Global Prediction Skill of Atmospheric Rivers

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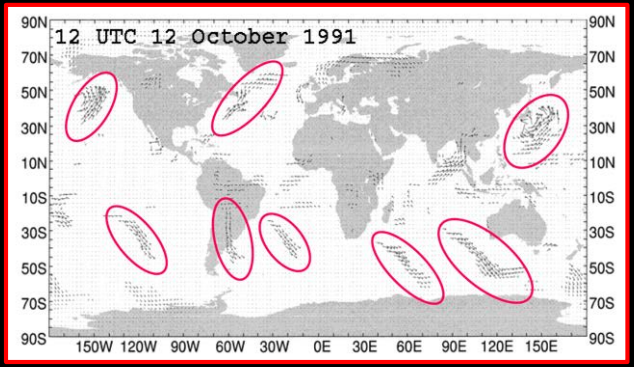
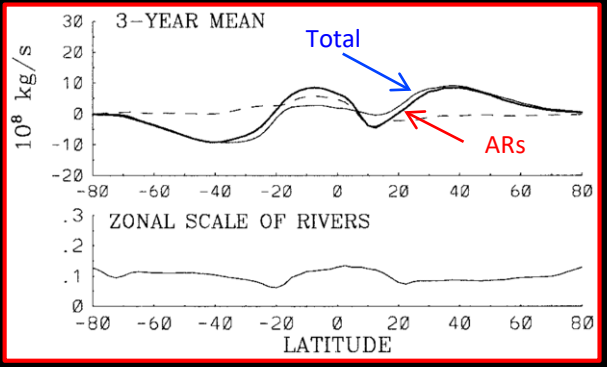
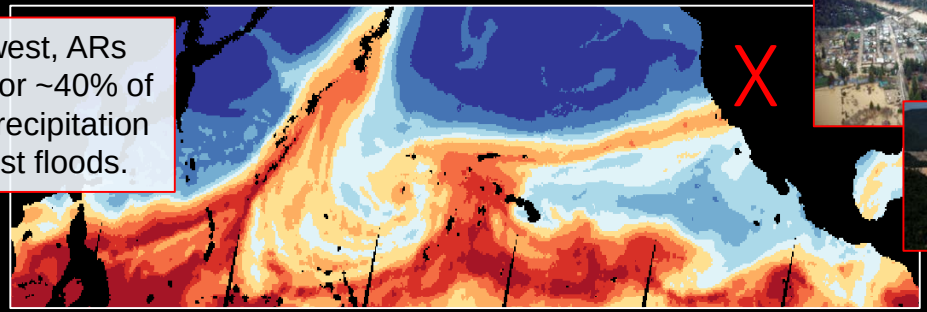
Atmospheric rivers and their associated flood and hazard risks occur globally and influence climate and water extremes.

