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A Geospatial Technological Approach to Monitor Convection over Arabian Sea

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ABSTRACT

In the land-atmosphere-ocean system, ocean acts as the heat reservoirs, thereby playing a role in weather and climate variability. Sea surface temperature variation across the ocean triggers heat exchange, initiating the deep convection resulting in the vertical movement of air parcels, leading to the formation of rain-bearing cloud systems. The local effect is seen in convection and resultant precipitation along coastal lines. In this study, an attempt is made to map the Sea Surface Temperature (SST), monitor the convection over Arabian Sea, analyse the SST variability over the latitude ranges of 0o N to 30oN and longitude ranges of 60oE to 95oE, so as to understand the relationship between the rainfall anomalies in the coastal Karnataka and the SST variability and convection in the Arabian Sea. The study showed that in the context of Karnataka state, during a good monsoon year (2013), the maximum convection zone (MCZ) was found to be hovering around 15 to 28 degrees north of the equator whereas, during a bad monsoon year (2016), the MCZ was below 15o north of the equator. The study also revealed that the maximum convection occurs in the Arabian Sea when the SST is above 27.5 degree Celsius in the summer and 28.5 degrees Celsius in winter months. The study reconfirms that the monsoon rainfall variability between a good and bad monsoon is dependent largely on the northward migration of the convection zone (i.e., the strength of the Hadley circulation).

Key Words: *Sea Surface Temperature, Cloud Fraction, Convection, Maximum Cloud Zone*

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1. INTRODUCTION

Indian monsoon system is one among complex monsoon systems throughout. The complexity arises due to India's topography, location of the Himalayas, geographical position etc, and influence of oceans on the peninsular India is another crucial factor. Monsoon and the cloud convection characteristics are related to its surrounding ocean dynamics, making the process more complex. Sea surface temperature, an important factor in the ocean dynamic system is indicated by measurements taken at depths that range from one millimeter to twenty meters. SST cause offshore wind to generate upwelling currents, causing cooling or warming of nearby land masses. Temporal evaluation of SST using satellite technologies provides globally consistent analytic information for likely SST impacts. The impacts include effect on ecosystem, coastal erosion and flooding, anomalies in coastal climate etc. Evidence of climate change both globally and locally in varying scales is evident, as sea surface temperature modifies the air masses in earth's atmosphere within a short distance of the shore. During convection, the rising moist air is forced upwards from an unstable environment which later grows into rain bearing cloud systems, chiefly into cumulus congestus and cumulonimbus cloud systems which has the capacity to release precipitation in abundance. Cumulonimbus clouds normally has considerable vertical extend which can ranges around 8-13kms. The sea surface temperature, convection and precipitation are interconnected phenomena where one leads to another. Maximum cloud zone (MCZ), which means the coordinate zone where maximum cloud zone is present, lies between 15^{o}N to 28^{o}N and is known as mean summer monsoon location [17]. During the drought years or rainfall anomaly years, non-uniformity is seen in the pattern of movement of rain-bearing clouds.

2. STUDY AREA

Arabian Sea and Bay of Bengal are major part of the study area. Coastal Karnataka forms part of the study, representing the land portion. The study is primarily focused upon the Arabian Sea and Karnataka Coastal districts. Comparison is carried out between Arabian Sea and Bay of Bengal analyzing both basins oceanic parameters. The study stretches between 0°N to 30°N and 60°E to 95°E. Rainfall for coastal Karnataka was analyzed for the years 2012 to 2016 to identify anomaly in rainfall so as to establish its relationship with the convection over Arabian Sea.

3. MATERIALS AND METHODS

Sea surface temperature is analyzed with the help of MODIS-AQUA data having resolution of 500 m. Convection parameter necessity was met with the help of cloud fraction data from MODIS-TERRA imagery. Monthly rainfall data for coastal districts of Karnataka was obtained from Karnataka State Natural Disaster Monitoring Centre. (KSNDMC) for a period of 5 years from 2012 to 2016.

