Influence of Surface Albedo Inhomogeneities on Remote Sensing of Cirrus Optical and Microphysical Parameters

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DLR

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JÜLICH FORSCHUNGSZENTRUM

HALO High Altitude and Long Range Research Aircraft

1. Introduction & Motivation

- Remote sensing above land heterogeneity has to be considered
- For thin cirrus surface albedo has to be known
- HALO campaign (TECHNO Mission, Germany, late 2010), measurements for thin cirrus ($0 < \tau < 2$)

- Measurements cover two ***variabilites:***

Cirrus inhomegeneities | ***Heterogeneous surface albedo***

Fig. 1: True color (Band 1-4-3) MODIS image (250m resolution) of Central Europe from October, 28th 2010.

Fig. 2: Photograph of typical landscape in the TECHNO Mission operation area from October, 27th 2010.

What is the exact influence of the surface albedo heterogeneity on the retrieval of cirrus optical depth and effective radius? Can τ and R_{eff} be quantified without knowledge of the accurate surface albedo?

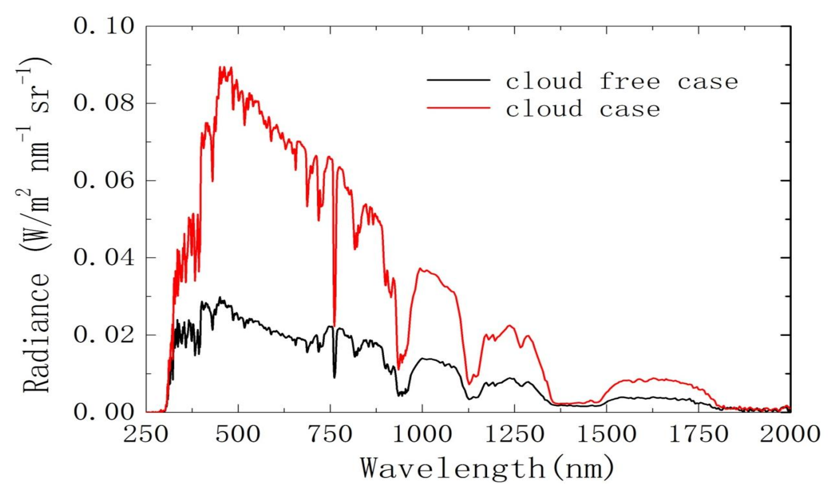
2. Instrumentation on HALO

- Spectral radiance measurements above cloud/ground looking downward (nadir)
- 2.1° Field of view
- Time resolution between 0.3 – 1 Hz
- Footprint size of measurement ca. 1 km²

Radiance (I_λ)	Spectral Range	Resolution
VIS	300-1000 nm	2-3 nm
NIR	1000-2000 nm	9-16 nm

- Determination of spectral cloud top reflectivity r_λ using simulated downward irradiance ($F_\lambda^\downarrow$)

