

IRI SubX-based Real-Time Subseasonal Precipitation and Temperature Forecasts

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IRI Climate and Data Library Groups

Outline

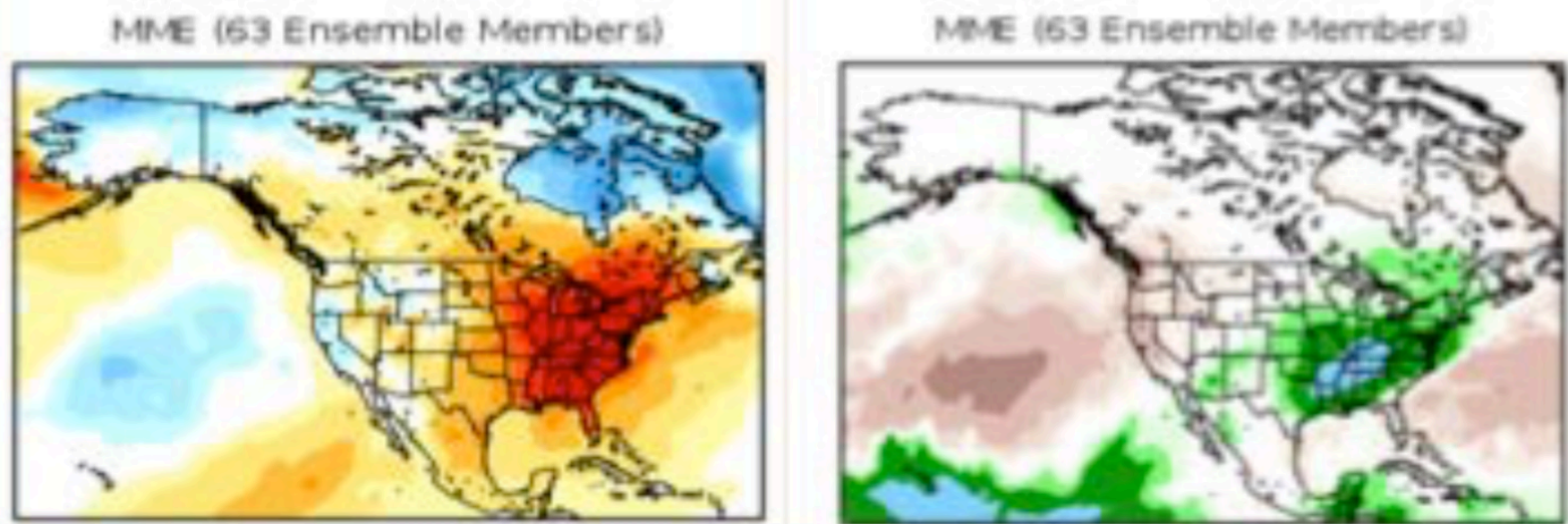
1. SubX and S2S data in IRI data Library
2. Calibration and multi-model ensembling post-processing of precipitation and temperature
3. Skill of week 3-4 hindcasts
4. Maprooms of real-time forecasts
5. A forecast example

The Subseasonal eXperiment (SubX)

By the Numbers...

- 7** Global Models
- 17** Years of Retrospective Forecasts
- 1** Year of Real-time Forecasts
- 3-4** Week guidance for CPC Outlooks

Real-time Multi-model Forecasts



IRI Data Library

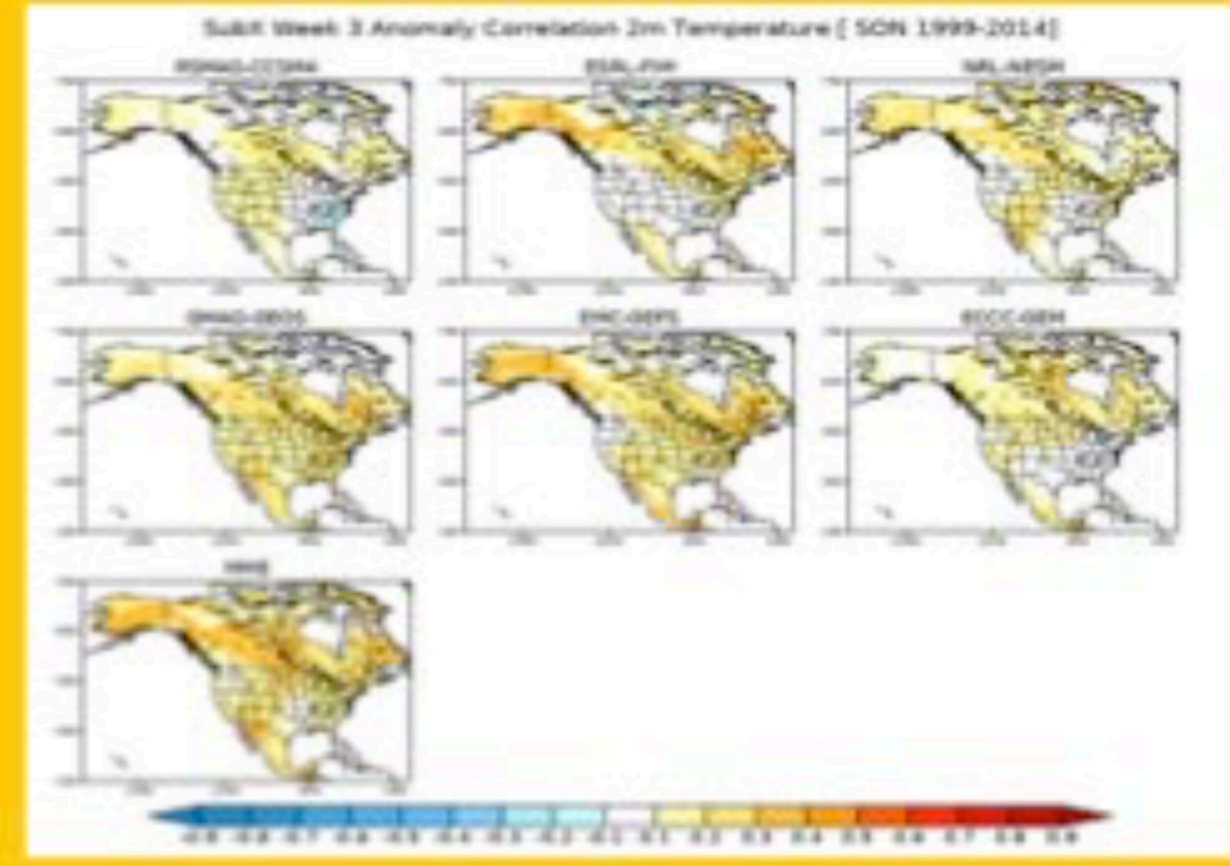
Forecast & Hindcast data publicly available

Current Data Holdings (Last updated: Feb 14, 2018)

Model	Ensemble	Start	End	Var	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CCC	CCC	1999-01-01	2017-12-31	2m												
ECM	ECM	1999-01-01	2017-12-31	2m												
ENS	ENS	1999-01-01	2017-12-31	2m												
FSU	FSU	1999-01-01	2017-12-31	2m												
GEPS	GEPS	1999-01-01	2017-12-31	2m												
IFS	IFS	1999-01-01	2017-12-31	2m												
M2012	M2012	1999-01-01	2017-12-31	2m												
M2014	M2014	1999-01-01	2017-12-31	2m												
M2016	M2016	1999-01-01	2017-12-31	2m												
M2017	M2017	1999-01-01	2017-12-31	2m												
M2018	M2018	1999-01-01	2017-12-31	2m												

<http://iridl.ldeo.columbia.edu/SOURCES/.Models/.SubX/>

Skill Evaluation



<http://cola.gmu.edu/kpegon/subx>

SubX Team



Select 3 models with Wednesday Starts

NCEP CFSv2
EMC GEFS
ESRL FIMr1p1



Courtesy of Kathy Pegion

The SubX Database

Re-Forecasts

Model	Ens Members (per day)	Init Interval	P1	P2	Climo	Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ECCC-GEM	4	7-days	☑	☑	☑	1995-2014	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
EMC-GEFS	11	7-days	☑	☑	☑	1999-2016	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
ESRL-FIM	4	7-days	☑	☑	☑	1999-2016	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
GMAO-GEOS	4	5-days	☑	☑	☑	1999-2015	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
NRL-NESM	1	4 inits every 7-days	☑	☑	☑	1999-2016	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
RSMAS-CCSM4	3	7-days	☑	☑	☑	1999-2016	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
NCEP-CFSv2	4*	1-days	tas,pr	☑		1999-2016	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Note: *NCEP-CFSv2 hindcasts are initialized at 0,6,12, and 18Z. These four starting times are combined to make a 4-member ensemble.

Forecasts


Model	Ens Members	Day of Week Init	P1	P2
ECCC-GEM	21	Thurs	☑	☑
EMC-GEFS	21	Wed	☑	☑
ESRL-FIM	4	Wed	☑	☑
GMAO-GEOS	4	Rotates	☑	☑
NRL-NESM	1	Sat,Sun,Mon,Tues	☑	☑
RSMAS-CCSM4	9	Sun	☑	

Model	Hindcast Period	# Members	Perturbation Methodology	Lead (days)	Atm	Ocn	Sea Ice	Land
NCEP/CFSv2	1999-2010	4/day	Time-lagged 0,6,12,18Z each day	45	T126L64 ICs CFSR	MOM4L40 0.25 deg EQ; 0.5 deg global ICs CFSR	Same as Ocn	NOAH ICs GLDAS
NCEP/GEFS	1999-2015	20	EnKF & ETR	35	T574L64 for 0-8 day & T382 for 8-35 day ICs Atm DA	N/A	N/A	T574 ICs GDAS
ECCC GEM	1995-2014	4	random isotropic perturbation	32	0.45x0.45 deg; 40 levels; ICs from ERA-interim	N/A	N/A	Offline SPS forced by ERA-Interim
NASA GEOS-5 AOGCM	1981-2015	10	scaled difference of two consecutive days of analysis	45	GEOS5-1/2 degree horizontal resolution,; 72 vertical layers ICs from MERRA2	MOM5 - 1/2 deg horizontal resolution, 40 vertical layers ICs GMAO Ocn Analysis	CICE ICs GMAO Analysis	Catchment Land Sfc Model ICs MERRA-2 precipitation corrected
Navy Earth System Model	1999-2015	4	time-lagged	45	NAVGEN-T0359L50 ICs atmos DA	HYCOM-0.08 deg; 41 vertical layers ICs from Ocn/Ice reanalysis	CICE4-0.08 deg ICs from Ocn/Ice reanalysis	Inline NAVGEM T0359 ICs from Agrmet
NCAR/CCSM4	1999-2015	3 or 4 per day	time-lagged	45	0.9x1.25deg L26	POPL60; 1deg global with 0.25 lat res in deep tropics	same as ocean	same as atmpshere
NOAA/ESRL FIM HYCOM	1999-2014	4 per week	time-lagged 12Z & 18Z Tues; 00Z & 06Z Wed	32	~60km w/64 vertical layers; ICs from CFSR	iHYCOM 60km	iHYCOM 60km	NOAH land sfc model; ICs from CFSR

WWRP/WCRP Subseasonal to Seasonal Prediction Project (S2S) Database

Vitart et al. 2017 *BAMS*

As of February 2022

	Real time					Reforecast				
	forecast length	model resolution	ens. size	forecast freq.	data available period	system (model ver.)	ens. size	reforecast frequency	reforecast period	orig data grid
BoM (Australia)	D1 – 62 (00UTC)	T47L17	33	Sun Thu	2015.01.01 -	fixed (2014.01.01)	33	1st, 6th, 11th, 16th, 21st, & 26th of each month	1981 - 2013	T47 (144x72)
CMA (China)	D0 – 60 (00UTC)	A: T106L40 B: T266L56	4	A: daily B: Mon, Thu	A: 2015.01.01 - B: 2019.11.11 -	A: fixed (2014.05.01-) B: on the fly (2019.11.11 -)	4	A: daily B: Mon, Thu	A: 1994 - 2014 B: previous 15yrs	1.5x1.5
ECCC (Canada)	D1 – 32 (00UTC)	A: 0.45° x 0.45° L40 B&C: 0.35° x 0.35° L45 (A&B: uncoupled)	21	Thu	A: 2016.01.07 - B: 2018.09.27 - C: 2019.07.04 - D: 2021.12.09 -	on the fly	4	Thu	A: 1995 - 2014 B&C: 1998 - 2017 D: 2001 - 2020	1.5x1.5
ECMWF (Europe)	A: D0 – 32 B&C: D0 – 46 (00UTC)	A&B: TL639L91(≤D10) TL319L91(>D10) C: Tco639L91(≤D10) Tco319L91(>D10)	51	A: Thu B&C: Mon, Thu	A: 2015.01.01 - B: 2015.05.14 - C: 2016.03.08 -	on the fly A: 2015.01.01 - B: 2015.05.14 -	A: 5 B: 11	A: Thu B: Mon, Thu	previous 20yrs (e.g. 1999-2018)	1.5x1.5
HMCR (Russia)	D0 – 61 (00UTC)	1.125° x 1.40625° L28 (uncoupled)	20	A: Wed B: Thu	A: 2015.01.07 - B: 2017.06.08 -	on the fly A: 2015.01.07-, B: 2017.06.08- C: 2021.07.01-	10	A: Wed B&C: Thu	A&B: 1985 - 2010 C: 1990 - 2015	1.5x1.5
ISAC-CNR (Italy)	A&B: D0 – 31 C: D0 – 32 (00UTC)	0.75° x 0.56° L54 (a 'slab' ocean)	41	A: Mon B&C: Thu	A: 2015.11.09 - B: 2017.01.19 - C: 2017.06.08 -	fixed (2017.06.08)	5	every 5 days	1981 - 2010	1.5x1.5
JMA (Japan)	A: D0.5 – 33.5 B: D0.5 – 32.5 (12UTC)	A: TL319L60 B: TL479L100 (≤D18), TL319L100 (>D18) (uncoupled)	A: 25 B: 50	A: Tue, Wed B: Wed*	A: 2015.01.06 - 2017.03.15 B: 2017.03.22 -	fixed A: 2014.03.04-, B: 2017.01.31- C: 2020.03.31-, D: 2021.03.31-	A&B: 5 C&D: 13	A&B: 10th, 20th, & the last date of each month C&D: 15th & the last date of each month	A: 1981 - 2010 B: 1981 - 2012 C: 1981-2010 D: 1981 - 2020	1.5x1.5
KMA (Korea)	D0 – 60 (00UTC)	N216 (0.83° x 0.56°) L85	4	daily	2016.11.01 -	on the fly A: 2016.11.01- B: 2020.09.01-	3	1st, 9th, 17th, & 25th of each month	A: 1991 - 2010 B: 1991 - 2016	1.5x1.5
Met. France (France)	A. D0 – 61 B. D0 – 32 C. D0 – 47 (00UTC)	A&B: TL255L91 C: TL359L91	A&B: 51 C: 25	A. monthly (1st) B&C. Thu	A. 2015.05.01 - B. 2016.03.03 - C. 2020.10.22 -	fixed (A&B: 2014.12.01 C: 2019.07.01)	A&B: 15 C: 10	A&B: 1st, 8th, 15th, & 22nd of each month C: Thu	A&B: 1993 - 2014 C: 1992 - 2017	1.5x1.5
NCEP (US)	D0 – 44 (00UTC)	T126L64	16	daily	2015.01.01-	fixed (2011.03.01)	4	daily	1999 - 2010	1.5x1.5
UKMO (UK)	D0 – 60 (00UTC)	N216 (0.83° x 0.56°) L85	4	daily	2015.12.01 -	on the fly A: 2016.01.01 - , B: 2016.04.17 - C: 2017.03.25 - , D: 2018.09.01 -	A&B: 3 C&D: 7	1st, 9th, 17th, & 25th of each month	A: 1996 - 2009 B&C: 1993 - 2015 D: 1993 - 2016	1.5x1.5

3 weeks behind real time

* After 21 March 2017, JMA's Tue forecast is combined with its Wed forecast for convenience

Dr. Mio Matsueda (Univ. Tsukuba)

S2S and SubX databases in IRI Data Library

IRI Data Library
ECMWF S2S

Language: english

Description Expert Mode

served from [IRI/LDEO Climate Data Library](#)

SOURCES - ECMWF - S2S

ECMWF S2S

ECMWF S2S: WWRP/WCRP Sub-seasonal to Seasonal Prediction Project.

Documents

- [overview](#) an outline showing sub-datasets of this dataset
- [BAMS paper](#) The Subseasonal to Seasonal (S2S) Prediction Project Database
- [ECMWF](#) ECMWF S2S Wiki Page
- [Model Table](#) S2S Model Description Table at ECMWF S2S Wiki Page
- [README](#) Please see these notes for explanation on accessing and using the S2S Database in the IRI Data Library
- [S2S Project](#) WWRP/WCRP S2S Project Page
- [Wiki](#) IRI Wiki Page with IRIDL S2S data examples

Datasets and Variables

- [BOM](#) BoM POAMA Ensemble.
- [CMA](#) Beijing Climate Center (BCC) Climate Prediction System version 1 for S2S.
- [CNRM](#) CNRM Ensemble Prediction System.
- [ECCC](#) ECCC Ensemble Prediction System.
- [ECMF](#) ECMWF Ensemble.
- [EI](#) Era Interim Reanalysis.
- [HMCR](#) HMCR Ensemble.
- [ISAC](#) ISAC-CNR Ensemble.
- [JMA](#) JMA Ensemble System.
- [KMA](#) KMA Seasonal Prediction System.
- [NCEP](#) NCEP CFSv2 Ensemble.
- [UKMO](#) UKMO Ensemble Prediction System.

IRI Data Library
Models SubX

Description Expert Mode

SOURCES - Models - SubX

Models SubX

Models SubX: Subseasonal Experiment (SubX).

