

estimated, the accuracy often is questionable. A new generation of in-situ gravimeters and NASA's Gravity Recovery and Climate Experiment promise the possibility of tracking the movement of the water on and beneath the earth surface. A research programme was started to investigate the possibility of detecting the variations in river basin water storage from measurements of the time dependent gravity field, and to assess the accuracy of these estimations using models. In this paper we study the hydrological effect on in-situ gravity measurements by means of water balance modeling. The relatively simple GIS-based Soil Moisture Routing (SMR) model is used to compute time varying storage change of spatially distributed pixels within the observation domain of a superconducting gravity observation station near Moxa (Germany). The so-derived mass changes in the vicinity of the gravimeter are then converted into a time varying gravity signal and is compared to the observed gravity residual. It is anticipated that this approach will yield valuable insights into the interaction of hydrologically driven mass changes and the in-situ gravity measurements, allowing for a more accurate correction and/or interpretation of the data.

H21G-08 1205h

Space Altimetry Method for Monitoring Lake Level Changes

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Accurate and continuous monitoring of lakes and inland seas are available since 1991 thanks to the recent missions of satellite altimetry (Topex-Poseidon, ERS-1, ERS-2, Jason-1 and Envisat). Global processing of the data of these satellites could provide temporal and spatial times series of lakes surface height from 1991 to 2003 on the whole Earth with a decimeter precision. The response of water level to regional hydrology is particularly marked for lakes and inland seas of semi-arid regions. Altimetry data can provide invaluable source of information in hydrology sciences, but in-situ data (rivers runoff, temperature, or precipitation) are still strongly needed to study the evolution of water mass balance of each lakes. Lake level variations can however be used as interesting constrained parameter in ungauging lake basin for water mass balance budget. Recent studies based on Topex-Poseidon data have shown evidence of significant inter-annual variations of the Caspian or the Aral sea levels. Analysis of Baikal, Issykkul, Balkhash and Hovsgol lakes level from 1993 to 2003 is also presented.

H21H MCC: 3024 Tuesday 1020h

Remote Sensing of the Land Surface II (joint with A, B)

Presiding: D P Lettenmaier,

University of Washington; J Famiglietti, University of California, Irvine

H21H-01 1020h

ASTER Observations of Surface Temperature and Emissivity over New Mexico Test Sites

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The multispectral thermal infrared data obtained from the Advanced Spaceborne Thermal Emission and Reflection (ASTER) radiometer on NASA's Terra satellite have been shown to be of good quality and provide a unique new tool for studying the land surface. ASTER has 5 bands in the 8 to 12 micrometer waveband with 90 m spatial resolution, when the data are combined with the Temperature Emissivity Separation (TES) algorithm the surface emissivity over this wavelength region can be determined along with the surface temperature. This paper will present some quantitative emissivity and temperature results obtained over test sites in southern New Mexico, USA; the Jornada Experimental Range and the White Sands National Monument. These results are compared with ground observations. The Jornada site is typical of a desert grassland where the main vegetation components are grass and shrubs with a large fraction of exposed soil while the White Sands site is mainly dunes of gypsum sand which provides a good relatively homogenous emissivity target with an interesting spectral signature. More than two dozen ASTER scenes over these New Mexico test sites have been acquired since the launch of Terra in December 1999. There were simultaneous field campaigns in May of 2000 - 2003 and September/October 2001 and 2002. Also, MASTER (MODIS-ASTER airborne simulator) coverage was obtained for several of the dates. The ASTER surface brightness temperatures compare very well with those obtained on the ground. The results appear to be in good quantitative agreement with laboratory measurements of the emissivity for the quartz rich soils of the Jornada with values less than 0.85 for the 8 - 9 micrometer channels. For the longest wavelength channels little spatial variation of the emissivity was observed with values of 0.96 +/- 0.005 over large areas. Emissivity values from the ASTER data for the gypsum at White Sands were in good agreement with values calculated from the lab spectra for gypsum and with each other. Gypsum has a strong emissivity minimum centered on the ASTER 8.63 micrometer band, and the satellite results for this band agree within 0.01 of the value calculated from the laboratory spectra. The extension of these results to mapping emissivity over large areas will be presented in the form of an emissivity map for the deserts of North Africa.

