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Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

# Experimental Subseasonal Forecasting Of Atmospheric River Variations For The Western U.S.

*Winters 2017-2018 and 2018-2019*


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**Frederic Vitart**
*ECMWF, Reading, UK*
**Jeanine Jones**
*California Department of Water Resources, Sacramento CA*



**International Conferences on Subseasonal to Decadal Prediction**
17-21 September, 2018
NCAR, Boulder, CO

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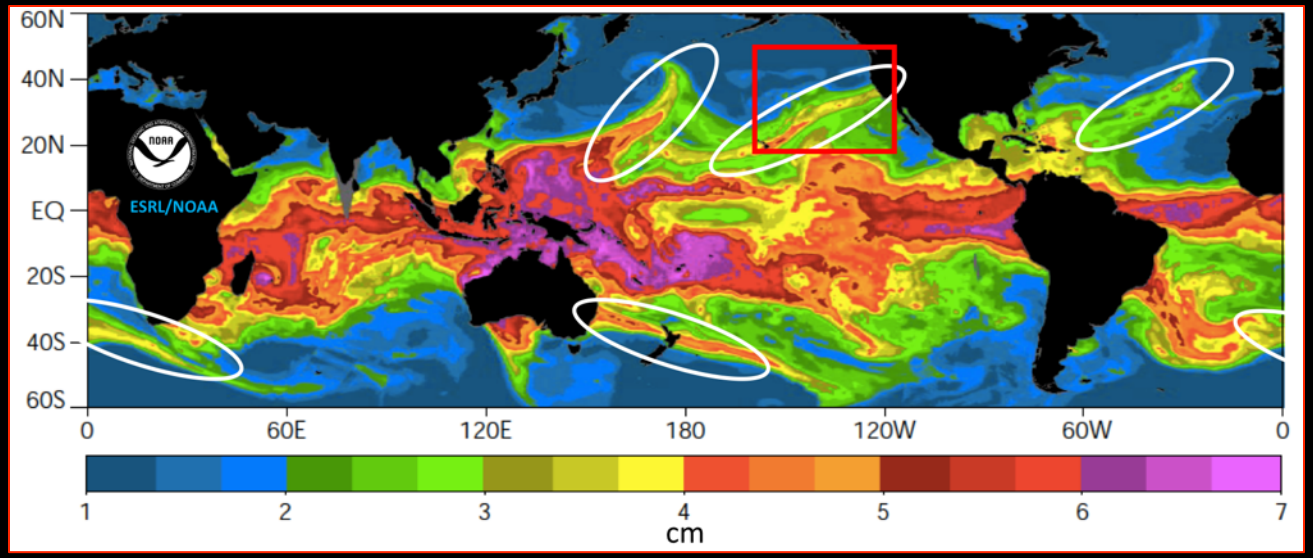
# Atmospheric Rivers

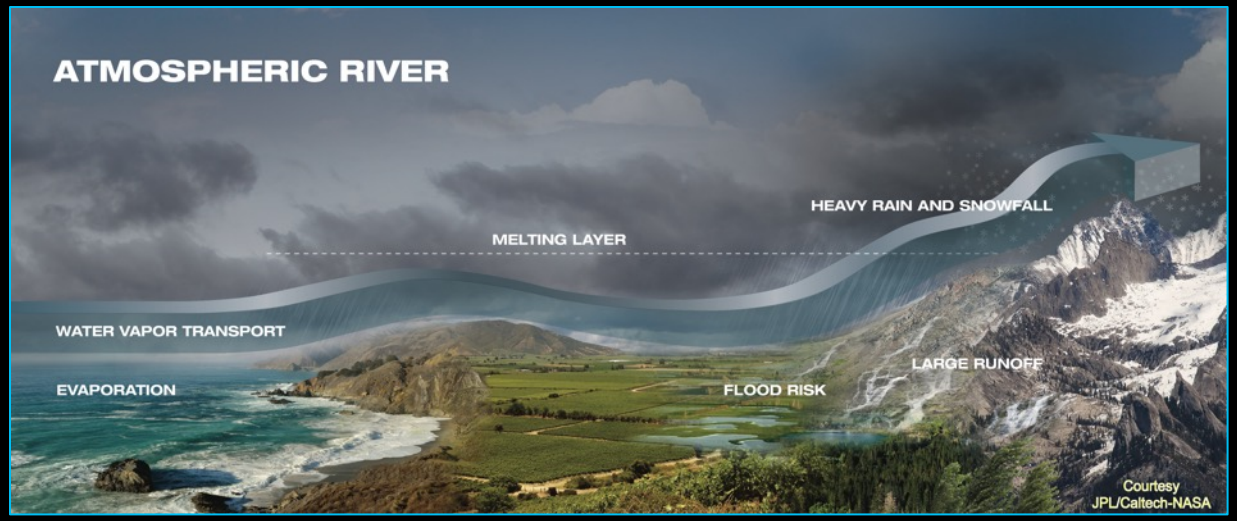
*See AMS Glossary Definition*




Identified first by Zhu and Newell, 1998.

Account for 90% of poleward meridional transport across midlatitudes.

Account for ~40% of California's annual water supply in a few storms.
Account for most flooding events on U.S. West coast.



