Predicting the atmospheric climate, based on the expected SST anomaly patterns:

Climate prediction designs:

Statistical – based on historical observed data for the predictand (e.g. rainfall, temperature) and for relevant predictors (e.g. SST, atmospheric pressure).

Dynamical – using prognostic physical equations

2-tiered systems (first predict SST, then climate).

1-tiered systems (predict ocean and atmosphere together)

Climate Prediction Systems:
statistical vs. dynamical system

	ADVANTAGES	DISADVANTAGES
Statistical	Based on actual, real-world observed data. Knowledge of physical processes not needed. Many climate relationships quasi-linear, quasi-Gaussian	Depends on quality and length of observed data Does **not fully account** for climate change, or new climate situations.
Dynamical	Uses proven **laws of physics**. Quality observational data not required (but needed for validation). **Can handle cases that have never occurred.**	Some physical laws must be abbreviated or statistically estimated, leading to errors and biases. Computer intensive.

In Dynamical Prediction System:
2-tiered vs. 1-tiered forecast system

	ADVANTAGES	DISADVANTAGES
1-tier	**Two-way air-sea interaction, as in real world** (required where fluxes are as important as large scale ocean dynamics)	Model biases amplify (drift); flux corrections Computationally expensive
2-tier	More stable, reliable SST in the prediction; lack of drift that can appear in 1-tier system Reasonably effective for regions impacted most directly by ENSO	**Flawed (1-way)** physics, especially unacceptable in tropical Atlantic and Indian oceans (monsoon)

IRI's Climate Forecasting System in 2010

IRI's 2-Tiered Forecast System

IRI uses a dynamical, multi-model, 2-tiered prediction system to probabilistically predict global temperature and precipitation with respect to the 3 categories defined by the terciles of the historical climatological distribution.

The system is 2-tiered because it is done in 2 steps:

1) Formulate a SST forecast, or a set of SST forecast scenarios

2) Run atmospheric models using the prescribed SST forecast(s)

IRI's 2-tiered Forecast System

IRI has also developed a fully coupled (1-tier) component, currently in the experimental phase.

Within the 2-tiered system IRI uses 4 SST prediction scenarios, and combines the predictions of 6 AGCMs.

The 6 AGCM predictions are calibrated spatially and locally using MOS (based on CCA), and then merged into a single forecast using equal weighting.

IRI's monthly issued probability forecasts of seasonal global precipitation and temperature

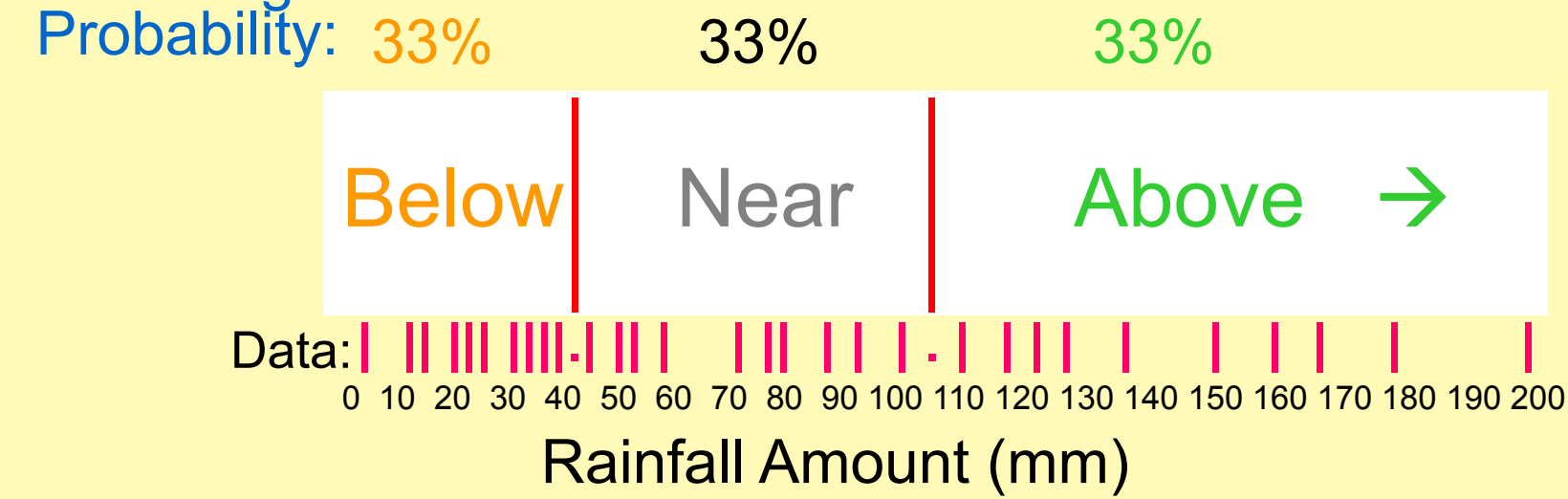
We issue forecasts at four lead times. For example:

NOV | Dec-Jan-Feb
Jan-Feb-Mar
Feb-Mar-Apr
Mar-Apr-May

Forecast models are run 7 months into future. Observed data are available through the end of the previous month (end of October in example above). Probabilities are given for three categories of the climatological distribution: below-normal, near-normal, above-normal.

Forecasts of the climate—Frame of Reference

Abbreviating the predicted shift in the pdf: The tercile-ranked category system: below, near, and above normal*



*The climatological ("normal") pdf is based on 30 years of historical data for a particular location & season)

IRI's 2-Tiered Forecast System: Calculation of Forecast Mean and Variance

In the 2-tiered system IRI uses 3 SST prediction scenarios, and combines the predictions of 6 atmospheric models. For merging of 6 predictions into a single one, steps are:

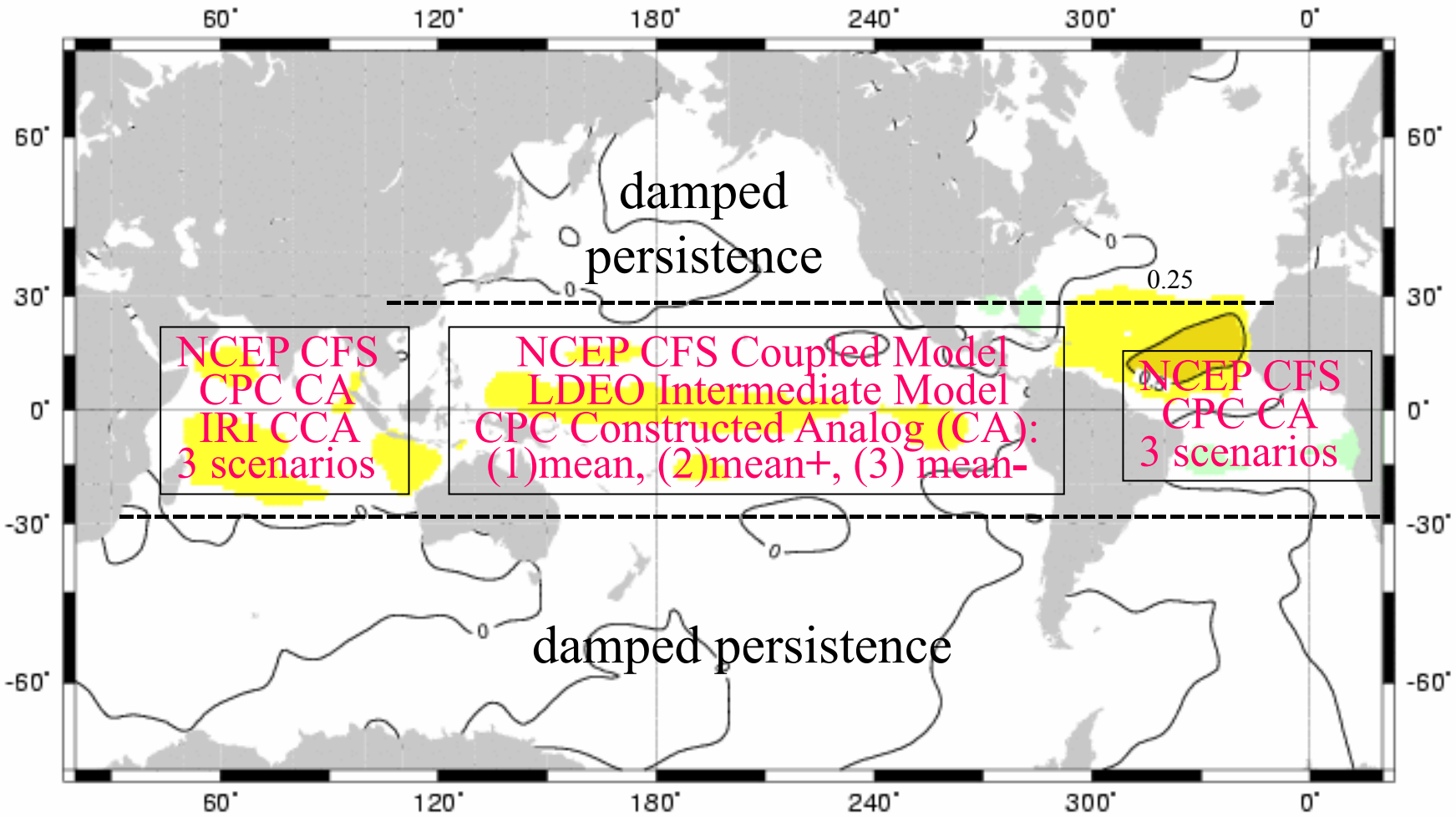
(1) statistical correction of systematic biases of each individual model (spatial and local MOS correction using CCA)

(2) merging of model forecasts into one forecast (equal weights)

(3) calibration of forecast uncertainty range according to the historical skill of multimodel ensemble in hindcasts. Higher skills lead to narrower uncertainty ranges.

Many forecasts (ensemble members) are run by each of the 6 atmospheric models, each having different initial atmospheric condition but using the same prescribed SST forecast.

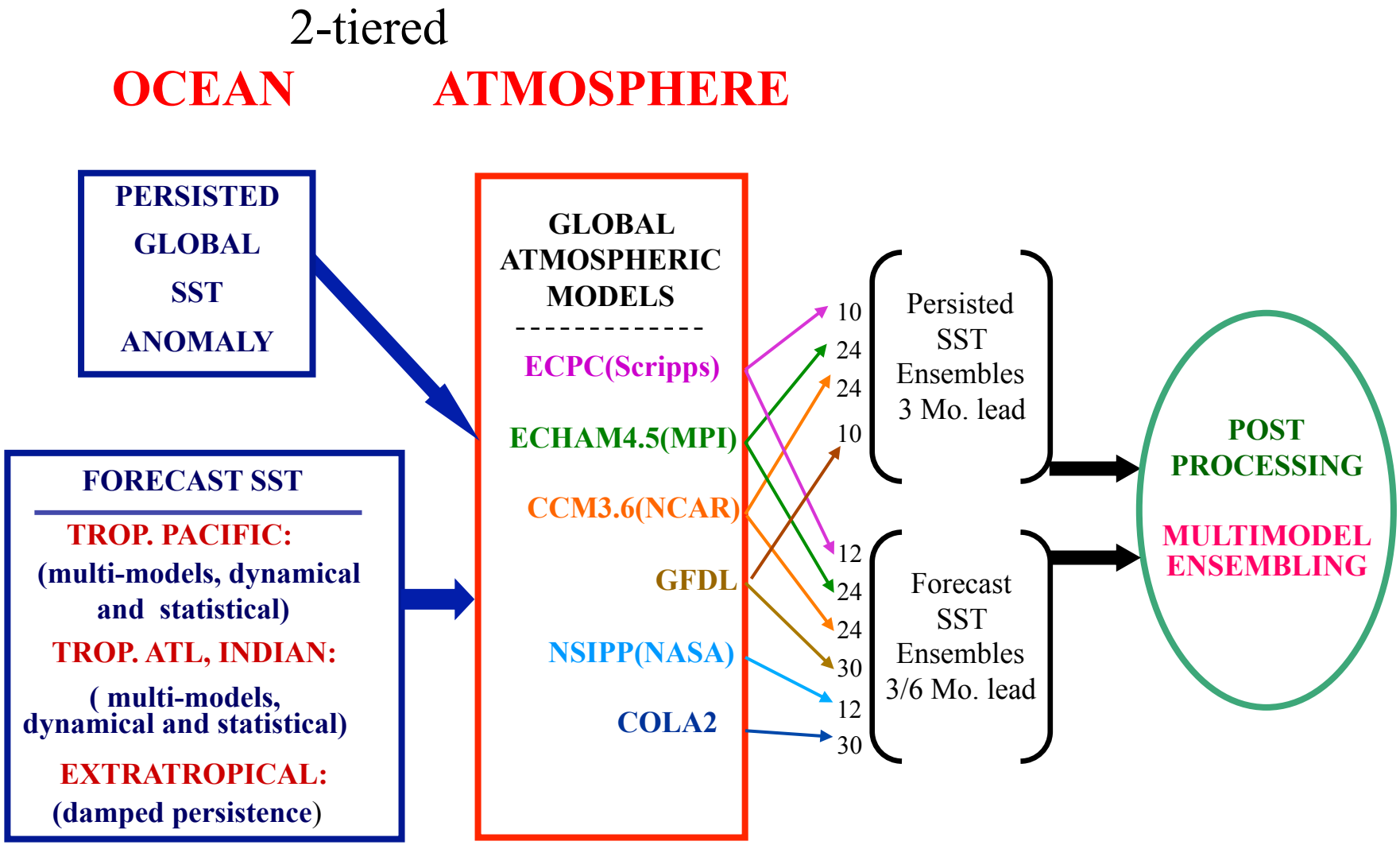
Method of Forming 3 SST Predictions for Climate Predictions