H21H-02 1035h

Assimilating MODIS Snow Areal Extent Data Using an Ensemble Kalman Filter

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The importance of snow to hydrologic prediction and water resources management in the West has long been recognized. Current model-based approaches to hydrologic prediction are limited by model shortcomings, while more empirical approaches are inevitably limited by the temporal and spatial sparseness of observations. Remote sensing offers an opportunity to augment the hydroclimatic information provided by in situ sensors and models. On the other hand, remote sensing data, and especially visible band snow extent estimates, are problematic as well because of discontinuities in coverage due to cloud cover, and the absence of coincident information about snow water storage. Data assimilation offers a framework for the optimal combination of observations and models for estimation of hydrologic state variables and fluxes. A major advantage of data assimilation is its capability to account for modeling and measurement errors. The ensemble Kalman filter (enKF), is one promising data assimilation technique that appears to be appropriate for many hydrologic applications. The enKF is different from the traditional Kalman filter in that it uses a Monte Carlo approach to propagate the error matrices. We describe an enKF-based approach to assimilating MODIS snow cover data into a macro scale hydrology model. The study area is the Snake River basin, where about 70% of runoff originates as snow. The dynamic modeling construct is based on the Variable Infiltration Capacity (VIC) model, applied at 1/8 degree spatial resolution, with subgrid partitioning into a maximum of five elevation bands. Results showed that the enKF is an effective and computationally attractive solution for the assimilation of remotely sensed data. The model was able to improve snow water equivalent prediction when compared to benchmark simulations. In addition to a theoretical evaluation using a simulation approach, the enKF-based estimates of snow areal extent and associated streamflow predictions are compared with a more ad hoc probability anomaly approach that adjusts the model's snow water equivalent toward anomalies of SNOTEL station data relative to the SNOTEL climatologies. Finally, specific limitations having to do with assumptions made about model errors and model sub-optimality are discussed.

H21H-03 1050h

Estimation of Net Radiation using MODIS-Terra Data

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Estimation of net radiation is critical for satellite based evapotranspiration calculations. A simple algorithm is developed to estimate net radiation from MODIS (Moderate Resolution Imaging Spectroradiometer) data. This method does not need complex atmospheric transmission codes like MODTRAN and it uses minimal ground based observations. Inputs for the algorithm are the MODIS calibration, land and atmosphere data products. Land surface temperature, emissivity and the Geolocation data set are provided used at a one kilometer spatial resolution while atmospheric profile product is used at a five kilometer resolution. Land surface emissivity is calculated by averaging the MODIS band emissivity and air emissivity is estimated using a parameterization that involves screen level temperature and pressure. Downward shortwave flux is estimated using a parameterization that accounts for humidity and solar zenith angle. We will test the validity of this algorithm over South Florida. The strength of the proposed net radiation estimates should be evaluated not only by how closely they reproduce surface based point observations but by their ability to provide a spatially consistent and distributed net radiation map over a large heterogeneous domain.

H21H-04 1105h

Soil moisture and evapotranspiration patterns from space: remote sensing techniques to determine large scale water balances

