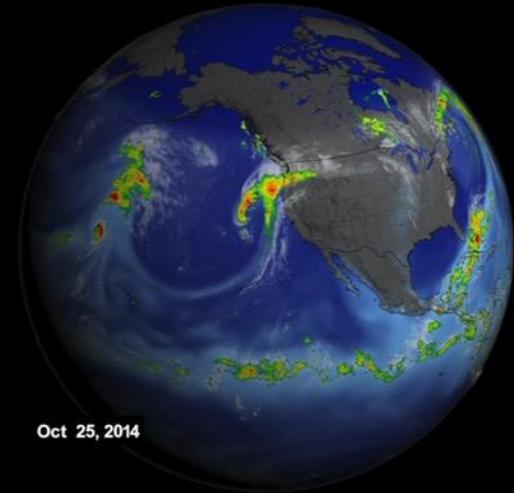




**Jet Propulsion Laboratory**

California Institute of Technology

**Duane Waliser**



# Improving S2S Prediction for Better Water Management & Resiliency in the West

Roundtable Conference on Water

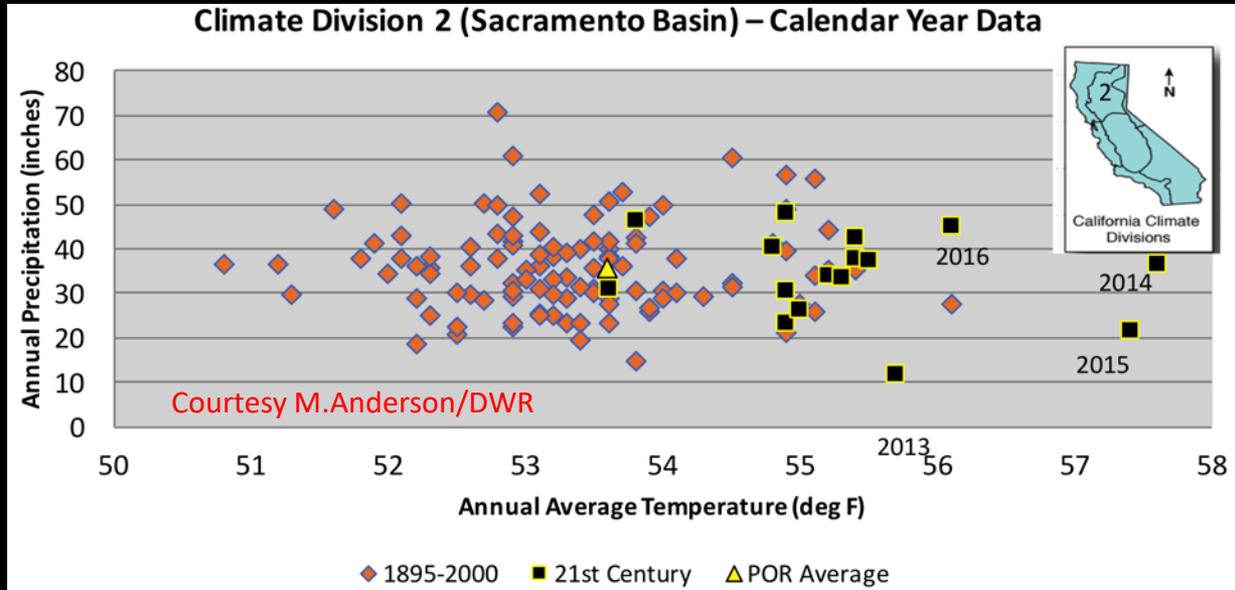
California Leaders' Guide to Weather Extremes: Are We Ready for the "New Normal?"

November 16-17, 2017

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.

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# Recent Climate in California



Annual Average Temperature - Looks like Warming  
Annual Average Precipitation - ?

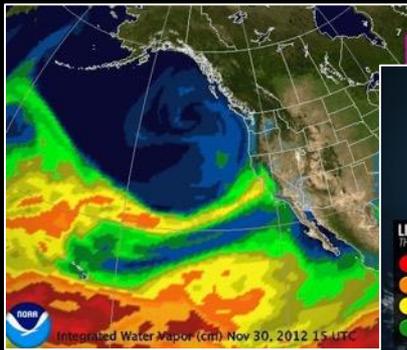
**For every year one can make:**

4 seasonal  
12 monthly  
52 weekly  
365 daily

} forecasts (& decisions)

