Subseasonal/Seasonal Forecasting with the NASA/GMAO Earth System Model

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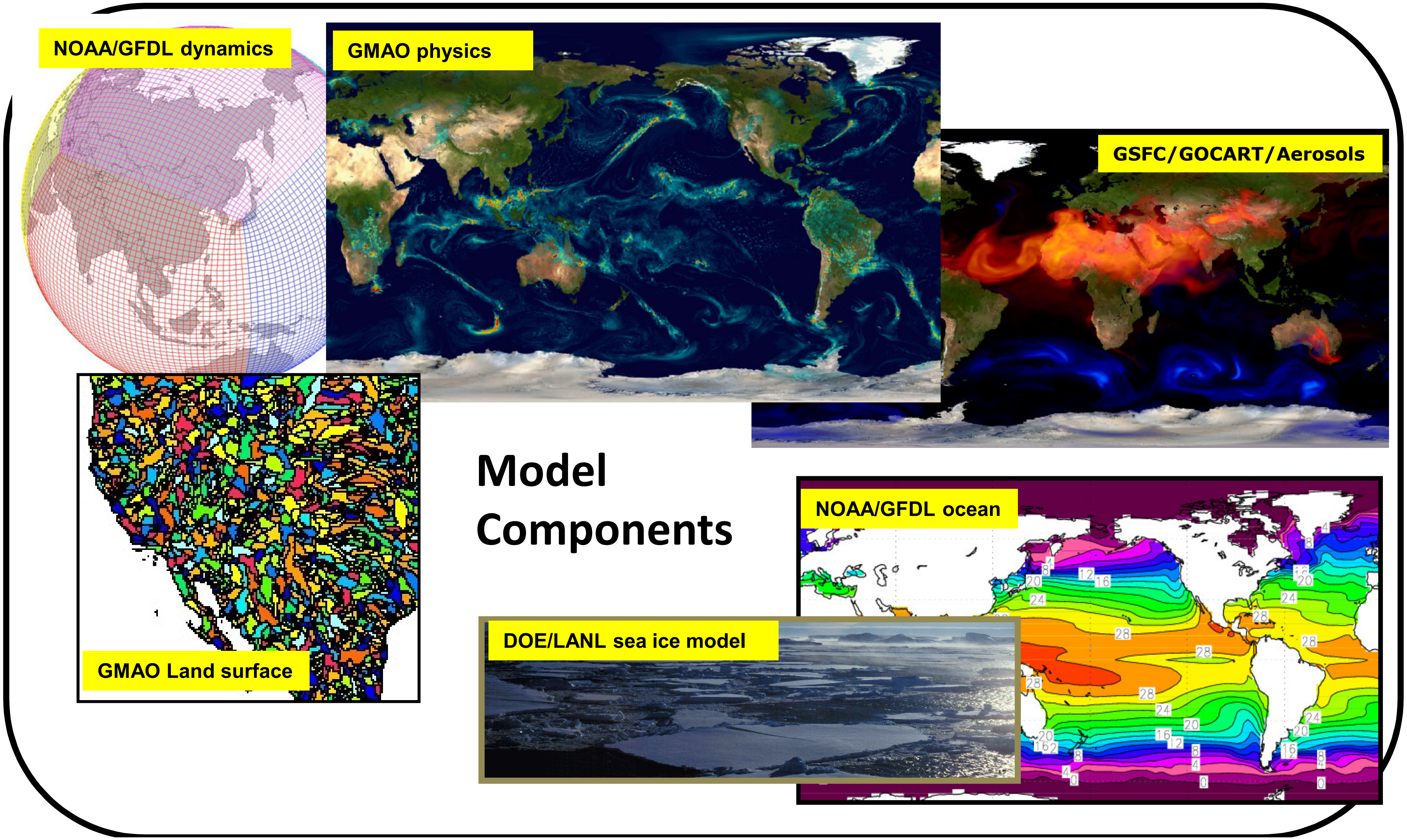
1. Prediction System

