National Research Council of Italy
Department of Earth System Science
and Environmental Technologies

Research Activity in Ny-Ålesund 2011-2012

CNR Italian Arctic Station

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Summary

Preface

A growing international interest in the Arctic has both scientific and political motivations. Scientific interest derives from results indicating that climate change is inducing maximum effects in this region, while political motivations arise from the region's enormous economic resources and commercial interest. Such an interest is confirmed by the growth of scientific activities, also witnessed by the increased number of research stations in the Arctic region and especially in the Svalbard Archipelago. Several countries have permanent research stations at Ny-Ålesund, and there are many ongoing international scientific projects.

Italy, and especially the National Research Council of Italy (CNR), has a very long lasting activity in developing research in the Arctic and especially at Ny-Ålesund. Indeed, CNR is coordinating and supporting the Italian scientific activities in the Region since 1997, with the operation of the "Station Dirigibile Italia" (SDI). In addition, in recent years CNR implemented two new infrastructures, the 35 m high "Climate Change Tower" (CCT) and the Gruvebadet aerosol Laboratory, therefore providing new opportunities to carry out monitoring and scientific activities on climate change and atmospheric physics. I believe that such initiatives, and especially the climate change tower, also used for mass and energy exchange studies at Ny-Ålesund, will allow increased international cooperation and the implementation of new projects on biosphere-hydrosphere-atmosphere relationships.

The scientific activities by CNR in the Arctic aim to strengthen international cooperation and to provide a significant contribution to the observational system in the Arctic, following the recommendations by Sustaining Arctic Observing Network (SAON). Furthermore, CNR is one of the partners who is promoting the ESFRI infrastructure Svalbard Integrated Arctic Observing System (SIOS) and the SIOS Consortium, and will support the full development of this infrastructure in the framework of the Arctic Observational system. Together with the improvement/development of a supersite at Ny-Ålesund, CNR is operating to contribute/ sustain thematic networks (Polar-AOD for aerosol and GMOS for mercury leaded by CNR), and will continue to participate to the development of EU initiatives on future infrastructures.

CNR recognizes the strategic value for the national and international scientific community in maintaining the scientific infrastructures in the Arctic and will therefore continue in supporting the effort of the Department of Earth System Science and Environmental Technologies (DTA) to favor the implementation of research excellence of research at Ny-Ålesund and in the Arctic.

This volume and the scientific contributions herein, testify the variety of the scientific activities carried out by the Italian community and provides opportunity to continue in supporting research projects in the High North.

Prof. Luigi Nicolais
President of CNR

Introduction

The National Research Council of Italy (CNR), since 1998, is continuing supporting and coordinating research projects and activities in the Arctic region, as part of the international community operating in Ny-Ålesund, one of the four permanent settlements in the island of Spitzbergen, in the Svalbard archipelago.

In more recent years, the building and the implementation of the "Amundsen-Nobile Climate Change Tower" (CCT) has been a major benefit for the Italian scientific community.
The CCT is located at Kolhaugen, just outside the Ny-Ålesund research village, at about 30 meters of altitude and it is 34 meters high. The tower is set up with several instruments to measure atmospheric physical parameters, greenhouse gases and micrometeorological parameters, and data are acquired and transmitted in real-time to CNR, Institute of Atmospheric Science and Climate (ISAC), Bologna. The CCT is part of the atmospheric monitoring system that involves instruments of different countries and is an important part of the ESFRI infrastructure Svalbard Integrated Observing System (SIOS), that is completing its preparatory phase.

CNR is actually increasing research activities at Ny-Ålesund and recently started using the Gruvebadet building as a laboratory carrying out measurements of atmospheric chemistry, focusing on aerosol size and distribution; moreover, the research "Station Dirigibile Italia" (SDI) is being implemented to increase laboratory facilities and to improve internet connection capabilities, both local and remote.

This report describes the activities performed at SDI during the years 2011-2012, with the coordination and support of CNR- Department of Earth System Science and Environmental Technologies (DTA), formerly Department Earth and Environment.

In addition to atmospheric research, a scientific area in which Italy has a long tradition, research activities carried out at SDI also includes studies in many disciplines and different thematic area.

Several chapters of this volume address research activities to climate and climate change and its effects at different levels of investigation, going from stratospheric research, atmospheric processes, ozone measurements, atmospheric pollutants (e.g., mercury), aerosols, greenhouse gas flux measurements, snow, ice and permafrost studies, to oceanographic studies in the Kongsfjorden and Svalbard margin of the Arctic Ocean.

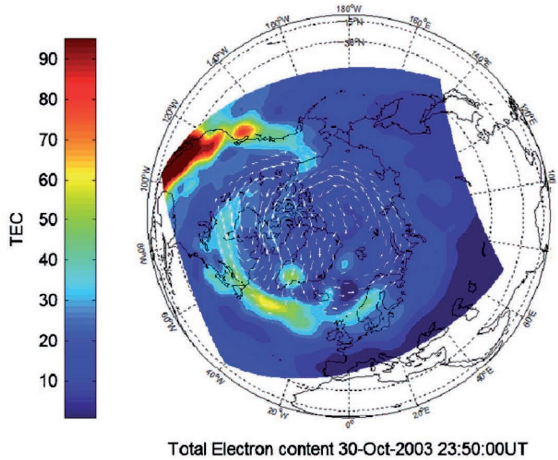
The last two chapters of the present volume are devoted to logistics aspects of research activities and "scientific communication, outreach and education", respectively. Communication and dissemination of scientific results, outreach and educational activities at school should be considered very important activities for scientists, to increase public opinion awareness in science; this is especially true for polar science, to let also new generations to grow up with increased understanding about climate change and the role of the Arctic in global circulation and its importance for human and societies.

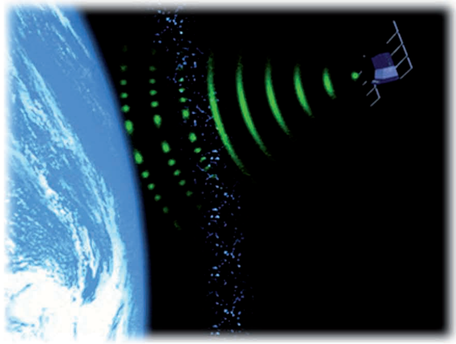
Finally, we would like to thank all scientists who are contributing to carry out the scientific activities described in this volume and provided information and scientific results. We are also grateful to all personnel involved in logistic activities. Special thanks are also due to King's Bay and its personnel, for their support to Italian scientists and technicians at Ny-Ålesund. The scientific and technical cooperation of all the Ny-Ålesund scientific community is also gratefully acknowledged.

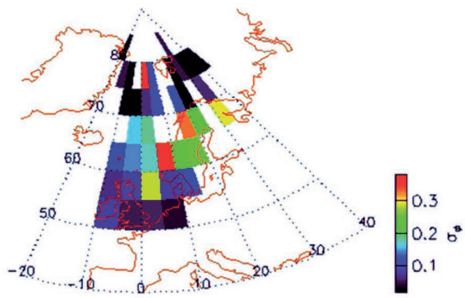
Ruggero Casacchia
Head of Polar Unit

Enrico Brugnoli
Director CNR-DTA

IONOSPHERE







ISACCO – Ionospheric Scintillations Arctic and Antarctic Campaign Coordinated Observations

Scope of the project is to measure the ionospheric Total Electron Content (TEC) and monitor ionospheric scintillations.

Research group

INGV - National Institute for Geophysics and Volcanology (Rome, Italy)
Giorgiana DE FRANCESCHI, Vincenzo ROMANO, Lucilla ALFONSI, Luca SPOGLI

Image on previous page: the Halloween super-storm in October 2003 generated turbulence and irregularities in the ionosphere. The phenomen lasted for several hours and the satellite signals were consequently disrupted, causing severe problems in navigation and precise positioning.
The ionospheric effect of the storm were monitored and studied in Northern Europe by using the ISACCO network.

Rationale

The disturbances that the ionosphere can induce on the electromagnetic signals emitted by the GNSS (Global Navigation Satellite System) constellations are due to the presence of electron density anomalies in the ionosphere, that occur with particular frequency at high latitudes where the upper atmosphere is highly sensitive to perturbations coming from the outer space.
Under disturbed conditions the ionosphere can present "bubbles" of high electrons concentration that can strongly jeopardize the satellite signal received at ground. This is the main reason why scintillations monitoring has a central role in the development of forecasting tools within the space weather activities addressed to navigational and positioning systems.

GISTM Network

The principal scope of the project ISACCO "Ionospheric Scintillations Arctic Antarctic Campaign Coordinated Observation" is to measure the ionospheric Total Electron Content (TEC) and to monitor the ionospheric scintillations by suitably modified GPS receivers – GISTM (GPS Ionospheric Scintillation and TEC Monitor).
The project ISACCO was born at the beginning of 2003 as a proposal submitted to the call for opportunity 2003–2004 for the access to the CNR (Italian National Research Council) Italian Arctic Station "Dirigibile Italia" (79.9N, 11.9E, Ny-Ålesund, Svalbard, Norway). After a positive outcome of the application, in September 2003 the first GISTM receiver was installed in Ny-Ålesund. In 2004, a second receiver was located about 1 km far from the first one and a third receiver was set up in Longyearbyen, 125 km from the other two. In January 2006, another GISTM was installed at the Italian Antarctic Station "Mario Zucchelli", Terra Nova Bay (74.7S, 164.1E) and in January 2008 two more receivers were deployed at the Italian-French Antarctic Station Concordia at Dome C (75.0S, 123.0E), on the Antarctic plateau.
Currently the GISTM bi-polar network consists of NovAtel OEM4 dual-frequency receivers with special firmware, comprises the major component of a GPS signal monitor, specifically configured to measure amplitude and phase scintillation from the L1 frequency GPS signals, and ionospheric TEC (Total Electron Content) from the L1 and L2 frequency GPS signals. Software is included in the GISTM to automatically compute and log the amplitude scintillation index, S4, and phase scintillation index, σ, computed over 1, 3, 10, 30 and 60 s. In addition, TEC and TEC phase are each logged every 15 s. Phase and amplitude data, either in raw form or detrended (to remove systematic variations), are also logged at 50 Hz.

eSWua DATA BASE

All scintillation and TEC data are stored locally and populate in near real time or off line (depending on the internet facilities) the eSWua (electronic Space Weather for upper atmosphere) data base.
eSWua (Romano et al, 2008) is a hardware-software system based on measurements performed by the instruments installed by the upper atmosphere physics group of the Istituto Nazionale di Geofisica e Vulcanologia (INGV) and now includes the GISTM stations operated by the IESSG (University of Nottingham, Geospace Institute, UK).
In Table 1 details on the GISTM network supporting eSWua DB are listed. Visiting eSWua web site (Figure 1) it is possible to access the database, realized to organize and manage the large amount of information acquired. The section of the DB designed for the TEC and scintillations data has been thought to address the needs of space weather as well as of scientific users. Through the web tools is possible to visualize, plot, extract and download the data of each station.
This interactive web site, supported by a well organized database, is a powerful tool for scientific and technological community in the field of telecommunications and Space Weather.

ID/Location	Receiver type	Owner	Lat.	Lon.	Since	Meas./Sampling
NYA0 Ny-Ålesund, Svalbard	NOVATEL	INGV	78.9°N	11.9°E	Oct 2003	Scintillations, TEC 50Hz
NYA1 Ny-Ålesund, Svalbard	NOVATEL	INGV	78.9°N	11.9°E	Nov 2006	Scintillations, TEC 50Hz
LYB0 Longyearbyen, Svalbard	NOVATEL	INGV	78.2°N	16.0°E	Nov 2006	Scintillations, TEC 50Hz
Trondheim (Norway)	NOVATEL	IESSG UoN/UK	63.40°N	10.40°E	2001	Scintillations, TEC 50Hz
Nottingham (UK)	NOVATEL	IESSG UoN/UK	52.90°N	1.20°W	2001	Scintillations, TEC 50Hz
Dourbes (Be)	NOVATEL	IESSG UoN/UK	50.10°N	4.60°E	2004	Scintillations, TEC 50Hz
DMC0 Concordia, Antarctica	NOVATEL	INGV UoB/UK	75.1°S	123.2°E	Jan 2008	Scintillations, TEC 50Hz
DMC1 Concordia, Antarctica	NOVATEL	INGV	75.1°S	123.2°E	Jan 2010	Scintillations, TEC 50Hz
BTN0 MZS, Antarctica	NOVATEL	INGV	74.7°S	164.1°E	Jan 2006	Scintillations, TEC 50Hz

Table 1 List of GISTM stations included in eSWua data base

Currently the data transmission procedure, the DB population algorithm, the linear plot and polar plot visualization tools, the statistics page and users management system are fully realized. The web access to data and tools is realised for treating data from the sites of Arctic, Antarctica and from other mid-low latitude GISTM stations. The eswua's data policy is that the visualization and downloading of plots and maps is open worldwide.
The downloading of data (raw and elaborated) needs authorizations from the administrator that can exclusively enable the registered user to download selected data concerning a specific GISTM station. Scintillation data are open and free for scientific use, in case of their use in a founded project or for commercial use an agreement is needed.

Ground Based Scintillation Climatology (GBSC)

As the establishment of the monitoring network, the idea came out to develop an original technique allowing the identification of areas of the ionosphere in which scintillation is more likely to occur (Spogli et al., 2009, 2010). Combining this technique, based on a suitable statistical treatment and representation of the scintillation data, with TEC maps as obtained by MIDAS (Multi Instrument Data Analysis System), the effects of the severe October/November 2003 storms over the North polar ionosphere and Northern Europe have been investigated (De Franceschi et al, 2008). Through MIDAS the plasma dynamics was reconstructed and high TEC "islands" identified over Northern Europe, more likely originated from the convection of plasma from the North American region.
Plasma convecting in this manner is dominated by the presence of F-region patches. In fact, severe amplitude and phase scintillations were observed in coincidence with steep TEC gradients, a characteristic of the edge of polar cap patches (Figure 2). These gradients can result in the production of small-scale irregularities by the gradient-drift instability. Recently GBSC has been successfully applied to investigate on the irregularities scale-size at bipolar region (Alfonsi at al., 2011). The main findings can be summarized schematically: amplitude scintillations (S4 index) are triggered by irregularities of scale sizes up to hundreds meters, the Rate of Total Electron Content (ROT) identifies larger scale sizes (few kilometers), and phase scintillations can be produced by irregularities of all scales sizes.

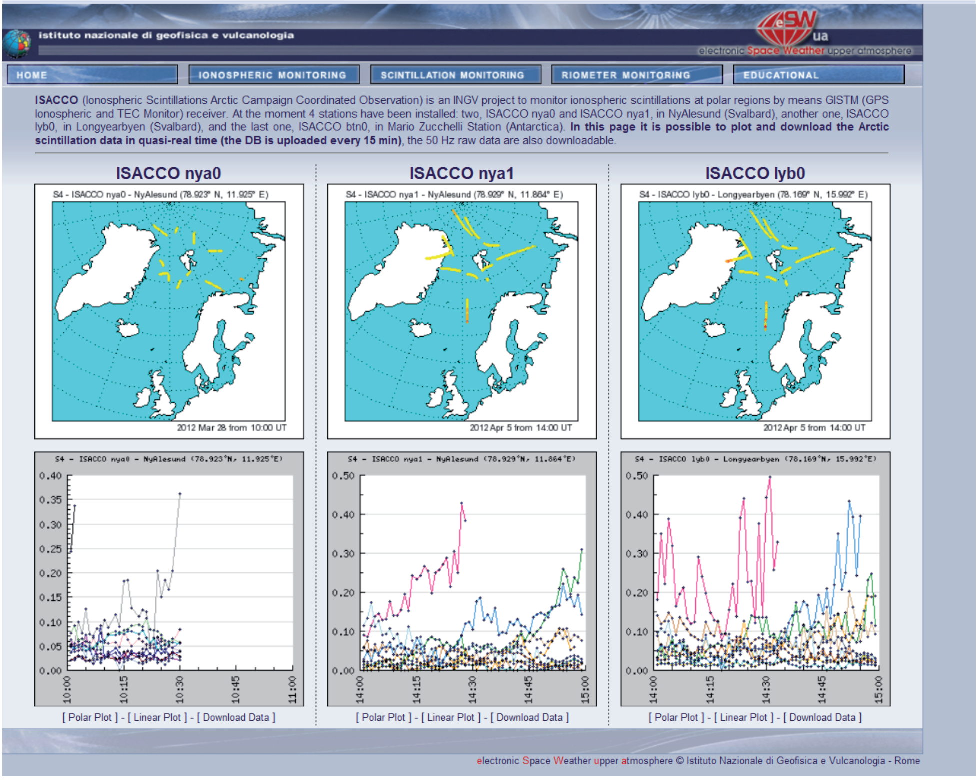


Figure 1 The arctic GISTM initial web page at eSWua (http://www.eswua.ingv.it/ingv/s_arc.php)

<u>Principal National/International Projects of Reference</u>

ESWua (Electronic Space Weather upper atmosphere) www.eswua.ingv.it. INGV co-funded by PNRA. P.I. Dr. V. Romano (INGV, Rome, Italy). It's a database project to manage historical and near-real time data coming from HF sounding and GNSS ionospheric scintillation monitoring.

Upper Atmosphere Monitoring and Space Weather, PNRA 2009/B.03-BIS - P.I. Dr. G. DeFranceschi. It's a project among INGV, PNRA, POLARNET, aiming to monitor and investigate the ionospheric scintillations over BI-POLAR region.

IDIPOS (Italian Database Infrastructure for Polar Observation Sciences) /PNRA 2009 PI - Dr. Vincenzo Romano). The project aims to realize a feasibility study of a hardware and software infrastructure that would allow the creation of relational databases of digital acquisitions from past and current experimental measurements performed in polar areas in both hemispheres.

ARCFAC-HF PROPAGATION - PI Prof Mike Warrington, University of Leicester, UK. HF path from Greenland to Ny-Ålesund experimental observations and comparison with polar patches and ionospheric irregularities observed at Svalbard.

GRAPE (GNSS Research and Application for Polar Environment). It is a SCAR (Scientific Committee for Antarctic Research) Expert Group, cross link between the Physical Science Standing Scientific Group and Geosciences Standing Scientific Group, led by Dr. G. De Franceschi (INGV, Italy), aiming at developing a GNSS bi-polar network for geodetic, atmospheric and ionospheric studies over the polar areas.

TRANSMIT (Training Research and Application Network to Support the Mitigation of Ionospheric Threats, www.transmit-ionosphere.net), 2011-2014, is an FP7 Marie Curie Initial Training Network focused on the study of ionospheric phenomena over global scale and their effects on systems embedded in our daily life. The project will develop a set of integrated real-time state-of-the-art tools capable to mitigate ionospheric threats to Global Navigation Satellite Systems (GNSS) and related applications, in areas such as civil aviation, marine navigation and land transportation.
At the core of TRANSMIT is the training of a group of young scientists, the TRANSMIT fellows, who will ultimately carry out the project's research work, culminating with a prototype of the Ionospheric Perturbation Detection Monitoring network. Dr. G. De Franceschi is TRANSMIT dissemination manager.

Report Campaign

The following objectives have been reached:
- upgrade of the acquisition system of station ISACCO-NYA0;
- maintenance of the stations ISACCO-NYA1 and LYB0;
- optimization of the acquisition procedures and of the near-real-time data processing software;
- raw and processed data download on hard drive and its shipping to Italy.

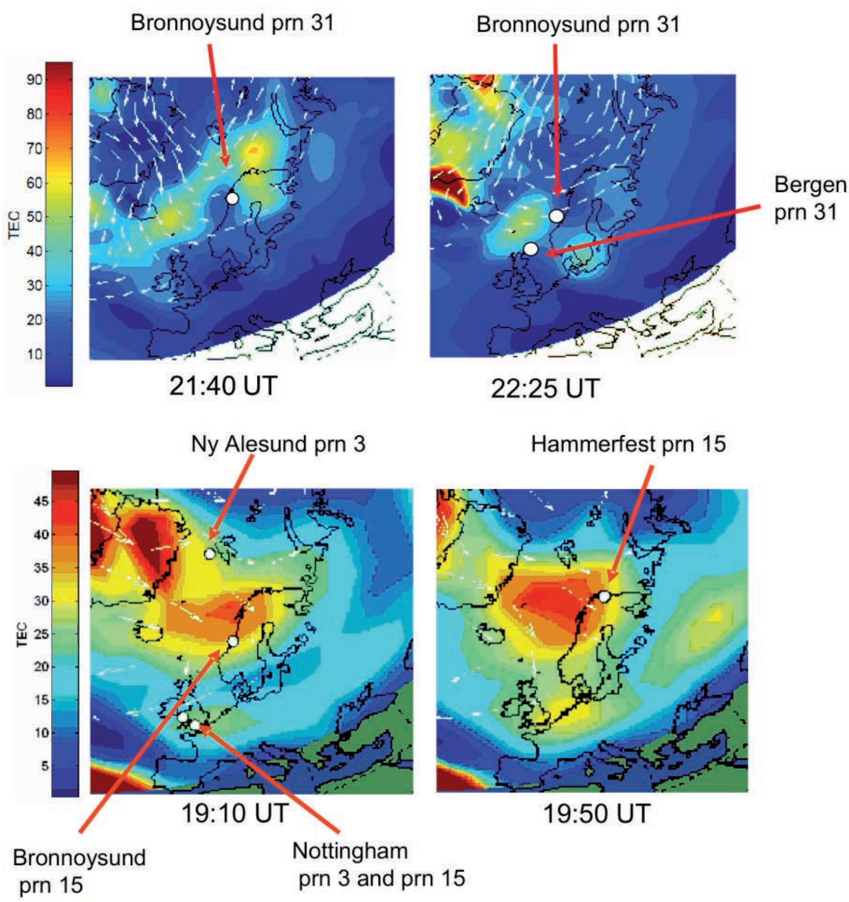


Figure 2 Equivalent vertical TEC (TECU) snapshots by MIDAS for 30 October at 21:40 and 22:25 UT (top), and 20 November at 19:10 and 19:50 UT (bottom). Phase scintillation index maxima for selected PRNs from the GISTM network chain are superimposed

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STRATOSPHERIC CIRCULATION

POP: Polar Observation Platform

Testing the stratospheric circulation in the polar winter using stratospheric balloons.

Research group

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CNR DTA - Dep. of Earth System Science and Environmental Technologies (Rome, Italy)
Emiliano LIBERATORI

Image on previous page: the preparatory activities for the launch from Ny-Ålesund (Svalbard).

Rationale

The target of this activity is to demonstrate the feasibility of long-duration stratospheric-balloon flights during the polar night in the Arctic. The long duration is obtained launching the balloons from the Svalbard Islands, and using the circumpolar vortex to obtain 1-2 weeks flights with recovery in Greenland.
These flights will be extremely useful for geophysical, atmospheric and astrophysical observation programs. Astrophysicists and cosmologists need to operate ultra-sensitive survey telescopes avoiding the very strong emission from the sun and the disturbance produced by the Earth's atmosphere. The Arctic winter stratosphere is optimal in this respect, because offers near-space conditions and, in addition, the Earth acts as a giant sunshield (shielding the telescope much better than what can be done in a deep-space space mission). The forthcoming LSPE (Large Scale Polarization Explorer) is a mm-wave polarimeter funded by the Italian Space Agency to study the very early universe by means of ultrasensitive measurements of the polarization of the cosmic microwave background. This experiment will be launched in winter 2015 from Svalbard. Many other experiments (in the visible, IR, sub-mm and mm-wave ranges) will use this facility once it is validated and established.

Before launching heavy-lift payloads, we are carrying out a preparatory activity, using small balloons with light payloads to demonstrate the circumpolar circulation pattern during the arctic winter, at the same altitude (35 to 40 km) which will be used by large balloons, and to validate the operation of critical sub-systems in the harsh environment (3 mbar, -80C, no solar power available) of the polar-winter stratosphere.

In this framework, using funds from the PNRA-CNR (activity 2010-A3.02) and ASI (activity LSPE), we have developed specialized flight hardware consisting of:

- flight train, including balloon, termination devices, parachute;
- bidirectional, low-power, slow data-rate, worldwide-coverage telemetry;
- environment sensors (pressure, temperature, position, altitude) suitable for the stratospheric environment;
- high performance passive thermal protection (to avoid heaters and saver weight);
- Radiation-hard microcontroller, and power supply system for the polar night.

In addition, we have developed and tested a launch infrastructure and launch procedures suitable for the polar winter.
We have performed 2 launches in January 2011, and 2 launches in January 2012, all from the CNR research facility Dirigibile Italia, located on the Brøgger Peninsula in the community of Ny-Ålesund on Spitsbergen Island, Svalbard (78°55'0" N 11°56'0"E). Ny-Ålesund is the world's northernmost functional public settlement. We had full logistic support from CNR-DTA, and friendly help from the King's Bay and AWI-IPEV personnel.

2011 Campaign

In January 2011 we used a much simplified payload including a battery powered ARGOS / GPS transmitter that delivered time, temperature, speed, heading, and altitude. The balloons were a cylinder design manufactured by Near Space Corporation (Tillamock, OR, USA). Each balloon was 2,523 m^3 (89,106 ft^3) with a payload range of 0 lb/ 0 kg – 85 lb / 38.56 kg.
The first launch was performed in mild conditions, -12C with < 2 kts. The balloon ascended nominally but then began to descend after reaching an altitude of 18 km, landing on a glacier approximately 79° 03' 30" N 12° 22' 26" E.

The second launch operation began in mild condition (-8C, 1 kt winds) until inflation began, when the winds rose to 12 kts throughout the inflation and launch. After the balloon was released from the spool the winds calmed down again and remained calm for the next 24 hours.
The second balloon maintained a nominal ascent (see fig. 1) and remained at the prescribed float altitude for 5.5 days. The trajectory of the second balloon confirms that east-bound stratospheric winds during the winter months can support a Long Duration Balloon flight (see fig.2).

Figure 1 The ascending balloon shortly after launch, with aurora in the background

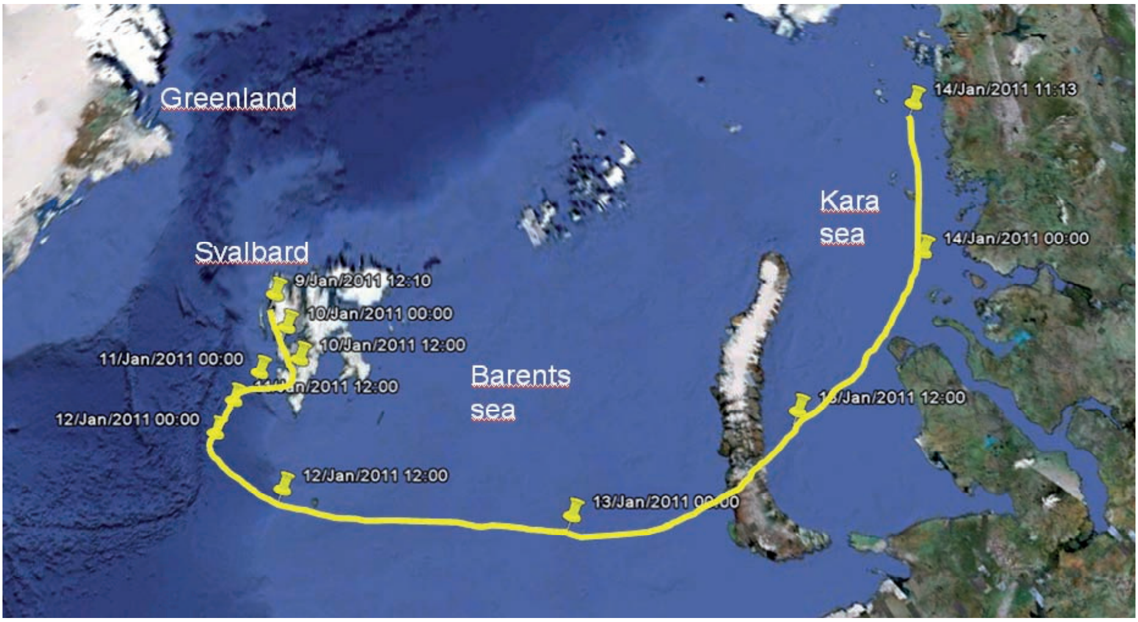

Figure 2 Ground track of flight POP-2011-12. The flight was terminated before reaching the Russia mainland, but the eastbound trajectory was demonstrated

2012 Campaign

During 2011 we prepared two custom lightweight (5 kg) payloads consisting of a GPS receiver, temperature and pressure sensors, an Iridium SBD communication system, a radiation-hard microcontroller, termination drivers, and a battery pack. The main challenge in the preparation of a payload for a long duration flight in the polar night is thermal insulation.

The system has to operate in an environment with a pressure of a few mbar and a temperature of -80C, supplied only by batteries. In order to minimize the weight of the system, we used lithium cells, which maximize the stored energy to weight ratio, and insulated very carefully the battery pack and the system electronics to avoid the use of electrical heaters. The system is surrounded by mylar superinsulation, suspended by Kevlar cords, and inserted in a vacuum vessel to minimize heat dispersion.

A sketch of the payload is shown in fig.3. The system has been able to operate in the harsh conditions of the polar winter stratosphere with just 1W of power.

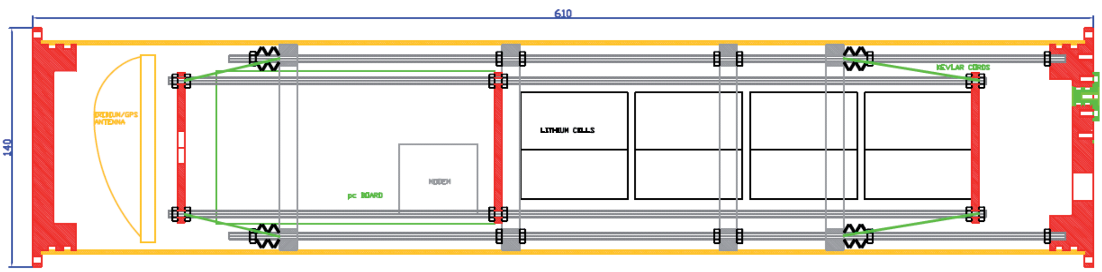

Figure 3 Sketch of the light-weight payload used to study stratospheric circulation in the Arctic during the polar winter (dimensions in mm)

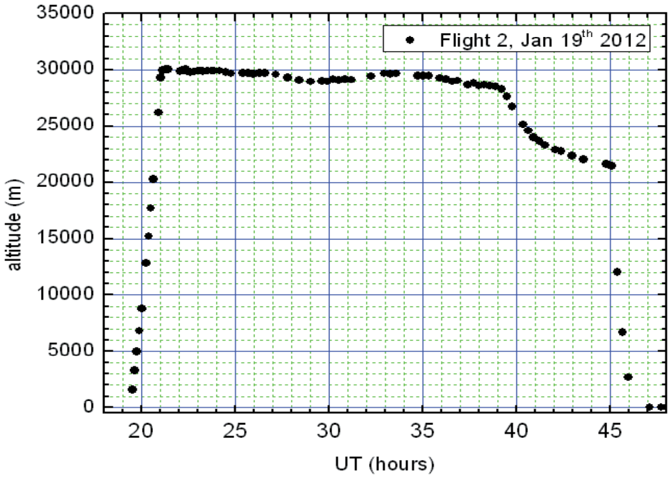

Figure 4 and 5 Launch of POP-2012-2 and flight profile

In January 2012 we had a second launch campaign in Ny-Ålesund. This time we used larger balloons (3800m^3). While the first balloon failed during ascent (probably due to a combination of very low air temperature and strong shear wind) the second one performed nominally (see fig.4 and 5).
The launch date was too late in the season to use the stratospheric vortex, but the flight allowed us to test extensively the performance of the payload and of the communication system. This worked nominally, despite of the extremely low environment temperature, validating the low-power / high-insulation design strategy and the choice of all of the subsystems.

The temperature of the controller board and of the iridium transceiver did not fall below -20°C, despite of the -80C measured air temperature. Due to the late launch date, the flight was south-bound, so the balloon was eventually illuminated by the sun. The gas bubble expanded, and a fraction of the gas went out of the balloon. This caused an altitude decrease at sunset, requiring the termination of the payload for safety reasons. The termination command and release device worked perfectly, and the landed near Visby (Sweden) were was recovered in perfect shape.
Having demonstrated the performance of these payloads, we are now replicating them to setup a systematic launch campaign, able to monitor the polar-winter circulation pattern, and to be used as pathfinders before launching heavy-lift balloons with expensive science payloads.

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OZONE

Stratospheric ozone monitoring over Ny-Ålesund

The paper shows some results of campaigns performed at the “Dirigibile Italia“ Station, useful for comparing satellite and ground-based stratospheric ozone concentrations, both acquired during the polar day, and analyzing the results of ozone measurements during a polar winter campaign using a special routine to evaluate the O_3 with UV radiation reflected by the Moon. The work is completed with a particular fast measurement during the eclipse event of Aug. 1st, 2008.

Research group

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Alessandro DAMIANI

Image on previous page: the spectrophotometer Brewer running in Ny-Ålesund, since 1997.

Introduction

Since the '30s the chemical industry has contributed to the production of gas emissions into the atmosphere in particular with large concentrations of synthetic halocarbons known as Chlorofluorocarbons (CFC). Research conducted on ice cores sampled in Polar Regions showed that, in the atmosphere, these compounds did not exist in the past, when the natural ozone depletors were very poor [1] and therefore are entirely due to human activities. The principal effect of the CFCs is the depletion of ozone by means of efficient catalytic cycles triggered by the sunshine over the surface of the polar stratospheric clouds (PSCs). The most important consequence of the depletion of stratospheric ozone is the increase of ultraviolet (UV) radiation reaching the ground, mainly in the UV-B (280 – 315 nm) and UV-A (315 – 400 nm) regions of the solar spectrum. In this context O_3 is the main safeguard of life from UV radiation damage. Therefore, the long-term monitoring of O_3 concentrations has assumed a vital importance.

