effective mobile dislocation density. Results indicate that under a constant stress of 1.45 MPa, particles increase the creep rate at particle concentrations up to 1 wt. %, above which the creep rate slightly decreases. At lower levels from 0.1 - 1.4 MPa, ice with 1 wt. % particles shows higher creep rates compared with particle-free ice, with the difference increasing at higher stress levels. Power-law creep behavior with an exponent of 3 was observed for both particle-free and particle-containing ice when the strain rate was greater than 7×10^{-9} s^{-1}. However, a transition to linear behavior was observed for both materials when the strain rates were below 7×10^{-9} s^{-1}. The results suggest that the transition is related to the strain rate rather than the stress. Model calculations show that the linear behavior is associated with the constant dislocation density, which can be explained by Harper-Dorn creep, while power-law behavior is associated with increased dislocation densities. This research was supported by NSF Office of Polar Programs, Arctic Natural Sciences Program (OPP 011737), Dr. Jane Dionne, Program Manager.

A41A-06 0830h POSTER

Determining the Orientations of Ice Crystals Using Electron Backscatter Patterns

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The presentation will show how electron backscatter diffraction can be employed to determine crystal orientations in ice. The technique involves obtaining and indexing electron back-scatter patterns (EBSPs) from uncoated ice using a scanning electron microscope equipped with a custom-built cold-stage and an Orientation Imaging System. Unlike any of the currently-used methods, the EBSP-based technique has considerably higher angular and spatial resolution and is significantly faster. We also present an orientation image map of a muti-grain region in laboratory-grown ice constructed by automatically indexing the EBSPs using an HKL, Inc Channel 5 Orientation Imaging System and discuss possible applications of the technique to the study of natural ice. Primarily, the focus will be on the characterization of the microstructure of dynamically recrystallized glacier ice whose texture is intrinsically related the flow process. Other applications include obtaining orientation images from frozen water-containing materials, such as clathrate hydrates. This research was supported by Army Research Office grant DAAD 19-03-1-0110 and National Science Foundation grants OPP-9981379 and OPP-0221120.

A41B CC: 220 C-E Thursday 0830h

Oxygen-18: Connecting Climate Models, Observations, and Paleodata I Posters *(joint with B, H, OS, C, GC, PP)*

Presiding: **G Hoffmann,** Laboratoire des Sciences du Climat et de l'Environnement**; A Paul,** University of Bremen

A41B-01 0830h POSTER

Gridding Global $\delta^{18}O_{water}$ and Interpreting Core Top $\delta^{18}O_{foram}$

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Estimations of the oxygen isotope ratio in seawater ($\delta^{18}O_{water}$) traditionally have relied on regional $\delta^{18}O_{water}$ to salinity relationships to convert seawater salinity into $\delta^{18}O_{water}$. This indirect method of determining $\delta^{18}O_{water}$ is necessary since ?18Owater measurements are relatively sparse. We improve upon this process by constructing local $\delta^{18}O_{water}$ to salinity curves using the Schmidt *et al.* (1999) global database of $\delta^{18}O_{water}$ and salinity. We calculate local $\delta^{18}O_{water}$ to salinity relationship on a 1x1 grid based on the closest database points to each grid box. Each ocean basin is analyzed separately, and each curve is processed to exclude outliers. These local relationships in combination with seawater salinity (Levitus, 1994) allow us to construct a global map of $\delta^{18}O_{water}$ on a 1x1 grid. We combine seawater temperature (Levitus, 1994) with this dataset to predict $\delta^{18}O_{calcite}$ on a 1x1 grid. These predicted values are then compared to previous compilations of core top $\delta^{18}O_{foram}$ data for individual species of foraminifera. This comparison provides insight into the calcification habitats (as inferred by seawater temperature and salinity) of these species. Additionally, we compare the 1x1 grid of $\delta^{18}O_{water}$ to preliminary output from the latest GISS coupled Atmosphere/Ocean GCM that tracks water isotopes through the hydrologic cycle. This comparison provides insight into possible model applications as a tool to aid in interpreting paleo-isotope data.

