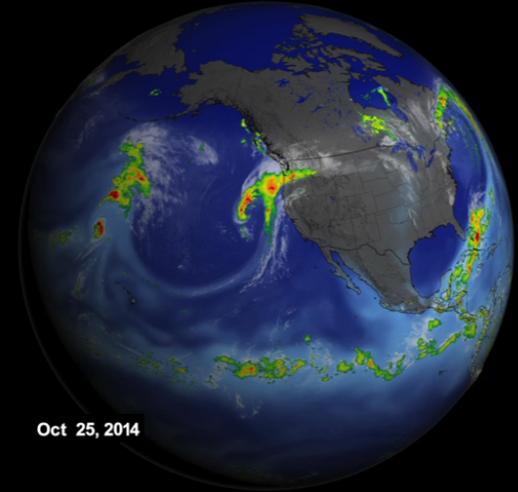




Jet Propulsion Laboratory
California Institute of Technology
Duane Waliser



Improving S2S Forecasting: National & International Activities

Public Winter Outlook Workshop
Water Year 2019: Feast Or Famine?
Water Education Foundation
December 5, 2018
Beckman Center, Irvine, CA

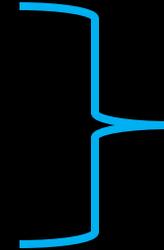
Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by the United States Government or the Jet Propulsion Laboratory, California Institute of Technology.

Outline

- What is "S2S" forecasting?
 - ✓ S2S definition
 - ✓ How can we predict weeks/months into future?
 - ✓ Use dice as a simple model and illustrative example, introduce role of MJO and ENSO, distinguish between weather prediction vs long range / seasonal outlooks.
- What does the U.S. NAS say about S2S?
- What is the WMO doing about S2S?
- What is the U.S. doing about S2S?

Forecast Lead Times

- Weather 0-14 Days
- **Subseasonal** **2-12 Weeks**
- **Seasonal** **3-12 Months**
- Interannual 1 year - Decade
- Climate Decades - Centuries



Subseasonal
to Seasonal
(S2S)
2 weeks -12
months

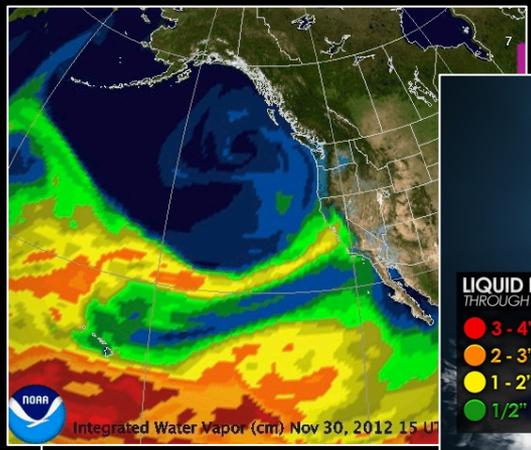
p.s. "subseasonal" aka "intraseasonal"

Weather Forecasts

“Deterministic Prediction”; 0-14 Days



Hurricanes



Atmospheric Rivers



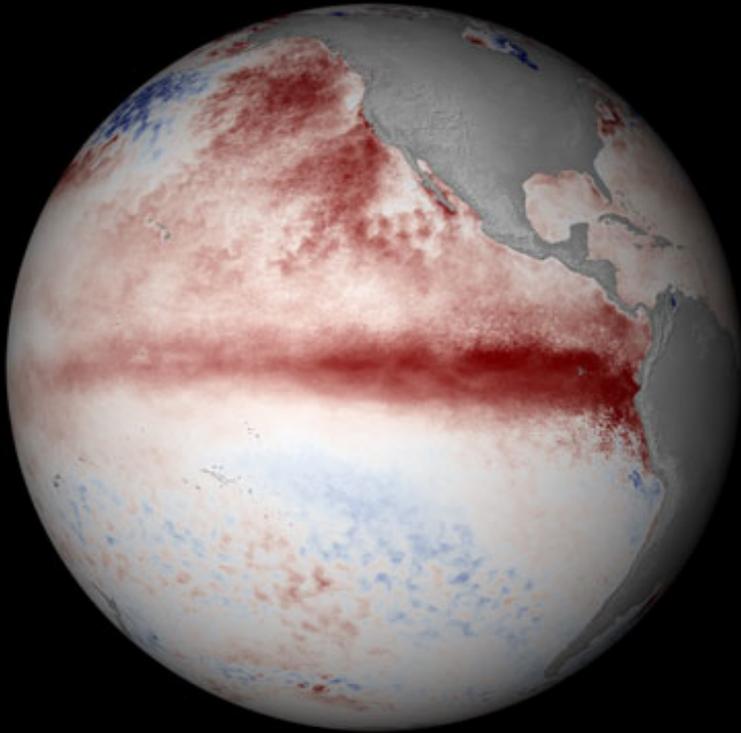
... cold spells, heat waves, thunderstorms/tornados, nor'easters, santa ana winds, etc

El Niño – Southern Oscillation (ENSO)

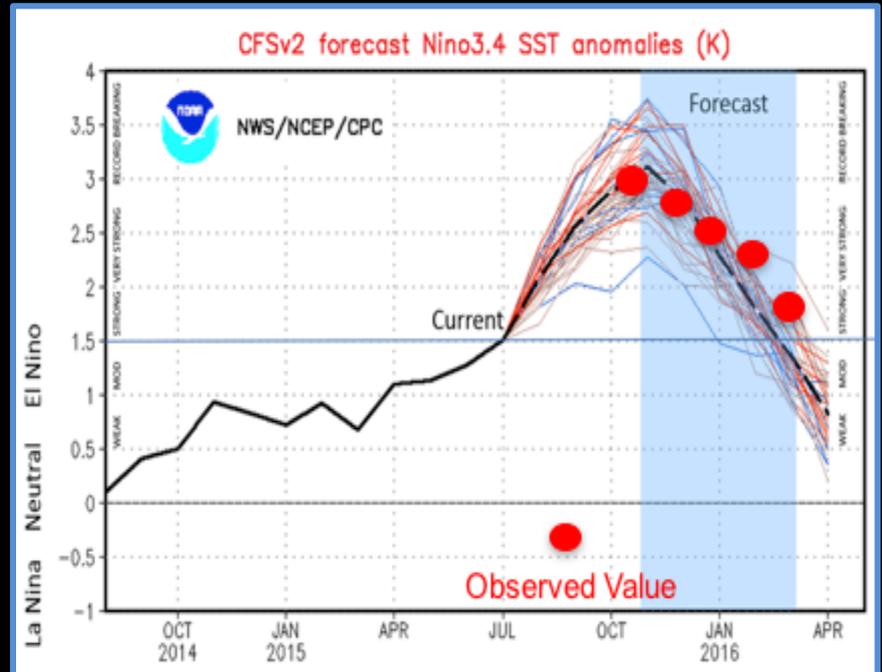
Life Cycle ~9-18 months

Quasi Oscillatory but Intermittent (~2-4 in 10 years)

Deterministic Prediction ~ 3-9 months.



