3D cloud effects on cloud retrievals using ship-based solar spectral transmissivity measurements

M. Brückner(1)*, M. Wendisch(2), A. Macke(1), T. Kanitz(1), B. Pospichal(2)

(1) Leibniz-Institute for Tropospheric Research (ITF), Leipzig, Germany
(2) Leipzig Institute for Meteorology (LIM), University of Leipzig

* contact: mbrueck@rz.uni-leipzig.de

1. Goals
- Ship-based measurements of spectral cloud transmissivity to retrieve cloud optical thickness and effective radius
- Evaluate three-dimensional (3D) cloud radiative effects on retrieval and energy budget

2. Instrumentation
- Integrated in OCEANET-Container on RV Polarstern
- Spectral radiance and irradiance measurements with C0mpact RAdiation measurement System (CORAS)
- Broadband radiation measurements for irradiance and radiation from Pyran- and Pygrometer
- Vertical structure of the cloud from the Raman lidar Polly²-XT (profiles of extinction coefficient and microphysical aerosol properties) and Microwave Radiometer HATPRO (profiles of the liquid water path (LWP))
- Full sky imager for information on the horizontal cloud variability

3. Methodology

Radiative transfer model (RTM)

Plan-parallel (PP) RTM

libRadtran [1]

Model $I_{\lambda,0}^{PP}(\mu_0, z_F)$ and $F_{\lambda,0}^{PP}(\mu_0, z_F)$ at sea level $z_F$ (using optical and microphysical observations)

3D Monte-Carlo RTM

MCUNIK [2]

Model $I_{\lambda,0}^{3D}(\mu, z_F)$ and $F_{\lambda,0}^{3D}(\mu, z_F)$ at sea level $z_F$ (using optical and microphysical observations)

Calculate modeled spectral transmissivity $T_{\lambda,0}^{PP}$ using a PP-RTM

$$T_{\lambda,0}^{PP} = \frac{\pi I_{\lambda,0}^{PP}(\mu_0, z_F)}{\mu_0 I_{\lambda}^{PP}(z_F)}$$

Calculate modeled spectral transmissivity $T_{\lambda,0}^{3D}$ using a 3D Monte-Carlo RTM

$$T_{\lambda,0}^{3D} = \frac{\pi I_{\lambda,0}^{3D}(\mu_0, z_F)}{\mu_0 I_{\lambda}^{3D}(z_F)}$$

4. Examples

Fig. 6: Modeled spectral transmissivity (PP-RTM) for a liquid water cloud in dependence on optical thickness and effective radius. Figure taken from [3].

Fig. 7: Time series from ICEALOT+ campaign of retrievals of optical thickness and effective radius with spectral cloud retrieval (slope) and 2-wavelength (2WL) method. LWP retrievals from NOAA Microwave radiometer (MWR) and from spectral radiation measurements. Figure taken from [3].

5. Outlook
- Integrated 3D cloud effects on ship-based and modeled spectral transmissivity using PP-RTM and 3D Monte-Carlo RTM
- Retrieve cloud optical thickness and effective radius using PP-RTM and 3D Monte-Carlo RTM to quantify 3D cloud effects on spectral transmissivity for different cloud types
- Classify systematically differences in retrieved cloud parameters by cloud fraction and cloud vertical inhomogeneities from full sky imager, lidar and microwave radiometer
- Determine dependence on solar zenith angle (SZA) for spectral radiation quantities
- quantify retrieval sensitivity to model assumptions

References:
http://www.atmos-chem-phys.net/5/1855/2005/

Fig. 5: Look up table for spectral cloud retrieval using modeled transmissivity (PP-RTM) and spectral slope fit through normalized transmissivity. Figure taken from [3].