Assessment of CFS Seasonal Forecast over the US Affiliated Pacific Islands

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Develop Dynamical Seasonal Rainfall Prediction System for the United States Affiliated Pacific Islands

- **Evaluate NCEP Climate Forecast System (CFS) 15 member ensemble hindcasts for the period 1981-2005. [9-month hindcast for all initial conditions]**

- **Assess the skill from deterministic (anomaly correlation), categorical (Heidke skill score, HSS) and probabilistic (rank probability skill score, RPSS)**

-Different scores - HSS measure forecast success rate (hits vs misses) relative to
- a random guess – predicting correct category (normal, > <)

- RPSS – Probabilistic skill – penalizes for forecasting wrong
- category – ensemble members

-*Convergence of different scores – forecast is useful"

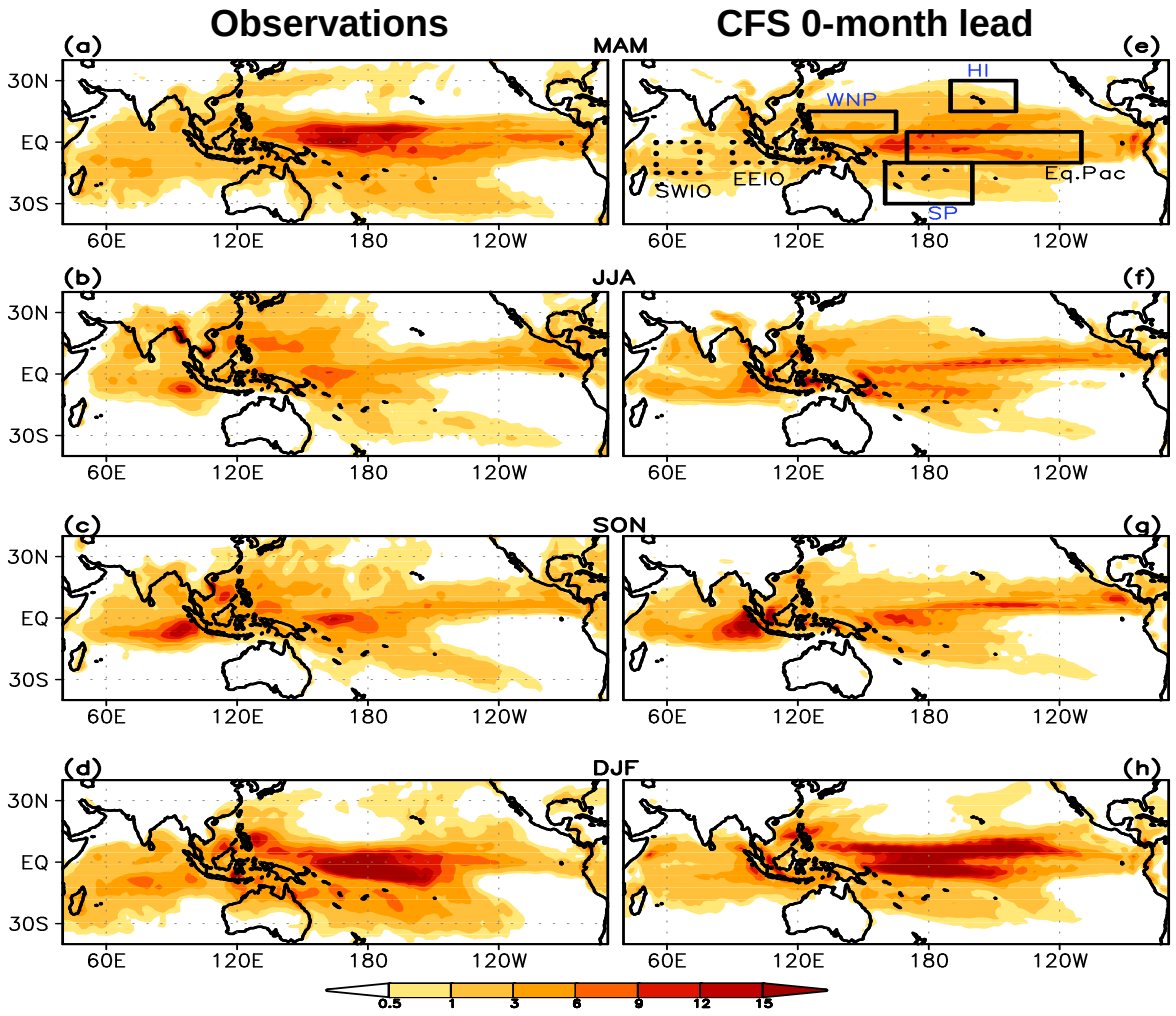
❑ For the USPAI, Operational Seasonal Prediction is based on empirical methods

(He and Barnston 1996)

❑ In a coupled models, a successful prediction of ENSO-related SST and precipitation anomalies over the tropical Indo-Pacific basins is expected to have predictive skill for USAPI rainfall and circulation anomalies

Ropelewski and Halpert 1989
Kumar and Hoerling 1996
Su and Neelin 2002
Annamalai et al. 2005
Annamalai et al. 2007

Precipitation variance for four standard seasons



south west Indian Ocean (15^{0}S-0, 55-75^{o}E; SWIO)

eastern equatorial Indian Ocean (10^{0}S-0, 90-110^{o}E; EEIO)

western north Pacific (5-15^{0}N, 125-155^{0}E; WNP)

