Multi-model assessment of global atmospheric river S2S prediction skill

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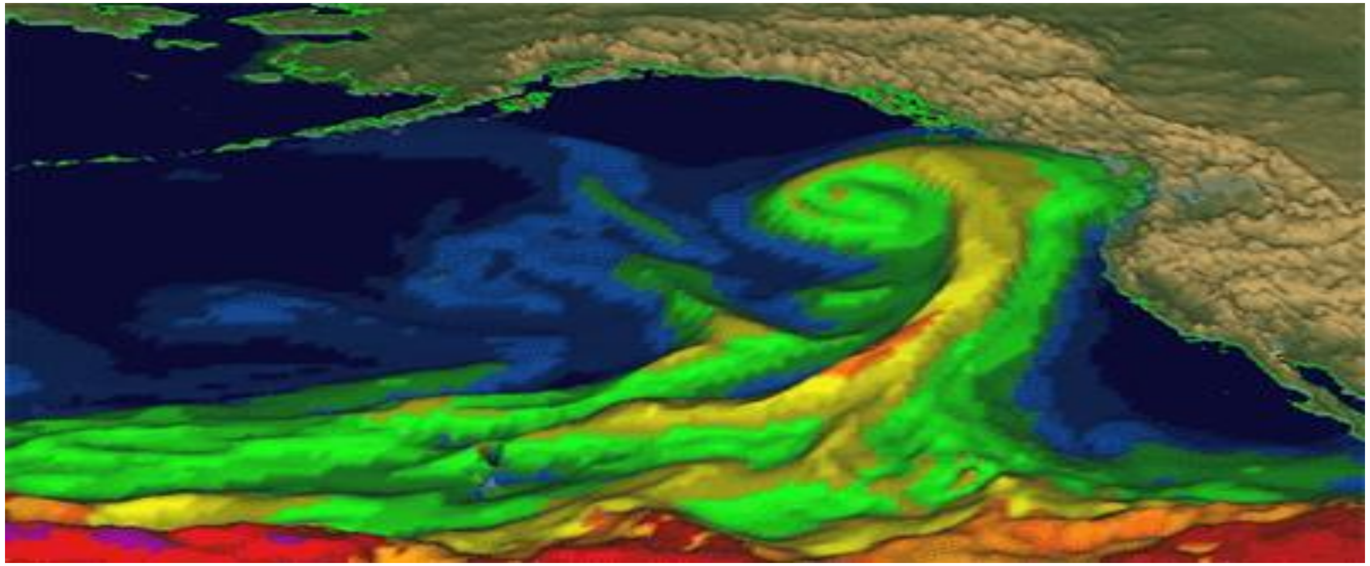
Contains key figures/concepts from:

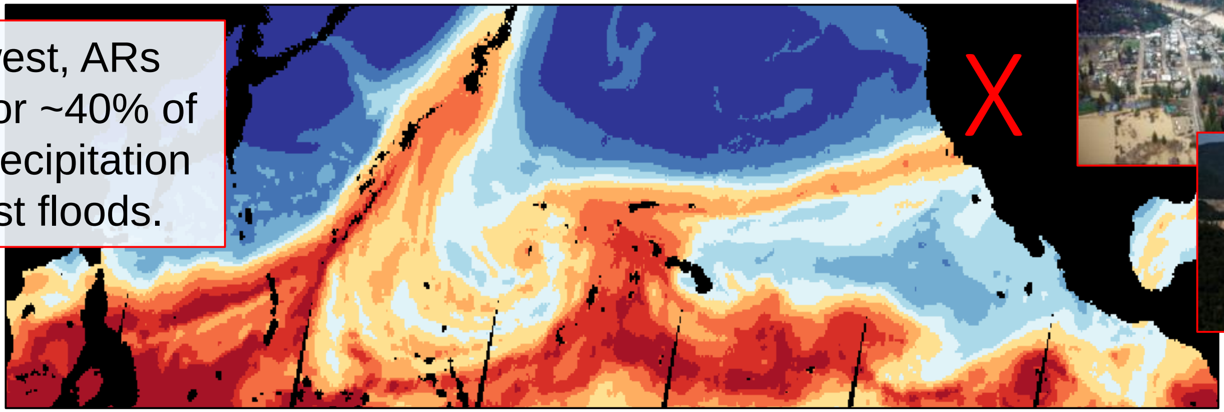
1. DeFlorio et al. 2017, **Global assessment of atmospheric river prediction skill**, J. Hydromet. (accepted)
2. DeFlorio et al. 2017, **Global evaluation of atmospheric river subseasonal prediction skill**, Clim. Dyn. (submitted)
3. Guan and Waliser 2015, **Detection of atmospheric rivers: Evaluation and application of an algorithm for global studies**, J. Geophys. Res., **120**, 12514-12535.

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



NOAA ESRL

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.

