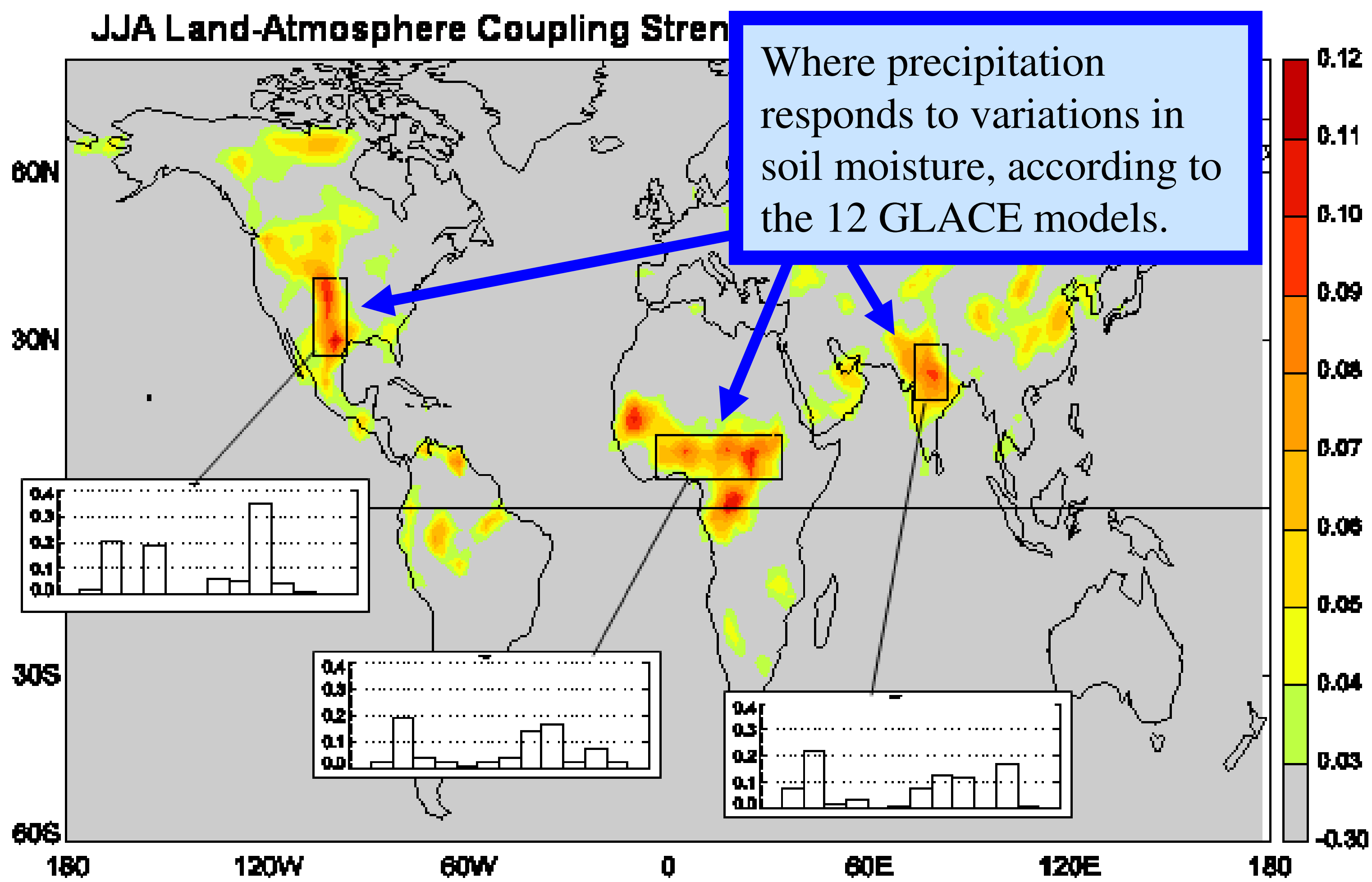
GLACE -2

The 2nd phase of the Global Land-Atmosphere Coupling Experiment

Randal Koster
GMAO, NASA/GSFC
randal.d.koster@nasa.gov

GLACE-1 was a successful international modeling project that looked at soil moisture impacts on precipitation...



Motivation for GLACE-2

For soil moisture initialization to add to subseasonal or seasonal **<u>forecast skill</u>**, two criteria must be satisfied:

1. An initialized anomaly must be "remembered" into the forecast period, and

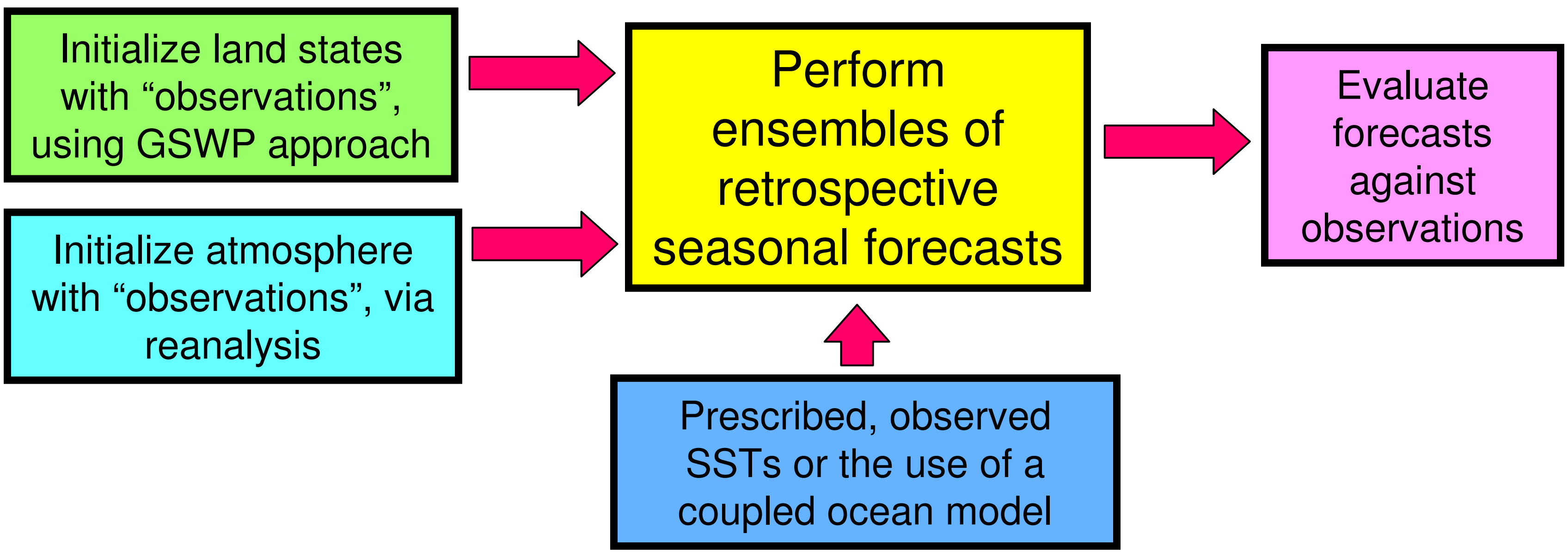
2. The atmosphere must be able to respond to the remembered anomaly.

