Sub-Seasonal to Seasonal Forecasting and the S2S Project

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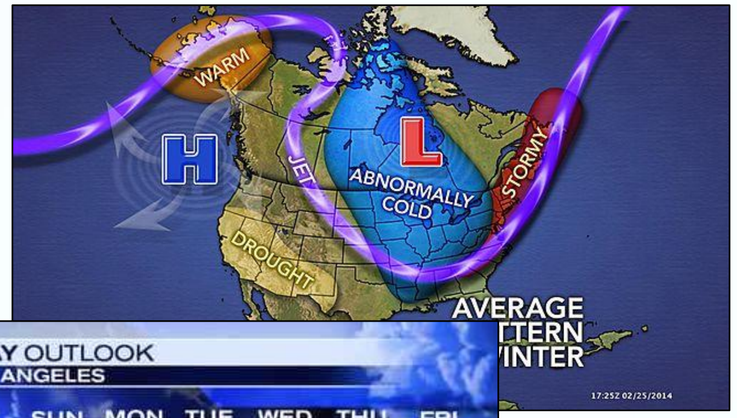
Many decisions in agriculture, water, disaster risk reduction and health fall in the sub-seasonal to seasonal (S2S) range. This time scale has been considered a "predictability desert", and received less work than medium-range and seasonal prediction. The goal of a new WWRP-WCRP joint research project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

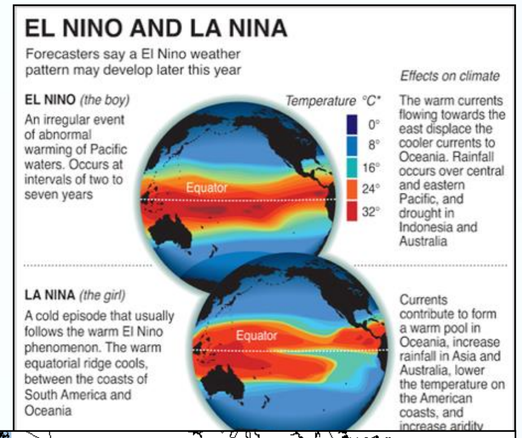
Weather vs Climate Forecasts

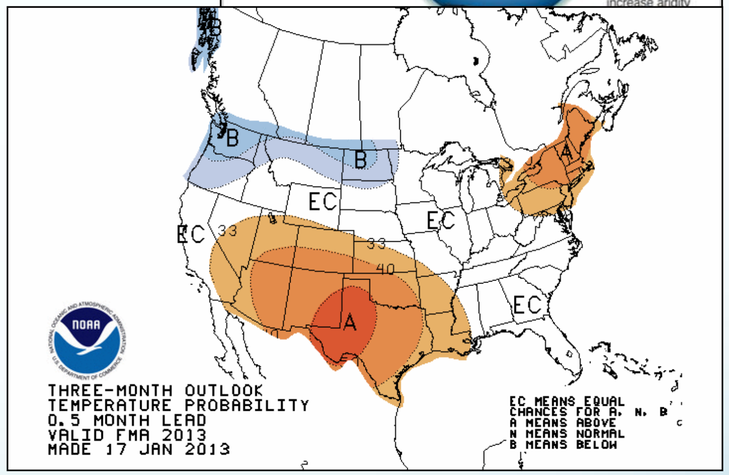


Weather Forecasts ~ O (10 Days)

(Mid-Latitude Baroclinic Instability & Cyclone Lifetime)

Dynamic Forecasts root back to 1910





Seasonal Forecasts ~ O (100 Days)

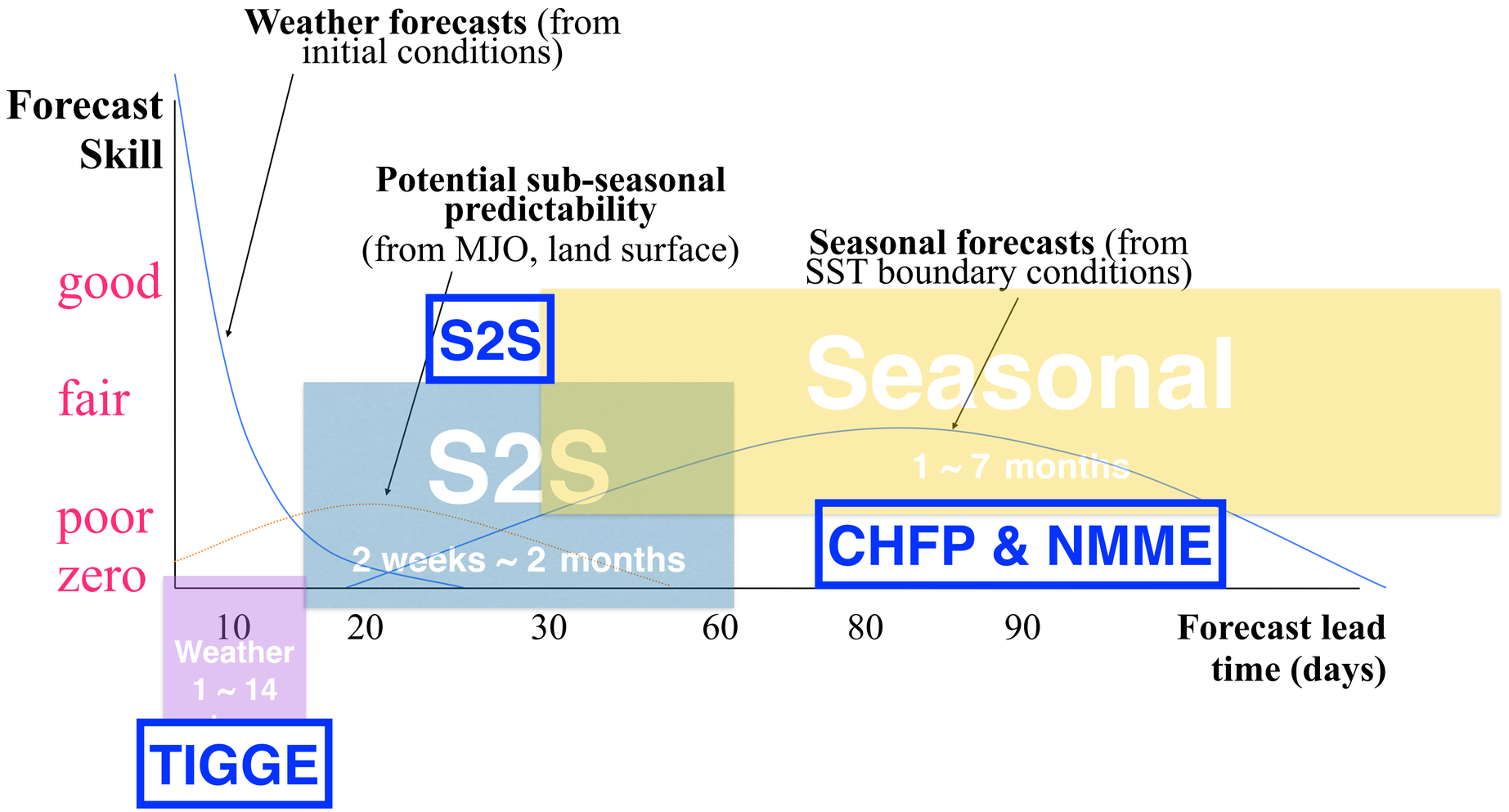
(ENSO phenomena & Local/Remote Circulation Impacts)

Dynamic Forecasts root back to Mid-1980's

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

from D. Waliser

Forecast Databases

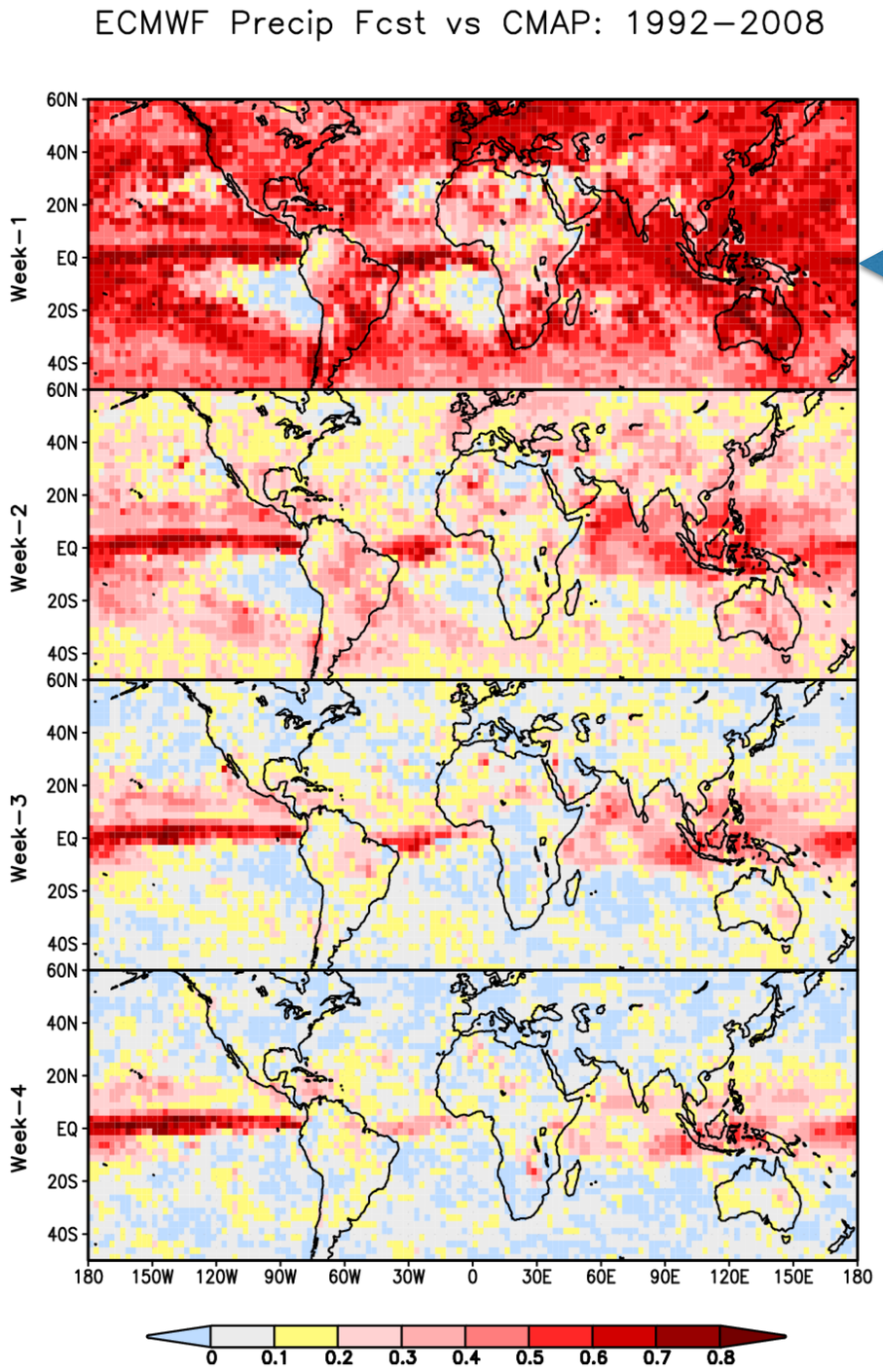


from Tony Barnston, IRI

ECMWF Sub-monthly forecast skill

Weekly average precip

Jun–Aug anomaly correlation skill



skill from atmos ICs

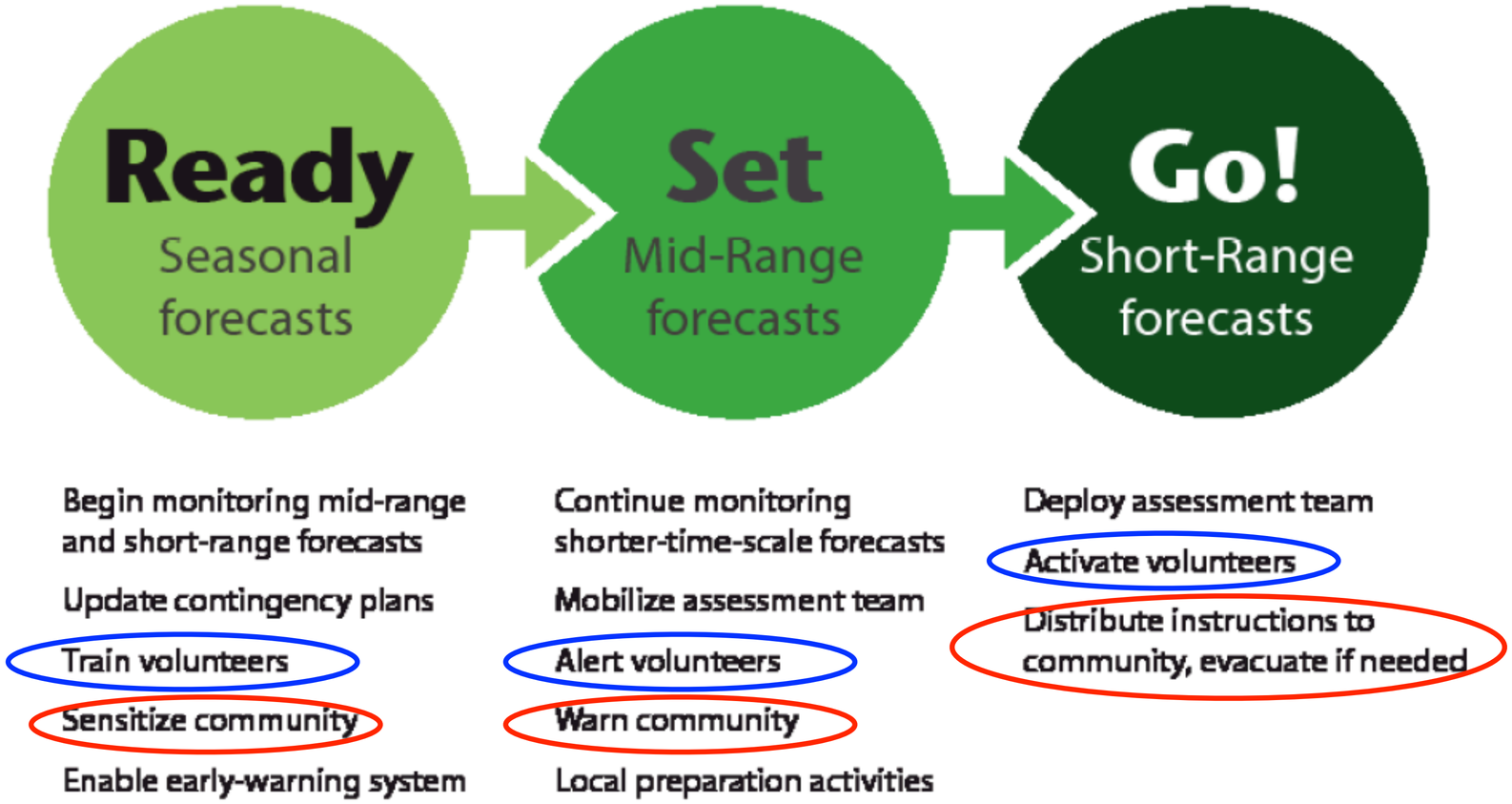
skill from MJO, surface BCs, …

Li and Robertson (2015)