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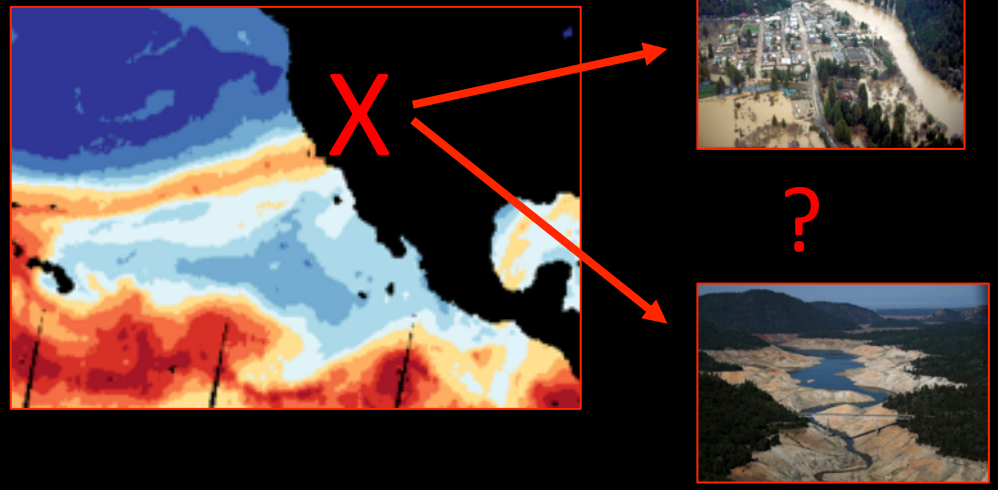
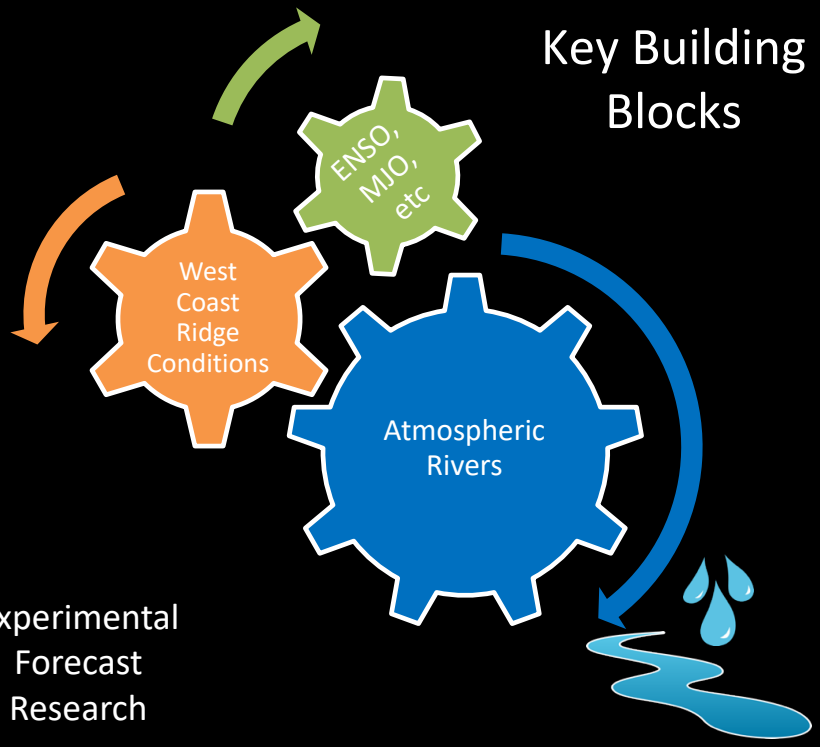
# Western U.S. : Wet or Dry?




**Objective**:
Predict Western US Precipitation Conditions At Subseasonal Lead Times

Key Building Blocks




Experimental Forecast Research

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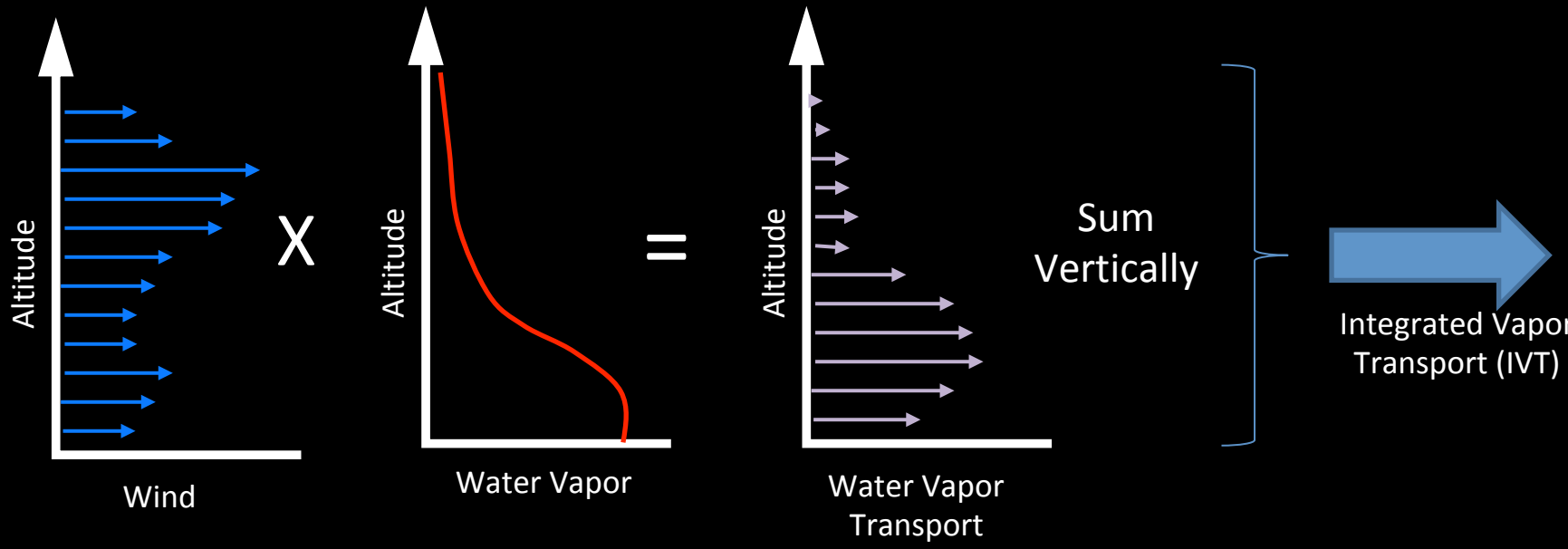
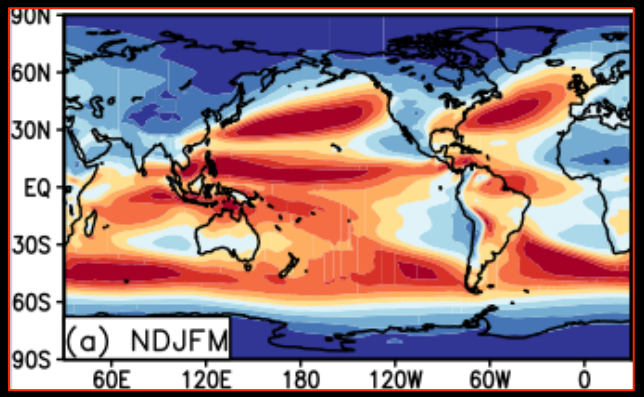
# Global AR Detection

