

ARGENTINA - National Report

- ACCOMPLISHMENT OF THE RECOMMENDATIONS FROM THE 7TH ORM (2008)

The frequent overpass of the Antarctic Ozone Hole each spring, the extreme UV radiation levels over the northwestern Andean Plateau and their effects put the territory of the Argentine Republic at a strategic situation for atmospheric ozone and solar UV radiation studies. Major issues related to the accomplishment of the 7th ORM recommendations during the period 2008-2011 are:

- Research within Argentine institutions in these subjects is at present significant. There is a strong political decision to sustain the investigations, as many of the research projects are economically supported directly by the Argentine State. Argentine private institutions participate also with increasing interest and support in these research fields.
- Support for collaboration with international projects was also strengthened with both logistic and scientific support, including monitoring and modeling of ozone, UV radiation and related parameters along the National territory and principally in the Argentine Antarctic stations.
- The Regional Calibration Center at the Argentine National Weather Service accomplished the scheduled tasks with the 2010 intercomparisons of South-American Dobson instruments, UV-Biometers and surface ozone instruments.
- New sophisticated equipment has been incorporated by several Argentine institutions (e.g. spectroradiometers), including instrumentation developed in Argentina (e.g. LIDAR).
- The efforts to maintain the monitoring networks are being fruitful. Several databases are reaching an extension of decades, allowing for an estimation of the climatological behavior of measured parameters.
- Satellite databases have been often used in many studies over the region.
- Data for international archiving are being sent currently to the corresponding databases.
- The extent of the springtime Antarctic Ozone Hole each year is still very significant and concerning for the region. Its pass over the continent several times within the period 2008-2011 emphasizes the need to closely follow its monitoring and study.
- The prevention of sunburning-related skin diseases and skin cancer for the population is taken as a subject of Public Health with annual diffusion campaigns. In November 2010, the Argentine Dermatological Society carried out the XVII National Campaign for the prevention of the skin cancer.
- There is an increasing trend to study the ozone-climate interactions within the frame of the Global Climate Change.

The present report is an update of the activities in Argentina and spans the period 2008-2011.

1. MONITORING

The following are the detailed measurement activities at the principal monitoring institutions and its contact address:

- Argentine National Weather Service (SMN)

Contact: MSc. Gerardo Carbajal Benítez

Servicio Meteorológico Nacional. Av. de los Constituyentes 3454, C1427BLS, Ciudad Autónoma de Buenos Aires. Phone: 54-11-51676767 int. 18306. Email: gcarbajal@smn.gov.ar.

Station	Location	Measured Parameters			
		Total O ₃ Column	Surface O ₃	Vertical O ₃ Profile	Broadband Surface UV irradiance
La Quiaca	22.11°S, 65.57°W, 3459m. a.s.l.		X		X
Pilar	31.66°S, 63.88°W, 338 m. a.s.l.		X		X
Mendoza	32.88°S, 68.87°W, 704m. a.s.l.				X
Rosario	32.96°S, 60.62°W, 25m. a.s.l.				X
Buenos Aires	34.61°S, 58.41°W, 25m. a.s.l.	X		X	X
Comodoro Rivadavia	45.78°S, 67.50°W, 46m. a.s.l.	X			X
San Julián	49.32°S, 67.75°W, 62m. a.s.l.		X		X
Ushuaia	54.80°S, 68.27°W, 14m. a.s.l.	X	X	X	X
Marambio	64.23°S, 56.72°W, 300m. a.s.l.	X		X	X

SMN is the WMO South-American Regional Calibration Center for Dobson Spectrophotometers and for UV-Biometers.

Projects in collaboration with: World Meteorological Organization, Finnish Meteorological Institute, Instituto Nacional de Meteorología (INM, Spain), Instituto Nacional de Tecnología Aeroespacial (INTA, Spain), Argentine Antarctic Institute.

- Argentine Antarctic Institute

Contact: Ing. Eduardo Calviño, Téc. Héctor A. Ochoa

Dirección Nacional del Antártico - Instituto Antártico Argentino. Dpto. Ciencias de la Atmósfera Cerrito 1248 - C1010AAZ - Capital Federal. Argentina. Phone: 54-11-4812-0071/72. Email: edcalvino@dna.gov.ar, haochoa@dna.gov.ar

Station	Location	Instruments and Measured Parameters					
		Total O ₃ Column	Surface O ₃	NO ₂ (DOAS)	O ₃ Profile	UV	LIDAR
Marambio	64.23°S, 56.72°W, 300m. a.s.l.	X		X	X	X	
San Martín	68.13°S, 67.13°W, 40m. a.s.l.	X				X	
Belgrano II	77.86°S, 34.62°W, 250m. a.s.l.	X	X	X	X	X	X

Projects in collaboration with: Servicio Meteorológico Nacional (Argentina), Instituto de Física Atmosférica de Roma (IFAR, Italia), Instituto Nacional de Técnica Aeroespacial (INTA, España), el Instituto Nacional de Meteorología (INM, España), Instituto Meteorológico Finlandés (IMF, Finlandia), Observatorio Solar y de Ozono del Instituto Hidrometeorológico de la República Checa.

- Argentine National Institute of Genetics and Molecular Biology (INGEBI) - Capital Federal

Contact: Ing. Susana B. Diaz

Instituto de Investigaciones en Ingeniería Genética y Biología Molecular (INGEBI). Obligado 2490, Capital Federal. Argentina. Phone: 54-11-47832871 int. 14. Email: rqdiaz@criba.edu.ar.

Station	Location	Instrument (Narrowband UV and PAR surface irradiances)	Last Calibration
San Salvador de Jujuy	24.17°S, 65.02°W, 1300m. a.s.l.	GUV-511	Next April 2011
Buenos Aires	34.58°S, 58.47°W, Sea level	GUV-511	2011
San Carlos de Bariloche	41.01°S, 71.42°W, 700 m. a.s.l.	GUV-511	2011
Trelew	43.25°S, 65.31°W, Sea level	GUV-511	2011
Ushuaia	54.83°S, 68.30°W, Sea level	GUV-511	Next Oct. 2011

Projects in collaboration with: National Science Foundation (NSF, USA), Centro Austral de Investigaciones Científicas (CADIC, Argentina), Dirección Nacional de Antártico (DNA, Argentina) y Dirección Nacional de Meteorología (INM, Spain), Instituto Nacional de Tecnología Aeroespacial (INTA, Spain), Programa Nacional para Investigaciones Antárticas (PNRA, Italy).

