ICTP/WCRP School on Climate System Prediction and Regional Climate Information, ANACIM, Dakar, Senegal, Nov 21-25, 2016

## Sub-Seasonal to Seasonal Forecasting and the S2S Project

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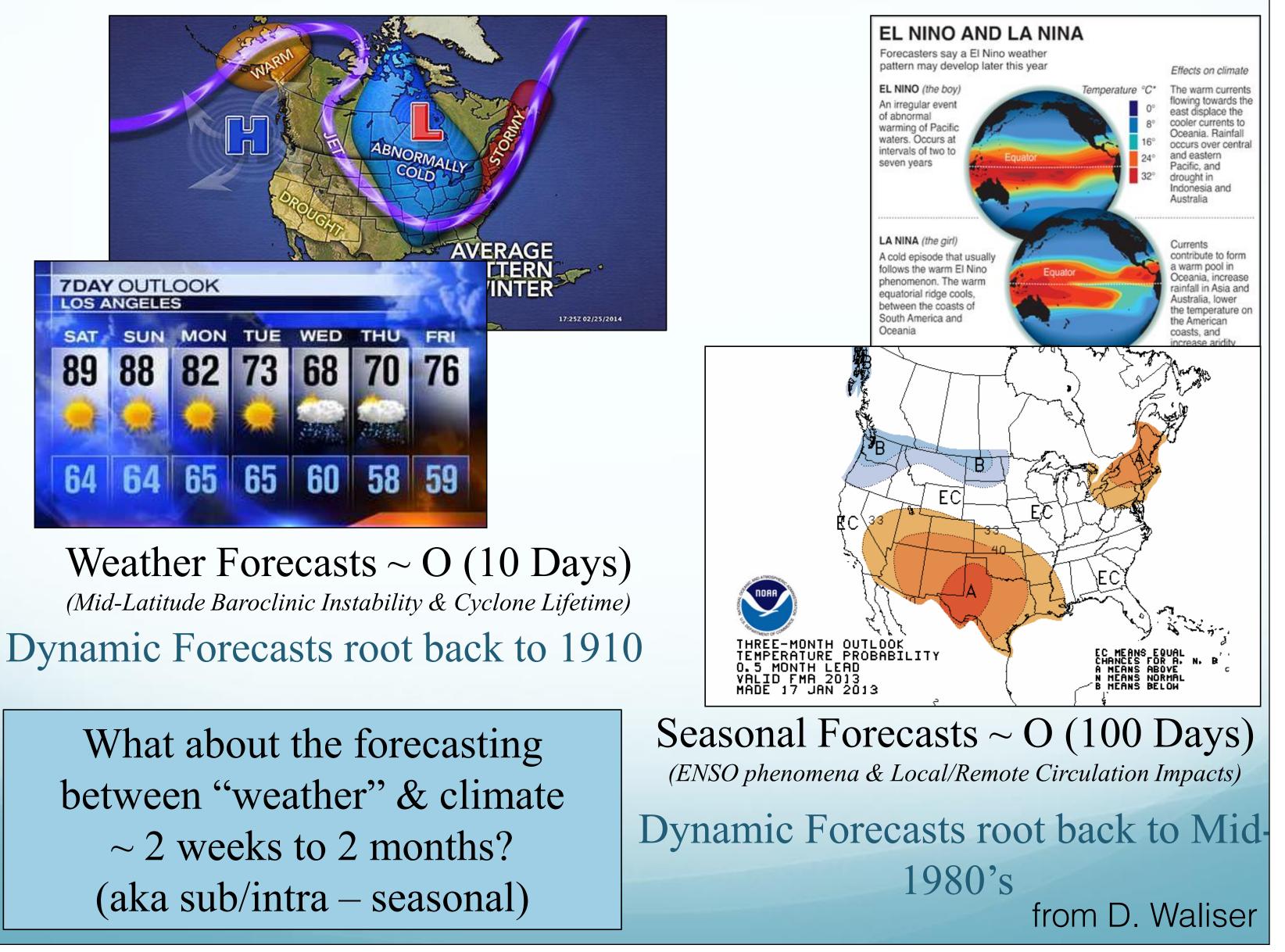
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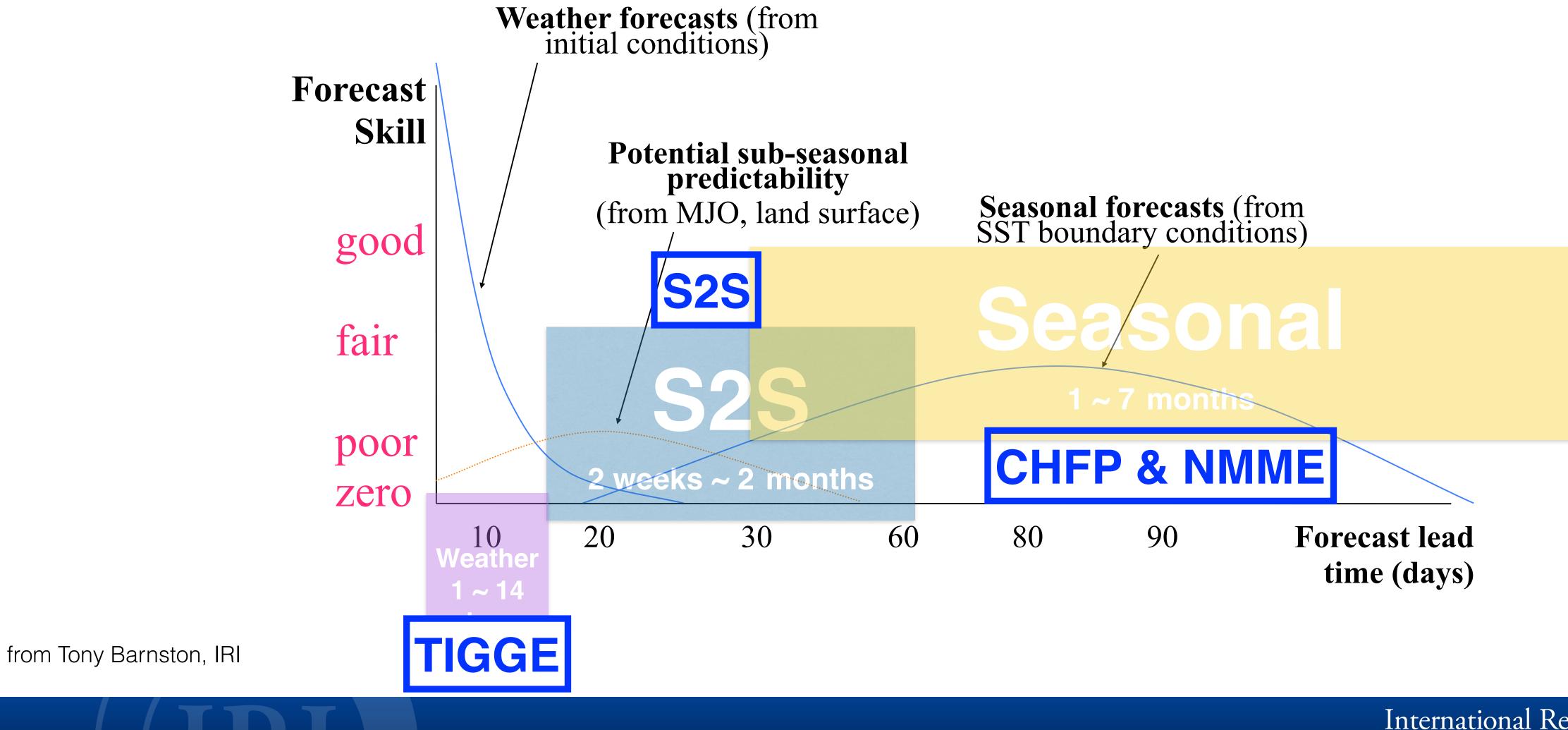
Many decisions in agriculture, water, disaster risk reduction and health fall in the sub-seasonal to seasonal (S2S) range. This time scale has been considered a "predictability desert", and received less work than medium-range and seasonal prediction. The goal of a new WWRP-WCRP joint research project is to improve forecasts and understanding on the S2S scale, and promote uptake by operational centers and use by the applications community.



# Weather vs Climate Forecasts



# Forecast Databases



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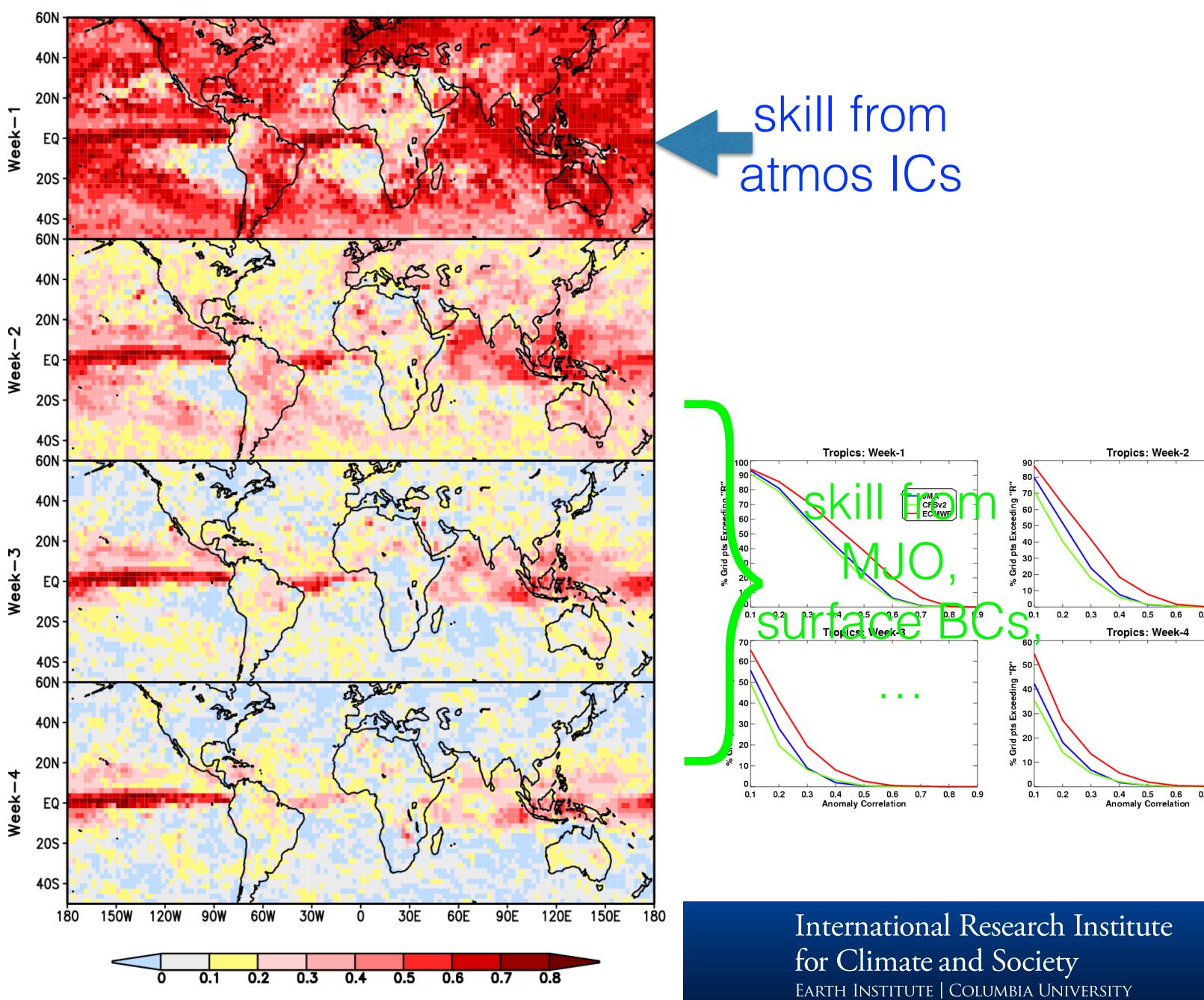
ECMWF Precip Fcst vs CMAP: 1992-2008

# ECMVF Sub-monthly forecast skill

Weekly average precip

Jun-Aug anomaly correlation skill

Li and Robertson (2015)





# S2S Forecasts are...

- More frequently updated (sub-weekly) than seasonal ones
- daily-weekly fields
- Connect weather and climate know-how
- Bring early-warning to early action

• More **specific** about timing of high-impact weather events, providing

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## Opportunity to use information on *multiple* time scales



