

**10th Meeting of the Ozone Research Managers of the Parties to the Vienna Convention for  
the Protection of the Ozone Layer  
Mar 28-30, 2017, WMO, Geneva, Switzerland**

**Chile – National Report**

**INTRODUCTION**

Chile is located in Southern South America, from 17°30' S in the north to 56°30' S (Cape Horn), bordering the South Pacific Ocean. Chile stretches over 4,300 km (2,700 mi) along the southwestern coast of South America from north to south, Chile extends 4,270 km (2,653 mi), and yet it only averages 177 km (110 mi) east to west.

The most austral region of Chile is the nearest one to the continent Antarctic, therefore that during the activity of the Hole of Ozone Antarctic in every spring season is possible to measure events of depletion of the ozone column in the most austral region of Chile. In this way the activities of observation of ozone column and ultraviolet radiation are of great importance for the international scientific community.

**1 ACCOMPLISHMENT OF THE 9<sup>TH</sup> ORM RECOMMENDATIONS**

Many of the recommendations of the 9<sup>th</sup> meeting for developing countries during the period 2014-2016 have been accomplished or efforts have been made to develop research in stratospheric ozone and ultraviolet radiation. In this sense, the projects should be noted between Chile, Japan and Argentina in Patagonia.

**2 OBSERVATIONAL ACTIVITIES**

Continuous monitoring of UV radiation in major cities is mainly operated and maintained by the National Meteorological Service of Chile (DMC, Dirección de Meteorología de Chile). Observations of total column ozone from spectroradiometer Brewer are carry out only in one station, in southern Chile (Punta Arenas), operated and maintained by the University of Magallanes (Umag). Ozone profile measurements, two stations are operating: in Isla de Pascua (Eastern Island) since 1995 and in Punta Arenas during 2009-2012 and 2014-now periods were carried out continuous observations with ECC ozonesonde. Two new stations are carry out

observations of solar spectrum and ozone column, this projects are maintained by the University of Santiago (USACH): Transportable Antarctic Research Platform (TARP-04) became operational in July 2016 on the Chajnantor plateau (located at 5,100 meters above sea level in the Atacama desert, nearby the ALMA Observatory). TARP-04 is a twin unit of TARP-02, deployed early 2015 on King George Island (62° 12' S; 58° 57' W, Antarctic Peninsula). TARP-04 is fitted with state-of-the-art instruments aimed at measurements of the solar spectrum.

The following tables are the detailed measurements activities according with specific variables.

## 2.1 Ozone Column Measurements

Station	Instruments	Institution	LAT.	LONG.	Period of observations	Calibrations
Punta Arenas	Brewer MKIV 068	University of Magallanes	53°18'S	70°54'W	1992-2000	
Punta Arenas	Brewer MKIII 180	University of Magallanes	53°18'S	70°54'W	2002 – Jun.2006	2003-2004
Punta Arenas	Brewer MKIV 124	University of Magallanes (Chile)- INPE (Brazil)	53°18'S	70°54'W	Aug.2007- Nov.2007	
Punta Arenas	Brewer MKIII 180	University of Magallanes	53°18'S	70°54'W	Nov.2007-today	2007-2009-2015

## 2.2 Ozone Profile Measurements

Station	Type	Institution	LAT.	LONG.	Period of observations
Punta Arenas	Umkehr	University of Magallanes	53°18'S	70°54'W	2002 – today
Punta Arenas	Ozone sondes -ECC-Z LMG6	University of Magallanes	53°18'S	70°54'W	2009 – today
Eastern Island	Ozone sondes ECC	DMC	27°09'S	109°27'W	1994- today

DMC: Dirección Meteorológica de Chile (National Meteorological Service)

## 2.3 UV Measurements

### Broadband

Station	Instruments	Institution	LAT.	LONG.	Period of observations
Arica	Solar Light 501	University of Atacama	13° 28'S	70° 20'W	1998 - 2005
Santiago	Solar Light 501	University of Santiago	33°26'S	70°40'W	1999 - today

