Session 3
Extreme Events: Predictability

Summary and Thoughts

Paul Dirmeyer, Michael Ek, Gianpaolo Balsamo

Keynote Presentations

- Two perspectives from the heads of land-model groups of two major operational weather/climate forecast centers:
  - Gianpaolo Balsamo (European Centre for Medium-range Weather Forecasts)
  - Michael Ek (National Centers for Environmental Prediction / National Weather Service)

Other presentations

- Ervin Zsoter, ECMWF, UK: "*Discharge Modelling Experiments with the TIGGE Archive*"
- Abdul Wahid Mohamed Rasmy, The University of Tokyo, Japan: "*Application of Multi-Frequency Passive Microwave Observations and Data Assimilation Strategies for Improving Numerical Weather Forecasting in the Developing Regions*"
- Qinjian Jin, Zong-Liang Yang, and Jiangfeng Wei: "*Modeling of Radiative Effects of Middle East Dust on Indian Summer Monsoon System*" [poster]

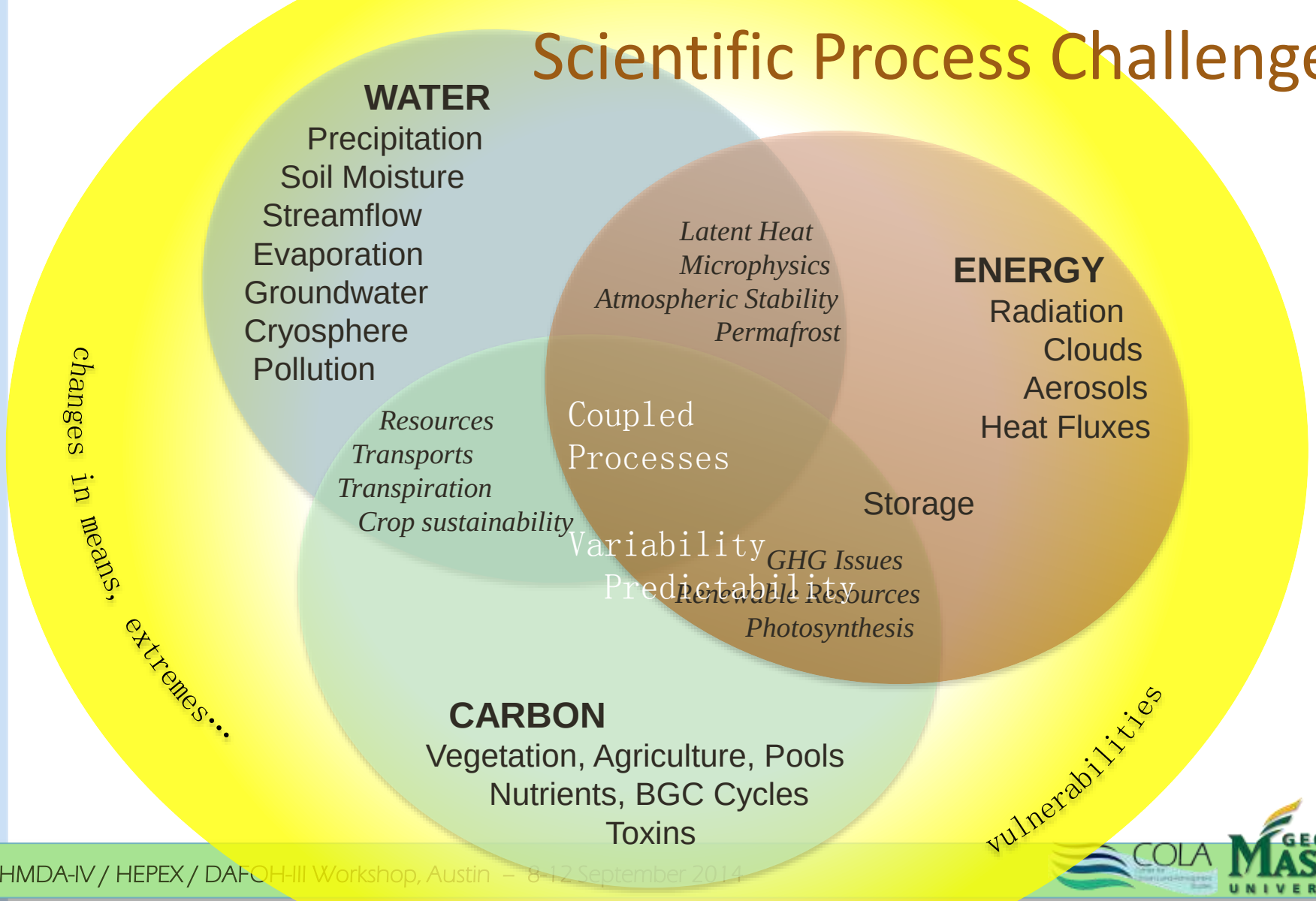