- Austral Center for Scientific Research (CADIC) - Tierra del Fuego

Contact: Ing. Susana B. Diaz

Instituto de Investigaciones en Ingeniería Genética y Biología Molecular (INGEBI). Obligado 2490, Capital Federal. Argentina. Phone: 54-11-47832871 int. 14. Email: rqdiaz@criba.edu.ar.

Station	Location	Measured Parameters	Instrument	Last Calibration
Ushuaia	54.83°S, 68.30°W, Sea level	Spectral solar irradiance (range: 280-620 nm)	SUV-100 spectroradiometer	2008 (every 15 days with secondary lamps)
		Total O ₃ Column, NO _x	EVA 4	2010
		Narrowband UV and PAR solar irradiance	GUV-511	2008
		Narrowband UV and PAR solar irradiance	NILU-UV	2011
		Total O ₃ Column Spectral solar irradiance (range: 280-325 nm)	Brewer MKIV spectroradiometer	2010

Projects in collaboration with: National Science Foundation (NSF, USA), Instituto de Investigaciones en Ingeniería Genética y Biología Molecular (INGEBI, Argentina), Dirección Nacional de Antártico (DNA, Argentina) y Dirección Nacional de Meteorología (INM, Spain), Instituto Nacional de Tecnología Aeroespacial (INTA, Spain), Programa Nacional para Investigaciones Antárticas (PNRA, Italy).

- Photo-Biological Station “Playa Union” - Chubut

Contact: Dr. Walter Helbling

Estación de Fotobiología Playa Unión. Casilla de Correos N°15 (9103). Rawson, Chubut, Argentina. Phone: 54-2965-498019. Email: whelbling@efpu.org.ar, efpu@efpu.org.ar

Station	Location	Measured Parameters	Instrument
Playa Union	43.30°S, 65.03°W, 10m. a.s.l.	Surface broadband UVB, UVA and PAR solar irradiance	ELDONET surface spectrometer
		Resolution: 1nm. Range: 190-1100 nm	Ocean Optics spectroradiometer
		Underwater broadband UVB, UVA and PAR solar irradiance	ELDONET submersible spectrometer
		Underwater solar irradiance	Ocean Optics submersible radiometer
		- Weather station - Laboratory equipment for biological-sample analysis	

Projects in collaboration with: Universidad de Concepción (Chile), Universidade de Sao Paulo, Fundação Universidade Federal do Rio Grande e Instituto Nacional de Pesquisas Espaciais (Brasil), CONICET, Estación de Fotobiología Playa Unión, Instituto Nacional de Investigación y Desarrollo Pesquero (Argentina), University of South Florida (USA), Centro de Procesamiento de Imágenes y Fundación La Salle (Venezuela), Interamerican Institute for Global Change Research (IAI), National Natural Science Foundation of China.

- Center for Laser Research and its Applications, CEILAP (CITEDEF-CONICET)

Contact: Dr. Eduardo J. Quel

CEILAP. Juan B. de La Salle 4397. B1603ALO - Villa Martelli, Buenos Aires. Argentina. Phone: 54-11-4709-8217. E-mail: equel@citefa.gov.ar

Station		Location	
Río Gallegos		51.60°S, 69.32°W, 15m. a.s.l.	
Instrument	Measurement	Institution	
DIAL LIDAR	Ozone profile between 15-45 km	CEILAP/Argentina	
YES UVB-1	UV erythematous irradiance	CEILAP/Argentina	
SAOZ UV-Vis. Spectrometer	Ozone and NO2 total column	SAOZ Network/France	
Pyranometer	Total solar radiation	CEILAP/Argentina	
GUV 541	Spectral bands at 305, 313, 320, 340 and 380 nm	CEILAP/Argentina	
Brewer Spectrophotometer S/N 124	Total ozone, NO2 and spectral UV every 0.5 nm	INPE/Brasil	
Milimetric waves radiometer	Upper stratospheric-mesospheric ozone profiles between 35 and 80 km	Nagoya University/Japan	

Projects in collaboration with: Network for the Detection of Atmospheric Composition Change (NDACC/NOAA), Laboratorio de Ozono y Radiación Ultravioleta de la Universidad de Magallanes, Punta Arenas - Chile, Japan International Cooperation Agency.

- Institute of Physics of Rosario

Contact: Dr. Rubén Piacentini

Grupo de Radiación Solar – IFIR (CONICET/UNR). 27 de febrero 210bis, 2000, Rosario. Argentina. Phone: 54-341-4472824 int. 30. E-mail: ruben.piacentini@gmail.com

Station	Location	Measured Parameters	Instrument	
Rosario	32.96°S, 60.62°W, 25m. a.s.l.	UV erythemat irradiance	YES UVB-1	
		Total solar irradiance	Kipp & Zonen CM5	
		Broadband Total UV	Kahl TUVR	
		Broadband UVB	EKO UVB	
		Broadband UVA	EKO UVA	
		Surface air quality: CO, NOx and O ₃		
		Surface aerosols size: 0.25-30 µm		
		Portable single monocromator sceptoradiometer with optical fiber		
		Automatic weather station		

Projects in collaboration with: CEILAP (Argentina), Universidad Federal de Pernambuco (Brasil), Japan International Cooperation Agency.

- Institute for Physical-Chemical Investigations – National University of Córdoba

Contact: Dra. Beatriz M.Toselli

Departamento de Físico Química – INFIQC. Facultad de Ciencias Químicas, Universidad Nacional de Córdoba. Ciudad Universitaria, 5000 Córdoba. Argentina. Email: tosellib@fcq.unc.edu.ar

Station	Location	Measured Parameters	Instrument
Córdoba	31.40°S, 64.18°W, 470m. a.s.l.	UV erythemat irradiance	YES UVB-1 (2)
		Total solar irradiance	YES TSP-700
		Spectoradiometer	Ocean Optics USB-4000
		Aerosols with size <10 µm and <2.5 µm	SKC Deployable particulate sampler
		Aerosols size distribution	SIOUTAS-SKC

- Projects in collaboration with: Institut für Chemie und Dynamik der Geosphäre, Forschungszentrum, Juelich (Germany), National Center for Atmospheric Research (USA).

