H31D-0495 0830h POSTER

Infiltration as Bounded by the Green-Ampt and Talsma-Parlange Limits

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This presentation explores some of the contributions of J.-Y. Parlange to predictive infiltration formulas. The Green-Ampt infiltration formula (1911) involves a remarkable combination of simplicity and physical realism. It is known, however, that the hydraulic functions for which this formula can be deduced from Richards' equation are reasonable only for a step change in the unsaturated hydraulic conductivity, i.e., the Green-Ampt infiltration formula is a limiting case that relies on the condition that the soil-water diffusivity varies rapidly, while the unsaturated hydraulic conductivity remains constant. Equally simple is the Talsma-Parlange formula (1972). This formula can be considered as another limiting case wherein the rapid variation in the diffusivity is mirrored by a similarly rapid variation in the conductivity (i.e., a Gardner soil). Both these formulas depend on two soil properties, the sorptivity, S, and the saturated hydraulic conductivity, K_S. Not surprisingly, actual soil behaviour lies between these limits. An interpolation leading to the "three-parameter" infiltration equation (1982) introduced an additional parameter, α, where $0 \leq \alpha \leq 1$. The former limit produces the Green-Ampt formula, and the latter gives Talsma-Parlange. Because the Gardner assumption on hydraulic properties is much more reasonable than the Green-Ampt assumption, it is, again, not surprising that infiltration is best described by α near 1 (e.g., $\alpha = 0.85$). The three-parameter equation applies when surface ponding is negligible; this condition was relaxed to give a generalisation that here is, for convenience, called the ponded three-parameter equation (1985). The ambiguous interpolation parameter, α, was given a physical basis (1990), where a new parameter, h_{str}, was introduced. Although the meaning of h_{str} is understood as the pressure jump necessary to establish a continuous air phase in the soil, a means by which it could be easily and unambiguously determined was unavailable until very recently (2002). Thus, the journey started with Parlange's realisation that infiltration is bounded by the Green-Ampt and Talsma-Parlange limits has now been completed with a fully physically based infiltration formula.

H31D-0496 0830h POSTER

Use of azimuthal resistivity survey in mapping subsurface fractures and assessing their hydraulic properties in crystalline rocks in Ghana.

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Azimuthal resistivity surveys (ARS) using the square array configuration were conducted at selected farmland sites in Nsawam District, Ghana with the objective of predicting the orientation of subsurface fractures which may serve as conduits for fluid flow and contaminant transport. Information about the orientations, apertures and lengths of fractures in the study area were obtained from geological mapping of few exposed outcrops. For areas with no outcrops, electrical resistivity surveys were performed to estimate the fracture parameters. The results of the fracture mapping using geophysical resistivity study correlated well with that of the geological mapping. This integrated geological and geophysical study indicates that there are two dominant fracture directions in the study area with other minor orientations which may control groundwater flow in the area. One fracture system is dominantly oriented in NW-SE direction (Kitase and Amanfrom) and another is in the NE-SW direction (Nsakye). It is thus shown that in the absence of rock exposure, ARS could be a viable complement in mapping subsurface fractures. Other fracture characteristics, fracture porosity, specific surface area which could give potential information on the hydraulic properties were also assessed.

H31D-0497 0830h POSTER

Temporal change in groundwater level following the 1999 Chi-Chi (Mw = 7.5) earthquake, Taiwan

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We analyze the post-seismic changes in the groundwater level after the 1999 Chi-Chi (Mw = 7.5) earthquake, Taiwan, as recorded by a network of 70 evenly distributed hydrological stations over a large alluvial fan near the epicenter of the earthquake. Two types of post-seismic responses may be distinguished: In type I, the groundwater level returned gradually towards the pre-seismic level. In type II, the post-seismic groundwater level remained nearly at the coseismic level or even departed further from the pre-seismic level for a period of time. In the type I post-seismic changes, two sub-groups may be identified: one with a characteristic time of 105 s for wells located in deformed rocks near the ruptured Chelungpu fault, the other with a characteristic time of 106 s for wells located in unconsolidated and undeformed sediments over the Choshui River fan. A model of subhorizontal aquifers with coseismic recharge and local discharge may explain the type I post-seismic changes. It predicts a characteristic length of 1500 - 5000 m for the confined aquifers, and of 150 - 500 m for the unconfined aquifers. Most type II post-seismic responses occurred along the coast and along the Peikang Stream, where the groundwater level is many meters below the surface water level. A model of sustained recharge of the aquifers from the surface water, due perhaps to enhanced vertical permeability from coseismic formation of fractures and cracks, may explain these type-II post-seismic changes. On the other hand, a model of sustained loss of groundwater, that outpaced the surface recharge, is needed to explain the continued lowering of groundwater level at the Liyu station near the ruptured Chelungpu fault.

