Understanding the Impact of Green Infrastructure on Urban Microclimate and Energy Use Through Simulation and Observation

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- http://www.mech.utah.edu/~pardyjak/UMD_BB_2013.php

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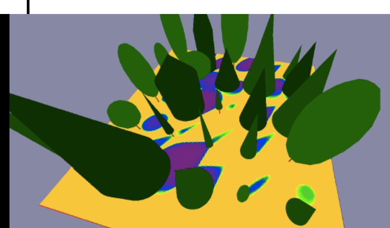
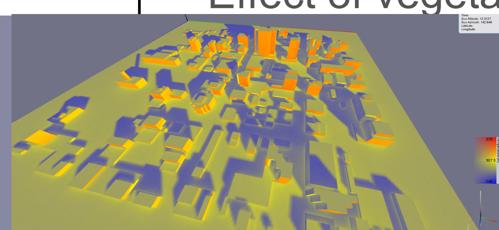
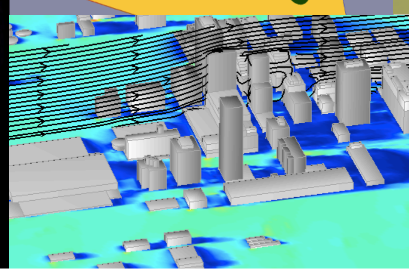
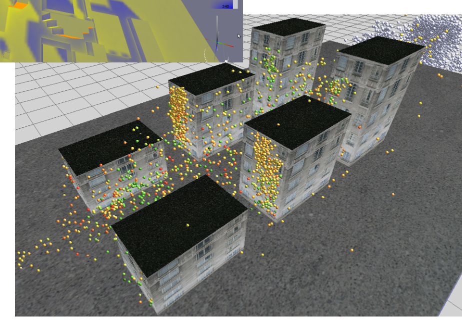