Land-Atmosphere Predictability Paradigm

- Coupling
  - When and where is there an active feedback between land surface states and the atmosphere?
  - Two-legged: land state--surface flux; surface flux--atmospheric properties/processes.
- Variability
  - A correlation results in a significant impact only where the forcing fluctuates sufficiently in time – source of extremes.
- Memory
  - If the forcing anomaly does not persist, the impact will be brief, minimal.

Representing the "Real World"

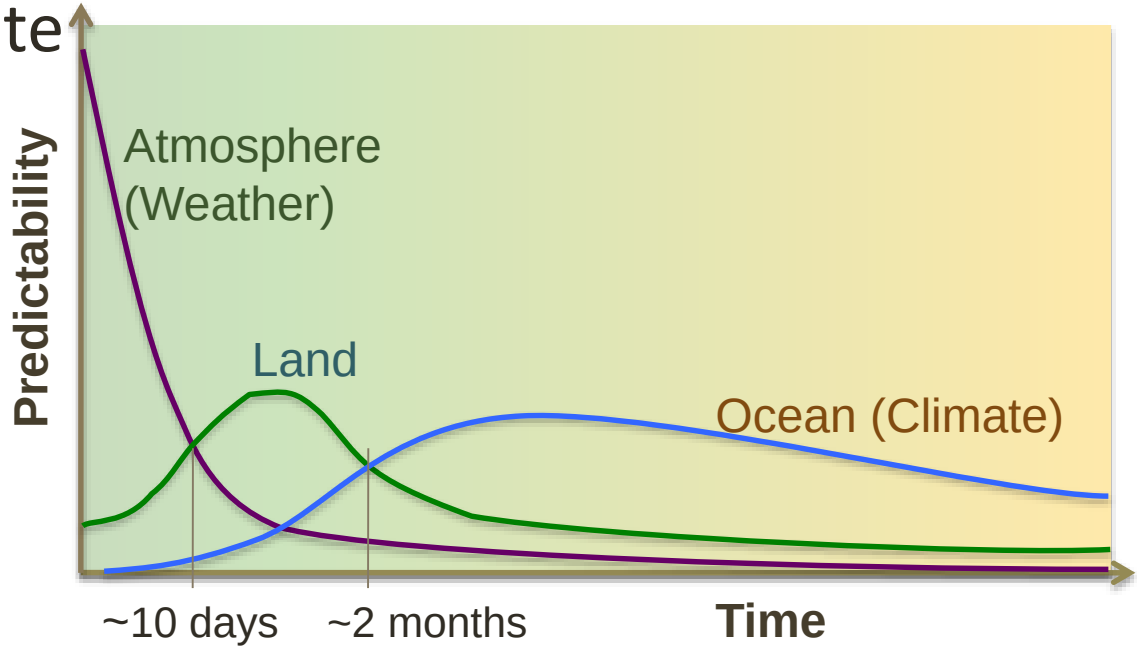
- Realizable predictability requires potential predictability (as an inherent property of the hydrologic system), and…
- A means to exploit the predictability (adequate models, which may be physically-based, statistical, a blend of the two)
- Progress will ultimately be limited without developing understanding of the physical system, processes, linkages, causes and effects.

