an international ice core research.. The broad elevational extent of snow accumulation zones in this region (ranging from 2500 to 5300 m asl) allows for the detailed investigation of environmental change extending from the planetary boundary layer through to the free troposphere via the collection and analysis of ice cores from different elevations. Multi-parameter, high resolution glaciochemical records are currently available from the Northwest Col on Mt. Logan (5340 m asl, 103 m deep; 270 year record;) and from three cores recovered from the Eclipse Icefield (3107 m asl) in 1996 (160 m deep; 100 year record) and in 2002 (345 m and 140 m deep). Snow accumulation rates at Eclipse are about 5 times larger than the summit average of 0.30 m water equivalent. Despite their close proximity, the climate signals recorded on the summit of Mt. Logan also differ from those at Eclipse. For example, while the Mt. Logan record shows no increase in sulfate or nitrate deposition over the past 100 years, all three Eclipse cores shows a clear increase in nitrate and sulfate deposition beginning in the late 1940s due to an increase in anthropogenic emissions in Eurasia during this time period. Over the last century, the sulfate time-series from Eclipse records from 32 discrete volcanic events, primarily from Alaskan, Aleutian, or Kamchatkan eruptions, while the summit site only records 8 volcanic events. The Eclipse summer d18O record displays a significant positive relationship with summer temperatures at both coastal and interior Alaskan sites, while the Mt. Logan d18O time-series does not correlate well with instrumental temperature records or most circum-Arctic paleoclimate records. Conversely, the summit ice core accumulation time-series strongly correlates with instrumental precipitation records from Japan and with indices of the El Nino- Southern Oscillation on both interannual and interdecadal time scales suggesting the summit records are uniquely situated for studies of global teleconnection patterns. Our results to date indicate that the two sites sample different air masses and that boundary layer dynamics play an important role in the glaciochemical signals preserved at each location. The Northwest Col and Eclipse records, in conjunction with analysis of new ice cores already recovered from Prospector-Russell Col (5300 m; 187 m; circa 35,000 years) by the Geological Survey of Canada and King Col (4135 m asl; 220 m deep; circa 2,000 year record) on the Logan Massif by the National Institute for Polar Research (Japan) offers an unprecedented opportunity for paleoclimate reconstruction along a vertical transect in the St. Elias Mountains and should provide a rich and multi-layered contribution to our understanding boundary layer dynamics and Holocene environmental change in the region.

A43C-03 1400h

The Relationship Between Snow Accumulation at Mt. Logan, Yukon, and Climate Variability in the North Pacific

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An ice core from Mt. Logan, Yukon, presents an opportunity to evaluate the degree to which ice core accumulation records can be interpreted as meaningful measures of interannual climate variability. Statistical analyses and comparisons with synoptic station data are used to identify the physical relationships between Mt. Logan ice core accumulation data and large scale atmospheric circulation. These analyses demonstrate that only the winters of high accumulation years have a robust connection with atmospheric circulation. There are no consistent relationships during anomalously low and average accumulation years. The wintertime of high accumulation years is associated with an enhanced trough-ridge structure at 500 hPa and in sea level pressure over the Northeast Pacific and Western Canada, consistent with increased southerly flow bringing in warmer, moister air to the region. While both storm (i.e. 2-6 days) and blocking (i.e. 15-20 days) events project onto the same climate pattern, only the big storm events give rise to the dynamical moisture convergence necessary for anomalous accumulation. Taken together these results suggest that while the Mt. Logan accumulation record is not a simple record of Pacific climate variability, anomalously high accumulation years are a reliable indicator of wintertime circulation and, in particular, of Northeast Pacific storms.