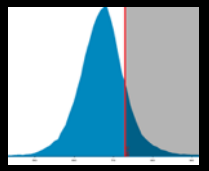
## I. Compute IVT




## II. Map IVT timeseries globally




## III. Apply AR Criteria



- IVT > 85th percentile
- Look for contiguous areas
- Length > 2000 km
- Length/Width > 2

Gives Long, Narrow Extreme Moisture Transports i.e. Rivers

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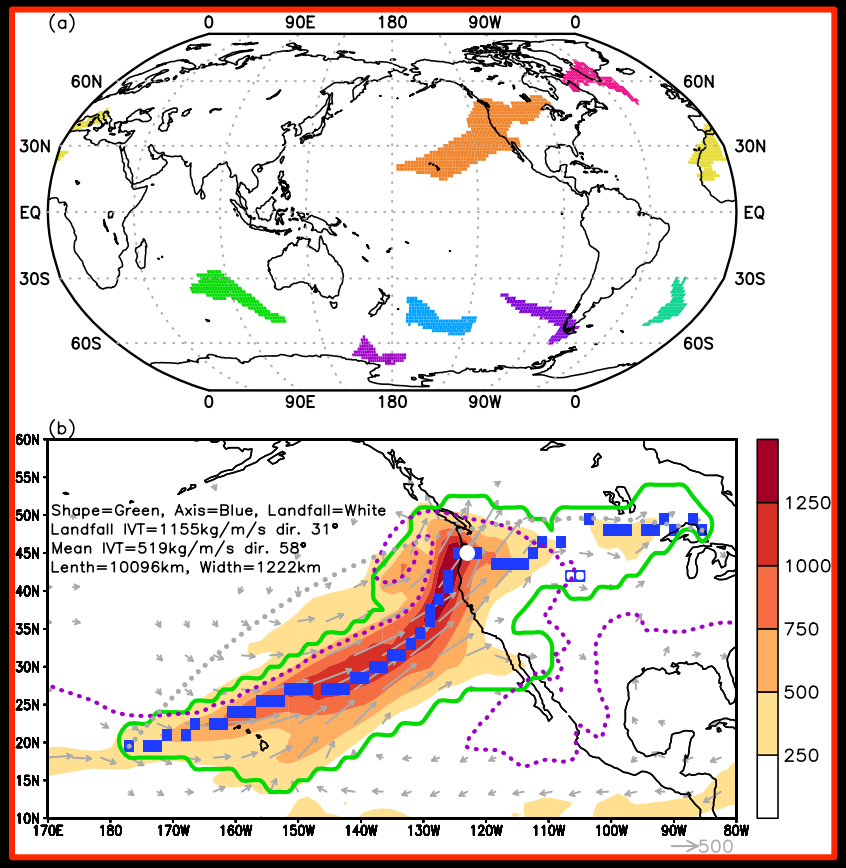
# Global AR Detection Algorithm




Guan and Waliser (2015)

- Based on Integrated Vapor Transport (IVT) fields and a number of common AR criteria (e.g. Ralph et al. 2004).
- Developed for global studies and for observations/reanalysis and models.
- Applied to:
  - MERRA-2, ERA-I, CFSR, NCEP/NCAR
- Code and databases available at:
  - https://ucla.box.com/ARcatalog
- Databases include AR Date, $IVT_{x,y}$, Shape, Axis, Landfall Location, etc.

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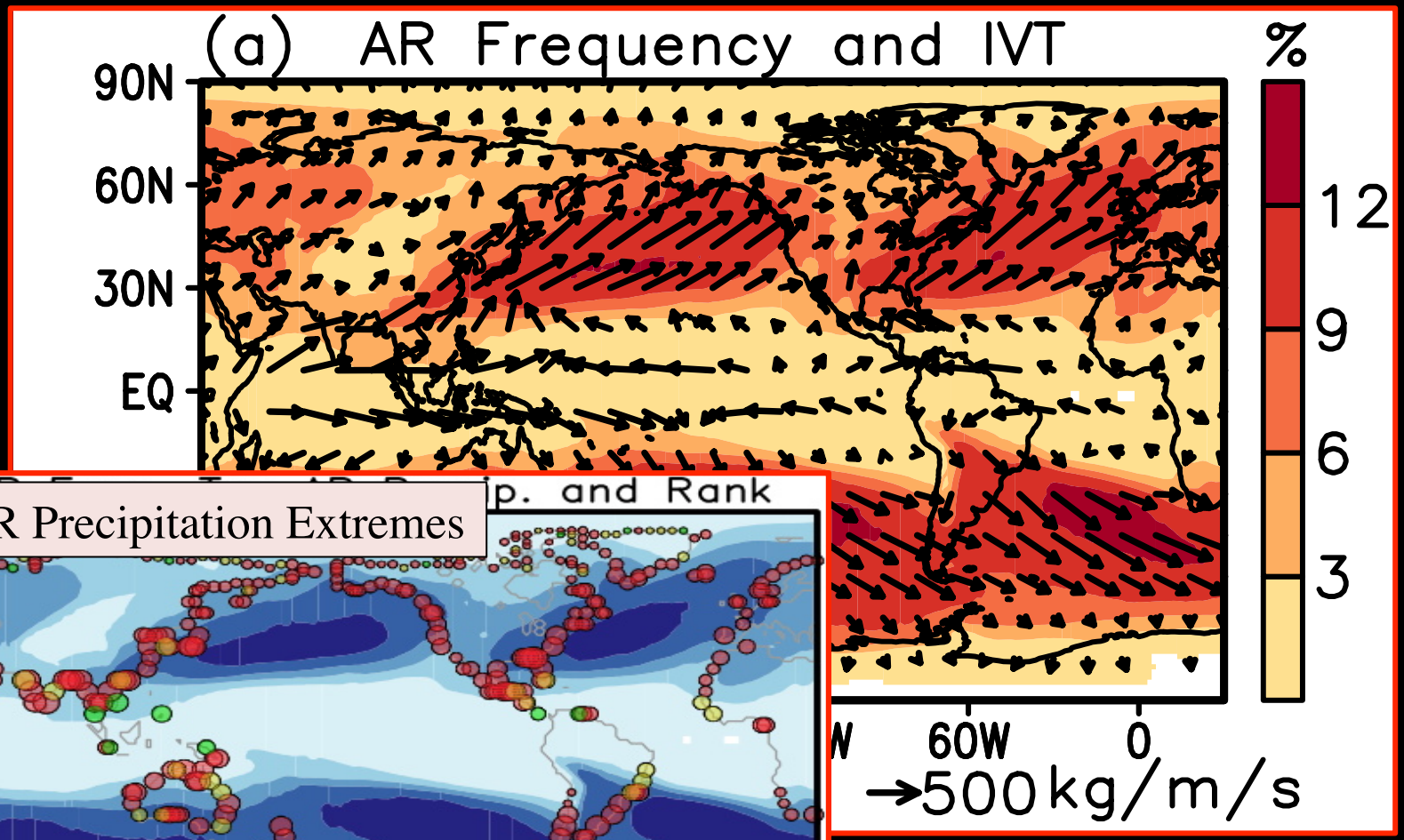
# Global View of ARs

