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Measurements of carbonyl sulfide (COS) at ground-based sampling stations show large seasonal variations that are strongly related to those observed for carbon dioxide. Specifically, the relative magnitude of seasonal decreases observed for COS during spring and early summer at seven Northern Hemispheric (NH) sites are strongly correlated (r^2=0.97) to those observed for CO_2. The seven sites at which COS measurements were made since 2000 include coastal sites in the arctic (Barrow, 71N, and Alert, 82N), mid-latitudes (Trinidad Head, 41N), and on Hawaii (Kumukahi, 20N), continental U.S. sites (Wisconsin, 46N, and Harvard Forest, 43N), and high altitude sites (Mauna Loa, 20N, and Niwot Ridge 40N). This correlation most likely arises because a major loss process for both CO_2 and COS is reaction with carbonic anhydrase in photosynthesizing plants. But whereas CO_2 is respired by vegetation and other organisms, COS is not similarly produced. This important point may help explain why the spring-summer relative drawn-down observed for COS is about eight times larger than that for CO_2 at these NH sites. Given our understanding of interactions between trace gases and vegetation, the observations suggest that COS measurements could provide constraints on our understanding of CO_2 uptake by plants independent of the influence of respiration. Sources and non-vegetative sinks of COS are also considered; constraints to their influence on COS seasonality in the Northern Hemisphere may possibly be derived, for example, from measurements at Southern Hemispheric sites.

A52C-0819 1330h POSTER

Use of Sulphur and Boron Isotopes to Identify Natural Gas Processing Emissions Sources

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Natural gas processing results in the emission of large amounts of gaseous pollutants as a result of planned and / or emergency flaring, sulphur incineration, and in the course of normal operation. Since many gas plants often contribute to the same air shed, it is not possible to conclusively determine the sources, amounts, and characteristics of pollution from a particular processing facility using traditional methods. However, sulphur isotopes have proven useful in the apportionment of sources of atmospheric sulphate (Norman et al., 1999), and boron isotopes have been shown to be of use in tracing coal contamination through groundwater (Davidson and Bassett, 1993). In this study, both sulphur and boron isotopes have been measured at source, receptor, and control sites, and, if emissions prove to be sufficiently distinct isotopically, they will be used to identify and apportion emissions downwind. Sulphur is present in natural gas as hydrogen sulphide (H_2S), which is combusted to sulphur dioxide (SO_2) prior to its release to the atmosphere, while boron is present both in hydrocarbon deposits as well as in any water used in the process. Little is known about the isotopic abundance variations of boron in hydrocarbon reservoirs, but Krouse (1991) has shown that the sulphur isotope composition of H_2S in reservoirs varies according to both the concentration and the method of formation of H_2S. As a result, gas plants processing gas from different reservoirs are expected to produce emissions with unique isotopic compositions. Samples were collected using a high-volume air sampler placed directly downwind of several gas plants, as well as at a receptor site and a control site. Aerosol sulphate and boron were collected on quartz fibre filters, while SO_2 was collected on potassium hydroxide-impregnated cellulose filters. Solid sulphur samples were taken from those plants that process sulphur in order to compare the isotopic composition with atmospheric measurements. A method was developed to extract and concentrate boron for isotope analysis. Isotopic composition and concentrations of both sulphur and boron were measured in order to determine whether emissions have distinct sulphur and/or boron isotopic compositions. Preliminary results of SO_2 and solid sulphur analysis show values that range from +3 to +30 $^o/_{oo}$.

A52C-0820 1330h POSTER

Seasonal Variability of 34S in Precipitation from two Urban Sites of Korea

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We measured the seasonal variations of 34S, together with major ions and naturally occurring 210Pb, 210Po, and 7Be in snow and rainwater samples from urban areas. Precipitation samples were collected from metropolitan city, Seoul and large port city, Busan, Korea, for one year from June 2002 to June 2003. The δ34S values of sulfate in precipitation ranged from -4.3$^o/_{oo}$ to +6.6$^o/_{oo}$ (mean: 3.72$^o/_{oo}$) and +1.0$^o/_{oo}$ to +18.6$^o/_{oo}$ (mean: 5.55$^o/_{oo}$) in Seoul and Busan, respectively. These δ34S values suggest that sulfate in Seoul precipitation originates more from anthropogenic sources relative to that in Busan. The elevated anthropogenic sources in Seoul might be influenced by industrial activities from surrounding industrial cities, while the scatter of δ34S values in Busan may be influenced by marine air. As such, Seoul and Busan showed significant differences in chemical compositions and naturally occurring radionuclides, such as 210Pb, 210Bi, and 7Be. In both areas, δ34S values are high in fall and low in spring, which indicates that δ34S values of spring time are affected by biogenic sources compared to those of other seasons.

