change. Not surprisingly, the associated level of uncertainty in this analysis increases tremendously. High flows are defined by a combination of magnitude, frequency, timing and duration parameters and their impact varies according to antecedent events. High flow bedload sediment transport records are rare, sediment transport equations are reliable usually to only an order of magnitude, practical applications of two and three-dimensional sediment transport models are in their infancy, the watershed historical record may be patchy with the link between cause and effect difficult to ascertain, and thresholds of channel morphological change are poorly understood.

As the first step in reducing uncertainty, it is essential to state precisely the ecological target objectives of prescribed high flows, and to link these objectives to the hydraulic and geomorphic thresholds to be achieved or exceeded. Such thresholds provide the basis for a systematic classification of high flows. Here we recognize a spectrum of ten high flow types grouped in four classes encompassing flows to maintain: flow depth and velocity, channel bed texture and mobility, channel width and bar morphology and migration, and floodplain sedimentation and disturbance regime. We review the predictive ability associated with a selection of flow types to illustrate the difficulties faced. Progressively greater flows are required in each class to achieve the habitat objectives and the level of uncertainly increases in parallel. In general, because of a lack of suitable data and predictive process models, the primary practical means of reducing uncertainty is to prescribe high flow releases using best available understanding, to treat high flow releases as experiments as much as restoration projects and to be rigorous in generating hypotheses against which to monitor and evaluate their geomorphic impact.

H71F-09 1055h

Integrating Science and Engineering to Reduce Uncertainty of Stream Naturalization: An Example from the Chicago Metro Area

John Schwartz[1] (217-333-0997; jsschwar@students.uiuc.edu); Bruce L. Rhoads[2] (217-333-1880; b-rhoads@uiuc.edu); Marcelo Garcia[1] (217-244-4484; mhgarcia@uiuc.edu); Jose Rodriguez[1] (217-244-4484; jfrodrig@students.uiuc.edu); Fabian Bombardelli[1] (217-244-4484; bombarde@students.uiuc.edu); Rebecca Wade[2] (217-333-1880; rjwade@uiuc.edu); Edwin Herricks[1] (217-333-0997; herricks@uiuc.edu)

[1]Department of Civil and Environmental Engineering University of Illinois at Urbana-Champaign, 205 N. Mathews Ave., Urbana, IL 61801, United States

[2]Department of Geography University of Illinois at Urbana-Champaign, 607 S. Mathews Ave., Urbana, IL 61801, United States

Many communities in the Midwest, through consultation with scientific and technical experts, are seeking to establish sustainable, morphologically and hydraulically varied, yet dynamically stable fluvial systems that are capable of supporting healthy, biologically diverse aquatic ecosystems - an integrated social, scientific and engineering enterprise referred to as stream naturalization. In highly modified urban streams, such as the West Fork of the North Branch of the Chicago River (WFNBCR) in downtown Northbrook, Illinois, naturalization often is severely constrained by existing infrastructure. The goal of the Northbrook naturalization project is to enhance in-channel morphologic, hydraulic and habitat diversity, while ensuring that channel planform remains stable and flooding is not exacerbated. To achieve these objectives, an innovative pool-riffle design has been developed for straight urban streams through integration of geomorphological, ecological and engineering principles. The design is based mainly on geomorphological understanding of pool-riffle structure and function, yet also considers habitat needs of fish. Engineering analysis has focused on the hydraulic performance and hydrological effects of the pool-riffle structures through numerical and physical modeling. Eleven pool-riffle structures were constructed in a 900 m reach of the WFNBCR between November 2001 and May 2002. Initial field analysis suggests the structures are performing as expected hydraulically and geomorphologically, and have enhanced habitat for fish.

H71F-10 1110h

Lessons from a Spawning Gravel Rehabilitation Program

Gregory B Pasternack[1] (530-754-9243; gpast@ucdavis.edu)

Joseph M Wheaton[1] (530-754-6442; jmwheaton@ucdavis.edu)

Joseph Merz[2] (209-365-1093; jmerz@ebmud.com)

[1]University of California, Davis, 211 Veihmeyer Hall, LAWR One Shields Avenue, Davis, CA 95616, United States

[2]East Bay Municipal Utility District, 1 Winemasters Way, Suite K-2, Lodi, CA 95240, United States

