Remote sensing of clouds and snow properties in the Arctic

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1. Introduction

Retrieval of cloud and snow properties

- Spectral solar radiation contains information on clouds and snow
- Spectral absorption of snow ice and cloud water not independent
- Assumptions on either clouds or snow properties needed
  - Spectral radiance component (with symbols)
  - Snow Grain Size, f(ad)
  - Cloud Albedo
  - Opt. Thickness, Effective Radius, f(ph)

- Frequent low level clouds over Arctic sea ice or Antarctic ice shield
- Large areas are currently not well covered

2. Limitation of Cloud Retrieval

- Low contrast between snow and clouds (visible wavelengths)
  - Spectral retrieval using near infrared wavelengths
  - Sensitivity study based on simulations:
    - Grain size assumed in retrieved: 200 µm / 50 µm
    - Grain size in reality: 50 µm / 200 µm
    - Differences especially for thin clouds
      - Up to 40 % for opt. thickness
      - Up to 50 % for effective radius

3. Separating the Spectral Signature of Clouds and Snow

Simulations of radiative reflectivity

- Cloud altitude 300 - 500 m, Åeff = 63 - 80
- Reflectivity ratios:
  - P1 = R(1040nm)/R(500nm)
  - P2 = R(1655nm)/R(1040nm)
  - P3 = R(1000nm)/R(1655nm)

4. Reflectivity-Ratio Retrieval Algorithm

- Forward simulations Åeff = 63 - 80
- Absorbing and scattering properties of dust, soot, black carbon
- Algorithms are applicable to different cloud types
- Separation of pixels by wavelengths
- Simulated spectral reflectivity grid for relatively thick clouds

5. Application

VERDI 2012 campaign

- INVVK/NVTV, Canada/April/May 2012
- Polar 5 aircraft at AWI
- Remote sensing
- In-situ cloud, aerosol and trace gases
- SMART-Albedo factor
- Spectral radiance:
  - 300 - 2100 nm
- Horizontally stabilized

Case study: 17 May 2012

- Homogeneous stratus (liquid)
- Flight track crossing ice edge
- Continuous retrieval results
- Large grain size likely due to sea ice and melting

6. Outlook

- Uncertainty analysis
- Improved wavelength selection
- Validation by in situ observations
- Comparison with satellite observations
- Snow retrieval in cloud free areas/days
- Cloud retrieval over ice free areas
- Application to more cases (RACEPAC 2014)