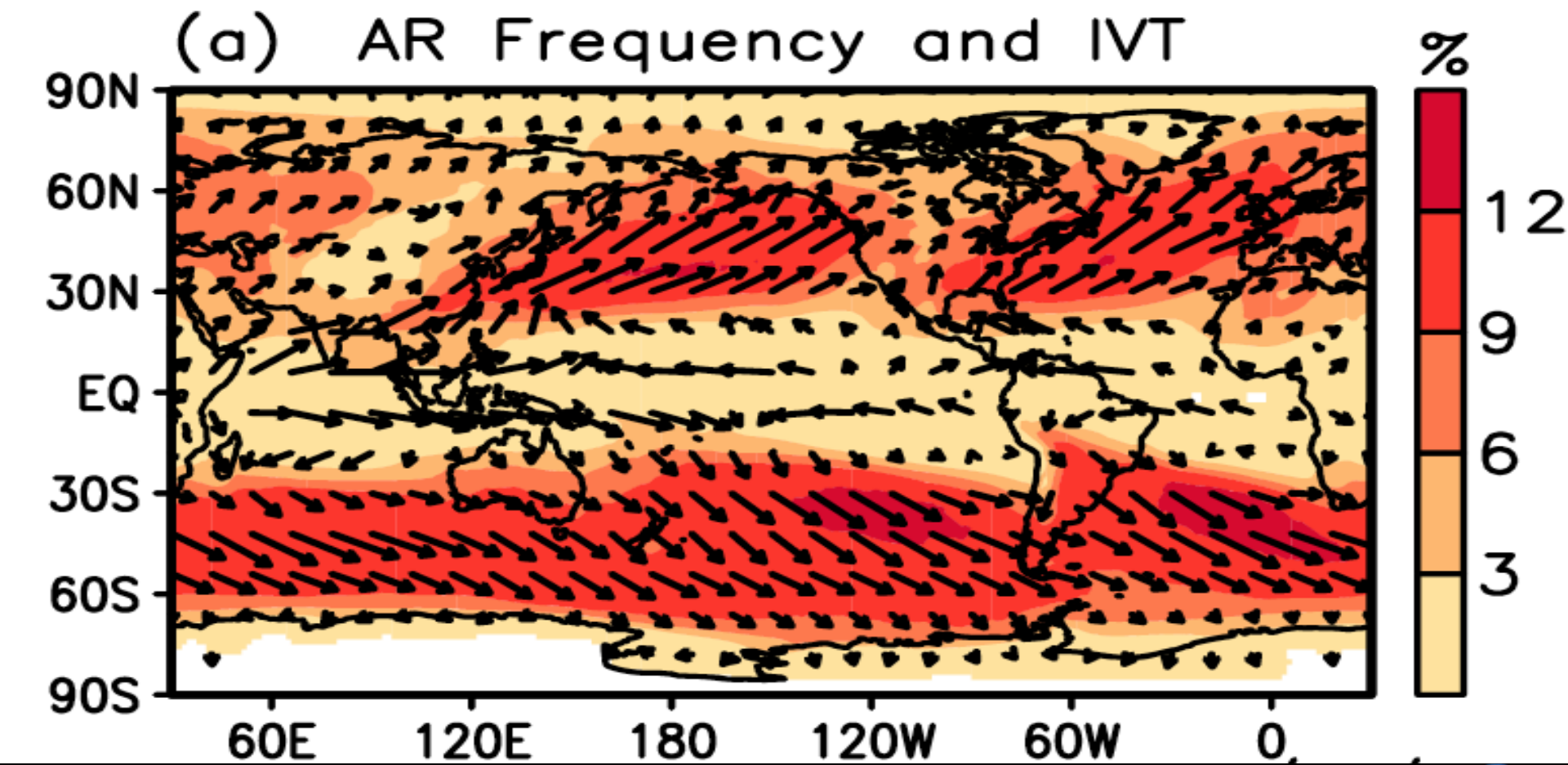




Over 90% of poleward moisture transport at midlatitudes is by ARs that take up only ~10% of the zonal circumference (Zhu and Newell 1998).

In the west, ARs account for ~40% of annual precipitation and most floods.





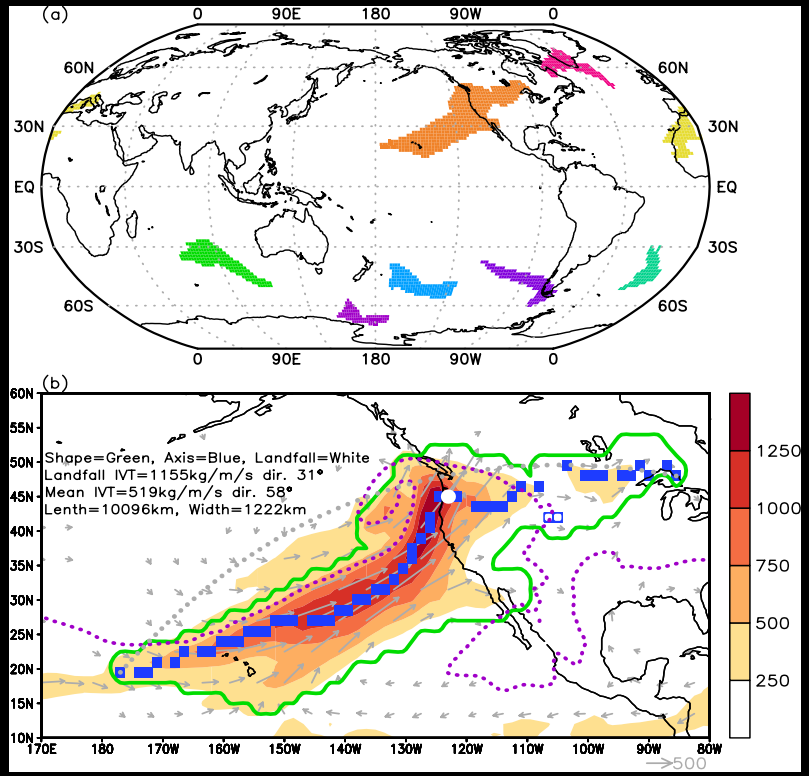
Guan and Waliser 2015

Motivation for this study:

There is a need for rigorous global assessment of AR prediction skill on subseasonal timescales to improve model development, weather forecasting, and water resources management.

Global AR Detection

AR Date, Transports, Shape, Axis, Landfall Location, etc.



