Sub-Seasonal to Seasonal Forecasting and the S2S Project

Andrew W Robertson
awr@iri.columbia.edu

International Research Institute
for Climate and Society
Earth Institute | Columbia University

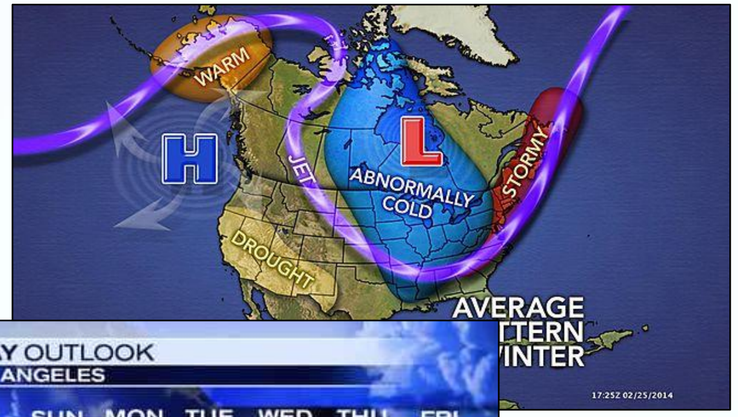
ICTP Advanced School on Tropical-Extratropical Interactions on Intra-Seasonal Time Scales (smr 3155) 16-27 October 2017

Outline

1. Weather and climate forecast timescales
2. The S2S Prediction Project
3. The S2S and SubX Databases
4. Sub-seasonal forecast skill

1. Weather and climate forecast timescales

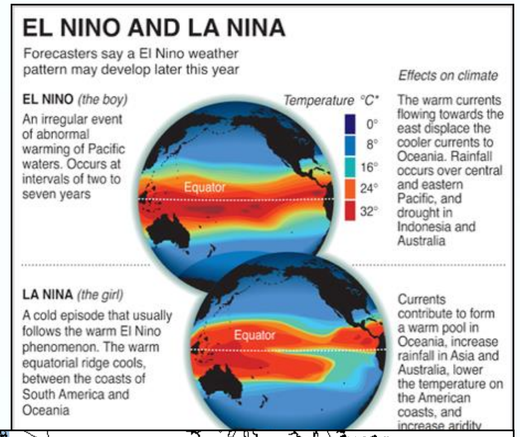
Weather vs Climate Forecasts

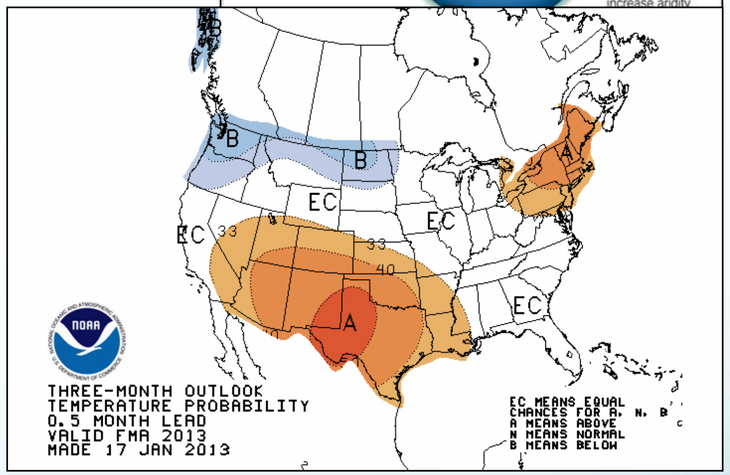


Weather Forecasts ~ O (10 Days)

(Mid-Latitude Baroclinic Instability & Cyclone Lifetime)

Dynamic Forecasts root back to 1910





Seasonal Forecasts ~ O (100 Days)

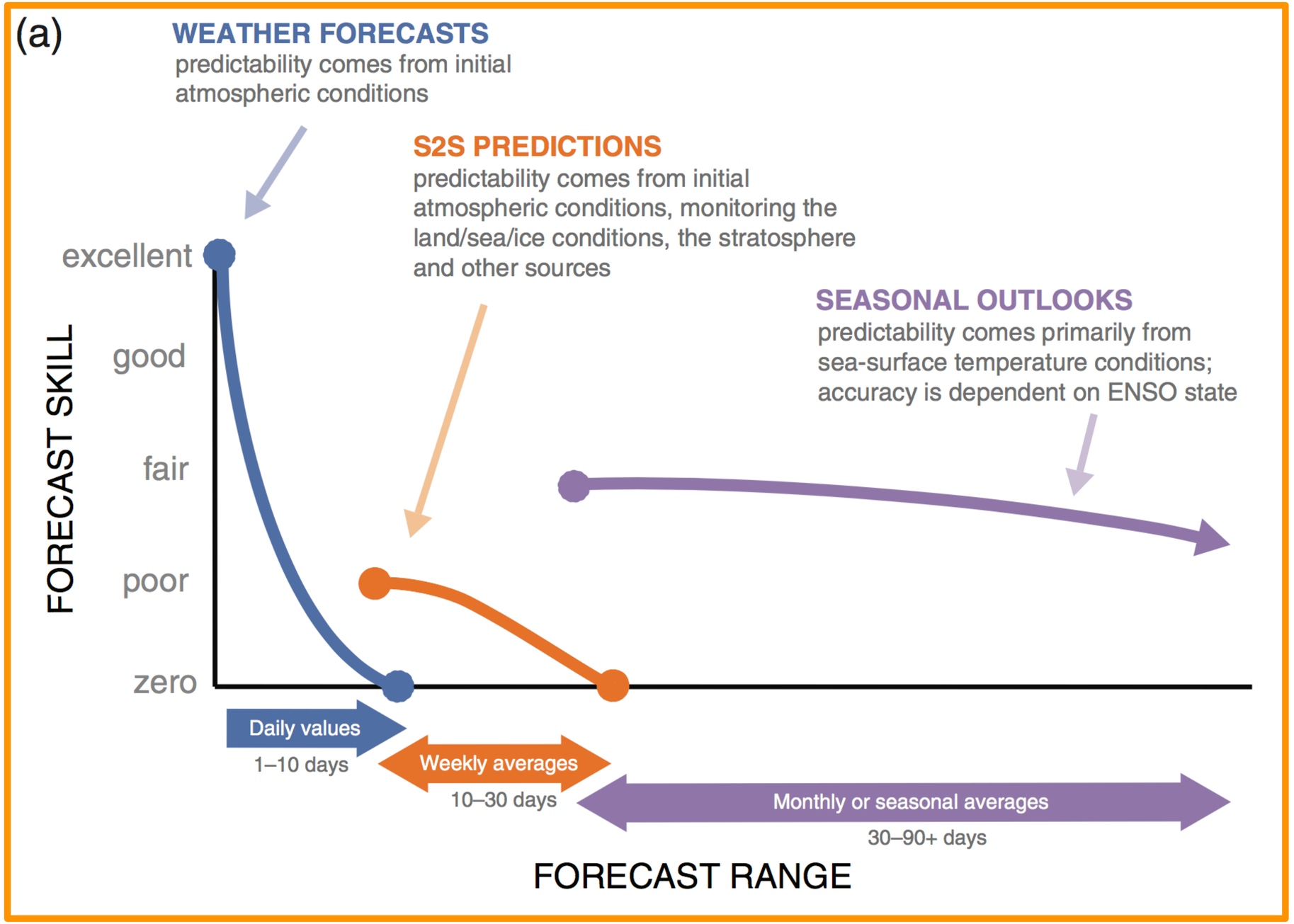
(ENSO phenomena & Local/Remote Circulation Impacts)

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

S2S: Filling the gap between weather and seasonal forecasts



Seamless forecasts?