A43C-04 1415h

North Pacific Volcanism in Three Ice Cores from Eclipse Icefield, Yukon Territory, Canada

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Prior work has demonstrated that a record of regionally significant volcanic eruptions in the North Pacific is available from Eclipse Icefield, Yukon Territory, Canada. The acquisition of two new cores from Eclipse Icefield during the 2002 field season allows us to extend the record of volcanism by at least five hundred years and assess the variability in volcanic signal preservation using the three ice core records now available from Eclipse Icefield. Non- sea - salt sulfate residuals above a robust spline and empirical orthogonal function (EOF) analysis were used to identify volcanic sulfate signatures. These signals were then matched to the historical record of volcanism to identify eruptions in the Eclipse ice core. At least ten of these identifications have been independently verified by means of tephrochronology, including, for the first time, recovery of tephra from the unknown 1809 eruption seen in both Greenland and Antarctic ice core records. The largest eruptions, such as Katmai 1912 (VEI 6) and Ksudach 1907 (VEI 5), as well as some moderate-sized eruptions (i.e., Redoubt 1989; VEI 3), are consistently recorded in each of the available cores. Meanwhile, other moderate to large eruptions, such as Bezymianny 1956 (VEI 5), are not recorded in any of the cores. Anthropogenic sulfate deposition at Eclipse since about 1950 appears to mask signals from large tropical eruptions such as Pinatubo (1991) and El Chichon (1982), while older tropical eruptions prior to the period of anthropogenic sulfate deposition such as Krakatau (1883), Tambora (1815), and the unknown 1809 eruption are clearly recorded at Eclipse Icefield.

A43C-05 1430h

EPICA DOME C : A 800 ky DEUTERIUM TEMPERATURE RECORD

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The two cores drilled at the Dome C site in East Antarctica (elevation 3233 m, mean annual temperature, - 54.5°C) in the frame of the European Program for Ice Coring in Antarctica, now provide a continuous deuterium profile covering the last 800 ky back to marine stage . Measurements have been performed on 55 cm samples with a precision of either ± 0.5 or ± 1.5 per mill depending of the part of the record considered. We will focus on describing the characteristics of this record, dated by inverse modelling, both in the time and frequency domains. Specific time periods such as termination V and the very bottom part of the core as well as comparison with marine and continental records covering the same time span, will be discussed.

A43C-06 1445h INVITED

Deuterium Excess in ice Cores: a Tricky Tracer of Past Global Environmental Changes

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Several deuterium excess histories from ice cores at different locations and timescales are shown in this presentation. We point out that deuterium excess is an integrated isotopic parameter, so a wealth of climate information, but in return difficult to interpret. First, at glacial-interglacial timescale, we compare Vostok deuterium excess history with the new Dome Fuji record. We discuss the possibility to reconstruct past changes both in site and source locations with the combination of deuterium excess and deuterium. In this framework, we discuss the recent comparisons done between source temperature (or deuterium excess) and a single-site SST and give some important caveats against such a comparison. Second, we compare different deuterium excess histories over the last glacial period both in Antarctica and Greenland. We point out similarities and differences, some of them remaining unexplained. Finally, we briefly show deuterium excess from tropical ice cores focusing on our poor understanding of the controls on deuterium excess at tropical low latitudes.

A44A CC: 520 D Thursday 1530h

Ice Cores: Contributions to Climate Variability and Dynamics III *(joint with B, OS, C, GC, PP)*

Presiding: **D Fisher,** Geological Survey of Canada**; J Jouzel,** Laboratoire des Sciences du Climat et de l'Environnement

A44A-01 1530h INVITED

Wonders From a new 3085m Deep ice Core From NorthGRIP on the Greenland ice Sheet.