Based on ERA-Interim 6-hourly IVT

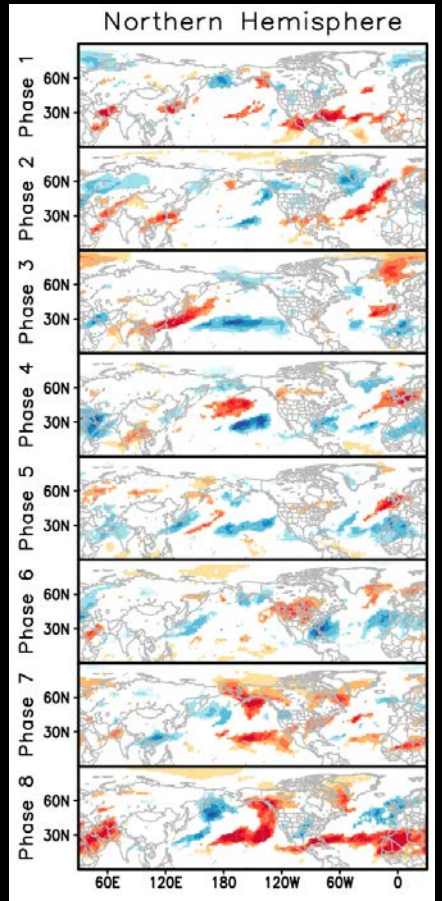
Over ~90% agreement in detected AR landfall dates compared to 3 independent studies in western US, Britain, and East Antarctica (Neiman et al. 2008; Lavers et al. 2011; Gorodetskaya et al. 2014)

Applications:

- Global characterization
- GCM evaluation
- Forecast assessment
- Climate change

Guan and Waliser 2015

AR frequency anomalies are sensitive to tropical variability on intraseasonal timescales…



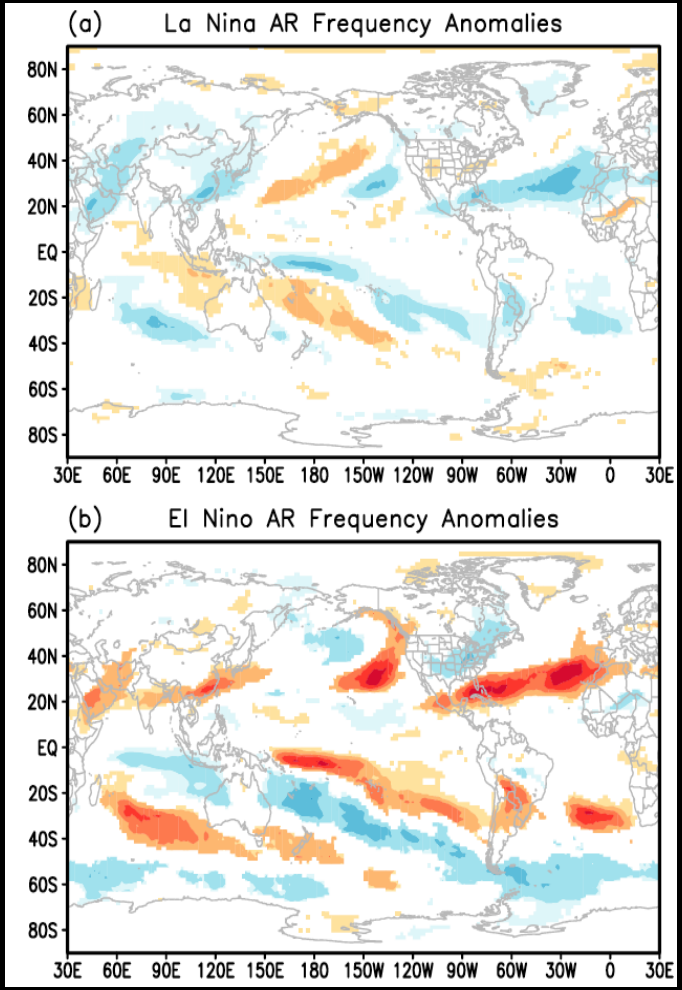
Madden-Julian Oscillation (MJO)

Guan and Waliser (2015)

… and interannual timescales.