$$r_\lambda = \frac{\pi\, I_\lambda^\uparrow}{F_\lambda^\downarrow}$$



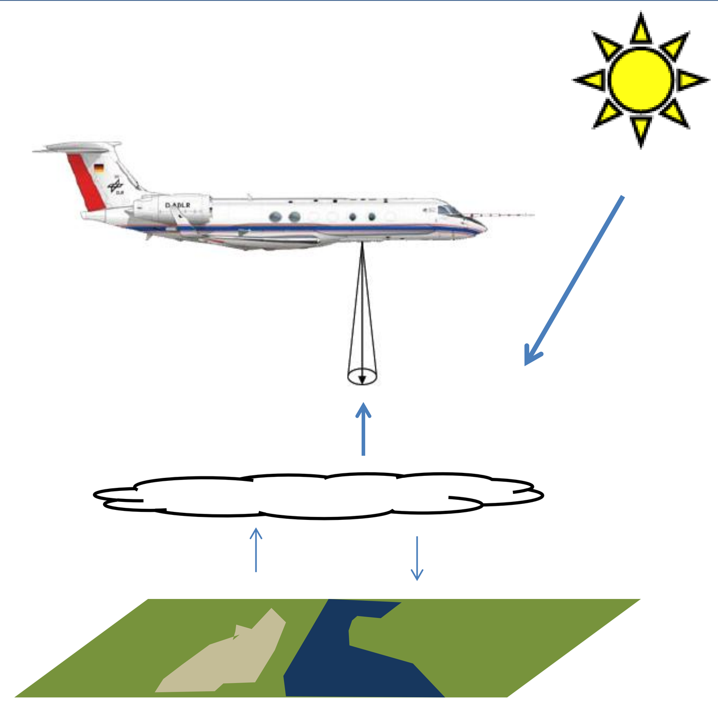


Fig. 3: Nadir measurement of reflected radiance.

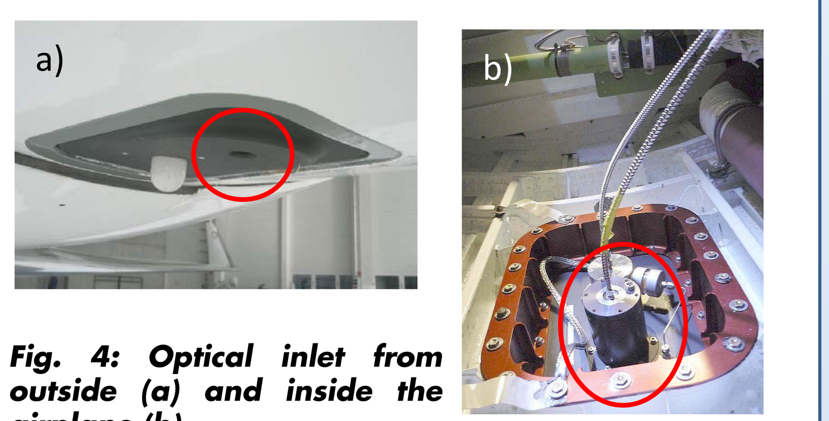


Fig. 4: Optical inlet from outside (a) and inside the airplane (b).

Fig. 5: Example measurement of upward directed radiance over a cloud and cloud free situation.

3. Measurements and Strategy

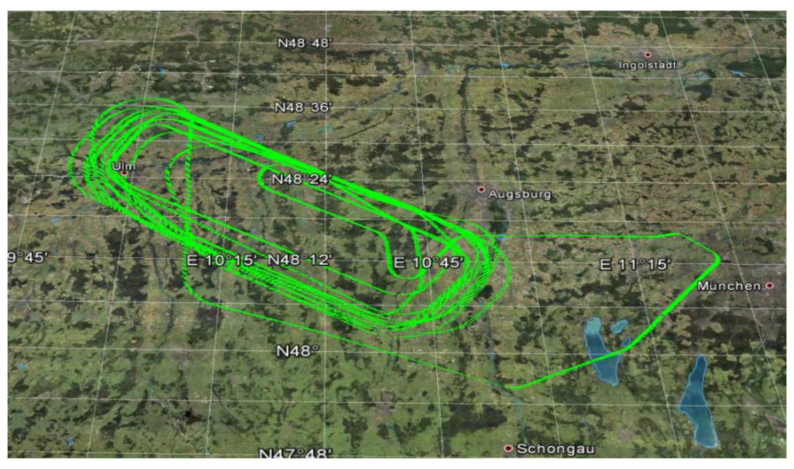


Fig. 6: Flight track illustrating the measurement area in the southern Germany region using GPS data (illustrated with Google Earth).