For each ocean basin, the 3 SST scenarios are (1) mean of the models used for that basin, (2) mean+p and (3) mean-p

p is uncertainty factor from 1st EOF of model historical error

IRI DYNAMICAL CLIMATE FORECAST SYSTEM



Collaboration on Input to Forecast Production

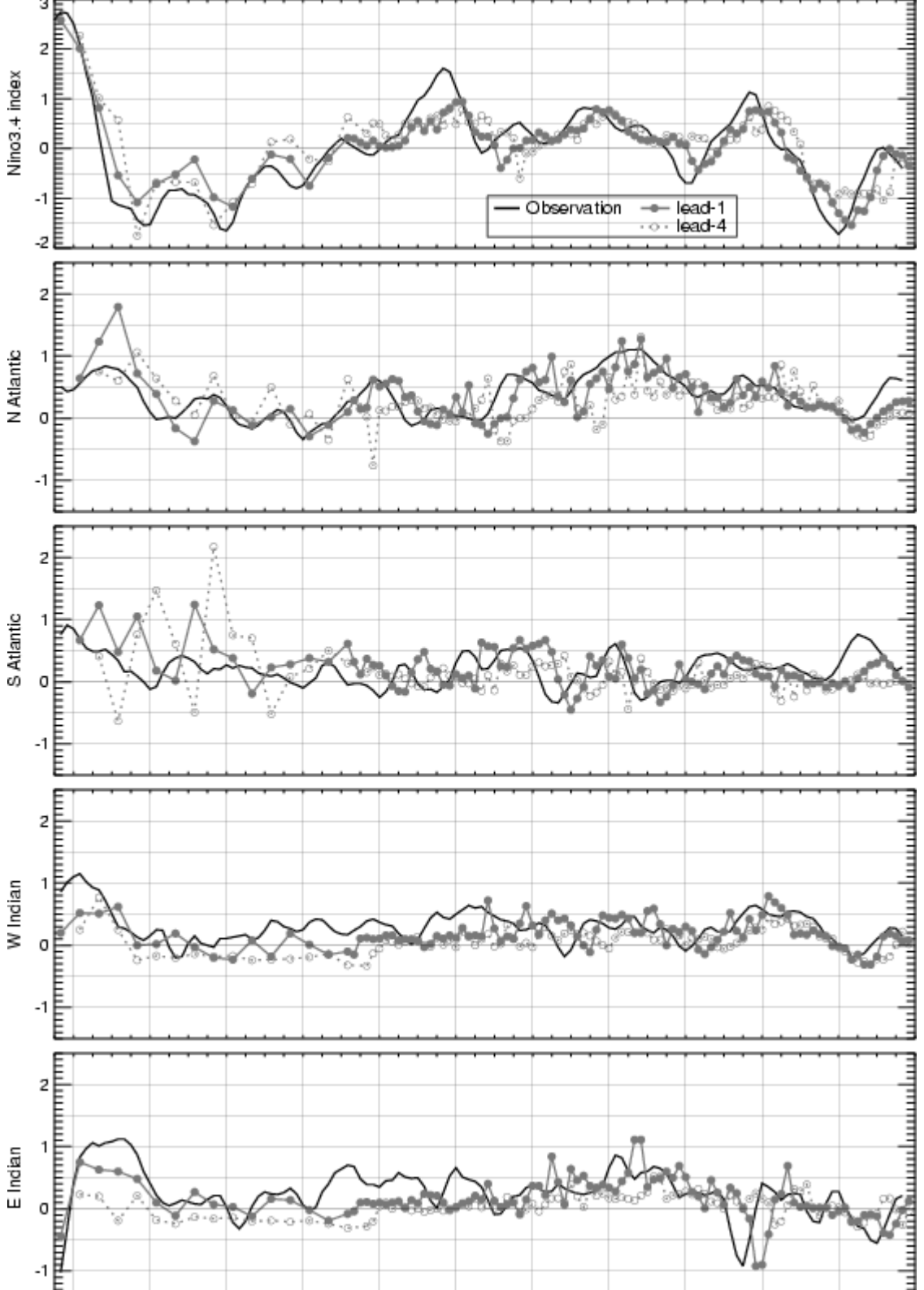
Sources of the Global Sea Surface Temperature Forecasts

Tropical Pacific	Tropical Atlantic	Indian Ocean	Extratropical Oceans
NOAA/NCEP CFS	NOAA/NCEP CFS	NOAA/NCEP CFS	Damped Persistence
LDEO Intermediate	Constr Analogue	Constr Analogue	
Constr Analogue		IRI CCA	

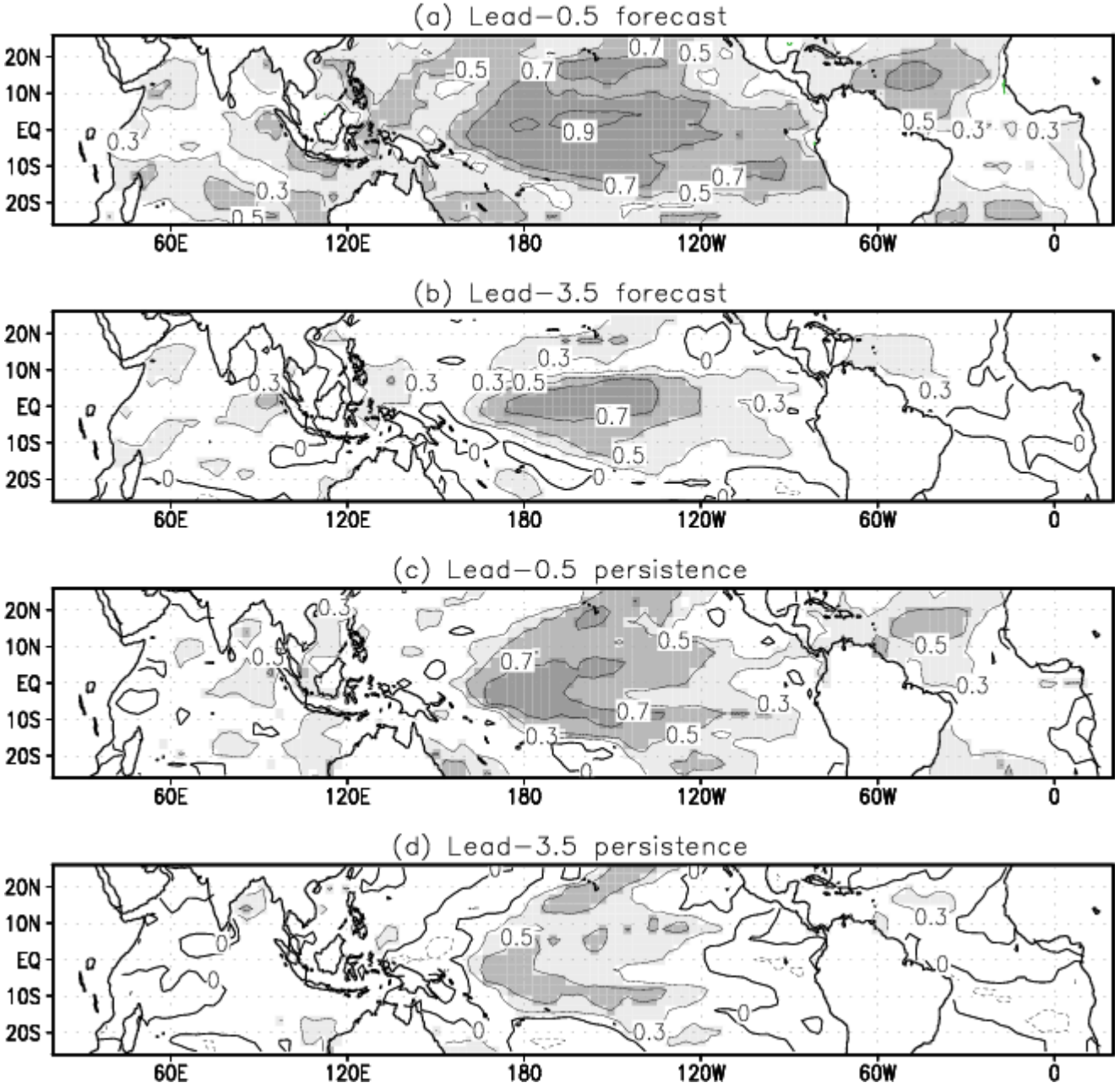
Atmospheric General Circulation Models Used in the IRI's Seasonal Forecasts, for multi-model ensembles

