# S2S Community Activities
## (WCRP/WWRP S2S Project, SubX, IWRCC)

**Duane Waliser, JPL/NASA**

Winter Outlook Workshop
Nov 1, 2018
Scripps Institution of Oceanography

# WWRP/WCRP

# S2S Project

Frédéric Vitart and Andrew Robertson

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

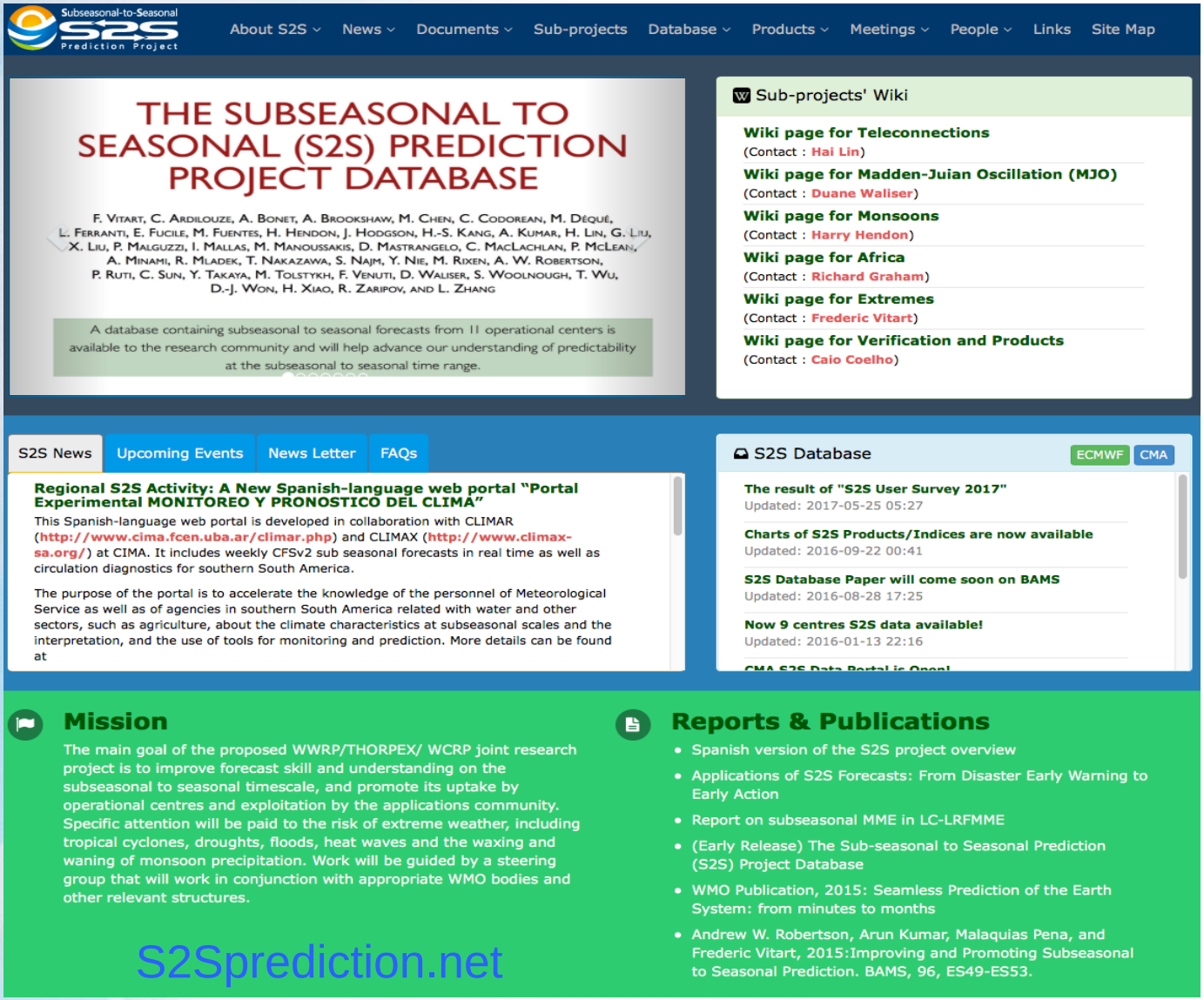
# Mission Statement

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

One of 3 Post-THORPEX Projects: S2S, HiW, PPP

# S2S Project Website

## *WCRP-WWRP S2S Project*

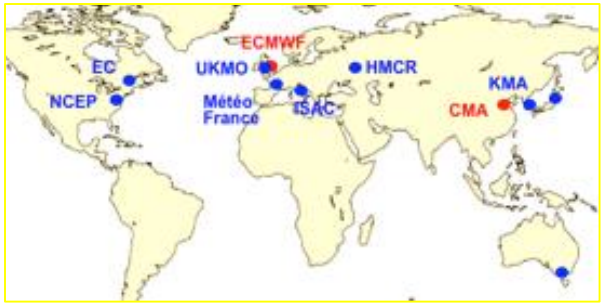



KMA – International Coordination Office

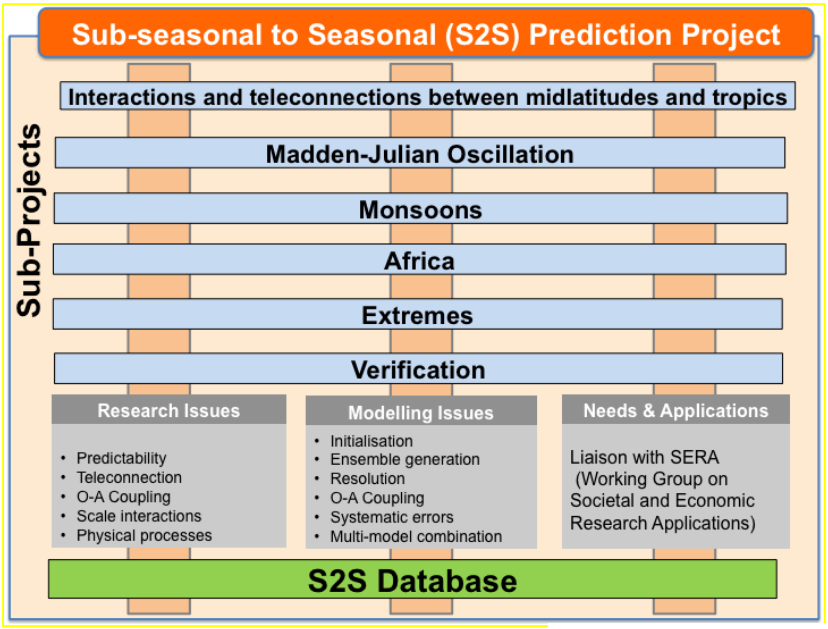
# **Subseasonal** Forecast Database

*WCRP-WWRP S2S Project*

S2sprediction.net

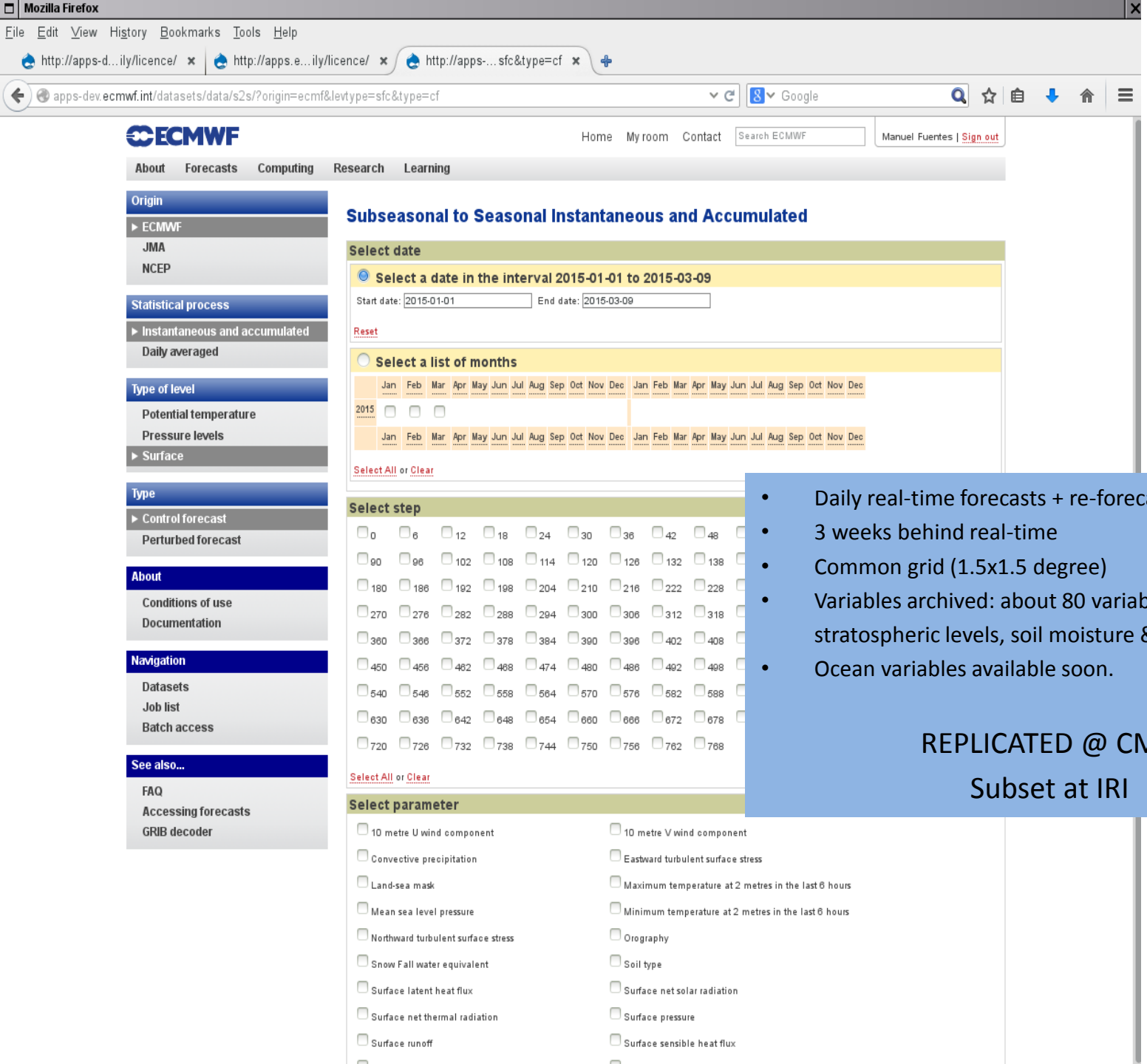



International Program for S2S Research




S2S Database

| | 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 | 1996-2009 | 4/month | 3 |
| **NCEP** | D 0-44 | N126L64 | 4 | 4/daily | Fix | 1999-2010 | 4/daily | 1 |
| **EC** | D 0-32 | 0.6x0.6L40 | 21 | weekly | On the fly | 1995-2014 | weekly | 4 |
| **CAWCR** | 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 |

