Applications: Climate Prediction

or

Soil Moisture
and Monthly/Seasonal Prediction

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What is land-atmosphere feedback on precipitation? One interpretation:

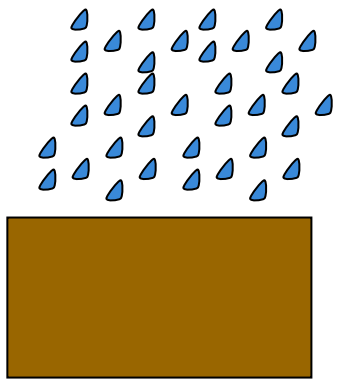
Precipitation wets the surface...

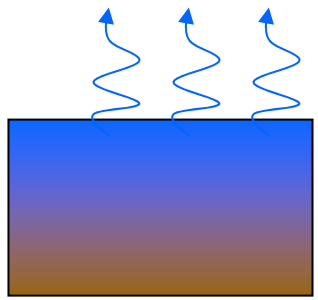
…causing soil moisture to increase...

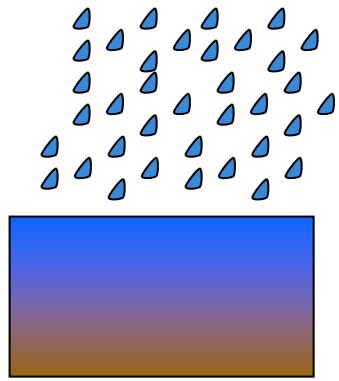
…which causes evaporation to increase during subsequent days and weeks...

…which affects the overlying atmosphere (the boundary layer structure, humidity, etc.)...

…thereby (maybe) inducing additional precipitation







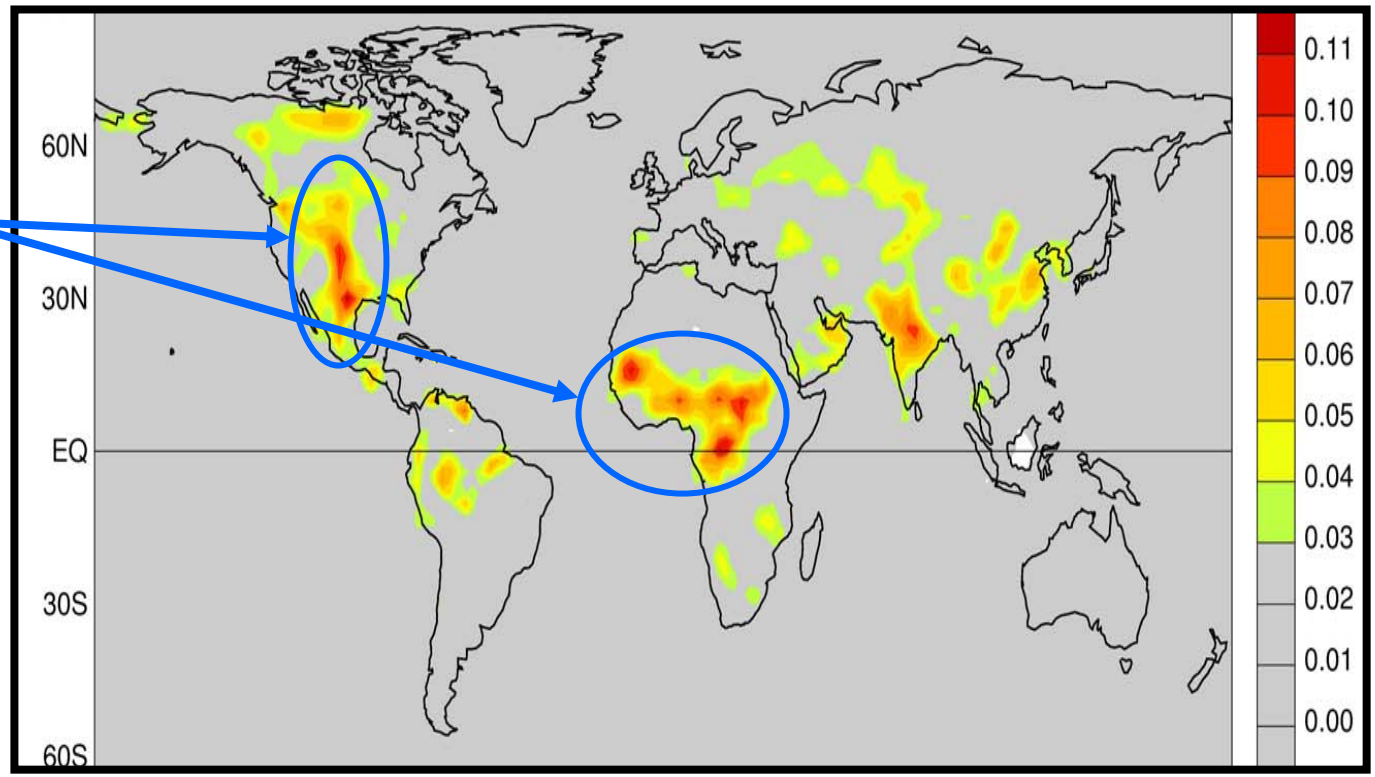
Where do variations in soil moisture affect rainfall?

