Towards Improving Hydroclimate S2S Prediction

(State of HiFLOR & Review of Advances in Statistics, FLOR, & Non-Uniform Grid Advances)

Sarah B. Kapnick, Ph.D.

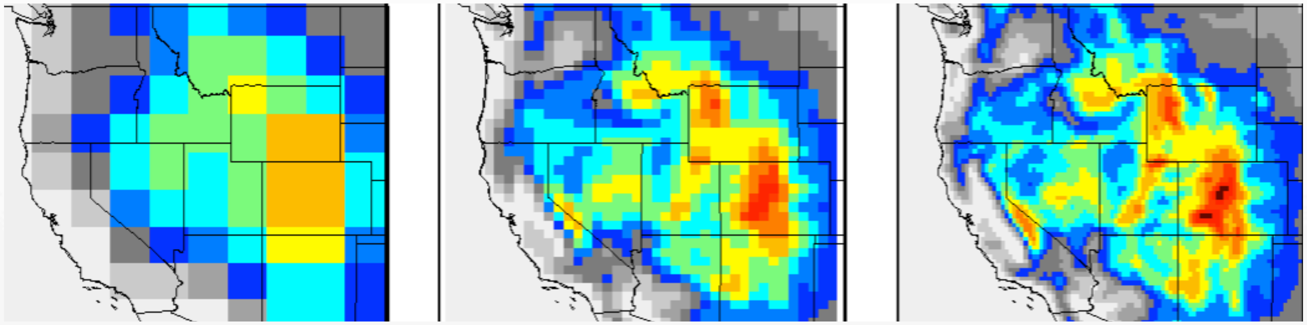
Western States Water Council and California Department of Water Resources Workshop

June 8, 2016

Advances in Global Climate Model Resolution: HiFLOR

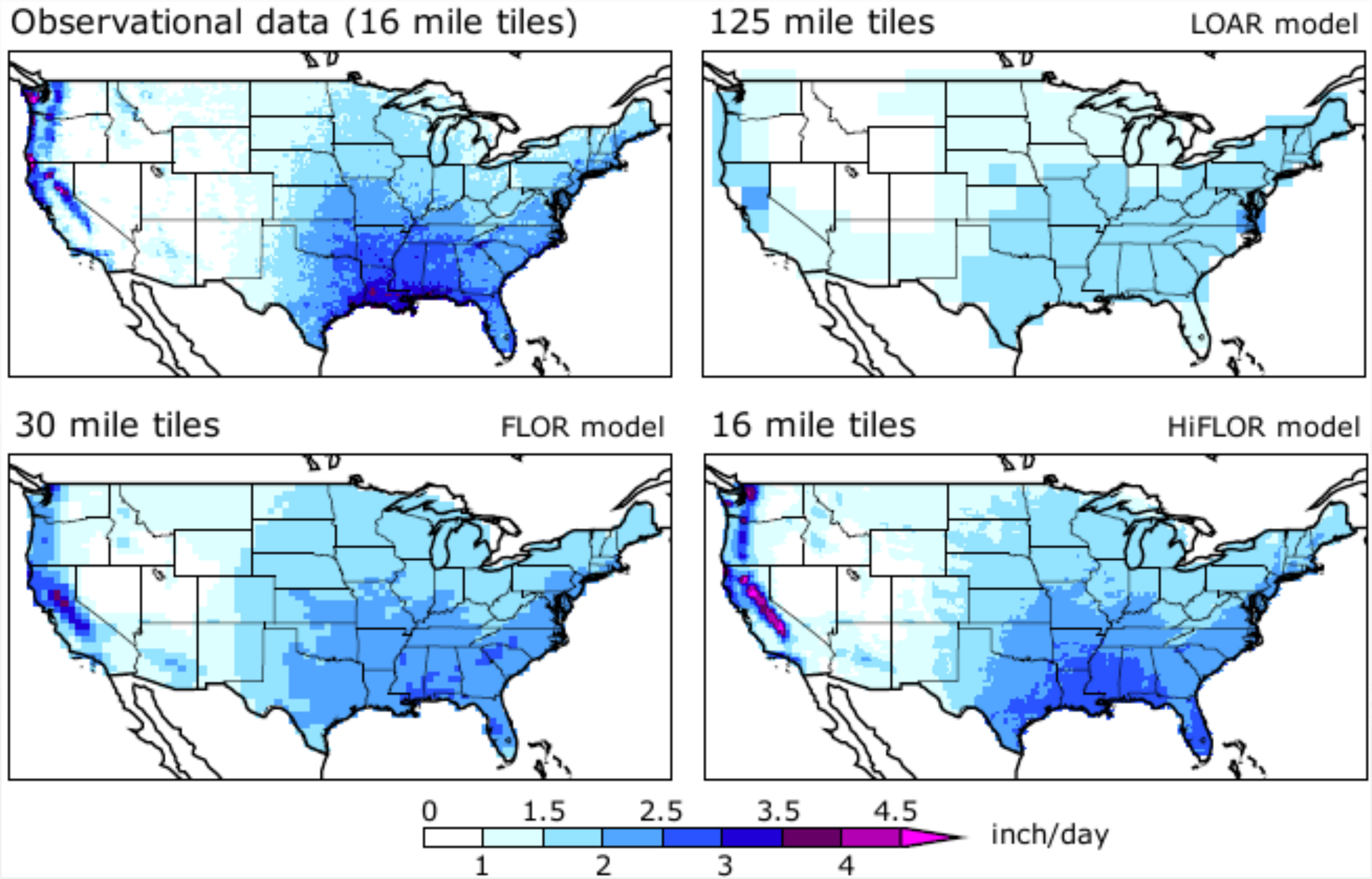
By the Numbers

Low to High Resolution Models



	CM2.1/LOAR	FLOR	HiFLOR
Atmospheric Grid Cell Size	*200 km (~160 miles)*	*50 km (~30 miles)*	*25 km (~16 miles)*
Computing Cost	*1*	*20*	*120*
Size of 5 Year of Daily Data File (ex: Total Precipitation)	*91 MB*	*1.5 GB*	*7.1 GB*

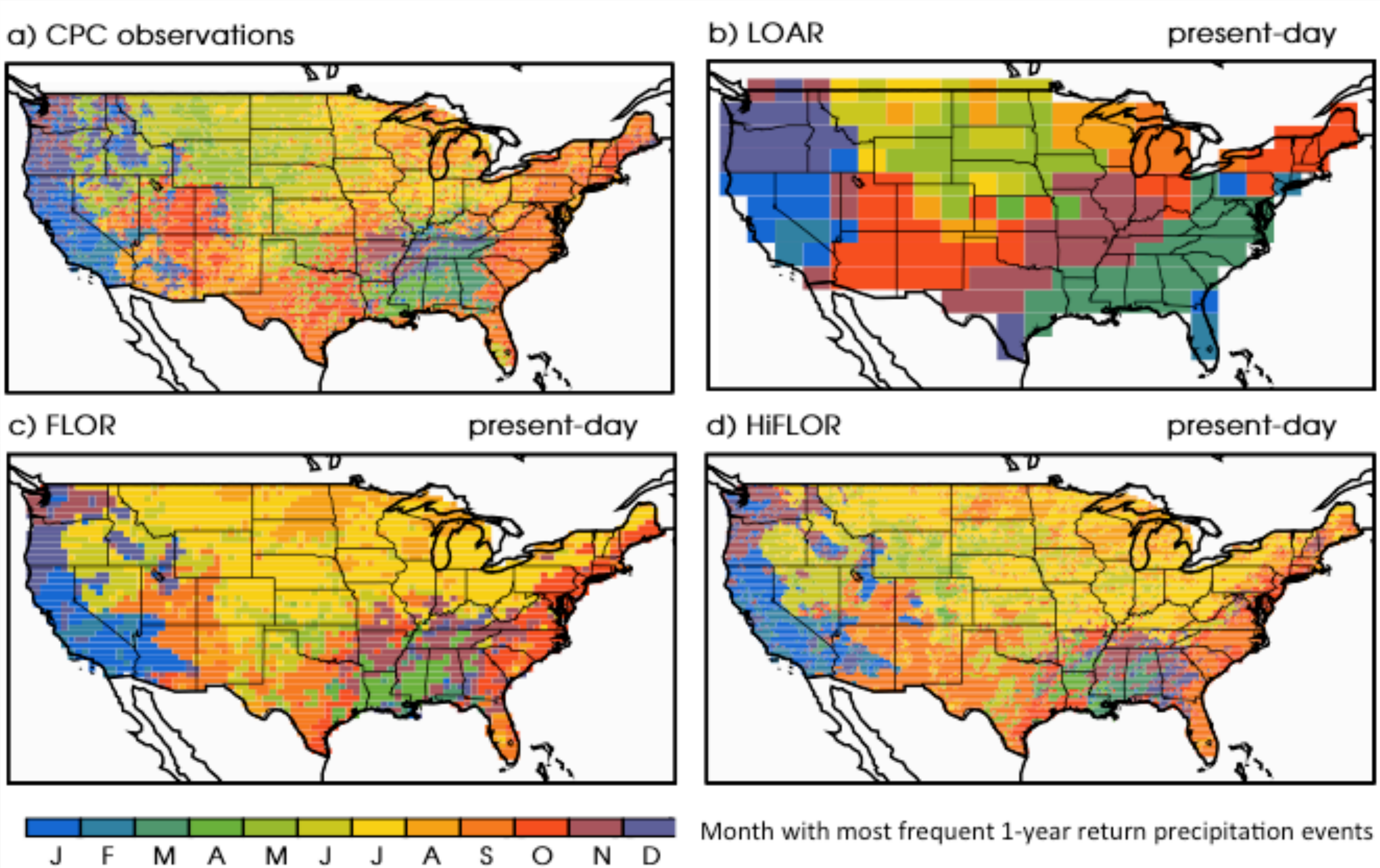
Annual US Precipitation Extreme



The magnitude (amount of extreme precipitation) improves with resolution

Source: Van der Wiel et al. 2016

How can we model precipitation extremes better?