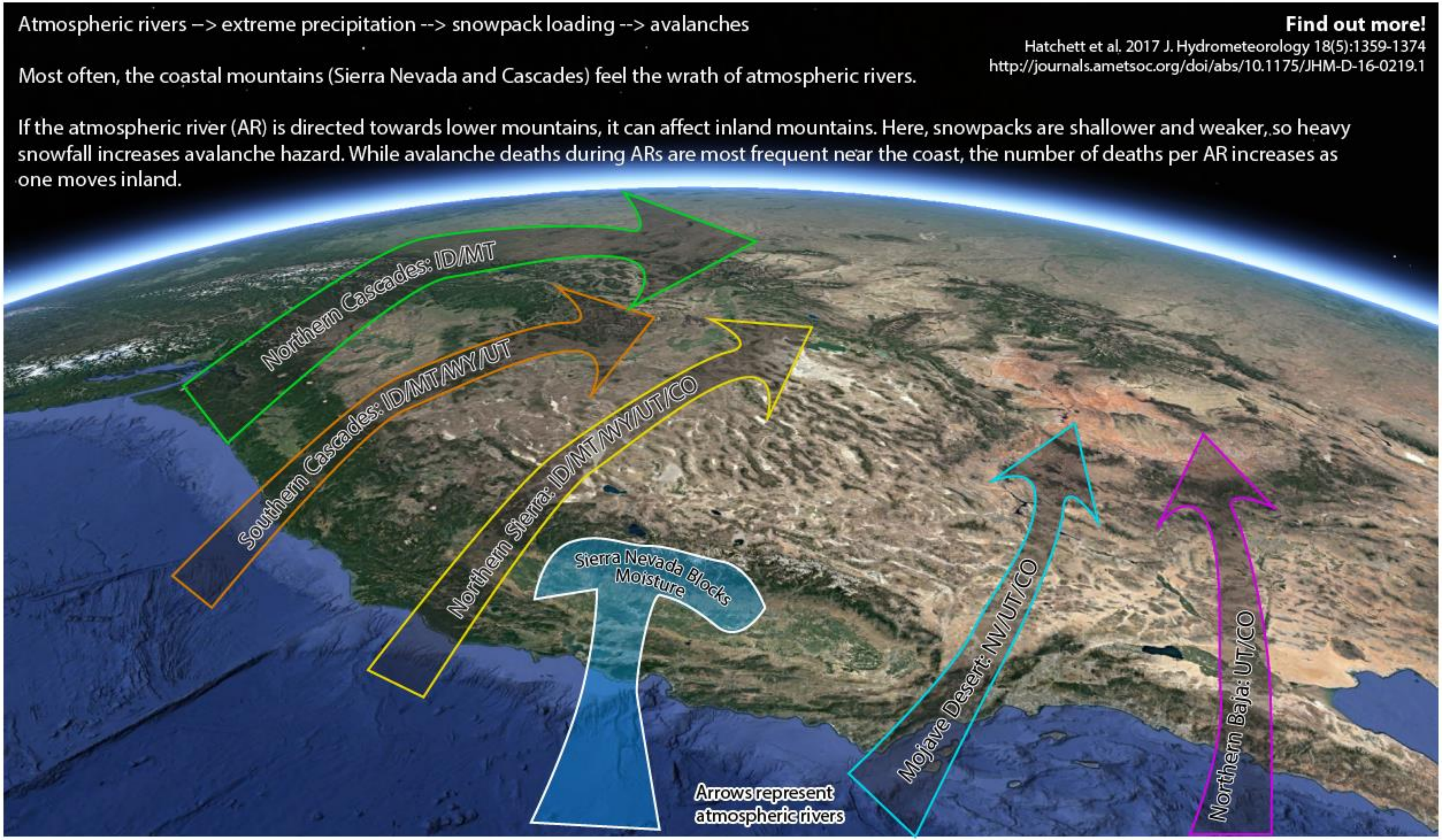


Figure from Desert Research Institute

Key Research Question

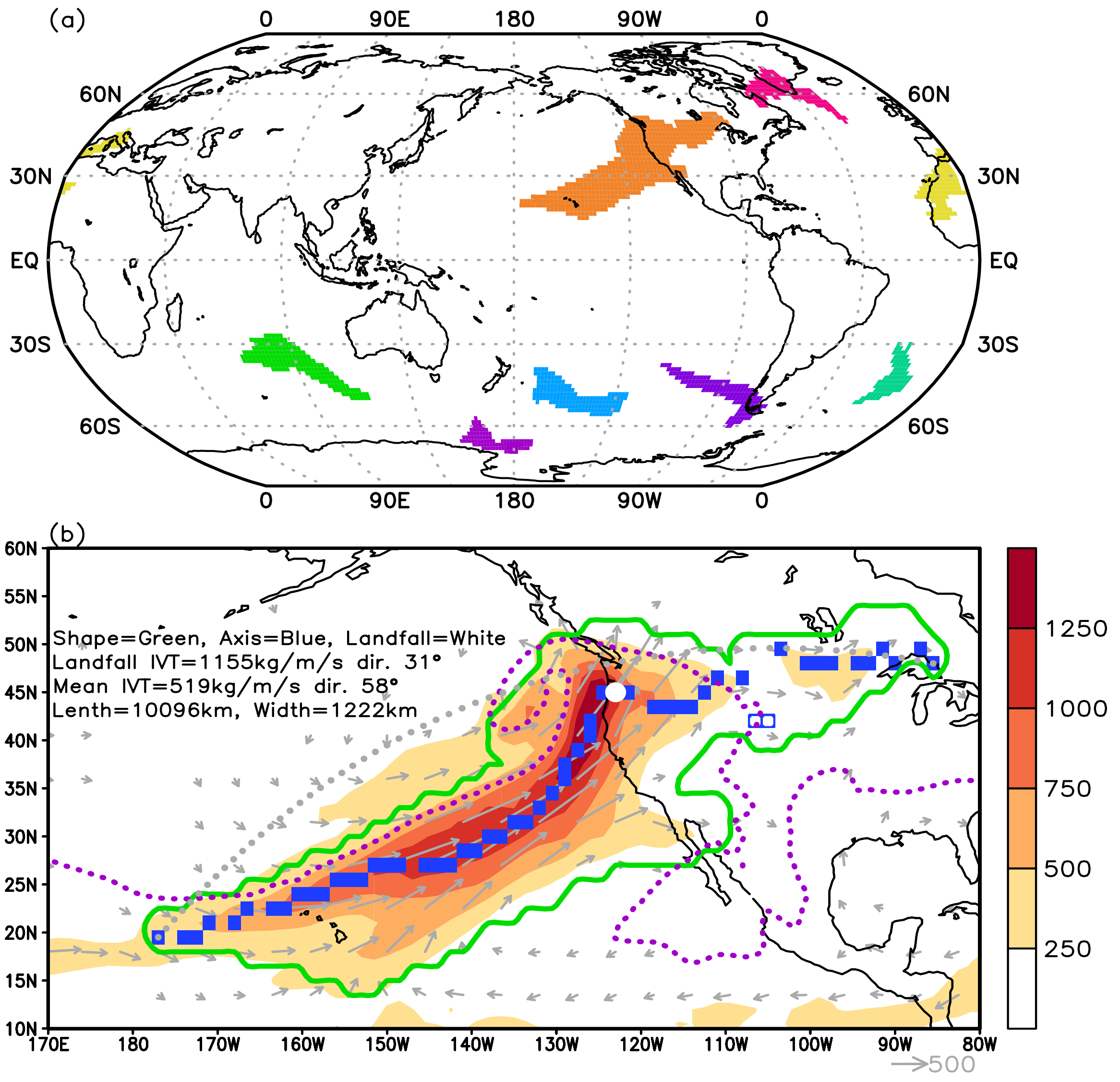
What is the limit of subseasonal (1-week to 1-month) prediction skill of 2-week AR occurrence (number of AR days per two weeks), and how does it vary as a function of season, region, and certain large-scale background climate conditions?

Key Applications Question

Can present-day S2S forecast systems provide benefit to CA water resource management decision makers?

A global, objective algorithm for AR identification

(Guan and Waliser 2015)

