



Long Range Forecasts of 2015 SW and NE Monsoons and its Verification

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INDIA METEOROLOGICAL DEPARTMENT

Outline

- ❖ **Verification of Operational forecasts for 2015 SW Monsoon**
- ❖ **Experimental Dynamical forecasting system**
- ❖ **Performance of Forecasts from other national and international Institutes**
- ❖ **Verification of Operational and experimental forecasts for 2015 NE Monsoon**
- ❖ **Climate Prediction products available from IMD, Pune website**
- ❖ **2016 SW Monsoon ?**
- ❖ **Conclusions**
- ❖ **Future Plans**



Skill of the statistical models currently used for the operational LRF of Monsoon Rainfall over India

Operational Long Range Forecast For the Southwest Monsoon Issued By IMD

Month of Forecast Issue



In addition, Forecast for Date of Monsoon Onset over Kerala in May

23-Feb-16

Forecast Period	Forecast Region	Model (Training Window Period)	CC. Actual Vs Forecast Rainfall (Period)	Root Mean Square Error (RMSE) in % of LPA (Period)
June to September	All India	5-P Statistical Ensemble Forecast System (SEFS) (23 yrs)	0.71 (1981-2014)	6.56 (1981-2014)
June to September	All India	6-P (SEFS) (23 yrs)	0.80 (1981-2014)	5.64 (1981-2014)
July	All India	6 -P Principal Component Regression (PCR) (23 yrs)	0.70 (1981-2014)	10.20 (1981-2014)
August	All India	5-P PCR (23 yrs)	0.29 (1998-2014)	11.70 (1998-2014)
September	All India	5-P PCR (23 yrs)	0.70 (1981-2014)	14.60 (1984-2011)
August-September	All India	5-P PCR (23 yrs)	0.57 (1981-2014)	10.83 (1981-2014)
June to September	Northwest India	5-P PCR (30 yrs)	0.65 (1988-2014)	12.70 (1988-2014)
June to September	Northeast India	5-P PCR (30 yrs)	0.56 (1988-2014)	10.97 (1988-2014)
June to September	Central India	5-P PCR (30 yrs)	0.44 (1988-2014)	12.1 (1988-2014)
June to September	South Peninsula	6-P PCR (30 yrs)	0.51 (1988-2014)	13.31 (1988-2014)



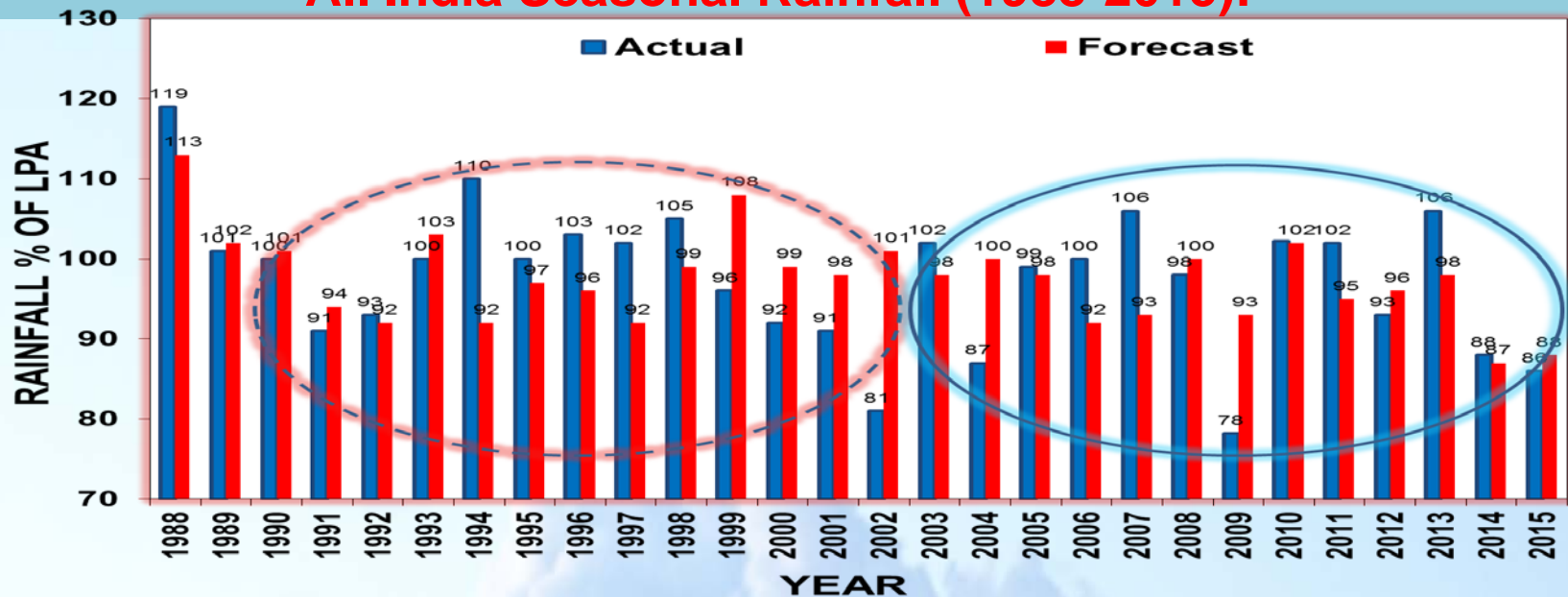
ESSO-IMD Operational Forecast for 2015 Monsoon Rainfall & Verification

Region	Period	Forecast (% of LPA)			Actual Rainfall (% of LPA)	
		22 th April	2 th June (Update)	2 nd August		
All India	June to September	93 ± 5	88 ± 4		86	
Northwest India	June to September		85 ± 8		83	
Central India	June to September		90 ± 8		84	
Northeast India	June to September		90 ± 8		92	
South Peninsula	June to September		92 ± 8		85	
All India	July		92 ± 9		84	
All India	August		90 ± 9		78	
All India	August to September			84 ± 8		77

The operational forecasts for the 2015 season rainfall over the country as a whole and that over four broad geographical regions (northwest India, central India, northeast India and south Peninsula) were within the limits of the forecasts issued in June and accurate. Similarly, the forecasts for the July as well as that for the rainfall during the second half of the monsoon season over the country as a whole were also accurate. However, the August forecast was an overestimate to the realized rainfall and was not accurate. .



Performance of Operational Forecast (Empirical Model) for All India Seasonal Rainfall (1988-2015):



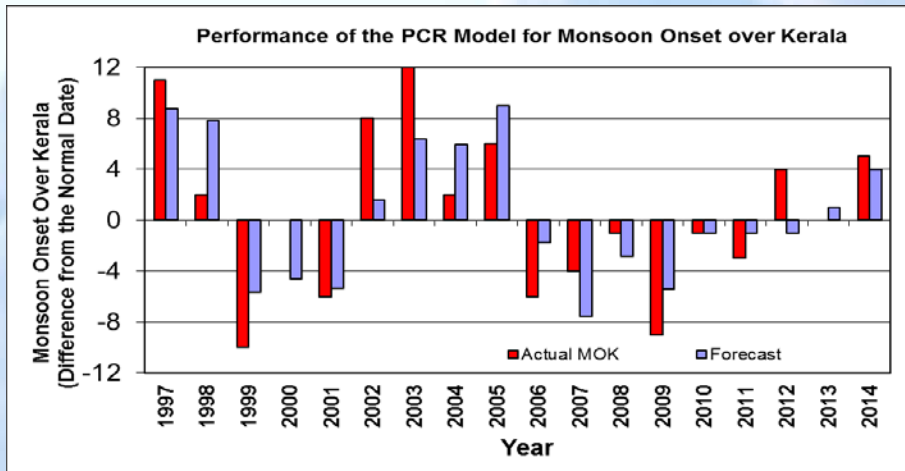
- ❖ Error $\geq 10\%$ in 7 yrs with highest in 2002 (20%) and 1994 (18%). Error in 2009 15%.
- ❖ Ave. absolute error during the last 13 years (2003 -2015) was 5.92% of LPA compared to that of 7.94% of LPA during the 13 years (1990 -2002) just prior to that period.
- ❖ C.C between the actual and forecast rainfall for (2003 -2015) & (1990-2002) are 0.42 & -0.24 respectively.
- ❖ During 1990-2002, the forecast within the $\pm 8\%$ of actual values during 9 years. Within these 9 years, forecast was within $\pm 4\%$ during 5 years. On the other hand during 2003-2015, the forecast was within the $\pm 8\%$ of actual values during 10 years with forecast within $\pm 4\%$ during 7 years. ***These clearly indicate improvement made in the operational forecast system in the recent 13 years period compared to earlier 13 years period.***



PCR model for the Forecasting date of Monsoon onset over Kerala

No	Name of Predictor	Period	C.C (1975-2000)
1	Zonal Wind at 200hpa over Indonesian region	16 th -30 th Apr	0.48
2	OLR Over South China Sea	16 th - 30 th Apr	0.40
3	Pre-Monsoon Rainfall Peak Date	Pre-monsoon April-May	0.48
4	Minimum Surface air Tem. over NW India	1 st -15 th May	-0.37
5	Zonal Wind at 925hpa over Equatorial South Indian Ocean	1 st -15 th May	0.52
6	OLR Over Southwest Pacific	1 st -15 th May	-0.53

Year	Actual Onset Date	Forecast Onset Date
2005	7 th June	10 th June
2006	26 th May	30 th May
2007	28 th May	24 th May
2008	31 st May	29 th May
2009	23 rd May	26 th May
2010	31 st May	30 th May
2011	29 th May	31 st May
2012	5 th June	1 st June
2013	1 st June	3 rd June
2014	6 th June	5 th June
2015	5 th June	31 st May



Model error = 4 days

The forecast issued for the 2015 monsoon onset over Kerala was not within the forecast limits



ESSO-IMD's Operational Probability long range Forecasts for the 2015 Southwest monsoon rainfall

The 5 category probability forecasts for the Seasonal (June to September) rainfall over the country as a whole is given below:

Category	Rainfall Range (% of LPA)	Forecast Probability (%)		Climatological Probability (%)
		April	June	
Deficient	Less than 90	33	66	16
Below Normal	90 - 96	35	27	17
Normal	96 -104	28	7	33
Above Normal	104 -110	4	0	16
Excess	more than 110	1	0	17

The 3 category probability forecasts for the monthly (July & August) Rainfall over the country as a whole are given below. All the 3 rainfall categories have equal climatological probabilities (33.33%).

Rainfall Category	July		August	
	Range (% of LPA)	Forecast Probability (%)	Range (% of LPA)	Forecast Probability (%)
Below Normal	<94	58	<94	61
Normal	94 -106	33	94 -106	28
Above Normal	>106	9	>106	11

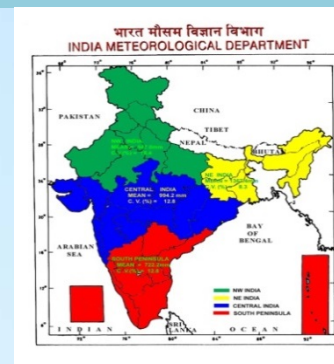
The tercile probability forecasts for the rainfall over the country as a whole during the 2015 second half of the monsoon season

Category	Rainfall Range (% of LPA)	Forecast Probability (%)
Below Normal	<94	86
Normal	94 -106	13
Above Normal	>106	01



ESSO-IMD's Operational Probability long range Forecasts for the 2015 Southwest monsoon rainfall

The 3 category probability forecasts for seasonal rainfall over the four broad geographical regions are given below. All the 3 rainfall categories have equal climatological probabilities (33.33% each). First forecast in June and update in August.



