"Seasonal prediction of the Indian summer monsoon rainfall for decision making in agriculture'.

Sulochana Gadgil
NCAOR, Goa
24 October 2013

Outline

- Background:
- Monsoon and agriculture-some facts
- Use of climate information for addressing questions posed by farmers-an example
- Seasonal to interannual variation of the Indian summer monsoon rainfall
- Impact on food-grain production and GDP
- Kind of forecasts required
- How good are such forecasts with state of art models?
- Way forward

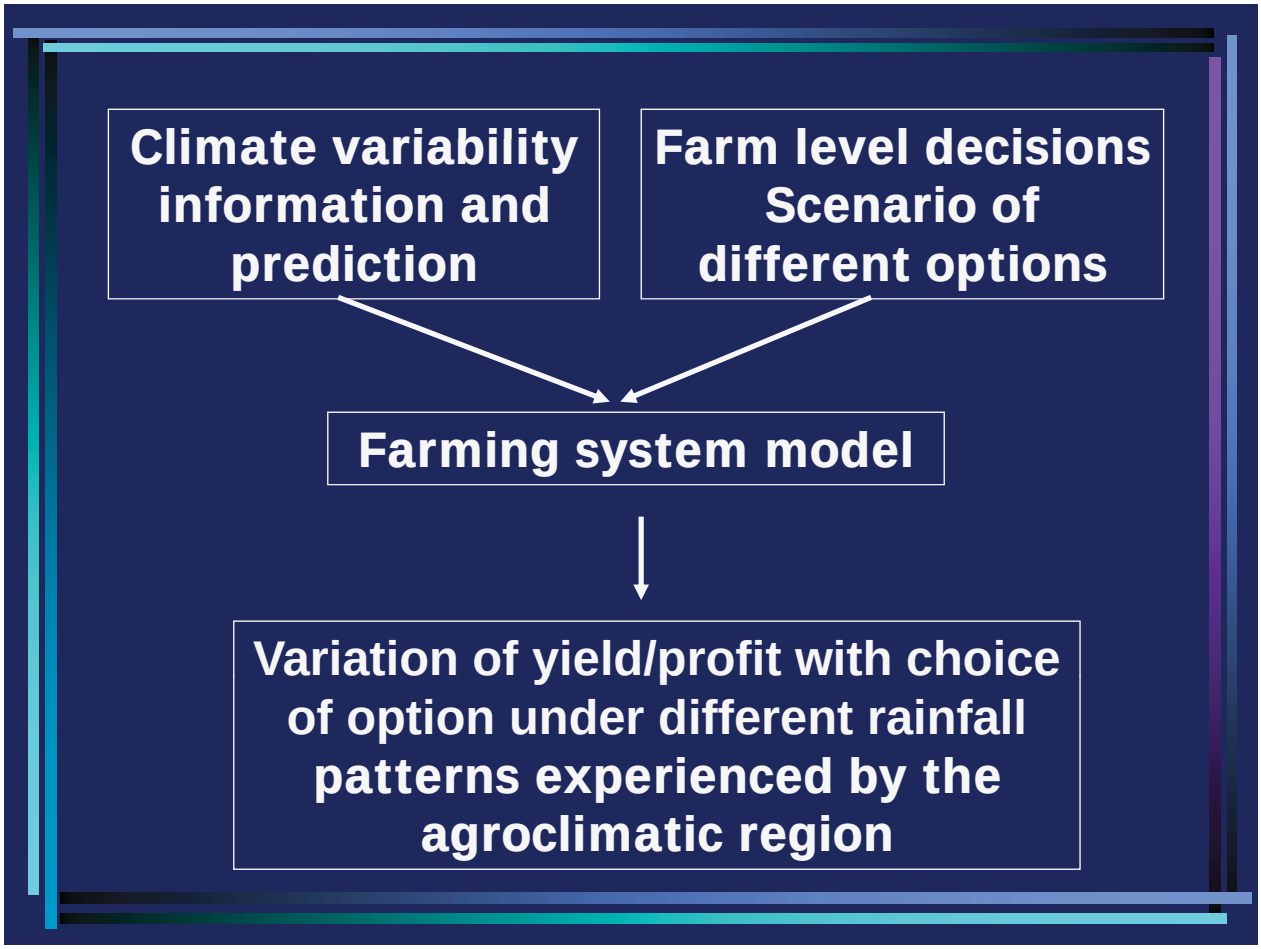
Monsoon and agriculture :background

- Very large impact of rainfall variability on agricultural production of rainfed areas.
- Information and prediction of climate variability should lead to farming strategies for enhancement of rainfed agricultural production.
- Although the green revolution led to a phenomenal increase in agricultural production, there has been hardly any increase in that over rainfed areas.
- Why?

Why has rainfed production not increased?

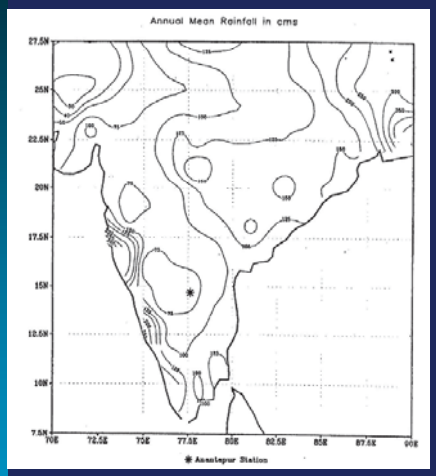
"The research farms programmes have mostly been scientist oriented and not farmer or user centered. These were perceived, planned, implemented, supervised and evaluated by scientists. The transfer of results followed a top down approach. In this "take it or leave it approach", the farmer was at best a passive participant. Scientific findings which became the so-called 'technologies' were born from small plots and short-term research and were invariably not associated with critical cost-benefit studies."

M. S. Swaminathan



- The cropping patterns/varieties have changed in the whole region since the 70s.
- For traditional crops, farming strategies evolved over the years to be suitable for the local rainfall variability
- For the new crops/varieties, it is necessary to work out the optimum strategies using available information the rainfall variability for the region (and prediction if available) along with modern tools such as crop models.

Cultivating rain-fed groundnut over Anantapur/Pavgada region



Package of recommendations developed by agricultural scientists :

- Sow in May-June;
- if no sowing opportunities in May-June, sow in July.
- However, if no opportunity occurs till the end of July, do not to sow groundnut at all in August.

