KIAPS
KOREA INSTITUTE OF ATMOSPHERIC PREDICTION SYSTEMS

GEORGE MASON UNIVERSITY

The Impact of Land Surface on Sub-seasonal Atmospheric Prediction and its Variability

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Motivation

Information about the land surface impact on atmospheric prediction and its variability is useful for

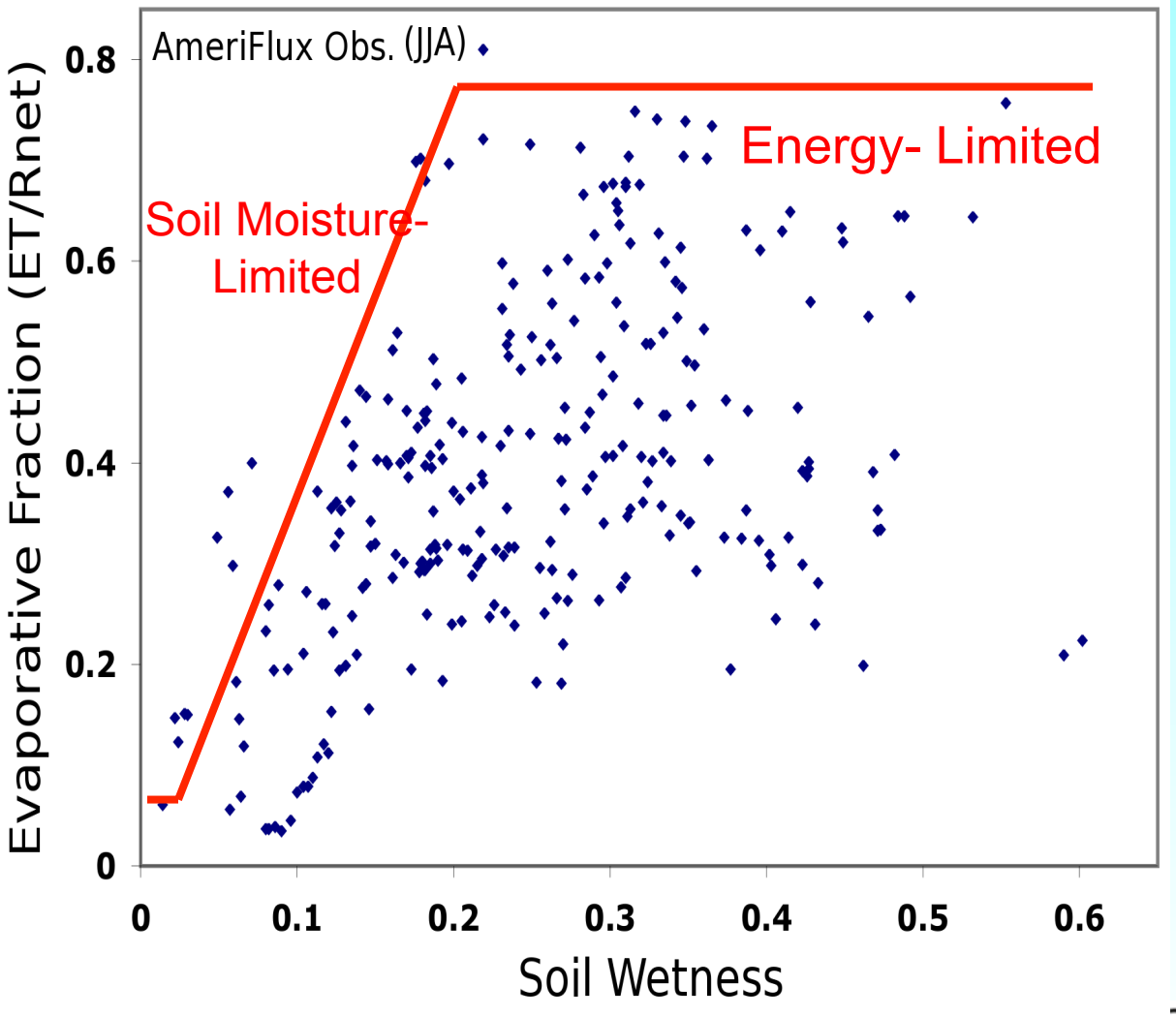
- Understanding how the land surface information contributes to the atmospheric predictability;
- Evaluating how well the land-atmosphere coupling strength is represented in the GCM modeling system, especially with observations;
- Optimizing soil moisture observation network to improve the seasonal and sub-seasonal forecast skill;

Topics expected in this talk

- Land-atmosphere coupling strength, and its temporal variability
- Contribution of land surface initialization to sub-seasonal predictability, its temporal variability, and connection to land-atmosphere coupling strength

Soil Moisture vs. Energy-Limited Regimes

- ✓Hydrological regime
- ✓Inter-annual variability
- ✓Sub-seasonal variability



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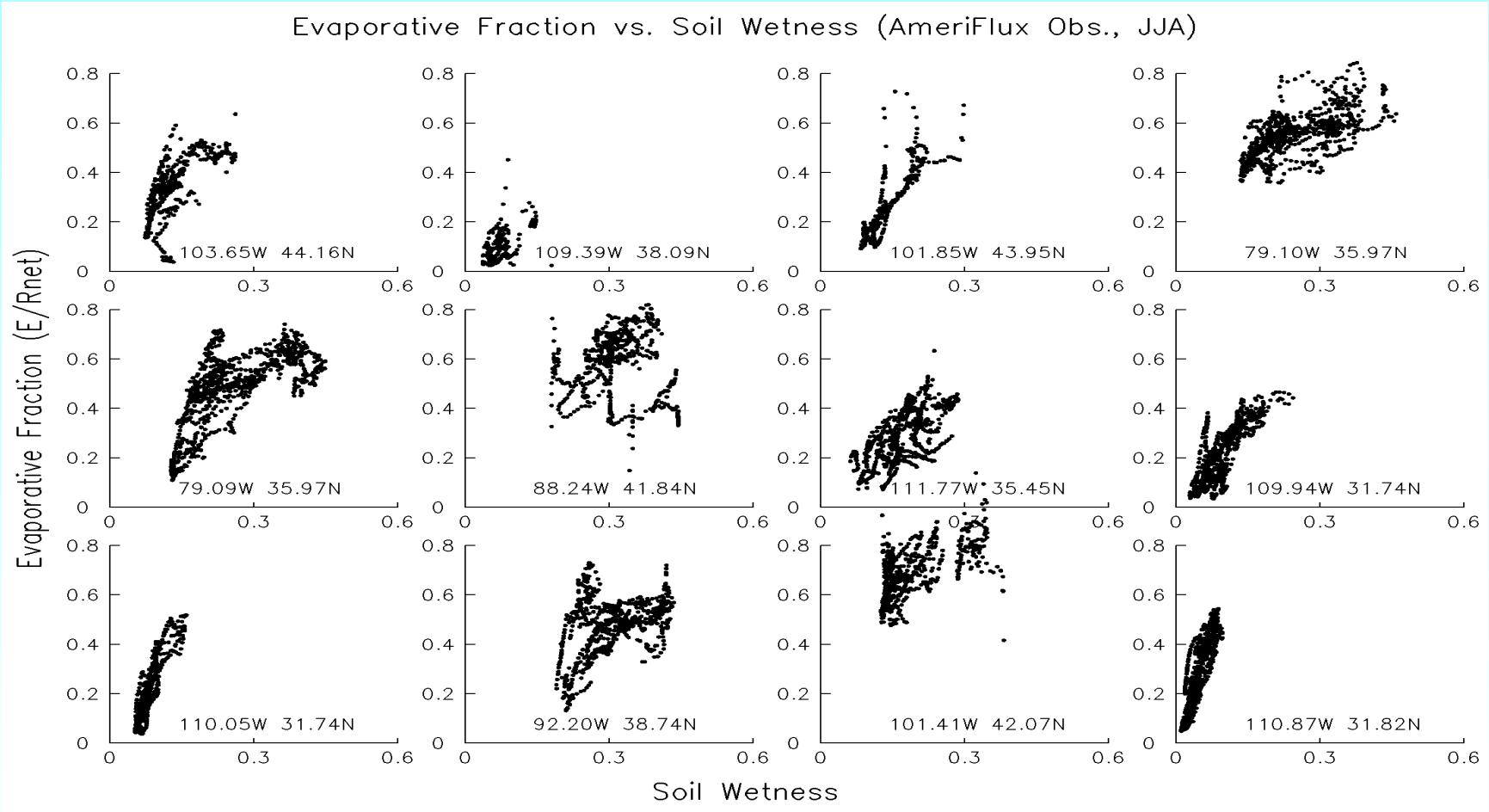
Sensitivity of Evaporation to SM and Hydrological Regime



