ITALY

The contributing institutions are:

INSTITUTION	Short name
CETEMPS/Dipartimento di Fisica, Universita' degli Studi dell'Aquila, L'Aquila	CETEMPS/UNIAQ
Università degli Studi di Urbino "Carlo Bo", Urbino.	UNIURB
Dipartimento di Fisica, Università di Roma "La Sapienza", Roma.	UNIRM
ARPA Valle d'Aosta (Regional Environmental Protection Agency).	ARPAVDA
CMCC,INGV, Roma.	CMCC/INGV

OBSERVATIONAL ACTIVITIES

Column measurements of ozone and other gases/variables relevant to ozone loss

CETEMPS/UNIVAQ: The ozone total columns observed on routine basis at L'Aquila (683 m asl, 43.38°N, 13.31°E) are derived from the balloon ozone-sonde profiles. This database has been used for a comparison with OMI (Ozone Monitoring Instrument, http://www.knmi.nl/omi/) onboard AURA satellite (http://avdc.gsfc.nasa.gov/).

UNIURB: In situ continuous measurements of Ozone Depleting Substances (ODS, Montreal Gases) by Gas Chromatography-Mass Spectrometry at the CNR Atmospheric Research Station "O. Vittori" at Monte Cimone (Northern Apennines, Italy (2165 m asl, 44°11' N, 10°42' E) and weekly measurements of the same gases at the ABC-Pyramid Atmospheric Research Observatory (Nepal, 27.95 N, 86.82 E) located in the Himalayas, Khumbu valley, at 5079 m a.s.l.

UNIRM: Total ozone and total nitrogen dioxide observations have been collected since 1992 at Rome (Lat. 41.9°N, Long. 12.5°E, 75m a.s.l) and at Ispra (Lat. 45.8°N, Long. 8.63°E, 240m a.sl) by using two Brewer MKIV spectrophotometers. Brewer MKIV 067 is located at the Physics Dept. of Sapienza University of Rome. Brewer MMIV 066, located at the Environment Institute of the Joint Research Centre, Ispra (Va) until January 2007, was moved to the alpine station of ARPA (Aosta Valley Regional Environmental Protection Agency) at Saint-Christophe, Aosta (Italy), at approximately 100 km east from Ispra. Aerosol optical depth (AOD) retrievals in the UV and visible regions are now available.

ARPAVDA: Total ozone and total nitrogen dioxide measurements have been collected sine 2007 in Saint-Christophe (45.74°N, 7.36°E, 570 m a.s.l.), Aosta, using the Brewer MKIV spectrophotometer #66. This instrument, owned by Sapienza – University of Rome, was moved from the Joint Research Centre, Ispra (VA), where it has been measuring since 1992. The spectrophotometer is now being operated by ARPA Valle d'Aosta. Estimates of the total ozone content every 30 minutes are available since 2006, retrieved from the Bentham spectroradiometer. The results have been successfully compared with those obtained by the Brewer #66 and OMI satellite data.

Profile measurements of ozone and other gases/variables relevant to ozone loss

CETEMPS/UNIAQ: The ozone profiles (balloon-sonde) have been collected since 1994. From 2004 this activity has achieved a routine pace: about 1.5/2 ozone profiles (from ground up to 10hPa altitude) per month (This activity is also part of the commitments included in a Convention between University of L'Aquila/CETEMPS -*Centre of Excellence for the integration of remote sensing techniques and modelling for the forecast of severe weather*- and Italian Government/Ministry of Environment. The Italian Ministry of Environment (*Ministero dell'Ambiente*

e della tutela del Territorio) provides the needed resources for the acquisition of the ozone-sondes, the maintenance of the radio-sonde system.). The ozone profiles database has been available for the calibration/validation campaign of the MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) instruments onboard ENVISAT. There is an overall agreement between the two technique (along about 20 spatial and temporal coincident measurements), the main difference (below 10%) are located in the lower stratosphere and troposphere, in the high stratosphere, the agreement is better than 5%.