The ozone is mainly located in the stratosphere, although smaller quantities can be found in the troposphere and in the mesosphere. His production occurs mainly in the tropical stratosphere from short-wave UV rays (in the UV-C band < 240 nm) reacting with oxygen and his typical values are around ~260 DU at the equator. Interannual variability (some percent) in O_3 are mainly related to the solar activity, the Quasi Biennial Oscillation (QBO), the El Niño-Southern Oscillation (ENSO) and volcanic eruptions.
In this context the "*ICES Group*" active in the CNR - IDASC is responsible, since the opening of the Station CNR "Dirigibile Italia" in Ny-Ålesund (78.91° N - 11.93° E; Svalbard Island - Norway) in 1997, of measurements of gaseous minor components in the stratosphere, O_3 – NO_2 - SO_2, through ground-based measures with a Brewer spectrophotometer.

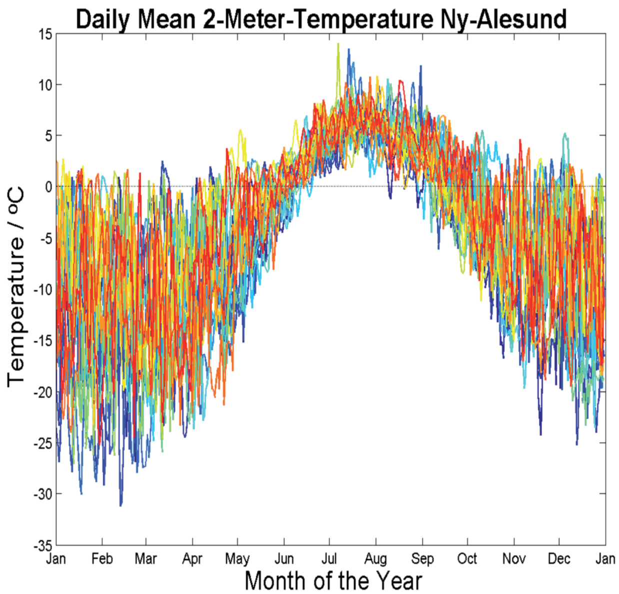


Figure 1 Daily mean surface temperature (2m) for years 1994 to 2011 at AWIPEV research base, Ny-Ålesund
[http://www.awi.de/en/infrastructure/stations/awipev_arctic_research_base/atmospheric_observatory/meteorological_measurements/surface_meteorology/]

This instrument is able to record the total ozone column (TOC) by solar UV radiation and during the night the solar UV reflected by the Moon. The relatively mild winter temperatures allow TOC measurements also during the Arctic night. In Figure 1 the daily mean surface temperature (at 2m of height) for years 1994 to 2011 at AWIPEV research base in Ny-Ålesund, are shown. The TOC carried out in Ny Ålesund are among the few datasets of nighttime O_3 for those latitudes.
The CNR station in Ny-Ålesund is in opposite latitude to that of Belgrano II (77.87°S - 34.62°W, Antarctica) and it allows, with the same type of instruments, comparisons with the effects observed in the South hemisphere [4, 5].

Of course these measurements can be performed only if proper management techniques are adopted; for this reason the Group participates in international calibration campaigns as QAARC Project – *Quality Assurance of solar UV Irradiance in the ARCtic*, carried out on 2010 in Ny-Ålesund [6]. The studies, funded by PNRA, the Italian National Program for Research in Antarctica, and by the CNR Arctic Project, are aimed at understanding the phenomenon of ozone depletion in the polar stratosphere related to solar UV radiation fluxes. This research is also related to the study of solar UV radiation effects on human health.

The activities are carried out in collaboration with the *Department "Technology and Health" of ISS - Istituto Superiore di Sanità* (Rome, Italy), the *NP - Norwegian Polar Institute* (Tromsø, Norway), the *NILU - Norwegian Institute of Atmospheric Physics* (Kjeller, Norway) and the *Department of Physics, University of Santiago de Chile* (Santiago de Chile, Chile).
This paper shows some results of campaigns performed in Ny-Ålesund, useful for comparing satellite and ground-based TOC, both acquired during the polar day, and also for analyzing the results of TOC measurements during a polar winter campaign using the Brewer "FM routine" [2, 3]. The work is completed with a particular fast measurement during the eclipse event of August 1st, 2008.

Ozone Measurements

Given the scarcity of high-quality ground-based measurements performed at high latitudes, measurements in Ny-Ålesund, provide a rare opportunity to check the quality of satellite-based data recorded in Arctic. Indeed, despite the vital importance of the satellite-based O_3 trends for polar latitudes, these observations are subject to larger errors with respect to measurements in middle-low latitudes [7].

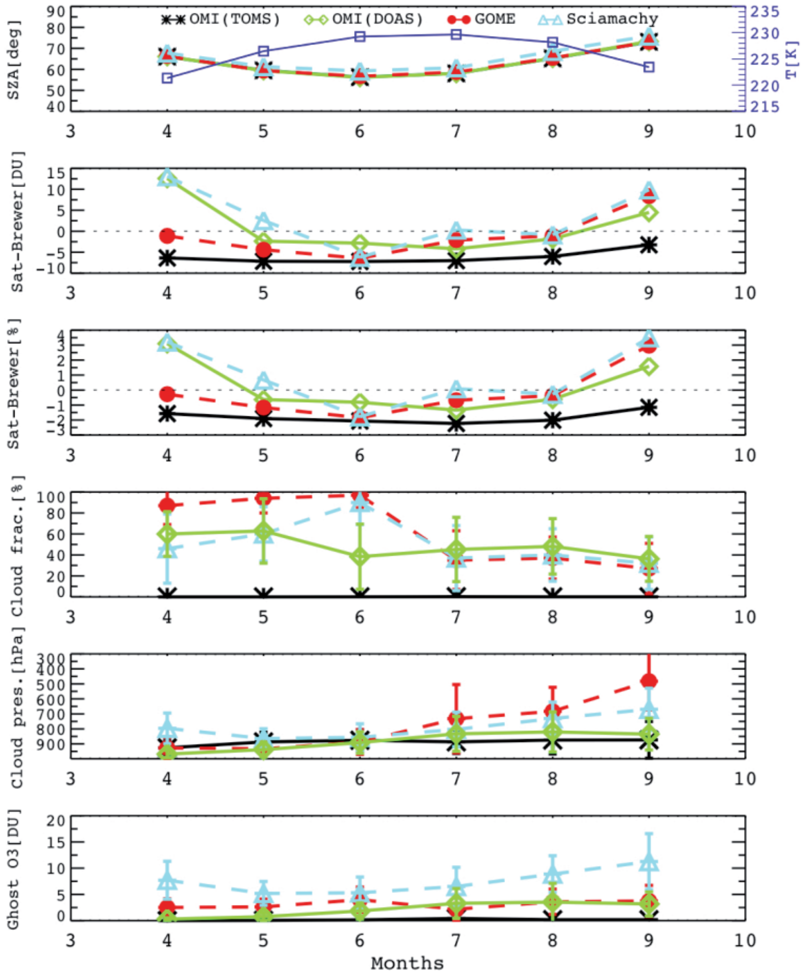


Figure 2 Time series of OMI-TOMS (black lines), OMI-DOAS (green lines), GOME (red dashed lines) and SCIAMACHY (cyan lines) monthly means for (from top to bottom) satellite solar zenith angle and temperature at 50 hPa from the ECMWF, absolute differences of satellite-Brewer total ozone, relative differences of satellite-Brewer total ozone, effective cloud fraction, effective cloud pressure and ghost tropospheric ozone (see [8])

Comparisons between the ground-based Brewer TOC measurements and satellite ozone readings retrieved from EOS Aura Ozone Measurement Instrument (OMI), retrieved from ERS-2 Global Ozone Monitoring Experiment (GOME) and from Envisat SCanning Imaging Absorption spectrometer for Atmospheric Cartography (SCIAMACHY) were performed in the years 2007-2009. Despite the extreme conditions that affect both ground- and satellite-based measurements, a good agreement was found (r=0.99 for OMI-TOMS, r=0.97 for both OMI-DOAS and GOME datasets and r=0.96 for SCIAMACHY). Nevertheless, space-based total ozone readings were found to underestimate ground-based data, in agreement with prior results [8].

On the other hand, DOAS-based datasets present an important seasonal dependence; an overestimation of the Brewer total ozone up to about 3 % is found in April and September with respect to OMI-DOAS and SCIAMACHY while in September with respect to GOME.

In contrast, differences between OMI-TOMS and Brewer total ozone do not present significant dependence on the season or on geometrical parameters (i.e., satellite solar and viewing zenith angles). Divergences in total ozone values among ground-based and satellite measurements seem to depend on the algorithm differences in dealing with cloud cover under high surface albedo (i.e., snow) conditions (see Figure 2).

Ozone during the polar night

The presence of ground based instruments in situ for the nighttime ozone monitoring are quite rare in the high latitude regions but they are essential for a corrected check of the few satellite sensors able to record O_3 without sunlight. In particular, during the night, the Brewer allows measurements of O_3 using the solar UV reflected by the Moon disk, employing a special routine named focused moon (FM). This possibility is available only in limited periods, depending on the phase and Zenith Angle (LZA) of the Moon that determines the optical path length of UV in the atmosphere (air mass factor).

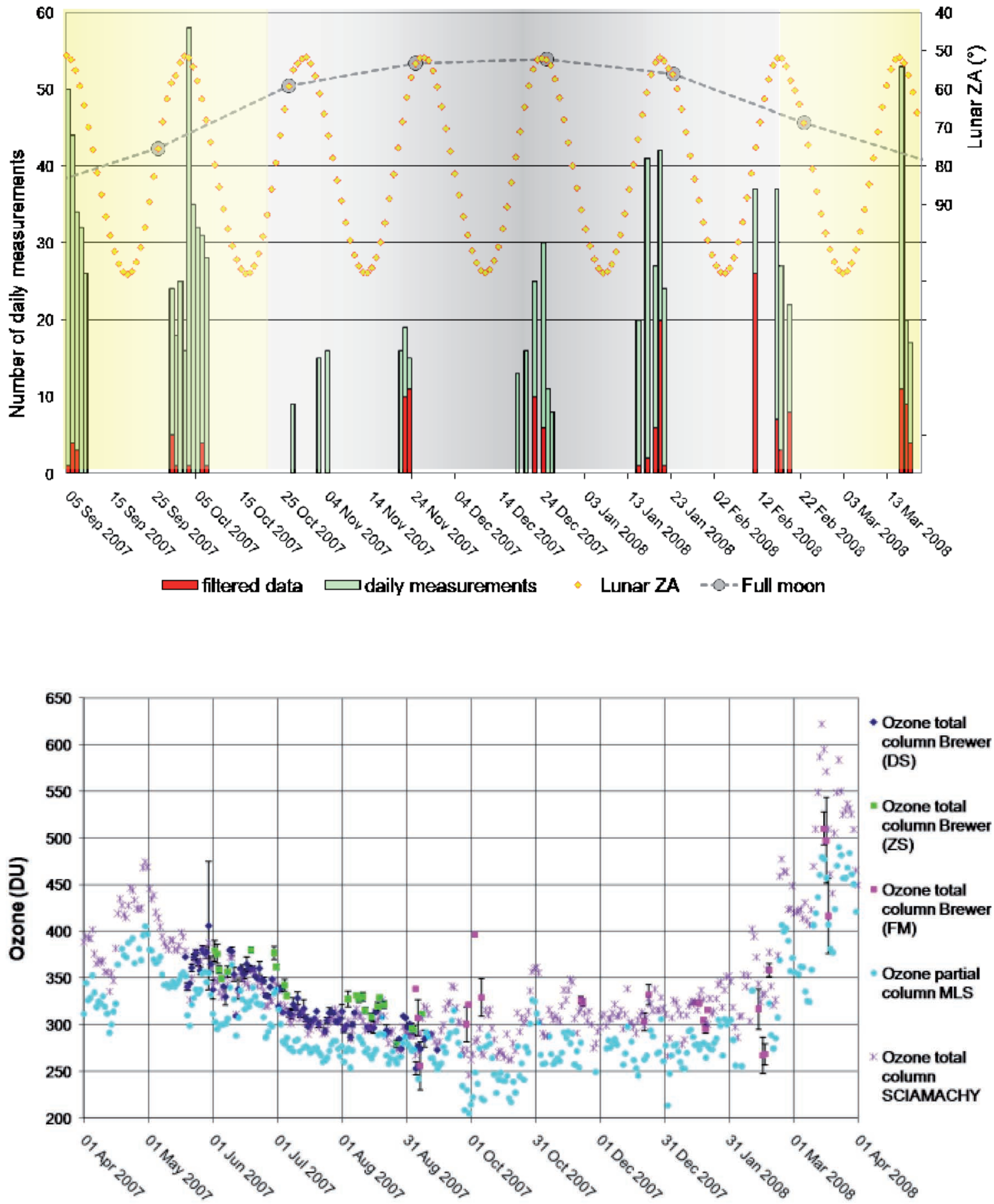


Figure 3 Ny-Ålesund: temporal distribution of Brewer ozone data collected during the winter polar night (top panel) and ozone column values (bottom panel) under sunshine (DS and ZS) and moonlight (FM) modality compared with MLS and SCIAMACHY satellite sensors (see [2])

The left panel of Figure 3 shows the number and the temporal distribution of the ozone data collected in Ny-Ålesund with the Brewer from September 2007 to March 2008. Further, the zenith angle (LZA, for more clarity we show the lower value of each day) and the phase of the Moon are drawn. The Brewer instrument records data roughly around the maximum lunar illumination even though some exceptions are evident. The low solar illumination still present in early October has probably caused the increased number of measurements until ten days after the full Moon of September 26, 2007.

In addition, two other important factors need to be considered; first of all the cloud coverage of the sky and the presence of mountains surrounding the station. The clean sky is essential to record ozone in FM modality. Even if the night is not very cloudy, thin cloud coverage in front of the Moon is enough to invalidate the measure, and this makes the FM O_3 not easy to manage. Finally the mountains around the station hide the Moon at low LZA and prevent to make measures even under full moon. To obtain the TOC values the standard technique of Brewer spectrophotometer for measurement under moonlight is applied. The devise produces a single TOC value by the average of five consecutive ozone observations, each one lasts about two minutes.

So the total length of a single TOC measurement is ~10 minutes. In order to obtain a daily average the instrument makes an average of all collected values and if the standard deviation is < 2.5 it considers this value correct. Unfortunately sometimes negative ozone values, clearly incorrect, are automatically considered for daily average. For this reason all the Brewer measurements are further filtered in the following way (red column of the histogram in left panel of Fig. 3): data collected between one hour before sunrise and one hour after sunset were excluded; moreover each datum with Variation Coefficient (RSD) > 5% were excluded; data collecting with LZA > 75° were excluded too.

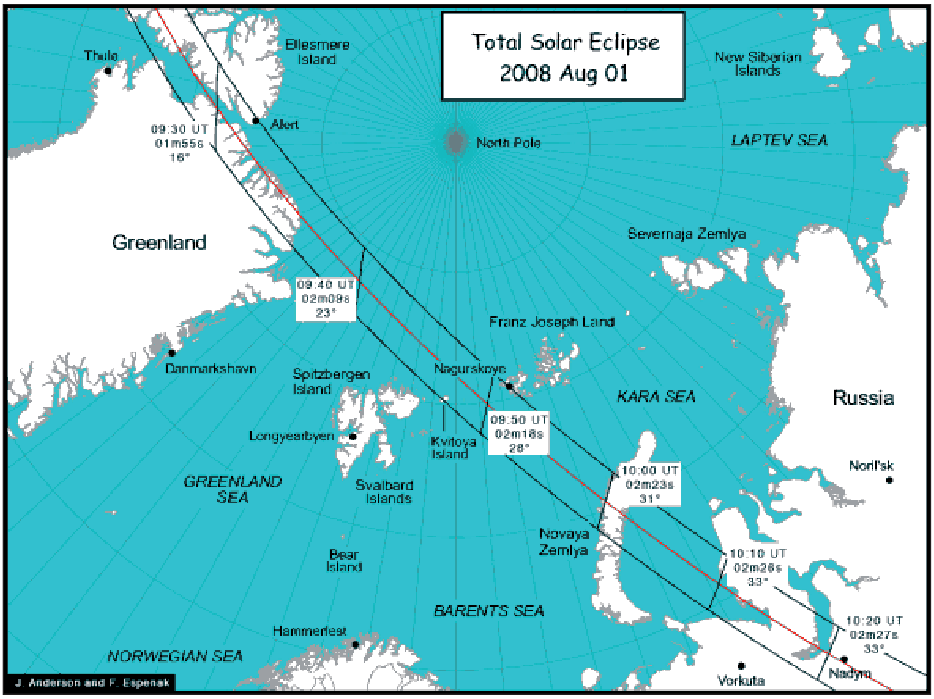
The right panel of Fig. 3 shows the Brewer ozone column values under sunshine (DS and ZS) and moonlight (FM) modality compared with MLS and SCIAMACHY satellite sensors. In particular, despite their somewhat large standard deviation, Brewer FM O_3 observations are in reasonable agreement with satellite SCIAMACHY data. Note that MLS ozone is reported as a partial column; from that an almost constant underestimation of the ground-based total column arises.

Ozone during a solar eclipse

A propitious opportunity has come up in August 1st 2008, between 08:38 – 10:41 UTC, when a total solar eclipse shadow path over passed the Arctic region not far from the Svalbard islands. These phenomena are useful to better understand the effect of UV over the stratospheric ozone and to study atmospheric photochemistry.

In Ny-Ålesund the maximum eclipse occurred at 9:39 UTC and the obscuration of the sun was up to about 94% (see the upper left panel of Figure4 for the path of eclipse's shadow); the reduced Sun disk coverage was sufficient to take measurement of Ozone by Brewer only at the beginning/end half hours of the eclipse. Previous studies reported variations of the total ozone column during a solar eclipse. Since the lifetime of the ozone molecules in the middle stratosphere (where the larger concentration of ozone resides) is quite long (about a month), short-time ozone variations occurring during a solar eclipse can hardly be ascribed to significant photochemical changes. Indeed, ozone variations have been observed to be negative or positive depending on the employed instrument. Therefore, the peculiar conditions during a solar eclipse could affect the good performance of the instrument.

The upper right panel of Figure 4 shows the temporal evolution of the ozone data collected during the August 1th compared with the values of the days before and after. The cease of ozone depletion due to the low levels of sun radiation during the eclipse is well evident. In the bottom panel the hourly TOC during the eclipse day is shown; and also here the variation during the eclipse is well evident.



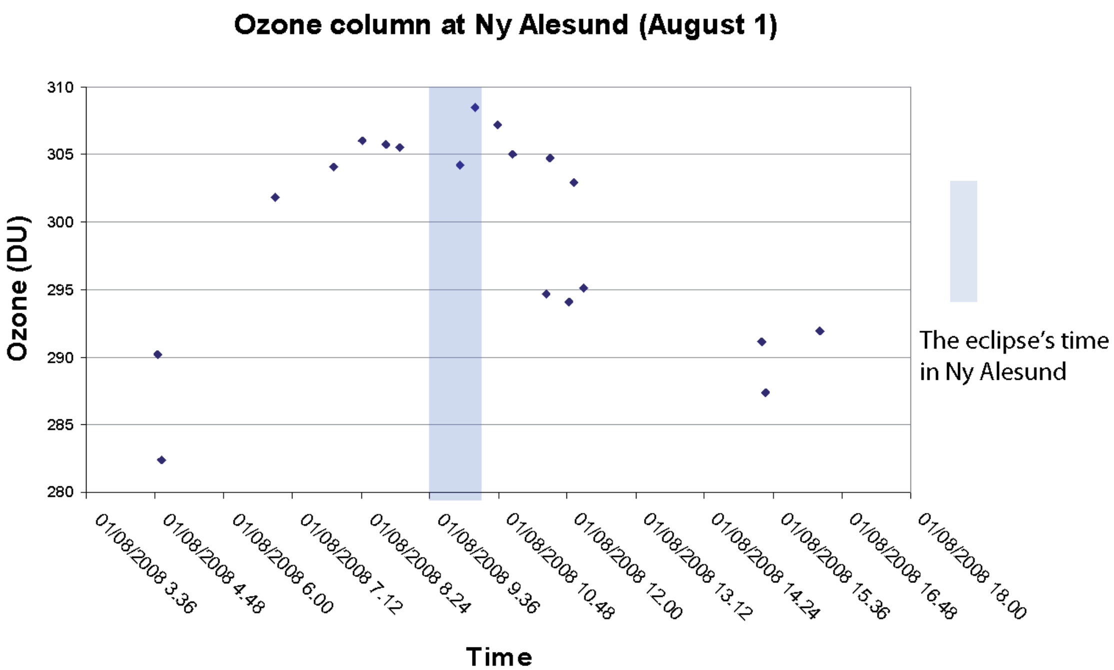
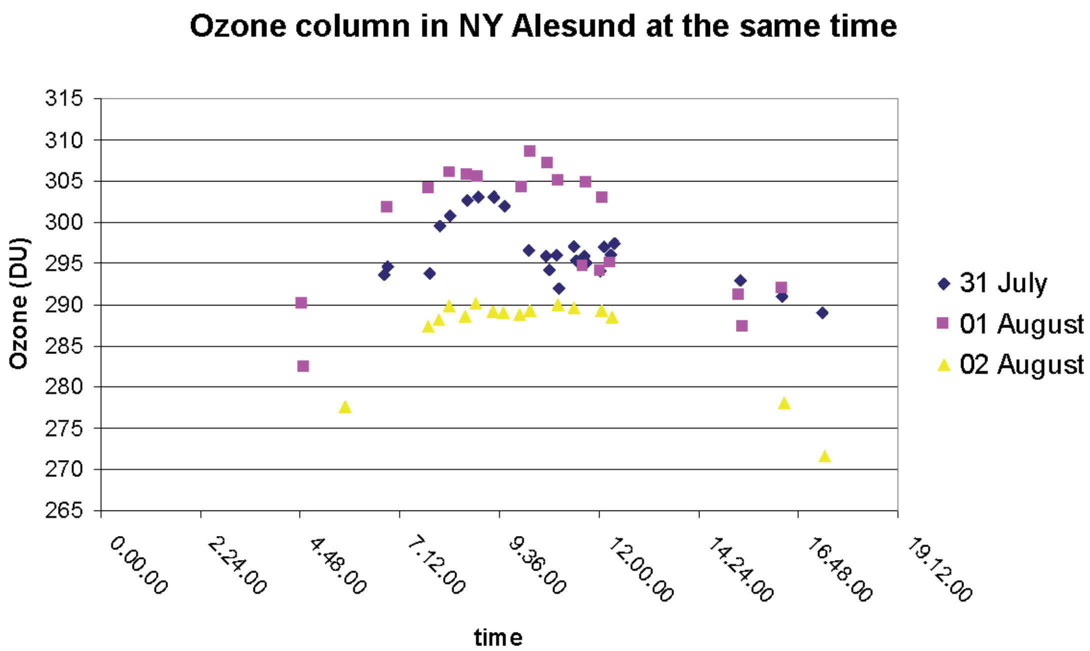


Figure 4 Path of total solar eclipse shadow (top).
On the bottom TOC during the eclipse period is highlighted



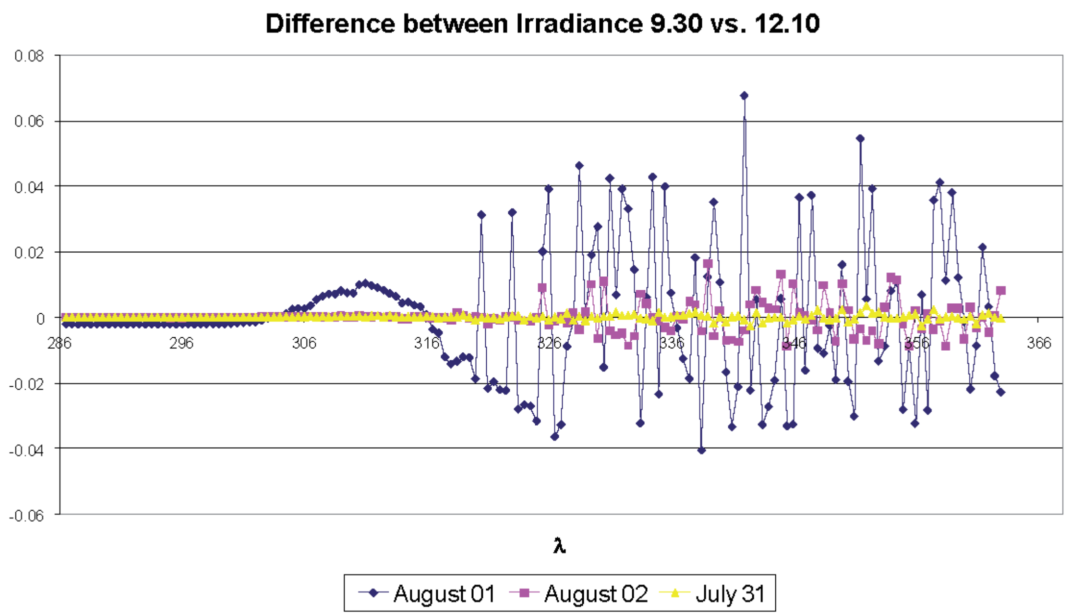


Figure 5 Comparison of TOC in two days around August 1st (top).
Irradiance comparison in the same hours in two days around the eclipse (bottom)

The ozone content during the eclipse event, Figure 5, is higher than the values during the same hours (i.e., same solar zenith angle) of the other days. However, due to the limited temporal resolution and lack of measurements toward the eclipse maximum, no final on the eclipse effects on the ozone conclusions can be drawn.
Moreover, the spectral effect of the limb darkening to global irradiance measurements was investigated. On the right panel the solar UV irradiance difference due to the solar disk coverage during eclipse's time is well evident. The effects of UV decreasing are well interesting too over the NO_2, SO_2, but not shown here.

Acknowledgement

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The authors are also grateful to PNRA and CNR for funding the activities.

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ATMOSPHERIC PROCESSES INVESTIGATION

Atmospheric studies at "Dirigibile Italia"

Low-atmosphere studies (in the Arctic and at middle latitudes) involves the accurate knowledge of the radiation and energy budget at the surface, knowledge of the Boundary layer dynamics and assessment of processes through which clouds, water vapour, aerosols and other short-lived pollutants as ozone, atmospheric composition and surface characteristics have a role and determine seasonal and inter-annual behaviour. Research activities at "Dirigibile Italia" are devoted, in a long-term perspective, to collect and provide information useful to deepen our knowledge on all these issues.

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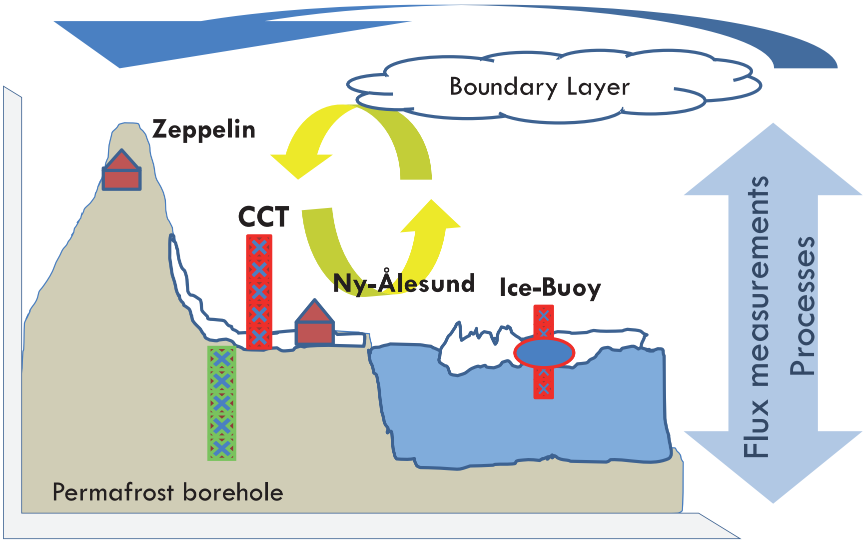
Image on previous page: overview of Ny-Ålesund area showing the location of some measuring sites (photo by Julia Boike).

The Climate Change Tower – Integrated Project

The characterization and parameterization of the boundary layer in the Svalbard area is quite complex. The coupling of the ABL with surface is one of the most important topic to be dealt with in both observations and modelling. Model results still show important deviations from observations. Forcing factors like radiation, cloudiness, turbulence, subsidence and large scale advection contribute to increase the complexity of the system. The upper part of the boundary layer can sometimes be decoupled from the surface forcing and properties. Moreover, due to such a complexity, the development of a stable ABL and the interpretation of measurements is still an open question.
Meteorological and micrometeorological observations have been taken at the CCT since October 2009. Wind speed and direction, humidity, temperature (by fast and slow response sensors), and radiative fluxes at different heights have been measured in order to characterise the thermodynamic structure of the atmospheric boundary layer (ABL).



Schematic drawing of the CCT-Integrated project

A statistical analysis is being carried out to identify the general features of the atmospheric circulation patterns, the seasonal variations, and the connections with the synoptic weather patterns. The analysis highlights three main flow directions: SSW, ESE, N. Each direction is related to different weather patterns affected also by the local topographic features. Further classifications need to be done in order to differentiate the meteo/climatic conditions like the presence/absence of snow, the radiation balance, the cloudiness and stress the link between the large scale advection and local circulations. By this classification nearly homogeneous data sets will be retrieved, useful to proceed in further specific analysis of the boundary layer structure, and in particular to perform a comparison between Monin-Obukhov Similarity Theory (MOST) predictions and selected data sets.

More details on the project can be found at the web site: www.isac.cnr.it/~radiclim/CCTower

The Amundsen-Nobile Climate Change Tower (CCT)

The National Research Council of Italy has financially supported the construction of a 34 m tower in Ny-Ålesund to host sensors for monitoring, observations and studies of the low level atmospheric layers.
The Amundsen-Nobile CCT is the first installation in Ny-Ålesund able to provide continuous observation of the atmospheric surface layer. It contributes to investigate the physico-chemical processes in the surface layer from a vertical point view. The measurements will permit to study heat transfer processes, fluxes at the air-snow interface, energy and radiation budget at the surface, turbulence and fine structure of PBL, as well as providing information on long time evolution of the same parameters, of the vertical thermal and dynamical characteristics and of the aerosol profiles.

Standard meteorological sensors to measure wind speed and direction, air temperature and humidity are installed at four level on the CCT. Sonic anemometers are also operational to measure turbulent fluxes and get better comprehension of the processes occurring at the air-soil/ snow interface.

The list of the instruments is shown in the following table. The project also includes observations of aerosol profiles with a high resolution micro-lidar (Mulid) to describe the aerosol variability in the PBL and asset the possibility to estimate the PBL height.

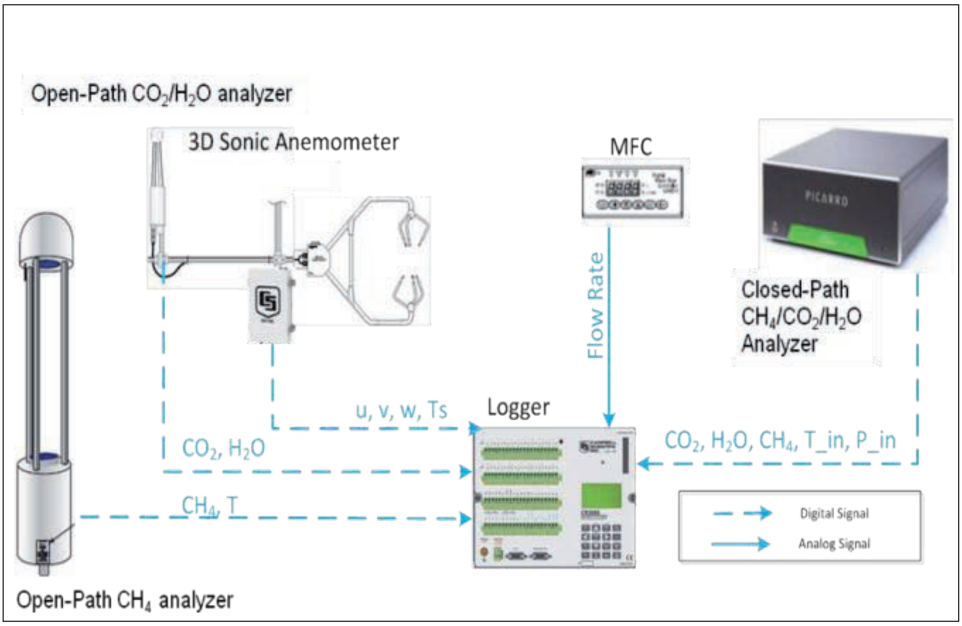
1 Net radiometer (K&Z CNR1)	[33 m]
2 Upwelling radiometers (K&Z CM11 and CGR4)	[25 m]
4 Young propeller anemometers	[33m , 10 m, 5 m, 2 m]
4 HMP45 Thermo-hygrometers	[33m ,10m, 5m , 2 m]
1 Gill R50 Solent sonic anemometer	[7.5 m]
1 KH-20 fast hygrometer	[7.5 m]
1 Gill R50 Solent sonic anemometer	[3.0 m]
1 KH-20 fast hygrometer	[3.0 m]
1 flux plate at the interface soil-snow	[ground surface]
2 PT100 for snow temperature profile	[17.5 cm, 7.5 cm]
1 IR120 infrared sensor for skin temperature	[5 m]
1 SR50 sonic range sensor for the snow height	[4.20 m]

The micro-lidar Mulid is hosted at the French-German station Koldewey, where it is co-located with the high-troposphere - stratospheric lidar KARL and a multipulsar lidar of the Japanese Polar Research Institute (NIPR). The lidar provides the vertical profile up to 5000 m of aerosol backscattering at 2 wavelenghts. Since the design of this lidar allows to have a first point at the height of 50 m, which is the level of CCT base above sea level, we have the opportunity to obtain, for any meteorological level, information on aerosol concentration and characteristics too.