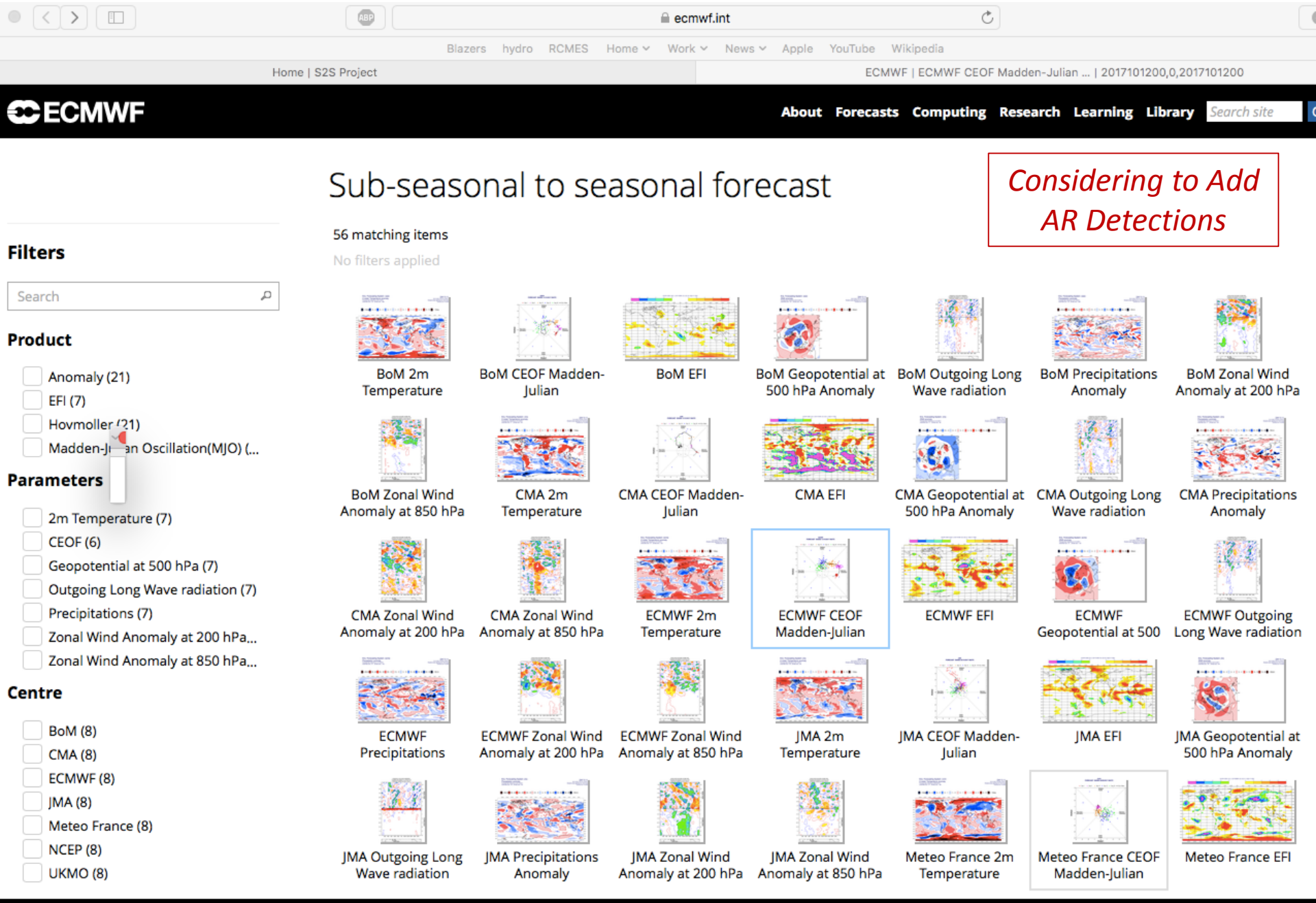



- Daily real-time forecasts + re-forecasts
- 3 weeks behind real-time
- Common grid (1.5x1.5 degree)
- Variables archived: about 80 variables including stratospheric levels, soil moisture & temperature
- Ocean variables available soon.

REPLICATED @ CMA

Subset at IRI

# Value Added Products



# Sub-seasonal to Seasonal (S2S) Prediction Project – phase 1

Sub-Projects

- Teleconnections
- Madden-Julian Oscillation
- Monsoons
- Africa
- Extremes
- Verification

| Research Issues | Modelling Issues | Needs & Applications |
|---|---|---|
| • Predictability<br>• Teleconnection<br>• O-A Coupling<br>• Scale interactions<br>• Physical processes | • Initialisation<br>• Ensemble generation<br>• Resolution<br>• O-A Coupling<br>• Systematic errors<br>• Multi-model combination | Liaison with SERA (Working Group on Societal and Economic Research Applications) |

S2S Database

# Sub-seasonal to Seasonal (S2S) Prediction Project – Phase 2

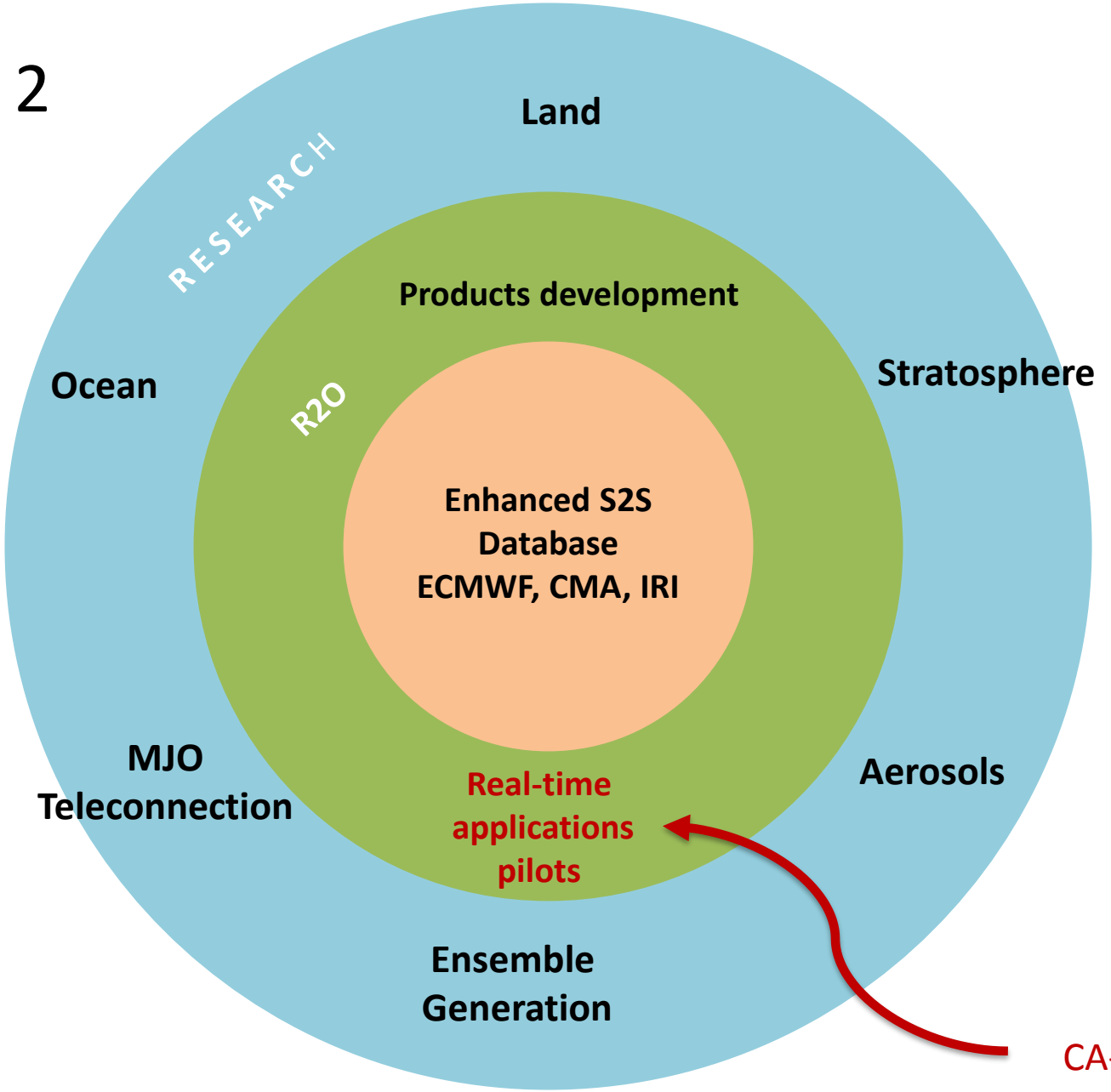
Sub-Projects

- MJO and Teleconnections
- Ocean Initialization and Processes
- Land Initialization and processes
- Aerosols
- Ensemble generation
- Stratosphere

| Predictability Issues | Modelling Issues | Needs & Applications |
|---|---|---|
| • Monsoons<br>• Extremes<br>• Verification<br>• Africa | • Resolution<br>• Systematic errors<br>• Multi-model combination | • Real-Time Pilot (S2S_SERA)<br>• R2O project |

