# Biosphere 2 Landscape Evolution Observatory

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## *LEO video:*

*produced by Shipherd Reed and Ruben Ruiz, Biosphere 2*

*Biosphere 2 YouTube channel*

# First Major Renovation of Biosphere 2

1. ***Farm soil was removed and related infrastructure was demolished***
2. ***Intense planning sessions involving scientists from around the country and from many different science disciplines occurred during 2007-2009 to plan this new flagship project of Biosphere 2***
3. ***It was decided to construct physical models of mountain slopes to study relationships among geology, hydrology, chemistry, ecology, and atmospheric science at a large scale – The Biosphere 2 Landscape Evolution Observatory***

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EOS

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

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VOLUME 90 NUMBER 14 7 APRIL 2009

EOS

## The Hills Are Alive: Earth Science in a Controlled Environment

—TRAVIS HUXMAN, PETER TROCH, JON CHOROVER, DAVID D. BRESHEARS, SCOTT SALESKA, JON PELLETIER, XUBIN ZENG, and JAVIER ESPELETA, Biosphere 2 Earth Science, University of Arizona, Tucson; E-mail: patroch@hwr.arizona.edu

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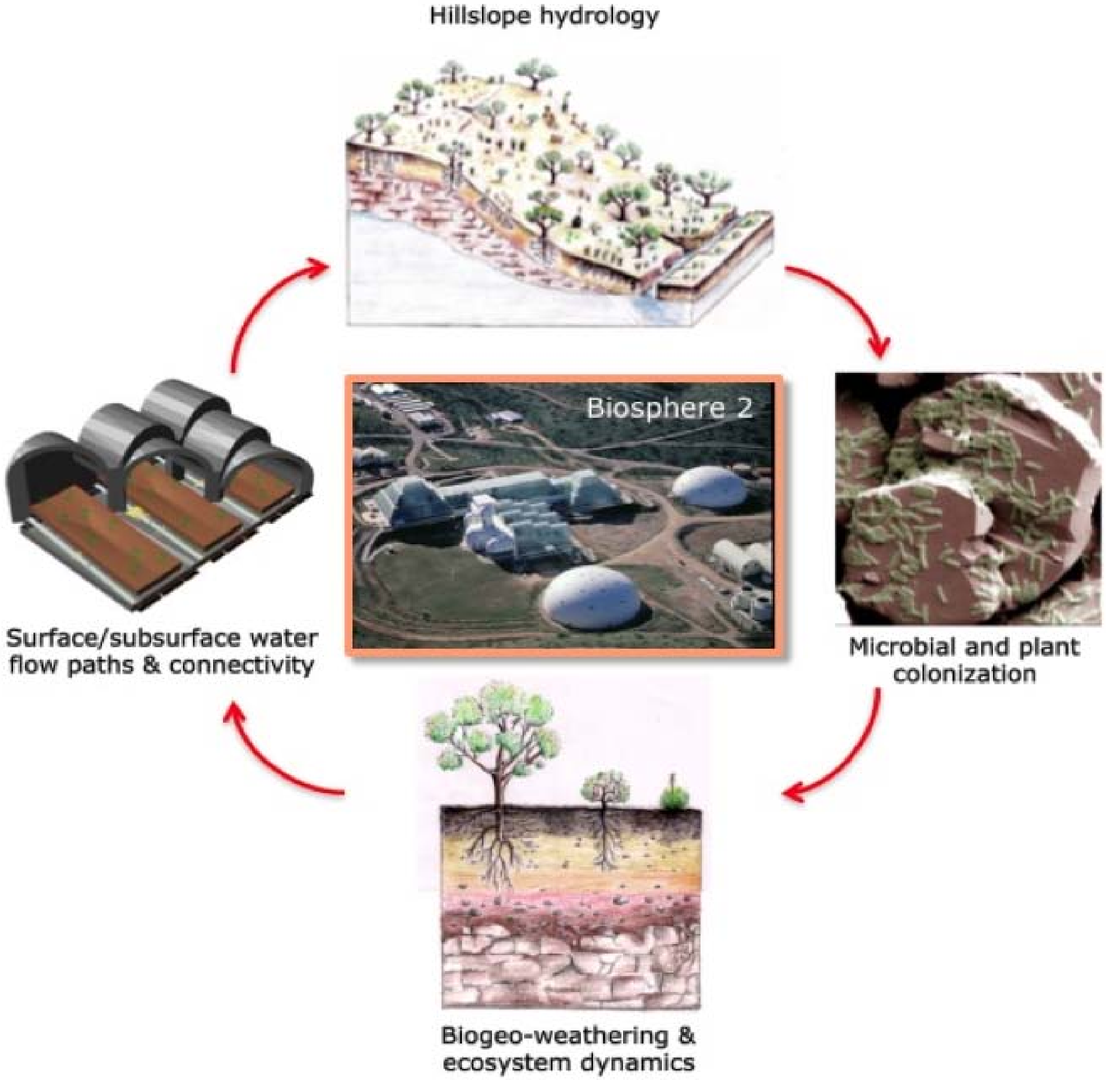

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Hydrol. Earth Syst. Sci., 13, 2105–2118, 2009
www.hydrol-earth-syst-sci.net/13/2105/2009/


Hydrology and
Earth System
Sciences

**Hillslope hyd ... al questions**
**of soil-water**

L. Hopp[1], C. Harman
[1]Department of Forest ... SA
[2]Department of Geogra
[3]Department of Hydrol
[4]Department of Crop a

1. What are the key considerations and constraints that need to be incorporated into the hillslope design from a hydrologic perspective?

2. How can modeling methodologies and results be used to guide the design process and develop a base hillslope design?

3. What are the effects of different climate regimes (as possible treatments in the overall experiment) on the hydrologic behavior of the simulated base hillslope design?

