Impact of tsunami on Tamil Nadu Monsoon Rainfall

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ABSTRACT

In 2004 Tamil Nadu was severely affected by Tsunami. After the incident Tamil Nadu has been experiencing erratic rainfall. The effect of the Tsunami on the atmospheric circulation related to the monsoon rainfall is investigated in this paper. The qualitative analysis is done by Poincare map and the quantitative analysis is done by calculating the Lyapunov exponent. The Poincare map was analysed and the ratio SD1/SD2 for Tamil Nadu. The Poincare value of the southeast monsoon rainfall before and after Tsunami was found to be 0.307 and 0.418. The Lyapunov exponent was calculated to be 0.285 and 0.799 respectively. North East monsoon rainfall was found to be 0.679 before Tsunami and 0.834 after Tsunami. The Lyapunov Exponent was found to be 0.5604 before Tsunami and 0.8606 after Tsunami. The values of Poincare and Lyapunov suggest that the Tamil Nadu North East monsoon rainfall has certainly been disturbed for the past few years.

Keywords: rainfall, monsoon, lyapunov exponent, poincare map.

1. INTRODUCTION

The oceans play a major part in creating conditions for life on land. Together with the atmosphere, oceans regulate global temperatures, shape weather and climate patterns. The ocean and the atmosphere are intimately connected. Changes in the pattern of sea surface temperature are linked with changes in the atmospheric circulation. They affect the incidence of extreme weather and are precursors of climatic variability on inter-annual and longer timescales. The enormous thermal inertia of the ocean implies that any systematic change of climate will be of long duration.

The tsunami disaster of 26 December 2004 demonstrated the awesome destructive power of the ocean. More gradually, the oceans exert a profound impact on the global biosphere through their influence on weather and climate.

Table-1. The Annual rainfall pattern of Tamil Nadu.

<table>
<thead>
<tr>
<th>Season</th>
<th>Months</th>
<th>Normal Rainfall in mm</th>
<th>Percentage of annual Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southwest Monsoon</td>
<td>June-September</td>
<td>322.00</td>
<td>32.96%</td>
</tr>
<tr>
<td>Northeast Monsoon</td>
<td>October - December</td>
<td>470.00</td>
<td>48.10%</td>
</tr>
<tr>
<td>Average Rainfall</td>
<td>-</td>
<td>977.00</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

The present paper is aimed at investigating the changes in the rainfall pattern of Tamil Nadu after the December 26th 2004 Tsunami. We have incorporated a qualitative analysis and a quantitative analysis to method to study the Rainfall pattern. Poincare method is followed for qualitative analysis. The Lyapunov Exponent calculation is done for quantitative analysis.

2. DATA

The Tamil Nadu rainfall data form 1994-2010 was obtained from Regional Meteorological centre, Chennai. The rainfall pattern is analysed for the different seasons of Tamil Nadu as mentioned in Table-1. All the data are split into two parts. The rainfall data before Tsunami occurrence and the rainfall data after the Tsunami occurrence.

3. METHODOLOGY

The rainfall data of Tamil Nadu is subjected to both qualitative and quantitative analysis.

POINCARE MAP-QUALITATIVE ANALYSIS

One commonly used nonlinear method that is simple to interpret is the so-called Poincare [2] plot. It is a graphical representation of the correlation between successive rainfall data i.e., plot of $X_{i+1}$ as a function of $X_i$. The standard deviation of the point’s perpendicular to the line-of identity denoted by SD1 describes short-term variability which is mainly caused by rainfall data. The standard deviation along the line-of-identity denoted by SD2, on the other hand, describes long-term variability. The standard Poincar’e plot can be considered to be of the first order [3].
The Lyapunov exponent gives the quantitative value for a non-linear dynamical system. A positive largest Lyapunov exponent indicates chaos. It is thus useful to study the mean exponential rate of divergence of two initially close orbits using the formula [4, 5].

\[
\lambda = \lim_{t \to \infty} \frac{1}{t} \ln \frac{|\Delta x(t)\Delta x(t)|}{|\Delta x(0)|}
\]

This number, called the Lyapunov exponent \(\lambda\), is useful for distinguishing among the various types of systems. It works for discrete as well as continuous systems.

\[
\begin{align*}
\lambda < 0 & \quad \text{Negative Lyapunov exponents are characteristic of dissipative or non-conservative systems} \\
\lambda = 0 & \quad \text{A Lyapunov exponent of zero indicates that the system is in steady state mode or conservative.} \\
\lambda > 0 & \quad \text{A large positive Lyapunov exponent indicates the system is unstable and chaotic.}
\end{align*}
\]

The values obtained from the qualitative and quantitative analysis of the Tamil Nadu Rainfall pattern are tabulated in Table-2.

<table>
<thead>
<tr>
<th>Season</th>
<th>Rainfall Before Tsunami</th>
<th>Rainfall After Tsunami</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poincare</td>
<td>Lyapunov</td>
</tr>
<tr>
<td>Southwest Monsoon</td>
<td>0.307</td>
<td>0.285</td>
</tr>
<tr>
<td>Northeast Monsoon</td>
<td>0.679</td>
<td>0.560</td>
</tr>
<tr>
<td>Average</td>
<td>0.555</td>
<td>0.5367</td>
</tr>
</tbody>
</table>

4. RESULT

The Poincare map for Southwest and Northeast monsoon data for a period of 1993 - 2003 was and the Standard deviation data SD1 and SD2 were calculated and the ration of SD1/SD2 was found to be 0.432 and 0.679 respectively. The value of SD1/SD2 ratio for a period of 2004-2010 was calculated to be 0.782 and 0.834 respectively. When the two rations are compared the, southwest and northeast monsoon rainfall of Tamil Nadu after tsunami are showing a higher ratio values indicating that the rainfall pattern is disturbed. The qualitative value from Poincare map is then further confirmed by calculating the Lyapunov exponent for the southwest and northeast monsoon rainfall. The Lyapunov exponent value for the southwest and northeast monsoon before Tsunami is 0.307 and 0.418 respectively. After Tsunami the Lyapunov Exponent was found to be 0.285 and 0.799. Thus after tsunami the southwest rainfall and the northeast rainfall of Tamil Nadu are showing a chaotic behaviour.

5. CONCLUSIONS

The occurrence of Tsunami in Tamil Nadu in the year 2004 has disturbed the oceanic atmospheric circulation conditions which in turn has caused changes in the Rainfall pattern over the state. The qualitative and the quantitative analysis of rainfall also emphasis this condition

REFERENCES