- However, on the basis of experience of about two decades, farmers, do not sow until late June and do sow in August (if no opportunity occurred earlier), despite the recommendation to the contrary.
- This is based on the experience that when the sowing was delayed to August, in some of the years high yields were obtained.

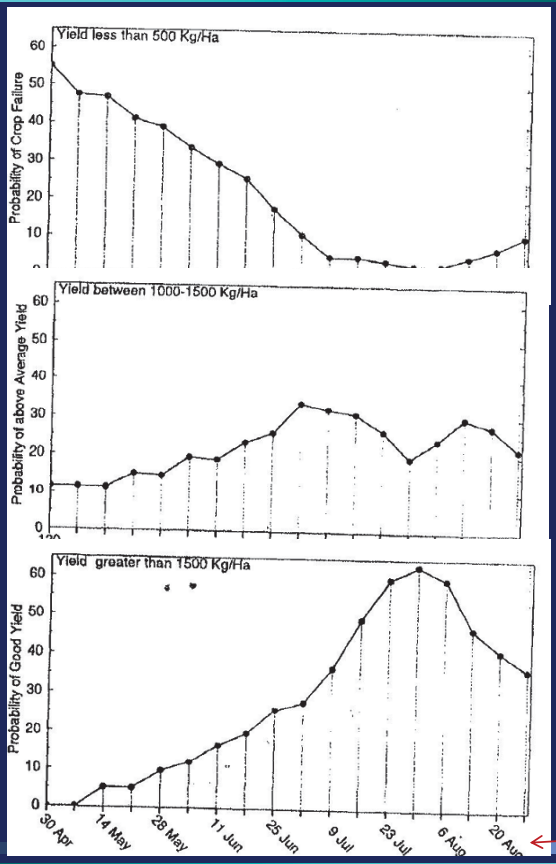
Problem posed by the farmers

- Hence, the farmers of the region suggested to us that one of the most important problems is the identification of the optimum sowing window associated with maximum production in the face of the rainfall variability of the region.

Probability of:
crop failure
(yield<500kg/ha

Of above average
yield:
Yield> 1000 kg/ha

Of very good
yield:
Yield>1500 kg/ha



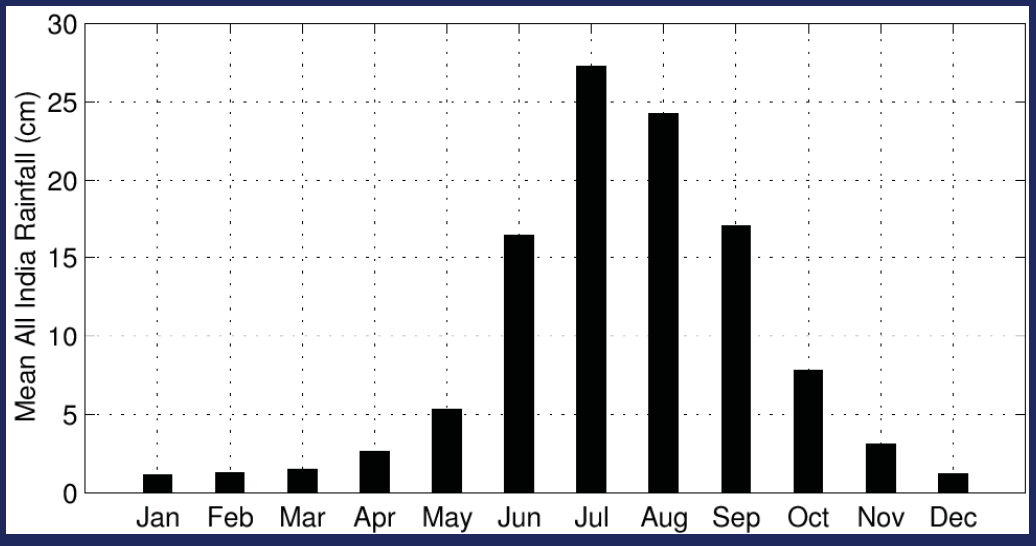
Lessons learnt

- Optimum sowing window associated with minimum risk of dry spell at critical stage (60-80days after sowing).
- Farmers, given the knowledge of critical stage and information of rainfall variability, can identify the optimum sowing window for their region .
- Nakshatras

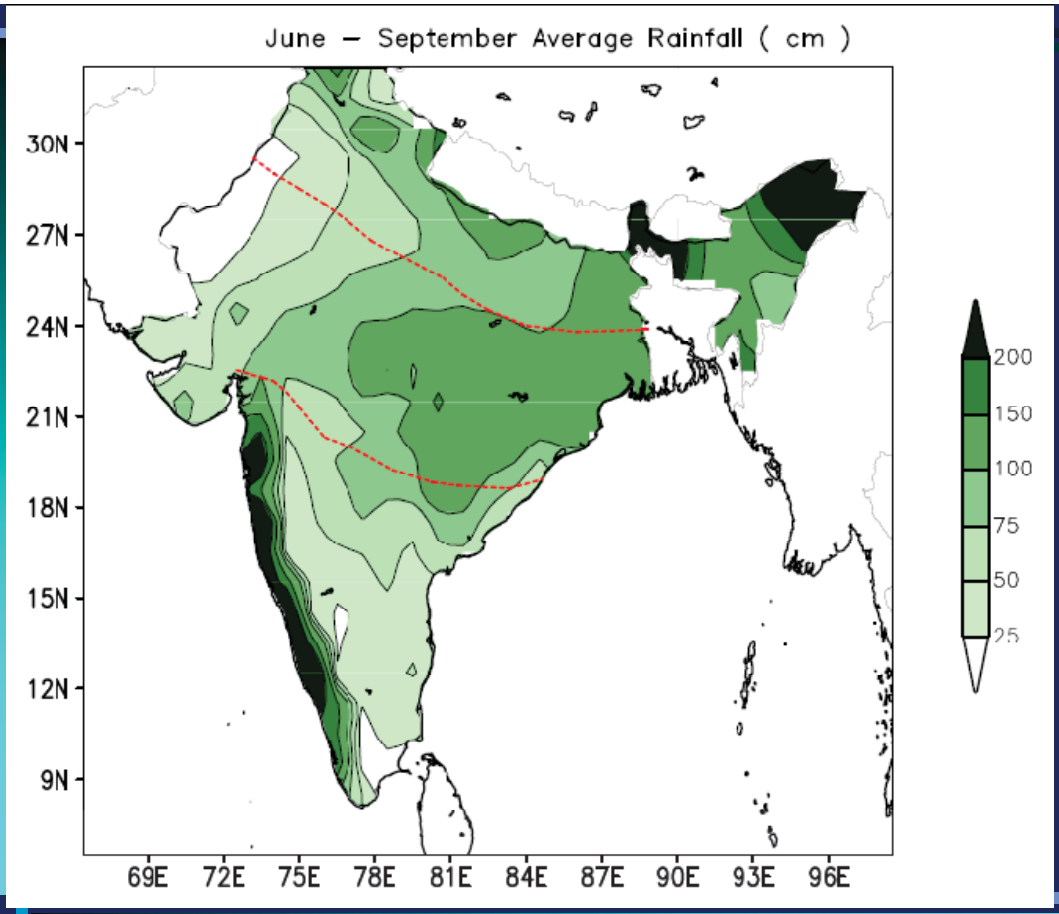
Seasonal to interannual variation of the Indian Monsoon