- NW India
- NE India
- Central India
- S. Peinsula

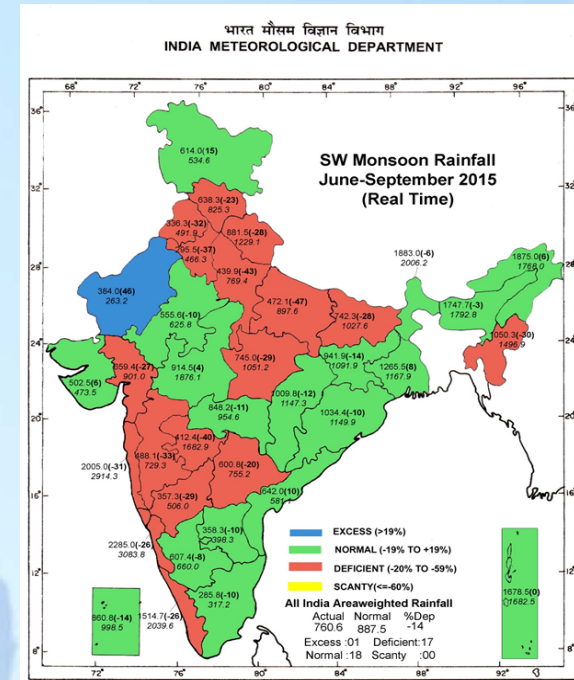
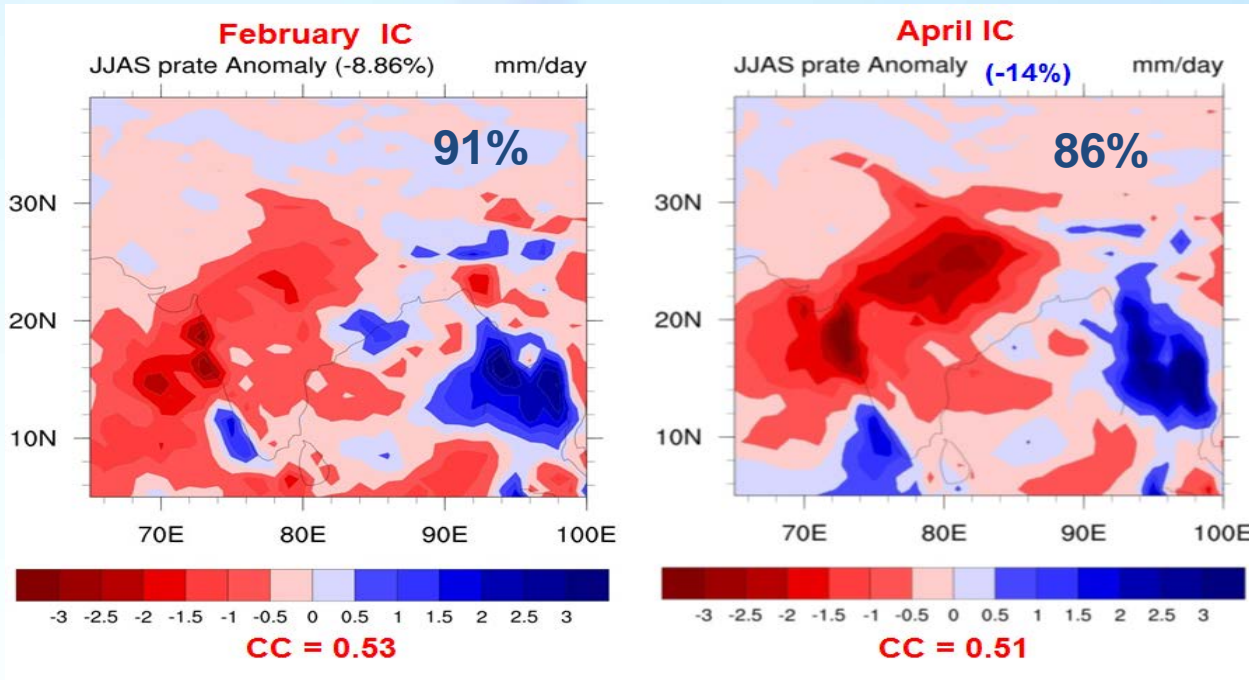
Rainfall Category	NW India		Central India		South Peninsula		Northeast India	
	Range	Forecast Pbbty	Range	Forecast Pbbty	Range	Forecast Pbbty	Range	Forecast Pbbty
Below Normal	<92	73	<94	63	<93	53	<95	68
Normal	92-108	25	94-106	28	93-107	35	95-105	24
Above Normal	>108	2	>106	9	>107	12	>105	8



Experimental Dynamical Model Forecasting System



Rainfall anomalies Predicted by the IITM CFS T382 (Initialized with Feb. & April Initial Conditions)



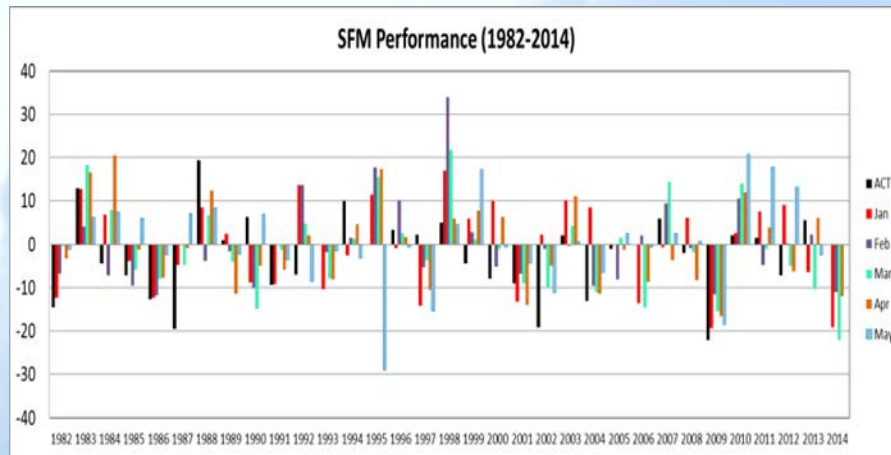
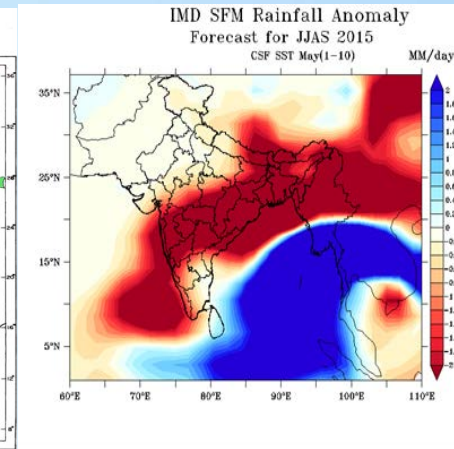
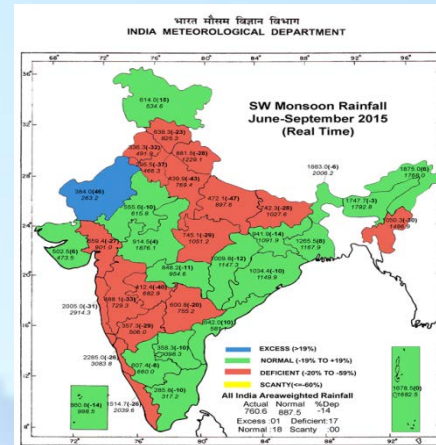
Category	Rainfall Range (% of LPA)	Forecast Probability (%)	Climatol. Probability (%)
		April	
Deficient	<90	61	16
Below Normal	90 - 96	24	17
Normal	96 - 104	13	33
Above Normal	104 - 110	2	16
Excess	> 110	0	17

Initial conditions (IC) of	JJAS		Forecast for 2015 (% of LPMA)
	C.C (1981-2008)	Corrected RMSE (% of LPMA) (1981-2008)	
February	~ 0.55	7.4%	91%
April	~ 0.4	8.3%	86%



IMD SFM Forecast For 2015

Forecast issued in	JUN		JUL		AUG		SEP		JJAS		AUG-SEP	
	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE
January (CFS Jan SST)	-0.07	21	-0.01	16	0.43	12	0.20	22	0.33	9	0.35	13
February (CFS Feb SST)	0.06	19	-0.01	16	0.31	11	0.41	18	0.34	9	0.49	9
March (CFS MAR SST)	0.04	20	0.31	15	0.27	14	0.39	16	0.50	8	0.52	10
April (CFS APR SST)	0	19	0.15	15	0.36	12	0.41	18	0.46	9	0.51	11
May (CFS MAY SST)	-0.2	21	0.27	16	0.09	14	0.16	22	0.33	9	0.29	12



Forecast issued in	Forecast: All India Rainfall (% of LPA)				
	Jun	Jul	Aug	Sep	JJAS
January	84.1	75.6	81.5	44.2	72.8
February	106.5	88.4	91.9	88.6	93
March	126.5	81.8	72.8	67.2	84.9
April	91.7	86.57	87.84	87.08	88.02
May	166	71.5	71.5	50	85
Actual	116	84	78	76	86



Forecasts from various Indian Institutes

S.No	Institute	Model	Forecast for 2015 (% of LPA)	
			Issued in April	Issued in June
1.	Space Applications Centre (SAC), Ahmedabad	Empirical model based on Genetic Algorithm	100% ± 4%	No update
2.	Indian Institute of Technology, Bhubaneswar	Multi Model Ensemble	98%	96%
3.	C-DAC, Pune	NCEP GFS T170L42	84% (March IC)	91% (May IC)
4.	Centre for Disaster Mitigation, Jain University, Bangalore	Statistical (Empirical Model Decomposition)	113%± 5%	115%± 5%

The experimental forecasts from 3 of the 4 models indicated normal to above normal ($\geq 96\%$ of LPA) monsoon season rainfall over the country as whole.

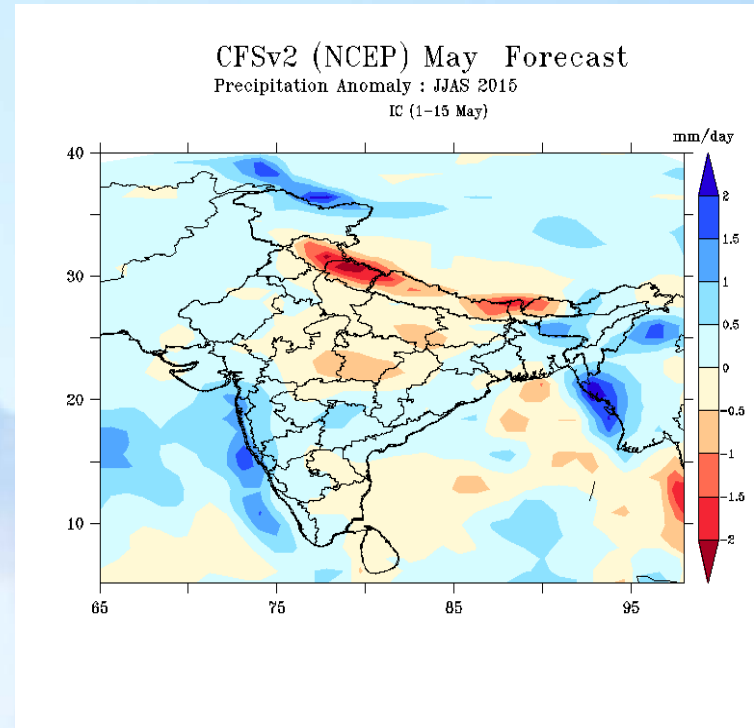


2015 Rainfall Predictions by Various International Climate Prediction Centers



NCEP CFSV2 Forecast 2015

Initial Conditions of	Forecast 2015 (% of LPMA)				
	JUN	JUL	AUG	SEP	JJAS
December(-1)	79.5	91.2	86.2	80.1	85.3
January	96.6	82.6	91.9	83.6	88.2
February	99	103.2	103.7	111.6	104.27
March	105.3	103.4	101.1	86.9	99.9
April	115	111	103	99	107
May (1-15)	92	98	108	101	100

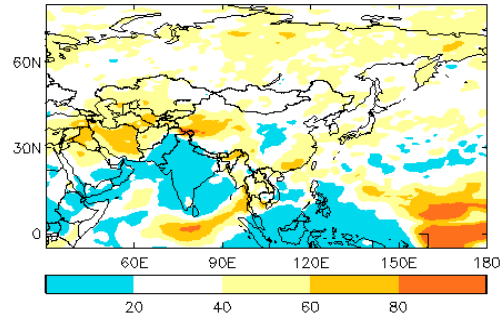


The experimental NCEP CFSV2 forecast based on the latest 4 ICs indicate normal rainfall is likely over the country as a whole.