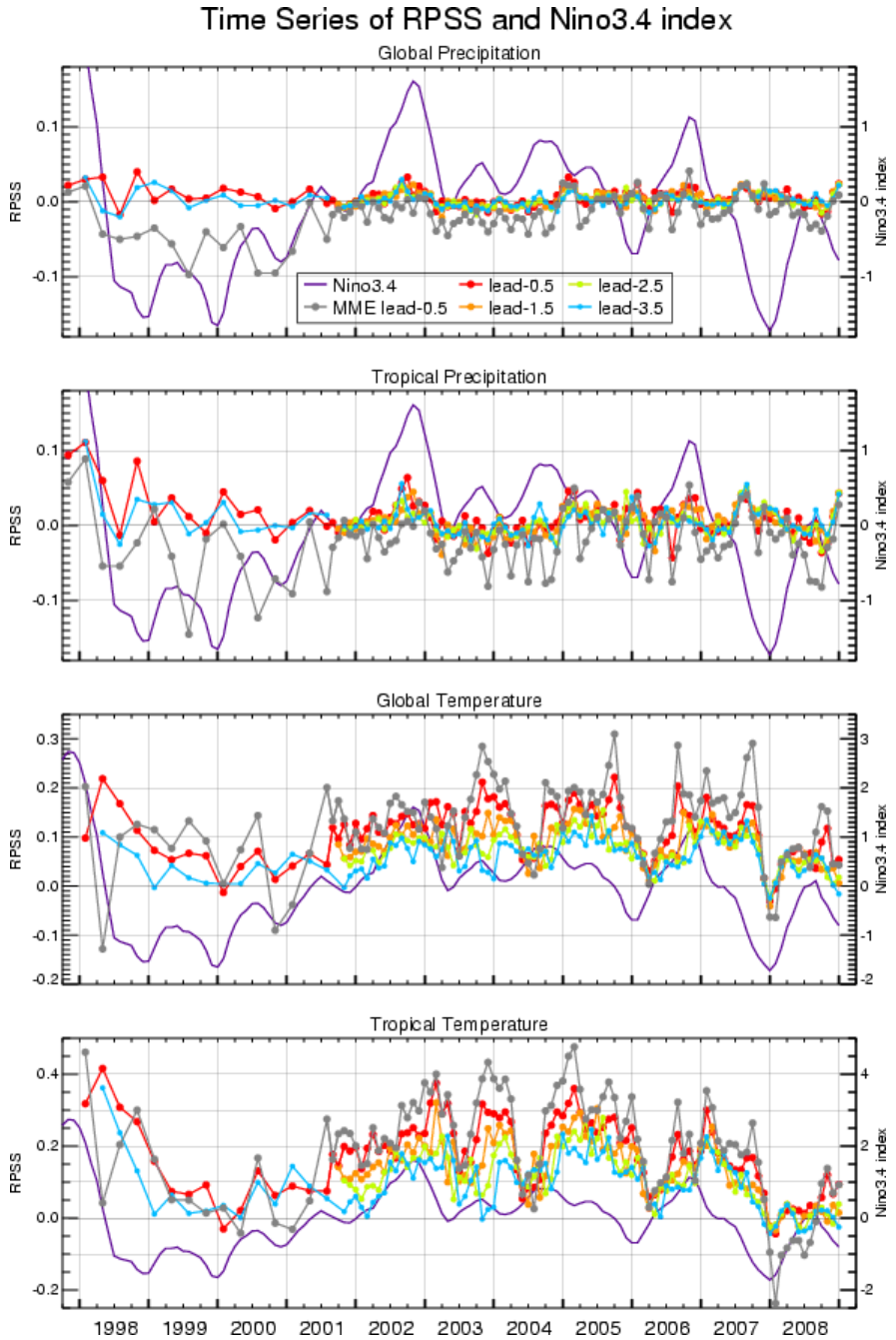
Name	Where Model Was Developed	Where Model Is Run
ECHAM 4.5	MPI, Hamburg, Germany	IRI, Palisades, New York
NSIPP	NASA/GSFC, Greenbelt, MD	NASA/GSFC, Greenbelt, MD
COLA	COLA, Calverton, MD	COLA, Calverton, MD
ECPC	SIO, La Jolla, CA	SIO, La Jolla, CA
CCM3.6	NCAR, Boulder, CO	IRI, Palisades, New York
GFDL	GFDL, Princeton, NJ	GFDL, Princeton, NJ

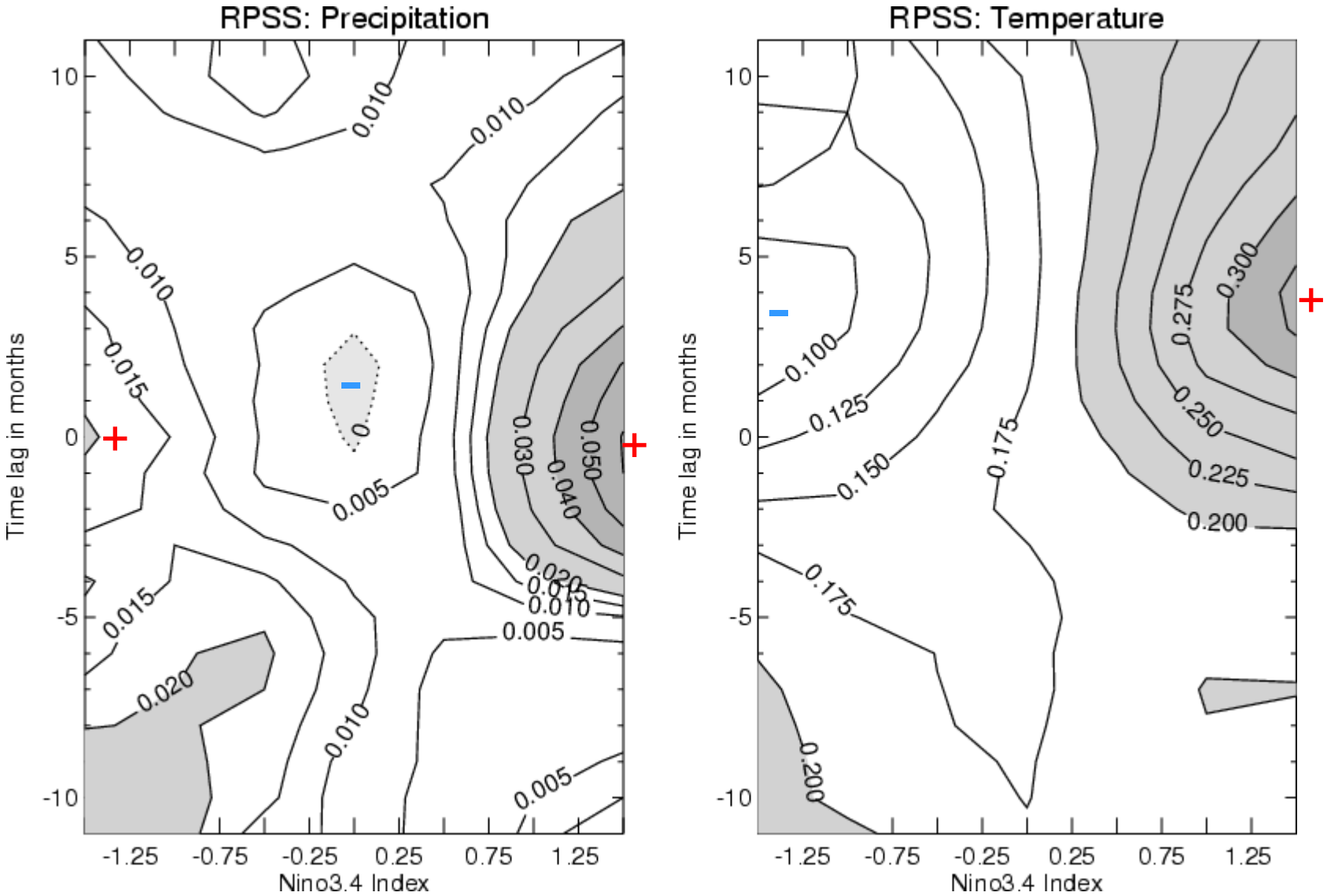
Verification of IRI's Climate Forecasts, 1997-2008