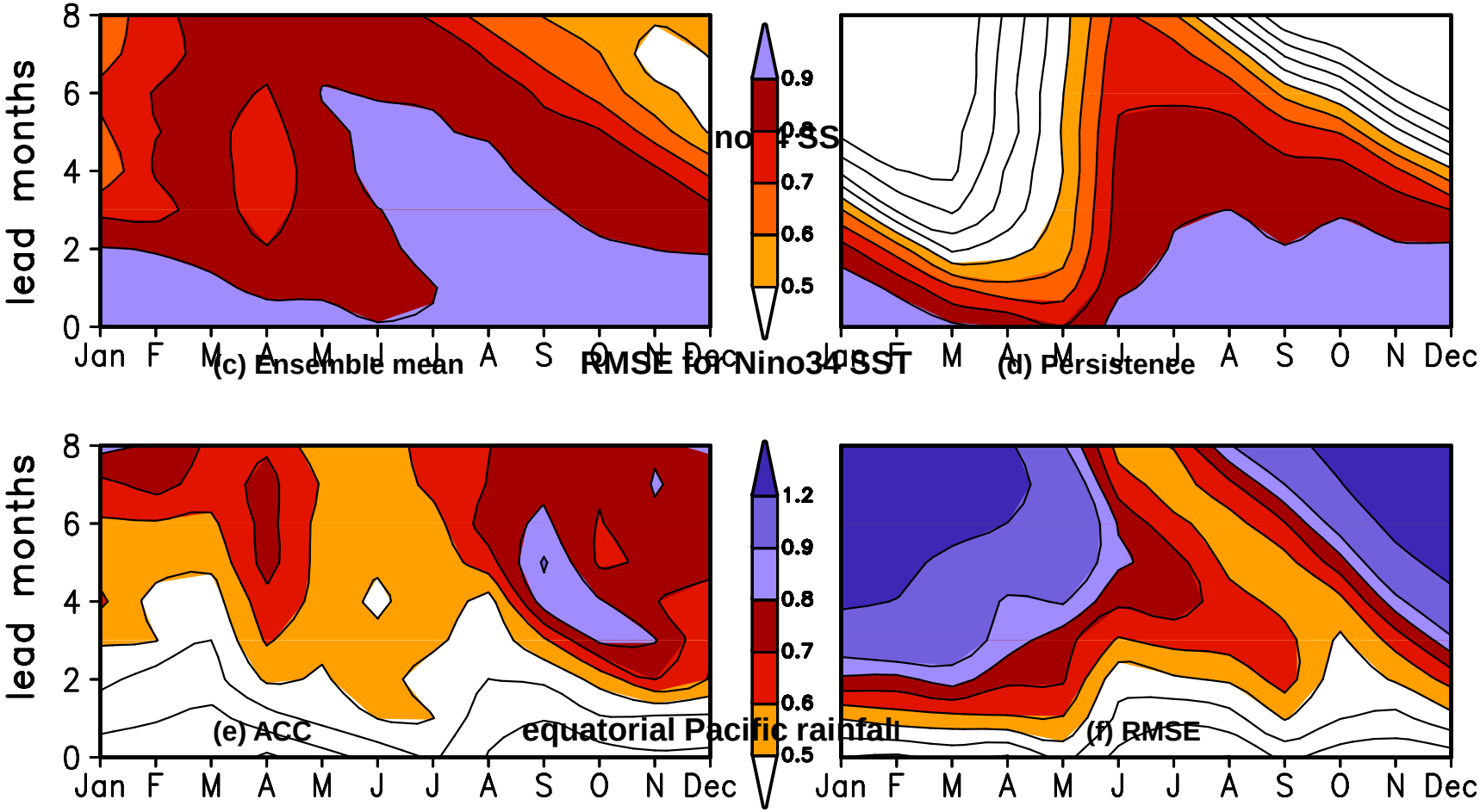
south Pacific (10-30^{0}S, 160-200^{0}E; SP)

Hawaii (15-30^{0}N, 140-170^{0}W; HI)

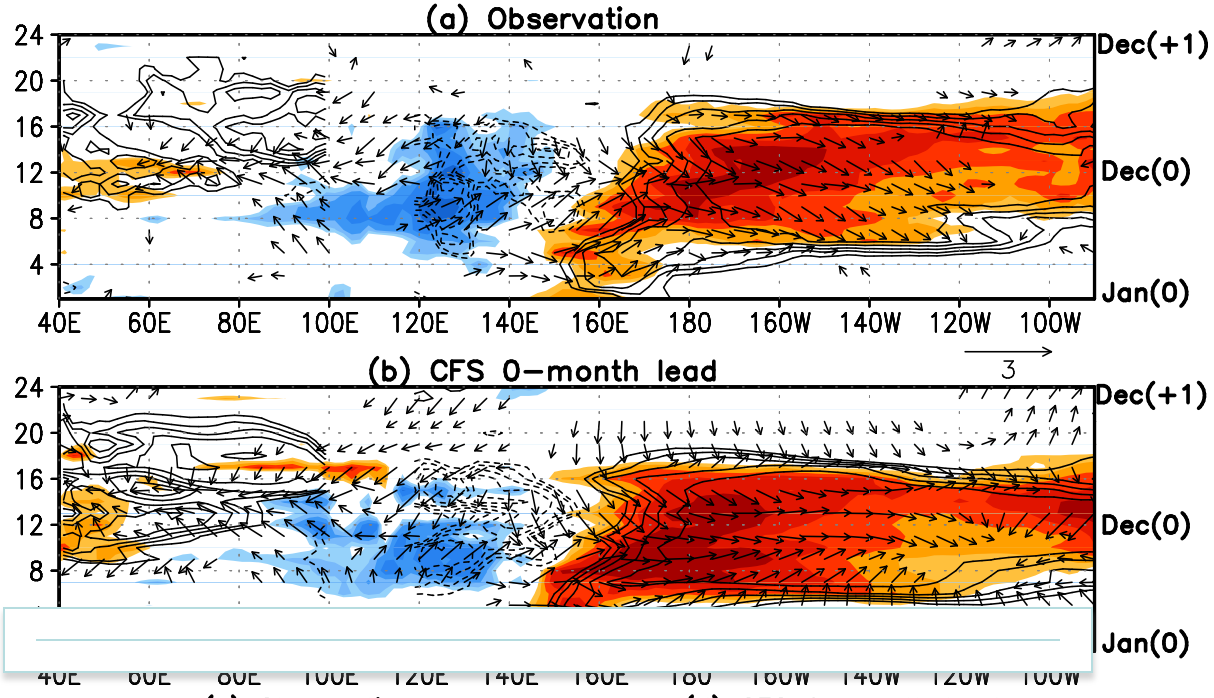
equatorial Pacific (10^{0}S-5^{0}N, 170^{o}E-110^{0}W; Eq. Pac)

❖**CFS captures the observed seasonal dependency in regional precipitation variance maxima over the tropics, with some systematic errors.**

