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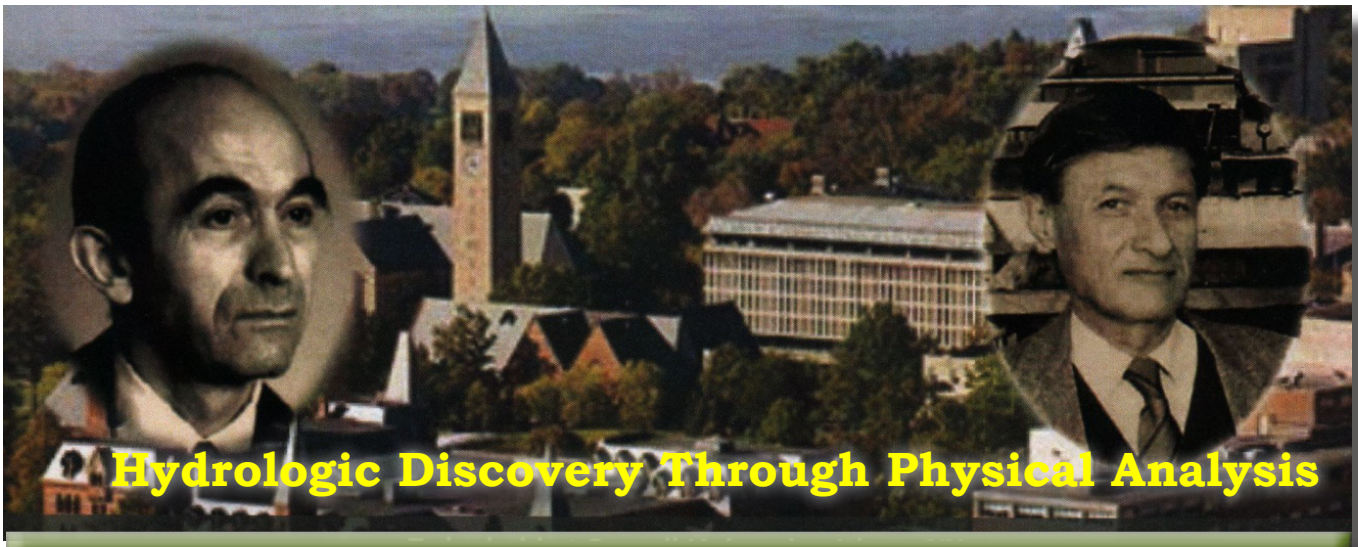

Oral Presentations

Abstracts with Links to the Videos

Honoring the Scientific Legacies of

Wilfred H. Brutsaert & Jean-Yves Parlange

May 14–15, 2012

Acknowledgments

The Symposium honoring Brutsaert and Parlange was organized by John Selker, Tammo Steenhuis,Todd Walter, Peggy R. Stevens, Andrew Barry and William Kustas, with special assistance from Marc Parlange,

Additional special assistance with the logistical support for the poster sessions was provided by Amy S. Collick. She also assembled and produced the booklet of abstracts for the oral presentations and the poster sessions. Steve Pacenka and Dan Fuka also provided valuable logistical support.

Peggy Stevens created the Symposium website and prepared the booklets and handouts for the Symposium. She also assembled and produced the booklet of abstracts for the oral presentations and the poster sessions. These Contents listings are a reformatted version of that document.

The videographers for the symposium were Peter Carroll and J. Robert Cooke, who also served as producer and editor for this online material. Mira Basara of the Cornell University Library posted these materials in eCommons in the Collection of Symposia as Hydrologic Discovery Through Physical Analysis Honoring the Scientific Legacies of Wilfried H. Brutsaert and Jean-Yves Parlange at **http://ecommons.library.cornell.edu/handle/1813/29545**

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EROSION

A1. Modelling hysteresis in sediment transport and continuous distributions of eroded sediment.

G.C. Sander[1], J.-Y. Parlange[2] and D.A. Barry[3]

[1] Loughborough University, Leicestershire, UK, [2] Cornell University, Ithaca, NY, [3] Ecole polytechnique fédérale de Lausanne (EPFL), Lausanne, Switzerland

Abstract: Sediment transport hysteresis occurs due to the different sediment fluxes for the same discharge on the rising and falling limb of the overland flow hydrograph. Experimental field data has shown that the common shapes of the hysteresis loops encompass (i) clockwise, (ii) anti-clockwise and (iii) figure 8 with both flow orientations. It has been suggested that the shape of these loops can be used to identify the different processes of runoff and sediment transport and the sediment source area. We present simulations carried out using the Hairsine-Rose (HR) erosion model which reproduces all of the above hysteresis loops for flow conditions that are straightforward to establish within a laboratory flume.

As both agricultural chemical and biological pathogens bind preferentially to the clay and silt sized particles, estimating contaminant fluxes to surface water bodies requires knowledge of the size distribution of transported sediment. We also present some recent work on extending the HR model from discrete sediment size classes to a continuous distribution of sizes along with some corresponding solutions.