La Niña anomaly

El Niño anomaly



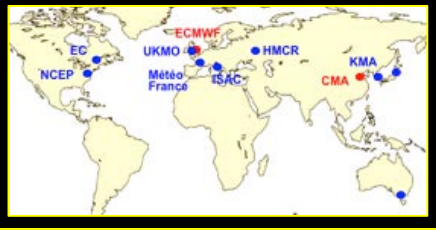
El Niño Southern Oscillation (ENSO)

Guan and Waliser (2015)

The S2S database: our toolbox for assessing global AR prediction skill and predictability

- Suite of real-time forecasts and several decades of hindcasts from 11 operational forecast models
- Maximum lead time ranging from 32 days to 60 days
- Hindcast ensemble size ranging from 1 to 33
- Variety of forecasting configurations and other model parameters (heterogeneity amongst models)
  - “dataset of opportunity”

The S2S Database: a joint WCRP-WWRP Project



	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

Vitart et al. 2016

ATRISK (Atmospheric River Skill) Global Algorithm

- First, Guan and Waliser 2015 detection algorithm applied to observations and each ensemble member
- Then, ATRISK algorithm quantifies contingency table values (hits, misses, false alarms, correct rejections) as a function of lead time

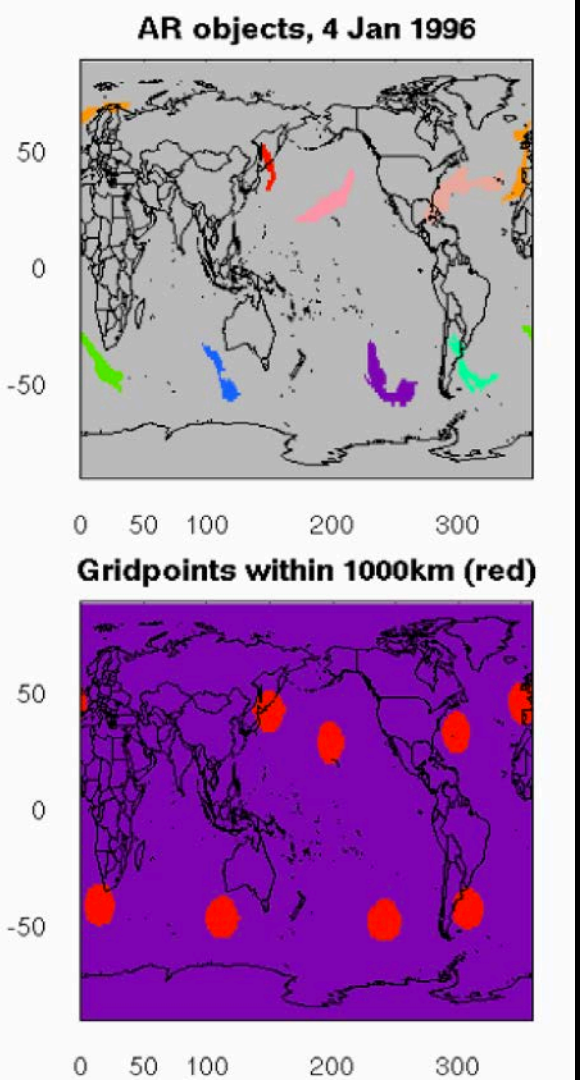
S2S Project Hindcasts - ECMWF (1996-2013)

Observations - ERA-Interim

DeFlorio, Waliser, Guan et al. (2016, in prep)

ATRISK (Atmospheric River Skill) Global Algorithm

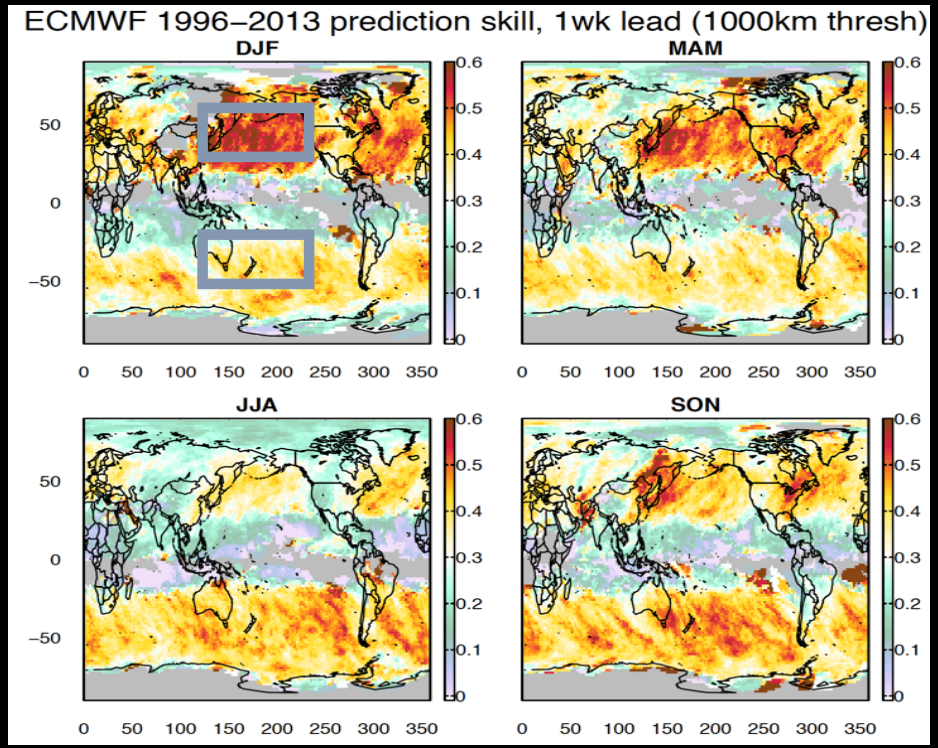
- red orbs show all grid cells within 1000km radius of AR centroid
- we assess prediction skill using AR hit and false alarm rates relative to each observed and modeled AR object



