

# Feasibility of Dynamical Precipitation Prediction System for the Pacific Islands

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❑ 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

□ 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, > < )

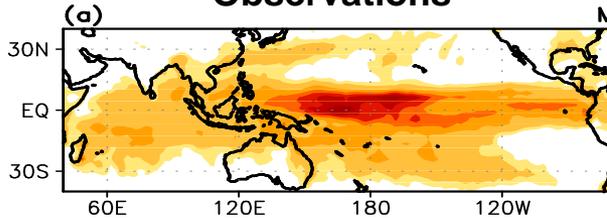
- RPSS – Probabilistic skill – penalizes for forecasting wrong category – ensemble members

- \*Convergence of different scores – forecast is useful”

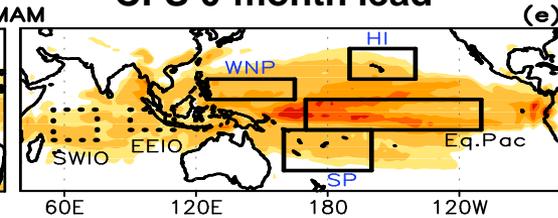
- Real-time forecasts (2006-09)

# Precipitation variance for four standard seasons

**Observations**



**CFS 0-month lead**



south west Indian Ocean  
(15°S-0, 55-75°E; SWIO)

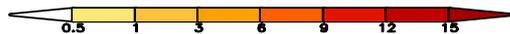
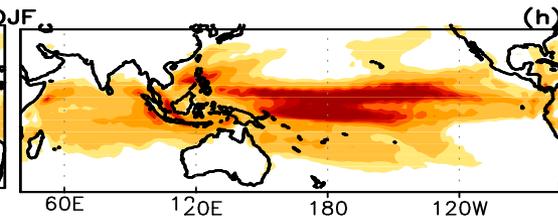
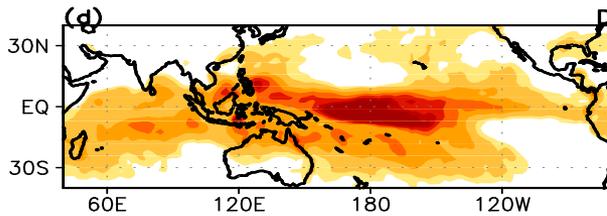
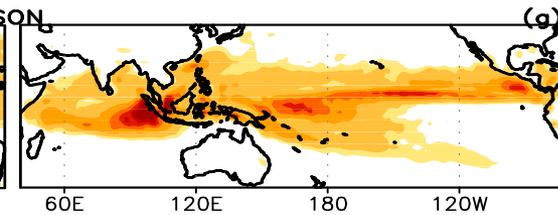
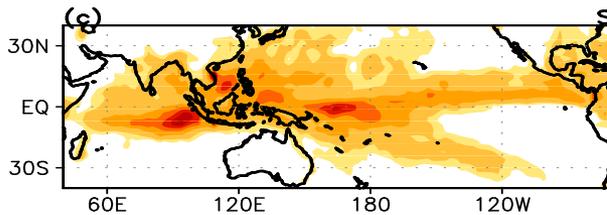
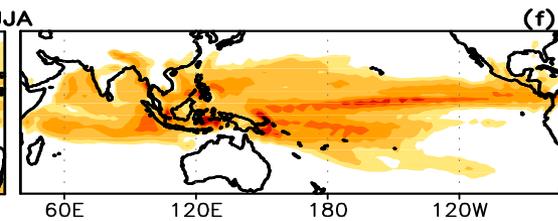
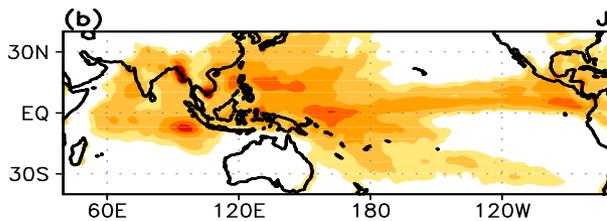
eastern equatorial Indian  
Ocean (10°S-0, 90-110°E;  
EEIO)

western north Pacific (5-  
15°N, 125-155°E; WNP)

south Pacific (10-30°S,  
160-200°E; SP)

