsonde data, with 50-km horizontal spacing, indicates the presence of a large amplitude breaking gravity wave that extends from above the 150-hPa level to 500 hPa. Flight-level data indicate a horizontal shear of over 10-3 s-1 across the breaking wave with 25 K potential temperature perturbations. This breaking wave may have important implications for momentum flux parameterization in mesoscale models, stratospheric-tropospheric exchange dynamics as well as the dynamic sources and sinks of the ozone budget. Additionally, frequent breaking waves over Greenland are a known commercial and military aviation hazard.

NRL's nonhydrostatic COAMPS$^{TM}$ model is used with four nested grids with horizontal resolutions of 45 km, 15 km, 5 km and 1.67 km and 65 vertical levels to simulate the gravity wave event. The model simulation captures the temporal evolution and horizontal structure of the wave. However, the model underestimates the vertical amplitude of the wave. The model simulation suggests that the breaking wave may be triggered as a consequence of vertically propagating internal gravity waves emanating from katabatic flow near the extreme slopes of eastern Greenland. Additionally, a number of simulations that make use of a horizontally homogeneous initial state and both idealized and actual Greenland topography are performed. These simulations highlight the sensitivity of gravity wave amplification and breaking to the planetary rotation, slope of the Greenland topography, representation of turbulent mixing, and surface processes.

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### A71D-0127 0830h POSTER

## The Stratospheric Aerosol and Gas Experiment: Early Results

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The Stratospheric Aerosol and Gas Experiment is a key part of NASAs Earth Observing System (EOS). SAGE IIIs role within EOS is to provide high resolution, vertical profiles of atmospheric constituents including ozone, aerosol, water vapor and temperature from the middle troposphere through the stratosphere that are crucial to understanding climate change.

The instrument was launched on a Russian Meteor-3M spacecraft on December 10, 2001 from the Baikonur Cosmodrome in Kazakhstan. Routine measurements began in late February 2002. Retrieval results for the different species from both solar and lunar occultation measurements will also be shown with comparison satellite observations from SAGE II, HALOE, and POAM III. These initial results show that, despite several instrument and platform related problems during the early operational period, the instrument is performing well. These results include data products that were not a part of previous SAGE missions such as using the oxygen A band to retrieve temperature and pressure and the use of lunar occultation to derive profiles of ozone, NO2, and NO3.

URL: http://www-sage3.larc.nasa.gov/

### A71D-0128 0830h POSTER

## Estimation of stratospheric intrusions along GOES-derived humidity gradients with a statistical model

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A robust correspondence between lidar-observed tropopause folds and strong GOES-derived spatial gradients in humidity is used to calibrate a predictive model for the occurrence of tropopause folding in the GOES-East and West extratropical field of view. Humidity gradients are retrieved from the Altered Water Vapor product, a derived product depicting upper-tropospheric specific humidity based on a correction to the GOES water vapor channel. Spatial gradients of humidity above a certain threshold correspond to tropopause breaks, which are seen to associate consistently with tropopause folding and stratospheric intrusions that result in a layering of stratospheric-type air in the free troposphere. In-flight ozone lidar from

the Tropospheric Ozone Production about the Spring Equinox (TOPSE) experiment provides the calibration dataset. This model shows regions of layering of stratospheric air in the troposphere with a ubiquity that has been suggested by recent observational studies but has yet to be duplicated by chemical transport models. The regional distribution of tropopause folding during the TOPSE February-May 2000 study period shows a maximum in the Gulf of Alaska and along the western edge of British Columbia, which would significantly impact the stratospheric contribution of ozone to the North American free troposphere.

#### A71D-0129 0830h POSTER

### NAT Clouds and NOx Near the Tropical Tropopause: Implications for $HNO_3$

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The presence of nitric acid clouds near the cold tropical tropopause was recently demonstrated using multi-wavelength measurements from the Halogen Occultation Experiment (HALOE). This finding was based on spectral identification using model predictions of the HALOE response to a variety of particle types. Tropical nitric acid clouds (TNCs) were found to exist primarily as nitric acid trihydrate (NAT), and occasionally as liquid ternary HNO3-H2O-H2SO4 aerosols (LTA). This progress has revealed an unexplored phenomena in our atmosphere, and raises numerous questions concerning these clouds. TNCs are under investigation using HALOE measurements in conjunction with model calculations. This work has addressed numerous aspects of these clouds including TNC formation mechanisms, relationships between TNCs and the odd nitrogen budget, and trends based on 11 years of HALOE observations. A variety of observed TNC characteristics have been reproduced by model calculations, including their altitude distribution, seasonal variability, and physical particle properties. HALOE TNC observations offer insight concerning $HNO_3$ near the tropical tropopause. While gas phase $HNO_3$ measurements in this region are sparse, the abundance of condensed HNO3 inferred from HALOE TNC measurements has implications for gas phase nitric acid, in addition to TNC formation mechanisms.

