GLACE-2: Impact of land initialization on subseasonal forecasts

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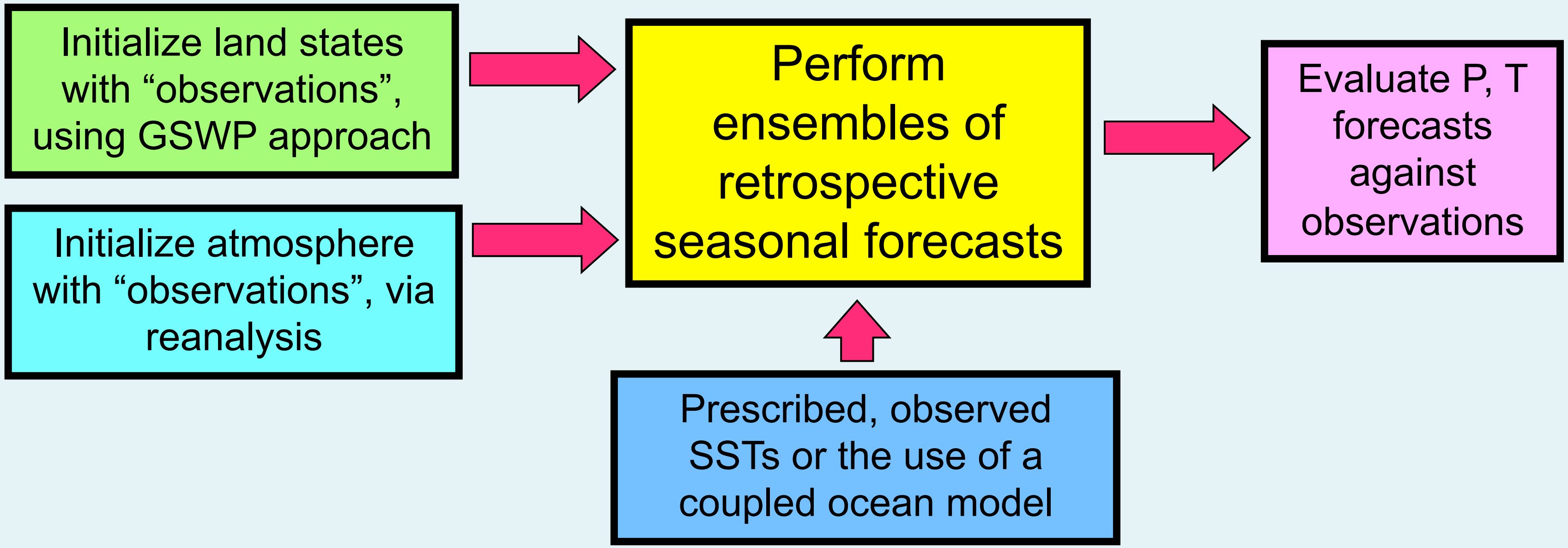
With contributions from the entire GLACE-2 team (see later slide)

GLACE-2: An international project aimed at quantifying soil moisture impacts on prediction skill.

Overall goal of GLACE-2: Determine the degree to which realistic land surface (soil moisture) initialization contributes to forecast skill (rainfall, temperature) at 1-2 month leads, using a wide array of state-of-the-art forecast systems.

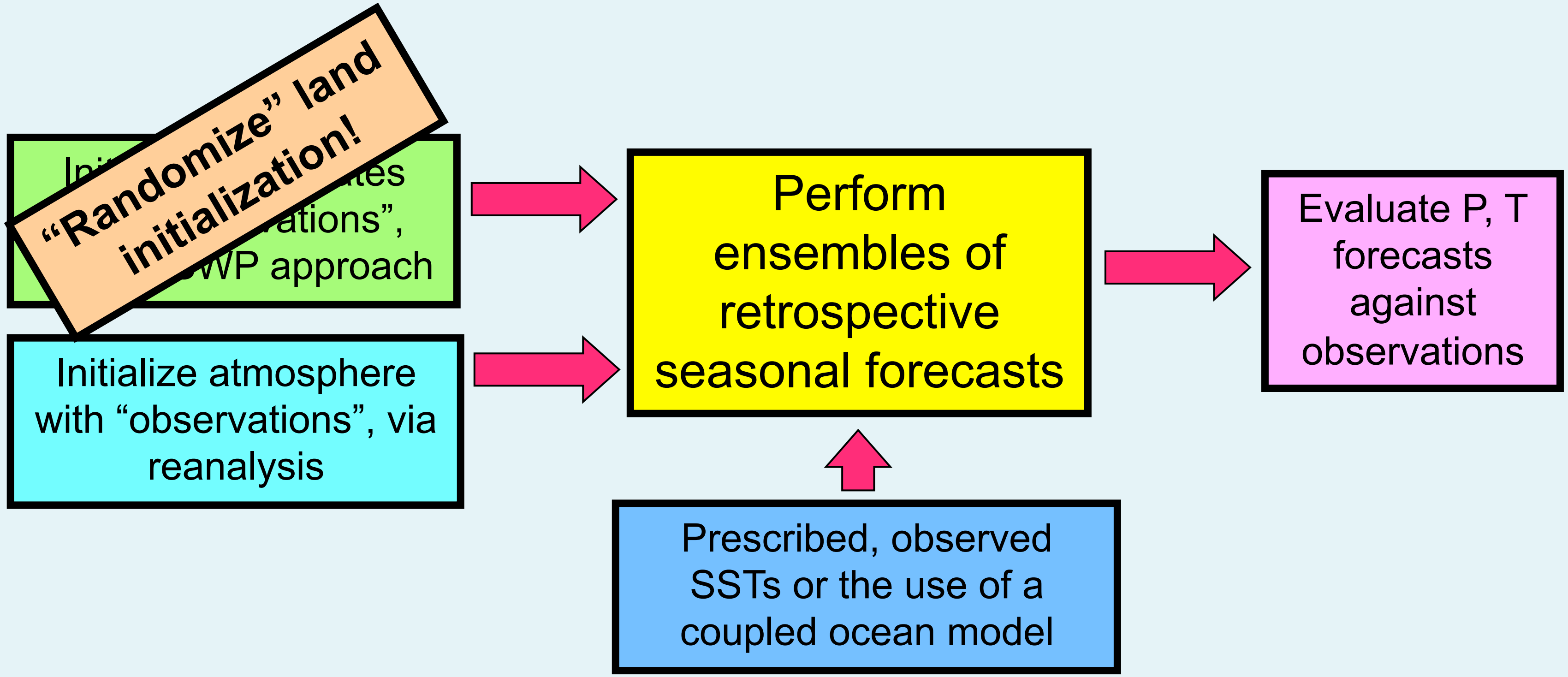
GLACE-2:
Experiment Overview

Series 1:



GLACE-2:
Experiment Overview

Series 2:

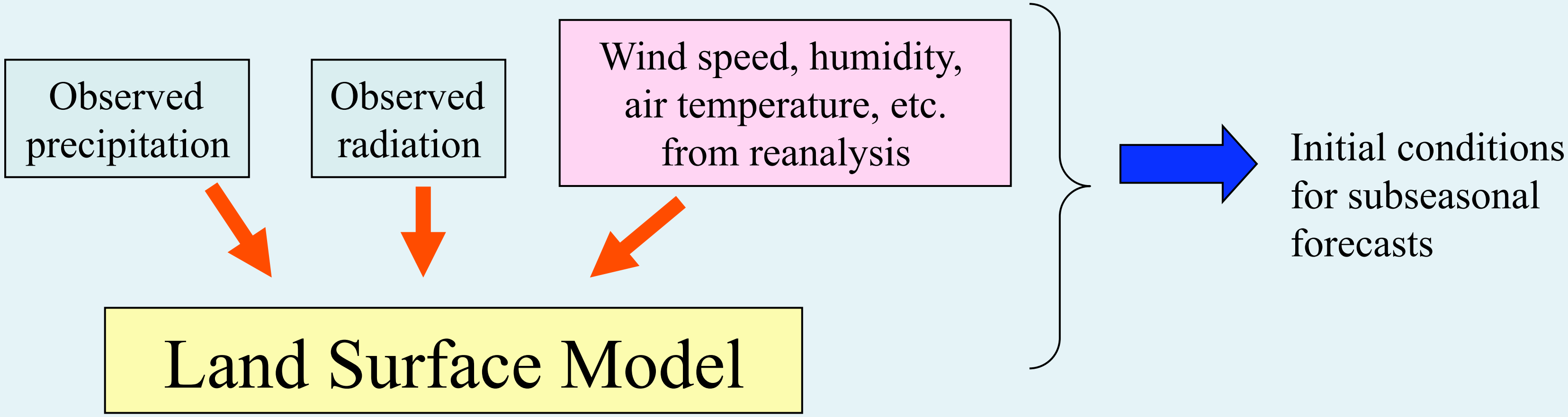


GLACE-2:
Experiment Overview

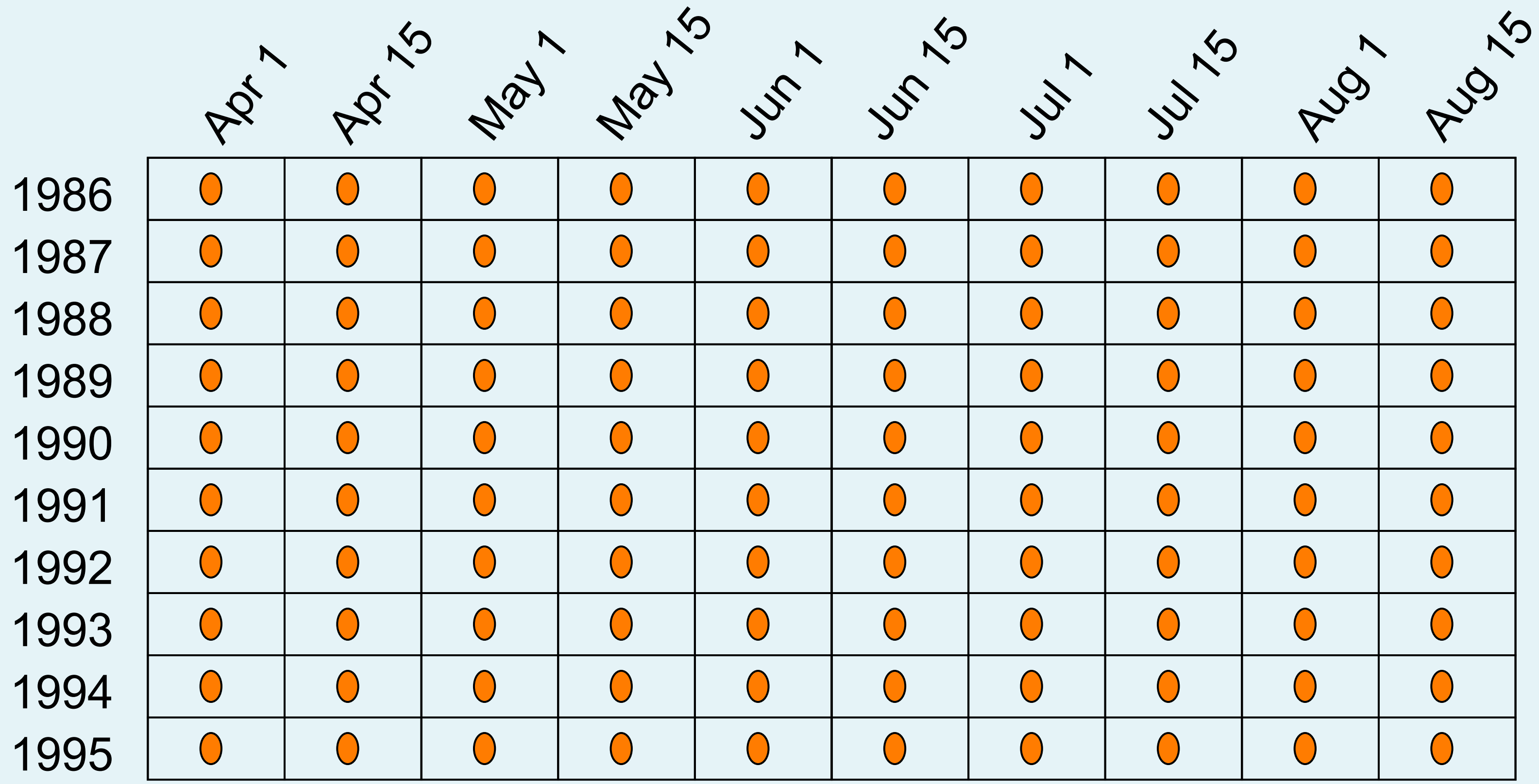
<u>Step 3:</u> Compare skill in two sets of forecasts; isolate contribution of realistic land initialization.