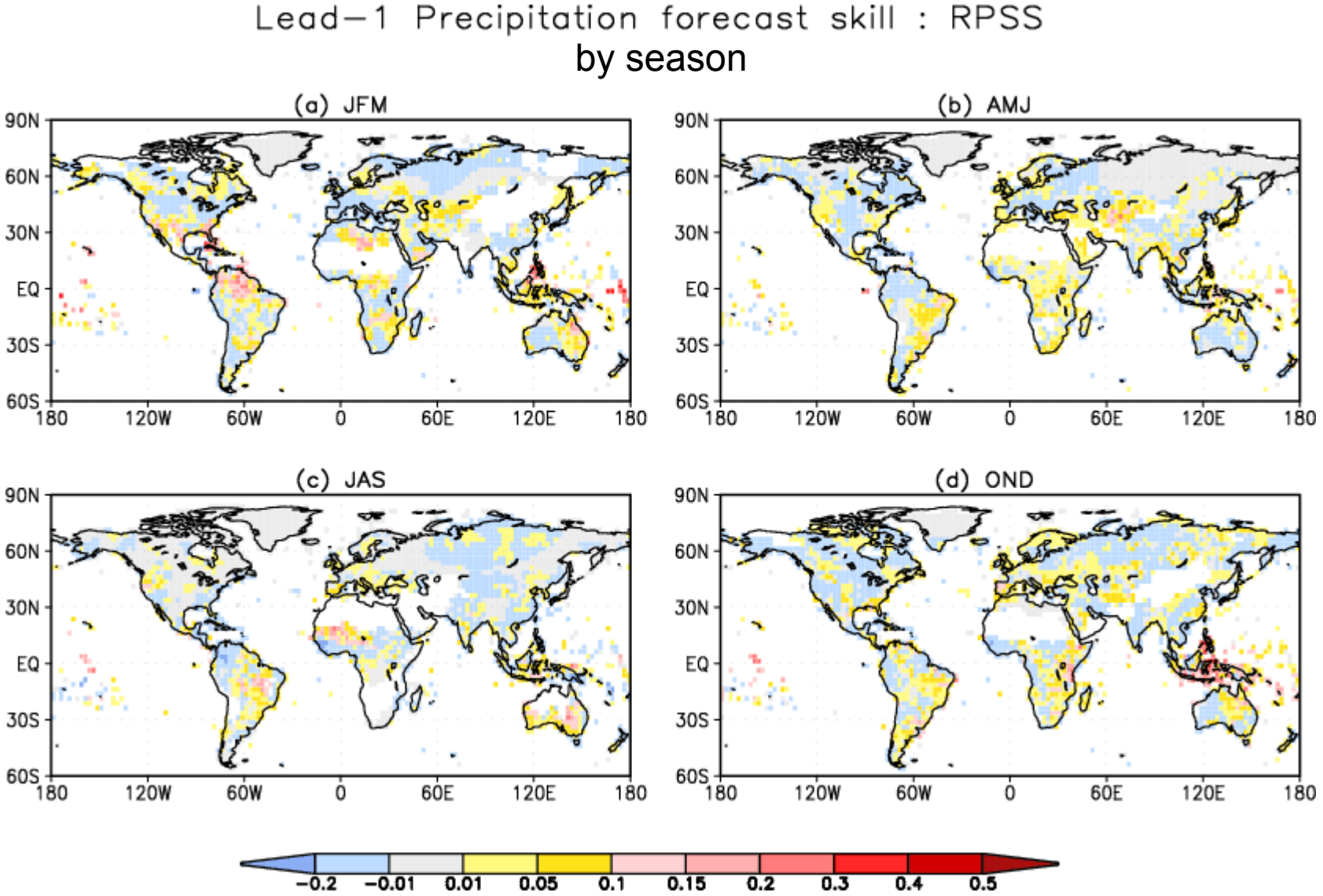

Nino3.4 index
N Atlantic
S Atlantic
W Indian
E Indian
Observation
lead-1
lead-4

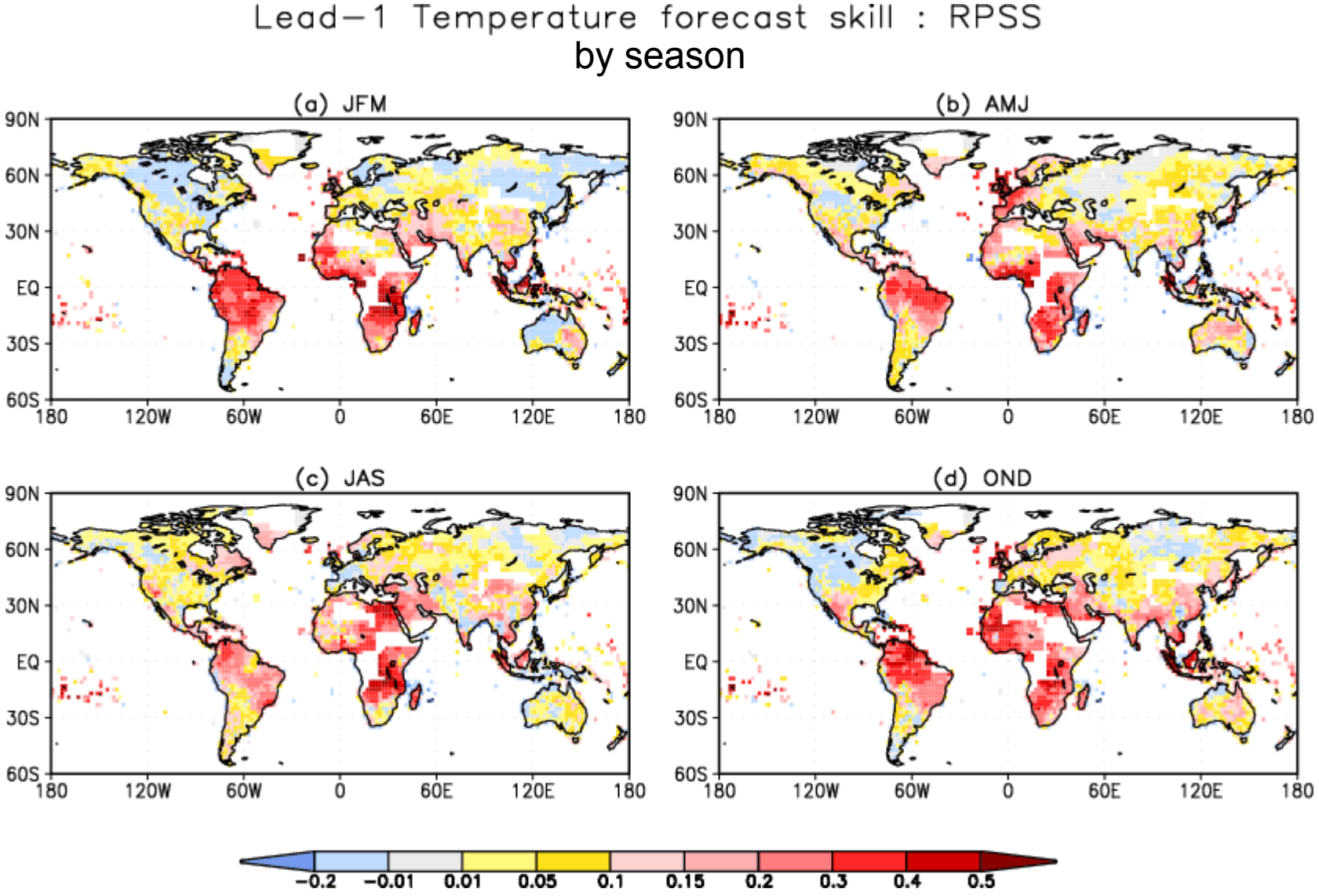
SST Forecast and persistence skill for all seasons: Correlation