Puerto Natales	Solar Light 501	University of Magallanes	51° 43'S	72° 31'W	1997 - today
Punta Arenas	Solar Light 501	University of Magallanes	53°18'S	70°54'W	1997 - today
Puerto Porvenir	Solar Light 501	University of Magallanes	53° 17'S	70°22'W	1997- 2002
Puerto Williams	Solar Light 501	University of Magallanes	54° 55'S	67° 37'W	1997 - 2010
Bernardo O'Higgins Station (Antarctic)	Solar Light 501	University of Magallanes	63°19'S	56°54'W	2007 - 2014

### DMC UV Network

STATION	TYPE	LAT	LONG	ELEV	PERIOD OF OBSERVATIONS
Arica	Pyranometer YES UV-B	18° 28' S	70° 19' W	23m	2006 – today
Iquique	Pyranometer YES UV-B	20° 33' S	70° 07' W	60m	1998 – today
María Elena	Pyranometer YES UV-B	22° 21' S	69° 40' W	1241m	2008 – 2010
San Pedro de Atacama	Pyranometer YES UV-B	22° 55' S	68° 12' W	2450m	2007 – today
Antofagasta	Pyranometer YES UV-B	23° 27'S	70° 26' W	145m	2006 – today
Isla de Pascua	Biometer Solar Light	27° 09' S	109° 26' W	47m	2009 – today
Desierto de Atacama	Pyranometer YES UV-B	27° 15' S	70° 46' W	204 m	Dec.2011- today
La Serena	Pyranometer YES UV-B	29° 54' S	71° 12' W	25m	2003 – today
El Tololo	Pyranometer YES UV-B Kip –Zonen /Li-Cor	30° 10' S	70° 48' W	2030m	1997 – today
Valparaíso	Biometer Solar Light	32° 56' S	71° 28' W	131 m	2002 – July 2012
	Pyranometer YES UV-B	33° 2' S	71° 37' W	28 m	July 2012- today
Farellones	Pyranometer YES UV-B	33° 21' S	70° 17' W	2746m	2011 – today
Valle Nevado	Pyranometer YES UV-B	33° 21' S	70° 15' W	3015m	2006 – 2009
Santiago- Pudahuel	Pyranometer YES UV-B	33° 23' S	70° 47' W	475m	1992 – 2006
Santiago- Quinta Normal	Pyranometer YES UV-B	33° 26' S	70° 40' W	520m	2002 – today
Rancagua	Pyranometer YES UV-B	34° 10' S	70° 46' W	491m	2010 – today
Talca	Pyranometer YES UV-B	35° 25' S	71° 40' W	100m	2010 – today

STATION	TYPE	LAT	LONG	ELEV	PERIOD OF OBSERVATIONS
Concepción	Pyranometer YES UV-B	36° 46' S	73° 03' W	8m	2002 – today
Termas Chillán	Pyranometer YES UV-B	36° 54' S	71° 24' W	1708m	DIC 2013- today
Temuco- Universidad Católica de Temuco	Pyranometer YES UV-B	38° 42' S	72° 32' W	153 m	2012-today
Valdivia – UACH	Spectroradiometer SUV 100	39° 48' S	73° 14' W	9m	1998 – 2007
Valdivia – Cecs	Pyranometer YES UV-B	39° 49' S	73° 15' W	18m	2010 – today
Puerto Montt	Pyranometer YES UV-B	41° 25' S	73° 05' W	85m	2001 – today
Coyhaique	Pyranometer YES UV-B	45° 35' S	72° 07' W	310m	2001 – today
Punta Arenas	Pyranometer YES UV-B	53° 00' S	70° 51' W	37m	2001 – today
Centro Meteorológico Antártico Presidente Eduardo Frei	Pyranometer YES UV-B	62° 25' S	58° 53' W	10m	1992 – today