Basic features of rainfall over India:

Mean monthly all-India rainfall

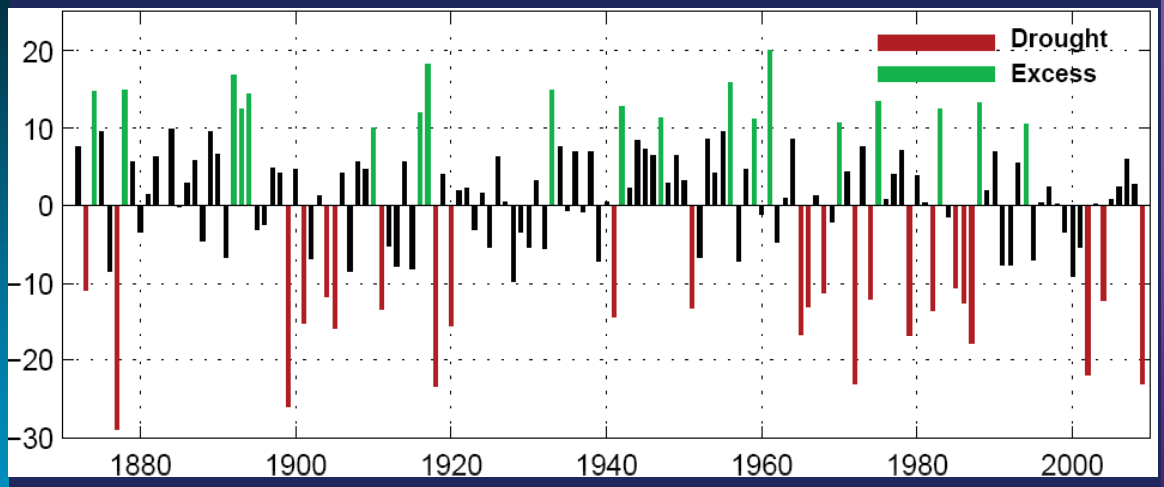


Most of the rainfall occurs during June-September-summer monsoon season; the focus of most studies is the summer monsoon. (However, over some parts such as the peninsula, the rainy season is different.)



Interannual Variation of the anomaly of ISMR

(as % of the mean); (std dev is about 10% of mean)



Drought: ISMR anomaly <-10% of the mean

Excess rainfall seasons: ISMR anomaly >10% of the mean

Monsoon of 2009 is the one of the top five most severe droughts during 1876-2009

The impact of the monsoon on the economy is large even after six decades of development:

'I seek the blessings of Lord Indra to bestow on us timely and bountiful monsoons.'

Pranab Mukherjee, budget speech in the Lok Sabha, February 2011

Which facet of the seasonal to interannual variation is important to predict?

'The most important need in monsoon forecasting is to pick out with a reasonable degree of success the years of low rainfall, the possible drought years … Until years of scarcity can be forecast with greater certainty, the forecasts can give little help to the public at large.'

Normand C, 1953

How would the farmers use this prediction?

Answer-letter I got from 14 marginal farmers in our study area,

- ***'We are very much worried about this (prediction). Last year (1999), we had severe deficit rainfall resulting in large losses. Since in the previous year (1998) we had good rains and good profits, we invested a lot in fertilizers and in leasing land for cultivation from other farmers. All of this was a loss.***
- ***This year, they are saying that again we will have deficit rainfall. What is your view on this? If you also say that rainfall will be deficit, as reported in the paper, we will not invest much in fertilizers, etc., for this year's cultivation.***

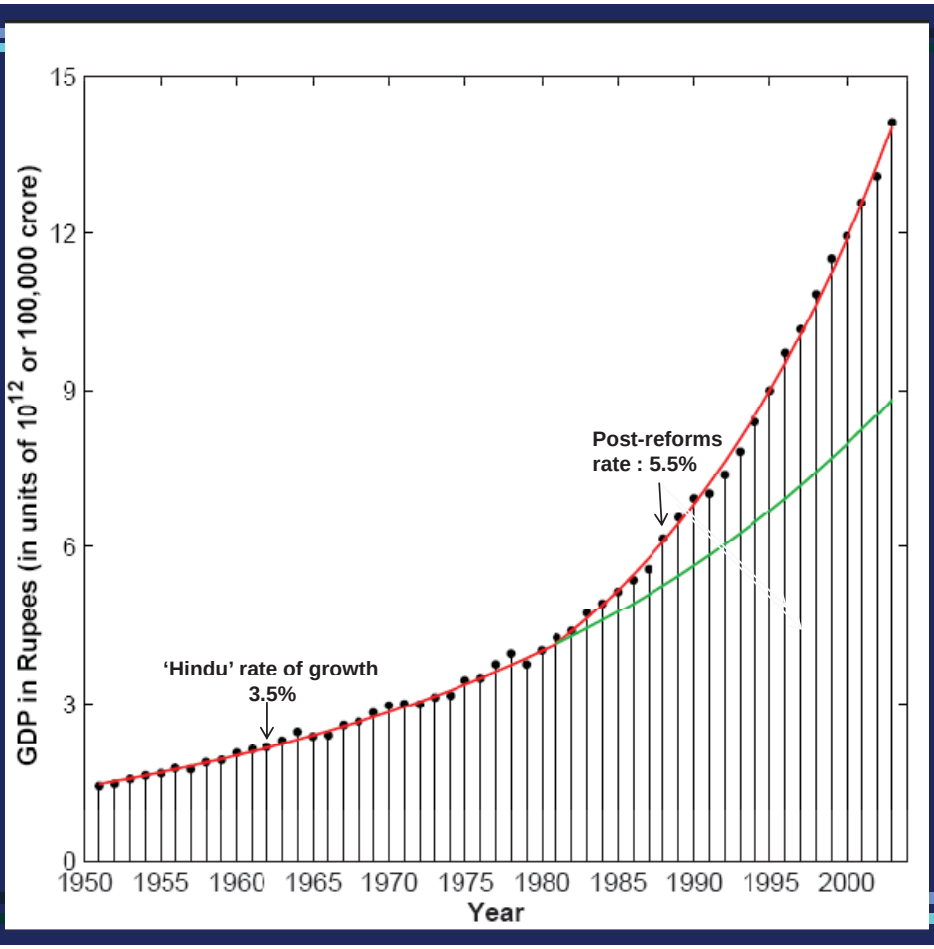
- *We will not take any loan. We will not borrow seeds from the moneylenders. If we get a good price, we will lease out our land. If by all this, we save money, we will buy lambs or piglets.*