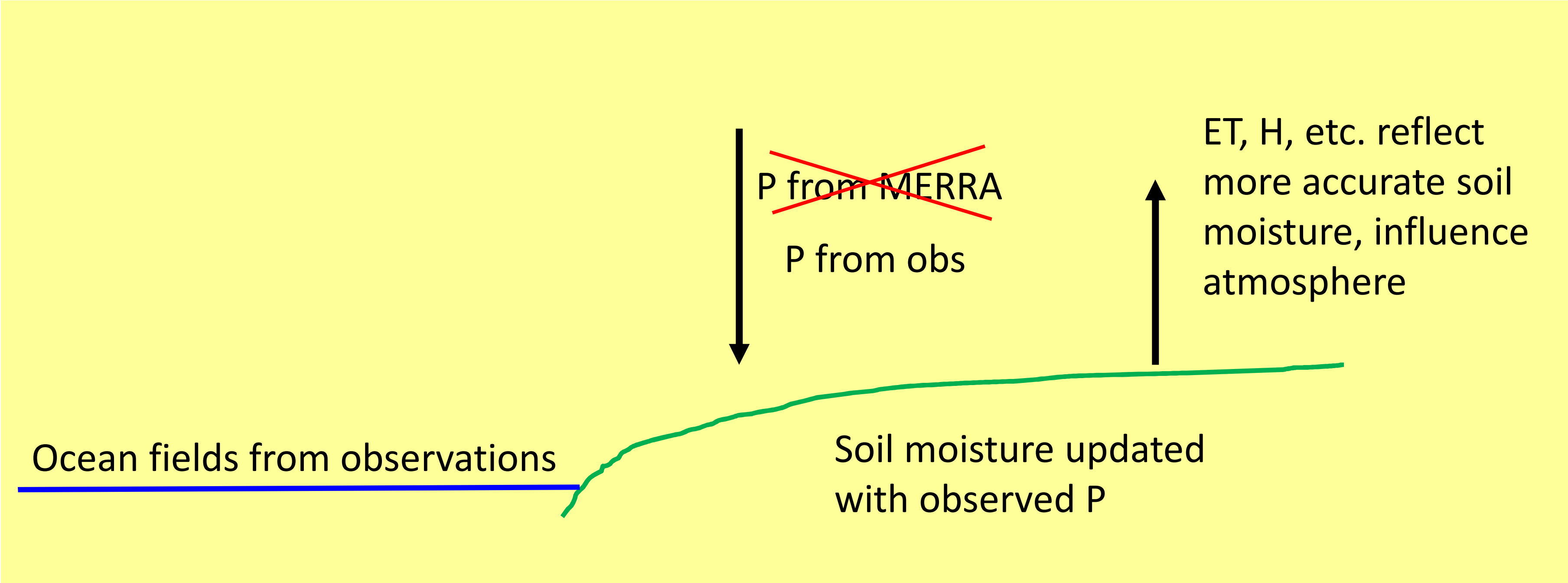
GEOS-5 Earth modeling and data assimilation system (GMAO, NASA/GSFC)



2. System Design

a. Initialization of atmosphere and land states.

Full atmospheric data assimilation up to the start of the forecast (basically the extending of MERRA), except*:



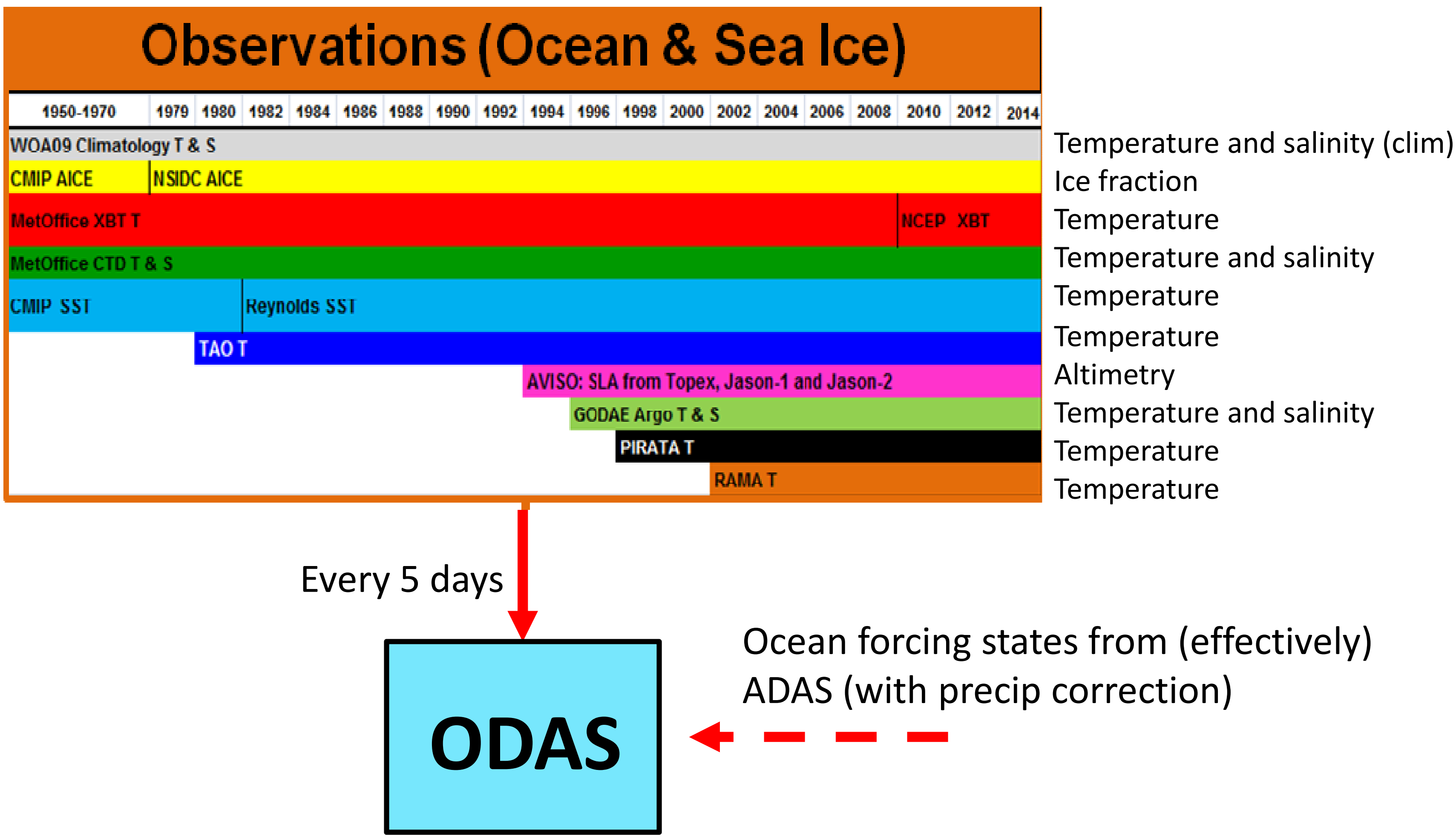
⇨ **Atmospheric and land fields see full benefit of atmospheric observations and observed precipitation.**

