Roskilde (Denmark) Thursday, March 24, 2016

4th PhD Training School under the COST Action TD1105 EuNetAir on

"***Modelling, Methods and Technologies for Air Quality Control***"

The document provides a description of lectures under the 5 ECTS PhD course given at Aarhus University Campus Emdrup in Copenhagen (Denmark) on 19-22 April 2016. The order of the lectures may be changed in the days before the course is taken place due to conference (EGU and others) participation of some of the lecturers during some of the days in the same week as the course takes place. The students will be informed about these changes before the course. More details about the course are in addition given at: http://www.cost.eunetair.it/cost/documents/training.php?where=Copenhagen

Objective: to provide the students a general introduction to the physical and chemical processes governing air pollution loads and levels in the ambient environment. Give a basic understanding of the applied measuring techniques and mathematic models used in research and management of air quality and its effects on health and environment. To provide the students' knowledge on current and potential future uses of low-cost sensors in air quality monitoring and air quality management, and to train the students' in presenting research in posters at international workshops and conferences.

Methods: The course consists of twenty three lectures given by highly trained researcher and air quality managers in the field. Each lecture will be followed up by exercises. These exercises will be outlined in evening sessions on the first three days, but they are expected mainly to be carried after the course. In the morning lecture on day two to four, there will be given time for the students to ask questions and provide feedback on the previous day's lectures and activities. In addition to the lectures and exercises, the students will present their research during two poster sessions. The best posters in selected poster theme categories will be awarded with poster prices and a specific diploma. After the course, the students will carry out brief reports with the solved exercises, and upon return of the reports, the students will receive course diplomas with a mark for the course exercises (unless the students request a diploma that only states participation in the course). By the end of the course all students will be asked to fill in an evaluation with their personal view on the single lectures of the course and the course as such. The aim of this evaluation is to provide feedback to the lectures on how to improve future courses and lectures.

Background: Air pollution has a variety of negative effects on climate, human health and nature. Climate is affected by releases to the atmosphere of particles and trace gases that change the radiation balance. Adverse health effects in the population are the result of short-term as well as long-term exposure to air pollution. Nature is affected by atmospheric deposition of acid gases and aerosols that in certain areas leads to acidification of lakes and terrestrial ecosystems. Loss of biodiversity may be the results of depositions that lead to eutrophication of sensitive terrestrial and marine ecosystems. Exposure to ozone affects the growth of the vegetation, and makes it more vulnerable to other types of stress. WHO (2012) estimate that seven million premature deaths annually can be related to exposure to air pollution; about half of this due to ambient air pollution and the other half due to indoor air pollution.

The premature deaths are in addition to a variety of other adverse health effects. EEA (2015) estimate that more than half of the European terrestrial ecosystems receive atmospheric nitrogen inputs that exceed the critical loads and therefore on the long-term may lead to loss of biodiversity. Eutrophication problems are common in coastal waters world-wide and in worst case situations leading to turnovers followed by death of fish and benthic fauna. Atmospheric nitrogen inputs have been shown to contribute 30% or more, to many of these ecosystems. The course will have its main focus on pollution that may affect human health, but it will also introduce the students to effects on biodiversity and climate.

Work load: The course is a 5 ECTS course which means a work load of about 150h for the students. The lecturing takes place as a four days intensive course. Prior to the course the student are expected to have read the listed literature. Also prior to the course, the students are expected to prepare posters showing their research. During two of the evenings at the course the students are expected to present these posters to each other in posters in two poster sessions. After the course the students need to produce a written report with all calculation exercises from the course. Exercises may be solved in hand, by excel or by programming. In the material provided for the students there will be a short introduction to FORTRAN programming and links to a free of charge GFortran compiler. However, there are no demands regarding how the students solve the exercises given during the course. In the reports, the students are expected to add explanatory text to demonstrate that their understanding of the exercises.