- *This year it did not rain in Ashwini (13–26 April) and rained in Bharani (27 April–10 May). Therefore, the tamarind crop is very good. We will invest in taking these trees on contract. Please let us know whether you expect good or poor rainfall this season.'*

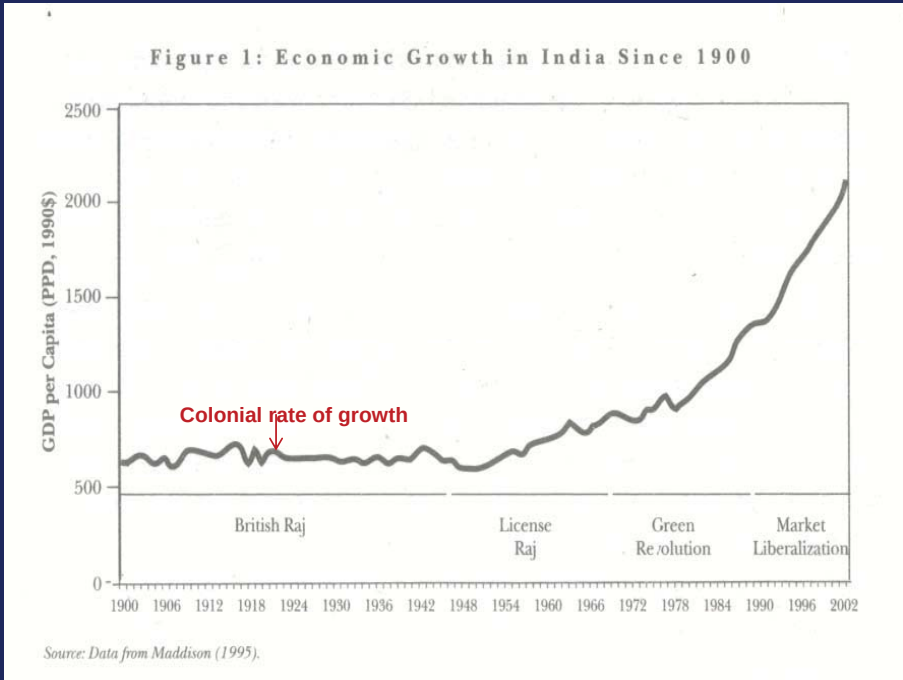
Impact of the monsoon : all-India scale

- **Variation of the food-grain production (FGP)**
- **Variation of GDP**
- **Quantitative assessment of the impact of events of each year (e.g. the monsoon) on FGP, GDP**

The Indian Monsoon, GDP and Agriculture, Gadgil, Sulochana and Siddhartha Gadgil, 2006, Economic and Political Weekly, XLI, 4887-4895