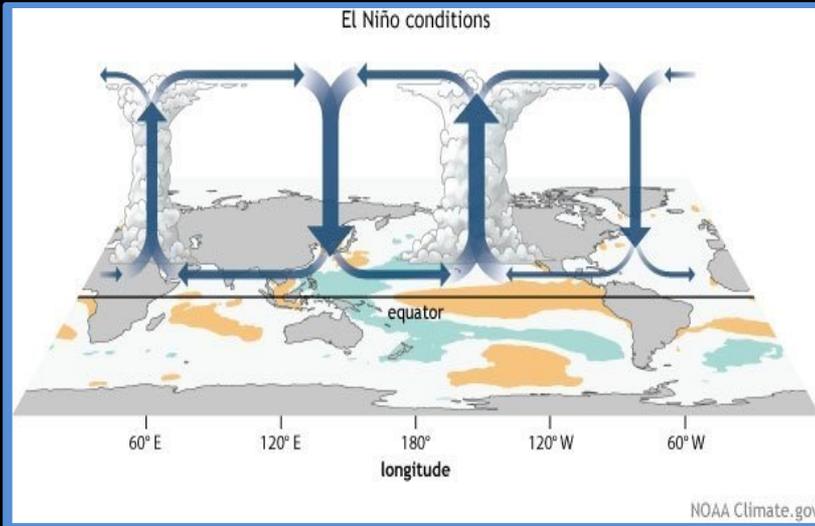
*El Nino
Ocean Surface
Temperature*



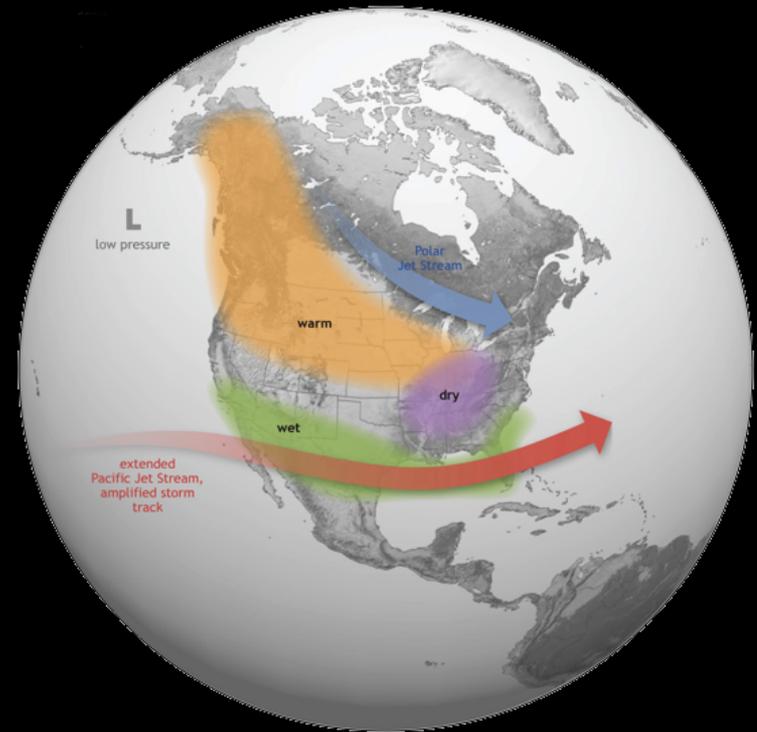
*We are fairly good at
predicting El Nino and La
Nina SST patterns a few
months ahead.*

El Niño – Southern Oscillation (ENSO)

Tropical circulation influences mid-latitude circulation in a somewhat consistent but complex manner.



ENSO strongly influences Tropical circulation in a fairly well behaved and understood manner.



