Towards Retrieval of Vertical Profiles of Cloud Microphysical Properties using A Radiance Ratio Technique

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1 Introduction

- Clouds exhibit a pronounced vertical structure of effective radius \( r_{\text{eff}} \).
- Impacts on the radiative properties due to vertical (inhomogeneous) assumption.
- Spectral solar cloud reflectivity measurements afford more information on the vertical structure of cloud microphysical properties.

### Objective

Developing a new method for airborne passive remote sensing to derive the profile of effective radius \( r_{\text{eff}} \) as a function of optical thickness \( \tau \) in the cloud using spectral solar cloud reflectivity measurements.

2 Campaign and Instrumentation

The ML-CIRrus campaign [1] study mid-latitude natural and contrail cirrus using HALO research aircraft between March – April 2014 over Europe.

**SMART (Spectral Modular Airborne Radiation measurement sysTem)**:
- Spectral solar irradiance downward and upward \( F_i \) and \( F_o \) with an active horizontal stabilization system and radiance upward \( F_t \)
- Range: 300 – 2200 nm, FWHM 2 – 16 nm, and temporal resolution of 2 Hz.
- Applications: cloud optical thickness \( \tau \), effective radius \( r_{\text{eff}} \), liquid water path LWP, thermodynamic phase, radiative forcing, spectral surface albedo.

3 The usual Radiance-Ratio Retrieval

Radiance-ratio retrieval algorithm [2] using two sets of wavelength combination and assuming vertically homogeneous cloud is applied to a cirrus cloud.

4 Comparing usual technique and in-situ

The vertical weighting function \( w(r) \) [3] is used to determine the estimate-altitude of retrieved \( r_{\text{eff}} \). Additional wavelengths of SMART are employed (1500 nm, 1550 nm, and 1700 nm), as well as MODIS cloud products \( r_{\text{eff,1240}} \) and \( r_{\text{eff,645}} \) (blue).

5 Retrieval of vertical profile

A proposed new method to retrieve the profile of \( r_{\text{eff}} \) as a function of \( \tau \) is applied for a cirrus and to be compared with the usual retrieval (multi NIR wavelengths).

A parameterization based on [3] is applied to derive the full profile from the three retrieved properties:

6 Conclusion

- Using different NIR wavelengths with different absorption characteristics in the retrieval algorithm results \( r_{\text{eff}} \) from different depths in the cloud.
- The conventional method results in one single bulk value and can only provide information from a narrow cloud layer.
- The new method successfully retrieves the profile of \( r_{\text{eff}} \) as a function of \( \tau \) and shows the potential to reconstruct the profile of cloud microphysical properties.

References:

