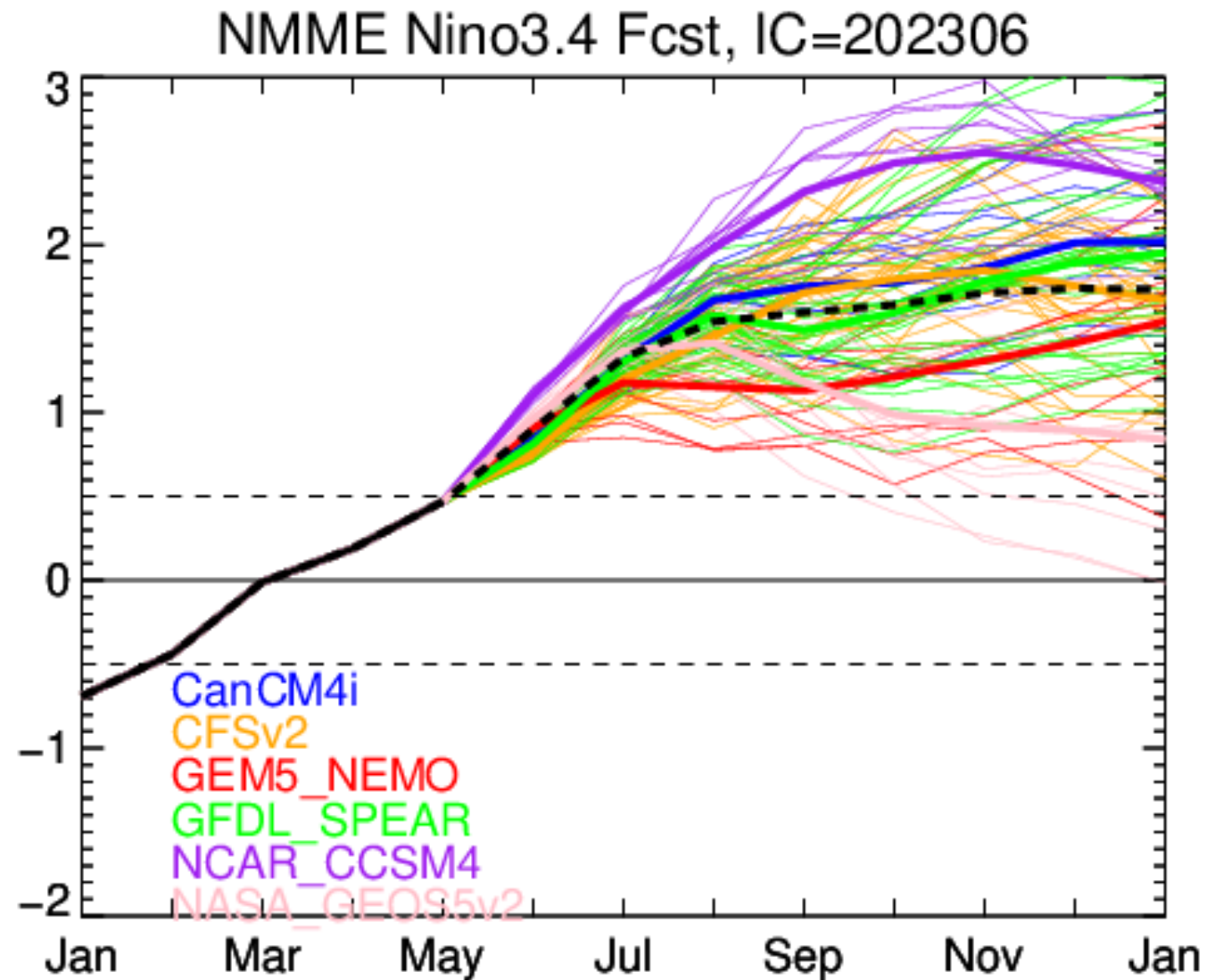


Ben Kirtman, Emily
Becker (UM/CIMAS)
& Matt Rosencrans
(NOAA/CPC)

NMME Prediction & Predictability Research



NMME Predictability & Prediction Research

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Evolution of NMME Models

THE NORTH AMERICAN MULTIMODEL ENSEMBLE

Phase-1 Seasonal-to-Interannual Prediction; Phase-2 toward Developing Intraseasonal Prediction

BY BEN P. KIRTMAN, DUGHONG MIN, JOHNNA M. INFANTI, JAMES L. KINTER III, DANIEL A. PAOLINO, QIN ZHANG, HUUG VAN DEN DOOL, SURANJANA SAHA, MALAQUIAS PENA MENDEZ, EMILY BECKER, PEITAO PENG, PATRICK TRIPP, JIN HUANG, DAVID G. DEWITT, MICHAEL K. TIPPETT, ANTHONY G. BARNSTON, SHUHUA LI, ANTHONY ROSATI, SIEGFRIED D. SCHUBERT, MICHELE RIENECKER, MAX SUAREZ, ZHAO E. LI, JELENA MARSHAK, YOUNG-KWON LIM, JOSEPH TRIBBIA, KATHLEEN PEGION, WILLIAM J. MERRYFIELD, BERTRAND DENIS, AND ERIC F. WOOD

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NASA-GMAO-GEOS52S	2018 – present	4	1 mem ev. 5 day	0-9	GEOS5 AGCM 0.5° L72	MOM5 L40 0.5° Eq	Molod et al. (2018)
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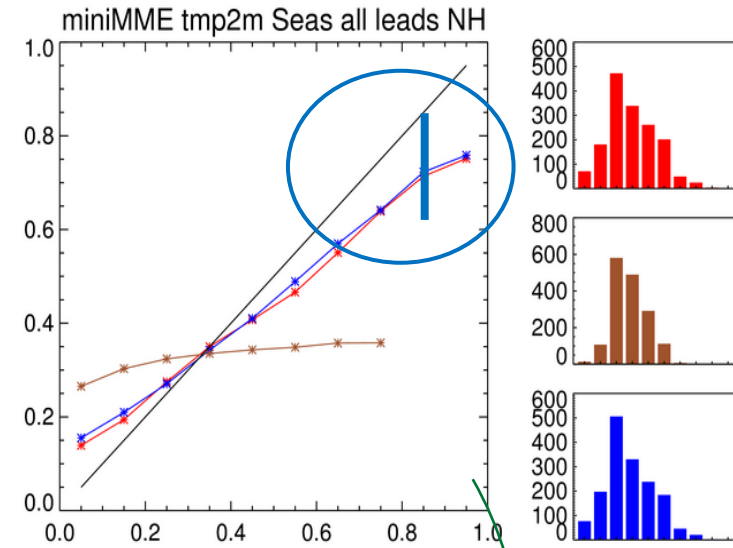
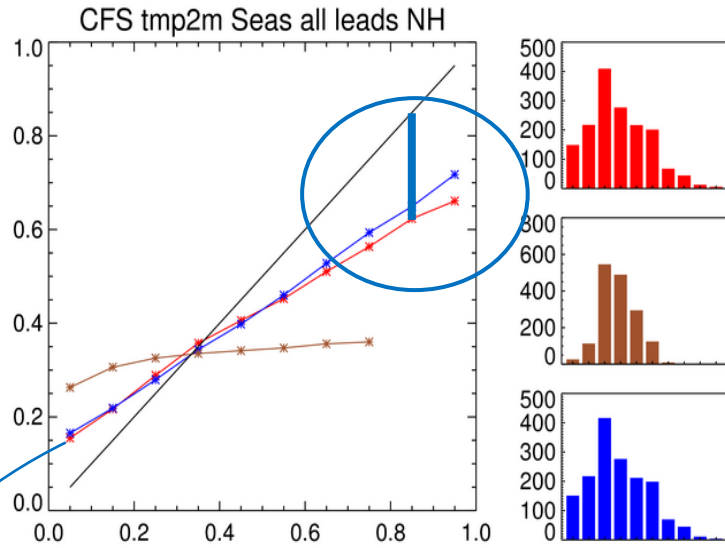
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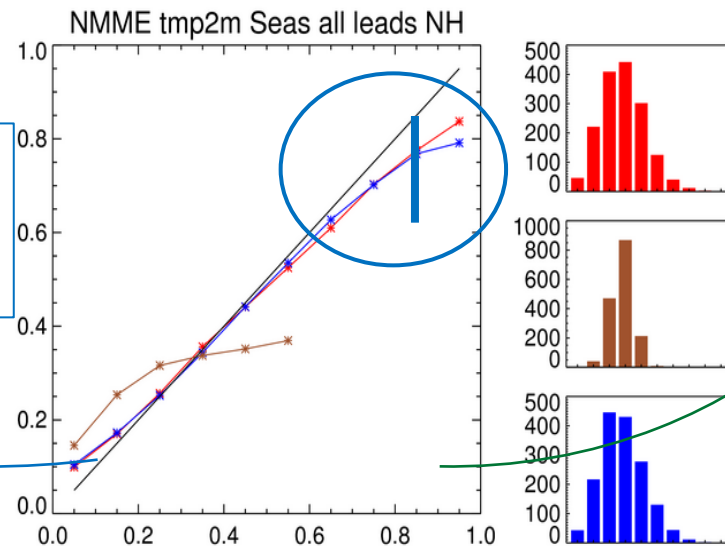
Evolution of NMME Models

Reliability: If the forecast calls for a 70% chance of being warm, was it in fact warm 70% of the time?

“Apples to Apples” for Multi-Model Impact



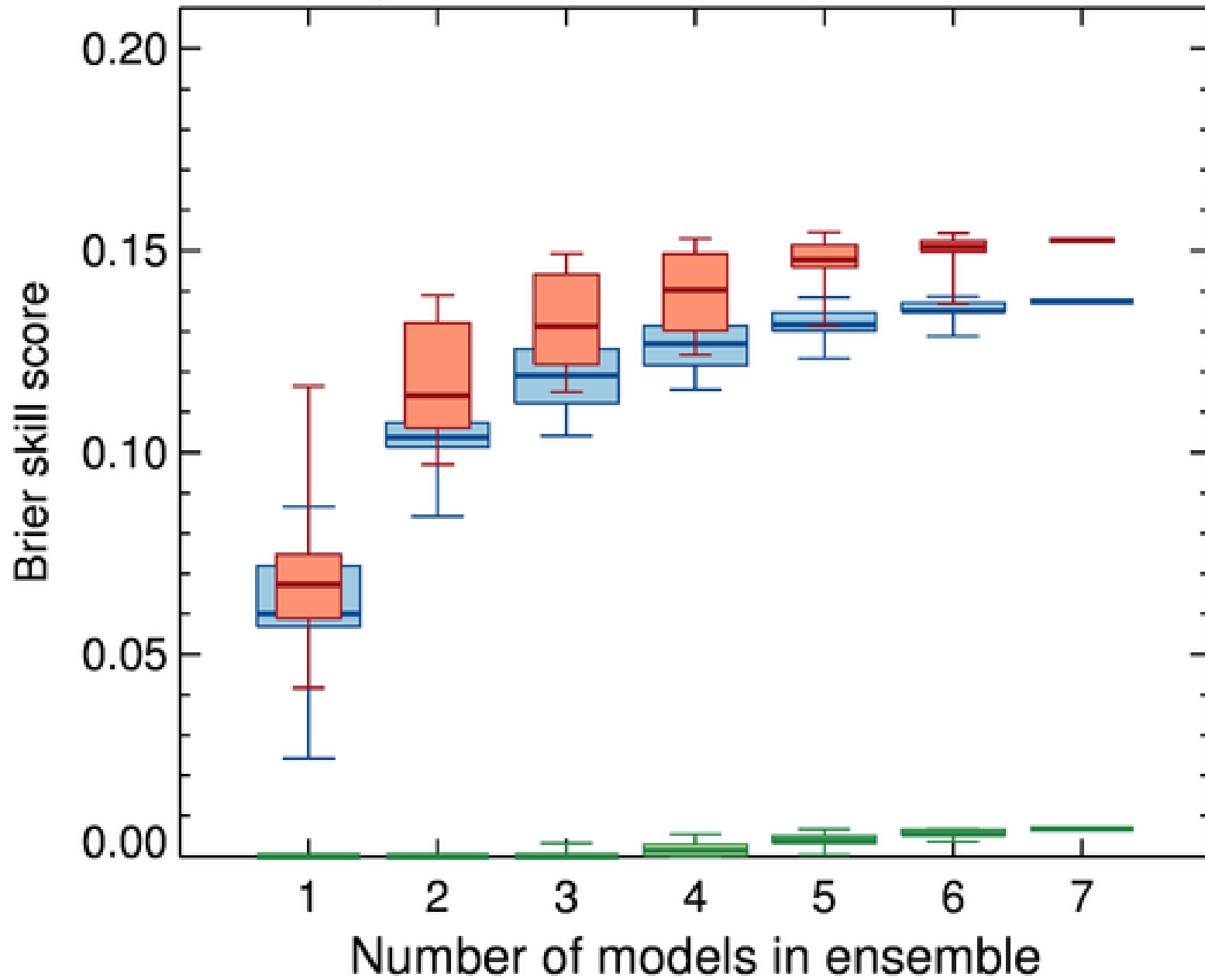
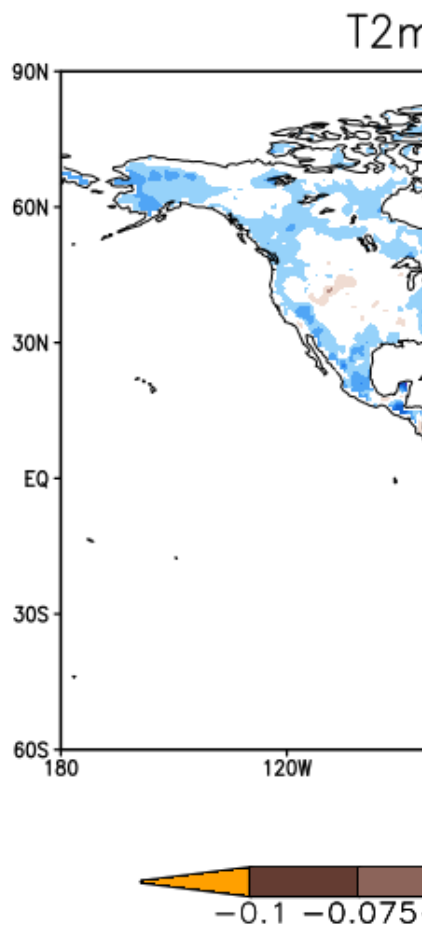
**“Oranges to Apples:”
Ensemble size and Multi-
Model**



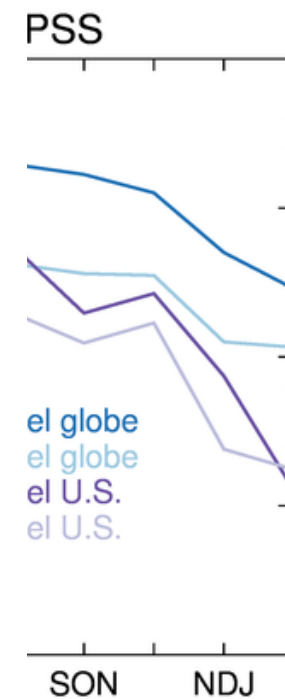
**“Apples to Apples” for
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**North American Multi-
Model Ensemble: NMME**