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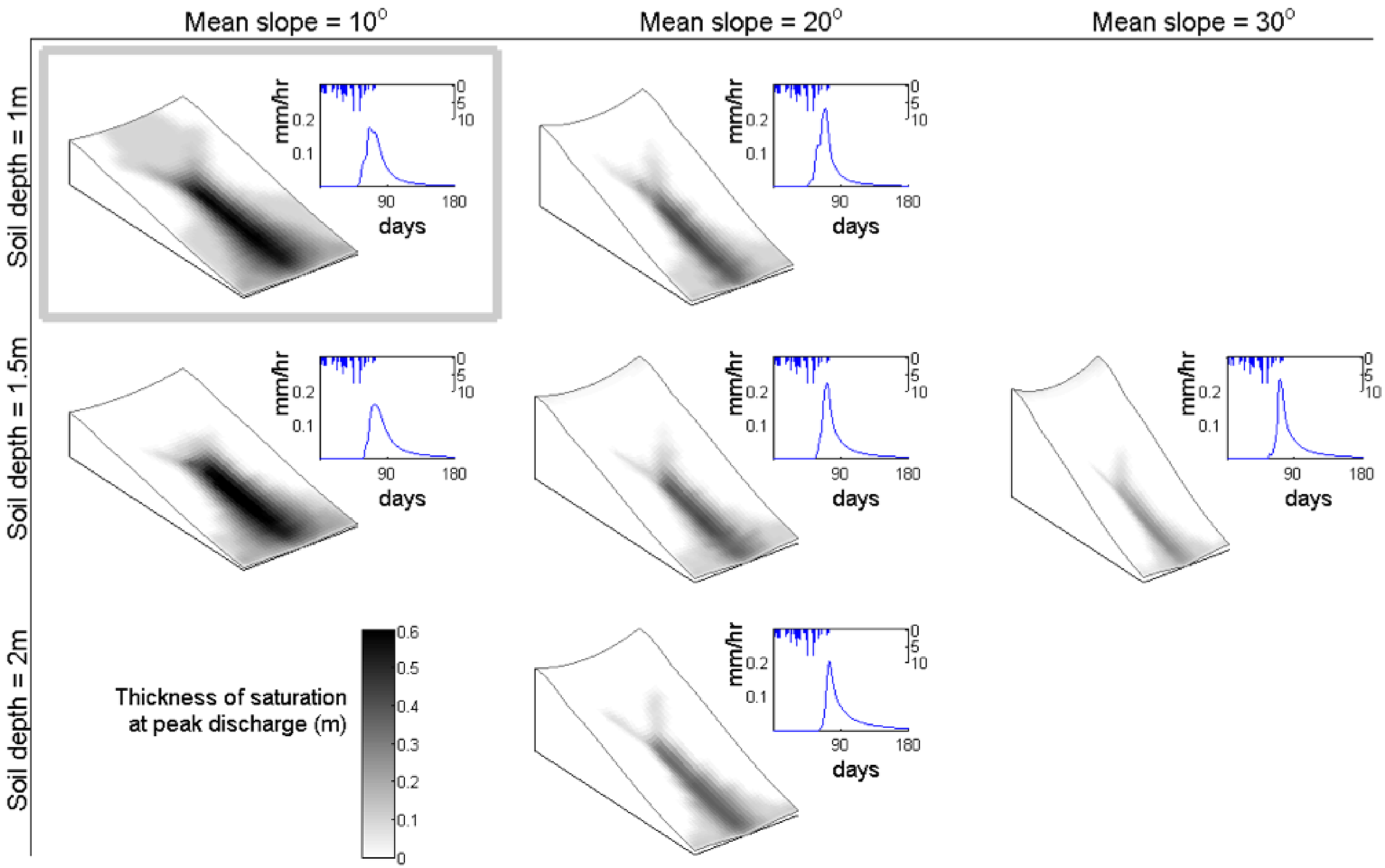

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Hydrol. Earth Syst. Sci., 13, 2273–2286, 2009
www.hydrol-earth-syst-sci.net/13/2273/2009/


Hydrology and Earth System Sciences

## Solid phase evolution in the Biosphere 2 hillslope experiment as predicted by modeling of hydrologic and geochemical fluxes

**K. Dontsova[1,2], C. I. Steefel[3], S. Desilets[4], A. Thompson[5], and J. Chorover[1,2]**

[1]B2 Earthscience, The University of Arizona, Tucson, AZ, USA
[2]Department of Soil, Water & Environmental Science, The University of Arizona, Tucson, USA
[3]Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA
[4]Department of Hydrology and Water Resources, The University of Arizona, Tucson, AZ, USA
[5]Department of Crop and Soil Sciences, University of Georgia, Athens, GA, USA

