

Optimised frequency grids for infrared radiative transfer simulations in cloudy conditions

Gerrit Holl

Stefan Buehler, Jana Mendrok, Ajil Kottayil

Luleå University of Technology
Kiruna Space Campus

Based on: Buehler et al., 2010, JQSRT; Holl et al., JQSRT, submitted **yesterday**

`gerrit.holl@ltu.se`

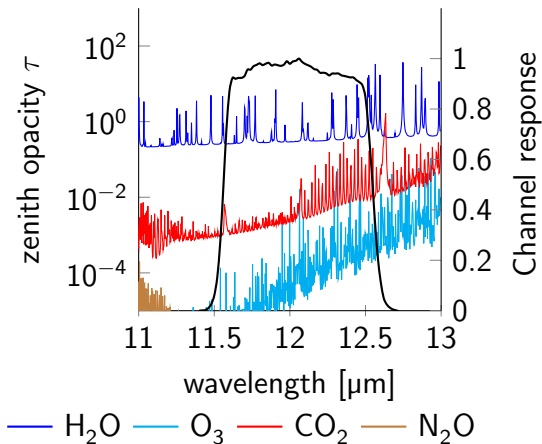
23 March 2012

Outline

- 1 The problem
- 2 Our radiative transfer model — ARTS
- 3 Our approach — Simulated Annealing (Buehler et al., 2010)
- 4 Analyses of optimised vs. full grid

The problem

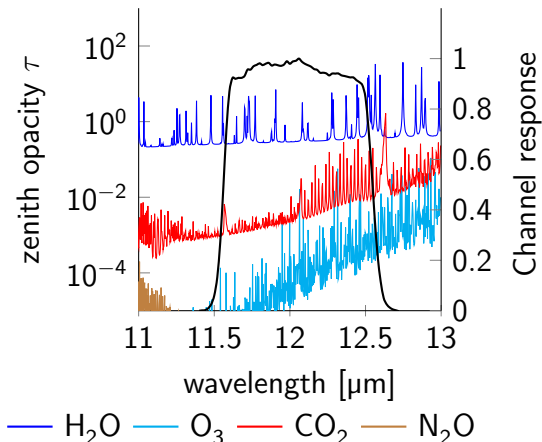
NOAA-19 AVHRR-5
and simulated opacity



- Radiative transfer simulation for infrared channel radiance
- Many frequencies, many lines
- Time-consuming

The problem

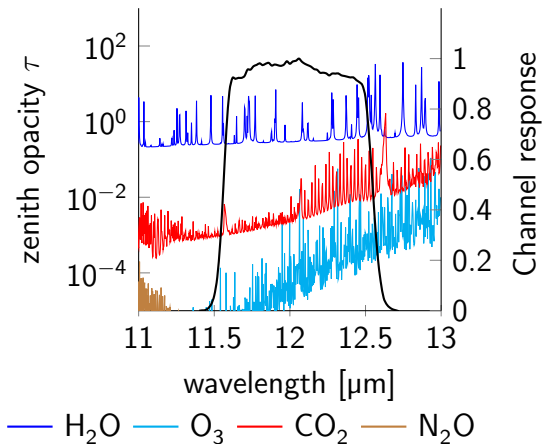
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ARTS

Atmospheric Radiative Transfer Simulator (Eriksson et al., 2011; Buehler et al., 2005)