Scientific Process Challenges



Predictability and Prediction

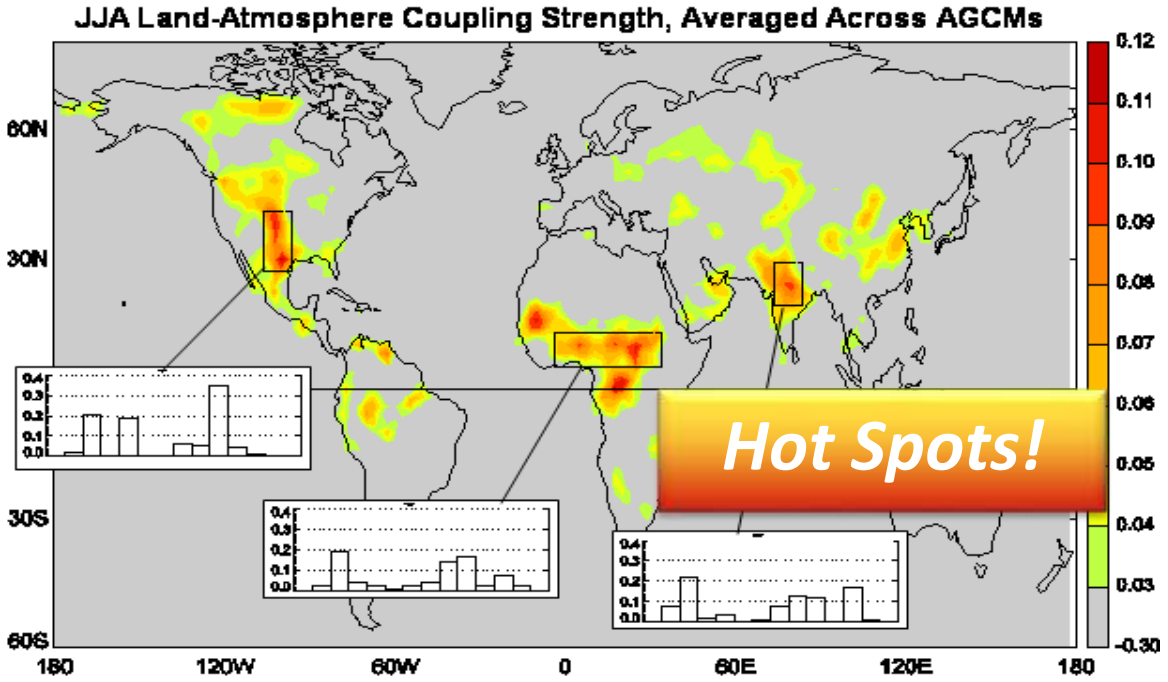
- Land states (namely soil moisture*) can provide predictability in the window between deterministic (weather) and climate (O-A) time scales.
- The 2-4 week "subseasonal" range is a hot topic in operational forecast centers now.



*Snow and vegetation too!

Global Land-Atmosphere Coupling Experiment

- Global models indicate "hot spots" of land-atmosphere coupling strength, several of which are in monsoon regions, namely India & Africa.
- Related model research shows South Africa, South America and Australia have hot spots in austral summer as well.
- Indicates potential predictability from the land surface!

