MANFRED BRATH, WS 2022

ADVANCED RADIATION AND REMOTE SENSING: INTRODUCTION

CONTACT

- Manfred Brath
- Room 1535
- +49 40 42828 8786
- manfred.brath@uni-hamburg.de

TIME AND PLACE

- Start: Tue, 18/10/2022
- End: Thu, 08/12/2022
- Tuesday 14h30 and Thursday 12h00
- Room 1536c

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 Jupyter (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

- For the exercises, we use jupyter lab.
- To start jupyter lab for this course:

1. Log on “Lehre” using the thin clients.

   (At home or when using your own laptop see https://www.cen.uni-hamburg.de/facilities/cen-it/vdi/vdi-extern.pdf)

2. Open a console/terminal (check that you are in your home directory) and type:

   - `sh /data/share/lehre/unix/rtcourse/start-jupyter-rtcourse.sh`

   If run for the first time, it will download all the needed data, will create the folder “arts-lectures” inside your home directory and will start jupyter lab. Otherwise it will only start jupyter lab.

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 and shape
2. Thermal radiation and basic radiative transfer
    2.1. Brightness temperature spectra
    2.2. Opacity rule
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.

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

extinction

$\kappa = \alpha + \sigma$

emission

scattering

RADIATIVE TRANSFER EQUATION WITHOUT SCATTERING

- Schwarzschild equation

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

absorption emission

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

ABSORPTION COEFFICIENT

For the atmosphere considering only gases holds:

$$\alpha = \sum_{i}^{N_{gas}} \alpha_i = \sum_{i}^{N_{gas}} n_i \, \sigma_{abs,i}$$

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