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CORRELATION BETWEEN SOUTHERN OSCILLATION INDEX AND TOTAL OZONE COLUMN USING BREWER AND TOMS AT SOUTHERN BRAZIL (29.4°S, 53.8°W) FROM 1997 TO 2003

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ABSTRACT

Total Ozone Column data in a station in the Brazilian Southern Space Observatory (29.4ºS, 53.8ºW) have been obtained using the MKIV (1997 – 2000), MKII (2000 – 2002) and MKIII (2002 – 2003) Brewer Spectrophotometers. The Total Ozone column data measured by the TOMS instruments in a grid point close to this station for the period from 1997 to 2003 is also used. The spectrophotometers measure Total Ozone Column on the wavelengths: 306.3, 310.1, 313.5, 316.8 and 320.0 nm with an accuracy of about 1 percent, while TOMS measures on**:** 317.5 and 331.2 nm with error of about 2 percent. These data are used to study the Total Ozone Column interannual variability in the Southern Brazil. The El Niño - Southern Oscillation (ENSO) phenomenon cycle is measured by the Southern Oscillation Index (SOI). This index gives information on the phase and the intensity of the event and it is the standardized difference between the sea level pressure anomalies in Tahiti and Darwin. Monthly ozone climatological means for both equipments were calculated using the base period from January/1997 to December/2003, totalizing seven years. The differences between the monthly ozone and the corresponding monthly ozone climatological mean give the monthly ozone anomalies (OA). The monthly OA for the Brewer and for the TOMS instruments show similar behaviors. In addition the linear correlations between the OA and the SOI are of 0.45 for the TOMS instruments and of 0.53 for the Brewer instrument. Accordingly to a Student t-test these correlations are statistically significant. Therefore, these correlations suggest a reduction (an increase) of Total ozone in the Southern Brazil during El Niño (La Niña) episodes.

INTRODUCTION

The ocean occupies 71% of the Earth surface and it performs fundamental role in modulating the climate variability through dynamics and thermodynamics processes in its interaction with the atmosphere. During the El Niño episode, the ocean-atmosphere interaction occurs at Tropical Pacific Ocean and it causes modification in the atmospheric circulation what results in climatic disasters as: floods, high temperatures, droughts, etc,... in several regions of the Globe. The modifications at sea surface temperature and air pressure during El Niño - La Niña episodes cause reduction – increase, respectively, in ozone total column at Pacific Coast and its effects can be extended to Southern Brazil due to convection increasing.

METHODOLOGY

SOI – SOUTHERN OSCILLATION INDEX

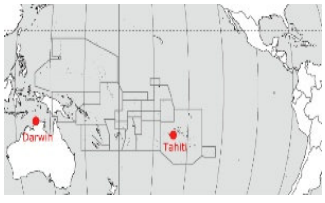

Fig. 1 – Darwin and Tahiti located at the Pacific Ocean.

It is the difference of air pressure between Tahiti and Darwin which expresses the intensity and phase of El Niño Southern Oscillation (ENSO). During El Niño event (negative phase), air pressure is below-normal at Tahiti and above-normal at Darwin. During La Niña event (positive phase), opposite conditions are observed.

OA – OZONE ANOMALY

The ozone anomaly is the difference between the monthly ozone mean (MO) and the monthly ozone climatological mean (MOC) calculated at Southern Space Observatory (SSO).

AO = MO – MOC

EQUIPMENT USED

➢ **Brewer Spectrophotometers** MKII, MKIV and MKIII were used in this analysis to obtain the ozone total column in Southern Brazil, Figure 2. Brewer MKIII #167 is installed at Southern Space Observatory (Lat. 29.4º S, Long. 53.8º W), located at São Martinho da Serra, RS, Brazil, Figure 3 and 4.

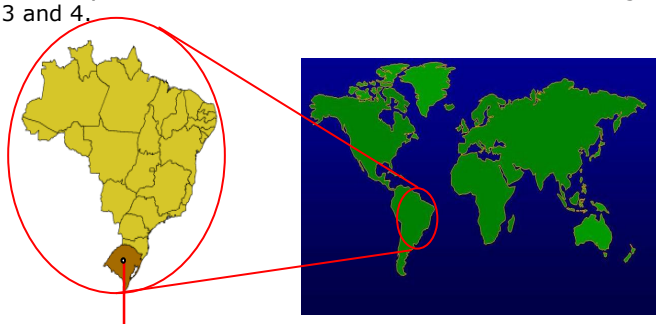

Fig. 2 – Brazil located at world map.

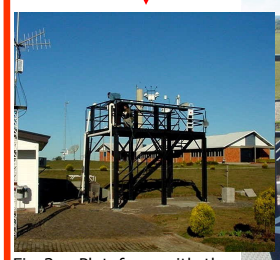

Fig 3 – Plataform with the instruments installed at Southern Space Observatory.

Fig. 4 – Brewer MKIII at SSO.

General Characteristi

✓ Ozone total column measured at: 306.3, 310.1, 313.5, 316.8 and 320.0 nm;
✓ Double monochromator;
✓ Resolution: 0.6 nm;
✓ Accuracy: ±1%.

In the time period of this analysis three Brewers have been used at SSO.