UV measurements
CETEMPS/UNIAQ: *Broadband measurements*
UV-A and UV-B (Yankee Environmental Systems) instruments have been operating since 2004.

UNIRM: Spectral UV irradiance (from 290 to 325nm at 0.5 nm stepwidth) have been measured by Brewer spectrophotometer #067 operational since 1992. Values of erythemal and Vitamin D dose rates are also available. In addition erythemal dose rates and doses are provided by the broadband UV radiometer (model YES UVB-1) operational since 2000.

ARPAVDA: Three UV broadband radiometers (2 KIPP&ZONEN UV-S-AE-T, double band A/E, and 1 Yankee YES UVB-1) have been operating since 2004 at three different sites (Saint-Christophe, 570 m asl, La Thuile, 1640 m asl, and Plateau Rosa, 3500 m asl) to account for the altitude and snow effect. Data are available as 5 minutes averages (sampling time 10 seconds) and transmitted to the elaboration centre by GSM modems. A Bentham double monochromator spectroradiometer has been operating continuously since 2004, measuring the global spectral irradiance in the range 290-500 nm (stepwidth: 0.25 nm, FWHM: 0.54 nm) every 15-30 minutes (scan time: 6 minutes). Global spectral UV irradiance is also measured by the Brewer spectrophotometer (from 290 to 325 nm at 0.5 nm stepwidth). Erythemal and integrated dose rates, along with the UV index, and doses are routinely calculated from the spectral measurements and compared with the broadband measurements.

Calibration activities
UNIRM: The absolute calibration of Brewer 067 is made by the IOS inc. (International Ozone Service) almost every year. Furthermore, UV measurements are intercompared with the travelling standard spectroradiometer B5503 from PMOD/WRC (Physikalisch- 10 Meteorologisches Observatorium Davos, World Radiation Center) every two years. The YES radiometer participated into the broadband radiometer inter-comparison at PMOD/WRC at Davos (Switzerland) in August 2006.

ARPAVDA: The ozone calibration of Brewer #66 is performed by the IOS inc. (International Ozone Service) almost every two years. UV measurements of the Brewer spectrophotometer and Bentham spectroradiometer are intercompared with the travelling standard QASUME from the PMOD/WRC (Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center) every two year.

The Bentham spectroradiometer is calibrated every month by a local operator by means of 2/3 calibration lamps (portable field calibrators, 200W, from Schreder CMS). The lamps are calibrated by the PMOD/WRC and represent a calibration triad. Cross-calibration between the spectroradiometer and the spectrophotometer are regularly performed. The broadband radiometers spectral response function and cosine response are measured every year in a specialized laboratory (Scheder CMS, Austria). Absolute calibration is performed by ARPA with reference to the double monochromator spectroradiometer, following the international guidelines (Ann Webb, Julian Gröbner, Mario Blumthaler, *A Practical Guide to Operating Broadband Instruments Measuring Erythemally Weighted Irradiance*) and calculating a calibration matrix (ozone-solar zenith angle). The YES radiometer participated into the COST-726 broadband radiometer intercomparison at PMOD/WRC at Davos (CH) in August 2006, giving satisfying results.

RESULTS FROM OBSERVATIONS AND ANALYSIS

CETEMPS/UNIVAQ: Ozone trend analyses**:** The extended ozone profile database (2004-2007) has got the quality-standards for being used in a preliminary analysis concerning the possible trends of the ozone content in the different atmospheric region. In summary, such studies show that: there is not any significant trend in the lower troposphere; the same in the higher troposphere and in the lower stratosphere (these data have a larger standard deviation); on the other hand in the middle stratosphere [20-25km], it is evident a small decreasing in the ozone content (about 10+/-5DU/decade) which is consistent with other kind of observations (i.e., IPCC's Special Report on Safeguarding the Ozone Layer and the Global Climate System, 2005)

UNIURB: ODS: Atmospheric trends of ODS and allocation of Source regions.