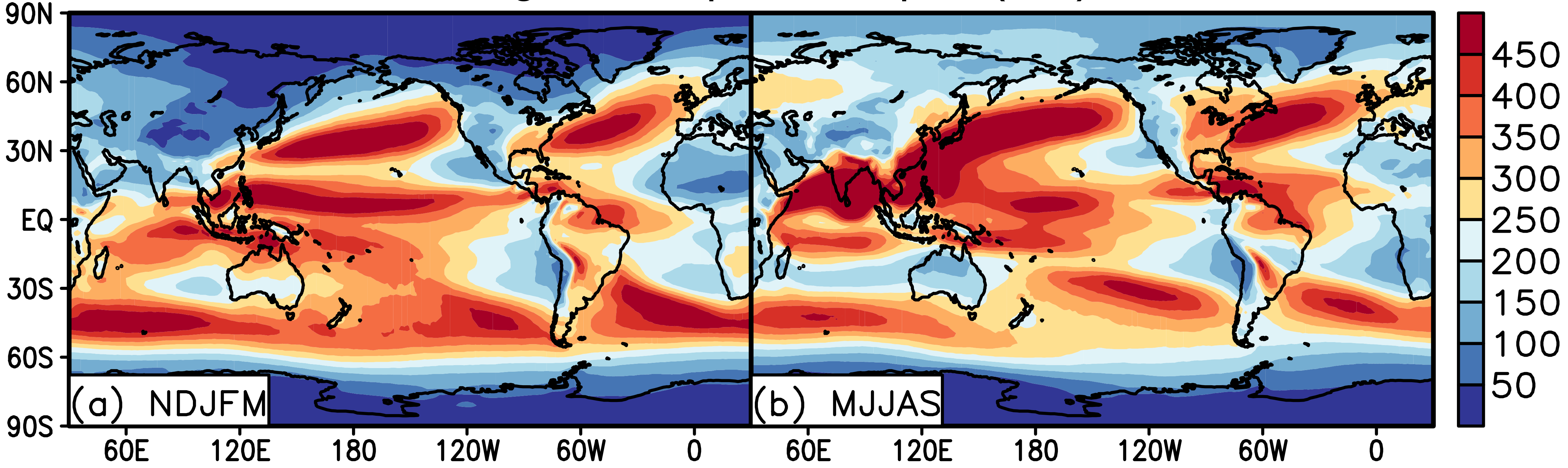


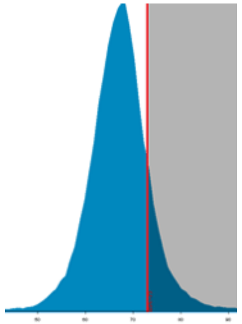
- Based on Integrated Vapor Transport (IVT) fields and a number of common AR criteria (e.g. Ralph et al. 2004)
- Applied to global hindcast/forecast systems and reanalysis datasets
- Code and databases available at: https://ucla.box.com/ARcatalog
- Databases include AR Date, $IVT_{x,y}$, Shape, Axis, Landfall Location, etc.
- Used for GCM evaluation (Guan and Waliser 2017), climate change projections (Espinoza et al. 2017, submitted), & forecast skill assessment (DeFlorio et al. 2017a and 2017b, accepted, submitted)

Global AR Climatology

Guan and Waliser 2015

Based on Integrated Vapor Transport (IVT), 1997-2014





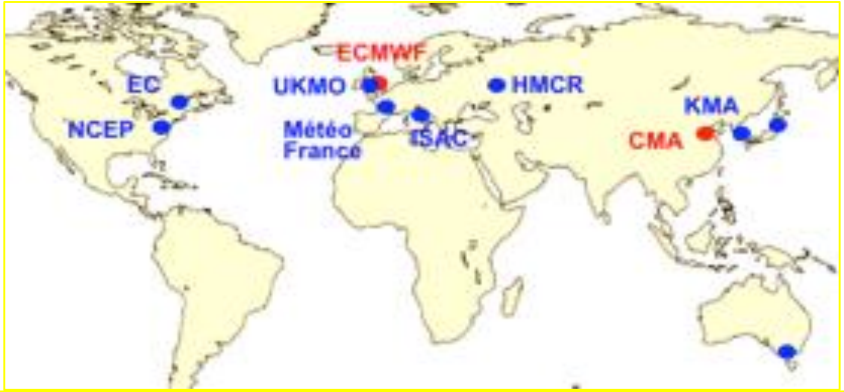
Intensity threshold:
IVT > max(85th percentile, 100 kg m-1 s-1)

Geometry threshold:
Length > 2000 km, Length/Width > 2

The S2S Project Database (s2sprediction.net)

World Climate Research Programme

- 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”



	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

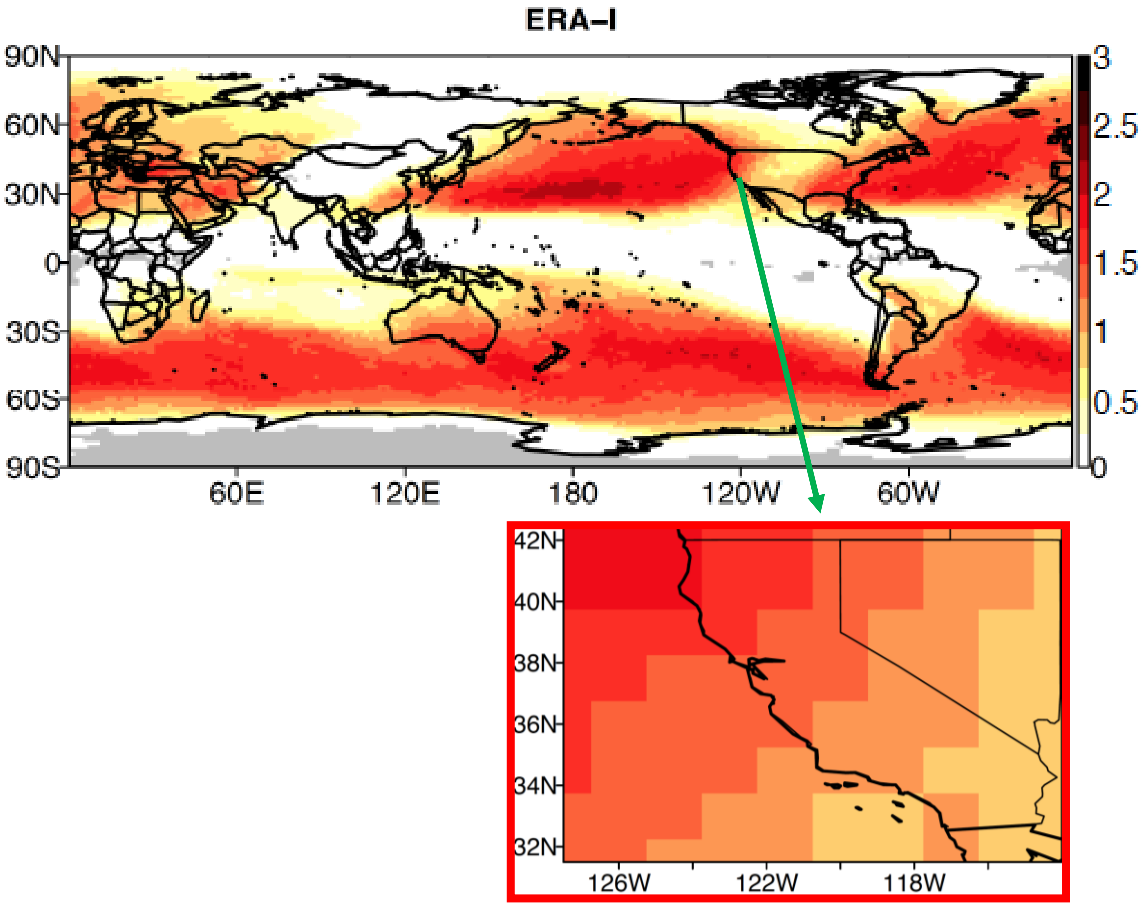
Vitart et al. 2017

Goal: use objective identification algorithm to assess global AR subseasonal prediction skill at lead times of 1-week to 1-month using S2S hindcast data