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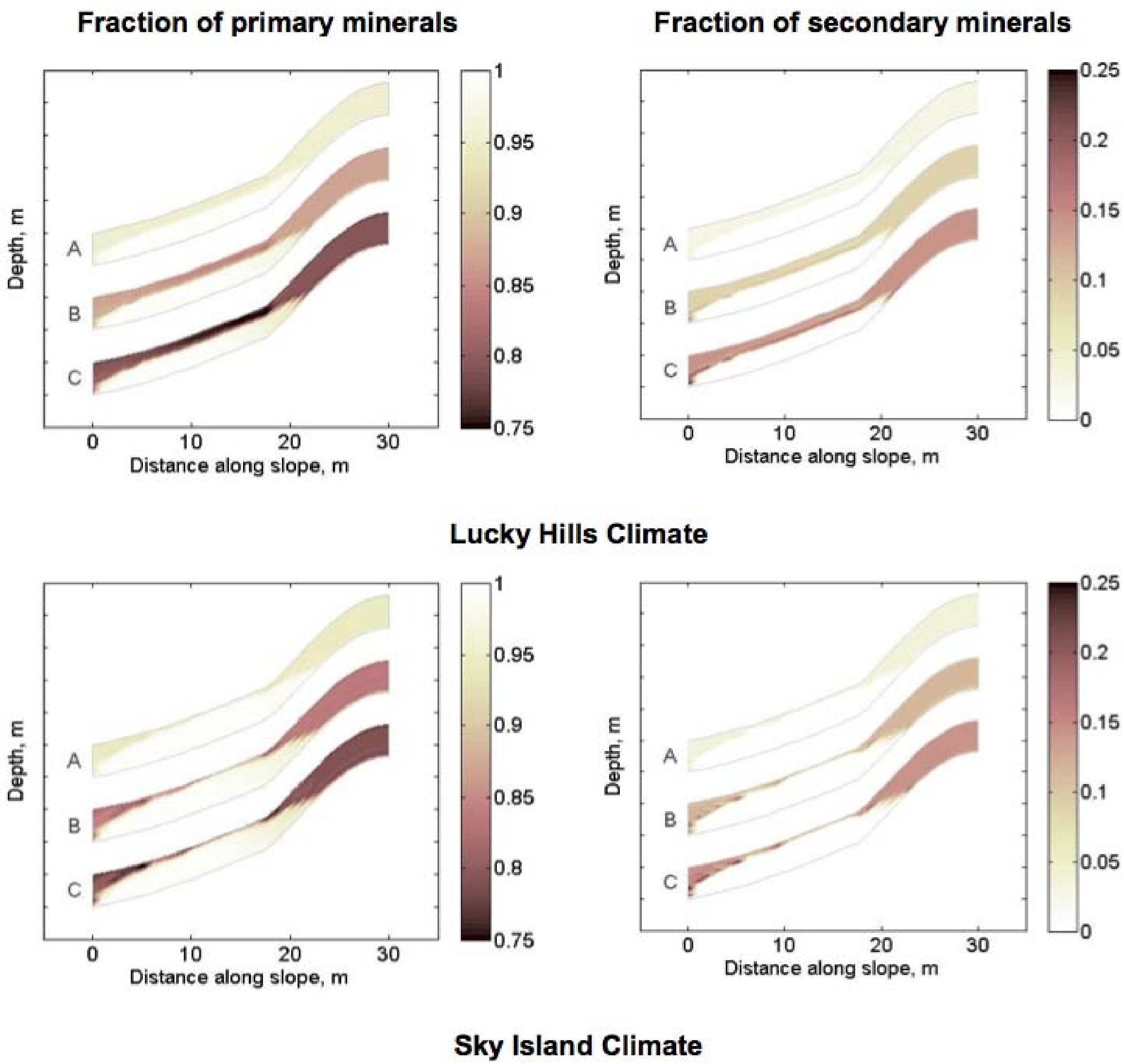

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WATER RESOURCES RESEARCH, VOL. 46, W09521, doi:10.1029/2009WR008611, 2010

# Hysteresis of soil moisture spatial heterogeneity and the "homogenizing" effect of vegetation

Valeriy Y. Ivanov,[1] Simone Fatichi,[1,2] G. Darrel Jenerette,[3] Javier F. Espeleta,[4] Peter A. Troch,[4,5] and Travis E. Huxman[4,6]

[1]Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, Michigan, USA.

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[3]Department of Botany and Plant Sciences, University of California, Riverside, California, USA.

[4]Biosphere 2, University of Arizona, Tucson, Arizona, USA.

[5]Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona, USA.

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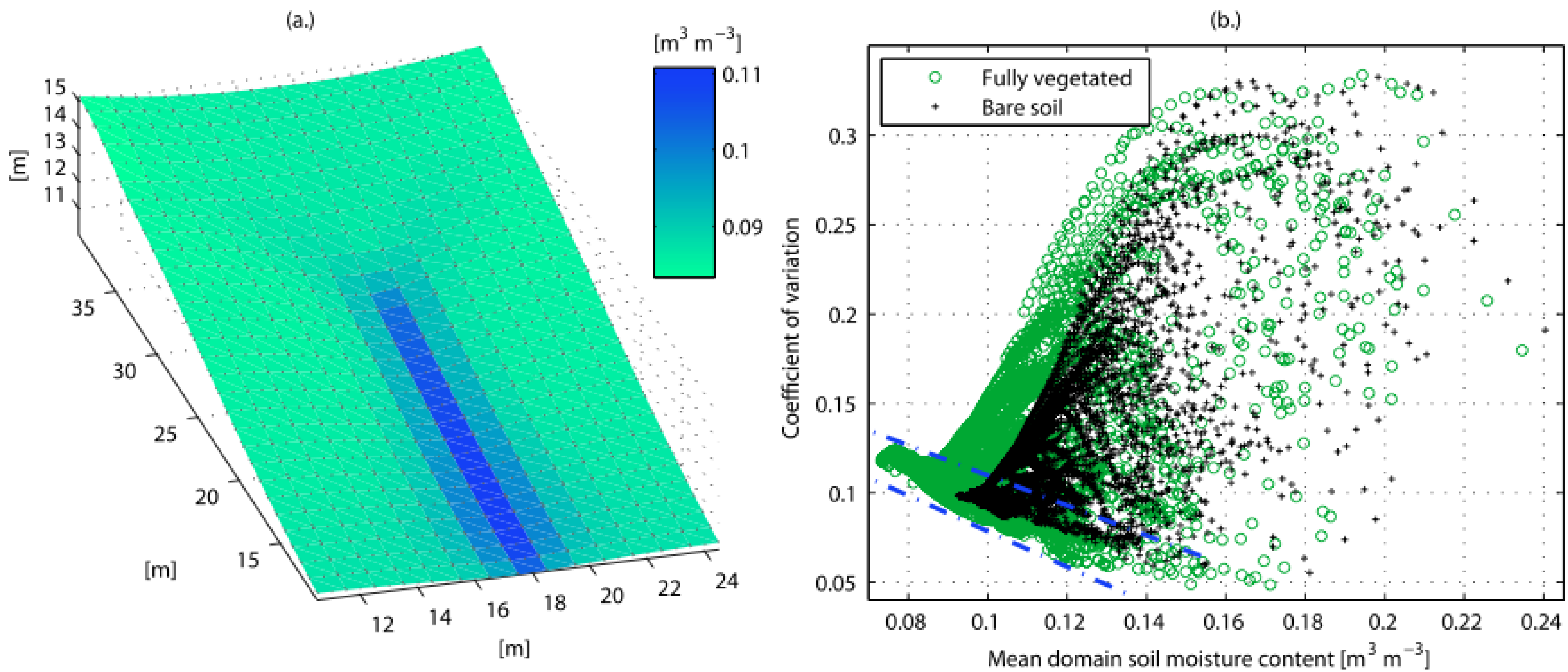


**Figure 1.** The results of continuous 11-year long simulations illustrating (a) the spatial distribution of mean root soil moisture and (b) the coefficient of variation of depth-integrated soil moisture content as a function of its mean daily value over the Biosphere 2 domain. The results correspond to fully vegetated (Figures 1a and 1b) and bare soil (Figure 1b) scenarios.

