

# Basics of S2S Prediction and Concepts

Andrew W Robertson, IRI



# Weather vs Climate Forecasts



Weather Forecasts ~ O (10 Days)

*(Mid-Latitude Baroclinic Instability & Cyclone Lifetime)*

Dynamic Forecasts root back to 1910

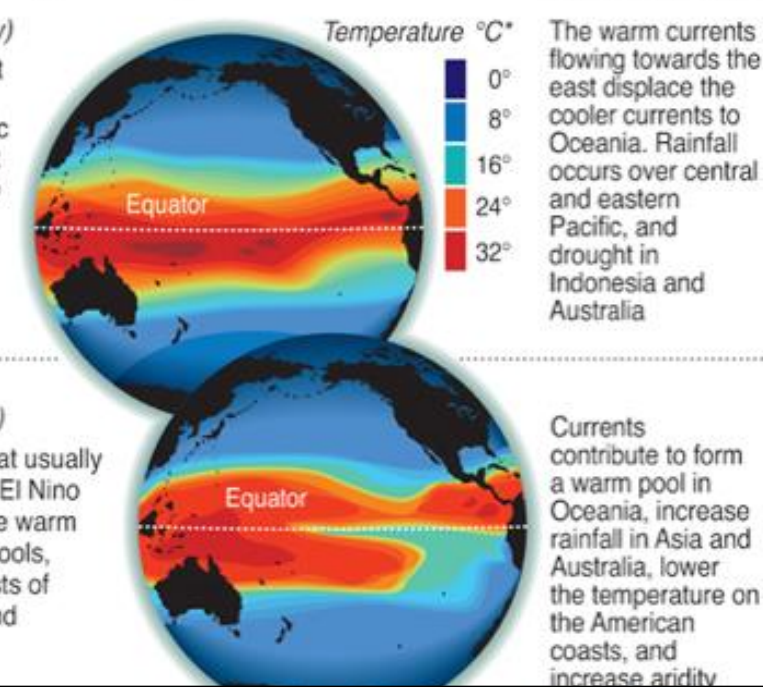
What about the forecasting  
between “weather” & climate  
~ 2 weeks to 2 months?  
(aka sub/intra – seasonal)

## EL NINO AND LA NINA

Forecasters say a El Nino weather pattern may develop later this year

### EL NINO (the boy)

An irregular event of abnormal warming of Pacific waters. Occurs at intervals of two to seven years



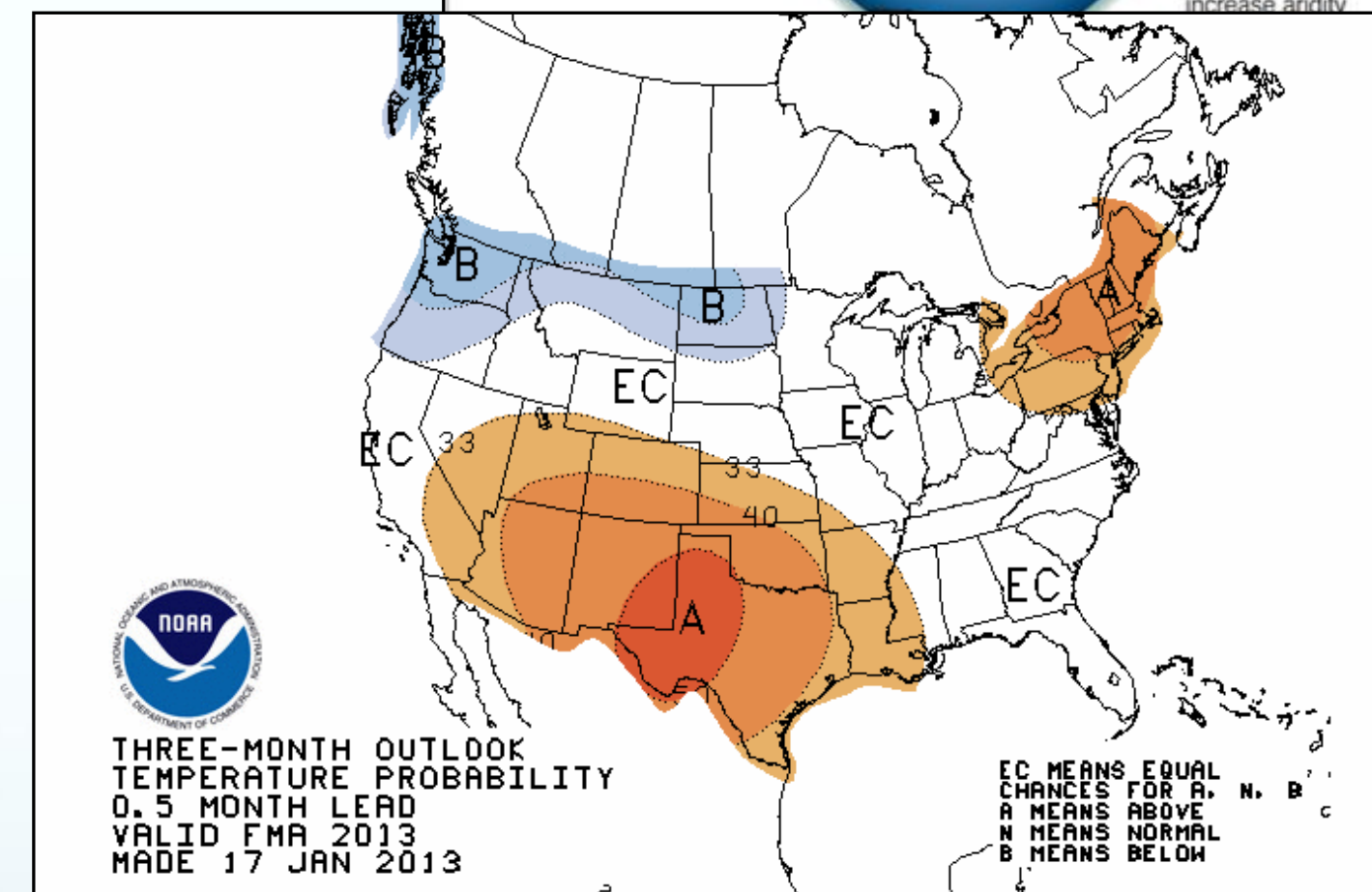
### Effects on climate

The warm currents flowing towards the east displace the cooler currents to Oceania. Rainfall occurs over central and eastern Pacific, and drought in Indonesia and Australia

### LA NINA (the girl)

A cold episode that usually follows the warm El Nino phenomenon. The warm equatorial ridge cools, between the coasts of South America and Oceania

Currents contribute to form a warm pool in Oceania, increase rainfall in Asia and Australia, lower the temperature on the American coasts, and increase aridity



Seasonal Forecasts ~ O (100 Days)

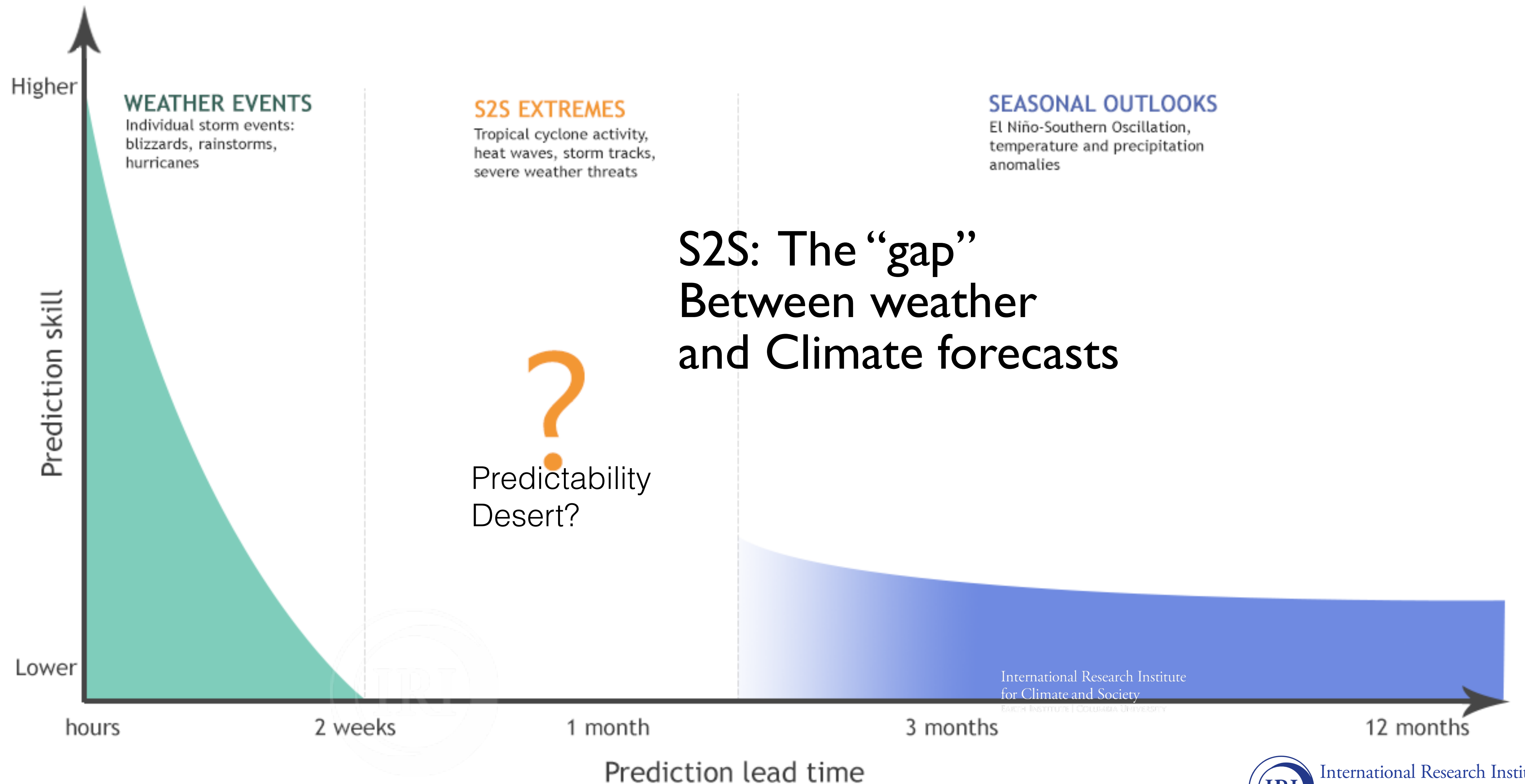
*(ENSO phenomena & Local/Remote Circulation Impacts)*

Dynamic Forecasts root back to Mid-1980's

from D. Waliser International Research Institute  
for Climate and Society  
EARTH INSTITUTE | COLUMBIA UNIVERSITY