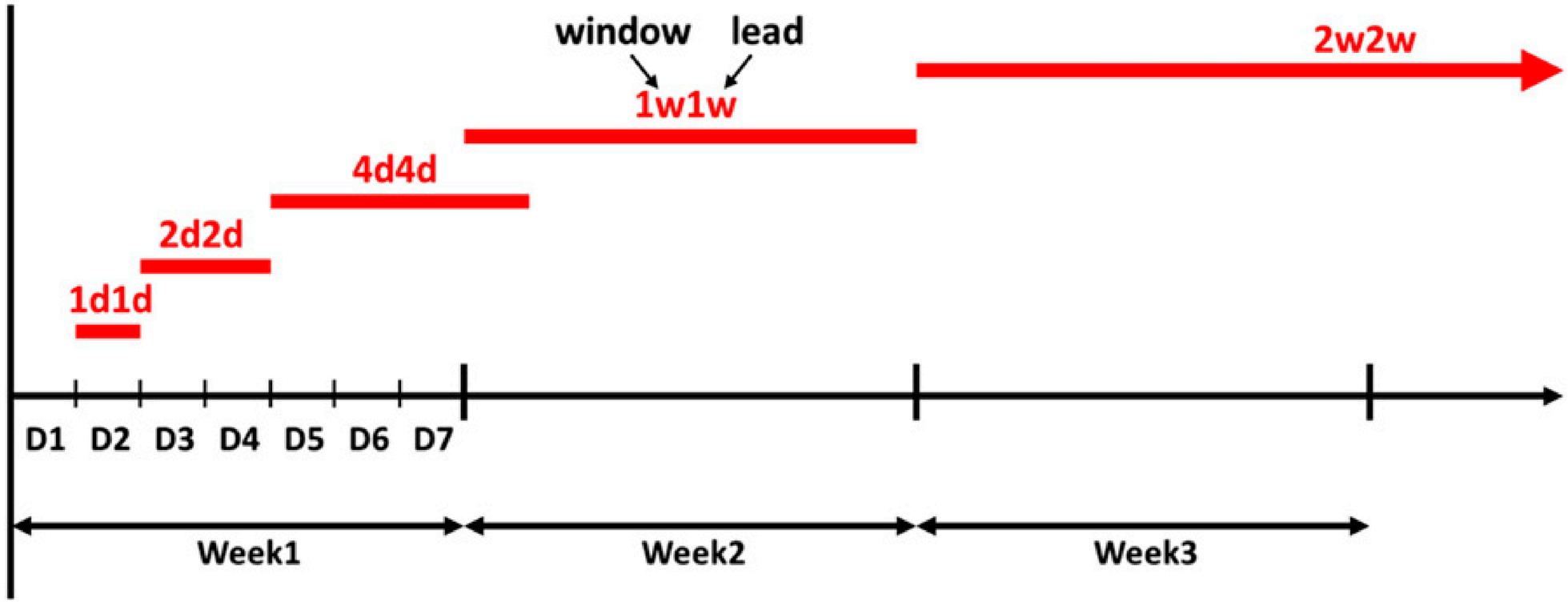
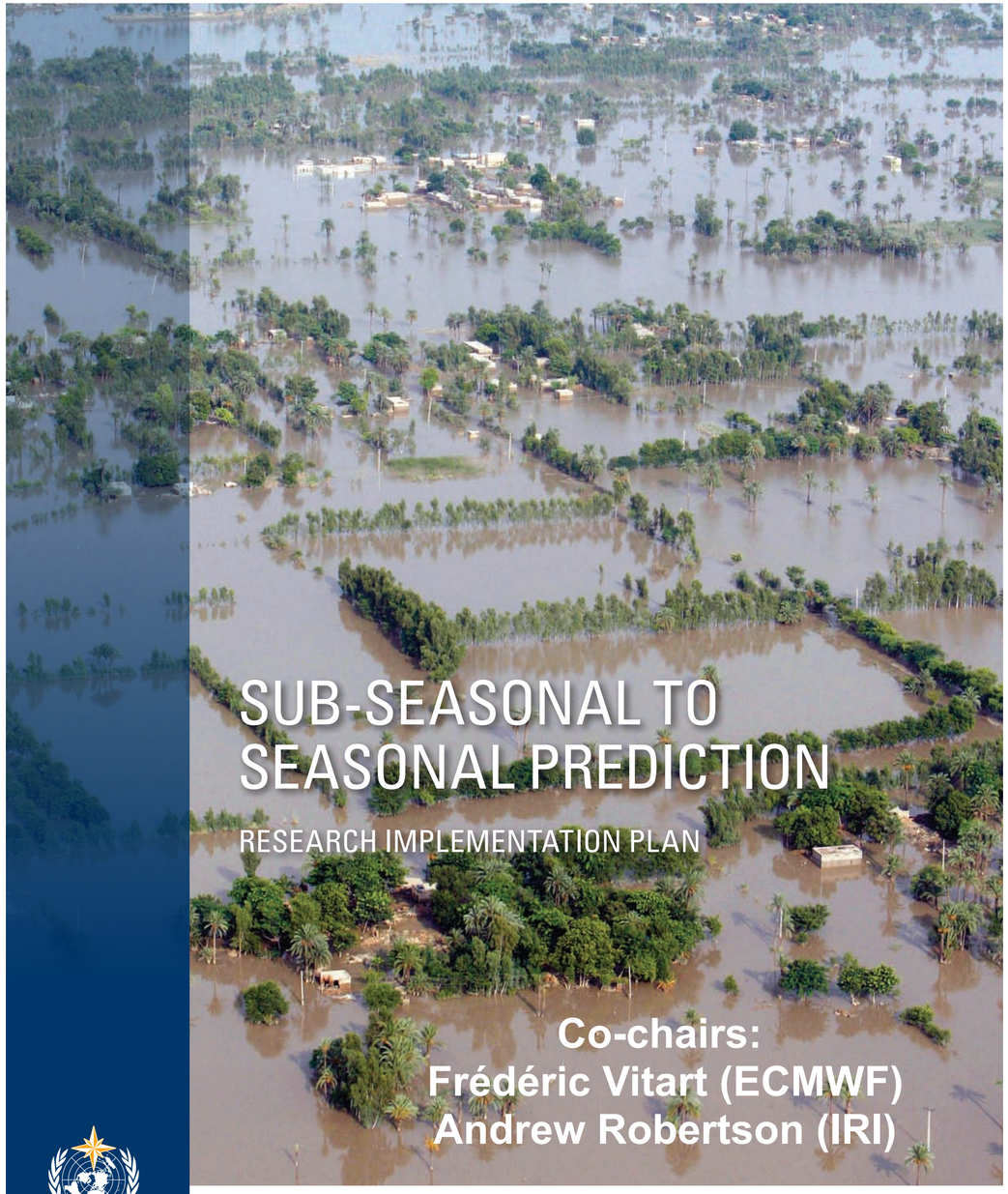


FIG. 1. Schematic of the time window and lead time definitions used in this analysis. The horizontal axis represents forecast time from the initial condition. The expression "1d1d" refers to an averaging window of 1 day at a lead time of 1 day. Similarly, "2d2d" represents an averaging window of 2 days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

2. The S2S Prediction Project

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.



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

Welcome to the S2S Museum

@University of Tsukuba, Japan

The Subseasonal to Seasonal Prediction (S2S) Project is a proposed WWRP/THORPEX/ WCRP joint research project.

The main goal of the S2S project is to improve forecast skill and understanding on the subseasonal to seasonal timescale, and promote its uptake by operational centres and exploitation by the applications community. Specific attention will be paid to the risk of extreme weather, including tropical cyclones, droughts, floods, heat waves and the waxing and waning of monsoon precipitation.

The S2S data portals provide the S2S data freely with a 3-week delay only for research and education purposes. For details,

Sub-projects' Wiki

Wiki page for Teleconnections
(Contact : Hai Lin)

Wiki page for Madden-Julian Oscillation (MJO)
(Contact : Duane Waliser)

Wiki page for Monsoons
(Contact : Harry Hendon)

Wiki page for Africa
(Contact : Richard Graham)

Wiki page for Extremes
(Contact : Frederic Vitart)

Wiki page for Verification and Products
(Contact : Caio Coelho)

S2S News | Upcoming Events | News Letter | FAQs

SubX data is now available!

The Subseasonal Experiment (SubX) is a project under the NOAA Climate Test Bed, which helps expedite the transition of research to NOAA's operational modeling centers that actually produce the forecasts given to the public. The SubX team's goal is to combine global models, which each have different strengths and weaknesses, and test the benefit of each model and the multi-model approach for week 3-4 outlooks. More information is available at the website: http://cpo.noaa.gov/News/News-Article/ArtMID/6226/ArticleID/1554/Newly-released-model-forecasts-could-help-advance-NOAA's-week-3-4-outlooks

The SubX data has just been released and is now available in the IRI Data Library: http://iridl.ldeo.columbia.edu/SOURCES/.Models/.SubX/

The SubX web site link is here: http://cola.gmu.edu/kpegion/subx/

S2S Database

ECMWF | CMA | IRI/LDEO Data Lib

The result of "S2S User Survey 2017"
Updated: 2017-05-25 14:27

Charts of S2S Products/Indices are now available
Updated: 2016-09-22 09:41

S2S Database Paper will come soon on BAMS
Updated: 2016-08-29 02:25

Now 9 centres S2S data available!
Updated: 2016-01-14 07:16

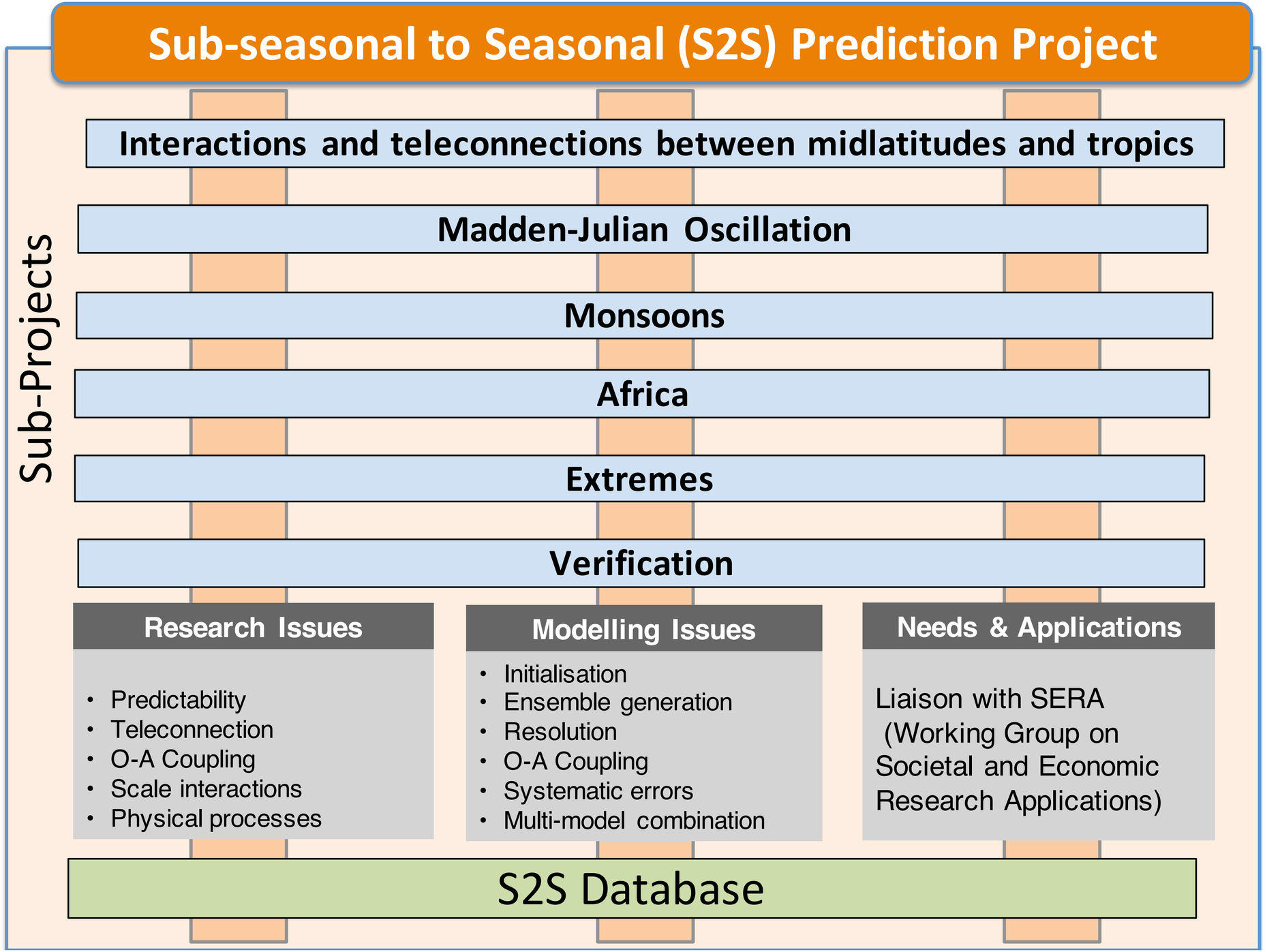
CMA S2S Data Portal is Open!

