

PORTUGAL

INTRODUCTION

In the national report of Portugal, presented in the 4th meeting of ozone research managers of the Parties to the Vienna Convention for the Protection of the Ozone Layer, Geneva, 28-30 April 1999 a historical review on the ozone and UV-B observations in Portugal was given.

In this report, the main activities and results obtained in the period 1999-2008 will be presented.

OBSERVATIONAL ACTIVITIES

As national authority on meteorological domain, the Portuguese Institute of Meteorology (IM) has followed the long term total ozone observations carried out since 1960 and total ozone and UV monitoring continues, despite the significant decrease of available personnel for instruments operation and data processing during last 10 years.

Column measurements of ozone

The current Portuguese total ozone network comprises 3 stations:

Table 1. Total ozone instruments currently in operation in Portugal.

Station	Instrument	Start year
Lisbon	Dobson #013	1960
	Brewer #047	2000
Funchal	Brewer #048	1989
Angra do Heroísmo	Brewer #102	2004

covering a wide geographical area of about $1.7 \cdot 10^6 \text{ km}^2$ of Eastern North Atlantic region (figure 1)

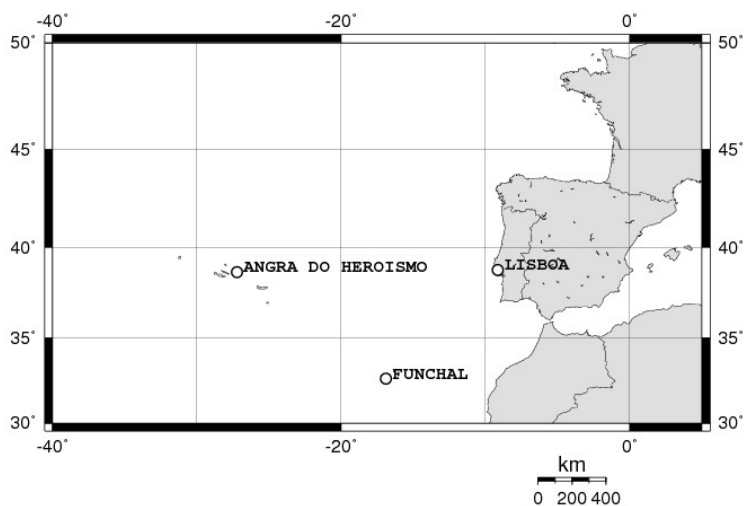


Figure 1: Portuguese total ozone stations.

The current Dobson observational programme includes hourly C, D and A pairs DS or ZS measurements performed every day. Brewer spectrophotometers located at Lisbon and Funchal are used for routine total ozone and SO₂ measurements (DS and ZS) and results are sent daily to the WMO Ozone Mapping Center. Brewer instrument located at Angra do Heroísmo (Azores Is.) station should be integrated on the GAW network after some operational improvements at the station, but basically with the same observational schedule.

Profile measurements of ozone

No regular ozone sounding programme is currently carried out in Portugal, however an intensive campaign performed on 2001 spring (Apr.-May) with simultaneous soundings in Lisbon, Funchal (Madeira Is.) and Lajes (Azores Is.) upper air stations (ROCA II), using Brewer-Mast ozone sondes, showed the impact of UTLS dynamics on ozone vertical distribution changes (figure 2).

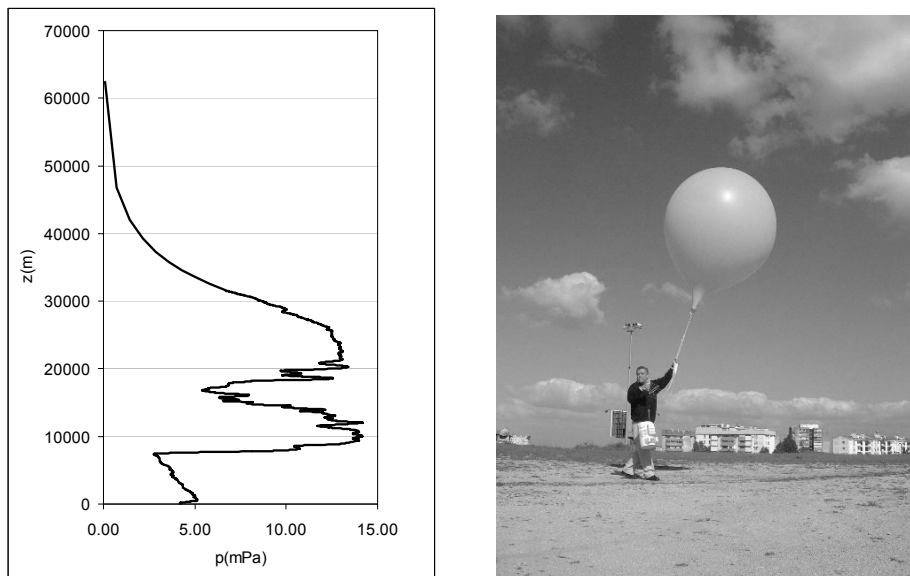


Figure 2: Left: Ozone profile measured at Lisbon on 02.05.2001, showing a second upper troposphere maximum; Right: Ozone sonde launching at Lisbon upper air station.

