data sets; lack of modern data collection; and limited use of quantitative tools for estimating sedimentation rates. Many applications of fluvial geomorphology rely only on qualitative conceptual models of channel equilibrium, and are not sufficiently robust for predicting form changes under transient and geometrically constrained conditions. Theories of channel form and change need to be developed from thoroughly instrumented studies of flow and sediment transport in complex channels. Definition of the fundamental connections between habitat characteristics and physical processes would allow probabilistic modeling of habitat use and its long-term evolution. Through these and similar studies, a research agenda could arise to support river restoration.

H31F MCC: 3024 Wednesday 1020h

Early Results From NASA's EOS Aqua Spacecraft Mission IV *(joint with A, OS)*

Presiding: **C L Parkinson,** NASA Goddard Space Flight Center**; S Platnick,** NASA Goddard Space Flight Center

H31F-01 1020h INVITED

The Earth's Radiation Budget: Early Aqua, TRMM, and Terra Results

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A new generation of data for the radiation balance of the planet from surface to top of the atmosphere is being enabled by the new NASA Earth Observing System data. Advances include improved instrument calibration, angular sampling, and time samping including diurnal cycles of radiative fluxes. The new radiation data also merges surface, aerosol, and cloud properties with each broadband radiation measurent. Data from up to 11 instruments on 7 spacecraft are used in the data analysis to improve time, angle, and space sampling. Surface and atmosphere fluxes are also derived in a manner consistent with the integrated data sources and constrained to agree with the instantaneous top of atmosphere radiative fluxes. Results will be shown summarizing these advances and comparisons will be made to the earlier ERBE standard for radiation budget. The global time averaged versions of these data ready for science applications will appear in spring, 2004 shortly after the AGU. The AGU presentation will preview these new data and discuss key applications and advantages for climate research, particularily for the study of the role of aerosols and clouds in climate change.

H31F-02 1035h

Comparison of CERES Cloud Properties Derived from Aqua and Terra MODIS Data and TRMM VIRS Radiances

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The Clouds and Earth's Radiant Energy System (CERES) Project is obtaining Earth radiation budget measurements of unprecedented accuracy as a result of improved instruments and an analysis system that combines simultaneous, high-resolution cloud property retrievals with the broadband radiance data. The cloud properties are derived from three different satellite imagers: the Visible Infrared Scanner (VIRS) on the Tropical Rainfall Measuring Mission (TRMM) and the Moderate Resolution Imaging Spectroradiometers (MODIS) on the Aqua and Terra satellites. A single set of consistent algorithms using the 0.65, 1.6 or 2.1, 3.7, 10.8, and 12.0-m channels are applied to all three imagers. The cloud properties include, cloud coverage, height, thickness, temperature, optical depth, phase, effective particle size, and liquid or ice water path. Because each satellite is in a different orbit, the results provide information on the diurnal cycle of cloud properties. Initial intercalibrations show excellent consistency between the three images except for some differences of 1K between the 3.7-m channel on Terra and those on VIRS and Aqua. The derived cloud properties are consistent with the known diurnal characteristics of clouds in different areas. These datasets should be valuable for exploring the role of clouds in the radiation budget and hydrological cycle.

URL: http://lposun.larc.nasa.gov/~cwg/

H31F-03 1050h

Synergistic use of MODIS cloud products and AIRS radiance measurements for retrieval of cloud parameters