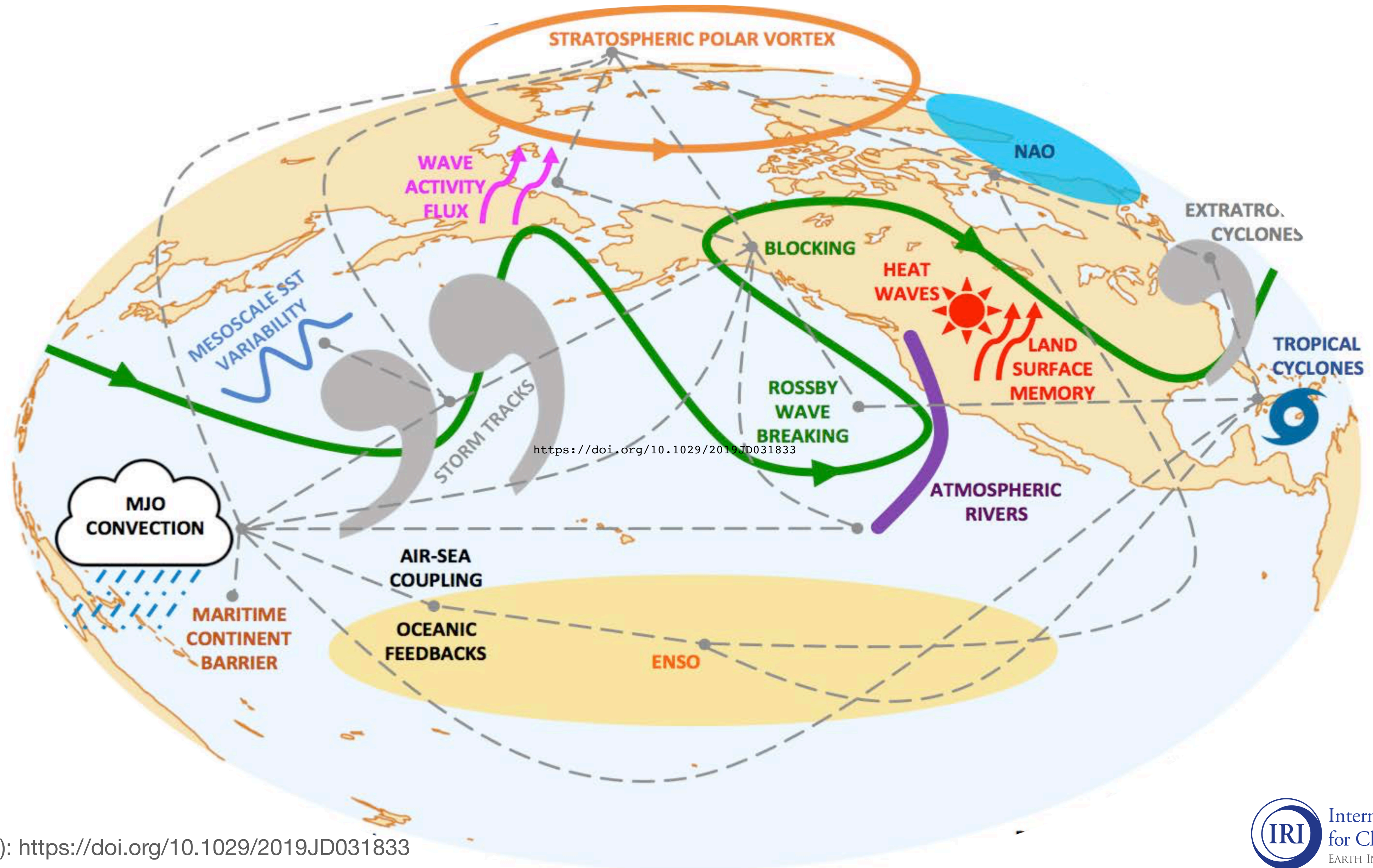


# Sub-seasonal to Seasonal prediction



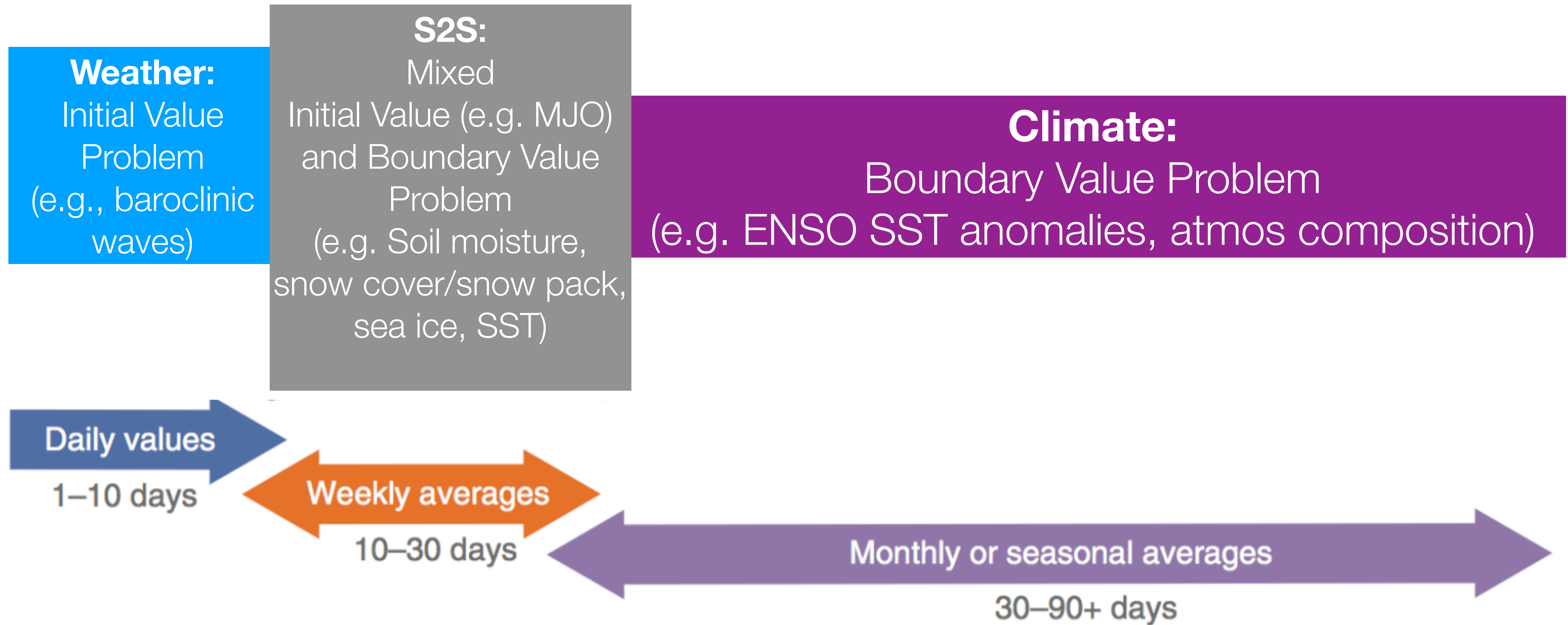


# Many Sources of S2S Predictability





# S2S Predictability

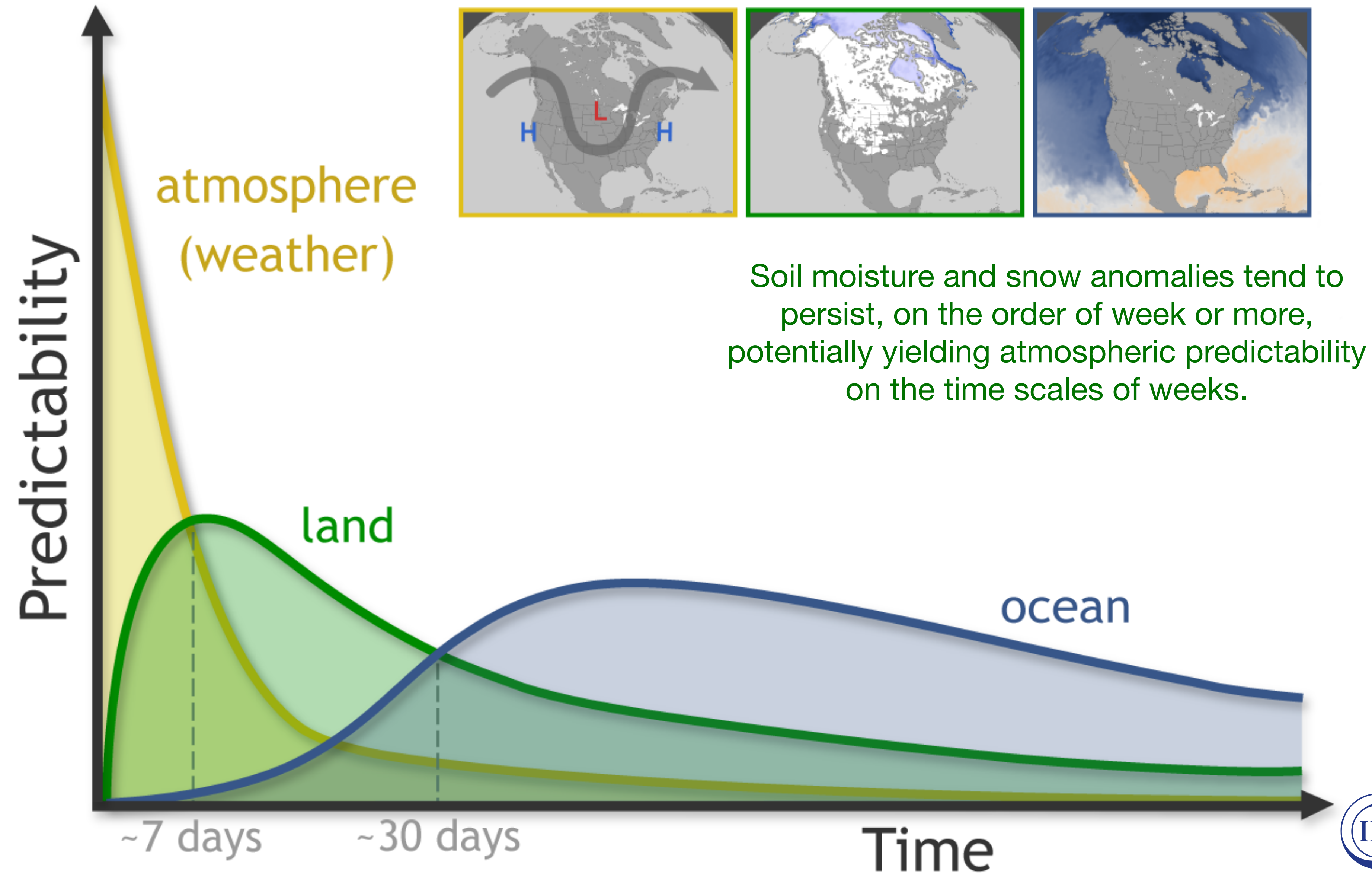


TIME AVERAGING

Predictability of the Second Kind (Lorenz, 1975)