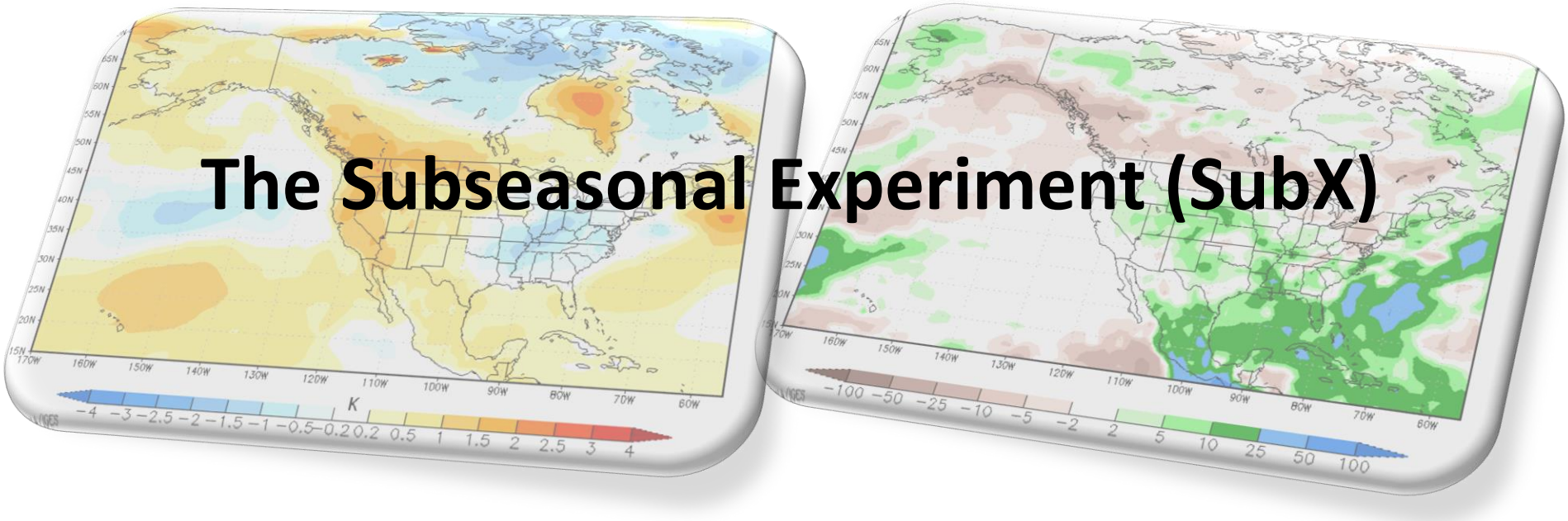
S2S Database

# Phase 2




CA-DWR
AR Exp Forecasts

WMO OMM




# The Subseasonal Experiment (SubX)

***Kathy Pegion***

George Mason University, Dept of Atmospheric, Oceanic, and Earth Sciences

Center for Ocean-Land-Atmopshere Studies

*Pegion, K. and Co-authors, 2018: The Subseasonal Experiment (SubX): A multi-model subseasonal prediction experiment, to be submitted to BAMS*

GEORGE MASON UNIVERSITY

NOAA

MAPP Modeling, Analysis, Predictions, and Projections

NATIONAL WEATHER SERVICE

Office of Naval Research Science & Technology

NASA

COLA


- Multi-model
- Monthly
- Re-forecasts & Forecasts
- Research & Predictions (R2O)


- Collection of NOAA MAPP PIs
- Collaboration to understand S2S predictability & prediction
- Uses data from other S2S Projects


- Multi-model
- Subseasonal (weekly)
- Re-forecasts & Forecasts
- Research & Predictions (R2O)


- International project
- Operational models
- Re-forecasts & Forecasts (delayed)
- Research

# What is Unique about SubX?

**Forecasts available in real-time**

Supports potential use in real-time applications

**Research models included**

Facilitates model development & improvements

# SubX BY THE NUMBERS

**7** Global Models

**1+** Years of *Real-time* Forecasts

**17** Years of *Retrospective* Forecasts

**3-4** week guidance for Climate Prediction Center Outlooks

# The SubX Team

**CORE TEAM**

Ben Kirtman
Kathy Pegion
Tim DelSole
Michael Tippett
Andy Robertson
Michael Bell
Robert Burgman
Jon Gottschalck
Dan Collins
Emerson LaJoie
Hai Lin

**NCEP-CFSv2**
Dan Collins
Jon Gottschalck
Emerson Lajoie
Emily Becker
Kyle MacRitchie

**NCEP-GEFS**
Yuejian Zhu
Wei LI
Eric Sinsky
Hong Guan

**NASA-GEOS5**
Deepthi Achuthavarier
Randy Koster
Lena Marshak

**ECCC-GEM**
Hai Lin
Bertrand Denis
Normand Gagnon

**Navy-ESM**
Neil Barton
Joe Metzger

**NCAR-CCSM4**
Ben Kirtman
Dughong Min
Kathy Pegion
Ray Bell

**ESRL-FIM**
Shan Sun
Stan Benjamin
Ben Green

# SubX Protocol

- Prediction System Details up to Provider
- Real-time and Retrospective Systems Identical
- Reforecast Period: 1999-2015
- At Least 3 Ensemble Members
- Minimum Length: 32 Days
- Real-time Forecast Made Available to CPC
  *Every Thurs* by 6am of *Every week*
- Data on Uniform 1x1 Grid

# SubX Models

| Model | Components | Ensemble Members | Length (Days) |
|---|---|---|---|
| NCEP-CFSv2 | A,O,I,L | 4 | 45 |
| EMC-GEFS | A,L | 11 [21] | 35 |
| ECCC-GEM | A,L | 4 [21] | 32 |
| GMAO-GEOS5 | A,O,I,L | 4 | 45 |
| NRL-NESM | A,O,I,L | 4 | 45 |
| RSMAS-CCSM4 | A,O,I,L | 3 [9] | 45 |
| ESRL-FIM | A,O,I,L | 4 | 32 |

# Priority 1 Variables – Required to Support Operations

On 500 and 200 hPa levels

| Variable | CF Standard Name | Abbrev | Unit | Frequency |
|---|---|---|---|---|
| Geopotential Height | geopotential_height | zg | m | Average of Instantaneous values at 0,6,12,18Z |

On 850 and 200 hPa levels

| Variable | CF Standard Name | Abbrev | Unit | Frequency |
|---|---|---|---|---|
| Zonal Velocity | eastward_wind | ua | ms-1 | Average of Instantaneous values at 0,6,12,18Z |
| Meridional Velocity | northward_wind | va | ms-1 | Average of Instantaneous values at 0,6,12,18Z |