Begin monitoring mid-range and short-range forecasts

Update contingency plans



Sensitize community

Enable early-warning system

Continue monitoring shorter-time-scale forecasts

Mobilize assessment team

Alert volunteers

Warn community

Local preparation activities



Deploy assessment team

Activate volunteers

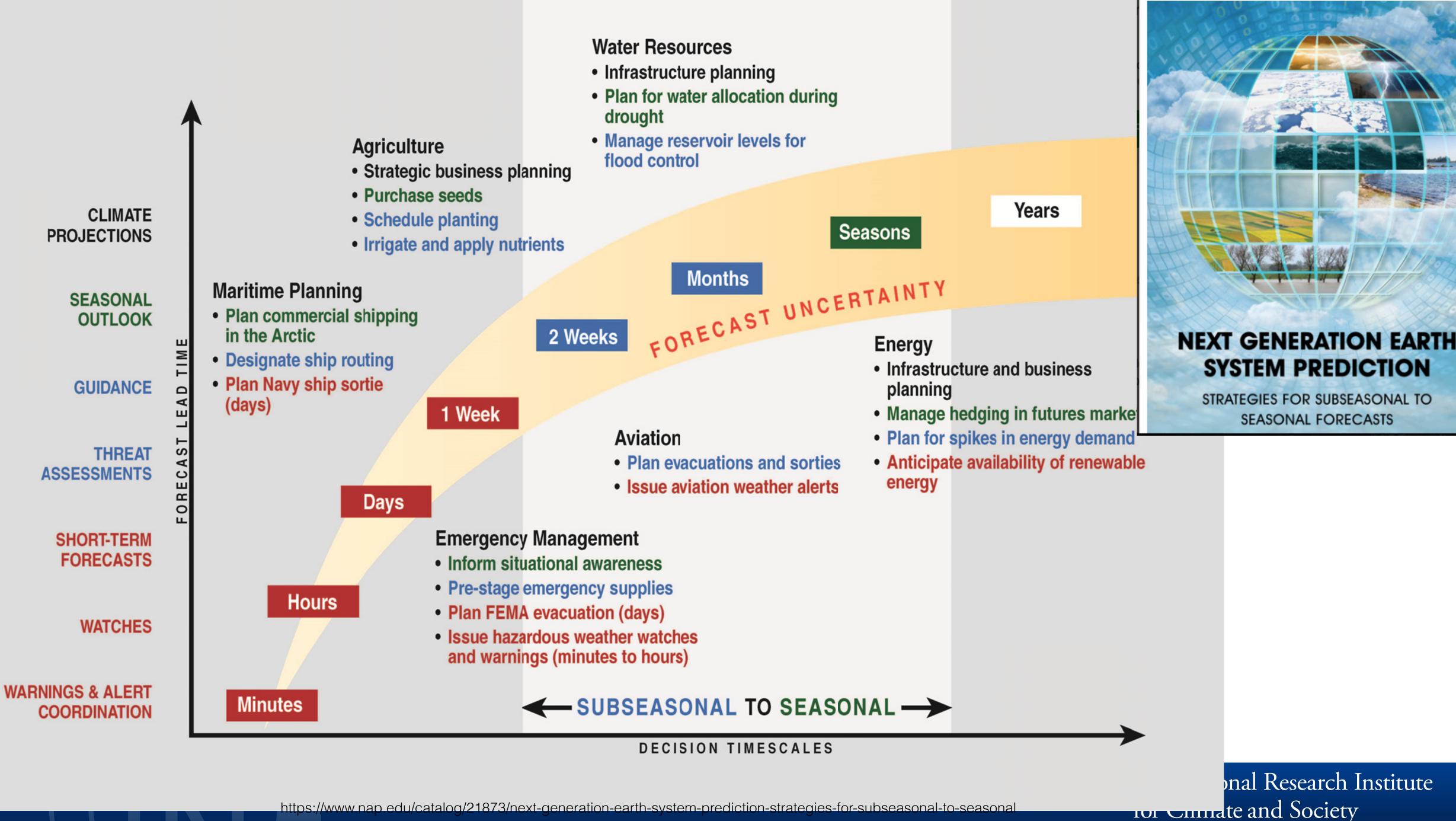
Distribute instructions to community, evacuate if needed

#### Source: M. Daly

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#### SUB-SEASONAL TO SEASONAL PREDICTION

**RESEARCH IMPLEMENTATION PLAN** 

Co-chairs: Frédéric Vitart (ECMWF) Andrew Robertson (IRI)



World Meteorological Organization Weather • Climate • Water









- 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 database

3-week behind real-time forecasts + re-forecasts (up to day 60)

#### Common grid (1.5x1.5 degree)

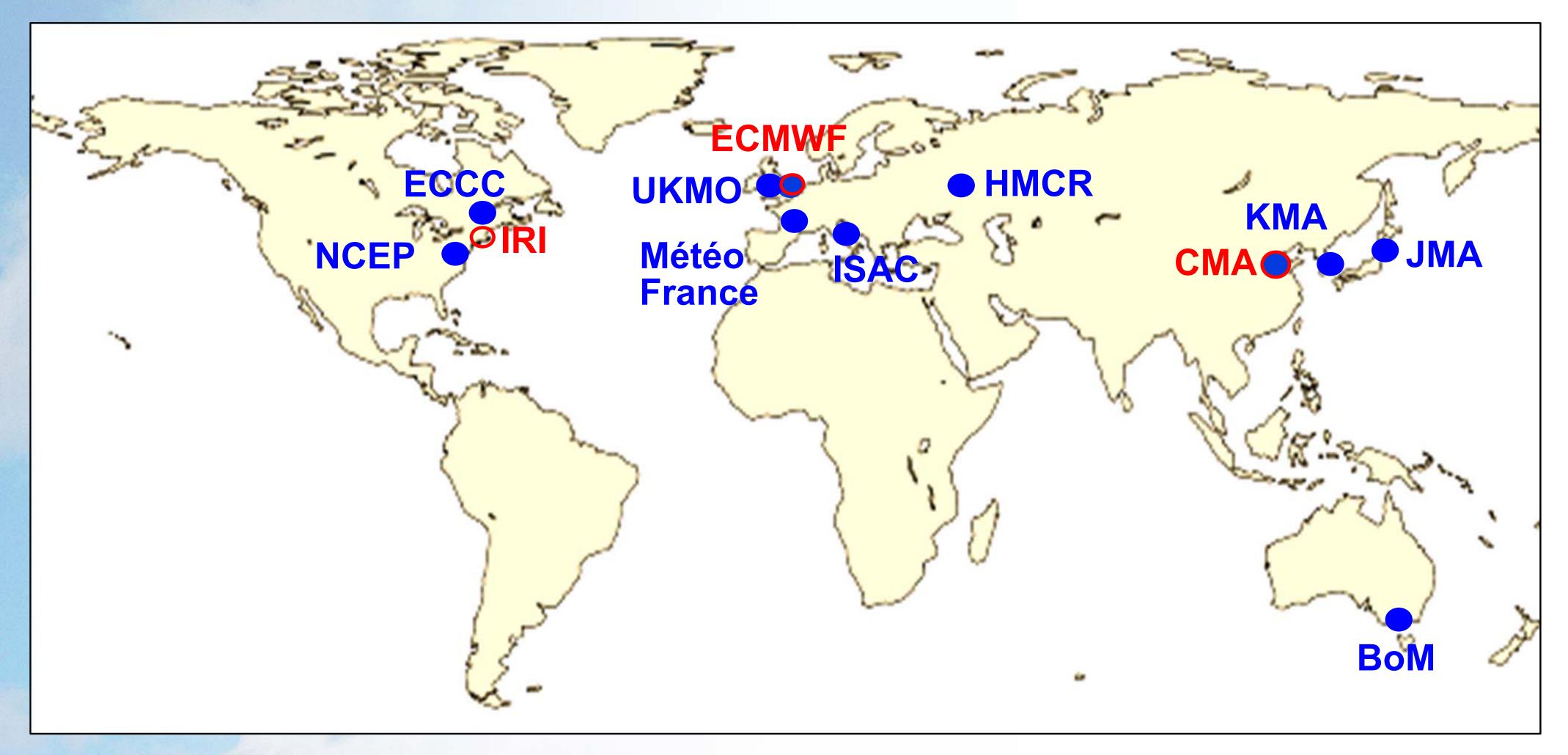
Data archived with a daily frequency (sub-daily for total precip/max) and min 2mtm) in GRIB2

#### About 80 parameters, including:

- 3D fields (u/v/w/z/t/q) on 10 pressure levels (up to 10 hPa)
- Surface fluxes
- Sea Surface temperature
- Sea-ice cover (fraction)
- Snow depth/density/snow fall/snow albedo

### **Contributing Centres to S2S database**

### • Data provider (11) O Archiving centre (3)



### **S2S Models**

	Time- range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-46	T639/319L91	51	2/week	On the fly	Past 20y	2/weekly	11
UKMO	D 0-60	N216L85	4	daily	On the fly	1993-2015	4/month	3
NCEP	D 0-44	N126L64	4	4/daily	Fix	1999-2010	4/daily	1
ECCC	D 0-32	0.45x0.45 L40	21	weekly	On the fly	1995-2014	weekly	4
BoM	D 0-60	T47L17	33	weekly	Fix	1981-2013	6/month	33
JMA	D 0-34	T319L60	25	2/weekly	Fix	1981-2010	3/month	5
KMA	D 0-60	N216L85	4	daily	On the fly	1996-2009	4/month	3
CMA	D 0-45	T106L40	4	daily	Fix	1886-2014	daily	4
CNRM	D 0-32	T255L91	51	weekly	Fix	1993-2014	2/monthly	15
<b>CNR-ISAC</b>	D 0-32	0.75x0.56 L54	40	weekly	Fix	1981-2010	6/month	1
HMCR	D 0-63	1.1x1.4 L28	20	weekly	Fix	1981-2010	weekly	10

#### S2S database models

ECMWFYESPlannedUKMOYESYESNCEPYESYESECCCNONOBOMYESPlannedJMANONOKMAYESYESCMAYESYESCNRMYESYESISA-CNRNONOHMCRNONO	Models	Ocean coupling	Active Sea Ice
NCEPYESECCCNOBoMYESJMANONONOKMAYESCMAYESCNRMYESISA-CNRYES	ECMWF	YES	Planned
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BoMYESPlannedJMANONOKMAYESYESCMAYESYESCNRMYESYESISA-CNRYESNO	NCEP	YES	YES
JMANOKMAYESCMAYESCMAYESCNRMYESISA-CNRYES	ECCC	NO	NO
KMAYESYESCMAYESYESCNRMYESYESISA-CNRYESNO	BoM	YES	Planned
CMAYESYESCNRMYESYESISA-CNRYESNO	JMA	NO	NO
CNRMYESISA-CNRYES	КМА	YES	YES
ISA-CNR YES NO	СМА	YES	YES
	CNRM	YES	YES
HMCR NO NO	ISA-CNR	YES	NO
	HMCR	NO	NO

# Two ways to get S2S data from ECMWF

Web INTERFACE: <u>http://apps.ecmwf.int/datasets/data/s2s/</u>

This is a "discovery" tool. Recommended for first time users. It gives a good idea of the content of the database, its structure and most importantly what is available. Easy to use. Good for small retrievals.

• WEBAPI: WebAPI+FAQ

This is a more advanced tool for data retrieval. Users install a "webapi key" on their computer. This allows them to run scripts to perform intensive S2S data retrievals. Recommended for advanced users with intensive data retrievals. Retrievals can be optimized.

https://software.ecmwf.int/wiki/display/WEBAPI/



#### http://apps.ecmwf.int/datasets/data/s2s/

S2S, Realtime, Instantaneous and Accumulated - Mozilla Firefox

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	Documentation Navigation	360	300	372	378	384	300	30.6	402	408	414	420	425					
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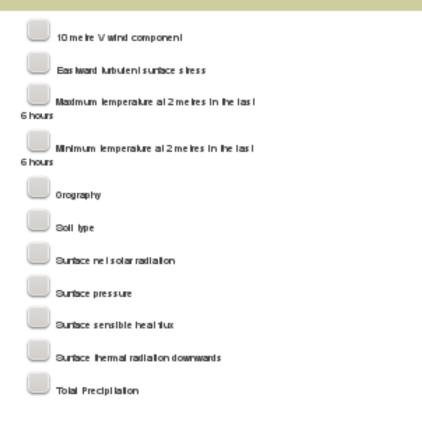
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General FAQ
WebAPI FAQ
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Land-sea mask	Max 6 hours
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http://apps.ecmwf.int/datasets/data/s2