- Institute of Ecology “Fundación Miguel Lillo” - Tucumán

Contact: Dr. Juan A. González, Dr. Fernando Eduardo Prado

Instituto de Ecología - Fundación Miguel Lillo. Miguel Lillo 251, 4000, Tucumán, Argentina. E-mail: lirros@cgcet.org.ar, fepra@csnat.unt.edu.ar

	Location	Measured Parameters	Instrument
San Miguel de	26.83°S, 65.22°W, 400m. a.s.l.	UVB irradiance	portable Solar Light PMA-2100

Tucumán		PAR and Total solar irradiance
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Projects in collaboration with: other Argentine institutions.

- Institute of the Bio-diversity and the Environment (INIBIOMA) - Río Negro

Contact: Dra. María Gabriela Perotti, Dra. María C. Diéguez, Dra. A. Patricia Perez
 INIBIOMA-Centro regional Universitario Bariloche. Universidad Nacional del Comahue. Quintral
 1250, 8400 Bariloche, Argentina. Phone: 54-2944-428505. Email: perottigaby@yahoo.com,
 dieguezmc@gmail.com, perezfotolab@gmail.com

Location		Measured Parameters	Instrument
San Carlos de Bariloche	41.15°S, 71.28°W, 700m. a.s.l.	Narrowband UV channels	GUV 500
		Underwater broadband UV irradiance	Ocean Optics submersible spectrometer
		During 2011 a new equipment will be installed: <ul style="list-style-type: none"> - Automatic weather station - CO₂ monitoring instrument - Aerosols monitoring instrument - Atmospheric Mercury monitoring instrument 	

Projects in collaboration with: other Argentine institutions, BBVA Foundation (Spain), European Union Program "Global mercury observation system".

2. REGIONAL CALIBRATION ACTIVITIES

Three calibration activities of the South-American WMO Network instruments have taken place during 2010 at the Regional Calibration Center for South America - Buenos Aires Central Station of the Argentine National Weather Service. In September 2010 it was developed the IV Regional Intercomparison of surface ozone measurement instruments. In November 2010 it were realized the calibrations of both the Dobson ozone spectrometers and the UV erythemal solar irradiance instruments (UV-Biometers).

The World Meteorological Organization (WMO) Secretariat and the Argentine National Weather Service with close cooperation and assistance of the USA National Oceanic and Atmospheric Administration's Climate Monitoring and Diagnostics Laboratory (NOAA/CMDL) coordinate Dobson calibrations.

The World Meteorological Organization (WMO) Secretariat and the Argentine National Weather Service with close cooperation and assistance of the Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center, coordinate UV-Biometers calibration. The Solar Light 501A reference radiometer from PMOD/WRC was used as reference instrument for this intercomparison.

3. THEORY AND MODELING

- Program for the Study of Atmospheric Processes Related to the Global Change (PEPACG UCA/CONICET) – Capital Federal

Contact: Dr. Pablo O. Canziani

Equipo Interdisciplinario Para el Estudio de Procesos Atmosféricos en el Cambio Global (PEPACG-UCACyT), Pontificia Universidad Católica Argentina. Alicia Moreau de Justo 1600, C1107AFF, Capital Federal, Argentina. Phone: 54-11-4349-0200 int. 2107. E-mail: canziani@uca.edu.ar, pocanziani@gmail.com

PEPACG is the principal research Group where modeling of the physical-chemical properties of the atmosphere, as well as climatological studies of the coupled troposphere-stratosphere system are carried out. Particularly, PEPACG study the dynamics and climatology of the coupled system Troposphere-Stratosphere over the Southern Hemisphere, included the ozone layer and solar UV radiation. PEPACG is cooperating with University of Reading (U.K.) in the development and application of an adaptive grid Chemistry Transport Model, called Adaptive Mesh Refinement or AMR-CTM, which is currently a 2-D model whose resolution adapts locally in order to better solve the evolving stratospheric features. Also included in this work is an interaction with Max-Planck Institut fur Atmospheric Chemie, University of Mainz, in order to install in the AMR-CTM the MECCA-MESSY Chemistry module. Work includes the development of a 2-D and 3-D trajectory code. Areas of study in the period 2008-2011 included: - Dynamic Climatology of the Tropopause over Argentina. - Sudden climate perturbations in the Southern Hemisphere's troposphere and stratosphere. - Cirrus, Tropopause and interchanges troposphere-stratosphere over Argentina.

Modeling of UV radiative transfer in the atmosphere is still limited to 1-D codes using principally the Discrete Ordinates algorithm with semi-spherical correction in the direct component, which is useful for cases of homogeneous-layers composition of the atmosphere.

4. DISSEMINATION OF RESULTS

Data Reporting

The SMN sends total ozone measurements as well as the ozonesonde data routinely to the WOUDC. The database is currently being transformed to the required CSV format. Surface ozone retrievals are submitted to the corresponding center in Japan.

Information to the public

The SMN continues providing a daily national UV Index forecast map for clear and cloudy conditions both in its web page (<http://www.smn.gov.ar>) as well as to the massive diffusion media. All mentioned institutions often provide information to the media. During the ozone hole season SMN, CADIC and PEPACG send to the media frequent reports describing the ozone hole evolution, using satellite retrievals and ground-based information.

In turn, over 50 plenary conferences within congress and other open to the public were given in the different specialties in the period 2008-2011.

Each November, the Argentine Dermatological Society carries out the National Campaign for prevention of the skin cancer.

