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Natural processes that relate to climatic variability (such as air circulation, air-water and air-soil energy exchanges) contain inherently stochastic components. Spatiotemporal random fields are frequently employed to model such processes and deal with the uncertainty involved. Covariance functions are statistical tools that are used to express correlations between process values across space and time. This work focuses on a review and visual representation of a series of useful covariance models that have been introduced in the Modern Spatiotemporal Geostatistics literature. Some of their important features are examined and their application can significantly improve the interpretation of space/time correlations that affect the long-term climatic evolution both on a local or a global scale.

GC31B-0195 0830h POSTER

Probabilistic Climate Forecasting

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As a European record-breaking summer draws to an end, climate 'stakeholders' are actively planning for the future, presenting the climate research communtiy with a new challenge. Today's coastal and water-supply engineers do not need 'projections' of how the climate might respond to rising levels of greenhouse gases, no matter how detailed and realistic. Rather they need to know what changes can be ruled out at a given level of confidence. This is probabilistic climate forecasting. The correct procedure for probabilistic climate forecasting begins with a perturbation analysis of the model to identify consistent relationships between observable quantities and forecast variables of interest(this is reffered to as: 'mapping the response manifold'). The resulting ensemble is weighted to accurately represent both current knowledge and uncertainty in observations and then used to infer future climate change. Mapping the respons manifold in a full-scale, non-linear climate model is a formidable chalenge well beyond the capabilities of conventional supercomputing resources. Today the only adequate resource of this scale is presented by the joint idle processing capacity of home and desktop computers of the general public: this is the climateprediction.net approach.

URL: http://www.climateprediction.net/index.php

GC31B-0196 0830h POSTER

Towards a rigorous MCMC estimation of PDFs of Climate System Properties.

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We have revised the method for estimating the uncertainty in climate system properties from Forest et al. (2002). To apply a fully Bayesian approach, we first approximate the response of the MIT 2DLO climate model with a statistical model that provides a response surface in the uncertain parameter space. The three-dimensional parameter space is defined as climate sensitivity (S), rate of deep-ocean heat uptake (K_v), and the net aerosol forcing (F_{aer}) and have been identified as the three major uncertain quantities that affect the ability to simulate accurately the 20th century climate record. The availability of this response surface permits one to perform a full Markov-Chain Monte-Carlo (MCMC) sampling of the joint posterior distribution of the parameters. This approach facilitates the testing of methodologies for performing the more computationally intensive project using the complete MIT 2DLO climate model, which is infeasible with current computer resources.

GC31B-0197 0830h POSTER

The Global Climate Anomaly in 1940-1942

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An unprecedented climatic anomaly occurred in the tropics and in the Northern Hemisphere in 1940-1942. During a strong and prolonged El Niño [Bigg & Inoué, *QJRMS* 118 (1992), 125], extremely cold winters were observed in Europe, accompanied by very warm temperatures in Alaska and large parts of the Arctic and a cold North Pacific. The anomalies were strong (comprising the two coldest European winters of the 20th century) and extraordinarily persistent. In addition, exceptionally high values of total ozone are reported [Langlo, *Geofys. Publ.* 18/6 (1952)], pointing to an anomalous stratospheric circulation. Events of this magnitude have a strong economical and environmental impact; the 1940s anomaly even affected World War II. Studying this anomaly in detail contributes to (1) document the extent of 20th century climate variability, (2) understand large-scale coupling processes between the tropics and the extratropics and between the troposphere and the stratosphere and (3) develop tools to analyze past upper-level climate variability prior to 1948, i.e., the reanalysis period. For this study we have compiled, digitized, and re-evaluated several tens of thousands of temperature and pressure profiles from aircraft and radiosonde ascents up to 50 hPa [Brönnimann, *Int. J. Clim.* 23 (2003), 769]. The upper-air data were supplemented with data from the Earth's surface and used to statistically reconstruct monthly upper-level fields for the extratropical Northern Hemisphere up to 100 hPa [Brönnimann & Luterbacher, *Clim. Dyn.*, submitted]. Although the quality of the reconstructed stratospheric fields is not comparable to more recent data, it is sufficient to allow a broad characterization of the circulation at 100 hPa during the early 1940s. In addition to upper-air data, several total ozone series from the 1940s were re-evaluated [Brönnimann *et al., QJRMS* 129 (2003), 2819], providing further information on the stratosphere. In this paper we present an analysis of these new data sets and compare the results to climate model data. It is demonstrated that the climate anomaly at the ground was accompanied in the lower stratosphere by a weak polar vortex and warm temperatures over the polar region, Eurasia, and the North Pacific. The total ozone data show a peak in 1940-1942 in all available records, at sites as far apart as China, North America, central Europe, and the Arctic. The co-occurrence of warm tropical SSTs (due to El Niño), a weak polar vortex and warm lower stratosphere over polar regions, and a total ozone increase is in agreement with findings by van Loon and Labitzke [*Mon. Wea. Rev.* 115 (1987), 357]. Using the 290-yr control run of the Community Climate System Model CCSM-2.0 provided by UCAR we show that such large-scale coupling events are related to an exceptionally large difference between tropical and northern-extratropical SSTs such as during strong El Niños. The coupling most likely proceeds through a change in planetary wave activity in the northern extratropics that manifests itself in a strong Aleutian low and a weak Icelandic low and in a disturbance of the polar vortex in the stratosphere. The 1940-1942 climate anomaly is not well known among scientists, but it is unprecedented in strength, yet exemplary in character, providing a unique opportunity to study large-scale climate variability.