# Weather Forecasts

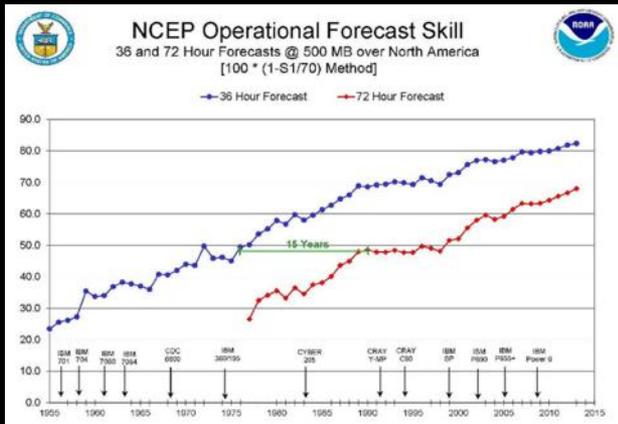
## 0-14 Days



e.g. Atmospheric Rivers

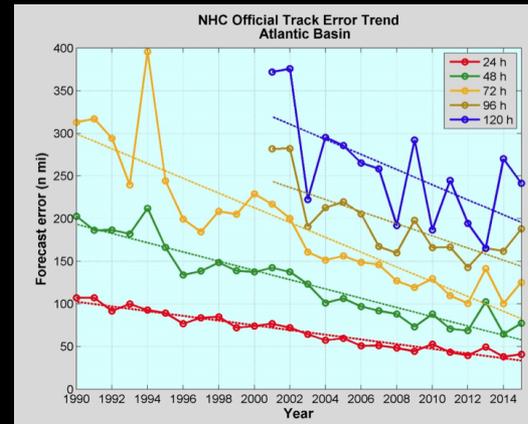


Forecast Skill Increasing



General Weather Patterns

Forecast Errors Diminishing



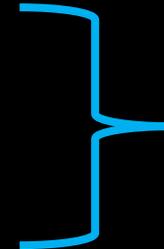
Hurricanes

More/Better Observations  
Improved Models  
More Computing Power

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

# Forecast Lead Times

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

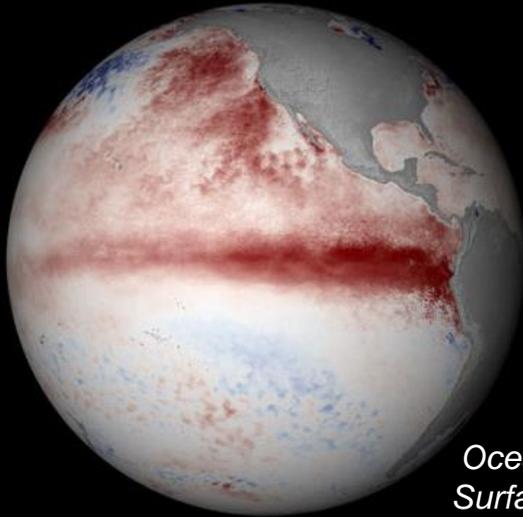


Subseasonal  
to Seasonal  
(S2S)  
2 weeks -12  
months

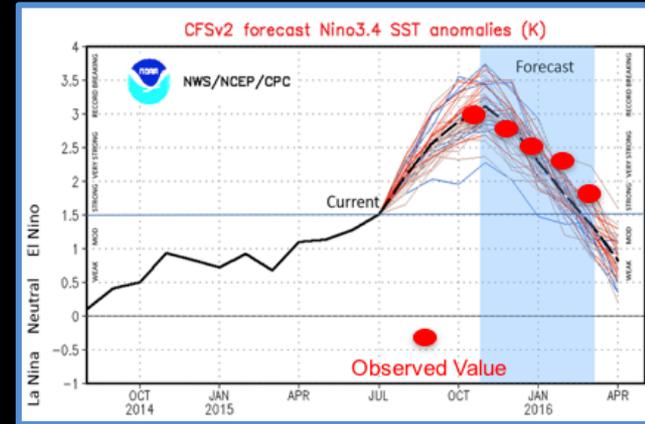
*p.s. "subseasonal" aka "intraseasonal"*