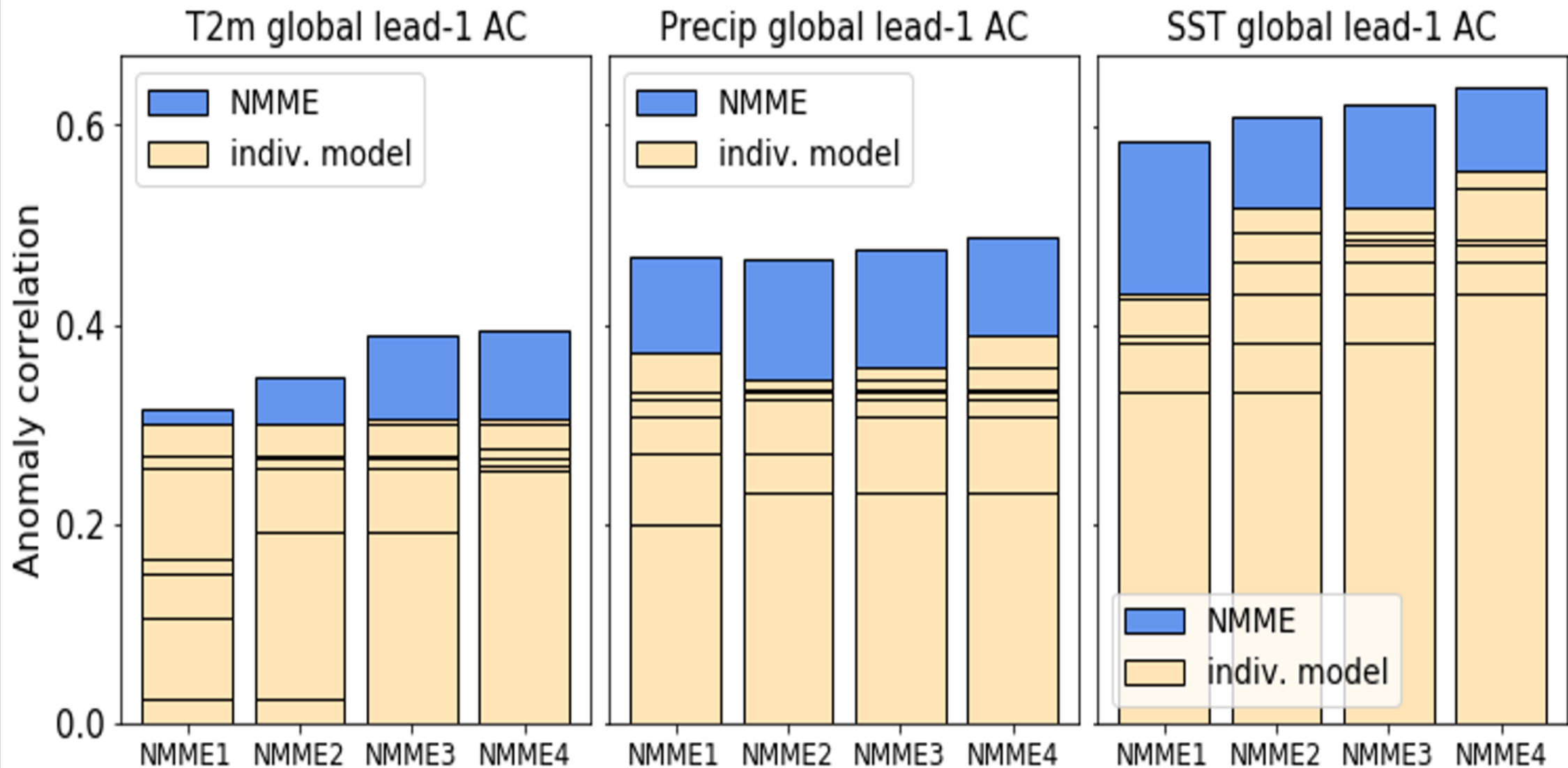
BSS tmp2m North. Hem., FebIC for MAM



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Individual Model Improvements Lead to NMME Improvements

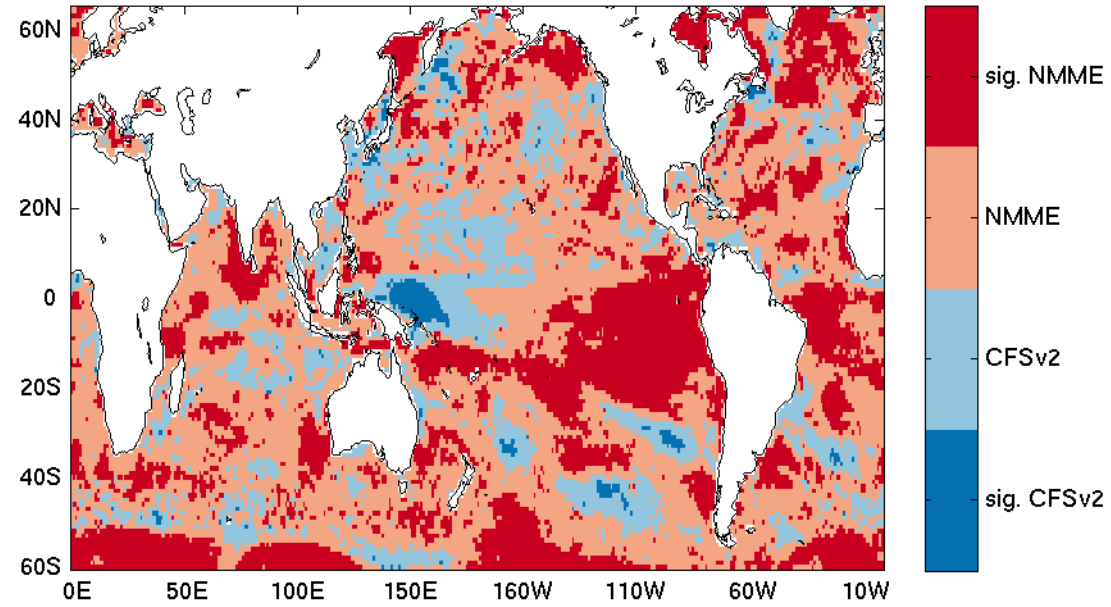


NMME Predictability & Prediction Research

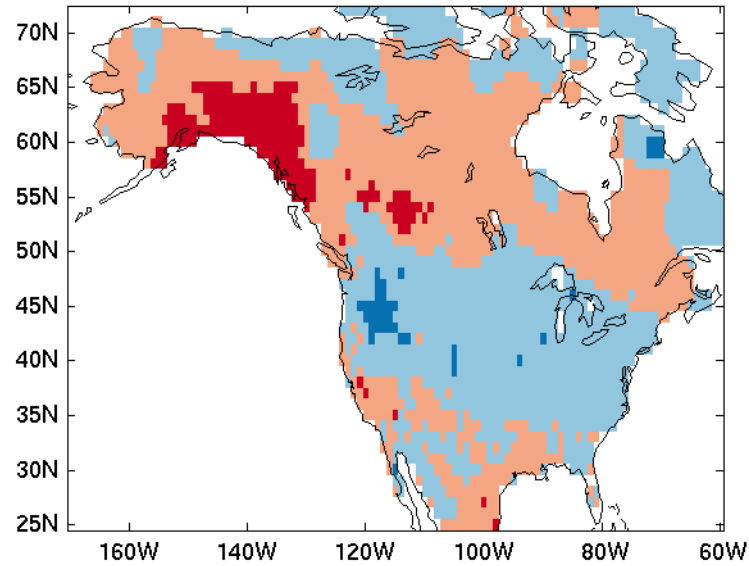
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Mean Squared Error Sign Test

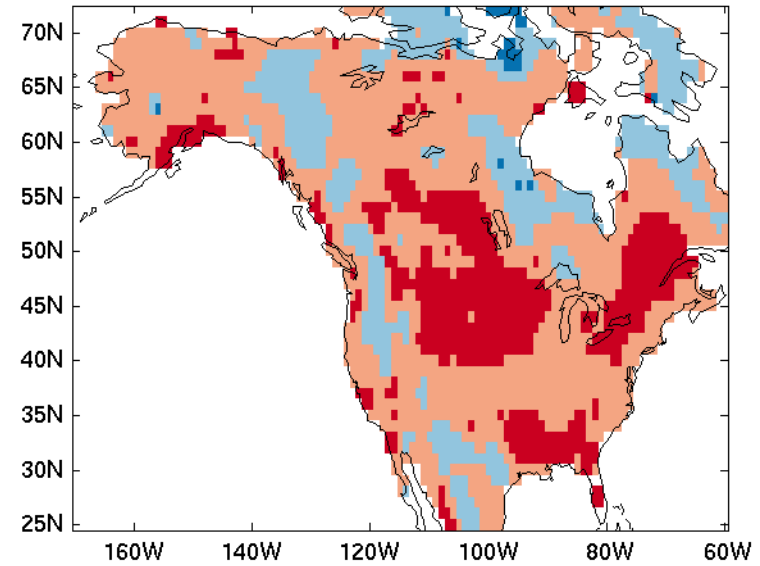
MSE advantage DJF Jul start SST (dual climatology)



MSE advantage DJF Jul start tref (dual climatology)



MSE advantage DJF Jul start prec (dual climatology)



NMME Predictability & Prediction Research

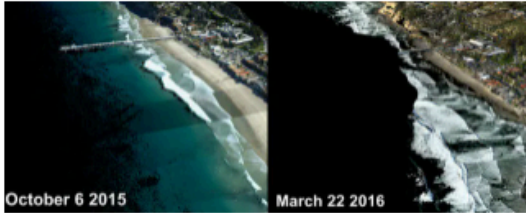
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TECH

Beach Erosion, Not Rain Was This El Niño's Major Impact

 by Chris Jennewein May 11, 2016

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Beach erosion south of the Scripps Pier caused by the El Niño. Courtesy Scripps Institution of Oceanography

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Predictable and Unpredictable Aspects of U.S. West Coast Rainfall and El Niño: Understanding the 2015/16 Event

BENJAMIN A. CASH AND NATALIE J. BURLS

Center for Ocean–Land–Atmosphere Studies, George Mason University, Fairfax, Virginia

Tropical Ocean Contributions to California's Surprisingly Dry El Niño of 2015/16

NICHOLAS SILER

Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California

YU KOSAKA

Research Center for Advanced Science and Technology, The University of Tokyo, Tokyo, Japan

SHANG-PING XIE

Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California

XICHEN LI

Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

Understanding Skill of Seasonal Mean Precipitation Prediction over California during Boreal Winter and Role of Predictability Limits