During El Niño , typically

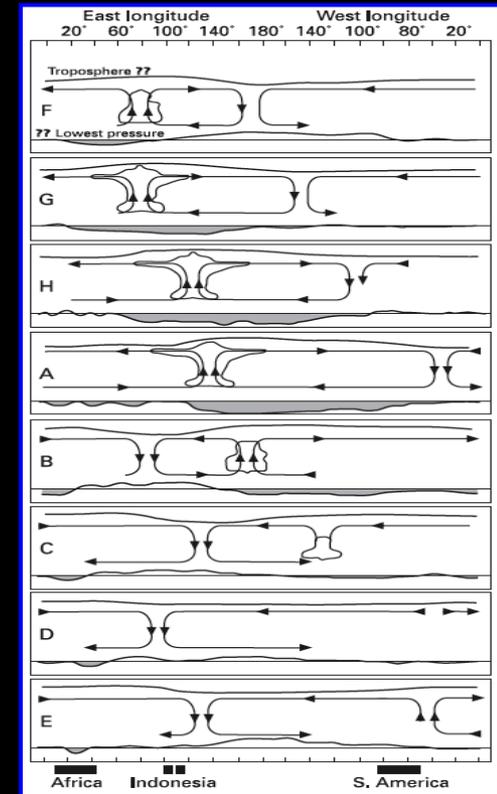
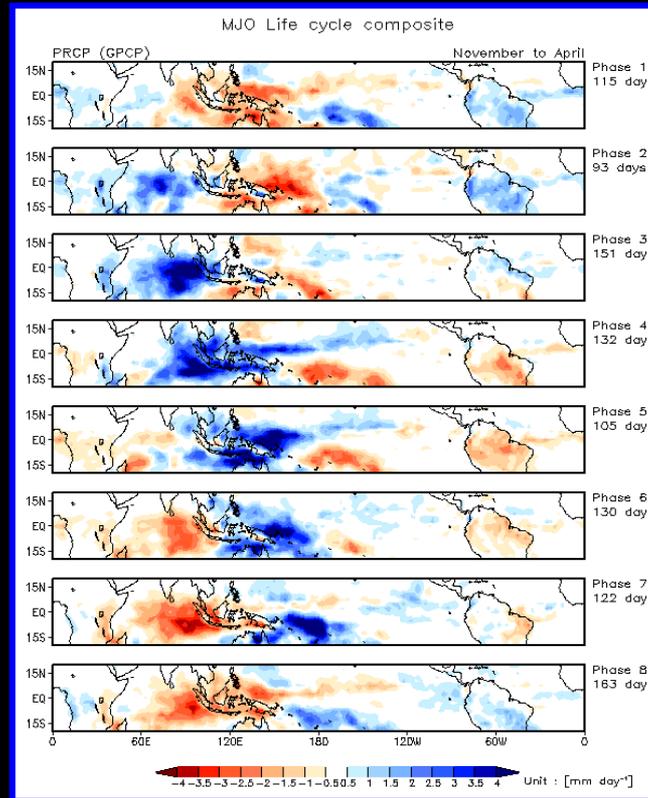
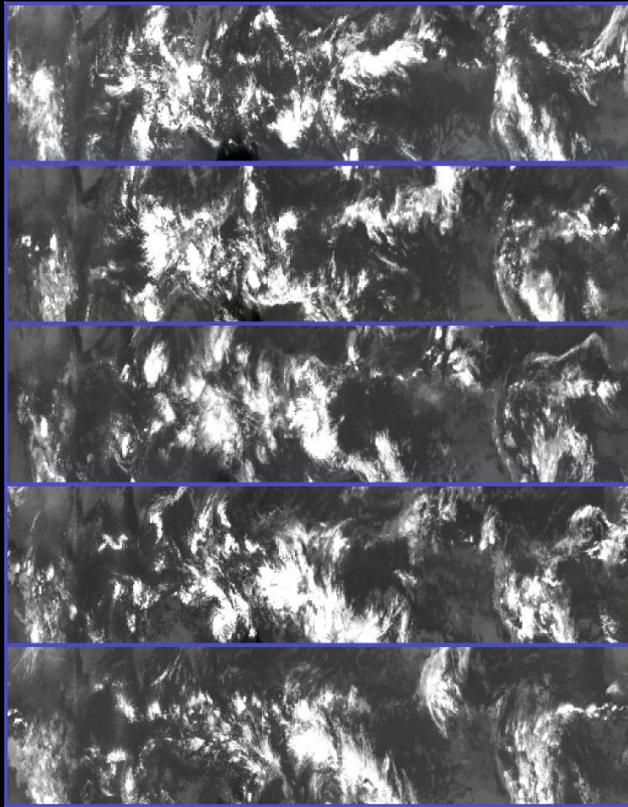
- *wet along the southern tier*
- *warm in the north*
- *dry in the northeast*

Madden-Julian Oscillation (MJO)

Life Cycle ~6-8 weeks

Quasi Oscillatory but Intermittent (~2-5 times/year)

Deterministic Prediction ~2-5 weeks

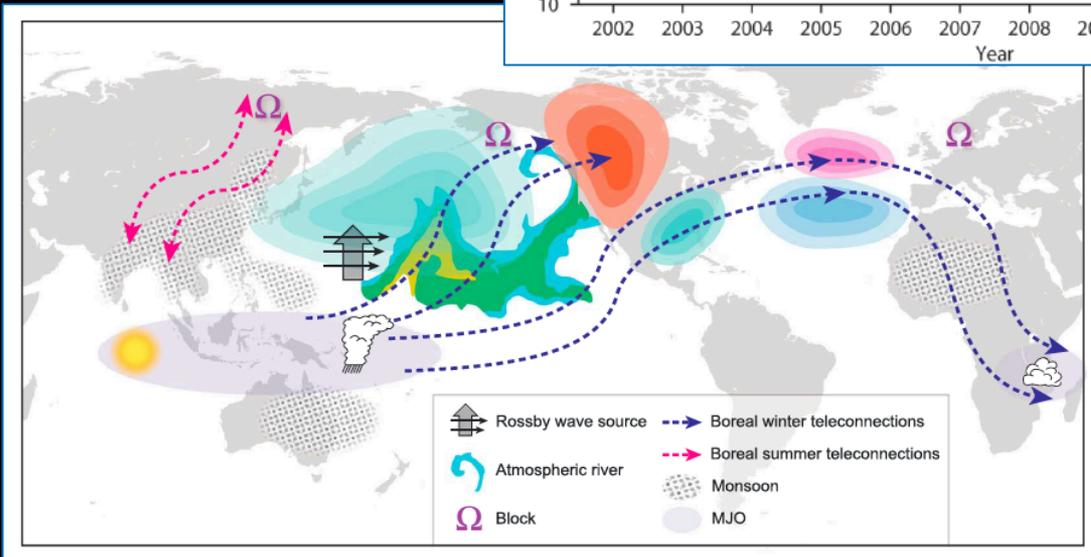
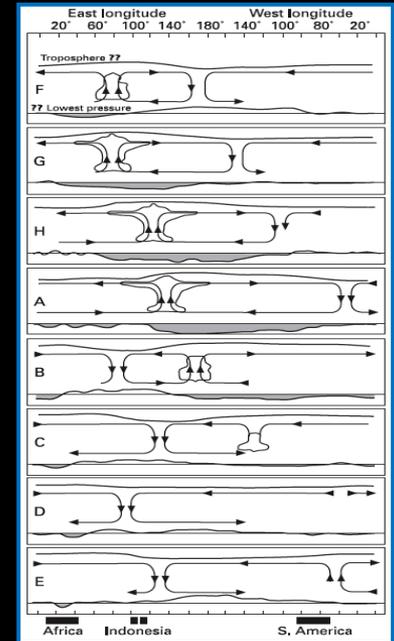
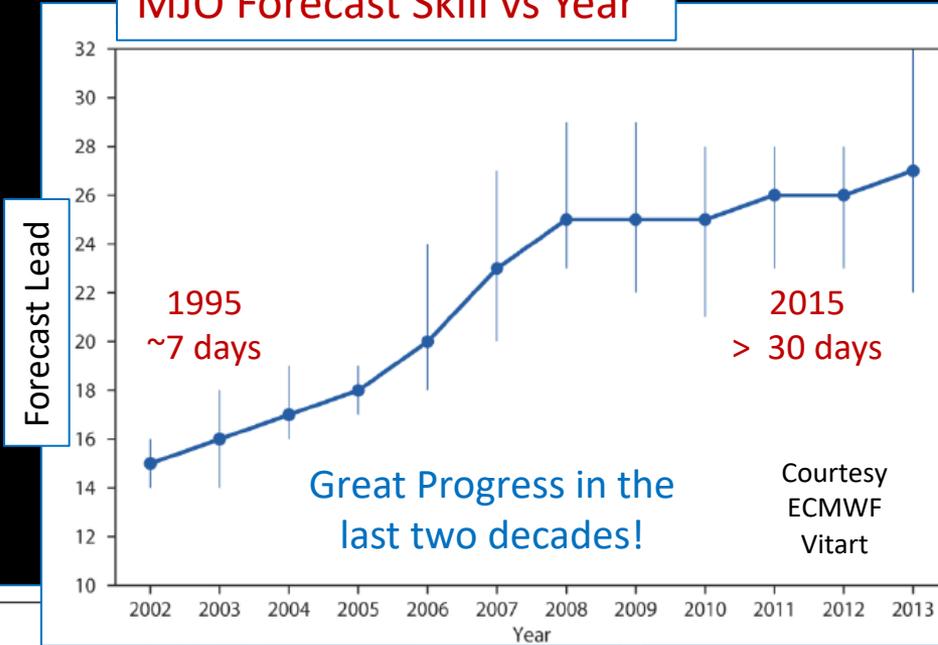