Documents

- [overview](#) an outline showing sub-datasets of this dataset
- [CTB](#) NOAA Climate Test Bed Website
- [DataCite DOI Metadata](#) DOI:10.7916/D8PG249H
- [SubX Data Information](#) Model/Data Information from SubX Project Website
- [SubX Project](#) SubX Project Website

Datasets and Variables

- [CESM](#) Models SubX CESM[30LCESM1 46LCESM1]
- [ECCC](#) Models SubX ECCC[GEM]
- [EMC](#) Models SubX EMC[GEFS]
- [ESRL](#) Models SubX ESRL[FIMr1p1]
- [GMAO](#) Models SubX GMAO[GEOS_V2p1]
- [NCEP](#) Models SubX NCEP[CFSv2]
- [NRL](#) Models SubX NRL[NESM]
- [RSMAS](#) Models SubX RSMAS[CCSM4]

<http://iridl.ldeo.columbia.edu>

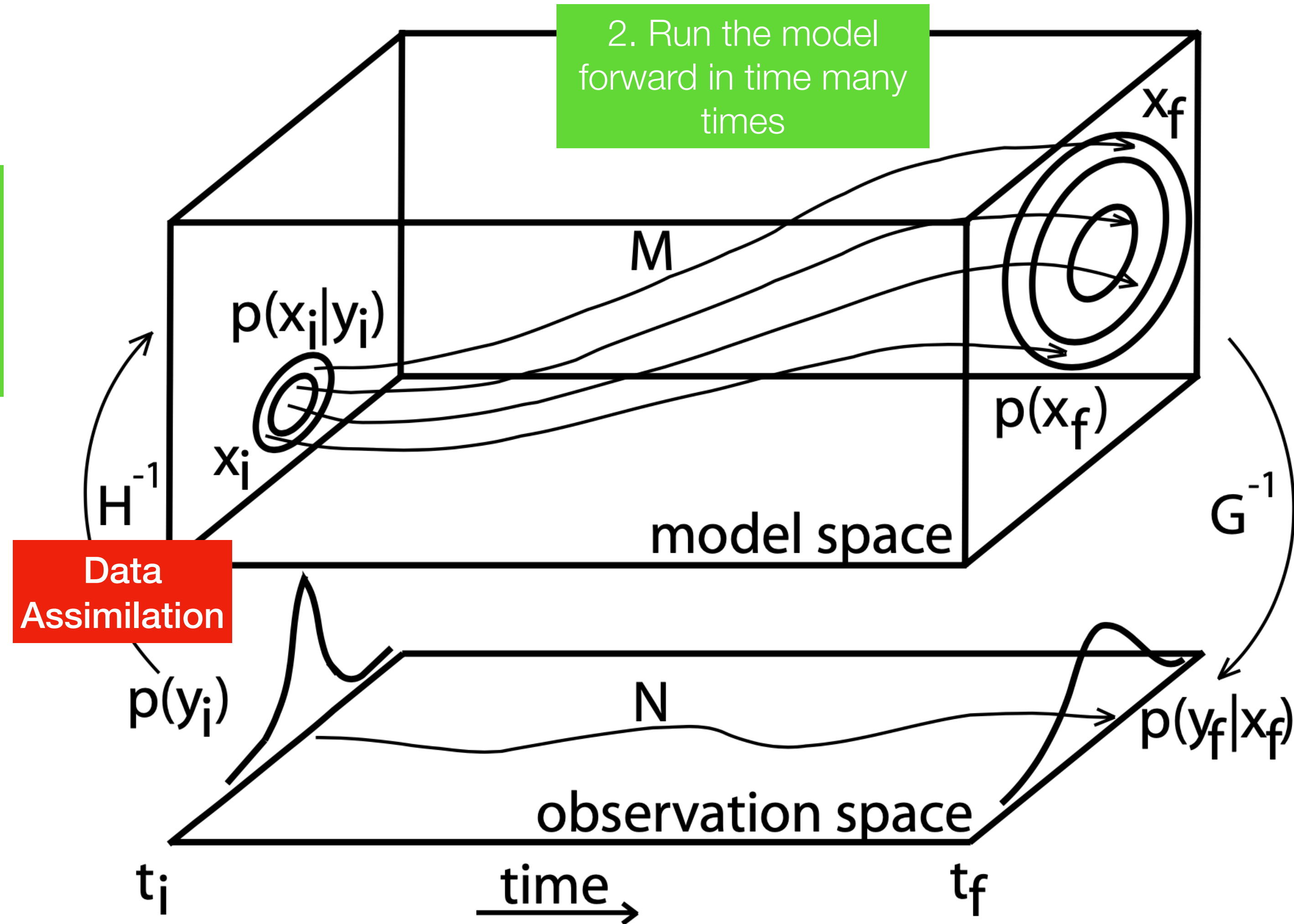
The Forecast Process

Models imperfectly represent the real world (systematic errors, grids).
 Their output must be calibrated against observed data in order for it to be useable.

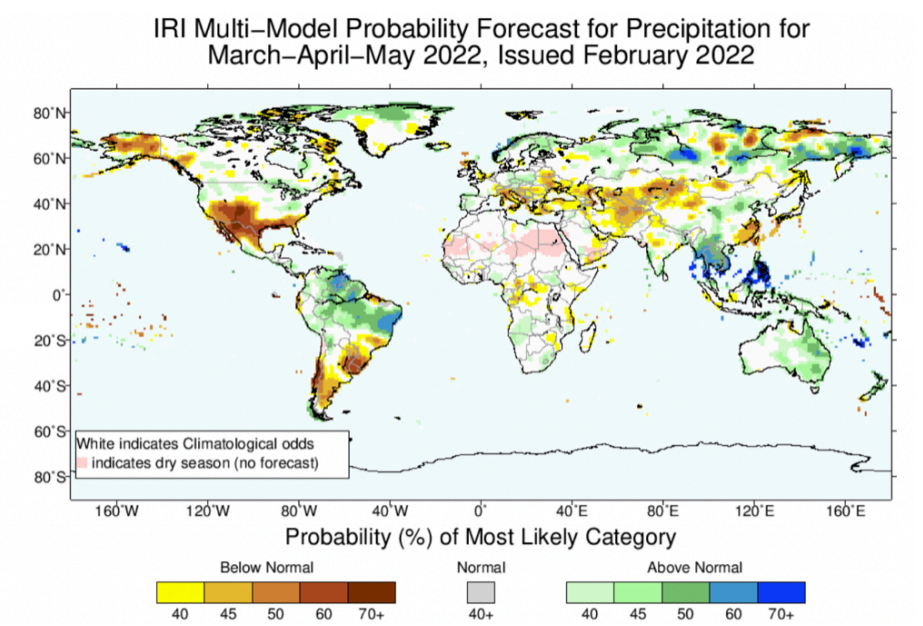
1. Translate observations of today's weather and climate into the model world to initialize the forecast

2. Run the model forward in time many times

3. Translate the forecast from the model world to the real world

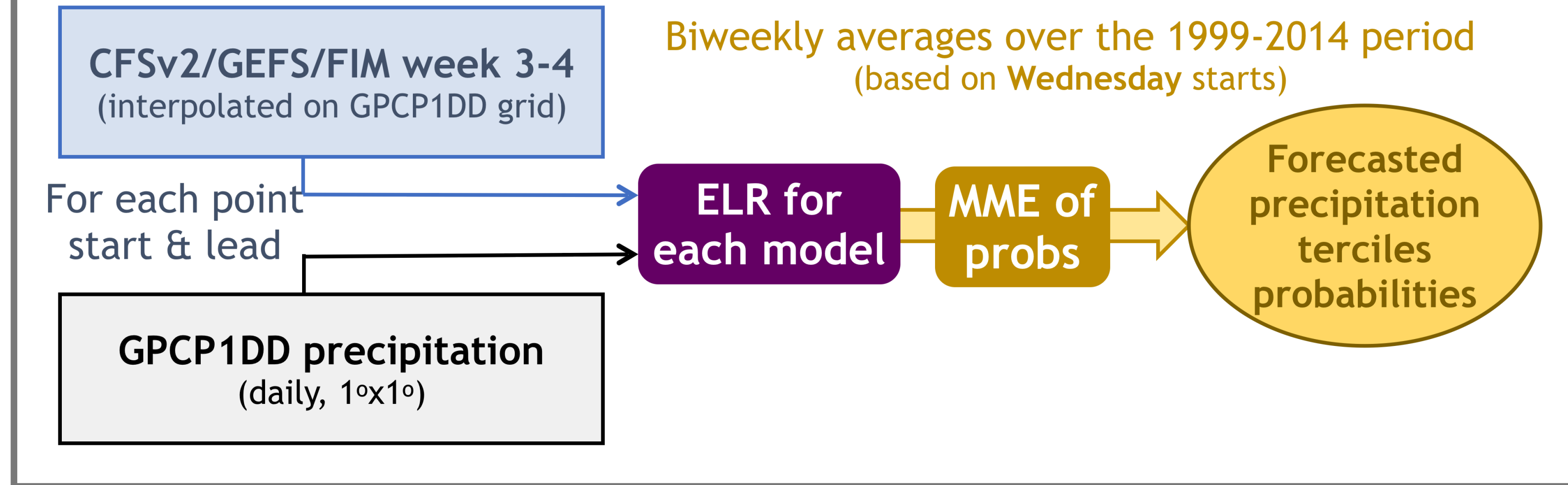


“Forecast Assimilation” or Calibration



IRI Multi-model Forecast Design

Vigaud et al. (2017, MWR)



- Since the model forecasts of precipitation at the S2S range often contain large biases, a regression approach is used to calibrate the forecasts.
- The regression is trained on past forecasts, and uses the model's ensemble mean as a predictor (signal).
- Logistic regression is used to predict the probability of exceeding a given quantile, based on the signal.

Extended Logistic Regression

$$\ln \left[\frac{p}{1-p} \right] = f(x) + g(q) \quad \text{with } p = Pr\{V \leq q\}$$

$$\text{and } \begin{cases} f(x) = b_0 + b_1 \bar{x}_{ens} \\ g(q) = b_2 q \end{cases}$$

IRI Real-time Calibrated Probabilistic Subseasonal Rainfall and Temperature Forecasts Based on SubX models

Issued every Friday for Week 1, 2, 3 & 4
Weeks 2-3 and 3-4

Subseasonal Forecasts

Subseasonal forecasts of precipitation and temperature.

This section is dedicated to subseasonal forecasts, i.e. that bridge the gap between medium range weather forecasts (up to 10 days) and seasonal climate predictions (above a month). They are issued at different frequencies (from daily to once or twice a week) forecasting daily values with lead times from 1 to about 40 days, depending on the Global Producing Center (GPC). The availability of forecast products in the subseasonal-to-seasonal time range offers an unprecedented opportunity to develop intra-seasonal forecast information that other forecasts can't, in association with increased lead time compared to medium range weather forecasts, and with higher temporal resolution than seasonal forecasts that give an overview of an upcoming seasons (3 months). For instance, subseasonal forecasts may allow delivering relevant information about key climate characteristics such as the timing of the onset of a rainy season for agriculture, the risk of extreme rainfall events or heat waves in regards to public health.

At present, these maprooms include experimental subseasonal forecasts of weekly and biweekly precipitation and temperature (terciles and above median) based on the multi-model ensemble of individual forecasts issued every Saturdays through the SubX real-time database and every Thursday through the delayed S2S database.

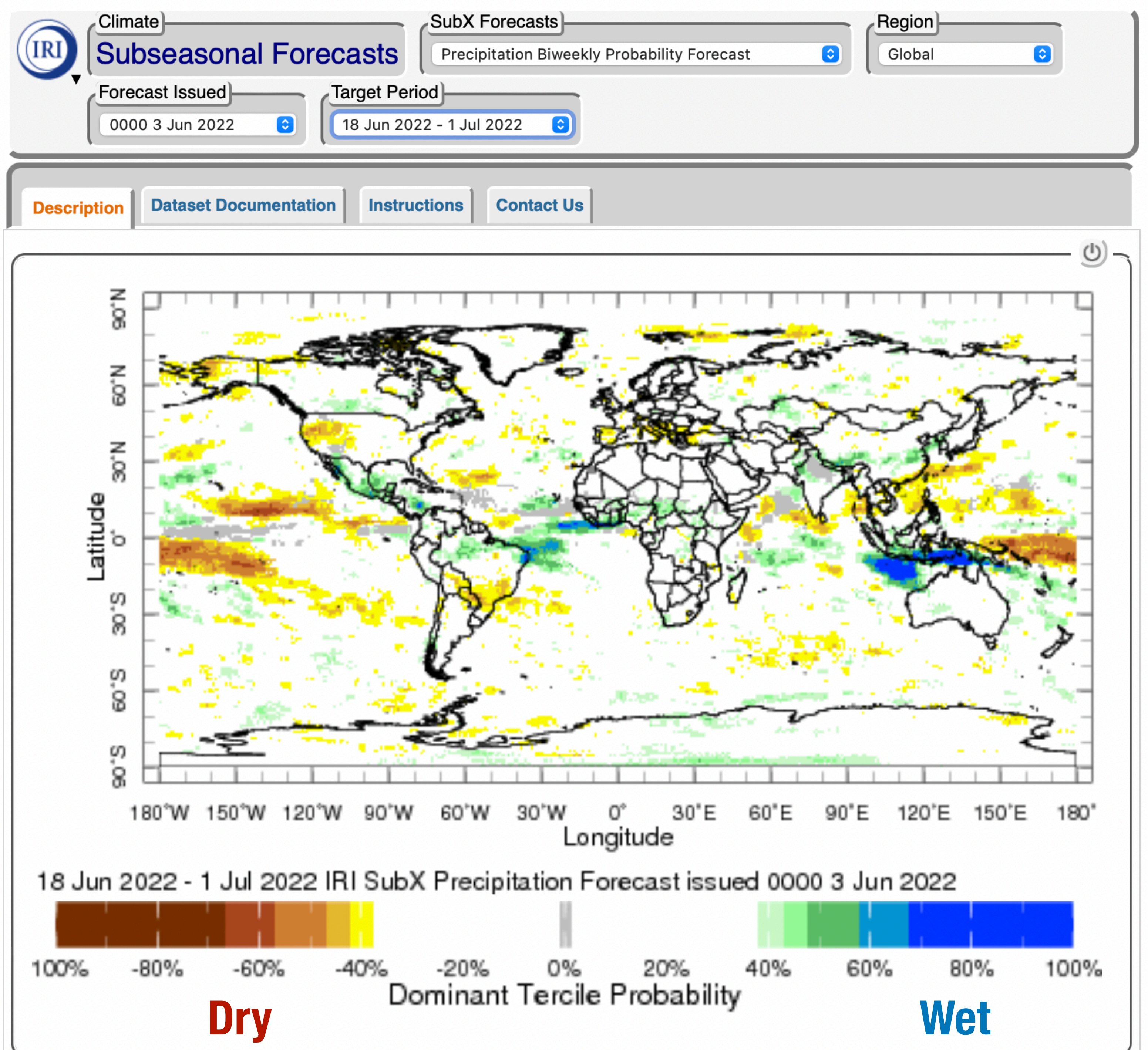
SubX Forecasts

- Precipitation Median Probability Forecast**
Calibrated Subseasonal Two-category precipitation real-time forecasts
- Precipitation Biweekly Probability Forecast**
Calibrated Subseasonal tercile category biweekly-precipitation forecasts
- Temperature Median Probability Forecast**
Calibrated Subseasonal Two-category temperature real-time forecasts
- Temperature Biweekly Probability Forecast**
Calibrated subseasonal tercile categories temperature forecasts
- Precipitation Weekly Probability Forecast**
Calibrated Subseasonal Tercile categories precipitation real-time forecasts
- Temperature Weekly Probability Forecast**
Calibrated subseasonal tercile categories temperature forecasts
- Temperature Weekly Probability Forecast (LELR)**
Subseasonal tercile categories temperature forecasts with pattern-based calibration
- Precipitation Flexible Biweekly Forecast**
This subseasonal forecasting system consists of probabilistic precipitation forecasts based on the full estimate of the probability distribution.
- Temperature Flexible Biweekly Forecast**
This subseasonal forecasting system consists of probabilistic temperature forecasts based on the full estimate of the probability distribution.

Week 3-4 Precipitation

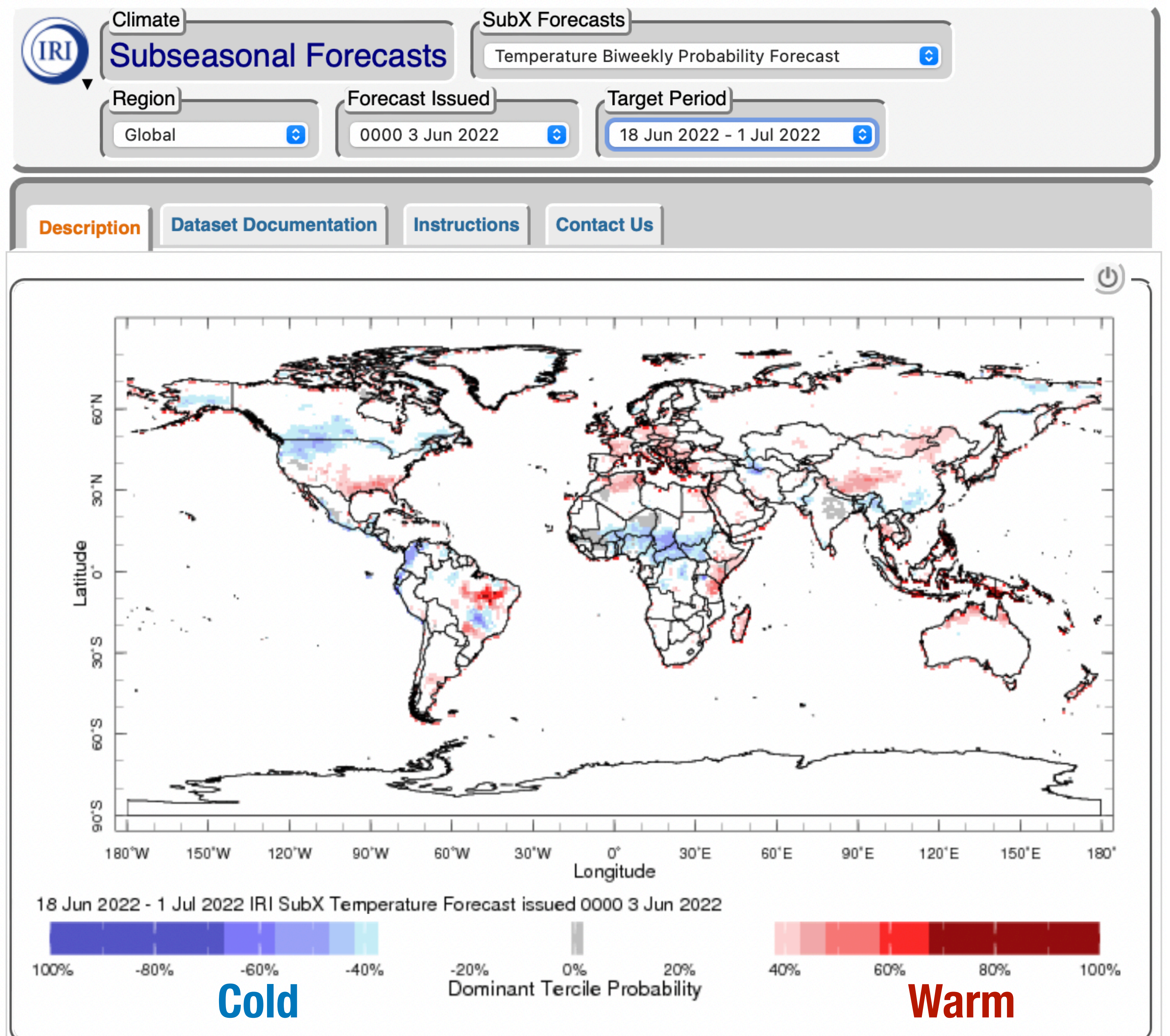
http://iridl.ldeo.columbia.edu/maproom/Global/ForecastsS2S/precip_subx.html?S=0000%203%20Jun%202022&L=22.0