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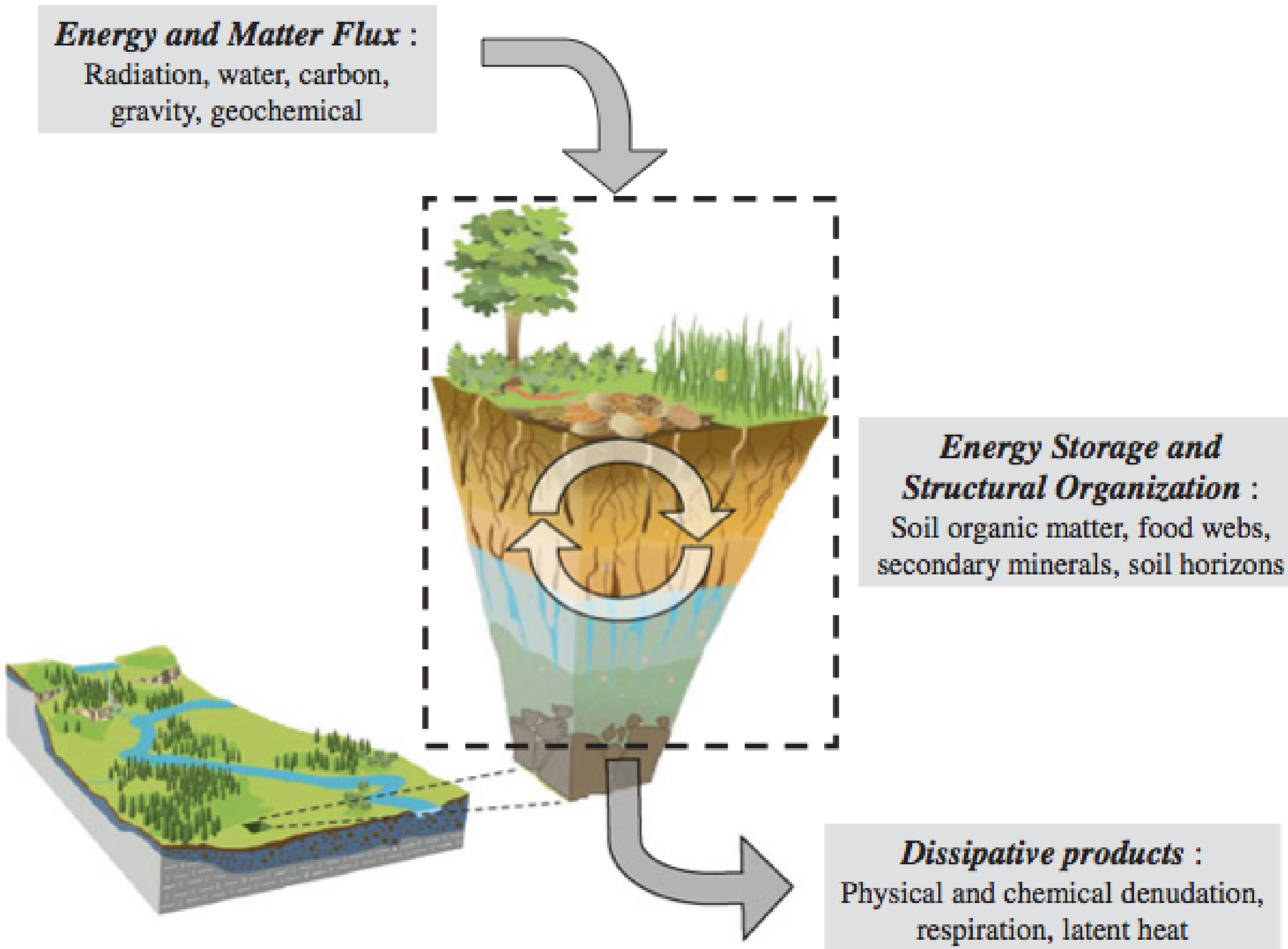
**Fig. 1** Conceptual model of the critical zone system; the dashed line indicates the open system boundary as defined for the model derivation presented herein. The relative energy and mass transfer components include (i) energy and mass flux into the critical zone, (ii) energy storage within the critical zone, and (iii) export of dissipative products from the system to its surrounding environment. Figure modified from Chorover et al. (2007) and Rasmussen et al. (2005). Schema here is presented as vertical flow for simplicity of presentation, but the model is not limited to 1-dimensional fluxes



