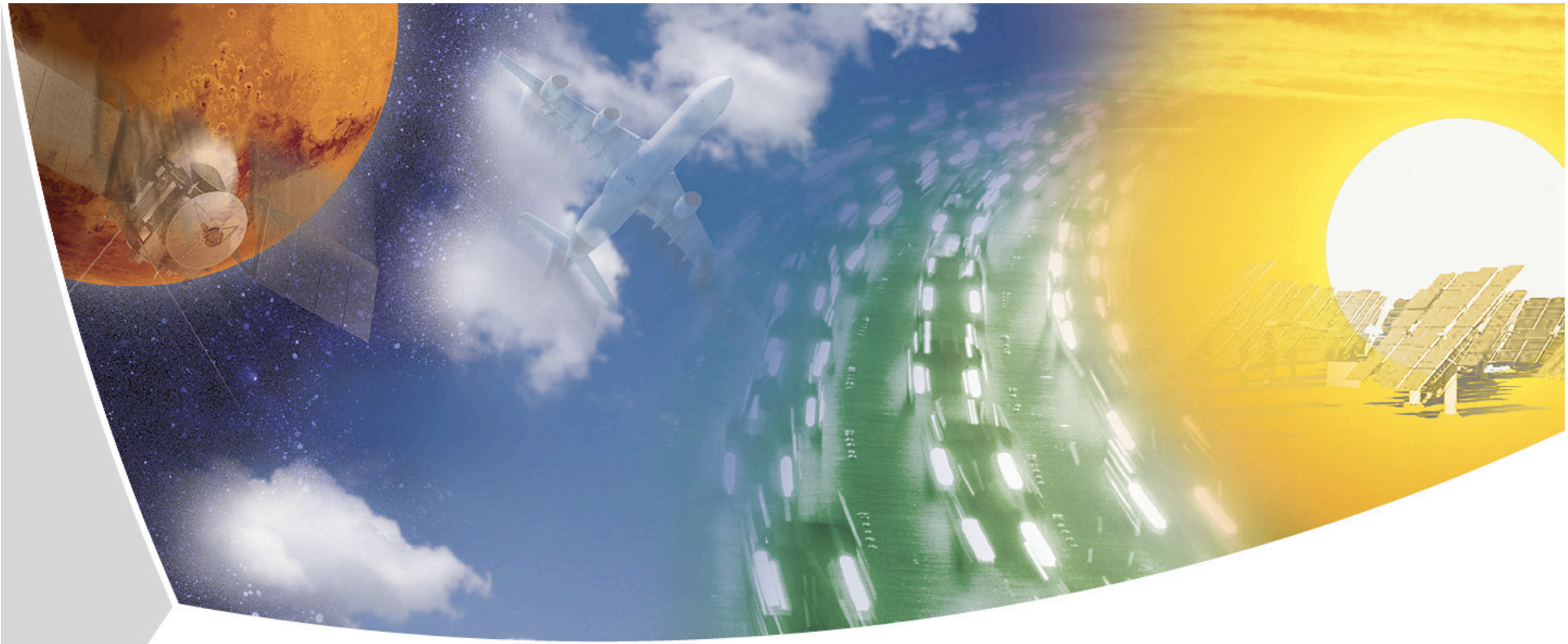


Deconvolution of high resolution radiances

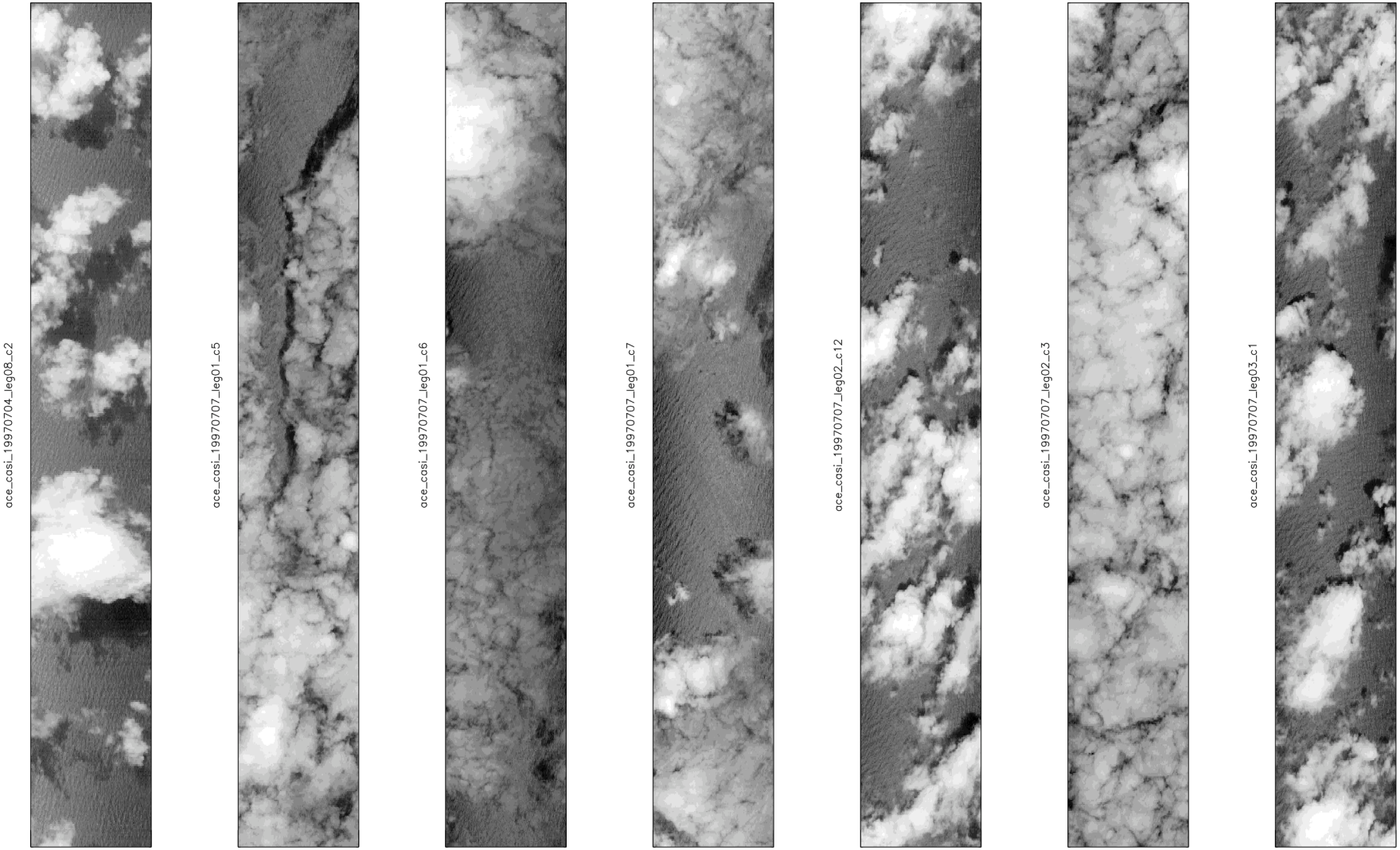
Tobias Zinner, Bernhard Mayer, Marc Schröder (FU Berlin)

Institut für Physik der Atmosphäre

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

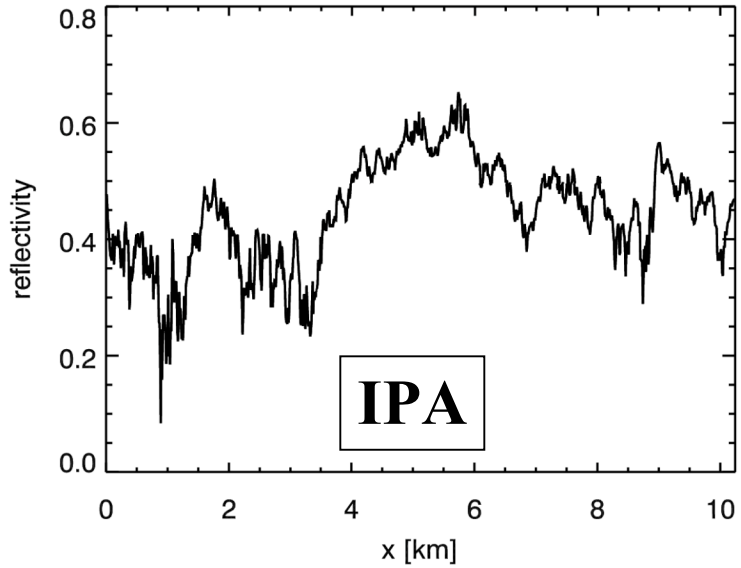
Structured cloud fields for radiative transfer

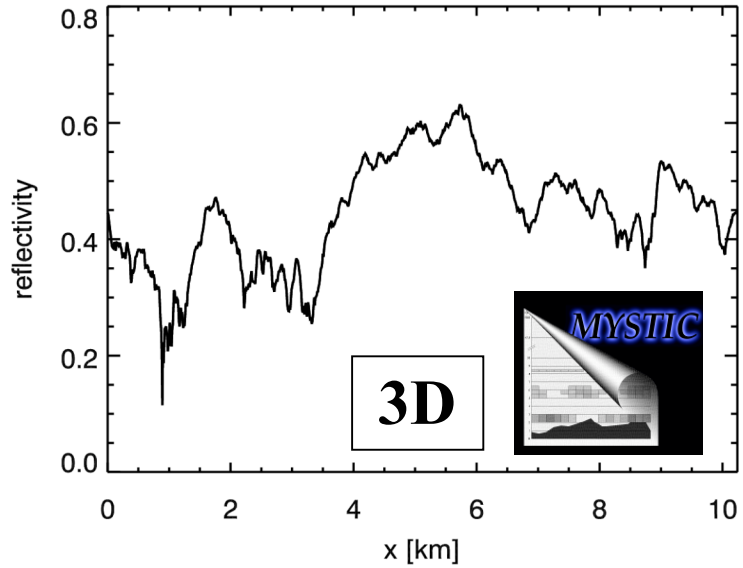
CASI (Compact Airborne Spectrographic Imager, FU Berlin)
radiance at 753 nm, 1.3 x10 km², horiz. res. 15 m, marine stratocumulus



