an average value downstream. O-18 in water also suggests that most organic carbon is transferred from landscapes to rivers during storm events. Taken as a whole, the data suggest two trends in diagenesis with altitude. Soil degradation increases along a transect from the relatively dry high altitude basins to lower altitude rain and cloud forests. However, FPOM begins to resemble plant OC at low altitudes, perhaps due to increased plant and surface soil inputs to lower altitude rivers, although soil OM still dominates FPOM. The current study also highlights the biogeochemical variability of headwater streams, indicating that lateral as well as longitudinal patterns must be considered in high altitude tropical river studies.

H11A-06 0945h INVITED

Coupling of Water and Carbon Cycles in Selected North American Watersheds

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The hydrologic cycle plays an important role in carbon cycling, due to the coupling of vapor release and CO_2 uptake during photosynthesis. This coupling, expressed as Water Use Efficiency or Transpiration Ratio, can provide an inexpensive alternative for estimating the Net Primary Productivity (NPP) of terrestrial ecosystems. The D/H and $^{18}O/^{16}O$ trends for river water and precipitation, combined with isotopic mass balance relationships, can be utilized to estimate the direct evaporative flux of surface water. The residual of the evapotranspiration flux from the basin therefore consists mostly of interception and transpiration, with interception approximated from field studies. The calculated water flux associated with transpiration is 59% of the annual precipitation flux for the Mississippi River basin, 45% for the Great Lakes basin, 58% for the North and South Saskatchewan River watersheds, and 46 $\pm$ 12% for the Ottawa River basin. The terrestrial biosphere therefore plays the dominant role in recycling of water into the atmosphere. Utilizing the average Water Use Efficiency value for each watershed (calculated from spatial coverage of C3 and C4 plants), the NPP for each watershed can be calculated. These first order estimates are 1.2×10^{15} gC/y for the Mississippi, 2.3×10^{14} gC/y for the Great Lakes, 4.4×10^{13} gC/y for the Saskatchewan, and 4.0×10^{13} gC/y for the Ottawa River basins. These estimates are similar to those of heterotrophic respiration based on empirical biological models of 1.1×10^{15} gC/y, 2.3×10^{14} gC/y, 4.7×10^{13} gC/y and $3.1 \pm 0.3 \times 10^{13}$ gC/y, respectively. Considering that the survey covers a range of ecosystems from warm temperate to boreal to grasslands, the results do not favor the postulated existence of a major sink for atmospheric CO_2 in the northern hemispheric ecosystems of North America. However, due to uncertainties in the input parameters, one cannot discount the possibility that these ecosystems act as modest sinks.

H11B CC: 520 A Monday 0830h

Remote Sensing, Hydrology, and Field Experiments I

Presiding: **J Entin,** NASA Headquarters**; V Lakshmi,** University of South Carolina

H11B-01 0830h

HYDROS Soil Moisture and Freeze/Thaw Mission Science and Algorithms Development

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The HYDROS Earth System Science Pathfinder (ESSP) mission has been recently approved by NASA with an estimated launch date in late 2009. The mission will use a combined passive/active low-frequency (L-band) microwave instrument to measure the land hydrosphere state globally from space. During the past year the science team has engaged in a number of risk-reduction activities related to the science and algorithms. These activities prepare the groundwork for the final trade-studies on the instrument. They also contribute to the algorithm implementation approach that is forthcoming in the next few years. In this presentation the results of simulation studies to quantify the roles of small-scale heterogeneity and instrument noise on soil moisture retrievals based on radiobrightness and backscatter measurements are presented. Also results using airborne measurements over field sites with ground-truth are presented. The science and algorithm development plan for the near-term is also outlined.