# Atmosphere/Ocean/Land Coupling

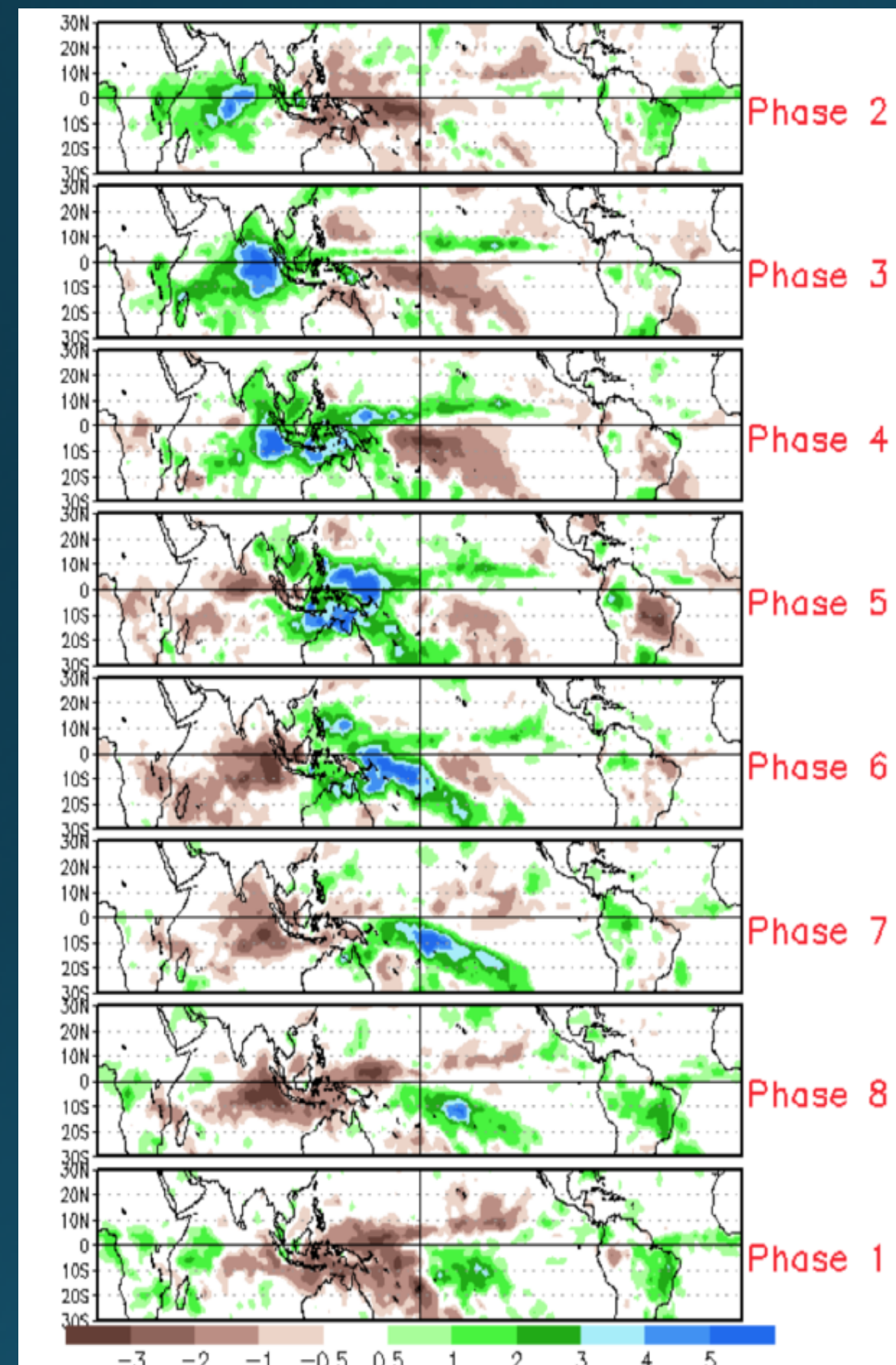




# Why Sub-seasonal to Seasonal Prediction?

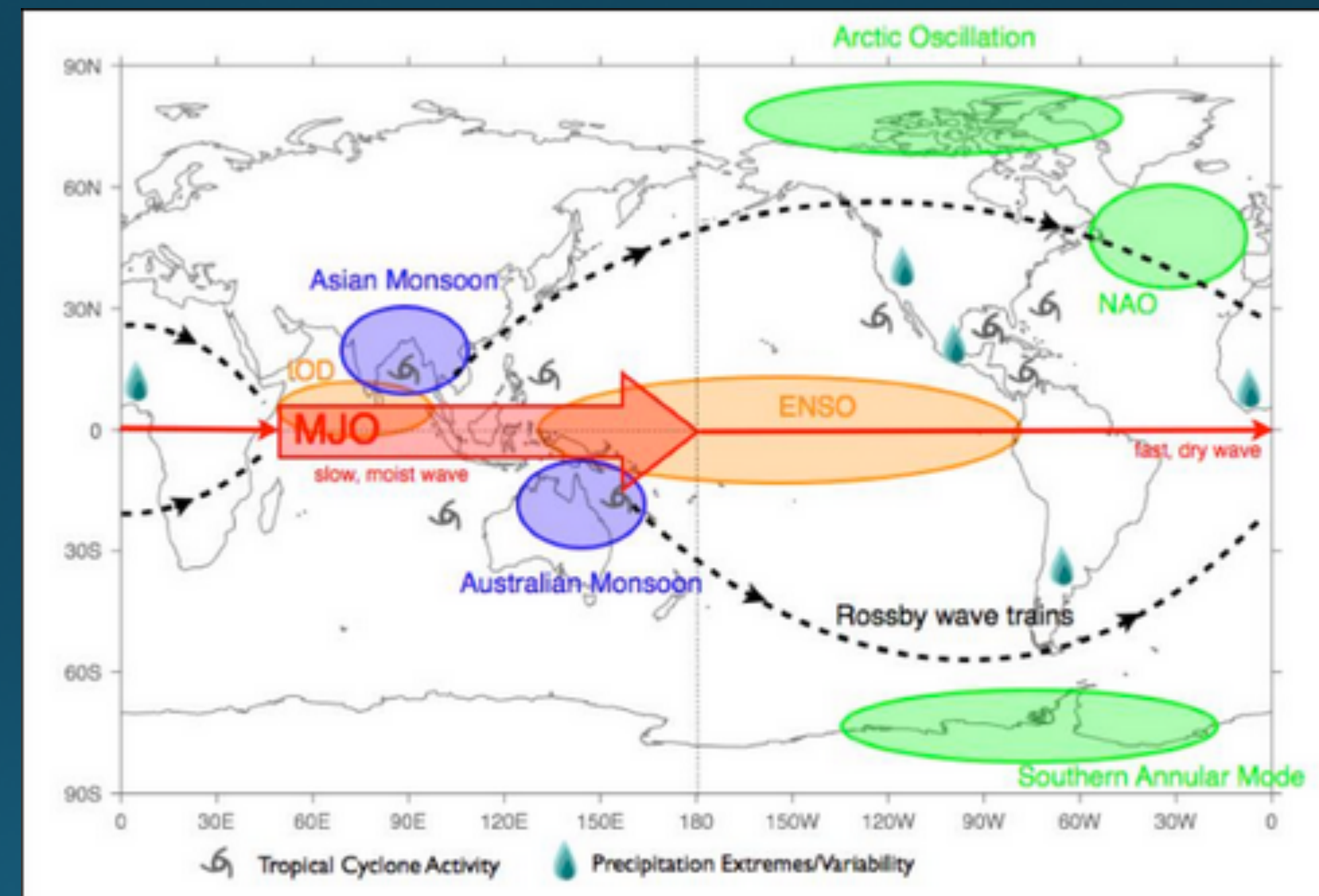
## The Madden Julian Oscillation

MJO phases



Gottschalk, 2014

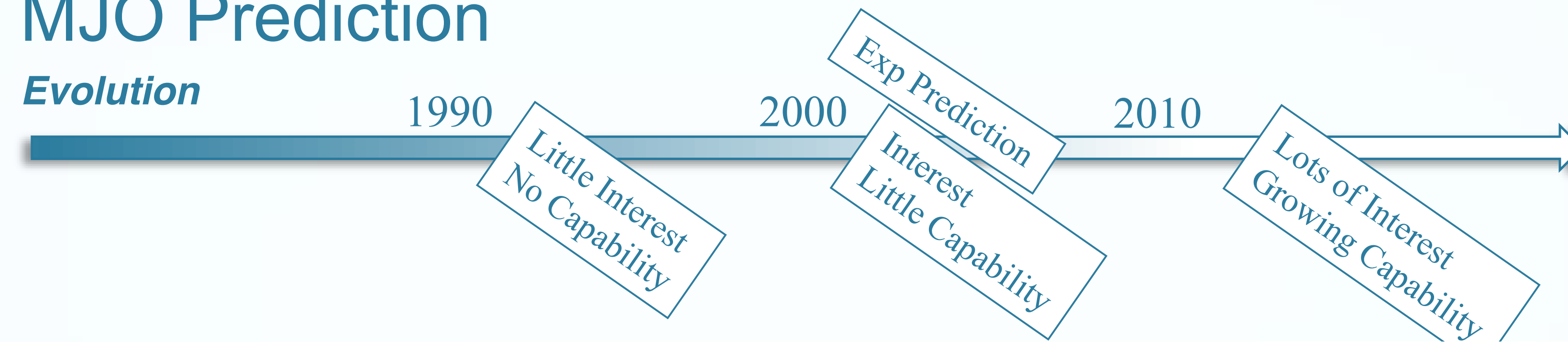
MJO Impacts



MJO forecast skill horizon exceeds 2 weeks

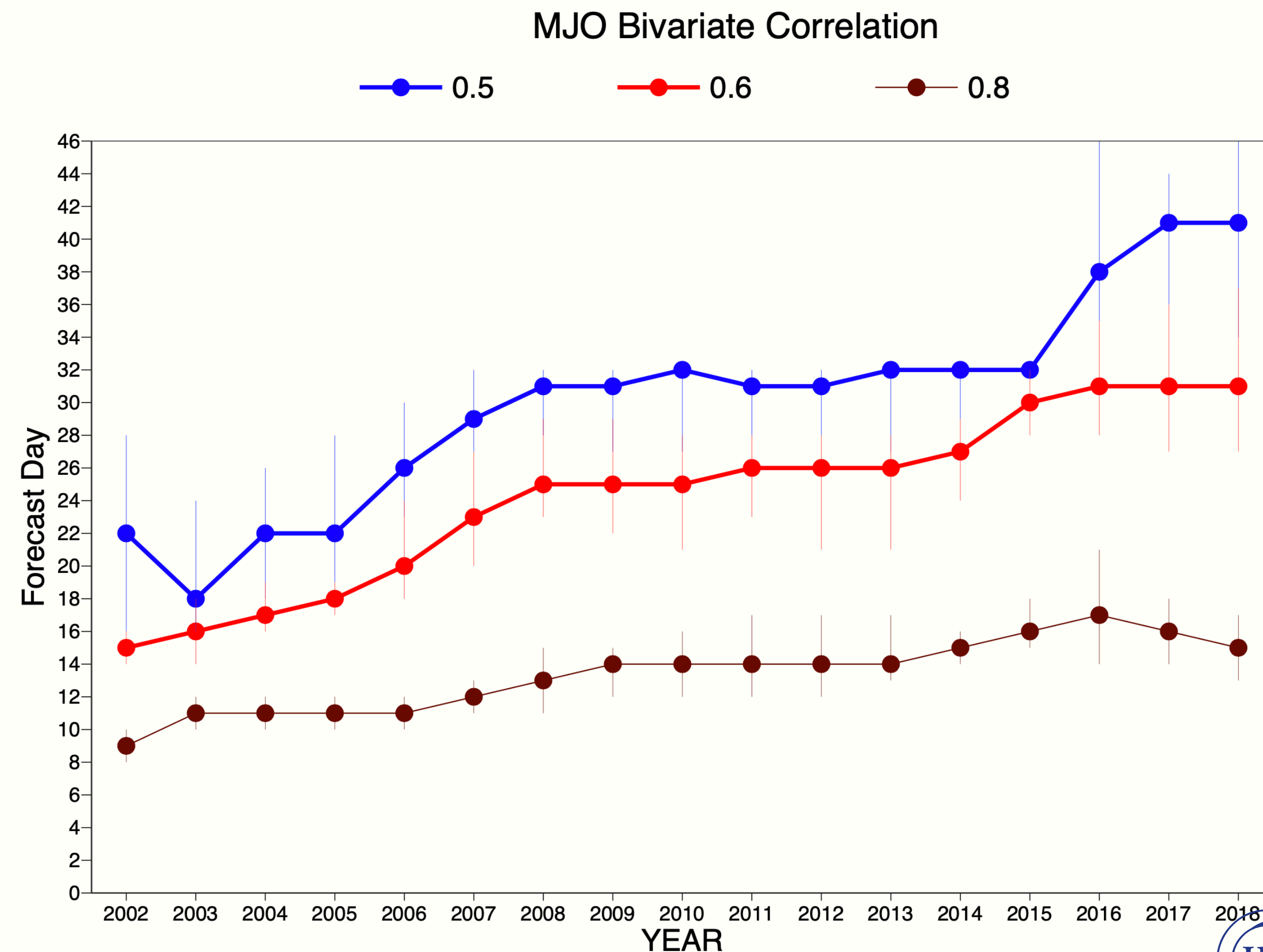
# MJO Prediction

*Evolution*



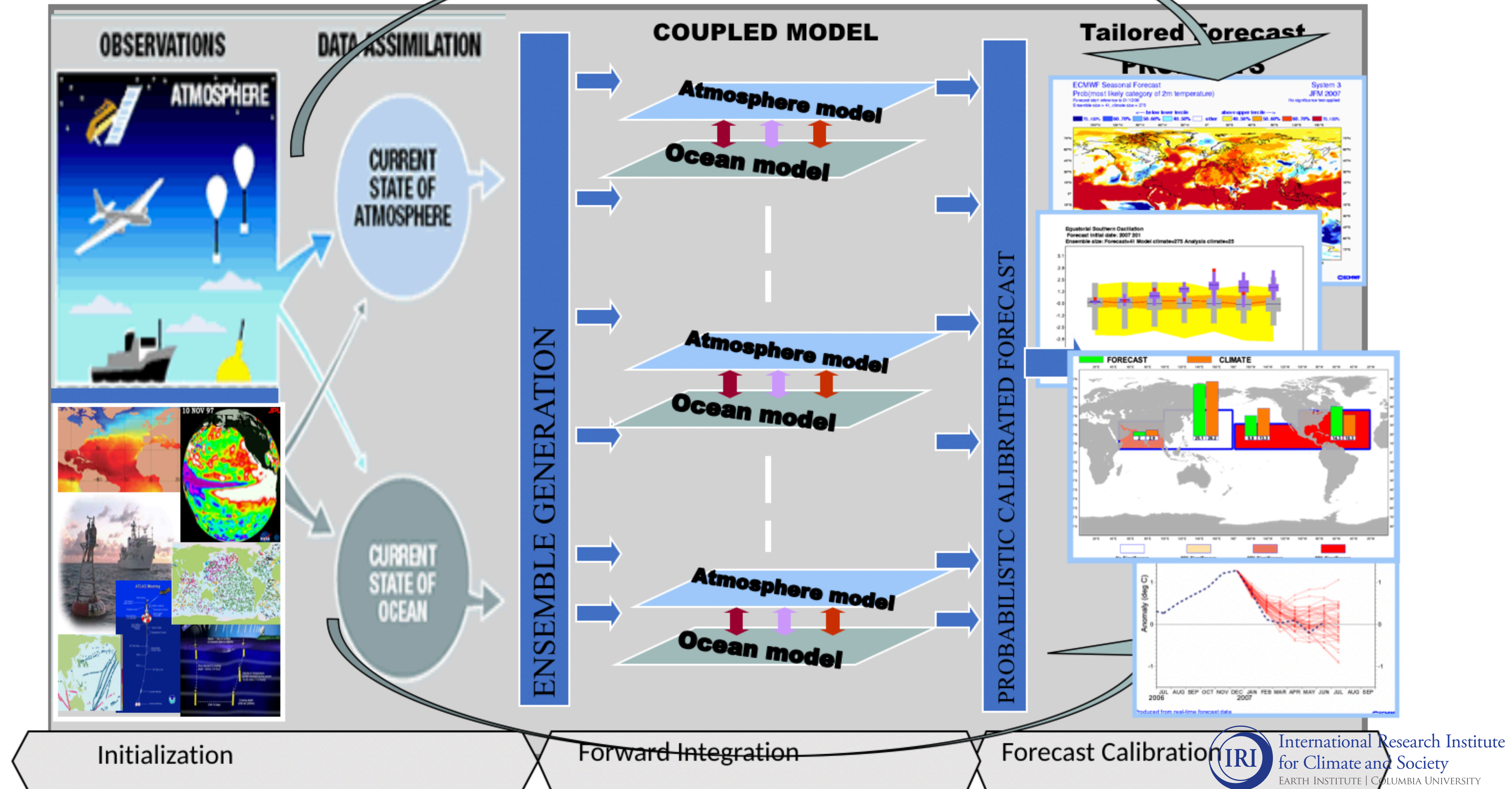
## Evolution of MJO Forecast Skill At ECMWF

Vitart (2014)  
DOI:10.1002/qj.2256





# How are S2S forecasts made?





# SUB-SEASONAL TO SEASONAL PREDICTION

RESEARCH IMPLEMENTATION PLAN

**Co-chairs:**

Frédéric Vitart (ECMWF)

Andrew Robertson (IRI)

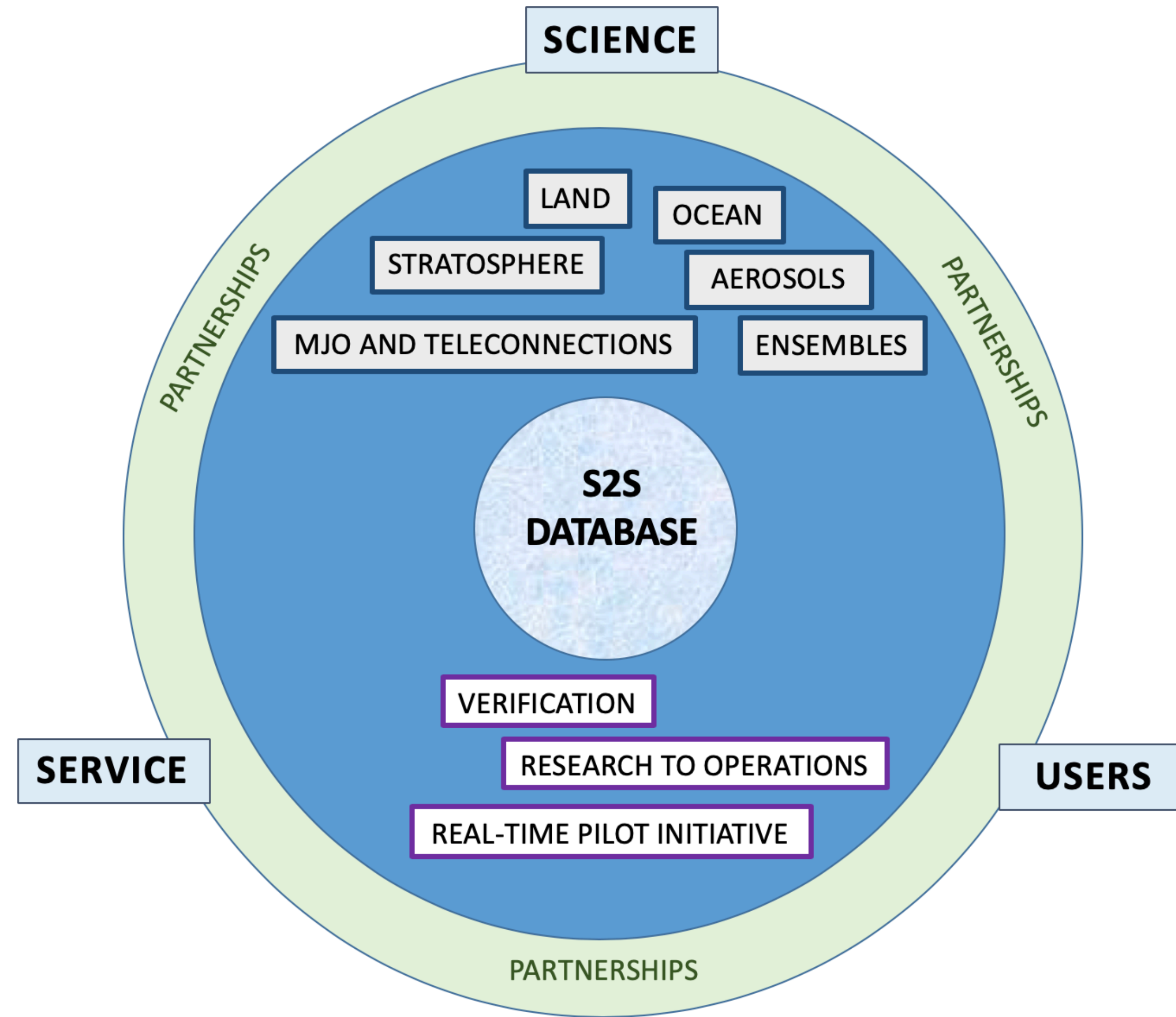