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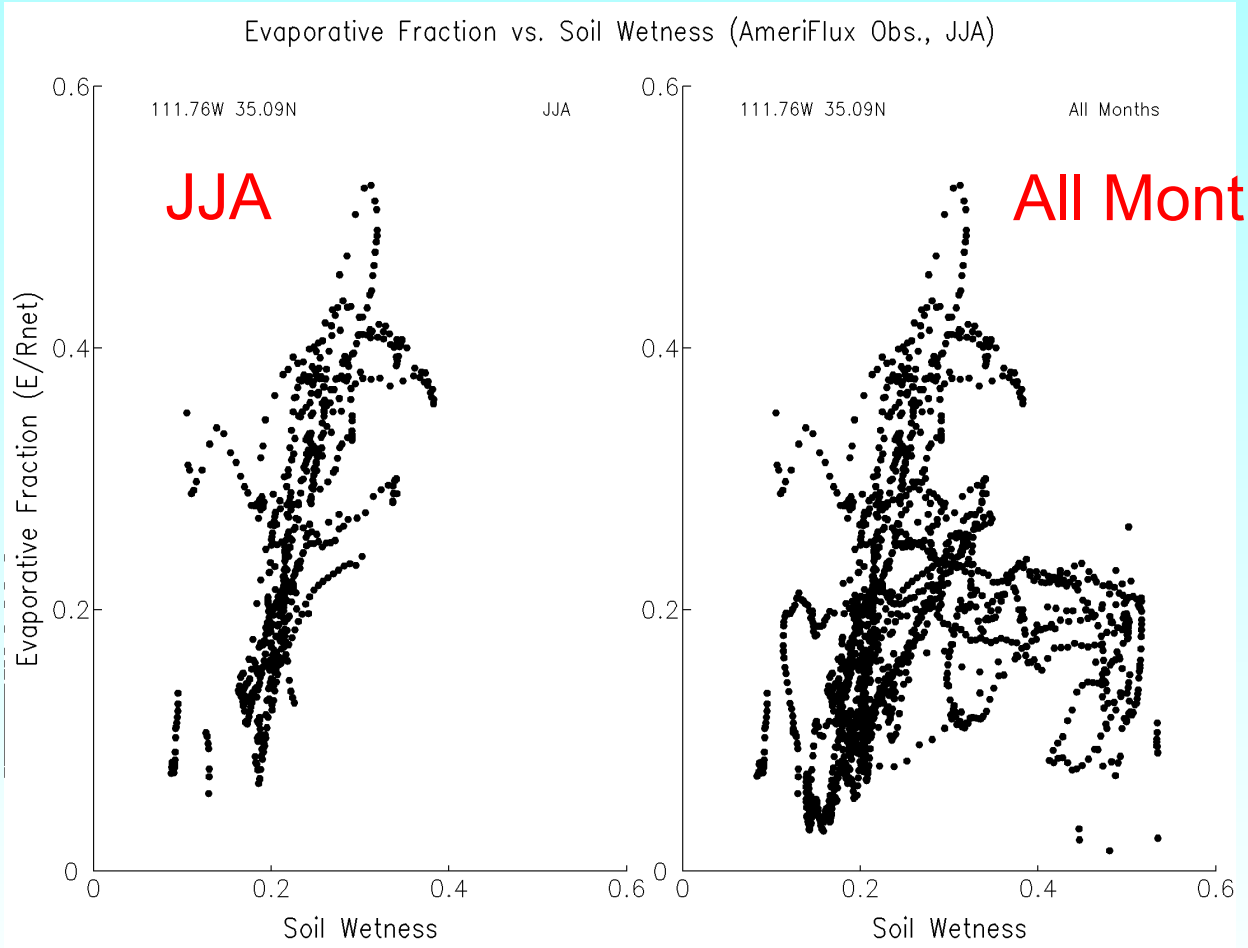
Sensitivity of Evaporation to SM and Temporal Variability