# Example of WEBAPI SCRIPT

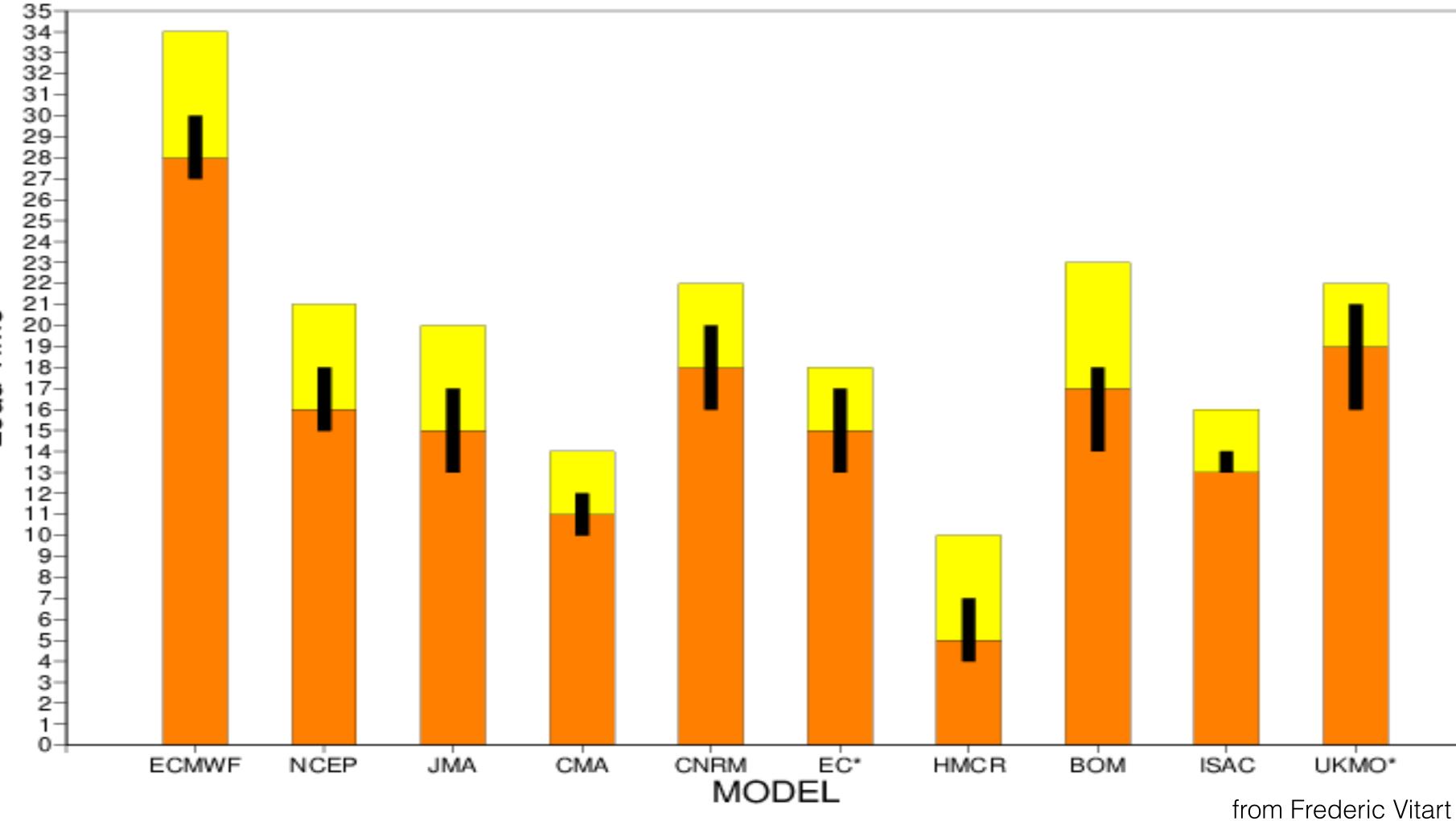
```
#!/usr/bin/env python
from ecmwfapi import ECMWFDataServer
server = ECMWFDataServer()
server.retrieve({
    "class": "s2",
    "dataset": "s2s",
    "date": "2015-01-01/2015-01-05/2015-01-08/2015-01-12/2015-01-15/2015-01-19/2015-01-22/2015-01-26/2015-01-29",
    "expver": "prod",
    "levtype": "sfc",
    "origin": "ecmf",
    "param": "165",
/696/720/744/768",
    "stream": "enfo",
    "target": "CHANGEME",
    "time": "00",
    "type": "cf",
})
```

You can also add other commands:

"grid": "1.5/1.5", "area": "15/-180/-15/180",

"step": "0/24/48/72/96/120/144/168/192/216/240/264/288/312/336/360/384/408/432/456/480/504/528/552/576/600/624/648/672

# Analysis of S2S Database



# Lead Time

#### MJO Bivariate Correlation S2S REFORECASTS 1999-2010

0.6 cor

0.5 cor

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### How should the target periods be defined for seamless forecasts?

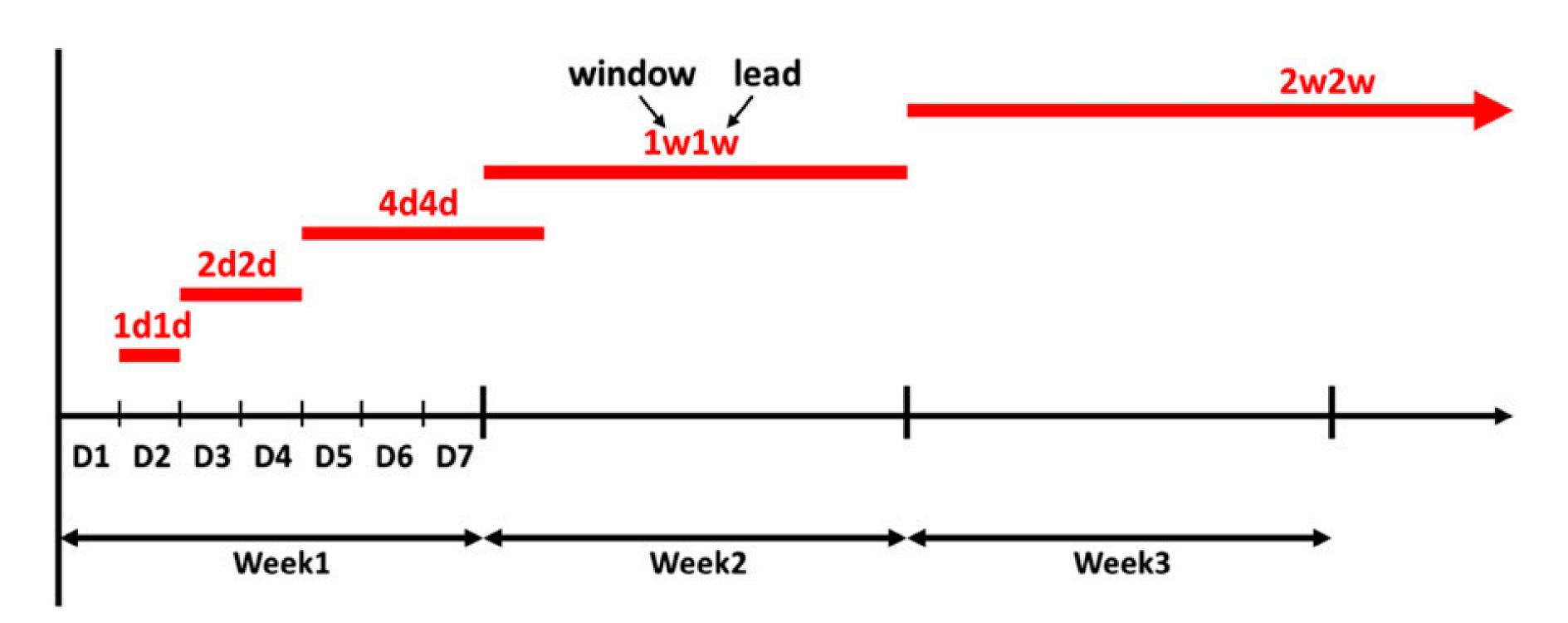


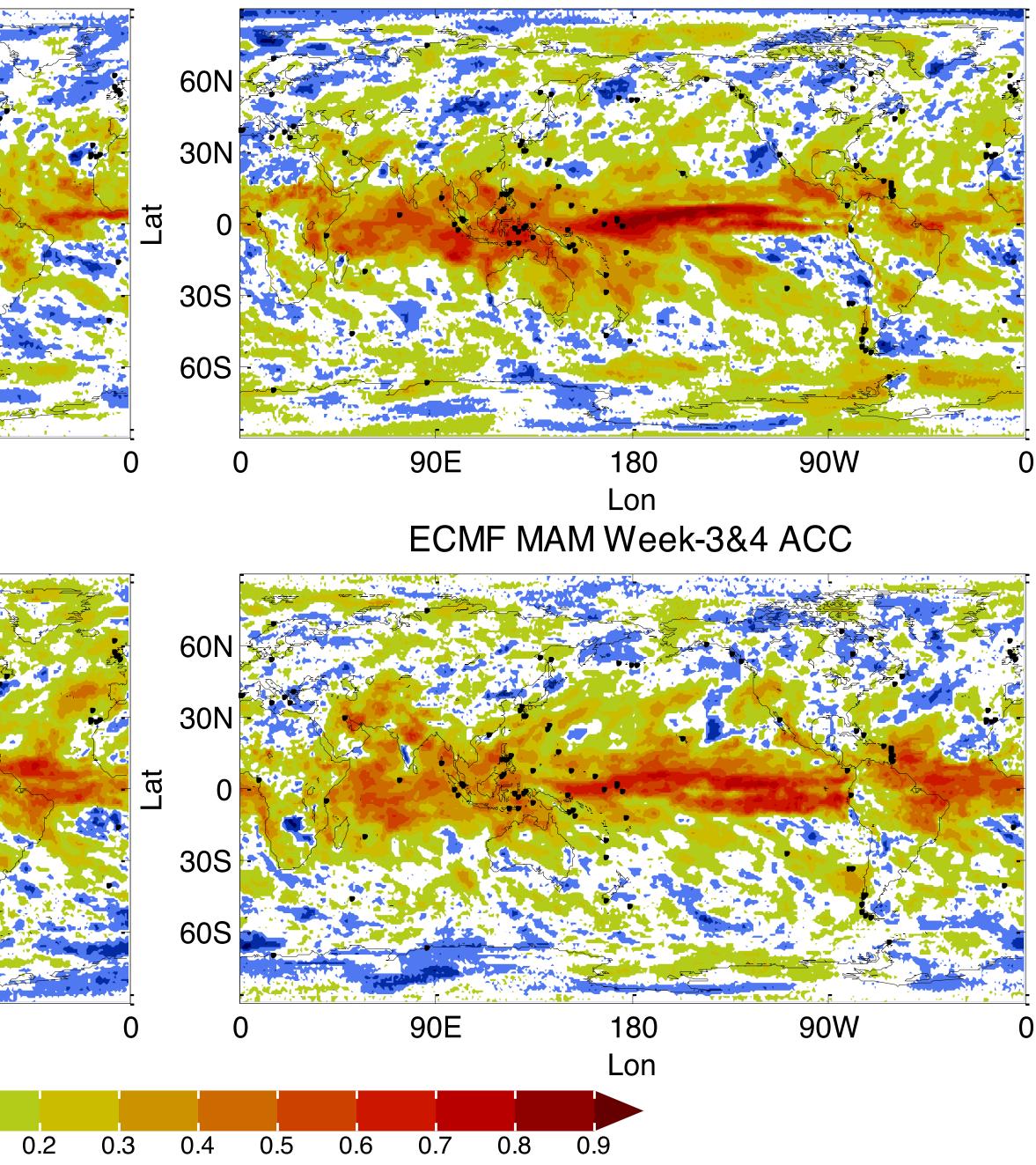
FIG. 1. Schematic of the time window and lead time definitions used in this analysis. The horizontal axis represents forecast time from the initial condition. The expression "1d1d" refers to an averaging window of 1 day at a lead time of 1 day. Similarly, "2d2d" represents an averaging window of 2 days at a lead time of 2 days, and so on. Note that 1d1d is what is usually called "day 2" in other papers, and 1w1w is what is usually called "week 2."