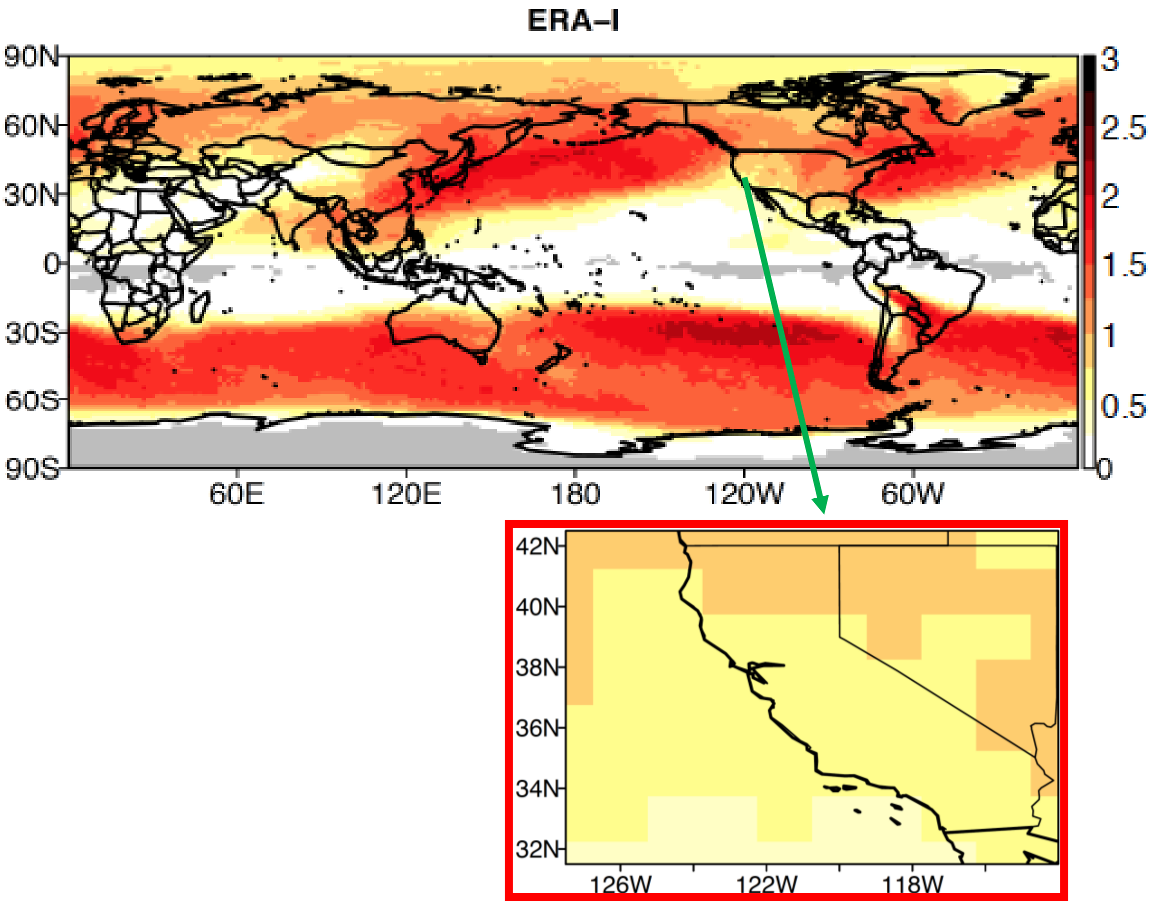
DeFlorio et al. 2017, **Global evaluation of atmospheric river subseasonal prediction skill**, Clim. Dyn. (submitted)

AR occurrence climatology (#AR days per two weeks; “AR2wk”)

