

# Technical aspects and current practices of operational climate prediction across different time and spatial scales

## Sub-seasonal Forecasts

Andrew W Robertson

# Outline

## Technical aspects:

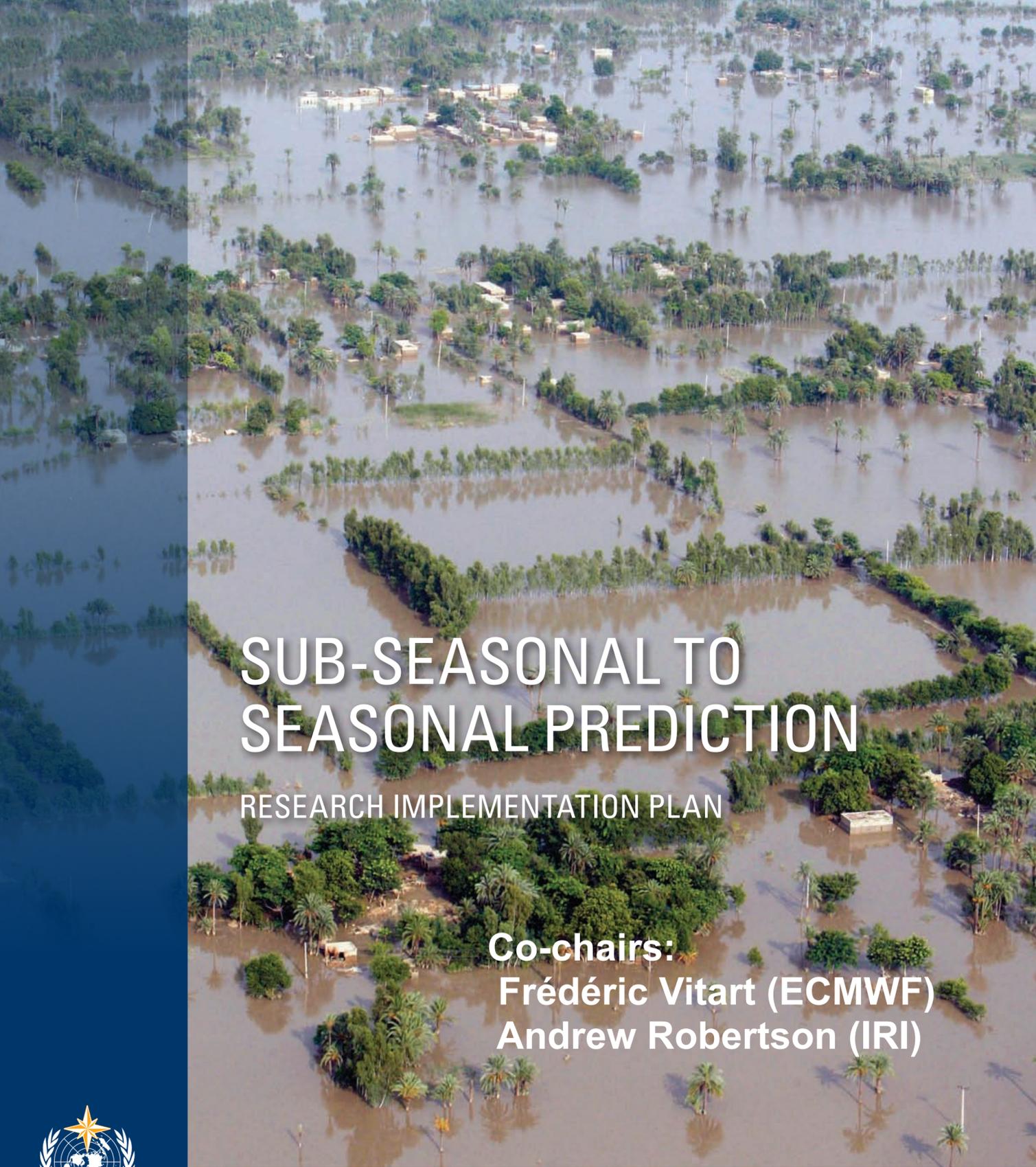
- Sub-seasonal = “Extended Range Plus” 10 to 45+ days
- Real time forecast/hindcast design – unlike in seasonal forecasting case, the hindcast set-ups generally don’t match the forecasts in ensemble size and start dates
- Initialization/ensemble generation – “burst” vs “lagged” ensembles
- Model components – increasingly sub-seasonal forecasts include coupling with ocean and sea-ice component

## Current practices:

- GPC models in S2S database – no protocol
- SubX models – has forecast/re-forecast protocol

## Issues:

- S2S hindcast harmonization for MME – still disparate; difficulties in calculating hindcast climatologies
- S2S non-public availability of real-time forecasts to research & applications communities
- Maintenance of S2S database at risk



# SUB-SEASONAL TO SEASONAL PREDICTION

RESEARCH IMPLEMENTATION PLAN

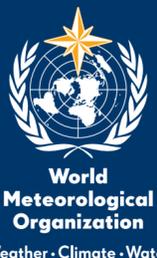
**Co-chairs:**  
Frédéric Vitart (ECMWF)  
Andrew Robertson (IRI)



- 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.*



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## What is SubX?