Solar radiation + 3D clouds

SZA 0°, Sensor 0°

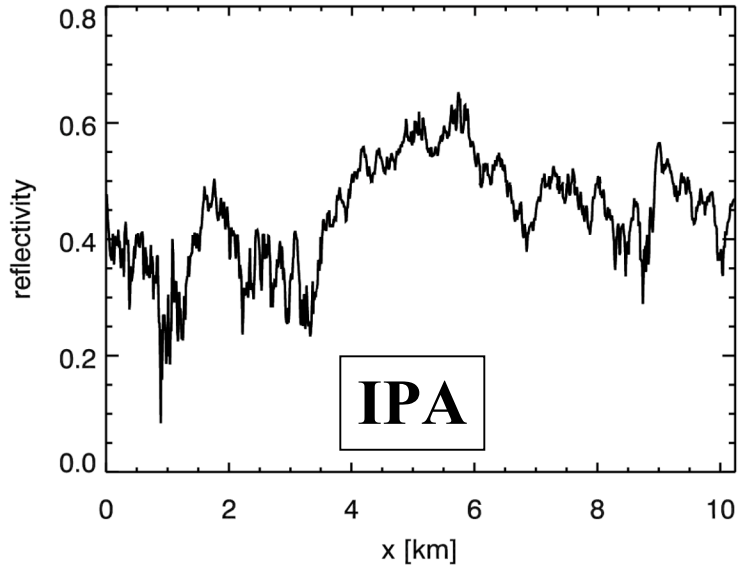


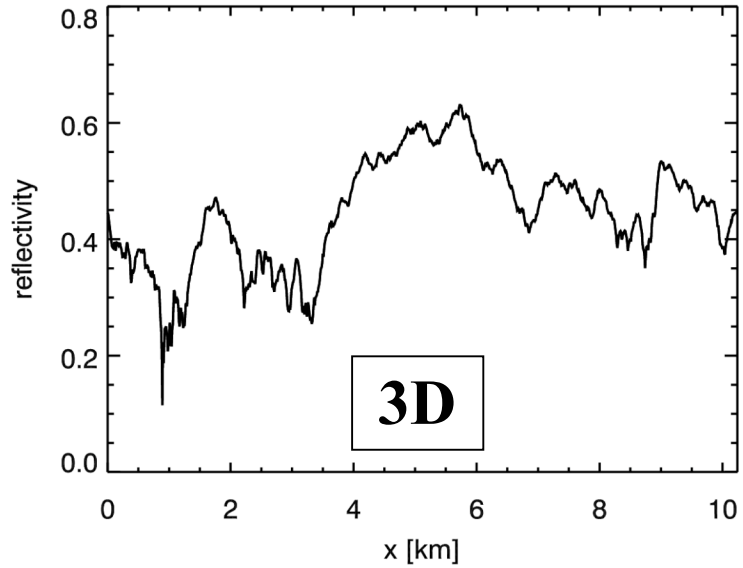


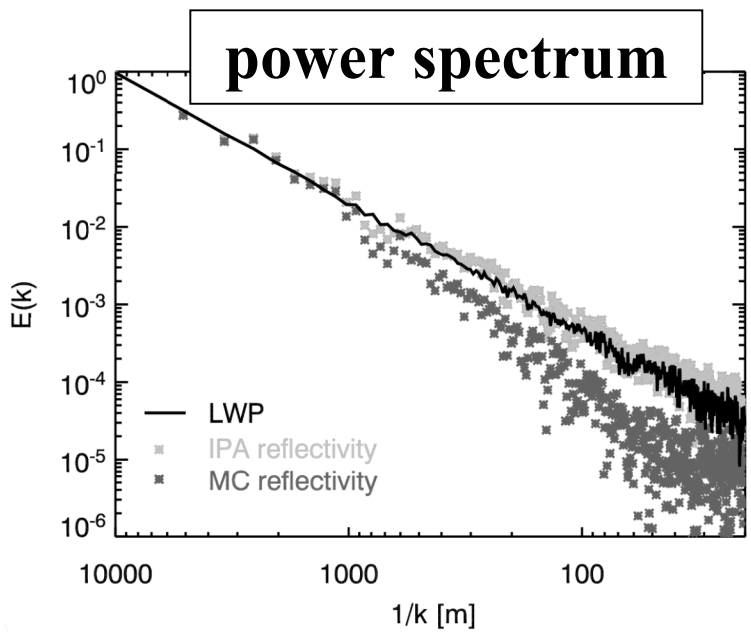
plane-parallel vertically homogenous cloud,
variable optical thickness

Solar radiation + 3D clouds

SZA 0°, Sensor 0°

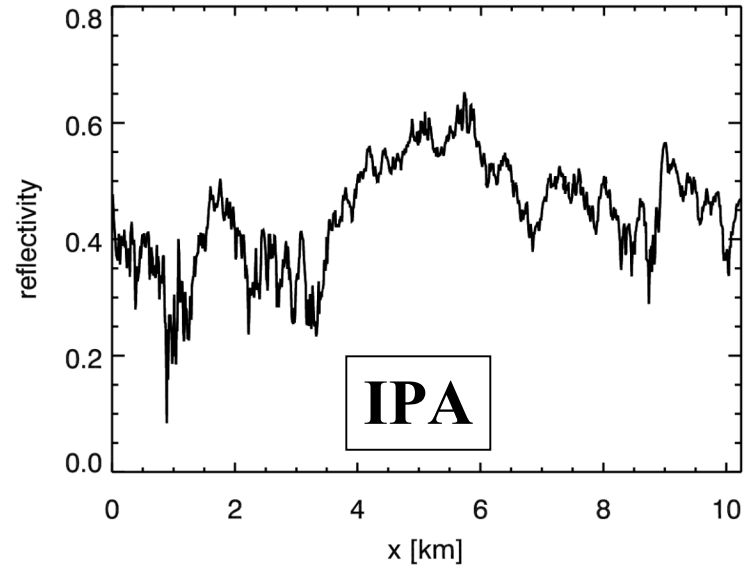


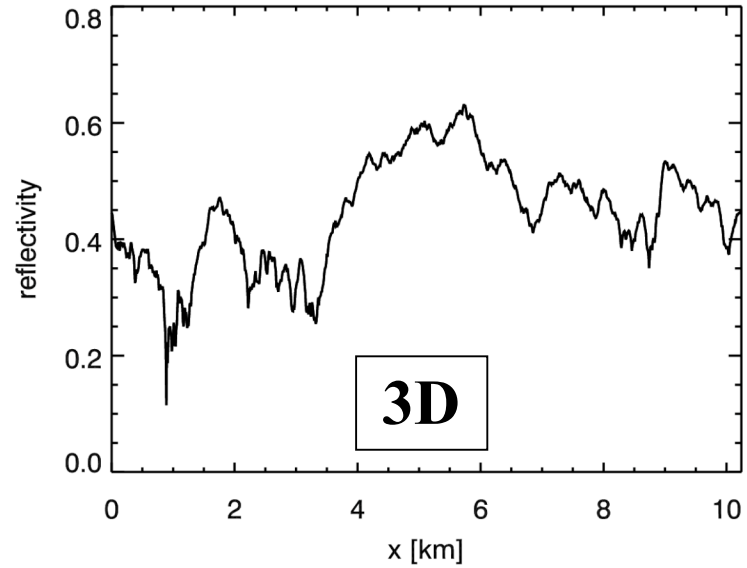


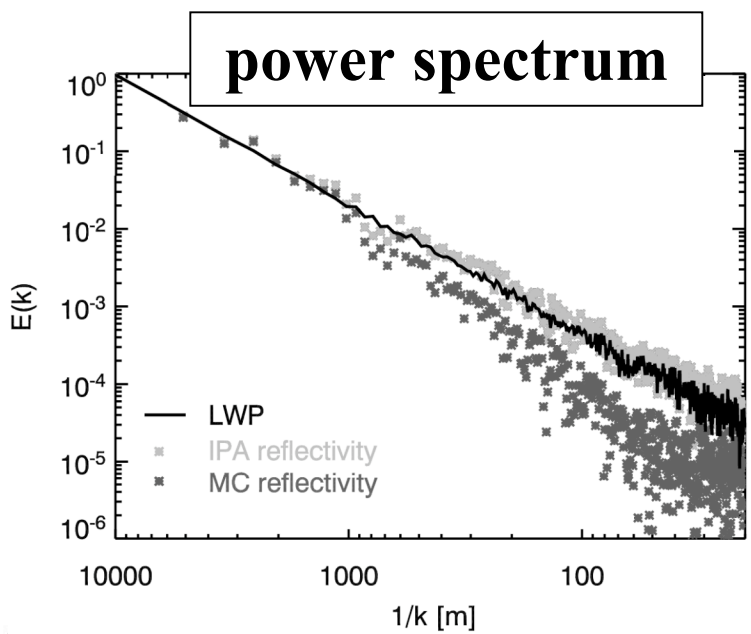


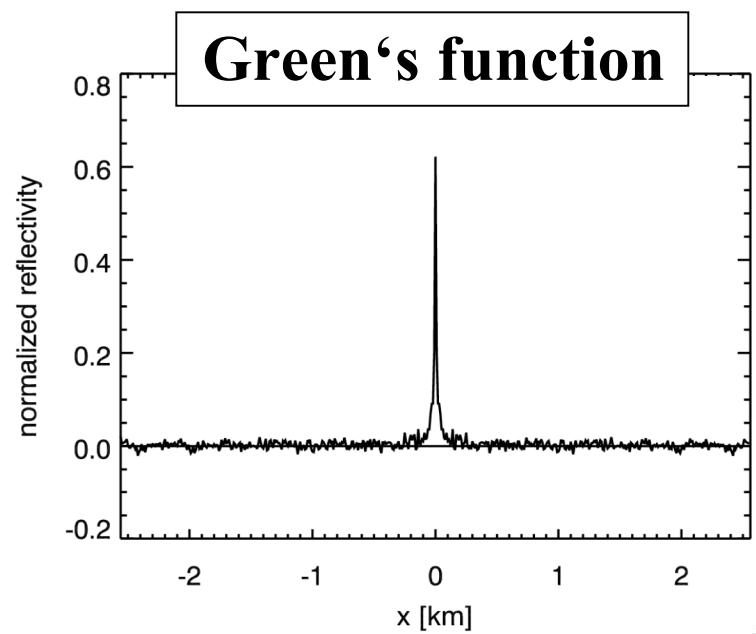
Solar radiation + 3D clouds

SZA 0°, Sensor 0°









Cloud top structure and microphysical profile?

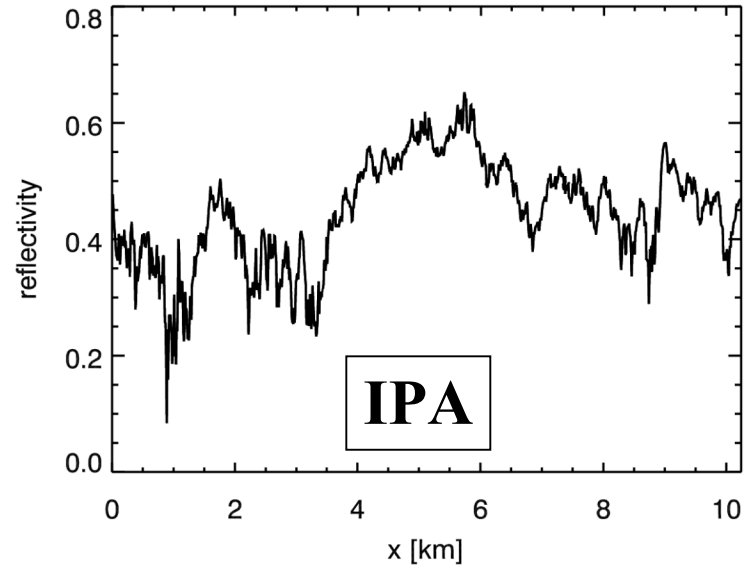
Adiabatic profile model !

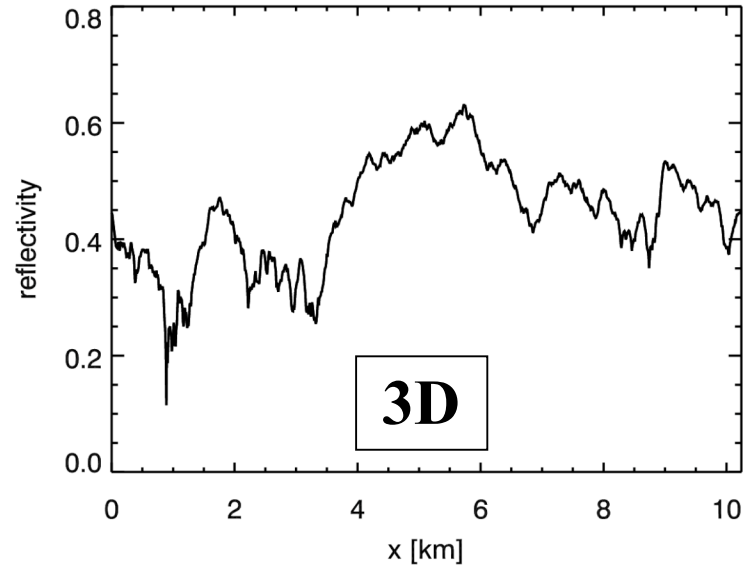
- approximately valid for warm boundary layer clouds (e.g. Finger et al., 1990; Brenguier et al., 2000 ...)
- fixed number of droplets grow according to the adiabatic value of liquid water condensation with height

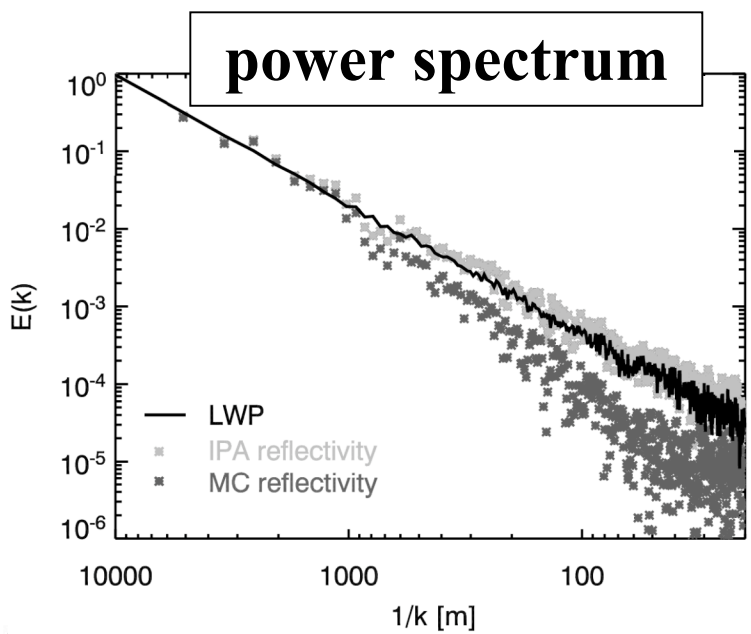
$\Rightarrow$ profile of LWC and r_{eff}