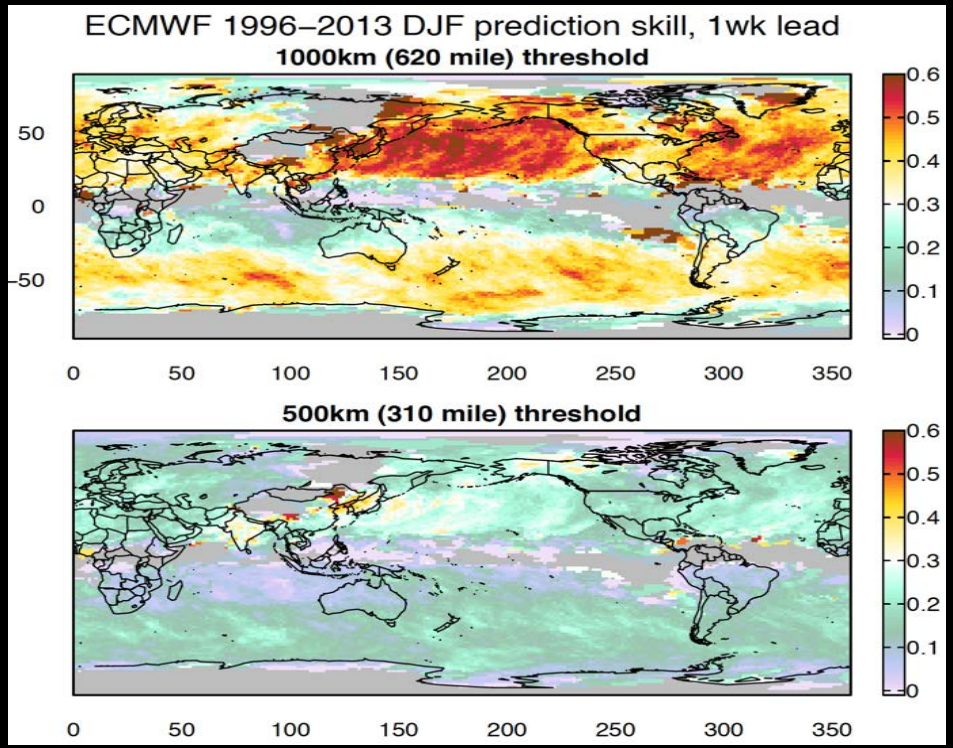
How does AR prediction skill vary as a function of season and hit threshold distance?

Global AR Prediction Skill

Seasonal Variability



Sensitivity To Distance Threshold



DeFlorio, Waliser, Guan et al. (2016, in prep)

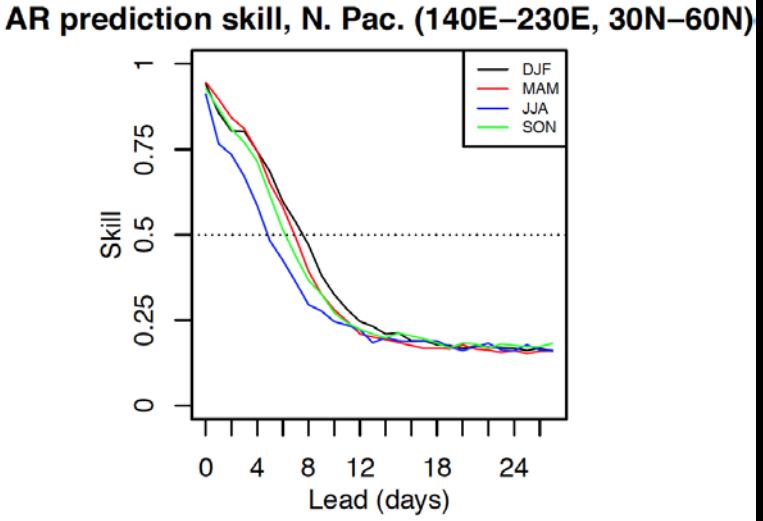
How does AR prediction skill vary as a function of lead time?

