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Impact Assessment of IOD/ENSO in the Asian Region

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Synopsis

Variability of climatic conditions in the tropical Indian and Pacific Oceans are dominated by the Indian Ocean Dipole (IOD) and the El Nino Southern Oscillation (ENSO). The identification of IOD/ENSO events has raised new possibility to make real advance in the predictability of climate variations in those ocean basins. Both have been recognized as an important event of the tropical ocean-atmosphere-continent coupled system of the tropics which brings various climatic impacts across the globe. The objective of this study is to assess the IOD/ENSO impact in the Asian region. The analysis shows that during IOD/ENSO years people killed and affected and the damage of property is very high. Even independent effects of IOD and ENSO have been established in the Asian region though both events occurred in the same year in few occasions. Hence both have strong impacts on the climate of the Asian region. The impacts of natural disasters in recent past are in an increasing and particularly in the South Asian region. During IOD/ENSO years the impact is manifold.

Keywords: Climate variability, El Nino Southern Oscillation, Indian Ocean Dipole, Predictability

1. Introduction

The climate pattern of Indian Ocean rim countries has been influenced by the Indian Ocean Dipole (IOD) and El Nino Southern Oscillation (ENSO) along with Asian Monsoon and other local patterns. Both IOD and ENSO have wide range of environmental and socioeconomic impacts on the global to local climate. Recent studies has found that IOD events have strong influence of the climate of East Asia (Saji and Yamagata, 2003), East Africa and Indonesia (Saji et al., 1999, Behera and Yamagata, 2003), Indian summer monsoon (Shukla and Paolino, 1983; Ashok et al., 2001, 2007), Australia, Brazil and the Mediterranean region (Saji and Yamagata, 2003; Yamagata et al., 2004), the recent southeast Australian “Black Saturday” bushfire in the state of Victoria in February 2009 also caused by the positive IOD (Cai et al. 2009).

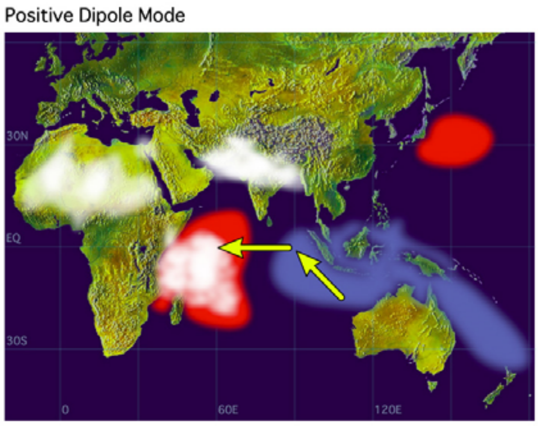
Historically ENSO has a strong relationship with Indian Monsoon (Bjerknes, 1969; Wright, 1979, Deser and Wallace, 1987; Neelin et al., 1998; Torrence and Webster, 1999). However, in the last couple of decades the frequent IOD occurrence has weakened the ENSO and Monsoon relationship (Kumar et al., 1999; Saji et al., 1999; Webster et al., 1999; Behera et al., 1999, Behera and Yamagata, 2003). IOD is normally characterized by anomalous cooling of Sea Surface Temperature (SST) in the south eastern equatorial Indian Ocean and anomalous warming of SST in the western equatorial Indian Ocean. ENSO is composed of an oceanic component, El Nino (La Nina) which is characterized by warming or cooling of surface waters in the tropical eastern Pacific Ocean, and an atmospheric component, the Southern Oscillation, which is characterized by changes in surface pressure in the tropical western Pacific.

The two components are coupled: when the warm oceanic phase (El Nino) is in effect, surface pressures in the western Pacific are high, and when the cold phase is in effect (La Nina) surface pressures in the western Pacific are low (Bjerknes, 1969; Deser and Wallace, 1987). Both IOD and ENSO have been recognized as an important event of the tropical ocean-atmosphere-continent coupled system of the tropics. While the ENSO got worldwide attention because of its societal impacts, IOD didn't pay much attention because of the variability of climate and seasonal winds influence.