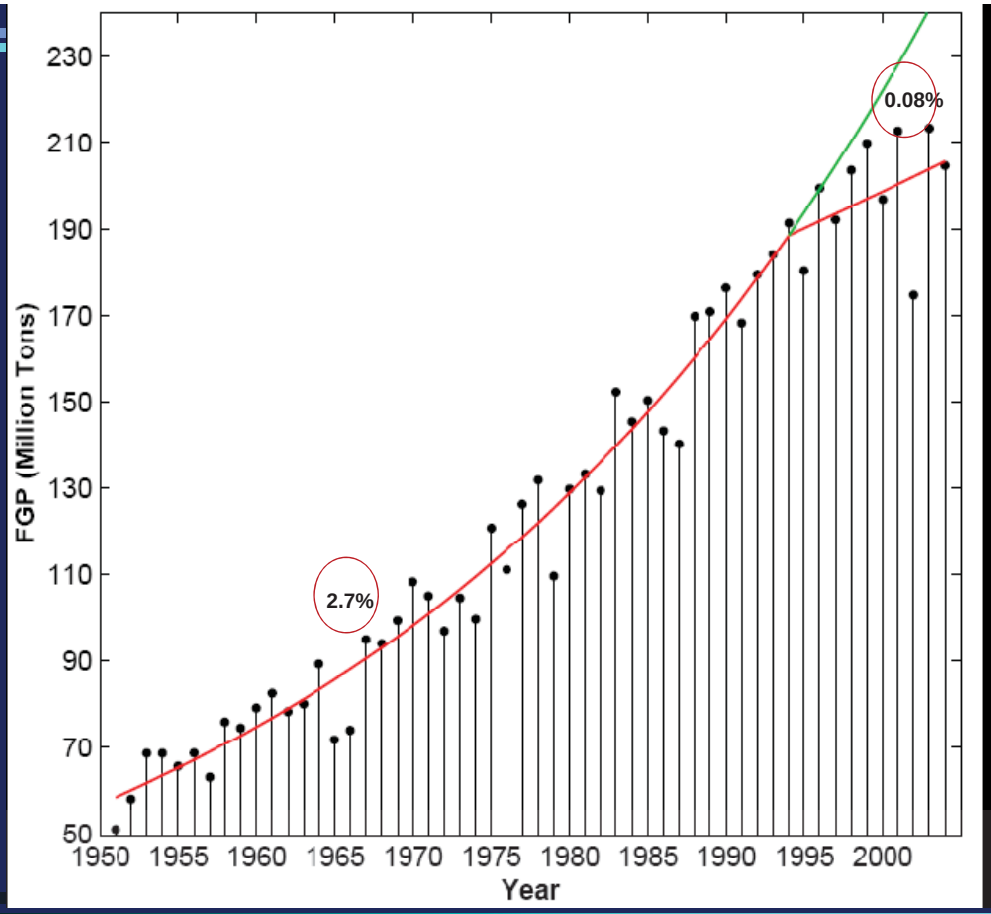


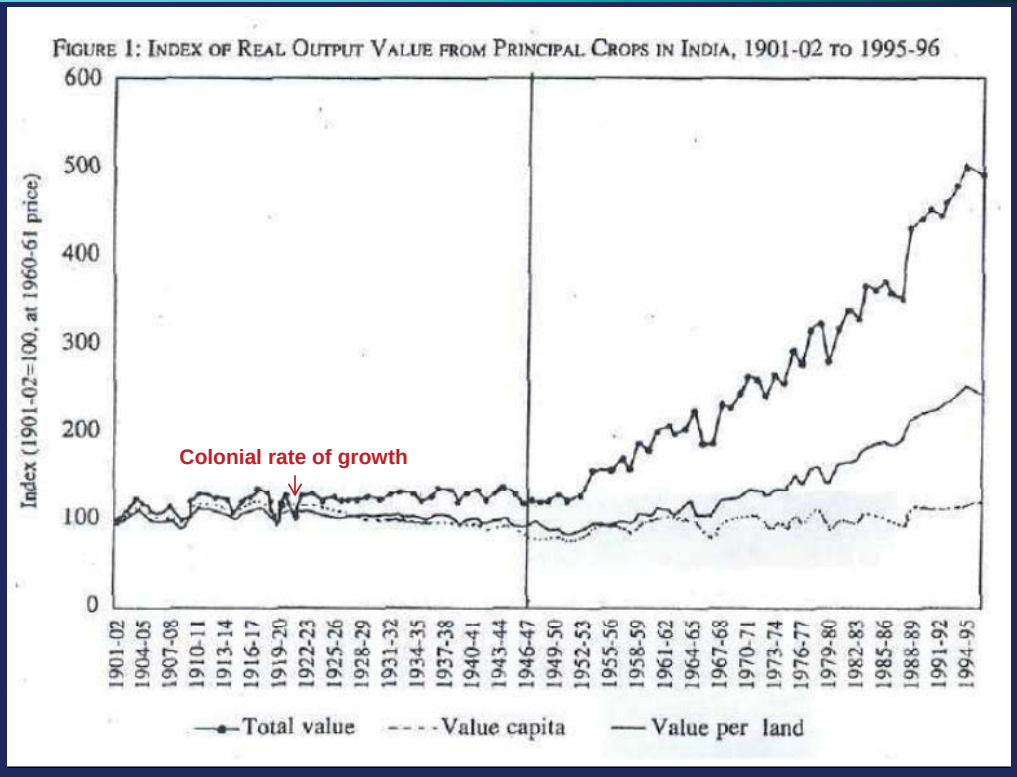
GDP per Capita



British Raj:1900-47, License Raj:1947-70, Green revolution :1970-91; Economic reforms : 1991-present

From 'End of Poverty" Sachs 2005, p181



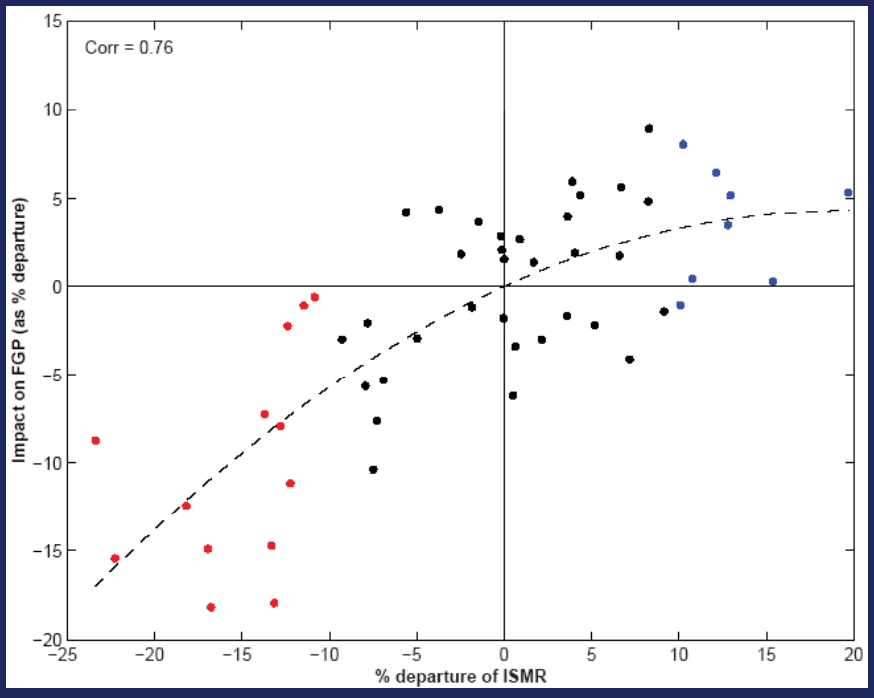


after Kurosaki T, EPW 25 Dec.1999

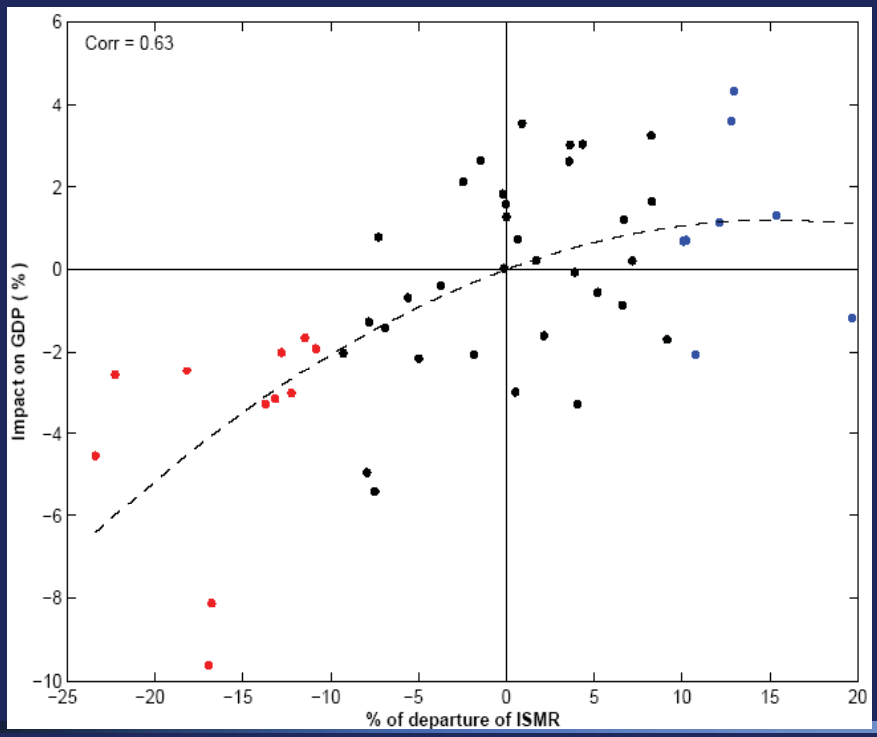
Calculation of the impact of the monsoon

- We expect the observed deviations of GDP and FGP for a specific year (i.e. DevGDP (year) and DevFGP (year) to be related to the important events in that year and particularly to the ISMR anomaly of that year.
- However, the deviation of the GDP from the fitted curve depends not only on the events of that year (such as a deficit monsoon), but also on the deviation of the previous year. This is taken care of in the calculation of the impact of the events in a specific year.