Addressed by GLACE

Addressed by GLACE2: the full initialization forecast problem

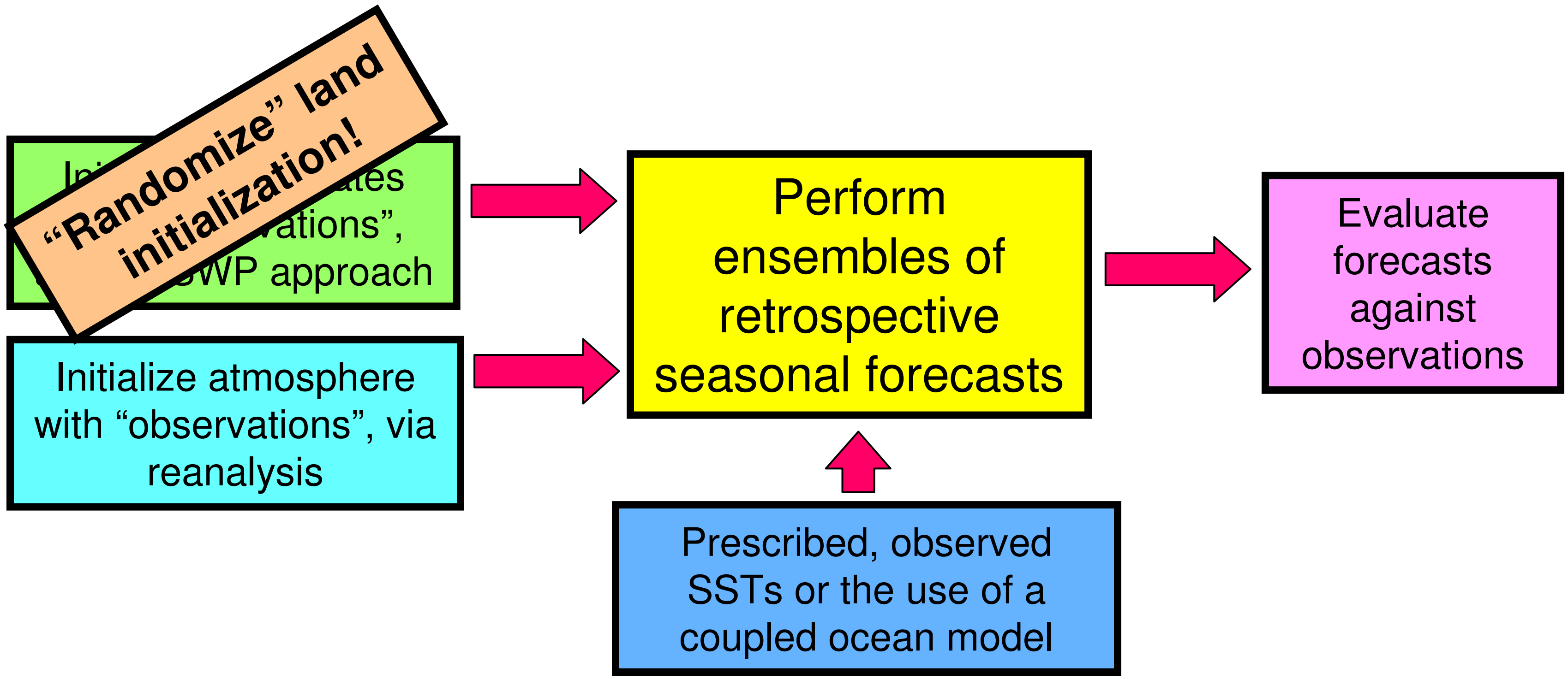
GLACE-2:
Experiment Overview

Step 1:



GLACE-2:
Experiment Overview

Step 2:



GLACE-2:
Experiment Overview

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

Forecast skill obtain in experiment using realistic land initialization

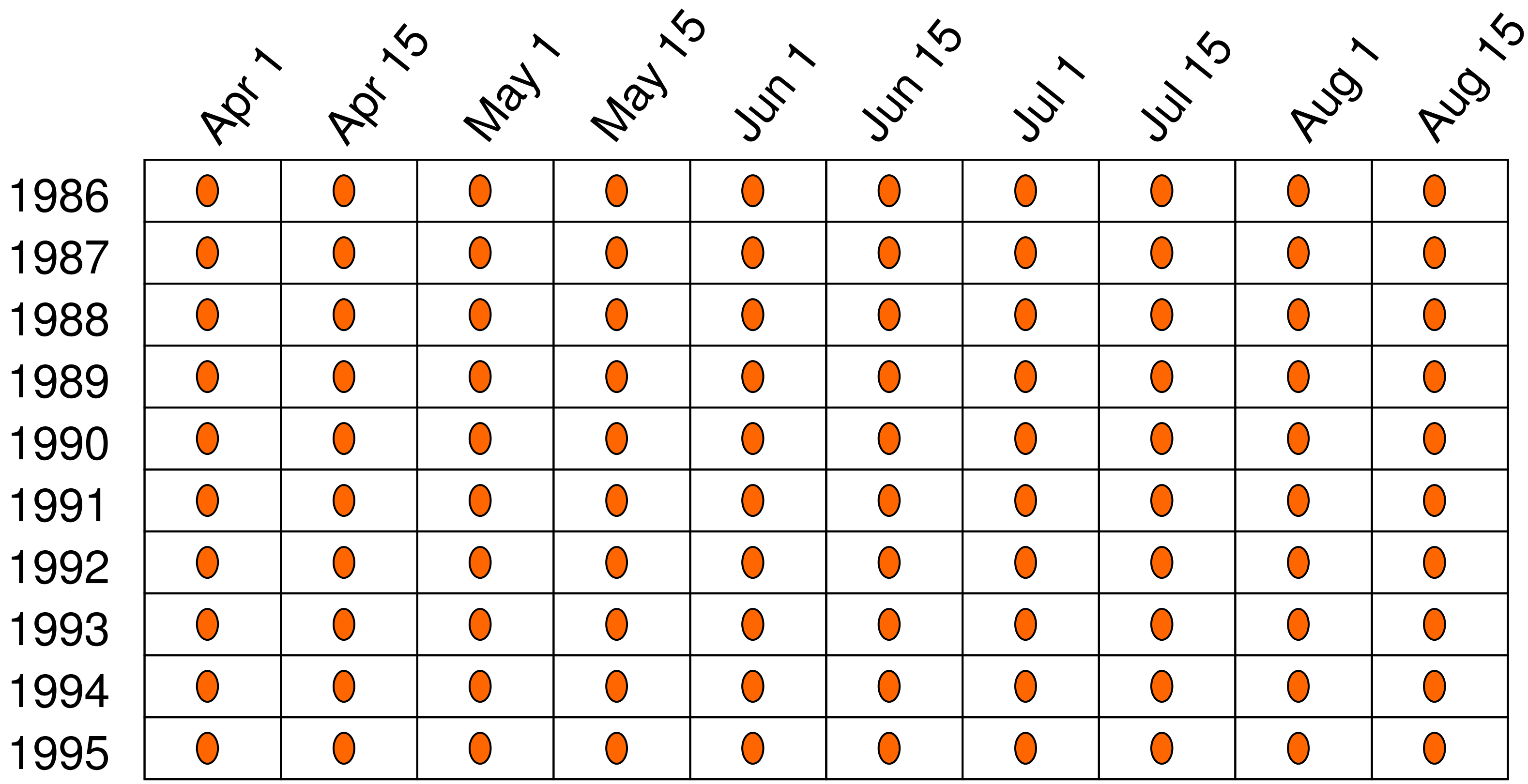
–

Forecast skill obtained in identical experiment, except that land is not initialized to realistic values