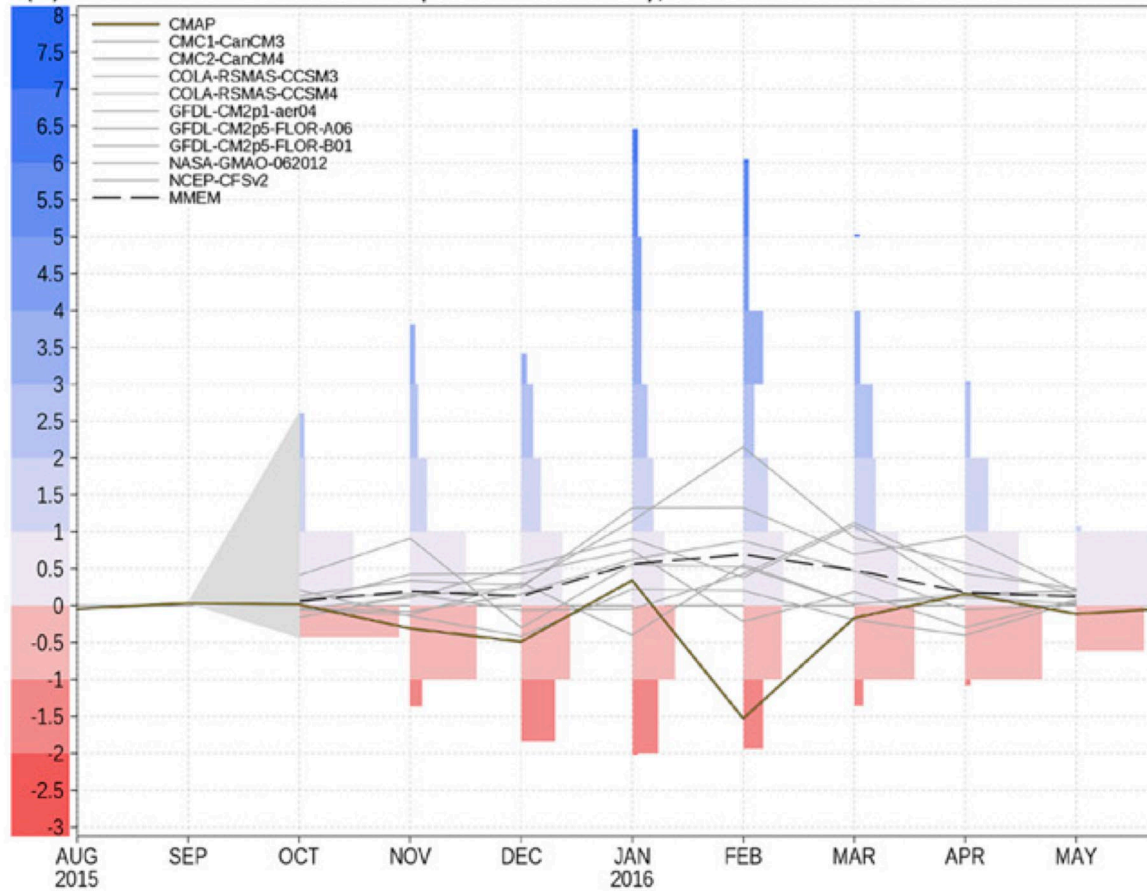
ARUN KUMAR AND MINGYUE CHEN

Climate Prediction Center, NCEP/NWS/NOAA, College Park, Maryland

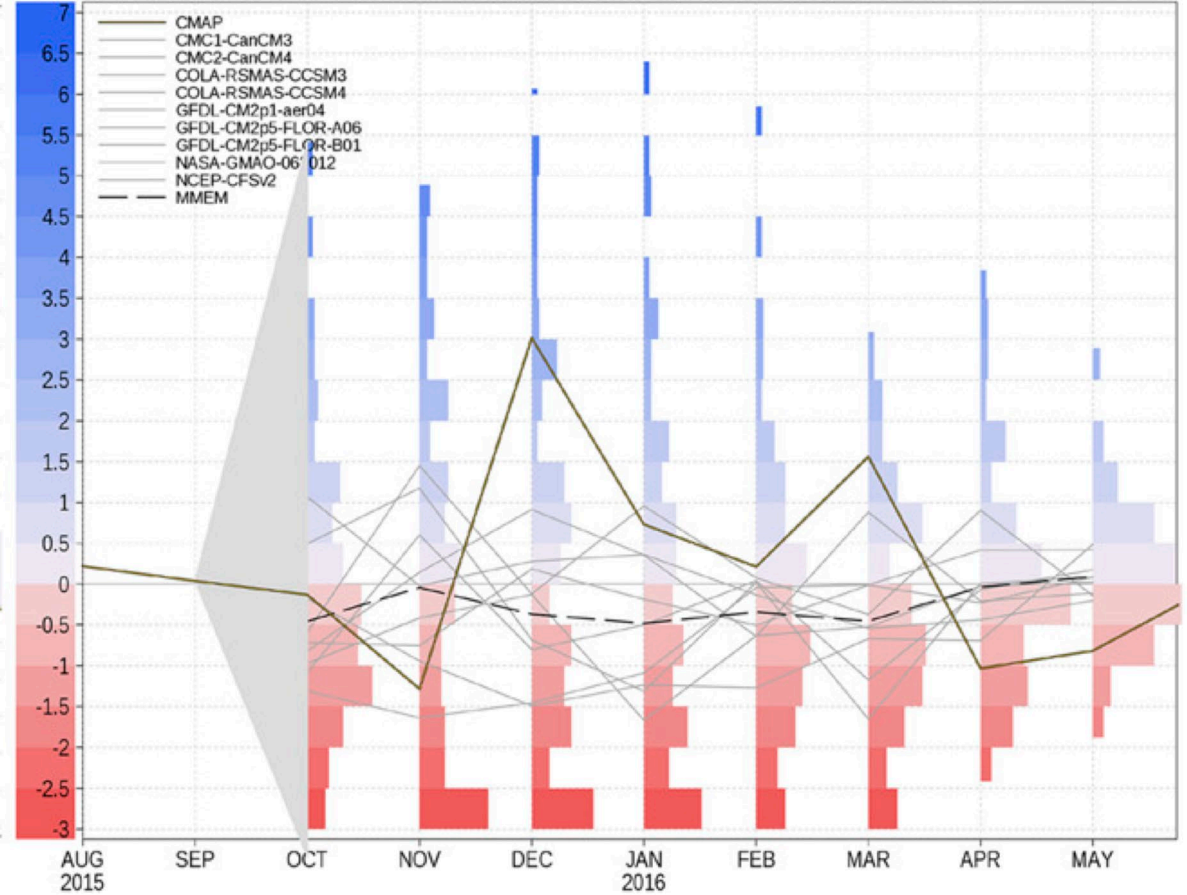
2015/16 Teleconnection that Wasn't

2015/16 Teleconnection that Wasn't – Predictability Issue

(e) Forecasts of SOCAL Precipitation anomaly, initialized October 2015

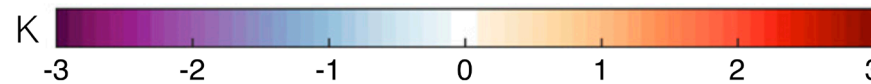
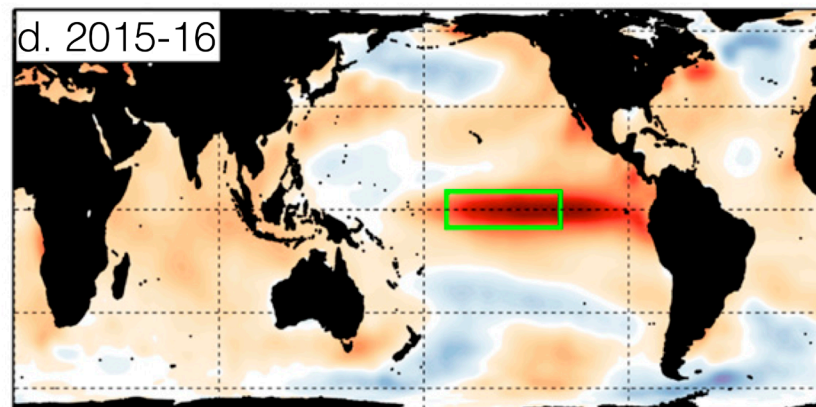
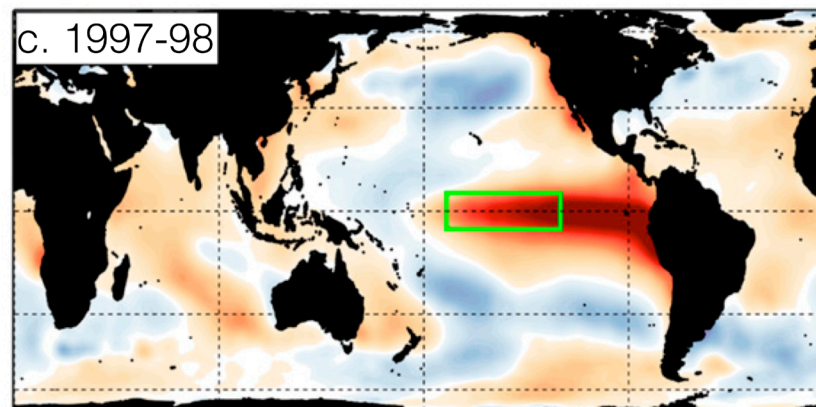
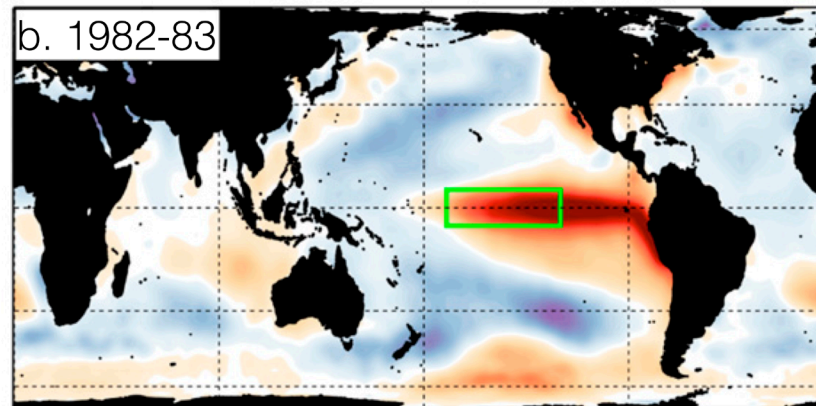
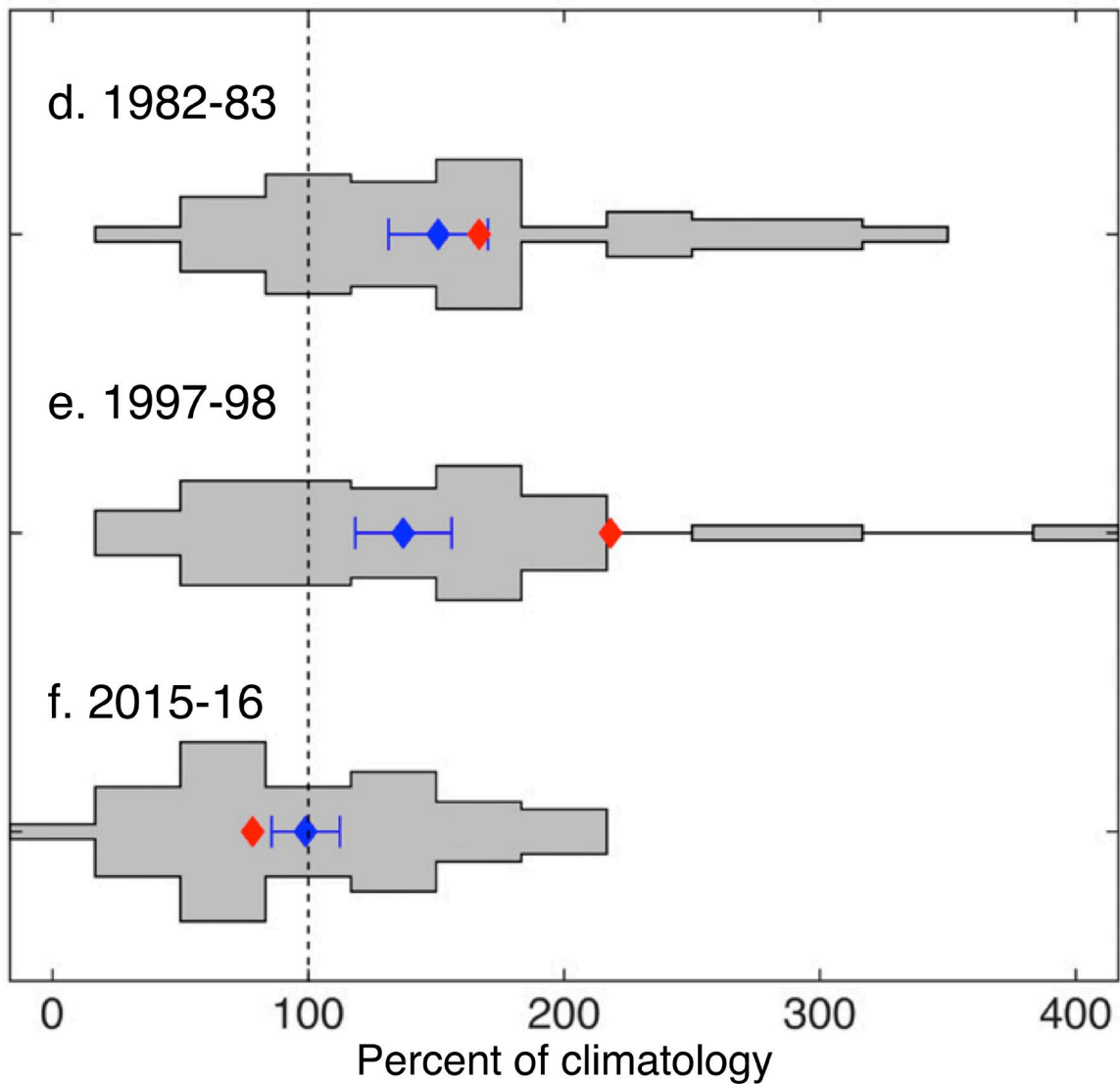


(f) Forecasts of PNW Precipitation anomaly, initialized October 2015



2015/16 Teleconnection that Wasn't – SST Forcing Issue

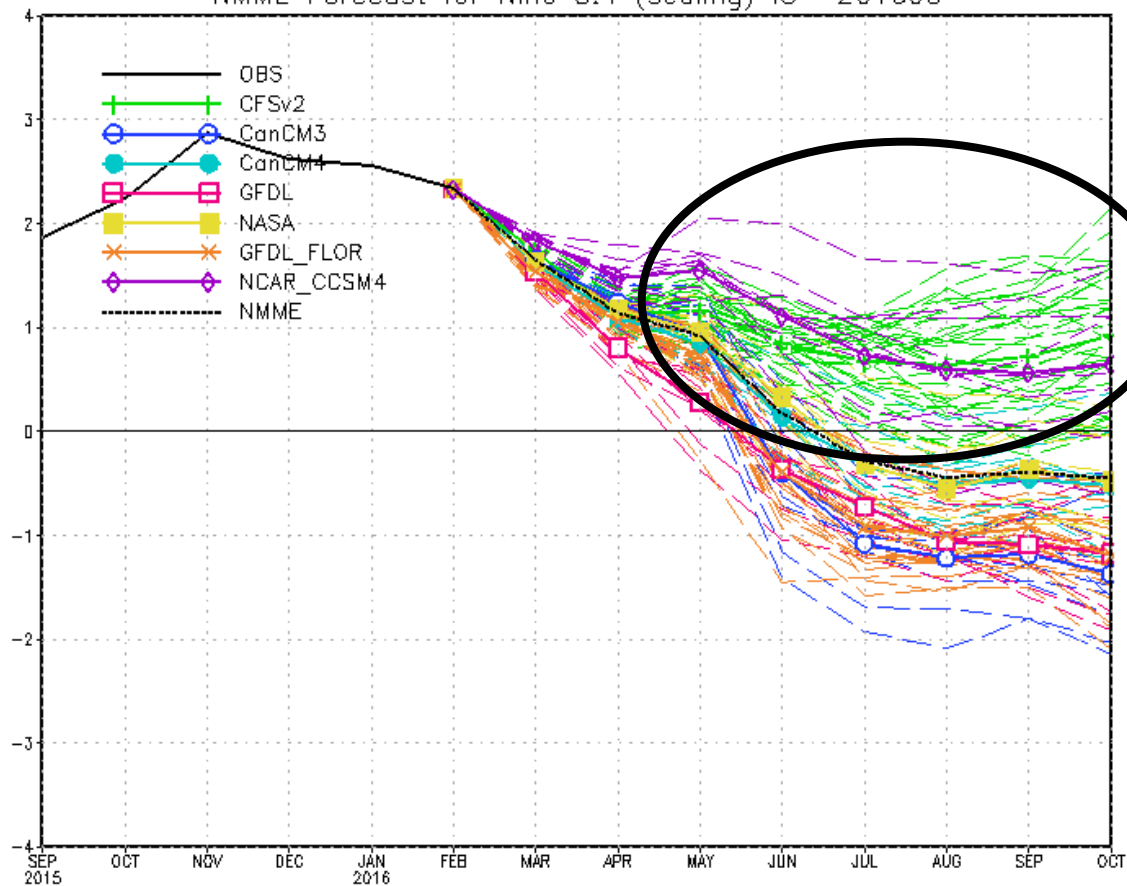
Southern California precipitation



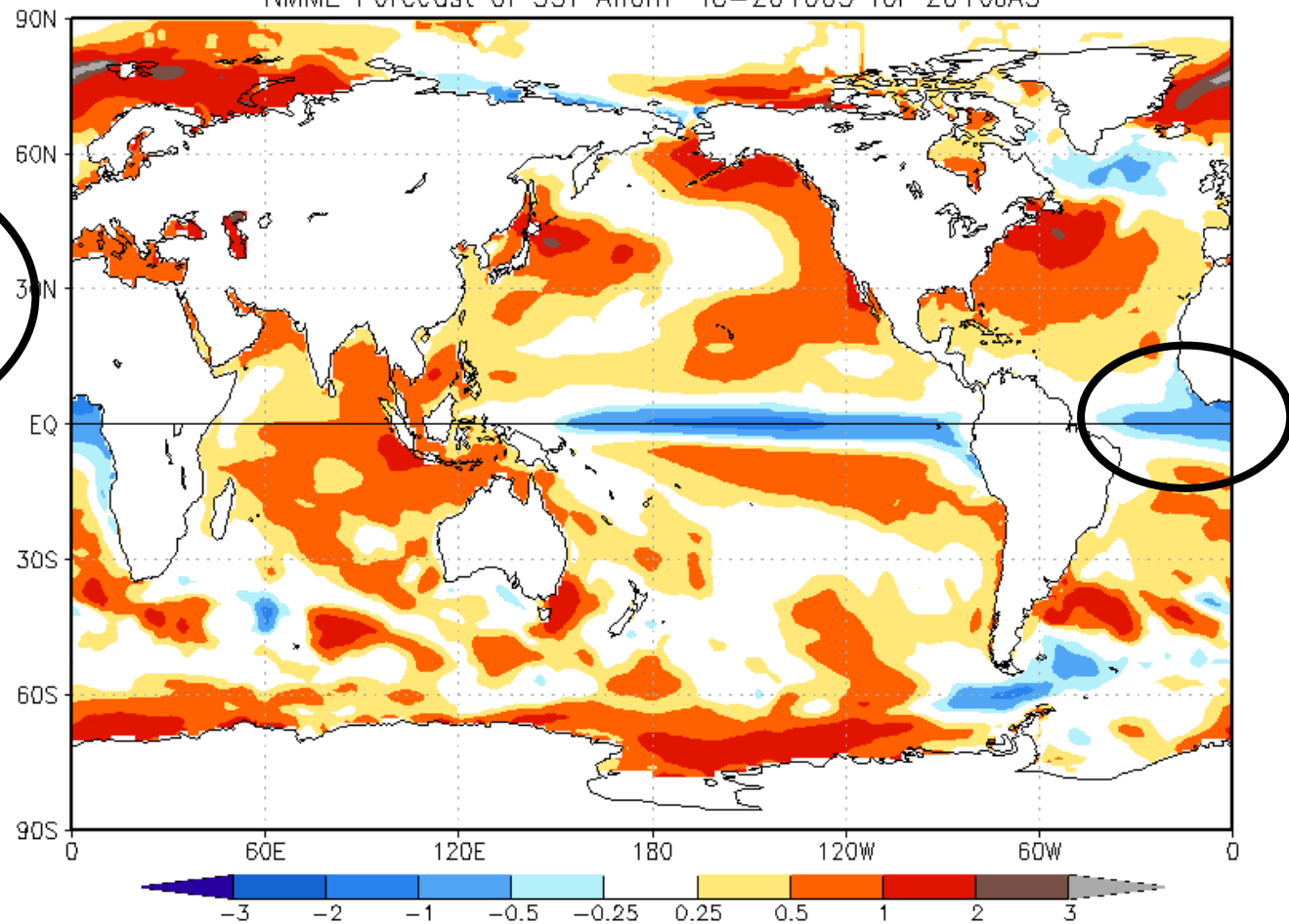
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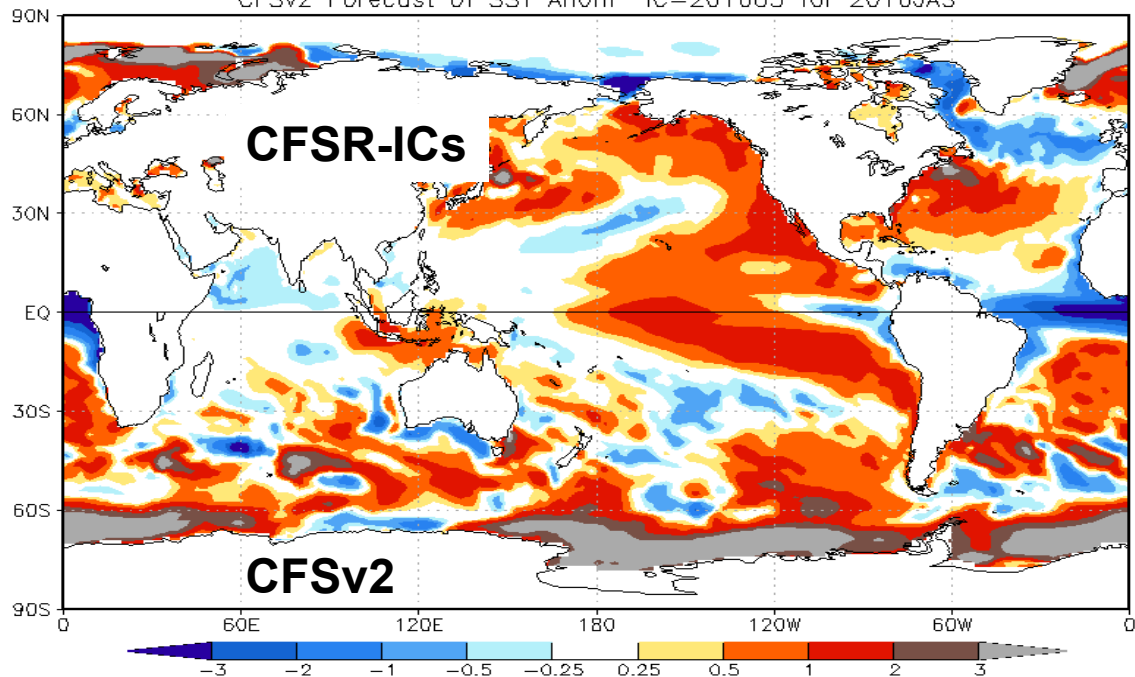
NMME Forecast for Nino 3.4 (scaling) IC= 201603



