Cloud side remote sensing
Droplet size profiles from specMACS

Florian Ewald, Tobias Zinner, Tobias Kölling, Tina Jurkat, Bernhard Mayer
Aerosol and Convection

Rosenfeld et al., 2008

Cloud side remote sensing

cloud particle phase (z), habit (z), $r_{\text{ef}}(z)$, LWC (z), 3D structure

aerosol, activation, CCN, type, mixing/entrainment
From 1D Nakajima-King

Combine “absorbing” and “scattering” channel to retrieve $\tau$ and $r_{\text{eff}}$

deterministic forward simulations for 1D plane-parallel clouds
Cloud side remote sensing

From 1D Nakajima-King

3D forward simulations for many realistic 3D cloud side cases
From 1D Nakajima-King to a 3D statistical retrieval

3D forward simulations for many realistic 3D cloud side cases

Marshak et al. 2006
Zinner et al. 2008
Ewald et al. 2013
Cloud side remote sensing

From 1D Nakajima-King to a 3D statistical retrieval

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From 1D Nakajima-King to a 3D statistical retrieval

\[ \tau_{\text{eff}} = 8 \, \mu m, \sigma = 0.5 \, \mu m \]

Marshak et al. 2006
Zinner et al. 2008
Ewald et al. 2013
Statistical retrieval based on forward simulations:

• **Regional Atmospheric Modelling System** (RAMS, Jiang an Li 2009, Feingold et al. 1996)
  - **warm cumulus (RICO)**
  - **Forward imagery from 3D RT model:**
    - 12 scenes x 4 viewing directions = 48 cases varying with varying SZA

→ **lookup table**: $1.5 \cdot 10^9$ radiance pairs binned by scattering angle
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3D lookup data base

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Synthetic test cases

Cloud model microphysics

original

2100 nm

flipped

2100 nm

870 nm

2100 nm
Synthetic test cases

Cloud model microphysics

Retrieved effective radius
ACRIDICON case AC17

VIIRS data, 27 Sept. 2014
ACRIDICON case AC17

specMACS RGB and shadow mask
ACRIDICON case AC17

specMACS RGB and vegetation mask
specMACS RGB and phase detection
ACRIDICON case AC17

specMACS RGB and effective radius retrieval
specMACS RGB and effective radius retrieval

CAS-DPOL in-situ profile
ACRIDICON case AC17

specMACS RGB, effective radius retrieval, and altitude
First specMACS derived droplet size profile!
specMACS RGB, effective radius retrieval uncertainty due to retrievable technique and calibration uncertainty
cloud side remote sensing with specMACS

- statistical microphysics retrieval combined with

- O2A derived distance/cloud surface orientation
Reflected radiance and cloud surface orientation

Combine "absorbing" and "scattering" channel to retrieve $\tau$ and $r_{eff}$

deterministic forward simulations for 1D plane-parallel clouds
Reflected radiance and cloud surface orientation

3D forward simulations for a water sphere cloud sides:
\( r_{\text{eff}} = 9 \ \mu\text{m} = \text{const}, \ \tau = 500 \), sun off observing direction by 45°.
Summarizing geometry and microphysics with specMACS.

- Statistical microphysics retrieval combined with
- O2A derived distance/cloud surface orientation

NEXT:
- Systematic comparison to in-situ cloud for ACRIDICON
- Stronger integration of cloud shape information into retrieval