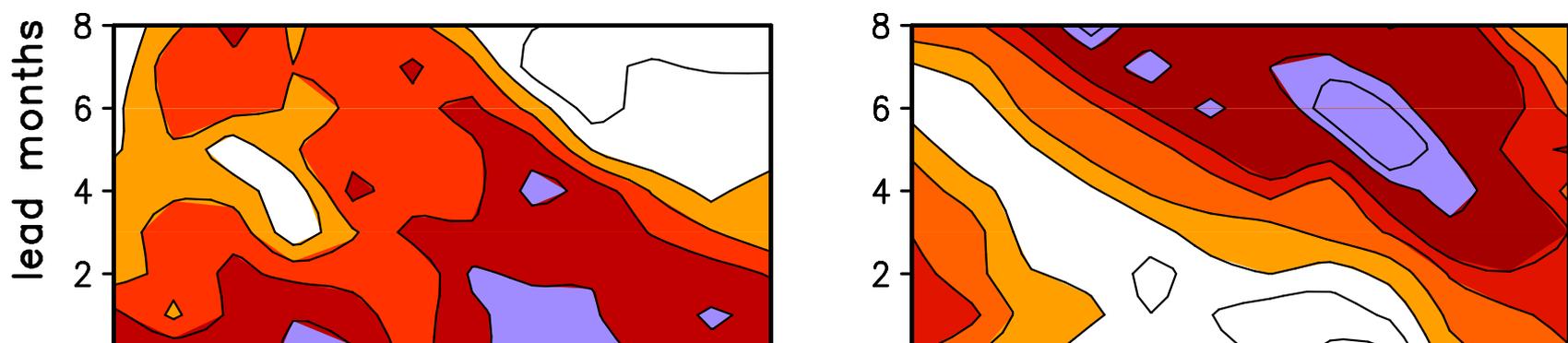
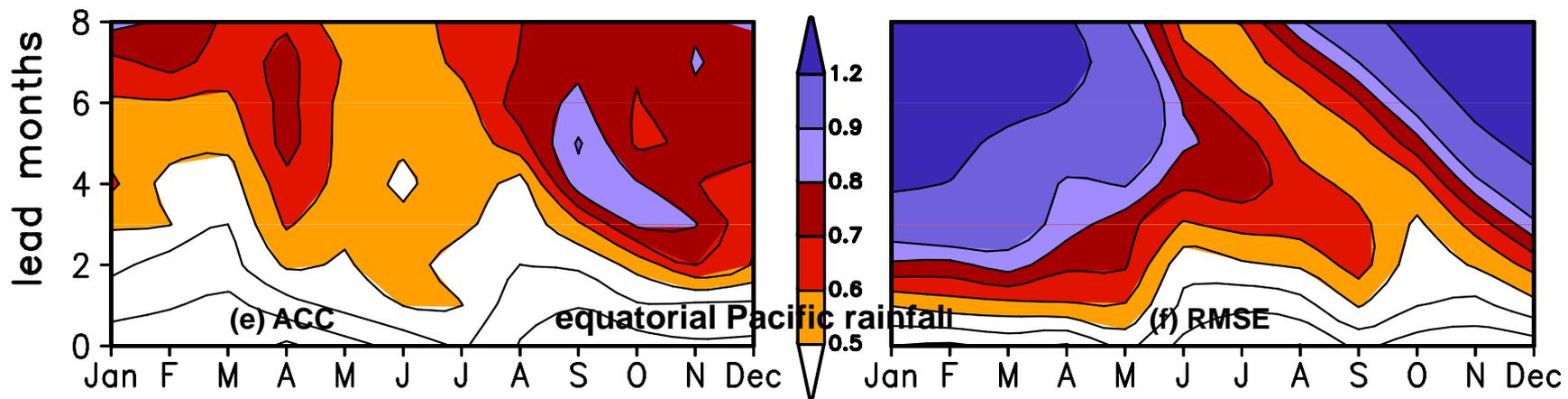
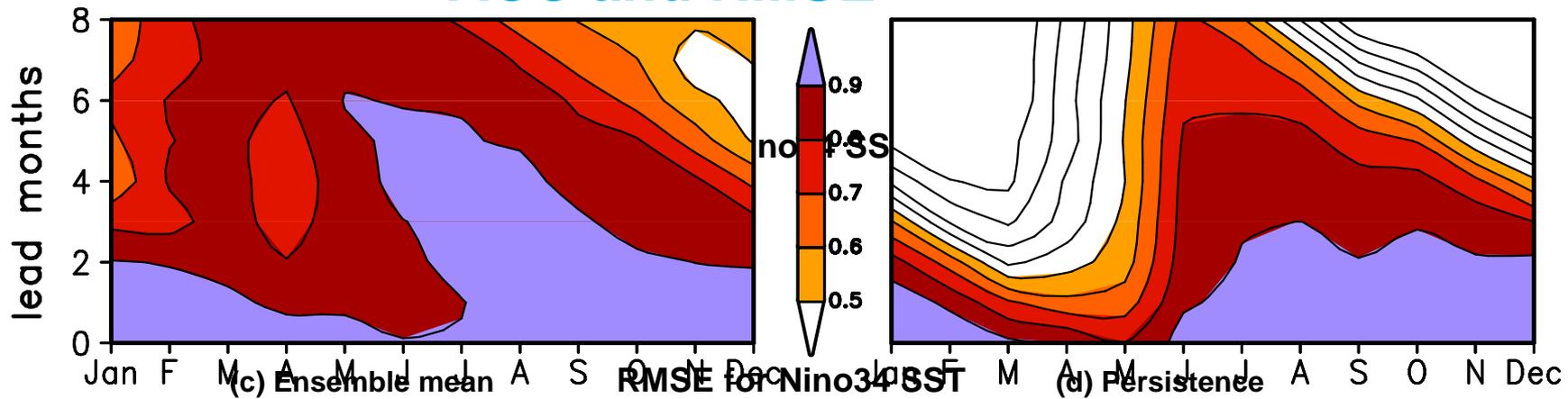
Hawaii (15-30°N, 140-  
170°W; HI)

equatorial Pacific (10°S-5°N,  
170°E-110°W; Eq. Pac)

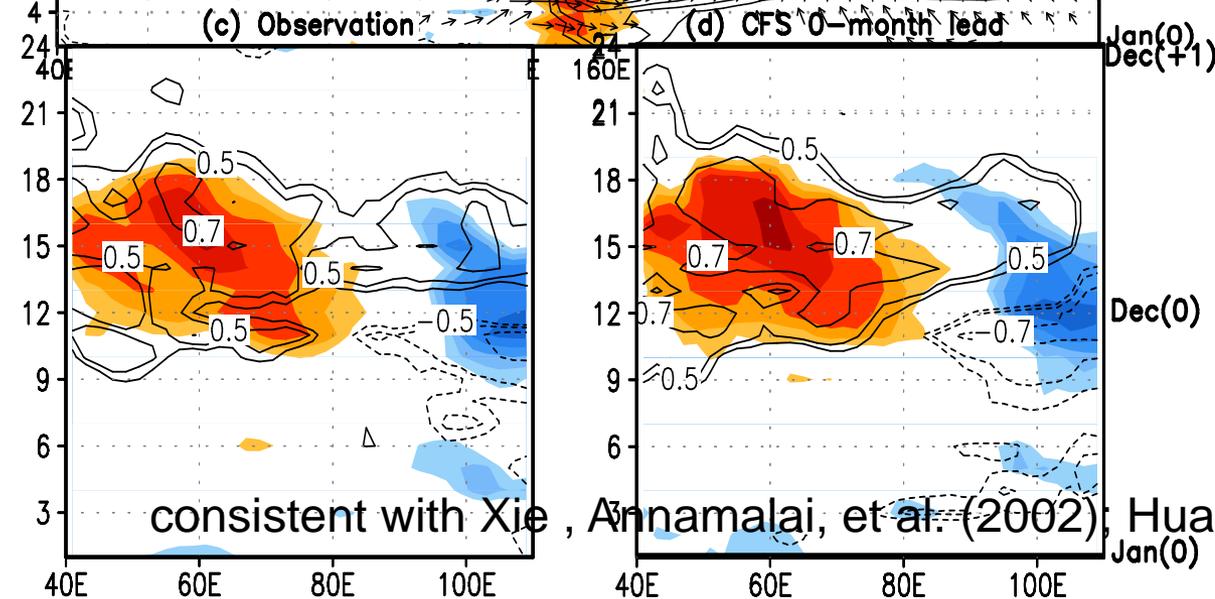
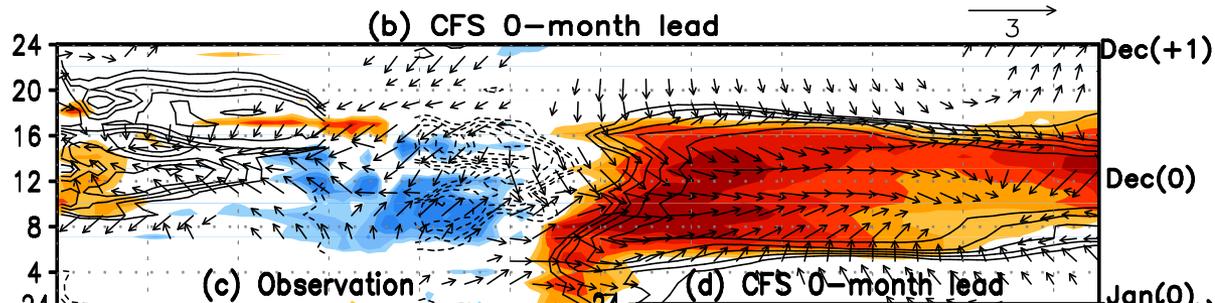
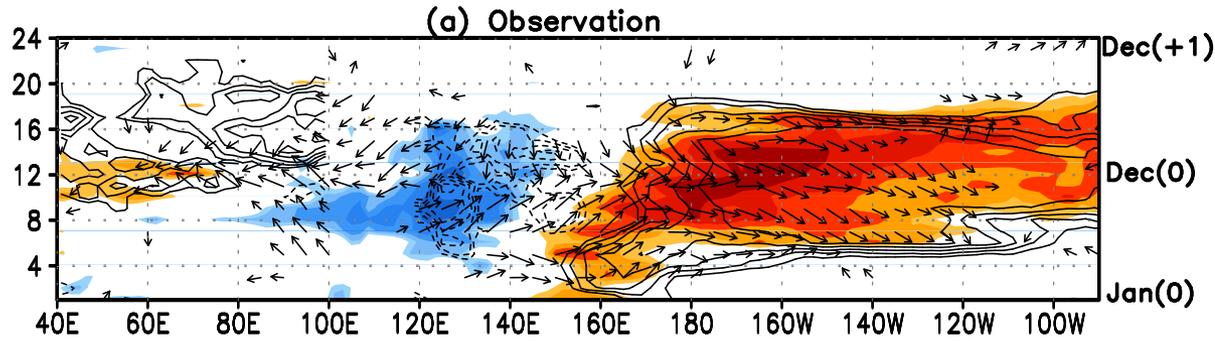