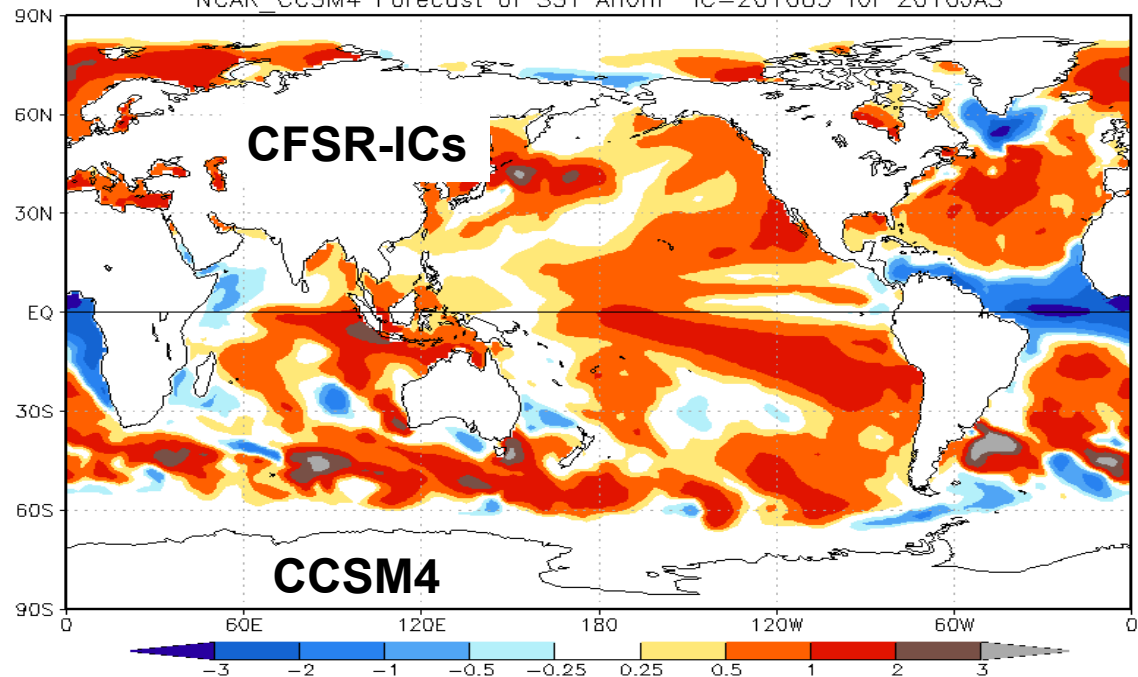
NMME Forecast of SST Anom IC=201603 for 2016JAS



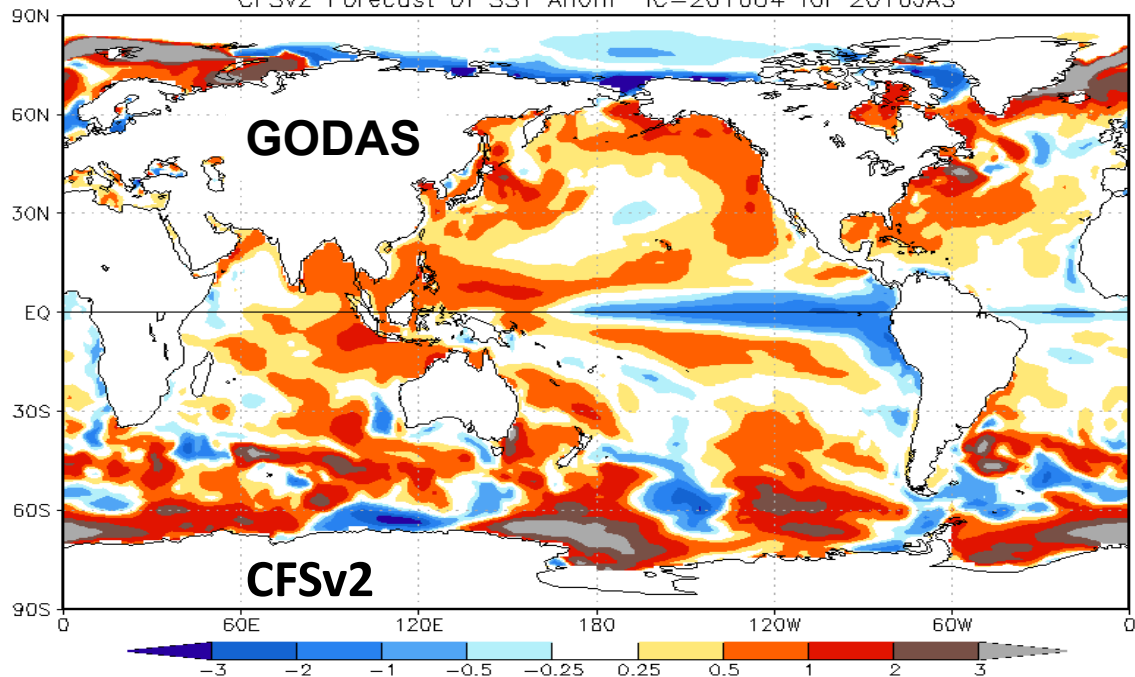
CFSv2 Forecast of SST Anom IC=201603 for 2016JAS



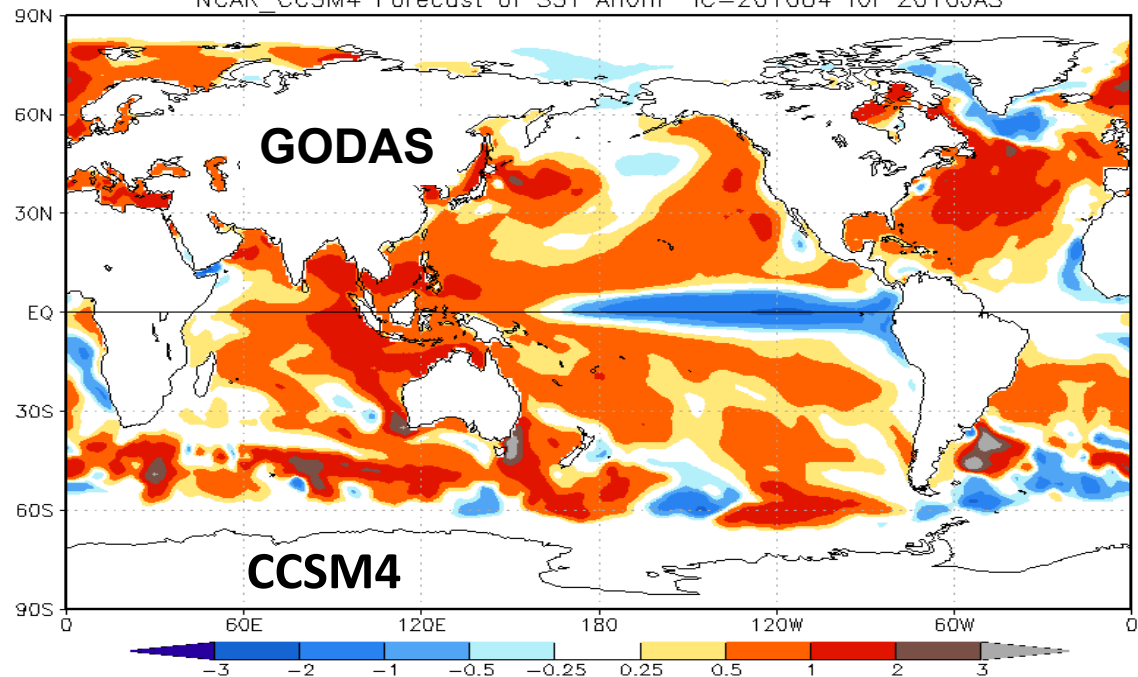
NCAR CCSM4 Forecast of SST Anom IC=201603 for 2016JAS



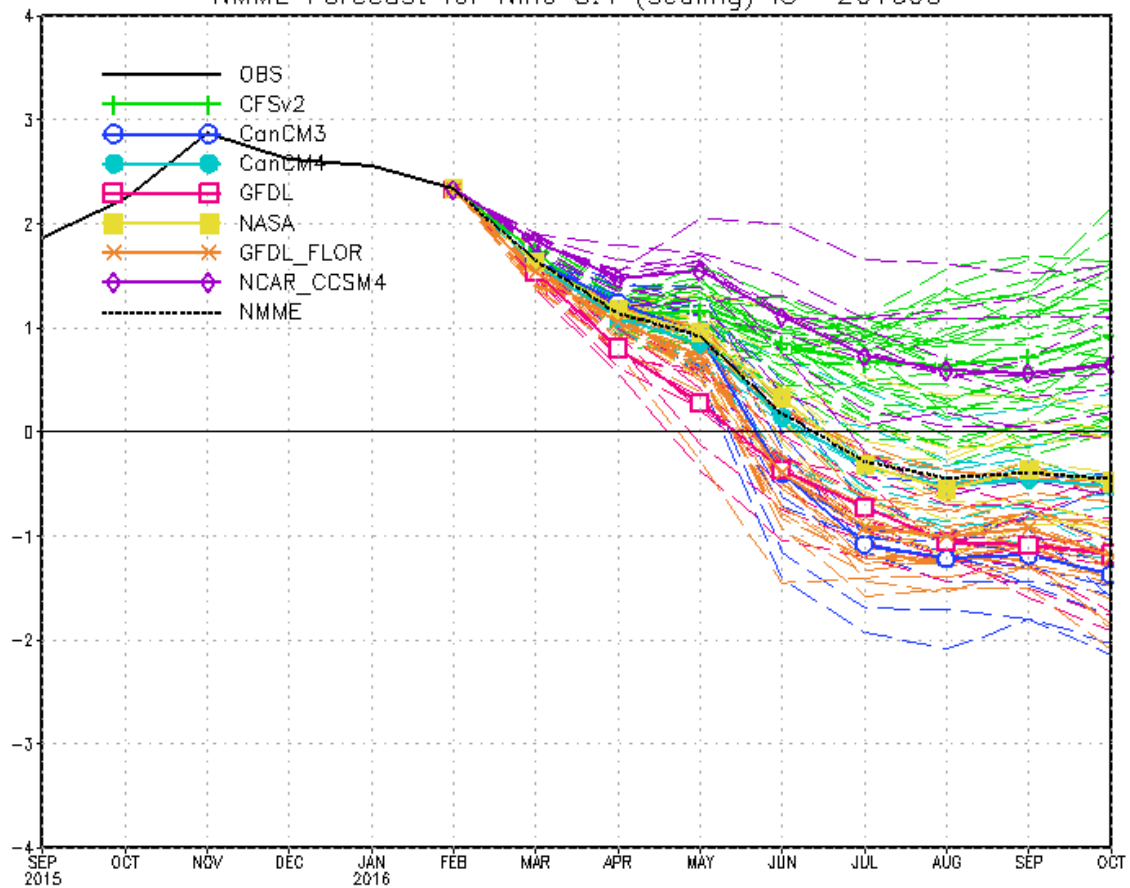
CFSv2 Forecast of SST Anom IC=201604 for 2016JAS



