



Brutsaert Parlange Symposium

Cornell University, Ithaca, NY USA May 14-15, 2012



About this book

“Hydrologic Discovery Through Physical Analysis Honoring Wilfried H. Brutsaert and Jean-Yves Parlange”

This is a photo album of candid images associated with this Symposium.

Photographs were provided by Brian Richards, Cathelijine Stoof, Jeanette Little, Remko Uijlenhoet, J. Robert Cooke, Peter Carroll and others.

Book was produced by J. Robert Cooke.

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1. Ithaca Environs

Surrounded by numerous State Parks (Taughannock Park depicted), the Cornell University main campus is located in the Finger Lakes Region of New York State.





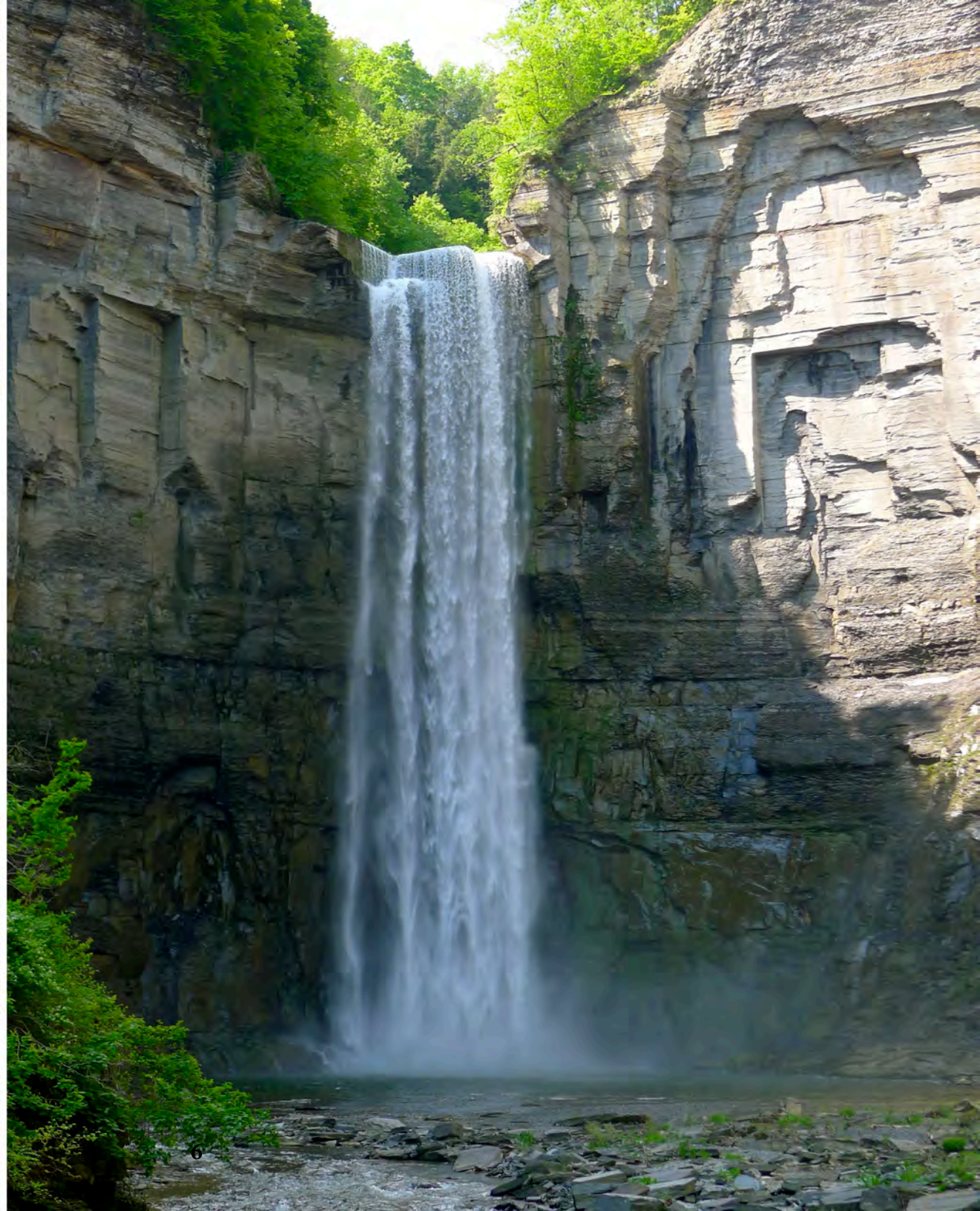
Cornell and surrounding area

On previous pages see Baker Lab (home of Chemistry and Chemical Biology), the new Physical Sciences Building where the Symposium was held, “Libe Slope”, and the iconic McGraw Bell Tower located adjacent to Olin Library.

The following photos show the Taughannock Falls State Park with its 400-foot cliffs and gorge eroded by a stream that plunges 215 feet in a single drop – one of the highest east of the Rockies.









Introduction to the Symposium

First Session











Erosion

May 14, 2012





Ilja van Meerveld

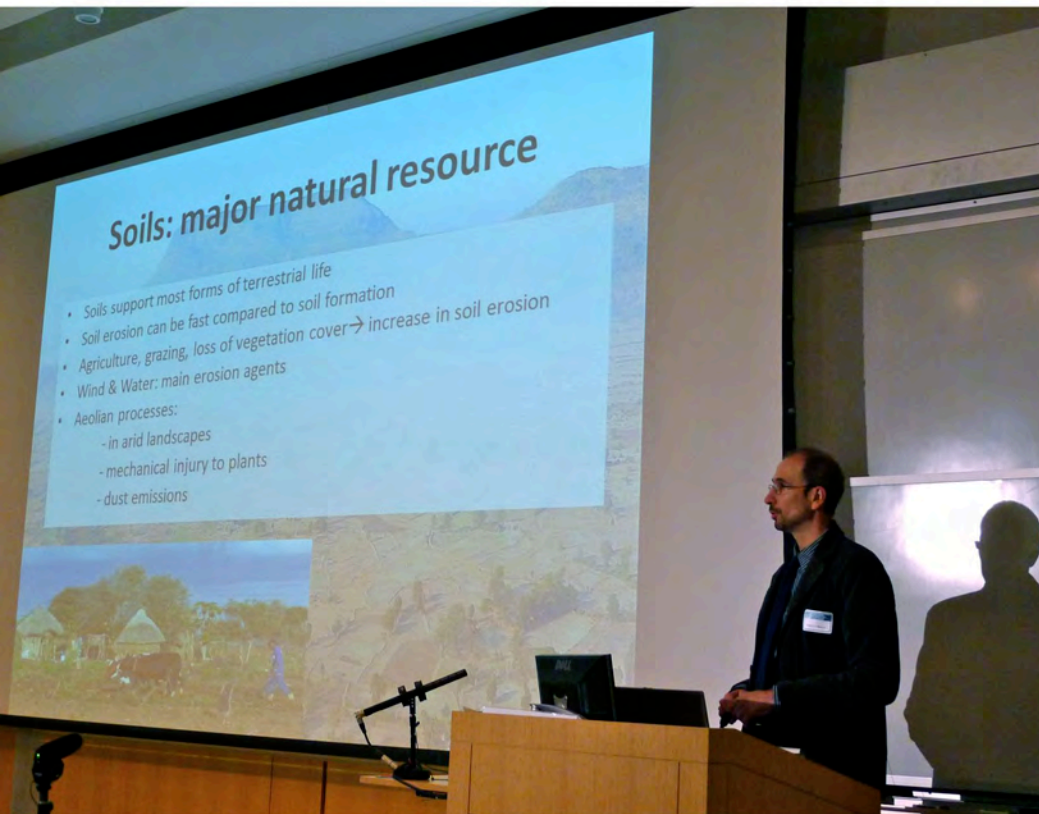




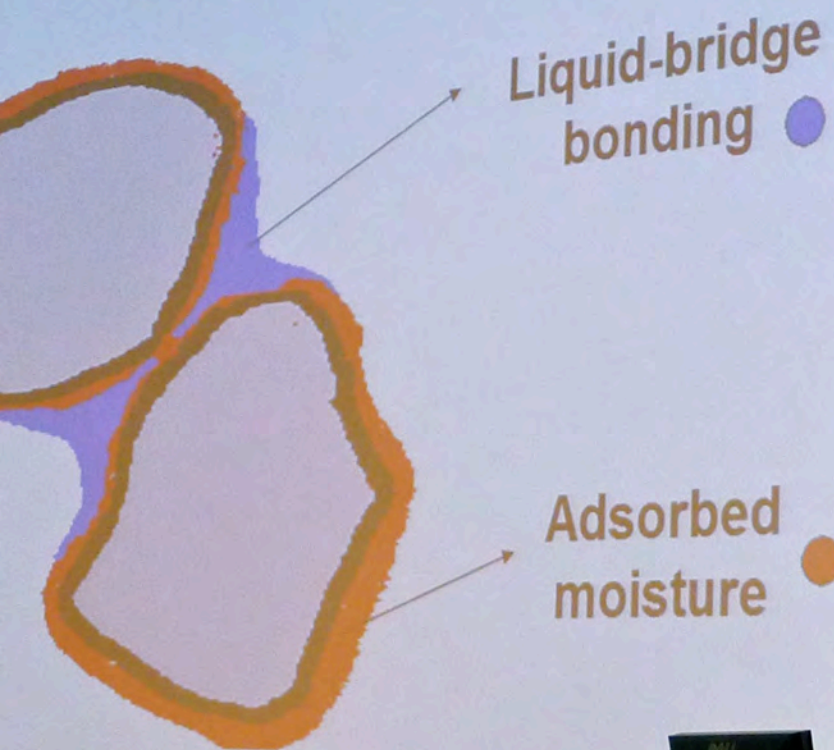


Matt Romkens





Particle forces due to moisture



Adsorbed
moisture

Liquid-bridge
bonding

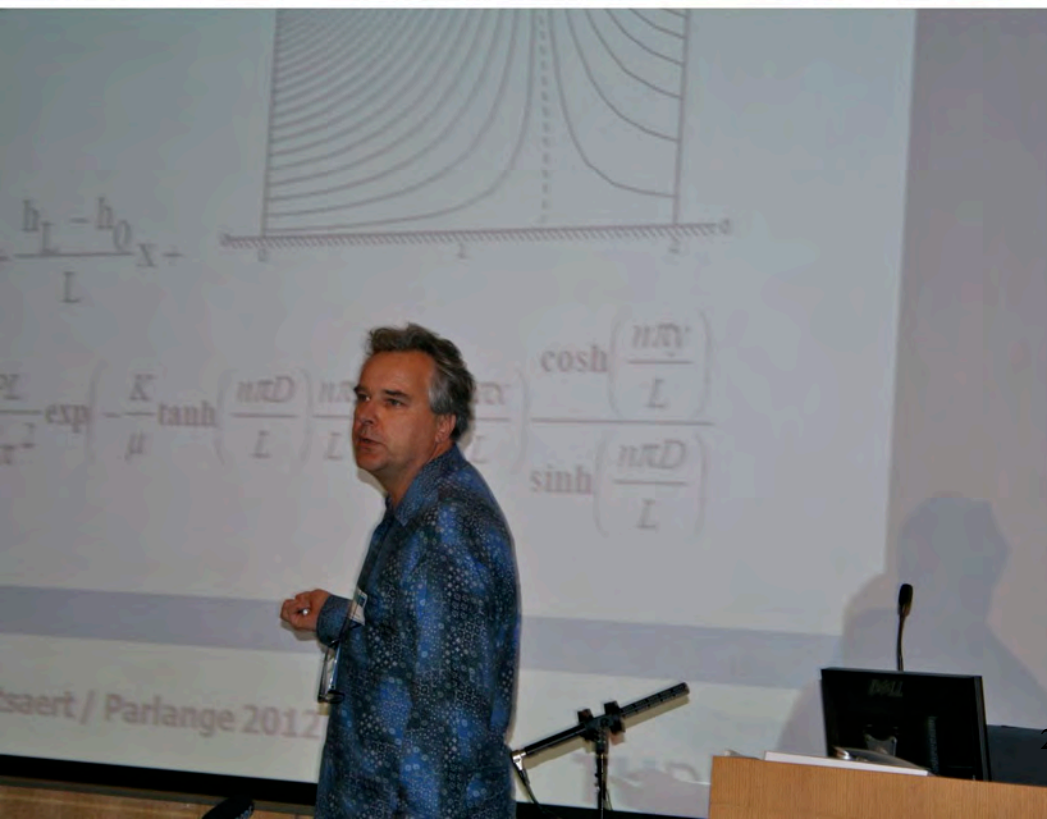




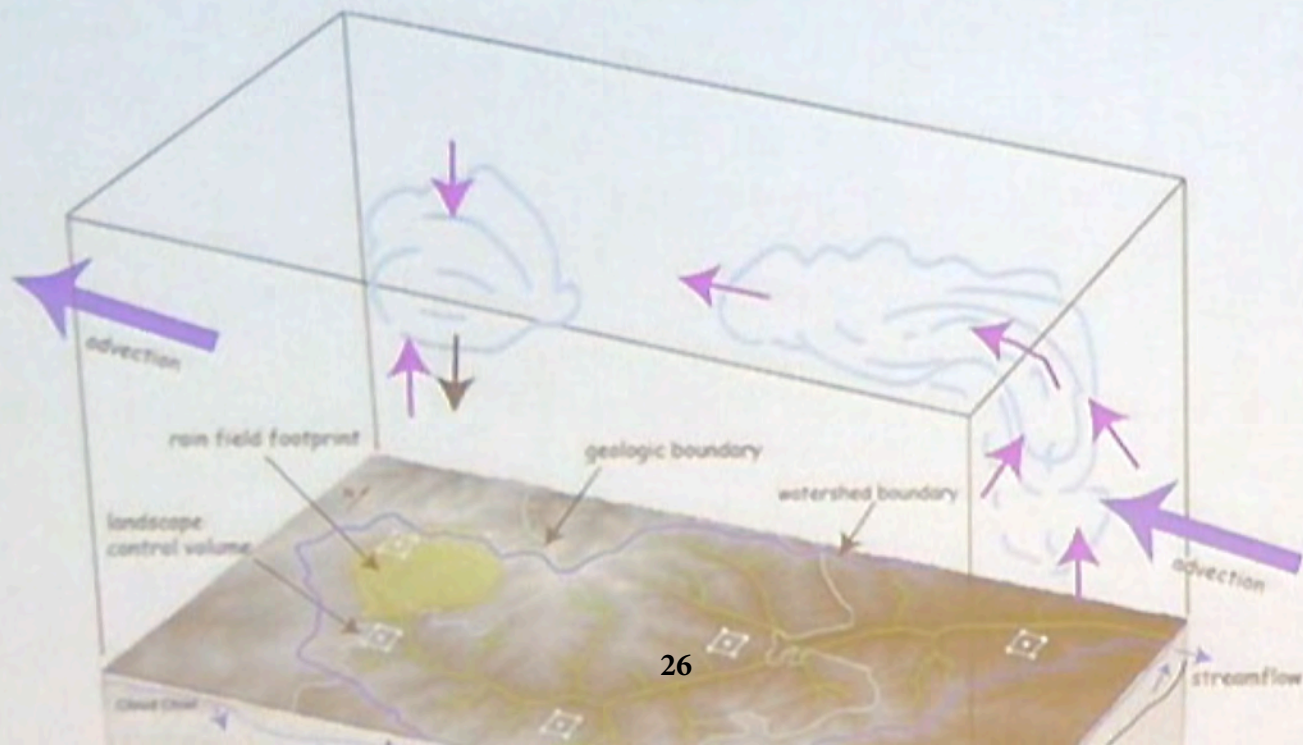
B. Boussinesq and Runoff Relationships

May 14, 2012



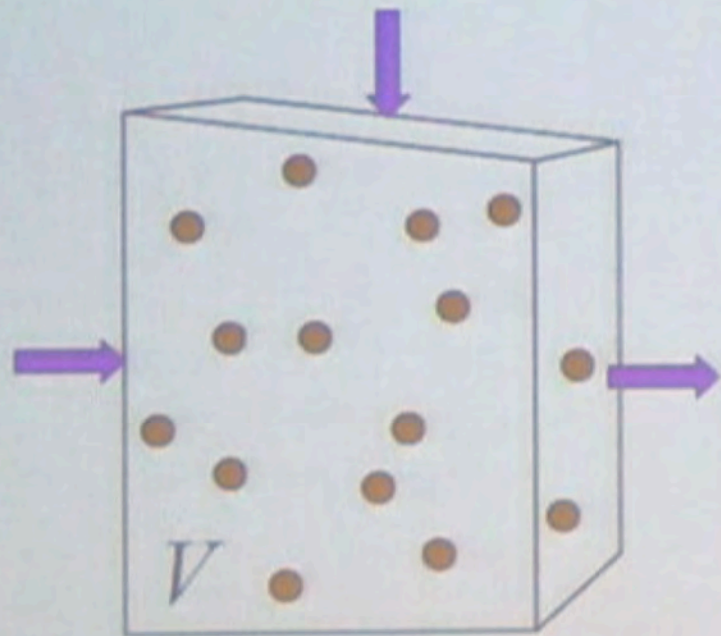


Christopher J. Duffy



A Transport Model for Age Distribution

enberg 1972, J, of Theoretical Biology, 37, 291-305



$$\frac{\partial c}{\partial t} + \frac{\partial c}{\partial \tau} = \Gamma_c - L(c)$$

$$L(c) \rightarrow D \frac{\partial^2 c}{\partial x^2} - u \frac{\partial c}{\partial x}$$

or

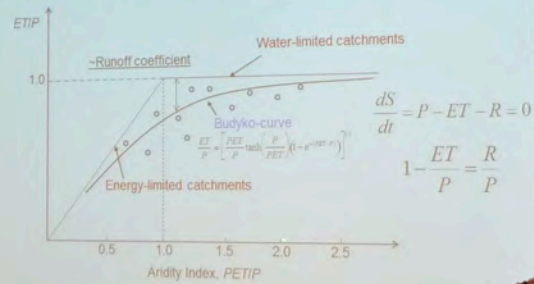
$$L(c) \Rightarrow \frac{Q_i}{V} (c_i - c)$$

$$DM(t, \tau) \frac{1}{V} = \left(\frac{\partial M}{\partial t} + \frac{\partial M}{\partial \tau} \right) \frac{1}{V}$$



Long-term hydrologic partitioning in river basins

Budyko (1974) developed an empirically based hydroclimatological relationship that describes the average river basin water balance in terms of the amount of rainfall that evaporates as a non-linear function of the aridity index:



Summary and conclusion

- Catchments compensate climate properties
 - When climate, on average, generates more/less ET/P the local catchment produces, on average less/more ET/P
 - Climate effects and filter effects are anti-correlated
- The tendency of a catchment to produce more ET/P is related to perched aquifer storage release time scale
 - This time scale groups geomorphologic, soil and climate properties of catchment hillslopes
- A catchment that developed in a climate that, on average, produces less/more ET/P (independent of filter) has vegetation properties that are more/less efficient
- Are we seeing evidence of co-evolution between climate-soil-vegetation properties at the catchment scale?