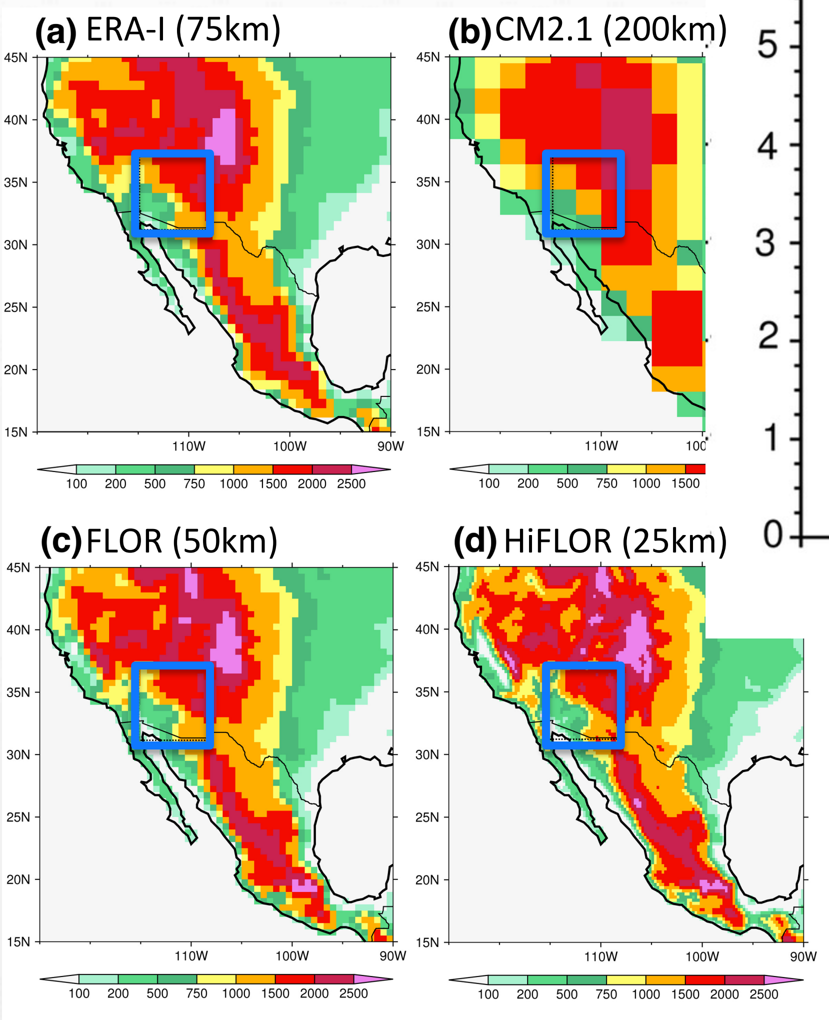


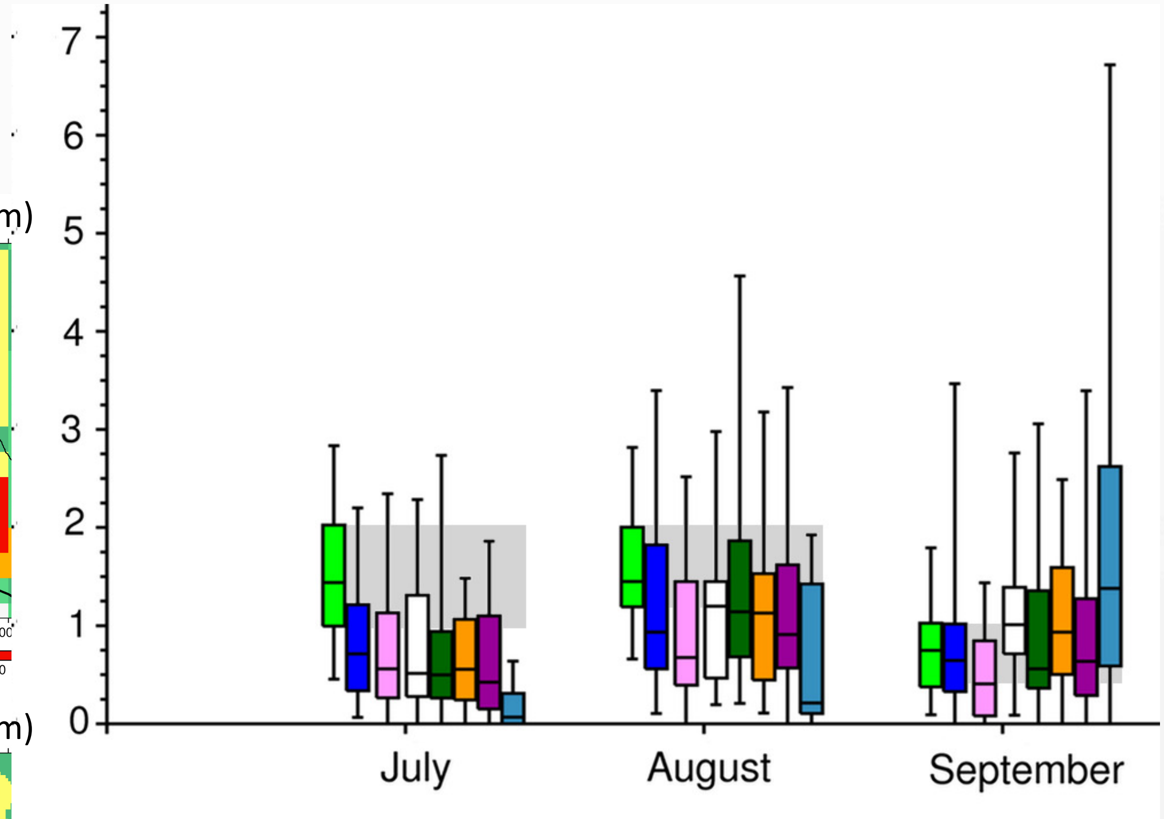
The seasonality (timing of extreme precipitation) improves with resolution

Source: Van der Wiel et al. 2016

North American Monsoon

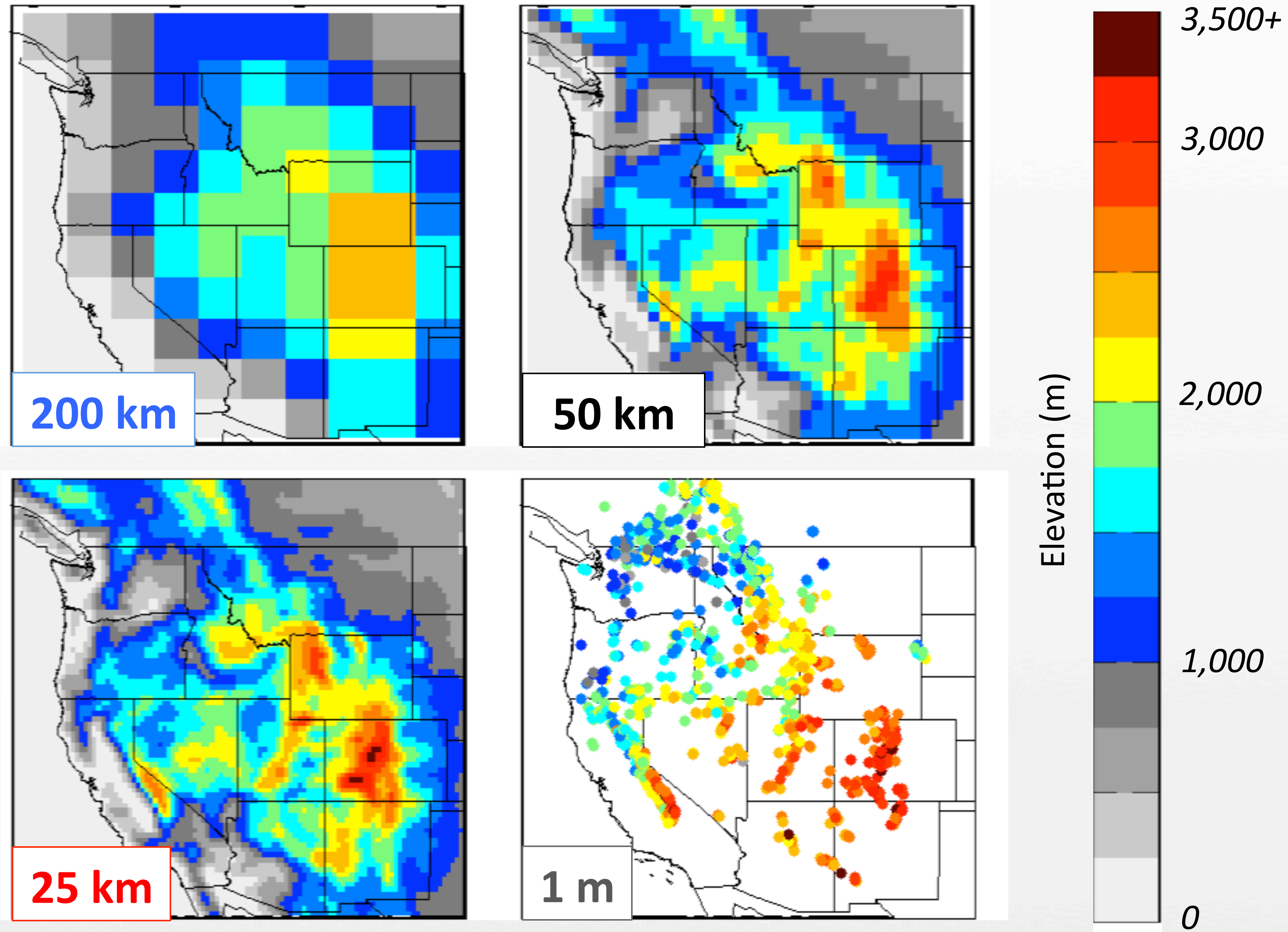
Elevation & JAS Surge-Related Precipitation (mm/day)



