

Final project report

<i>Project ID</i>	2004/6.04
<i>Title</i>	Climatic effects of aerosol particles and thin clouds over the East Antarctic Plateau
<i>Principal investigator</i>	Vito Vitale
<i>Institution</i>	ISAC-CNR Bologna
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<i>Duration</i>	3 years
<i>Assigned funding</i>	250.000,00 Euro

Activities and results

The research programme aims to provide (i) a complete characterization of the aerosol particle polydispersion in the lower troposphere over the East Antarctic Plateau, and an assessment on sources, transport processes, aerosol-climate interactions; (ii) obtain information on thin clouds, their multi-layered structure, water phase, and physical characteristics. An observational over determined data-set, including both remote sensing and in-situ measurements were implemented at Concordia station, where year-round activities started in 2004-2005. Continuous observations, based on lidar and sun/sky radiometers remote sensing techniques, supplying information on the whole atmospheric column, as well as chemical sampling (integral and size-segregated) at the surface, make possible to study in detail inter-annual and seasonal variations of aerosols over the high, interior Plateau. Strong cooperation with Finnish Meteorological Institute and Helsinki University, able us to improve size distribution measurements on a wide radius range (AIS, DMPS, dust monitor) and implement absorption measurements (PSAP). Unlikely, hard environment caused breaks and large holes in remote sensing observations.

All year-round size-segregated aerosol sampling allowed to highlight the seasonal trends of the main sources and transport processes of aerosols reaching the inner Antarctic plateau. Some specific markers have been used to identify and quantify the major sources of aerosol that reaches the inland areas of Antarctica, such as sea spray (Na^+ , Mg^{2+} and, partially, Cl^-), continental dust (Ca^{2+}), biogenic emissions (methanesulfonate - MSA, and non-sea-salt sulphate nss-SO_4^{2-}) and atmospheric reaction forming nitrogen cycle compounds (NO_3^- and NH_4^+).

In summer, ionic aerosol load is dominated by secondary species arising from biogenic marine activities, with sub-micrometric sizes. Vice versa, in winter aerosol is neutral as consequence of contributions arising from sea spray and continental sources with super-micrometric sizes. Total number concentrations as low as $<10 \text{ cm}^{-3}$ were frequently detected during winter months. In summer time, the total concentration exceed several times 1000 cm^{-3} . Occasional new particle formation events and particle growth were also detected. Typical daily average values of aerosol optical thickness (AOT) at 500 nm were found to be around 0.015, while slope of AOT spectral behaviour range around 1.6 (coastal values about 0.035 and 1, respectively). These values are very similar to those determined at South Pole. Measurements shown lidar powerfulness in deeply investigate vertical structure of the troposphere and its evolution, identifying ice crystal precipitation, snow-drift layers, ice/water clouds and their evolution just through qualitative interpretation of color plots that are automatically generated by the system.

This research develops in the frame of POLAR-AOD network and contributed to IPY 2007-2008 observational activities.

Products

A – papers in scientific magazines

1. R. Udisti, S. Becagli, S. Benassai, E. Castellano, I. Fattori, M. Innocenti, A. Migliori, R. Traversi. 2004, *Atmosphere-snow interaction by a comparison between aerosol and uppermost snow layers composition at Dome C (East Antarctica)*, Ann. Glaciol., 39, pp. 53-61.
2. O. Largiuni, E. Castellano, A. Migliori, R. Traversi, G. Piccardi, R. Udisti, 2004, *Preliminary study of HCHO spatial*