The Subseasonal Experiment (SubX) is a project producing retrospective and real-time predictions on subseasonal timescales. Six global models are producing seventeen years of ensemble retrospective forecasts initialized weekly with daily output to investigate subseasonal prediction and predictability. Additionally, one-year of real-time predictions will be produced and provided to the NOAA/NWS Climate Prediction Center as additional guidance for their week-3/4 outlooks.

The Objectives of the SubX Project are:

- Collecting and serving data both internally at CPC for use by operational forecasters and for the external community via the IRI data library
- Providing a baseline verification particularly for the weeks 3-4 temperature and precipitation probability forecasts
- Multi-model evaluations and combinations including selecting suitable models, optimizing the design of the system, and evaluation of the prediction products
- Enhancing communications between operational forecasts and the model forecast producers



Modeling, Analysis, Predictions and Projections Program



The Office of Naval Research



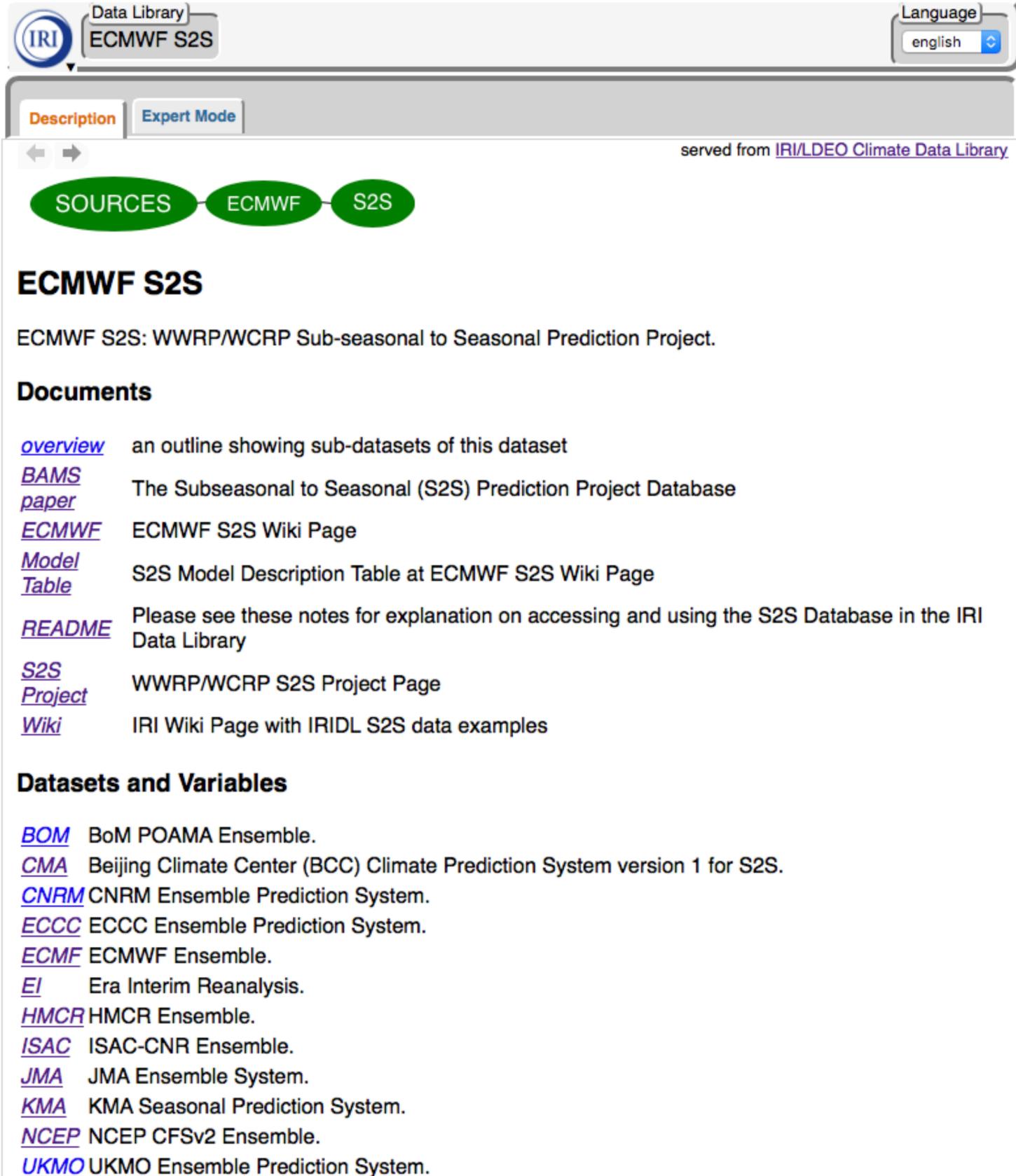
MAP Program



Office of Science and Technology Integration