GLACE (the Global Land-Atmosphere Coupling Experiment), a coordinated multi-model analysis of land impacts on rainfall, provided two key results:

- The 12 participating AGCMs, from climate groups across the world, show substantial intermodel differences in the ability of soil moisture variations to affect rainfall.
- Nevertheless, certain patterns are common to many of the models. These patterns emerge in the multi-model average of the results:

Land-atmosphere coupling strength diagnostic, averaged across 12 AGCMs (northern hemisphere summer)

The diagnostic shows where rainfall is affected by soil moisture variations. Arguably, given limitations in the observations and in single-model analyses, this multi-model estimate is the best estimate available to us.



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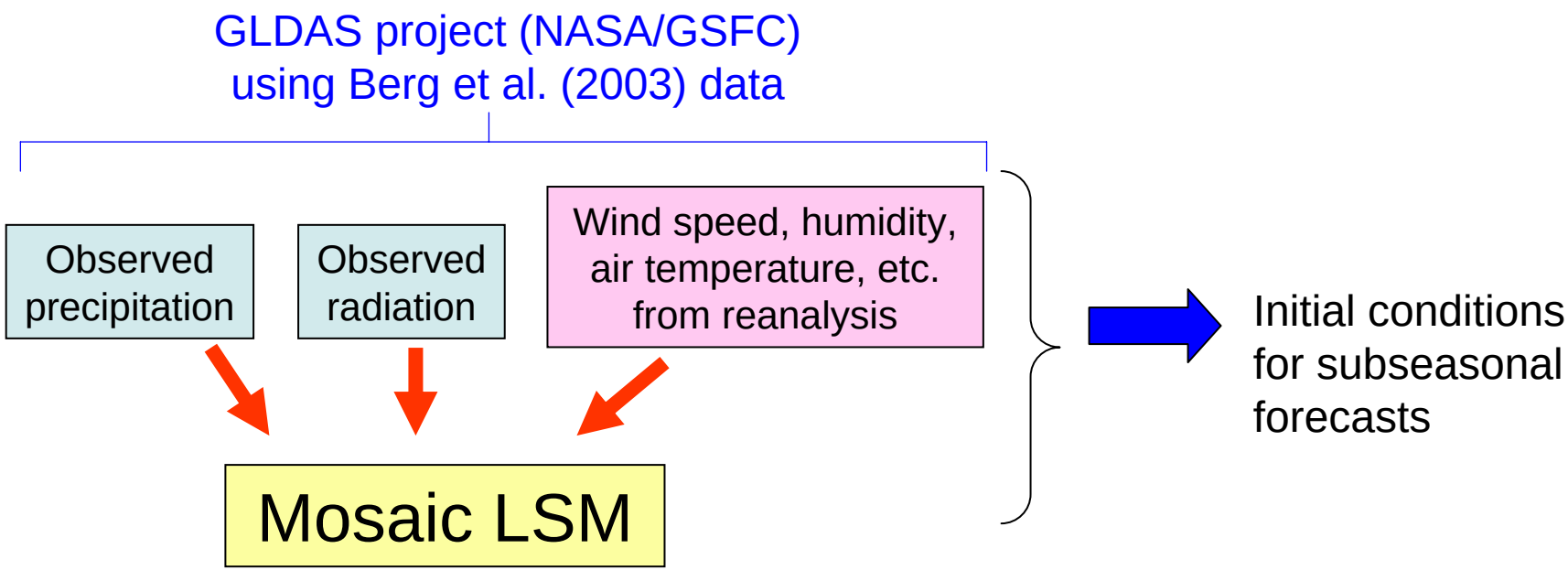
Thus, according to models, soil moisture can potentially affect the evolution of precipitation in certain well-defined areas – basically, transition zones between wet and dry regions.