GC32A MCC: Level 1 Wednesday 1330h

Geophysical Field Studies and Techniques Applied to Underground Storage of Greenhouse Gas Emissions in All Phases of Site Characterization, Injection and Storage Operations, and Monitoring II Posters

Presiding: **K K Cohen,** National Energy Technology Laboratory, U.S. Department of Energy**; C Byrer,** National Energy Technology Laboratory, U.S. Department of Energy

GC32A-0198 1330h POSTER

The Global Distribution of Candidate Geological CO2 Reservoirs and Their Economic Implications for Deployment of Carbon Capture Technology

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Geological storage of anthropogenic point-source CO2 is an increasingly important strategy for mitigation of greenhouse-gas emissions. Much research has focused on the costs of capture, with the assumption that storage options would be relatively cheap, plentiful and would be located in close proximity to future CO2 point sources. But, capture and disposal will take place at the local and regional scale and it must compete with other mitigation options. In this paper we provide an initial examination of the consequence of regionally disaggregated sources and sinks of carbon within the context of a globally disaggregated, long-term analysis of both the geology and the economics of carbon capture and disposal. In our analysis, we assume that large volume CO2 point sources will seek to sequester their CO2 in regional reservoirs. We consider sedimentary basins on land and continental shelves. We examine options for saline aquifer, enhanced oil recovery (EOR), and coal storage based on calculated volumes and costs. Shelf and land options are treated as separate options, and very deep saline aquifers are also treated separately. Sedimentary basins are counted as targets broadly, while cratonal areas are excluded. Within basins, pore-volume estimates are made for targets below the critical point of CO2 assuming typical crustal heat flux and lithostatic pressure. By subdividing the globe into 14 economic provinces as defined by the MiniCAM energy and economic integrated assessment model, we are able to make regional estimates of sequestration loads (i.e., the amount of carbon needing to be sequestered in any time period) and the economic implications of this the degree to which there these candidate reservoirs are available in the region. Our preliminary analysis suggests that some regions will see their ability to deploy capture and disposal systems constrained by a lack of quality target reservoirs relative to major sources and population centers in that region, while other regions appear to have sufficient disposal capacity to easily carry them through this century. We examine the regional and global economic implications of the distribution of these sources and sinks in meeting various potential limits to CO2 concentrations in the atmosphere. We also examine the degree to which the relative abundance of CO2 capture and disposal opportunities in a region influences the adoption of other emissions mitigation technologies.

GC32A-0199 1330h POSTER

Geophysical Methods, Tracer Leakage, and Flow Modeling Studies at the West Pearl Queen Carbon Sequestration/EOR Pilot Site