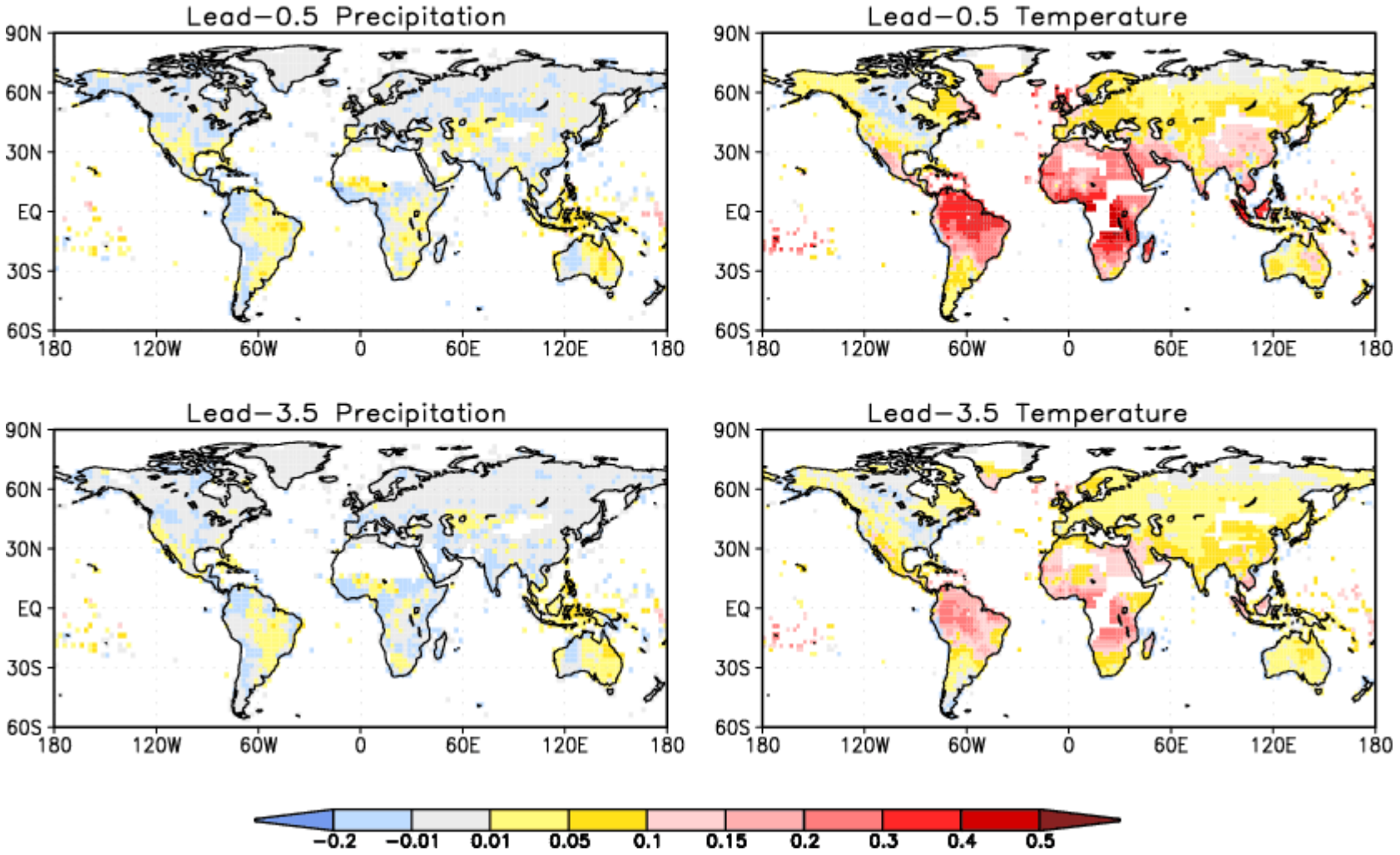

Time Series of RPSS and Nino3.4 index
Global Precipitation
Tropical Precipitation
Global Temperature
Tropical Temperature
RPSS
Nino3.4 index
Nino3.4
MME lead-0.5
lead-0.5
lead-1.5
lead-2.5
lead-3.5
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008


RPSS: Precipitation
Time lag in months
Nino3.4 Index
10
5
0
-5
-10
-1.25
-0.75
-0.25
0.25
0.75
1.25
0.010
0.015
0.020
0.005
0.030
0.040
0.050
RPSS: Temperature
Time lag in months
Nino3.4 Index
0.100
0.125
0.150
0.175
0.200
0.225
0.250
0.275
0.300

