dynamics. In this study, we have examined mineral palsa dynamics along the Boniface river (subarctic Quebec) in relation to changes in precipitation and temperature. A detailed mapping of palsas and thermokarst ponds allowed us to compare permafrost landforms in 1957 (from aerial photographs) and in 2001 (using data from field surveys). Dates of formation and decay of 15 palsas were assessed from radiocarbon dating of paleosols and tree-ring dates of establishment and mortality of black spruce and planeleaf willow. Two major periods of palsa formation were associated with periods of climatic cooling: around 1300 BP, and around the 15th and 18th centuries (Little Ice Age). Between 1957 and 2001 the area occupied by palsas decreased by 29% whereas thermokarst ponds increased by 76%. No new palsa developed during this period. For the 15 palsas studied, degradation began at the end of the 19th century and climaxed during the 20th century. Palsa dynamics is closely related to distance from the river. The youngest palsas were located in the river bed and were most affected by thawing processes (an average of 48% of area lost). The older palsas were at 1.2 to 14.7 m from the river margin and their decay was less pronounced (an average of 19% of area lost). The spatiotemporal distribution of palsas suggests that changes in water level is one of the most important factor influencing riparian palsa dynamics. As the river retreats, sediments are exposed to frost penetration, leading to the formation of mineral frost mounds along to the spatiotemporal gradient. When the water level increases, the degradation is more important for palsas directly in conctact with the water compared to those located on river margins.

GC12A-0158 1330h POSTER

Analysis of the Surface Radiation Budget Data in Terms of Empirical Orthogonal Functions (EOFs)

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The version Release 2 from the WCRP/GEWEX SRB project at the NASA Langley Research Center is a significant upgrade from the V1.1 WCRP SRB Shortwave 4-year data set. The new version has a 1-degree spatial resolution in both latitude and longitude and covers the period from July 1983 to October 1995. Meanwhile, we have acquired the field observations of shortwave radiation at about 1000 sites worldwide for the past thirty plus years. Previous analysis of seasonal variations showed that the seasonal cycles of net shortwave radiation and net total radiation can be described by first 3 EOFs so that more than 98 % of the variance is expressed. The net longwave radiation is more complex and requires many more terms. A subsequent study showed that the EOFs which express the geographical distributions could be simply related to the climate classes. In this study, we focus upon the interannual fluctuations using the monthly means of the surface shortwave radiation from the above databases, and we apply the EOFs to the analyses of both the SRB data and the surface-based observations and their differences. We show, among other things, the first few EOFs of the global surface shortwave flux and their associated principle components (PCs). The EOF whose associated PC shows significant correlation with the El Nino Southern Oscillation (ENSO) Index (SOI) epitomizes the variability of the surface shortwave flux associated with the ENSO. A geographical PC analysis will seek to identify the dominant processes determining long-term variability in the dataset.

GC12A-0159 1330h POSTER

Comparison Between Speleothem Isotopic And Instrumental Climate Records: Annual δ^{18}O Cycles, And Inter-annual δ^{18}O And δ^{13}C isotopes