Madden & Julian, 1972

Predicting the MJO

Up to 5 Weeks Ahead

MJO Forecast Skill vs Year



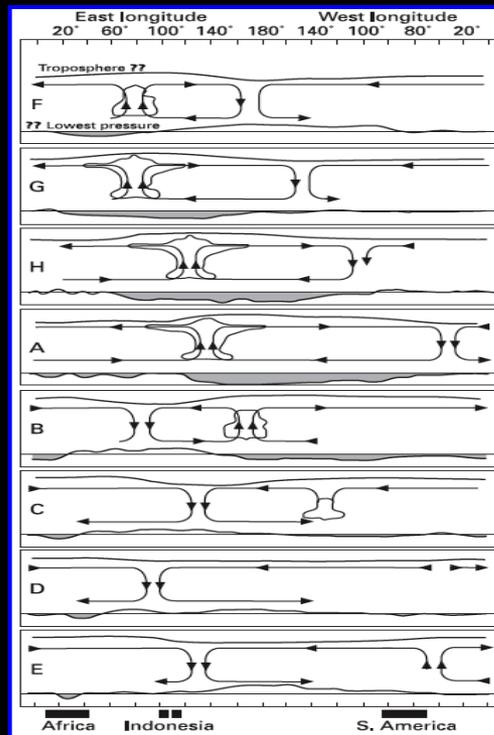
Putting it Together: S2S Prediction

Opportunities and Challenges

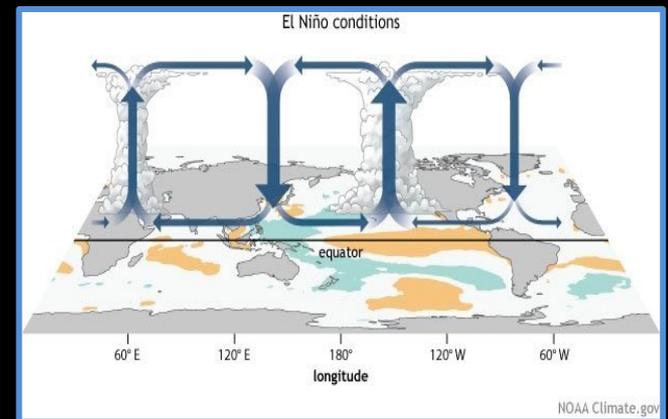
Weather : Atmospheric Rivers



MJO



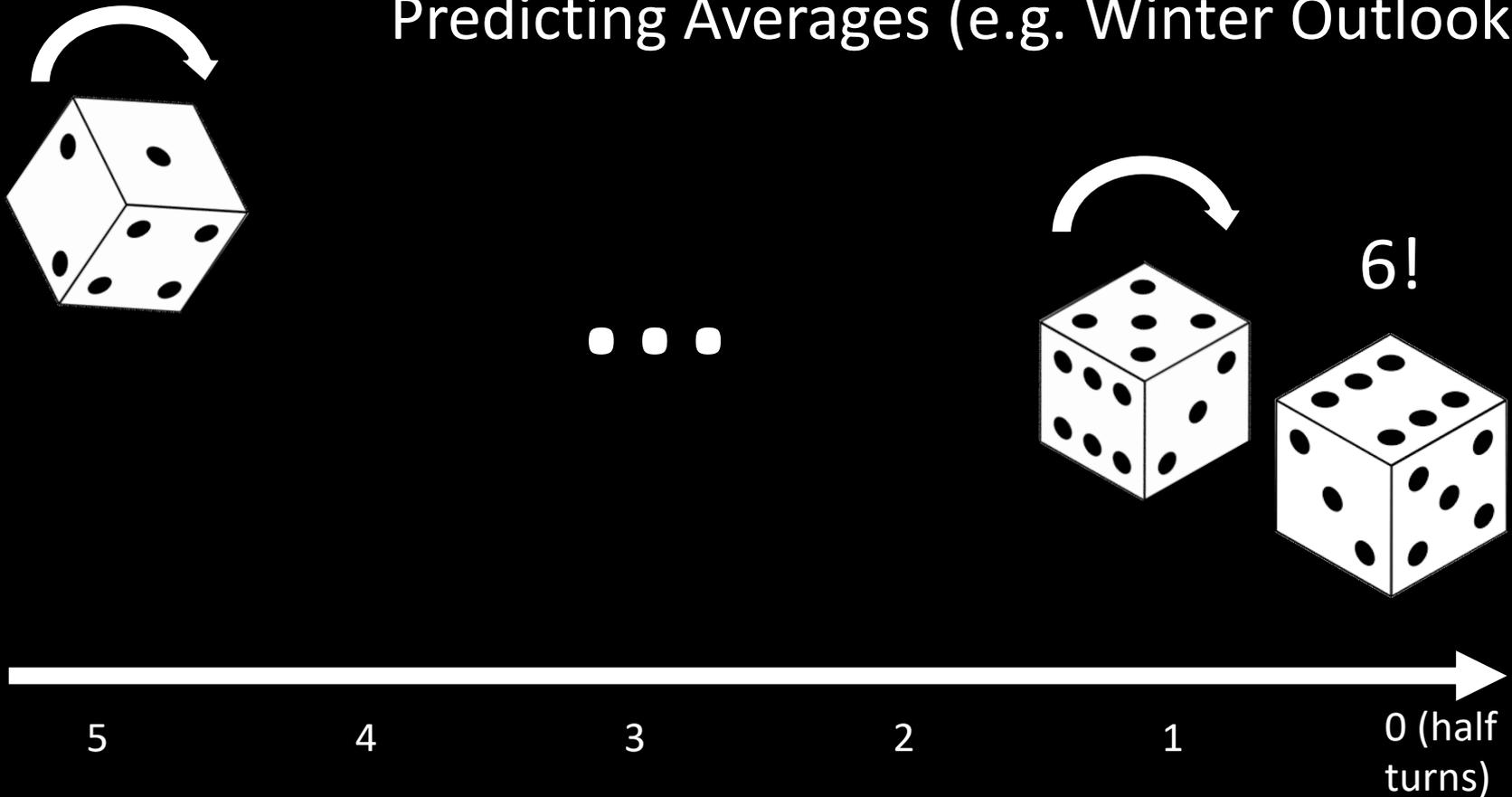
ENSO



“Predicting Specifics (i.e. Weather)”

vs

Predicting Averages (e.g. Winter Outlook)



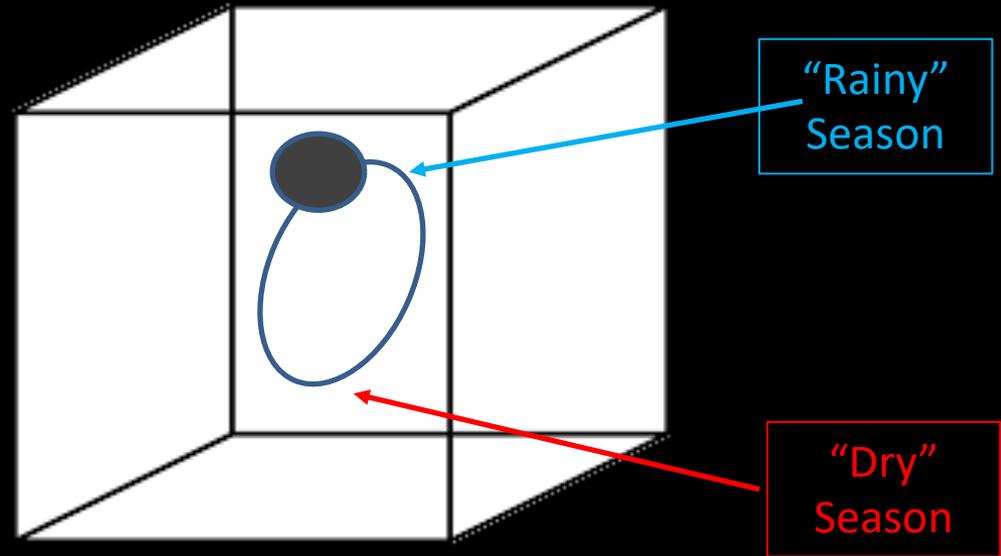
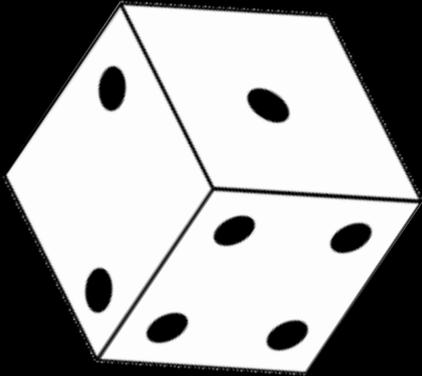
- Given a measurement of height off the table, rotation rate and velocity, and the surface friction, the dice (i.e. weather) should be “predictable” within a few half turns (i.e. days) of its final resting place
- Moreover, all things being equal, we also can expect the averages (i.e. climate) of many dice rolls (i.e. equal chances for 1-6).