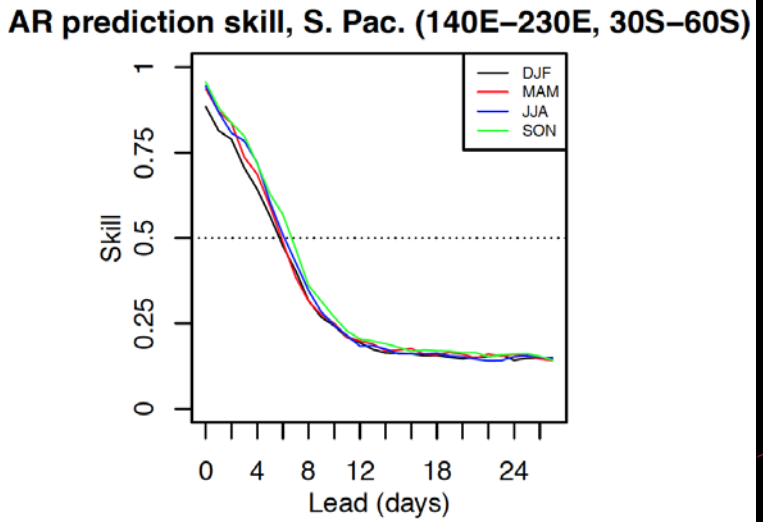
Global AR Prediction Skill

- Skill generally saturates around 10-12 day lead
- Larger seasonal variability in North Pacific

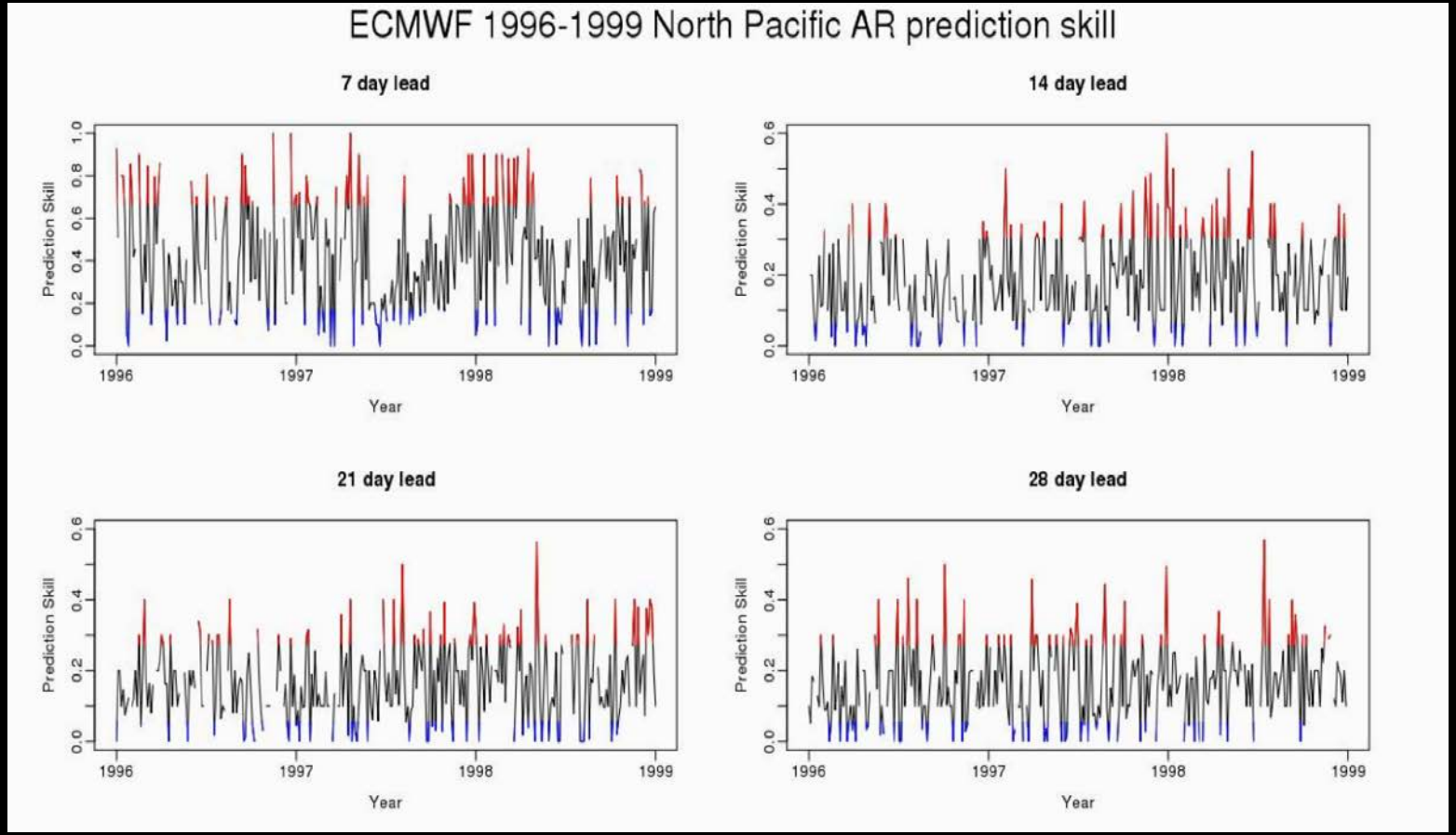
- Key question: Can we exploit higher skill conditioned on certain atmospheric/oceanic states?

