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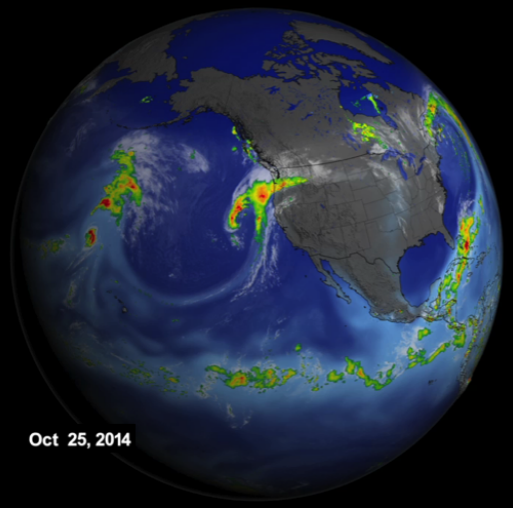
California Institute of Technology
Duane Waliser



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?

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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"

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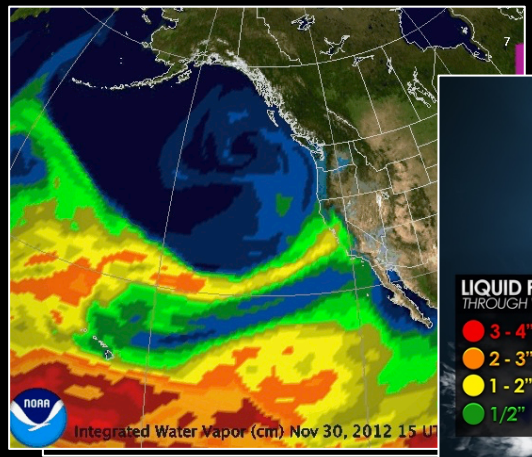
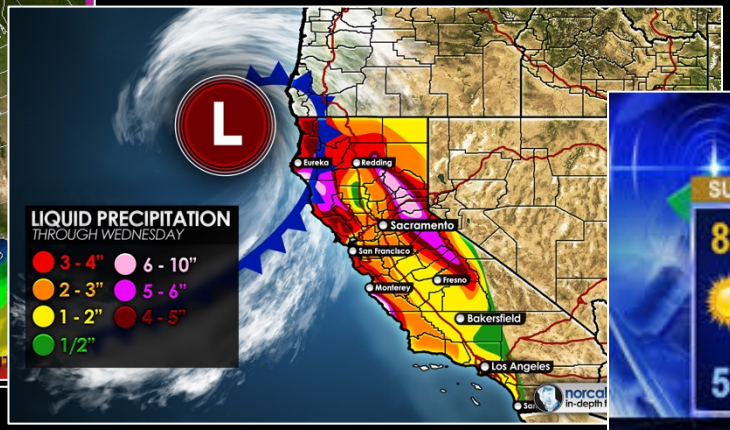
Weather Forecasts

"Deterministic Prediction"; 0-14 Days

Hurricanes





Atmospheric Rivers

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

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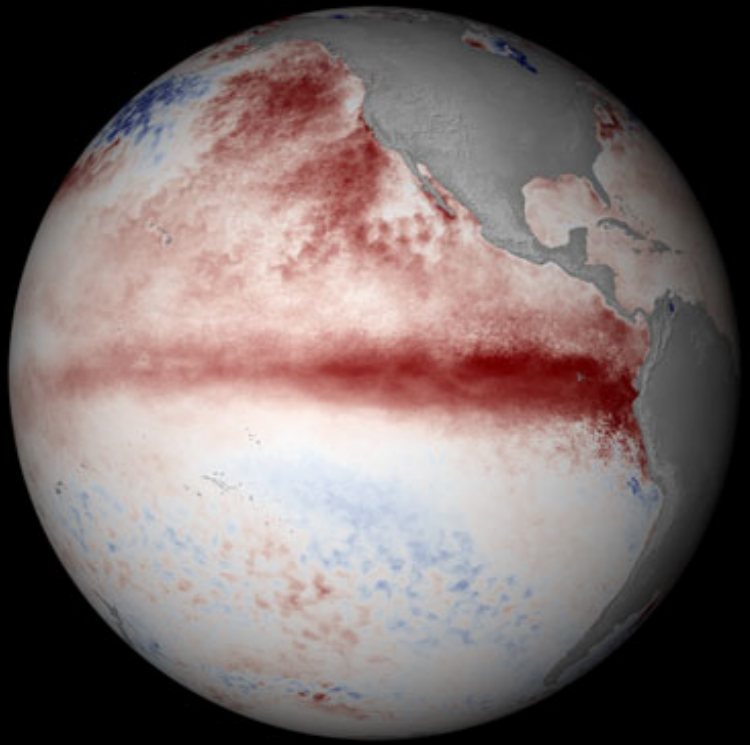
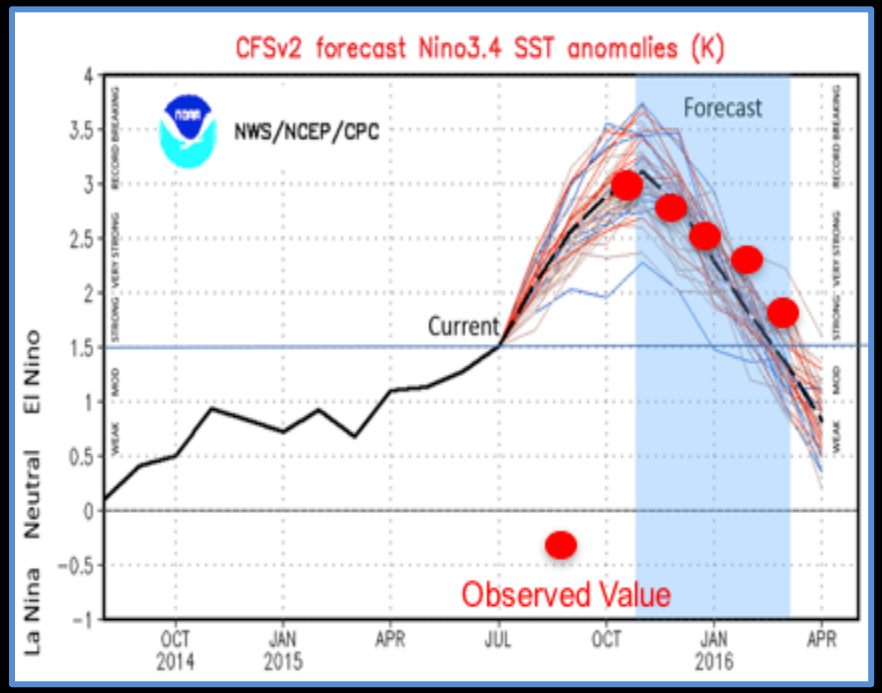
El Niño – Southern Oscillation (ENSO)

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.