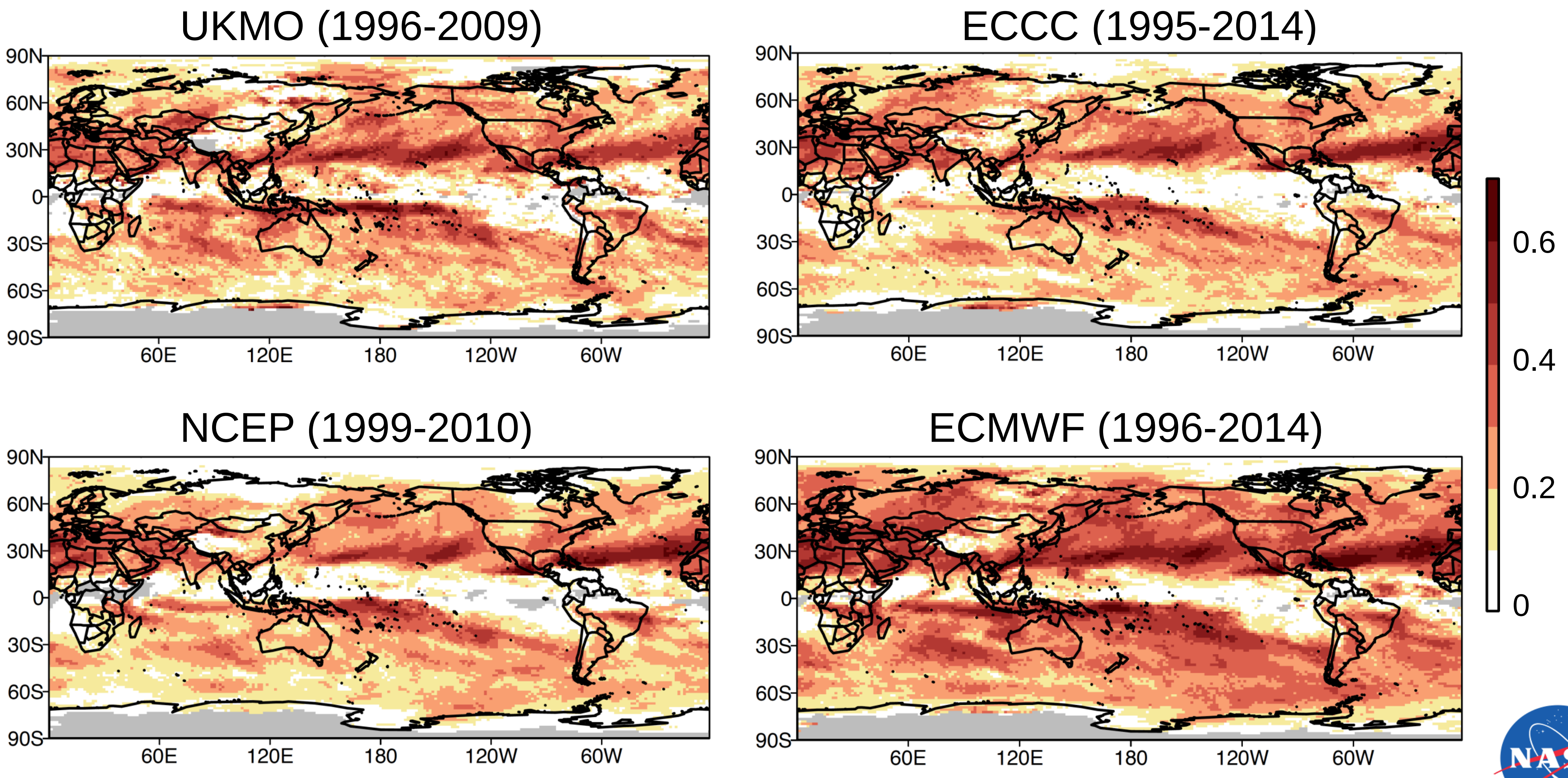
NDJFM



MJJAS

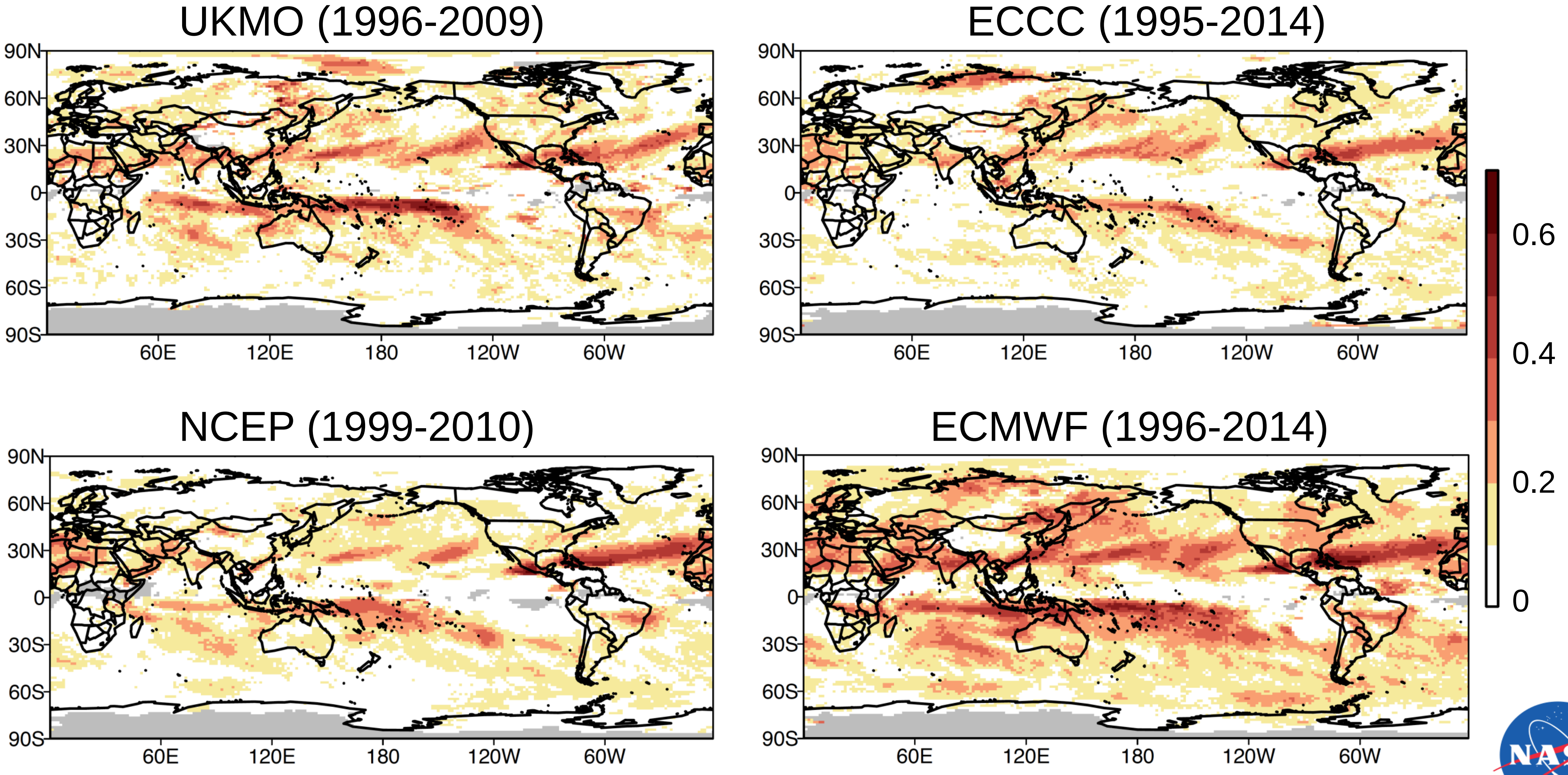


NDJFM AR2wk Forecast skill: 7d-21d lead window



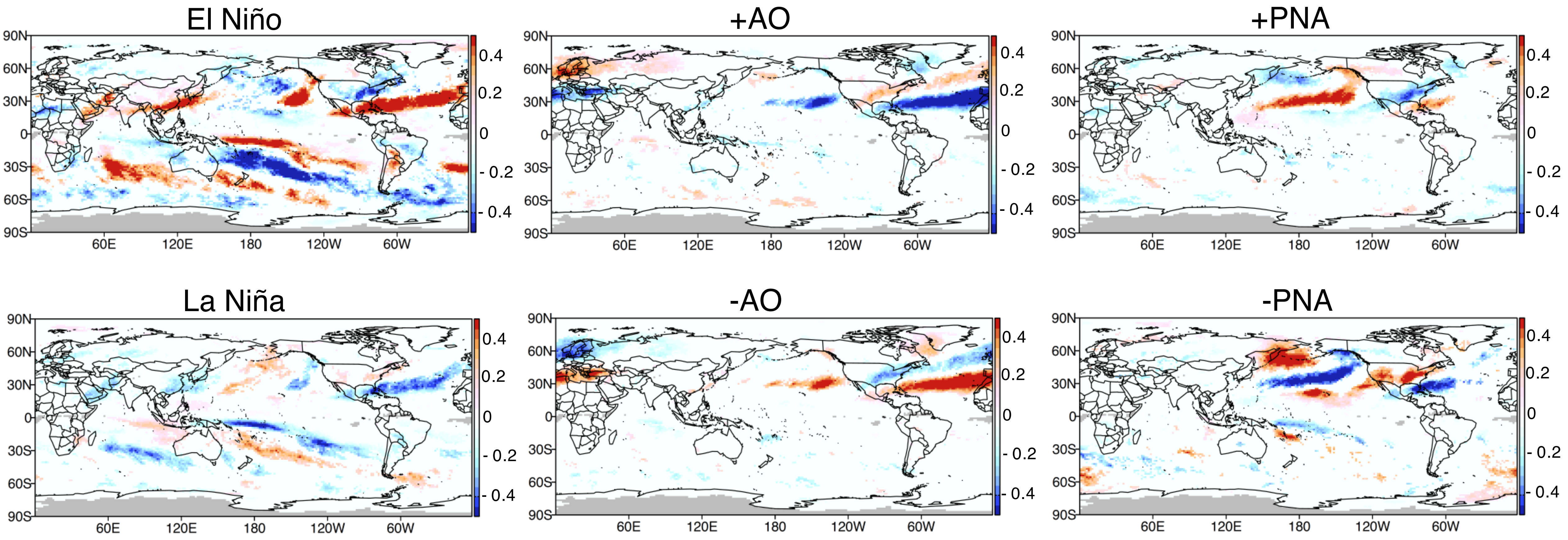
Note: forecast skill is defined as the anomaly correlation of AR2wk for ERA-I and each model