Altered sediment and flow regimes in dammed and regulated rivers limit available spawning habitat to salmonids. River managers have attempted rehabilitation of spawning habitat with gravel augmentation and riffle construction projects, but often neglect well-established conceptual models of geomorphic and ecologic processes, let alone apply them in a predictive manner. Application of such models could not only improve rehabilitation projects, but also serve to further test and evaluate the underlying scientific theories against the rigors of real-world uncertainties. For the past two years a new science-based approach to rehabilitate spawning gravels for salmonids has been under development and testing to overcome these deficiencies. The approach includes a balance of science-based quantitative tools from multiple disciplines and qualitative local knowledge relevant to the region in which it has been applied. In 2001 and 2002 it was used to design and implement the placement of 907 and 2787 metric tons of gravel, respectively, on separate reaches of the lower Mokelumne River in Central California. A long-term monitoring program to quantify outcomes and assess sustainability is on-going. Lessons from these efforts are providing for adaptive management and will be presented.

URL: http://lawr.ucdavis.edu/faculty/gpast/shira/shira_contents.htm

H71F-11 1125h

Modelling the Geomorphological and Ecological Dynamics of River Corridors: Developing a Simulation Tool for River Management

James Brasington[1] (+44 1223 339956; jb10016@cam.ac.uk)

Keith Richards[1] (ksr10@cam.ac.uk)

Mike Bithell[1] (mike.bithell@geog.cam.ac.uk)

[1]University of Cambridge, Department of Geography, University of Cambridge, Cambridge CB2 3EN, United Kingdom

Interest in the integrated restoration of managed river corridors has arisen in response to falling levels of riparian and floodplain biodiversity due to flood control works including channalization and flow regulation by headwater impoundments. This decline is in part, a direct response to the impact of engineering works on the geomorphological dynamics of rivers and in particular, upon rates of channel migration. Channel instability, through the processes of bank erosion, avulsion and cutoff, and within and overbank sedimentation, continuously renews the floodplain creating virgin territory for plant colonization. The varying age of alluvial surfaces, in combination with differences in topography and sediment calibre influence plant succession pathways and gives rise to a mosaic of floodplain plant communities. This geomorphological influence underpins the intermediate disturbance hypothesis which suggests a non-linear relationship between floodplain turnover rates and biodiversity, which is low in both highly stable and unstable rivers regimes. In the former case, diversity is limited as stable regimes promote succession towards relatively uniform stands of floodplain forest while the in the later case, extreme instability results in the sole dominance of early coloniser species. By contrast, diversity is maximized for intermediate levels of disturbance, which result in a range of habitats at varying positions along successional pathways.

While conceptually satisfying, calibration and validation of this perceptual model is confounded by the differing local conditions and environmental history of individual rivers, which complicates simple empirical inter-comparisons. Prescription of the appropriate levels of disturbance necessary to optimise habitat and biological diversity therefore remains unclear and difficult to translate into practical frameworks for river management. This paper presents an alternative approach to investigate this interdependence through the development of a numerical model which captures the primary geomorphological and ecological dynamics of river systems at appropriate levels of complexity tuned to reach and decadal space and time scales. Here a prototype model is presented for braided rivers, in which a simplified flow routing procedure is used to drive predictions of sediment transport and sorting based on a cellular spatial discretization, a force-balance entrainment model and a step-length advection and grain sorting procedure. This sub-model provides the topographic and sedimentological boundary conditions for a stochastic plant succession model which simulates colonization and community development on the evolving braidplain. The model is parameterised and validated against distributed datasets from the braided River Feshie, Scotland. A Monte-Carlo based sensitivity analysis is used to explore the one-way interaction between channel migration and habitat development, with an emphasis placed on the structure of the evolving timeseries of reach-scale biodiversity indicators. Importantly however, the framework also permits full coupling of this interrelationship by modelling the influence of vegetation on bank stability so that feedback can occur to affect channel migration and floodplain turnover. Such feedback is critical in understanding the autogenic switching between channel planform types (meandering and braiding) and a new computational framework for simulating this behaviour is presented.

