Subseasonal Atmospheric River Research & Prediction

Considerations from a Global Approach

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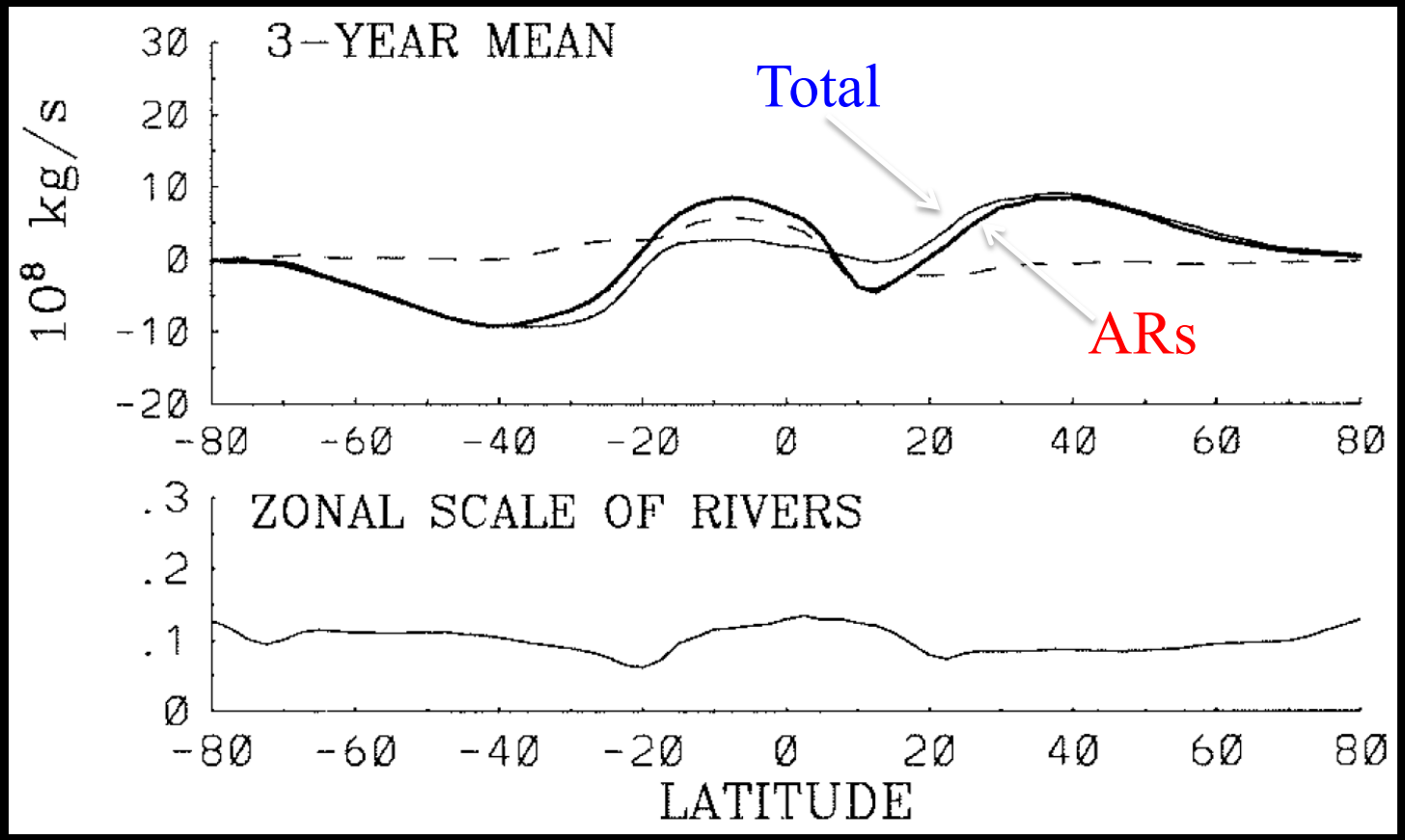
With significant collaboration and support from the Center for Western Weather and Water Extremes (M. Ralph et al.) and Department of Water Resources (J. Jones).

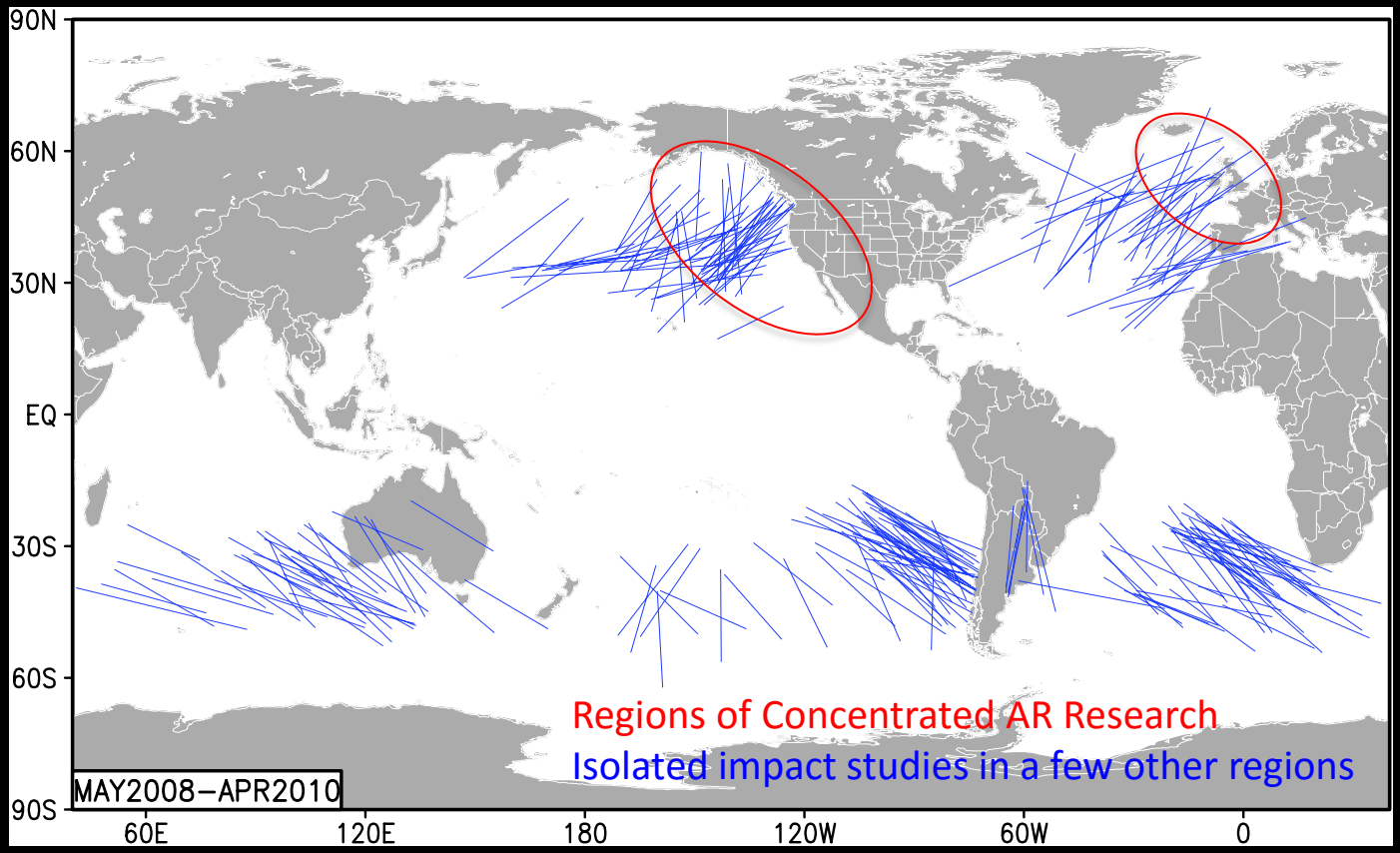
Western States Water Council
San Diego, CA
June 2016

Original Motivation: Role of ARs in Global Water & Energy Cycle



Over 90% of poleward IVT at midlatitudes is realized by ARs that take up only ~10% of the zonal circumference; Zhu and Newell (1998)

