

IRI FORECAST SYSTEM & DROUGHT PREDICTION:

Real-time climate information, potentials for sub-seasonal predictability & relationships with large-scale variability

N. Vigaud, A.W. Robertson, P. Ceccato, S. Li, B. Lyon, and M. Tippett

The International Research Institute
for Climate and Society

EARTH INSTITUTE | COLUMBIA UNIVERSITY



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OUTLINE

- 1 Fire Early Warning System in Kapuas, Kalimantan
- 2 Development of a dynamic crop calendar for managing drought risks in rice-based farming systems
- 3 Potentials for sub-monthly climate predictions
- 4 East African droughts during the long rain season and Pacific decadal variability

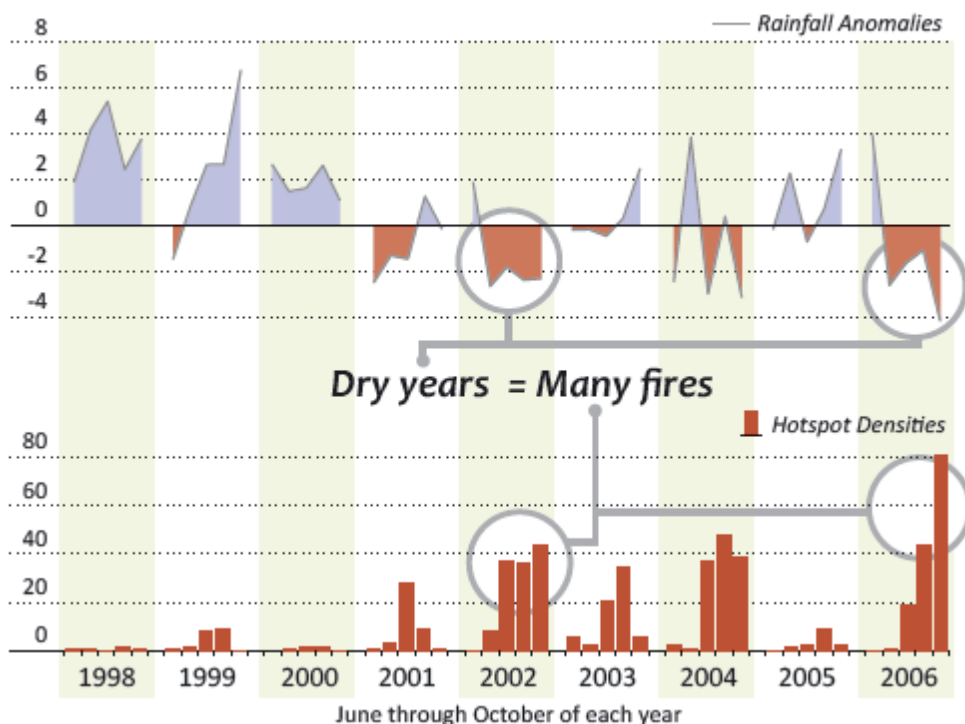
Part 1: Fire Early Warning System in Kapuas, Kalimantan

*P. Ceccato, A.W. Robertson, R. Boer, M. Ardiansyah
and S. Thoha (CCROM at IPB)*

Background & motivations

- ❖ Peatland fires are an increasing problem in Indonesia (80% of SE Asia peatlands)
- ❖ Uncontrolled fires in Central Kalimantan have destroyed vast peatland forest areas, ruined livelihoods, and led to massive releases of smog and greenhouse gases

Climate and Fire in Central Kalimantan



Severity of fire activity strongly associated with **rainfall during the dry season** (June-October)

Strong ENSO influence on local rainfall
=> **Tropical Pacific SSTs** used as **predictor**

Towards fire risk maps...

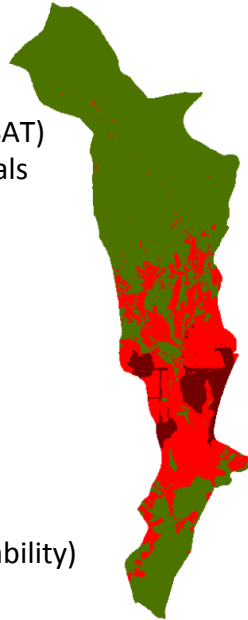
Vulnerability maps

Based on **environmental factors**:

- Vegetation types** (30m LANDSAT)
- Distances** from roads and canals
- Peat depths**
- Land use practices**
- Fire activity** (MODIS hotspots)

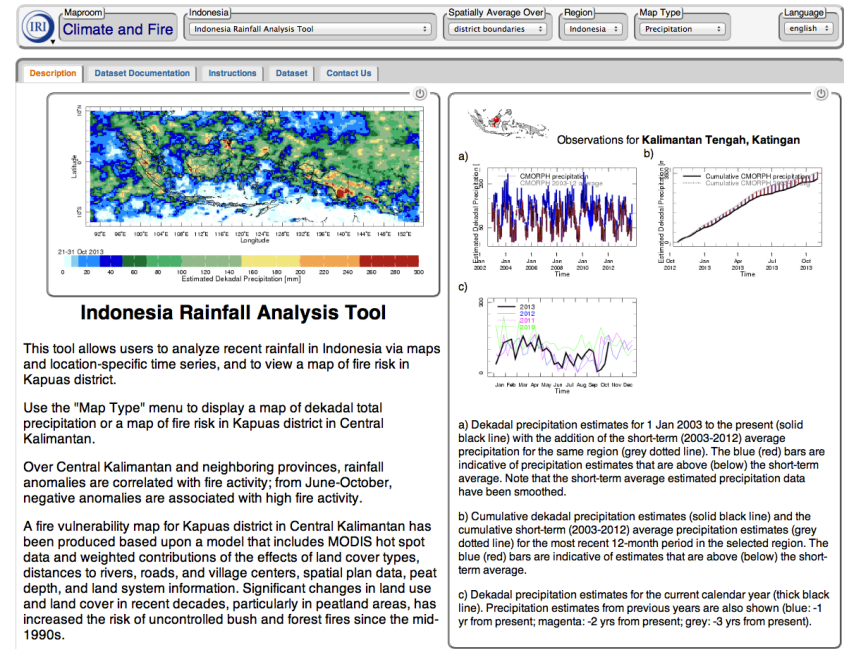
Figure: 2009 vulnerability map
(**green/red/dark red** indicates **medium/high/very high** fire vulnerability)

Courtesy from R. Boer and collaborators at CCROM (IPB)



Real-time rainfall anomalies monitoring

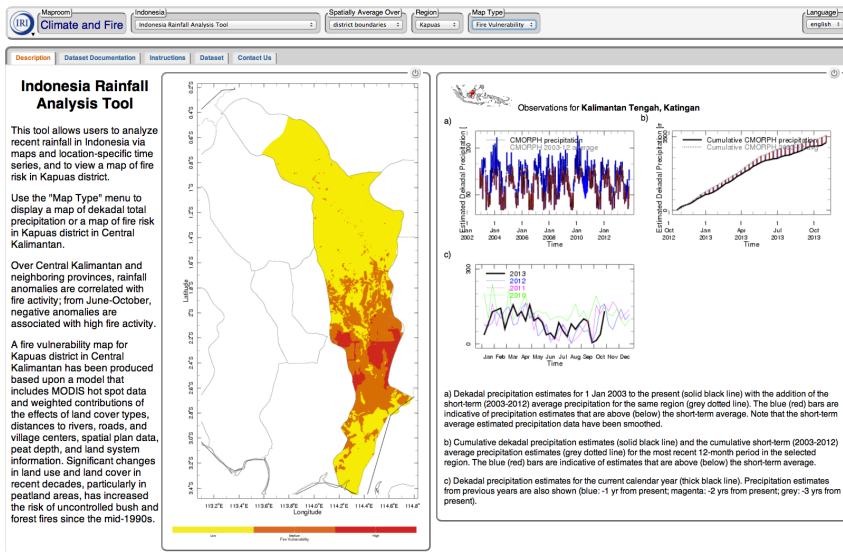
Dekadal precipitation estimates based on daily **CMORPH** satellite data



http://iridl.Ideo.columbia.edu/maproom/Fire/Regional/Indonesia/Dekadal_Rainfall.html

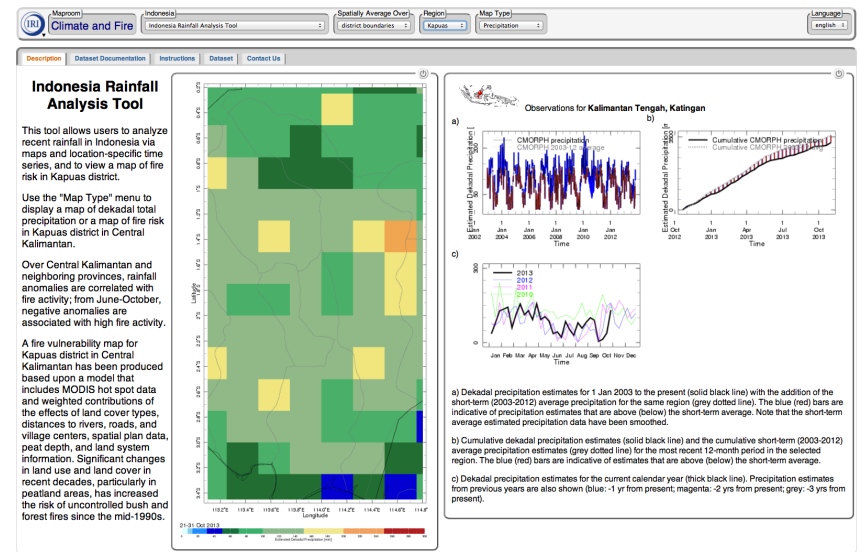
Towards fire risk maps...