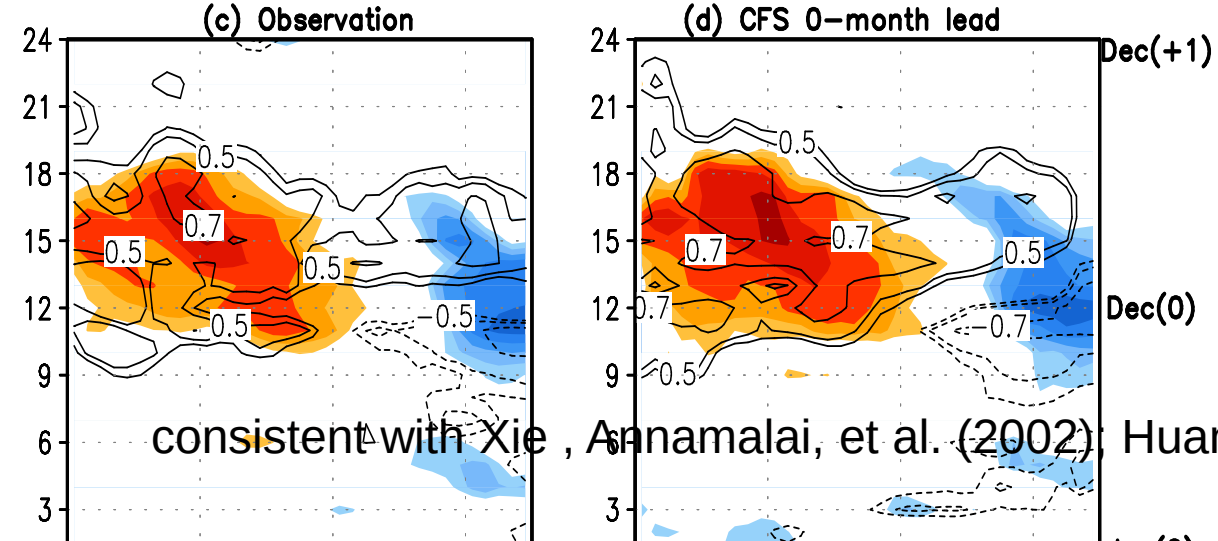
ACC and RMSE


lead months
8
6
4
2
0
Jan F M A M J J A S O N Dec
0.9
0.8
0.7
0.6
0.5
(c) Ensemble mean
RMSE for Nino34 SST
(d) Persistence
1.2
0.9
0.8
0.7
0.6
0.5
(e) ACC
equatorial Pacific rainfall
(f) RMSE

Teleconnection between the tropical Pacific and Indian Oceans



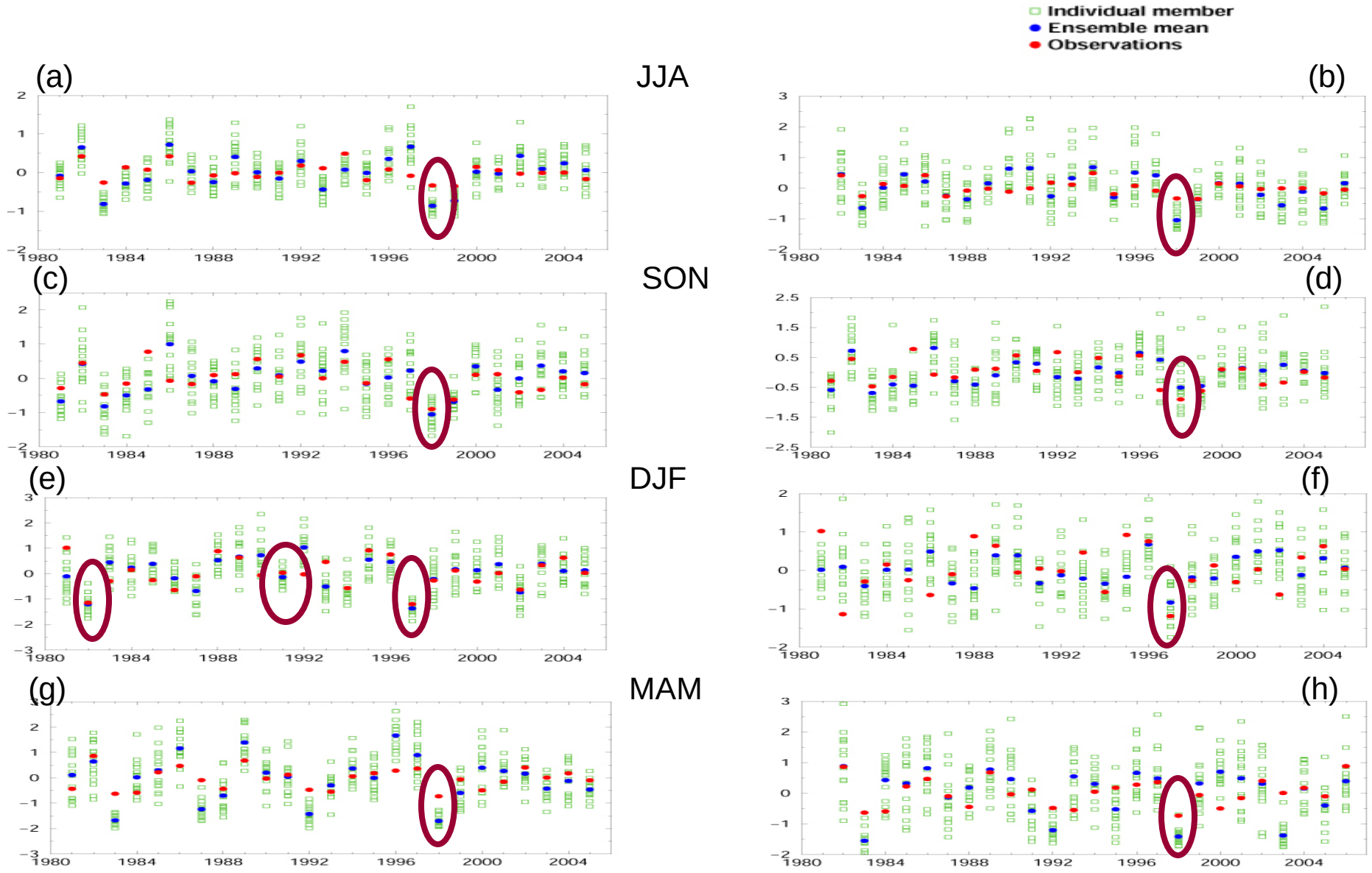
Lagged correlations of SST (contours), rainfall (shaded) and 850 hPa wind averaged in 3^0S-3^0N with winter (DJF) Nino3.4 SST index



lagged correlations of SST (contours) and SSH (shaded) averaged in 8^0S-12^0S with winter Nino3.4 SST index

consistent with Xie , Annamalai, et al. (2002); Huang and Kinter (2002)

Seasonal rainfall forecast at 0-month (left) and 6-month (right) lead over Hawaii region

