Wonderful to be with all of you at Cornell to Celebrate with Brutsaert and Parlange
Probing the Atmospheric Boundary Layer
.....southwest France, Les Landes, Dr. W. Brutsaert, 1986
Les Landes, swampy wet place, not easy to get through – people regularly held up etc...

....a hydrology problem
Napoleon III

....started to plant trees and dig drainage canals...
Questions from Brutsaert:-
What is the regional roughness?
How do we obtain the regional evaporation?
We need to go to the field of course.
Some time later....26 years ago, Les Américans arrived in Les Landes
Our house...involved a lot of running,
...discovered Brutsaert had a 2:43 pr
Precise temperature, humidity, pressure measurements, ...parachute, reflector
Home away from home.. Measure in the field at scales of interest.
Discovered the joys of football, 1:00 am watching World Cup,....French Open...
People: Former PhD students, WRR/Steve Burges, people at Davis....
... we became rugby fans
The launch team

500 Balloons
Sometimes really exciting
Velocity measurements, lucky to have this advisor!!
How sodars used to look...turned out very useful
Le mât des Anglais, start of eddy correlation
Measuring interception....
Local evaporation

...Richard Cuenca’s neutron probe
Surface flux measurements over an oat field
Variable landscape
Brutsaert, WRR, 1998, Langbein Lecture, AGU
Brutsaert was always interested in the next generation, what they were doing, where were they going....
Johns Hopkins, PhDs
...co-advised with Charles Meneveau

Tony Cahill.

Fernando Porte-Agel

Jan Kleissl

Elie Bou-Zeid

Chad Higgins

Markus Pahlow.

Vijyant Kumar

Marcelo Chamecki

Mariana Adam
Determining $h_b$ from LES data

Using the lower and upper quartiles of velocity data
Parameterization:
Equation for blending height

- IBL grows till it reaches the blending height (Miyake, 1956)

\[ h_b \left[ \ln \left( \frac{h_b}{z_{o,e}} \right) - 1 \right] = 0.85 \kappa (nL_p) \]

**LES data \(\rightarrow n = 2\)**
Realistic surfaces – Les Landes

\[
\left( \frac{h_b}{1.7\kappa L_{p} + h_b} \right)^2 = \sum_{i=1}^{N} f_i \left( \ln \frac{h_b}{z_{o,i}} \right)^2
\]

\[
z_{o,e} = h_b \exp \left[ -\frac{1.7\kappa L_{p}}{h_b} - 1 \right]
\]
Parameterization for $z_{o,\text{effective}}$

\[
\left( \frac{h_b}{1.7 \kappa L_p + h_b} \right)^2 = \sum_{i=1}^{N} f_i \left( \frac{1}{\ln \left( \frac{h_b}{z_{o,i}} \right)} \right)^2 \quad \text{with} \quad z_{o,e} = h_b \exp \left[ -\frac{1.7 \kappa L_p}{h_b} - 1 \right]
\]
Experimental Site

Dranse de Ferret Alpine Catchment

Val Ferret, Swiss Alps
45.902°N, 7.123°E
7 July to 30 Sept. 2010
West-facing slope
Altitude range: 1900 to 2200 m ASL
Val Ferret, Switzerland
Val Ferret, Swiss Alps

Snowmelt
Val Ferret, Swiss Alps

Simple hydrological model

Glacier melt

Simoni et al., 2011, WRR
Experimental Setup

- **S1 – S2**: Sensorscope stations
- **A1 to A5**: IR sensing stations
- **T1**: Energy balance
- **LS**: Tethered sonde
- **T2**: 10-m tower
- **TC**: Thermal camera
Evening Transition
Val Ferret, Switzerland
1 September 2010
Val Ferret: 01-Sep-2010 18:00:25

Nadeau et al., QJRMS, 2012
Thermal Energy Balance

\[ \frac{\partial \bar{\theta}_v}{\partial t} = -u \frac{\partial \bar{\theta}_v}{\partial x} - w \frac{\partial \bar{\theta}_v}{\partial z} - \frac{\partial w'\bar{\theta}_v'}{\partial z} - \frac{1}{\rho c_p} \frac{\partial \bar{R}_n}{\partial z} \]

Large divergence of sensible heat flux

Median values of 9 convective days, 1.5 m above sfc @ 10-m tower (site T2)
Turbulent Kinetic Energy Balance (dk/dt)

\[ \frac{\partial \bar{k}}{\partial t} = \gamma \frac{w' \theta'}{\theta_v} - \bar{u}' \bar{w}' \frac{\partial \bar{u}}{\partial z} - \varepsilon \]

- **Buoyancy**
- **Mechanical shear**
- **Dissipation**

\[ \varepsilon = ar^{-1}D(r)^{3/2} \]

**TKE Budget**

- Median values of 9 convective days, 1.5 m above sfc @ 10-m tower

- Sharp decrease of buoyancy
- Early evening calm period
- No mechanical prod. of turbulence!
Thanks Dr. Brutsaert
2011 Field Campaign – First Results

- 3 wind lidars deployed during a few IOPs