### Narrowband filter instruments

Station	Instruments	Institution	LAT.	LON.	Period of observations
Santiago	GUV 511	University of Chile	33°26'S	70°40'W	1995 – today
Valdivia	GUV 511	University Austral	39°48'S	73°14'W	1995 – 2007
Punta Arenas	GUV 511	University Magallanes	53°18'S	70°54'W	1993 – today
Punta Arenas	NILU UV	University of Magallanes	53°18'S	70°54'W	2010 – today
Base Prof. Julio Escudero	NILU UV	University Magallanes	62°12'S	58°57'W	2005 – 2009

### Spectroradiometers

Station	Instruments	Institution	LAT.	LON.	Period of observations
Valdivia	SUV 100	DMC-Austral University	39°48'S	73°14'W	1997 – 2007
Punta Arenas	Brewer MKIII 180	University of Magallanes	53°18'S	70°54'W	2002–today

## Radiometers

Station	Instruments	Institution	LAT.	LON.	Period of observations
Chajnantor Plateau Atacama Desert	Bentham Double Monochromator	University of Santiago (USACH)	23°1'S	67°5'W	2016-today
Santiago	Bentham Double Monochromator	University of Santiago (USACH)	32°27'S	70°41'W	2013-today
Escudero Antarctic Peninsula	Bentham Double Monochromator	University of Santiago (USACH)	62°1'S	58°6'W	2015-today

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### 3 Calibration activities

- a) **DMC-network:** In collaboration with University of Santiago (USACH), had been developed calibration activities in following dates:  
November 2013, one week  
April 2014, one week  
February-March 2015, one week  
Reference instrument: Bentham Monochromator.
- b) **BREWER 180 (Punta Arenas):** The last calibration carry out for International Ozone Services Inc. (IOS) did the ozone and UV calibration and service of Chilean Brewer Spectrophotometer #180 during November 2015 at Punta Arenas, Chile.
- c) **Biometers network (University of Magallanes):** The Solar Light instruments of the group of the University of Magallanes are calibrated each two year using the Brewer 180 located in Punta Arenas.

### 4 RESULTS FROM OBSERVATIONS AND ANALYSIS

#### Results of Studies at Punta Arenas Chile (Lat. 53S, Long. 70W).

The Brewer observations have been operational at Punta Arenas from May 1992 until today. The Fig. 1

was constructed using TOMS data(1978-1992), Brewer #068 (1992-2000) and Brewer #180 (since year 2002). This Figure shows the variation of the ozone column with monthly mean. A polynomial fit (order 2) shows a slight increase in the total ozone column at Punta Arenas, and the recovery of the ozone column values to pre 80 should occur approximately between 2030-2040.