There are two modes of IOD events like EL Nina and La Nina of ENSO. A positive IOD period is characterized by cooler than normal water in the tropical eastern Indian Ocean and warmer than normal water in the tropical western Indian Ocean. A positive IOD event causes drought in Indonesia, more rainfall in India, Bangladesh and Vietnam and dry and hot summer in Japan, Korea, and Eastern part of China.

A negative IOD year is characterized by warmer than normal water in the tropical eastern Indian Ocean, near Indonesia, and cooler than normal water in the tropical western Indian Ocean, near Africa. A negative IOD sea surface temperature pattern often results in an increase of rainfall over parts of Australia and Indonesia whereas droughts in East of Africa and Indian Subcontinent. An IOD event usually starts around May or June, peaks between August and October and then rapidly decays (Saji et al., 1999; Webster et al., 1999; Behera et al., 1999). Many IOD events in the recent past occurred independently of the El Nino/La Nina. Even independent effects of IOD and ENSO have been established in the Asian region though both events occurred in the same year in few occasions. Hence both have strong impacts on the climate of the Asian region.

(a)



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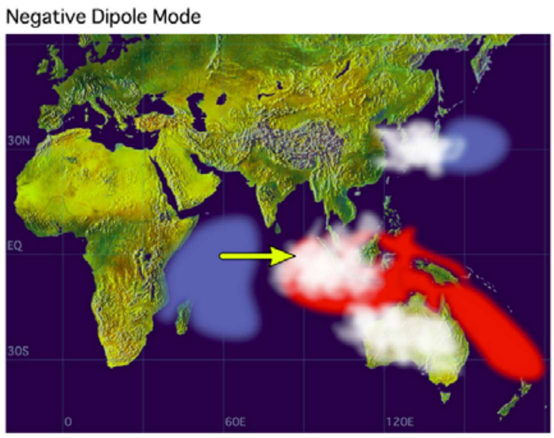


Figure 1 SST anomalies (red: warm anomalies, blue: cold), increased convective activities (white) and anomalous wind directions (arrows) during IOD events (sources: http://www.jamstec.go.jp/frcgc/research/d1/iod/).

In this paper we try to put an assessment of IOD /ENSO impacts and how the IOD has been recognized. The IOD is commonly measured by an index that is the difference between sea surface temperature (SST) in the western (50°E to 70°E and 10°S to 10°N) and eastern (90°E to 110°E and 10°S to 0°S) equatorial Indian Ocean. The index is called the Dipole Mode Index (DMI). If the SST difference between Western and Eastern Indian Ocean is positive it is known as positive IOD.

When the SST difference between the Western and Eastern Indian Ocean is negative it is known as negative IOD.

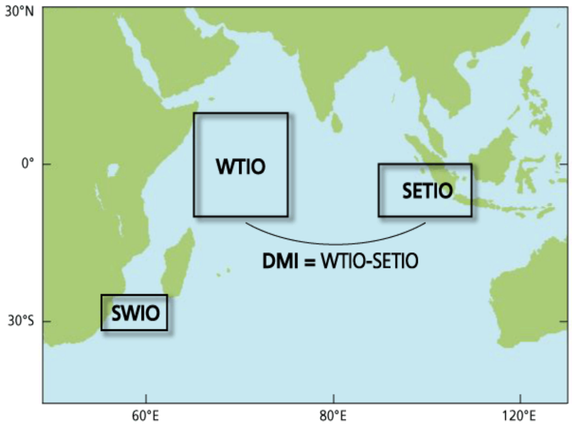


Figure 2. The Dipole Mode Index (DMI) of the Indian Ocean, sources: (www.jamstec.go.jp)