=

Forecast skill due to land initialization

FORECAST START DATES

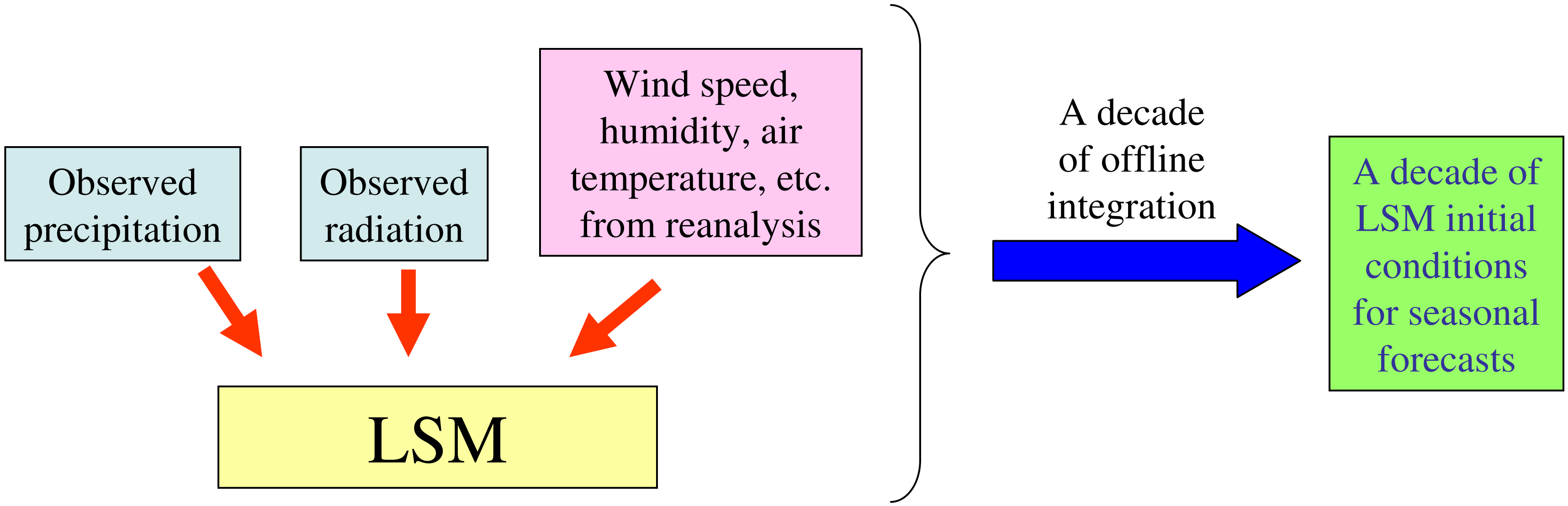


100 different 10-member forecast ensembles.

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

LAND STATE INITIALIZATION

via offline simulations, a la GSWP



The resulting LSM initial conditions reflect observed antecedent atmospheric forcing.

Two goals of project:

1. Calculate “potential predictability” in each forecast system – where does atmospheric noise overwhelm any potential signal?

2. Calculate skill in P and T prediction associated with the accurate initialization of land surface states.

Progress to date…

Integration into WCRP/TFSP project
(TFSP = Task Force on Seasonal Prediction)

WCRP REPORT
World Climate Research Programme

ICSU

Position Paper

WCRP Position Paper on
Seasonal Prediction

Report from the
First WCRP Seasonal Prediction Workshop
(Barcelona, Spain, 4-7 June 2007)

February 2008

WCRP Informal Report No. 3/2008
ICPO Publication No. 127

condition sensitivity experiments. Could tentative steps be taken toward initializing existing ice models?

6.2 Land Surface

A wealth of numerical model analyses and some complementary observational studies have shown that soil moisture anomalies can induce anomalies in precipitation and air temperature. This is not true everywhere; in very dry regions, evaporation is too low for its variation to influence an atmosphere already disinclined to generate rainfall, and in very wet regions, evaporation is controlled mostly by atmospheric demand and thus does not respond strongly to soil moisture variations. In the transition zones between wet and dry regions, however, soil moisture variations do seem to lead to precipitation and air temperature variations, as revealed by the GEWEX/CLIVAR-sponsored GLACE modeling experiment. This finding, coupled with the fact that soil moisture anomalies (both in models and in nature) persist for weeks to months, suggests that the initialization of land moisture states in a seasonal forecast system may lead to improved forecasts, at least in some areas.

Recommendations: The above potential will be addressed in GLACE-2, an ambitious follow-on to GLACE. In GLACE-2, modeling groups will perform the same two series of 2-month forecasts, one in which land moisture states are initialized realistically (through an offline exercise utilizing realistic meteorological forcing) and one in which the land state initialization is essentially random. Evaluation of precipitation rates and air temperatures produced in both sets of forecasts against observations will allow us to isolate any increase in skill stemming from the realistic land state initialization. GLACE-2 ostensibly focuses on soil moisture, but because of the way all the land states are initialized together in the experiment, GLACE-2 also addresses, at least peripherally, two other potential land-based sources of predictive skill: snow cover and subsurface heat reservoirs. Future studies should address the snow component more directly (e.g., with spring transition forecasts). A fourth potential source of land surface memory, vegetation health (leafiness), is also worth considering in future studies.