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

# 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

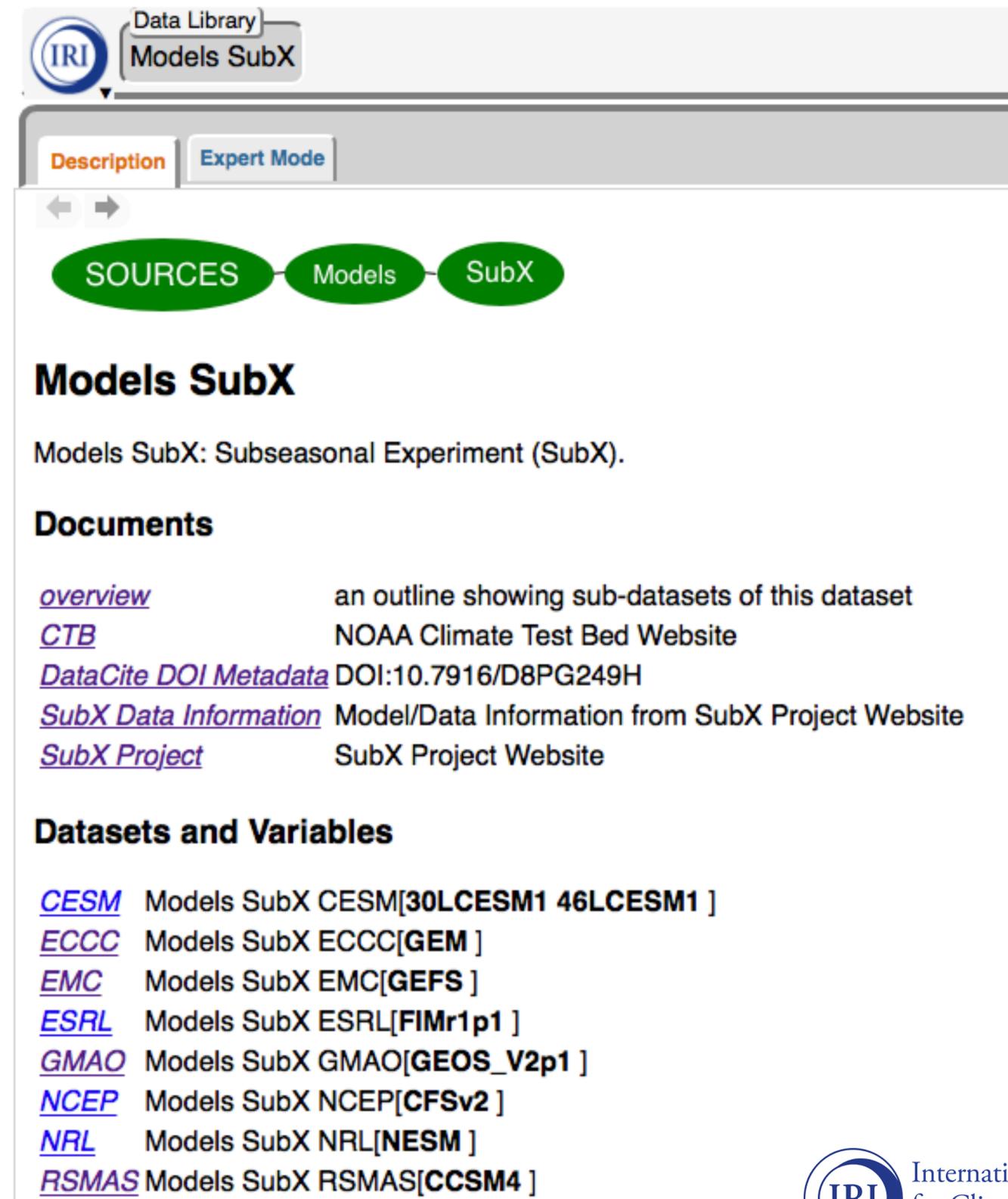
ECMWF S2S: WWRP/WCRP Sub-seasonal to Seasonal Prediction Project.

### 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

Language: english

Description Expert Mode

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

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 ]

# S2S Database Models

## Forecasts

## Hindcasts

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

see [s2sprediction.net](http://s2sprediction.net) for details and to access data

Forecasts available 3 weeks behind real time, on 1-deg grid

Currently ~70 Tbytes



# S2S Model Components

Models	Ocean coupling	Active Sea Ice
ECMWF	YES	YES
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

# SubX Protocol

- **Prediction System Details up to Provider**
- **Real-time and Retrospective Systems Identical**
  - **Ensemble Generation Issues**
- **Reforecast Forecast Period: 1999-2015**
- **At Least 4 Ensemble Members**
- **Minimum Length 32 Days**
- **Real-time Forecast Made Available to CPC Through NCO Every Wednesday by 5pm of Every week**
- **Data on Uniform 1x1 Grid**