Vulnerability maps



Real-time rainfall anomalies monitoring

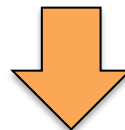
Dekadal precipitation estimates based on daily CMORPH satellite data



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Access from Climate & Fire map room for Kapuas
(2009 map for now, yearly updates to be implemented)

Tailored map room for Kapuas

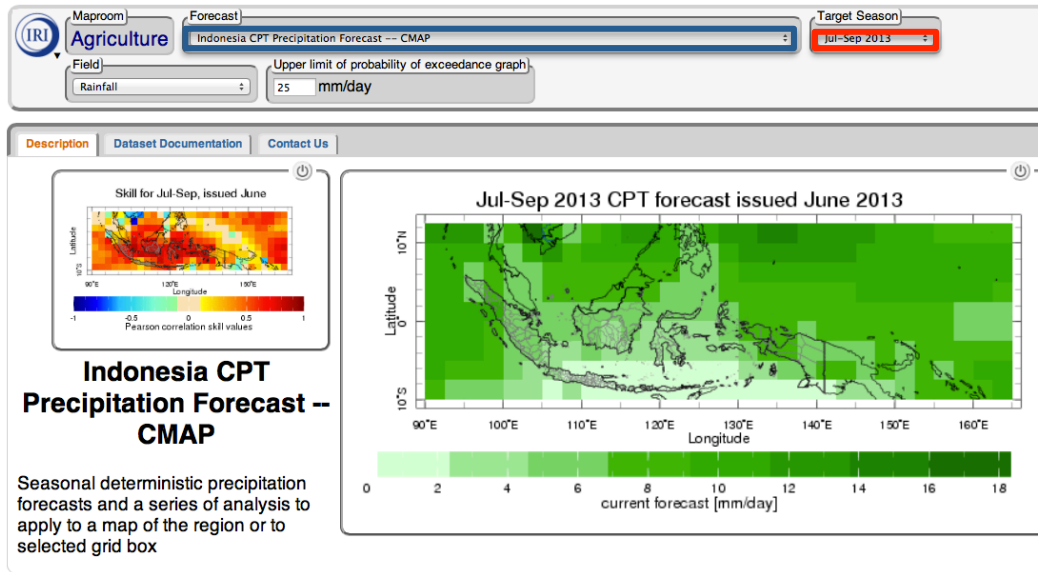


FIRE RISK MAPS	BELOW NORMAL RAINFALL	NORMAL RAINFALL	ABOVE NORMAL RAINFALL
VERY HIGH VULNERABILITY	VERY HIGH	VERY HIGH	HIGH
HIGH VULNERABILITY	VERY HIGH	HIGH	HIGH
MEDIUM VULNERABILITY	HIGH	MEDIUM	MEDIUM

Precipitation seasonal forecast tools

(From IRIDL Agriculture Maproom)

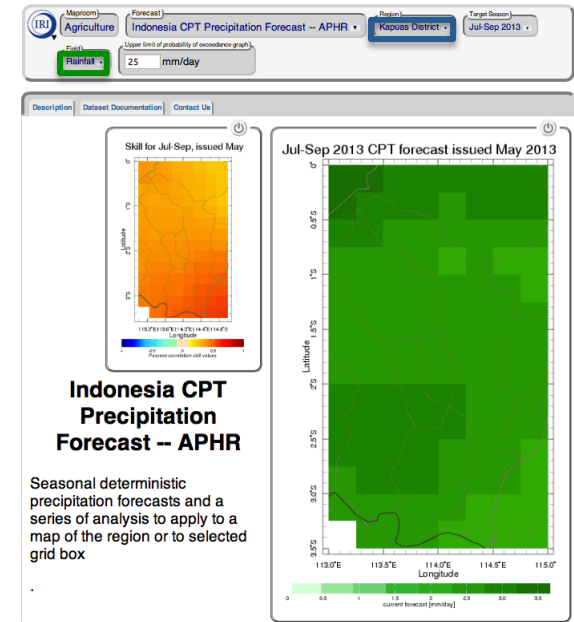
Indonesia precipitation seasonal forecasts



CPT forecasts for 12 3-month seasons based on ECHAM4.5 hindcasts and APHR/CMAP/GPCP (1972-2007)

http://iridl.ideo.columbia.edu/maproom/Agriculture/Forecast/Indonesia_Precip_CMAP.html

Kapuas seasonal forecasts



CPT forecasts for 4 3-month seasons based on 3 model hindcasts (CFSv2, CanCM3, COLA-CCSM3) and APHRODITE data (1982-2006)

Fields available

Rainfall, anomalies, percent of median, percentage of exceeding/non-exceeding flexible threshold

Predictive tools for fire activity in Kapuas

Maproom Indonesia Province: Tengah Lead Time: 1 month Number of Fires Threshold: median NINO4 Threshold: median Language: english

Predictive Tool for Fire Activity in Kalimantan, Indonesia

These are experimental forecasts of the likelihood of high or low fire activity in the province of Central Kalimantan, Indonesia. By monitoring the NINO 4 index of the sea surface temperature from April to September, it is possible to estimate the fire activity one to two months in advance.

This page presents experimental forecasts of the likelihood of high or low fire activity in the provinces of South, Central, West, and East Kalimantan in Indonesia. This experimental research was conducted by IRI through a partnership with Bogor Agriculture University with support from CARE Indonesia. IRI is currently working with the Indonesian Meteorological Service (BMKG) to compare methodologies for forecasting relevant to fires; this work is being funded by USAID.

By monitoring the NINO4 index of the Sea Surface Temperature (SST) from April to September, it is possible to estimate the fire activity one to two months in advance. This analysis is based on data from 1998-2006 on fire hotspots (derived from NOAA-AVHRR) and on the [NINO4 index](#). The four graphs that appear further down on this page show the results of this analysis for each of the four Kalimantan provinces in Indonesia.

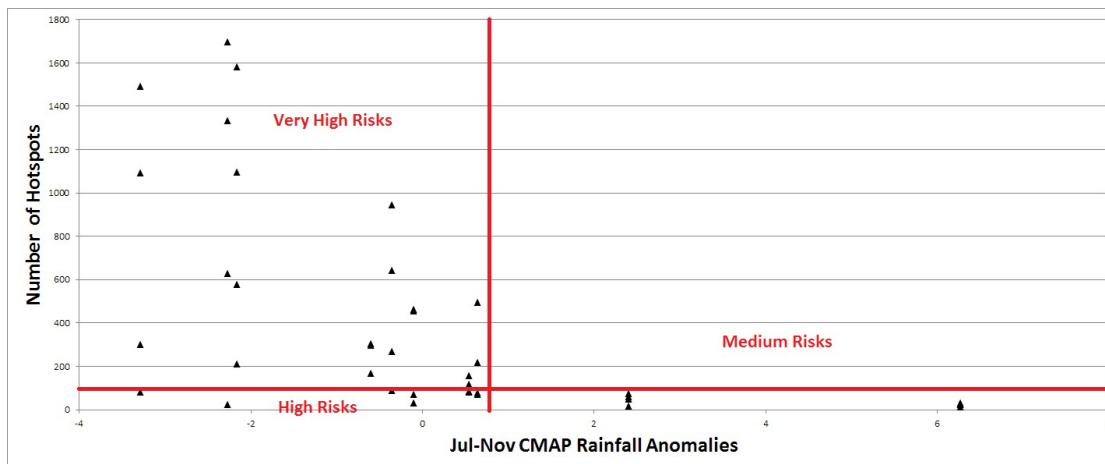
The time series of the NINO4 index (shown in the graph above) is updated every month. Based on its relationship to fire activity, users may view the NINO4 data and forecast 1-2 months ahead whether fire activity is likely to be above or below median levels.

Estimation of **fire activity** (number of hotspots in Kapuas) **one to two months ahead** by monitoring **Nino3.4** from April to September,

Based on NOAA-AVHRR fire hotspots (1998-2006) with NINO3.4 index updated every month

Months with **high/low** fire hotspots activity (**387 fires median threshold**) usually accompanied by **higher/lower** NINO3.4 values (**0.4 median threshold**)

<http://iridl.ldeo.columbia.edu/maproom/Fire/Regional/Indonesia/NINO4.html?selregion=indonesia>



Relationship between the **number of hotspots in Kapuas** and **seasonal rainfall anomalies...**

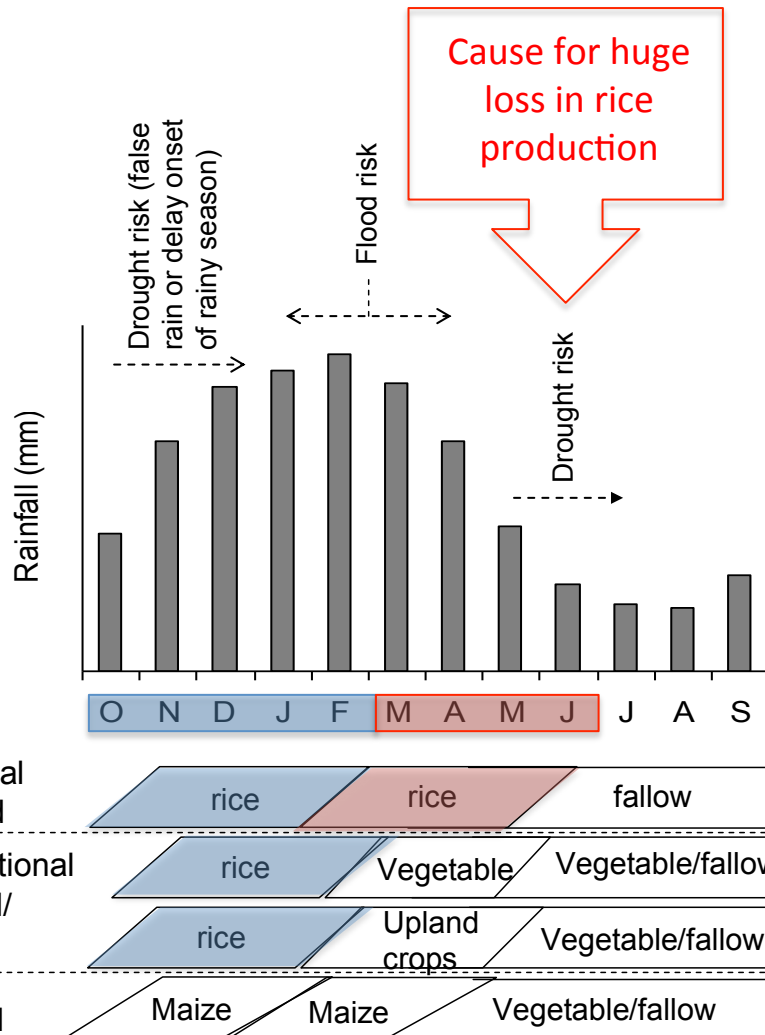
(to be developed)