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An intra and inter-annual stable isotope record has been obtained from a southwest Australian speleothem whose age is confidently confined by the boardwalk on which it grew (1911-1992). This provides an excellent test of speleothem climate proxies because the regional climate is strongly seasonal (wet winter/dry summer), and has experienced a 20% reduction of mean rainfall since 1964 (Smith et al., 2001) and 0.8^{o}C temperature rise since 1953. Inter-annual variations of oxygen (δ^{18}O) and carbon (δ^{13}C) isotopes (1.5-2 year increments) were measured by conventional mass spectrometry whilst intra-annual δ^{18}O was measured using a high spatial resolution ion microprobe. Comparing the speleothem O and C isotope and instrumental climate records reveals surprising trends. Speleothem δ^{18}O varies positively with temperature on both intra- and inter-annual timescales, eliminating a cave temperature effect (McCrea, 1950). On the inter-annual scale, δ^{18}O rises 0.3$^{o}/_{oo}$ after 1974. This occurs 10 years after the regional rainfall decrease but synchronous with a delayed response seen in P and Mg concentrations, which otherwise vary strongly with rainfall, indicating that speleothem δ^{18}O is responding to rainfall δ^{18}O. This is confirmed by the detection of annual 1-2$^{o}/_{oo}$ δ^{18}O cycles which record rainfall δ^{18}O, smoothed by storage in the overlying limestone. Rainfall in the region is isotopically lightest in the wet winters and heaviest in the relatively dry summers, driven by the intensity and proximity of passing low pressure systems. Preservation of the annual rainfall δ^{18}O signal suggests that rainfall amount is recorded by speleothems in this region. A 2.5$^{o}/_{oo}$ rise in δ^{13}C since 1934 cannot be related either to rainfall or temperature. Furthermore, there are no consistent relationships between δ^{13}C with speleothem growth rate or with trace elements leached from the limestone, but a kinetic control for δ^{13}C is not ruled out. Mean δ^{18}O rises by 0.5$^{o}/_{oo}$ between 1929-1957, which coincides with faster speleothem growth; however, the results do not support accepted theory (Hendy, 1971), which suggests δ^{18}O should be less sensitive to precipitation kinetics than δ^{13}C. McCrea, J. 1950. J. Chem. Phys. 18: 849; Hendy, C. 1971. GCA 35: 802; Smith, I, et al. 2000. Inl. J. Climat. 20: 1913.

GC12A-0160 1330h POSTER

Climate Effect on Circulation in Lake Tanganyika: Increase of the Anoxic Hypolimnion and Loss of Productivity

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Lake Tanganyika, largest by volume of the East African Great Lakes (maximum depth 1470 m), has warmed up over the past century. Heating rates, the density depth gradient and the oxygen distributions were examined. The amount of energy absorbed by Lake Tanganyika is substantial on a global heat budget scale and is in the same order as that absorbed by the melting of Arctic sea-ice in the past century. At higher temperatures density decreases. Because the surface warmed up more than deep water the difference in density between shallow and deep water increased. The increased density gradient has slowed down vertical mixing and circulation and as a result oxygen concentrations and the maximum depth of oxygen penetration have decreased. SO4, introduced to the lake by river inflow, is now almost completely (98 %) lost from the lake by reduction at the oxic-anoxic interface. As a result the depth at which H2S is detectable has become much more shallow, from 300 m in 1938 to 120 m in 2000. At the south end where mixing is traditionally deepest in the lake, driven by south east trade winds, organisms which lived at 100-300 m a century ago are now forced into a more shallow distribution. The increase of the density gradient from deep nutrient rich to shallow nutrient poor water and the reduced mixing capacity of the lake has substantially impacted the offshore ecosystem. Primary production by phytoplankton has decreased as shown by increased silica concentrations and lower algal biomass, probably by reduced availability of essential macro and micro nutrients in epilimnetic water. The epilimnetic dissolved silica concentration tripled as diatom production and sedimentation of biogenic silica dropped in the last decades of the past century. Blooms of cyanobacteria in the stratified season may have been more common earlier in the century compared with the present and the lake is now much more transparent. Temperature is an important parameter in tropical lakes and climate warming has changed the ecosystem in Lake Tanganyika over the past century. Both reduced productivity and a reduced oxygen penetration will threaten the persistence of some of the hundreds of endemic species in Lake Tanganyika, as their habitats contract spatially and become more nutrient poor.

