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Aerosol layer height retrieval using the O_2-A and O_2-O_2 band

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A sensitivity analysis of the O_2-A and O_2-O_2 band for retrieving aerosol layer height is presented. We investigate to what extent specific knowledge of the aerosol single scattering albedo is needed for accurate and precise height retrieval. Results will be used for developing the TROPOMI aerosol algorithm.

1. Aerosol retrieval and TROPOMI

The April 2010 eruption at Eyjafjallajökull showed the importance of detailed knowledge of the height of thick elevated aerosol layers, such as the ash plumes disrupting air traffic over most of northern Europe.

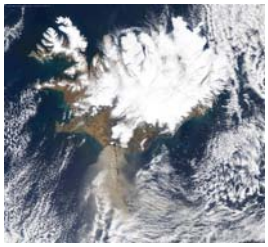


Figure 1. *MODIS image of Iceland (April 17)*

KNMI is the principal investigator institute for the Tropospheric Monitoring Instrument (TROPOMI), which is scheduled for launch in 2015. TROPOMI is the follow-on to the Ozone Monitoring Instrument (OMI). OMI measures in the ultraviolet and visible wavelength range. TROPOMI will also measure in the near-infrared and shortwave infrared ranges.

The O_2-O_2 absorption band in the UV is currently used by OMI to retrieve cloud pressure. It might potentially also be used for retrieving aerosol layer height (cf. Dirksen et al. 2009). However, the O_2-A band in the NIR offers another possibility to retrieve aerosol height.

How does height retrieval via the O_2-A (758-770 nm) and O_2-O_2 (460-490 nm) absorption bands compare in terms of accuracy and precision? To what extent is a lack of knowledge of the aerosol type a limiting factor?

2. Simulating Retrieval

2.1 General

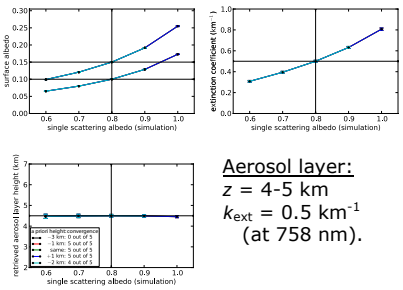
The analysis is done with DISAMAR, which is a software package developed in our group that (1) simulates measured backscattered radiances and (2) applies retrieval algorithms under different assumptions. The retrieval method used is Optimal Estimation. Instrument specifications (signal-to-noise ratio, resolution, spectral sampling) are as anticipated for TROPOMI.

2.2 Experiments

- We introduce a bias in the single scattering albedo: In the simulation, the SSA was varied; in the retrieval, its value was held constant at 0.8.
- Three parameters are fitted:aerosol layer height (z), extinction coefficient (k_{ext}) and surface albedo (A_s)
- Six scenarios for the aerosol layer: three extinction coefficients × two layer heights
- Degree of polynomial for surface albedo: one for O_2-A band and two for O_2-O_2 band.

3. Results

3.1 Example run O_2-A band



Aerosol layer:
z = 4-5 km
k_{ext} = 0.5 km^{-1}
(at 758 nm).

Figure 2. *Example of a full O_2-A band run.*

3.2 Overall: O_2-A band

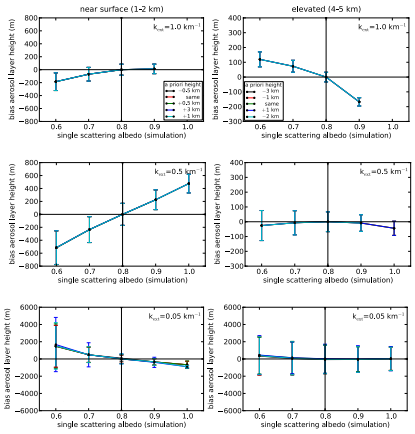


Figure 3. *O_2-A band: Biases in retrieved aerosol layer height as a function of the single scattering albedo for six aerosol scenarios.*

Accuracy: retrieved height well below the threshold requirement (1 km), even when SSA in simulation and retrieval differ by as much as 0.2. **Precision**: error increases with increasing HG asymmetry parameter (not shown).

3.2 Overall: O_2-O_2 band

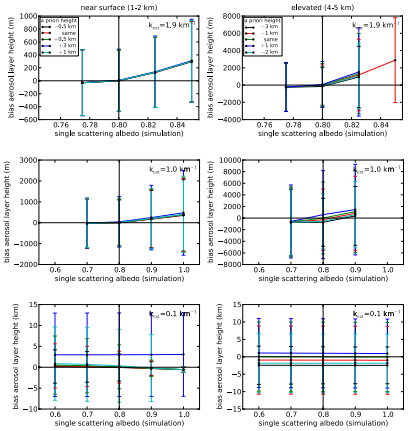


Figure 4. *O_2-O_2 band: Biases in retrieved aerosol layer height as a function of the single scattering albedo for six aerosol scenarios.*

Accuracy: retrieved height still at the threshold requirement, but less tolerant for bias in SSA. **Precision**: poor, making retrieval very sensitive to disturbances (compare effect of a priori height).

4. Conclusion

- O_2-A band is suited for height retrieval of thick elevated aerosol layers: volcanic ash plume height, biomass burning and desert dust transport. Retrieval via O_2-O_2 band is problematic because of poor precision due to weak absorption by O_2-O_2.
- Aerosol algorithm for TROPOMI will be partly based on O_2-A band. Future work includes correcting/ flagging for cirrus contamination and improving computational efficiency.

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