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New satellite-derived climate monitoring products for the Arctic

As component of EUMETSAT's activities in climate monitoring, the Satellite Application Facility on Climate Monitoring (CM-SAF; www.cmsaf.eu) provides climate monitoring products derived from meteorological satellites. The CM-SAF's product suite has recently been extended to the Arctic.
Several cloud parameters (cloud fraction; cloud type; cloud top height / temperature / pressure) as well as surface albedo are derived from the Advanced Very High Resolution Radiometers (AVHRR) on-board polar-orbiting satellites (NOAA-17/18/19 and MetOP2).

CM-SAF's operational processing environment generates daily and monthly mean products with a spatial resolution of 15km*15km on a day-to-day basis. The processing exploits AVHRR data at full spatial resolution (~1.1 km at nadir) for all available overpaths (~ 43 per day for three satellites) and is based on algorithms that were provided by the "EUMETSAT SAF in Support to Nowcasting and Very Short-Range Forecasting". These are based on multi-spectral threshold techniques applied to each pixel of the satellite scenes. Operational production started with January 2009. Selected months in 2007 had been generated for product validation. In this contribution we illustrate features of these datasets and show results of validations against ground-based measurements (synoptic manual observations) and other satellite instruments. In agreement with other studies, the data indicate that for some part of the Arctic, low cloud amounts occurred in summer 2007 which could be a contributing factor to the unprecedented rapid melting of sea ice during the polar summer of 2007. The new CM-SAF products offer additional opportunities for such analyses and regular monitoring of such processes.

In support of the International Polar Year the same products have also been reprocessed for winter 2007/08.

Satellite-derived climate monitoring products for the Arctic

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Abstract

As component of EUMETSAT's activities in climate monitoring, the Satellite Application Facility on Climate Monitoring (CM-SAF; www.cmsaf.eu) provides climate monitoring products derived from meteorological satellites. The CM-SAF's product suite has recently been extended to the Arctic. In this new AVHRR processing scheme, several cloud parameters ***(cloud fraction, cloud type, cloud top height / temperature / pressure)*** as well as ***surface albedo*** are derived from the Advanced Very High Resolution Radiometers (AVHRR) on-board polar-orbiting satellites (currently NOAA-17//19 and MetOP-A). ***Daily and monthly mean products with a spatial resolution of 15*15km² are generated*** **on a day-to-day basis.** A potential application is the validation of regional climate simulations. Furthermore, the satellite based datasets complement Arctic surface observations and support climate monitoring in the Arctic. **In support of the International Polar Year, CM-SAF has also generated these products for winter 2007/08.**

CM-SAF's new AVHRR processing scheme

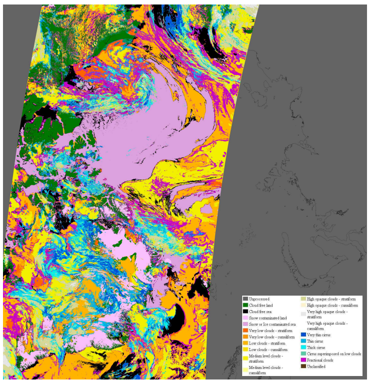


Figure 1: Cloud types as detected by NWCSAF's PPS-software for one selected satellite scene: MetOp overpass from 16.07.2007, scene starting at 21:52 UTC. The figure shows the *CM-SAF Arctic region* (square with a size of 5010 km * 5010 km centered to the pole with grid cells oriented parallel to the 0° and 90° meridians) at a spatial resolution of 1 km * 1 km.

The production of CM-SAF's Arctic products is based on the *Polar Platform System Software (PPS)* that was provided by the 'EUMETSAT SAF in Support to Nowcasting and Very Short-Range Forecasting (NWC-SAF)'. The algorithms are based on a multi-spectral threshold technique applied to each pixel of the satellite scenes. The updated version (2008) of the PPS operates on satellite swaths as illustrated in Figure 1.

For each AVHRR pixel, the following products are derived for the Arctic:

– Cloud mask: The Cloud Mask scheme attempts to delineate all absolutely cloud-free pixels with a high confidence based on a threshold algorithm and additional auxiliary data. The scheme uses off-line radiative transfer simulations of cloud free atmospheres to estimate the optimal thresholds valid for the given scene.