URL: http://www.geog.cam.ac.uk/people/brasington

H72A MCC: Hall C Sunday 1330h

Hydrology From Time Variable Gravity and Other Space-Based Remote Sensing Techniques Posters *(joint with G)*

Presiding: **I Velicogna,** University of Colorado**; M Rodell,** NASA Goddard Space Flight Center

H72A-0837 1330h POSTER

Measuring local hydrological effects on the long-term gravity variation in Membach, Belgium

Michel Van Camp[1] (+ 32 2 373 02 65; mvc@oma.be); Ren Warnant[1] (+32 2 373 02 51; rene.warnant@oma.be); Kris Vanneste[1] (+ 32 2 373 02 80; kris.vanneste@oma.be); Koen Verbeeck[1] (+ 32 2 373 02 80; koen.verbeeck@oma.be); Toon Petermans[1] (+ 32 2 373 03 14; toon.petermans@oma.be); Abdelhali El Bouch[1] (+ 32 2 373 03 14; ali.elbouch@oma.be); Alain Dassargues[2] (+32 4 3662817; Alain.Dassargues@ulg.ac.be); Olivier Crommen[2] (+32 4 3662817; Adelbert@swing.be)

[1]Royal Observatory of Belgium, Avenue Circulaire, 3, Brussels B-1180, Belgium

[2]Universit de Lige, Hydrogologie-GEOMAC, B.19, Sart-Tilman, Lige B-4000, Belgium

Absolute (AG) and superconducting (SG) gravity measurements have been performed since 1996 at the underground Membach Station (Ardenne, eastern Belgium). Two effects can be distinguished: one seasonal-like and a long-term geophysical trend.
The first effect is a 5 μGal seasonal-like term due most probably and mainly to hydrological variations. To determine the thickness of the porous unconsolidated layer covering the fissured bed-rock (low-porosity argillaceous sandstone with quartzitic beds) through which the tunnel was excavated, electrical tomography measurements were performed above the Membach station. Results of these measurements, as well as preliminary geological investigations are presented here. This will allow us to correct the gravity variations induced by the highly variable mass of water stored in the shallow partially saturated soil. This work can be essential to correct local effects that can mask regional effects such as changes in continental water storage. Local effects, indeed, could prevent the combination of satellite data (e.g. GRACE) with ground-based gravity measurements. On the other hand, studying the local seasonal variations also contributes to investigate the influence of the water storage variations in small river basins on the time dependent gravity field.
The second effect is the detection of a very low geophysical trend in gravity of -0.9 μGal/year. The SG drift, the hydrological effects, and the origin of the low trend are discussed. In particular, we show a good correlation between the gravity measurements and the continuous GPS measurements being made since 1997 at 3 km from the station. Possible crustal deformations could be linked to active faults in the Ardenne and/or bordering the Roer Valley Graben, or perhaps linked to the Eifel plume.

H72A-0838 1330h POSTER

Sensitivity of In-situ Gravity Measurements to Local Hydrometeorological Processes

Ruben IJpelaar[1] (31-317-48-27-73; ruben.ijpelaar@wur.nl)

Peter Troch[1] (peter.troch@wur.nl)

Piet Warmerdam[1] (piet.warmerdam@wur.nl)

Han Stricker[1] (han.stricker@wur.nl)

[1]Wageningen University and Research Centre, Sub-department of Water Resources The Netherlands, Wageningen 6709 PA, Netherlands

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A new generation of in-situ gravity meters and remote sensing techniques enable the detection of small variations (equivalent to less than 10 mm water layer) in mass at the Earths surface, such as water storage in surface and subsurface reservoirs. The general aim of the research is to investigate the possibility to detect variations in river basin water storage from measurements of the time dependent gravity field, and to assess the accuracy of these estimations based on in-situ and satellite observations of the gravity field. This could be beneficial for water balance models and catchment water management in general.

This poster describes a first approach to detect hydrological signals, caused by seasonal processes or sudden events, in time series of in-situ gravity measurements. Some first analysis results of the sensitivity of gravity to local hydrometeorological processes are shown.

Based on data from the Global Geodynamics Project (GGP), some time series of gravity that are accompanied with hydrological measurements will be analysed. Other elements of the observed gravity field, such as tides, air pressure and instrumental drift have been removed from the raw gravity signal to obtain the residual gravity. A water balance model, driven by meteorological data is employed to estimate changes in soil moisture. Soil moisture, groundwater and precipitation, are used to estimate the change of water storage in the direct vicinity of the in-situ gravity meter. The correlation between the observed and expected residual gravity change at multiple measuring sites is quantified. The expected gravity change is estimated from the change in water storage and the geometric distribution of the different storage reservoirs around the gravimeter. Time-series will be analysed for the relative sensitivity to several hydrometeorological variables, e.g. precipitation, snow accumulation, groundwater depletion and strong evapotranspiration.