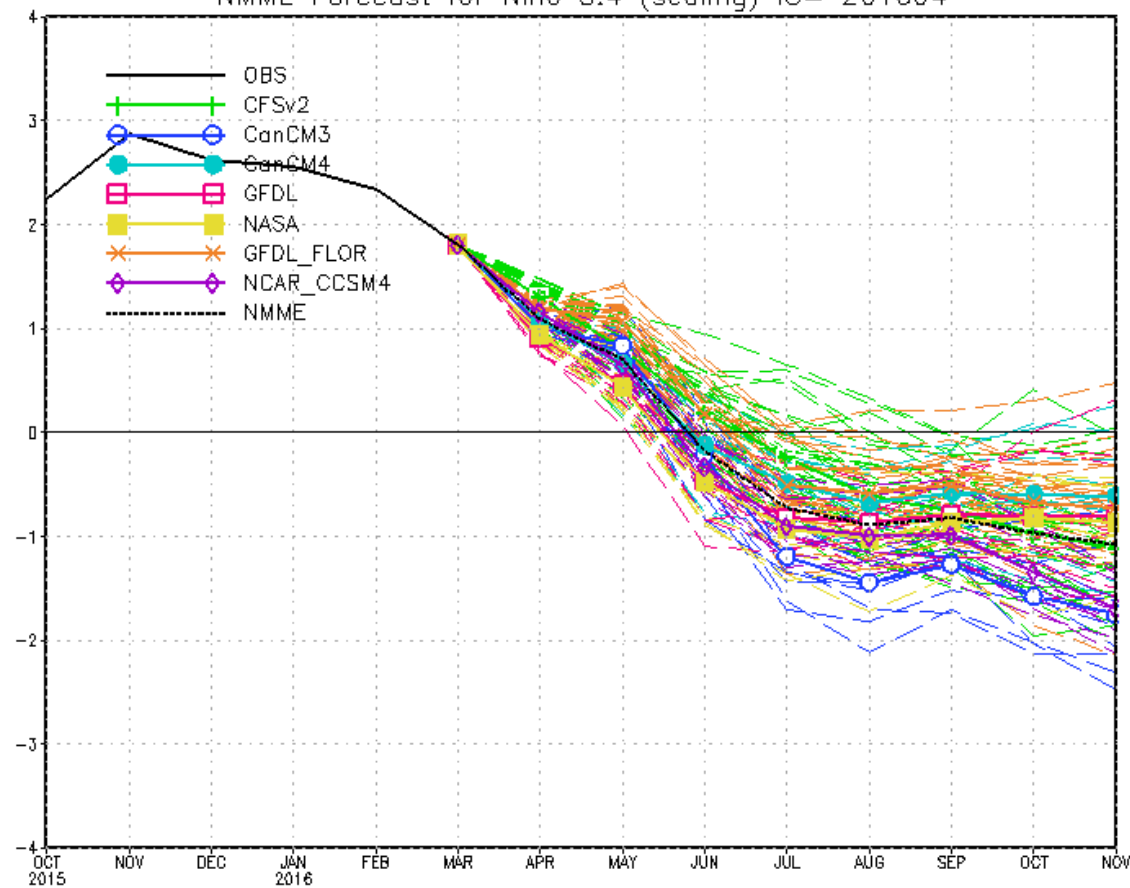
NCAR CCSM4 Forecast of SST Anom IC=201604 for 2016JAS



NMME Forecast for Nino 3.4 (scaling) IC= 201603



NMME Forecast for Nino 3.4 (scaling) IC= 201604

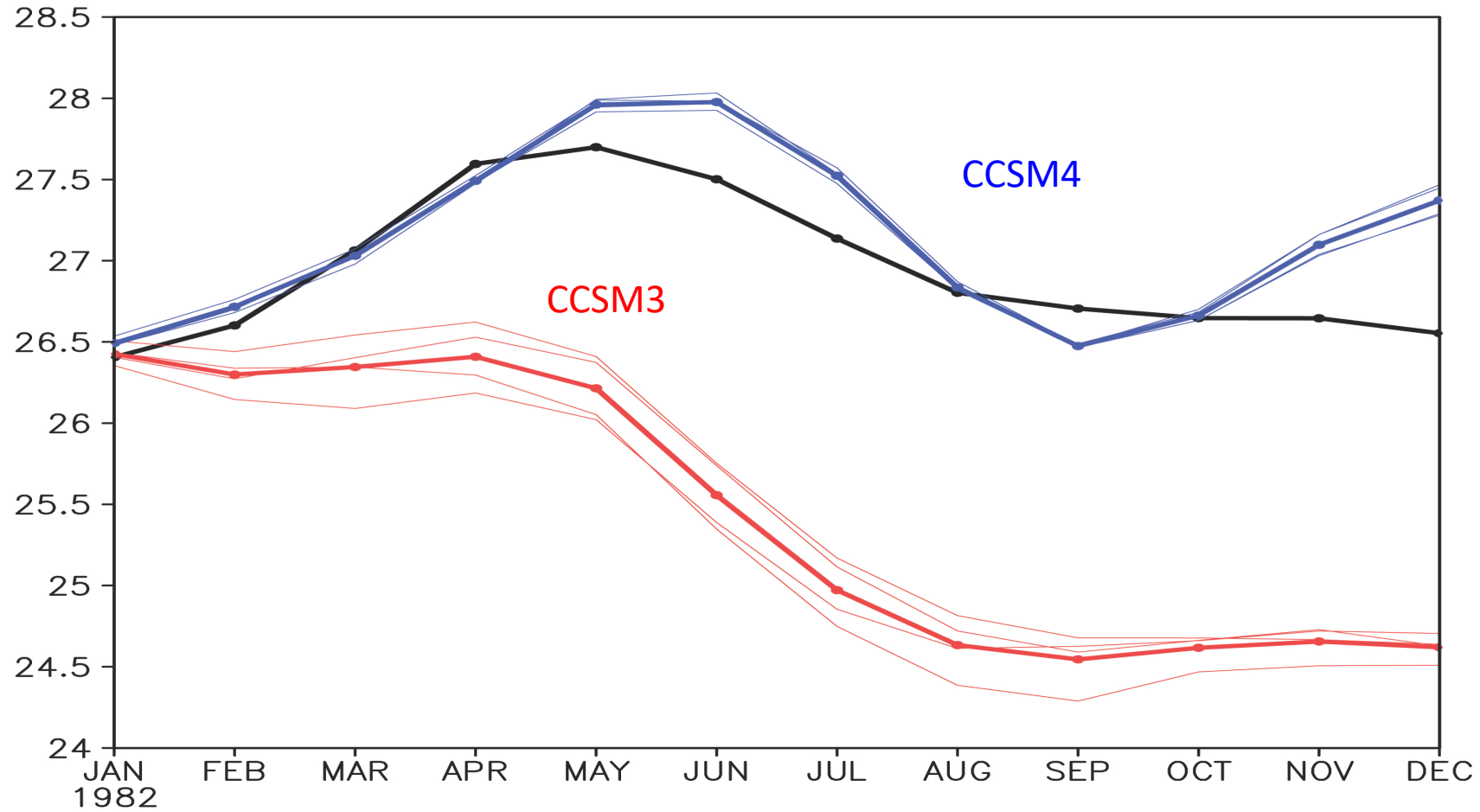


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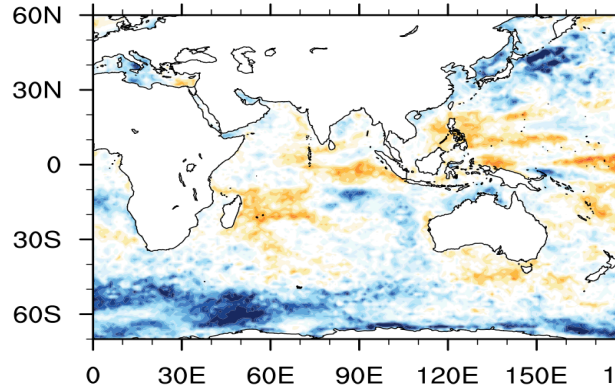
CCSM3 vs. CCSM4

Systematic Error - January Starts

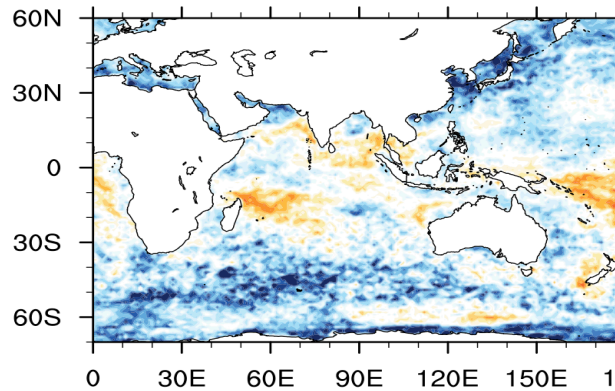


Better Model and

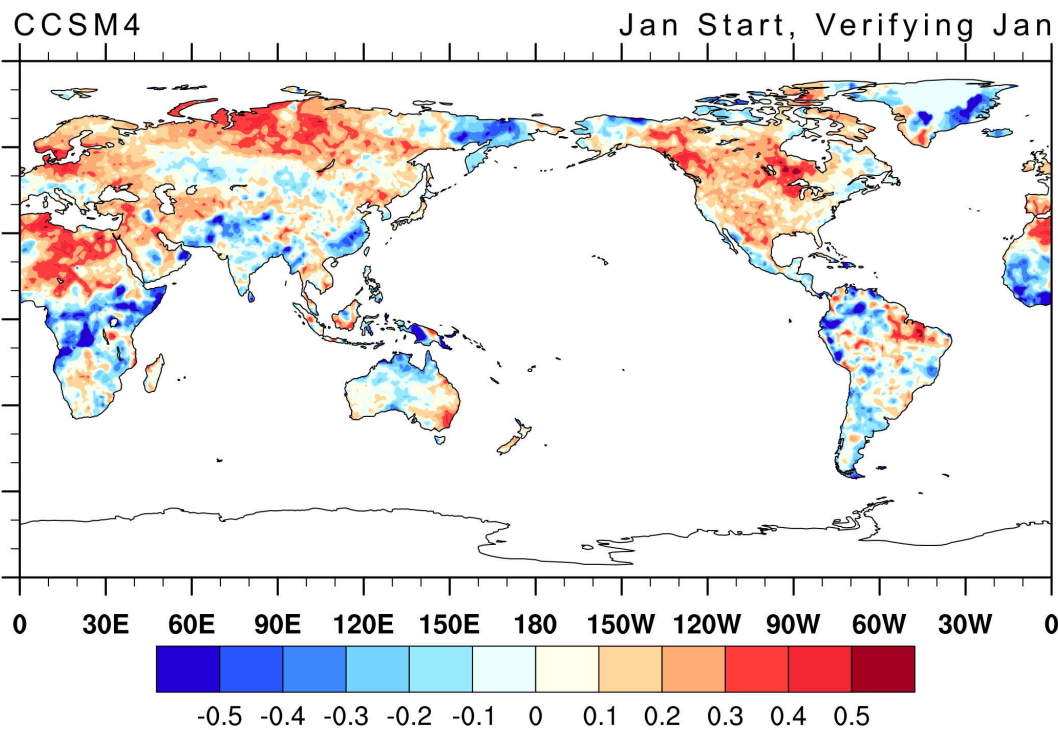
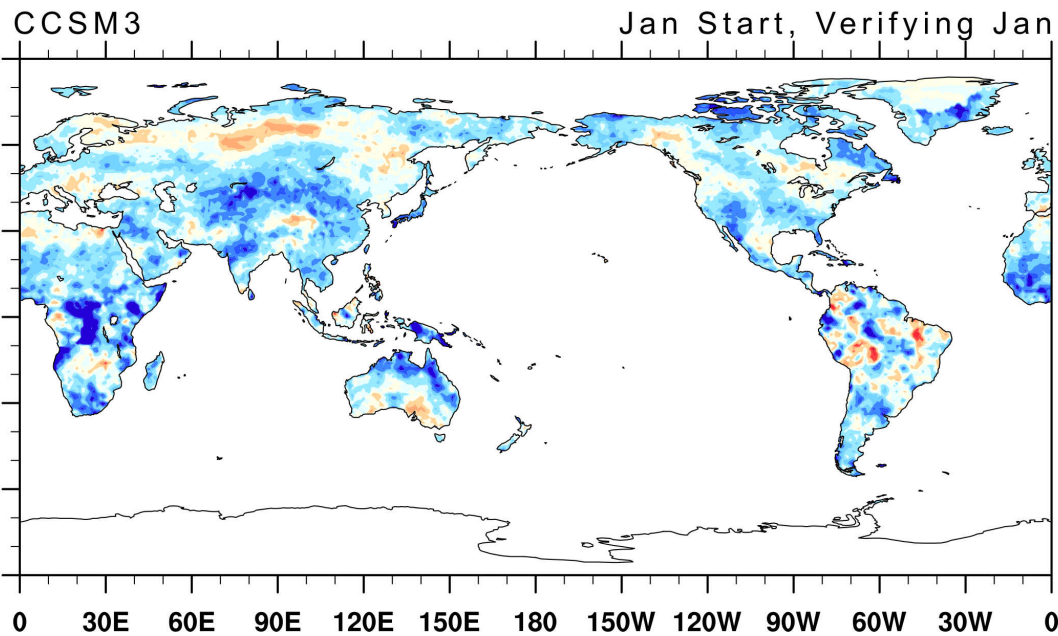
(a) RPSS - Jan