Session 1: Introduction to air pollution. Lecturer: Professor Ole Hertel AU. This lecture will provide the students a basic introduction to air pollution. What is air pollution? What are the sources, and what kind of effects does it have on climate, health and environment? How do we abate the negative impacts? The student will be introduced to Integrated Monitoring - combining measurements and model calculations, Air quality guidelines, national emission ceilings (NEC) as well as other national and international agreements. The student will be introduced to air pollution health studies and briefly to studies on impact on biodiversity in sensitive ecosystems. This introduction will serve as an appetizer to the lectures that follow in the rest of the course.

Exercises: The students will be asked to write an essay of 2-3 pages on the main air pollution issues in their home countries.

Session 2: Air pollution Meteorology - impact on transport, deposition and dispersion. Lecturer: Senior Scientist Kaj Mantzius Hansen AU. The participants receive a basic introduction to turbulence and dispersion in the atmosphere, which is fundamental for understanding the dispersion and transport of air pollutants. Special focus will be on the boundary layer processes, atmospheric stability, mechanical and thermal turbulence, atmospheric radiation balance, vertical profiles in the basic meteorological parameters like wind speed, wind direction, temperature, pressure and humidity. Furthermore the course will introduce the students to local wind circulation systems like urban heat island, mountain – valley circulations and land - sea breezes. Examples will be given on how such local wind circulations affect the local pollution levels in various regions.

Exercises: The students will solve exercises that demonstrate the impact of atmospheric stability on local dispersion conditions.

Session 3: External costs of Air Pollution - outset in the Danish EVA model system. Lecturer: Professor Jørgen Brandt AU. Negative health effects related to exposure to air pollution are associated with substantial costs to society. The lecture will introduce the students to the methodologies behind the Danish EVA (Economic Valuation of Air Pollution) system for calculating externalities related to health effects of air pollution in Denmark and Europe. The lecture will take the students through the air quality models, the exposure - effect relationships, to the cost estimates of premature deaths, hospital admissions etc. Examples of results from the system will be outlined and discussed in context of political impact and public awareness.

Exercises: the students will be asked to write an essay of the perspectives, advantages and disadvantages, political impact and public awareness associated with the application of such systems.

Session 4: Atmospheric Chemistry - transformation in the atmosphere. Lecturer: Professor Ole Hertel AU. This session provides an introduction to the fundamental atmospheric chemistry. This includes the daytime hydroxyl-radical chemistry and the night time nitrate-radical chemistry, as well as the nitrogen oxide chemistry and the chain reactions leading to the formation of photo-oxidants. The students will be introduced to the possible reactions when air masses are leaving street canyons into the urban back ground and further what happens in the urban plumes down-wind from the urban area.

Exercises: The students will solve exercises related to the chemical transformations in the atmosphere.

Session 5: Atmospheric Chemistry - heterogeneous transformation in the atmosphere. Lecturer: Professor Ole Hertel AU. The session will provide an introduction to heterogeneous chemistry where gas phase compounds react on various surfaces including the surface of atmospheric particles. The students will hear about the impact of road dust resuspension, wood smoke particles and other anthropogenic and semi-anthropogenic particles, but also natural particles generated from sea spray, dessert dust, cloud, and rain and fog droplets and how these affect chemical transformations..

Exercises: The students will solve exercises related to the chemical transformations in the atmosphere.

Session 6: Atmospheric particles - physical properties - sources and sinks. Lecturer: Senior Scientist Andreas Massling AU. Some aerosol particles are anthropogenic and emitted with the exhaust gases from traffic or in the plume from power plants and other industries where as others are formed from the condensation of gaseous pollutants. Other particles are the result of natural emissions by sea spray processes over the oceans, wind-blown dust (e.g. from deserts), and bio-aerosols emitted by the biosphere. Particles emitted by biomass burning can either be of anthropogenic or natural origin depending on if the fires were natural or not. This session module will introduce the students to the basic physical and chemical processes governing the fate of atmospheric particles in the atmosphere; a detailed understanding of particle number size distributions will be given and processes that include nucleation, condensation, coagulation, evaporation, and deposition will be explained and followed by a discussion of sources and sinks of particles in the atmosphere.