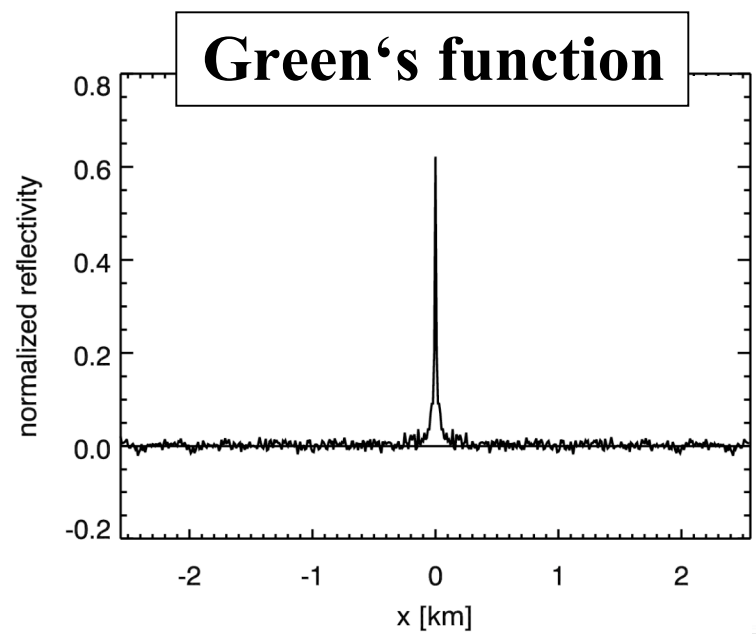
Solar radiation + 3D clouds

SZA 0°, Sensor 0°



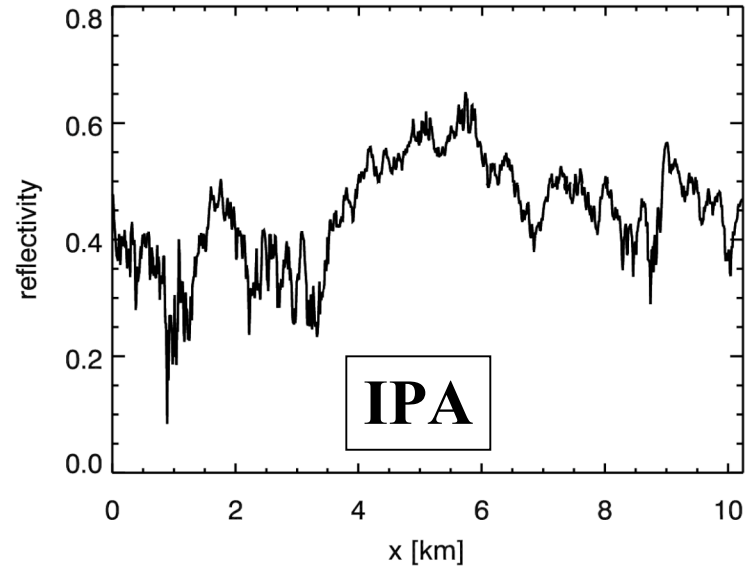


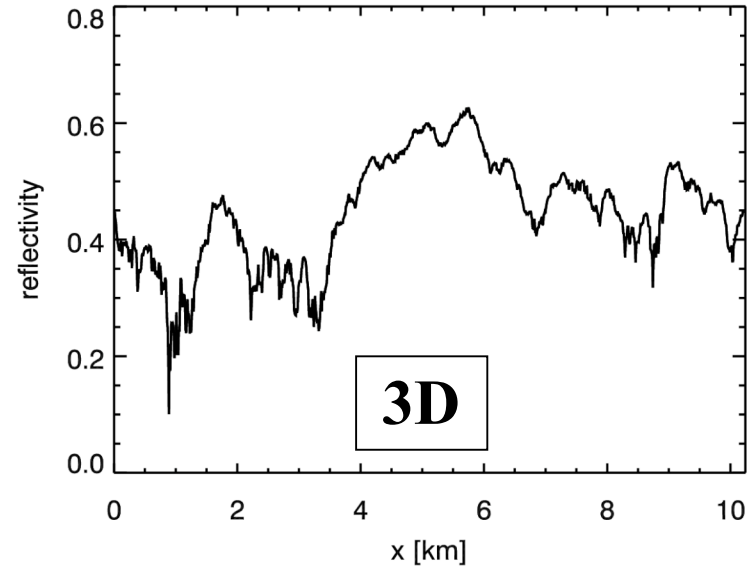


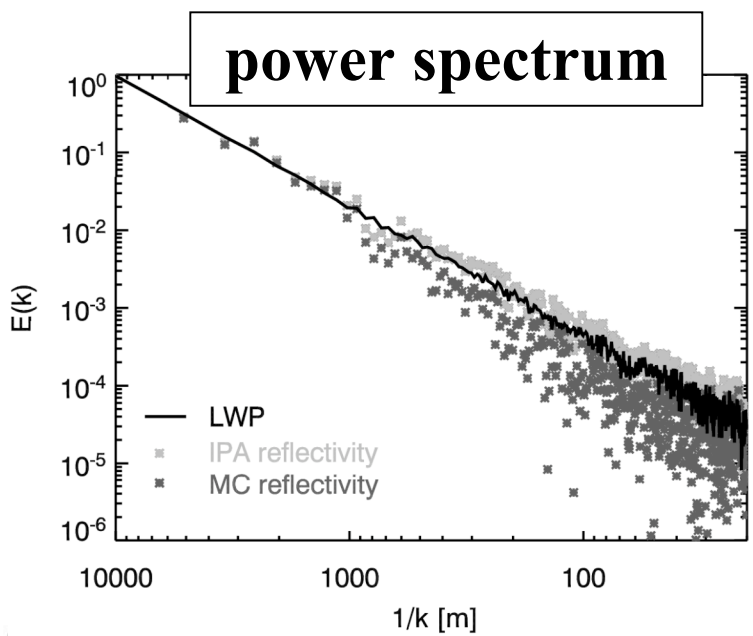


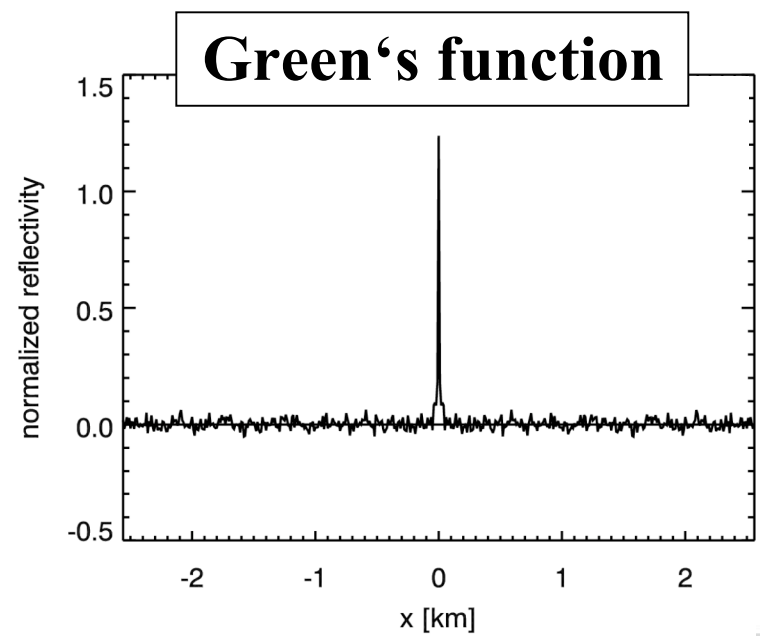
Solar radiation + 3D clouds

SZA 0°, Sensor 0°



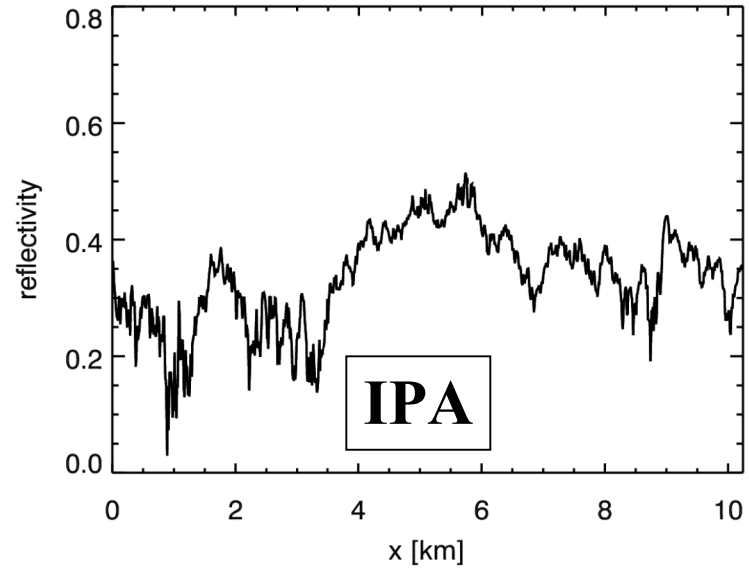


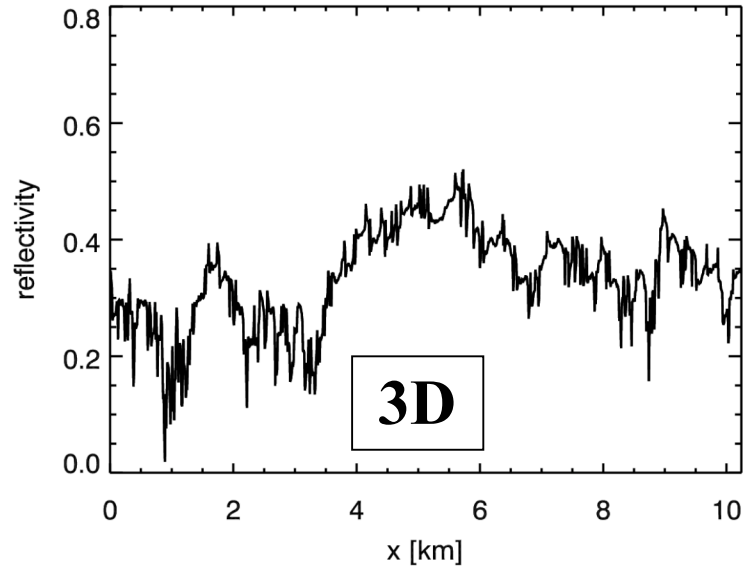


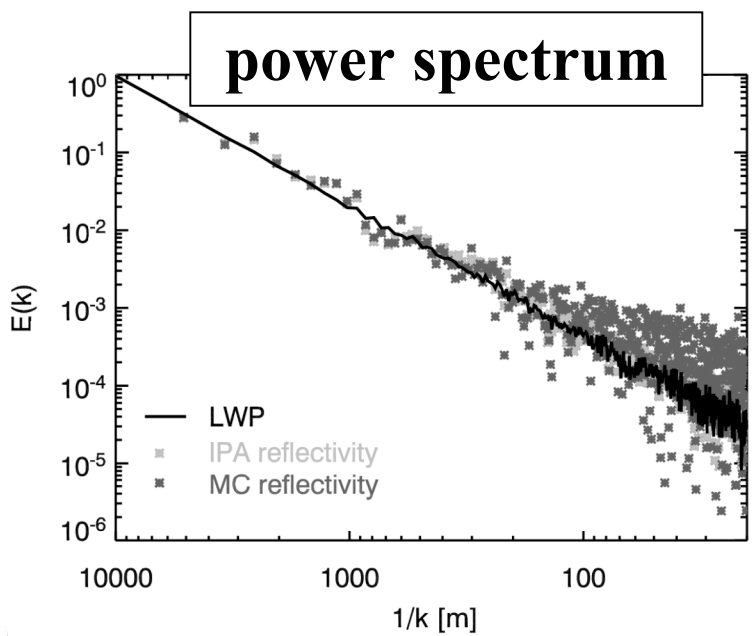


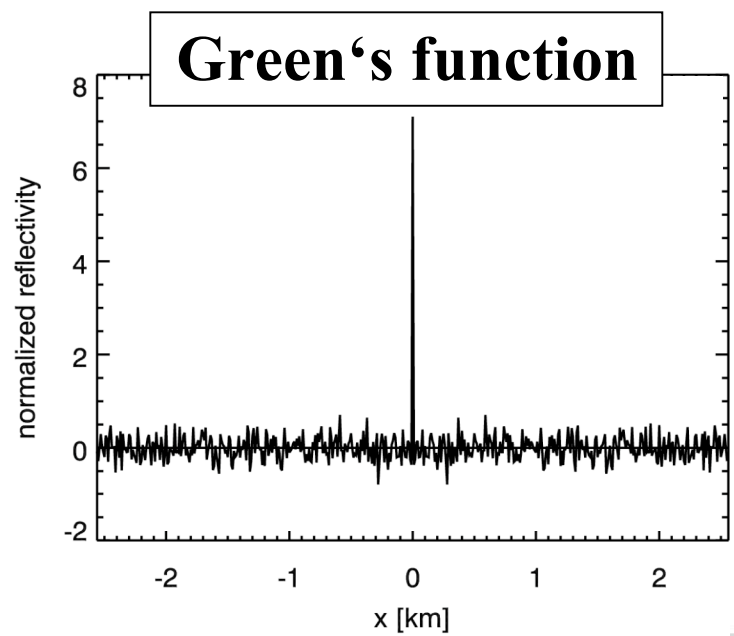
Solar radiation + 3D clouds

SZA 30°, Sensor 0°

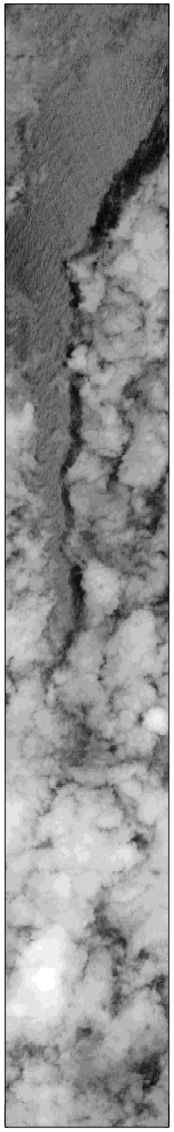








Deconvolution of high resolution radiances



- single channel retrieval ...
  → 2D field of optical thickness

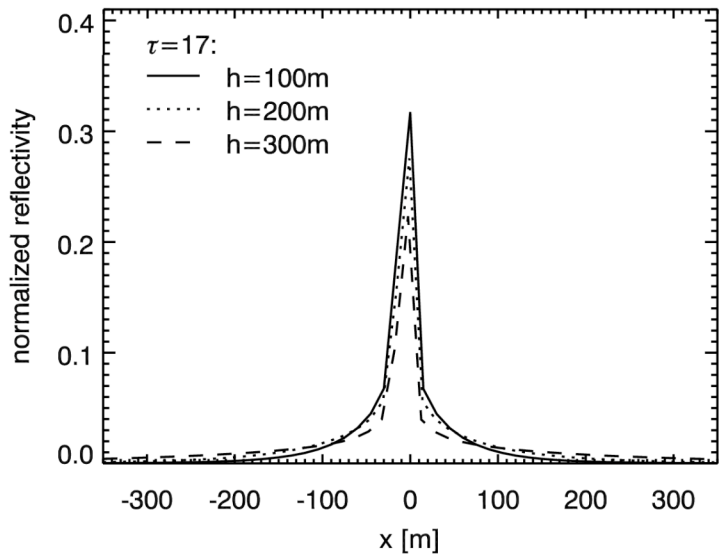
- adiabatic profile
  → vertical profile of LWC and r_{eff}
  (fixed cloud bottom ⇒ cloud top structure)

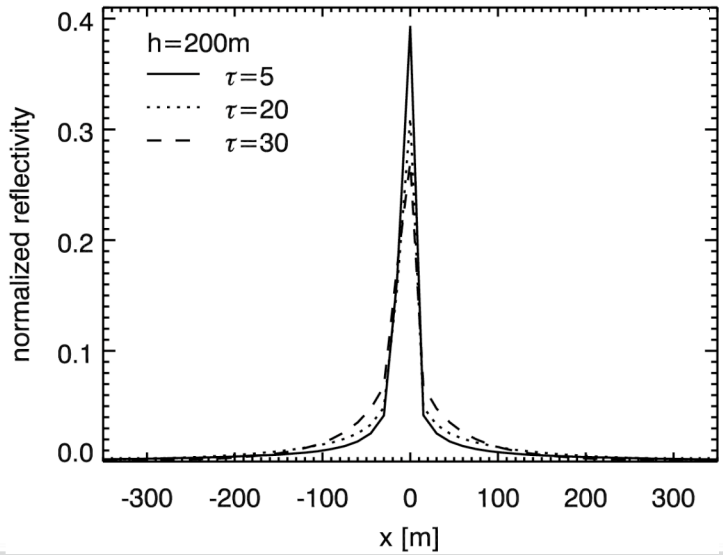
? radiative smoothing ?
? radiative sharpening ?

⇔ flexible iterative method

Deconvolution of high resolution radiances