H72A-0839 1330h INVITED POSTER

A Method for Retrieving Water Storage Variability from GRACE

John Wahr[1] (wahr@lemond.colorado.edu)

Sean Claude Swenson[1] (swensosc@colorado.edu)

P. C. D. Milly[2] (pcm@GFDL.NOAA.GOV)

[1]Department of Physics and CIRES, University of Colorado, CB390, Boulder, CO 80309-0390

[2]U.S. Geological Survey and Geophysical Fluid Dynamics Laboratory/NOAA, P. O. Box 308, Princeton, NJ 08542

Time-variable gravity field solutions provided by GRACE can be used to infer changes in continental water storage, averaged over regions having areas of $2 \cdot 10^2$ km^2 or larger. The accuracy of water storage estimates is limited by both satellite measurement error and leakage from gravity signals outside the region of interest. Accuracy can be improved by using approximate averaging kernels to recover the water storage signal. Optimal averaging kernels can be constructed which attempt to minimize an *a priori* model of these error sources. Of particular interest is a method which incorporates azimuthally symmetric models of satellite measurement error and leakage error. Using this method, we apply an iterative approach to construct optimal averaging kernels for North American river basins. We then discuss the accuracy and resolution with which changes in water storage for these basins can be recovered from GRACE data.

H72A-0840 1330h INVITED POSTER

Hydrological Applications of the GRACE Satellite Gravity Mission

John Wahr[1] (303-492-8349; wahr@lemond.colorado.edu)

Sean Swenson[1] (swensosc@lemond.colorado.edu)

Isabella Velicogna[1] (isabella@giove.colorado.edu)

P.C.D. Milly[2] (pcm@gfdl.gov)

[1]Dept of Physics and CIRES, U of Colorado, CB 390, Boulder, CO 80309, United States

[2]USGS and GFDL/NOAA, P. O. Box 308, Princeton, NJ 08542, United States

The twin satellites of the GRACE (Gravity Recovery And Climate Experiment) mission were launched in March, 2002. The five-year mission, sponsored jointly by NASA and the Deutsches Zentrum fur Luft und Raumfahrt, is expected to deliver highly accurate, monthly estimates of the Earth's time-variable gravity field down to scales of several hundred km and larger. These estimates can be used to recover monthly variations in the distribution of mass at the Earth's surface. One of the particularly exciting applications is the possibility of estimating monthly variations in the distribution of water, snow, and ice in continental regions. Our preliminary studies suggest that if GRACE is able to achieve its pre-launch accuracy goals, it should be possible to deliver monthly estimates of changes in water/snow/ice storage that are accurate to better than 1 cm of water thickness when averaged over areas of 200,000 km^2 or larger.

As of this writing, GRACE is still in its commissioning phase, and gravity field solutions are not yet publically available. With any luck, solutions will be available by the time of this talk, in which case we will present preliminary hydrological estimates. In any case, we will discuss some of the possible hydrological applications of GRACE data, how the gravity data can be transformed into water storage estimates, and how we have used simulated GRACE data to arrive at our accuracy estimates.

H72A-0841 1330h POSTER

Monitoring Terrestrial Hydrological Processes Using GRACE

Ki-Weon Seo[1] (kiweon@speer.geo.utexas.edu)

James Famiglietti[2] (949-824-9434; jfamigli@uci.edu)

Matthew Rodell[3] (mattro@dao.gsfc.nasa.gov)

Clark Wilson[1] (clarkw@speer.geo.utexas.edu)

Sally Holl[2] (sholl@uci.edu)

[1]University of Texas at Austin, Dept. of Geological Sciences, Austin, TX 78712, United States

[2]University of California, Irvine, Dept. of Earth System Science, Irvine, CA 92697-3100, United States

[3]NASA Goddard Space Flight Center, Hydrological Sciences Brance, Greenbelt, MD 20771, United States

GRACE offers tremendous potential to monitor changes in water storage for large land areas. When combined with auxiliary data sources, the total water storage signal can be decomposed into its component terms, including evapotranspiration and groundwater recharge. In this presentation we explore the utility of GRACE for estimating evapotranspiration and groundwater recharge for selected basins around the globe. Additionally, uncertainties in the estimates will be quantified. Depending upon GRACE data availability, first results will be presented.

