Physico-chemistry of the atmospheric and air quality

Solène Turquety
3 ECTS – MU5SCA33

This course presents the mechanisms that control the composition of the atmosphere in the lower atmosphere, in remote and polluted environments. A first part introduces the basics of chemical kinetics and photochemical equilibria in the troposphere. The equilibrium of the stratosphere and the evolution of the ozone layer are then studied. The rest of the course is devoted more specifically to the understanding of the oxidative capacity of the troposphere and the composition and properties of atmospheric aerosols. The main processes involved in the development of air pollution episodes at urban and regional scales, as well as the tools used by the scientific community and air quality management services for air quality monitoring and forecasting, are then described. The specific structure of the boundary layer and the associated chemical and dynamical processes are detailed, including emissions, deposition and chemical evolution.
All aspects are introduced theoretically before providing a specific description of the practical application in modeling platforms. These models are presented in the context of current air quality policies in Europe and key issues are presented to understand the realistic abatement choices discussed for improving air quality and limiting climate change. Various current applications are described such as extreme case analysis, scenario studies up to operational forecasting, health impact assessment, chemistry-climate analysis.

Implementation
Tuesdays, 13h30-16h30 (note: there will be 2 sessions until 17h30).
Each course will be divided into a lecture and an associated tutorial with applied examples. In addition, students will work in groups on two practical projects:

- Numerical modelling project to understand chemical regime controlling photo-oxidant pollution episodes (ozone) in the Paris area;
- Data analysis project using the air quality observation network in the Paris area, as well as the observations from the Qualair station in Jussieu. Key questions will be: what variability in surface pollutants? what complementarities between observing systems?

Lectures will be given in English if one or more master student does not understand French.

Evaluation
Two reports (30% of final mark), final written exam (70% of final mark).

Course outline
1) Introduction and basics of atmospheric chemistry

2) Stratospheric composition
- Understanding the ozone layer
- Ozone hole development and recent trends

3) Tropospheric composition
- Gaseous atmospheric chemistry

    - The radical cycle
    - Photochemical equilibrium
    - NOx and VOCs chemistry
- Chemical regimes

4) Introduction to aerosols
- Characteristics of a population of aerosol: chemical composition and size distribution;
- Formation of secondary aerosols.

3) Modelling emissions, deposition, chemistry and transport
- General concepts and modelling choices: from box models to 3D Earth system models;
- Example with a numerical application.

4) Polluted boundary layer and air quality management
- Meteorological characteristics of the boundary layer
- Development of pollution episodes

5) Interactions between air quality and climate

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