Modulation of Weather

Annual Cycle

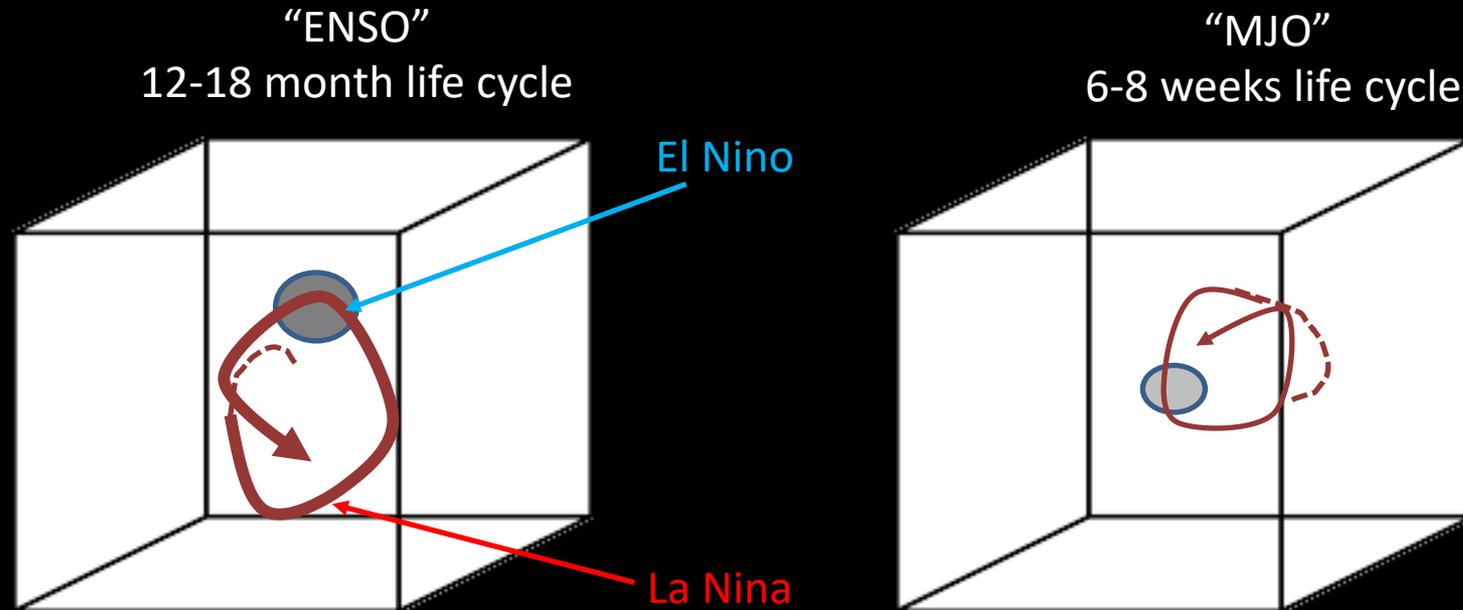
Life Cycle = 1 Year

Lets peer inside the dice



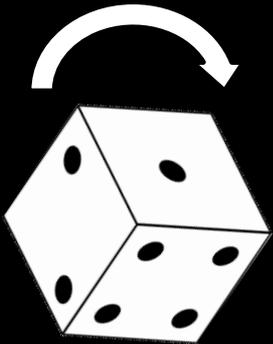
- Annual cycle impacts are easy to predict based on historical data alone.
- Physical mechanisms are well understood (i.e. Earth’s orbit & solar heating variations).

Modulation of Weather “Natural Modes of Variability”



- Both ENSO and MJO are intermittent (**weight comes and goes; gets bigger and smaller**)
- Both ENSO and MJO can occur at the same time
- Other modulating oscillations occur as well (e.g., IOD, PDO)

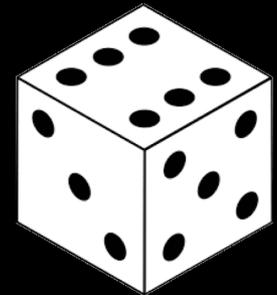
Week-3 Predictions & Winter Outlooks



...



4s, 5s, 6s