*Frequency, IVT, Landfalls & Precipitation*




Guan and Waliser (2015)

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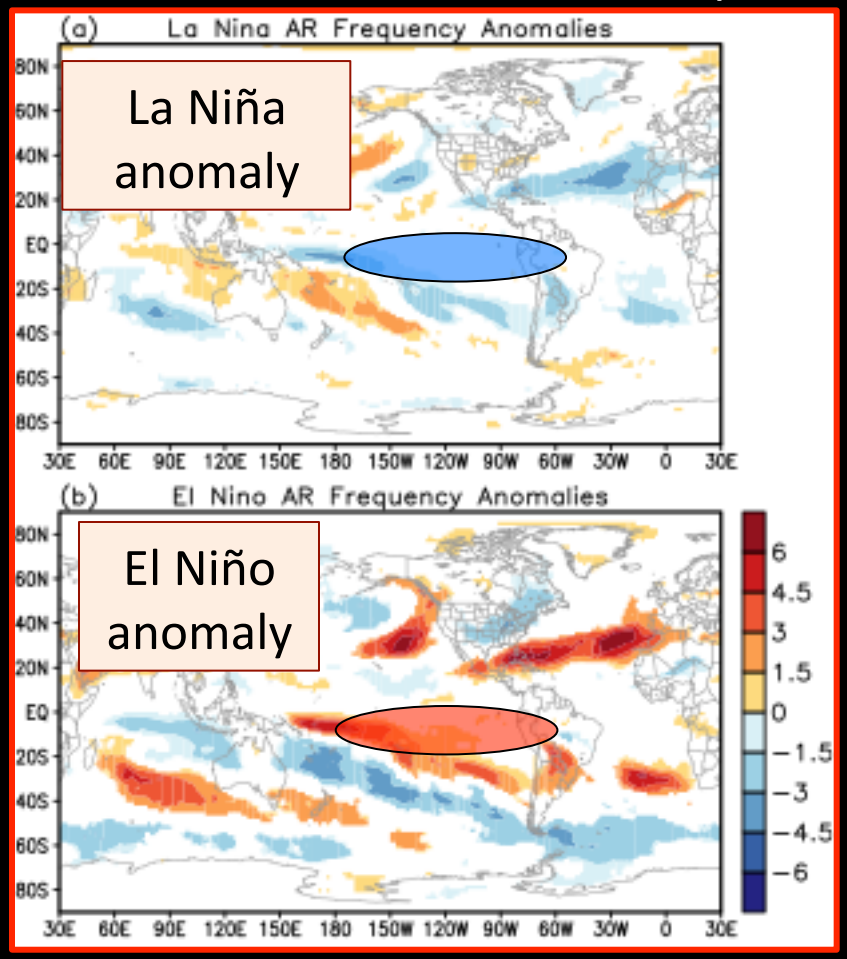
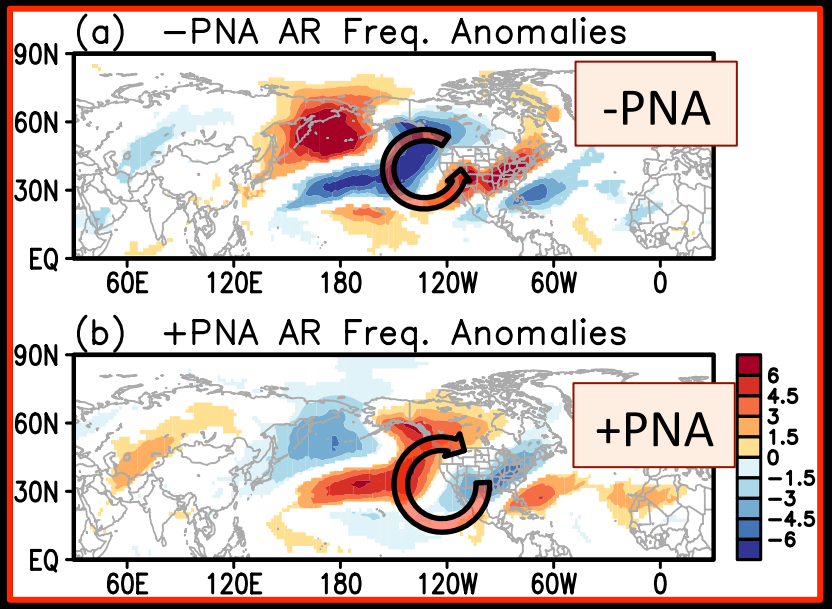
# Climate Patterns and ARs