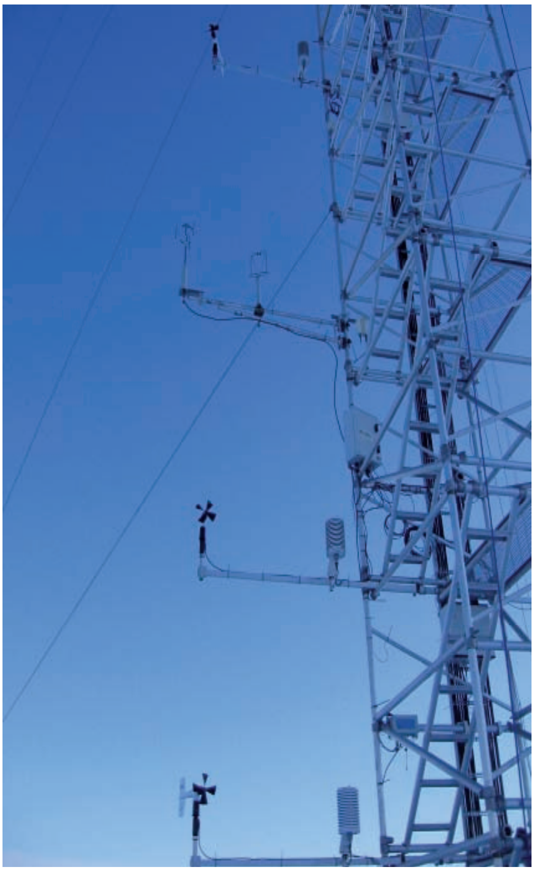
The microlidar on the roof of AWI observatory in Ny-Alesund

Picture of the 34 m Climatic change tower

The meteorological and micrometeorological set up was implemented using a specific payload measuring the greenhouse gas fluxes during May 2012, as part of the cooperation activities between CNR and KOPRI, regulated by a MoU signed in Seoul on February 2012.



Sketch of the gas analyser set up



Detail of the scientific set up in the first 10m of the CCT

Open- and closed- path eddy covariance system, measuring directly the exchanges of CO_2, CH_4, energy and momentum between the atmosphere and permafrost, have been installed at a height of 22 m on the CCT. Moreover the EC system, combined with two other sonic anemometers at 7.5 and 3.0 m above the ground, will be used to profile the turbulent parameters and verify the validity of the Monin Obukov similarity theory in such a complex orographic area.

Gruvebadet laboratory

The Gruvebadet laboratory in Ny-Ålesund has been equipped with a series of instruments aimed at measuring physical and optical properties of aerosols at ground level from spring (Arctic haze) to late summer. The scattering coefficient (K_{sca}) at 530 nm was measured by a Radiance Research M903 nephelometer and stored as minute average. The absorption coefficient (K_{abs}) was measured at three wavelength (467, 530 and 660 nm) using a Radiance Research and glass fibre Pallflex filters (mod. E70-2075W).

View of the aerosol samplers set up in the Gruvebadet laboratory

In the following table the complete list of measurements performed at "Dirigibile Italia" arctic station:

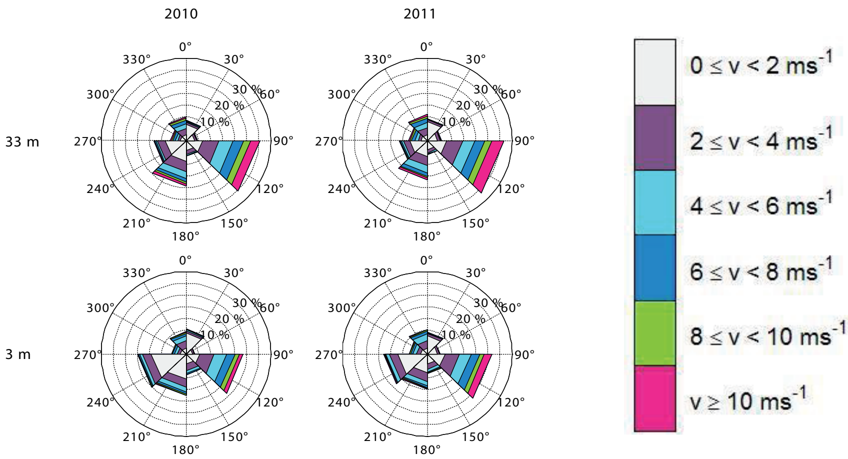
- aerosol light absorption (3 wavelength PSAP);
- aerosol light scattering (2 wavelength Radiance Research Nephelometer M903);
- size distribution 6 nm – 20 um (TSI-SMPS 3034 + TSI-APS 3321). Collection of one spectrum of 106 size-classes every 10 min;
- PM10 aerosol sampling by using a Tecora Skypost sequential sampler (15 filters autonomy) and a medium-volume Tecora Echo PUF with Teflon filters (ions and metals content by IC, ICP-AES, ICP-MS, PIXE). Sampling resolution: 1 to 7 days;
- size segregated aerosol sampling with (one 4 stage Dekati PM10 Impactor + two 12 stages Dekati SDI Impactors) for ions, metals and elements analysis (IC, OPC-AES, OPC-MS, PIXE). Sampling resolution: 4-7 days;
- organic pollutants (POPs) and elemental (EC) and organic carbon (OC) from aerosol sampling with a medium volume Tecora Echo PUF on quartz filters (GC-MS, Thermo-Optical Sunset analyser). Sampling resolution: 4-7 days;
- concentrations and fluxes NOx, NO and NO_2 above snow surfaces by means of high sensitivity analyzer (Sonoma Technologies - 6 min sampling rate).
- snow physics and photochemistry (SSA, stratigraphy, vertical profile, ionic composition of snow, etc.).

Sampling as well as physical and optical aerosol measurements are performed continuously during the spring and summer season, usually from March to September. The upgrade of the Gruvebadet lab discussed and planned with Kings Bay AS has been completed in spring 2013 to make this Lab year-round operational.

Some results on ABL investigations and on aerosol characterisation

To provide a homogeneous data set, a seasonal characterisation of the atmospheric variables referred to different meteo/climatic conditions such as radiation balance, cloudiness, presence of snow, sea-ice melting/formation phase has been defined.
This is closely connected to advection processes and to mesoscale and local circulations interaction. Following some examples of the data collected are presented to show the peculiarity of the site and the possible characterization of the ABL structure, also in terms of aerosol optical characteristics and size distribution.

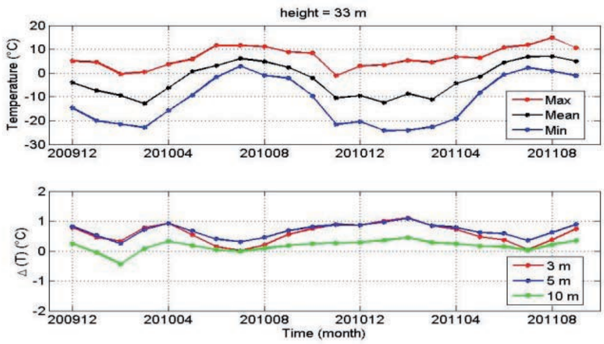
<u>Annual wind distribution</u>
The wind distribution in the area, (shown by the wind roses, for the years 2010 and 2011, below) confirm the climatological analysis that indicate the sectors E- SE and S – SW as dominant directions for the wind filed, with prevailing intensities from the sector from SE.
Even if the data set isn't long enough, no evident variations in wind distribution are present between the two years. More important is the difference observed in relation to the height. In particular at 3 m an increase of the occurrence of wind from the sector SW-W can be observed, associated to the gravity current originated from the glacier inland of the Brøgger peninsula.



Wind speed and direction distributions for at 3 and 33 m at CCT for 2010 and 2011

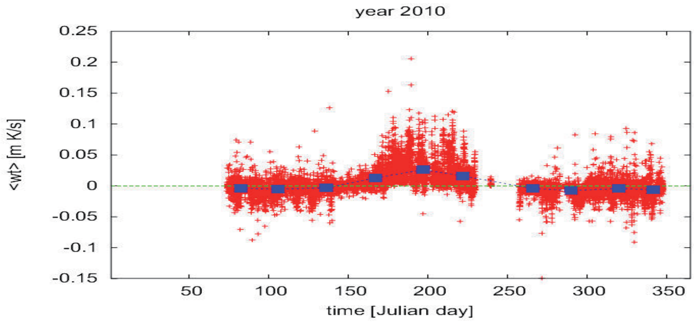
<u>Temperature trend and heat fluxes</u>

Concerning the wind, one and a half year of measurements is not sufficient to identify the climatological trend of temperature at the site, even though a preliminary characterization of thermal stratification can be done. The monthly averaged temperature differences between the top and the lower levels of measurement (see Figure on the next page) shows the presence of the largest vertical gradients in the surface layer (below 10 m).



Temperature and temperature difference. Trends during the 2009- 2010

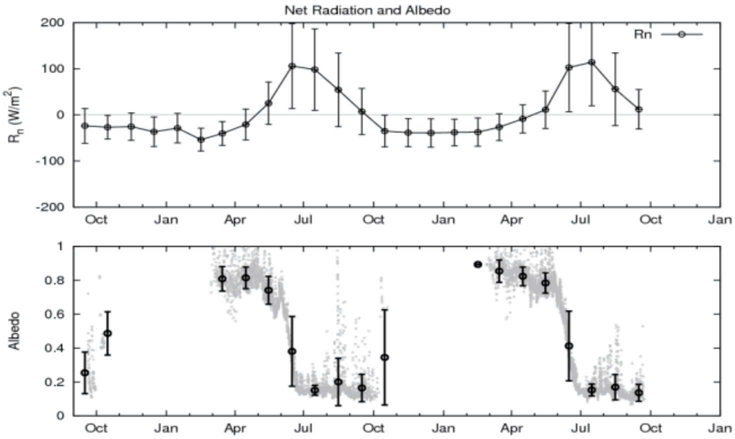
During summer the heating of the surface due to incident the solar radiation determines relatively large positive heat flux, often lasting all day long.



Time series of the surface heat fluxes at 7 m on the CCT

Radiation budget and albedo

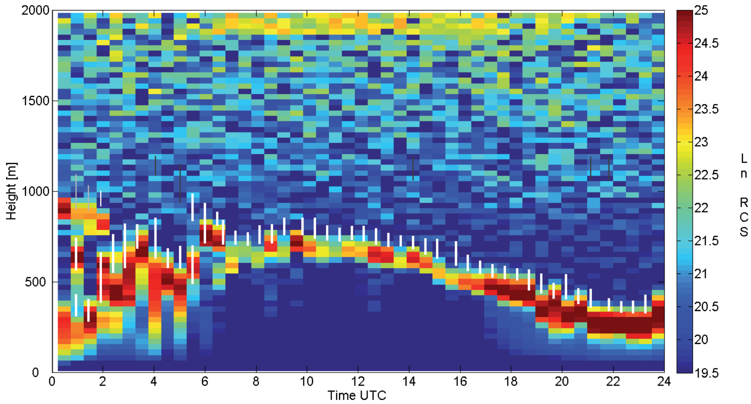
The radiation budget is fundamental, in particular at high latitudes, to describe and analyse the processes that contribute to the interpretation of the meteo/climatic variability at different scales. In the next figure the net radiation and the albedo measured from the top of the CCT are shown. These parameters are strictly connected to the energy balance at the surface, in particular during the transition phase between the seasons, to discriminate the presence of snow at the surface.



Net radiation and Albedo measured at 33 m

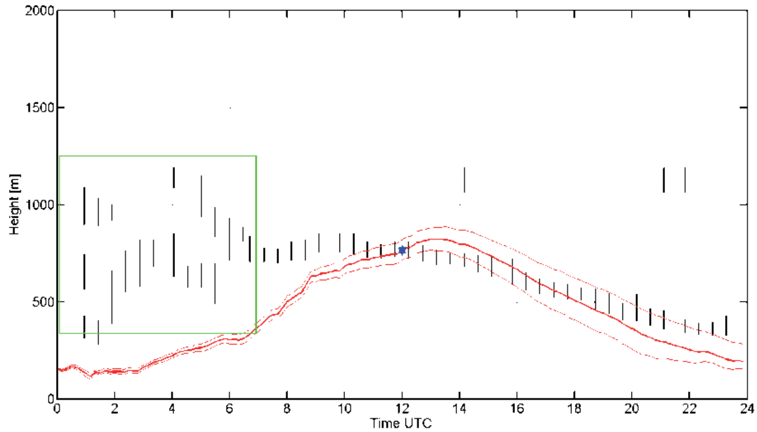
Boundary layer height estimation by Lidar

Lidar observations had been used to determine the PBL height. The gradient method had been applied to a dataset covering one day (June 14, 2010) with a convective PBL, typically occurring in the spring-early summer season in the Arctic. The logarithm of the range-corrected signal collected by the lidar had been processed by a Discrete Wavelet Transform method to determine the inflection points in the aerosol backscatter profile. These aerosol layers were then compared with radiosonde-based estimates of the PBL height and with the one dimensional zero order Batchvarova and Gryning model. The characterization of the first layers of the atmosphere is well represented by lidar measurements shown in next picture where the logarithm of the lidar RCS is referred to the entire day duration. The higher the ln(RCS), the larger the aerosol cross section. Gray and white bars represent the top of aerosol stratifications.



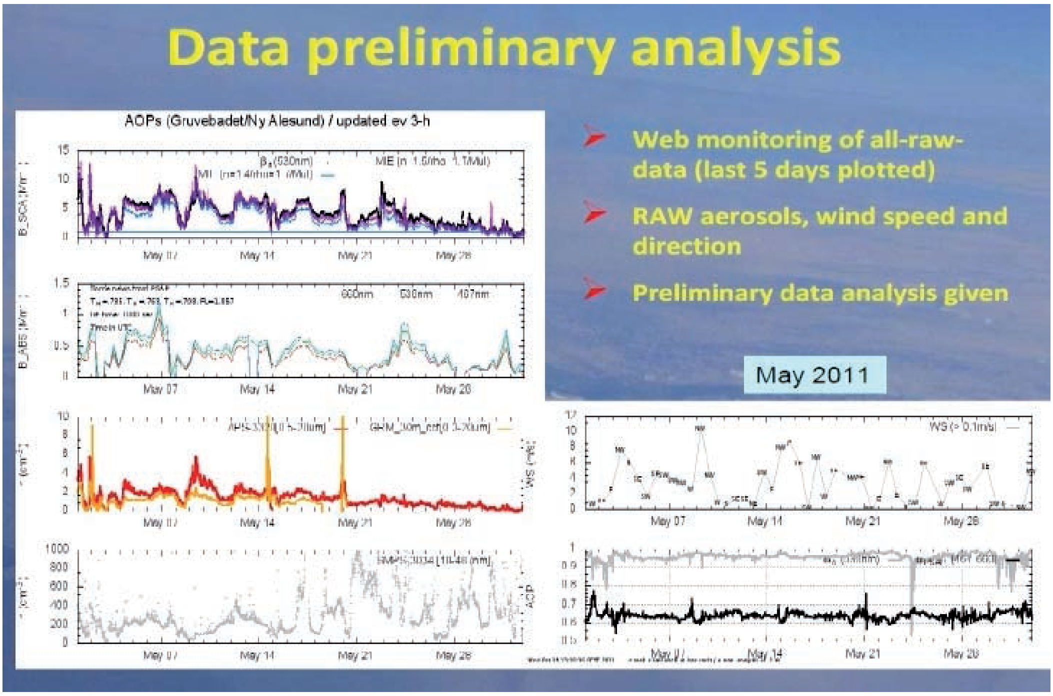
Natural logarithm of the RCS at 532 nm (parallel polarization)

The four different estimates are within 20 m, leading to an unambiguous determination of the PBL height by radio sounding. Considering the mean of these four values, the PBL height at 12 UTC can be set to 767 m above sea level (see picture below). The PBL height as obtained from the Batchvarova and Gryning model (red line) and radiosonde (blue star) for 14 June 2010. Black lines indicate the top of the aerosol layers, as detected by the DWT on lidar data. The aerosol layers enclosed in the green box are associated to hazy layers that likely do not mark off the PBL.



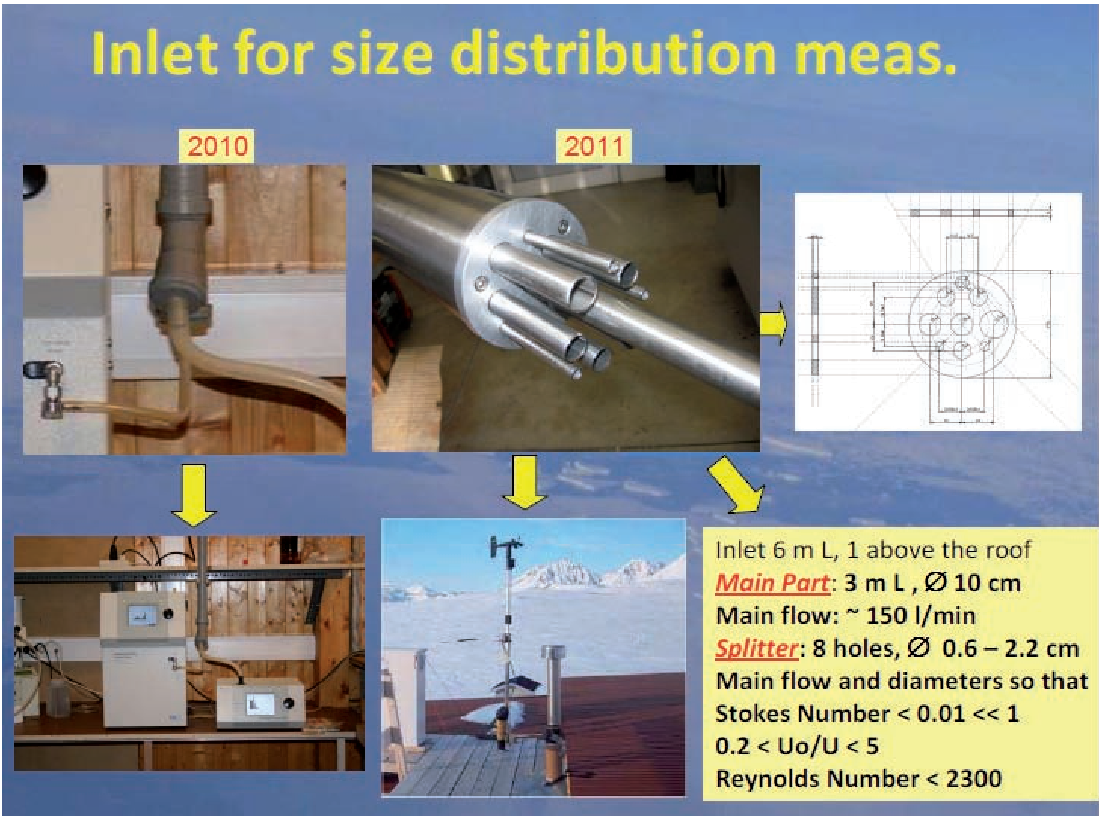
The PBL height as obtained from the different techniques

<u>Aerosol size distribution parameter and comparison with Zeppelin station data</u>
Continuous measurements of the aerosol size distribution have been performed, from March to September, since 2010. Daily median size distributions from 500 nm to 20 um, obtained from APS measurement considering a particle density ρ_p of 1.7 g/m3, are shown in Figure 2 of the chapter 2 “Climate and Environment”.



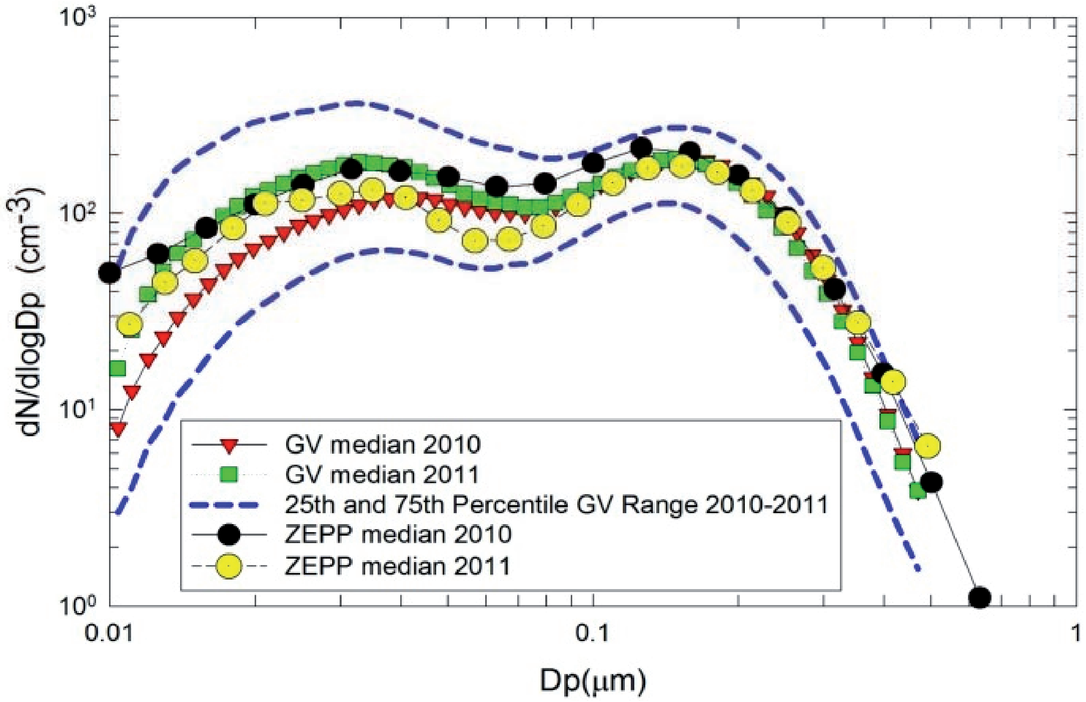
The graphical system to check the data quality

Data scanned with SMPS and APS were acquired every 10 minutes (optical parameters with one minute resolution).
A graphical system was implemented to provide a first preliminary analysis and quality check.
Percentile range (25-75%) of hourly average aerosol number size distributions collected during March-August 2010 and 2011 at Gruvebadet with the SMPS (10 - 500 nm) and corresponding annual median are shown in figure below.
Also given are the median of hourly average aerosol number size distributions collected at Zeppelin station, always from March to August.
The large sensitivity improvement from 2010 and 2011 in our measurements in the range of Aitken and nuclei particles (Dp < 100 nm) is very clear and is a consequence of the large improvement in the air inlet system shown below.

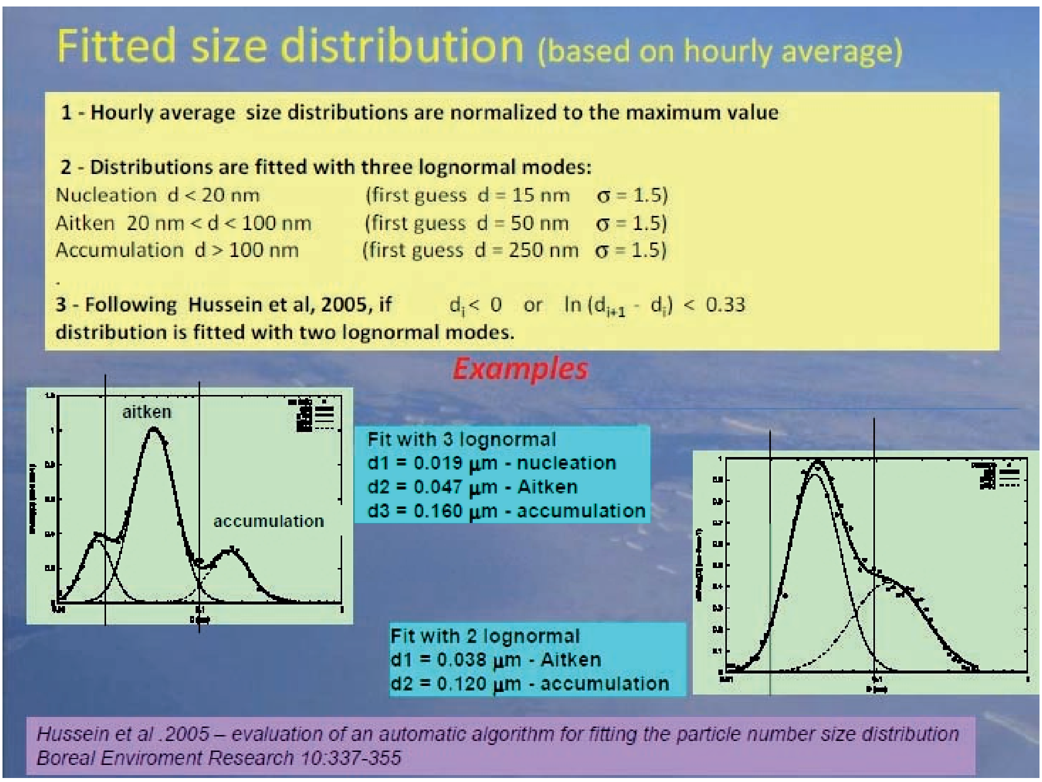


Inlet improvements from 2010 to 2011

Median diurnal variation ranged around 20% both in 2010 and 2011. Average hourly values, however, range around 70th percentile, and in 2011 show much higher values and variability. Diurnal variability measured at Gruvebadet is consistent with data measured at Zeppelin.
However mean values show a sensitivity to pollution episodes and/or anthropogenic disturbances.
A fitting procedure was developed to determine quantitative characteristics of aerosol measured size distributions in terms of log-normal size distributions.



Hourly median at GVB and Zeppelin

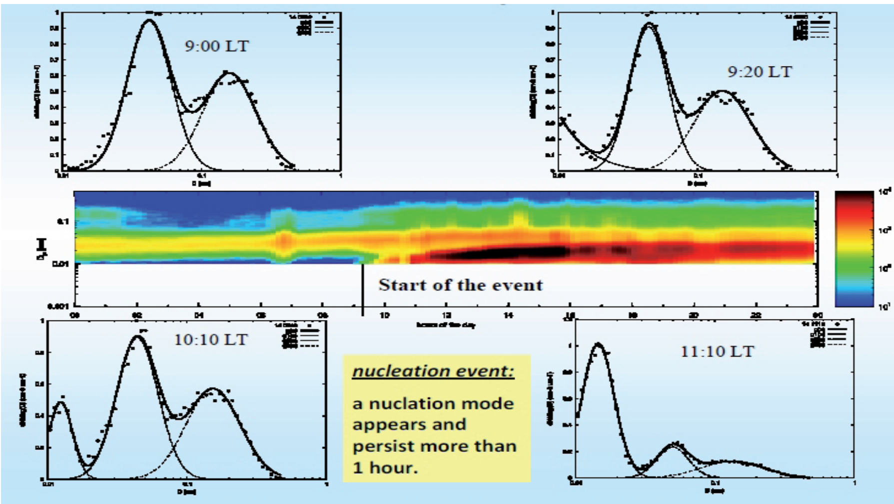


The procedure developed to fit the measured size Distribution

Nucleation processes

Nucleation processes were investigated and a classification methodology was applied. Development of a clear nucleation event is shown in Figure below.

Measured and fitted size distributions normalized to the maximum value are shown for 4 different time: before nucleation, when nucleation have been classified, along the development of nucleation event up to the maximum



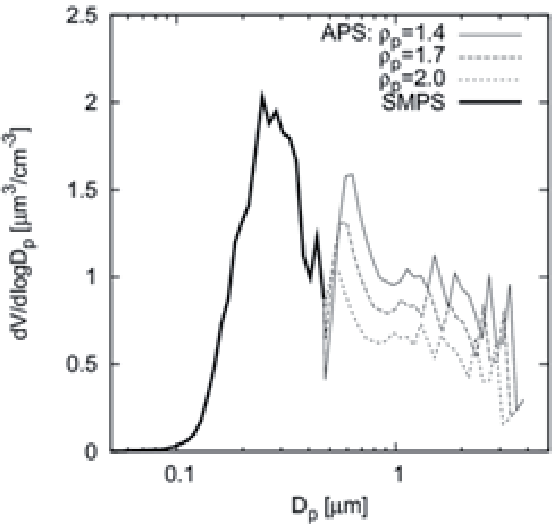
The start and development of a nucleation

Nucleation events were identified if a nucleation mode (10 < Dp < 20 nm) appears and is maintained for at least 1 hour. Growth rate of the nucleation mode (increase of average diameter) and Nucleation rate (growth of particles number in the nucleation mode) were evaluated and utilized to classify nucleation event in two categories: CLEAR NUCLEATION EVENTS (both growth rate and nucleation rate have positive derivative and robust growth behaviour - R2 > 0.6); LESS CLEAR NUCLEATION EVENTS (one or both parameter indicated above have not positive derivative or not robust behaviour). Nucleation cases were found all along the entire measurement period, with higher percentage during summer. The number of cases were much higher in 2011 than in 2010 (the same was for number concentration), demonstrating clearly that interannual variability can be very near or above 100%.

Aerosol scattering coefficient and retrieval of the refractive index

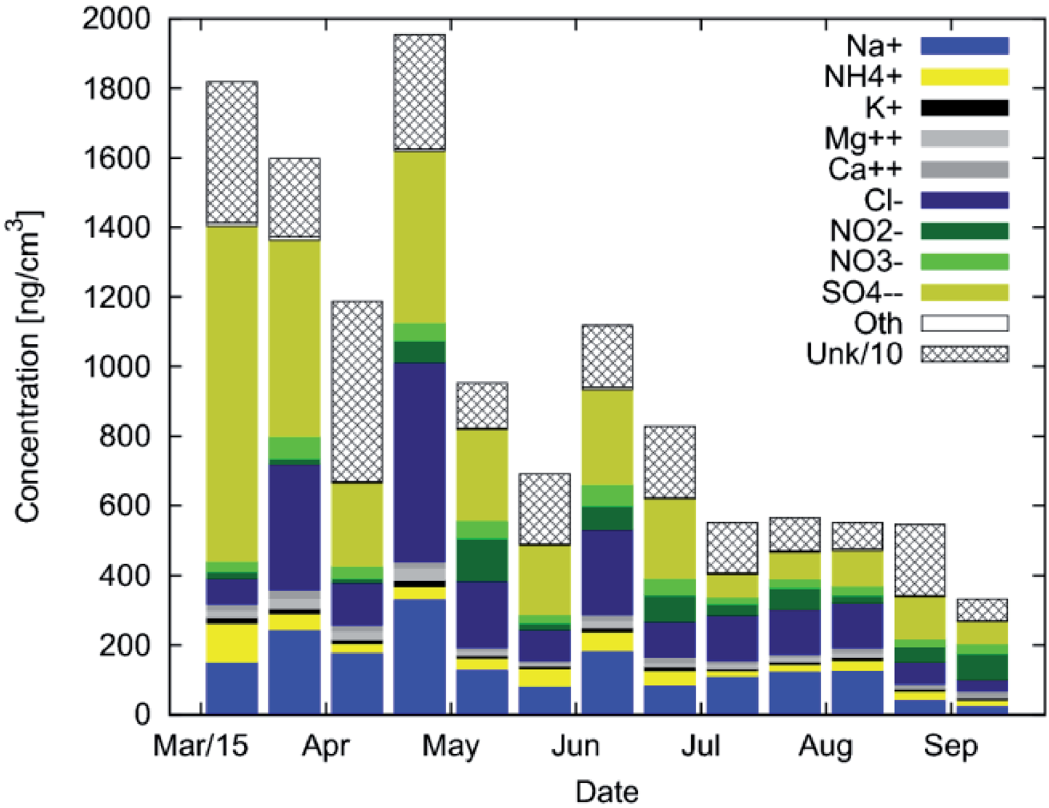
The combination of K_{sca} and K_{abs} at 530 nm was used to obtain the aerosol extinction coefficient K_{ext} and the single scattering albedo (SSA).

The size distribution was characterized with a TSI Scanning Mobility Particle Sizer (SMPS mod. 3034) for mobility diameters Dm varying from 10 to 487 nm, and a TSI Aerodynamic Particle Sizer (APS mod.3321) for aerodynamic diameters from 0.5 um to 20 um. Both instruments classify particles in 54 size classes, each with a geometrical width dlogD equal to 32. An example of the dependence of the size distribution from the particle mass density is given in figure for a SMPS-APS composite scanning (14 March 2010 00:00 UTC). It is clear that with increasing p the total volume decreases, and APS modes shift to lower values of D_p.



Composite volume size distribution from SMPS(solid black line) and APS (thin lines)

Nevertheless, this assumption appears to be overestimated looking at the chemical composition of typical Arctic aerosol during that period, as shown in the figure below.



Average chemical composition for the 2011. Unknown fraction was reduced by a factor of 10

The method based on the correspondence of dV/dlogD values obtained by SMPS and corrected APS in the resulting overlapping channels, could not be applied here because of the lack of channels overlap, due to the limited upper range of the mod. 3034 SMPS (487 um) with respect to mod. 3936L10 used in other experiments.

Greenhouse gas fluxes measurements

The system to measure greenhouse gases consists of 3-D sonic anemometer, open-path CO_2/H_2O analyzer, open-path CH_4 analyzer and closed-path $CH_4/CO_2/H_2O$ analyzer.

Set up of the eddy covariance system and the open path gas analyzer at 20 m on the CCT

Data are sampled at a rate of 10 Hz and stored in a data logger, backed up in a laptop computer through RS232 communication and transferred to KOPRI via internet. The data access is provided by ISAC – CNR.

The eddy covariance system will be long-term and continuously operated and used to evaluate whether the permafrost near Ny-Ålesund, Svalbard at high Arctic region is a sink or source for the atmospheric carbon at the moment and how its role as sink/source changes with the Arctic warming.

Discussion and perspectives

The preliminary data analysis presented in this paper has put into evidence the complexity of the site in terms of orography, meteorology, climatic conditions.

The data record is too short to detect any climatic signal; comparison with longer records from other Arctic sites can be useful to indentify and characterize local peculiarities.

Particular attention must be paid to the meteorology and to the interaction between the local scale dynamics and the large scale circulation processes. The extensive data set available up to now (and increasing in the future) will be used to test and possibly to improve parameterization schemes for the boundary layer in weather forecast and atmospheric chemical composition models.