GC31A MCC: 2008 Wednesday 0800h

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 I

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

GC31A-01 0800h

Seafloor micro-gravity survey of the Sleipner CO2 sequestration site

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The Sleipner fields make up a natural gas production area in the North Sea operated by Statoil, the major Norwegian oil company. The gas recovered there has an excess CO2 content of about 7 percent, which is separated out and collected. CO2 collected from most production areas is released into the atmosphere, increasing the atmospheric content of this greenhouse gas. Sleipner is the world's first large scale concentrated CO2 sequestration project. Each year 1 MT of CO2 is injected into a large, deep saline reservoir called the Utsira formation. This is a high porosity sandstone aquifer capped by low porosity shale 720 m below the seafloor. The multi-institutional SACS (Saline Aquifer CO2 Storage) group began geologic analysis, reservoir simulations, seismic modeling, and geophysical monitoring of Sleipner in 1998. The primary monitoring technique is 4-D or time-lapse seismics. The results show a clearly defined CO2 bubble. However, uncertainties exist such that the density, thus mass, of CO2 within the Utsira sand is not precisely known. Preliminary gravity modeling indicates that the density changes due to a year of CO2 injection should cause a change in the local gravity ranging from 5-15 microGal (the range is due to an uncertainty in the reservoir temperature). In August of 2002, we carried out the first phase of a seafloor gravity survey, establishing a baseline for time-lapse gravity monitoring of the CO2 bubble as well as obtaining a gravity data set for initial reservoir modeling. Gravity was measured on the seafloor above the Sleipner CO2 injection site from the 15th to the 21st of August, 2002, on top of 30 concrete benchmarks, which were permanently deployed on the seafloor spaced from 300 to 500 m apart. The area spans about 7 km E-W and 3 km N-S and has a water depth of 80 m. Gravity measurements were gathered using ROVDOG (ROV deployed Deep Ocean Gravimeter), a package consisting of three relative gravimeters. In relative gravity surveys, the uncertainty is given by the repeatability of the measurements, thus each benchmark was visited at least three times. Based on repeatability, the uncertainty in the station averages is estimated to be 2.5 microGal. For time-lapse measurements, there is additional uncertainty associated with the reference null level, determined from stations outside the CO2 area, of about 1-2 microGal. Therefore, the final detection threshold for time-lapse changes is about 5 microGal. Modelling of the data from our initial gravity survey, in conjunction with seismic and borehole data, is a first attempt at estimating the CO2 density and mass within the reservoir. Subsequent surveys that provide time-lapse data will be an independent and more reliable means to estimate these quantities. The time scale for a repeat survey is 2 to 5 years.

GC31A-02 0815h

4D Geophysical Monitoring of the Carbon-dioxide Plume at Sleipner, North Sea: a Status Review

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CO2 produced at the Sleipner natural gas field is being injected into the Utsira Sand, a major saline aquifer. The SACS project and its successor CO2STORE, aim to monitor the injected CO2 by time-lapse geophysical methods. Time-lapse (4D) seismic data were acquired in 1999 and 2001, with respectively, 2.35 and 4.26 million tonnes of CO2 in the reservoir. The CO2 plume is imaged as a number of bright sub-horizontal reflections, growing with time, underlain by a prominent velocity pushdown that locally attained 60 ms in 2001. The reflections are interpreted as tuned responses from thin (less 8 m thick) layers of CO2 trapped beneath thin intra-reservoir mudstones and the reservoir caprock. The data show that no detectable leakage of CO2 into the caprock has so far occurred. Seismic modelling aimed at verifying the in situ injected mass of CO2 has utilised both inverse and forward modelling techniques. Recent inverse modelling of the 1999 plume has produced a three-dimensional CO2 saturation distribution that can account for the known injected mass of CO2, within the limits of parameter uncertainty. Signal attenuation effects in the 2001 plume render it less suitable for direct inversion. Synthetic seismic (forward) modelling of a flow simulation of the 2001 plume has produced an acceptable fit to the observed reflectivity, but significant discrepancies with the observed velocity pushdown remain. Signal attenuation is likely to become a more significant factor as the plume grows further, perhaps reducing the efficacy of quantitative seismic verification techniques. Other time-lapse geophysical methods may become increasingly useful at this stage. To this end, an initial seabed microgravity survey has recently been acquired at Sleipner.