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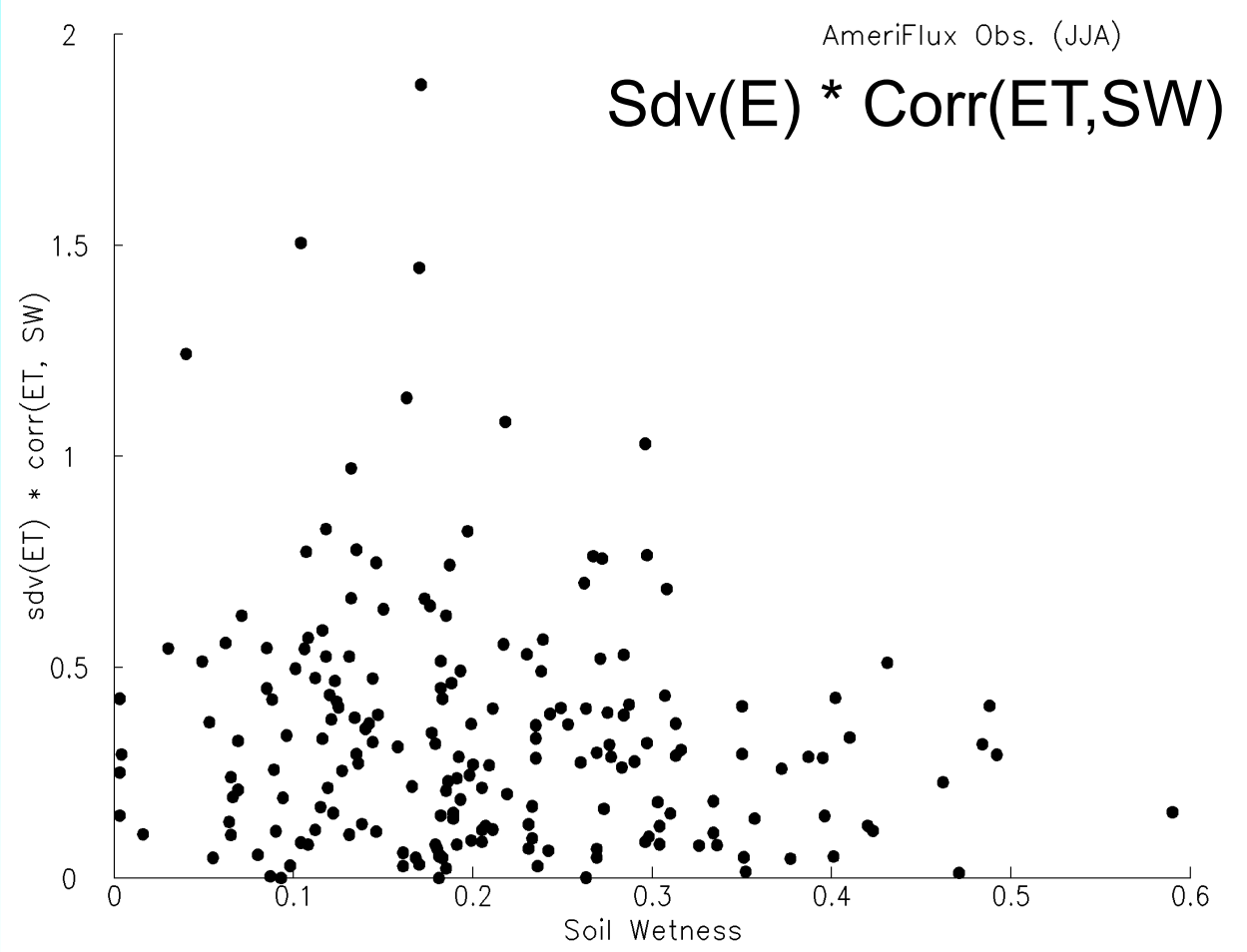
Land-atmosphere Coupling Strength Proxy



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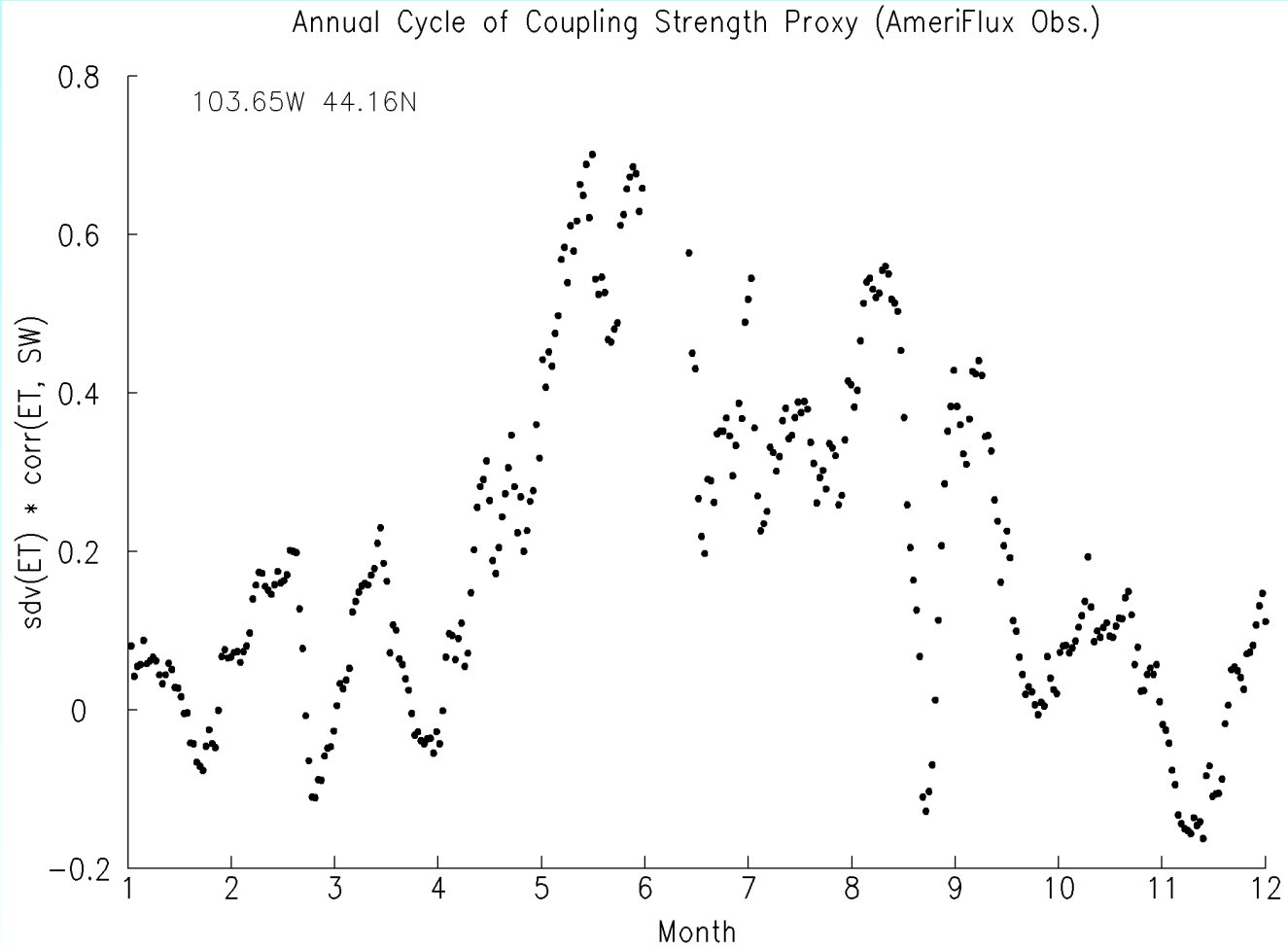
Seasonal Variability of Land-atmosphere Coupling Strength