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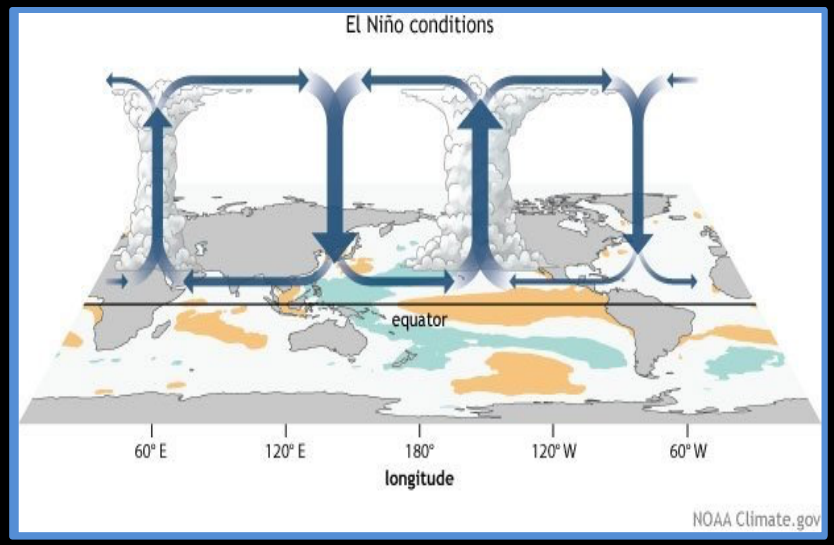
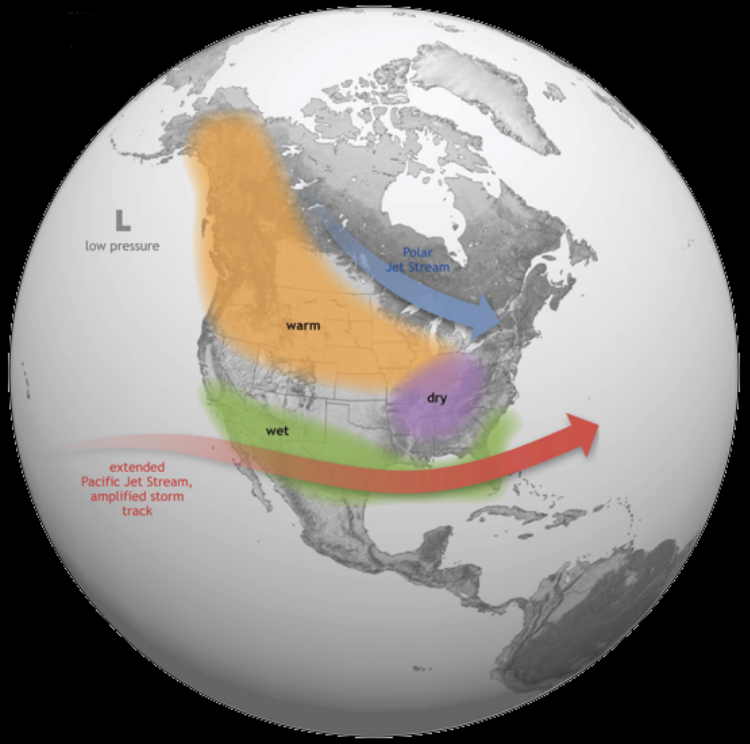
El Niño – Southern Oscillation (ENSO)



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

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



During El Nino , **typically**

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

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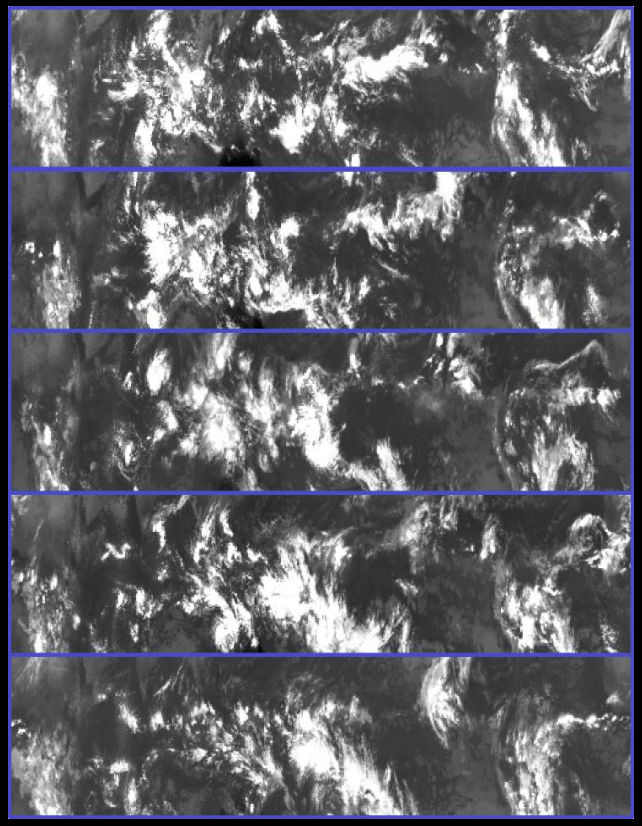
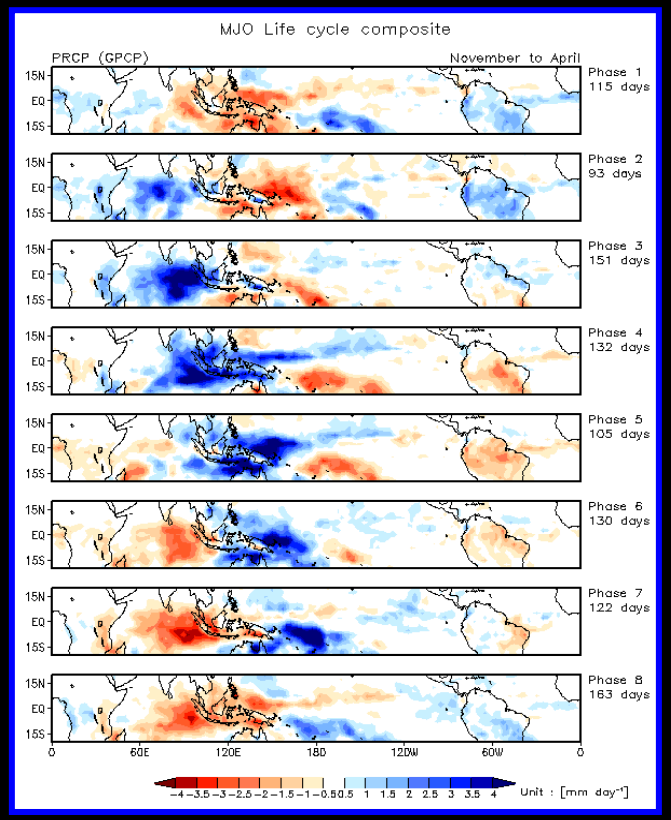
Madden-Julian Oscillation (MJO)

