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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Operational climate monitoring from space: the EUMETSAT satellite application facility on climate monitoring (CM-SAF)" *by* J. Schulz et al.

J. Schulz et al.

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General comments

We thank reviewer 3 for the very constructive and detailed review. We will revise the paper attempting to take into account all the comments raised by reviewer 3.

Answers to specific comments of reviewer 3

1.0.0.1 The paper, in general, reflects high quality and clearly demonstrates the authors vast experience with the subject, and thorough knowledge about the data presented in

particular.
Thank you very much!

1.0.0.2 Given the large number of different satellite- and other data, going in to this SAF and the impressively many products coming out, it would help this reader if you could provide an graphical overview. Was it possible to generate a flowchart-like diagram of the information flow, from sensor, through various interdependent algorithms and sub-products, to the suite of released products.
1.0.0.3 Similarly, it would be nice if you could think up a way to illustrate the combined spatial-temporal coverage of the different products.

We agree with the reviewer that a better representation for the products is needed to help the reader to find the way through the CM-SAF sensors and derived products. We will provide it in the revised version in the beginning of section 3 on the products by providing a table that gives information on spatial-temporal resolutions also including information on the current and anticipated length of the data series.

1.0.0.4 You talk a lot about "CDRs", "Reprocessed CDRs" and "A third class of CDRs" in the beginning of the paper, but never returns to these concepts as you go through all the services. How are the various types of CDRs relevant, how are they varying across the services?

The reviewer is right in the observation that we only indirectly return to the point of the different CDR classes. The reason for this is that with the exception of the SSM/I water vapor data set all presented data products belong to the first class as described in section 2. In the revised version we will make that clearer by mention the CDR class very clearly in the product description table.

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Discussion Paper

1.0.0.5 The structure of the paper is not immediately clear, e.g. both paragraph 3.1.2 and 3.2.1 are called "Validation" and are immediately followed by subparagraph called "ATOVS products". Could this be restructured to create a more logical structure in the paper.

Section 3 is ordered along the four CM-SAF product groups cloud properties, water vapor, top of atmosphere radiation and surface radiation (sections 3.1-3.4). In the section 3.2 on water vapor a subsection headline Retrieval/Method is missing, we will include it.

2 Abstract
Products based on intercalibrated radiance data can also be used for climate variability analysis up to inter-annual scale.

Though explained later, in some detail, it is quite unclear at this point, how exactly this "usability" emerges. Instrument drift might spring to mind, but is not mentioned. The fact that you reefer to these data being of a more trustworthy nature than the latter, is far from clear at this point.

Indeed the reviewer is right. We will include a sentence into the abstract that makes clear that the variability to be assessed is getting smaller and smaller the longer the time scale is. This variability can only be assessed if the data are corrected for jumps created by instrument changes and more subtle effects like instrument and orbit drift.

3 Introduction

Existing satellites, especially the operational meteorological satellites, now provide

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sufficiently long data series for climate analysis.

The term "sufficiently long data series" is ambiguous. Please make a reference to where this is specified and justified in more exact details.

There are a lot of papers emerging on variability and trend analysis employing satellite data. So we will include some citations to make the term “sufficiently“ less ambiguous.

4 Background and objectives;

CDRs for operational climate monitoring are constructed from so called Environmental Data Records (EDR).
Though the connection emerges, gradually, from reading on, a short introduction to EDR, CDR, and related concepts would increase the readability of this section, and the rest of the paper.

We will improve this section of the paper by pointing to the EDR-CDR concept of NOAA including a citation of the document: NRC (National Research Council). 2004: Climate Data Records from Environmental Satellites: Interim Report, The National Academies Press, Washington, D.C., 150 pp.

This should at least include inter satellite homogenisation and frozen ...

I assume "frozen" means something like: Not to be changed? The word is used at least one other time in your "sum-up and perspective" section towards the end of the paper.

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The word “frozen“ means fixed retrieval scheme over time. We will change the text accordingly.

5 Products, retrieval schemes and validation

Humidity products: Total (HTW) ...
It is not clear what 5 (and six) layers this refer to.

Water vapor product features (layers and levels) are clarified within a table. The layers for the product are Surface-850, 850-700, 700-500, 500-300, 300-200 hPa, respectively. The total column water vapor is integrated up to 100 hPa.