H72A-0842 1330h POSTER

Estimated Effects of Vegetation Canopy Mass Variations on Earths Gravity Field and Rotation

Matthew Rodell[1] (301-286-9143; Matthew.Rodell.1@gsfc.nasa.gov)

Benjamin F. Chao[2] (301-614-6104; Benjamin.F.Chao.1@gsfc.nasa.gov)

Andrew Y. Au[3] (301-614-6114; Andrew.Y.Au.1@gsfc.nasa.gov)

[1]NASA, Goddard Space Flight Center Hydrological Sciences Branch, Code 974.1, Greenbelt, MD 20771, United States

[2]NASA, Goddard Space Flight Center Space Geodesy Branch, Code 926, Greenbelt, MD 20771, United States

[3]Raytheon ITSS, Goddard Space Flight Center Space Geodesy Branch, Code 926, Greenbelt, MD 20771, United States

Changes in the quantity and distribution of water and biomass stored near the land surface cause variations in Earth's gravity field and rotation. Advanced techniques for measuring these geodetic variations now exist and are continuing to develop. In particular, the Gravity Recovery and Climate Experiment (GRACE) may soon deliver global models of the time variable gravity field with enough precision to detect monthly to seasonal changes in total terrestrial water storage and biomass at regional scales. Hydrological and biological measurement and modeling systems will be called upon to explain the geodetic observations, in both time-variable gravity and rotation, to disaggregate the mass change estimates into changes in the component storages: groundwater, soil moisture, surface water, snow and ice, and vegetation. However, these systems are not based on, nor have they yet produced, a mature understanding of the magnitudes and distributions of each of the component changes. The research presented attempts to discover the monthly to interannual effects of global vegetation canopy mass variations on the Earth's gravity field and rotation. Eighteen years of monthly, global maps of canopy water storage and biomass were derived from satellite observations of leaf area index and vegetation type. These were used to compute gravitational coefficients and angular momentum variations, which were then compared with existing geodetic observations as well as the expected measurement sensitivity of GRACE.

H72A-0843 1330h INVITED POSTER

Use of Aqua/AMSR-E and Synergistic Microwave Data to Study Soil Moisture Variability From Space

Eni G. Njoku[1] (818-354-3693; eni.g.njoku@jpl.nasa.gov)

Tsz K. Chan[1] (818-354-7320; steven.chan@jpl.nasa.gov)

Son V. Nghiem[1] (818-354-2982; son.v.nghiem@jpl.nasa.gov)

[1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, United States

The Advanced Scanning Microwave Radiometer is one of six instruments launched on the Aqua spacecraft in May 2002 as part of NASAs Earth Observing System (EOS). Designated AMSR-E (for EOS), the instrument was provided by the National Space Development Agency (NASDA) of Japan, and is a modified version of the AMSR instrument planned for launch in late 2002 on Japans ADEOS-II spacecraft. The AMSR instruments operate at frequencies in the range 6.9 to 89 GHz, providing global coverage in 2-3 days. The instruments have potential for improved soil moisture estimation over previous spaceborne radiometers such as the Special Sensor Microwave/Imager (SSM/I) and TRMM Microwave Imager (TMI) due to the combination of lower microwave frequency and higher spatial resolution. The AMSR-E spatial resolution varies from 60 km at 6.9 GHz to 5 km at 89 GHz although the higher frequencies are not useful for soil moisture estimation due to attenuation of the soil signal by atmospheric moisture and vegetation. A more advanced instrument, the Conical-scanning Microwave Imager/Sounder (CMIS), that includes an increased range of channels between 6.6 and 183 GHz, is planned for launch as part of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) in the 2009 timeframe. The AMSR and CMIS instruments should provide a capability to sense soil moisture over land surfaces with low vegetation cover, but vegetation will still impose a significant limitation on the accuracy and spatial extent of the retrievals, and only the top 1-cm surface layer will be sensed. Other microwave instruments that have shown response to surface soil moisture include the SeaWinds radars on Quikscat and ADEOS-II that operate at 13.4 GHz with 25-km resolution. The AMSR-E and SeaWinds radiometer and radar instruments indicate complementary sensitivities to soil moisture, vegetation, and surface roughness. These sensor data can therefore be used jointly to enhance understanding of the variability of global land surface moisture. In this paper we review some of the early results from the AMSR-E instrument, including sensor and retrieval model calibration, examination of radio-frequency interference effects, and comparisons with in situ measurements of soil moisture and precipitation. We also show examples of synergistic applications of AMSR-E and SeaWinds data. Combinations of passive and active microwave sensors in an integrated observing capability are an exciting possibility for future hydrologic applications. A new mission called HYDROS that combines a passive and active microwave sensor at 1.2-1.4 GHz is described in a separate paper.