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Recently, a few thousand tons of CO_2 were injected into the West Pearl Queen field, a depleted oil reservoir in southeastern New Mexico, for a pilot carbon sequestration project. Small amounts of 3 different perfluorocarbon tracers were injected with the CO_2. Approximately 50 capillary absorption tube samplers (CATS) were located across the field within 2m of the grounds surface to detect the tracers in extremely small (10^{-13}L) quantities. After only several days, the CATS detected quantities of tracers at distances of up to 350m from the injection well. Greater amounts of tracers were detected in the different directions. The underground transport mechanism(s) are uncertain; however, appearance of tracer in the CATS after only a 6 day period suggests that CO_2 movement may have occurred through near-surface processes. Subsequent tracer measurements made over 10 and 54 day time periods revealed continued tracer leakage. To try to understand the tracer information, we conducted lineament interpretations of the area using a black and white aerial photo taken in 1949, digital orthophotos, and Landsat TM imagery. Lineament interpretations revealed distinct northeast and northwest trending lineament sets. These directions coincided roughly with the direction of tracer-leakage into areas northwest and southwest of the injection well. The near-surface geology consists of a few-feet thick veneer of late Pleistocene and Holocene sand dunes covering the middle Pleistocene Mescalero caliche. A survey of the caliche was made using ground penetrating radar (GPR) to attempt to identify any preferential migration pathways. Modeling studies also were performed to identify the potential leakage pathways at the site. Because of the relatively fast appearance of tracers at large distances from the injection well, simple diffusion through the surface layers was ruled out. Wind patterns in the area have also made transport through the atmosphere and back into the ground highly unlikely. Other potential leakage pathways were transport from the well through the saturated zone and diffusion into the unsaturated zone or combined pressure-driven and diffusive flow through the vadose zone. An analysis of these alternatives has been made for this study.

GC32A-0200 1330h POSTER

Evaluation of Partitioning Gas Tracer Tests for Measuring Water in Landfills

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Methane is an important greenhouse gas, and landfills are the largest anthropogenic source in many developed countries. Bioreactor landfills have been proposed as one means of abating greenhouse gas emissions from landfills. Here, the decomposition of organic wastes is enhanced by the controlled addition of water or leachate to maintain optimal conditions for waste decomposition. Greenhouse gas abatement is accomplished by sequestration of photosynthetically derived carbon in wastes, CO2 offsets from energy use of waste derived gas, and mitigation of methane emission from the wastes. An important issue in the operation of bioreactor landfills is knowing how much water to add and where to add it. Accurate methods for measuring the amount of water in landfills would be valuable aids for implementing leachate recirculation systems. Current methods for measuring water are inadequate, though, since they provide point measurements and are frequently affected by heterogeneity of the solid waste composition and solid waste compaction. The value of point measurements is significantly reduced in systems where water flows preferentially, such as in landfills. Here, spatially integrated measurements might be of greater value. We are evaluating a promising technology, the partitioning gas tracer test, to measure the water saturation within landfills, the amount of free water in solid waste divided by the volume of the voids. The partitioning gas tracer test was recently developed by researchers working in the vadose zone. We report the results from laboratory and field tests designed to evaluate the partitioning gas tracer test within an anaerobic landfill operated by the Delaware Solid Waste Authority. Vertical wells were installed within the landfill to inject and extract tracer gases. Gas flow and tracer gas movement in the solid waste were controlled by the landfill's existing gas collection system, which included vertical wells installed throughout the landfill through which a vacuum was applied. The results from this test are reported along with an overview of a similar test planned for the bioreactor landfill cells operated by the Yolo County Department of Planning and Public Works.

GC32A-0201 1330h POSTER

Rapid Prediction of CO2 Movement in Aquifers, Coal Beds, and Oil and Gas Reservoirs

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Predictions of the mix of future primary energy sources often include significant use of fossil fuels, and scenarios envisioning a switch to renewable and/or nuclear primary energy sources rely on fossil fuels for the extended period required to install large-scale systems. Effective means of sequestering CO2 will be required to reduce emissions of CO2 in these scenarios. The earth's crust presents three major classes of geologic formation that appear suitable for long-term storage: deep formations containing salt water, unmineable coalbeds, and depleted oil and gas reservoirs. With injection into oil and gas reservoirs and coalbeds, it may be possible to recover net energy in concert with CO2 storage. If CO2 injection into geologic formations is undertaken on a large scale, high-resolution, but low computational cost, numerical methods will be needed. Such simulations may be used to predict where CO2 is likely to flow, interpret the volume and spatial distribution of the subsurface contacted by injectant, and optimize injection operations. These elements will certainly be necessary if geological sequestration is proven feasible and public acceptance is to be gained. In this paper, we present research on developing ultra-fast computational methods and tools applicable to the suite of geologic formations suitable for CO2 storage. The underpinnings of these methods are streamline-based computations. The flow field in 3D is decoupled into a series of 1D flow problems linked by common injection and boundary conditions. Periodically, streamline trajectories are updated as the pressure field in the volume under consideration evolves. The advantages of this approach are a reduction in the dimensionality of the numerical problem, the possibility to employ analytical solutions along each streamline, and a significant reduction in the effects of numerical dispersion. In contrast, conventional finite-difference based numerical techniques suffer from excessive numerical dispersion and long computation times. Finally, we demonstrate by calculation examples the different mechanisms controlling the displacement behavior of CO2 sequestration schemes, the interaction between flow and phase equilibrium and how proper design of injection gas composition and well completion are required to co-optimize oil production and CO2 storage.