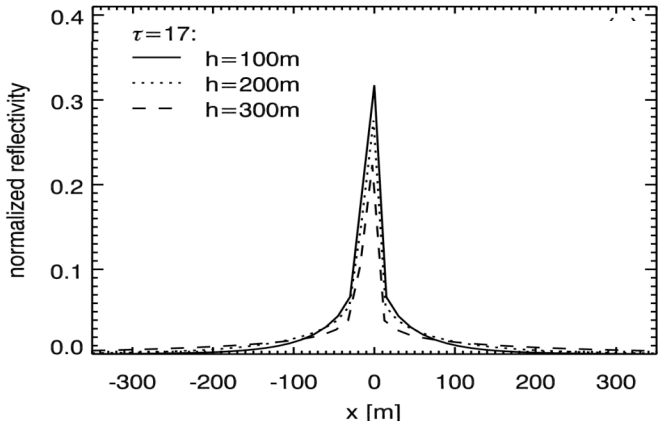
- approximate Green's function PSF (τ,h)





Deconvolution of high resolution radiances

- approximate Green's function PSF (τ,h)

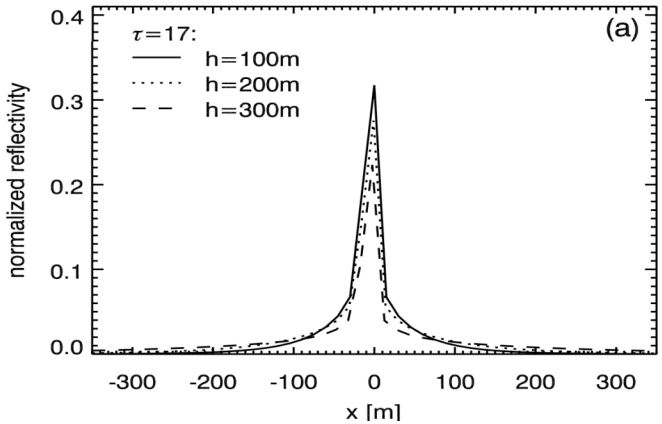


- Richardson-Lucy algorithm (Richardson 1972, Lucy 1974):

$$O_{i+1} = \left[\left(\frac{I}{O_i \otimes PSF} \right) \otimes PSF \right] O_i$$

Deconvolution of high resolution radiances

- approximate Green's function PSF (τ,h)



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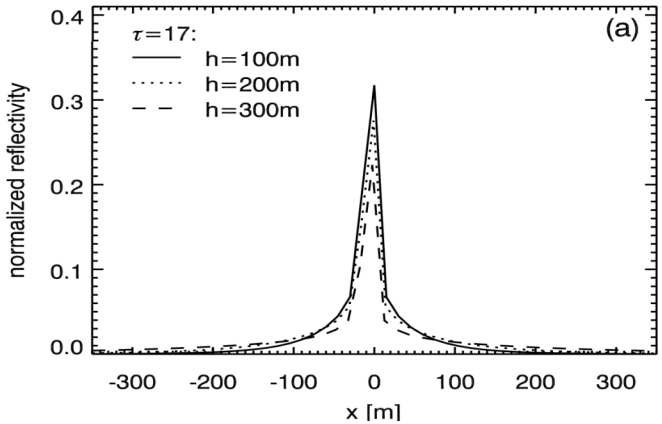
$$O_{i+1} = \left[\left(\frac{I}{O_i \otimes PSF} \right) \otimes PSF \right] O_i$$

i=i+1

- remote sensing → 2D field of τ + CTH →
→ 3D MC simulation → test radiance field

Deconvolution of high resolution radiances

- approximate Green's function PSF (τ,h)



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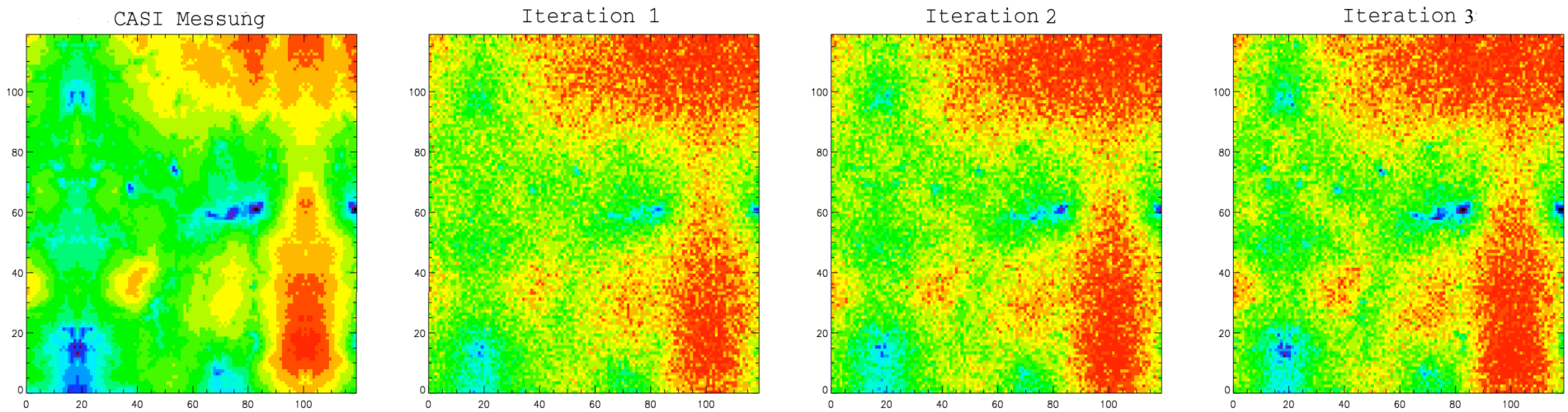
i=i+1

- remote sensing → 2D field of τ + CTH →
  → 3D MC simulation → test radiance field