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- and temporal distribution from coastal to plateau areas in Antarctica, Intern. J. Environ. Anal. Chem., 84(6-7), pp. 537-549.
3. C. di Carmine, M. Campanelli, T. Nakajima, C. Tomasi and V. Vitale, 2005: *retrievals of Antarctic aerosol characteristics using a Sun-sky radiometer during the 2001-2002 austral summer campaign*, Journal of Geophysical Research, 110, D13202, doi:10.1029/2004JD005280.
 4. Ilaria Fattori, S. Becagli, S. Bellandi, M. Innocenti, A. Mannini, M. Severi, V. Vitale and R. Udisti, 2005: *Chemical composition and physical features of summer aerosol at TNB and Dome C (Antarctica)*, Journal Environmental Monitoring (J. Environ. Monit.), 2005,(12), pp. 1265-1274 DOI:10.1039/b507327h.
 5. Truzzi, C.; Lambertucci, L.; Illuminati, S.; Annibaldi, A.; and Scarponi, G. 2005, *Direct gravimetric measurements of the mass of the Antarctic aerosol collected by high volume sampler: PM10 summer seasonal variation at Terra Nova Bay*. Ann. Chim., 95, pp. 867-876.
 6. S. Becagli, M. Proposito, S. Benassai, R. Gragnani, O. Magand, R. Traversi and R. Udisti, 2005, *Spatial distribution of biogenic sulphur compounds (MSA, nssSO₄²⁻) in the northern Victoria Land - Dome C- Wilkes Land area (East Antarctica)*, Ann. Glaciol., 41, pp. 23-31.
 7. Annibaldi, A.; Truzzi, C.; Illuminati, S.; Bassotti E.; Scarponi, G. 2007, *Determination of water-soluble and insoluble (dilute-HCl-extractable) fractions of Cd, Pb and Cu in Antarctic aerosol by square wave anodic stripping voltammetry: distribution and summer seasonal evolution at Terra Nova Bay (Victoria Land)*, Anal. Bioanal. Chem., 387, pp. 977-998.
 8. C. Tomasi, B. Petkov, E. Benedetti, L. Valenziano, A. Lupi, V. Vitale and U. Bonafè, 2008: *A Refined Calibration Procedure of Two-channel Sun-Photometers to Measure Atmospheric Precipitable Water at Various Antarctic Sites*, Journal of Atmospheric and Oceanic Technology, 25, 2008, 213-229.
 9. C. Tomasi, V. Vitale, A. Lupi, C. Di Carmine, M. Campanelli, A. Herber, R. Treffeisen, R. S. Stone, E. Andrews, S. Sharma, V. Radionov, W. von Hoyningen-Huene, K. Stebel, G. H. Hansen, C. L. Myhre, C. Wehri, V. Aaltonen, H. Lihavainen, A. Virkkula, R. Hillamo, J. Ström, C. Toledano, V. Cachorro, P. Ortiz, A. de Frutos, S. Blindheim, M. Frioud, M. Gausa, T. Zielinski, T. Petelski and T. Yamanouchi, 2007, *Aerosols in polar regions: A historical overview based on optical depth and in situ observations*,. Journal of Geophysical Research, **112**, D16205, doi:10.1029/2007JD008432, 2007.
 10. Marino F., S. Becagli, E. Castellano, A. Mannini, E. Salvietti, O. Cerri, R. Traversi, S. Caporali, V. Maggi, R. Udisti., 2008, *Geochemical characterization of present-day dust by all-year-round high-volume aerosol sampling: planned activity for the 2005-2006 Dome C campaign*. Terra Antarctica Report, 14, 169-174.
 11. Truzzi C., A. Annibaldi, S. Illuminati, E. Bassotti, S. Becagli, R. Traversi, R. Udisti & G. Scarponi, 2008, *Sources of Antarctic Aerosol in Victoria Land Identified by Means of Principal Component Analysis (Varimax Rotation) of Snow Chemical Data*, Terra Antarctica Report, 14, 179-185.
 12. Jourdain B., S. Preunkert, O. Cerri, H. Castebrunet, R. Udisti, M. Legrand., 2008, *Year round record of size-segregated aerosol composition in central Antarctica (Concordia station): implications for the degree of fractionation of sea-salt particles.*, J. Geophys. Res., 113, D14308, doi: 10.1029/2007JD009584.
 13. Preunkert S., B. Jourdain, M. Legrand, R. Udisti, S. Becagli, O. Cerri, 2008, *Seasonality of sulphur species (dimethyl sulfide, sulfate and methanesulfonate) in Antarctica: inland versus coastal regions.*, J. Geophys. Res., 113, D15302, doi: 10.1029/2008JD009937.
 14. Gasso' S., A. Stein, F. Marino, E. Castellano, R. Udisti, J. Ceratto, 2010, *A combined observational and modeling approach to study modern dust transport from the Patagonia desert to East Antarctica*, Atm. Chem. Phys., 8287-8303, doi: 10.5194/acp-10-8287-2010.
 15. Annibaldi, A., Truzzi, C.; Illuminati, S.; Scarponi, G., 2010, *Direct gravimetric determination of aerosol mass concentration in central Antarctica*, Journal: Analytical Chemistry, in press.
 16. C. Tomasi, B. Petkov, R.S. Stone, E. Benedetti, V. Vitale, A. Lupi, M. Mazzola, A. Herber, W. Von Hoyningen-Huene, 2010, *Characterizing Polar Atmospheres and Their Effect on Rayleigh-Scattering Optical Depth*, Journal of Geophysical Research, **115**, D02205, doi: 10.1029/2009JD012852
 17. doi: 10.1029/2009JD012852

