Intra-seasonal oscillations of total ozone over the Indian region during the dry monsoon year 2002 - A study based on Morlet wavelet analysis

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1.Introduction:

Ozone plays an important role in the global weather and climate even though the total atmospheric composition is less compared to other trace gases. Intraseasonal to decadal variability of ozone is related to dynamical behavior of the atmosphere. The Total Column Ozone (TCO) in the tropical atmosphere depends on both chemical and dynamical processes and has been extensively studied during the last few decades. Several studies have investigated ozone trend (e.g., Stolarski *et.al*, 1992), annual cycle (e.g., Shiotani, 1992), interanual variations associated with the quasi-biennial oscillation (e.g., Bowman1989), El Nino-Southern Oscillation (e.g., Camp *et al*., 2003), intraseasonal variations and their connection to the Madden-Julian Oscillation (e.g. Tian *et al*., 2007 and Ziemke *et al.*, 2007) and solar cycle (e.g., Hood, 1997). A very few studies are available on variations of total ozone over Indian stations (Mani *et al.,* 1993; Tiwari, 1992 and Kundu ,1993 and Londhe *et al.,* 2006) .

Moreover ozone in the tropopause acts as a strong greenhouse gas and increasing ozone trends at these altitudes contribute to climate change. Exposure to ozone creates many health problems in human beings such as skin cancer, coughing and breathing difficulties etc. Hence understanding the temporal and spatial variation, production, depletion and forecasting of ozone is very relevant in the present scenario. In this study we highlighted the intraseasonal oscillations (ISO) of TCO along with Indian Summer Monsoon Rainfall (ISMR) over six Indian stations are presented from the Fifteen stations selected during the dry monsoon year 2002.

2. Data and Methodology

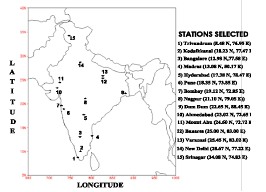
- Daily Total Column Ozone from the Earth Probe TOMS satellite for the period 1996 to 2005 for the twelve Indian stations
- Indian Summer Monsoon Rainfall (ISMR) of high resolution (1° X 1° Lat./Lon.) gridded rainfall data set for the Indian region for 53 years (Rajeevan *et al*., 2006).
- The TCO and the rainfall anomaly for the year 2002 were calculated from the climatology of TCO and ISMR of the respective stations during the monsoon period .
- Intraseasonal oscillations in TCO and ISMR for the stations were studied using the Morelet Wavelet Analysis (and to test the significance of these oscillations using the Power Spectrum method.
- Mathematically, a Wavelet Transform (WT) decomposes a signal s(t) in terms of some elementary functions derived from a "Mother Wavelet" or "Analyzing Wavelet" by dilation and translation:

$$\psi_{b,a}(t) = \frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right) \quad (1)$$

Where "b" denotes the position (translation) and a (> 0) the scale (dilatation) of the wavelet; are called "daughter wavelets" or, simply, "wavelets".

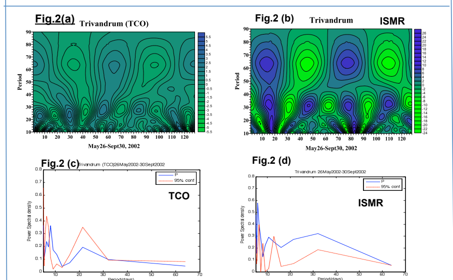
- An energy normalization factor in equation (1) keeps the energy of the daughter wavelets the same as the energy of the mother wavelet.
- Wavelets consist of those in which no restriction is placed on the value of the dilation and translation parameters are called continuous wavelets and have a symmetric structure.
- One of the most widely used continuous wavelets in geophysics is the complex Morlet wavelet (Morlet, 1983), which consists of a plane wave modified by a Guassian envelope.

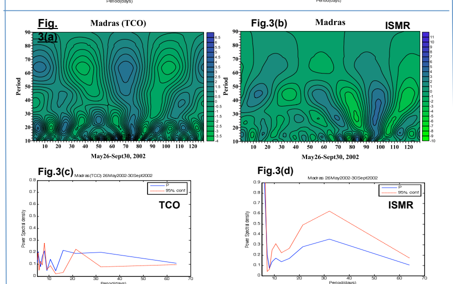
Figure 1: Indian Stations selected for ISO Study

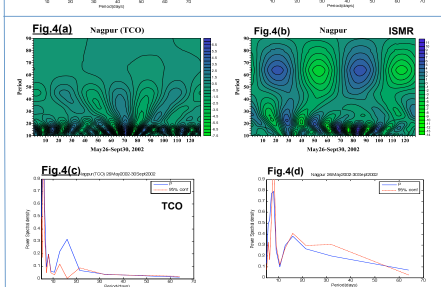


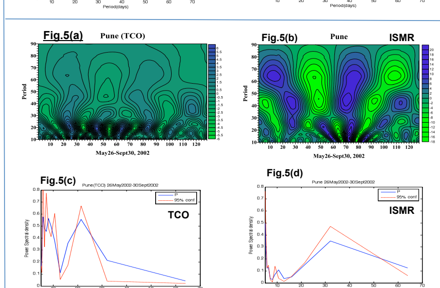
3. Results

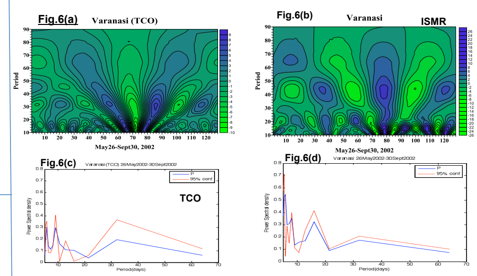
Figures (2) to (7) , show the Intraseasonal Oscillations (ISO) in TCO and ISMR for the selected stations, **Trivandrum**(*Fig.2*)**, Madras** (*Fig.3*)**, Nagpur** (*Fig.4*)**, Pune** (*Fig.5*)**, Varanasi** (*Fig.6*) **and Srinagar**(*Fig.7*) respectively. These stations are representing the north , south, east, west and central Indian regions. The Wavelet spectrum of TCO and ISMR anomaly for all the stations during the dry monsoon year 2002 is represented with (a) and (b) and corresponding Power spectrum are represented with (c) and (d) in each figure.

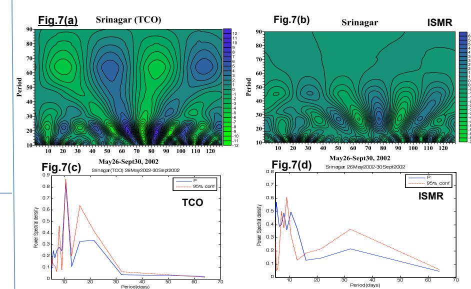












5. Conclusions

•From the study of intraseasonal variability of TCO and ISMR anomalies, it was found that the Intraseasonal oscillation of TCO shows exactly similar pattern with ISMR anomaly for low latitude stations compared with the higher latitude stations.

•Ozone anomaly and ISMR generally shows three type of Intraseasonal oscillations(ISO) with periodicities 10-20 days, 20-30 days and 30-60 days(Madden Julian Oscillations)

•.As you go away from the low latitude to higher latitude stations the MJO period (30-60 days) is less significant and the Intraseasonal Oscillations (ISO) with low periods (10-20 days) are more significant.

•In future study , we would like to look into the difference of ISO in TCO during Dry and Wet years of Indian Summer Monsoon.

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