Zhu et al (2014, MWR, DOI: 10.1175/MWR-D-13-00222.1)

#### ECMF JJA Week-3&4 ACC

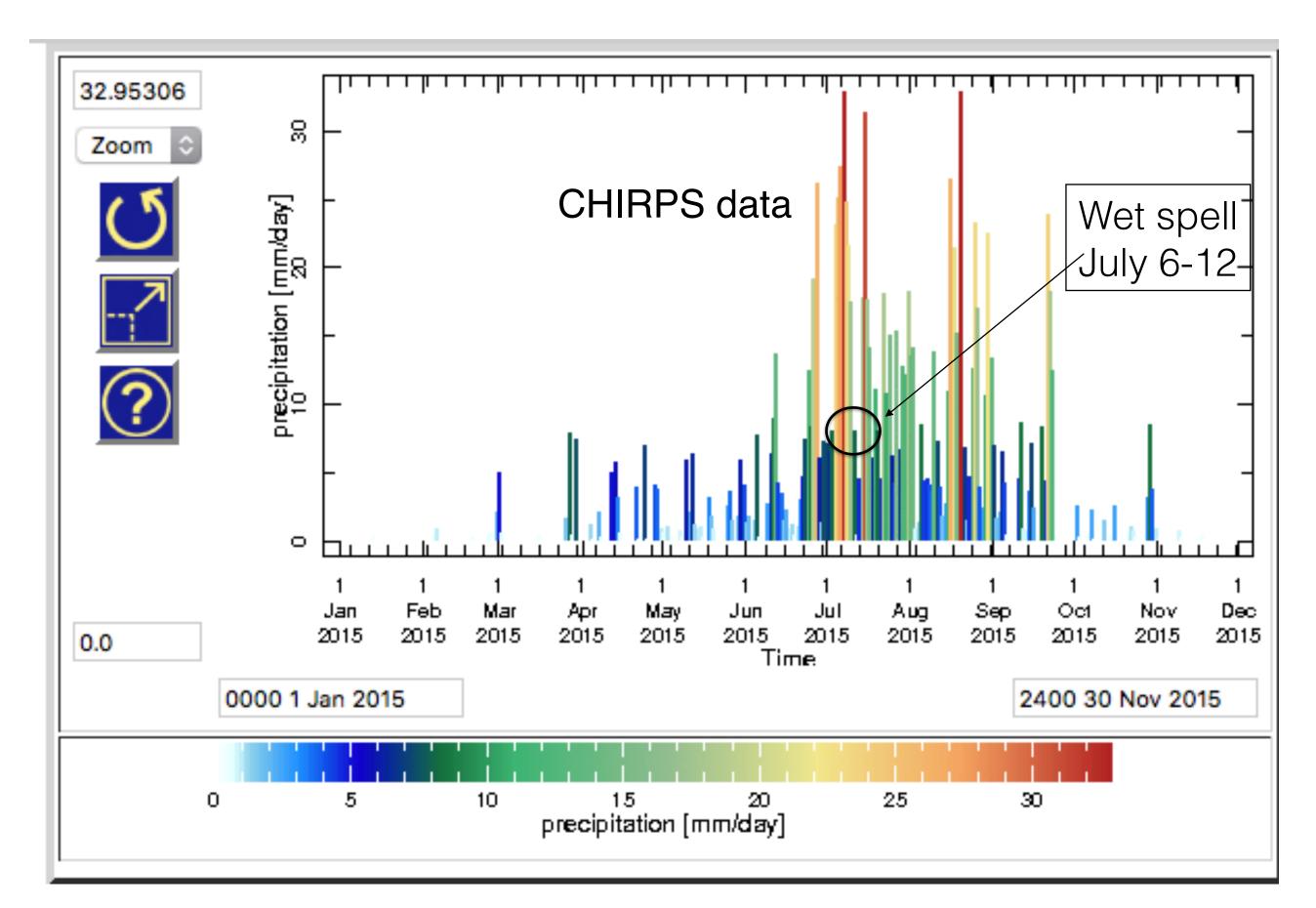
60N 30N Lat 30S ECMWF 60S Week 3+4 90E 90W 180 Anomaly Lon ECMF DJF Week-3&4 ACC Correlation with CMAP 60N data 30N Lat 30S 60S 90E 90W 180 0 Lon Included are all forecasts starts in each season -0.2 -0.1 -0.3 0.1

#### ECMF SON Week-3&4 ACC

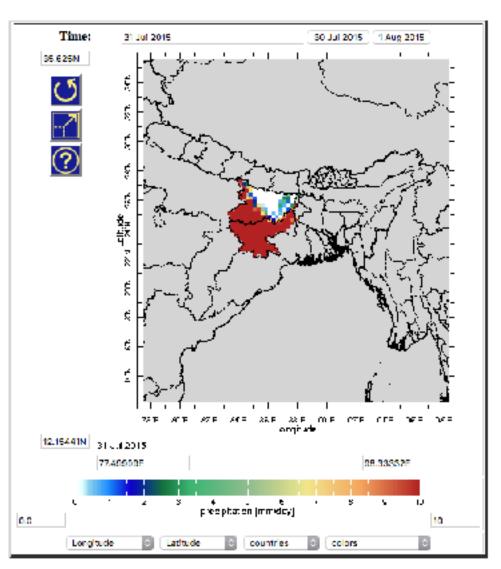


- Anomaly Correlation skill in week 3+4 is often low over Africa
- Does this mean the S2S forecasts are useless?
- Or are there aspects of the forecasts (synoptic features, phases of ENSO or MJO ..) where the forecasts have more skill?
- We will look at some case study examples
- Later, you could experiment with downscaling (e.g. downscaleR)

### Example: Heavy rainfall over Bihar in 2015 Can S2S Forecasts capture it?



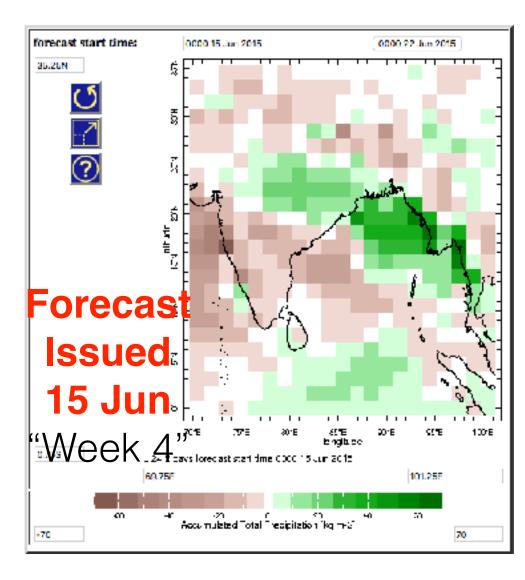


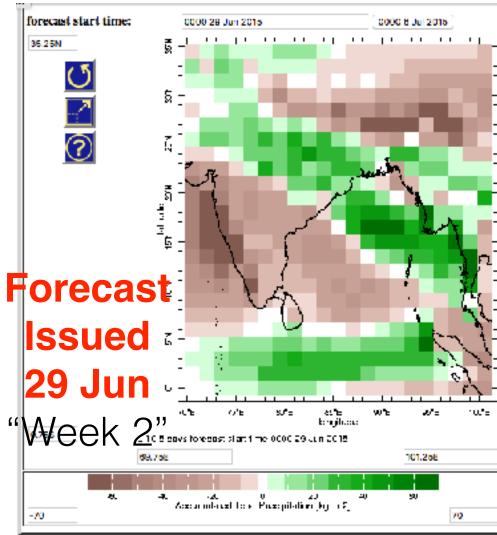


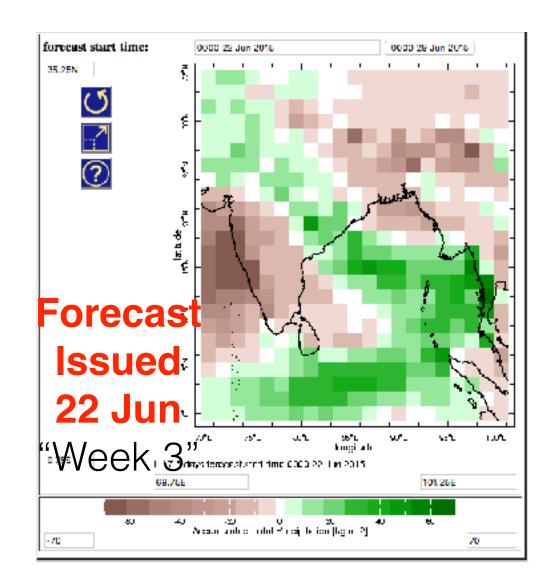
IRI Data Library

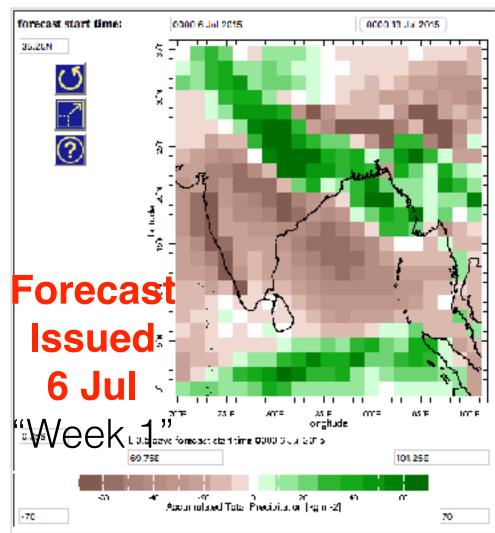
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# Diagnostics with S2S Database





