ResClim / CRAICC course on "the physics and chemistry of atmospheric particles"

When: 19-23 November 2012
Where: Forskningsparken / University of Oslo
What level: Ph.D. students
Responsible: Dr. Andreas Massling, Prof. Jón Egill Kristjánsson

Background:

Some aerosol particles are emitted with the exhaust gases from traffic or in the plumes from power plants and other industries whereas others are formed from the condensation of gaseous pollutants. These particles are of anthropogenic origin. On the other hand, we find natural emissions of particles by sea spray processes over the oceans, or wind-blown dust from particular deserts, and bioaerosols emitted by the biosphere. Naturally emitted sulfuric gases from volcanoes as well as from algae in the ocean can also form sulfate particles. Particles emitted by biomass burning can either be of anthropogenic or natural origin.

Particles may act as active surfaces for heterogeneous transformations of gaseous pollutants, and gases and particles show intense interactions under atmospheric conditions in the real world. The impacts of atmospheric particles on global climate are a subject of scientific debate, as the knowledge on this subject is still mostly qualitative, rather than determined on a quantitative base. In the Arctic, where the current temperature rise is twice the global mean, physical and chemical processes seem to be more complex, so that knowledge from mid-latitudes cannot be extrapolated to the polar regions.

This aerosol course on atmospheric physics and chemistry will give a general insight into the fate of aerosols as they impact on our present and future climate. In addition, impacts that arise with regard to air quality and corresponding health effects will be discussed in one or two sessions as it is unavoidable to talk about air quality issues when explaining the fate of particles in the atmosphere.

Learning outcomes:

At the end of the course the students should be able to:

- sort out the importance of different climate aspects with relation to atmospheric particles
- describe principles and processes of importance to formation and transformation of atmospheric particles in the atmosphere
- describe interactions between gas and particle phase
- describe the main aspects of aerosol-cloud interactions in warm and cold clouds
- explain the basic techniques used in aerosol science in order to measure and analyze particulate matter
- evaluate and discuss the importance of human activities to air quality
- explain the basic techniques used in environmental monitoring
- synthesize collected material for discussion
- sort out and present relevant material to their peers
- write a basic scientific report

Scientific level:

Ph.D.

Methods:

Course preparation:

Prior to the course the students will have to prepare for the various sessions. This amount is budgeted with the working hours of a full week. Preparation material will be given 4 weeks prior to the course and will include the reading of book chapters or scientific papers. Additionally, a web-research or video watching via the web may include the course preparation.

Course

The course will comprise a total of 10 sessions, with each session consisting of 3 hours of teaching. Each session will be a combination of lectures, group work, exercises and short presentations prepared by the students. Lectures will be theoretically based, but will also introduce experimental techniques used in aerosol science as well as modeling tools used in atmospheric science. Group work will consist of, e.g. solving an exercise that is given by the teacher or preparing a presentation based on material which was given prior to the course.

Examination:

The students need to show that they meet the objectives of the course by preparing a presentation prior to the course and by preparing a final short and concise report after the course. The presentations will include the topics of one or two sessions that are taught during the course. The students will base their presentations on material given prior to the course and additional material, which they will have to select. Presentations should have a length of 15 min. plus 5 min. discussions. The report will be focusing on one or two of the sessions taught in the course, but has to be different from the sessions selected for the presentation. The total length of the report should be between 2000 and 3000 words excluding figures and tables. The report should be written in Times 12 pt, line spacing 1.5 lines, and 2.0 cm margins. The language must be English. Each report will be evaluated by two teachers of the course independently. The deadline for the report submission is 3 weeks after the course. This way the students can choose specific topics of personal interest and can demonstrate what they have learned during the course and how they meet the learning objectives.

Session 1:
General introduction to atmospheric particles - sources and sinks- anthropogenic aerosols.
Lecturer: Andreas Massling

This session gives a general introduction to the sources and sinks of particles in the atmosphere. Topics covered include the understanding of the emissions and dispersion of atmospheric pollutants and their implications for climate, visibility and human health. The lectures also provide a general introduction to atmospheric gas phase chemistry. Lectures cover subjects like emissions of atmospheric air pollutants, their lifetimes and their removal processes, while also natural aerosols will be discussed.

Session 2:
Atmospheric particles – physical properties.
Lecturer: Andreas Massling

This session introduces the students to the basic physical processes governing the fate of atmospheric particles concerning number concentrations, size, surface area, volume, morphology, etc. Lectures provide a detailed understanding of particle number size distributions and corresponding processes that include nucleation, condensation, coagulation, evaporation and deposition. Instrumental lectures present common measurement techniques in aerosol science and give an introduction to field studies, where these techniques are applied.