UV measurements

Global UV radiation measurements have been done using spectroradiometers (Brewer MKII) but also broadband detectors (figure 3). Broadband measurements were carried out with Solar Light 501 UV-Biometer detectors during a research project during near two years (2000-2001). Currently, only spectral measurements are done at the three ozone stations referred above. Since June 2004, a Brewer spectrophotometer MKII was re-installed at Angra do Heroísmo (Azores Is.) resuming the measurement programme previously done on 1992-1997.

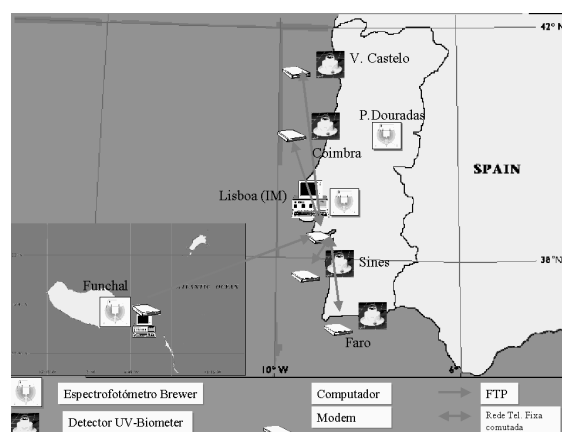


Figure 3: UV spectral-broadband network (200-2001).

Broadband measurements

Broadband UV measurements were carried out using Solar Light 501 UV-Biometer in the scope of a national funded project (HARTLEY) during 2000-2001. The detectors were located at 4 weather stations near the shore: Viana do Castelo, Coimbra, Sines and Faro. Data collected at the stations were transmitted daily to a central computer by modem phone lines.

Portuguese UV time series are too short for trend studies, however they are very useful for comparison with another sites and with model results. Annual maxima measured UV index values usually ranges from 10 to 11 at (figure 4) mainland and 12 at Funchal. While moderate values started earlier in southern regions, high values ($7 \leq \text{UVI} \leq 8$) started almost at the same time on summer.

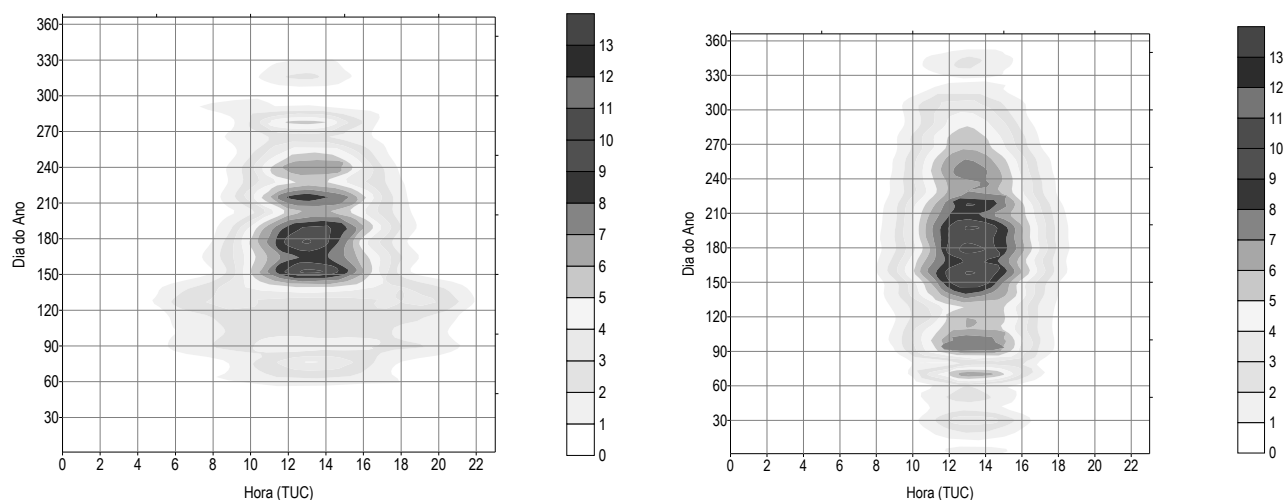


Figure 4: Hourly variation of UV index with the day of year at Viana do Castelo (left) and Sines (right).