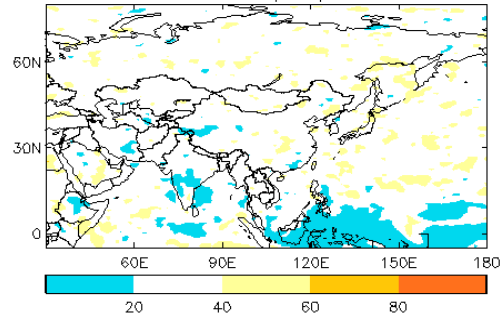


UK Met Office

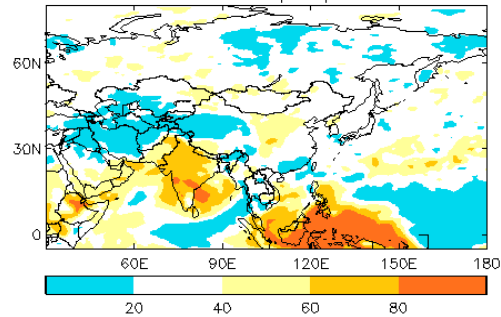
Probability of tercile categories Jun/Jul/Aug Issued May 2015
above-normal precipitation



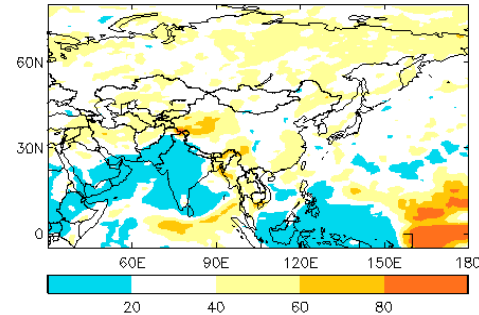
near-normal precipitation



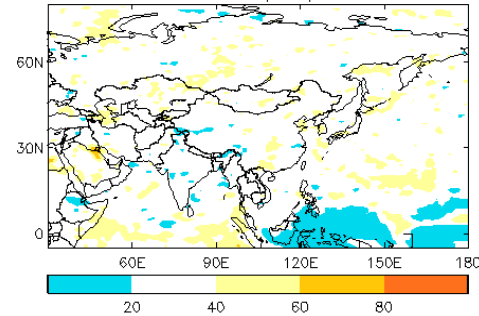
below-normal precipitation



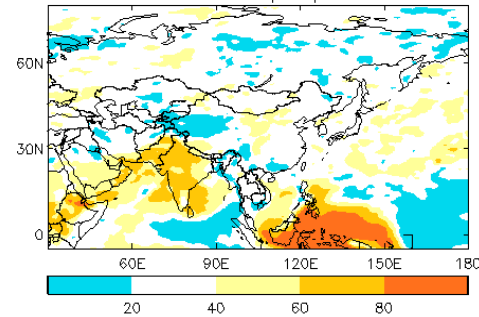
Probability of tercile categories Jul/Aug/Sep Issued May 2015
above-normal precipitation



near-normal precipitation



below-normal precipitation



Normal to above normal rainfall is most likely over Northeast India.

Below normal rainfall is most likely over remaining areas.



ECMWF Forecast: JJA & JAS 2015

Probability Forecast

ECMWF Seasonal Forecast

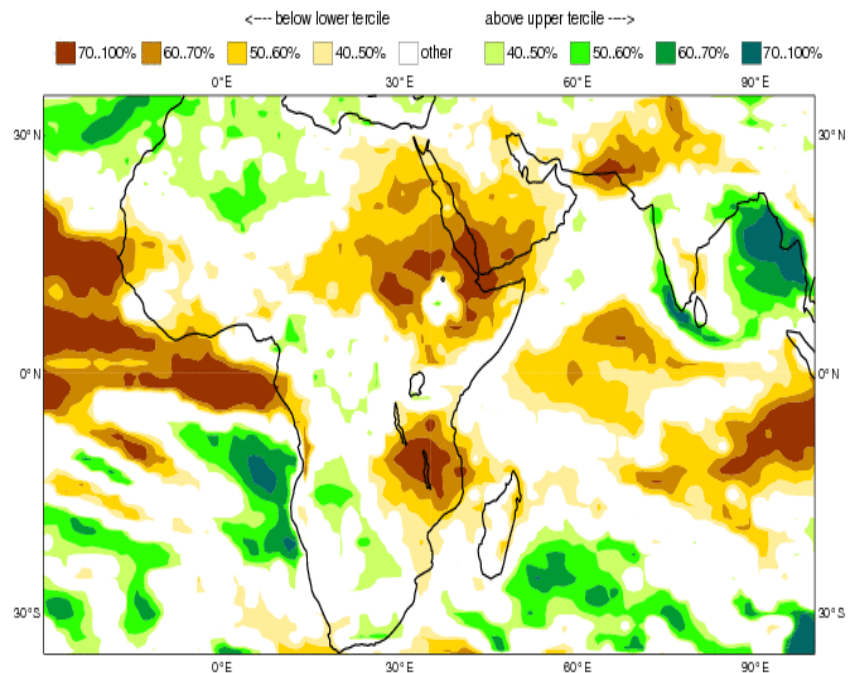
Prob(most likely category of precipitation)

Forecast start reference is 01/05/15

Ensemble size - 51, climate size - 450

System 4

JJA 2015



ECMWF Seasonal Forecast

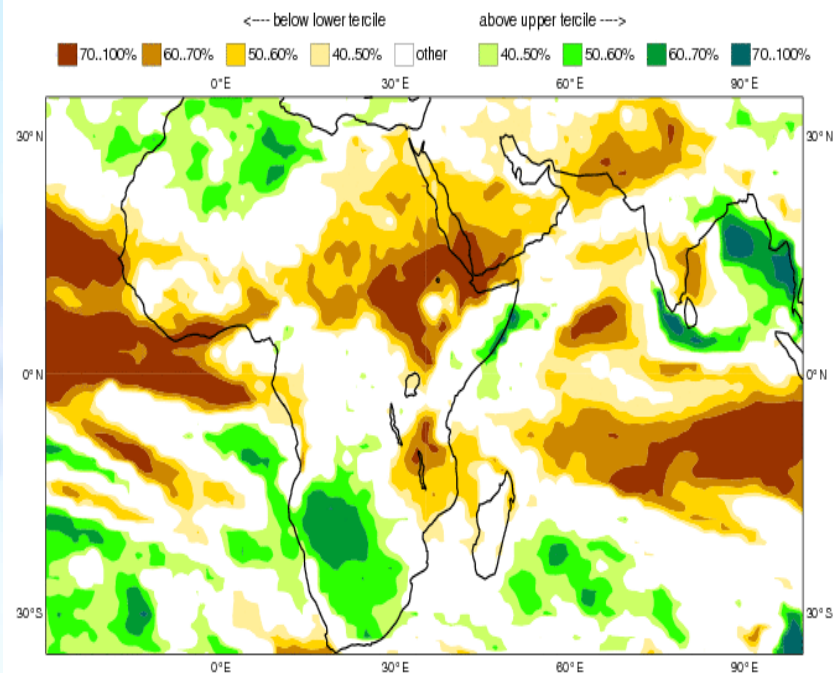
Prob(most likely category of precipitation)

Forecast start reference is 01/05/15

Ensemble size - 51, climate size - 450

System 4

JAS 2015



Below Normal rainfall is most likely over Northwest India, north India, southeast parts of Peninsula. No specific signal for remaining areas.



Multi-model Forecast from ECMWF: EUROSIP

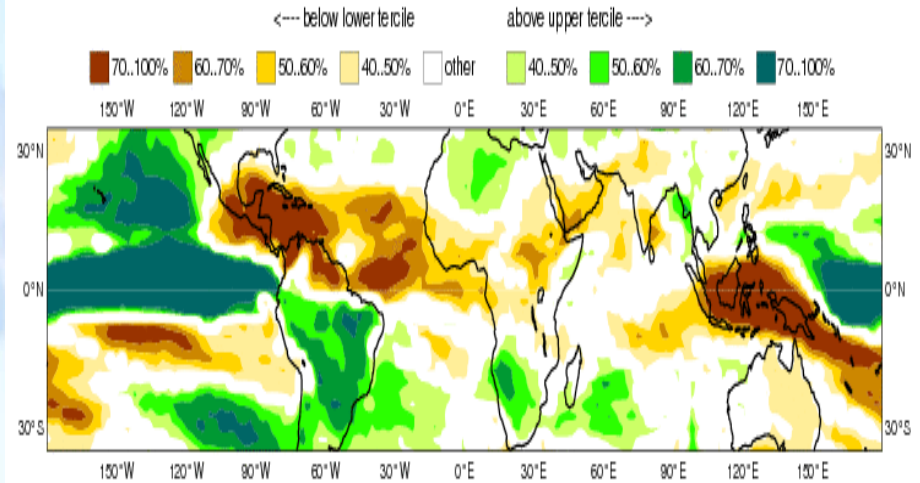
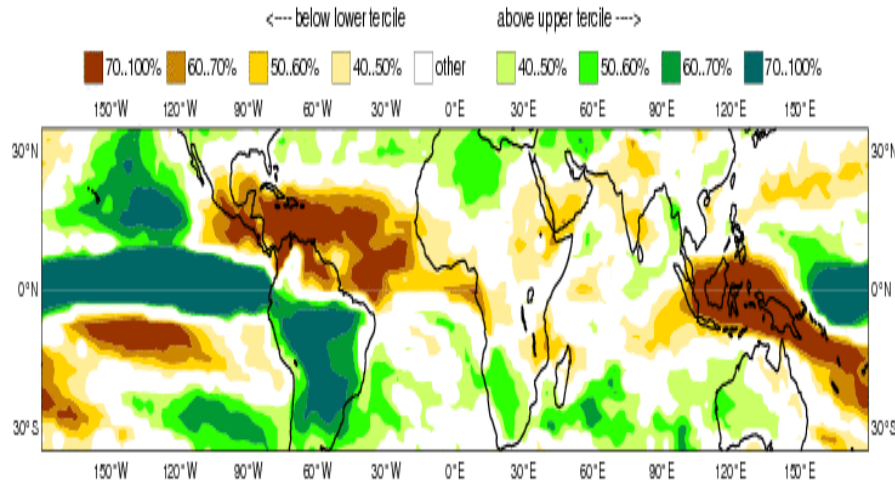
2015 – JJA & JAS

EUROSIP multi-model seasonal forecast
Prob(most likely category of precipitation)
Forecast start reference is 01/05/15
Unweighted mean

ECMWF/Met Office/Meteo-France/NCEP
JJA 2015

EUROSIP multi-model seasonal forecast
Prob(most likely category of precipitation)
Forecast start reference is 01/05/15
Unweighted mean

ECMWF/Met Office/Meteo-France/NCEP
JAS 2015



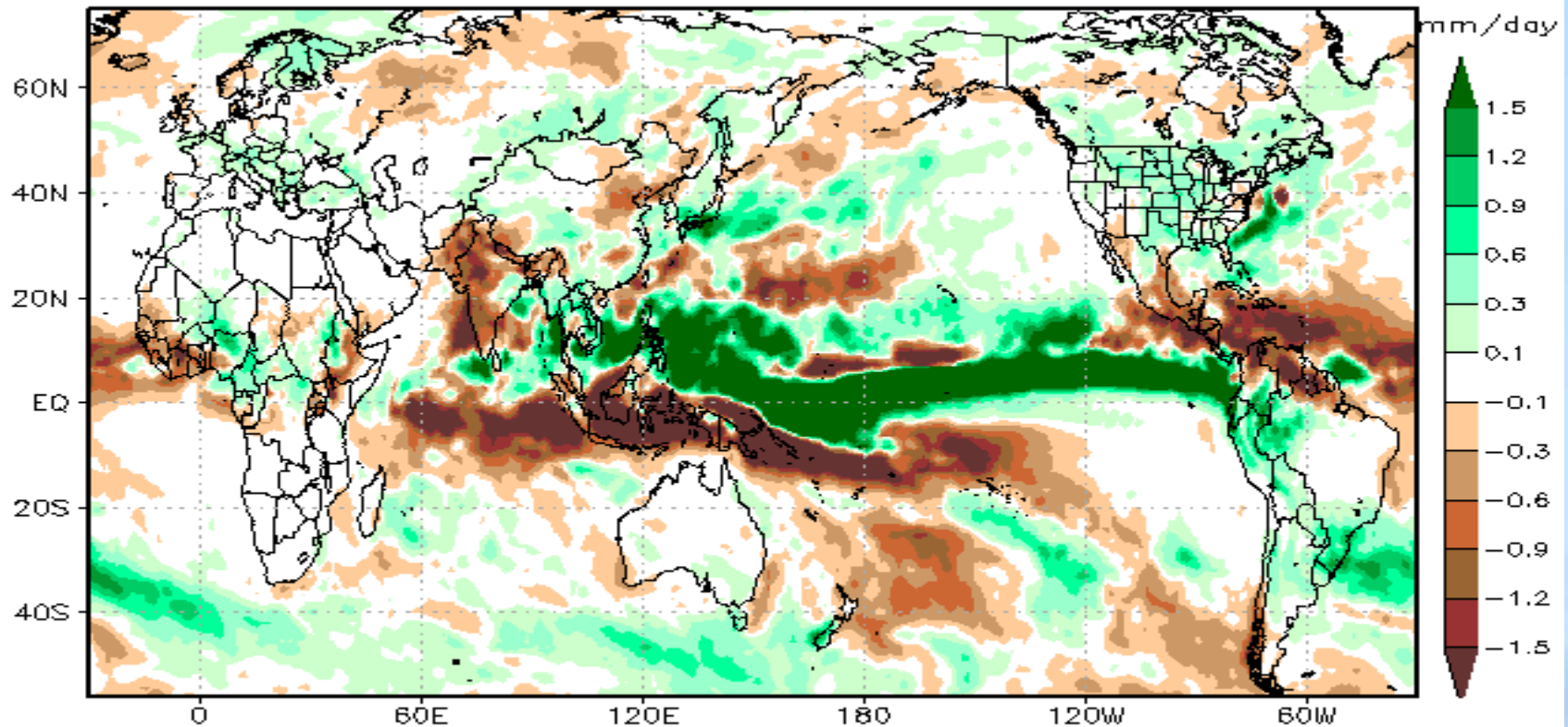
4 Models:
ECMWF UKMO, Meteo-France
NCEP CFSV2

Below normal rainfall over most parts of Northwest India and south Peninsula. No specific signal for remaining areas.