- selection of best match compared to original observation

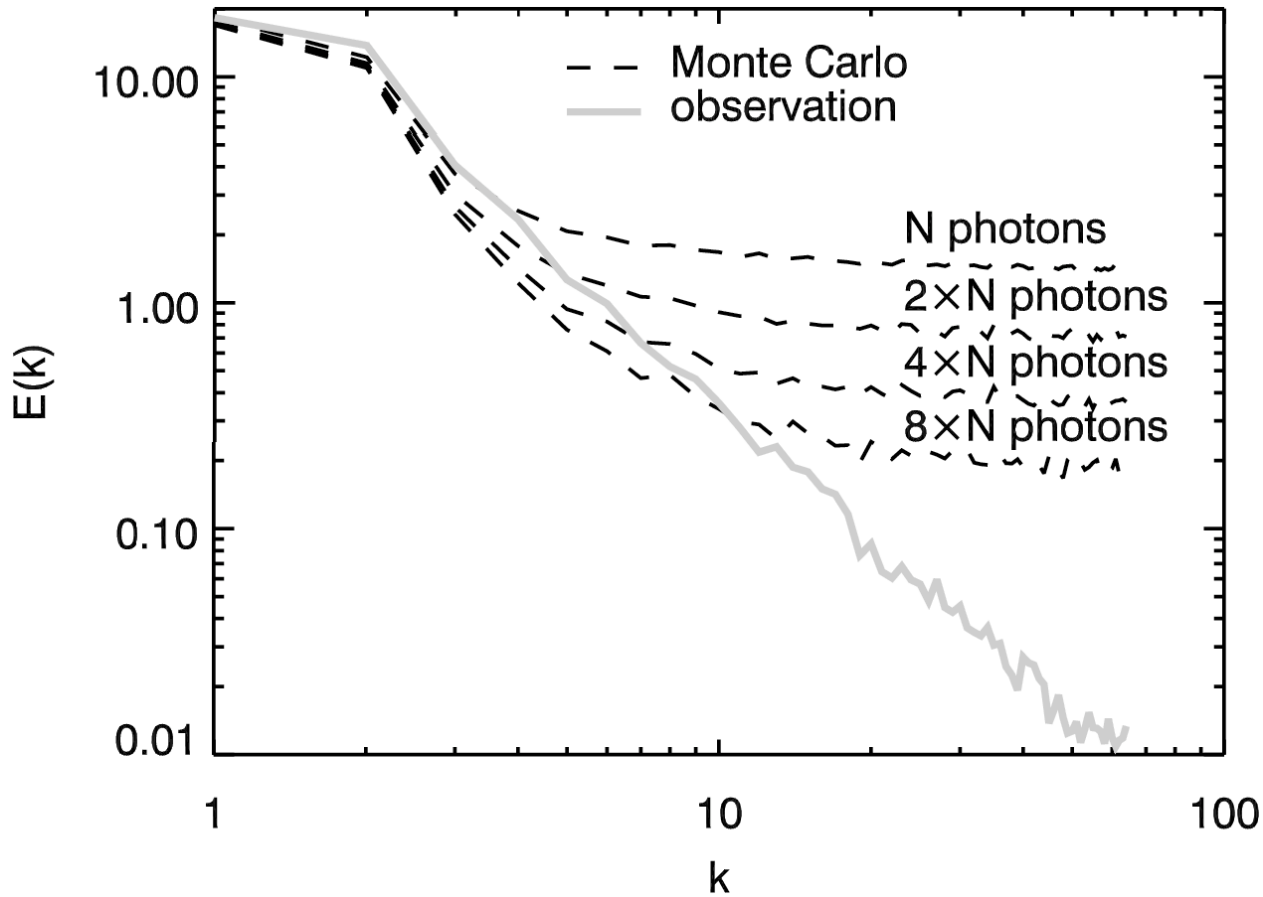
Deconvolution of high resolution radiances

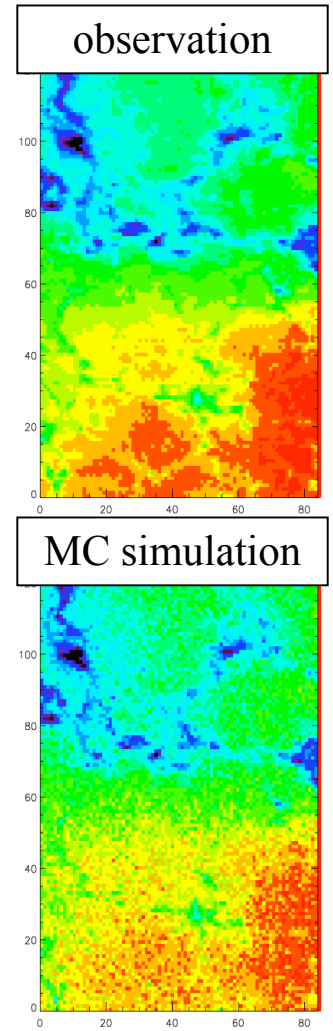


criterion 1:

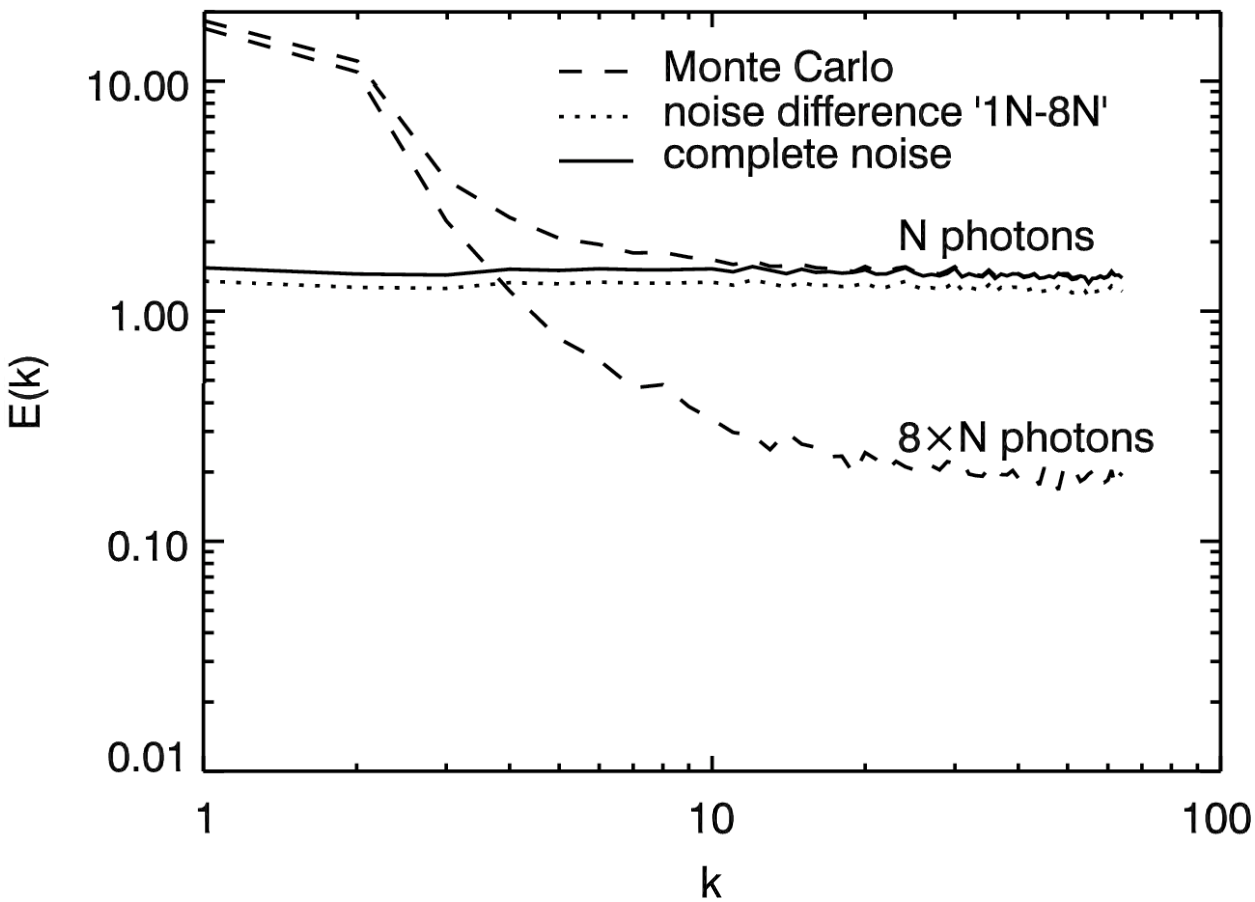
power spectrum

Monte Carlo simulations are always noisy!