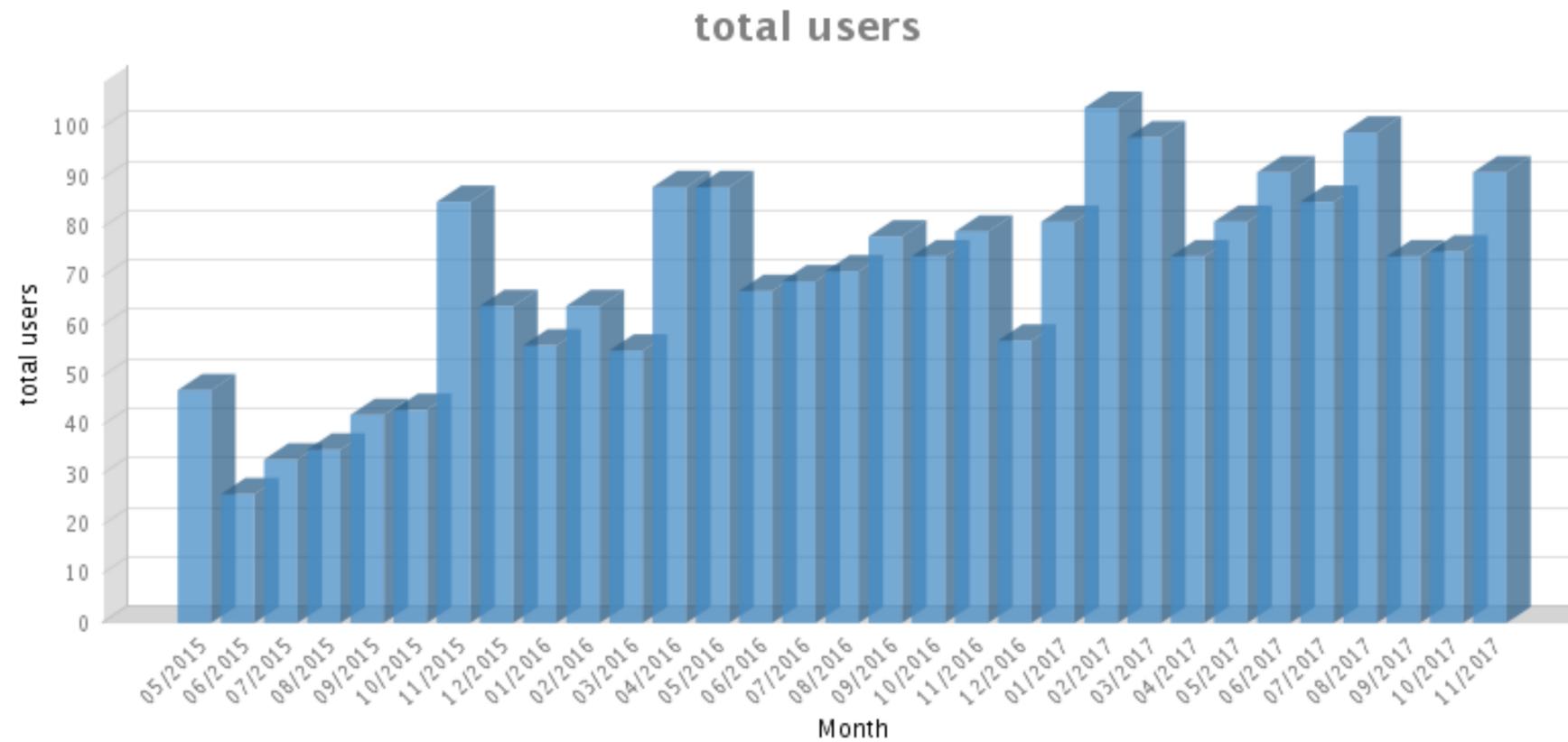
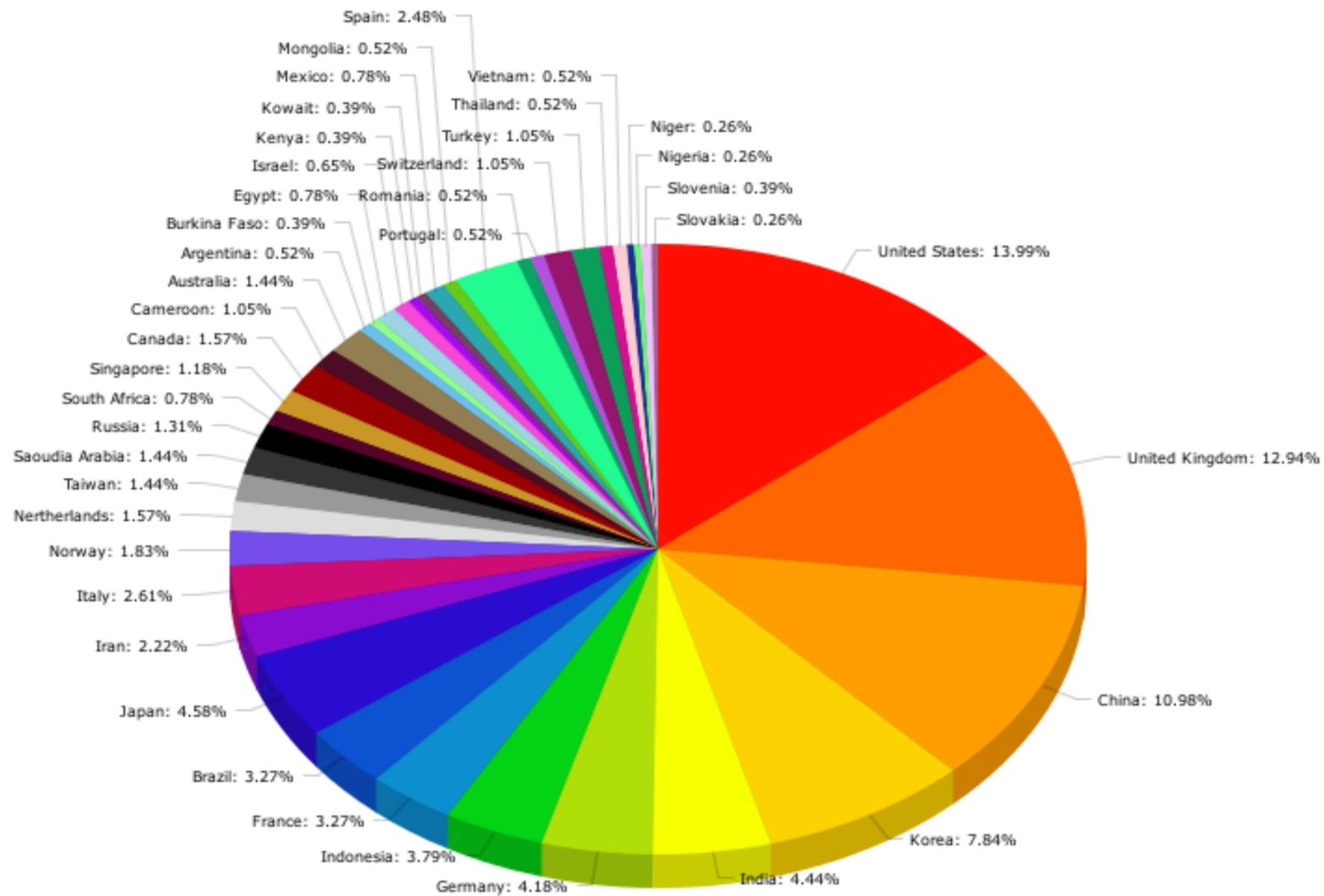
# SubX Models