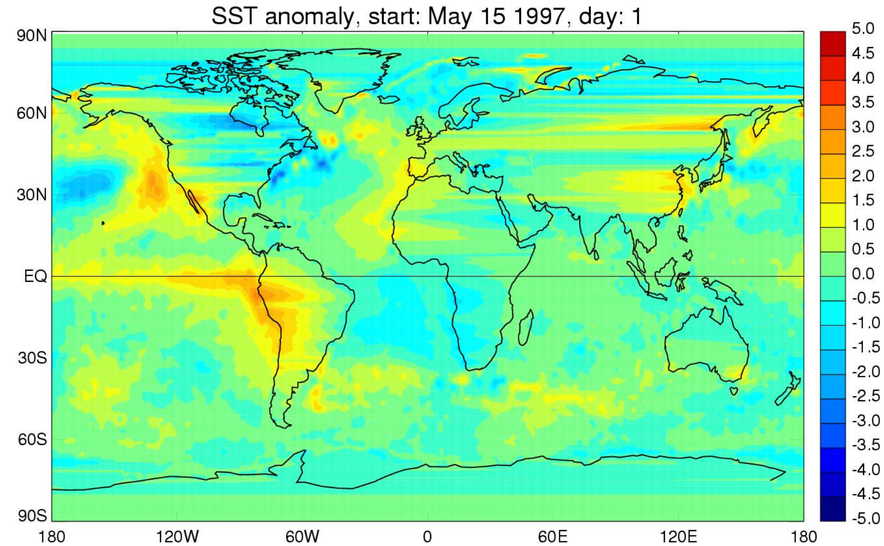
6.3 Stratospheric Processes

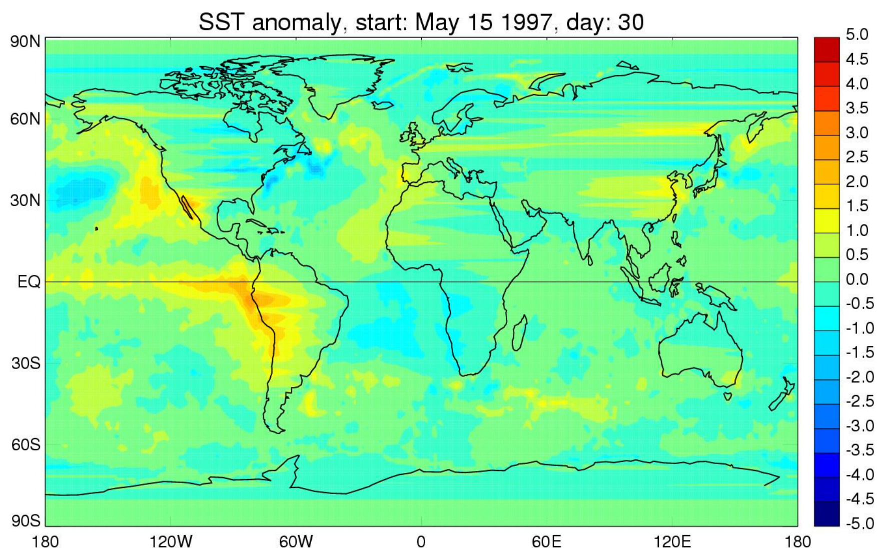
In many ways the stratosphere acts as a boundary condition for the troposphere. The stratospheric circulation can be highly variable, with a time scale much longer than that of the troposphere. The variability of the stratospheric circulation can be characterized mainly by the strength of the polar vortex, or equivalently the high latitude westerly winds. Stratospheric variability peaks during Northern winter and Southern late spring. When the flow just above the tropopause is anomalous, the tropospheric flow tends to be disturbed in the same manner, with the anomalous tropospheric flow lasting up to about two months. The surface pressure signature looks very much like the North Atlantic Oscillation or Northern

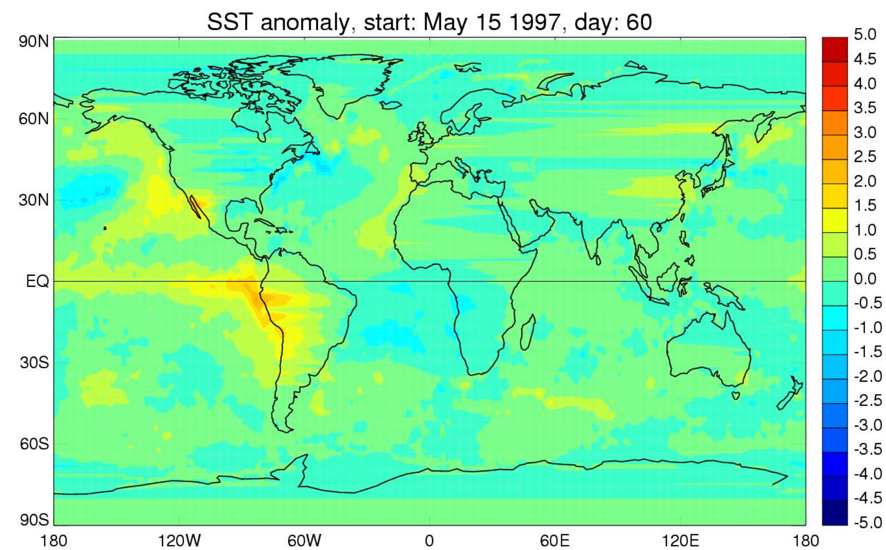
Established Participant List

Group/Model	# models	Points of Contact
1. NASA/GSFC (USA): GMAO seasonal forecast system (old and new)	2	R. Koster, T. Yamada
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, R. Andreas
5. KNMI (Netherlands): ECMWF	1	B. van den Hurk, H. Camargo, G. Balsamo
6. GFDL (USA): GFDL system	1	T. Gordon
7. U. Gothenburg (Sweden): NCAR	1	J.-H. Jeong
8. CCSR/NIES/FRCGC (Japan): CCSR GCM	1	T. Yamada
	10 models	

“Persisted” SST boundary conditions have been constructed and are now available online. (T. Yamada)

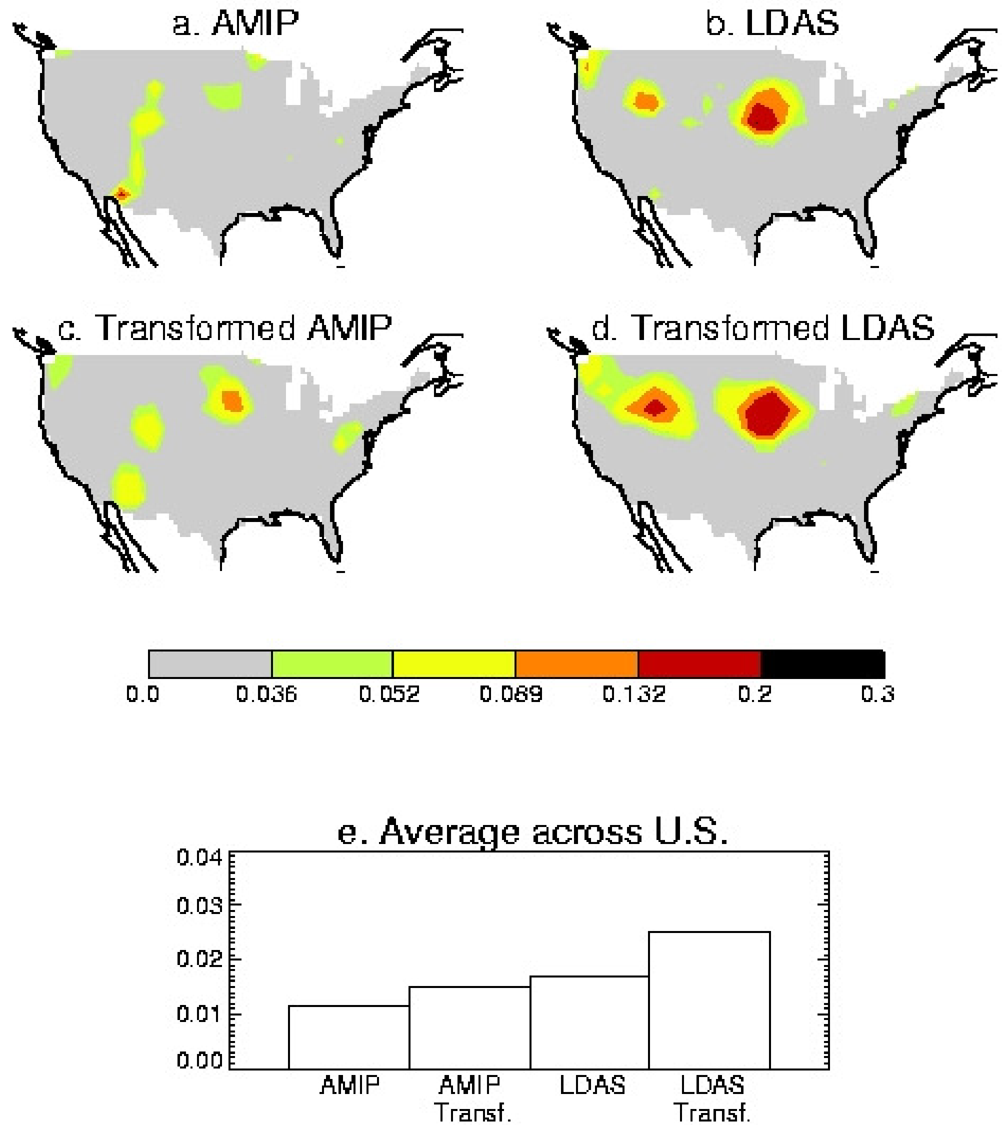






Developed statistical algorithms to extend forecast skill.
(Example for GMAO below; will apply to GLACE-2 models…)