5. HIGHLIGHTED RESULTS 2008-2011

- Austral Spring Stratospheric and Tropospheric Circulation Interannual Variability [Agosta and Canziani, 2010]

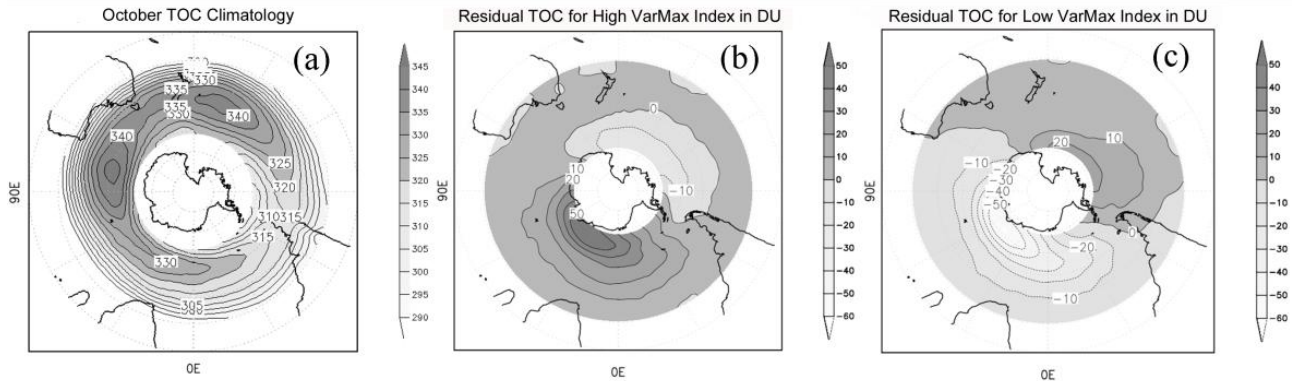


Figure 2: a) October mean TOC 1979-2005 climatology (contours interval: 5DU). Composite residual TOC maps for upper (b) and lower (c) VarMax index quartiles (contour interval 10DU).

- Increased UV radiation at Southern Sub-polar Latitudes in the period 1997–2005 [Pazmiño et al., 2008]

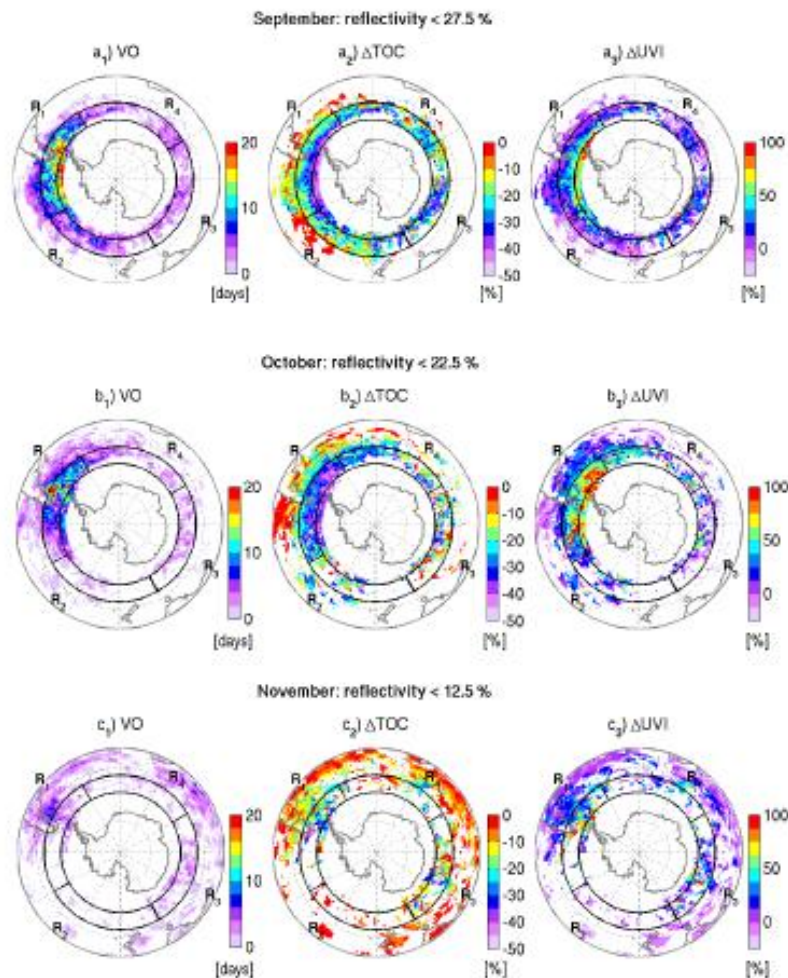


Fig. 6. (1) Number of vortex occurrences (VO), (2) TOC differences and (3) UVI changes for September (a), October (b) and November (c) months over the 1997–2005 period. Latitude band 50°S–60°S is emphasized. Only data corresponding to reflectivity values lower than 27.5%, 22.5% and 12.5%, respectively, are considered.

- Small total O3 columns and high UV radiation over the southern tip of South America during the 2009 Antarctic O3 hole season [de Laat et al., 2010]