Forecast skill, Series 1	−	Forecast skill, Series 2	=	Forecast skill due to land initialization

Land model initialization



Baseline: 100 Forecast Start Dates



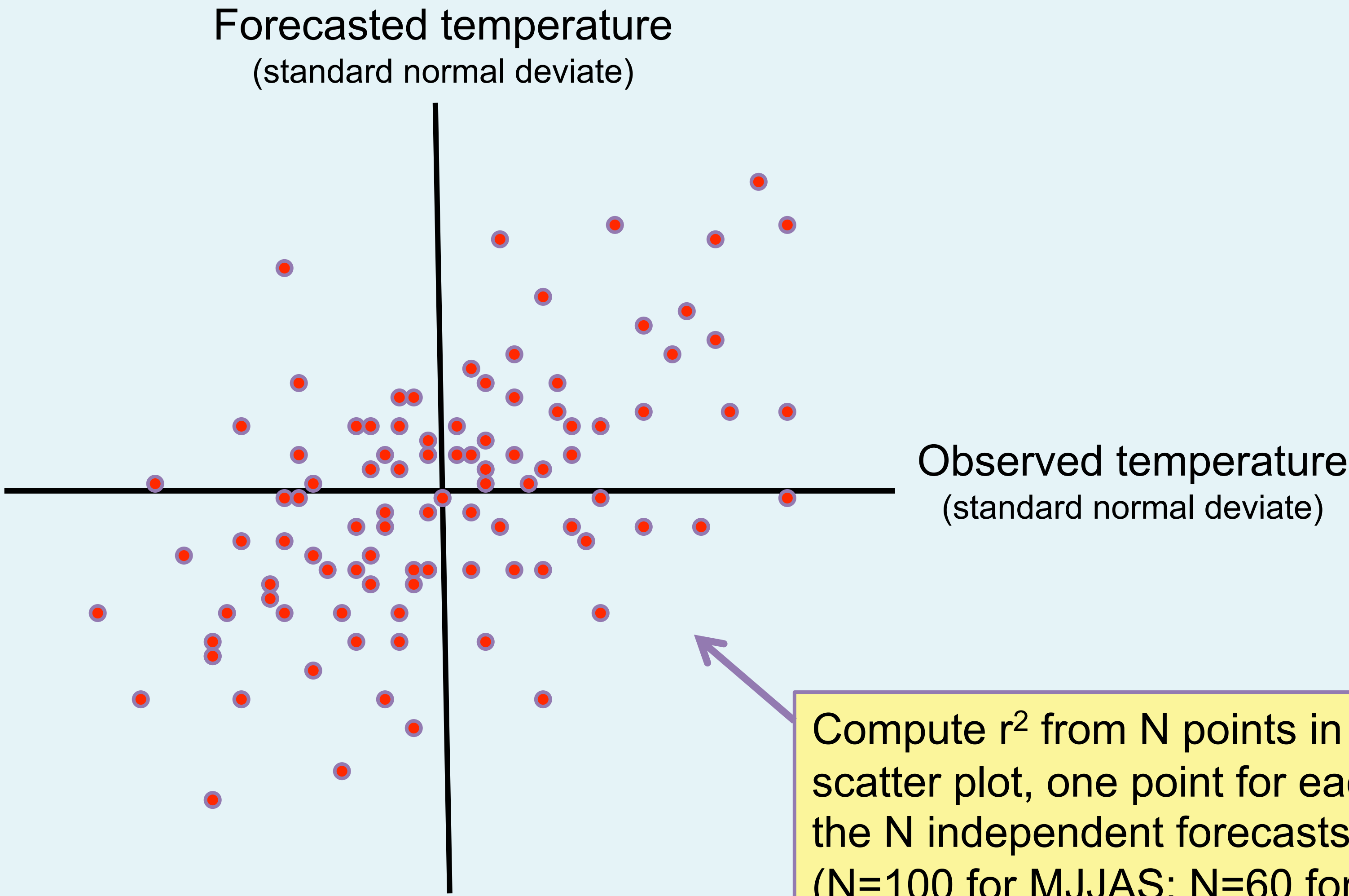
Each ensemble consists of 10 simulations, each running for 2 months.

1000 2-month simulations.

Participant List

Group/Model	# models	Points of Contact
1. NASA/GSFC (USA): GMAO seasonal forecast system (old and new)	2	R. Koster, S. Mahanama
2. COLA (USA): COLA GCM, NCAR/CAM GCM	2	P. Dirmeyer, Z. Guo
3. Princeton (USA): NCEP GCM	1	E. Wood, L. Luo
4. IACS (Switzerland): ECHAM GCM	1	S. Seneviratne, E. Davin
5. KNMI (Netherlands): ECMWF	1	B. van den Hurk
6. ECMWF	1	G. Balsamo, F. Doblas-Reyes
7. GFDL (USA): GFDL system	1	T. Gordon
8. U. Gothenburg (Sweden): NCAR	1	J.-H. Jeong
9. CCSR/NIES/FRCGC (Japan): CCSR GCM	1	T. Yamada
10. FSU/COAPS	1	M. Boisserie
11. CCCma	1	B. Merryfield
	13 models	

Skill measure: r^2 when regressed against observations



Compute r^2 from N points in scatter plot, one point for each of the N independent forecasts. (N=100 for MJJAS; N=60 for JJA)

- After first picture, we focus on multi-model "consensus" view of skill.
- We focus here on JJA, the period when N.H. evaporation is strongest.
- We focus here on the U.S., for which:
  - -- models show strong inherent predictability associated with land initialization (GLACE-1!)
  - -- observations are reliable over the forecast period

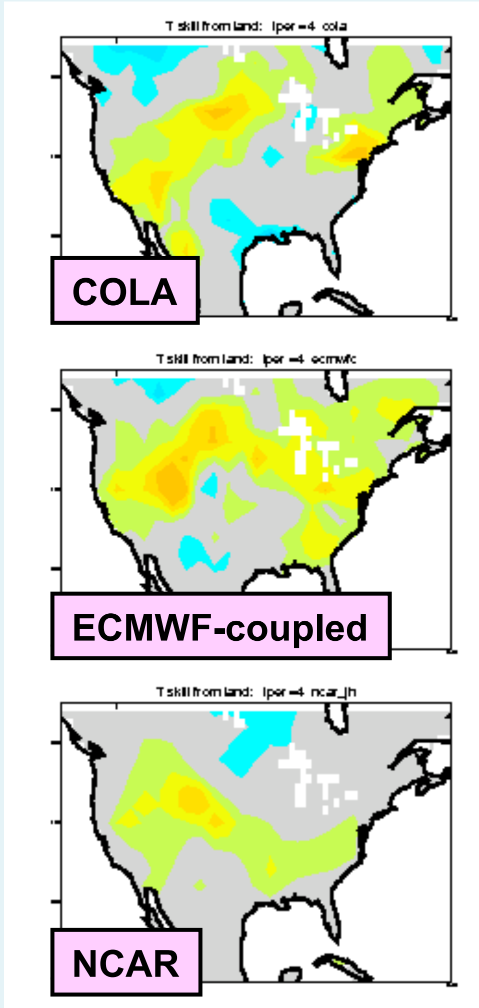
Sample results: Isolated impact of land initialization on r^2 skill score for 3 different models (r^2 from Series 1 minus r^2 from Series 2).