## El Nino Southern Oscillation (ENSO)




## Pacific-North American (PNA)




MJO, AO, etc

Guan and Waliser (2015)

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# Predicting AR Activity

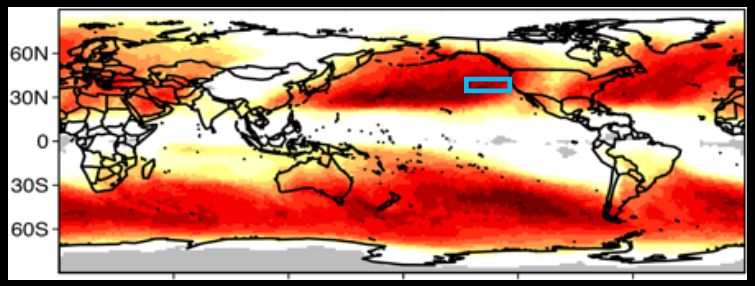
## *Considering Subseasonal Lead Times*

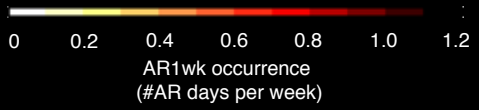
Purpose of Study

- Evaluate global hindcast prediction skill of 1-week AR occurrence (AR1wk; number of AR days per week) at 1-week to 1-month lead times
- Quantify interannual variability of AR1wk magnitude, and identify conditions of climate variability which exhibit higher/lower AR1wk prediction skill

Global climatology of wintertime AR1wk, 1996-2015

**Observations; ERA-I**




*DeFlorio, Waliser, Guan, Ralph, Vitart (2018b)*

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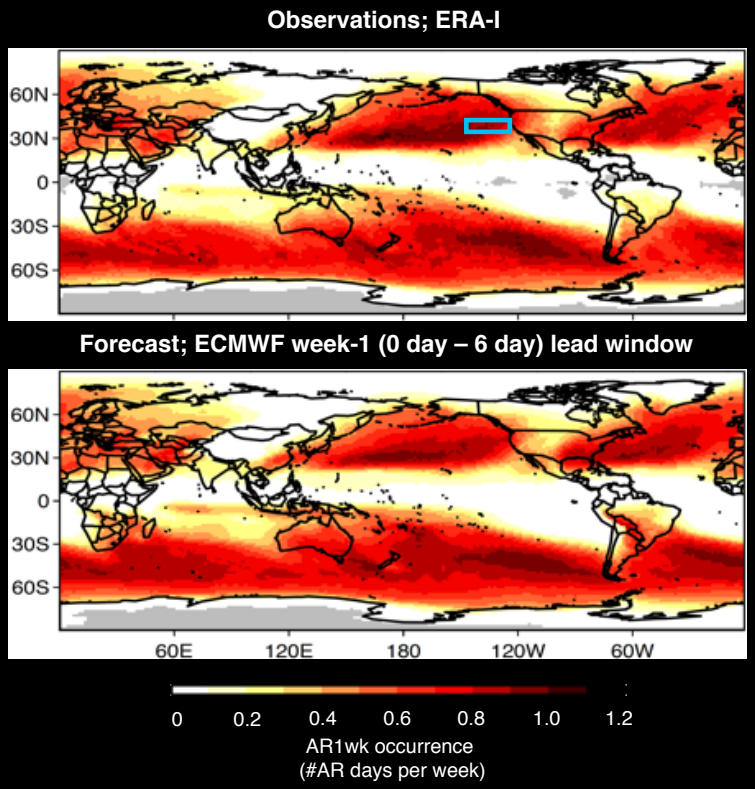


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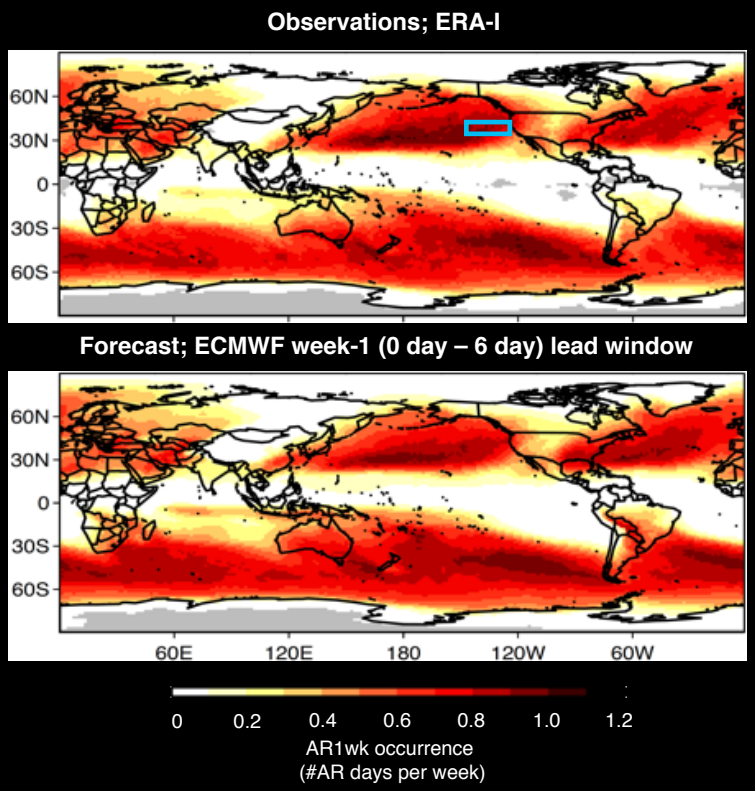