Exercises: The students will work with log-distributions used in the presentation of particle measurements of mass and number concentrations.

Session 7: Atmospheric particles - chemical properties. Lecturer: Senior Scientist Andreas Massling. Depending on their origin and history, particles will have highly different chemical composition. Field and laboratory studies provide crucial information about the actual composition, and thereby also about the governing processes in the atmosphere. The students will be introduced to differences in chemical composition of particles in various environments: urban, rural and remote like the Arctic. The students will be introduced to various sampling and analysis methods that are used for these studies including the most recent equipment and the perspectives these provide in relation to know knowledge.

Exercises: The student will generate small simulation programmes that demonstrate some of the governing physical processes of atmospheric particles.

Session 8: Ambient air measurements - Air Quality monitoring. Lecturers: Senior Scientists Andreas Massling, AU. This session will introduce the students to the most common techniques currently applied in routine monitoring including integrated monitoring where measurements are combined with model calculations. The measurement techniques include remote sensing, automatic monitoring, but also techniques that involve analysis in the laboratory like sampling on filters and application of passive samplers. The students will be introduced to quality control and quality assurance. The students will be presented for photos for typical monitoring sites.

Exercises: The students will carry out an essay (2-3 pages) on air quality monitoring in their home country - current issues and perspectives in air quality loads and levels.

Session 9: Ambient air measurements - field studies and personal exposure monitoring. Lecturers: Senior Scientists Andreas Massling, AU. Various techniques are applied field studies of air pollutants. This session will introduce the students to the most common techniques currently available in process studies of air pollution, and to how the field studies are often linked up to and taking advantage of routine monitoring and modelling. The students will be introduced to differences in setup of field studies in various environments.

Exercises: The students will write an essay (2-3 pages) on issues related to various types of field studies and personal exposure monitoring.

Session 10: Local scale Air pollution modelling - plume models, urban scale and CFD. Lecturer: Senior Scientist Matthias Ketzel AU. The students will be introduced to the basic principles behind urban scale models, plume models, and Computation Fluid Dynamics (CFD) models. The most common parameterisations of the physical and chemical processes as well as the applied numerical techniques will be outlined. The session will include model validation studies, interpretation of results as well as estimation of uncertainties. The session will include examples of results from research and monitoring and assessment studies.

Exercises: The student will perform calculations using simple plume models.

Session 11: Local scale Air pollution modelling - street pollution modelling and human exposure assessment. Lecturer: Senior Scientist Matthias Ketzel AU. The students will be introduced to the basic principles behind street pollution modelling and human exposure assessment. The most common parameterisations of the physical and chemical processes as well as the applied numerical techniques will be outlined. The session will include model validation studies, interpretation of results as well as estimation of uncertainties.

Exercises: The students will perform calculations related to the nitrogen chemistry parameterisation in the Operational Street Pollution Model (OSPM) for urban street pollution.

Session 12: Regional scale to long-range transport Air pollution modelling – processes and methodologies. Lecturer: Scientist Ulas Im AU. The students will be introduced to Lagrangian and Eulerian models of long-range transport. The most common parameterisations of the physical and chemical processes as well as the applied numerical techniques will be outlined. The students will be introduced to nested grid techniques in current state-of-the-art Eulerian models like WRF-Chem and the Danish DEHM. The session will include model validation studies, interpretation of results as well as estimation of uncertainties.

Exercises: The students will solve exercises related to the differences between the concept of Eulerian and Lagrangian models.

Session 13: Regional scale to long-range transport Air pollution modelling - examples from specific research, monitoring and assessment studies. Lecturer: Scientist Ulas Im AU. The students will be introduced to Lagrangian and Eulerian models of long-range transport. The session will include examples of results from research and monitoring and assessment studies.

Exercises: The students will solve exercises related to the differences between the concept of Eulerian and Lagrangian models.

Session 14: Airborne volcanic ash. Lecturer professor Ole Hertel. In 2009 a volcanic eruption on Iceland lead to substantial emissions of volcanic ash. The releases had substantial impact on European air traffic for many days. The lecture will discuss monitoring and modelling efforts with outset in the specific event but also making links to other episodes of natural/semi-natural particle emissions.