H11B-02 0845h

An approach for spatial disaggregation of radiometer estimated soil moisture using higher resolution radar observations

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The SMEX02 experiments held in June - July 2002, at Iowa demonstrated the potential of an L band radiometer (PALS) in estimation of near surface soil moisture under dense vegetation canopy conditions. The L band radar was also shown to be sensitive to near surface soil moisture and radar and radiometer estimates of soil moisture were found to be in very good agreement. These results are very encouraging and serve to verify the algorithms applied in retrieval of soil moisture from satellite mounted radiometers such as AMSR-E. However, the spatial resolution of a typical satellite mounted L band radiometer is of the order of 10's of kilometers which is not sufficient to serve the science needs of land surface hydrology and weather modeling applications. Disaggregation schemes for deriving sub pixel estimates of soil moisture from radiometer data using higher resolution radar observations hold the promise of making global soil moisture observations at much finer scale available. The HYDROS instrument is proposed to have an L band radiometer and L band radar onboard. The passive instrument will have spatial resolution of the order of tens of kilometers and will operate along with the active instrument that will take observations at a resolution of tens of meters. Therefore, we present in this study, a methodology for disaggregation of radiometer derived soil moisture into estimates at the much finer spatial scale of the radar instrument. An accurate value of the aggregate soil moisture in a pixel is obtained using the radiometer brightness while the sub pixel variability of soil moisture is quantified in terms of the radar observations. The performance of this technique is demonstrated using the PALS passive data and AIRSAR active data from the SMEX02 experiments.

H11B-03 0900h

Soil Moisture Experiments 2004 (SMEX04)

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Soil Moisture Experiments 2004 (SMEX04) will be conducted during the summer of 2004 to address overlapping science issues of the North American Monsoon Experiment (NAME) and soil moisture remote sensing programs. Surface boundary conditions play an important role in initiation and maintenance of the system that controls summer precipitation over much of the NAME region. A working hypothesis of NAME is that among the land surface antecedent boundary conditions that control the onset and intensity of the precipitation is soil moisture in the southwestern U.S. and northern Mexico. Surface soil moisture can change dramatically after rain events. This increased soil moisture after precipitation can increase evapotranspiration between storm events, which may contribute to enhanced convection and further precipitation. Soil moisture can vary both spatially, due to topography, soil, vegetation and precipitation variability, and temporally, due to differences in soil physical characteristics that control drainage and accumulated evapotranspiration. SMEX04 will focus on providing these critical soil moisture products using the new generation of satellite sensors supported by insitu observations and high-resolution aircraft mapping. Intensive study regions will be established over 50 by 75 km domains in southeastern Arizona and northwestern Mexico. Insitu observations will be collected over an extended time frame. Aircraft mapping and intensive regional ground sampling will be performed between mid-July and mid-August. The field campaign will at the same time contribute to the validation of these satellite products, expand our knowledge of the effects of key land surface features, establish algorithms for future satellite sensors, and explore the potential of new technologies.

URL: http://hydrolab.arsusda.gov/smex04/

H11B-04 0915h

Soil Moisture Retrievals Using L-band Radiometer Observations in SMEX02: Successes and Challenges

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Measurements at L-band are widely considered to be optimal for soil moisture remote sensing, taking into account emitting depth and complications arising from roughness and vegetation. Although there

is no operational satellite-borne L-band radiometer today, plans are underway to deploy one by the end of the decade. During the Soil Moisture Experiments in 2002 (SMEX02), the Passive and Active L and S-band (PALS) instrument was flown over the Walnut Creek Watershed in Iowa. This agricultural region was selected to facilitate testing of microwave remote sensing algorithms under conditions of highly variable and sometimes dense vegetation cover. L-band brightness temperature observations from PALS were used to retrieve near-surface soil moisture for conditions representative of the dominant corn and soybean land covers in the watershed. Sensitivities of the retrieved soil moisture to surface temperature, surface roughness and the vegetation B parameter have been evaluated for both crops. Retrievals for corn were found to be highly sensitive to the vegetation B parameter, while retrievals for soybeans were most sensitive to surface roughness. The vegetation water content of approximately 4 kg/m2 for the corn sites appears to be high enough to make soil moisture retrievals problematic, but retrievals appear relatively robust for soybeans with a vegetation water content of 0.3-0.7 kg/m2. For both corn and soybeans there is considerable overlap in the parameter spaces (combinations of surface roughness and vegetation B parameter) that yield accurate moisture retrievals for three wet days analyzed, but these parameter values do not translate well to dry conditions. This may indicate potential deficiencies in the roughness and vegetation correction algorithms for agricultural areas and raises concerns about global operational soil moisture retrieval from satellite-borne microwave sensors.