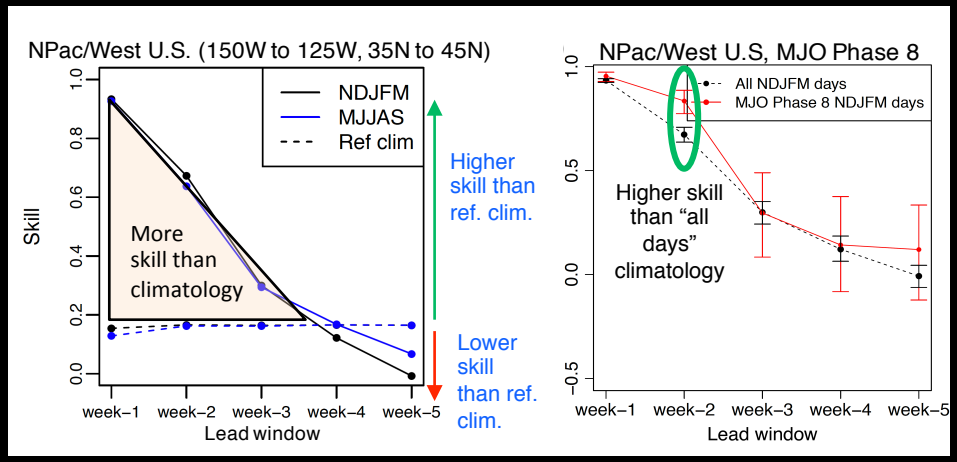


- (left) ECMWF AR1wk occurrence forecast skill outperforms a reference forecast based on monthly climatology of AR1wk occurrence at week-3 (14d-20d) lead over the North Pacific/Western U.S. region
- (right) Higher forecast skill is evident during Phase 8 of the Madden-Julian Oscillation at week-2 (7-day to 13-day) lead

*DeFlorio, Waliser, Guan, Ralph, Vitart (2018b)*

# Experimental Synoptic and Subseasonal AR Forecasting for Winter 2017-18 and 2018-19


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Frédéric Vitart

Jay
Cordeira

Jeanine Jones

Arun Kumar

Hai Lin

# Multi-model Experimental S2S Atmospheric River Forecast*

Issued on Thursday, September 13, 2018

**Contents:**

**Definition of "Subseasonal" -** US west coast weather/precipitation forecast for week 3 considering the number of atmospheric river days predicted to occur in the given forecast week.
*Novelty – an S2S forecast presented only in terms of AR likelihood - specifically for week 3, an extended/ long-range or "subseasonal" prediction*

**Slides 1-2:** ECMWF (European Centre for Medium-Range Weather Forecasts) forecast system
**Slides 3-4:** NCEP (National Centers for Environmental Systems) forecast system
**Slides 5-6:** ECCC (Environment and Climate Change Canada) forecast system

**This is an experimental activity for the 2017-18 and 2018-19 winters. Methodologies and hindcast skill are documented in DeFlorio et al. (2018a,b). Further validation of the real-time forecast results is required and underway. This phase of the research includes gathering stakeholder input on the presentation of information – feedback is welcome.*

POC: Michael J. DeFlorio (michael.deflorio@jpl.nasa.gov)

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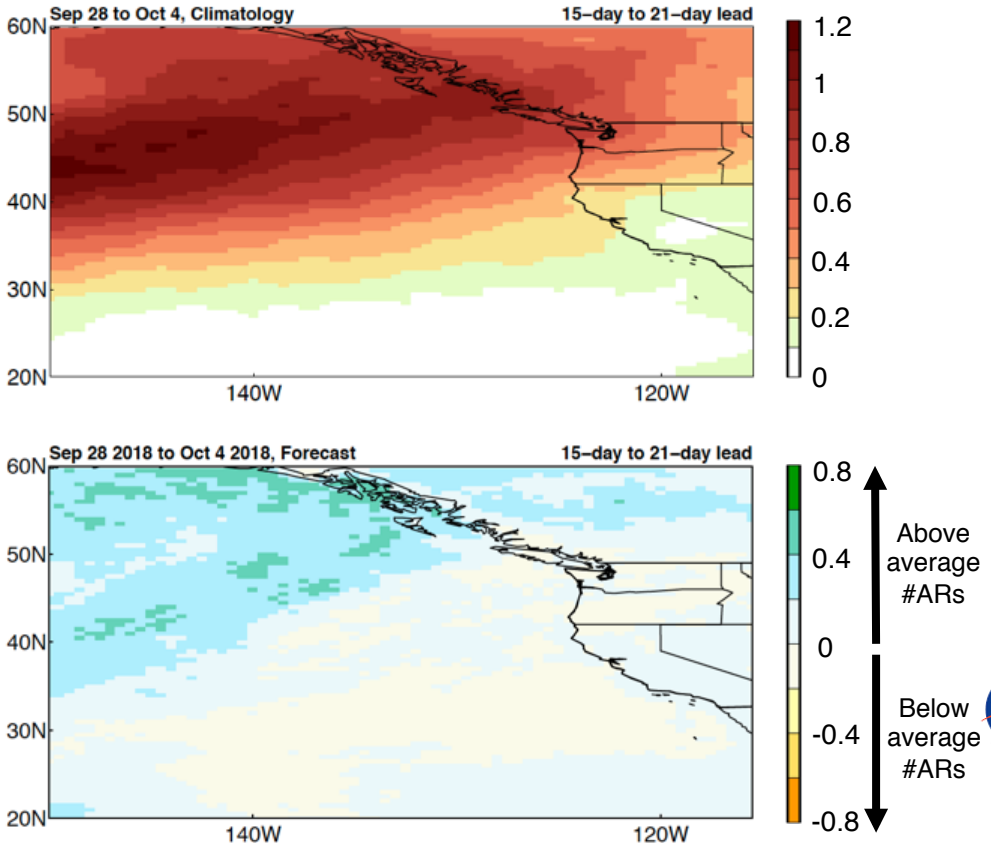
# ***EXPERIMENTAL S2S AR FORECAST***

September 13, 2018 forecast: number of AR days during week-3




ECMWF

## Week-3

### (Combined 15-day to 21-day lead)

Top row: hindcast climatology (ECMWF 1996-2015 data)
Bottom row: real-time forecast minus climatology (ECMWF 51-member ensemble)