Model	Hindcast Period	# Members	Perturbation Methodology	Lead (days)	Atm	Ocn	Sea Ice	Land
<a href="#">NCEP/CFSv2</a>	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
<a href="#">NCEP/GEFS</a>	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
<a href="#">ECCC GEM</a>	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
<a href="#">NASA GEOS-5 AOGCM</a>	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 Ocn Analysis	Catchement Land Sfc Model ICs MERRA-2 precipitation corrected
<a href="#">Navy Earth System Model</a>	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
<a href="#">NCAR/CCSM4</a>	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 atmopshere
<a href="#">NOAA/ESRL FIM HYCOM</a>	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

# Increasing use of the S2S Database

by end of 2017:

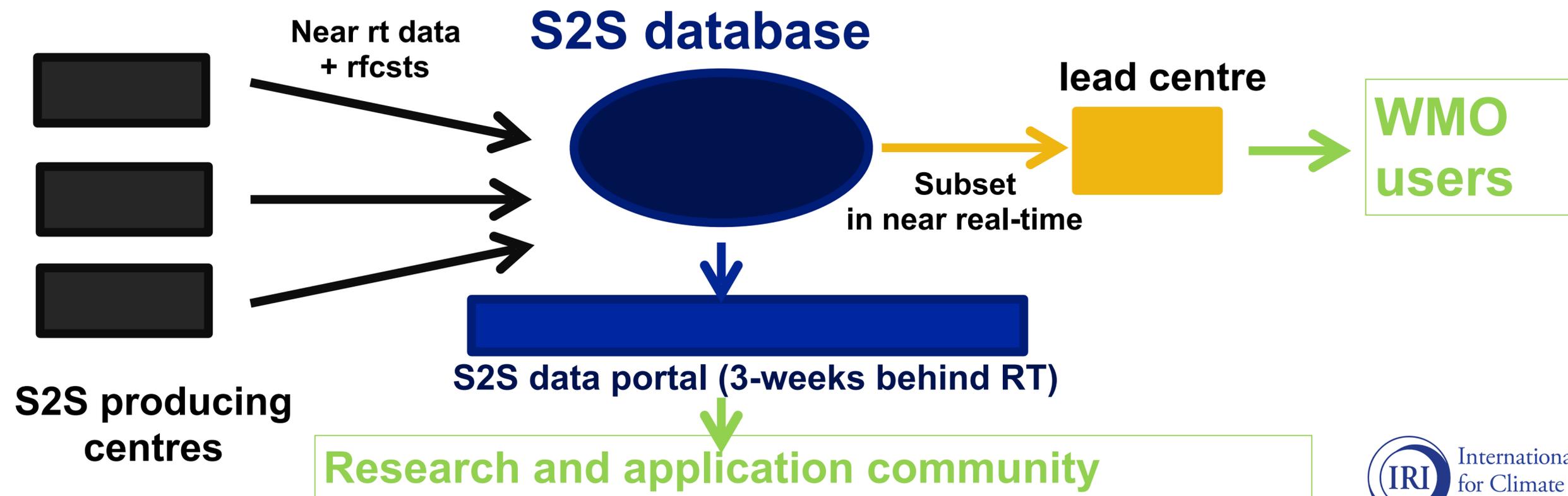
- 848 registered users from 88 countries at ECMWF
- 222 register users mostly from China at CMA



# S2S Linkage with CBS

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

- Research into sub-seasonal predictability under S2S is to be conducted in close liaison with developing infrastructure and procedure for operational sub-seasonal prediction as they develop under CBS.
- The S2S database is used to provide real-time data to CBS.



WWRP/WCRP Sub-seasonal to  
Seasonal Prediction Project (S2S)  
Phase I Final Report

(November 2013–December 2017)

Proposal submitted for 5-year extension 2018-2023 (S2S Phase 2) for approval by the WMO EC in June 2018. Already approved by WWRP SC and WWRP JSC.