JAMSTEC Forecast: JJA & JAS 2015: Precipitation Anomaly

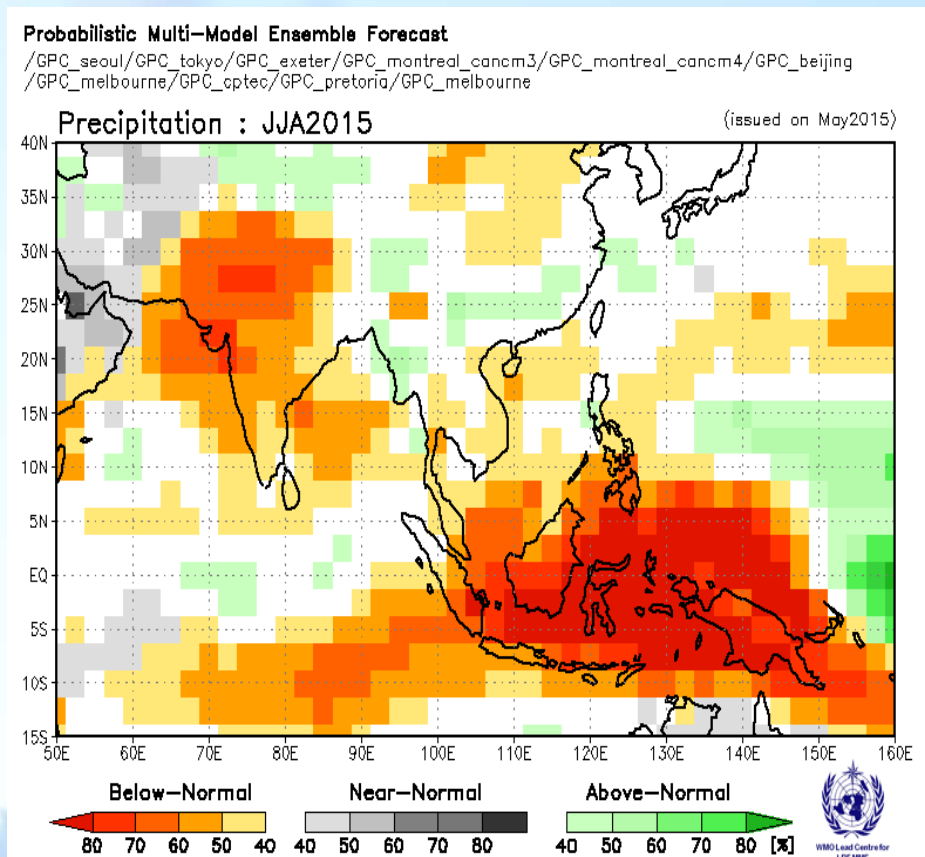
Predicted JJA2015 tprep anom. from 1may2015 (9-member)



Below normal rainfall likely over most parts of the country.



WMO LC_LRF MME

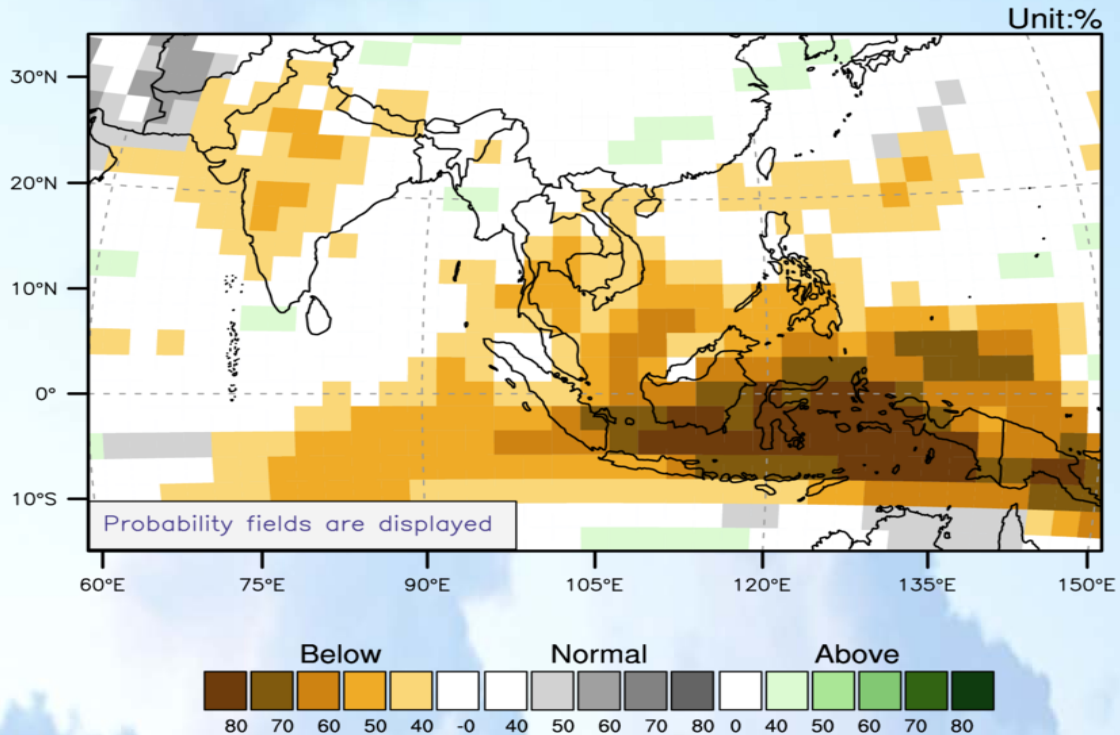


Below Normal rainfall is most likely over most parts of the country



APEC Climate Center

Precipitation for June-August 2015



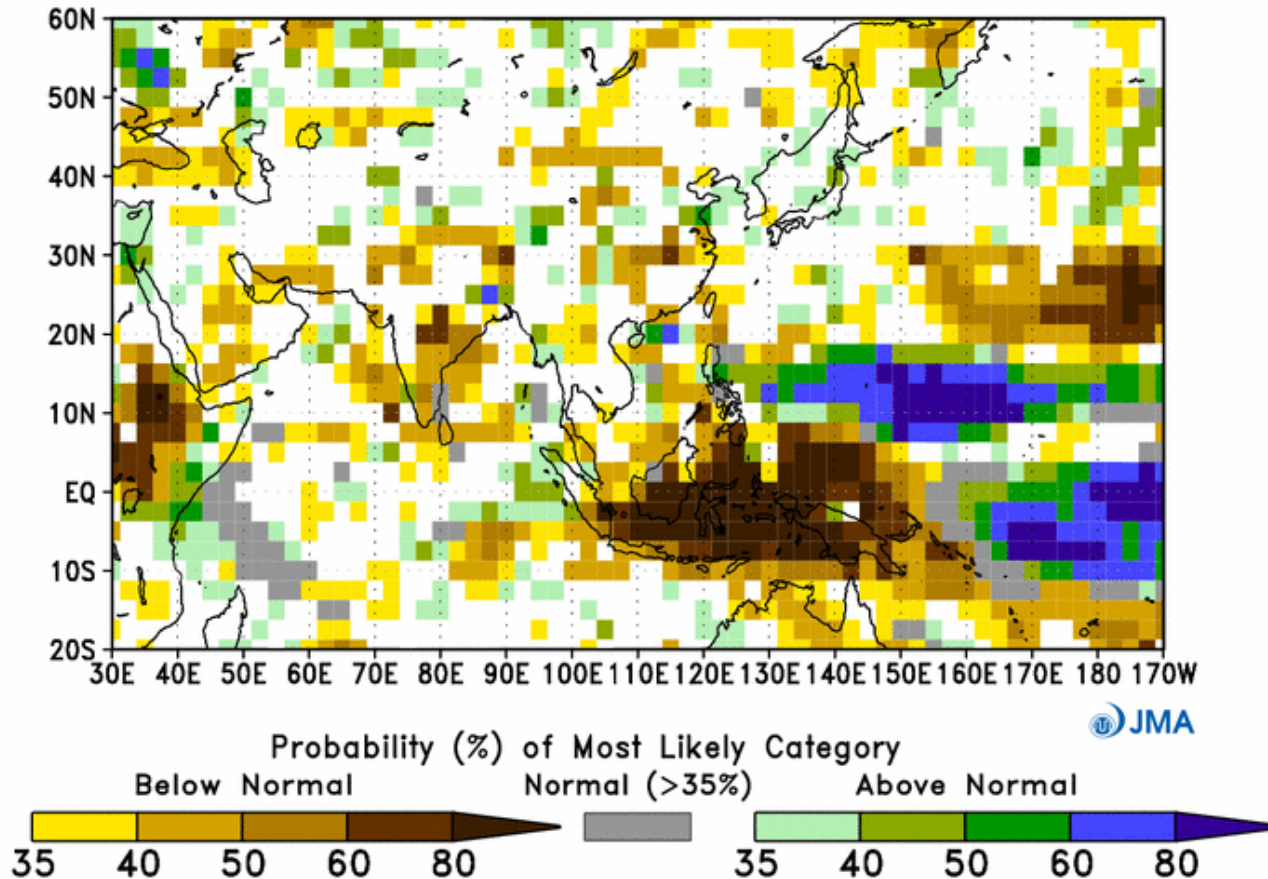
© APEC Climate Center

Below Normal rainfall is most likely over most parts of the country



Japan Met. Agency (JMA)

JMA Seasonal Forecast (Forecast initial date is 11 05 2015)
Most likely category of Precipitation for JJA 2015



Below Normal rainfall is most likely over most parts of the country



Summary of Experimental Forecasts From Various Climate Research Centers

All Forecast models except NCEP CFS (of USA) suggests the 2015 nation-wide southwest monsoon rainfall likely to be below normal.

Most of the Models indicate large rainfall deficiency over northwest India and central India.



4-Mar-16

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4-Mar-16



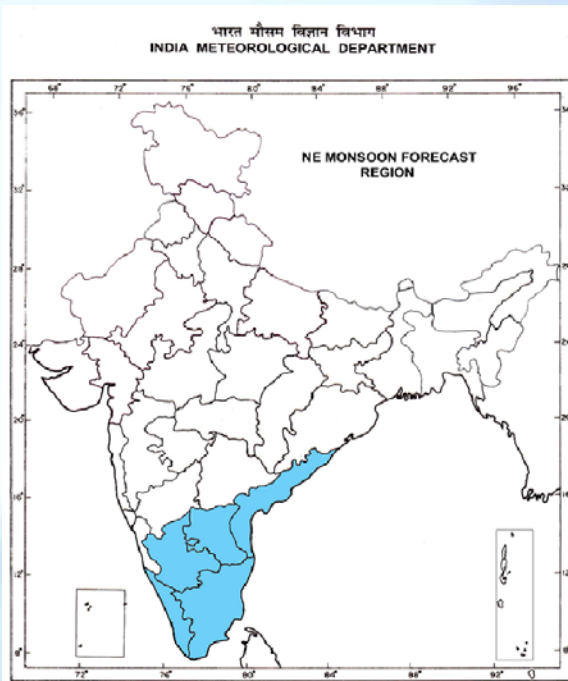
NE Monsoon Forecast and Verification – 2015

Region

South Peninsula consisting of 5 sub divisions (Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu, South Interior Karnataka and Kerala).