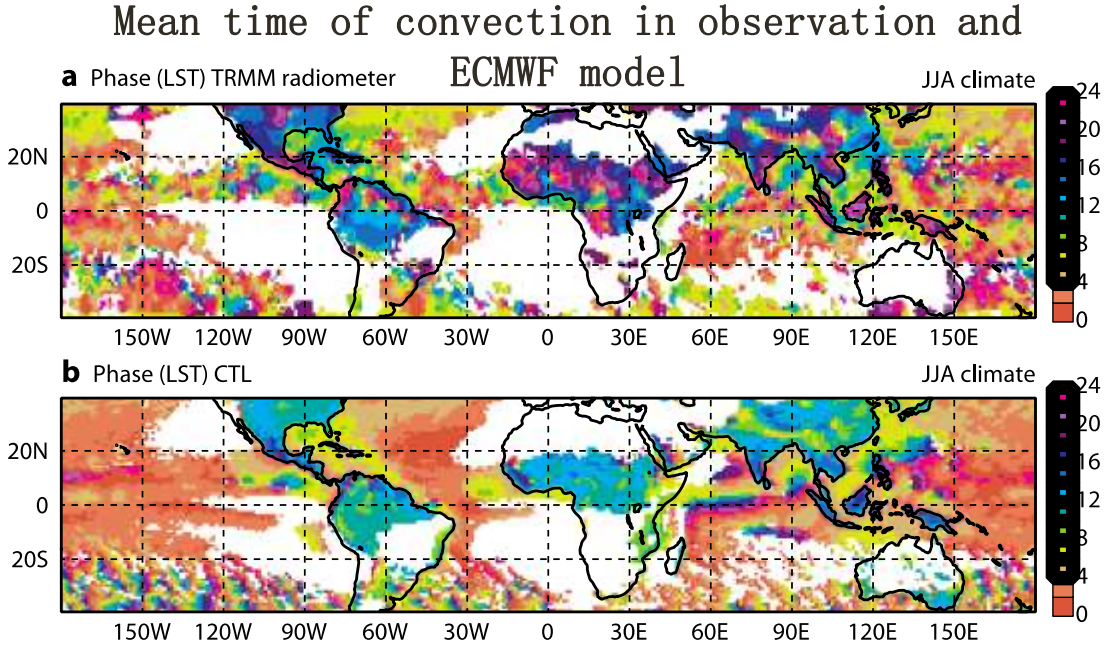


Koster, R. D., P. A. Dirmeyer, Z. Guo, G. Bonan, E. Chan, P. Cox, H. Davies, T. Gordon, S. Kanae, E. Kowalczyk, D. Lawrence, P. Liu, S. Lu, S. Malyshev, B. McAvaney, K. Mitchell, T. Oki, K. Oleson, A. Pitman, Y. Sud, C. Taylor, D. Verseghy, R. Vasic, Y. Xue, and T. Yamada, 2004: Regions of strong coupling between soil moisture and precipitation. *Science*, 305, 1138-1140.

Model Biases

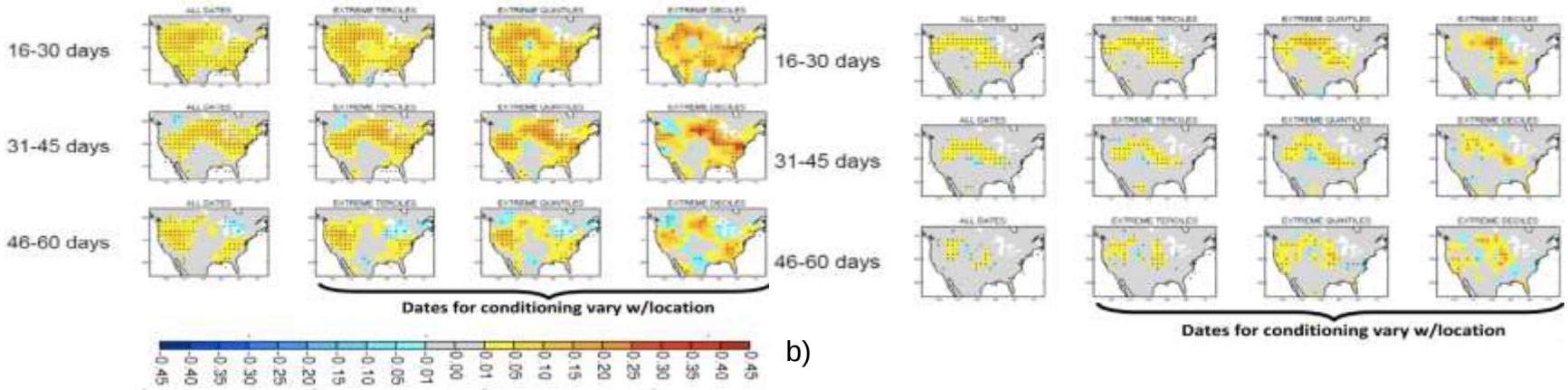
- Continental convection poorly represented in GCMs
- Drizzle-bias (intensity spectrum is poor)
- Incorrect timing (always rains at noon)

⇒What we "give" to our hydrologic and land surface models is not reality.

