Aerosol-radiation interactions from space spectrometers over the tropical Atlantic

M. de Graaf[1,2], L.G. Tilstra[2], P. Stammes[2]

[1]Department of Geosciences and Remote Sensing, Delft University of Technology, Delft, The Netherlands
[2]Department of Satellite Observations, Royal Netherlands Meteorological Institute, De Bilt, The Netherlands
Keywords: aerosol, clouds, climate effects, satellite observations.
Presenting author email: m.degraaf@tudelft.nl

The largest consumption of biomass by fire in the world, of about 25Tg of carbon year^{-1} occurs in tropical Africa during the monsoon dry season. When smoke from these fires is transported under the influence of equatorial easterlies, it overlies one of the planet's major semi-permanent stratocumulus decks, which exist due to low sea surface temperatures in the upwelling region of the southeast Atlantic Ocean, west of the continent.

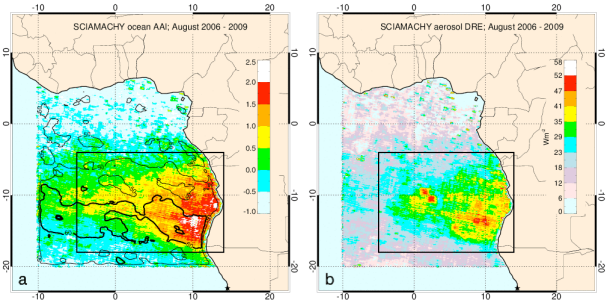

Figure 1. Cloud fraction, Absorbing aerosol Index and DRE over the southeast Atlantic Ocean.

The smoke absorbs solar radiation, warming the atmosphere locally above the clouds, and reducing the amount of radiation reaching the surface, cooling the Earth's surface. This changes the planetary albedo, while simultaneously changing the atmospheric stability, affecting cloud fraction, cloud lifetime, and the formation of precipitation.

Observations of aerosols from space are challenging in the presence of clouds, because cloud screening is often applied before aerosol properties are retrieved, hampering the study aerosol-cloud-radiation interactions in cloud scenes. We introduced a new technique that uses shortwave hyperspectral measurements from space to distinguish the absorption of aerosols, that is large in the ultraviolet (UV), from the scattering by cloud droplets in the shortwave infrared (SWIR). With this, the aerosol direct radiative effect (DRE) of small smoke particles over clouds can be quantified, without retrieving aerosol parameters first. Instead, the aerosol-free cloud scene is simulated and compared with the measured aerosol-cloud scene, see Figure 2. Application to SCIAMACHY measurements over the southeast Atlantic Ocean during the African monsoon dry season (June-Sept.) in 2006-2009, produced aerosol DRE over cloud with very high accuracy. The aerosol DRE over clouds was up to 128 ± 8 Wm^{-2} instantly, with a monthly average of about 35 Wm^{-2} (De Graaf *et al.*, 2012). This is much larger than previously estimated with General Circulation Models (GCMs), that simulate a monthly mean aerosol DRE up to about 6 Wm^{-2}. Nowhere is the discrepancy between model simulations so pronounced than over the southeast Atlantic Ocean. The large uncertainty in GCMs in the radiative effects of aerosols on clouds limit our ability to project and attribute climate change and quantify climate sensitivities. Reconciliation of GCM simulations with observations failed to identify the processes in the models that are responsible for the underestimation of the DRE, but cloud brightness is most likely the most critical parameter (De Graaf *et al.*, 2014).

Since SCIAMACHY was lost in 2012, new measurements from OMI and MODIS were used to continue the observations of aerosol absorption over clouds from space. Each instrument by itself does not provide enough information on both aerosols and clouds, but OMI gives detailed information of UV aerosol absorption, while MODIS broadband channels provide cloud information from the SWIR. OMI and MODIS are flying in formation in the A-Train constellation, providing observations about 7 minutes after one another. Furthermore, MODIS provides cloud products and AOD at 1x1 km resolution, and better, which can be used to test and improve the DRE retrieval algorithm.

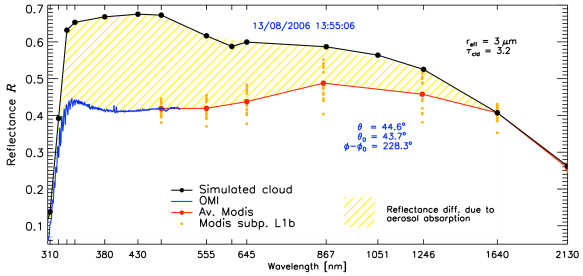

Figure 2. Combination of OMI and MODIS spectral measurements, compared to a simulated aerosol-free cloud scene spectrum.

We will introduce new results from the combination of OMI and MODIS, as well as preparations for a field campaign in Walvis Bay, Namibia, in 2016.

De Graaf, M. L.G. Tilstra, P. Wang and P. Stammes (2012), *Retrieval of the aerosol direct radiative effect over clouds from space-borne spectrometry*, J. Geophys. Res. **117**.

De Graaf, M. , N. Bellouin, L.G. Tilstra, J. Haywood, P. Stammes (2014), *Aerosol direct radiative effect of smoke over clouds over the southeast Atlantic Ocean from 2006 to 2009*, Geophys. Res. Lett. **41**.