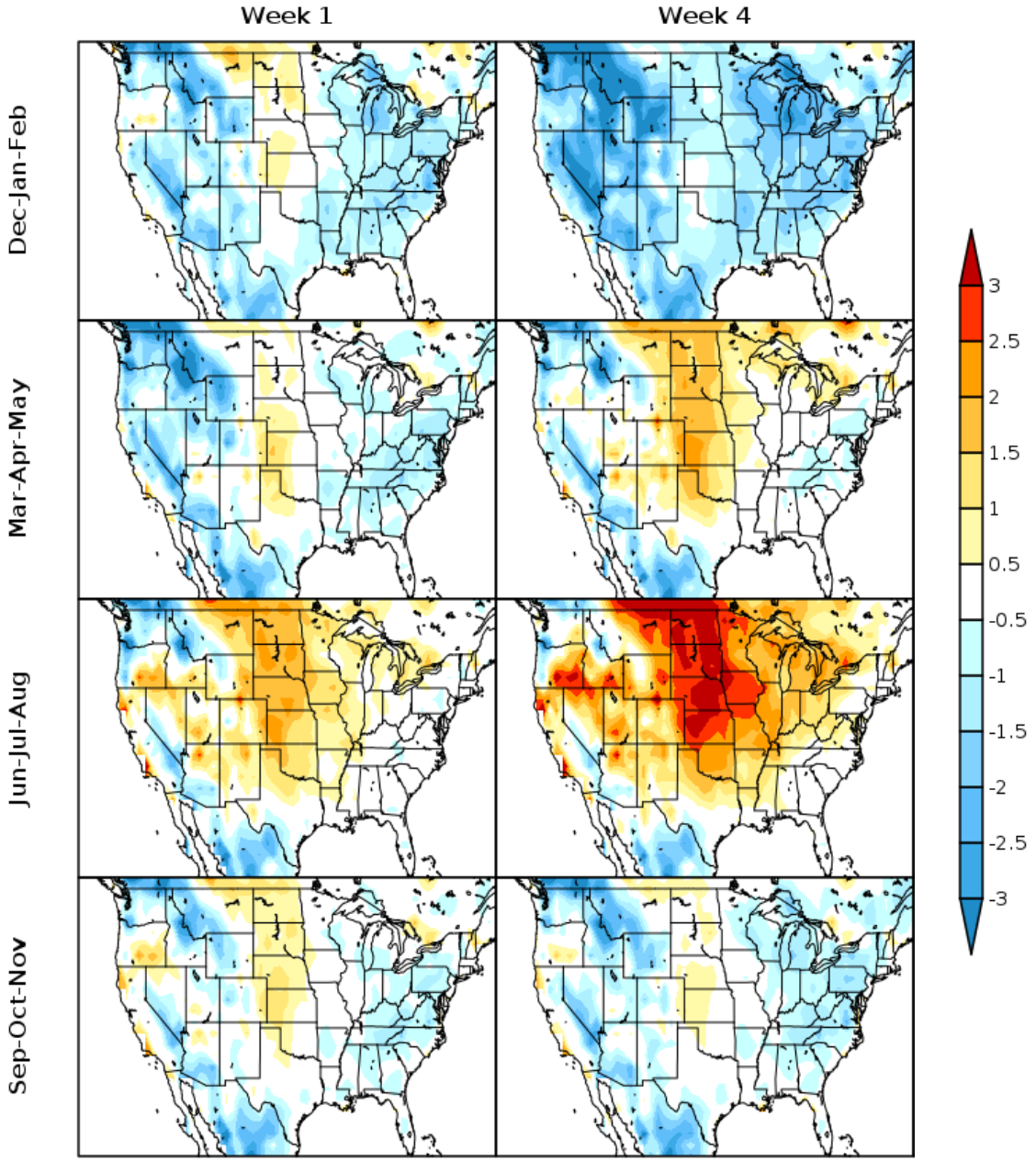
On a single level

| Variable | CF Standard Name | Abbrev | Unit | Frequency |
|---|---|---|---|---|
| 2m Temperature | air_temperature | tas | K | Daily Average |
| Precipitation | precipitation_flux | pr | kgm-2s-1 | Accumulated every 24hrs |
| Surface Temperature (SST+Land) | surface_temperature | ts | K | Daily Average |
| Outgoing Longwave Radiation at top of Atm | toa_outgoing_longwave_flux | rlut | Wm-2 | Accumulated every 24hrs |

# SubX Current Status & On-going Activities

- ✓ Re-forecast & real-time forecast database
- ✓ Real-time forecast maps
- ✓ Real-time forecast data to NCEP/CPC
- ✓ Re-forecast Evaluation: probabilistic and deterministic skill, bias
- ✓ Sources of predictability/phenomena: MJO, NAO

# SubX Multi-model Biases 2m Temperature




- Bias patterns established in week 1, grow into week 4
- Summer warm/dry bias
- MME bias is smaller than individual models

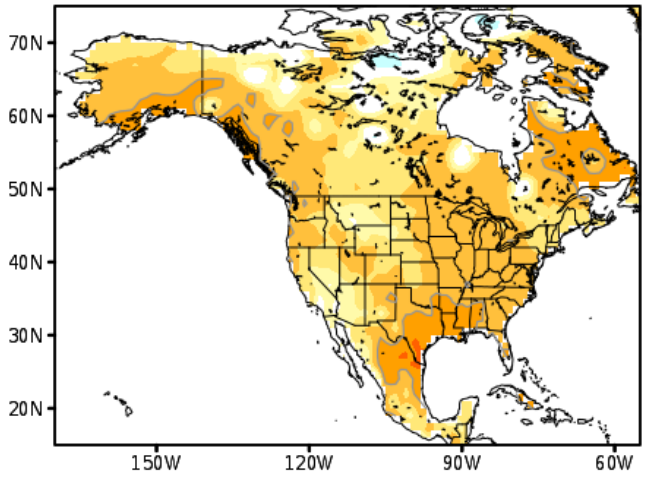
# SubX Multi-model Anomaly Correlation Week 3-4