DeFlorio, Waliser, Guan et al. (2016, in prep)





Potentially, since prediction skill varies considerably on subseasonal timescales.

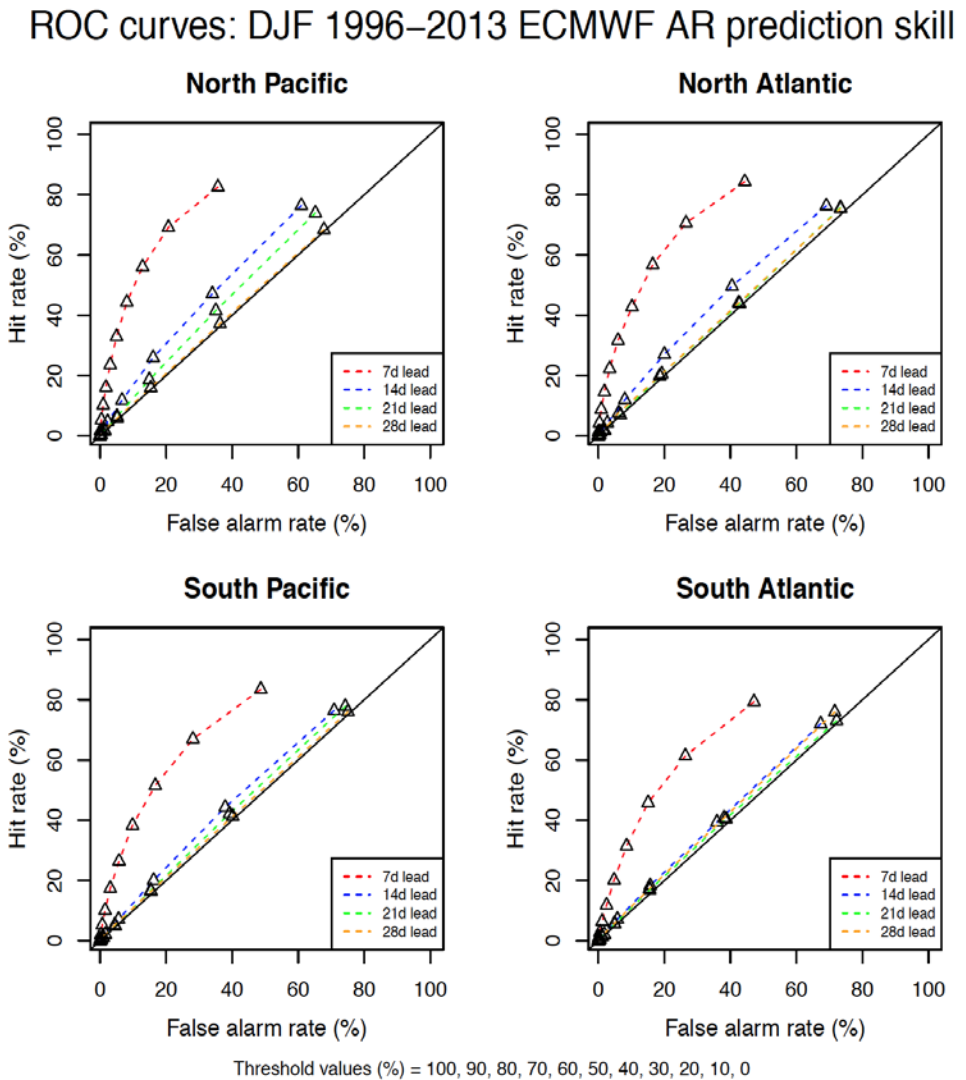


DeFlorio, Waliser, Guan et al. (2016, in prep)