C. Instability and Fluid Mechanics

May 14, 2012



History

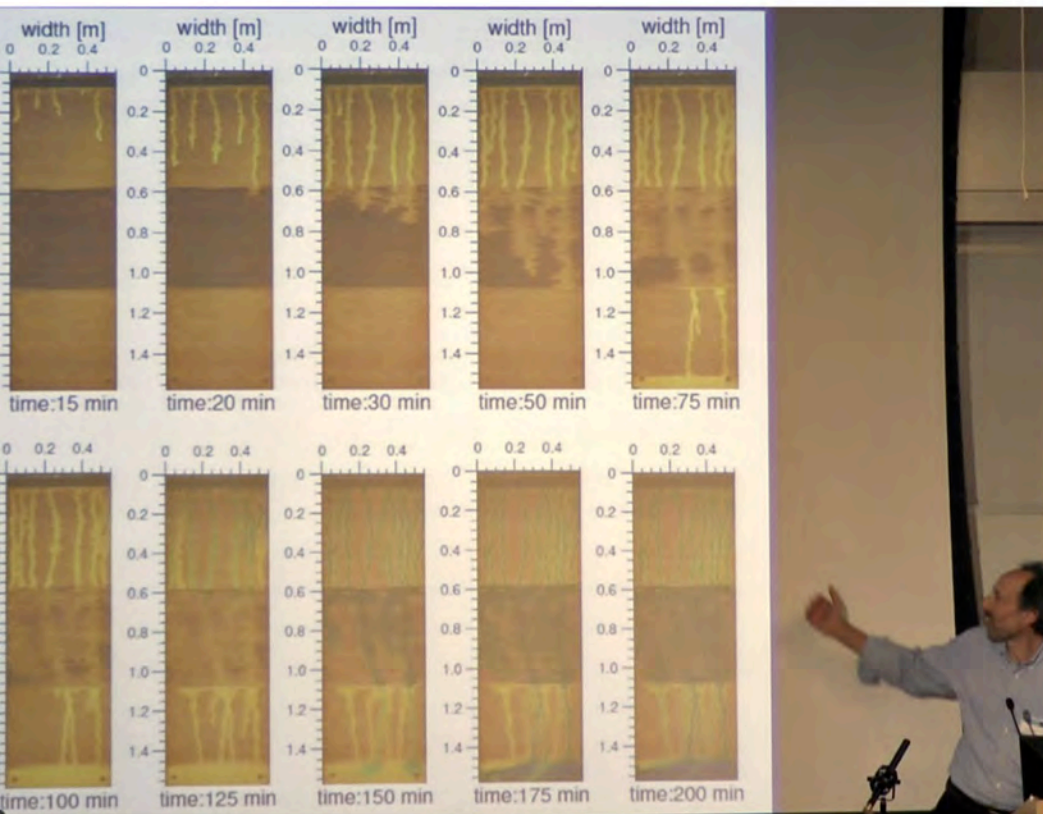
1972 – Hill and Parlange publish the first paper focused on fingered flow

1973 Raats publishes his concept

1975 Philip publishes his concept

1976 Parlange and Hill publish their concept

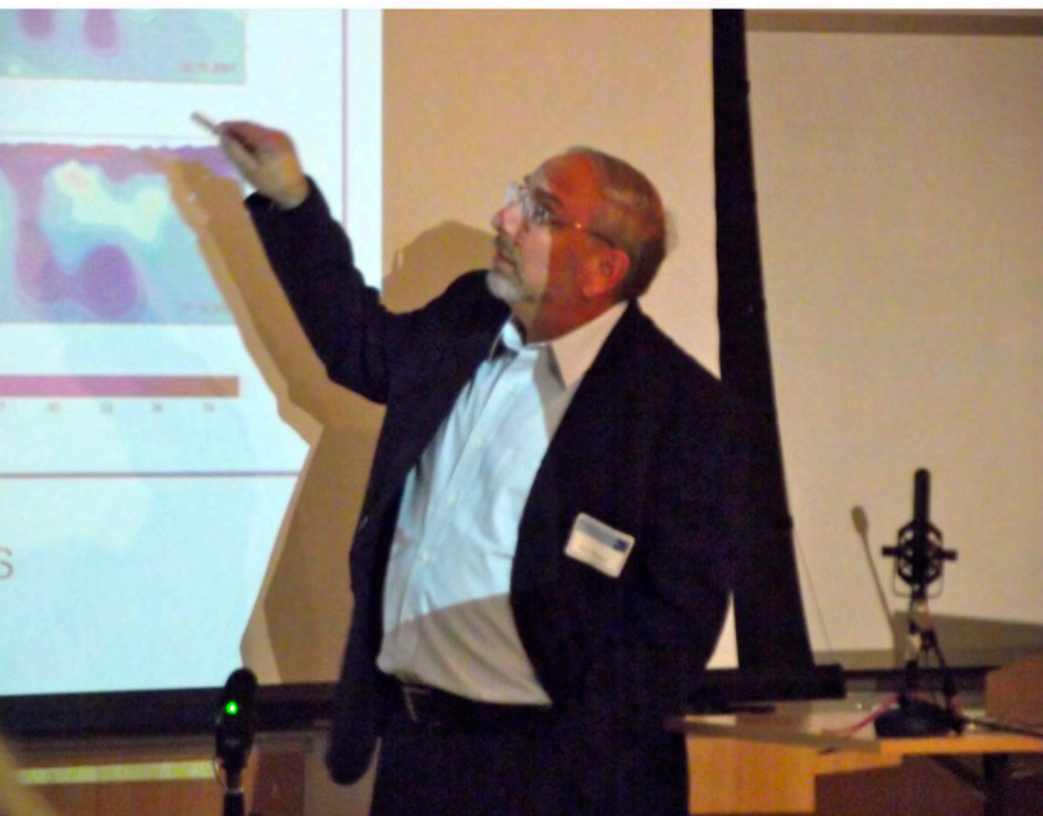
Since then – almost every major soil physicist is required to do so (seriously!)





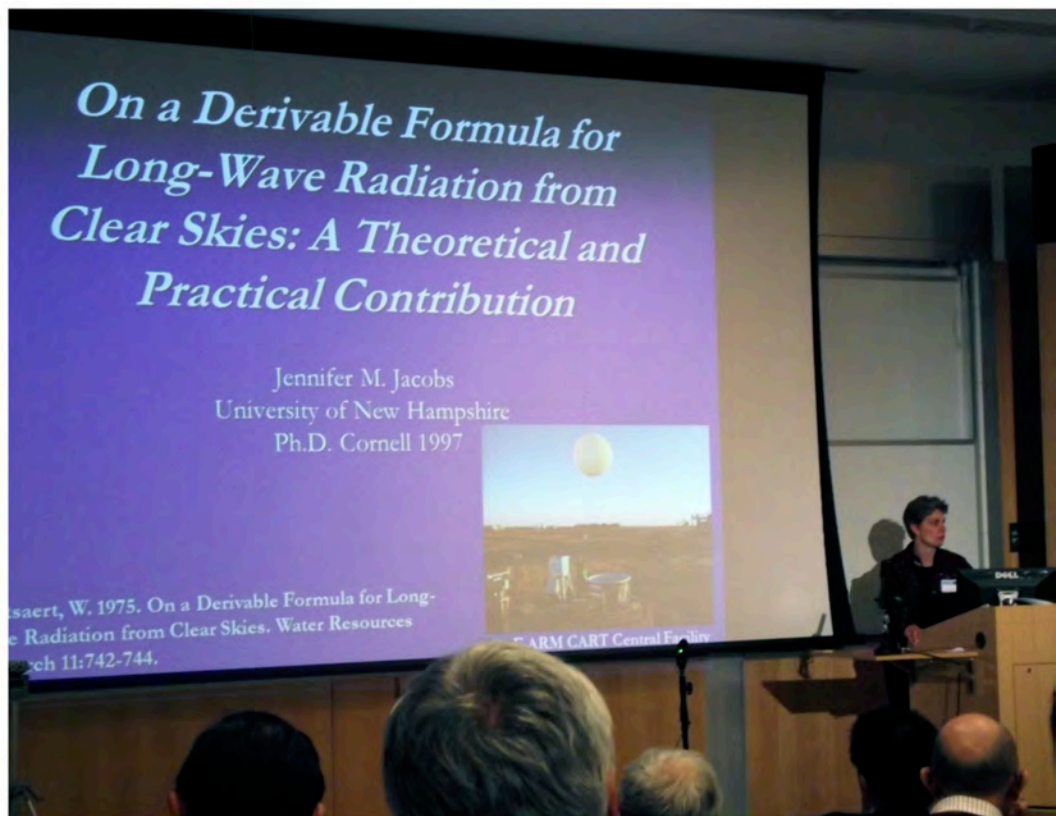


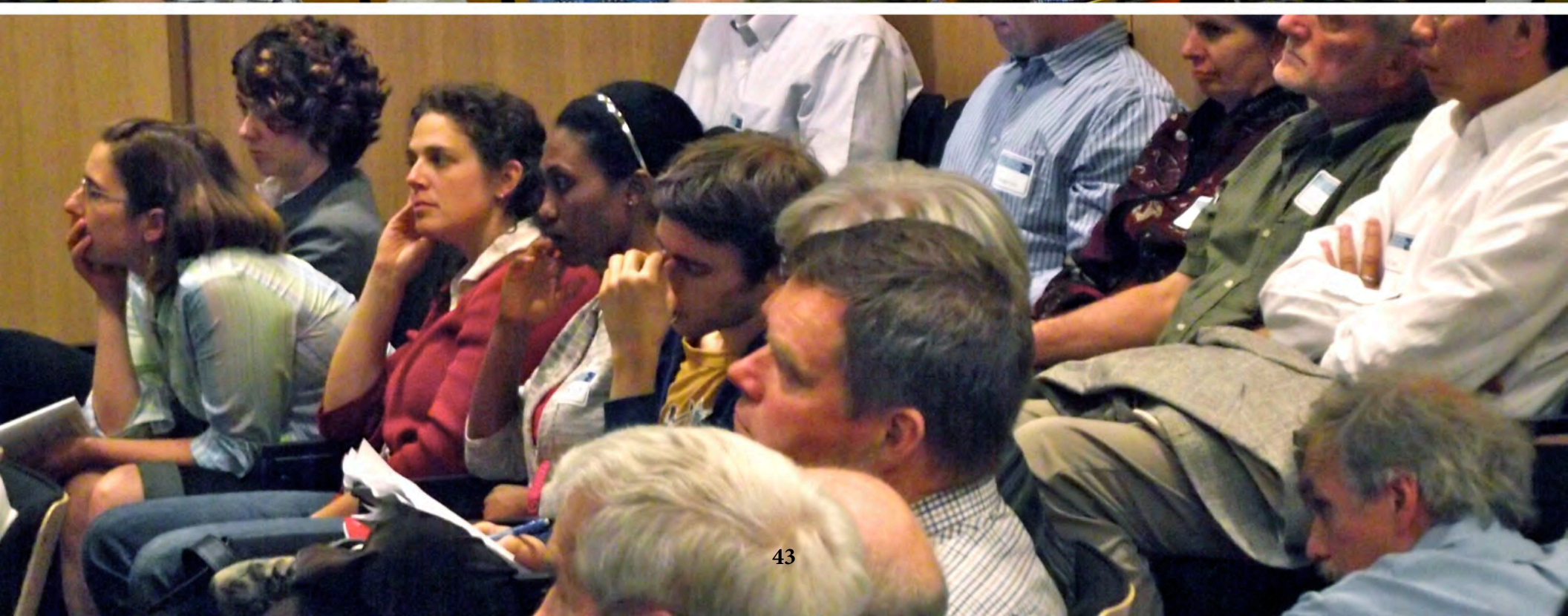










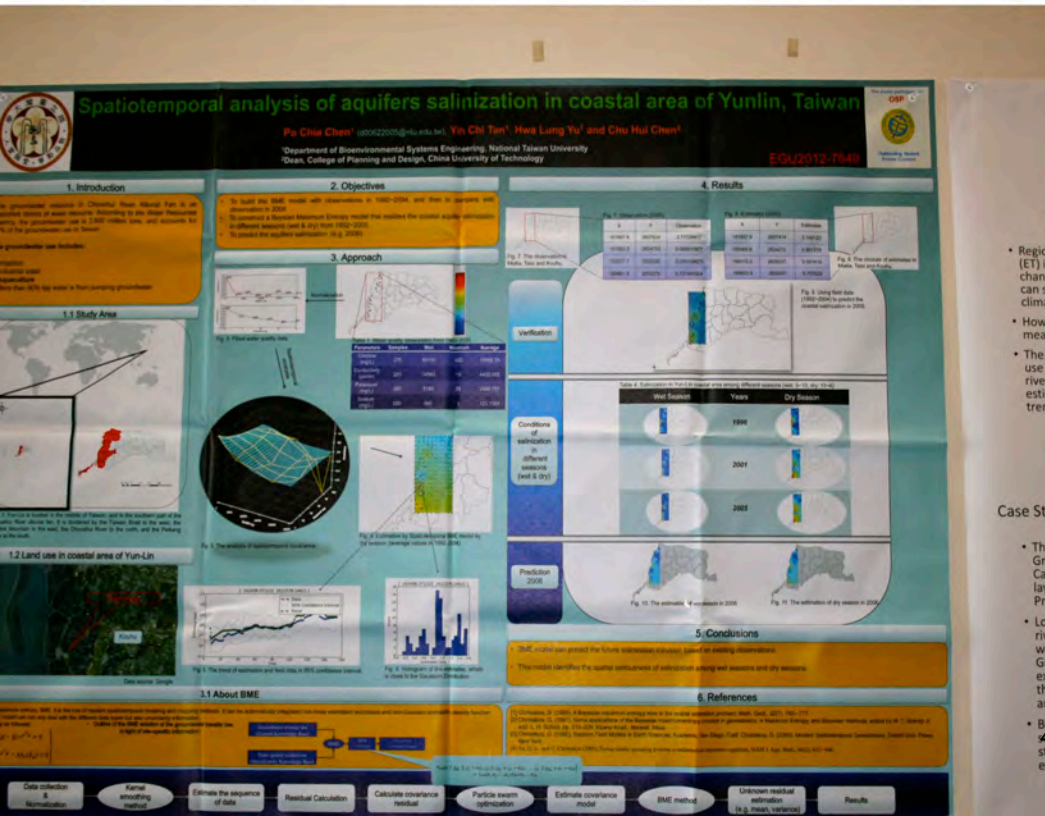
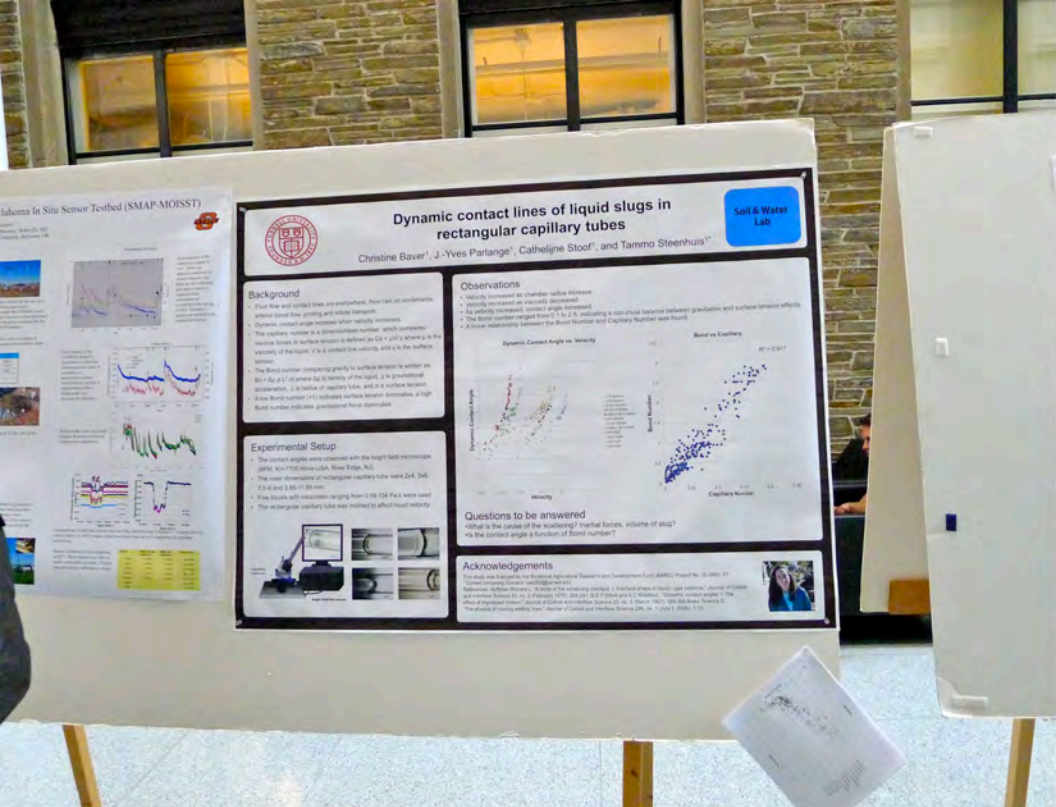