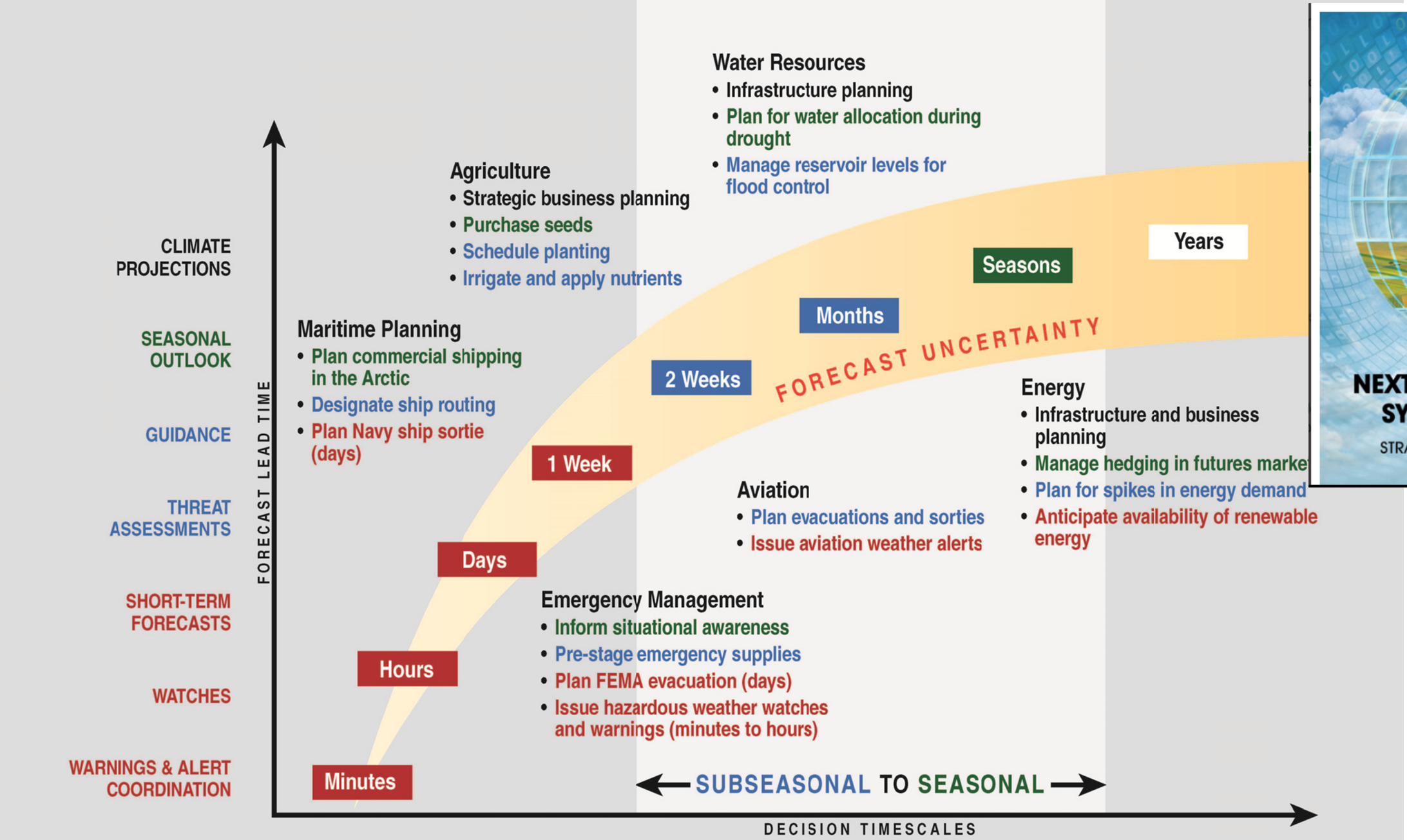
S2S Forecasts are…

- More **frequently updated** (sub-weekly) than seasonal ones
- More **specific** about timing of high-impact weather events, providing daily-weekly fields
- Connect **weather and climate know-how**
- Bring **early-warning to early action**

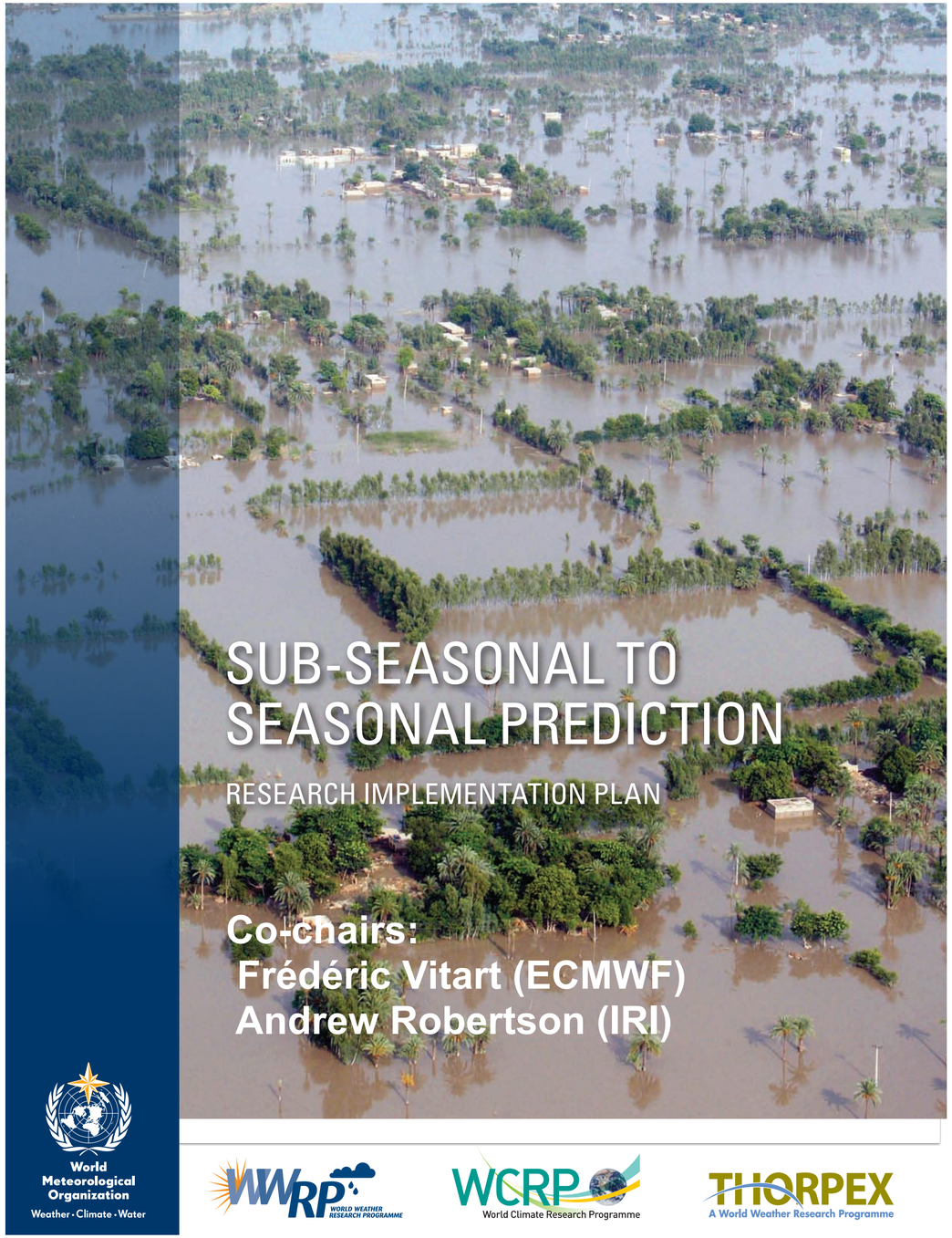
Opportunity to use information on *multiple* time scales



Source: M. Daly



https://www.nap.edu/catalog/21873/next-generation-earth-system-prediction-strategies-for-subseasonal-to-seasonal



Subseasonal-to-Seasonal S2S Prediction Project

- 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.

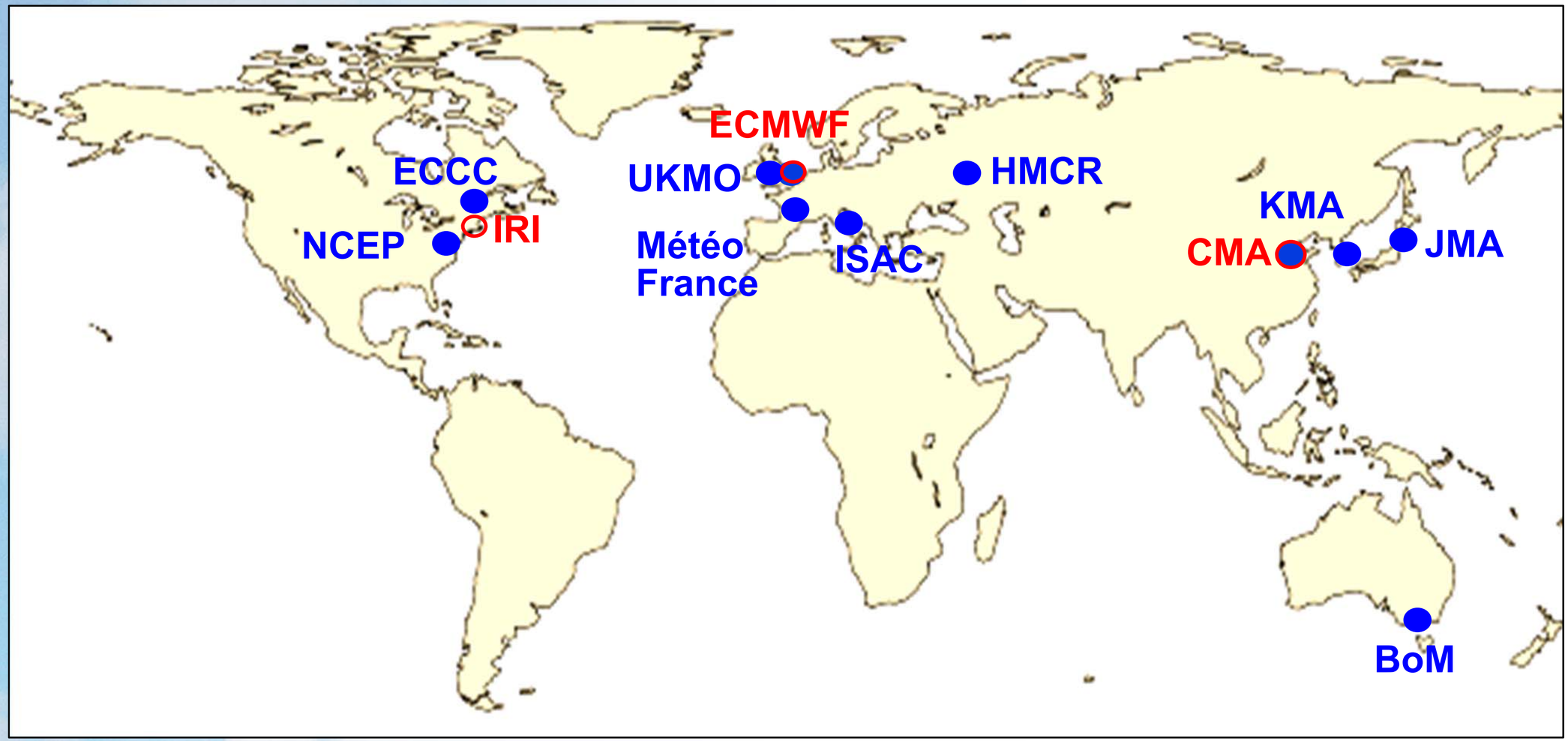
The project focuses on the forecast range between 2 weeks and a season.

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
CNR-ISAC	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

Models	Ocean coupling	Active Sea Ice
ECMWF	YES	Planned
UKMO	YES	YES
NCEP	YES	YES
ECCC	NO	NO
BoM	YES	Planned
JMA	NO	NO
KMA	YES	YES
CMA	YES	YES
CNRM	YES	YES
ISA-CNR	YES	NO
HMCR	NO	NO