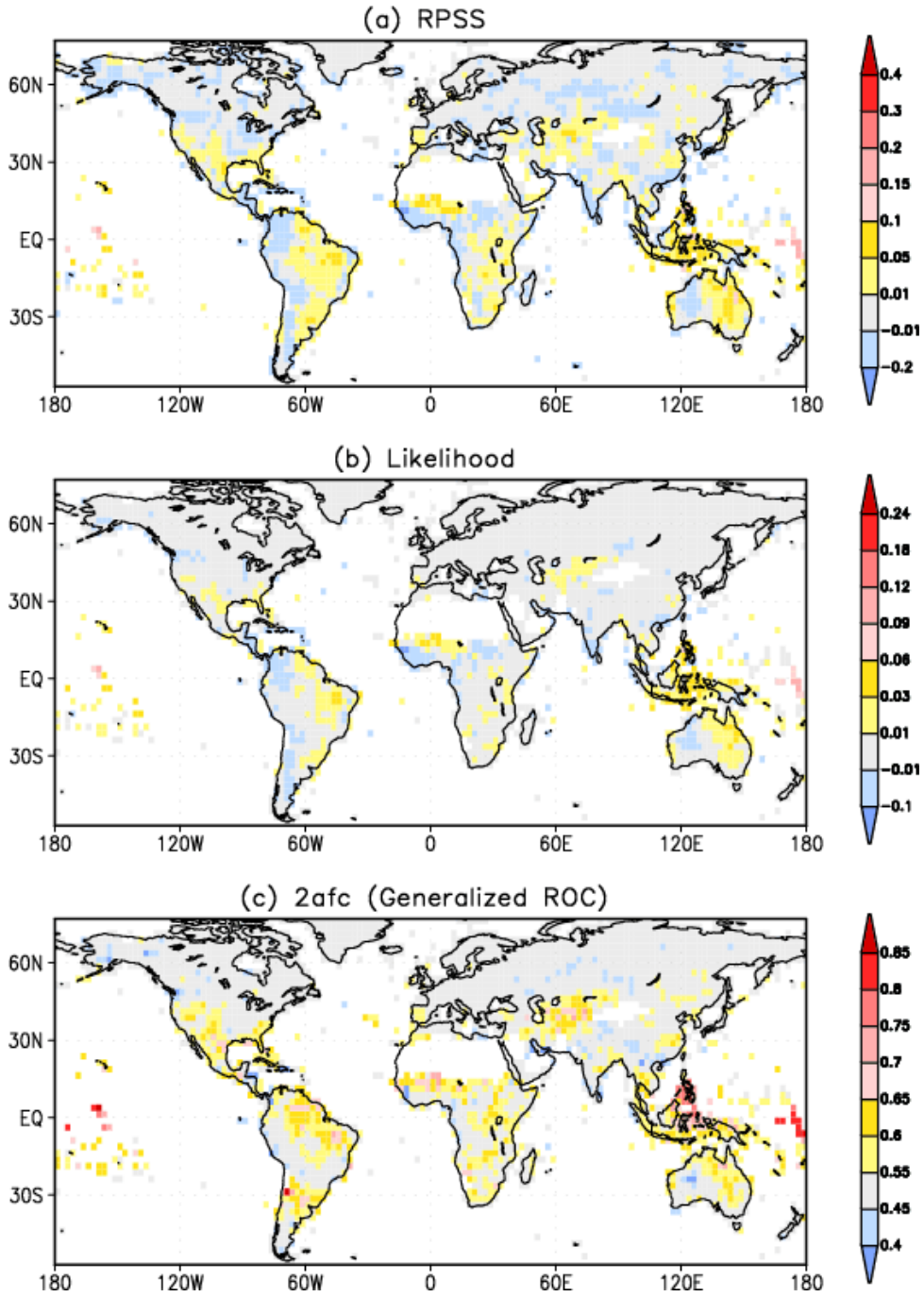

Lead−1 Precipitation forecast skill : RPSS
by season
(a) JFM
(b) AMJ
(c) JAS
(d) OND
90N
60N
30N
EQ
30S
60S
180
120W
60W
0
60E
120E
180
−0.2
−0.01
0.01
0.05
0.1
0.15
0.2
0.3
0.4
0.5


Lead−1 Temperature forecast skill : RPSS
by season
(a) JFM
(b) AMJ
(c) JAS
(d) OND
90N
60N
30N
EQ
30S
60S
180
120W
60W
0
60E
120E
180
−0.2
−0.01
0.01
0.05
0.1
0.15
0.2
0.3
0.4
0.5