Skill (r^2):
Results for
Precipitation

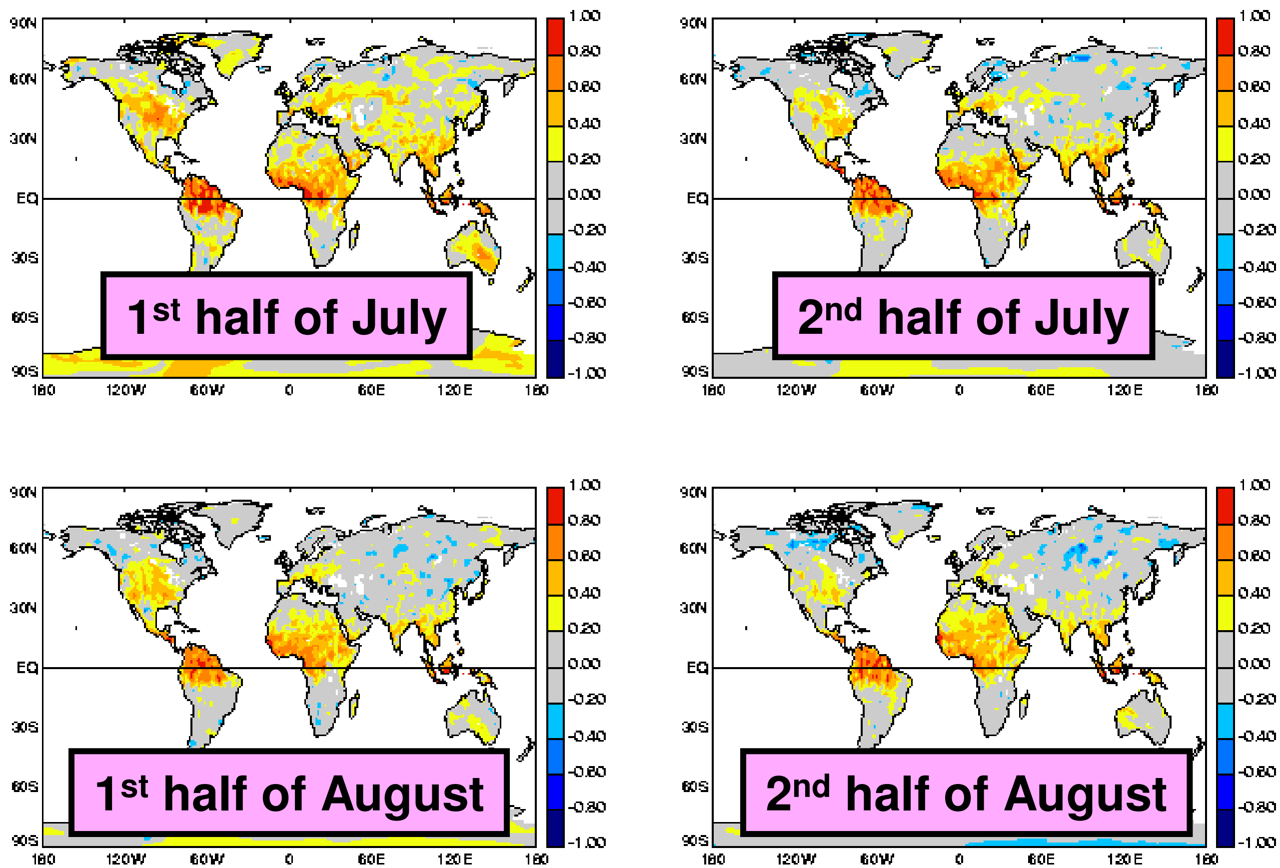


Results From Individual Groups

Fcst. Model	*Points of Contact*	*Progress to Date*
COLA GCM ; NCAR/ CAM GCM, via COLA	Paul Dirmeyer, Zhichang Guo	-- Forcing data interpolated to proper resolution; offline land simulations proceeding. -- *Completed 10 years of COLA runs* -- NCAR runs being set up.

Potential Predictability (r), Precipitation

(July 1 start, land initialized)



Fcst. Model	*Points of Contact*	*Progress to Date*
NCAR (USA, via U. Gothenburg, Sweden)	Jee-Hoon Jeong	-- *Baseline set of simulations for the period 1986-1995 is finished (Series 1 and Series 2).* -- Performing additional forecasts with modified initialization strategy.

Series 1 skill results (days 1-15)

Series 2 skill results

Differences: Impact of land initialization

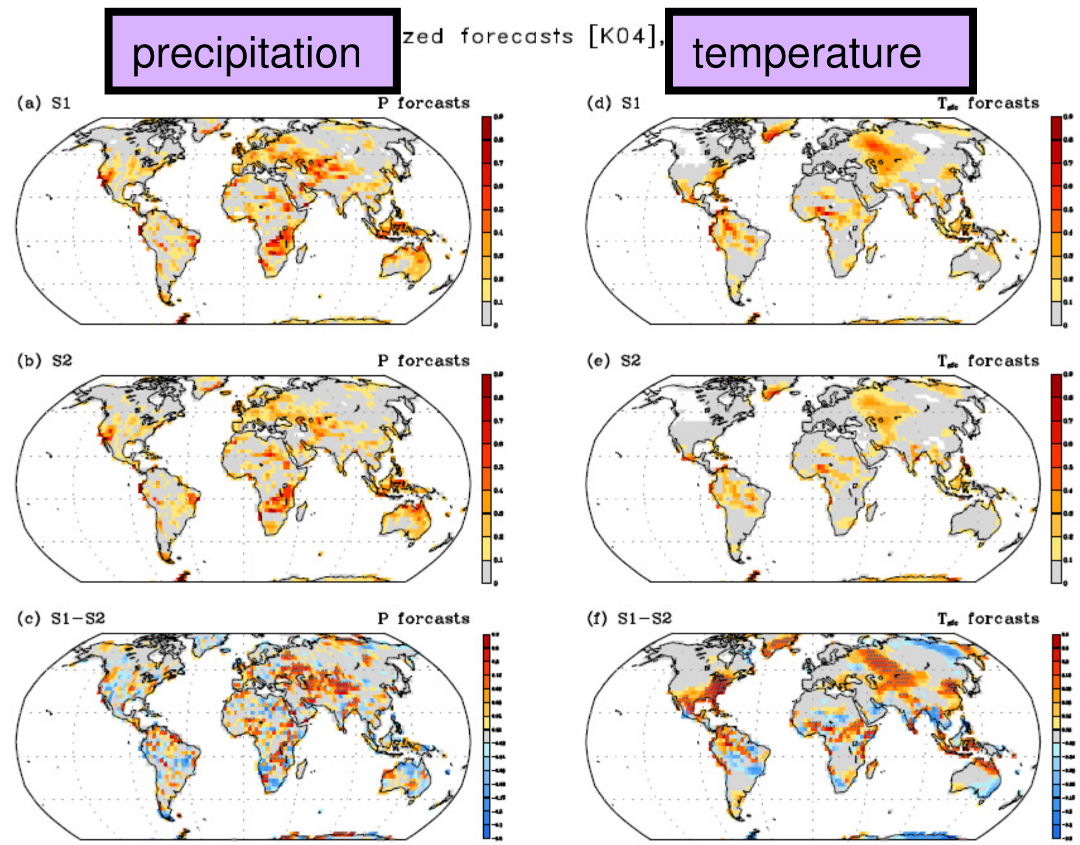
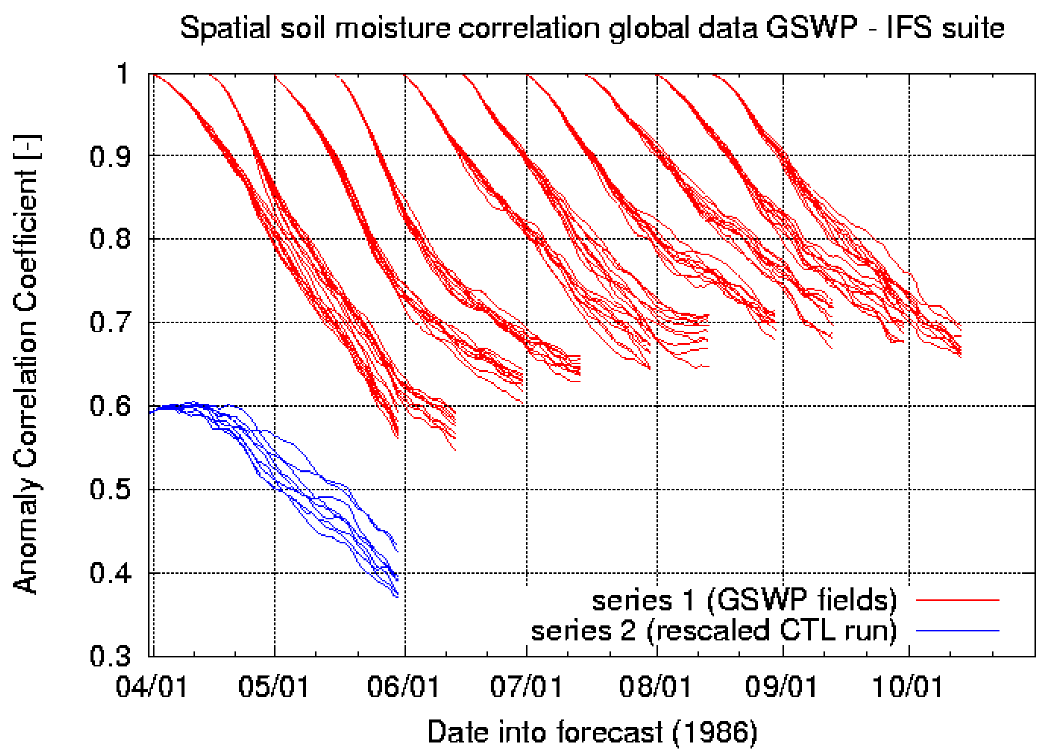