CLIMATE AND ENVIRONMENT

Activity and preliminary results from the 2011 and 2012 field seasons at Ny-Ålesund

In this report, the main scientific activities carried out during the 2011 and 2012 summer campaigns in Ny-Ålesund and around Svalbard Islands are shortly described. Activities include aerosol, sea-water and sea-sediment samplings and measurements. In particular, aerosol was sampled and/or measured at the Gruvebadet site, along the air column with a tethered balloon, on the top of the CCT tower and on board Oceania ship (AREX 2011 oceanographic campaign).

Some preliminary results on the aerosol composition are also reported.

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Image on previous page: view of the Gruvebadet laboratory.

Rationale

The scientific activity carried out in the Arctic Region, in the Svalbard Islands, aims at studying the feedback processes between climate and environment in a very critical region for climate change. The overall goal is the achievement of a better understanding of the complex processes characterizing the radiant energy budget, the atmospheric aerosol load and chemical composition (sources, transport processes, photochemistry), the PBL dynamic characteristics and the exchange of mass, heat and momentum occurring at the air-snow-soil and air-snow-sea interfaces in the Arctic. The gained knowledge will contribute to an improved parameterization of these processes in climate models and will reduce the uncertainties concerning future scenarios in the Arctic.

Observations and samplings were carried out in the Ny-Ålesund area, including Kongsfjord, and in the Norwegian Sea, from Tromsø to Svalbard, in the framework of the AREX 2011 oceanographic campaign on board Oceania ship.

The planned activities include:

1. chemical and physical properties of aerosols: sources, atmospheric reactions and transport processes. Information on the size distribution and chemical characterization of aerosols in different seasons (as a function of changes in emission sources, efficiency of transport processes and atmospheric reactivity);
2. chemical and physical processes at the air/snow/soil and air/snow/sea interfaces. The processes at the air/snow interface of gaseous aerosol precursors (compounds belonging to the carbon and nitrogen cycles) will be studied, as well as the bio-available fraction of biologically relevant metals (e.g., Fe) at the air/sea interface and in the marine particulate material;
3. transport, deposition and bio-accumulation processes of organic (POPs) and inorganic (heavy metals) pollutants. The long-range transport processes of POPs and metals from anthropized areas will be studied, as well as the effect of climate forcing of black carbon on the snow surface and in the aerosol.

In order to achieve these scientific goals, two sampling/measurement campaigns were carried out during spring/summer 2011 and 2012. Here below, some highlights of the on-field activity and of some results are reported.

Aerosol sampling and measurements

Gruvebadet laboratory (Figure 1)

Size-segregated aerosol samplings were carried out using several cut-off samplers and multi-stage impactors:

- Low-volume daily PM10 - 146 samples in 2011 (29 Mar - 6 Sept) and 169 samples in 2012 (23 Mar - 7 Sept). Goal: high temporal resolution of ions and metals composition;
- 4-stage impactor (>10, 10-2.5, 2.5-1, <1 um), 4-day resolution - 39 samplings in 2011 (29 Mar - 17 Sept) and 42 samplings in 2012 (23 Mar – 7 Sept). Goal: size distribution of the main ions;
- 12-stage impactor (>8.5 – 0.045 um), 4 day resolution - 39 samplings in 2011 (28 Mar – 18 Sept) and 42 samplings in 2012 (22 Mar - 7 Sept). Goal: size distribution of selected elements by PIXE analysis;
- Medium-Volume PM10 sampler, 4-day resolution - 24 samples in 2011 (29 Mar – 26 Lug) and 36 samples in 2012 (16Apr – 7 Sept). Goal: heavy metal composition;
- Low-volume PM10 on quartz filters, 4-day resolution - 39 samples in 2011 (29 Mar – 17 Sept) and 42 samples in 2012 (23 Mar – 7 Sept). Goal: determination of Elemental Carbon (EC) and Organic Carbon (OC) fractions.

<u>Oceania cruise (AREX 2011 Oceanographic campaign)</u>

Low-volume 12-h PM10 - 79 samples from 20 June to 31 July 2011. Goal: high temporal resolution of ionic composition and metal content.

Low-volume daily PM10 on quartz filters – 42 samples from 20 June to 12 Aug 2011. Goal: determination of EC and OC fractions.

Medium Volume sampler for particle phase (Quartz filter) and gas-phase (Poly-Urethane Foam – PUF) organic compounds; 2-day resolution - 24 samplings from 20 June to 08 August 2011. Goal: determination of polycyclic aromatic hydrocarbon (PAHs) and *n*-alkanes.

Figure 1 Gruvebadet station: detail of the roof (top) and indoor laboratory (bottom)

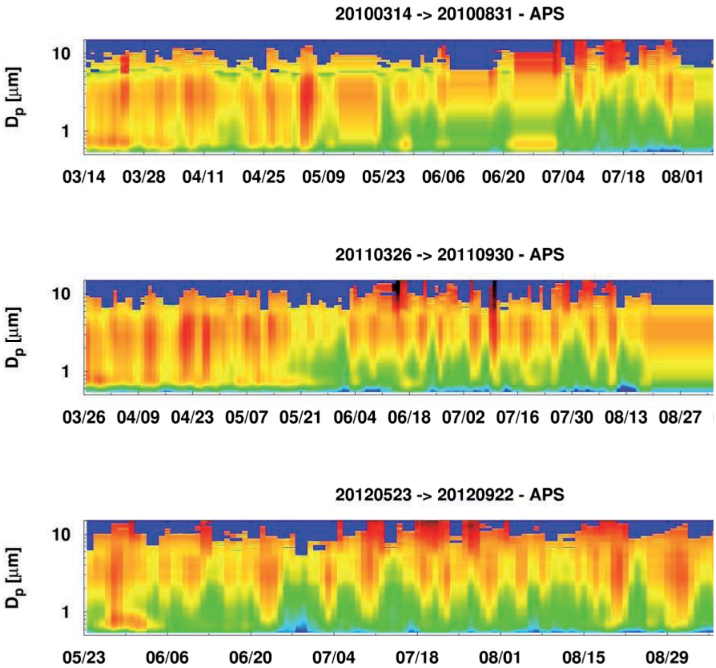

Figure 2 Daily median size distribution (500 nm – 20 um) and particle concentration (see color scale on the right of the plot) for 2010-2012 campaigns, as obtained by APS measurements

Simultaneously to the aerosol samplings, size-distribution measurements were carried out at the Gruvebadet laboratory by two particle sizes: an Aerodynamic Particle Sizer (APS), able to analyze particles in 52 classes in the range 0.5 - 20 um, and a Scanning Mobility Particle Sizer (SMPS), 54 classes in the range 6 – 500 nm. The two systems worked in a synchronized mode with the acquisition of one size spectrum every 10 minutes (Figures 2 and 3).

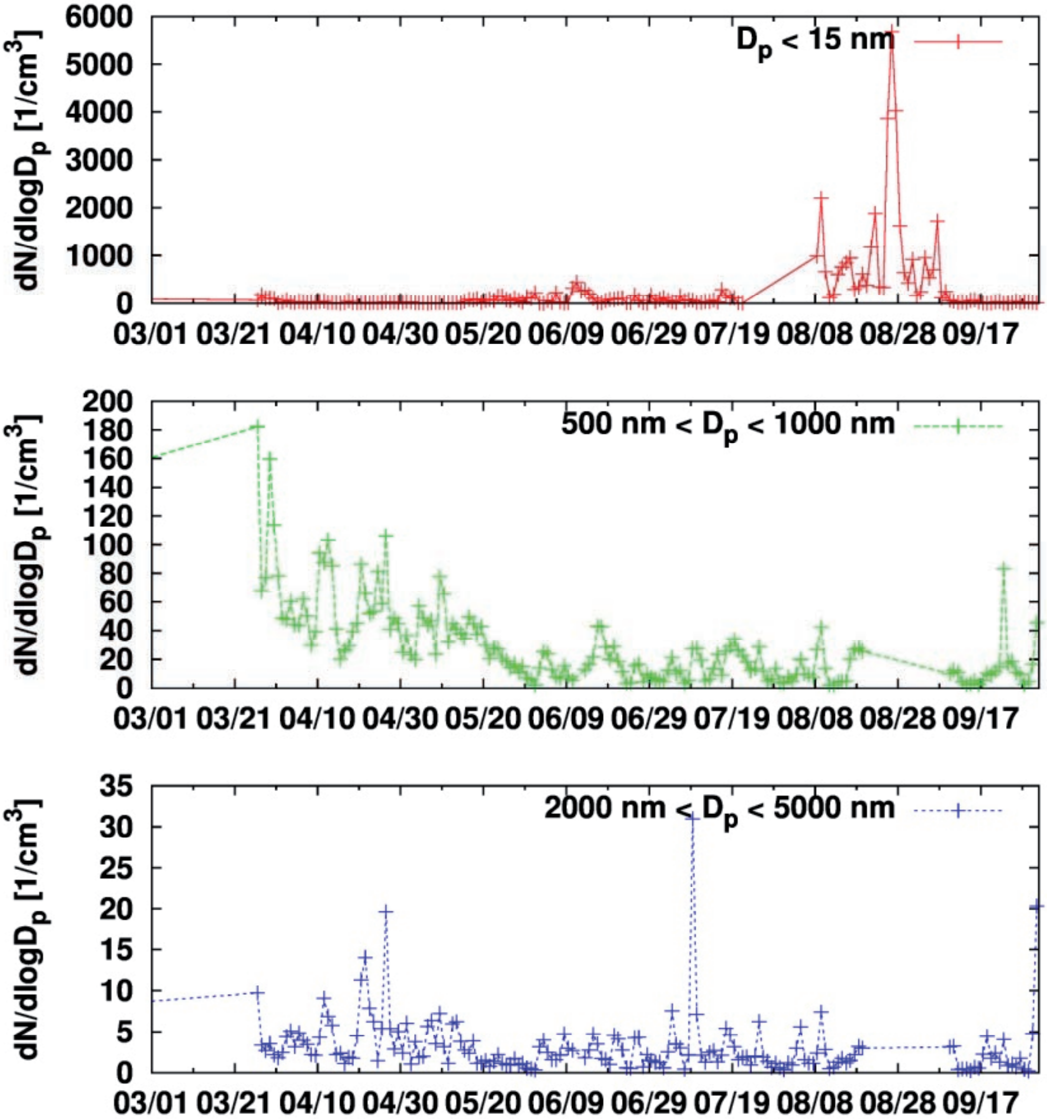

Figure 3 Temporal evolution of particle number concentrations for three selected size classes (from top to bottom, Dp < 15 nm - SMPS, 500-1000 nm - APS, 2-5 um - APS) in the 2011 sampling campaign

The temporal profiles of MSA and nss-sulphate in PM10 samples are shown in Figure 4. An example of size distribution of some aerosol components collected by a 12-stage impactor and analysed by PIXE is shown in Figure 5.

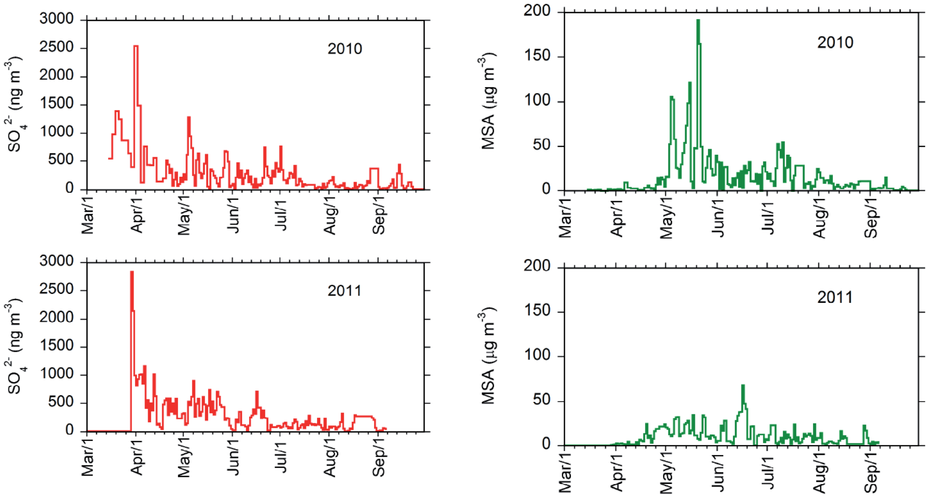

Figure 4 Sulphate (red) and MSA (green) temporal profiles of daily concentration in PM10 during 2010 and 2011 campaigns.The concentration spikes observed in sulphate record during spring can be ascribed to long-range transport processes, whereas MSA spikes are representative of intense marine biogenic activity

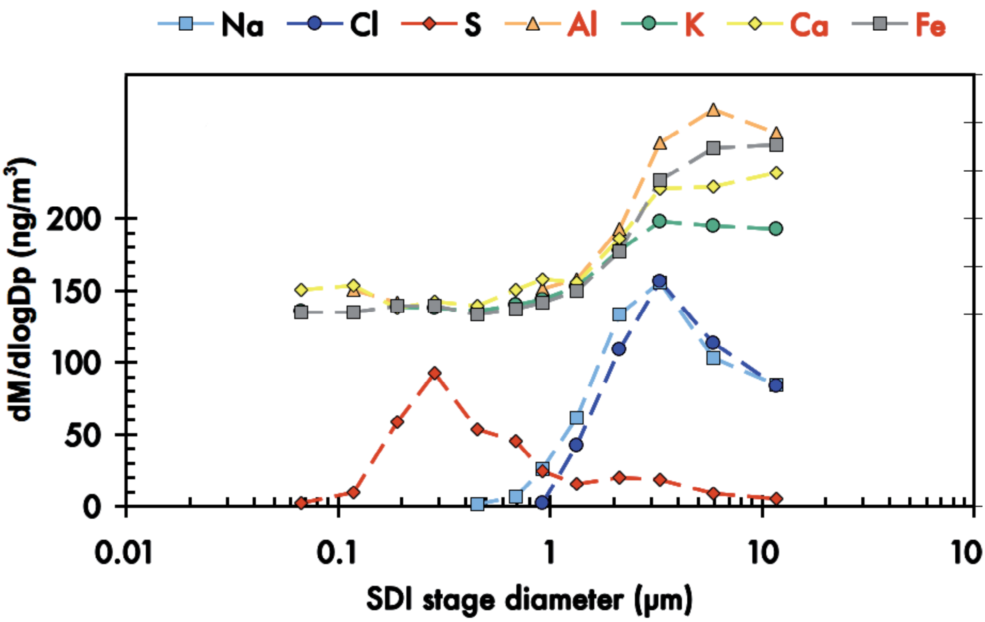

Figure 5 size distribution of the concentrations of sea spray and crustal markers, as determined by PIXE measurements on a 12-stage impactor during an intense sea-spray production event

Measurements of vertical profiles of aerosol and ozone by a tethered balloon

This scientific activity aims at studying the physical and chemical properties of the aerosol as a function of the altitude (up to about 1,000 m asl), in order to understand the role of the PBL dynamics in controlling the atmospheric load and chemical composition of the aerosol in the area of Ny-Ålesund. Aerosol measurements were carried out together with ozone profiles.

The instrumental setup included (not all instrumentation was used in the same launch):

- an Optical Particle Counter (OPC – GRIMM 1.107) – 31 size classes in the range 0.25 – 32 um;
- a miniaturized Nanoparticle Counter (Diffusion Size Classifier - miniDiSC) for particles < 250 nm;
- a Micro-Aethalometer (AE51, Magee Scientific), for Black Carbon measurements;
- a miniaturized cascade impactor (Sioutas SKC), set up with 2 size stages (< 1 um and > 1 um) during the 2011 campaign and with just 1 stage (Total Suspended Particulate – TSP) in the 2012 campaign;
- a fast Ozone monitor (2Btech);
- a Meteorological Station (LSI-Lastem).

<u>Sampling campaign 2011</u>

Balloon measurements were carried out in spring (March – April) and summer (July). In March 2011, the launch platform was installed near the Gruvebadet laboratory and the instrumental set was tested at the Arctic conditions. The measurements started on late March with a 4.30-m diameter spherical balloon, but the balloon was lost on 09 April during a strong wind storm. The experimental setup was reduced and selected measurements were performed by using a Vaisala meteo-balloon, in collaboration with the AWI-IPEV research group. This activity lasted up to 30 April.

A total of 84 aerosol and ozone profiles have been obtained. Besides, six 3-hour samplings were carried out with the 2-stage impactor. On 30 April, a joint activity with the Polar 5 flight (AWI) was carried out.

After balloon measurements, one OPC was installed on the top of the CCT tower, in order to record the high-resolution size distribution of the aerosol, in the size range 0.25 – 32 um, at the altitude of 34 m (with respect to the ground level). OPC data were collected up to the end of June. In July, a summer campaign was carried out collecting 18 aerosol profiles using a new balloon, airship shaped (Figure 6).

Figure 6 Tethered balloon and related gondola (circled in red in the picture on the left) equipped with meteorological sensors, sampling devices and measurement instruments

<u>Sampling campaign 2012</u>
A second summer campaign was carried out from 13 June to 17 July). In total, 94 aerosol (nano-particles total number, size distribution of sub-micrometric and micrometric particles), black carbon and ozone profiles were obtained.

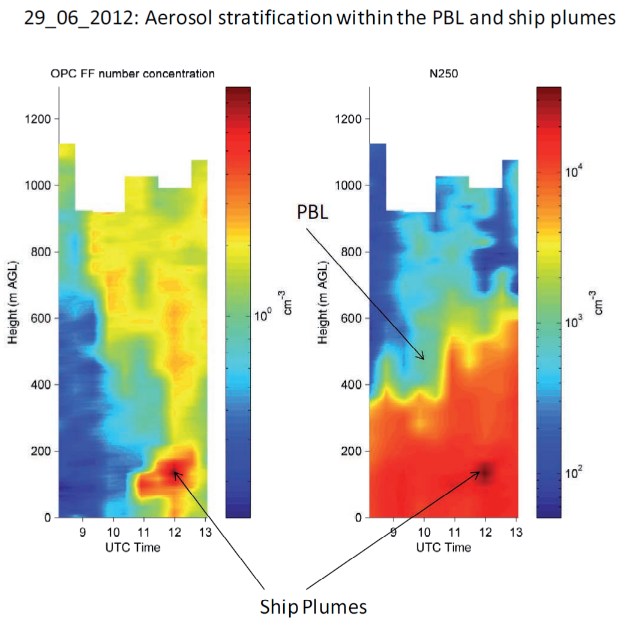

Figure 7 Evolution of the vertical profile of particle concentration in the aerosol fine fraction by OPC measurements performed on the tethered balloon on June 29th 2012

Besides, fourteen 8-hour (corresponding to air volumes of about 6-8 m^3) TPS samplings were carried out at fixed heights (selected on the basis of OPC and ozone profiles), in order to obtain a chemical characterization of the aerosol particles (ionic composition by Ion Chromatography and geochemical composition by SEM-EDS analysis). Finally, a prototype of a meteorological gondola, able to transmit on-line (169 MHz) to the ground the acquired meteo-data, was tested.
During the 2012 summer campaign, some transport events of ship emissions from the Ny-Ålesund harbor occurred. During such events, particle size distributions, characterized by high concentrations of sub-micrometric particles and high atmospheric concentrations of black carbon from the ship plumes, were recorded (figure 7).

SEM-EDS measurements of single aerosol particles

During the 2011 summer campaign, 4 size-segregated aerosol samplings (in the period 18-29 April) were carried out at the Gruvebadet site for geochemical analysis by SEM-EDS (Scanning Electron Microscopy, Energy Dispersive X-ray Spectroscopy). Samplings were performed from the Gruvebadet roof (4-stage impactor) and by the tethered balloon (2-stage impactor).

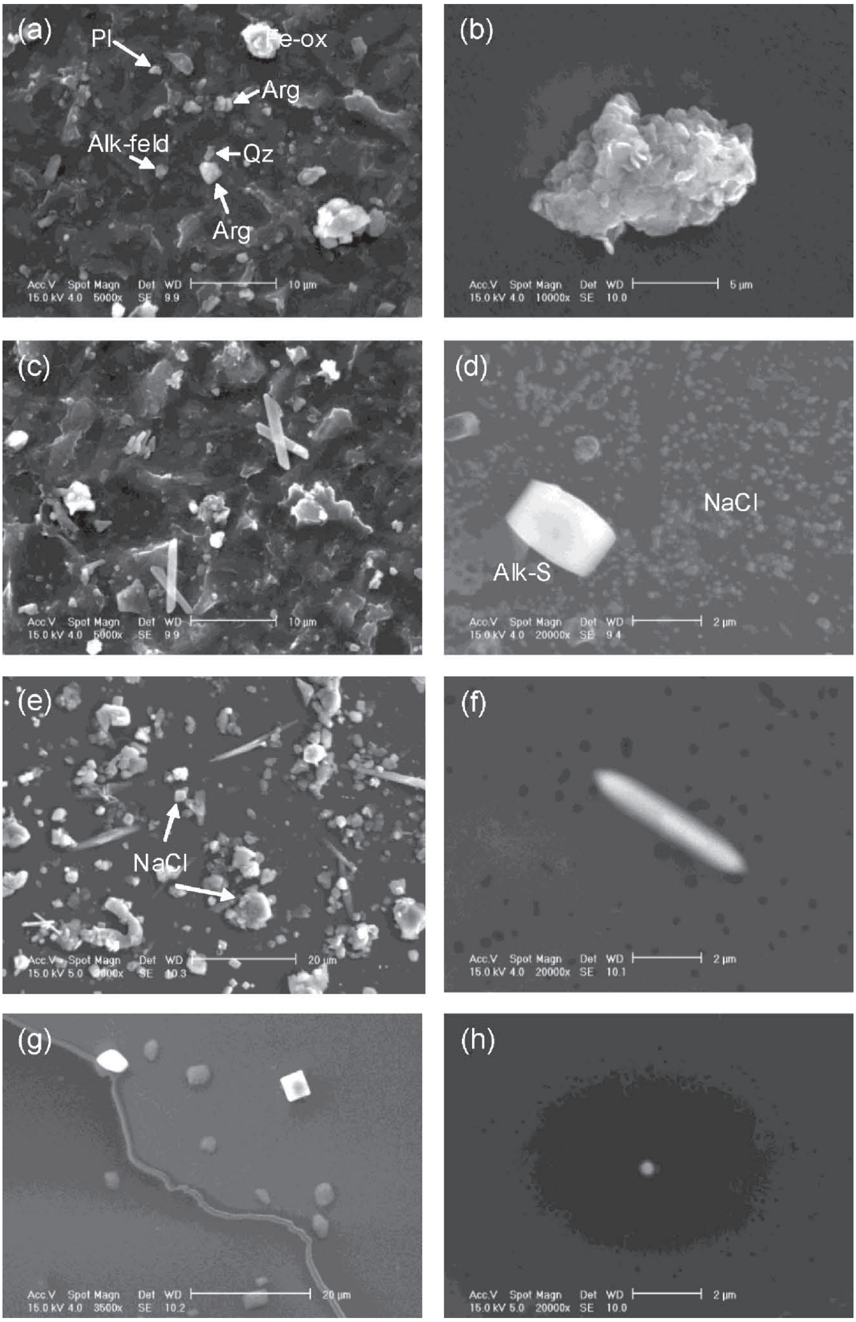

Figure 8 Mineralogical classification of particles by SEM. The following types were observed: (a) silicate (Pl, plagioclase; Alk-Feld, alkali feldspate); (b) fragment of micritic limestone, (c) prismatic fasciculated gypsum; (d-e) sulphates (stocky and lamellated/acicular) and chloride (small NaCl crystals); (f) Cu-S acicular; (g) KCl in different shapes and size; (h) Cu-ox spherule

SEM-EDS measurements were carried out on the particles collected on polycarbonate filters after graphitization. In order to achieve a geochemical characterization of the atmospheric particulate, a significant number of particles were analyzed for each filter and the elemental ratios in the aerosol were compared with the literature data for specific mineral phases.

Figure 8 shows some examples of the mineralogical characterization of selected particles sampled in the 2011 summer campaign.
In the analyzed samples, the crustal component was relevant, with high contributions of metal oxides and siliclastic particles arising from local sources. Some particles showed mineral phases containing marine-originated sulphate and chloride compounds. Compositional data suggest the precipitation of evaporites in cold conditions. Besides, metal enriched particles seem to indicate an anthropogenic origin.

Scientific activity in Kongsfjorden

During the 2012 summer campaign, seawater and sediments (Figure 9) were collected in Kongsfjorden, aiming at studying the distribution of organic and inorganic pollutants in the fiord. Two sampling campaigns were carried out in late spring (29 May – 14 June) and in late summer (27 Aug – 10 Sept) on board of the Teistein-Kings Bay vessel. Samples will be analyzed for the determination of selected heavy metals and organic substances (POPs – Persistent Organic Pollutants).

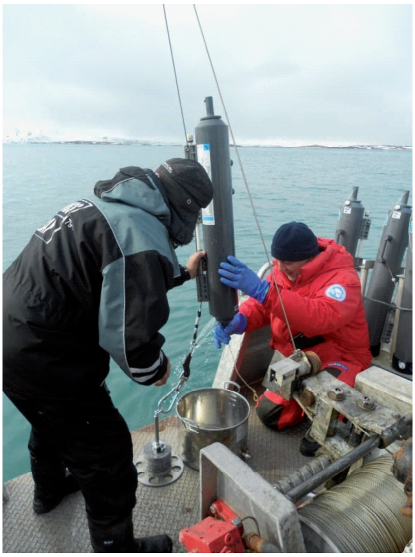


Figure 9 Marine sampling activity in the Kongsfjorden during summer 2012

The sites (labeled A-D in Figure 10) were chosen as representative of different glacial runoff and anthropic impact. Besides, areas with high sedimentary fluxes were preferred. Station A, near the Ny-Ålesund pier, is not directly affected by the glacial runoff and it is characterized by the highest anthropic impact. Station B is scarcely affected both from runoff and anthropic sources. Station C and D are sites with high sedimentation (especially the D station) and heavily affected by the glacial fluxes.
Seawater samplings were carried out at several depths by Niskin and Go-Flo bottles and marine sediment were collected by a stainless steel Van Veen bucket. Before the sampling, in every site, conductivity, fluorescence, temperature and dissolved oxygen were determined along the water column by a CTD profiling probe.
Seawater samples (20 L for organic pollutants – Niskin bottle, and 5 L for heavy metals, nutrients and marine biological pigments – Go-Flow bottle) were collected at the surface, at the maximum fluorescence depth, at intermediate depth and at the bottom.
Table 1 shows the sampling information.

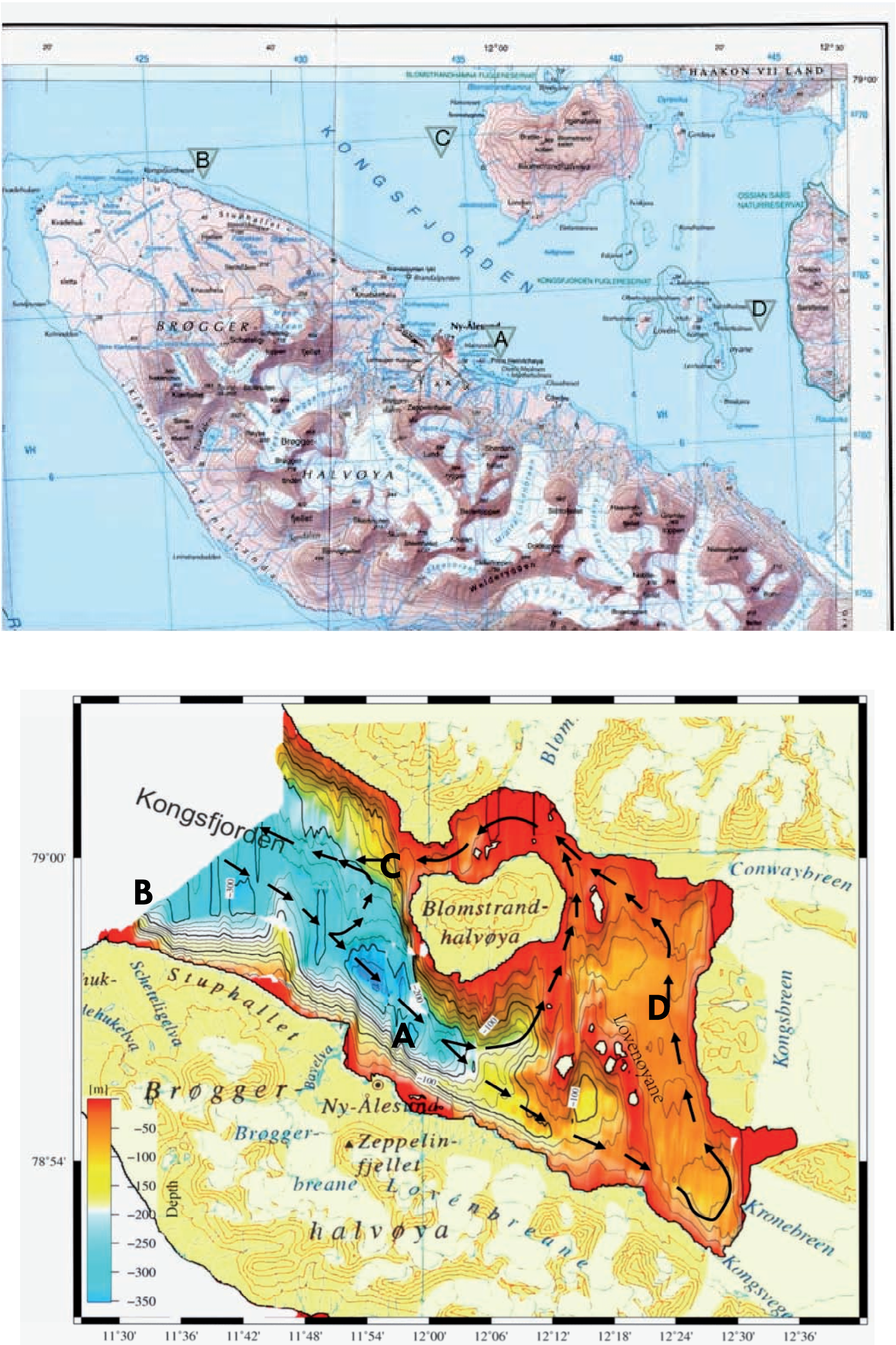

Figure 10 Location and characteristics of the sampling sites in the Kongsfjorden

Sites	Latitude (N)	Longitude (E)
A	78° 55.920	11° 56.696
B	78° 58.474	11° 35.271
C	78° 59.304	11° 56.805
D	78° 56.236	12° 23.670

Station A bottom: 44 m		Station B bottom: 160 m		Station C bottom: 190 m		Station D bottom: 44m	
04 Jun	30 Aug	01 Jun	04 Sept	01 Jun	04 Sept	04 Jun	06 Sept
depth (m)	depth (m)	depth (m)	depth (m)	depth (m)	depth (m)	depth (m)	depth (m)
3	5	5	5	5	5	3	4
20	22	20	50	35	30	15	15
35	40	50	100	180	70	35	35
		140	140		180		

Table 1 Position and sea-water sampling data in each of the four sites in the Kongsfjorden

Organic compounds were extracted from the seawater samples with n-hexane in the “Dirigibile Italia” laboratories just after sampling, obtaining a pre-concentration factor around 1,000. Pre-concentrated seawater samples were stored a + 4 °C until analysis.
For the determinations of chlorophyll, other feopigments, nutrients and trace elements (micronutrients and toxic metals) in the suspended sea water particulate, the seawater samples were filtered on 0.45 um porosity polycarbonate filters in the “Dirigibile Italia” laboratory.
Sediment samples were stored frozen (-20 °C) until analysis.

All scientific activity described in this report was carried out thanks to the scientific and logistic support of the CNR-DTA structures (“Dirigibile Italia” Station and Gruvebadet Laboratory) and personnel.