Mission

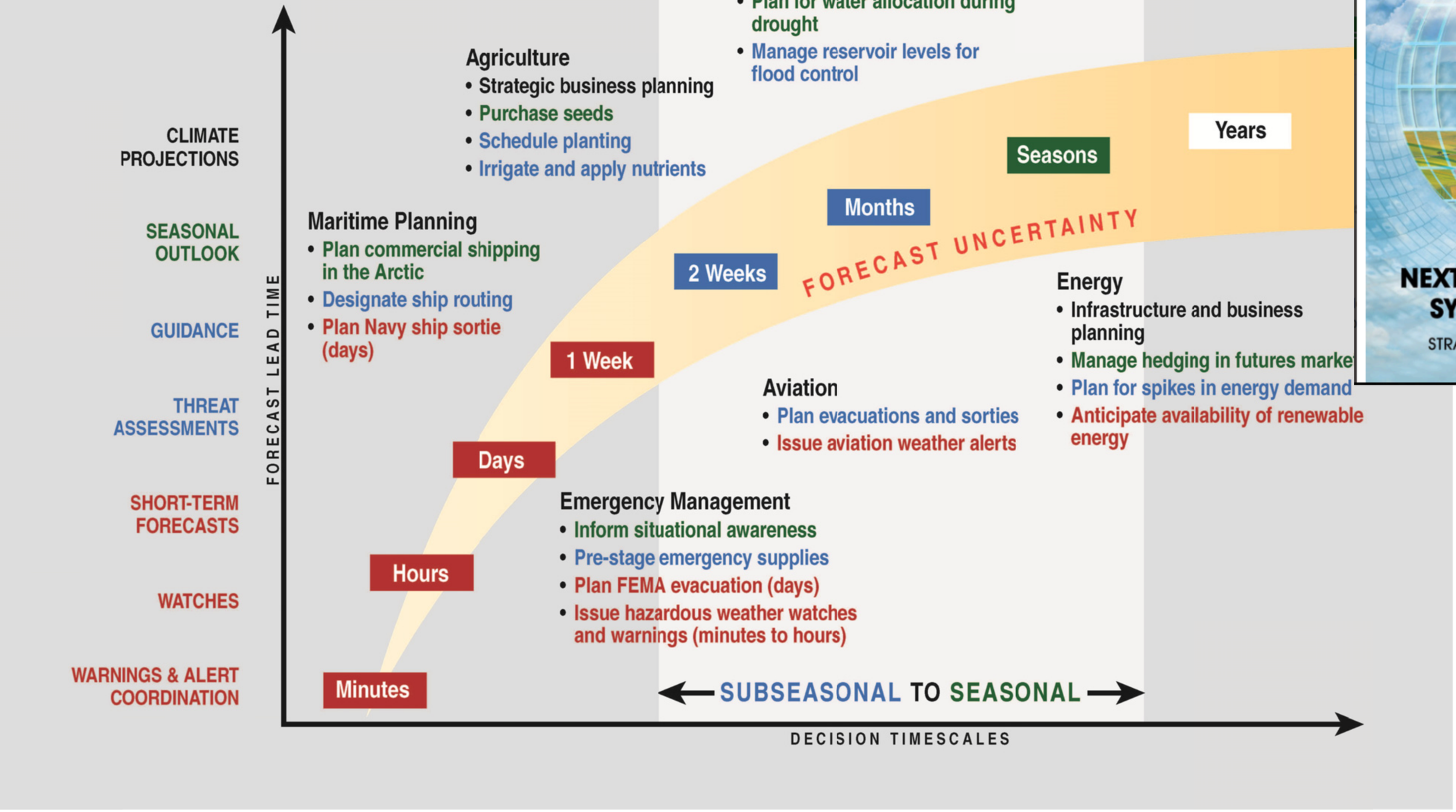
The main goal of the proposed WWRP/THORPEX/ WCRP joint research project is to improve forecast skill and understanding on the subseasonal to seasonal timescale, and promote its uptake by operational centres and exploitation by the applications community. Specific attention will be paid to the risk of extreme weather, including tropical cyclones, droughts, floods, heat waves and the waxing and waning of monsoon precipitation. Work will be guided by a steering group that will work in conjunction with appropriate WMO bodies and other relevant structures.

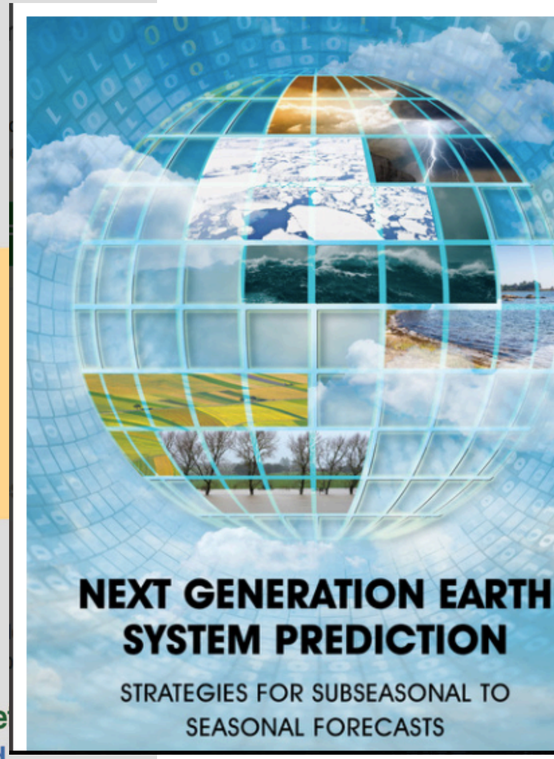
Reports & Publications

- Spanish version of the S2S project overview
- Applications of S2S Forecasts: From Disaster Early Warning to Early Action
- Report on subseasonal MME in LC-LRFMME
- (Early Release) The Sub-seasonal to Seasonal Prediction (S2S) Project Database
- WMO Publication, 2015: Seamless Prediction of the Earth System: from minutes to months
- Andrew W. Robertson, Arun Kumar, Malaquias Pena, and


Sub-seasonal to Seasonal (S2S) Prediction Project
Sub-Projects
Interactions and teleconnections between midlatitudes and tropics
Madden-Julian Oscillation
Monsoons
Africa
Extremes
Verification
Research Issues
• Predictability
• Teleconnection
• O-A Coupling
• Scale interactions
• Physical processes
Modelling Issues
• Initialisation
• Ensemble generation
• Resolution
• O-A Coupling
• Systematic errors
• Multi-model combination
Needs & Applications
Liaison with SERA (Working Group on Societal and Economic Research Applications)
S2S Database

Applications





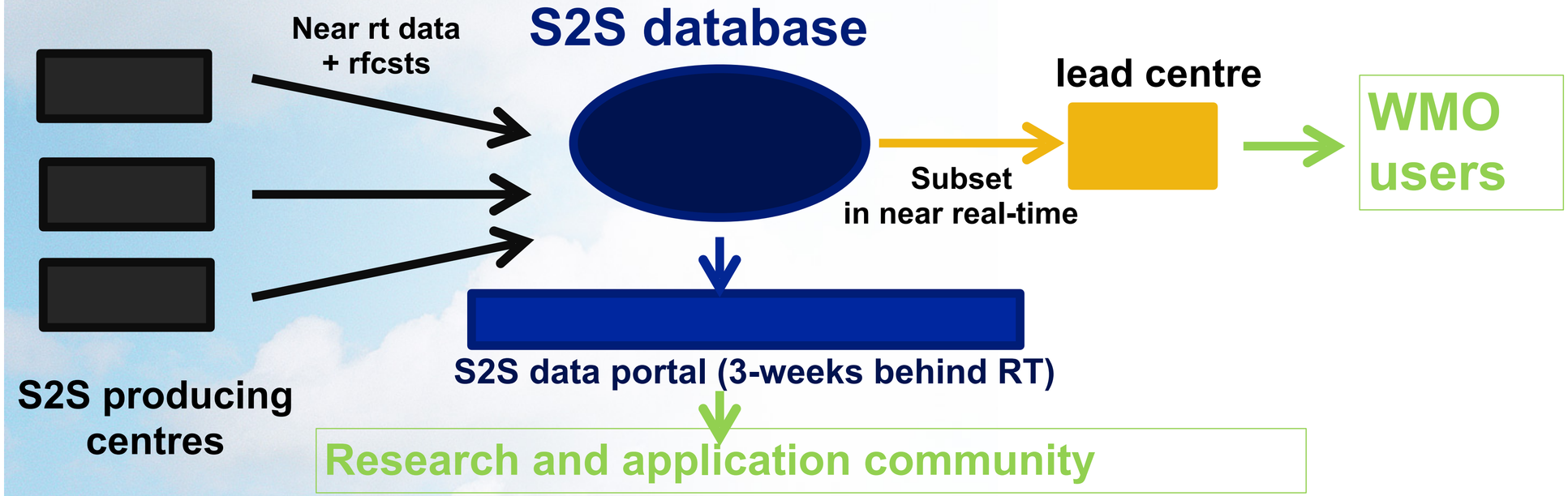
https://www.nap.edu/catalog/21873/next-generation-earth-system-prediction-strategies-for-subseasonal-to-seasonal

S2S Linkage with CBS

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.