**2m Temperature**

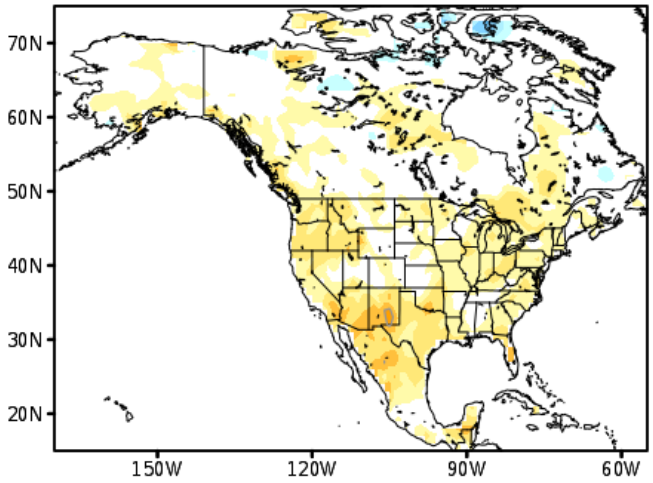
**Precipitation**

**Winter**

a) 2m Temperature Dec-Jan-Feb

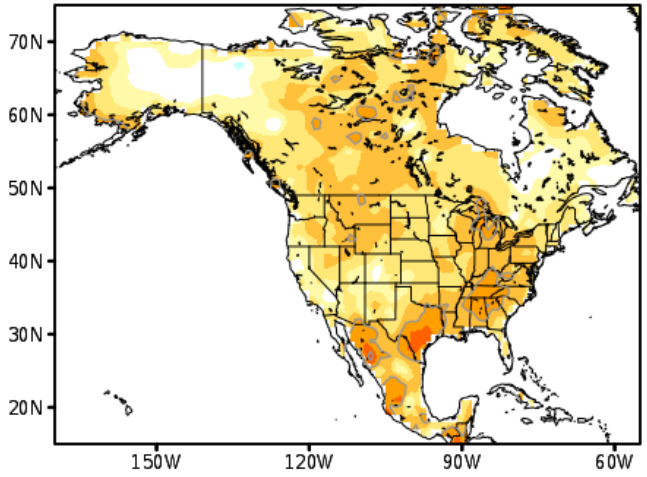



a) Precipitation Dec-Jan-Feb

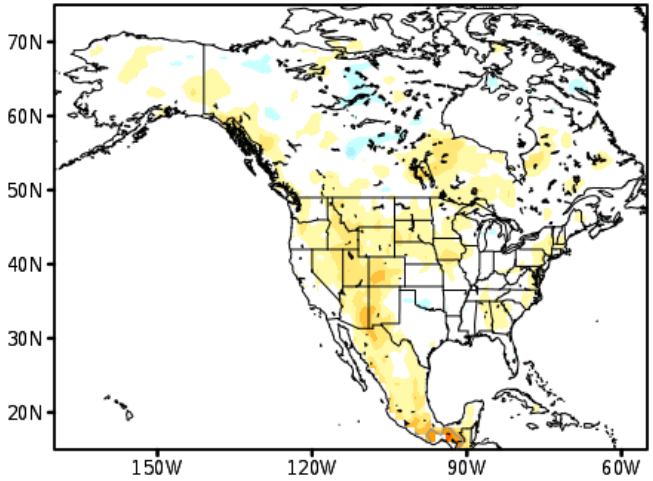


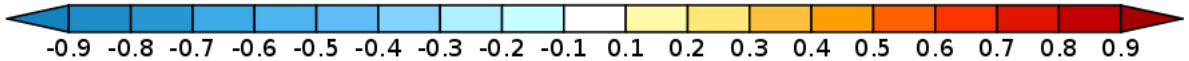

**Summer**

c) 2m Temperature Jun-Jul-Aug




c) Precipitation Jun-Jul-Aug

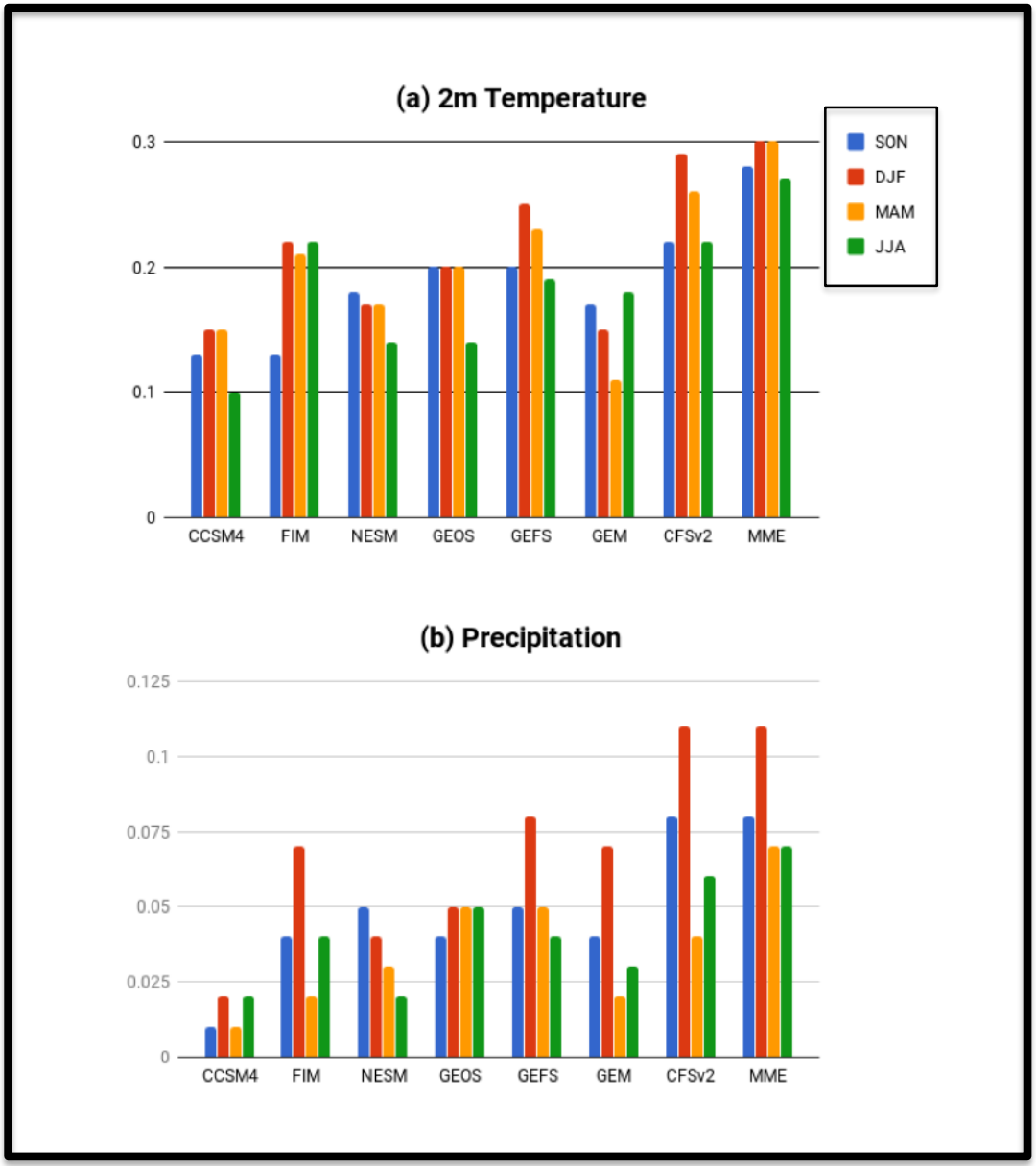



- Skill is positive
- There is ”useful” skill for some regions and seasons

# SubX Average Anomaly Correlation
# North America Week 3-4

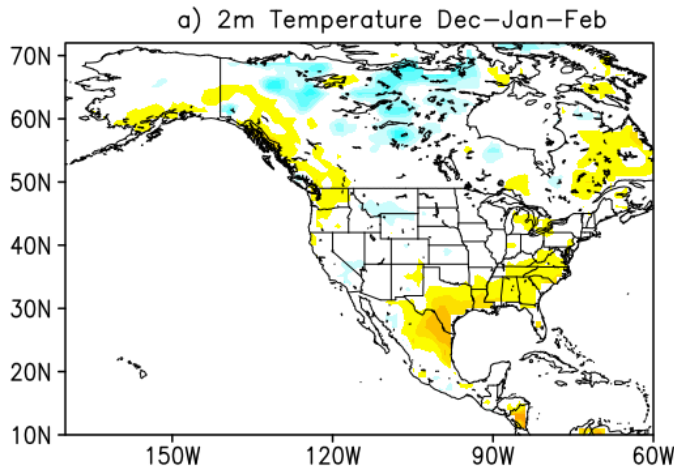
- MME more skillful than individual models in all seasons
- No stratification of skill by model configuration