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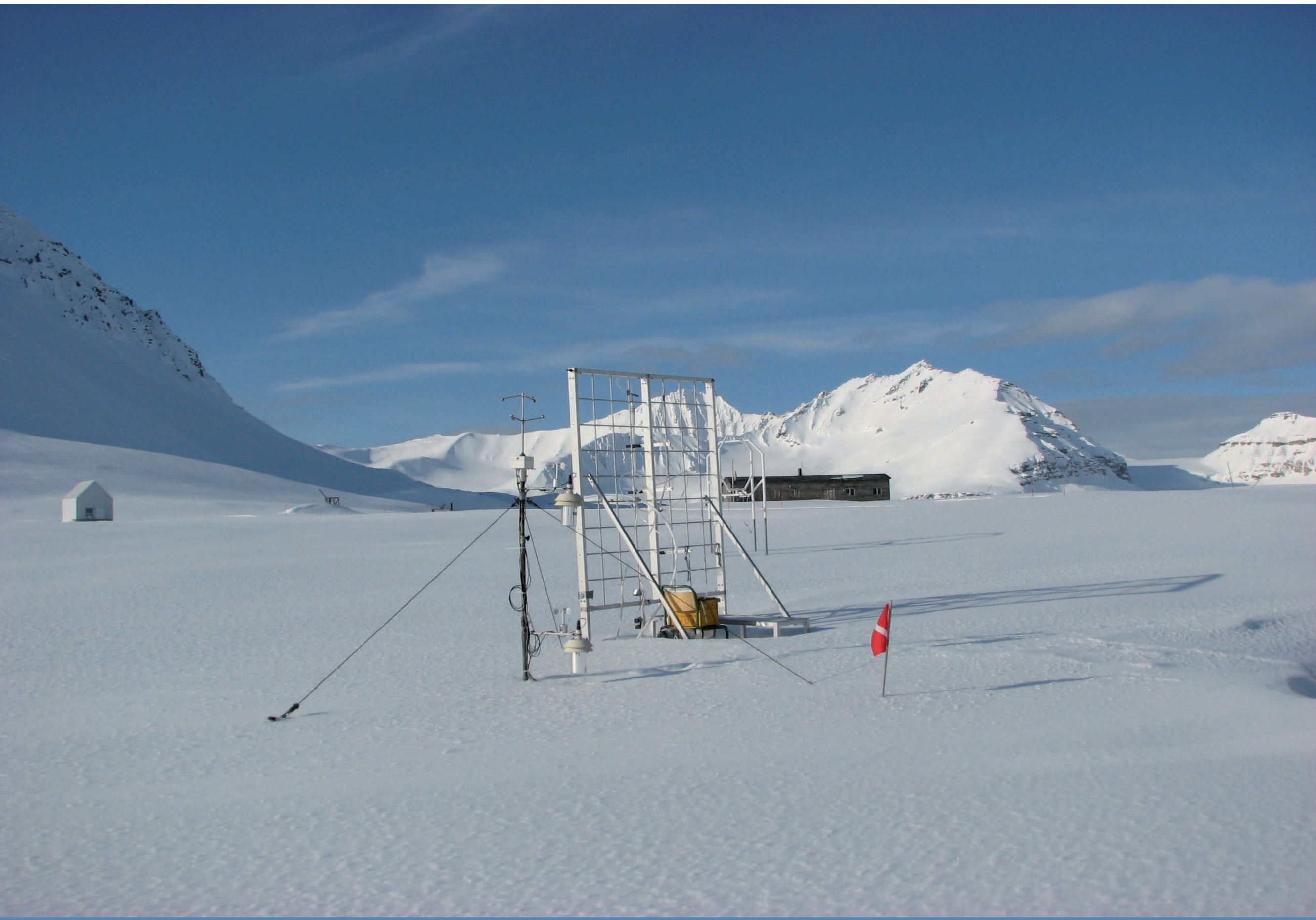
ATMOSPHERIC EFFECTS AND SNOW-AIR INTERACTIONS



Distribution and budget of reactive nitrogen compounds (NO_y) in European high Arctic

This work aims to identify the atmospheric sources of snow NO_3^-, to understand the exchange mechanisms between snow and the atmosphere and determine the atmospheric fluxes of nitrogen species above the snow surface.

Research group

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Image on previous page: instrumentation to measure nitrogen compounds.

Rationale

Polar troposphere plays an important role in environmental concerns for global change. Furthermore, these areas are also characterized by several photochemical processes not fully understood, occurring at the surface and in the atmospheric boundary layer, such as the ozone (O_3) formation and depletion and the re-activation of snow nitrate (NO_3^-).

Observations on atmospheric chemistry of reactive nitrogen ($NO_y = NO_x + HNO_3$ + particulate NO_3^- + PAN + etc.) in the polar regions are limited, due to uncertainties surrounding the NO_y distribution and budget, as they are transported into the polar sites, and the mechanism for the conversion between nitrogen oxides (NO_x) and NO_y. Several studies have shown that the photolysis of snow NO_3^- produces NO_x and nitrous acid (HONO), altering the OH_x ($HO+HO_2$), NOx and O_3 budgets in the overlying atmosphere.

Although several field experiments have been carried out to quantify the emission fluxes of NO_x and HONO from the snow surface, the sources of snow NO_3^-, the air-snow interaction, the deposition of NO_y and the role of oxidants are currently unknown. Furthermore, climate changes, such as changes in UV radiation, in concentrations of pollutants, in snow cover and in temperature, could affect the extent of these depositional and air-snow processes.

Measurements of atmospheric concentrations of O_3, NO, NO_2, atmospheric fluxes NO and NO_2 above the snow surface, micrometeorological properties, and chemical and physical properties of snow (ionic analysis, specific surface area, density, temperature, irradiance) were carried out during spring season 2011 in Ny-Ålesund (Svalbard), as part of the PRIN2009 "ARCTICA - ARCTic research on the Inter-connections between Climate and Atmosphere" and PNRA (2010/A3.01) projects. This work aims to identify the atmospheric sources of snow NO_3^-, to understand the exchange mechanisms between snow and the atmosphere and determine the atmospheric fluxes of nitrogen species above the snow surface.

Introduction

Polar Regions are considered a unique natural laboratory because of their peculiar characteristics and play a key role in environmental concerns for global changes. Climate records reveal warning trends in polar regions. The snow and ice environments are very sensitive to this temperature increase and human and environmental implications, and climate feedbacks in the polar regions warrant urgent attention. In particular, due to low water vapour concentrations, low levels of solar radiation and temperature, the atmospheric lifetimes of many pollutants in Polar Regions, such as hydrocarbons, ozone (O3), nitrogen and sulphur containing compounds, are the longest of any environment on Earth.

Observations on atmospheric chemistry of reactive nitrogen ($NO_y = NO_x + HNO_3$ + particulate nitrate + PAN + etc.) in the global atmosphere are limited but, in particular, in the polar regions due to uncertainties surrounding the NO_y distribution and budget as they are transported into the polar sites and the mechanism for the conversion between NO_x and NO_y. Several studies have shown that NO_x and HONO productions from nitrate (NO_3^-) in snow surfaces are sufficient to alter the global OH_x ($HO+HO_2$), NO_x and O_3 budgets in the overlying atmosphere.

Hence, knowledge of the natural background concentration and main sources of NO_y is pivotal in determining their influence and the impact of human activity on the atmospheric photochemistry and on ecosystems in polar environments.

Thus, while the release of nitrogen species from snow surface has been investigated, little is known about the sources of snow NO_3^- and the air-snow interaction and deposition of NO_y. The current understanding of this process is the absorption of NOy by snow surfaces determining the presence and reduction of nitrate in a surface phase. Inorganic NO_3^- species, as HNO_3 and NO_3^- particles as a neutral salt (NH_4NO_3), or as fixed sea salt, are likely the predominant precursors of snow NO_3^-.

However, other NO_y species can be deposited and converted to NO_3^- in snow. While early studies from the Arctic pointed to the dominance of PAN in the NO_y budget and to its role as a major source of NO_x, any fractionation associated with PAN decomposition to contribute to snow NO_3^-, the relative chemical mechanism, post-depositional processes and the role of oxidants are currently unknown. Hence, a better understanding of these processes controlling the fate of NO_y in the Polar Regions is needed.
Besides, climate change such as changes in UV radiation, in concentrations of pollutants, in snow cover, and in temperature could affect the extent of these depositional and air-snow processes.
As a part of the PRIN2009 "ARCTICA - ARCTic research on the Inter-connections between Climate and Atmosphere" and PNRA (2010/A3.01) projects, the goals of this work were to determine the atmospheric concentrations, the partitioning and the budget of NO_y, quantify the direction and magnitude of NO_y fluxes at the snow-atmosphere interface, identify chemical processes that control NO_y deposition in the snow and, then, hypothesize about the sources of snow NO_3^-. Besides, dedicated investigations were designed for a better understanding of the lifetimes and loss processes for NO_y, of snow physics and chemistry, of UV radiations and photolysis rates for NO_y, and of adsorption and desorption coefficients for NO_y in the snow surface. This suite of investigations will provide a unique opportunity to comprehend the unravelling the O_3-NO_x photochemistry, the recycling between NO_x and NO_y, and, then, the climatic effects in the polar regions.

The experiment

All measurements were carried out from 1 to 27 April 2011 in a flat and undisturbed snow area near the Gruvebadet Laboratory, located at about 1 km south from the Ny-Ålesund International Arctic Research and Monitoring Facility, Svalbard (78°55'N, 11°54'E, 40 m msl).
All the instruments had been located in a laboratory hut. This measuring site was chosen to minimize the influence of local pollution from the research community, which is located at the southern shore of the Kongsfjord on the west coast of Spitsbergen in the Norwegian high Arctic, where the sun is above the horizon for 24 h a day from late April to late August.

Atmospheric concentrations of nitrogen monoxide (NO), nitrogen dioxide (NO_2) and nitrogen oxides (NO_x) have been determined using a modified commercial 2-channel high-sensitivity chemiluminescence detector (Sonoma Tech). Channel 1 sampled air at 5 cm (low line) and channel 2 at 150 cm (high line) above the snow in order to determine the concentration gradients of the nitrogen species (Δ). These gradients can be calculated for each species by the difference between the concentration measured with the "low" line and the concentration measured with the "high" line. NO_2 was detected as NO, following photolysis between 350 and 420 nm by LEDs (Light-Emitting-Diodes). The instrument was calibrated every 6 h by standard addition of 2.0 standard-cm^3 min^{-1} (sccm) of 5.0 ppmv NO (Scott-Marrin, inc) to the sample flow of 1200 sccm, corresponding to an addition of 15.6 ppbv of NO. The 3σ NO detection limit was 4.4 and 3.3 pptv for channel 1 and 2, respectively, in a 1 min average.
The conversions efficiency of the photolytic NO_2 converter was calibrated every 3 h by standard addition of NO_2. This NO_2 was produced from the NO standard by reaction with O_3, which was photolytically generated in a 2.0 sccm flow of O_2 by irradiation with a UV lamp. The 3σ NO_2 detections limit was 10 and 7 pptv for channel 1 and 2, respectively, in a 1 min average.
Simultaneous measurements of atmospheric turbulence using a sonic anemometer 3-D (Gill, model HS-50) and of micrometeorological parameters (temperature, wind direction and wind speed, relative humidity, UV radiation), in order to determine the turbulent diffusivity (D, eddy diffusivity) for the calculation of atmospheric fluxes of nitrogen species, were carried out at the same heights and locations.

In addition, measurements of spectral reflectance of the snowpack were performed using a spectro-radiometer (Fieldspec 3 - ASD; 350-2500 nm) in order to determine the structural characteristics of the snow surface and the specific surface area (SSA), which is the surface area of snow crystals that is accessible to gas per unit mass. These determinations were accompanied by an analysis of the physical properties of the snow (shape and size of the grains of snow, density, hardness, temperature, surface roughness, specific surface area, snow profiles, stratigraphy of snow) in order to assess the changes in snowpack reflectance with the evolution of the processes of snow metamorphism and to understand the exchange processes at the air-snow. In particular, triplicate samples of near surface snow and deeper layers were collected and analyzed in order to determine the pH, the ionic conductivity and composition (Cl^-, Br^-, NO_2^-, NO_3^-, SO_4^{2-}, Na^+, NH_4^+, K^+, Mg^{2+} and Ca^{2+}).
Furthermore, during the period of the experimental measurements, samplings of the snow layers were performed in collaboration with the North Polar Institute (NPI) for the determination of the isotopic composition of nitrogen ($^{14}N/^{15}N$) in order to obtain information about fractionation processes and the sources associated with the cycle of nitrogen compounds and chemical and biological processes affecting the nitrate and nitrite concentrations in the snow. Finally, the collaboration with the University of London (Department of Geology, Royal Holloway University of London) allowed to assemble all data about the chemical properties (nitrite and nitrate concentrations) and physical (optical properties) of snow in order to obtain an estimate of the photolysis constants of nitrite and nitrate in the snow with the application of radiative models, of the NO_x and HONO fluxes and of the OH radical productions in the snowpack.

Preliminary results

Figure 1 show the temporal patterns of O_3, NO and NO_2 determined during the spring season 2011 in Ny-Ålesund. A number of depletion events of ozone tropospheric (ODEs) were observed. This event is a typical process in Arctic during the spring season and consists in a decrease of O_3 concentrations due to the presence of high levels of halogen compounds such as sea salt particles. In particular, the most significant ozone depletion occurred between 6 April and 10 April 2011 with an average decrease of O_3 concentrations (58%) from about 45 ppb to about 19 ppb. All ozone depletion events were associated to winds blowing from the north-west direction, ie from Arctic Ocean. Thus, the transport of these air masses carrying halogen species (sea salt) caused chain reaction mechanism which resulted in a decrease of O_3 concentrations.
Median values of NO and NO_2 concentrations during the experimental campaign were about 30 and 80 ng/m^3. These values are within the ranges found for these species in the coastal Arctic boundary layer at this time of year, in the absence of ozone depletion events.

The net fluxes (F) of nitrogen compounds were computed combining the gradient concentrations (Δ) with the atmospheric eddy diffusivity (D):

$$F = D \times \Delta \quad (1)$$
$$\Delta = \text{Concentration (low line)} - \text{Concentration (high line)} \quad (2)$$

A positive flux ($F > 0$) means emission from the snow surface, while a negative flux ($F < 0$) means deposition on the snow surface.
Fluxes of these gases are shown in Figure 1. NO_2 and NO fluxes were almost always negative, indicating deposition of these species on the snow surface due to the simultaneous presence of snowfall events causing the immobility of nitrate present in the snow. Instead, during the ozone depletion events these fluxes were positive.

The results of the specific surface area (SSA) measurements showed that highest values of SSA were related to highest emission fluxes of NO_2 and, therefore, the smallest NO_3^- concentration in the snow surface (Figure 2).

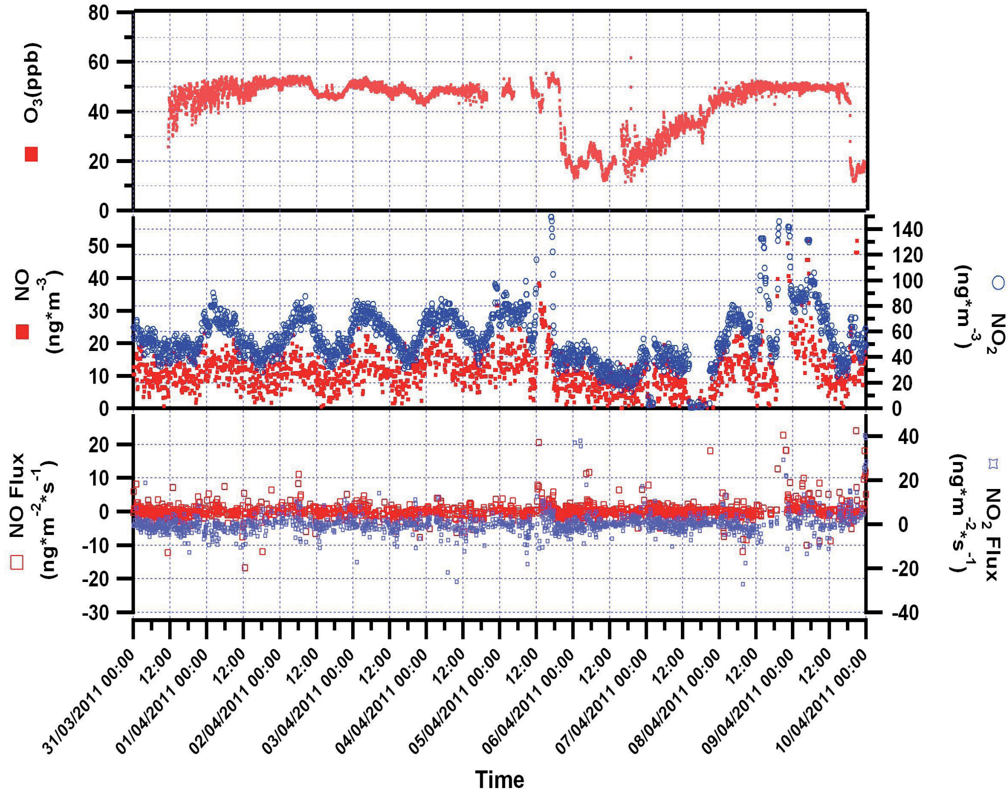

Figure 1 Temporal trends of O_3, NO and NO_2 and NO and NO_2 fluxes determined during April 2011 in Ny-Ålesund

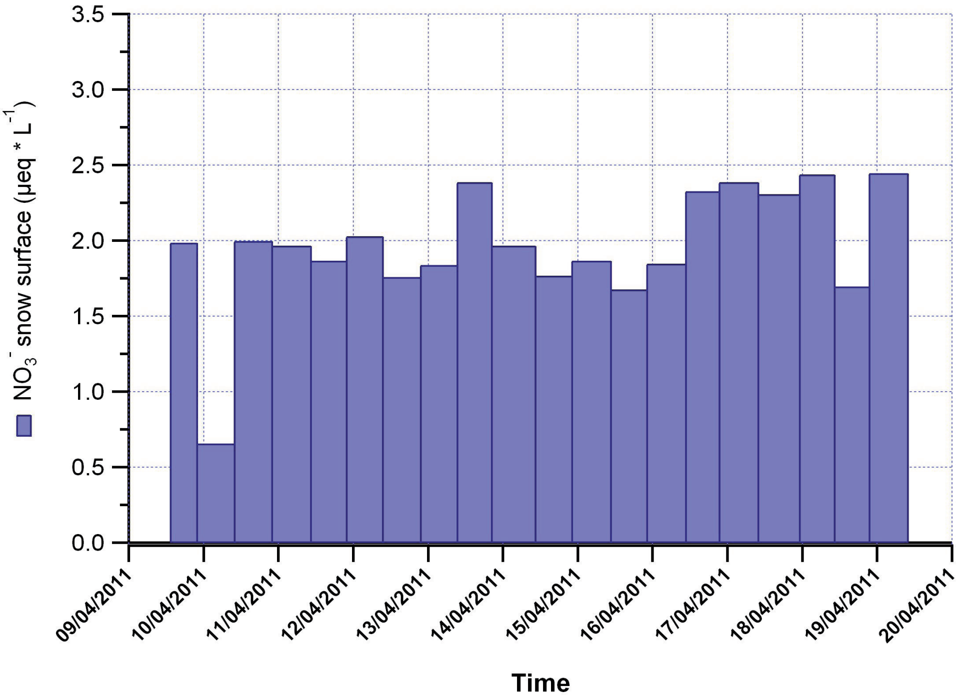

Figure 2 Temporal trend of snow surface nitrate determined during April 2011 in Ny-Ålesund

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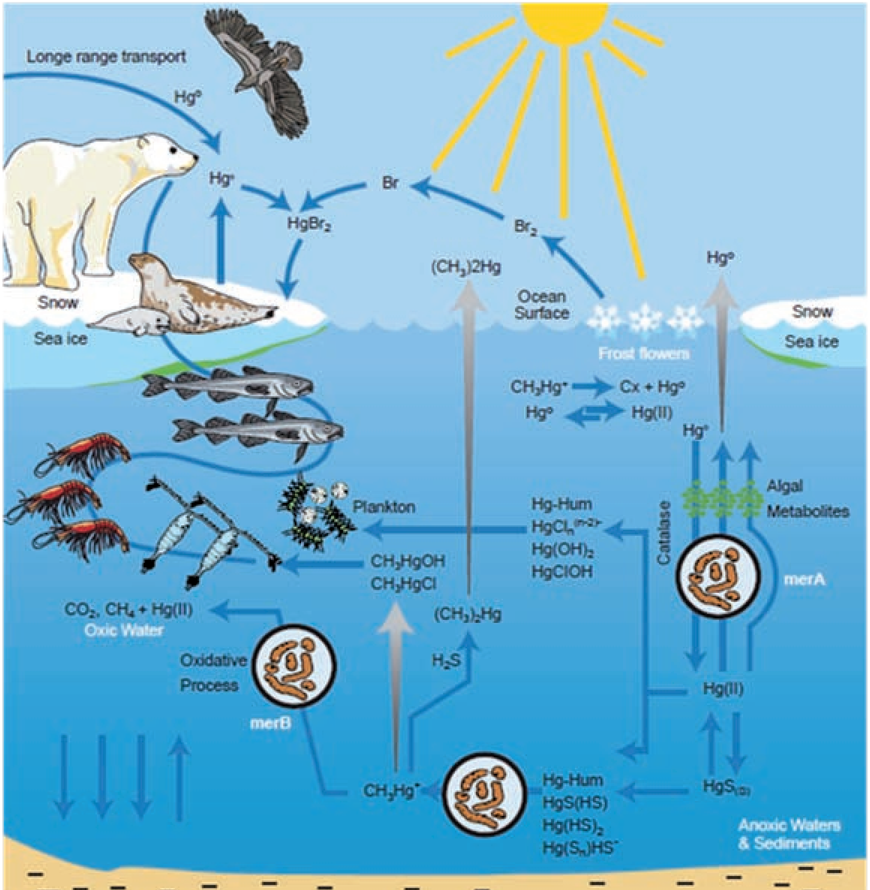
ATMOSPHERIC MERCURY



Detection of atmospheric mercury species in Ny-Ålesund

The surprising discovery of springtime Atmospheric Mercury Depletion Events (AMDEs) observed in polar regions synchronized with ozone depletion events (ODEs) suggested that both species could be removed by similar chemical reactions involving reactive halogen species responsible for the increase in the oxidation rate of Hg^0 and the formation of more water-soluble oxidized Hg compounds which quickly deposit with dangerous impact on polar ecosystems. The goal of the work performed in Ny- Ålesund in 2011 was to assess atmospheric Hg species and evaluate the chemical/physical processes that influence the Hg behavior during the AMDEs. These activities aimed at supporting the goals of the EU-Global Mercury Observation System (GMOS) project coordinated by the CNR-IIA as well as the objectives of international programs for which CNR-IIA acts as coordinator (UNEP-Hg-Program, Task Force-HTAP of the UNECE-LRTAP).

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Image on previous page: the cycle of mercury in the Arctic region.

Several research activities were carried out in different areas of the world, including the polar regions, aiming at assessing the level of Hg species in ambient air observing their variation over time. The Hg depletion events (AMDEs) occurring in polar regions has encouraged further studies aimed at assessing the mechanisms governing AMDEs and their impact on polar environments due to the rapid conversion of Hg^0 into more water-soluble forms, bioavailable and potentially dangerous for polar ecosystems.
The activities carried out by the CNR-IIA in the framework of the PEA 2010-2012 project in Ny-Ålesund (Svalbard, Norway) aimed at supporting the overarching goals of the Global Mercury Observation System (GMOS) project (EU-FP7) coordinated by the CNR-IIA which involves nearly 40 monitoring sites including Ny-Ålesund, as well as the objectives of other international programs for which CNR-IIA acts as coordinator since many years (UNEP-Hg-Program, Task Force-HTAP of the UNECE-LRTAP). The goal of the work performed during springtime 2011 was to evaluate Hg species in polar areas and chemical/physical processes occurring during the AMDEs in polar regions.

Introduction

Polar regions used to be considered pristine environments, however, due to a combination of long-range transport associated with a specific climatology, the Arctic and, to a lesser extent the Antarctic, are affected on a large scale by pollutants originating from the mid-latitudes. The different distribution of landmasses around both poles influences the atmospheric mercury (Hg) annual mean concentration observed in the Arctic (1.6 ngm^{-3}) and Antarctica (1.0 ngm^{-3}). The surprising discovery of Atmospheric Mercury Depletion Events (AMDEs) in the Arctic provided a great impetus for Hg chemistry in several nations interested in preventing pollution of polar regions (Sprovieri et al., 2005a,b; Dommergue et al., 2010).
During the Arctic spring, in fact, the Hg lifetime is only a few hours due to fast atmospheric processes that convert gaseous elemental (Hg^0) to reactive gaseous mercury (RGM) during AMDEs. Then RGM is removed quickly from the atmosphere by deposition. It is important to quantify and understand the processes responsible for the removal of mercury from the atmosphere due to the negative environmental impact of mercury. AMDEs first noted in the Arctic in 1995 (Steffen et al., 2008) and later in Antarctica (Dommergue et al., 2010) occur at the same time as tropospheric ozone depletion events (ODEs) suggesting that both species were removed by similar unknown homogeneous and/or heterogeneous chemical reactions involving reactive halogen species (such as Br and BrO) which could be responsible for the increase in the oxidation rate of Hg^0 and the formation of less volatile and more soluble RGM compounds which quickly deposit with deleterious impact on polar ecosystem (Sprovieri et al., 2002; Sprovieri et al., 2005a,b; Sprovieri et al., 2010; Dommergue et al., 2010).

The exact mechanism of the transformation of Hg^0 to RGM is as yet undetermined, the known gas phase Hg oxidation reactions appear to be too slow to account for the observed changes, but may be similar to the photochemical pathways that deplete ozone into the Arctic boundary layer. The combined measurements of O_3 and Hg therefore provide a 'laboratory' to study the response of Hg^0 to the release of halogen-containing compounds, the rate of release of which can be constrained by the comparatively well-known chemistry of ODEs.
Snow on the other hand, can act as an efficient surface for the sorption of newly formed RGM and again newly deposited RGM can be transformed within the snowpack into Hg^0, leading to snow-to-air transfer of Hg through redox transformations which may lead to changes in the evasion and deposition of Hg in cold regions. This reduction of Hg can either be driven by photochemical or biological processes, although the latter have received less attention until recently. As for the atmospheric compartment the processes involving the transformation of Hg^0 to RGM are affected by high uncertainty.

This uncertainty is primarily due to the little progress made so far in evaluating the role of chemical, physical and biological processes in the snow-icepack system and in the lower atmosphere above the snow-sea icepack interfaces. In order to study these mechanisms, an intensive sampling campaign of about one month was performed in the Arctic, at the Gruvebadet site in Ny-Ålesund during springtime 2011 in the framework of the project "Investigation on Chemical and Physical Processes that affect the Cycle of Atmospheric Mercury in the Polar Regions" funded by the Italian Research Antarctic Program (PNRA), to assess the AMDEs processes occurred during Arctic springtime and the Hg chemical-physical transformations that influence the mercury behavior in the polar regions.

Site Location and Sampling and Analytical Methods

Mercury measurements were carried out at Gruvebadet, at an elevation of 18 m above sea level. Gruvebadet is located at 1 km west far from Ny-Ålesund (78°55' N, 11°56' E) which is a small settlement near sea level on the western coast of Spitsbergen, the largest island in Svalbard. Simultaneous measurements of mercury species as well as O_3 concentrations have been continuously performed at the monitoring site. Hg^0, RGM, and Hg(p) concentrations were recorded by a Tekran 2537A/1130/1135 automated Hg speciation sampling system. Hg^0 samples (5 min) were quantified by the 2537A mercury vapour analyser.

The technique is based on amalgamation on two Au-traps within the analyser working alternately, and mercury detection by CVAFS. The integrated Tekran speciation system was configured to collect 2h RGM and Hg(p) samples on a quartz KCl-coated annular denuder and quartz filter assembly, respectively. Particles larger than 2.5 µm are removed from the air stream by a cyclone before entering the denuder, and smaller particles pass through without deposition on the reactive inner surface under the proper flow rate conditions (10 l min^{-1}).

After the 2h sampling period, a one hour analysis procedure begins by flushing the 1130 and 1135 systems with mercury free air. The Hg(p) and RGM collected on the quartz filter and annular denuder, respectively, were thermally decomposed (at 800 and 500 °C respectively) into the mercury free air stream and detected as Hg^0. During the sampling campaign annular denuders were re-coated and replaced weekly. The Tekran 2537A analyser was calibrated on a daily basis using the internal permeation tubes. The permeation tube was calibrated just prior to the study using a Tekran model 2505 primary calibration unit. The detection limit for RGM and Hg(p) under the operating conditions used was less than 2 pg m^{-3}. A description of the method employed is previously described (Sprovieri et al., 2002; Landis et al, 2002). O_3 concentrations were carried out by an automatic API-Ozone-Analyser by UV absorption.

Discussion and Conclusion

Previous Hg sampling campaigns that we performed in Ny-Ålesund, in the European Arctic, highlighted Hg concentrations in the lower atmosphere that varied in synchrony with ozone levels during the Arctic spring (Sprovieri et al., 2005a; 2005b; Aspmo et al., 2005).

In the present study, the Hg^0 and O_3 mean concentrations recorded are in agreement to those previously observed showing their synchronized behavior with a good correlation between two species (Fig. 1) suggesting a link with the chemical reactions that destroy tropospheric ozone as suggested by several authors (Sprovieri et a., 2002; 2005a; 2005b; Steffen et a., 2008). It is now hypothesized that O_3 is destroyed by a photochemical reaction with RHS (e.g., Br, BrO) derived from sea-salt aerosols in areas of active open water where the wave activity and sea-salt aerosol generation is very high.

The positive correlation observed between Hg^0 and O_3 concentrations means that the depletion of Hg0 also depends on photochemically produced oxidants and thus on the rates of Br atom production and loss. While during previous springtime 2003 study Hg^0 concentrations decreasing very fast to undetectable values (<0.1 ng m-3) during a strong MDE (Sprovieri et al., 2005a), the

Hg^0 concentrations carried out during the 2011 sampling campaign ranged from background levels (around 1.6 ngm-3) to 0.45 ngm-3 in connection with minor MDEs observed (Fig. 1). In particular, from the 9th to 14th of April 2011 a series of minor AMDEs were recorded, and a short depletion event was also observed on the 18th of April with Hg^0 decreased below 1.0 ng m-3 (Aspmo et al., 2005). Furthermore, while the Hg^0 depletion observed in Ny-Ålesund in 2003 was concurrent with dramatically increased levels in both oxidized gas-phase Hg species highlighting that BrO or another halogen-containing radical or compound is responsible for an increase in oxidation of Hg0 and the formation of less volatile compounds which are more readily scavenged, RGM and mercury bound to particulate [Hg(p)], these phenomena were not observed during 2011 springtime measurements (Fig.2).

The RGM concentrations, in particular, show a constant pattern during the whole sampling period with mean background concentrations below 2.5 pgm-3 as well as Hg(p) values ranged between 9 pgm-3 and 1.7 pgm-3 with mean concentrations below 5 pgm-3 (Fig. 2). Previous measurements also showed that Hg(p) is generally low in Ny-Ålesund with concentrations often below 10 pg m-3 (Steffen et al., 2008). Both RGM and Hg(p) have been measured during AMDEs at many Arctic sites (Lindberg et al., 2002; Steffen et al., 2008; Sprovieri et al., 2005a) highlighting that the relative distribution of these two atmospheric species differs between locations. In Alert, the overall predominant species in spring is Hg(p) (Steffen et al., 2008) whereas in Barrow, RGM is the predominant species observed (Lindberg et al., 2002). Several studies in Ny-Ålesund have shown that, in general, there is no predominance of either RGM or Hg(p) (Sprovieri et al., 2005a,b) suggesting that the distribution of the RGM and Hg(p) could be an indication of the age of an air mass and or that such distribution is the result of transported events to the measurement site (Lindberg et al., 2002; Steffen et al., 2008; Sprovieri et al., 2005a). The different RGM and Hg(p) behavior observed during spring 2011 could support these findings. It's indeed well known in that, due to chemical-physical RGM properties, it has an atmospheric lifetime of a few days. Therefore, it can be transported only for short distances from its point source being highly soluble compared to Hg^0 and this strongly influences both processes involved in its removal and its deposition rate.

The RGM results observed at Gruvebadet in 2011 seem to highlight that the relative contribution of atmospheric transport should be significant. Furthermore, the highest Hg(p)/RGM ratio observed mainly during the minor MDEs, from the 9th to 14th and on 18th of April 2011suggested that the link between Hg(p) and MDEs could be a chemical association through transport. To examine potential influences of meteorological factors on atmospheric reactions occurring during MDEs at Gruvebadet, mercury concentration-time series together with selected additional meteorological and chemical parameters were evaluated. Results from this investigation seem to support the influence of transport on mercury data observed during spring 2011. The depletion episodes observed from the 9th to 14th of April 2011 were in fact characterized by several dips and spikes in the Hg^0 trend which occurred in conjunction with a rising wind speed (about 10 ms-1) and a rapid shift in wind direction to NNE indicating intrusion of an air mass coming from the Arctic Ocean highlighting that the MDEs observed could be the result of atmospheric long-range transport of depleted air masses (Sprovieri et al., 2005a).

The AMDE dynamics observed in this study confirm the results of the previous experimental campaigns carried out in Ny-Ålesund. The ratio between mercury deposition and reemission is an important parameter that determines the impact of MDEs in the Arctic environment.

More research and investigation on possible reaction mechanisms and chemical kinetics of these phenomena are required to successfully improve our understanding of chemical-physical processes involved in the mercury cycle, and assess the resulting net input into the polar environment. The activities carried out by the CNR-IIA in the framework of the PEA 2010-2012 project at Gruvebadet (Ny-Ålesund, Svalbard, Norway) aimed to support, in fact, the overarching goals of the GEO (Group of Earth Observation) Task HE-09-02d "Global Monitoring Network for Mercury" in the context of the Global Mercury Observation System (GMOS) project (EU-FP7, 2010-2015) coordinated by the CNR-IIA (www.gmos.eu) which involves nearly 40 monitoring sites distributed both in the northern and southern hemispheres (polar areas included) at high altitude (i.e., EvK2CNR in Nepal, 5050 m. asl, and Dome C, Antarctica 5320 m. asl) as well as at sea level locations for developing a coordinated mercury network on global scale and benefiting from the experience from other measurement networks and the on-going design of regional and national Hg networks.

Therefore, the data produced during these studies will contribute to the achievement of the overarching objectives of GMOS and other international programs where CNR-IIA has been acting as coordinator since many years (UNEP-Hg-Program, Task Force-HTAP of the UNECE-LRTAP). More research in polar areas will be therefore performed in collaboration with International and European research groups, such as, the University Joseph Fourier, CNRS – Laboratoire de Glaciologie et Geophysique de l'Environment (LGGE), (Grenoble, France) which during the spring 2011 worked with us on snow samples collected close to the Gruvebadet site, in order to investigate on the redox transformations occurred into the snow and on the Hg processes involved at the air-snow interfaces to fully understand the sources/fate of Hg in the polar atmosphere.