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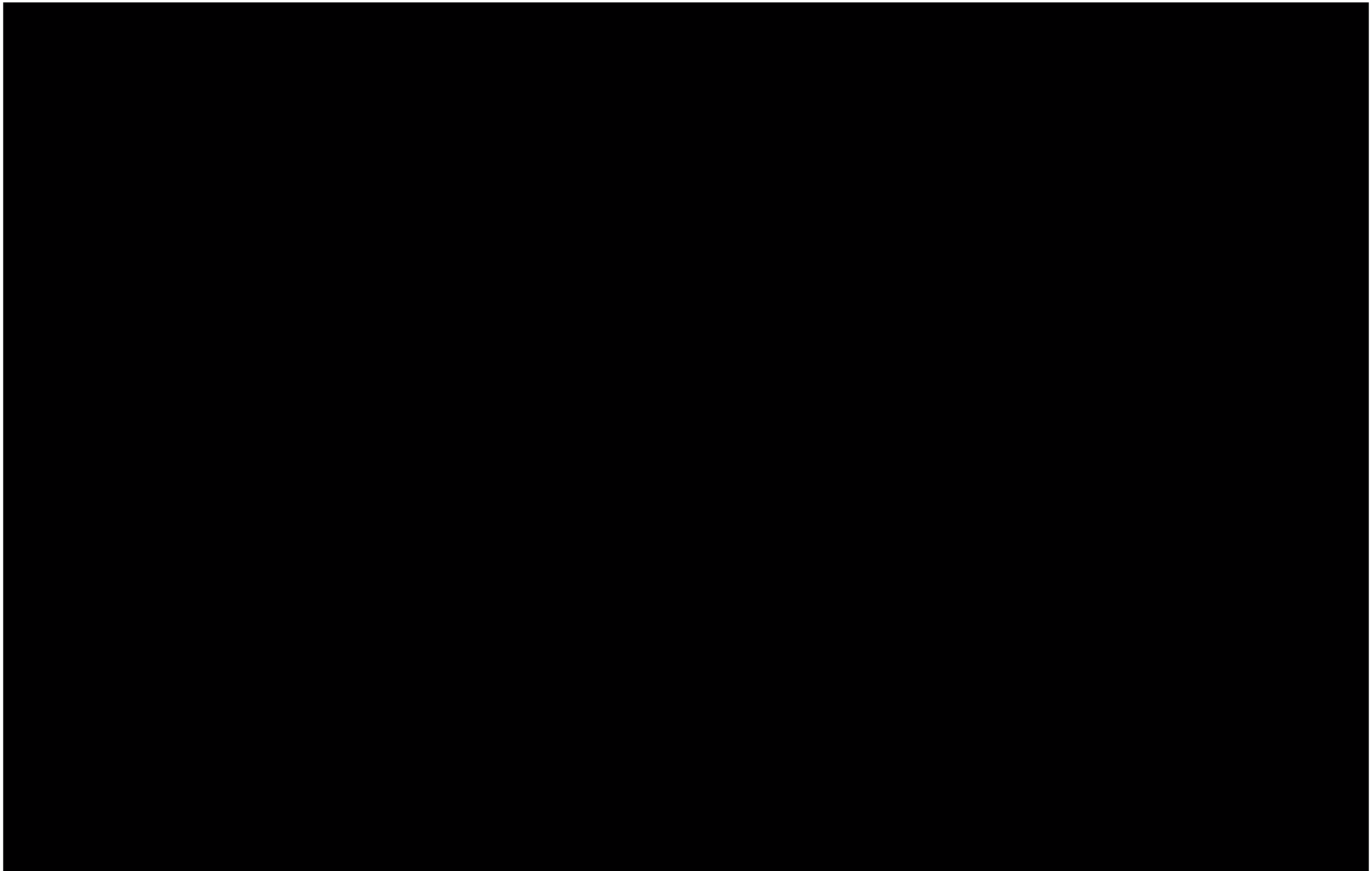

# Why build physical models of mountain slopes?

1. ***How does water move through landscapes to get to rivers, etc?***
2. ***How might the way water moves through landscapes change in future climate scenarios, and how will that affect water resources for people?***
3. ***How does the water, energy, and carbon cycles interact at the Earth's surface?***
4. ***How do biological systems modify landscapes?***

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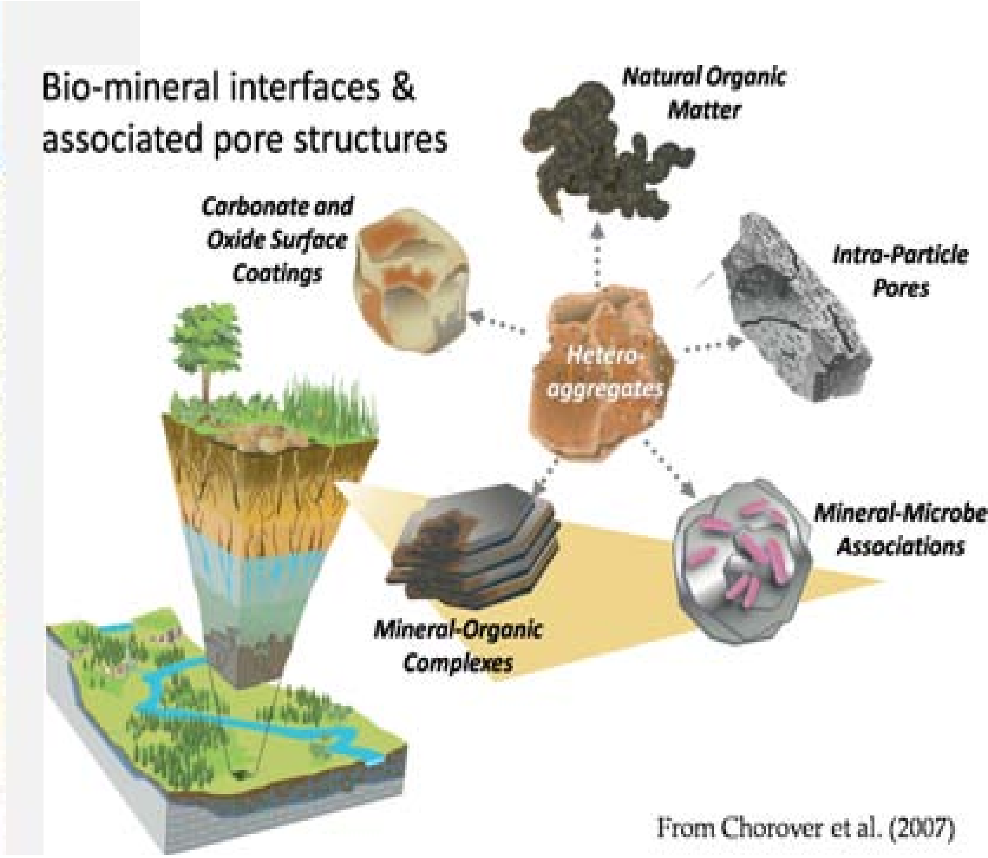