Two ways to get S2S data from ECMWF

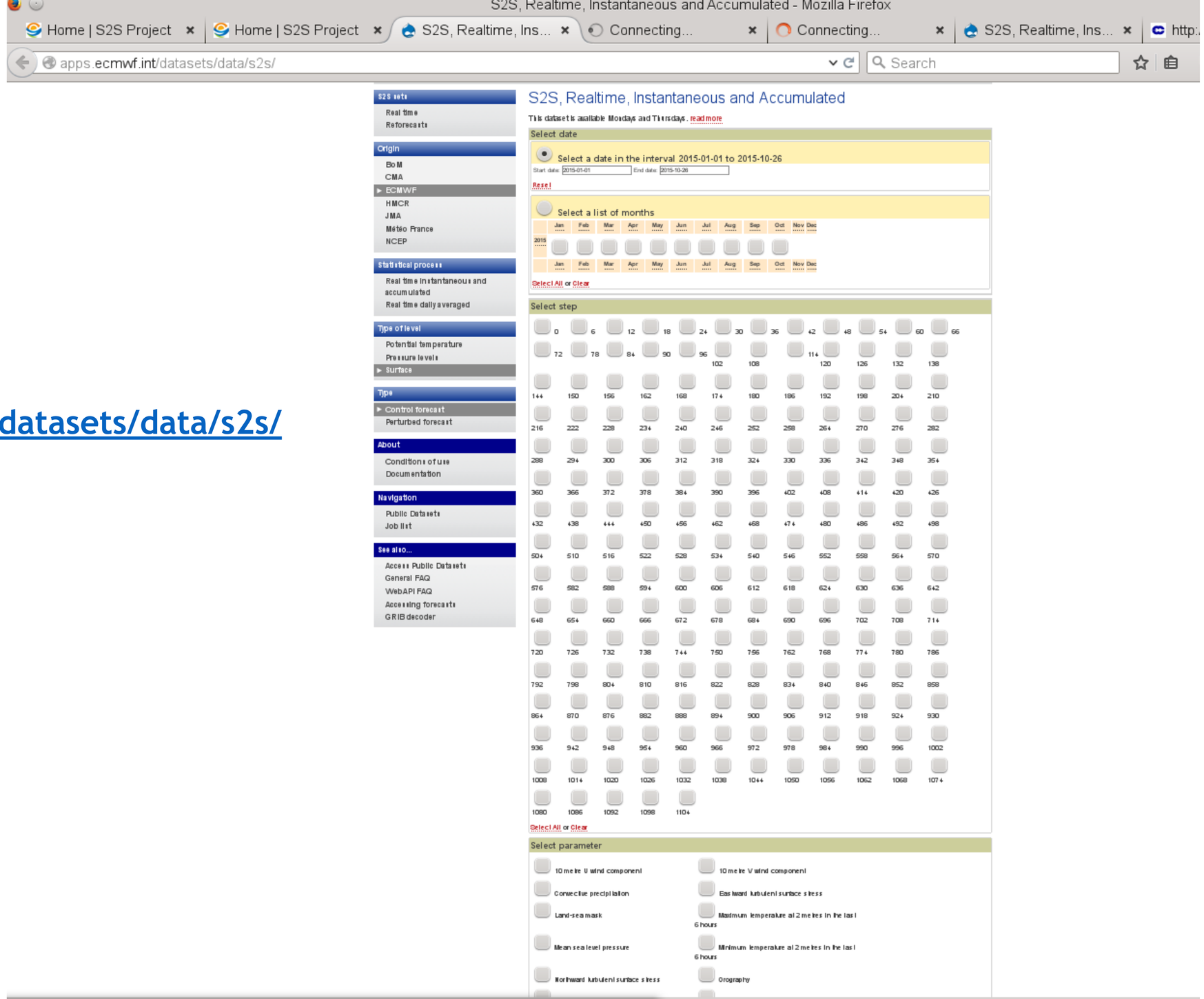
- **Web INTERFACE**: http://apps.ecmwf.int/datasets/data/s2s/

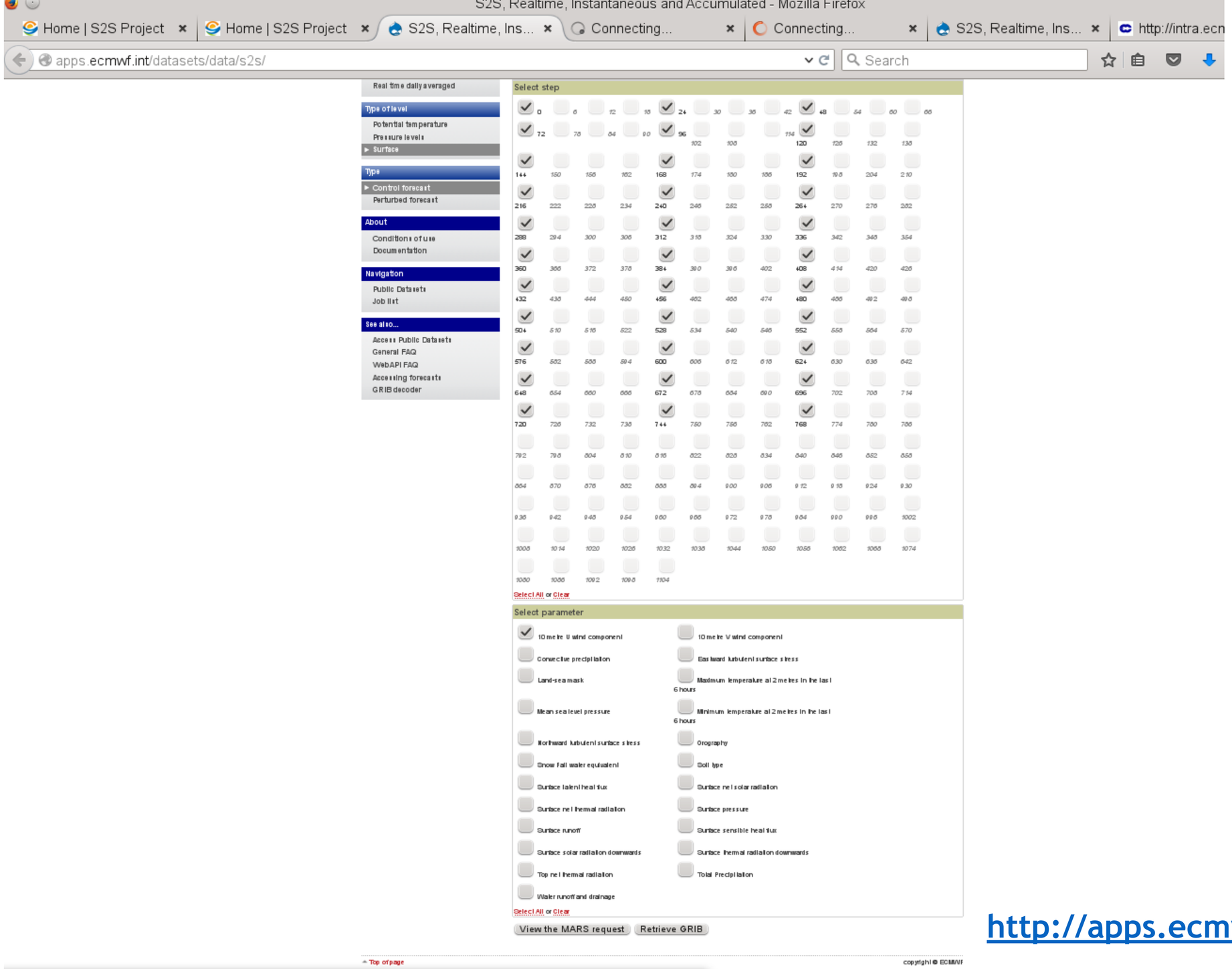
This is a “discovery” tool. Recommended for first time users. It gives a good idea of the content of the database, its structure and most importantly what is available. Easy to use. Good for small retrievals.

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

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





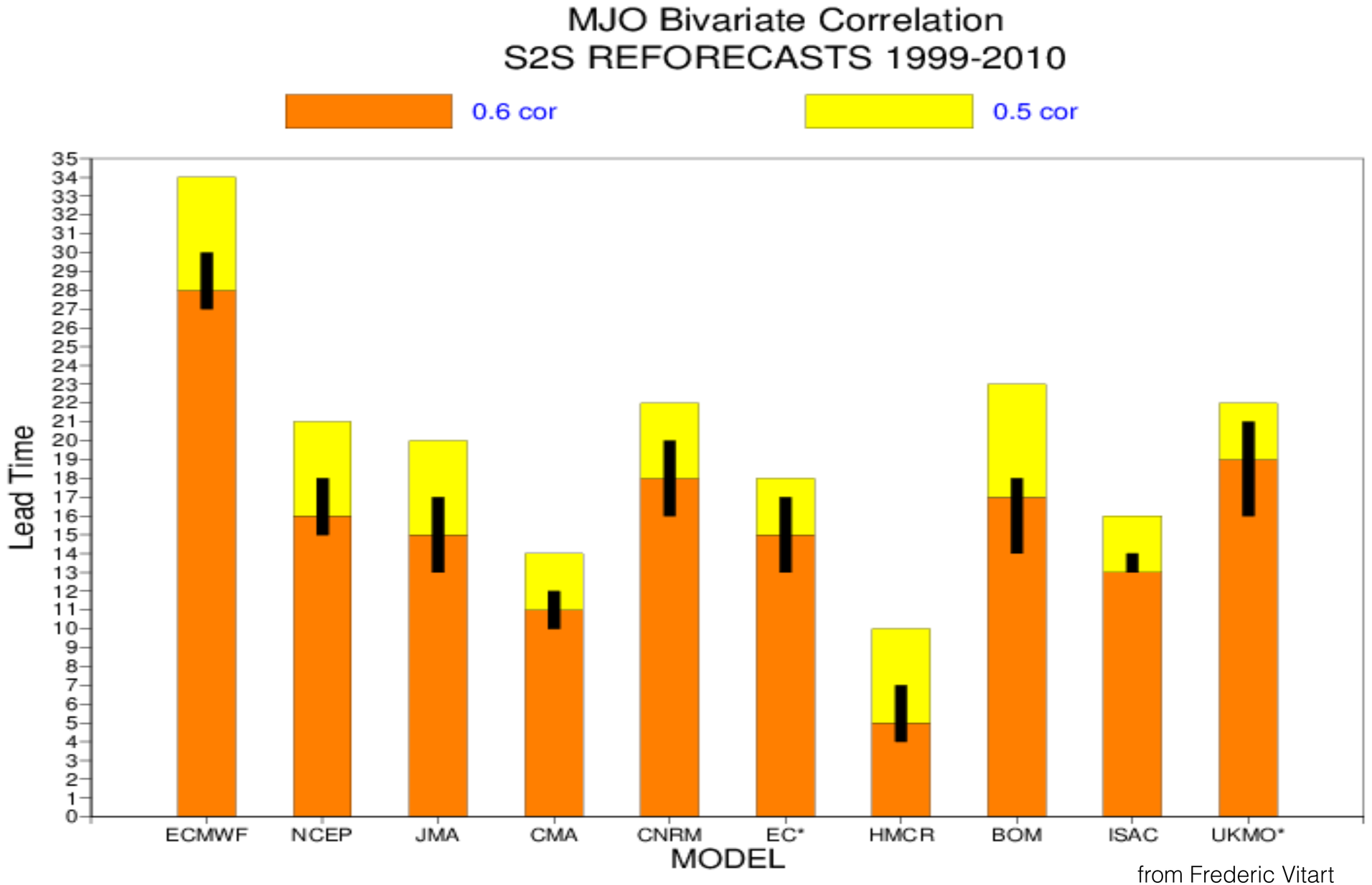
http://apps.ecmwf.int/datasets/data/s2

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",
    "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
/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",

Analysis of S2S Database



from Frederic Vitart

How should the target periods be defined for seamless forecasts?

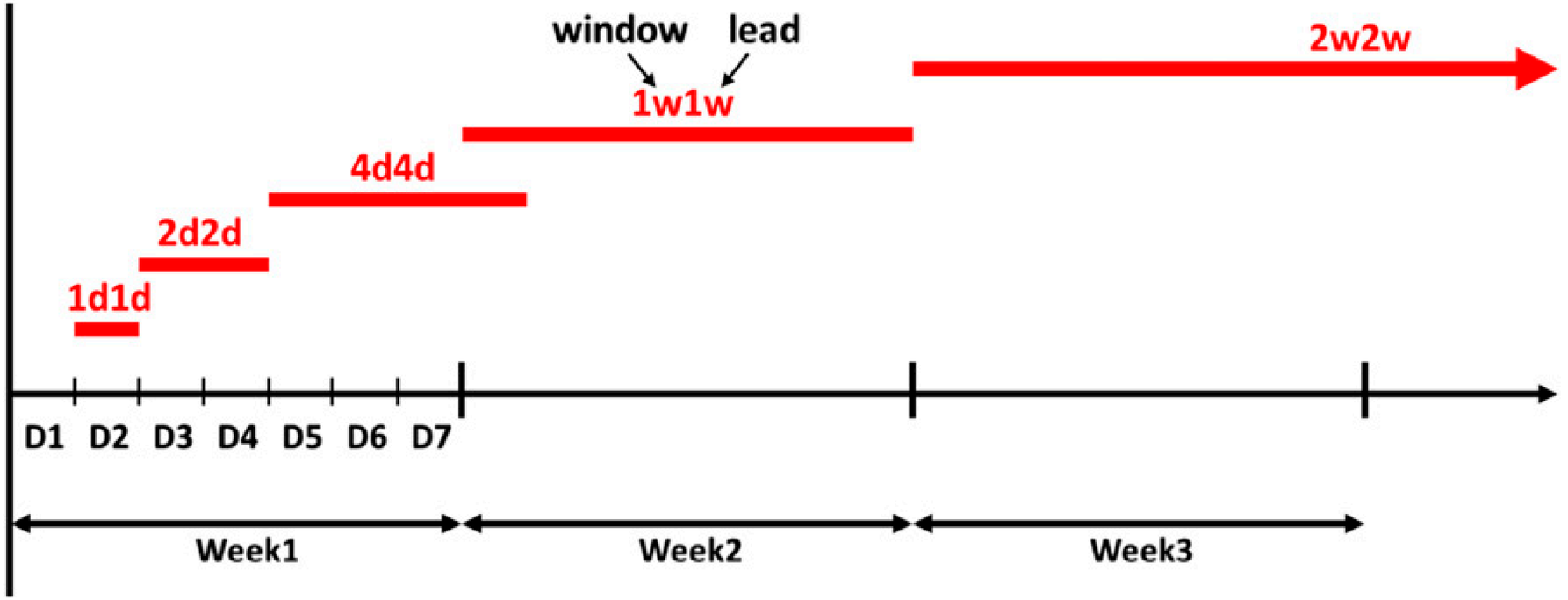
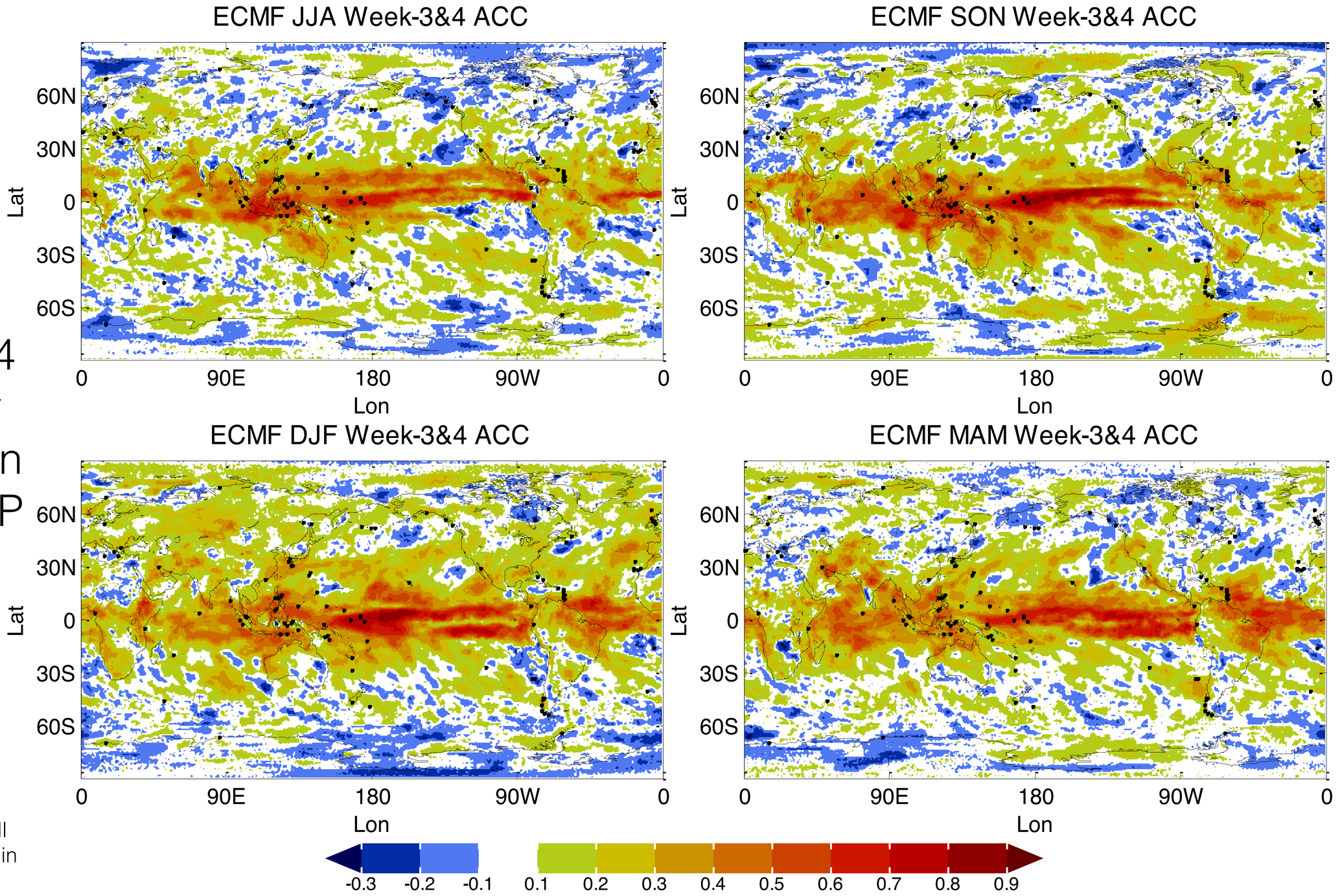