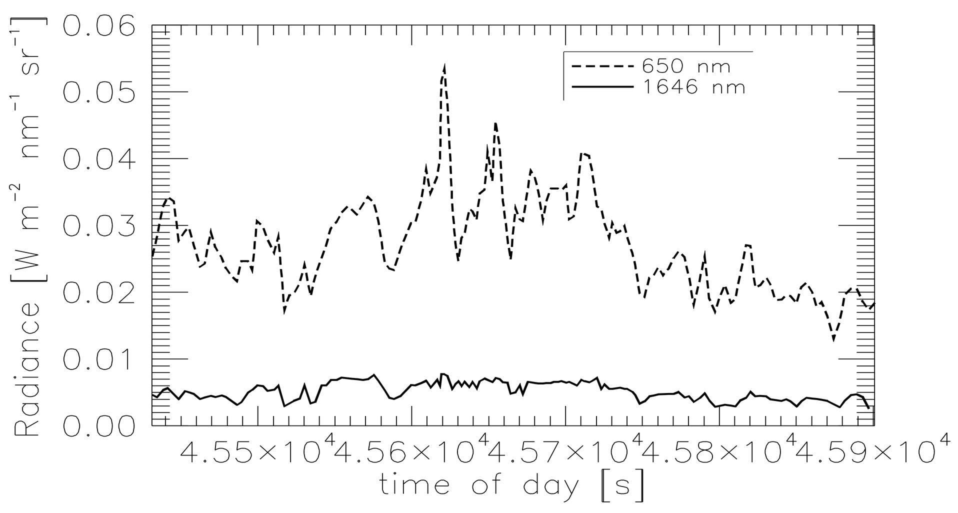


Fig. 7: Time series of nadir upwelling radiance reflected by cirrus. Variability in the measured radiance results either from the heterogeneity of surface albedo or cloud properties.

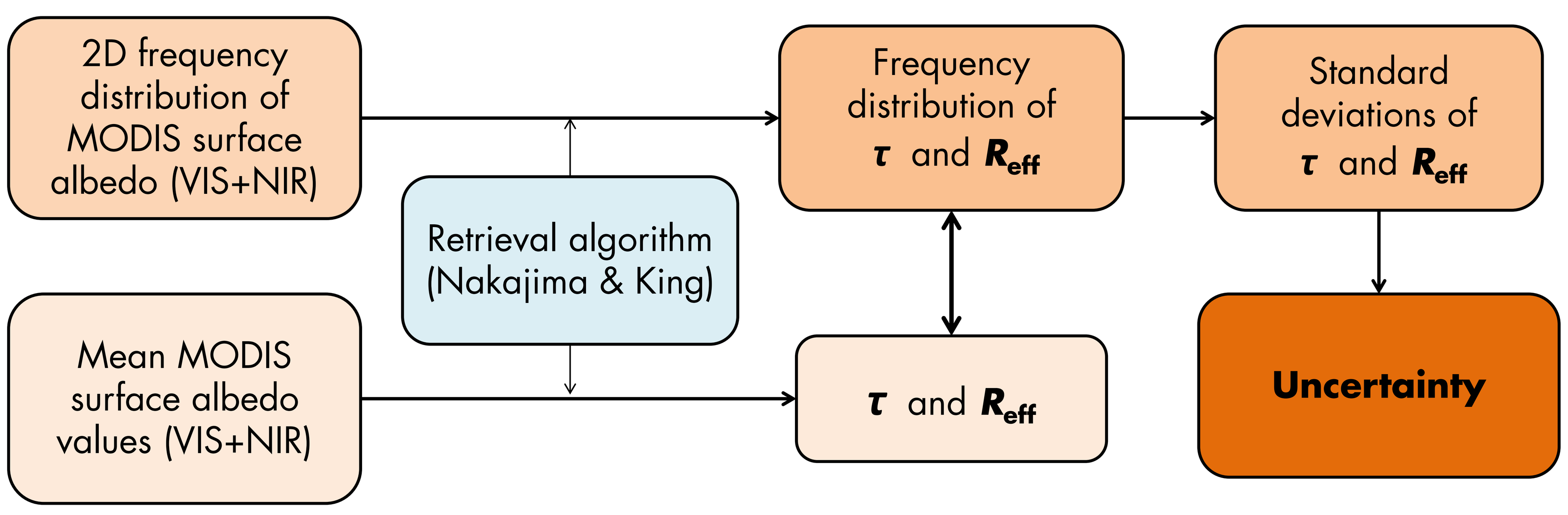


Fig. 8: Strategy of statistical retrieval of cirrus optical depth and effective radius.