Part 2: Development of a dynamic crop calendar for managing drought risks in rice-based farming systems

A.W. Robertson, R. Boer & collaborators at CCROM (IPB)

Background & motivations

Common types of climate risks



For lowland rice farming systems

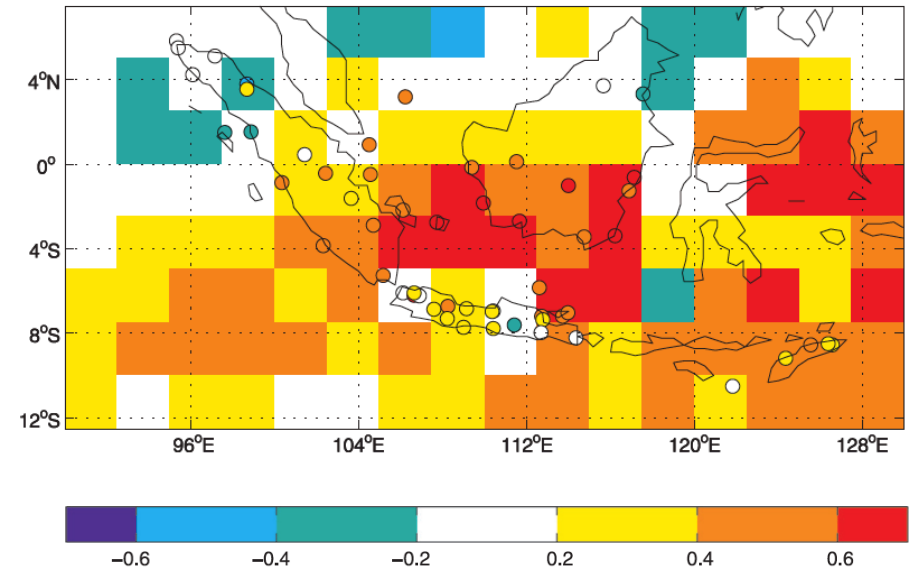
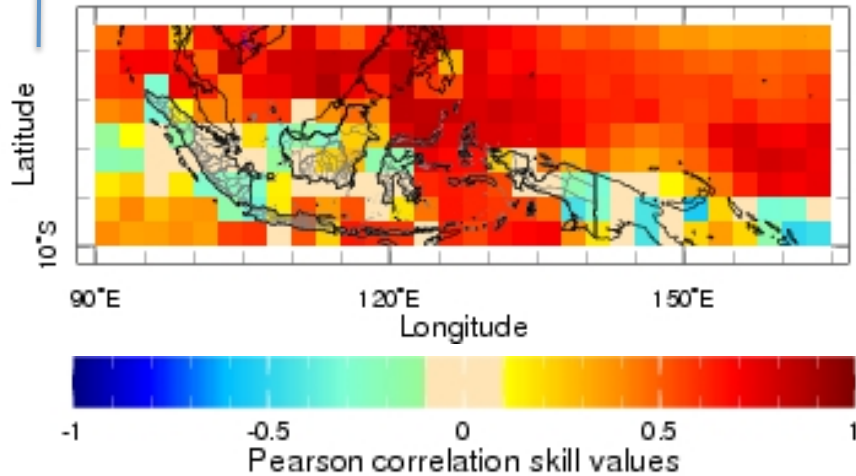
- ❖ **1st rice:** flood risk in Jan-Feb
- ❖ **2nd rice:** drought risk due to **early onset of dry season** (rainy season ends earlier than normal)

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The **delay of monsoon onset** shifts the cropping sequence thus **increasing the risk of drought in the second planting**

Predictability of drought occurrences

Skill for Mar-May, issued February



Weak skill in predicting **rainfall amounts**....

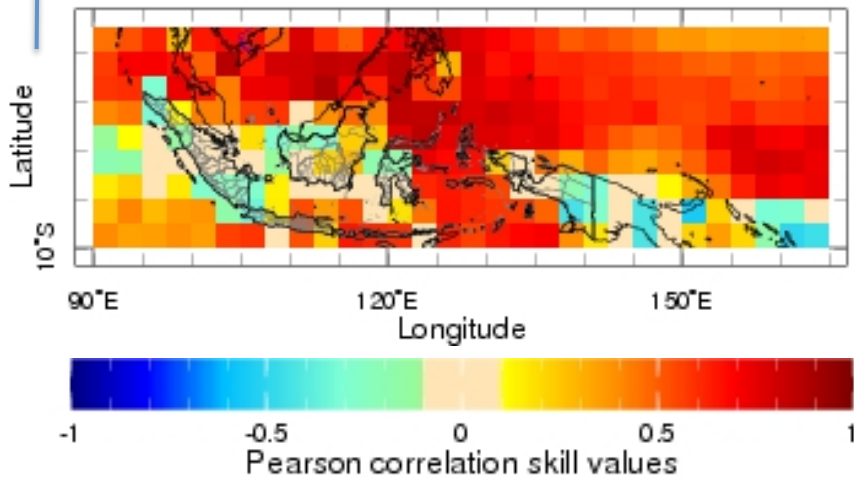
BUT

Good skill in predicting **monsoon onset**
(Moron et al, 2009)

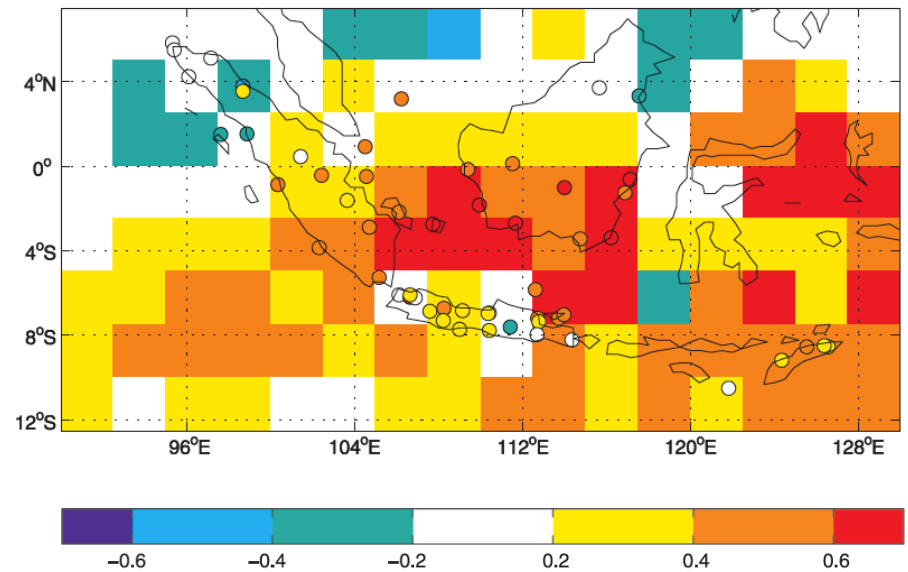
- ❖ **Largest** amplitudes of cumulative **rainfall anomalies** before or near **onset date**
⇒ Potentials for rainfall seasonal **predictability** associated with **monsoon onset**
- ❖ Promising hindcast **skills** using **July Pacific and Indian Oceans SSTs** (Moron et al, 2009)

Dynamic crop calendar concept

Skill for Mar-May, issued February



Weak skill in predicting rainfall amounts.... **BUT**



Good skill in predicting monsoon onset
(Moron et al, 2009)

Decision based on drought probability threshold

Adjustment of crop pattern by:
Reducing planting area
or
Changing crops

MJJA seasonal rainfall forecasting

Support Vector Regression (SVR) based on **SOI** and **SSTs** in **July-February** (2 mths lead time)

Developed at CCROM

- (i) estimate parameters of **drought distribution**
- (ii) predict **drought distribution** during dry season
- (iii) generate **drought/affected areas probability**

Part 3: Potentials for sub-monthly climate predictions

S. Li and A.W. Robertson (2013) An evaluation of sub-monthly forecast skill from Global Coupled Models, *Mon. Weath. Rev.*, submitted

On sub-monthly predictions

Particularly important where **initial conditions** & **intra-seasonal oscillations** are **strong** while **seasonal predictability** is **relatively weak** (ex. Asian monsoon regions)

- ❖ **Goal:** fill the gap between medium-range & seasonal forecasts
- ❖ **Aim:** evaluate sub-monthly forecast skill from a few GCMs
- ❖ **Objective:** identify sources of sub-monthly predictability and examine their contributions to forecast skill (i.e. MJO vs ENSO)

Data & Method

❖ **Data:** three hindcasts used at sub-monthly time-scale

Model	Resolution	Ensemble	Frequency
ECMWF	1x1 (T639)*	5	weekly
CFSv2	T126	4	5-day
JMA	2.5 (T159)*	5	3/month

Common period: 1992-2008
(late May to mid-Sept to focus on the Asian monsoon)

* In parentheses are the original model resolution

+ **CMAP** pentad precipitation interpolated at weekly time-scale
=> Hindcasts interpolated on CMAP 2.5x2.5 grid