Posters

Baker Portico





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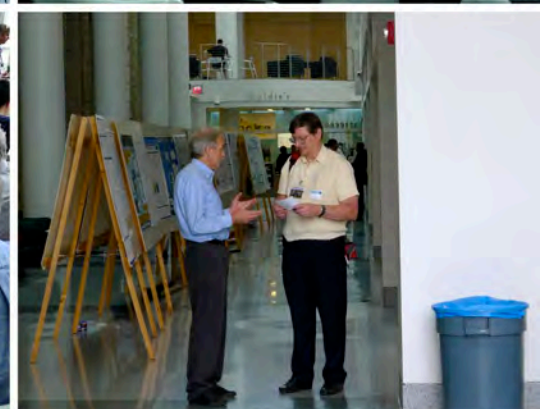


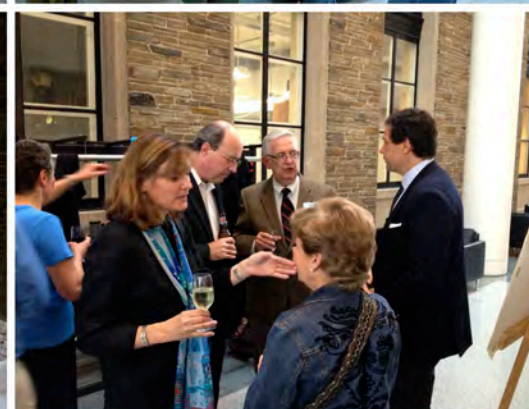
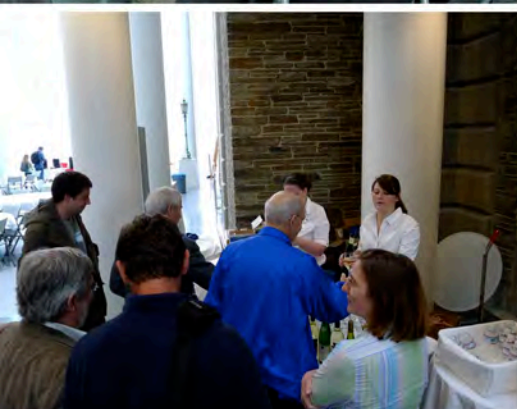
Conversations

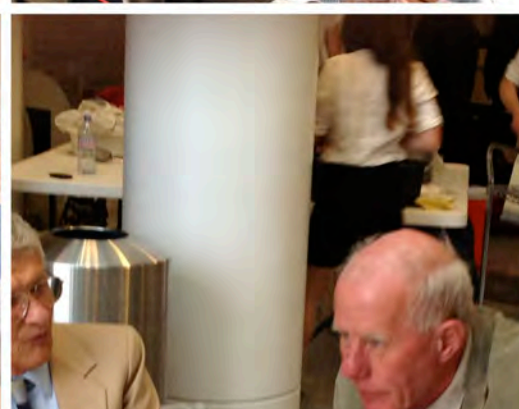
& Food

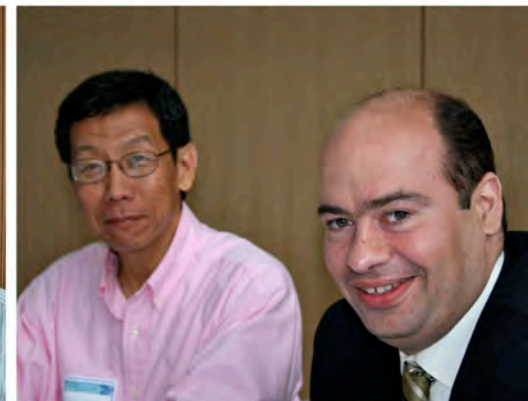








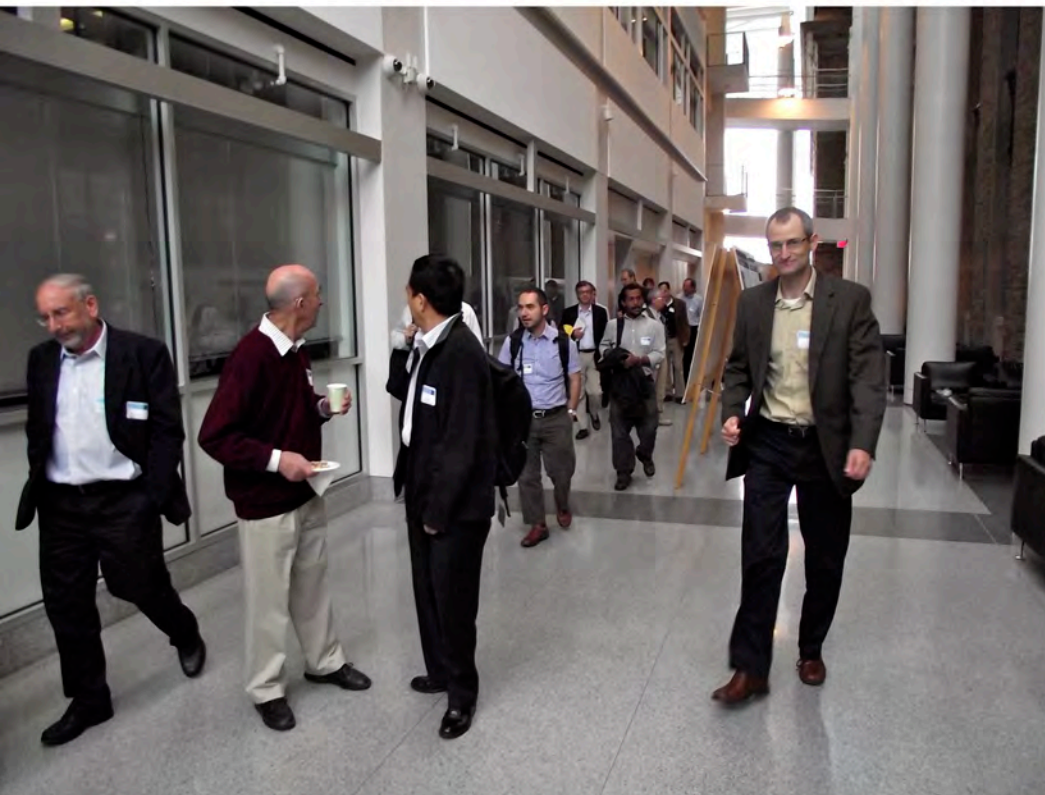










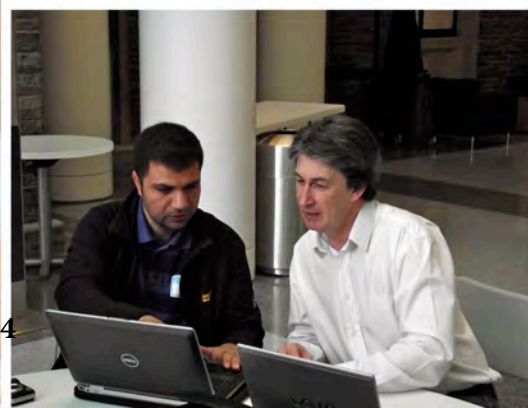
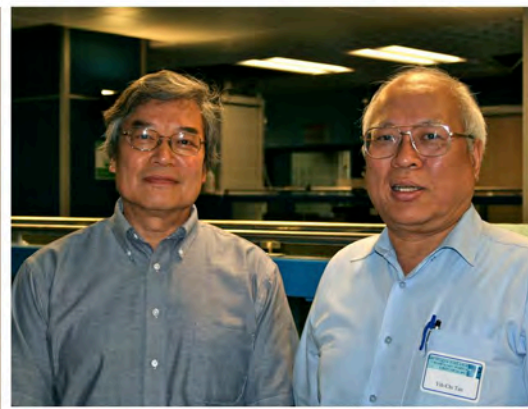








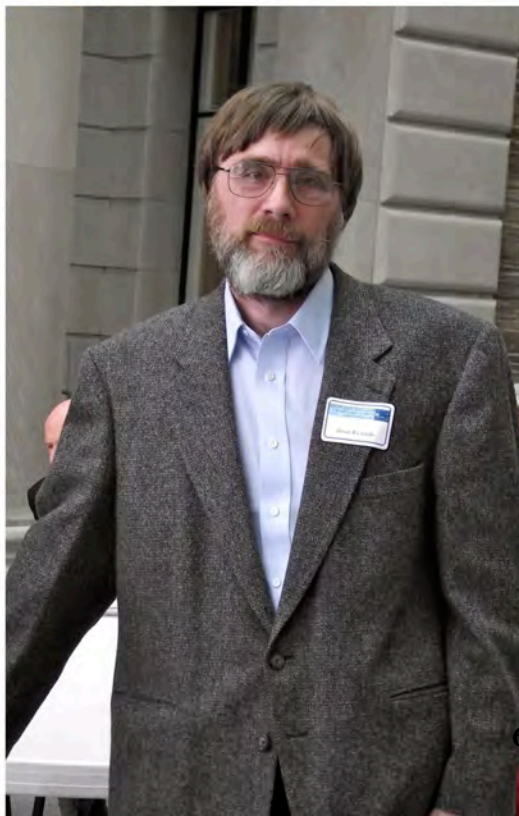














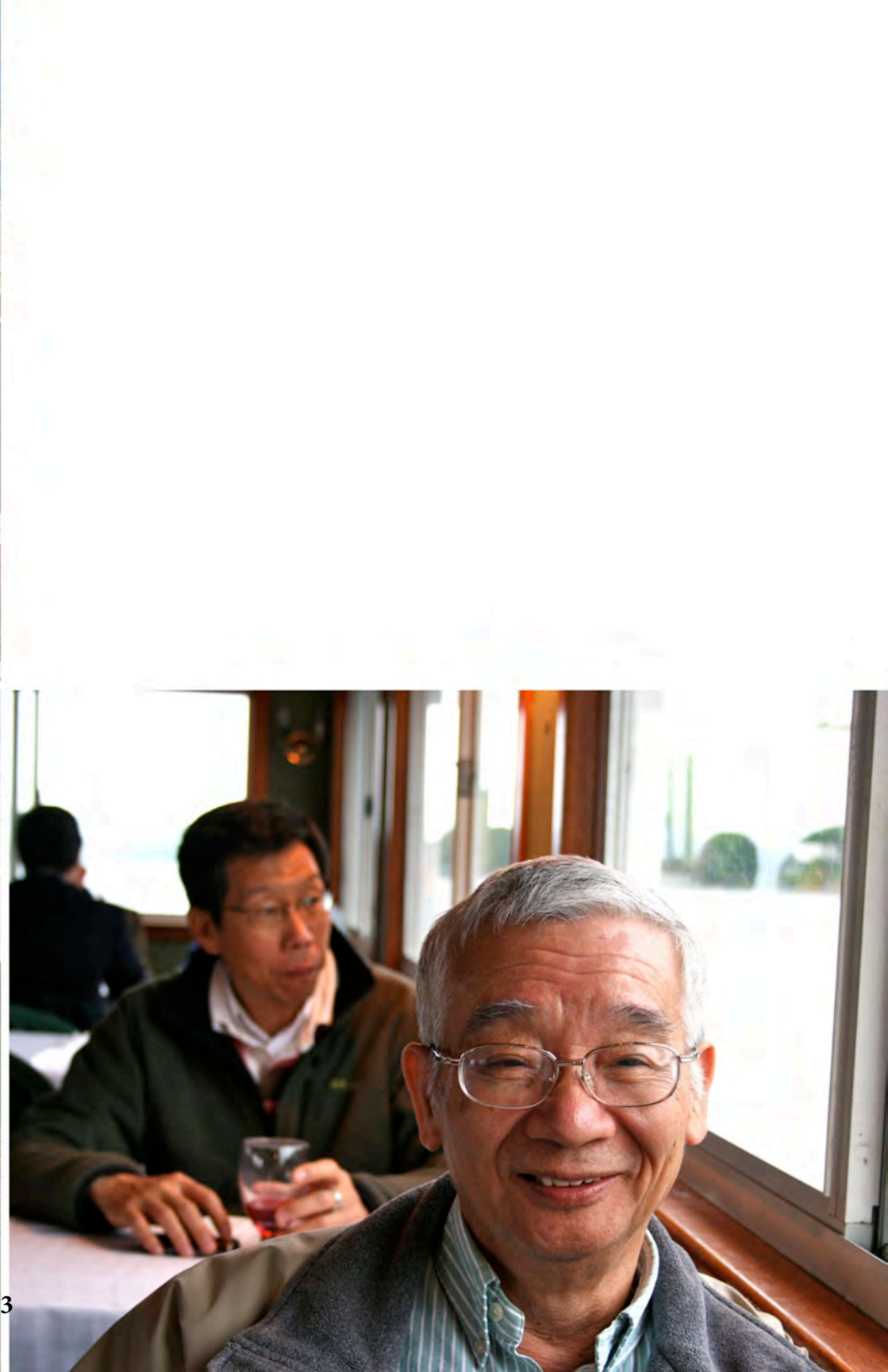


Dinner Cruise

May 14, 2012



M/V COLUMBIA
FOR RESERVATIONS
607.256.0898 or CayugaLakeCruises.com





Turbulence in ABL

May 15, 2012



The mean velocity profile in a sheared and thermally stratified turbulent atmospheric boundary layer



Gabriel Katul^{1,2}, Amilcare Porporato^{1,2},
and Alexandra Konings^{1,3}

¹Nicholas School of the Environment and

²Civil and Environmental Engineering Department, Duke University



Main Result

THE USE OF DIMENSIONAL EQUATIONS.
BY E. BUCKINGHAM.
Phys. Rev. 4, 345–376 (1914)

- Proposed using dimensional analysis by Monin and Obukhov¹, a 'stability correction function' accounts for distortions to the logarithmic mean velocity profile (MVP) due to surface heating (or cooling).
- The universal shape is confirmed by many field experiments (e.g. the Kansas experiment²) and Large Eddy Simulations³.
- Theories that predict this universal shape are currently lacking.

Conclusions:

- First phenomenological approach linking Kolmogorov's theory for locally homogeneous and isotropic turbulence with the MVP to explain all the power-law exponents of the stability correction function for momentum¹.
- The factor '9 to 16' in Businger-Dyer, while not predicted, was shown to be primarily linked to anisotropy in 'eddy sizes' due to thermal stratification¹.



