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Signature of the Antarctic Circumpolar Wave in the Surface Temperature Over Maitri

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ABSTRACT

The gridded surface temperature (ST) anomalies over *Maitri* for the period January 1979 – December 2005 were analyzed using continuous wavelet analysis. The early part of the study showed the influence of 2 – 8 month wave on variation of ST. Combined analysis of the wavelet power spectrum and the ST anomalies revealed that high fluctuations in the surface temperature during the year 1989 – 1991 were associated with the superposition of Antarctic circumpolar wave and the quasi-biannual signal. The later part of the study period showed strong effect of the 16 – 24 month signal over the ST variation.

INTRODUCTION

Antarctica the southernmost icy continent is known for extreme climatic conditions. The vast ice field of the Antarctic acts as a sink of the global climate engine. Any perturbation in oceanic/meteorological parameters disturbs the global circulation and hence affects local weather and global climate. On the other hand, a number of studies have suggested that atmospheric, oceanic, and sea ice fields around Antarctica linearly co-vary with the tropical Pacific El Nin˜o–Southern Oscillation (ENSO) phenomenon (Turner, 2004; Yuan, 2004; Kwok and Comiso, 2002; Yuan and Martinson, 2000; Liu et al., 2002; Liu et al., 2004). Also, the weather and climate in the Antarctic are affected by the Antarctic Circumpolar Wave (ACW) (White and Peterson, 1996; White et al., 1998; Venagas, 2003) and the Southern Ocean annular mode. The Antarctic circumpolar wave is a coupled air sea interaction propagating eastward in a wave train with a periodicity of around 4–5 yr and a propagation speed of 6 – 8 cm/s, and is composed of two waves taking approximately 8 years to circle the globe (White and Peterson,1996). The eastward propagation of the ACW is also characterized by coherent variations in sea surface temperature anomalies, which drive meridional surface wind (MSW) anomalies in the overlying atmosphere. The MSW anomalies feedback corresponding zonal surface wind (ZSW) anomalies causing anomalous SST tendency through anomalous meridional Ekman heat advection , and hence affect the weather and climate of the Antarctic. The weather and climate in the Antarctic is a cumulative effect of the local as well as the global effect.

In the present study we analyzed the available gridded surface temperature (ST) observations surrounding Maitri to find the signature of ACW and its effect.

DATA AND METHODOLOGY

The gridded monthly surface temperature data over the whole globe for the years 1979 to 2005 were downloaded from the Goddard Institute for Space Studies (http://data.giss.nasa.gov/gistemp/). The gridded surface air temperatures measurements were generated using the unadjusted data of the Global Historical Climatology Network (Peterson and Vose, 1997 and 1998), United States Historical Climatology Network (USHCN) data, and SCAR (Scientific Committee on Antarctic Research) data from Antarctic stations. These data sets are available in a 2° × 2° latitude-longitude grid. The surface temperature data for the Maitri region were extracted. The climatology of surface temperature for each month was calculated by taking the mean for each month from 1979 – 2005. It was found that for three months data were not available. ST for those months have been replaced by the climatology of the month. The monthly surface temperature anomalies over Maitri were calculated by subtracting the monthly mean from that for each individual month. The anomalies in the surface temperature over Maitri are shown in **Figure 1**.

To isolate the non-stationary power at different frequencies, the ST anomalies were analyzed using continuous wavelet transform (WT) (Torrence and Compo, 1998). In this transform the Morlet wavelet is used as the mother wavelet. The transform was performed in Fourier space (for details see Torrence and Compo, 1998; Jevrejeva et al., 2003). To reduce the wraparound effects the time series was padded with zeros to make their length a power of 2. The Monte Carlo method was used to find the statistical significance at the 5% level against the red noise. The WT has edge artefacts because the wavelet is not completely localized in time. Therefore, the cone of influence (COI) was introduced in which the edge effects cannot

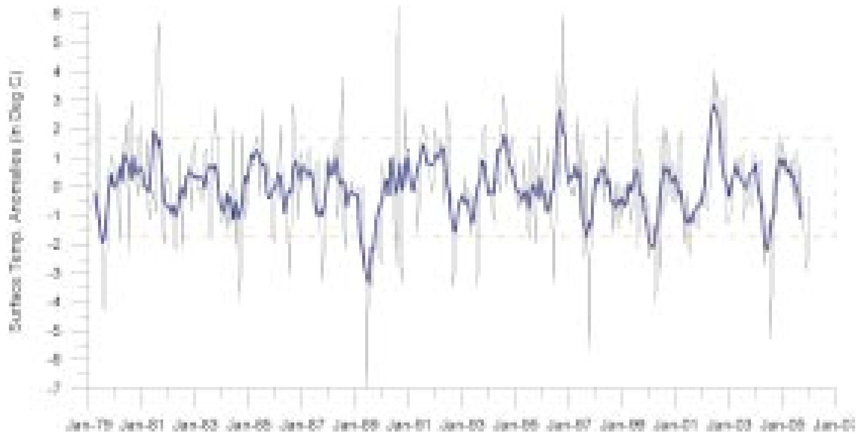

Fig. 1 : The gridded surface temperature anomaly over Maitri (shown in black colour). The 3 month running average of the same data set is shown with the blue line. The red dashed horizontal line indicates the standard deviation in the data set

be ignored (Jevrejeva et al., 2003). The wavelet coherence is shown in the **Figure 2**.

