summer. More importantly, the un-calibrated model with the frozen ground component outperforms the un-calibrated model with no frozen ground component for all tested basins. Spring floods analysis suggests also that it is impossible to remove runoff biases without modification of frozen ground hydraulic properties.

H22B-05 1130h

REPRESENTATION OF CHANNEL MORPHOLOGY AND RIVER NETWORK TOPOLOGY AS A DYNAMIC BAYESIAN NETWORK: TOWARDS A PROBABILISTIC RUNOFF ROUTING

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Flood propagation through a river network is a complex process affected by an enormous variability of stream slopes, channel and floodplain geometries, etc. In addition, it has been observed that hydrologic response of a basin is a nonlinear process with a degree of nonlinearity decreasing with contributing area. From the complexity and the scale-dependent nonlinearity it follows that by implementing a deterministic model for runoff routing and supplying this model by the expectations of the inputs, one may obtain a result which is not necessarily a good estimate of the expected output from the system. To account for the above complexity and scale-dependent nonlinearity, we propose a new dynamic stochastic concept for probabilistic runoff routing. More specifically, we: (1) Represent channel hydraulic geometry (HG: originally, power laws connecting discharge to stream geometry) as joint distributions of discharge and cross-sectional area in the log-domain. This representation is a result of extensive (remotely sensed) data analysis and implementation of statistical-physical concepts, and accounts for the main channel - floodplain interactions. (2) Use network topology to compose a directed graph connecting the stochastic HGs representing individual channels or channels of a given Strahler order. (3) Compute the stochastic "state" of the system consisting of the distributions of discharge and cross-sectional area at any junction conditional on the upstream input. Such a directed graph consisting of conditional distributions changing at every time step is known as a Dynamic Bayesian Network. Some preliminary results show the potential of the concept for both theoretical (e.g. analysis of the dependence of error variance on different external factors) and applied (e.g. as a part of data assimilation and flood decision support systems) aspects of hydrologic science.

H22B-06 1145h

Uncertainty Analysis of Flash Flood Guidance: Topographic Data and Model Parameter Errors

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Flash Flood Guidance (FFG) is the volume of rainfall required to generate bankfull flows at the outlet of a basin over a specified time interval and initial soil moisture conditions. Operationally the soil moisture conditions are generated every 6 hours by the execution of the Sacramento - Soil Moisture Accounting (SAC - SMA) model at the River Forecast Centers (RFC's). This guidance is used with actual radar rainfall data over the basin to assist with the production of flash flood warnings. The backbone of the FFG system is the Threshold Runoff (Thresh-R), the calculation of which is done offline as a one time task. Thersh-R is the volume of effective rainfall of a given duration needed to cause bankfull flows at the basin outlet. In this study, bankfull conditions from uniform steady flow and the Geomorphologic Unit Hydrograph theory are used for the calculation of Thresh-R for a basin located in Illinois River at Oklahoma. The uncertainty related with the GIS and channel data for the calculation of thresh-R is introduced and an ensemble of threshold runoff values is produced. Then, the FFG is modeled with the use of a time-continuous approximation of the upper zone of the SAC-SMA hydrologic model and quadratic function approximations. The thresh-R ensemble is fed into the FFG model to study the uncertainty in the FFG values due to the uncertainty in the GIS and channel data that contribute to the uncertainty of threshold runoff. The numerical experiments are then repeated but additional uncertainty in the key parameters of the analytical Sacramento model solution is added, to study the synergistic effect of both uncertainties. The results of analysis are presented and the parameters that affect more the FFG uncertainty are identified. The need of transforming the currently deterministic operational FFG system to a probabilistic or an ensemble one is also discussed.

H23A CC: 220 C-E Tuesday 1330h

Remote Sensing, Hydrology, and Field Experiments IV Posters

Presiding: **V Lakshmi,** University of South Carolina**; T J Jackson,** USDA Agricultural Research Service

H23A-01 1330h POSTER

Convective Planetary Boundary Layer Evolution and Land Surface Energy Balance

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The relationships among convective planetary boundary layer (PBL) properties and land surface energy balance on diurnal and regional scales are explored using 132 days worth of data from ARM-SGP. Previous attempts to infer land-surface properties from observations of the PBL have been constrained by difficulties in accurately parameterizing the conservation equation, and have been limited to multi-day averages or small samples of daily case studies. A empirical investigation of relationships among PBL and land surface properties indicates that atmospheric stability in the layer of PBL growth is the most influential variable controlling PBL development, followed by soil moisture, 2m-potential temperature, and 2m-specific humidity. These relationships are exploited using a statistical technique to predict and explain PBL growth from observations of stability and soil water content. Using this approach, it is possible to use limited observations of the PBL to estimate soil moisture, and by extension, land surface energy balance on daily timescales without the need for detailed land surface parameterizations.