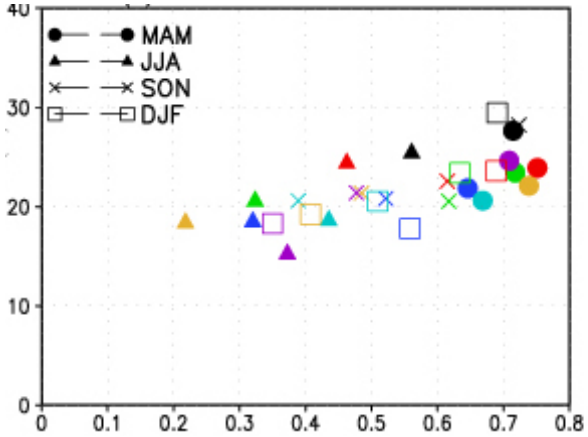


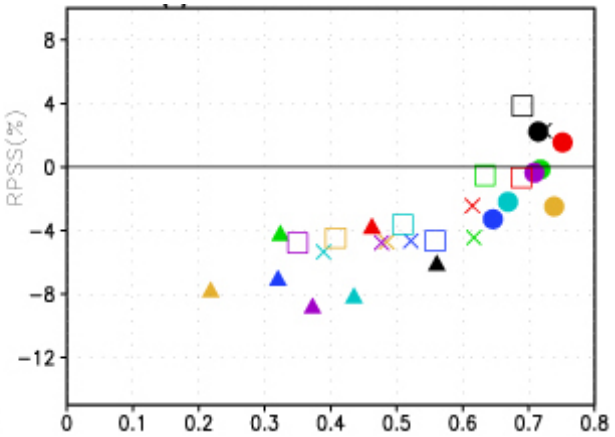
CFS Skill measures for rainfall over U.S. Affiliated Pacific Islands (USAPI)

ACC *versus* HSS **ACC *versus* RPSS**

South Pacific Islands
(160-200°E; 10-30°S)

HSS



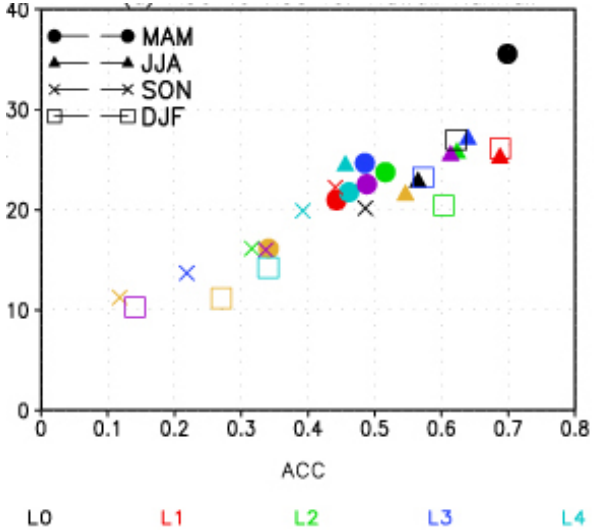


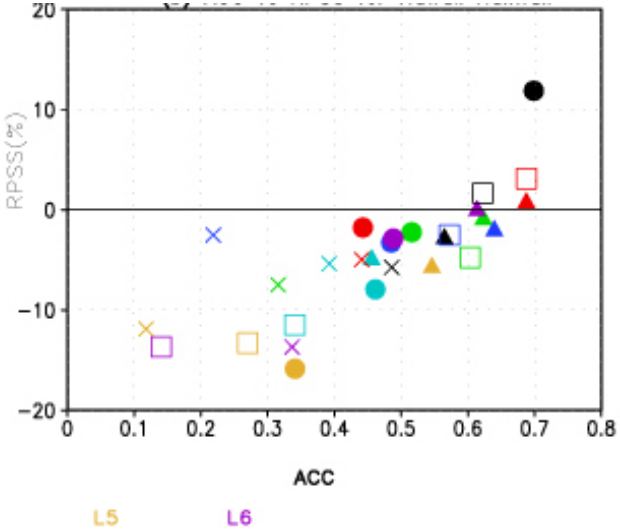
RPSS

-ve not better than Climatology

Hawaiian Islands
(190-200°E; 15-30°N)