Approaches

"bulk" budgets (Townsend, 1958; Brutsaert, 1972); γ from slab emissivities.

$$0 = -\overline{w'u'} \frac{\partial \bar{u}}{\partial z} - \frac{1}{2} \frac{\partial \overline{w'u'_i u'_i}}{\partial z} + \frac{g}{\theta} \overline{w'\theta'} - \frac{1}{\rho} \frac{\partial \overline{w'p'}}{\partial z} - \epsilon_e,$$

$$0 = -2\overline{w'\theta'} \frac{\partial \bar{\theta}}{\partial z} - \frac{\partial \overline{w'\theta'\theta'}}{\partial z} - 2(\epsilon_{\theta\theta} + \epsilon_{R\theta}),$$

$$\epsilon_{R\theta} = \gamma \overline{\theta'\theta'}.$$

"spectral budgets" Spiegel (1957); Goody (1964); Schertzer and Simonin (1981); Coantic and Simonin (1984); Dias and Brutsaert (1998); $N(k)$ from band models.

$$2 \frac{\partial \bar{u}}{\partial z} E_{wu} + T_e - 2 \frac{g}{\theta} E_{w\theta} + 2\nu k^2 E_e = 0,$$

$$2 \frac{\partial \bar{\theta}}{\partial z} E_{w\theta} + T_{\theta\theta} + 2\nu_\theta k^2 E_{\theta\theta} + 2N(k)E_{\theta\theta} = 0.$$

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emma
UFPR

Working with Wilfried Brutsaert: some old and new results on radiative dissipation of temperature fluctuations and scalar similarity in the Surface Layer

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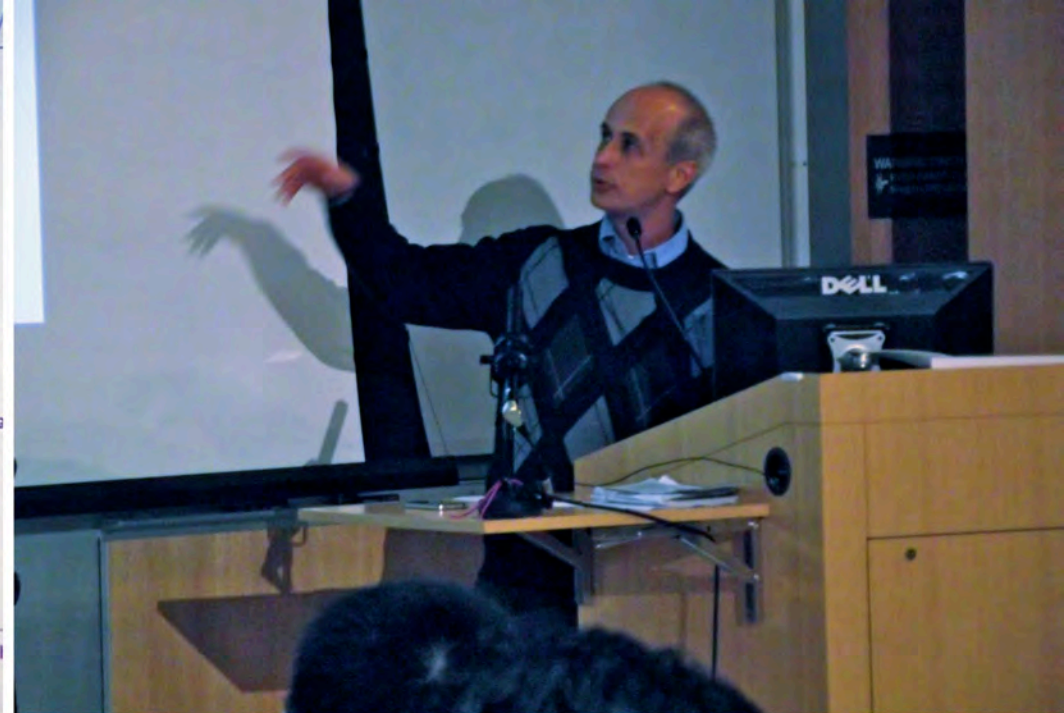
Hydrologic Discovery Through Physical Analysis — Honoring the Scientific Legacies of Wilfried H. Brutsaert and Jean-Yves Parlange
Ithaca NY, May 14–15 2012



Laboratory for Environmental Monitoring and Modeling Anal
Department of Environmental Engineering
Federal University of Paraná, Brazil



Nelson Luis Dias



Similarity of scalars: a modern definition, implications, results

00:31:50 - 19

Dias & Brutsaert 1996

BROST is not directly invoked, but stationarity, horizontal homogeneity of neglect of 3rd-order moments and explained Brost (1979)'s results.

$$x = \phi_A = \phi_{\epsilon aa},$$

$$y = \phi_B = \phi_{\epsilon bb},$$

$$x + y = \phi_A + \phi_B = 2\phi_{\epsilon ab} = z,$$

$$\frac{z^2}{xy} = \frac{\phi_{\epsilon ab}^2}{\phi_{\epsilon aa}\phi_{\epsilon bb}} = \frac{\nu_a^2 + 2\nu_a\nu_b + \nu_b^2}{4\nu_a\nu_b} r_{\nabla_a \nabla_b}^2; \quad \text{new: } Le \equiv \nu_a/\nu_b \Rightarrow$$

$$= \frac{1}{4} \left(Le + 2 + \frac{1}{Le} \right) r_{\nabla_a \nabla_b}^2 \approx r_{\nabla_a \nabla_b}^2 \quad \text{if } Le \sim 1.$$

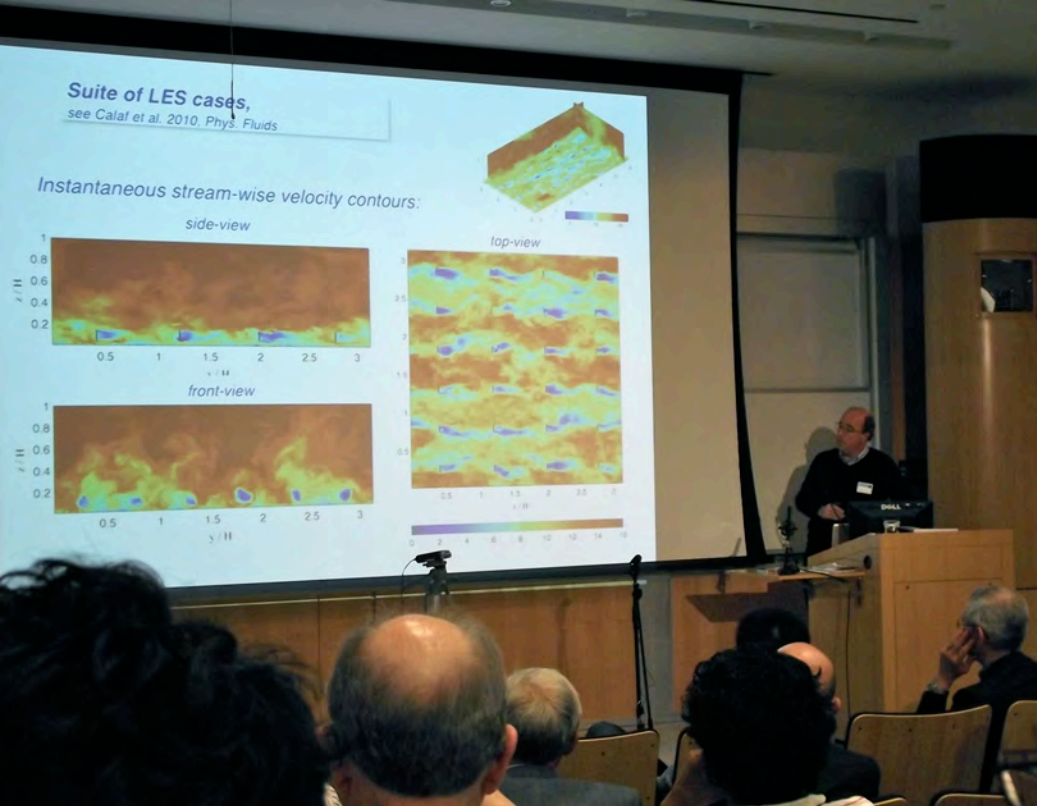
and (**) have solution

$$\frac{x}{z} = 1, \quad \frac{y}{z} = 1, \quad r_{\nabla_a \nabla_b}^2 = 1 \Rightarrow r_{ab}^2 = 1.$$

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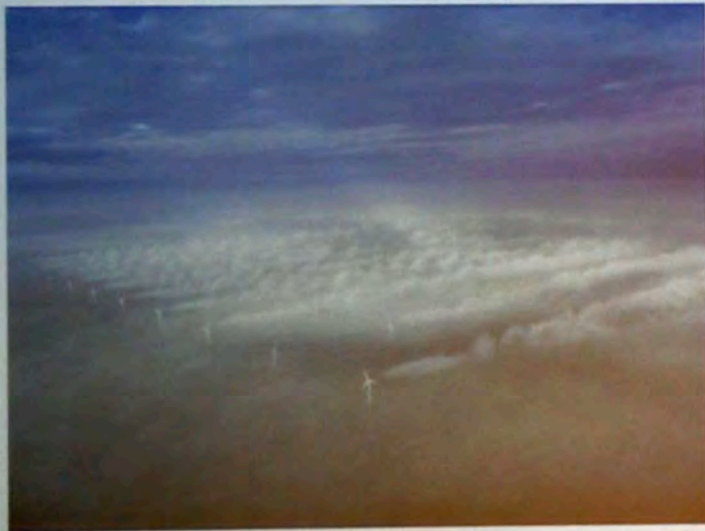
Charles Meneveau



Large Eddy Simulation Study of scalar transport in a wind turbine array atmospheric boundary layer)

Marc Calaf (EPFL), Charles Meneveau (JHU),
Marc B. Parlange (EPFL) (also J. Meyers, KU Leuven)

the windturbine-array boundary layer (WTABL)

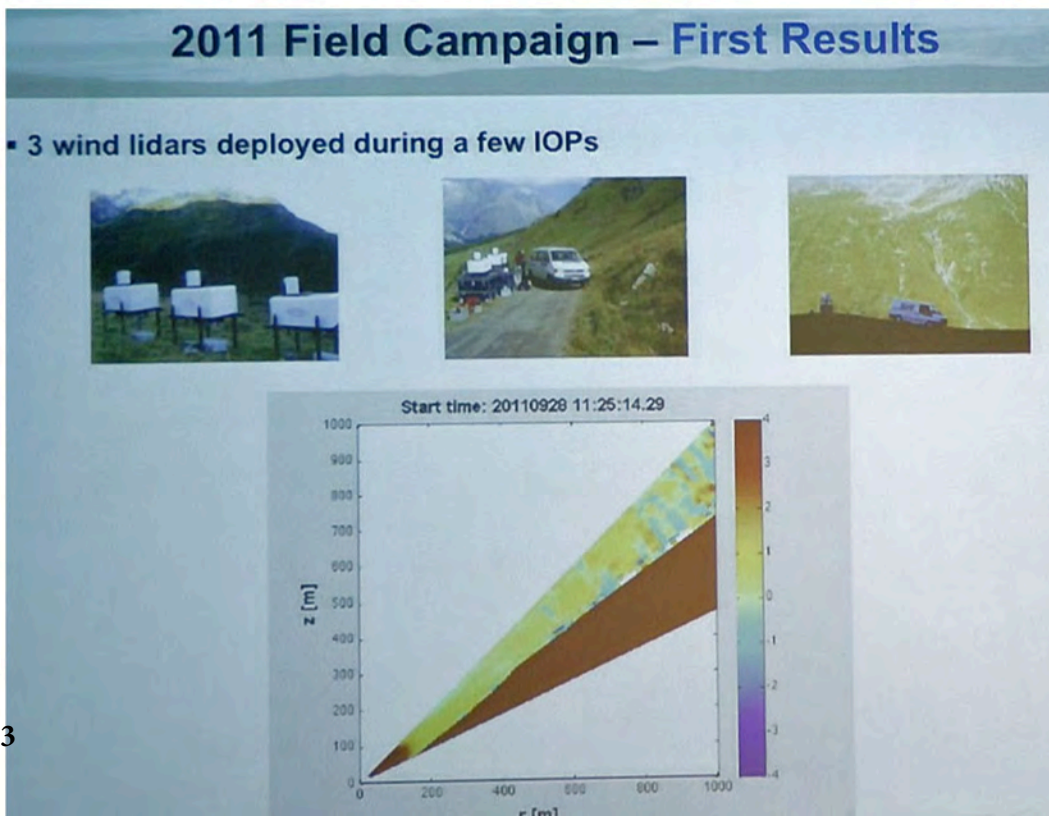
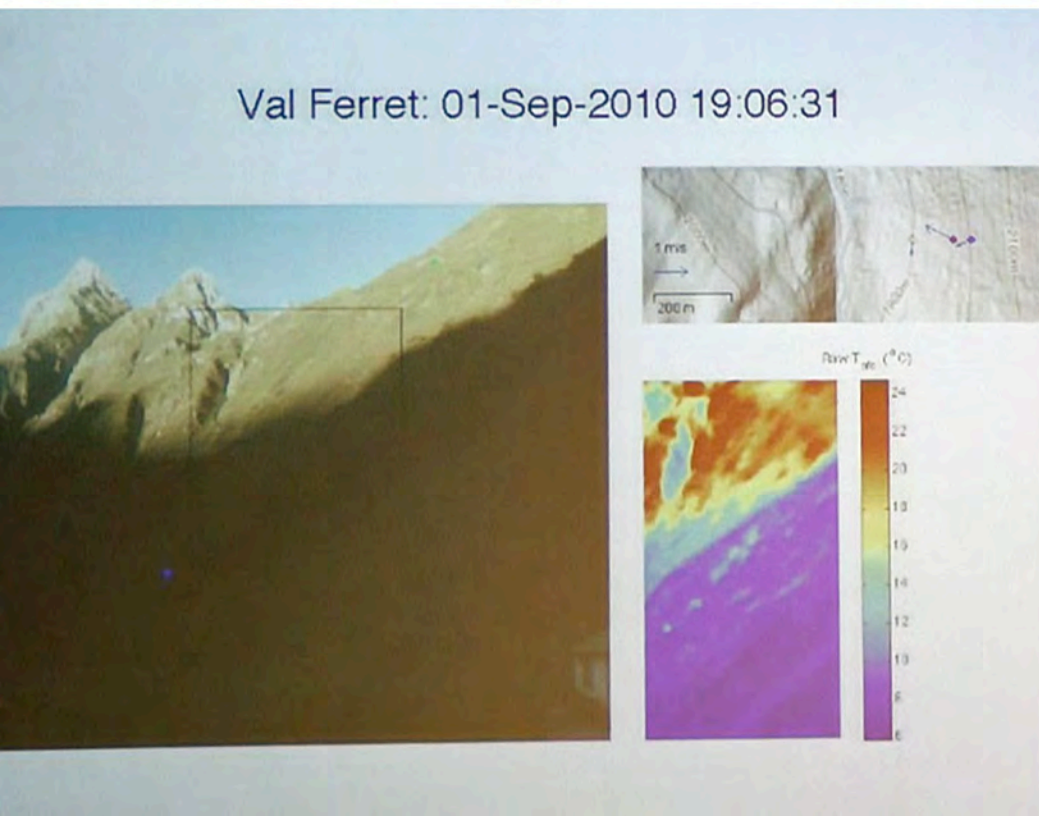
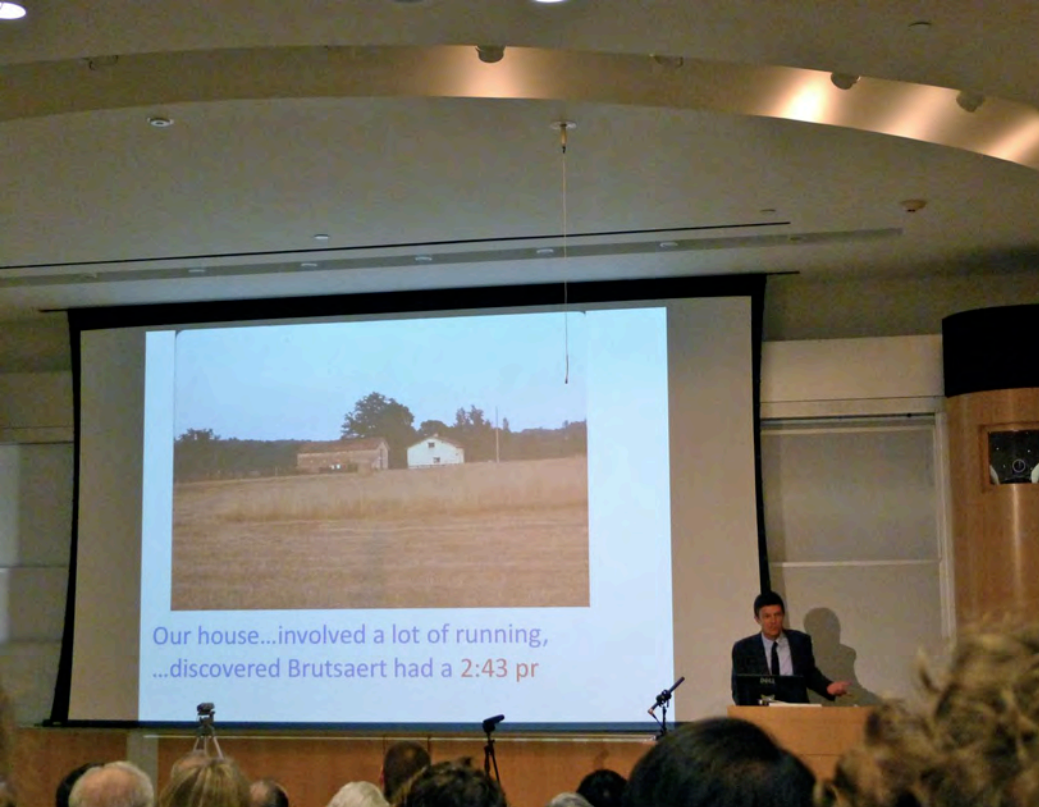


Horns Rev 1 owned by Vattenfall,
Photographer: Christian Skemss

ays are getting bigger: when $L > 10-20 H$ (H : height of ABL)
approach "fully developed" FD-WTABL







