

Final project report

Project ID: 2002/6.01
Title: ***Thin optical depth stratospheric gases measurements with ground-based off-axis UV-visible spectrometer at Dome Concordia NDSC station***

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Duration: 2002-2003
Assigned funding: € 60.000,00

Activities and results

The main results of this project can be summarized as i) the technological ones, meaning the development and setup of the new equipment called SPATRAM/DC+MIGE (Spectrometer for Atmospheric Tracers Measurements/DomeC + Multiples Input Geometry) thanks to the collaboration between the ISAC-CNR institute, the Geophysics Centre of the University of Evora (Portugal) and ENEA; ii) the scientific ones regarding the deep studies of the atmospheric Nitrogen Dioxide and Ozone at mid-latitude and in Antarctic Regions in terms of diurnal and seasonal variations. Furthermore, advanced inversion methods allowed for the retrieval of the vertical distribution of the above mentioned atmospheric compounds.

i) The SPATRAM is based on the optic module of the GASCOD (Gas Analyzer Spectrometer Correlating Optical Differences) installed at the Mario Zucchelli station since '95. The new spectrometer allows for the retrieval of minor compounds in the atmosphere with improved temporal resolution, flexible management and enhanced capability of measurements in comparison with GASCOD. The SPATRAM Optical Mechanical Unit is equipped with an already tested monochromator, allowing for reliable and trustfully measurements of the radiation entering from the slit. The opto-mechanical modules of this equipment (primary input, optic fibres inputs, external devices for the transmission of the radiation with optic fibres and the optic fibres itself) were developed and selected taking into account the features of the monochromator (mainly the f-number) in order to ensure the optimum optical matching. One of the main enhancements of this equipment is the possibility to change the input of the radiation allowing for quasi simultaneous measurements in the same spectral region from different geometry; i.e. i) measurements of zenith sky radiation from the primary input; ii) measurement in directions different from the zenith one by means of a different optic system for the input of the radiation via optic fibre (using the optic fibre input); iii) measurements in active mode using a telescope including the source coupled with a retro reflector mirror.

ii) The analysis of the spectral data obtained at the Mario Zucchelli Station allowed for some improvements to the Differential Optical Absorption Spectroscopy (DOAS) technique. In particular, the algorithm that allows for the best spectral alignment between a high-resolution wavelength-calibrated spectrum and the spectrum obtained with the GASCOD spectrometer, which is then utilized as the reference spectrum in the DOAS methodology. This last result give a reduction of the systematic errors that a non-wavelength calibrated reference spectrum could introduce in the slant column value retrieval. A new method for the estimation of the magnitude of the NO₂ slant column value corresponding to the reference spectrum used in the DOAS analysis is developed. In the Antarctic region the maximum nitrogen dioxide content is achieved during the summer season, while the minimum values are observed in winter, as expected considering its photochemical activity.

The close relation between NO₂ Vertical Column (VC), stratospheric temperature and potential vorticity, is examined. The NO₂ VC low values obtained during 2002 can be explained in the frame of the stratospheric warming phenomena that had lead to the anticipated extinction of

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the polar vortex. At mid-latitudes, one SPATRAM was installed in 2004 at the Observatory of the CGE in Portugal and the analysis of the dataset for the O3 total column led to the identification of the occurrence of strong variations in the period October 2006-March 2007 and the marked inter annual variability in O3 content. The vertical profiles obtained for ozone and nitrogen dioxide allow for the identification of events of tropospheric pollution occurring at the Observatory of Évora.

Unfortunately it was not possible to install the new equipment in the DOME/C station during the period of the project due to structural delays. In this regard the foreseen goals of the research project were partially reached. Anyway the SPATRAM/DC+MIGE are ready for the installation in Antarctic Regions.