Forecast period:

October to December, 2015.



Sub Division	Seasonal (Oct- Dec) Rainfall (in mm)	Coefficient Of Variation (CV) (%)	Per cent of annual total (%)
Tamil Nadu	438.2	31.5	47.92
Rayalaseema	219.2	37.8	31.04
Coastal Andhra Pradesh	327.4	38.7	31.97
South Interior Karnataka	209.6	38.4	20.57
Kerala	480.7	28.8	16.44
South Peninsula	332.1	25.3	29.88



Models used & Forecasts

- 5- P principal component regression (PCR) model for quantitative & probabilistic forecasts of NE monsoon rainfall over south Peninsula.
- Forecast: $134 \pm 20\%$ of LPA

Category	Rainfall Range (% of LPA)	Forecast Probability (%)
Below Normal	<89	1
Normal	89 -111	11
Above Normal	>111	88

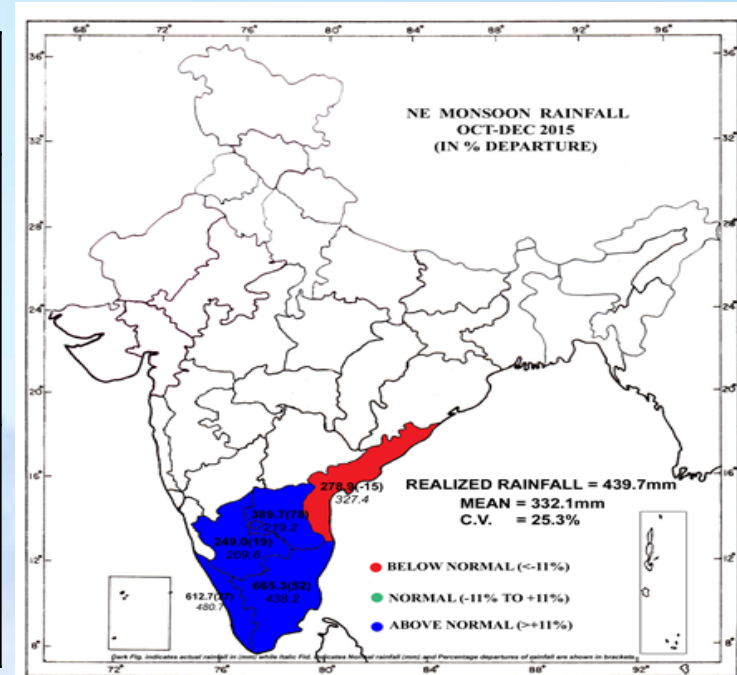
- A new 4-p PCR Model for qualitative & probabilistic forecasts of NE monsoon rainfall over Tamil Nadu
- Forecast: $145 \pm 25\%$ of LPA.

Category	Rainfall Range (% of LPA)	Forecast Probability (%)
Below Normal	<88	1
Normal	88 -112	9
Above Normal	>112	90

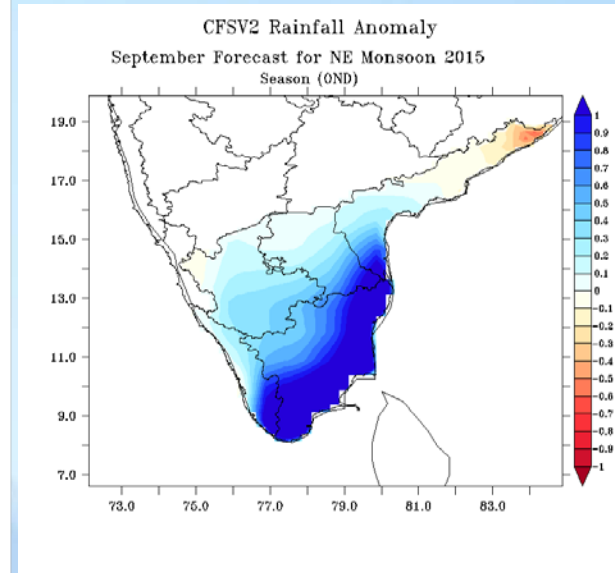
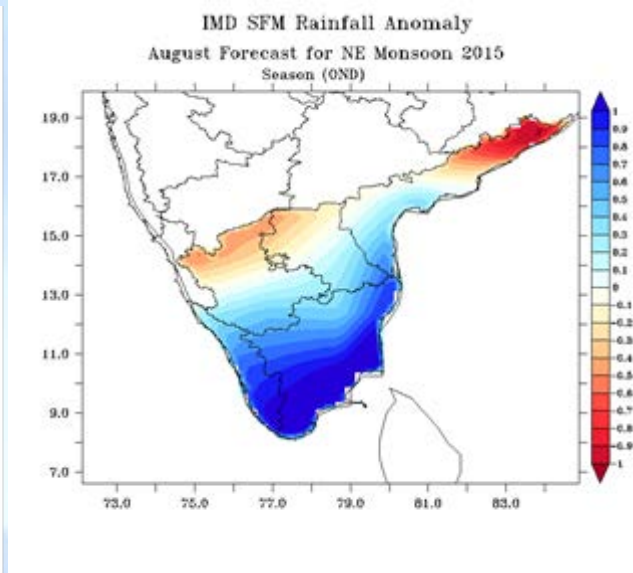
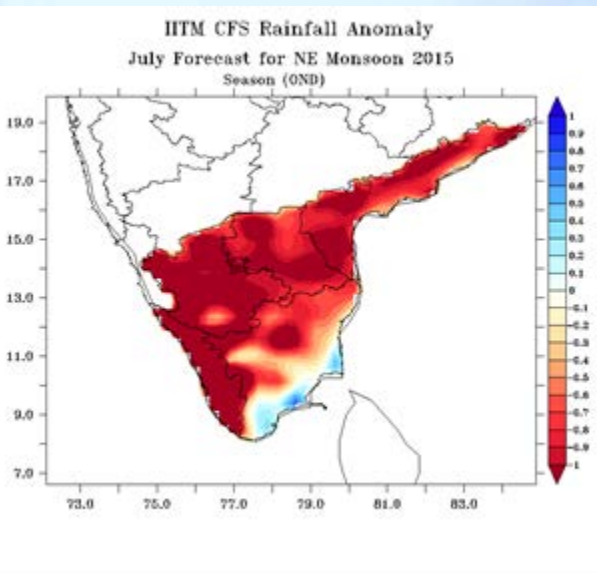


Verification of NE Monsoon Rainfall - 2015

Region	Long Range Forecast	Actual
South Peninsula	The 2015 NE monsoon (Oct-Dec) rainfall is most likely to be above normal (>111% of long period average (LPA)).	The 2015 NE monsoon (Oct-Dec) rainfall was 132% of LPA.
Tamil Nadu	The 2015 NE monsoon (Oct-Dec) rainfall is most likely to be above normal (>112% of LPA) .	The 2015 NE monsoon (Oct-Dec) rainfall was 152% of LPA.



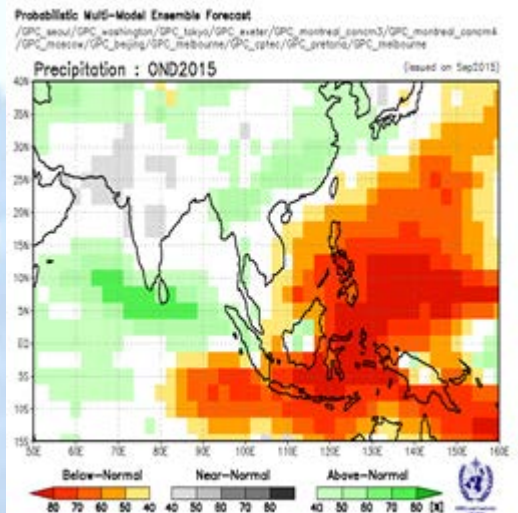
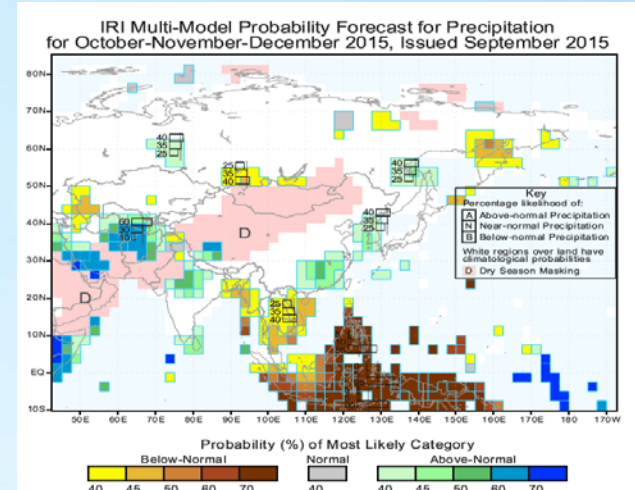
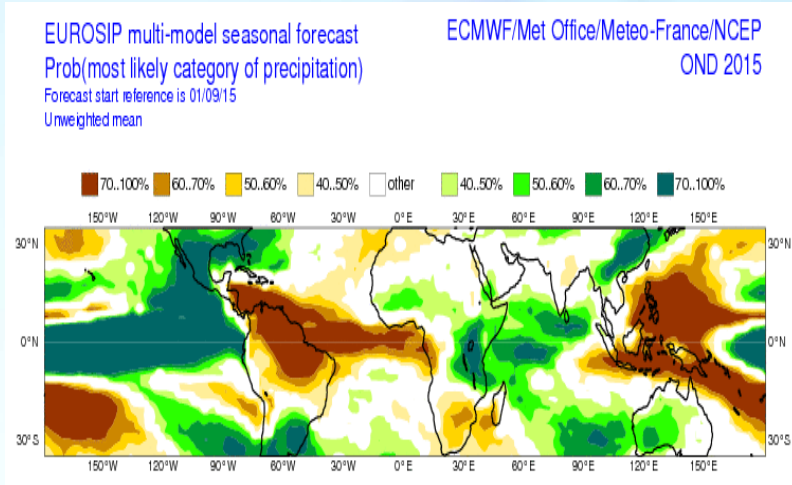
Experimental Dynamical Model Forecast 2015



Model	Initial condition	Skill Score C. C. (1982-2013)	Forecast for 2015 (% of LPMA)
ESSO CFS	July	-0.37	74
ESSO-IMD SFM	August	0.11	108
NCEP CFS	September (1-15 th)	0.18	124



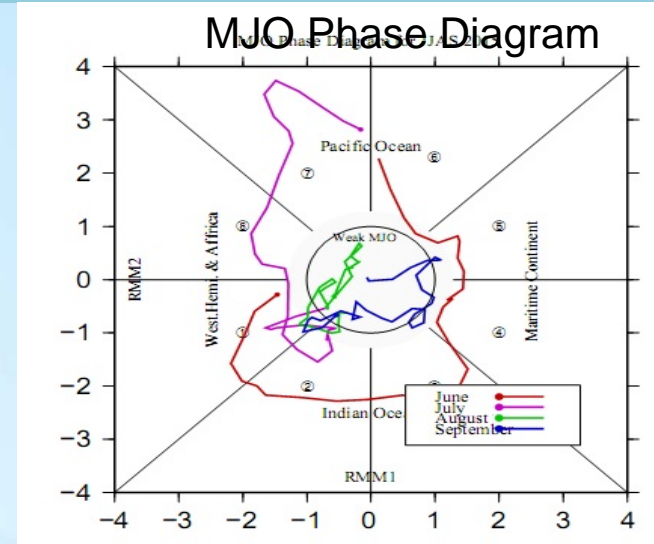
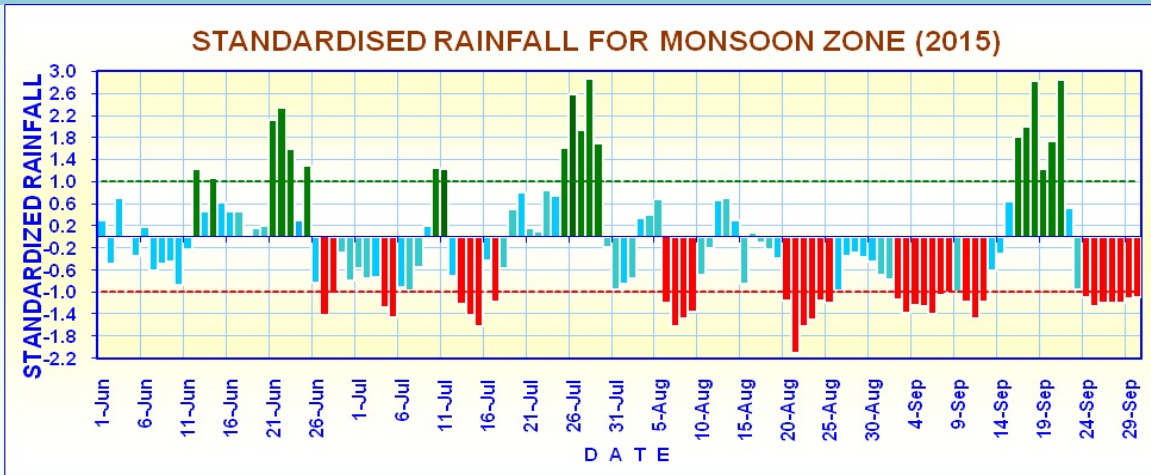
MME Forecast for 2015 NE Monsoon Rainfall From International Centers