Asymmetry in response to droughts vis a vis surpluses

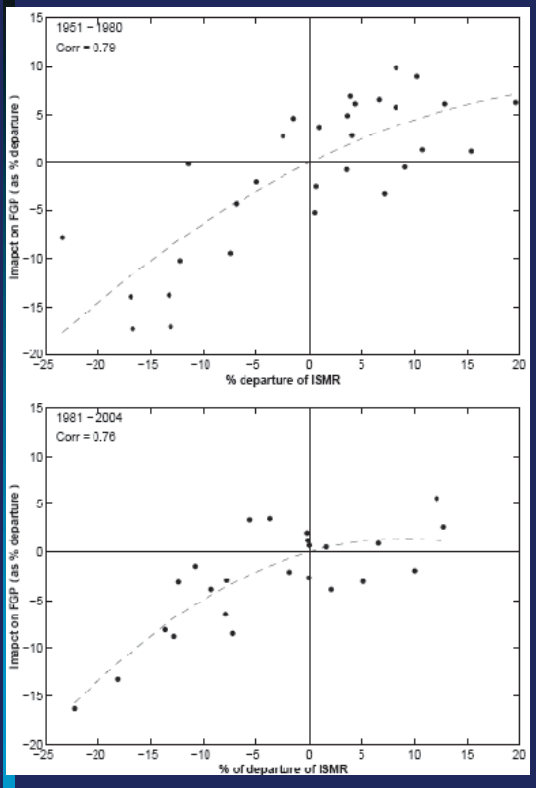


Asymmetry in response to droughts versus surpluses



- Thus the impact of the monsoon on FGP and GDP is highly nonlinear, with **the magnitude of the impact of a negative ISMR anomaly being larger than that of a positive ISMR anomaly of the same magnitude.**
- Hence even if the ISMR does not vary over long periods, the impact of deficit rainfall years will not be made up by that of normal or good monsoon years.

- **Furthermore, this asymmetry in the impact of the monsoon on FGP increased sharply in the last three decades.**
- **Whereas in the earlier era, the magnitude of the impacts of a drought and a surplus on FGP were comparable in magnitude; while after 1980 the impact of surpluses has become almost negligible.**

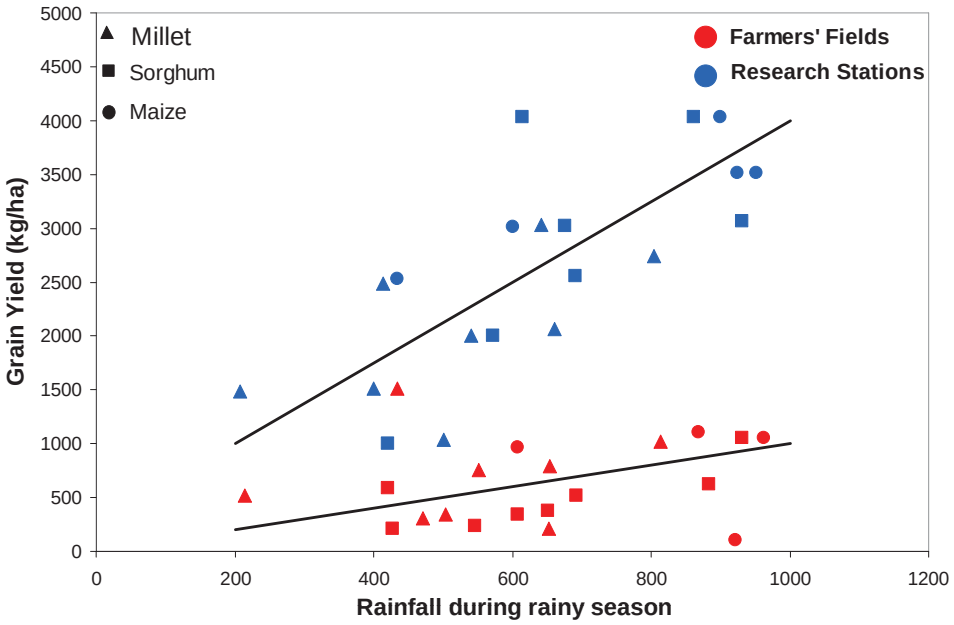


Period	1951 - 80	1981 - 04
ISMR	FGP	FGP
-25	-19.13	-18.81
-20	-14.41	-13.29
-15	-10.13	-8.65
-10	-6.30	-4.89
-5	-2.93	-2.00
0	0.00	0.00
5	2.48	1.12
10	4.50	1.37
15	6.08	0.73
20	7.21	-0.79

We have suggested a factor that can lead to the marked asymmetry since the 80s.

Note the major changes

- Change in cropping systems,
- Non sustainable agriculture:
- intensive agriculture leading to loss in fertility of the soils,
- mono-cropping over large areas leading to several pests becoming endemic and facilitating spread of diseases
- So it is not possible to get good yield even in good rainfall years without application of fertilizers and pesticides in this era.



Relationship between rainfall during the rainy season and yield of maize , sorghum and millet at 15 dryland locations in India (after Shivakumar et al. 1983)

ICRISAT

Yield gap is large only for above average rainfall years

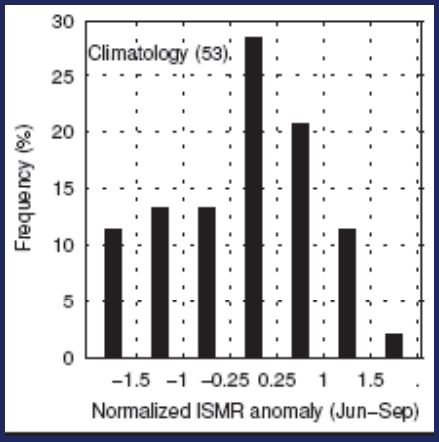
Similar result for groundnut, soyabean, pigeonpea and chikpea

Why does the yield gap increase with seasonal rainfall?