2. Data and Methods

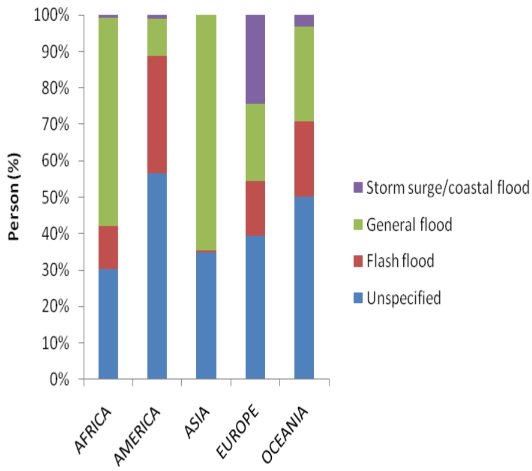
In this paper the IOD/ENSO impacts will be addressed from different view point like number of people killed, total affected and economic loss. For this we have collected 80-100 years of historical records of different types of disasters (general flood, flash flood, cyclone/storm surges and unspecified flood) in various Asian countries from Asian Disaster Reduction Center (ADRC), Center for the Research on the Epidemiology of Disasters (CRED) and other sources as well. The data has been collected from 1975-2008. Some statistical and Correlation methods are used to analyze the data. With the use of Statistical analysis tools different diagrams and figures are made with relation to normal years and IOD/ENSO years. The result of this analysis shows that impact was severe during IOD/ENSO year than to normal years. Different impact assessments are also done independently for IOD and ENSO and clearly show distinct results with impact variability.

3. Results and Discussions

The impacts of natural disasters in recent past are in an increasing trend in the Asian region and particularly in the South Asian region. Whether climate variabilities modes played any role for the increasing disasters is still not very clear, however its also the fact that from the last few decades the extreme IOD and ENSO events had occurred. Due to predominantly developing in nature, highly vulnerable, poor quality of life, one of the densest populated region with increasing growth rate, and lack of advanced technological applications the Asian region is not adequately able to mitigate the natural disasters. The increase frequency of flood, drought and cyclones of various magnitudes affects this region adversely.

If we take a look to the figure 3 (a) which shows that out of total people killed during 1975-2008 maximum percentage are from Asia and followed by Africa. Only in case of unspecified flood case America is the highest and followed by Oceania. Flash flood is highest in America, followed by Oceania, Europe, Africa and Asia. Population killed by storm surges/coastal flood is highest in Europe and followed by Oceania, Africa, America and Asia. However, the total number of people in absolute value (figure 3 (b)), is the highest for the Asia and followed by America, Africa, Europe and Australia.

(a)



(b)

Serial no.	Years of p IOD	Years of n IOD	Years of El Niño	Years of La Niña
1	1961	1958	1963	1964
2	1963	1960	1965	1967
3	1967	1964	1969	1970
4	1972	1970	1972	1971
5	1977	1989	1976	1973
6	1982	1992	1982	1975
7	1994	1996	1986	1988
8	1997	-	1991	-
9	-	-	1997	-
10		2005		
11	2006		2006	2005
12	2007			2007
13	2008			