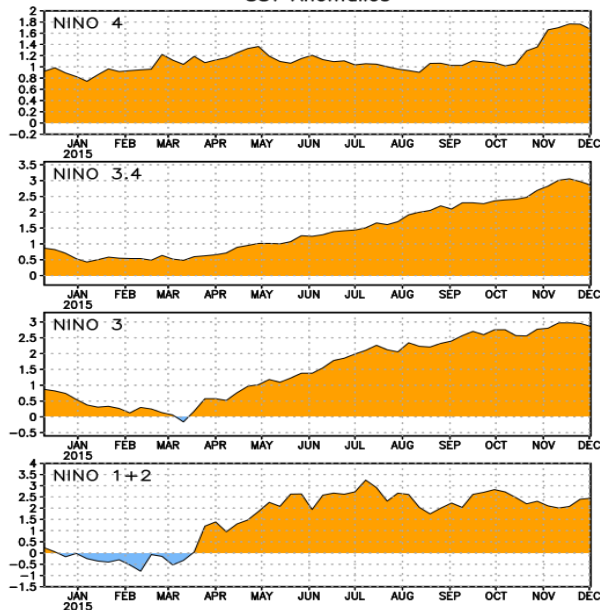
Multi-model ensemble forecast from international climate centers suggested normal NE monsoon season rainfall over south Peninsula



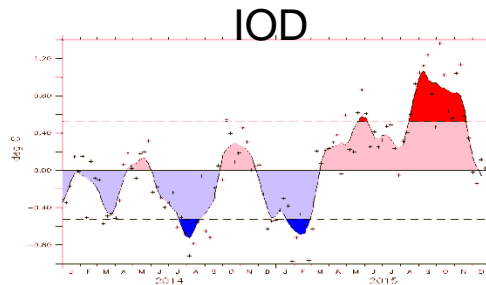
Probable reasons for the Deficient 2015 SW Monsoon



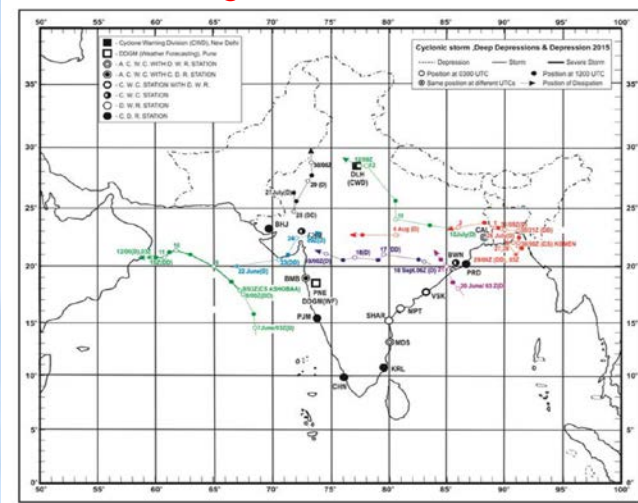
El Nino Indices



During 1901-2015 29 El Niño years. 19 (65.5%) years were below normal. 16 (55%) years of them were deficient. All the recent 4 El Niño years (after 1997) were deficient.



Eight depressions formed during this season as against the normal of 4-6



Long Range Forecast Products Available from IMD, Pune Website Based on Monsoon Mission CFS

http://www.imdpune.gov.in/Clim_Pred_LRF_New/Products.html

Operational Long Range Forecast Issued
For the Southwest Monsoon Rainfall

All India

- All India June - September Rainfall (April)
- Update for All India June - September Rainfall (June)
- All India Monthly (July & August) Rainfall (July)
- All India Second Half of Season August - September Rainfall (August)

Geographical Regions

- All India Monthly September Rainfall (August)
- June - September Rainfall for Four Geographical Regions

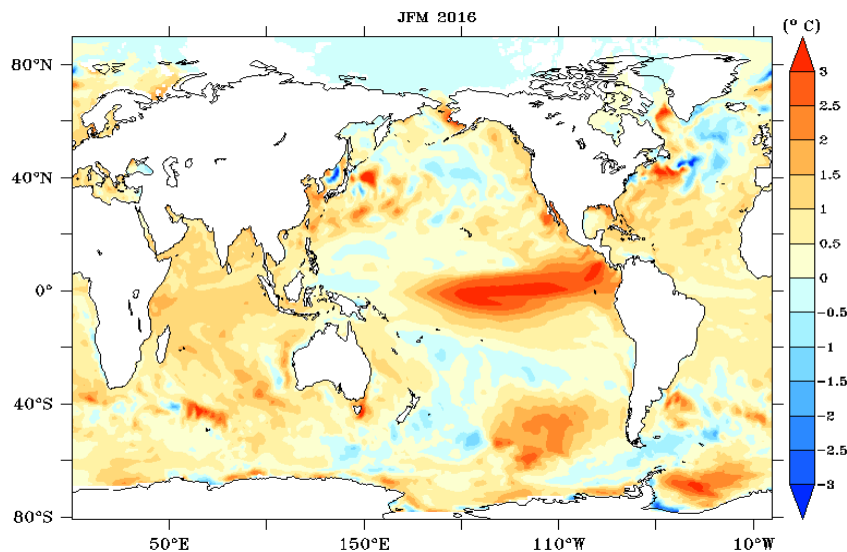
In addition, Forecast for Date of Monsoon Onset over Kerala in May

- Global monthly and seasonal forecast anomaly maps of rainfall and Temperature for next 8 months (Every month)
- ENSO & IOD Forecast Bulletins (Every month)
- Seasonal Forecast Outlook of Rainfall and Temperatures over South Asia (updated every month)
- Consensus forecast of SW Monsoon Rainfall over South Asia (issued in April every year)

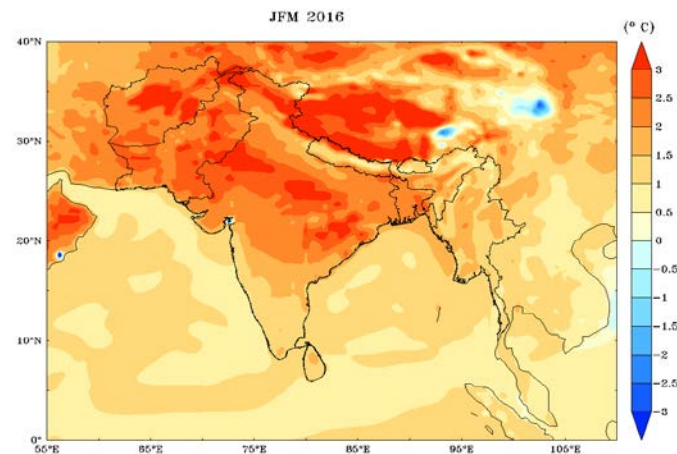


Global monthly and seasonal forecast anomaly maps of rainfall and Temperature for next 8 months (Every month)

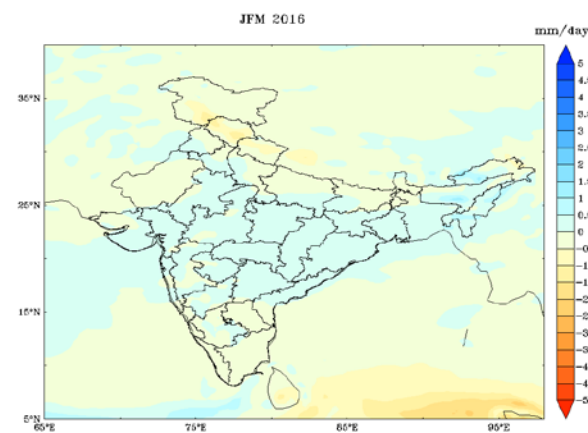
IITM CFSV2 Sea Surface Temperature Anomaly : DEC 2015 IC



IITM CFSV2 Surface Temperature Anomaly : DEC 2015 IC



IITM CFSV2 Rainfall Anomaly : DEC 2015 IC



ENSO & IOD Forecast Bulletin (Every month)



Ministry of Earth Sciences
Government of India

El Nino/La Nina
Indian Ocean Dipole
Update (10th December 2015)

1. Current Sea Surface Temperature (SST) Conditions over Pacific & Indian Oceans

During November 2015, positive SST anomalies ($\geq 1^{\circ}\text{C}$) were observed along entire equatorial Pacific east of 180° . Anomalies $\geq 2^{\circ}\text{C}$ observed over equatorial Pacific (Fig.1a) with warmest anomalies ($\geq 3^{\circ}\text{C}$) observed over smaller region of equatorial and eastern most Pacific. Positive SST anomalies ($\geq 1^{\circ}\text{C}$) were also observed over northeast Pacific Ocean along the west coast off North America. Cool SST anomalies were observed in the subtropical south Pacific and along west equatorial Pacific. The changes in temperature anomalies from October to November show (Fig.1b) -1°C cooling over the equatorial Pacific, northern and southern subtropical Pacific and warming tendency of 0.5°C and 1°C over a smaller region of south of equatorial Pacific Ocean and along west coast off North America.

During November 2015, anomalies 0.5°C were observed most parts of Indian Ocean (Fig.1) with anomalies $\geq 1^{\circ}\text{C}$ observed over small area of Arabian Sea off the Indian coast and in parts over subtropical south Indian Ocean. However, slight negative anomalies were observed over parts of East Indian Ocean close to maritime continent. During the last two months, cooling of SSTs ($\leq -0.5^{\circ}\text{C}$) was observed over many areas of Arabian Sea, Bay of Bengal, equatorial East and subtropical south Indian Ocean (Fig.1b). There is slight warming in the Agulhas region (East coast of southern Africa) and Ningaloo region (west coast of Australia).

1.1. El Nino Southern Oscillation (ENSO) conditions over the Pacific Ocean

The monthly time series of Nino3.4 SST anomalies for the last 12 months (Fig. 2a) suggests strengthening of El Nino conditions from weak in March (0.5°C to 1.5°C) to strong (2.5°C and above) in November. Associated with this, during November 2015, warm subsurface anomalies (Fig. 2b) were observed in the eastern tropical Pacific east of date line and cool subsurface anomalies were observed in the western Pacific overtaking the date line towards east.

1.2. Indian Ocean Dipole (IOD) Conditions over Indian Ocean

The October Dipole Mode index (DMI) suggests weak warm IOD conditions (Fig. 2c). However, warm subsurface (Fig. 2d) anomalies were observed in the Equatorial Indian Ocean up to 85°E and cool subsurface anomalies were seen beyond east of 85°E .

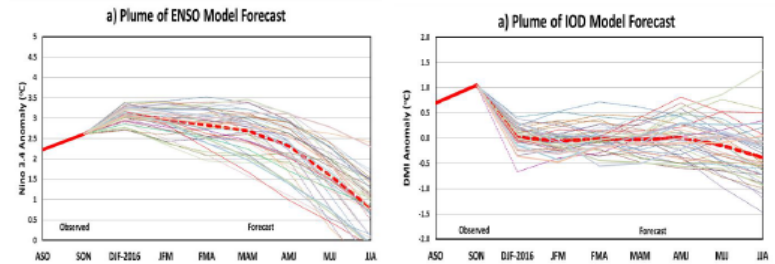


Fig.4: Plume of (a) Nino 3.4 SST anomalies, (b) Indian Ocean Dipole Mode Index forecasted by high resolution CFSv2. The solid red line is the observed SST anomaly and dashed red line is the ensemble SST anomaly forecast mean of 36 members. The individual ensemble member forecasts are shown in light dotted lines of different colours.