NDJFM AR2wk Forecast skill: 14d-28d lead window

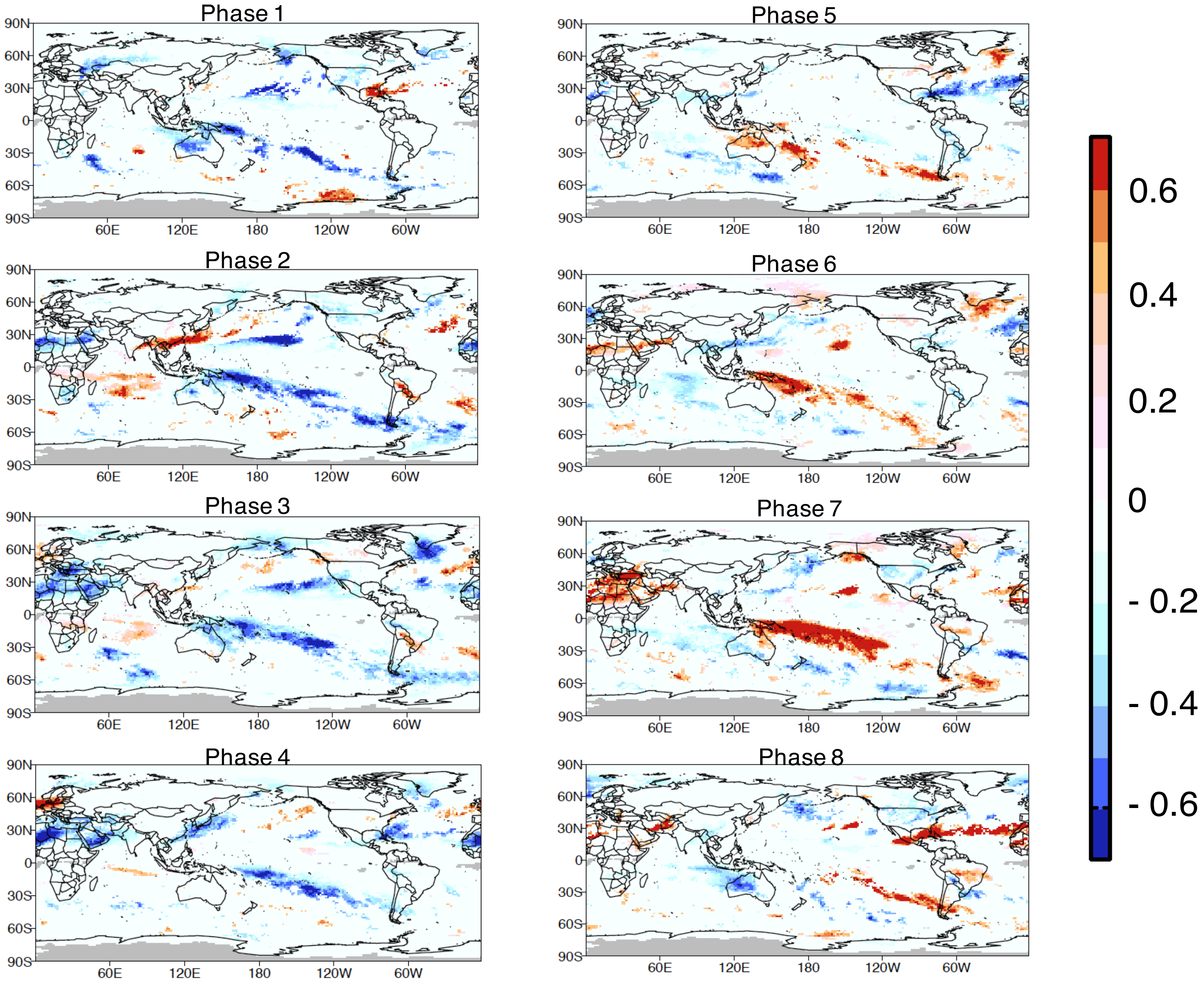


Note: forecast skill is defined as the anomaly correlation of AR2wk for ERA-I and each model

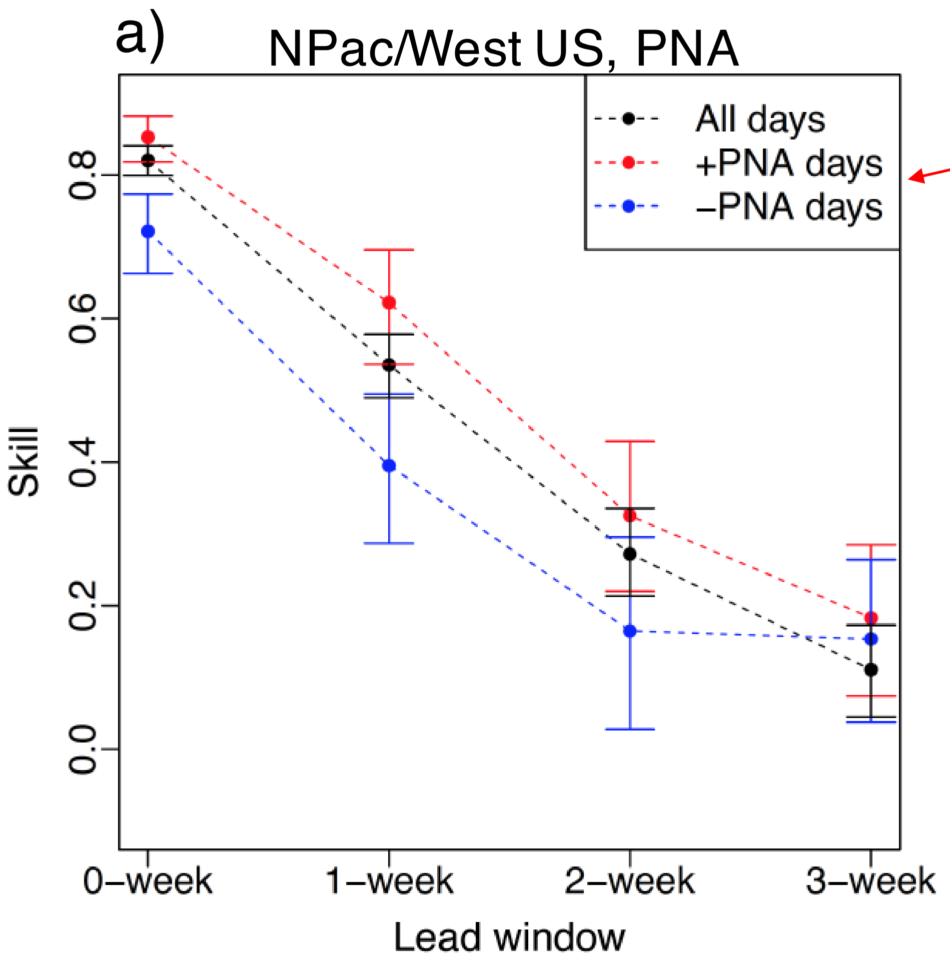
NDJFM AR2wk Occurrence Anomalies: ENSO, AO, and PNA, ERA-I