FIG. 1. Schematic of the time window and lead time definitions used in this analysis. The horizontal axis represents forecast time from the initial condition. The expression "1d1d" refers to an averaging window of 1 day at a lead time of 1 day. Similarly, "2d2d" represents an averaging window of 2 days 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)

ECMWF Week 3+4 Anomaly Correlation with CMAP data

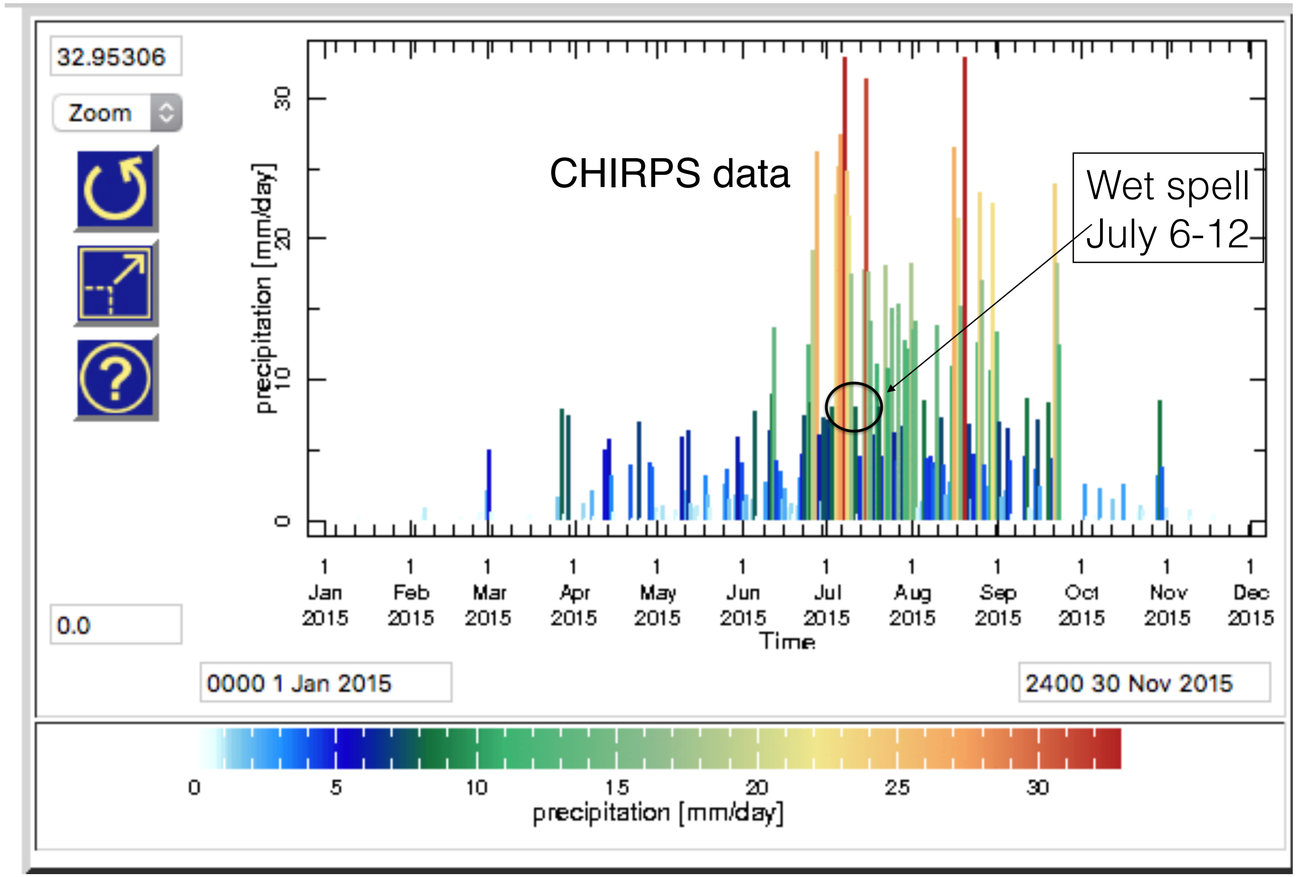


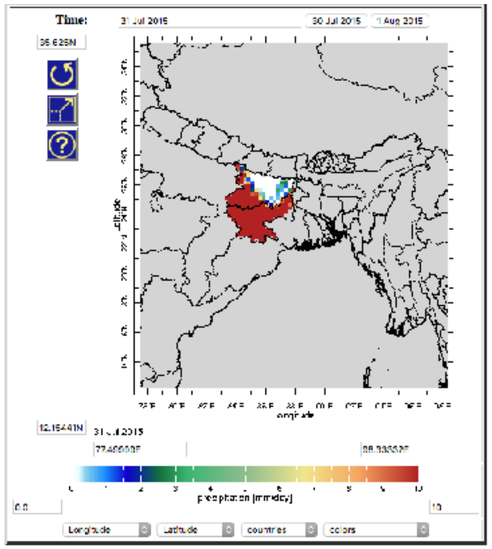
Included are all forecasts starts in each season

- 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

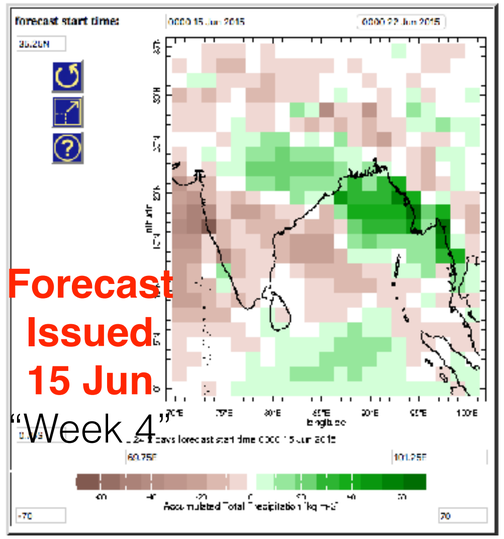
Can S2S Forecasts capture it?





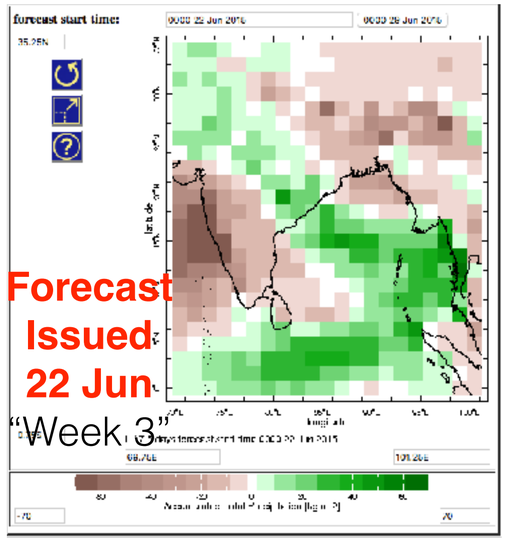
IRI Data Library

Diagnostics with S2S Database



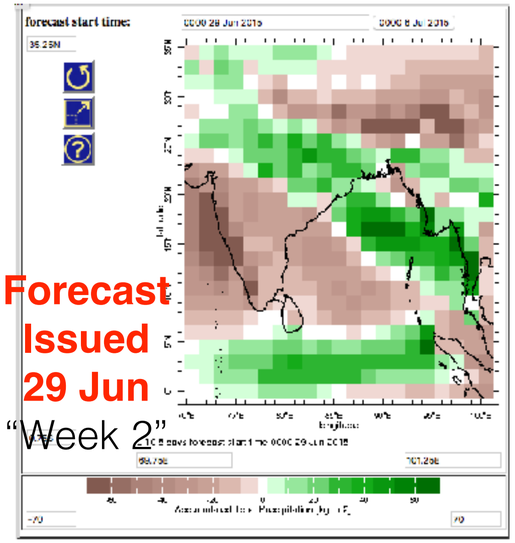
Forecast Issued 15 Jun

"Week 4"



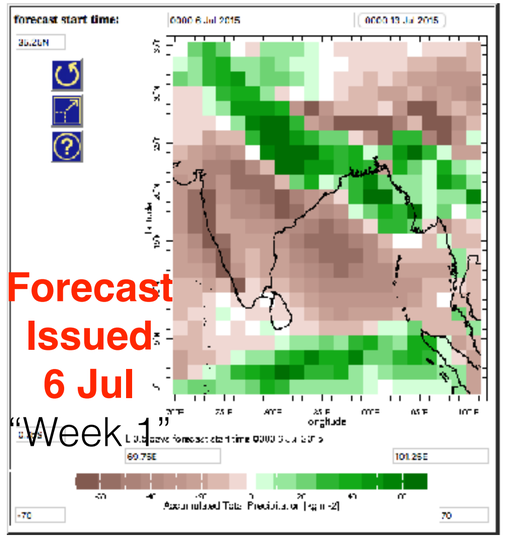
Forecast Issued 22 Jun

"Week 3"



Forecast Issued 29 Jun

"Week 2"



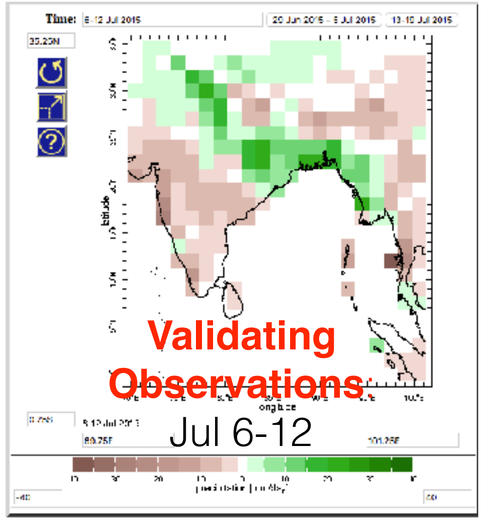
Forecast Issued 6 Jul

"Week 1"

ECMWF Forecasts

valid for Jul 6-12, 2015

Weekly average precip anomalies



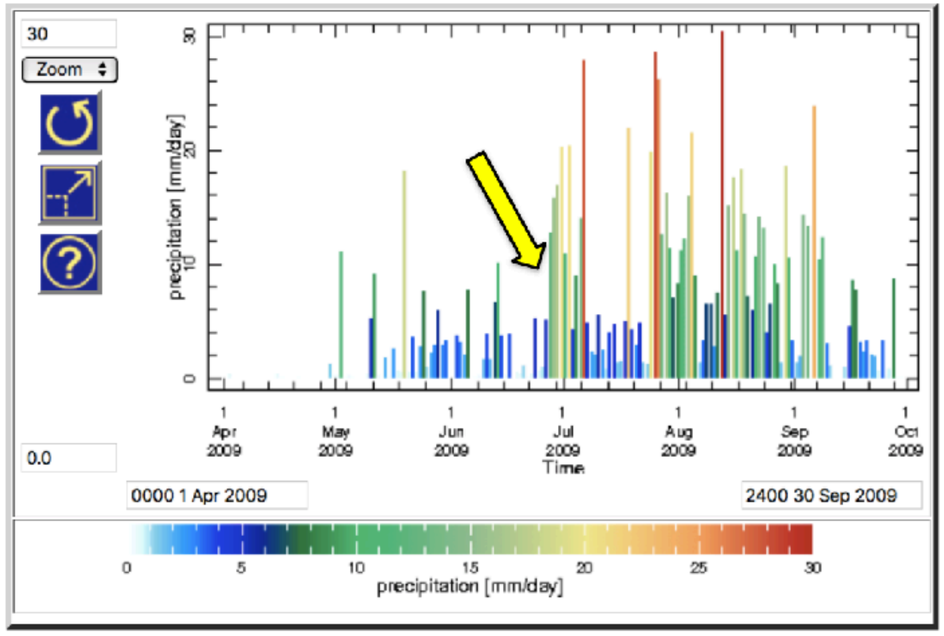
Validating Observations

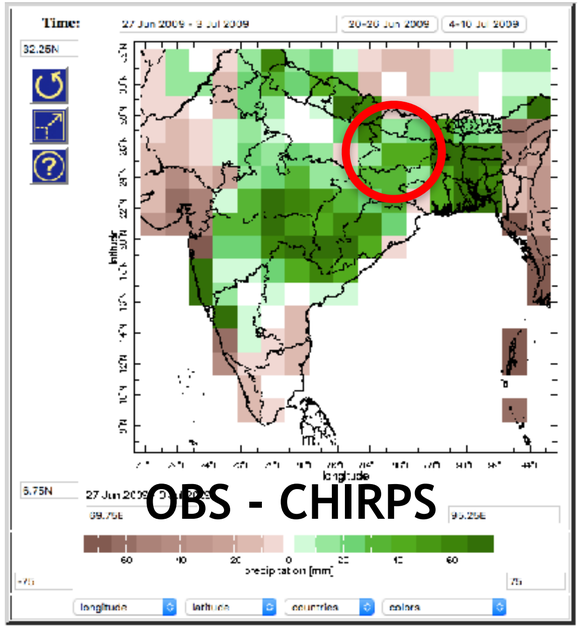
Jul 6-12

IRI Data Library

- some other cases …

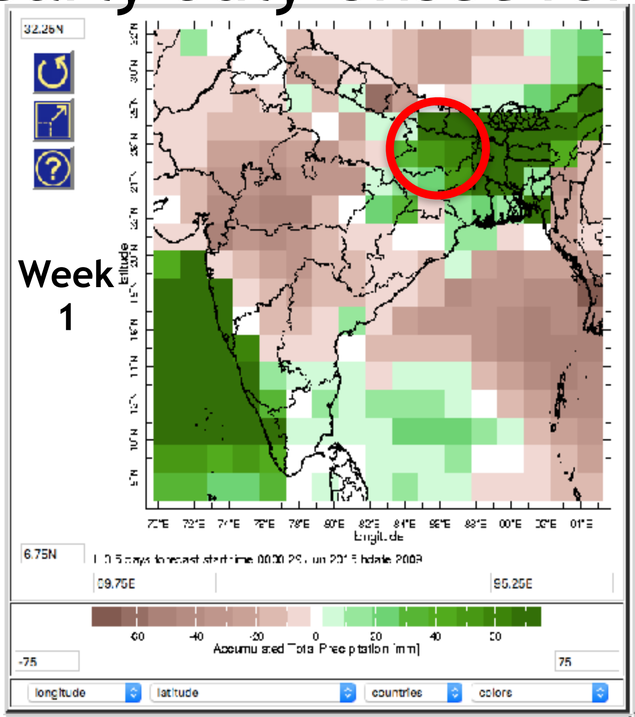
How well was the late June/early July onset forecasted?