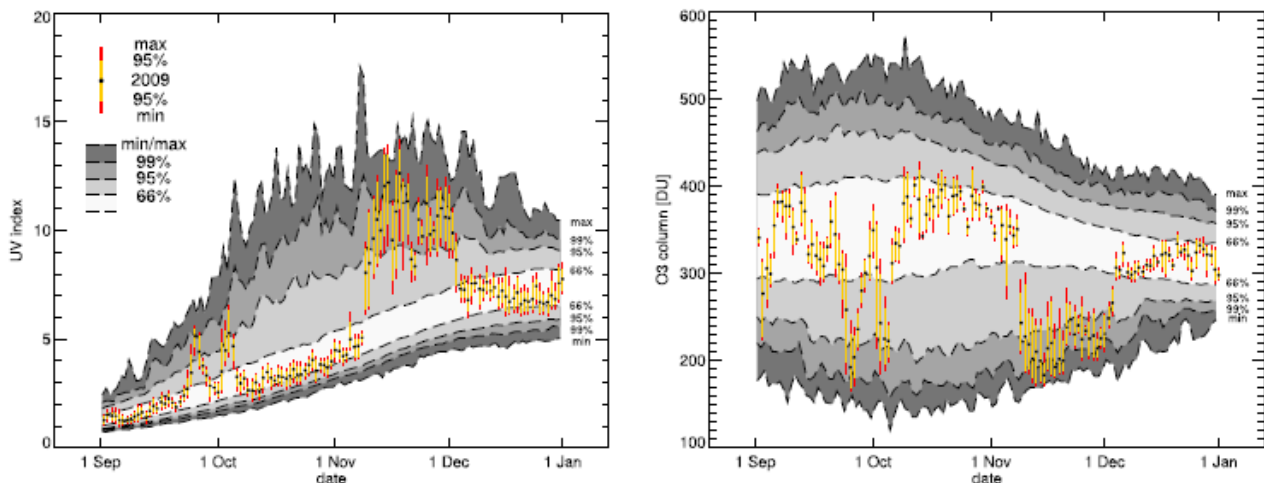


Figure 3. Time series of daily average (left) UVI values and (right) MSR total O3 columns (in DU) for the period 1 September – 1 January. The shaded areas indicate the occurrence intervals of total O3 columns and UVI values for 1979–2008 for the latitude band 52°–56°S. Occurrence intervals are calculated on a daily basis, and intervals are shown for 66%, 95% and 99% as well as the minimum and maximum MSR values. The numbers indicate the percentage of total O3 columns or UVI values that fall within this range. The red/yellow bars represent the 2009 values for the area 52°–56° S, 77°–65° W (see Figures 1 and 2). Mean values are indicated by the black dots, the 2σ root-mean-square of O3 and UVI values within the area are shown by the yellow bars, and the minimum and maximum range within the area are indicated by the red bars.

- UVR exposure for biological systems along a latitudinal gradient [Vernet et al., 2009]

a) DNA	Mean +/- Standard Deviation		Percentage of Total	
	Positive Anomalies	Negative Anomalies	Positive Anomalies	Negative Anomalies
Jujuy	0.155 +/- 0.137	-0.138 +/- 0.115	66%	34%
Buenos Aires	0.098 +/- 0.094	-0.087 +/- 0.100	68%	32%
Santiago	0.059 +/- 0.055	-0.061 +/- 0.086	65%	35%
Valdivia	0.072 +/- 0.076	-0.061 +/- 0.083	63%	37%
Bariloche	0.070 +/- 0.078	-0.059 +/- 0.081	61%	39%
Trelew	0.063 +/- 0.069	-0.057 +/- 0.077	64%	36%
Punta Arenas	0.043 +/- 0.065	-0.027 +/- 0.034	55%	45%
Ushuaia	0.043 +/- 0.063	-0.028 +/- 0.034	55%	45%

b) Phyto-plankton	Mean +/- Dev		Percentage of Total	
	Positive Anomalies	Negative Anomalies	Positive Anomalies	Negative Anomalies
Jujuy	0.594 +/- 0.477	-0.661 +/- 0.423	66%	34%
Buenos Aires	0.466 +/- 0.258	-0.531 +/- 0.421	69%	31%
Santiago	0.284 +/- 0.187	-0.377 +/- 0.375	70%	30%
Valdivia	0.474 +/- 0.260	-0.479 +/- 0.428	65%	35%
Bariloche	0.363 +/- 0.219	-0.488 +/- 0.439	70%	30%
Trelew	0.294 +/- 0.156	-0.435 +/- 0.392	71%	29%
Punta Arenas	0.327 +/- 0.292	-0.291 +/- 0.262	60%	40%
Ushuaia	0.300 +/- 0.293	-0.279 +/- 0.261	60%	40%

Table 7. Statistics of the positive and negative UVR anomalies (1995-2002), a) for DNA and b) for phytoplankton photosynthesis-weighted irradiances.

- Remote sensing of stratospheric O₃ and NO₂ using a portable and compact DOAS spectrometer [Raponi et al., 2011]

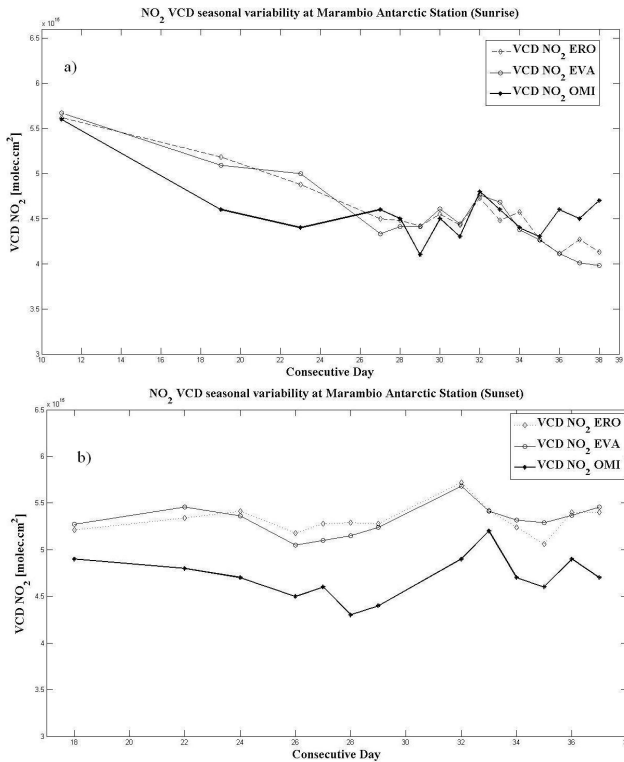


Figure 2. NO₂ VCD variability at Marambio Antarctic Station during (a) the sunrise and (b) the sunset.

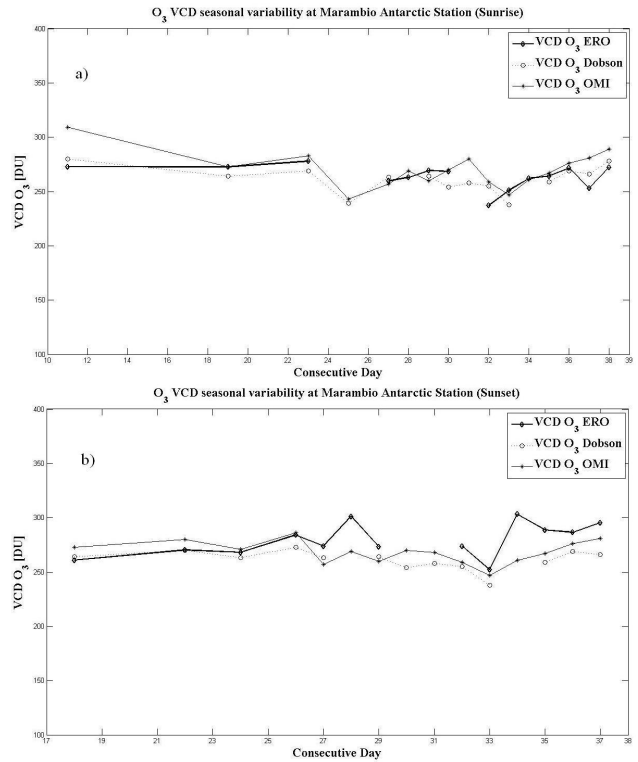


Figure 3. O₃ VCD variability at Marambio Station, during (a) the sunrise and (b) the sunset.