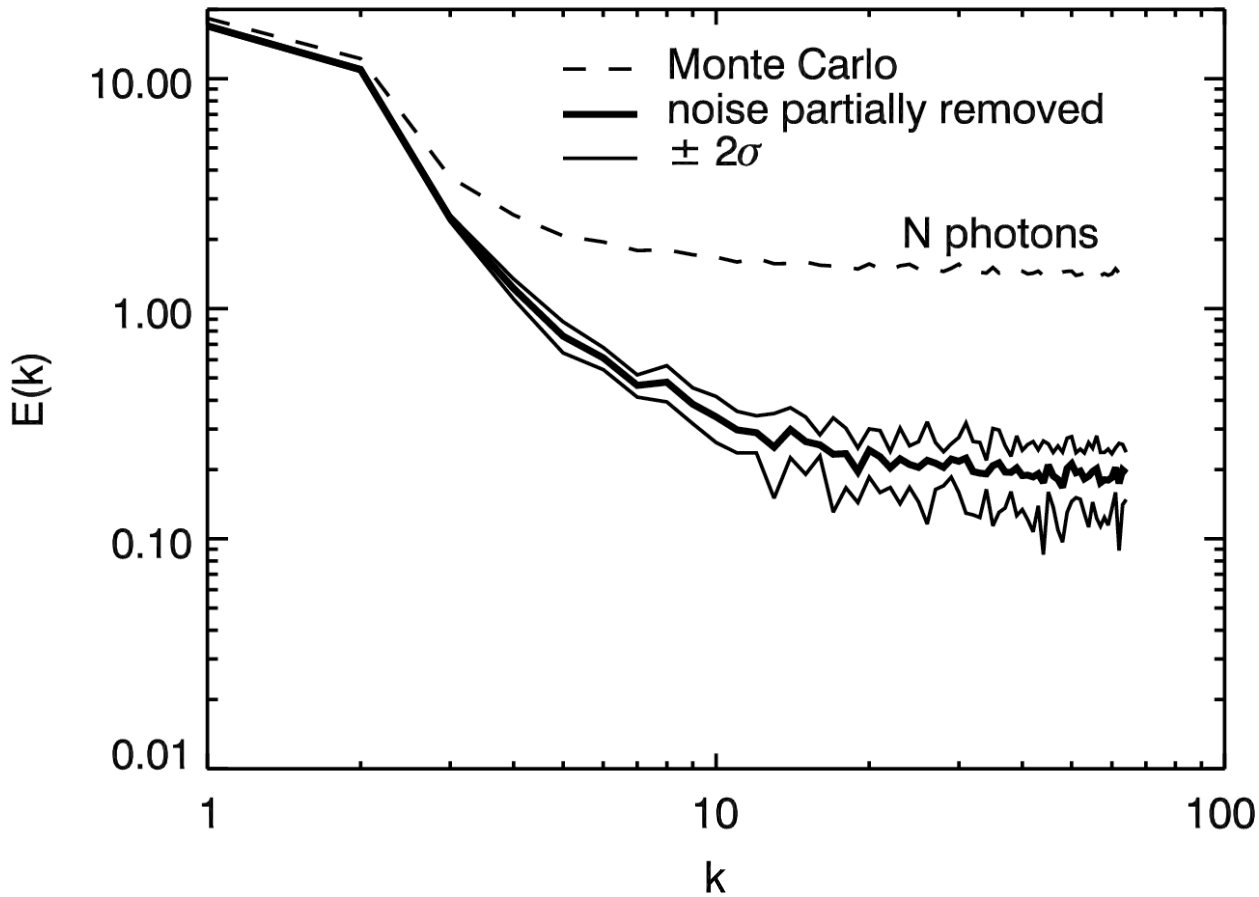




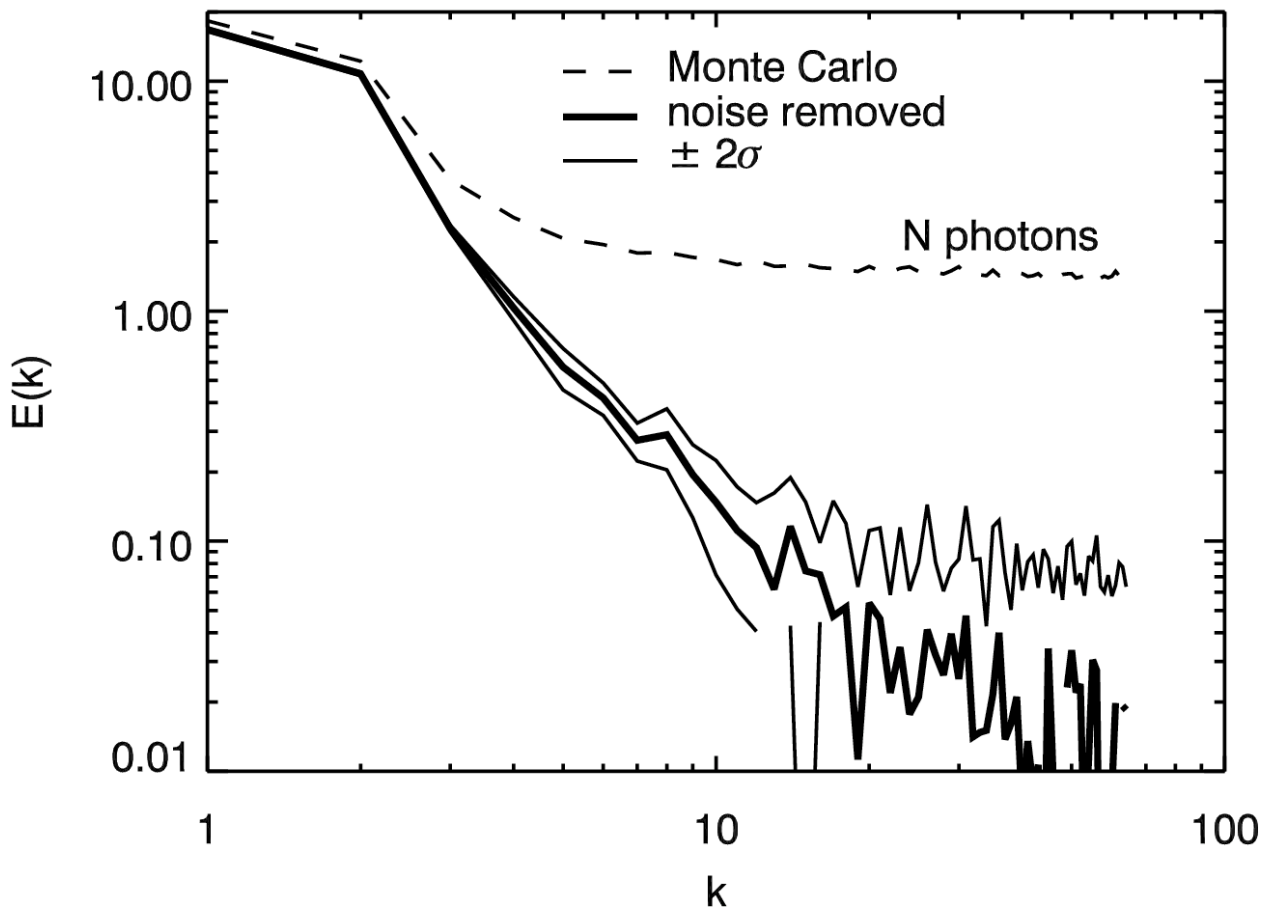
De-noising the power spectrum



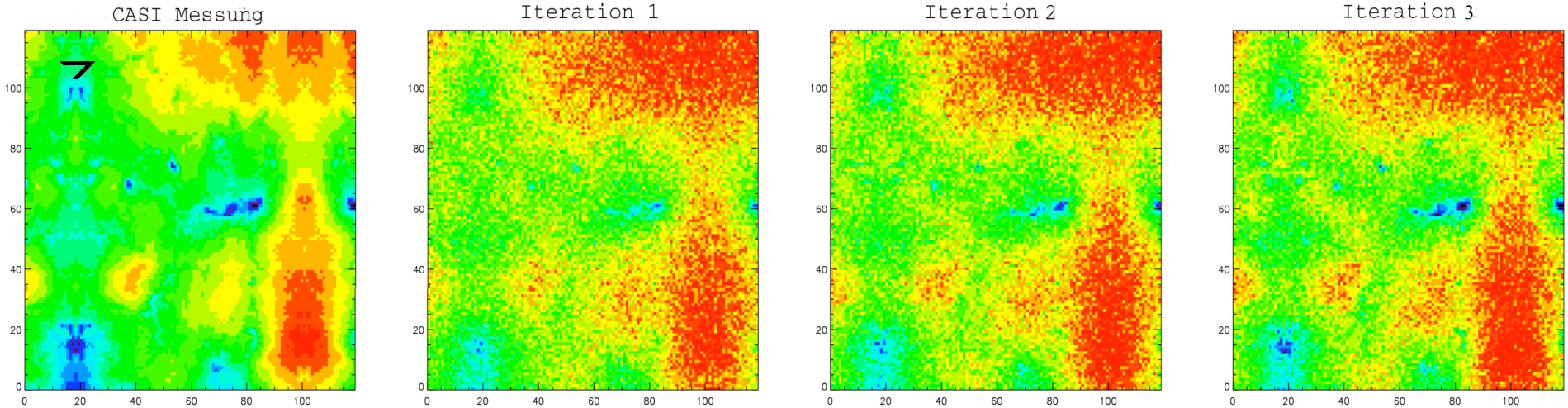
De-noising the power spectrum



De-noising the power spectrum

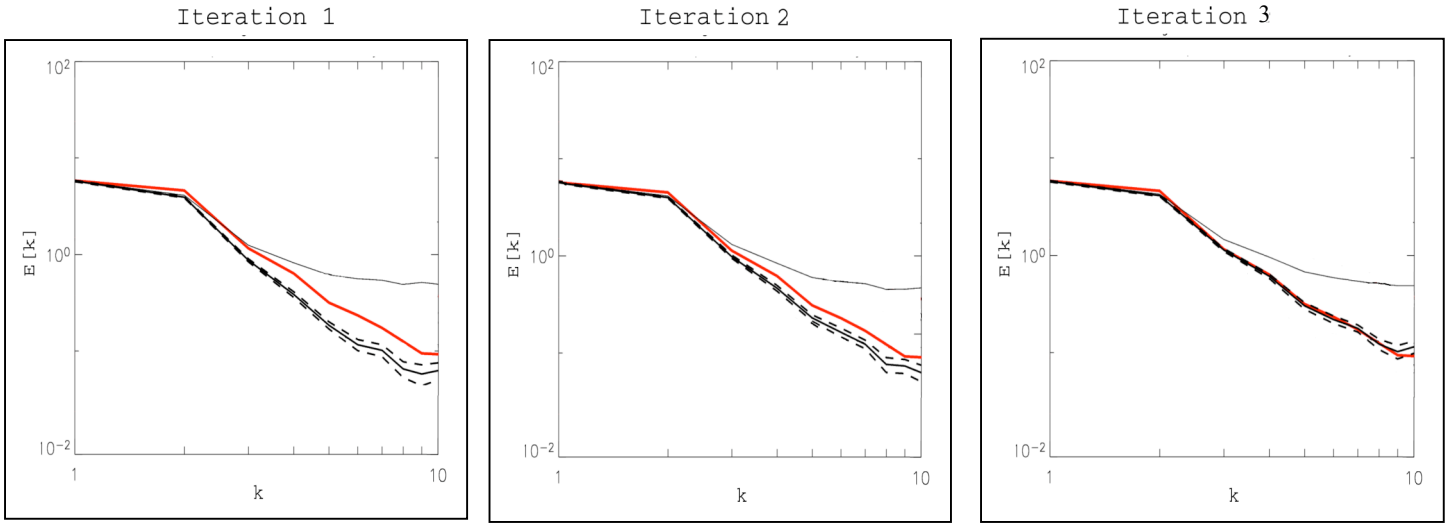


Deconvolution of high resolution radiances

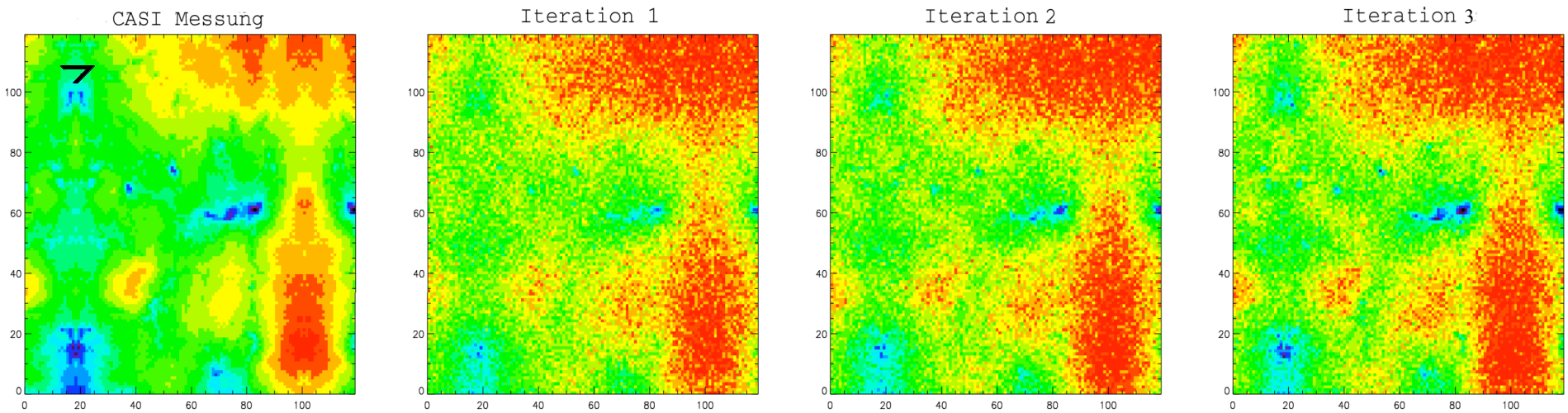


criterion 1:

power spectr.



Deconvolution of high resolution radiances

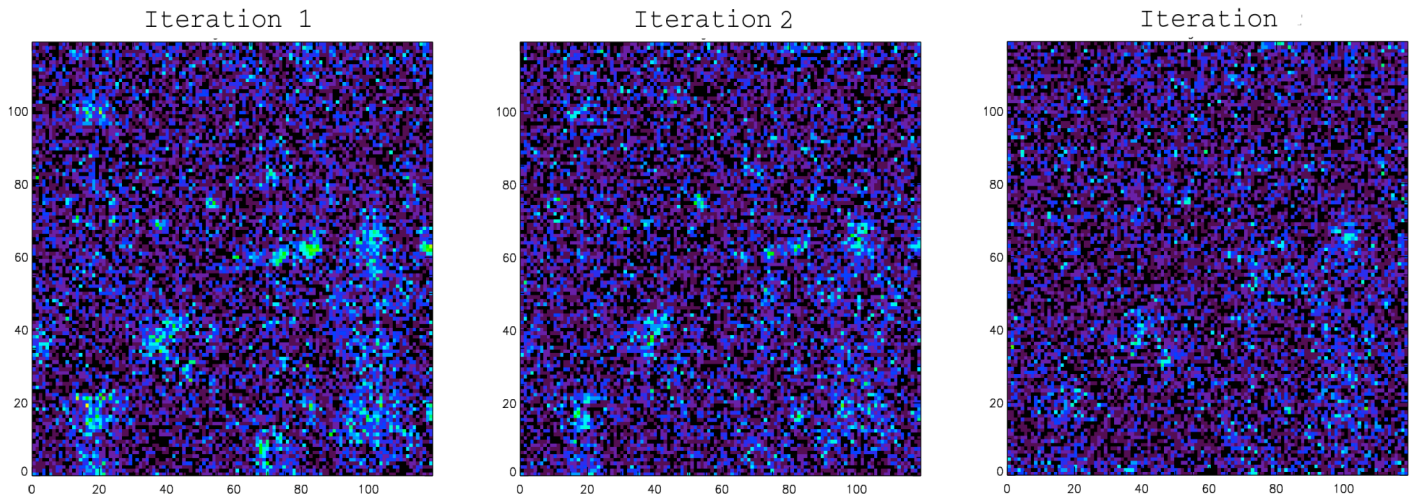


criterion 1:

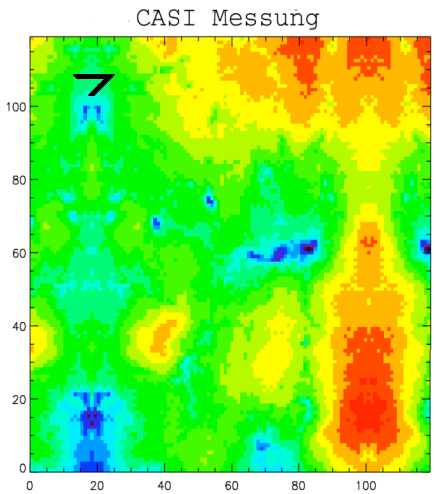
power spectr.