HSS



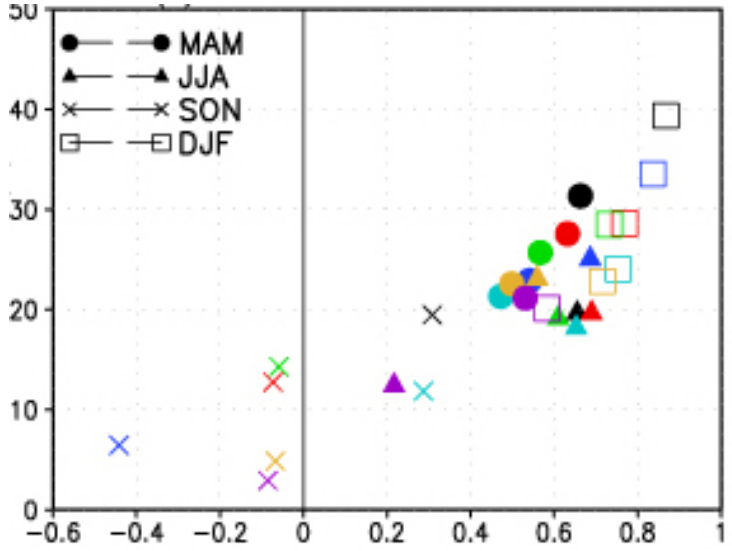


RPSS

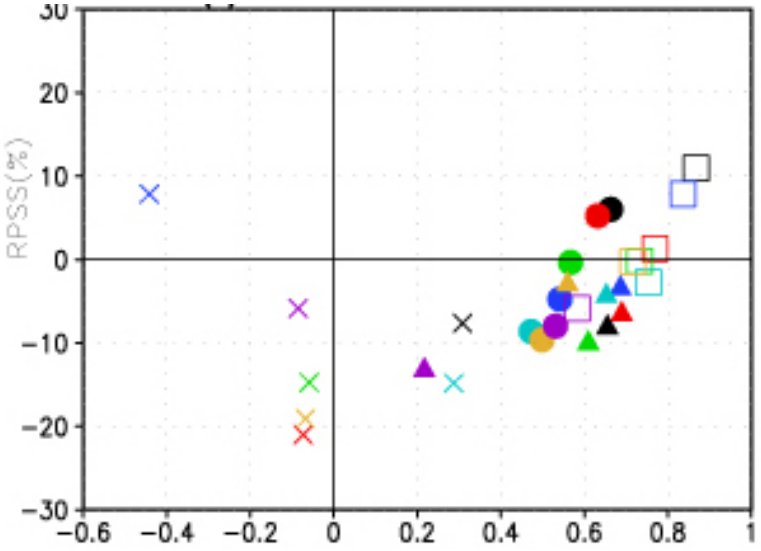
L0 L1 L2 L3 L4 L5 L6

West Pacific Islands

HSS



ACC



ACC

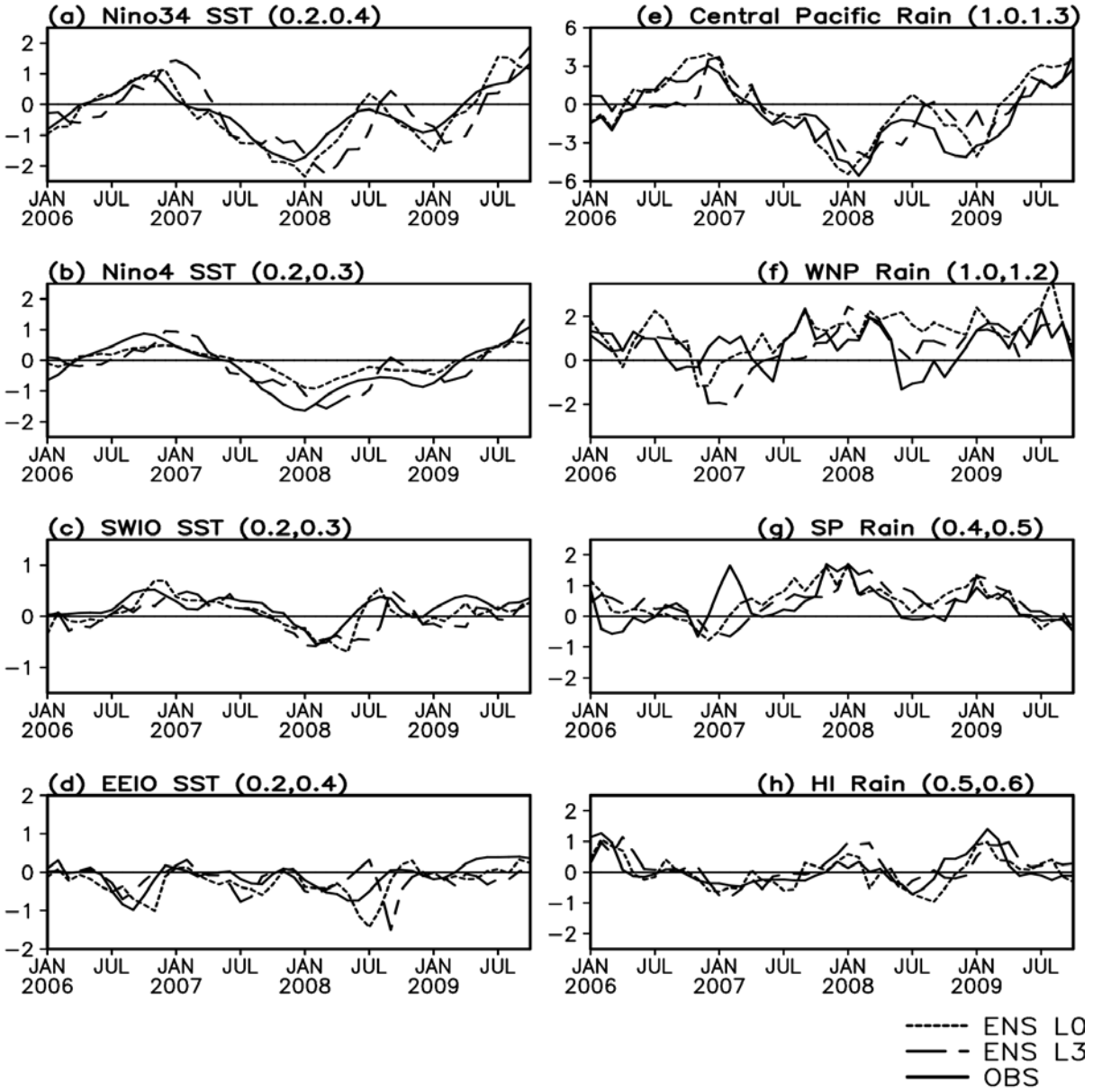
RPSS

DJF/MAM – forecasts appear useful up to 3-4 month leads

"summer – ACC and HSS are high but RPSS is negative"

"Convergence of deterministic, categorical and probabilistic scores suggests that the forecast is useful""

Real-time forecasts (2006-09) Three-month running mean



Real-time forecasts (2006-09) – Skill over west Pacific islands weaker than hindcasts

Sooraj et al. (2011) – Weather and Forecasting (in press)

http://apdrc.soest.hawaii.edu/projects/seasonal_prediction/

Precipitation Prediction System over the Pacific Islands

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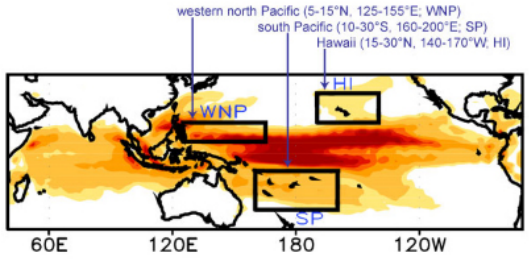
Our Mission

For all U.S. Affiliated Pacific Islands (USAPI), we have developed a prototype long range precipitation prediction system based on NOAA's operational Climate Forecast System (CFS). Development of such a system is expected to fill a critical gap in the Climate Prediction Systems suite of operational forecasts for the USAPI that currently are purely derived based on empirical techniques. The vision of the Climate Test Bed (CTB) is to "significantly increase the accuracy, reliability, and scope of NOAA's suite of operational climate forecast products to meet the needs of a diverse user community". The multi-institutional collaboration, by bringing in the local and operational expertise, has allowed the development of a real-time precipitation forecast system for the USAPI.



Real-time prediction

We are using the prediction system to issue experimental long-range forecasts. The forecasts for each region (Figure above) can be assessed below for various lead times into the future. Our terminaology for the lead times is such that a "0 month" forecast for JFM2010 would be produced using December 2009 initital conditions, a "1 month" forecast for FMA2010 would be produced using December 2009 initital condition, and so on.