UNIRM: Surface UV radiation: A climatological characterization based on the time series of UV index was carried out. The mean of maximum UV index is (7.2±0.2) at Ispra and (8.9±0.4) at Rome under clear sky conditions. High exposure category (6< UV index < 7) is more frequent at Rome (32%) than at Ispra (26%). Very high UV indexes (≥ 8) occur only at Rome.

ARPAVDA: Surface UV radiation: The UV indexes measured in the three stations are published in real-time on the web site www.uv-index.vda.it using the colour scale recommended by the WMO. UV doses are calculated. Extreme UV indexes occur in the Alps of Valle d'Aosta: close by 9 at Aosta and La Thuile, during summer, and higher than 12 at Plateau Rosa, because of the coupled effect of altitude (3500 m asl) and snow cover (perennial snow is always present on the glacier).

THEORY, MODELLING, AND OTHER RESEARCH

CETEMPS/UNIVAQ: Stratospheric and tropospheric Ozone: Research and assessment studies on stratospheric ozone have been made using a global chemistry-transport model (ULAQ-CTM) and a chemistry-climate coupled model (ULAQ-CCM), both including an interactive module for calculation of aerosol formation and growth. Both models have been validated with satellite and aircraft data and then used for future projections of the ozone layer and changes of the ozone radiative forcing on climate. The above models have also been adapted and used for studies of tropospheric ozone and its precursors, as well as for future trends of tropospheric O3. CETEMPS/UNIAQ modelling activities have also contributed to the UNEP/WMO/IPCC: Scientific Assessment of Ozone Depletion: 2006; Chapter 5: Climate-Ozone Connections, *Review Ed. D. Albittron*, 49 pp., Geneva, Switzerland, 2007; and to UNEP/WMO/IPCC: Scientific Assessment of Ozone Depletion: 2006; Chapter 6: The Ozone Layer in the 21st Century.

UNIRM: Comparison with Ozone and UV satellite data: The daily mean ozone values from Brewer spectrophotometer #067 showed a good agreement with OMI ozone data retrieved by means of both OMI-TOMS 5 (bias=−1.8%) and OMI-DOAS (bias=−0.7%) algorithms. The comparisons between satellite-based and ground-based UV data showed that, on average, OMI UV products exceed ground-based UV measurements by more than 20%. This may be attributed to the fact that the satellite instrument does not effectively probe the boundary layer, where the extinction by the aerosols can be important, mainly in an urban site as Rome.

Assessment of solar UV exposure in the Italian population: In the last four years several campaigns are carried out focused on quantifying the solar UV exposure in Italian populations such as sunbathers, skiers and vine growers searching a possible relation among biological markers of individual response to UV exposure. Preliminary results were showed during national conferences. Recent results were submitted to international journals. The variability of calibration curves of polysulphone dosimetry was widely studied during several ad hoc field campaigns at different middle latitude sites (urban, semi-rural and rural sites) and in any season of the year. It was concluded (Casale et al., 2006) that a careful quantification of the polysulphone calibration curve under the same atmospheric conditions of exposure of population groups is recommended in the personal UV measurement programmes.

ARPAVDA: Radiative transfer models (e.g. LibRadtran) are routinely used for the forecasts of the UV index in cloudless conditions and for quality control. The forecasts are daily published on the UV website www.uv-index.vda.it in the form of WMO-compliant maps of Aosta Valley. The standard libRadtran model was modified to take into account some effects typical of a mountain region (effective albedo, altitude and "cutted" atmospheric profiles) and compared with a 3D model, giving satisfying results (±1 UV index maximum difference). A near-real time UV map of Aosta Valley is computed every 15 min accounting for cloud amount, using satellite data from Meteosat Second Generation. The daily mean and instantaneous measurements from Brewer spectrophotometer showed an agreement with OMI ozone data (daily mean and overpass values), similar to that observed and published for other mountain sites. The bias is about -3%, the correlation index is 0.99 and the RMS is 3.5%.