Session 3:
Atmospheric particles – chemical properties.

Lecturer: Andreas Massling

This session gives an overview of chemical properties of atmospheric particles. Both inorganic as well as carbonaceous/organic chemistry will be covered. The principles of chemical aging of aerosols during transport will be explained and investigated and the interactions between gases and particles will be studied. Instrumental lectures will present technical equipment developed for sampling as well as for chemical analysis of atmospheric particles.

Session 4:
The chemistry of the lower Arctic atmosphere
Lecturer: Henrik Skov

The Arctic environment is currently undergoing dramatic changes. This also has consequences for the atmospheric processes in the Arctic. Therefore it is very important to understand these processes. Lectures will have focus on the chemical processes in the atmosphere with main focus on the special processes in the Arctic. The fate of mercury and short lived climate forcers (CH_4, O_3, black carbon as well as other particle bound species) will be discussed.

Session 5:
Natural aerosols against geoengineering.
Lecturer: Andreas Massling

Natural aerosols comprise biological material, geogenic particles, oceanic emissions and particles originated from volcanoes. Lectures will present and explain the major contribution of natural aerosols to the total amount of particulate matter in the atmosphere. Different sources, their temporal occurrence and their impact on climate and health will be discussed to understand the fate of natural aerosols in the atmosphere. The principle of geoengineering will be presented and evaluated.

Session 6:
Global modelling of atmospheric particles
Lecturer: Michael Schulz

Atmospheric particles have become a major component in global chemistry transport models. The treatment of aerosols in these models is complex as they underlie a number of physical transformation processes that change the aerosol population continuously in a given air mass. In addition atmospheric particles interact with the gas phase not only changing the physical properties but also impacting on the chemical composition of the observed aerosol population. This session will give a general overview of how atmospheric particles are treated in global models.

Session 7:
Transport and transformation of atmospheric particles in the atmosphere.
Lecturer: Andreas Massling

More specific lectures address the transport and transformation of atmospheric particles. Subjects covered include aerosol aging during transport, depending on meteorological conditions and the presence of aerosol precursors. Specifically, particles are investigated as their properties change at ambient relative humidity. Their corresponding transformation in the atmosphere and their interaction with water vapor and the gas phase, cloud processes, evaporation and precipitation will be the foci of this session.

Session 8:
Effects of atmospheric particles with a special focus on the Arctic.
Lecturer: Andreas Massling

The lectures introduce the field of atmospheric air pollution and the corresponding effects of anthropogenic particles on global climate. The direct and indirect effects of aerosols will be introduced, as well as their implications to global change, viewed in relation to anthropogenic greenhouse gas forcing. An additional lecture is dedicated to the effects of atmospheric particles in the Arctic and their estimated impacts.

Session 9:
Aerosol-cloud interactions – from processes to modeling
Lecturer: Jon Egill Kristjansson

The lectures will address cloud droplet nucleation and ice crystal nucleation in the atmosphere, and how they are influenced by anthropogenic emissions. Also, cloud processing of aerosols will be discussed. Results from measurement campaigns will be presented with a special attention given to the Arctic. This will be followed by a description of how aerosol-cloud interactions are being treated in numerical models. Some recent results from modeling studies will be presented, ranging from large-eddy simulations (LES) to global climate models (GCMs).

Session 10:
Climate forcing and response of BC aerosols.
Lecturer: Terje Berntsen

Most anthropogenic aerosols are expected to contribute to negative climate forcing as they scatter solar radiation or increase the albedo of clouds through their involvement in cloud formation processes. These effects lead to a net cooling of the atmosphere. Black carbon (BC) is an important fraction of atmospheric particulate matter, too, and is known to contribute to positive climate forcing both by absorbing solar radiation directly in the atmosphere and through its deposition on snow and ice covered surfaces, thereby lowering their albedos. The climate response of BC aerosols will be discussed in detail in this session.

Additional session (only needed in case of absence of a teacher because of sickness, etc.):
Air quality, exposure levels of air pollutants, dose and adverse health effects
Lecturer: Andreas Massling

This session specifically focuses on the effects of atmospheric particles as they impact on air quality and thereby on human health. Lectures sharpen the general understanding of how particles reach the human body telling the story from emission of particles over their transport and transformation to their deposition in the human airways. Adverse health effects of various air pollutants will be discussed and put into context in relation to the ambient air quality legislation which is set by the European Union.