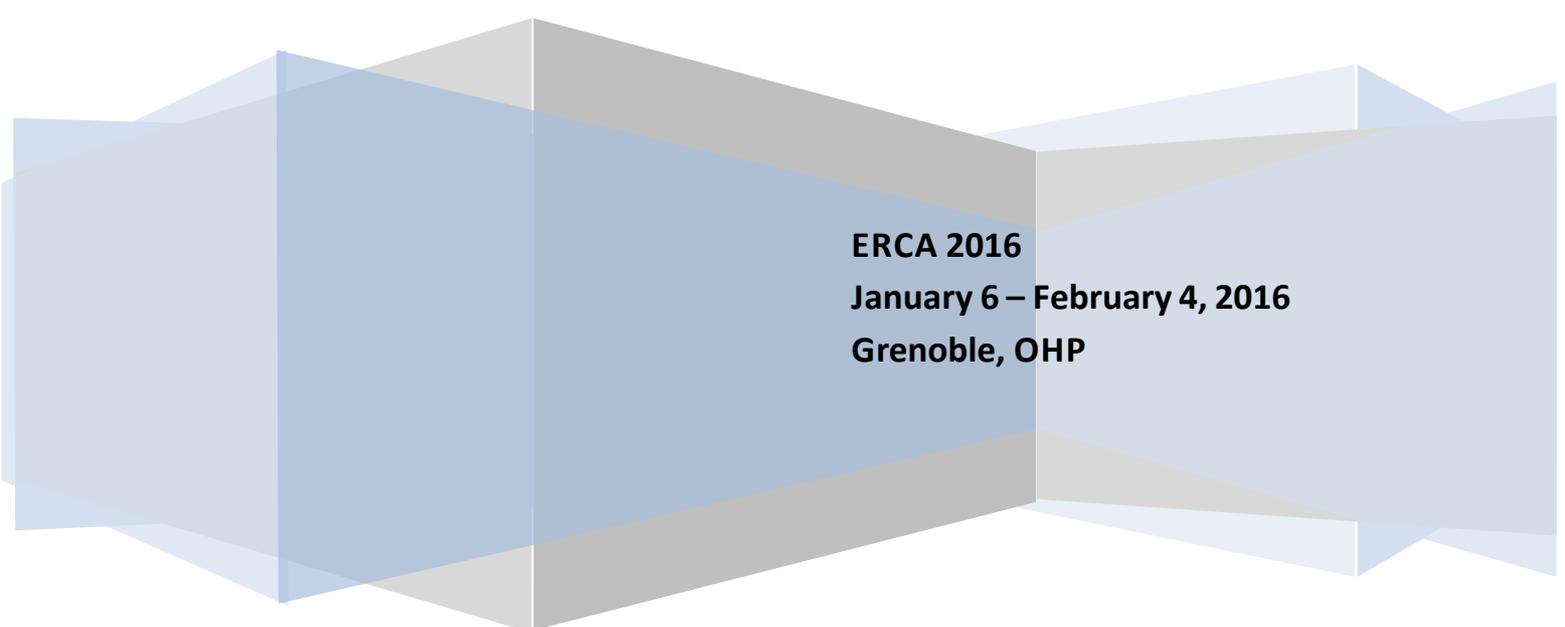




University Grenoble-Alpes (UGA)
Centre National de la Recherche Scientifique (CNRS)

European Research Course on Atmospheres – ERCA 2016



ERCA 2016
January 6 – February 4, 2016
Grenoble, OHP

ERCA 2016

Scientific report of the 24th session of ERCA

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1. Organization of the session

This 24th session of the European Research Course on Atmospheres (ERCA) has been the second session directed by Pr. **Didier VOISIN** of the Grenoble-Alpes University. This session followed the first 20 sessions directed by Pr. Claude BOUTRON, and two other sessions directed by Dr. Paolo LAJ, both at the Grenoble-Alpes University.

The Director was assisted by the Office of the Grenoble European schools, a management committee and a scientific committee.

The Office of the Grenoble European schools is located at the 'Maison des magistères', a belonging of the Joseph-Fourier University located on the 'Scientific Polygon', in West Grenoble.

The Office of the European schools comprises:

- Anna BARANOVA-FRÜH (ERCA school, UJF)
- Youlia MAZET (financial and administrative management of the European schools, UJF)
- Clotilde EFFANTIN-BONHOURE (ESONN school, UJF)
- Isabelle GAUVIN (HERCULES school, UJF)
- Joseph GERMIANO (financial assistant of the European schools, UJF)

The Management Committee is composed of:

Dr. Mathieu BARTHELEMY (IPAG, Joseph-Fourier University)
Dr. Gilles DELAYGUE (deputy director, LGGE, Joseph-Fourier University)
Dr. Stéphane LA BRANCHE (EDDEN, University Pierre-Mendès-France)
Dr. Samuel MORIN (CEN Grenoble, Météo France)
Dr. Luc FAVRE (Université Aix-Marseille)
Dr. Alain SARKISSIAN (LATMOS, CNRS Verrières)
Pr. Didier VOISIN (LGGE, Joseph-Fourier University)

The Scientific Committee is composed of:

Pr. Carlo Barbante, University Ca'Foscari of Venice, Italy
Dr. Carl Brenninkmeijer, Max-Planck Institute for Chemistry, Mainz, Germany
Pr. Peter Brimblecombe, University of East Anglia, Norwich, UK
Dr. Nathalie Poisson, French Environment and Energy Management Agency (ADEME), Paris, France
Pr. Ralf Ebinghaus, Helmholtz-Zentrum Geesthacht, Germany
Dr. Jean Liliensten, CNRS / University of Grenoble, France
Pr. Markus Quante, Helmholtz-Zentrum Geesthacht, Germany
Pr. Yinon Rudich, Weizmann Institute, Israel

2. Financial supports

The Joseph-Fourier University (now University Grenoble-Alpes) and the local CNRS representative ('Delegation Alpes') are our main supports, without which ERCA could not exist. In addition to them, several other institutions trust ERCA and are important funders. These funds are either directly given to ERCA, or specifically attributed to students (to cover registration and travel/housing costs).