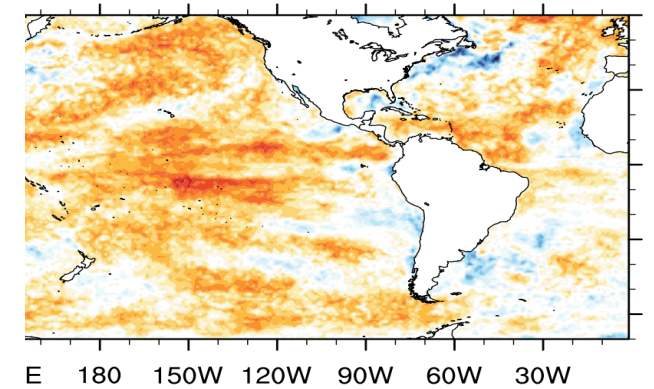
(b) RPSS - Jun



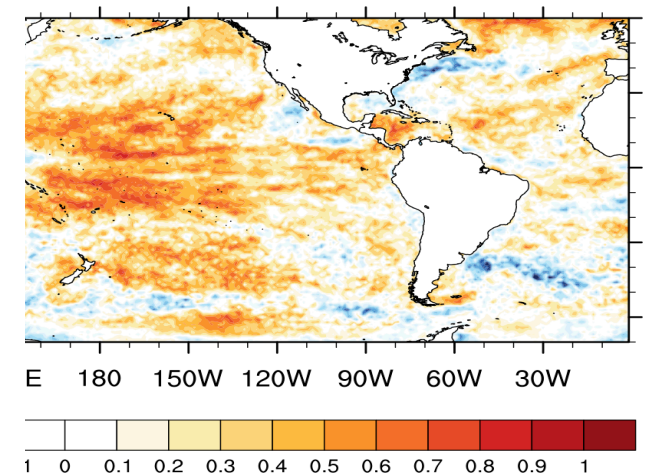
CCSM3



JanIC JFM CCSM4

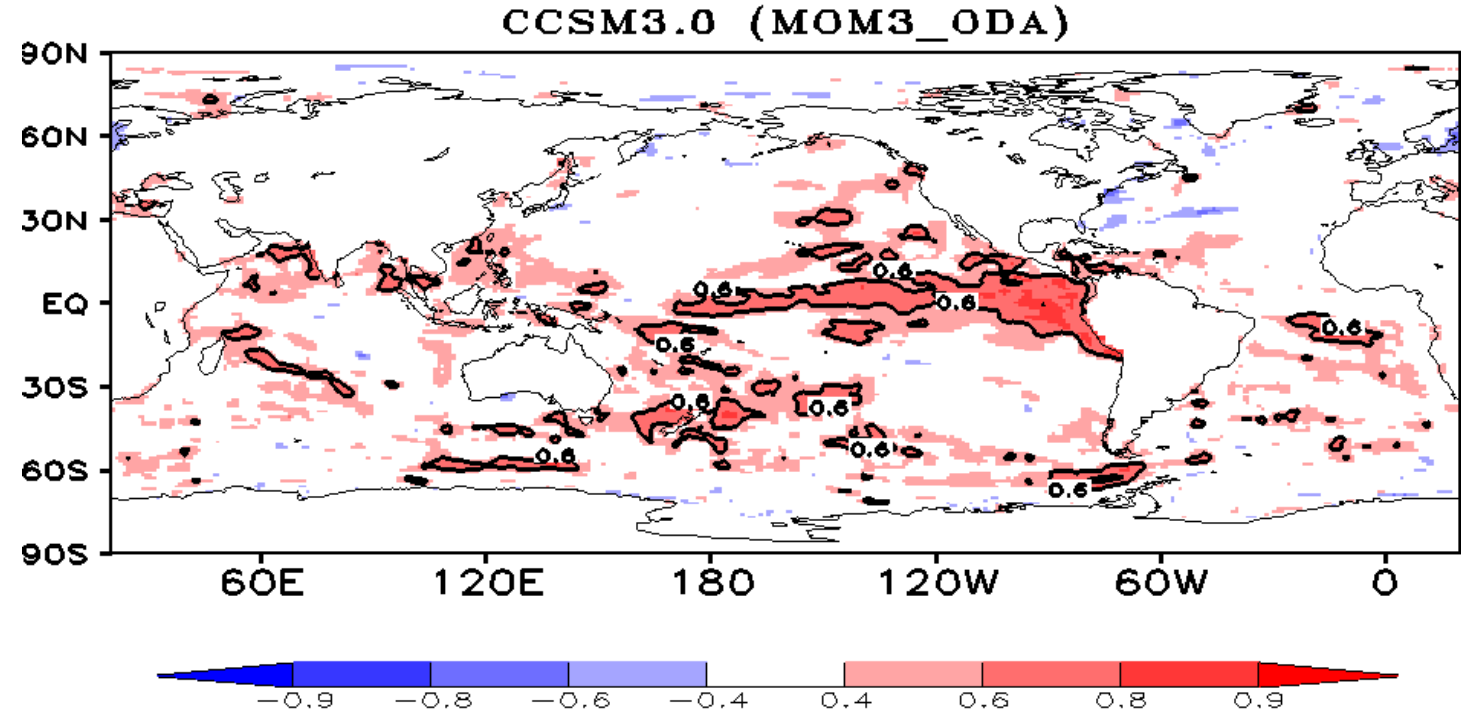


JunIC JJA CCSM4

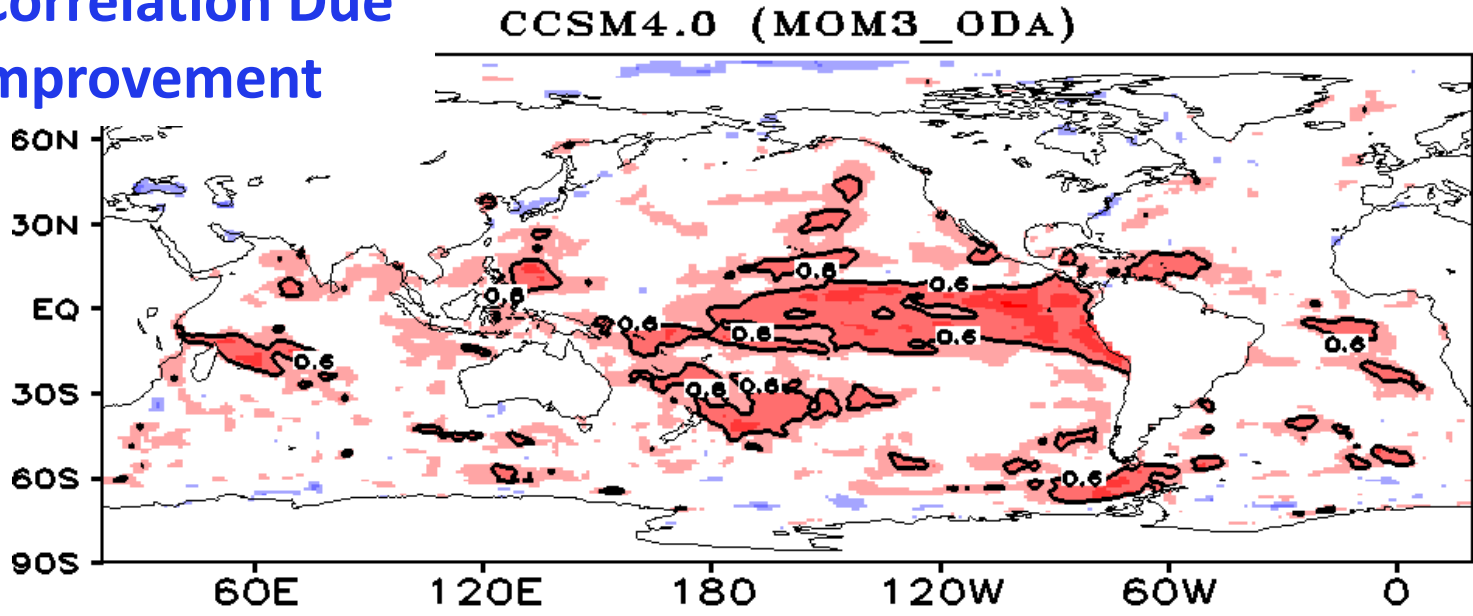


CCSM4

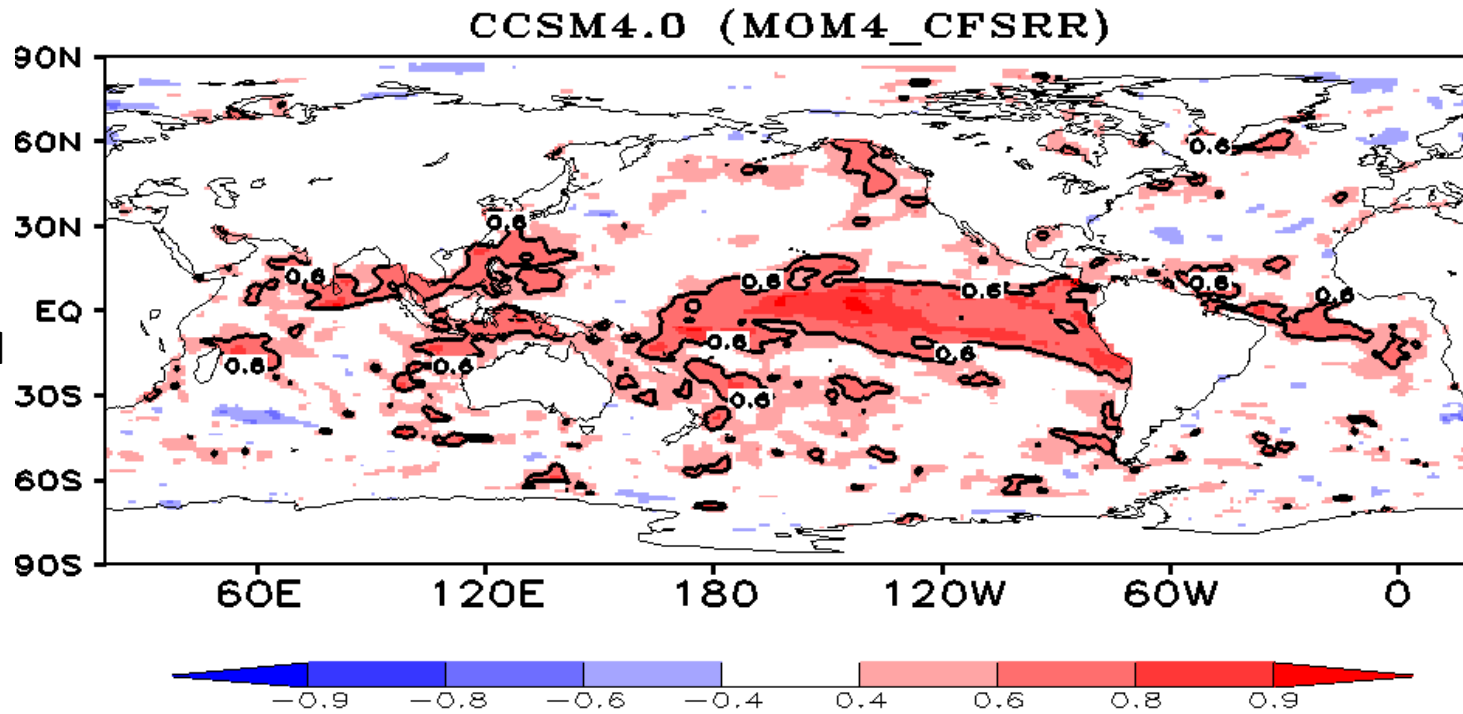
May Initial
Conditions
3-Months Lead



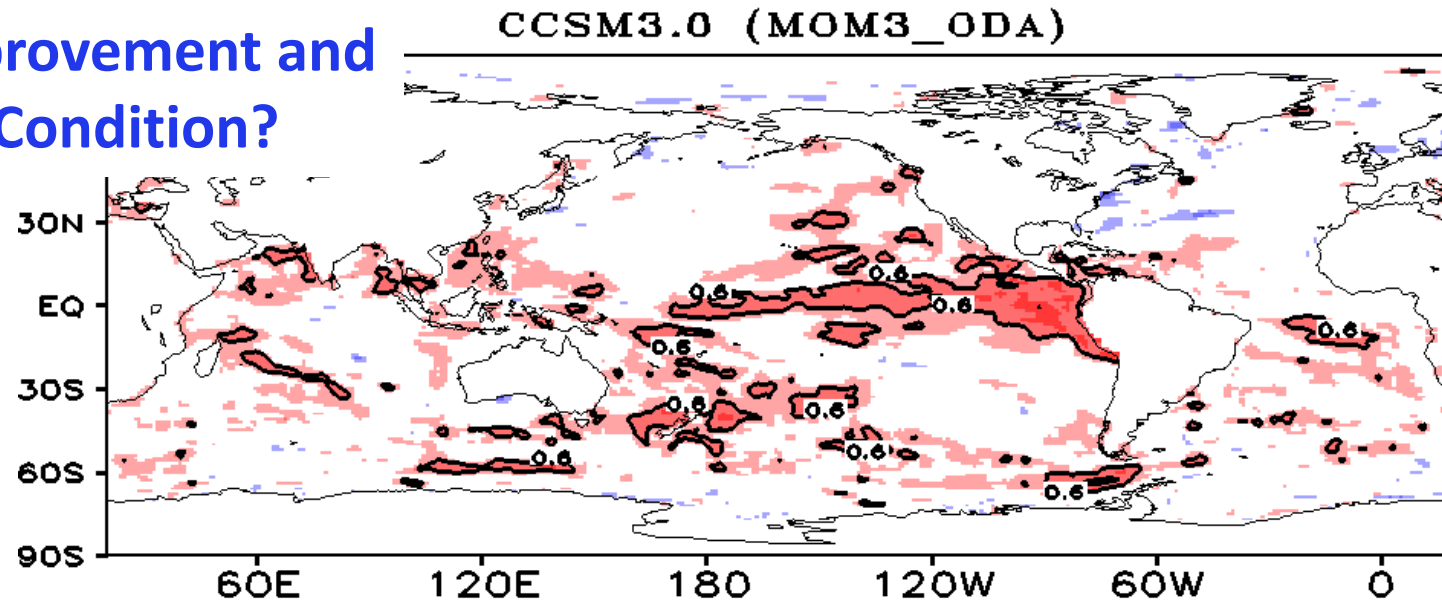
Improved Correlation Due
to Model Improvement



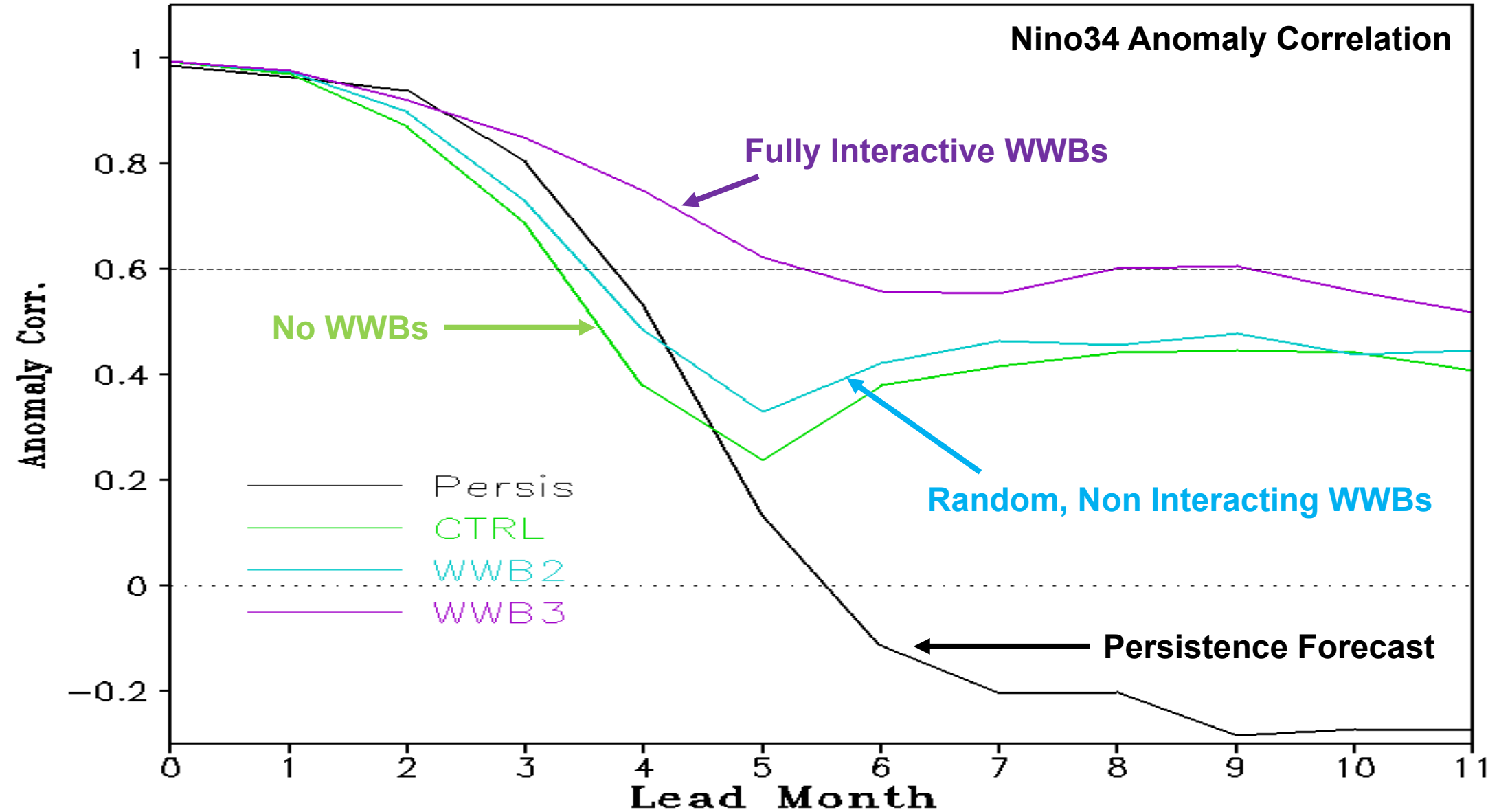
May Initial
Conditions
3-Months Lead



Improved Correlation Due
to Model Improvement and
Better Initial Condition?



Missing Processes: Westerly Wind Bursts (WWBs)?