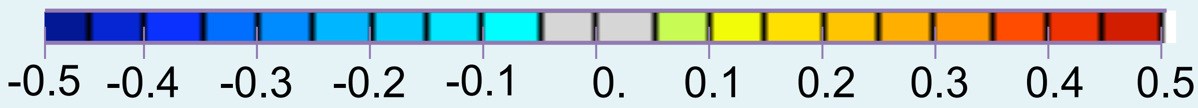
Predicted variable: Air temperature at 16-30 days.

Models appear to differ in their ability to extract skill from land initialization.

Some models (not shown) have almost no skill.

Results for precipitation forecasts are much weaker.

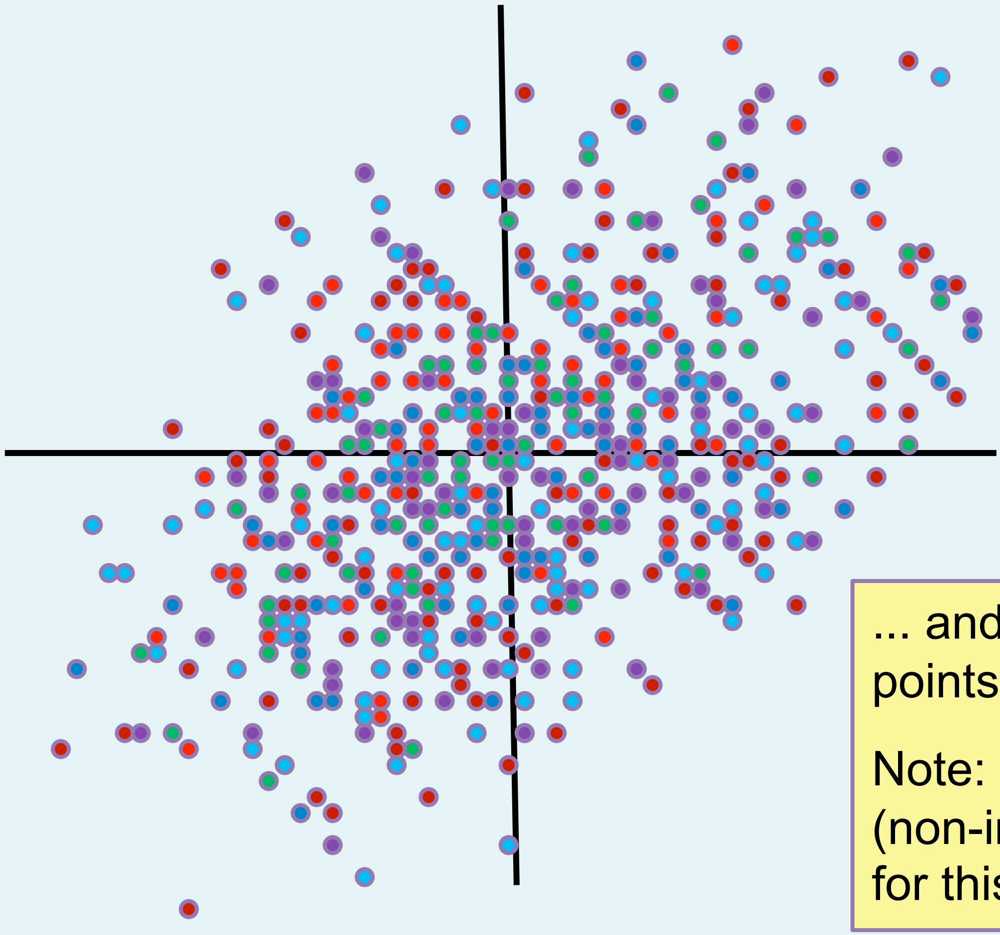




Multi-model "consensus" measure of skill: a prerequisite to a conditional skill analysis

Forecasted temperature
(standard normal deviate)

Plot results for all M models on the same scatterplot...

