Long term ozonesonde observations at Marambio, Antarctic Peninsula

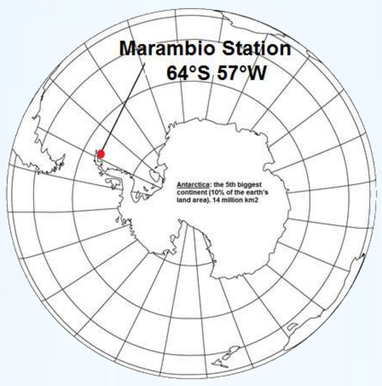
a climatological study of the ozone distribution

R. Sanchez (1), R. Kivi (2), G. Carbajal (1,3), G. Perez Fogwill (1), G. Gambarte (1), G. Copes (1), M. Albertini (1), J. Ferrara (1), M. Mei (4,1)

(1) National Weather Service, Buenos Aires, Argentina, (ozono@smn.gov.ar), (2) Finnish Meteorological Institute, Sodankylä, Finland, (rigel.kivi@fmi.fi), (3) Pontificia Universidad Católica Argentina, Buenos Aires, Argentina, (gcarbajal@smn.gov.ar), (4) Instituto de Investigaciones Científicas y Técnicas para la Defensa, Buenos Aires, Argentina, (mmei@citedef.gob.ar)

ABSTRACT

The ozonesonde measurement program at Marambio was established in late 1980s, soon after the discovery of the Antarctic ozone hole. The Marambio Antarctic Station is located in an island at the North-East of the Antarctic Peninsula, surrounded by Weddell Sea (at 64º14'S - 56º38´W 198 m.a.s.l). The location is suitable for observing Antarctic ozone hole. In addition to the springtime measurements we have also performed regular soundings during other seasons. The soundings have been made by Electrochemical Concentration Cell ozonesondes, using a potassium iodide solution. The sounding system at Marambio is DigiCORA III from Vaisala and the radiosondes are Vaisala RS92-SGP. The sondes measure ozone profiles from surface up to the altitude of 30-35 km. The effective altitude resolution is 100-150 meters. Uncertainty of the stratospheric ozone measurements is about 5%. In this study we present results of the long term measurements. The time series have been recalculated using the knowledge from dual ozone sonde experiments. Some results show high variability in the different layers of the atmosphere during the ozone hole season. The ozone sonde observations are also compared to the available total ozone measurements by a ground based Dobson instrument at Marambio and by satellite borne instruments.

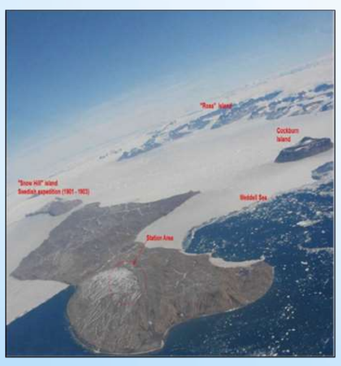


INTRODUCTION

The west circulation of winds, as a result of the "polar vortex", causes strong winds during the winter months in the stratosphere over Antarctica. They insulate the Antarctic weather from the rest of the atmosphere causing temperature decreases and maintains it very low and stable during the winter. During this period, the ozone layer is affected by trapping "Stratospheric Polar Clouds" inside the vortex, witch cause ozone depletion by CFC's reactions. Monitoring the ozone layer over Antarctica to determine the trends, makes a significant contribution to mankind.

From 1988 on, at Marambio Antarctic Station carried out vertical profiles observations with *ECC* ozone sondes launched by joint agreement between the Finnish Meteorological Institute and the Argentine National Weather Service.

The main purpose of this analysis is to study and analyze the seasonally varying ozone climatology and trends. The results of this long term activity are presented showing averaged monthly ozone values based on a large amount of measurements. Both the stratospheric temperature variability and the total ozone amount in specific layers are presented.



Marambio Island: *located in the Antarctic Peninsula, at 64°S, 56°W 198 m.a.s.l. Surrounded by Weddell Sea.*

METHODOLOGY

The 1389 soundings used in this poster cover the November 1988-August 2016 period by using ECC sondes. The frequencies of launchings are variable according to the season and were made following ozonesonde operations procedures specified in the mandatory operating protocols and recommendations described in SOP.

Over the past 28 years, a lot has improved thanks to the changes in technology, e.g. at the beginning the vertical profile resolution from the surface up to an altitude of about 35 km were about 100 m. At present the resolution is higher (~10 m). The software for analysis and apparatus (Vaisala) were furthermore properly updated several times during this period.