14-day target period, 16 to 29 days after the forecast was issued



Week 3-4 Temperature

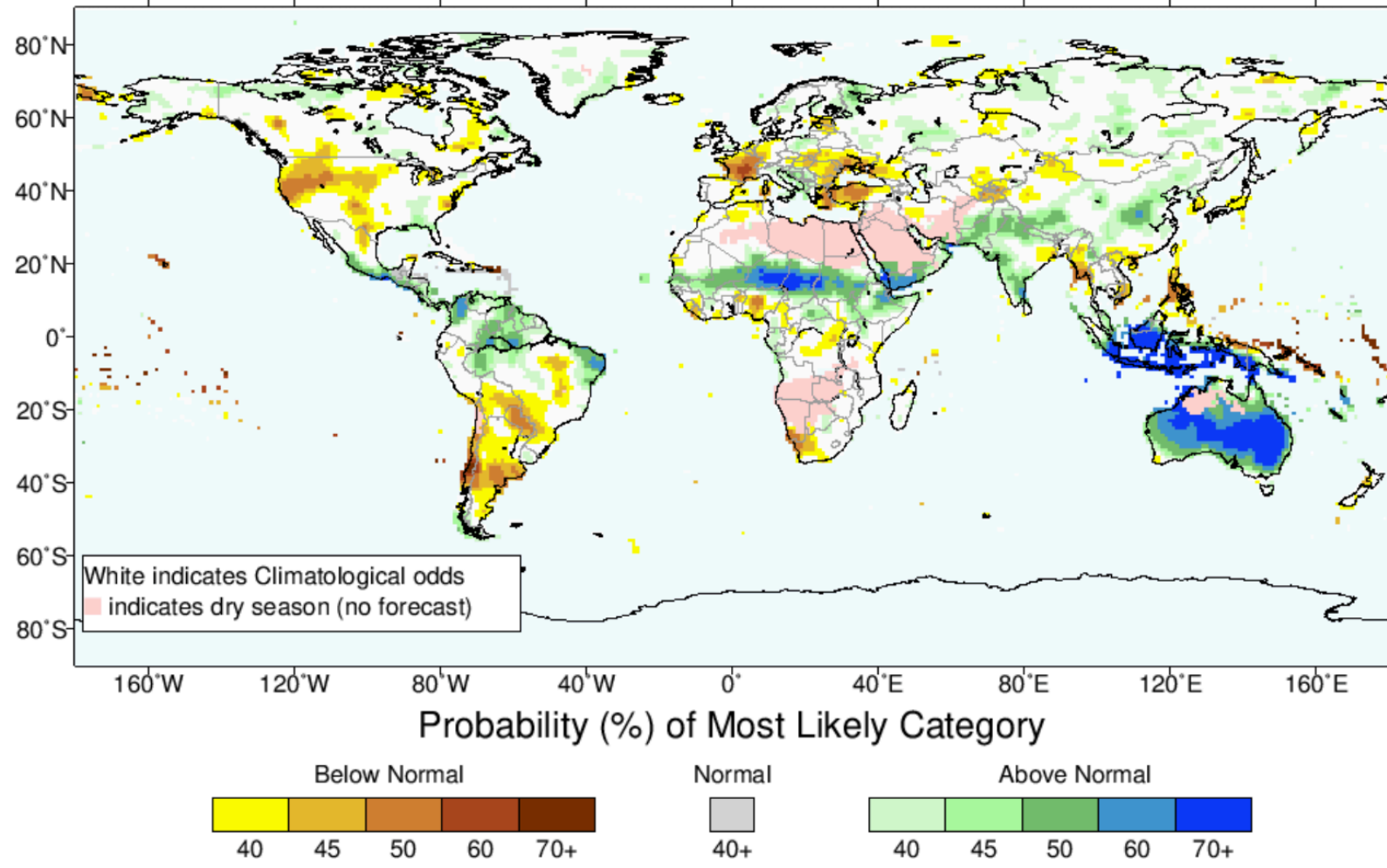
http://iridl.ldeo.columbia.edu/maproom/Global/ForecastsS2S/temperature_subx_biweekly_avg.html?S=0000%203%20Jun%202022&L=22.0



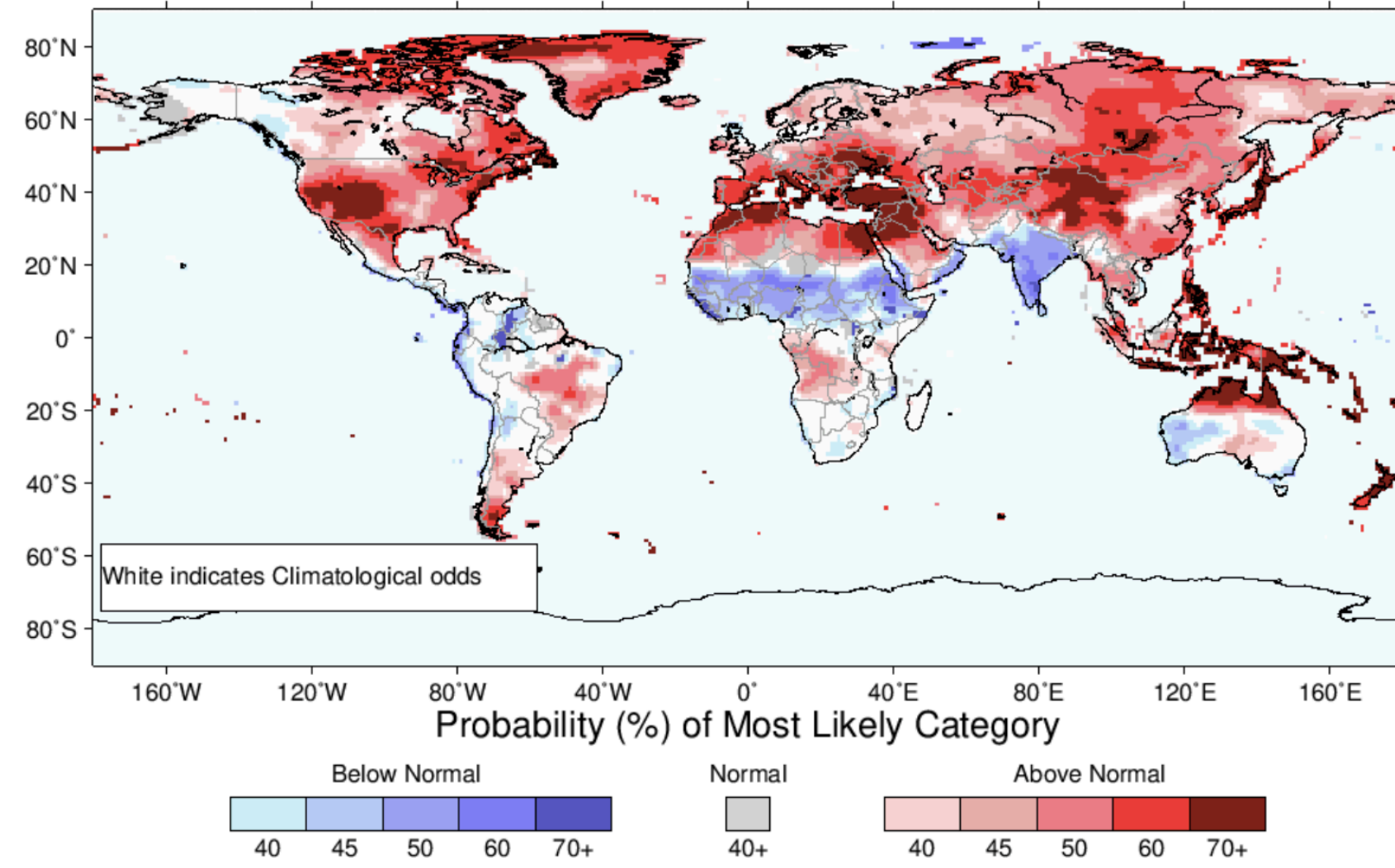
Current IRI Seasonal vs Subseasonal Forecasts

Seasonal

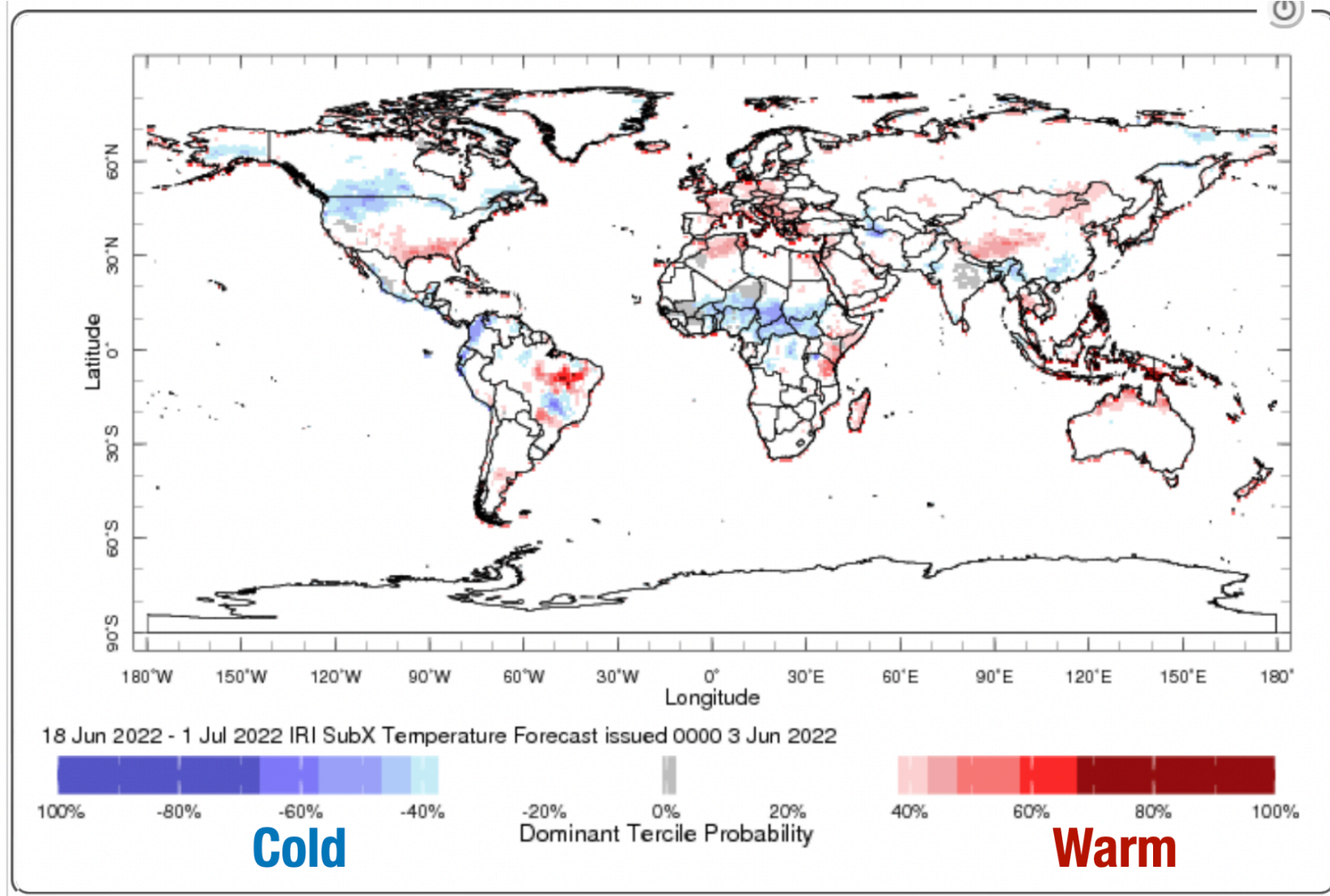
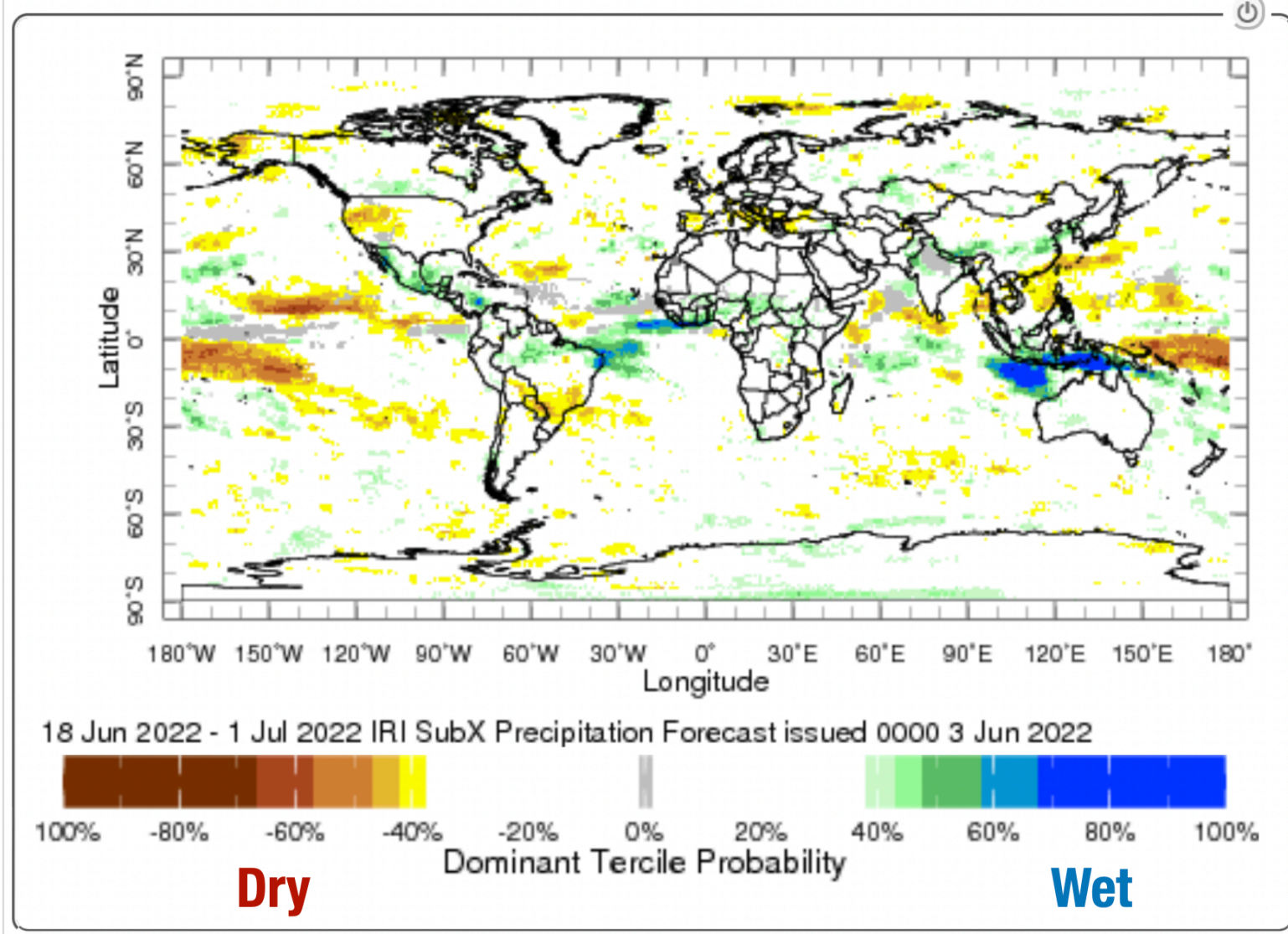
IRI Multi-Model Probability Forecast for Precipitation for June-July-August 2022, Issued May 2022



IRI Multi-Model Probability Forecast for Temperature for June-July-August 2022, Issued May 2022

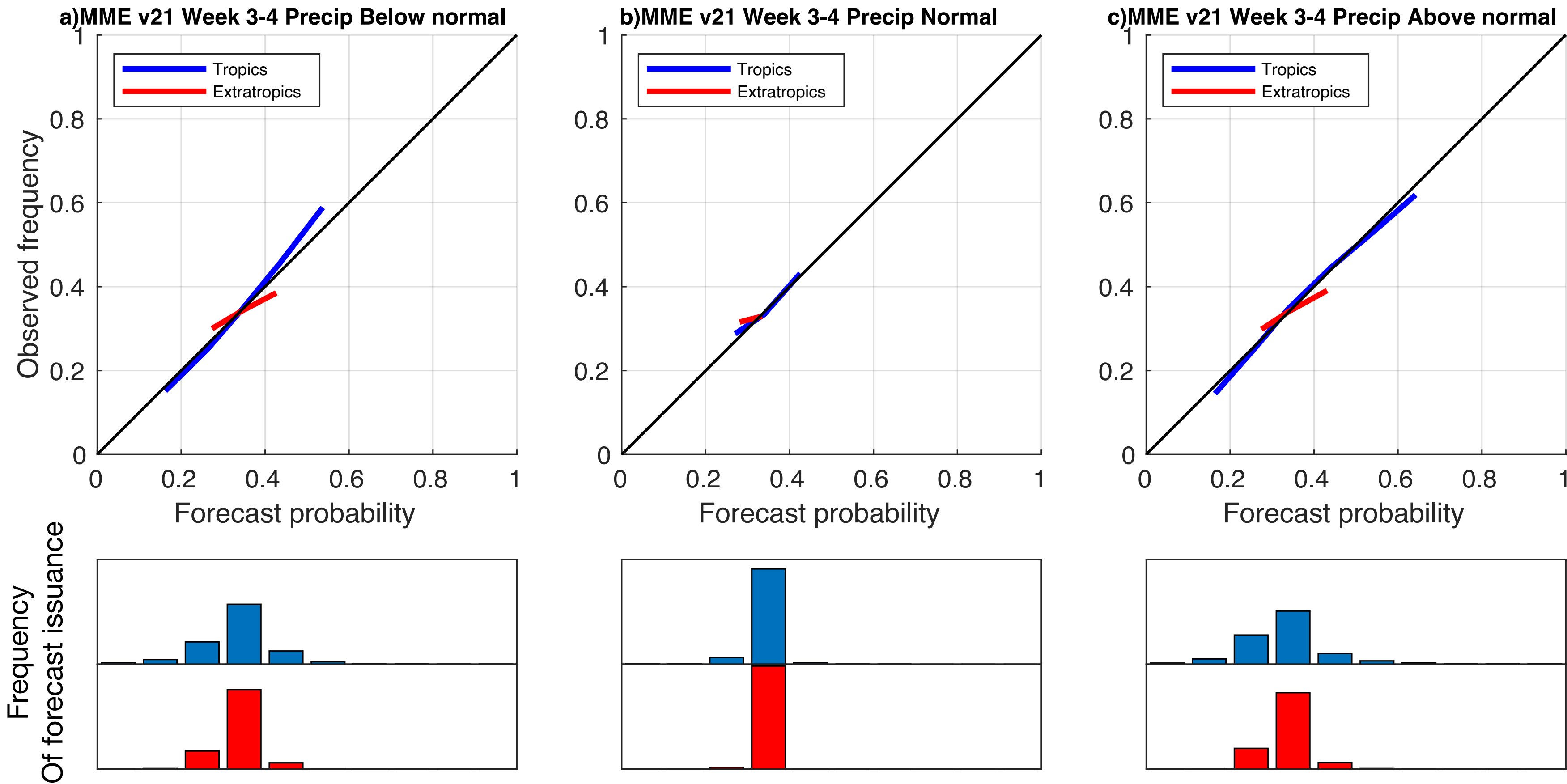


Week 3-4



Week 3-4 Precipitation Forecast Reliability

Are the issued tercile-category probabilities correct on average?



