

## An insight into the severe floods in India during 2005, 2006 & 2007

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**सार** – इस शोध पत्र में वर्ष 2005, 2006 और 2007 की दक्षिण पश्चिम मानसून (जून से सितम्बर) ऋतुओं के दौरान आई भयंकर बाढ़ का संबंध सिनाप्टिक प्रणालियों से गहरे रूप से जुड़े होने का पता लगाया गया है। वर्ष 2005, 2006 और 2007 में कुल मिलाकर 22 राज्य भयंकर बाढ़ से प्रभावित हुए। दक्षिण प्रायद्वीप में केवल केरल और कर्नाटक ही भयंकर बाढ़ से प्रभावित हुए। वर्ष 2006 और 2007 के दौरान आयी भयंकर बाढ़ काफी लम्बे समय तक रही और इससे अनेक राज्य प्रभावित हुए। जबकि 2005 के दौरान आयी भयंकर बाढ़ थोड़े समय तक रही परंतु इससे भी दक्षिण प्रायद्वीप को छोड़कर अधिकांश राज्य प्रभावित हुए।

वर्ष 2006 में बंगाल की खाड़ी में लगातार उत्पन्न हुए सामान्य से अधिक, कम दाब और अवदाब के क्षेत्रों के उत्पन्न होने और पश्चिम उत्तरपश्चिम दिशा में सामान्य गति से मध्य प्रदेश और पूर्वी राजस्थान तक बढ़ने के कारण गुजरात, महाराष्ट्र, राजस्थान, मध्य प्रदेश, छत्तीसगढ़, उड़ीसा और आन्ध्र प्रदेश में भयंकर बाढ़ का कहर 28 जुलाई से 12 सितम्बर 2006 तक जारी रहा। वर्ष 2007 में मानसून द्रोणी के स्थानांतरित होने, गौण मानसून द्रोणी की उपस्थिति तथा पश्चिमी पवनों में द्रोणी के कारण अधिकतर उत्तरी पूर्वी राज्यों में भयंकर बाढ़ का कहर 12 जुलाई से 10 अक्टूबर 2007 तक जारी रहा।

**ABSTRACT.** In this paper severe flood during South West monsoon seasons of 2005, 2006 & 2007 have been identified with the related synoptic features. A total of 22 states reeled under severe floods during 2005, 2006 & 2007. In the south peninsula only Karnataka and Kerala were affected by severe floods. During 2006 & 2007 severe floods continued for a longer period and affected many states where as during 2005 severe floods affected most of the states except peninsular India but they continued for short periods comparatively.

Formation of excess No's of low pressure areas and depressions in the Bay of Bengal during July, Aug and Sept 2006, in succession, and their WNW movements upto M.P. and east Rajasthan caused severe floods in Gujarat, Maharashtra, Rajasthan, Madhya Pradesh, Chattisgarh, Orissa and Andhra Pradesh for a longer period i.e. from 28 July to 12 September 2006. During 2007, Shifting of monsoon trough, presence of secondary monsoon trough and trough in westerly, caused severe floods in most of the North eastern states from 12 July to 10 October 2007.

**Key words** – Secondary Monsoon trough, Eastward moving systems, Trough in westerly, EZMC (Equatorial zones of maximum cloudiness), WML (well marked low).

### 1. Introduction

India is the most flood affected nation in the world after Bangladesh. It accounts for 20 % global deaths due to floods. On the average 30 million people are evacuated every year. 22 states in India and 1 U.T. (Andaman Nicobar) are most vulnerable to floods. However, the most vulnerable states in India are Uttar Pradesh, Bihar, Assam, West Bengal, Gujarat, Andhra Pradesh, Orissa,

Madhya Pradesh, Maharashtra, Punjab and J & K. The heavy rainfall in Himalayas during south west monsoon is the main cause of severe floods in the rivers of Uttar Pradesh, Bihar, Assam and West Bengal, while central and southern rivers get flooded due to heavy rain by Bay depressions. During the period 1980- 2004 no Monsoon season has witnessed nationwide severe flood in India. There may be flash floods, river floods and coastal floods due to sudden heavy rainfall, continuous rise of water