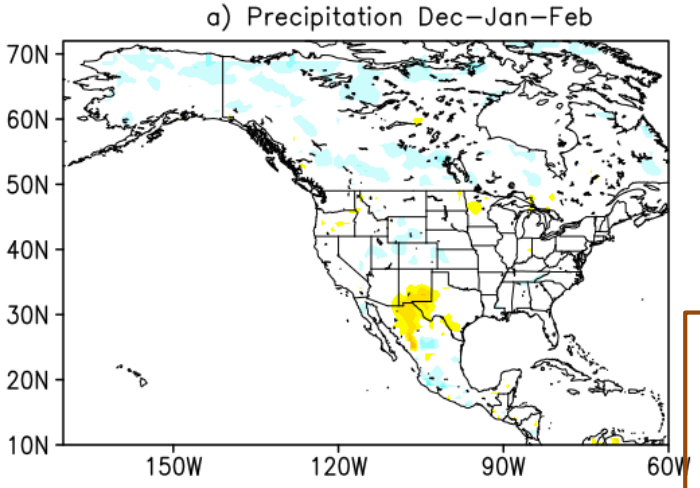


# SubX Multi-model RPSS Week 3-4

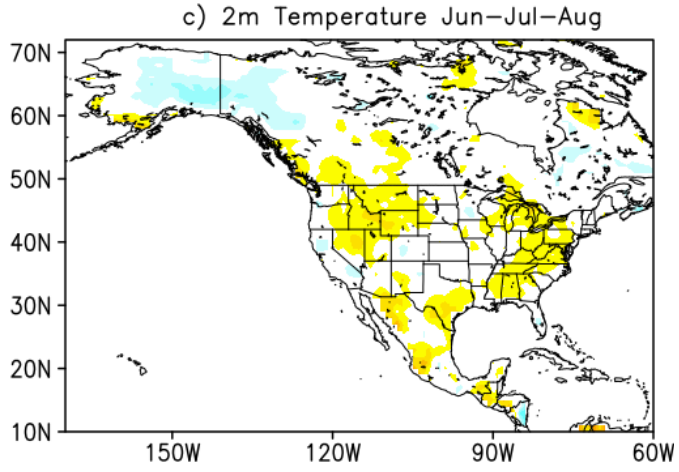
**2m Temperature** | **Precipitation**

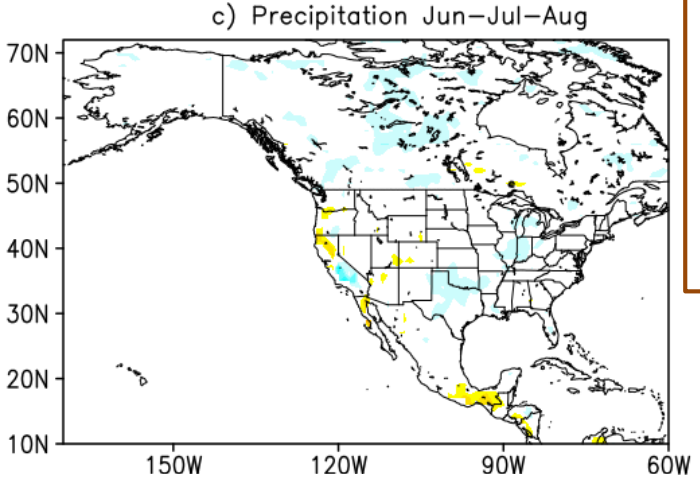
**Winter**

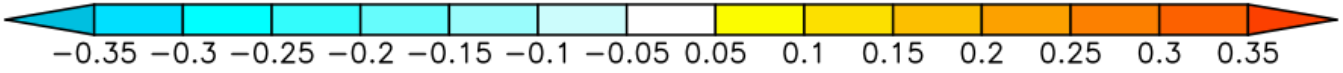



**Summer**

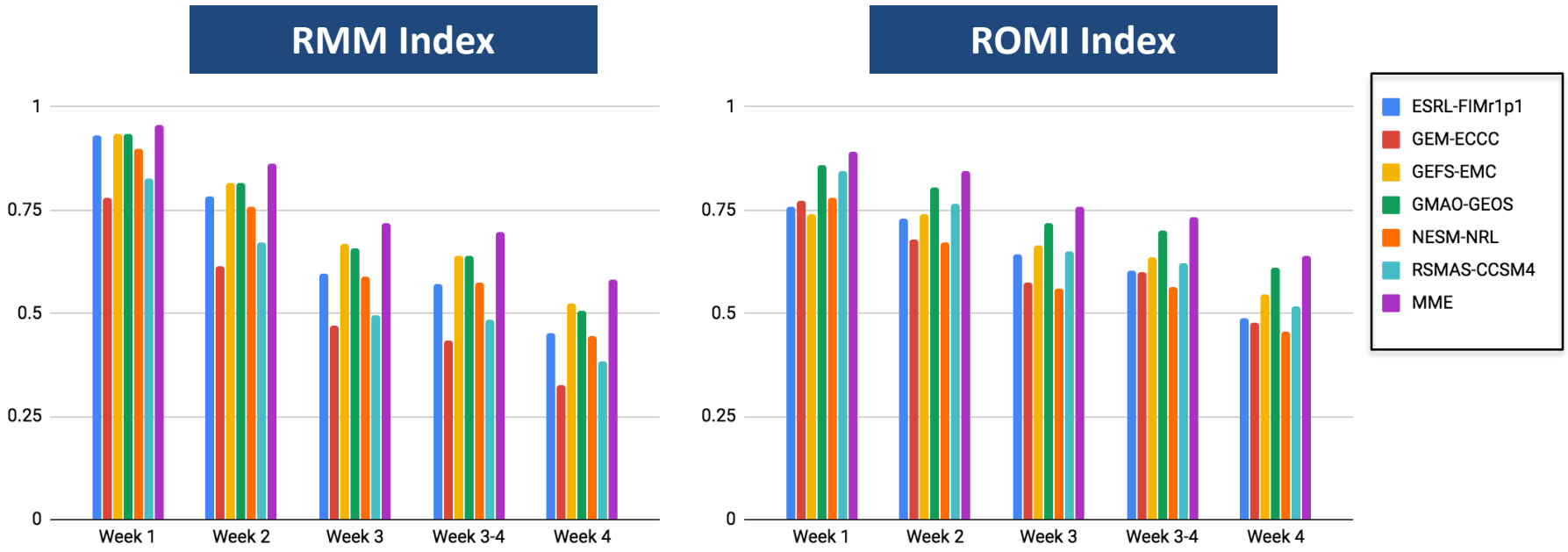



- Consistent with ACC
- There is skill for T2M
- Little skill for precip

# MJO Skill: Anomaly Correlation

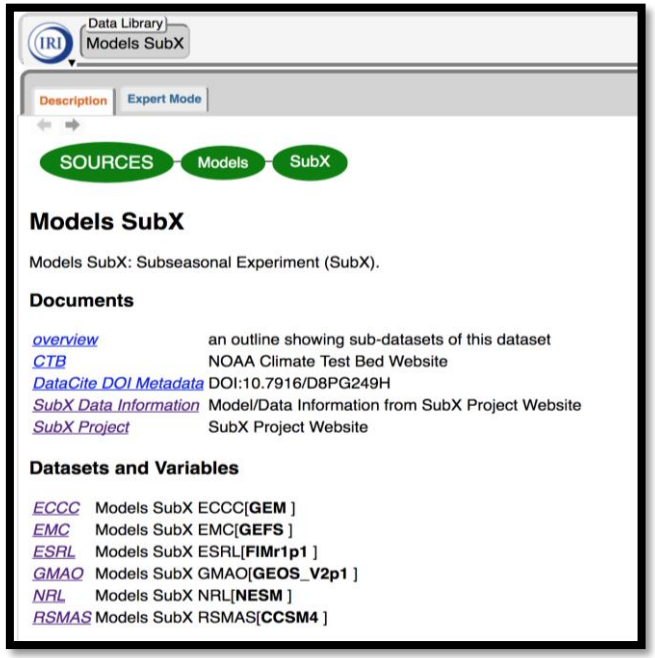



- Skill >0.5 at week 3-4
- Skill is similar to WWRP/WCRP S2S Models
- Two most skillful models have very different configurations
- MME has higher skill than individual models

*Thanks to Shuguang Wang, Columbia University, ROMI Indices*

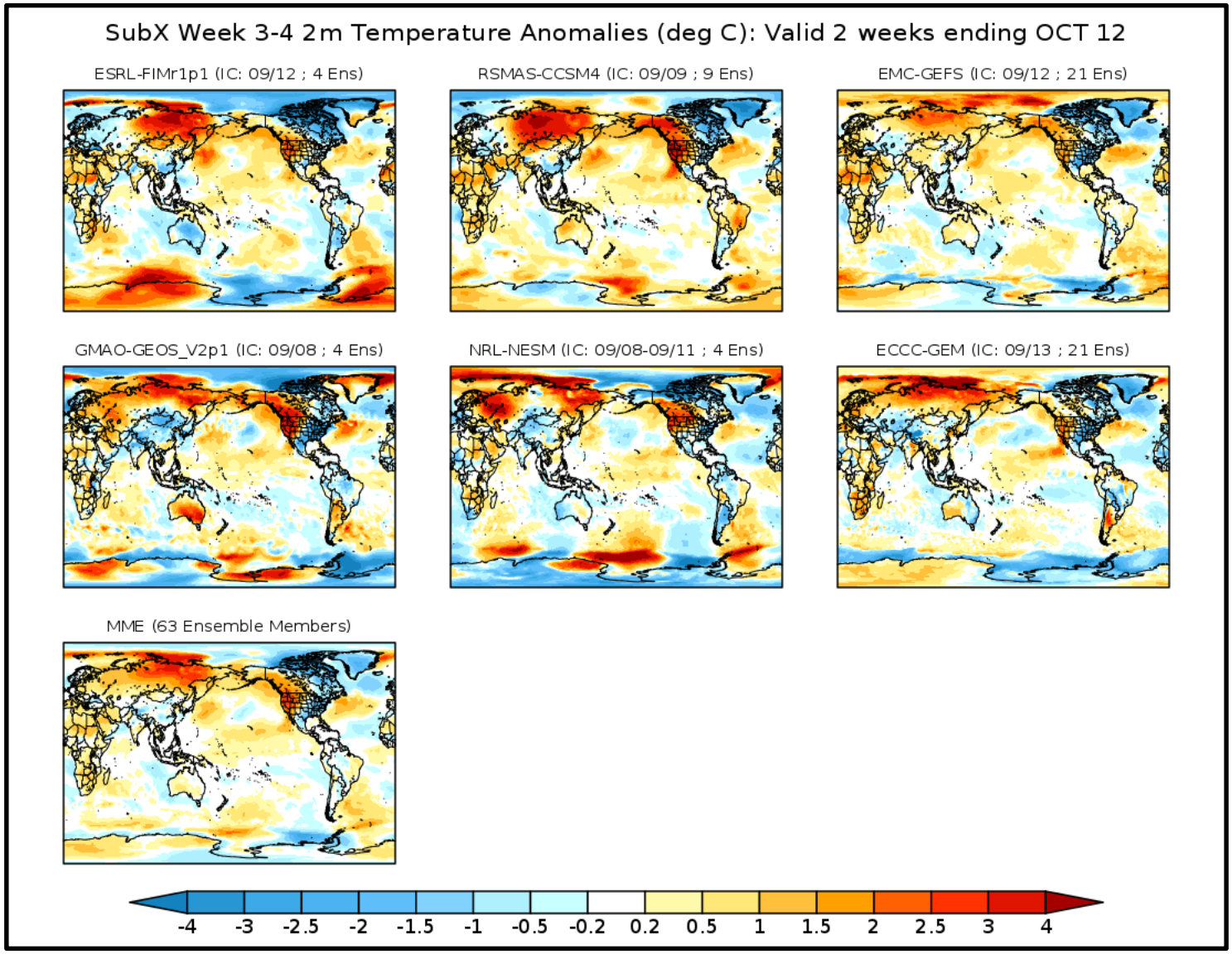
# Real-time Forecasts

- CPC processes for their week 3-4 outlooks
- SubX Team processes for publicly available forecast plots
- All data are publicly available




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

# Example: Real-time forecast maps on SubX Website




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

# Summary

- SubX provides a publicly available re-forecast and real-time forecast database for S2S research, operations, and applications.

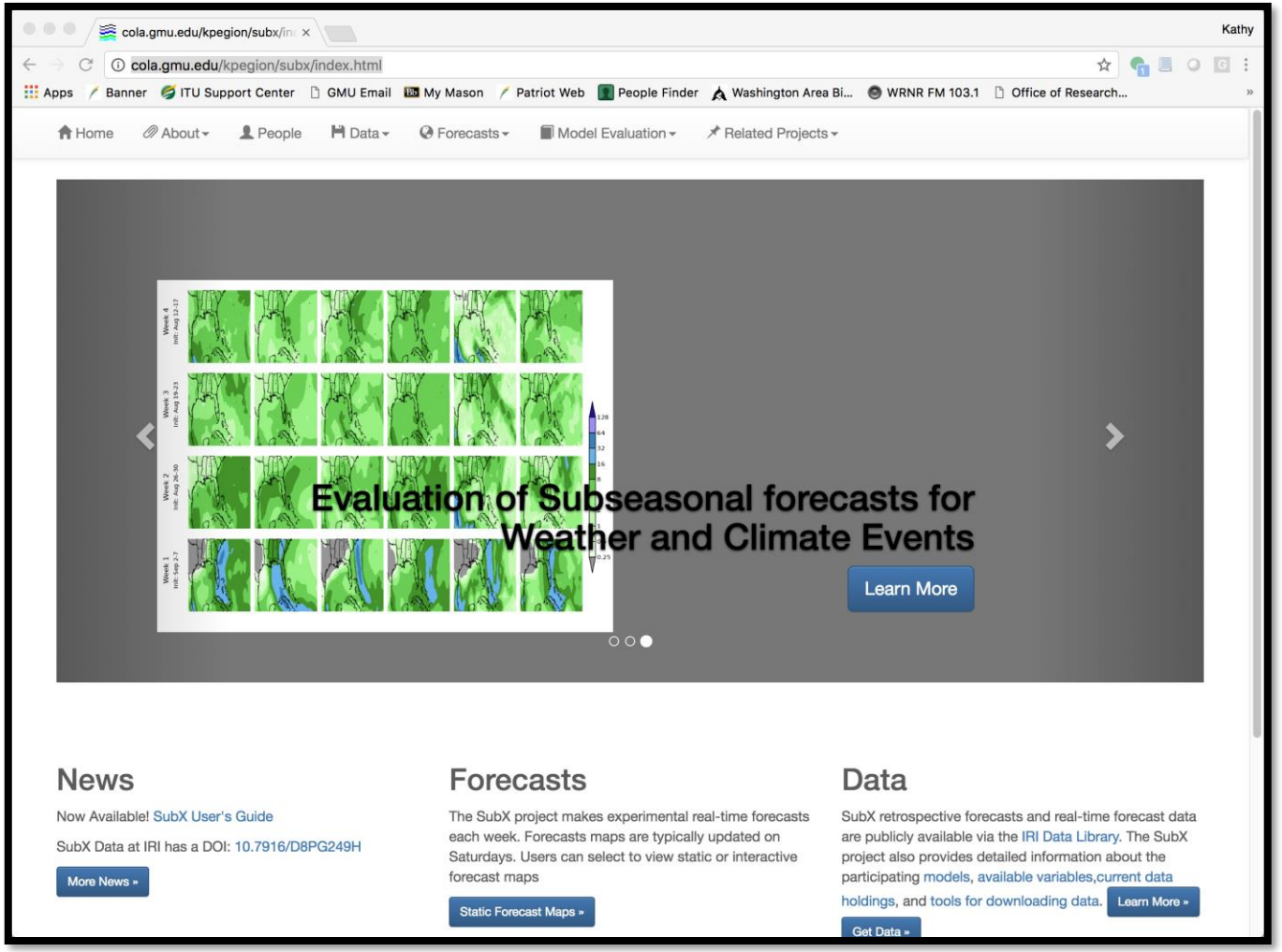
- SubX Complimentary to other S2S efforts:
  - real-time forecasts
  - research models

- Evaluation of model biases, skill, sources of predictability demonstrate skill at subseasonal timescales in specific regions and seasons and benefit of MME
  - Much more to be done…

- SubX provides useful contributions to operational week 3-4 forecast guidance

- SubX is an ideal framework for testing model improvements
  - Sun, Lantao et al., Contribution of stratospheric processes to tropospheric predictive skill on subseasonal time scale in NCAR's CESM1

# Where to find more information:
# **http://cola.gmu.edu/kpegion/subx/**





- SubX Data Users Guide
- Codes for Downloading and processing data
- Model Evaluation Plots
- Real-time Forecast Plots

# *Weather Research Science Working Group (WRSWG)*

## *Introduction and Description of Activity*

**Duane Waliser & Sim James**

OFCM

*Office of the Federal Coordinator for Meteorological Services and Supporting Research*

GROUPS | PUBLICATIONS | MEETINGS | ABOUT


## OVER A HALF-CENTURY OF MULTI-AGENCY COLLABORATION

# Office of the Federal Coordinator for Meteorology

The OFCM is the overall coordinating body of the Federal Weather Enterprise of which the WRSWG is a part.