Although cloud products and surface radiation ...
Since these sensors are on different platforms (NOAA respectively MSG) what are the accuracy loss in this operation? To what extent are the georeferencing a challenge? What about the different spatial resolution, what methods are used to overlay the data in a reasonable manner?

The merging is performed at the level of monthly mean products on the product grid $(15x15km)^2$ and not at pixel level. So problems with the georeferencing of individual satellite pixels is not an issue here.

Due to lower temporal sampling of AVHRR south of 55° N the accuracy of monthly means is less compared to SEVIRI estimates. North of 55° N the accuracy of SEVIRI estimates is decreasing because of the larger viewing angles. This has been shown in

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various CM-SAF validation reports available at www.cmsaf.eu.

As explained in the manuscript, a simple linear average only depending on latitude has been chosen. At 55°N we start with a 100 % SEVIRI estimate and end at 65°N with a 100 % AVHRR estimates. The weights for the instruments are simply changed 10 % per degree latitude.

5.1 Retrieval

Since we also provide cloud-top ...
Who are "we" and who are the others? What exactly impacts what here?

The term "we" refers to the CM-SAF project in general as represented by the full list of authors.

Concerning the meaning of the actual statement: The message is that the quality of the cloud top products depends also to some extent on the quality of the background temperature profiles from analyses produced by numerical weather prediction models. The background information is used more heavily for the cloud top temperature and cloud top height products than for the basic cloud top pressure product. The reason is that the conversion from cloud top pressure to temperature and height is made by referring to the background temperature profiles. However, also the primary product cloud top pressure has some dependency on the NWP analysis since information about the surface temperature and surface pressure (to determine the measured radiance in cloud free conditions) is needed as input to the used radiance ratio methods. This information is also taken from NWP analysis.

We will reformulate the sentence accordingly.

5.2 Validation, e.i. 3.1.2

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Furthermore, the SEVIRI-based retrieval overestimates ...

Where (what latitude?) do the mode shift? What consequences do this have, in general, and in particularly in the region near the "shift"?

The change is gradual and simply a function of the satellite viewing angle. Thus, there is no particular latitude or viewing angle where this suddenly occurs. Since the viewing angle is largest near the edge of the visible part of the Earth disk it is also here we find the largest overestimation of cloudiness. We actually do not recommend the use of results outside of viewing angles of 70 degrees where errors in cloud amounts will definitely exceed 10 %. But this information is clearly communicated to our users and it is up to them to decide the usefulness for their applications.

The consequence of this is that the CM-SAF results from SEVIRI will be most useful for the African region and for most of the European region. The only exception here is the most northern part of Europe (e.g. Scandinavia) where the products from polar satellites (NOAA and MetOp) should preferably be used instead.

5.3 ATOVS product in 3.2
The needed first guess for such an retrieval ...

How sensitive is the profiles of temperature and mixing ratio to this "initial guess", and what end-products and -services are effected by this inaccuracy?

During the development of the current operational processing software for ATOVS observations its dependency on the initial guess was analysed. IAPP was operated without initial guess and with initial guess from GME and NCEP NWP models. The resulting end products revealed the necessity for an initial guess, mainly to constrain

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the retrieval at layers which are not sufficiently covered by information from the satellite instruments, e.g. infrared channels offer not much information in the mid-troposphere at high water vapor loadings. The model related results exhibit different levels of quality at different layers when compared to radiosonde observations, with results related to NCEP having a tendency to be warmer and more humid than GME related results. Due to the slight advantages of the resulting quality we use GME output as initial guess for the retrieval. The end products would only suffer if NWP model changes would lead to sharp changes in the representation of the water vapour field which is not very likely.

We will not expand the paper on this point too much as it is too specific for an overview paper.

5.4 ATOVS product and SSM/I product, both in 3.2
An optimal interpolation method ...

Kriging method is also used to combine the SSM/I measurements in an optimal way. This is not clear.

Kriging as a method, usually associated with geostatistics, to interpolate a value of a field at an unobserved location from observations of the fields value at nearby locations. It usually works with one field. Optimal Interpolation is a type of data assimilation (others being: Kalman filtering, 3D- and 4D-var) It is often used to adjust a field (often a model generated field), based on independent measurements at specific locations within the fields spatial coverage (often reference measurements). If you intent to, indirectly, say that IO and Kriging is mathematical identical a reference would bee needed.

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The reviewer is right, we do not perform data assimilation in a sense that we adjust our estimates to a reference. We only do an interpolation of the satellite estimates from the swath representation to the product grid employing an objective analysis. Accordingly, we changed the sentence to: "An objective analysis method (Kriging) is applied that provides a spatial distribution of mean values and their errors."

5.5 ATOVS product in 3.2.1

Note that a comparison to radiosonde data is more or less equivalent ...
Basically the validation is only really possible over northern hemispheric land, and here the products are performing well. Alternatively to captive the graph "Global comparison..." was it perhaps possible to separate the ocean and Antarctic measurements with different markers on the graph, to emphasis the quality of the product.

The comparison is rather global because the GUAN radiosonde stations are almost equally distributed over global oceans. To improve the presentation of different environments we replaced the scatter plot with four scatter plots (all data, ocean, land and data north and south of 60° on both hemispheres).

Meanwhile we found several inconsistencies in the processing of the radiosonde and ATOVS data prior to the comparison. The original comparisons included radiosonde profiles where the lowest part of the profile was missing in some radiosondes, occasionally leading to a large positive bias of the ATOVS estimates. The vertical integration of the satellite retrievals suffered from an incorrect implementation of an profile correction for orography. In addition, TPW and precipitable water in the highest layer (300-200hPa) were defined differently for the radiosondes and the satellite

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retrievals.

The correction of these inconsistencies led to much lower systematic deviations between satellite and radiosonde data. Hence, the ATOVS product appears to be better than presented in the original version of the paper.

As an example Fig. 5 shows a scatter plot ...
Two things: 1) "correlation (0.94)" is a somewhat loose term. If that is the "Pearson product-moment correlation coefficient", which accordingly is referred as "r" on the graph, this might be noted. 2) "between both data sets" is assumed to be read "between the two data sets" or are there more than one comparison illustrated in this graph?

On (1): It is “Pearson product-moment correlation coefficient“. This will be added to the text. On (2): Compared are radiosondes to ATOVS estimates, so only two data sets are involved.

There is a slight tendency of higher biases ...
Are there less clouds over land, during the winter, than during the summer? Most likely yes, but a reference would be nice.

As mentioned above we have redone the comparisons to the radiosondes with a number of corrections. The time series of bias between ATOVS products and radiosonde observations is shown in a new Fig 6 of the revised manuscript version.

In contradiction to our statement in the ACPD version of the paper after the correction of above described inconsistencies we observe a tendency for an annual cycle of

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TPW and LPW4 biases, with a maximum during northern hemisphere summer months. More frequent radiosonde stations influenced by continental climate and a difference in temporal sampling of the diurnal cycle of precipitable water between ATOVS and radiosondes might cause the annual cycle of the bias. The time series separated in land an ocean actually shows that the annual cycle appears only over land. To really proof this seems beyond the scope of this paper. The speculation about the cloudiness over land during winter is deleted from the manuscript.

The GME model input used as background ...
The word "background" is unclear at this point... Is it "filling in" where satellite data are absent?

Indeed, the formulation was not very good and partially incorrect. As mentioned above the initialization with the GME model results has largest impact in the lower- to mid-troposphere (900-700 hPa). Here the initial guess provided by the model is changed the least by the satellite observation. However, looking at the new figure 6, this does not lead to the lowest deviation with the radiosondes. So our conclusion that the constraint with the model results lead to better agreement with radiosondes was not correct.

5.6 Top of atmosphere radiation fluxes

Throughout this chapter the terms "shortwave", "longwave", "narrow-" and "broadband" are used. Could you please give a formal definition (cut off frequencies) for each of them. If it is the same throughout the text a formal introduction is preferable, otherwise the definition should appear whenever appropriate.

Solar radiation with wavelengths roughly below 4 micron, is referred to as shortwave broadband radiation. Emitted thermal radiation with wavelengths roughly above 4 micron, is referred to as longwave broadband radiation. The term narrowband radiation

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is used to refer to the measurement by individual channels of a multispectral imager.

The definitions are added into the revised manuscript.

5.7 Top of atmosphere radiation fluxes / Retrieval

Example products are shown in Fig. 6 ...