❖ **Two deterministic metrics for prediction skills:**

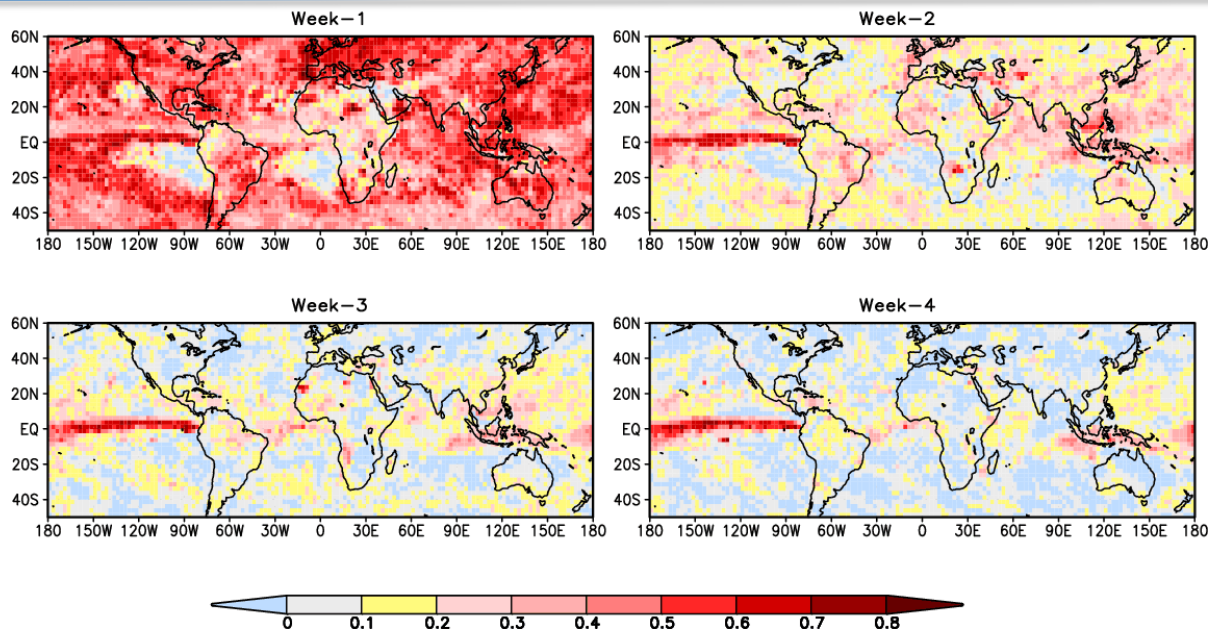
ACC: Anomaly correlation coefficients (potential skill of unbiased forecast)

MSSS: Mean squared error skill score (contribution from biases in the mean)

=> Analyses performed on all 17 years and all starts

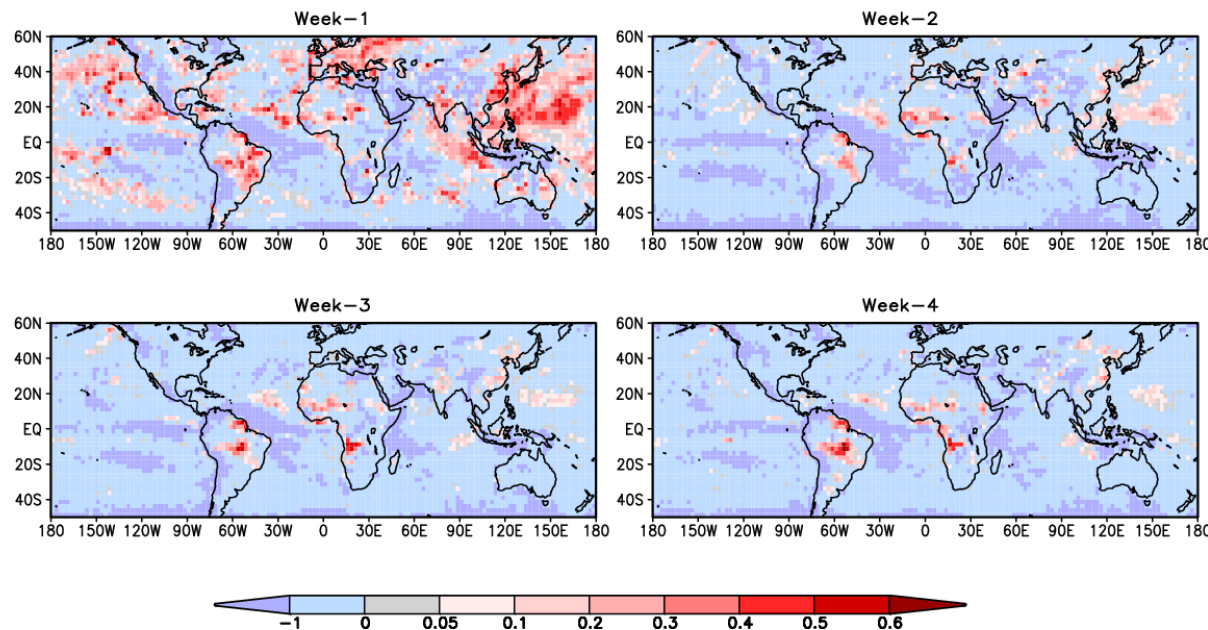
JMA Precip Forecast vs CMAP

ACC



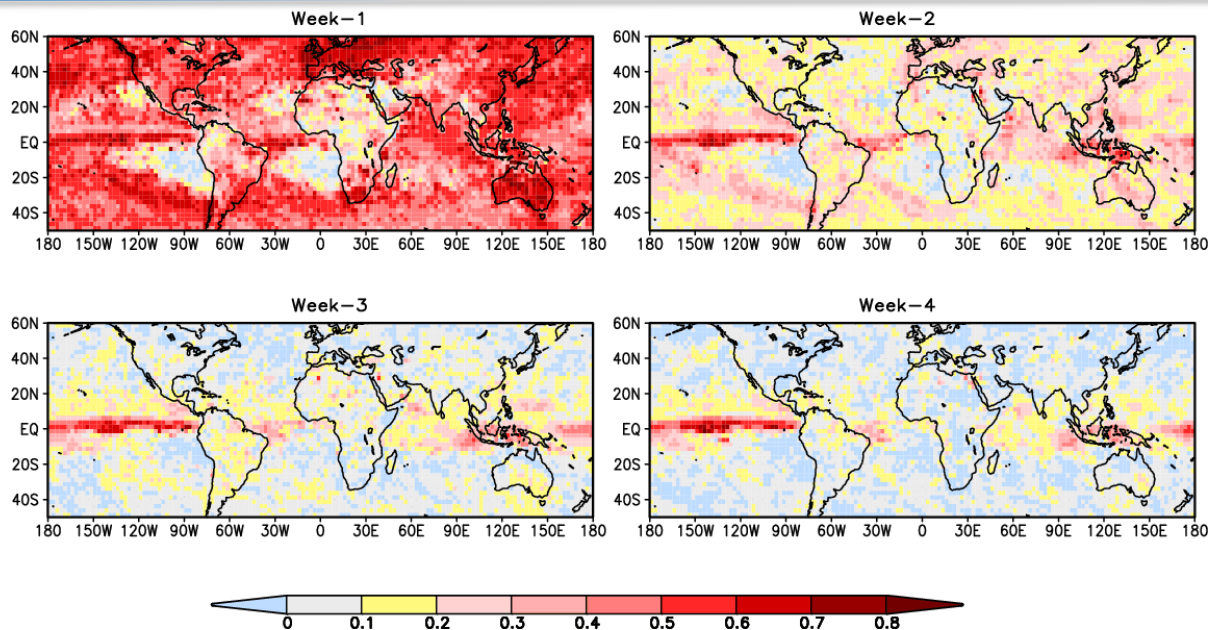
Substantial skill for the 1st week but dropping considerably from week 2 to 4