The sea surface temperature data as well as the cloud fraction data is analyzed using GrADS. Inverse Distance Weighted (IDW) model is adopted to interpolate the rainfall data. The Sea Surface Temperature is analyzed grid-wise. The software requires data in NETCDF or HDF data format so as to manage and manipulate data in bulk. The data acquired from CERES-ISCCP consisted of monthly averaged data sets from 2012 to 2016 and was sorted into required coordinate values for visualizing the cloud fraction data in gridded imagery format.

The following figure represents the flow chart of the process.

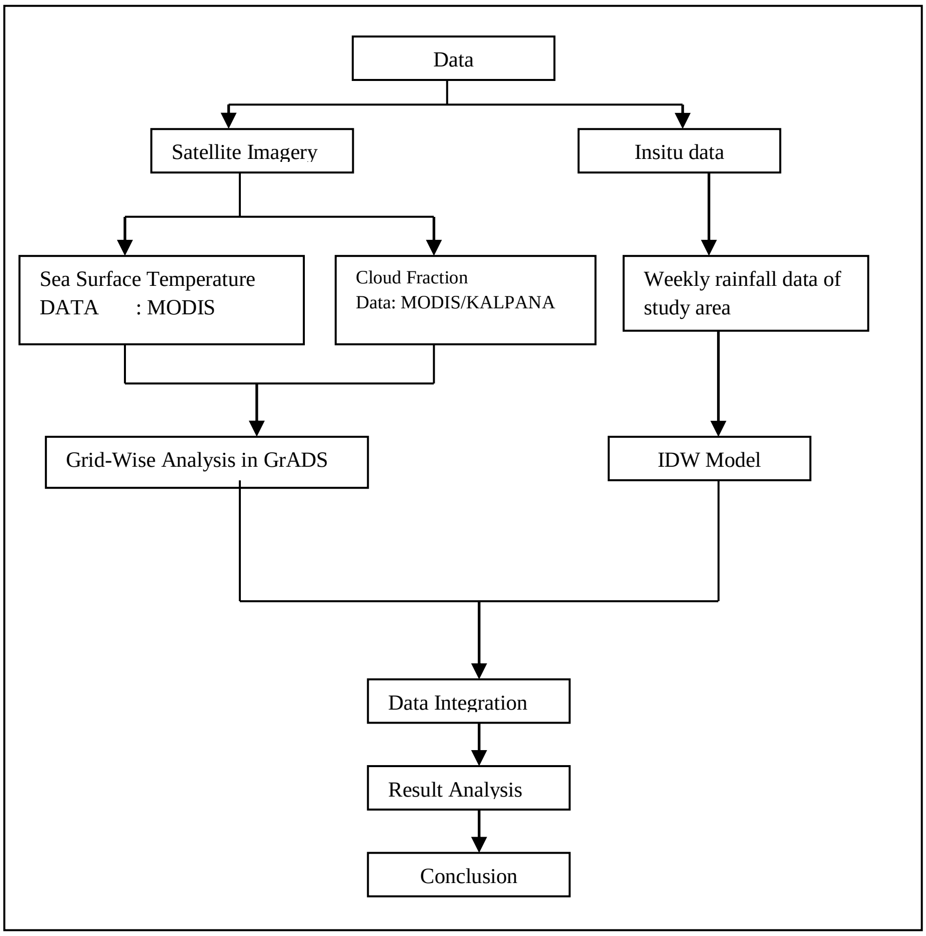

Fig 1: Flow chart representation of Methodology

4. RESULTS AND DISCUSSION

The land mass of study area received good rainfall in the year 2013. 2012 and 2014 were moderate rainfall years for Karnataka whereas 2015 and 2016 where rainfall deficit years. An investigation was made to analyze these anomalies by considering the role of convection over Arabian Sea in it. Figures 2, 3, 4 and 5 represent SST (right), rain-bearing cloud fraction (left), and rainfall pattern (bottom) for the years 2013 and 2016. The data represented are for the months May, June, July and August respectively.