- Effect of clouds on surface UV-B and total solar irradiance at Córdoba, Argentina [López et al., 2009]

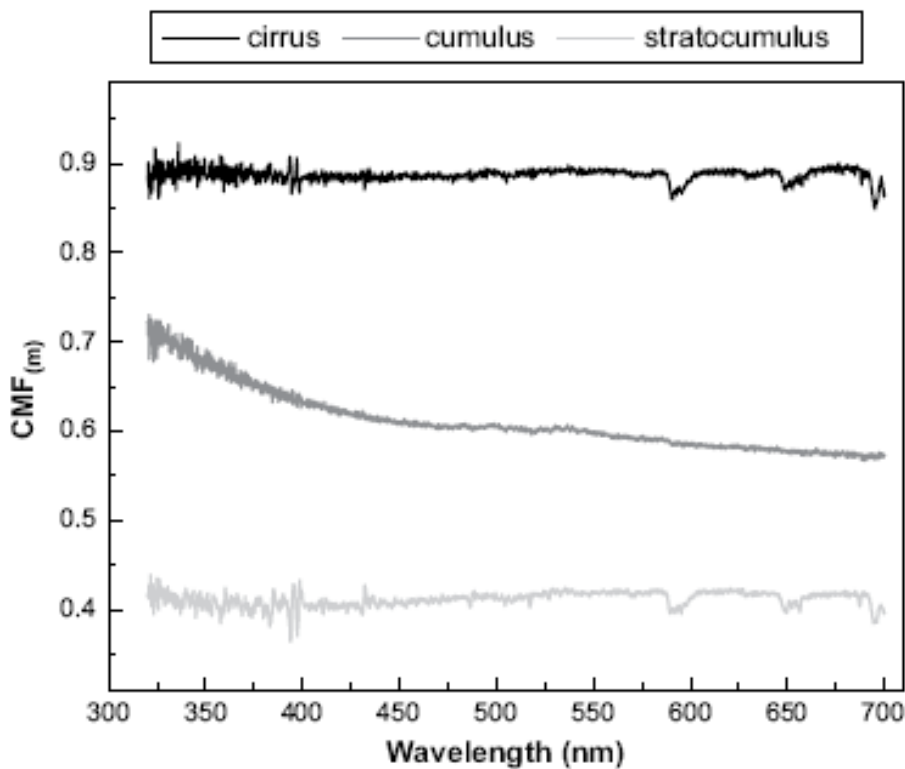


Fig. 5. Modified Cloud Modification Factors (CMF_m) as a function of wavelength for cirrus and cumulus. In the stratocumulus case the CMF was calculated.

- Leaves of *Citrus aurantifolia*'s sensibility to solar UV-B radiation [Ibáñez et al., 2008]

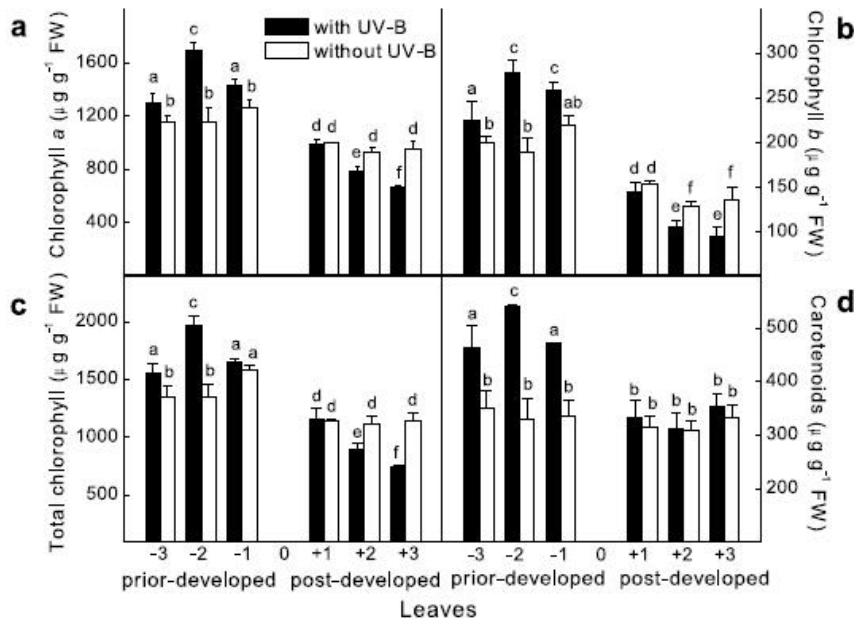


Fig. 2. Changes in the level of photosynthetic pigments in prior-developed and post-developed leaves of *C. aurantifolia* grown with and without solar UVBR. (a) Chlorophyll a; (b) chlorophyll b; (c) total chlorophyll; and (d) carotenoids. Data correspond to the mean (\pm SD) of four replicates. Columns within a grouping marked by a different letter are significantly different at $P \leq 0.05$.