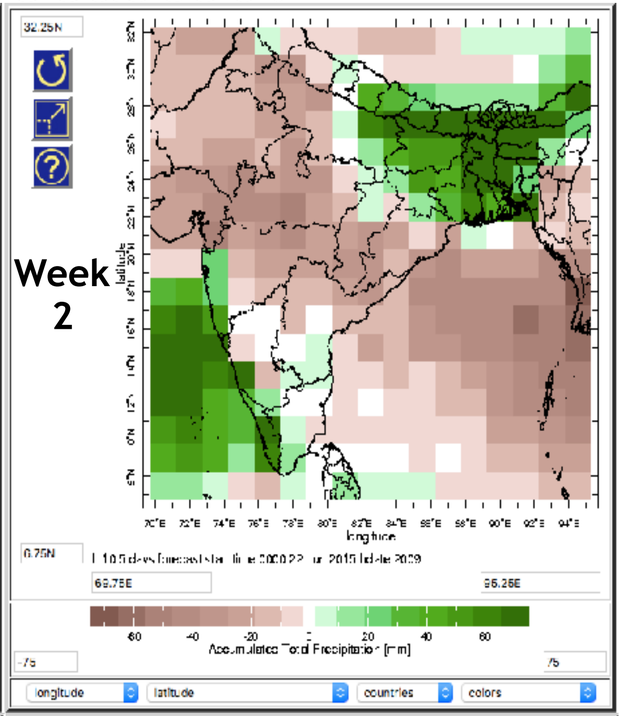


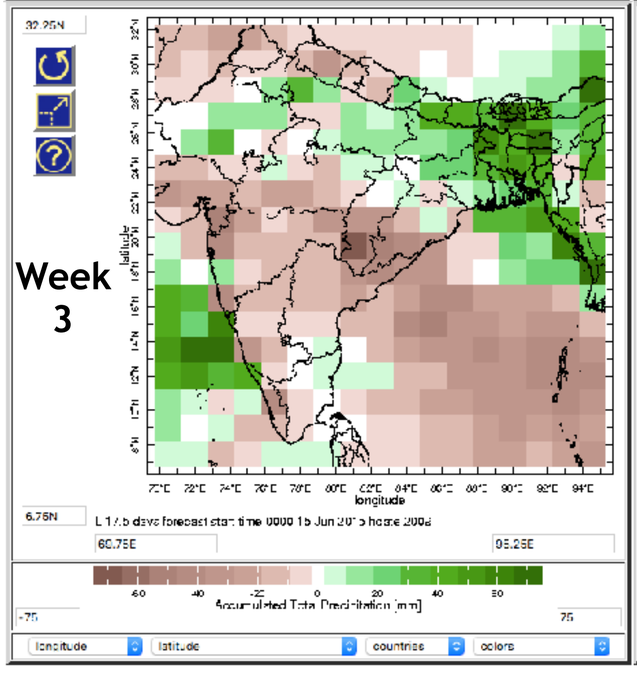


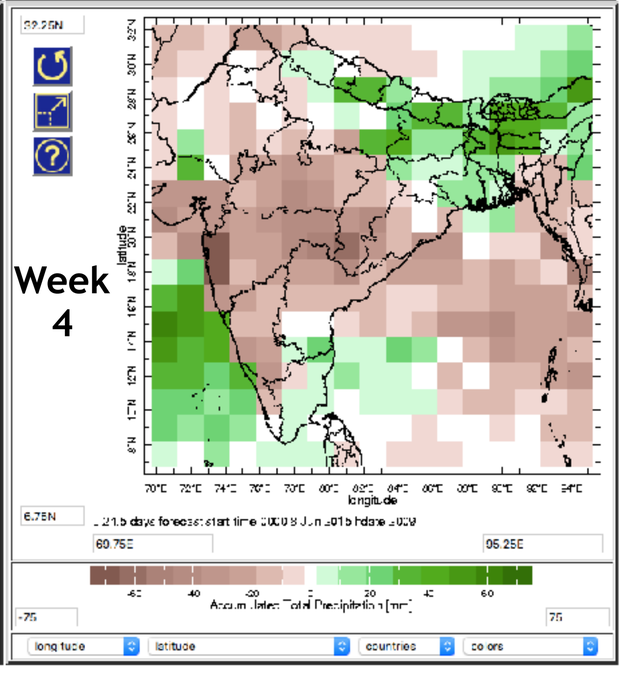
OBS - CHIRPS

Target:
27 Jun – 3 Jul
2009

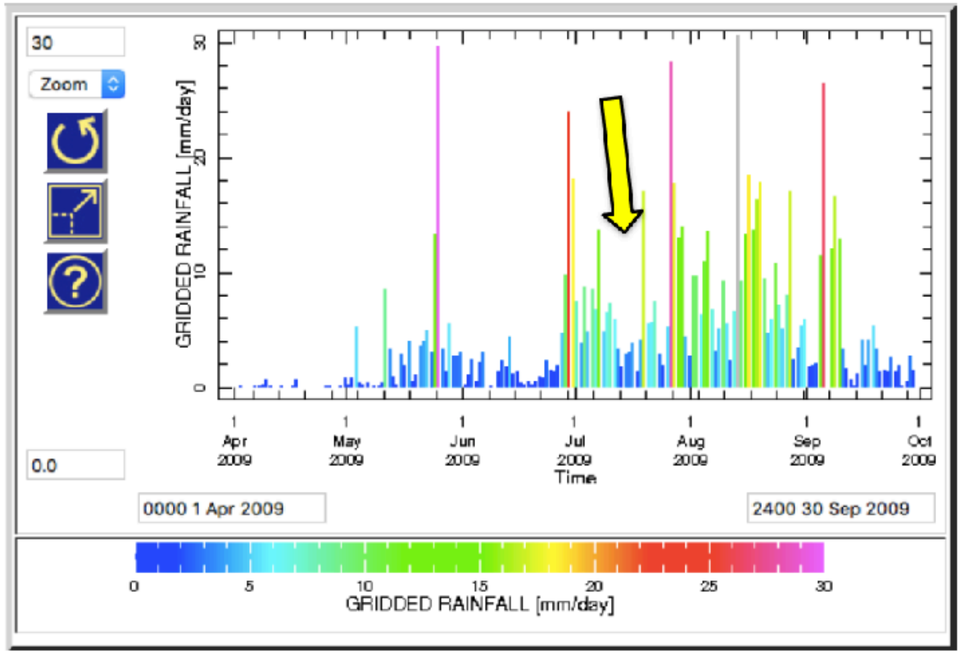


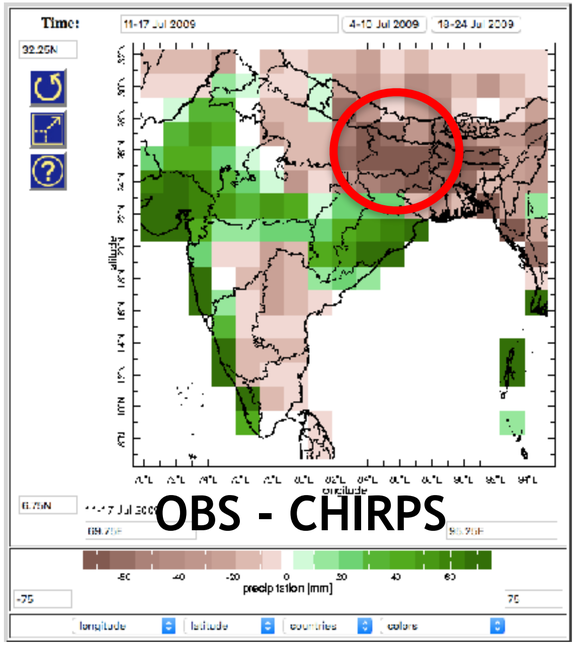






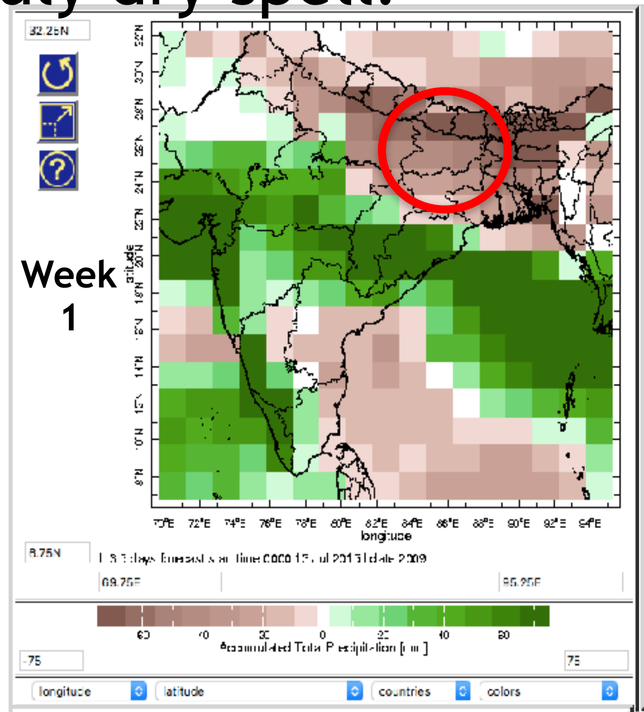
How about the mid-July dry spell?