Seasonal Retrospective Forecasts: Active Eddy Years (AEY) – Inactive Eddy Years (IEY)

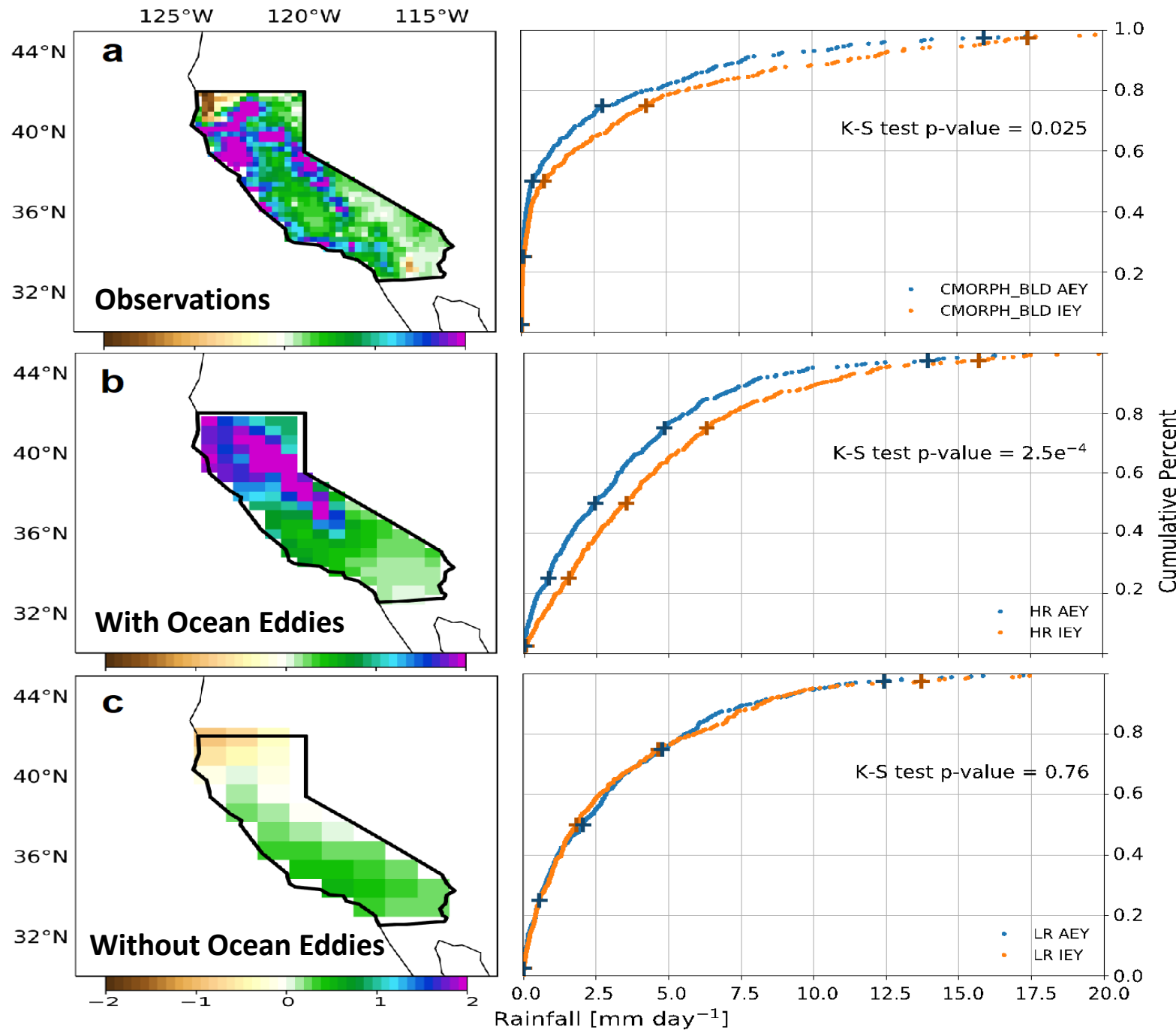
CCSM4 NMME Protocol Initialized Forecasts

Low Resolution: 1.0 Degree Atmosphere; 1.0 Degree Ocean (LRC)

High Resolution: 0.5 Degree Atmosphere; 0.1 Degree Ocean (HRC)

Initialized Retrospective Ensemble (5 member) Forecasts. Seven (7) Active – Inactive Eddy Years
Ocean Eddy Resolving vs. Ocean Eddy Parameterized (NMME)

Ocean Eddies Improving Seasonal Rainfall Forecasts Over California



Active (AEY)
—
Inactive (IEY)

NMME Predictability & Prediction Research

- **Multi-Model Forecast Quality Assessment**
 - History
 - New Assessment Tools
- **Real-Time Forecasts Informing & Motivating Research**
 - 2015/16 West Coast ENSO Teleconnection that Wasn't
 - What's Going on with CCSM4 & CFSv2
- **NMME as a Research Test-Bed**
 - Assessing Model Improvements/Missing Processes
 - **Assessing Forecasts – Prediction Science**
 - Improving Forecasts

Skill of Seasonal Arctic Sea Ice Extent Predictions Using the North American Multimodel Ensemble

K. J. HARNOS

NOAA/Climate Prediction Center, College Park, and Innovin, LLC, Greenbelt, Maryland

M. L'HEUREUX

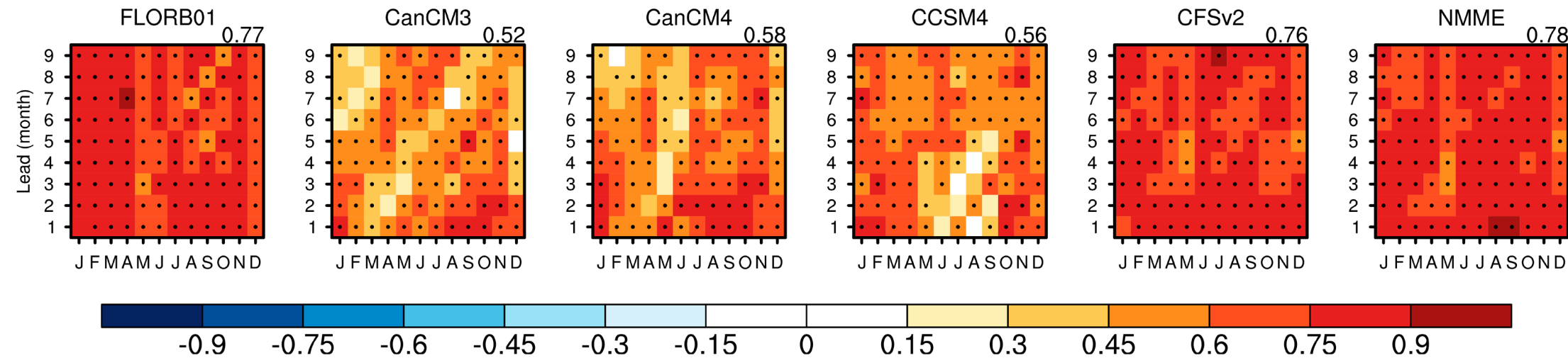
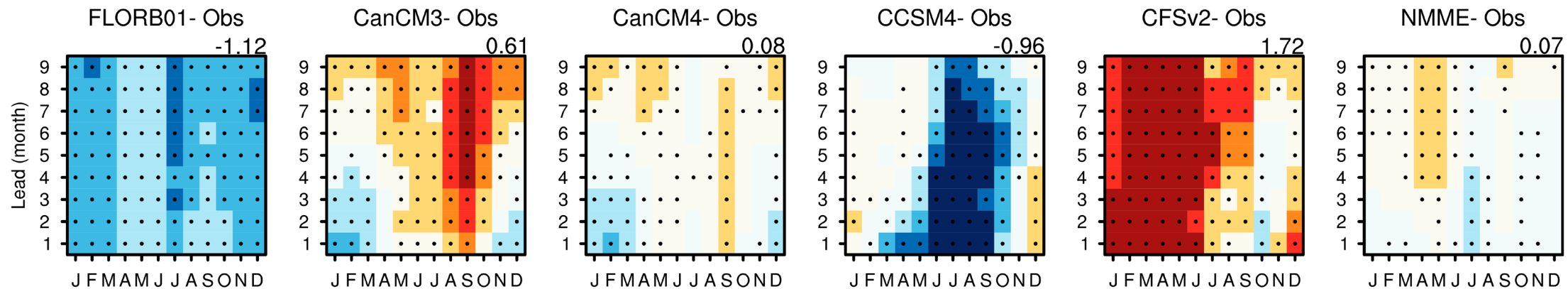
NOAA/Climate Prediction Center, College Park, Maryland

Q. DING

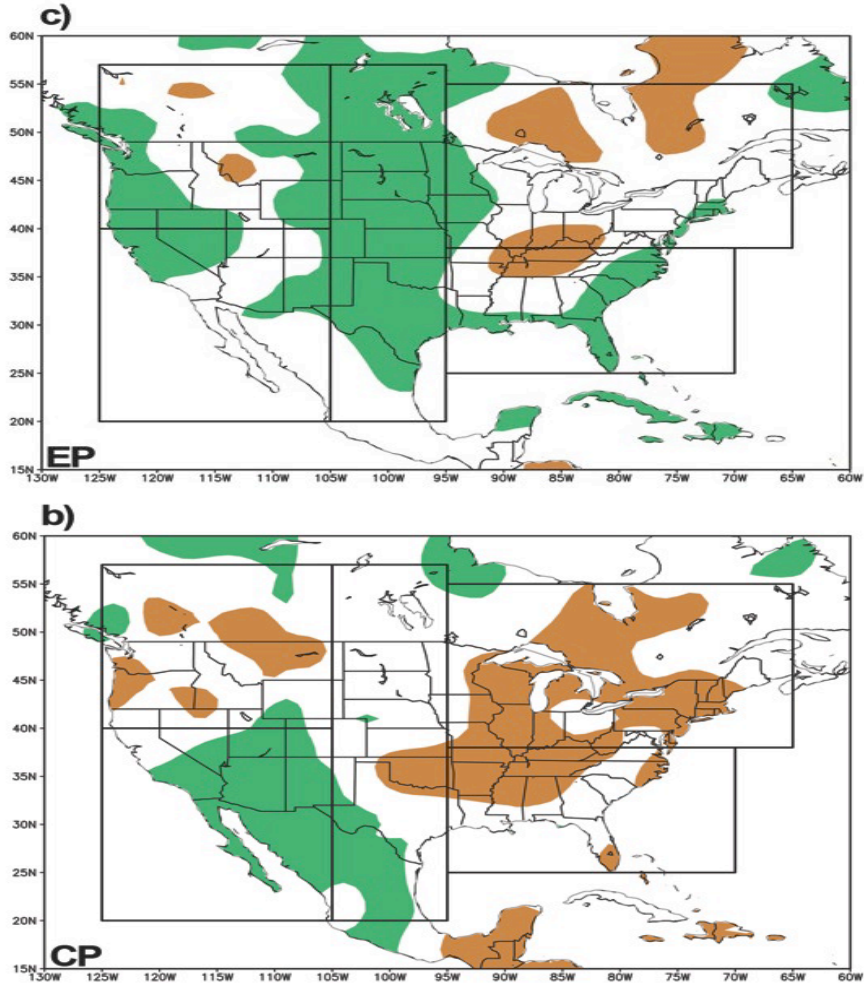
Department of Geography, and Earth Research Institute, University of California, Santa Barbara, Santa Barbara, California

Q. ZHANG

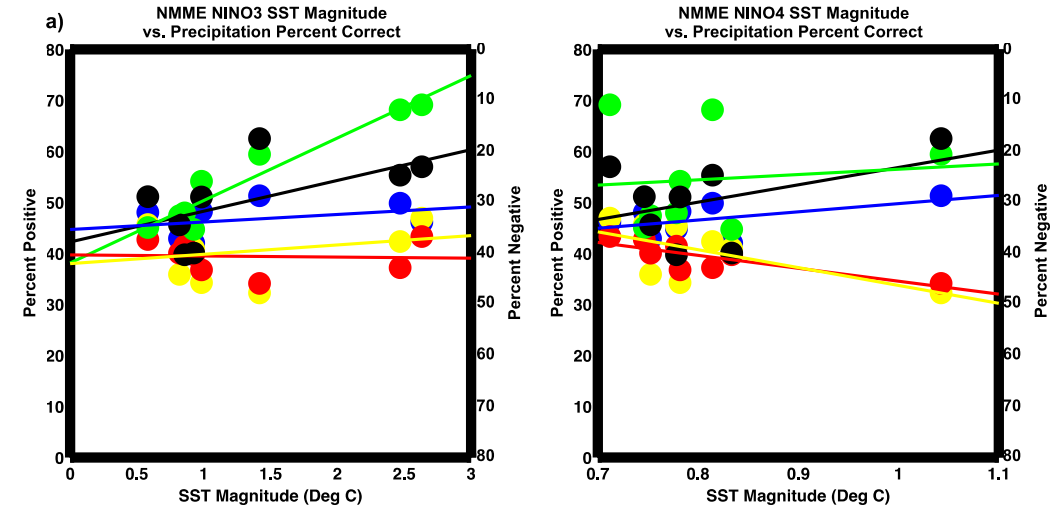
NOAA/Climate Prediction Center, College Park, Maryland