All calendar months
1999-2016 hindcast
period,
using leave-1-year-out
cross validation

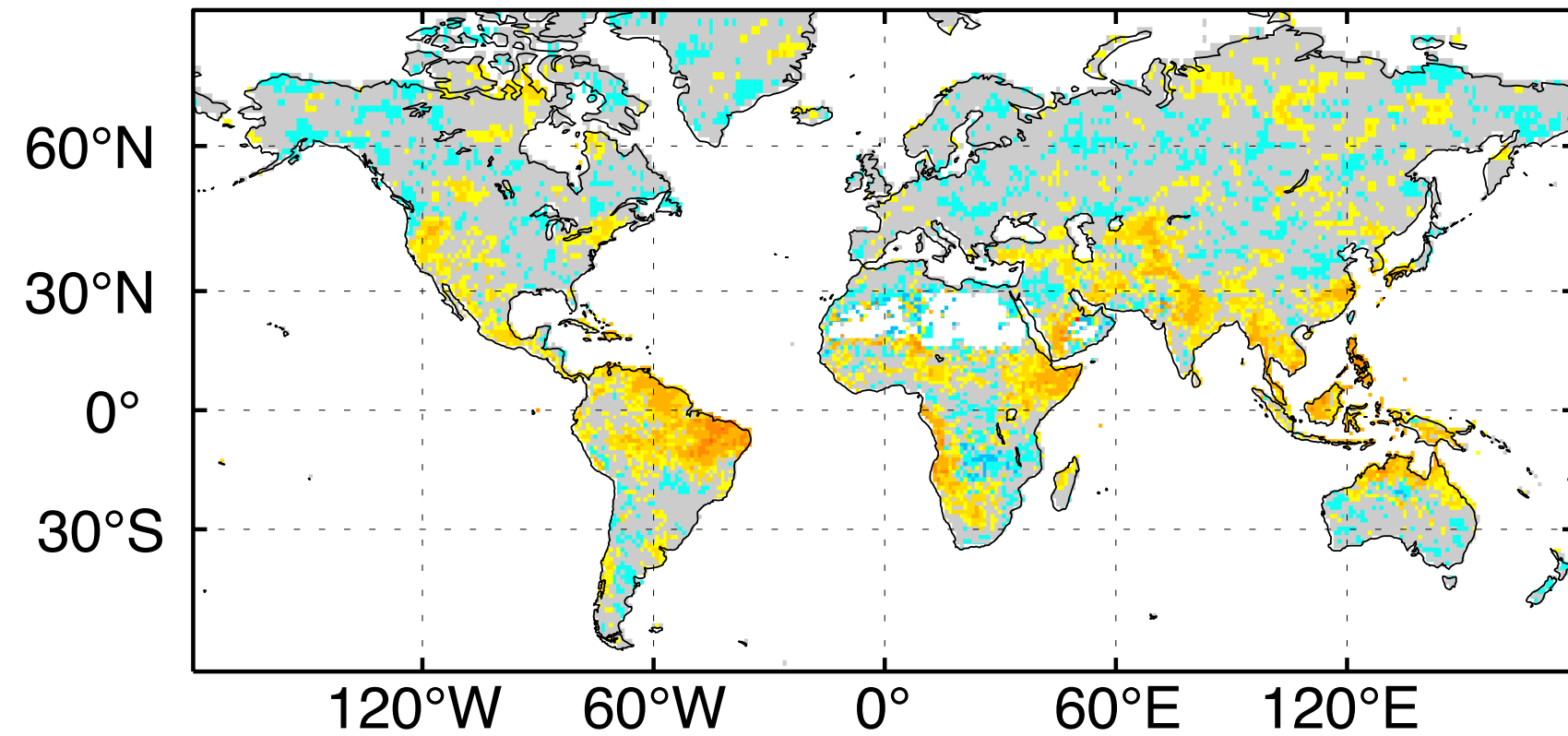
Forecast probabilities
falling on the diagonal line
are “reliable”.

All calendar months
1999-2016 hindcast
period,
using leave-1-year-out
cross validation

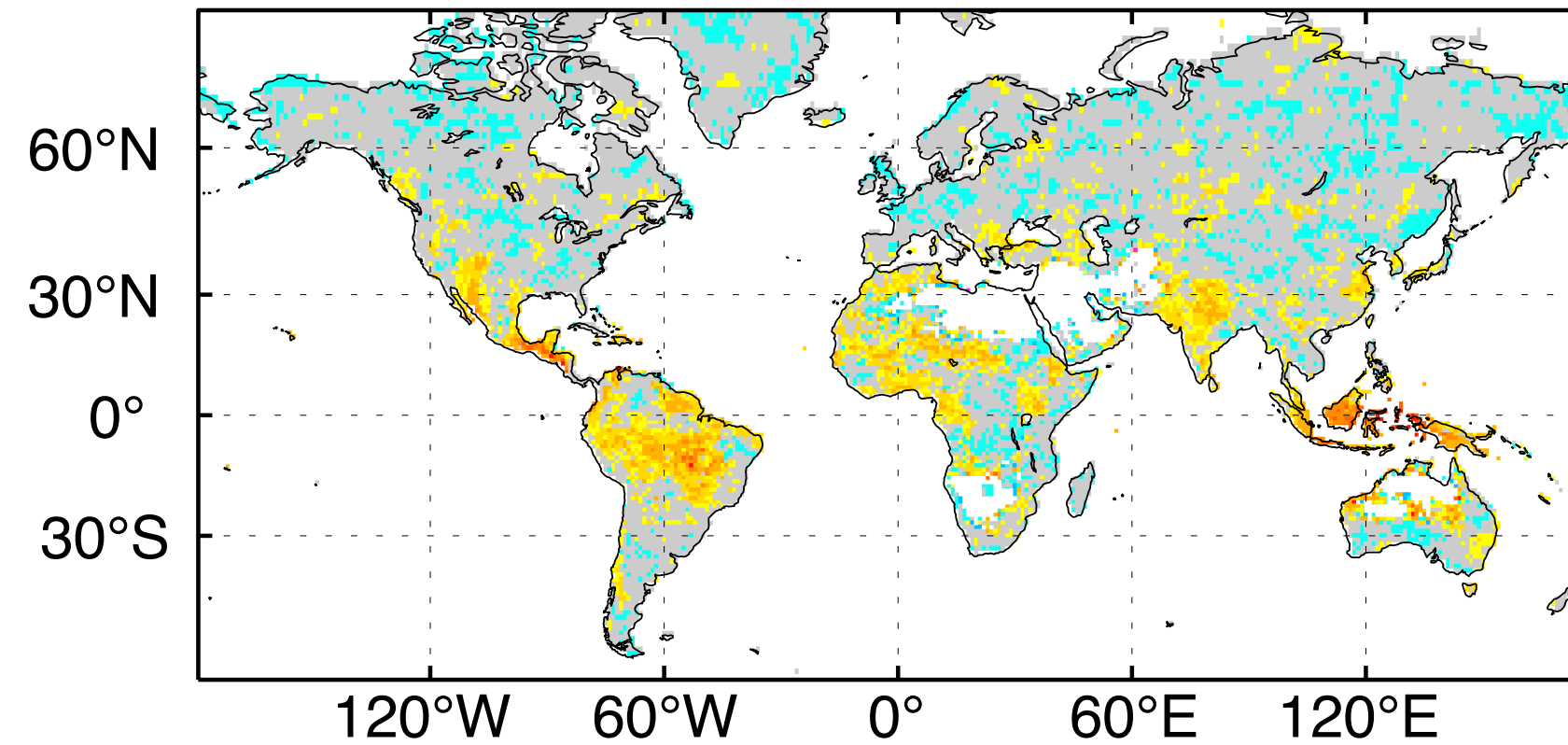
Forecast probabilities
falling on the diagonal line
are “reliable”.

Precipitation Ranked Probability Skill Score (RPSS)

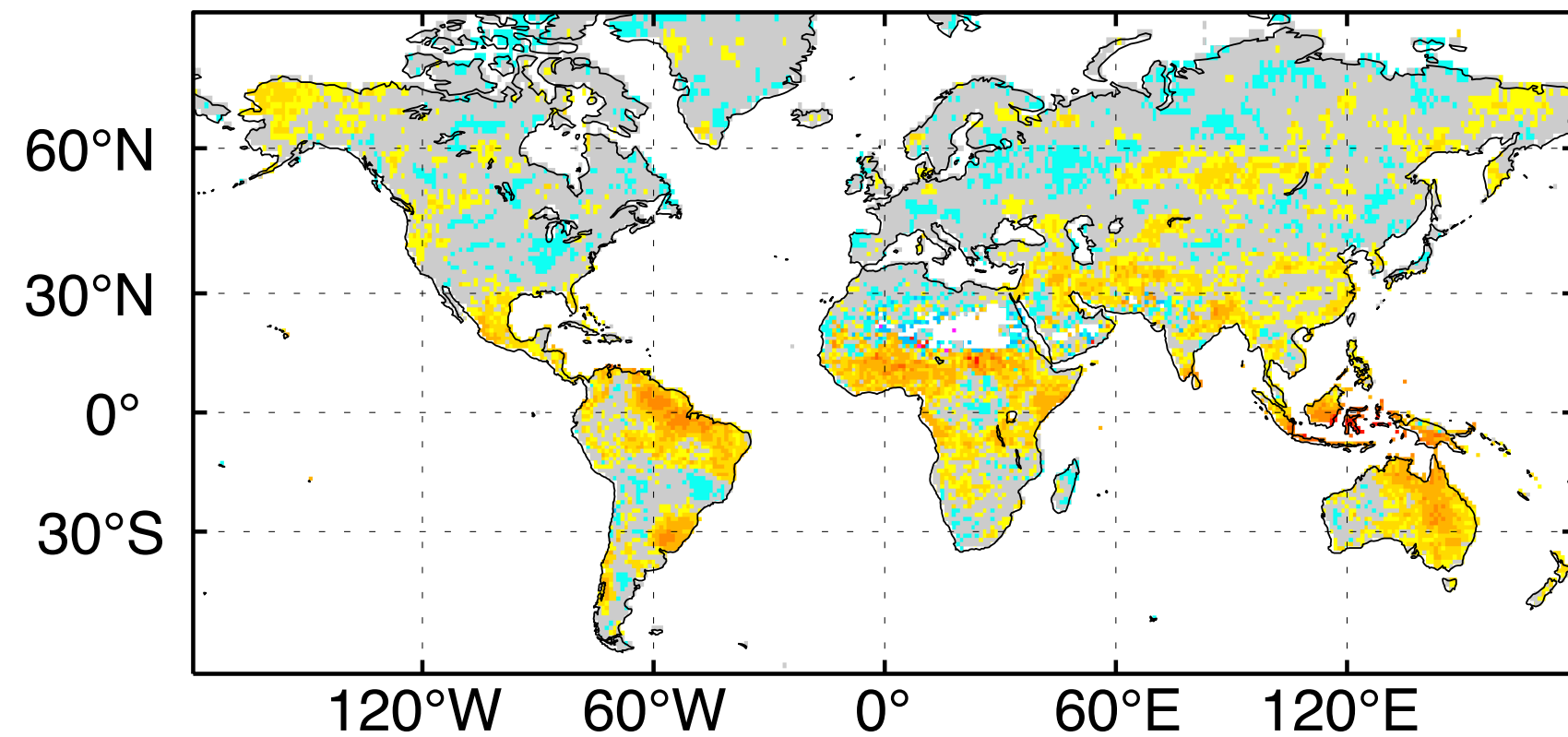
a) RPSS Week 3-4 Precip MAM



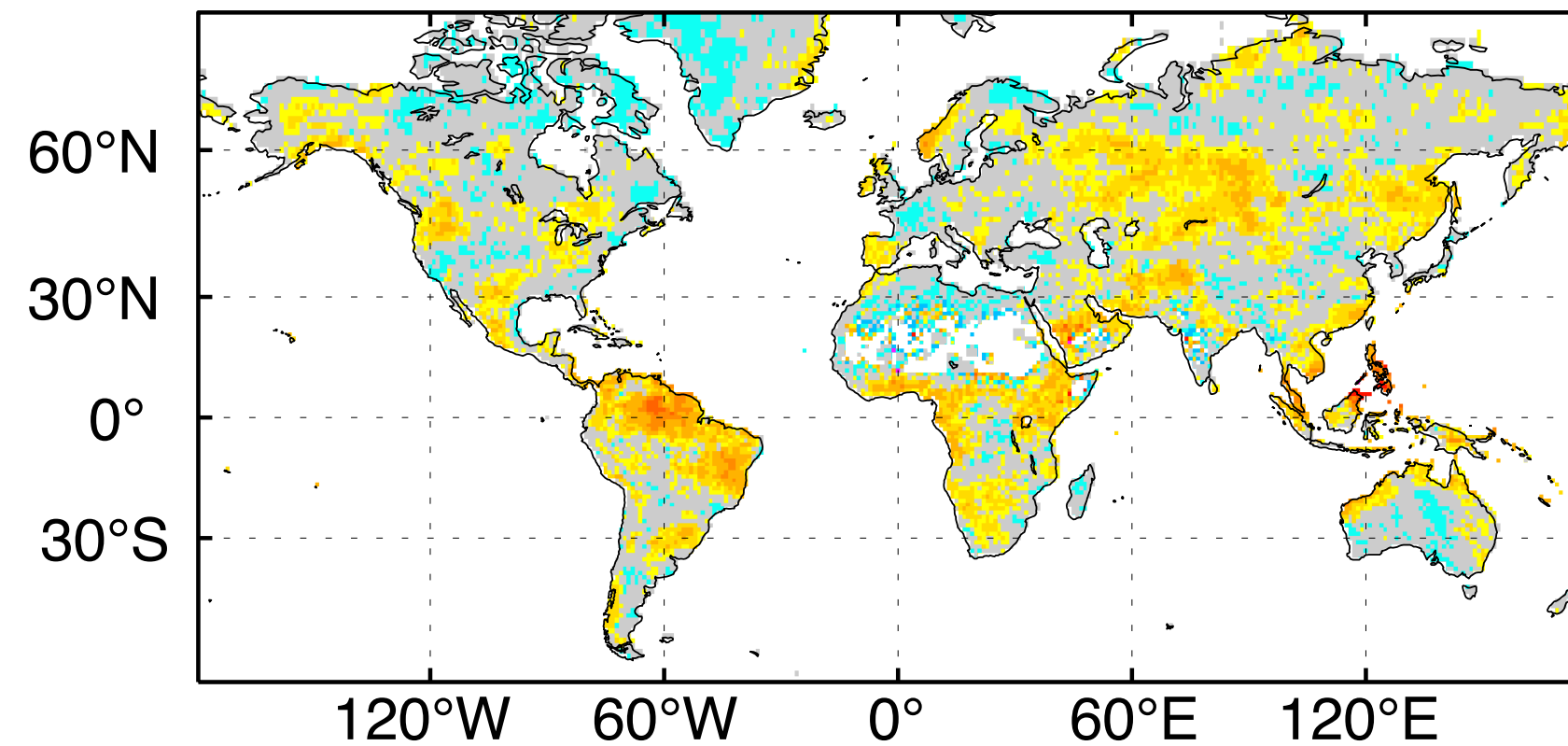
b) RPSS Week 3-4 Precip JJA



c) RPSS Week 3-4 Precip SON



d) RPSS Week 3-4 Precip DJF



All calendar months
1999-2016 hindcast
period,
using leave-1-year-out
cross validation.