Supports from international agencies

- **The World Meteorological Organization (WMO)** is a specialized agency of the United Nations. It is the UN system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources.
- **The Global Atmosphere Watch (GAW)** programme of WMO is a partnership involving the Members of WMO, contributing networks and collaborating organizations and bodies, which provides reliable scientific data and information on the chemical composition of the atmosphere, its natural and anthropogenic change, and helps to improve the understanding of interactions between the atmosphere, the oceans and the biosphere. GAW focal areas are aerosols, greenhouse gases, selected reactive gases, ozone, UV radiation and precipitation chemistry (or atmospheric deposition).
- **The Abdus Salam International Centre for Theoretical Physics (ICTP)**: Founded in 1964 by the late Nobel Laureate Abdus Salam, ICTP has been a driving force behind global efforts to advance scientific expertise in the developing world, under the auspices of the Italian government, UNESCO and IAEA
- **Max-Planck Institute for Chemistry (MPIC)**. The leading German agency for funding and managing research, training and knowledge exchange in chemistry. It carries out investigations of the earth system and chemical processes in the atmosphere as well as the interactions between air, water, earth and mankind.

- **Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG):** As a member of the Helmholtz Association of German Research Centres, the largest scientific organization in Germany, the Helmholtz-Zentrum Geesthacht is engaged in long-term activities in the fields of materials and coastal research that are making a major contribution to resolving the large and pressing issues facing society and the scientific and business worlds.

Supports from national agencies

- **The French Ministry for Higher Education and Research (MESR)** supports participants from Eastern Europe, Asia, and Southern America with the ACCES and the '*Investissement d'Avenir*' programs.
- **Institut de Recherche pour le Développement (IRD)** has focused its research for over 65 years on the relationship between man and its environment, in Africa, Mediterranean, Latin America, Asia and the French tropical overseas territories. Its research, training and innovation activities are intended to contribute to the social, economic and cultural development of southern countries.
- **Centre National d'Etudes Spatiales (CNES, National Agency for Space Studies)** is the government agency responsible for shaping and implementing France's space policy in Europe.
- **Meteo-France** is the national agency for meteorology and climatology, especially responsible of meteorological vigilance. **Centre d'Etudes de la Neige (CEN)** in Grenoble is MeteoFrance centre dedicated to snow and avalanche forecast and study.
- **Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME)** is a public agency which aims are to encourage, supervise, coordinate, facilitate and undertake operations with the aim of protecting the environment and managing energy.
- **L'Institut National des Sciences de l'Univers (INSU)** has a national responsibility of definition and coordination of research activities in astronomy, Earth sciences, ocean and space sciences.
- **IRSTEA** is a research organization which, since more than 30 years, boasts a dual culture of researchers and engineers who tackle environmental matters from three angles: research, innovation and expertise. By studying ecosystems on a countrywide basis, they provide indispensable theoretic knowledge to help understand ecosystems, and work to create solutions to reduce the impacts of human activity on the environment whilst providing expertise on public policies at the request of decision-makers.

Aix-Marseille Université (AMU) is the largest university in France with 74,000 students; it is located in the French second city along the Mediterranean sea, Marseille, as well as in Aix-en-Provence.

Pytheas Institute is an Earth observatory of Aix-Marseille Université. It runs the Observatoire de Haute-Provence which hosts ERCA, as well as the Oak observatory at OHP (O3HP), which studies the Mediterranean forest.

- **L'école doctorale des sciences de l'environnement d'Île-de-France (EDSEIF – ED 129)** trains PhD students of the Paris area to become specialists in the pluridisciplinary sciences of the environment, atmosphere, ocean, and continental surfaces. It supports the ERCA program at OHP.
- **L'observatoire de Versailles Saint-Quentin-en-Yvelines (OVSQ)** is a national Earth observatory. It is run by the University of Versailles Saint-Quentin-en-Yvelines (UVSQ). OVSQ runs the instrumented platform 'Gérard-Mégie' at the Observatoire de Haute-Provence (OHP). The staff of OVSQ provides a great support to ERCA by organising and managing the ERCA session at OHP.

Supports from local agencies

- **Observatoire des Sciences de l'Univers de Grenoble (OSUG)** is a geosciences observatory within the University of Grenoble, grouping six laboratories. It supports ERCA with the Labex2020 program.

- **The Physics, Engineering, Mecanics, and geosciences department (PhITEM)** of the University of Grenoble
- **The Collège Doctoral (Doctoral school) of the University of Grenoble** manages about 3700 PhD students (of them, 45% foreigners) and is especially responsible for their training. ERCA is a part of this training.
- **GIANT partnership** in Grenoble is building links between research and industry to foster breakthroughs in challenges at the forefront of Grenoble research: communication technologies, renewable energies, and health/medical science.
- **Grenoble Alpes Métropole** operates the metropolitan area around Grenoble. It supports its economy, scientific activities, and the universities.

These supports have been acknowledged regularly, to the participants as well as in our communication means (web site <http://erca-school.eu>, posters, programme).

3. Course of events

This 24th ERCA session took place from January 6th to February 4th, 2016. The first 4 weeks (6 to 29th January) took place in Grenoble, at Maison des Magistères, a building of the Joseph-Fourier University. The last week (31th January to 4 February) took place at the Observatoire de Haute-Provence, close to Forcalquier, in South France.

Key-note lecture

The key-note lecture of this session was given by Dr. Franck LECOCQ, director of CIRED, who is specialist of the economy of climate change. His lecture helped the audience to understand how important is the recent Paris agreement on climate change mitigation reached during COP21 in December 2015.

Training programme

The training programme of the first 4 weeks in Grenoble comprised a very consistent package of scientific lectures (about 100 hours), proposal building, debates, and poster sessions during which participants presented their research work.

The scientific session comprised six main thematics:

Atmospheric chemistry & atmospheric composition changes
Earth climate system & the science of climate change
Earth Science system - Impact & society
Experimental techniques & research methodologies for the atmospheric sciences
Hydrology & precipitation: Water cycle in climate change
Planetary atmosphere, solar activity & space weather

The participants have been confronted to very diverse thematics and lecturers, providing them both a global picture of the climatic system, as well as advanced views through specific seminars and tutorials. Currently, no other school than ERCA provides a similar training, which explains the success of ERCA, especially with first year PhD students, as well as with young researchers willing to get to the field of environment. About 60 lectures have been provided by 36 lecturers (Annex 2). The presentations were available to participants on the ERCA web site. Lectures covered not only scientific problems, but also communication tools for young researchers: how to write a scientific paper and a proposal.

Research project

This year a new activity on writing a **research project** has been proposed with the aim to train students building a research proposal corresponding to a research call. For this, three different research calls were proposed, based on actual ones. The topics were:

Project A: Agriculture and air quality: Evaluation, impacts and management

Project B: Water Vapor and Precipitation Processes in a Changing Climate

Project C: Arctic Observing and Research for Sustainability

The complete research calls are given in Annex 1.