Keywords: soil erosion, sediment size class distributions, sediment discharge hysteresis, clockwise, anti-clockwise,figure eight loops, distributed sediment sources

URL (videos & slides): http://hdl.handle.net/1813/29547

A2. Influence of Antecedent Moisture Conditions on Inter-rill Soil Erosion

*Ilja (H.J.) van Meerveld**

Vrije Universiteit Amsterdam, Amsterdam, The Netherlands

Abstract: Few studies have looked at the effects of antecedent soil moisture conditions on inter-rill soil erosion and in many models soil erodability parameters are considered constant, even though it is well known that the soil's inherent ability to resist erosion varies temporally due to differences in temperature, soil frost, time since ploughing, consolidation, microbial activity, soil organic matter content, soil moisture, etc. Therefore, 11 high rainfall intensity (>45 mm/hr) experiments were done on the 6-m × 2-m EPFL erosion flume to determine the effects of antecedent moisture conditions on inter-rill soil erosion. Pore pressure at 0.05 m below the soil surface at the start of the experiment had a large effect on peak sediment concentrations; wetter antecedent moisture conditions led to higher peak sediment concentrations, with the largest changes occurring near saturation. Antecedent moisture conditions also influenced the composition of the eroded sediment; wetter conditions led to a disproportionately large flux of clay- and silt- sized particles. The finding that the composition of the eroded sediment not only changes during an event but is also dependent on the antecedent moisture conditions has important implications for modelling the transport of chemical fluxes associated with the sediment flux, such as phosphorous fluxes. Antecedent moisture conditions did not influence the steady-state sediment concentrations. One of the optimized non-dimensional parameters in the analytical solutions of the Hairsine-Rose erosion model (α, the ratio of the re-detachability of the soil and runoff depth to the runoff ratio and the mass per unit area of sediment required for complete shielding) was linearly related to pore pressure at the start of the experiment. Using the linear relation between this non-dimensional parameter and pore pressure, the sediment concentrations and the composition of the eroded sediment could be simulated for a range of antecedent soil moisture conditions and events.

This work builds on Dr. Parlange's contributions to erosion research and finding analytical solutions to describe erosion processes, and is another step towards operational soil erosion models that can be used under a wide range of conditions.

Keywords: soil erosion, particle size, antecedent soil moisture conditions, EPFL erosion flume, Hairsine-Rose model

URL (videos & slides): http://hdl.handle.net/1813/29548

A3. Selected Aspects of Hydraulic and Hydrologic Soil Erosion Processes

M. J. M. Römkens

USDA ARS National Sedimentation Laboratory
Oxford, MS

Abstract:

Keywords:

URL (videos & slides): http://hdl.handle.net/1813/29549

A4. Hydrologic Controls on Wind Erosion in Arid Landscapes

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Abstract: Wind erosion is a dominant geomorphological process in arid landscapes. It contributes to the loss of soil resources and the emission of mineral dust, with major impacts on regional climate, biogeochemical cycles and human health. Wind erosion occurs when the wind speed exceeds a certain threshold value, which depends on a number of factors including surface soil moisture. Through this control on the threshold velocity, hydrological processes affect the soil's susceptibility to wind erosion and the rate of sediment transport. In arid regions the atmospheric humidity plays an important role in determining both the surface moisture content and the threshold shear velocity. The dependence of threshold velocity on near surface air humidity and fire-induced water repellency is discussed using a series of wind tunnel tests, laboratory measurements, and theoretical frameworks.

Keywords:

URL (videos & slides): http://hdl.handle.net/1813/29550

BOUSSINESQ AND RUNOFF RELATIONSHIPS

B1. Laplace – Boussinesq: 3-1

Nick van de Giesen[1], Tammo S. Steenhuis[2], Jean-Yves Parlange[2]

[1] Delft University of Technology, *n.c.vandegiesen@tudelft.nl*; [2] Cornell University, Ithaca, NY 14853

Abstract: In 1993, Jean-Yves Parlange developed a very generic solution for the Laplace equation in the archetypal drainage geometry of an aquifer on an impermeable layer between two parallel drains with linearized boundary conditions. The solution is based on Eigenfunction expansion and has as main advantage that it can accommodate any spatial and temporal distribution of recharge into the aquifer and any shape of the initial groundwater table. A parallel solution was developed for the Boussinesq equation. As such, the solutions provide a nice "toy model" to test the validity of the Dupuit assumption that the vertical pressure distribution in an aquifer is basically hydrostatic, which underlies the Boussinesq equation. The good news is that Boussinesq is indeed valid as long as the underlying assumption is valid. There are, however, also cases in which Boussinesq fails. The presentation will go in some detail to show where trouble is to be expected, and where safe sailing reigns. Although the geometry and the linearization of the boundary conditions do not allow for a complete analysis, the analysis does have clear heuristic value. For example, at short times after sudden drawdowns, vertical water movement and associated energy losses are very relevant, limiting the validity of the Boussinesq equation. The same holds when the aquifers, or drained fields, are relatively deep in comparison to theirs widths, as is the case in the raised beds found in the wetlands of Rwanda that prompted the original research.