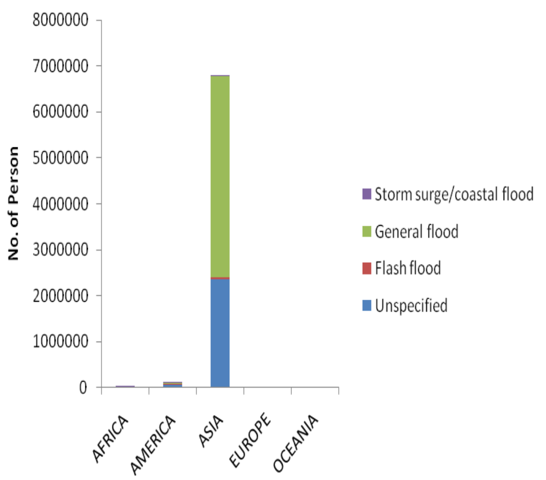


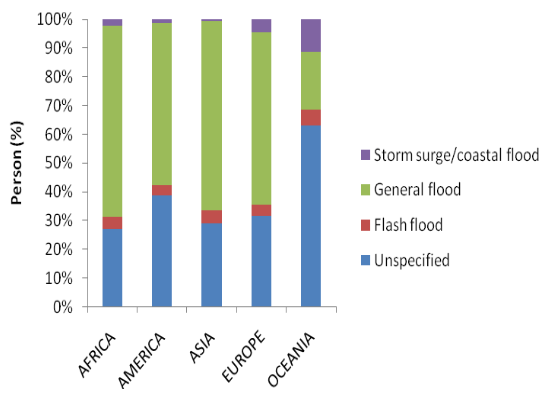
Figure 3 percentage (a) and number (b) of people killed in different continent during the IOD/ENSO years from 1975-2008.

From the table 1 we can see during 1970s and 1980s the occurrence of ENSO events are predominant, however during 1990s onwards the IOD cases are occurred more often. What causes this climate variability mode shifts is still unknown. However, Nobuko et al (2009) in there findings has claimed that the warming of the Western Indian Ocean has played the major role in this mode shift with there study of 115 year coral record from Kenya found that this sfift is because of global warming-induced Indian Ocean Dipole variability.

Table 1 The year of IOD/ENSO from 1958 to 2008, p IOD and n IOD denote positive and negative IOD respectively.

The frequent occurrence of IOD events also raised the question of ENSO- Asian sumer monsoon relationship (Ashok et al., 2001, Behera and Yamagata, 2003). This frequent climate dymanics severely affect the Asian region. The total people affected during the 1975-2008 periods in figure 4 (a), (b) shows that percentage of people in the Africa and Asia continent are severely affected and followed by Europe, America and Oceania. General and unspeciafied flood are the dominant cases in almost all the continents. Flash flood is the higest the Oceania, followed by Europe, Africa, America and Asia. In the total number it affects more to the people of Asia than America, Africa, Europe and Oceania in the same order. But this figure shows that the natural disasters with extreme cliamate dynamics affects more to the Asian region than to other continents as the Asian region is affected by both the Pacific and Indian Ocean climate variabilities.

(a)



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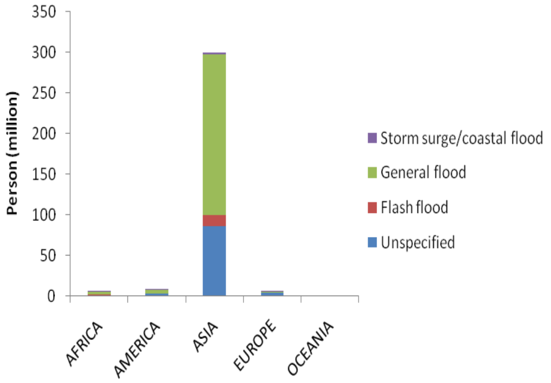
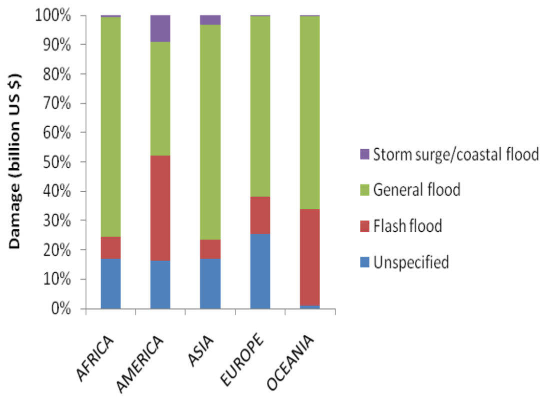


Figure 4 percentage (a) and number (b) of people affected in continent wise during IOD/ENSO years from 1975-2008 in million.

Being the most populated continent, with more than four billion population which consists of above 60% population in the world, around 50 % depends there livelihood on agriculture in the Asian continent. The increasing poopulation, lack of development, poor quality of social life style, and poverty this region is very prone to flood and cyclone disasters. The damage caused by the climate variations modes are severe in Asia compared to other continents. Baring few countries most of this region is based on primary sources of income. Almost the whole of southeast Asia, the densest population corridor of the world suffers the most in the flood and cyclonic activities.