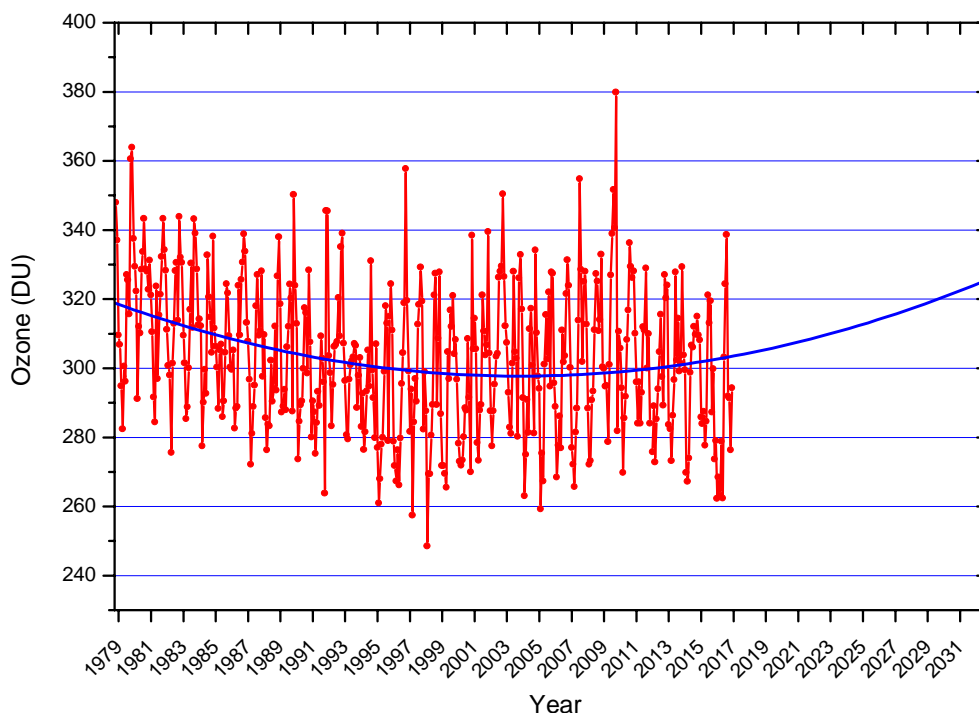


Fig.1 - Ozone over Punta Arenas Chile 1978-2016 obtained with TOMS and Brewer spectroradiometer (# 068 and # 180).

The number of days in which the Antarctic Ozone Hole (AOH) has been over South cone region varies year to year. Figure 2 shows the number of events of low ozone to Punta Arenas. The criteria for defining an event of low ozone is that ozone column (daily average) must be lower than the reference (mean monthly climatological values for Punta Arenas from TOMS overpass data for the period 1978-1987), minus twice the standard deviation of the mean (mean monthly -  $2\sigma$ ). The number of days per year is shown in part (a), these data show a cyclical variability of about 10 years. Last three years shows significant minimum, if these values remain low during next years it would be a sign of recovery of total column ozone to pre-80 values.

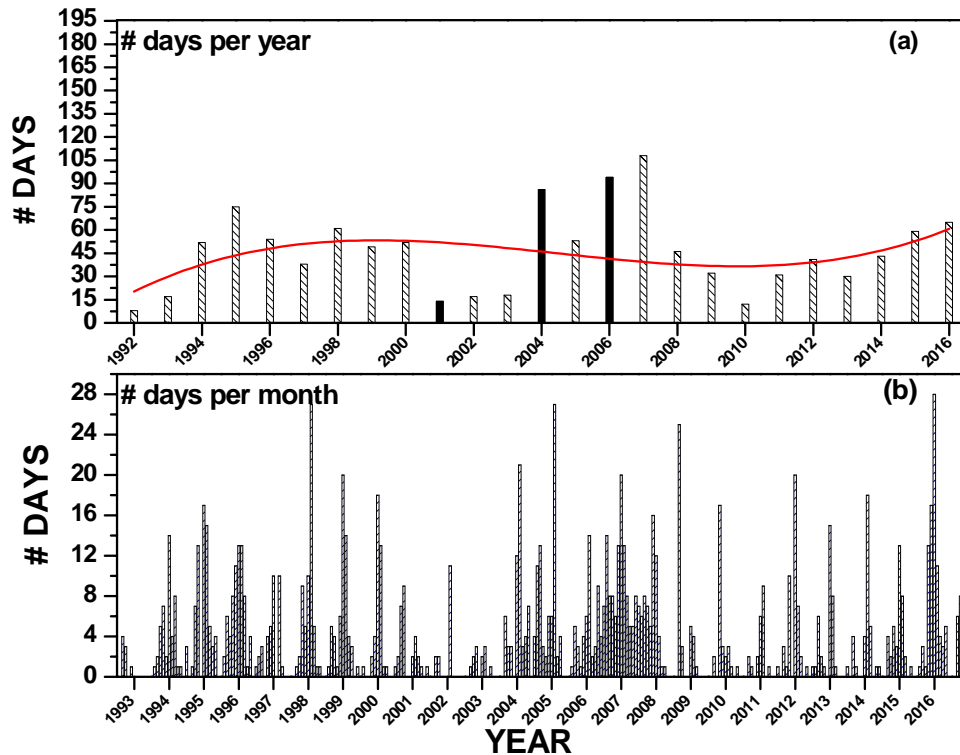


Fig. 2.- Number of days per year under the climatological (1978-1987) average minus two standard deviations, period 1992-2016.