Keywords: groundwater flow, Laplace, Boussinesq, drainage formulas, raised beds, Dupuit-Forchheimer assumption

URL (videos & slides): http://hdl.handle.net/1813/29551

B2. The Isotopic Age of Runoff in Natural Flow Systems

Christopher Duffy

Penn State University, State College, PA

Abstract: This paper outlines a theory describing fundamental controls on the isotopic "age" of runoff from watersheds. In this context "age" is defined as the time since the water and environmental tracer entered the system as precipitation. The paper first examines the theoretical basis for directly modeling "age" of environmental tracers, and explains how subsurface flow (Boussinesq equation) and transport processes affect age dynamics. Solutions for the age of watershed runoff are presented for storm events, seasonal and stochastic tracer inputs. Through a simple analogy to boundary layer theory and potential flow, a strategy to estimate the effective depth and corresponding age of groundwater circulation is presented. The approach reveals an important relationship for flow-depth and age, which can be used to define the practical mixing layer for environmental tracers contributing to runoff. Extension of the model to the unsaturated zone and the effects of mobile-immobile on flow and transport on the age of runoff are briefly outlined. Preliminary results from a field experiment for stable isotopes at the Shale Hills Critical Zone Observatory provides some initial validation and estimates for the "dynamic" age of runoff.

Keywords:

URL (videos & slides): http://hdl.handle.net/1813/29554

B3. Climate-vegetation-soil Interactions and Long-term Hydrologic partitioning: Signatures of Catchment Co-evolution?

Peter A. Troch

Department of Hydrology and Water Resources, The University of Arizona, Tucson

Absract: Catchment hydrologic partitioning, regional vegetation composition and soil properties are strongly affected by climate (Budyko, 1974; Whittaker, 1962; Jenny, 1941), but the effects of climate-vegetation-soil interactions on river basin water balance is still poorly understood. Here we use a physically-based hydrologic model applied to 12 US catchments across a climate gradient to decouple climate and landscape properties in an attempt to gain insight into the role of climate-vegetation-soil interactions in long-term hydrologic partitioning. The 12 behavioral catchment models are subjected to the 12 different climate forcings, resulting in 144 10-year model simulations. The results are analyzed per catchment (one catchment model subjected to 12 climates) and per climate (one climate filtered by 12 different models), and compared to water balance predictions based on Budyko's hypothesis ($E/P=\phi(EP/P)$; E: evaporation, P: precipitation, EP: potential evaporation). We find significant anti-correlation between average deviations from predicted evaporation index (E/P) computed per catchment vs. per climate. Catchments that on average produce more E/P have developed in climates that on average produce less E/P, when compared to Budyko's prediction. Water and energy seasonality could not explain these observations, confirming previous results reported by Potter et al. (2005). Next, we analyze which model (filter) characteristics explain the catchment's tendency to produce more or less E/P. We find that the time scale that controls perched aquifer storage release explains the observed trend. This time scale combines several geomorphologic and hydraulic soil properties. Catchments with relatively longer aquifer storage release time scales produce significantly more E/P. Vegetation in these catchments have longer access to this additional groundwater source and thus will be less prone to water stress. Further analysis reveals that climates that give rise to more (less) E/P are associated with catchments that have vegetation with less (more) efficient water use parameters. In particular, the climates with tendency to produce more E/P have catchments that have lower % root fraction and less light use efficiency. Our results suggest that their exists strong interactions between climate, vegetation and soil properties that lead to specific hydrologic partitioning at the catchment scale. This co-evolution of catchment vegetation and soils with climate needs to be further explored to improve our capabilities to predict hydrologic partitioning in ungaged basins.

Keywords:

URL (videos & slides): http://hdl.handle.net/1813/29555

B4. Capillary Effects on Groundwater Waves in Unconfined Coastal Aquifers

Jun Kong[1], Cheng-Ji Shen[2], Pei Xin[2], Zhi-Yao Song[3], Ling Li[2,], D.A. Barry[4], D.-S. Jeng[5], D. A. Lockington[2], F. Stagnitti[6] and J.-Y. Parlange[7]*

[1]Hohai University, Nanjing, China; [2]The University of Queensland, Brisbane, Australia, [3]Nanjing Normal University, Nanjing, China, [4]Ecole polytechnique fédérale de Lausanne (EPFL), Lausanne, Switzerland, [5]University of Dundee, Dundee, UK, [6]Universiyt of Ballarat, Ballarat, Australia, 7Cornell University, Ithaca, USA

Abstract: Various types of Boussinesq model exist, including those that account for finite-depth aquifers and capillary effects. Such models are used to simulate propagation of groundwater waves (watertable fluctuations) due to, for example, tides. However, discrepancies remain between experimental data and theoretical results. We proposed a Boussinesq-type model that (i) accounts for combined saturated-unsaturated zone flow and (ii) considers both horizontal and vertical flow. The unsaturated zone flow was modeled using Gardner's hydraulic functions. The model, first solved numerically, provided predictions that improved agreement with experimental data on the propagation of tidal signals in a coastal aquifer. An approximate analytical solution to the model was also derived. The analytical approximation shows that the unsaturated zone's storage capacity permits watertable fluctuations to propagate more readily than predicted by previous models. This occurs because the exchange of water with the capillary fringe is minimal during the passage of groundwater table fluctuations. The propagation characteristics of the groundwater waves predicted by the new analytical solution were examined in detail with respect to amplitude damping, phase shift and over-height of the fluctuating watertable.