❖ **CFS captures the observed seasonal dependency in regional precipitation variance maxima over the tropics, with some systematic errors.**

# ACC and RMSE



# Teleconnection between the tropical Pacific and Indian Oceans

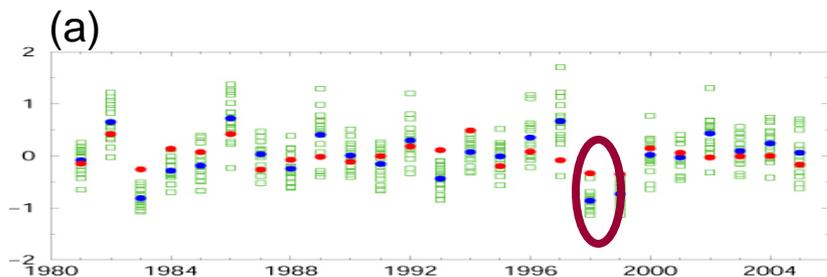


Lagged correlations of SST (contours), rainfall (shaded) and 850 hPa wind averaged in  $3^{\circ}\text{S}-3^{\circ}\text{N}$  with winter (DJF) Nino3.4 SST index

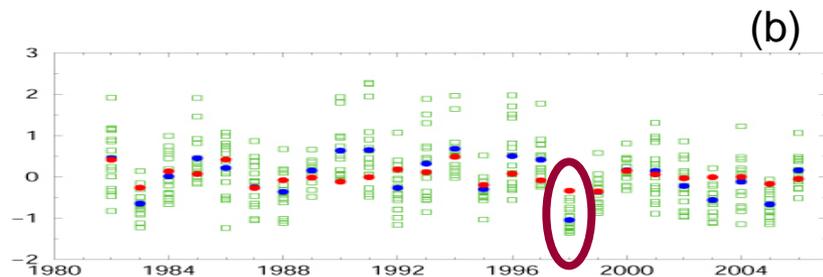
lagged correlations of SST (contours) and SSH (shaded) averaged in  $8^{\circ}\text{S}-12^{\circ}\text{S}$  with winter Nino3.4 SST index

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

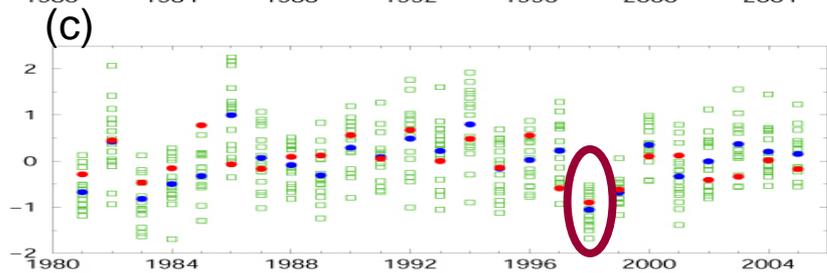
□ Individual member  
● Ensemble mean  
● Observations



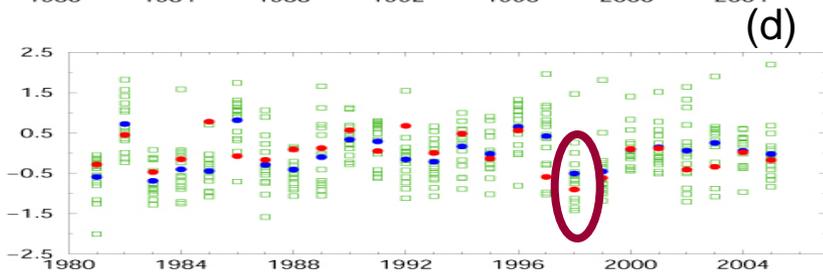
JJA



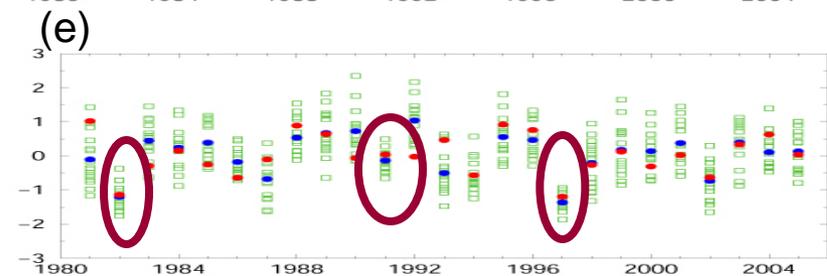
(b)