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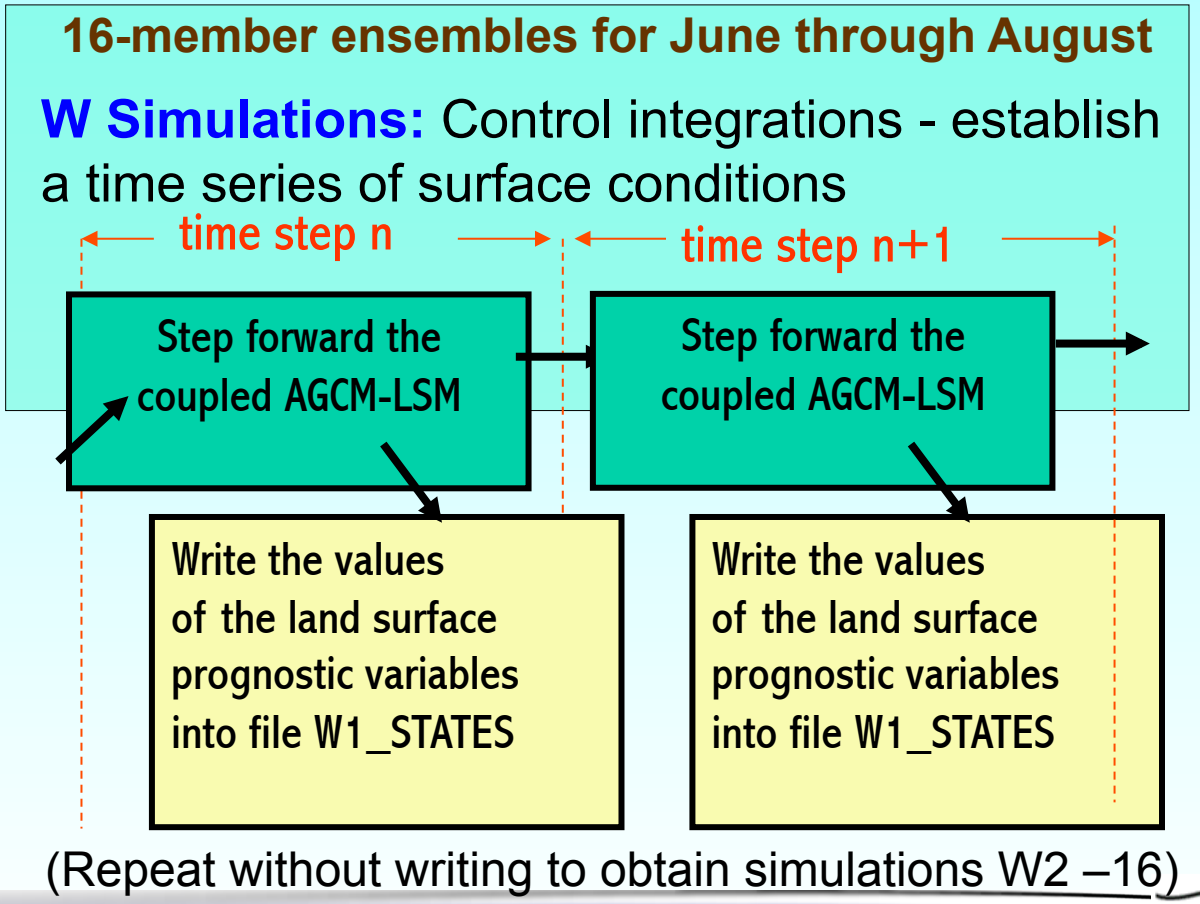
Global Land-Atmosphere Coupling Strength Experiments (GLACE-1)

- Integration for June-August with specified SST.
- In the control case (W), land surface state variables evolve freely.
- One ensemble member is used as the source of land state variables to be specified in every member of the test cases.

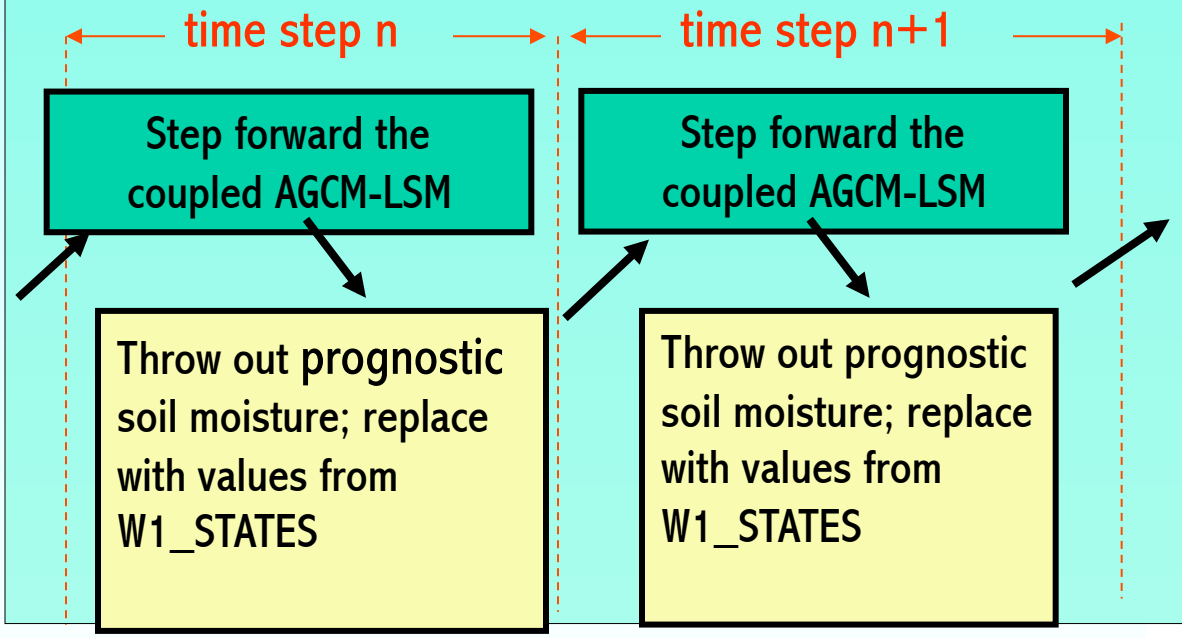


Test Cases

- In case S, sub-surface soil moisture is replaced with states established in W experiments.

- A diagnostic variable Ω is defined to describe the impact of the surface boundary on the generation of precipitation

