Enhanced absorption of solar radiation by horizontal variability of cloud microphysics

Andreas Macke, Ronald Scheirer, Christine Brandau

Leibniz-Institute for Marine Research, IFM-GEOMAR
Kiel, Germany
GESIMA: 3d, non-hydrostatic, bulk cloud physics
cloud water, rain, ice, snow/graupel
Absorption: PPHOM – Full 3D

Total Absorption

Convective Cloud
Stratiform Cloud
Multi-layer Cloud

Homogeneous – Full 3D [W m⁻²]

Optical Thickness
0.2 – 4.0 microns

SZA [degree]
15
30
45
60
75
Absorption: ICA – Full 3D

Total Absorption

Δ Convective Cloud  □ Stratiform Cloud  ≡ Multi-layer Cloud

Optical Thickness
0.2 – 4.0 microns

IPA – Full 3D [W m⁻²]
Absorption: (3D-ext, 1D-scatter/abs) – Full 3D
horizontally homogeneous microphysics – full 3D
Abs (Δ + ) > Abs ( Δ + Δ )

mean bias:
1.2 Wm$^{-2}$ (θ = 75°) - 4.0 Wm$^{-2}$ (θ = 15°)
cloud microphysics effect on absorption...

- ...increase with decreasing solar zenith angle (deeper penetration of solar photons into the cloud)
- ...decrease with increasing solar zenith angle (less horizontal transport into higher absorbing regions)
- ...depend on horizontal variability of particle size
Variability of water cloud optical properties
Vergleich 1:

**Homogen (Fall 1)**

\[
\begin{align*}
\tau &= 15 \\
r_{\text{eff}} &= 10 \ \mu\text{m}
\end{align*}
\]

**Inhomogen (Fall 2)**

\[
\begin{align*}
\tau &= 15 \\
r_{\text{eff}} &= 15 \ \mu\text{m}
\end{align*}
\]

\[
\begin{align*}
\tau &= 5 \\
r_{\text{eff}} &= 5 \ \mu\text{m}
\end{align*}
\]
hom. \( \mu \Phi \): 2D vs ICA

inhom. \( \mu \Phi \): 2D vs ICA

\[ \lambda \]

3rd I3RC Workshop, IFM-GEOMAR, October 11 – 14, 2005
CLABAUTAIR Cloud (Ronald Scheirer)

Cloud liquid water content and effective radius retrieval by an automated use of AIRcraft measurements
Solar broadband absorption

3D cloud with horiz. hom. $\mu\phi$

Difference: hom $\mu\phi$ – inhom. $\mu\phi$

Absorptivity

Absorptivity
Absorption and Horizontal Transport

3D-Inhomogen, $\lambda = 3.5 \mu m$