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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Effects of absorbing aerosols in cloudy skies: a satellite study over the Atlantic Ocean" *by* K. Peters et al.

Anonymous Referee #2

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The aim of this paper is to quantify the aerosol radiative forcing above clouds. Absorbing aerosols located above clouds may reduce the amount of light reflected back into space by the clouds, causing a local positive radiative forcing that is not currently well understood (Forster et al., 2007). The subject of the paper is then relevant for publication in ACP but my point of view is that the methodology proposed by the authors to derive this aerosol radiative forcing is too crude and may lead to erroneous conclusions. Therefore, I do not recommend the publication of this paper in the current form. I provide some explanations below justifying my recommendation and list the major issues I found.

The short-wave local planetary albedo α in case of aerosols above clouds depends on: (1) the cloud albedo : Cloud Optical Thickness (COT) and microphysical properties.

(2) the properties of the aerosol located above the cloud : Aerosol Optical Thickness (AOT) and microphysical properties. (3) the vertical structure of the atmosphere: the respective locations of cloud and aerosol layers along the vertical

The authors use a combination of satellite observations in order to derive a statistical relationship between the short-wave local planetary albedo α, the liquid water path (LWP) and the aerosol optical thickness (AOT) in cases when aerosols are located above clouds.

The relation is

α = a0 + a1*ln(LWP) +a2*ln(AOT) (Eq. 1)

The α is derived using the CERES TOA shortwave flux, the LWP form AMSR-R and the AOT from MODIS, with the 3 intruments onboard the AQUA satellite.

This is the most important relation of the paper and all the results come from this equation.

Major issues:

(1) The AOT used to perform the calculations is not the one retrieved above the clouds but the AOT retrieved close to the clouds for non-cloudy pixels. Without information on the vertical structure of the atmosphere (the authors deliberately choose not to use lidar observations), we can't be sure that the AOT retrieved close to the clouds over ocean is the same that the one above the clouds. In case of aerosols in cloudy scenes, the aerosols may be inside the clouds or even below the clouds and the AOT assumed above the clouds for such cases is clearly wrong.

The authors use the aerosol index (AI) provided by OMI to check the presence of absorbing aerosols in cloudy pixels. I agree that the OMI AI allows detecting (qualitatively) the presence of absorbing aerosols in cloudy skies however the OMI AI cannot quantify how much aerosols are above or inside the clouds.

To my point of view, the only valid approach to derive the aerosol radiative forcing above clouds is to start from an estimate of the aerosol optical thickness retrieved above the clouds.

(2) The cloud albedo is the parameter that primarily drives the short-wave local planetary albedo α in case of scenes with aerosols above clouds. In Eq. 1, the effect of the clouds properties on α comes from the second term (a1ln(LWP)).

The LWP is not suitable to represent the effect of the cloud albedo on α and equation 1 does not account for cloud microphysics.

A well know simple expression of LWP is

LWP = 2/3 * CODvis *reffc * w

(COD : cloud optical thickness, reffc : cloud particles effective radius, w : density of liquid water)

LWP mixes the information on the cloud optical thickness and the cloud microphysical properties (i.e. effective radius). Same LWP value is obtained for COD=16, reffc=16μm and for COD=8, reffc=32μm. But the cloud albedo in the first case is significantly larger than in the second case (the cloud albedo integrated over the solar spectrum increases with increasing CODvis values and decreasing reffc values).

It means that a given LWP value can result in different cloud albedo values. So, LWP is not a suitable quantity to represent the effect of the cloud albedo on α.

(3) In Eq. 1, the effect of the aerosol properties on α comes from the third term (a2ln(AOT)). Impact of the aerosol layer on the TOA shortwave flux is depending on the cloud albedo below (see for instance Chylek and Wong, GRL, 1995). Are the a2 values reflecting the effect ?

(4) It seems to me that Eq. 1 does not account for aerosol microphysics. α is the TOA shortwave flux at TOA integrated over the solar spectrum and then Eq. 1 should

account for the spectral variability of the AOT or the aerosol microphysics. Are the a0 values accounting for the aerosol microphysics? Also, the authors did not say if the AOT in Eq. 1 was dependent on the wavelength or not.

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