MANFRED BRATH, WS 2021/22

ADVANCED RADIATION AND REMOTE SENSING: INTRODUCTION

CONTACT

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GOAL

- Course is a continuation of the course optics, radiation and remote sensing in the bachelor program.
- Get deeper knowledge in
  - remote sensing,
  - radiation and its interaction with the atmosphere,
  - and simulating radiative transfer with our radiative transfer model ARTS.
- After the course you should be able to use ARTS and the tools around it for your own projects.

CONTRIBUTIONS

- This course, its exercises and its material are based on/taken from the former “Advanced radiation and remote sensing” course of Prof. Stefan Bühler and several other contributors.

MODUS OPERANDI

- The course consists as a mixture of small lectures and a lot of practical exercises.
- The course is to be planned as to be interactive as possible with no strict difference between lecture and exercise.
  - **The main focus of this course are the exercises, for which we use our radiative transfer model ARTS and Jupiter (Python) notebooks.**

EXAMINATION

- Exam: Investigate a small remote sensing or radiation problem of your own choice.
- Hopefully, you will find some inspiration for a project during the course.
- You have to present your results in the last week of the course in a 10 minute presentation.
- Presentations will be graded, and the grade will be based on the criteria ambition level, originality, figure quality, and presentation quality.

PRACTICAL INFORMATION

Instructions on running the exercises on the DKRZ JupyterHub can be found online on our webpage at

https://collaboration.cen.uni-hamburg.de/display/RaRe/ARTS+Lecture.

RECOMMEND READING

- Liou, Kuo-Nan. An Introduction to Atmospheric Radiation. 2. ed. Academic Press, 2002. (Book/ebook: BIS für Erdsystem-forschung)
- or any other book about atmospheric radiation/radiative transfer.

OVERVIEW OF PLANED TOPICS

1. Absorption properties of the atmosphere
    - 1.1. Molecule spectra
    - 1.2. Line strength
    - 1.3. Line shape
2. Basic radiative transfer and remote sensing
    - 2.1. Brightness temperature spectra
    - 2.2. Jacobian and opacity rule
    - 2.3. Inversion (retrieval)
3. Radiation and climate
    - 3.1. Outgoing long wave radiation
    - 3.2. Heating rate
4. ...

SOME RECAP...

INTERACTION OF RADIATION AND MATTER

Electromagnetic (em) radiation has three kind of interaction with matter:

- absorption
- emission
- scattering

Each process depends in general on the state of matter and the frequency of the em radiation.

RADIATIVE TRANSFER EQUATION

The change of the spectral radiance (intensity) I along path s

- For most of the course, we neglect scattering.

$$\frac{\mathrm{d}I}{\mathrm{d}s} = -\kappa I + \alpha B(T) + \frac{\sigma}{4\pi}\int_{\Omega} IP\mathrm{d}\Omega$$

extinction

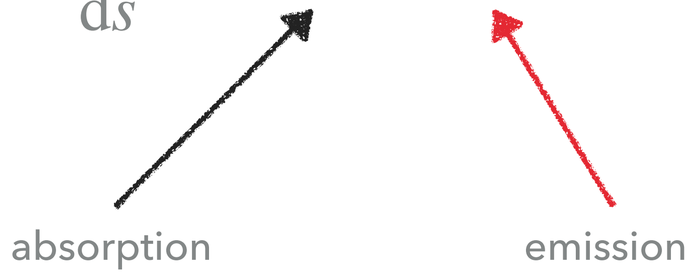
$\kappa = \alpha + \sigma$

emission

scattering

RADIATIVE TRANSFER EQUATION WITHOUT SCATTERING

$$\frac{\mathrm{d}I}{\mathrm{d}s} = -\alpha I + \alpha B(T)$$



- The absorption coefficient α describes the absorption of radiation within matter.

ABSORPTION COEFFICIENT

For the atmosphere considering only gases holds:

$$\alpha = \sum_{i}^{N_{gas}} \alpha_i = \sum_{i}^{N_{gas}} n_i \hat{\sigma}_{abs,i}$$

Absorption coefficient of constituent i in $[\mathrm{m}^{-1}]$

Number density of constituent i in $[\mathrm{m}^{-3}]$

depends on macroscopic state

Absorption cross section of constituent i in $[\mathrm{m}^{2}]$

depends on molecular spectral properties