*through a supplemental "replay" run

2. System Design

b. Initialization of ocean and sea ice states.

Use of state-of-the-art ocean data assimilation system. Overly simplified view:



2. System Design

c. Reforecast Frequency and Ensemble Size

--15 ensemble members every month (after 1993)

--12 ensemble members every month since 1981:

-- Each forecast run for 9 full months

--10 launched on day 1 of month; 1 more launched every 5 days.

Format of ensembles
Seasonal GEOS-5 coupled model forecast

ENS / IC TYPE	1	2	3	4	5	6	7	8	9	10
ANALYSIS	O	O	O	O	O	O	O	Q	Q	Q
PERTURBATION		B-	B+	I-	I+		B+		P-	P+
ANALYSIS	A	A	A	A	A	A	A	A	A	A
PERTURATION		B-	B+	I-	I+	I-			B-	B+
AVAILABLE FROM	1981	1981	1981	1981	1981	1981	1981	1993	1993	1993

O, Q	-EnOI A005 and A004 (Altimeter) ocean analyses I.C.
A	-source for atmospheric, ice and saltwater I.C.
B, P	-perturbations generated using breeding technique and either standard or Altimeter ocean analyses
I	-perturbations generated using GEOS-5 analysis on two days: 5-days to current and current

More details at http://http://gmao.gsfc.nasa.gov/products/climateforecasts/GEOS5/DESC/em_perturb.php

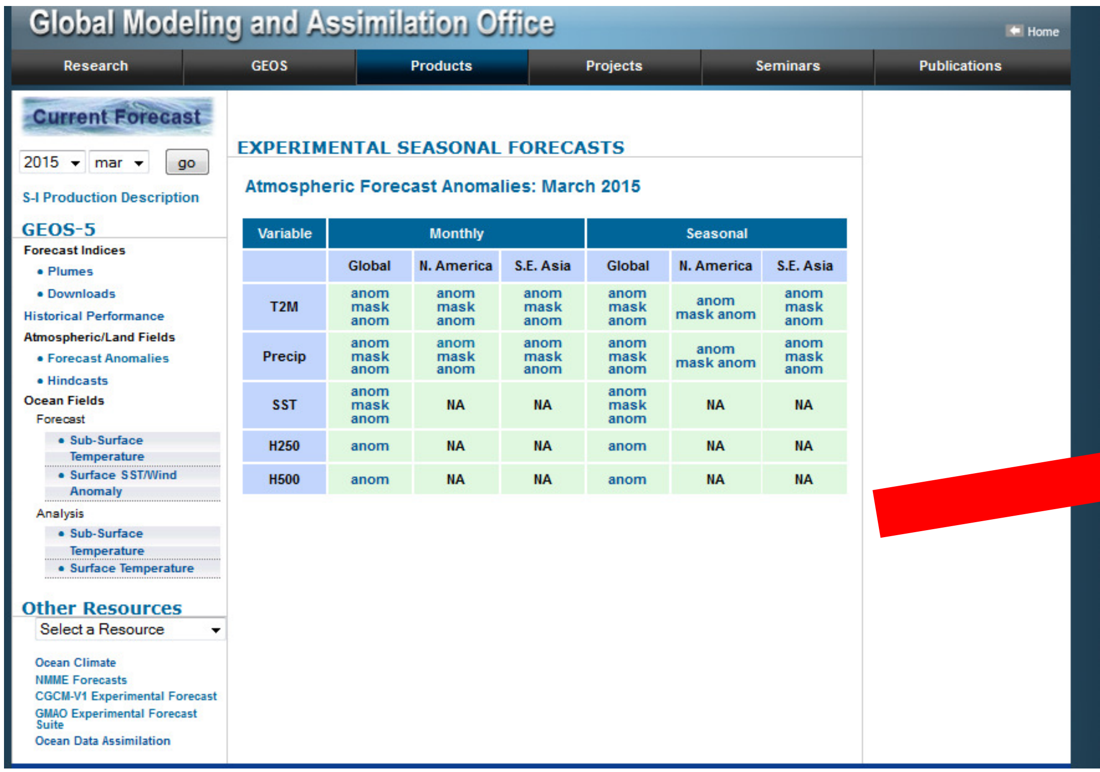
2. System Design   d. Computational Aspects