Evaporation and Infiltration

May 15, 2012







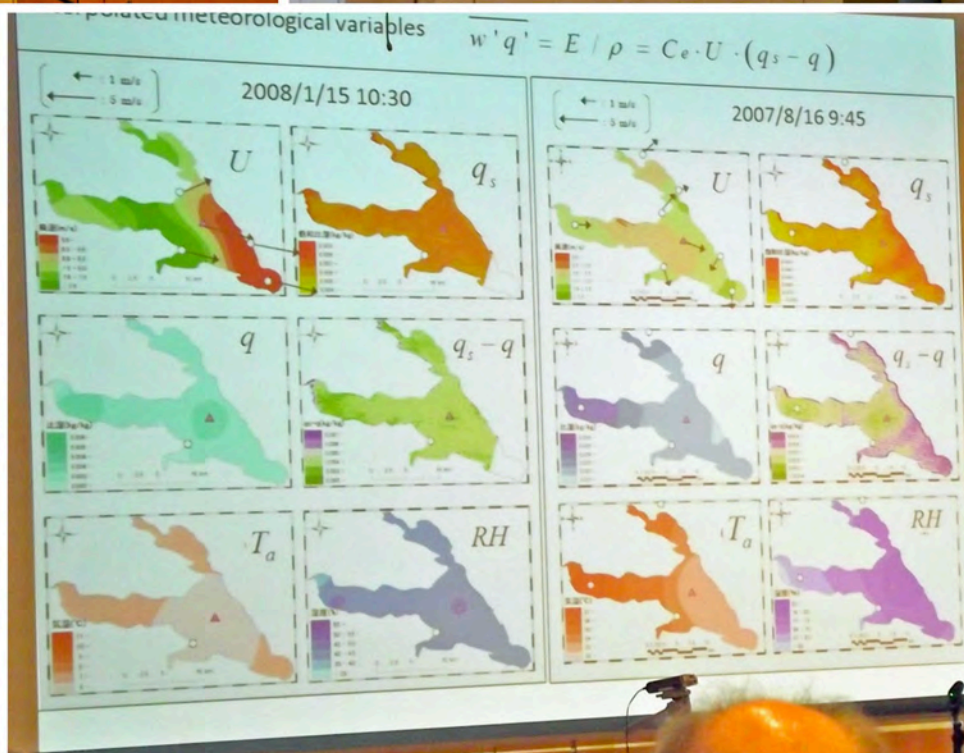
Spatial distribution of annual lake evaporation

$$E = \rho C_e U (q_s - q)$$

T_s at Koshin observatory

Interpolation (Kriging) to produce spatial map

- U and q : interpolated from observation of meteorological stations
- q_s : represented by obs. at Koshin observatory
- C_e : estimated from interpolated U , T_s and T_a
- Target year: 2008
- Time resolution: 3 hours



is similarity can be formulated as follows:

$$\frac{k u_* \tau_0}{E} \left(\frac{\partial q}{\partial z} \right) = \phi_w \quad (1)$$

where u_* is the friction velocity, τ_0 the shear stress at the surface, E the vertical water vapor flux at the surface, and q the mean specific humidity. ϕ_w is supposed to be a universal function,

$$\phi_w = \phi_w(\zeta) \quad (2)$$

$$\zeta = z/L \quad (3)$$

where L is the Obukhov length, which, when the humidity is included, is defined by

$$u_*^3 \rho / kg [(H/T_0 c_p) + 0.61 E] \quad (4)$$

where H is the vertical sensible heat flux, T_0 the temperature of the air near the surface, and c_p the specific heat at constant pressure.

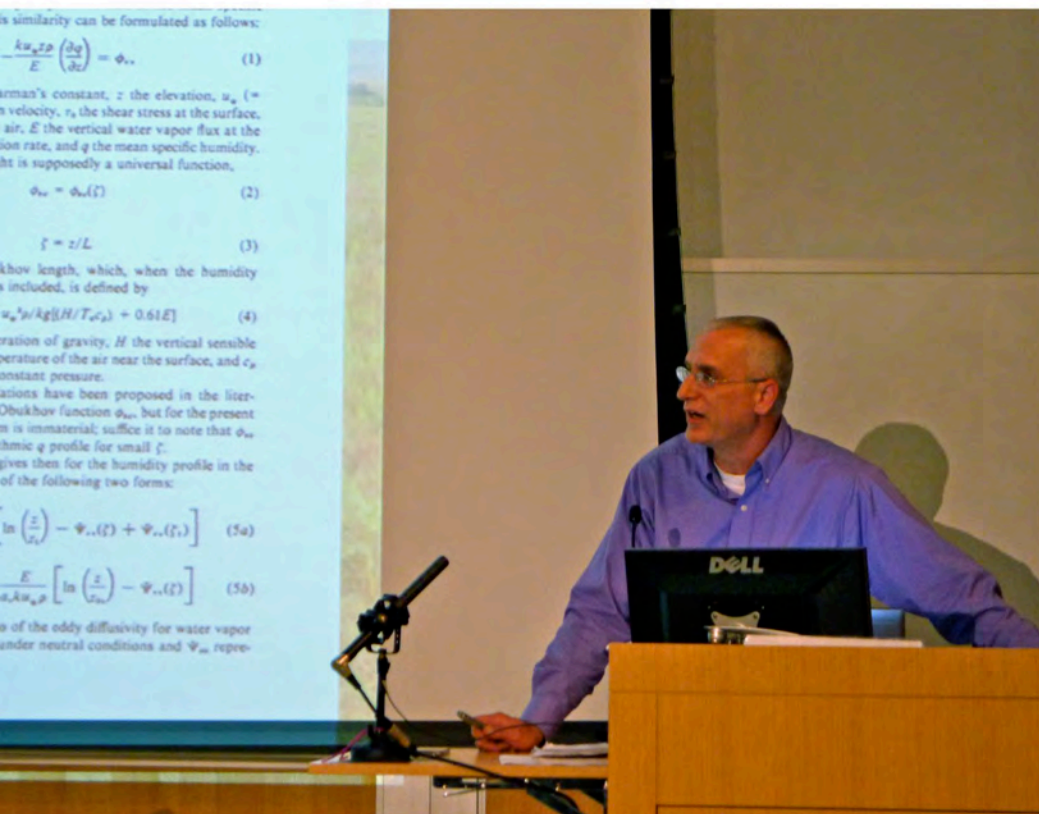
Several forms have been proposed in the literature for the Obukhov function ϕ_w , but for the present purposes, it is immaterial; suffice it to note that ϕ_w is a function of ζ .

For the humidity profile for small ζ , the following two forms:

$$\ln \left(\frac{z}{z_0} \right) - \Psi_w(\zeta) + \Psi_w(\zeta_0) \quad (5a)$$

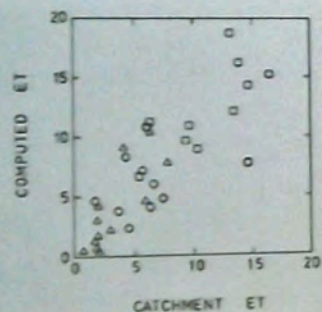
$$\frac{E}{k u_* \rho} \left[\ln \left(\frac{z}{z_0} \right) - \Psi_w(\zeta) \right] \quad (5b)$$

where k is the eddy diffusivity for water vapor, ρ the density of the air, and Ψ_w represents the correction for non-neutral conditions and Ψ_w represents the correction for non-neutral conditions.



ONAL EVAPOTRANSPIRATION HERIC BOUNDARY LAYER (ABL)

formulations produce regional
 rates of the surface fluxes
 applied over statistically
 rm surfaces.



4. Monthly evapotranspiration from the Omaha region com-
 by means of an observed height procedure versus watershed
 transpiration from the Treynor basins [Saxton, 1972] for
 November of 1969-1972. Units and symbol designations are the
 as those for Figure 3.

The Applicability of Planetary Boundary Layer Theory to Calculate Regional Evapotranspiration

WILFRIED BRUTSAERT AND JOHN A. MAWDSLEY

College of Engineering, Cornell University, Ithaca, New York 14853

A formulation is obtained for the calculation of evapotranspiration from a region even when the water supply to the surface may be limited. The theoretical model is based on general similarity principles for a steady uniform boundary layer under any conditions of atmospheric stability. The resulting mass transfer formulas have the advantage that the necessary data ("rawinsonde") are often routinely published or otherwise easily available. In contrast, most presently used methods for the determination of evapotranspiration either require a special experimental setup for rarely available data or are purely empirical without a firm physical basis. The proposed method can be applied in hydrologic simulation for drought studies and for the determination of antecedent moisture conditions in flood prediction.

INTRODUCTION

In recent years, rapid advances have been made in the development of instrumentation, allowing the direct measurement of turbulent or "Reynolds" fluxes of water vapor in addition to the fluxes of momentum and sensible heat by means of sensitive fast-response anemometers, thermometers, and hygrometers [e.g., Brunt and Gilmer, 1969; Golic et al., 1970; Miyake and McBean, 1970; Phelps et al., 1970; Hicks and Goudman, 1971; McGinnis et al., 1971]. However, in spite of considerable progress the problems involved in this type of instrumentation remain difficult. Therefore use is still made of the numerous procedures that have been developed for determining actual or potential evapotranspiration indirectly from other perhaps more easily measured parameters. Reviews of common methods, usually based on either energy budget considerations or semiempirical turbulent transfer considerations in the atmospheric surface layer, have been presented by Feihmeyer [1964], Tassner [1966], Van Bavel [1966], and Monte and Yaglom [1971]. Nevertheless, these indirect methods also require special or rarely available micrometeorological instrumentation, so that they are not always easily applicable on a routine basis. The more practical procedures, namely, those that can be applied with the normally available meteorological data [e.g., Jensen, 1966; Criddle, 1966; Pruitt, 1966], are invariably purely empirical without a very firm physical basis.

In other words, until now, in the absence of special instrumentation, it has been very difficult, if not impossible, to determine actual evapotranspiration, or water vapor transfer at the earth's surface, on the basis of sound theoretical principles by means of routinely observed and published weather data. It is the purpose of this paper to discuss the applicability of recently developed concepts in atmospheric boundary layer theory to the formulation of a practical procedure to estimate regional evapotranspiration by means of standard meteorological data. Thus this paper is a further development of the approach suggested earlier by Brutsaert and Brutsaert [1973].

SIMILARITY FORMULATIONS FOR ATMOSPHERIC WATER VAPOR TRANSFER

The planetary boundary layer is the region where dynamic and thermodynamic effects resulting from the earth's surface are directly detectable. Typically, its thickness δ is of the order of 1 km.

Copyright © 1976 by the American Geophysical Union

The inner, or surface, sublayer. The lowest 10% or so of the boundary layer is referred to as the surface sublayer; in this sublayer the vertical turbulent fluxes change relatively little with elevation, so that they are often assumed to be constant. It is now generally accepted that the characteristics of the turbulence in the surface sublayer for steady flow over a uniform surface can be described by the similarity theory of Monin and Obukhov [1954]. In the case of the mean specific humidity profile this similarity can be formulated as follows:

$$\frac{k u_* \rho}{E} \left(\frac{\partial q}{\partial z} \right) = \phi_w \quad (1)$$

where k is von Karman's constant, z the elevation, u_* ($= (\tau_0/\rho)^{1/2}$) the friction velocity, τ_0 the shear stress at the surface, ρ the density of the air, E the vertical water vapor flux at the surface, or evaporation rate, and q the mean specific humidity. The term on the right is supposedly a universal function.

$$\phi_w = \phi_w(f) \quad (2)$$

in which

$$f = z/L \quad (3)$$

Here L is the Obukhov length, which, when the humidity stratification effect is included, is defined by

$$L = -u_*^3 / (kg[H(T_s) + 0.61E]) \quad (4)$$

where g is the acceleration of gravity, H the vertical sensible heat flux, T_s the temperature of the air near the surface, and c_p the specific heat at constant pressure.

Numerous formulations have been proposed in the literature for the Monin-Obukhov function ϕ_w , but for the present purpose its exact form is immaterial; suffice it to note that ϕ_w should yield a logarithmic q profile for small f .

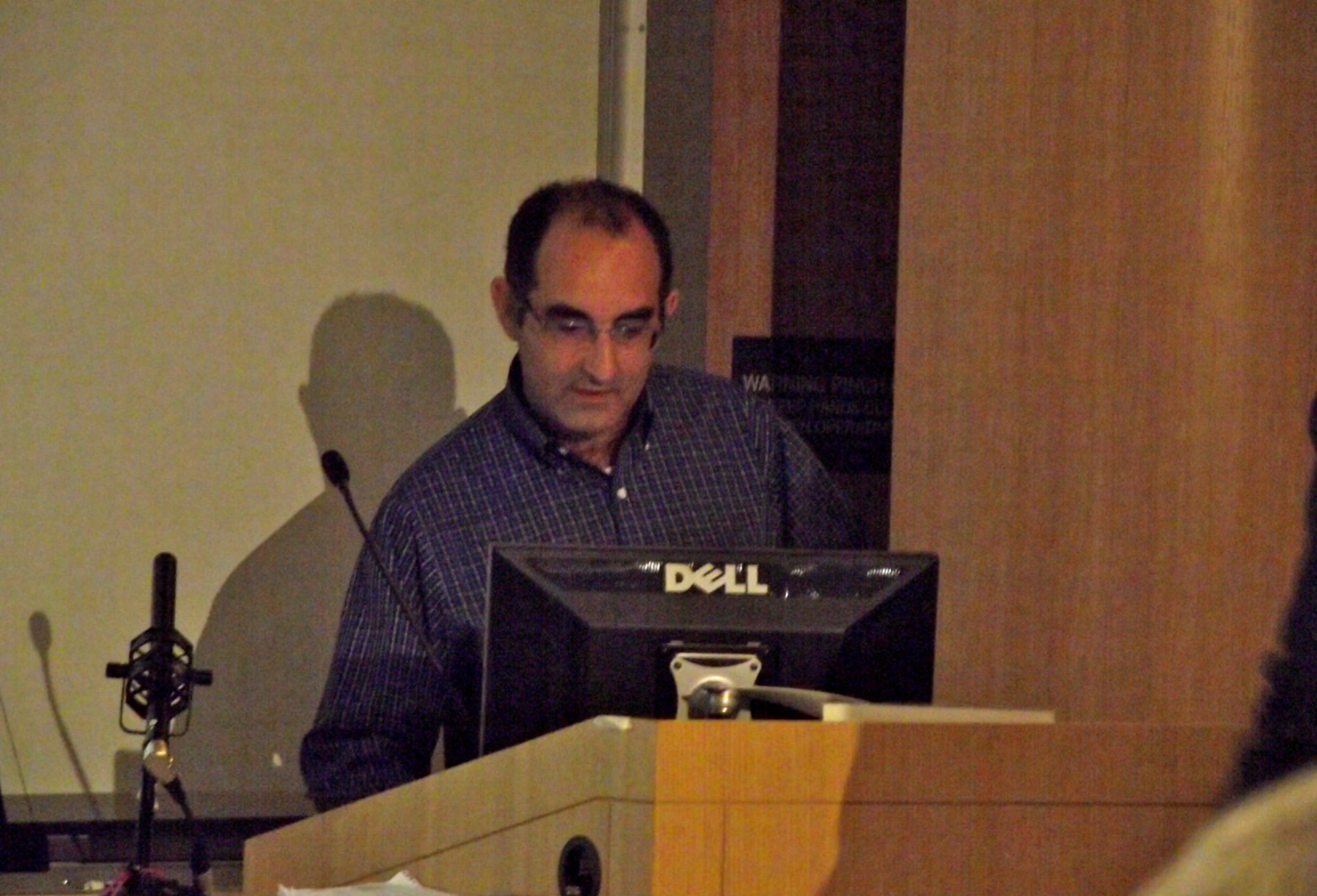
Integration of (1) given then for the humidity profile in the surface sublayer one of the following two forms:

$$\phi_w = \phi_w = \frac{E}{k u_* \rho} \left[\ln \left(\frac{z}{z_0} \right) - \Psi_w(f) + \Psi_w(f_0) \right] \quad (5a)$$

or

$$\phi_w = \phi_w = \frac{E}{k u_* \rho} \left[\ln \left(\frac{z}{z_0} \right) - \Psi_w(f) \right] \quad (5b)$$

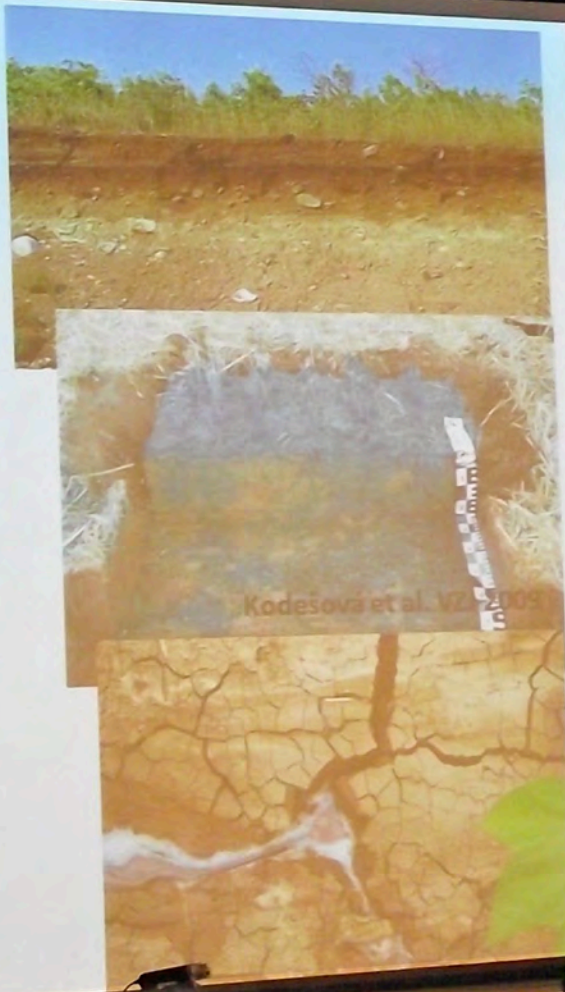
in which ϕ_w is the ratio of the eddy diffusivity for water vapor to the eddy viscosity under neutral conditions and Ψ_w represents the integral



of Infiltration

: Entry of water into
ce and *its*
vertical motion
soil profile
(2005).

is a complex
ch depends upon
rs: water supply rate;
of the hydraulic
within the soil profile;
boundary conditions;
water quality; soil
sodicity; temperature
thin the soil profile....



