Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2020-137-RC2, 2020

Atmospheric Measurement Techniques Discussions

Interactive comment on "Empirically-Derived Parameterizations of the Direct Aerosol Radiative Effect based on ORACLES Aircraft Observations" *by* Sabrina P. Cochrane et al.

Anonymous Referee #2

Received and published: 10 July 2020

Review on "Empirically-Derived Parameterizations of the Direct Aerosol Radiative Effect based on ORACLES Aircraft Observations" by Cochrane et al.

Summary: This paper consists of two major parts. In the first part, an algorithm to retrieve the scattering properties of above-cloud smoke aerosols from air-borne SSFR measurements was introduced and applied to a few ORACLES cases. In the second part, the smoke aerosol scattering properties from the first part were first used to drive the radiative transfer model to compute the DARE which in turn were used to derive an empirical parameterization scheme of DARE.

The structure of this paper seems a little odd. It feels like two separate papers that deal

with very different topics being stitched together. The first part, i.e., aerosol retrieval algorithm, accounts for almost half of the length of the paper is not reflected in the title. There are a number of typos and small mistakes in the paper. In addition, the motivation for developing such DARE parameterization scheme is not clear to me. Overall, I think this manuscript needs significant revision and improvement before it can be accepted for publication. Below is a list of my questions and comments.

Major questions and comments: What is the motivation of this work? After reading the Introduction and even the whole paper, I'm still confused about the motivation of this paper. Why do the authors want to develop a DARE parameterization scheme? Note that the radiative transfer theory and methods for computing DARE have been well developed. There are also many broadband radiative transfer models (e.g., RRTM, Fu-Liou, Libradran) that are readily available. So, the computation of DARE is fairly straightforward once the aerosol scattering properties and the environmental factors (e.g., surface/cloud reflectance) are known. Why should someone use a less accurate and seemingly complicated parameterization scheme to estimate DARE?

What is the usefulness of the parameterization scheme and who should be interested in using it? The DARE computation and parameterization in this are based on the scattering properties retrieved from a handful research flights during the ORACLES campaign (i.e., SSA and g in Figure 3). While these measurements are unique and valuable, they are still highly limited in terms of sampling rate. Whether and how can the parameterization scheme be used to deal with the DARE computation in more general cases? For example, can it be used outside of ORACLES period or location when or where the aerosol scattering properties are different from those in in Figure 3? I think these questions should be clarified so that the readers can understand if and how the parameterization could be helpful for their research.

Significantly shorten the first part. As mentioned above, the structure of the paper feels odd. The first part, which is about 5 pages, describes a retrieval algorithm in detail, while the second part, which is about 6 pages, described a parameterization

scheme. The only connection between the two parts I can see is that the first part provides the scattering properties (i.e., SS and g) for the computation of DARE for the second part. In addition, the first part seems to be rather minor extension of a published method in Cochrane et al. (2019). Actually, it is very hard to follow the first part without reading the Cochrane et al. (2019) beforehand because of the frequent references it. So, it seems that the first part of the paper is not original or novel, and it only distracts the reader from the main point of this paper. For example, an understanding of how the SSFR measurements are filtered does not help the readers understand the DARE parameterization scheme at all. I would suggest shortening the first part substantially or putting most of it in the appendix to emphasize the most important and novel DARE parameterization part of the work.

Minor comments:

Line 24: Does the "scene albedo" actually mean cloud albedo? If it really means "scene albedo" then what types of scenes (ocean, land, snow etc.) have been included?

Line 86: similarly, it should be clarified here if "scene albedo" actually just means "cloud albedo". Note that the spectral signature of land reflectance/albedo is very different from cloud albedo.

Eq. (3) and (4): It should be pointed out explicitly if these equations are for instantaneous or diurnal averaged DARE. Also why is the dependence of DARE on solar zenith angle omitted in these equations? SZA is part of the parameterization (Table 4b), no?

To what extent is the DARE dependent on atmospheric profiles, such as water vapor profiles? There are some recent studies that suggest a correlation between the presence of above-cloud smoke and an enhanced water vapor in the ORACLE region. Should this correlation be considered in the parameterization?

Cochrane et al., 2019.has been cited many times in the paper, often in different formats. Please be consistent and also considering use abbreviation e.g., C19 to refer to

Cochrane et al., 2019.

Line 148: Figure 3 should be Figure 2.

Eq. (5) and (6), why are the parameters a_lambda and b_lambda the same for upward and downward irradiances? What is the underlying physics?

Again, Section 2.2.1 and 2.2.2 seem to be a replay of Cochrane et al., 2019. They should be put in the Appendix or substantially shortened.

Around line 150, this part is confusing and needs detail explanation. For example, "both upwelling (F_up) and downwelling (F_dn) irradiance profiles have an approximately linear relationship to AOD due to the absorption and scattering of the aerosol layer." Shouldn't the downwelling (F_dn) be exponential with AOD as a result of Beer's law? "Any deviation from the linear relationship is attributed to changes in the underlying cloud" Why? Can't the vertical variation of aerosol properties, e.g., SSA and/or g cause deviation from the linear relationship? How does cloud cause the deviation? These questions need to be clarified.

Does the retrieval algorithm assume H-G phase function? What are the higher-order terms of the phase function expansion other than asymmetry factor, g? What is the uncertainty associated with the phase function assumption?

Line 286: Russel et al., 1997 should be Russell et al., 1997; deGraaf should be de Graaf

Eq. (12) and (13): The formula looks quite arbitrary. Is there any physics behind these polynomial parametrizations or are they only empirical? Note that there are some well-established 2-stream or 4-stream formula for layer reflection, e.g., Coakley (1975). Is it possible to draw some theoretical basis or physical meaning for the parameterization from these 2-stream or 4-stream approximations? Also, some previous studies have tried to use the concept of adding doubling to approximate the reflection of two layers (Lenoble 1985). Do you think these formulae might be helpful?

Why is SZA dependence of DARE omitted in Eq. (12) and (13)?

Eq. (14) and (15): again, these parameterizations look arbitrary. Is there any underlying physics?

Eq. 21 – 24: I understand that dSSA term is introduced to make the parameterization scheme more general and more accurate. But as I mentioned above, a broadband RTM can easily compute the DARE given any type of SSA and g. Why bother developing such a complicated parameterization?

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-137, 2020.