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The Moderate-Resolution Imaging Spectroradiometer (MODIS) and Atmospheric Infrared Sounder (AIRS) measurements from the Earth Observing System's (EOS) Aqua satellite will enable global monitoring of the distribution of clouds. MODIS is able to provide at high spatial resolution (1 5km) the cloud mask, surface and cloud types, cloud phase, cloud-top pressure (CTP), effective cloud amount (ECA), cloud particle size (CPS), and cloud water path (CWP). AIRS is able to provide CTP, ECA, CPS, and CWP within the AIRS footprint with much better accuracy using its greatly enhanced hyperspectral remote sensing capability. The combined MODIS / AIRS system offers the opportunity for cloud products improved over those possible from either system alone. The algorithm developed was applied to process the AIRS longwave cloudy radiance measurements; results are compared with MODIS cloud products, as well as with the Geostationary Operational Environmental Satellite (GOES) sounder cloud products, to demonstrate the advantage of synergistic use of high spatial resolution MODIS cloud products and high spectral resolution AIRS sounder radiance measurements for optimal cloud retrieval. Data from ground-based instrumentation at the Atmospheric Radiation Measurement (ARM) Program Cloud and Radiation Test Bed (CART) in Oklahoma were used for the validation; results show that AIRS improves the MODIS cloud products in certain cases such as low-level clouds.

H31F-04 1105h

Sensitivity analysis of cirrus clouds using high-resolution IR spectra: Simulations and observations

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A set of simulated nadir-oriented high-resolution infrared emission spectra of synthetic cirrus clouds is analyzed to asess the spectrally dependent variability of radiance from the adjustment of some microphysical and bulk cirrus cloud properties. A principal component analysis is applied to the simulated spectra to diagnose the cloud parameters that contribute most to the sensitivity in top-of-atmosphere radiance. The spectral shape and magnitude of empirical orthogonal functions (EOF) shows similarities and differences from one physical quantity to another. In certain cases, it is possible to identify the EOF that represents variability with respect to one or more physical quantities. For a set of simulations with simultaneous variation in the quantities of ice water path, water vapor mixing ratio, and effective radius over a set of effective radii 10s of microns and smaller, the sensitivity with respect to the joint variation of all quantities is well approximated by the sum of the sensitivities with respect to variations in each quantity separately. Effects of particle shape, cloud height and thickness, and atmospheric temperature on the shape and magnitude of the EOFs will be discussed as well. Comparisons of simulations with spectific cases of Atmospheric Infrared Sounder data containing cirrus clouds will be presented.

H31F-05 1120h

Global Observations of Dust in the Infrared using AIRS

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The Atmospheric Infrared Sounder (AIRS) on AQUA provides nearly complete spectral coverage of the 9-12 micron atmospheric window with a resolving power of $\sim$1200. The relatively large size of dust particles, coupled with their variable index of refraction in this spectral region allows the retrieval of particle sizes and optical depths under certain conditions. We will present global maps, ocean only, of the monthly mean impact of dust on AIRS brightness temperatures for the first year of AIRS operation. These maps, based on the clear scene brightness temperature differences between window channels with differential sensitivity to dust, show that AIRS retrievals will have to take dust contamination into account over large geographic areas, primarily due to dust from the African continent. More detailed studies of individual dust events show good agreement with MODIS observations of dust. The physical retrieval of dust optical properties for several of these events will be presented, and their potential impact on longwave forcing.

H31F-06 1135h

Latest summary of MODIS land data products from Aqua

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The MODIS Land datastream from Aqua has now been operating for about 1 year. A partial listing of MODIS land products include atmospherically corrected surface reflectances, albedo, surface temperature, snow cover, land cover, vegetation cover, vegetation indices, leaf area index, net primary production and thermal anomalies. These data are being generated globally at 0.25 to 1km resolution, usually at 1-16 day intervals. This paper will summarize the latest progress in processing and validation of the MODIS land product suite and provide some initial comparisons between the Aqua and Terra land data.

H31F-07 1150h

VPD Estimation from Land Surface Temperature (MOD11) for global map of evapotranspiration and NPP.