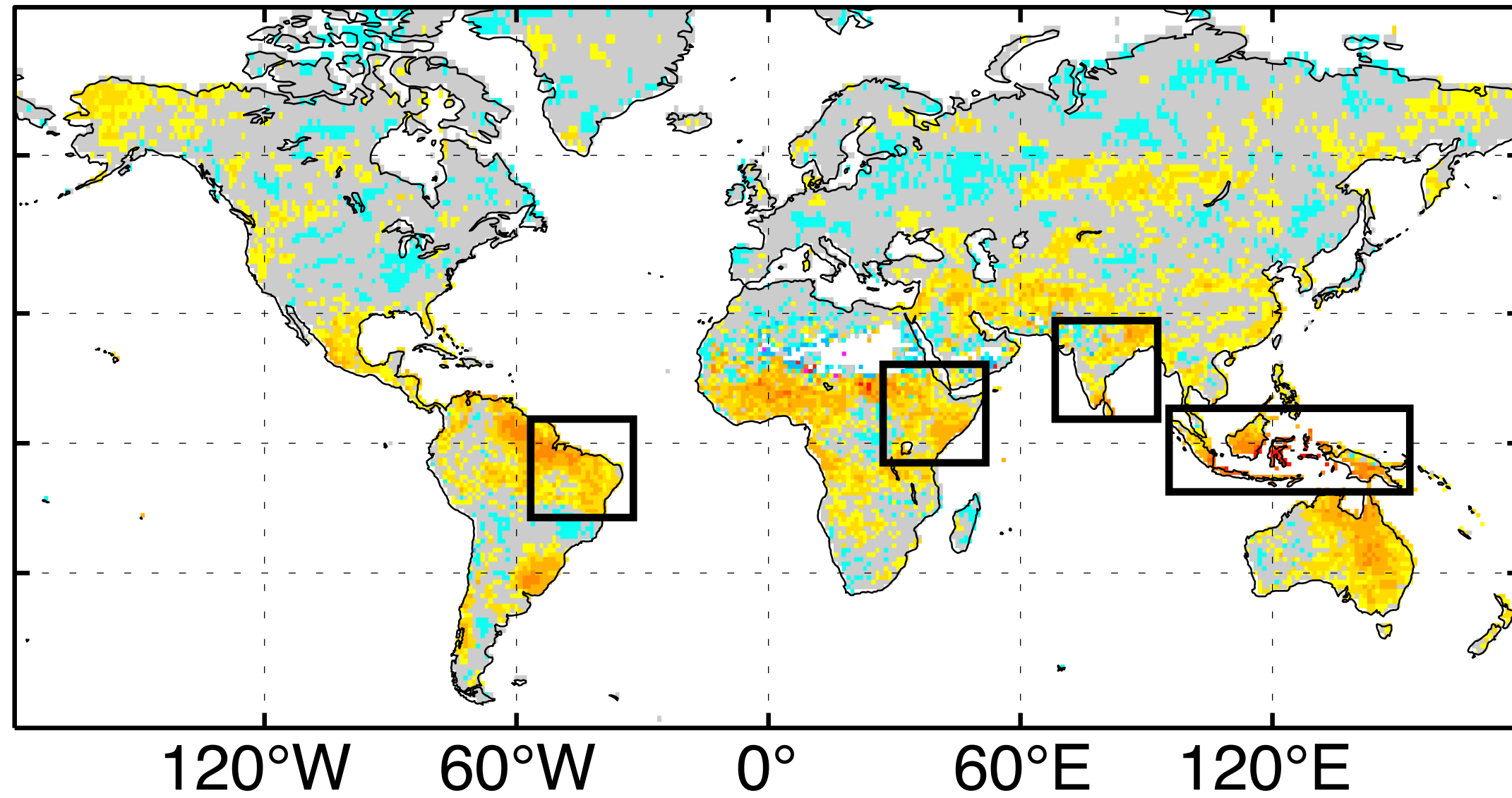
r : 0.4 0.5



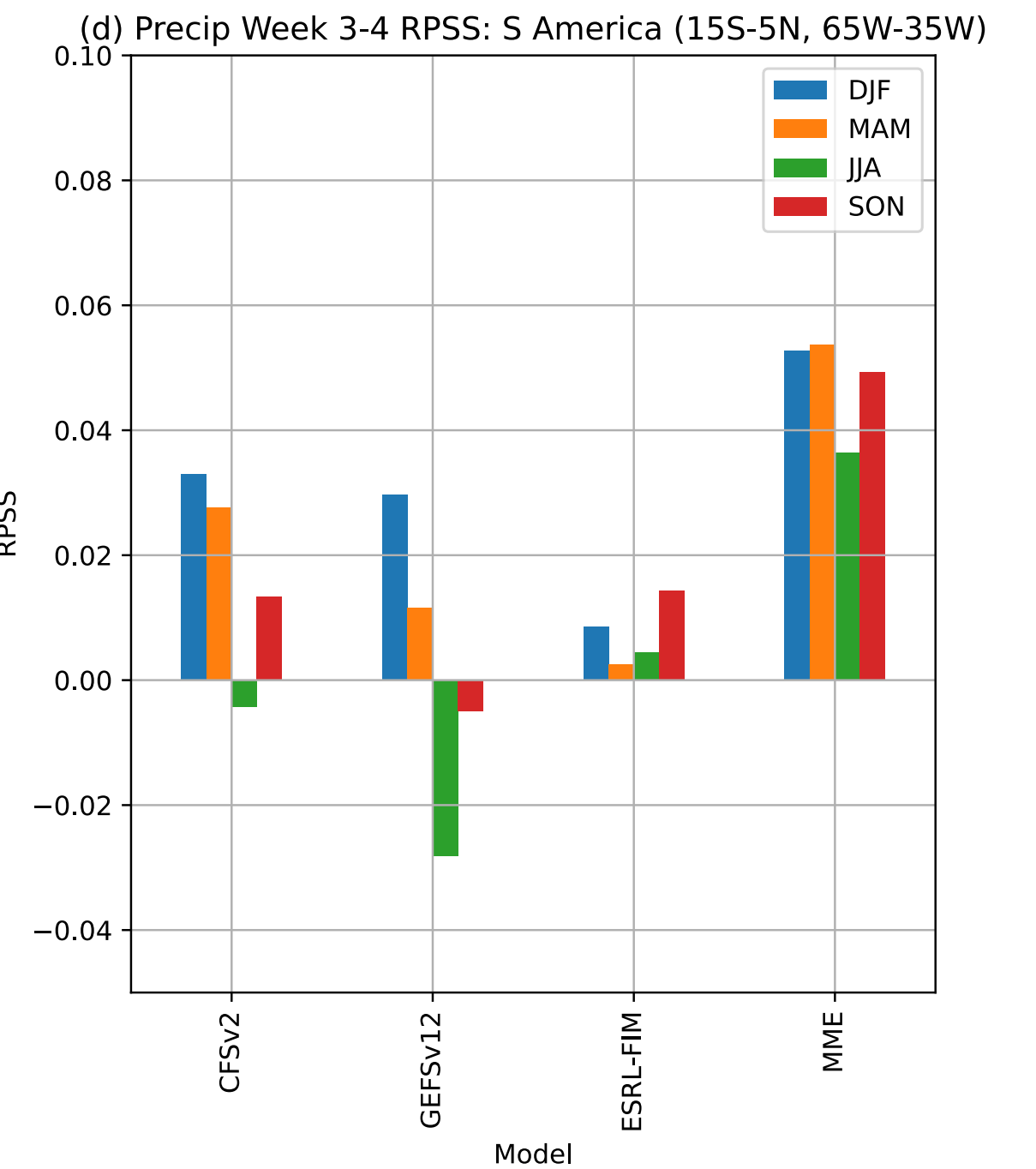
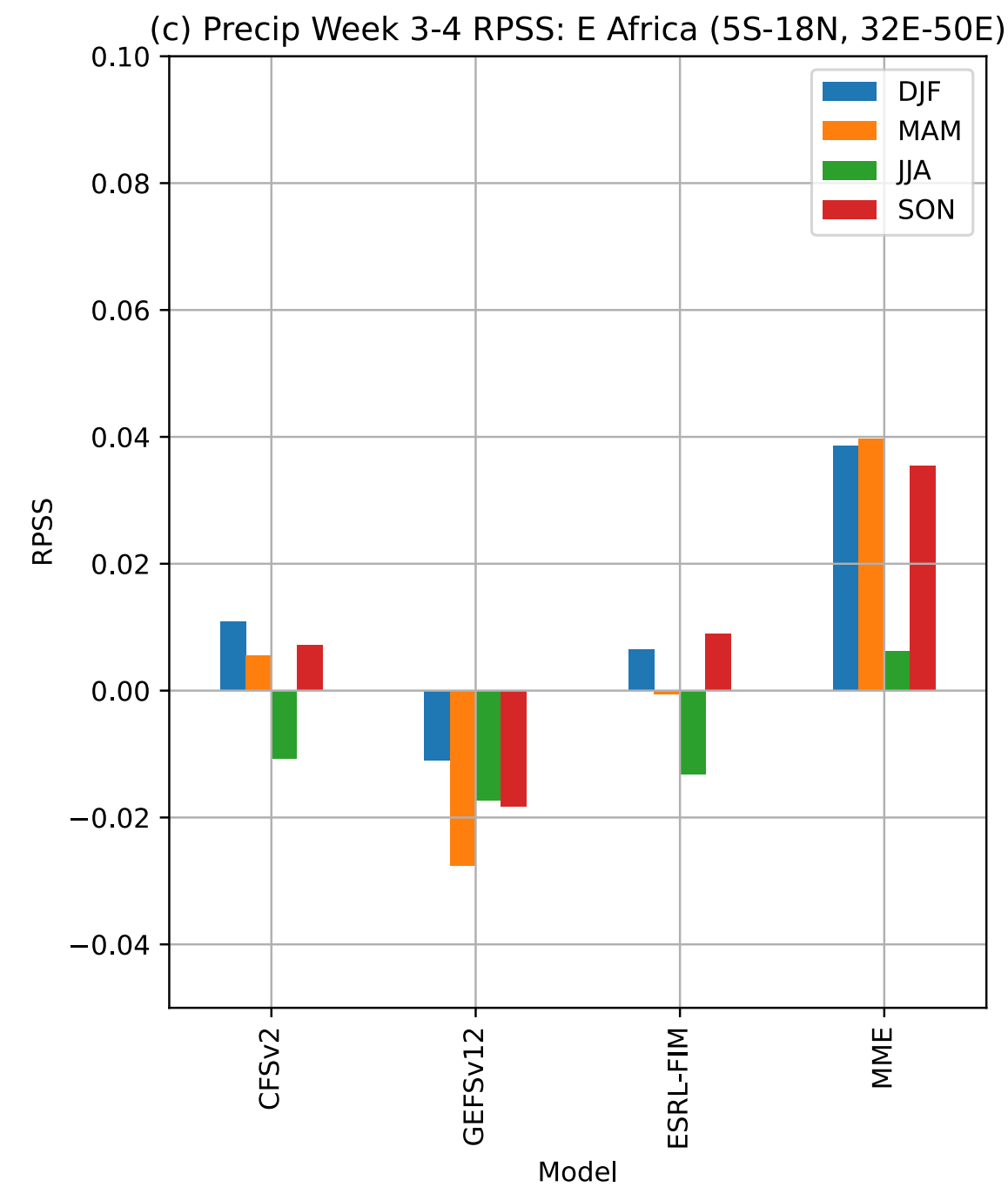
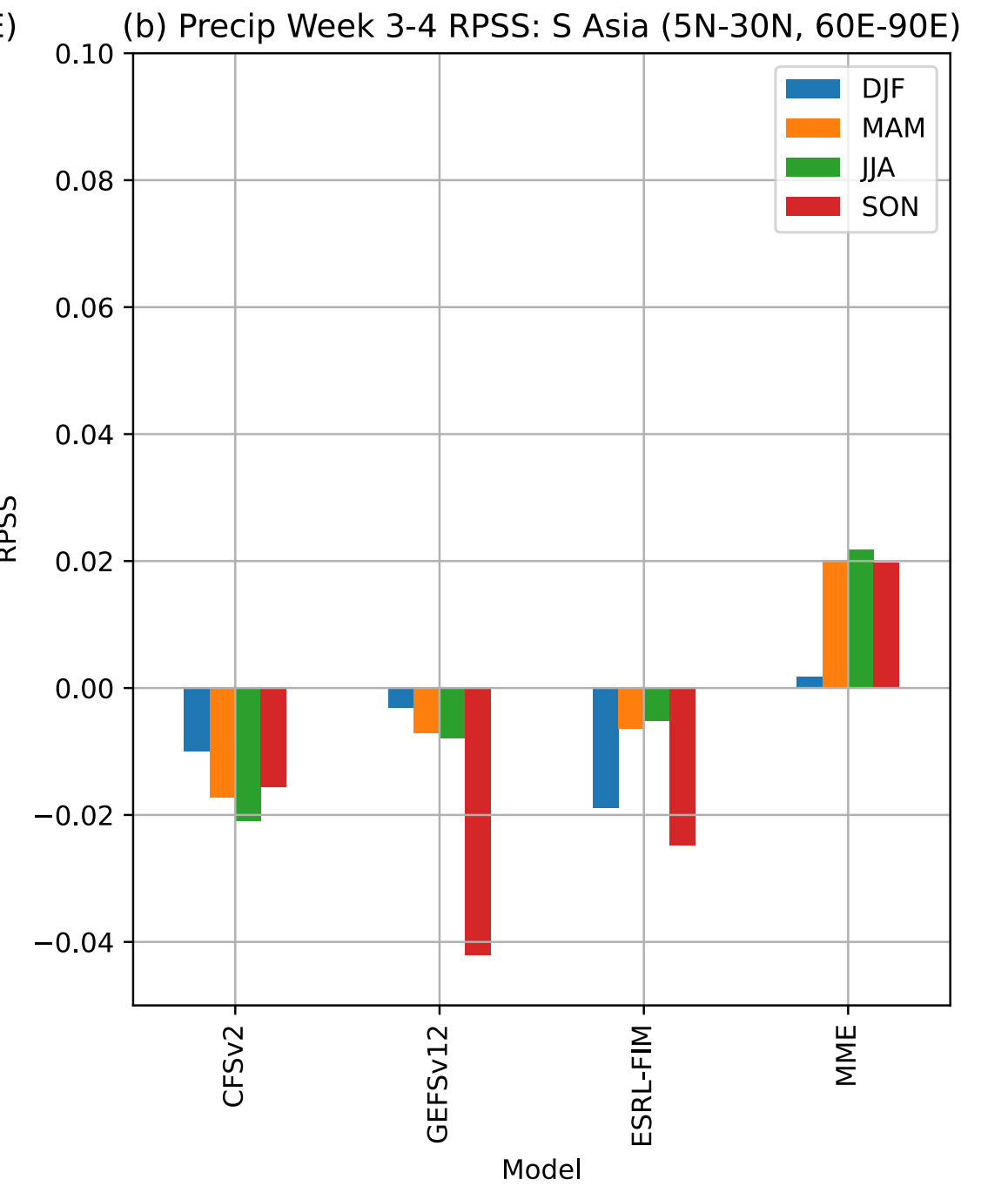
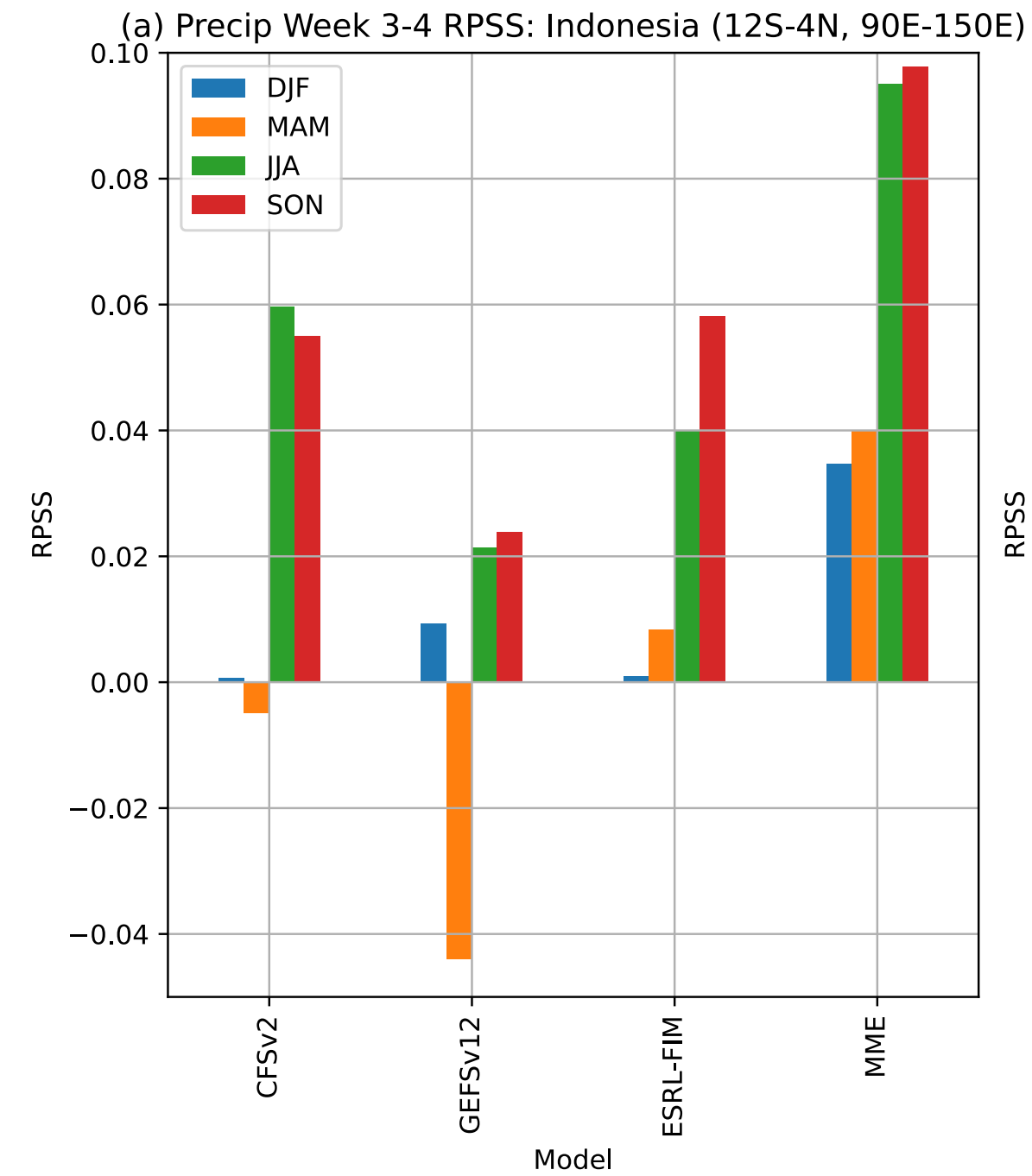
Precipitation RPSS

Impact of Model Combination

c) RPSS Week 3-4 Precip SON

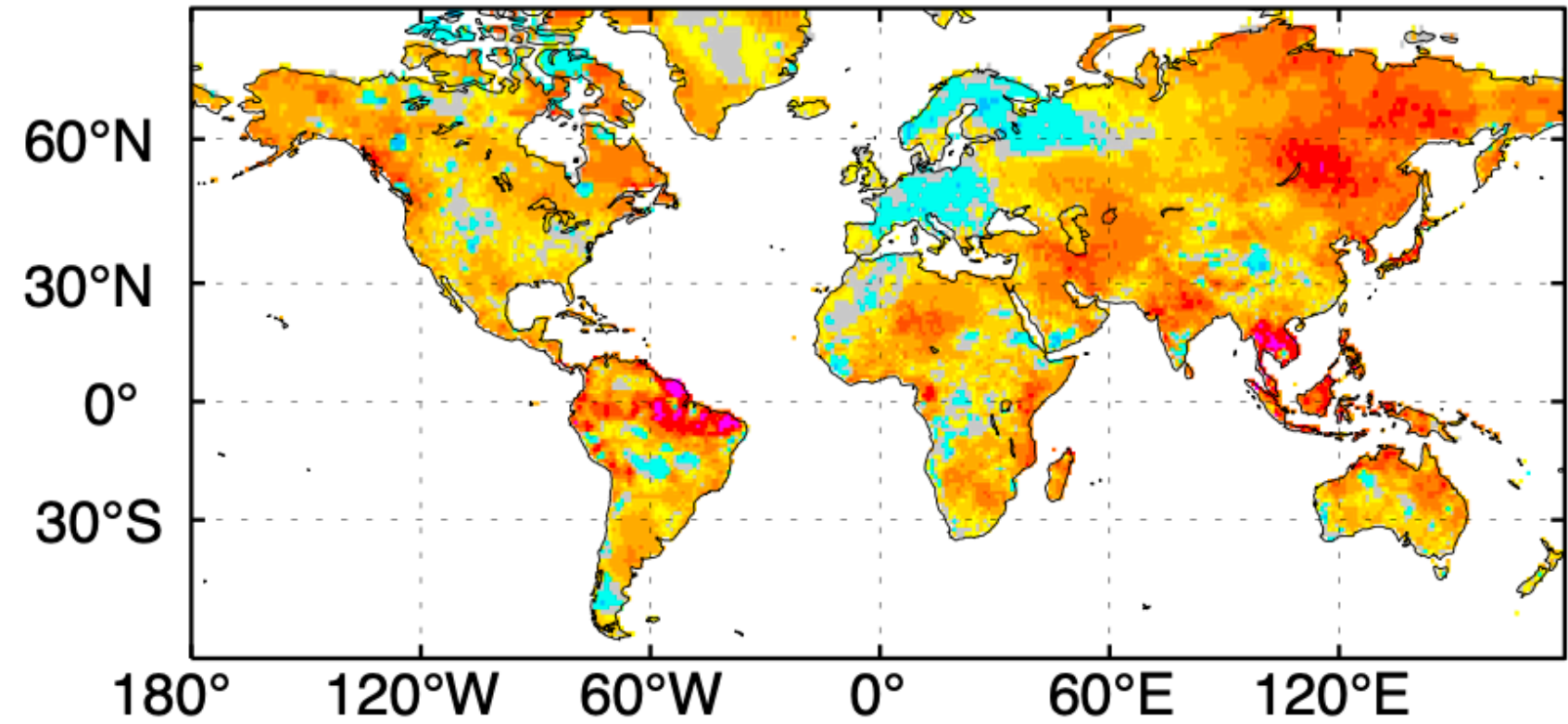


The skill of the multi-model combination exceeds that of any individual model in all 4 regions and seasons.