# s2S: El Nino – La Nina

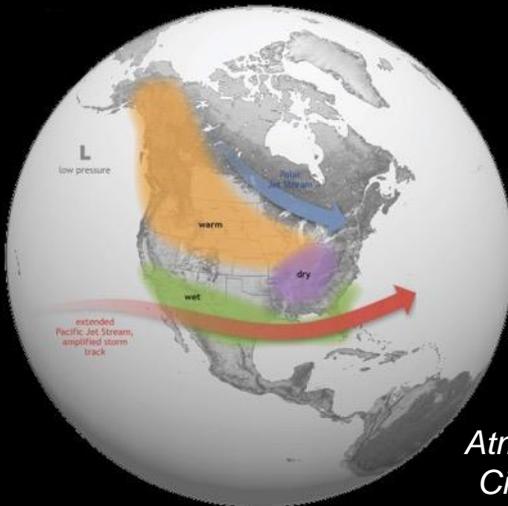
## LifeCycle ~Months



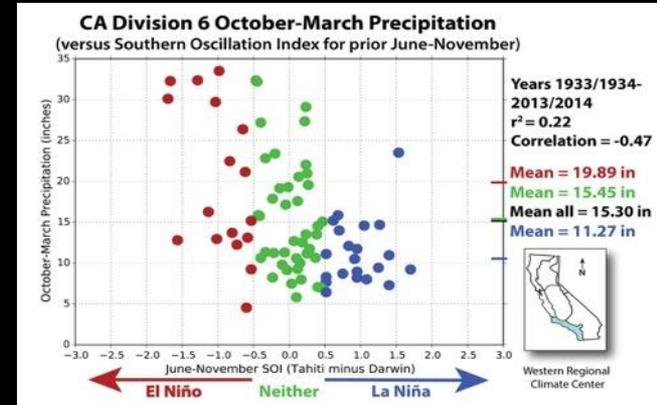
Ocean Surface Temperature



Tropical SST – Capabilities to Predict



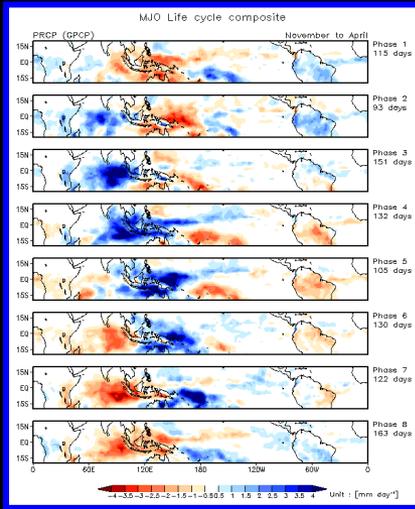
Atmospheric Circulation



Extra-tropical Impacts – Difficult/Still Learning

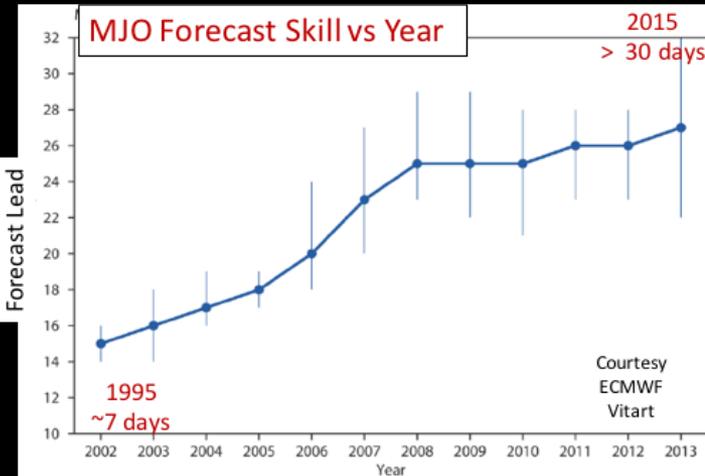
# S2S: Madden-Julian Oscillation

LifeCycle ~Weeks



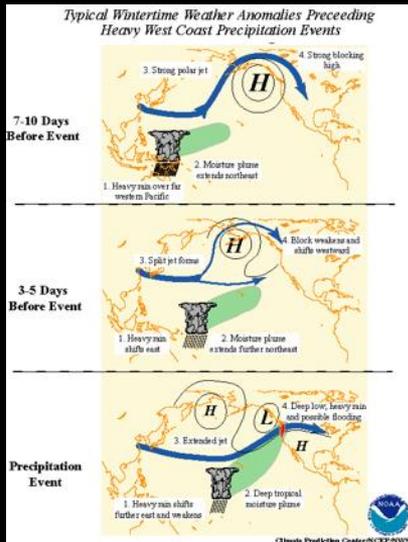
40-50 Days

Tropical  