- UVR-induced photoinhibition of summer marine phytoplankton communities from Patagonia [Villafañe et al., 2008]

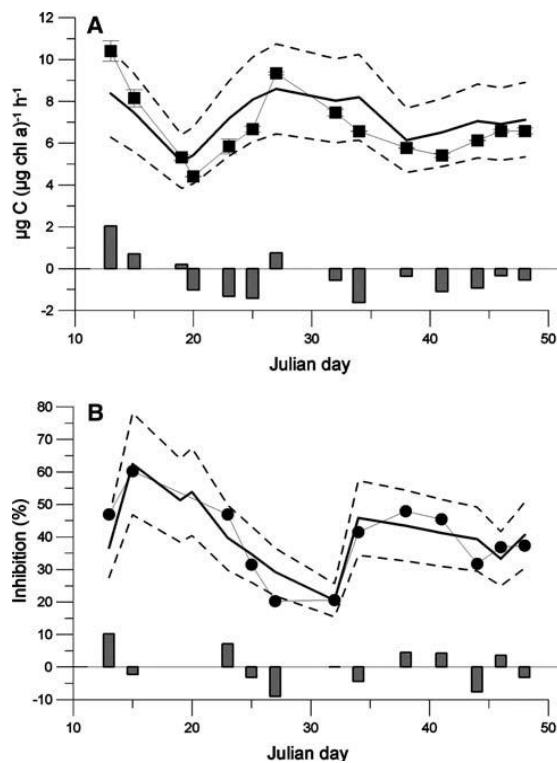


Fig. 7. Output from the multiple linear regression models as compared to the data obtained for the assimilation numbers for the PAR treatment in IC ($\text{lg chl a}^{-1} \text{ h}^{-1}$) (a), and for UVR inhibition (b). The thin lines and symbols are the experimental data while the thick lines are the modeled data; the broken lines represent the 95% limit. The vertical bars in each panel are the residuals from the models.

6. RELEVANT SCIENTIFIC PAPERS 2008-2011

- Agosta E.A. and Canziani, P.O., *Austral Spring Stratospheric and Tropospheric Circulation Interannual Variability*. *Journal of Climate*. doi: 10.1175/2010JCLI3418.1. Accepted 2010.
- Canziani P.O., F.E. Malanca, E.A. Agosta, *Ozone and UT/LS variability and change at Southern midlatitudes: 1980-2000: decadal variations*. *J. Geophys. Res.*, 113, D20101, doi: 10.1029/2007JD009303. 2008.
- Agosta E.A. and Canziani, P.O., *Interannual variations in the Zonal Field of the subpolar latitudes Total Ozone Column during the Austral Spring*. *Geoacta*, accepted 2010.
- Lakkis S.G., Lavorato, M.B., Canziani, P.O., *Monitoring cirrus clouds with lidar in the Southern Hemisphere: A local study over Buenos Aires. 1. Tropopause heights*. *Atmospheric Research*. 2009.
- Yuchechen A. E., S. A. Bischoff, and P. O. Canziani, *Latitudinal height couplings between single tropopause and 500 and 100 hPa within the Southern Hemisphere*. *International Journal of Climatology*, 30, 492-508, doi:10.1002/joc.1914. 2010.
- Lakkis S.G., P.O. Canziani, *A comparative analysis of the temperature behavior and multiple tropopause events derived from GPS, radiosonde and reanalysis datasets over Argentina, as an example of Southern mid latitudes*. *Revista de Climatología*, 9, 1-14. 2009.
- Pazmiño Andrea, Godin-Beekmann Sophie, Luccini Eduardo, Piacentini Rubén, Quel Eduardo and Hauchecorne Alain. *Increased UV radiation due to polar ozone chemical depletion and vortex occurrences at southern sub-polar latitudes in the period [1997-2005]*. *Atmospheric Chemistry and Physics*, 8, 5339-5352. 2008.
- García P. E.; Diéguez, M. C.; Ferraro, M. A.; Zagarese H. E. and Pérez A. P.. *Mycosporine-like amino acids in freshwater copepods: potential sources and some factors that affect their bioaccumulation*. *Photochemistry and Photobiology*, 86: 353–359. 2010.
- Van Gijssel J.A.E., D.P.J. Swart, J.-L. Baray, H. Claude, T. Fehr, P. Von Der Gathen., S. Godin-Beekmann., G.H. Hansen, T. Leblanc, I.S. Mcdermid, Y.M. Meijer, H. Nakane, E.J. Quel, W. Steinbrecht, K.B. Strawbridge, B. Tatarov and E.A. Wolfram. *Global validation of ENVISAT ozone profiles using lidar measurements*. *Special Issue on the Montreal Protocol in the International Journal of Remote Sensing* 30, (15-16):3987-3994. 2009.
- de Laat A. T. J., R. J. van der A, M. A. F. Allaart, M. van Weele, G. C. Benitez, C. Casiccica, N. M. Paes Leme, E. Quel, J. Salvador, and E. Wolfram. *Extreme sunbathing: Three weeks of small total O₃ columns and high UV radiation over the southern tip of South America during the 2009 Antarctic O₃ hole season*. *Geophys. Res. Lett.*, 37, L14805, doi:10.1029/2010GL043699. 2010.
- Raponi M M, R Jiménez, E Wolfram, J O Tocho and E J Quel. *Remote sensing of stratospheric O₃ and NO₂ using a portable and compact DOAS spectrometer*. *J. Phys.: Conf. Ser.* 274 012094. 2011.
- Raponi Marcelo; Jiménez, Rodrigo; Wolfram, Elian; Tocho, Jorge; Quel, Eduardo. *Development and application of a low-cost, portable DOAS system for stratospheric composition monitoring over the Argentinean Patagonia and Antarctic stations*. *Geophysical Research Abstracts*. Vol.12, EGU2010-14471-2. 2010.
- Parrondo M^a Concepcion, Margarita Yela, Manuel Gil and Hector Ochoa, *Ozone variability over Antarctic continent*, *Geophysical Research Abstracts*, Vol. 12, EGU2010-10158, EGU General Assembly. 2010.
- de Laat A.T.J., R.J. van der A, M.A.F. Allaart, M. van Weele, G. Carbajal Benitez, C. Casiccica, N.M. PaesLeme, E. Quel, J. Salvador and E. Wolfram. *Extreme sunbathing: three weeks of small total O₃ columns and high UV radiation over the Southern tip of South America during the 2009 Antarctic O₃ hole season*. *Geophysical Research Letters*, 2010GL043699. 2010.
- Van der Leun J, Piacentini R D and de Gruijl F. *"Climate change and human skin cancer"*. *Photochemical and Photobiological Sciences*. 7, 730-733, DOI: 10.1039/b719302e. 2008.
- Piacentini RD, Salum GM, Fraidenaich N and Tiba C. *"Extreme total solar irradiance due to cloud enhancement at sea level of the NE Atlantic coast of Brazil"*, *Renewable Energy*, 36, 409-412. 2011.
- Vernet M., S. Diaz, H. Fuenzalida, C. Camilion, C. R. Booth, S. Cabrera, C. Casiccica, G. Deferrari, C. Lovengreen, A. Paladini, J. Pedroni, A. Rosales and H. Zagarese. *Quality of UVR*