Utility of AR Prediction Skill: ROC approach

- Prediction skill utility diminishes significantly on 2-4 week timescales

DeFlorio, Waliser, Guan et al. (2016, in prep)

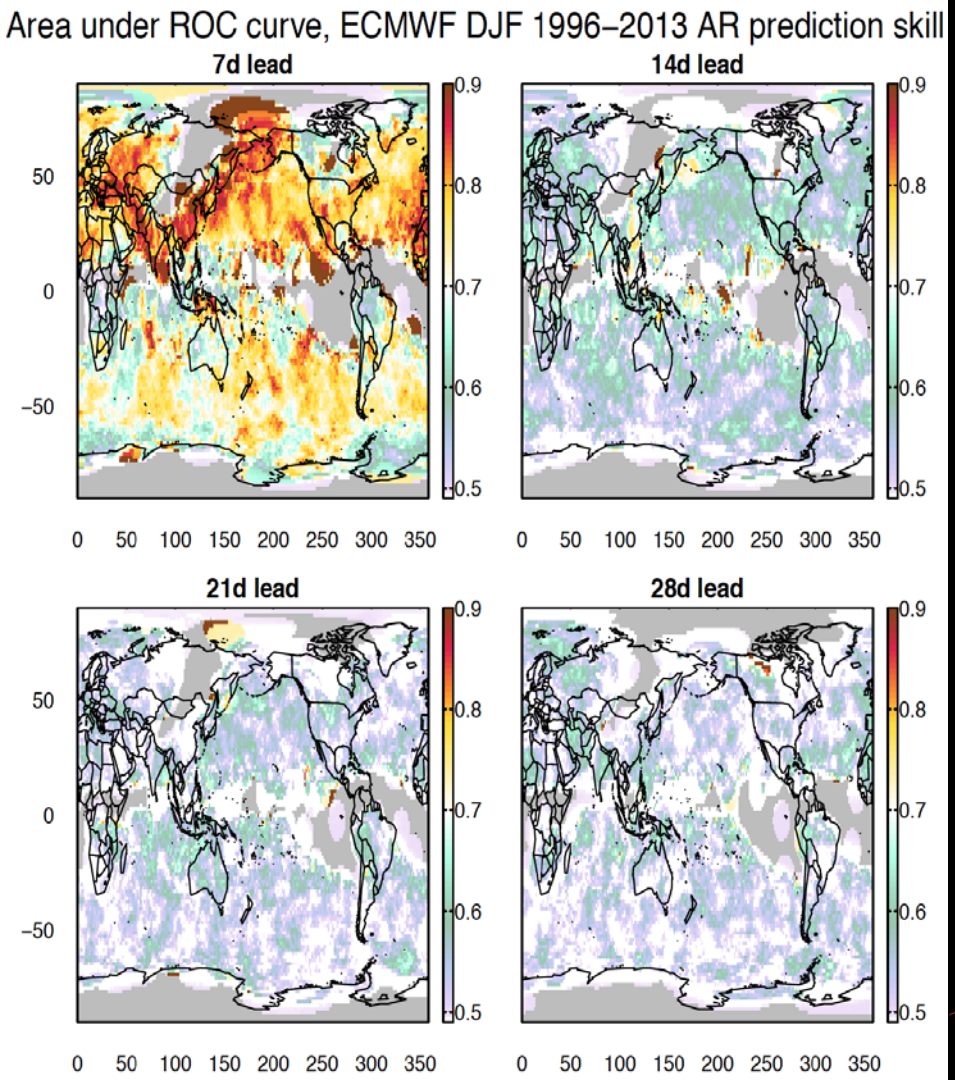


Area under ROC curve: measure of forecast utility

- 0.5 = little gain over a random forecast
- 1 = perfect forecast

- in prep: conditional ROC curves and maps

DeFlorio, Waliser, Guan et al. (2016, in prep)



Summary and conclusions

- Atmospheric rivers are 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 (Guan and Waliser 2015) that can be *consistently and objectively* used on global "observations" (i.e. re-analyses), climate simulations and forecast models.
- Our new ATRISK global algorithm provides a flexible methodology for calculating contingency table values for AR events in operational forecast models.
  - ATRISK provides the first global assessment of AR prediction skill to date
- There is considerable utility in regional (order ~1000km) forecasts of prediction skill at 7-10 day lead time.
  - generally higher prediction skill at 1-2 week leads in DJF relative to MAM
- There is considerable subseasonal variability of prediction skill, which suggests potential for conditioning AR skill estimates on various climate states.
- We are currently expanding methodology to utilize a dozen S2S operational models, and to estimate predictability of ARs.

Thanks!

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