<u>Resolution</u>

Ocean: Tripolar grid (720x410, or ~0.5 degree, with 40 vertical levels)
Atmosphere: 1.25x1, with 72 vertical levels

Executed on NCCS supercomputer: 168 CPU for each forecast. 18 hrs to complete 9 months

Forecasts are sent to NMME on 6th of each month; website then updated.



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Current Forecast

2015 mar go

S-I Production Description

GEOS-5

Forecast Indices

• Plumes

• Downloads

Historical Performance

Atmospheric/Land Fields

• Forecast Anomalies

• Hindcasts

Ocean Fields

Forecast

• Sub-Surface Temperature

• Surface SST/Wind Anomaly

Analysis

• Sub-Surface Temperature

• Surface Temperature

Other Resources

Select a Resource

Ocean Climate

NMME Forecasts

CGCM-V1 Experimental Forecast

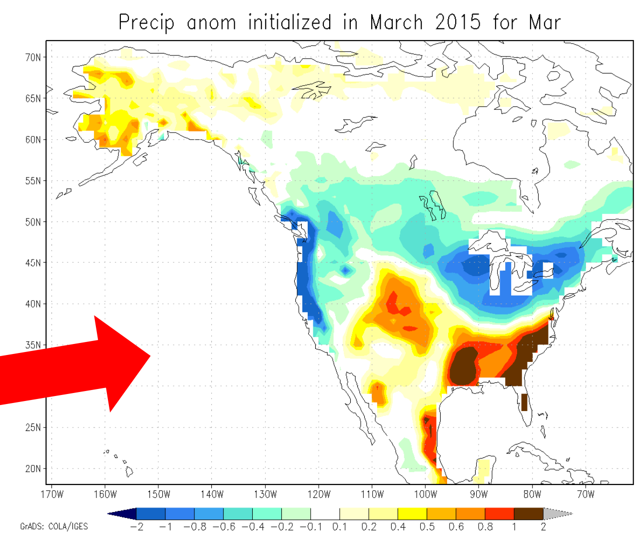
GMAO Experimental Forecast Suite

Ocean Data Assimilation

EXPERIMENTAL SEASONAL FORECASTS

Atmospheric Forecast Anomalies: March 2015

Variable	Monthly			Seasonal		
	Global	N. America	S.E. Asia	Global	N. America	S.E. Asia
T2M	anom mask anom	anom mask anom	anom mask anom	anom mask anom	anom mask anom	anom mask anom
Precip	anom mask anom	anom mask anom	anom mask anom	anom mask anom	anom mask anom	anom mask anom
SST	anom mask anom	NA	NA	anom mask anom	NA	NA
H250	anom	NA	NA	anom	NA	NA
H500	anom	NA	NA	anom	NA	NA



3. Current Prediction Products

The following data are available for every forecast:

Monthly averages (surface temperature, winds, salinity, surface turbulent fluxes, surface stresses, precipitation, radiation quantities, heights, UVTHQ on 25 levels, land surface variables, and more…)

Daily averages (UVTHQ on 25 levels, heights, surface air temperatures, precipitation components, radiation quantities, winds, land surface variables, and more…)

Hourly, 3-hr, or 6-hr values (UVTPQ, surface air temperature, humidity, precipitation, and more…)

4. Requirements for Future Development (Interpret here as planned upgrades)

Ocean/ice data assimilation:
-- Assimilation of ice thickness
-- Assimilation of salinity from Aquarius
-- Short term: work with MERRA-2 atmosphere; long-term (MERRA-3) involves coupled data assimilation
-- (Possibly) EnKF (software is there, resources are questionable)
-- (Possibly, in long term) Ocean color, GRACE

Atmosphere/land assimilation
-- Atmosphere assimilation based on MERRA-2
-- Assimilation of SMOS, SMAP soil moisture data