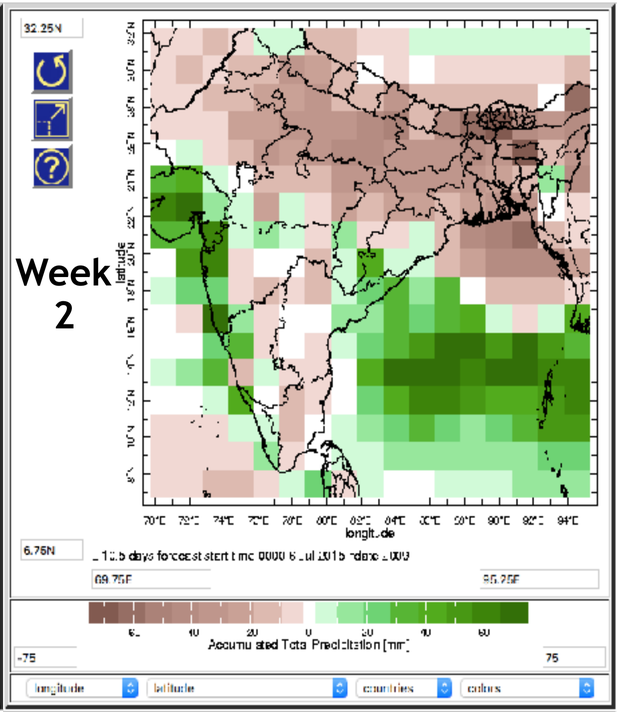


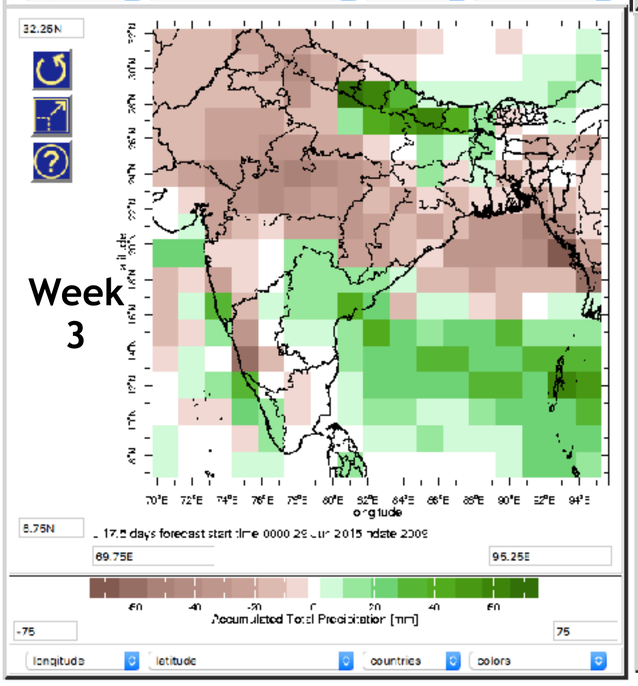


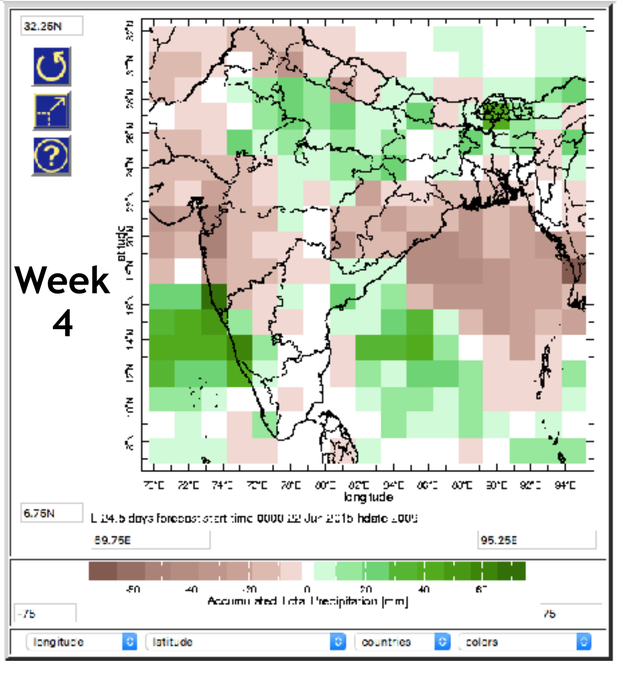
OBS - CHIRPS

Target:
11–17 Jul
2009

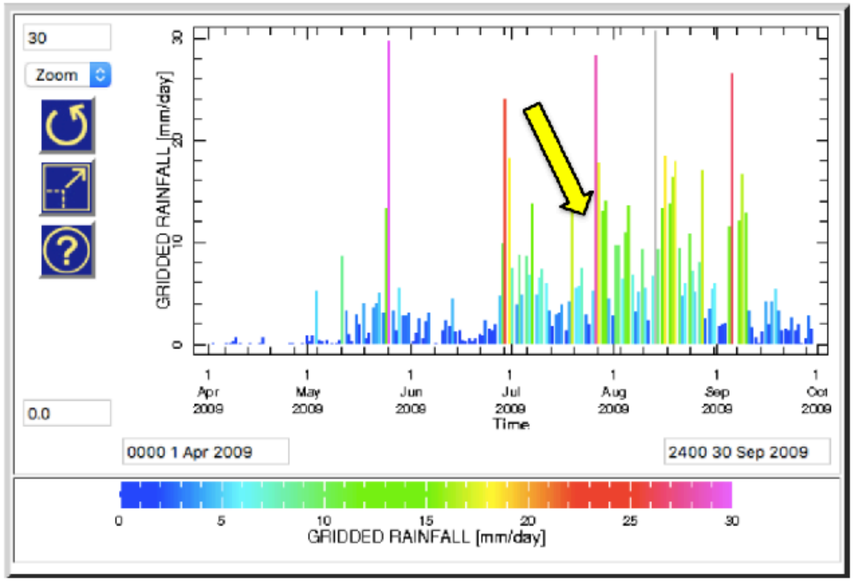


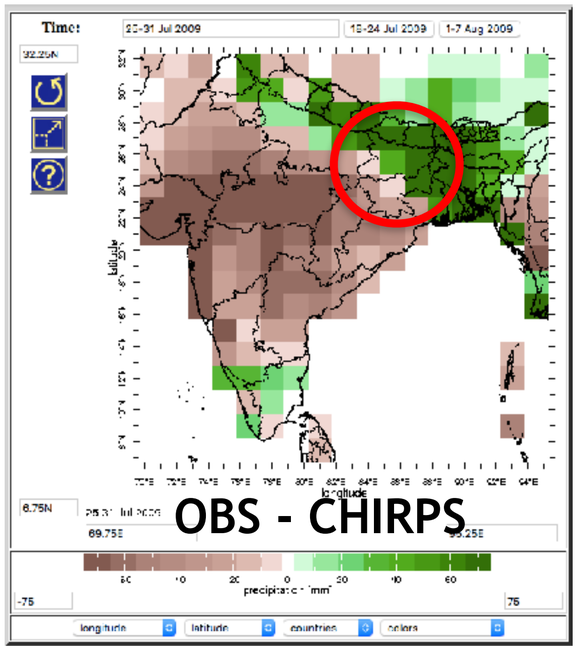




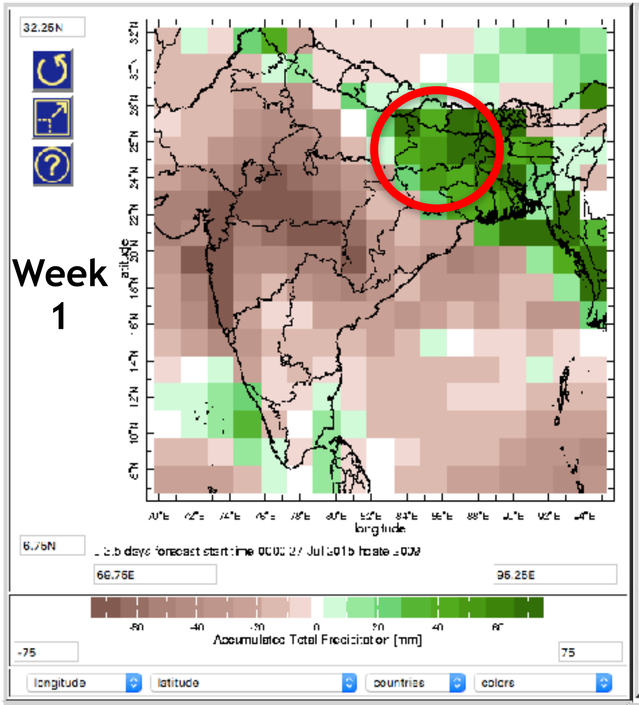


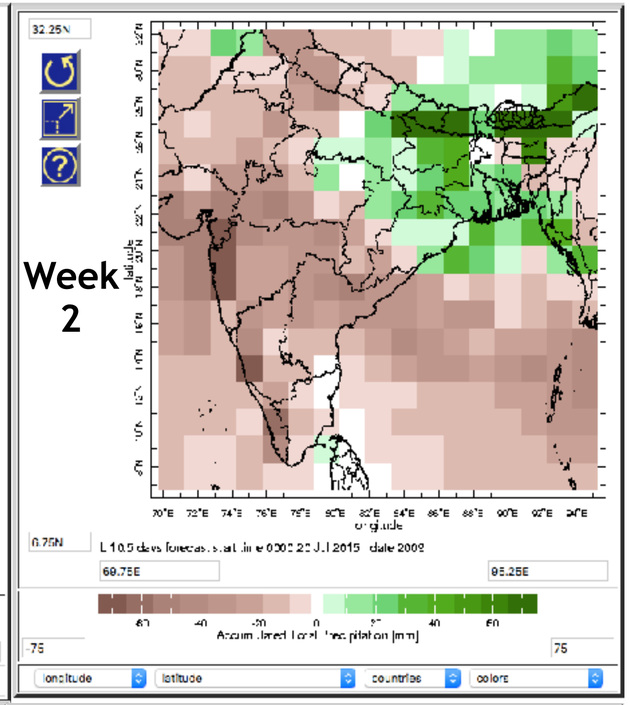
How about the late-July burst of rain?

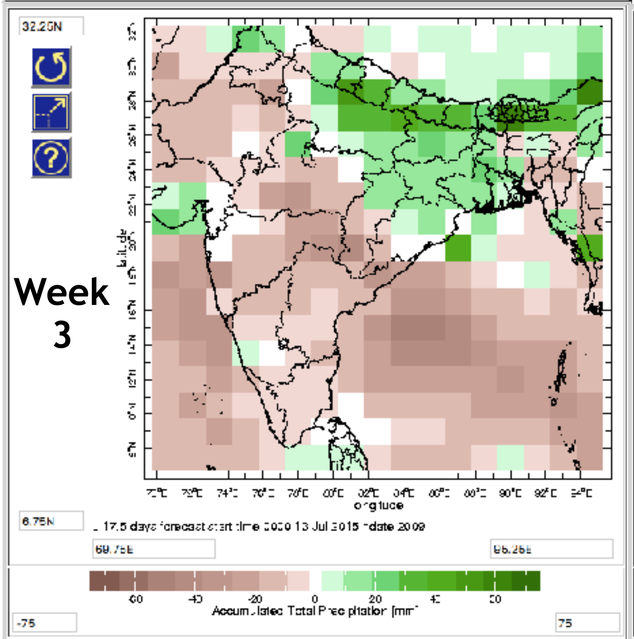


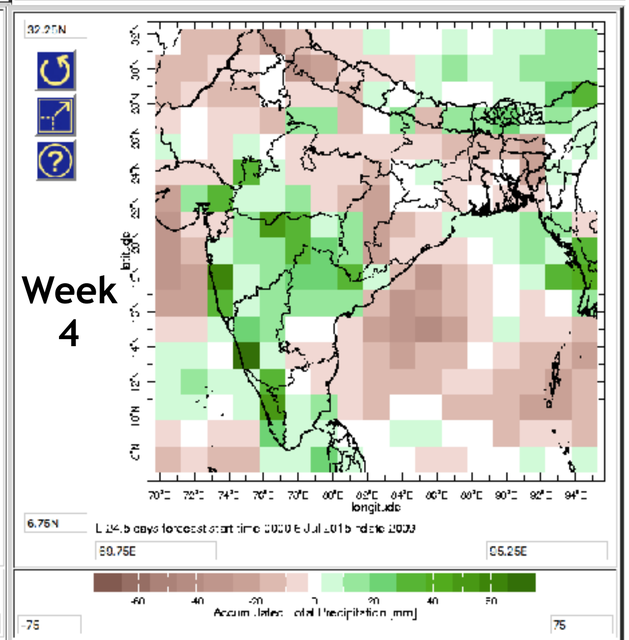


Target:
25–31 Jul
2009



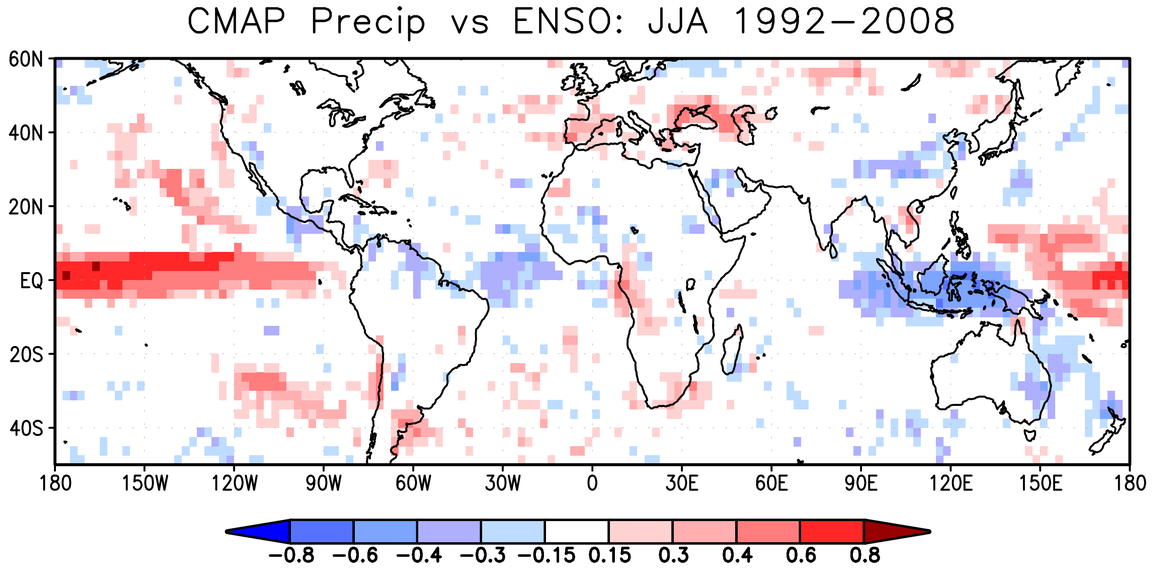




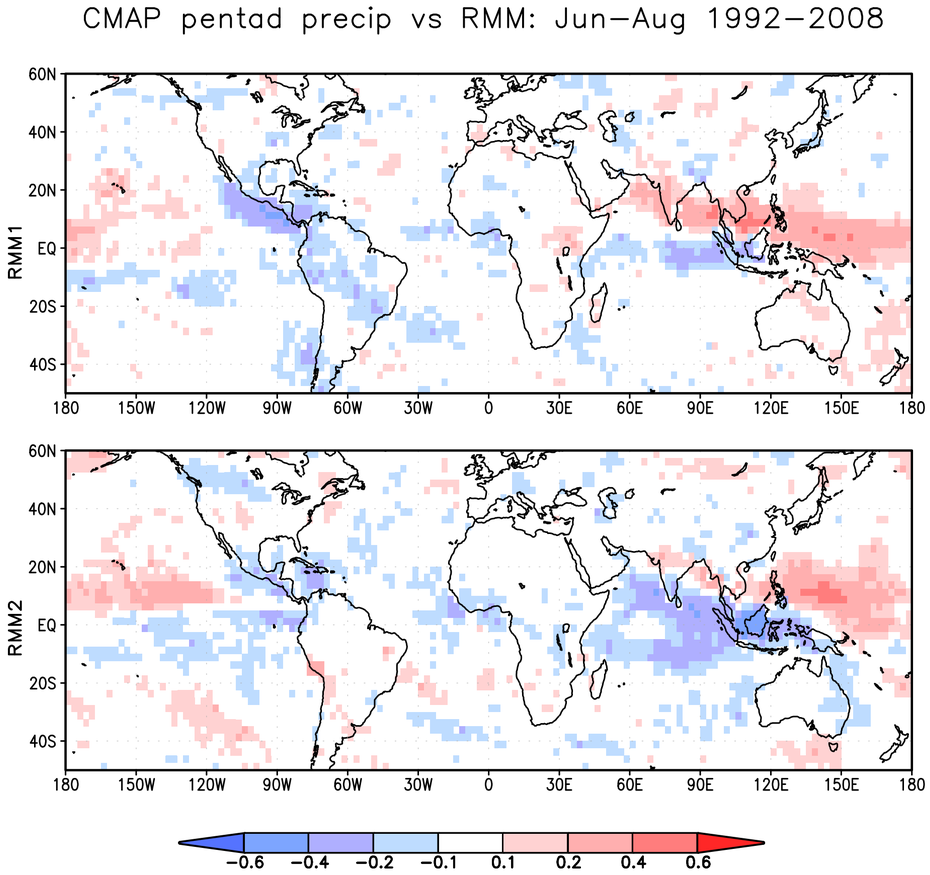


- where does this S2S predictability come from?

