

## Syllabus - Clouds and atmospheric convection

First part of the course, 10 sessions, taught by Caroline Muller  
(the second part of the course, 5 sessions, will be taught by Nicolas Rochetin).

### I Fundamental aspects of clouds

1. Definition, basic questions
2. Spatial distribution (online video "A year of weather")
3. Visualization from space, homework and online module from meted
4. Cloud classification: introduction

### II Dry thermodynamics

1. First law of thermodynamics (Bohren & Albrecht Chp1)
  2. Ideal gas law (Bohren & Albrecht Chp2)
  3. Mixture of gas, Dalton's law (Bohren & Albrecht Chp2)
  4. Hydrostatic approximation (e.g. Wallace & Hobbes Chp3)
  5. Joule's law, enthalpy (e.g. Wallace & Hobbes Chp 3)
- ⇒ Summary of equations in specific form (per unit mass)

### III Dry convection: application to the atmosphere

1. Potential temperature  $\theta$ , dry static energy, dry adiabatic lapse rate (Bohren & Albrecht Chp3)
2. Stability to dry convection, Brunt Väisälä frequency (Bohren & Albrecht Chp3)
3. Centrifugal convection (Emanuel Chp12, Houze Chp2)
4. Symmetric instability and slantwise convection (Emanuel Chp12, Houze Chp2)

### IV Entropy, second law of thermodynamics

1. Definition and link with  $\theta$  (Bohren & Albrecht Chp4)
2. Second law and stability (entropy maximisation) (Bohren & Albrecht Chp4)

### V Moist thermodynamics

1. Evaporation and condensation: the Clausius Clapeyron equation (Bohren & Albrecht Chp5&6)
2. Moist thermodynamic variables (Emanuel Chp4)

### VI Moist convection: application to the atmosphere

1. Convection of unsaturated moist air: virtual potential temperature (Emanuel Chp4)
2. Equivalent potential temperature  $\theta_e$ , moist static energy, moist adiabatic lapse rate (Emanuel Chp4; Bohren & Albrecht Chp6)
3. Skew-T diagrams, online module from meted
4. Conditional instability, CIN, CAPE
5. Life cycle of a convective cloud in an unstable atmosphere (Houze Chp8)

### VII Phenomenology of the different cloud types

1. Cloud classification (Houze Chp1)
2. Processes of cloud formation for each cloud type (Houze Chp5,6&7)
3. Link with the large scales

### BOOKS:

- "Atmospheric Sciences", Wallace & Hobbes
- "Cloud Dynamics", Houze
- "Atmospheric Convection", Emanuel
- "Atmospheric Thermodynamics", Bohren & Albrecht
- "Physics of Climate", Peixoto & Oort