Precipitation  
& Circulation



Tropical MJO – Skill out to 3-4 Weeks

Extra-tropical Impacts – Difficult/Still Learning



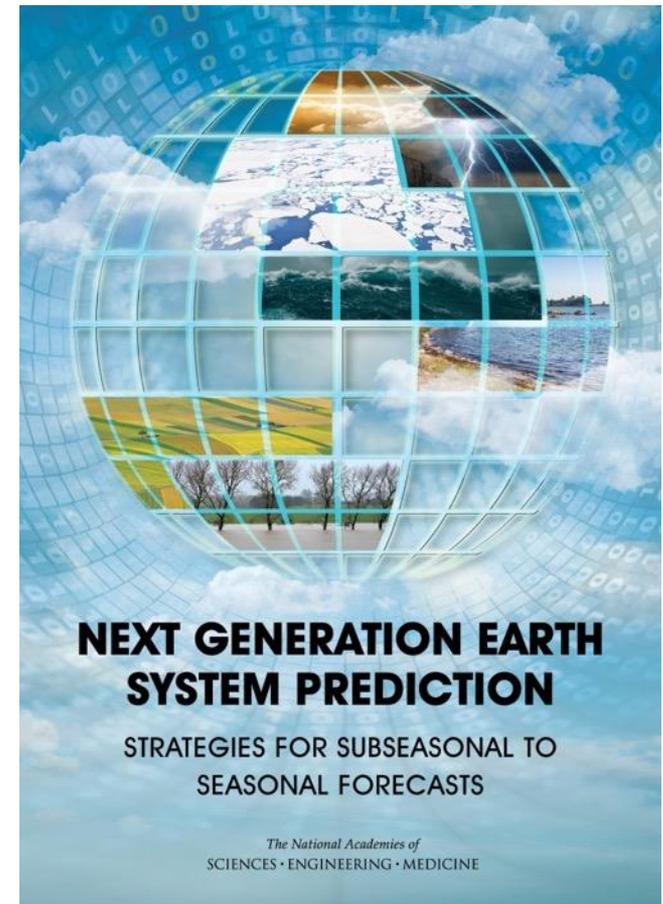
Extra-tropical  
Atmospheric  
Circulation

More/Better Observations  
Improved Models  
More Computing Power

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

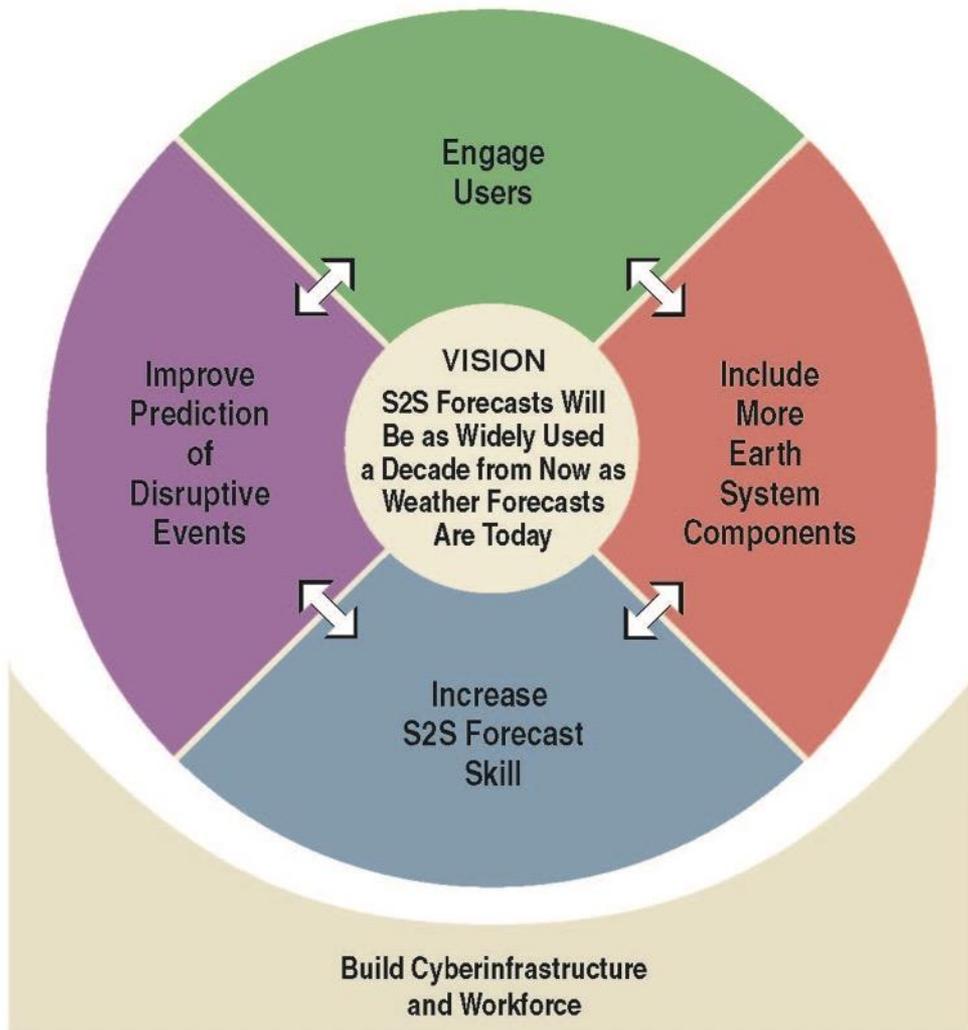
**Bold Vision: S2S forecasts will be as widely used a decade from now as weather forecasts are today**