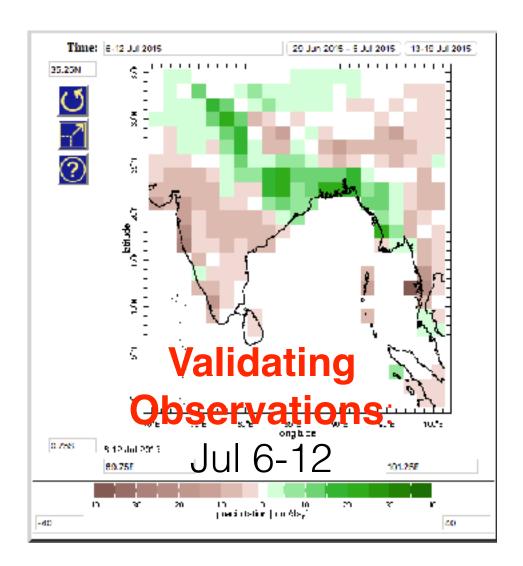






#### ECMWF Forecasts valid for Jul 6-12, 2015

*Weekly average* precip anomalies

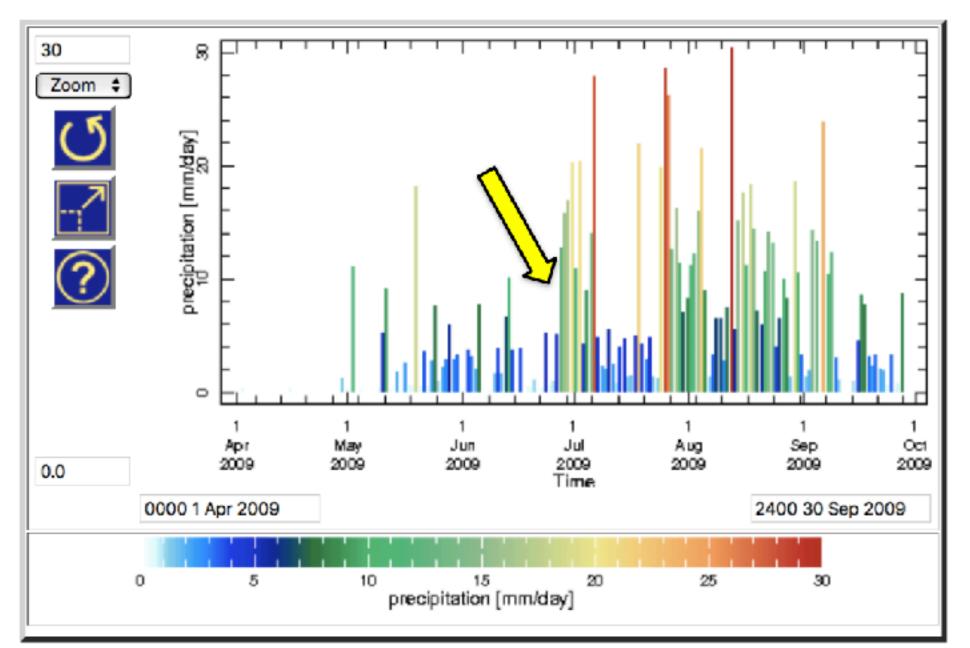


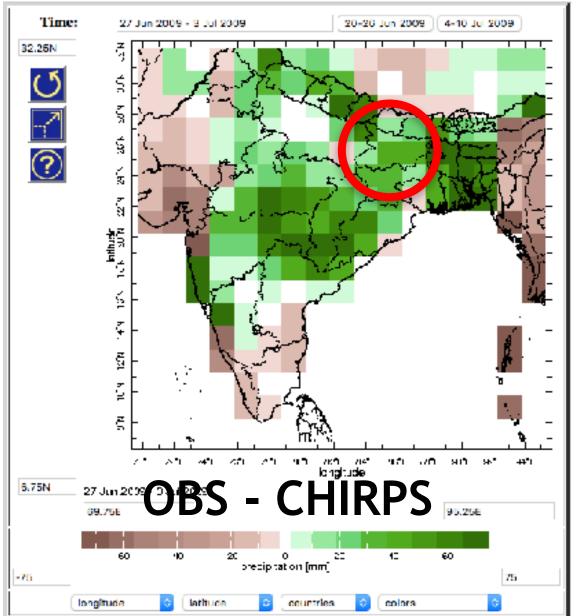
#### IRI Data Library

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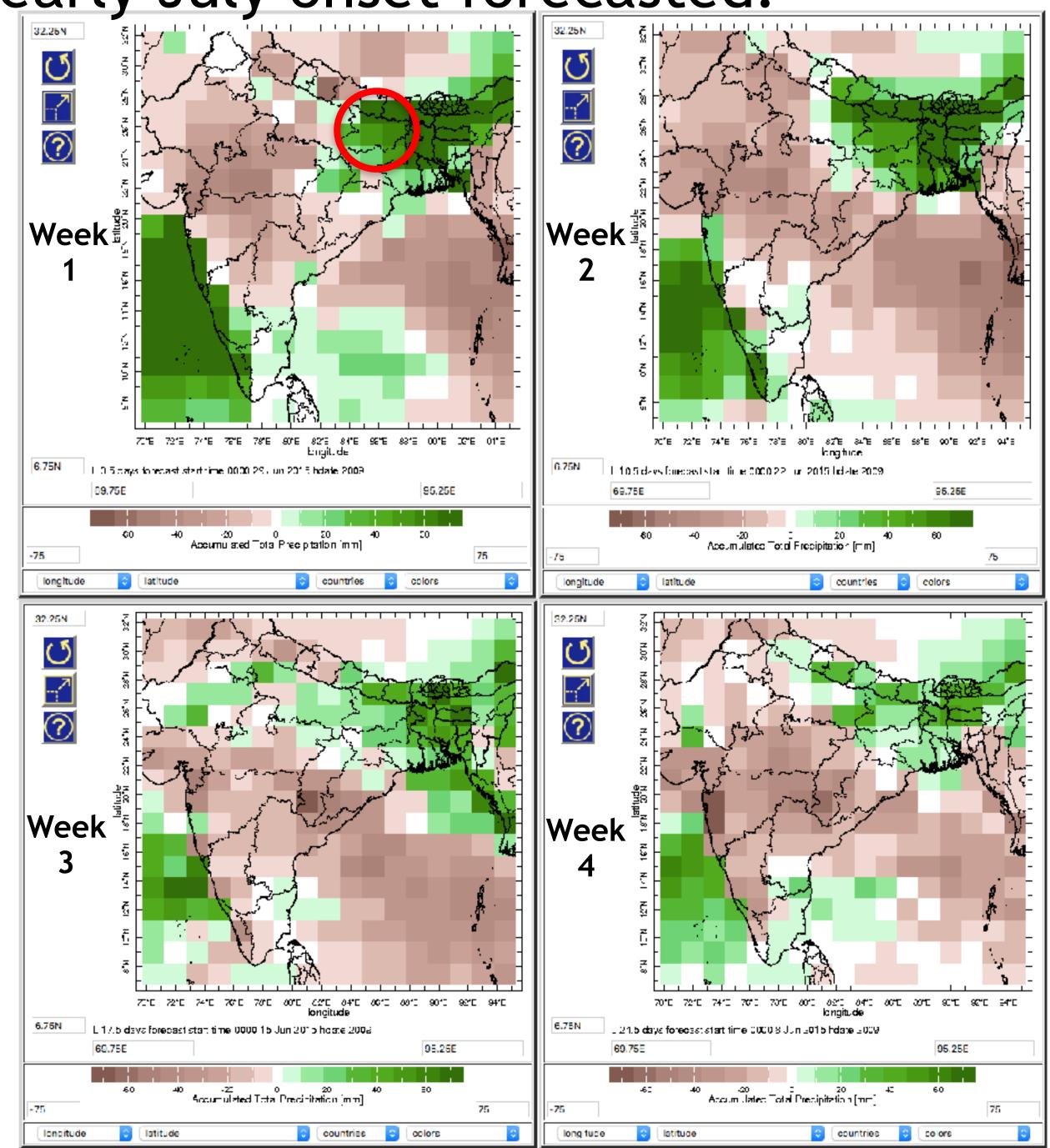
#### • some other cases ...