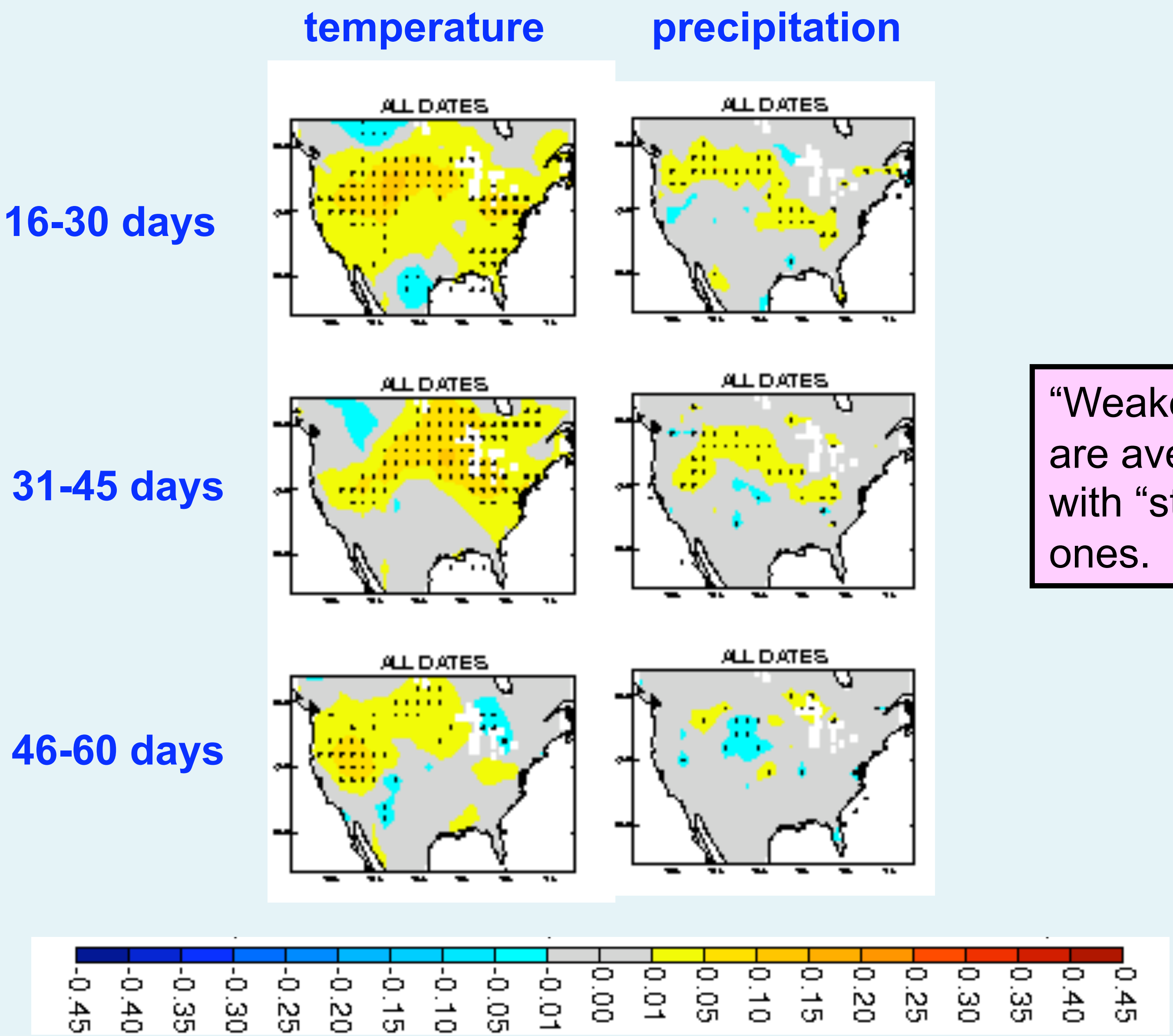


Observed temperature
(standard normal deviate)

... and then compute r^2 from 6MN points, N from each model.

Note: models may behave similarly (non-independently); must account for this in significance testing.

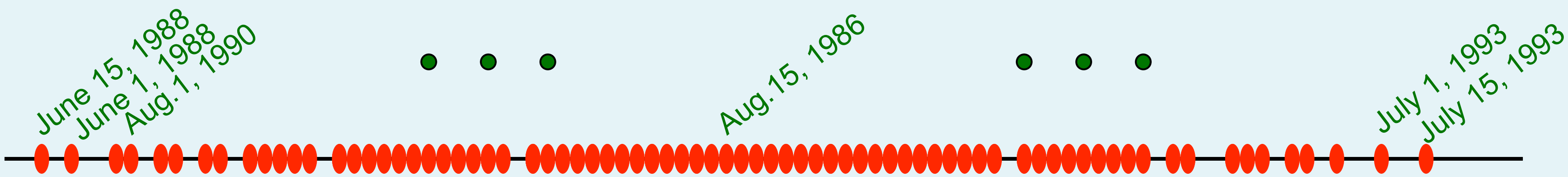
Forecasts: “Consensus” skill due to land initialization (JJA)



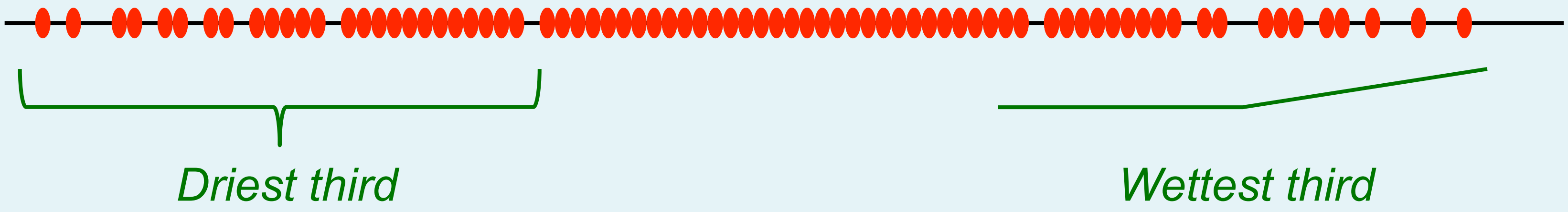
“Weaker” models are averaged in with “stronger” ones.

Conditional skill: **Suppose we know at the start of a forecast that the initial soil moisture anomaly, W_i, is relatively large...**

Step 1: At each grid cell, rank the forecast periods from lowest initial soil moisture to highest initial soil moisture:

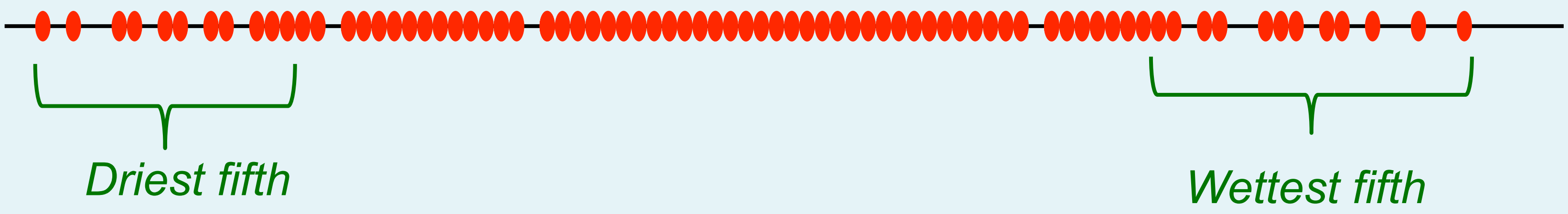


Step 2: Separate into terciles:



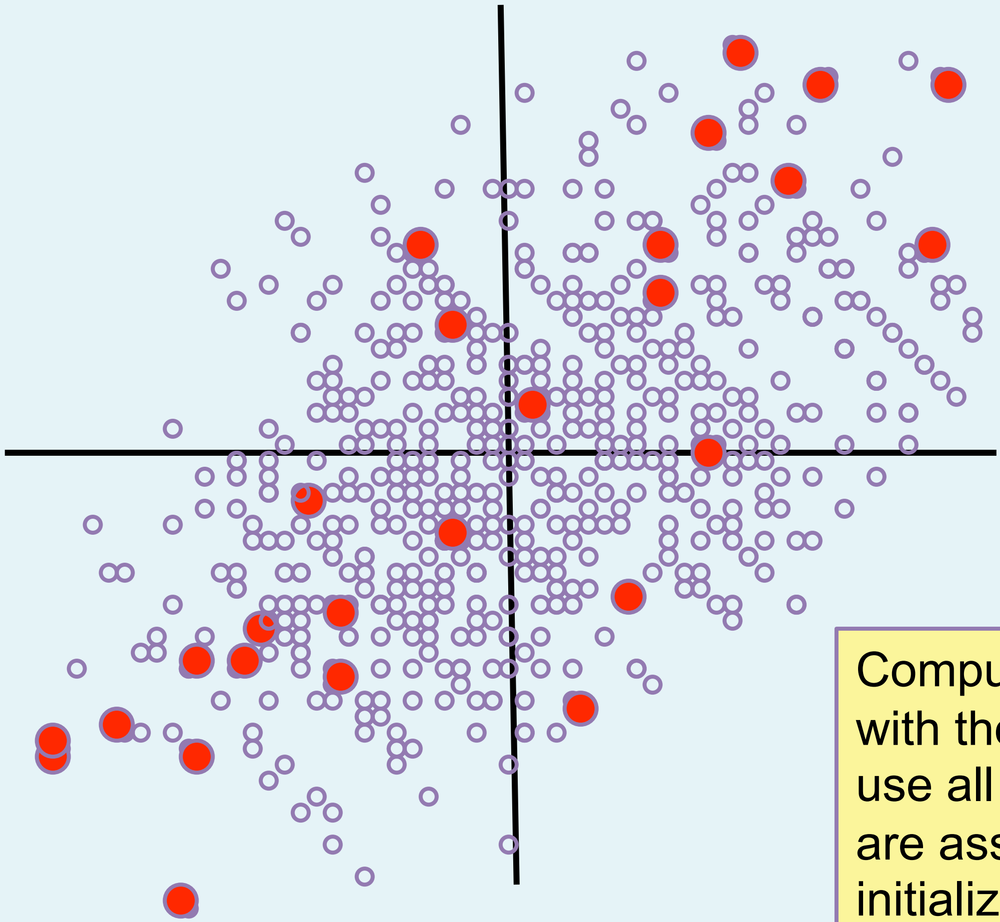
Conditional skill: Suppose we know at the start of a forecast that the initial soil moisture anomaly, W_i, is relatively large...

Step 2: Separate into quintiles:



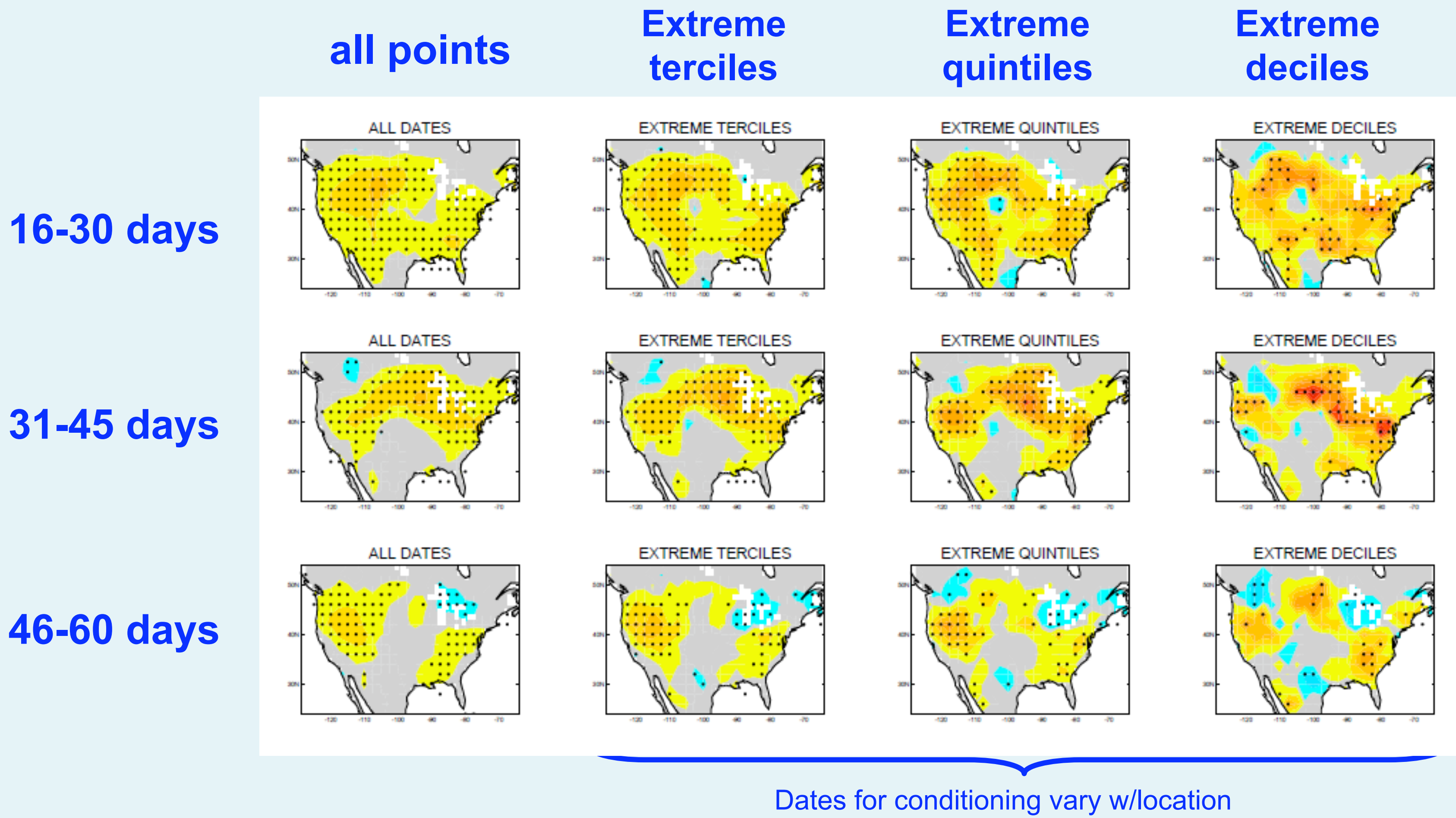
Step 3: Separate into deciles:

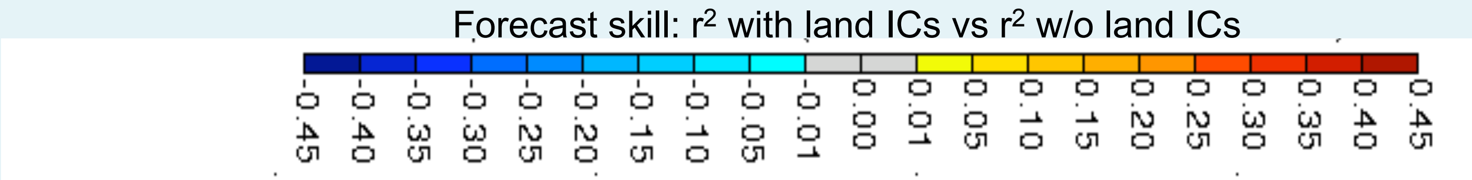
Identify start dates for which W_i is in top or bottom tercile (or quintile, or decile)



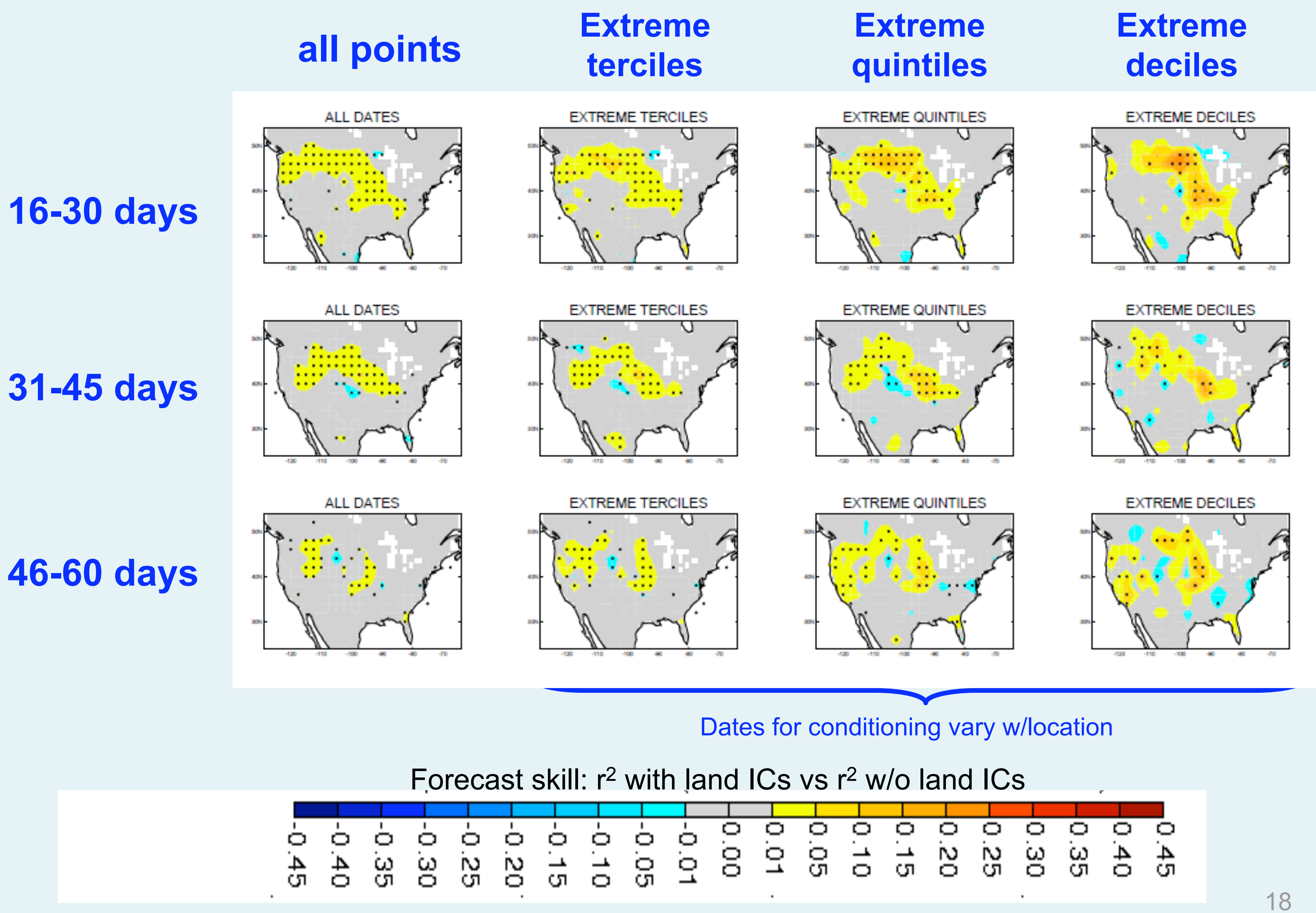
Compute r^2 from only those points with those start dates. (As before, use all models together.) Here, we are assuming that “local impacts” of initialization are most important.

Temperature forecasts: Increase in skill due to land initialization (JJA)
(conditioned on strength of local initial soil moisture anomaly)





Precipitation forecasts: Increase in skill due to land initialization (JJA)
(conditioned on strength of local initial soil moisture anomaly)