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Justin Sheffield (6092581551; justin@princeton.edu) The estimation of state variables such as the soil moisture and surface temperature has been a key research area for many years. The importance of this information for land surface studies has motivated the development of different estimation techniques for these variables. Increasingly, there exists the capacity to independently determine components of the hydrological cycle from remote sensing data. Developing techniques to effectively combine the multiple streams of information required for a water budget assessment provides a difficult challenge, particularly given the disparities in spatial and temporal scales between measurements and predictions. The launched EOS Terra and Aqua platforms contain sensors that have an improved capability to retrieve these variables. Coupling these measurements with measurements from TRMM-TMI and GOES satellite platforms with large scale meteorological forcing data available as part of the Global Land Data Assimilation System (GLDAS), offers an increased opportunity to examine global and continental scale hydrological patterns. This presentation reports on recent efforts to measure components of the water budget through remote sensing. The presentation will focus on the estimation of soil moisture and evapotranspiration over the southern Great Plains region of the United States for spring and summer 2002. The retrieved values are compared with available validation data and qualitatively examined against each other to assess their association. A number of potential data assimilation approaches that could be employed to incorporate such information into a robust water balance framework are discussed.

H21H-05 1120h

Defining Parameters from NOAA AVHRR Imagery to Map Regional ET

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An Agrometeorological model (MAGRET) was developed to solve the energy balance over vegetated surfaces. The magnitude of surface temperature for grass and crops is the result of the energy balance and in-fers to the state of its water stress. The sensible (H) and latent heat fluxes (ET) are computed using the classical equations of turbulent transfer. Soil heat flux and temperature profiles in the soil computed using the Fourier equation. Solving the energy balance equation at hourly time step, net radiation, sensible, soil, Latent heat fluxes and surface temperature were derived. Model inputs are hourly and daily climatic data and parameters that describe the properties of soil and vegetation. The objective of this research is to combine the combine the model with parameters derived from NOAA AVHRR satellite for determining the evapotranspiration in regional scale. The surface temperature obtained from satellite is used to define the model parameters at meteorological stations by comparing surface temperature obtained from model and temperature obtained from the satellite. Comparing the model predicted surface temperature with satellite surface temperature, energy balance parameters are adjusted. The model was evaluated as part of the Southern Great Plains hydrology experiment (SGP97) during July in central Oklahoma over the predominantly grassland areas. The model was calibrated with data from four ET flux station and the results scaled up to the surround region. Results from the study show a good potential use of the MAGRET model for assessment of regional ET in agricultural areas.

H21H-06 1135h**High Resolution Evaporative Fluxes Over Corn and Soybean Crops from Lidar**William E. Eichinger¹ (319-335-6034;william-eichinger@uiowa.edu); D. I. Cooper² (505-665-6501; dcooper@lanl.gov); L. E. Hipps³ (435-797-2009; biomet@cc.usu.edu); W. P. Kustas⁴ (301-504-9498; bkustas@hydrolab.arsusda.gov); C. M. U. Neale⁵ (435-797-3689; cneale@cc.usu.edu); J. H. Prueger⁶ (515-294-7694; prueger@nssl.gov)¹Department of Civil and Environmental Engineering, University of Iowa, Iowa City, IA 52242, United States²Experimental Atmospheric and Climate Physics, Los Alamos National Lab, Los Alamos, NM 87545, United States³Dept. of Plants, Soils and Biometeorology, Utah State University, Logan, UT 84322, United States⁴U.S. Dept. of Agriculture, Hydrology and Remote Sensing Laboratory, Beltsville, MD 20705, United States⁵Dept. of Biological and Irrigation Engineering, Utah State University, Logan, UT 84322, United States⁶U.S. Dept. of Agriculture, National Soil Tilth Laboratory, Ames, IA 50011, United States

The Soil Moisture-Atmosphere Coupling Experiment (SMACEX) was conducted in the Walnut Creek Watershed near Ames, Iowa over the period from June 15-July 11, 2002. A main focus of SMACEX was the investigation of the interactions between the atmospheric boundary layer, surface moisture and current vegetative state. The Lidar collected data over fields of soybeans and corn, with mutually supporting measurements by the NRC Twin Otter atmospheric research aircraft, the Utah State University Piper Seneca remote sensing aircraft, two elastic Lidars, and an array of eddy covariance towers in the nearby fields. The aircraft and lidar will provide a high resolution mapping of the evaporation rate over the fields and the changes between them. A mapping of the evaporative fluxes that existed during the field campaign, with a comparison to the topology of the local area will be presented.