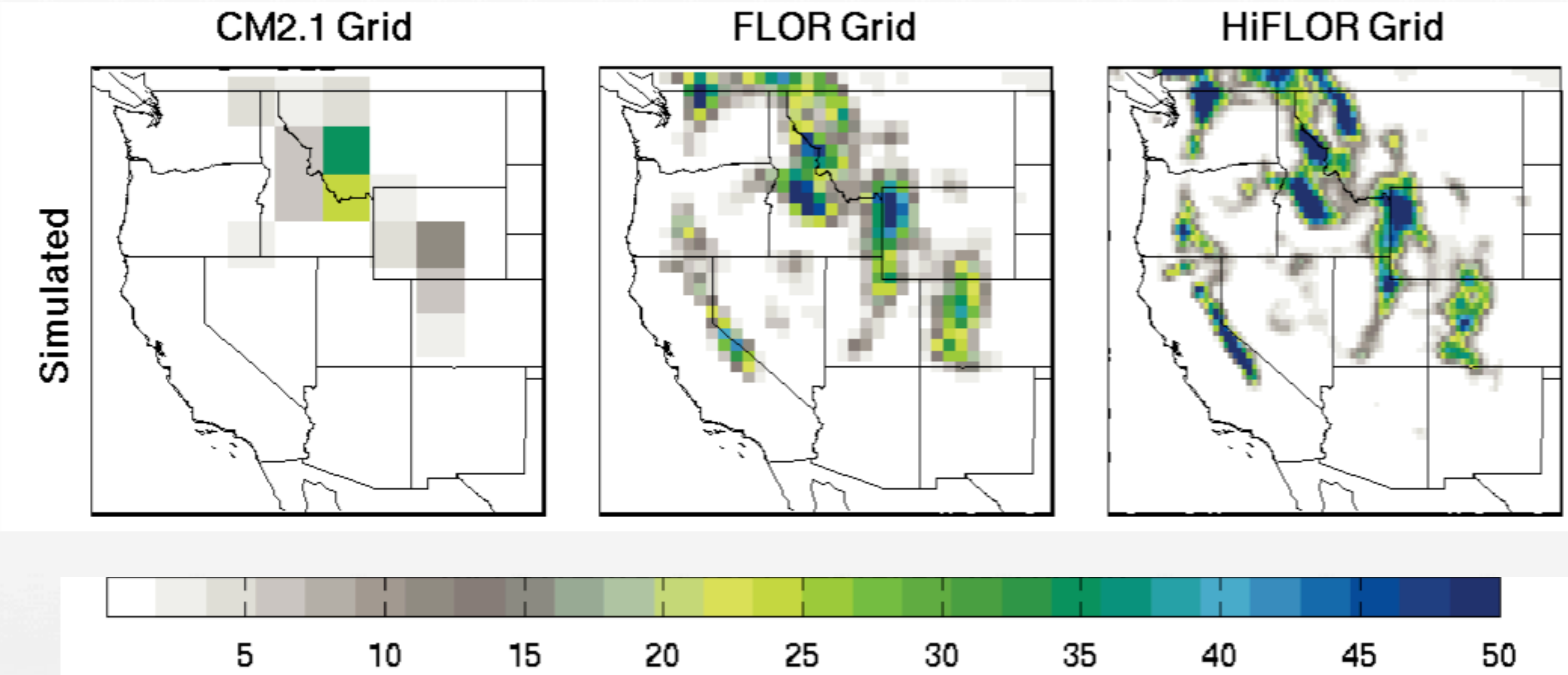


Source: Pascale et al. 2016

Elevation Resolution Dependency



Snowpack Climatology (Average Spring Snowpack)



Average Present-Day Spring Snowpack (cm of water equivalent)

Source: Kapnick et al., in preparation

2015/2016 and the Importance of Initialization

ENSO Forecasting: Cane et al. 1986

NATURE VOL. 321 26 JUNE 1986 ARTICLES 827

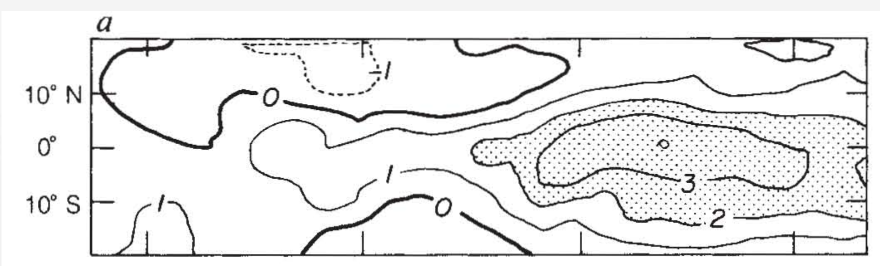
Experimental forecasts of El Niño

Mark A. Cane, Stephen E. Zebiak & Sean C. Dolan

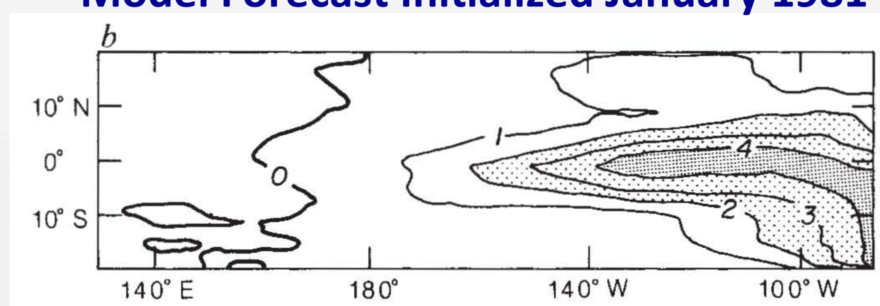
Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964, USA

Experimental forecasts of El Niño events occurring since 1970, made with a deterministic model of the coupled ocean–atmosphere system, indicate that El Niño is generally predictable one or two years ahead. A forecast for 1986 is also presented.

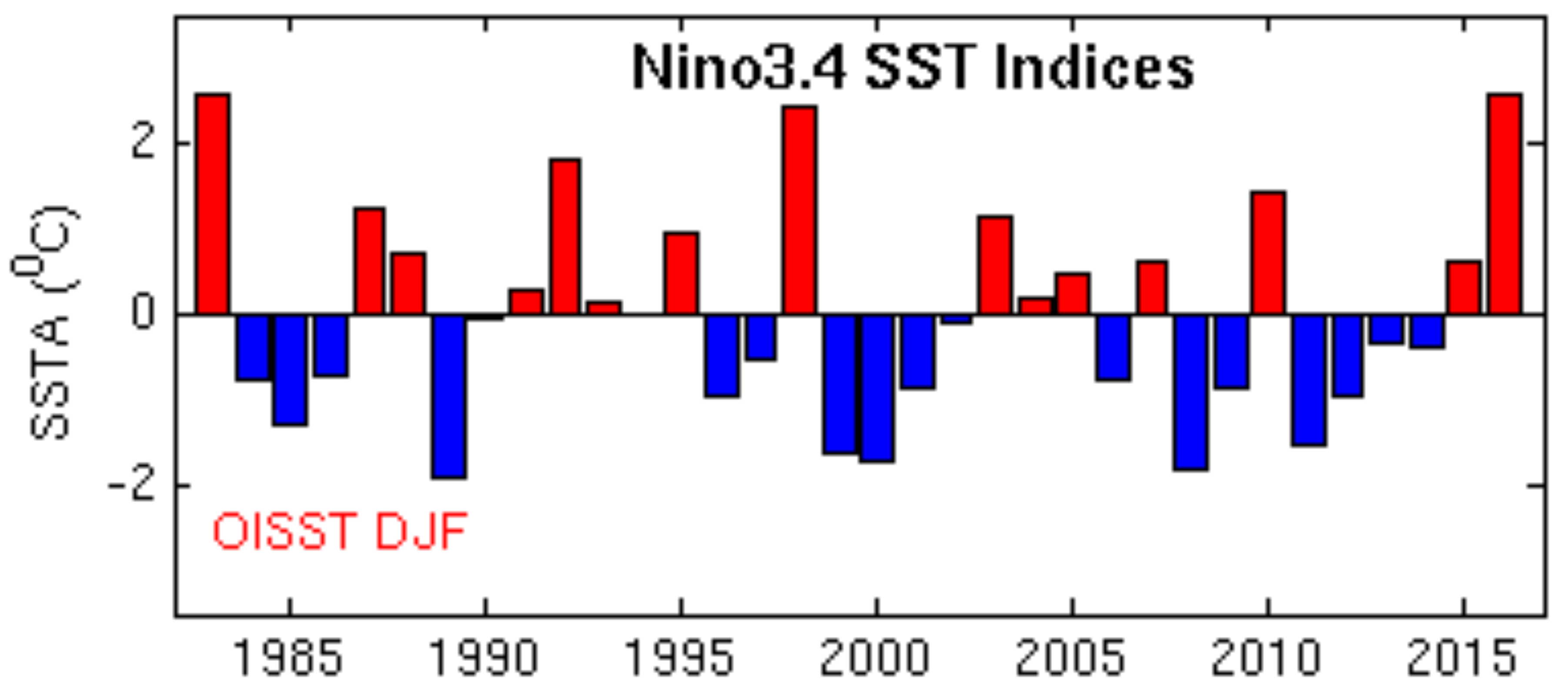
Observed SST Anomalies January 1983



Model Forecast Initialized January 1981



El Niño Record



- Strongest El Niños in ’82-83, ’97-98, ’15-16
- If a strong El Niño alone could predict regional precipitation, ’97-98 should have given forecast guidance