=> If we know soil moisture at the beginning of a forecast period, we may be able to increase the skill of the forecast in these areas.

Do we have any concrete evidence for this?

Forecast experiment:



The resulting initial conditions:

(1) Reflect observed antecedent atmospheric forcing, and

(2) Are consistent with the land surface model used in the AGCM.

1-Month Forecasts Performed

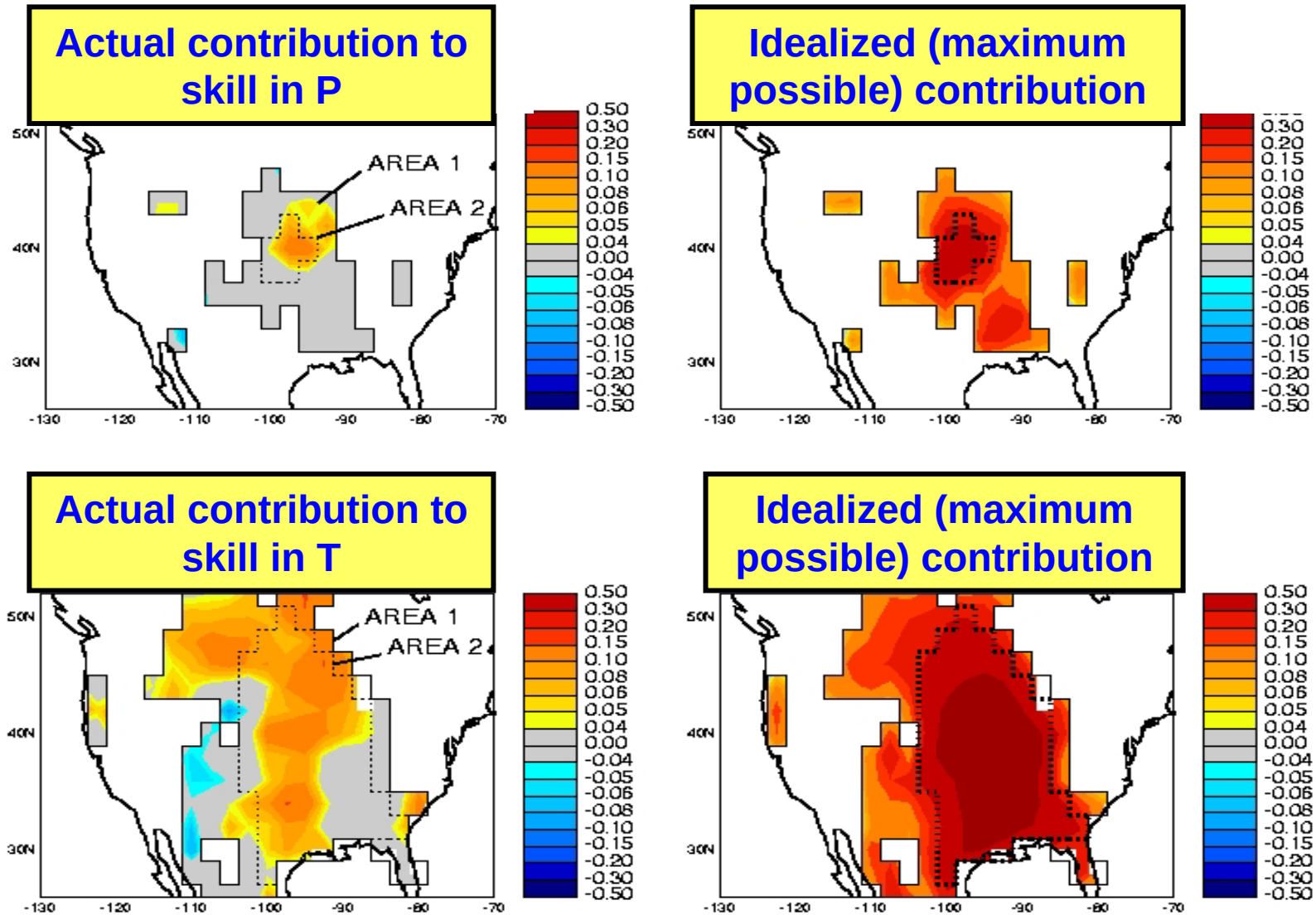
Land initialized on:

	May 1	June 1	July 1	Aug. 1	Sept. 1
1979	✓	✓	✓	✓	✓
1980	✓	✓	✓	✓	✓
1981	✓	✓	✓	✓	✓
⋮			⋮		
1992	✓	✓	✓	✓	✓
1993	✓	✓	✓	✓	✓

75 separate 1-month forecasts, each of which can be evaluated against observations.

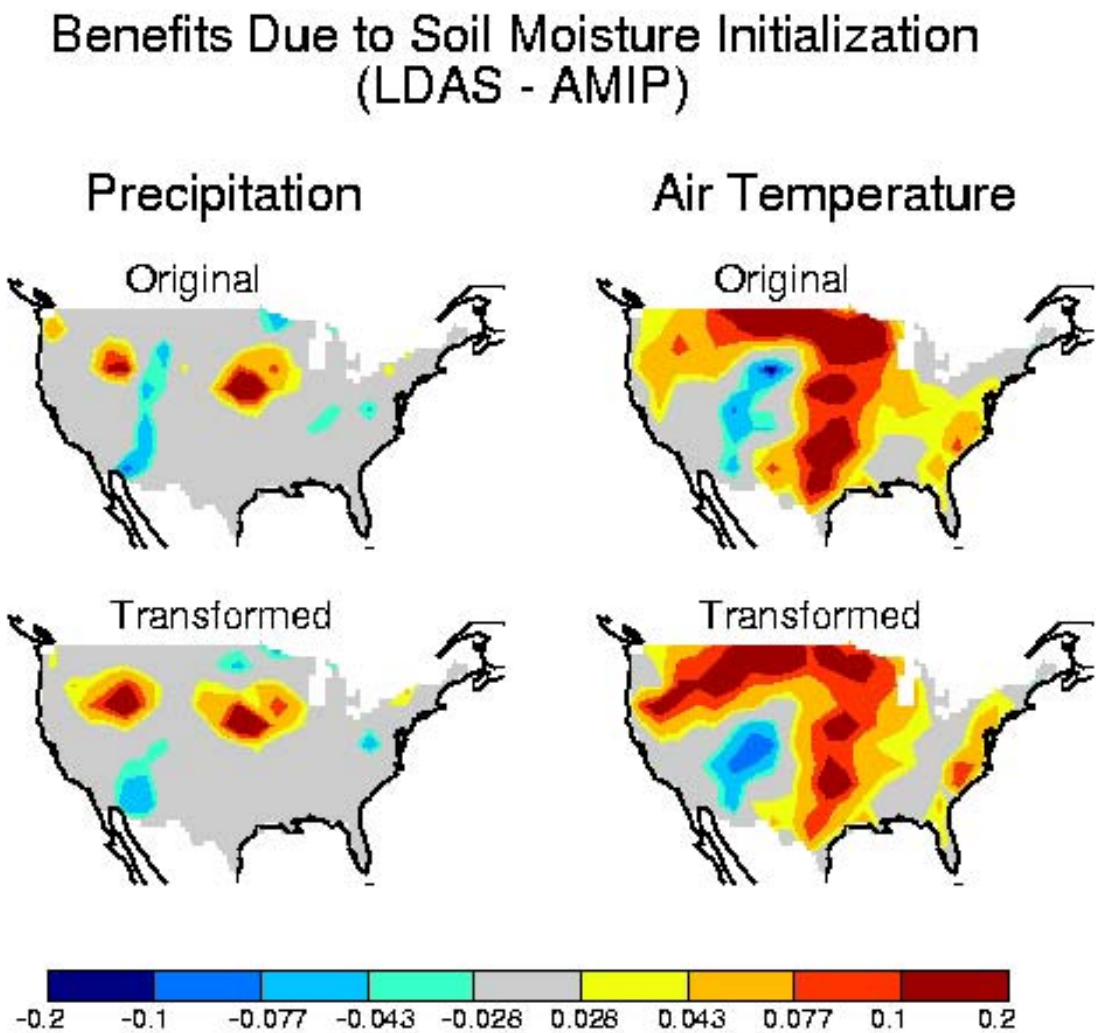
(Note: each forecast is an average over 9 ensemble members.)