#### How well was the late June/early July onset forecasted?

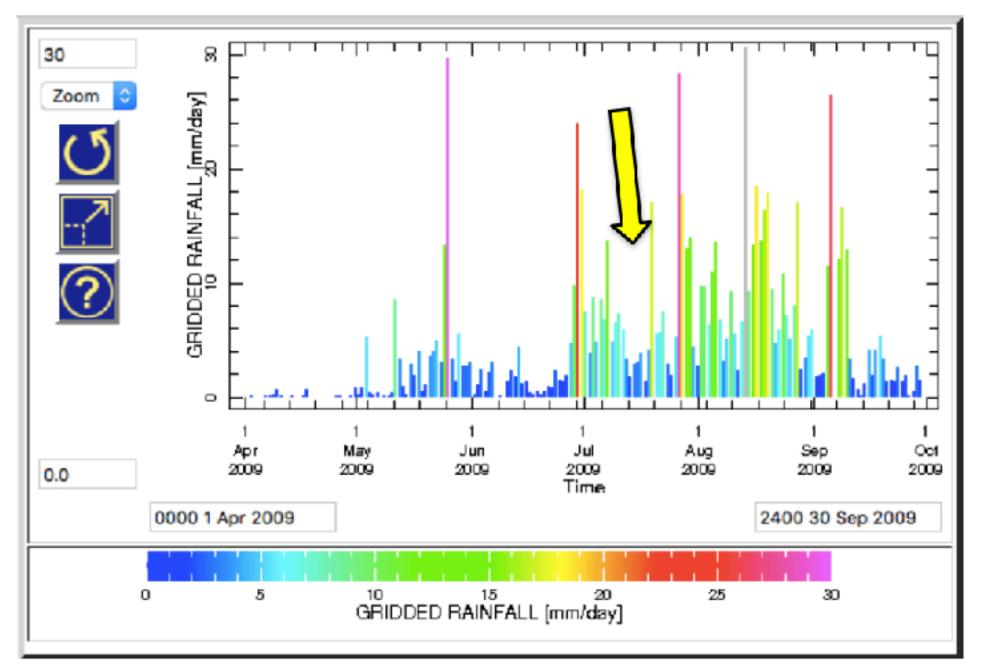


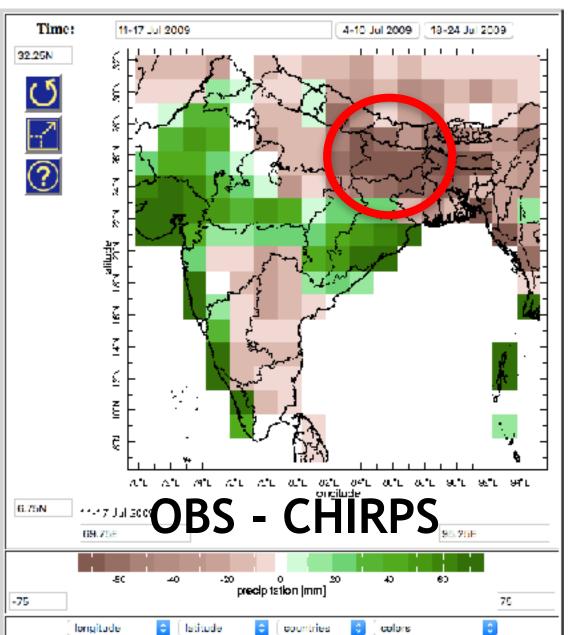


### Target: 27 Jun – 3 Jul 2009

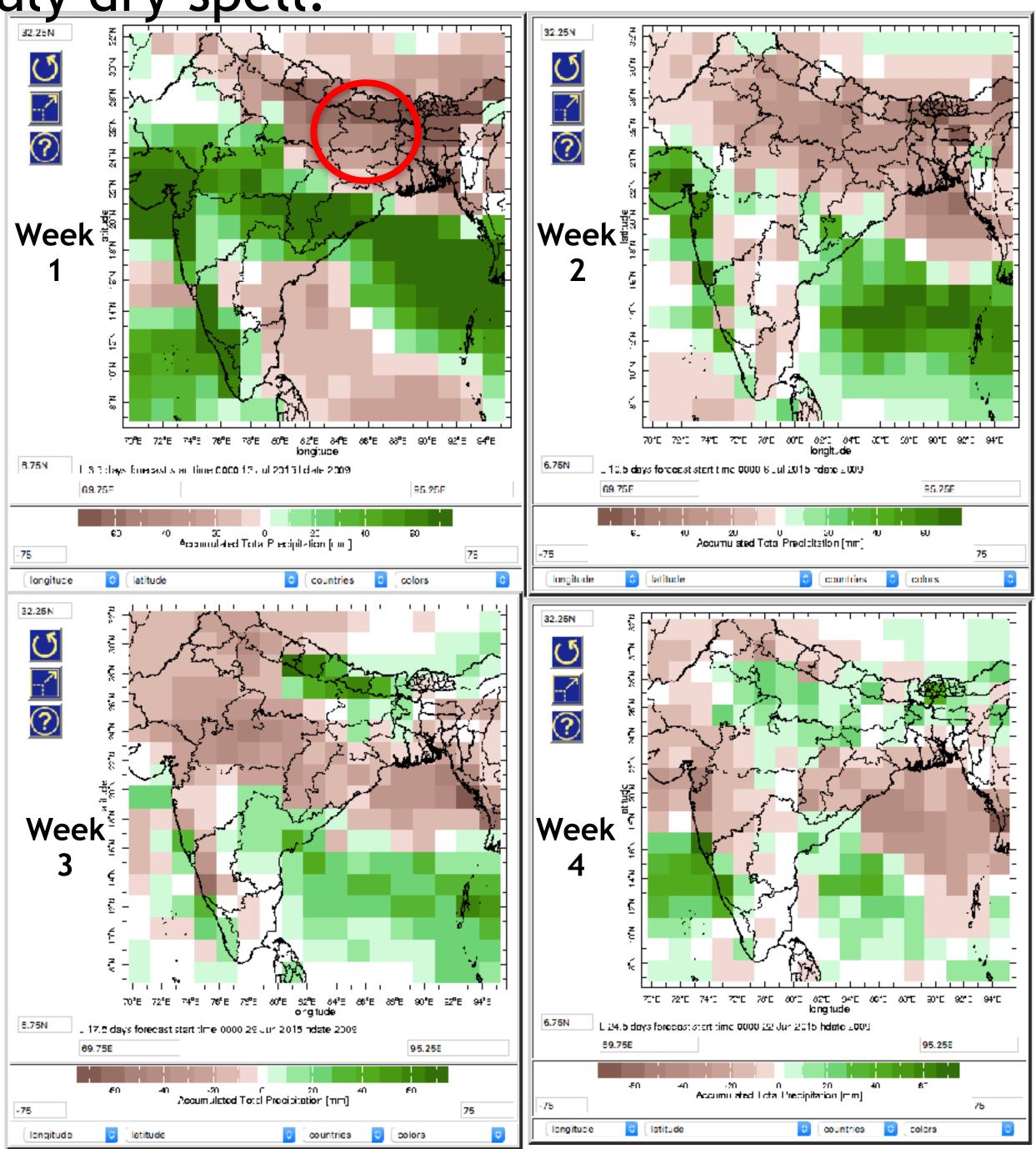


### How about the mid-July dry spell?

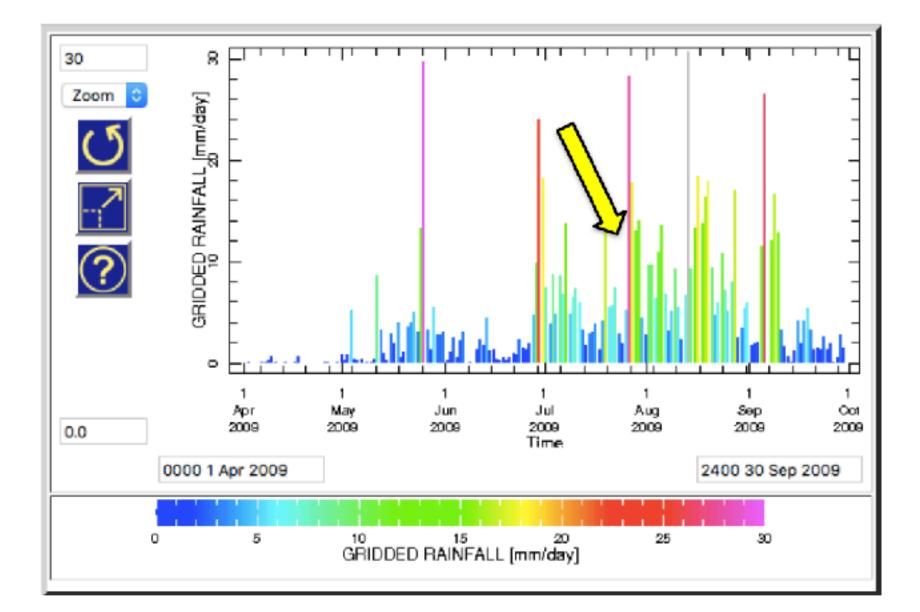


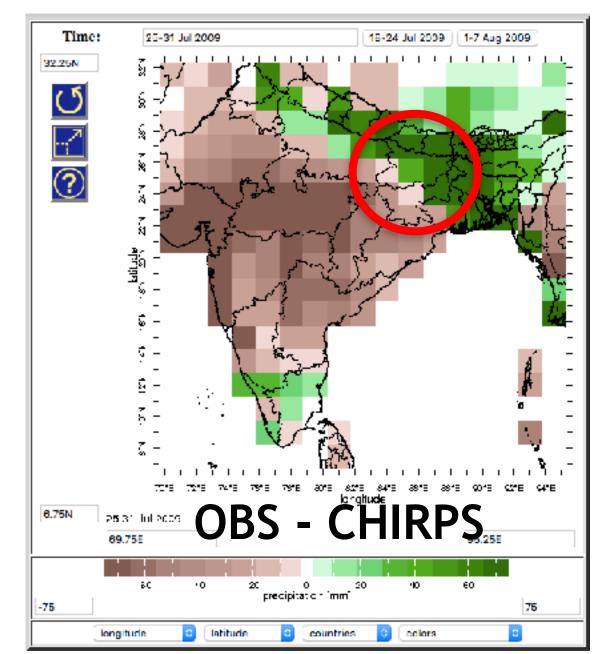


#### Target: 11–17 Jul 2009

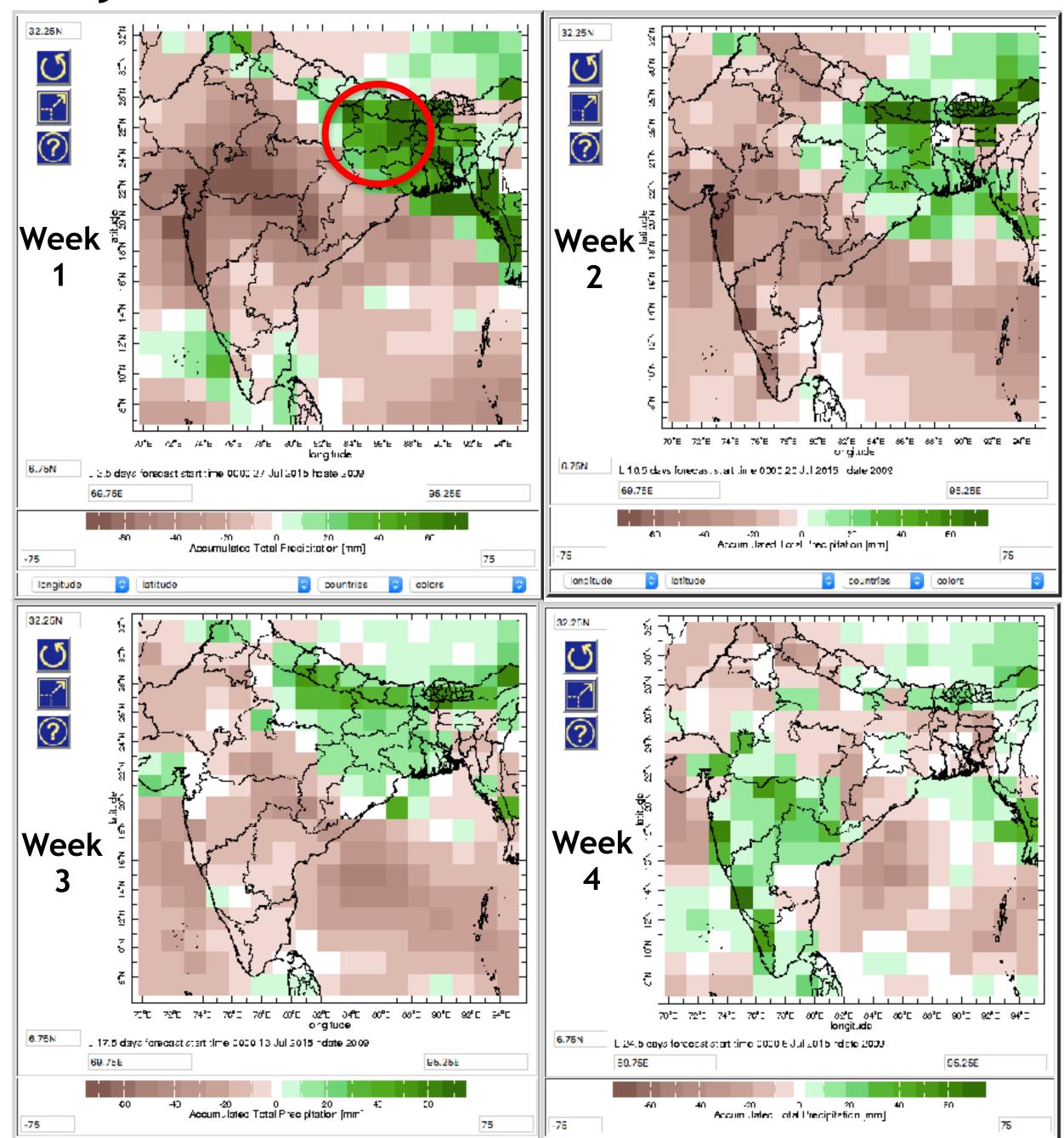


### How about the late-July burst of rain?



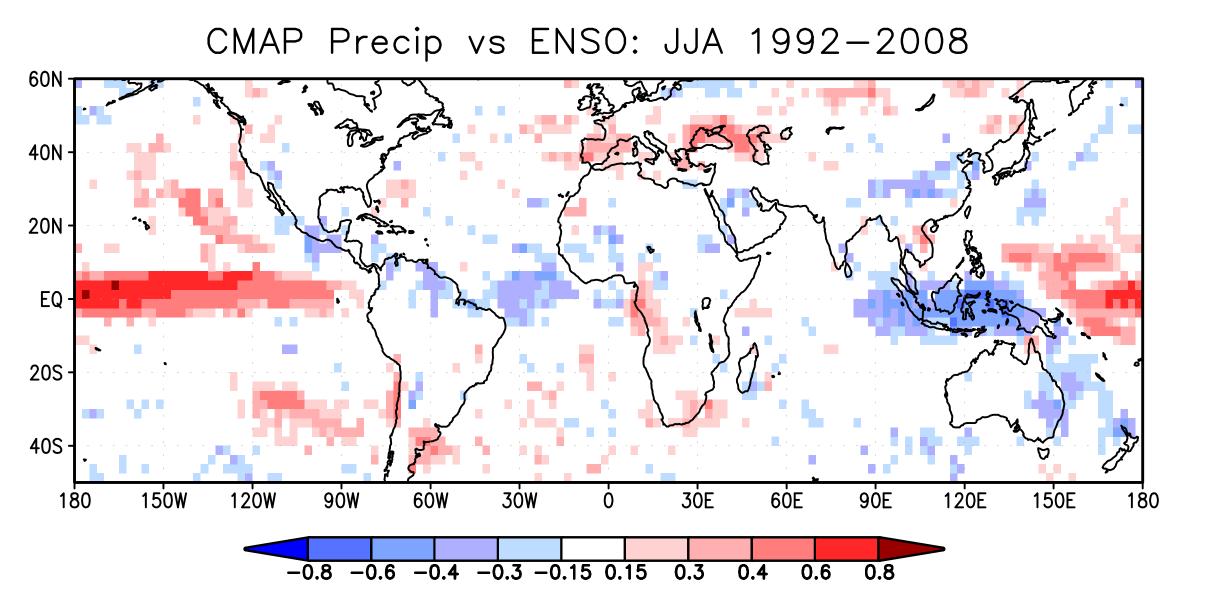


#### Target: 25–31 Jul 2009



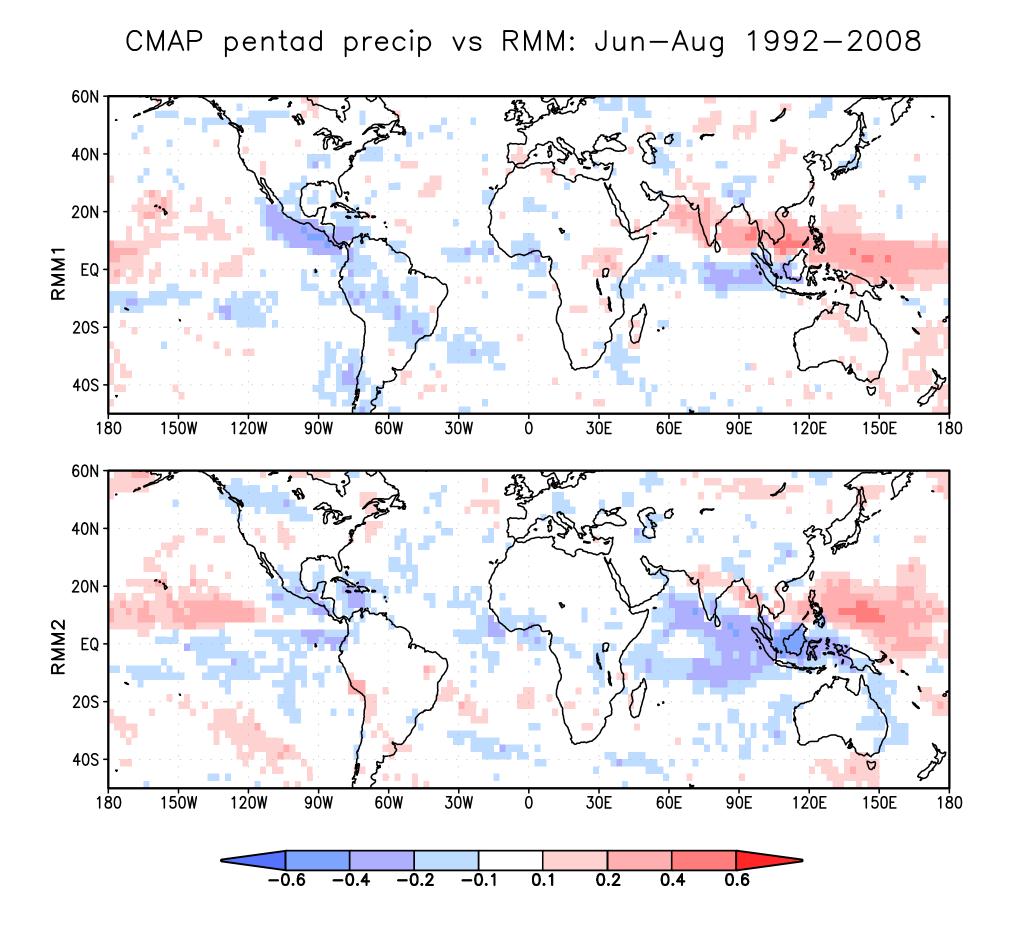
#### • where does this S2S predictability come from?

# ENSO & MJO Signals during boreal summer



#### Anomaly correlation coefficient

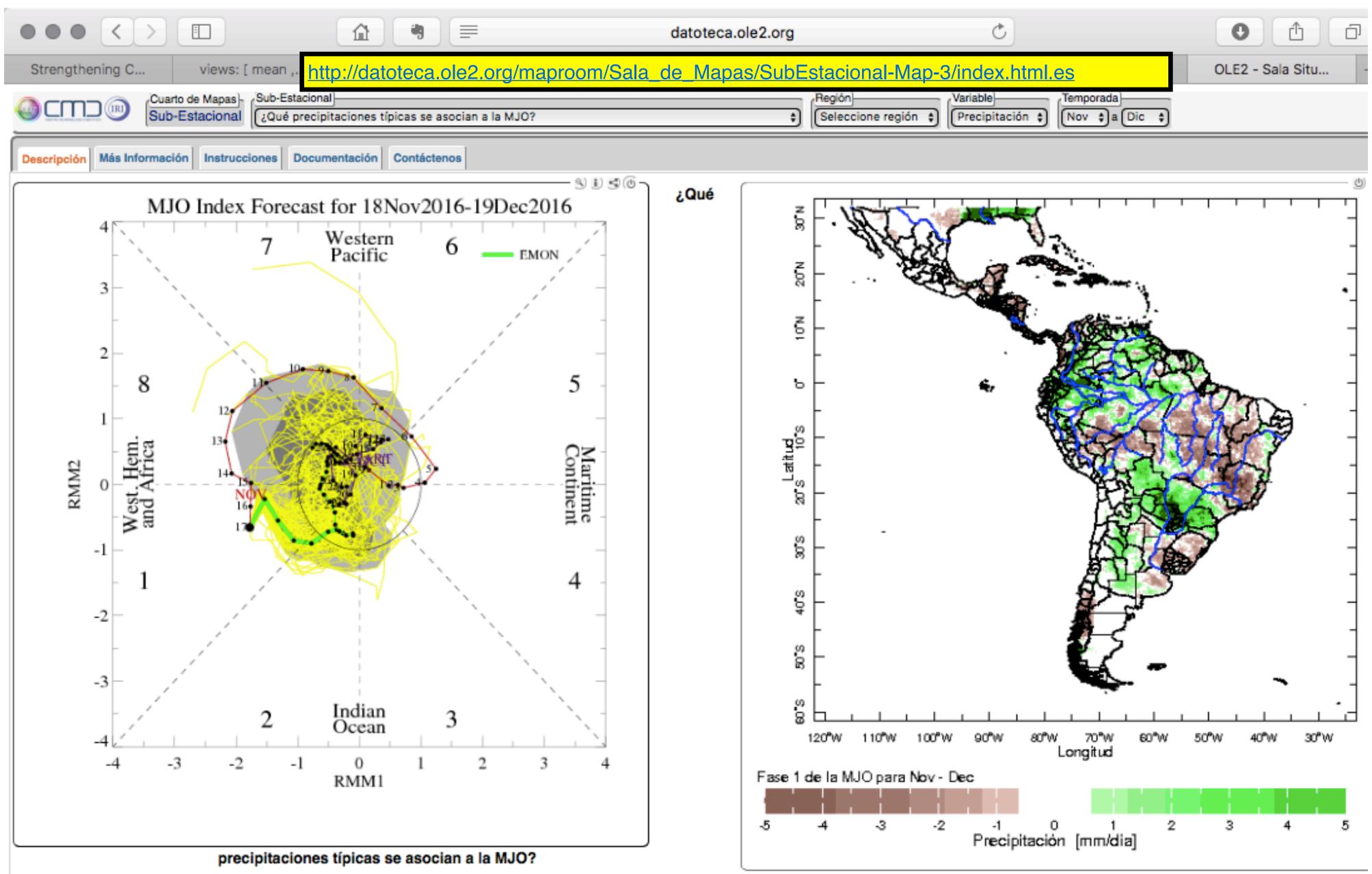
Li and Robertson (2015)