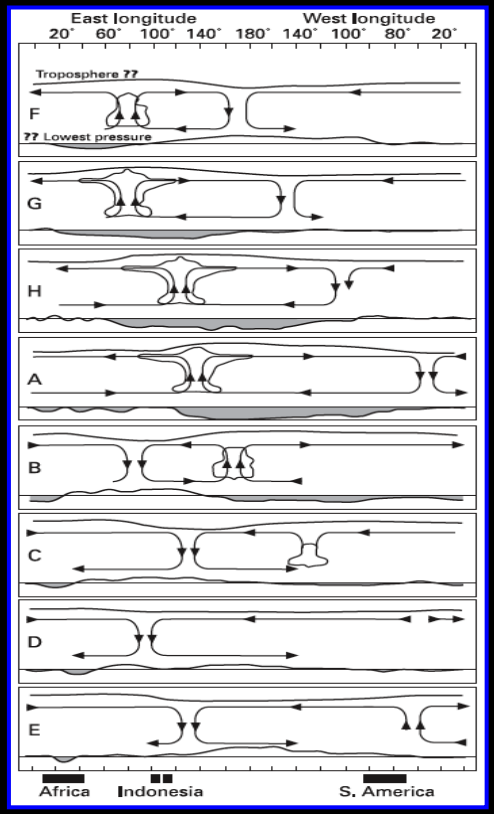
Life Cycle ~6-8 weeks

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

Deterministic Prediction ~2-5 weeks







Madden & Julian, 1972

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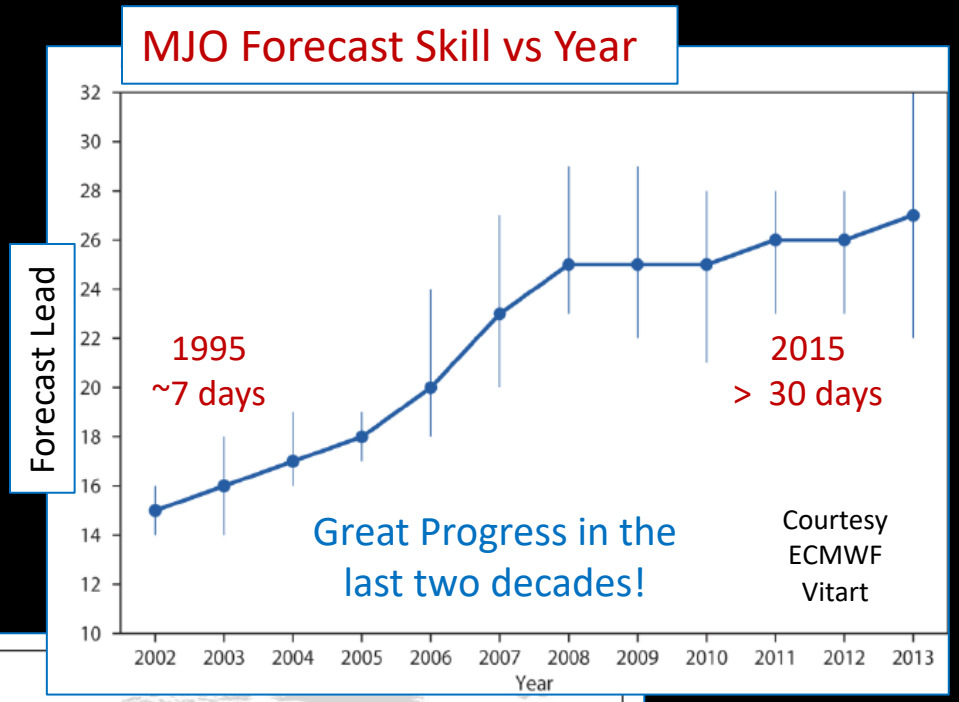
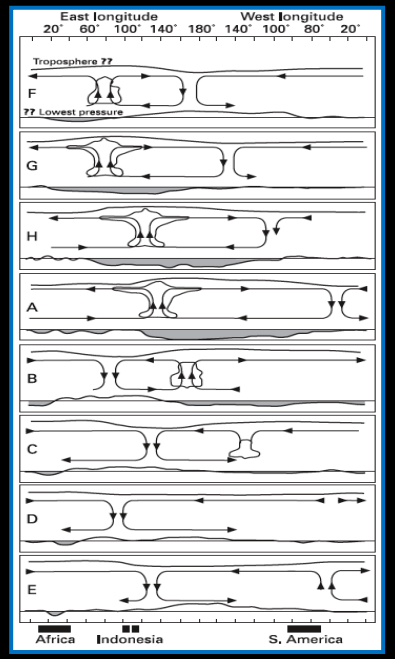
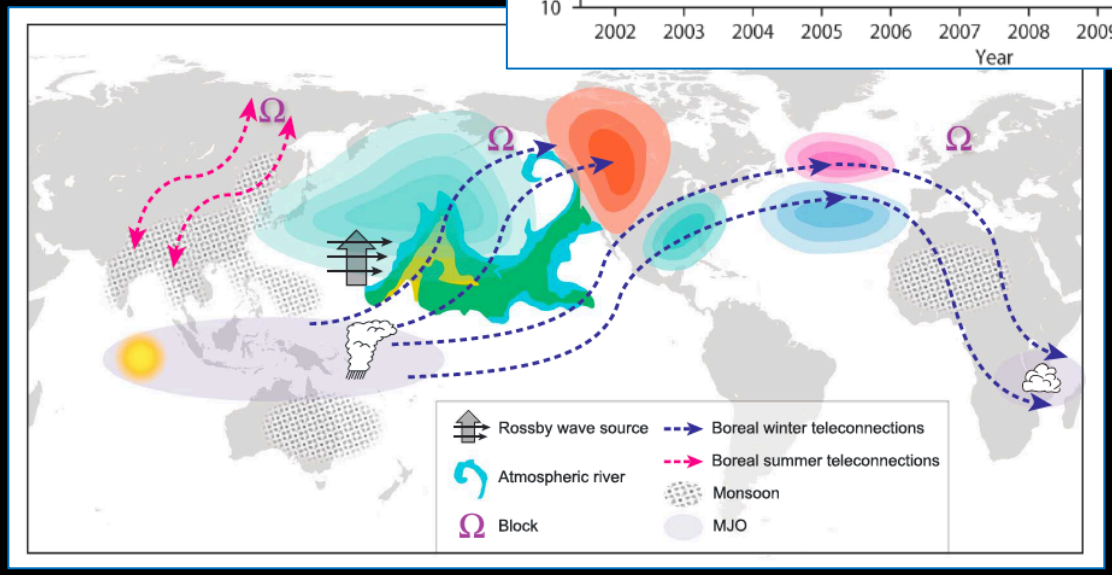
Predicting the MJO