Products

A – papers in scientific magazines

1. Bortoli D., A.M. Silva, M.J. Costa, A.F. Domingues and G. Giovanelli, Monitoring of atmospheric minor compounds at the Evora Station - Portugal, *International Journal of Remote Sensing*, 2009. (in press)
2. Bortoli D., A.M. Silva, G. Giovanelli, A new multipurpose UV-Vis spectrometer for air quality monitoring and climatic studies, *International Journal of Remote Sensing*, 2009. (in press)
3. Werner, R., Kostadinov, I., Valev, D., Hempelmann, A., Atanassov, At., Giovanelli, G., Petritoli, A., Bortoli, D., Ravegnani, F., Markova, T. NO2 column amount and total ozone in Stara Zagora (42°N, 25°E) and their response to the solar rotational activity variation. *Advances in Space Research Volume 37, Issue 8, 2006, Pages 1614-1620 (2006)*
4. Bortoli, D., G. Giovanelli, F. Ravegnani, I. Kostadinov and A. Petritoli, Stratospheric Nitrogen Dioxide in the Antarctic, *Int J. Of Remote Sensing*, 26, 16, 3395–3412, 2005
5. G. Giovanelli, D. Bortoli, A. Petritoli, E. Castelli, I. Kostadinov, F. Ravegnani, G. Redaelli, C. M. Volk, U. Cortesi, G. Bianchini and B. Carli. Stratospheric minor gas distribution over the Antarctic Peninsula during the APE-GAIA campaign. *Int. J. Remote Sensing*, 26 (16) 3343-3360 2005
6. E. Palazzi, A. Petritoli, G. Giovanelli, I. Kostadinov, D. Bortoli, F. Ravegnani, S.S. Sackey. PROMSAR: A backward Monte Carlo spherical RTM for the analysis of DOAS remote sensing measurements. *Advances in Space Research* 36 (5), pp 1007-1014. (2005)
7. Ulanovskii AE, Luk'yanov AN, Yushkov VA, Sitnikov NM, Volk M, Ivanova EV, Ravegnani F. Estimation of the chemical loss of ozone in the Antarctic stratosphere in the 1999 winter-spring season from direct measurements and simulations. *Izvestiya Atmospheric and Oceanic Physics*, 40 (6): 695-703 (2004)
8. Rex, M., Salawitch, R.J., Harris, N.R.P., Gathen, P. von der, Braathen, G.O., Schulz, A., Deckelmann, H., Chipperfield, M., Sinnhuber, B.M., Reimer, E., Alfier, R., Bevilacqua, R., Hoppel K., Fromm, M., Lumpe, J., Küllmann, H., Kleinböhl, A., Bremer, H., König, M. von, Künzi, K., Toohey, D., Vömel, H., Richard, E., Aikin, K., Jost, H., Greenblatt, J.B., Loewenstein, M., Podolske, J.R., Webster, C.R., Flesch, G.J., Scott, D.C., Herman, R.L., Elkins, J.W., Ray, E.A., Moore, F.L., Hurst, D.F., Romashkin, P., Toon, G.C., Sen, B., Margitan, J.J., Wennberg, P., Neuber, R., Allart, M., Bojkov, R.B., Claude, H., Davies, J., Davies, W., Backer, H. de, Dier, H., Dorokhov, V., Fast, H., Kondo, Y., Kyrö, E., Litynska, Z., Mikkelsen, I.S., Molyneux, M.J., Moran, E., Murphy, G., Nagai, T., Nakane, H., Parrondo, C., Ravegnani, F., Skrivankova, P., Viatte, P., Yushkov, V. Chemical loss of Arctic ozone in winter 1999/2000, *Journal of Geophysical Research*, 107/D20, 8276, doi:10.1029/2001JD000533. (2002)
9. Giovanelli, G., D. Bortoli, I. Kostadinov, A. Petritoli and F. Ravegnani, THIN OPTICAL DEPTH STRATOSPHERIC GASES DETECTION WITH GROUND BASED OFF-AXIS UV-VIS SPECTROMETER AT DOME CONCORDIA NDSC STATION, *Polar Atmospheres - Scientific and technical report series*, 2, 47-53, 2001

B – book chapters

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C - proceedings of international conferences

1. Bortoli, D., Giovanelli, G., Ravegnani, F., Silva, A.M., Costa, M.J., and Kostadinov, I., 2008: 10 years of stratospheric Nitrogen Dioxide and Ozone measurements in Antarctica. In *Proceedings of Quadrennial Ozone Symposium 2008, 29th June – 5th July, Tromsø, Norway* CD-Rom Eds.
2. Bortoli D., Giovanelli G and Silva A.M, Stratospheric trace gases monitoring in Antarctic region: 10 years of NO2 measurements and future activities during the International Polar Year, 6ª Assembleia Luso Espanhola de Geodesia e Geofísica, February 2008, Tomar, Portugal, 551-552.
3. Bortoli, D., A. Petritoli, G. Giovanelli, F. Ravegnani, I. Kostadinov, Stratospheric NO2 over Antarctica - 9 years of observation with GASCOD Spectrometer, *Geophysical Research Abstracts*, Vol. 7, 07263, 2005
4. Palazzi E., Premuda M., Petritoli A., Giovanelli G., Ravegnani F., Kostadinov I. And Bortoli D. Promsar: A Multiple Scattering Atmospheric Model For The Interpretation Of DOAS Measurements. *Atti della Fondazione Giorgio*