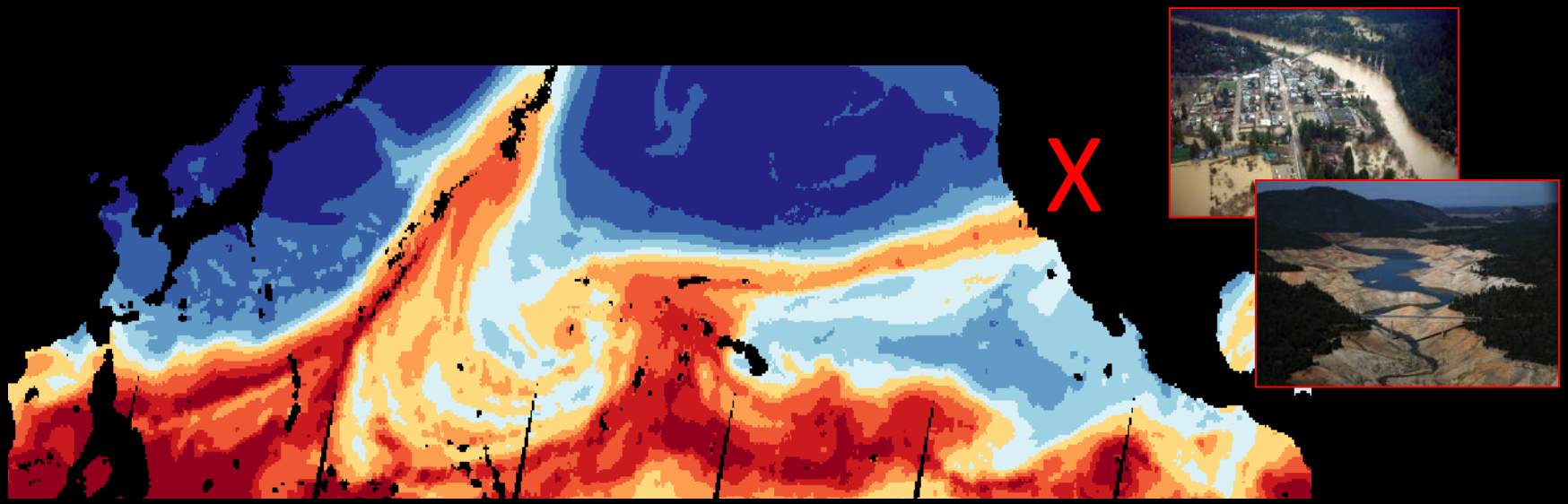
Limited Global Perspective of ARs



Manually identified AR locations for 2 years - courtesy B. Guan; Waliser et al. (2012)

Value of a Global Perspective

Can it help with my regional concerns?



- AR “weather” predictions & “climate” projections are based on global models – how good are these models?
- ARs impacted by global climate patterns/modes – how, where, when?
- ARs have regional impacts globally – US West, UK, S. America…?

Despite this motivation, there have been no means to examine the above considerations from a global perspective.

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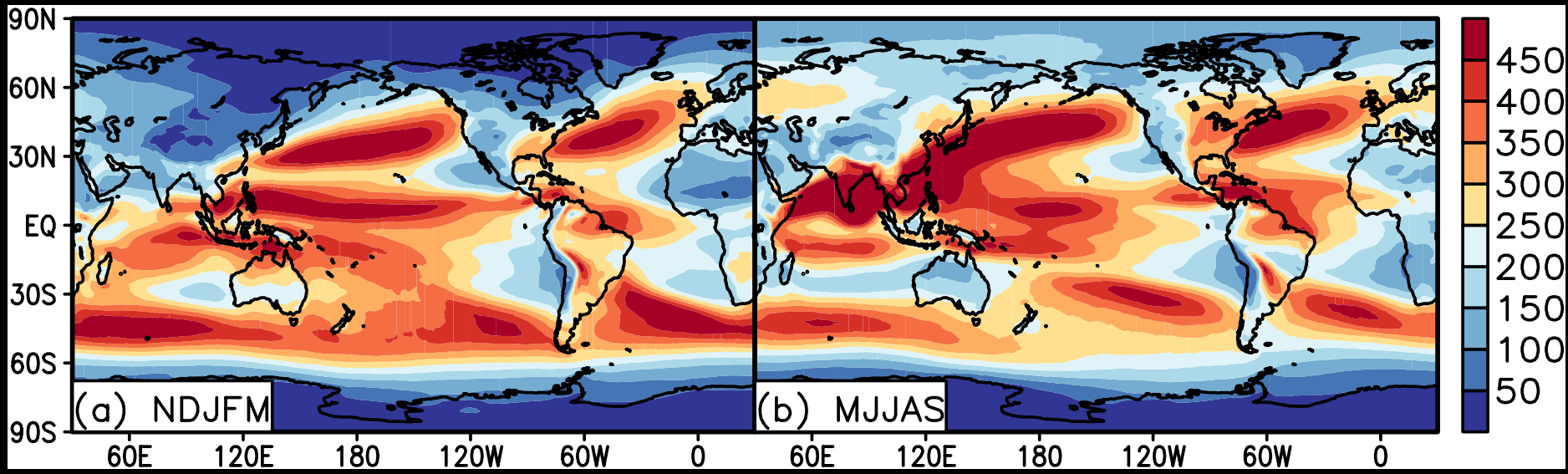
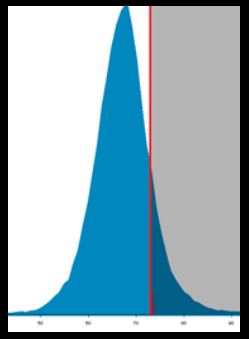
Global AR Detection

Guan & Waliser 2015





Intensity threshold:

IVT > max(85th percentile, 100 kg m-1 s-1)

Geometry threshold:

Length > 2000 km, Length/Width > 2

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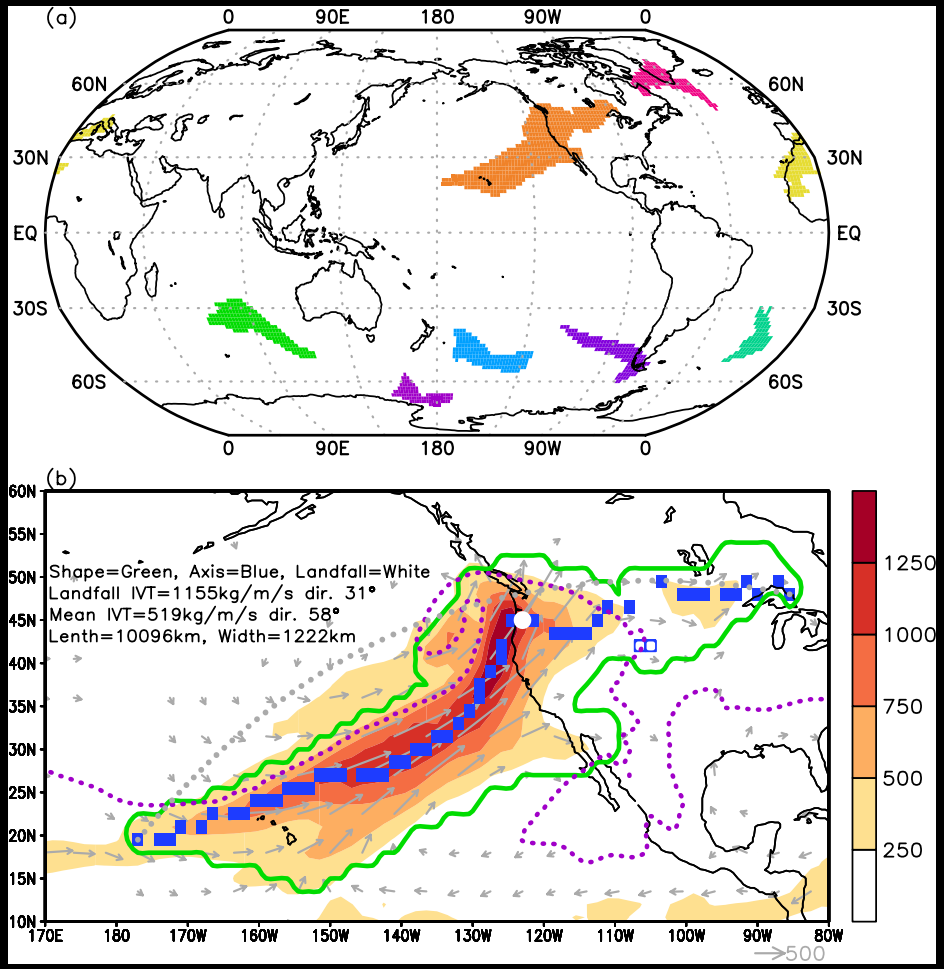
Global AR Detection

AR Date, WV Transports, Shape, Axis, Landfall Location, Etc.



