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. Intrasessional 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), interannual variations associated with the quasi-biennial oscillation (e.g., Bowman, 1999), El Niño-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, 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 exposure to ozone creates many health problems in these altitudes contribute to climate change.

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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.
• Intrasessional oscillations in TCO and ISMR for the stations were studied using the Morlet 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:

\[ \psi_{a,b}(t) = \frac{1}{\sqrt{|a|}} \psi \left( \frac{t-b}{a} \right) \]

Where "b" denotes the position (translation) and a (> 0) the scale [dilation] 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 Gaussian envelope.

3. Results
Figures (2) to (7), show the Intrasessional 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 and west 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.

4. References