H72A-0844 1330h POSTER

An Evaluation of Soil Moisture and Vegetation Estimation Using Passive/Active Microwave and Optical Remote Sensing

John D. Bolten[1] (803-777-6823; jbolten@geol.sc.edu)

Venkat Lakshmi[1] (803-777-3552; vlakshmi@geol.sc.edu)

Albin J. Gasiewski[2] (303-497-7275; al.gasiewski@noaa.gov)

Eni G. Njoku[3] (818- 354-3693; eni.g.njoku@jpl.nasa.gov)

Thomas J. Jackson[4] (301- 504-8511; tjackson@hydrolab.arsusda.gov)

[1]Department of Geological Sciences, Univeristy of South Carolina, 700 Sumter Street, Columbia, SC 29208, United States

[2]NOAA Environmental Technology Laboratory , 325 Broadway, R/ET1, Boulder, CO 80305, United States

[3]NASA Jet Propulsion Laboratory , M/S 300-233, 4800 Oak Grove Drive, Pasadena, CA 91109, United States

[4]USDA ARS Hydrology Laboratory, 104 Bldg 007 BARC-West, Beltsville, MD 20705, United States

Advances in remote sensing technology and their applications to hydrology and land surface modeling have progressed over the last decade. The abundance of available aircraft/satellite-based platforms, in addition

to extensive validation studies, has led to robust retrieval algorithms of geophysical parameters (i.e., vegetation and soil moisture) supporting global change monitoring efforts. The newly launched Aqua satellite will allow global coverage of these surface parameter estimates. In order to best simulate the surface properties using satellites, it is necessary to combine several temporal and spatial resolutions. Given that sensors have varying frequencies, spatial/temporal resolutions and sensitivities to vegetation and surface roughness, proper methods for accounting for these differences are required for algorithm development.

This work will emphasize an analysis of soil moisture and vegetation parameter retrievals using a)Satellite (Landsat Thematic Mapper) data, b)Aircraft (Passive/Active L/S Band instrument (PALS) data, and the Polarimetric Scanning Radiometer (PSR) data), c)In-situ data acquired during the 1999 Southern Great Plains experiment (SGP99). The temporal and spatial co-location of these instruments enables an assessment of remote sensing capabilities combining multiple wavelengths, active/passive/optical data, and polarization ratios/frequency indexes for optimum parameter estimation.

H72A-0845 1330h INVITED POSTER

The Hydrosphere State (HYDROS) Mission Approach to High Resolution and Frequent Revisit Data Products for Hydrometeorological and Hydroclimatological Applications

Dara Entekhabi[1] ((617) 253-9698; darae@mit.edu)

Eni Njoku[2] ((818) 354-3693; eni.g.njoku@jpl.nasa.gov)

Paul Houser[3] ((301) 614-5772; houser@hsb.gsfc.nasa.gov)

[1]Massachusetts Institute of Technology, 48-331, Cambridge, MA 02139, United States

[2]Jet Propulsion Laboratory, M/S 300-233, Pasadena, CA 91109, United States

[3]NASA Goddard Space Flight Center, Code 974, Greenbelt, MD 20771, United States

The design and expected characteristics of the Hydrosphere State (HYDROS) Mission space-borne system for high-resolution mapping of surface soil moisture and landscape freeze/thaw dynamics are outlined. The HYDROS proposal has been selected by NASA as the alternate mission in the current set of three approved Earth System Science Pathfinder (ESSP) projects. The unique approach of the HYDROS mission is to combine active and passive sensor observations. The radiometer instrument on board the satellite provides polarized brightness temperature fields at 1.4 GHz across a wide swath (900 km) at a resolution of 40 km. The radar operates at 1.2 GHz (VV, HH, and HV) and is capable of high-resolution mapping (<3 km) over 70 precent of the swath and low-resolution across the remainder. All terrestrial land regions are revisited within 2-3 days. The microwave approach allows estimating soil moisture and surface freeze/thaw in nearly all weather conditions and regardless of solar illumination. The active and passive measurements are used to develop land hydrology products. Soil moisture and its freeze/thaw state are critical determinants of the rates of water, energy, and carbon cycles over the continents because they are key controls on land-atmosphere flux exchanges. Significantly, the data products address science questions about processes that link these cycles. In this presentation it is shown that combining active radar and passive radiometer sensor measurements result in land hydrology data products with resolution and accuracy that are not possible when only once sensor measurement is used. The heritage and performance of the algorithms and algorithm components over diverse surface conditions and based on ground and airborne field campaign data are summarized.