Students worked in three different groups, each focused on one call. Twelve slots were officially dedicated to their writing work, with some help provided by tutors.

In a second phase, students were asked to formally evaluate the other projects, based on a written document. We think that such an evaluation is a very important part of their training, aimed at improving their building capacity.

In a third phase, students were asked to re-write their proposal, with a formal oral presentation of their final project.

This work was done during almost the whole session so that students could benefit from the inputs of different lecturers. We have been impressed by the students who took this project very seriously, and by the way they share the tasks and manage the writing. Since this work took quite a lot of time, we had to decrease the number of lectures compared to previous years (about 10 lectures less).

Other Training

A debate on the mitigation of global warming impacts has been conducted by a specialist of political negotiations (Stéphane La Branche from IEP Grenoble). This debate was especially important after the Paris agreement on global warming mitigation (COP21).

Three more informal debates have been organized at Café des Arts, downtown Grenoble, dealing with philosophy of science, and the social aspects of natural risks.

A poster session has been organized at LGGE during which students both presented their research work and discussed with the other students. The session was organized as in a scientific meeting, and we think that such a poster session is a very good opportunity for the students.

Visits to laboratories

During the session the participants visited:

The Laboratoire de Glaciologie et de Géophysique de l'Environnement (LGGE), supported by the French National Center for Scientific Research (CNRS) and the University Grenoble-Alpes. Its scientific reputation is based on outstanding research achievements related to the reconstruction of past changes of climate and atmospheric composition during the last climatic cycles from polar ice cores.

The Planeterrella, an experiment created by Jean Lilensten and his colleagues at the Institute of Planetology and Astrophysics of Grenoble (IPAG). See the description below.

Tutorials

Four tutorials were organized for the participants during the ERCA 2016 session, during a half day. A tutorial was designed as a very special occasion to exchange with specialists around an experimental setup. Each participant had to choose one of the following 4 tutorials:

Planeterrella, proposed by IPAG (Mathieu Barthélémy, Anne Vialatte)

The Planeterrella is an experiment inspired from the Terrella developed by Kristian Birkeland from 1896 to 1917, and is basically an aurora demonstrator for the Earth. Yet, its exceptional flexibility enables one to simulate all kinds of planetary systems (Uranus and Neptune with their inclined

rotation axis, Ganymeda - Jupiter interactions). In this practical, students have studied the spectra of the aurora. This was recorded and analyzed by using emission line catalogues. The aim was to understand the mechanism at the origin of the auroral emissions.

Coriolis platform (Henri-Claude Nataf from ISTERRE)

The Coriolis platform, 13 m in diameter, is the largest rotating platform in the world dedicated to fluid dynamics. Its main activity is the experimental modeling of geophysical flows, taking into account the rotation of the Earth, in the presence or not of density stratification or topography. The large size provides access to the inertial regimes that characterize ocean dynamics, with little influence of viscosity and centrifugal force. Laboratory experiments can thus provide support to model ocean dynamics and develop their physical parameterizations. The platform is run by the LEGI laboratory. It belongs to the European HYDRALAB and EuHIT infrastructures.

Snow monitoring at the Col-de-Porte station, proposed by CEN/MétéoFrance (Samuel Morin)

A wide range of automated and manual snow and meteorological observations are co-located at the Col-de-Porte station (1325m elevation, ~ 30km away from Grenoble) and serve as: testbed for new instrumentation, establishment of driving/evaluation data for snowpack model development and build-up of climatologically relevant dataset. The practical at Col-de-Porte consisted of an illustration of key snow-related processes (surface energy and mass balance) together with existing and novel instrumentation to probe them (challenges for radiation, precipitation, wind measurements).

Scintillometry and flux measurements, proposed by LTHE (Jean-Martial Cohard)

Scintillometry is a method which links the scintillation of an electromagnetic signal propagating through the atmosphere to turbulent properties. Turbulent exchanges between surface and atmosphere, namely sensible or latent heat fluxes, can then be derived from the observed scintillation. These estimates are representative of km² landscape units, which corresponds to the scale of satellite observations or model forecasts.

Last week of the session at Observatoire de Haute-Provence

The last week dealt with the study of instruments installed on the site of the Observatoire de Haute-Provence (OHP), directed by Dr Auguste LE VAN SUU. This observatory is a service unit attached to the Observatoire des sciences de l'univers Pythéas (INSU/Aix-Marseille University/IRD/Collège de France), directed by Pr Bruno HAMELIN. OHP is a premium site for observing:

- atmosphere, with lidars and spectrometers run by the Laboratoire Atmosphères, Milieux et Observations Spatiales (LATMOS) of the University of Versailles-Saint-Quentin-en-Yveline (UVSQ), and greenhouse gases measurements for the Integrated Carbon Observation System (ICOS);
- space, with the historical telescopes of the Observatory (0.8 to 2m), especially the one with which the first exoplanet was discovered in 1995;
- the Mediterranean forest, with the help of an instrumented platform run by the Pythéas OSU and by the research federation ECCOREV (directed by Joël GUIOT).

The principle of the various instruments, operating procedures and applications, has been first presented to the participants by specialists, especially by a group of scientists from LATMOS. Then, the participants have been divided into several groups in order to study the running instruments and to work on measurements.

4. Lecturers

There were 36 lecturers, of them 8 women, from 9 countries: France (21), Germany (3), China (3), Italy (2), USA (2), Israel (2), Switzerland (1), Finland (1), Croatia (1).

The detailed list of the lecturers with their affiliation is given in Annex 2.

Lecturers have been proposed by the scientific and management committees. They were selected for their renowned scientific expertise, as well as for their educational abilities. The number of lectures has been decreased this session in order to let students work on their research proposal.

5. Participants

Participants have been selected from the approx. 100 applications posted on the ERCA web site. Such elevated number of applications proves the great interest and the reputation of ERCA at an international level. Many researchers who participated to ERCA in the past now send their students train with ERCA. Among the 37 selected participants, 2 eventually did not participate to ERCA, one of them because of problem with a visa. Hence we had 35 participants to ERCA 2016.

ERCA 2016 had 16 females and 19 males (i.e. 46% of women), with 22 different nationalities: Argentina (2), Australia (1), Belarus (1), Belgium (1), Bolivia (1), China (5), Denmark (1), Estonia (2), France (3), Germany (4), Greece (1), Hungary (1), India (2), Iran (1), Israel (1), Poland (1), Russia (3), South Korea (1), The Netherlands (1), Turkey (1), UK (1).