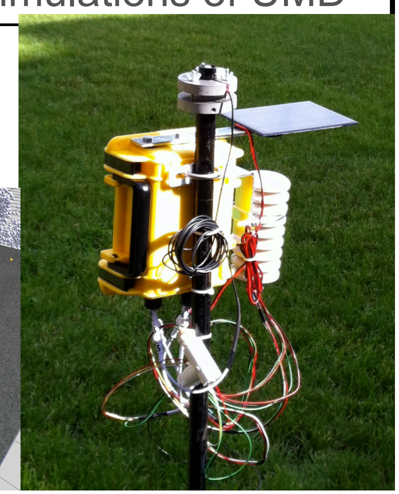
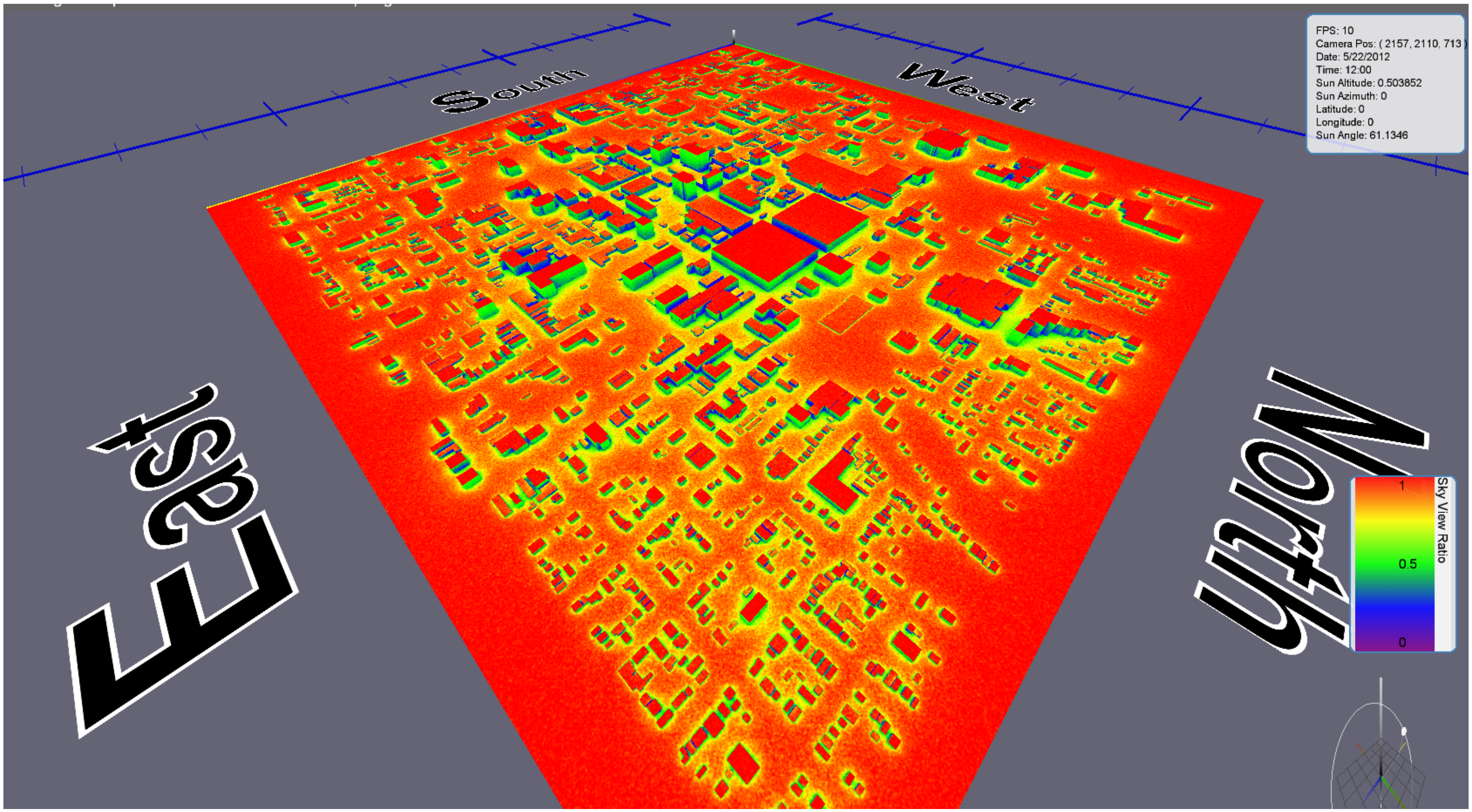
Day	Hypothesize	Observe/ Discuss	Design & Simulation
Monday	Surface/Air Temperature	LEMS stations & HOBOS	Introduction to QUIC Modeling system
Tuesday	Energy Efficient Cities	Mobile sensor measurements	Test Efficient Designs with QUIC Energy
Thursday	Effect of vegetation and buildings on urban energy balance	Download and analyze data	
Friday		Effect of vegetation	QUIC-Energy Simulations of UMD