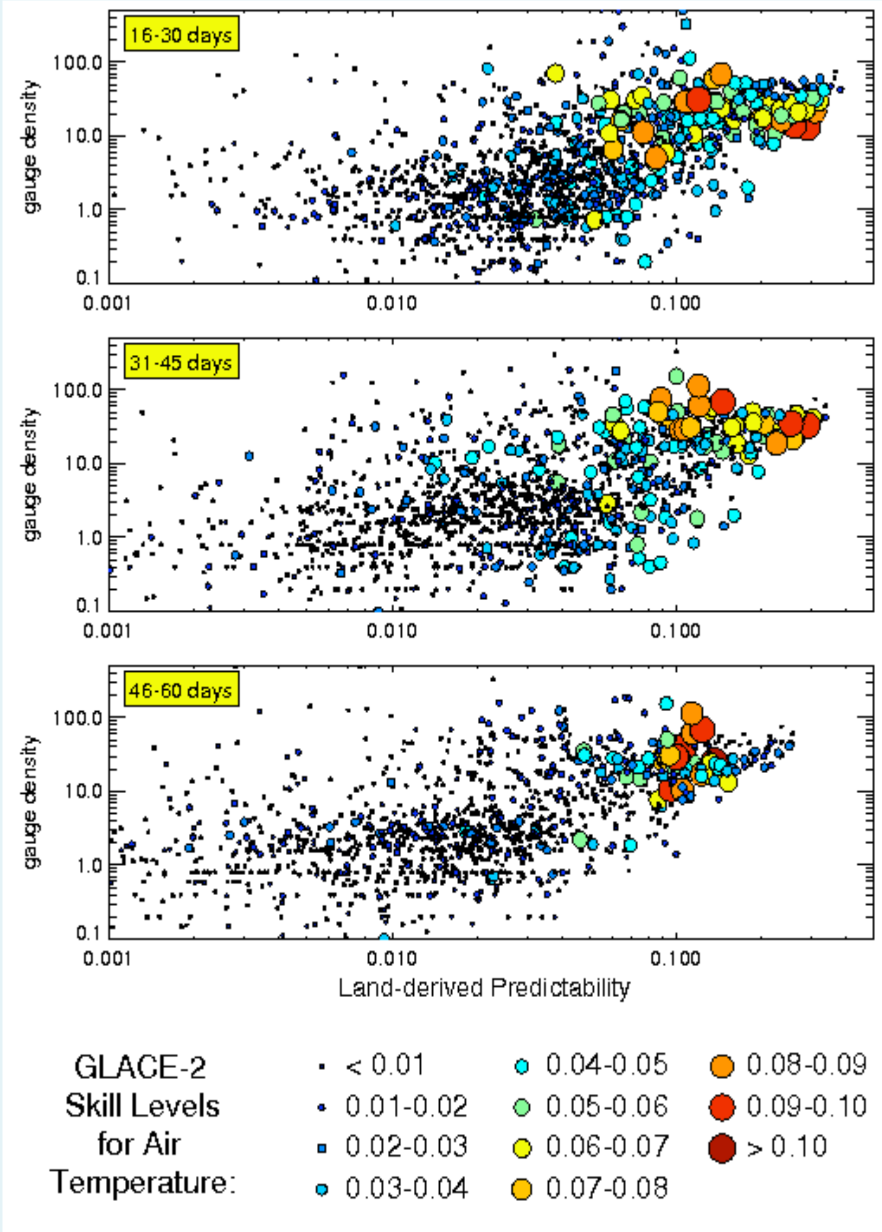


Forecast skill levels are highest in regions with both:

a)some inherent model "predictability", and

b)an adequate observational network for accurate initialization

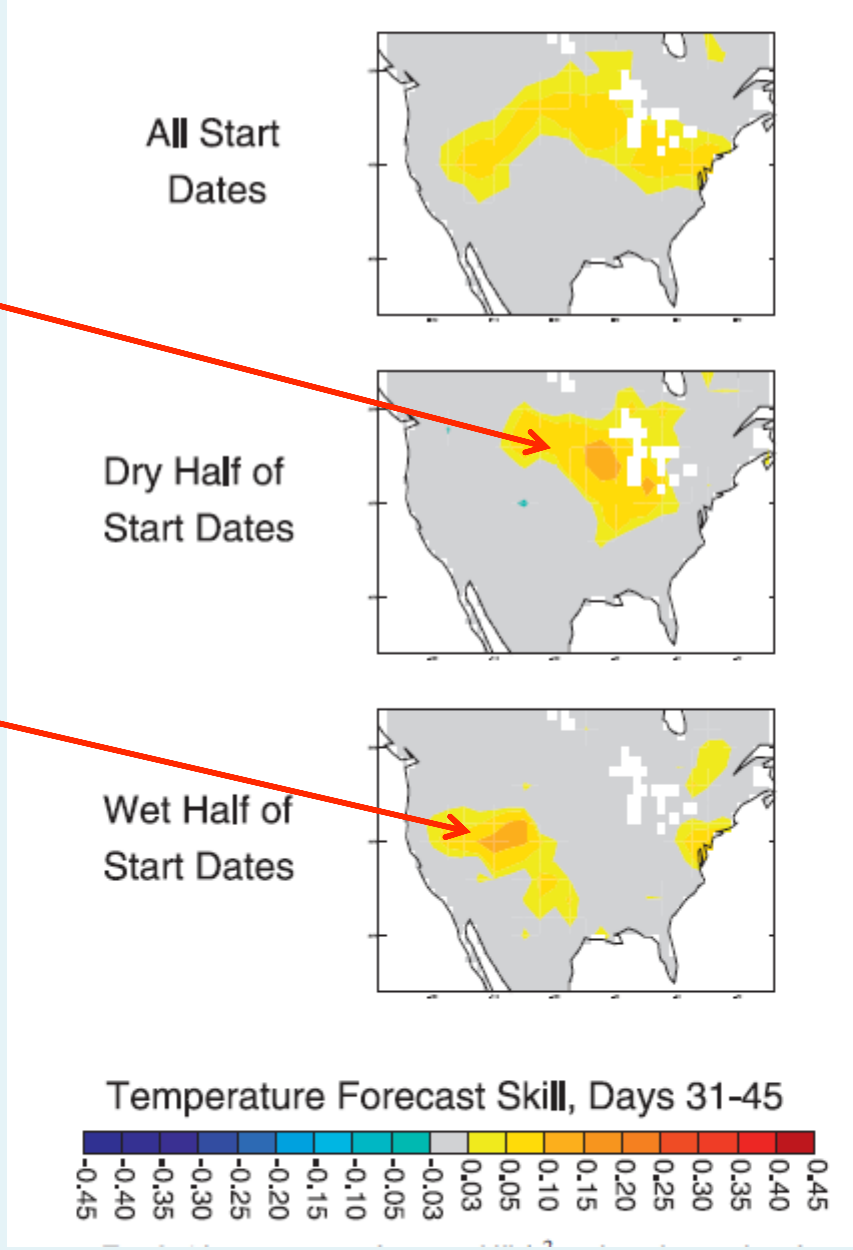
(This is a global analysis.)



Wet/dry asymmetry in skill contributions

Drier-than-average initial conditions provide skill here…

… whereas wetter-than-average initial conditions provide skill here



Conclusions of GLACE-2 Analysis

1. The experiments for GLACE-2 were performed with 13 models.

2. The individual models vary in their ability to extract forecast skill from land initialization. In general,
   -- Low skill for precipitation
   -- Moderate skill (in places) for temperature, even out to two months.

3. Land initialization impacts on skill increase when conditioned on the size of the initial local soil moisture anomaly.

   → If you know the local soil moisture anomaly at time 0 is large, you can expect (in places) that initializing the land correctly will improve your temperature forecast significantly, and your precipitation forecast slightly, even out to 2 months.

4. The results highlight the potential usefulness of improved observational networks for prediction and provide some indication of wet/dry asymmetry in skill contributions.

The Second Phase of the Global Land–Atmosphere Coupling Experiment: Soil Moisture Contributions to Subseasonal Forecast Skill

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ABSTRACT

The second phase of the Global Land–Atmosphere Coupling Experiment (GLACE-2) is a multi-institutional numerical modeling experiment focused on quantifying, for boreal summer, the subseasonal (out to two

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