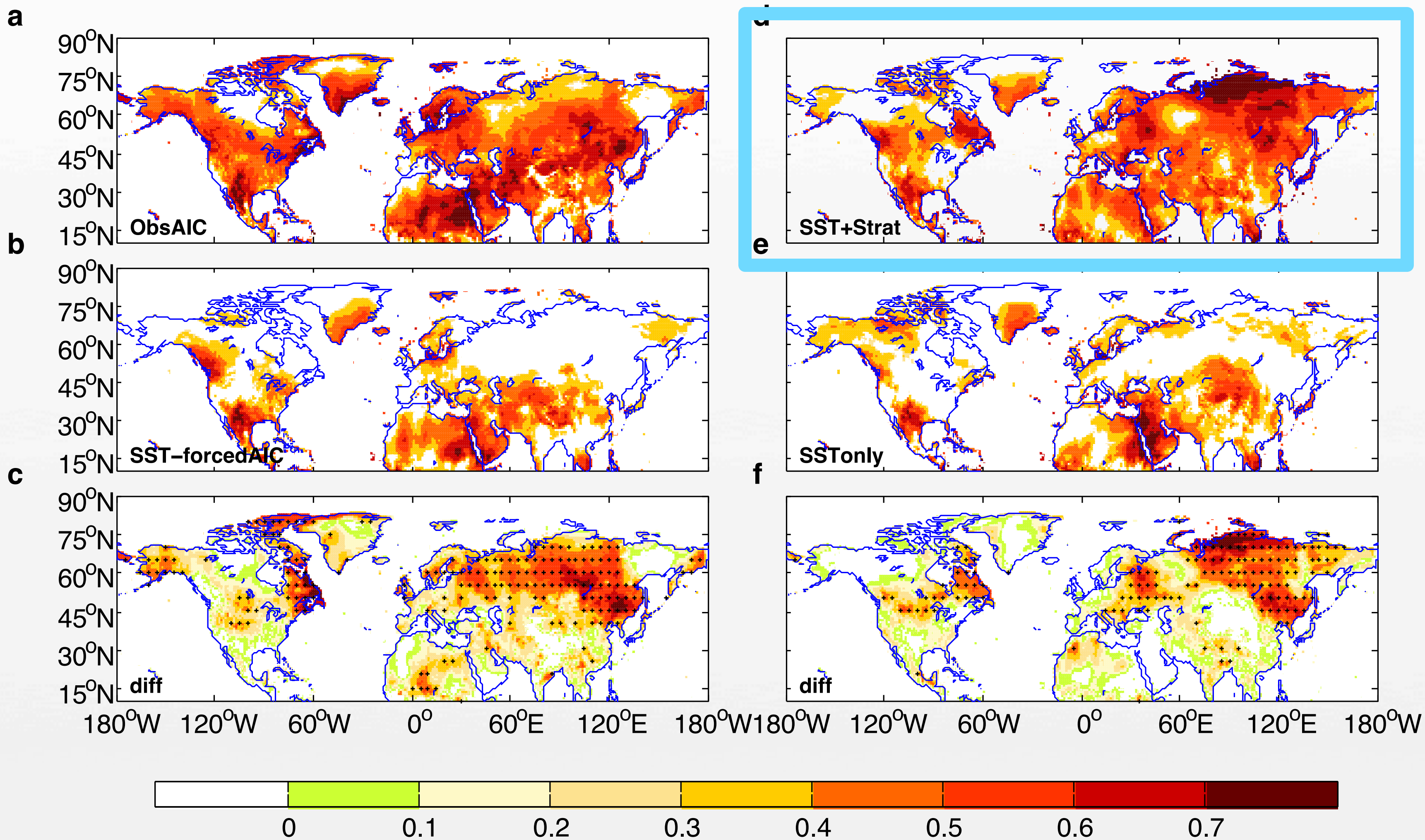
Why the 2015-16 Winter Predictions Failed