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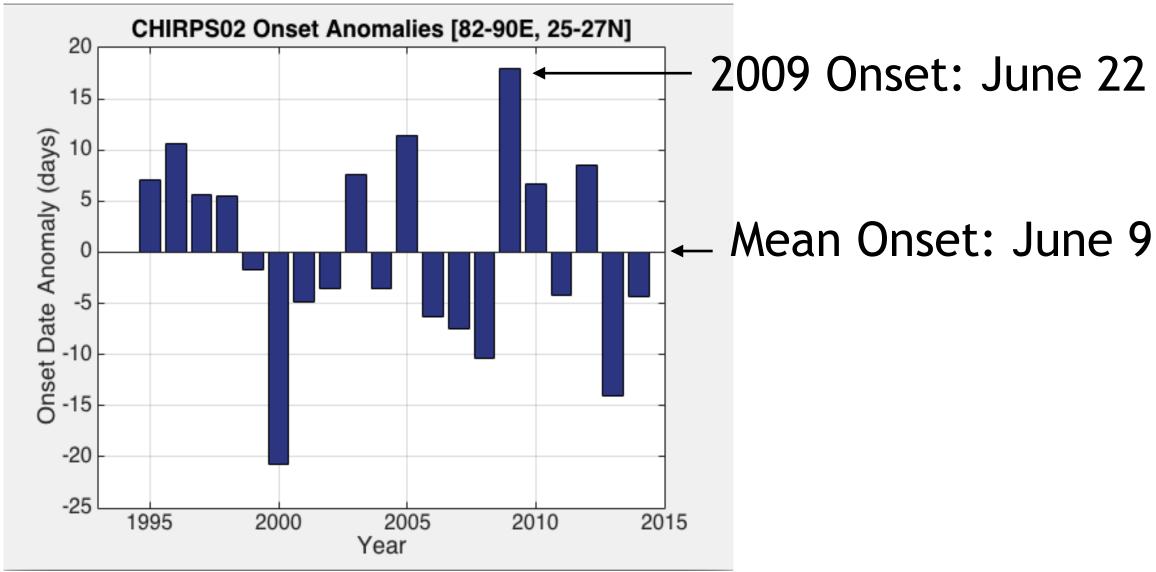


## Sub-seasonal Forecast Products



## Monsoon onset date

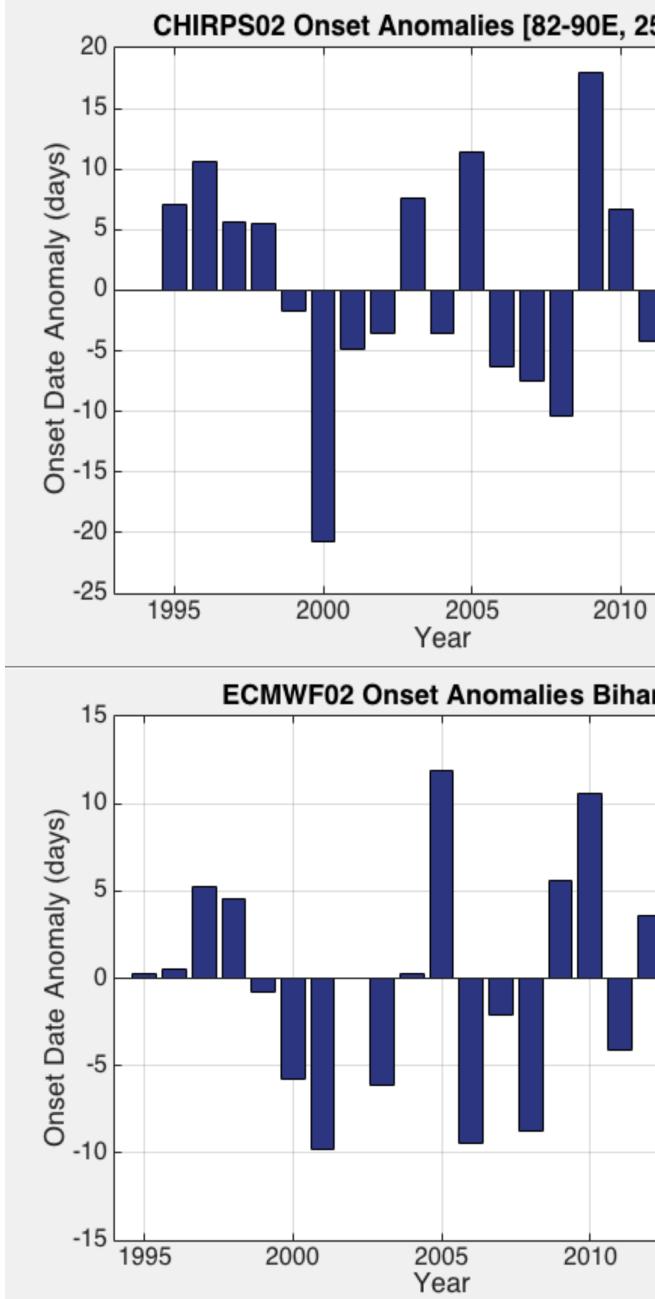
- Defined as the first wet day of the first 7-day wet spell, not followed by a long dry spell
- Calculated locally, then averaged over state of Bihar



2009 onset Mean 30 Zoom 🛟 [mm/day] --^ ? Sep Col Apr Мау Jun Jul Aug 2009 2009 2009 20092009 2009 2009 0.0 Time 0000 1 Apr 2009 2400 30 Sep 2009 15 20 2530 precipitation [mm/day]



#### How do ECMWF model forecasts of onset compare?



#### "Observed" Onset date

#### Forecasted Onset date

	et comp	ale:	Forecast	
25-27N]	Year	<u>Obs Onset</u>	Onset	Forecast Error
-	1995	June 16	June 12	- 4 days
	1996	June 20	June 12	- 8 days
	1997	June 14	June 17	+ 3 days
	1998	June 14	June 16	+ 2 days
	1999	June 8	June 11	+ 3 days
	2000	May 19	June 6	N/A
	2001	June 4	June 2	- 2 days
	2002	June 6	N/A	N/A
	2003	June 16	June 6	- 10 days
0 2015	2004	June 6	June 12	+ 6 days
2015	2005	June 21	June 24	+ 3 days
ar	2006	June 3	June 2	- 1 day
	2007	June 2	June 10	+ 8 days
	2008	May 31	June 3	+4 days
	2009	June 27	June 17	- 10 days
	2010	June 16	June 22	+ 6 days
	2011	June 5	June 8	+ 3 days
	2012	June 18	June 15	- 3 days
	2013	May 26	June 6	N/A
	2014	June 5	June 22	+ 17 days