Keywords: Capillarity, groundwater wave, capping effect, non-hydrostatic approximation, perturbation solutions, atmospheric turbulence

URL (videos & slides): http://hdl.handle.net/1813/29556

INSTABILITY AND FLUID MECHANICS

C1. Macro-scale Evidence of Pore-scale Processes: The Promise and Peril seen in 40 years of Studying Fingered Flow

John Selker

Oregon State University, Corvallis, OR

Abstract: Fingered flow in coarse textured media has long been studied as an exemplar system for exhibiting the interplay between gravity and capillarity at easily observable scales. Early work by Parlange and Hill explained the system using linear stability analysis of solutions to the Richard's equation, and were able to explain the relationship between finger width and media texture. These results were largely confirmed by the doctoral work of Glass, under the supervision of Parlange and Steenhuis. However thereafter several tests of the fundamental behavioral dependencies have been seen as being inconsistent with the theory, and have remained actively examined. Recent strategies to explain fingered flow behavior have seemingly given up on mechanistic physics and invoked new sources of hydrodynamic potential based on curvature of the wetting front. Others attribute the results to an expression of time-dependency in the soil characteristic curve. This talk presents highlights of this history illustrating the outstanding issues in this field, as well as pointing out the remarkable insights and conundrums that this easily-seen behavior has evoked over the 40 years since being reported in the literature.

Keywords:

URL (videos & slides): http://hdl.handle.net/1813/29557

C2. Preferential Flow and Extensions to Richards Equation

David A DiCarlo

The University of Texas at Austin

Abstract: Multi-phase flow instabilities have always been a great interest in fluid flow in porous media, as they can create fingers and drastically change the travel times of solutes to ground water and/or change the sweep efficiency. Yves Parlange has been at the forefront of this research for the past 40 years, beginning with his classic papers on front stability with Hill.

In the last decade, it has become apparent that gravity driven instabilities profiles cannot be described by traditional unsaturated continuum flow models (e.g. the Richards Equation). In this talk, I will detail this connection, and in turn, show how measurements of flow instabilities are key to developing the correct physical extensions of multi-phase flow.

Keywords:

URL (videos & slides): http://hdl.handle.net/1813/29558

C3. On Wettability and Unstable Flow in Porous Media

Rony Wallach

The R.H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Israel

Abstract: The effect of contact angle (CA) between water and porous media on flow regime in water repellent and sub-critically repellent soils will be illustrated and discussed. Water flow pattern that was monitored in a thin transparent flow chamber that ensures a 2D flow for water repellent soils (initial contact angle $\theta > 90^0$) and sub-critical repellent porous media (permanent contact angle $30^0 < \theta < 75^0$) was remarkably affected by the CA. Plumes that were initiated by a point source at the soil surface (local perturbation) had different shape, size and longitudinal and transversal water content distributions for different contact angles and water application rates. The contact angle and water application rate control in particular the development of sharp water content decrease along the peripheral wetting front and non-monotonous water content variation along vertical cross section directions that are associated with unstable flow. For the low water application rate, thin and long plumes with saturation overshot behind the wetting front were observed for higher contact angles and wide plumes with lower average water content flow for the lower contact angles. On the contrary, negligible differences among the plumes were observed in all media for the high water application rates. Differences among the plumes became apparent only during the following drainage stage. The plumes in the media of high contact angle barely changed during the drainage period while the water content gradient along vertical cross sections turned positive at the lower part and negative along the upper part of the plumes in the media of lower contact angle. The discussion will include simulations made by a model developed for a bundle of capillaries of constant and variable cross section area and different contact angles.

Keywords:

URL (videos & slides): http://hdl.handle.net/1813/29559

ATMOSPHERIC RADIATION

D1. Parameterization for Atmospheric Radiation: Some New Perspectives

Kuo-Nan Liou

Joint Institute for Regional Earth System Science and Engineering (JIFRESSE) and Atmospheric and Oceanic Sciences Department University of California, Los Angeles, CA, USA

Abstract: We first introduce Wilfried Brutsaert's contributions to atmospheric radiation in terms of his original work on deriving a simplified broadband emissivity for calculating downwelling long-wave radiation at the ground. This is followed by a discussion of sorting atmospheric absorption lines based on the concept of the correlated k-distribution approach, which can effectively be coupled with the multiple scattering processes of cloud and aerosol particles for spectral radiative flux calculations. Subsequently, a number of unsolved and challenging problems in radiative transfer are discussed, leading to the presentation of three-dimensional radiative transfer over inhomogeneous mountains/snow in conjunction with surface energy budget and within the context of absorbing aerosols and mountain/snow albedo feedback in a regional climate system.

Keywords: correlated k-distribution, greenhouse gases, atmospheric composition, atmospheric radiation, emissivity, band model, correlated k-distribution, greenhouse gases

URL (videos & slides): http://hdl.handle.net/1813/29560

D2. On a Derivable Formula for Long-Wave Radiation from Clear Skies: A Theoretical and Practical Contribution

Jennifer Jacobs

University of New Hampshire, Durham, NH

Abstract: This talk will focus on the theoretical and practical contribution of Wilfried Brutsaert's 1975 article On a Derivable Formula for Long-Wave Radiation from Clear Skies. This seminal intellectual advancement will be considered in light of its central importance to past, present and future atmospheric, hydrologic and remote sensing communities. This retrospective recognition also serves to provide insights on recognizing and fostering distinctive scholarship in the present day.