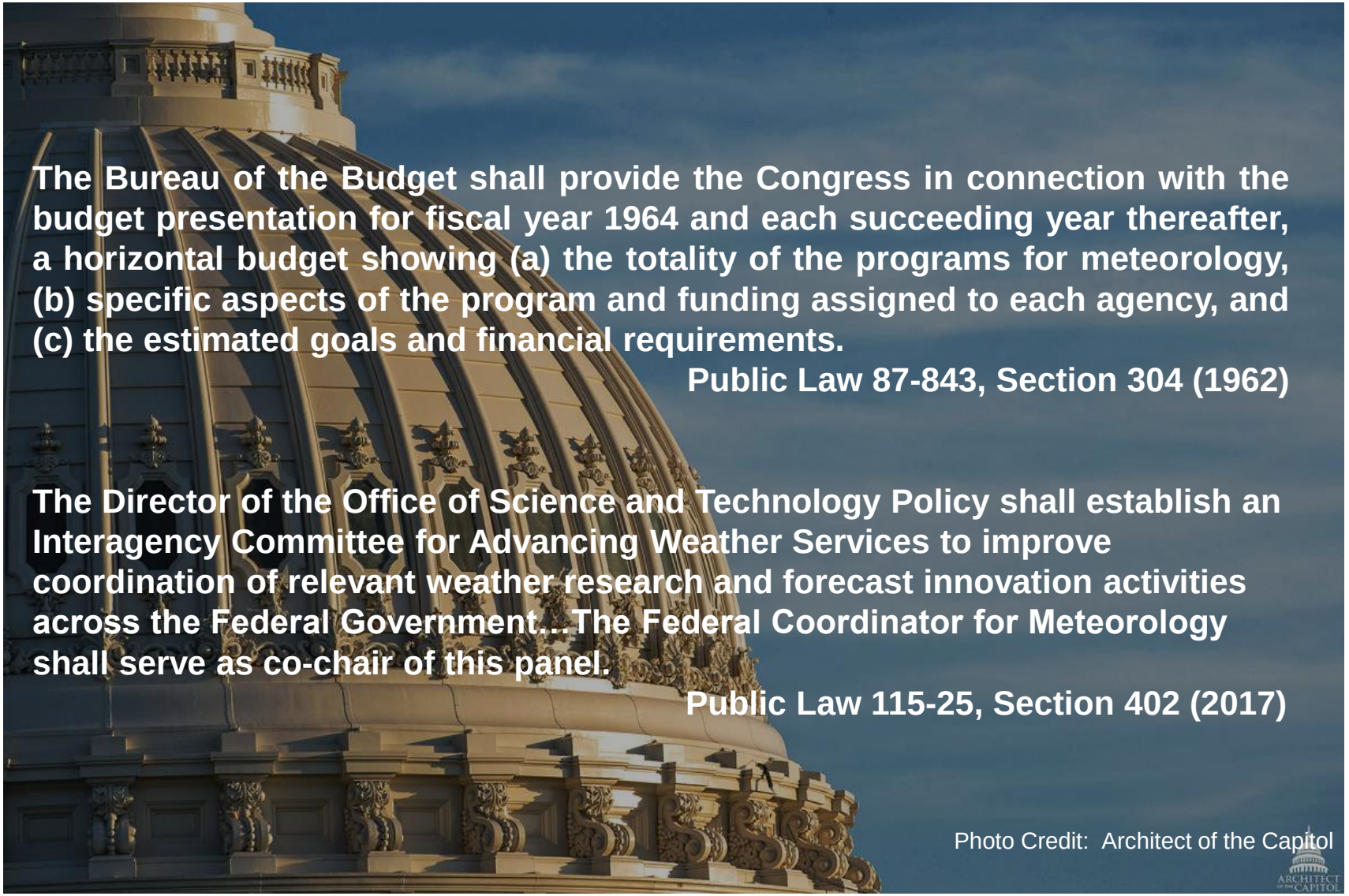
OFCM focus: Establish a routine among federal agencies of getting together at the right frequency with the right people to create awareness of, discuss opportunities within, and devise action plans to address, common issues in conducting meteorological services and research.

a) Coordinate: Facilitate the exchange of information, plans and concerns among the FWE to help the nation get the most out of the approximately $5.3B spent annually on meteorological services and supporting research.

b) Advise: Provide strategic and operational views of interagency federal weather efforts in order to support related decisions at high levels.

c) Plan: Produce and maintain key documents including:
    a) Federal Weather Enterprise Budget and Coordination Report
    b) Federal Meteorological Handbooks
    c) National Hurricane Operations Plan

# Historical, Legal Perspectives



**The Bureau of the Budget shall provide the Congress in connection with the budget presentation for fiscal year 1964 and each succeeding year thereafter, a horizontal budget showing (a) the totality of the programs for meteorology, (b) specific aspects of the program and funding assigned to each agency, and (c) the estimated goals and financial requirements.**

**Public Law 87-843, Section 304 (1962)**

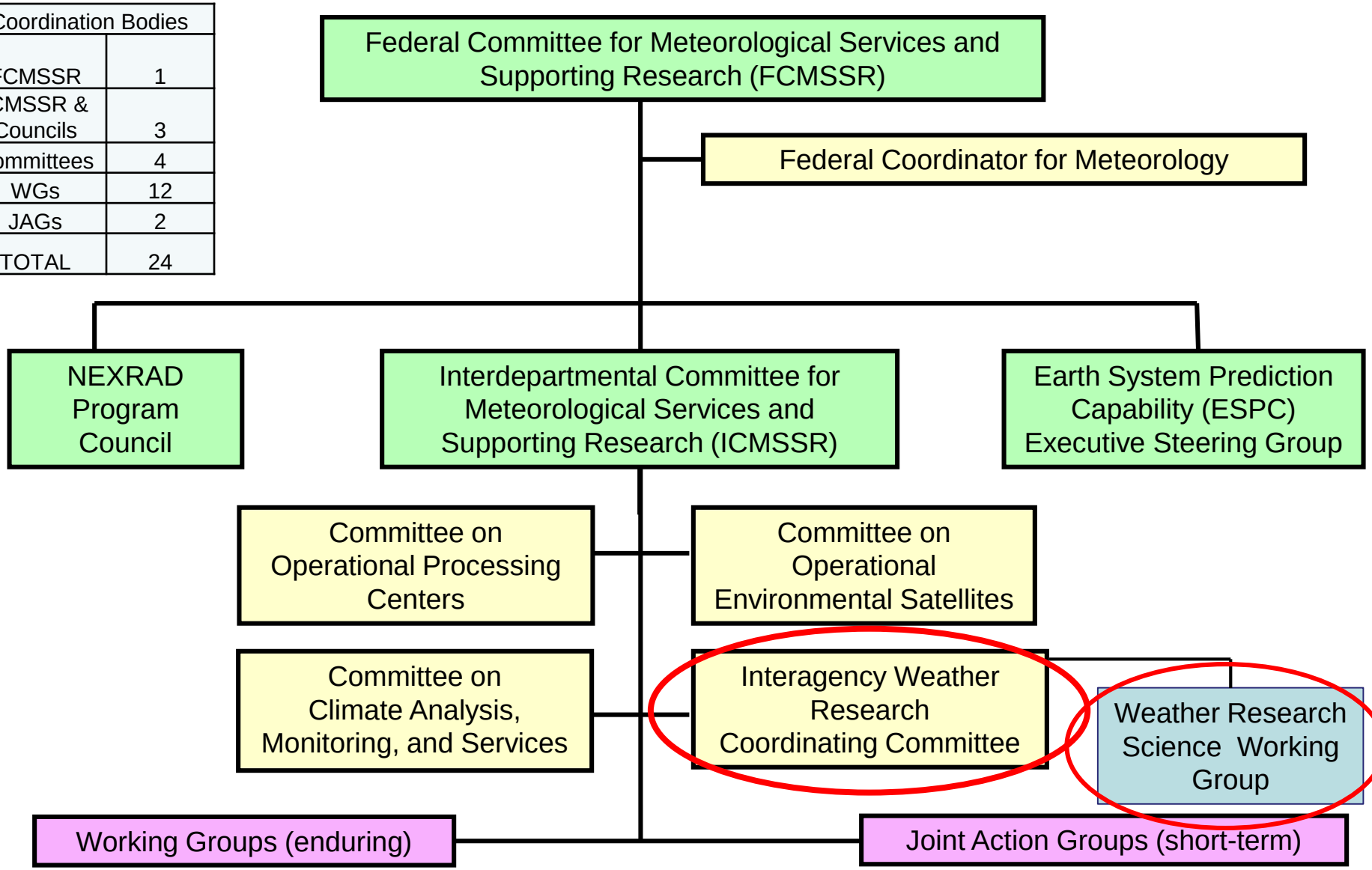
**The Director of the Office of Science and Technology Policy shall establish an Interagency Committee for Advancing Weather Services to improve coordination of relevant weather research and forecast innovation activities across the Federal Government…The Federal Coordinator for Meteorology shall serve as co-chair of this panel.**

**Public Law 115-25, Section 402 (2017)**

Photo Credit: Architect of the Capitol

# Federal Weather Enterprise Coordinating Infrastructure

| Coordination Bodies | |
|---|---|
| FCMSSR | 1 |
| ICMSSR & Councils | 3 |
| Committees | 4 |
| WGs | 12 |
| JAGs | 2 |
| TOTAL | 24 |



# Interagency Weather Research Coordination Committee

The IWRCC is one of the committees OFCM is responsible for coordinating**.**

**IWRCC focus:** The IWRCC promotes and helps to coordinate basic and applied U.S. research activities aimed at a better fundamental understanding and improved prediction of high-impact weather .