Up to 5 Weeks Ahead







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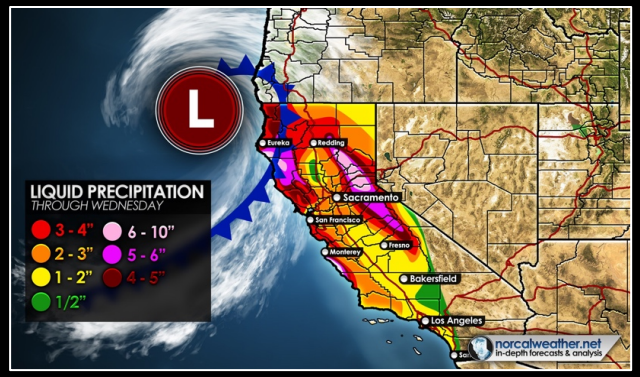
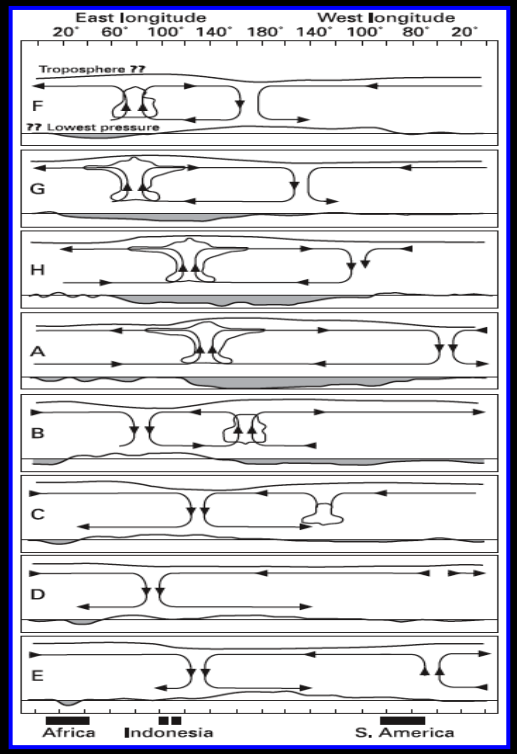
Putting it Together: S2S Prediction

Opportunities and Challenges

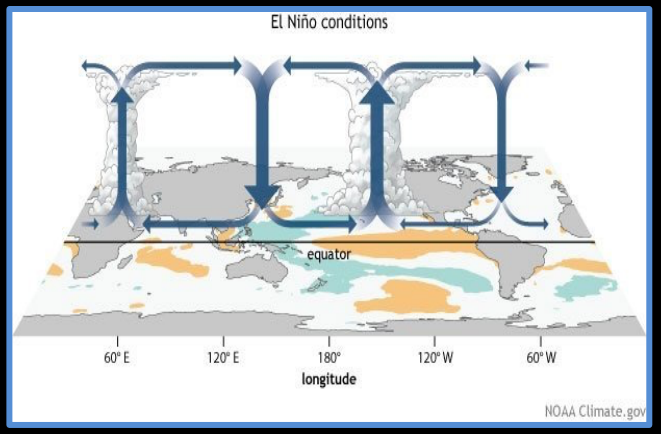
Weather : Atmospheric Rivers



MJO



ENSO



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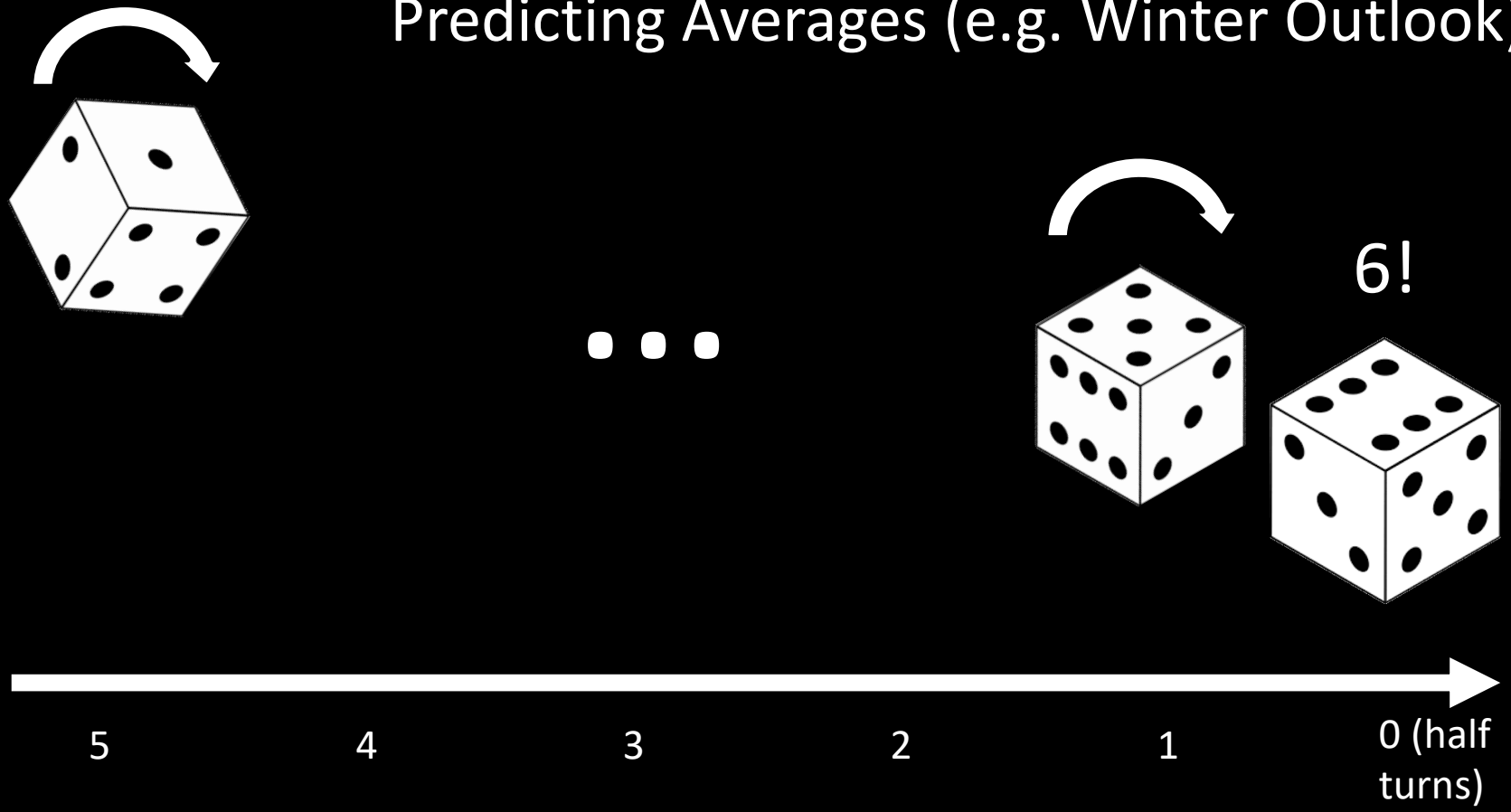
"Predicting Specifics (i.e. Weather)
vs
Predicting Averages (e.g. Winter Outlook)



- 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).