H72A-0846 1330h INVITED POSTER

Global River and Lake Monitoring from Satellite Altimetry

Philippa A.M. Berry[1] (+44 116 257 7497; pamb@dmu.ac.uk)

Ralph Allen Pinnock[1] (+44 116 207 8501; rap7@dmu.ac.uk)

[1]De Montfort University, Geomatics Unit, The Gateway, Leicester LE1 9BH, United Kingdom

A series of satellite altimeter missions has gathered data over the earths oceans. Several of these instruments have also acquired data over land. Of particular relevance, both Topex and ERS1&2 have now amassed a continuous time series over ten years of echoes from both ocean and land surfaces, including inland water. However, data from varying topographic surfaces are generally complex and difficult to interpret.

Echoes from large lakes can often be successfully processed using the existing ocean processing algorithms; however, river echoes present problems except in the widest estuaries, as land contamination complicates the echo shape. By developing a suite of algorithms to reprocess non-ocean echoes, river data can now be successfully retracked to yield good heights.

This paper presents results of an extensive study over the earths major river systems, using both ERS and Topex data. The tracking advantage of ERS ice mode is discussed, together with an assessment of the benefits and drawbacks of different repeat patterns for recovery of time-varying signals.

The global applicability of these automated techniques for river height extraction means that it is now possible to create a decadal time series of global river heights, and hence to estimate the global hydrology runoff budget. This valuable time series is being continued by ENVISAT and Jason-1.

H72A-0847 1330h POSTER

QuikSCAT/SeaWinds Monitoring of Large Seasonal Wetlands

G. Robert Brakenridge[1] (603-646-2870; Brakenridge@dartmouth.edu)

Heather Carlos[1] (603-646-0887; Heather.Carlos@Dartmouth.edu)

Son V. Nghiem[2]

Elaine Anderson[1] (603-646-0887; Elaine.Anderson@Dartmouth.edu)

[1]Dartmouth College, Dartmouth Flood Observatory, Hanover, NH 03755, United States

[2]Radar Science and Engineering, Jet Propulsion Laboratory, Pasadena, CA 91109, United States

Polarization ratio measurements of the SeaWinds radar backscatter are sensitive to surface water area expansions and contractions in large seasonal wetlands (areas greater than 10,000 sq km). Examples include the Sudd, in the upper Nile Basin, the Barotse Plain and Chobe Swamp in the upper Zambezi, the Llanos de Mojos in Bolivia, and the Rio Araguiaia floodplain in Brazil. QuikSCAT provides new information on a near-daily basis but at relatively coase spatial resolutions (tens of km at best). We use multispectral classification techniques on MODIS optical data at resolutions of 250 m or 500 m to locate and accurately measure surface water areas when cloud cover allows. This allows calibration of the radar polarization information to water surface area. The moisture status of these evapotranspiration sources can thereby be re-evaluated with each new QuikSCAT pass. Because the wetlands play a large role in the associated river basin moisture mass balances, radar monitoring should facilitate improvements in river discharge prediction within these basins.

URL: http://www.dartmouth.edu/artsci/geog/floods/wetlands/Wetlands.html

H72A-0848 1330h POSTER

Comparison of evapotranspiration estimates from the Surface Energy Balance Algorithm (SEBAL) and flux tower data, middle Rio Grande Basin

Hongjie Xie[1] (hjxie@nmt.edu)

Jan Hendrickx[1] (hendrick@nmt.edu)

Shirley Kurc[1] (Shirley.Kurc@Colorado.EDU)

Eric Small[1] (esmall@nmt.edu)

[1]Dept. of Earth and Environmental Science, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, NM 87801, United States