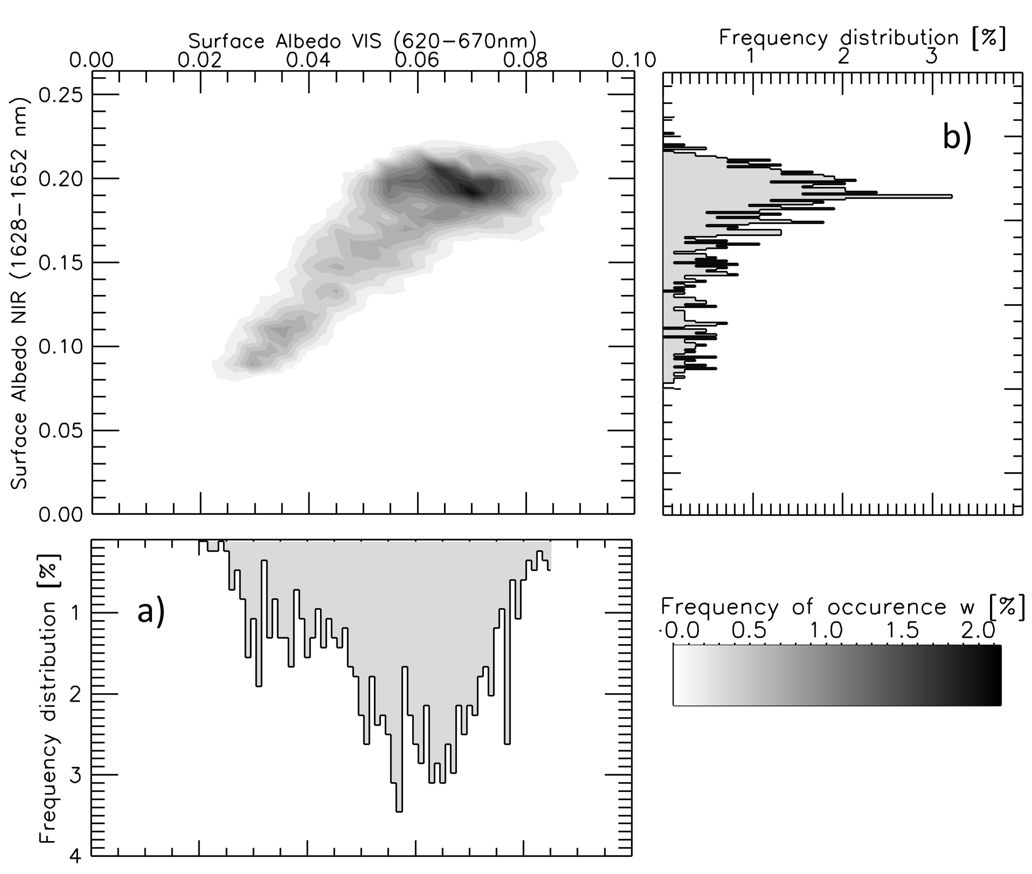


Fig. 9: 2D frequency distribution of the combined VIS+NIR (a,b) surface albedo of the flight track. Each value stands for a surface albedo pair with bin size of 0.005.