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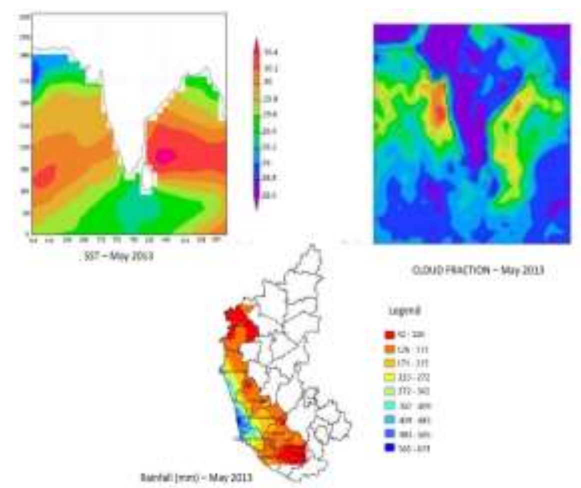

Fig 2: Analysis of 2013 May data

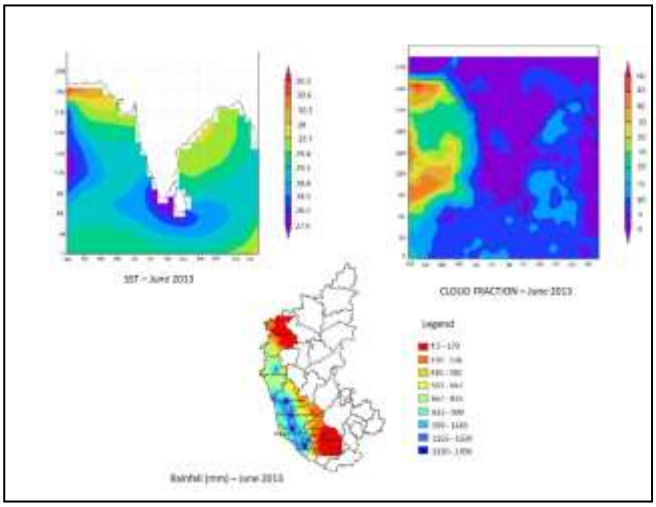

Fig 3: Analysis of 2013 June

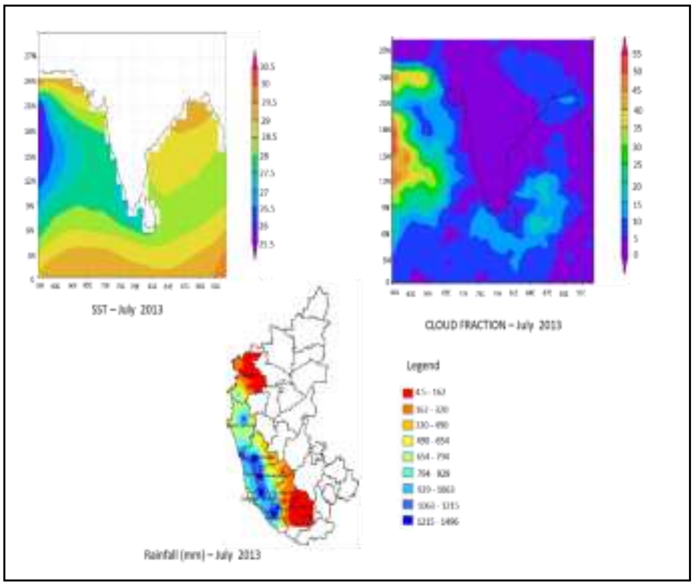

Fig 4: Analysis of 2013 July data

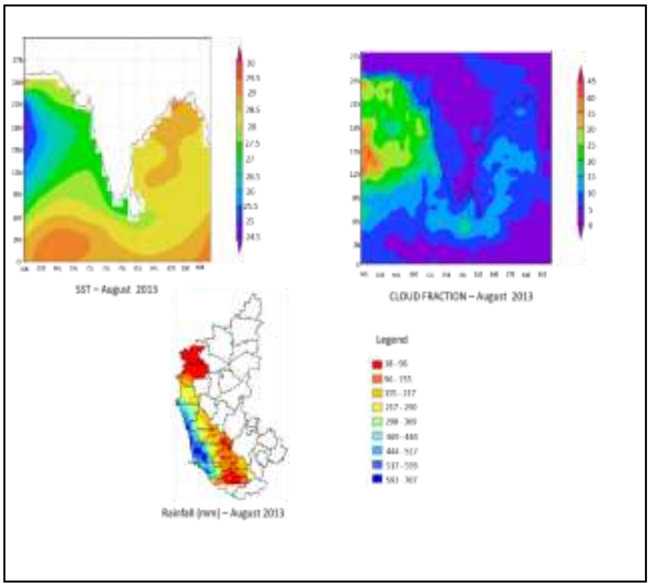

Fig 5: Analysis of 2013 August data

Above figures represents the analysis of SST, Cloud fraction and Rainfall pattern for the months of May, June, July and August of 2013.

Figure (2) shows a comparison of all three parameters i.e., SST, convection (rain-bearing cloud fraction) and rainfall in coastal districts of Karnataka for the month of June, 2013. It is seen that the relation between SST and cloud fraction goes hand in hand. There is good amount of convection seen in Arabian Sea along with appropriate amount of SST (above 26^{o}C and below 30^{o}C). The maximum convection is observed above a latitude zone of 9^{o} N TO 28 ^{o} N.

Rainfall of June 2013 is also found to be above average in Karnataka coastal districts. Maximum rainfall was 1496 mm in June. Similar observations are made in figure (3) as well, maximum convection is seen around 26^{o} C to 29^{o} C. The rainfall is also observed to be above average. Maximum convection zone is observed to be above 12^{o} N. The maximum rainfall was around 1496 mm in the month of July. August month also observed sufficient amount of rainfall in coastal districts. The SST is again seen to be moderately warmed with adequate amount of convection above a zone of 12^{o} N latitude. Maximum rainfall was found to be around 707 mm for coastal districts. Similar analysis was done for the year 2016.

2016 was a rainfall deficit year for Karnataka. Considering the month of May data, it is found that the maximum cloud convection has happened around 6^{o} N. Maximum rainfall occurred in coastal districts was only around 150 mm. For the month June of 2016, SST variations were high compared to June of 2013. It ranged mostly around 28.8 to 30.5 ^{o} C. The convection was

