H21G MCC: 3020 Tuesday 1020h

Hydrologic Predictions in Ungauged Basins: PUB III *(joint with NG)*

Presiding: **V Lakshmi,** University of South Carolina**; X Liang,** University of California

H21G-01 1020h

MOPEX Contribution to Prediction for Ungaged Basins (PUB)

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The goal of the Prediction for Ungaged Basins (PUB) initiative is to reduce uncertainty in hydrologic precitions for ungaged basins. Model Parameter Estimation Experiment (MOPEX), an ongoing international project to develop a priori parameter estimation techniques for both gaged and ungaged basins, can contribute the PUB initiative in several ways. First, MOPEX can contribute to PUB science as MOPEX leads to improved understanding of how model parameters are related to basin climatic and geophysiological properties and heterogeneities. Second, the large number of data sets assembled by MOPEX for international basins can facilitate the PUB research and model intercomparison studies. Third MOPEX provides vehicles to transfer knowledge from gaged basins to ungaged basins. This paper presents an overview of MOPEX project. MOPEX science strategy, data sets and workshop experiences are discussed. Suggestions are made on how MOPEX can contribute to PUB science advancement and subsequent achievement of PUB objectives.

H21G-02 1035h

Multifractals and the Temporal Structure of Precipitation: Where are we Standing, What can we Expect

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Precipitation is the driving agent of many other processes. Its temporal and spatial variability are important issues in many studies and areas of research. However, information on the amount and distribution of precipitation in space and time is often restricted because of its strong temporal and spatial variation. Therefore, hydrological models have usually to conceptualize processes based on simple, often homogeneous, approximations of nature (e.g. precipitation is expressed as depths over periods of a day). Such conceptualizations often lack sufficient temporal and spatial resolutions to permit a detailed modeling of complex hydrological processes. Moreover, empirical scale truncations are made often, and one scale is studied independently of the others. Thus, it is pertinent to know whether there are intrinsically different phenomena as one moves from one scale to the next; and whether results obtained on one scale can be "transported" to the other. Scale-invariant studies of precipitation are being successful in clarifying the spatial and temporal structure of precipitation and in quantifying the variability in this process. In particular, multifractal theory can be used to better understand the strongly irregular fluctuations of precipitation, which are manifested over a broad range of scales, because it has the potential to assess the full range of precipitation dynamics. The prototypical multifractal process is a cascade: the extreme small-scale variability is precisely the consequence of the wide range of scales over which it can build up. This study explores the invariance of properties manifested across scales and determines the multifractal behavior of precipitation in time, using data from different origins. The statistical properties of precipitation are characterized by empirical multifractal exponent functions describing the scaling of the probability distributions and moments of the precipitation intensity. The description of these functions using a multifractal model based on Levy random variables is investigated. Special attention is given to using multifractal innovative tools for assessing the probability of occurrence of extreme events. Results can contribute to improve data collection, with respect to the required temporal sampling resolution, and the generation of high-resolution synthetic precipitation data.

H21G-03 1050h

A Watershed Similarity Index for Characterizing Homogeneity in Storm Runoff due to Saturation Excess Overland Flow

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A physically based, watershed similarity index is proposed for use in regionalization studies. The index is based on the steady state assumption and is applicable to watersheds where storm runoff is generated principally by the saturation excess (Dunne) mechanism. It uses variables that can be derived from readily available data for topographic, soil and climatic attributes. The method is applied to nine watersheds (4 to 83 km2) located in the state of Victoria, Australia. Finite mixture estimation is used to identify clusters of watersheds that group according to the similarity index. A three-component log-normal mixture model provides an adequate fit to the index distribution, suggesting the existence of three subpopulations. Comparisons with groupings indicated by hydrograph recession analysis, multifractal analysis of daily runoff, and a peak-over-threshold analysis of hourly discharge show reasonable agreement.