RESULTS AND DISCUSSION

The 2° × 2° gridded monthly surface temperature (ST) anomalies over *Maitri* from January 1979 to December 2005 are shown in Figure 1. The dotted lines represent the one standard deviation in the anomalies. The thick curve shows the running average of 3 months to suppress the high frequency components in the ST anomalies. The time difference between two conjugative picks in the ST anomalies were found to be 1.5 – 2 years, which matches with the half cycle of ACW. It is very interesting to note that there are three conjugative high frequency variations observed in the surface temperature anomaly after January 1989 repeated after an interval of almost 8 years. This matches with the periodicity of the ACW circumventing the whole globe. The fluctuations in the ST were less before 1989 compared to that after 1989. The negative peaks in the running average curve after 1989 were found to be repeated after 3 – 4 years, which matches with the full-cycle of ACW. These observations clearly show the significance of the ACW on the ST variation over *Maitri*.

The time-scale decomposition of power spectra of the ST anomalies were derived using the continuous wavelet transform **(see Fig. 2)**. The cone of influence is overlaid on the power spectrum. The thick dark contours in

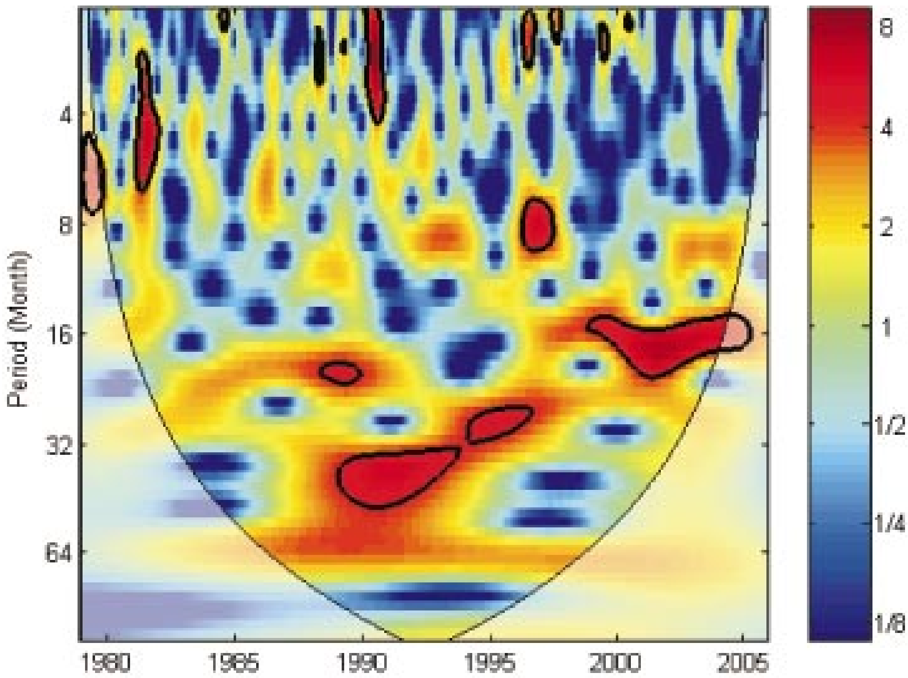

Fig. 2 : The continuous wavelet spectrum of the surface temperature anomaly given in Figure 1. The cone of influence is shown with less transparent colours. The thick dark curves show the 5% significance level of the wavelet spectrum of the surface temperature

the figure represent 5% significance of the spectrum. Fewer fluctuations in the ST anomalies were noticed during early years of the study period (see Figure 1). The wavelet spectrum showed high strength of 2 – 8 months signal during this period. It may be attributed to the local and seasonal variations. The effect of the ACW for this period can not be concluded from this analysis with confidence, since for low frequency waves these regions are included within the cone of influence. The magnitudes of the ST anomalies which were high during the year 1989 – 1991 may be attributed to the superposition of the waves having period 32 – 48 months (that of one cycle of ACW) and the wave with periodicity of 2 years (see Figure 2). During subsequent months upto 1997 the effect of ACW was felt in the ST. Post 1999 period showed strong effect of quasi-biannual signal, with periodicity 16 -14 months, on the SST anomalies over Maitri **(see Figure 2)**.

CONCLUSIONS

The analysis of ST anomalies over *Maitri* for the period January 1979 – December 2005 showed that the variation in the ST during the early part of the study was due to the presence of 2 – 8 month signal. Combined analysis of the wavelet power spectrum and the ST anomalies revealed that high fluctuations in the surface temperature during the year 1989 – 1991 were associated with the superposition of ACW and the quasi-biannual signal. The later part of the study showed a strong effect of the 16 – 24 month signal over the ST variation.

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