A41B-02 0830h POSTER

Seasonal Variations in the $\delta^{18}O$ Values of Global Meteoric Water and Climate Dynamic Patterns

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Climate change often manifests itself through changes in seasonal weather patterns and dynamics, but paleoclimate records rarely have intra-annual resolution. The precipitation $\delta^{18}O$, either directly measured or indirectly inferred from other datable materials, is one of the most widely used proxies for paleoclimate studies. It is important, therefore, that we understand the seasonal distribution of meteoric $\delta^{18}O$ in relation to climate dynamics. Here we present a study of the $\delta^{18}O$ seasonality pattern of global meteoric water and discuss its strong connection to the general circulation of the atmosphere. We used the GNIP (Global Network for Isotopes in Precipitation) database (IAEA/WMO, 2001; Global Network for Isotopes in Precipitation) for this study. For each station having at least 12 months of measurements, we fit the mean and the phase and amplitude of an annual sine curve using the least-squares method. The mean annual $\delta^{18}O$ is generally highest in the tropics and lowest toward the poles, but there is a narrow zone of slightly lower $\delta^{18}O$ at the equator. The phase of the seasonal variation in precipitation $\delta^{18}O$ is surprisingly uniform within each of four world zones. North of 30 °N latitude, the most ^{18}O-enriched precipitation falls in early July. South of 30 °S, the maximum ^{18}O enrichment occurs in early January. Between the equator and 30 °N, precipitation $\delta^{18}O$ reaches a maximum in February, which is nearly opposite to the August isotopic maximum between the equator and 30 °S. At the equator, 30 °N, and 30 °S the isotopic maximum often occurs in September or March. The magnitude of seasonal variation in precipitation $\delta^{18}O$ appears to decrease toward the equator. In addition, marine and coastal seasonality across the globe is significantly smaller than continental seasonality. It appears that the seasonality in precipitation $\delta^{18}O$ is controlled by the global circulation cells of the atmosphere through their effects on evaporation, moisture transport, and precipitation patterns. A few small regions with $\delta^{18}O$ anomalous for their respective zones are affected by monsoons or by stationary mesoscale circulation systems that influence local water vapor transport.

A41B-03 0830h POSTER

An Oxygen-18 Proxy Record of Recent Hurricanes in Belize: Speleothems as a new Tool for Paleotempestology

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The high winds, storm surge, and extreme precipitation produced by landfalling tropical cyclones (hurricanes and tropical storms) generate some of the most deadly and destructive natural disasters faced by coastal populations. Stakeholders such as coastal planners and developers, property owners, emergency planners, and (re)insurers are concerned about future risk from the most devastating events, particularly because significant changes in climatic boundary conditions have been projected for this century. However, historical tropical cyclone records are not sufficient to address the sensitivity of hurricane intensity to projected changes, and modeling exercises have as yet been unable to settle the debate. Consequently, paleotempestologists have turned to the geologic record for more information about past hurricane activity that could be used to improve forward models. Toward that end, we have developed a new proxy for individual tropical cyclone rainfall events using very high-resolution $\delta^{18}O$ analyses of speleothem calcite. This proxy is based on the depleted isotopic signature of tropical cyclone rainfall compared to other summer season meteoric waters. We applied recent developments in microsampling techniques to a rapidly growing speleothem from Belize, Central America. The resulting record (20 micron sampling interval, yielding ∼weekly temporal resolution) allowed us to detect individual, historical tropical cyclone events over the last three decades. The speleothem $\delta^{18}O$ paleotempestology proxy facilitates very accurate estimates of the time between tropical cyclone events: the proxy was able to resolve two hurricanes that struck Belize in the same year. The recurrence interval (RI) we estimated using the speleothem hurricane record agrees closely with the RI published for the same period by the Belize Meteorological Service. Preliminary work indicates that the $\delta^{18}O$ storm signal preserved in speleothem calcite carries some information about the local storm intensity (a function of storm category at landfall and distance from storm track). This new tool for paleotempestology can complement existing proxies based on coastal sediments, corals, and tree rings. By extending such records into the geologic past, when climatic conditions (such as sea surface temperature patterns, position of the North Atlantic High, etc.) were different from today's, it should be possible to resolve more exactly the relations between hurricane activity and specific climatic boundary conditions. This will enable modelers to more accurately project hurricane recurrence in light of expected future trends.