Contributions of land moisture initialization to the skill (r^2) of subseasonal (one-month) forecasts of P and T



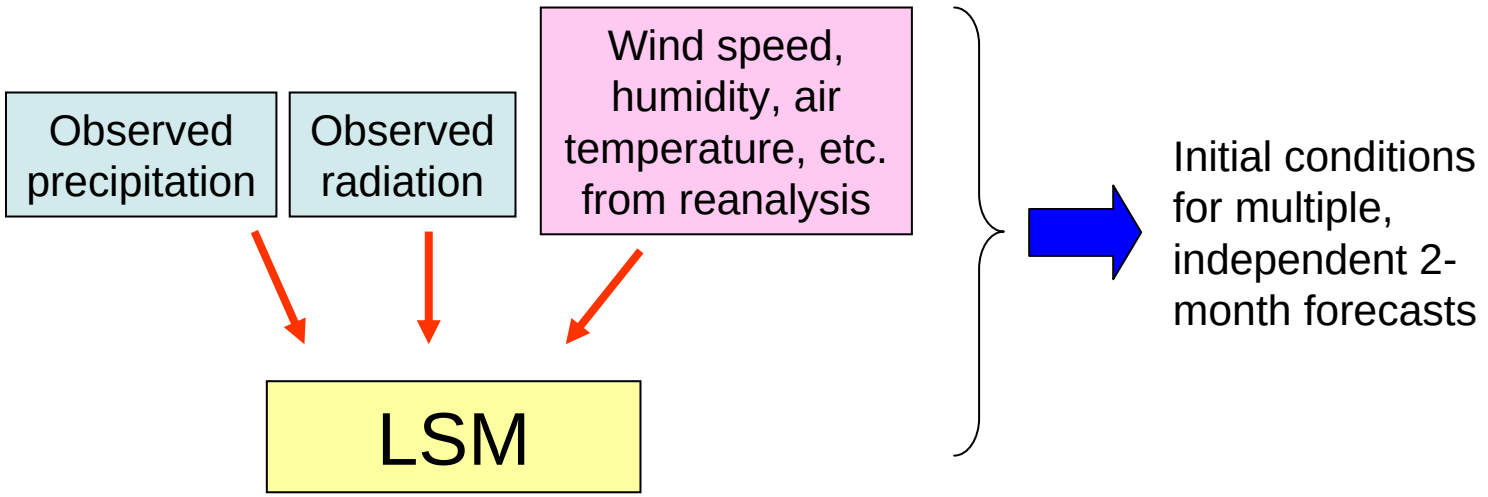
Koster et al., *Journal of Hydrometeorology,5*, pp. 1049-1063, 2004

The increase in skill due to soil moisture initialization can be enhanced through a forecast transformation approach that corrects for known model biases (Koster et al., submitted).



GLACE-2

An international, multi-model forecast experiment along the lines of that just described. Goal: to determine the contribution of land moisture initialization to forecast skill across a suite of systems.