Results over almost two years had shown a reasonable good agreement with clear sky model (MESTRAD) over 37°N - 42°N latitude range (figure 5). However, measured UVI was sometimes higher than modeled in spring and early summer.

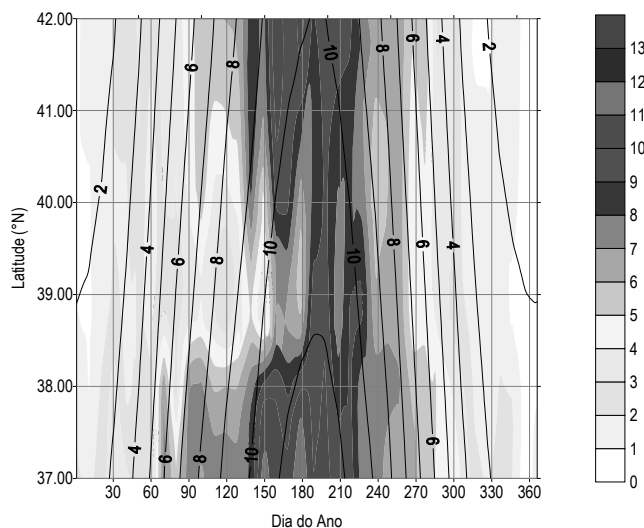


Figure 5: Measured (shaded) and modelled (contour) UVI distribution with day of year and latitude (37°N - 42°N).

Spectroradiometers

Global UV spectral measurements have been done since 1990 (Funchal) with a Brewer MKII (290-325 nm). Spectral UV measurements were resumed in Lisbon on June 2000, continuing the measurements started on 1989-1992. Later, in June 2004, a Brewer spectrophotometer MKII was re-installed at Angra do Heroísmo (Azores Is.) resuming the measurement programme previously started on 1992-1997. Preliminary results showed that Brewer UVI values are generally higher than SL500 but closer to the model results using actual total ozone measurements (figure 6).

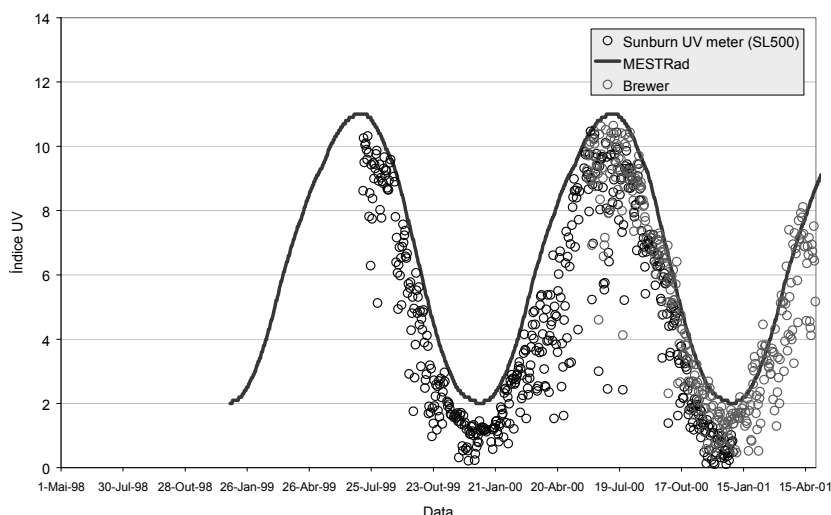


Figure 6: Observed (circles) Brewer and SL500 and modelled (solid line) UVI daily values at Lisbon (1999-2001).

Calibration activities

Since 1999, the Portuguese ozone and UV instruments have participated in several intercomparison campaigns in Europe (table 2).

Table 2: International Intercomparison/Calibration campaigns.

Instrument	Place	Campaign	Year	Type
SL501 #3749	Thessaloniki	COST 713	1999	UV
Dobson #13	Hohenpeissenberg	WMO	2000	Total ozone
Dobson #13	Hohenpeissenberg	WMO	2004	Total ozone
Brewer #047	Lisbon	QUASUME	2004	UV
Dobson #13	El Arenosillo	WMO/Iberonesia	2007	Total ozone
Brewer #102	El Arenosillo	WMO/Iberonesia	2007	Total ozone/UV
SL501 #3749	El Arenosillo	WMO/Iberonesia	2007	UV



Figure 7: El Arenosillo Intercomparison - Campaign September 2007 (Brewer set up).

RESULTS FROM OBSERVATIONS AND ANALYSIS

Total ozone observations were analyzed to evaluate potential stratospheric intrusion events over Portugal (STRATOZON project). Results showed that total ozone daily changes are more frequent in Funchal (Madeira Is.) than in mainland (Figure 8).