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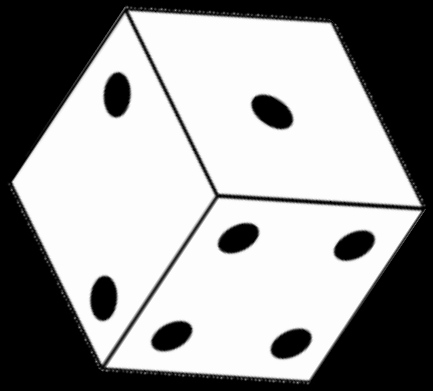
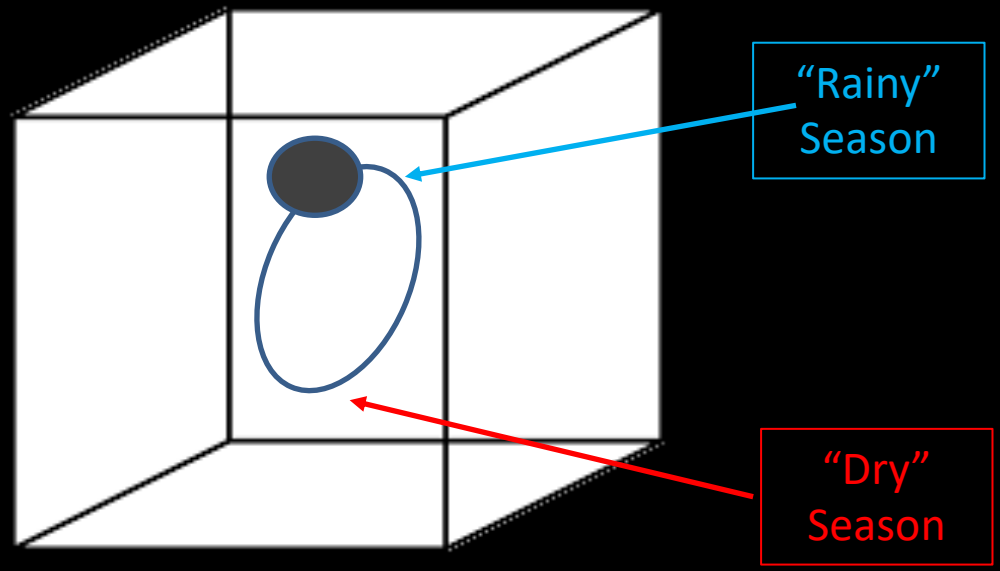
Modulation of Weather

Annual Cycle

Lets peer inside the dice



Life Cycle = 1 Year



- 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).

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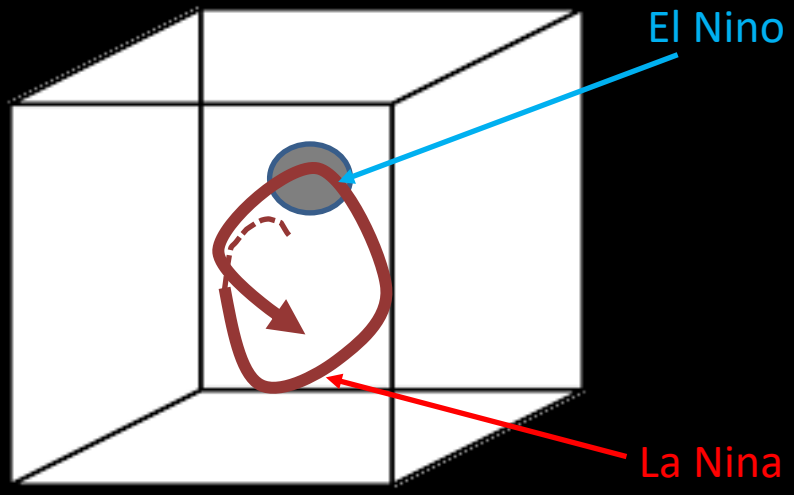
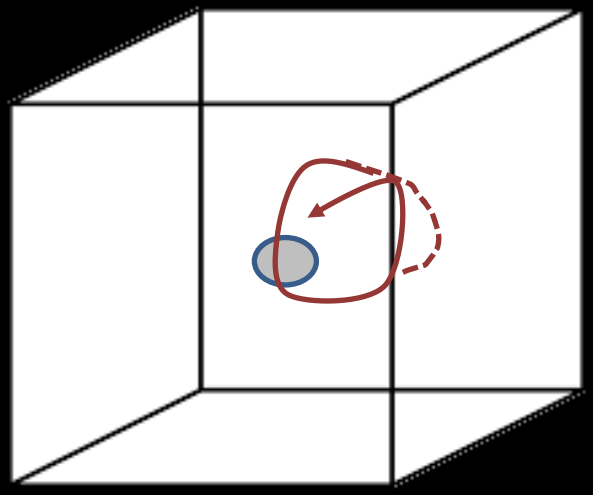
Modulation of Weather
"Natural Modes of Variability"

"ENSO"
12-18 month life cycle



"MJO"
6-8 weeks life cycle



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

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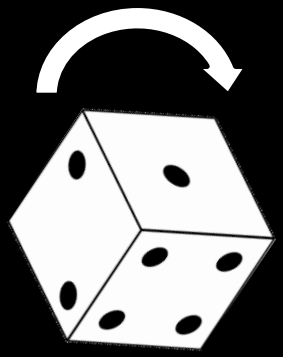
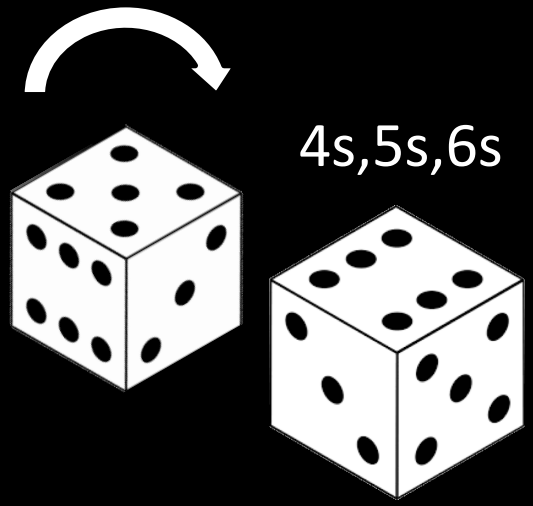
Week-3 Predictions & Winter Outlooks





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.

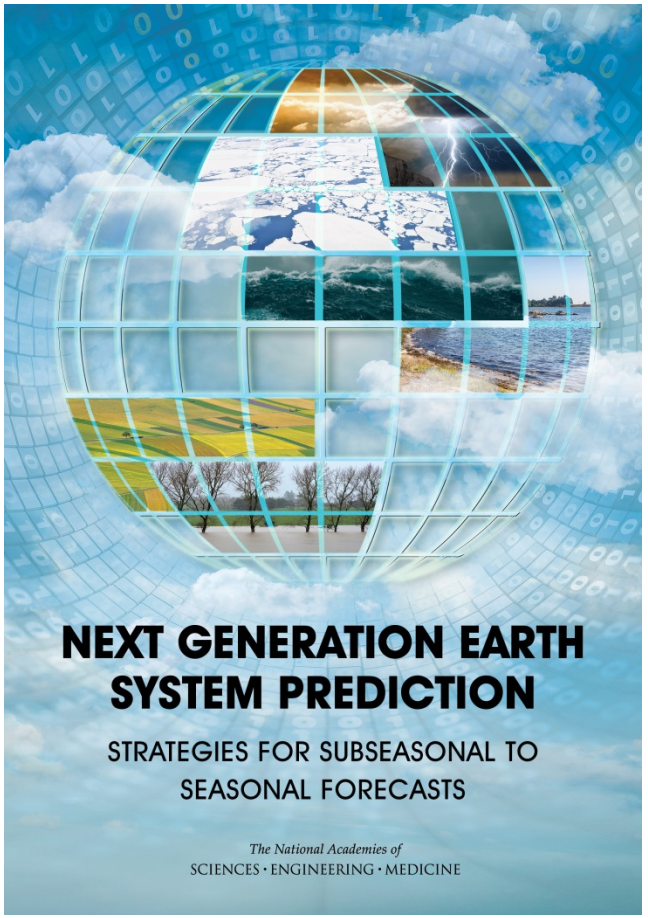
50 40 30 20 10 0 (half turns)