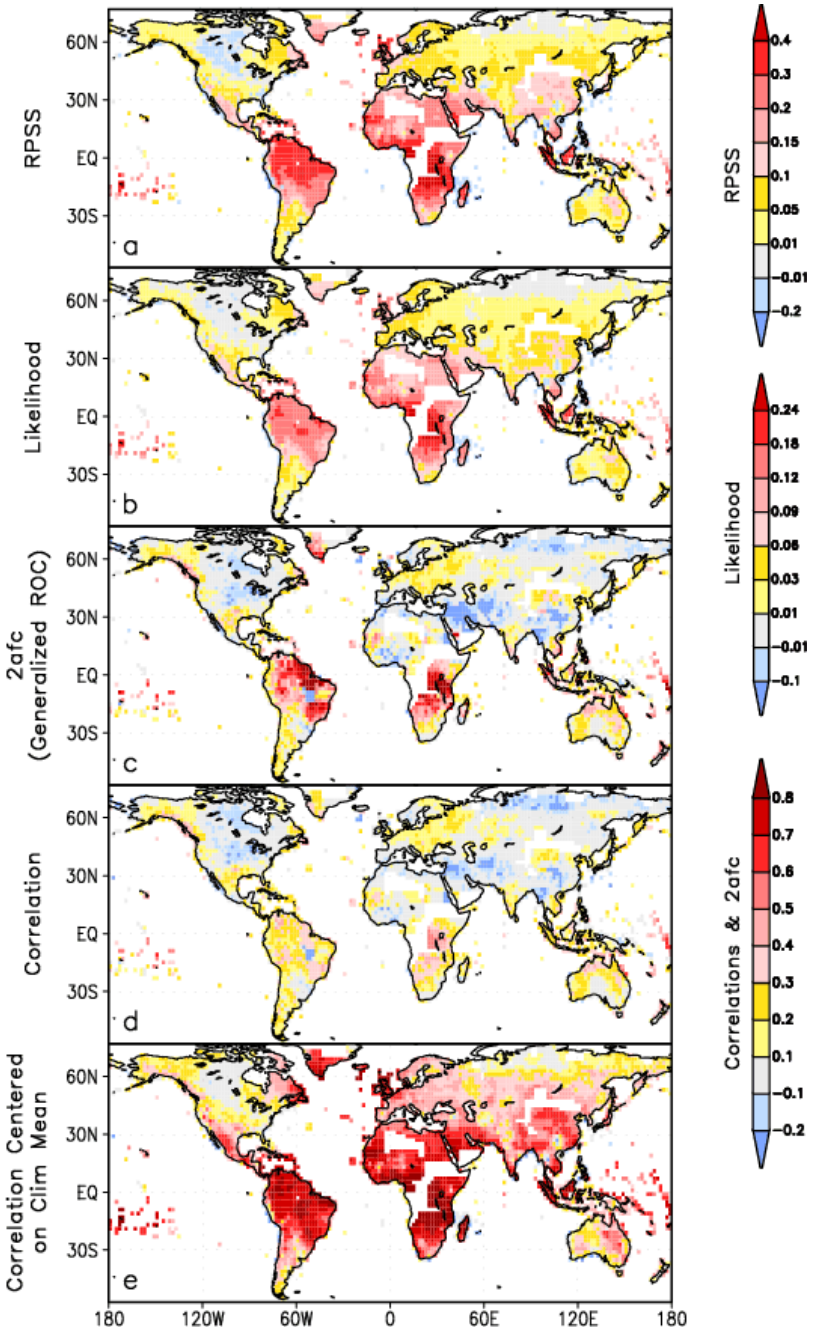
Forecast skill for all seasons: RPSS



Precip 0.5-month lead by skill score



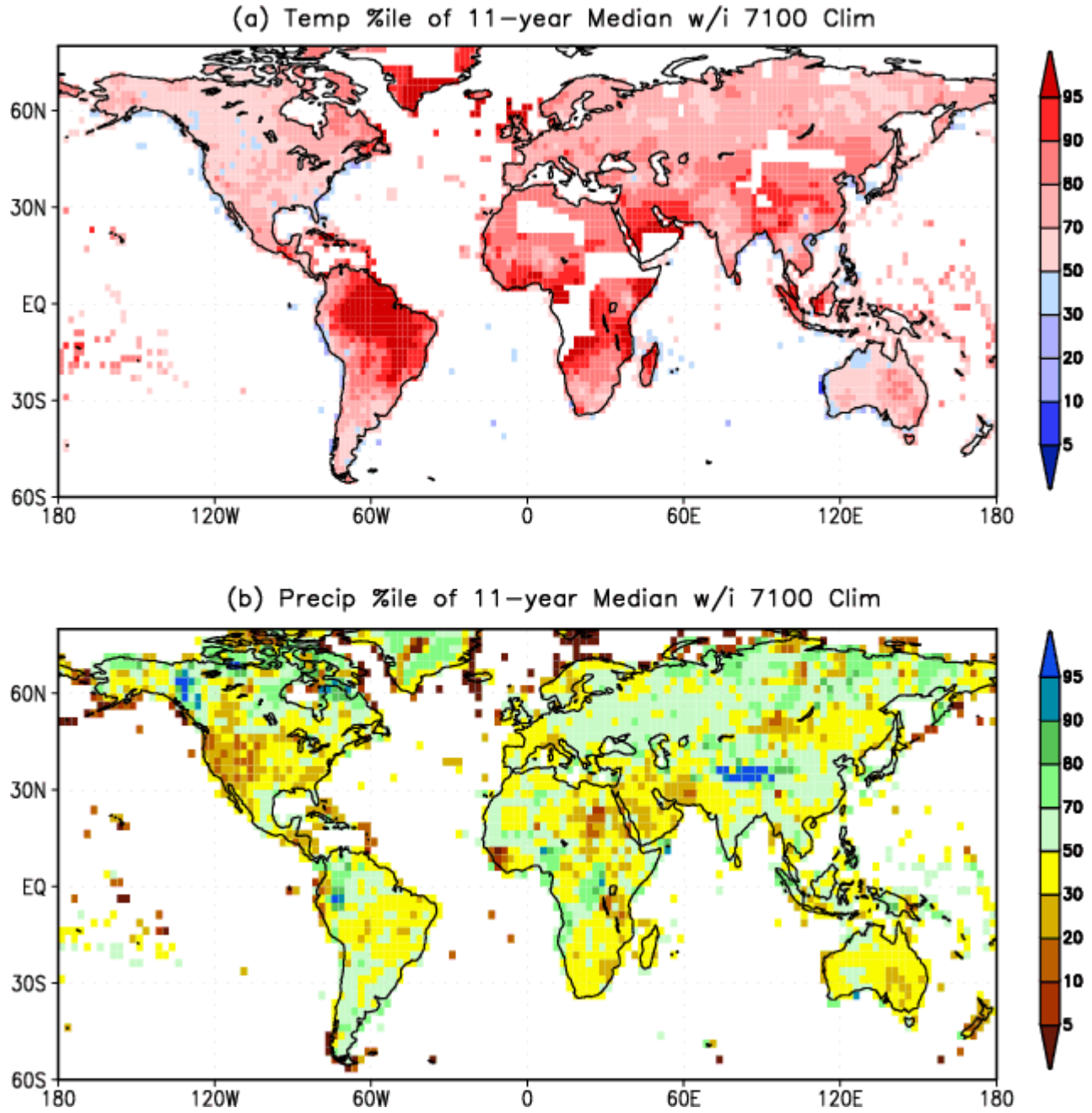
Temp 0.5-month lead by skill score



Temp

Size of climate change factor

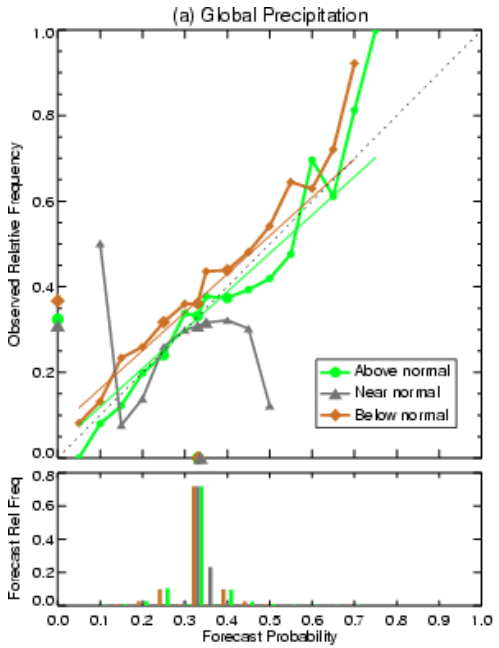
Precip

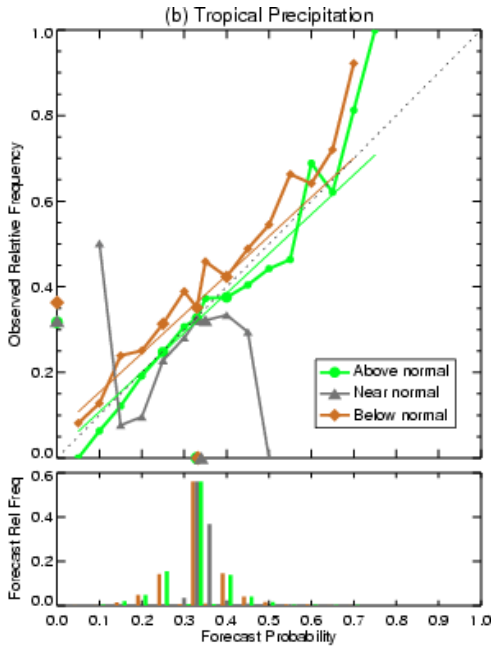


Precip

Reliability Diagnosis

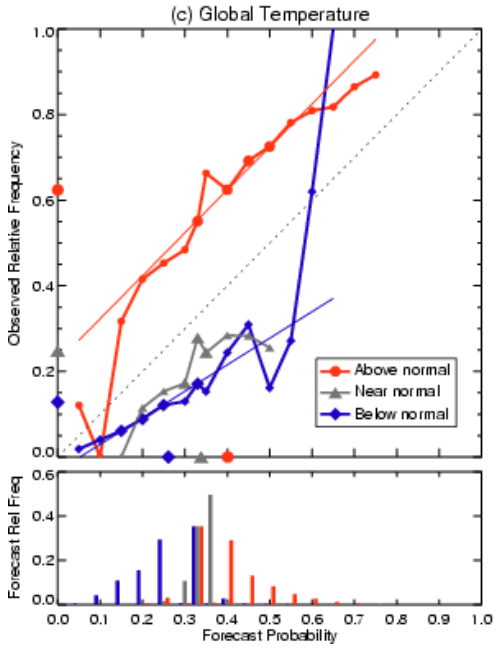
Temp

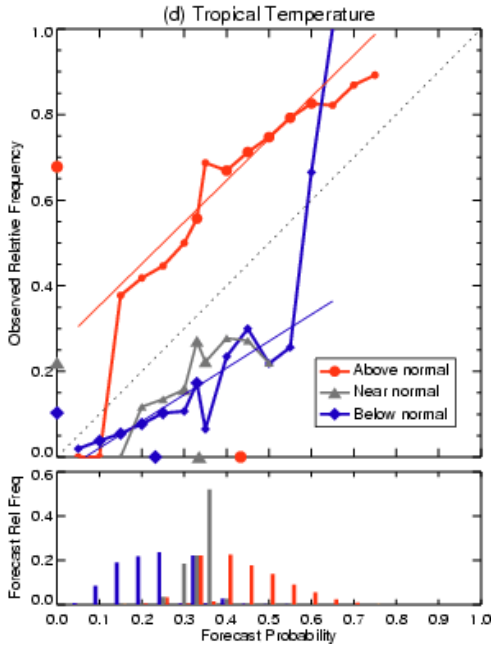




Forecast prob vs. observed relative freq

freq. of Issuance





Forecast prob vs. observed relative freq

freq. of Issuance