TABLE 1

## States affected by severe floods and associated synoptic features

S. No.	State affected	Period	Synoptic features
1.	Jammu & Kashmir	5 - 26 Jul 2005 24 Jul - 22 Aug 2006  12 - 17 Aug 2007	(i) 8 No's of eastward moving systems in the westerlies to the North. (ii) 6 No's of upper air cycirs in the westerlies to the north east. (iii) Trough in the westerlies. (iv) Western end of monsoon trough to the North of its normal position. (v) A Low pressure area over the region. (vi) Monsoon trough close to foothills.
2.	Punjab	31 Aug - 11 Sep 2006  12 - 17 Aug 2007	(i) A Low pressure area over the region. (ii) Trough in mid and upper tropospheric westerlies. (iii) Western end of monsoon trough to the north of its normal position. (iv) Monsoon trough close to foothills.
3.	Himachal Pradesh	5 - 26 Jul 2005 12 - 17 Aug 2007	(i) 8 No's of eastward moving systems in the westerlies to the North. (ii) Monsoon trough close to foothills.
4.	Haryana	12 - 17 Aug 2007	(i) Monsoon trough close to foothills.
5.	Uttarakhand	7 - 27 Jul 2005 12 - 17 Aug 2007	(i) 8 No's of eastward moving systems in westerlies to the North. (ii) Monsoon trough close to foothills.
6.	Uttar Pradesh	7 - 27 Jul 2005 16 - 30 Sep 2005 24 Jun - 3 Aug 2006 29 Aug - 4 Sep 2006 3 Jul - 22 Sep 2007	(i) 8 No's of eastward moving systems in westerlies to the North. (ii) A depression of 12-16 Sept (North west Bay to this area) (iii) Westerly systems became active during Hiatuses in NLM of 1-8 July & 12-19 July. (iv) Western end of monsoon trough to the north of its normal position. (v) A deep depression of 4-9 July (Bangladesh coast to East Rajasthan). (vi) WML of 13-18 July (North west Bay to the East U.P.)
7.	Bihar	7 - 27 Jul 2005 23 - 25 Sep 2006 3 Jul - 22 Sep 2007	(i) Shifting of monsoon trough towards N.E. India. (ii) A land depression of 21-24 Sept (Jharkhand to Bihar) (iii) A deep depression of 4-9 July (Bangladesh coast to East Rajasthan). (iv) A WML of 13-18 July (Northwest Bay to East Uttar Pradesh). (v) A WML of 10-14 August (North West Bay to Bihar). (vi) A WML of 18-21 August (North Bay to North East Madhya Pradesh)
8.	Gujarat	28 Jun - 15 Jul 2005  4 - 7 Jul 2006 28 Jul - 12 Sep 2006  1 - 13 Jul 2007 8 - 15 Aug 2007	(i) A land depression of 27 June-5 July (Gangetic West Bengal to West Rajasthan). (ii) MTC over 3.1 and 5.8 km a.s.l over Gujarat state and neighbourhood. (iii) Offshore trough from south Gujarat to Kerala coast. (iv) An upper air cycir over Saurashtra and Kutch (28 June-1 July). (v) A WML of 27 July-1 Aug (North Bay to the West Rajasthan). (vi) Formation of 5 monsoon depressions in succession over North Bay and NW Bay and their WNW movements (NW Bay to vidarbha, North Bay to Chattisgarh, North Bay to North west M.P., NW Bay to East Rajasthan and NW Bay to North Chattisgarh) during the periods 2-5 August, 12-13 August, 16-18 August 29 August - 1 September and 3 - 4 September respectively. (vii) A deep Depression of 28-30 June (North west Bay to East Rajasthan). (viii) A deep Depression of 4-9 July (Bangladesh coast to North west M.P.) (ix) A deep Depression of 5-7 August (North west Bay to Central part of M.P.)
9.	Maharashtra	26 Jul - 2 Aug 2005  28 Jul - 12 Sep 2006  1 - 6 Jul 2007	(i) A WML of 23-28 July (North Bay to West M.P.). (ii) Well marked east-west shear line in the lower troposphere and interaction of enhanced monsoon westerly current. (iii) Formation of 5 monsoon depressions, in succession over North Bay and NW Bay and their WNW movements (NW Bay to vidarbha, North Bay to Chattisgarh, North Bay to North west M.P., NW Bay to East Rajasthan and NW Bay to North Chattisgarh) during the periods 2-5 August, 12-13 August, 16-18 August, 29 August - 1 September and 3 - 4 September respectively. (iv) A deep Depression of 28-30 June (North west Bay to East Rajasthan). (v) A deep depression of 4-9 July (Bangladesh coast to East Rajasthan)
10.	Rajasthan	28 Jul - 12 Sep 2006	(i) A WML of 27 July - 1 August (North Bay to the West Rajasthan).

TABLE 1 (Contd.)