They are working in 21 different countries: Argentina (2), Australia (1), Belgium (1), Bolivia (1), China (4), Denmark (1), Estonia (1), France (2), Germany (5), Hungary (1), India (2), Iran (1), Israel (1), Poland (1), Russia (4), South Korea (1), Sweden (1), Switzerland (1), Turkey (1), UK (2), USA (1).

The list of participants can be found in Annex 3, which includes their position and research thematic.

The age of the participants ranges from 21 to 38 years, with a median value of 27 years.

28 participants are undergrad or PhD students, 7 are early career researchers.

The selection of participants was multi-criteria: the research thematic, the laboratory, the country and the possibility to get a visa; the possibility to get funded, the advisor support.

Grants have been allowed to 13 participants, to cover the whole registration cost. The origins of these grants are the following:

Abdus-Salam International Center for Theoretical Physics: 2 grants

The French Ministry for Higher Education and Research with the ACCES Programme: 4 grants

INSU national institute: 2 grants

OSUG with the LabEx OSUG@2020 programme: 2 grants

GIANT Alliance with the programme "FOSTERING Science": 1 grant

6. Detailed Programme

The daily programme is given in Annex 4.

7. ERCA Community

One of the ERCA strengths is to facilitate exchanges between lecturers and participants, and between participants themselves, in order to create a multidisciplinary scientific community dealing with the ERCA thematics. Selection of candidates has been made to have a very representative panel of participants from both well-established research institutions and fast-developing research

institutions from emerging countries. Half of participants originate from countries with emerging economies as defined by UNO representing all different continents. In addition, invitation to lecturers from developing countries completes the clear ERCA strategy to offer students a course that responds to actual needs in countries outside the OECD, in particular the very strong problem of air pollution.

It is important to note that many students from emerging economies are involved into ERCA through their advisors, often themselves former ERCA participants. ERCA intends to continue being at the forefront of post-graduate education provided at international level and opened to all different countries. The organization of ERCA has been pro-active to create the conditions for exchange amongst participants, by ensuring participants of balanced origin and gender and providing special opportunities to meet throughout the session.

In addition to the regular coffee breaks, the Monday scientific debates were followed by dinners which were opportunities to exchange with lecturers. Free day trips were also organized: a snowshoe trip in the mountains, and a sightseeing of the historical castle of Vizille. Although based on volunteering almost all participants were participating..

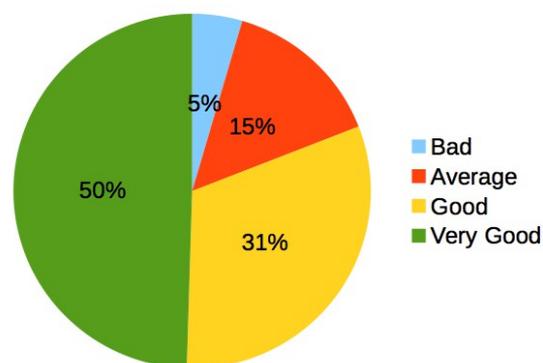
8. Evaluation of ERCA

Evaluating the lectures and the whole session organization is a major concern. For four years now, such an evaluation is done by the participants through the ERCA web site, which allows us to get digital results and to compute them quickly. Satisfaction of participants is one of the parameters accounted for when selecting lecturers and when modifying the programme of ERCA. A survey is proposed both on lectures and on the general organization of ERCA.

Concerning the quality of the lectures, participants have been asked to grade each of them using one of the following grades: « *Very good* », « *good* », « *average* » or « *bad* ». The results for this session show a very high level of satisfaction (cf. Figure below)

Figure: Evaluation of the ERCA lectures (based on 730 answers).

ERCA benefits from a long term process of selecting lecturers, which allows us to provide top quality lectures. A special feature of ERCA is also to keep, year after year, a core of highly motivated and active lecturers. The satisfaction level is consistently very high. In addition to evaluating ERCA, participants also gave comments and propositions for improvement, which will be of course accounted for when organizing the next session.



9. Impacts and fallouts

The overall objectives for the 2016 sessions of ERCA have been reached: to offer high-quality training, both theoretical and practical, to offer access to state-of-the-art equipment, to favor multidisciplinary, and finally create and stimulate scientific exchange between lecturers and students of different geographic and scientific origins. This can be measured by the satisfaction survey organized anonymously for participants, expressing a high degree of satisfaction with the scientific level of lectures, and the overall organization.

ERCA international visibility probably contributes to the very high international ranking of the University Joseph-Fourier of Grenoble (UJF) in the Earth and environmental sciences. For instance,



the 2015-2016 QS World University Rankings place UJF at the 37th world level for “Earth & Marine sciences” and at the 128th level for “natural sciences”.

ERCA is a recurrent yearly event. Next year session will be held in January/February 2017. Some modifications will be implemented in the 2017 program, based on the evaluation of the 2016 session. Especially, we have to better evaluate the training of the participants, so that they get some formal evaluation, both for their poster and for the research proposal. The main part of the program will be defined by the end of May 2016 and announced via electronic mailing lists in June 2016. The internet site of the school (<http://erca-school.eu>) will be used for announcements and for registration.

ERCA is one of the reference training in the atmospheric science and climate fields for the international scientific community. We hope that ERCA contributes to gather and train young scientists from all over the world.

Acknowledgements

We have to acknowledge all the personal contributions which made ERCA 2016 another great session. We are especially grateful to the very kind staff of Café des Arts.

Annex 1: Research calls proposed to the students

Project A. Agriculture and air quality: Evaluation, impacts and management

Many long standing issues associate agriculture and environment; they are linked to the development of an activity that combines natural environment, technology and economy, while occupying large territories. Relations between agriculture, atmosphere and air quality have raised more recent concerns: biomass burning emissions, contribution to springtime air quality alerts due to particulate matter, or pesticides emissions and fate in the atmosphere. Monitoring and reducing agricultural emissions to the atmosphere is therefore on the public policy makers agenda. Meanwhile, agriculture is also significantly impacted by pollution: ozone for example decreases crop yields.