Experimental AR forecast issued on Thursday, September 13, 2018 by M. DeFlorio, D. Waliser, A. Goodman, B. Guan, A. Subramanian, Z. Zhang, and M. Ralph using 51-member real-time ECMWF data for an Experimental AR Forecasting Research Activity sponsored by California DWR

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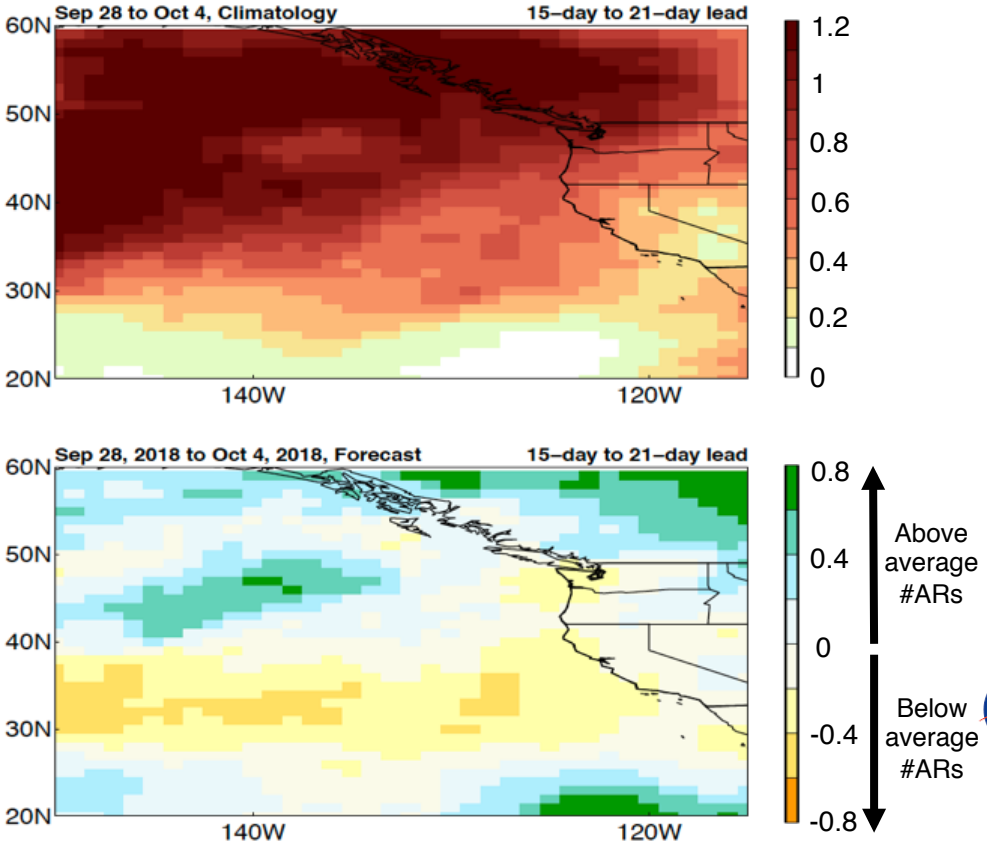
Contact: M. DeFlorio
(michael.deflorio@jpl.nasa.gov)

# ***EXPERIMENTAL S2S AR FORECAST***

September 13, 2018 forecast: number of AR days during week-3




## NCEP

## Week-3

### (Combined 15-day to 21-day lead)

Top row: hindcast climatology (NCEP 1999-2010 data)
Bottom row: real-time forecast (NCEP 16-member ensemble)

Experimental AR forecast issued on Thursday, September 13, 2018 by M. DeFlorio, D. Waliser, A. Goodman, B. Guan, A. Subramanian, Z. Zhang and M. Ralph using 16-member real-time NCEP data for an Experimental AR Forecasting Research Activity sponsored by California DWR

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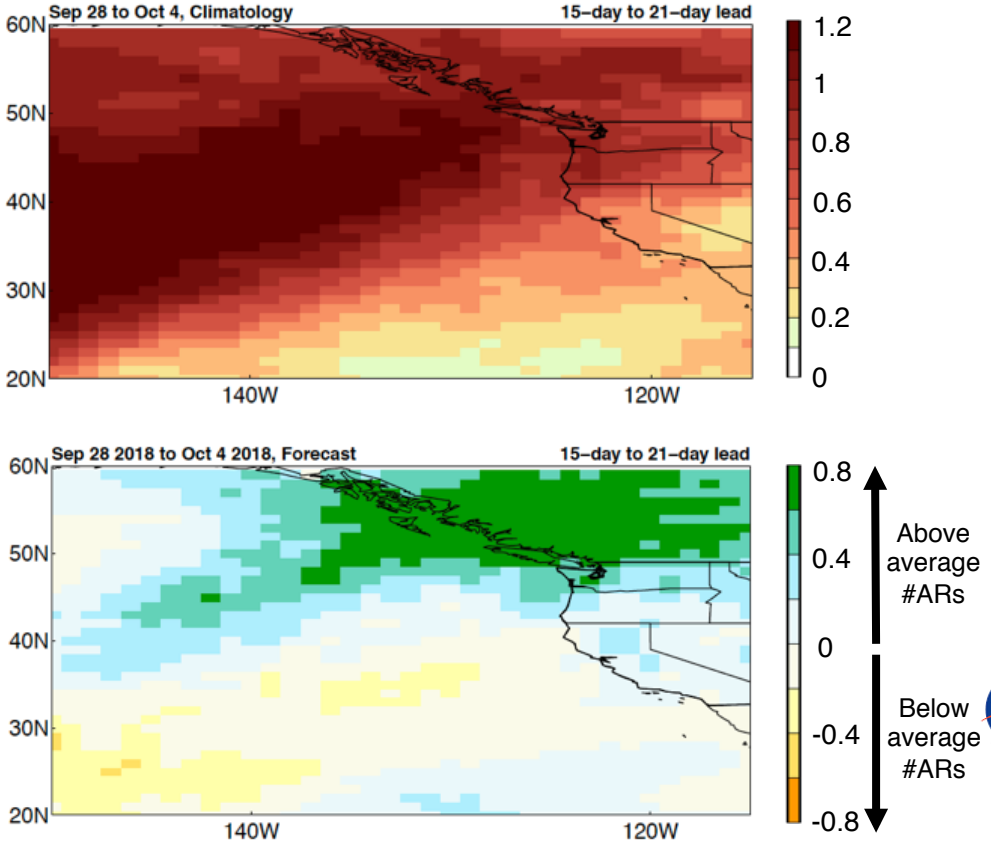
September 13, 2018 forecast: number of AR days during week-3