S. No.	State affected	Period	Synoptic features
	Rajasthan	28 Jul - 12 Sep 2006	(ii) Formation of 5 monsoon depressions, in succession over North Bay and NW Bay and their WNW movements (NW Bay to Vidarbha, North Bay to Chattisgarh, North Bay to North west M.P., NW Bay to East Rajasthan and NW Bay to North Chattisgarh) during the periods 2-5 Aug, 12-13 Aug, 16 - 18 Aug, 29 Aug - 1 September and 3-4 September respectively. (iii) An upper air cycir up to 3.1 km a.s.l. of 24-29 July (East U. P. to central part of Rajasthan). (iv) A low pressure area of 20-23 July (Gangetic West Bengal to East Rajasthan)
		1 - 13 Jul 2007	(i) A deep Depression of 28-30 June (North west Bay to East Rajasthan). (ii) A deep depression of 4 - 9 July (Bangladesh coast to NW M. P. and East Rajasthan)
11.	Madhya Pradesh	2 - 15 Jul 2005	(i) A land depression of 27 June to 5 July (Gangetic West Bengal to NW M.P.). (ii) Low pressure area of 30 June - 1 July (stationary over M.P.).
		28 Jul - 12 Sep 2006	(i) A WML of 27 July - 1 August (North Bay to West Rajasthan). (ii) An upper air cycir over West M.P. on 29 July. (iii) Formation of 5 monsoon depressions, in succession over North Bay and NW Bay and their WNW movements (NW Bay to Vidarbha, North Bay to Chattisgarh, North Bay to North west M.P., NW Bay to East Rajasthan and NW Bay to North Chattisgarh) during the periods 2-5 August, 12 - 13 August, 16 - 18 August, 29 August - 1 September and 3 - 4 September respectively.
		1 - 13 Jul 2007	(i) A deep depression of 28 - 30 June (North west Bay to East Rajasthan). (ii) A deep depression of 4 - 9 July (Bangladesh coast to NW M. P. and East Rajasthan).
12.	Chattisgarh	14 - 26 Sep 2005	(i) A depression of 12 - 16 September (North west Bay to west U.P.),
		28 Jul - 12 Sep 2006	(i) A WML of 27 July-1 Aug (North Bay to west Rajasthan). (ii) Formation of 5 monsoon depressions, in succession over North Bay and NW Bay and their WNW movements (NW Bay to Vidarbha, North Bay to Chattisgarh, North Bay to North west M.P., NW Bay to East Rajasthan and NW Bay to North Chattisgarh) during the periods 2 - 5 August, 12 - 13 August, 16 - 18 August, 29 August - 1 September and 3 - 4 September respectively. (iii) A low pressure area of 20-23 July (Gangetic west Bengal to East Rajasthan).
		30 Jun - 13 Jul 2007	(i) A depression of 28-30 June (North west Bay to East Rajasthan). (ii) A deep depression of 4-9 July (Bangladesh coast to North West M.P. and adj East Rajasthan)
13.	West Bengal	7 - 27 Jul 2005	(i) Shifting of eastern end of Monsoon trough towards N.E. India.
		18 Sep - 5 Oct 2006	(i) A land depression of 21-24 September (Jharkhand to Bihar and neighbourhood).
		3 Jul - 22 Sep 2007	(i) A deep depression of 4-9 July (Bangladesh coast to NW M.P. and East Rajasthan). (ii) A WML of 13-18 July (North West Bay to East U.P.). (iii) A WML of 10-14 August (North west Bay to Bihar). (iv) A WML of 18-21 August (North Bay to Bihar and North East M.P.)
		22 Sep - 8 Oct 2007	(i) A depression of 21-24 September (North Bay to North Chattisgarh)
14.	Orissa	30 Jul - 3 Aug 2005	(i) A deep depression of 29-31 July (NW Bay to central part of M.P.), (ii) WML of 3-4 August (North west Bay to Northern part of Chattisgarh).
		3 - 8 Jul 2006	(i) A deep depression of 2-5 July (North Bay to West M.P.).
		1 Aug - 10 Sep 2006	(i) A WML of 27 July -1 Aug (North Bay to West Rajasthan). (ii) Formation of 5 monsoon depressions, in succession over North Bay and NW Bay and their WNW movements (NW Bay to Vidarbha, North Bay to Chattisgarh, North Bay to North west M.P., NW Bay to East Rajasthan and NW Bay to North Chattisgarh) during the periods 2-5 August, 12-13 August, 16-18 August, 29 August - 1 September and 3-4 September respectively. (iii) A WML of 21-24 August (North Bay to Jharkhand and adj Chattisgarh).
		30 Jun - 13 Jul 2007	(i) A deep depression of 20-30 June (NW Bay to East Rajasthan), (ii) Deep depression of 4-9 July (Bangladesh coast to NW M.P. and East Rajasthan )
		3 - 27 Aug 2007	(i) A deep depression of 5-7 August (NW Bay to central part of M.P.), (ii) A WML of 10-14 August (NW Bay to Bihar and neighbourhood), (iii) A WML of 18-21 August (North Bay to North East M.P.)
		22 Sep - 8 Oct 2007	(i) A depression of 21-24 September (West Central Bay to North Chattisgarh).
15.	Andhra Pradesh	10 & 11 Jul 2005	(i) L.P. area of 7-9 July (NW Bay to Orissa and neighbourhood).
		14 - 26 Sep 2005	(i) A depression of 12 -16 September (NW Bay to West U.P.).
		1 Aug - 10 Sep 2006	(i) A WML of 27 July -1 August (North Bay to West Rajasthan).