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A new 3085m deep ice core has been retrieved from (75.1N, 42.3W), the northern part of the Greenland Ice Sheet. The North GReenland Ice core Project was initiated in 1996 by an international team of researchers from Denmark, Belgium, France, Germany, Iceland, Japan, Sweden, Switzerland and USA and after 7 field seasons bedrock was reached on 17 July 2003. The purpose of the NorthGRIP program was to obtain an undisturbed climatic record of ice older than 105 ka, especially to recover a record of the last interglacial period, the Eemian, 115-130 ka before present. This period was not recovered in chronological order from the two central Greenland ice cores GRIP and GISP2 because the deep ice was disturbed by flow over mountainous bedrock. The NorthGRIP drill site was chosen 325 km down the gently NNW sloping ice ridge originating from the top point of the Ice Sheet, where the European GRIP core was drilled. The site is located at a position where the bedrock is very smooth and the annual accumulation rate is 0.195 m/a, the mean annual surface temperature is -32 deg C Approaching bedrock it became clear from measurements of temperatures in the borehole that the basal ice would be on the melting point. High resolution measurements on the ice cores confirmed that basal melting must occur. Drilling in the warm ice near the bedrock turned out to be difficult and new drilling techniques were developed before bedrock was reached in July 2003. The ice core has been measured in high resolution for stable oxygen isotopes, soluble and unsoluble impurities, optical line scan, electrical and dielectrical properties and crystal rheology. Gas, tephra and beryllium measurements are ongoing. The results from the ice core show that the basal melt rate is 0.7 +-0.2 cm ice/a and the ice at the base is 123 +-4 ka old. The continuous impurity measurements and the optical line scan on the ice core are so highly resolved that annual layers can be detected though the whole ice core with layer thicknesses of 1 cm from 70-123 ka BP. The NorthGRIP ice core will thus provide a counted timescale for the whole glacial period and most of the Eemian period. The climate record from the Eemian period and the decline of the Eemian to Glacial conditions (115-123 ka BP) covers 80m of ice core. No rapid cooling events during the Eemian period are observed and the Eemian period has been 5 deg C warmer than our present interglacial period. Reaching bedrock basal melt water flooded the bottom 45m of the borehole and 8 kg of the material was recovered from the drill after been immersed in the meltwater. The refrozen basal water is reddish and contains a high concentration of the windblown impurities found in the ice cores as well as gas. Studies of DNA, pollen and other organic material are ongoing. We will try to drill the 45m of now refrozen meltwater during the 2004 field season because we believe this material will be much less contaminated by the drill liquid than the material recovered from the drill that has been pulled 3085m up though the drill liquid.

A44A-02 1545h

Spatial and Temporal Variability of Volcanic Deposition on Antarctic ice Sheet by Comparing EPICA-Dome C and other Ice-core Sulfate Records

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The Holocene volcanic record, as recorded in the Antarctic ice sheet, has been reconstructed by using the sulfate record of the EDC96 ice core, drilled in the framework of the European Project for Ice Coring in Antarctica (EPICA). The number of volcanic signatures recovered in the EDC96 ice core during the Holocene is 95, with a mean value of 7.9 events per millennium. The distribution of the volcanic frequencies per millennium is here compared with data from other Antarctic ice cores, showing that the last 2000 years were characterized by an enhanced volcanism. The comparison of the volcanic flux profiles in several Antarctic cores reveals a good agreement in the dating of the signatures recorded in the last millennium, but the fit among the volcanic events becomes more and more poor going back in time. Volcanic fluxes show a large variability for isochronous signatures in different Antarctic cores during the last millennium. A flux normalization procedure, obtained by dividing the flux of each event by the Tambora (1815) flux in the same core, was used to compare the intensity of the signatures recorded in different locations. In addition, the standard deviations associated with the ratios of isochronous signatures at different sites show the highest variability in the 1100-1500 A.D. period. This result was interpreted in terms of changes in regional atmospheric transport and linked to climatic changes that occurred during the last millennium.

A44A-03 1600h

A delayed medieval warming observed and simulated in high southern latitudes

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An annual resolution d18O and deuterium excess record has been obtained on Law Dome DSS ice core. We will discuss the interpretation of stable isotopes at coastal locations in Antarctica. The deuterium excess record of the last millennium is interpreted to reflect a warming of subantarctic ocean surface temperature peaking in the 14th and 15th centuries, at a time when northern hemisphere temperatures are already decreasing. Ensemble simulations conducted with the intermediate complexity climate model ECBILT-CLIO suggest that this signal is a delayed response, amplified at high southern latitudes by sea-ice albedo feedbacks, to external forcings (volcanism and solar irradiance). Model simulations show that ocean deep waters formed under slightly warmer conditions in the north Atlantic release the excess heat about 150 years later when upwelling around Antarctica, leading to an apparent contrast between the temperature fluctuations in the north, at the onset of the little ice age, and in the south, having a delayed medieval warming. These results are also supported by available temperature proxies from sediment and ice cores.