H31D-0498 0830h POSTER

Application of Analytical Models of Pumping Induced Stream Depletion to Real Stream-Aquifer Systems: a Practical Approach?

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Two-dimensional analytical models of stream-aquifer interactions are commonly used to predict pumping induced stream depletion (SD) rates from drawdown data. In the case of most natural streams, however, predicted SD rates are virtually impossible to verify with direct measurements obtained via stream gauging due to relatively large measurement errors in the field. Thus, other ways must be found to test the applicability of these models to real stream-aquifer systems. This study utilizes three-dimensional numerical flow models to test the applicability of analytical models based on the assumption that more flexible numerical models can represent real stream-aquifer systems more realistically. The stream-aquifer system considered in this study consists of an aquifer associated with the braided-river depositional environment that is hydraulically connected with a naturally meandering stream at the top. Drawdown data from two pumping tests performed in presence and absence of streamflow were collected in a dense monitoring network on both stream banks (point bar and cut bank). The drawdown data were analyzed using simple analytical models and more realistic numerical models that incorporate aquifer heterogeneity, the plane stream geometry, an approximation of the stream-aquifer interface, and aquifer return flow. The numerical models consistently explained the measured system's responses under the distinct hydrologic conditions. Comparison of SD rates obtained with the analytical and numerical models suggests that analytical models can provide a good proxy of SD. In the analytical models, however, the streambed conductance concept of a semi-pervious streambed has only little resemblance in the field as follows from direct observations. This concept is better interpreted as an operational theory in our case. Techniques applied in this study are useful for SD rate estimation, delineation of aquifer heterogeneity, and streambed characterization.

H31D-0499 0830h POSTER

Rain Induced Infiltration Into Soil With Dynamic Surface Seals

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For the purpose of developing infiltration equation under a dynamically sealing soil surface Richards' equation of unsaturated flow for a two layered system is considered. An analytical approach based on the concept of dynamic wetting front is utilized to form the basis of transport process in a substrate whereas a kinematic approximation is utilized in the surface seal. First, the general solutions of unsaturated flow with appropriate boundary conditions are developed, which consist of concentration and flux boundary values. Richards' equation in the domain of the seal is approximated by a kinematic approach which yields a closed-form solution permitting the satisfaction of continuity of transport conditions between the seal and the substrate. Further analysis of the resulting set of equation yields a nonlinear integral equation. Solutions of the integral equation show direct dependence on physical parameters pertaining to the seal and the substrate as well as the rain characteristics. Results of the present model are compared with the available experimental data of cumulative infiltration pertaining to sealing soils under various rainfall regimes.

H31E MCC: 3001-3003 Wednesday 0830h

Langbein Lecture

Presiding: **L Smith,** University of British Columbia

H31E-01 0835h INVITED

River Restoration as a Challenge to Hydrological Science

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The readiness of affluent societies to invest resources in changing degraded rivers and floodplains to some other desired state (widely referred to as 'restoration') raises the question of how hydrological scientists might contribute their knowledge to the effort. The interdisciplinary nature of post-1990 hydrologic science makes it a promising contributor to river restoration. A central role in this effort has to be played by fluvial geomorphology, the science that explains the formation and continual evolution of channel and floodplain topography, and thus of habitat characteristics that depend on channel bed stability, flow depths and velocities, drainage conditions, and sediment textures and chemistry. Prediction of how such features develop requires understanding of sediment supplies, the effects of active tectonics and recent geologic history (such as deglaciation or sea-level rise) that influence the sediment budget of reaches, as well as the role of flow regimes, altered by catchment changes or reservoir storage. Hydrologists need to characterize flow regimes in ways that are more explicitly useful for understanding valley-floor inundation and drainage than are traditional methods developed for planning flood control and reservoir storage. They also need to develop ways of predicting future streamflow regimes, given the emerging recognition that global geophysical processes generate both persistent excursions and long-term trends away from our current streamflow paradigm of stationary, random inter-annual variability. Interactions between surface and ground waters within the subtle, complex topography and sedimentology of floodplains create habitats and affect their chemistry. The most difficult set of problems involves translating knowledge of the physics of variable form and flow conditions into quantitative understanding of habitat characteristics and their significance for biological diversity and productivity as these characteristics fluctuate through time. The increasingly interdisciplinary geophysical societies are the appropriate forums for developing the essential knowledge for restoration. This conclusion raises the question of how to motivate scientific studies of these fundamental processes, to minimize the need for trial-and-error solutions and static characterizations of each new river restoration target. Scientific studies of rivers and floodplains are rare. Widely tested prediction models for the behavior of alluvial environments and their biota are not emerging as quickly as the need arises. We have not, for example, developed an approach to anticipating the flow regimes of rivers over the next century. Predictions of catchment sediment supplies and sediment transport, including channel-floodplain exchanges rely on: concepts and calibrations from sparse, decades-old 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 ~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.

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H31F-07 1150h

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

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