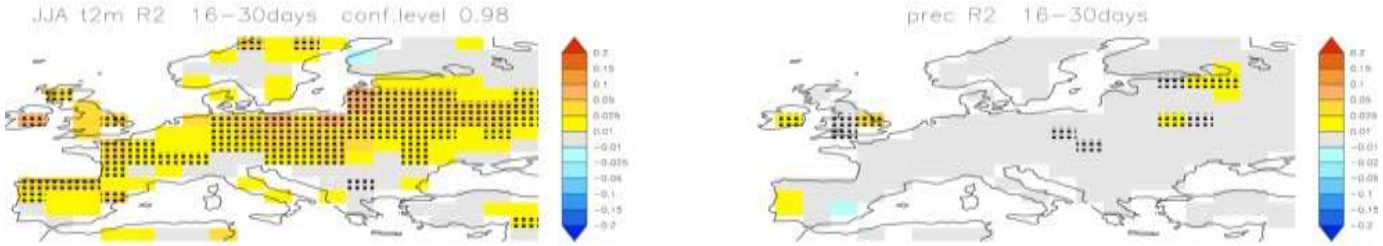


Bechtold, P., N. Semane, P. Lopez, J.-P. Chaboureau, A. Beljaars, and N. Bormann, 2013: Representing equilibrium and non-equilibrium convection in large-scale models, *J Atmos Sci*, **71**, 734–753.

Predictability from soil moisture initialization



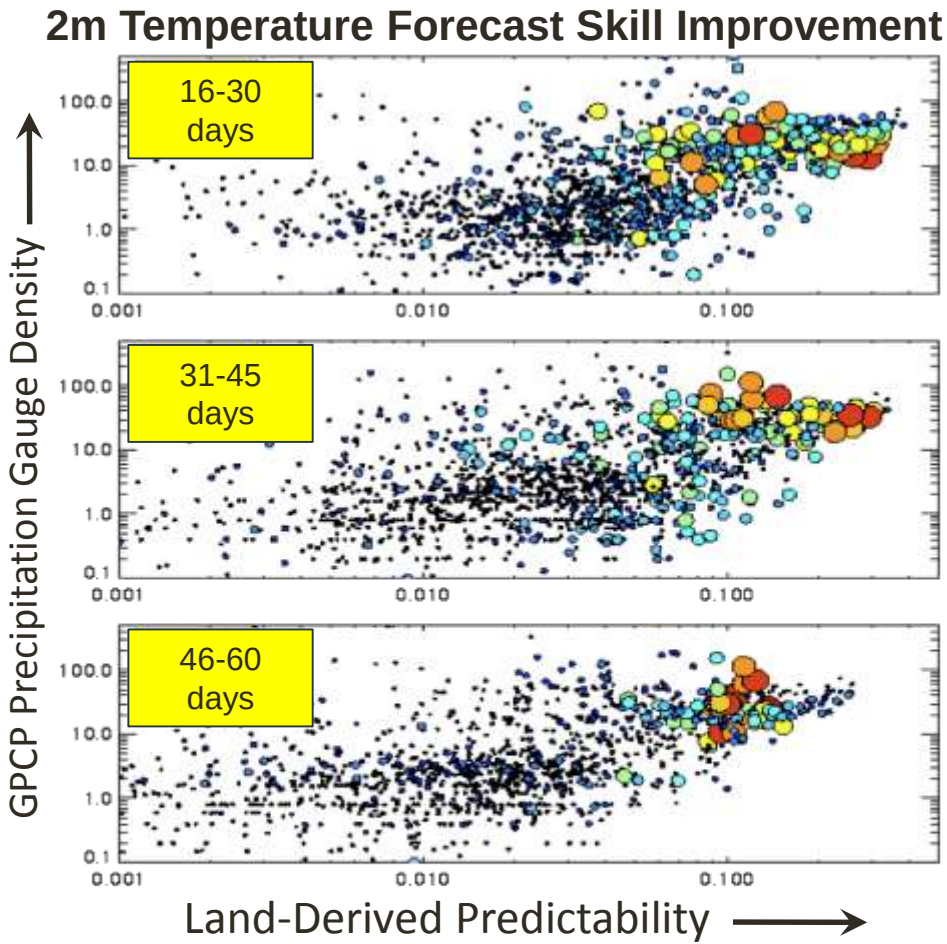
Predictability gain (mesured in r^2) for (a) 2m temperature (b) precipitation when initializing with realistic soil moisture (following GLACE2 Koster et al. 2010). Columns refer to (i) all dates, (ii) dates upper terciles, (iii) quintile (iv) decile, according to soil moisture anomaly.



Predictability gain (mesured in r^2) for Europe for 2m temperature (left) and precipitation (right) from van den Hurk et al., (2012) for the 16-30 days of the forecast range.

Skill Contributions

- Even with our flawed models, we see the signature of the observing network.
  - Initial soil moisture states for forecasts come from LSMs driven uncoupled by "observed" meteorology.
  - Where rain gauges are dense, ICs are good, forecast skill benefits most.