A52C-0821 1330h POSTER

Measurement of Atmospheric Carbon Dioxide on Tower in Berezorechka, West Siberian Forest Region

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Atmospheric CO2 concentration is observed in the lower troposphere over the west Siberian forest region around Berezorechka village (56.17N, 84.33E) since October 2001 to reveal CO2 variation in and over planetary boundary layer (PBL). Ground based measurement is conducted using a tower with its height about 90m, and lower tropospheric observation is done between 100-2000m height every 1-3 weeks using aircraft. The tall tower stood in forest with its canopy height of 10-15m and four air intakes are attached at about 80, 40, 20 and 5 m height of the tower. The pressurized air by a diaphragm pump is dehumidified and introduced into analyzer (Li-Cor : LI-7000) at constant flow rate (35 ml min-1). Sample air at each height is introduced into analyzer for six minutes and last one minute signal is used for calculation. The CO2 concentration is determined against three CO2-in-air standard gases based on the National Institute for Environmental Studies (NIES) standard gas scale. The feature of this system is to employ on-site compressed air as both reference gas for analyzer and sub-standard gas. Ambient air compressed into 48L cylinder up to about 0.5MPa is kept for about ten days and then used for the reference and sub-standard gas. Analysis of all four heights sample air and sub-standard gas is done every 30 minutes except twice a day when three standard gases are analyzed. Total precision is estimated to be 0.3ppm. The observed CO2 concentration generally shows diurnal variation with low value in daytime, increase from evening till early morning and decrease till evening. The amplitude of diurnal variation is large in summer and small in late winter. The CO2 diurnal variation is different day by day even in a same season and well correlated with temperature profile variation. Clear inversion layer is observed in calm and/or clear sky night, and the concentration increases from ground surface to higher height accompanied with inversion layer growth. Larger vertical CO2 difference in July than in February at night suggests that CO2 release from land biosphere is also larger in July than in February. On a day when inversion layer is not observed, CO2 variation at each height is similar to each other, and its difference is in 5ppmv. These CO2 temporal and vertical variations are resulted from covariance of biospheric activity, photosynthesis and variation of inversion layer.

A52D MCC: 3018 Friday 1340h

Ocean/Atmosphere Modeling II *(joint with OS, NG)*

Presiding: **A Wallcraft,** Naval Research Laboratory**; L P Davis,** DOD High Performance Computing Modernization Program

A52D-01 1340h INVITED

High-Resolution Global Ocean and Ocean/Ice Models for Synoptic and Climate Prediction

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Realistic high-resolution ocean and ice components of a future global coupled air/ocean/ice model are being developed, tested, run, and evaluated for use in future synoptic and climate prediction systems. The ocean model is the Parallel Ocean Program (POP); it is configured on a displaced North Pole grid to allow the inclusion of the Arctic, it has a horizontal spacing of 0.1^o at the equator and 40 vertical levels, and has an active mixed layer. It is forced with synoptic surface forcing whenever possible. Quantitative evaluations of the two-decade simulation will be presented with particular focus on the mean characteristics of the general circulation and comparisons of the surface variability from data sets with global or near-global coverage such as satellite altimeters and surface drifting buoys. Model biases will be addressed along with efforts to improve unrealistic aspects of the simulation. The inclusion of a dynamic/thermodynamic ice model, such as the Los Alamos National Laboratory CICE model, will improve the realism of the ocean model. Towards this end we are testing a global coupled POP/CICE model at eddy-permitting resolution in the first instance. CICE fields will be compared with satellite data and available observations.

URL: http://www.oc.nps.navy.mil/navypop

A52D-02 1410h

Predictability Experiments With the Navy Operational Global Atmospheric Prediction System

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There are several areas of research in numerical weather prediction and atmospheric predictability, such as targeted observations and ensemble perturbation generation, where it is desirable to combine information about the uncertainty of the initial state with information about potential rapid perturbation growth. Singular vectors (SVs) provide a framework to accomplish this task in a mathematically rigorous and computationally feasible manner. In this study, SVs are calculated using the tangent and adjoint models of the Navy Operational Global Atmospheric Prediction System (NOGAPS). The analysis error variance information produced by the NRL Atmospheric Variational Data Assimilation System is used as the initial-time SV norm. These VAR SVs are compared to SVs for which total energy is both the initial and final time norms (TE SVs). The incorporation of analysis error variance information has a significant impact on the structure and location of the SVs. This in turn has a significant impact on targeted observing applications. The utility and implications of such experiments in assessing the analysis error variance estimates will be explored. Computing support has been provided by the Department of Defense High Performance Computing Center

at the Naval Oceanographic Office Major Shared Resource Center at Stennis, Mississippi.