MSSS



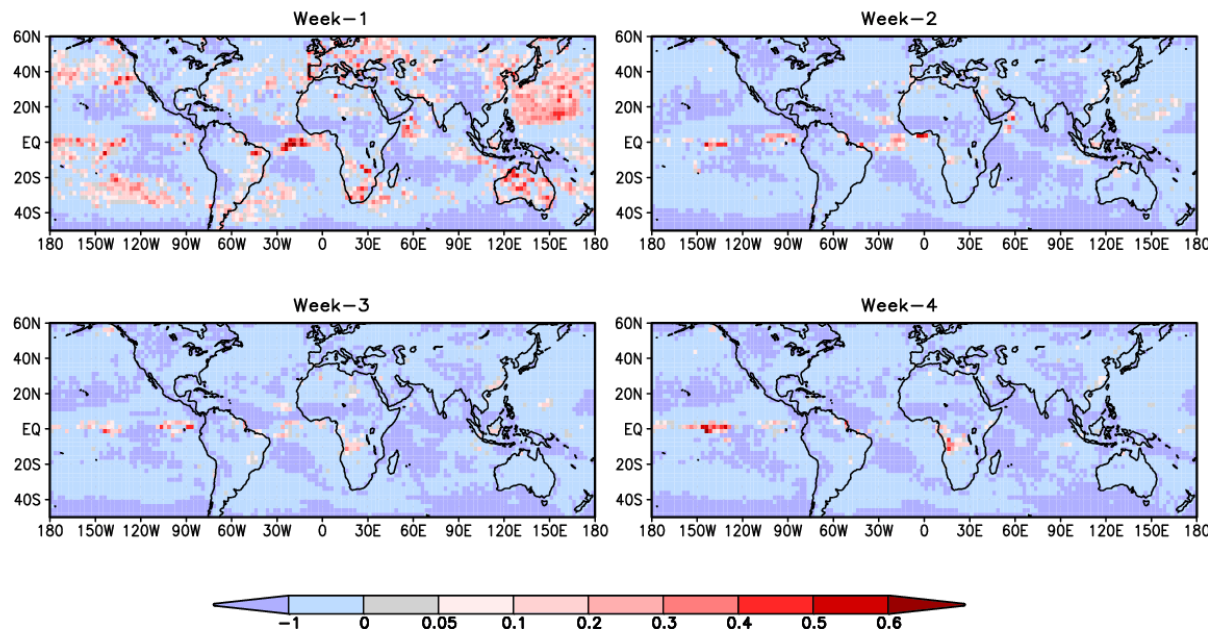
CFSv2 Precip Forecast vs CMAP

ACC



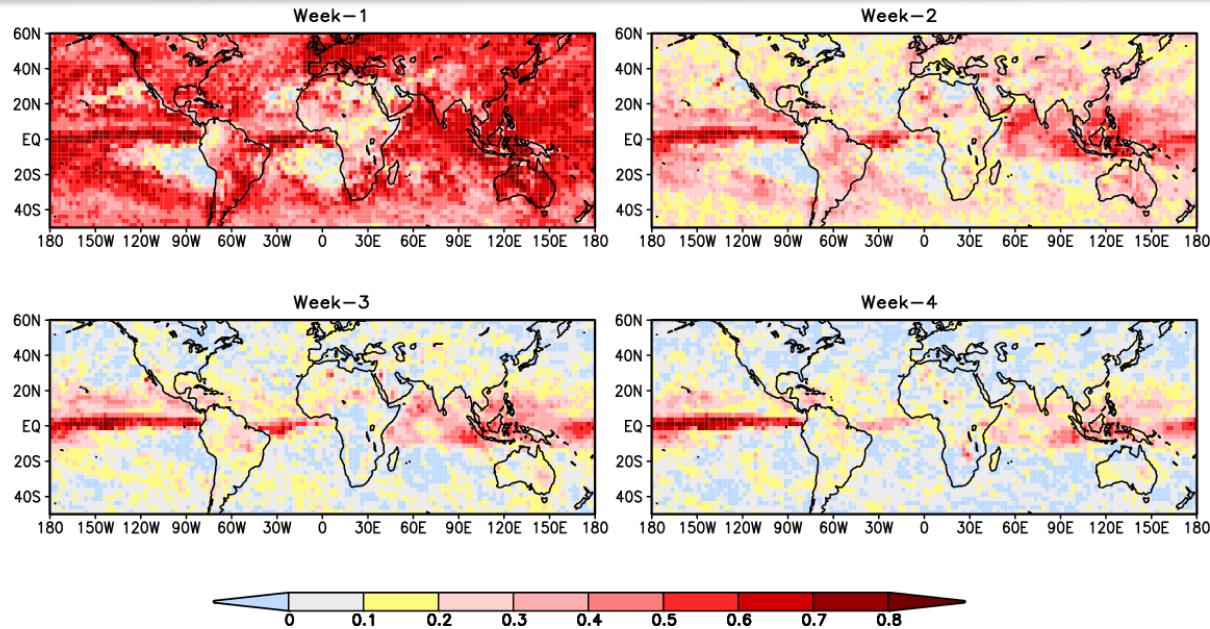
Substantial skill for the 1st week but dropping considerably from week 2 to 4

MSSS

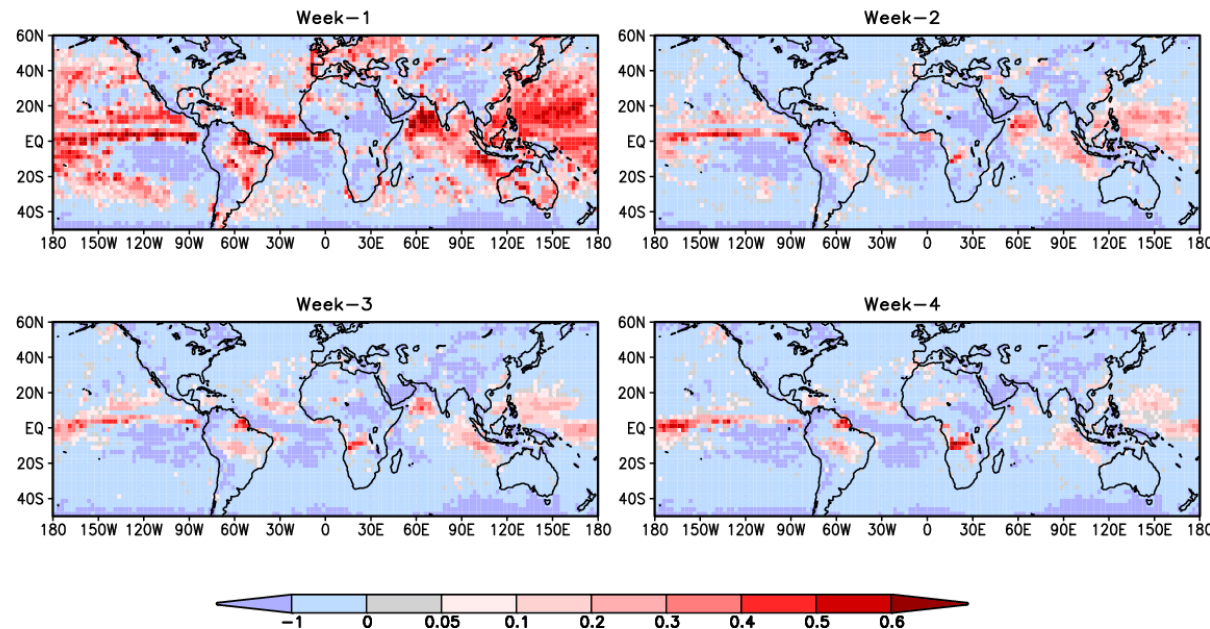


ECMWF Precip Forecast vs CMAP

ACC



MSSS



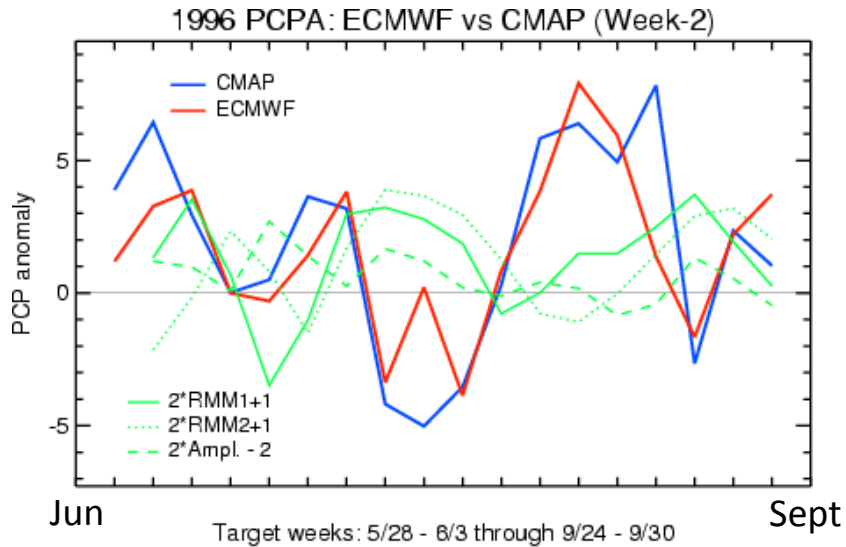
Better skill for the 1st week, persisting over the tropics for the 2nd week and over the equatorial Pacific/maritime continent until week 4

Case study: Borneo Island



Borneo Island # 4-gridbox averaged

1996 neutral ENSO conditions

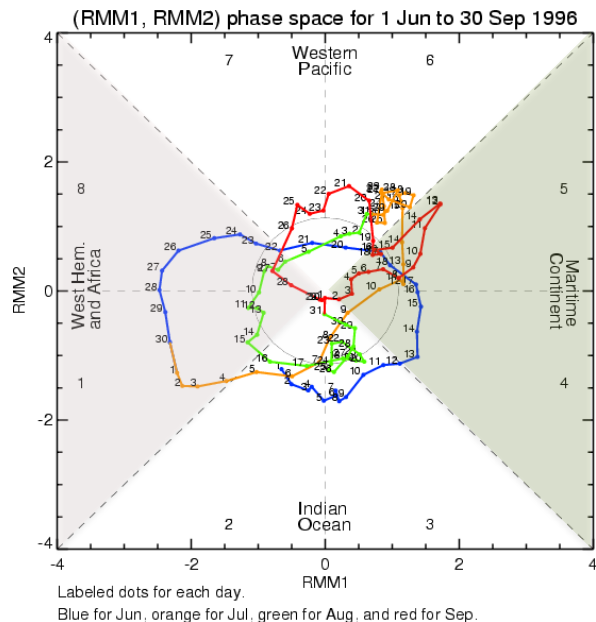


Correlations with ECMWF rainfall anomalies:

(RMM1: <10%)