Over ~90% agreement in detected AR landfall dates compared to 3 independent studies in western US, Britain, and East Antarctica (Neiman et al. 2008; Lavers et al. 2011; Gorodetskaya et al. 2014)

Applications

- Global characterization
- GCM evaluation
- Forecast assessment

Based on ERA-Interim 6-hourly IVT

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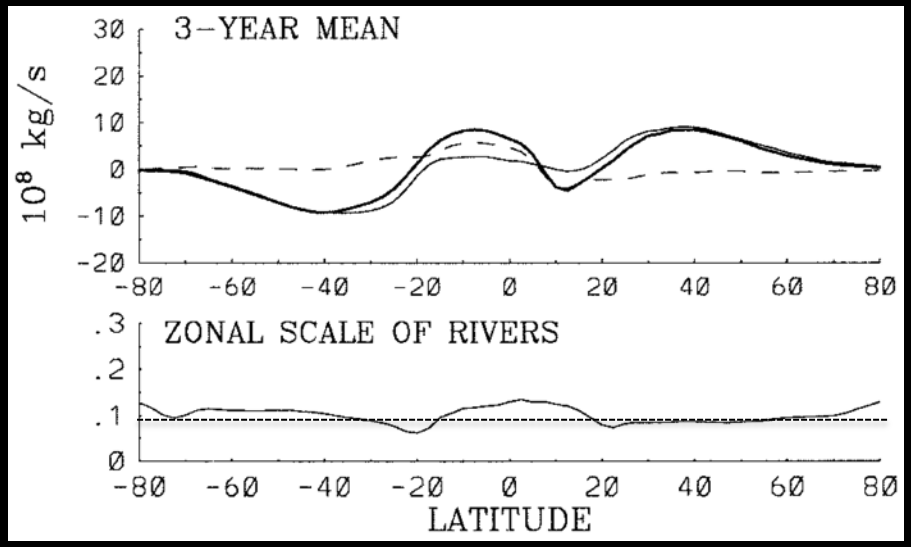
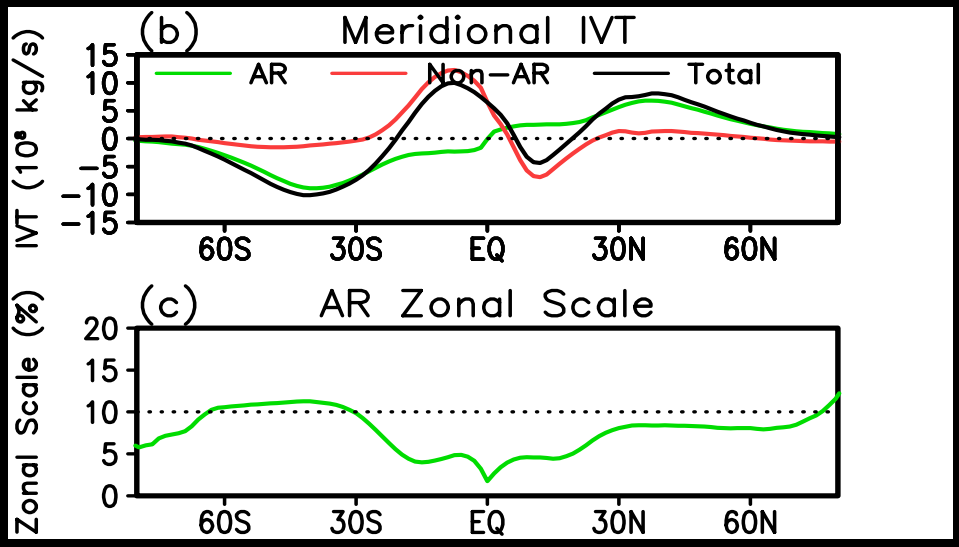
Poleward Water Vapor Transport

Captures Original Finding / Key Characteristic



Zhu and Newell (1998)

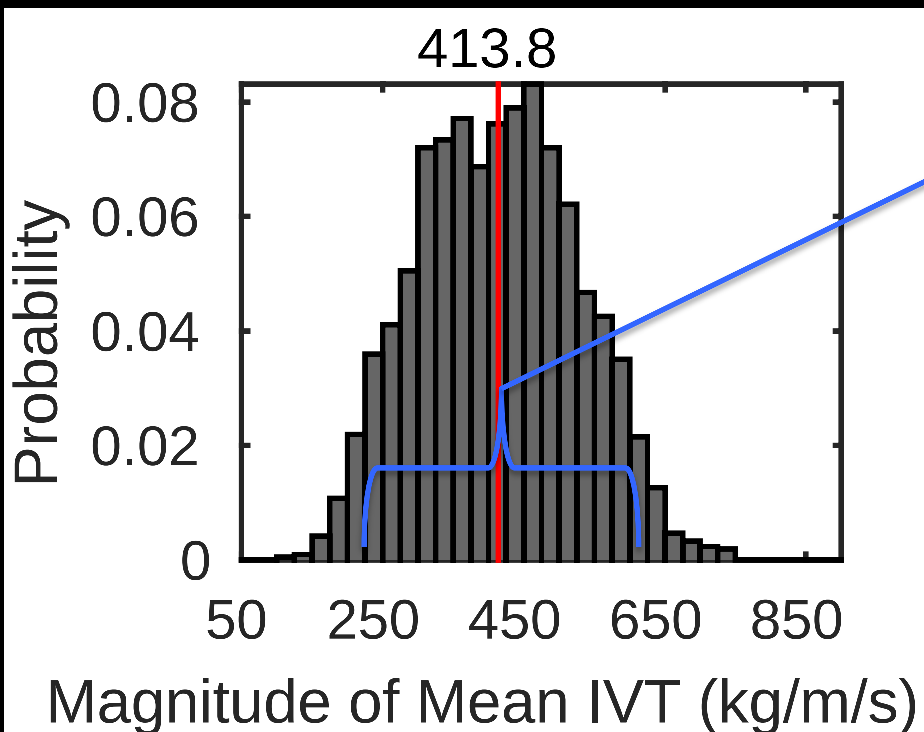


Guan and Waliser (2015)

AR fractional poleward IVT and integrated zonal scale largely consistent with original estimate by Zhu and Newell (1998)

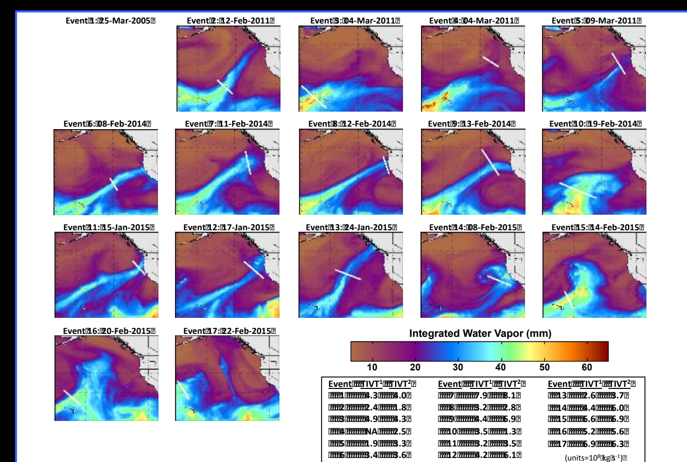
Comparison to CalWater Dropsonde Measurements

IVT Histogram Based On
2140 NE Pacific ARs
124-164W, 23-43N; Jan 15-Mar 25



Guan & Waliser 2015

17 AR Event Transects
450 +/- 200 kg/m/s
Min 130; Max 810



Ralph et al. (2016)

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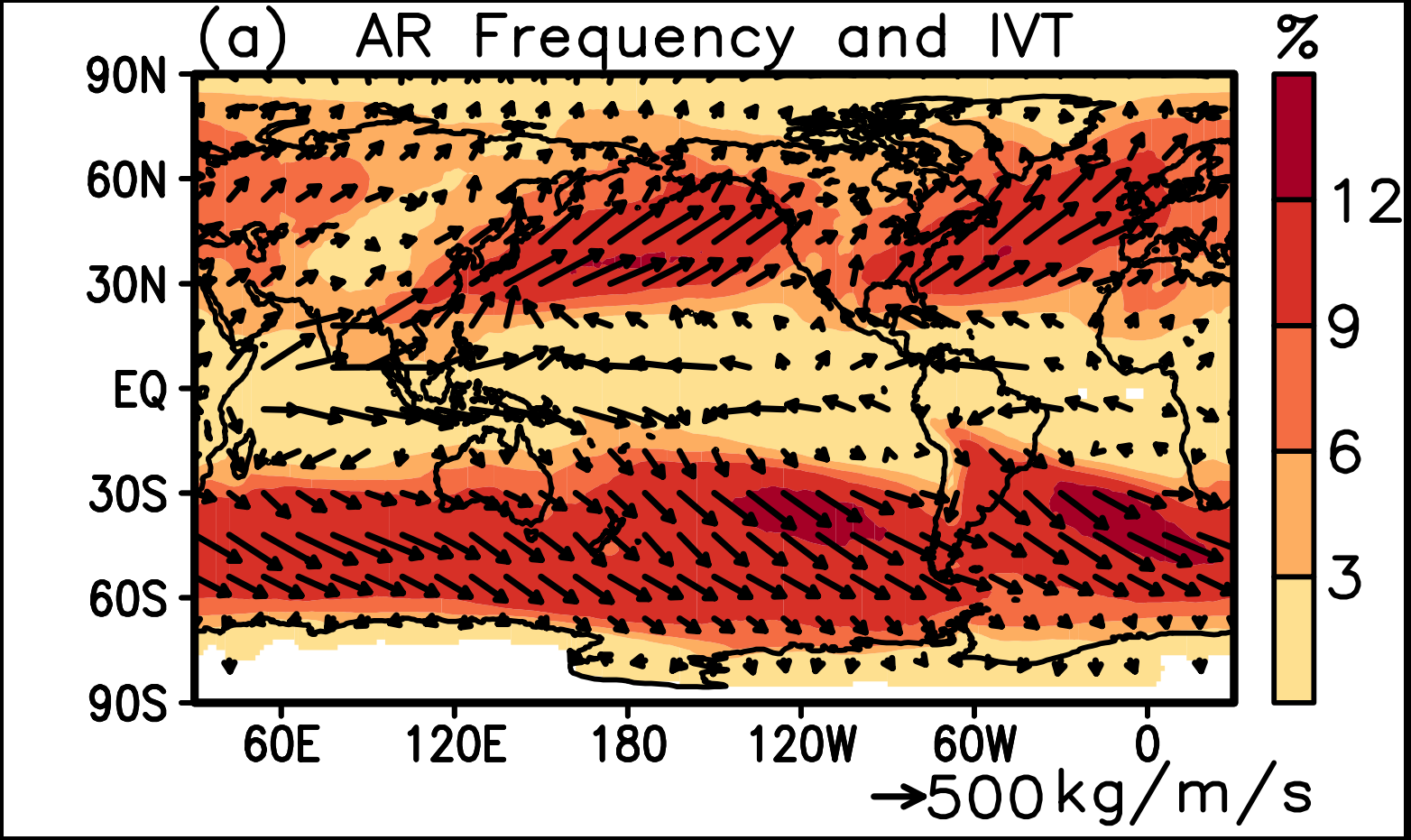
Global Map of AR Frequency and IVT