TABLE 1 (Contd.)

S. No.	State affected	Period	Synoptic features
	Andhra Pradesh	1 Aug - 10 Sep 2006	(ii) Formation of 5 monsoon depressions, in succession over North Bay and NW Bay and their WNW movements (NW Bay to Vidarbha, North Bay to Chattisgarh, North Bay to North west M.P., NW Bay to East Rajasthan and NW Bay to North Chattisgarh) during the periods 2-5 August, 12-13 August, 16-18 August, 29 August - 1 September and 3-4 September respectively. (iii) A WML of 21-24 August (North Bay to Jharkhand and adj Chattisgarh).
		18 Sep - 5 Oct 2006	(i) L.P. area of 15-18 September (West central Bay to coastal A. P).
		22 Jun - 4 Jul 2007	(i) Cycir up to mid tropospheric level over Telangana. (ii) A deep depression of 21-23 June (west central Bay to Peninsular India).
		16 Sep - 7 Oct 2007	(i) A depression of 21 -24 September (West central Bay and adj. North west Bay to North Chattisgarh)
16.	Karnataka	22 Jun - 4 July 2007	(i) A deep depression of 21-23 June ( west central Bay to Peninsular India)
17.	Kerala	16 - 20 Jul 2007	(i) A deep depression of 21-23 June (west central Bay to Peninsular India). (ii) Activation of off shore trough along west coast by well marked low of 13-18 July over NW Bay.
18.	Assam	7 - 27 Jul 2005 1 - 21 Jun 2006 12 Jul - 10 Oct 2007	(i) Occasional shifting of eastern end of monsoon trough towards NE India. (i) Upper level divergence provided by a deep westerly trough. (i) Occasional shifting of monsoon trough towards foothills. (ii) Also, presence of secondary monsoon trough. (iii) A low level trough in westerly.
19.	Tripura	1 - 21 Jun 2006 12 Jul - 10 Oct 2007	(i) Upper level divergence provided by a deep westerly trough. (i) Occasional shifting of monsoon trough towards foothills. (ii) Also, presence of secondary monsoon trough. (iii) A low level trough in westerly.
20.	Arunachal Pradesh	7 - 27 Jul 2005 12 Jul - 10 Oct 2007	(i) Occasional shifting of eastern end of monsoon trough towards NE India. (i) Occasional shifting of monsoon trough towards foothills. (ii) Also, presence of secondary monsoon trough. (iii) A low level trough in westerly.
21.	Meghalaya	Do	Do
22.	Manipur	Do	Do

level in the rivers due to rain and heavy rainfall and due to cyclone activities respectively. According to Singh (1992) Severe floods affected the Punjab, J & K, Haryana and Himachal Pradesh during the monsoon in 1988 due to interaction of mid latitude westerly trough with monsoon pulses in the form of equatorial zones of maximum cloudiness (EZMC) located south of 20° N. Floods have occurred in Jammu & Kashmir and neighbouring states due to depressions recurring over Rajasthan towards North or Northeast and reaching the state [Ananthakrishnan and Bhatia (1960)]. Deep penetration of moisture over this area occurs even in the absence of depressions due to presence of lows in the lower tropospheric levels associated with the trough in upper level westerlies with an embedded jet stream [Ghosh and Veeraraghavan (1975)]. The severe Floods that occurred in quick succession in Jammu & Kashmir state and neighbourhoods in the first two weeks of August 1976 were the result of the formation of two independent

circulations over J & K state. Satellite pictures suggested that the first these two vortices had in fact intensified into monsoon depression over J & K on 1<sup>st</sup> August and other system close to a cyclonic storm over Punjab, J & K and adjoining hills of Uttar Pradesh and Himachal Pradesh on 6 August 1976 [Singh 1987(a)]. In this paper nationwide occurrence of severe floods during the monsoon seasons of 2005, 2006 & 2007 have been analysed with respect to synoptic features responsible for disastrous situations over the affected states of India.

