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Atmospheric Measurement Techniques Discussions

Interactive comment on "Determination of land surface reflectance using the AATSR dual-view capability" *by* L. Sogacheva et al.

L. Sogacheva et al.

larisa.sogacheva@fmi.fi

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We would like to thank Reviewer #2 for the effort in evaluating, commenting, and thus improving our manuscript and for the time spent to perform this work.

Below are the comments (in Italic) and our answers.

This paper presents a validation of a land surface reflectance product derived using the ADV AATSR aerosol retrieval algorithm. The ADV product is compared to both the ASRVN and MODIS surface BRDF products and the results described as a function of surface type. The paper is generally well written and the methodology sound. I am somewhat dubious of the usefulness of a product that amounts to a pseudo-directional surface reflectance (for the AATSR viewing geometry) at 550 and 660 nm, but if nothing

else the work is further validation of the ADV aerosol retrieval scheme. I recommend publication once the following comments and questions have been addressed.

General comments:

The authors need to be more specific in their definitions and use of terms such as albedo and surface reflectance.

First of all, I would like to mention the lack of standardization for the surface reflectance terminology and albedo products becomes a considerable source of misinterpretation of the derived products. The generic term 'albedo' often refers to a variety of different geophysical variables, which correspond to different definitions and measurements (http://gosic.org/content/gcos-terrestrial-ecv-albedo)

In the introduction the authors appear to be describing the bi-hemispheric spectral reflectance, or spectral white sky albedo (they mention that to determine albedo the surface reflectance needs to be integrated across all sun-view geometries).

The sentence is corrected: Obtaining the albedo requires the integration of reflectance over all sun-view geometries and across the solar spectrum.

The unqualified term Albedo generally refers to the spectrally integrated (across the solar spectrum) white sky albedo - this appears to be what they are referring to as the "surface shortwave albedo" around line 10 on page 7454.

This is further clarified by adding the sentence: Actual albedo is a value which is interpolated between black-sky albedo and white-sky albedo as a function of the fraction of diffuse skylight which is itself a function of the aerosol optical depth (Lucht, 2000).

Furthermore, the term "surface reflectance" is also problematic. At the start of page 7454 the authors mention that instrumental methods measure surface reflectance for a given sun-view geometry, but fail to note the dependence on the ratio of direct to diffuse incoming radiance - i.e. the measured surface reflectance will not be purely bi-directional, but will include a diffuse to direction component which depends on the

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turbidity of the atmosphere.

The following sentence has beens added to Sec. 5.1: Another reason for the disagreement is that the surface reflectance measured from a satellite will not be purely bi-directional, but will include a diffuse to direction component which depends on the turbidity of the atmosphere (Shaepman-Strub et al., 2006).

These points may seem finicky, but they illustrate the mire of related but distinct values which tend to be used interchangeably. I strongly suggest the authors clearly define the terms and nomenclature they using and stick to it.

We fully agree with the reviewer that the clear definitions are needed. We refer to the manuscript by Shaepman-Strub et al., 2006, where definitions for reflectance quantities are considered and follow these in the revised MS.

I was left wondering what the point of section 6 was. I understand the desire to show an application of the ADV surface reflectance product, but this seems rather forced.

Section 6 has been included in the manuscript as an illustration to show the annual changes in surface properties which can be seen in the surface reflectance retrieved with the ADV algorithm. The AATSR/ATSR2 long-term record and low ADV resolution (10km2 for the operational algorithm, 1km2 for the scientific algorithm) allows for studying the land cover and changes therein during the AATSR/ATSR2 operational period (1995-2012).

The authors provide no real motivation for this work, nor do they provide any real conclusions.

In the revised manuscript the method to retrieve the surface reflectance using AATSR has been introduced. Validation and comparison results show that the method gives reasonable, compared to ASRVN and MODIS, results, which fulfill the climate model requirements.

Specific points: These points refer to the specific page and line number indicated.

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pg.7456 ln.22: The ATSR-2/ERS-2 date range is incorrect. The ERS-2 satellite was operational until 2011 and I think ATSR-2 was producing data up until 2009. Currently Level 1 data from ATSR-2 is available to mid 2003 (when the on-board tape storage on ERS-2 failed).

We consider that there is no sense to mention the operation period for the instrument if data are corrupted and, hence, can't be used. To be more precise, we corrected the sentence as: The Advanced Along Track Scanning Radiometer (AATSR) on board the ENVISAT satellite (2002-2012) and its precursor ATSR-2 (data available for the period 1995-2003) onboard the ERS-2 are dual view instruments with across-track conical scanning for both views.

pg.7457 ln.2: Please be specfic: The ADV algorithm uses the "555" "659" and "1610" nm channels, other algorithms use a different selection of channels.