CMCC/INGV: Global Modelling of Stratospheric Ozone: The anthropogenic perturbation of the atmospheric composition is at the origin of global environmental changes of the Earth System. Within this context, our research objectives are aimed at identifying and quantifying the connections between ozone evolution and climate change, by using and developing global numerical models with interactive meteorology and chemistry. In particular we are working with the MAECHAM general circulation models of the troposphere, stratosphere and mesosphere, as well as with one of its version coupled to a stratospheric ozone chemistry model [the MAECHAM4CHEM chemistry climate model (CCM), and its further evolution, the ECHAM5/MESSy1]. CCMs include the full representations of dynamical, radiative, and chemical processes in the atmosphere and their interactions. We have been part of the MAECHAM4CHEM model team that has contributed to the coordinated simulations of past ozone evolution and scenarios of future ozone projection of the last ozone assessment (WMO, 2007). In the last few years, we have been part of several international teams and co-authored a number of publications aimed at analyzing various aspects of the modelling of stratospheric ozone with comprehensive global numerical models: - the evaluation of inter-annual variations in total ozone and lower stratospheric temperature in the MAECHAM4CHEM model has been addressed; -the comparison of long term evolution of upper stratospheric ozone of the MAECHAM4CHEM model with selected observational stations within the Network for the Detection of Stratospheric Change (NDSC); - the assessment of the simulation by a number of CCMs of stratospheric temperature, tracer, and ozone in the recent past and of stratospheric ozone projection in the 21st century; - and the evaluation of the solar cycle and temperature in CCMs.

Modelling of shortwave radiative transfer in Atmospheric Global Models. The spectral resolution of the shortwave radiation parameterization used in the Middle Atmosphere (MA) ECHAM5 model has been increased from 4 to 6 bands, in order to improve the representation of ozone absorption in the stratosphere.

DISSEMINATION OF RESULTS

Data reporting

CETEMPS/UNIVAQ: The multi-annual UV and ozone profile data can be freely used on request at CETEMPS. Model data for international data centres.

UNIRM: Daily total ozone are submitted to international datacentres at the end of every year.

ARPAVDA: Every measurement is published in real time on the website of ARPA. Daily total ozone and B-files are submitted daily to the WOUDC.

CMCC/INGV: Preparation of numerical data from the MAECHAM4CHEM model for submission to the British Atmosphere Data Centre (BADC) data centre, within the procedures for the last ozone assessment (WMO, 2007).

Information to the public

CETEMPS/UNIVAQ: An annual report concerning the stratospheric ozone and surface UV levels is yearly compiled within the existing Convention between CETEMPS/UNIAQ and Italian

Government/Ministry of Environment. The observational procedures and their scientific content are widely exploited along continuous on-site visiting activities (secondary schools, university students, foreign scientists) and press releases.

ARPAVDA: UV forecasts for clear sky are published daily on the ARPA website and on national newspapers (La Stampa, regional page). The recommended solar protection factors and the erythemal times are reported for some site of Aosta Valley and different phototypes

Relevant scientific papers

CETEMPS/UNIVAQ:

Brunner D., et al.: An evaluation of the performance of chemistry transport models. Part 2: Detailed comparison with two selected campaigns, Atmos. Chem. Phys., 5, 107-129, 2005.

Pyle, J., et al.: IPCC/TEAC special report on: Safeguarding the ozone layer and the global climate system: issues related to HFC and PFC; Chapter 1: Ozone and Climate, Metz et al. Eds., Cambridge University Press, Review Eds. M. McFarland, 83-132, 2005.

Stevenson, D.S., et al.: Multi-model ensemble simulations of present-day and near-future tropospheric ozone, J. Geophys. Res., 111, D08301, doi:10.1029/2005JD006338, 2006.

Andersen, S.B., et al.: Comparison of recent modelled and observed trends in total column ozone, J. Geophys. Res.,111, D02303, doi: 10.1029/2005JD006091, 2006.

