Investigation of the Directional Structure of Horizontal Cloud Inhomogeneities Derived from Ground-Based and Airborne Spectral Imaging and Cloud Resolving Models


1 Introduction

- Clouds exhibit significant horizontal optical and microphysical inhomogeneities
- Directional, horizontal structure of cloud optical thickness ($\tau$) fields investigated
- Fields of $\tau$ retrieved from spatial 2D spectral radiance fields (<10 m resolution)
- Two cloud types investigated [1]:
  - Cirrus obtained during CARRIBA (Clouds, Aerosols, Radiation, and Turbulence in the trade wind regime over Barbados)
  - Arctic stratus obtained during VERDI (Vertically Resolved Distribution of Io in Arctic clouds)

2 Fields of Cloud Optical Thickness

Retrieved fields of $\tau$ from 2D fields of spectral radiance

4 ground-based cases of cirrus (Ci-01 to Ci-04)
10 airborne cases of Arctic stratus (St-01 to St-10)

Specifications:
- Cloud type: Cirrus, Stratus
- Cloud top: 10-14 km, 1 km
- Origin: Tropics, Arctic
- Phase: Ice, Liq., Wat.

3 Characterization of Cloud Inhomogeneity

Scalar 1D Inhomogeneity Parameters [2,3]
- Often applied to quantify cloud inhomogeneities
- Easy to calculate
- Not able to reproduce the 2D structure of cloud inhomogeneities
- Ratio of logarithmic to linear mean
- Standard deviation of logarithmic mean

4 Size and Structure of Cloud Inhomogeneities

1D and 2D Spatial Autocorrelation Functions $P_r$:
- Investigation of the directional structure of cloud inhomogeneities
- Autocorrelation function of measurement case (a) Ci-01 and (b) Ci-03, and across the predominant directional structure of cloud inhomogeneities

5 Comparison to Simulations

COSMO:
- High resolution allows focus on clouds
- Idealized simulations:
  - 64 x 64 grid points
  - 100 m horizontal resolution
  - Periodic boundary conditions
  - 3D turbulence scheme
  - 12 min temporal resolution
  - 4 VERDI cases simulated

6 Summary & Outlook

- Directional structure of cloud inhomogeneities cannot be reproduced from 1D inhomogeneity parameters → misinterpretation possible using 1D observations (e.g. LIDAR)
- 2D analysis of the cloud structure helps to identify the directional, horizontal characteristics of cloud inhomogeneities
- Increasing cloud inhomogeneities in dependence of their temporal evolution → Investigations will be extended to more cases using COSMO (with longer temporal evolution) and upcoming 2D observations performed during ACLUD

References