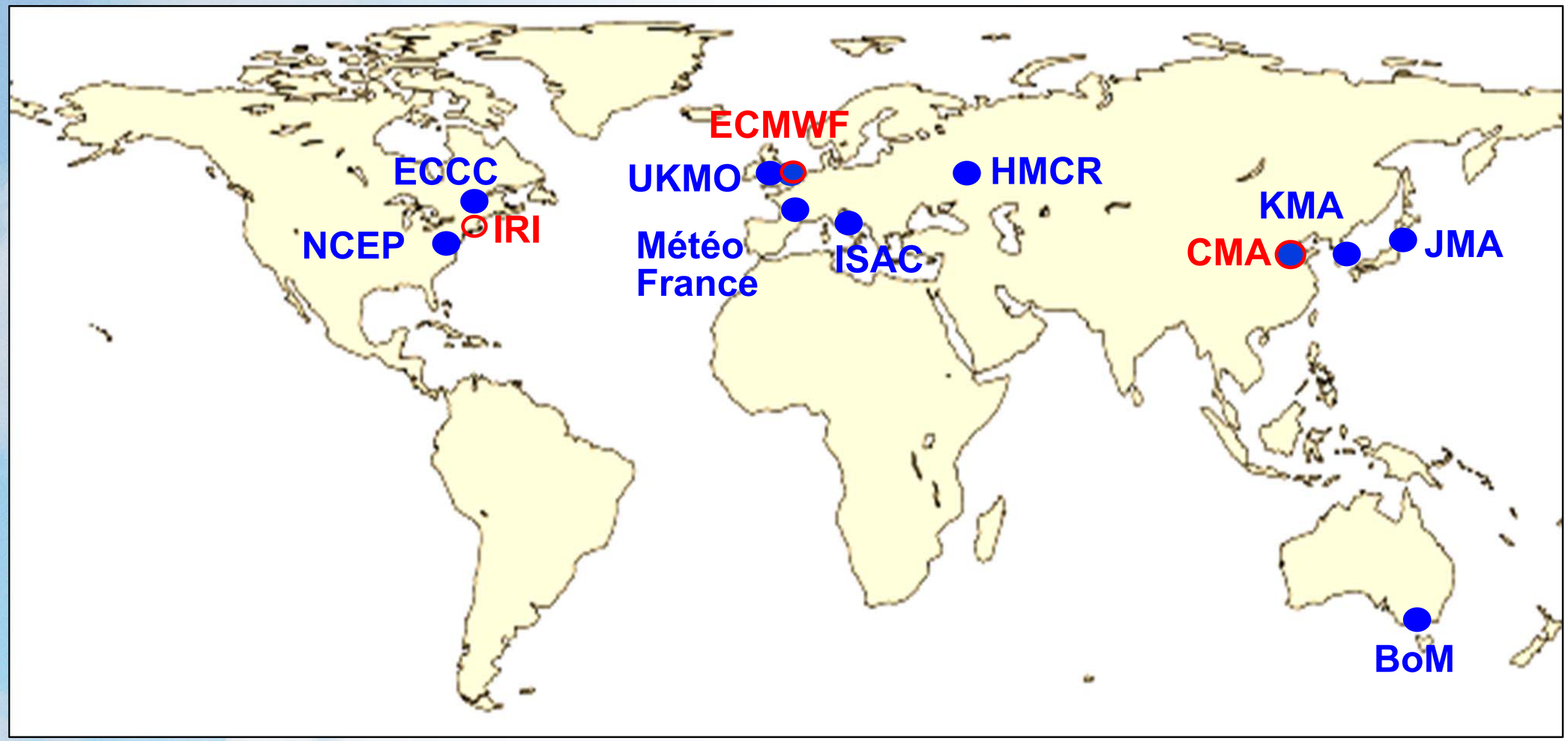
3. The S2S and SubX Databases

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

			Forecasts			Re-Forecasts		
Model	**Time range**	**Resolution**	**Ens size**	**Freq**	**Rfc[a]**	**Rfc period**	**Rfc freq**	**Rfc size**
BoM	Days 0–62	~2° × 2°, L17	33	Twice weekly	Fixed	1981–2013	Six per month	33
CMA	Days 0–60	~1° × 1°, L40	4	Daily	Fixed	1994–2014	Daily	4
ECCC	Days 0–32	0.45° × 0.45°, L40	21	Weekly	On the fly	1995–2012	Weekly	4
ECMWF	Days 0–46	0.25° × 0.25° days 0–10 0.5° × 0.5° after day 10 L91	51	Twice weekly	On the fly	Past 20 years	Two per week	11
HMCR	Days 0–61	1.1° × 1.4°, L28	20	Weekly	On the fly	1985–2010	Weekly	10
CNR-ISAC	Days 0–31	0.8° × 0.56°, L54	41	Weekly	Fixed	1981–2010	Every 5 days	1
JMA	Days 0–33	~0.5° × 0.5°, L60	25	Twice weekly	Fixed	1981–2010	Three per month	5
KMA	Days 0–60	~0.5° × 0.5°, L85	4	Daily	On the fly	1996–2009	Four per month	3
CNRM	Days 0–61	~0.7° × 0.7°, L91	51	Weekly	Fix	1993–2014	Two per month	15
NCEP	Days 0–44	~1° × 1°, L64	16	Daily	Fixed	1999–2010	Daily	4
UKMO	Days 0–60	~0.5° × 0.8°, L85	4	Daily	On the fly	1996–2009	Four per month	3

Vitart et. al (2017, BAMS): DOI: http://dx.doi.org/10.1175/BAMS-D-16-0017.1

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

S2S Database now available in IRI Data Library

http://iridl.ldeo.columbia.edu/SOURCES/ECMWF/S2S

Description | Expert Mode

SOURCES > ECMWF > S2S

ECMWF S2S

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

Documents

overview	an outline showing sub-datasets of this dataset
BAMS paper	The Subseasonal to Seasonal (S2S) Prediction Project
ECMWF	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	S2S Project Page

Datasets and Variables

BOM	BoM POAMA Ensemble.
CMA	Beijing Climate Center (BCC) Climate Prediction System ve
CNRM	CNRM Ensemble Prediction System.
ECCC	ECCC Ensemble Prediction System.
ECMF	ECMWF Ensemble.
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.

Other Info

reference

Vitart, F., C. Ardilouze, A. Bonet, A. Brookshaw, M. Chen, C. C
Hodgson, H. Kang, A. Kumar, H. Lin, G. Liu, X. Liu, P. Malguz
A. Minami, R. Mladek, T. Nakazawa, S. Najm, Y. Nie, M. Rixen,

SOURCES > ECMWF > S2S > ECMF > forecast

ECMWF S2S ECMF forecast

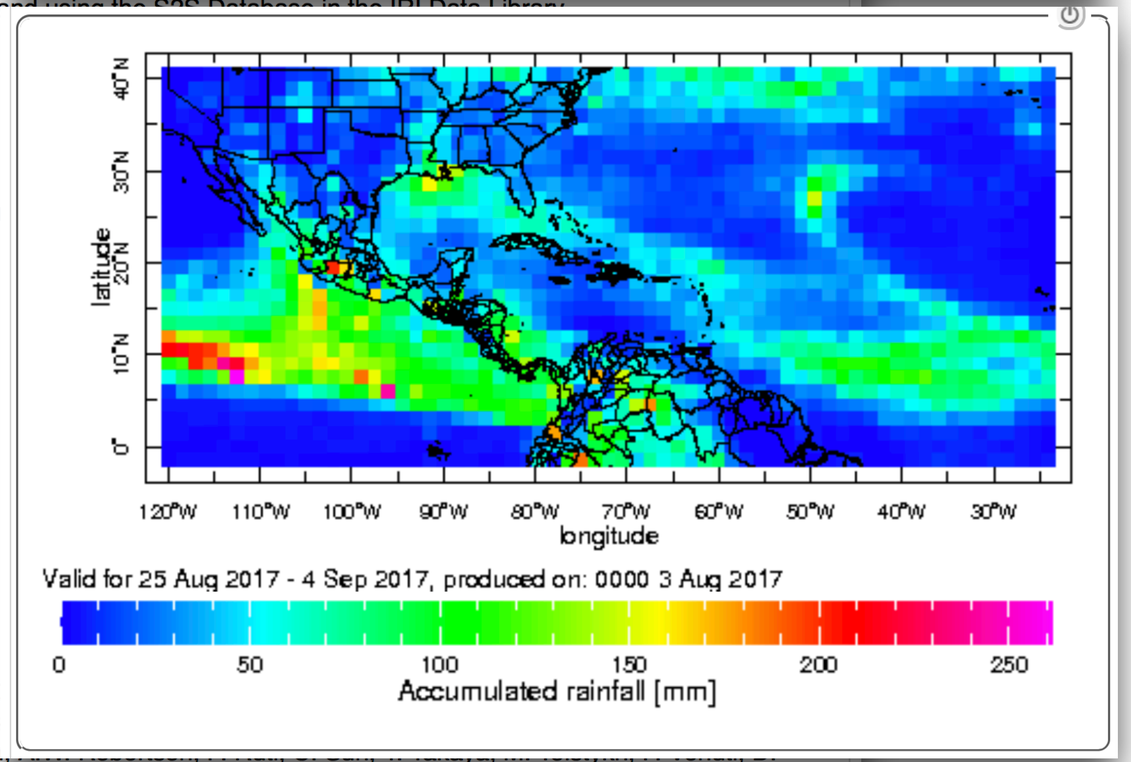
forecast from ECMWF S2S ECMF: ECMWF Ensemble.