B – book chapters

1. R. Udisti, *Snow biogenic processes*, In B. Riffenburgh Ed., "Encyclopedia of the Antarctic", Taylor and Francis Group, New York (NY), 2007, Vol. 2, pp. 902-904.
2. Lupi, C. Lanconelli, M. Mazzola, V. Vitale, C. Tomasi, 2007. *Effetti radiativi diretti indotti dagli aerosol presso le stazioni MZS e Dome C in Antartide*. In *Clima e Cambiamenti Climatici*, le attività di ricerca del CNR (a cura di B. Carli, G. Cavarretta, M. Colacino, S. Fuzzi), Consiglio Nazionale delle Ricerche, ISBN 978-88-8080-075-0, pp. 327-330.

C - proceedings of international conferences

1. **V. Vitale** and V.F. Radionov, 2004: *Aerosol optical depth measurements in polar regions*, Proceedings del **1st WMO/GAW Expert Workshop on A Global Surface-Based Network for Long Term Observations of column Aerosol Optical Properties**, Davos, Svizzera, 8-10 marzo 2004, GAW report 162, 75-81 (cfr. the web site
2. <http://www.wmo.ch/files/arep/AODavos2004/ToC.htm>)

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3. V. Vitale, C. Tomasi, T. Yamanouchi, A. Herber, and R. S. Stone, 2007: The Polar Aerosol Optical Depth Measurement Network Project (POLAR-AOD-IPY). Proceedings of the International Symposium "Asian Collaboration in IPY 2007-2008", 1st March 2007, Tokyo (Japan), pp. 222-225.
4. E. Asmi, A. Virkkula, P.P. Aalto, R. Hillamo, K. Teinilä, C. Lanconelli, M. Busetto, R. Schioppo, V. Vitale and M. Kulmala, 2009, *Aerosol particle number size distribution measurements at a high plateau site in Antarctica*, Proceedings of 18th ICNAA. (International Conf. on Nucleation & Atmospheric Aerosol) Prague Czech Republic, August 10-14, in stampa.
5. V. Vitale, 2009, *Radiative processes in the troposphere and their role in climate changes at high latitudes: a bipolar perspective*, **invited talk**, E-ICES 5 Conference, Malargue, Argentina, November, 24-27, 2009.
6. M. Del Guasta, F. Castagnoli, V. Vitale, 2010, *An automated lidar for the monitoring of tropospheric clouds and aerosols at Concordia station (Antarctica)*, Proceedings of the 25th International Laser Radar conference (ILRC), S. Petesburg, 5-9 luglio, 2010, in stampa