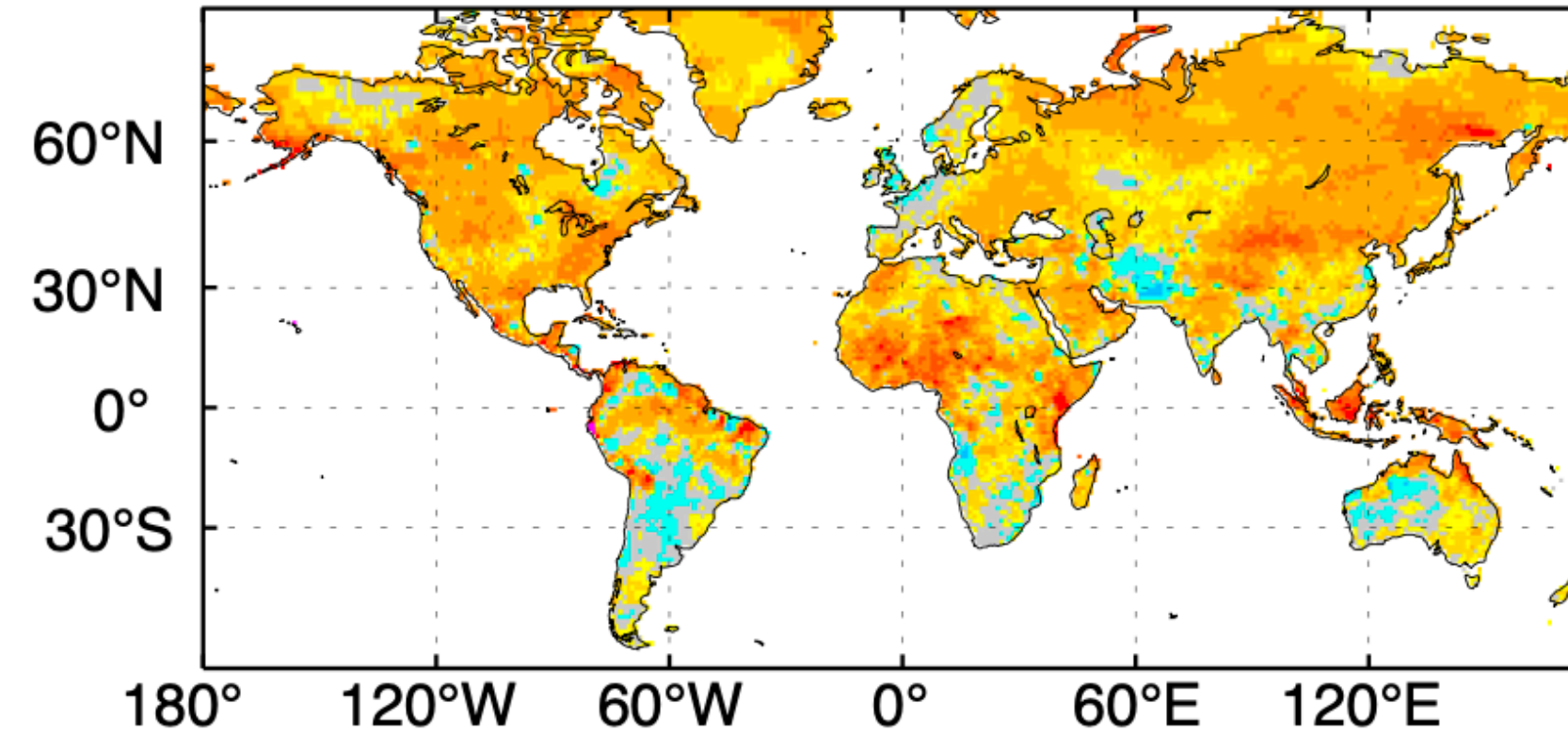


Temperature (2m) Ranked Probability Skill Score (RPSS)

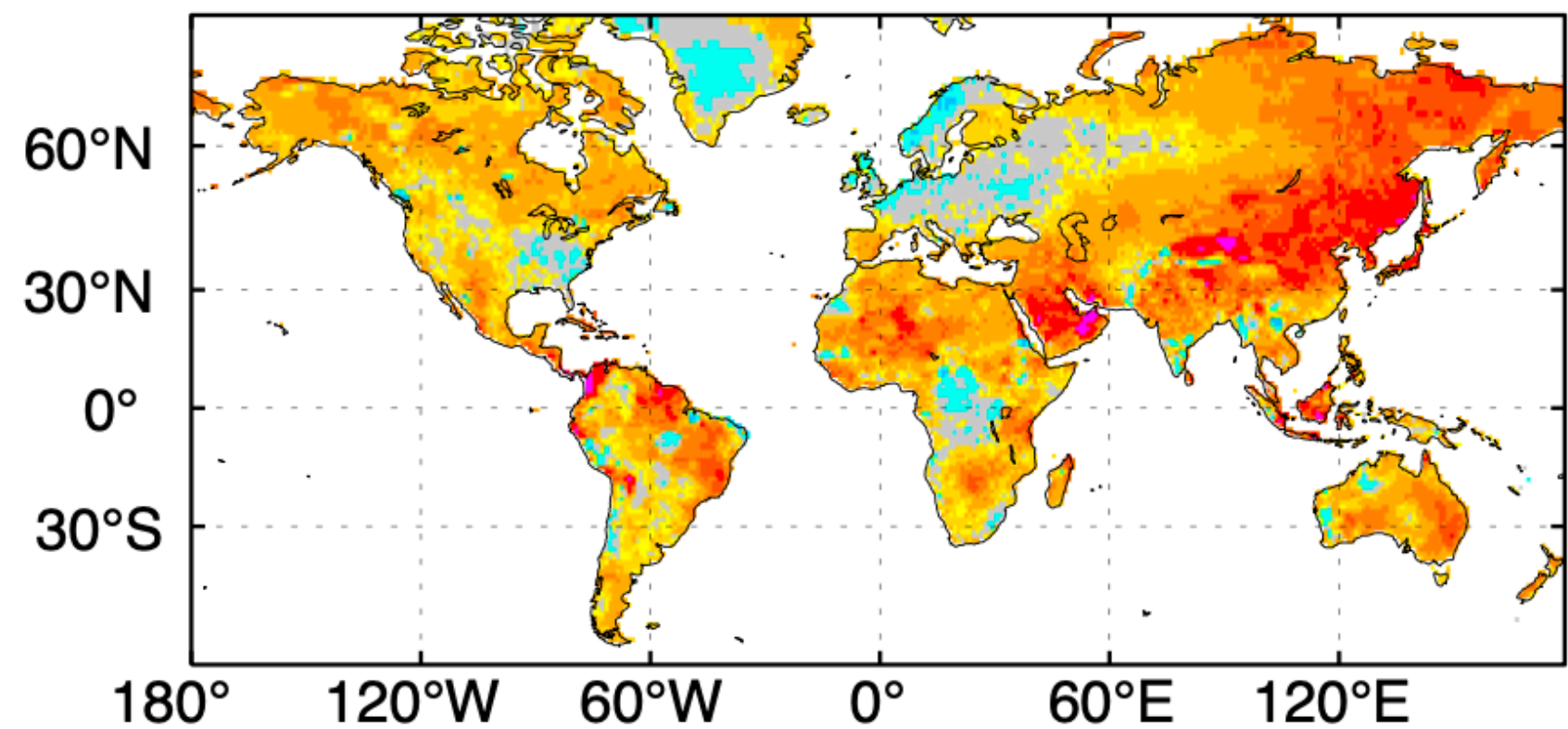
a) RPSS Week 3-4 T2m MAM



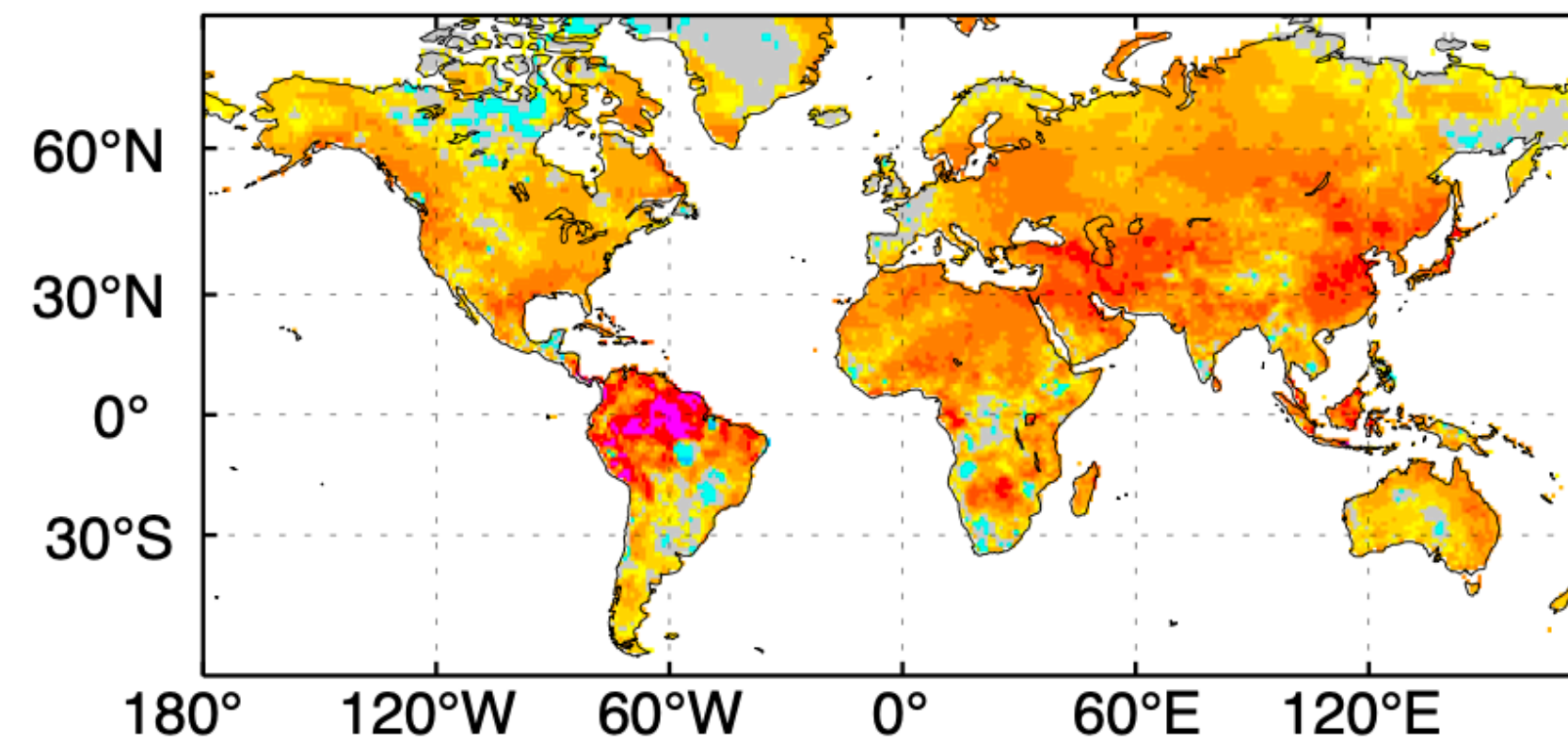
b) RPSS Week 3-4 T2m JJA



c) RPSS Week 3-4 T2m SON



d) RPSS Week 3-4 T2m DJF



All calendar months
1999-2016 hindcast
period,
using leave-1-year-out
cross validation.



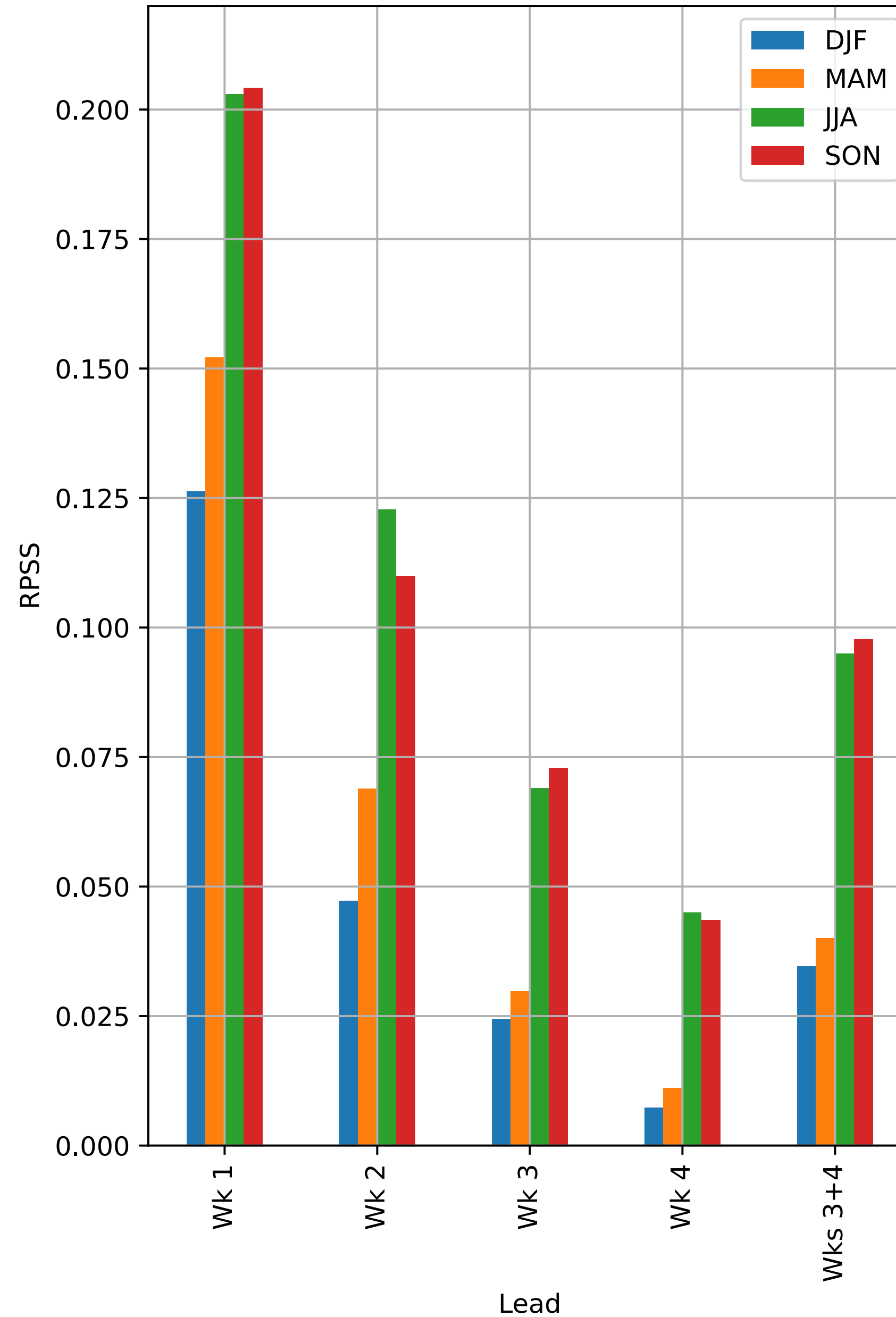
Indonesia Skill

By Lead Time

The skill of the week 3-4 biweekly average is greater than the week 3 average, in all seasons.

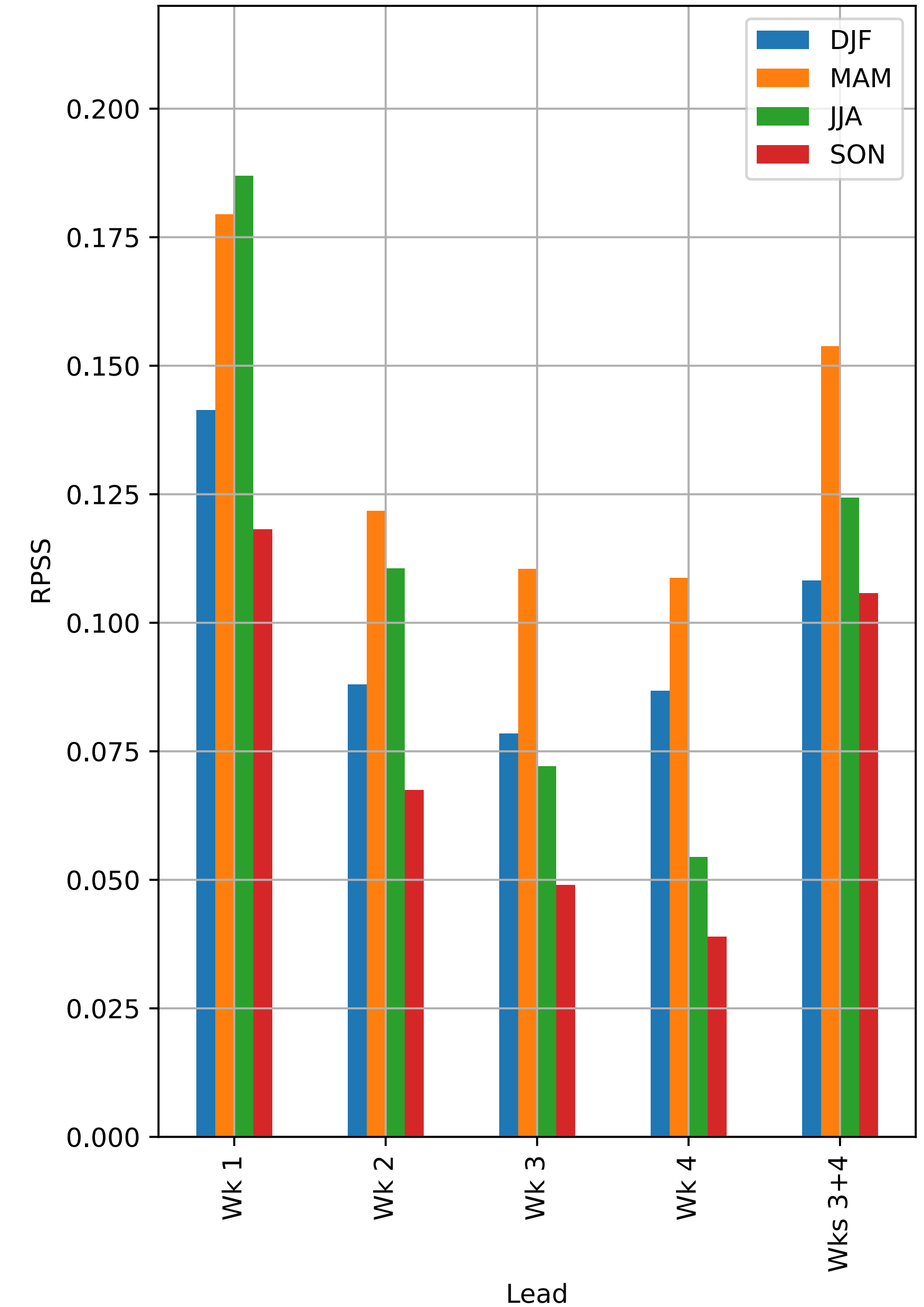
Precipitation RPSS

(a) Precip MME RPSS: Indonesia (12S-4N, 90E-150E)



Temperature RPSS

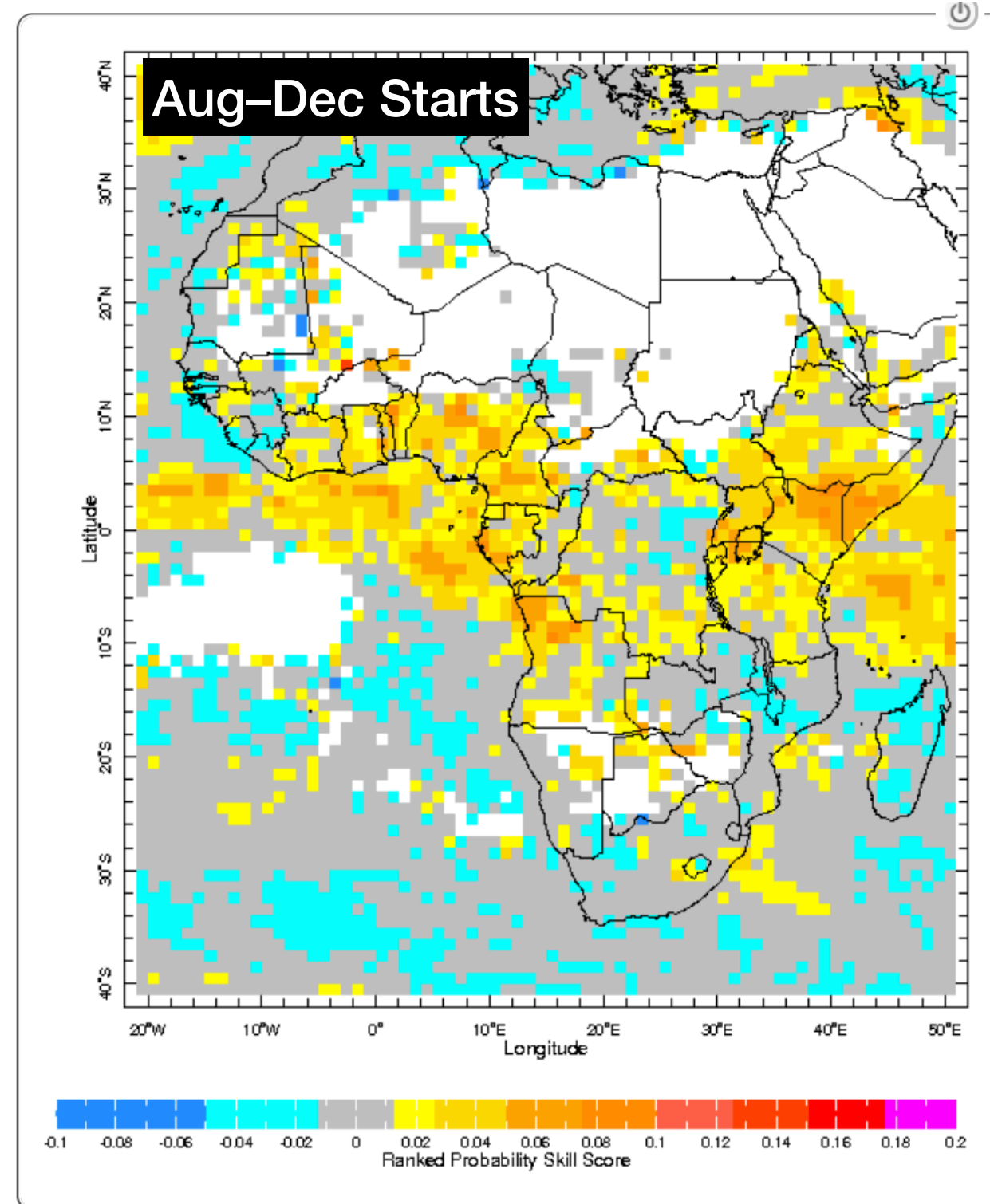
(b) T2m MME RPSS: Indonesia (12S-4N, 90E-150E)