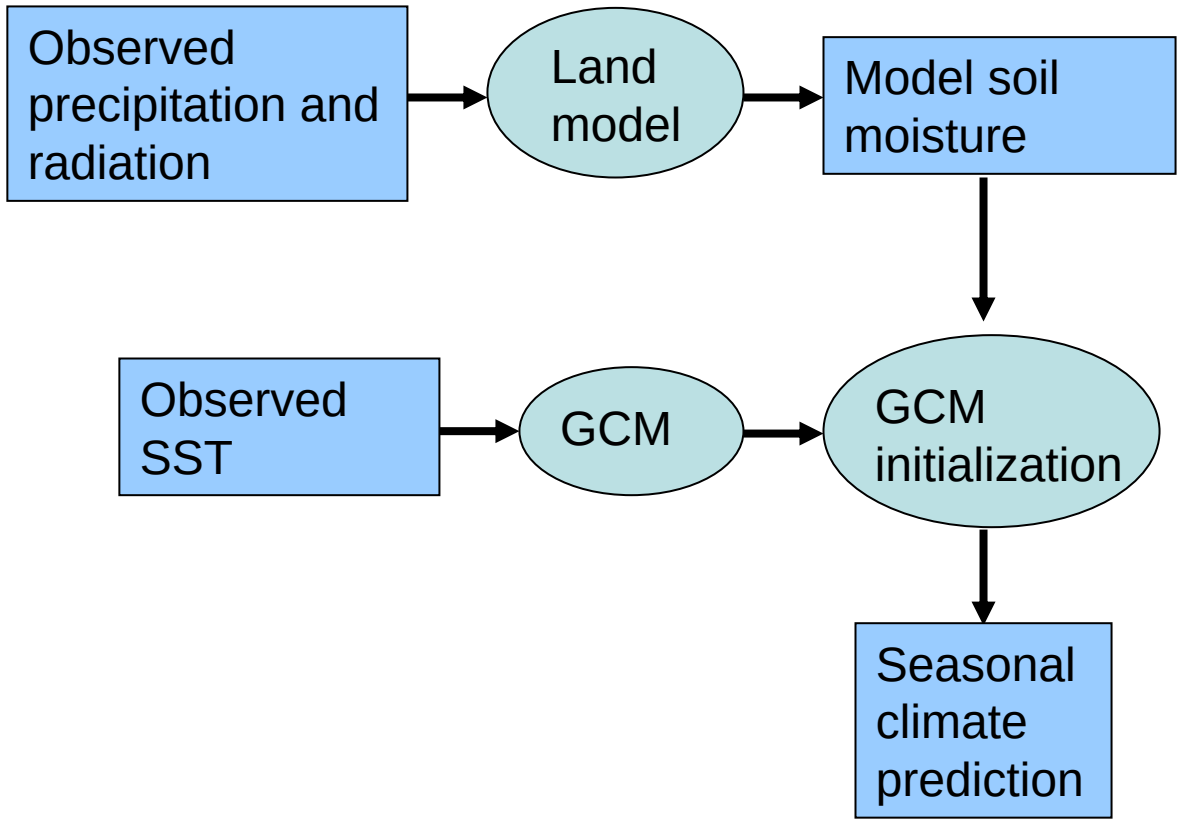


Thus, realistic soil moisture initialization *does* increase forecast skill (if only modestly) in certain regions.

How do SMAP products fit in?