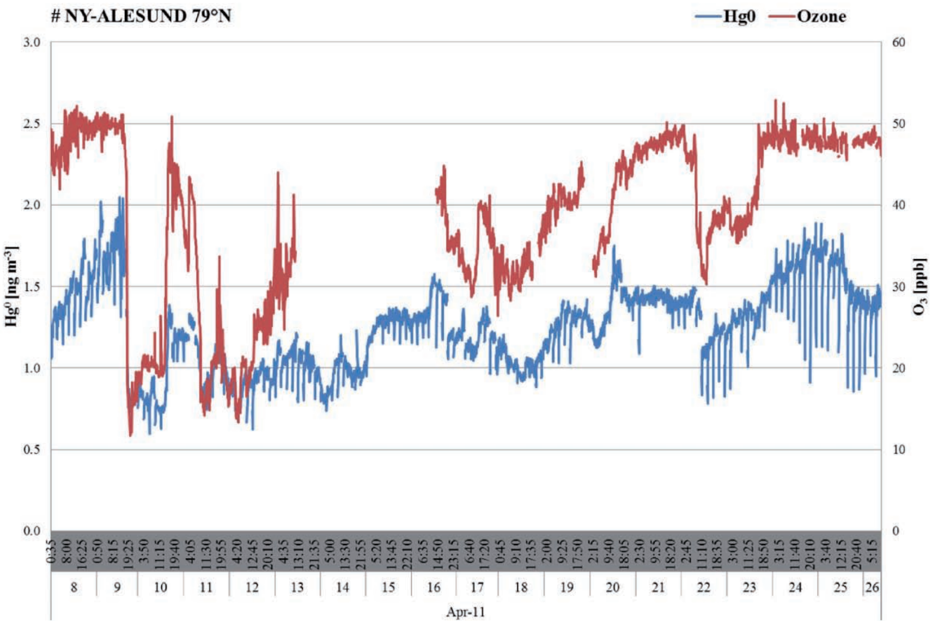

Figure 1 Hg^0 and O_3 concentrations recorded during the Arctic spring campaign and AMDEs observed from 9th to 14th and on the 18th of April 2011

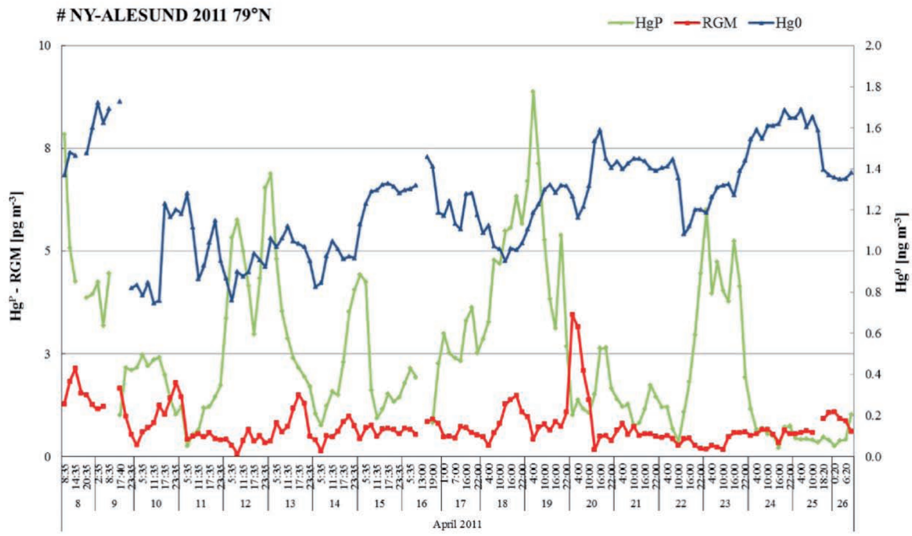

Figure 2 Hg^0, RGM and Hg(p) concentrations recorded during the sampling campaign

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SNOW STRUCTURE AND CHEMICAL COMPOSITION

The nivological and glaciochemical survey of Svalbard glaciers

During the Arctic field campaign 2012 (Svalbard), nivological and glaciological investigations on different glaciers were carried out. Snow samples, both stratigraphic and bulk, were collected in 20 snowpits dug at different locations on these glaciers.

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Image on previous page: snow sampling in the silence of the Midtre Lovenbreen glacier.

Abstract

During the Arctic field campaign 2012, nivological and glaciological investigations on different Svalbard glaciers were carried out. Snow samples, both stratigraphic and bulk, were collected in 20 snowpits dug at different locations on these glaciers. On the top of the Holtedhalfonna (79° 09' N, 13° 23' E), at an altitude of 1150 m a.s.l., a 11 m long shallow firn core was drilled. The samples were processed, decontaminated and aliquoted in clean conditions (class-100 clean-bench) in the lab-facilities at the Italian permanent station in Ny-Ålesund. Trace elements and halogens (I and Br) were quantified in the samples with the aim to investigate the occurrence, the distribution and the temporal variability of these elements and understand the magnitude of possible post-depositional effects.

Report

In 2012, extensive nivological and glaciological investigations were carried out on the Austre Brøggerbreen, Midtre Lovenbreen, Kongsvegen and Holtedhalfonna glaciers, in Svalbard Islands. The main goals of this project were to produce a stable isotopes, major ions and trace elements profiles to verify the preservation of the seasonal signals and to reconstruct the climatic and environmental profiles over the last decade. In addition the spatial and temporal variations of bromine and iodine have been investigate in a shallow ice core to better understand which processes control their concentration in the snow deposition.

Halogens, and in particular iodine and bromine are particularly active in the polar atmosphere hence their stability have been evaluated in the snowpack to determine if post-depositional processes alter bromine and iodine concentrations. The spatial variability of Br and Na has also been investigated collecting samples from the glaciers. In addition, in the Kongsvegen glacier, from the bottom part to the summit, we recovery 10 surface snow sample necessary to understand if the distance from the sea influences the Br\Na mass ratio.

Stratigraphic and bulk snow samples were collected from different Svalbard glaciers. We conducted an extensive sampling in the glaciers of Austre Brøggerbreen (BRG), Midtre Lovenbreen (MLB) (Figure 1, cyan triangles) by several snow pits. In particular 10 snow pits have been dug in the BRG glacier and 8 in the MLB in order to better establish the source, distribution and fate of several trace elements and halogens species in these glaciers.

Other 3 snow pits have also been dug: 1 in the summit of the Kongsvegen (KNG) glacier and 2 in the Holthedalfonna (HDF), one at the top and one close to the bottom. In all snow pits, snow stratigraphy has been identified and physical parameters such as temperature, snow density, grains shape and size, hardness index (hand test) have been considered, according to the International Association of Cryospheric Science classification.

In the glaciers of Austre Brøggerbreen, Midtre Lovenbreen an extensive snow depth measurement was also carried out to identify where accumulation and depleted area are located (Figure 1), in order to identify the snow transport process on the two glaciers surface.

On top of the HDF, a 10 m long shallow firn core was drilled using a 98 mm internal diameter aluminum auger, powered by an electrical external drill. The core sections have been characterized and the main firn features (layering, dust horizons, ice lens, crystallography) have also been recorded. The collected samples have been sealed in double polyethylene bags and then transported into insulated boxes to the scientific Italian station in Ny-Ålesund.

The snow-pit samples were melted at room temperature under a class 100 laminar flow clean bench. For the trace elements determination, 10 mL aliquot will be transferred to ultra-clean LDPE vials and acidified with ultra-pure HNO_3 (2% v/v).

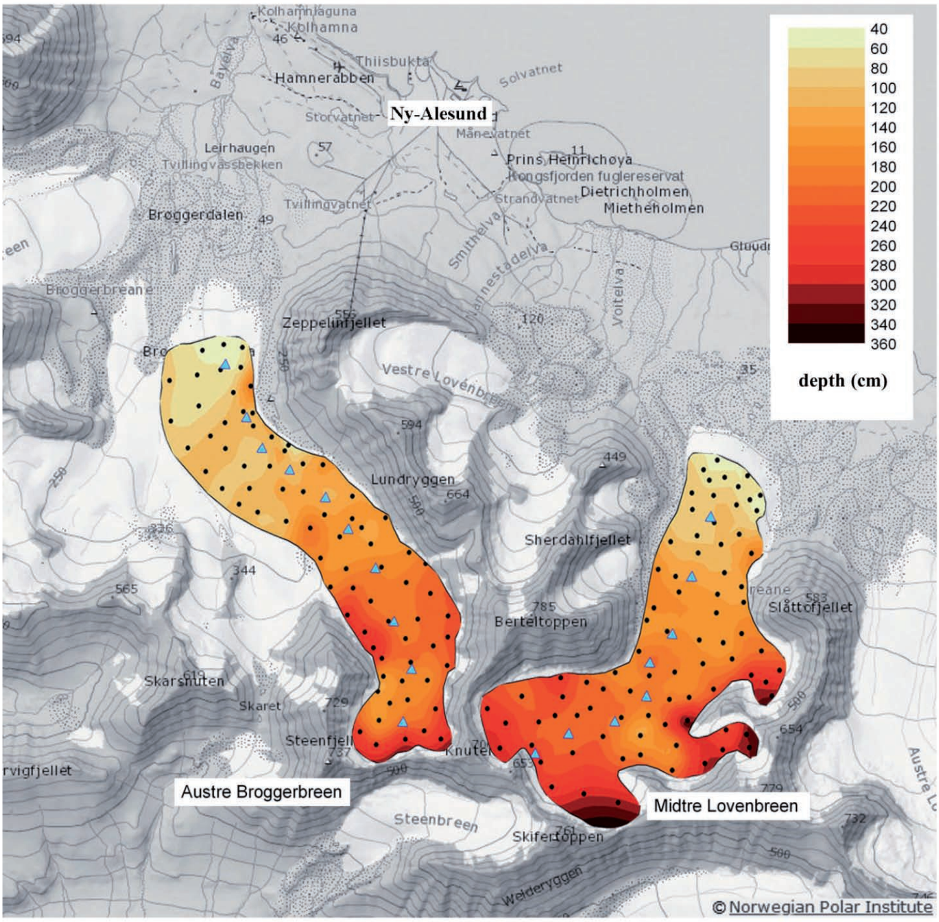

Figure 1 Snow depth of the Austre Broggerbren and Midtre Lovenbreen. The depth is expressed in cm. The depth profile is summarized in colored graph where the snow depth increases from yellow to red. Black dots show the measurement locations for the snow depth while the cyan triangles the location of the snow pit dug. Map courtesy of Norwegian Polar Institute

Two sample aliquots (~ 10 mL) were transferred to pre-rinsed LDPE vials for stable isotopes and Br and I analysis, respectively. Finally, 40-50 mL samples have been placed in LDPE pre-washed bottles for halogen speciation analysis, electrical conductibility, major ions, alkalinity, and total organic carbon (TOC) analysis. An aliquot (about 50g) of the snow/firn core samples was melted at room temperature in glass beaker for detect the presence and amount of large particles.
During sampling activities, scientists wore special clean-room clothing and polyethylene gloves (Figure 2) to minimize the risk of contamination. The wall of the snow-pits has been firstly scratched with a polyethylene bar, scraping out the exposed sections that are potentially contaminated during the digging and the glaciological measurements. Sampling has been conducted by plunging 125 mL low-density polyethylene (LDPE) vials perpendicularly into the snow-pit wall. The sampling has been performed from the surface down to the bottom of the snow-pit, with a spatial resolution of 5 cm necessary to obtain a sub-seasonal resolution. The bottles have been capped, packed in double LDPE bags and brought back to the laboratories in Ny-Ålesund.

Figure 2 Snow pit sampling at the summit of the Holthedalfonna Glacier

Snow structure measurements highlight the presence of ice lenses in all the glaciers studied, confirmed by the shallow core recovered. In particular the occurrences of ice lenses rapidly increase moving to lower elevation, especially for the Austre Brøggerbreen and Midtre Lovenbreen. Small changes in elevation (< 100 m) seem drastically change the snow propriety and post-depositional process. Thought ice lenses have been also found at the top of the Holthedalfonna, suggesting a summer melt of the surface layers, their frequency is lower. The snow depth measured at the Midtre Lovenbreen and Austre Brøggerbreen show accumulation in the ranges between 40 cm up to 360 cm (Figure 1).

Austre Brøggerbreen present lower accumulation compared to the Midtre Lovenbreen mostly due to the orographic shape of its valley. Measurement of electrical conductibility for the snow pit dug in the Austre Brøggerbreen (BRG), Midtre Lovenbreen (MLB), Kongsvegen (KNG) e and Holthedalfonna (HDF) suggest a decreasing of ionic charge from the coast to inland. Similar electrical conductibility (30 µS in average) has been measured in the BRG and MLB glaciers, while for KNG and HDF we measured an electrical conductibility of 10 µS and 5 µS respectively. Bromine concentration also present higher values close to the coast (BRG and MLB glaciers) in the range between 10 and 20 ng g^{-1} and lower moving further inland. Samples collected at the top of KNG show concentrations in the range of 10-15 ng g^{-1} while HDF samples show concentration between 0.5 to 5 ng g^{-1}.

Thought the surface samples collected in the KNG, covering about 20 km from the cost to the summit, do not show a clear decreasing in bromine concentration and changes in Br\Na with the distance, the results obtained in HDF seem suggest the dependence of bromine concentration from the distance confirming the sea as the main source of this elements. Iodine is a biological emitted element from the sea, however the samples recovered in the different glaciers show similar concentration, from 0.1 ng g^{-1} to 1 ng g^{-1}. Opposite to bromine, iodine seems not influenced by distance.
Despite more than half of the Svalbard glaciers have a negative mass balance, the top of Holtedahlfonna still has a positive accumulation balance with a preservation of a consistent part of the annual deposition. At stake 8, on the top of the Holtedahlfonna glacier (1150 m a.s.l.) in the last decade the net balance ranged from 61 to 133% of the winter deposition. These data are confirmed by the water stable isotope profile that demonstrates the climatic signal is preserved.

Figure 3 Recovery of the shallow firn core at the summit of the Holthedalfonna Glacier

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A scientific publication of the results obtained is in preparation.

SPETTRORADIOMETRY AND STRUCTURE OF SNOW

Spectroradiometric field measurements in Ny-Ålesund

Spectral measurements of snow surfaces and ancillary snow data were collected at selected sites in Ny-Ålesund in order to analyze albedo spatial and temporal variations and their influence on climate studies.

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Image on previous page: spectroradiometric measurements in Ny-Alesund in the proximity of the Climate Change Tower.

Abstract

In April 2011 spectroradiometrical field measurements were carried out in Ny-Ålesund according to the planned activities related to the PRIN project (ARCTICA – ARCTic research on the Inter-connections between Climate and Atmosphere) and to the international project CICCI (*Coordinate Investigation of Climate-Cryosphere Interactions*.

Spectral measurements of snow surfaces and ancillary snow data were collected at selected sites in order to analyze albedo spatial and temporal variations and their influence on climate studies.

The measurement sites were selecteted in agreement with the different scientific groups operating in the same period in Ny-Ålesund; for each site the top layer of the snow cover was sampled to determine the amount of the black carbon.

Spectroradiometrical measurement were also used as ground truths for ASTER satellite images analysis and for albedo measurements taken in the same period by unmanned vehicles operating in Ny-Ålesund.

At the Gruvebadet site, daily measurements of snow thickness and snow layer characteristics (grain type and size, temperature, hardness) were collected during the campaign to study the effects of nitrogen atmospheric compounds on snow/air interface.

An experimental "snow field" at the same site was also monitored to model the snow cover metamorphism and contribute to the development of avalanche prevision model.

Field work

The extension and the thickness of the snow covered areas and terrestrial and marine ice, represents one of the most valuable variable of global change studies. Monitoring these variables can be efficiently carried out using multispectral remote sensed images.

Snow reflectance, in the visible and near-infrared wavelengths, is due to snow light scattering properties, which are function of the size and shape of snow grains, of the absorption by the ice medium, of the presence of impurities and of the surface roughness (Wiscombe &Warren, 1980, Warren 1982, Painter et al.2003, Nolin & Dozier 2000).

In particular, snow reflectance is higher in the visible part of the electromagnetic spectrum, while decreases rapidly at longer wavelengths. The increase of grain size determines a decrease of reflectance all over the spectral range from visible to short wave infrared (350-2500 nm); analysis of field data has also provided evidence of the great role of surface roughness in controlling snow spectral behavior.

Moreover recent studies (Gallet et al 2009, Matzl & Schneebeli 2006, Domine et al. 2006) suggest that radiometrical field data can also be used to estimate the specific surface area (SSA) of the snow, defined as the surface area of snow crystals that is accessible to gases per unit mass. It has been verified that during snow metamorphism, as the grain size increases, the SSA decreases, thus supplying an important contribution to atmosphere-snow interaction models.

The scientific challenge of the research activity, that this group is developing within the international scientific community of Ny-Ålesund, is the understanding of the relationships between the spectral behavior of snow and its physical characteristics, in order to detect the subtle differences in the snow grains and types not only with field measurements but also using remote sensed images that can easily allow regional observations. The possibility to merge field data and remote sensed images of the same study area can allow the improvement of existing snow mapping algorithms and reflectance model for radioactive balance studies.

The snow radiometrical activities of our group, supported by PRIN and PNRA research program, joined the actions carried out in Ny-Ålesund by other national teams, working in a common international cooperation project "Cooperative Investigation of Climate-Cryosphere Interaction"(CICCI). The main goal of this peculiar.

initiative was to improve the understanding of processes controlling the distribution of black carbon (BC) in the Arctic atmosphere and deposition to snow and ice surfaces and the resulting climate impacts. Each national team decided to contribute to this project in order to share knowledge, data and to build the basis for future common activities.

The spectroradiometrical measurements campaign was therefore organized taking in to account not only the original schedule activities but also the common international activities. In particular the measurements sites were selected in order to collect data with different instrument on the same area. The snow spectral behavior was investigated on the ground by Italian, Norwegian and US teams and un-manned aerial surveys were conducted by Norwegian and US teams.

The areas close to the CCTower and to Gruvebadet Laboratory were the principal test sites for PRIN and PNRA research activities. The successful intervention of directing the common international efforts on our investigation areas represents a great opportunity to provide a robust set of measurements that will be of significance to climate modeling and forecasting of Arctic variability.

Moreover the area close to the CCTower, named *CNR-ground*, was selected as the site where instruments were inter-calibrate and ground truth site for the overflight activities planned in CICCI program.

Field Data

During 2011 campaign, measurements of the snow reflectance were carried out with a portable spectroradiometer (Field Spec, Analytical Spectral Devices, Boulder, CO, USA), that allows to acquire reflectance data in the 350-2500 nm spectral range.

Field Spec automatically calculates the reflectance value as the ratio between the incident solar radiation reflected from the surface target and the incident radiation reflected by a reference white Spectralon® panel, to be regarded as a Lambertian reflector. For these measurements, a bare fiber optics with a FOV of 25° was used. Special care was taken that the radiometer was nadir viewing over the surveyed surface and sun-facing.

Weather conditions during the campaign were generally severe and the sky was very often overcast. These conditions interfere mainly at NEAR IR wavelengths where the solar radiation is absorbed by clouds causing a lower signal/noise ratio. in this portion of the spectrum.

Field measurements were carried out in Brogger peninsula mainly close to the CCTower (*CNR ground* site), following the triangular geometry designed for minimizing the effects of snow surfaces roughness.

For each radiometrical site a nivological observation was performed, investigating the first 20 cm of the snow pack. Grain size and shape, density, temperature (at -2 and -10 cm of depth), were recorded together with a photographic documentation of the site.

Due to the severe weather conditions only 7 series of radiometrical measurement were performed at Gruvebadet Laboratory Site even if snow data were collected regularly (morning and evening) for the whole campaign in order to follow the snow metamorphism.

In order to continue the snow cover evolution studies at Gruvebadet started in 2010, a "*snow field*" of 25mx25m was monitored measuring snow depth and superficial grains size daily, according to a grid of 5mx5m; complete snow profiles were performed at four vertices of the" *snow field*". Data collected allow to define the total amount of snow during the observation period and the volume changes due to the processes of sublimations as well as the effects due to snowfall and wind accumulation (Figure 1).

At selected sites of the Brøgger Peninsula, also snow samples were taken in order to analyze the black carbon content. These snow samples were collected in a flat area, far from snowmobile track; chemical analyses of these samples will support the investigation on snow-atmosphere interactions.

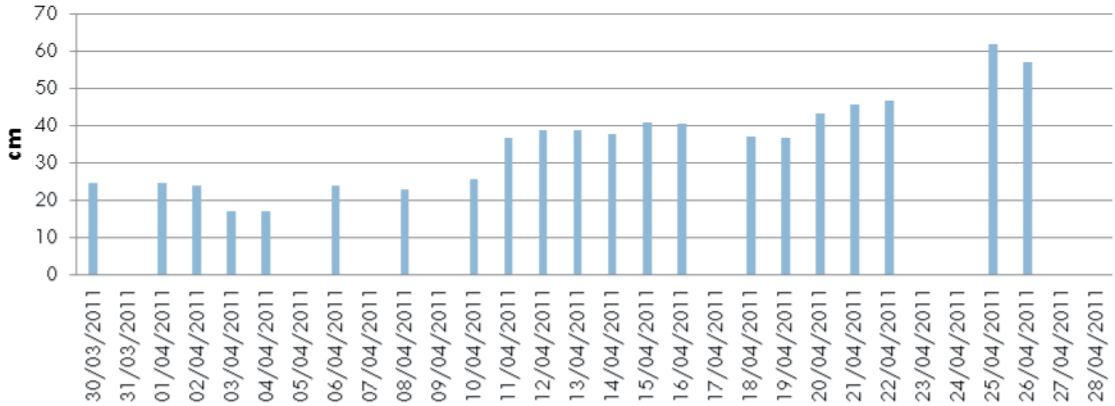


Figure 1 Snow thickness at Gruvebadet "snow field"

During the campaign a further experiment was carried out exploring the possibility of acquiring snow spectral radiance measurements automatically all day long to study snow reflectance variations in the melting season. The radiometer was thus mounted on the CCTower and data were recorded for 3 days (Figure2).

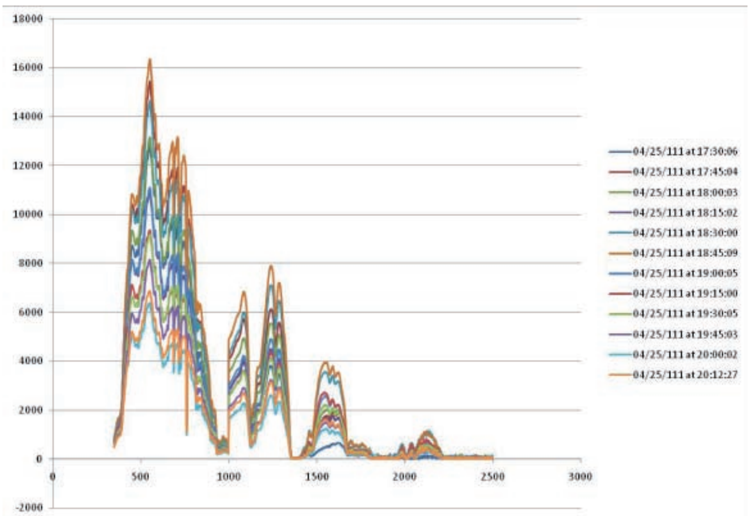


Figure 2 Radiometrical measurements at the CCTower

All the investigated sites were previously recognized on the satellite images (Landsat TM and ASTER) used for this project. Image analyses will produce albedo maps as well as snow classification maps to be used to describe climate behavior of the Brøgger peninsula.

Preliminary results

Preliminary observations confirm the relation between snow characteristics and reflectance values in the infrared wavelength range even if the frequent snow precipitation events made the investigated surfaces very homogeneous in grain size and shape.
Nevertheless it is possible to notice the decreasing of reflectance values in the range between 800-900 nm according to grain size increasing when their shape can be considered as a sphere (Figure 3,Table 1). On the contrary, fresh snow (stellar dendrite) shows high reflectance values also with large crystals (3-4 mm) due to the anisotropic distribution of the grain and the presence of many

reflective faces. These preliminary observations are in accord with the results of the campaigns carried out in Ny-Ålesund in previous years when the weather conditions were more stable and the signal/noise ratio was lower.
Snow observations at Gruvebadet allow to model the SSA and its variation during the observation period: this data will be processed with chemical data (collected by Italian and Norwegian research team) to understand the interchange processes in the snow/atmosphere interface.

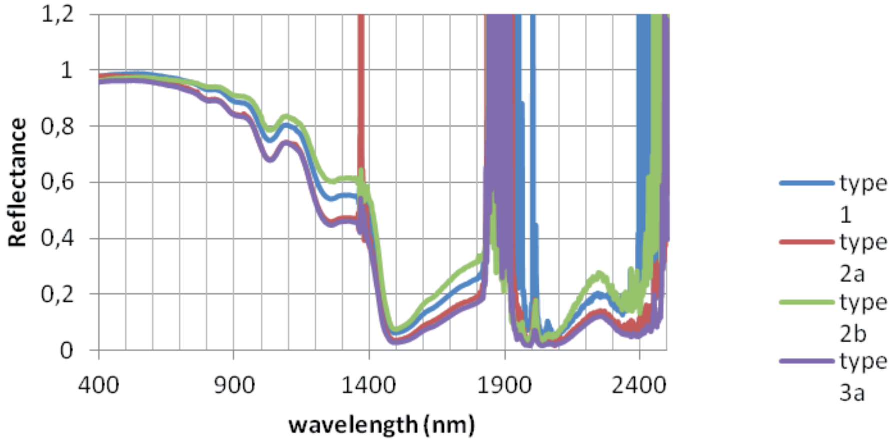


Figure 3 Field reflectance of different snow types. (3a=1mm, 1d=4mm, 2a=1.5mm 2b=2mm 3a=1mm)

Basic classification	type
Precipitation particles	1
Decomposing and fragmented Precipitation particles	2
Partly decomposed particles	2a
Highly broken particles	2b
Rounded grain	3
Small rounded particles	3a
Large rounded particles	3b
Faceted crystals	4
Cup-shaped crystals and depth hoar	5
Wet grains	6
Feathery crystals	7
Ice masses	8
Surface deposits and crust	9

Table 1 Snow grains description (Colbeck et al.1990)

ASTER images (May and July 2001 and July 2007) were acquired for the project. The images were radiometrically calibrated in order to obtain reflectance values from DN values. Infrared bands were corrected using "dark object" methodology, considering sea water as valid dark object for these wavelength ranges; visible image were than inter-calibrated with this new data sets.

The reflectance values, derived from the images, were compared with spectroradiometric data collected in the same region on flat areas during the snow surveys.
The good agreement between image-reflectance values and field-reflectance values suggests that further atmospheric and geometric corrections are not necessary.
Snow cover extension on ASTER images were emphasized with a false color representation of the data obtained with visible and near infrared bands and the snow index NDSI (normalized difference snow index) for the images were computed in order to obtain a preliminary distribution of snow cover.
The particular environmental and morphological conditions of the Ny-Ålesund area suggested to preserve the different spatial resolution of ASTER bands (table 2). These data were therefore georeferred, but not resized on the same pixel resolution. This methodological approach has permitted to use the whole spectral information of the data leading the analyses to two different scales. Processing the first 3 bands that have more spatial detail, it was possible to follow the snow cover extension also on the glaciers; the SWIR images integrated with field spectral and nivological data were instead used to discriminate ice/snow surfaces and to characterize different types of snow cover.

Characteristic	VNIR	SWIR	TIR
Spectral Range	Band 1: 0.52 - 0.60 µm	Band 4: 1.600 - 1.700 µm	Band 10: 8.125 - 8.475 µm
	Band 2: 0.63 - 0.69 µm	Band 5: 2.145 - 2.185 µm	Band 11: 8.475 - 8.825 µm
	Band 3: 0.76 - 0.86 µm	Band 6: 2.185 - 2.225 µm	Band 12: 8.925 - 9.275 µm
	Band 3: 0.76 - 0.86 µm	Band 7: 2.235 - 2.285 µm	Band 13: 10.25 - 10.95 µm
		Band 8: 2.295 - 2.365 µm	Band 14: 10.95 - 11.65 µm
		Band 9: 2.360 - 2.430 µm	
Ground resolution	15 m	30m	90m

Table 2 ASTER sensors characteristics

Field spectral signatures of different snow samples were processed in the same wavelength ranges of ASTER spectral bands (Figure 4). The reflectance values of the first 3 bands showed significant differences that can be successfully used to classify these images.

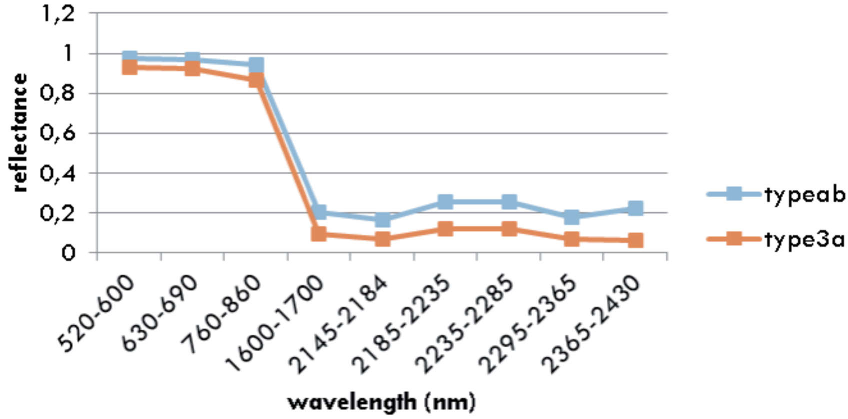
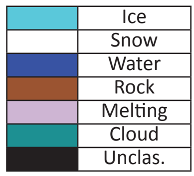


Figure 4 Field reflectance of different snow types at ASTER wavelength ranges

The images collected in the SWIR, even if showed more difference in reflectance values, were considered less significant to the aim of classification due to their lower spatial resolution. Following this observation, only the visible and the near infrared images were used in the image classification procedures.
The summer images of the Ny-Ålesund area (acquired on 2007 and July 14th 2001) were analyzed and classified paying particular attention in detecting the snow in the upper part of the glacier, the snow close to melting front and the pure ice on the glacier (Figure 5). The spectral differences between these surfaces in the near wavelengths allowed a good identification of this unit on the images and field data avoided the problem of mixed pixels. The accuracy of images classification thus obtained was around the 95%.



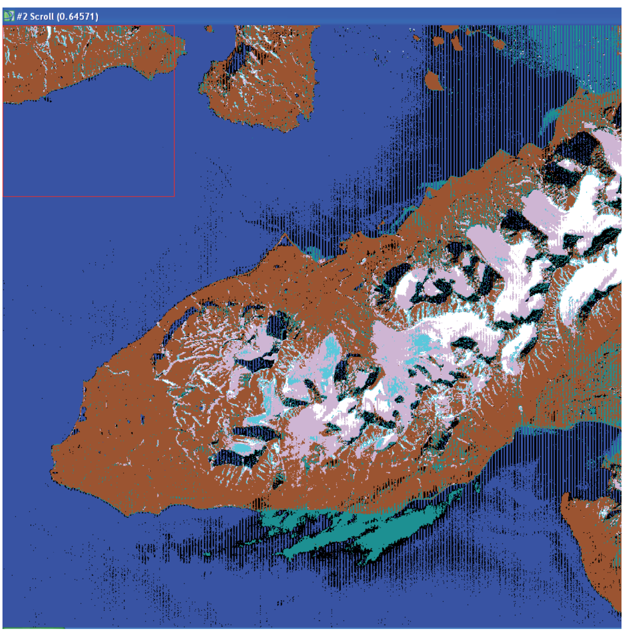


Figure 5 Snow cover classification derived by ASTER image (July 12th 2007)

Field data collected in previous campaigns in Ny-Ålesund (Salzano et al., 2006) suggest that it is possible to derive the SSA using reflectance values in infrared ranges as follows:

SSA =3054.2 reflectance tm5+30.083
SSA =3620.1 reflectance tm7+47.125

These relations, derived using Landsat TM data, have been applied to reflectance values derived by ASTER images and the preliminary results of the experimentation seems to demonstrate that it is possible to discriminate snow cover with different values of SSA also using ASTER infrared images. This was made possible by a good knowledge of the spectral and structural features of the snow targets achieved at the ground.

The observations derived by image processing procedures also underlines that the remote sensed images can be used to describe the distributions of the different types of snow, since at VIS and IR wavelengths, absorption is very high and the size of the particles is the main factor on the diffusion of light.
The next step of the image processing research activity will be the analysis of multi-temporal images: this opportunity will improve the knowledge of snow cover on the whole Svalbard territory as requested by the international community.

Products

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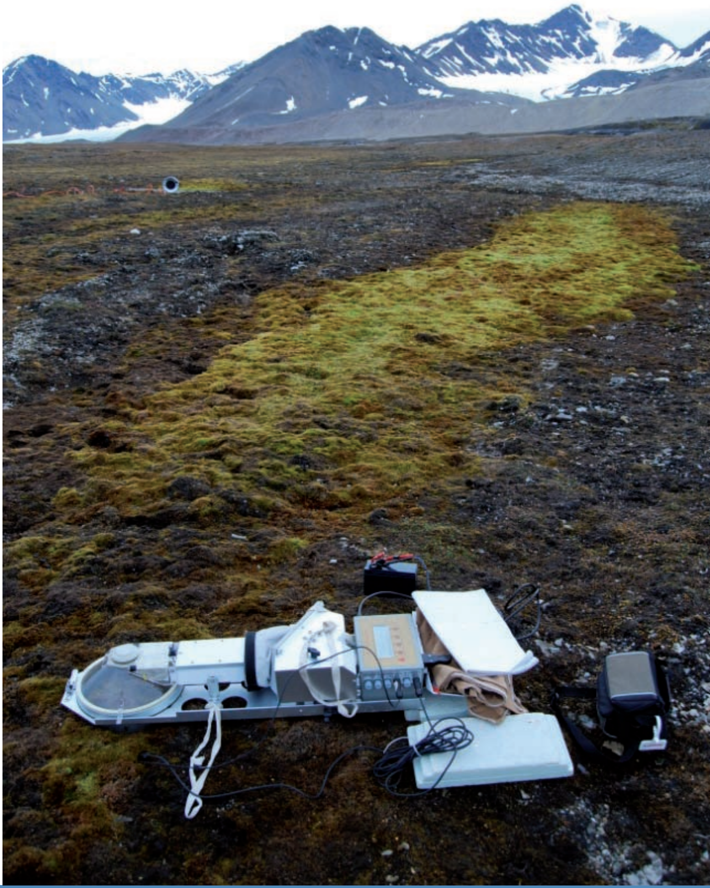
PERMAFROST



Field campaign in Ny-Ålesund

Characterization of the vegetation, the active layer and the underlying permafrost coupled with measurements of CO_2 fluxes of the analysed ecosystems.