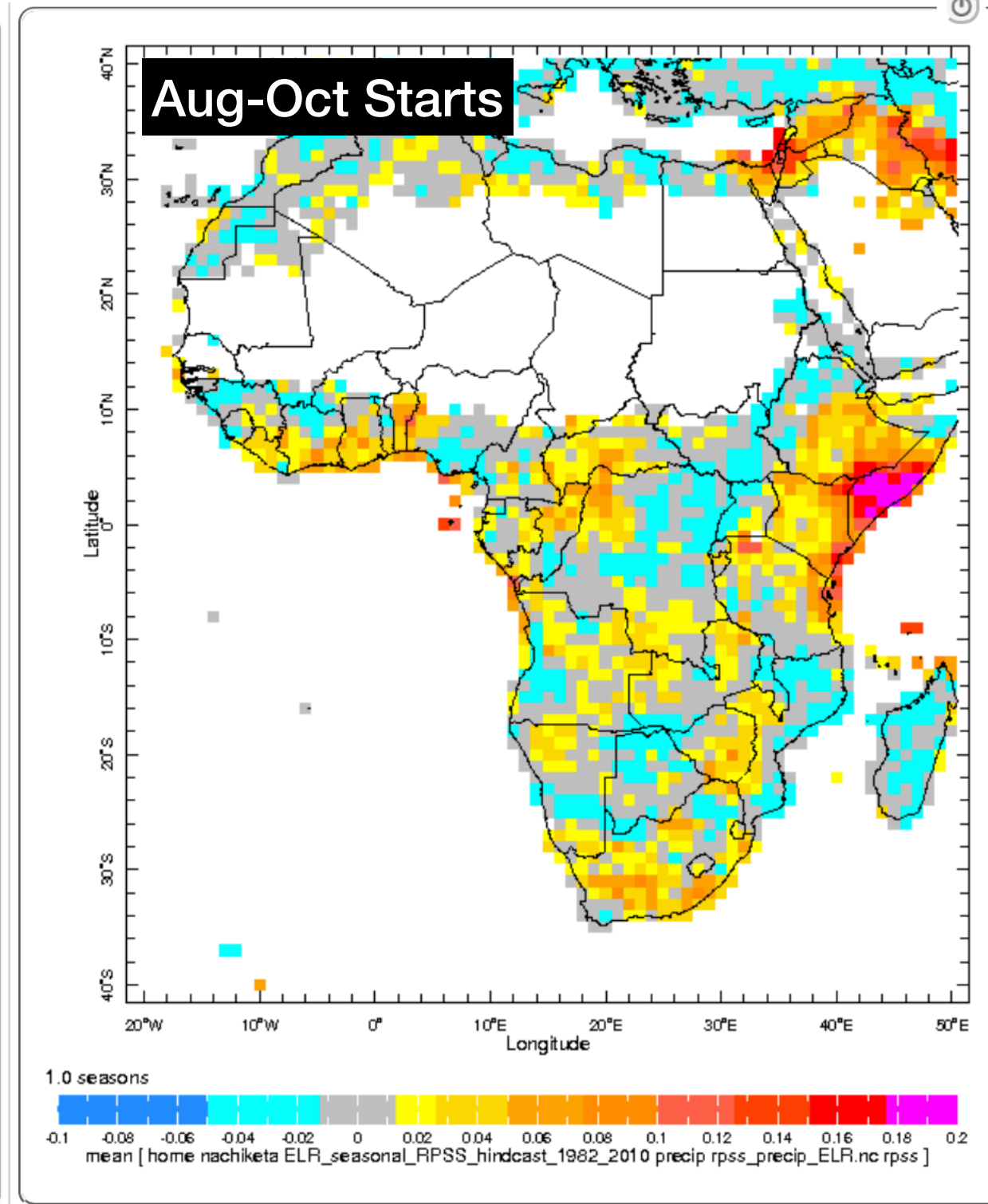
Estimates of Subseasonal vs Seasonal rainfall forecasting skill

Ranked Probability Skill Score

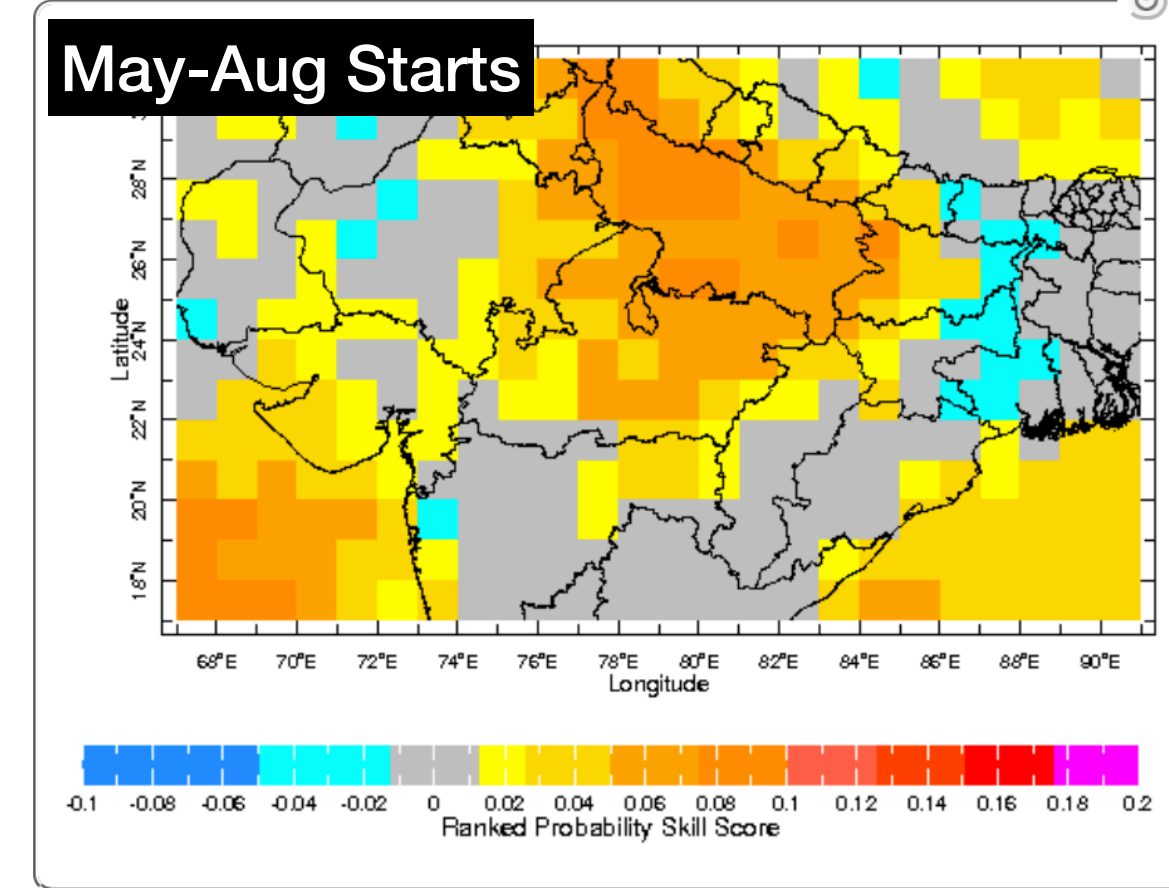
Weeks 3-4 (15-28 days ahead)



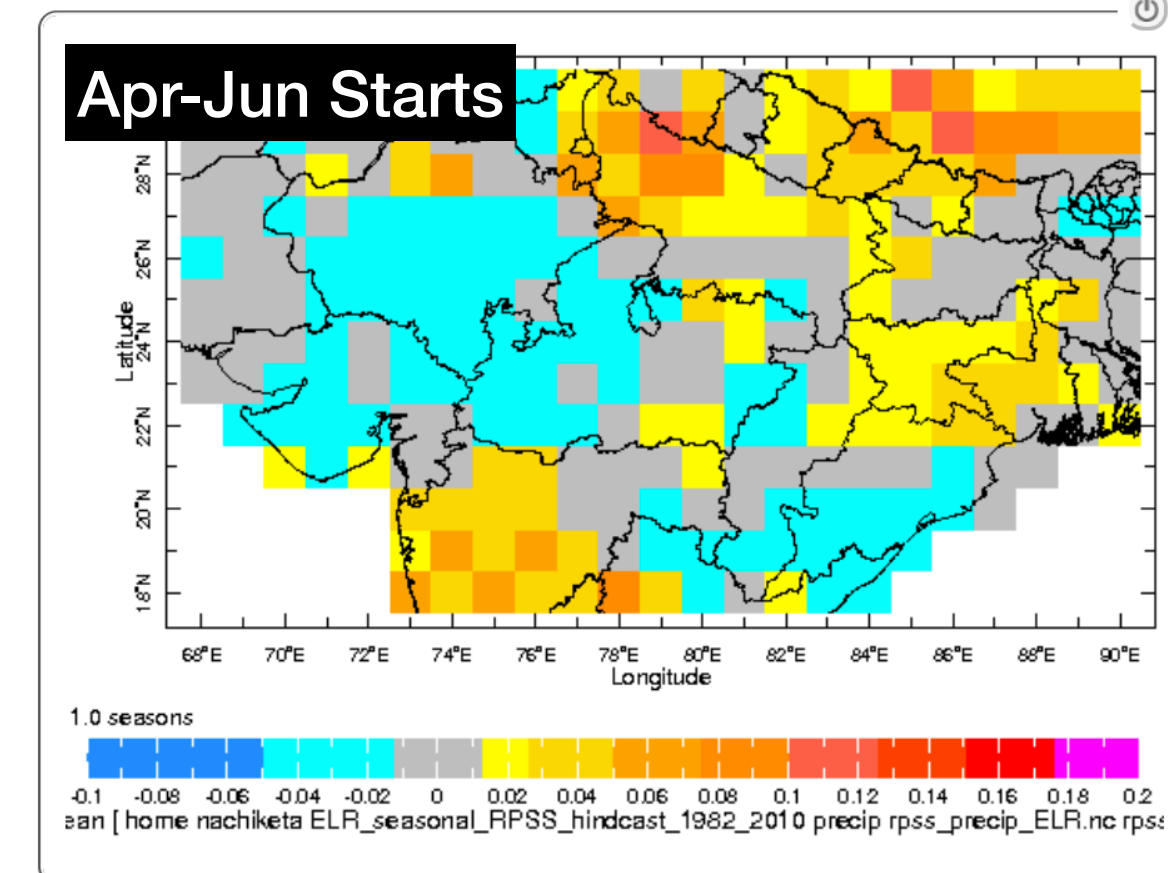
Seasonal (2-4 months ahead)



Weeks 3-4 (15-28 days ahead)



Seasonal (2-4 months ahead)



Orange-red colors indicates potentially useful skill.

The newly-developed subseasonal forecasts generally indicate comparable or better skill compared to the established seasonal ones.

The seasons were chosen to align with the monsoons in East Africa and India. “Starts” refers to the initial time of the forecasts. Seasonal forecasts were made at the beginning of each calendar month. The subseasonal forecasts are made every Friday. Skill is based on hindcasts for a past period.

These maps were obtained from the IRI Maprooms:
 Seasonal Forecasts: <http://iridl.ideo.columbia.edu/maproom/Global/Forecasts/index.html>
 Subseasonal Forecasts: <http://iridl.ideo.columbia.edu/maproom/Global/ForecastsS2S/index.html>

Climate Subseasonal Forecasts IRI

SubX Forecasts: Precipitation Flexible Biweekly Forecast

Region: Africa

Forecast Issued: 0000 26 Nov 2021

Target Period: 11-24 Dec 2021

Probability: non-exceeding

Percentile: 20.0

%-ile

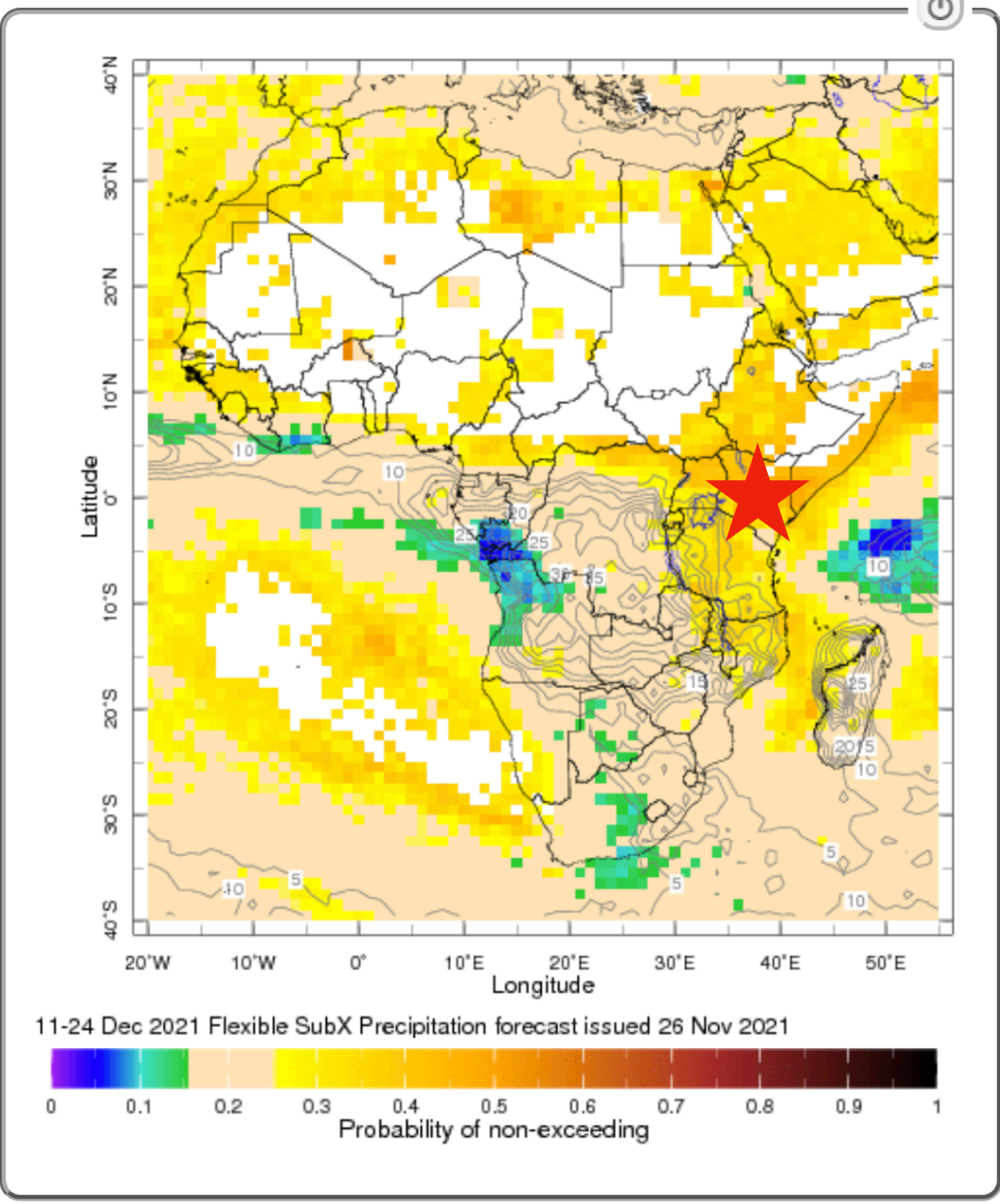
Precipitation Units: mm

Weeks 3-4 Forecast 20%-ile drought

Precipitation Flexible Biweekly Forecast

This subseasonal forecasting system consists of probabilistic precipitation forecasts based on the full estimate of the probability distribution.

Probabilistic subseasonal forecasts from multi-model ensembles through the use of *statistical recalibration*, based on the historical performance of those models, provide reliable information to a wide range of climate risk and decision making communities, as well as the forecast community. The flexibility of the full probability distributions allows delivery of interactive maps and point-wise distributions that become relevant to user-determined needs.