RMM2: -65%

Amplitude: -43%



MJO phase diagram based on
Wheeler and Hendon (2004) index

Irregularly strong MJO
activity over the region

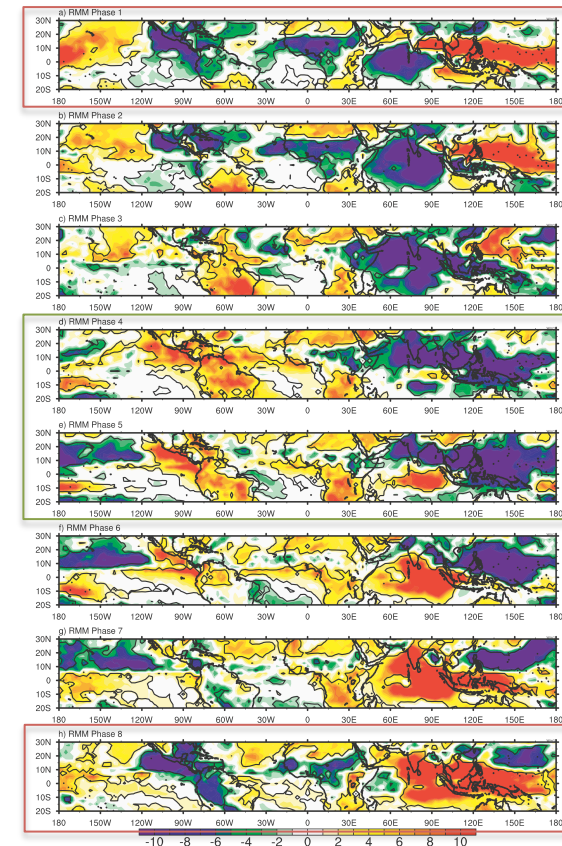
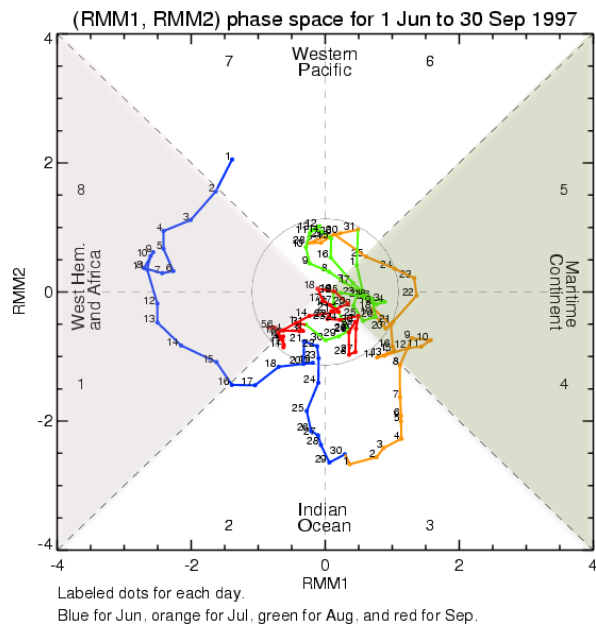
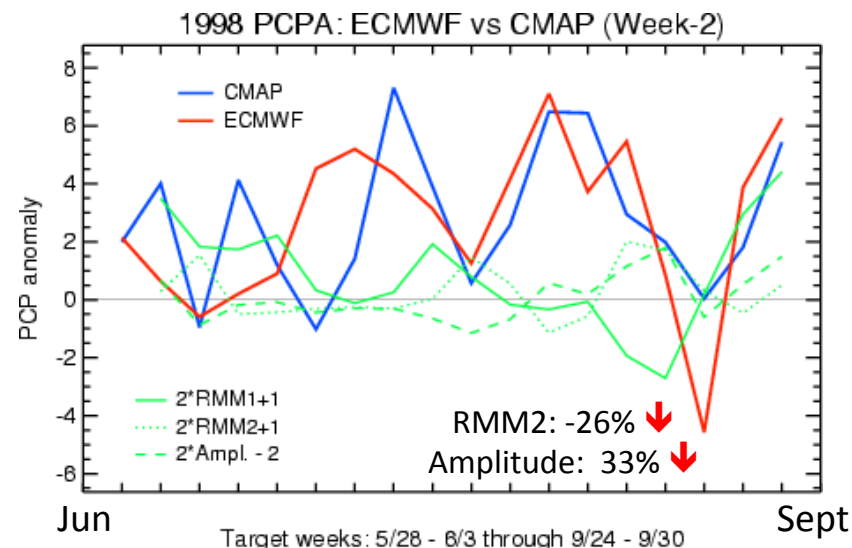
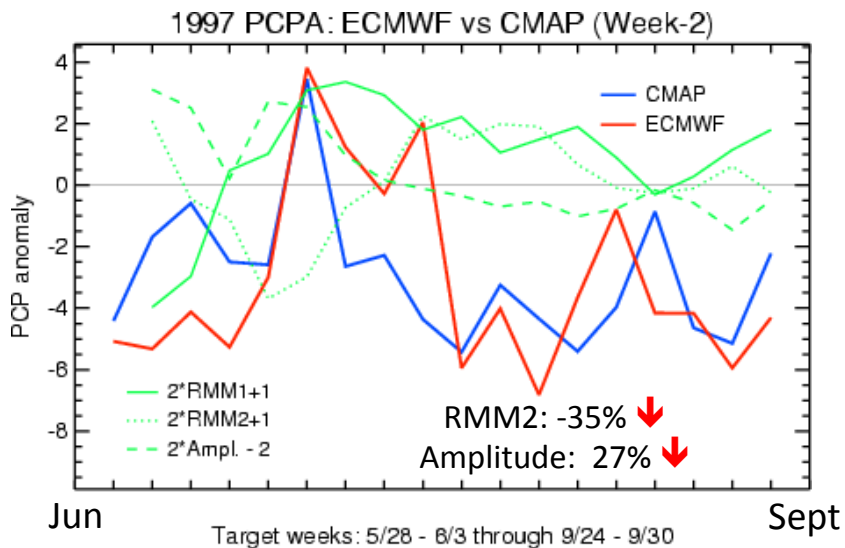


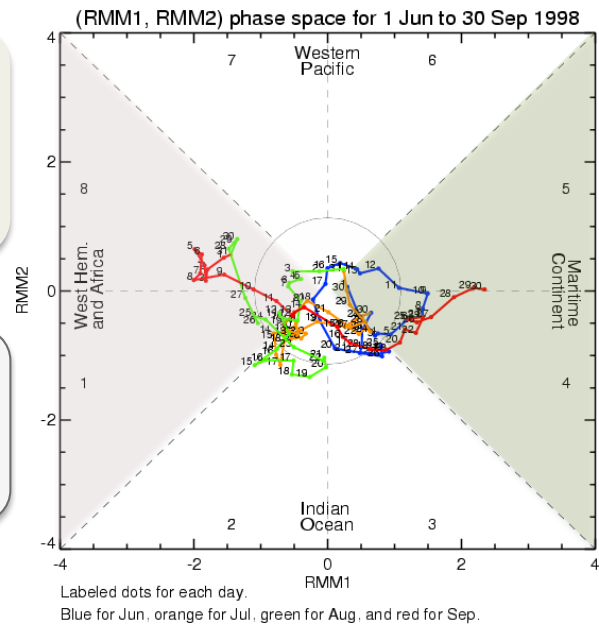
Figure: NOAA daily averaged
interpolated OLR anomalies
for JJASO from 1989 to 2008
for each RMM phase
(*Ventrice et al., 2011*)

1997 El Niño/1998 La Niña conditions

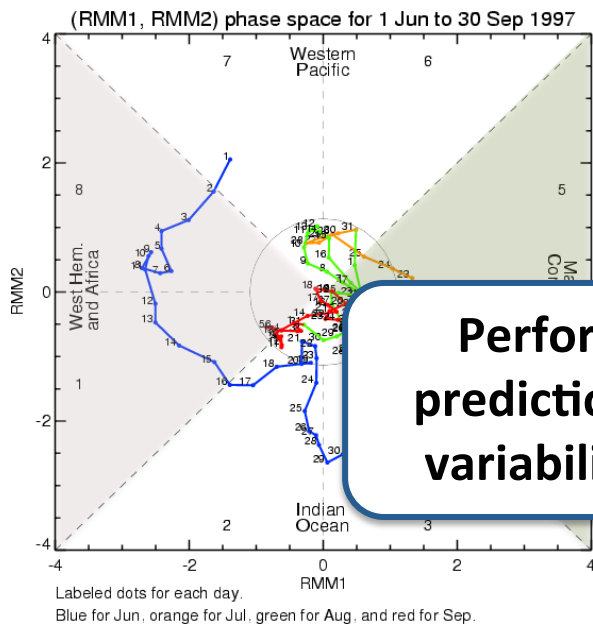
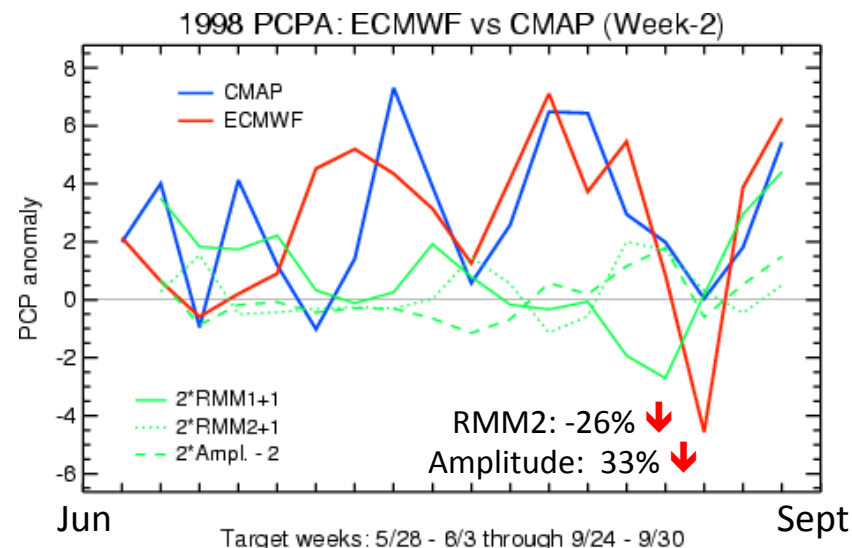
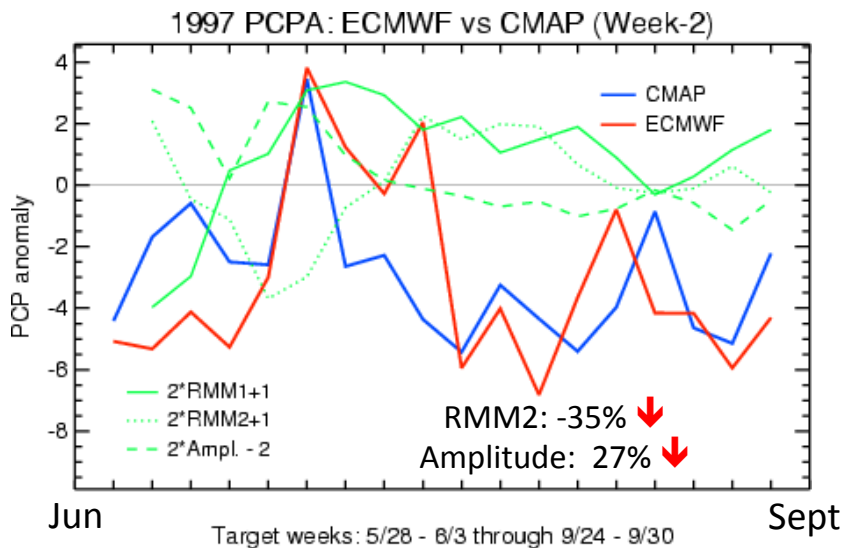


Weaker relationships with MJO during ENSO events

Links with reduced MJO activity locally?