GC31A-03 0830h

Strategies for CO2 Sequestration in Geologic Formations and the Role of Geophysics

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Among proposed options for CO2 emissions mitigation, capture and sequestration is a promising solution that has the advantage of being able to cope with the large volume of CO2 involved, which will increase because of a growing energy demand. Consequently, an important component of the United States Department of Energy's (DOE) research and development program is dedicated to reducing CO2 emissions from power plants by developing technologies for capturing CO2 and for subsequent utilization and/or sequestration. Capture technologies target novel, low-cost approaches for separation and capture of CO2 from energy production and conversion facilities. Injection of CO2 into geologic formations is being practiced today by the petroleum industry for enhanced oil recovery, but it is not yet possible to predict with confidence storage volume, formation integrity and storage permanence over long time periods. Many important issues dealing with geologic storage, monitoring, and verification of fluids (including CO2) in underground oil and gas reservoirs, coal beds, and saline formations are now being addressed. Preliminary field tests are being conducted to confirm practical considerations, such as economics, safety, stability, permanence, and public acceptance. This paper presents an overview of DOE's research program in the area of CO2 sequestration and storage in geologic formations and specifically addresses the status of new knowledge, improved tools and enhanced technology for cost optimization, monitoring, modeling and capacity estimation. This paper also highlights those fundamental and applied studies, including field tests, sponsored by DOE that are measuring the degree to which CO2 can be injected and remain safely and permanently sequestered in geologic formations while concurrently assuring no adverse long term ecological impacts. Field geophysical techniques are playing a major role in these demonstrations, such as the Weyburn project in North Dakota and Canada, the Mountaineer Power Plant project in Ohio, and the Frio Formation project in Texas.

GC31A-04 0845h INVITED

Microseismic Monitoring at the Weyburn CO_2 Injection Site

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CO_2 sequestration in geological reservoirs is being evaluated internationally as a viable means of long-term CO_2 storage and climate change mitigation. The International Energy Agency Weyburn CO_2 Monitoring and Storage Project is investigating the technical and economic feasibility of CO_2 storage in a partially-depleted oil reservoir near Weyburn, Saskatchewan, Canada. In the fall of 2000, EnCana Resources (the field operator) initiated CO_2 injection into the reservoir as part of a tertiary enhanced oil recovery project. CO_2 is injected at a rate of $\sim 3x10^6 m^3$ per day, with the cumulative volume of injected CO_2 reaching $\sim 2x10^9 m^3$ by May, 2003. As part of this study, microseismic monitoring is being conducted to help assess the dynamic response of the reservoir to CO_2 injection. Toward this end, an 8-level array of 3C geophones has been cemented in place 200 m above the reservoir which resides at 1400 m depth. Data acquisition was initiated in August of 2003 and is intended to continue for at least 6 months. Microseismicity will be analyzed to constrain the location, magnitude, source mechanism, likely geologic source and frequency of occurrence of the characteristic seismicity, and will be compared in detail with the CO_2 injection schedule and production rate variability. Passive monitoring will be evaluated as an alternative means of monitoring the CO_2 flood.

GC31A-05 0900h INVITED

Geophysical Characterization and Monitoring for the Frio Pilot Test

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The Frio Pilot test involves injection of approximately 3000 tons of CO2 into the brine-saturated Frio formation at a depth of approximately 1500 m at a test site located northeast of Houston. The CO2 is injected from a new well drilled for the test while an existing well provides subsurface access for monitoring. Geophysical data for characterization included 3-D surface seismic and well logs, which were available because of the extensive oil and gas exploration and production in the area. Seismic interpretation coupled with petrophysical analyses and other geologic data showed that the test site is located in a small fault block off the flank of a salt dome. The injection interval consists of alternating layers of sand and shale, with sand layer thickness on the order of 10 m, overlain by the 75 m thick Anahuac shale. Well logs in the new well provide data to confirm test site stratigraphy as well as data needed for interpretation of geophysical monitoring measurements. Geophysical monitoring involves time-lapse measurements, incorporating both surface and borehole techniques. Selection of techniques was aided by modeling in which reservoir simulation predicted fluid distributions, which were then input to geophysical models to predict performance of candidate techniques. Interpretation of crosswell seismic with appropriate rock physics models can potentially provide quantitative information on CO2 saturation between boreholes. Vertical seismic profiling will be used to map the areal distribution of the plume. Low resolution but inexpensive streaming potential measurements will also be carried out to sense the advancing CO2 front.

