CLIMATIC TRENDS OF SOME PARAMETERS OF THE SOUTHERN OCEAN DERIVED FROM REMOTE SENSING DATA

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ABSTRACT. As it was shown recently, climate changes in Antarctica resulted in interannual trends of some climatic parameters like sea level pressure, surface air temperature, ice thickness and others. These tendencies have effect on the Southern Ocean meteorological and hydrological regime. The following remote sensing data: AVHRR MCSST data, satellite altimetry data (merged data of mission ERS-2, TOPEX/Poseidon, Jason-1, ENVISAT, GFO-1) are used to analyse the interannual and/or climatic tendency of sea surface temperature (SST) and sea level anomaly (SLA). According to the obtained results, SST has negative trend -0.02±0.003°C/yr for 24-yr record (1982-2005) and SLA has positive trend 0.01±0.005 cm/yr for 24-yr record (1982-2005) and 0.24±0.026 cm/yr for 12-yr record (1993-2005). However in some areas (for example, Pacific-Antarctic Ridge) SST and SLA tendencies are stronger -0.065±0.007°C/yr and -0.21±0.05 cm/yr, respectively.

KEY WORDS: sea level, sea surface temperature, Southern Ocean, satellite altimetry, IR radiometry, climatic trend.

1. INTRODUCTION

The Southern Ocean plays a key role in the climatic system on the Earth. According to recent investigations sea level pressure, simulated from NCEP–NCAR reanalysis, has the following climatic tendency at 65°S -0.166±0.039 hPa/yr for the period 1957–1998 and -0.177±0.062 hPa/yr for 1969–1998. The negative tendency weakens with time to -0.123±0.221 hPa/yr for 1979–1993 (Hines et. al., 2000). The trend of maximum ice values for each year in the Southern Hemisphere is of 0.3 ± 0.5 % per decade for ice thickness and 1.2 ± 0.6 % per decade for ice area for 1979-2003 (Comiso, 2004). The surface air temperatures inferred from infrared satellite data from 1979 to 1998 have the trend of −0.042 ± 0.067°C/yr (Comiso, 2000)

It means that some of basic climatic parameters have different trends. This shows that Earth's climatic system changes very largely.

These climatic variations have an effect on the position of the Subantarctic and Polar Fronts (Moore et al., 1999; Kostianoy et al. 2003; Kostianoy et al. 2004; etc.) and consequently on the Antarctic Circumpolar Current (ACC) and its intensity (Fu and Chelton, 1984). In the Drake Passage and near the Kerguelen Plateau, position of the ACC axis shifts to the south with a rate of about 0.016 deg/yr or 1.8 km/yr (Lebedev, 2006).

The Antarctic Circumpolar Current plays a key role in the Earth's climate system. Water mass transformations in the Southern Ocean "close" the overturning circulation by converting deep water.

The ACC connects the ocean basins, allowing a global overturning circulation to exist, and allowing anomalies to propagate between basins. Observations have been sufficient to establish the influence of the Southern Ocean on the mean state of the World Ocean and Earth's climate.

All changes in the ACC can be seen in sea surface temperature (SST) and sea level anomaly (SLA) interannual trends based on remote sensing data (IR-radiometry and satellite altimetry).

2. DATA AND METHODOLOGY

Analysis of interannual trends of SST was based on weekly mean MCSST (AVHRR, 1998) data with spatial and temporal resolution of 1/6° and one week. The SST data were derived from the AVHRR (Advanced Very High Resolution Radiometers) mounted on the NOAA satellites. These data are produced in the Physical Oceanography Distributed Active Archive Center of Jet Propulsion Laboratory since 1981 with the temperature resolution of about 0.1°C (McClain et al., 1985).

Monthly SST fields were constructed with spatial resolution of 1/2°. Then we analysed the SST temporal variations in each point of the grid (fig. 1) and each meridional section (fig. 2).

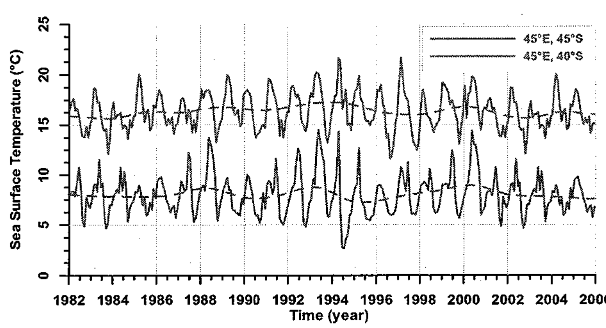

Figure 1. Temporal variation of monthly (line) and interannual (dotted line) SST in points 45°E, 45°S and 45°E, 40°S.