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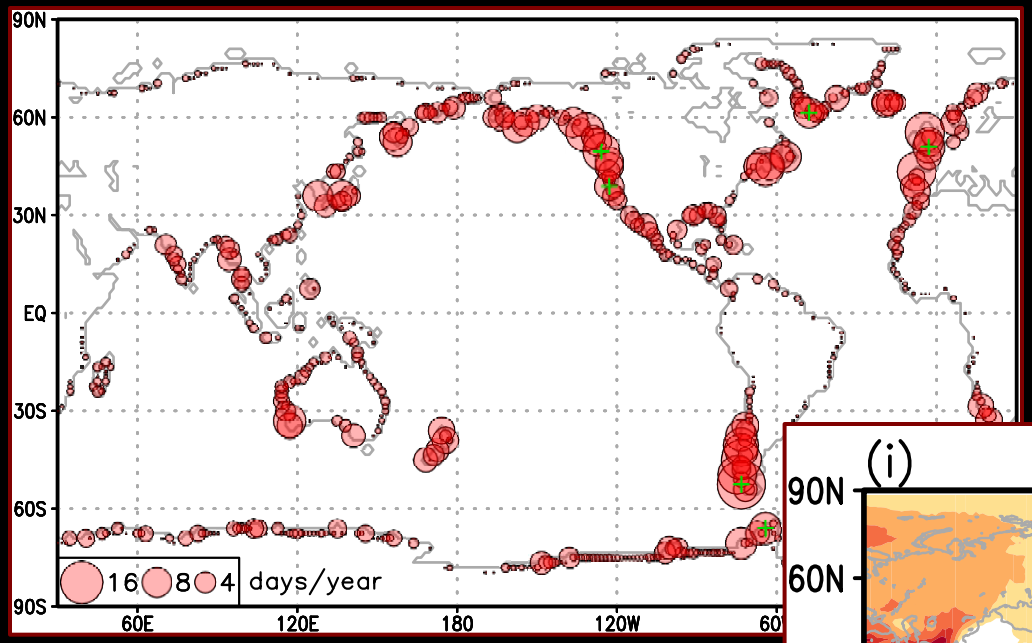
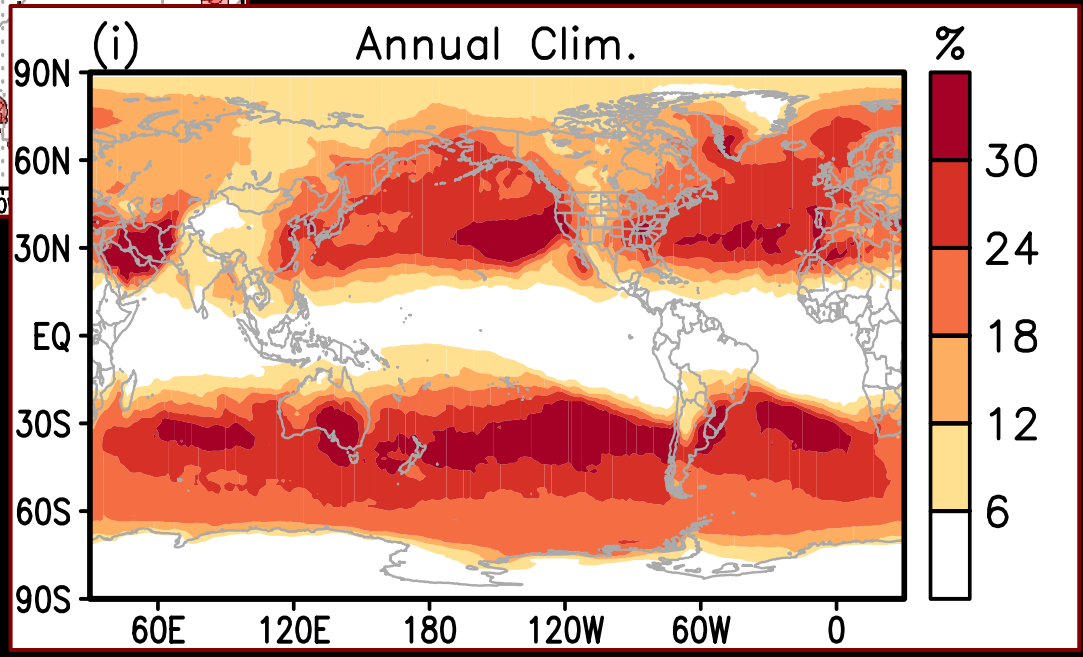
AR Landfalls Fraction of Annual Precipitation



A Global Perspective



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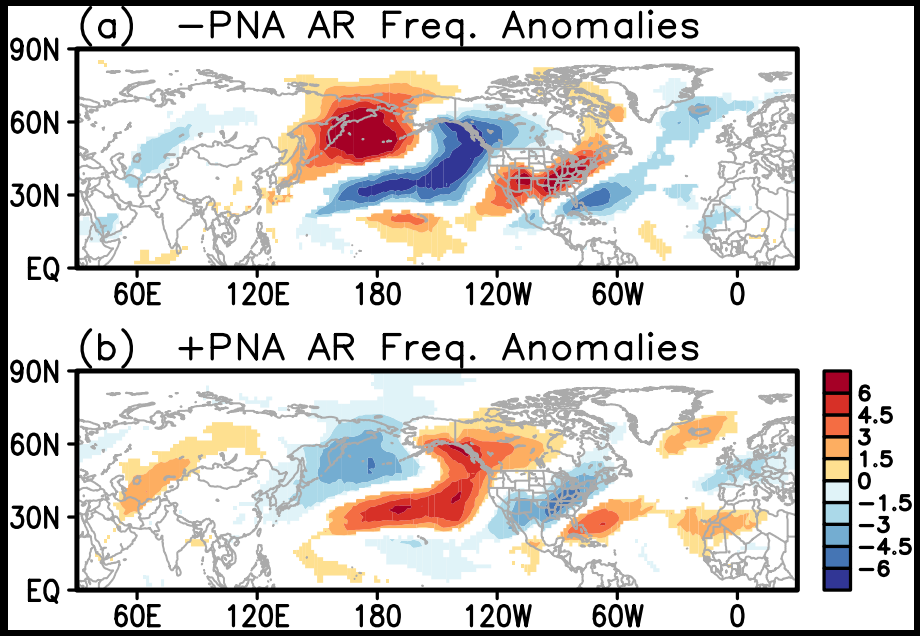
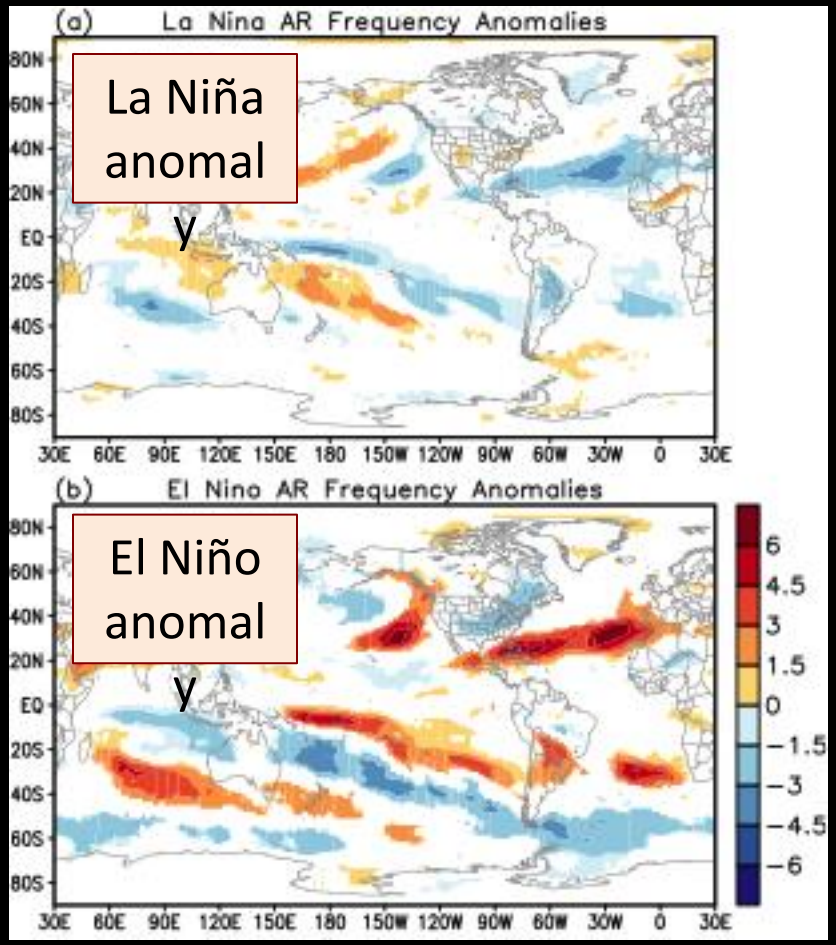
Global Climate Variability & ARs