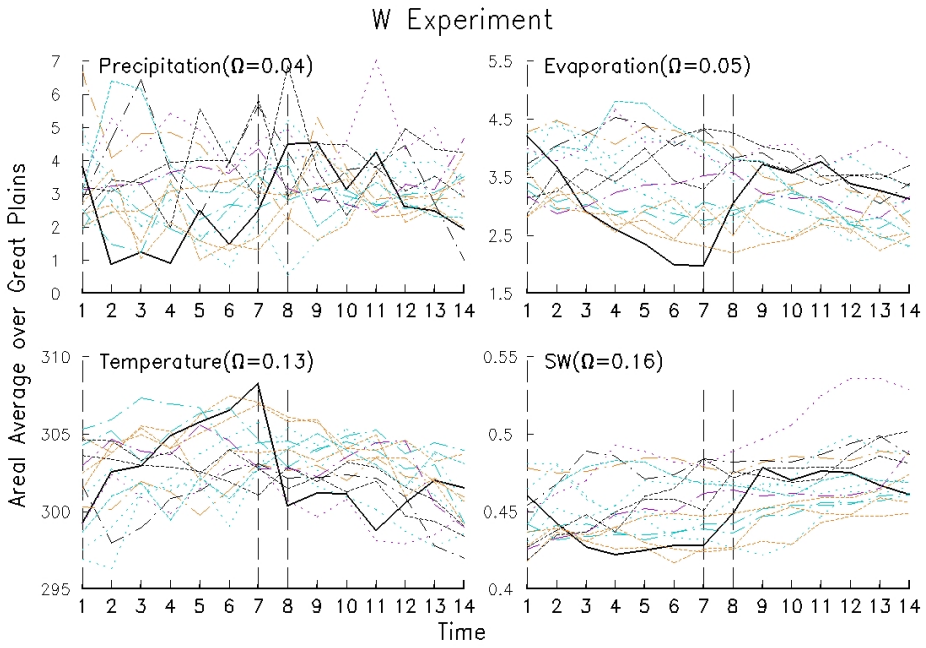
S Simulations: Run a 16-member ensemble, with each member forced to maintain the same time series of subsurface soil moisture prognostic variables



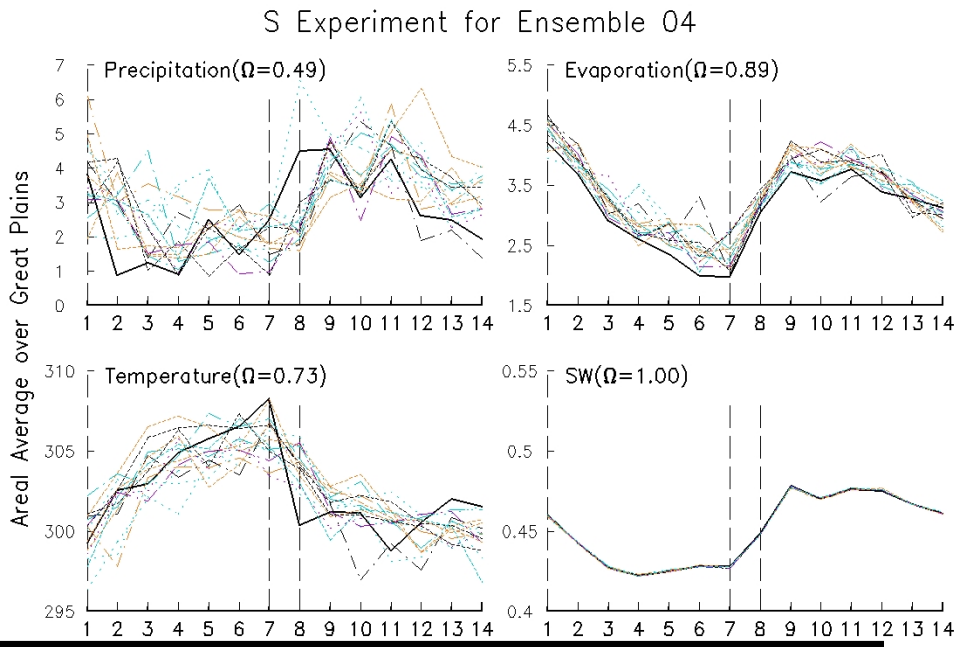
COLA AGCM GLACE-1 Experiments

- Atmospheric initial states: NCEP-NCAR Reanalysis;
- Land surface initial states: SSiB offline simulations (GOLD, driven by Princeton meteorology forcing data);
- Integrate COLA AGCM for June-August for the years 1982 - 2006;
- Initialization for each of 16 ensemble members: initial states for 16 days around June 1 for each year (May 24 - June 8);

Diagnostic Variable Ω



W Experiment: small Ω



S Experiment: large Ω

Large difference in Ω indicates large impacts of soil moisture on atmosphere, thus land-atmosphere coupling strength is strong.

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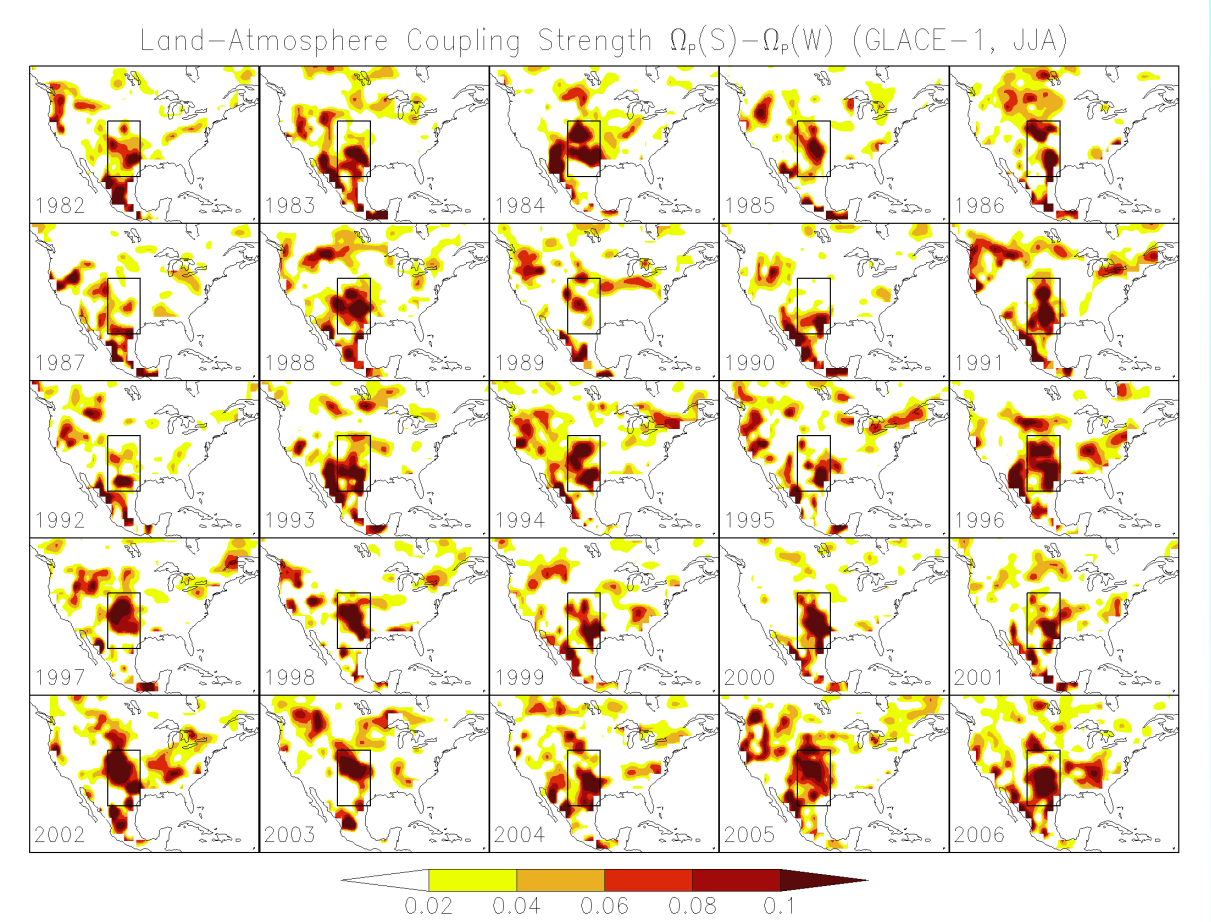
Interannual variability of land-atmosphere coupling strength