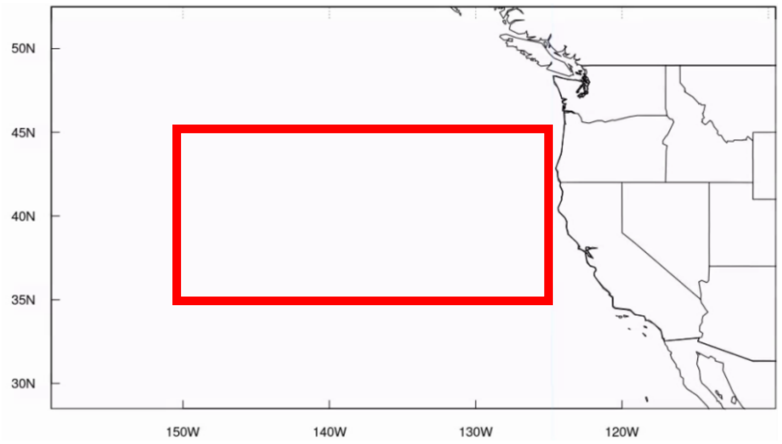
NDJFM AR2wk Occurrence Anomalies: MJO, ERA-I



NDJFM AR2wk Occurrence ECMWF Forecast Skill: PNA Composite

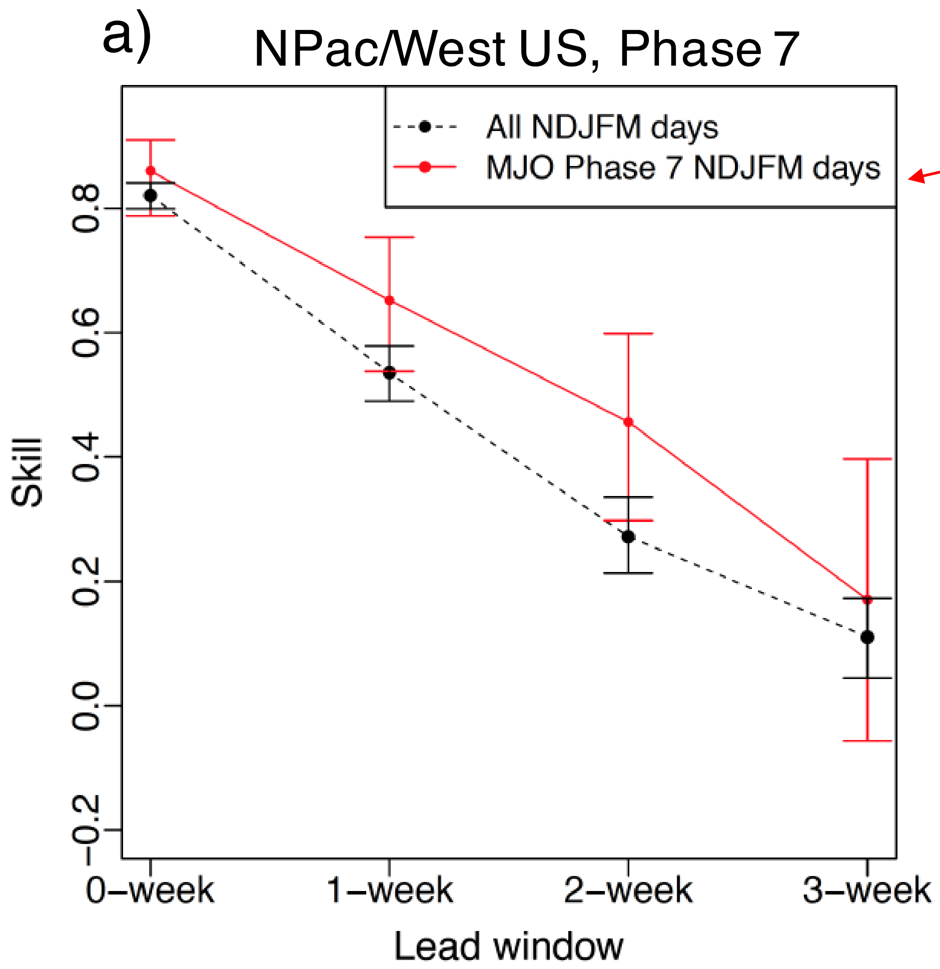


Relative to state of PNA at time of hindcast initialization

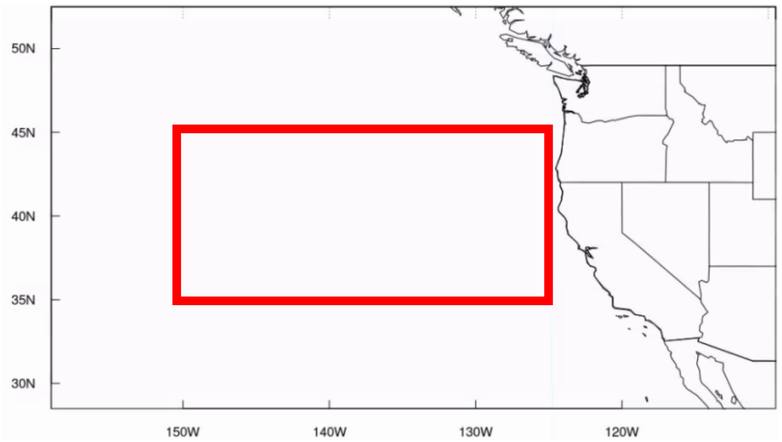


Also: higher ratio of hits relative to false alarms during +PNA conditions relative to –PNA conditions for individual AR events at 3d, 7d, 10d lead times (DeFlorio et al. 2017, J. Hydromet., accepted)

NDJFM AR2wk Occurrence ECMWF Forecast Skill: MJO Phase Composite

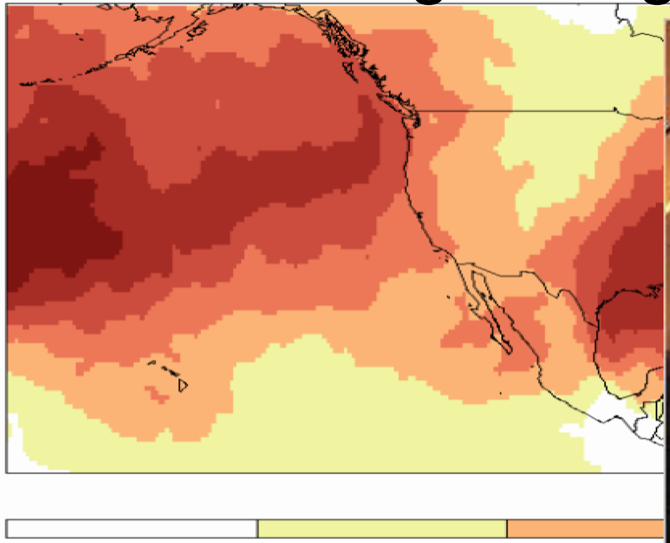


Relative to state of MJO at time of hindcast initialization



Experimental global ECMWF AR S2S occurrence forecasts: chance of AR occurring during a week-long window