Keywords: Downwelling Longwave radiation, Wilfried Brutsaert, Net Radiation, Evapotranspiration

URL (videos & slides): http://hdl.handle.net/1813/29561

TURBULENCE IN ABL

E1. Mean Velocity Profile in a Sheared and Thermally Stratified Atmospheric Boundary Layer

Gabriel G. Katul[1,2,], Alexandra Konings[1,3], and Amilcare Porporato[2,1]*

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Abstract: Most human activity and biological processes occur within the lower atmosphere, a thermally stratified region characterized by shear and buoyancy-driven turbulence. Thermal stratification arises because of diurnal heating and cooling resulting in finite sensible heat flux at the Earth's surface, while turbulence is mechanically produced due to the reduced mean velocity near the ground. The coexistence of shear- and buoyancy-generated turbulence leads to many difficulties in describing the flow properties in the lower atmosphere. Even for a stationary, horizontally homogeneous, high Reynolds number flow above an infinite flat and heated (or cooled) surface, the description of elementary flow statistics such as the mean velocity profile (MVP) has resisted complete theoretical treatment. There are inklings of a possible universal behavior in the MVP across a wide range of thermal stratification conditions as demonstrated by the collapse of data from multiple field experiments using dimensional analysis, known as Monin-Obukhov similarity theory. The Monin-Obukhov similarity framework has shaped micrometeorology and surface hydrology for more than 60 years now, and it remains the corner stone of virtually every single textbook on lower-atmospheric turbulence. The stability correction functions (SCF) are used in all climate, atmospheric, air quality, hydrologic, and ecological applications, including models of land-surface processes when land-surface fluxes are to be coupled to the state of the atmosphere. Yet, despite the SCF's wide usage, even phenomenological theories that predict their canonical shape are still lacking. A previous link between the spectrum of turbulence and the MVP is expanded here to include the effects of thermal stratification on the turbulent kinetic energy dissipation rate and eddy-size anisotropy. The resulting theory provides a novel explanation for the power-law exponents and coefficients of MVP already reported from numerous field experiments. When taken together with a similar derivation for Manning's equation and the Reynolds number dependence of the Nikuradse friction-factor, a blueprint for a unifying theory that bridges the Kolmogorov turbulent kinetic energy spectrum to widely used empirical results describing high Reynolds number flows in hydrology is beginning to unfold.

Keywords:

URL (videos & slides): http://hdl.handle.net/1813/29562

E2. Working with Wilfried Brutsaert: Some Old and New Results on Radiative Dissipation of Temperature Fluctuations and Scalar Similarity in the Surface Layer

Nelson Luís Dias

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Abstract: There is a style of thinking and approaching a problem to be learned from every good teacher. In this presentation, an attempt is made at giving an objective account of two subjects that I worked on as W. Brutsaert's graduate student (radiation and scalar similarity), but highlighting the personal influence and style that I came to know and that helped to illuminate the way. Longwave radiation interacts with temperature fluctuations, by dissipating them in a process which has similarities to molecular effects, but which has a very different spectral behavior. The pioneering work of Brutsaert on the subject served as a basis to extend the original ideas to the spectral domain and, by doing this, identifying some new governing dimensionless parameters that can help to determine the extent to which radiative effects are important in the stable surface layer. A full comparison of the spectral approach with Brutsaert's early formulation for the radiative dissipation had not been made, however, and some simple spectral shapes are used to show how this can be done. Moving to scalar similarity, the motivations for questioning the validity of Reynolds' analogy between any two scalars are briefly reviewed. A lot of the physical basis to assume scalar similarity rests on the validity of a simple equilibrium between gradient production and molecular dissipation of scalar variance, and on the ratio between their molecular diffusivities being of order 1. As the essence of these results is revisited, they are recast in a way that gives them more generality, away from the original emphasis on temperature-humidity similarity and towards (hopefully) applicability to such important atmospheric components as carbon dioxide and methane. As in the case of radiation, some further results are also commented: the subject continued to attract the attention of other researchers from the Brutsaert School, and such topics as chessboard variability and its prediction of the importance of the active/passive role of scalars; experimental evidence on differences between the Monin-Obukhov Similarity functions for temperature and humidity; and the similarity hypothesis application to the bandpass eddy-covariance method are briefly reviewed. Finally, some on-going research is reported on scalar similarity that allows diagnosing the validity of the aforementioned equilibrium between gradient production and molecular dissipation with dimensionless parameters, and to further the understanding of the effects of molecular diffusivities and the active/passive role of scalars by means of numerical simulations of a chaotic system.

Keywords: Monin-Obukhov similarity theory, scalar similarity, scalar fluxes, long-wave radiation, radiation-turbulence interaction.

URL (videos & slides): http://hdl.handle.net/1813/29563

E3. Large Eddy Simulation Study of Scalar Transport in a Wind Turbine Array Atmospheric Boundary Layer

Charles Meneveau

Johns Hopkins University

Abstract: The structure of the turbulent atmospheric boundary layer is affected by the presence of thermal stratification. Brutsaert's contributions to understanding and parameterizing such effects have had great impact in the field. We describe our efforts trying to parameterize thermal effects on atmospheric boundary layers in the presence of large wind farms using Large Eddy Simulation. As a first step, we examine the structure of passive scalar transport in the wind turbine array boundary layer (WTABL). Initial results from this project (performed in collaboration with Marc Calaf and Marc B. Parlange of EPFL, and funded by the National Science Foundation) will be presented.