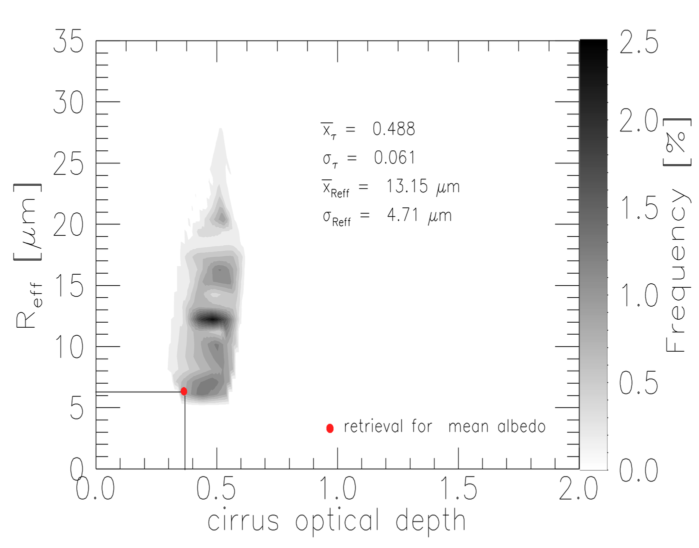
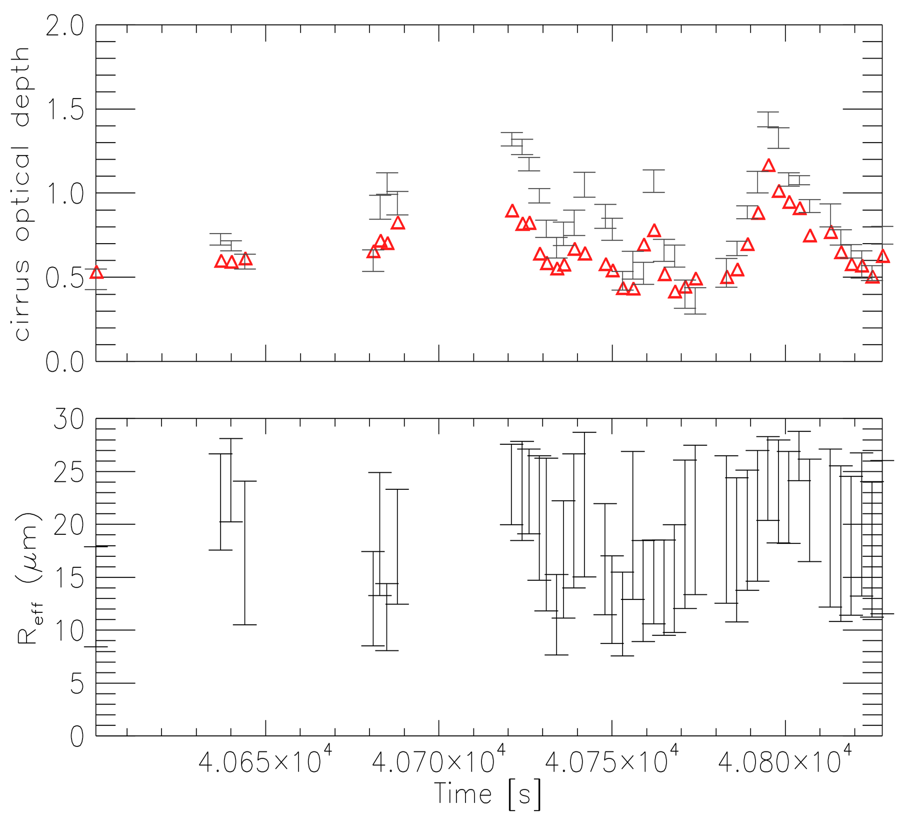


Fig. 10: Example solution space of mean value and deviation for τ and R_{eff} for the flight of November, 4th. Beside that, the retrieval result for assuming the mean surface albedo is illustrated as red dot. The mean surface albedo retrieval underestimates due to a nonlinear distribution of the surface albedo.

4a. Comparison with Lidar measurements

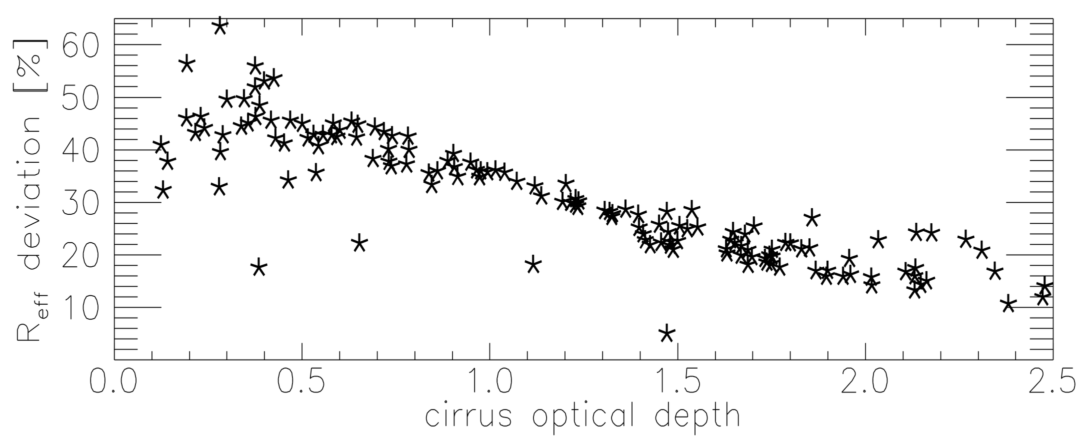


	τ	R_{eff}
Thick cirrus	Small uncertainty	Small uncertainty
Thin cirrus	Small uncertainty	High uncertainty

Fig 11: Influence of cirrus optical depth on retrieval of τ and R_{eff}.