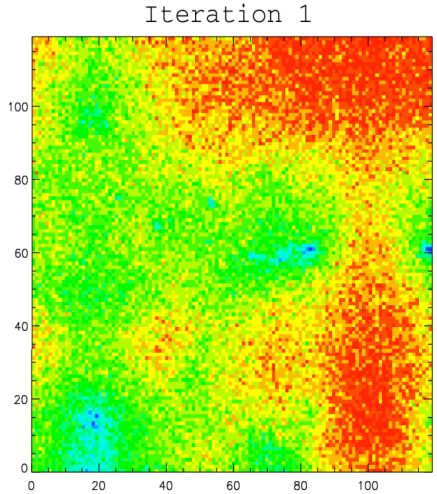
criterion 2:

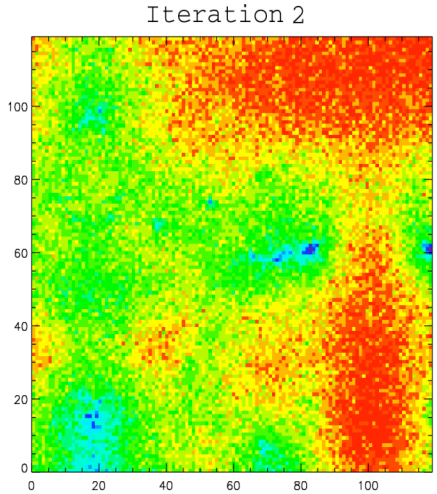
RMSE

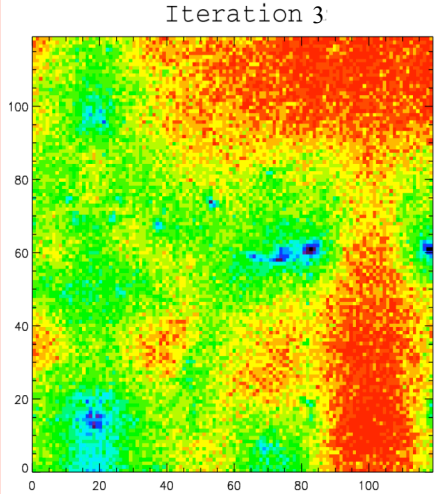


Deconvolution of high resolution radiances







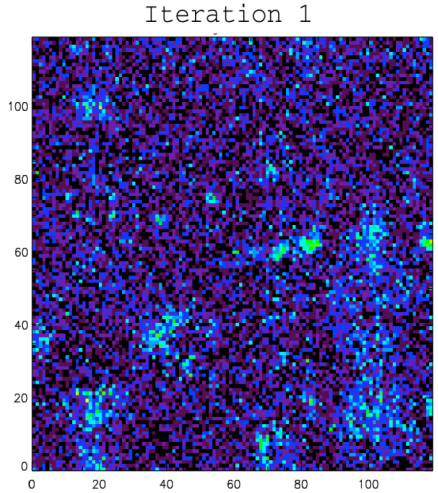


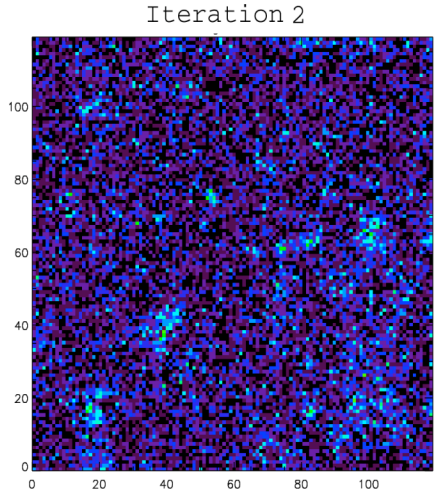
criterion 1:

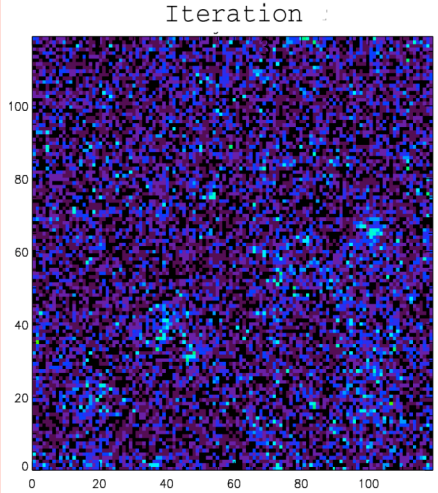
power spectr.

criterion 2:

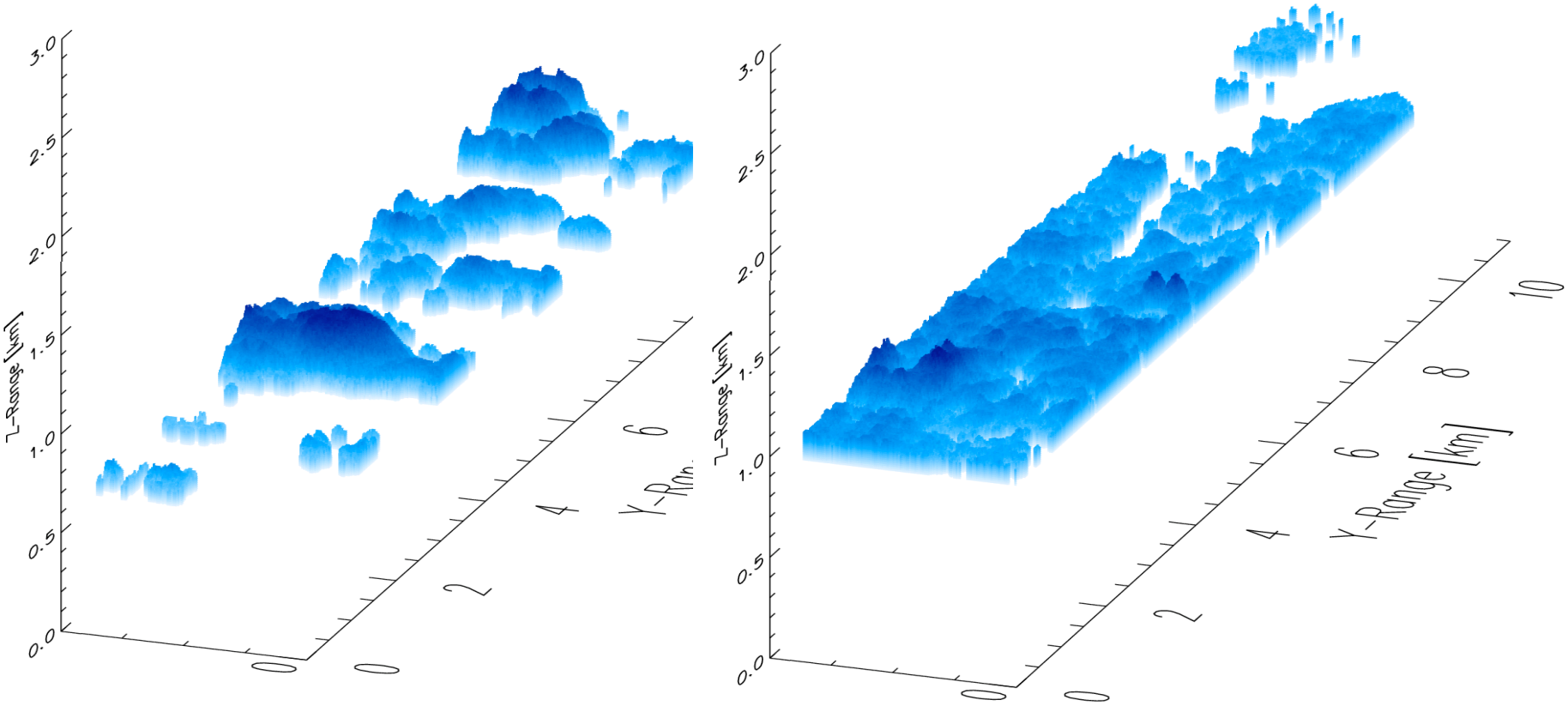
RMSE







3D cloud structures



27 stratocumulus cloud structures

approx. 1.3 km x 10 km size, resolution 15 m x 15 m x 10 m

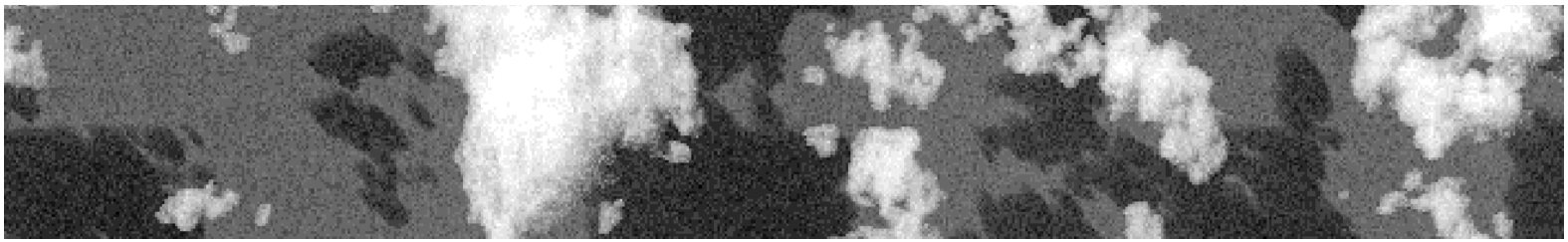
Application

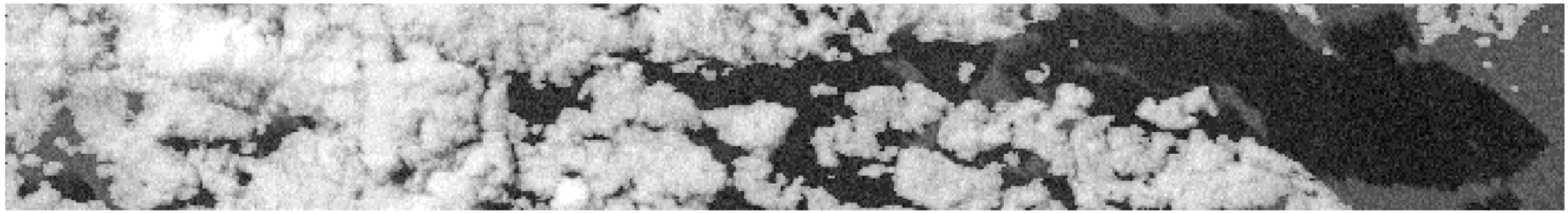
Testbed for investigation of the impact of cloud inhomogeneity on remote sensing techniques

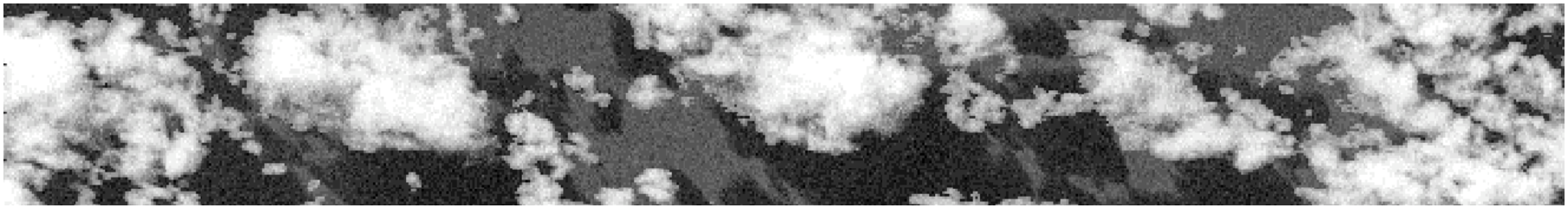
- simulation of arbitrary satellite sensor channels
- simulation of standard remote sensing
- comparison of results with testbed values