GC31A-06 0915h

Surface Monitoring of Leakage From Geologic CO_2 Sequestration

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The capture of carbon dioxide (CO_2) from large point sources and long term storage in geological formations has received much recent attention as a potential green house gas mitigation option. Among the proposed storage locations are active and depleted oil and natural gas reservoirs, unmineable coal seams, and deep saline aquifers. The success of any candidate storage location greatly depends on its ability to keep CO_2 underground for a long period of time. In order to evaluate the success or failure of a CO_2 storage operation, it is important to monitor injection sites to detect CO_2 released at the surface. The U.S. Department of Energy has placed a high priority on the development of inexpensive, effective methods to measure, monitor, and verify long term sequestration of CO_2 in geological sinks. Monitoring the leakage of CO_2 is a challenging task, due to the small expected concentrations above a leaking reservoir as well as the relatively large background of CO_2 present in the atmosphere. Another complication is the fact that CO_2 continually diffuses from the soil into the atmosphere due to plant and microbial respiration. Any leak of CO_2 from a reservoir would have to be differentiated from these other processes. In cooperation with the Texas Bureau of Economic Geology at the University of Texas, the National Energy Technology Laboratory is conducting a comprehensive surface monitoring effort at the site of a pilot scale injection project. In this project, approximately 4000 tons of CO_2 will be injected into the Frio formation, a deep, non-petroleum bearing saline aquifer. Surface monitoring includes the detection of injected tracer molecules, direct measurement of CO_2 soil flux, soil gas analysis, and carbon isotope analysis from soil gas CO_2. These measurements, in conjunction with a parallel modeling effort and deep seismic surveys, will provide an accurate measure of the leak rate of CO_2 to the surface (or an upper limit of leakage). Such an understanding of the leakage rate is critical to assessing the realized benefit of sequestration in geologic formations.

GC31A-07 0930h INVITED

Geophysical Characterization for a CO2 Sequestration Potential in the Ohio River Valley Region

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A site at the American Electric Power's (AEP) Mountaineer Power Plant, WV in the Ohio River Valley in the Midwestern U.S., a region with the economy heavily dependent on fossil fuels, such as coal, oil,

and gas, is being evaluated to determine the potential for geologic sequestration. The project is supported by the U.S. Department of Energy, Battelle, AEP, BP, The Ohio Air Quality Development Office, and Schlumberger. The major objective of the current phase is to characterize the reservoir at the plant site. Future decisions with regard to CO2 injection will be subject to the evaluated reservoir properties. The effort includes acquisition of 2-dimensional seismic data, assessment of regional geology, drilling to PreCambrian rocks and formation analysis and testing in a 2,800 meters deep well, reservoir simulations, risk assessment, and stakeholder outreach. The test well reached total depth in summer 2003. Wireline logging and reservoir testing was performed for each section of the borehole, including extensive tests in the lowermost 885 meters to estimate formation properties and pressure gradients. The logs included gamma-ray, neutron and density, and array resistivity, magnetic resonance relaxation for permeability information, elemental composition via capture spectroscopy, and resistivity based formation image. The seismic survey was conducted over approximately 11 miles along 2 lines: one along strike and one along dip. The results of the geophysical surveys combined with the field observations provide an integrated assessment of the major injection parameters for the two main injection reservoirs of interest, the Rose Run Formation and the Lower Maryville formation. In addition, the properties of the potential caprock formations overlying the candidate injection zones were also determined. The results of this characterization will be presented with emphasis on geophysical testing and seismic survey. These results are also being used to conduct reservoir simulations and risk assessment. Eventually, the geophysical tests and reservoir simulations will provide guidance for designing a demonstration project for CO2 sequestration in deep saline reservoirs at this site and preparing the necessary injection permits should a decision be made to move forward to the next phase. These tests also help improve understanding of the geologic characteristics in the wider Appalachian Basin area and form a basis for assessment of other sites in the region.