H11B-05 0930h

Horn antenna GPR measurement of crop canopy biophysical and near-surface hydrologic parameters

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GPR with a suspended 1 GHz horn antenna was deployed in the greenhouse and field for measurements of wheat canopy properties and soil water content dynamics. Dielectric permittivity and water content of soil and canopy were independently determined from surface reflection (SR) and from signal propagation time (PT) to a reflective layer (aluminum foil) underlying plant canopy or a soil layer. SR values progressively decreased with increasing canopy biomass according to Beer-Lambert type relationships. More attenuation was measured for the denser greenhouse dwarf wheat than in the field study. In contrast to SR measurements, PT values remained unaffected by canopy thereby provided an accurate account of soil water content dynamics. Canopy removal restored SR-based soil water content measurements to PT values as confirmed gravimetrically. Bulk canopy layer dielectric properties were inferred from canopy propagation times (CPT) and were related to canopy water contents (CWC) inferred from phenological measurements (height-mass relationships) and leaf type (narrow or broad). Distinct reflections were correlated with key canopy biophysical parameters. Results demonstrate the usefulness of horn antenna GPR for characterization of vegetation canopy effects, and for subcanopy water content measurements within a well-defined footprint, thereby offering a means for calibration and verification of radar data collected from air- and spaceborne platforms and for use in ground-based environmental and agricultural applications where high temporal resolution is required.

H11B-06 0945h

Application of Radar Profilers in Multi-Sensor Field Campaigns

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Precipitation profiling from ground-based radar profilers designed to look vertically have been demonstrated to be useful tools in several field campaigns during the past decade. Beginning with TOGA COARE and most recently during TRMM Ground Validation field campaigns profilers have been utilized to record the vertical structure of diverse precipitating cloud systems. The precipitation profilers are low-powered versions of the boundary layer radars developed within the NOAA Aeronomy Laboratory over a decade ago for wind measurement within tropical boundary layers. In addition to providing a continuous visual record of the evolution of precipitating clouds the profilers provide quantitative information of reflectivities and drop-size distributions that are essential for quantitative precipitation estimation. The profilers are most naturally calibrated by reference to a collocated disdrometer and are in turn useful for providing calibration for scanning radars.

H11C CC: 520 F Monday 0830h

Understanding Flow and Reactive Transport Processes in Sulfide-Bearing Porous Material I

Presiding: **J W Molson,** Ecole Polytechnique**; R Lefebvre,** Institut National de la Recherche Scientifique

H11C-01 0830h INVITED

Predicting the Release of Sulfide Oxidation Products at Mine Waste Sites

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Reactive solute transport models provide sophisticated tools for predicting the magnitude and duration of acid generation and metal release in mine waste disposal facilities. Over the past decade, these models have become increasingly advanced. The ability of reactive solute transport models to simulate integrated biogeochemical and hydrological processes now challenges our ability to characterize these systems on the field and laboratory scale. Application of reactive solute transport models relies on the development of an accurate conceptual model and specification of the chemical, physical and hydrological characteristics of the waste materials. Release of acidic water and dissolved metals from mine waste disposal facilities is controlled by a complex combination of physical, chemical, and biological processes. The oxidation of sulfide minerals is ultimately controlled by the availability of oxygen, which is usually transported in its gaseous form. The reaction between oxygen and sulfide minerals is catalyzed by chemolithotrophic bacteria. The oxidation of individual sulfide minerals occurs at differing rates. Sulfide oxidation reactions release acid, sulfate and dissolved metals. The acid released may be neutralized by reaction with carbonate, hydroxide and aluminosilicate minerals. The metals released may be attenuated by precipitation of secondary minerals, by coprecipitation or by adsorption reactions. Thorough characterization of the waste properties which control gas transport and water flow through the waste materials is required. In addition, a thorough knowledge of the initial composition and mineralogy is required to develop representative estimates of the environmental effects of the waste materials. When sufficient information is available, the results of reactive solute transport simulations show close agreement to measurements made at field sites and in laboratory experiments.