Brewer MKVI # 081 operated from 1997 to 2000, Brewer MKII #056 operated from 2000 to 2002 and finally Brewer MKIII #167 is in operation since 2002. For this study, only DS (Direct Sun) data were used.

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➢ **Total Ozone Mapping Spectrometer (TOMS)** was used to compare with Brewer ozone total column data. TOMS instruments are carried on board the Earth Probe spacecraft.

General Characteristics:

✓ Ozone total column measured at 317.5 and 331.2 nm;
✓ Error: ± 2%;
✓ Earth Probe spacecraft is operating since 2000;
✓ Data used: Version 8

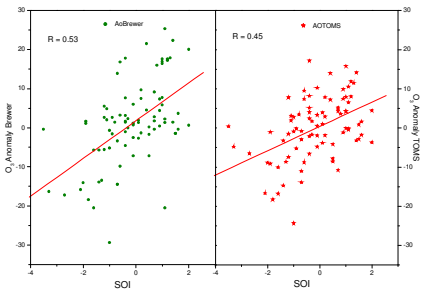
➢ **A net of buoys** are spread out over Pacific Ocean, they provide data and permit the monitoring of air pressure. These data are used to obtain the Southern Oscillation Index by the National Centers for Enviromental Predictions (NCEP).

EL NIÑO/ LA NIÑA OCCURRENCE IN THE PERIOD ANALYZED

EL NIÑO: Jan/1997 – Apr/1998 LA NIÑA: May/1998 – Apr/2001

RESULTS AND DISCUSSIONS

In this analysis, monthly means were used due to some interruptions on Brewer's data caused by rainy days and equipment changes. Monthly ozone anomalies were calculated, for the period proposed at SSO, using Brewer and TOMS data and correlated to SOI, Figure 5 (a) and (b), respectively.



(a) (b)

FiG. 5 - Correlation between ozone anomaly by Brewer (a) and SOI, and TOMS (b) and SOI.

SOI is negatively correlated with Brewer and TOMS OA, R = - 0.53 and R = - 0.45, respectively. Considering a serie of 84 values for each correlation, accordingly to a Student t-test, these correlations are statistically significant.

In order to compare OA and SOI, they were analyzed for the time period, 1997 to 2003, Figure 6. In Figure SOI is represented on the left scale and Brewer and TOMS OA scale are represented on right. It is possible to observe that OA follow SOI what indicates the variation of ozone total column with El Nino and La Nina episodes.

During El Nino episodes, Pacific Ocean water is warmer more than normal and due to atmosphere-ocean interaction the atmosphere becomes warmer, increasing tropopause altitude, called *Tropopause effect*. Due to this effect, more ozone molecules will be at Troposphere and these molecules are going to react chemically with tropospheric compounds, which decreases ozone total column. In addition, *advection effect*, can contribute to ozone total column decrease by countergradient flow (Hasebe, 1993). These effects mentioned above were proposed for Pacific water, but due to increasing in convection during El Niño episodes, the consequence of these effects can be expanded to Southern Brazil, consistent with previous work (Kayano, 1997; Ambrizzi et al., 1998).

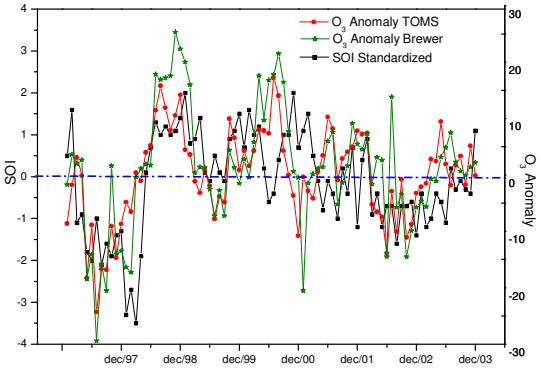


Fig. 6 - Comparison of SOI, Brewer and TOMS OA data from 1997 to 2003.

In order to quantify the increasing - reduction on ozone total column, a ratio between MO and MOC was calculated for Brewer and TOMS equipments. For El Niño episode reductions of 3.4% ±3.7 and 3.1% ±2.7 were obtained for Brewer and TOMS, respectively, while for La Niña episode increasings of 2.4% ±3.7 and 1.3% ± 2.4 were obtained for Brewer and TOMS, respectively. It is observed that the ozone reduction is higher than ozone increasing, that occurs because of El Niño intensity which was much stronger than La Niña episode. It can be observed in Figure 6 through SOI.

The increasing - reduction found are very significant for the Southern Brazil, where a reduction of 1% on ozone total column implicates on an increasing of about 1% in UV-B Radiation over the region, (Guarnieri, et al 2004).

CONCLUSIONS

✓ The Brewer OA data have been better correlated with SOI than TOMS data, but both correlations are statistically significant, where Brewer data correlation presented R = - 0.53 and TOMS correlation presented R = - 0.45.

✓ Increasing - reduction on ozone total column was observed at Southern Brazil for El Niño - La Niña episodes, from 1997 to 2003.

✓ The reduction on ozone total column during El Niño is higher than the increasing for La Niña. The values reduction/ increasing obtained for Brewer and TOMS were 3.4% ±3.7 and 3.1% ±2.7/ 2.4% ±3.7 and 1.3% ± 2.4, respectively.

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