Modeling system
-- Update ocean model from MOM4 to MOM5 (and eventually to MOM6)
-- Update system from Fortuna to Ganymed versions of model (redo all hindcasts)
-- Higher resolutions for the ocean and atmosphere

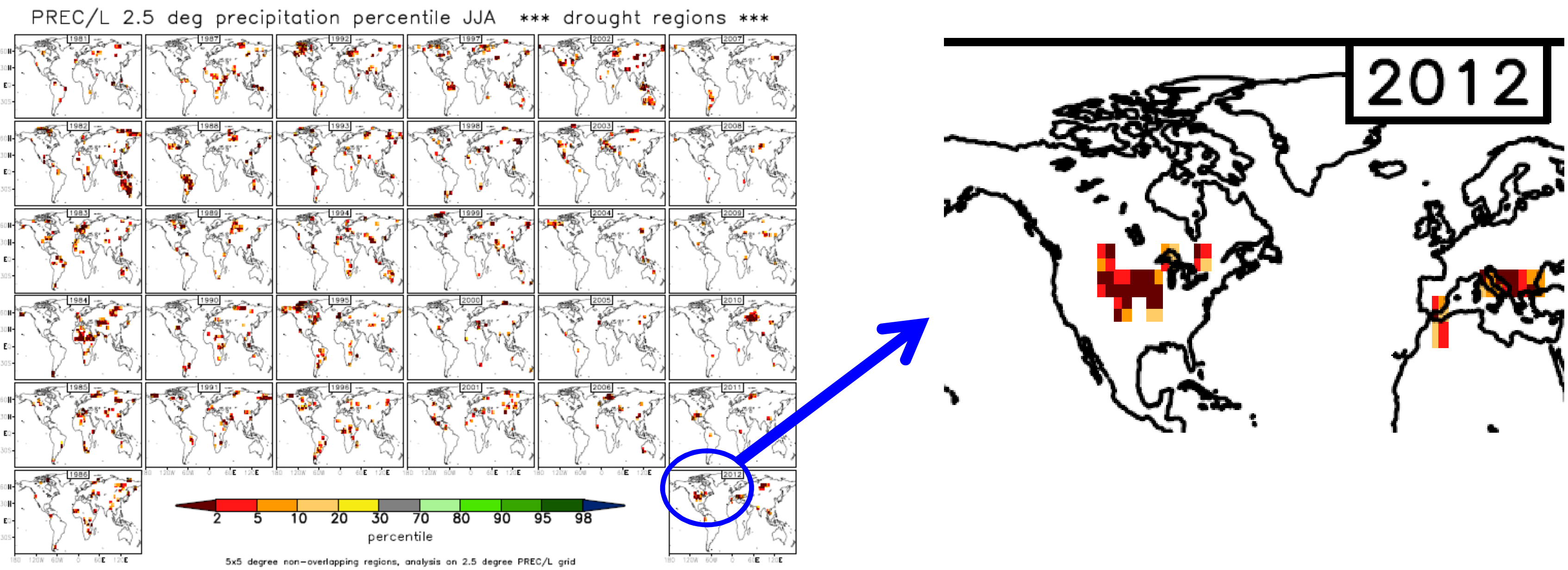
5. Readiness of Hindcasts for Research

Data (see above) from a full set of hindcasts (1981-present) are available for scientific research.

Example (if there's time): Determination of the ability of the forecast system to predict (at lead 0) seasonal precipitation and temperature extremes.

Global evaluation of drought forecasts over the period 1981-2012 with the GMAO forecast system