Red: Large Improvement

Black: No Improvement

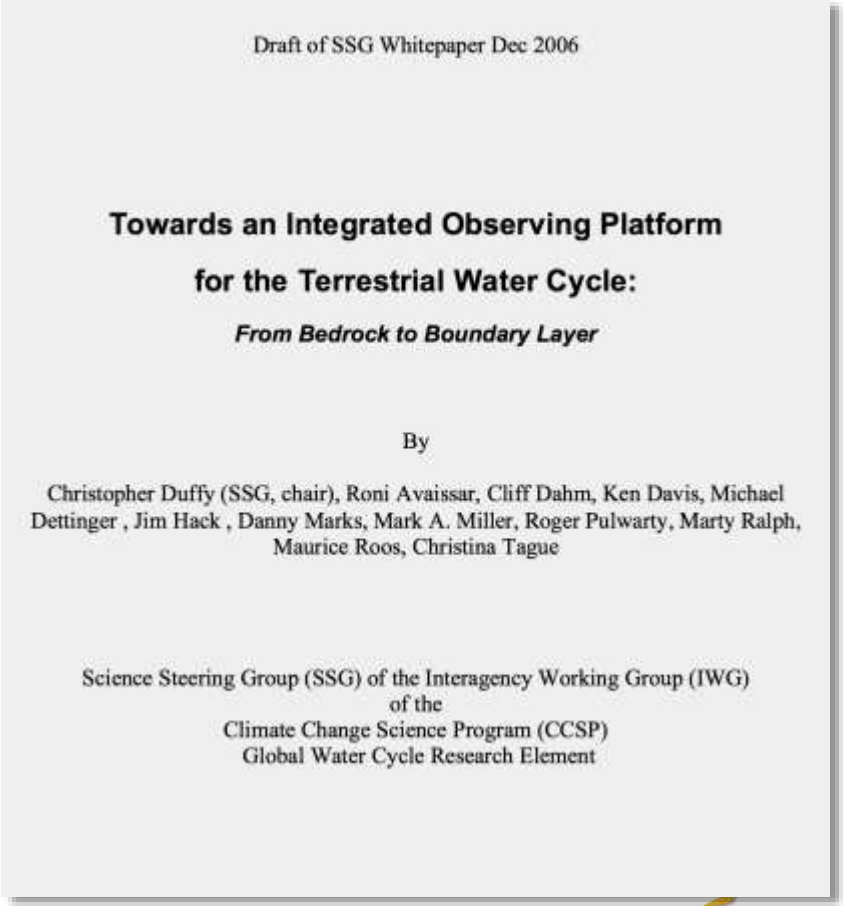
Koster, R. D., and co-authors, 2011: The second phase of the Global Land-Atmosphere Coupling Experiment: Soil moisture contributions to subseasonal forecast skill. *J. Hydrometeor.*, **12**, 805 – 822.

COLA

GEORGE MASON UNIVERSITY

“Bedrock to Boundary Layer”

- All hydrologic cycle states and fluxes are observed, but nowhere at the same place and time.
- To advance our understanding of the processes that link atmosphere, surface, and subsurface, need long-term co-located observations to inform model development, provide calibration and validation data.
- **We under-measure the system!**



Draft of SSG Whitepaper Dec 2006

Towards an Integrated Observing Platform

for the Terrestrial Water Cycle:

From Bedrock to Boundary Layer

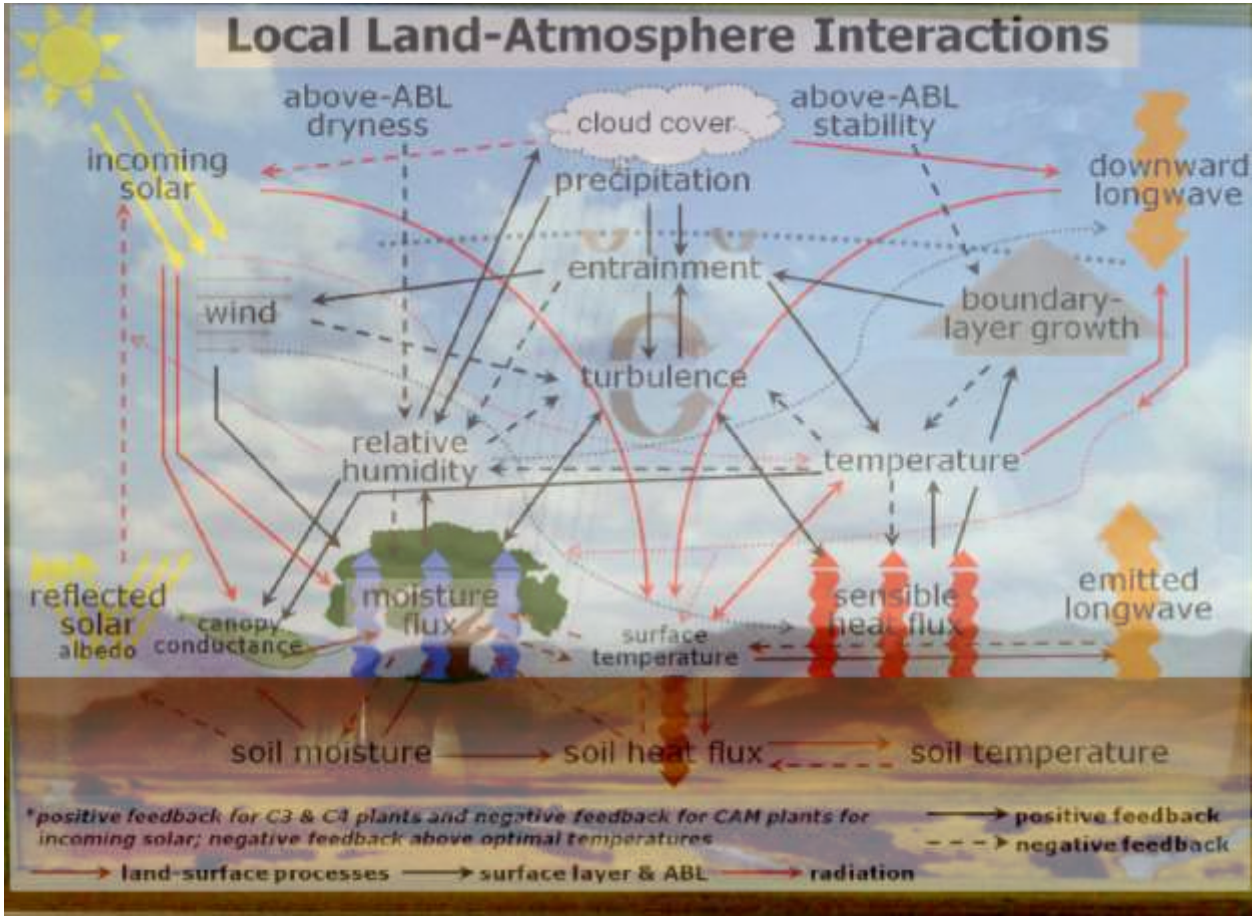
By

Christopher Duffy (SSG, chair), Roni Avaissar, Cliff Dahm, Ken Davis, Michael Dettinger , Jim Hack , Danny Marks, Mark A. Miller, Roger Pulwarty, Marty Ralph, Maurice Roos, Christina Tague

Science Steering Group (SSG) of the Interagency Working Group (IWG)
of the
Climate Change Science Program (CCSP)
Global Water Cycle Research Element

Comments?

Dry Soil Advantage!



Recall the 2001 "Hornberger Report"

Priority Science Questions:

1. What are the underlying causes of variation in the water cycle on both global and regional scales, and to what extent is this variation induced by human activity?
2. To what extent are variations in the global and regional water cycle predictable?
3. How will the variability and changes in the cycling of water through terrestrial and freshwater ecosystems be linked to variability and changes in cycling of carbon, nitrogen and other nutrients at regional and global scales?

Hornberger, G. M., J. D. Aber, J. Bahr, R. C. Bales, K. Beven, E. Foufoula-Georgiou, G. Katul, J. L. Kinter III, R. D. Koster, D. P. Lettenmaier, D. McKnight, K. Miller, K. Mitchell, J. O. Roads, B. R. Scanlon, and E. Smith. 2001. A Plan for a New Science Initiative on the Global Water Cycle. U.S. Global Change Research Program, Washington, D.C., 118pp.