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Atmospheric Measurement Techniques
Discussions

Interactive comment on "HelioFTH: combining cloud index principles and aggregated rating for cloud masking using infrared observations from geostationary satellites" *by* B. Dürr et al.

B. Dürr et al.

bruno.duerr@gmail.com

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We want to thank the referee for the constructive and detailed comments on our manuscript. The following text states our replies to the specific comments of the referee. Additional references are given in the appendix of our author comments.

#1 (p1860-L13): ok

#2 (p1861-L18): ok

#3 (p1862-LL3-8): In the revised manuscript we will avoid the statement that processing raw counts is an advantage. Instead we will emphasize the fact that the new

scheme has to be independent from any auxiliary model or satellite input data. The first paragraph will be formulated as follows: "The calculation of the longwave cloud index for HelioFTH using Heliosat principles is based on raw sensor counts instead of brightness temperature. The calculation of brightness temperature is dependent on the calibration of the MVIRI IR window channel. Despite the blackbody cavity on board the Meteosat First Generation satellites a vicarious calibration method has to be applied to obtain the calibration coefficients (Gube et al, 1996). The vicarious calibration is based on radiative transfer calculations for cloud-free pixels using atmospheric input data from numerical weather prediction (NWP) models. The restriction to cloud-free pixels shows some deficiencies for the calibration of the coldest sensor counts (Knapp, 2007). Another potential vulnerability is the dependency on satellite data from different platforms as demonstrated by Knapp (2007) for the ISCCP B1 dataset. Therefore a feasibility study is presented here which elaborates the potential to define a IR cloud mask for geostationary satellites based on Heliosat principles and a modified SPARC rating scheme without the need for auxiliary model or satellite input data."

#4 (p1862-L10): SDL has already been introduced on page 1861, line 15.

#5 (p1862-L11): The Heliosat cloud index for visible channels estimates the relative influence of the clouds on the surface incoming solar (SIS) radiation: high reflectances at the cloud top are correlated with low SIS values at the surface, i.e. the clouds influence on SIS is close to 100% compared to cloud-free conditions, where the cloud influence is 0%. Analogously the HelioFTH scheme proposed here estimates the influence of the clouds on the surface downward longwave (SDL) radiation: very low cloud top sensor counts are correlated with high SDL values at the surface, i.e. the clouds influence on SDL is close to 100% compared to cloud-free conditions, where the cloud influence is 0%. SDL mainly originates from the cloud base and therefore the HelioFTH longwave cloud index (LCI) has to be able to estimate the influence of the clouds on SDL measured at the surface. The analogy of the HelioFTH LCI with Eq. (2) for surface radiation measurements is going to be explained in more detail in the revised manuscript in section 3 (see author comment #7 below).

#6 (p1862-LL14-19): The formulation of LCI in Eq. (1) is generally valid for vertically expanded clouds (convective clouds or frontal zones). The referee comment is correct for stratiform clouds such as altostratus or cirrostratus clouds. As far as cirrus clouds are detected with the single channel SPARC algorithm, they are mostly interpreted as middle- or high-level clouds (<680 hPa) and therefore correctly rejected by the FTH algorithm.

#7 (eq. 1): ok, parapraph 2 of p1862 together with eq. 1 will be moved to section 3.

#8 (p1863-LL7-9): The information about the CM SAF product is not written very clearly in the manuscript. The CM SAF products are used for satellite inter-comparison only. A more detailed description of the CM SAF products is going to be included in the revised manuscript. Most of the text from the beginning of section 2 is going to be moved to subsection 2.1.3. We propose to change the order of sections 2.1.3 and 2.1.2. Former section 2.1.3 will be formulated as follows: "The cloud screening and cloud masking are performed using the NWC SAF MSG v2010 algorithm, which is described in more detail in Derrien and Gleau (2005). The cloud mask comprises 6 categories: Cloud filled, cloud-free, partially cloudy and non-processed, snow/ice contaminated, undefined. The cloud fractional cover is defined as the fraction of cloudy pixels per grid square compared to the total number of analyzed pixels in the grid square. Pixels are counted as cloudy if they belong to the classes cloud filled or cloud contaminated. Fractional cloud cover is expressed in percent. The cloud mask is produced in an operational environment since summer 2006. Therefore, ...(from section 2.)... A typical issue with passive IR is the detection of thin clouds with an optical thickness of approximately 0.3 or less. Some thin clouds (particularly, ice clouds) over cold ground surfaces may remain undetected even if having cloud optical thicknesses higher than the above mentioned detection limit. Even though a special twilight transition procedure has been applied, the switch from day- to night-time algorithm might lead to spurious spikes. Finally, a distinct dependency on viewing zenith angle (VZA) occurs that leads

to an overestimation of cloudiness at high VZA (Kniffka et al., 2012)."