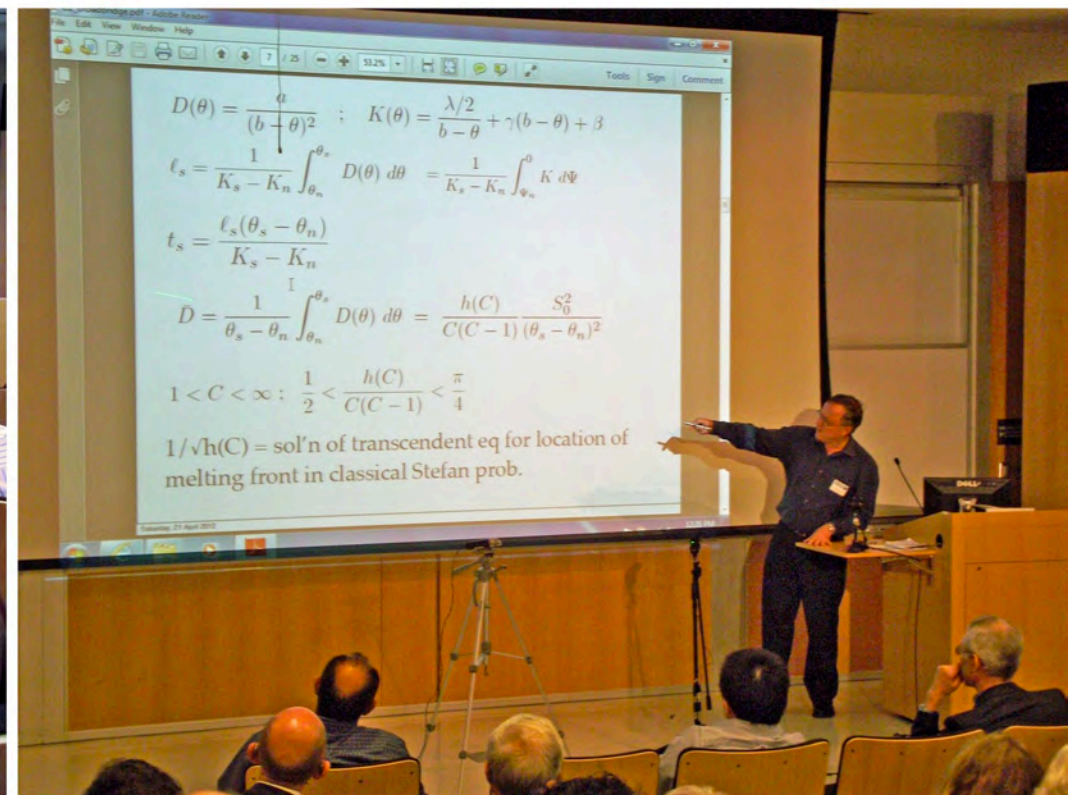
Conclusions

- Brutsaert and Parlange have made seminal contributions to the understanding and the ability to quantify the complex process of infiltration
- We should be grateful because:
 - we had the chance to learn directly from them
 - they have left some unresolved issues so that we could get the opportunity to apply what we have learned