Corrected

pg.7458 ln.5: "Cloud reflectance dominates" rather than "Cloud reflectance overwhelms".

Corrected

pg.7458 eq.1: This is a good example of where the authors need to be more precise about the assumptions made in the forward model. The define _s as simply surface reflectance, without noting that this formulation assumes that the surface is a Lambertian reflector. It assumes the same surface reflectance for the direct+diffuse transmitted solar-radiation (top line) and the downwelling multiply reflected sky radiance (bottom line).

Discussion on the Lambertian surface assumption has been added to the text.

pg.7459 ln.15-21: The authors state that "The determined AOD is independent of assumption of surface properties". This is not true - the k-ratio is an explicit assumption of the spectral dependence of the surface BRDF (which the authors acknowledge on

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ln 21), in addition to the assumption described in my previous comment. Thus the retrieved AOD is dependent on at least two assumptions of the surface properties.

The part of the sentence mentioned is taken away from the text. Assumption on the Lambertian surface is added (see previous comment), the k-ratio assumption is discussed on pg.7459, lines 21-24

pg.7460 ln.8-9: The description of ASRVN is to brief to be informative. What is AERONET data used for and what is meant by "MODIS TOA measurements are used for atmospheric correction"?

The reference to ASRVN data base has been given for more details (Wang et al., 2009). “The ASRVN algorithm uses .... ancillary AERONET aerosol and water vapor data. The atmospheric correction is achieved by fitting the MODIS top of atmosphere measurements, accumulated for 16-days intervals, with theoretical reflectance parameterized in terms of coefficients of the Li-Sparse Ross-Thick (LSRT) model of the bidirectional reflectance factor (BRF)”. pg.7460 ln.8-9 has been modified to: ASRVN is an operational processing system which uses ancillary AERONET aerosol and water vapor data while MODIS TOA measurements are used for atmospheric correction (Wang et al., 2009).

pg.7460 ln.14-15: Contradictory statements: Is the resolution of ASRVN 500 m or 1km?

“The ASRVN computes ... products at 1 km resolution for seven 500m MODIS bands”. (Wang et al., 2009). The sentence has been rephrased to: ... and a theoretical normalized BRF (NBRF) computed for a standard viewing geometry, VZA=0°, SZA=45° for the MODIS wave bands 1-7 (http://modis.gsfc.nasa.gov/about/specifications.php).

pg.7460 ln.27 - pg.7461 ln.5 (last paragraph of section 3.1): Is this classification of the surroundings of ASRVN sites something that was done as part of this work? If so, more detail should be provided as to how this classification was done; otherwise provide a

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reference.

This rough but detailed enough classification has been done by L. Sogacheva for the validation of the AOD product and used in current work for the surface reflectance validation. The clarification is added to the text: To examine the performance of the retrieval for different surface types, ASRVN locations have been subjectively divided (using the author's knowledge and AERONET images) into 8 groups, according to the land type and industry/population in the surroundings: . . .

pg.7461 ln.10-13: The description of the RTLS weighting parameters/kernels given in the brackets is very difficult to follow. Please reword.

Reference has been added and text has been rephrased: Three parameters: 1) isotropic scattering, 2) radiative transfer type volumetric scattering (from horizontally homogeneous leaf canopies), and 3) geometric-optical surface scattering (from scenes containing three dimensional objects) are provided for all MODIS spectral bands as well as for three broad bands (0.3-0.7μm, 0.7-5.0μm, and 0.3-5.0μm). These parameters (e.g., Roujean et al., 1992) can be used to reconstruct the surface anisotropic effects and thus correct directional reflectance to any needed view geometry. pg.7463 ln.5: Where does 675 nm come from? Is this a typo (i.e. should it be 659)?

Apologies, this was a typo which has been corrected

pg.7463 ln.7-10: The sentence starting "Spatial coverage varies..." is poorly worded and doesn't scan well. Please reword.

Reworded to: Spatial coverage varies from month to month due to the seasonal changes in solar angle and due to the occurrence of snow and ice. AOD can in general not reliably be retrieved with the ADV over surfaces with very high reflectance (see Sec 3.1), such as over snow and ice, and thus cannot be used for atmospheric correction.

pg.7464 ln.3-4: Are the references given for the surface albedo accuracy requirements (which are 21 and 31 years old) valid for current climate modelling surface reflectance

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modelling? Furthermore, are these values referring to broadband albedo or spectral albedo (and if so, at what spectral resolution)? How do these values relate to the validation of the pseudo-directional surface reflectance retrieved by ADV?

In the Assessment of the status of the development of the standards for the Terrestrial Essential Climate Variables (2009, http://www.fao.org/gtos/doc/ECVs/T08/T08.pdf) it is mentioned that determination of characteristics of the albedo products (accuracy; consistency over time; compatibility with the same or similar products from different sensors and time periods; etc.) is an area of active research. No real numbers are given in the document. We could not find in the literature any objections from the modelers that the accuracy requirements indicated by Henderson-Sellers and Wilson (1983) and Sellers (1993) are not satisfied. Both Henderson-Sellers and Wilson (1983) and Sellers (1993) discuss (land) surface albedo. Henderson-Sellers and Wilson (1983) mention that "Albedo usually varies as a function of incident angle, and therefore diffuse and direct albedos are likely to differ". However, the recommendations are given for "albedo", which, we guess, means the broadband albedo. Additional errors occur when converting from narrowband to broadband albedo.Gruber et al. (2003, http://www.geo.uzh.ch/∼stgruber/pubs/gruber_2003-EARSEL.pdf) concluded that the extrapolation assumptions for blue and UV light are very sensitive and can affect the broadband albedo in the range of ±5-10% Liang et al. (2000) have produced equations through a modeling approach for a series of eight different satellite sensors that have yielded accuracies of less than 0.02 when compared to ground measurements for many different surface types. The absolute error for the surface reflectance retrieved with ADV is about 0.02 for both wavelengths. Thus, considering the narrow-to-broadband conversion error of 0.02, the surface reflectance retrieved with ADV still meets the requirements (0.05) from Henderson-Sellers and Wilson (1983).

pg.7464 ln.22: The fact that brighter surfaces have a higher correlation is more related to the fact that they provide a wider range of reflectance values than any improvement in the agreement between the ASRVN and ADV results (as is evidenced by the RMS

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and absolute error values provided in tables 1-3).

Agree. However, all the data retrieved have been used in validation.

pg.7465 ln.6: When the authors say "typical average cases", are they referring to some average aerosol loading?

The atmospheric correction for ASRVN-retrieved reflectance is achieved by fitting the MODIS top-of-atmosphere measurements, accumulated for a 16-day interval, with theoretical reflectance parameterized in terms of the coefficients of the Li SparseRoss Thick (LSRT) model of the bidirectional reflectance factor (Wang et al., 2009). Thus, instead of the “real” conditions, the 16-day accumulated MODIS measurements are used. The sentence is corrected: One of the reasons for the disagreement between ADV and ASRVN-retrieved reflectance is likely that the ASRVN polynomial coefficients used to compute the directional reflectance are derived using the MODIS top-of-atmosphere measurements accumulated for a 16-day interval as the atmospheric correction.

pg.7465 ln.25: How are the uncertainties in the averaged values derived? Do the authors mean that the average ADV-ASRVN discrepancy is given in table 3? If so, this is not an uncertainty in the average value!

Table 3 and associated text have been taken away.

pg.7466 ln.21: The observed differences could also be partly due to the limitations of the RHLS BRDF model.

The following sentence has been added: However, the observed differences could also in part be due to the limitations of the RHLS BRDF model (see discussion in sections 3.2 and 3.3)

pg.7467 ln.16-20: I’m not sure what point the authors are making with the sentence starting "For this transect...". Please clarify.

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The authors show the variability in the solar zenith angle along the transect, which might influence the surface reflectance results. However, the variability in solar zenith angle along the chosen transect is not very high, so we make another assumption that the surface reflectance retrieved does not change much because of the solar zenith angle and the surface reflectance can be comparable along the transect without making corrections for the solar zenith angle.

pg.7468 ln.1-4: This sentence is not very clear and should be reworded.

Reworded to: Higher surface reflectance (up to 0.15-0.2 in summer and autumn) is observed in south-western Australia in the Dryland agriculture area, as well as on the Nullarbor Plain, which is a livestock grazing area.

pg.7469 ln.26: Would the ADV surface reflectance at 555 and 659 nm really be sufficient for calculating a broadband albedo which would be a improvement over current estimates? Given that the ADV algorithm neglects the 870 nm channel, which has the strongest sensitivity to vegetation, I am sceptical.

We made the following correction in the text: The ADV surface reflectance retrieved for 555 nm and 659 nm might also be used for narrow to broadband albedo conversion in the visible part of the spectrum (Liang, 2000, Lucht et al., 2008) , which is sensitive to the land surface type (Liang et al., 2005, Dozier et al., 2009).

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