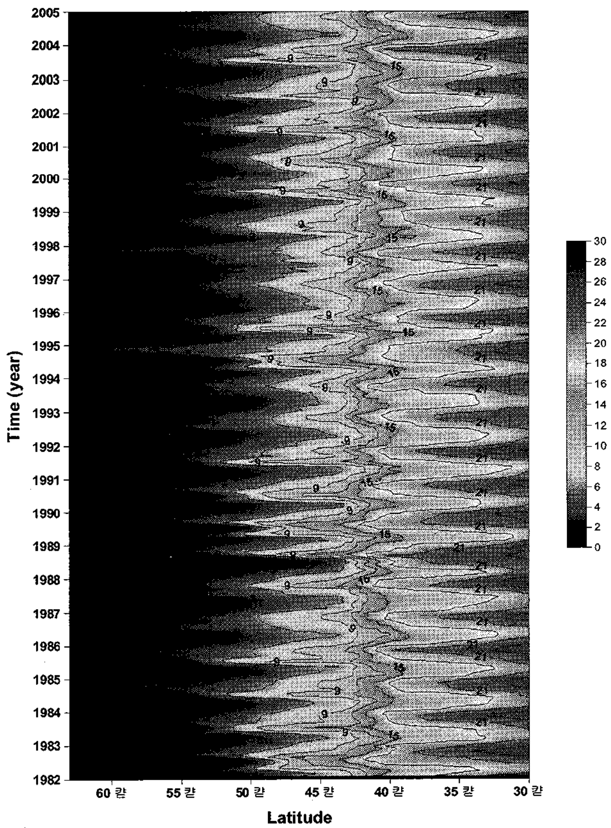

Figure 2. Temporal variation of SST (°C) along the meridional section at 45°E.

To take into consideration the influence of the Antarctic Circumpolar Wave (ACW) on the interannual SST trends, spectral density was calculated in each point of the grid. Period of ACW is estimated as of 3 to 6 years (White and Peterson, 1996). For the period between 1982 and 2005 the results show that maximum value of the SST spectral density pertains to the annual signal (fig. 3-4).

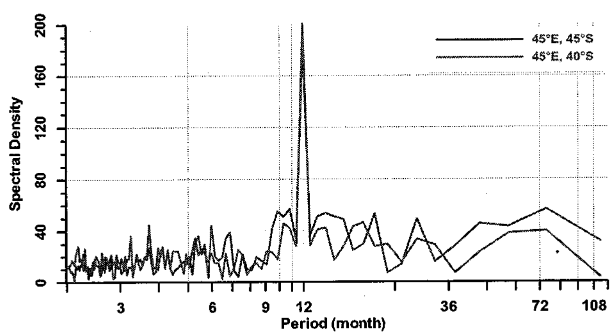

Figure 3. Spectral density of SST in points 45°E, 45°S and 45°E, 40°S.

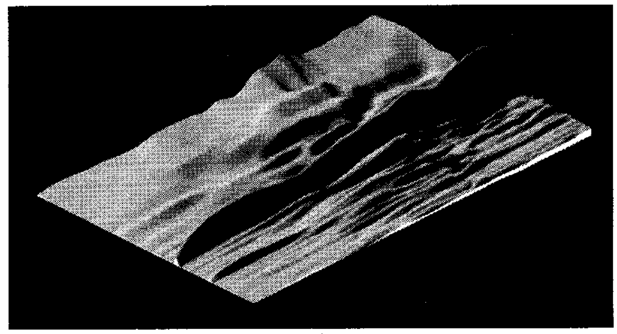

Figure 4. Spectral density of SST along the meridional section at 45°E.

Analysis of interannual trends of SLA was based on the merged sea level anomaly products (data of ERS-2, TOPEX/Poseidon, Jason-1, ENVISAT, GFO-1 missions) of the Collecte Localisation Satellites CNES as part of the Environment and Climate European Commission Projects (ENACT – EVK2–CT2001–00117, AGORA – ENV4–CT956–0113 and DUACS – ENV44–T96–0357) (Le Traon et al., 1998; Le Traon et al., 2001; AVISO, 2002).