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Vapor Pressure Deficit (VPD) is one of the key climate variables for ecosystem modeling. Potential evapotranspiration is usually expressed partly as a function of VPD. Stomata regulate the transpiration in response to VPD, thus VPD also influence photosynthesis indirectly. However, unavailability of spatial distribution of VPD makes it difficult to estimate regionally both evapotranspiration and Net Primary Production (NPP). We used the radiometric land surface temperature (LST) for the VPD estimation based on Granger [1991]. Granger [1991] showed that LST could be a good estimator of VPD from the feedback links between the land surface and the overlying air. Better estimates of LST (MODIS11), available daily and globally, allow us to test this method. We tested this method for data of 2001 for India, Amazon and USA. We also examined the spatial variability of the coefficients globally. All the results indicated that this method is feasible for VPD estimation both globally and temporally. The high-resolution maps of VPD can be useful for improving land-atmosphere modeling studies.

H31F-08 1205h

Improved MODIS burned area mapping by combined use of multi-temporal Terra and Aqua MODIS data – early results

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The MODIS burned area detection algorithm was developed using MODIS Terra observations to map the approximate 500m location and day of burning. The algorithm is based upon the inversion of a Bidirectional Reflectance Distribution Function (BRDF) model against a long time series of observations with a moving temporal window. It is adaptive to the number, viewing and illumination geometry of the observations, and allows for combination of observations from different sensing systems. In this paper the combined utility of Terra and Aqua MODIS data is investigated. Early results indicate that the increased number and angular sampling of observations provided using both the Terra morning and the Aqua afternoon overpasses improve burned area mapping accuracy. Improvements in mapping accuracy are primarily through more reliable BRDF model inversion and a reduction in the number of cloud contaminated observations. Issues with Aqua shortwave infrared band striping are discussed and illustrative results for 2003 dry season burning in Southern Africa and Australia are presented with provisional validation provided by comparison with the MODIS 1km Aqua and Terra active fire products. The implications of this work for MODIS burned area mapping in other fire regimes and for fusion of observations from other sensing systems are also discussed.

H31G MCC: 3022 Wednesday 1020h

Hillslope Hydrologic Processes: New Directions in Monitoring and Modeling I *(joint with NG)*

Presiding: **L E Band,** University of North Carolina**; J McDonnell,** Oregon State University**; M Weiler,** Oregon State University

H31G-01 1020h INVITED

Identifying Characteristic Responses of Hydrological and Geochemical Behavior at Hillslope and Catchment Scales

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Time series of hillslope or catchment water content, subsurface flow, and solute chemistry typically show complex and highly variable behavior. Event-based approaches are often used to characterize input-output responses (e.g., tracking an isotopically unique precipitation event, or by fitting a seasonality curve to the data). However, such approaches typically quantify just one characteristic response when we know that hillslopes and catchments have a distribution of characteristic time scales. Thus, we seek an alternative approach, one where we can identify distributions of characteristic responses and quantify individual variance contributions. Besides improving our conceptual understanding of how hillslopes and catchments work, the goal is to develop low-dimensional "empirical" and/or physically based models that more fully represent the distribution of characteristic responses. To this end, singular spectrum time series analysis is used to identify characteristic times of hydrologic and geochemical variables at hillslope and catchment scales. For our semiarid study sites we find that soil water content, spring flow (representing catchment scale behavior), and geochemical responses can be characterized by a small suite of periodic or quasi-periodic characteristic "modes' that account for a major fraction of the total system variance. The remaining modes (i.e., those that only account for a small fraction of the variance) typically display "red-noise" type behavior suggesting a simple stochastic model. Our results show that singular spectrum analysis offers new insights on hydrologic and geochemical response and should be a fruitful way of developing improved hillslope- and catchment-scale models.