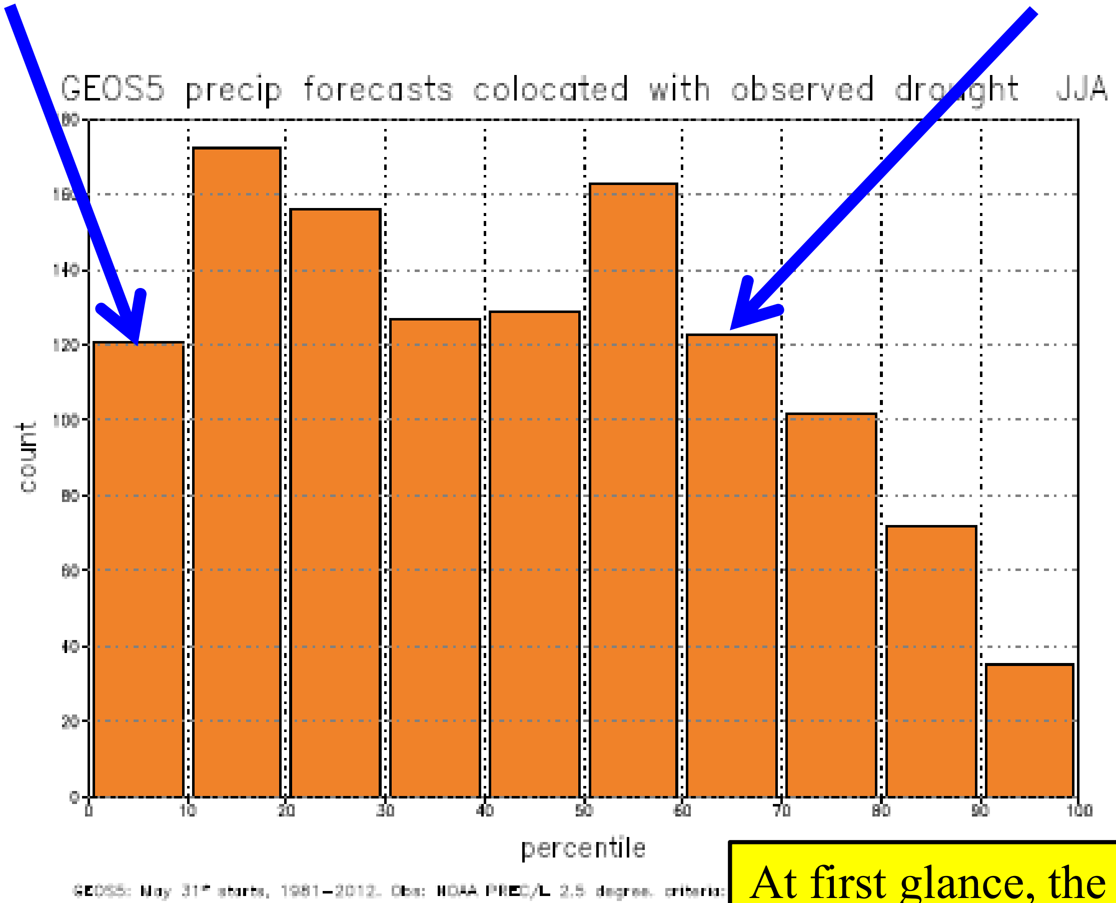
Step 1: Locate times and locations for which the observations show JJA precipitation (across a 5^ox5^o area) to be in the lowest (driest) decile.



Step 2: Determine whether the corresponding GCM forecasts (initialized in early June) also place the JJA precipitation at the noted location in the lowest decile.

If, in a given instance, the forecast system accurately predicted JJA precipitation to be in the lowest decile, add a count to this bin.

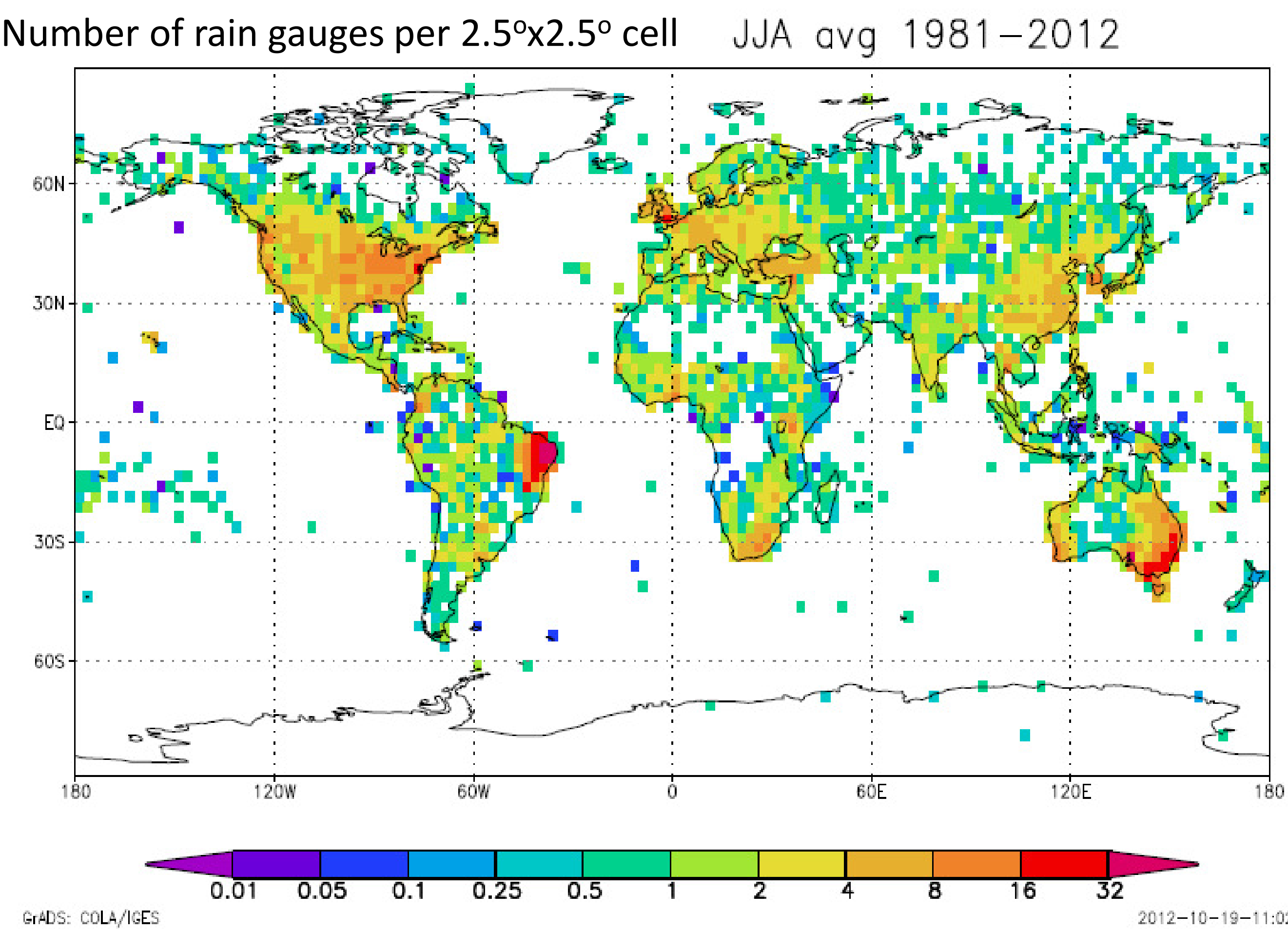
If the forecast system predicted precipitation to be in the 60%-70% decile, add a count to this bin.