- exposure for different biological systems along a latitudinal gradient. *Photochem. Photobiol. Sci.*, 8, 1329-1345. 2009.
- Redondas A., C. Torres, O. Meinander, K. Lakkala, R. Garcia, E. Cuevas, H. Ochoa, G. Deferrari, and S. Diaz. Antarctic Network of Lamp-calibrated Multichannel Radiometers for Continuous Ozone and UV Radiation Data. *Atmos. Chem. Phys. Discuss.*, 8, 3383–3404. 2008.
- Palancar G. G. , R. E. Shetter, S. R. Hall, B. M. Toselli, and S. Madronich. Ultraviolet actinic flux in clear and cloudy atmospheres: model calculations and aircraft-based measurements. *Atmos. Chem. Phys. Discuss.*, 11, 3321-3354. 2011.
- López María Laura, Gustavo G. Palancar and Beatriz M. Toselli. Effects of different type of clouds on the surface UV-B and total solar irradiance at southern mid-latitudes: CMF determination at Córdoba, Argentina. *Atmospheric Environment*, 43, 3130-3136. 2009.
- Interdonato R. M. Rosa, C. Nieva, JA. González, M. Hilal and FE. Prado. Effects of low UV-B doses on the accumulation of UV-B absorbing compounds and total phenolics and carbohydrate metabolism in the peel of harvested lemons. *Environmental and Experimental Botany* 70 (2-3): 204–211. 2011.
- González J.A. Mariana Rosa, María F. Parrado, Mirna Hilal, Fernando E. Prado. Morphological and physiological responses of two varieties of a highland species (*Chenopodium quinoa* Willd.) growing under near-ambient and strongly reduced solar UV-B in a lowland location. *Journal of Photochemistry and Photobiology B: Biology*. 96: 144-151. 2009.
- Ibañez S. Mariana Rosa, Mirna Hilal, Juan A. González, Fernando E. Prado. Leaves of *Citrus aurantifolia* exhibit a different sensibility to solar UV-B radiation according to development stage in relation to photosynthetic pigments and UV-B absorbing compounds production. *J. Photochemistry and Photobiology B: Biology* 90 (2008) 163–169. 2008.
- Villafañe V.E., P.J. Janknegt, M. de Graaff, R.J.W. Visser, W.H. van de Poll, A.G.J. Buma and E.W. Helbling. UVR-induced photoinhibition of summer marine phytoplankton communities from Patagonia. *Marine Biology*, 154: 1021-1029. 2008.
- Gonçalves R.J., S. Souza, J. Aigo, B. Modenutti, E. Balseiro, V.E. Villafañe, V. Cussac and E.W. Helbling. Responses of plankton and fish from temperate zones to UVR and temperature in a context of global change. *Ecología Austral*, 20: 129-153. 2010.
- Häder D.-P., E.W. Helbling, C.E. Williamson and R.C. Worrest. Effects of UV radiation on aquatic ecosystems and interactions with climate change. *Photochemical and Photobiological Sciences*, 10: 242-260. 2011.

7. FUTURE PLANS

In view that the main problems concerning the ozone depletion and its consequences will affect particularly the Argentine territory and its neighborhood for many years, future research activities will be a continuation and extension of current investigations. Then, future plans and recommendations are basically similar to those of the ORM-2008. Among the principal subjects:

- Evolution of the total ozone column over the region. Trends of ozone and UV levels. Dynamics, chemistry and inter-annual variation of the Antarctic ozone hole.
- Study of the influence of the near vortex and ozone hole incursions over Patagonia
- Study the relationship between tropospheric and stratospheric dynamic and climatic behavior and the links with ozone change.
- Ozone and climate change interactions.
- The chemistry and dynamics of stratosphere-troposphere exchange.
- Cirrus clouds, the tropopause, and ozone.
- Effects of the UV radiation on the human health in the region. Biological effects of the UV radiation, especially on crops in the region.
- Studies of solar radiation and its components and biological effects in Antarctic Peninsula.

8. NEEDS AND RECOMMENDATIONS

- Antarctica and the Southern Cone of South-America must be still for many years considered the most critical region in the world related to ozone depletion and its consequences.
- The Antarctic Ozone Hole must be continuously monitored by all means for many years. Permanent ground-based and satellite-based instruments are an essential complement for this task.
- The current monitoring networks must be maintained in qualified operation. One main problem faced by Argentina, related to monitoring and research activities, has been the lack of adequate support to maintain such activities over time. This is particularly relevant since at this stage the ozone layer seems to be reaching the peak state of its depletion and sensitive monitoring and important research is necessary to determine the future evolution and the start of the possible recovery ozone layer and ozone hole.
- There is growing evidence that the ozone layer is both acting in response to current climate variability and change as well as affecting climate over the Southern Hemisphere. Such coupled studies are an important component of understanding needed to assess climate variability and climate change processes. Hence it is important to strength all atmospheric measurements relevant to both processes. This also requires a strong support in capacity building at the technician and research levels to continue both with monitoring and relevant research as proposed by SPARC-WCRP and its links with the various WCRP initiatives.
- The Argentine National Weather Service, main national institution for atmospheric monitoring, is still undergoing a mayor restructuring and requires support for its new strategies, in particular monitoring and calibration aspects, and replacement of obsolete and obsolescent equipment and facilities. It also requires including new monitoring activities to provide relevant information for both these topics, including long-term monitoring.
- It is essential that research activities be enhanced regionally and globally in the double-pronged aspect of ozone depletion and change within the framework of Climate Change due to the many joint aspects and couplings that are now starting to be known. Hence it is essential to sustain national and international projects regarding these as relevant issues.
- Until the recovery of the ozone layer does not become evident and sustained in time and as long as the international scientific community does not have a clear and fully developed picture of the linkages between the ozone layer, the stratosphere and the troposphere, within the scope of climate change and variability such research must be supported, nationally, regionally and internationally.

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