H31G-02 1040h

Inferring residence time distributions from hillslope tracer experiments

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Water residence time in catchments is typically determined by black-box modeling of environmental tracers (e.g., ^{18}O and ^{2}H), in which input (rainfall) and output (discharge) tracer concentrations are used to estimate parameters of an assumed distribution that represents the residence time. In this study, a different approach was taken, where the residence time distribution (RTD) was determined directly from an artificial tracer experiment. Two tracers (Amino G acid and bromide) were applied as line sources (20 and 40 m from the stream, respectively) to the soil surface of a steep forested hillslope in the H.J. Andrews Experimental Forest. Tracer concentrations and seepage flow were monitored for approximately 100 days. The resulting breakthrough curves were modeled using a simple, process-based hillslope model conditional on spatially varying soil depth and depth-varying drainable porosity and hydraulic conductivity. The model preserved internal hydrological behavior such as water table dynamics and satisfactorily reproduced seepage discharge and tracer concentrations. Using the model and assuming the same parameterization, we infer the RTD of conservative tracers applied to the entire hillslope. The derived RTDs were then compared to functions that represent RTDs used in black-box models.

H31G-03 1055h INVITED

Nonlinearity in Storage-Discharge Relationships of Heterogeneous Hillslopes and Implications for Baseflow Recession

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Existing models of groundwater discharge from hillslopes and small watersheds are largely empirical or are based on analytical solutions to the Boussinesq equation. As such, the effects of partially saturated flow, hillslope shape, and heterogeneity in soil hydraulic properties have not been well studied. Numerical modeling of Richards equation is used here to examine these effects on the saturated storage-discharge relationship and on baseflow recession. Model solutions under steady rainfall conditions indicate that the saturated storage-discharge relationship can take a variety of nonlinear forms depending on hillslope shape and pattern of heterogeneity; only over small ranges of saturation can the relationship be assumed linear. Dynamic simulations are currently underway; however it is hypothesized that the inherent nonlinearity of the saturated storage-discharge relationship will result in baseflow recession time series that differ from the exponential decay model often assumed.

H31G-04 1115h

Hillslope-storage Dependent Drainable Porosity to Account for Capillarity Effects on the Dynamic Response of Complex Hillslopes

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Specific yield is a parameter used to quantify the available amount of water for drainage. The instantaneous release of water from the aquifer during drainage however is captured by a related parameter, viz drainable porosity. In landscapes with relatively shallow groundwater table the drainable porosity is among others a function of the local total subsurface storage. Here we derive an analytical expression to compute the drainable porosity as a function of water table depth and soil hydraulic parameters. This expression then allows us to extend the hillslope-storage Boussinesq equation, recently introduced by the authors, to account for capillarity effects during free drainage from complex hillslopes. We test our model for different soil types and compare our results with a 3D Richards' equation based numerical model.

H31G-05 1130h INVITED

Hillslope Hydrological Modeling in a Boreal Forest - Tools for Assessment of Logging Impacts on Runoff Generation and Nitrogen Loads

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Advance in runoff generation models requires measurements of water quantity and quality both at the outlet of a catchment and along hillslopes residing within a catchment. Predicting response of streamflow volumes to land-use changes is challenging, but it is even more demanding to produce realistic estimates of surface and subsurface runoff components and solute fluxes within a catchment. This work, which is part of the FEMMA project, presents development and application of a deterministic hillslope hydrological model, which combines hydrological, biological, and solute transport computation schemes. The model simulates canopy processes, snow accumulation and melt, soil and ground water movement, and nitrogen transport. Here the modeling system is applied to two coniferous-forested catchments (56 and 29 ha) located in Eastern Finland. One of the catchments was partially clear-cut (35 %) while the other one was left as a control. Measured meteorological, snow, streamflow, and nitrogen concentration data cover a nine-year period starting five years before the treatment. The model parameterization is based on spatial data on topography, soil types, soil depths, and location of treated areas with respect to the stream network draining the catchment. Spatial data analysis condenses information on catchment physical properties for identification of one or several typical hillslopes, which are assumed to represent the behavior of the entire catchment. Results derivable directly from the measured data suggest that timing and volume of streamflow changed soon after loggings were completed. In the modeling exercise these changes are attributed to increased melt intensity and absence of interception in