#### A71D-0130 0830h POSTER

### Stratospheric Tropospheric Exchange Simulated by a Hybrid Isentropic Model

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Simulations of the fine-scale structure of the stratospheric/tropospheric exchange of potential vorticity, water vapor and clouds, and inert atmospheric constituents by the University of Wisconsin (UW) Hybrid Theta Eta Coordinate Model are presented to demonstrate feasibility and accuracy. The current UW Hybrid Model which smoothly transitions from sigma to isentropic coordinates in the upper troposphere realistically captures the fine scale structure of stratospheric tropospheric exchange within amplifying baroclinic waves. The model also provides a means to study the systematic meridional exchange of atmospheric properties and constituents throughout the stratosphere and troposphere that occurs within the thermally forced mean isentropic zonally averaged Hadley circulations. The numerical accuracies of these exchange processes are assessed with respect to the model's ability to appropriately conserve potential vorticity and dry and moist entropy, the results of which are compared to other global model simulations. Detailed numerical simulations will be presented utilizing VIS 5D

#### A71D-0131 0830h POSTER

### Comparison of Rayleigh Lidar and GPS Radio Occultation Temperature Profiles between 30-60 Kilometers in Altitude.

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GPS radio occultation (GPS/RO) soundings have shown great promise to resolve vertical structures of the atmosphere due to their global coverage and vertical sensitivity. Some previous studies of possible vertical wave structures of the upper troposphere and mesosphere found in GPS/RO measurements have had to rely on climatological and zonal analysis due to the paucity of other measurements in that region. Others compare GPS/RO measurements with global climate analysis models, which can smooth out vertical features. The Aerospace Transportable Lidar System (ATLS) collects data in altitude intervals of 37 meters and time increments of 3 or 5 minutes. When averaged over 0.25 km range elements and 15 minute integration time, temperature retrievals are characterized by RMS errors of 1 K over the range 35-65 km. This system has been routinely used to provide accurate ground-truth useful for comparison with other satellite instruments. In this paper, we compare ATLS measurements coincident with GPS/RO retrieved temperature profiles to show remarkable agreement in the vertical temperature structure between 30-60 km above MSL.

#### A71D-0132 0830h POSTER

### Improved Resolution and Accuracy of Temperature Retrievals from GPS Occultations

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GPS occultations provide global active limb-sounding measurements of the atmosphere under all-weather conditions whereby high vertical resolution profiles of atmospheric refractivity, density, pressure, and temperature (or water vapor) are derived. Sub-Kelvin temperature profiles at sub-kilometer vertical resolution are achievable in the upper troposphere and the stratosphere. The current inversion method is limited by Fresnel diffraction to a vertical resolution of 1–1.5 km. However, more recent techniques bypass this limit by properly taking into account the diffraction effects in the observed signal. These methods can resolve fine-scale vertical structures in the atmosphere. We show that with the higher vertical resolution, the occultations capture sharper tropopause structures with colder temperature minima than the global analyses, thus setting different constraints on the stratospheric-tropospheric exchange of water vapor. By comparing CHAMP and SAC-C occultation events that are temporally and spatially co-located, the resolution, precision, and accuracy of these temperature retrievals are demonstrated.

## A71E MCC: 125 Sunday 0830h

### Dust Storm Forecasting, Detecting, and Monitoring I *(joint with P)*

***Presiding:*** **W A Sprigg,** University of Arizona**; D Westphal,** Naval Research Laboratory

#### A71E-01 0830h INVITED

### Status and Future of Dust Storm Forecasting

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In recent years, increased attention has been given to the large amounts of airborne dust derived from the deserts and desertified areas of the world and transported over scales ranging from local to global. This dust can have positive and negative impacts on human activities and the environment, including modifying cloud formation, fertilizing the ocean, degrading air quality, reducing visibility, transporting pathogens, and inducing respiratory problems. The atmospheric radiative forcing by the dust has implications for global climate change and presently is one of the largest unknowns in climate models. These uncertainties have lead to much of the funding for research into the sources, properties, and fate of atmospheric dust.

As a result of advances in numerical weather prediction over the past decades and the recent climate research, we are now in a position to produce operational dust storm forecasts. International organizations and national agencies are developing programs for dust forecasting. The approaches and applications of dust detection and forecasting are as varied as the nations that are developing the models. The basic components of a dust forecasting system include atmospheric forcing, dust production, and dust microphysics. The forecasting applications include air and auto traffic safety, shipping, health, national security, climate and weather. This presentation will summarize the methods of dust storm forecasting and illustrate the various applications. The major remaining uncertainties (e.g. sources and initialization) will be discussed as well as approaches for solving those problems.

#### A71E-02 0845h INVITED

### Near-real-time detection and monitoring of dust events by satellite (SeaWiFS, MODIS, and TOMS)

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Over the last few years satellites have given us increasingly detailed information on the size, location, and duration of dust events around the world. These data not only provide valuable feedback to the modelling community as to the fidelity of their aerosol models but are also finding increasing use in near real-time applications. In particular, the ability to locate and track the development of aerosol dust clouds on a near real-time basis is being used by scientists and government to provide warning of air pollution episodes over major urban area. This ability has also become a crucial component of recent coordinated campaigns to study the characteristics of tropospheric aerosols such as dust and their effect on climate.

One such recent campaign was ACE-Asia, which was designed to obtain the comprehensive set of ground, aircraft, and satellite data necessary to provide a detailed understanding of atmospheric aerosol particles over the Asian-Pacific region.

As part of ACE-Asia, we developed a near real-time data processing and access system to provide satellite data from the polar-orbiting instruments Earth Probe TOMS (in the form of absorbing aerosol index) and SeaWiFS (in the form of aerosol optical thickness, AOT, and Angstrom exponent). The results were available via web access. The location and movement information provided by these data were used both in support of the day-to-day flight planning of ACE-Asia and as input into aerosol transport models. While near real-time SeaWiFS data processing can be performed using either the normal global data product or data obtained via direct broadcast to recieving stations close to the area of interest, near real-time MODIS processing of data to provide aerosol retrievals is currently only available using its direct broadcast capability.

In this paper, we will briefly discuss the algorithms used to generate these data. The retrieved aerosol optical thickness and Angstrom exponent from SeaWiFS will be compared with those obtained from various AERONET sites over the Asian-Pacific region. The TOMS aerosol index will also be compared with AERONET aerosol optical thickness over different aerosol conditions, and comparisons between the MODIS and SeaWiFS data will also be presented.

Finally, we will discuss the climate implication of our studies using the combined satellite and AERONET observations.