Gauss, M., et al.: Radiative forcing since preindustrial times due to ozone change in the troposphere and the lower stratosphere, Atmos. Chem. Phys., 6, 575-599, 2006.

UNEP/WMO (Contribution G. Pitari): Scientific Assessment of Ozone Depletion: 2006; Contribution to Chapter 5: Climate-Ozone Connections, Review Ed. D. Albittron, 49 pp., Geneva, Switzerland, 2007.

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Cortesi U, et al.: Geophysical validation of MIPAS-ENVISAT operational ozone data Atmos. Chem. Phys., 7, 18, 4807-4867, 2007.

UNIURB:

Greally, B.R. et al.: Observation of 1,1-difluoroethane (HFC-152a) at AGAGE and SOGE monitoring stations 1994-2004 and derived Global and regional emission estimates, J. Geophys. Res., 112, D06308, doi:10.1029/2006JD007527.

Bonasoni, P. et al.: Climate Altering Trace Gases in the Mediterranean Area: Trends and Source Allocation in Regional Climate Variability and Its Impacts in the Mediterranean Area, A. Mellouki and A.R. Ravishankara, Eds., NATO Science Series, pp 51-61.

Maione, M. et al.: Localization of source regions of selected hydrofluorocarbons combining data collected at two European mountain Stations, the Science of Total Environment, 391 (2008) 232-240.

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UNIRM:

Casale, G.R. et al.: Variability among polysulphone calibration curves, Phys. Med. Biol., 51 4413-4427, 2006.

Sisto R., et al.: Solar UV radiation exposure in a population of Tuscany vineyard workers" 28th International Congress on Occupational Health Milano, 11 - 16 June 2006, 107, 2006.

Casale G.R., et al.: Spectral Changes of Paper exposed to Ambient Solar Radiation", in "1st International meeting on Chemometrics and Multivariate Analysis Applied to Cultural Heritage and Environment (ISBN 88-548-0765-6), Nemi (RM) 2-4 October, 2006, 61-62, 2006.

Siani A.M. et al.: Surface UV radiation monitoring at two Italian Brewer stations (Rome and Ispra): a first comparison with OMI data", Proc. The International Symposium on Optical Science and Technology, Remote Sensing of Clouds and the Atmosphere XI, 6362, 63622G-1-63622G-8, 2006.

Seckmeyer, G. et al.: Variability of UV irradiance in Europe", Photochem Photobiol. 83, 1-8, 2007.

ARPAVDA:

H. Diémoz and B. Mayer: UV radiation in a mountainous terrain: comparison of accurate 3D and fast 1D calculations in terms of UV index, Proceedings of the UV Conference "One Century of UV Radiation Research'", 18-20 September 2007, Davos, Switzerland.

Siani, A. M., et al.: Personal UV exposure on a ski-field at an alpine site, Atmos. Chem. Phys. Discuss., 8, 2745-2769, 2008.

CMCC/INGV:

Cagnazzo C., et al.: Aspects of stratospheric long-term changes induced by ozone depletion, Climate Dynamics, 2006. DOI10.1007/s00382-006-0120-1, 2007.

Cagnazzo, C., et al.: Impact of an improved shortwave radiation scheme in the MAECHAM5 General Circulation Model, Atmos. Chem. Phys., 7, 2503-2515, 2007.

UNEP/WMO (Co-Autor, Elisa Manzini): Scientific Assessment of Ozone Depletion: 2006; Chapter 6: The Ozone Layer in the 21st Century. Geneva, Switzerland, 2007.

UNEP/WMO (Contributor, Elisa Manzini): Scientific Assessment of Ozone Depletion: 2006; Chapter 5: Climate-Ozone Connections, Geneva, Switzerland, 2007.

Eyring, V., et al.: Multimodel projections of stratospheric ozone in the 21st century, J. Geophys. Res., 112, D16303, doi:10.1029/2006JD008332, 2006.