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

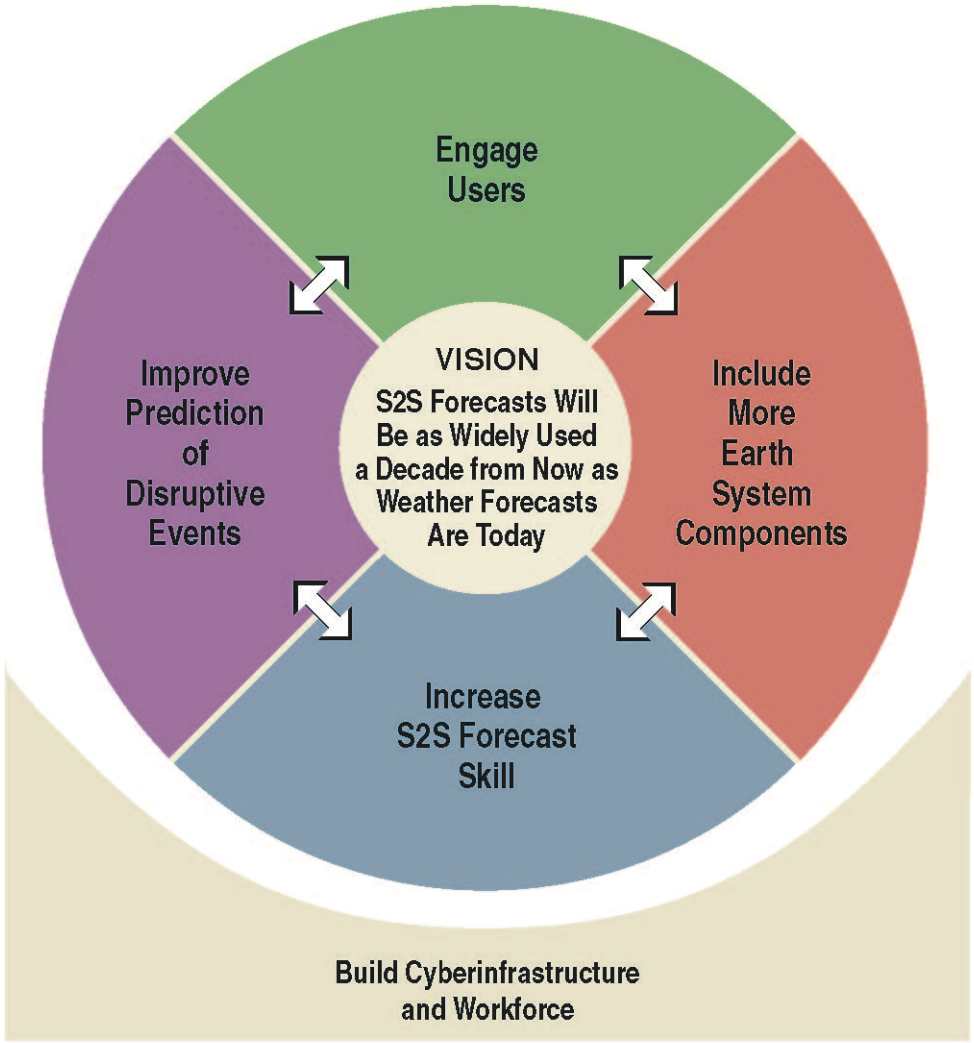
- Benefiting business, government and individuals
- Fulfilling this vision will take sustained effort and investment



2016

Supported by NASA, ONR and Heising-Simons Foundation

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

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

Mission Statement

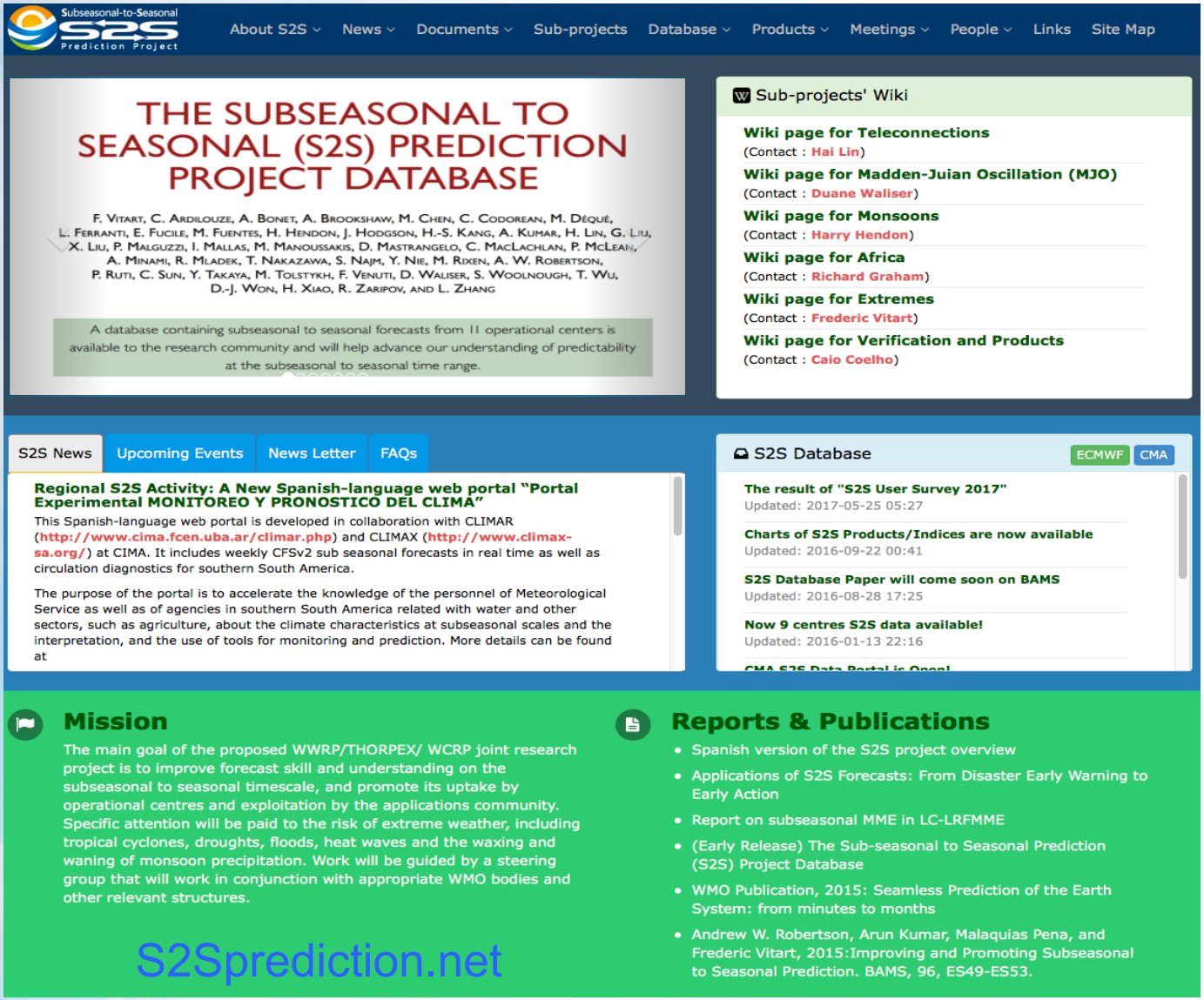
- **"To improve forecast skill and understanding on the sub-seasonal to seasonal timescale with special emphasis on high-impact weather events"**
- **"To promote the initiative's uptake by operational centres and exploitation by the applications community"**
- "To capitalize on the expertise of the weather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