ENSO & MJO Signals during boreal summer

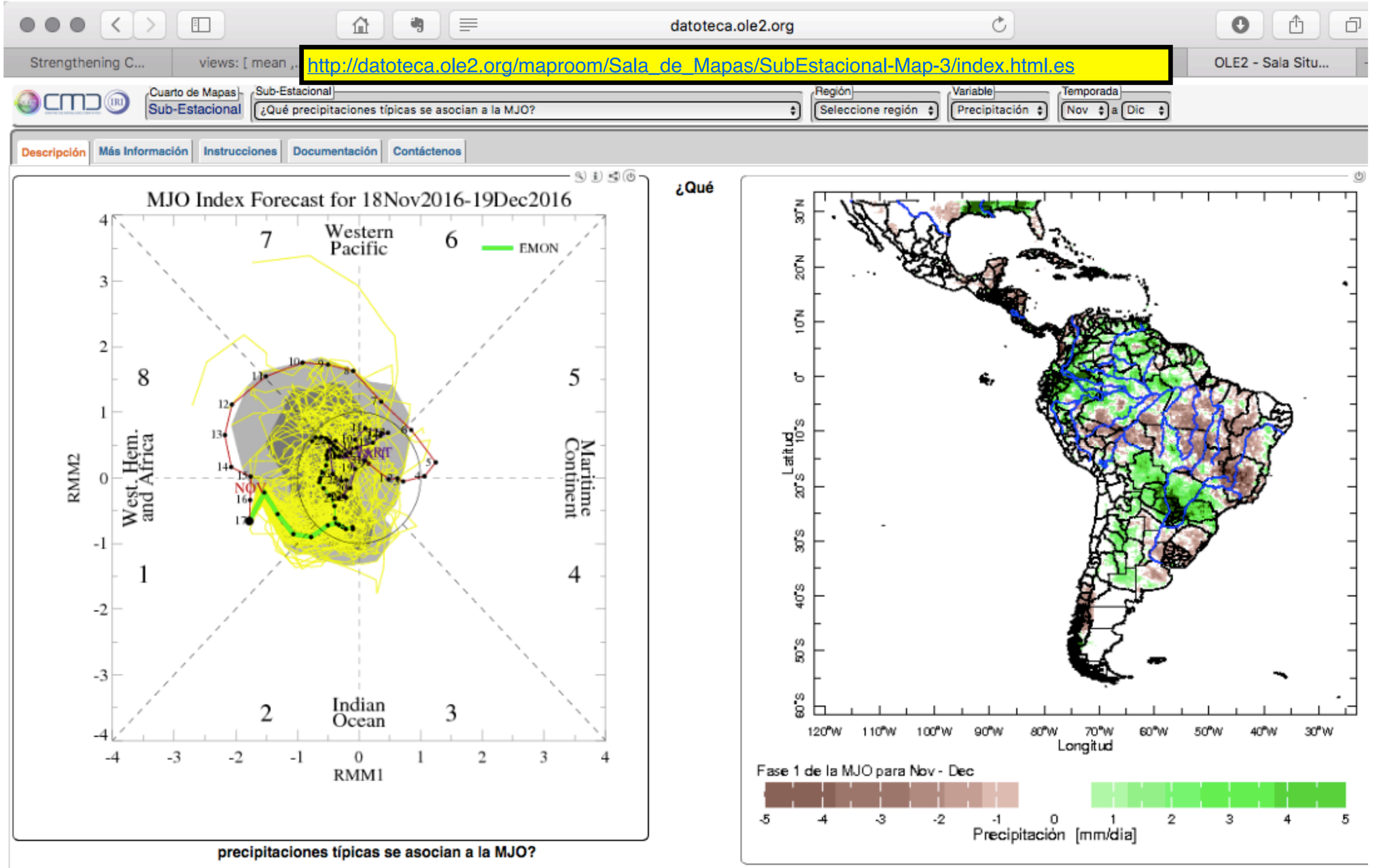


Anomaly correlation coefficient



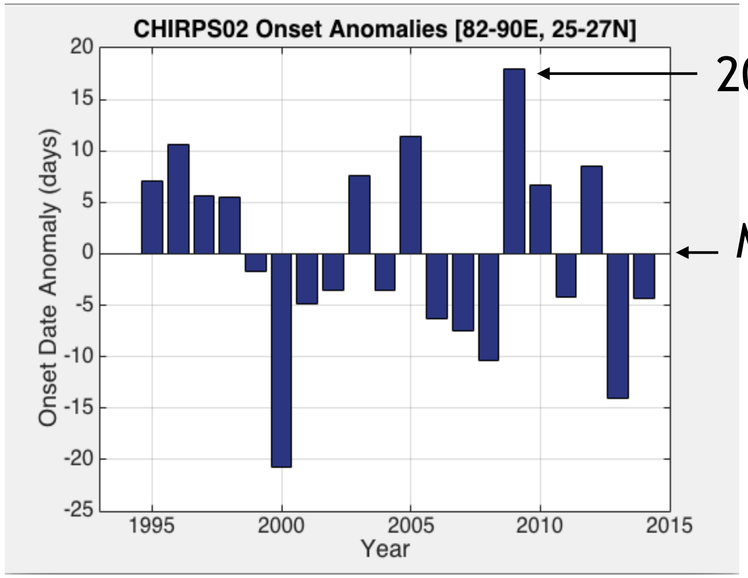
Li and Robertson (2015)

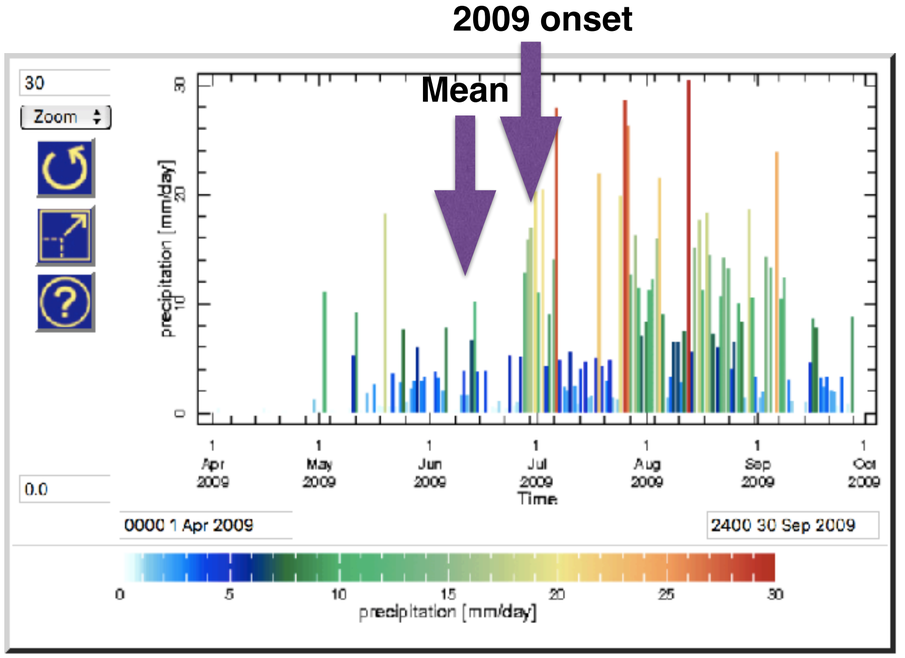
Sub-seasonal Forecast Products



Monsoon onset date

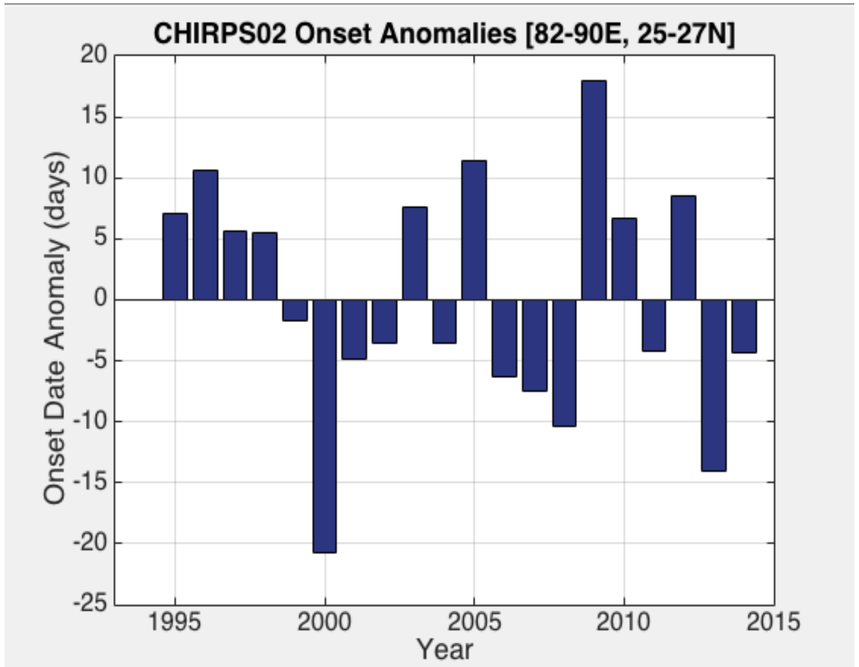
- Defined as the first wet day of the first 7-day wet spell, not followed by a long dry spell
- Calculated locally, then averaged over state of Bihar



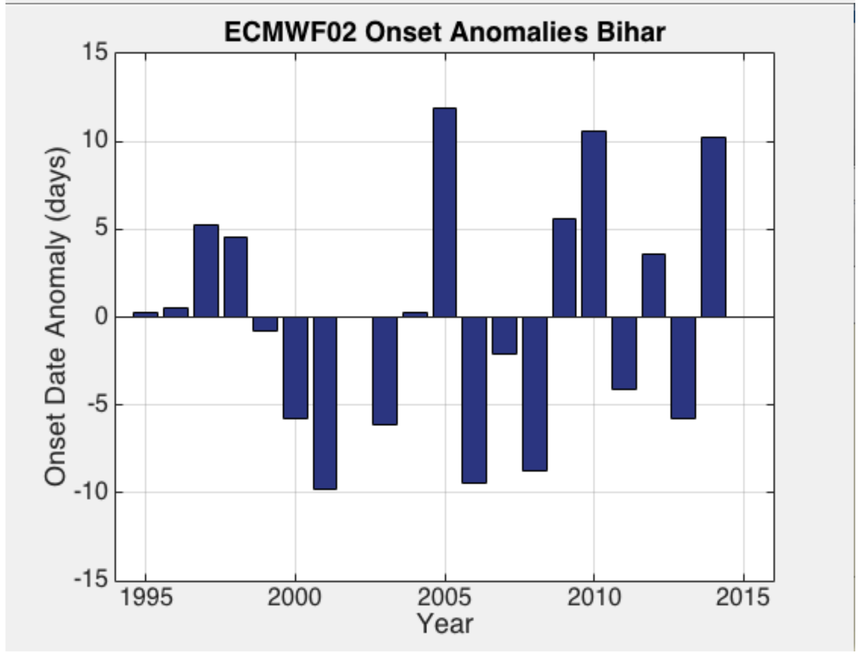


How do ECMWF model forecasts of onset compare?

"Observed" Onset date



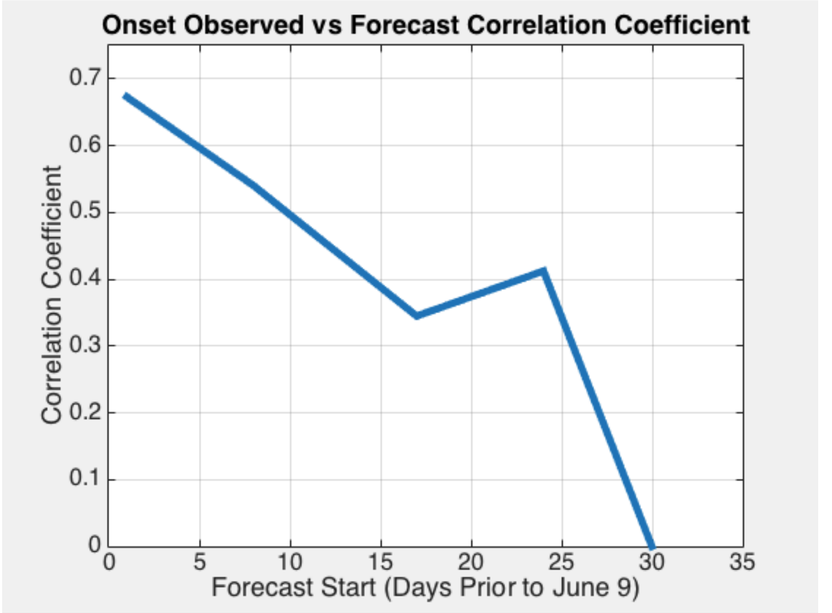
Forecasted Onset date



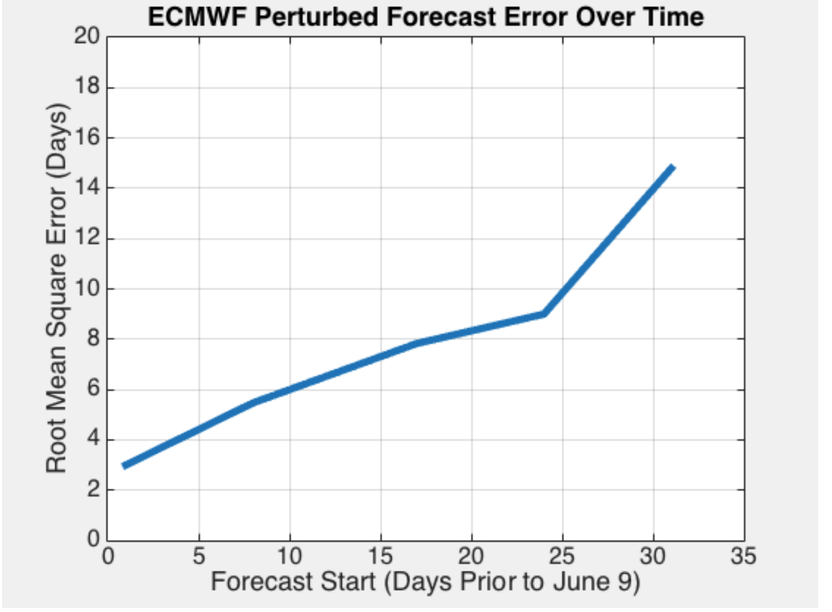
Year	Obs Onset	Forecast Onset	Forecast Error
1995	June 16	June 12	- 4 days
1996	June 20	June 12	- 8 days
1997	June 14	June 17	+ 3 days
1998	June 14	June 16	+ 2 days
1999	June 8	June 11	+ 3 days
2000	May 19	June 6	N/A
2001	June 4	June 2	- 2 days
2002	June 6	N/A	N/A
2003	June 16	June 6	- 10 days
2004	June 6	June 12	+ 6 days
2005	June 21	June 24	+ 3 days
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