A41B-04 0830h POSTER

Variability of water isotopes in a coupled ocean-atmosphere-sea ice model

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We incorporate the physics of water isotopes ($H_2^{18}O$, HDO) into the state-of-the-art GISS GCM, including a full atmosphere, dynamic ocean, sea ice and land surface components. The water isotopes follow every aspect of the hydrological cycle (including a prognostic cloud water scheme) with fractionation at relevant changes of phase. We use the control run of this model to examine the modelled variability of the water isotopes on seasonal, interannual and interdecadal timescales and how this is coupled to variation in temperature, salinity and other climate variables. In particular, we examine the variability of isotope ratios and the deuterium excess as a function of the AO/NAO circulation pattern in the Northern Hemisphere and the overturning streamfunction in the North Atlantic.

A41B-05 0830h POSTER

Modeling the Phase Relationship Between Global Ice Volume and the Mean Oxygen-Isotope Composition of the Ocean

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A two-dimensional (latitude-height) thermomechanical ice-sheet model is used to simulate the oxygen-isotope distribution in a Pleistocene ice sheet. In order to study the relationship between global ice-volume and

the mean oxygen-isotope composition of the ocean, the ice-sheet model is coupled to an ocean box model. The only forcing is high-latitude northern hemisphere summer insolation. Experiments are performed for (1) an isothermal ice sheet and (2) varying ice temperature. The snow-δ^{18}O parameterization considers the depletion in ^{18}O of precipitation with altitude. Snapshots of the modeled δ^{18}O distribution in the ice sheet at different moments during the last glacial-interglacial cycle are presented. Furthermore the model output is compared to sea-level reconstructions from corals as well as to foraminiferal δ^{18}O. Upon glacial inception, the simulated mean ocean δ^{18}O changes faster than ice volume, but then the ice volume is found to lead the mean ocean δ^{18}O throughout the rest of the glacial cycle (including the termination) by up to 6 kyr. The significance of this result is discussed with respect to the phase relationships between ice volume inferred from foraminiferal δ^{18}O, insolation and the atmospheric carbon dioxide concentration.

A41C CC: 520 D Thursday 0830h

Tropospheric Chemistry and Dynamics Using Data From Measurement of Pollution in the Troposphere (MOPITT) Experiment I

Presiding: **J R Drummond,** University of Toronto**; J C Gille,** National Center for Atmospheric Research

A41C-01 0830h

Measurements Of Pollution In The Troposphere (MOPITT): Past, Present and Future

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The MOPITT instrument has now been in orbit for over four years. A nearly continuous dataset has been accumulated from the instrument over that time. The first part of this talk will quickly review the history and status of this dataset and highlight some of the strengths and weaknesses. The applications of these data are similarly diverse and some examples will be highlighted although other papers in the session will provide more details. As the MOPITT measurements become more mature and experience in using them grows, the range of science applications also grows. This not only points to an increase in the potential science, but also permits a more detailed analysis of the potential for future missions. A successor instrument is being studied and a number of scientific and instrumental improvements are being considered. These instrumental include (among others) changes in the spectral passbands, the spatial resolution, and the revisit time. These in turn change the potential science. The second part of this talk will discuss the possibilities for such an instrument and how this might expand the range of scientific applications.

A41C-02 0845h INVITED

Observations of Carbon Monoxide and Aerosol From the Terra Satellite: Northern Hemisphere Variability

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Measurements from the Terra satellite launched in December of 1999 now provide a global record of the recent inter-annual variability of tropospheric air quality: carbon monoxide (CO) from the Measurement Of Pollution In The Troposphere (MOPITT) instrument, and of aerosol optical depth (AOD) from the Moderate-resolution Imaging Spectroradiometer (MODIS). This paper compares and contrasts these data sets with a view to understanding the general features of the overall pollutant loading of the Northern Hemisphere (NH). We present a detailed examination of the seasonal and recent inter-annual variability of the fine mode AOD and CO column, first considering the variation of the global zonal average for both quantities, and then concentrating on several geographical regions with the aim of isolating different emissions. This is accompanied by a discussion of the various sources and sinks of CO and of the aerosol types that contribute to the fine mode AOD. In a zonal sense, the principal NH sources are related to anthropogenic urban and industrial activity. We show that both the CO loading and the AOD zonal seasonal variations reflect the atmospheric oxidant loading which determines the primary sink of CO and the production of sulfate aerosol. As a consequence, the seasonal cycles are several months out of phase, with perturbations resulting from wildfire or biomass burning emissions. In these cases, carbonaceous particles define the AOD, and this results in the best correlation with the CO column. The MODIS AOD measurement is more sensitive to the boundary layer than the MOPITT CO measurement, thus making it the more reliable indicator of wildfire and biomass burning locations. Conversely, the MOPITT CO measurement is more useful for tracing long-range transport of fire emissions. The two measurements are therefore complimentary in building up the overall picture of plume evolution. Of the four years of data available from the Terra satellite, the Winter and Spring of 2002/2003 showed anomalously high NH pollutant loadings compared to the previous years. This was a result of fires in western Russia in the late Summer and Fall of 2002, and intense fires in the southeast of Russia in the Spring of 2003. We examine these events using fire counts from MODIS to indicate the burning regions, and investigate how the timing of the fires in relation to atmospheric oxidant concentrations affects the resultant seasonal pollutant loadings. Finally, we trace the emissions from these fires to indicate how intense local pollution sources can impact continental and global scale air quality.