Figure 1. r^2 (by the methodology of Koster et al. 2004) values for P and Tsfc forecasts averaged for day 1- 15.

Fcst. Model	*Points of Contact*	*Progress to Date*
ECMWF (via KNMI, the Netherlands)	Bart van den Hurk, Helio Camargo, Gianpaolo Balsamo	-- GSWP2 forcings regridded to their GCM's resolution. -- 10-yr climatology run with the GCM, to allow for soil moisture scaling. -- Land model incorporated into LIS, for efficient offline simulation. *-- 1+ years of Series 1 forecasts, 1 set of Series 2 forecasts. (Forecasts are ongoing.)*

First results showing forecasted soil moisture's agreement with "truth" across the globe:
-- decrease of agreement with time
-- agreement differs amongst ensemble members.
-- longer apparent memory in mid-summer



Fcst Model	*Points of Contact*	*Progress to Date*
GEOS5 GCM; NSIPP GCM (NASA/GSFC)	Randal Koster, Tomohito Yamada	-- Simulated 50 years of land surface conditions for initialization -- Ran GEOS5 GCM 10 years to generate climatology -- Forecasts are underway.
NCEP (via Princeton, USA)	Eric Wood, Lifeng Luo	-- Simulated 50 years of land surface conditions for initialization. -- Ready to go; waiting for time on NCEP machine.
ECHAM (via IACS, Switzerland)	Sonia Seneviratne, Roesch Andreas	-- Series 2 simulations for GSWP2 period are finished for most start dates in 10-year period.

Fcst Model	***Points of Contact***	***Progress to Date***
GFDL (USA)	Tony Gordon	-- AMIP style control run performed for atmospheric initial conditions and for scaling of land variables. -- 10 years (1st of each of month, 10 ensemble members) completed, for both Series 1 and Series 2. -- All Series 1 runs done; scaled and unscaled; Series 2 done two ways: with pdf, and with average.
CCSR/NIES/ FRCGC (Japan)	Tomohito Yamada	-- Simulated 50 years of land surface conditions for initialization.

Summary (in five words or less):

GLACE-2 is moving forward nicely.

Do *you* want to participate?

If so, contact Randy Koster at randal.d.koster@nasa.gov

Thank you!

Back-up slides

Computational requirement:

100	x	10	x	1/6	x	2
forecast start dates		ensemble members per forecast		years (2 months) per simulation		experiments (including control)

= 333 years of simulation

Required output diagnostics (to be provided to GLACE data center):

1. For each of the 4 15-day periods of each forecast simulation, provide global fields of:

- 15-day total precipitation
- 15-day average near-surface air temperature (in the lowest AGCM level)
- 15-day total evaporation
- 15-day average net radiation
- 15-day average vertically-integrated soil moisture content.
- 15-day average near-surface relative humidity

Required output diagnostics (to be provided to GLACE data center):

2. For each day of the first 30 days of certain forecast simulations, provide global fields of:

- vertically-integrated soil moisture content.

This will allow us to analyze the decay with lead time of the information provided by soil moisture initialization.

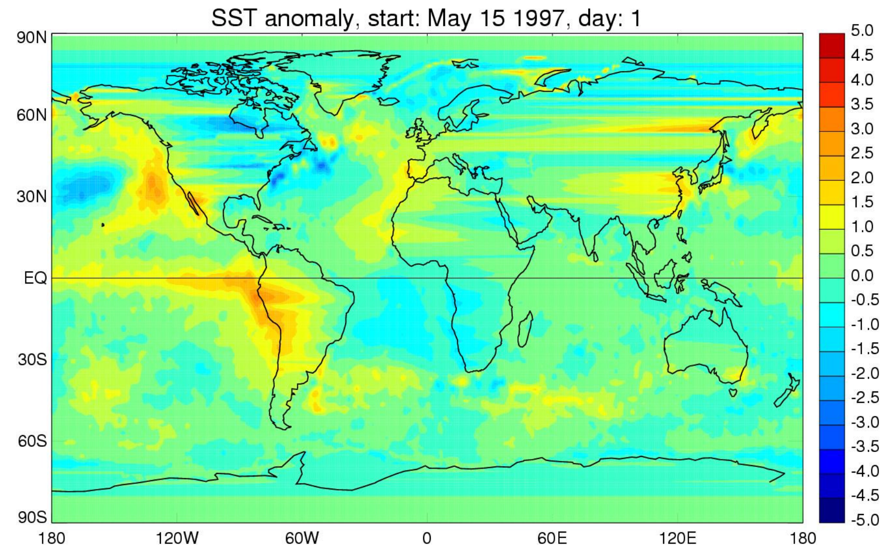
The forecast simulations chosen for this output are:
Apr. 1, May 1, June 1, July 1, and Aug. 1 of 1986, 1988, 1990, 1992, and 1994.