D – proceedings of national meetings and conferences

1. Fattori, S. Becagli, S. Bellandi, M. Innocenti, A. Mannini, M. Severi, V. Vitale, R. Udisti, 2004: *Caratterizzazione chimica dell'aerosol atmosferico campionato su due differenti classi dimensionali a BTN e Dome C*, 10^o Convegno Nazionale "La contaminazione chimica in Antartide", Venezia, 10-11 giugno 2004, Atti del Convegno (P. Cescon Ed.), pp. 15-28.
2. M. Innocenti, I. Fattori, A. Mannini, S. Bellandi, E. Castellano, S. Becagli, R. Udisti, 2004, *Tecniche di analisi di superficie (AFM) per la caratterizzazione dimensionale dell'aerosol atmosferico a Terra Nova Bay e Dome C*, In: "La contaminazione chimica in Antartide", P. Cescon ed., Venezia (Italy), 2004, 8-14.
3. M. Innocenti, S. Becagli, S. Bellandi, I. Fattori, A. Mannini, M. Severi, R. Udisti, 2004, *Surface-distribution pattern of atmospheric aerosol particles collected in coastal and inner Antarctic sites by Atomic Force Microscopy measurements*, In: "Italian Research on Antarctic Atmosphere" - M. Colacino ed., SIF - Bologna, 2004, 89, 87-99.
4. Fattori, S. Bellandi, S. Benassai, M. Innocenti, A. Mannini, R. Udisti, 2004, *Ion balances of size resolved aerosol samples from Terra Nova Bay and Dome C (Antarctica)*, In: "Italian Research on Antarctic Atmosphere" - M. Colacino ed., SIF - Bologna, 2004, 89, 101-115.
5. M. Innocenti, S. Bellandi, I. Fattori, A. Mannini, E. Salvietti, R. Udisti, 2005, *Aerosol a Dome C: un riferimento per la definizione di aerosol di background troposferico*, In: "La contaminazione chimica in Antartide", P. Cescon ed., Venezia (Italy), 2005, 108-114.
6. I. Fattori, S. Bellandi, M. Innocenti, A. Mannini, E. Salvietti, R. Udisti, 2005 *Indicatori ambientali nel marine boundary layer da misure di aerosol a Mario Zucchelli Station*, In: "La contaminazione chimica in Antartide", P. Cescon ed., Venezia (Italy), pp. 99-107.
7. A. Petroselli, C. Truzzi, S. Illuminati, A. Annibaldi, and G. Scarponi, 2005, *Aerosol antartico: frazionamento solubile/insolubile di metalli in tracce*. 11^o Conv. Naz. "La Contaminazione Chimica in Antartide", Venezia, 23-24/6/2005. Extended abstracts, pp. 87-98.
8. Becagli S., E. Castellano, O.Cerri, M. Chiari, F. Lucarelli, F. Marino, A. Morganti, S. Nava, F. Rugi, M. Severi, R. Traversi, V. Vitale, R. Udisti., 2009, *All year round background aerosol at Dome C (Antarctica). Chemical composition of size-segregated samples collected during the 2004-05 campaign.*, In. M. Colacino e C. Ravanelli Eds, Conference Proceedings, XI Workshop Italian Research on Antarctic Atmosphere, SIF Bologna, 97, 17-42.
9. Lupi, A., C.Lanconelli, M. Mazzola, B. Petkov, V. Vitale, C. Tomasi, 2009, *Direct aerosol radiative effects along the Ross Sea coast and over the high Antarctic Plateau*, In. M. Colacino e C. Ravanelli Eds, Conference Proceedings, XI Workshop Italian Research on Antarctic Atmosphere, SIF Bologna, 97, 95-102.
10. V.Vitale, A.Lupi, M.Mazzola, C.Lanconelli, M.Busetto, S.Becagli, R. Traversi, R. Udisti, 2010, *Caratteristiche degli aerosol in antartide e loro impatto sul bilancio di radiazione delle regioni costiere e interne del continente*, SIF Proceedings, in stampa.
11. R. Udisti, S. Becagli, D. Frosini, G. Galli, C. Ghedini, M. Severi, R. Traversi, A. Lupi, M. Mazzola, C. Lanconelli, M. Busetto, V. Vitale, 2010., *Aerosol di background in Antartide: una fonte di studio sulle interazioni tra clima e ambiente nel periodo attuale e nel passato.*, SIF Conference Proceedings, in stampa.

E – thematic maps

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F – patents, prototypes and data bases

1. Implementation in Concordia of the chemical Lab in cooperation with activities planned in the frame of other projects (Italian, French) in particular connected to Glaciology.
2. Design and realization of a minilidar system
3. Design and realization, thanks to an Agreement with IAO Institute of Russian Academic Science in Tomsk, of a sun radiometer for sky-brightness measurements at Concordia in the spectral range 400 – 4000 nm.
4. Implementation at Concordia of in-situ physical-optical aerosol measurements (in cooperation with FMI and UHEL Finnish Institutions – dr. Virkkula, dr. Kulmala, dr. Hillamo)

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G – exhibits, organization of conferences, editing and similar

1. partecipazione 1st WMO/GAW Expert Workshop sul tema *A Global Surface-Based Network for Long Term Observations of column Aerosol Optical Properties*, Davos, Svizzera, 8-10 marzo 2004 e comunicazione su invito
2. organizzazione del Workshop *Tropospheric aerosol researches at Dome C*, 22-23 October, 2004, Bologna, e presentazione della comunicazione *Climatic effects of aerosol particles and thin clouds over the East Antarctic Plateau*.
3. Organizzazione del Workshop, *Quantification of Tropospheric Aerosol and thin clouds Variability over the East Antarctic Plateau, including Radiation budget (TAVERN)*, 11-12 Aprile 2005, e presentazione della comunicazione *Clean air facility, IPY expression of intent, sun-photometric measurements, connection with other research activities at Dome C*.
4. organizzazione e partecipazione alla first intercomparison POLAR-AOD Campaign, Ny Alesund 25 Marzo - 3 Aprile, 2006
5. organizzazione e partecipazione al 2th POLAR-AOD workshop 4-5 aprile 2006, Ny Alesund
6. public lecture presso il Centro Congressi di Ny Alesund dal titolo *Concordia (Dome C): a new research station over the high inner Antarctic Plateau*
7. partecipazione al Sunphotometry workshop di esperti *Polar AOD issues during the IPY*, St. John's Newfoundland, May 27-28, 2007
8. organizzazione e partecipazione alla seconda intercomparison POLAR-AOD Campaign, Izagna 03 Ottobre - 21 Ottobre, 2008
9. partecipazione al Convegno E-ICES5, 21-24 Novembre 2009, Malargue, Argentina con presentazione su invito