Documents

overview an outline showing sub-datasets of this dataset

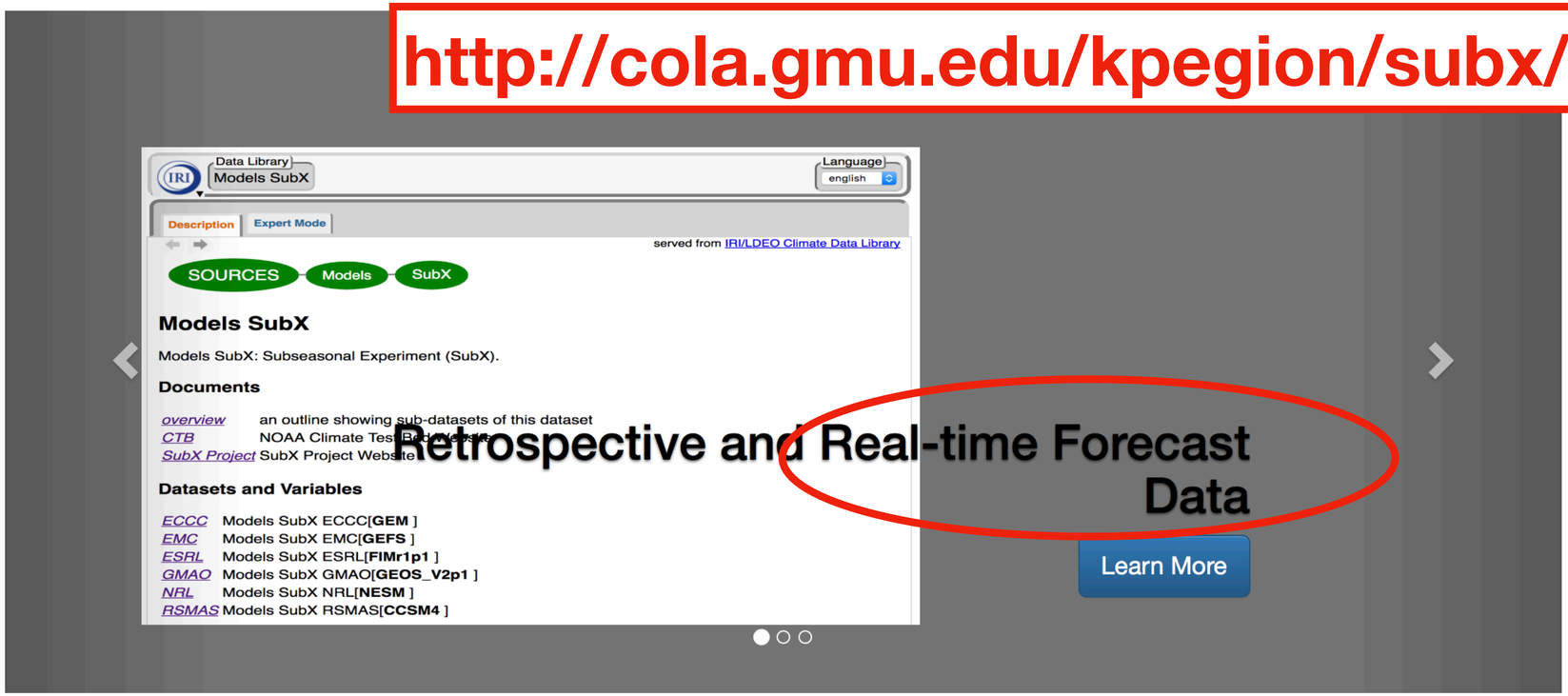
Datasets and Variables

control	ECMWF S2S ECMF forecast control[**sfc_temperature sfc_stress top_of_atmosphere sfc_runoff pressure_level_q 0-1_m_below_ground 320K_isentropic_level sfc_pressure 10m_above_ground 2m_above_ground pressure_level_w sfc_heat_flux pressure_level_gh sfc_rad_flux 0-0p2_m_below_ground sfc_precip sfc_snow_ice atmos_column pressure_level_u pressure_level_v pressure_level_t**]
perturbed	ECMWF S2S ECMF forecast perturbed[**sfc_temperature sfc_stress top_of_atmosphere sfc_runoff pressure_level_q 0-1_m_below_ground 10m_above_ground sfc_pressure 2m_above_ground 320K_isentropic_level pressure_level_w sfc_heat_flux pressure_level_gh sfc_rad_flux 0-0p2_m_below_ground sfc_precip sfc_snow_ice atmos_column pressure_level_u pressure_level_t pressure_level_v**]
RMMS	ECMWF S2S ECMF forecast RMMS[**ensemble_mean ensembles**]



The NOAA SubX Project

http://cola.gmu.edu/kpegion/subx/index.html



News

Oct 13: COLA/GMU Interactive SubX Forecast Viewer Now Available

Oct 2: SubX Real-time Forecast Maps Now Available

Sep 28: SubX Forecasts of Harvey and Irma Presented on MAPP Webinar

Sep 13-15: SubX Research Presented at the NMME/SubX Science Meeting

Forecasts

The SubX project makes experimental real-time forecasts each week. Forecasts maps are updated on Saturdays. Users can select to view static or interactive forecast maps

Static Forecast Maps »

Interactive Forecast Maps »

Data

SubX retrospective forecasts and real-time forecast data are publicly available via the IRI Data Library. The SubX project also provides detailed information about the participating models, available variables, current data holdings, and tools for downloading data. Learn More »

Get Data »

SubX Data in IRI Data Library

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

Description | Expert Mode

Models SubX

Models SubX: Subse

Documents

overview an out
CTB NOAA
SubX Project SubX

Datasets and variables

ECCC Models SubX ECCC[GEM]
EMC Models SubX EMC[GEFS]
ESRL Models SubX ESRL[FIMr1p
GMAO Models SubX GMAO[GEOS
NRL Models SubX NRL[NESM]
RSMAS Models SubX RSMAS[CCSM

Data Library: Models SubX EMC GEFS forecast pr | X: 0.5W - 0.5W | Y: 90.5S - 90.5N | S: 30 Jun 2017 - 3 Oct 2017 | Language: english
L: [0.5 34.5] days | M: 0 - 20

Description | Views | Data Filters | Data Selection | Data Files | Data Tables | Expert Mode

served from IRI/LDEO Climate Data Library

SOURCES > Models > SubX > EMC > GEFS > forecast > pr

Models SubX EMC GEFS forecast pr: Total Precipitation data

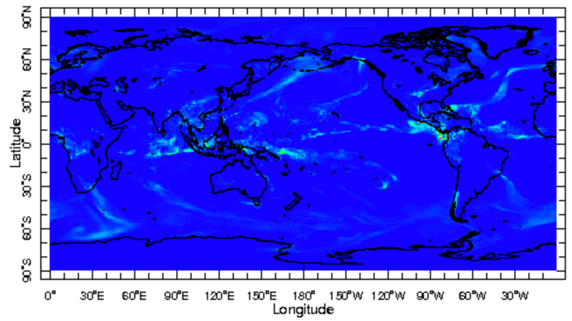
EMC GEFS forecast pr Total Precipitation from Models SubX: Subseasonal Experiment (SubX).

Independent Variables (Grids)

Lead (forecast_period)
grid: /L (days) ordered (0.5 days) to (34.5 days) by 1.0 N= 35 pts :grid
Ensemble Member (realization)
grid: /M (ids) ordered (0) to (20) by 1.0 N= 21 pts :grid
Start Time (forecast_reference_time)
grid: /S (days since 1960-01-01) ordered (0000 30 Jun 2017) to (0000 4 Oct 2017) by 1.0 N= 97 pts :grid
Longitude (longitude)
grid: /X (degree_east) pe
Latitude (latitude)
grid: /Y (degree_north) or

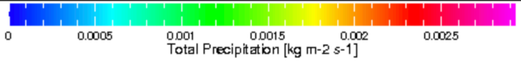
Models SubX EMC GEFS forecast Total Precipitation	0.5W - 0.5W	90.5S - 90.5N	30 Jun 2017 - 3 Oct 2017	[0.5 34.5] days	0 - 20	WGS 84

Start Time: 0000 4 Oct 2017 | 0000 3 Oct 2017
Lead: 0.5 | 1.5
Ensemble Member: 0 | 1



Start Time 0000 4 Oct 2017 Lead 0.5 days Ensemble Member 0

0.5W | 0.5W



0.0 | 0.002931

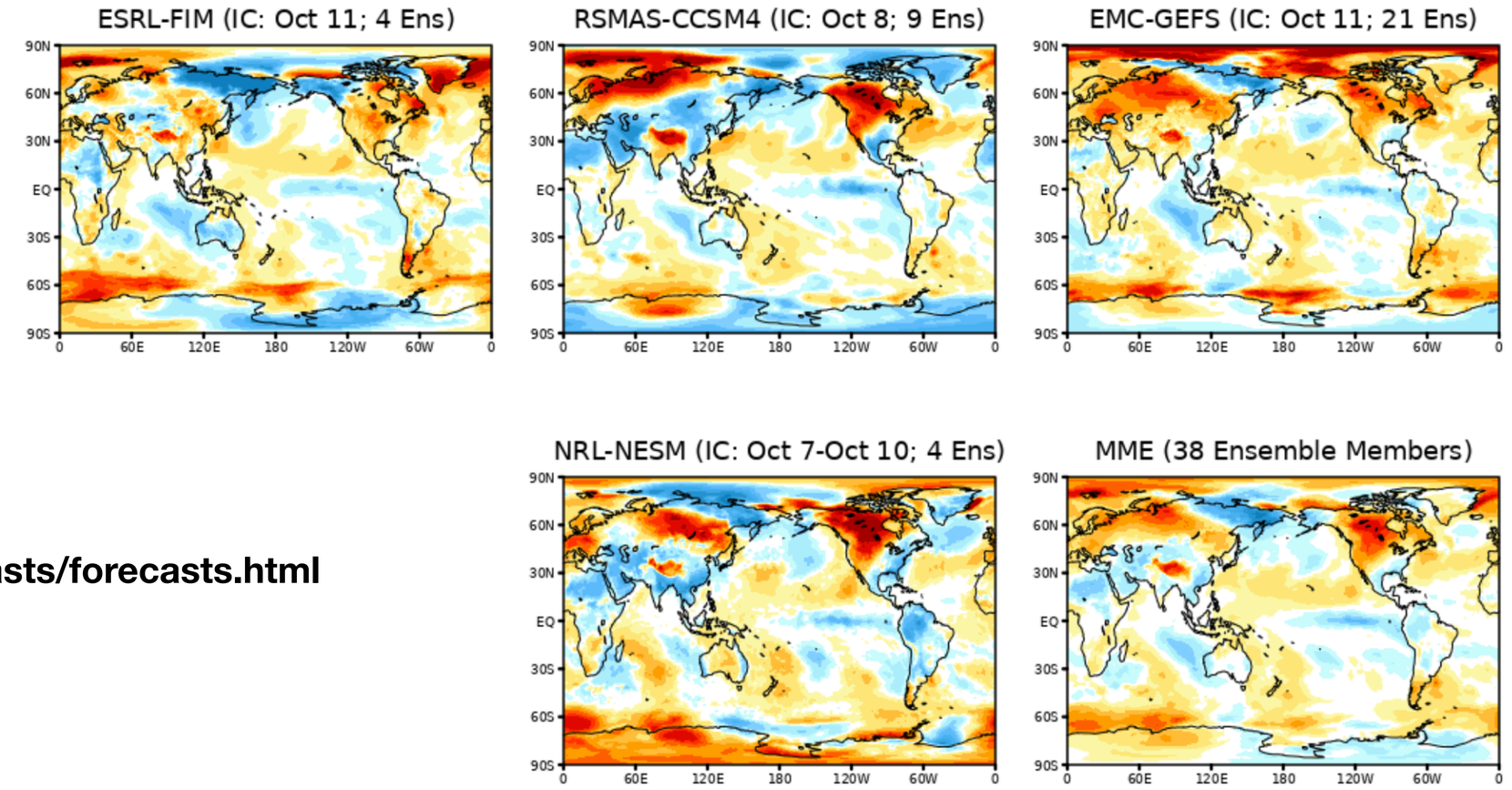
Longitude | Latitude | draw coasts | colors