Will be released later in 2016

Source: Yang et al., Submitted

Seasonal (MAM) Temperature Prediction

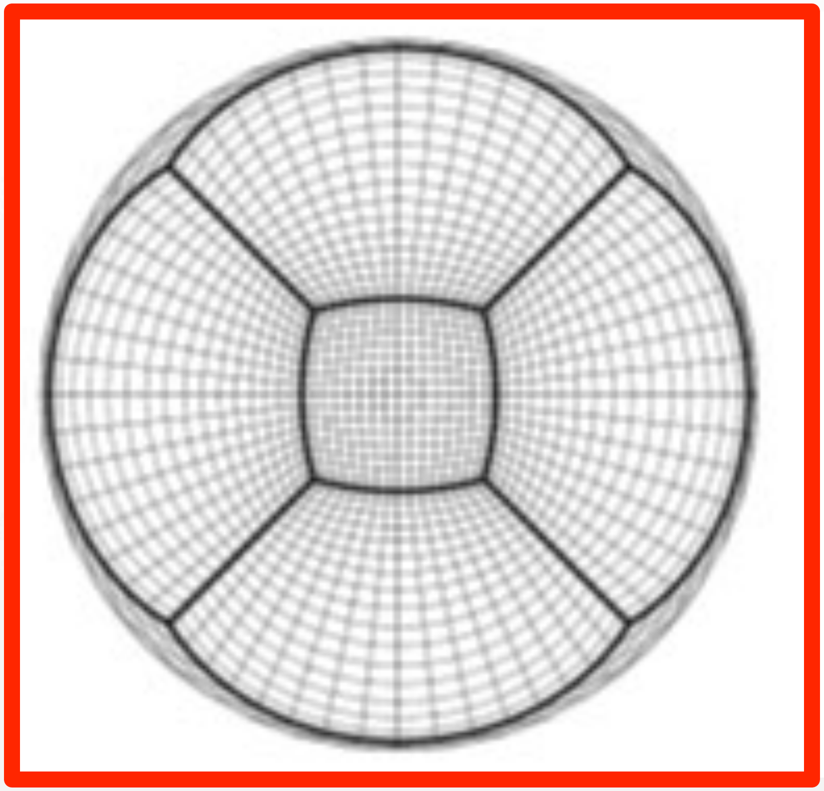
The Role of the Stratosphere

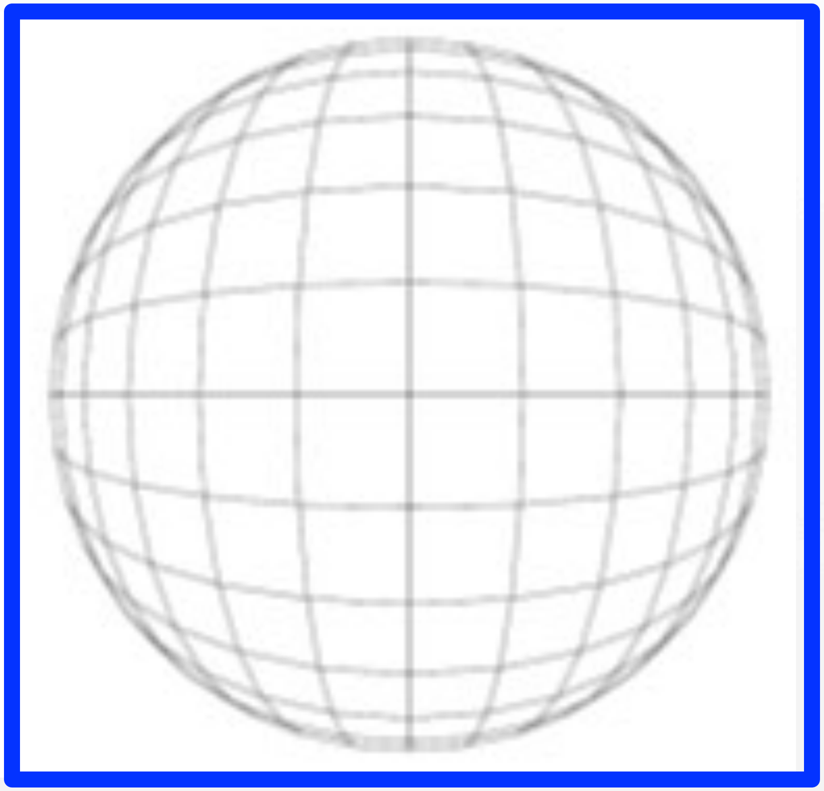


Source: Jia et al. 2016, Submitted

Non-Uniform Grids

Other Non-Uniform Grids: Stretching



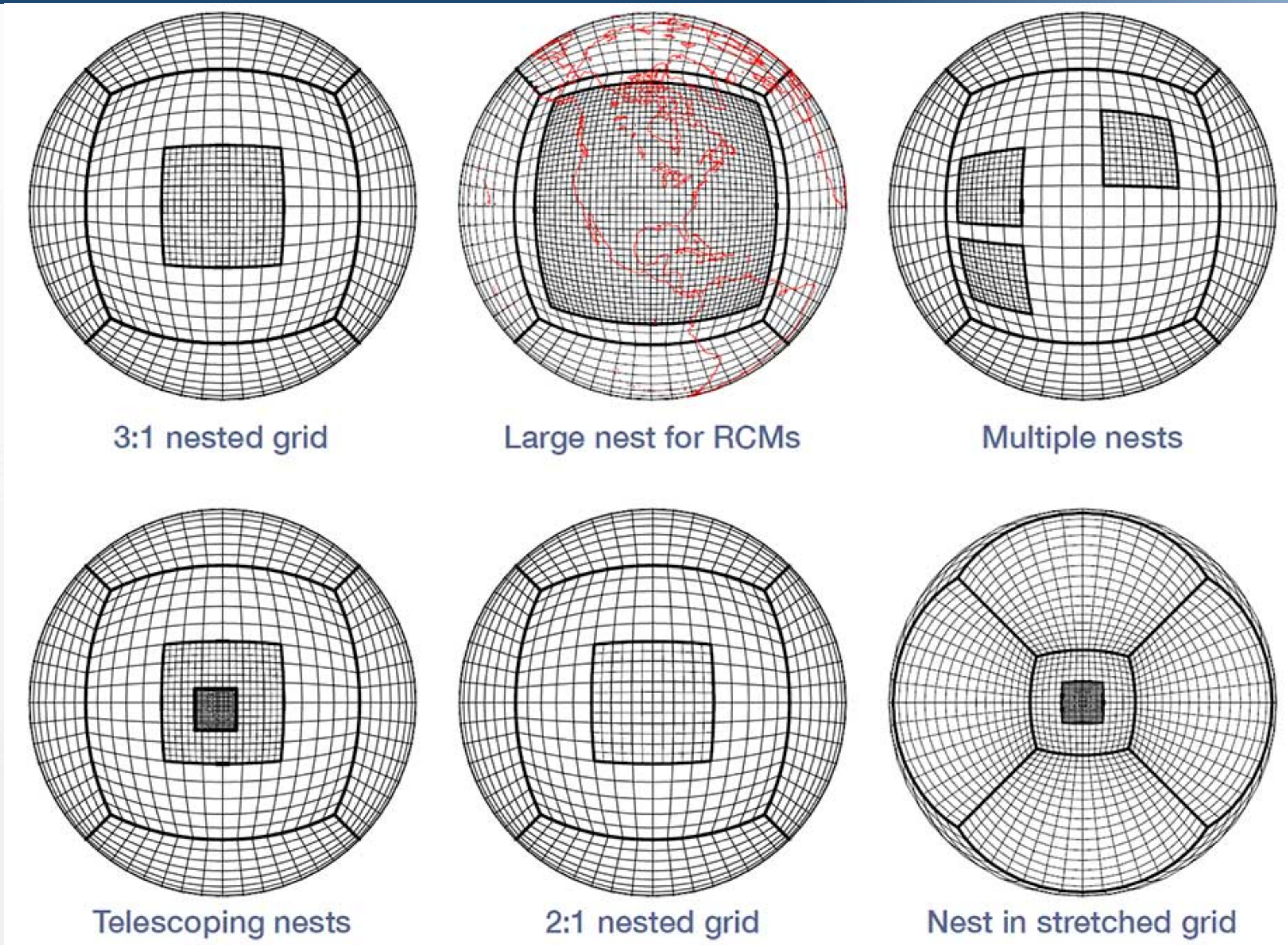


- Smoothly-varying resolution between the enhanced- and degraded-resolution regions
- This configuration has been used to explore tornado-producing supercell predictions (500m)

Source: Described in Harris et al. 2016

Other Non-Uniform Grids: 2-Way Nesting

Sample improvements: orographic precip, hurricane intensity, large-scale climate stats

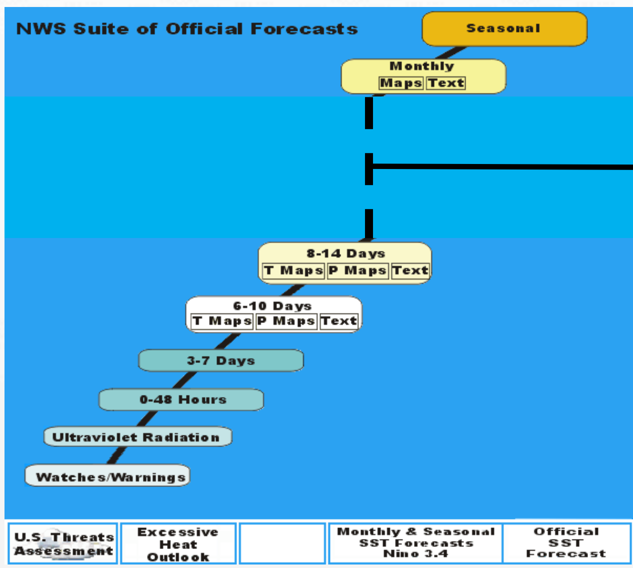


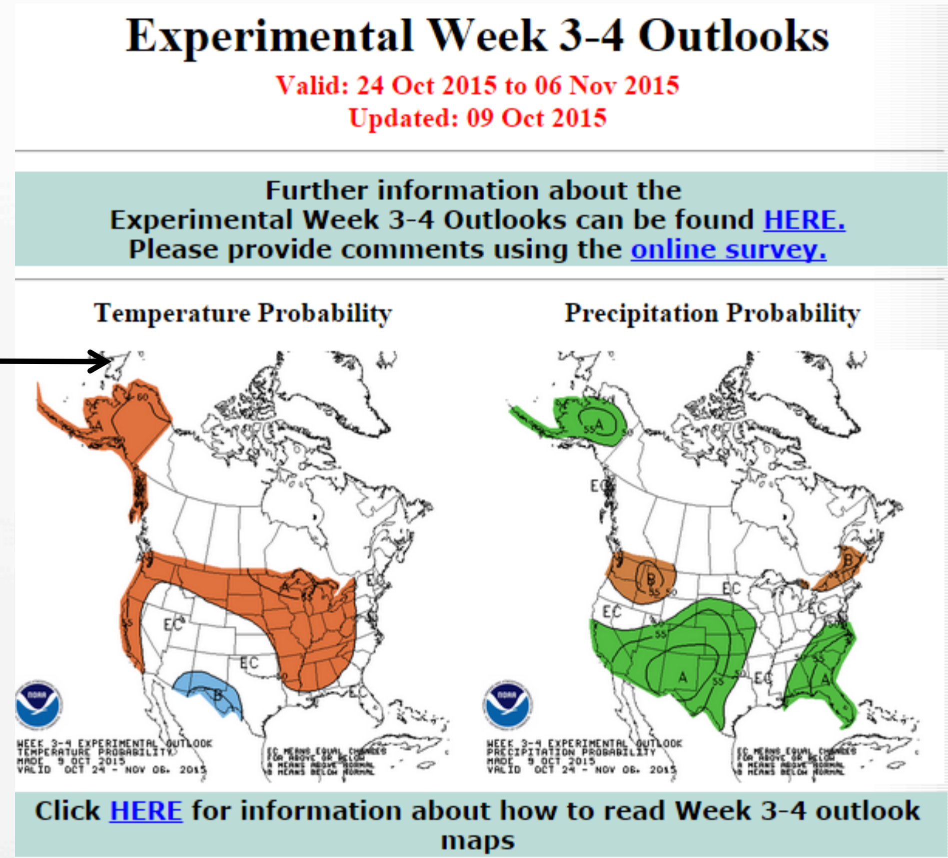
10 km over North America in Harris et al. 2016; 25 km in Harris et al. 2014

Special recognition to Stephen Baxter (CPC) and especially to Dan Harnos (CPC) for providing forecast performance data

Statistical Forecast Guidance

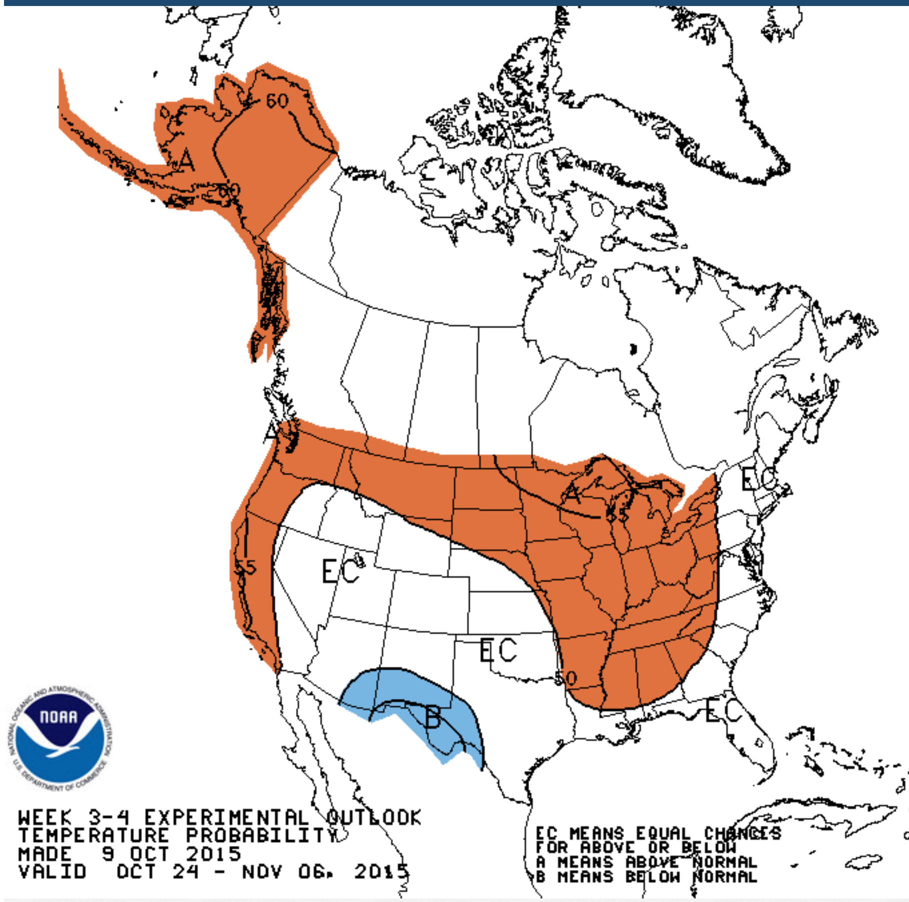
Scientists at GFDL are developing new S2S statistical forecast guidance for operational products