GC31A-08 0945h

Carbon Dioxide Sequestration in Fractured Diabase: Experimental Results From Field and Laboratory Studies

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We investigate the potential of CO_2 sequestration in basalt aquifers. Such mafic rocks provide cations like magnesium, calcium and iron to solution, which can facilitate precipitation of carbonate minerals from injected CO_2-saturated fluids and may lead to secure, long-term geological sequestration of CO_2 from anthropogenic sources. We present results from field and laboratory experiments, including results from small-scale CO_2 injections into fractured zones in the Palisades Diabase sill and the underlying Triassic sediments of the Newark Basin Series. Geophysical logging and hydrogeological tests conducted prior to the CO_2 injection experiments indicate several highly fractured zones within the diabase. Porosity varies from less than 3% in massive intervals to maximum 10% in highly fractured zones. Fluid resistivity logs detected water producing and water receiving zones in the diabase. The transmissivity of each of these permeable zones is estimated using flowmeter measurements as well as slug and pump tests to range from 0.0025 to 0.02 $m^2 day^{-1}$. A mixed CO_2-water injection (pCO_2 of 1 to 10 bar), with NaCl added as a chemical tracer, into one highly fractured zone isolated in the borehole allows for estimates of the magnitude of flow recovery in the formation. The pH, electrical conductivity and temperature of the injected solution and the flow rate were monitored in real-time. Fluid samples analyzed for major ion chemistry show that the calcium and magnesium concentration in the water increased approximately five times after several days, indicating the neutralization reaction of the CO_2-saturated injection fluid with the host diabase rock. In addition, laboratory experiments with flow-through columns are performed to investigate the dissolution rates of diabase samples in acidified aqueous solutions with pH 1 to 4 at temperatures 20 to 70°. Comparison of field and laboratory results will be presented and the potential for CO_2 sequestration in fractured mafic formations will be discussed.

GC31B MCC: Level 1 Wednesday 0830h

General Global Climate Change Posters *(joint with A, B, H, OS, PP, C, PA)*

Presiding: **M Lemos,** School of Natural Resources and Environment, University of Michigan**; H Beltrami,** St. Francis Xavier University

GC31B-0168 0830h POSTER

Evidence of Younger Dryas Event in Taiwan

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Younger Dryas Event, the reversal of the warming trend heading from Last Glacial Maximum to Holocene, was first discovered about three quarters of a century ago in polar region, is now known as a widespread phenomenon of human dimension. It is generally believed that the Event started in around 11,000 years and ended in around 10,000 years before present of Carbon-14 age. Here we report the progress of our search for records of the Event in a tropic to subtropical land, Taiwan. Means for investigating climatic changes such as Younger Dryas Event in region like Taiwan is difficult to come by. In principle, carbon-isotope composition of lacustrine organic sediments is one suitable proxy for the investigation. Experimental study has so far confirmed this. Presence of unusual dust-storm deposits may also be used for the investigation. It can be argued that glacial-like worlds are also dusty worlds. We have employed both means and the results are encouraging. This report concerns with the carbon-isotope study. We have been analyzing the stable carbon isotope composition of carbon-14 dated core samples from a fossil lake, Toushe Basin, in Central Taiwan. Preliminary results had suggested the presence of a record of the Event. We have recently completed an eight-meter long core samples representing about the past 12,000 years of carbon-14 ages. This is a report of the results. The results confirm unequivocally the presence of a record of Younger Dryas Event in the core. The duration of the Event appears to be about 1,000 years, from about 11000 years to 10000 years before present of C-14 ages; The Event is characterized by abrupt flipping over at both the beginning and the end and large oscillation in between. These are consistent with that of Greenland ice core results and confirm the global nature of the Event. The results indicate that the climate of Taiwan during the Event is probably much colder and dryer than it is now.

