

Interactive comment on “Relationship between cloud radiative forcing, cloud fraction and cloud albedo, and new surface-based approach for determining cloud albedo” by Y. Liu et al.

Anonymous Referee #2

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Review of "Relationship between cloud radiative forcing, cloud fraction and cloud albedo, and new surface-based approach for determining cloud albedo" by Liu et al.

General comments:

This is a very nice study, presenting a well-motivated way to estimate cloud albedo from surface observations. The method is to some extent also validated through comparison with satellite observations, and the surface-based estimates are used to study interrelations between cloud forcing, cloud fraction and cloud albedo on different time scales. It is suggested that the method for determining cloud albedo could be applied to regions beyond the one studied in the paper, which may be quite useful. Cloud

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albedo estimates are much-needed as this is presently a poorly constrained quantity.

The paper is well structured, and I have no major issues with its publication. I have some points I would like the authors to address, in addition to a number of technical/semantic remarks and suggestions.

Specific comments:

1. There is some confusion between cloud radiative forcing, surface cloud radiative forcing and relative surface cloud radiative forcing - you might want to go through the manuscript and make sure you are using the right term in the right place (in text as well as in section headings).
2. Regarding cloud fraction, there is not much mention of the inherent difficulties in using and defining this term. How similar or different are the retrievals of cloud fraction in the surface observations and the satellite observations, for instance? Obviously, the one is observed from below and the other from above, and although these two perspectives should yield the same f , perhaps you want to mention this fact?
3. How are clear/cloud distinctions made, and how are clear-sky fluxes derived in the different data sets? From satellite data clear-sky fluxes are normally given using nearby pixels classified as clear, but using a single grid point as done here, that is not possible. Yet, you use Eq. 2 (incl. clear sky flux) to estimate the relative surface shortwave cloud radiative forcing. Is this an issue at all?
4. A key assumption for the derivation of the analytical expression for cloud albedo (e.g. for Eq 4a and Eq 7a) is that of a single homogeneous cloud layer. How good is that assumption for the site used? Implications?
- 5a. The comparison of the surface- and satellite derived cloud albedo (section 3.2) is a bit superficial, and the discussion could be expanded. For instance, you may want to emphasize that the use of Eq. (7a) is a way to get around the problems with estimating cloud albedo from satellite (mentioned in Sect 3.1). It is not obvious how you get

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albedo, cloud fraction and surface albedo (to go into Eq. (7b)) from a single satellite pixel. The discrepancies between the two cloud albedo estimates and possible reasons for could be discussed further in this section and/or in the concluding remarks (page 5690, line 13), where you presently say only that satellite and surface observations compare favourably.

5b. The relation between surface and satellite derived cloud albedos (Fig 1) shows a reasonably high correlation coefficient, but it doesn't look very linear. Perhaps rather than a linear regression line (which I assume that the red line is), it would be more useful to show a 1:1 line? Fig 1 also displays a bimodality with high frequencies at low and high albedos, with a dip at intermediate albedos. What does that mean? How is it related to the validity of the single homogeneous cloud layer? High values of cloud albedo are absent in the satellite data - why is that?

6. Regarding year-to-year variations, page 5689, line 26, you give the 13-year averages, perhaps you could also give the variation around these averages (+/-) to give an indication of the stability mentioned.

7. The end of Section 4 is a bit unclear. On page 5690, line 4, should reference to Eq. (4) be to Eq (5c)? What is meant by "the three quantities tend to vary largely in phase"? The similarity in occurrence of minima/maxima between the was just demonstrated. The sentence beginning with "Together..." doesn't read very well. Do you mean that the variability in relative surface shortwave cloud radiative forcing is mainly driven by variability in cloud fraction? The ranges for cloud fraction and cloud albedo look rather similar. But the relation between relative surface shortwave cloud radiative forcing and cloud albedo doesn't look linear at all, except maybe on an annual scale. Please clarify.

8. In discussing CRF and it's utility as well as problems for cloud feedback study (page 5683), you might want to refer to Soden et al. (2004)

Technical comments:

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page 5682, line 4: surfaced-based => surface-based

page 5682, line 10 "A decade long data *set* on cloud albedo *is* obtained..." and then page 5682, line 13 "The surface-based cloud albedo *data* are further compared with those..."

Further, last sentence of abstract (page 5682, line 14 and onwards) doesn't read very well. I assume you want to say that you use the cloud fraction, relative surface shortwave cloud radiative forcing and cloud albedo observed/derived respectively from the surface-based remote-sensing site, to examine multiscale variations and covariation between those parameters. Perhaps the sentence could be broken into two for clarity.

page 5683, line 7 "it's variation with temperature" perhaps should be "it's variation under climate change" or "CO2-forcing" or something like that? maybe not

page 5683, line16 "at least in the 1970s" should perhaps be "already in the 1970s"

page 5683, line 22, GCMs do not particularly parameterize total cloud fraction and cloud albedo, perhaps it's better to say inadequate parameterizations related to determination of cloud fraction and cloud albedo

page 5683, line 26-27 "This expression is the applied to obtain time series for cloud albedo" seems to be only a repetition of the end of the previous sentence "...and then use this relationship to derive cloud albedo from surface-based measurements of cloud fraction and shortwave radiation".

page 5684, line 2 "compared to the satellite measurements", please clarify what this refers to

page 5684, line 3 "The decade-long triple surface-observation based data sets..."

page 5684, line 8 I would say that the difference between clear-sky and all-sky radiation fluxes still remains the definition of CRF (rather than that only being the original definition)

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page 5685, line 8-9 "in a symmetric form as a function of..."
page 5685, line 10 replace , with .
page 5685, line 11 " ...is actually approximately a product of..."
page 5685, line 18 you may want to add a reference for the ISCCP data. Rossow and Schiffer (1991) appears in the reference list, but not in the text
page 5686, line 2 "cloud fraction f. For this..."
page 5685, line 5 replace , with .
page 5687, line 5 aircrafts => aircraft
page 5687, line 8 remove . after (Wielicki et al, 2005)
page 5687, line 9, when discussing earthshine you may want to mention the several additional issues related to these measurements, discussed e.g. by Loeb et al. (200?)
page 5687, line 24-25 "surface downwelling SW radiation fluxes" is repeated
page 5688, line 2 reference to Eq (5) should be to Eq (6)
page 5688, line 14, replace , with .
page 5688, line 18, replace ,. with .
page 5689, line 6, cloud fraction.
page 5689, line 7, please clarify "indirect satellite surface measurements"
page 5689, line 11, as derived from surface-based remote sensors
page 5689, line 18 any => and
page 5690, line 19 the sentence beginning "No discernible..." does not read very well. Year-to-year variability (although small compared to shorter time scales) , but no trend can be discerned

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page 5690, line 21 "...in phase with the..."

References:

Soden et al. (2004) On the use of cloud forcing to estimate cloud feedback, J. Climate, 17, 3661-3665

Loeb et al. (2007) Variability in global top-of-atmosphere shortwave radiation between 200 and 2005, Geophys. Res. Lett., 34, L03704

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 5681, 2011.

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