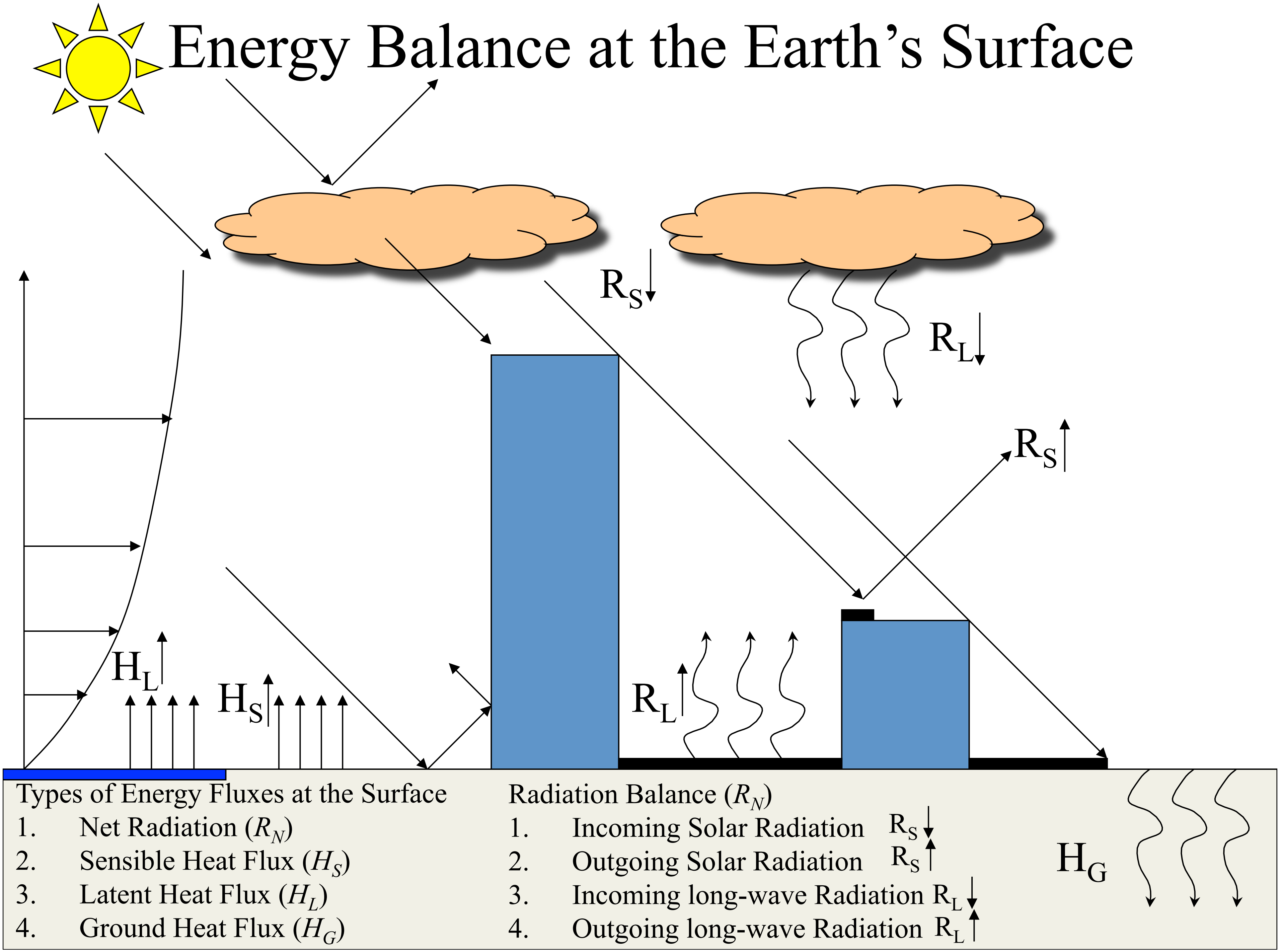







What is Green Infrastructure?