Philip Broadbridge





The Symposium Participants

May 15, 2012



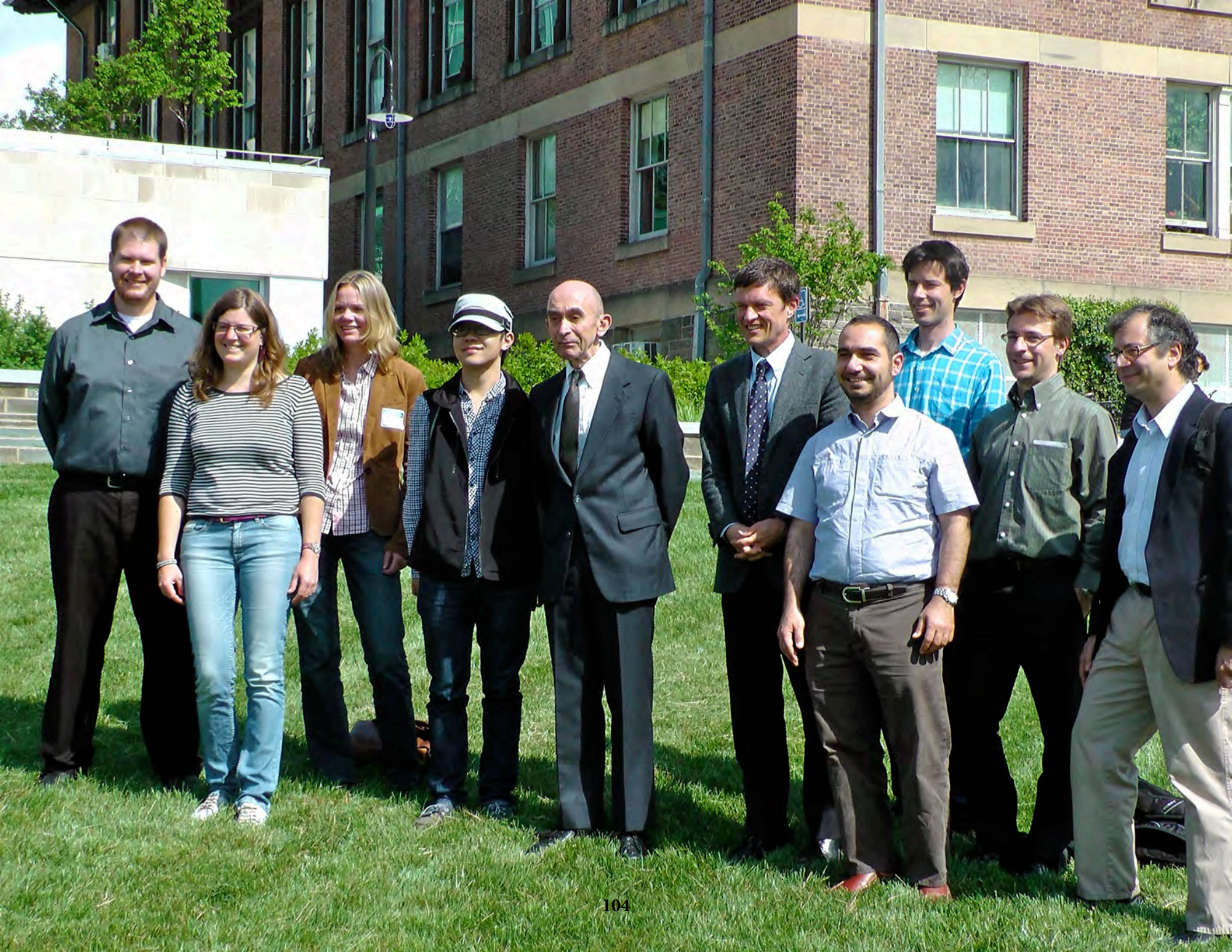


















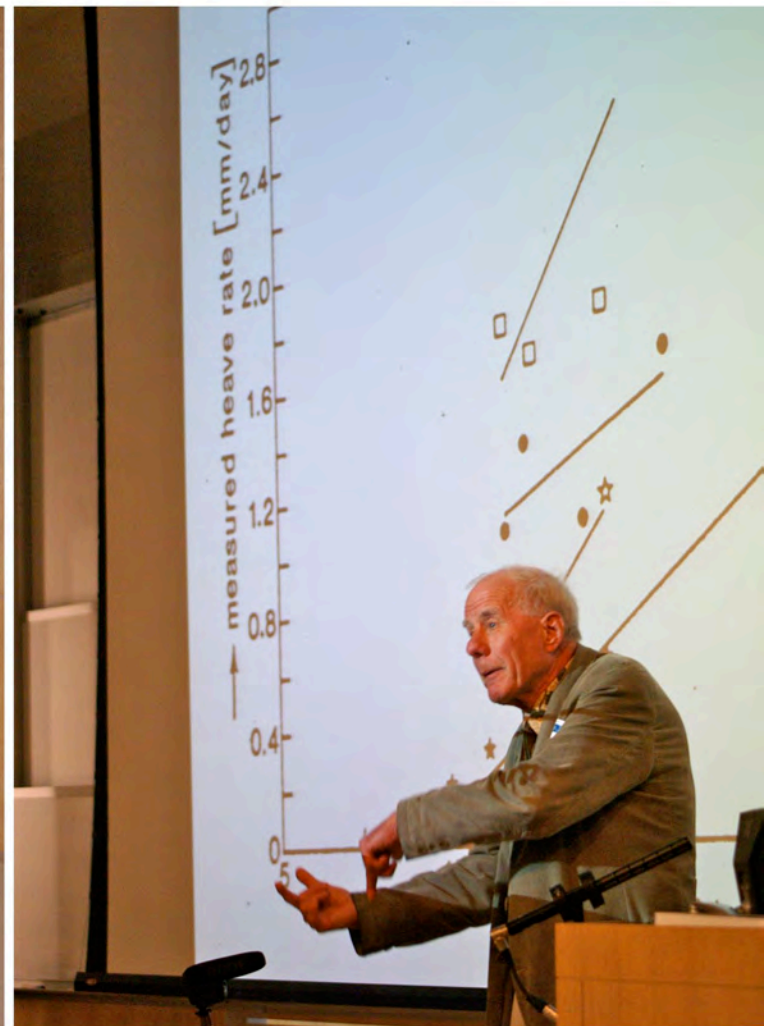


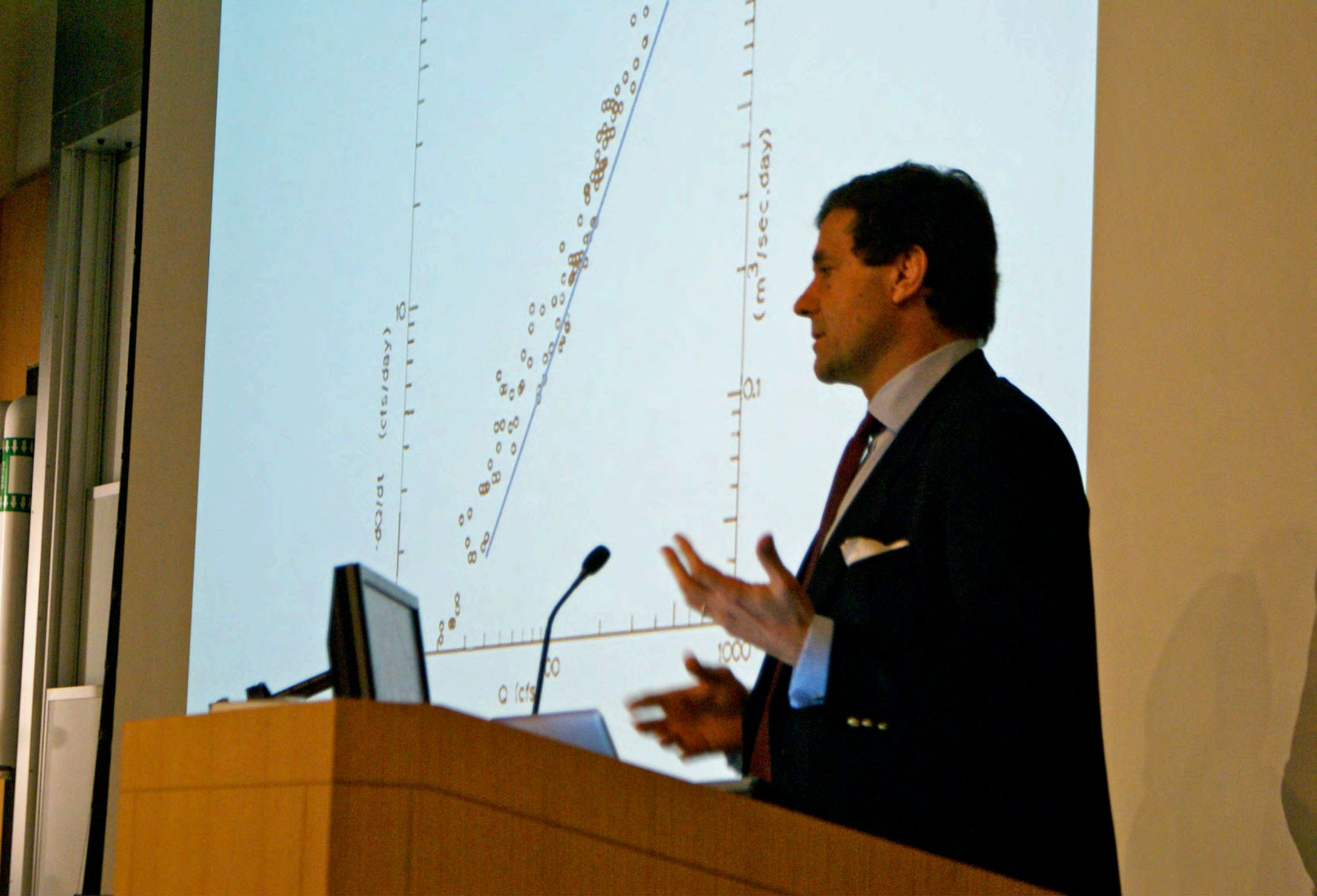


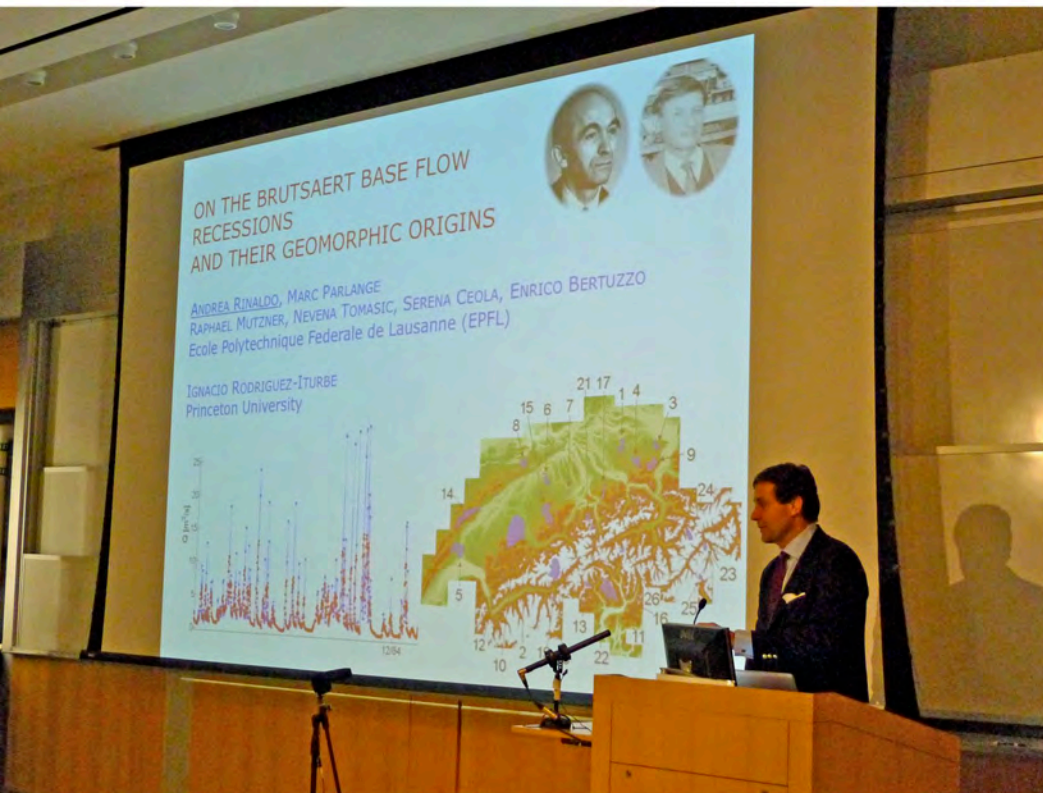
Thermodynamics and Open Channels

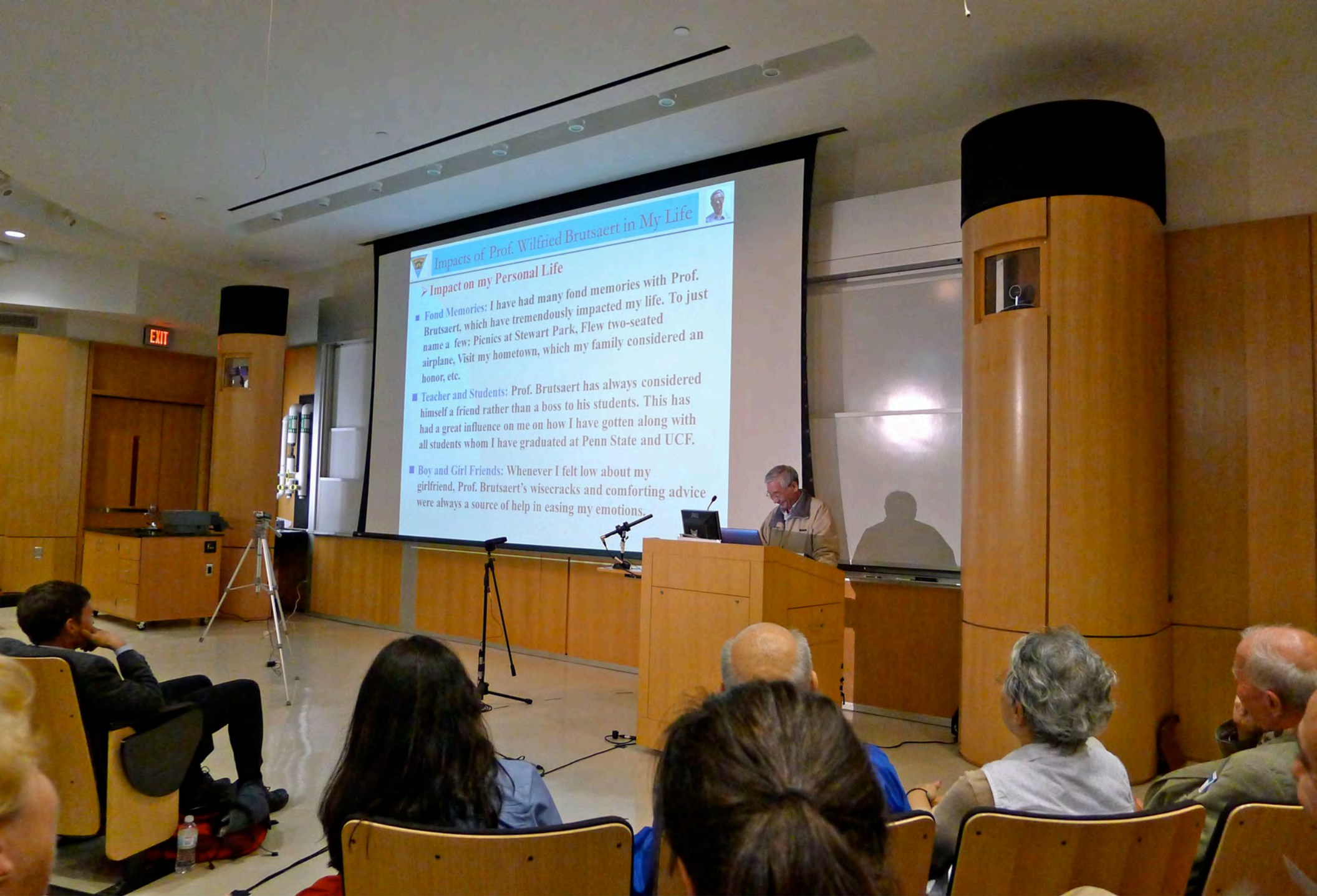


Pieter Groenevelt





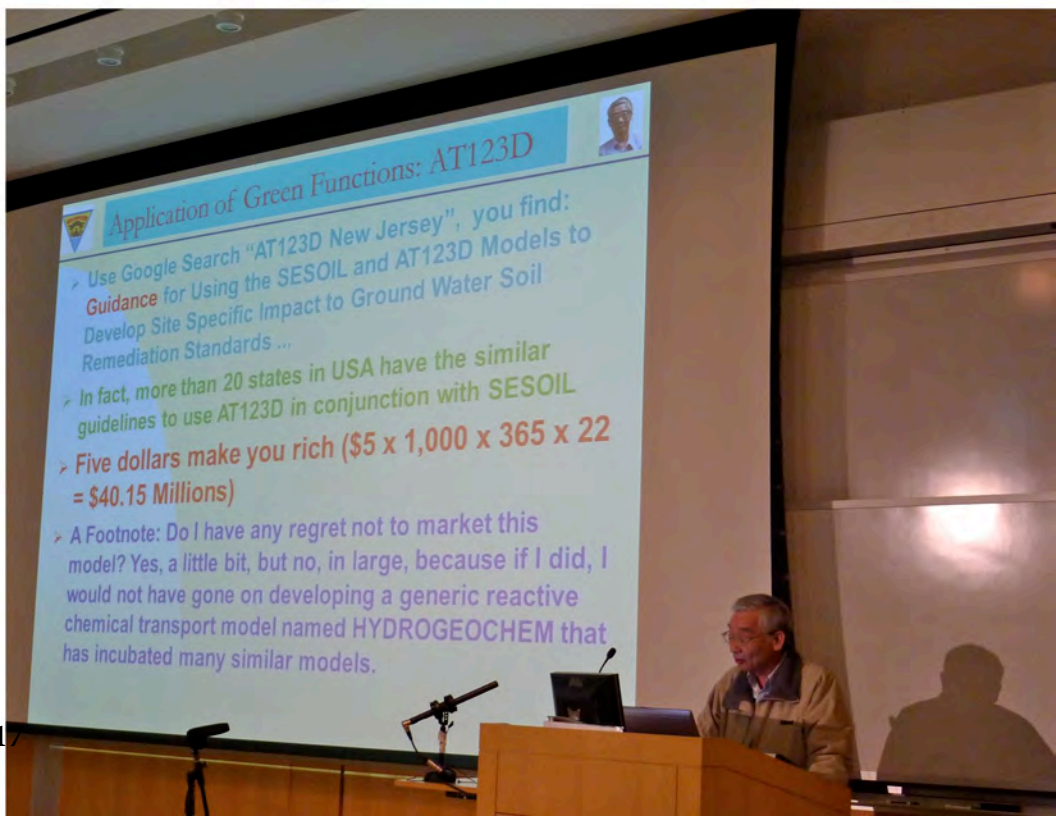
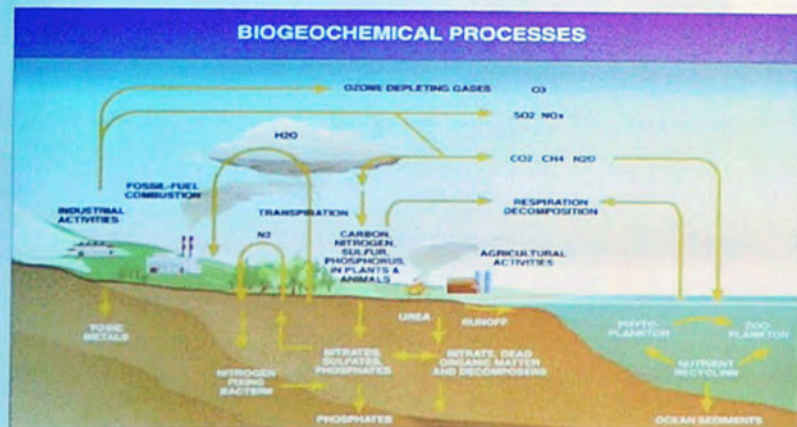




- ### Impacts of Prof. Wilfried Brutsaert in My Life
- Impact on my Personal Life
 - Fond Memories: I have had many fond memories with Prof. Brutsaert, which have tremendously impacted my life. To just name a few: Picnics at Stewart Park, Flew two-seated airplane, Visit my hometown, which my family considered an honor, etc.
 - Teacher and Students: Prof. Brutsaert has always considered himself a friend rather than a boss to his students. This has had a great influence on me on how I have gotten along with all students whom I have graduated at Penn State and UCF.
 - Boy and Girl Friends: Whenever I felt low about my girlfriend, Prof. Brutsaert's wisecracks and comforting advice were always a source of help in easing my emotions.



Multi-processes: Biogeochemical Cycles



Application of Green Functions: AT123D

- Use Google Search "AT123D New Jersey", you find: **Guidance for Using the SESOIL and AT123D Models to Develop Site Specific Impact to Ground Water Soil Remediation Standards ...**
- In fact, more than 20 states in USA have the similar guidelines to use AT123D in conjunction with SESOIL
- Five dollars make you rich ($\$5 \times 1,000 \times 365 \times 22 = \40.15 Millions)
- A Footnote: Do I have any regret not to market this model? Yes, a little bit, but no, in large, because if I did, I would not have gone on developing a generic reactive chemical transport model named HYDROGEOCHEM that has incubated many similar models.

Tributes

May 15, 2012



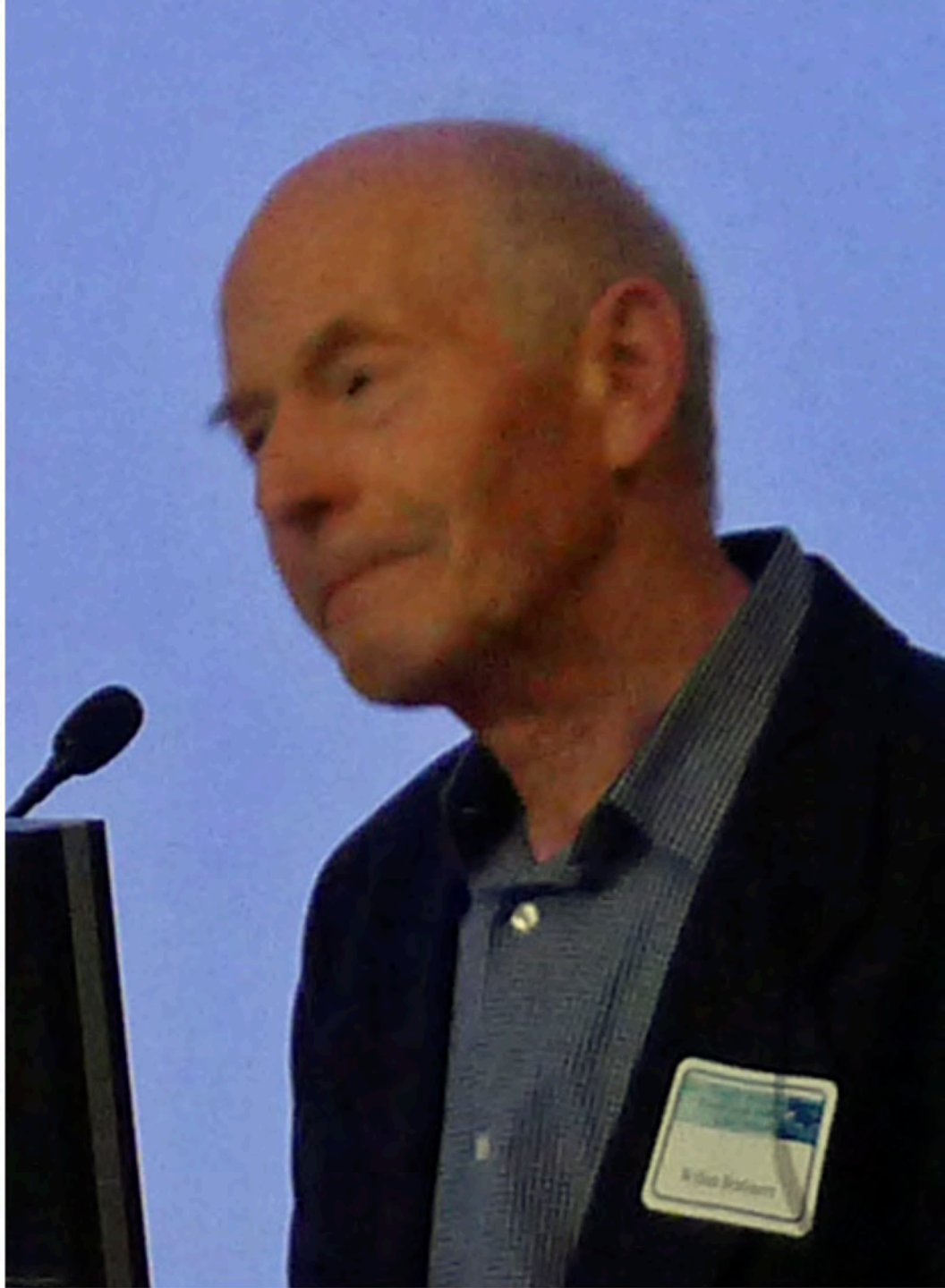


Mary Parlange salutes Eileen Parlange and Toyoko Brutsaert





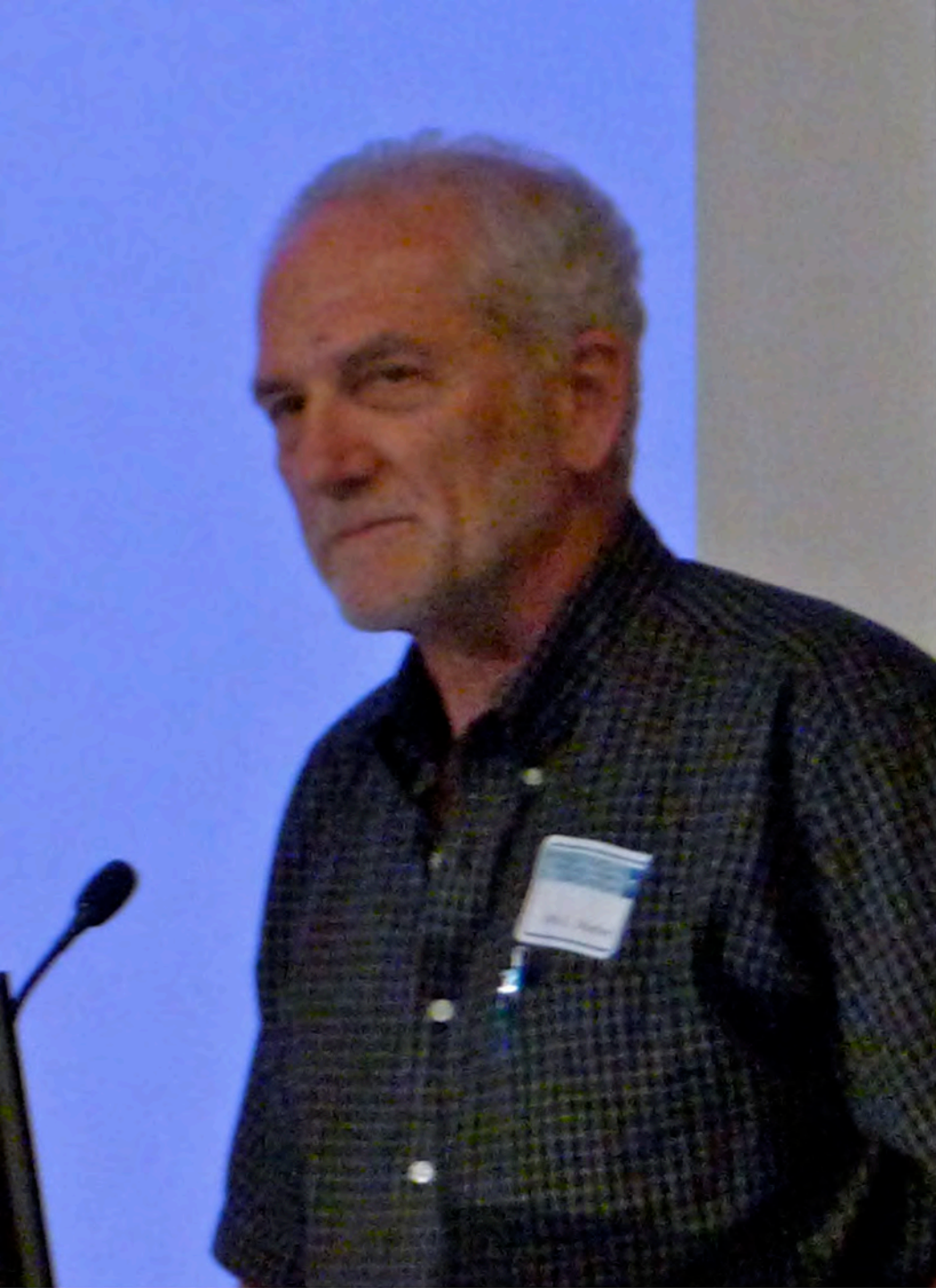




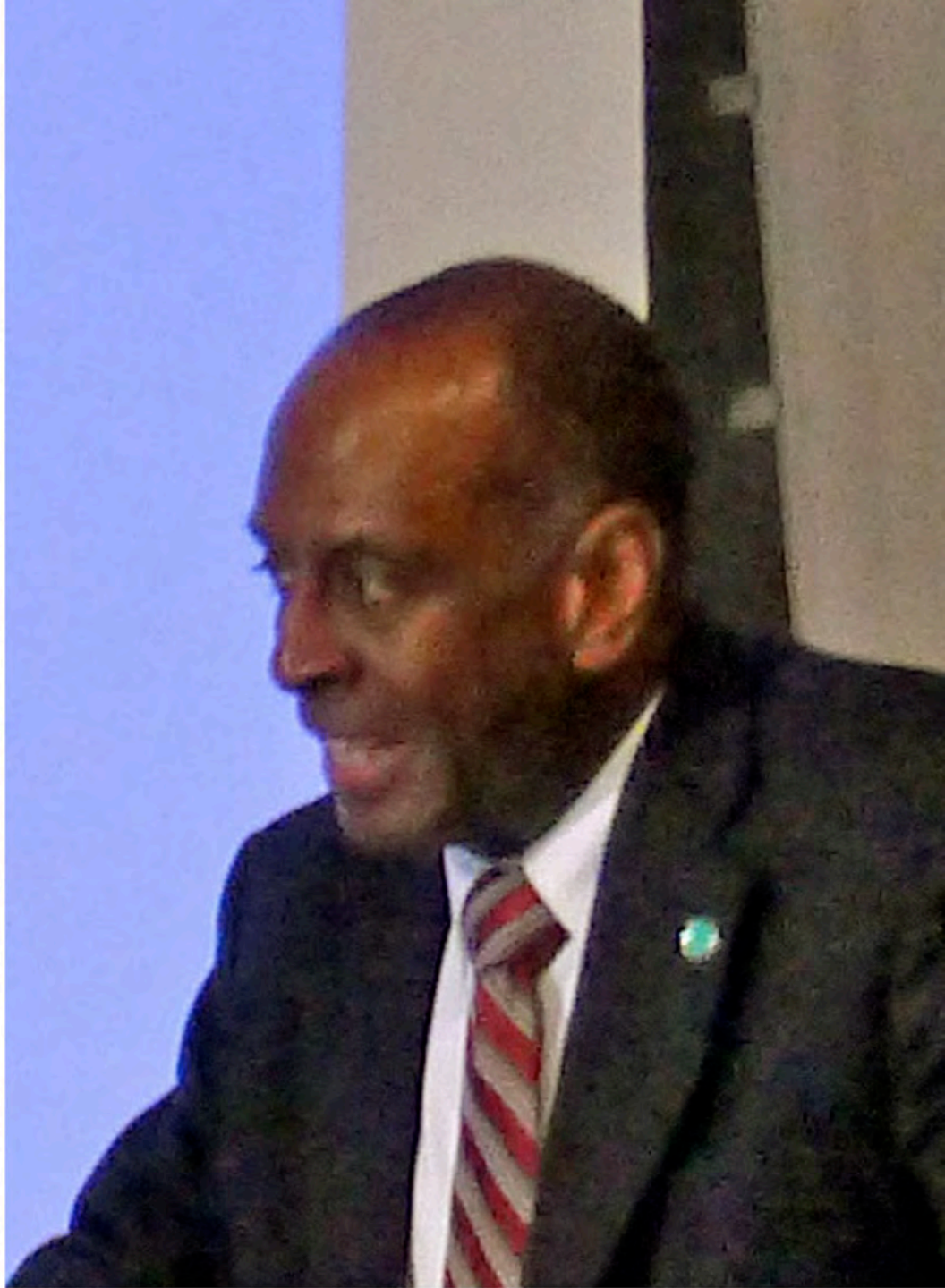
Dave Elrich, and Willem Brutsaert (proud brother)