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



**2016**

# Fulfilling the Vision: Research Strategies



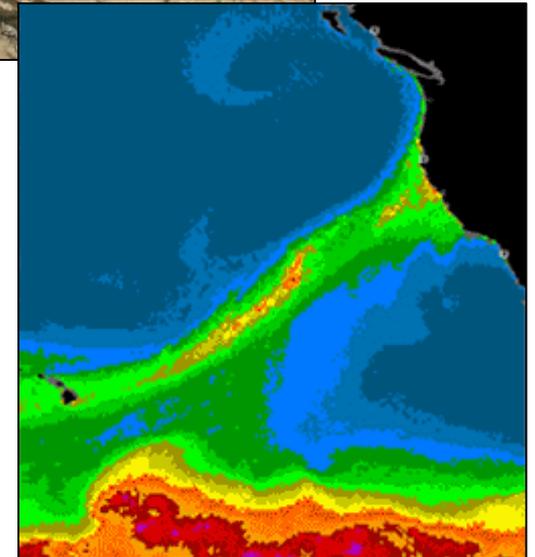
1. Engage Users
2. Increase S2S Forecast Skill
3. Improve Prediction of Disruptive Events
4. Include More Earth System Components

# Research Strategy 1 : Engage Users

## *Example - Water Resource Management*

Improved S2S predictions of drought and the probability of atmospheric river events will:

- Support improved management of reservoirs, including drought management, flood control, and planning for hydropower
- Need engagement to understand critical decisions and to produce forecast information that fits water project/agency location and timing needs

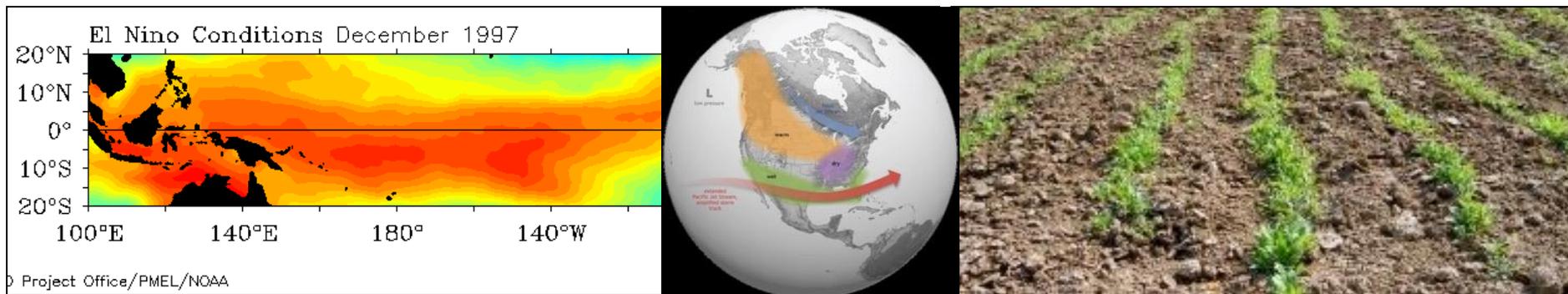


# Research Strategy 2: Increase S2S Forecast Skill

- 1) Improve **understanding** of sources of S2S predictability
  - Natural “oscillations” e.g. ENSO, MJO, QBO, etc
  - Slowly varying surface processes, e.g. snowpack, sea ice, soil moisture, etc
- 2) Improve **models** to better represent these processes
- 3) Improve **observations** to better measure these processes.