H21H-07 1150h**Surface Water Applications of Satellite Scatterometry**Son V Nghiem¹ (818-354-2982;Son.V.Nghiem@jpl.nasa.gov); David G Barber² (204-474-6981; dbarber@ms.umanitoba.ca); G Robert Brakenridge³ (603-646-2870; brakenridge@dartmouth.edu); George A Leshkevich⁴ (734-741-2265; george.leshkevich@noaa.gov); Thorsten Markus⁵ (301-614-5882; Thorsten.Markus.1@gscf.nasa.gov); Gregory Neumann¹ (818-354-7273; gregory.neumann@jpl.nasa.gov); Eni G Njoku¹ (818-354-3693; eni.g.njoku@jpl.nasa.gov); Donald K Perovich⁶ (603-646-4255; donald.k.perovich@rdc.usace.army.mil); Konrad Steffen⁷ (303-492-4524; konrad.steffen@colorado.edu); Matthew Sturm⁶ (msturm@ccrel.usace.army.mil); Michael L Van Woert⁸ (301-394-3105; mvanwoert@natic.navy.mil)¹Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, MS 300-235, Pasadena, CA 91109, United States²University of Manitoba, Department of Geography, Winnipeg, MB R3T 2N2, Canada³Dartmouth Flood Observatory, Department of Geography University of New Hampshire, Hanover, NH 03755, United States⁴NOAA Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd, Ann Arbor, MI 48105, United States⁵NASA Goddard Space Flight Center, Code 975 Bldg.33, Rm.A412, Greenbelt, MD 20771, United States⁶US Army Cold Regions Research and Engineering Laboratory, 72 Lyme Road, Hanover, NH 03755, United States⁷CIRES, University of Colorado, Campus Box 216, Boulder, CO 80309, United States⁸National Ice Center, NOAA/NESDIS, Route: E/SP Federal Office Building #4, Room 2301 5200 Auth Road, Suitland, MD 20746, United States

We present an overview of the use of satellite scatterometry to detect surface water in liquid and solid phases for various regional geophysical applications. We study scatterometer/radiometer signatures of surface soil moisture with in-situ data from SCAN, Oklahoma Mesonet, and NCDC/GSOD stations. Results indicate scatterometer data can detect and inventory wet surface events due to rains to determine the regional frequency of surface water cycling. Animated time-series of scatterometer data over the SMEX (Soil Moisture Experiment) region in mid-west US illustrate the monitoring of surface water variabilities over large scales. An automated flood processing algorithm implemented at the Jet Propulsion Laboratory (JPL) provides daily updated data over the world to the Dartmouth Flood Observatory (DFO) for early flood detections. We verify the flooded areas with MODIS clear-sky observations. We obtain weekly wetland results in Africa, Asia, North America, and South America. We show wetland monitoring results over the Eastern Arkansas - Mississippi River Valley with a comparison of the maximum extent to MODIS standard water. We investigate scatterometer signatures of snowmelt with field experiments carried out in Alaska to develop algorithms for snowmelt detection over the northern hemisphere. We present animated snowmelt results over the Lena River region in Siberia leading to floods (in 2000-2003) including the 2001 Lena Flood of the Century. Snowmelt timing parameters derived from scatterometer data are appropriate for assimilation into hydrology models for river discharge estimate and for flood forecast. We map ice cover over the Great Lakes and compare the results with observations from US Coast Guard (USCG) Mackinaw icebreaker and from a web camera on Granite Island. Over Greenland, we map and monitor surface melt areas and compare the results to in-situ measurements from the Greenland Climate Network (GC-Net). Results show extensive melt over the Greenland ice surface in 2002 in record amounts. We carried out a sea-ice mapping field experiment using the USCG Healy icebreaker over the Barents Sea in 2001. We detect a peculiar sea-ice barrier east of Svalbard, which poses hazards to ship navigation east of Svalbard. We map sea ice melt and refreezing areas by combining QuikSCAT and SSM/I products over the Arctic sea ice with verification from the Canadian C-ICE field experiment. Finally, we discuss limitations of current satellite scatterometers and the need for future advanced satellite sensors for surface-water applications.