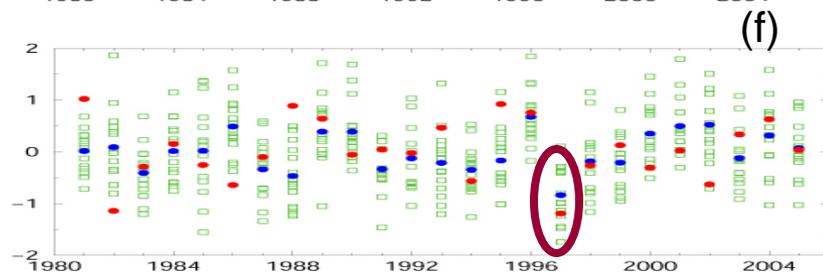
SON



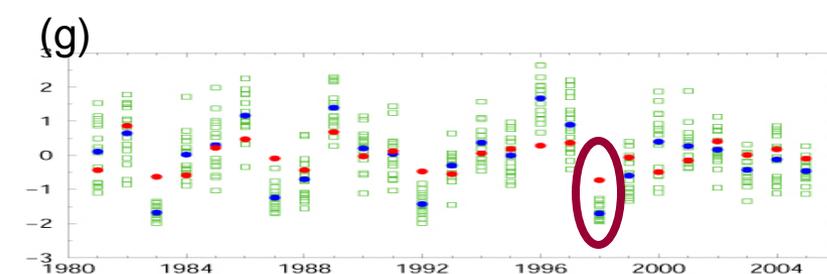
(d)



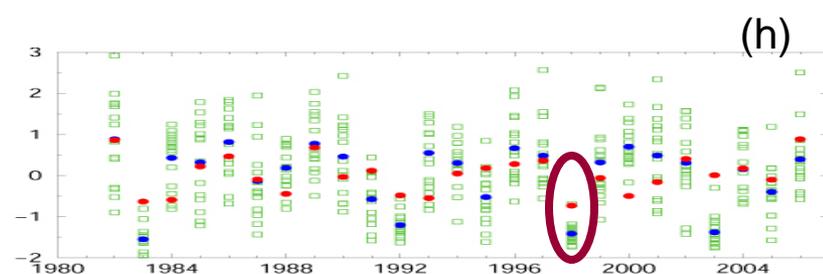
DJF



(f)

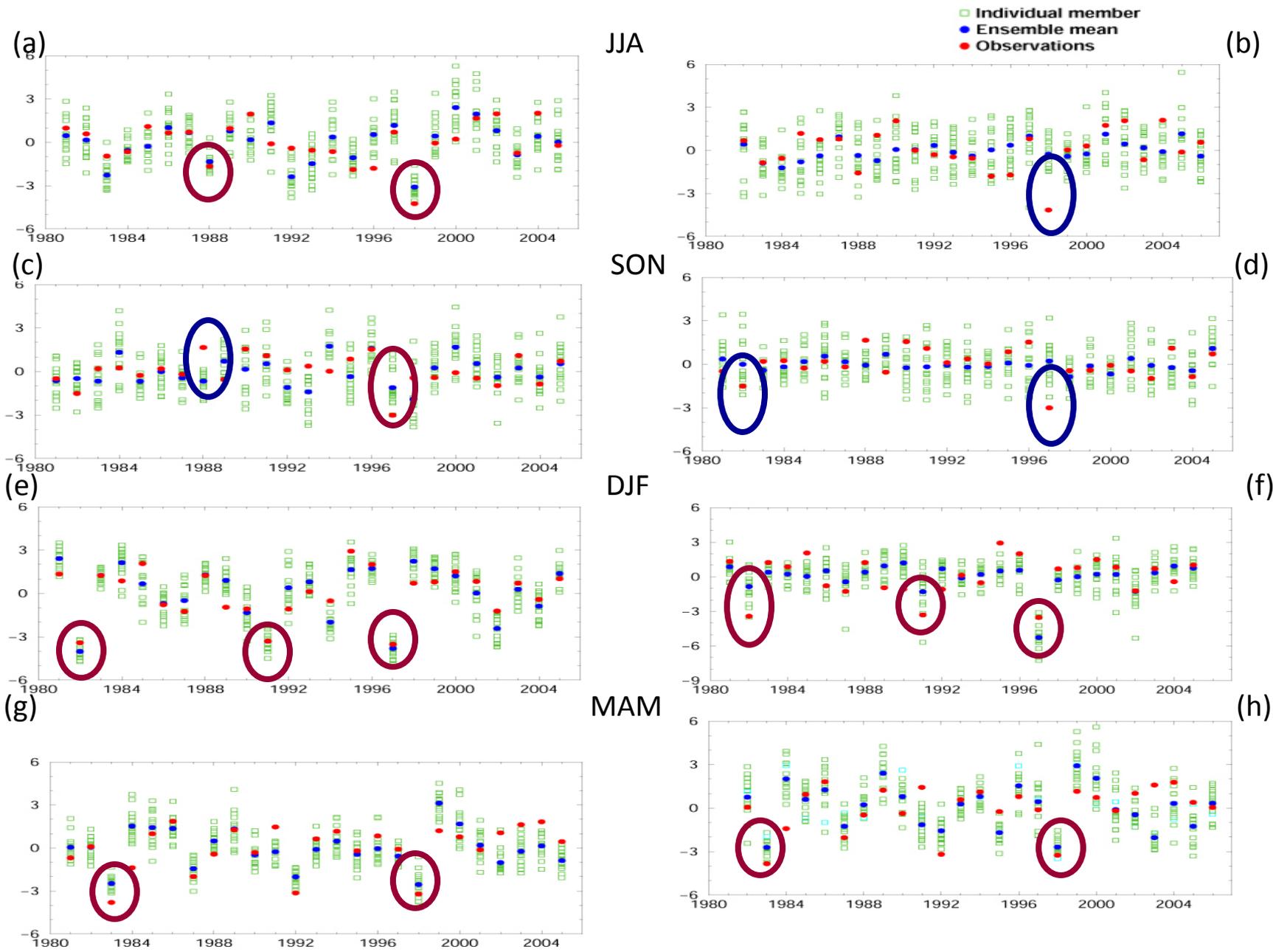


MAM



(h)

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



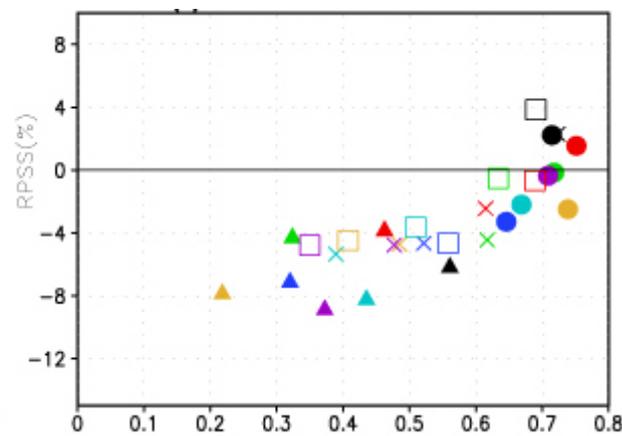
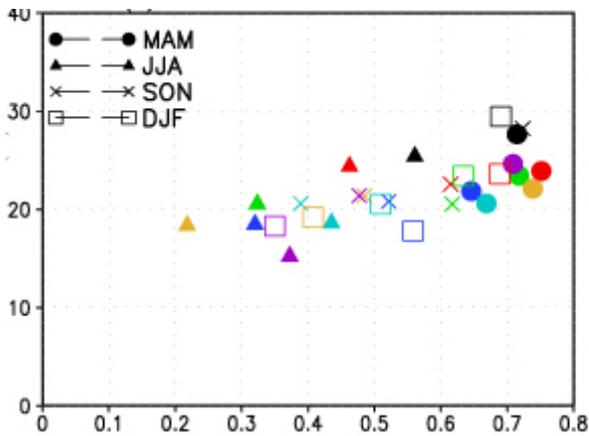
CFS Skill measures for rainfall over U.S. Affiliated Pacific Islands (USAPI)