In this context, some key issues need to be resolved, and decision making tools need to be developed to inform policy makers. The present call for research seeks proposals in two main venues of research:

1. Characterize and reduce atmospheric pollutants emissions from agricultural and forestry production systems : we know what species are emitted by agricultural processes, but our knowledge of those emissions is varied, despite recent progress made for example on emission factors or on quantifying agriculture share in aerosol loading at receptor sites. Part of the difficulty is due to the space-time variability of agricultural sources: some are point sources (buildings, ...), others are diffuse (fields, cattle, ...), and most are very sensitive to environmental variables (weather, soil properties, ...). A better evaluation of those sources should help advancing some of those questions : (1) how do agricultural and forestry practices and their evolution relate to pollutants emissions ? (2) how can we better qualify pollutant emissions, their contributions and exchanges between environmental compartments ? (3) How much do agricultural emissions contribute to air pollution at various scales ?
2. Characterize impacts of air pollution on forestry/agricultural productions, and health, environmental, and economical impacts of air pollution from agricultural origin : atmospheric pollution leads to decreased crop yields and decreased crop quality. These impacts need to be better characterized through (1) measurements of human and ecosystems exposure to atmospheric pollution and deposition, (2) dose – effects relations established for realistic concentrations and pollution cocktails, (3) evaluation of the vegetation's adaptive capacity and of ecosystems modifications induced by atmospheric deposition or (4) economic estimates of crop yield decrease. These studies should help to evaluate better the effects of atmospheric pollution on ecosystems services, and their effect on agricultural production, climate, environmental quality or biodiversity.

Project B. Water Vapor and Precipitation Processes in a Changing Climate

A direct, immediate response to increased carbon dioxide in Earth's atmosphere is an atmospheric radiative imbalance that leads to a gradual retention of more energy in the Earth system and temperature increases at Earth's surface. One feedback to increased temperatures of the air is higher vapor content which leads to yet more retention of energy in the Earth system and yet even greater temperature increases at Earth's surface. That is, retention of water vapor molecules by the atmosphere is a positive feedback in that it strengthens the initial temperature increases that result from carbon dioxide.

Observational quantification of the amount of water vapor in Earth's atmosphere and its trending with time is a critical piece of the puzzle in characterizing unambiguously the consequences of increased atmospheric carbon dioxide concentrations at this time. Moreover, the consequences of increased atmospheric water vapor concentrations on precipitation processes are as important to humanity as changes in Earth surface temperatures.

This proposal call seeks research to ascertain the trends in atmospheric water vapor concentrations over the past decades and to propose measurement strategies to measure them with high accuracy going forward. A second component of the proposal call seeks investigations that characterize ongoing

changes in the properties of precipitation on regional to global spatial scales and weekly to decadal time scales.

Notes: This research is related to the Tropical Rainfall Measuring Mission (TRMM), the Global Precipitation Measurement (GPM) mission and the Precipitation Measurement Mission (PMM). On the modeling side this research is related to regional down-scaling of climate model outputs as well as mesoscale numerical weather prediction of specific storm systems that are potentially harbingers of things to come. Finally, there are no more important quantities to humanity than surface temperatures and precipitation processes.

Project C. Arctic Observing and Research for Sustainability

In recent decades, the Arctic has undergone rapid changes – sea ice decline, dramatic coastline erosion, permafrost thawing, shifting migration patterns of people and animals, a growing demand for northern oil and energy infrastructure and increased interest in seasonally ice-free transport routes. The effects of these changes on Arctic communities are diverse. Approximately 4 million people live in the Arctic, in communities that span a range from small subsistence hunting, fishing, gathering, and herding communities to regional business and government centers to large resource extraction cities.

A sustainable Arctic that can cope with current environmental change and increased human activity will need continuously improving scientific knowledge and proven mitigation strategies. While existing Arctic observations and observing networks provide a basis for assessing the natural environment, there is a need to integrate observations and transdisciplinary research on coupled systems in the Arctic.

This Collaborative Research Call seeks to advance research within one or more of the following :

1-natural and living environment – focusing on in-depth understanding of the nonlinear physical and biological interactions within the Arctic.

2-built environment and infrastructures – housing and transportation structures, energy, and communications technologies, climate-resilient materials, sustainable observing designs, ...

3-natural resource management and development – comprising drivers and impacts in natural and human systems, within the Arctic and interaction with the rest of the world, including food and water.

Since the Arctic is a highly interdependent system, these themes are not unrelated and projects may address interactions among these themes. Below, without being exhaustive, are some examples:

Food and water security encompasses subsistence activities, but also looks at the relationship of conservation, regulation, economic, built infrastructure, socio-cultural, and health factors on access to natural foods and clean water. Migrating animals relocate to new habitats or suffer reproductive decline as climate change progresses and their food sources and breeding grounds change or disappear, limiting access to traditional foods.

Natural resources may include traditional and farmed foods, such as fish and caribou, but also the challenges and opportunities presented by extractive industry and clean energy technologies.

Oil and gas extraction in an ice-free Arctic Ocean presents both opportunity in terms of economic prosperity and challenges in the form of environmental impacts in an area where the baseline and climate-stressed ecosystem states are little known, and effective prevention and response strategies to spills have not yet been developed among the Arctic Nations.

Permafrost thaw, retreating glaciers, and greening of the Arctic modify the landscape, which may induce shifts in the cycle of entire biomes, affect subsistence practices, and contribute to deteriorating communication and transport systems, housing, and food storage methods. These changes may also



motivate the engineering of climate-resilient structures and materials and open the possibility for developing natural resources, highly efficient green technologies, ...

Ice and weather conditions, once predictable for hunting and gathering, have become increasingly erratic and the traditional methods for predicting them unreliable. As the ice recedes from the coastline and thaws on the land surface, the terrestrial and marine ecosystems and human infrastructure it protected from wind, waves, and warming are now exposed, as are the natural resources and greenhouse gas reserves contained below the surface.

Environmental changes can affect overall health and security in an already stressed population. Warming induces release of pollutants once trapped in the ice, snow, permafrost and introduces new disease vectors into the air and local water supplies. The increased occurrence of extreme weather events can further destabilize already vulnerable structures and create health emergencies which may exceed the capacity of local government and health care facilities.