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seen around 28.2 to 29.7 ^{o} C. Maximum convection zone was seen above 9 ^{o} N. Rainfall of coastal districts met 1600 mm in June. Similar trends were observed in the month of July 2016. Convection was found to be less than normal and SST ranged variably from 27 to 30 ^{o} C Maximum rainfall observed was around 1000mm in coastal districts of Karnataka. Maximum convection zone was found above 9 ^{o} N in 2013 July. Trends were again observed to be similar in August 2016. Maximum rainfall was around 700 mm. Convection increased into a moderate shape with maximum convection zone falling above 12^o N. It is found that convection is observed when SST is between the range 27 to 29.5^o C Good monsoon is observed when maximum convection zone is above 12^o N. The data was also analyzed graphically and maximum convection zone movement was studied.

5. GRAPHICAL ANALYSIS OF SST AND CONVECTION RELATIONSHIP

It is found that the convection is happens maximum along a temperature range of 27 to 29^o C. For duration of June to October of summer monsoon period, Cloud fraction is obtained to be attaining its maximum at 27.5^{o}C. The cloud fraction increases from an SST range of 24.5^{o}C, and reaches its maximum at 27.5^{o}C and comes down to 5% towards an SST of above 30^{o}C. The parameter shows a parabolic trend by increasing at first and decreasing at a later stage. For winter months of December to April, the trend of convection slightly shifts compared to June-October months. The maximum convection was found for SST of 28.5^{o}C. Convection started at a temperature of 24^{o}C and decreased to 5% at 30^{o}C. The graphical representation of same is shown below in figure 6 and 7.