In the recent years the cases of floods are higher in Bangladesh, India, China, Indonesia, Pakistan, Philipines, Thailand, Malyasia and others. All these countries are developing in nature and not taken adequate flood control measures. Poverty is also another major problem in this region. With already poor driven conditions, the occurrence of extreme climate change induced variability modes like IOD/ENSO causes severe socio-economic damages. The figure 5 (a) indicates the damage percentage is highest in the Asia and followed by Africa, America, Europe and Oceania. Where the cases of general flood caused highest damage in all the continents and fallowed by unspecified flood, flash flood and storm surges respectively. The figure 5 (b) denotes the damage in US $, indicates that during the period from 1975-2008 the total economical losses in the Asian continent is more than four fold than the second damage continent Europe. The America, Africa and Oceania placed by third, fourth and fifth respectively.

(a)



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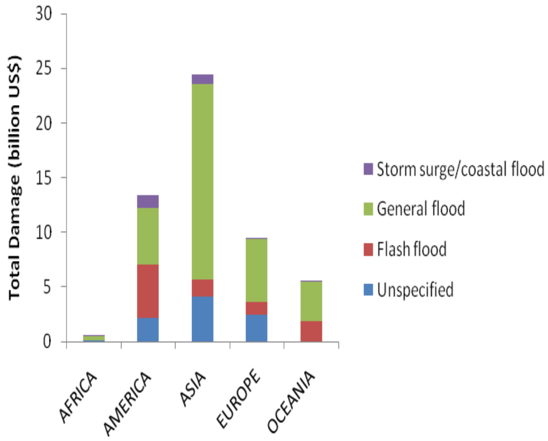

Figure 5 percentage (a) and total property (b) damage in continentwise from 1975 -2008 during IOD/ENSO years in 000 m US$.

4.Conclusion

From last few decades it has been seen that climate variability modes played important role for the large scale environmental and societal effects across the globe. With the unprecedented occurrence of thre IOD events from 2006-2008 also raises many questions about the IOD/ENSO relationship with weekening ENSO events years. The tropical Indo-Pacific region is the main driving force behind these modes. The east and south east Asia are influenced by Pacific dynamics along with Indian Ocean dynamics. Hence this region is totally influenced by the climate change induced ocean–atmosphere variability modes.

This study shows that the total number of people killed and affected and the total damage in monetary terms are highest in the Asian region, which indicates very prone to the natural disasters The impact assessment analysis shows that the extreme natural events are increasing from last few decades , though causes are still not scientifically proved, however it is a fact that from 1990s onwards IOD dominants with frequent occurrence compared to ENSO in the climate modes history. However, its impact is from regional to global scale. Whether the link of this economic and human losses have direct implications to the IOD/ENSO climate modes needs further scientific investigations. This study will further be extended to regional scale with scientfic analysis across the Asian region taking hydrological and atmospheric coorrelation parameters from different regions..

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インド洋ダイポールモードおよびエルニーニョ南方振動のアジア地域への影響

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要　旨

インド洋および太平洋地域の気候変動はインド洋ダイポールモード(IOD)およびエルニーニョ南方振動(ENSO)により支配されている。IODおよびENSOは地球規模の気候変化をもたらしうる大気圏・陸域圏・水圏の相互作用として広く認知されており，両イベントを予測できればこれらの地域の気候変化の予測に大きく貢献する事ができる。本研究においては主にアジア地域へのIODの影響について焦点をあてる。近年IODの発生回数が増え，ENSOを弱めているという報告があり，また2006年から2008年にかけて正のダイポールモードが三年連続して発生したが，これは気象史上非常にまれなケースである。検討結果によるとIODおよびENSOの発生年にはより多くの自然災害が発生し，経済的被害が大きく，被災人口がより多くなる傾向があることが分かった。

キーワード：気候変動，インド洋ダイポールモード，エルニーニョ南方振動、