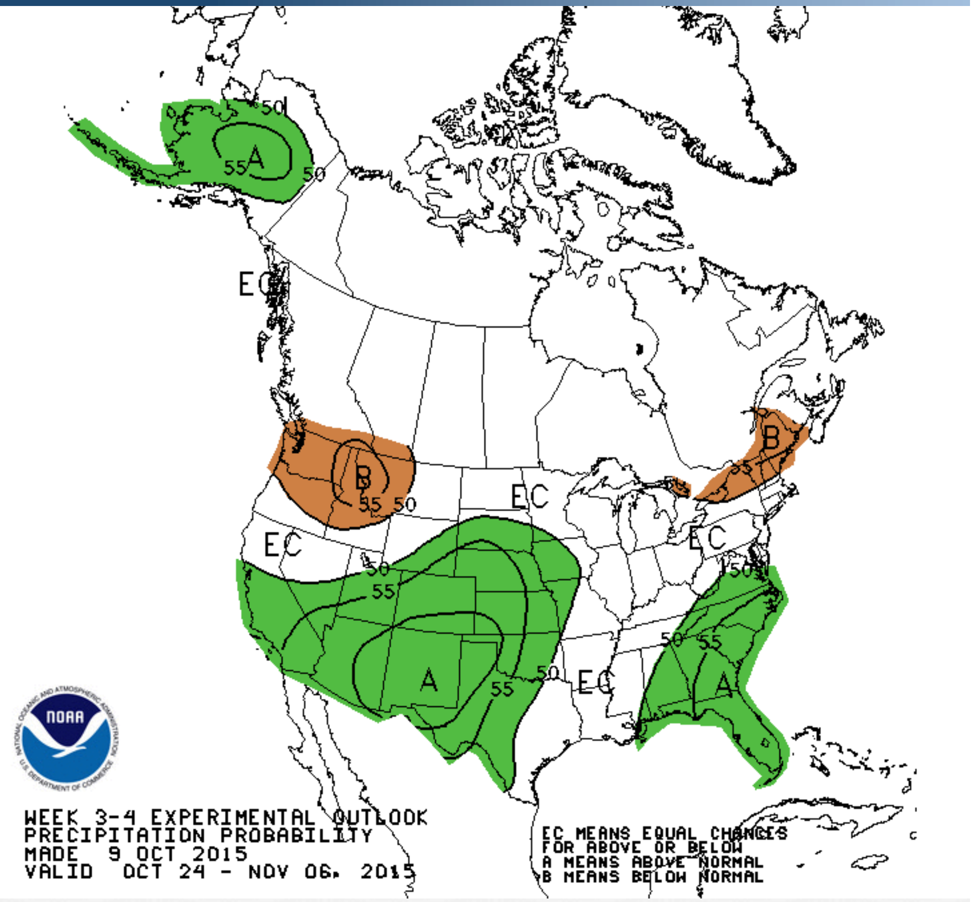




- Collaboration with NOAA CPC to bridge the forecast gap in weeks 3-4
- Statistical forecast model based on: ENSO, the MJO, and linear trend
- Forecast guidance transitioned into implementation of Experimental Week 3-4 Outlooks – awaiting transition to official operations

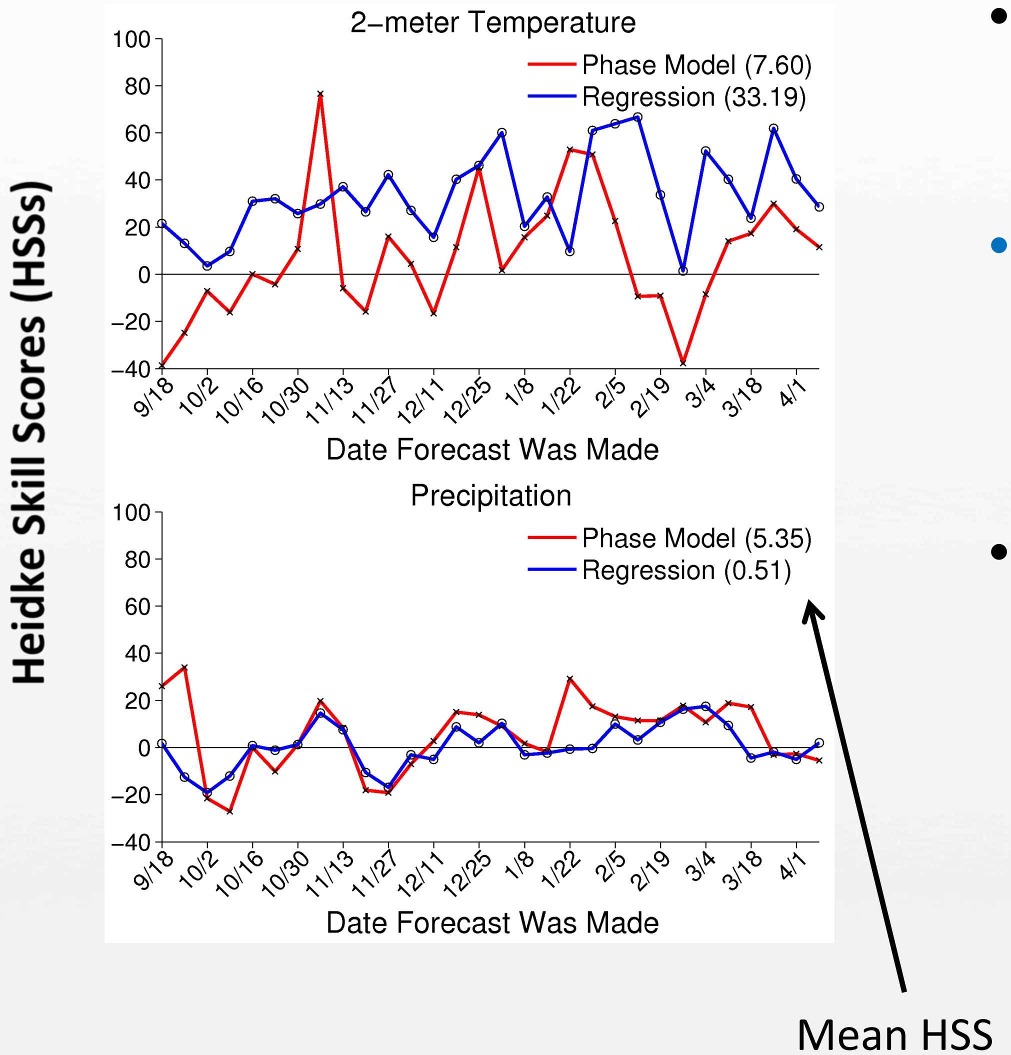
Example utilization of statistical forecast guidance





Statistical guidance emphasizing the subseasonal ENSO footprint was strongly utilized. This guidance, along with the dynamical consensus leads to a more confident precipitation outlook relative to temperature. Above-median precipitation is favored

The statistical forecast guidance been successful over CONUS but **success greater for temperature than for precipitation.**

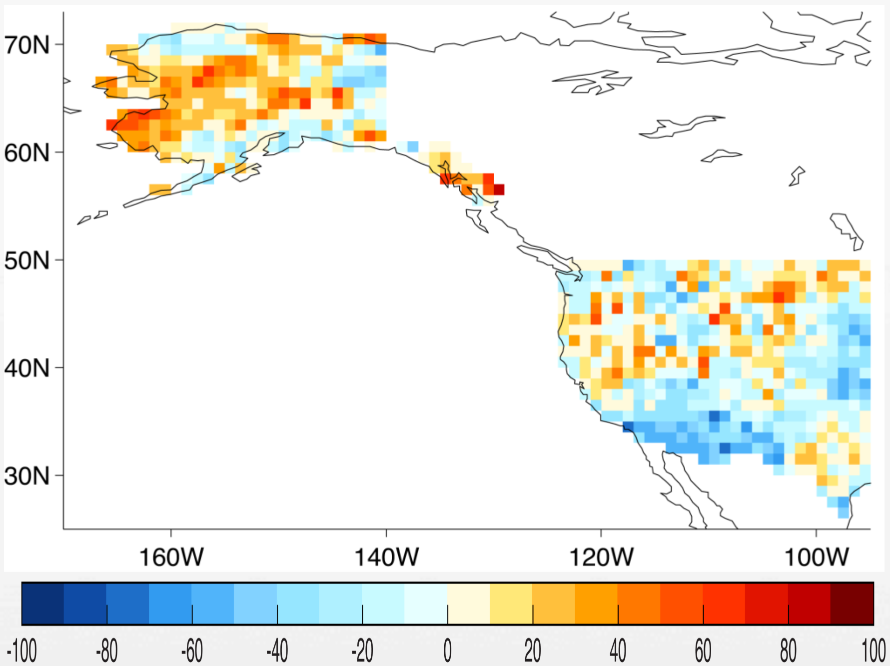


- HSS > 0: skill relative to a random forecast
- Blue and red lines: two different versions of the statistical model
- Precipitation phase model has outperformed the ECMWF (mean HSS = 2.9) and JMA (-0.7) but not the CFSv2 (11.0) dynamical forecast models