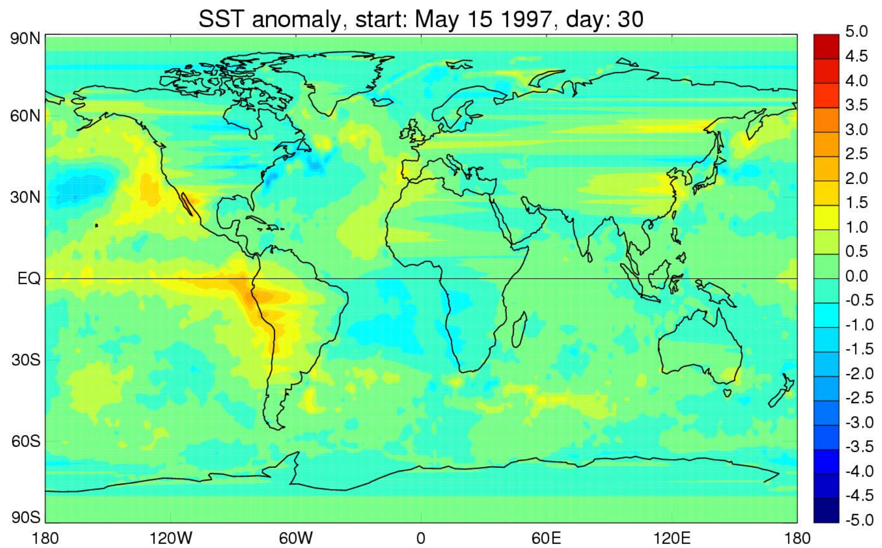
3. Generation of SST Boundary Conditions

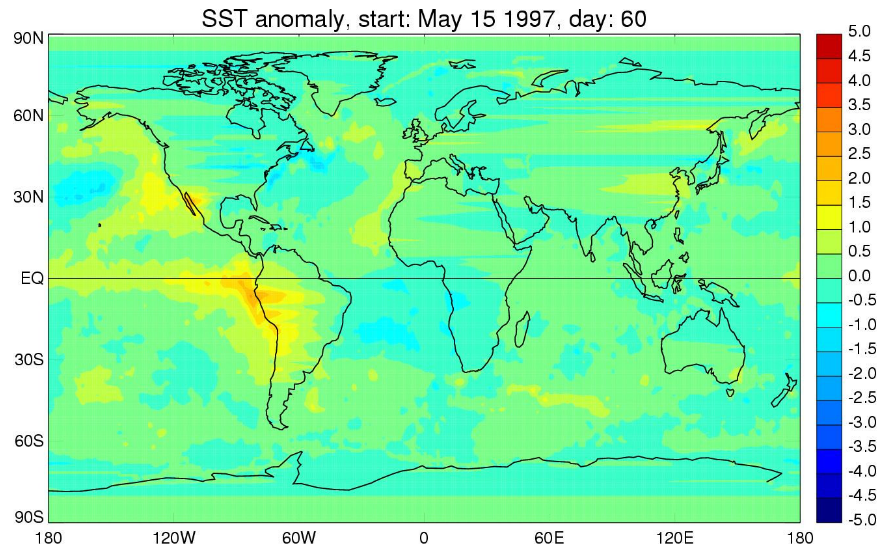
Needed: SST conditions for forecasts that do not include measurements of SSTs during the forecast period.

Approach: Determine persistence timescales from observational record (with data exclusion) and reduce initial (measured) SST anomalies with time into the forecast, using those timescales.

“Persisted” SST boundary conditions have been constructed and are now available online. (T. Yamada)



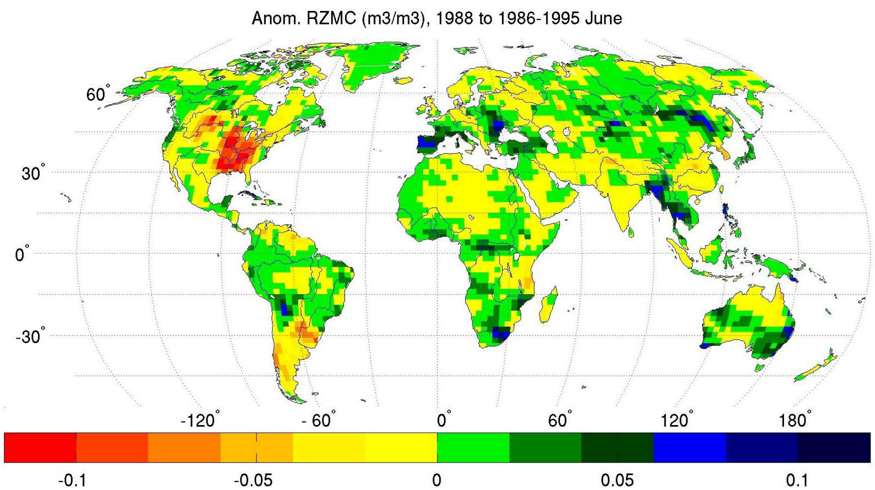




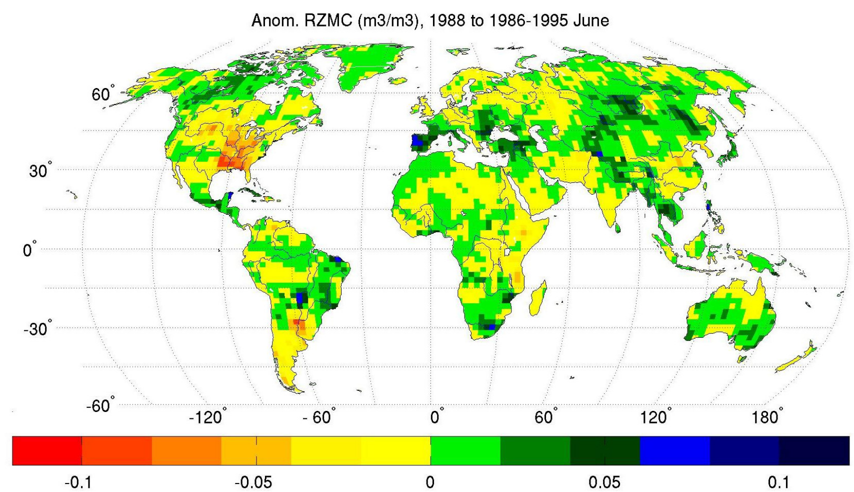
4. Examined forcing datasets (T. Yamada)

June 1988 Soil Moisture Anomaly (against 1986-1995)