One of 3 International Projects: S2S, HiW, PPP

S2S Project Website

WCRP-WWRP S2S Project

S2sprediction.net

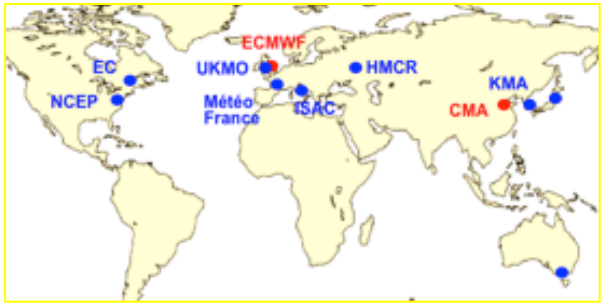


KMA – International Coordination Office

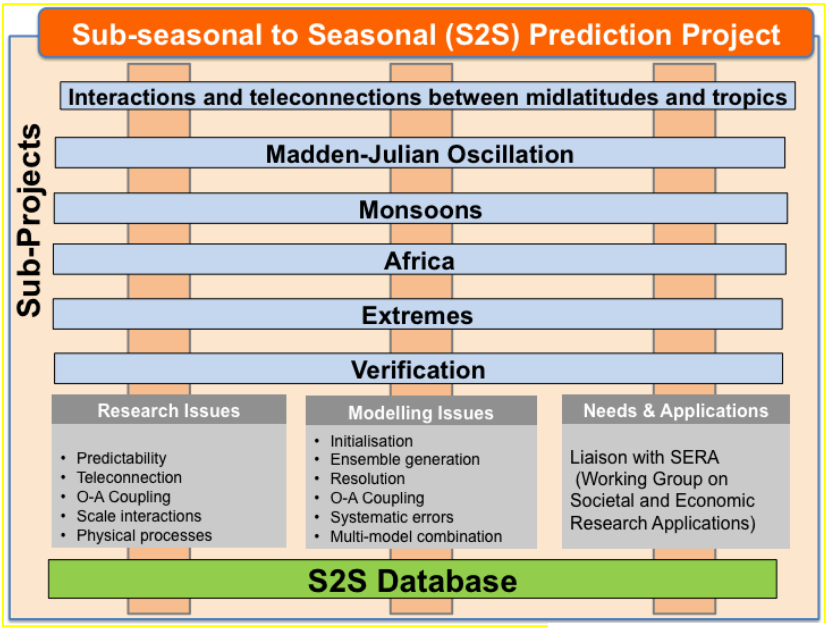
Subseasonal Forecast Database

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

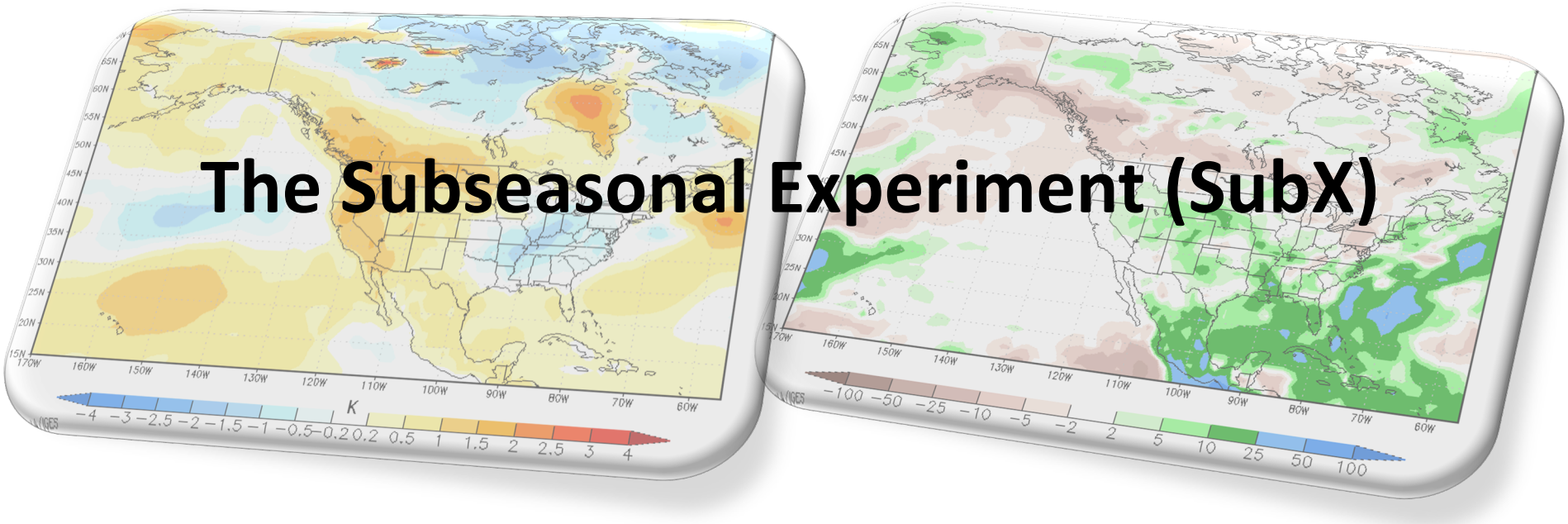
Sub-seasonal to Seasonal (S2S) Prediction Project – Phase 2

Sub-Projects

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

Predictability Issues	Modelling Issues	Needs & Applications
• Monsoons • Extremes • Verification • Africa	• Resolution • Systematic errors • Multi-model combination	• 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-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