Guo, Z.-C. and P. A. Dirmeyer, 2013: Interannual variability of land-atmosphere coupling strength. Journal of Hydrometeorology, 14, 1636-1646

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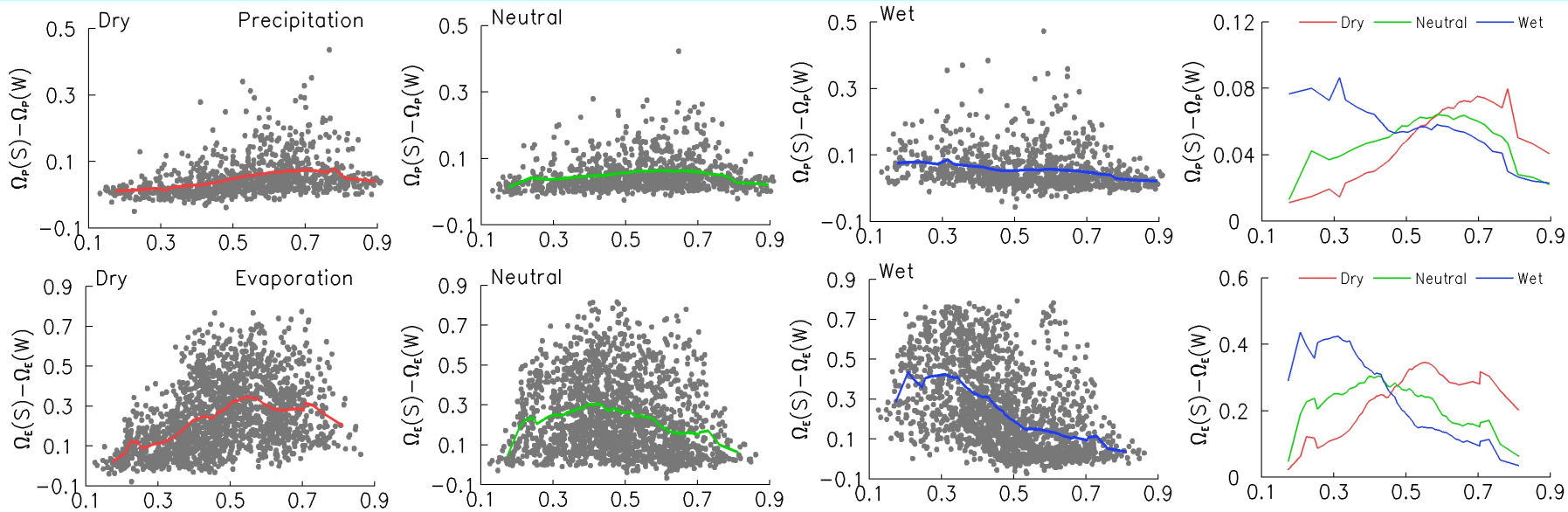
Interannual variability of land-atmosphere coupling strength and hydrological states



Guo, Z.-C. and P. A. Dirmeyer, 2013: Interannual variability of land-atmosphere coupling strength. Journal of Hydrometeorology, 14, 1636-1646

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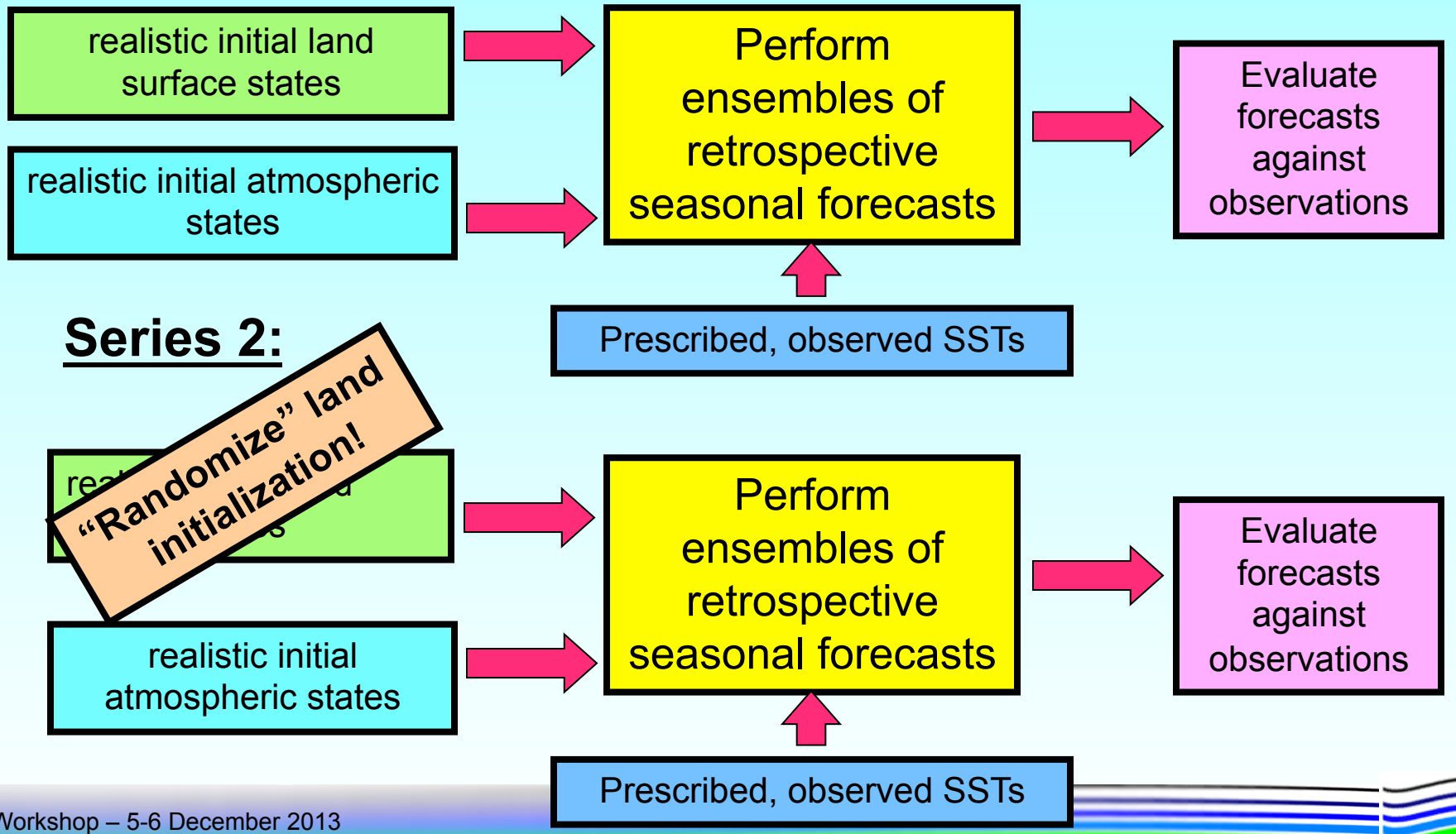
GLACE-2: Experiment Overview