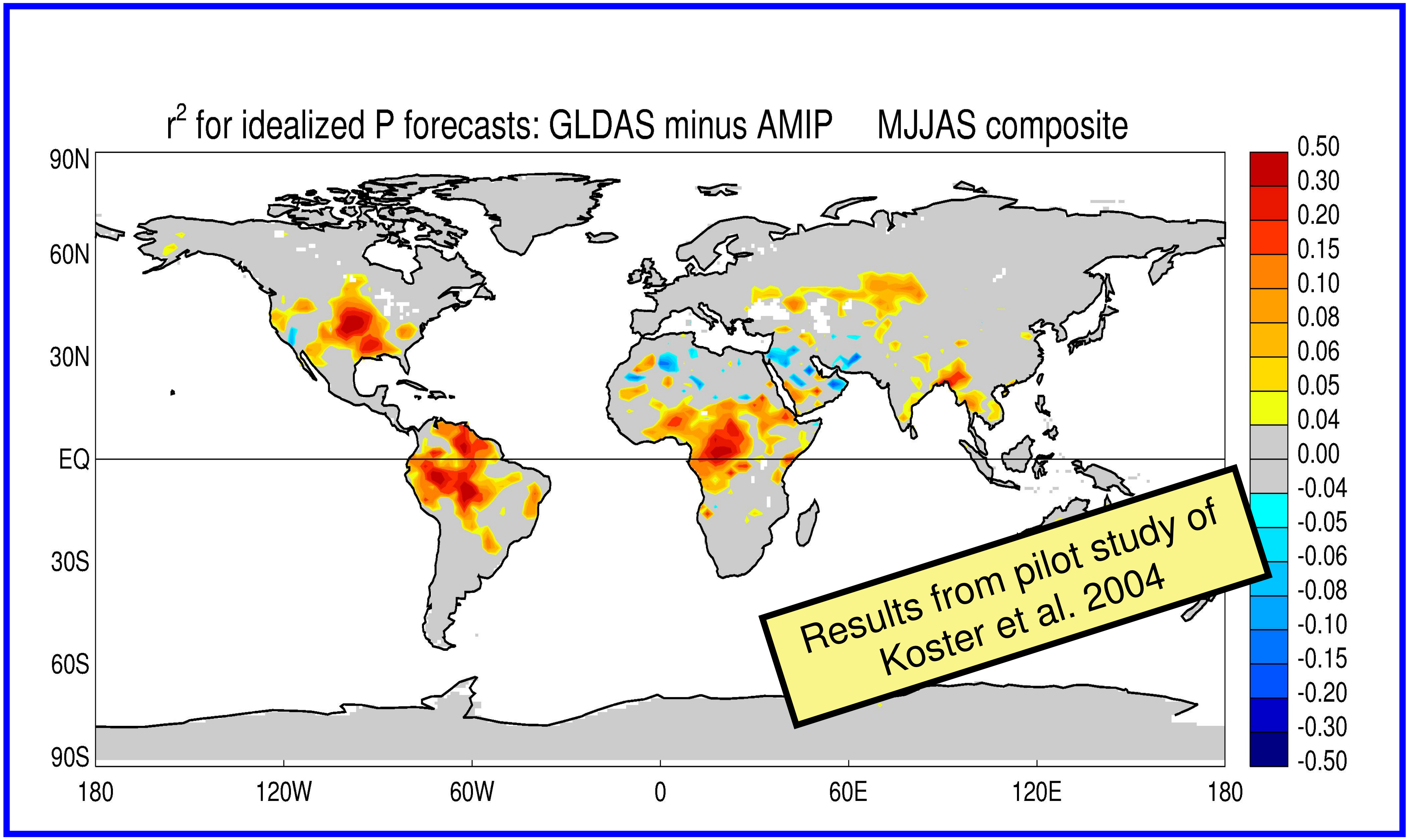
GSWP2



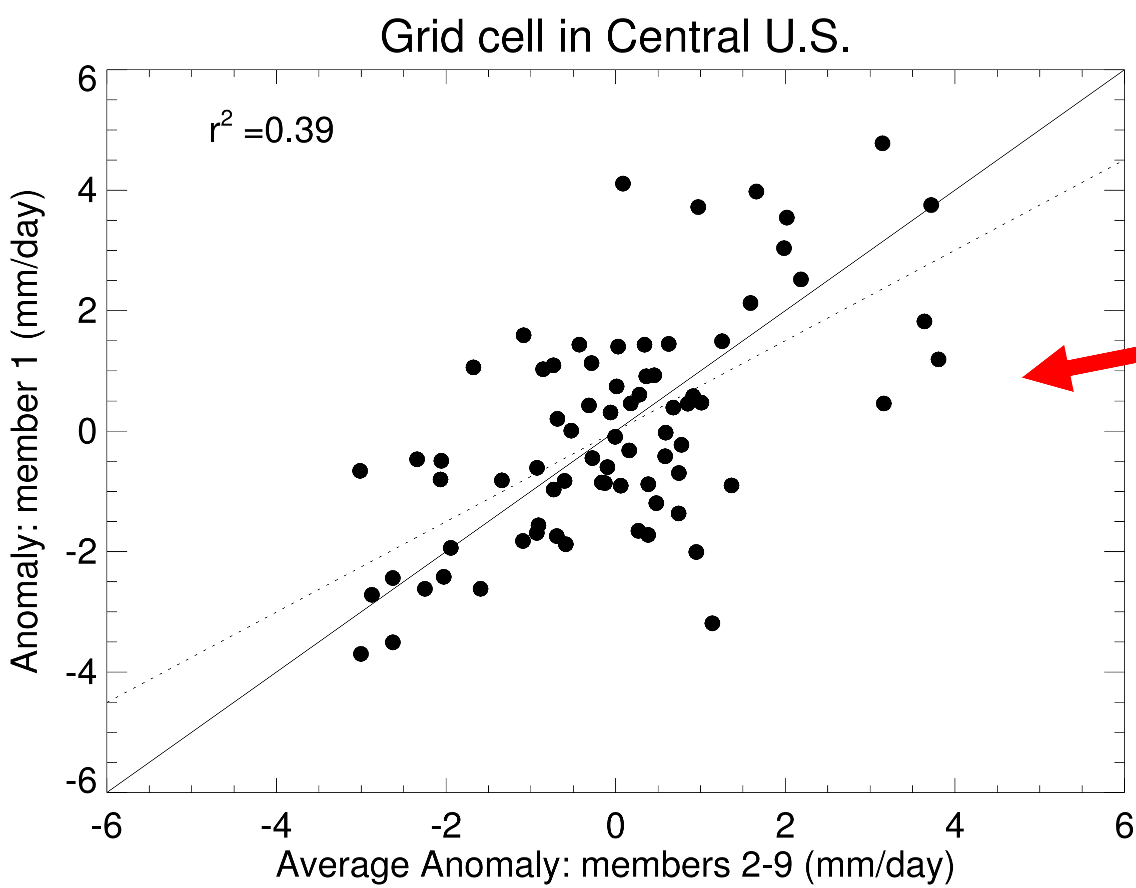
Princeton



1. Determine maximum level of precipitation (and air temperature) predictability associated with land initialization.



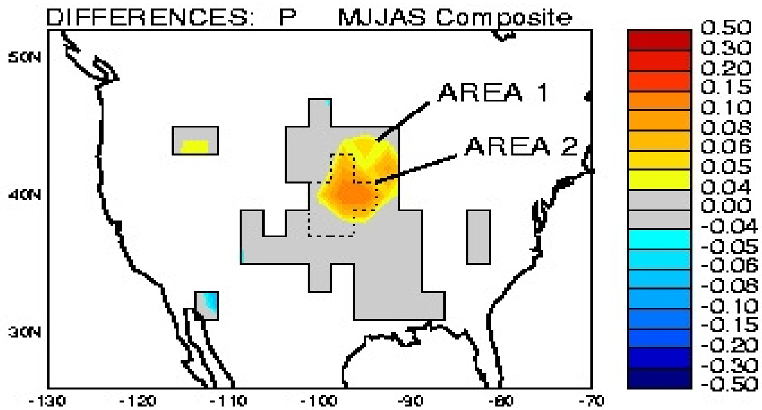
2. Determine forecast skill for precipitation (and air temperature) associated with land initialization.



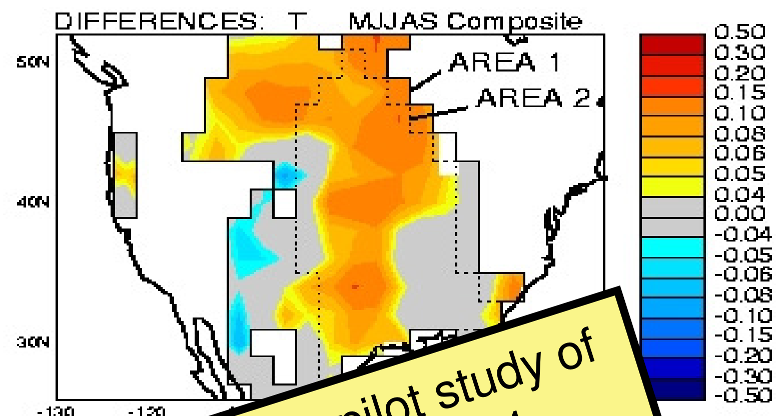
Regress full forecast against actual observations to retrieve r^2.

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

Contribution to skill: P forecasts



Contribution to skill: T forecasts



Results from pilot study of Koster et al. 2004

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