Region	Lead time (month)						
Hawaii	0	1	2	3	4	5	6
western north Pacific	0	1	2	3	4	5	6
south Pacific	0	1	2	3	4	5	6

Seasonal prediction and other sites

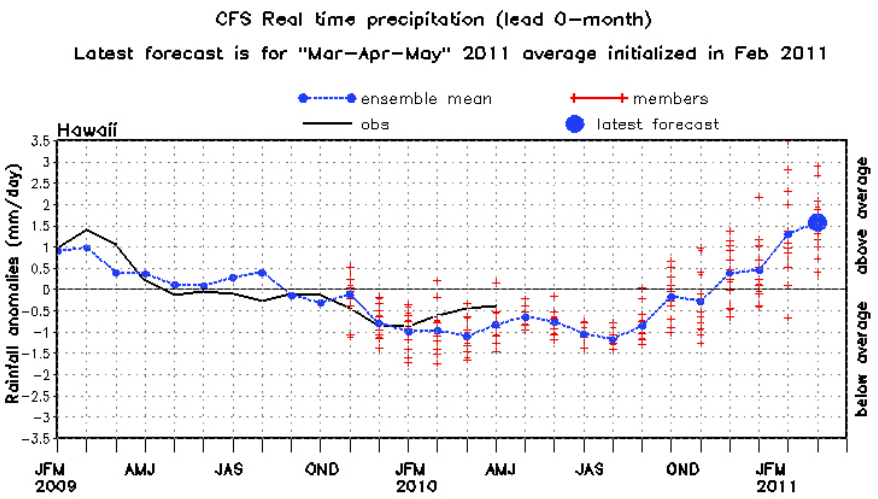
Users with a need for precipitation forecasts over the next three months may want to consult the web site of the UH/National Weather Service Pacific ENSO Applications Climate Center who have real time forecasts for 14 individual stations in Hawaii and other USAPI.

- http://www.prh.noaa.gov/peac/update.php
- http://www.prh.noaa.gov/peac/rainfall.php

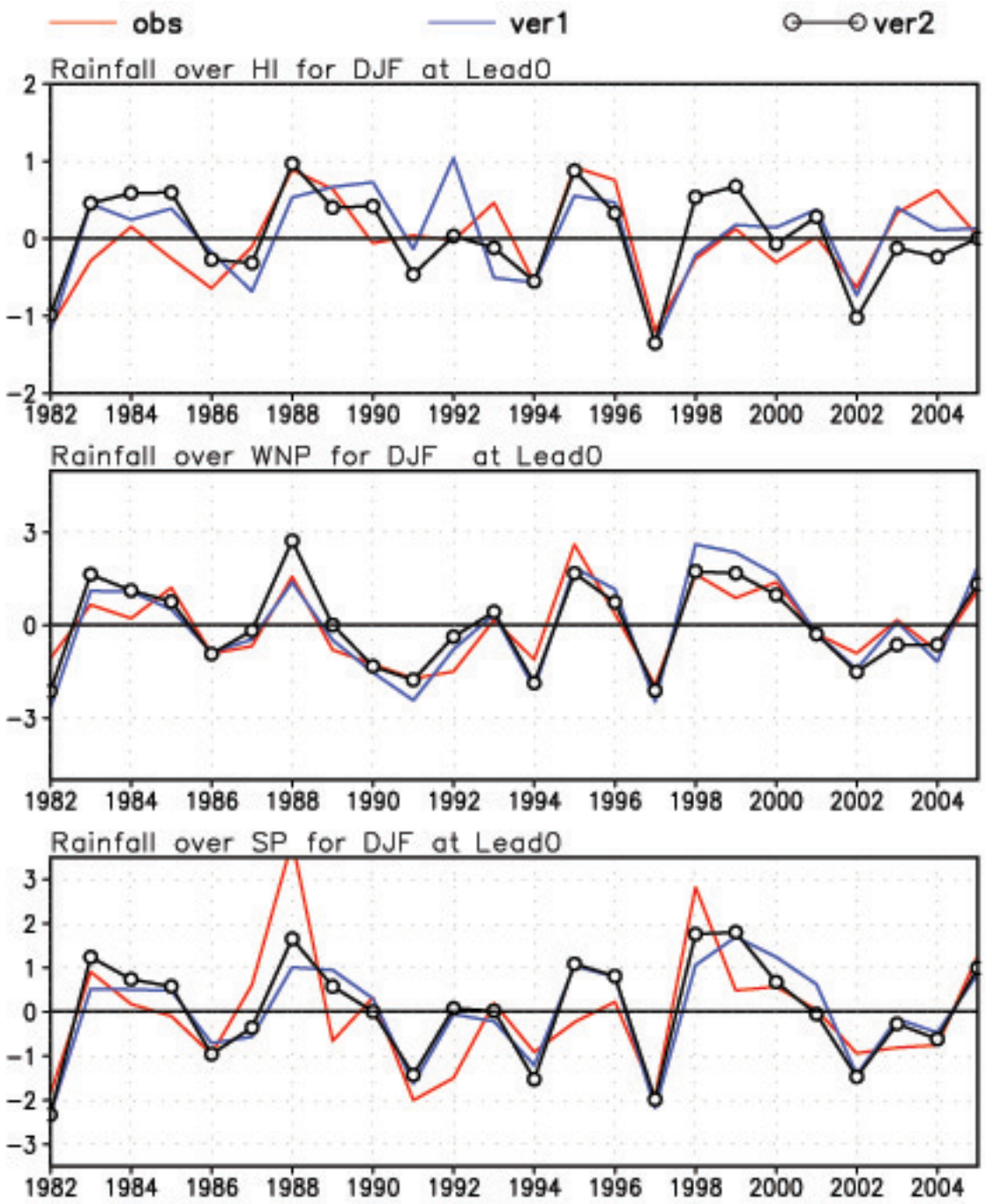
For technical details

Contact H. Annamalai

Real-time rainfall forecast for USAPI



The average deviation from climatology rainfall in mm/day for the period "Mar-Apr-May" 2011 as predicted by the ensemble means (large blue dot) and by the 15-ensemble members (red crosses) of the model that was initialized in Feb 2011. Past 0-month lead forecasts are also shown to illustrate the models forecast skill. Quality control observations (solid black line) are available only through June 2010. Each tick mark represents a 3-month period.


obs
ver1
ver2
Rainfall over HI for DJF at Lead0
Rainfall over WNP for DJF at Lead0
Rainfall over SP for DJF at Lead0
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004

Summary…

(i) For the USAPI, forecasting the persistence of dryness from El Nino winter into the following spring-summer is skilful at leads longer than 3 months

(ii) Our results suggest the feasibility that a dynamical system based seasonal prediction of precipitation can be considered (statistical method (0.4-0.6 ACC)

Work ongoing

(i)CFS new version – analysis – Update the Seasonal Prediction Website

(ii) ENSO and non-ENSO influence (500-year runs)

(iii) Understand the reasons for poor performance during boreal summer (monsoons?)