Probability Forecast for Nino 3.4 and Dipole Mode Index

Nino 3.4 Probability Forecast								DMI Probability Forecast							
	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA		DJF	JFM	FMA	MAM	AMJ	MJJ	JJA
>2.5	100	88	81	90	49	4		>2.5							
1.5:2.5		11	18	34	40	54	13	1.5:2.5							
0.5:1.5					13	34	56	0.5:1.5	4	2	2	9	9	6	
0.5:-0.5						6	25	0.5:-0.5	97	93	93	93	81	70	47
-0.5:-1.5							4	-0.5:-1.5	2	2	4	4	9	20	43
-1.5:-2.5								-1.5:-2.5							2
<-2.5								<-2.5							

Fig.5: Probability forecast of (a) Nino 3.4 and (b) Indian Ocean Dipole Mode Index from high resolution CFSv2. The SST anomaly bins are indicated in green color boxes of SST.

The forecast suggests that strong El Nino conditions will persist during DJF, JFM and FMA (with 100, 88 & 81% probability respectively). Thereafter, the probability of moderate El-Nino conditions picks up from MAM (34%) up to MJJ (54%). JJA shows the weakening of El-Nino conditions with a probability of 56% for Nino 3.4 anomalies in the range 0.5 to 1.5 $^{\circ}\text{C}$. Thus, forecast indicates strong El-Nino conditions during boreal winter and moderate El-Nino conditions during spring.

The DMI probability forecast suggests neutral dipole mode conditions during the boreal winter and spring.

Prepared by ESSO-IITM and ESSO-IMD with inputs from ESSO-INCOIS and ESSO-NCMRWF



Seasonal Climate Outlook for South Asia



Ministry of Earth Sciences
Earth System Science Organization
India Meteorological Department
WMO Regional Climate Centre
(Demonstration Phase)
Pune, India
Seasonal Climate Outlook for South Asia
(December 2015 to March 2016)

Issued in December 2015

- During November 2015, moderate El Niño conditions prevailed over equatorial Pacific with sea surface temperatures across most of the equatorial Pacific being warmer than normal. The latest coupled model forecast suggests moderate El Niño conditions currently prevailing are likely to become strong during the boreal winter season and remain moderate during spring.
- The 2015 DJF mean precipitation is likely to be normal to wetter than normal over northwest, central and eastern south peninsula in India, parts of Afghanistan and Pakistan, Sri Lanka and Myanmar. The mean precipitation is likely to be drier than normal over Nepal, Bhutan, Bangladesh and north east India. The JFM mean precipitation is likely to be nearly similar to that of DJF season except for wetter than normal precipitation over northeast India.
- The country averaged monthly precipitation likely to be normal to wetter than normal for Bangladesh, India, Myanmar and Sri Lanka. Nepal and Pakistan is likely to have drier than normal monthly precipitation anomaly for all months.
- The 2015 DJF mean temperatures are likely to be warmer than normal over all South Asian Countries. The JFM mean temperatures are likely to be nearly similar as that during DJF showing stronger warm anomalies over central and northwest part of India, Pakistan and Afghanistan and near normal temperatures over rest of the countries.
- The country averaged monthly temperature is likely to be warmer than normal for all South Asian countries for all the months (December, January, February and March).

DISCLAIMER:

- (1) The long range forecasts presented here are currently experimental and are produced using techniques that have not been validated.
- (2) The content is only for general information and its use is not intended to address particular requirements.
- (3) The geographical boundaries shown in this report do not necessarily correspond to the political boundaries.

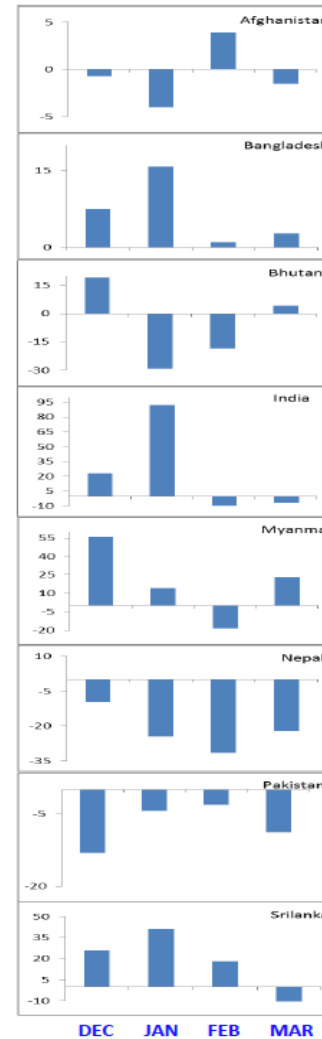


Fig.7: Monthly country averaged rainfall forecast expressed as percentage departures (%) during December 2015 to March, 2016.

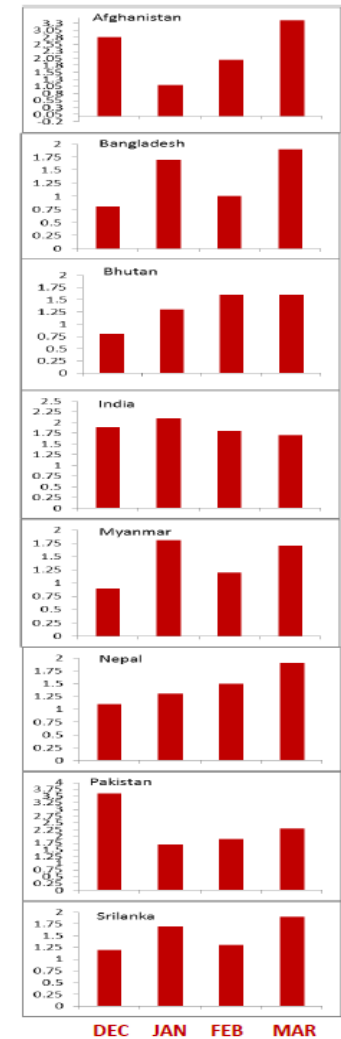
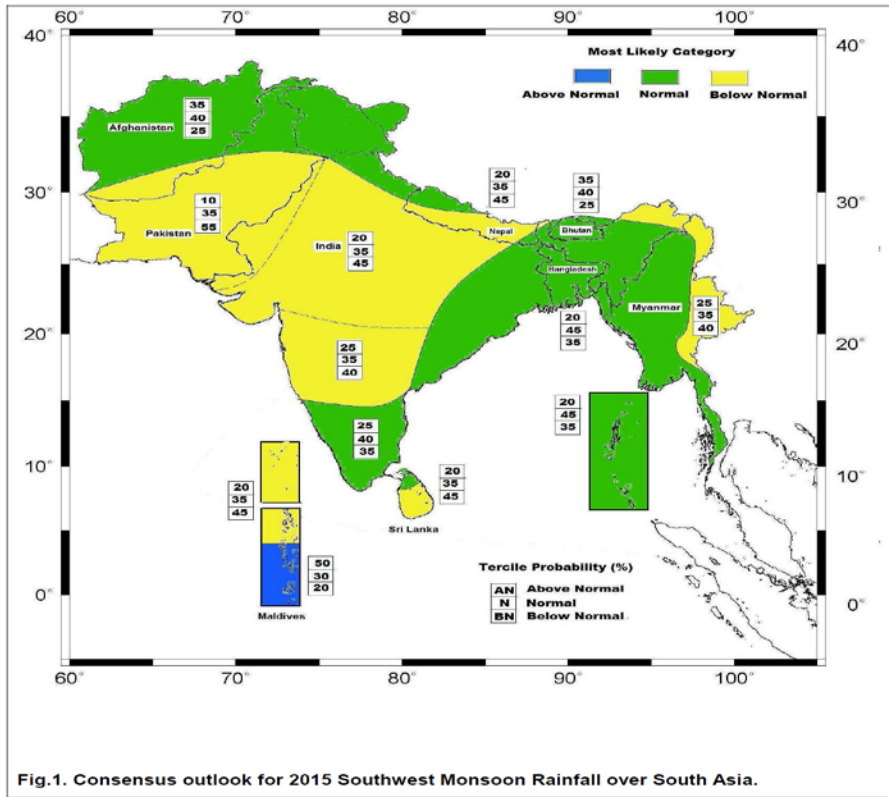


Fig.8: Monthly country averaged temperature anomaly (°C) forecast during December 2015 to March, 2016.

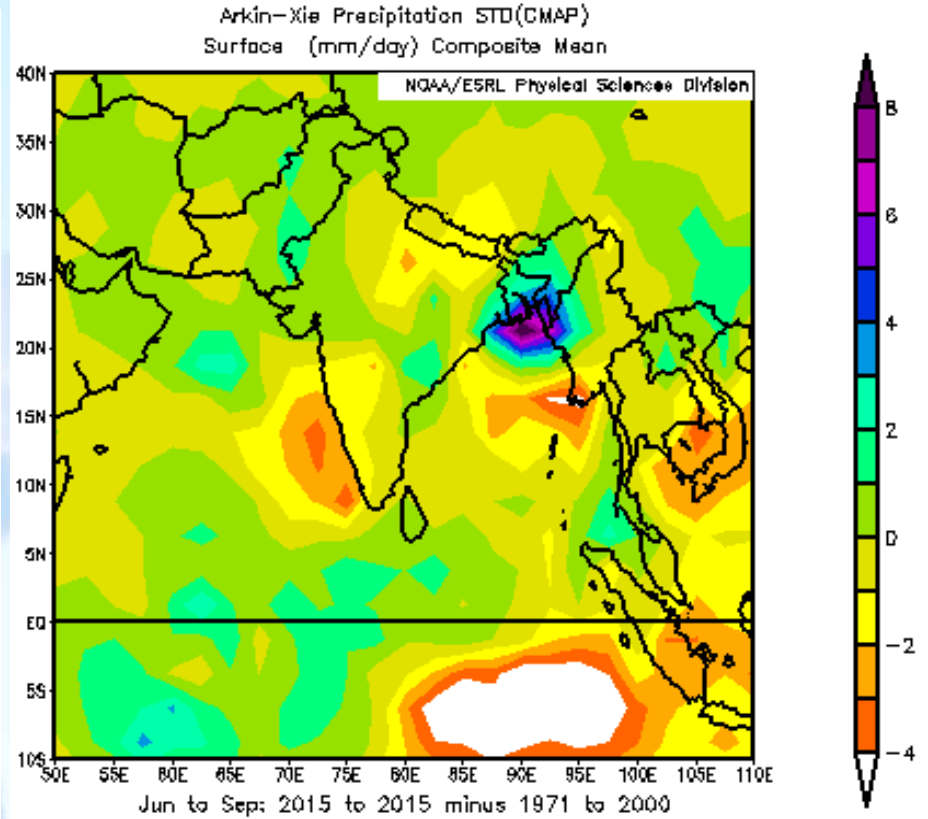


Consensus forecast of SW Monsoon Rainfall over South Asia (issued in April every year)