SubX Real-time Forecasts

Home | About | People | Data | Forecasts | Related Projects

Latest | Weeks 3&4 | 2m Temp Global | Submit

SubX Week 3-4 2m Temperature Anomalies (deg C)
Valid Oct 28 - Nov 10



http://wxmaps.org/subx_custom.php

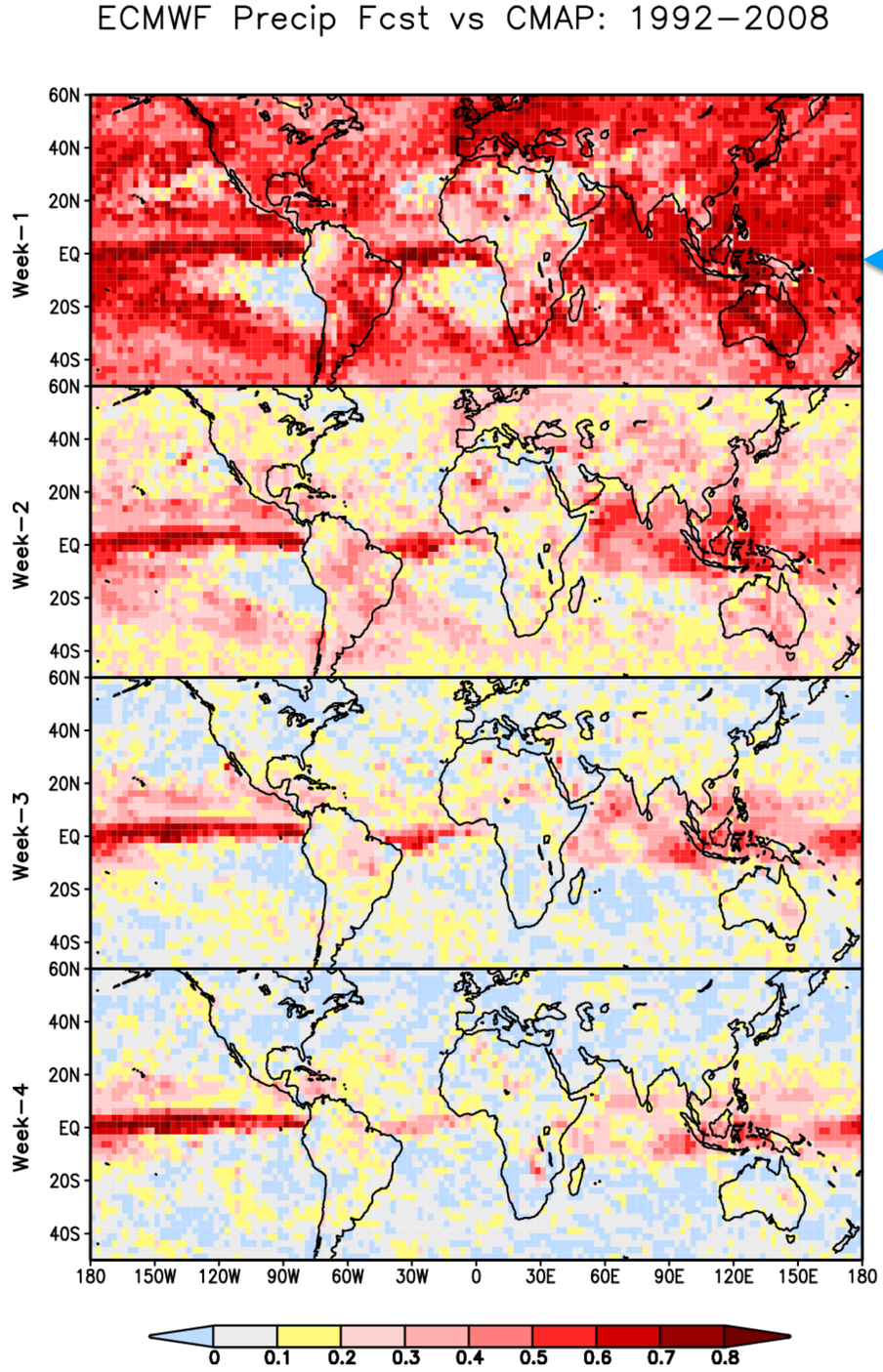
http://cola.gmu.edu/kpegion/subx/forecasts/forecasts.html

4. Sub-seasonal forecast skill

ECMWF Sub-monthly Precip Forecast Skill

Weekly average precip

Jun–Aug anomaly correlation skill

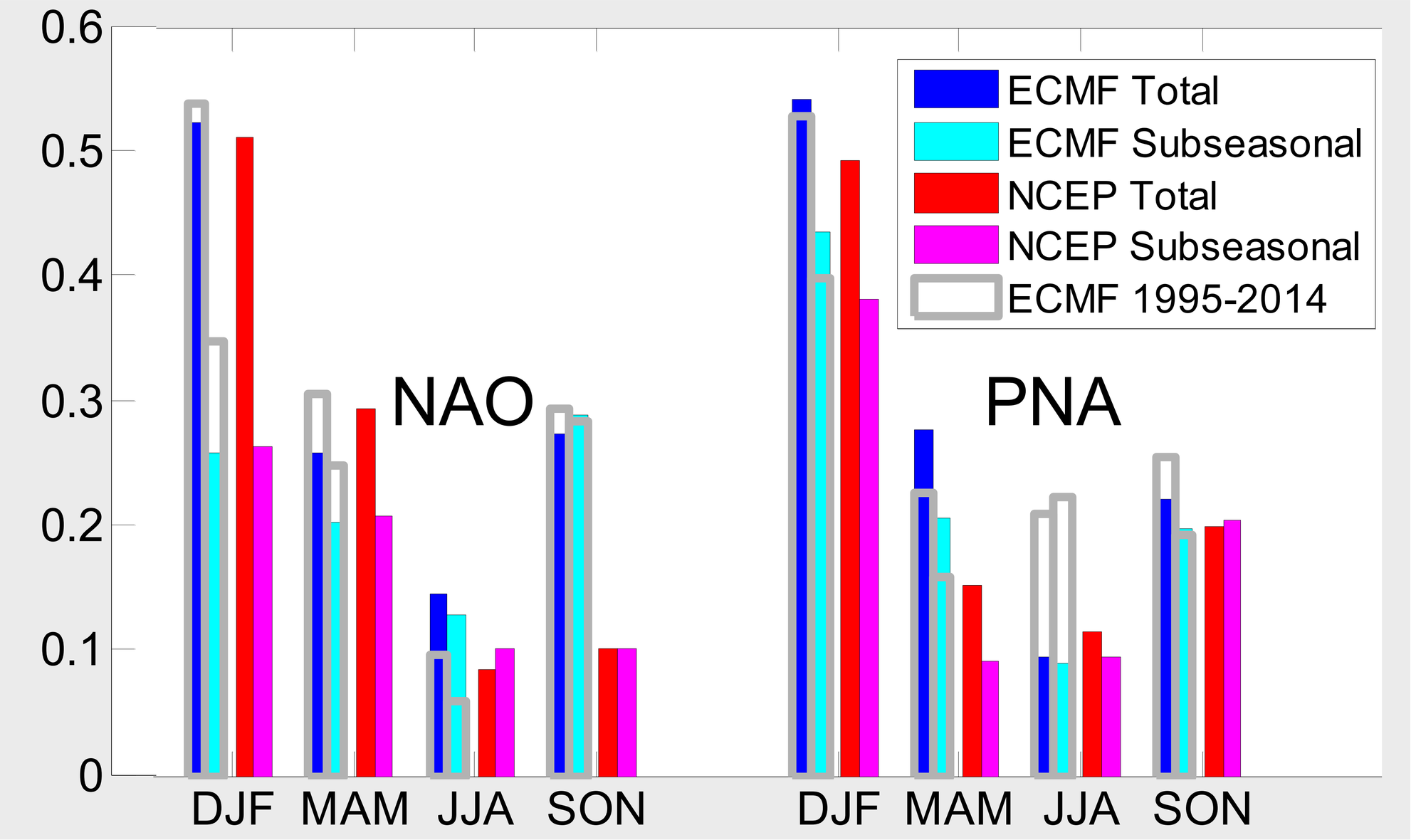


skill from atmos ICs

skill from MJO, surface BCs, Stratosphere, …

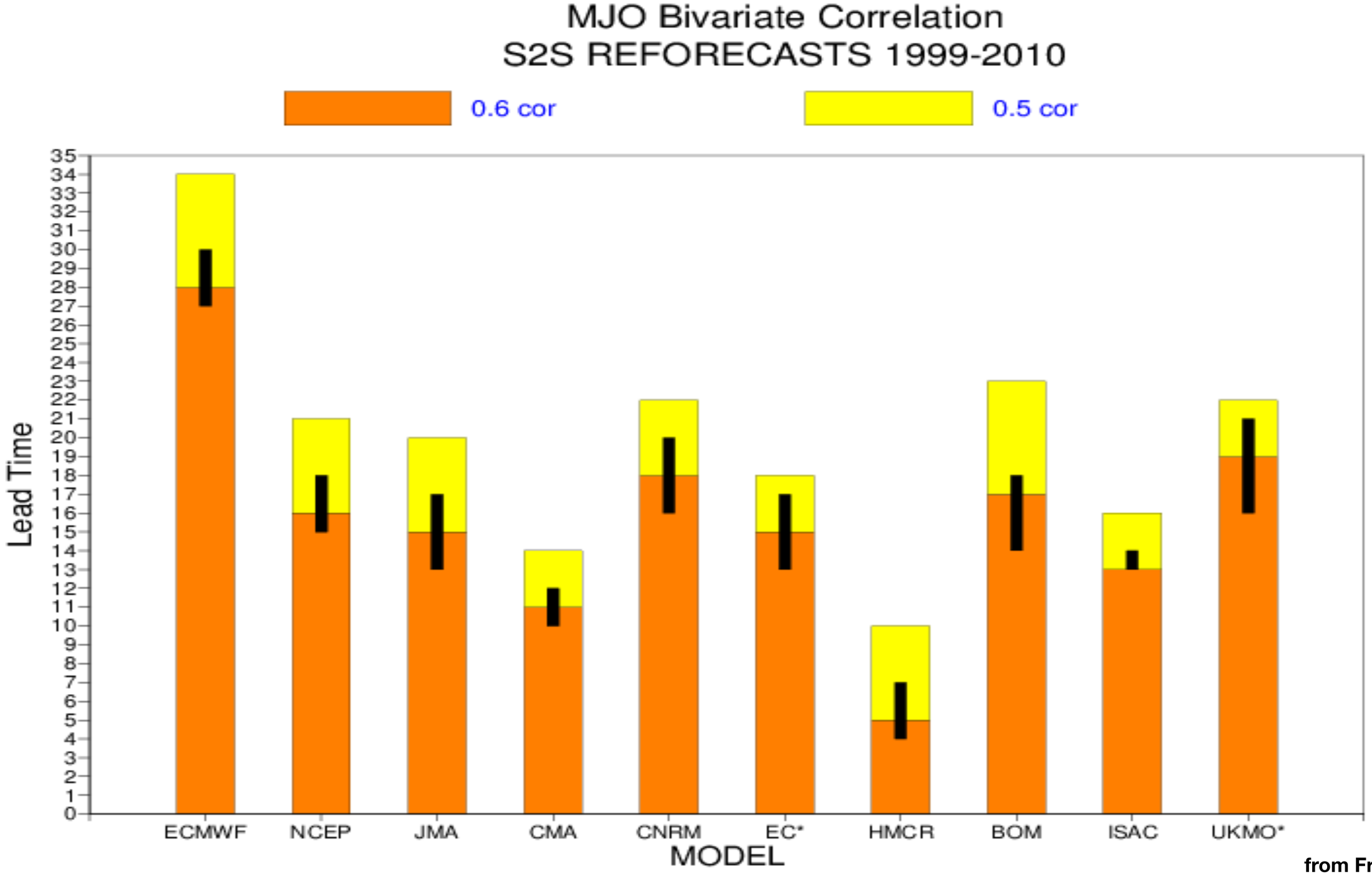
Li and Robertson (2014)
https://doi.org/10.1175/MWR-D-14-00277.1