**For long-lead S2S predictions, 1-3 mean globally.**

*What happens far away matters to a local S2S forecast.*



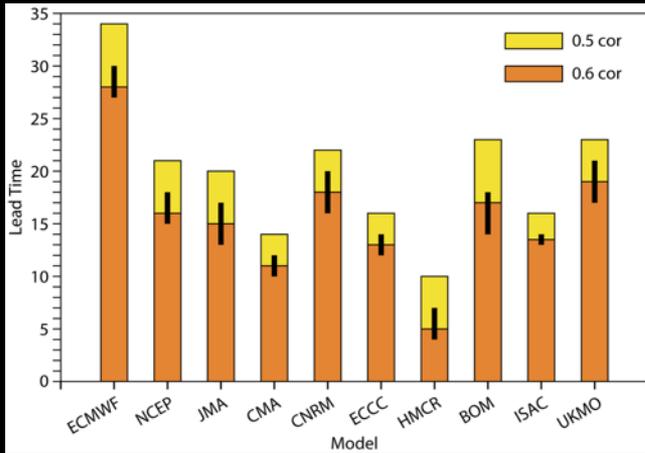


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BACKUP

# Forecast Skill Comparisons

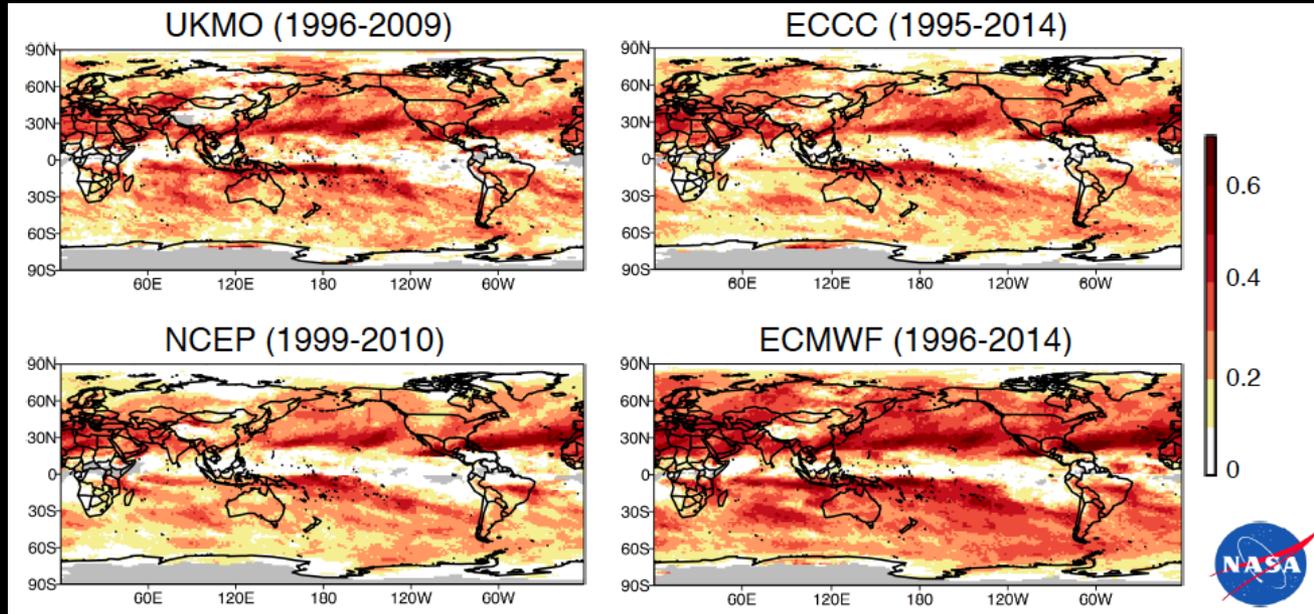
## MJO Forecast Skill



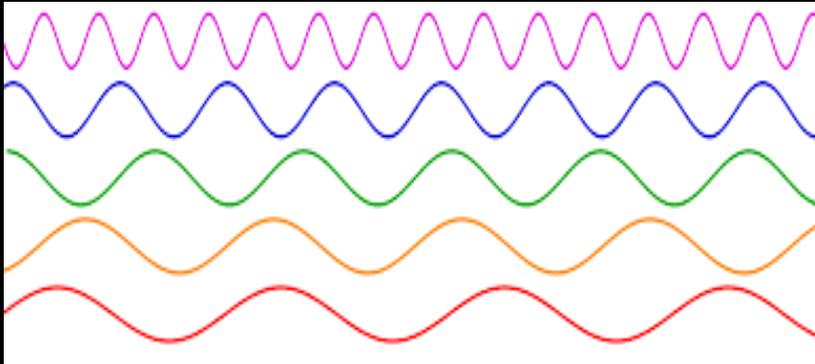
Vitart and Robertson, 2017

## Atmospheric River Forecast Skill

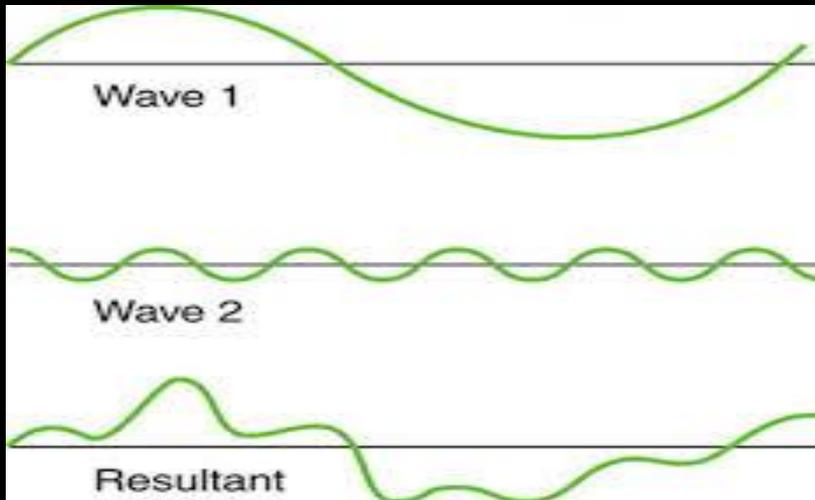
DeFlorio et al. (2017; submitted)