## S2S Phase 2 plans:

- **S2S Database enhancement** – ocean variables, more surface variables 4xdaily, additional models (eg IMD)
- **New research foci** (sub-projects) – **MJO** prediction and teleconnections; roles of **Ocean and sea ice**, **Land surface**, **Stratosphere**, **Atmospheric composition** and **Ensemble generation**.
- **Enhancing operational infrastructure, user applications & real-time pilot experiment**

# S2S Phase II Plans:

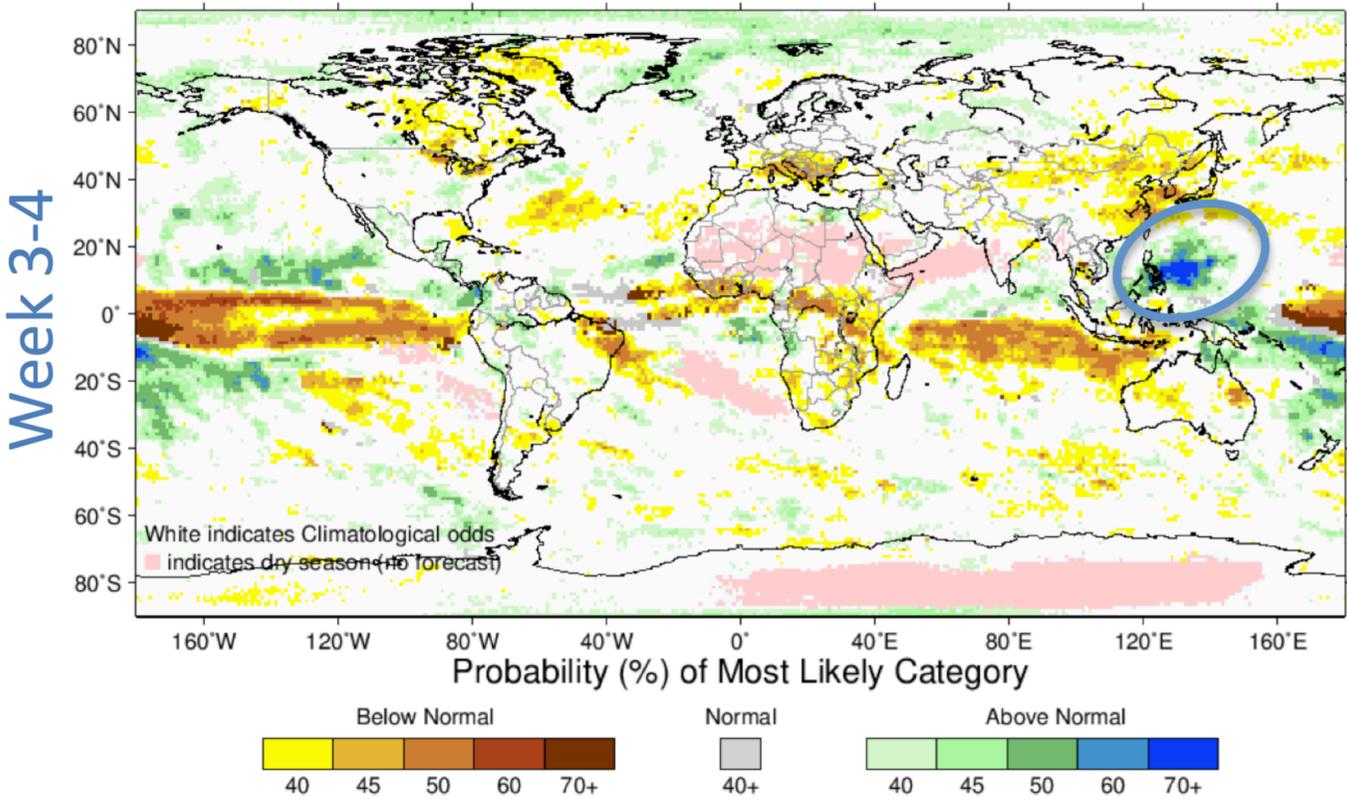
## Enhancing operational infrastructure & user applications

1. Research to Operations (R2O) and S2S Forecast and Verification Products Development:
  - Accelerate development of methodologies for forecast calibration, multi-model combination, verification, and forecast formats (e.g. probability of threshold exceedance)
  - Encourage Operational Centres to harmonize their real-time and re-forecast set-ups
  - Assist WMO to develop operational criteria for Global Producing Centers for S2S Predictions, and data exchange standards for S2S hindcasts/real-time forecasts for WMO Lead Centre
2. Establish a real-time forecast pilot program for S2S applications of 1–2 years duration, with goal of demonstrating S2S forecast value using real-time S2S forecasts

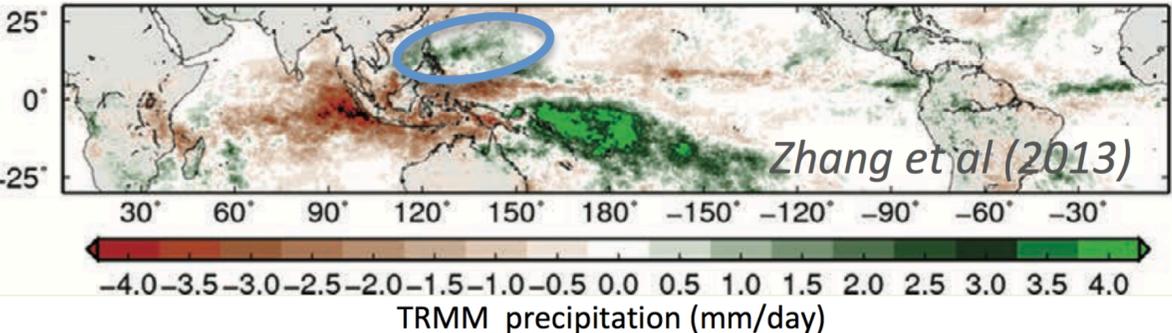
# Sub-seasonal prediction research at IRI

On Feb 13–15 2018, Tropical cyclone Basyang/Sanba hit the Philippines (150,000 affected & 50,000 displaced)  
 Could it be predicted 3–4 weeks ahead?