## 5 DISSEMINATION OF RESULTS

### Data reporting

#### University of Magallanes stations

- Data from Brewer 180 being sent to the WOUDC.
- Data of ozone profiles obtained in Punta Arenas being sent to the WOUDC.

#### DMC stations

- Submission of UVI data to the WOUDC in process.
- Submission of greenhouse gases data (CH<sub>4</sub>, CO, CO<sub>2</sub>, O<sub>3</sub>) from GAW station Tololo to WDCGG, on March 2016.

### Information to the public

National Meteorological Service (DMC)

- UVI Hourly Monitoring online.
- UVI daily Forecast, by 24 hours, with Clouds.
- UVI daily forecast by three days. Without Clouds.  
University of Magallanes
- Since 1999 the Ozone Laboratory and RUV of the University of Magallanes provides a UV-Index daily forecast during spring and summer time (TEMIS).

## 6 RELEVANT SCIENTIFIC PAPERS 2014-2016

Cordero R.R., Damiani A., Seckmeyer G., Jorquera J., Caballero M., Rowe P., Ferrer J., Mubarak R., Carrasco J., Rondanelli R., Matus M., Laroze D., The Solar Spectrum in the Atacama Desert, *Sci. Rep.* (2016), 6, 22457

Cordero R.R., Seckmeyer G, Damiani A, Jorquera J, Carrasco J, Muñoz R., Da Silva L., Labbe F, Laroze D, Aerosol Effect on the UV Irradiance in Santiago de Chile, *Atmospheric Research* 149 (2014) 282–291.

Damiani A, Funke B, López-Puertas M, Gardini A, von Clarmann T, Santee ML, Cordero RR, Changes in the composition of the northern polar upper stratosphere in February 2009 after a sudden stratospheric warming, *Journal of Geophysical Research – Atmospheres* (2014), 119(19), 11-429.

Cordero, R.R., Damiani A., Carrasco J, Ferrer J., Rayas J., Jorquera J., Tobar M., Labbe F., Laroze D., “UV Irradiance and Albedo at Union Glacier Camp (Antarctica): a case study”, *Plos One* (2014), 9(3): e90705

Damiani A, Cordero RR, Laurenza M. Rafanelli C., “Cloud cover and UV index estimates in Chile from satellite-derived and ground-based data”, *Atmospheric Research*, (2014) 138 139–151.

Cordero RR, Seckmeyer G, Riechelmann S, Damiani A, Labbe F, D. Laroze, “The world’s highest levels of surface UV”, *Photochem. Photobiol. Sci.*, (2014) 13 70 - 81

## 7 FUTURE PLANS

The research group of the University of Magallanes will be continue ozone observations. Collaboration with other groups will be intensified, especially with the CEILAP group in Rio Gallegos.

DMC: 1) Capacity Building and Twinning for Climate Observing Systems, CATCOS Project. GAW station EL Tololo. Greenhouse Gases measurements. Instrument: PICARRO.

2)Project for development of the atmospheric environmental risk management system in South America. Japan (JICA, JST, NIES, Nagoya University), Argentina (SMNA, CITEDEF), Chile (DMC, UMAG). Includes measurements and studies of profile and column of ozone, volcanic ash, aerosols and ultraviolet



radiation. 2013-2018.

## 8 NEEDS AND RECOMMENDATIONS

- Financial support for supplies for ozonesonde of Punta Arenas is a priority, because the “**Project for development of the atmospheric environmental risk management system in South America**”, supported for **Science and Technology Research Partnership for Sustainable Development (SATREPS-Japan)** and the **Japan International Cooperation Agency (JICA)**, will be finished the help to buy ozonesondes.

### **Recommendations 10- ORM**

Provide resources for sustainable, long-term operation and research in developing countries. Several regional centers for Dobson and Brewer instrument calibration have been established. It is of vital importance that these centers receive sufficient support to arrange regular calibration exercises for the instruments in their respective regions.

It is necessary emphasize that the first priority at present for Chile is to maintain their current monitoring of ozone profile at Punta Arenas due Cone of South-America must be still for many years the best region to observe the recovery of Antarctic Ozone Hole

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