A44A-04 1615h

Bipolar correlation of volcanism with millennial climate change

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Analyzing data from our optical dust-logger, we find that volcanic ash layers from the Siple Dome (Antarctica) borehole are simultaneous (with 99% rejection of the null hypothesis) with the onset of millennium-timescale cooling recorded at GISP2 (Greenland). These data are the best evidence yet for a causal connection between volcanism and millennial climate change, and lead to possibilities of a direct causal relationship. Evidence has been accumulating for decades that volcanic eruptions can perturb climate and possibly affect it on long timescales, and that volcanism may respond to climate change. If rapid climate change can induce volcanism, this result could be further evidence of a Southern-lead North-South climate asynchrony. A volcanic-forcing viewpoint is of particular interest, and the high correlation and relative timing of the events, taken together with the Antarctic atmospheric CO_2 record, are consistent with a scenario in which volcanic ash and sulfate abruptly increase the soluble iron in large surface areas of nutrient-limited oceans, stimulate growth of phytoplankton that increase ocean and atmosphere albedo and sequester CO_2, and trigger global cooling on millennial timescales. Large global temperature swings may be limited by feedback within the volcano-climate system: if warming and deglaciation increase volcanism, and if volcanic activity can in turn promote glaciation, this represents a mechanism for regulation of atmospheric temperature.

A44A-05 1630h

The Cryosphere: the Last Vast Water Reservoir. Isotopic Composition of the Greenland and Antarctic ice Sheets.

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Polar ice sheets contain a rich and complex record of climate history, but also constitute a largely unknown dynamic reservoir of water isotopes that must be understood to properly interpret ice core and marine sediment records. Recent advances in ice sheet modelling now allow to predict the fine isotopic stratigraphy of the Greenland and Antarctic ice sheets. In particular, all major ice cores can be simultaneously modelled with great accuracy for each of the polar ice sheets, providing a powerful tool for reconstructing a climatic history that is consistent with the arrays of ice cores. The model reveals the ice dynamic processes that affect ice flow and ice sheet geometry and thus facilitates interpretation of ice core records. In this paper, we combine ice dynamics models with tracer transport and isotopic deposition models to separately estimate the isotopic composition of the Greenland and Antarctic ice sheets and their contribution to the global isotopic budget in the climate system. We also address the question of the time-evolving relationship between the volume of the ice sheets and their isotopic content, a relationship commonly assumed to be linear.

A44A-06 1645h

Spatial variability of stable isotope ratios in snow: How representative are ice cores?

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Isotopic records from ice cores are used as a proxy for temperature history. However, to what extent annual average (or sub-annual) isotopic values derived from an isotopic record is representative of a larger area is not well known. Prior work has addressed this issue through replicate coring and has shown that the 'deposition noise' (i.e. the uncorrelated variance of two adjacent time series) in isotope records are inversely related to local accumulation rate. These studies have used ice cores separated by a few kilometers (Dome C) or tens to hundreds of kilometers (ITASE). Time series separated by these distances may record different climatic conditions and should not necessarily show a large correlation coefficient. In this study, we examine the meter-scale spatial variability of stable isotope ratios in snow by collecting several snow samples from a single stratigraphic layer. Samples were collected from snow pits in Antarctica with a range of accumulation rates from $\sim$ 5 to 50 cm a^{-1}. Preliminary results confirm that the small-scale lateral variability in high accumulation rate areas is much smaller than the seasonal variability. However, the lateral variability can become as large as (or larger than) the seasonal variability as accumulation rate decreases. These results suggest that: (1) The large isotopic variation of precipitation and atmospheric vapor on short time scales (e.g. daily variation measured at Summit, Greenland) may be preserved due to the episodic nature of snow accumulation. However, some of the lateral variation in near-surface snow may be due to post-depositional changes, particularly in low-accumulation rate areas. Further measurements should be able to separate these two effects. (2) Caution is required when using annual average isotopic values derived from a single isotope record due to potentially large meter-scale spatial variability. (3) Since the lateral isotopic variability can be