In several places, e.g. on the coast of Africa (lat. 0..10, lon. -15..10) it seems that reflected solar radiation over land and ocean are about the same. In other places, e.g. around Saudi Arabia (lat. 10..30, lon. 30..60) the coast seem to have significant influence on the signal. Could you please elaborate a bit on this, is it pure coincidence, a real atmospheric phenomena or an artifact of the selected method?

The high values of the reflected solar radiation and the low values of the emitted thermal radiation around the equator (see fig.6) are due to the abundance of deep convective clouds in the tropical convergence zone associated with the rising branch of the Hadley circulation. Since in the tropical convergence zone the reflected solar radiation is dominated by the presence of clouds, there is little land-ocean contrast. To the contrary, for the region around the Sahara and Saudi Arabia, clear sky conditions occur frequently due to the large scale subsidence associated with the descending branch of the Hadley circulation. Therefore in the subsidence region, the reflected solar radiation is determined by the surface albedo, and there is a high land-ocean contrast due to the high albedo of the desert, and the low albedo of the ocean.

This explanation has been added at the end of paragraph 3.3.1.

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5.8 Incoming solar radiation

It uses the well-known relationship ...
A reference would be appropriate.

The relationship between the broadband atmospheric transmittance and the reflectance at the top of atmosphere is described in Laszlo and Pinker (1992). Thus, a reference is already given in the sentence before. The first two sentences of 3.4.1 will be reformulated to make that clearer.

The relation between the solar ...
How manyfold? How many different "states" and "albedos" is the table entry characterized by? What are the criteria of these "states"?

The inherent symmetry according to solar zenith angles and the contribution of each independent variable to the inversion problem have been used to reduce the number of entries in the look-up-tables. The basic look-up tables for the retrieval in cloudy conditions has been calculated for three cloud optical depths, 10 aerosol optical depths, 3 single scattering albedos, 2 asymmetry parameters, 6 sun zenith angles and 7 surface albedos. The effect of variations in water vapor and ozone relative to the fixed values used in the calculation of the basic look-up tables is corrected by using a parametrization (Mueller, 2004). This information has been added to the revised manuscript.

5.9 Downwelling longwave radiation
The parametrization requires the temperature profile of the lowest layers of the atmosphere, ...

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The temperature profile of, especially the lowest part, of the atmosphere is known for being difficult to estimate accurately from remote sensing. How is this accuracy here, Compared to other parts of your data, is that an insignificant problem?

Temperature and water vapor profiles from the NWP model are used to compute the downwelling longwave fluxes. Thus, the monitoring product is partly a model driven product as only the important cloud information is derived from satellite data. Compared to the quality of cloud information the difference in accuracy between model and remotely sensed temperature profiles is of secondary importance. Remotely sensed temperature profiles, e.g. derived from ATOVS, are also not used because the observation time between those profiles and SEVIRI estimates does not match. Additionally, the validation of the downwelling longwave radiation at the surface does not show a strong dependence on the model used.

The outgoing longwave flux at ...
How many different, and which, "surface types" do this include.

Wilber et al. (1999) compiled surface emissivity for a subset of 20 different land surface type classes from the USGS land-typ classification. This classification has been used. The revised manuscript contains this information and a citation of the paper by Wilber et al. (1999).

5.10 Surface albedo.
Viewing and illumination conditions are corrected employing ...
Again. How many different, and which, "surface types" do you include in your BDRF calculations.

Six different bidirectional reflectance distribution functions for the surface types barren, forest, cropland, grassland, snow/ice, and ocean are used. The source for the determination of surface type is a combined USGS/Corine 2000 land use classification dataset. This information is added to the text.

5.11 Product examples
Two other product examples, monthly mean results of September 2007 ...
Could you please, in the same good way, give examples of use for these products.

The surface radiation budget product can be used to evaluate climate models w.r.t. the effect of clouds on the surface energy balance. Also for estimates of net heat fluxes at the surface the radiation budget might be of great value. Surface albedo is being used to study the effect of albedo on snow and ice mass balance in Northern Europe. We extended section 3.4.5 accordingly but did not add additional figures.

6 Summary and future perspectives
This is a very important, and here very well explained, background ....

Yes, we agree with the reviewer that this part is much better suited for the Introduction. Additionaly, we refer to it when the three classes of CDRs are introduced in section 2 (Backgrounds).

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 8517, 2008.

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