If we know state of ENSO, MJO, etc 10's of days before (the positions and size of the weights), we can predict there statistical effects on the dice outcomes.

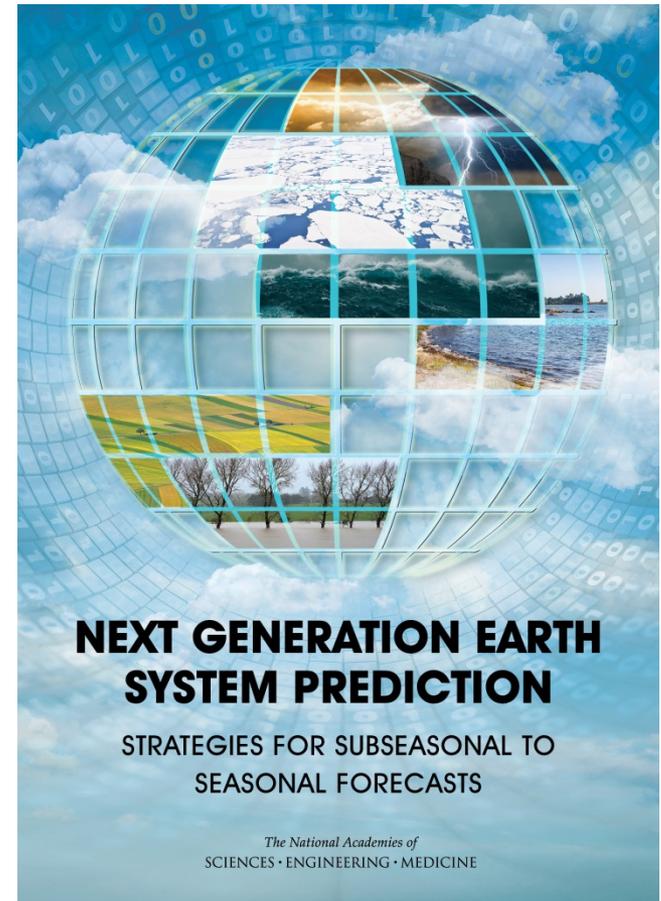


In addition to the internal weights (e.g. natural modes of climate variability), additional predictability might come from knowing more about the surface conditions the dice lands on (e.g. tilted, rough, icy, wet, sticky), which can be equated to variations in sea ice, soil moisture, snow pack, etc which also lend some predictability.

U.S. National Academy of Sciences Study on S2S Forecasting

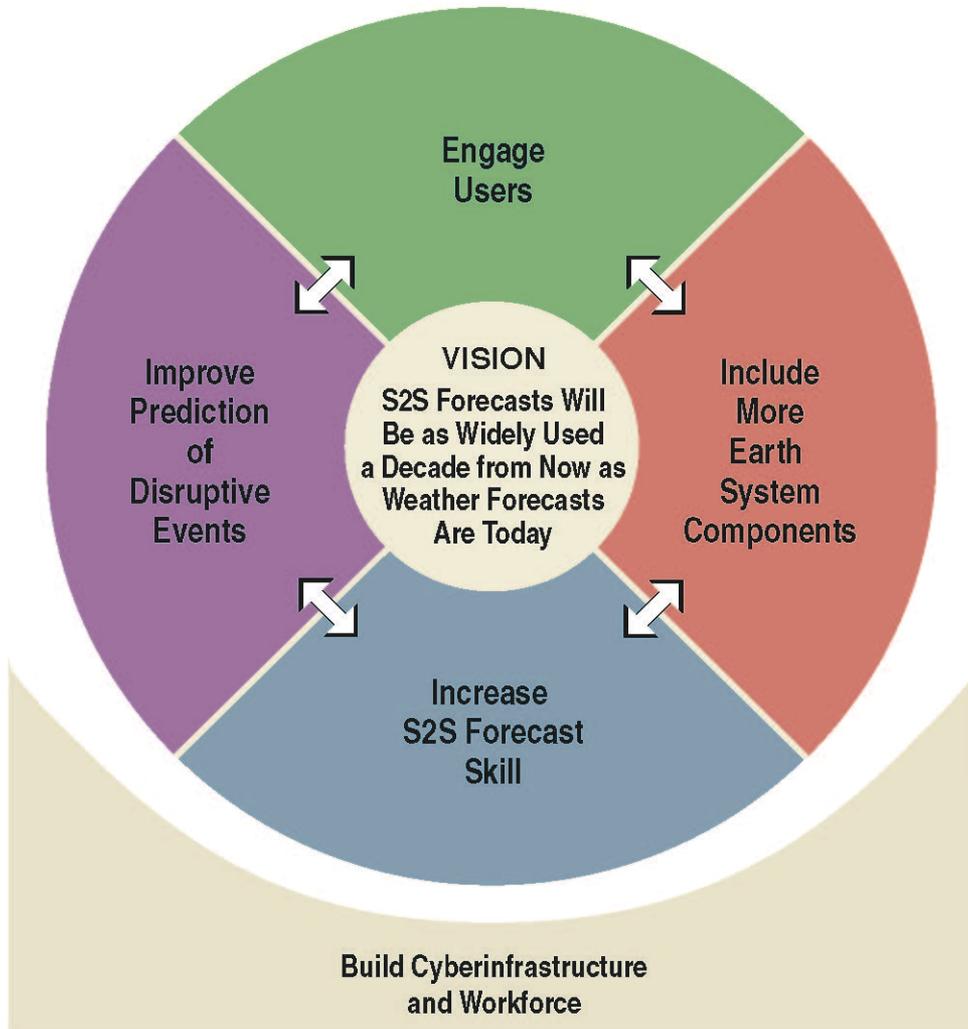
Bold Vision: S2S forecasts will be as widely used a decade from now as weather forecasts are today