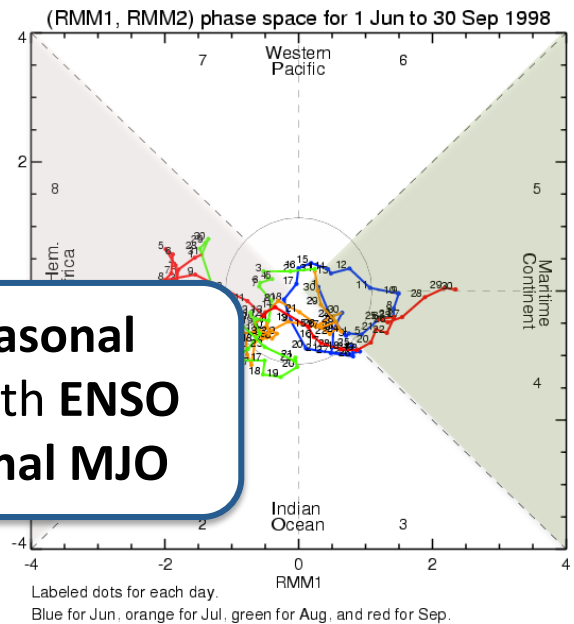


1997 El Niño/1998 La Niña conditions



Weaker relationships with MJO during ENSO events

Performance of sub-seasonal predictions associated with ENSO variability & intra-seasonal MJO

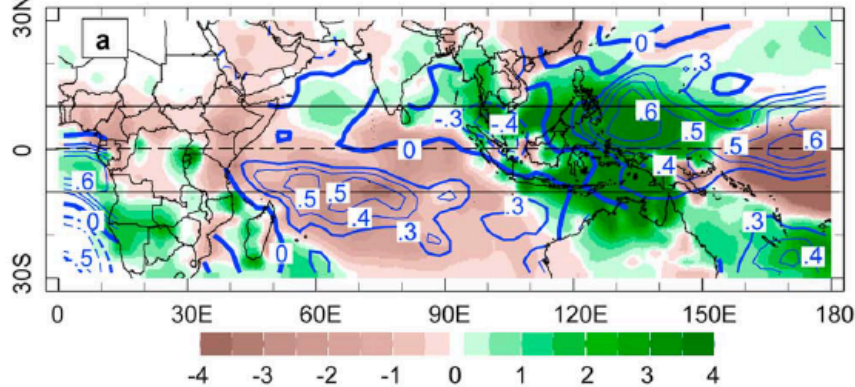


Part 4: East African droughts during the long rain season and Pacific decadal variability

B. Lyon and D.G. DeWitt (2012) A recent and abrupt decline in the East African long rains, *Geophys. Res. Lett.*, DOI:10.1029/2011GL050337

2011 drought in East Africa

MAM 2011 CAMSOPI rain anomalies (shadings) & GPCP correlation with ERSST (contours)

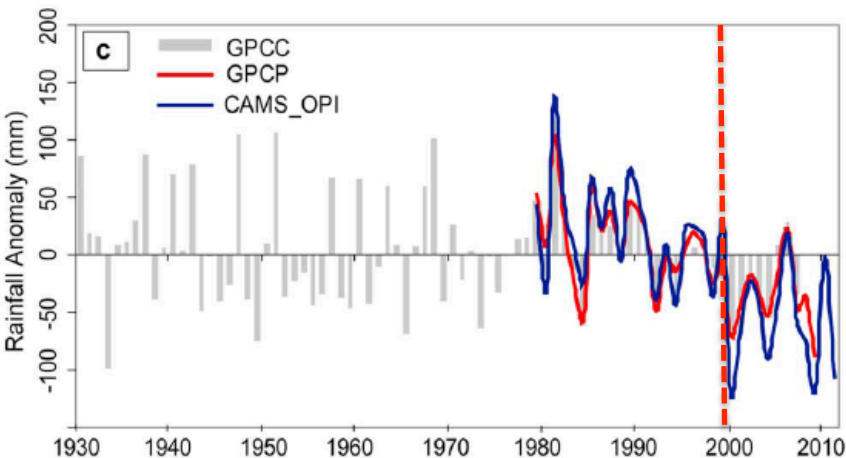
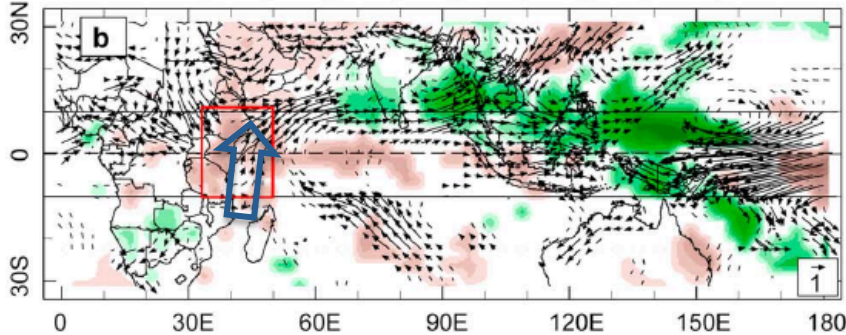


❖ **Severe drought in 2010-2011** over Eastern African regions due to the **failure of both short (OND) & long rains (MAM)**

❖ Associated with

-an **abrupt decline of MAM rainfall since 1999**

-**Southerly anomalies** along the **coast** becoming northerly across the EQ

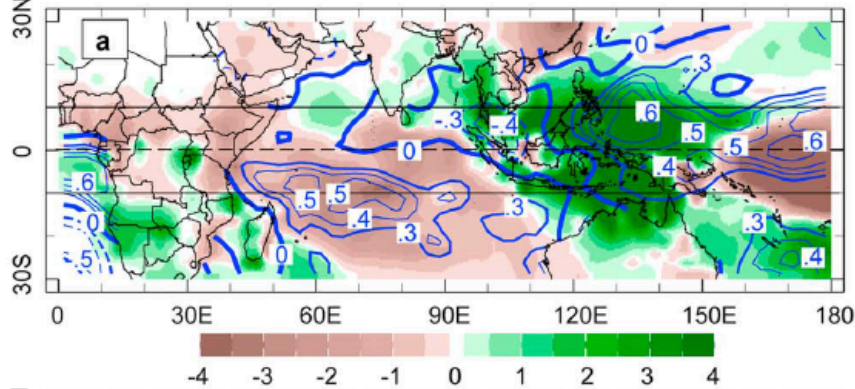


2011

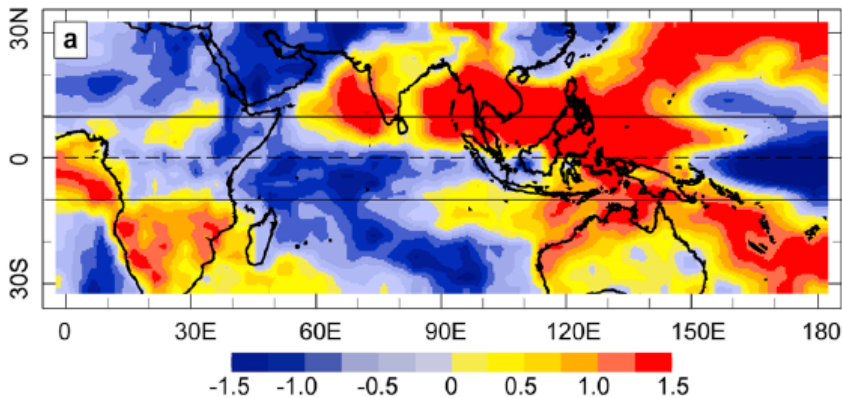
1999-2009 anomalies
(GPCP & NCEP 850hPa winds)

2011 drought in East Africa

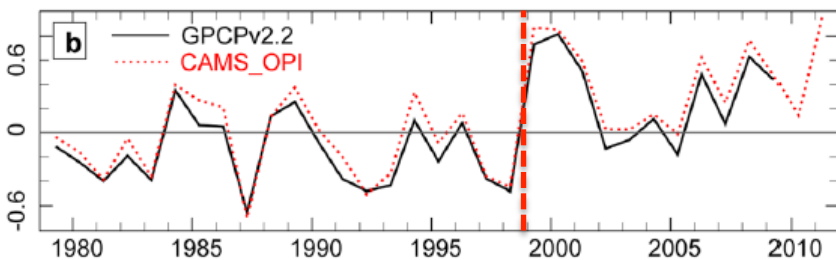
MAM 2011 CAMSOPI rain anomalies (shadings) & GPCP correlation with ERSST (contours)



- ❖ Severe drought in 2010-2011 over Eastern African regions due to the failure of both short (OND) & long rains (MAM)
- ❖ Associated with
 - an abrupt decline of MAM rainfall since 1999
 - Southerly anomalies along the coast becoming northerly across the EQ



- ❖ MAM GPCP EOF1 pattern similar to MAM post 1999 rainfall anomalies
=> shift in rainfall large-scale pattern



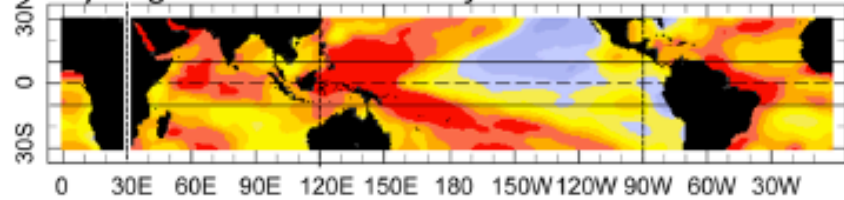
Is there evidence for large-scale changes in the state of the global oceans since 1999?