Annex 2: ERCA 2016 Lecturers

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Annex 3: ERCA 2016 participants

Family name	First name	Nationality	Age	Research field	Affiliation
ALLARD	Julie	France	25	Atmospheric chemistry and physic	LGGE, Université Grenoble-Alpes, Grenoble, France
BAYKARA	Metin	Turkey	28	Atmospheric Chemistry and Air Quality Modelling	Istanbul Teknik Universitesi, Istanbul, Turkey
BOTTYÁN	Emese	Hungary	24	Biogeochemical cycles	Eötvös Loránd University, Department of Meteorology, Budapest, Hungary
DOLLNER	Maximilian	Germany	26	Aerosol	Ludwig-Maximilians Universität, München, Germany
DRABASHEUSKAYA	Katsiaryna	Belarus	26	Ozone content in the lower stratosphere	Russian State Hydrometeorological University, Saint-Petersburg, Russia
ECKERT	Ellen	Germany	32	Stratospheric Ozone Trends/Changes in the Stratosphere	Karlsruhe Institute of Technology, Institute for Meteorology and Climate Research, Germany
GUOBAO XU	Guobao	China	31	Climate change and Tree rings	Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou, China
HAFERMANN	Sascha	Germany	30	Atmospheric Chemistry	Max-Planck Institute for Chemistry, Mainz, Germany
HOCHMAN	Assaf	Israel	38	Climate Change	Porter School of Environmental Studies, Tel-Aviv university, Tel-Aviv, Israel
JANKOWSKI	Damian	Poland	34	Atmospheric Physics	Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland
JÜRI	Kamenik	Estonia	28	Climatology, Weather extremes, Atmospheric circulation	Department of Geography, institute of Ecology and Earth Science, University of Tartu, Estonia
KARU	Einar	Estonia	26	Atmospheric chemistry (sulphur compounds)	Max-Planck Institute for Chemistry, Mainz, Germany
KONKOVA	Elizaveta	Russian Federation	26	Monitoring of background pollutants	Institute of Global Climate and Ecology, Moscow, Russia



Family name	First name	Nationality	Age	Research field	Affiliation
LANFRI	Lucia	Argentina	25	Physical Chemistry	National University of Cordoba, Córdoba, Argentina
LANZACO	Bethania	Argentina	26	Tropospheric aerosols	National University of Cordoba, Córdoba, Argentina
LI	Yaju	China	27	Stable isotopes	Nanjing University, Nanjing, China
LIEBMANN	Jonathan	Germany	29	Atmospheric Chemistry	Max-Planck Institute for Chemistry/ University of Mainz, Mainz, Germany
MACKENZIE-RAE	Felix	Australia	24	atmospheric chemistry	University of Western Australia, Crawley, Australia
MAMONTOV	Alex	Russian Federation	26	Turbulence research, aerosol, lidar sensing	Obukhov Institute of Atmospheric Physics, Moscow, Russia
MARTYNOVA	Yuliya	Russian Federation	33	atmospheric dynamics	Institute of Computational Mathematics and Mathematical Geophysics, Novosibirsk, Russian Federation
MICHALOPOULOU	Eleni	Greece	30	Chemistry of the Atmosphere	School of Chemistry, University of Bristol, United Kingdom
NIELSEN	Ingeborg Elbæk	Danemark	29	Atmospheric Chemistry and Physics	Aarhus University, Riskilde, Danemark
OSMONT	Dimitri	France	23	Glaciology	Departement für Chemie und Biochemie, Universität Bern, Bern, Switzerland
PANAHIFAR	Hossein	Iran	30	Atmospheric Remote sensing	Institute for Advanced Studies in Basic Sciences, Zanjan, Iran
PIVOT	Sébastien	France	24	Geochemistry	CEREGE/University Aix-Marseille, Aix en Provence, France
PUGSLEY	Katherine	United Kingdom	24	Atmospheric Chemistry	School of Chemistry, University of Bristol, United Kingdom
REIJRINK	Nina	The Netherlands	21	Atmospheric Chemistry	Department of Chemistry, University of Oslo, Sweden
ROCA	Manuel	Bolivia	29	Atmospheric physics	UMSA, University campus, La Paz, Bolivia
SARASWATI		India	32	Atmospheric physics	National Physical Laboratory, New Delhi, India
SHIN	Jinhwa	South Korea	32	Paleoclimate, Ice core	LGGE, Université Grenoble-Alpes, Grenoble, France
SUBBA	Tamanna	India	26	Atmospheric Science	Centre for Atmospheric Studies, Assam, India
TROMPET	Loïc	Belgium	26	Planetary aeronomy	Royal Belgian Institute for Space Aeronomy, Uccle, Belgium



Family name	First name	Nationality	Age	Research field	Affiliation
WANG	wu	China	36	Permafrost and environment	Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou, China
YUE	Guangyang	China	35	permafrost ecology	Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou, China
ZHENG	Yiqi	China	27	Atmospheric Chemistry	Yale University, New Haven, Connecticut, USA



Annex 4: Detailed programme in Grenoble (4 weeks) and at OHP (Observatoire de Haute-Provence) (1 week)

Wednesday 6 January 2016	
10.00-10.30	Welcome Coffee, Maison Jean Kuntzman, 110 rue de la Chimie, university campus 38400 Saint Martin d'Hères
10.30-11.15	Official opening - Amphitheatre at Maison Jean Kuntzman
11.15-12.00	Keynote lecture by Franc Lecocq , Director of Centre International de Recherche sur l'Environnement et le Développement "Evolution of climate policies and implication on recent and international negotiations"
12.15-14.00	<i>Buffet at Maison Jean Kuntzman</i>
14.00- 15:30	Introduction of the project Didier Voisin, Jean Lilensten LGGE 54 rue Moliere, university campus, 38400 Saint Martin d'Hères
15.30-16.00	<i>Coffee break LGGE Cafeteria</i>
16.00- 17.30	Introduction of the project (continuation)
18.30	<i>Ice-breaking party at Café des Arts downtown (36, rue Saint Laurent, Grenoble)</i>



	Thursday 7/01/2016	Friday 8/01/2016
9.00-10.30	Alain Hauchecorne Fundamentals of atmospheric dynamics	Alain Hauchecorne Coupling between atmospheric layers: from the surface to the thermosphere
10.30-11.00	<i>Coffee break</i>	<i>Coffee break</i>
11.00-12:30	Anne Monod Atmospheric chemistry and photochemistry	Anne Monod Secondary organic aerosol in the troposphere: formation, fate and impacts (part 1)
12.30-14.00	Lunch @ Student's Restaurant GreEn Er CROUS	Lunch @ Student's Restaurant GreEn Er CROUS
14.00-15.30	Alain Hauchecorne Waves and turbulence in the atmosphere	Ralf Ebinghaus : Emission sources, regional and global distribution of persistent organic pollutants (POPs).
15.30-16.00	<i>Coffee break</i>	<i>Coffee break</i>
16.00-17.30	Ralf Ebinghaus : Emission sources, regional and global distribution of atmospheric mercury.	Anne Monod Secondary organic aerosol in the troposphere: formation, fate and impacts (part 2)