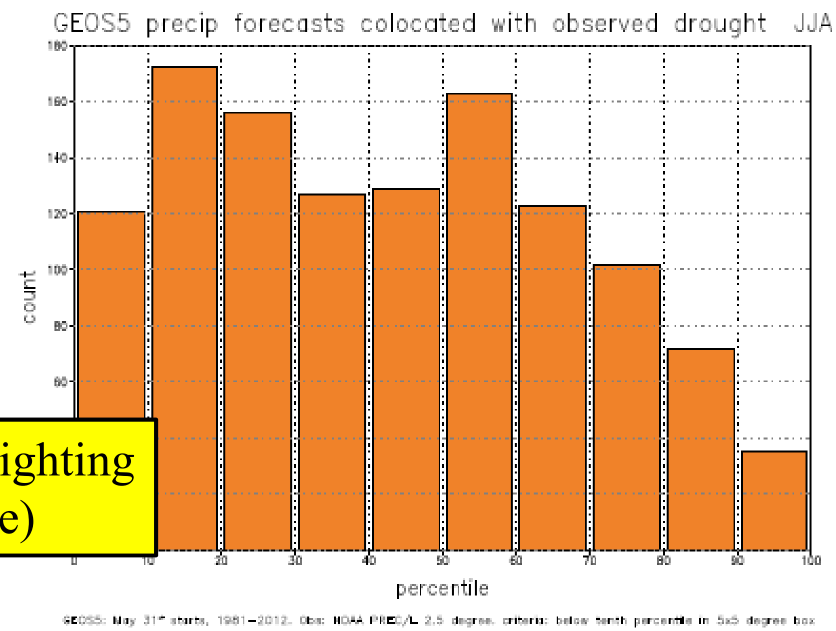
At first glance, the forecast system appears to have little skill.

Note, however, that in the binning procedure, we are giving equal weight to all predictions, including those in locations for which we have very little information about the precipitation. In these ungauged regions, we cannot trust the model initialization.

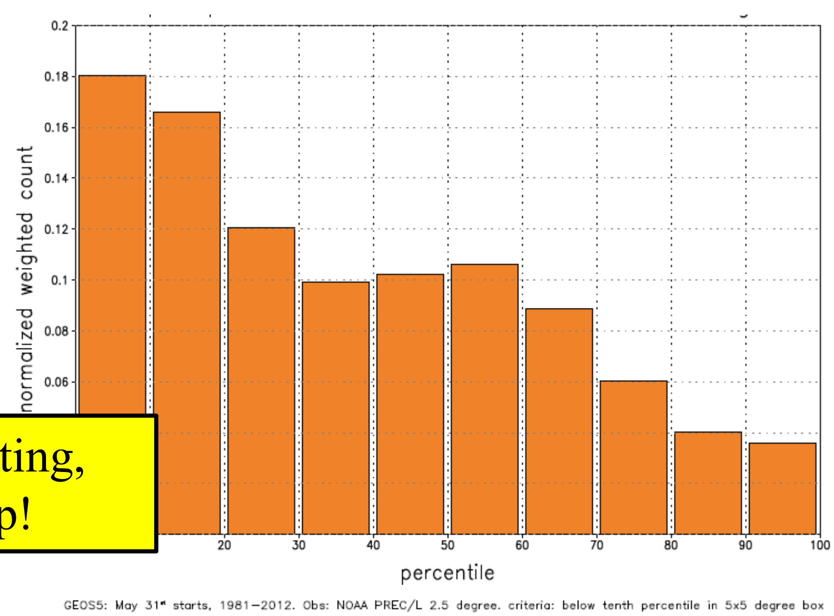
Number of rain gauges per 2.5°x2.5° cell



We can weight the counts added to a given bin by the density of rain gauges within the area considered ➡ perhaps a more sensible approach to evaluating forecast skill.