H21H-08 1205h**Everglades' hydrology from space**Shimon Wdowinski¹ (shimonw@rsmas.miami.edu)Falk Amelung¹ (famelung@rsmas.miami.edu)Fernando Miralles-Wilhelm¹
(fmiralle@rsmas.miami.edu)Tim Dixon¹ (tdixon@rsmas.miami.edu)Richard Carande² (carande@vexcel.com)¹University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, United States²Vexcel Corporation, 4909 Nautilus Court, Boulder, CO 80301, United States

The Everglades region in south Florida is a unique ecological environment. Anthropogenic changes in the past 50 years, mainly for water supply, agricultural development and flood control purposes, have disrupted natural water flow and severely impacted the regional ecosystem. Currently, Everglades' flow is controlled by a series of structures (e.g., levees, gates), which provide a large-scale natural laboratory for monitoring and modeling wetland surface flow. Everglades' water level is currently monitored by about 100 stations, about half of which provide real-time data. We use space-based Interferometric Synthetic Aperture Radar (InSAR) to monitor water level variations in the entire Everglades region with a high spatial resolution (30 x 30 m²). Our data consists of three 225x75 km² swaths of eastern South Florida, acquired in June, August and December 1994 by the L-band (1.275 GHz) JERS satellite. A comparison between the space-based InSAR observations and 28 ground-truth station data points shows a remarkable agreement. The most significant water level changes are observed in the northern section of the study area, known as Water Conservation Areas (WCA) 1, 2A, and 2B. Our results show dynamic water topography caused by gate operation on man-made levees. The data show up to 1 m of elevation difference across 5-15 km length scale. We detected both regional N-S unidirectional and radial topography patterns. We model the dynamic water topography using 1-D unidirectional and radial diffusion flow models. Our models allow us to determine a regional-scale flow conductivity parameter, which reflects the resistance to water flow due to vegetation. Future 2-D numerical flow models will enable us to determine local variations of the conductivity parameter as well as better tools for modeling and managing surface flow in the Everglades. URL: <http://www.geodesy.miami.edu/~amelung/everglades/>

H22A MCC: Level 2 Tuesday 1330h**Geocentrifuge Advances in Studying Subsurface Environmental Processes Posters****Presiding: E D Mattson, Idaho**

National Engineering and Environmental Laboratory; P J Culligan, Columbia University

H22A-0902 1330h INVITED POSTER**Centrifugally Driven Flow in Diverse Porous Media Over Wide-Ranging Moisture Conditions**John R. Nimmo¹ (650-329-4537; jrnimmo@usgs.gov)Maria Clementina Caputo² (39-080-5820536; caputo@area.ba.cnr.it)¹USGS, 345 Middlefield Road MS-421, Menlo Park, CA 94025, United States²Water Research Institute - IRSA - CNR, Via F. De Blasio, 5, Bari 70123, Italy

Centrifugal force has been successfully applied to measurement of saturated and unsaturated hydraulic properties of soils and rock. The basis of most methods is to apply a steady flow of water, by either a constant head or a metering pump, to a sample in a centrifuge. If the centrifugal force is great enough to constitute the dominant driving force, measurements of the steady-state flux, water content, and matric pressure can yield highly accurate values of hydraulic conductivity and water retention. The great force permits measurement of properties and conditions that are otherwise impossible or impractical. For example an experiment lasting a few days can measure unsaturated conductivity as low as 1E-9 cm/s. Our new approach expands the range of media and conditions to which centrifugal techniques are applicable, using an assessment of the deviations from steadiness that can be tolerated without appreciable loss of accuracy and a quasi-steady methodology that controls flow within acceptable limits. Secondary goals are to reduce the cost and specialized nature of the necessary equipment, and to reduce the operator time and level of training required.