- Improve forecast skill and understanding on the sub-seasonal to seasonal timescale with special emphasis on high-impact weather events
- Promote the initiative's uptake by operational centres and exploitation by the applications community
- Capitalize on the expertise of the weather and climate research communities to address issues of importance to the Global Framework for Climate Services

*The S2S Database, hosted by ECMWF and CMA, went online in May 2015. International Coordination Office hosted by KMA.*

*The project focuses on the forecast range between 2 weeks and a season.*



# S2S Phase II: 2019–2023



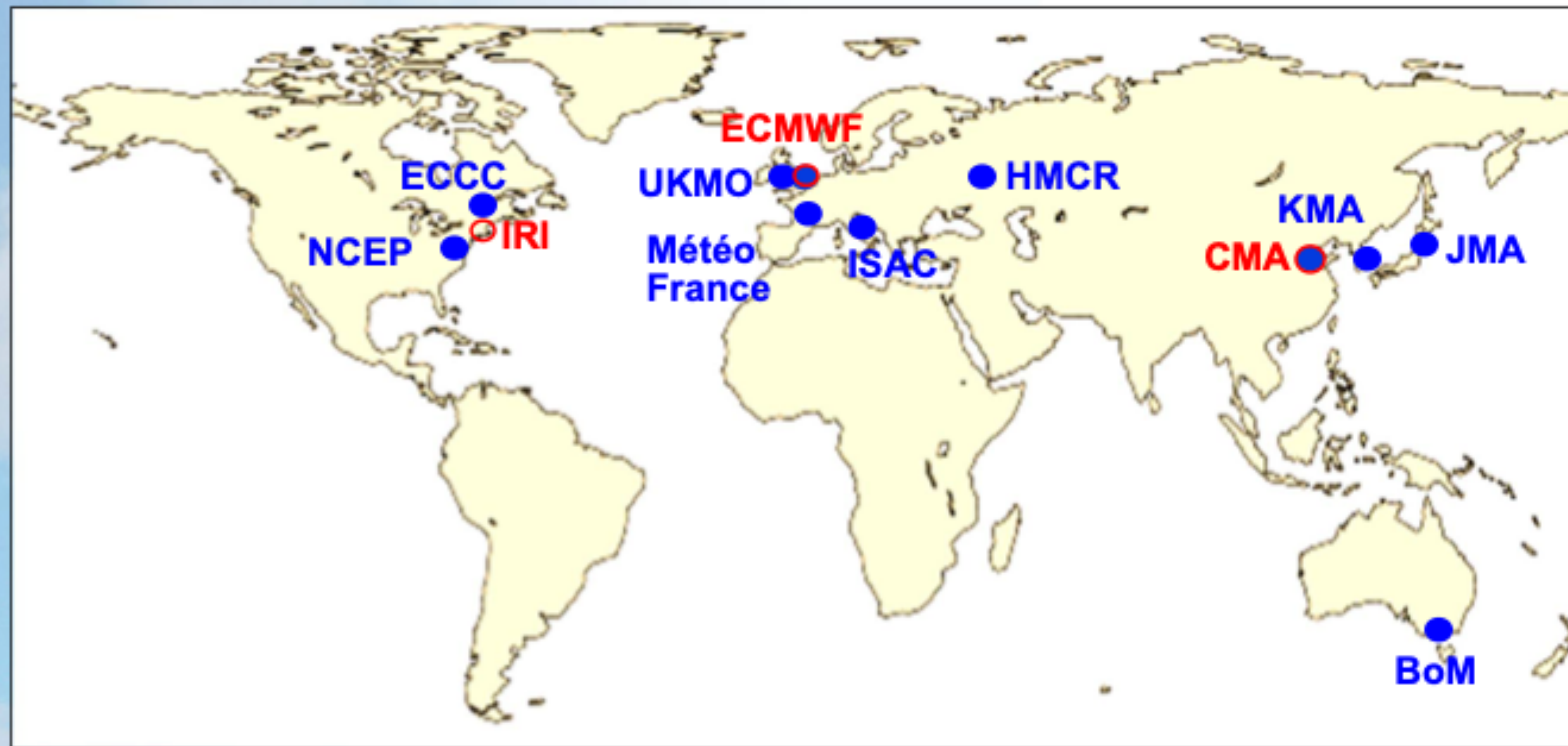
WMO OMM

# The WWRP/WCRP S2S Database

## Contributing Centres to S2S database

● Data provider (11)

○ Archiving centre (3)