*Landscape scale*

*Soil pit scale*

***Water Cycle***

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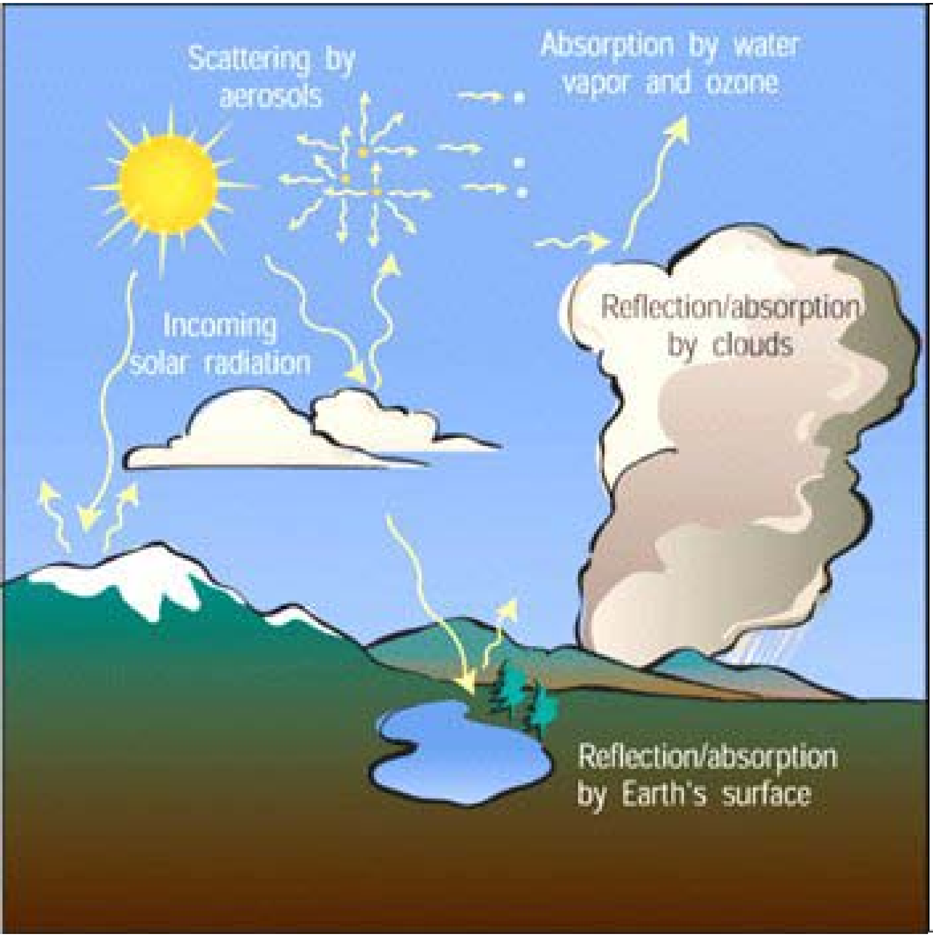
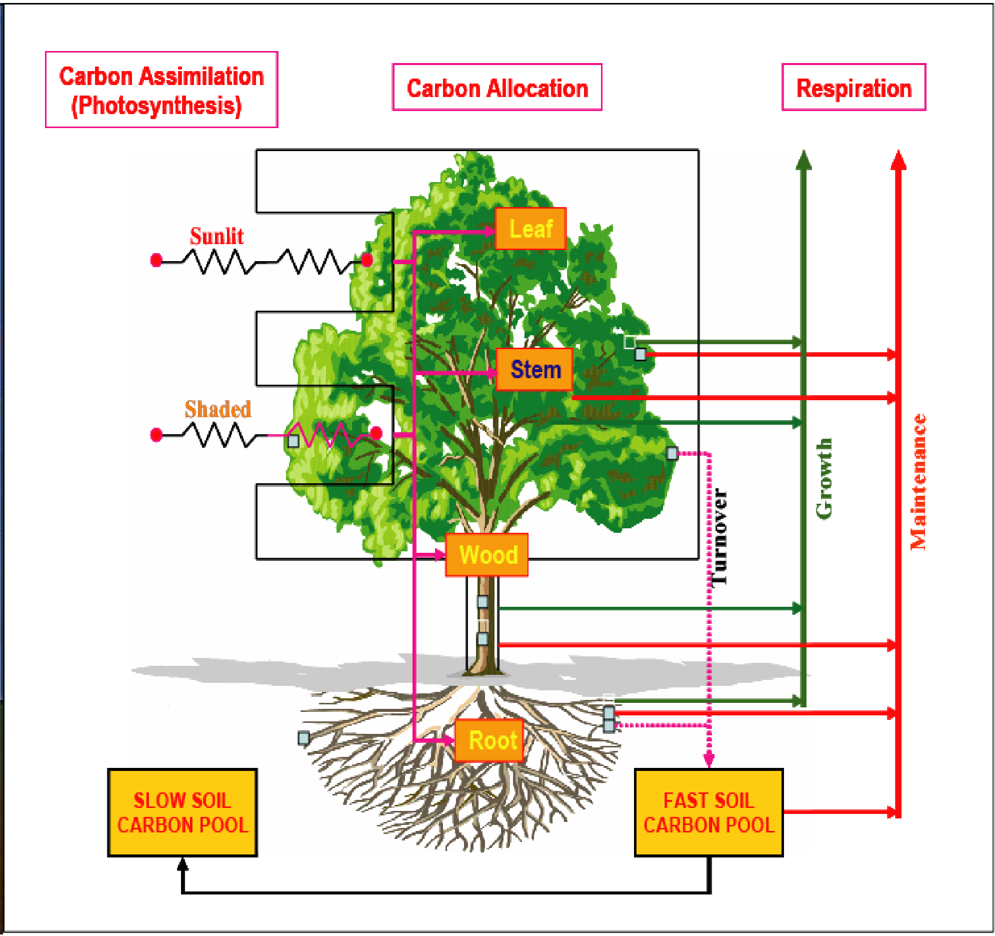