- Benefiting business, government and individuals
- Fulfilling this vision will take sustained effort and investment



2016

Fulfilling the Vision: Research Strategies



1. Engage Users
2. Increase S2S Forecast Skill
3. Improve Prediction of Disruptive Events
4. Include More Earth System Components

WWRP/WCRP

S2S Project

Frédéric Vitart and Andrew Robertson



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 International Projects: S2S, HiW, PPP

S2S Project Website

WCRP-WWRP S2S Project

S2sprediction.net

Subseasonal-to-Seasonal S2S Prediction Project

About S2S | News | Documents | Sub-projects | Database | Products | Meetings | People | Links | Site Map

THE SUBSEASONAL TO SEASONAL (S2S) PREDICTION PROJECT DATABASE

F. VITART, C. ARDILOUZE, A. BONET, A. BROOKSHAW, M. CHEN, C. CODOREAN, M. DÉQUÉ, L. FERRANTI, E. FUCILE, M. FUENTES, H. HENDON, J. HODGSON, H.-S. KANG, A. KUMAR, H. LIN, G. LIU, X. LIU, P. MALGUZZI, I. MALLAS, M. MANOUSSAKIS, D. MASTRANGELO, C. MACLACHLAN, P. MCLEAN, A. MINAMI, R. MLADEK, T. NAKAZAWA, S. NAJM, Y. NIE, M. RIXEN, A. W. ROBERTSON, P. RUTI, C. SUN, Y. TAKAYA, M. TOLSTYKH, F. VENUTI, D. WALISER, S. WOOLNOUGH, T. WU, D.-J. WON, H. XIAO, R. ZARIPOV, AND L. ZHANG

A database containing subseasonal to seasonal forecasts from 11 operational centers is available to the research community and will help advance our understanding of predictability at the subseasonal to seasonal time range.

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

Regional S2S Activity: A New Spanish-language web portal "Portal Experimental MONITOREO Y PRONOSTICO DEL CLIMA"

This Spanish-language web portal is developed in collaboration with CLIMAR (<http://www.cima.fcen.uba.ar/climar.php>) and CLIMAX (<http://www.climax-sa.org/>) at CIMA. It includes weekly CFSv2 sub seasonal forecasts in real time as well as circulation diagnostics for southern South America.

The purpose of the portal is to accelerate the knowledge of the personnel of Meteorological Service as well as of agencies in southern South America related with water and other sectors, such as agriculture, about the climate characteristics at subseasonal scales and the interpretation, and the use of tools for monitoring and prediction. More details can be found at

S2S Database

ECMWF | CMA

- The result of "S2S User Survey 2017"**
Updated: 2017-05-25 05:27
- Charts of S2S Products/Indices are now available**
Updated: 2016-09-22 00:41
- S2S Database Paper will come soon on BAMS**
Updated: 2016-08-28 17:25
- Now 9 centres S2S data available!**
Updated: 2016-01-13 22:16
- 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

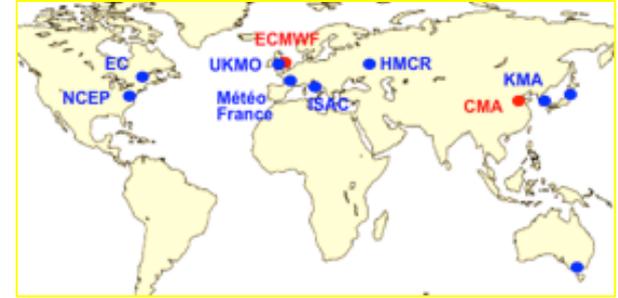
- Spanish version of the S2S project overview
- Applications of S2S Forecasts: From Disaster Early Warning to Early Action
- Report on subseasonal MME in LC-LRFMME
- (Early Release) The Sub-seasonal to Seasonal Prediction (S2S) Project Database
- WMO Publication, 2015: Seamless Prediction of the Earth System: from minutes to months
- Andrew W. Robertson, Arun Kumar, Malaquias Pena, and Frederic Vitart, 2015: Improving and Promoting Subseasonal to Seasonal Prediction. BAMS, 96, ES49-ES53.

S2Sprediction.net

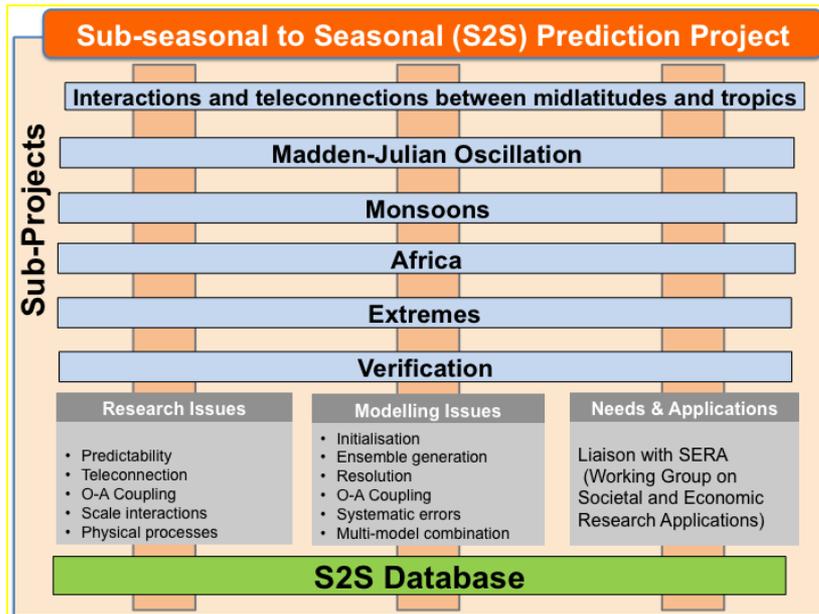
Subseasonal Forecast Database

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
HMCRC	D 0-63	1.1x1.4 L28	20	weekly	Fix	1981-2010	weekly	10