as large or larger than the vertical variability, isotopic diffusion may be considered to act in three dimensions (rather than only vertically) when reconstructing seasonal climate parameters from isotopic records.

A51A CC: 220 C-E Friday 0830h

Atmospheric Sciences General Contributions Posters

Presiding: **B Crosson,** Global Hydrology and Climate Center

A51A-01 0830h POSTER

Climatology of large-scale cloud characteristics and precipitation amount in the East Asia

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The aerosol indirect effects of both the first and second kinds are still uncertain in climate issues as IPCC reports indicate. In particular, the second kind which deals with precipitation and cloud lifetime is more difficult. More and more pollutants are emitted recently in China due to rapid economical growth, so this influence on the atmosphere is of quite concern from social and scientific points of view. In this paper, we try to investigate the relationship between the low-level cloud fields and precipitation over China. We focus on low-level clouds here because of more interaction with aerosols compared to middle and higher clouds. We use the cloud properties such as the particle size and vertically integrated particle number obtained from AVHRR satellite remote sensing, and precipitation data that were collected from ground-based rain gauges. Then we compared monthly-mean cloud properties with precipitation amount. As for the comparison between the particle size and precipitation, we observe larger particle size as precipitation amounts increase. And as for the comparison between the cloud particle number and precipitation, less cloud droplet number can be seen as precipitation amounts increase. These phenomena are explained mainly as follows. Precipitation substantially scavenge CCN (cloud condensation nuclei) particles from the atmosphere, therefore the number of low-level cloud droplets decrease, and the cloud particle size can get larger in the less CCN environment, when precipitation increases. Larger cloud droplet size might become drizzle more easily as well in the wet condition of rainy season. In addition, we examine geographical correspondence between the low-level cloud fields and precipitation. Of course, the cold rain process such as precipitation associated with the Asian monsoon is predominant in this region. Thus we need to be careful to make direct comparisons as performed here. This sort of preliminary investigation would be, however, valuable as a primary step to get further understanding of the aerosol indirect effects of the second kind.

A51A-02 0830h POSTER

Broadband Meteorological Sensors for GPS, Geophysical and Atmospheric Measurements

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Broadband Meteorological Sensors are successfully used for GPS, geophysical and atmospheric applications. These sensor networks enable scientists to make very accurate position measurements and to detect very small pressure signals. Broadband meteorological sensors co-located with GPS networks may make it possible to detect or forecast a wide range of phenomena such as fog, rainfall, floods, storms, aircraft wake turbulence and wind shear as well as seismic and nuclear events.

URL: http://www.paroscientific.com/GPSMETSupport.htm

A51A-03 0830h POSTER

Full Spectrum Correlated-k for Shortwave Atmospheric Radiative Transfer

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Fast and accurate atmospheric radiation heating and cooling rate calculations are important for improving global climate and numerical weather prediction model performance. The radiative transfer calculations in atmospheric models must be fast so that the underlying methods can actually be implemented in the models and the calculations must be accurate so that heating and cooling rate errors do not introduce large errors into the model simulations. At present correlated-k approaches to handling gaseous absorption represent the state-of-the-art, but their efficiencies are limited by the requirement that the radiation sources be constant across relatively narrow spectral bands. In this presentation we will present the results of applying a new approach, called the full spectrum correlated-k approach, to atmospheric broadband shortwave heating rate calculations. As the full spectrum correlated-k approach does not require the radiation source to be constant across the spectrum, this approach produces clear-sky flux and heating rate errors less than 1% and 5%, respectively, using only two spectral bands. The first band extends from 0.24 - 0.68 microns and requires five quadrature points, while the second band extends from 0.68 - 4.60 microns and requires ten quadrature points. Requiring only 15 calculations for relatively accurate broadband shortwave heating rate calculations, the full spectrum correlated-k approach may turn out to be an attractive one for numerical model radiative transfer calculations.