*Energy Cycle*




*Carbon Cycle*

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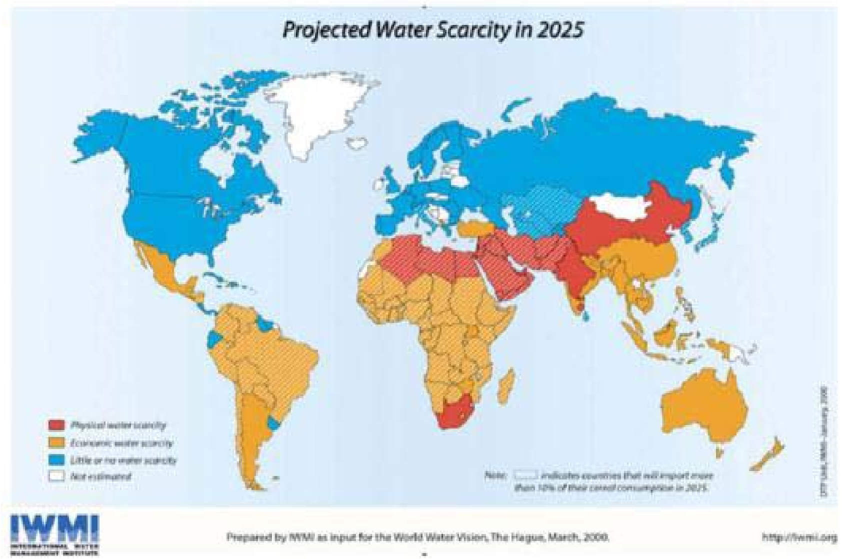
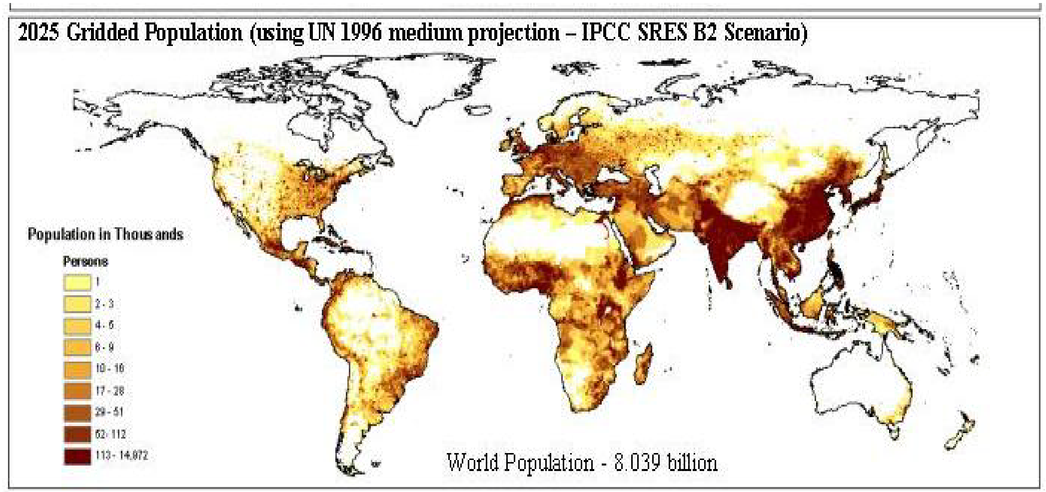
- *As land use, climate, and vegetation change, the availability of surface water (and ground water) will change*
- *This could be particularly problematic in arid and overpopulated regions*
- *In arid regions such as Arizona, high-elevation areas are natural “water towers” and mountain slopes transfer water to rivers and aquifers*



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*At Biosphere 2 we are building physical models of natural slopes to address these issues.*

- *We can control the environment in B2, and make denser (in time and space) measurements in constructed slopes than in natural systems.*
- *Because we are designing and building it, we will know the internal structure and "initial conditions" – **we never really know these in natural systems***

# Biosphere 2 Landscape Evolution Observatory

*360 $m^2$ hillslope forms*

*1 meter of engineered soil*

*Thousands of environmental sensors to measure water, energy, carbon  and geochemical fluxes through soil, plants, atmosphere*

# Biosphere 2 Landscape Evolution Observatory

- *Overarching scientific goals:*
  - *How will the carbon, water, and energy cycles change as climate changes?*
  - *How do physical and biological systems coevolve?*
- *Technical project goals:*
  - *High-precision and real-time quantification of hydrological partitioning at hillslope scale - in space and time*
  - *Determination of rates and climatic controls on solid-phase geochemical evolution*
  - *Quantification of rain-splash and overland flow erosion*
  - *Observation of microbial and vegetative colonization*
  - *Study of coupling among vegetation, hydrology, climate and lithology at hillslope scale*

*Each of these goals also drive us towards the goal of improved coupled Earth-systems computational models*

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*Construction began 7/29/2011 after ~18 months of engineering design, contractor selection, etc.*