Contains 3-week behind real-time S2S forecasts (up to day 60) and re-forecasts



WMO OMM



# S2S database models

## Forecasts

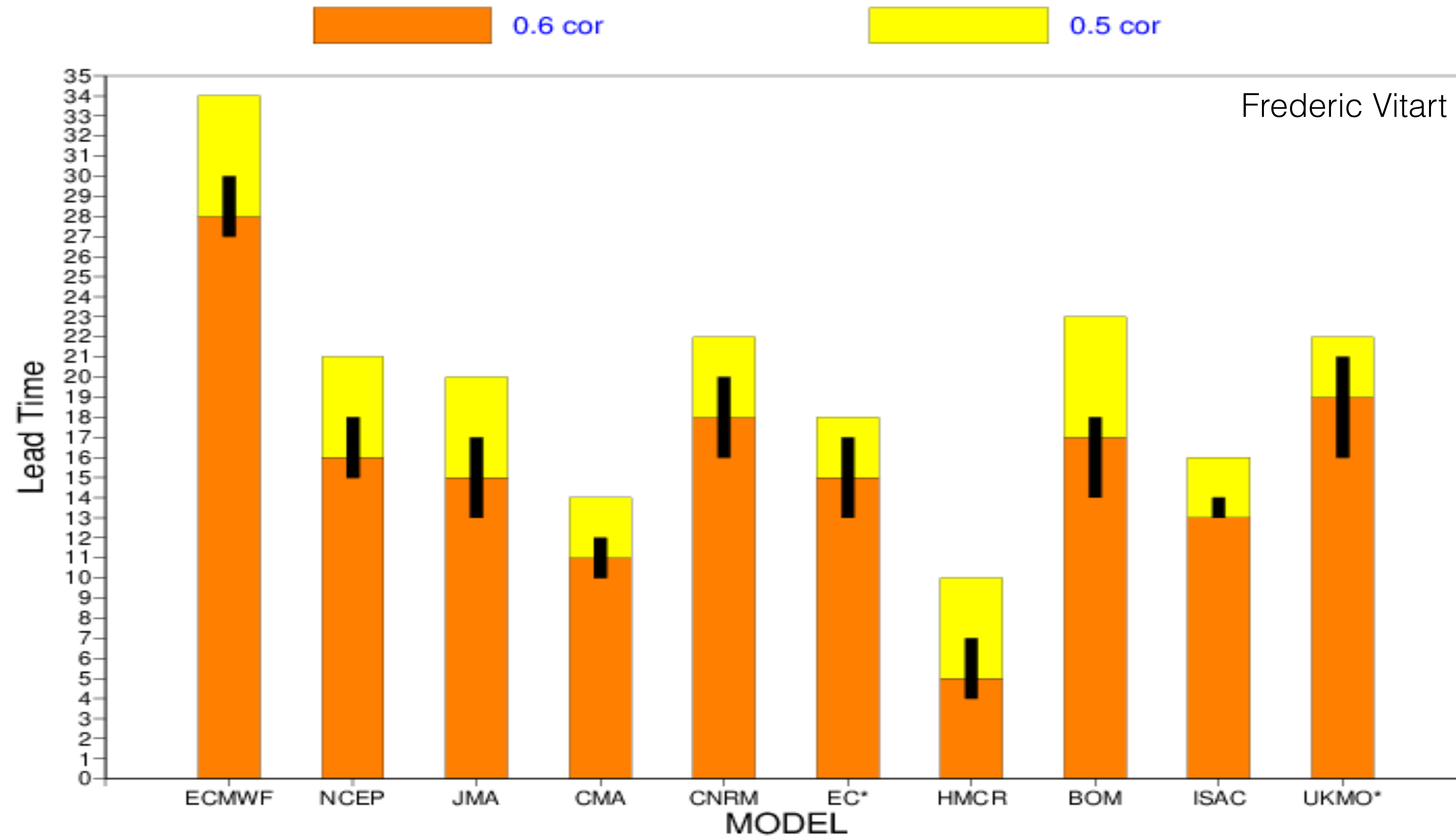
## Hindcasts

Status on 5th January 2018	Time range	Resolution	Ens. Size	Frequency	Re-forecasts	Rfc length	Rfc frequency	Rfc size
BoM (ammc)	d 0-62	T47L17	3*11	2/week	fix	1981-2013	6/month	3*11
CMA (babj)	d 0-60	T106L40	4	daily	fix	1994-2014	daily	4
CNR-ISAC (isac)	d 0-32	0.75x0.56 L54	41	weekly	fix	1981-2010	every 5 days	5
CNRM (lfpw)	d 0-32	T255L91	51	weekly	fix	1993-2014	2/month	15
ECCC (cwao)	d 0-32	0.45x0.45 L40	21	weekly	on the fly	1995-2014	weekly	4
ECMWF (ecmf)	d 0-46	Tco639/319 L91	51	2/week	on the fly	past 20 years	2/week	11
HMCR (rums)	d 0-61	1.1x1.4 L28	20	weekly	on the fly	1985-2010	weekly	10
JMA (rjtd)	d 0-33	TI479/TI319L100	50	weekly	fix	1981-2010	3/month	5
KMA (rksl)	d 0-60	N216L85	4	daily	on the fly	1991-2010	4/month	3
NCEP (kwbc)	d 0-44	T126L64	16	daily	fix	1999-2010	day	4
UKMO (egrr)	d 0-60	N216L85	4	daily	on the fly	1993-2015	4/month	7

see [s2sprediction.net](https://s2sprediction.net) for details and how to access the S2S data

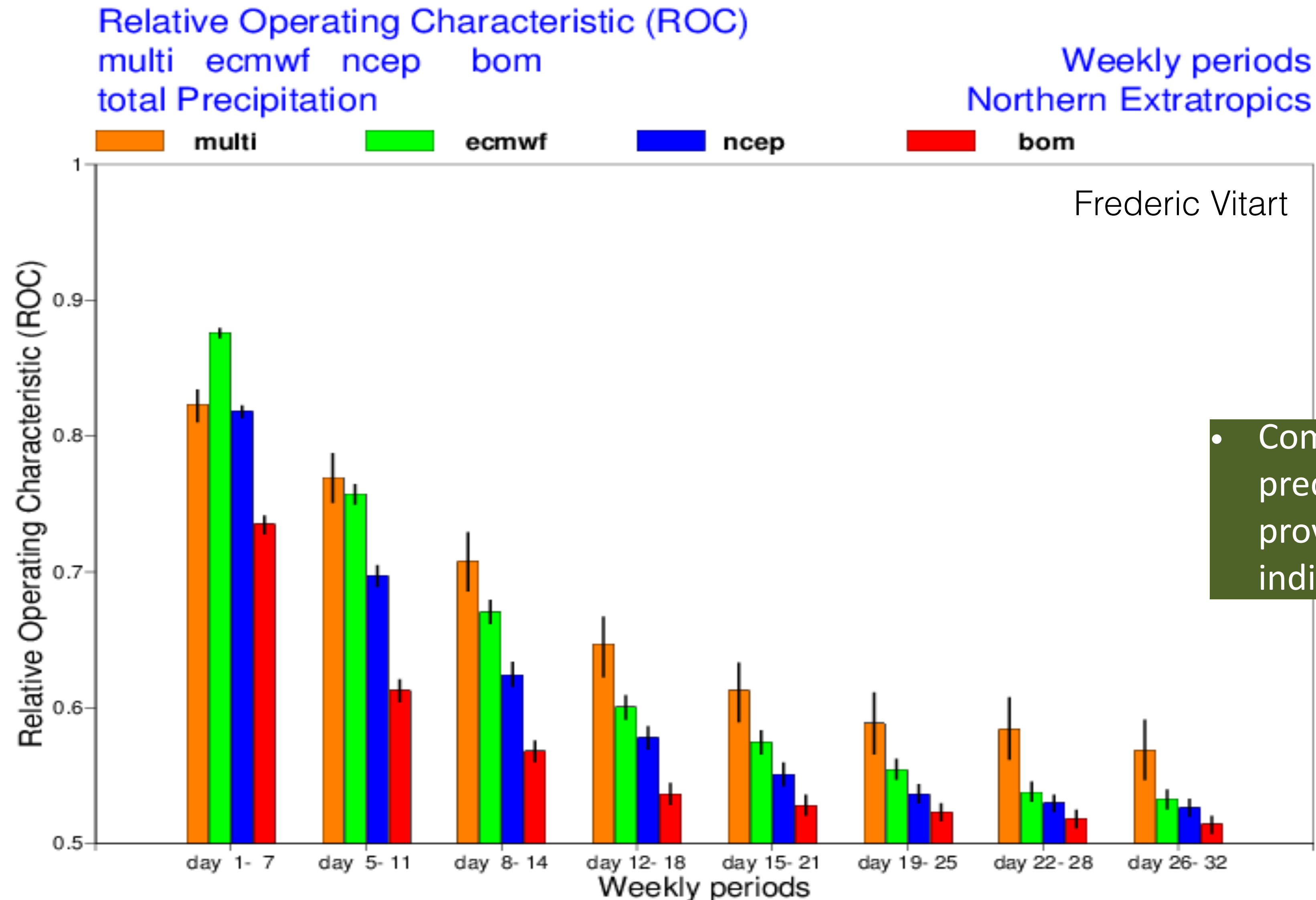


# MJO Bivariate Correlation S2S REFORECASTS 1999-2010



# Assessing the benefit of multi-model S2S prediction

## From the S2S database



- Combining S2S forecasts of precipitation from different models provides more skilful forecast than individual models.