Simulation of the Energy Balance in Cities



Energy Balance at the Earth's Surface



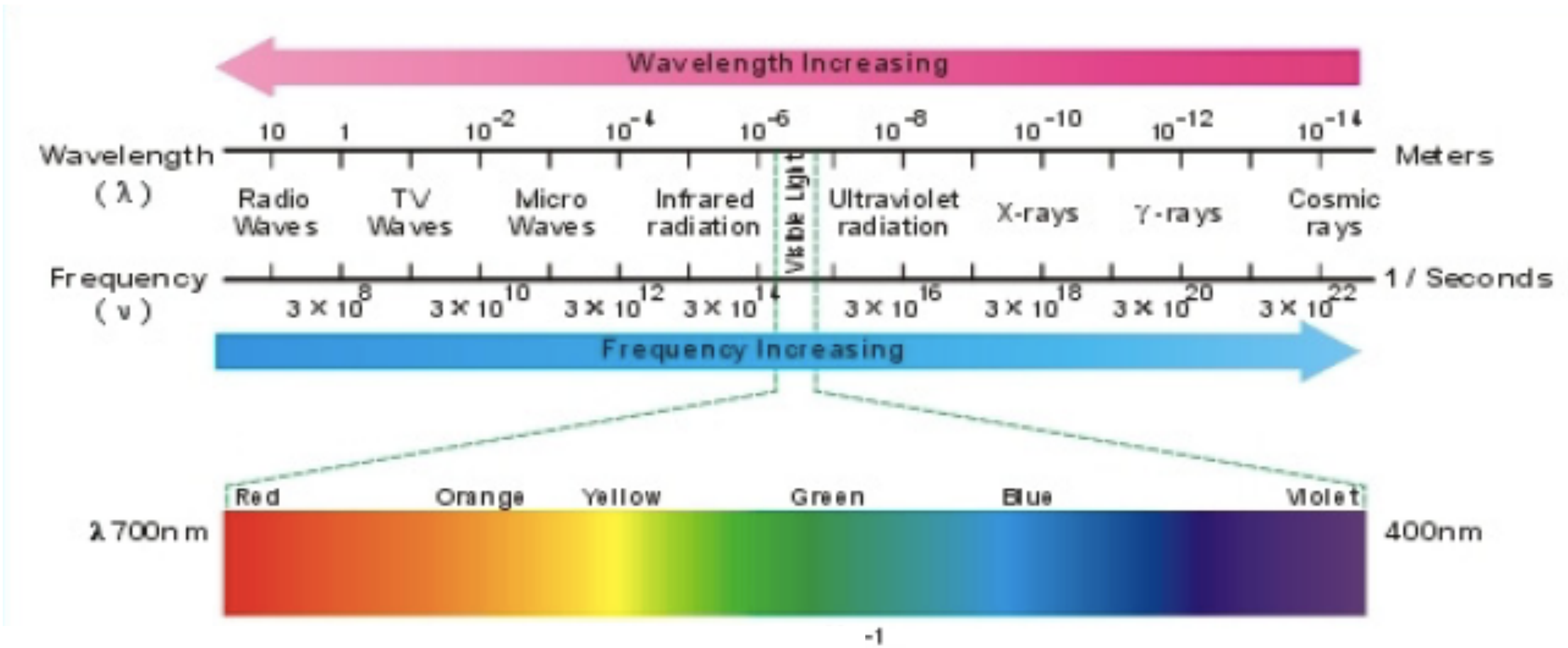
Types of Energy Fluxes at the Surface

1. Net Radiation (R_N)
2. Sensible Heat Flux (H_S)
3. Latent Heat Flux (H_L)
4. Ground Heat Flux (H_G)

Radiation Balance (R_N)

1. Incoming Solar Radiation $R_S\downarrow$
2. Outgoing Solar Radiation $R_S\uparrow$
3. Incoming long-wave Radiation $R_L\downarrow$
4. Outgoing long-wave Radiation $R_L\uparrow$

Electromagnetic Spectrum



R_s – Shortwave (solar) Radiation:
~0.15-4.0 μm

R_L – Longwave (terrestrial) Radiation:
~3.0-100 μm

Radiative Properties of Surfaces

Table 1.1 Radiative properties of natural materials.

Surface	Remarks	Albedo α	Emissivity ε
Soils	Dark, wet Light, dry	0·05– 0·40	0·98– 0·90
Desert		0·20–0·45	0·84–0·91
Grass	Long (1·0 m) Short (0·02 m)	0·16– 0·26	0·90– 0·95
Agricultural crops, tundra		0·18–0·25	0·90–0·99
Orchards		0·15–0·20	
Forests			
Deciduous	Bare Leaved	0·15– 0·20	0·97– 0·98
Coniferous		0·05–0·15	0·97–0·99
Water	Small zenith angle Large zenith angle	0·03–0·10 0·10–1·00	0·92–0·97 0·92–0·97
Snow	Old Fresh	0·40– 0·95	0·82– 0·99
Ice	Sea Glacier	0·30–0·45 0·20–0·40	0·92–0·97

Sources: Sellers (1965), List (1966), Paterson (1969) and Monteith (1973).