A51A-04 0830h POSTER

Development of Quantitative Precipitation Forecast (QPF) Confidence Factor Using Short Range Ensemble Forecasts

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Hydrometeorological Prediction Center (HPC) produces a suit of deterministic quantitative precipitation forecast (QPF). The verification statistics shows a steady but gradual improvement. While these forecasts have proven to be useful as they are, they offer no information concerning the uncertainties of individual forecasts. The uncertainty in manually derived HPC QPF can be related directly to the inherent uncertainty in model predictions that is the basis for all HPC forecasts. The availability of ensemble forecasts has allowed forecasters to better assess the uncertainty of model forecast. This study is an attempt to objectively quantify the level of confidence that is justified in a particular HPC QPF by relating errors in HPC QPF to ensemble forecast spread. The first step was to seek out a relationship between the desired quantity, the absolute error (AE) of the HPC QPF, and a known quantity such as the spread from the short range ensemble forecast. Our study indicates that the AE of HPC QPF is highly correlated with ensemble QPF spread. Using the regression model equations derived at each horizontal grid point for each season, we predict an AE of HPC QPF associated with an individual ensemble QPF spread and 95% confidence interval (CI) of the AE. Based on the AE CI forecast and the QPF itself, we also predict 95% CI of the QPF. Currently the CI forecasts are processed for the continental US twice (00z and 12z) per day. The verifications for these CI forecasts have been (and will be) performed for a variety of seasons, geographical regions, various CI ranges, and QPF categories as well as overall regime.

A51A-05 0830h POSTER

The Low-Level Jet and Moisture Transports Over the Upper Mississippi Basin as Simulated by the Canadian Regional Climate Model

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The feedbacks between the low-level jet (LLJ) and the soil moisture are studied with the CRCM that includes a physically-based land-surface scheme (CLASS). Hypothesis testing experiments are designed to explore the connection between the location and temporal variability of the LLJ and sources of moisture over the continent and the Gulf of Mexico. The drought of 1988 and floods of 1993 were used as periods to evaluate the model and determine the equilibration time scale for the land scheme which was found to be about 18 months. The model is able to simulate precipitation and moisture fluxes that are similar in both magnitude and pattern to observational data during summers of 1988 and 1993. To explore the local influence of soil moisture, the simulated values of 1993 were replaced with those simulated for the 1988 summer moisture fields. The results show a significant reduction in precipitation but also an important change in the magnitude and location of a southerly LLJ over the Upper Mississippi basin region. Additional experiments have been designed to explore the influence that orography exerts over the local development of the southerly LLJ in particular the observed reversal occurring from winter to summer. The relative importance of thermal influences versus a mechanical explanation of the maintenance of the jet is evaluated.

A51A-06 0830h POSTER

Snow Sublimation and Canopy Radiation Issues in the Canadian Land Surface Scheme

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The Canadian Land Surface Scheme (CLASS) does not explicitly include multiple scattering below canopies although Nijssen and Lettenmaier (1999) have demonstrated that this can impact significantly on the energy budget when there is snow on the ground. The model also omits blowing snow sublimation. This paper targets the representation of sublimation from snow in canopies and in blowing snow through the incorporation of multiple scattering and an empirical fit to Piektuk model blowing snow results. Friction velocity and the determination of the blowing snow threshold wind velocity are keys to the transfer of Piektuk model results to CLASS.

A51A-07 0830h POSTER

Effects of Urban Heat Island Mitigation Strategies on Current and Future Meteorology of Atlanta, Georgia

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