GC31B-0169 0830h POSTER

Precipitation Change in Taiwan: Evidence of Impacts of Sulfur-rich Volcanic Eruption and Anthropogenic Process

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Precipitation change in Taiwan during the twentieth century is investigated. Five year running mean indicate that stronger rainfall intensity and larger rainfall variability ensued from rapid economic development and urbanization in 1960s. Four major drought episodes are identified. They are 1906-1910, 1961-1966 1978-1982 and 1993-1995. Above normal rain day is observed during the period between 1906-1960. The observed increase of rainfall variability and intensity during last four decades is inferred to be a consequence of greenhouse warming and anthropogenic aerosols forcing. The coupled occurrence of the episodic high sulfur rich volcanic eruptions and drought events is intriguing. Sulfur-rich volcanic eruption forcing is evident in the Pinatubo eruption in 1991 on the drought episode of 1993-1995. The Agung, and St. Helen coincide with the center of drought episode of about half decade long duration. The salient features of precipitation change in Taiwan illustrate impacts of sulfur-rich volcanic eruption and anthropogenic process.

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Interannual Variability Observed in the Early Summer Climate in the Western North Pacific

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The early summer climate in the western Norh Pacific is largely controlled by the Baiu phenomenon. The interannual meridional fluctuation of the Baiu front and the relevant large-scale circulations are examined using empirical orthogonal function (EOF) analysis and the composite or correlation analyses based on the EOF time coefficients. The first EOF mode indicates the low-frequency fluctuation with a period of four to five years (LF mode) appearing to the south of 35°N. The development is concurrent with the horseshoe sea surface temperature anomalies (SSTAs) in the entire tropical Pacific that are associated with the El Niño/Southern Oscillation (ENSO). The westernmost SSTAs control the anomalous southward expansion of Baiu front through the modification of convection around 20°-30°N in the western Pacific. The LF mode is negatively correlated with the activity of South-Southeast Asian summer monsoon. The second EOF mode is characterized by the meridional seesaw-like fluctuation with a node around 28°N and by the time scale of biennial oscillation (BO mode). The horseshoe SSTAs again control the mode but with the different spatial phase in the tropical western Pacific through the anomalous convection off the Philippines. The BO mode has the negative correlation with the activity of tropical western North Pacific monsoon. The SSTAs associated with the BO mode tend to be confined to the tropical western Pacific, while the signals of LF mode rather extend in the tropical Pacific-Indian Ocean sector broadly, suggesting that the tropical BO is the aborted ENSO being dominant in the tropical central-western Pacific. The spatial phase of horseshoe SSTAs adjusts the detailed interannual variability in the meridional fluctuation of Baiu front.

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Climate on Abnormal Occurrence of Wildfires around Eurasia and Northern America

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A great many wildfires sometimes occurred around Eurasia and Northern America: especially, Siberia and Mongolia in summer of 1998 and 2002. Generally speaking, the wildfires are caused by extreme hot and dry conditions. We could see what was happened in 1998 (Kimura et al., 2002). Now we can analyze the climatic conditions in 2002. Then we found that the climatic conditions in 1998 and 2002 from Siberia to Northern America. We use the dataset below: (1) Global Surface Summary of Day Data compiled by NCDC (2) NCEP Reanalysis Data (3) JMA Historical Map (4) Wildfire Area Data analyzed by Remote Sensing data Indeed, in 1998 summer it was high temperature and little precipitation, and it was hotter and drier than that of 2002 summer. We can see the pressure distribution at Sea Level and 500hPa in summer. The ridge or blocking high pressure at 500hPa level is seen over the western Siberia. It corresponds to the high pressure area at Sea Level in Siberia. And also the waves at the 500hPa meander effect to the climate of North America. Next, seasonal change in summer is picked up, as wildfire had seasonal change. Sometimes it rains, but sometimes no precipitation continued more than 2 weeks in Siberia. During this period, the SLP had been high level, and southern component of wind continued to blow. This phenomenon means hot and dry condition was kept. The low relative humidity air mass moved eastward gradually, but sometimes it covered for many days. While this climatic condition continues, many wildfires occurred.