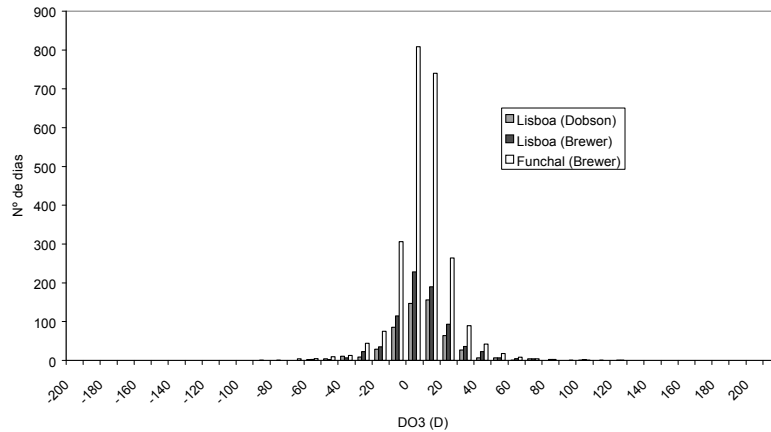


Figure 8: Histogram of number of days with total ozone consecutive difference classes.

THEORY, MODELLING, AND OTHER RESEARCH

Total ozone and global radiation measurements have been used to derive UV radiation from simplified transfer models (figure 9).

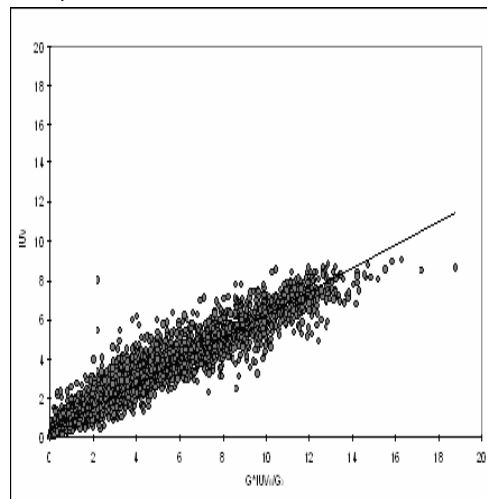


Figure 9: Brewer UVI observed values vs estimated values from observed global observations and modeled cloudless global and UV (Angra do Heroísmo, 2004-2007).

DISSEMINATION OF RESULTS

Data reporting

Total ozone data from Lisbon and Funchal has been submitted daily to the World Mapping Center (LAP-AUTH). Processed and corrected data have been submitted with some delay to the WOUDC. UV spectral data have been submitted to the EDUCE database.

Information to the public

The interest of the public on the UV index information has increased in Portugal. Dissemination of current ozone and UVI information in Portugal is done at the Portuguese Institute of Meteorology webpage www.meteo.pt. (figure 10). UVI forecasts are based on the products disseminated by the WMO UV specialized regional centre (DWD).

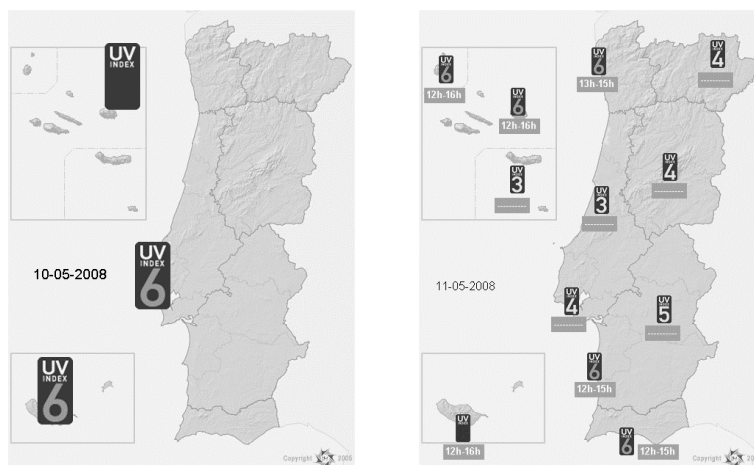


Figure 10: Yesterday's UVI observed values (left) and today's forecasted (right) UVI for mainland and islands.

PROJECTS AND COLLABORATION

During this period, the Portuguese IM has participated in several national, European international projects related with ozone and UV fields:

National Projects:

ROCA II
 HARTLEY
 STRATOZON
 CLIMAAT
 CLIMARCOST

International Projects

COST 713
 COST 723
 COST 726
 Iberonesia
 EDUCE
 QUASUME
 Pico-NARE (IGAC)