ECCC

## Week-3

### (Combined 15-day to 21-day lead)

Top row: hindcast climatology (ECCC 1995-2014 data)
Bottom row: real-time forecast (ECCC 21-member ensemble)

Experimental AR forecast issued on Thursday, September 13, 2018 by M. DeFlorio, D. Waliser, A. Goodman, B. Guan, A. Subramanian, Z. Zhang, and M. Ralph using 21-member real-time ECCC data for an Experimental AR Forecasting Research Activity sponsored by California DWR

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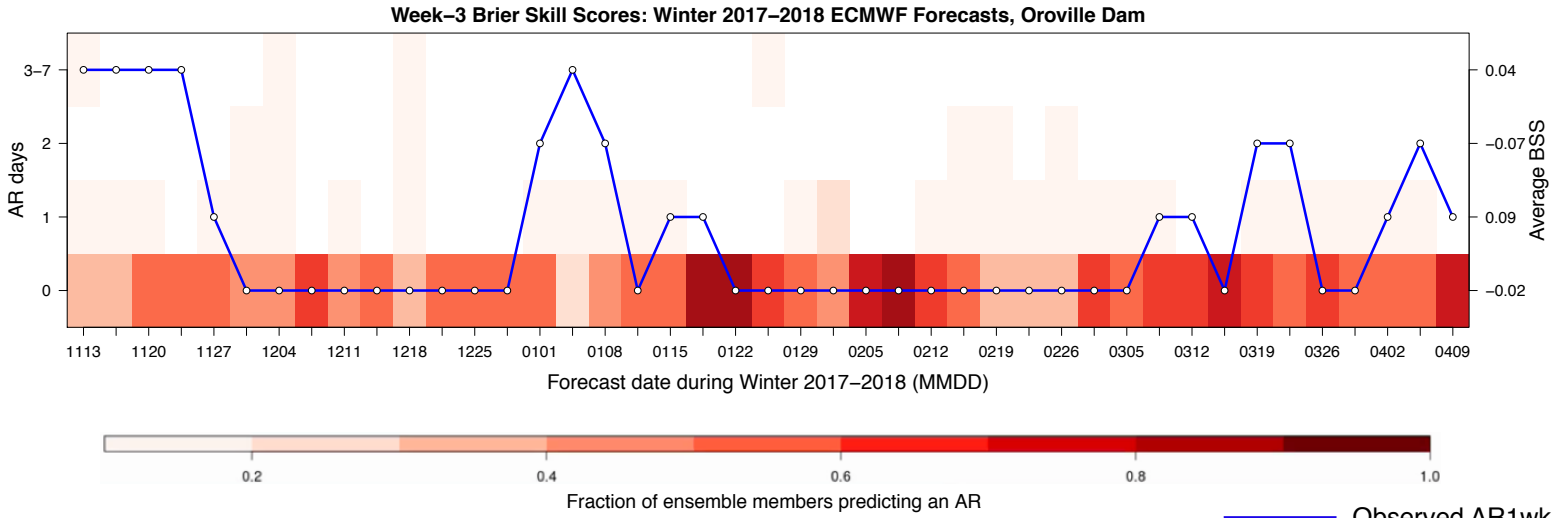
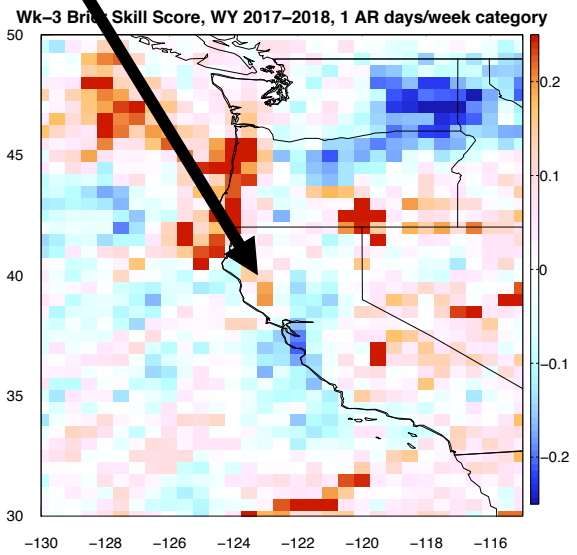
# Considering Categorical Verification Via BSS




Categories of AR occurrence:

- ”0 days” - no AR activity
- ”1 day” - low AR activity
- “2 days” - moderate AR activity
- ”3-7 days” - high AR activity

Calculate the average Brier Skill Score (BSS) over forecast period for each category




MERRA-2 used as observation reference

# Summary

- Atmospheric Rivers (ARs) occur globally, shape the Earth's climate, water and energy cycles, as well as account for regional weather and water extremes.
- ARs account for a significant fraction of west coast freshwater supply and nearly all flooding west coast flooding events.
- Using a global detection algorithm, we have quantified the forecast skill in an operational S2S/weather prediction model – ECMWF, show some marginal skill at week 3.

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- Via our California Department of Water Resources sponsor, a collaborative team has developed an experimental protocol and products to provide week 1, 2 and 3 guidance on wintertime AR activity over the west coast.
- Verification studies are in progress.
- CPC/NCEP (J. Gottschalck) has exhibited interest to consider these in their week 3+4 outlook discussions this coming winter.
- Work with GMAO/NASA to include their forecasts.
- Experimental AR products from this project that look to have some value to stakeholders will be be produced and posted on cw3e.ucsd.edu.
- Next two years will also focus on west coast ridging variability and interactions.