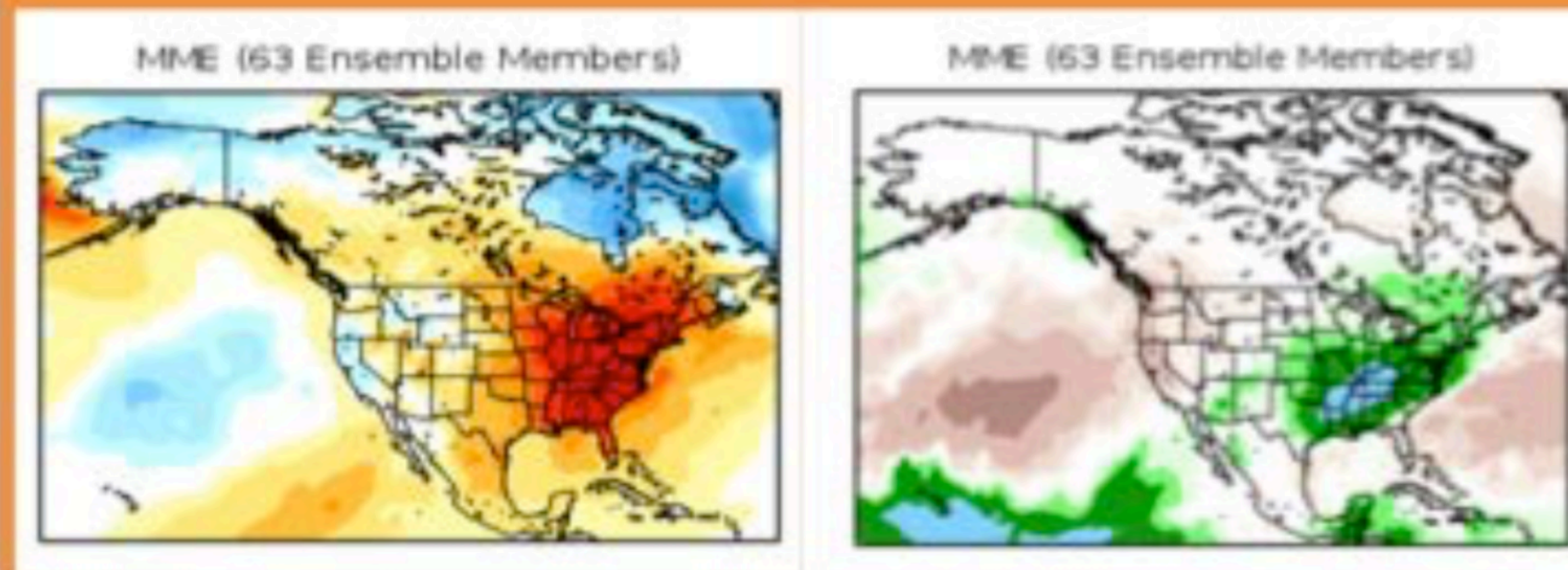


# The Subseasonal eXperiment (SubX)

## By the Numbers...

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

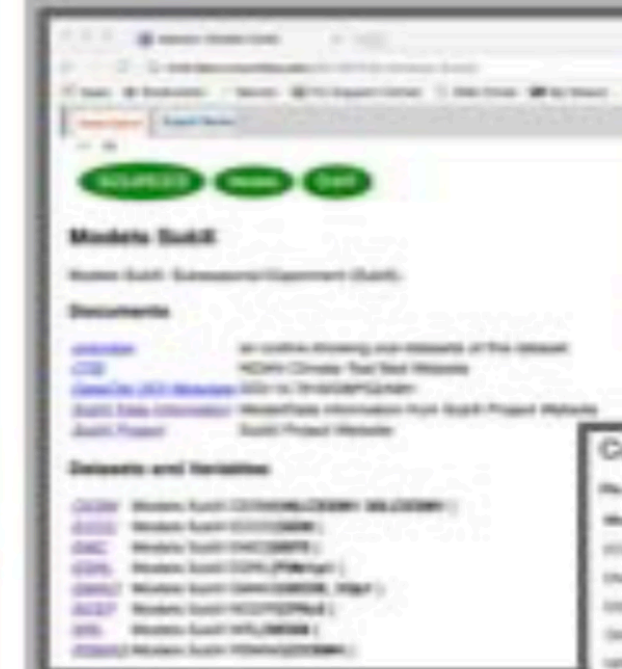
## Real-time Multi-model Forecasts



## SubX Team



## IRI Data Library



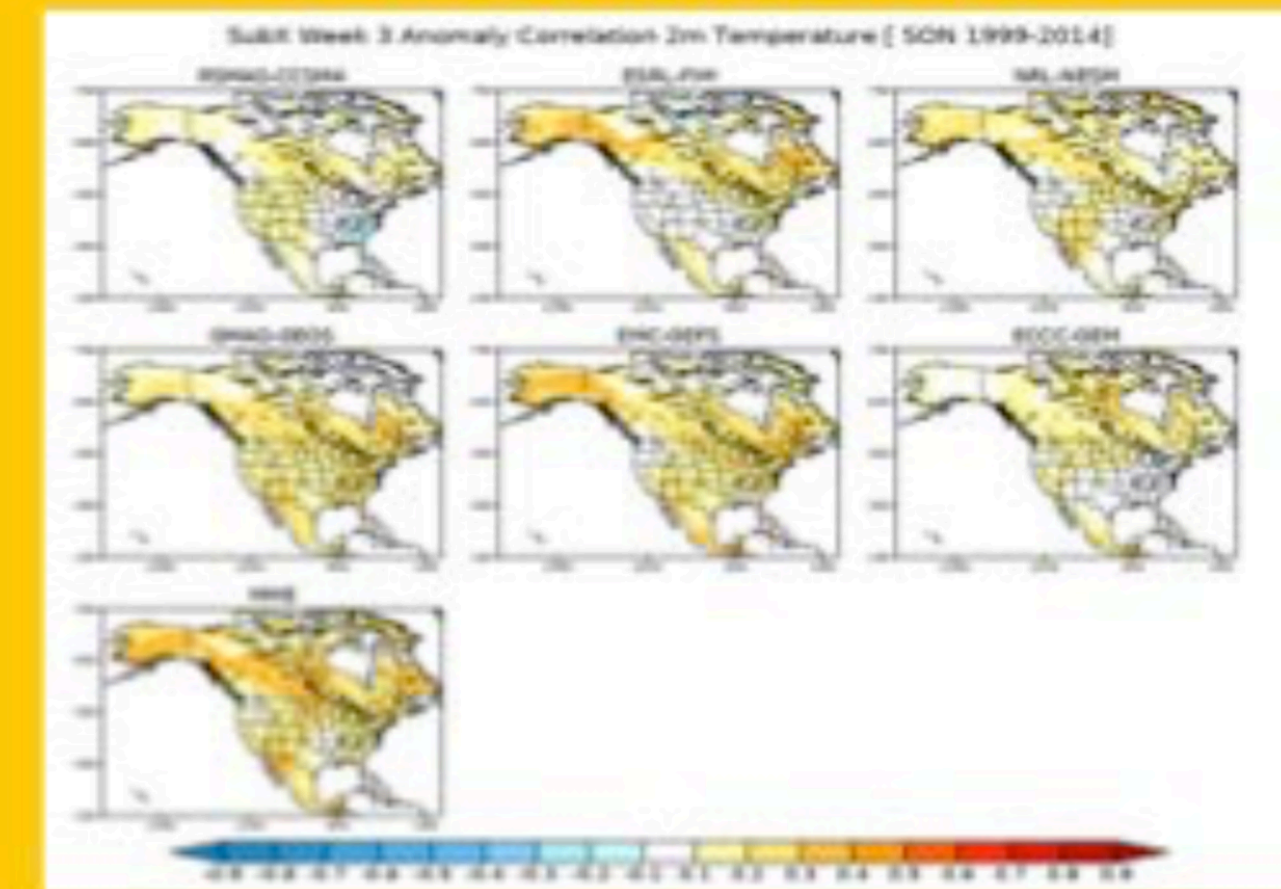
Forecast & Hindcast data  
publicly available

Current Data Holdings (last updated: Feb 14, 2016)

Model	Ensemble Members	Retrospective	Real-time	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ECMWF-ENSE	51	1999-2014	2015	2015												
ECMWF-ENSE	51	1999-2014	2015	2015												
ECMWF-ENSE	51	1999-2014	2015	2015												
ECMWF-ENSE	51	1999-2014	2015	2015												
ECMWF-ENSE	51	1999-2014	2015	2015												
ECMWF-ENSE	51	1999-2014	2015	2015												
ECMWF-ENSE	51	1999-2014	2015	2015												
ECMWF-ENSE	51	1999-2014	2015	2015												
ECMWF-ENSE	51	1999-2014	2015	2015												
ECMWF-ENSE	51	1999-2014	2015	2015												

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

## Skill Evaluation




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



Courtesy of Kathy Pegion



# S2S and SubX databases in IRI Data Library

 Data Library  
ECMWF S2S

Language  
english

DescriptionExpert Mode

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

SOURCESECMWF 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 Model Table](#) ECMWF S2S Wiki Page

[S2S Project Wiki](#) 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 Wiki](#) 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.

 Data Library  
Models SubX

DescriptionExpert Mode

SOURCESModels 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 ]

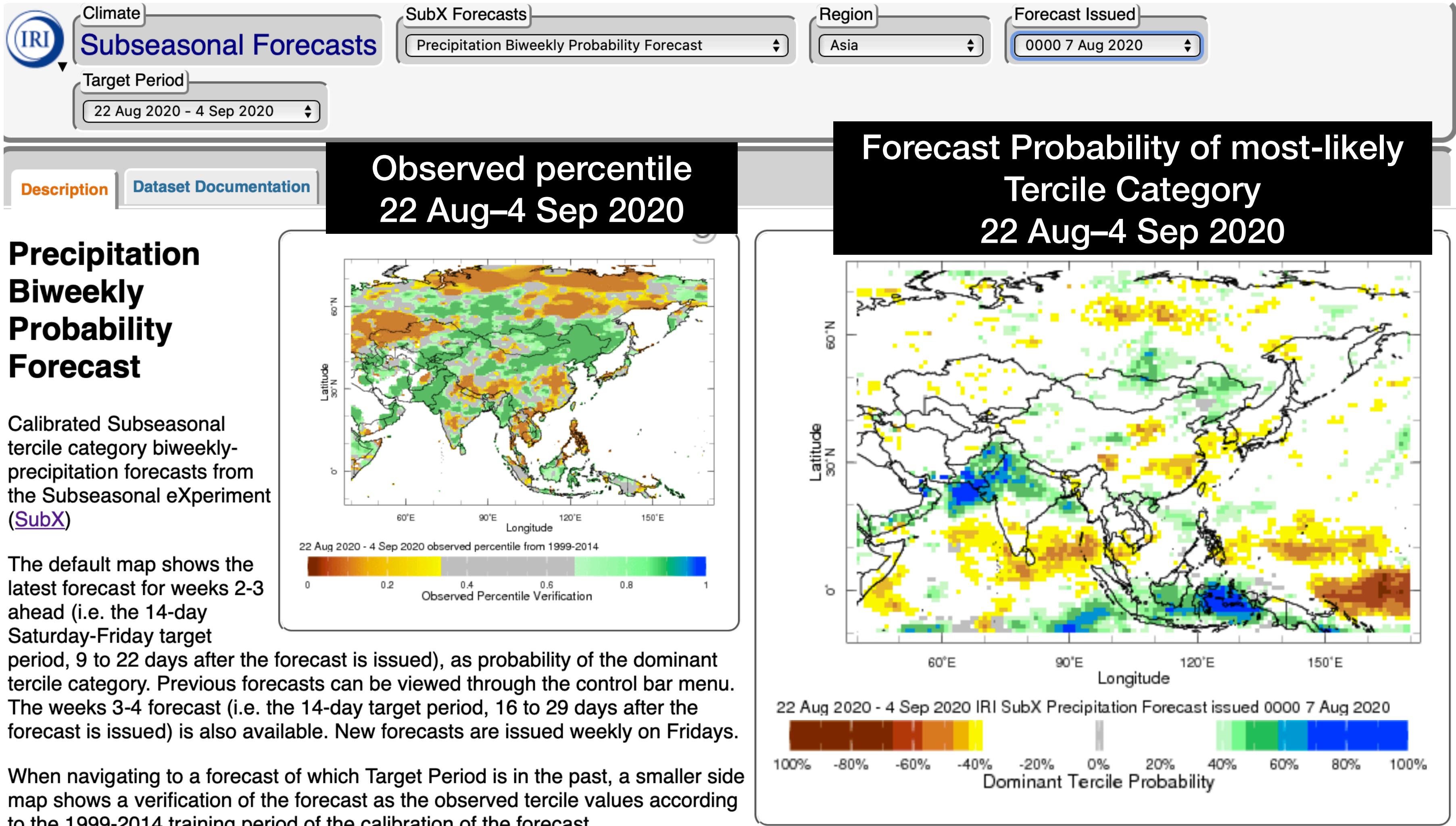
[RSMAS](#) Models SubX RSMAS[CCSM4 ]