GC32A-0202 1330h POSTER

Carbon Dioxide Sequestration and ECBM in the Powder River Basin

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Coal seams are both a source of coal bed methane (CBM) and a potential carbon dioxide sink. For sub-bituminous coals like those in the Powder River Basin (PRB), the CO2/CH4 adsorption ratio is approximately 10:1, which indicates the significant potential for sequestering carbon dioxide. In addition, injected carbon dioxide would also enhance the production of methane from the coal seam because of its higher adsorption capacity. This means that the injection of carbon dioxide in coal beds may have the dual benefit of sequestering carbon dioxide and enhancing CBM production. Moreover, if carbon dioxide injection efficiently displaces the adsorbed methane, it may reduce the amount of water produced from CBM wells as part of the depressurization process. Our work in the Powder River Basin indicates that drilling and completion operations result in hydraulic fracturing of the coal and possibly the adjacent strata. This would result in both excess CBM water production and inefficient depressurization of coals. We have been able to collect water-enhancement tests data in coals to obtain the magnitude of the least principal stress in the coal seam. The preliminary data we have analyzed indicates that the hydrofracs are horizontal in some areas because the least principal stress corresponds to the overburden. It is interesting to speculate that one could use horizontal hydrofracs near the bottom of the coal seam for carbon dioxide injection and a horizontal hydrofrac near the upper part of the coal seam for methane production.

GC32A-0203 1330h POSTER

Geologic Sequestration of CO2 and Associated H2S and SO2 in Bedded Sandstone-Shale Sequences

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The injection of CO2 and associated acid gases such as H2S and SO2 into deep sedimentary aquifers is a means by which net anthropogenic atmospheric emissions of greenhouse gases might be reduced. Aquifer host rock aluminosilicate minerals alter very slowly under ambient conditions and their study is not amenable to laboratory experiment. We therefore developed a numerical model to investigate the fate of CO2 and other acid gases in bedded sandstone-shale sequences using hydrogeologic properties and mineral compositions characteristic of Texas Gulf Coast sediments. The simulations were performed using the reactive fluid flow and geochemical transport code, TOUGHREACT, to analyze mass transfer between sandstone and shale layers, the consequent immobilization of gases through mineral precipitation, and the impact of cocontaminated H2S and SO2 gases on CO2 sequestration. The gas sequestration capacity by both aqueous and mineral phases was evaluated. Porosity changes due to mineral dissolution and precipitation were also monitored. The simulations provide useful insights into potential sequestration processes, and their controlling conditions and parameters during long-term containment of acid gases in deep sedimentary formations.

GC32A-0204 1330h POSTER

The Streaming Potential Coupling Coefficient of Liquid Carbon Dioxide Injected Into Water Saturated Berea Sandstone

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The streaming potential coupling coefficient was determined for a liquid carbon dioxide flood of a water-saturated sample of Berea sandstone. The coupling coefficient for the rock/water case was determined both before and after each CO2 flood of three samples using a low-pressure static head method. Next, liquid CO2 was allowed to flow through each sample. As the CO2 displaced the water the coupling coefficient decreased. At longer times, when all mobile pore water was displaced, the coupling coefficient maintained a steady state, and was lower than that for water by about 10 times. The results of this testing reveal a coupling coefficient of 30 mV/0.1MPa, for 125 Ohm-m water flow through the sample, and 3.0 mV / 0.1 MPa

for liquid CO2 flow. Calculated zeta potentials are -3.4 mV using water as the pore fluid and -1.7 x 10-6 mV for liquid CO2. We propose that the lower coupling coefficient for CO2 flow is primarily a result of changes in zeta potential, since changes in pore fluid resistivity and viscosity would act to increase the coupling coefficient. Zeta potential for the liquid CO2 / mineral interface is a function of the low polarity and lack of mobile ions associated with liquid CO2. We find no anomalous 2-phase liquid/gas effects, which may have augmented single-phase streaming potentials by many times. We propose that although CO2 gas may have been present for some of the higher pressure drop events, the low gas fraction (or quality) of the two-phase mixture did not lead to any significant anomalous or augmented observations. Implications of this work include spatial and temporal monitoring of CO2 injectate in subsurface reservoirs and the identification of flow paths, with the recommendation being to attempt to image the advancing CO2/water front, where the coupling coefficient is higher.