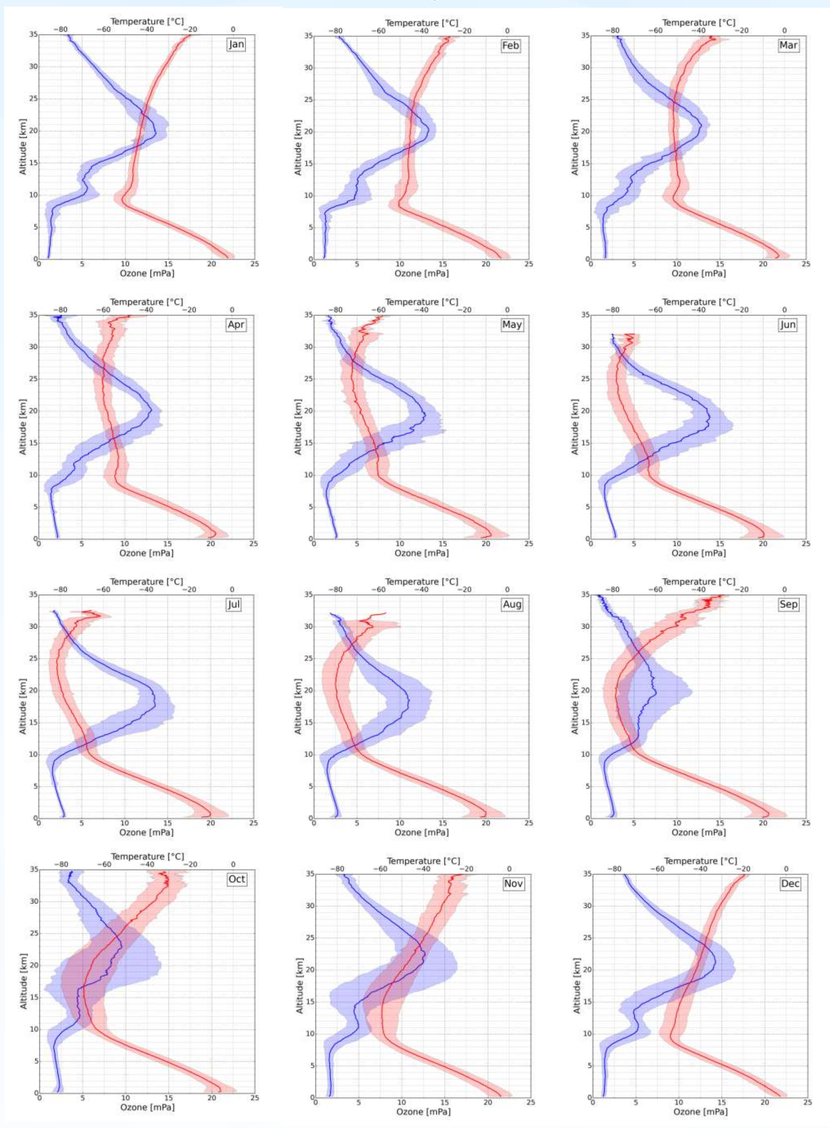
Three types of ECC ozonesondes have been in use since the beginning: the 5A and 6A model (Science Pump Corp.) and the Z model (ENSCI Corp). The latter, with differences in construction and in recommended concentrations of the potassium iodide sensing solution. Since a standard 1 % buffered-KI solution with ENSCI sondes were used at Marambio from 2003 to 2006 (inclusive), there have been larger differences above the expected. We have made a correction for this bias by following the method described in O3S-DQA - Guide Lines for Homogenization of Ozone Sonde Data (Version 2.0: 19.November 2012). *H. Smit et al.*

The batch sounding profiles were corrected by multiplying the ozone partial pressure by m=0.96 for p> hPa, and by m=0.90+0.041*log10(p), for p<30 hPa.