A41C-03 0900h INVITED

CO as a Precursor of Ozone and a Tracer of Transport: Evidence from MOPITT Data

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Carbon Monoxide(CO) retrievals from MOPITT are used to explore two facets of CO in the troposphere, namely its role as a precursor of ozone in the biomass burning areas of the southern tropics and as a tracer of transport phenomena. The correlation with ozone is studied at 6 ozonesonde stations: Reunion, Irene, Natal, Ascension, San Cristobal and Paramaribo. Three year climatologies (March 2000-March 2003) of CO indicate distinct seasonal patterns at each station. All stations show enhanced CO levels during September-November period reflecting the austral burning with additional signatures of burning in Northern Africa and Northern Amazonia at some stations. The aerosol optical depths retrieved contemporaneously from MODIS show generally similar variations as CO with some notable anomalies. Tropospheric ozone from the sondes shows a generally good correlation with CO at most stations, but shows several instances of ozone enhancements uncorrelated to CO. This might help delineate the reasons for ozone variations in the southern tropics. At San Cristobal strong CO enhancements during March-April are not accompanied by any significant change in ozone. The potential of MOPITT CO measurements as tracers of convection and stratosphere-troposphere exchange (STE) events is also examined. The problem of limited vertical resolution of MOPITT retrievals is alleviated to a certain extent by the large number of profiles at any place. Case studies showing signatures of convection and STE in the MOPITT CO data will be presented.

A41C-04 0915h

Trans-Pacific Transport of CO Derived From MOPITT Observations and Data Assimilation

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The Measurements Of Pollution In The Troposphere (MOPITT) instrument on the EOS Terra Spacecraft has obtained data from which the vertical distribution and total columns of CO have been obtained on a global basis since March 2000. These data have been assimilated using the MOZART model, combined with the source strengths inferred by Petrone et al. This results in daily, global data from which studies of transport can be made. Here we present results detailing the transports from January-May, the months of maximum transport from Asia across the Pacific toward North America. The agreement between original measurements and the assimilation results shows that the original accuracy is retained, but missing areas are filled in to provide a more complete picture. The mix of sources from biomass burning in SE Asia and industrial regions in China and elsewhere is displayed. The magnitude of the derived transports are shown as cross-sections at several longitudes, indicating the expected movement toward higher latitude and altitude as the air moves eastward. These are compared with trajectory analyses, which show the fates of some of the plumes. Comparing 3 years of data gives an idea of the size of inter-annual variations.

A41C-05 0930h

Tracking of Pollution Plumes Using MOPITT Measurements

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The measurements performed by the MOPITT remote sensor onboard TERRA provide global scale information on the CO distribution for a period of 4 years. When studying the CO budget over a specific geographic area, one has to take into account different sources, including biomass burning and industrial emissions, to understand the CO concentration as measured by the instrument. This work investigates the possibility of detecting pollution plumes directly emitted above major cities using the MOPITT data. A selection of the more qualitatively reliable retrieved L2 data was performed. We have chosen several locations, both over polluted cities (e.g. LA, Mexico City, Beijing) and over remote areas (Jungfraujoch Alpine station), to analyse the time-evolving CO concentrations as measured by MOPITT and to compare these data with local measurements, and with regional CTM model simulations.