*Fig. 12: **top:** τ comparison between statistic retrieval (bars) and values derived of the DLR Lidar WALES (red triangle) from a 30-min timeframe of the November, 4th flight .*
***bottom:** Uncertainty for Reff of the corresponding timeframe.*

4b. Uncertainty dependance



- With increasing cirrus optical depth the uncertainty of effective radius decreases as the influence of the surface albedo reduces.

Fig. 13: Correlation between the deviation/uncertainty of effective radius and optical depth.

4c. Influence of ice crystal shape

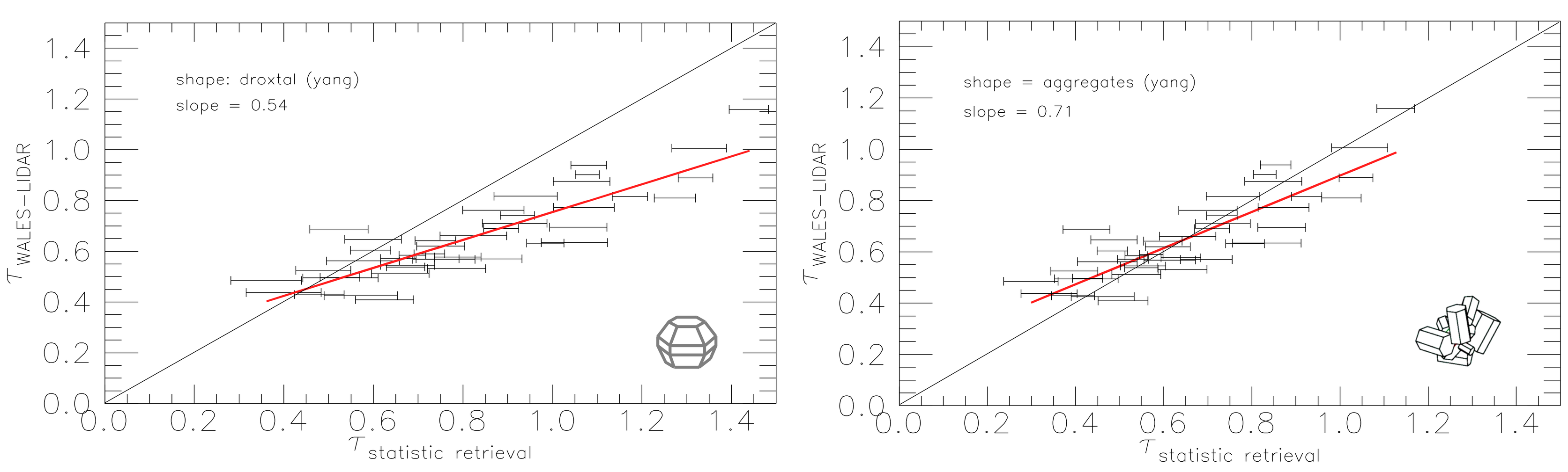


Fig. 14: Comparison of cirrus optical depth retrieved by statistical approach and DLR lidar WALES illustrating the influence of the ice crystal shape on the retrieval. The influence increases with increasing cirrus optical depth.

5. Conclusions

- Influence of surface albedo inhomogeneities significant for optical depths below 2
- Statistical retrieval suitable for retrieving cirrus optical depth
- R_{eff} uncertainty decreases with increasing optical depth
- With increasing τ, the influence of the ice crystal shape increases
- Possible 3D as well as bidirectional reflectance function (BRDF) effects will be investigated in the future

References

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