H11C-02 0845h

Measurement and prediction of the oxygen diffusion coefficient in partly saturated media

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Molecular diffusion is an important mechanism for gas transport in various natural and man-made systems. This is particularly the case with soil covers installed on acid generating mine tailings, where oxygen availability has to be controlled. One of the most important roles of such covers is to limit gas flux, which depends on the effective diffusion coefficient De of the cover materials. This paper presents an experimental procedure and results from oxygen diffusion tests performed on different types of materials, at various degrees of saturation. The determination of De in the laboratory from the test data is based on solutions to Fick's laws. The ensuing values of De are compared to values calculated from available models that relate De to basic material properties, including porosity and degree of saturation. Statistical indicators are used to evaluate the accuracy of selected models, individually and on a comparative basis. It is shown that modified versions of the Millington-Quirk and Millington-Shearer models provide De values close to the measured data. A semi-empirical expression, ensuing from these models and measurements, is proposed as a simple means of estimating De.

H11C-03 0900h

Comparison of Different Methods for Determination of Pyrite Oxidation Rate in Wate Rock Pile at Mine Doyon, Quebec, Canada

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Mine Doyon is a gold mine located close to Noranda, Québec, Canada. The South waste rock pile contains mostly highly friable sericite schists with pyrite content up to 7 wt percent. Oxidation of pyrite resulted in the production of acid mine drainage with pH values of about 2.0, and sulfate concentrations in pore water above 200 g/L. The waste rock material is characterized by high permeability allowing thermally driven convective supply of oxygen at temperatures reaching up to 67°C close to the slopes of the pile. Several methods for the determination of pyrite oxidation rate (POR) in waste rock have been compared and evaluated. Methods based on data collected in situ such as the interpretation of oxygen concentration profiles in waste rock pile and pyrite concentrations in solid phase were compared with the oxygen consumption method (OCM) in the laboratory. Analytical 1-D solution based on oxygen and temperature profiles in the pile was used for preliminary determination of POR. Analytical modeling results were used as an input for 2-D numerical model using TOUGH AMD. POR values based on pyrite mass balance (PMB) in solid phase were also calculated, assuming that average pyrite content in the deep, almost non-oxidized zone of the pile represents pre-oxidation conditions. Calculations were performed for prismatic columns with 1 m^2 base. An approach based on dissolved sulfate mass balance was not used because of the lack of data from early stage of the pile and the non-conservative behavior of sulfate (precipitation of gypsum and jarosite in the pile). Finally, the oxygen consumption method (OCM) in the laboratory was based on oxygen concentration decline in headspace of closed chamber, where samples of waste rock sprinkled by water were located. Both fresh samples from mining operation and partially weathered samples collected in the pile were used. A range of POR values ($mol(O_2).kg^{-1}.s^{-1}$) were obtained from the various methods. At Site 6 on the slope of the pile, TOP gave $3.93x10^{-9}$ and PMB provided $2.21x10^{-9}$. At Site TBT and Site 7 at the core of the pile, PMB gave respectively $1.76x10^{-9}$ and $2.03x10^{-9}$. Finally, the average rates estimated for the pile are $1.45x10^{-9}$ with TOP and $2.0x10^{-9}$ with PMB. The OCM average rate with fresh material is $6.60x10^{-8}$ whereas weathered material yielded $3.40x10^{-9}$. POR close to slopes were higher than for the core of the pile by a factor of about 3. Results fram PMB also matched the trend, but differences were subtle due to a large uncertainty in estimation of initial pyrite content. Results based on the OCM method in the laboratory were higher for fresh non oxidized material. However, results of OCM with weathered material were consistent with results of other methods. This means that POR values obtained by relatively rough methods like PMB and OCM can be used with acceptable results in a waste rock pile with fast oxygen supply.