Keywords: Wind energy, Wind farms, Large eddy simulation, Atmospheric turbulence

URL (videos & slides): http://hdl.handle.net/1813/29564

E4. Probing the Atmospheric Boundary Layer: A Life-long Adventure Thanks to Wilfried Brutsaert

Marc Parlange, Gabriel Katul, William Eichinger, John Albertson, Jozsef Szilagyi, Tony Cahill, Fernando Porte-Agel, Jan Kleissl, Markus Pahlow, Elie Bou-Zeid, Chad Higgins, Mariana Adam, Vijayant Kumar, Marcelo Chamecki, Nikki Vercauteren, Martin Froidevaux, Marc Calaf, Daniel Nadeau, Valentin Simeonov, Charles Meneveau

Abstract: During the 1986 Hapex-Mobilhy field campaign, deep in the middle of Les Landes pine forest of southwest France, we released more than 500 radiosondes to measure vertical profiles of temperature, humidity and wind speed in the atmospheric boundary layer (ABL). We were not there to sample the after effects of the Chernobyl disaster (or follow the world cup in Mexico), as many of the locals thought at the time, but rather to understand the blending properties of the turbulent atmosphere over variable terrain. Since that time we have continued in search of a better understanding of how the atmosphere responds to complex terrain, development of an improved formulation of evaporation into the atmosphere for hydrologic purposes, the measurement of turbulence and the numerical simulation of the ABL. Some field campaigns and findings will be highlighted including results on Taylor's hypothesis using the EPFL raman lidar at Seedorf, Switzerland. Though instrumentation and computing have improved and the field sites change, the many pleasures of discussing science, life and running with Dr. Brutsaert remains the same today.

Keywords: Hapex-Mobilhy, Les Landes, Southwestern France, Atmospheric Boundary Layer, Regional Scale Surface Roughness Parameterization, Land-atmosphere exchange, Alpine slope flow during evening transition

URL (videos & slides): http://hdl.handle.net/1813/29565

EVAPORATION

F1. An index of maximal land-atmosphere coupling and its use in estimating evaporative fraction across a range of Ameriflux sites

Guido D. Salvucci[1] and Pierre Gentine[2]

[1] Boston University, Boston, MA; [2] Columbia University

Abstract: Examination of heat and moisture fluxes at a wide range of Ameriflux sites reveals what appears to be an emergent property of the relative humidity profile, possibly due to strong coupling of the land-atmosphere system. Specifically, the magnitude of the gradient of relative humidity profile near the surface (i.e. at a nominal source height Zo+d) appears to be minimized over the course of a diurnal cycle, possibly reflecting a tendency toward thermodynamic equilibration between the land surface and boundary layer. The analysis leading to this observation is conducted as follows: Temperature and specific humidity profiles are calculated to be consistent with a simple Penman-Monteith model of evaporation, i.e. they: 1) follow simple law-of-the wall scaling (log((z-d)/Zo) consistent with the observed screen height windspeed, temperature and humidity; 2) reflect excess water vapor resistance due to stomatal and/or soil moisture limitations as expressed with a canopy resistance term; and 3) yield fluxes that are in energy balance with observed net radiation and ground heat flux. With rough estimates of the roughness and displacement heights (herein based on observed vegetation height), the preceding analysis yields a relative humidity profile, at each measurement time (e.g. half hour), for any given value of canopy resistance. At each Ameriflux site (here we focus on the Vaira Ranch, California, and the Duke Forest, North Carolina, as end-members), we calculate a set of 48 half-hourly RH profiles for each of 100 values of canopy resistance. We then calculate the sum of the 48 squared gradients of RH, evaluated at the source (Zo+d), for each canopy resistance. We find that the canopy resistance that yields the smallest mean squared gradient on a given day tends to be a close estimate of the canopy resistance that best reproduces the observed evaporation and sensible heat fluxes (and thus evaporative fraction). The ability to use this apparent intrinsic property of the coupled land-atmosphere system as a means to estimate evaporative fraction is particularly dramatic at the Vaira Ranch site, which undergoes a major seasonal dry down. In the analysis, the screen height temperature and humidity are observed, while the surface temperature and humidity are estimated by varying the canopy resistance. However, we interpret that the resulting minimization of near surface RH differences is more likely a rapid response of the boundary layer temperature and humidity to more slowly varying surface conductance, as opposed to a response of the surface to the atmosphere. In other words, we interpret the «selected» canopy resistance parameter as being the value most likely to have yielded the observed air temperature and humidity. Possible feedbacks that could yield the observed RH behavior are being systematically explored in a simplified coupled diffusion and radiative transfer model, and will be discussed.