Former section 2.1.2: "ISCCP provides cloud properties over a period of more than 25 years (Rossow and Schiffer, 1991; Rossow et al., 1996; Rossow and Schiffer, 1999). This project was established in 1982 to analyze weather satellite radiance measurements (from geostationary and polar orbiting satellites) to infer the global distribution of clouds, their properties, and their diurnal, seasonal and inter-annual variations. This project and its results are considered to be the state of the art today on what can be derived from routine weather satellite data to study the role of clouds in climate. ISCCP is the first existing TCDR for cloud physical properties. The ISCCP-DX product contains a cloud mask and CTP and is available at 30 km and 3 h spatio-temporal resolution. The 3-hourly ISCCP-DX product was obtained from the EOS data server (http://eosweb.larc.nasa.gov/PRODOCS/isccp/table isccp.html) and the cloud flag was calculated according to Rossow et al. (1996, see Sect. 2.3.4). The ISCCP-DX cloud mask is based on an IR threshold test during night and a VIS (if available) or a near infrared threshold test (not available for Meteosat-7) during day. Stubenrauch et al. (2012) provides estimates on uncertainties: cloud fractional cover within 10 % and CTP within 100 hPa."

#9 (p1868-LL11-16): Here the referee overseen the fact that a simplified Heliosat scheme was applied to the MVIRI visible channel, where the contrast in brightness between clouds and the sea surface is obvious.

#10 (eq. 12): The parameter “s” is explained just before equation 12 in line number 5.

#11(section 3.5): We agree with the referee that the current latitudinal-dependent formulation of Cmin is not well suited to describe cloud top pressure (CTP) for mid-latitudes. In the revised manuscript we will include a new formulation of Cmin, where Cmin is determined from the lowest sensor counts values +/- 30 degrees N/S around the equator only and where Cmin is not a function of the latitude anymore. With this new formulation the CTP values (see eq. (24)) are more realistic for mid-latitudes, because LCI » LCImin and thus CTP » 130 hPa. A limb view correction was not included in the current formulation of HelioFTH due to an inaccurate interpretation of a EUMETSAT technical manual of the OpenMTP data format. In the revised manuscript we will include a purely geometric limb correction suggested by Minnis (1984) based on the satellite viewing zenith angle.

#12 (eq. 23): The threshold of 0.1 is purely heuristic. This will be mentioned in the revised manuscript.

#13 (p1873-L6): We will formulate this sentence as follows: “The long-wave cloud index (LCI) contains implicit information about cloud top pressure (CTP).” We will add a figure to the revised manuscript which compares HelioFTH CTP to CM SAF and ISCCP DX CTP.

#14 (p1873-LL7-21): We agree with the referee that the correlation between LCI and CTP is rather weak. Nevertheless some information about cloud height is needed and we suggest a formulation as follows: “A requirement for the development of HelioFTH is the capability to separate low-level clouds from middle- and high-level clouds. For this separation CTP information is needed, with low-level clouds being defined by CTP > 680 hPa. The retrieval of CTP from a single channel and with the additional requirement not to use e.g., NWP input is highly challenging. Therefore, the CTP retrieval can only be based on a simple scheme, and CTP is not considered as a stand alone product, rather it is used for the separation of low-level from middle- and high-level clouds only.” The first paragraph of section 3.7 until line 14 will be moved to the end of section 3.7. CTP will be only used as an internal quantity in our paper to separate low-level from middle- and high-level clouds. As suggested by the referee the correlation between LCI and CTP was investigated again and we will introduce a simple linear relationship for CTP in Eq. (24) as follows: CTP = CTPmax – (CTPmax – CTPmin)*((LCI – LCImin)/(LCImax – LCImin)), where CTPmin = 50 hPa, LCImin = 0% and LCImax = 110%. For the calculation of CTPmax with Eq. (25) a constant height offset dz = 500m is added to the mean pixel altitude to account for the vertical extent of low-level

clouds. The root mean square deviation (RMSD) of instantaneous HelioFTH CTP values compared to ISCCP-DX CTP decreased in the order of 10% – 20% for De-Aar (South Africa) or Carpentras (France) with the new formulation of CTP.

#15 (p1874-LL13-159): In the revised manuscript a threshold of 680 hPa instead of 700 hPa will be applied. 680 hPa is the threshold between low- and middle-level clouds for the ISCCP products. We will change the formulation to middle- and high-level clouds throughout the paper instead of high-level clouds only.

#16 (eq. 28): Eq. (28) will be removed in the revised manuscript.

#17 (p1876-LL7-12): The following text will be added to the second paragraph on page 1876: “The accurate observation of clouds during nighttime is dependent on the sky illumination, which significantly influences the observed cloud amount (Hahn et al., 1995)”.

#18 (p1876-LL21-26): In the revised manuscript it will be explicitly mentioned that the current formulation of SPARC for HelioFTH does not have a snow detection method.

#19 (p1878-LL10-16): This point will be mentioned in the new section 5 called “future work” just before the new section 6 (conclusions).

#20 (p1879-LL8-9): Results published by Stubenrauch et al. (2012) indicate that ISCCP CTP seems to miss many cases with cirrus clouds when compared e.g. to the Calipso cloud lidar.

#21 (p1879-LL16-21): A high probability of false detection (POFD) of cloud-free scenes for the ISCCP product means that many high-level clouds (e.g. cirrus) are missed by the ISCCP cloud mask or they are misinterpreted as low clouds (CTP > 680 hPa). This directly affects the quality of the free tropospheric humidity (FTH) retrieval. Therefore an alternative IR cloud masking scheme should have a notably lower POFD for cloud-free scenes for middle- and high-level clouds. This was the main prerequisite for the HelioFTH scheme presented here.

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