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



# SubX Real-Time Calibrated MME Maproom

## Precipitation Example: Aug 7, 2020

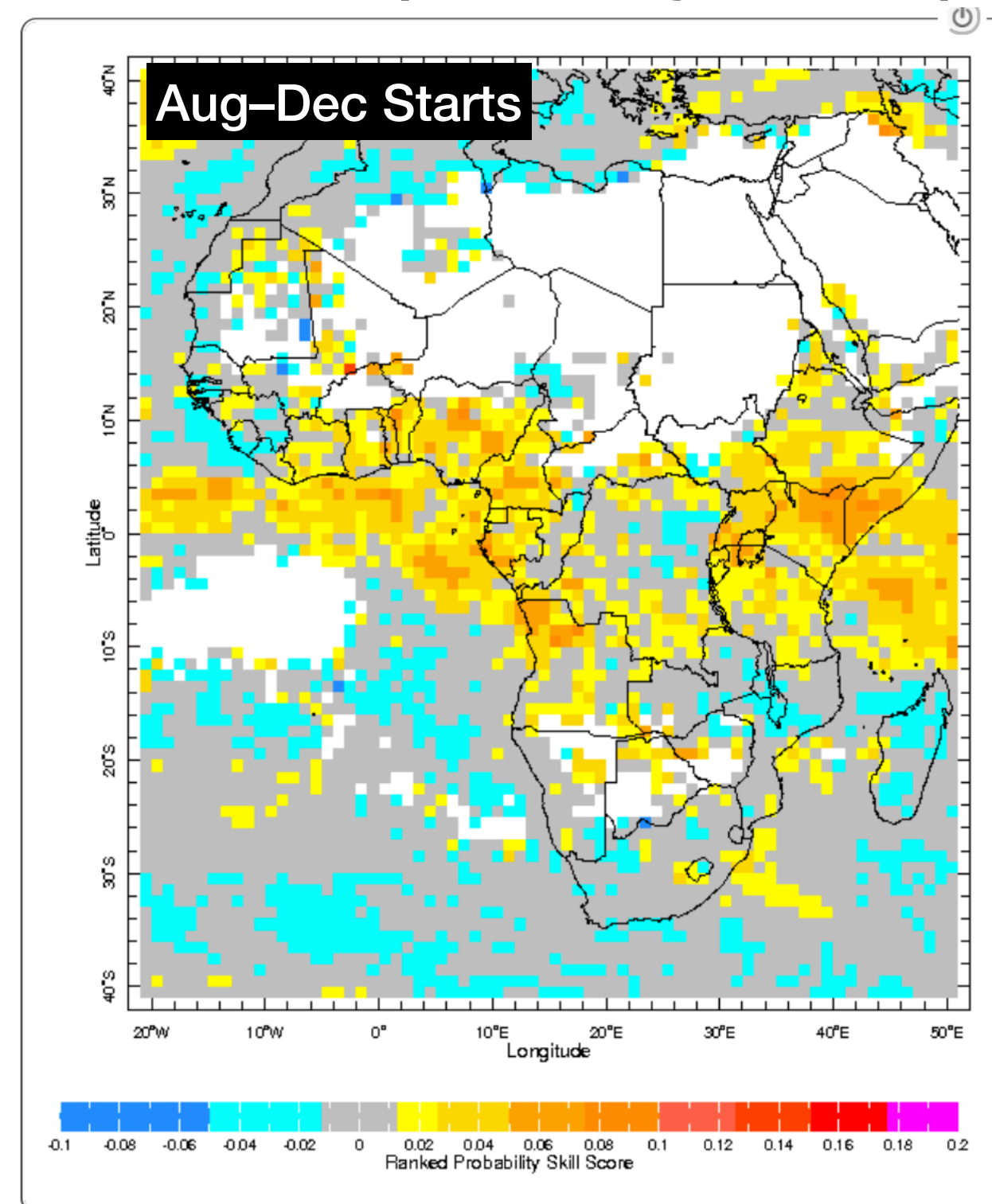




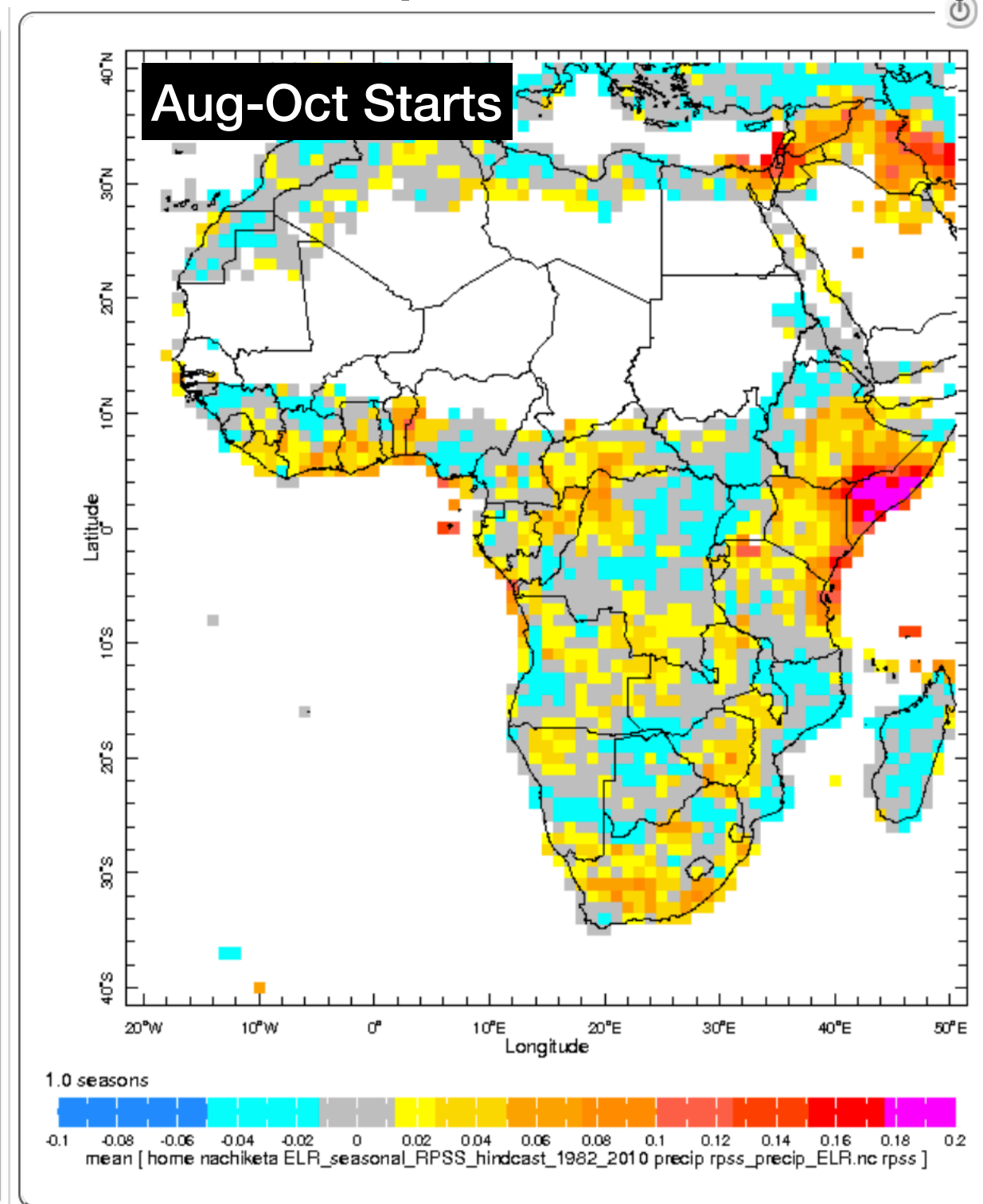
# Estimates of Subseasonal vs Seasonal rainfall forecasting skill

## Ranked Probability Skill Score

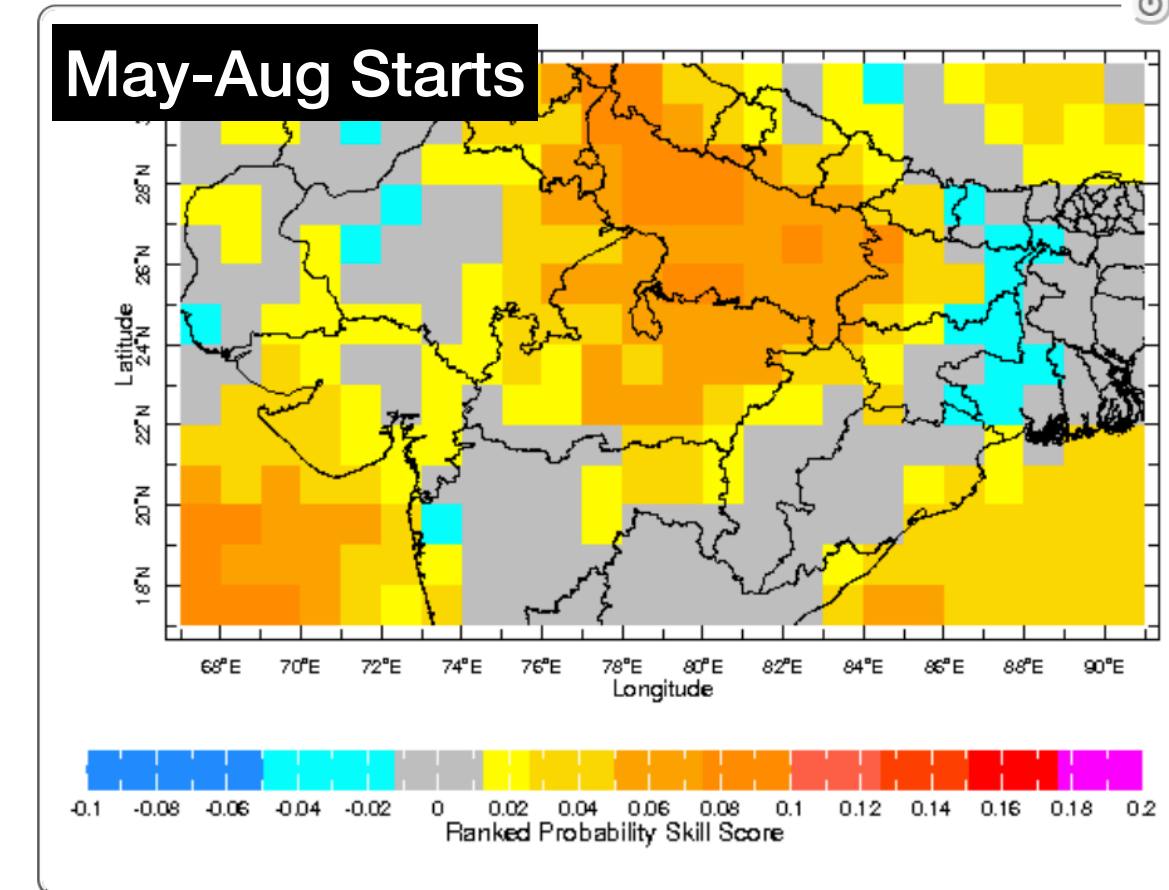
Weeks 3-4 (15-28 days ahead)



Seasonal (2-4 months ahead)

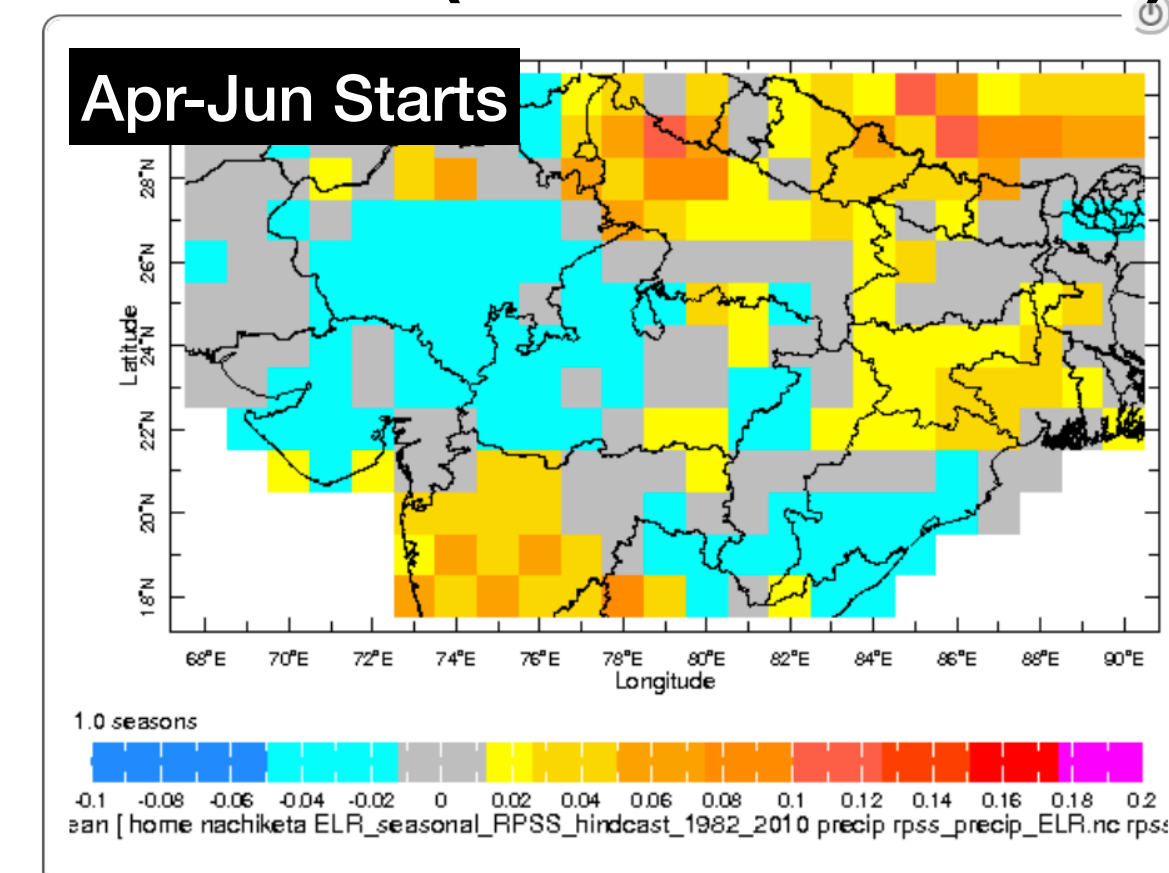


Weeks 3-4 (15-28 days ahead)



Orange-red colors indicates potentially useful skill.

Seasonal (2-4 months ahead)



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.