Forecast Skill Charts

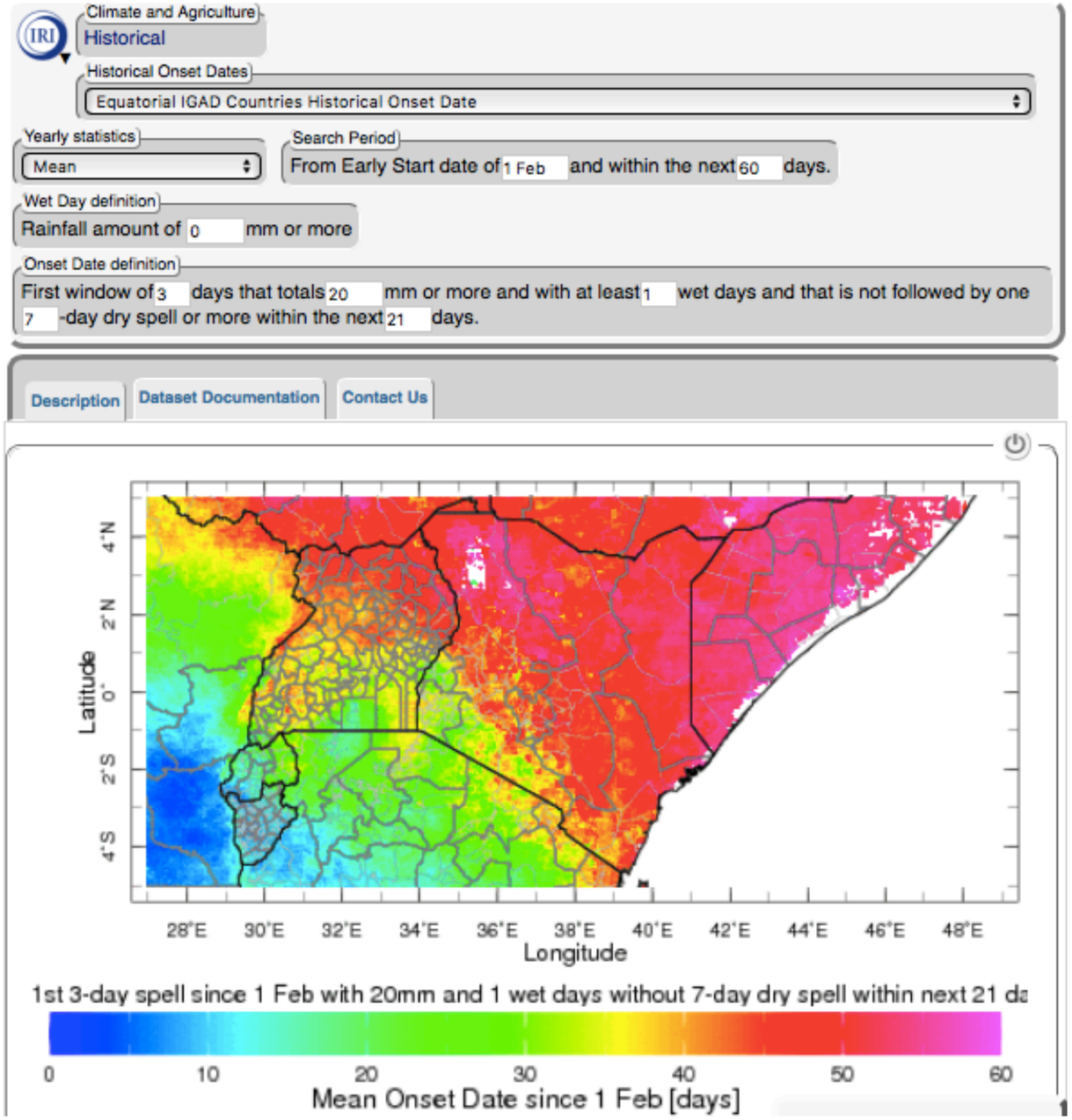
Correlation Coefficient



Root Mean Square Error

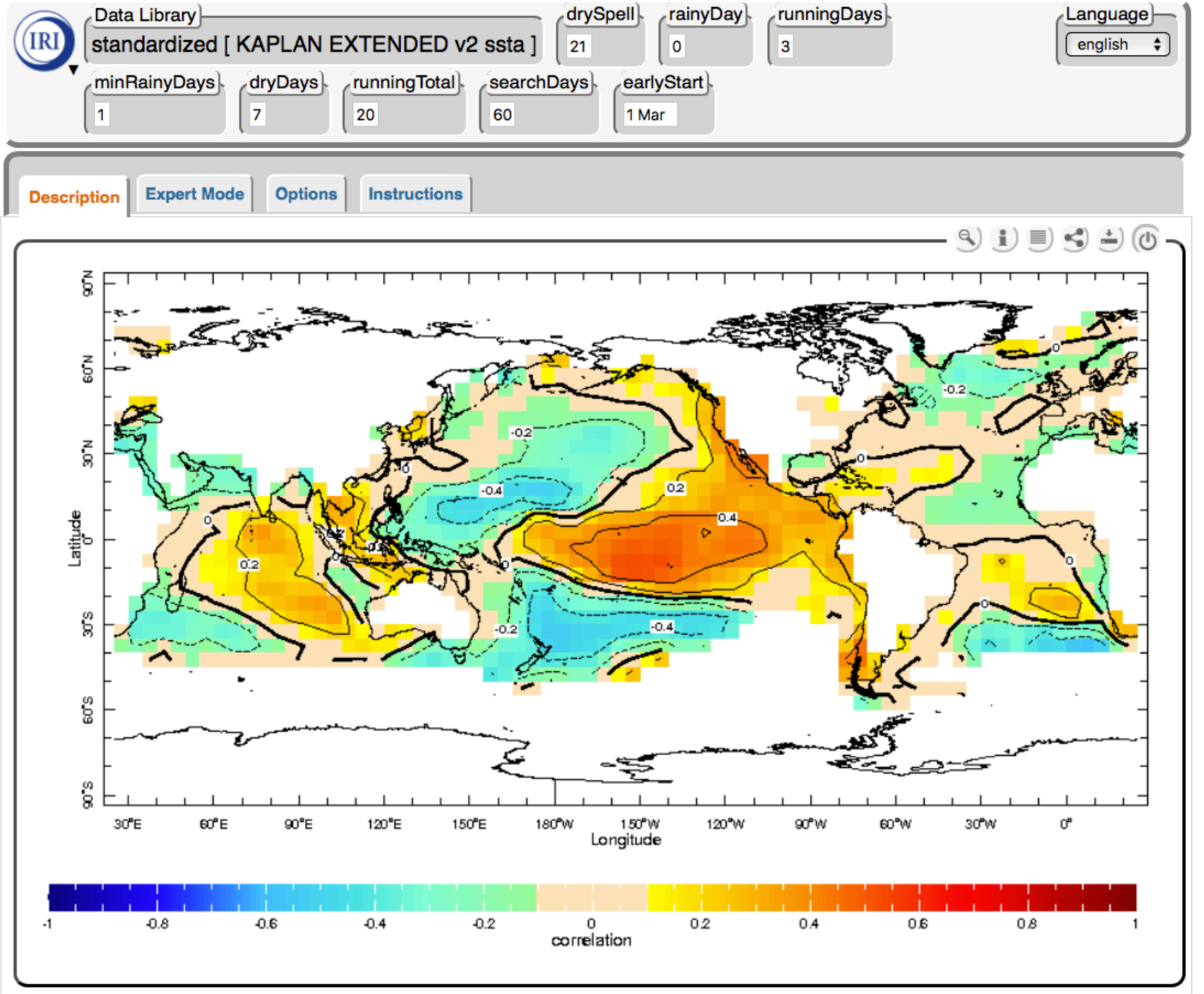


Onset Date Maproom



http://remic.maproomdev.iri.columbia.edu/maproom/Agriculture/Historical_Onset/ICPAC_Eq_Onset.html

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:

- 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 and other stakeholder communities.

- Improve understanding of the climate modes that drive sub-seasonal variability in Africa and their representations in models.

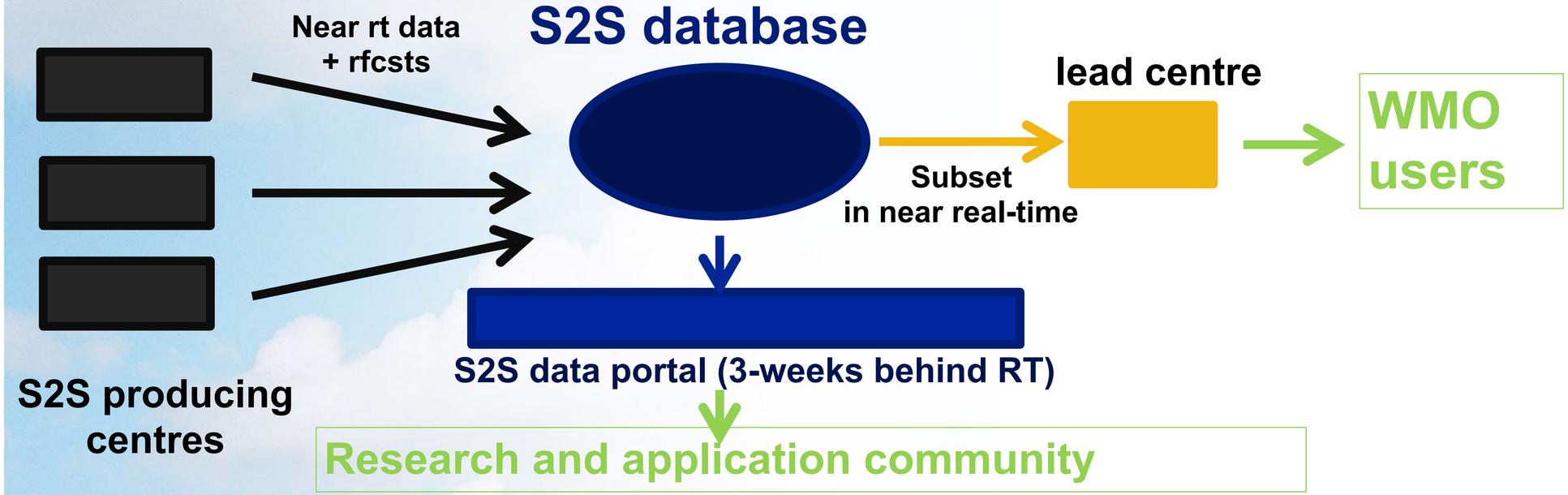
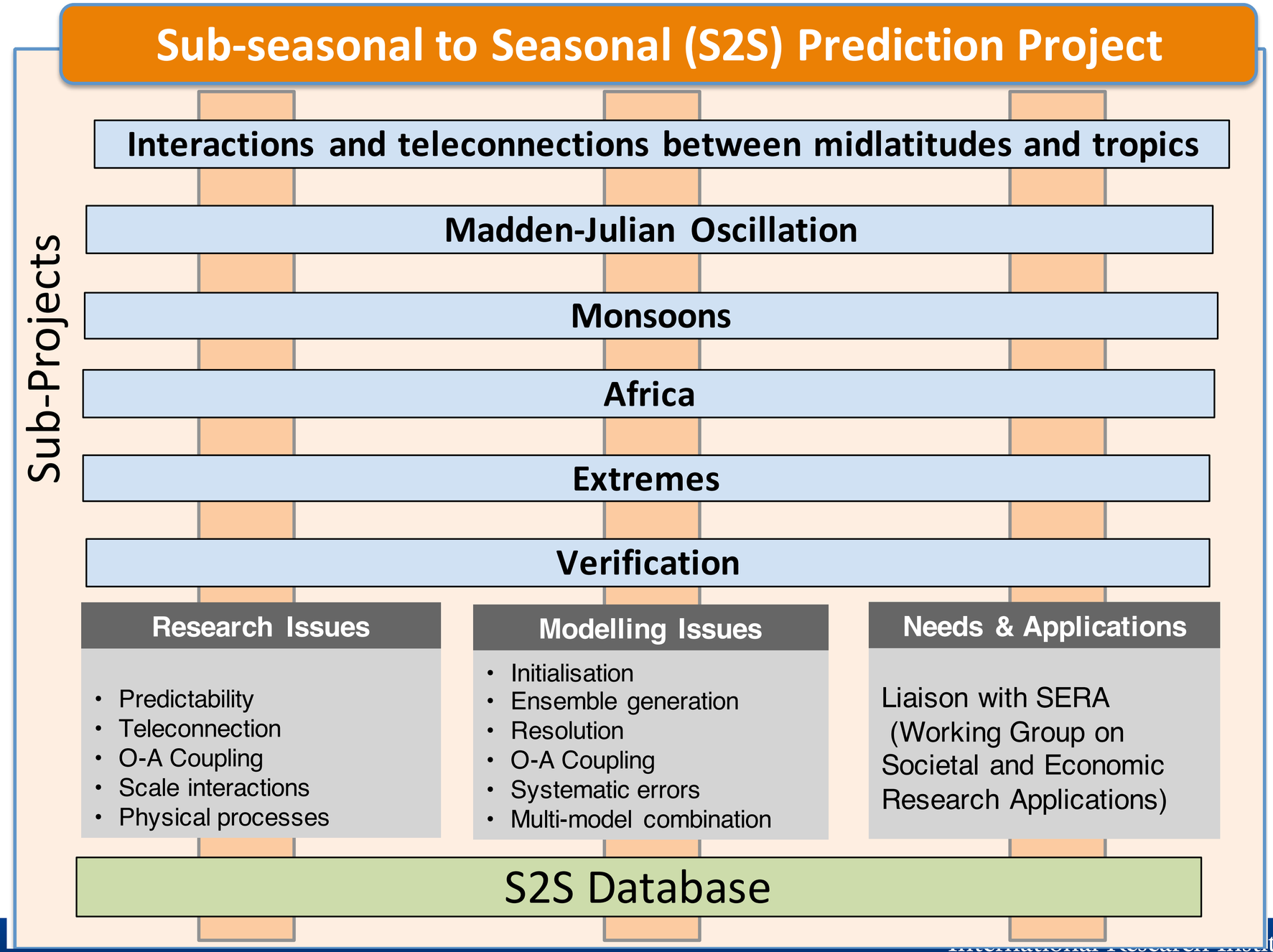
- The Africa sub-project will work with post-Africa Climate Conference 2013 framework (recently named “Climate Research for Development CR4D)” to connect international with African climate communities. An S2S activity is envisaged to be one of the first CR4D pilot activities, through a joint CR4D-S2S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

Linkage with WMO Operational Activities

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

- Research into sub-seasonal predictability under S2S will be conducted in close liaison with developing infrastructure and procedure for operational sub-seasonal prediction as they develop under CBS.]

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



Summary of S2S