# Variations in Weather/Climate

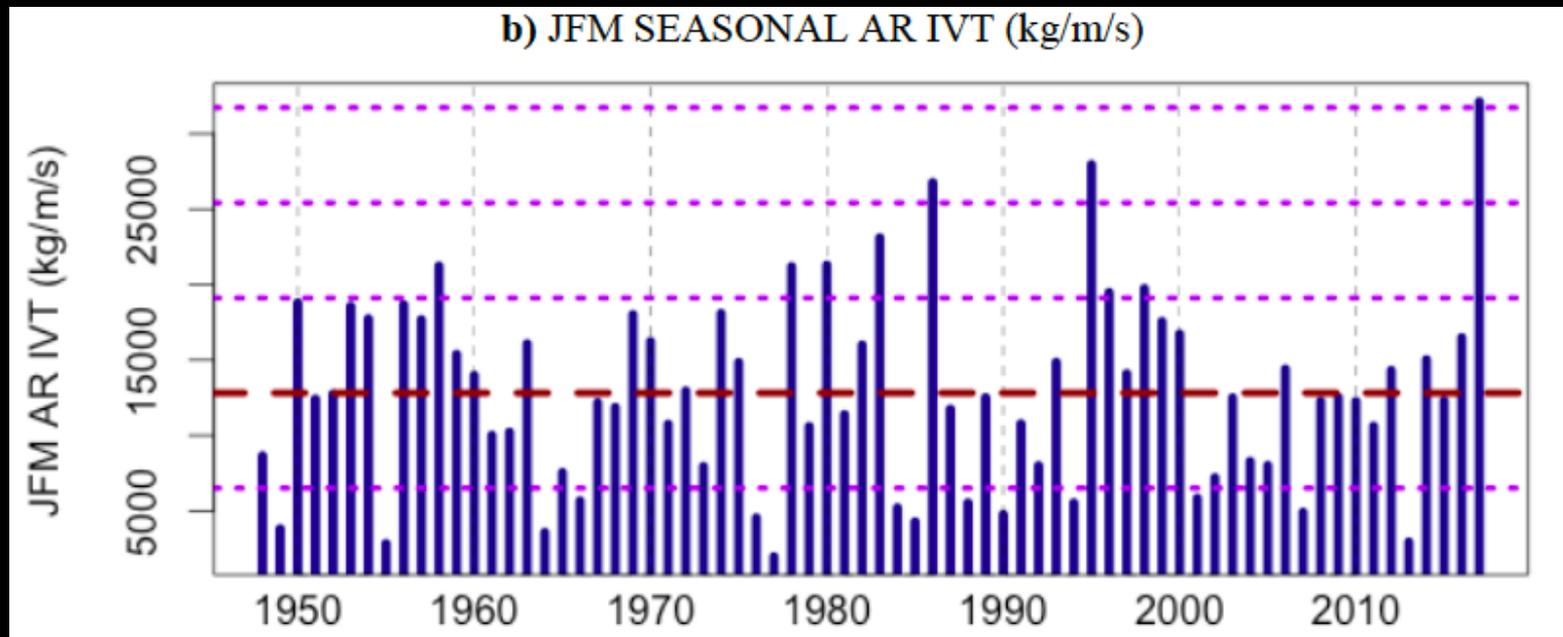


e.g.  
AR  
MJO  
ENSO  
PDO



e.g. MJO & weather

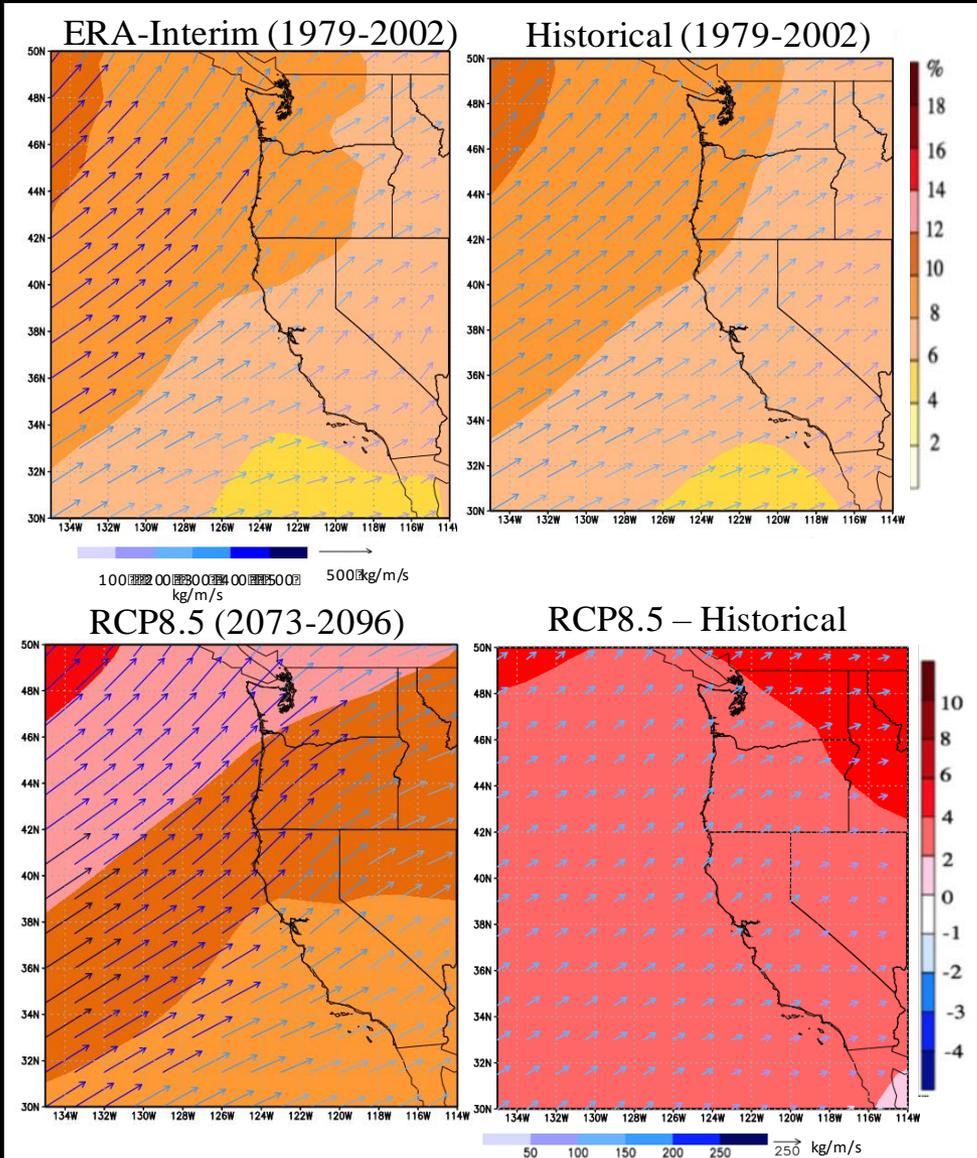
# Atmospheric River Moisture Transport to California



Gershunov et al. 2017

# Climate Change & ARs

## AR Frequency & Transport: 21 CMIP5 Models



### % AR Frequency for Western US

- Historical/ERA-Interim AR Frequency: 7-9%
- RCP8.5 (2073-2096) AR Frequency: 9-13%
- AR Frequency Increase: 2-4%;
- Relative Increase 30-40%

### IVT Increase for Western US

- Historical IVT  $\sim 250$  kg/m/s
- RCP8.5 IVT  $\sim 350$  kg/m/s
- Relative Increase  $\sim 40\%$ .

**More Extremes/ARs**

*Espinoza, Waliser, Guan, Lavers, Ralph  
(2016, Submitted)*