ACC versus HSS

ACC versus RPSS

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

HSS

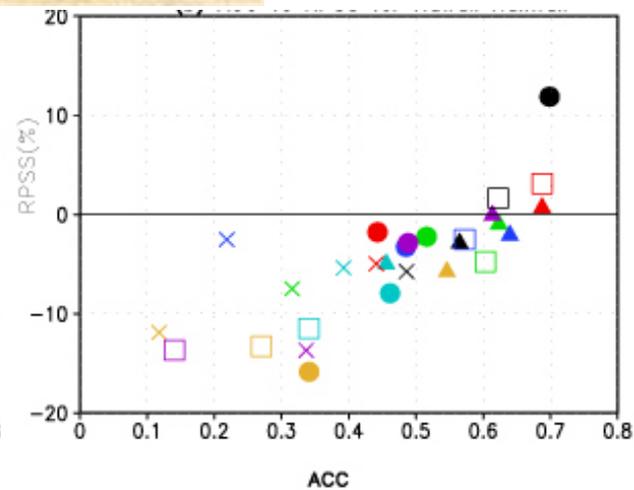
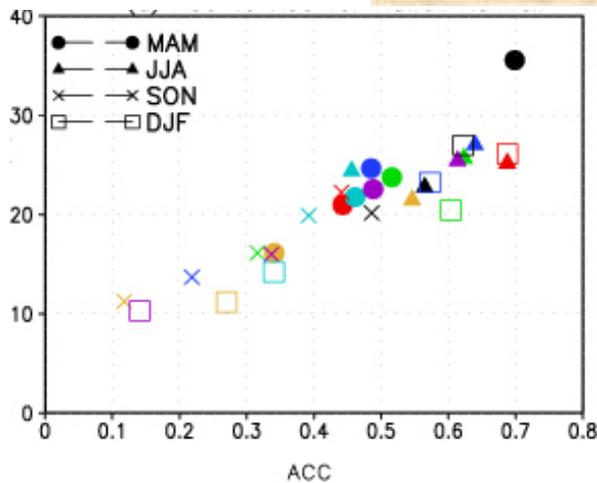


RPSS

-ve not better than  
Climatology

Hawaiian Islands  
(190-200°E; 15-30°N)

HSS



RPSS

L0

L1

L2

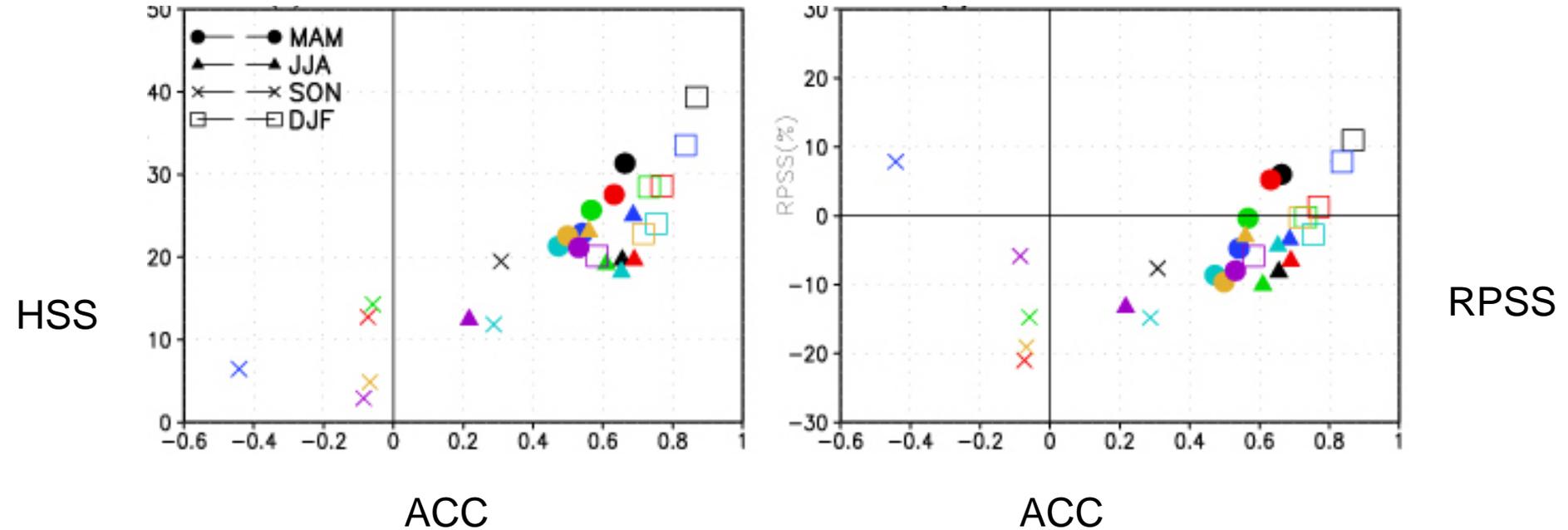
L3

L4

L5

L6

# West Pacific Islands



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) – 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/](http://apdrc.soest.hawaii.edu/projects/seasonal_prediction/)**

## 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?)

- Our Mission
- Project Background
- Hindcast Skills
  - CFS hindcasts description
  - Verification methods
  - Skill of ENSO hindcasts
  - Skill of Precipitation hindcasts over the USAPI
  - Heidke and RPSS scores over the USAPI
- Real-time prediction
  - By Lead time
    - 0-month
    - 1-month
    - 2-month
    - 3-month
    - 4-month
    - 5-month
    - 6-month
  - By Region
- Previous Forecast
  - Jul 2010
  - Aug 2010
  - Nov 2010
  - Dec 2010
- References

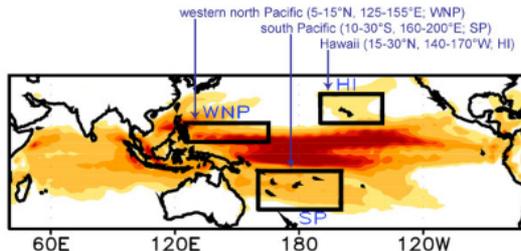
## Precipitation Prediction System over the Pacific Islands

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2. Climate Prediction Center, NOAA, Washington D.C, USA
3. Water and Environmental Research Institute, University of Guam, USA

### 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 terminology for the lead times is such that a "0 month" forecast for JFM2010 would be produced using December 2009 initial conditions, a "1 month" forecast for FMA2010 would be produced using December 2009 initial condition, and so on.

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

### Seasonal prediction and other sites

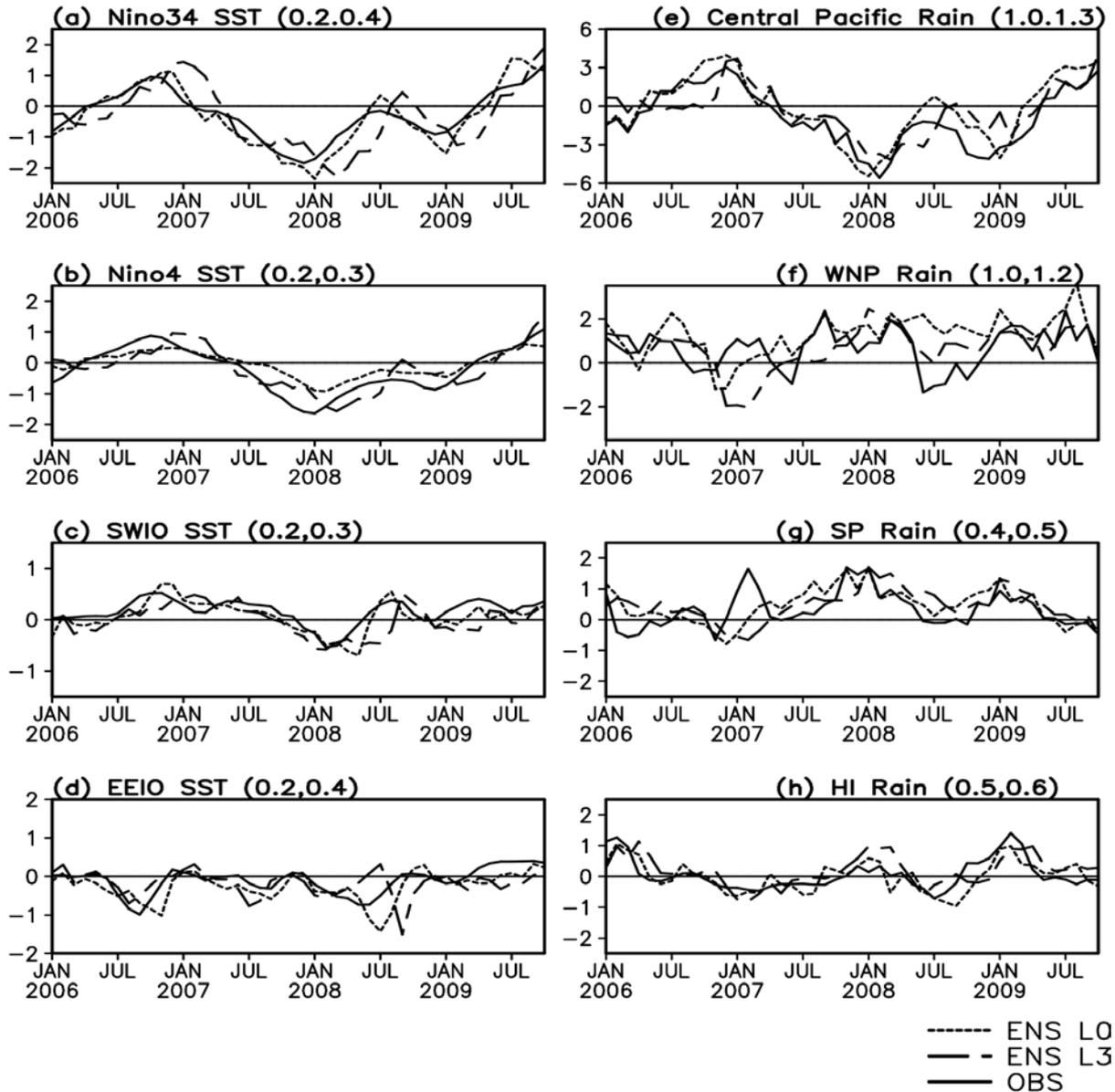
Users with a need for precipitation forecasts over the next three months may want to consult the web site of the UH/National Weather Service Pacific ENSO Applications Climate Center who have real time forecasts for 14 individual stations in Hawaii and other USAPI.