Albedo

$$\alpha = \frac{R_S \uparrow}{R_S \downarrow} = \int_{0.15\,\mu m}^{4\,\mu m} \alpha_\lambda d\lambda$$

Emissivity

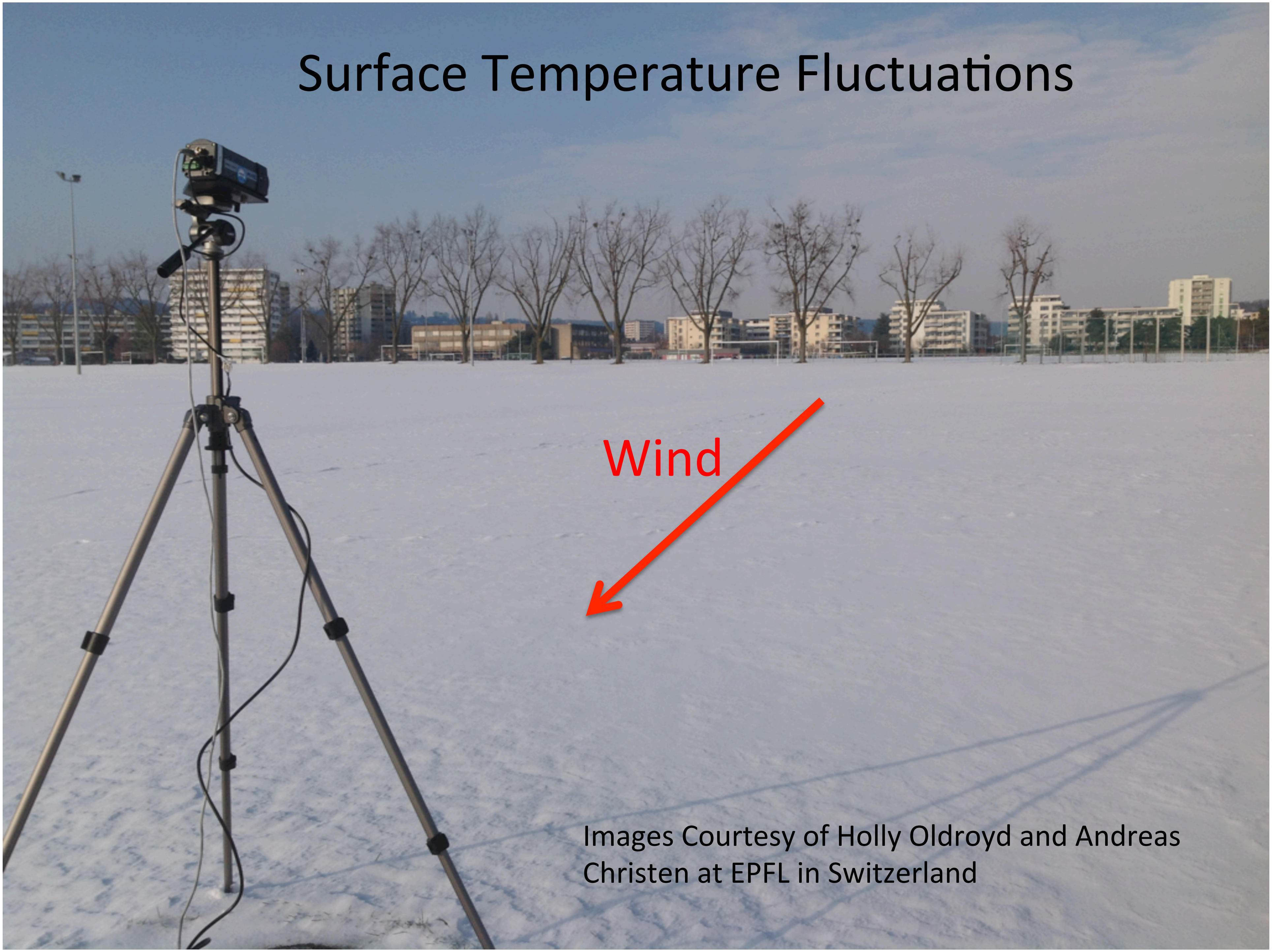
$$\varepsilon = \int_{3\,\mu m}^{100\,\mu m} \varepsilon_\lambda d\lambda$$