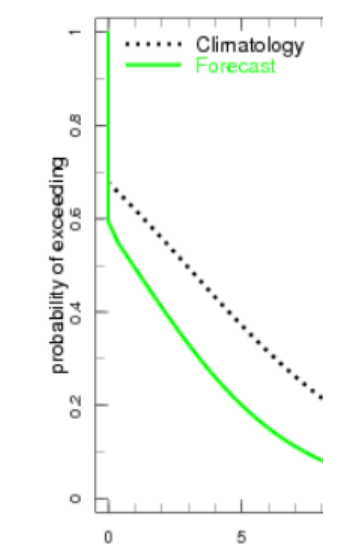
http://iridl.ldeo.columbia.edu/maproom/Global/ForecastsS2S/precip_flex_subx.html

Forecast made located in , EA:

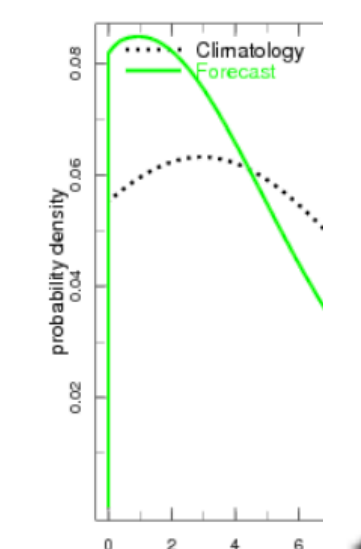
Target Date	Issue Date	Lead Time
11-24 Dec 2021	0000 26 Nov 2021	

Forecast made located in , EA:

Probability of

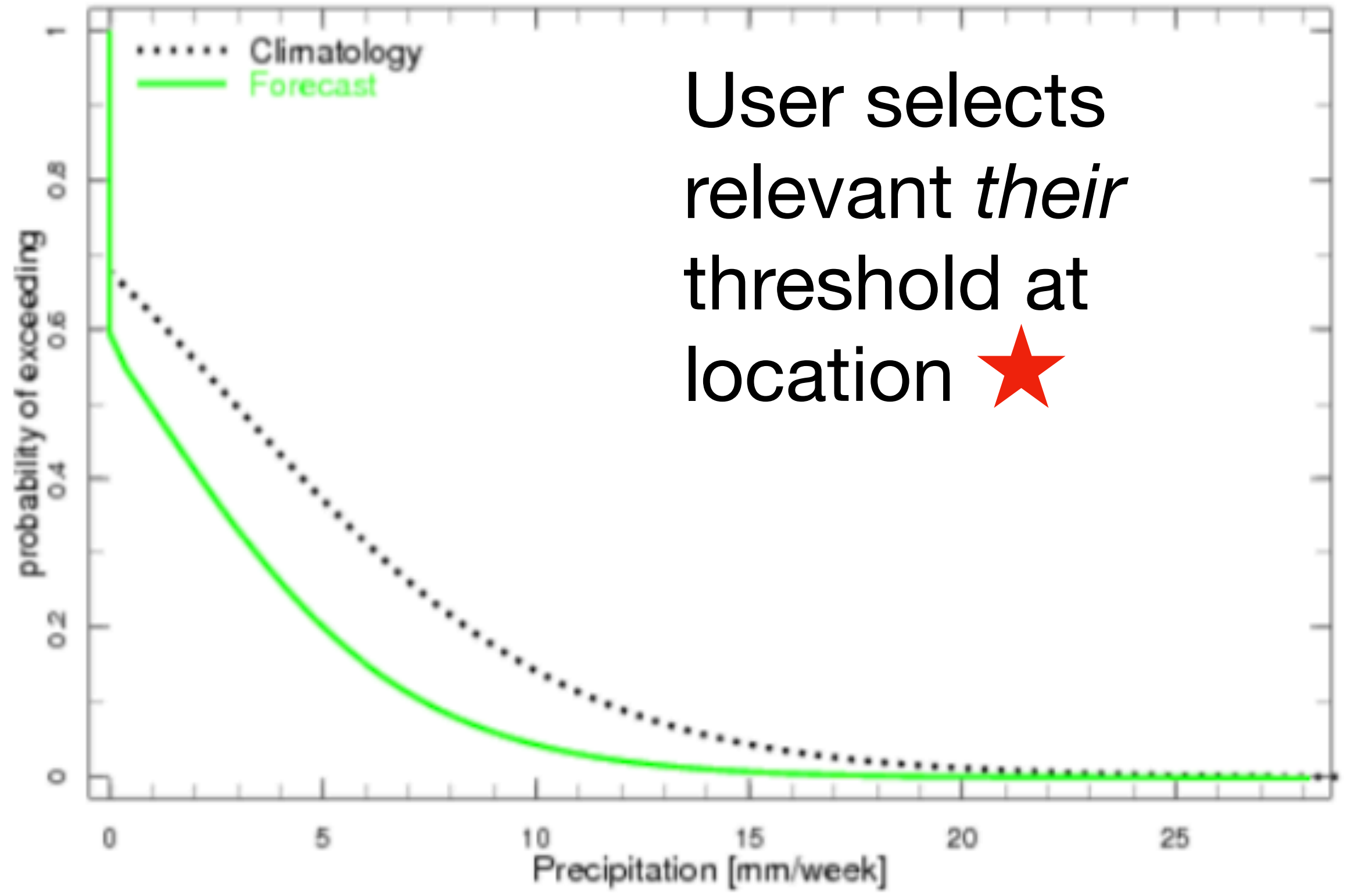


Probability Di



Decision thresholds: What quantile is most relevant?

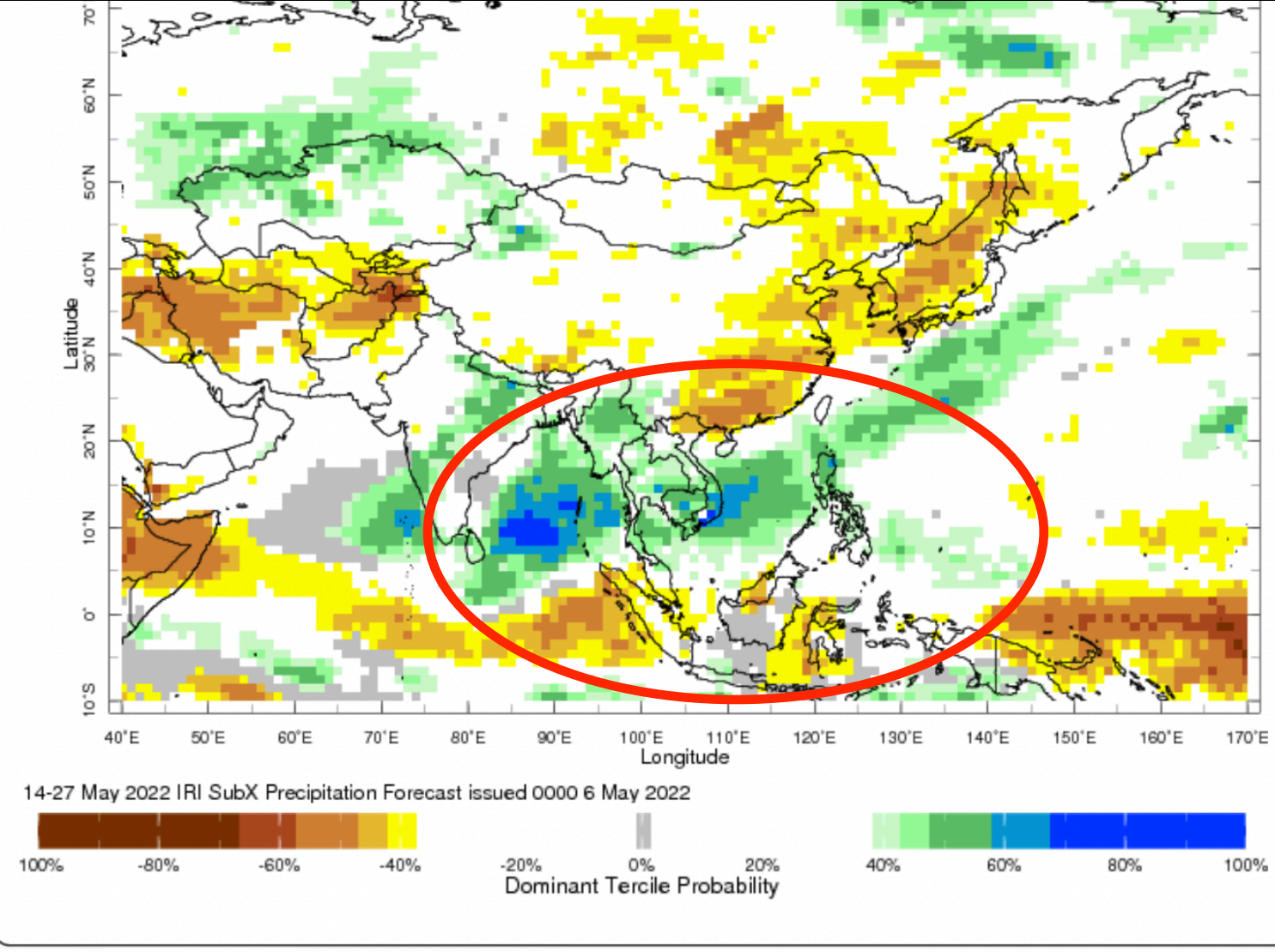
And how much confidence (% probability) is required? [risk aversion]



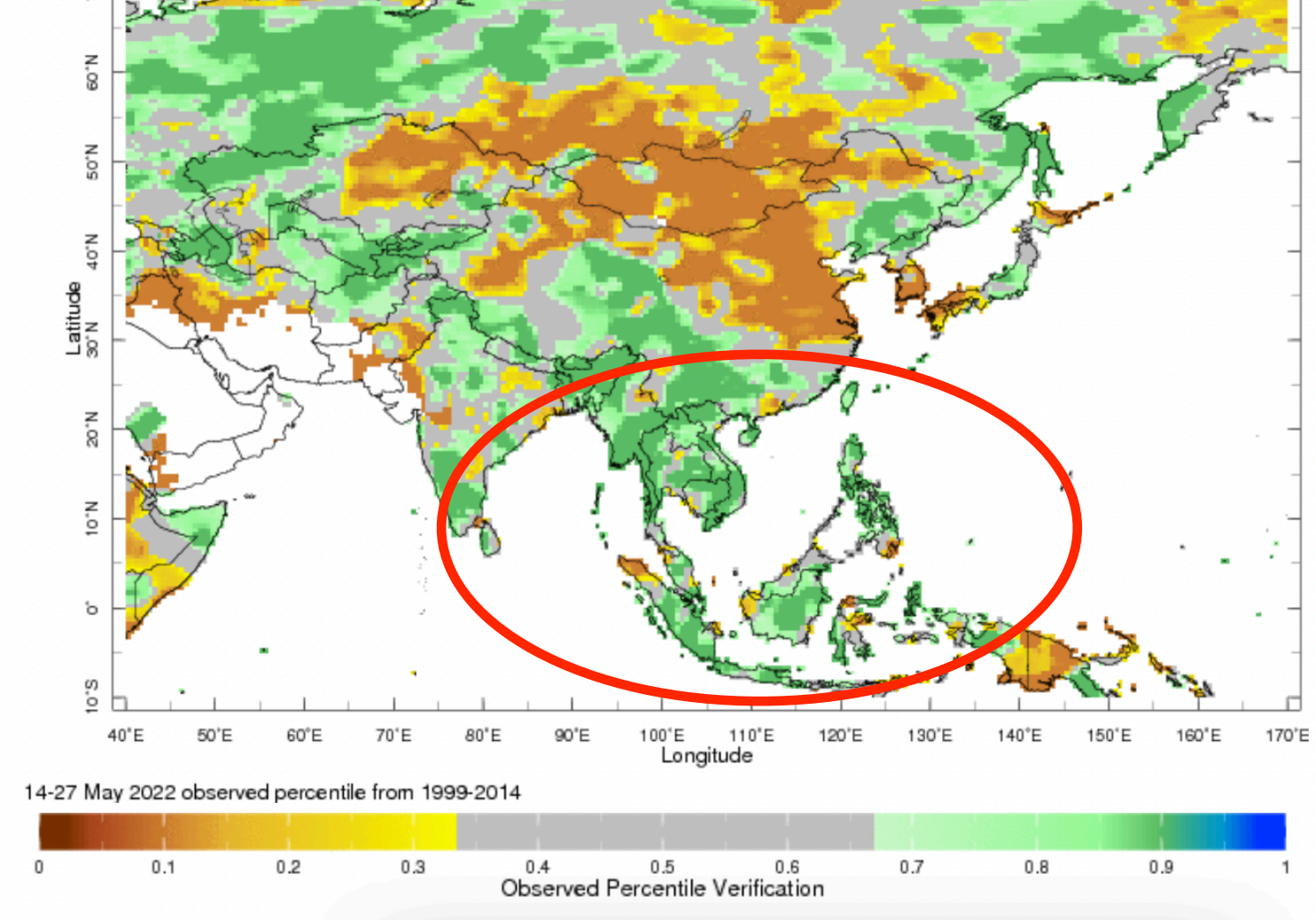
User selects relevant *their* threshold at location ★

Recent Forecast Case over SE Asia

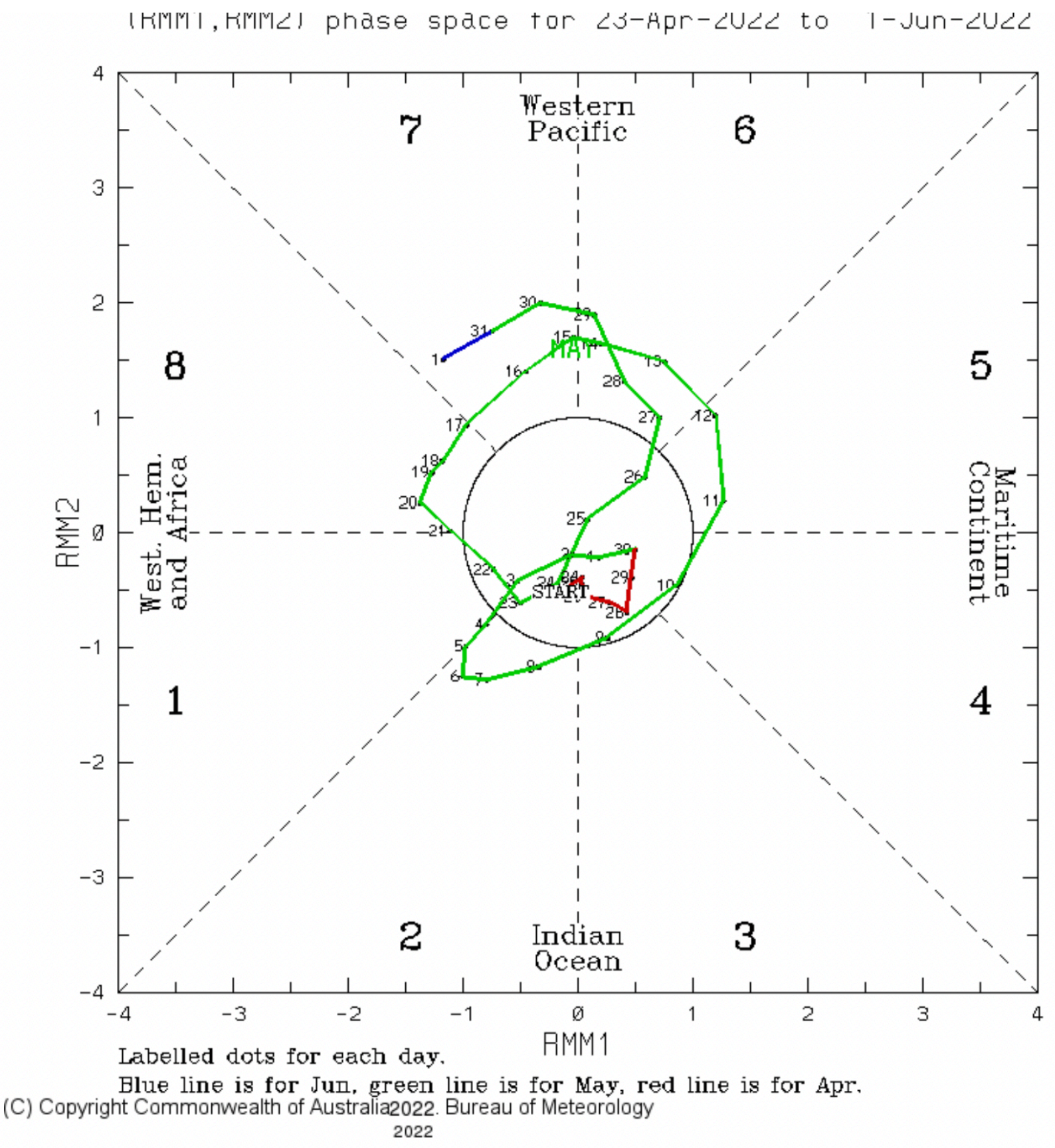
Precip Forecast May 14-27, 2022 from May 6



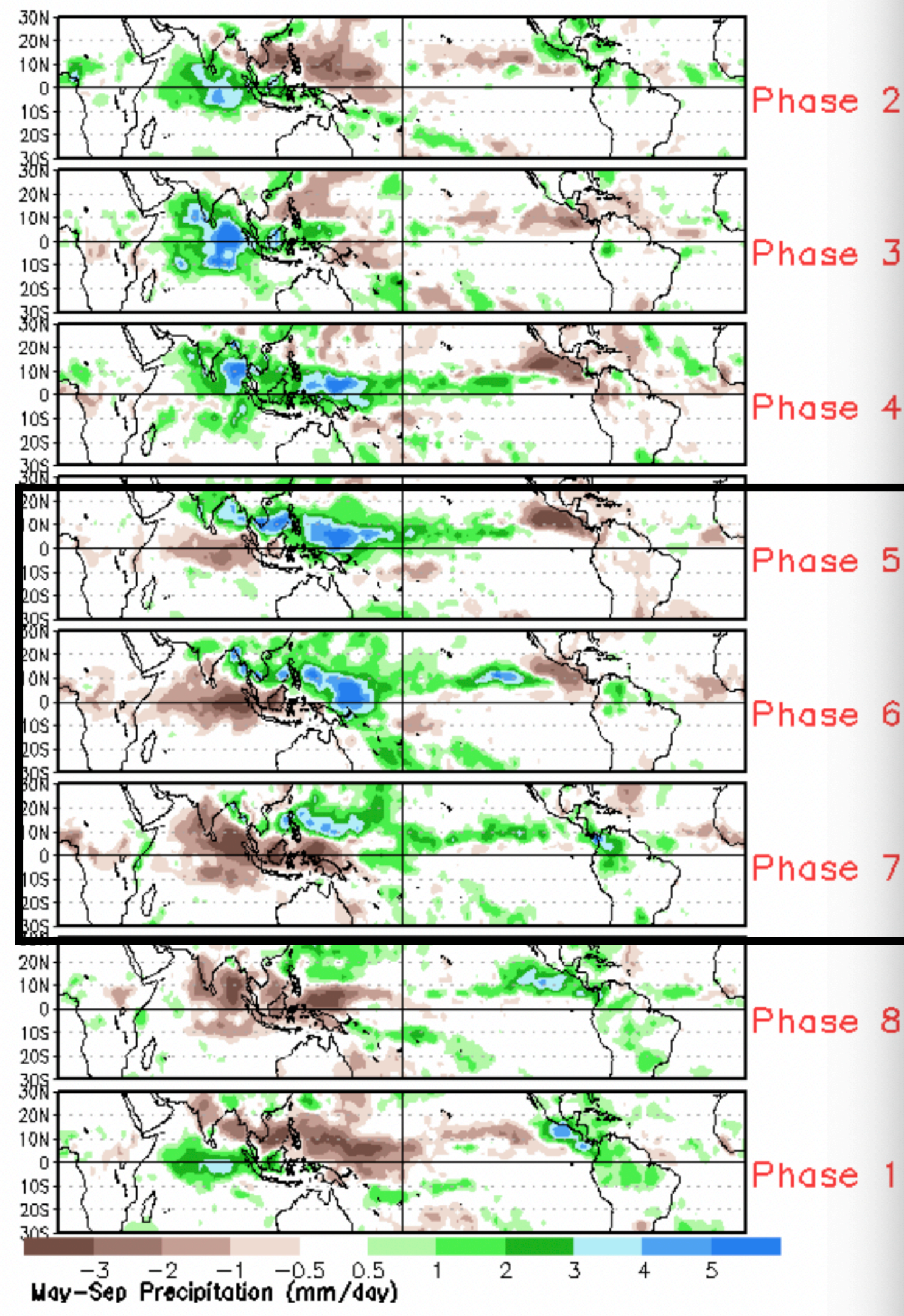
Observed Percentile May 14-27, 2022



MJO Observed Evolution in May 2022



May-Sep MJO phase composites CPC



Summary

- Calibrated probabilistic multi-model real-time SubX forecasts and precipitation and temperature forecasts are produced routinely at IRI, since 2018
- Every Friday; Weeks 1-4; Weeks 2-3 and 3-4
- Based on GFSv12, CFSv2 and ESRL-FIM forecasts issued on Wednesdays
- Tercile and flexible full-pdf formats
- Includes the observed percentile validation for previously-issued forecasts
- RPSS hindcast skill maproom available soon