H23A-02 1330h POSTER

GRACE in the Murray Darling Basin: Integrating Remote Sensing with Field Monitoring to Improve Hydrological Model Prediction

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Hydrological processes occurring throughout the earth's surface lead to temporal changes in the distribution of mass, which subsequently cause subtle changes in the earth's gravity field. The GRACE mission (Gravity Recovery And Climate Experiment) of NASA and the German Aerospace Centre will provide global data sets of changes in earth's gravity field at unprecedented accuracy over the next several years. This mission has the potential to provide the first-ever global measurements of changes in terrestrial water storage for large regions at monthly to annual time scales. In this paper we present a methodology designed to address two fundamental questions regarding the applicability of GRACE: (1) is the soil moisture component of terrestrial water storage change detectable in the vertically integrated gravity signal, and (2) can such large-scale measurements of gravity changes be used to improve our understanding and simulation of catchment-scale hydrological processes? The methodology involves three key components: (1) ground-based monitoring of gravity and terrestrial water storage changes at 40 sites throughout the Murrumbidgee catchment in Australia; (2) development of a modelling framework which includes the downscaling and disaggregation of GRACE data; and (3) using AMSR (Advanced Microwave Scanning Radiometer) remotely-sensed surface soil moisture observations to further constrain the downscaling and disaggregation. The GRACE data will be processed through assimilation into a hydrological model of the entire Murray-Darling Basin, and the results verified against the monitoring network. Preliminary results from 18 monitoring sites installed in 2001 suggest that changes in root-zone soil moisture represent the dominant fraction of terrestrial water storage changes occurring in the Murrumbidgee and the magnitude of such changes (monthly changes as high as 130 mm at the point-scale and 38 mm at the mean catchment-scale) should produce a statistically significant signal in both GRACE and ground-based observations of gravity.

URL: http://www.civenv.unimelb.edu.au/~jwalker/data/oznet/

H23A-03 1330h POSTER

Seasonal fluctuations of surface water levels in the Mekong River basin from satellite altimetry and other remote sensing data

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Ten years of satellite altimetry data from the Topex/Poseidon satellite have been analysed to construct water level time series and five years of satellite SPOT Vegetation imagery have been used to monitor the flood extent over the Mekong River basin. Areas overflown by T/P include the Tonle Sap Lake, seasonaly inundated areas and several branches of the hydrographic network of the Mekong delta. Very strong seasonal signal is reported over the Tonle Sap, amplitude reaching annually 5-8 meters peak to peak. Clear interannual signal is also visible. For example year 1999 corresponds to weak floods, contrasting with year 2000 during which strong flood is noticed. Southward, we also observe large seasonal fluctuations (2-3 m) over inundated floodplains, as identified using imagery data from the SPOT Vegetation instrument. Several water level time series have also been constructed at intersections of T/P tracks and waterways of the Mekong Delta. Depending on the location, quite different annual amplitudes are observed, the closer to the Mekong mouth, the smaller the signal. We interpret this observation as the effect of dams built over the Delta in the recent years/decades. We also analysed the interannual water level signal together with precipitations over the whole Mekong basin.

H23A-04 1330h POSTER

Testing The Roles Of Sediment Supply And Bedrock Erodability Using The Stream Power Law For A Glaciated Terrain In Nova Scotia: An Application Of A High Resolution DEM From LIDAR

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Bedrock incision from streams is an important process that controls landscape evolution for many areas. Although the mechanisms that control incision rates