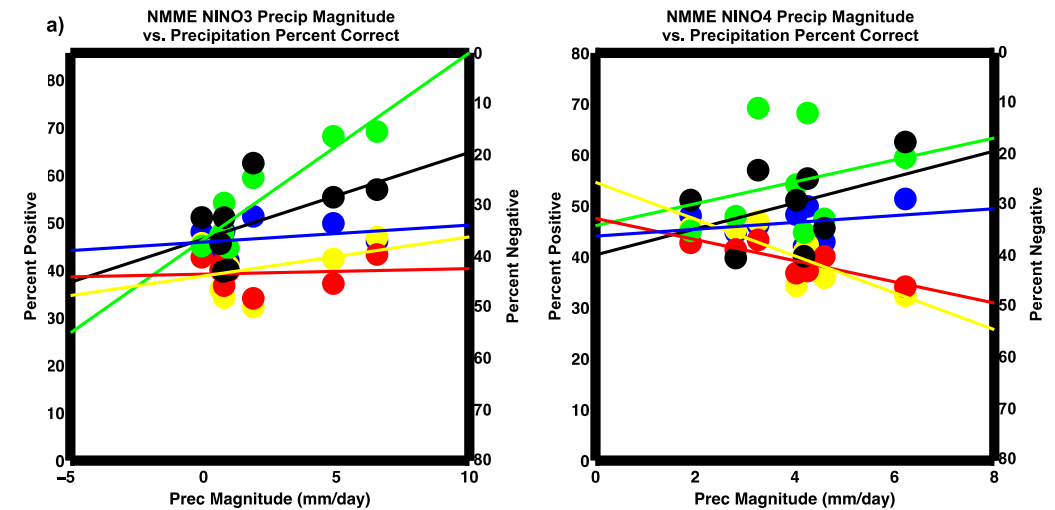
Observed Rainfall Composites



Tropical "SSTA" Forcing

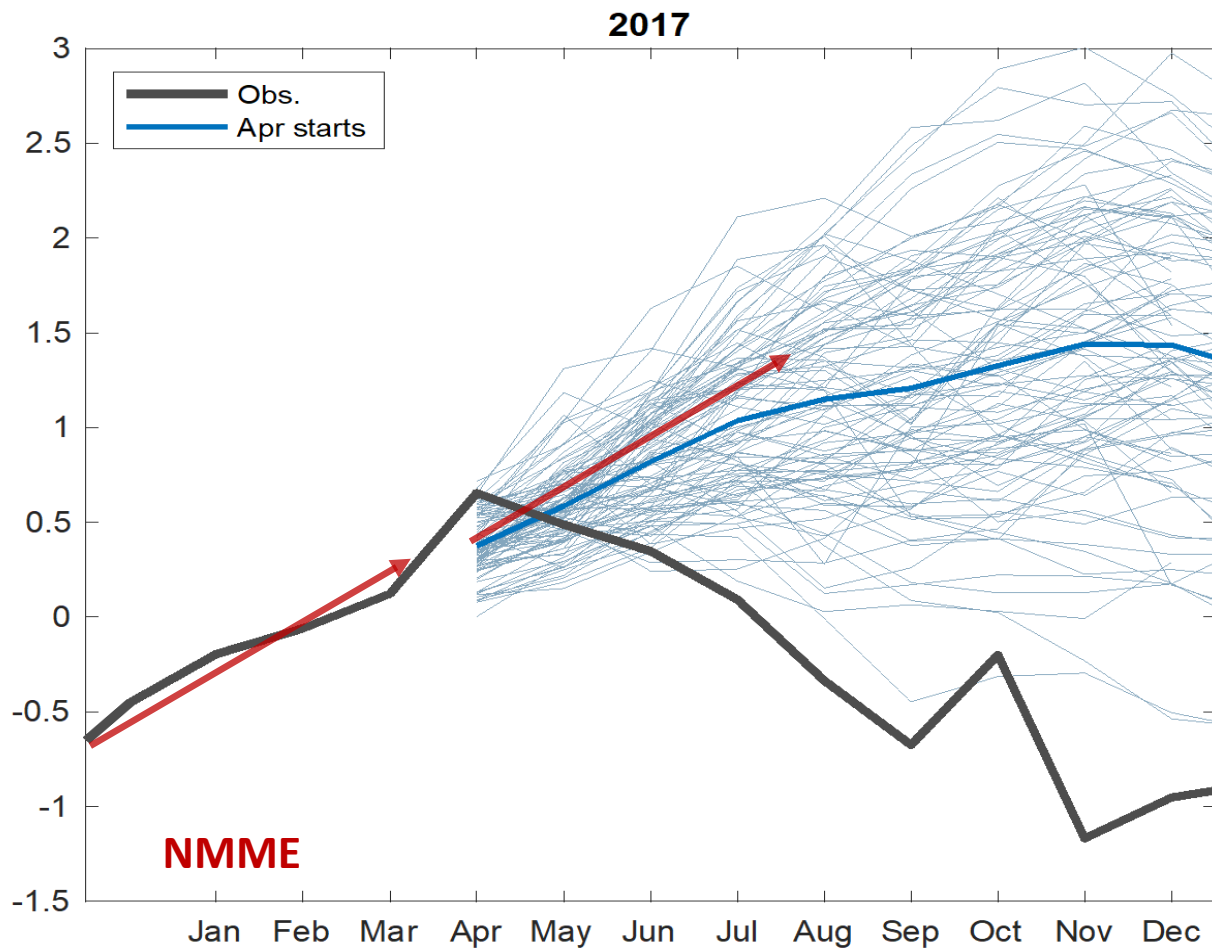


Tropical "Precip" Forcing



North American rainfall and temperature prediction response to the diversity of ENSO

NMME Nino34 SSTA Plumes 2017



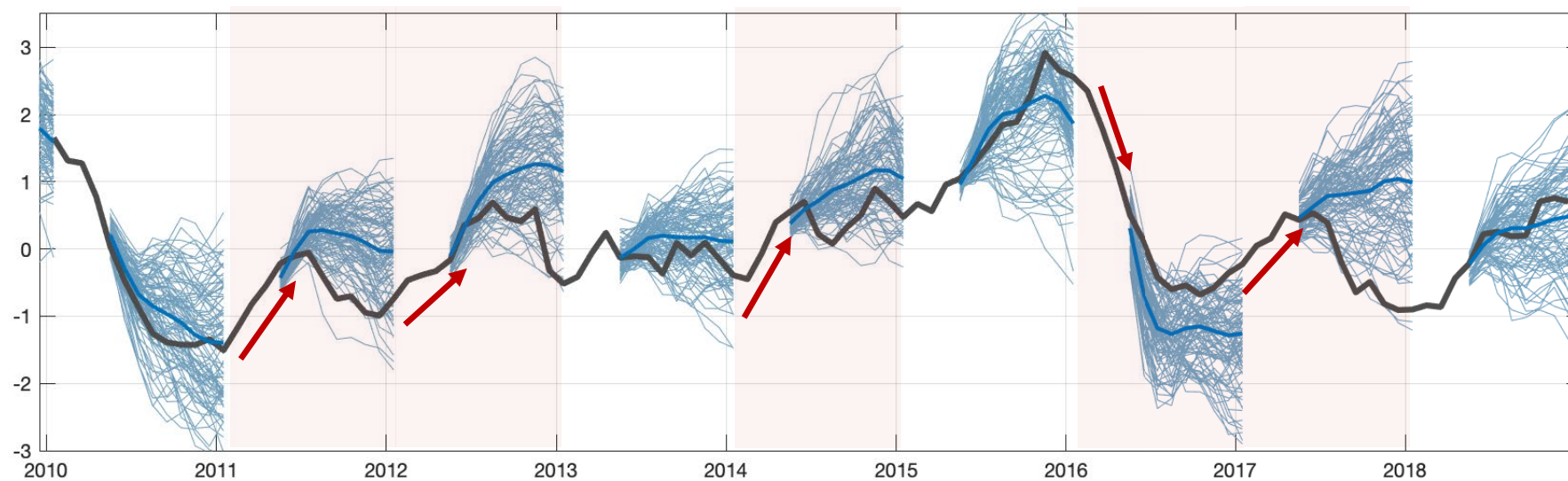
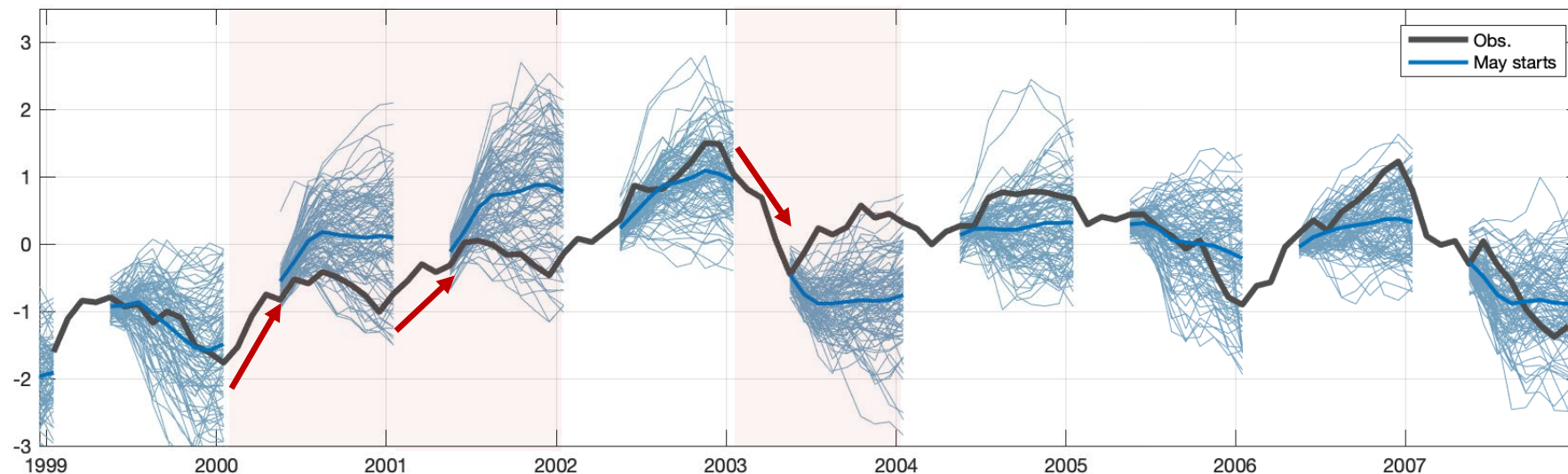
“Excessive momentum” poster child

Excessive Momentum and False Alarms in Late-Spring ENSO Forecasts

Michael K. Tippett¹, Michelle L. L'Heureux², Emily J. Becker³, and Arun Kumar²

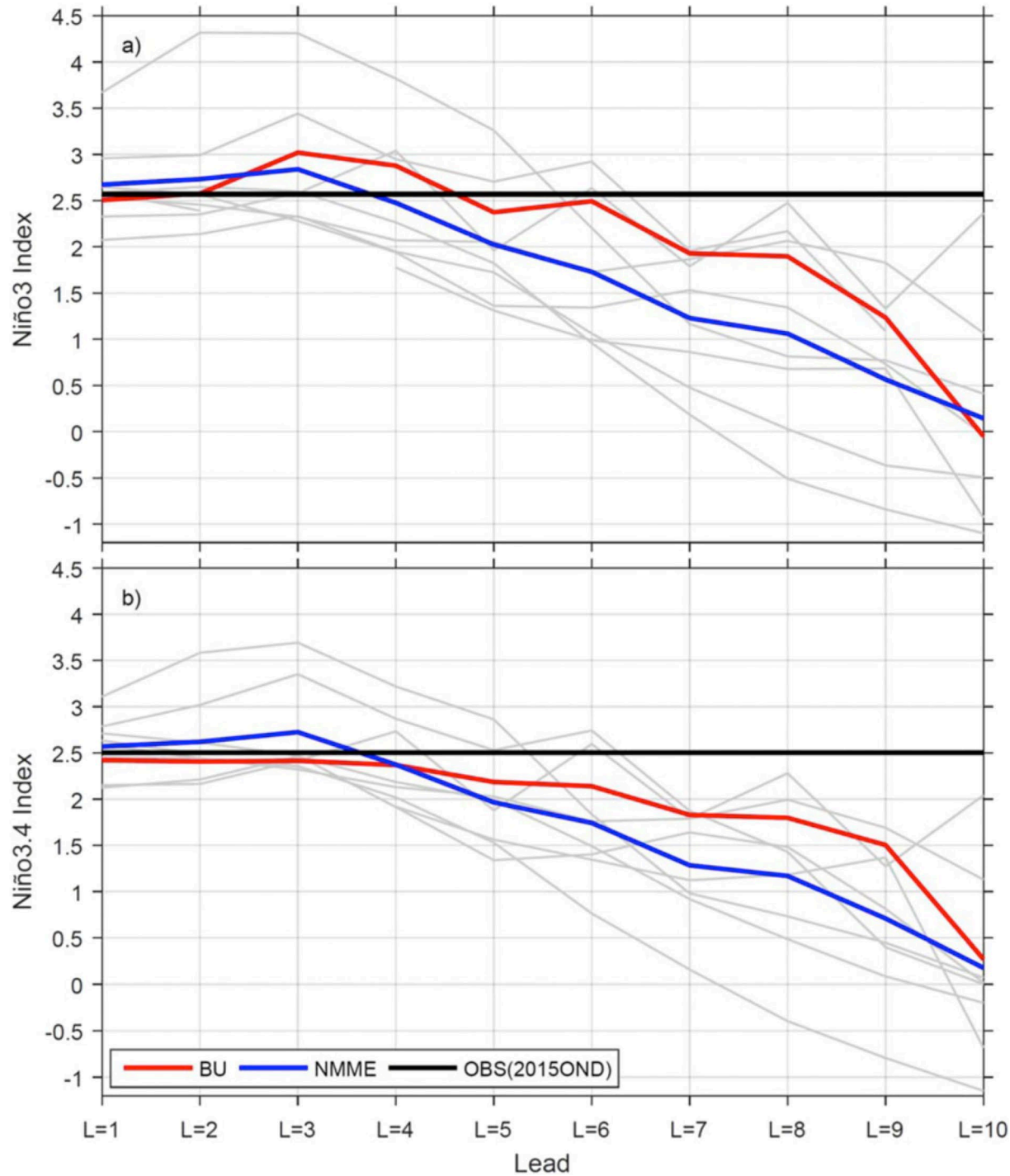
¹Department of Applied Physics and Applied Mathematics, Columbia University, New York, NY, USA, ²NOAA/NWS/NCEP/Climate Prediction Center, College Park, MD, USA, ³Cooperative Institute for Marine & Atmospheric Studies (CIMAS), Rosenstiel School of Marine & Atmospheric Science, University of Miami, Coral Gables, FL, USA

Nino 3.4 and
May NMME
ensemble
forecasts
1999—2018



~100 members

“Excessive momentum”



Improved ENSO Forecasting Using Bayesian Updating and the North American Multimodel Ensemble (NMME)

WEI ZHANG AND GABRIELE VILLARINI

IIHR–Hydroscience and Engineering, The University of Iowa, Iowa City, Iowa

LOUISE SLATER

IIHR–Hydroscience and Engineering, The University of Iowa, Iowa City, Iowa, and Department of Geography, Loughborough University, Loughborough, United Kingdom

GABRIEL A. VECCHI

Department of Geosciences, Princeton University, Princeton, New Jersey

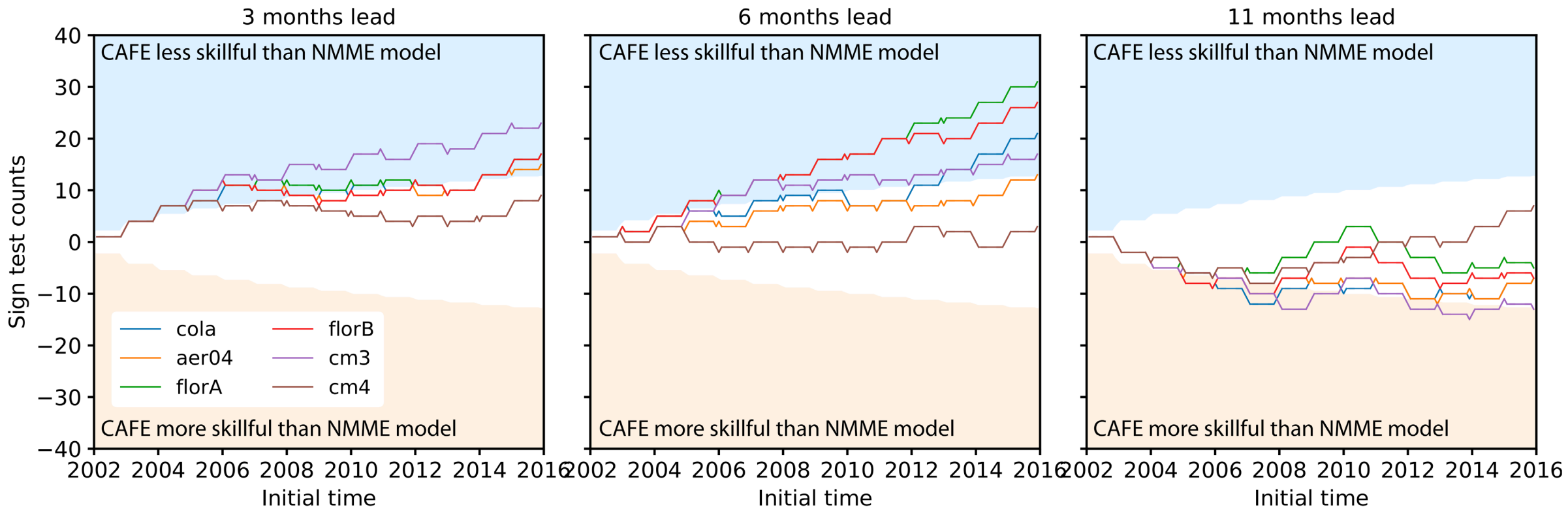
A. ALLEN BRADLEY

IIHR–Hydroscience and Engineering, The University of Iowa, Iowa City, Iowa

Enhanced ENSO Prediction via Augmentation of Multimodel Ensembles with Initial Thermocline Perturbations

TERENCE J. O'KANE, DOUGAL T. SQUIRE, PAUL A. SANDERY, VASSILI KITSIOS,
RICHARD J. MATEAR, THOMAS S. MOORE, JAMES S. RISBEY, AND IAN G. WATTERSON

CSIRO Oceans and Atmosphere, Hobart, Tasmania, Australia



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