Pacific-North American (PNA)



El Nino Southern Oscillation (ENSO)



Global AR Database: Applications

Model & Forecast Evaluations

- Weather/Climate Simulation Evaluation of ARs - Guan
  - *WCRP-WWRP GASS/YOTC 27 Member Multi-Model Database*
- AR S2S Forecast Skill Assessment – Deflorio
  - *WCRP-WWRP S2S Project Database*
- Global Climate Change Impacts on ARs – Espinoza
  - *CMIP5 Database*

PRELIMINARY RESULTS/COMING ATTRACTIONS

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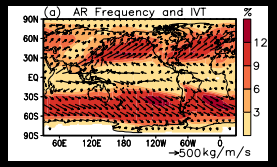
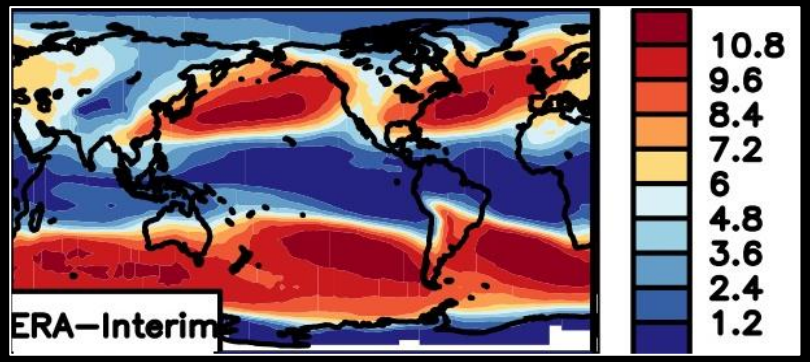
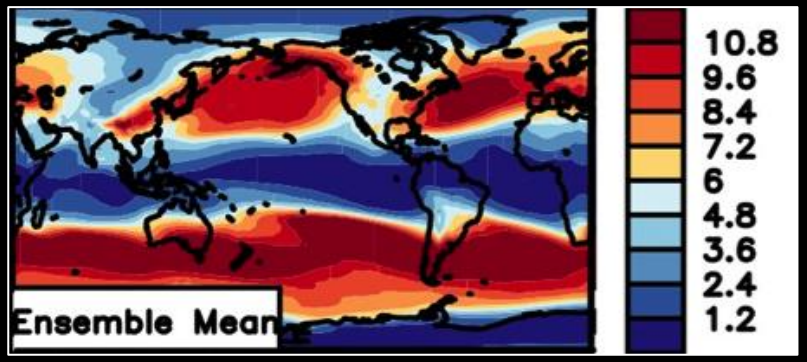
Evaluating Weather/Climate Simulations of ARs

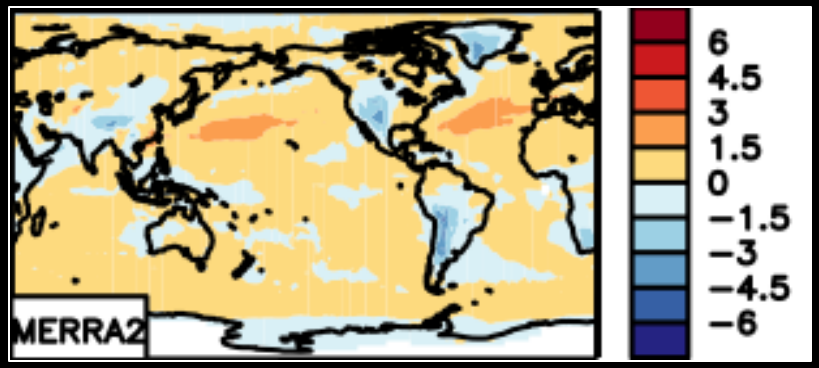


Observed Frequency; ERA-Interim

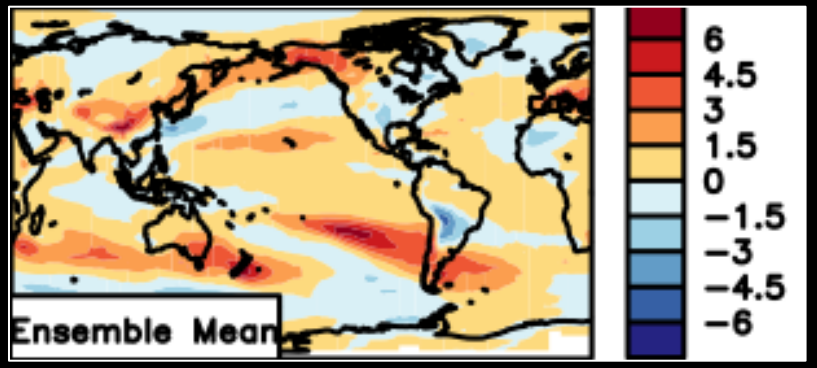


20-year simulations from 24 global climate/weather models





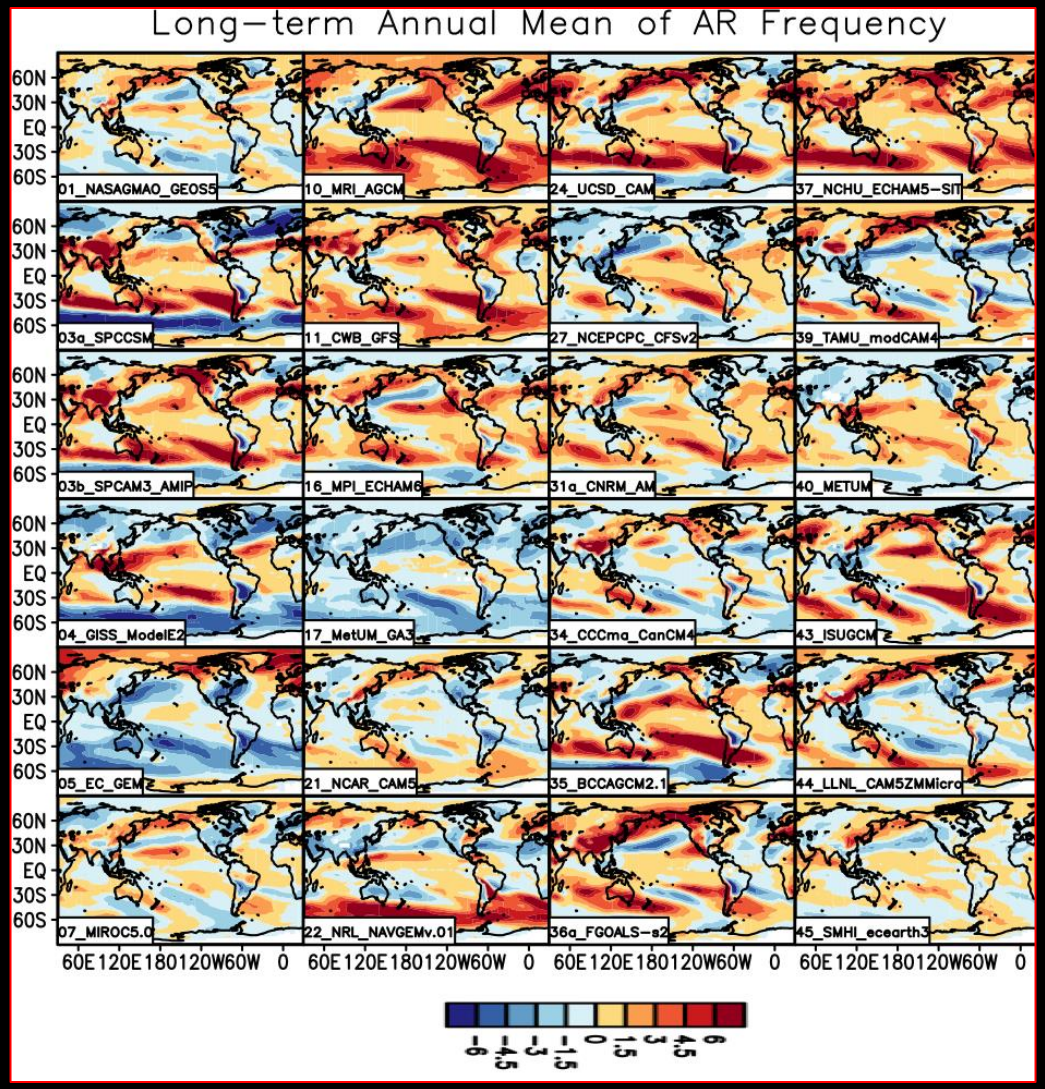
Difference with 2nd Observation Reference; MERRA-2