RESULTS

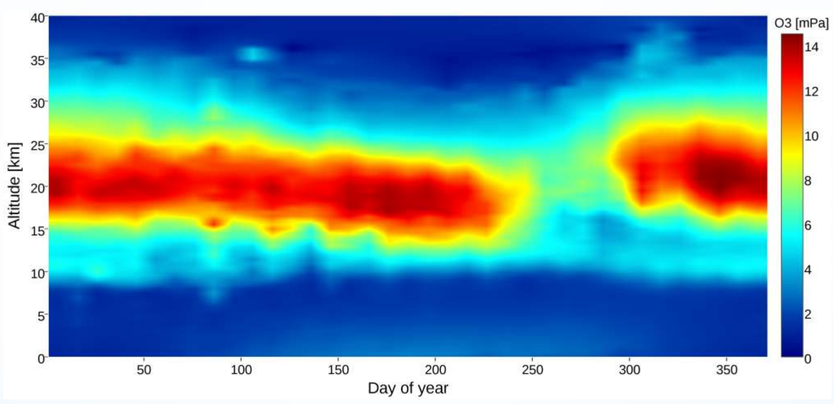
The meteorological conditions in the low stratosphere during the Southern Winter (June-August) set the stage for the seasonal annual cyclic ozone loss phenomena. Temperatures below −78 °C allow the formation of PSCs clouds in the stratosphere and the conditions that would trigger the ozone depletion.

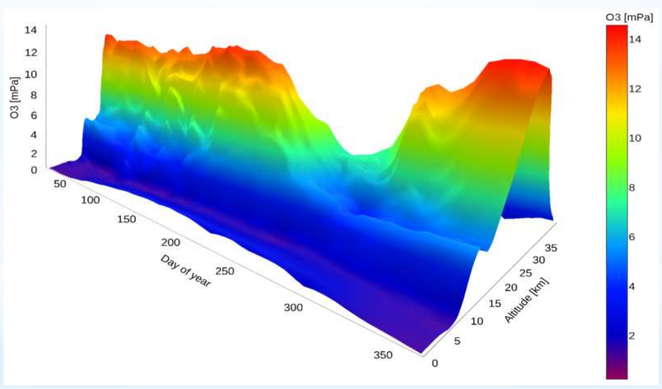
During August-September are the coldest stratosphere conditions; meanwhile in October there are evidences of higher variability in stratospheric temperature and several episode of ozone destruction were observed in a wide vertical range.



Ozone vertical variation during the year (mPa) :

The O3 depletion over Marambio occurs suddenly between day ~235 to ~300. The aim in the near future is to study in more detail the smoothly varying tropopause height and the O3 vertical variation in the range of 5-15 km and the interlink with ozone hole phenomena.

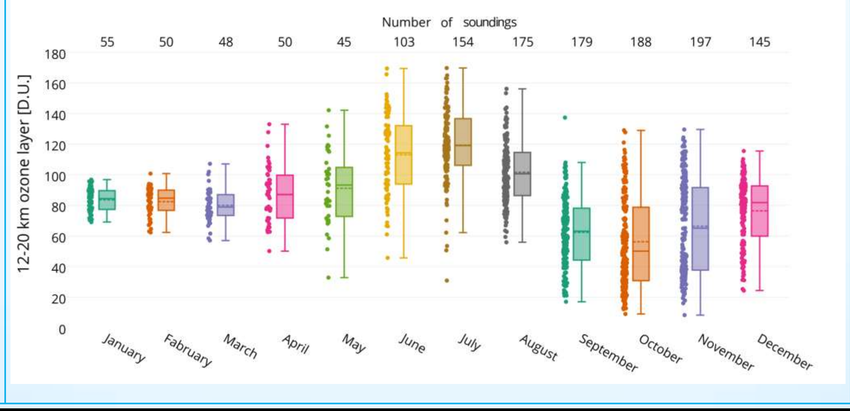




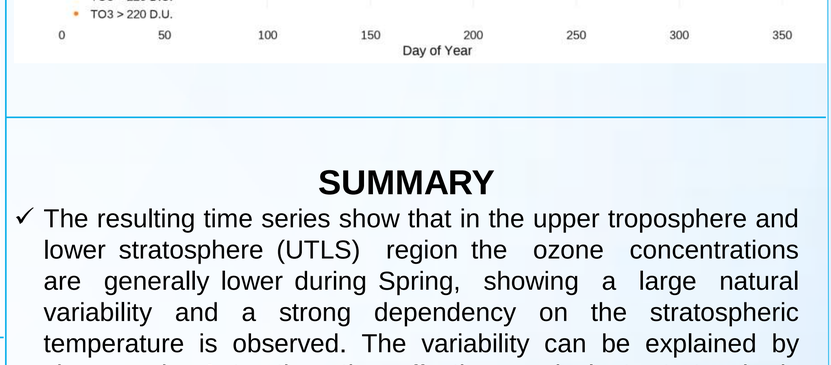
The monthly partial column of ozone in the 12-20km altitude range (D.U):

The rapid ozone destruction process starts during early Southern Spring, when sunlight returns and activate the chlorine production and the catalytic cycle begins.