Research group

Insubria University (Varese, Italy)
Mauro GUGLIELMIN, Nicoletta CANNONE, Roberto GAMBILLARA

Image on previuos page: active layer thickness and CO_2 fluxes at Stranvatnet.

Abstract

During the summer of 2012 the Insubria Research group started a research programme focused on the characterization of the vegetation, the active layer and the underlying permafrost around the CCT tower and in the surrounding of Ny-Ålesund coupled with the first measurements of CO_2 fluxes of the analysed ecosystems (vegetation + underlying active layer).
In the brief preliminary campaign (5/08-17/08) we performed 11 ERT (Electrical Resistivity Topographies) with 2 or 1 m of span for determining the active layer thickness and its spatial variability along a transect at Strandvatnet and very close to the coast and, above all on a 50X50 m grid of (6 lines every 25 m) close to the CCT. In the same sites 9 plots in correspondence of the main vegetation communities were selected to measure the CO_2 fluxes through an IRGA system.
For each site a simplified soil profile was described and the different horizons within the upper part of the active layer were sampled. After this characterization a 50x50 m grid for the permanent active layer monitoring (that will be part of the CALM network) has been established.
The results of the field measurements are still in processing and will contribute both to the understanding of the relationships among permafrost (and its active layer), vegetation and CO_2 fluxes in a Climate Change scenario.

Report

During the summer of 2012 the Insubria Research group started a research programme focussed on the characterization of the vegetation, the active layer and the underlying permafrost around the CCT tower and in the surrounding of Ny-Ålesund coupled with the first measurements of CO_2 fluxes of the analysed ecosystems (vegetation + underlying active layer).

The main goals of the campaign were two:

a) *estimation of the spatial variability of the active layer thickness and the permafrost distribution around the CCT tower and, for comparison, in one site closer to the coast;*
b) *estimation of the variability of the CO_2 emission related to the active layer thickness and the vegetation types.*

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a) *Estimation of the spatial variability of the active layer thickness and the permafrost distribution around the CCT tower and, for comparison, in one site closer to the coast.*

For the objective a) ca 830 m of electrical topographies (ERT) were performed, 6 lines of which (3 lines N-S and 3 E-W oriented, with a span of 2 m) placed at a distance of 25 m from each other and centered on the grid of 50x50 m located immediately southward to the CCT tower (Figure 1). A short altitudinal transect close to Strandvatnet from the road to the shoreline was also carried out.
This transect was composed by an upper line NNE oriented 94 m (span 2 m) long between 25 and 20 m a.s.l. and 3 lines (with 50% of overlapping to maintain the same investigation depth, for a total length of 94 m) with the same orientation but a span of 1 m, located between 15 and 7 m a.s.l. crossing a saturated moss bank. Finally a line NW-SE oriented, orthogonal to the NNE line, of 32 m (span 1 m) was also carried out.

Figure 1 Location of the study sites

Preliminary results of the ERT indicate that the active layer (defined here as maximum thawing depth) is extremely variable from a few decimetres up to more than 3 m and, above all, the existence of some taliks was detected. Taliks are portion of ground in which water occurs as liquid despite ground temperatures are likely well below 0°C and therefore are within permafrost (see Figure 2).

This complex hydrogeological system is already known also in other coastal areas of the Arctic and even in Antarctica but it is surely a peculiar feature that needs particular attention both for the ecosystem and the landscape evolution.

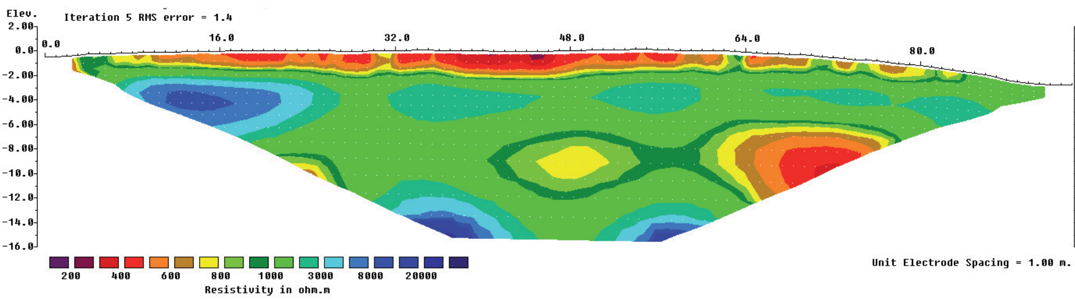

Figure 2 Example of ERT along one of the six lines (North on the left and South on the right of the figure and located in the middle of the CALM grid). (in the Y axes the 0 correspond to the absolute elevation of 55 m a.s.l.. Resistivity values above 2000 ohm should represent frozen ground

Permafrost thickness is generally thinner and not more continuous closer to the shoreline (where it occurs only below the windswept ridges like in Figure 3). The surface characteristics (e.g. the vegetation type) also strongly influence the spatial variability of the active layer and the permafrost distribution. Indeed, below a saturated moss bank (with less than 30 cm of peat) permafrost seems not to occur at least in the first 8 m, while below the adjacent ridge characterised by *Cassiope tetragona* and grasses the frozen ground is at least 6 m thick.

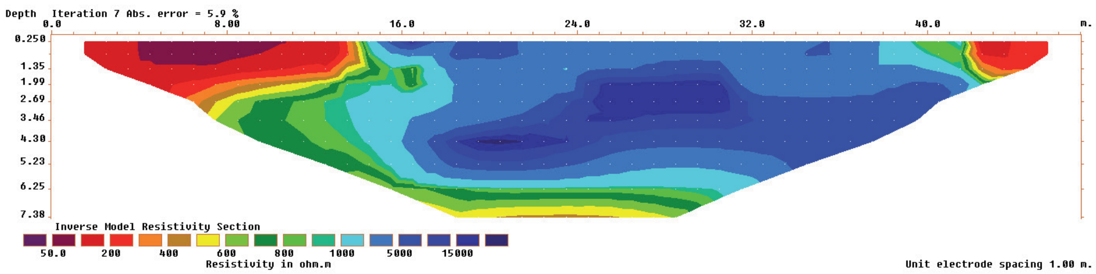

Figure 3 Example of ERT along one of the lines carried out close to the beach at Strandvatnet. (in the Y axes the 0 correspond to the absolute elevation of 8 m a.s.l.) Resistivity values above 2000 ohmm should represent frozen ground. On the left there is the saturated moss bank area (in the first 12 m) while the middle is a ridge characterised by grasses and Cassiope Tetragona

b) Estimation of the variability of the CO_2 emission related to the active layer thickness and the vegetation types.

To estimate the variability of the CO_2 fluxes related to the active layer thickness and the vegetation types after a preliminary vegetation survey to define the main vegetation communities 6 different communities were examined within the CALM grid (Fig. 4) and 9 plots along the transect at Strandvatnet.

At the CALM grid site, the spatial distribution of vegetation follows topographic and edaphic gradients, with mosaics of different vegetation types: tundra barrens (dominated by the graminoid *Carex rupestris*) and dwarf shrubs (respectively composed by patches of *Dryas octopetala* and *Cassiope tetragona*) in the most exposed and xeric sites; patches of snowbed vegetation dominated by *Salix polaris* with mosses, or exclusively composed by mosses in the wettest sites and in areas where the microtopographic conditions promote snow accumulation and persistence; tundra barrens dominated by *Saxifraga oppositifolia* in mesic sites and occurrence of cryptogrammic crusts of Cyanobacteria on finer material.

At the CALM grid site the CO_2 fluxes were analyzed in patches all included in the CALM grid and adjacent to the CCT tower, in correspondence of the following vegetation types:

1. shrubland with *Dryas octopetala*;
2. shrubland with *Cassiope tetragona*;
3. grassland with *Carex rupestris*;
4. snowbed with *Salix Polaris*;
5. snowbed with *Salix polaris* and mosses;
6. pioneer vegetation with *Saxifraga oppositifolia*;
7. moss vegetation;
8. cryptogamic crust of Cyanobacteria;
9. barren soil.

While we carried out extended measurements in the first six plots, spot measurements were also carried out on barren soils (with vegetation cover < 5%), on patches with only moss vegetation and on the cryptogrammic crust of Cyanobacteria.
At the Strandvatnet transect site, we selected the same vegetation types already analyzed at the CCT site, in order to obtain comparable data on the spatial variation of CO_2 fluxes in relation to vegetation and active layer. As the Strandvatnet transect site is characterized by a topographic and edaphic gradient, here we selected two subsites along the transect investigated for the estimation of the spatial variability of the active layer thickness and the permafrost distribution: one located at a higher topographic position (and therefore more exposed and dry) and another located at a lower topographic position and characterized (less exposed and wetter).

At the Strandvatnet transect site we selected the following vegetation types for the analyses of the CO_2 fluxes:

1. shrubland with *Dryas octopetala* (2 subsites: high and low);
2. pioneer vegetation with *Saxifraga oppositifolia* (2 subsites: high and low);
3. snowbed with *Salix polaris* (2 subsites: high and low);
4. shrubland with *Cassiope tetragona* (only at the higher subsite);
5. grassland with *Carex rupestris* (only at the higher subsite);
6. wetland with mosses (only at the lower site).

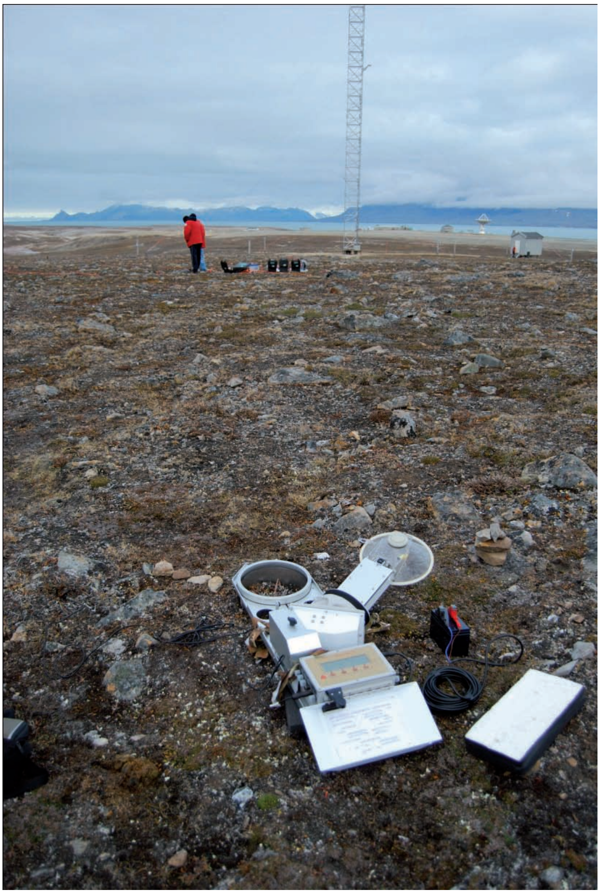

Figure 4 CO_2 fluxes measurements in one of the 6 plots selected within the CALM grid and close to CCT tower. On the background the ERT instrumentation, the CCT tower and the Ny-Ålesund airstrip

The preliminary results show that both sites are characterized by a spatial variability of CO_2 fluxes in relation to vegetation types. As an example, during one day at the CCT site it is possible to observe that NEE is negative (resulting in a net CO_2 uptake from the atmosphere) only for the *Dryas octopetala* vegetation, while all the other vegetation types show positive NEE (resulting in a CO_2 release from the ecosystem to the atmosphere), due to the fact that respiration exceeds photosynthesis (Fig. 5).

One potential reason for the positive NEE measured could be the phenological phase of almost all investigated vegetation types. Indeed, it was notable and advanced senescence of leaves and of all the aboveground biomass for most species, as we performed our measurements at the end of the growing season.
In any case, these results are useful to define significant differences of CO_2 fluxes among different vegetation types and provide a basis for future investigations on these topics.

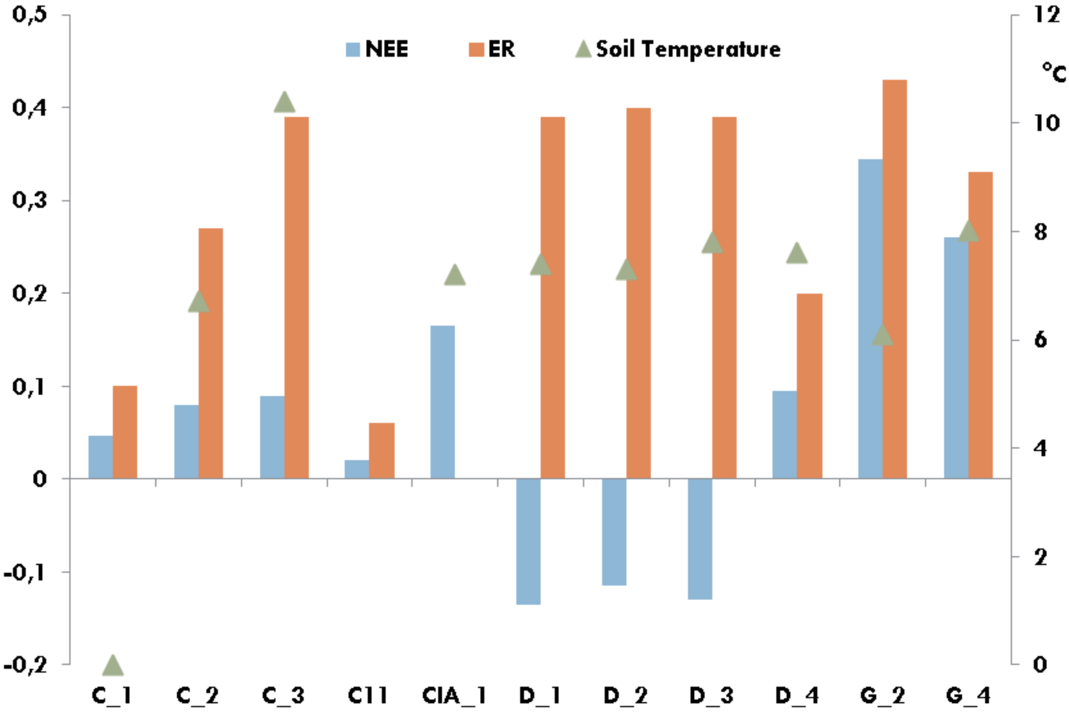

Figure 5 Example of the spatial variation of CO_2 fluxes in relation to different vegetation types measured in one date at the CCT site. Legend: NEE = Net Ecosystem Exchange; ER = Ecosystem Respiration; C (1, 2, 3, 11) = Cassiope tetragona vegetation; CIA = cryptogamic crust with Cyanobacteria; D (1, 2, 3, 4) = Dryas octopetala vegetation; G (1, 2, 3, 4) = graminoid barren dominated by Carex rupestris

ECOSYSTEMS: MICROBIAL COMMUNITIES

Structure and function of microbial communities in challenging, polar terrestrial habitats: a pan-Arctic survey

This study was built on a large amount of data collected from 2002 to 2011 in various localities of Svalbard, mainly around Ny-Ålesund, and intended to extend the investigations to other Arctic regions mainly by accessing Arctic research station through the EC Transnational Access Program INTERACT.

Research group

CNR ISE - Institute of Ecosystem Study (Florence, Italy)
Stefano VENTURA

Image on previous page: example of a cyanobacterial population growing immediately under the surface of a calcareous rock. Ossian Sarsfjellet, Kongsfjorden, Spitsbergen, Svalbard. Red/white bars 1 cm.

Introduction

After several years of research on terrestrial microbial ecology performed in Svalbard, an international group of microbiologists and cyanobacteriologists decided to launch a study of microbial terrestrial communities around the Arctic with the goal to explore the effects of climate change on Arctic extreme environments. The study has been built on a large amount of data collected in the period 2002 – 2011 in various localities of Svalbard, mainly around Ny-Ålesund, and intended to extend the investigations to other Arctic regions mainly by accessing Arctic research station through the EC Transnational Access Program INTERACT.
The whole project addresses the study of selected microbial communities of diverse extreme habitats in the terrestrial Arctic, in the process of adaptation to climate warming mediated by water regime.
In areas of the polar terrestrial ecosystem where harsh climate conditions impair plant growth, Biological Soil Crusts (BSC) and epilithic colonizations (or lithobiota) represent the stable vegetation coverages. These vegetation coverages are dominated by cyanobacteria and fungi, especially in habitats where environmental parameters like UV irradiance, temperature, water regime, and nutrient availability approximate the extremes for life.

In opposite conditions with regard to water availability, stand the spring and seepage communities which face other stressful conditions, the fluctuating water availability in seepages, and local constrains like radioactivity or homoeothermy for springs.
The research is carried on by a European team, encompassing members from Italy, Austria, and Czech Republic, giving a contribution to the establishment of strong collaborative links at a European level. All the three countries are deeply involved in ecological research on extreme environments, encompassing polar regions, as also demonstrated by the substantial participation of the team members to the the activities of the recent EU Coordinated Action CAREX on life in extreme environments.
The team members have previous experience of research on polar themes, also carried out together in Svalbard. The actual work has already started in Svalbard, and team members have recently operated in Ny-Ålesund, Bockfjorden, and Petunia Bukta. The plan is to visit stations in Greenland, the American Arctic, Siberia, and alpine Sweden, covering the entire Arctic region during the next few years. The research results will be also potentially useful nationally to approach the conservation and rehabilitation of alpine and arid areas that are present in the three countries.

Research background

Research on BSC has developed greatly in the last two decades thanks to the contribution of US scientists (J. Belnap and others), who concentrated on drylands and hot and cold deserts. The composition, structure, hydrology of BSC and their response to climate, mainly to rain precipitations, have been examined in details in the studied crust systems. Another substantial contribution to these systems has been given by R. De Philippis, a member of this research team, and co-workers who approached the study of the role of exopolysaccharides (EPS) in structuring the crusts and determining their hydrodynamics.

They also worked on artificial soil crusts intended to stabilize arid areas, to block the desertification and to rehabilitate land for agricultural practices. A limited number of studies has dealt with BSC in polar environments while much more attention has been given to microbial mats growing underwater near the shores of lakes and ponds in Antarctica and to a less extent, in the Arctic. BSC and epilithic developments on iron rich mineral substrates have been characterized on the front moraine of a glacier in Svalbard by S. Ventura, the team leader, and co-workers, investigating the biodiversity of the community and the nutritional interactions mediated by iron release.

As regards the polar regions, epi- and endo- lithic fungi have been extensively studied in the Antarctic Dry Valleys, and only recently their study has been started in Svalbard, Ny-Ålesund area, by K.Sterflinger, another member of the team, who, at home, is primarily involved in the study of lithobiota of the stone cultural heritage.
Seepages have been characterised in marine Antarctica and, to a lesser extent in Svalbard, mainly by a Czech research group which includes the team member O. Komarek. More generally, Antarctic freshwater cyanobacterial communities have been the most extensively studied, in particular mats and planktic communities.

The research, which is based on previous detailed studies recently performed by the proponent team and others in Svalbard, is meant as a step toward a complete characterisation of BSC, lithobiota and spring / seepages cyanobacterial communities all over the Arctic. It would evaluate the adaptation and distribution of microbial biodiversity in the different local conditions of the Arctic region. It is planned that the complete research will cover the entire Arctic region, through visiting several Stations.

Figure 1 Thin Bacterial Soil Crust developing on sandy substrate. The crust was mainly constituted by phototrophic microorganisms. Inner Kongsfjorden, Spitsbergen, Svalbard

Objectives of the study

Bacterial Soil Crusts. In the polar ecosystem, BSC undergo long and delicate succession processes that, through the establishment of complex topological and functional relationships among the mineral and the biological components of these systems, will finally lead to the stabilization of the mineral substrate and to a possible development of soil with an increase of fertility and resilience against erosion. In these times of rapid climate warming, BSC are exposed to severe environmental constrains but, at the same time, large areas where the vegetation coverage is absent or impaired

are continuously made available to primary colonization by BSC, thus increasing the role of these systems at a global scale in the stabilization of fragile polar habitats.
We hypothesise that common patterns of development of BSC exist through the Arctic and in more general terms in all environments where these structures dominate; these patterns would be controlled to a large extent by water regime and less by temperature. To verify this hypothesis, the research team investigates the macro and micro structure, the EPS content and the related hydrodynamic properties, and the community composition of BSC in the initial stages of development. BSC in the region around the Arctic Station are under comparison with corresponding BSC developing in Kongsfjorden (Ny-Ålesund area), Svalbard, with the objective to identify commonalities and differences in their structure, function and biodiversity.

Figure 2 Rock wall under water flow. The wet rock surface was covered by a thick phototrophic mat coloured in green, orange and red. The black stripes in the less wet upper part were unicellular cyanobacterial populations which produced high amounts of UV protecting black pigments. Plateau behind Arctic Station, Qeqertarsuaq, Disko Island, Greenland

Epilithic and Endolithic Microbial Communities. Since the pioneering discoveries of Imre Friedmann, exposed rocks have been recognised as the habitat of specialised microbial communities able to survive extreme climate conditions. These communities, that always include cyanobacterial and fungal populations, are able to withstand long periods of dryness, and in the polar regions, also of total darkness and freezing. The short periods of vegetative activity depend from water availability, thus the climate warming, changing the water regime, could exert a strong impact on them.

We hypothesise that water represents the key factor controlling the development of those communities and that a restricted number of well adapted fungal and cyanobacterial species are diffused all over the Arctic; the populations dominating each exposed rock surface would be selected by the relative degree of water and/or humidity, the lithotype and the exposure.

The research objective are the identification and characterisation of the dominating members of fungal and cyanobacterial populations colonising exposed rock surfaces in different microclimatic conditions in the regions visited during the study, as a contribution to cataloguing the rock microbial communities of the Arctic. A comparison with the rock microbial community recently investigated in the Ny-Ålesund area will be readily possible.

Cyanobacterial communities of springs and seepages. Microalgal communities with dominant cyanobacteria develop in meltwater seepages in deglaciated areas of the maritime Antarctica during the Antarctic summer season; these communities show a characteristic succession, vertical structure and species composition, and represent a unique biocoenosis important in terrestrial successional processes. The communities appear to be endemic to coastal Antarctic regions in terms of species composition, distinctive mat structure and seasonality. Far less detailed studies have been performed up to now on corresponding habitats in the Arctic, and indeed they mainly consisted of lists of retrieved cyanobacterial species and genera, uniquely based on the old morphological system which postulated that the distribution of the majority of cyanobacterial species be cosmopolitan.
We hypothesise that cyanobacterial communities of springs and seepages in the Arctic are less isolated than the corresponding communities in the maritime Antarctica, but still represent specialised communities whose members are largely autoctonous and in part related to northern Scandinavian populations. The research objectives will be the determination of the members of the cyanobacterial community and their comparison with a recent study performed in Petunia Bukta, Svalbard, to evaluate cyanobacterial diversity at the intra-Arctic level. Comparison with Antarctic cyanobacterial populations will be also performed.
Homoeothermic springs in the area around the Arctic Station will be also investigated and their cyanobacterial community compared with data available but not yet published on the homoeothermic spring system of Bockfjorden, Svalbard.

Methods of the study

The methodological approach included the collection and stabilisation of samples to be further analysed at home. BSC samples, with and without the extraction of the EPS matrix, were fixed and embedded in resin ex situ to preserve and later study their micro-structure. EPS were extracted from BSC and characterised at home. The hydraulic conductivity of the BSC has been measured. Microfungi and cyanobacteria will be isolated, identified, and characterised from collected samples, also with the application of an extensive metagenomic approach.
Most of research material consisted of small environmental samples collected during each day in the field and immediately stabilised once back to the Station's laboratories. Samples were fixed for DNA analysis, microscopic observation, and preserved in living conditions for subsequent isolation of fungal and cyanobacterial strains. Disposables, reagents and small instruments were shipped by freight; this represented one of the major logistics steps in the organization of the single expeditions.

State of the project

In the period 2002 – 2011, several study trips have been performed in different localities of Svalbard, with the support of CNR and of the European Science Foundation.
Many other samples from Svalbard and other locations in the Arctic were received from colleagues, mainly from Matthias Zielke, Bioforsk, Norway.
During summer 2012 the first INTERACT trip of the team took place to Arctic Station, Disko Island, Greenland.
In summer 2013 another INTERACT sponsored trip to visit Zackenberg research station in East Greenland is foreseen.
Analysis of collected samples takes presently place in the laboratories of the team members.

Figure 4 Laminar macrocolony of Nostoc cf. commune developing on mosses. Tundra near Arctic Station, Qeqertarsuaq, Disko Island, Greenland. Black/white bars 1 cm

Research activities performed during the 2012 INTERACT trip to Arctic Station, Greenland

Given the reduction of the requested funding and consequently of the duration of the stay, much of the planned laboratory activities could not been performed. Instead, we concentrated all efforts in collecting the largest possible number of different samples to be analysed once back home.

A difficulty that had been underestimated was the distance from the Arctic Station of the places which we wanted to visit. In two days of very intensive hiking and by the use of a fast boat, we were actually able to reach most of the planned places and collect a variety of samples. Also around the Station we could carry out an intensive sampling of BSC and especially of homoeothermic springs. The environment of the region around the Arctic Station very well complemented our pan-Arctic study plan, representing a relatively southern and much vegetated area in comparison with Svalbard. We had thus the opportunity to sample BSC colonizing special spots that for some reasons were subtracted from a generalized plant coverage.

The lack of an updated and detailed map of the region represented a difficulty for trip planning, especially when we wanted to get to the glacier front that had actually been retreated a long way in respect to what reported on the available map.

We are confident that the analysis of the numerous samples we collected, currently under way in our laboratories, could give excellent results.

Expected scientific and societal impact of the research

A deeper knowledge of polar BSC structure and performances, epilithic colonisations, and spring communities could possibly lead to the identification of types of fungal and cyanobacterial species, and BSC structures unique to the Arctic. The phylogenetic and taxonomic study of cyanobacterial and fungal strains will contribute to clarify the issue regarding the controversial existence of autoctonous and/or cosmopolitan taxa; in this respect, the comparison with related Antarctic species will be essential, also to quantify more precisely the degree of isolation of the Arctic ecosystem. At least for cyanobacteria, the description of new taxa from extreme habitats will contribute to check the hypothesis on the evolution of sister cyanobacterial genera driven by adaptation to extreme life conditions, recently formulated by S.Ventura and co-workers (Sili et al., 2011).

The results are also expected to be useful to better understand the role of homologous structures in the temperate European region, how these structures could be protected, how they could contribute services for the rehabilitation of low buffered fragile habitats in alpine and arid regions, promoting and preserving a dynamic ecosystem equilibrium under rapidly changing conditions. Once the functional constrains and dynamics of BSC in all environments where they dominate will be known, artificial BSC could be developed and used as environmental tools to block desertification, restore marginal land, and favour soil development by increasing fertility and resilience against erosion.

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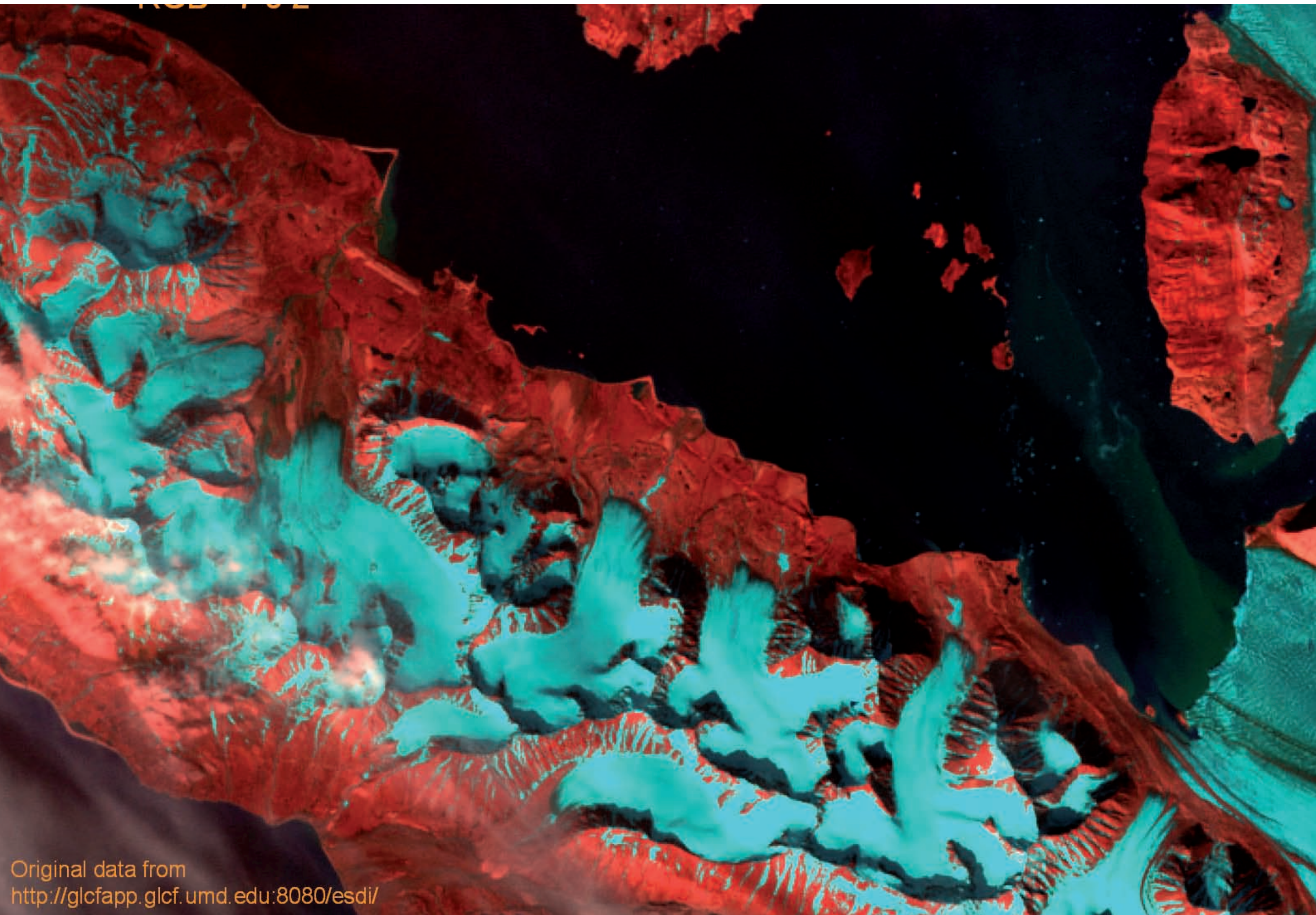

A structural geologic survey in western Svalbard

The Roma Tre University Team investigates on brittle deformations related to the transform/strike-slip geodynamics of the Arctic regions responsible for the formation of the Western Spitsbergen Fold and Trust belt. The work is done at the various scales from satellite images to the outcrop scale investigations and is aimed on the study of the upper crust deformation. Fieldwork is based on a series of station of brittle deformation measures. This multi-scalar integration allow the definition of a tectonic model for the western portion of the island and the kinematics of the regional faults.

Research group

Roma Tre University (Rome, Italy)
Francesco SALVINI, Paola CIANFARRA

Image on previous page: LANDSAT TM false colour image of Brøggerhalvøya.

Introduction

A large transform fault separates the North Atlantic and the Arctic Ocean and its movement is responsible for the evolution and deformation of the Svalbard Is. and Barents Sea. It runs from the NW coasts of Norway to Canada and the effects of its evolution ruled the development of geological environments favorable to the deposition and successive production of natural resource as coal and oil.

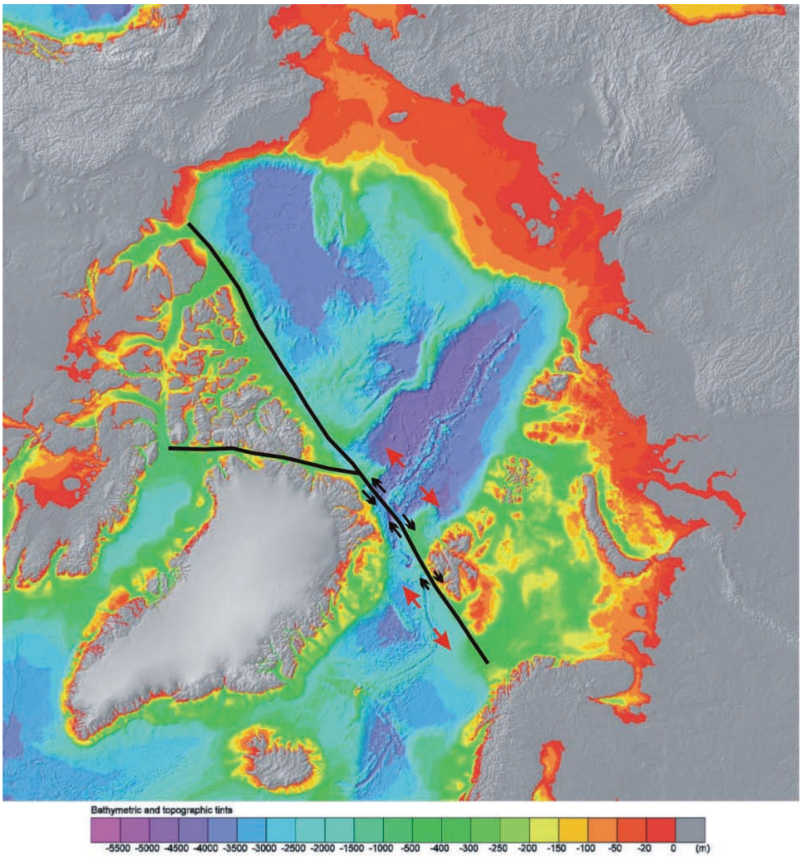

Figure 1 Bathymetry of the Arctic Ocean from IBCAO data (http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/currentmap.html) Black bold lines show the transform fault separting North Altlantic and Arctic Oceans. Arrows shows the relative movements between crustal blocks

The Roma Tre University Team investigates on the Neogene-Quaternary brittle deformations related to the transform/strike-slip geodynamics of the Arctic regions responsible for the formation of the Western Spitsbergen Fold and Trust belt. The work is done at the various scales from satellite images to the outcrop scale investigations and is aimed at studying the upper crust deformation that mainly consists on fractures and associated brittle deformation. Fieldwork is based on a series of station of brittle deformation measures. Station location is based on morphological evidence. This multi-scalar integration allow the definition of a consistent tectonic model for the western portion of the island to be compared for compatibility with the kinematics of the regional fault and the definition of an intraplate strike-slip fault.

