Transport of Low Ozone air masses to South America middle latitudes: impact on solar UV irradiance

Wolfram Elian¹,², Orte F.¹, Salvador J. ¹,₃, Pazmiño P.⁴, Godin-Beekmann S.⁴, Quel E¹, Akiyoshi H.⁵, Sugita T.⁵, Mizuno A.⁶.

¹ CEILAP (CITEDEF-CONICET), UMI-IFAECI-CNRS 3351, Villa Martelli, Argentina;
² Universidad Tecnológica Nacional, Facultad Regional Buenos Aires, Buenos Aires, Argentina.
³ Universidad Nacional de la Patagonia Austral UNPA-UARG, Río Gallegos, Argentina;
⁴ LATMOS/IPSL/UVSQ – CNRS, France
⁵ National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan
⁶ Institute for Space-Earth Environmental Research, Nagoya University, Nagoya, Aichi, Japan.
Projects that support the network

MINDEF Special Project
MD 31554/11 (2011-2013). Argentina


E. Wolfram - QOS 2016, Edinburgh, UK
Ozone and UV

Monitoring Program

Research Program

Social Contribution

E. Wolfram - QOS 2016, Edinburgh, UK
Intensive Measurement Period 2006
Case of Study: October 4

DIAL measurements - OAPA-NDACC Station

OMI Total Ozone for Oct 3, 2006
OMI Total Ozone for Oct 4, 2006
OMI Total Ozone for Oct 2, 2006

E. Wolfram - QOS 2016, Edinburgh, UK
Equivalent Latitude Maps

Source data: ERA-Interim

E. Wolfram - QOS 2016, Edinburgh, UK
Extreme Persistent Ozone Hole over Río Gallegos 2009

E. Wolfram - QOS 2016, Edinburgh, UK
Increase of UV Radiation Due to the Depletion of Ozone.

The unusual persistence of an ozone hole over a southern mid-latitude station during the Antarctic spring 2009: a multi-instrument study
OMI Total Ozone for Oct 5, 2005

Dobson Units
Dark Gray < 100 and > 500 DU

E. Wolfram - QOS 2016, Edinburgh, UK
OMI Total Ozone for Oct 7, 2005

Dobson Units
Dark Gray < 100 and > 500 DU

E. Wolfram - QOS 2016, Edinburgh, UK
OMI Total Ozone for Oct 8, 2005

Dobson Units

Dark Gray < 100 and > 500 DU
OMI Total Ozone for Oct 13, 2005

Dobson Units

Dark Gray < 100 and > 500 DU

E. Wolfram - QOS 2016, Edinburgh, UK
Motivation

- Menos de 0.1
- 0.2 - 1
- 1.1 - 5
- 5.1 - 25
- 25.1 - 100
- Mayor a 100
- Sin datos

Hasta 432.310
- 432.311 - 992.595
- 992.596 - 1.448.188
- 1.448.188 - 3.308.876
- 15.625.084

Habitantes por provincia
Total Ozone Column (Oct-Dec)

MLS/AURA ozone profiles
Oct 4-13, 2005 for Rio Gallegos

Buenos Aires
Trelew
Comodoro Rivadavia
Rio Gallegos
2005

MLS/AURA ozone profiles
Oct 4-13, 2005 for Comodoro Rivadavia

Total Ozone Column (Oct-Dec)

E. Wolfram - QOS 2016, Edinburgh, UK
MLS/AURA ozone profiles
Oct 4-13, 2005 for Buenos Aires

Total Ozone Column (Oct-Dec)
2005

Equivalent Latitude to four station at 550K

Buenos Aires
Trelew
Comodoro Rivadavia
Rio Gallegos

Equivalent Latitude - 550K

RG

COM

BAR

BA

10/02 10/09 10/16 10/23 10/30 11/06 11/13
Metodology

- **Total Ozone Column analysis in 4 cities of Argentina for OMI sensor (2005-2015)**
  - Buenos Aires (34.5 S)
  - Trelew (43.2 S)
  - Comodoro Rivadavia (45.7 S)
  - Río Gallegos (51.6 S)

- **Event is detected with the criteria** $\text{Ozone}(dj) < \text{OzoneMean}(dj) < 1\text{SD}$

- **Use of Potential vorticity at 550K maps to follow the flame and EL at 550K**

- **Use of parametric model to calculate the Clear-sky UV index**

\[
\text{UVI} \sim 12.5 \mu_0^{2.42} (\Omega/300)^{-1.23}
\]

*Photochemistry and Photobiology, 2007, 83: 1537–1538*

**Research Note**

**Analytic Formula for the Clear-sky UV Index**

*Sasha Madronich*

National Center for Atmospheric Research, Boulder, CO

Received 29 June 2007; accepted 25 July 2007; DOI: 10.1111/j.1751-1097.2007.00200.x*
Total Ozone Column (Oct-Dec)

~2-3 days
2005

Total Ozone Column

Modeled Max UVI

100%
40%

01-Oct 15-Oct 01-Nov 15-Nov 01-Dec 15-Dec
Day Number

Total Ozone Column (DU)

Buenos Aires
Trelew
Comodoro Rivadavia
Rio Gallegos

E. Wolfram - QOS 2016, Edinburgh, UK
2005

![Map of Argentina with locations marked: Buenos Aires, Trelew, Comodoro Rivadavia, Rio Gallegos.]

**Total Ozone Column**

**Modeled Max UVI**

- 50%
- 25%

![Graph showing modeled UVI and total ozone column from 01-Oct to 15-Dec.]