Consensus Rainfall Forecast: 2015

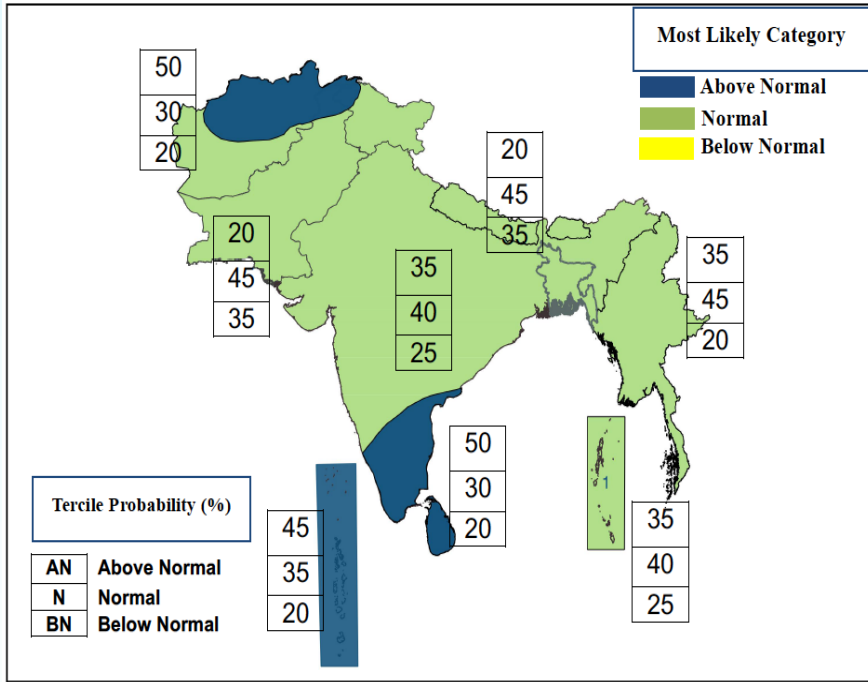


Observed Rainfall

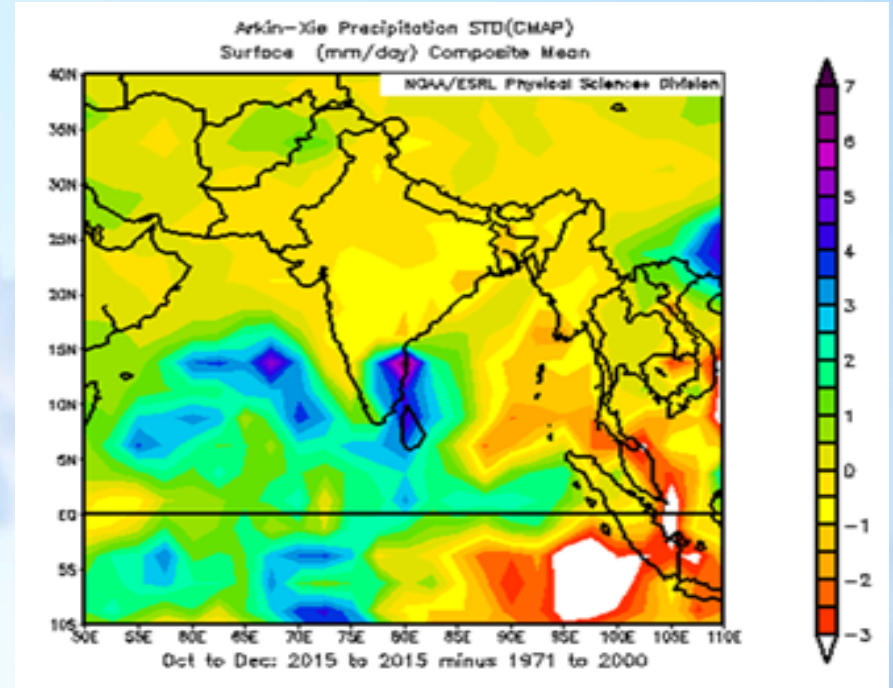


Consensus outlook for 2015 northeast Monsoon Rainfall over South Asia

Consensus Rainfall Forecast

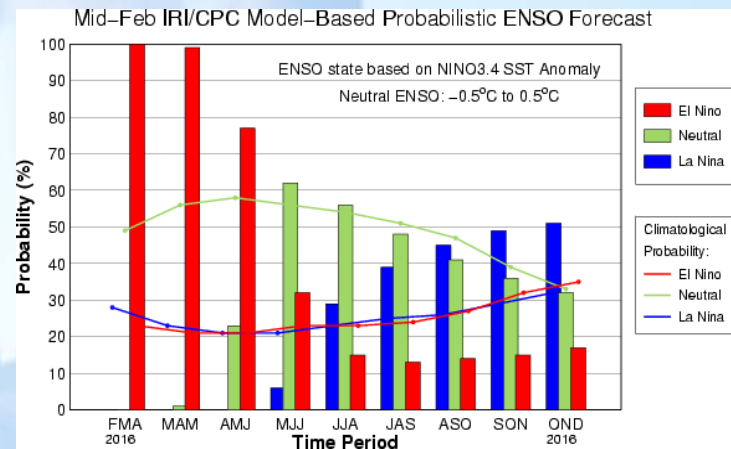
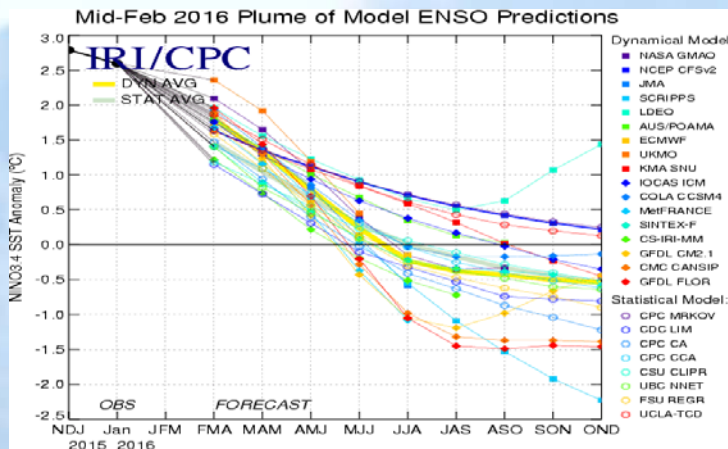
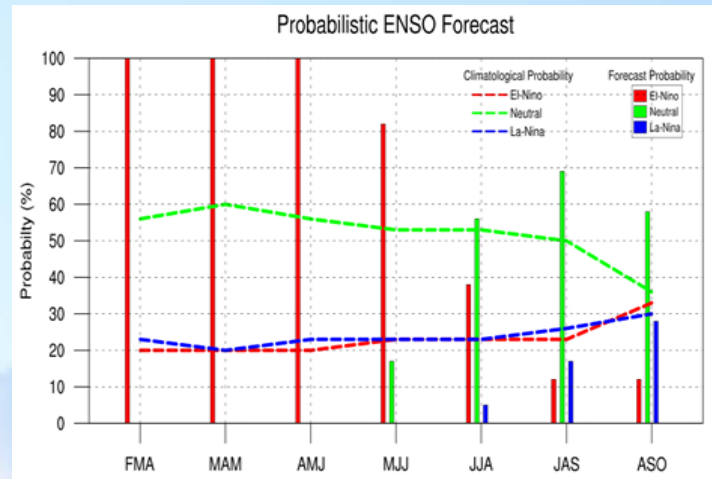
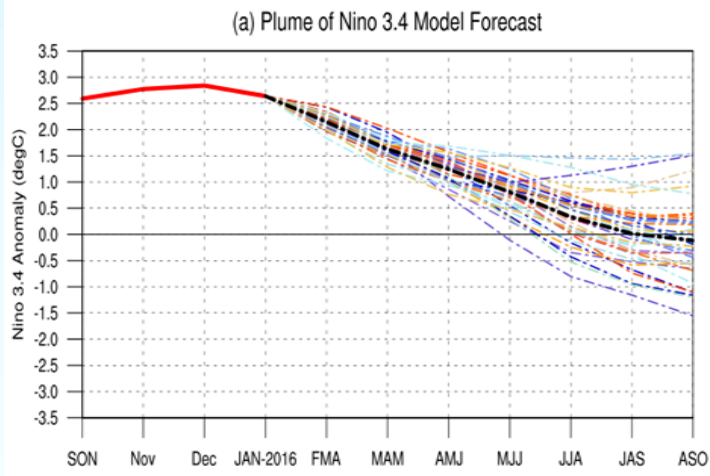


Observed Rainfall



2016 SW Monsoon?

IITM CFS T382



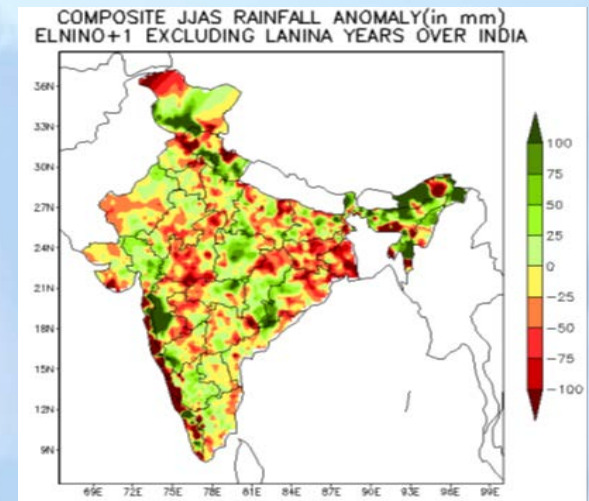
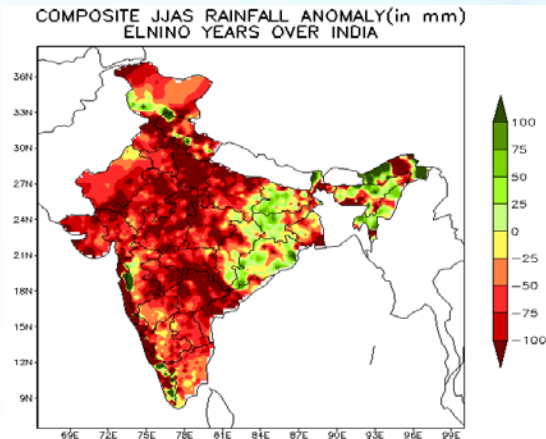
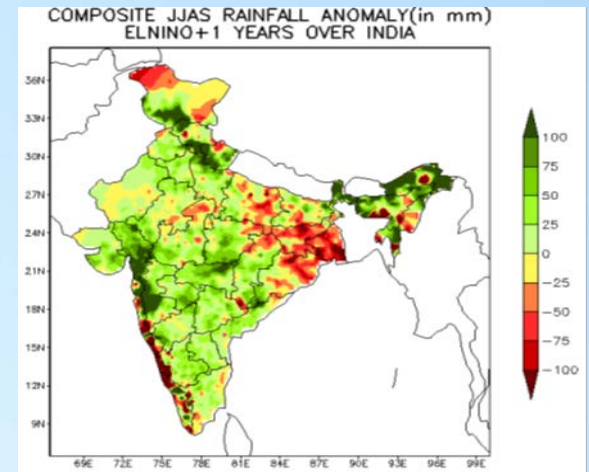
Most ENSO prediction models indicate slowly weakening El Niño conditions over the coming several months, returning to neutral by late spring or early summer 2016, with a chance for La Niña development during fall.



El Nino +1 rainfall statistics (1901-2015)

During 1901-2015, there were 29 El Nino years. 19 (65.5%) years were below normal. 16 (55%) years of them were deficient. All the recent 4 El Nino years (after 1997) were deficient.

EL NINO+1 YEARS	JUN-SEPT RAINFALL	
	RF(%DEP)	BN/N/AN
1903	103	N
1905	83	BN
1906	104	N
1912	96	BN
1915	91	BN
1919	106	AN
1931	103	N
1941	87	BN
1942	114	AN
1952	92	BN
1954	103	N
1958	110	AN
1964	110	AN
1966	87	BN
1969	100	N
1970	112	AN
1973	108	AN
1977	104	N
1978	109	AN
1983	113	AN
1987	81	BN
1988	119	AN
1992	93	BN
1995	98	N
1998	104	N
2003	102	N
2005	99	N
2010	102	N
BELOW NORMAL(<96)	8(28.6%)	
NORMAL(96 TO 104)	11(39.3%)	
ABOVE NORMAL(>104)	9(32.1%) (E4 (14.3%))	



There is 71.4% probability for normal or above normal in the year El Niño +1 year. However, actual performance will depend on the influence of other factors also.



Conclusions

- ❑ In 2015, the operational forecasts for the two contrasting monsoons (deficient southwest monsoon rainfall over the country as a whole and excess northeast monsoon rainfall over the south Peninsula) were accurate. It is first time in the history that IMD predicted deficient southwest monsoon rainfall over the country as a whole and it came correct.
- ❑ The experimental forecasts from Monsoon Mission CFS for the season rainfall over the country as whole based on both February and April initial conditions could correctly indicate realized deficient rainfall. However, it is interesting to note that forecasts issued by NCEP, which used the original version of CFSv2, did not show any signal of possible below normal monsoon over India.
- ❑ The experimental forecasts from most of the other Indian institutes indicated normal to above normal rainfall while those from international climate centers indicated below normal to normal rainfall.
- ❑ The consensus forecasts for the southwest monsoon season (June to September) and NE Monsoon Season (October-December) rainfalls over south Asia issued under SASCOF activities were also correct.
- ❑ From May, 2015 onwards started to issue ENSO outlook based on CFSV2 developed by IITM, Pune under Monsoon Mission. The ENSO bulletin is updated every month.
- ❑ Issued seasonal forecast outlook for the monthly and seasonal rainfall and temperature over south Asia under RCC activities.



Future Plans

- Introduce Temperature Forecast outlook for the country for the 2016 summer Season (April to June).
- Start running operational version of Monsoon Mission (MM) high resolution CFSv2 at IMD, Pune
- Start issuing subdivision wise forecast outlook for India based MM CFSv2





Thank You All



3/4/2016

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

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