Eyring, V., et al.: Assessment of temperature, trace species, and ozone in chemistry-climate model simulations of the recent past, J. Geophys. Res., 111, D22308, doi:10.1029/2006JD007327, 2006

Manzini, E., et al.,: The influence of sea surface temperatures on the Northern winter stratosphere: Ensemble simulations with the MAECHAM5 model, J. Climate, 19, 3863-3881, 2006.

Steinbrecht, W., et al.,: Long-term evolution of upper stratospheric ozone at selected stations of the network for the detection of stratospheric change (NDSC), J. Geophys. Res., 111, D10308, doi:10.1029/2005JD00645, 2006

Steinbrecht, W., et al.: Interannual variation patterns of total ozone and lower stratospheric temperature in observations and model simulations, Atmos. Chem. Phys., 6. 349-374, 2006.

Steil, B., et al.: A new interactive chemistry-climate model: 1. Present-day climatology and interannual variability of the middle atmosphere using the model and 9 years of HALOE/UARS data, J. Geophys. Res., 108(D9), 4290, DOI: 10.1029/2002JD002971, 2003.

PROJECTS AND COLLABORATION

CETEMPS/UNIVAQ:

National projects:

Convention between CETEMPS/UNIAQ and Italian Government/Ministry of Environment.

International projects:

EC-SCOUT-O3; SPARC-CCMVal; EU-ACCENT; AEROCOM; HTAP; WMO Assessments; IPCC Assessments.

UNIRM:

International collaborations

Australian Sun and Health Research Laboratory, Queensland University of Technology, Institute of Health and Biomedical Innovation, Brisbane, Australia; ARPA Valle d'Aosta; Management Committee Member of COST Action 726 “Long term changes and climatology of UV radiation over Europe”.

ARPAVDA:

National projects

Agire POR: exchange program promoted by the Italian economy ministry between ARPA Valle d'Aosta and ARPA Basilicata; ARPA Piemonte, Forecast and Environmental Monitoring Area, University of Rome (La Sapienza), University of Turin, Institute of Atmospheric Sciences and Climate (ISAC-CNR, Italy), Italian Air Force, Weather Service

International collaborations

General Joint Research Centre (JRC), Institute for Health and Consumer Protection (ICHP), Physical and Chemical Exposure Unit, Ispra (VA), Italy; Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center (PMOD/WRC), Davos, Switzerland; World Ozone and Ultraviolet Radiation Data Centre, Meteorological Service of Canada, Toronto, Ontario, Canada; Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), Institut fuer Physik der Atmosphaere, Oberpfaffenhofen, Germany; Department of Medical Physics, Innsbruck Medical University, Innsbruck, Austria; Deutscher Wetterdienst, KU3, Human Biometeorology, Freiburg, Germany, EUMETSAT, Darmstadt, Germany; Royal Netherlands Meteorological Institute (KNMI), Atmospheric Composition, Climate Research, De Bilt, The Netherlands.

CMCC/INGV:
International collaborations
EC-SCOUT; WMO Assessments; SPARC-CCMVal;

FUTURE PLANS

CETEMPS/UNIVAQ: Development of global models (increased horizontal resolution, upgrade of hydrocarbon chemistry for tropospheric ozone).
Re-establishment of ano zone DIAL (DIfferential Absorption Lidar) to extent the temporal coverage of the ozone profile monitoring.

UNIRM: Further development of UV sensors for the assessment of human UV exposure; investigation on total ozone UV irradiance trend.

ARPAVDA: Further research on solar photometry and aerosol optical depth (AOD) measurements.

CCM/INGV: Development of the investigation concerning the impact of ENSO on Stratospheric Temperature and Ozone. Global Modelling of Climate Change and Ozone: it is planned to incorporate the MAECHAM5 stratosphere resolving model in the coupled atmosphere ocean general ocean model (AOGCM) available at CMCC. The first objective will be to evaluate the coupled model with the stratospheric resolving atmosphere by a climate control simulation.

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