Keywords: Evaporation, Land-Atmosphere Interaction, Non parametric estimation of evaporation, Bouchet-Morton Complementary Evaporation, Relative Humidity

URL (videos & slides): http://hdl.handle.net/1813/29566

F2. Evaporation from Lake Kasumigaura: Bulk Coefficients and Spatial Distribution of Latent Heat Flux

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Abstract: Study of lake evaporation includes various aspects of Dr Brutsaert's interests such as the exchange processes on water surface, the development of internal boundary layer, estimation of evaporation rate, among others. In the present study, issues on air-water interaction were first revisited. Secondly, horizontal distribution of latent heat fluxes over the lake surface was estimated to study its variability. For these purposes, 10 Hz water vapor, temperature, and wind velocity data have been obtained at the Koshin Observatory located near the center of Lake Kasumigaura, the second largest lake in Japan (220 km2 with mean depth of 4 m) since June of 2007. The corresponding fluxes were determined by applying the eddy correlation method to estimate the bulk coefficients. Agreement and disagreement with previous studies on the bulk transfer coefficients were identified. Also, the influence of lake current, wave, gustiness was investigated. Based on the derived functional form for the bulk coefficient, horizontal distribution of latent heat flux was estimated by first deriving a 100-m grid map of air temperature, wind speed and humidity over the lake area from interpolation of the observed data at meteorological stations in and around Lake Kasumigaura. The bulk method was then applied to each grid to derive latent heat flux every six hours over a year, by assuming the same surface temperature as that at the Koshin Observatory. This was acceptable as the satellite infrared images indicated the presence of quasi-uniform surface water temperature, presumably to reflect well-mixed water body of the shallow lake. The results indicate larger fluxes at the lake center with smaller values near lake shores, mainly to reflect wind speed differences. In comparison, humidity and air temperature is of lessor importance to cause latent heat variability. The mean evaporation over the entire lake surface was found to be 976 (±56) mm/y, while that at the Koshin observatory was 878 mm/y.

Keywords: Atmosphere-water surface interaction, Lake Kasumigaura, drag coefficients, lake evaporation"

URL (videos & slides): http://hdl.handle.net/1813/29567

F3. Regional Evaporation Using Atmospheric Boundary Layer Profiles (a.k.a Brutsaert's Balloons)

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Abstract: Land surface temperature (LST) from thermal remote sensing is a surface boundary condition that is strongly linked to the partitioning of the available energy between latent (evapotranspiration) and sensible heat flux. Numerous modeling approaches have been developed ranging in level of complexity from semi-empirical to numerically-based soil-vegetation-atmosphere schemes. Many of the approaches require an accurate LST because the heat fluxes are related to the surface-air temperature differences. There is also difficulty estimating appropriate exchange coefficients for heterogeneous landscapes having a mixture of soil and vegetation temperatures influencing the LST observation and associated aerodynamic temperature. For regional applications this also means requiring an accurate air temperature distribution over the area of interest. These requirements have rendered many of the modeling approaches unusable for routine applications over complex land surfaces. However a two-source energy balance (TSEB) modeling scheme using time differencing in LST observations coupled to an atmospheric boundary layer growth model has been developed to adequately address the major impediments to the application of LST in large scale evapotranspiration determination. The modeling system, Atmospheric Land EXchange Inverse (ALEXI), using geostationary LST observations and the disaggregation methodology (DisALEXI) together with data fusion techniques will be described. This modeling system is currently providing regional and continental scale evapotranspiration estimates in the U.S. and plans are to develop a global product.

Keywords: Regional Evaporation, Atmospheric Boundary Layer, Monin-Obukhov Similarity

URL (videos & slides): http://hdl.handle.net/1813/29568

INFILTRATION

G1. Infiltration into Soils

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Abstract: Infiltration is a complex process, which depends upon several factors. Brutsaert and Parlange have made seminal contributions to the understanding and the ability to quantify this process. The main approaches developed to solve the unsaturated flow equation are reviewed, and their impact on subsequent studies and solutions is emphasized.

The unique relationship between infiltration rate and cumulative infiltration in homogeneous media is underlined. This characteristic of the infiltration process provides the basis for the Time Compression Approximation used to estimate time-to-ponding and to express the post-ponding infiltration function. The uniqueness of this relationship is altered in systems where temporal and spatial variability of soil and rainfall properties prevail.

Keywords: Flow equations, Infiltration, Analytical solutions

URL (videos & slides): http://hdl.handle.net/1813/29569

G2. Snippets from Infiltration: Where Approximate Becomes Exact

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Abstract: The Darcy-Buckingham macroscopic approach to soil-water modelling, leading to a nonlinear Richards' diffusion-convection equation, has been very useful for many decades. Some sharp results of the 1970s by W. Brutsaert and J.-Y. Parlange have been an influence on many, including myself. Since the 1980s, several groups have used an integrable one-dimensional version of Richards' equation, with realistic nonlinear transport coefficients, to predict experimentally verifiable quantities. Neat expressions have been derived for time to incipient ponding, for the dependence of sorptivity on pond depth and for the second and higher infiltration coefficients. These exact results are at odds with those of the traditional Green-Ampt model. In the limit of delta-function diffusivity, the water content profile approaches a step function, so the water content is everywhere close to either the boundary value or the initial value. As explained by Barry et al (1995), far from there being a unique "Green-Ampt limit", practical predictions in the limit of a delta function diffusivity depend subtly on the relationship between diffusivity and conductivity at intermediate values of water content. In fact, the traditional Green-Ampt predictions, with a constant potential at the wet front, may be recovered from a linear, rather than step-function behaviour of conductivity vs water content.

A number of practical predictions of the integrable model agree exactly with those of the approximate analytic method originated earlier by Parlange, involving approximations within an integrand after expressing the water conservation equation in integral form. The exactly solvable model refutes the traditional Green-Ampt model and validates the quasi-analytic integral formulation.