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are controversial, there is general acceptance that incision rates are a function of the streams ability to do work and are related to the amount of discharge. The stream gradient and sediment flux are considered to be the factors controlling incision into bedrock. Stream gradient can be measured from maps. Sediment flux is a more difficult quantity to measure, and the contributing drainage area is used to approximate this quantity. From this the "stream power law" has evolved to model incision, where erosion E is related to the stream gradient S and drainage area A by, E = kSmAn, k is a constant that is related to the channel geometry and other factors such as sediment supply, m and n are exponent coefficients, where the ratio of m/n represent the cancavity of the stream long profile. Although the availability of moderate resolution DEMs has facilitated the testing of this model, many questions remain unresolved such as the role of sediment supply and the erodability of the bedrock in the streambed. In this study, a high resolution DEM derived from LIDAR (Light Detection and Ranging), for the Annapolis Valley, Nova Scotia that is part of the Mesozoic Fundy Rift Basin. The area has relief (on the order of 260 m), that is in part due to the bedrock geology, and has a variety of rock types ranging from the elevated Paleozoic metasedimentary rocks of the South Mountain Batholith (SMB) granites of the Meguma Terrane to the south, Jurassic sedimentary rocks that underlie the valley floor, and the Triassic North Mountain Basalt (NMB) which forms a cuesta on the northern flank of the valley. In addition to the variable relief due to the bedrock geology, the area has had a complex glacial history with up to 4 different ice phases from the last glaciation. A thick blanket of till covers half of the North Mountain, while the rest of the North Mountain has a thin veneer of till. This contrast in cover material allows us to test the role of sediment supply to incision rates using the stream power model. Bedrock incision rates are determined by examining stream longitudinal profiles and relief derived from the LIDAR DEM. The high resolution and minimum artifacts in this DEM allow the generation of stream profiles with accuracies that previously were only available from field surveys. The three flow units within the NMB have been mapped using the DEM based on their topographic expression that results from their contrasting resistance to erosion. The effect of bedrock resistance to erosion will be tested by comparing the NMB stream profiles and relief with the streams on the SMB that are underlain by homogeneous granite.

H23A-05 1330h POSTER

Validity of Self-Preservation for Diurnal Surface Energy Budget Predictions using Remote Sensing Observations in Florida

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Evapotranspiration (ET) is an important component of the water balance, but its quantification at large spatial scales presents many problems. Over the last two decades, many retrieval algorithms using optical satellite imagery have been developed to estimate spatially distributed actual ET at regional scales. Algorithms, including the Surface Energy Balance Algorithm for Land (SEBAL) and the variant of the triangle method, provide the ratio of ET to available energy from remotely sensed data, which is then typically combined with ground-based net radiation data to derive daily ET. A limitation of the use of these algorithms in conjunction with MODIS (Moderate Resolution Imaging Spectroradiometer) and Landsat is they can only produce instantaneous estimates of ET at coarse temporal resolutions. Daily estimates rely on the assumption of "self-preservation" that dictates that the relative partitioning of energy flux among its main components remains constant. If so, the evaporative flux ratio (ER), defined as the ratio of latent heat flux (LE) to that of another component of the energy budget may be assumed constant through the day. This analysis investigates the applicability of the self-preservation concept across several sites in the humid sub-tropical climate of Florida. Accordingly, daytime evaporation values were estimated by the self-preservation method using instantaneous LE values that were measured at times corresponding to MODIS and Landsat overpasses. Half-hourly daytime climate data from ground stations are used to calculate daytime LE and are compared to measured LE values The estimated daily evaporation error varied with the instantaneous record time and ER used, with best results achieved using a combination of overpass times.

H23A-06 1330h POSTER

Effect of soil moisture on land surface temperature retrieval: A case study for the Southern Great Plains

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Land surface temperature (LST) is an important element of the climate system. Remote sensing methods for estimating LST have been developed in the past and several of them have been implemented at large-scales. Geostationary satellites are of particular interest because they depict the diurnal cycle. Soil moisture has a strong effect on the magnitude of surface temperature via its influence on emissivity, yet, information on soil moisture at large scales is meager. It is of interest to estimate what effect soil moisture has on the retrieval accuracy of surface temperature by methods of remote sensing. In this study, newly developed algorithms to estimate land surface temperature (LST) from geostationary satellites will be applied to GOES-8 observations during the Southern Great Plains 1997 Hydrology Experiment (SGP97) when surface observations of both soil moisture and surface temperature were made. The ground observations were used to first demonstrate the influence of soil moisture on the diurnal cycle of the surface temperature, its amplitude and the lag in LST maxima. Subsequently, it was established that errors in LST as derived from GOES-8 measurements have a negative correlation with soil moisture, namely, increasing with the decrease of soil moisture.