- Major difference in the management at agricultural stations and farms: application of fertilizers and pesticides.
- These do not enhance yields in poor rainfall years.
- In the absence of a reliable forecast of no drought, farmers do not consider them cost-effective and hence do not invest in them (although they have the know-how and do apply them over irrigated patches).

- However, at agricultural stations farm economics is irrelevant and liberal doses of fertilizers and pesticides can be applied.
- Even then, the yields are not very much better than the farmers' yields in poor rainfall years (which is why the farmers do not apply them) .
- However, in normal or good monsoon years the yield enhancement due to this application is very large. Hence the yield gap increases with seasonal rainfall.

Thus a reliable forecast of the non occurrence of droughts can enhance production in seasons of normal or good rainfall (i.e. 75% of the mosoon seasons).

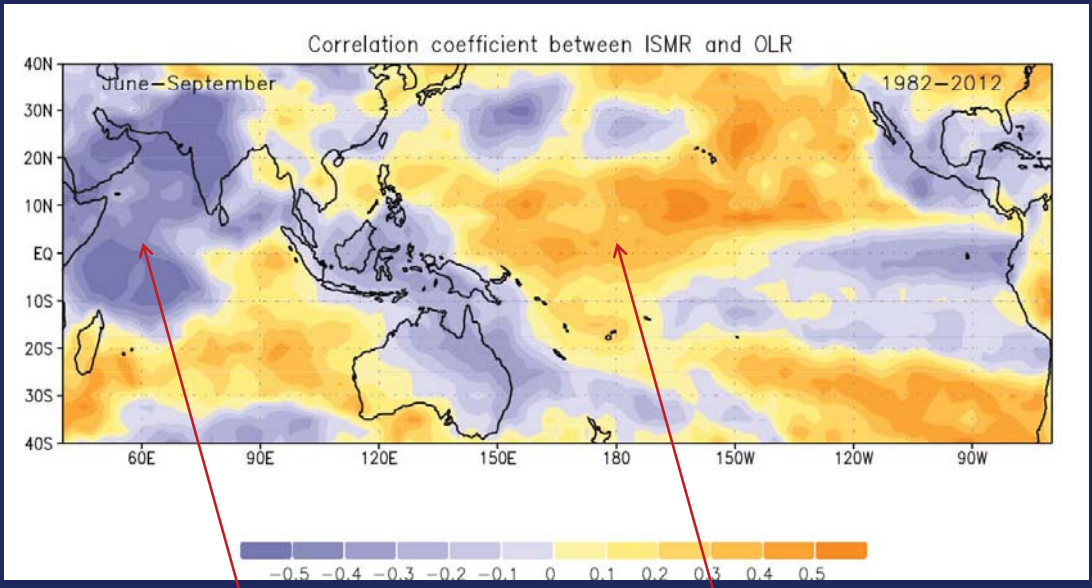


ISMR	Climatology (n=53)
ISMR <= -1.0	24.5
-1 < ISMR <= -0.25	13.2
-0.25< ISMR < 0.25	24.5
0.25 <= ISMR < 1	22.7
ISMR >=1.0	15.1

Use of seasonal prediction

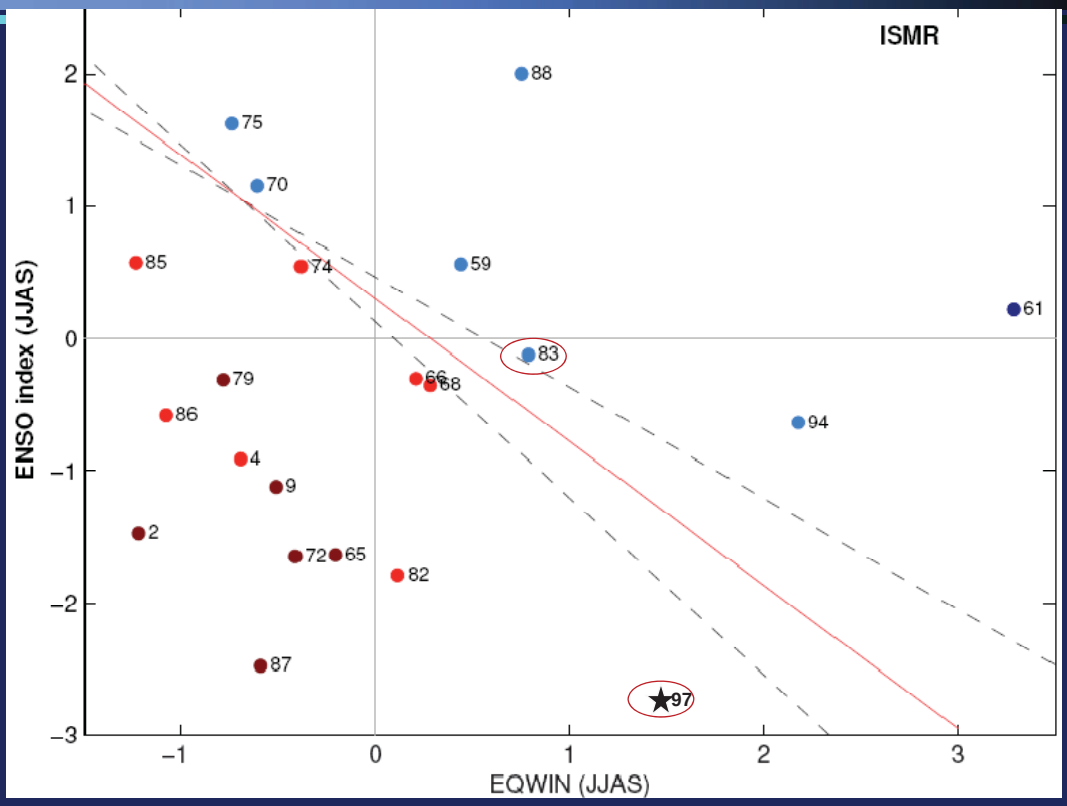
- In general, predictions of the occurrence or non-occurrence of extremes (i.e. droughts or excess rainfall seasons) is important for farm-level decision making.
- Can we generate reliable predictions of extremes?

Teleconnections of the monsoon



EQUINOO

ENSO



How good are the seasonal forecasts of the extremes of the Indian summer monsoon rainfall?

- How good?

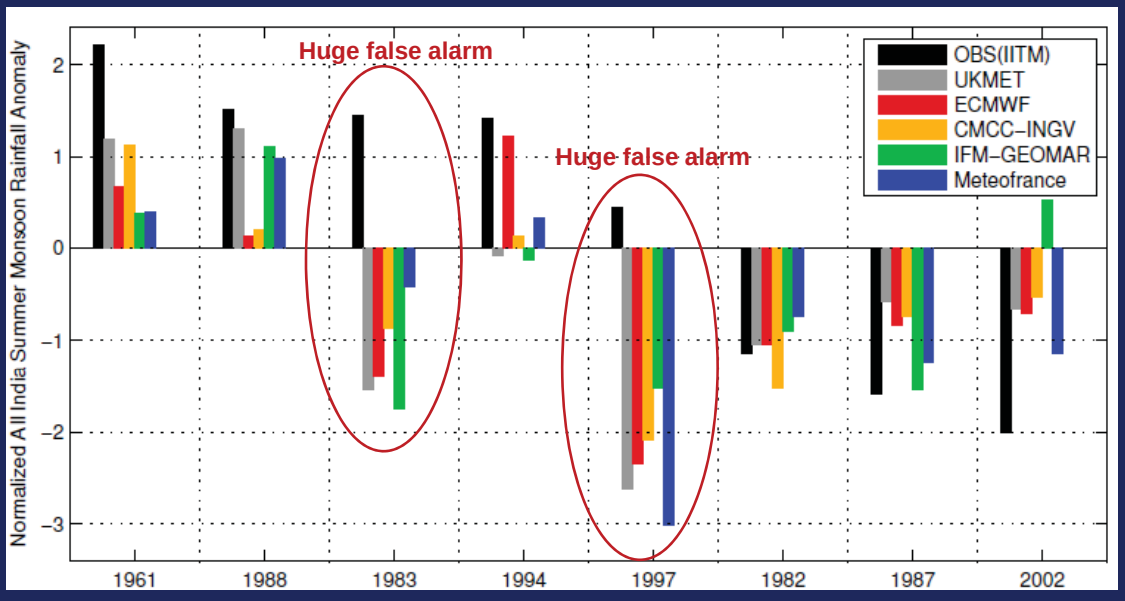
Analysis of :

ENSEMBLES project: retrospective predictions for 1960-2005 for five models

CFS1, CFS2 of NECP : retrospective predictions for 1982-2005

- Why?

- There has been considerable improvement in the models (e.g. from DEMETER to ENSEMBLES-Correlation between (retrospectively predicted ISMR by MME and the observed ISMR has gone up from 0.28 to 0.45 : Rajeevan et. al.2011).
- Now at least the sign of the predicted ISMR anomaly is correct for almost all the observed extremes.
- However,



Note the coherence of the errors across the board

=> Large uncertainty in prediction of droughts

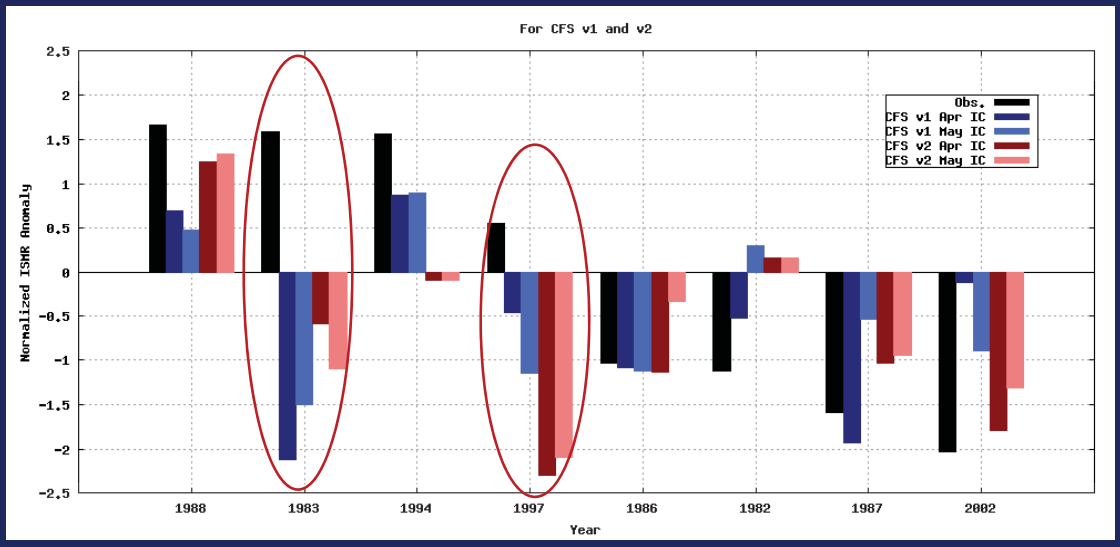


Table 1. Correlation coefficient between observed and predicted rainfall (June–September)

	Pattern correlation coefficient between simulated and CMAP (GPCP) mean rainfall for all available years between 1979 and 2009	Correlation coefficient between predicted and observed ISMR	
Model	Region: 60–100°E, 10°S–30°N	All available years	All available years, excluding 1983 and 1997
UKMO*	0.56 (0.57)	0.43	0.53
MeteoFrance*	0.60 (0.58)	0.36	0.47
CMCC*	0.71 (0.57)	0.33	0.47
IFM*	0.65 (0.47)	0.30	0.41
ECMWF*	0.79 (0.76)	0.29	0.40
CFS1**	0.66 (0.60)	0.14	0.33
CFS2**	0.81 (0.74)	0.41	0.57

*Period: 1960–2005; **Period: 1982–2009

Table 2. Correlation of ISMR with ENSO index and rainfall over WEIO

Model	Correlation coefficient between predicted and observed ENSO indices	Correlation coefficient between ISMR and ENSO index	Correlation coefficient between ISMR and rainfall over WEIO
UKMO*	0.82	0.66	−0.03
MeteoFrance*	0.75	0.75	−0.06
CMCC*	0.72	0.74	−0.13
IFM*	0.73	0.63	−0.25
ECMWF*	0.83	0.29	0.32
CFS1**	0.69	0.44	−0.3
CFS2**	0.65	0.78	−0.32
Observed		0.54†	0.51‡

*Period: 1960–2005; **Period 1982–2009; †Period: 1960–2009; ‡Period: 1979–2009.

Thank you