Keywords: Unsaturated flow, infiltration coefficients, time to ponding, ponded sorptivity

URL (videos & slides): http://hdl.handle.net/1813/29570

HYSTERESIS AND THERMODYNAMICS

H1. Groenevelt Autobiography

Pieter H. Groenevelt

School of Environmental Sciences, University of Guelph, Canada

Abstract: Pieter H. Groenevelt, using time reallocated due to absence of a speaker, provided a broad view of his life experience and expressed his heartfelt gratitude for the "generosity beyond belief" he received after World War II.

Keywords:

URL (videos & slides): http://hdl.handle.net/1813/29571

H2. Hot Thermodynamics for Frozen Soils

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Abstract: Q. What is the driving force that lifts buildings, pipelines and roads into the air when the soil underneath freezes? A. Ask Clapeyron……A unifying theory is proposed, bringing together the CRRELL School of Duwayne Anderson and the CORNELL School of Bob Miller, leading to the definition of a Heave Index for the sensitivity of soils to exhibit frost heave.

While traveling through the Northern parts of Idaho and Montana with my colleagues, Wilco van Loon (left) and Ed Perfect (right), we were warned about the hazards of freezing soil

Keywords: Freezing soil, Heaving pressure, Heave rate, Segregation Potential, Clapeyron, Heave Index

URL (videos & slides): http://hdl.handle.net/1813/29572

OPEN CHANNELS

I1. Green's Function and Watershed Modelling

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Abstract: Watershed modelling deals with multiple processes occurring in multiple media. The processes include flow and thermal, salinity, sediment, and biogeochemical transport. The multiple media cover stream/river/canal/open channel networks, lakes/reservoirs, land surfaces, and subsurface media. Analytical and numerical models are commonly employed for simulations to understand sciences or to assess environmental consequences. Why analytical models offer the advantage of clearly and easily explaining the physics involved, the numerical models give practical applications of assessing the impact and interaction among processes and media. This presentation will discuss the issues and difficulties associated with the employment of Green functions to yield analytical models and troubles associated with the use of numeric to generate computational models. Various means of overcoming these difficulties and troubles will be outlined and addressed.

Keywords: Green's Function, Channel Flow, Overland Flow, Subsurface Flow, Hydrologic Cycle, Biogeochemical Cycles, Watershed Modeling, WASH123D, AT123D

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I2. On the Brutsaert Baseflow Recessions and Their Geomorphic Origins

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Abstract: Moving from a classic study on the base flow characteristics of six basins in the Finger Lakes region [1], a set of Brutsaert recession curves (the lower envelope of available records of |dQ/dt| as a function of Q, where Q is at-a-station gauged flow rate) has been constructed from Swiss streamflow data relatively unaffected by snowmelt. The Lecture builds on the functional dependences found in [1] (chiefly through Boussinesq' nonlinear solution of free-surface groundwater flow, yielding a specific relation to local drainage area and total stream length) and on the expedient avoidance of proper time references, to apply and generalize recent results aimed at the geomorphic origins of recession curves [2], that is, fully integrating sizable geometric and topologic complexity. In particular, such results propose a link between river network morphology and the parametrization in [1], in particular by assimilating the basic scaling exponent a (i.e. |dQ/dt|μQa) to that characterizing the empirical relation N(x) μ G(x)a (where x is the downstream distance from the channel heads, N(x) is the number of channel reaches exactly located at distance x from their heads, and G(x) is the total drainage network length at a distance greater or equal to x down to the gauging station where Q is recorded [2]). Application of the method, originally tested on DTMs and daily discharge observations in 67 US basins, suggests a definite linkage of active drainage and source functions with the basic features of the Brutsaert envelopes.

The possible morphological predictability of base flow features is central to transport processes at catchment scales, not least for its implications on our understanding of the geomorphic structure of the hydrologic response [3] and of the stationarity of the ensuing travel time distributions leading to the so-called old water paradox [4]. These issues are briefly discussed in the Lecture. Here, through a broad survey of Swiss field data, we go on suggest that the method [2] provides excellent results only in catchments where drainage density (roughly defined as the ratio of total channel network length to its drainage area [L-1], defined at a station) can be regarded as spatially constant. When uneven drainage densities are observed, chiefly in our test cases for high mountainous areas where drainage density varies significantly owing to complex cryosphere dynamics and geologic or pedologic constraints, the method's assumptions do not hold. In the Lecture a detailed reexamination of the premises of the approaches [1,2] is proposed. A revision is then proposed, which includes geomorphic corrections based on a proper description of the drainage density seen as a random space function [5]. Such corrections properly vanish should drainage density become spatially constant. Overall, it is recognized a definite geomorphic origin for Brutsaert recessions, with notable implications.

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URL (videos & slides): http://hdl.handle.net/1813/29574

Appreciations

Tributes to Eileen Parlange and Toyoto Brutsaert

Mary Parlange

URL (videos): http://hdl.handle.net/1813/29575

Reflections by Colleagues

Part 1: *Norman R. Scott, Dave Elrich, Willem Brutsaert, Kaoru Takara, Frank Stagnitti*

Part 2: *John L. Nieber, William P. Kustas, Remko Uijlenhoet, Larry P. Walker, Stephen J. Burgess, Gilbert Levine, Jery Stedinger, Peter Troch*

URL (videos): http://ecommons.library.cornell.edu/handle/1813/29576