In particular, IWRCC helps to…

a) Coordinate U.S. agency weather research priorities,

b) Promote U.S. interests in the participation of well-defined international projects

c) Explore and engage with new national and international weather research initiatives, including those associated with the THORPEX legacy projects. IWRCC provides a forum where agencies can best leverage efforts among themselves and in the international community to achieve agency goals.

# Weather Research Science Working Group

The SWG is the Working Group subordinate to the IWRCC.  It is composed of a combination of Subject Matter Experts across government and academia.

**WRSWG focus:** The WRSWG promotes scientific leadership for the coordination in the World Weather Research Project (WWRP) of the World Meteorological Organization (WMO) three major weather research projects related to THORPEX:

- Polar Prediction project (PPP)
- Subseasonal to Seasonal Prediction Project (S2S)
- High Impact Weather Prediction Project (HIW)

The WRSWG promotes scientific leadership for the coordination of U.S. involvement in the PPP, S2S and HIW efforts. Additionally, the WRSWG informs the IWRCC on matters concerning the scientific integrity and progress of such projects. (E.G. S2S Database)

# Weather Research Science Working Group

| | |
|---|---|
| Co-Chairmen | |
| Waliser, Duane | duane.e.waliser@jpl.nasa.gov |
| Bromwich, Dave | bromwich@polarmet1.mps.ohio-state.edu |
| Morgan, Mike | mcmorgan@wisc.edu |
| Executive Secretary | |
| Sim James | sim.james@noaa.gov |
| Brunet, Gilbert | |
| **S2S** | |
| Reynolds, Carolyn | Carolyn.Reynolds@nrlmry.navy.mil |
| Lang, Andrea | alang@albany.edu |
| Pegion, Kathy | kpegion@gmu.edu |
| Carman, Jessie | jessis.carman@noaa.gov |
| Kleist, Daryl | daryl.kleist@noaa.gov |
| **HiWx** | |
| Doyle, Jim | James.Doyle@nrlmry.navy.mil |
| Hence, Deanna | dhence@illinois.edu |
| Knox, John | johnknox@uga.edu |
| Sun, Jenny | sunj@ucar.edu |
| **PPP** | |
| Cavallo, Steven | cavallo@ou.edu |
| Intrieri, Janet | janet.intrieri@noaa.gov |
| Powers, Jordan | powers@ucar.edu |
| Grumbine, Bob | robert.grumbine@noaa.gov |

# US Agency S2S Support

## *Emphasis on Subseasonal*

A Rough, High-Level Inventory

*S2S Emphasis of*
*Weather Research Working Group (WRWG) of the*
*Interagency Weather Research Coordination Committee (IWRCC)*

*Duane Waliser (S2S co-chair) Carolyn Reynolds, Andrea Lang,*
*Kathy Pegion, Jessie Carman, Daryl Kleist*
*Executive Secretary: Sim James*

August, 2018

POCs: duane.Waliser@jpl.nasa.gov; sim.james@noaa.gov

# NASA

**Overall Thrust of Contributions**: Earth Observations, Earth System Science and Modeling, Weather Modeling and Data Assimilation

**Foundational Contributions**: GEOS-5, MERRA-2, EOs (e.g. GPM, SMAP, JASON-x, etc)

**Research Contributions:**

- Subseasonal component of Modeling, Analysis and Prediction (MAP): 5 Investigations (Sobel, Wang, Kuang, Rosseauex, Alexander).
- MJO component of the CYGNSS Science Team: 3 Investigations (Maloney, Waliser, Lang).
- GMAO Hindcast/Forecast contribution to NMME Subseasonal SubX Activity via co-support from NOAA (Achuthavarier, Koster, Marshak).
- NASA Applied Science SERVIR project downscaled global NMME forecasts and distributed to the SERVIR regions (Irwin, Limaye).

**Other Contributions:**

- Support of 2016 NAS Study on Next Generation Earth System Prediction: Strategies for Subseasonal to Seasonal Forecasts

# ONR

**Overall Thrust of Contributions**: Ocean, Atmosphere and Sea Ice Processes/Interactions, Field Programs and Modeling; NWP and Data Assimilation

**Foundational Contributions**: Navy Earth System Model (NESM)

**Research Contributions:**

- Departmental Research Initiative (DRI; Eleuterio) – Propagation of IntraSeasonal Tropical Oscillations (PISTON) – ~15 investigators and Summer'18 Field Program in S. China Sea.
- Departmental Research Initiative (DRI; Ferek) – Overcoming the Barrier to Extended Range Prediction over the Arctic – ~15 investigators and field activities in 2019 and 2020.
- NRL Hindcast/Forecast contribution to NMME Subseasonal SubX Activity (Barton, Metzger).

**Other Contributions:**

- Support of 2016 NAS Study on Next Generation Earth System Prediction: Strategies for Subseasonal to Seasonal Forecasts

# NSF

**Overall Thrust of Contributions**: Basic research - process understanding, field program activity and model development.

**Foundational Contributions**:

- PI-Based Fundamental Research - Including Disciplinary, Multi-/Inter-disciplinary and Science+Technical Synergies
- Community Earth System Model (CESM)
- Field Campaign Support (e.g. DYNAMO)

**Research Contributions:**

- At any given time, at least 40 or more PI-led research activities relevant to S2S research (e.g. 18 started since 2015 relevant to MJO; 34 to ENSO)

# NOAA

**Overall Thrust of Contributions**: Operational prediction, basic and applied weather and climate research, observing systems and field experiment activities.

**Foundational Contributions**: CFS Model/Forecast System, CFS-R, Earth Observations (e.g. tropical moorings, operational weather satellites)

**Research Contributions Presented on Following Slides**

# NOAA/OAR S2S Activities

- **OAR Labs and Programs:**
  - Advance core capabilities and engage the broad internal/external community
  - Engage both weather and climate communities to address S2S challenges
- **Examples:**
  - **GFDL** Global high-resolution modeling of the coupled climate system, with seamless predictability from day to subseasonal to seasonal timescales (e.g. severe storms, floods/droughts/fire)
  - **ESRL**: Medium-range modeling; attribution for extremes; forecasting for water management
  - **OWAQ**: High-impact weather research (extreme precipitation, severe storms, tropical cyclones) transition activities; risk communication and social science
  - **CPO:** Foundational climate research; observations; process studies; transition activities; products, tools, communication and engagement

# NOAA CPO S2S Research and R2O Efforts

- **S2S predictability & prediction research**
  - CVP process studies on MJO: DYNAMO, Year of Maritime Continent
  - MAPP FY16 S2S research & transition initiatives (e.g., S2S Task Force, SubX)
- **Improve S2S modeling under the unified modeling framework**
  - Assess benefits of high-resolution modeling
  - Improve physical representations in models via Climate Process Teams
  - Coupled data assimilation
  - Model software infrastructure
- **Climate reanalysis**: OAR-NWS Service Level Agreement gap project
- **Ensemble Predictions (CTB/R2O)**
  - NMME seasonal forecast system (in operation)
  - SubX Project to test real-time S2S ensemble predictions
- **Test weeks 3-4 prediction tools** (e.g., hybrid statistical-dynamical)
- **S2S Applications** (e.g., drought/NIDIS; Marine ecosystem; coastal inundation).
- **Tropical Pacific Observing System (TPOS):** design the future ocean observing system for forecasts at S2S and longer timescales.

# DOE

**Overall Thrust of Contributions**: Earth system modeling, modeling variability and extremes, observations, high performance computing

**Foundational Contributions**: Energy Exascale Earth System Model (E3SM), ARM observations, leadership in high performance computing

**Research Contributions:**

- E3SM for modeling variations of water cycle, biogeochemical, and cryospheric processes across a range of scales (labs, NCAR and universities)
- CAPT (The Cloud-Associated Parameterization Testbed) to use short term forecasts for diagnosis of model biases (LLNL, universities) related to precipitation and clouds
- (ILIAD) InitiaLIzed-ensemble Analysis/Development framework is designed to create, execute, and analyze ensembles of hindcasts using the E3SM and DOE/NSF Community Earth System Model (CESM) to evaluate and examine behavior of extreme events
- Modeling and analysis of various modes of variability, extreme events, and tropical-extratropical teleconnections from subseasonal to century time scales (LLNL, PNNL, LBNL, NCAR, universities)
- Development of metrics and diagnostics for understanding model behaviors (labs and universities)
- Observing and modeling processes (e.g., clouds and radiation) as fundamental building blocks of S2S predictions (labs and universities)

**Other Contributions:**

- Support of 2015 High-Resolution Coupling and Initialization to Improve Predictability and Predictions in Climate Models Workshop, September 30 – October 2, 2015, College Park, MD