Albedo of wet grass is a few % less than dry grass

Surface/Skin Temperature

- T_s - The temperature at the air-soil interface. For an "ideal" surface which varies in time in response to energy fluxes at the surface
  - Depends on:
    - *Radiation Balance*
    - *Surface exchange processes*
    - *Vegetative cover*
    - *Thermal properties of the subsurface*
  - Difficult to Measure (very large temperature gradients near the surface both in the air & soil)
    - Extrapolate air/soil temps
    - Radiometer – uses $R_L \uparrow \sim -\varepsilon\sigma T_s^4$

Surface Temperature Fluctuations



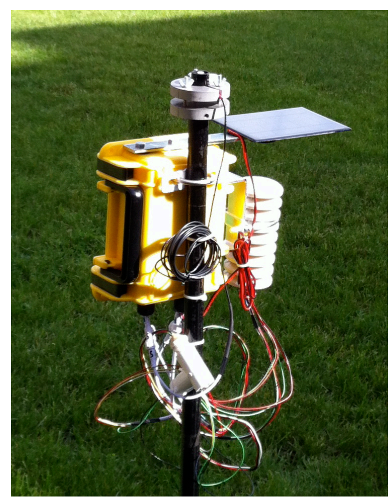
Images Courtesy of Holly Oldroyd and Andreas Christen at EPFL in Switzerland

Arduino Microprocessors For Observation

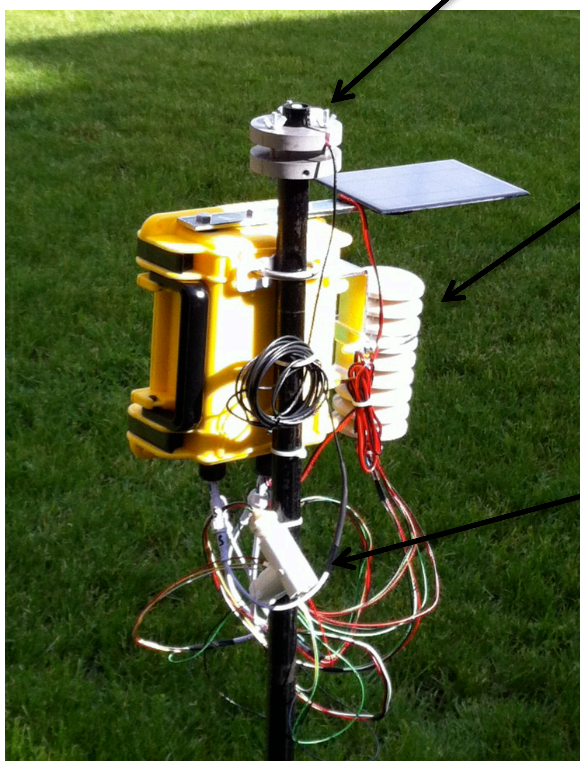
www.arduino.com

- Open hardware platform

- Useful webstites:
- Arduino -
  - blog with projects inspiration
  - forum good for help
- Sparkfun
  - Kits getting start - sensing
  - http://www.sparkfun.com/categories/157
- Adafruit - data logging shield
- 4PCB.com
- http://tronixstuff.wordpress.com/
- Even just Google searches
- http://www.digi.com/xbee/



LEMS
Local Energy-budget station



HOBOs – Stationary Air Temperature/ Relative Humidity

Mobile Measurements

- Infrared Thermometer – measures surface radiation and computes a temperature from:
- Stephan-Boltzman Law: $R_L \uparrow \sim -\varepsilon\sigma T_s^4$
- Air Temperature - Thermistor
- Relative Humidity – Capacitive Sensor