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

### For technical details

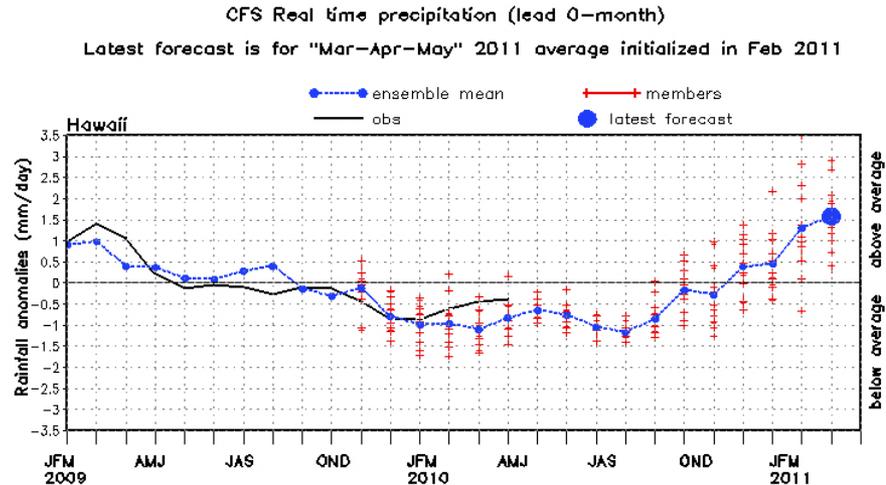
Contact H. Annamalai

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

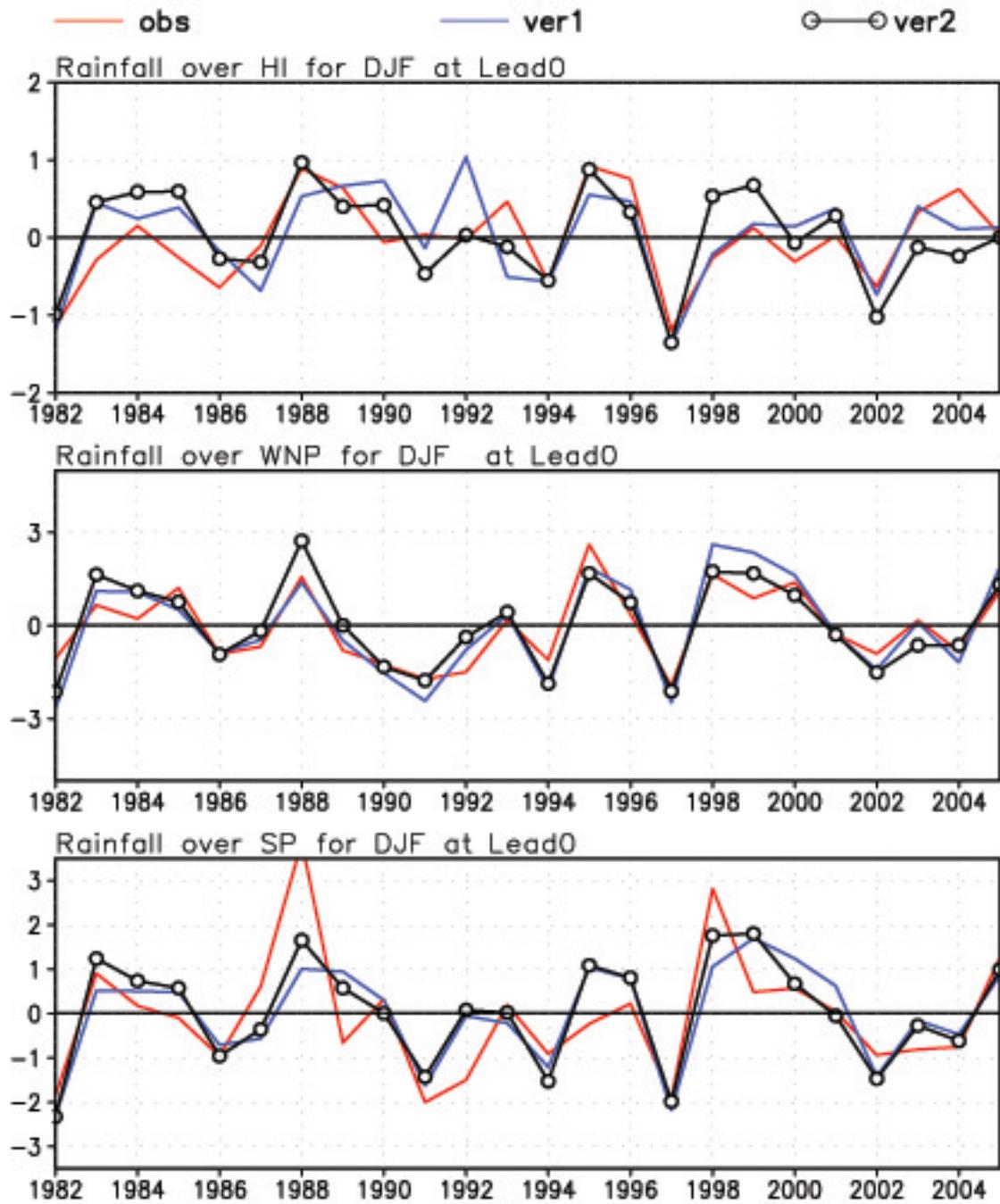


Real-time rainfall forecast for USAPI

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- [Real-time prediction](#)
  - [By Lead time](#)
    - [0-month](#)
      - [Hawaii](#)
      - [western north Pacific](#)
      - [south Pacific](#)
    - [1-month](#)
    - [2-month](#)
    - [3-month](#)
    - [4-month](#)
    - [5-month](#)
    - [6-month](#)
  - [By Region](#)
- [Previous Forecast](#)
  - [Jul 2010](#)
  - [Aug 2010](#)
  - [Nov 2010](#)
  - [Dec 2010](#)
- [References](#)



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 model's forecast skill. Quality control observations (solid black line) are available only through June 2010. Each tick mark represents a 3-month period.



## 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

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

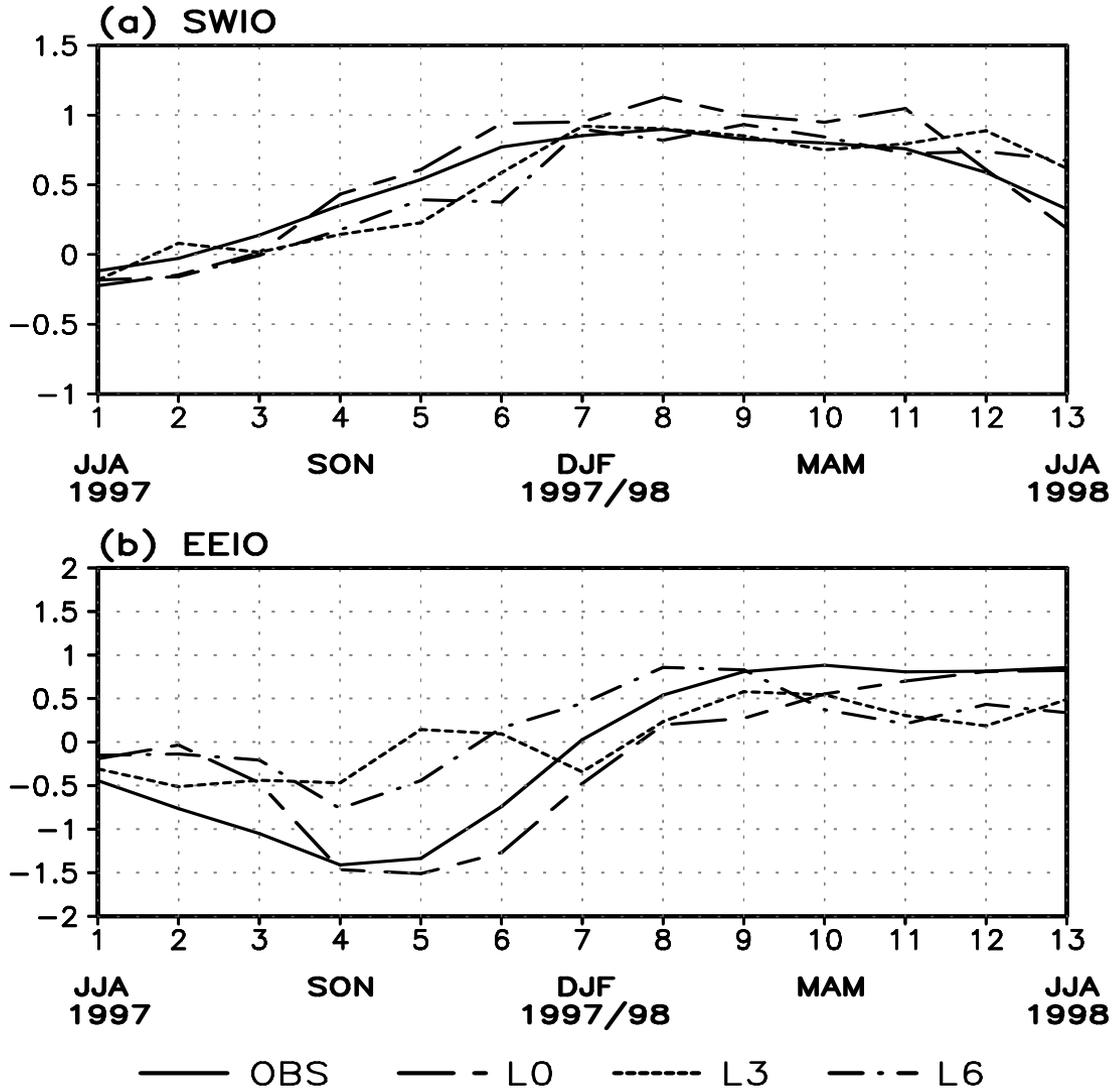
where  $N = 3$  for tercile forecasts. Here  $f_m$  represents the cumulative probabilities of the forecast up to category  $m$ , and  $o_m$  is the cumulative observed probability up to category  $m$ .