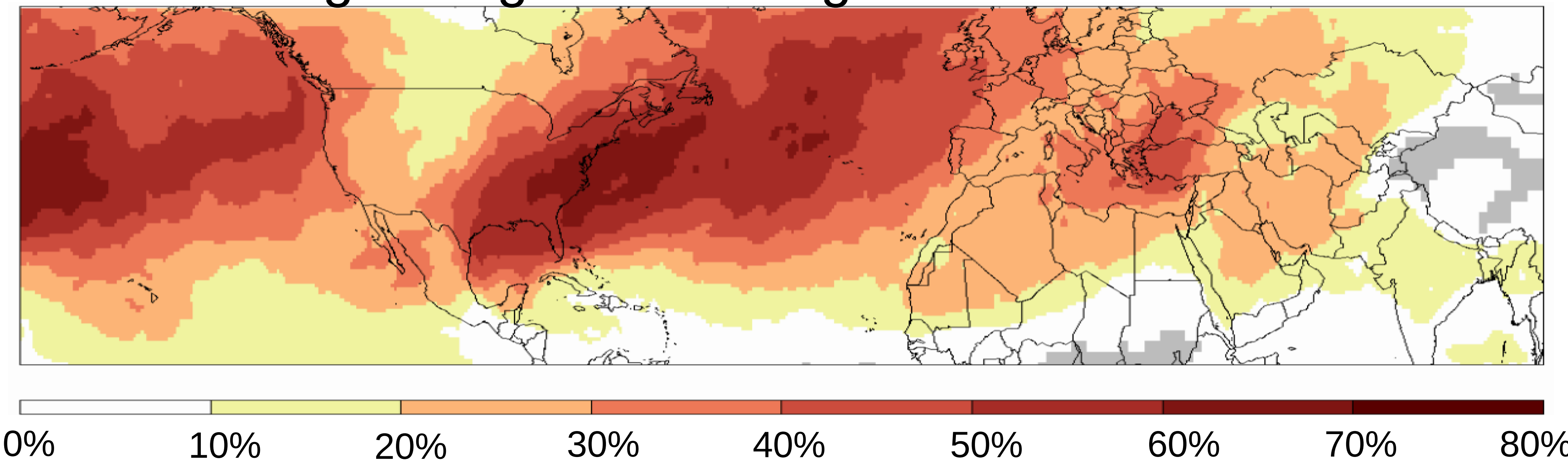
Climatology, 1996-2015 ECMWF Nov 27 hindcasts



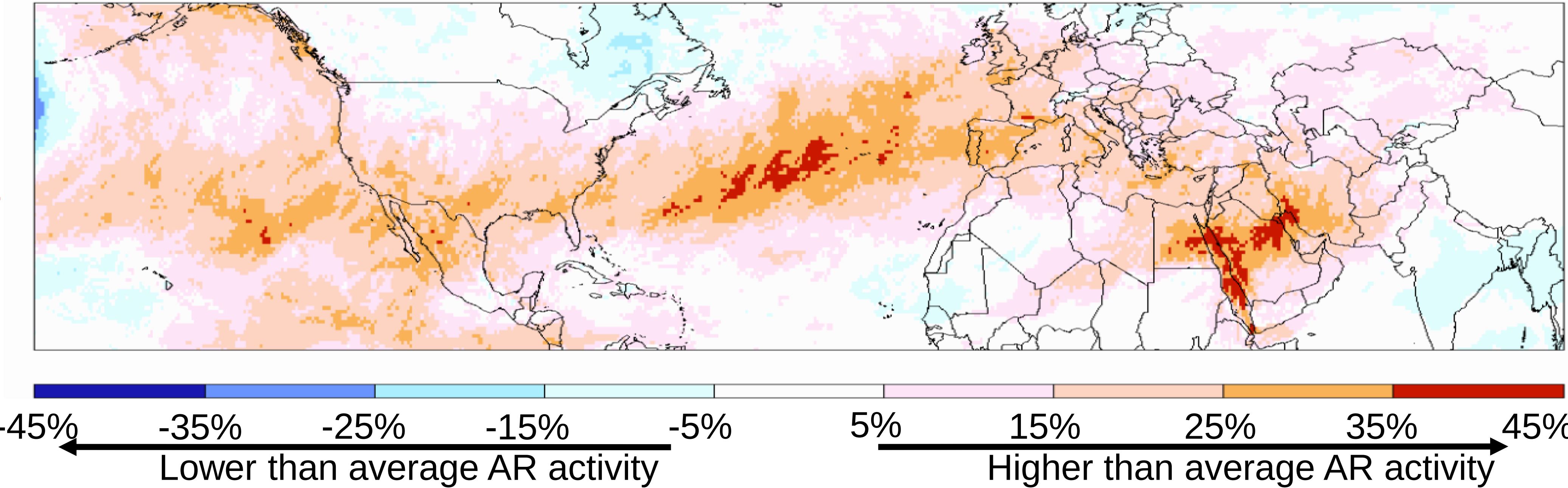
Real-time week-2 ECMWF Nov 27, 2017 forecast minus climatology (valid Dec 5-11)

Experimental global ECMWF AR S2S occurrence forecasts: chance of AR occurring during a week-long window

Climatology, 1996-2015 ECMWF Nov 27 hindcasts



Real-time week-3 ECMWF Nov 27, 2017 forecast minus climatology (valid Dec 12-18)



Summary: subseasonal AR prediction skill

- Subseasonal (1-week to 1-month lead time) AR prediction skill evaluated globally for the first time in multi-model S2S framework (DeFlorio et al. 2017, submitted)
    - Skill metric = correlation between observed and model “number of ARs occurring in a two week window” (AR2wk, or AR occurrence)
- ECMWF forecast system is generally most skillful model in 7-21 day and 14-28 day lead windows
- Observed AR occurrence is sensitive to large scale climate mode variability
    - S2S AR prediction skill is sensitive to large scale climate mode variability

- Higher prediction skill over the North Pacific/Western U.S. region:
    - at 0-week and 1-week lead time during +PNA relative to –PNA
    - at 1-week and 2-week lead time during MJO phase 7 relative to “all days” forecast (but not quite at 95% confidence)

Ongoing and future research plans

- Analysis of entire S2S model suite
- Multi-model (ECMWF, ECCC, NCEP) experimental week-3 S2S forecasting (collaboration with CW3E; S. Gershunov, A. Subramanian, F. M. Ralph) for winter 2017-18 and 2018-19
  - CA-DWR sponsored
  - Proposed S2S Project applications pilot study
- Joint consideration of statistical and dynamical approaches, optimizing conditional AR skill estimation parameters
- Emphasize importance of distinguishing ARs (and their prediction skill) from all baroclinic systems that produce extreme precipitation
- How can S2S research community distill results into something useable for applications community?

Thanks!

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