This altimetry data have spatial and temporal resolution of 1/3° on Mercator projection and one week with the sea surface height resolution of about 4.2 cm (Fu and Pihos, 1994; Chelton et al., 2001).

Monthly SLA fields were constructed with spatial resolution of 1/2°. Then we analysed the SLA temporal variations in each grid point (fig. 5) and along each meridional section (fig. 6).

We took temporal interval for the analysis since 1993 till 2005. Spectral density for temporal variations was analysed in each grid point (fig. 7) and along each meridional section (fig. 8).

Results show that maximum value of spectral density pertains to the position of the Antarctic Circumpolar Current (fig. 8).

Interannual or climatic trends of SST and SLA were calculated as linear regression for each grid point with spatial resolution of 1/2°. Results of these computations are shown in figures 9-10.

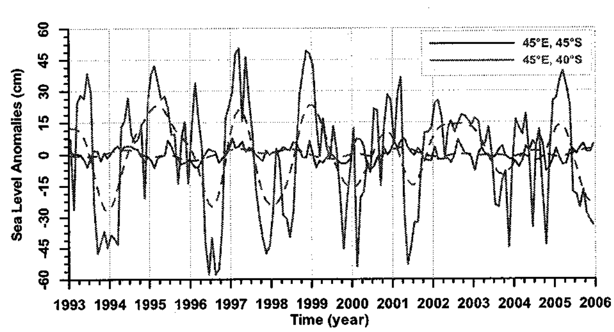

Figure 5. Temporal variation of monthly (line) and interannual (dotted line) SLA in points 45°E, 45°S and 45°E, 40°S.

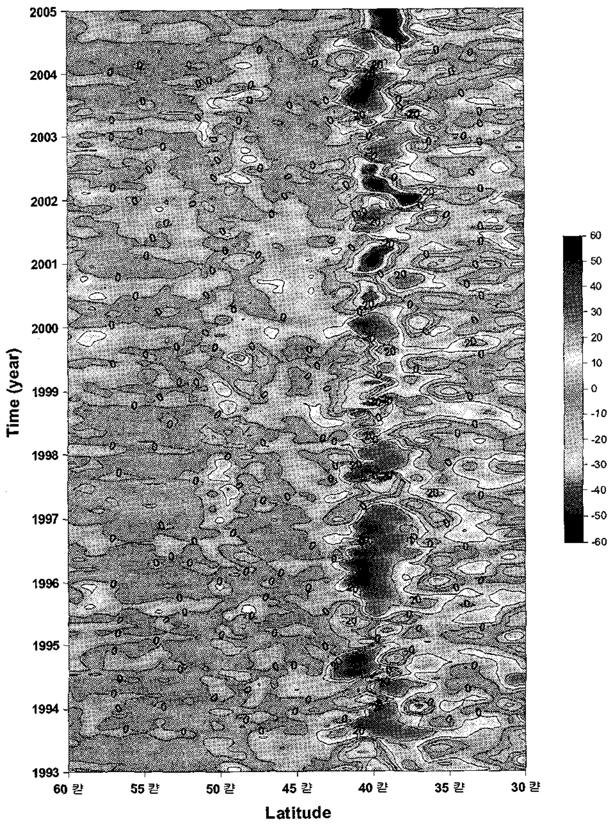

Figure 6. Temporal variation of SLA (cm) along the meridional section at 45°E.

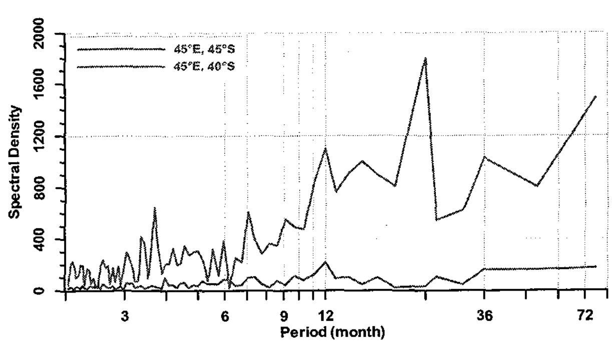

Figure 7. Spectral density of SLA in points 45°E, 45°S and 45°E, 40°S.