## 2. Data source

For this paper data have been taken from quarterly journals of Meteorology, Hydrology and Geophysics, July 2006 Volume 57, No. 3, 562-564, July 2007 Volume 58 No. 3, 455-457 and July 2008 Volume 59, No. 3, 428-429. The various synoptic features due to them, the severe

floods occurred in the states have been tabulated in order to streamline the causes of occurrence of floods.

### 3. Results and discussion

During the southwest monsoon seasons 2005, 2006 & 2007 most of the states were affected by severe floods. Synoptic features responsible for occurrence of heavy to very heavy and exceptionally heavy rainfall resulting into severe floods over different states have been shown in Table 1.

Northward positioning of monsoon trough in part or full is very significant to cause floods over northwest India, eastern India and Northeast India. The states which received excessive rains and had severe floods due to corresponding positions of monsoon trough are : J&K, Punjab, Himachal Pradesh, Haryana and Uttarakhand (Aug 2007) - monsoon trough close to foothills ; North eastern states (Jul-Sept 2007) – occasional shifting of monsoon trough towards foot hills along with secondary monsoon trough ; J&K, Punjab and Uttar Pradesh (July – Aug 2006) – Western end of monsoon trough to the north of its normal position; Bihar, West Bengal, Arunachal Pradesh and Assam (Jul 2005) – shifting of eastern end of monsoon trough towards northeast India.

Eastward moving systems in the westerlies to the north (July 2005) caused excessive rains over J&K, Himachal Pradesh, Uttarakhand and Uttar Pradesh. Because most of the upper air cyclonic circulations formed up to mid tropospheric levels and located initially and finally over J&K and neighbourhood.

Intense weather systems which led to severe floods mostly formed over North Bay and north west Bay. However a few systems formed over west central Bay and Bangladesh coast. Common weather systems which caused wide spread heavy to very heavy rainfall and then floods over different states for the same period are: A land depression (27 June - 5 July 2005 ) from Gangetic west Bengal to north west M.P – Gujarat and M.P for the period (2 July - 15 July 2005); A deep depression (28-30 June 2007) from the north west Bay to east Rajasthan and another one (4-9 Jul 2007) from Bangladesh coast to east Rajasthan – Gujarat, Maharashtra, Rajasthan, M.P, Chattisgarh and Orissa for the period (1-13 July 2007) ; A well marked low (27 July - 1 August 2006 ) from north Bay to West Rajasthan and 5 numbers of depressions in succession during the period (2 August - 4 September 2006) from North West Bay to East Rajasthan – Gujarat, Maharashtra, Rajasthan, M.P., Chattisgarh, Orissa and Andhra Pradesh for a longer period (28 July -12 September 2006) ; Upper level divergence provided by a

deep westerly trough – Assam and Tripura for the period (1-21 June 2006).

Whenever depressions /well marked low pressure areas formed over north Bay and North West Bay, move in west northwesterly/North Westerly direction and advance up to east Rajasthan, they often cause wide spread floods in Uttar Pradesh and Bihar in addition to other states as shown in Table 1 in the year 2007. West Bengal, Orissa and Andhra Pradesh are frequently affected by severe floods mainly because of intense systems formed over North Bay and North West Bay. But on some occasions West Bengal gets severe floods due to land depression and Andhra Pradesh due to deep depression from west central Bay.

Karnataka and Kerala are less frequently affected by severe floods. Notwithstanding they also had severe floods during 2007 when a deep depression formed over West Central Bay advanced up to Peninsular India causing floods over Karnataka, and a well marked low pressure area formed over North West Bay activated off shore trough along the west coast with the result Kerala had severe floods.

### 4. Conclusion

Following broad conclusions can be drawn during the year 2005 -2007.

(i) Long lasting (28 July -12 September) wide spread floods in central and west India in addition to Orissa and Andhra Pradesh during 2006 occurred mainly due to development of 5 numbers of monsoon depressions one after another over Bay of Bengal and their long track from Bay of Bengal up to Rajasthan and neighbourhood. Occasional shifting of monsoon trough close to foot hills of Himalayas and presence of secondary monsoon trough also caused long lasting (12 July - 10 October) severe floods in the states of North east India in the year 2007.

(ii) Western end of monsoon trough to the north of its normal position led to severe floods in J&K, Punjab and Uttar Pradesh for a short period in the year 2006. Similarly shifting of eastern end of monsoon trough towards north east India led to severe floods in Bihar, West Bengal, Assam and Arunachal Pradesh for a short period in the year 2005.

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