GC32A-0205 1330h POSTER

CIRF.B Reaction-Transport-Mechanical Simulator: Applications to CO2 Injection and Reservoir Integrity Prediction

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An important component of CO2 sequestration in geologic formations is the reactions between the injected fluid and the resident geologic material. In particular, carbonate mineral reaction rates are several orders of magnitude faster than those of siliciclastic minerals. The reactions between resident and injected components can create complex flow regime modifications, and potentially undermine the reservoir integrity by changing their mineralogic and textural compositions on engineering time scale. This process can be further enhanced due to differences in pH and temperature of the injectant from the resident sediments and fluids. CIRF.B is a multi-process simulator originally developed for basin simulations. Implemented processes include kinetic and thermodynamic reactions between minerals and fluid, fluid flow, mass-transfer, composite-media approach to sediment textural description and dynamics, elasto-visco-plastic rheology, and fracturing dynamics. To test the feasibility of applying CIRF.B to CO2 sequestration, a number of engineering scale simulations are carried out to delineate the effects of changing injectant chemistry and injection rates on both carbonate and siliciclastic sediments. Initial findings indicate that even moderate amounts of CO2 introduced into sediments can create low pH environments, which affects feldspar-clay interactions. While the amount of feldspars reacting in engineering time scale may be small, its consequence to clay alteration and permeability modfication can be significant. Results also demonstrate that diffusion-imported H+ can affect sealing properties of both siliciclastic and carbonate formations. In carbonate systems significant mass transfer can occur due to dissolution and reprecipitation. The resulting shifts in in-situ stresses can be sufficient to initiate fracturing. These simulations allow characterization of injectant fluids, thus assisting in the implementation of effective sequestration procedures.

GC32A-0206 1330h POSTER

Identification of bottom-simulating reflectors related to gas hydrates, silicate diagenesis, and other P/T dependent sediment processes

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Large quantities of the green-house gas methane exist in the form of gas hydrate within continental margin sediments. Bottom-simulating reflectors (BSR) are the most prominent geophysical indication for such gas hydrate reservoirs, but there are other geological processes that create similar seismic phenomena. It is therefore important to analyse the seismic character of different BSR in order to be able to distinguish between them. Three classes of BSR cross-cut the post-breakup sediments of the mid-Norwegian margin. The first class is caused by gas hydrates, which trap free gas at the base of their pressure- and temperature-dependent stability zone. The second class of BSR is caused by the diagenetic transition from opal A to opal CT. The third class is always observed underneath the opal A / opal CT transition but heat flow data and the amplitude characteristics of this event exclude one of the known silicate diagenetic transitions or gas hydrates as the explanation for this arrival. ODP Site 643 drilling results suggest two possible processes as the reason for this BSR: (a) smectite dewatering, or (b) a sudden increase in the abundance of authigenic carbonates. The genesis of both is pressure- and temperature-dependent and could potentially result in a cross-cutting seismic reflector. The data are not conclusive as to which process is causing the observed third class of BSR. Comparison of the seismic characteristics of the different types of BSR shows that apparent polarity without previously applied automatic gain control is the best way to distinguish between them, as gas hydrate related BSR have reverse polarity and the diagenetic transitions cause normal polarity BSR. On the other hand, seismic amplitude variations can be very similar for all classes of BSR.

GC32A-0207 1330h POSTER

CO_2 Extraction from Ambient Air Using Alkali-Metal Hydroxide Solutions Derived from Concrete Waste and Steel Slag