The project includes:

i) field measurements of fracturing intensity across the main lineament domains and tectonic lineaments identified on synthetic scale images (satellite Landsat, ASTER images and digital elevation models, DEMs). In fact, those lineaments have been recognized to rule the recent evolution of the landscape (i.e. ice and water drainage pattern, enhanced erosion etching on the pathways created by tectonics);

ii) identification of recent/active faults cutting the Quaternary glacio-marine deposits in order to evaluate the tectonic contribution to the post glacial isostatic uplift.

Field work

In the period August, 22nd – September, 8th a geological field campaign was carried out, including structural geology measurements and landscape morphological analysis of the Permo-Carboniferous carbonate and clastic sequences. This campaign completed and integrated the previous reconnaissance campaign of 2003 and 2004 (for a total of 16 days) and integrated the preliminary results of the 2010 campaigns (for a total of 23 days). Studied outcrops located in the Broggerbreen, in Blomstrandhalvoya Is., Loven Is., Capp Mitra and Cross Fjord region. Field activity included reconnaissance survey with colleagues led by Prof. Arun Kumar from Earth Science Dept. of Manipur University, India in order to evaluate the geotectonic stability of a GPS monument. Measurements stations located nearby Ny-Ålesund where reached by walking, while distant stations were reached thanks to the NP facilities (boat).
A total of 13 field surveys were performed with the selection of 36 stations for the measurement of brittle deformations for a total of 1051 structural data including faults, extensional fractures, shear cleavage as well as morphological alignments in the Quaternary glacial and glacio-marine deposits. Those morphological alignments are also evident in satellite images (Landsat, ASTER) and DEM (ASTERGDERM and SRTM).
Results from the analysis of the collected structural data showed that the most recent tectonic event relates to an N-S oriented, strike-slip faulting. The brittle crustal deformation associated to this tectonic event together with the glacial activity is the key factors ruling the present-day geomorphic evolution of the landscape.
This last strike slip tectonic event dissects the Mesozoic compression fault system related to the building of the West Spitsbergen Thrust and Fold Belt. Strike slip faults cutting the Quaternary moraines were newly discovered together with their brittle deformation associated.

An increasing fracturing intensity has been observed near automatically identified lineaments from synthetic scale images. This increasing deformation is consistent with the theory on the origin of the lineament domains considered as the surface expression of crustal weaknesses related to the recent/active stress field.
An intense fracturing of the outcropping rocks has been measured near the VLBI geodetic antenna (Ny-Ålesund airport) and the other sites of geodetic measurements performed in 2001 by Vittuari and others around Ny-Ålesund. These analyses have been used to tune an ad hoc methodology used to evaluate the geotectonic stability of geodetic monuments. This methodology will be used also in the next Antarctic campaign (XXVIII).
A scientific paper on the obtained results is in preparation.
Facilities available at the Arctic Station 'Dirigibile Italia' were fully satisfactory. The boat provided by NP was particularly useful for the transfer to the measurement sites as well as for the reconnaissance surveys. The availability of an helicopter to reach the furthest sites would have improved the results of the campaign.

Future Activities

- Publication and presentation at meetings of the obtained results.
- Starting collaboration with the Geodesy group of Manipur University, India for the integration of structural geologic and geodetic data.
- Continuation of the study of the active/recent character of the N-S, strike-slip faults ruling the Neogene-Quaternary geologic evolution of the western margin of Spitsbergen.
- Framing of the studied faults in a Cenozoic tectonic evolutionary model of the Arctic region defining the role of the transform/strike-slip faults in the geodynamic setting specifically in the region between Greenland and Lomonosov Ridge/Arctic Ocean.
- Interpretation of geodetic data in the light of the recent tectonic evolution of Spitsbergen Is. (e.g. relative movements along active faults, vertical movements).
- Study of the Bockfjorden Quaternary Volcanoes through a dedicated summer campaign.

Figure 2 Thrust fault cutting Middle Carboniferous-Late Permian limestones in the Broggerhalvoya with its associated fracturing

OCEAN SCIENCE

Oceanographic measurements in Kongsfjorden and Svalbard margin

Aim of the project is to collect time-series of oceanographic measurements at sea glacier interfaces in Kongsfjorden and on the continental margin of Svalbard.

Research group

CNR ISMAR - Institute of marine Science (La Spezia, Italy)
Stefano ALIANI, Mireno BORGHINI

CNR ISMAR - Institute of marine Science (Bologna, Italy)
Federico GIGLIO, Ilaria CONESE, Fabrizio DEL BIANCO, Luca GASPERINI, Leonardo LANGONE, Stefano MISEROCCHI

Image on previous image: The sea-glacier interface of Blomstrandbreen Glacier. On the right a small beach is visible after ice retreat (2010); here the glacier doesn't touch the sea any more. Small melting ice fragments on the sea surface affect surface salinity of the ocean.

Rationale

The Arctic Ocean is the northern hemisphere heat sink for our planet and is experiencing drastic and fast changes in recent years, but we do not know whether these represent temporary perturbations, long-term trends, or new equilibria. Two aspects of the interaction between the Arctic Ocean and global climate that has been stressed as very important for global climate are: sea ice and surface heat and mass budgets. Mass and heat balance in the Arctic is the part that has more gaps in knowledge and many points of mass balance of fresh water in the Arctic still have to be addressed to full understand relationships with climate. One point that has only recently addressed, and up to now only in the Greenland sea (Straneo et al., 2010), is the estimation of submarine melting of tidewater glaciers. Indirect measurements have been done using ice flow and ice thickness (Holland et al., 2008; Motyka et al., 2010) and direct measurements of temperature and currents are logistically challenging. Furthermore, glaciers melting affects sedimentation processes and biogeochemical cycles. Sediments cores can document the record of similar melting processes that took place in the recent past.

Sea Glacier Interface in Kongsfjorden

In the inner part of Kongsfjorden, many glaciers reach the sea and the shape of the glacier front is an almost vertical walls of ice above seawater. Kongsfjorden also has the peculiar feature that under some conditions, veins of warm (about 5°C) and salt (up to 35) water from the West Spitzbergen Current (WSC) intrude into the fiord and touch the glaciers' front in a relatively ice-free sea environment (Aliani et al., 2004). This makes a unique opportunity to study the ocean-glacier interface.

Morphology of inner Kongsfjorden seabed

A shallow moraine, whose emerging shoals are the islets of Lovenoyane, separates the fiord itself from the very inner part, where there are sea glaciers. A shallow passage about 40 m deep and 4 km large connect them in the southern part. The northern passage is trough a narrow and shallow channel north of Lovenoyane and a recently ice free channel between Blomstrand island and Blomstrandbreen Glacier. Accurate seabed morphology data was compulsory information to deploy instruments for time-series and to plan any seagoing activity, but it was missing for the inner part. A seismic survey was performed in all the Kongsfjorden, also including the inner part that has recently become accessible after rapid glacier retreating. Over 130 nautical miles of Chirp sub-bottom profiles (4kW Benthos DSP-662 Chirp III with 4 towed transducers) were acquired. The morpho-bathymetric features and surficial seismo-stratigraphy has been described and a map was produced (Figure 1). A widespread outcrop of bedrock dominates the bottom of the fiord. Several morphological structures were detected, mainly related to relict sub-glacial and ice scoured topography produced during the glacial re-advances of the Weichselian (20 ky BP) and again during the last major Holocene re-advance of the Little Ice Age.

These features are several tens meter high above the sea bottom level, and in the south-eastern part also emerges as the small Lovenoyane islands separating the inner fiord into two parts. The area in the inner part of the fiord, close to the calving line, is characterized by higher sediment accumulation rates, and a thin (>10m) layer of coarse-grained sediment thickness, probably due to the interaction of the 3 proximal ice-tongues, was observed. Ground truth of acoustic data was by short sediment cores collected all over the fiord.

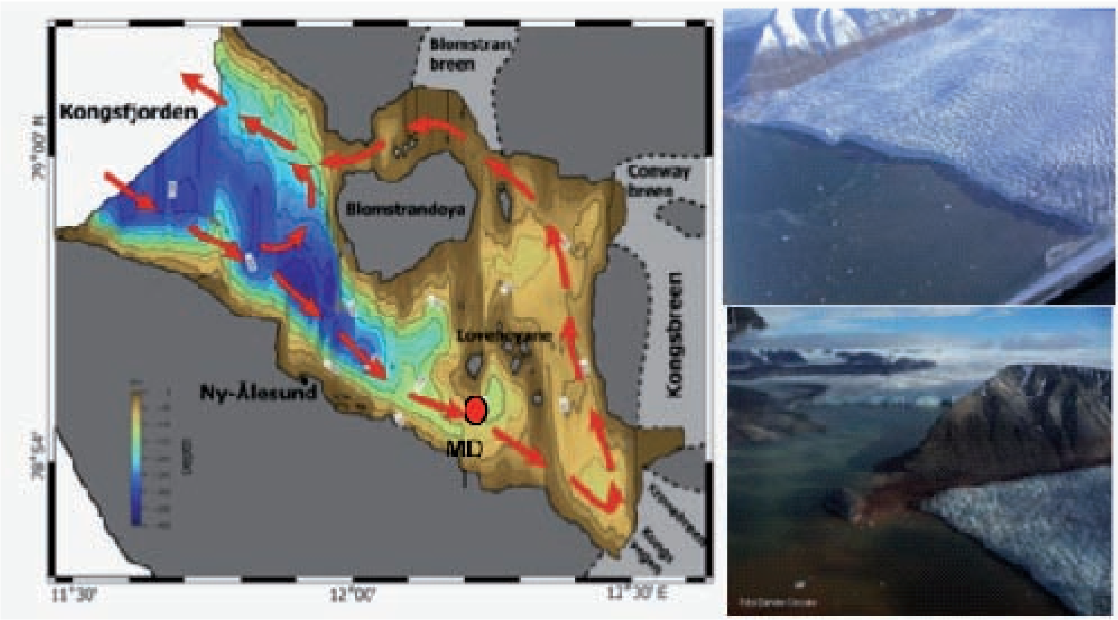

Figure 1 Bathymetric map of Kongsfiorden with direction of general current in summer, superimposed as red arrows. Red dot shows position of Dirigibile Italia Mooring (MDI)

Mooring Dirigibile Italia

The best site to deploy long-term data collection equipment for permanent mooring has been selected after bathymetric survey at GPS position 78° 54.862N 12° 14.733E. The site was a compromise between proprieties of the water passing across strait, bottom depth and measurable sedimentation rates. Mooring Dirigibile Italia (MDI_2010) has been deployed in September 2010 and serviced and deployed again in September 2011 (MDI_2011) and September 2012 (MDI_2012). A sketch of the mooring also reporting deployed instrument is reported in Figure 2.

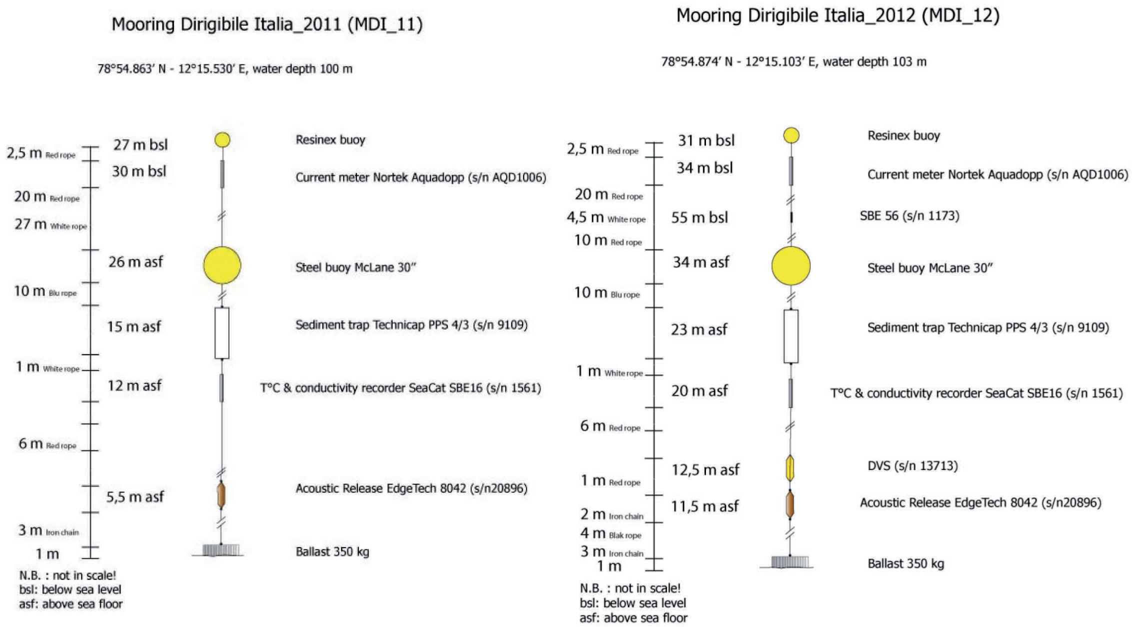

Figure 2 Sketch of mooring Dirigibile Italia as it was in 2011 and 2012. Temperature and conductivity recorders, current meters and sediment trap are depicted

Time-series were continuously collected for three years now: oceanographic data are stored in ISMAR SP data center in SeaDataNet standard, CHIRP data are stored on ISMAR Bologna servers, trap samples and cores has been partly processed and properly stored at ISMAR Bologna sample collection.

Both oceanographic data set and particle fluxes had a seasonal pattern: during the first collection year, seawater temperature at near-bottom ranged from freezing point in winter to 3°C and salinity ranged from 34.2 in early winter to 34.7 in early spring. Water currents were modulated by tide and on average net current direction was 170°N entering the inner fiord across Lovenoyane's southern passage (Figure 3).

Particle fluxes were low through the first 10 months, while in July and August increased up to 72 g m^{-2} d^{-1}. Due to the low organic content , the origin of these flux peaks is related to the increased runoff and/or sub-glacial meltwater during the summer season. On the other hand, during May and June, both higher OC content and less negative values of $\delta^{13}C$ prove a higher proportion of vertical rain of particles by marine origin.

Hydrology

Up to 50 SBE19 CTD casts per year were performed in September 2010 and 2011 and improve our hydrological data set from September 2001 and 2003 campaigns.

Summer circulation through the shallow passage is controlled by wind and tides. Warm water (about 5°C) enters the passage at about 25 depth. Along glaciers fronts temperature decrease to about 2°C and exit through the passage north of both Lovenoyane and Blomstrand constrained by topography.

In 2001, a very thin layer of fresh water was found in the northernmost part of inner fiord and the plot of temperature had a regular decreasing gradient along an almost continuous glacier front. In 2011, glaciers retreated and the plot of temperature did not show a similar gradient, but intrusions of veins of cold water at 20 m depth were recorded,. TS diagram also highlighted the presence of low salinity water masses that were not found in 2001.

Data transmission

Two acoustic modems successfully transmitted data from SBE recorder at sea to the Ny-Ålesund Marine Lab. CTD casts evidenced strong stratification in properties of water column, which created problems in acoustic links due to sound transmission properties. The Tritech system we used was able to successfully transmit data underwater using its auto setting properties to minimize errors. Data were sent to Marine Lab trough a cable. If data connection was successful, bringing data out of the water has some critical points and building infrastructures are required to create a real time connection to permanent deployments underwater that can survive wintertime marine surface icing. Alternatively VHF connection is a possibility to be explored after proper authorisation to use of radio frequency in Ny-Ålesund.

Principal National/International Projects of Reference

- **Nysmac** (Ny-Ålesund Scientific Management)**:** http://nysmac.npolar.no.

It is a project to enhance cooperation and coordination amongst research activities at the Ny-Ålesund International Arctic Research and Monitoring Facility.

- **ASOF** (Arctic SubArctic Ocean Fluxes) Meetings: **http://asof.npolar.no** P.I. - Dr. S. Aliani.

ASOF is an international program on the oceanography of the Arctic and Subarctic seas and their role in climate. ASOF focuses on ocean fluxes of mass, heat, freshwater, and ice in the Arctic and subarctic oceans.

- **SIOS Initiative** (Italian Database Infrastructure for Polar Observation Sciences)

http://www.sios-svalbard.org P.I. - Dr. S. Aliani.
Svalbard Integrated Earth Observing System (SIOS) is an international infrastructure project. There are 28 partners from Europe and Asia involved.

- **PAME** (Protecting Arctic Marine Environment). P.I.- Dr. S. Aliani.

It is a working group of Arctic Council dedicated to Arctic Ocean.

- **Hermione** (http://www.eu-hermione.net), is an FP7 project.

The project ran from April 2009 to September 2012, and was made up of a consortium of 41 partners - research organizations, universities and small organizations - from 13 countries across Europe.

Objectives accomplished

The following objectives have been reached:

- mapping the Kongsfjorden seabed morphologies;
- deployment of long term oceanographic data acquisition system (mooring Dirigibile Italia);
- sediment cores and timeseries of sediment trap samples;
- description of hydrological properties by CTD casts;
- testing of low-cost low-power acoustic modems for underwater real-time data transmission;
- raw and processed data in Sea-DataNet format stored in ISMAR SP servers, sediment samples at ISMAR BO repository.

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LOGISTICS

Support to scientific programmes

The italian Station “Dirigibile Italia” in Ny-Ålesund-Svalbard, is the main infrastructure managed by the National Research Council to support research programmes in the Arctic region.

Logistic work has involved the following people:

CNR DTA - Dept. of Earth System Science and Environmental Technologies (Rome, Italy)
Roberto SPARAPANI, Emiliano LIBERATORI, Luigi MAZARI VILLANOVA

CNR ISAC - Institute of Atmospheric Sciences and Climate (Rome, Italy)
Maurizio BUSETTO, Alessandro CONIDI

CNR UIEC - ICT Office (Rome, Italy)
Vittorio TULLI, Fabio PALMIERI

University of Florence, Dept. of Chemistry (Firenze, Italy)
Giulia CALZOLAI, Francesco RUGI

Image on previous image: CNR Arctic Station “Dirigibile Italia”(photo by Emiliano Liberatori)

When we deal with research in remote environments, such as the Arctic and the Svalbard Islands, we must take into consideration the huge amount of logistic work required, that is the management of all the infrastructures that CNR has made available to the scientific communities and the support to research groups to access Ny-Ålesund and to carry out field experiments.
The facilities managed by the CNR in the area of Ny-Ålesund include the Research "Station Dirigibile Italia" (SDI), an infrastructure of 323 sq.m., with 170 sq.m. for laboratories and offices and room to host 7 people.
Since 2009 CNR has a new facility called the Amundsen-Nobile Climate Change Tower (CCT), a 34 m high infrastructure made of 17 modules (floors) able to host scientific instrumentation, with internet connection and real-time access to scientific data.
The Gruvebadet Atmospheric Laboratory is another facility managed by CNR including a winter room and a summer room/guest room, for a total of about 90 sq.m., and a new area for hosting instrumentation for collaborations.
CNR also has 50 sq.m. of space in the Storage room at Ny-Ålesund and access to the Kings Bay Marine Laboratory, with 19% of partnership in the Marine Consortium managing this facility for marine biology studies.
These facilities are accessible all year round and transportation and logistic support to activities related to these infrastructures are provided by the CNR logistic staff, with snowmobiles, bicycles, car and safety and scientific equipment.

Figure 1 The Amundsen-Nobile CCT

This requires continuous support activities to the research teams using such infrastructures as well as renovation and updating of offices, laboratories and other logistic material necessary to support the activities, including important means of transportation such as boats, rubber boats, snowscooters, cars and bicycles. Logistics in the Arctic also includes the shipment of scientific and logistic material from Italy to Svalbard and back, and the purchase, renting and transportation of vehicles and other equipment in Norway and Svalbard.

Another important issue, especially when research is carried out in the Arctic is safety. All scientists and logistic staff must be trained with shooting classes in using rifles, flares and other safety procedures, and must learn how to drive a snowscooter and a car in the snow, learn how to use safety equipment on boat, and know how to react to many situations and emergencies which may occur in a dangerous environment as the Arctic, isolated and populated by polar bears.

During the years 2011 and 2012 many logistic actions were carried out to support all the Italian projects in Ny-Ålesund and to improve the functionality of the CNR infrastructures:

- Logistic support on boat for project “Sensor network for oceanography in shallow water - Kongsfjord experiment (SNOW)”, Deployment of the Mooring in the Kongsfjord and sampling with Niskin bottle.
- Logistic support to the “Climate Change Tower Integrated Project (CCT-IP)”, annual test of the Tower and reinforcement of Tower foundations.
- Support to Italian tv team for the shooting of documentary on Arctic research.
- Logistic support to the winter launches of stratospheric balloons in January 2011 and 2012, for the project “Polar Observation Platform (POP)”.
- Logistic support to the deployment, storing, transportation and launches of tethered balloons for aerosol profiles in the ABL in the context of the PRIN Project.
- Supply of helium bottles for both balloon projects, in collaboration with AWIPEV stations in Ny-Ålesund.
- Logistic support in remote areas for the project: “Arctic Sea Ice and HAlogen Deposition: investigation for a new paleoclimatic tool”, with shallow icecoring in the Arctic.”
- Support on boat to the project: “Ice and rock deformations along intraplate strike-slip faults at Svalbard Islands and their role in microclimate changes”, with geology research in islands close to Ny-Ålesund.
- Support to project “Climate change impacts on the sensitive system permafrost-vegetation: spatial variability of active layer thickness, vegetation and CO_2 fluxes”.
- Renovation works at the Gruvebadet Laboratory: insulation and assembling of winter laboratory, and new roof for building. Placing of cabin for atmospheric measurements near the Gruvebadet laboratory and cabling to the main building. Transportation and support to research teams to Gruvebadet.

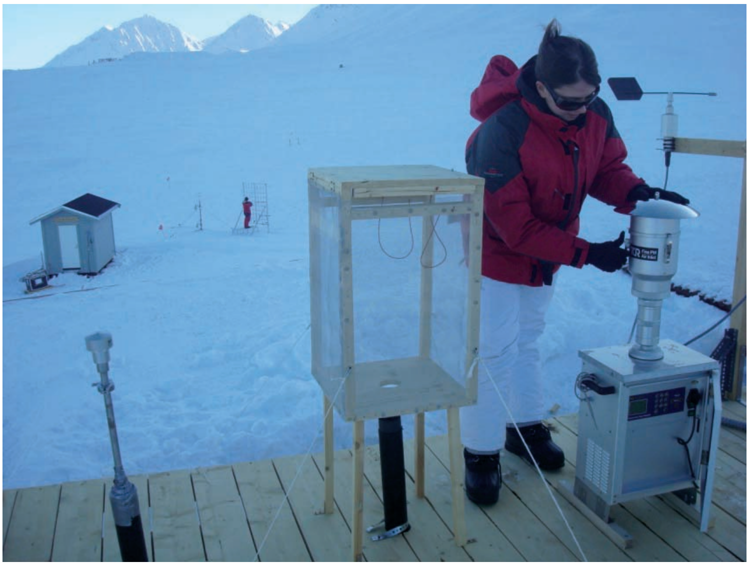

Figure 2 Installing instruments on top of the Gruvebadet laboratory

IT (Information Technology) technical support for new cabling of the Italian Station and reorganization of IP addresses, installation of teleconference system and new computers.
Use of new electric bicycle for transportation and other logistic needs.
Partial reorganization of offices, laboratories and living areas at the Italian Station Dirigibile Italia.

OUTREACH AND EDUCATION

Promotional activities and diffusion

The CNR Department of Earth System Science and Environmental Technologies (DTA) is engaged in promotional activities and outreach initiatives aiming at promoting science and knowledge, with particular focus on polar research.

Outreach and education activities are carried out by the following staff:

CNR DTA - Dept. of Earth System Science and Environmental Technologies (Rome, Italy)
Ruggero CASACCHIA, Tiziana CICIOTTI, Roberto SPARAPANI, Emiliano LIBERATORI, Paolo BRAICO, Luigi MAZARI VILLANOVA

CNR UIEC - ICT Office (Rome, Italy)
Vittorio TULLI

CNR ISMAR - Institute of Marine Sciences (La Spezia, Italy)
Stefano ALIANI

INGV - National Institute of Geophysics and Volcanology (Rome, Italy)
Giorgiana DE FRANCESCI, Lucilla ALFONSI, Vincenzo ROMANO, Luca SPOGLI

Image on previous image (courtesy of Gianluca Manzo): ESCA is the italian acronym of the project "Explore, Discover and Know the Arctic".

Outreach and education

CNR - Department of Earth System Science and Environmental Technologies

The CNR Department of Earth System Science and Environmental Technologies is active in outreach and education activities; in the light of the great interest for the research performed in the Arctic, the Department promotes the activities in these extreme environment in order to attract young generations to the issues and understanding of Climate Change, as well as to history and political economies of pivotal importance for the future of our planet.

Outreach and education activities of DTA are carried out by 5 units of technical and scientific personnel, occasionally assisted by other CNR staff from the IT Group and the Press Office.

During these years DTA took part in many events of major outreach impact, such as:

- The Week of Scientific and Technological Research carried out by the CNR Press Office in local institutes of Rome;
- The BIG-BLU event promoted and organized by MAR (Marine Research Association) with opening in the morning dedicated only to schools, where DTA had its stand to promote an exhibition on the life of Fridtjof Nansen, the well-known Norwegian explorer, scientist and peace ambassador (winner of the Nobel Peace Prize in 1922);
- The Week of Science organized by the Italian Ministry of Research (MIUR), in collaboration with the CNR Central Library, which allowed schools to visit the Library and participate to seminars on Fridtjof Nansen and the history of Arctic exploration;
- Presentation of the Project Explore, Discover and Know the Arctic in schools of different grades in Rome and nearby, which reached 25 schools and 800 students; the project was carried out in collaboration with the CNR Press Office;
- Collaboration with Expo-Med for the construction of the Aquarium of Rome: CNR was responsible for the polar basin and for the production of a video on CNR polar activities addressed to schools and shown at the International Expo in Yeosu (Korea) from 12 May to 12 August 2012;
- Development of an editorial project for an educational book on the North with illustrations and cartoons
- Continuation of collaboration with the National Antarctic Museum (MNA) for the development of outreach and education projects on scientific activities related to the Italian Antarctic Research Program (PNRA).
- Opening conference for the celebrations of Fridtjof Nansen's 150th birth anniversary, organized and sponsored by the Royal Norwegian Embassy.

The original exhibit, made of posters and Inuit art recovered by Nansen in Greenland in 1882, was initially shown at the Natural History Museum of Milan (14/10 – 27/11/2011), and then at the Regional Museum of Natural Sciences of Torino (13/01 – 15/03/2012) and finally at the Museum of L'Aquila (May 2012). The Royal Norwegian Embassy in collaboration with the CNR Department of Earth Science System and Environmental Technologies realized an integrated and more interactive version of the exhibition, finding a perfect location at the City of Science in Naples where it will be shown from February to May 2013.

The exhibition was divided in thematic areas. The original posters were integrated with interactive multimedia stressing the legacy of Nansen's work through the achievements of other great Arctic explorers (ex. Amundsen and Nobile), inspired by his scientific intuitions and oceanographic studies. Nansen's lesson is still visible today in the research projects that the CNR has been carrying out for 15 years in Ny-Ålesund, at the Svalbard Islands.

The CNR DTA has organized two events of great impact on the media. In April 2011 a troupe of Skytg 24 and Rai Tv visited the Station and broadcasted on-air programmes for their tv channels, which had great diffusion in Italy for many days.
In 2012 a whole episode of the tv programme Atlantide was dedicated by La7 Italian Channel to Svalbard and to the Italian Research Station. Many radio and tv analysis and interviews were also dedicated to specific scientific issues.

CNR ISMAR - Institute of Marine Science

Stefano Aliani acted as Lecturers in Italy in many outreach initiatives.
Stefano Aliani also performed three TV interviews for Italian television programs: RAI1-Telegiornale1 ore 20:30, RAI Scienza, Linea BLU. Sky TG24.

Several videos describing activities has been prepared and put on the web at:
http://www.youtube.com/watch?v=7u83sEv4l9Y
http://www.ismar.cnr.it/eventi-e-notizie/notizie/cnr-in-prima-linea-nella-ricerca-al-polo-nord
Stefano Aliani supervised Progetto"Ambiente Futuro", funded by Ministry for Youth's Policy and Province of La Spezia. Two undergraduated students (Irene Dorai and Eva Hysa) visited Ny-Ålesund Base and report their experience during the EV funded Researchers' night event of 2011 in Lerici.

INGV - National Institute of Geophysics and Volcanology

Lucilla Alfonsi, Vincenzo Romano, Luca Spogli acted as Lecturers at Politecnico di Torino, Italy, in the frame of the Master Course: Atmospheric Effects for Navigation and Remote Sensing, May 2012. The lectures addressed GNSS Data Analysis and modeling of the polar ionosphere.
The team is quite active in supporting the outreach initiatives addressed to the Polar Sciences and promoted by "Scienzaperta 2012", at Istituto Nazionale di Geofisica e Vulcanologia, Roma
http://istituto.ingv.it/l-ingv/divulgazione-scientifica/archivio-divulgazione-2012/scienzaperta-2012/view

List of acronyms and abbreviations

ABL	Atmospheric Boundary Layer
AMDE	Atmospheric Mercury Depletion Events
APS	Aerodynamic Particle Sizer
ASOF	Arctic Sub-Arctic Ocean Fluxes
BRG	Austre Brøggerbreen
BSC	Biological Soil Crusts
CCT	Climate Change Tower
CCT-IP	Climate Change Tower – Integrated Project
CFC	ChloroFluoroCarbons
CICCI	Coordinated Investigation of Climate-Cryosphere Interactions
CNR	National Research Council of Italy
D	Diffusivity
DB	Data Base
DTA	Department of Earth System Science and Environmental Technology
EC	Elemental Carbon
ENSO	El Niño-Southern Oscillation
EPS	ExoPolySaccharides
ER	Ecosystem Respiration
ERT	Electrical Resistivity Topographies
ESCA	Explore, Discover and Know the Arctic (educational project)
ESWua	Electronic Space Weather for the upper atmosphere
F	Fluxes
FM	Focused Moon
GBSC	Ground Based Scintillation Climatology
GEO	Group of Earth Observation
GISTM	GPS Ionospheric Scintillation and TEC Monitoring
GMOS	Global Mercury Observation System
GNSS	Global Navigation Satellite System
GOME	Global Ozone Monitoring Experiment
GRAPE	GNSS Research and Application for Polar Environment
HDF	Holthedalfonna
IDASC	Institute of Acoustics and Sensors “O.M. Corbino”
IDIPOS	Italian Database Infrastructure for Polar Observation Science
IDPA	Institute for the Dynamics of Environmental Processes
IIA	Institute of Atmospheric Pollution Research
INFN	National Institute of Nuclear Physics
INGV	National Institute for Geophysics and Volcanology
ISAC	Institute of Atmospheric Sciences and Climate

ISACCO	Ionospheric Scintillations Artic Campaign Coordinated Observations
ISE	Institute of Ecosystem Study
ISMAR	Institute of Marine Science
ISS	Institute of Health
ISTAR	The International Science Technology and Research
KNG	Kongsvegen
LDPE	Low-Density PolyEthylene
LED	Light-Emitting-Diodes
LGGE	Laboratoire de Glaciologie et Geophysique de l'Environment
LSPE	Large Scale Polarization Explorer
LZA	Lunar Zenith Angle
MAR	Marine Research Association
MDI	Mooring Dirigibile Italia
MIDAS	Multi Instrument Data Analysis System
MIUR	Italian Ministry of Research
MLB	Midtre Lovenbreen
MNA	National Antarctic Museum
MOST	Monin-Obukhov Similarity Theory
NDSI	Normalized Difference Snow Index
NEE	Net Ecosystem Exchange
NILU	Norwegian Institute for Atmospheric Physics
NIPR	Japanese Polar Research Institute
NOx	Nitrogen Oxides
NPI	Norwegian Polar Institute
NYA	Ny-Ålesund
NySMAC	Ny-Ålesund Scientific Management Commitee
OC	Organic Carbon
ODEs	Ozone Depletion Events
OMI	Ozone Measurement Instrument
PAME	Protecting Arctic Marine Environment
PCB	PolyChlorinated Biphenyls
PNRA	Italian Research Antarctic Program
POP	Polar Observation Platform
POP	Persistent Organic Pollutants
PSCs	Polar Stratospheric Clouds
QAARC	Quality Assurance of solar UV irradiance in the ARCtic
QBO	Quasi Biennial Oscillation
RGM	Reactive Gaseous Mercury
ROT	Rate Of Total electron content
SCAR	Scientific Committee Antarctic Research

SCIAMACHY	SCanning Imaging Absorption spectrometer for Atmosphere Cartography
SDI	Station Dirigibile Italia
SEM-EDS	Scanning Electron Microscopy-Energy Dispersive X-ray Spectroscopy
SIOS	Svalbard Integrated Observing System
SIOS Initiative	Italian Database Infrastructure for Polar Observation Sciences
SMPS	Scanning Mobility Particle Sizer
SNOW	Sensor Network for Oceanography in shallow Water
SSA	Single Scattering Albedo/Specific Surface Area
TEC	Total Electron Content
TOC	Total Organic Carbon/Total Ozone Column
TRANSMIT	Training Research and Applications Network to Support the Mitigations of Ionospheric Threats
UIEC	Information Communication and Technology Office
UV	UltraViolet
WSC	West Spitzbergen Current