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Titolo:
Characterization of the Antarctic atmosphere with (mostly) optical methods: the COMPASS project

Relatore:
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Outline

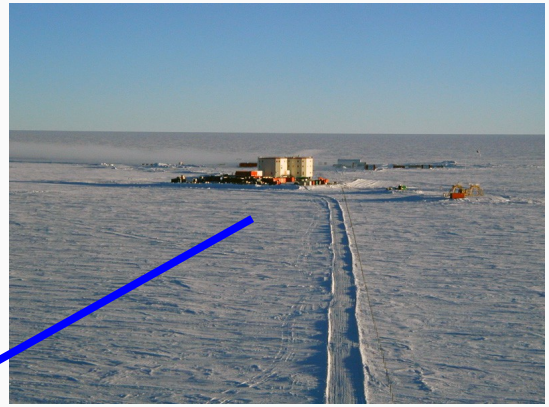
- Introduction: studying the Antarctic atmosphere
- The Physics Shelter at Concordia station, an atmospheric physics laboratory in Antarctica
- The REFIR infrared spectroradiometer
- Water vapor and climate: studying the vertical structure of the Antarctic troposphere
- Cirrus and Climate: analysis of the radiative properties of cirrus in the far-infrared

The Antarctic atmosphere

Antarctic Plateau:

- Extremely low amounts of water vapor (due to low temperatures and high altitude).
- Absence of orographic features provide an unperturbed system over several hundreds of kilometers.

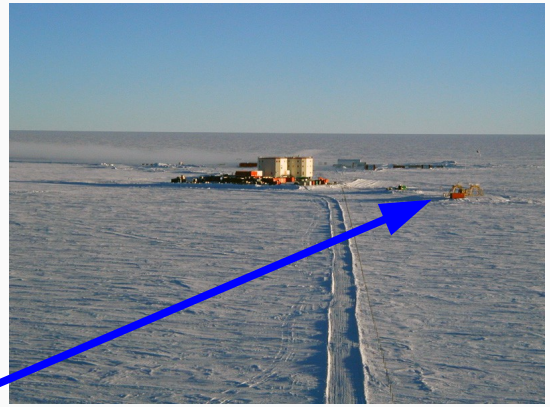
Concordia Station



Italian-French base:
Concordia Station
3.200 m a.s.l.
75° S, 123° E

The Physics shelter

An Italian-French atmospheric physics research laboratory in the middle of the Antarctic plateau...



- HAMSTRAD μW radiometer (Meteo France)
- SAOZ UV radiometer (LATMOS-IPSL)
- REFIR-PAD spectroradiometer (INO-CNR)
- Tropospheric LIDAR (INO-CNR)
- Stratospheric LIDAR (ISAC-CNR)
- ICE-CAMERA (INO-CNR)
- AWS, Sky cameras, GPS

The COMPASS project

COncordia Multi-Process Atmospheric StudieS

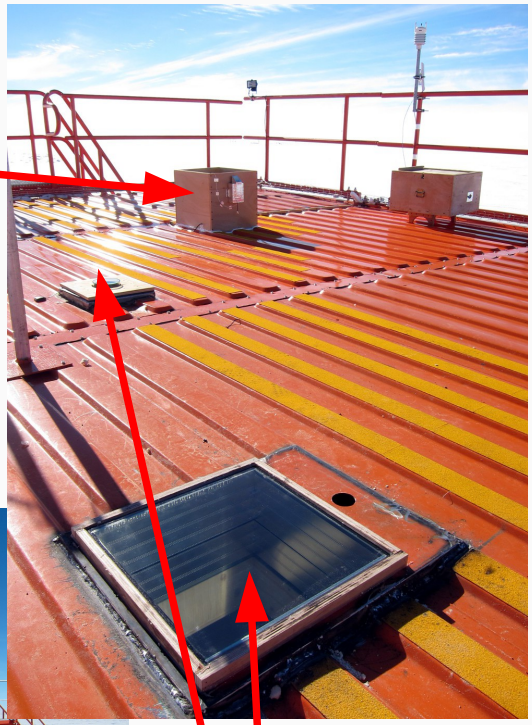
Remote sensing with optical (& sonic) methods

- Planetary boundary layer: structure, composition, meteorology (SODAR, IR spectrometer, radiometers, sonics)
- Troposphere: radiative properties and microphysics of clouds and water vapor (tropospheric LIDAR, IR spectrometer)
- Stratosphere: monitoring of the ozone column during night time (stratospheric LIDAR, IR spectrometer)

The COMPASS setup

Surface-Layer
Mini **SODAR**
(in a dedicated shelter)

REFIR
Infrared
FTS
(Physics
shelter)



IR and VIS-UV
radiometers, sonic
anemometers, AWS
(Physics shelter)

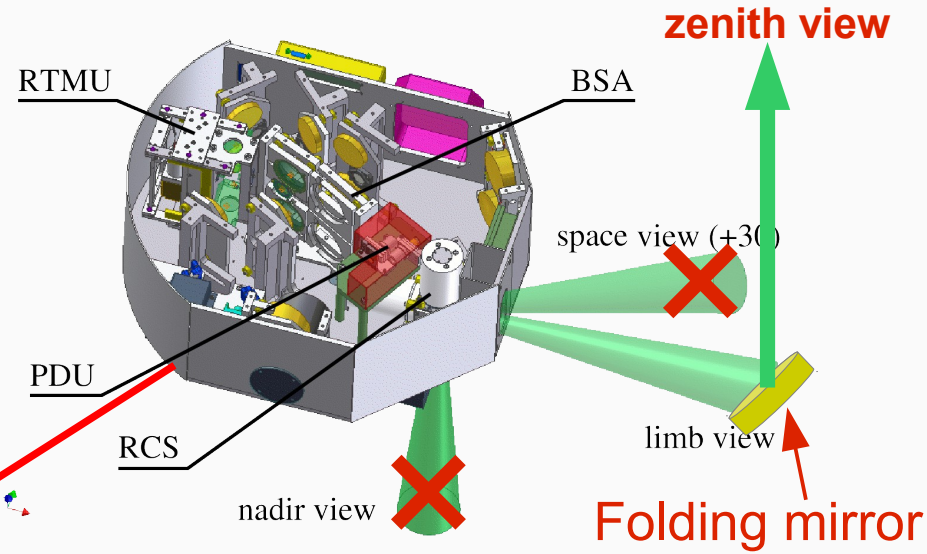
2 **LIDAR**s
(Physics
shelter)

Making measurements at Concordia

Antarctic installation issues:

- **Continuous operation**: a significant dataset can be built only if measurements extend beyond the ~3 months of summer season.
- **Autonomous, (almost partially) unattended operation**: during 9 months a year the station operates with a reduced crew and in extreme environmental conditions → very limited possibilities of human intervention on the instrument.
- **Thermal control problems**: not only the expected (i.e. low temperatures), but more often overheating problems due to inefficient heat dissipation and packing of instrumentation in small spaces...
- **Small (if any) bandwidth for data transfer**: data link provides 512 kbps to share between all scientific projects and crew → need for local storage of large amount of raw data and on-line data analysis.

REFIR-PAD FT spectroradiometer



Compact, self-contained FTS with 100 – 1900 cm^{-1} spectral range and up to 0.25 cm^{-1} spectral resolution

- **Room temperature operation**
- **On board radiometric calibration**

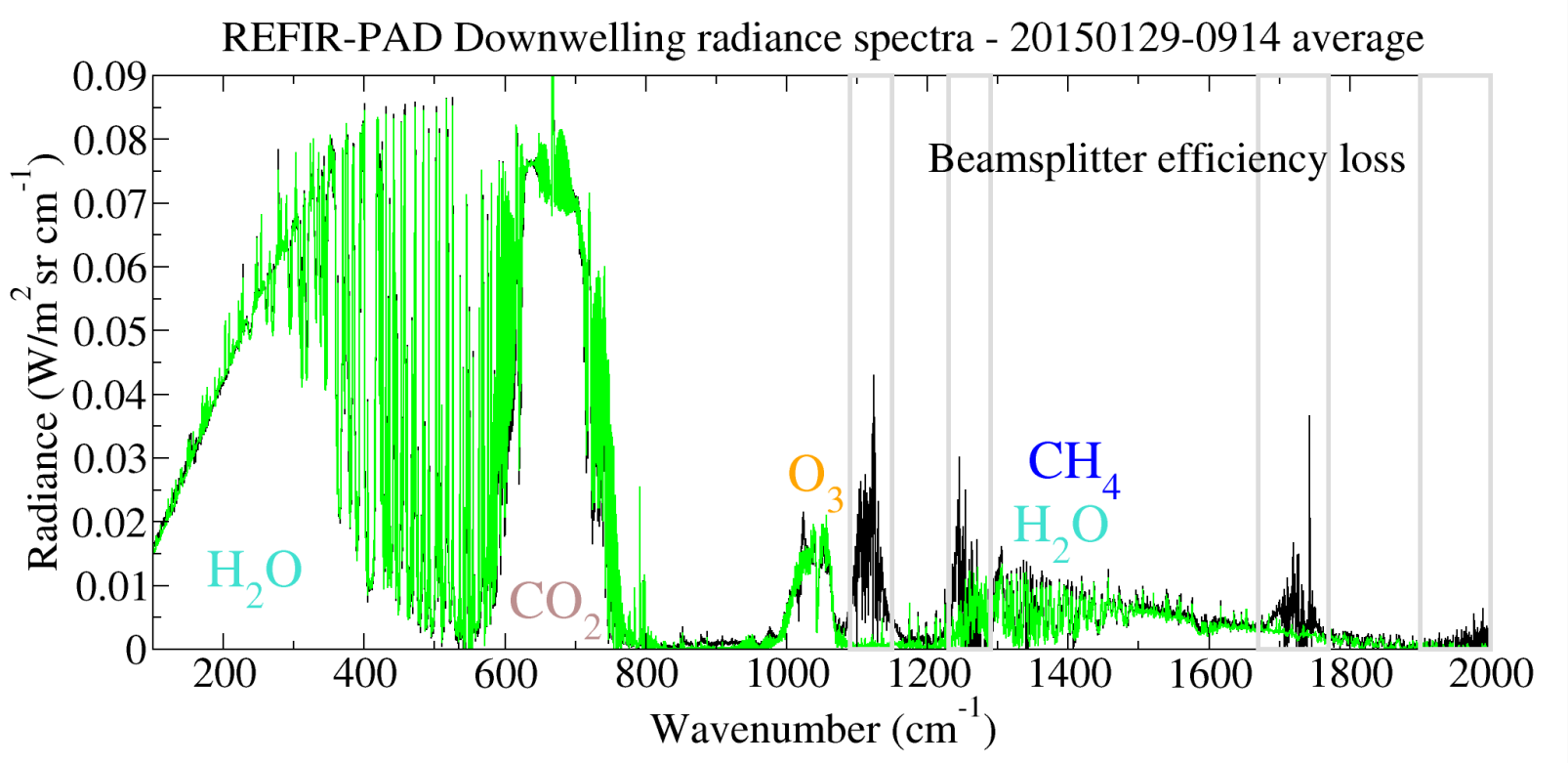
REFIR-PAD @ Concordia Station

REFIR-PAD measurement capabilities:

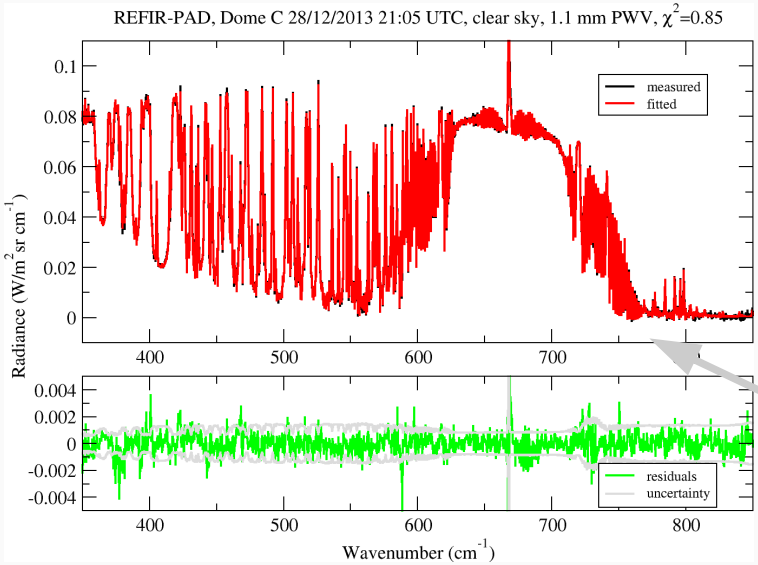
- **Spectrally resolved radiometry**: characterization of the Earth's radiation budget with the possibility to separate and evaluate the different contributions due to water vapor, greenhouse gases, clouds.
- **Composition and structure of the atmosphere**: through the inversion of spectral data it is possible to retrieve vertical profiles of water vapor and temperature, cloud optical thickness and columnar values of other atmospheric constituents.
- **Radiative signature of clouds**: in the particular case of thin clouds like cirrus, the contribution to ERB is still to be understood and characterized systematically (**NEXT TALK, Gianluca Di Natale**).

Spectrally resolved radiometry

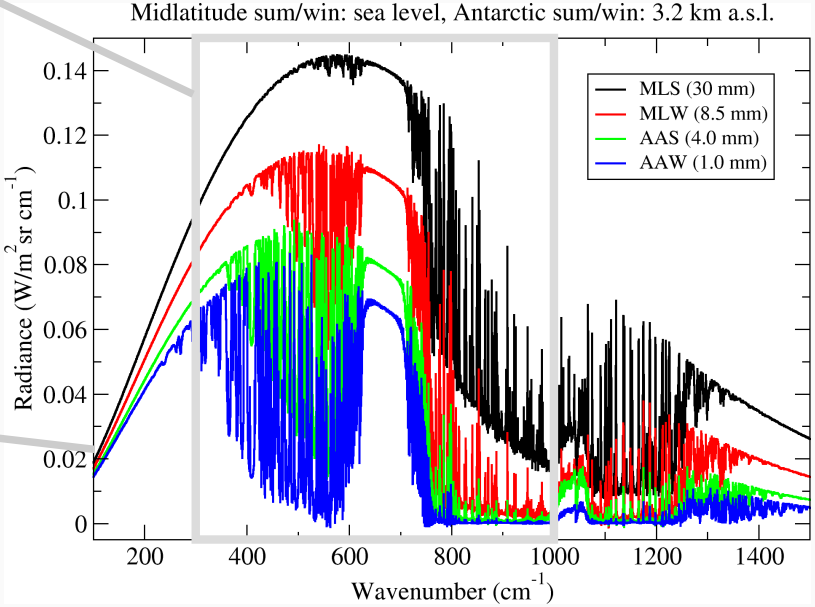
Almost the **entire Earth's thermal emission spectrum** is measured, providing *vertical tomographic information* on atmospheric composition.

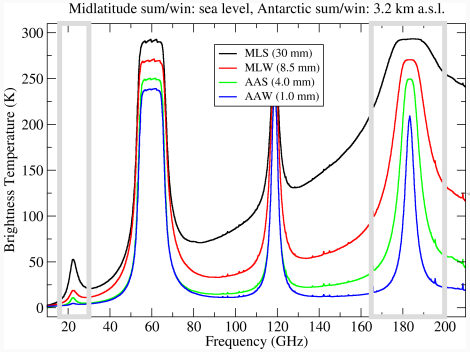


REFIR-PAD data analysis



- LBLRTM v. 12.0 forward model
- MINUIT routines (from CERN) to perform χ^2 minimization
- Fitted variables: **5 atmospheric levels per profile (H_2O, T), cloud optical thickness,** ILS, frequency correction

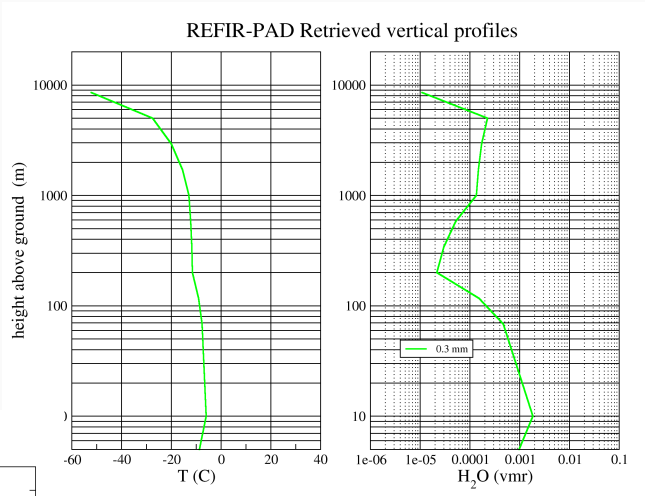




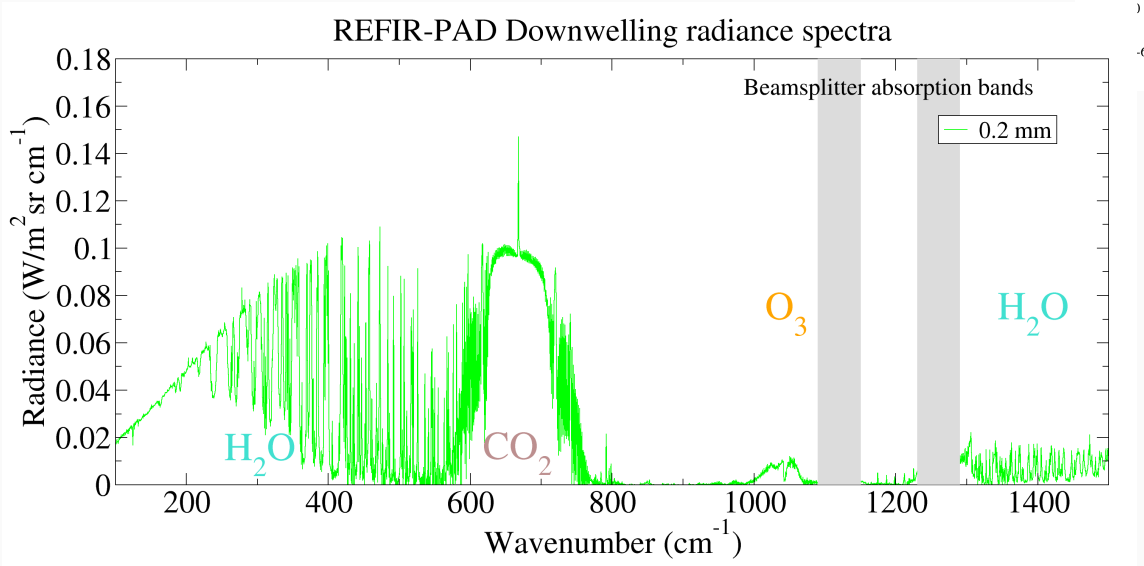
microwave radiometer windows

REFIR-PAD measurement capabilities

More than 2 orders of magnitude in PWV: between atmospheric window and water vapor rotational band there are always strong and non saturated water lines.



Retrieved profiles



Measured downwelling radiance spectrum

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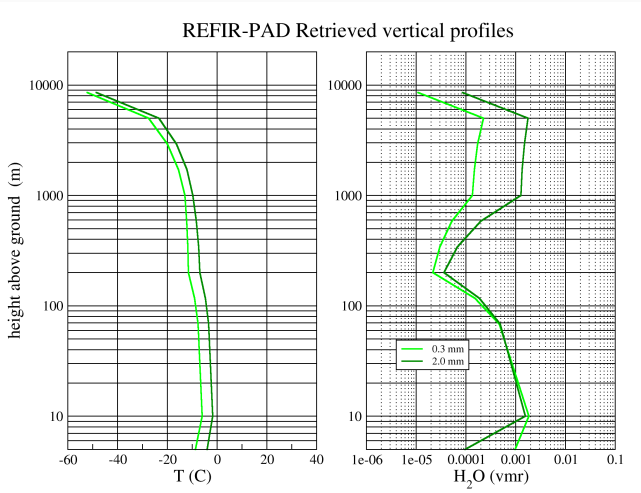

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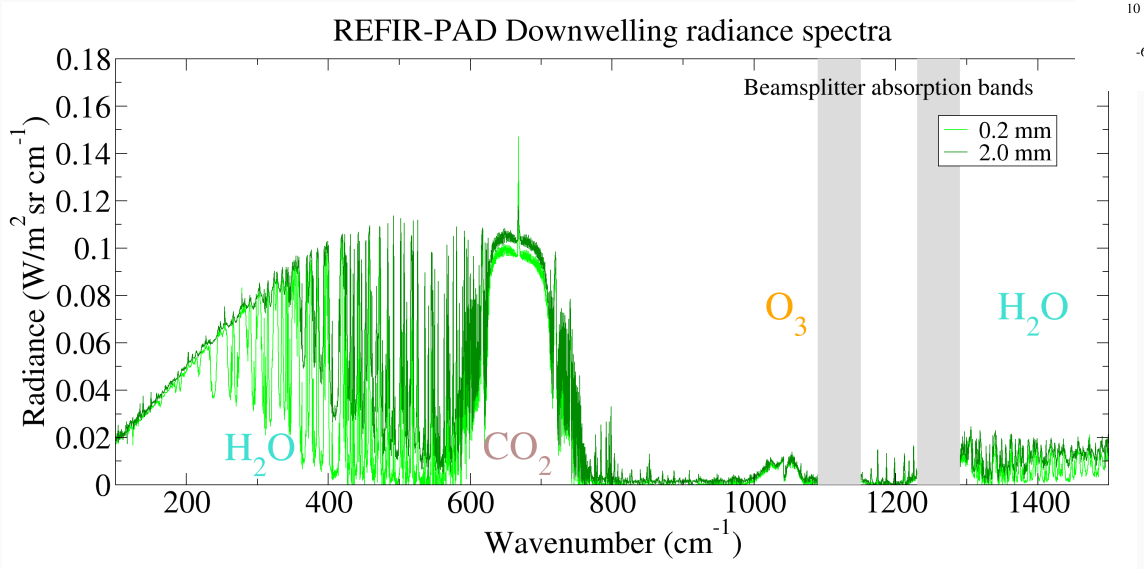

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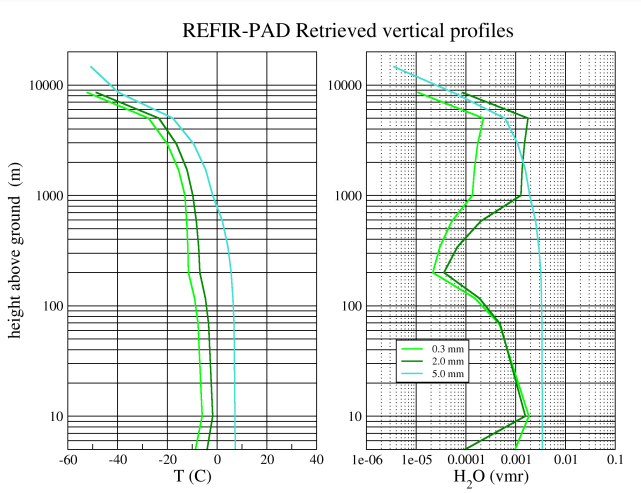

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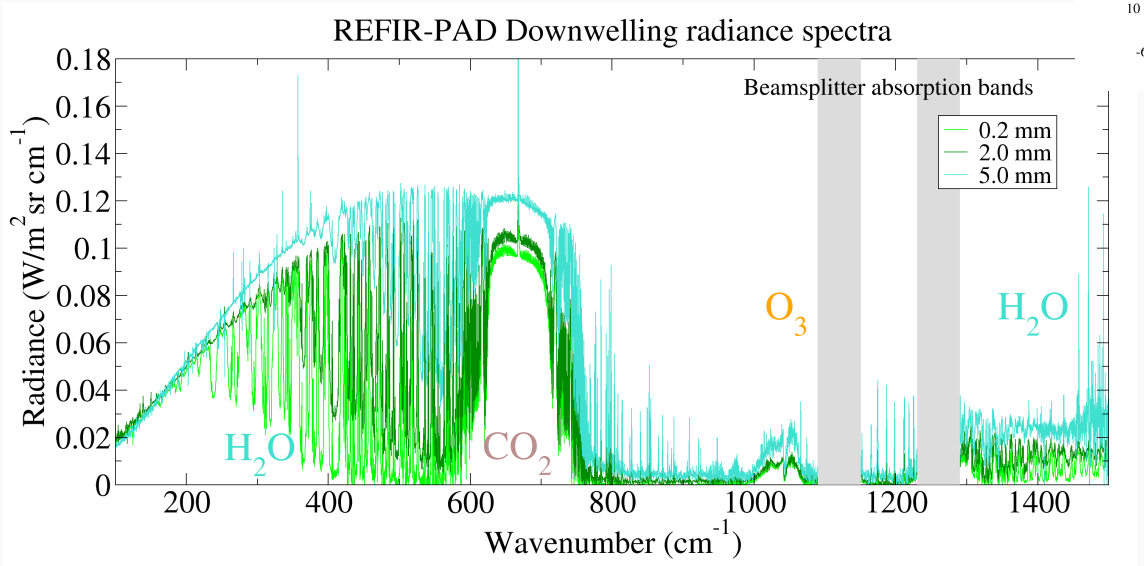

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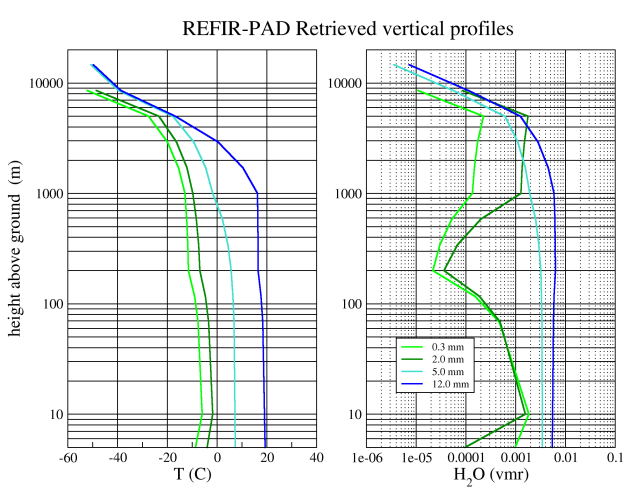

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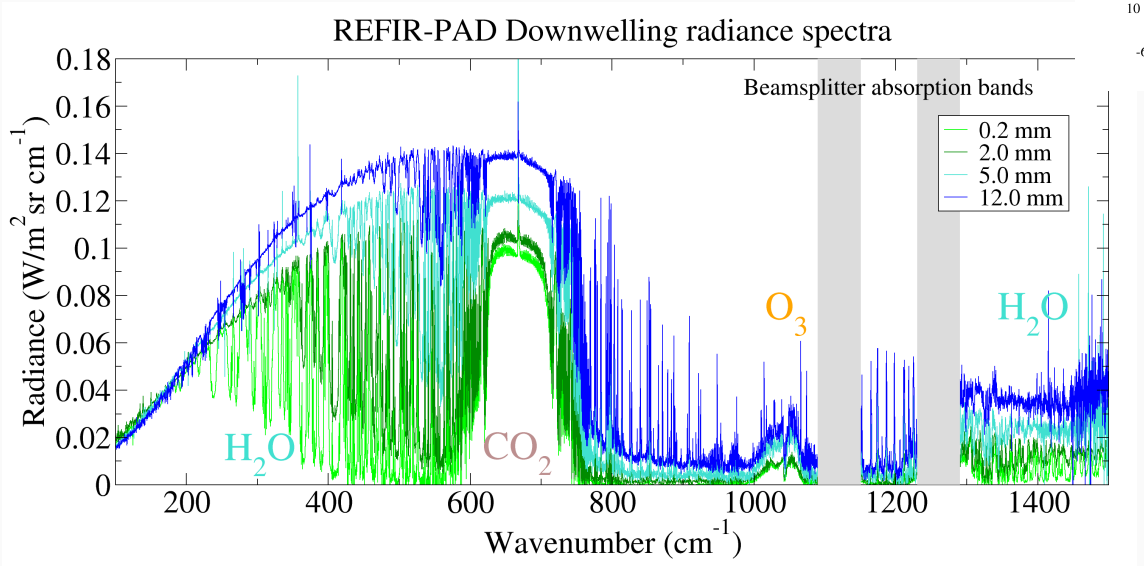

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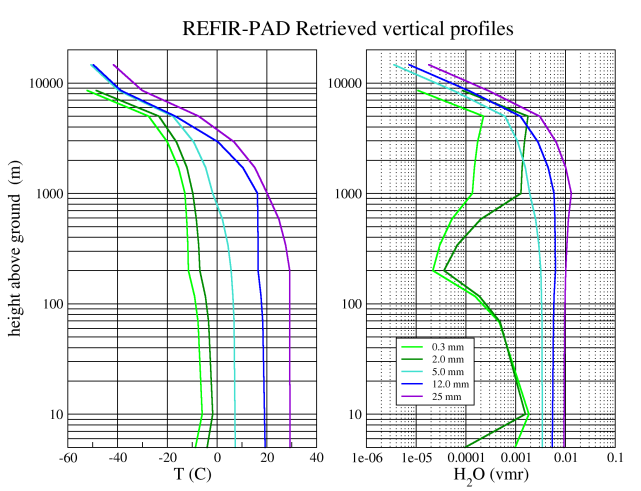

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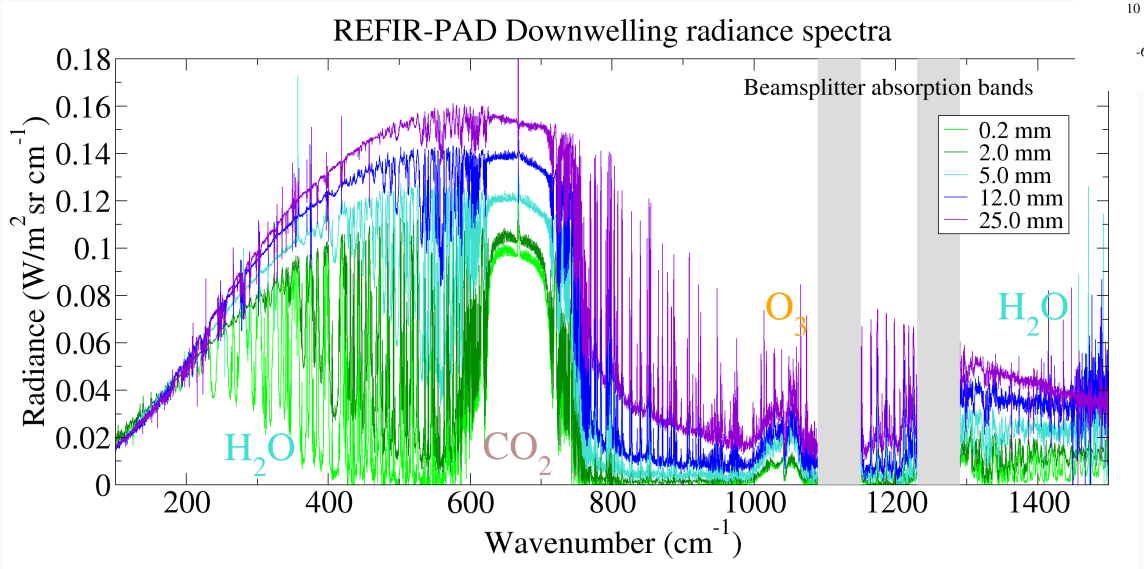

Measured downwelling radiance spectrum

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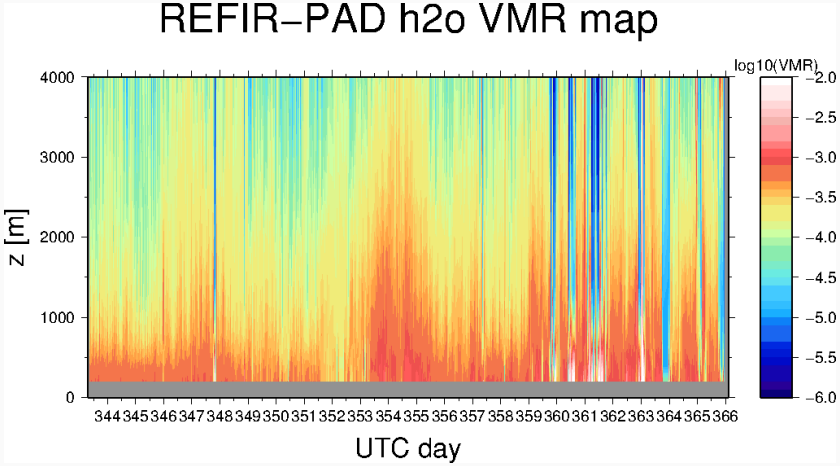
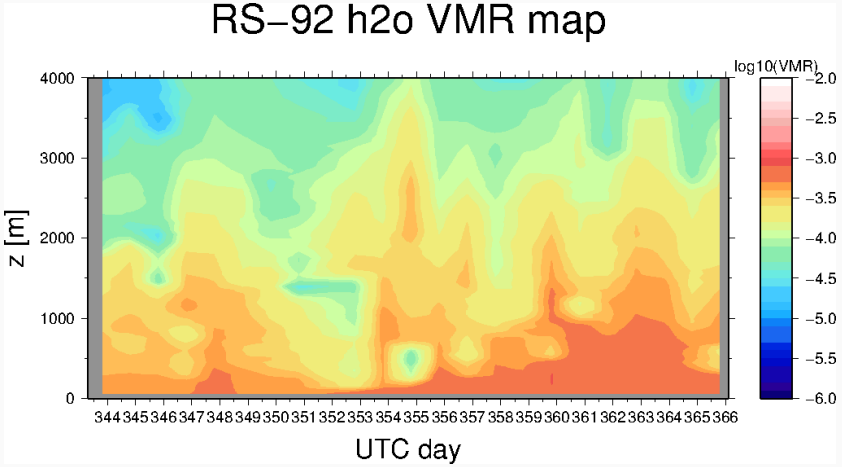
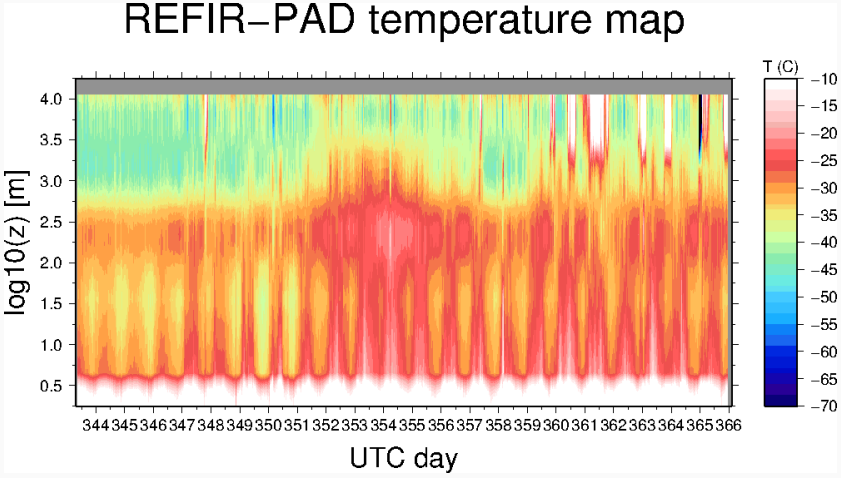
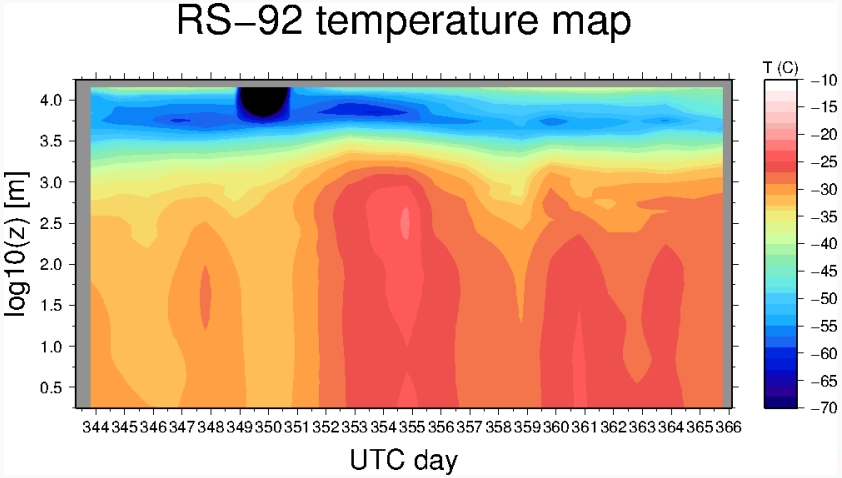
Water vapor & temperature profiles









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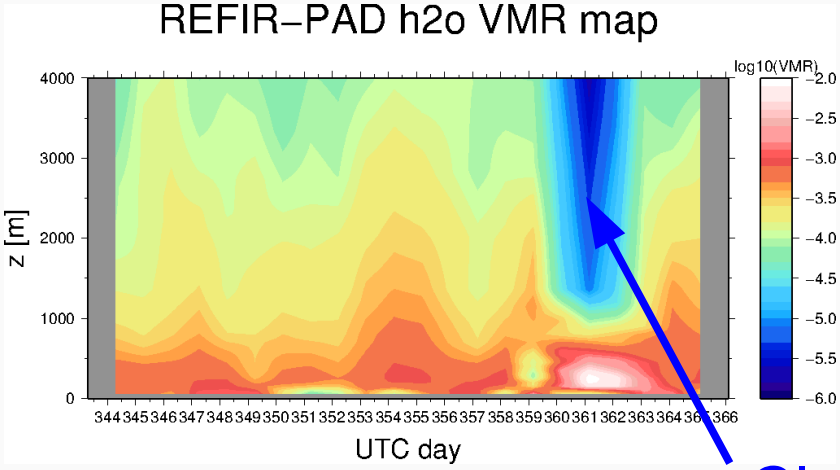
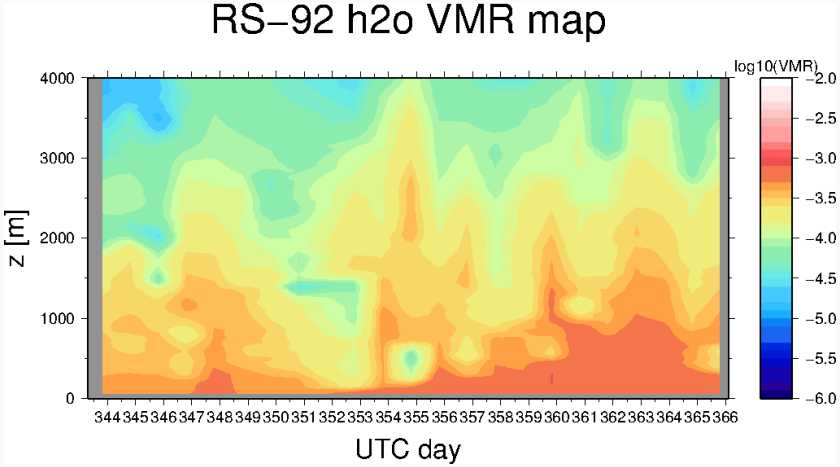
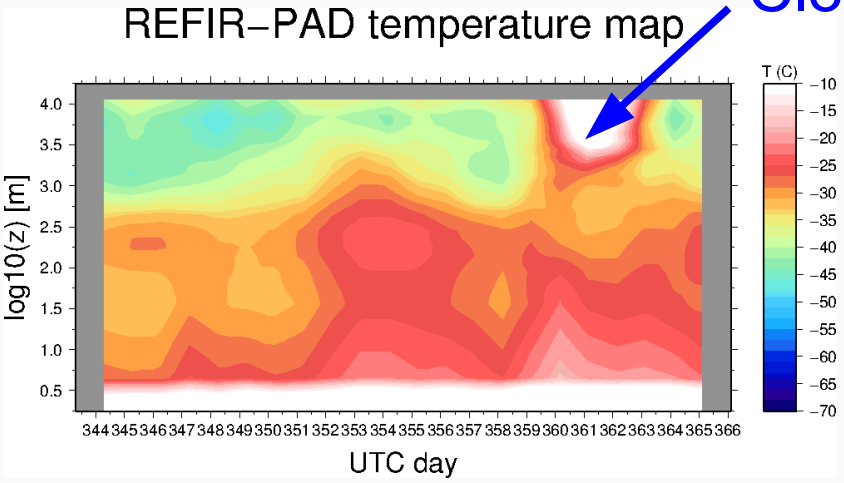
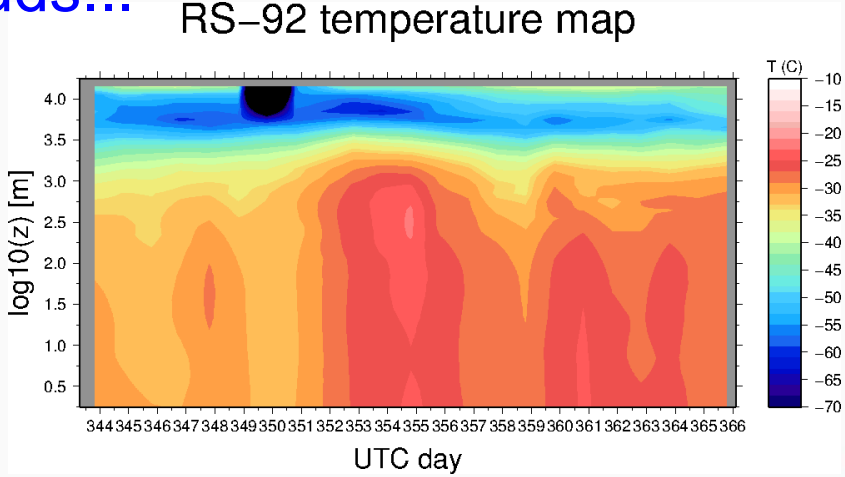
Water vapor & temperature profiles



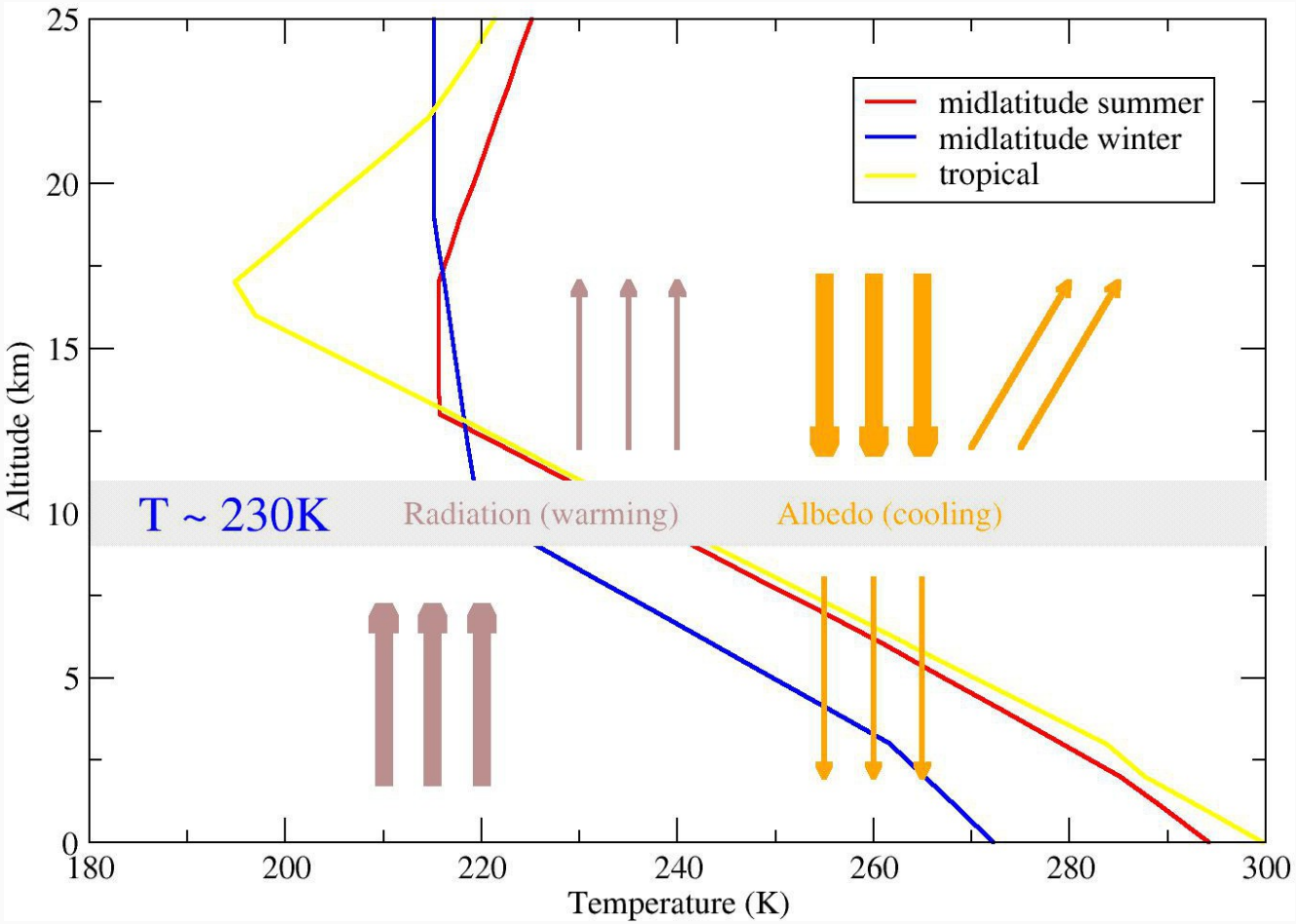


Clouds...





Cirrus and Climate



High troposphere, low temperatures

↓

Lower thermal emission, Warming effect

+

Cloud albedo effect (Cooling)

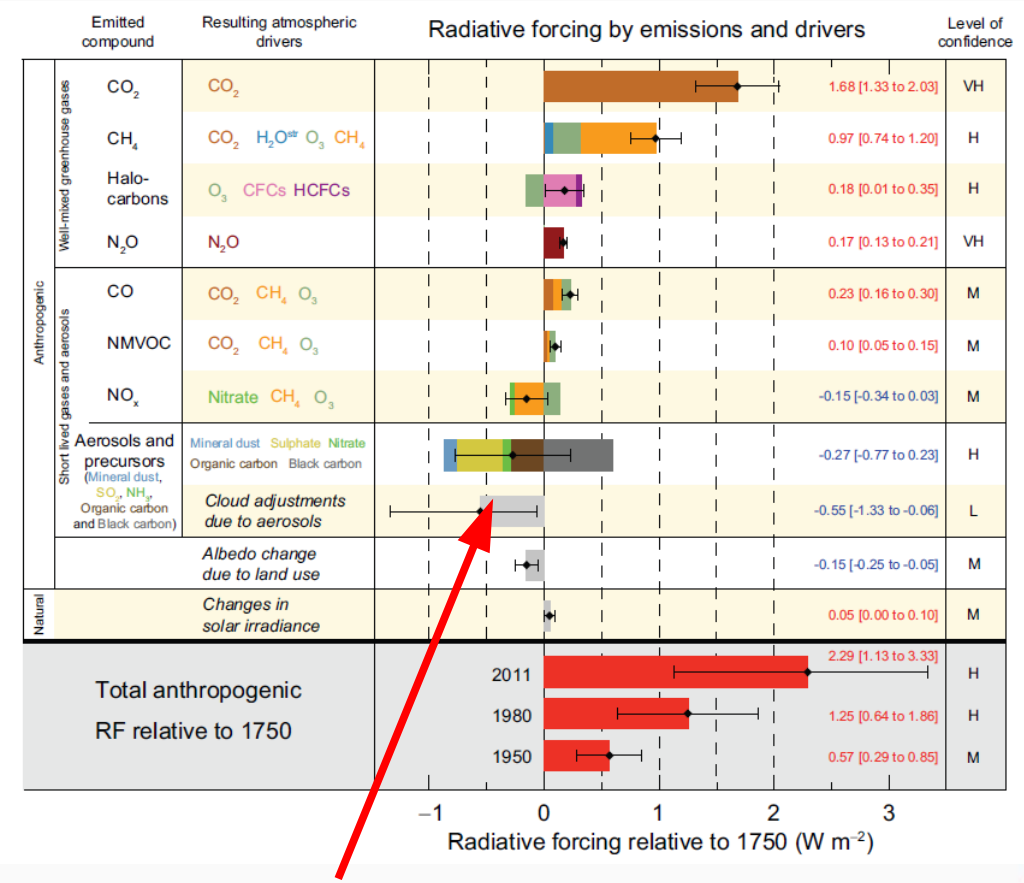
Cirrus and Climate

About 30% permanent global cover, up to 70% in the tropics. High altitude, low temperature.

Radiative forcing strongly dependent on microphysical properties of clouds

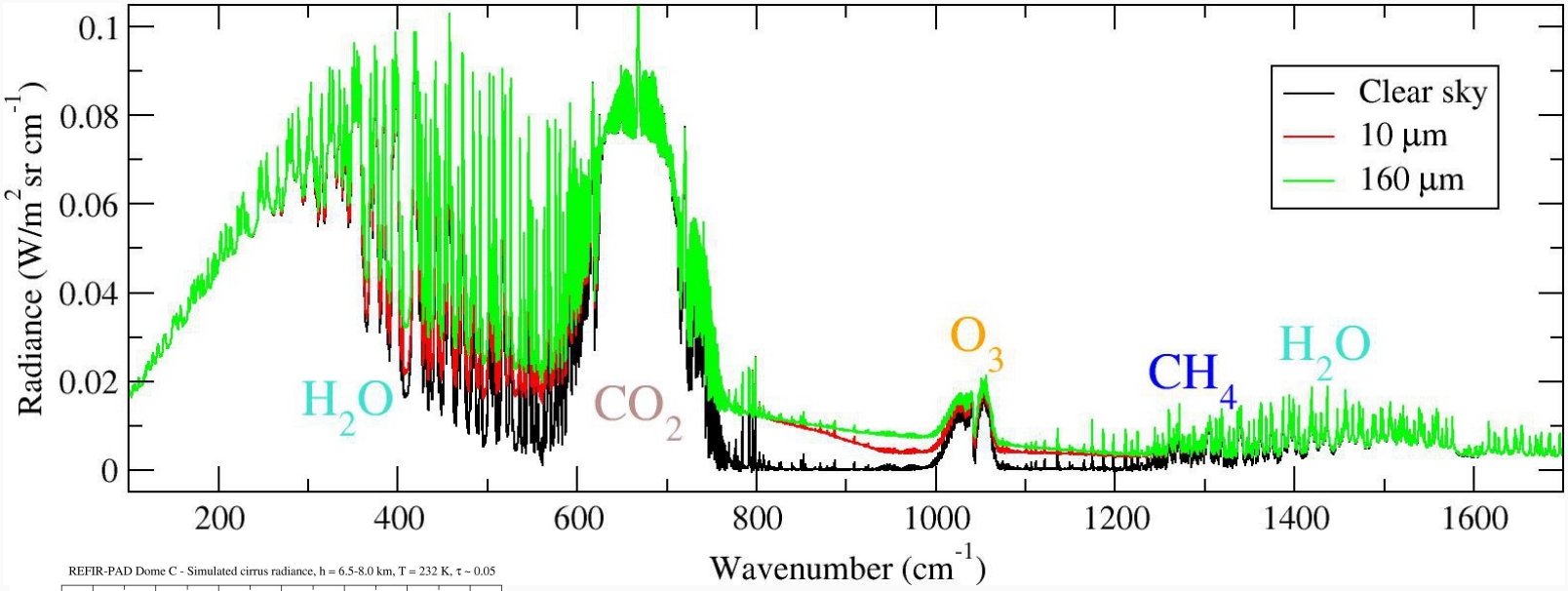
- Thin clouds, large particle size: up to 20 W/m² warming
- Thick clouds, small particle size: up to -40 W/m² cooling

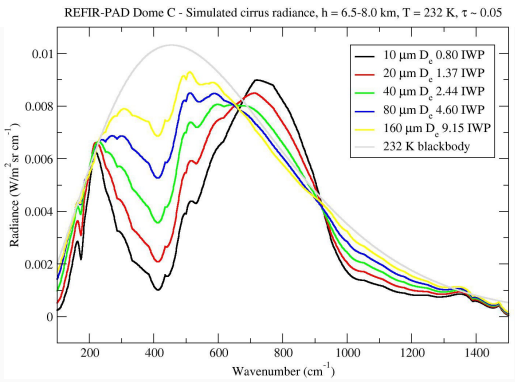
IPCC 2014



Contributes to the largest source of uncertainty in radiative forcing

Radiative signature of clouds





NEXT TALK:

Gianluca Di Natale, "Caratterizzazione ottica e microfisica delle nubi sottili antartiche tramite la combinazione di misure lidar e spettroscopiche nell'infrarosso termico.

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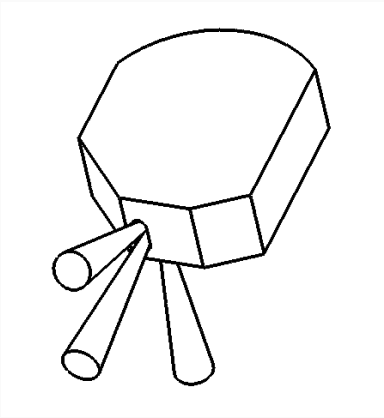
Thanks!



http://refir.fi.ino.it/refir-pad-results-en.html