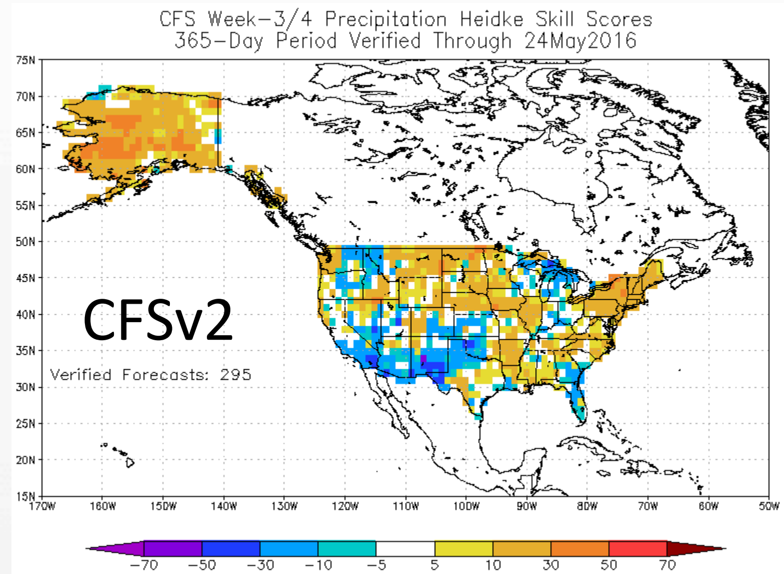
However, both statistical and dynamical forecast models have performed poorly in the southwestern U.S.

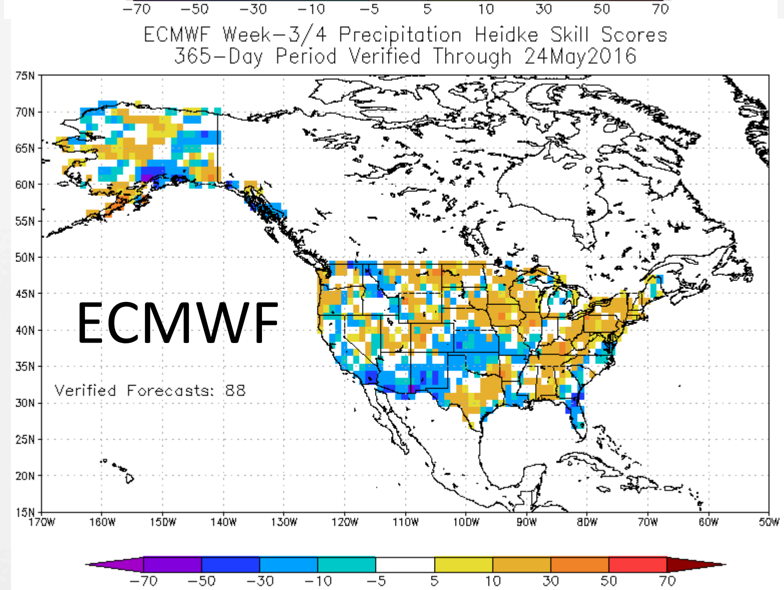
Statistical guidance

Mean Weeks 3-4 HSS for precipitation phase model since 9/18/15



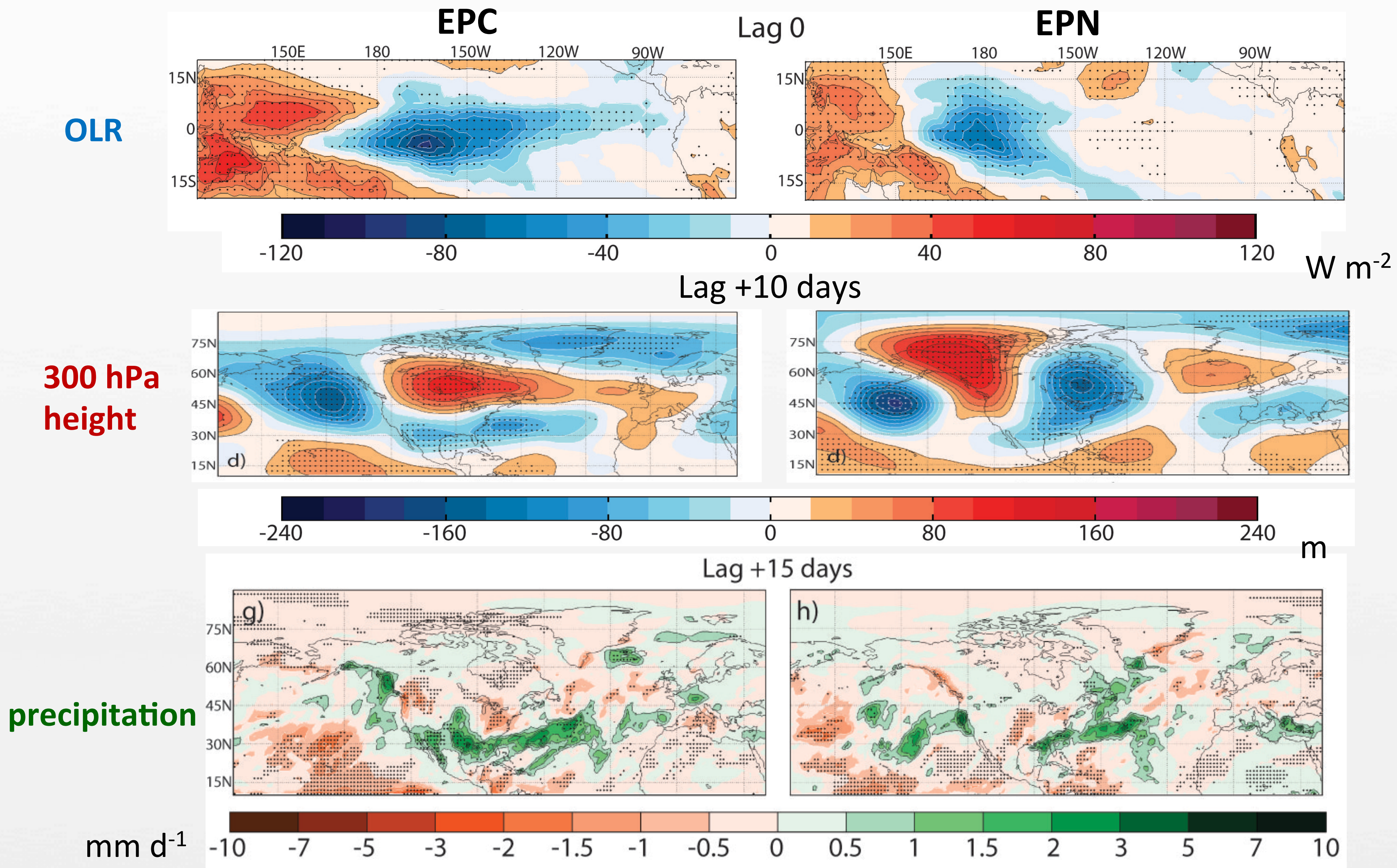
Dynamical guidance





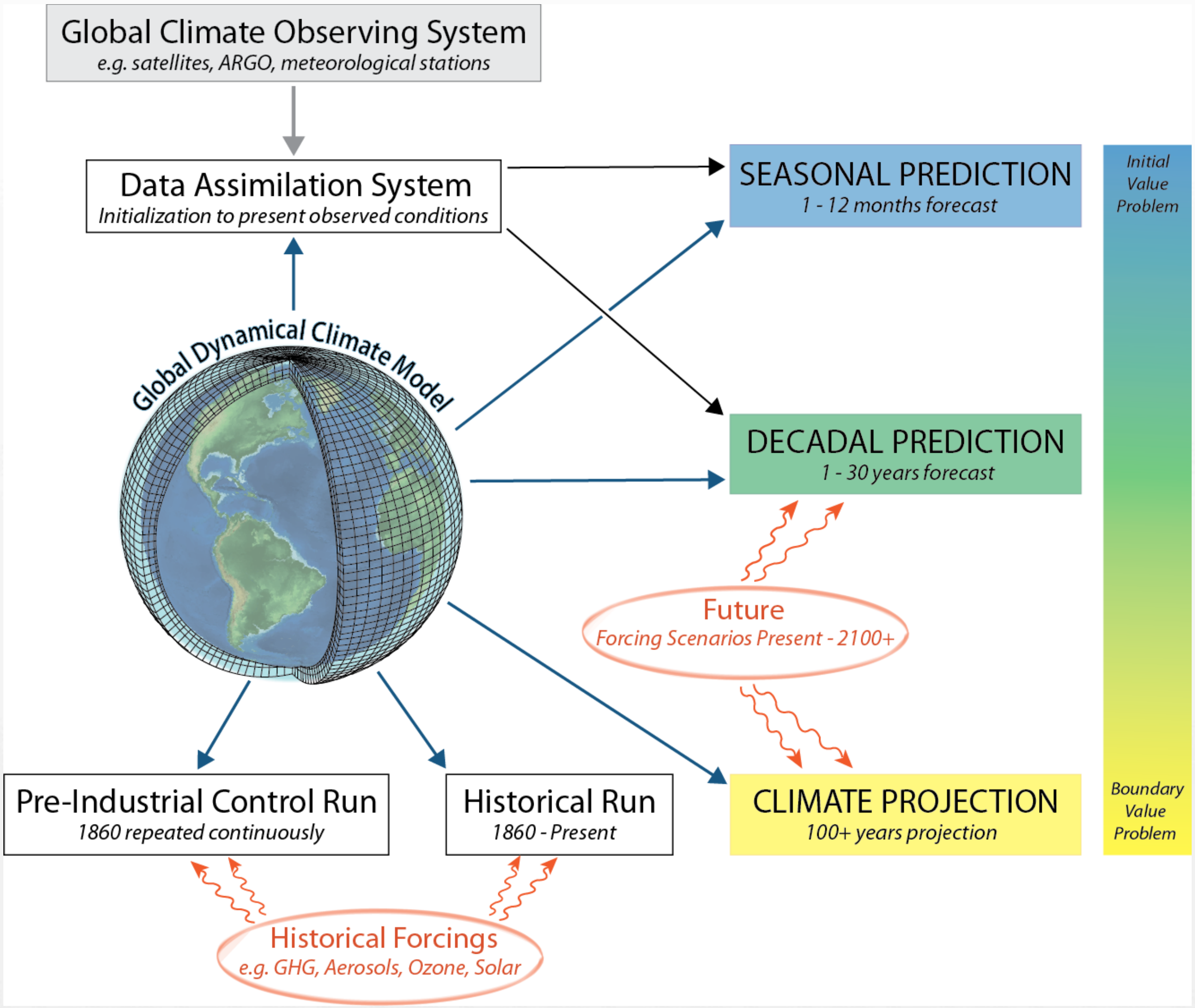
GFDL scientists have been investigating variations in the S2S precipitation response to El Niño.