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

1. **MASTER THESIS** - Fondi Jessica. 2005 - Chimica, Univ. Firenze: Caratterizzazione chimica dell'aerosol atmosferico campionato nel plateau antartico su varie classi dimensionali
2. **MASTER THESIS** - Mazzone Nicola. 2006 - Univ. Bologna: Caratterizzazione chimica e fisica del particolato atmosferico in aree marine remote.
3. **MASTER THESIS** -Rugi Francesco. 2006 – Chimica, Univ. Firenze: Sviluppo e ottimizzazione di metodi in HR-ICP-MS per la determinazione di metalli in matrici ambientali
4. **PhD THESIS** - Fattori Ilaria. 2005 – Sc. Chimiche, Univ. Firenze: Studio della composizione chimica e della distribuzione dimensionale delle particelle in atmosfera, in relazione alle fonti e ai diversi ecosistemi remoti e antropizzati.
5. **PhD THESIS** -Mannini Alessandra. 2006 - Sc. Chimiche, Univ. Firenze: Caratterizzazione dell'aerosol atmosferico in siti a differente grado di antropizzazione.
6. **PhD THESIS** - Cerri Omar. In corso - Sc. Chimiche, Firenze: Caratterizzazione chimica e fisica dell'aerosol in Antartide e sua interazione con i sistemi di circolazione atmosferica. In corso di svolgimento.
7. **PhD THESIS** – Rugi Francesco. In corso - Sc. Chimiche, Univ. Firenze
8. **GRANT** - Castellano Emiliano. 2007 – Univ. Firenze: Identificazione e quantificazione di marker ambientali nel PM1.
9. **POST MASTER THESIS** Lorenzo Moggio, 2009, *Influenza Del Trasporto A Lunga Distanza Di Aerosol Dal Sud America Sul Bilancio Di Radiazione Della Penisola Antartica*, tesina finale della classe accademica di scienze e Tecnologie dell' Istituto Universitario di Studi Superiori (IUSS), Pavia, Anno Accademico 2008-2009, pp. 59.

Research units

Research Unit 1: COL-VIT

Vito Vitale, Ricercatore P.I. del progetto	ISAC-CNR
Mauro Mazzola, Post doc	ISAC-CNR
Christian Lanconelli, Post Doc	ISAC-CNR
Angelo Lupi, Post Doc	ISAC-CNR
Boyan Petkov, Ricercatore	ICTP e ISAC-CNR
Giuliano Trivellone, Collaboratore CTER	ISAC-CNR
Francesco Piero Calzolari, Collaboratore CTER	ISAC-CNR

Research Unit 2: COL-GUA

Massimo Del Guasta, Ricercatore	IFAC-CNR,
Marco Morandi, Collaboratore CTER	IFAC-CNR
Francesco Castagnoli, Collaboratore CTER	IFAC-CNR
Valerio Venturi, Collaboratore CTER	IFAC-CNR

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Research Unit 3: COL-INN

Massimo Innocenti, Ricercatore
Ilaria Fattori, PhD student
Alessandra Mannini, PhD student
Silvano Bellandi, tecnico
Franco Lucarelli, Prof. Associato
Ezio Bolzacchini, Prof. Associato
Maria Grazia Perrone, PhD student

Dip. Chimica Univ. FIRENZE
Dip. Chimica Univ. FIRENZE
Dip. Chimica Univ. FIRENZE
Dip. Chimica Univ. FIRENZE
Dip. Fisica Univ. FIRENZE
DISAT Univ. MILANO-BICOCCA
DISAT Univ. MILANO-BICOCCA

Research Unit 4: COL-SCA

Giuseppe Scarponi, Prof. Ordinario
Luca Lambertucci, PhD student
Anna Annibaldi, PhD student
Silvia Illuminati, PhD student

Dip. Scienze del Mare, Univ. Polit. Marche
Dip. Scienze del Mare, Univ. Polit. Marche
Dip. Scienze del Mare, Univ. Polit. Marche
Dip. Scienze del Mare, Univ. Polit. Marche

Research Unit 5: COL-INN

Federica Rossi, Primo Ricercatore
Marianna Nardino, assegnista
Maurizio Barazzutti, Collaboratore CTER

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Date: 09-02-2011

Notes: