Referee (#2)

The authors would like to thank Referee #2 for his/her thoughtful and helpful comments and suggestions. Below are the comments by Referee #2 in blue and answers in black. Any modification made to the text has been highlighted within a green box. The line numbers correspond to the version of the manuscript available for online discussion.

Comment 1

Almost all analyses are made for a domain over the Amazon forest. This choice is never motivated. In terms of NO_2, this is not the most relevant region I can think of.

The motivation to show the analysis over the Amazon forest was that the surface LER across track dependency is very strong over that region, and there are occasionally elevated amounts of NO_2 associated with biomass burning. Figure AC1 shows that surface LER directionality is also very strong over similar regions like Equatorial Africa, and it is also relevant over Asia.

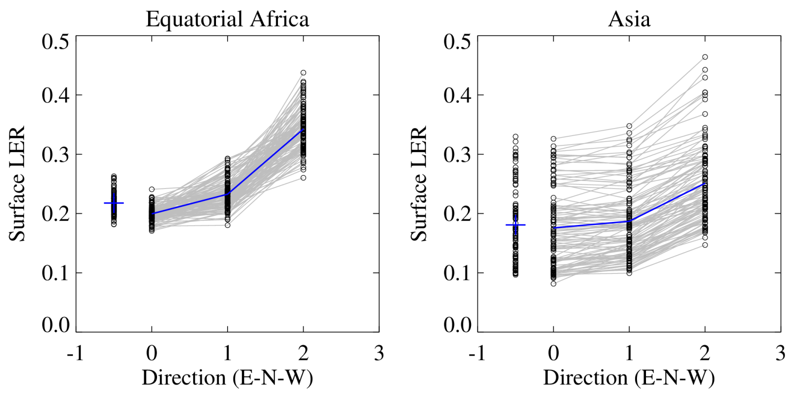

Figure AC1: Directional dependence of surface LER climatology (2007-2013) derived from individual measurements along the swath: East (E) for the 8 easternmost pixels, Nadir (N) for the 8 center pixels and West (W) for the 8 westernmost pixels. (Same as Fig. 1d in the manuscript).

When we analysed the retrieved cloud fractions over the Amazon, we found a strong East-West across track bias, so we decided to focus on that region. We also found important biases in other regions like France (Fig. AC2), which we also investigated in detail.

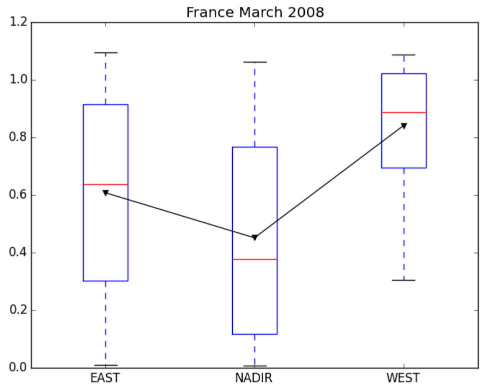

Figure AC2: Box-plot of cloud fractions retrieved with FRESCO cloud retrieval for GOME-2A for March 2008 over France (Lat:44-49N, Lon:0-6W).

Comment 2

Because of the focus on this forested region, the analyzed BRDF effects may be larger than over other regions of the globe with less dense and tall vegetation. This should be better emphasized in the paper (e.g. in the abstract). In the discussions and conclusions section on page 23, line 3, for example, it is mentioned that surface albedo is underestimated by as much as a factor 2 over "vegetated" scenes, but "vegetated" in this case actually means forested. Results would likely be quite different over other vegetated surfaces like grass- or croplands.

We agree, so have changed the term vegetated in Sect. 6. and in other relevant sentences and we have included the term "forest" in the abstract to emphasize that the larger cloud fraction bias found in the analysis is over Amazonia.

We agree that the results might be different over other vegetated regions, but in order to make concluding statements about the effects over different land cover types, a global analysis would be needed. That we also find cloud fraction bias over France, and that the differences in NO2 AMFs are also substantial there, suggests that the effects are relevant also over non-forested surfaces. The study by Noguchi et al. (2014), addressing different land cover types, showed that all land types show a similar behaviour on the surface BRDF (Fig. 7 from Noguchi et al. (2014)).

Comment 3

GOME-2 and OMI have different equator crossing times (GOME-2 has a morning, OMI and after-noon orbit), an information that seems missing in the manuscript but is relevant for the interpretation of the results. Because GOME-2 is further away from noon, I would expect BRDF effects to be larger for GOME-2 than for OMI.

This is a very good point. However, we think that from our study the conclusion that BRDF effects are larger for GOME-2 than for OMI due to the different equator crossing time cannot be made. The fact that cloud fraction across-track dependency is stronger for GOME-2 than for OMI is more likely to be related to the spectral region used for the cloud retrievals. The major difference between cloud fractions from OMI and GOME-2 is the spectral window from which they are retrieved. That GOME-2 retrieves clouds in the NIR, where the atmosphere is more transparent than in the VIS and surface BRDF effects are stronger, makes FRESCO more sensitive to surface BRDF. Furthermore, OMI pixels are smaller, so it is less likely that BRDF effects are smeared out as in the larger GOME-2 pixels. The study by Noguchi et al. (2014) suggested that, for a geostationary sensor, BRDF effects are not weaker in the morning when the RAA is low compared to the afternoon when RAA is high. We conclude that the strength of the BRDF-effect depends mostly on the specific relative position of the sun and the satellite, and on the spectral range where the retrievals are done.

Comment 4

The study emphasizes the importance of satellite missions that can provide surface BRDFs like MODIS. Since the MODIS missions have surpassed their designed lifetime already by far, the community should think about alternatives for the post-MODIS period. Can the Sentinels fill this gap? Maybe this would be worth a sentence in the discussions section.

This is a good point that we should keep in mind. Below we provide a short summary of current and future Land Earth Observation capabilities, and we added few sentences in the last paragraph of the discussion (Sect. 6).

MODIS-Terra is expected to last until 2022 and has sufficient fuel to last until 2030. MODIS-Aqua can stay in the same orbit until 2025 and may have enough fuel possibly until 2035. Suomi NPP-VIIRS (Visible Infrared Imaging Radiometer Suite, and JPSS-VIIRS) now produce a MODIS-like BRDF (a fixed 16-day window updated daily). This constellation assures continuity of land data until 2038.

From the Copernicus Sentinels, Sentinel-3 could be employed to generate a BRDF similar to the one from the ESA GlobAlbedo broadband and the QA4ECV spectral albedo product after some years of measurements.

Modification to last paragraph in Sect. 6:

A viable alternative to the current LER climatologies is provided by the MODIS-derived BRDF-parameters at a spatial resolution better than the GOME-2, OMI, and TROPOMI pixel sizes. MODIS Terra and Aqua are expected to last until 2025 and afterwards the Joint Polar Satellite System (JPSS) satellite constellation assures continuity of land observations needed to produce surface BRDF data. Sentinel-3 could be employed to generate a BRDF similar to the one from the ESA GlobAlbedo broadband and the QA4ECV spectral albedo after some years of measurements. Another alternative is to make a directionally dependent LER database from TROPOMI once there is enough surface reflectance data acquired by the satellite itself.