2011

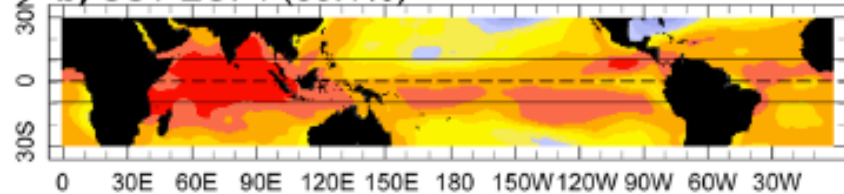
MAM GPCP EOF1
(1979-2009)

Relationships with global SSTs

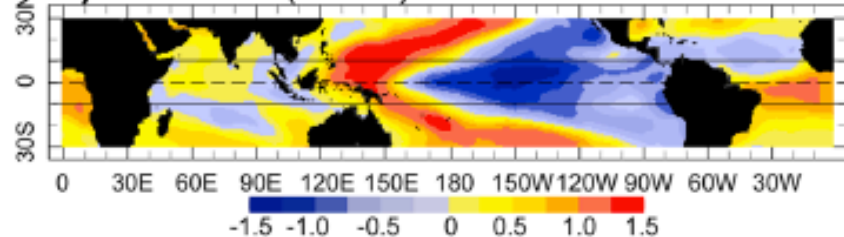
a) Avg. Std. SST Anomaly 1999-2010



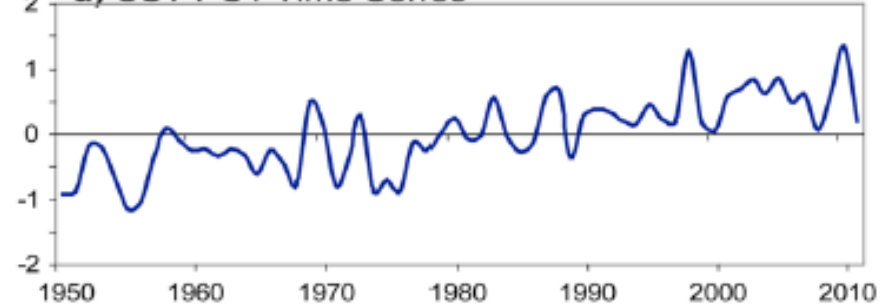
b) SST EOF1 (33.1%)



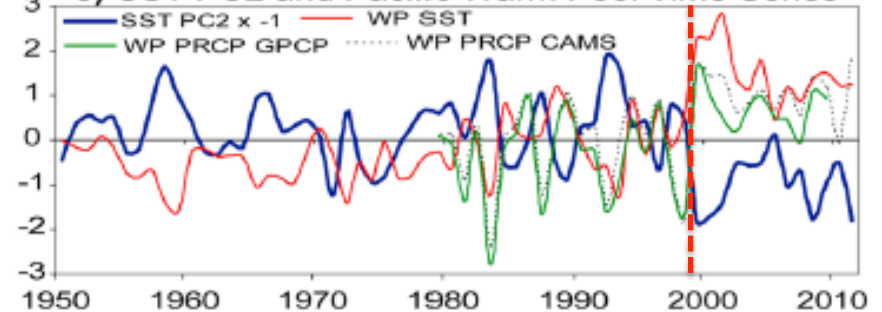
c) SST EOF2 (15.4%)



d) SST PC1 Time Series

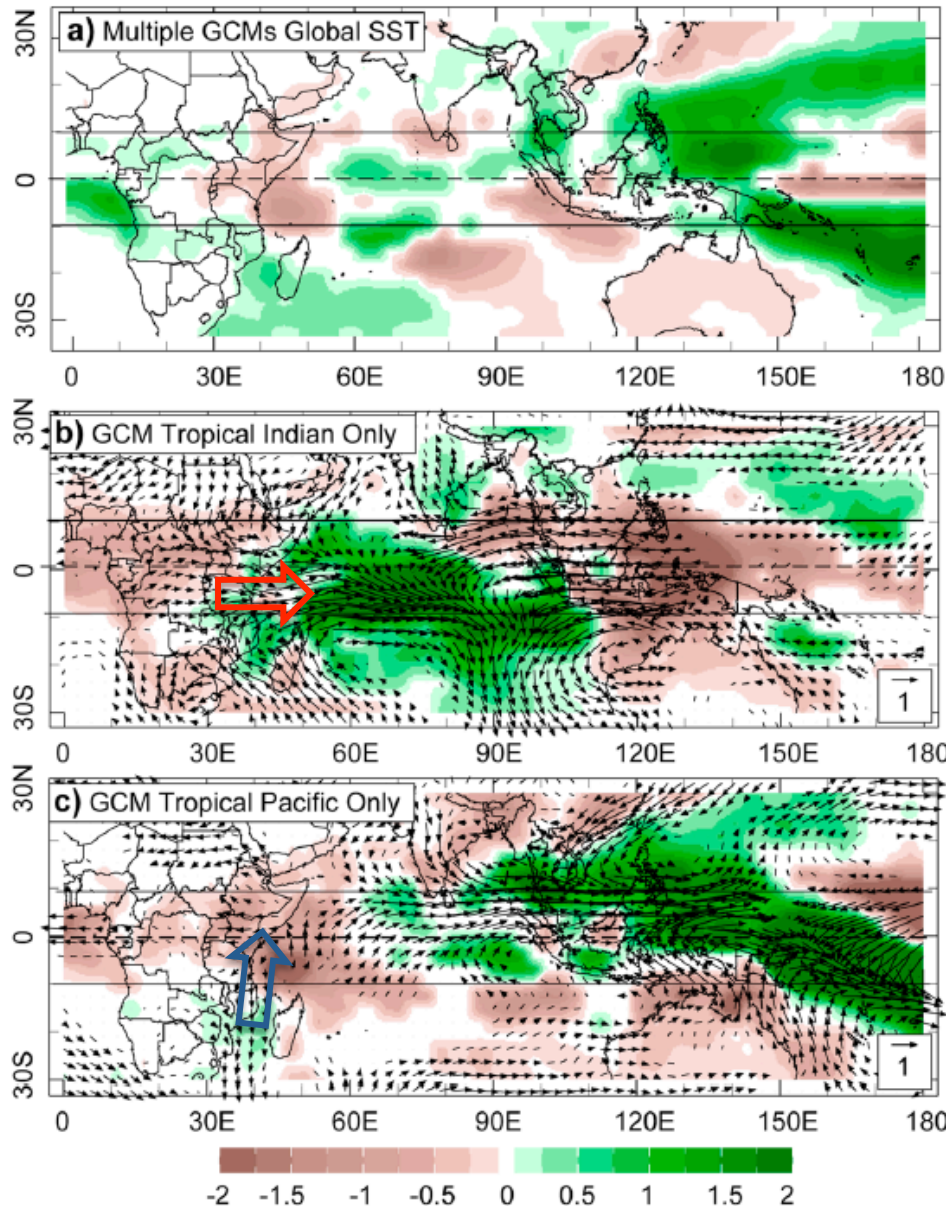


e) SST PC2 and Pacific Warm Pool Time Series



- a) Post 1999 SST anomalies characterized by **highest loadings in the Pacific**
- b) EOF1 typical of the **warming trend** within the global ocean
- c) EOF2 similar to post 1999 anomaly pattern & shows an **abrupt shift in 1999**

Results from model experiments



MAM GCMs ensemble

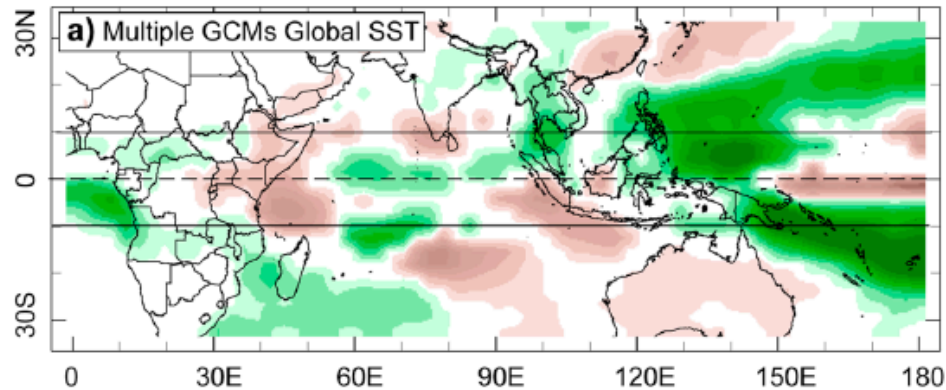
(ECHAM4.5/5, CCM3.6, 24 members)

Drying for 99-09 (vs 79-09)

Tropical Indian Ocean only
enhanced rainfall over the basin and **westerly anomalies** along the east African coast

Tropical Pacific Ocean only
reduced rainfall pattern with **southerly anomalies** along the east African coast

Results from model experiments



MAM GCMs ensemble

(ECHAM4.5/5, CCM3.6, 24 members)

Drying for 99-09 (vs 79-09)

- The **abrupt decline in east African rainfall** is **primarily forced by large-scale SST changes in the tropical Pacific** (not closely related to known patterns of decadal variability/ENSO)
- The **persistence of SST anomalies in the tropical Pacific** suggests a **continuation of poor long rain** performance in east Africa (contrasting with the wettening predicted over the region)

IRI regional activities & key partners



Ongoing regional collaborations

➤ **Water security under climate risks**

(PI: A. Ines)

(Adaptation strategy for agriculture in the Philippines)

Partners: University of the Philippines Los Banos (UPLB), Dept of Agriculture-Regional Field Unit 5 (DA-RFU5), Bicol University College of Agriculture and Fisheries (BUCAF), Central Bicol State University of Agriculture (CBSUA)



➤ **Crop modeling improvement**

(PI: A. Ines)

(Integrating remote sensing/forecast information over Hokkaido, Japan)

Partners: International Digital Earth Applied Science Research Center (IDEAS), Chubu University, IHI Corporation (Japan)



➤ **Climate risk management for agriculture over S/SE Asia**

(Demonstration sites in Indonesia, Laos and Bangladesh) (PI: A. Greene)

Partners: Climate Center for Risk and Opportunity Management in SE Asia and the Pacific (CCROM) in Indonesia, World Fish (CGIAR) in Bangladesh, National Agriculture and Forestry Research Institute (NAFRI) in Laos



THANK YOU

vigaud@iri.columbia.edu

