Clouds, Aerosols and Precipitation

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3 ECTS

Clouds constitute the visible part of the water cycle in the atmosphere. They regulate precipitations and atmospheric water vapour, they interact with the surface and with pollution (e.g. by producing smog), they are one of the main modulators of the Earth temperature through their interaction with solar and telluric radiations. Aerosol particles play a significant role on air quality but also on climate through their interaction with radiation and clouds. Without aerosol particles, cloud formation in the atmosphere would not occur at the temperatures and relative humidities at which clouds are observed to exist.

This course provides key elements of aerosol, cloud and precipitation physics, from the small scale (the particles composing clouds) to the regional scale (a cloud system) and up to the global scales. It includes:

- Origin and chemical composition of aerosols
- Spatial and vertical distributions of particles in the atmosphere
- Microphysics of aerosols: brownian motion, coagulation, condensation, deposition, cloud nucleation
- Optical properties of aerosols
- Aerosol radiative forcing: direct, semi-direct, indirect, impact on snow and ice surfaces
- Water in the atmosphere: thermodynamics of moist air
- Microphysics of warm clouds: formation and growth of cloud droplets
- Microphysics of cold clouds: formation and growth of ice crystals
- Precipitation processes: Rain and Snow
- Optical properties of clouds
- Effect of clouds on radiations
- Cloud feedbacks and link with climate sensitivity.

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General outline

Lecture 1 : Cloud microphysics, H. Chepfer
Microphysical processes in warm/cold clouds (nucleation, vapor diffusion, collection, settling, phase mixing) and in ice clouds (vapor, liquid, precipitating liquid, ice, precipitation ice).

Lecture 2 : Overview on atmospheric aerosols, JC Raut
Origin, chemical composition, vertical distribution, microphysical processes, size distribution.

Lecture 3 : Cloud optical properties, H. Chepfer
Radiation-cloud particles interactions, optical properties of cloud particles (liquid droplets and ice crystals).

Lecture 4 : Clouds and radiation, H. Chepfer
Equation of radiative transfer in the atmosphere containing clouds; cloud albedo effect (cooling) and cloud greenhouse effect (warming).

Lecture 5 : Dynamics of aerosol particles, JC Raut
Brownian displacement, aerosol thermodynamics, coagulation, condensation, dry and wet deposition, aerosol and cloud droplets nucleation.

Lecture 6 : Clouds and climate, H. Chepfer
Response of clouds to natural and anthropogenic forcings. Cloud feedbacks mechanisms and link with climate sensitivity. Role of clouds on uncertainties on future climate predictions

Lecture 7 : Optical properties of an aerosol population, JC Raut
Radiation-particles interactions, aerosol scattering, absorption, refractive index and mixing state.

Lecture 8 : Aerosol radiative impacts, JC Raut
Direct, indirect, semi-direct effects, deposition on snow and ice surfaces.