E. Wolfram - QOS 2016, Edinburgh, UK
Modeled Max UVI for 4 cities

- Buenos Aires (34S)
- Rio Gallegos (51S)
- Comodoro (45S)
- Trelew (41S)

E. Wolfram - QOS 2016, Edinburgh, UK
## Results

### Inter Annual Variability

Considering the Month of September-October-November-December

<table>
<thead>
<tr>
<th>Year</th>
<th>BsAs(34S)</th>
<th>MdP(38S)</th>
<th>TWL(43S)</th>
<th>CM(46S)</th>
<th>RG(51S)</th>
<th>Nro</th>
<th>BsAs</th>
<th>MdP</th>
<th>TWL</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>57%</td>
<td>57%</td>
<td>57%</td>
<td>57%</td>
</tr>
<tr>
<td>2006</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>83%</td>
<td>83%</td>
<td>83%</td>
<td>83%</td>
</tr>
<tr>
<td>2007</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>83%</td>
<td>83%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2008</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2009</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>40%</td>
<td>40%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>2010</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>75%</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2011</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>67%</td>
<td>67%</td>
<td>83%</td>
<td>100%</td>
</tr>
<tr>
<td>2012</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>86%</td>
<td>86%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2013</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>75%</td>
<td>75%</td>
<td>88%</td>
<td>88%</td>
</tr>
<tr>
<td>2014</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2015</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>75%</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Events</th>
<th>52</th>
<th>53</th>
<th>62</th>
<th>63</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>74%</td>
<td>76%</td>
<td>89%</td>
<td>90%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Total Number of Events in 11 years**

---

E. Wolfram - QOS 2016, Edinburgh, UK
Results

Increase in Erythemal UV irradiance for the selected sites
And for clear sky conditions

\[ \text{RAF}(\theta, \Omega_1/\Omega_2) = \frac{\ln(P_1/P_2)}{\ln(\Omega_2/\Omega_1)}. \]

\[ \frac{dP_{12}}{P_2} = U(\theta)(d\Omega_{12}/\Omega_2 + 1) - \text{RAF}(\theta) - 1 \]

P=Erythemal Weighted Irradiance
\(\Omega\)= Ozone total column
\(\Theta\)= SZA
RAF: Radiation Amplification Factor

Erythemal Irradiance Change (2005-2015)

E. Wolfram - QOS 2016, Edinburgh, UK
Cloud Cover Impact in UVI

Pyra UV-A UV-B

GUV 541

Attenuation

Clear Sky Model reference

E. Wolfram - QOS 2016, Edinburgh, UK
Attenuation of UV radiation by clouds in low total ozone column cases

- UV Index – GUV
- UV Index – Model
- Total Ozone Column

- Oct – Nov – Dic. from 2005 to 2012
- Cases of low ozone (TOC(OMI) < 270DU)

56 days

Results of Rio Galegos OAPA station
Cloud cover impact on surface UVI

October 8, 2005

Time Averaged Map of Cloud Fraction (Daytime/Ascending) daily 1 deg. [AIRS AIRX3STD v006]

OMI/Giovanni

CERES SYN1deg/3-hourly regional means

E. Wolfram - QOS 2016, Edinburgh, UK
Cloud cover impact on surface UVI

October 9, 2005

OMI/Giovanni

Time Averaged Map of Ozone Total Column (DOAS) daily 0.25 deg. [OMI OMDOA03a v006]

CERES SYN1deg/3-hourly regional means

Time Averaged Map of Cloud Fraction (Daytime/Ascending) daily 1 deg. [AIRS AIRX3STD v006]

Total Ozone

UVI

Cloud Cover

E. Wolfram - QOS 2016, Edinburgh, UK
Cloud cover impact on surface UVI

October 10, 2005

Total Ozone

UVI

Cloud Cover

OMI/Giovanni

CERES

Syn1deg/3-hourly regional means

Time Averaged Map of Cloud Fraction (Daytime/Ascending) daily 1 deg.
AIRS AIRX3STD v006

E. Wolfram - QOS 2016, Edinburgh, UK
Cloud cover impact on surface UVI

October 11, 2005

Total Ozone

OMI/Giovanni

UVI

Cloud Cover

Time Averaged Map of Cloud Fraction (Daytime/Ascending) daily 1 deg. [AIRS AIRX3STD v006]

E. Wolfram - QOS 2016, Edinburgh, UK
Conclusions

- The analysis of 11 years of Total Ozone Column in 4 sites of South hemisphere Middle latitudes (Sep-Oct-Nov-Dec) shows that:
  - There are a mean of 6 events per year in RG and 75% of these events reach Buenos Aires (~34S)
  - The changes in Ozone induce increments of mean Erythemal solar irradiances (UVI) of: 20% in RG, 15% in Middle Patagonia (COM, TLW) and 10% at the Buenos Aires
  - The cloud cover impact on solar surface irradiance is to strong in Patagonia, blocking 90% of the extreme UVI and 78% of UVI very high and high.
  - The stronger impact on UVI at Buenos Aires is produced in Nov-Dec.
  - The SAVER-Net project is making several activities on Ozone and UV monitoring program and also will permit to study the cloud cover impact on UV with ground based instruments.

E. Wolfram - QOS 2016, Edinburgh, UK
But!!! Take a little of care: Not always the attenuation is coming from the atmosphere.....

Acknowledgements
To JICA and UTN/FRBA to support the participation in QOS 2016

ewolfram@gmail.com
www.division-lidar.com.ar
www.savernet-satreps.com