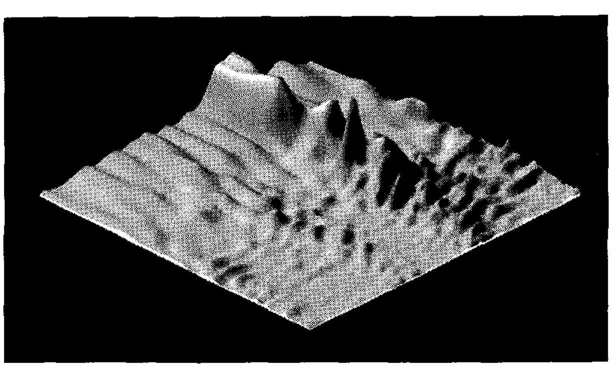

Figure 8. Spectral density of SLA along the meridional section at 45°E.

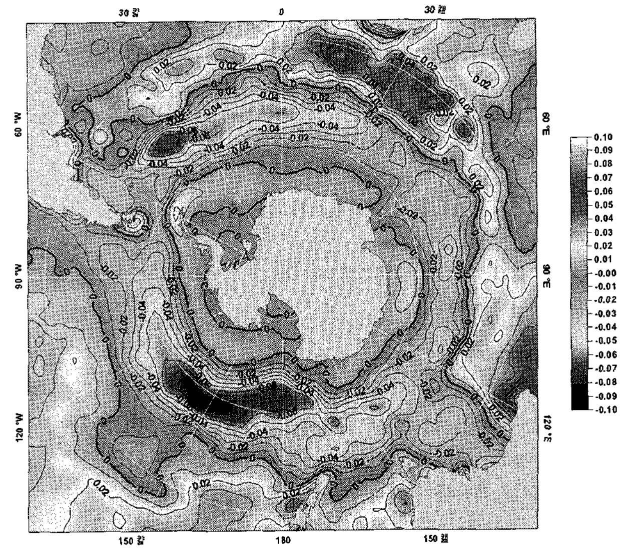

Figure 9. Map of SST interannual trends (°C/yr).

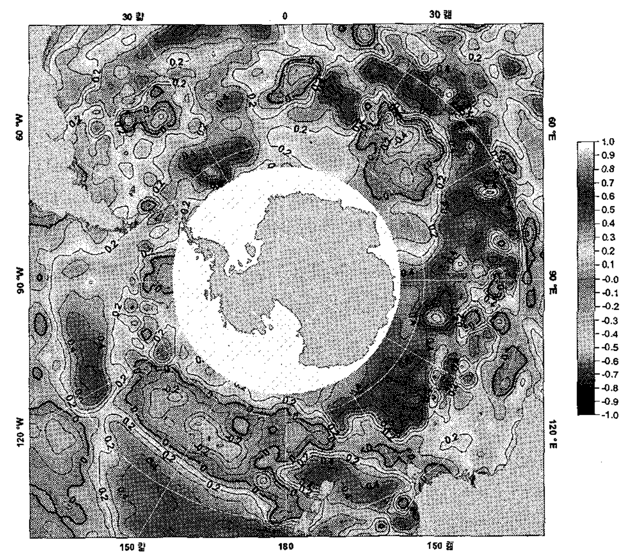

Figure 10. Map of SLA interannual trends (cm/yr).

3. RESULTS

According to the obtained results SST has positive trend higher than 0.01±0.005 °C/yr for 24-yr record (1982-2005) within 300–1000 km northward of the Antarctic coast (fig. 9). However, on average for the Southern Ocean it has negative trend of about -0.02±0.003 °C/yr.

In the area between the Southwest Pacific Basin and Pacific-Antarctic Ridge, and southward of the Argentine Basin and Mid Atlantic Ridge SST trend is more than -0.065±0.007 °C/yr.

Sea level anomalies or absolute sea level increases in all area of the Southern Ocean (fig. 10) and has average rate of about 0.24±0.026 cm/yr for 12-yr record (1993-2005). However it has a negative trend about -0.21±0.05 cm/yr in area between the Southwest Pacific Basin and

Pacific-Antarctic Ridge. In the southeastern part of the Argentine Basin and southward of the Cape Basin rate of the sea level change is more than -0.11±0.03 cm/yr. To the northeast of the Enderby Abyssal Plain sea level decreases with a rate of -0.19±0.07 cm/yr .

ACKNOWLEDGEMENTS

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