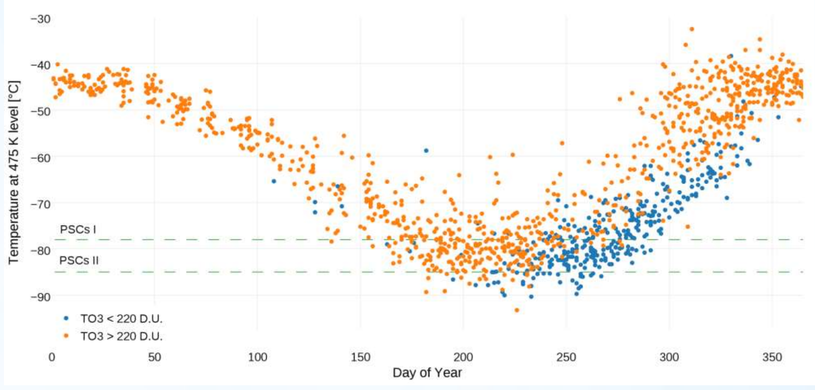
The lines inside the box show the arithmetic mean and median, meanwhile the limits of each box are the quartiles. The whisker maximum and minimum values are shown.



Total O3 column: monthly mean from the sonde, (integral+residual) and ground-based Dobson spectrophotometer #099 observations (DS & ZS Obs. 1988-2016). Dobson measurements are not possible during winter season at this latitude. Column ozone level of less than 220 D.U. is considered as "ozone hole" conditions, as a result of the ozone loss from chlorine and bromine compounds.



Temperatures at the 475 K level: the orange dots show temperatures corresponding to those soundings the results of which were higher than 220 D.U. (outside the ozone hole), while the blue ones are temperatures from that soundings carried out under ozone hole conditions (less than 220 D.U). For this analysis, the balloons that reached an altitude under 21 km have been omitted.



SUMMARY

- ✓ The resulting time series show that in the upper troposphere and lower stratosphere (UTLS) region the ozone concentrations are generally lower during Spring, showing a large natural variability and a strong dependency on the stratospheric temperature is observed. The variability can be explained by changes in Antarctic the effective equivalent stratospheric chlorine (EESC) and meteorological conditions while in the upper stratosphere (range 25-30km) the ozone concentrations maintain a similar amount along the year.
- ✓ In the troposphere, mean profiles show a stable tendency of ozone concentrations over the year as well.
- ✓ The ozone sondes record provides the relevance source for deriving ozone trends in the troposphere and UTLS, especially during seasons when the sunlight is not present and it is not possible to use other ozone observational methods.
- ✓ Each flight providing complement measurements to the ozone and temperature information, such as vertical profiles of wind, pressure and RH% is crucial for a further research by inter-linked strands to understand the concept of the evolution and changes in the Antarctic atmosphere.
- ✓ It is important to continue monitoring the ozone layer to be sure that we are on the right track according to the Montreal Protocol objectives and observing the predicted ozone layer long-term recovery in the next decades.

REFERENCES

Solomon S. 1999. Stratospheric ozone depletion: A review of concepts and history. Rev. Geophysics. 37 : 275 – 316

O3S-DQA Activity: Guide Lines for Homogenization of Ozone Sonde Data (H.Smit et al)

WMO Antarctic Bulletin (by G.Braathen)

Ozone Loss Rates over the Arctic and Antarctic Measured with the Match Approach (Streibel, M. et. al)

GRUAN OZONESONDE TECHNICAL DOCUMENT
Version 1.1.0.3 (http://croc.gsfc.nasa.gov/shadoz/)

WMO Report #201 Quality Assurance and Quality Control for Ozonesonde Measurements in GAW by Herman G.J. Smit and the Panel for the Assessment of Standard Operating Procedures for Ozone sondes (ASOPOS) (http://www.wmo.int)

ACKNOWLEDGEMENT

The present work is supported by FMI and SMNA. We want to thank the people that were involved since the beginning: Prof. Kyrö, Ing. Máximo Ginzburg, Dr. Petteri Taalas, Mr. Mario García & Lic. Eduardo Piacentini among others.

Gratefully acknowledged to the Argentina Air Force and all the operators at Marambio Station.

Many thanks to Dr. G. Braathen of the WMO/GAW programmes for reflecting the results in WMO Antarctic Ozone Bulletins.

Most of the ozone sonde data are available in WOUDC. The complete set of data files will be submitted in near future (http://www.woudc.org)