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Radiative forcing by absorbing aerosols over clouds measured by SCIAMACHY

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Aerosols affect the Earth's albedo and shortwave radiation balance by scattering and absorption of sunlight. It appears that the radiative effect of aerosols strongly depends on the underlying scene, whether it is dark or bright. For example, absorbing aerosols above a bright cloud can lower the albedo of the cloud and thereby perform a strong heating effect. However, it is difficult to obtain quantitative information from satellites on this direct aerosol effect. The reason is that most aerosol detection algorithms fail in the presence of clouds, because cloudy scenes are considered to be too bright to allow aerosol retrieval. This detection problem can be avoided by the use of the absorbing aerosol index (AAI) to detect absorbing aerosols. The AAI is a differential spectral index to identify UV absorbing aerosols, like desert dust and smoke. The strength of the AAI aerosol detection method is that it works equally well for land and sea surfaces, and that it works even in the presence of clouds.

Global information on absorbing aerosols over clouds have been obtained with the satellite instrument SCIAMACHY on Envisat. SCIAMACHY measures the Earth's reflectance from 240 to 1750 nm, i.e. the major part of the shortwave spectrum. We focus on clouds and smoke from biomass burning in Southern Africa. It appears that clouds that exist in the presence of smoke aerosols have a typical reflectance spectrum, with a lower reflectance in the UV and visible than clouds without smoke. This lower reflectance is caused by the light absorption by smoke aerosols above and inside the clouds, which is strongly wavelength-dependent. From integration of the measured reflectance spectrum of these smoke-polluted clouds over the SCIAMACHY wavelength range, we obtain a direct estimate of the shortwave absorption of polluted clouds. The measured radiative forcing effect is interpreted with an accurate doubling-adding radiative transfer model.