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

$$RPSS = 1 - \frac{RPS_{fcst}}{RPS_{clim}}$$

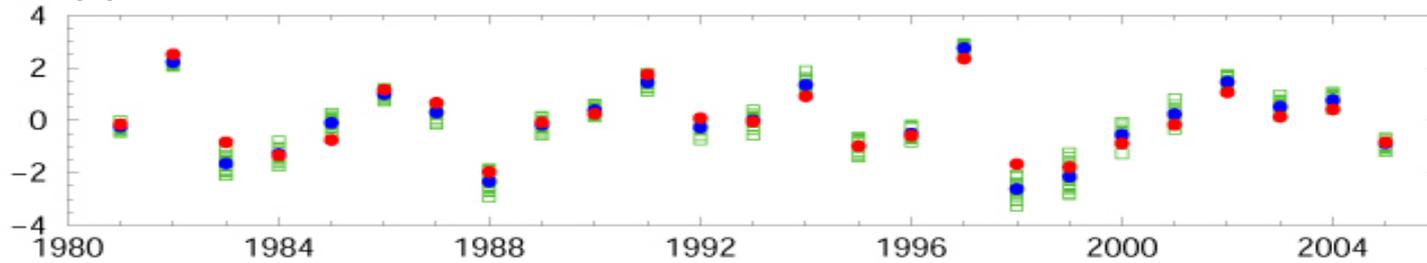
where  $RPS_{fcst}$  is the RPS for the actual forecast and  $RPS_{clim}$  is the RPS of the climatology forecast.

**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.**

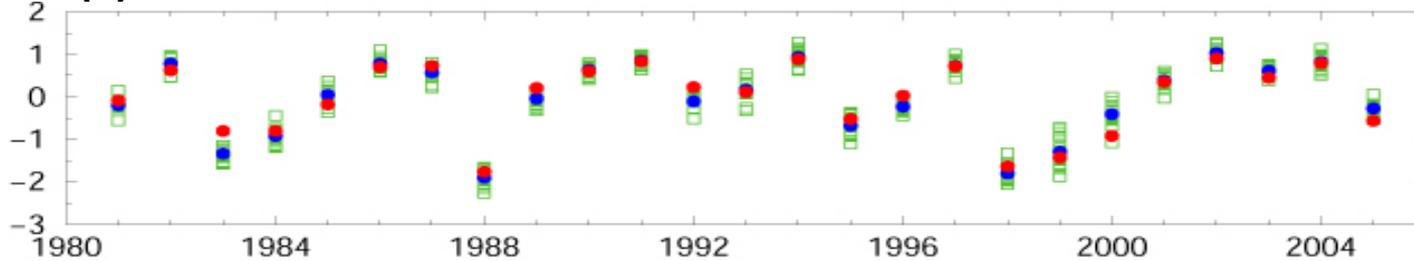


# Hindcast of boreal winter (DJF) SST/precipitation at lead 0-month.

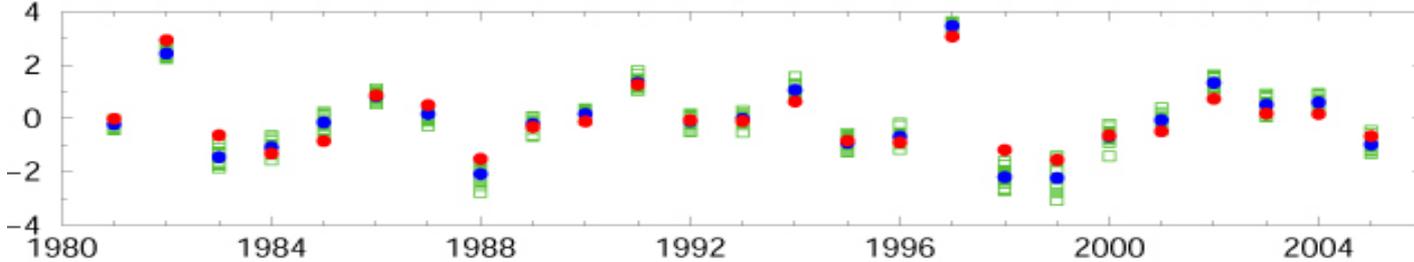
(a) Nino3.4 SST



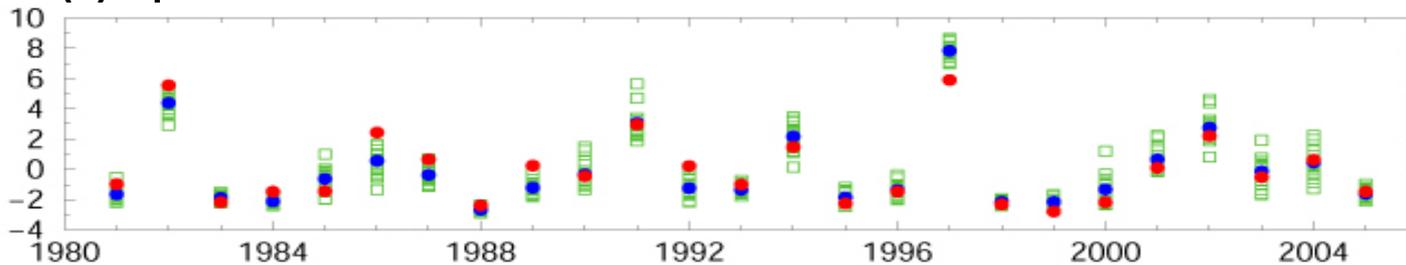
(b) Warm Pool El Niño SST



(c) Cold Tongue El Niño SST



(d) Equatorial Pacific rainfall



□ Individual member  
● Ensemble mean  
● Observations

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