UA School of Architecture/Biosphere 2

LEO
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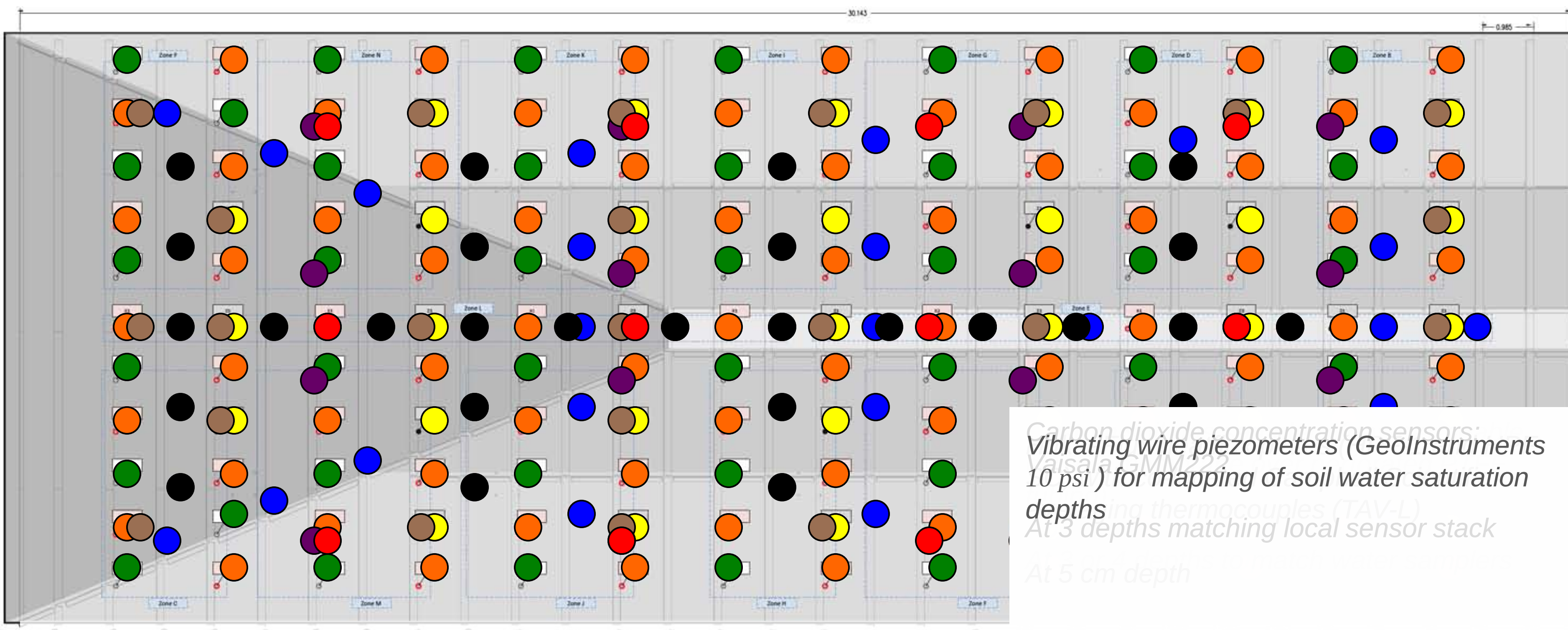
*The backbone of our approach to coupled Earth systems science is the dense LEO sensor network and associated cyberinfrastructure, which is being developed in-house and in collaboration with UA ECE*




*Vibrating wire piezometers (GeoInstruments 10 psi ) for mapping of soil water saturation depths*

***Each LEO hillslope will have 1,835 sensors embedded in the "soil" material***

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*LEO will be the world's largest weighing lysimeters, and the only place that the full water budget can be balanced in real time at the landscape scale*

To fulfill this objective, the *in situ* sensor network will be complemented by:

- An engineered rain system capable of 0.5 – 5.0 cm/hr
- Mag flow meters to measure precipitation flux
- Mag and tipping bucket meters to measure soil water flux at seepage face
- Overland flow flux measurement and collection system
- Custom load cells embedded into steel structure that will monitor system weight in real time at 0.05% precision or better, so that total water content is always known.
- Atmospheric instrumentation

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*LEO is already a nexus for integrated science*

The Biosphere 2 research faculty is poised to work with faculty members from campus to operate LEO, to foster collaboration beyond the institution, and to run a truly interdisciplinary Earth systems science research institute with LEO as its unifying focus.

*LEO construction began July 29, 2011, and will take an estimated 15 months to complete*

**Several ongoing activities include assessment of early-stage soil microbiology, planning activities related to vegetation selection, and a growing outreach, education, and documentation effort.**

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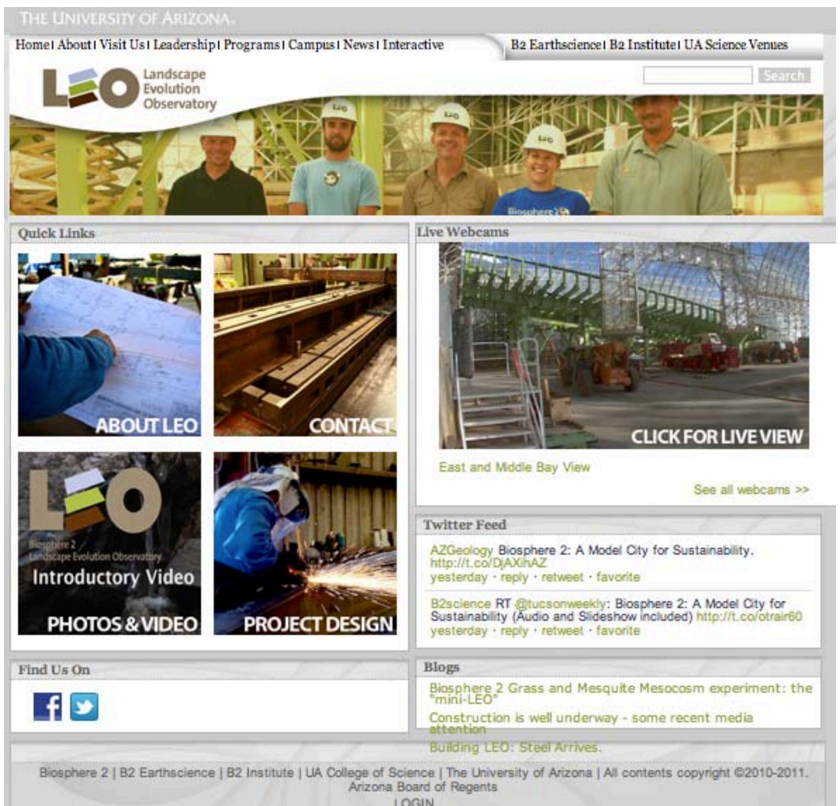
***The LEO project serves as a tool for STEM education, public outreach, and is being professionally documented as it is constructed and operated***

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LEO Exhibit Coordinator

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*leo.b2science.org*

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