WEEK 2: GRENOBLE

	Monday 11 /01	Tuesday 12/01	Wednesday 13/01	Thursday 14/01	Friday 15/01
9.00-10.30	Peter Brimblecombe: Air pollutants and their health impact.	Eugene Clothiaux Radiation through clear and cloudy atmospheres	Eugene Clothiaux Radiation and Remote Sensing: A Few Current Applications	Yoav Yair From ions to thunderstorms: a review of atmospheric electricity	Poster session @ LGGE
<i>10.30-11.00</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>
11.00-12:30	Eugene Clothiaux Atmospheric radiation: basic physics and concepts	Peter Brimblecombe: Indoor air pollution.	Peter Brimblecombe Climate change and cultural heritage	Yoav Yair Lightning in the solar system and beyond	Poster session @ LGGE
<i>12.30-14.00</i>	Lunch (GreEn ER CROUS)	Lunch (GreEn ER CROUS)	Lunch (GreEn ER CROUS)	Lunch (GreEn ER CROUS)	Lunch Buffet at LGGE
14.00-15.30	Caroline Brimblecombe Developing focus and productivity in academic and technical writing	Project work	Project work	Project work	Planeterrella/ LGGE visit
<i>15.30-16.00</i>	<i>Coffee break</i>				<i>Coffee break @ LGGE cafeteria</i>
16.00-17.30	Caroline Brimblecombe Developing focus and productivity in academic and technical writing	Project work	Project work	Project work	Planeterrella/ LGGE visit
18.30	Debate / Café des arts/ Stéphanie Ruphy "Philosophy of science"				

WEEK 3: GRENOBLE

	Monday 18/01	Tuesday 19/01	Wednesday 20/01	Thursday 21/01	Friday 22/01
9.00-10.30	Markus Quante The role of Clouds in Climate and Environment	Yinon Rudich: From deserts to reefs: global processes of mineral dust.	Tao Wang: Air pollution in China: a review of control efforts, their effectiveness, and challenges	Tao Wang: Photochemical ozone and smog in China: insights learned from several large research projects	Carlo Barbante Ice-core records of climate and atmospheric chemistry
<i>10.30-11.00</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>
11.00-12:30	Barbara Nozière Aerosols and warm cloud formation	Markus Quante Clouds and precipitation physics	Stéphane La Branche Climate game Introduction	Give back project	Irène Xueref-Rémy The carbon cycle
<i>12.30-14.00</i>	Lunch (GreEn ER CROUS)	Lunch (GreEn ER CROUS)	Lunch (GreEn ER CROUS)	Lunch (GreEn ER CROUS)	Lunch (GreEn ER CROUS)
14.00-15.30	Yinon Rudich: Primary Biological Aerosol Particles: Climate, ice and health	Project work	Project work	Give back project	Stephane La Branche : Climate Debate
<i>15.30-16.00</i>	<i>Coffee break</i>			<i>Coffee break</i>	
16.00-17.30	Yinon Rudich: Optical properties of aerosols : theory and new measurement methods	Project work	Project work	Carlo Barbante Ice core records as archives of past climate and atmospheric composition	
18.30	Debate/Café des Arts/ Jean Liliensten :				

WEEK 4: GRENOBLE

	Monday 25/01	Tuesday 26/01	Wednesday 27/01	Thursday 28/01	Friday 29/01
9:00- 10:30	Casey Brown Floods, risk estimation and management	Jasa Calogovic Composite analysis and Monte Carlo methods - an example with Forbush decreases and cloud cover	Jed Kaplan The role of land surface processes in the climate system: Global modeling of biogeophysical and biogeochemical feedbacks	Filippo Giorgi: Regional climate modeling; update and CORDEX developments	Filippo Giorgi: Climate change and the hydrologic cycle
<i>10:30-11:00</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>
11:00- 12:30	Ilya Usoskin The variable sun (solar magnetic activity and cycles)	Casey Brown Droughts, risk estimation and management TBC	Andreas Richter Satellite measurements of troposphere composition - principles, results, and future developments	Ilya Usoskin The heliosphere and Solar Wind	Julien le Sommer : Role of the oceans in the climate system: processes and time-scales
<i>12:30-14:00</i>	<i>Lunch (GreEn ER CROUS)</i>	<i>Lunch (GreEn ER CROUS)</i>	<i>Lunch (GreEn ER CROUS)</i>	<i>Lunch (GreEn ER CROUS)</i>	<i>Lunch (GreEn ER CROUS)</i>
14:00- 15:30	Jasa Calogovic A cosmic ray–cloud link and cloud observations	Evaluation panels	Samuel Morin Snow and Climate	Andreas Richter: Nitrogen oxides in the troposphere - sources, distributions, impacts, and trends.	Practicals
<i>15:30- 16:00</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>	<i>Coffee break</i>	
16:00- 17:30	Climate game Debriefing	Evaluation panels	Jed Kaplan The co-evolution of the Earth System and human civilizations over the preindustrial Holocene	Projet rework	
18:30	Debate/Café des Arts Isabelle Ruin "What is catastrophe of aleas?"				



WEEK 5: OBSERVATOIRE DE HAUTE PROVENCE (OHP) – day 1

Time	Sunday 31/01/2016
8.00	<i>Departure from Grenoble / residence Marie-Curie to OHP</i>
12.00	<i>Arrival at OHP "Maison Jean Perrin"</i>
12.30-14.00	<i>Lunch at Maison Jean Perrin (buffet)</i>
14.00-15.00	<i>Settling the participants in their rooms at Maison Jean Perrin</i>
15.00-15.45	Luc Favre: Presentation of the "Observatoire de Haute-Provence" (movie theatre)
15.45-16.00	<i>coffee break</i>
16.00-17.00	Sergey Khaykin : Lidar technique for Atmosphere observations (movie theatre)
17.00-18.00	Luc Favre: Astronomical observations at OHP and elsewhere
18.00-20.00	<i>Diner at Maison Jean Perrin</i>
20.00-21.00	Group 1: Astronomy on open sky (TBA) Group 2: 80 cm telescope (Luc Favre) Group 3: Visit of Observatory (Sergey Khaykin) Group 4: (pause)
21.00-22.00	Group 4: Astronomy on open sky (TBA) Group 1: 80 cm telescope (Luc Favre) Group 2: Visit of Observatory (Sergey Khyakin) Group 3: (pause)
22.00-23.00	Group 3: Astronomy on open sky (TBA) Group 4: 80 cm telescope (Luc Favre) Group 1 Visit of Observatory (Sergei Khaykin) Group 2: (pause)
23.00-00.00	Group 2: Astronomy on open sky (TBA) Group 3: 80 cm telescope (Luc Favre) Group 4 Visit of Observatory (Sergey Khaykin) Group 1: (pause)