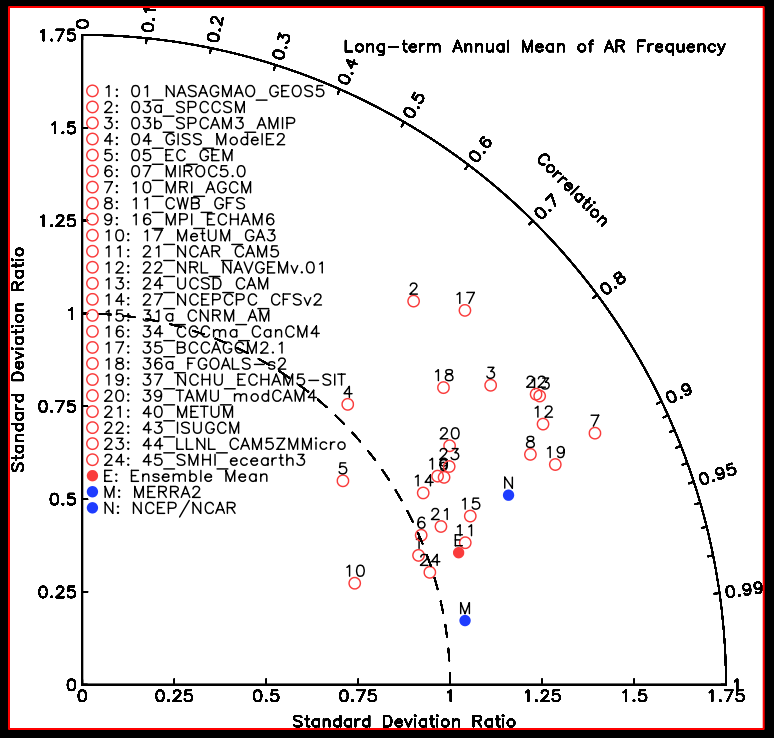
Modeled – Observed

GEWEX / YOTC / MJO TF Multi-Model Experiment

Evaluating Weather/Climate Simulations of ARs



Significant Variation in Model Fidelity in Spatial Patterns of AR Frequency



Experiment's model output allows interrogation of AR processes –> Future Work

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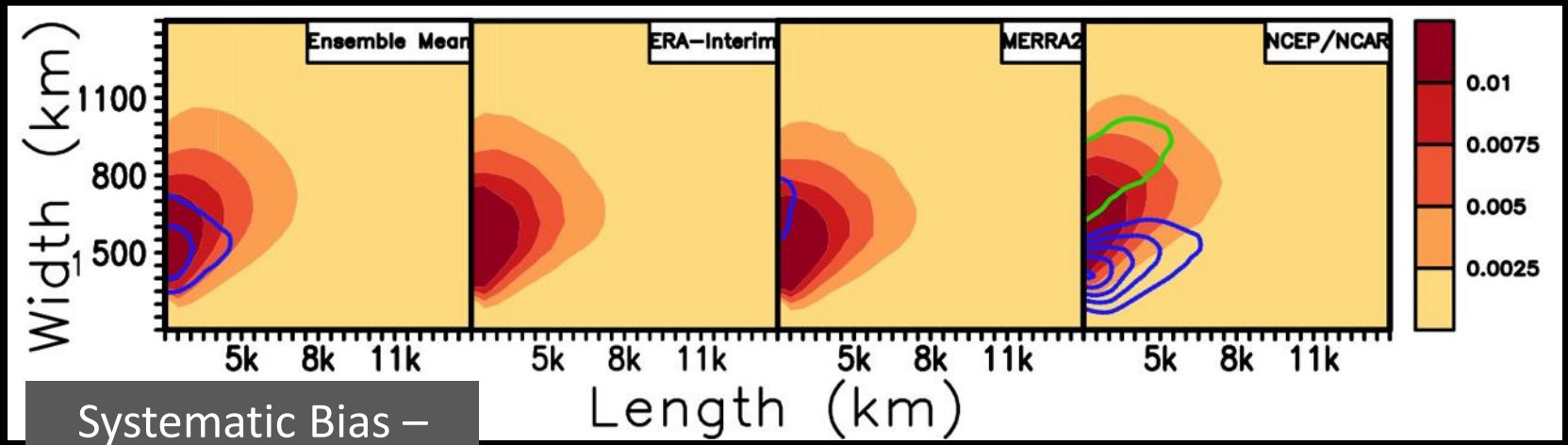
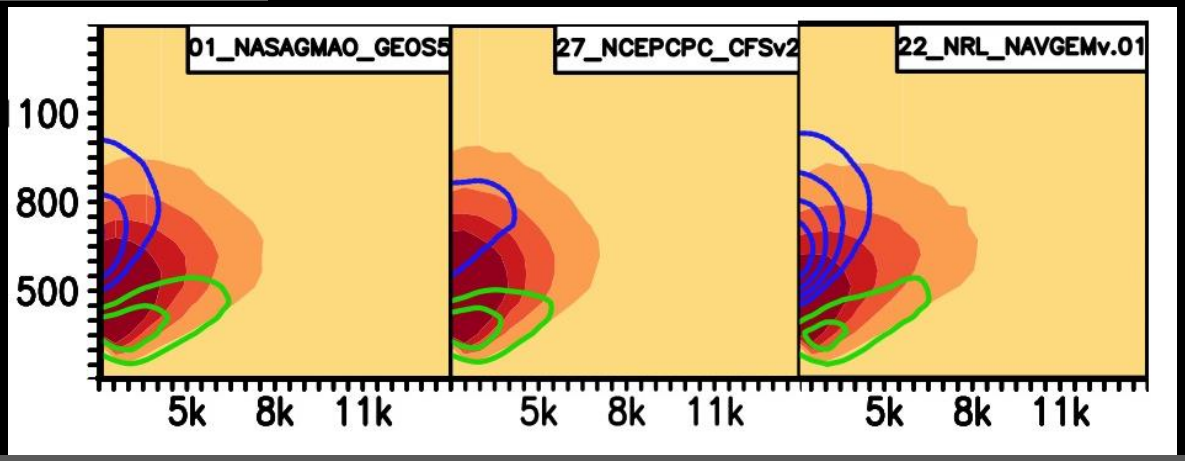
Evaluating Weather/Climate Simulations of ARs

AR Widths and Lengths



Systematic Bias – Too few narrow ARs



Systematic Bias – Too many (few) narrow (wide) ARs

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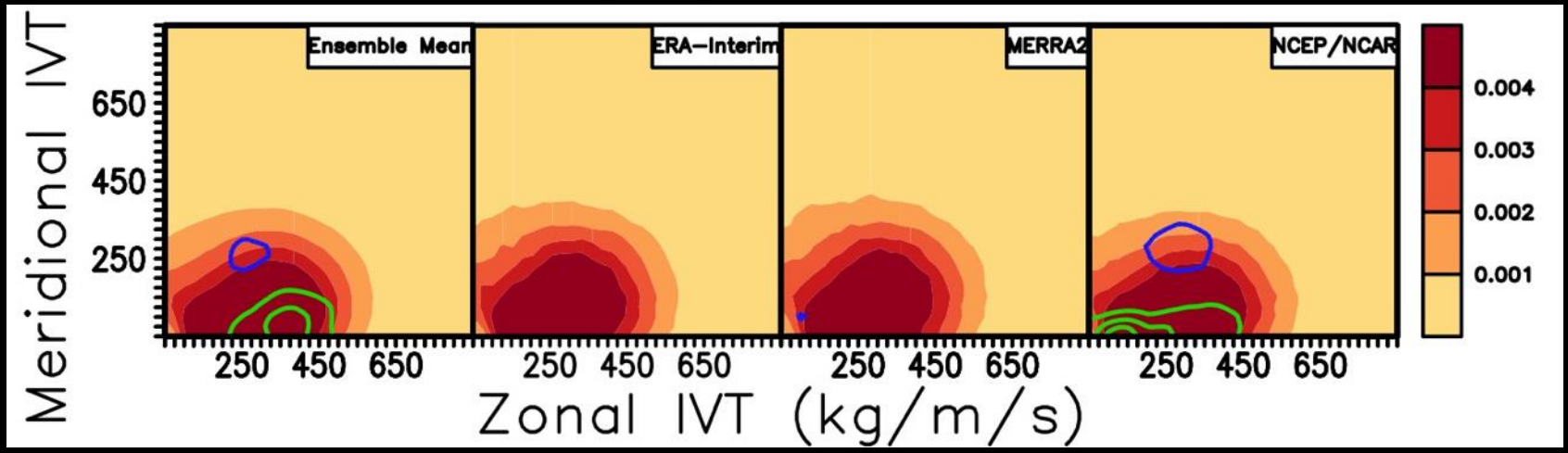
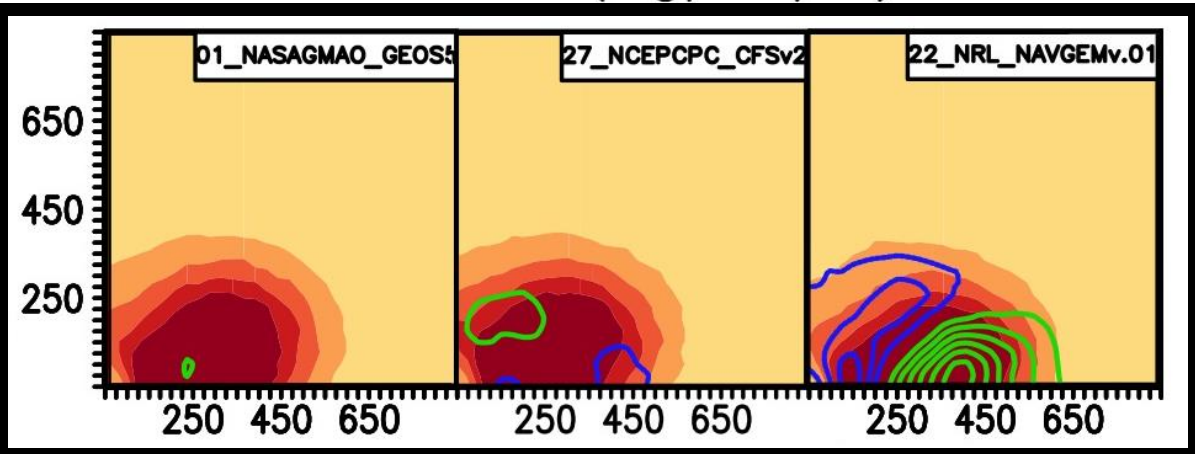
Evaluating Weather/Climate Simulations of ARs