A52D-03 1425h

A Scalable Spectral Element Eulerian-Lagrangian Global Atmospheric Model :Dynamical Core Tests

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The Navy is currently testing a new dynamical core for implementation into its existing operational prediction system (called NOGAPS). This new dynamical core is based on the spectral element method which combines the high-order accuracy of the spectral transform method with the geometric flexibility of the finite element method. The spectral element method has been shown to yield more accurate solutions than any up-and -coming numerical method while scaling linearly on distributed-memory computers, and allowing for the use of any type of grid including: icosahedral, hexahedral, and adaptive unstructured grids. The Eulerian semi-implicit version of the model presented in this talk yields exponential convergence (as in typical spectral transform models) while yielding forecasts up to 50% more efficient than the Navy's existing operational model. We present results for test cases with analytical solutions to show the accuracy of the model. In addition, we show performance results for the new model on an IBM SP4.

URL: http://www.nrlmry.navy.mil/~giraldo/publications.html

A52D-04 1440h INVITED

On Arctic Environmental Change - 1979-2001 coupled ice-ocean model results

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The Arctic Ocean has been traditionally a challenging region for modeling due to the presence of the multi-year ice pack, complex bathymetry and the grid singularity at the North Pole. Regional models of the Arctic Ocean have been developed in part to address some of these issues and to give feedback to global ocean and climate models on requirements for realistic modeling of this region. Results from a coupled ice-ocean model of the pan-Arctic region, configured at a 1/12-degree and 45-level grid and integrated for seven decades using realistic atmospheric data are analyzed to understand recent climate variability in the region. The primary simulation consists of a 48-year spinup followed by a 23-year interannual run forced with a combination of daily-averaged reanalyzed and operational ECMWF data for 1979-2001. The interannual integration provides insights into the recent climate regime shifts between the late 1970s and the 2000s. Model results allow a large-scale view of the sea ice and ocean circulation and changes. At the same time, high resolution provides means to investigate physical processes controlling large-scale ocean and sea ice conditions and their variability. Our earlier findings point to the atmosphere as a dominant driver of the sea ice and ocean circulation, which is confirmed in this current work. The model suggests a relatively efficient horizontal momentum transfer in the vertical direction from the atmosphere through the sea ice into the ocean. The boundary flow along the perimeter of deep basins appears to be one of the critical oceanic processes both responding to and distributing change throughout the region. Analysis of model results for the 2000s helps with understanding most recent changes observed in the Arctic Ocean. Extrapolation of recent trends provides means for limited prediction of future environmental conditions in the region.

A52D-05 1510h

Coupled Sea Ice Modeling within Global Atmosphere-Ocean Models

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Coupling sea ice models within global atmosphere-ocean models adds several computational and scientific hurdles to the grand challenge of global climate and weather simulation. Producing a truly realistic simulation of polar climate, sea ice cover, thickness and ice drift is still elusive in global models. Problems inherent in the atmosphere, ice, and ocean models all contribute to problems in the sea ice simulations. Numerical stability of ice, atmosphere and ocean models near the poles create limitations in the usable model timestep and grid resolution, so alternate global grids have been implemented in many models. The evolution of coupled ice models from simple slabs to the present dynamic-thermodynamic models with elastic-visco-plastic rheologies, and the future of high-resolution modeling of discrete ice floe interactions will be presented.