- 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

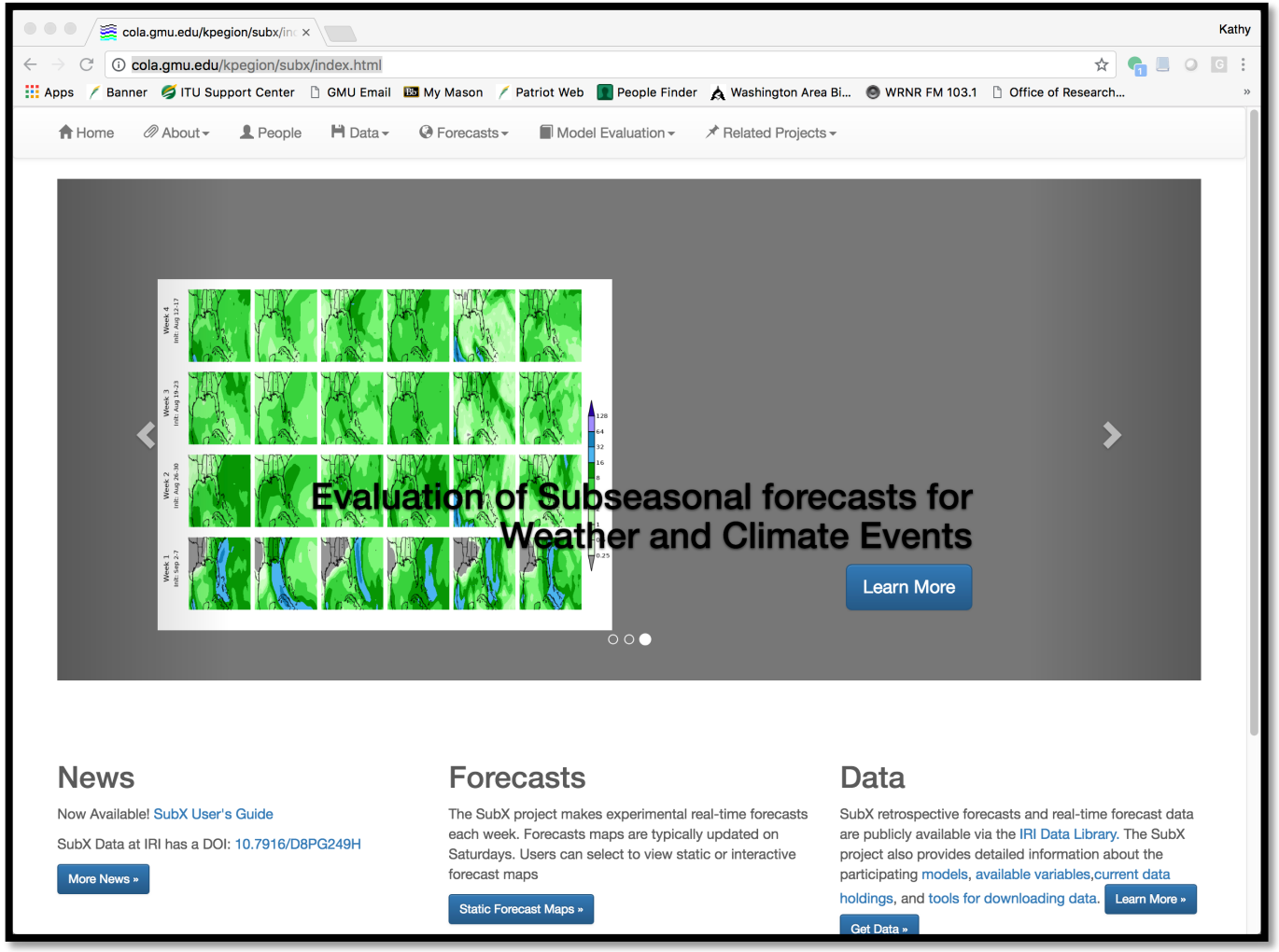
7 Global Models

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/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

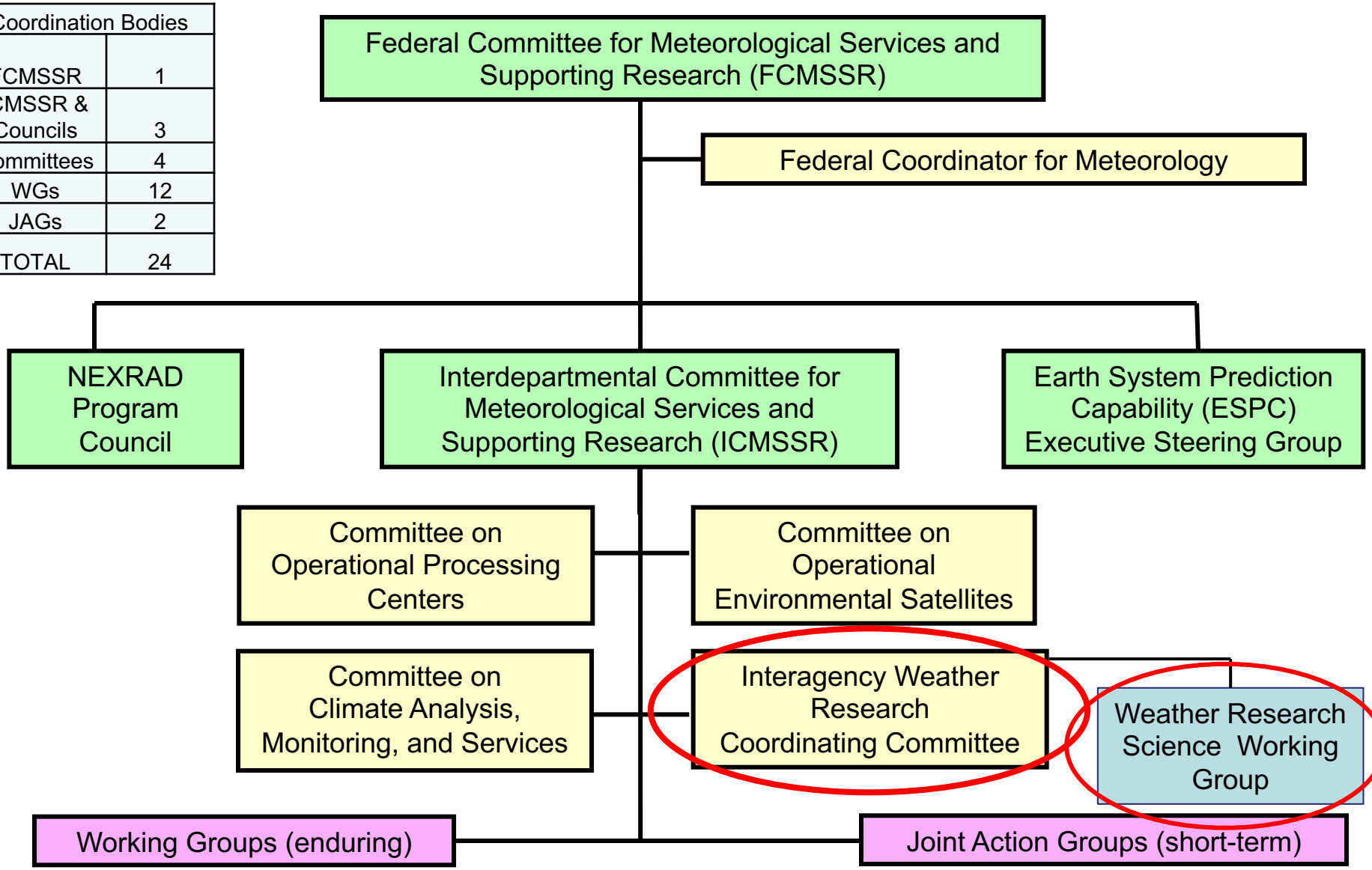
OFCM

Office of the Federal Coordinator for Meteorological Services and Supporting Research

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).