Zonal and Meridional IVT Strength





In some cases, too many ARs with strong (weak) zonal (meridional) ITVT

AR Forecast Evaluation

WCRP-WWRP S2S Project

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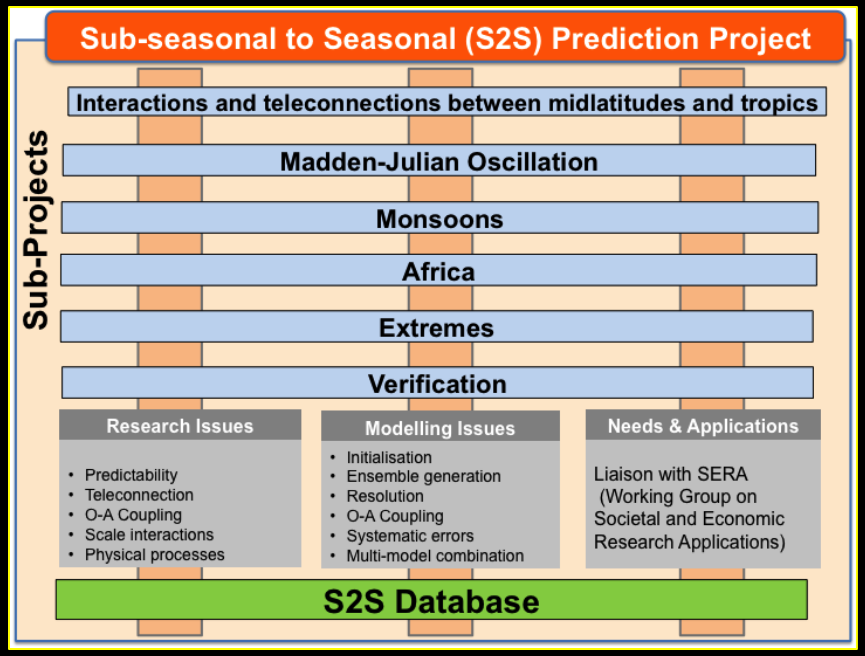
International Program for S2S Research



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

- 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

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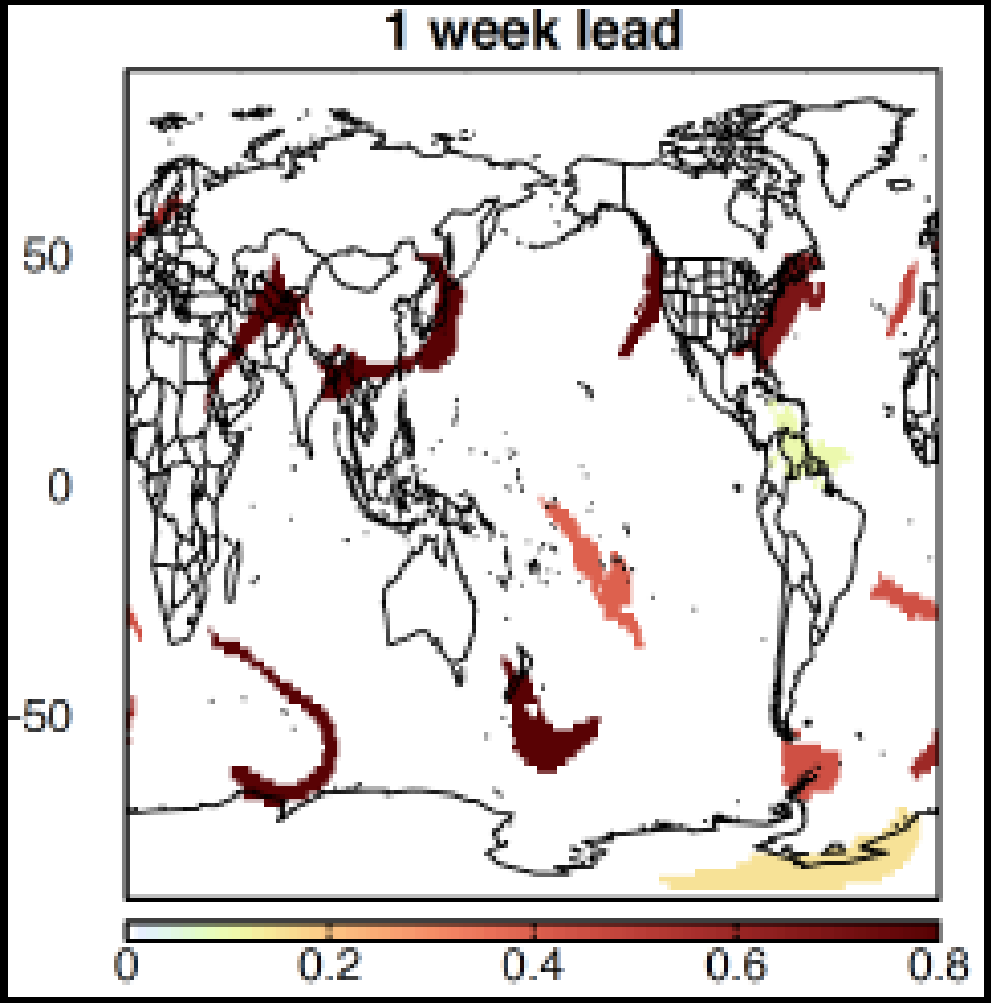
AR Forecast Evaluation