Exercises: No specific exercises for this lecture

Session 15: Emission inventories – methodologies and results. Lecturer Senior Advisor Ole-Kenneth Nielsen AU. Methodologies in emission inventories are outlines in guidelines and based on various national, regional and local data sets and statistics. The inventories are crucial in comparing with National Emission Ceilings but also as essential input to chemistry-transport modelling. The session will introduce the students to the applied methodologies and selected results.

Exercises: No specific exercises for this lecture

Session 16: Agricultural air pollution. Lecturer professor Ole Hertel. Agricultural emissions affect health, nature and climate. The lecture will describe atmospheric emissions of nitrogen and how these affect nature, but also how these affect particle loading and thereby health of the population. Agricultural emissions of pesticides may affect health and ecosystems far from the sources.

Exercises: The students will calculate atmospheric nitrogen depositions for specific examples

Session 17: Health effects related to air pollution exposure - methodologies and results of assessments. Lecturer Professor Torben Sigsgaard AU. Health effects of air pollution are related to both short-term and long-term air pollution exposures. The students are introduced to the studies determining exposure - effect relationships applied in health effect assessments. Exposures may be determined on basis of routine monitoring data, local scale and personal exposure monitoring as well as by application of various air pollution models. Methodologies are described and recent results from exposure – effect relationships are presented.

Exercises: The students will make a brief essay on health effects related to air pollution in their home country.

Sessions 18 and 19: Air pollution Management - Impact on health and environment. Lecturer: Senior Scientist Steen Solvang Jensen AU. The students will be introduced to basic concepts, frameworks, methodologies and techniques within assessment and management of air quality in urban area. There will be an introduction to decision-support systems, use of externality estimation and cost-benefit analysis, and there will be provided examples of various assessment studies, analysis of field data and measurements from the routine monitoring, and scenario studies of the impact of various reduction strategies as well as the expected development in emissions.

Exercises: The students will use local scale models in specific assessment studies.

Session 20: Data-oriented analysis and modelling for air quality control. Lecturer: Associate professor Kostas Karatzas. This session will provide with basic knowledge on data analysis (descriptive statistics, trend analysis), and will explain multivariate correlation analysis and periodicity identification with the aid of FFT (1.5 hours). Then it will move towards computational intelligence methods, elaborating on Artificial Neural Networks for modelling (2 hours) and on Self Organizing Maps for data investigations and profiling (1.5 hours). Students will be asked to deliver solutions for small exercises involving AQ datasets (all or some of the aforementioned submodules can be included in this session).

Session 21: From AQ data to personalized Quality of Life Information services. Lecturer: Associate professor Kostas Karatzas. The availability of AQ information (resulting from monitoring networks, modelling and nowadays from embedded micro-sensors) has generated a pool of information that may be explored towards the creation of personalized, QoL information services. Participating students will be asked to work on the design of mockups for (i) a web-based information portal and on (ii) a personalized app for smartphones, making use of any type of available information related to AQ, including Earth Observation data, EEA archived data, local monitoring network data, modelling outputs etc. Special emphasis will be put on personal exposure and on “green city routes”. Students will be

asked to deliver a small report with “home town experience” on AQ related information services and on their favorite apps related to the environment (overall session duration of 3 hours).

Sessions 22 and 23: Airborne allergic pollution. Lecturer: PhD student Pia Viuf Ørby. About 20% of the European population suffers from hay fever which is today recognized as a mild version of asthma (that may later in life develop into more severe asthma). Pollen and fungal spore monitoring is still based on labor demanding techniques developed in the 1950s. Air pollution exposed to air pollution has been shown to be more allergenic than “clean” pollen, but most data on health effects of pollen are based on rather old studies. Modelling of pollen and fungal spores is complex due to little knowledge on emissions. The lecture will present results from new studies and discuss perspective in this research area.

Literature:

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Supplementary literature:

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Lecturers:

All lecturers at the 2016 course are taking place at:

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