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Measures for Predictability:

$$\textbf{STR} = \frac{\text{variability of ensemble mean}}{\text{total variability}}$$

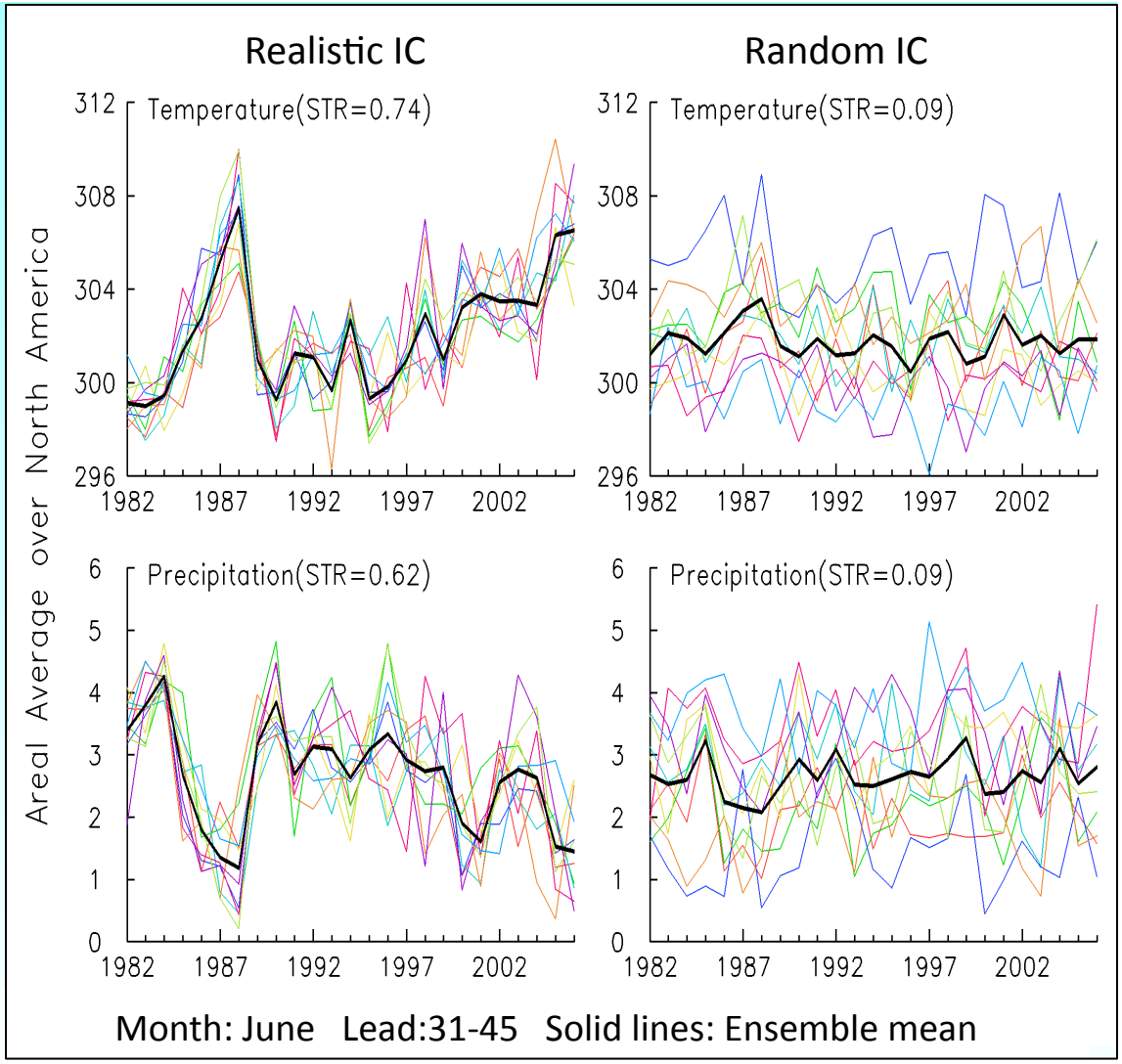
$$\textbf{SNR} = \frac{\text{variability of ensemble mean}}{\text{variability about ensemble mean}}$$

Measures for Land Impacts on Predictability:

$$\frac{\text{variability of ensemble mean for realistic IC}}{\text{variability of ensemble mean for random IC}}$$

Assume same noises for both realistic and random cases, this is equivalent to the ratio of SNR. We use the following metric to evaluate land impact on predictability

$$\textbf{Log}_{10}\frac{\textbf{signal for realistic IC}}{\textbf{signal for random IC}}$$