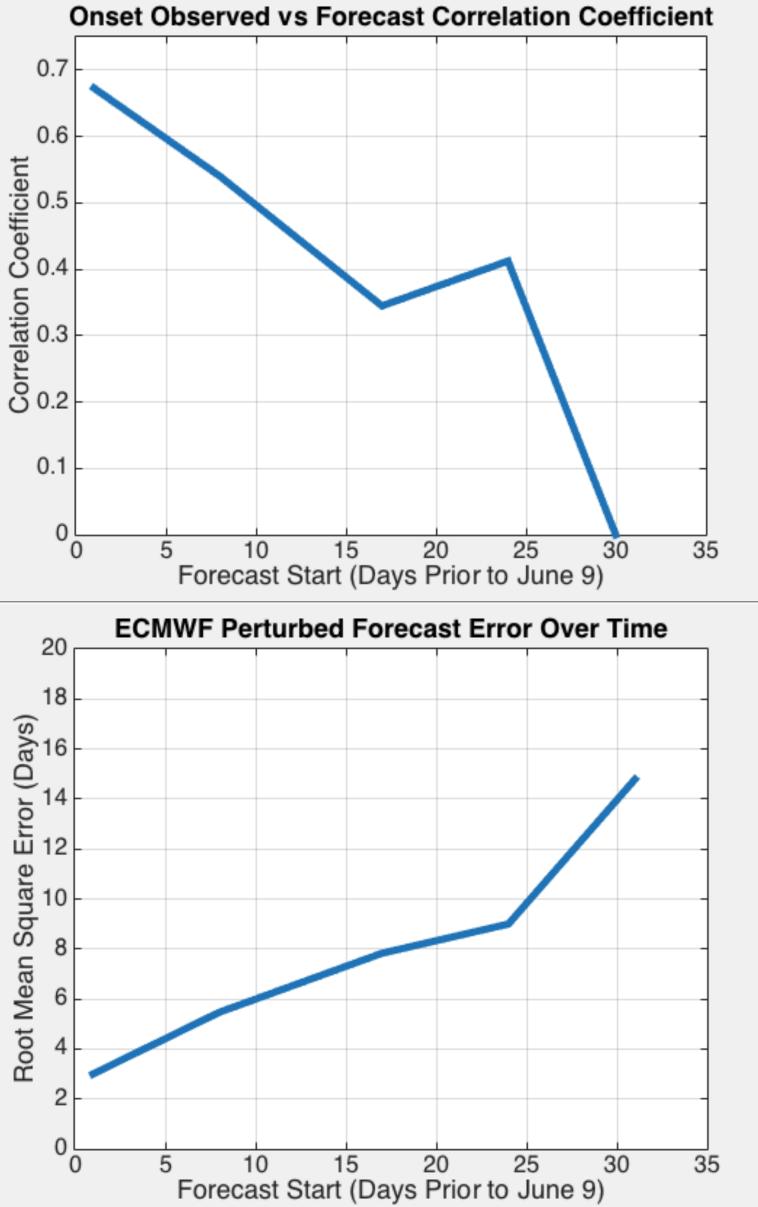
2015

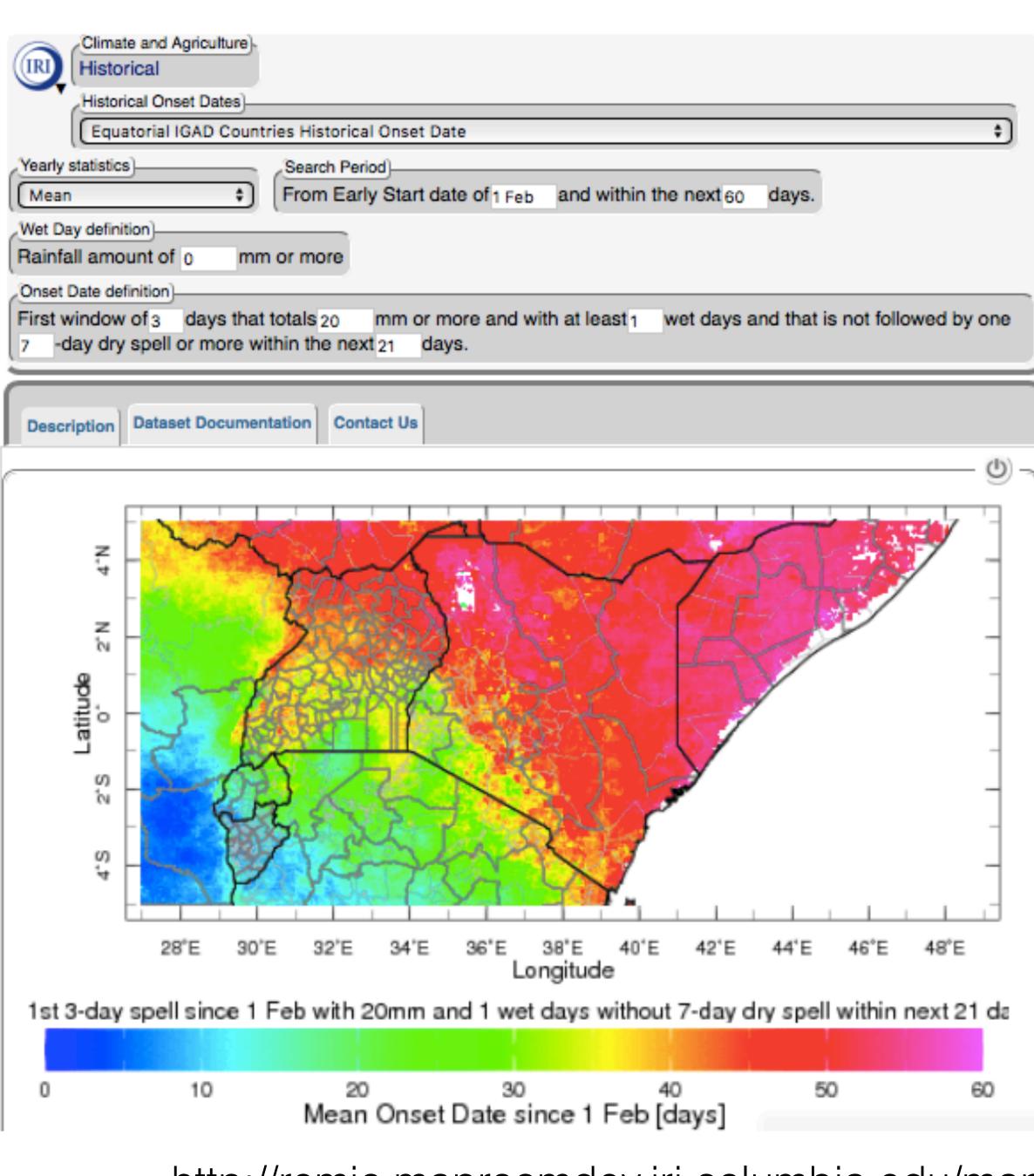


### Correlation Coefficient

Root Mean Square Error

## Forecast Skill Charts

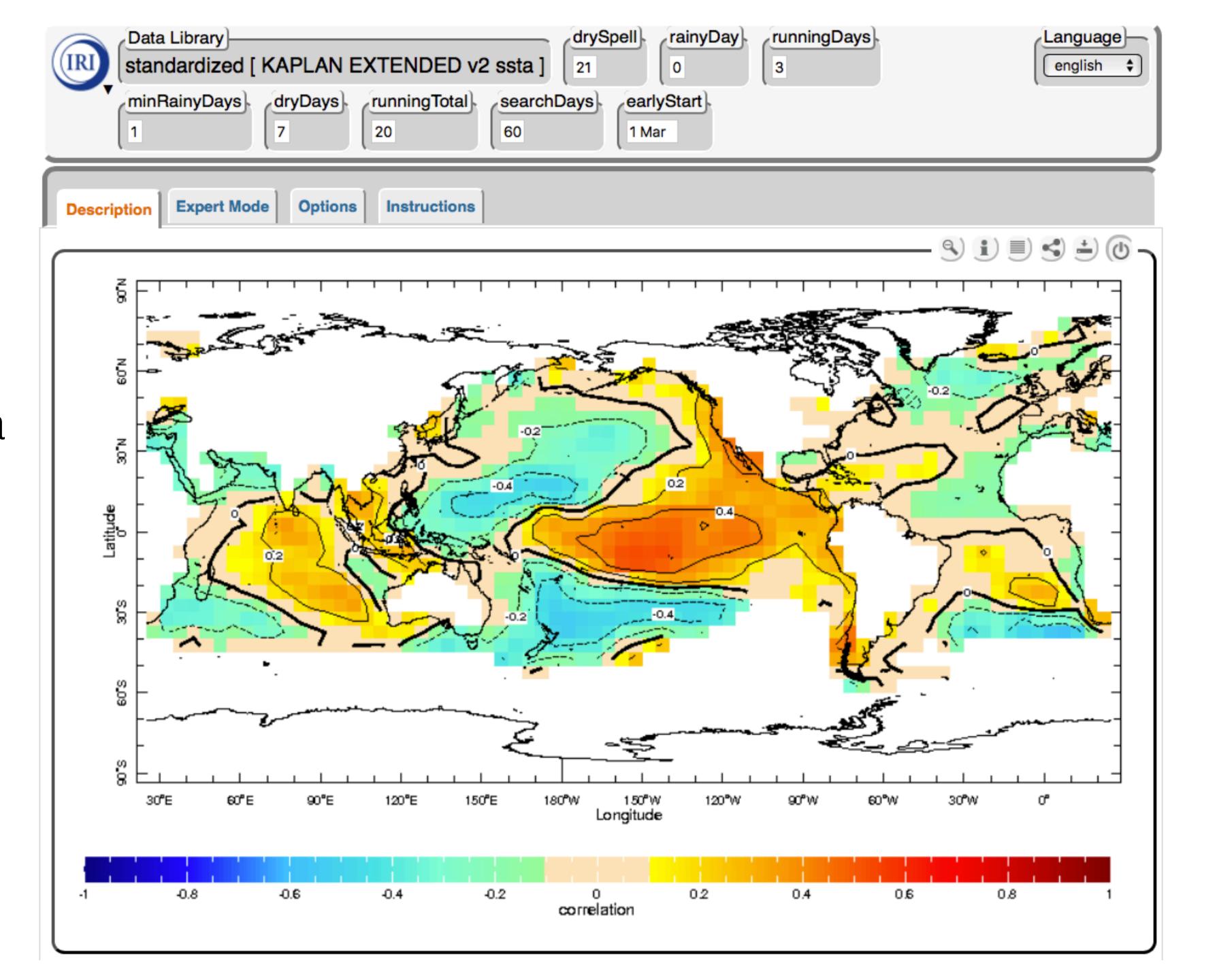




http://remic.maproomdev.iri.columbia.edu/maproom/Agriculture/Historical\_Onset/ICPAC\_Eq\_Onset.html

# Onset Date Maproom





#### Correlations of E Africa Onset date with Jan–Mar SST 1981–2015

#### what about Africa?

### **Africa sub-project**

#### Main Goal

To develop skilful forecasts on the S2S time scale over Africa and to encourage their uptake by national meteorological services and other stakeholder groups.

#### **Objectives:**

- and other stakeholder communities.
- their representations in models.
- •

Assess the performance of forecasts for 5-40 days ahead using the S2S forecast archive, with focus on rain-day frequency, heavy rainfall events, dry spells and monsoon onset/ cessation dates, with relevance to agriculture, water resources and public health.

Develop metrics for measuring the success of forecasts in ways that are useful for farmers

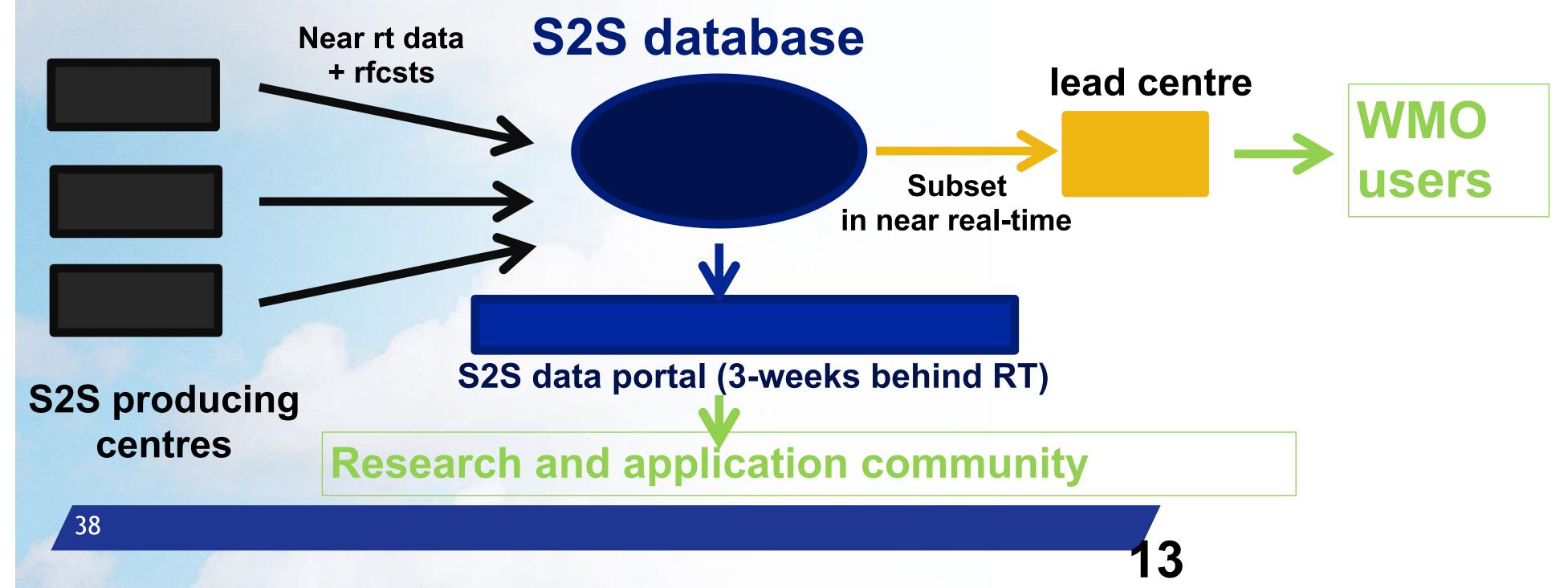
Improve understanding of the climate modes that drive sub-seasonal variability in Africa and

The Africa sub-project will work with post-Africa Climate Conference 2013 framework (recently named "Climate Research for Development CR4D)" to connect international with African climate communities. An S2S activity is envisaged to be one of the first CR4D pilot activities, through a joint CR4D-S2S proposal to Future Earth program funding.

### Linkage with WMO Operational Activities

#### A major goal of S2S is to support CBS operational sub-seasonal activities

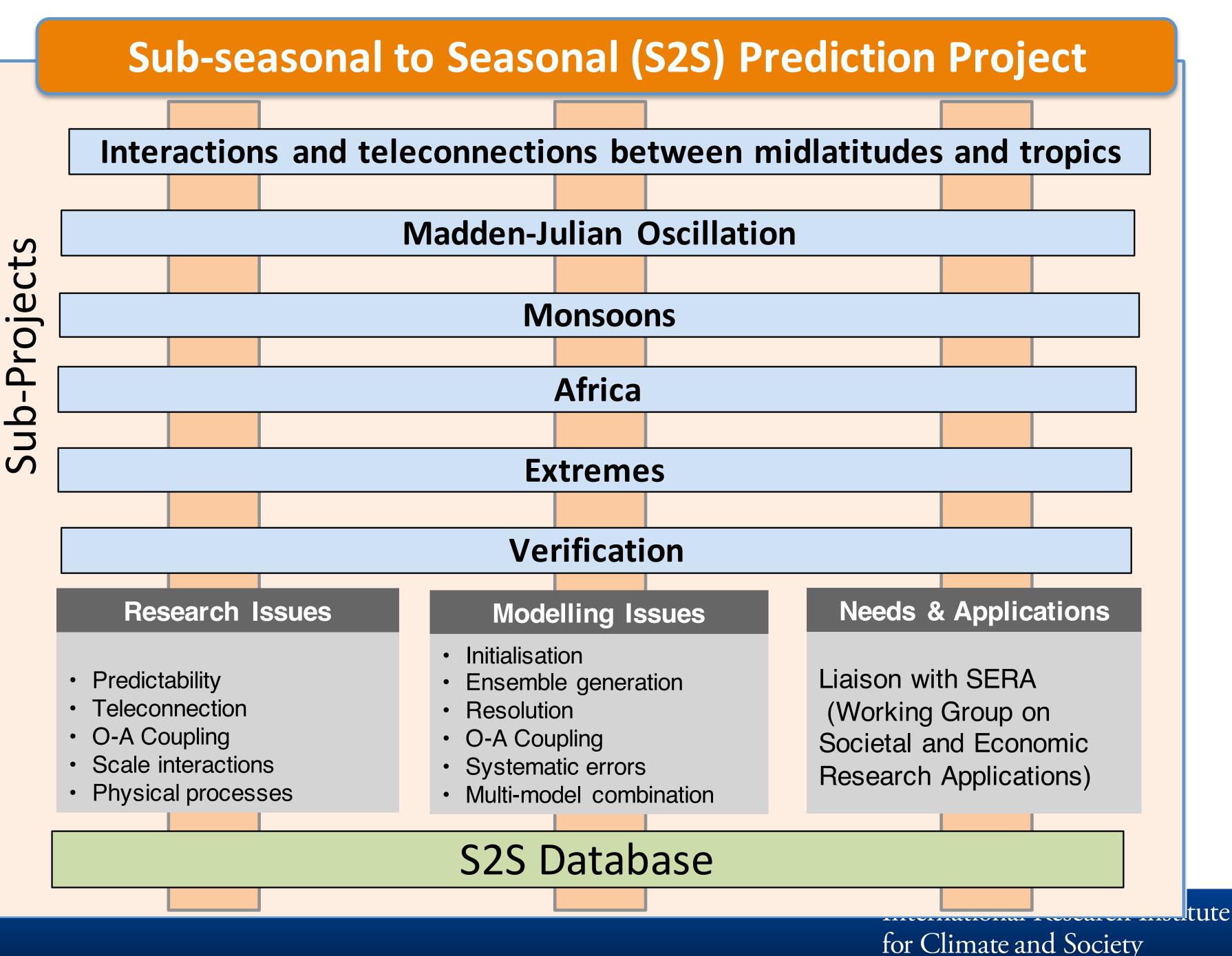
- sub-seasonal prediction as they develop under CBS.]
- **CBS** activities.



Research into sub-seasonal predictability under S2S will be conducted in close liaison with developing infrastructure and procedure for operational

It has been proposed to use the S2S database to exchange real-time data for

## Summary of S2S



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