Heidke Skill Score (HSS)

For dichotomous forecasts, the HSS for time-series of length n is defined as

$$HSS = \frac{\left(F_c - \frac{n}{3} \right)}{\left(n - \frac{n}{3} \right)}$$

where F_c is the correct number of forecasts, i.e., the number of cases when the observed category is also the forecast category.

Rank Probability Skill Score (RPSS)

Rank probability skill (RPS) is computed as the sum of the squared differences between the cumulative distributions of the forecasts and observations.

The RPS is defined as

$$RPS = \sum_{m=1}^{m=N} (f_m - o_m)^2$$

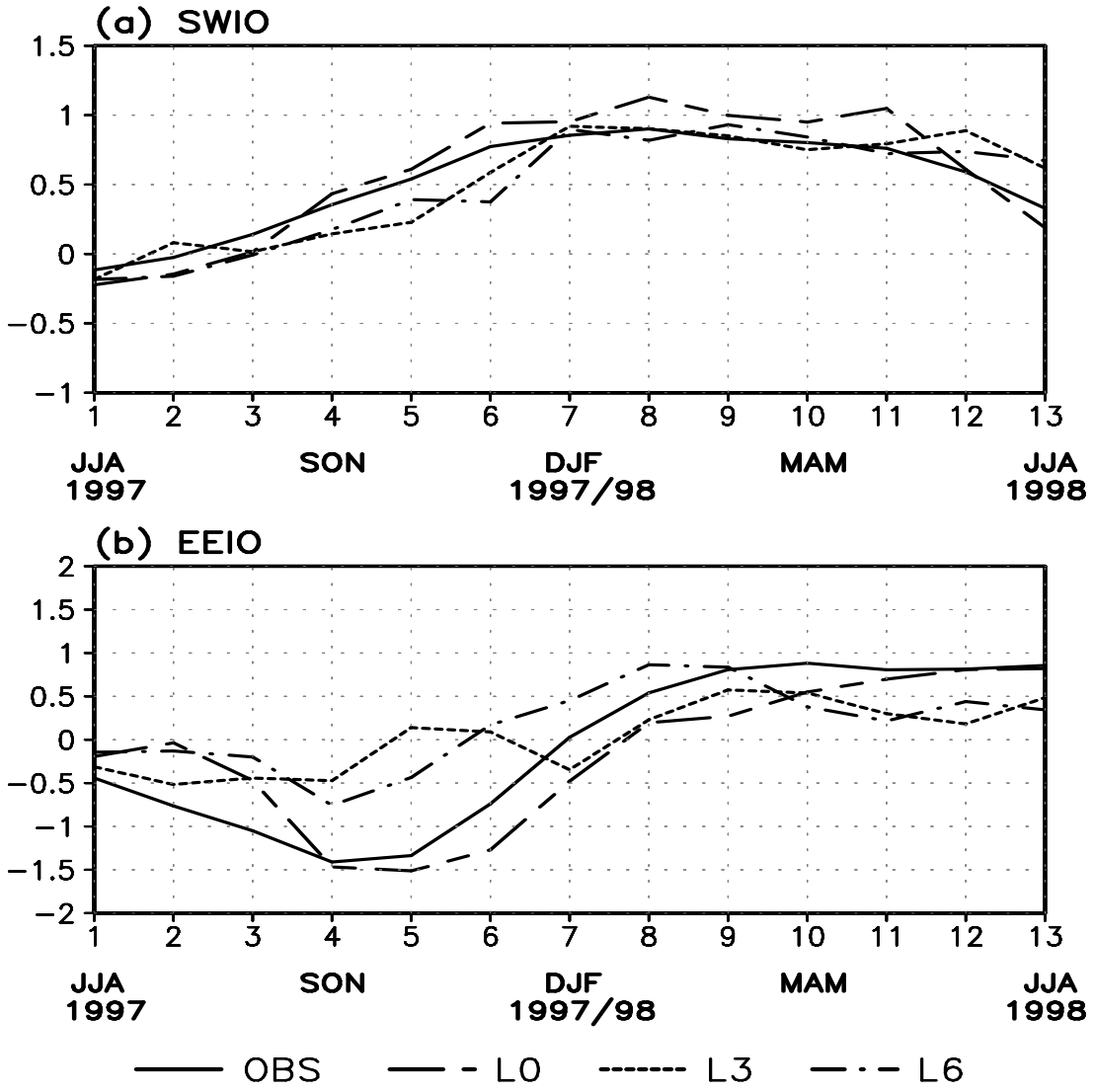
where N = 3 for tercile forecasts. Here f_m represents the cumulative probabilities of the forecast up to category m, and o_m is the cumulative observed probability up to category m.

- The RPSS which measures the skill with respect to the climatology forecast is defined as