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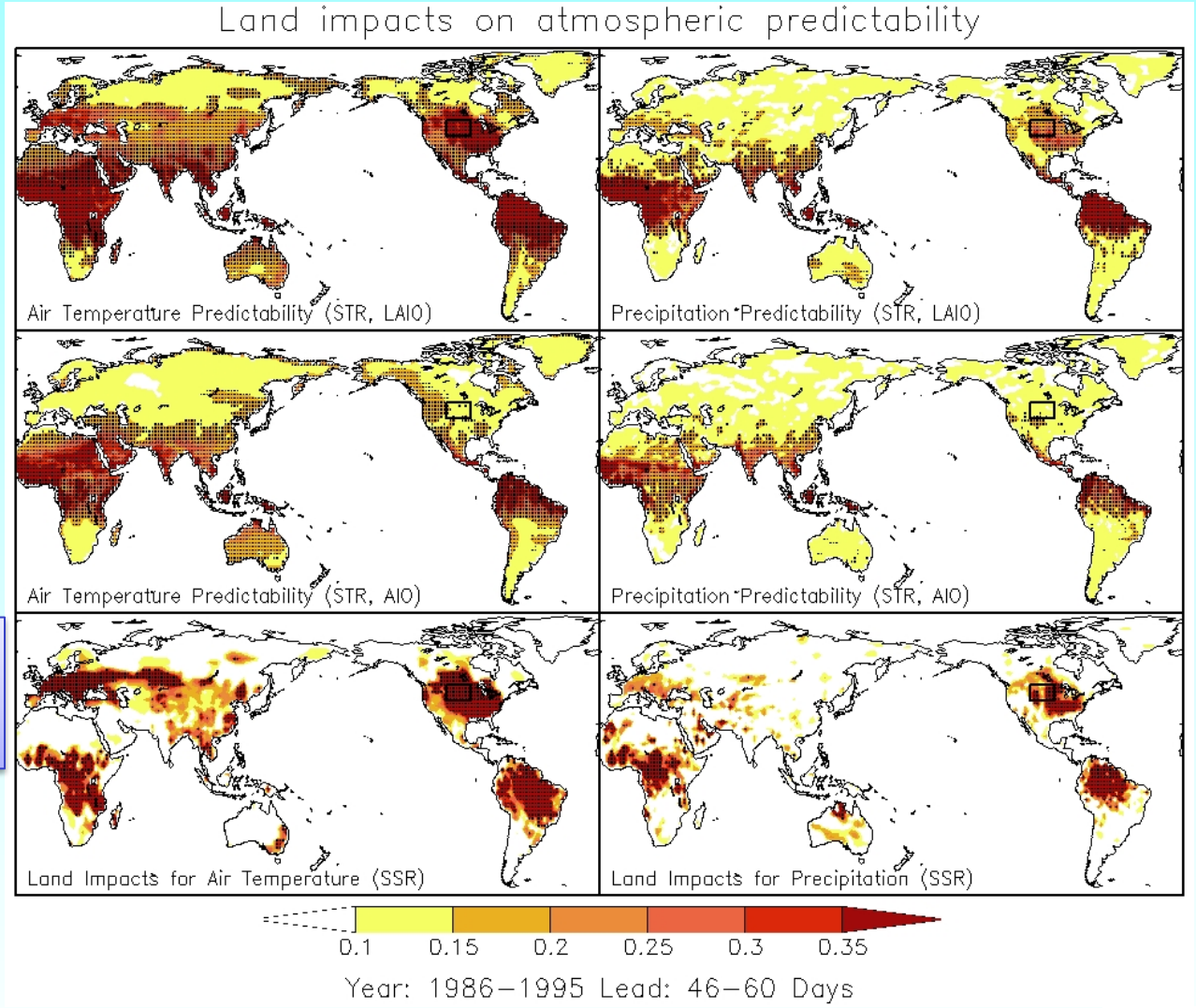
Impact of Land Surface on Atmospheric Predictability

Guo, Z., P. A. Dirmeyer, and T. DelSole, 2012: Land Surface Impacts on Subseasonal and Seasonal Predictability. *Geophys. Res. Lett.*, **38**



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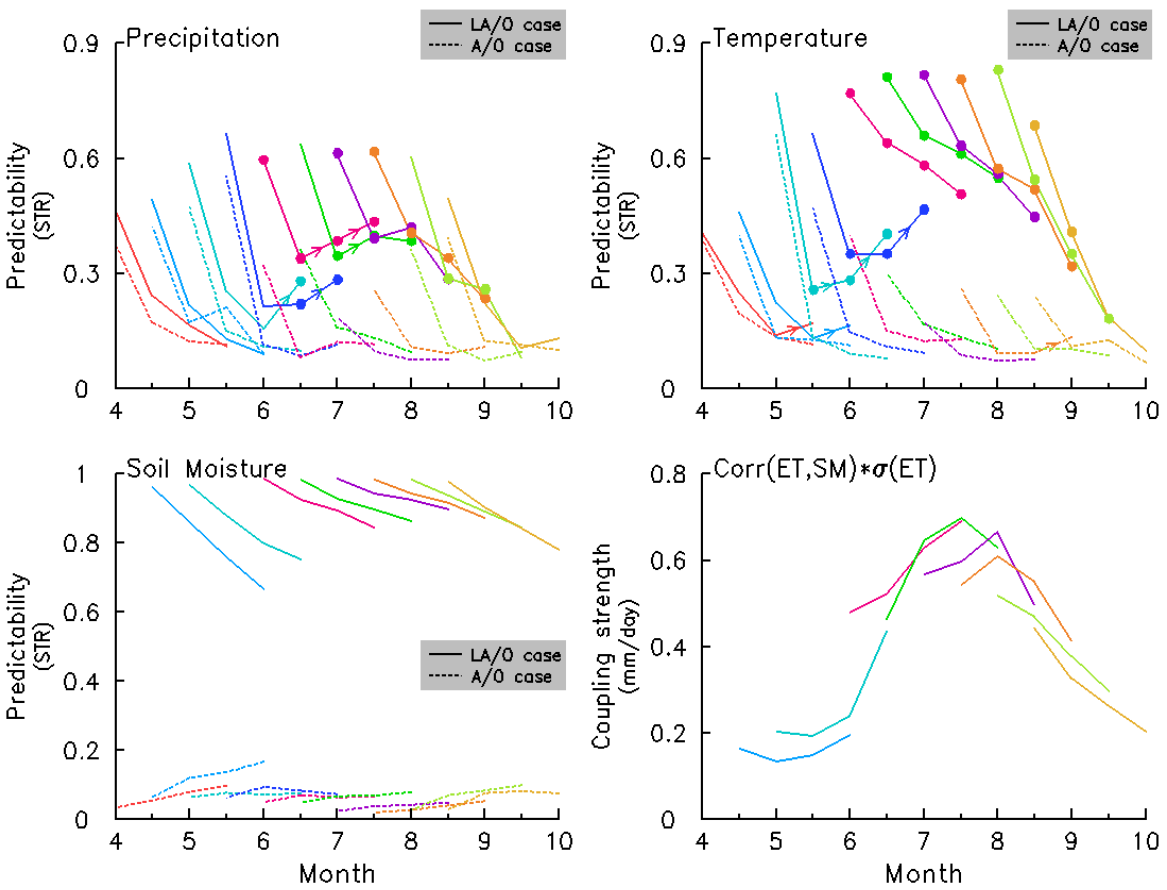
Impact of Land Surface on Atmospheric Predictability



Guo, Z., P. A. Dirmeyer, T. DelSole, and R. D. Koster, 2012: Rebound in Atmospheric Predictability and the Role of the Land Surface *J. Climate*, **25**, 4744-4749.

- Land surface has significant impact on atmospheric predictability during boreal summer when the land-atmosphere coupling strength peaks
- Atmospheric predictability over North America rebounds during late spring to summer because of information stored in the land surface.

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Conclusion

- Results from observations show that the dry to intermediate soil wetness is the range where evaporation is most sensitive to soil wetness, and the land-atmosphere coupling strength peaks.
- Change in hydrological states has impact on land-atmosphere coupling strength, which results in temporal variability.
- Land surface has significant impact on atmospheric predictability during boreal summer when the land-atmosphere coupling strength is strong.

Conclusion (Continued)

- Atmospheric Predictability over North America rebounds during late spring to summer because of information stored in the land surface. Soil moisture anomalies has little impact on atmosphere during early spring due to a lack of LA. Coupling becomes established in late spring, enabling the effects of soil moisture anomalies to increase atmospheric. This predictability is maintained through summer, then drops as coupling fades again in fall.
- Work on the inter-annual variability of LA coupling strength and its impact on atmospheric predictability is still going on.