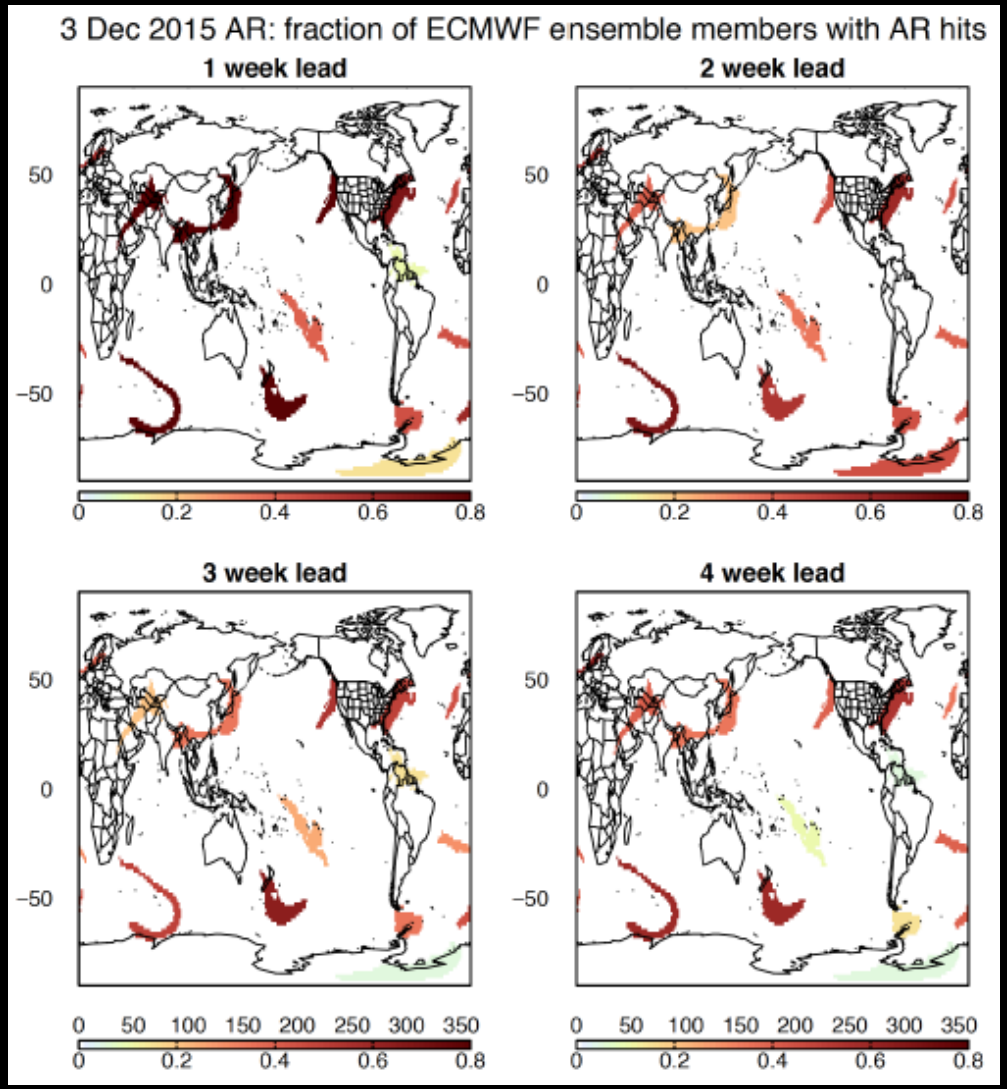
ECMWF S2S Forecasts



- Identify ARs in observations and all 20 forecast members
- For each observed AR, determine how many members get a “hit” (d < 2000 km)
- Compute fraction of AR forecast hits for each lead time (1 week to 4 weeks).

AR Forecast Evaluation

ECMWF S2S Forecasts



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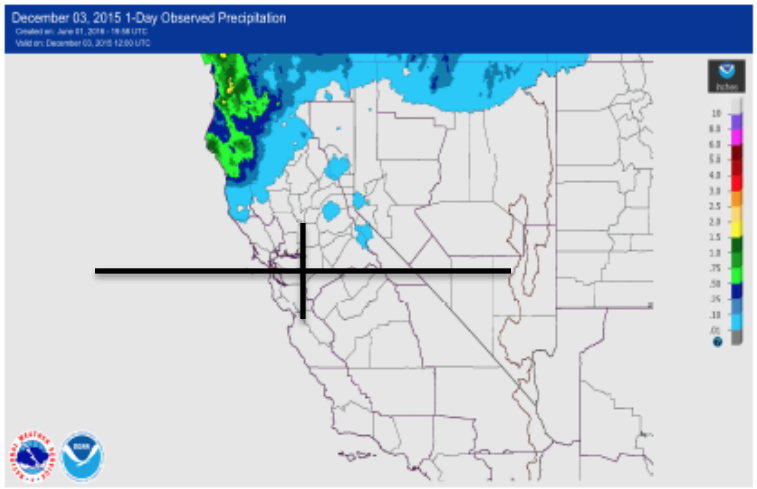
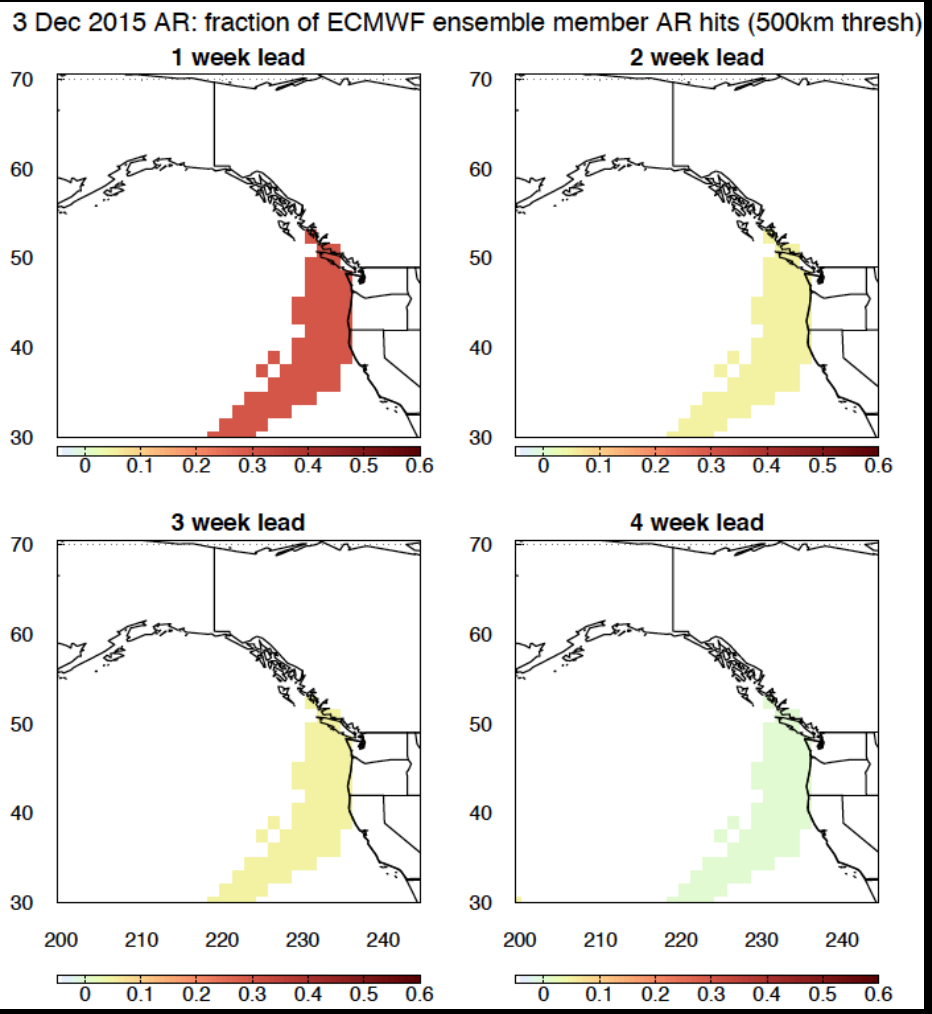
AR Forecast Evaluation

ECMWF S2S Forecasts

Zooming in to the Western US



Soon we'll have aggregate results across 2+ decades of re-forecasts for 11 operational forecast systems, including predictability estimates



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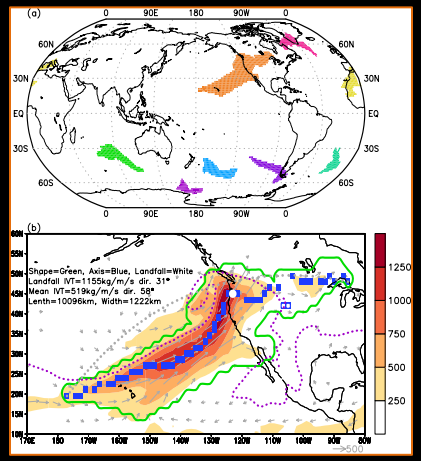
Climate Change Impacts on ARs



Global Detection Algorithm

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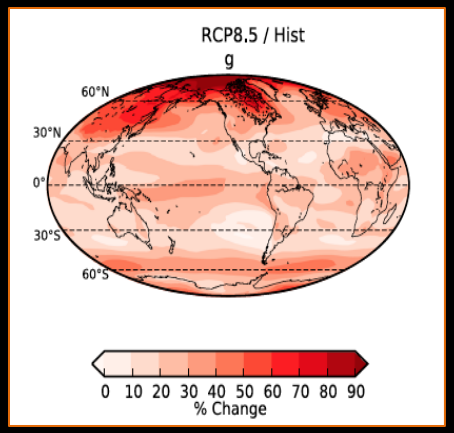

Lavers et al. (2015)
CMIP5 Analysis of IVT
Climate Changes for
22 CMIP5 Models

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JPL 2016
Summer Intern
USC Graduate
Student

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Global Characterization of
Climate Change Impacts on ARs

Stay Tuned

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Summary

- Atmospheric Rivers are a global phenomena that shape the Earth's climate, water and energy cycles, as well as account for regional weather and water extremes.
- We've developed a detection algorithm that can be *consistently* used on global "observations" (i.e. re-analyses), climate simulations and forecast models.
- Using this detection algorithm, we are developing model diagnostics and performance metrics, in conjunction with other observations (e.g. in-situ CalWater, satellite), to:
  - Evaluate model performance and identify weaknesses to guide model improvement.
  - Quantify forecast skill in a suite of operational S2S/weather prediction models.
  - Characterize projected 21ST century changes in Atmospheric Rivers.

In each of these cases our intentions are to produce targeted analysis and interpretation for the Western States