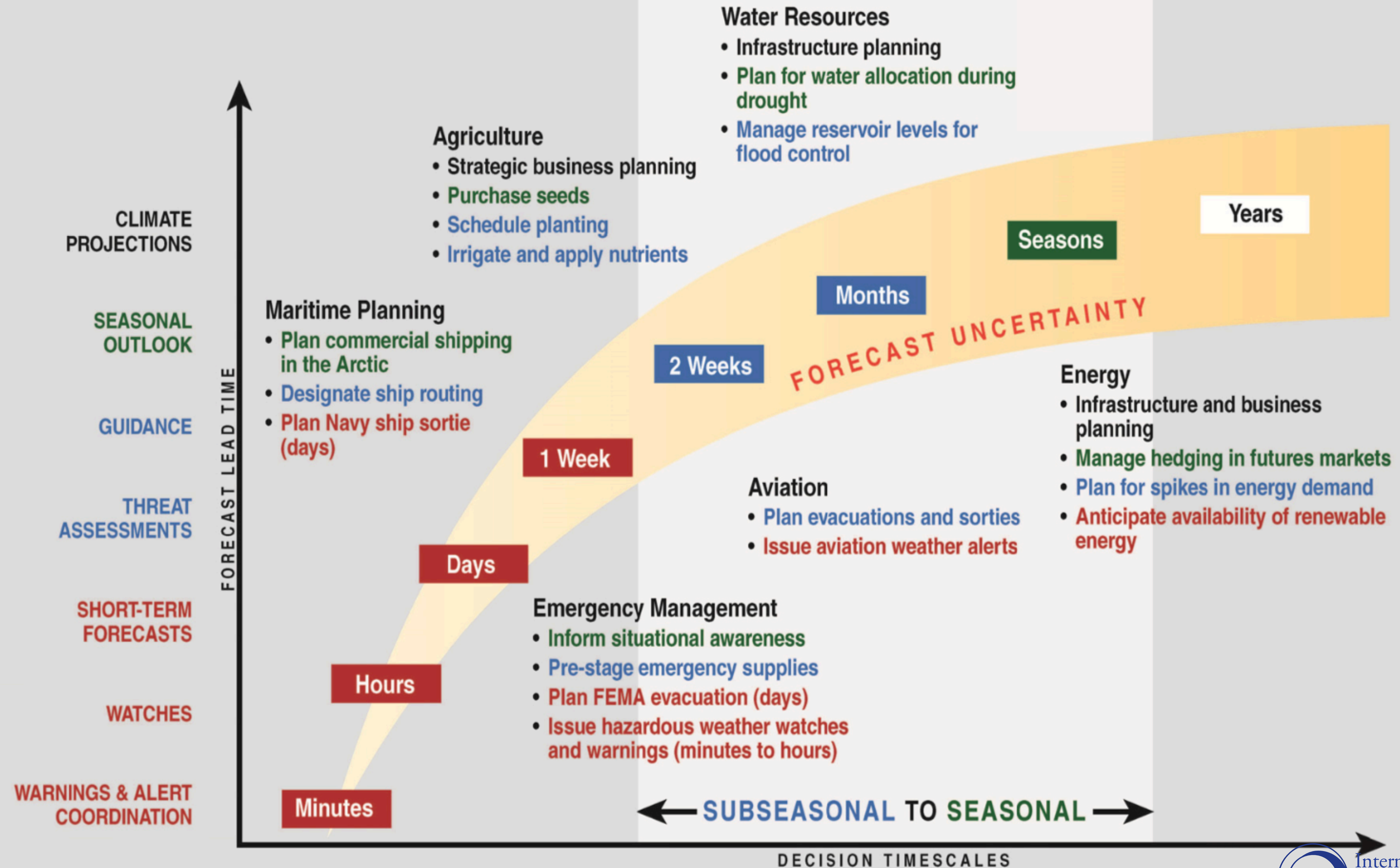
These maps were obtained from the IRI Maprooms:

Seasonal Forecasts: <http://iridl.ldeo.columbia.edu/maproom/Global/Forecasts/index.html>

Subseasonal Forecasts: <http://iridl.ldeo.columbia.edu/maproom/Global/ForecastsS2S/index.html>



# Potential uses for S2S Forecasts in many sectors



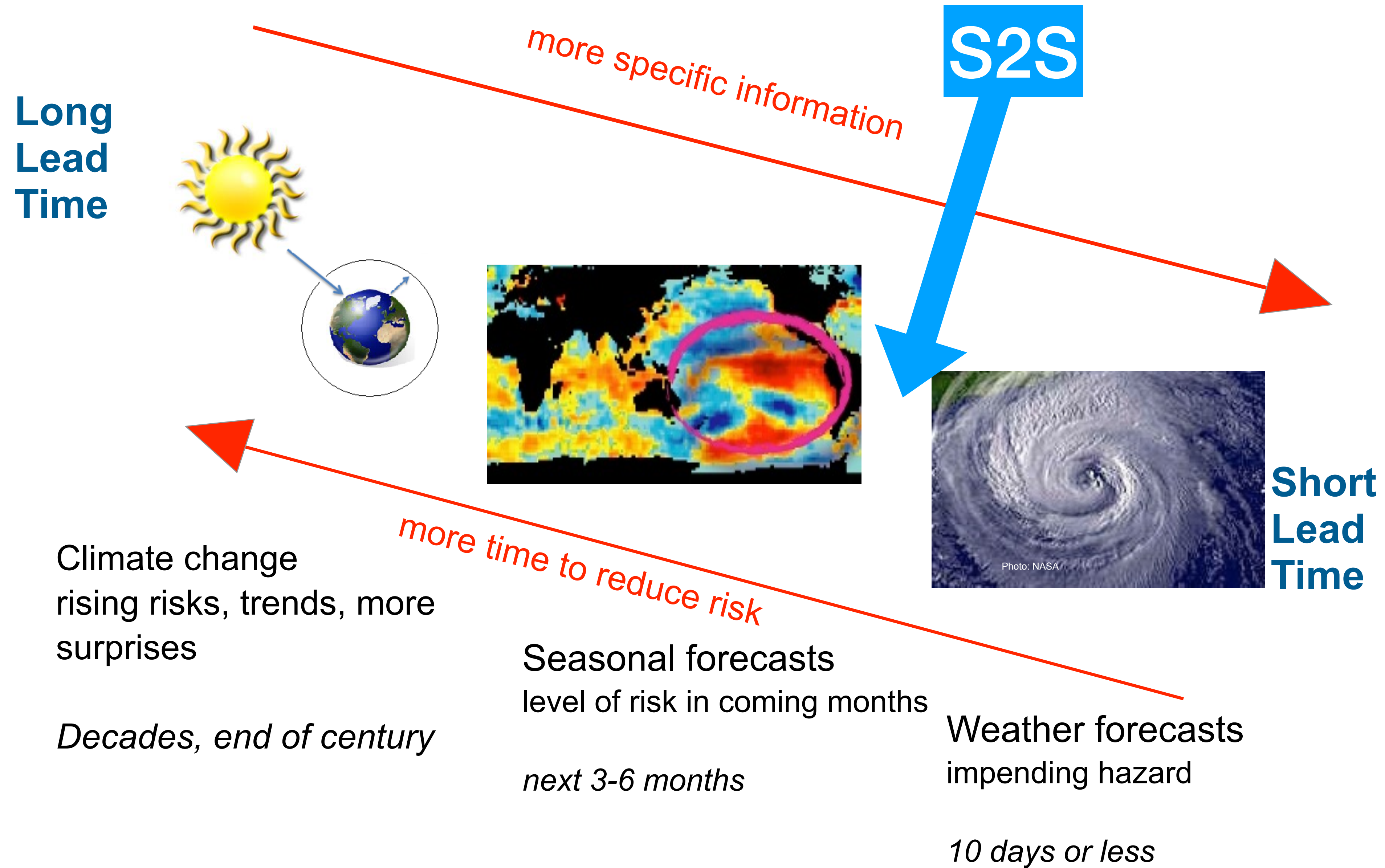


# Conclusions

- S2S prediction is still in its infancy. It fills the gap between weather and climate forecasting. Its predictability comes from atmospheric initial conditions as well as from boundary conditions (e.g. MJO).
- S2S predictability is not constant in time. It depends strongly on the occurrence of sources of predictability (e.g. SSWs, MJOs, soil moisture anomalies...).
- Forecast skill for weeks 3 and 4 is generally low, but models have improved over the past decades. Multi-model ensembles can produce more skilful forecasts of precipitations.
- Databases such as S2S or SubX are valuable resources to evaluate the impact of various sources of predictability in state-of-the-art S2S models and identify potential benefits or limitations in the use of S2S forecasts.



# Predictive information on *multiple* time-scales has potential to reduce climate risk by proactive interventions





S2S News

Events/Meetings

Newsletters

Webinar

### S2S AI-ML Challenge

We would like to announce the launch by WMO of a prize challenge to improve sub-seasonal to seasonal prediction of 2-metre temperature and precipitation 3 to 6 weeks in advance using Artificial Intelligence and Machine Learning methods. This competition is organized by the WWRP/WCRP S2S project in collaboration with the Swiss Data Science Center (SDSC) and ECMWF.

Detailed information about the challenge can be found in the **flyer attached** and via this link: <https://s2s-ai-challenge.github.io/>.

Updated: 2021-05-09 20:15

### Atmospheric Blocking Virtual Workshop 2021 (27-29 Sep. 2021)

A virtual **workshop on the dynamics and process understanding of Atmospheric Blocking** will take place from **27-29 September 2021**. See more



### Sub-projects Wikis

- **MJO and Teleconnections** (Dr. Cristiana Stan)
- **Aerosols** (Dr. Frederic Vitart)
- **Land** (Dr. Paul Dirmeyer)
- **Ocean** (Dr. Charlotte DeMott)
- **Stratosphere** (Dr. Amy Butler)
- **Ensembles** (Dr. Yuhei Takaya)
- **Research to Operations/Verification** (Dr. Caio Coelho)
- **Applications** (Dr. Joanne Robbins & Dr. Chris White)

### Regional Activities Wikis

- **Africa**
- **Australia and South Pacific**
- **South-East Asia**
- **South Asia**
- **East and Central Asia**
- **Europe**
- **North America**
- **Latin America & Caribbean**

### S2S Database & Products

#### S2S Archiving Data Center

ECMWF

CMA

IRI/LDEO Data Lib.

ECMWF Products (graphics)

S2S Museum

Github Codes

### Real-time Pilot Wiki

List of Projects participating in the S2S Real Time Pilot Initiative

### Machine Learning Wiki

Forecast and verification products development

### Statistics

ECMWF

Usage statistics (Data volumes, # of requests, active users, and users/country)

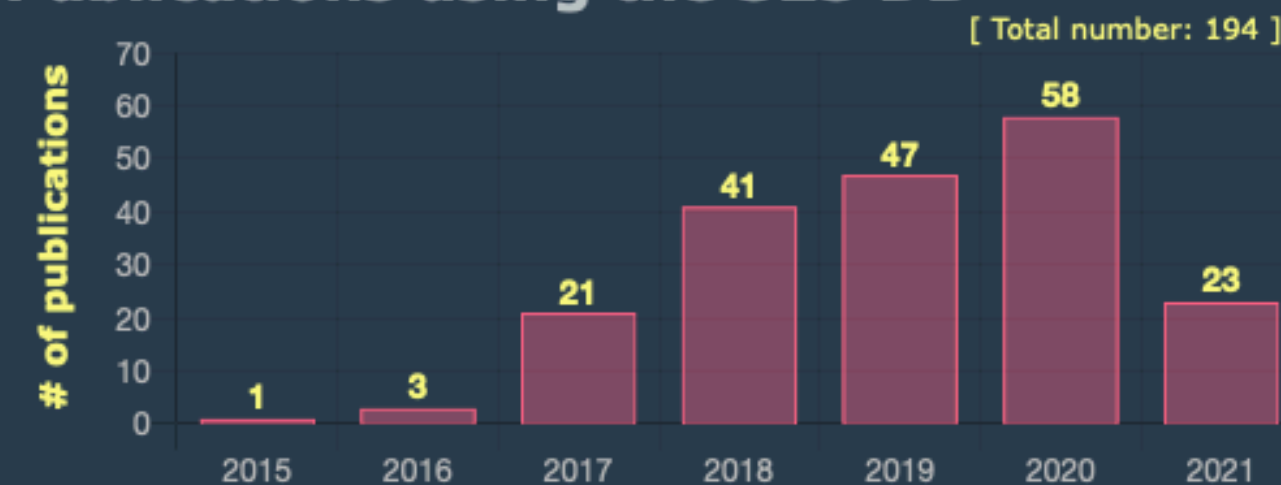
CMA

Usage statistics

IRI

Usage statistics

### Publications using the S2S DB



### Mailing List

The S2S Prediction Project mailing list allows members to receive the latest information on the S2S Prediction Project activities, newsletters, and updates to the S2S database. To join the mailing list, sign up by pressing the "Join the S2S Mailing List" button.

Join the  
S2S Mailing List

Learn more at  
[s2sprediction.net](https://s2sprediction.net)