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

- Monsoons
- Extremes
- Verification
- Africa

Modelling Issues

- Resolution
- Systematic errors
- Multi-model combination

Needs & Applications

- Real-Time Pilot (S2S_SERA)
- R2O project

S2S Database

The Subseasonal Experiment (SubX)

Kathy Pegion

George Mason University, Dept of Atmospheric, Oceanic, and Earth Sciences
Center for Ocean-Land-Atmosphere Studies

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





- National/N.America project
- Multi-model
- Operational and Research models
- Subseasonal (weekly)
- Re-forecasts & Forecasts (real-time)



- International project
- Multi-Model
- Operational models
- Subseasonal (weekly)
- Re-forecasts & Forecasts (delayed)

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

Where to find more information:
<http://cola.gmu.edu/kpegiion/subx/>

NEW

cola.gmu.edu/kpegiion/subx/index.html

Home About People Data Forecasts Model Evaluation Related Projects

Evaluation of Subseasonal forecasts for Weather and Climate Events

Learn More

News
Now Available! [SubX User's Guide](#)
SubX Data at IRI has a DOI: [10.7916/D8PG249H](https://doi.org/10.7916/D8PG249H)
More News »

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

- 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

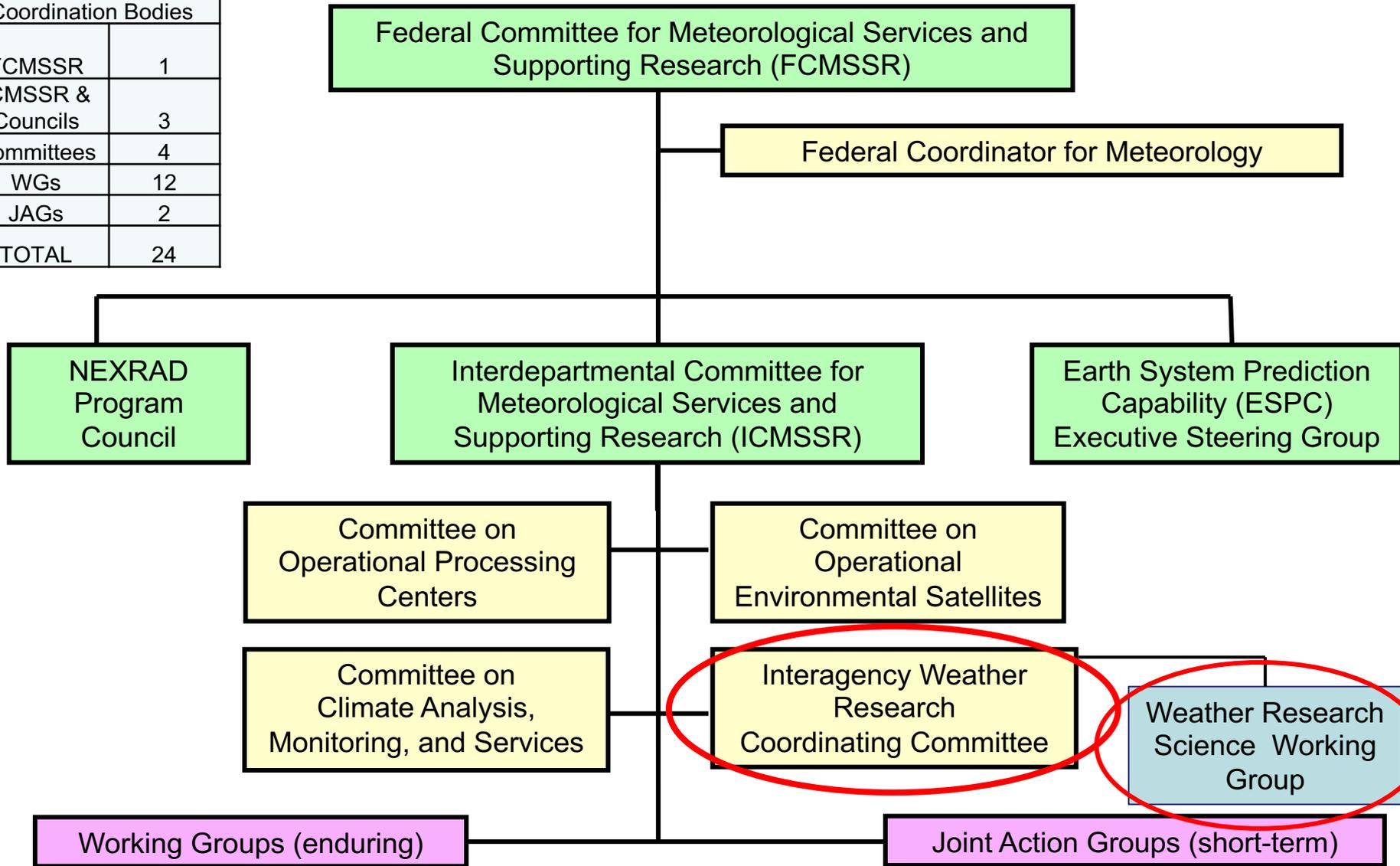
Image Courtesy of NOAA



OVER A HALF-CENTURY OF MULTI-AGENCY COLLABORATION

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 Plans

- 1) **Developed an agency inventory of major S2S capabilities, activities and plans. Obtain community input on priorities for Working Group coordination activities.**

- 2) **Working group ideas for coordination:**
 - Identify new observing system priorities for S2S prediction: Develop community model experimentation and guidance, particularly for slowly varying surface conditions (e.g. snowpack, sea ice, soil moisture, etc).

 - Facilitate the rollout and use of NOAA's open model framework (to advance capabilities for S2S).