H21G-04 1105h

A Paired Basin Study for Hydrologic Prediction in Ungauged Basins

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A study has been initiated to assess the transferability of hydrologic model parameters and model structure to estimate runoff in ungauged basins. Twenty basin pairs are currently being modeled on a daily time step. Each basin pair has similar landscape and climate characteristics. A parameter sensitivity analysis was conducted for each basin and sensitive parameters were calibrated for one basin in each pair using an automated-calibration procedure. The sensitive parameters were calibrated in three steps, identifying parameters influencing model response to: (1) solar radiation; (2) potential evapotranspiration; and (3) runoff. A super-ensemble approach to watershed modeling is being used which involves configuring multiple hydrologic models within the Modular Modeling System, each with different algorithms for simulating components of the hydrologic budget. Parameter sensitivities, model configurations, and resulting parameter calibrations will be examined for each hydrologic landscape region. The reliability of hydrologic predictions in an ungauged basin will then be examined by transferring model configuration and calibrated parameter sets to the second basin in each basin pair. The procedures developed will serve as a basis for improvement of hydrologic models, provide estimates of the reliability of hydrologic forecasts, and provide information for regionalizing parameter sets for various model configurations across the continental United States.

H21G-05 1120h

Use of Satellite Remote Sensing in Prediction of Ungaged Basins

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Ungaged basins pose a challenge to hydrological studies as they lack both calibration and validation data for the use of land surface models. Therefore, one has to use the satellite data that is available which describes the aspects/attributes of the basin from a hydrological perspective. Soil moisture is routinely mapped by the Advanced Microwave Scanning Radiometer (AMSR). Vegetation is characterized by MODIS (Moderate Resolution Imaging Spectroradiometer) and surface temperature is estimated using AIRS (Advanced Infra-Red Sounder) as well as MODIS. Precipitation is measured (in the tropical regions) from the TRMM (Tropical Rainfall Measuring Mission) Microwave Imager (TMI) with the Global Precipitation Mission (GPM) due to be launched in a few years. The synergistic use of these data sets along with hydrological models would help us to (a) input precipitation and vegetation information into a hydrological model and calculate the soil moisture and surface temperature using the water and energy balance equations (b) the measured soil moisture and surface temperature can be used in two ways (i) to calibrate certain model parameters (ii) to verify the output of the model through validation. The overland runoff from the hydrological model would be routed in the stream channel network (obtained from the Digital Elevation Data) to obtain the streamflow at the catchment outlet. This would help in estimation of the water resources for the catchment.

H21G-06 1135h

Uncertainties Associated With Base Flow Parameterizations in The Variable Infiltration Capacity Land Surface Model in Ungauged Basins Under Cold Climate

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Identifying dominant physical processes and estimating the model parameters associated with these processes through a physically based approach is critical for improving hydrologic simulations and predictions with reduced uncertainties for given regions. For ungauged basins, this is probably even more important because often the hydrological model predictions suffer significantly more uncertainties. In this study, we focus on investigating the subsurface flow process and evaluate its associated model parameter estimations for cold regions through water and energy budget simulations by applying a new version of the Three-Layer Variable Infiltration Capacity (VIC-3L) land surface model, called VIC-ground, which incorporates dynamically the surface and groundwater interactions. In VIC-ground, groundwater table depth can be dynamically simulated and thus could greatly facilitate the investigation of an alternative base flow parameterization based on Boussineq equation for unconfined flow in a sloping aquifer. This base flow parameterization has more physical basis and its associated model parameters can be related with watershed characteristics. Therefore, comparing with the original ARNO base flow parameterization used in VIC-3L, the Boussineq equation may offer a great potential in reducing the uncertainties in parameter estimations which is especially important for ungaged basins. The study site is the Usadievskiy watershed at Valdai, Russia, which is a small boreal grassland watershed with its multiple measurements on water fluxes provided by the Project for Intercomparison of Landsurface Parameterization Schemes (PILPS) Phase 2(d). The VIC-ground simulated groundwater table, streamflow, snow water equivalent, evaporation, soil moisture profile and freezing front will be compared with the Valdai observations. Sensitivity of the base flow parameterization based on Boussineq equation on water and energy budgets will be investigated. Also, the uncertainties associated with the two base flow parameterizations will be investigated.

H21G-07 1150h

Application of a Distributed Hydrological Model to Detect Hydrological Effect on Gravity

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A major problem in many hydrological studies is that almost all of the stocks and fluxes in the hydrologic cycle are difficult to measure, and if measured or

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 inlands 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-Poseïdon 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 suboptimality 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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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 NOAAA AVHRR Imagery to Map Regional ET

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