Convective (**EPC**) and non-convective eastern Pacific (**EPN**) events (Johnson and Kosaka 2016)



SUMMARY

Dynamical Models for Data Assimilation to Climate Scales



Source: Tommasi et al., in preparation

Selected Team members of presented research

GFDL

- TL Delworth
- R Gudgel
- L Harris
- SB Kapnick
- SJ Lin
- C Stock
- S Underwood
- GA Vecchi
- F Zeng

Princeton U.

- S Fueglistaler
- L Jia
- N Johnson
- P Lin
- H Murakami
- D Tommasi
- K van der Wiel

UCAR (at GFDL)

- WF Cooke
- X Yang

Various

- S Bordoni and S Pascale (Caltech)
- CY Tu (Academia Sinica)
- Adam Schaife (Met Office)
- Participants (Fisheries Prediction Workshop)

Referenced GFDL Research

- Harris, L.M., Lin, S.-J., and Tu., C.Y., 2016: High-Resolution Climate Simulations Using GFDL HiRAM with a Stretched Global Grid. Journal of Climate, 29, DOI:10.1175/JCLI-D-15-0389.1.
- Harris, L.M. and S.-J. Lin, 2014: Global-to-regional nested-grid climate simulations in the GFDL High Resolution Atmosphere Model. Journal of Climate, 27(13), DOI:10.1175/JCLI-D-13-00596.1.
- Jia, L., Yang ,X., Vecchi, G., Gudgel, R., Delworth, T., Fueglistaler, S., Lin, P., Scaife, A., Underwood, S., and Lin, S.J., 2016: Seasonal Prediction Skill of Northern Extratropical Surface Temperature Driven by the Stratosphere. Submitted.
- Johnson, N., and Y. Kosaka, 2016: The role of eastern equatorial Pacific convection on the diversity of boreal winter El Niño teleconnection patterns. In Press at Climate Dynamics. DOI:10.1007/s00382-016-3039-1.
- Kapnick, S., and Coauthors, 201X: Prediction of US Snowpack. In Preparation.
- Pascale, S., Bordoni, S., Kapnick, S., Vecchi, G., Jia, L., Delworth, T., Underwood, S., Anderson, W., 2016: The impact of horizontal resolution on North American monsoon Gulf of California moisture surges in a suite of coupled global climate models. In Press at Journal of Climate
- Tommasi, D., and Coauthors, 201X, Managing living marine resources in a dynamic environment: the role of seasonal to decadal climate forecasts. In Preparation.
- van der Wiel, K., Kapnick, S., Vecchi, G., Cooke, W., Delworth, T., Jia, L., Murakami, H., Underwood, S., and Zeng, F., 2016: The resolution dependence of US precipitation extremes in response to CO2 forcing. In Press at Journal of Climate.
- Yang, X., Vecchi, G.A., Jia, L., Kapnick, S., Delworth, T.L., Gudgel, R., Underwood, S., 2016: On the flipping of the western United States 2015/2016 winter El Niño precipitation pattern. Submitted.

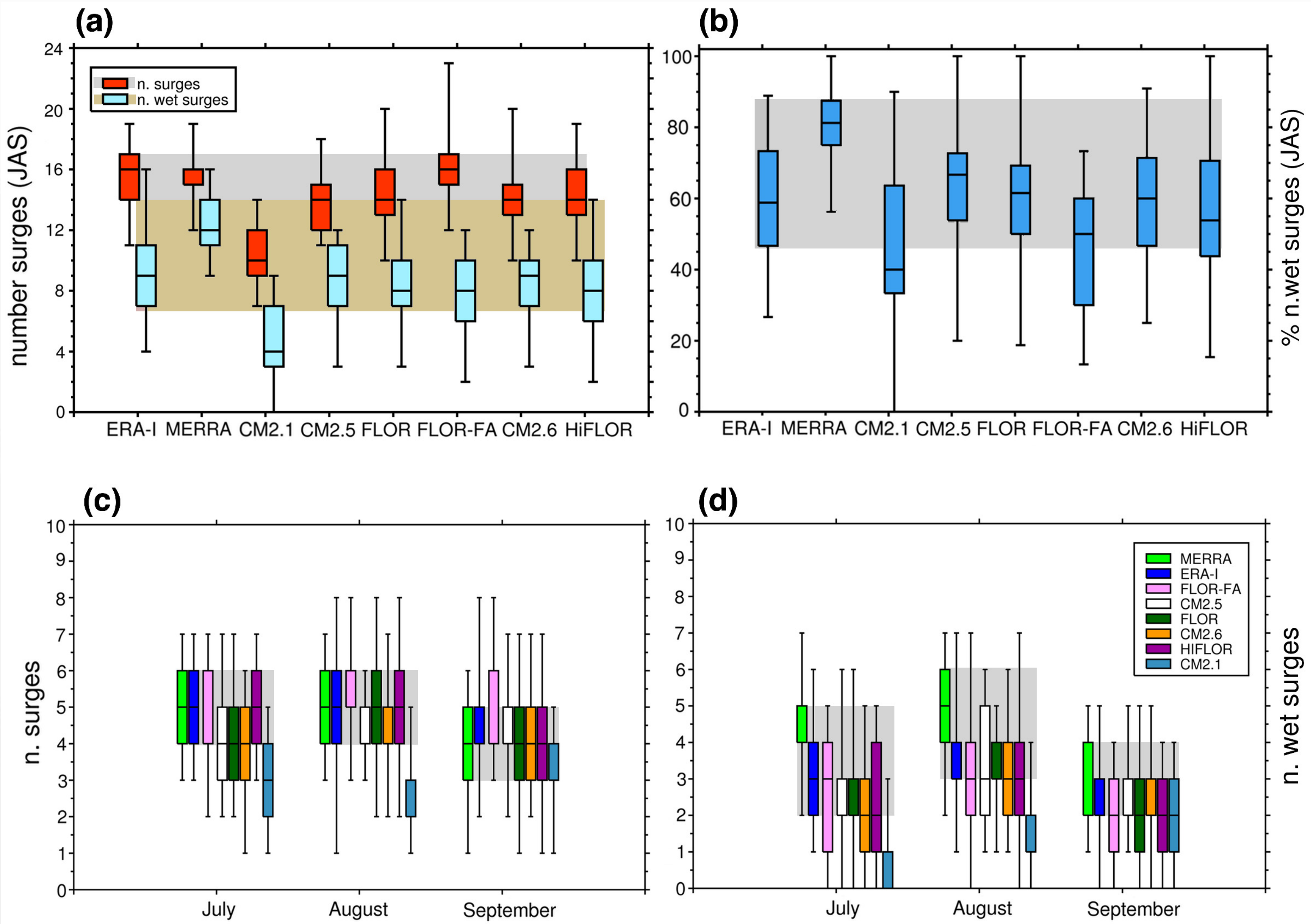
EXTRAS

GFDL Coupled CM2X Models

Model	Atmosphere resolution (horizontal/vertical)	Ocean resolution (horizontal/vertical)	General reference
CM2.1	$2^\circ \times 2^\circ$(lat$\times$lon)/L24	$1^\circ \times 1^\circ$ / L50	Delworth et al. (2006)
FLOR	$1^\circ \times 1^\circ$ / L32	$1^\circ \times 1^\circ$ / L50	Vecchi et al. (2014)
FLOR-FA	$1^\circ \times 1^\circ$ / L32	$1^\circ \times 1^\circ$ / L50	Vecchi et al. (2014)
HiFLOR	$0.25^\circ \times 0.25^\circ$ / L32	$1^\circ \times 1^\circ$ / L50	Murakami et al. (2015)
CM2.5	$1^\circ \times 1^\circ$ / L32	$0.25^\circ \times 0.25^\circ$ / L50	Delworth et al. (2012)
CM2.6	$1^\circ \times 1^\circ$ / L32	$0.1^\circ \times 0.1^\circ$ / L50	Delworth et al. (2012)

Source: Pascale et al. 2016

North American Monsoon



Source: Pascale et al. 2016