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- Ronchi, Anno LX, n.4 Selected Papers of Gold IEEE Remote Sensing Conference, M. Migliaccio and A. Iodice Eds, pg 689-695, 2005
- Bortoli, D., G. Giovanelli, F. Ravegnani, F. Calzolari, M. J. Costa, A.M. Silva, S. Beirle, T. Wagner, M. Wenig and U. Platt, Stratospheric Nitrogen Dioxide Over Terra Nova Bay Station From Ground Based And Satellite Observation, SIF Conf. Proc., 89, 153-168, 2004.
 - Bortoli D., F. Ravegnani, G. Giovanelli, A. Petritoli, I. Kostadinov, Stratospheric Nitrogen Dioxide In Antarctic Region, Proc. XX Ozone symposium, Vol. II.,940-941, Christos S. Zerefos, eds 2004.
 - Giovanelli G., A. Petritoli, E. Castelli, D. Bortoli, I. Kostadinov, F. Ravegnani, G. Redaelli, C. M. Volk, U. Cortesi , G. Bianchini, and B. Carli. Stratospheric minor gas distribution over the Antarctic Peninsula during the APE-GAIA campaign. Proc. Of the XX Quadrennial Ozone symp., 1-8 June 2004, Kos, Grece. C. Zerefos Ed. Pg 960-961 vol2 (2004)
 - Bortoli, D., F. Ravegnani, Iv. Kostadinov, G. Giovanelli, A. Petritoli, F. Calzolari, M.J. Costa, A.M. Silva, S. Beirle, T. Wagner, M. Wenig and U. Platt, Stratospheric Nitrogen Dioxide In Antarctic Regions From Ground Based And Satellite Observation During 2001, Proc. SPIE, Vol. 4882 304-313, 2003.
 - Werner, A. C. M. Volk, E. Ivanova, O. Riediger , M. Strunk, U. Schmidt, A. Ulanovsky F. Ravegnani. Transport in the Antarctic lowermost stratosphere from in situ measurements on board the M55 Geophysica aircraft. Stratospheric Ozone 2002, Proc of the 16th European symposium, 2-6 september 2002, N.R.P. Harris, G.T. Amanatidis and J.G. Levine Eds. pg 482- 485 (2003)
 - Bortoli, D., F. Ravegnani, Iv. Kostadinov, G. Giovanelli, A. Petritoli, P. Bonasoni and R. Werner, Stratospheric Ozone And Nitrogen Dioxide Amount Obtained With GASCOD Type DOAS Spectrometer At Terra Nova Bay (Antarctica) During December 2000-January 2001, Proc. SPIE, Vol. 4485, 225-235, 2002.

D – proceedings of national meetings and conferences

- Bortoli D., G. Giovanelli, F. Ravegnani, I. Kostadinov, S. Masieri, E. Palazzi, A. Petritoli, F. Calzolari, G. Trivellone, Studio delle variazioni di NO₂ nella stratosfera Antartica a diverse scale temporali, in *Clima e cambiamenti climatici: le attività del CNR*, Editore: Consiglio Nazionale delle Ricerche – Roma, ISBN 978-88-8080-075-0, pp. 483-486, 2007.

E – thematic maps

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F – patents, prototypes and data bases

- Bortoli D. e G. Giovanelli: Campagna di misura con lo spettrometro LIS installato a Lampedusa ed analisi dati (50 pagine). 4° ed ultimo obiettivo intermedio del Contratto attivo fra ISAC-CNR ed ENEA: "Studio di fattibilità, progettazione e realizzazione di strumentazione per la misura delle quantità colonnari di ozono e di altri gas atmosferici minori presso la stazione climatica di Lampedusa (rif. ENEA n. 99-58/47872 AMB-AMM-CON)". Bologna, 28 ottobre 2003
- Giovanelli G. e D. Bortoli: Realizzazione dello spettrometro LIS, elaborazione software di gestione strumento e software per elaborazione dei dati, messa a punto ed esecuzione test funzionali, redazione dei manuali d'uso e manutenzione, addestramento personale all'uso dello strumento (85 pagine). 2° obiettivo intermedio del Contratto attivo fra ISAC-CNR ed ENEA: "Studio di fattibilità, progettazione e realizzazione di strumentazione per la misura delle quantità colonnari di ozono e di altri gas atmosferici minori presso la stazione climatica di Lampedusa (rif. ENEA n. 99-58/47872 AMB-AMM-CON)". Bologna, 12 settembre 2002.

G – exhibits, organization of conferences, editing and similar

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H - formation (PhD thesis, research fellowships, etc.)

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Research units

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Fabrizio Ravegnani	ISAC-CNR
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Notes