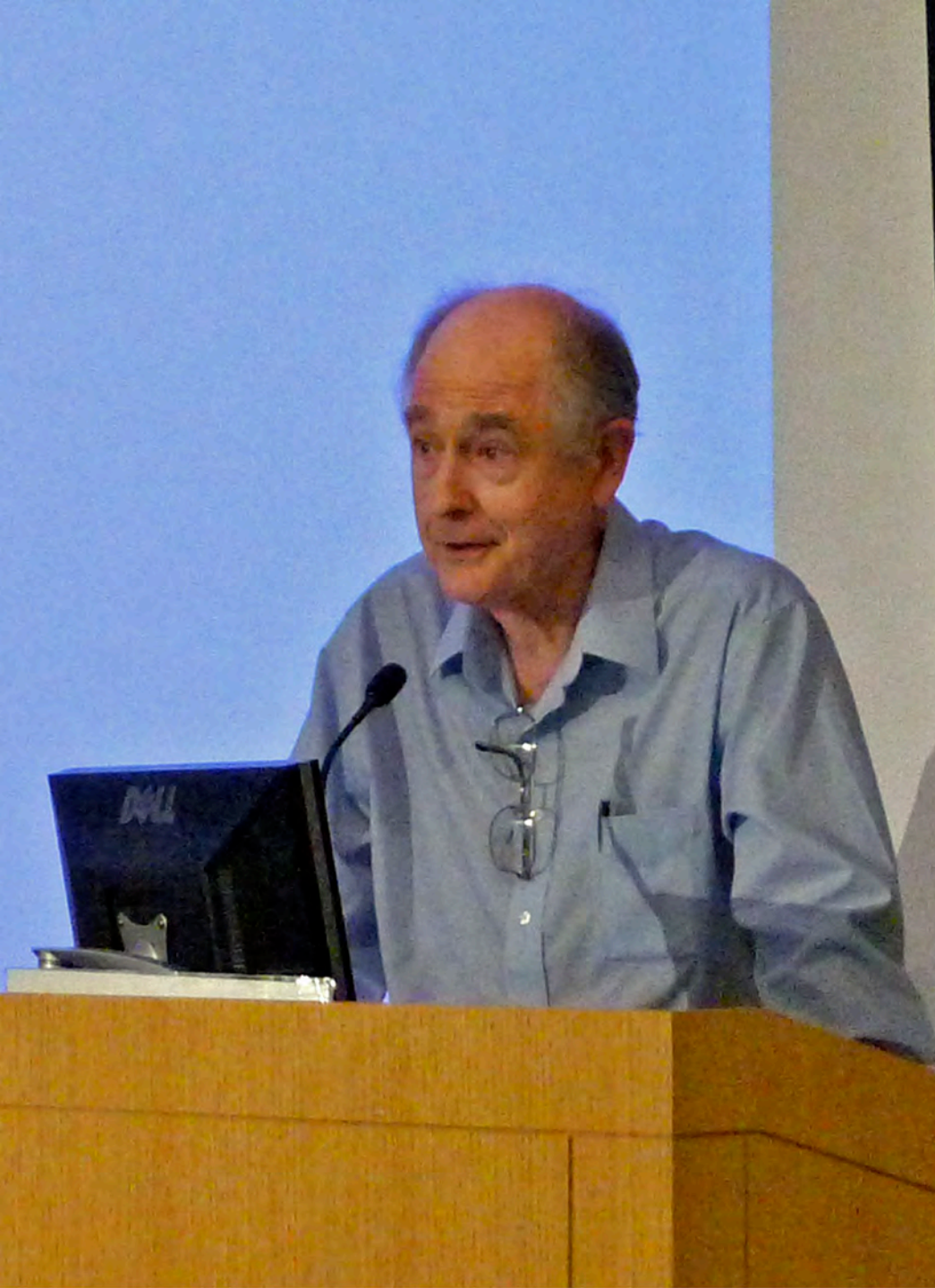
Kaoru Takara and Frank Stagnitti

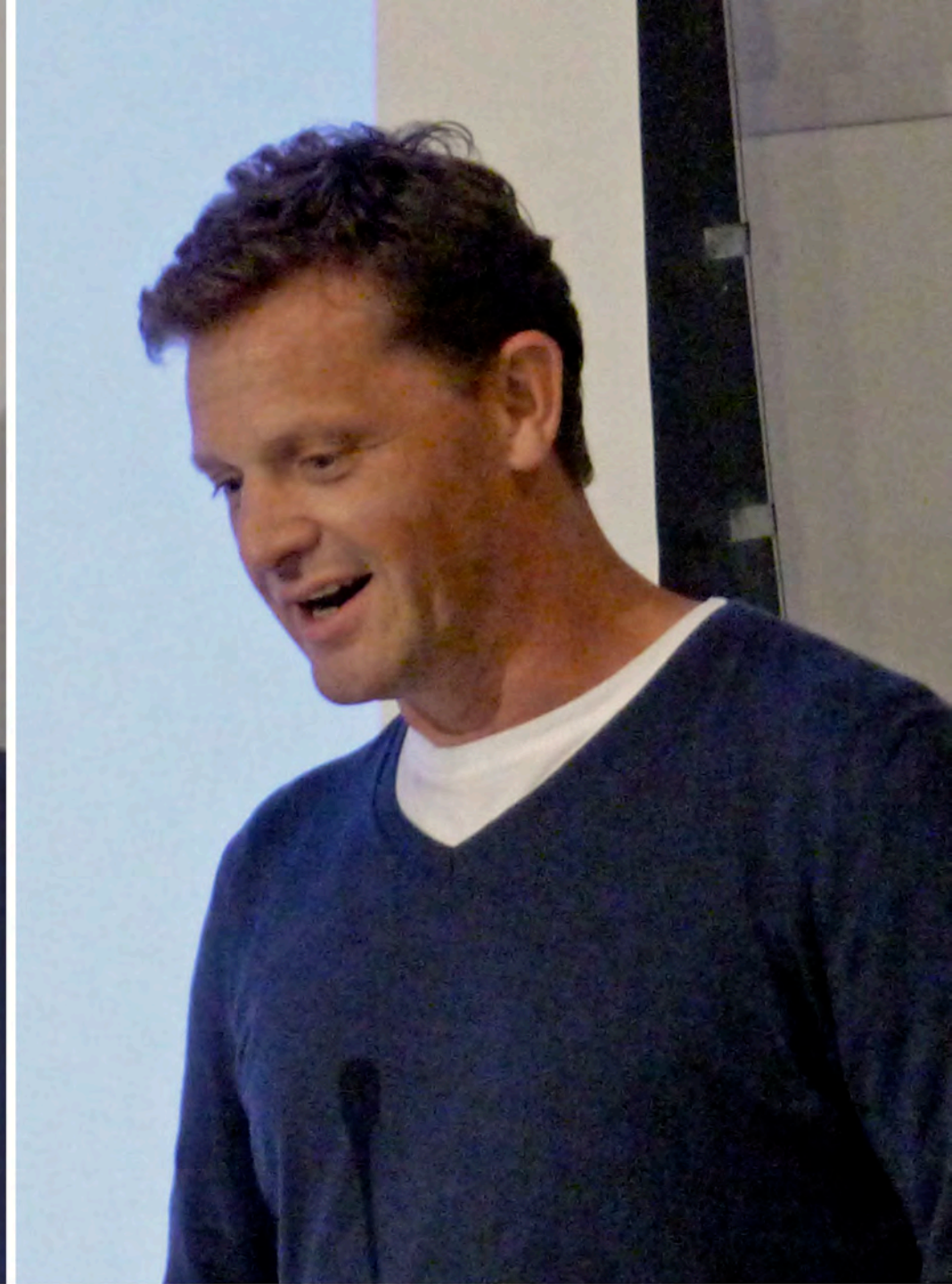
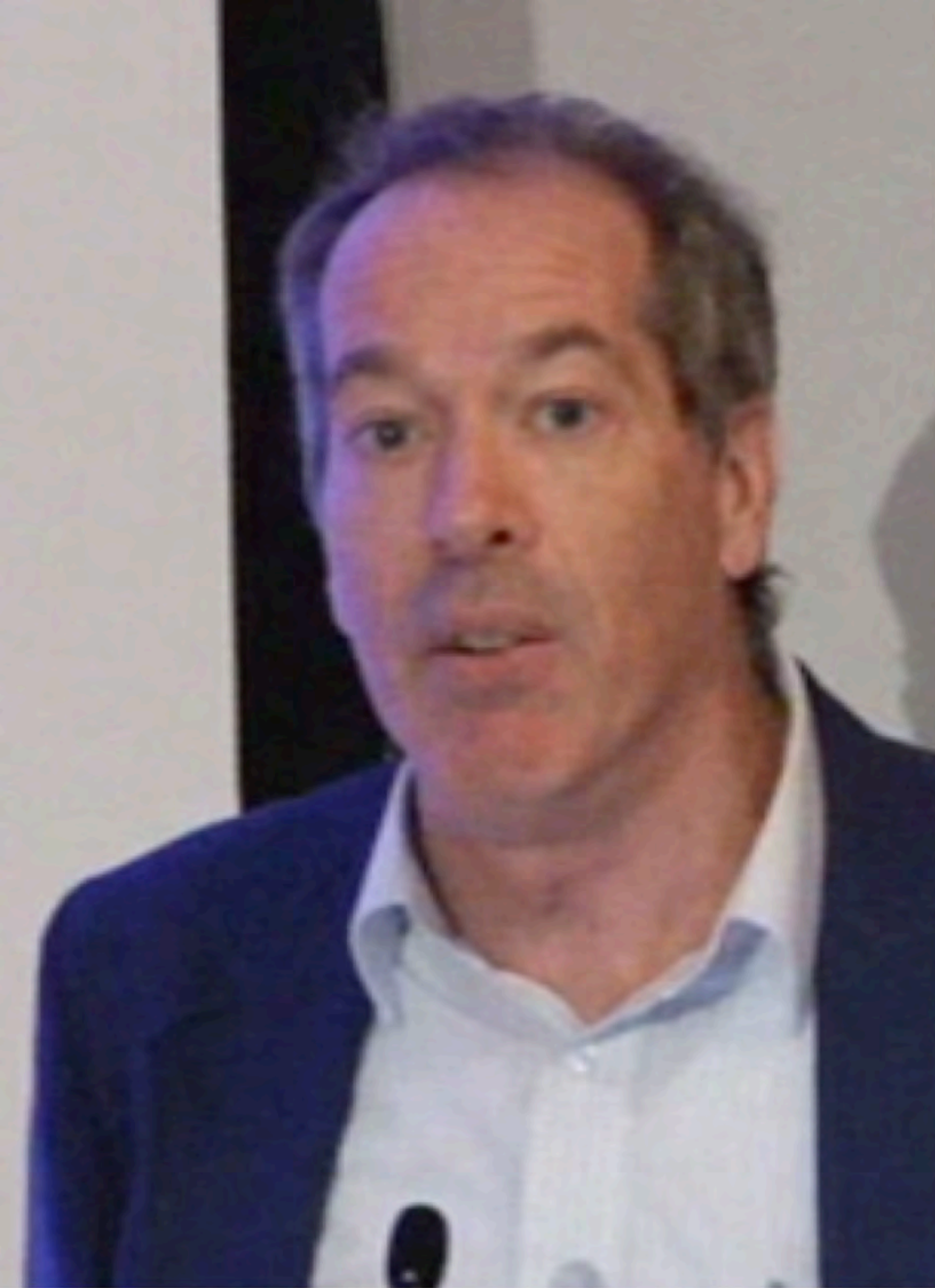


John L. Nieber and William P. Kustas

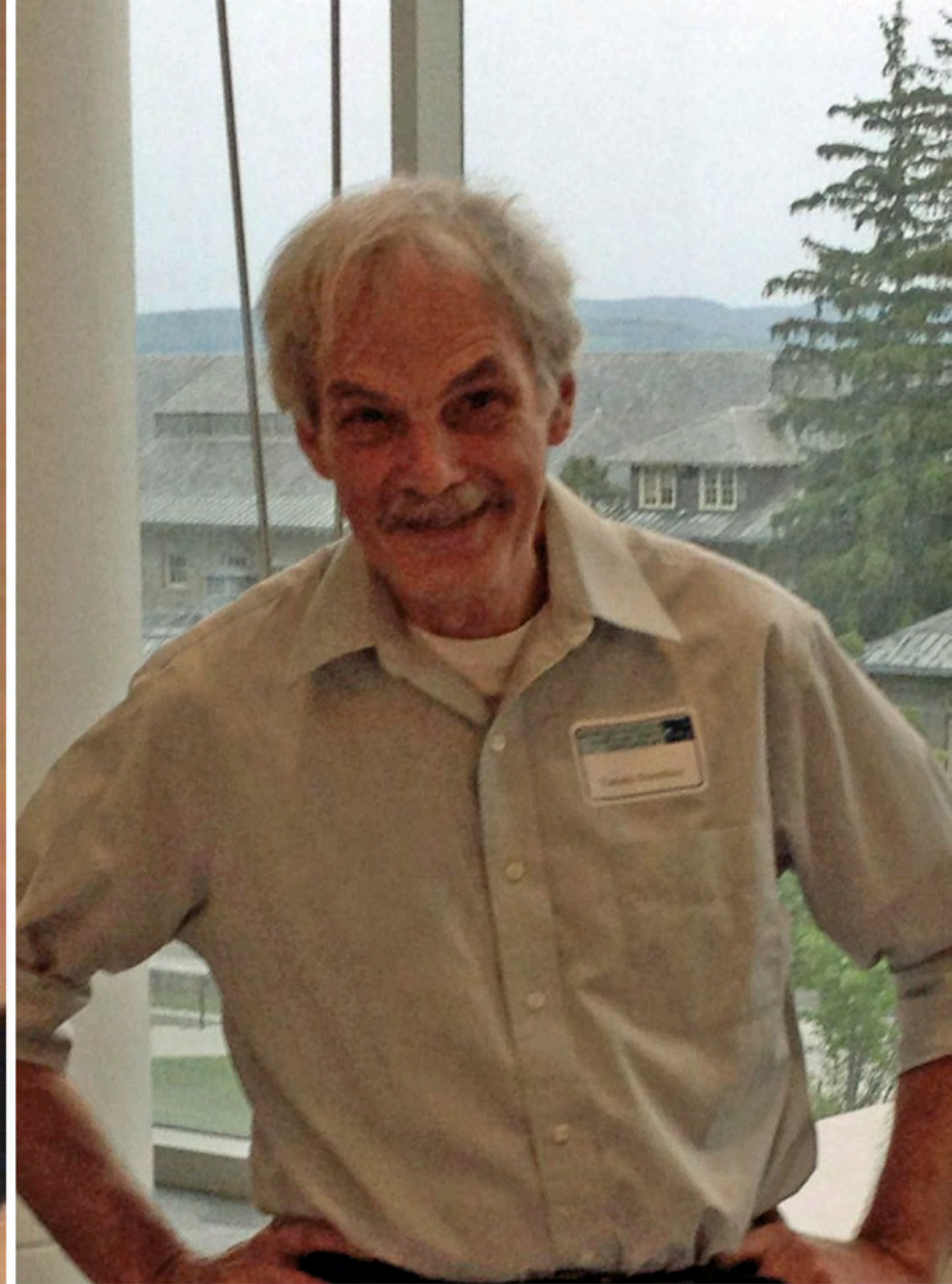


Remko Uijlenhoet and Larry P. Walker





Jery Stedinger and Peter Troch



Cathelijne R. Stoof and Tammo Steenhuis



AD White House Reception

“Retirement” Party for Wilfried H. Brutsaert 15 May 2012



