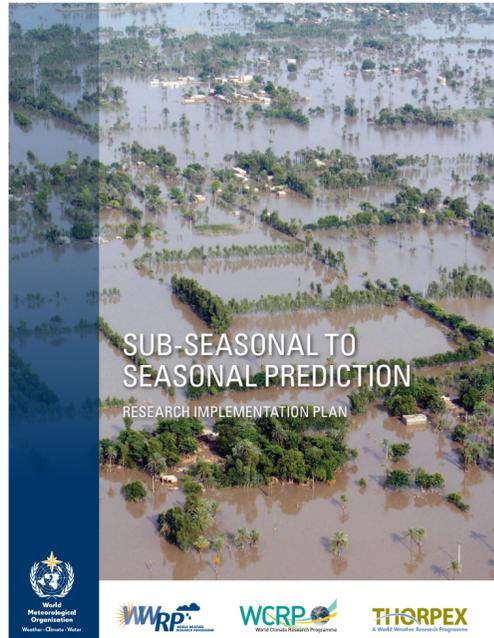
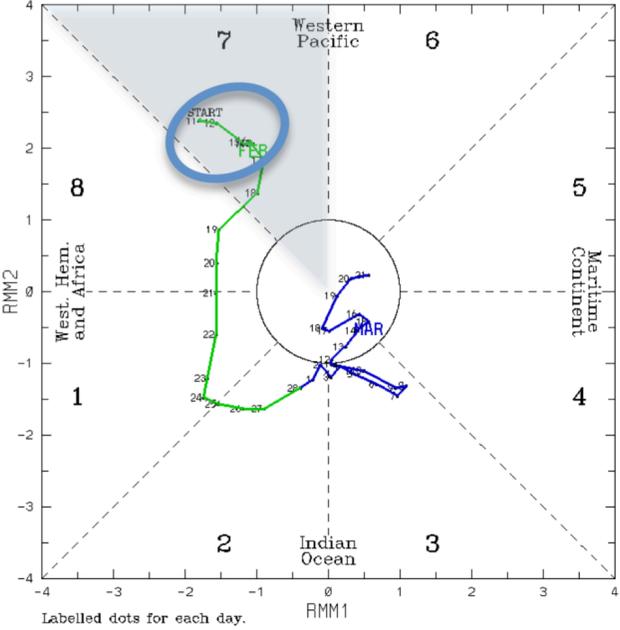
Experimental Precipitation Probability Forecast for 20180208–20180215, Issued on 18 January 2018



MJO phase 7 precipitation anomalies (1998-2012 baseline)



Skill relationship to strong MJO activity in phase 7



- This research applies IRI’s expertise in seasonal prediction to the subseasonal scale to develop a multi-model calibrated probability forecast system, and identify sources of predictability (here the “MJO”)

# IRI's User-Oriented "Flexible Forecast" Seasonal Forecast Maproom

Climate

Flexible Forecasts

Region

Target Time

Probability

Forecasts

Precipitation Flexible Seasonal Forecast

South America

Sep-Nov 2018

non-exceeding

Percentile

20.0

%-ile

Description

Dataset Documentation

Instructions

Contact Us

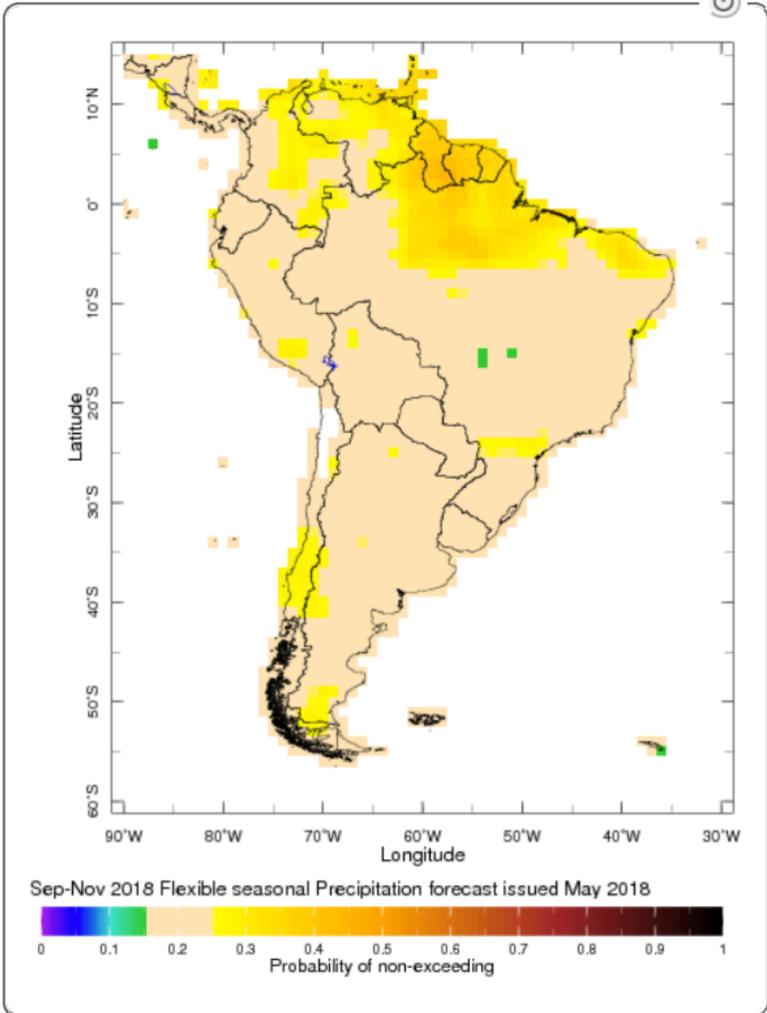
## Precipitation Flexible Seasonal Forecast