A52D-06 1525h

Modeling Study of Arctic Storm with the Coupled MM5-Sea Ice-Ocean Model

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Recent studies demonstrated that the Arctic environment has been undergoing noticeable changes, which are manifested, for example, by the shrinking of sea-ice and the increasing of storminess. This provides a new challenge for weather forecast and synoptic studies in the Arctic region. The reduced and highly variable sea-ice cover naturally changes surface thermal condition and may result in feedbacks between atmosphere and underlying surface. In order to detect such processes and improve weather forecast, we developed a coupled meso-scale modeling system, named as the Arctic MM5, based on the PSU/NCAR MM5 model. In this modeling system, a thermodynamic sea ice model and an ocean mixed layer model were coupled with the MM5 to consider the interactions between the sea ice, ocean and atmosphere. Observations over the Arctic are very limited. However, the SHEBA deployment was carried out from October 1997 to October 1998, which provides valuable measurements. During SHEBA, a well-developed storm process in the middle May 1998 was captured. This storm moved slowly northward from the Bering Sea and the Gulf of Alaska to the Beaufort Sea, bringing about an outstanding warm air advection over the sea ice and leads. We employed our modeling system to carry out a modeling study of this storm process, verified the modeling results with the SHEBA measurements and investigated storm development and associated atmosphere-sea ice interactions.

A52E MCC: 3016 Friday 1340h

Contributions to Middle Atmosphere Science by Solar Occultation Instrumentation IV *(joint with SA)*

Presiding: **L W Thomason,** NASA Langley Research Center**; P L DeCola,** NASA Headquarters**; R Bevilacqua,** Naval Research Laboratory

A52E-01 1340h

On the Influence of the Tibetan High on the Distribution of Column Ozone and Polar Stratospheric Clouds in the Southern Hemisphere

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We describe a new hypothesis regarding a teleconnection between the boreal summer and austral winter: the distribution of ozone in the southern hemisphere is controlled primarily by outflow from the top of the northern Asian monsoon (Tibetan High). The anthropogenic ozone hole which appears each September and October over Antarctica is surrounded by a croissant-shaped ozone maximum in the 40-60S latitude band, characterized by a broad maximum of larger column ozone amounts centered south of Australia (in the Australian High) and lower amounts over the South Atlantic. The shape of the ozone croissant relates directly to the longitudinal distribution of polar stratospheric clouds (PSCs) at high latitudes. The existence of this structure and its particular longitudinal distribution is hitherto unexplained. Observational analyses and numerical simulations will be shown which illuminate the process by which the ozone croissant is established. Solar occultation data from HALOE, SAGE, and POAM are used to characterize the distribution of ozone and PSCs. A major current of air flows out of the Tibetan High across the Indian Ocean, where it runs into the southern hemisphere winter westerly flow. Outflow surges occur in pulses lasting several days, with southward flow generating an anticyclone over the Indian Ocean - Australia sector. The pulsed flow excites a train of Rossby waves which propagate eastward. Descent of ozone-rich air occurs preferentially just to the east of the synoptic anticyclones. Extensive mixing occurs within the train of breaking Rossby waves. The coincident climatological ozone maximum and Australian High are viewed as a 3D mixing lens of higher ozone from above and higher potential vorticity from the tropics. This mechanism brings chemicals from the upper troposphere over Asia into juxtaposition with stratospheric air in the southern middle latitudes and is thus important for a variety of global climate change problems. It contributes to our understanding of interhemispheric transport of important trace gases, how the ozone croissant is formed and maintained, what controls the shape and intensity of the ozone hole, and provides a broader understanding of a new teleconnection in the atmospheric general circulation.

A

A52E-02 1355h

Reconstruction and Simulation of Stratospheric Ozone Distributions During the 2002 Austral Winter

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Satellite-based solar occultation measurements during the 2002 Austral winter have been used to reconstruct global, three dimensional ozone distributions. The reconstruction method uses correlations between potential vorticity and ozone to derive "proxy" distributions from the geographically limited occultation observations. Ozone profiles from the Halogen Occultation Experiment (HALOE), the Polar Ozone and Aerosol Measurement (POAM) III, and the Stratospheric Aerosol and Gas Experiment (SAGE) II & III are incorporated into the analysis. The reconstruction method is described, and the evolution of the solar occultation data and proxy ozone fields throughout the winter is discussed. The results support the idea that dynamical forcing early in the 2002 winter influenced the morphology of the stratosphere in a significant and unusual manner. The proxy is compared with ozone from mechanistic, primitive equation model simulations of passive ozone tracer fields during the time of the warming. In regions where chemistry is negligible compared to transport, the model and proxy ozone fields agree well. The agreement between, and changes in, the large scale ozone fields in model and proxy indicate that transport processes, particularly enhanced poleward transport and mixing, are the primary cause of ozone changes through most of the stratosphere during this unprecedented event. The analysis culminates with the calculation of globally distributed column ozone during the major warming, showing quantitatively how transport of low-latitude air to the polar region in the middle stratosphere led to the diminished ozone hole in 2002.