WEEK 5: OBSERVATOIRE DE HAUTE PROVENCE (OHP) – day 2

Time	Monday 1/02
9.00-10.30	Irène Xueref-Rémy "Observing atmospheric gases " (movie theatre).
10.30-10.40	<i>coffee break</i>
10.40-11.20	Group 1 Practical on CO2 measurements (Irène Xueref-Rémy) Group 2 Atmospheric spectroscopy from scratch (Didier Voisin) Group 3 Practical on Lidar inversion (Sergey Khaykin) Group 4 Visit of Oak Observatory(Jean-Philippe Orts)
11.20-12.00	Group 4 Practical on CO2 measurements (Irène Xueref-Rémy) Group 1 Atmospheric spectroscopy from scratch (Didier Voisin) Group 2 Practical on Lidar inversion (Sergey Khaykin) Group 3 Visit of Oak Observatory(Jean-Philippe Orts)
12.00 -13.45	<i>Lunch at "Maison Jean Perrin"</i>
13.45-14.30	Luc Favre & Luc Arnold: Visit of the 1.93m telescope
14.30-15.10	Group 3 Practical on CO2 measurements (Irène Xueref-Rémy) Group 4 Atmospheric spectroscopy from scratch (Didier Voisin) Group 1 Practical on Lidar inversion (Sergey Khaykin) Group 2 Visit of Oak Observatory(Jean-Philippe Orts)
15.10-15.50	Group 2 Practical on CO2 measurements (Irène Xueref-Rémy) Group 3 Atmospheric spectroscopy from scratch (Didier Voisin) Group 4 Practical on Lidar inversion (Sergey Khaykin) Group 1 Visit of Oak Observatory(Jean-Philippe Orts)
15.50-16.10	Coffee-Break
16.10- 17.40	Philippe Keckhut: Observation of climate changes with NDACC instruments.
18.00-20.00	<i>Dinner at Maison Jean Perrin</i>
20.00-00.00	Visit to the lidars and observation with 0.80 m optical telescopes.
20.00-22.00	Group 3: 0.80 m optical telescope (Luc Favre) Group 4: Spectroscopic databases and their practical use (Marie-Renée De Backer-Barilly, Didier Voisin) Group 1 Ozone Lidars (Sergey Khaykin) Group 2 Temperature and wind lidars (Philippe Keckhut)
22.00-00.00	Group 2: 0.80 m optical telescope (Luc Favre) Group 3: Spectroscopic databases and their practical use (Marie-Renée De Backer-Barilly, Didier Voisin) Group 4 Ozon Lidars (Sergey Khaykin) Group 1 Temperature and wind lidars (Philippe Keckhut)

WEEK 5: OBSERVATOIRE DE HAUTE PROVENCE (OHP) – day 3

Time	Tuesday 2/02/2016
9.30-10.30	Lecture: Jean-Marc Ané: "Is nuclear energy sustainable" (movie theatre)
10.30-10.45	<i>Coffee break</i>
10.45-12.00	Lecture: Jean-Marc Ané: "Is nuclear energy sustainable" continued
12.00-14.00	<i>Lunch at Maison Jean Perrin (buffet)</i>
14.00-15.30	Marie-Renée De Backer-Barilly: Spectroscopic measurements of stratospheric constituents (movie theatre)
15.30-15.50	<i>Coffee break</i>
15.50-17.00	Visit to instruments and Data Analysis
15.50-16.20	Group 1: Dobson and SAOZ spectrometers (Marie-Renée De Backer-Barilly) Group 2: Lidars (Philippe Keckhut) Group 3 : Visit of the 120 and 152 cm telescopes (Luc Favre) Group 4 : Preparation of Ozone sondes (Sergey Khaykin)
16.20-17.00	Group 4: Dobson and SAOZ spectrometers (Marie-Renée De Backer-Barilly) Group 1: Lidars (Philippe Keckhut) Group 2 : Visit of the 120 and 152 cm telescopes (Luc Favre) Group 3 : Preparation of Ozone sondes (Sergey Khaykin)
18.00-20.00	<i>Dinner at Maison Jean Perrin</i>
20.00-00.00	Visit to the lidars and observation with 0.80 m optical telescopes.
20.00-22.00	Group 3: 0.80 m optical telescope (Luc Favre) Group 4: Spectroscopic databases and their practical use (Marie-Renée De Backer-Barilly, Didier Voisin) Group 1 Ozone Lidars (Sergey Khaykin) Group 2 Temperature and wind lidars (Philippe Keckhut)
22.00-00.00	Group 2: 0.80 m optical telescope (Luc Favre) Group 3: Spectroscopic databases and their practical use (Marie-Renée De Backer-Barilly, Didier Voisin) Group 4 Ozon Lidars (Sergey Khaykin) Group 1 Temperature and wind lidars (Philippe Keckhut)



WEEK 5: OBSERVATOIRE DE HAUTE PROVENCE (OHP) – day 4

Time	Wednesday 3/02/2016
10.00-10.40	Ozone balloon launch+coffee break
10.40-11.20	Group 3: Dobson and SAOZ spectrometers (Marie-Renée De Backer-Barilly) Group 4: Lidars (Philippe Keckhut) Group 1 : Visit of the 120 and 152 cm telescopes (Luc Favre) Group 2 : Preparation of Ozone sondes (Sergey Khaykin)
11.20-12.00	Group 3: Dobson and SAOZ spectrometers (Marie-Renée De Backer-Barilly) Group 4: Lidars (Philippe Keckhut) Group 1 : Visit of the 120 and 152 cm telescopes (Luc Favre) Group 2 : Preparation of Ozone sondes (Sergey Khaykin)
12.00-14.00	Lunch at "Maison Jean Perrin"
14.00-15.30	Projects. Final presentation.
15.30-16.00	Coffee-break
16.00-17.00	Projects. Final presentaion
18.00	Departure by bus to the Gala-dinner at Chateau Sauvan
18.30-00 .00	Visit of Château Sauvan guided by the family and Gala-dinner at Chateau Sauvan
00.00	Departure to OHP, Maison Jean Perrin



WEEK 5: OBSERVATOIRE DE HAUTE PROVENCE (OHP) – day 5

Time	Thursday 4/02/2016
9.00	Departure from Maison Jean Perrin to Grenoble
14.00 (indicative time)	Arrival to Grenoble Railway station.