H23A-07 1330h POSTER

Integration of Multi-Source and Multi-Resolution Data for Soil Moisture Estimates

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Various remote sensing techniques have been evaluated and proven to be a valuable source of information for different hydrological applications. For example, with the actual Earth observation satellites, we can observe the entire river basins rather than sparse points and provide unique information about properties of the surface or shallow layers of the earth. Furthermore, the actual remote sensing sensors offer the potential of measuring new hydrologic variables not generally possible with traditional techniques such as soil moisture, snow status, land cover parameters...etc. Recent advances in microwave remote sensing technology indicate that surface soil moisture can be inferred with remote sensing systems operating in the microwave region of the electromagnetic spectrum. The ability to estimate soil moisture in the upper surface layer by microwave remote sensing (active and passive) has been demonstrated under a variety of the topographic and land-cover conditions. The primary intent of this project was to produce a spatial estimation of soil moisture with sufficient spatial and temporal resolution using multi-source microwave data (active and passive). Two types of microwave remote sensing techniques have been used in this research: passive microwave from SSM/I sensor for global estimation (low resolution 25 x 25 km) and SAR from RADARSAT Satellite (SCANSAR mode) for local estimation (high resolution 100 x 100 m). The study area is located in Oklahoma (97d35'W, 36d15'N). Two Radarsat-1 images acquired in Scansar Mode during the summer of 1997 were used in combination with soil moisture data measured by ESTAR Instrument (Electronically Scanned Thinned Array Radiometer) during the SGP97 campaign (operated by NASA). This paper describes the first steps in evaluating the microwave data for mapping and monitoring soil moisture.

H23A-08 1330h POSTER

Preliminary Analysis of Snow Water Equivalent Estimation Over La Grande River Watershed Using SSMI data: Comparison of two Neural Network Approach.

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A Steady flow of information on snow cover extent and water equivalent is crucial for hydrologic forecasting, particularly in region where a large percentage of total precipitation falls as snow. However, because of inaccessibility and the large extent of northern areas, snow surveys are expensive, even more when accurate estimation of the spatial distribution of snow cover variables are required. Combining snow surveys with remote sensing data offers an alternative to estimate snow water equivalent (SWE). Furthermore, using passive microwaves is advantageous for snow mapping, since the microwaves are relatively independent of atmospheric constraints and solar illumination. The main goal of this study is to estimate the snow water equivalent (SWE) over La Grande River watershed in a taiga area. (Northern Quebec, Canada) using SSMI data. More specifically, we have tested the performance of two Artificial Neural Network (ANN) model in SWE estimation: the backpropagation neural network with variable learning rate and the counterpropagation fuzzy neural network. For this purpose the input data include the seven channels of SSM/I sensor in descending mode and the minimum air temperature, while the target examples consisted of SWE measurements conducted by Hydro-Quebec, Alcan and the Churchill Falls and Labrador company (CflCo) from January to March during the period between 1993 and 2002. The preliminary results of training process show that for each ANN model the error is less when the training is made on monthly basis comparatively to an annual basis.

H23A-09 1330h POSTER

Estimation of snow-cover parameters using a combination of microwave and optical remote sensing data

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Snow-cover parameters are being increasingly used as input to hydrological models. Furthermore, an accurate knowledge of the onset of snow melts and snow water equivalent values are important variables in different hydrological applications such as flooding prediction, reservoir management and agricultural activities. However, the traditional field sampling methods and the ground-based data collection are often very sparse, time consuming, and expensive compared to the coverage provided by remote sensing techniques. Various remote sensing techniques have been evaluated and proven to be an effective tool for snow mapping. In particular, microwave remote sensing techniques have been investigated by numerous researchers using various sensors and have been demonstrated to be effective for monitoring snow pack parameters such as spatial and temporal distribution, snow water equivalent, depth, and snow condition (wet/dry state). Those researches have resulted that the microwave brightness temperature and the microwave backscattering are related to the snow cover structure with different correlation degrees. The primary objective of this research is to produce a spatial estimation of snow water equivalent in a timely fashion with sufficient spatial and temporal resolution using multi-source microwave and optical data. The final product of this project will be an additional tool for flood warning and water resource forecasts, which can be an additional input to the actual hydrological models. The contribution of remote sensing snow related information into the advanced hydrologic prediction system (AHPS) operated by NWS/NOAA (with 4 km grid resolution) will be also evaluated. The study area is located in the north of the state of New York (42-44 N and 73-78 W). A variety of multitemporal remote sensing data (SSM/I, RADARSAT and AVHRR) acquired during three successive winters (1999-2000, 2000-2001, and 2001-2002) have been provided for this project.