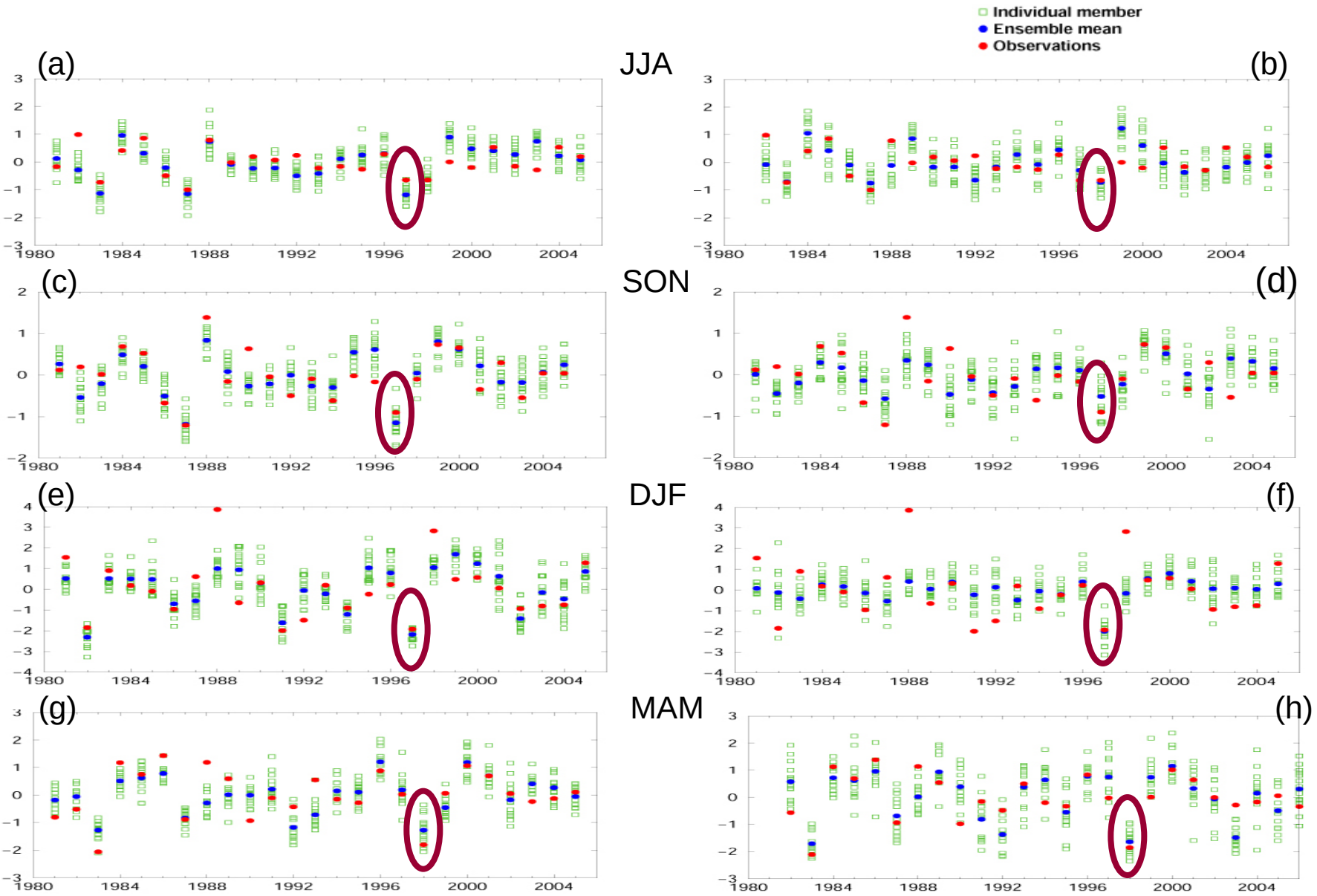
$$RPSS = 1 - \frac{RPS_{fcst}}{RPS_{c\,\mathrm{lim}}}$$

where RPS_{fcst} is the RPS for the actual forecast and RPS_{clim} is the RPS of the climatology forecast.

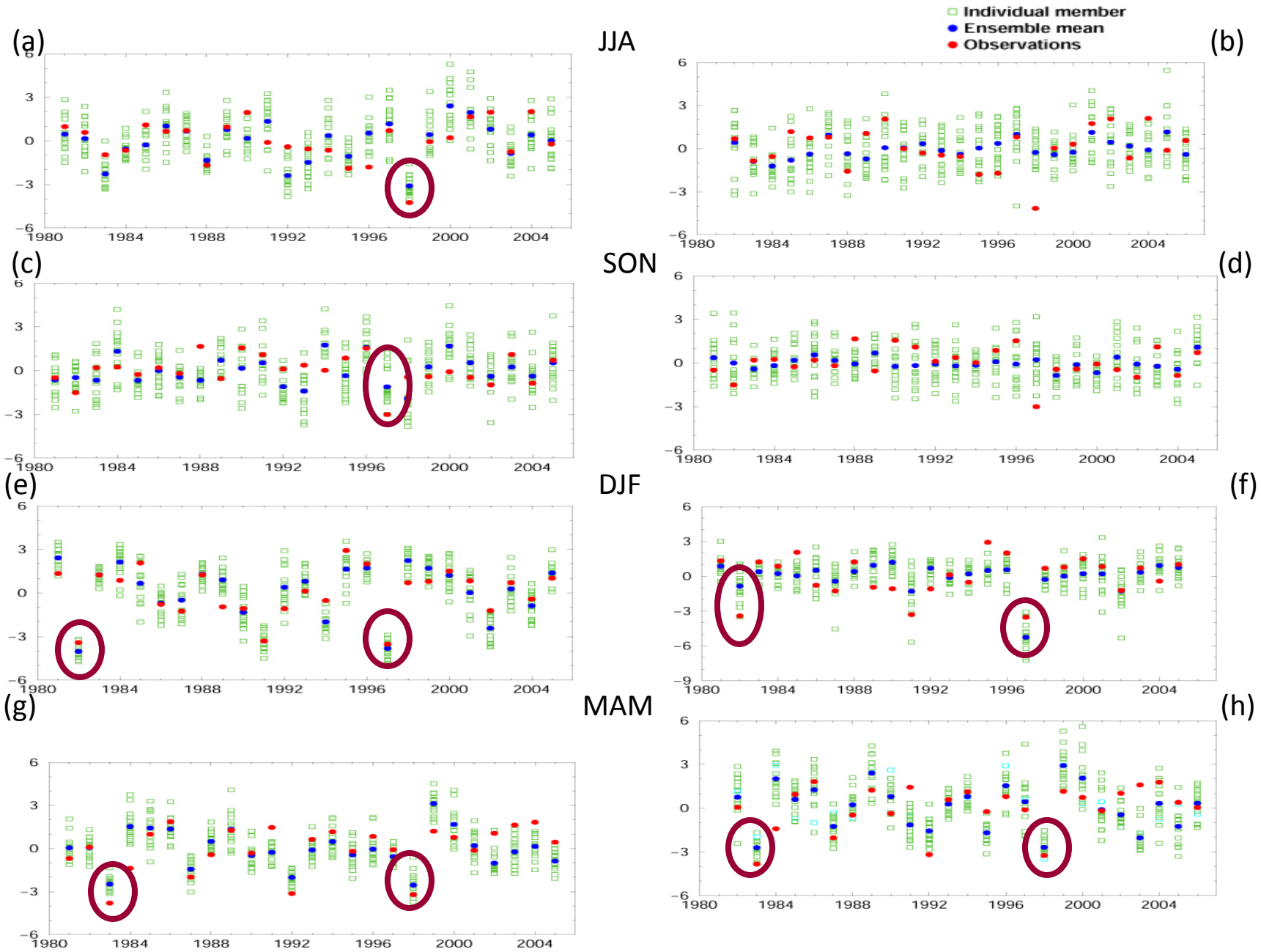
3-month average CFS ensemble mean SST forecast at 0 (dashed), 3 (dotted) and 6 (dashed-dot) month leads over (a) SWIO, and (b) EEIO.



Seasonal rainfall forecast at 0-month (left) and 6-month (right) lead over South Pacific region



Seasonal rainfall forecast at 0-month (left) and 6-month (right) lead west North Pacific region



Hindcast of boreal winter (DJF) SST/precipitation at lead 0-month.