The screenshot shows the website for ARTS. At the top left is the 'Satellite Atmospheric Science Group' logo. To the right are logos for 'KIRUNA SPACE CAMPUS', 'SRI - Division of Space Technology', and 'IRF'. Below these are navigation links: 'Home', 'Publications', 'ARTS', 'Projects', 'Education', 'Events', 'Education', 'Diversity', 'Search'. The main content area has a banner for 'ARTS - The Atmospheric Radiative Transfer Simulator' with a small graphic. Below the banner is a list of links: 'What is ARTS?', 'Science with ARTS', 'Getting ARTS', 'Documentation / Support', 'Related Tools', 'Automated builds', and 'Previous versions (ARTS 1.0)'. There is a 'News' section with a link 'Show all news' and a news item dated '2012-02-24' stating 'ARTS development moving on to 2.1, stable 2.0 version available in branch.' Below the news item is a paragraph: 'We would like announce that the development of ARTS in the Subversion trunk is moving on to version 2.1. If you like to stick with the latest stable version, we recommend that you switch to the new 2.0 branch. Head over to the "Getting ARTS" page to learn how to checkout the latest stable version.' At the bottom of the screenshot, there is a note: 'The version numbers of related tools like atrilab and PyARTS have been increased to 2.0 to reflect compatibility with the corresponding ARTS version. Downloaded information is available on the "Getting ARTS" page.'

- Freely licensed (GPL)
- IR, sub-mm, microwave
- Polarised 1-D – 3-D
- Two independent modules for treating scattering.
- Highly flexible
- Line-by-line with optimisations
- RTTOV validated to ARTS (English et al., 2003, ITSC-13)

www.sat.ltu.se/arts

ARTS

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Satellite Atmospheric Science Group

KIRUNA SPACE CAMPUS
SRT - Division of Space Technology

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ARTS
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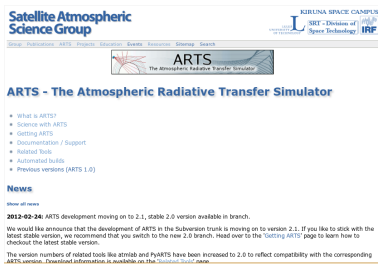
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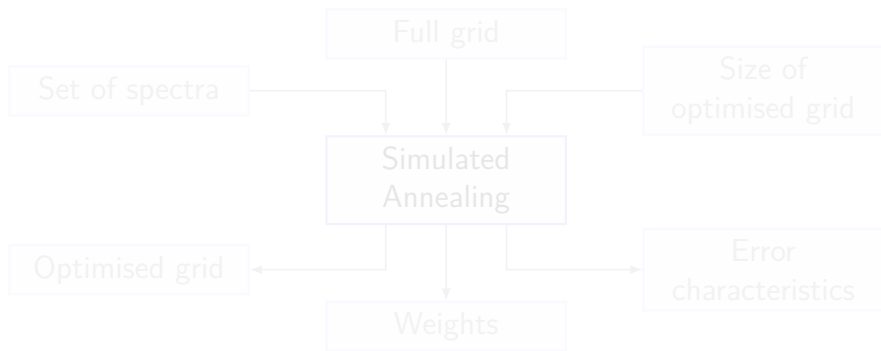
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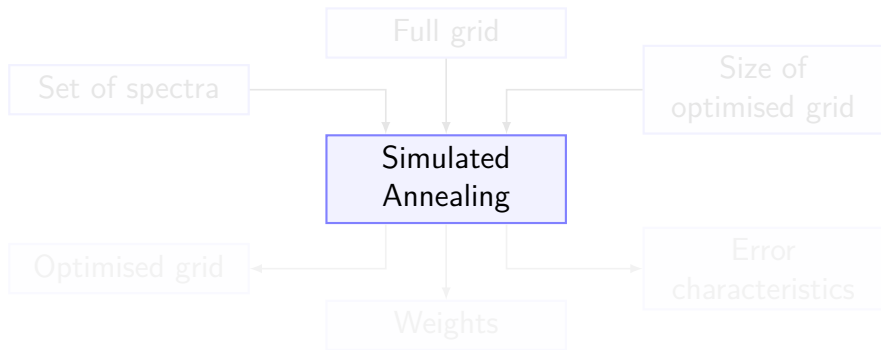
Simulated Annealing

- Aim: find optimised frequency grid with much (factor 100 to 1000) less frequencies than full grid
- Method: simulated annealing (Buehler et al., 2010, JQSRT)
- Code publicly available (Matlab)



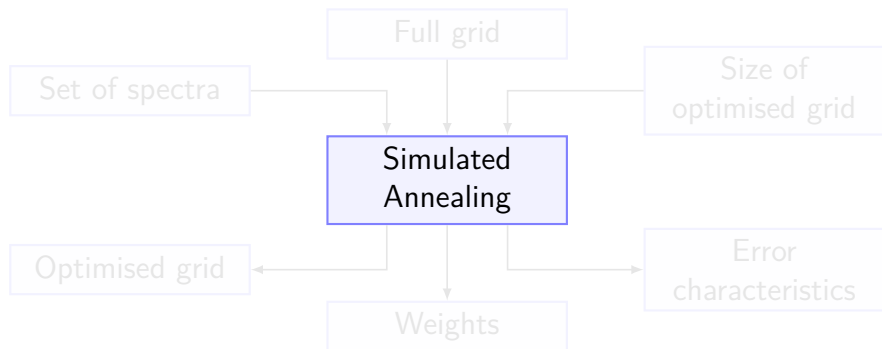
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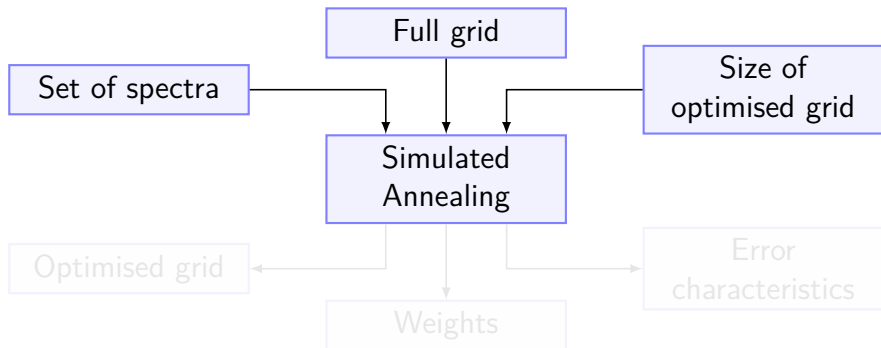
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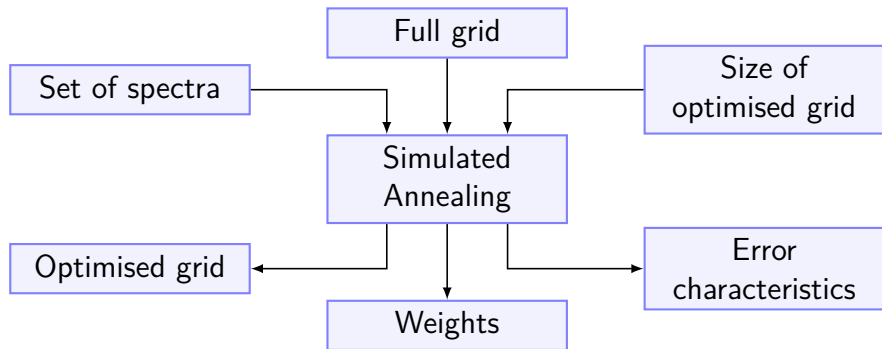
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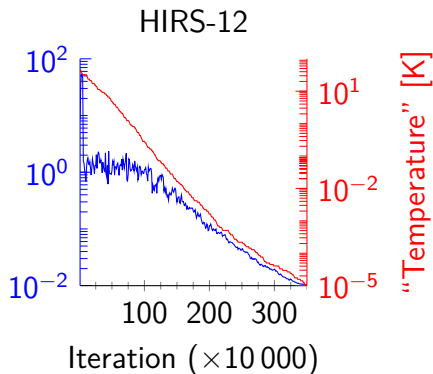
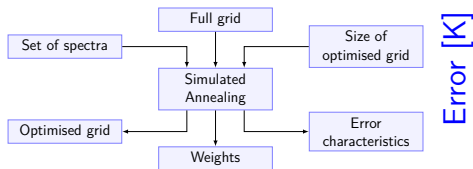


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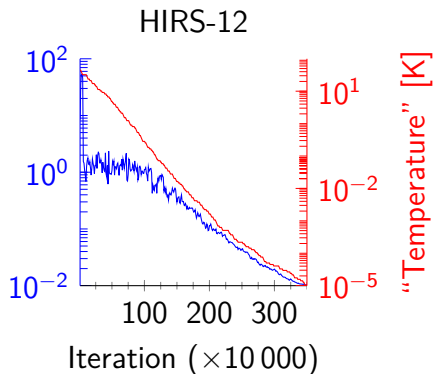
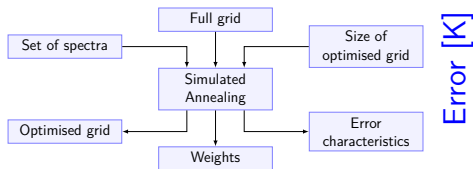


One annealing run



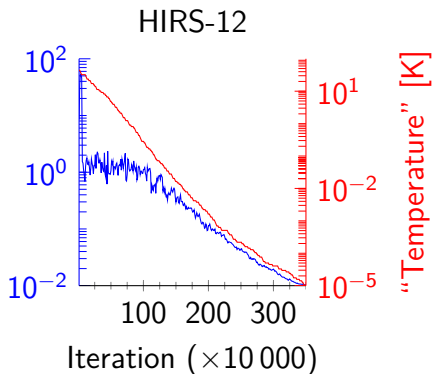
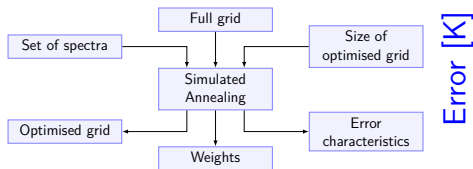
- Derivation using clear-sky dataset with 42 profiles (Garand et al., 2001)
- Annealing took 15 hours on workstation for one channel
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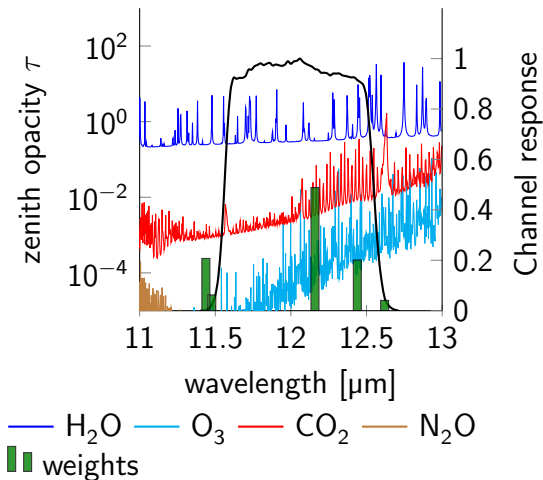
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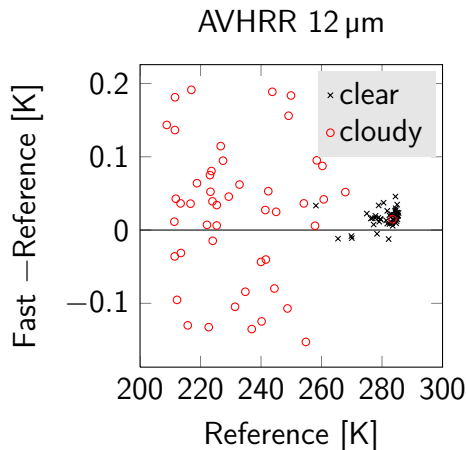
The solution

NOAA-19 AVHRR-5
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Optimised vs. full grid

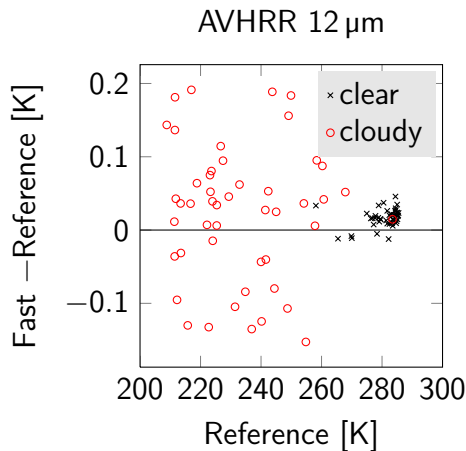
Clearsky or cloudy



- **Derived clear-sky**
- Testing for clear and cloudy (cloudy with ARTS-MC)
- Using ECMWF-based dataset (Chevallier et al., 2006)
- Only small bias
- Optimised 10 × faster (for same no. photons per channel)

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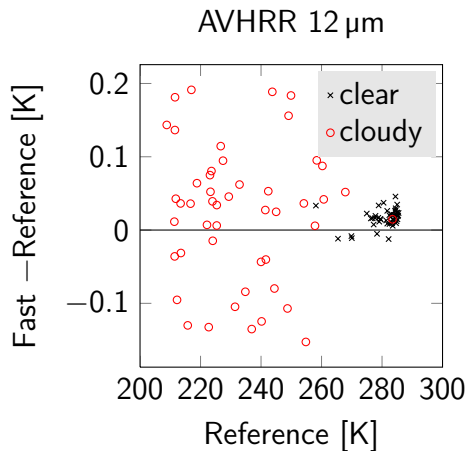
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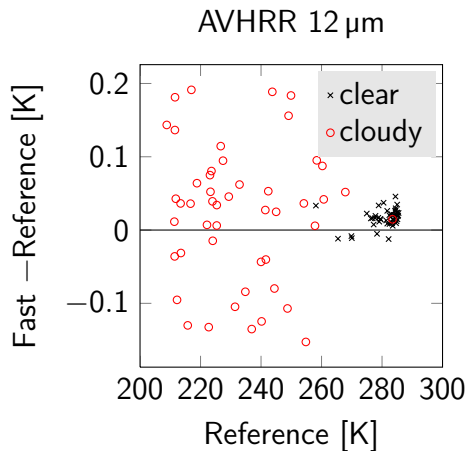
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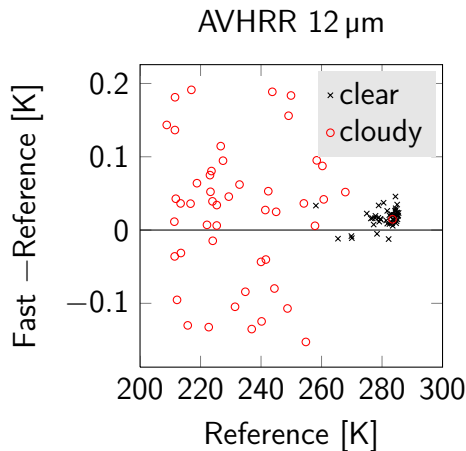
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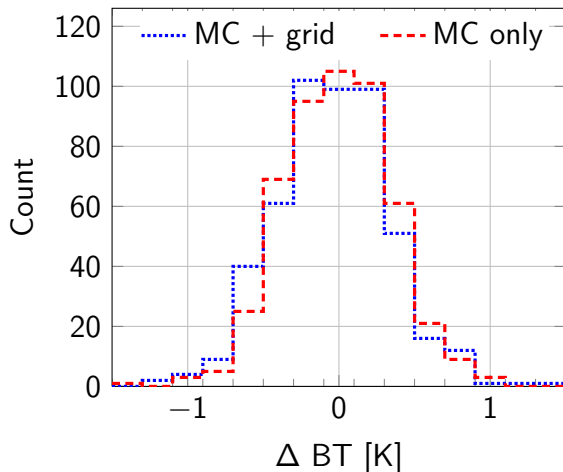
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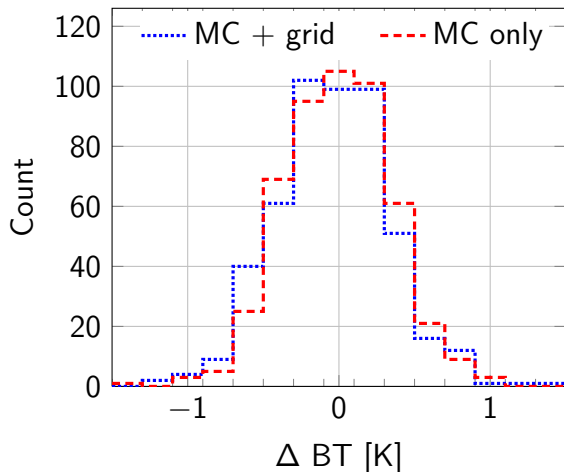
HIRS-11 error characteristics



- Variability due to Monte Carlo
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- Optimised grid represents full grid for cloudy

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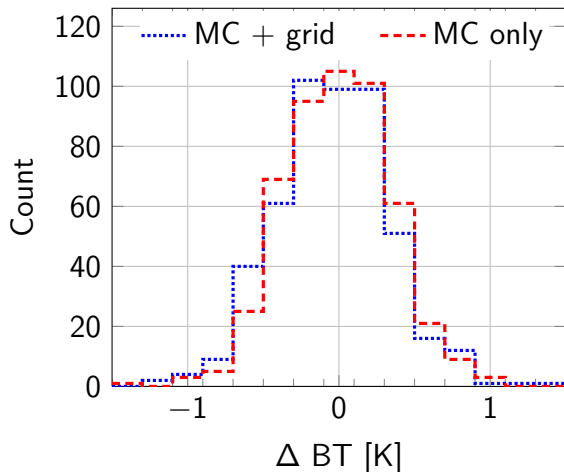
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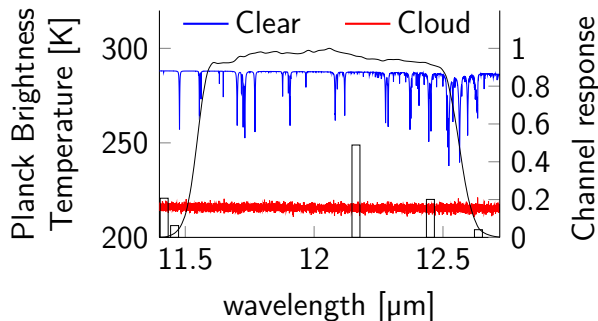
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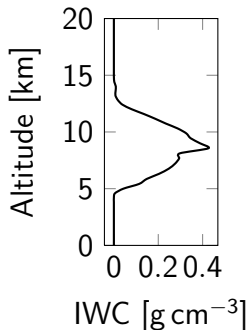
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Spectrum

AVHRR-5 spectrum,
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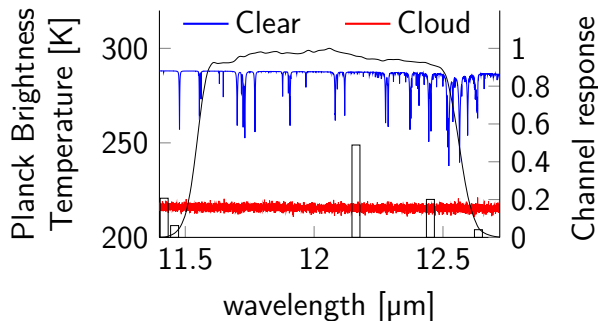
IWC profile



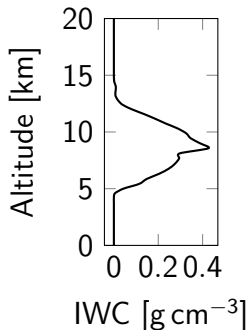
- Gas optical properties spectrally strongly varying
- Cloud optical properties spectrally quite flat
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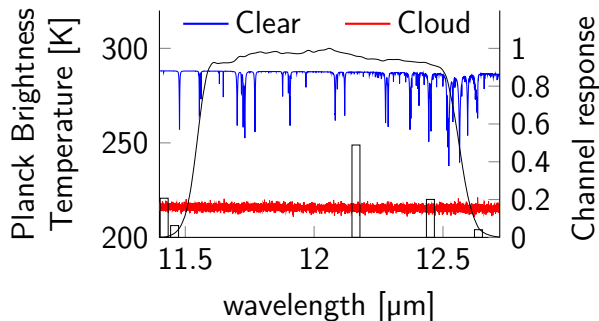
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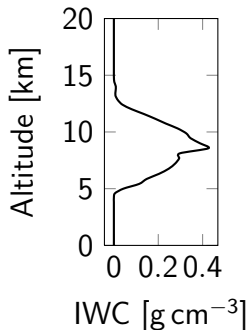
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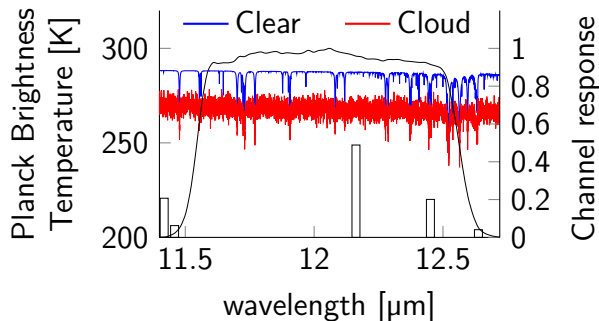
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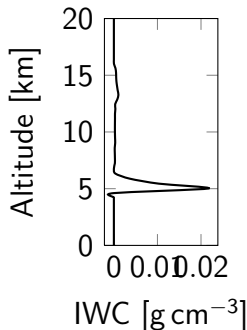
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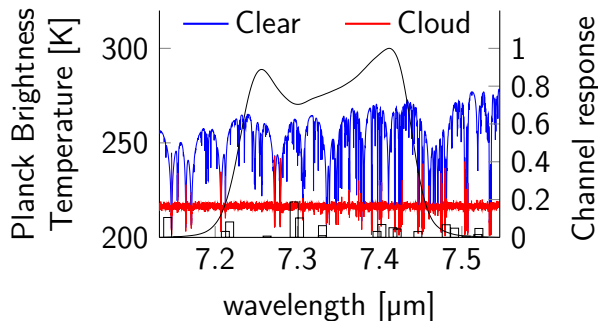
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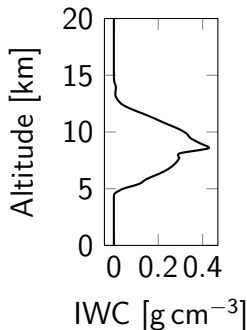
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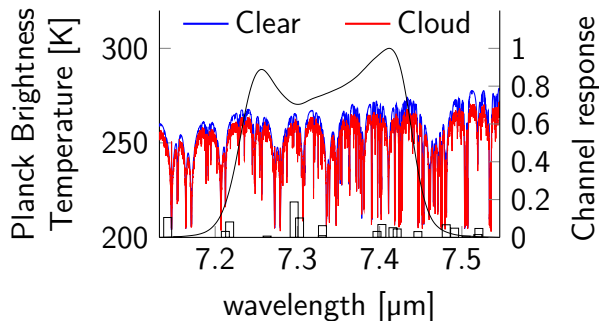
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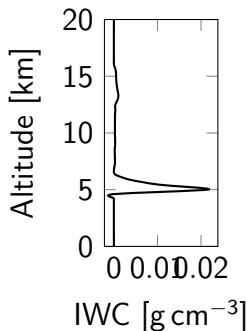
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- Results applicable to other sensors or models
- Speed allows for doing retrievals

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Thanks

Thank you for your attention.
Questions?

Bibliography I

- Buehler, S. A., Eriksson, P., Kuhn, T., von Engeln, A., and Verdes, C. (2005). ARTS, the atmospheric radiative transfer simulator. *J. Quant. Spectrosc. Radiat. Transfer*, 91(1):65–93.
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