Week 3+4 Anomaly Correlation Skill



Skill mostly in DJF; mostly subseasonal in PNA; interannual in NAO

L. Wang

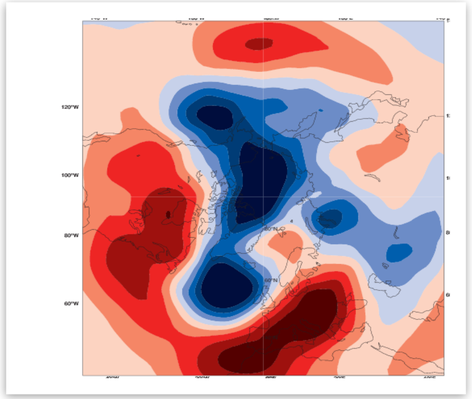


from Frederic Vitart

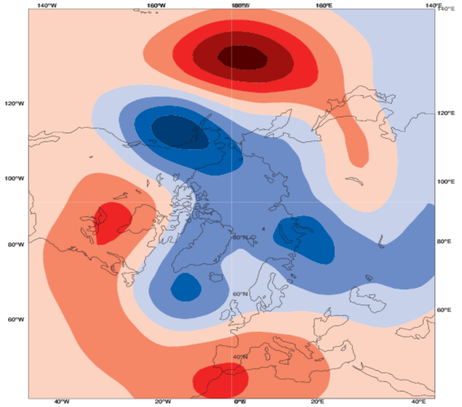
MJO Teleconnections (S2S re-forecasts)