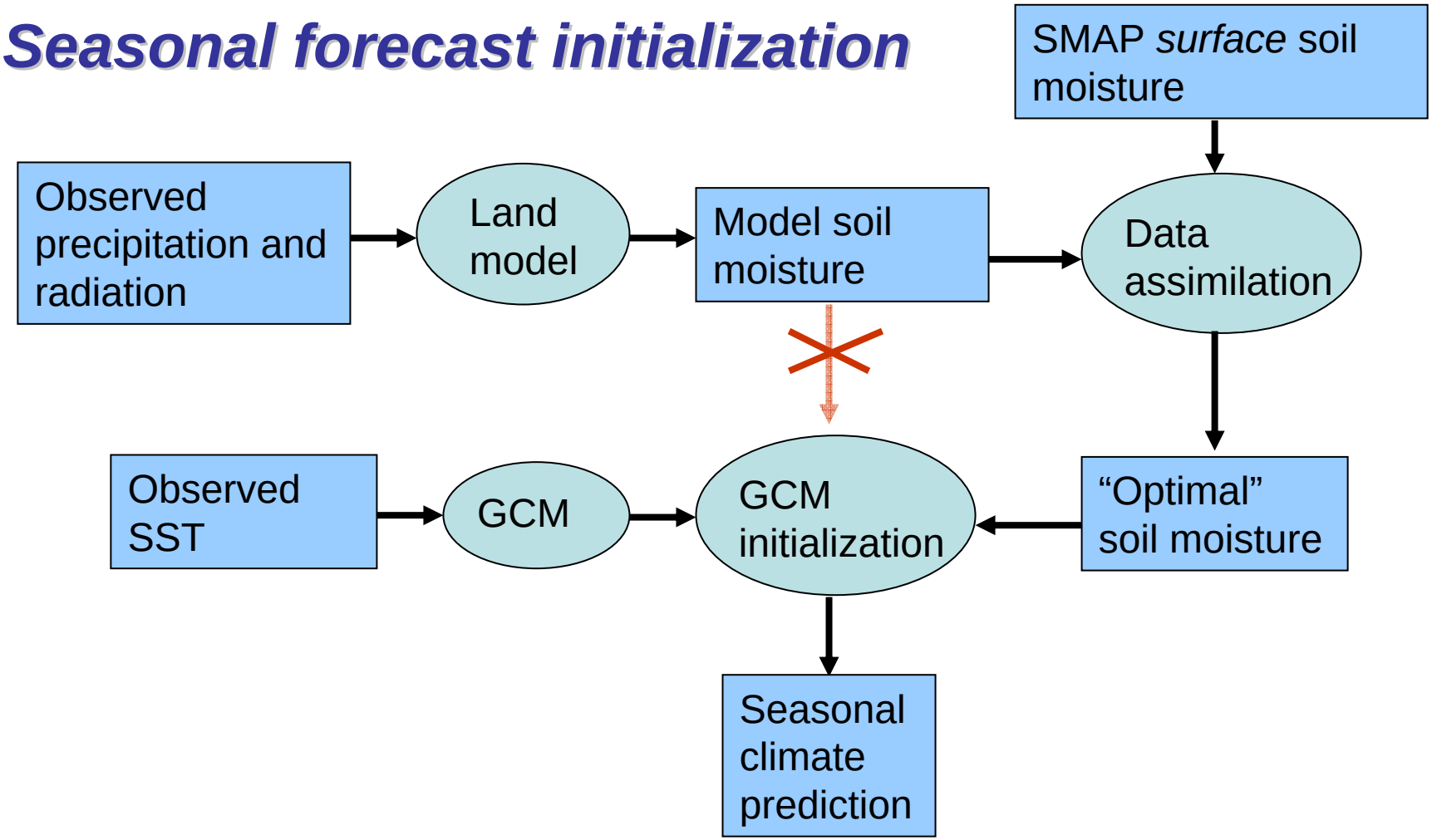
How we initialize our forecasts now:

Seasonal forecast initialization



How we can use SMAP products to improve the initialization:

Seasonal forecast initialization



Soil moisture data assimilation *does* work

			Time series correlation coeff. with in situ data [-] (with 95% confidence interval)			Confidence levels: Improvement of assimilation over	
		N	**Satellite**	**Model**	**Assim.**	**Satellite**	**Model**
SMMR	Surface anomalies	66	**.32±.03**	**.36±.03**	**.43±.03**	**99.9%**	**99.9%**
SMMR	Root zone anomalies	33	**n/a**	**.32±.05**	**.35±.05**	**n/a**	**80%**
AMSR-E	Surface anomalies	17	**.37±.03**	**.40±.03**	**.48±.03**	**>99.99%**	**>99.99%**
AMSR-E	Root zone anomalies	16	**n/a**	**.39±.03**	**.42±.03**	**n/a**	**91.5%**

Assimilation product agrees better with ground data than satellite or model alone.