Evapotranspiration (ET) is one of the most important components of the water balance, but also one of the most difficult to measure. Field techniques such as soil water balances and Bowen ratio or eddy covariance techniques are local, ranging from point to field scale. SEBAL (Surface Energy Balance Algorithm for Land) is an image-processing model that calculates ET and other energy exchanges at the earths surface. SEBAL uses satellite image data (TM/ETM+, MODIS, AVHRR, ASTER, and so on) measuring visible, near-infrared, and thermal infrared radiation. SEBAL algorithms predict a complete radiation and energy balance for the surface along with fluxes of sensible heat and aerodynamic surface roughness (Bastiaanssen et al, 1998; and Allen et al. 2001). We are constructing a GIS based database that includes spatially-distributed estimates of ET from remote-sensed data at a resolution of about 30 m. The SEBAL code will be optimized for this region via comparison of surface based observations of ET, reference ET (from windspeed, solar radiation, humidity, air temperature, and rainfall records), surface temperature, albedo, and so on. The observed data is collected at a series of tower in the middle Rio Grande Basin. The satellite image provides the instantaneous ET (ET_inst) only. Therefore, estimating 24 hour ET (ET_24) requires some assumptions. Two of these assumptions, which are (1) by assuming the instantaneous evaporative fraction (EF) is equal to the 24-hour averaged value, and (2) by assuming the instantaneous ETrF (same as crop coefficient, and equal to instantaneous ET divided by instantaneous reference ET) is equal to the 24 hour averaged value, will be evaluated for the study area. Seasonal ET will be estimated by expanding the 24-hour ET proportionally to a reference ET that is derived from weather data.

References:

Bastiaanssen,W.G.M., M.Menenti, R.A. Feddes, and A.A.M. Holtslag, 1998, A remote sensing surface energy balance algorithm for land (SEBAL): 1. Formulation. J. Hydrology 212-213, p. 198-212.

H72B MCC: Hall C Sunday 1330h

The Science and Uncertainty of River Management and Restoration II Posters *(joint with B, T, PA)*

Presiding: **A Collison,** Philip Williams and Associates**; S Darby,** University of Southampton**; P Downs,** Stillwater Sciences**; D Sear,** University of Southampton

H72B-0849 1330h POSTER

Challenges in Assessing the Effects of Experimental Flow Regimes from Glen Canyon Dam on Fine Sediment Storage and Native Fish Populations in the Colorado River in Grand Canyon

Theodore Melis[3] (928 556 7282; tmelis@usgs.gov)

Josh Korman[1] (604 737-8314; jkorman@ecometric.com)

Carl J Walters[2] (604 822 6320; c.walters@fisheries.ubc.ca)

[1]Ecometric Research Inc., 3560 w22nd Ave., vancouver, bc v6s 1j3, Canada

[2]Fisheries Centre University of British Columbia, 2204 Main Mall, vancouver, bc v6t 1z4, Canada

[3]Grand Canyon Monitoring and Research Center US Geological Survey, 2255 North Gemini Dr., Flagstaff, az 86001, United States

The Colorado River ecosystem between Glen Canyon Dam (GCD) and upper Lake Mead, Arizona, provides a unique opportunity to test various ideas about river management and the use of adaptive management experiments to help resolve scientific uncertainties about best management practices. Beginning in the early 1990's, a variety of experimental discharge regimes from GCD have been implemented including the well-publicized 1996 controlled flood and the costly 2000 steady flow experiment (ca. $21 million in lost power revenues). The experimental flows and the extensive monitoring, research, and modeling efforts have focused on quantifying the effects of flow on the storage of fine sediment in the Marble and Grand Canyon reaches of the Colorado River and on the survival and growth of native fish, with an emphasis on the endangered humpback chub (Gila cypha). Analysis of sediment and flow discharge data from natural hydrologic events and experimental flows has been more helpful in formulating current flow management regimes focused on sediment retention than results from single and multi-dimensional sediment transport models. Inferences from historical analyses have been limited by the resolution of sediment transport data, while inferences from multi-dimensional models have been limited by difficulties in scaling-up site specific results to reaches that are 10's to 100's of km long. Evaluation of the status and trends of exotic and native fish populations in Grand Canyon is highly uncertain because of the difficulties of conducting representative catch-per-unit-effort sampling in a large and turbid river with very difficult access, and because of multi-year delays associated with mark-recapture data. Application of stock assessment modeling procedures, originally developed for managing commercial fisheries, has been helpful for estimating population trends from the historical fisheries data, but not sufficient to resolve whether declines in native fish populations have been caused by the increasing abundance of exotic fishes, dam operations, or a combination of the two. Our ability to detect fish population responses to future experimental flows is weak in spite of the lessons learned from stock assessment modeling and expanded monitoring efforts. In contrast, near-term experimental flows proposed for 2002 through 2004 will likely be highly informative for