Z500 anomalies 10 days after an MJO in Phase 3

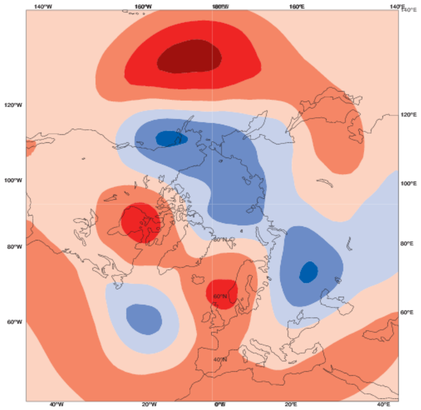
Analysis



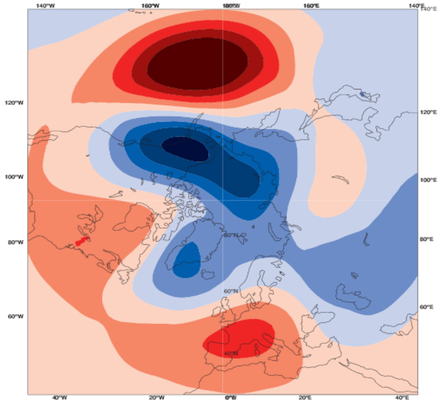
ECMWF



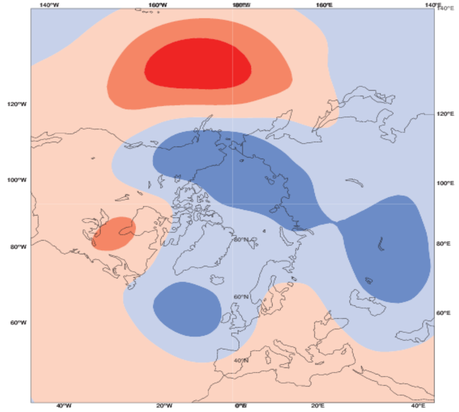
JMA



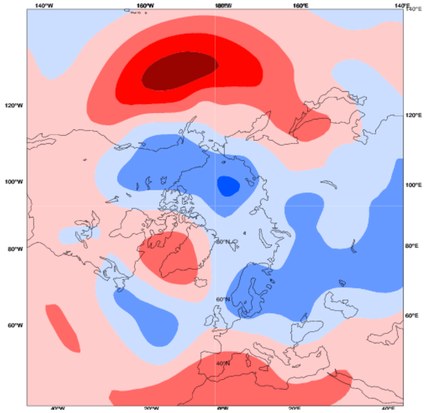
NCEP



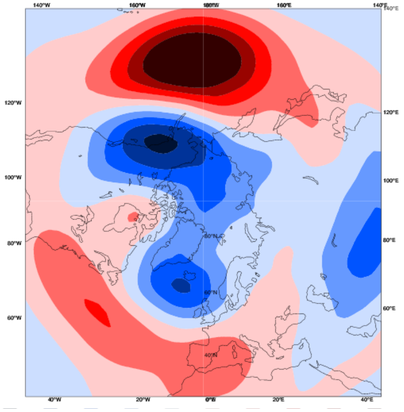
CAWCR



CNRM



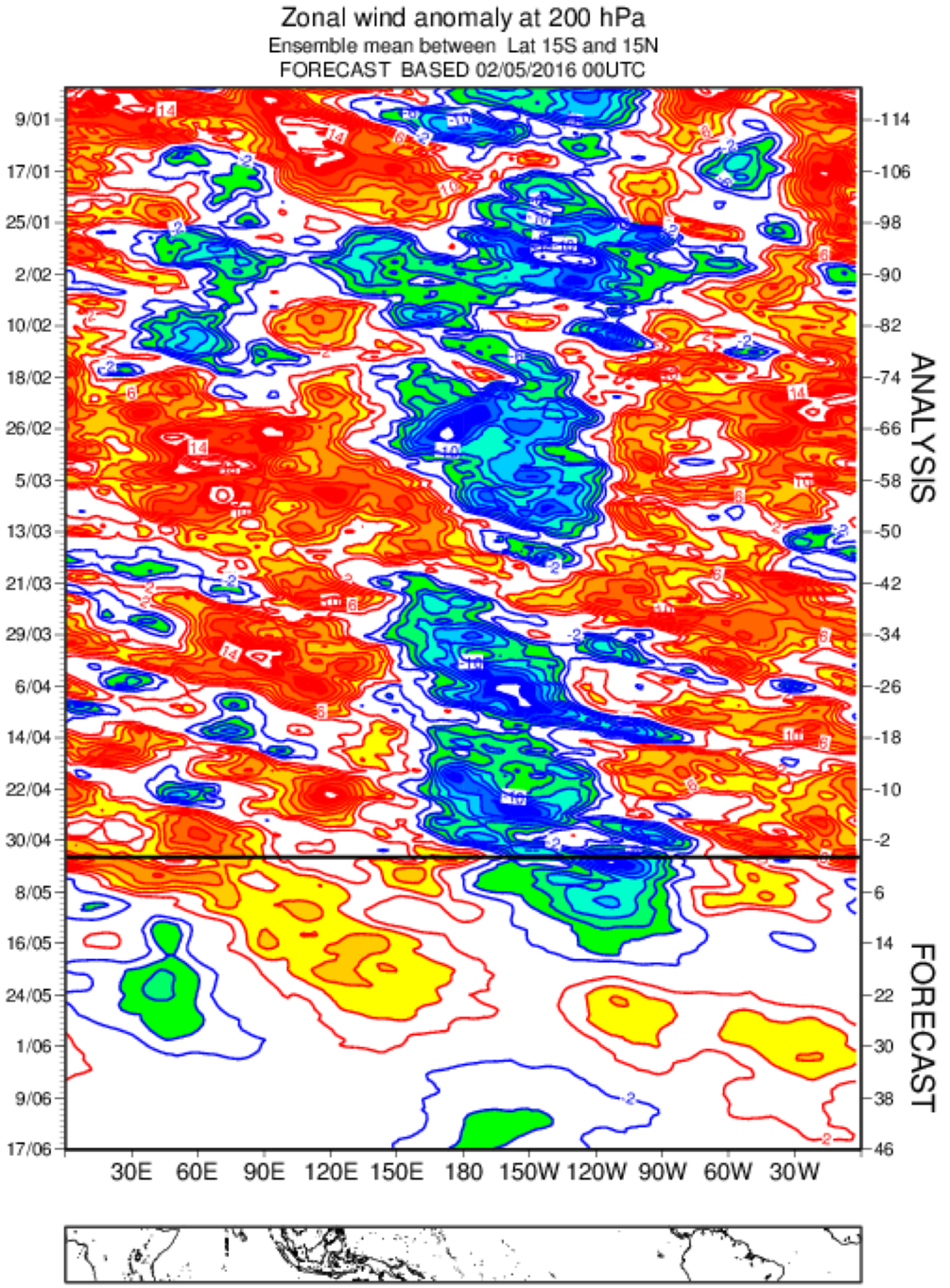
EC



from Frederic Vitart

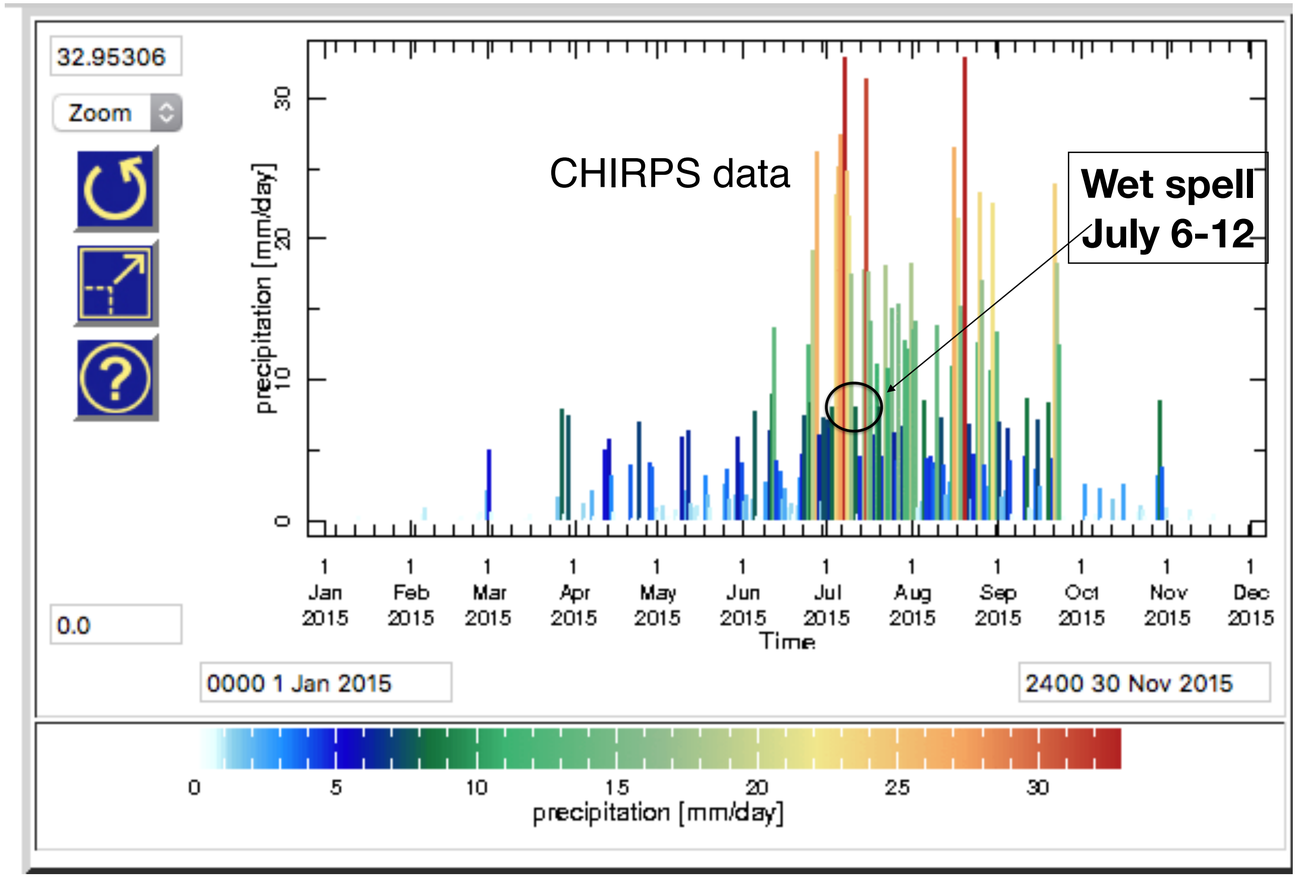
MJO indices from S2S models

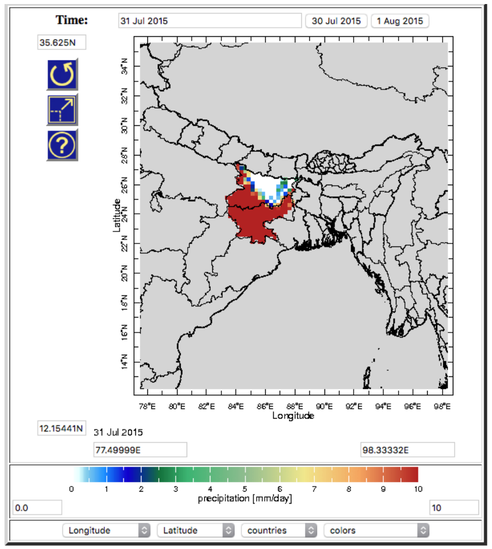
The computation of the MJO index at ECMWF follows the methodology described in Gottschalk et al (2010), except that we compute the index on forecast anomalies computed with respect to each model rather than using the NCEP-NCAR reanalysis climatology.



Case Study of heavy rainfall event over Bihar

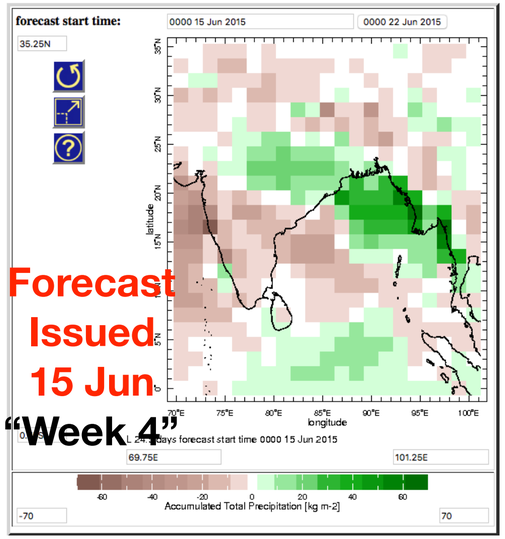
Can S2S Forecasts capture it?





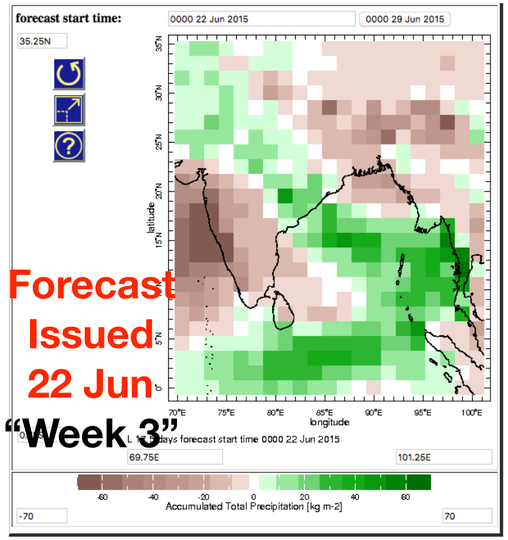
IRI Data Library

Diagnostics with S2S Database



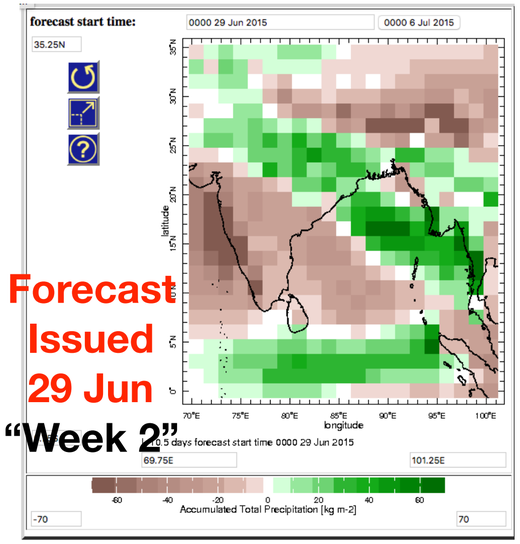
Forecast Issued 15 Jun

"Week 4"



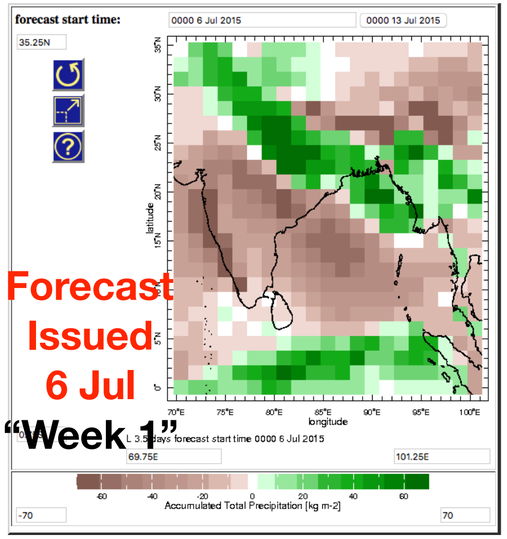
Forecast Issued 22 Jun

"Week 3"



Forecast Issued 29 Jun

"Week 2"



Forecast Issued 6 Jul

"Week 1"

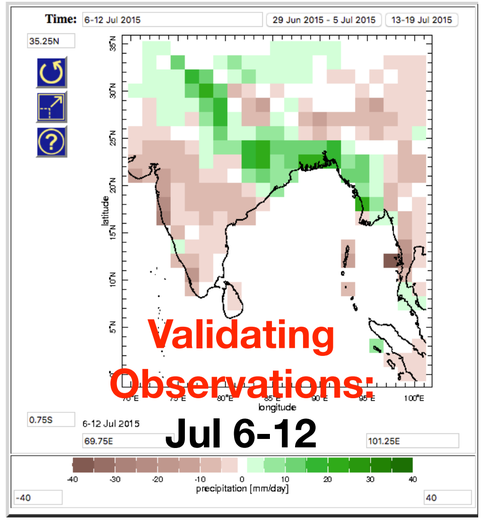
ECMWF Forecasts

valid for

Jul 6-12, 2015

Weekly average

precip anomalies



Validating Observations:

Jul 6-12

IRI Data Library

Summary

1. Weather and climate forecast timescales: S2S forecasts (2 weeks to a season) are a grey area with some aspects of weather (impact of atmospheric initial conditions), and some of climate (time averaging is needed).

2. The WWRP/WCRP S2S Prediction Project: Aims to improve understanding and forecast skill in the 2-weeks-to-a-season range. Teleconnections are one of the research foci.

3. The S2S and SubX Databases: S2S includes 11 models, SubX 7 has models. Real time forecasts are 3 weeks behind real time in S2S, but real time in SubX.

4. Sub-seasonal forecast skill: MJO, NAO & PNA all exhibit skill in weeks 3-4 (days 15-28). Still some serious biases in the MJO extratropical teleconnections.