Impact of cloud inhomogeneity on remote sensing

MYSTIC nadir radiance, 830 nm, SZN=60°, SAZ=315°

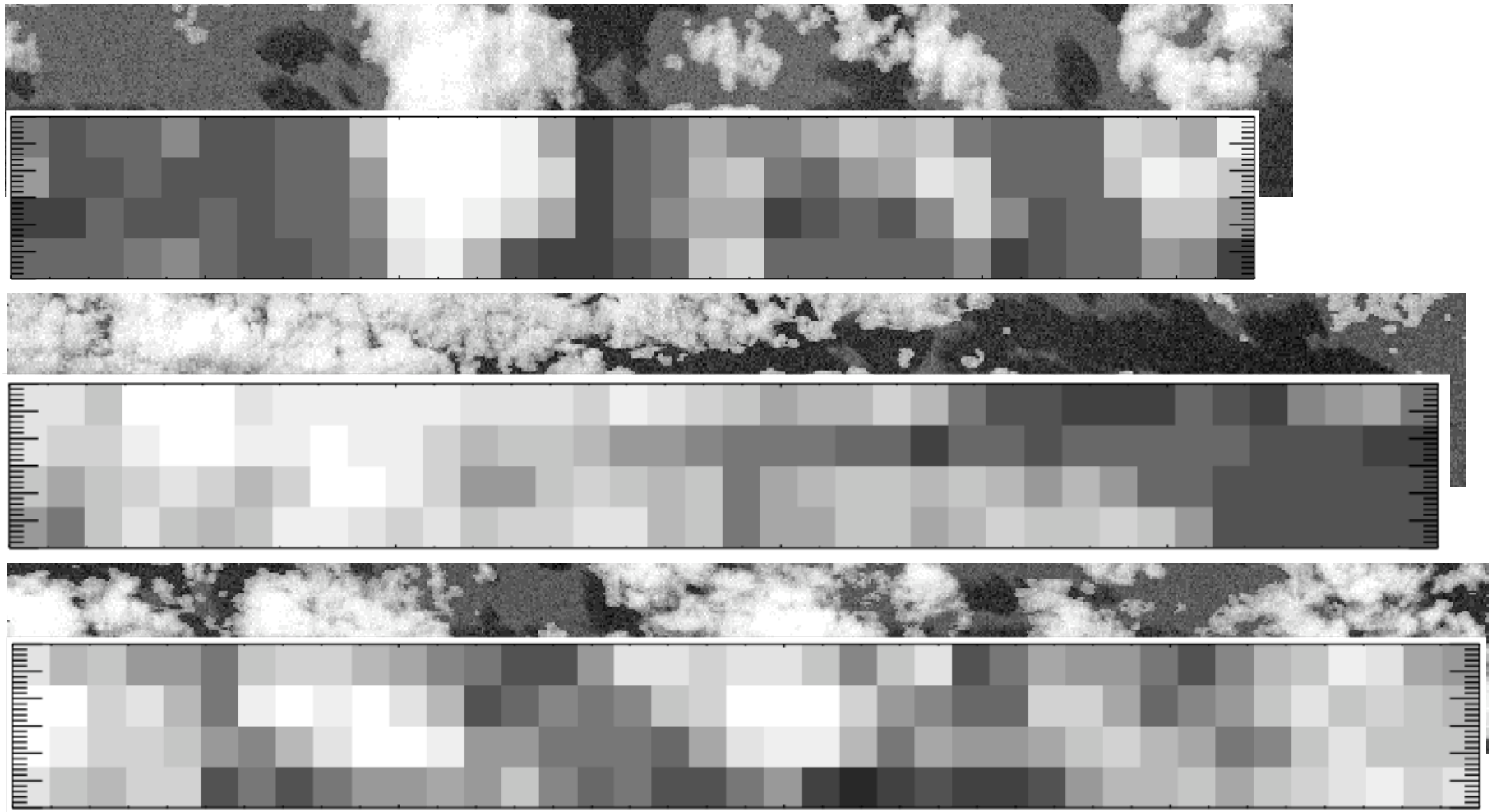






Impact of cloud inhomogeneity on remote sensing

MYSTIC nadir radiance, 830 nm, SZN=60°, SAZ=315°



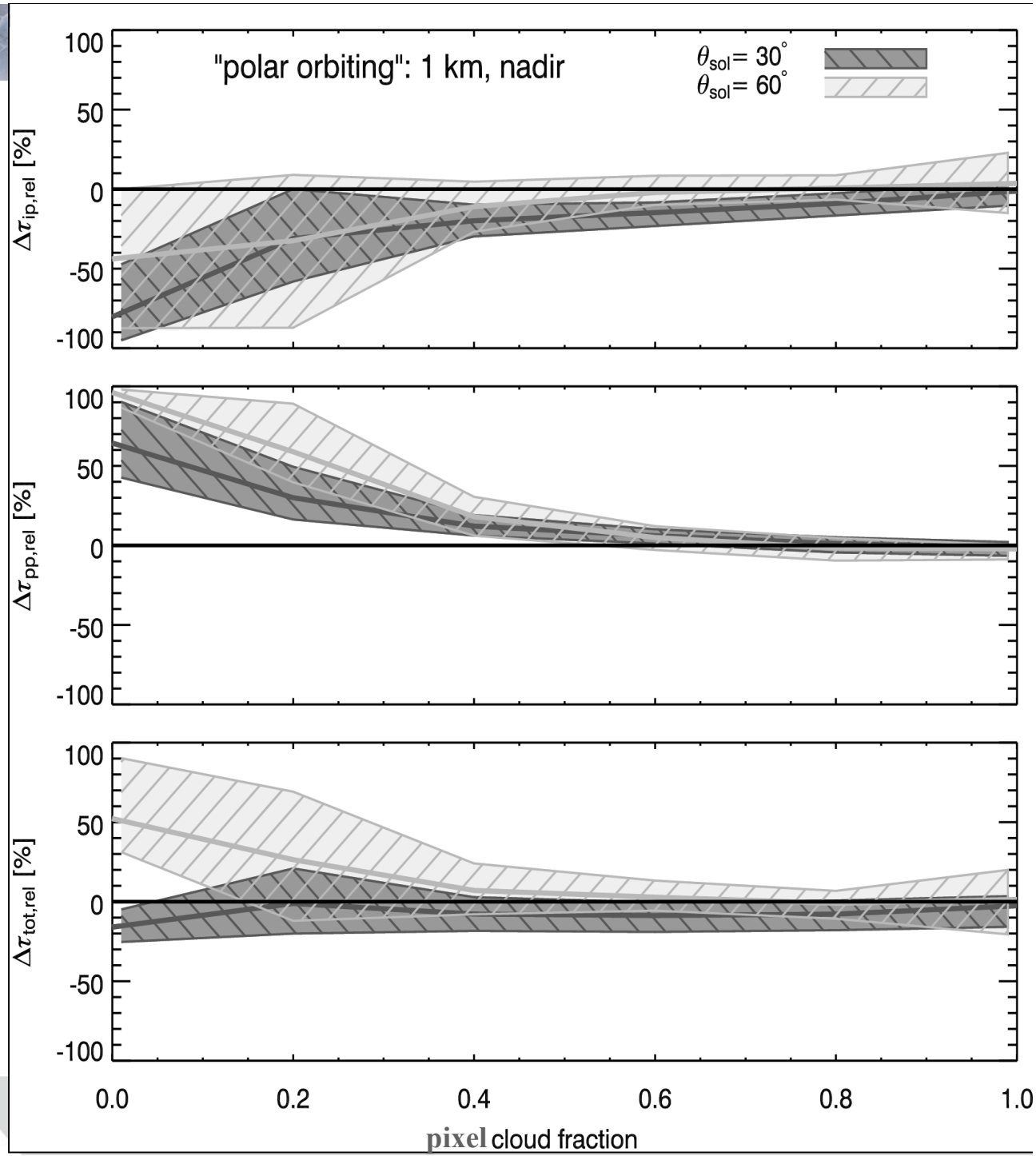
1x1 km^2, nadir view

Results

independent pixel error:

plane parallel error:

total uncertainty:



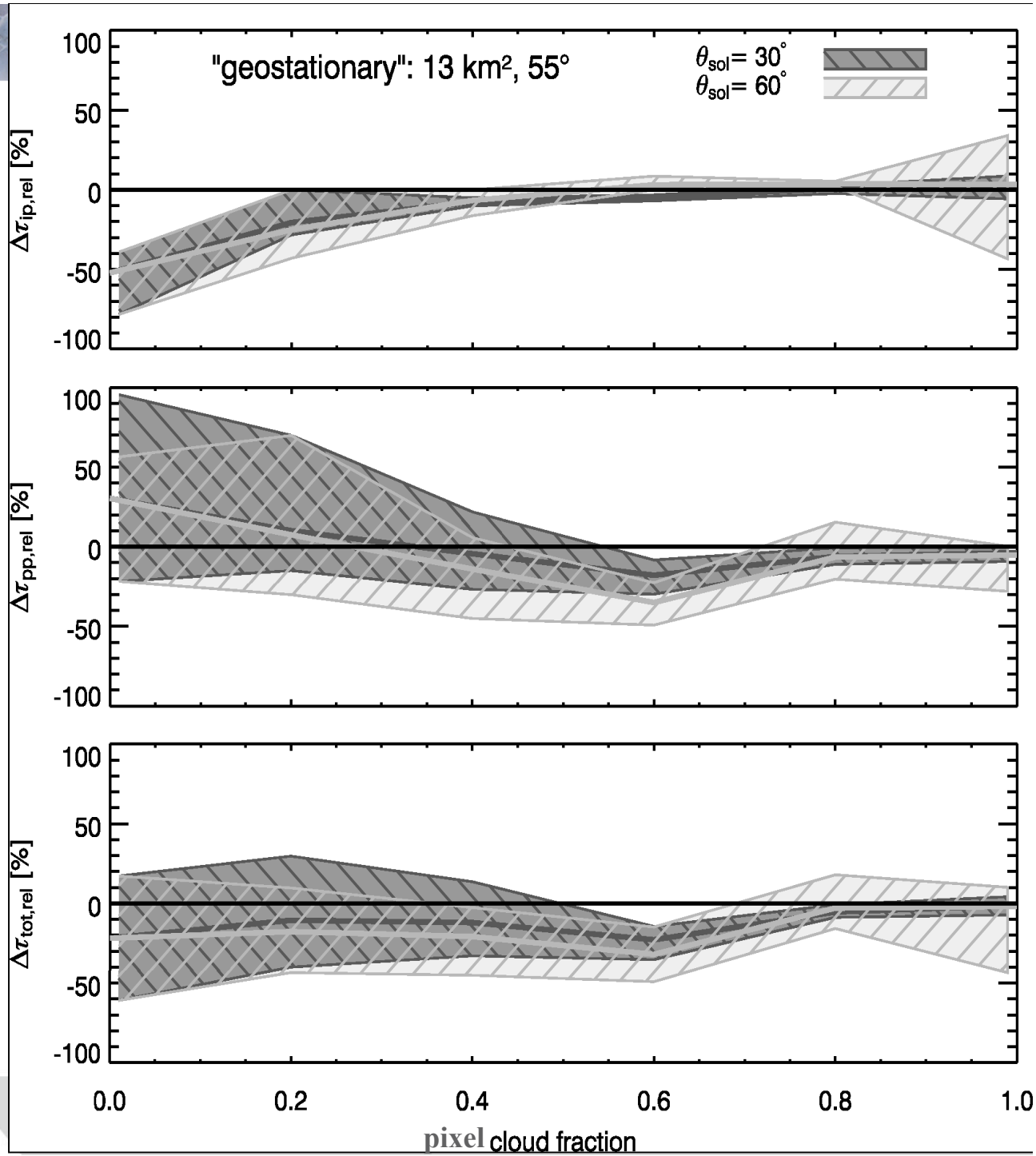
13 km², sensor zenith 55°

Results

independent pixel error:

plane parallel error:

total uncertainty:



Summary

Realistic cloud structures directly derived from observation
(Zinner, Mayer, Schröder; JGR accepted; 2005)

- Remote sensing technique to retrieve 3D cloud structures taking into account 3D radiative transfer effects
- Very high spatial resolution of retrieved cloud structures (15 m)

Study of the impact of cloud inhomogeneity on cloud remote sensing