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

**Please refer to our [licensing agreement](#) for permission to use any IRI forecast material.**

Probabilistic seasonal 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 to deliver interactive maps and point-wise distributions that become relevant to user-determined needs.

The default map shows globally the seasonal precipitation forecast probability (colors between 0 and 1) of exceeding the 50<sup>th</sup> percentile of the distribution from historical 1982-2010 climatology. The forecast shown is the latest forecast made (e.g. Dec 2017) for the next season to come (e.g. Jan-Mar 2018). Four different seasons are forecasted and it is also possible to consult forecasts made previously. The forecasts are directly computed from the [extended logistic regression](#) model as probabilities of exceeding (or non-exceeding) of every 5th percentile of the climatological distribution. The specific quantile (in steps of 5 percentile points) can then be selected. The user can also specify a quantitative value in physical units (here seasonal total precipitation in mm) for probability of exceeding

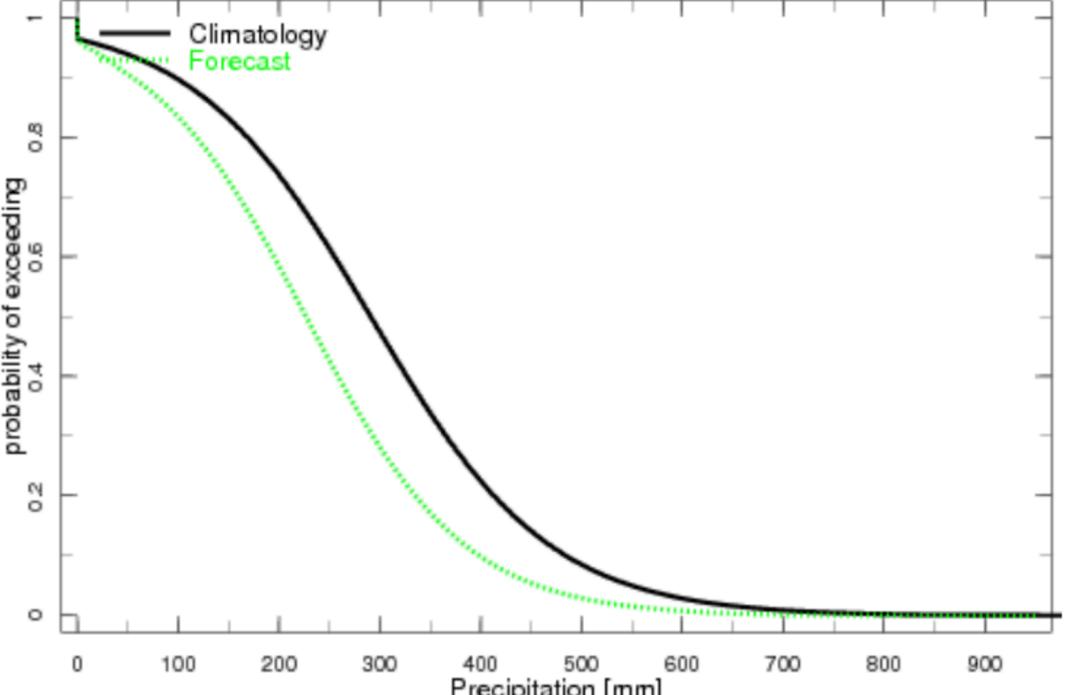




Target Date	Issue Date	Lead Time
Sep-Nov 2018	0000 1 May 2018	5.5

Forecast made for [59W-58W, 1N-2N] located in or near **Oriximina, Para, Brazil**

### Probability of Exceeding



Sep-Nov 2018 Flexible seasonal Precipitation forecast issued May 2018

- User can query the full probability distribution
- Choose relevant quantile, or physical quantity relevant to their decision
- Seasonal precipitation and temperature

# Summary

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- Sub-seasonal = “Extended Range Plus” 10 to 45+ days
- Real time forecast/hindcast design – unlike in seasonal forecasting case, the hindcast set-ups generally don’t match the forecasts in ensemble size and start dates
- Initialization/ensemble generation – “burst” vs “lagged” ensembles
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