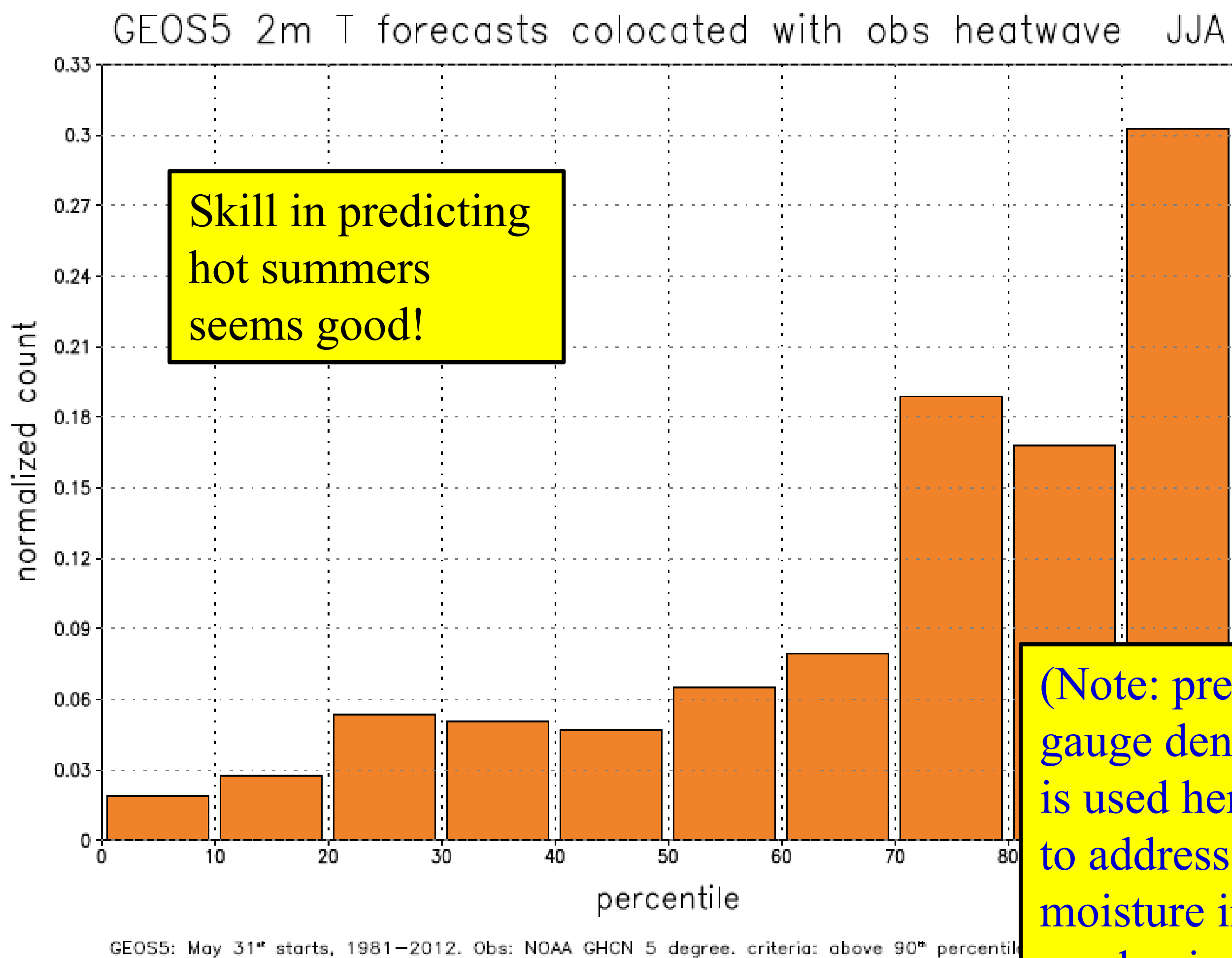
Without weighting (from before)



With weighting, skill goes up!

Now perform a similar exercise for air temperature (T2M):

1) Determine the instances for which the observations show JJA temperatures (at 5^ox5^o) to be in the warmest decile.
2) Bin the forecasted JJA T2M percentiles for these instances accordingly.



Skill in predicting hot summers seems good!

(Note: precipitation gauge density weighting is used here also in order to address the soil moisture initialization mechanism.)