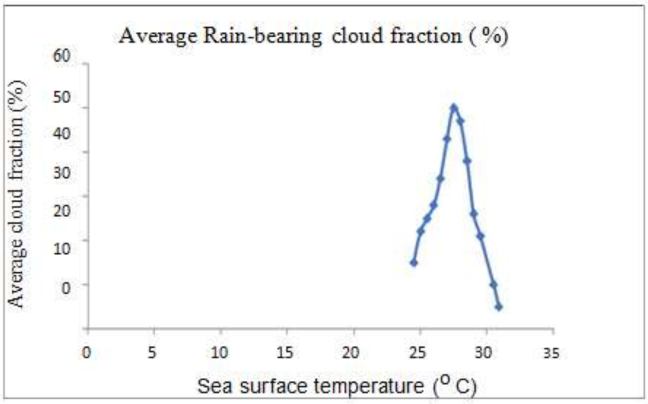

Fig 6: Average Rain-bearing cloud fraction (%) June to October

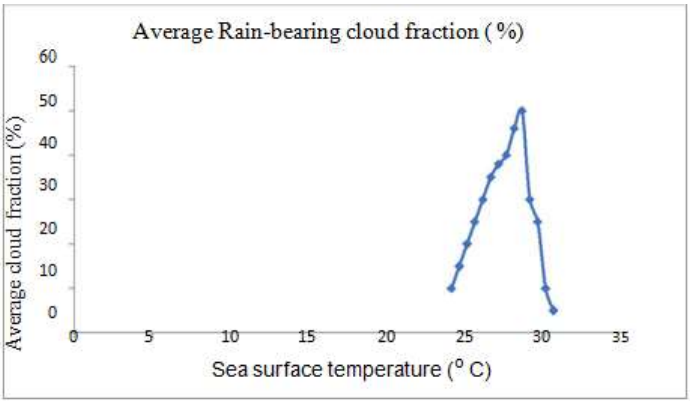

Fig 7: Average Rain bearing cloud fraction (%) December to April

From graphical analysis for SST –Rain bearing clouds relationship, it was found that during summer monsoon period, from June to October, maximum convection was seen at a temperature of 27.5^o C where as in winter, during December to April, maximum convection and rain bearing cloud fraction was seen at a temperature of 28.5^{o}C. This means that there is a shift of 1^{o}C in the maximum convection temperature of both the seasons. Also, it is found that deep convection rate is slow when temperature increases from 29.5^o C. A parabolic trend is visible in the rate of convection as the convection starts at around 24^{o}C, increases to a peak rate and comes down to lower rate after SST reaches above 29.5^{o}C.

6. MAXIMUM CONVECTION ZONE (MCZ) ANALYSIS

Maximum convection zone is the zone at which maximum amount of convection takes place. For a drought year, 2016, the pattern of movement of MCZ as well Maximum SST Zone is non-uniform. It is found that the Maximum Convection zone doesn't go up to 15^{o}N of latitude by May like 2013. The MCZ is found to come down from the mean summer monsoon location during the crucial monsoon months of July and August as shown in figure 8 below.

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Fig 8: The location of MCZ north of equator during 2013 and 2016. Note that during the deficit monsoon rainfall year (2016), the MCZ is much below that of a good monsoon year (2013)

7. SUMMARY

MCZ, the zone where maximum rain-bearing cloud linger around for the majority of days was seen different for a good monsoon year and a monsoon deficit year. For 2013, a good rainfall year, the MCZ on the northern latitudes took an ascending path towards 15^{o} N to 24^{o}N. After reaching a peak at around 24^{o}N by the month of July, the MCZ started descending towards the south of the Northern latitudes i.e., lower than 15^{o}N. During the year 2016, an uneven movement of the MCZ was observed. The movement started at 4^{o}N in an ascending range but fell down by March to 5^{o}N. Similar rise and fall was observed throughout the traverse. During the main monsoon months of July and August, instead of reaching maximum northward latitude above 24^{o}N, MCZ came down to 13^{o}N for two months. Karnataka's central latitude is at 15^{o}N. The summer monsoon location of $15\text{-}24^{o}$N thus favours the coastal districts of the state.