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To mitigate global climate change, deep reductions in CO_2 emissions are required in the coming decades. Carbon sequestration will play a crucial role in this reduction. Early adoption of carbon sequestration in low-cost niche markets will help develop the technology and experience required for large-scale deployment. One such niche may be the use of alkali metals from industrial waste streams to form carbonate minerals, a safe and stable means of sequestering carbon. In this research, the potential of using two industrial waste streams—concrete and steel slag—for sequestering carbon is assessed. The scheme is outlined as follows: Ca and Mg are leached with water from a finely ground bed of steel slag or concrete. The resulting solution is sprayed through air, capturing CO_2 and forming solid carbonates, and collected. The feasibility of this scheme is explored with a combination of experiments, theoretical calculations, cost accounting, and literature review. The dissolution kinetics of steel slag and concrete as a function of particle size and pH is examined. In stirred batch reactors, the majority of Ca which dissolved did so within the first hour, yielding between 50 and 250 $\frac{mg\ Ca}{g\ slag}$ and between 10 and 30 $\frac{mg\ Ca}{g\ concrete}$. The kinetics of dissolution are thus taken to be sufficiently fast to support the type of scheme described above. As proof-of-concept, further experiments were performed where water was dripped slowly through a stagnant column of slag or concrete and collected at the bottom. Leachate Ca concentrations in the range of 15 mM were achieved — sufficient to support the scheme. Using basic physical principles and numerical methods, the quantity of CO_2 captured by falling droplets is estimated. Proportion of water loss and required pumping energy is similarly estimated. The results indicate that sprays are capable of capturing CO_2 from the air and that the water and energy requirements are tractable. An example system for enacting the scheme is presented, along with capital and operational cost estimates. The system is found to be profitable for carbon credits above $\$5/ton\ C$. Many findings in this research apply to a more general set of systems which capture CO_2 from the air for sequestration. The metal-hydroxide solution in these systems is regenerated on site, allowing application of this scheme on as large a scale as needed. Implications of this study's findings for these more general carbon-capture systems is discussed.

GC52A MCC: 3010 Friday 1340h

Reconstructing Hydroclimatic Variability in North America: Progress, Methods, and Uncertainties I *(joint with H, PP)*

Presiding: **C Woodhouse,** NOAA Paleoclimatology Branch**; R Webb,** NOAA/OAR Climate Diagnostics Center

GC52A-01 1340h INVITED

The North American Drought Atlas

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A large part of the western US has been experiencing unusually severe and persistent drought over the past 5 years. This drought highlights both the vulnerability of this semi-arid region to shortfalls in rainfall and the need to better understand long-term drought variability and its causes in North America. To this end, centuries long, annually-resolved tree-ring records have been used to reconstruct annual changes in both drought and wetness over large portions of North America. The drought metric used for this purpose is the summer-season Palmer Drought Severity Index (PDSI). The PDSI reconstructions have been produced on a 297-point 2.5x2.5° regular grid that covers most of North America. This new generation of North American drought reconstructions was made possible through support from the NOAA Office of Global Programs. These drought reconstructions, some of which extend back almost 2,000 years into the past, have been used to create a North American Drought Atlas that provides a detailed spatial and temporal history of drought and wetness. This effort has been supported by the NSF Paleoclimatology Program. The North American Drought Atlas, which will be available on a CD-ROM and can be accessed inter-actively using standard web browsers, has been created to make the drought reconstructions easily accessible. Each of the 297-point summer PDSI reconstructions, with their estimated uncertainties, can be displayed in PDF format. There are also 1,992 annual PDSI maps also in PDF format that can be selected and displayed by year. The annual maps have also been linked together into an animation to provide a dynamic look at patterns of drought and wetness as they develop across parts of North America where tree-ring estimates exist back in time. The numerical values of the PDSI reconstructions will also be available on the CD-ROM for independent analyses. Some properties of past reconstructed drought over North America will also be described in context with that which is currently afflicting the western US. In particular, an examination of the area affected by drought conditions of at least incipient severity (i.e., PDSI< -1 or worse) reveals the occurrence of a prolonged period of elevated aridity over the western US during the AD 850-1300 interval. This dry epoch, which is arguably a hydrologic expression of the Medieval Warm Period, is unprecedented over the past 1,200 years. If this is an indication of how warmer conditions in the past have affected the incidence of drought in the western US, it cannot be viewed as good news as we enter into a warmer world increasingly forced by greenhouse gases.

GC52A-02 1400h

The Atlantic Basin as a Source for North American Drought: New Perspectives from Proxy Climate Networks

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Investigations into the causes of severe, persistent droughts in North America have focused primarily on interannual (ENSO) to decadal-scale (PDO) variability in Pacific sea surface temperatures (SST). This, in turn, has justified rapid development of high-resolution proxies to extend Pacific SST fields beyond the instrumental record. However, recent studies show that low-frequency (30-70 yr) modes in North Atlantic ($0-70^{\circ}$

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