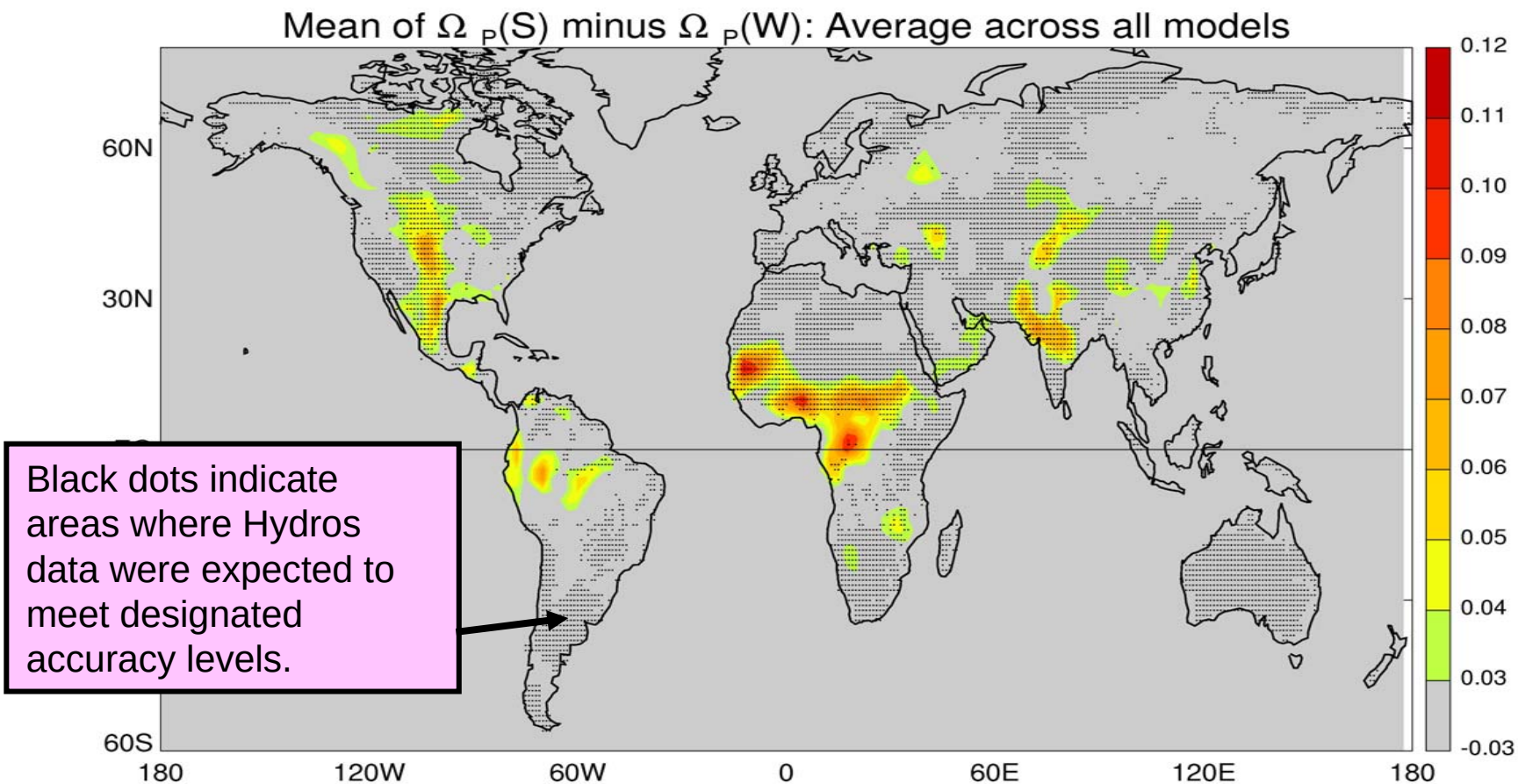
Modest increase may be close to maximum possible with *imperfect* in situ data.

SMMR: Reichle & Koster, *GRL* 2005
AMSR-E: Reichle et al., JGR, 2007

So, to summarize,

- Soil moisture initialization can improve forecast skill in places, and
- Tools already exist to make use of SMAP data for this purpose.

Important side note: SMAP data will tend to be accurate in the areas for which the atmosphere is strongly responsive to soil moisture anomalies.



Black dots indicate areas where Hydros data were expected to meet designated accuracy levels.