REFERENCES

1. Balaji R and Peter Molnar (2011). Pacific Ocean sea-surface temperature variability and predictability of rainfall in the early and late parts of the Indian summer monsoon season. *Journal of climate.* 39**:** 1543-1557.

2. Chacko, K.V., Kumar, P.H., Kumar, M.R., Mathew, B. and Bannur, V.M., 2012. A note on Arabian Sea warm pool and its possible relation with monsoon onset over Kerala. *International Journal of Scientific and Research Publications*, p.286.

3. Creutin, J.D., Lacomba, P. and Obled, C.H., 1986. Spatial relationship between cloud-cover and rainfall fields: a statistical approach combining satellite and ground data. *Hydrologic applications of space technology (Publication No. 160)*, pp.81-90.

4. D R Sikka and Sulochana Gadgil (1980). Monthly weather review on the maximum cloud zone and ITCZ over Indian Longitudes during southwest monsoon. *Monthly Weather Review.*
Volume 108.

5. Eastman, R., Warren, S.G. and Hahn, C.J., 2011. Variations in cloud cover and cloud types over the ocean from surface observations, 1954–2008. *Journal of Climate*, *24*(22), pp.5914-5934.

6. Gadgil, S., 2003. The Indian monsoon and its variability. *Annual Review of Earth and Planetary Sciences*, *31*(1), pp.429-467.

7. Joseph, P.V., Eischeid, J.K. and Pyle, R.J., 1994. Interannual variability of the onset of the Indian summer monsoon and its association with atmospheric features, El Nino, and sea surface temperature anomalies. *Journal of Climate*, *7*(1), pp.81-105.

8. Kelkar, R.R., 2007. *Satellite meteorology*. BS Publications.

9. P V Joseph, John K Eicheid and Robert J Pyle (1994). Interannual variability of the Indian Summer monsoon and its association with atmospheric features, El Nino and sea surface temperature anomalies.*Journal of Climate.* Volume 7**:** 81-105

DOI: 10.31695/IJASRE.2018.33010

10. Roxy, M.K., Ritika, K., Terray, P., Murtugudde, R., Ashok, K. and Goswami, B.N., 2015. Drying of Indian subcontinent by rapid Indian Ocean warming and a weakening land-sea thermal gradient. *Nature communications*, *6*, p.7423.

11. Sathiyamoorthy, V., Mahesh, C., Gopalan, K., Prakash, S., Shukla, B.P. and Mathur, A.K., 2013. Characteristics of low clouds over the Arabian Sea. *Journal of Geophysical Research: Atmospheres*, *118*(24).

12. Shukla, J. and Misra, B.M., 1977. Relationships between sea surface temperature and wind speed over the central Arabian Sea, and monsoon rainfall over India. *Monthly Weather Review*, *105*(8), pp.998-1002.

13. Shenoi, S.S.C., Shankar, D. and Shetye, S.R., 2002. Differences in heat budgets of the near-surface Arabian Sea and Bay of Bengal: Implications for the summer monsoon. *Journal of Geophysical Research: Oceans*, *107*(C6).

14. Shenoi, S.S.C., Shankar, D. and Shetye, S.R., 2004. Why is Bay of Bengal warmer than Arabian Sea during the summer monsoon?.

15. Udayashankara T.H., Sadashiva Murthy B.M., Madhukar M (2016). Impact of climate change on rainfall pattern and reservoir level. *Journal of Water Resource Engineering and Management.* Volume 3, Issue 1:10-14

16. Zhang, C., 1993. Large-scale variability of atmospheric deep convection in relation to sea surface temperature in the tropics. *Journal of Climate*, *6*(10), pp.1898-1913.

DOI: 10.31695/IJASRE.2018.33010