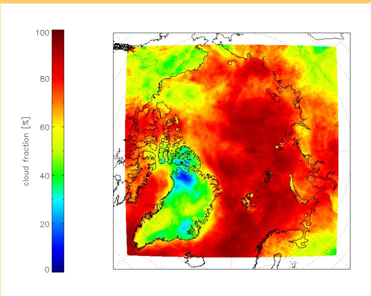
– Cloud type: The main objective is to distinguish between thin and opaque clouds, to provide a rough estimate of the cloud top height, and try to distinguish between water clouds and ice clouds. PPS detects 19 cloud types which are aggregated to 5 categories in the final CM-SAF monitoring product.

– Cloud phase: The cloud type algorithm also distinguishes between water and ice clouds which is used as the basis for CM-SAF's cloud phase product.

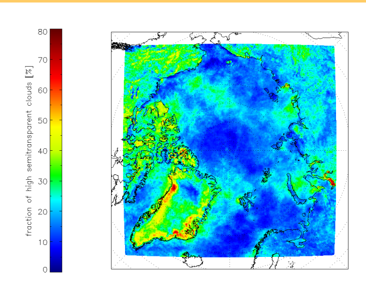
– Cloud top: The cloud top product is provided in three alternative versions: Cloud top temperature (CTT) [K], cloud top height (CTH) [m] relative to the topography and cloud top pressure (CTP) [hPa].

After retrieving these parameters for each pixel, they are remapped to an Lambert azimuthal equal-area projection and averaged to daily and monthly means.

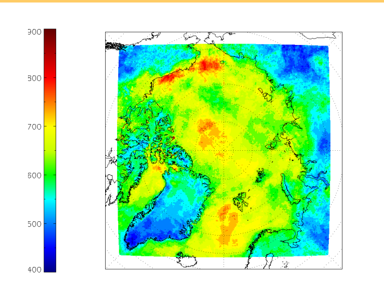
Product examples



Monthly mean cloud fraction in the Arctic [%] for August 2007.



Monthly mean fraction [%] of high semi-transparent clouds in August 2007 as an example for one category in the CM-SAF cloud type product.



Monthly mean cloud top pressure [hPa] for August 2007.

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Validation and monitoring of product quality

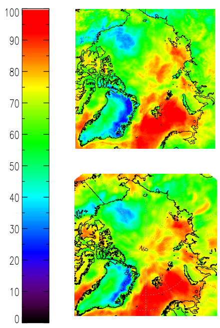

Figure 2: Comparison between monthly mean Cloud Fractional Coverage (%) in June 2007 from AVHRR (top) and the corresponding product derived from Terra MODIS data (bottom).

Operational production of Arctic products started with January 2009, but selected months in 2007 have already been generated for validation. Continuous validation will be performed on an annual basis in order to maintain high quality of the products. Annual validation reports are available at www.cmsaf.eu. They give comprehensive information on the accuracy of all operational monitoring products of CM-SAF. The majority of validation results is based on comparisons with in-situ observations from meteorological networks, e.g. synoptic station data or radiosonde data, as well as comparisons to other satellite products, esp. the more sophisticated and spectrally superior MODIS instrument in case of cloud products.

First comparisons for the new Arctic products have shown that the products are within the required accuracy, e.g. the monthly mean cloud cover products of polar summer 2007 are capable of reproducing similar results as those based on the MODIS instrument (Figure 2). Results of comparisons against ground-based and CloudSat/Calipso measurements are shown in Figure 3 and 4 respectively.

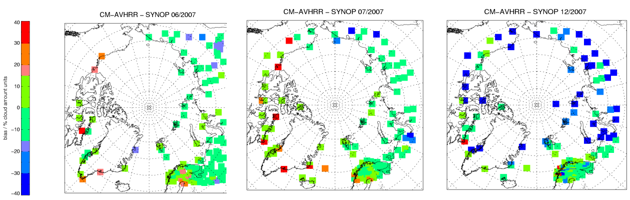

Figure 3: Biases in cloud fraction for monthly mean products compared to synoptic observations for June (left), July (middle) and December (right). Colour coding according to defined accuracy requirements: optimal (green), target (light red, light blue) and threshold (dark red and dark blue) accuracy.

Month (2007)s	Accuracy CloudSat-CPR (m)	Accuracy CALIPSO-CALIOP (m)	Target Accuracy (m)	Precision CloudSat-CPR (m)	Precision CALIPSO-CALIOP (m)
June	-1590	-50	+/- 1200	2120	2005
July	-1499	-381	+/- 1200	1976	1970
August	-1160	-492	+/- 1200	1875	1931
December	-829	-228	+/- 1200	1663	2309

Table 1: Summary of AVHRR CTH accuracy (bias) and precision (bc-RMS) results over all matchup cases per month and for both CloudSat-CPR and CALIPSO-CALIOP observations as references.

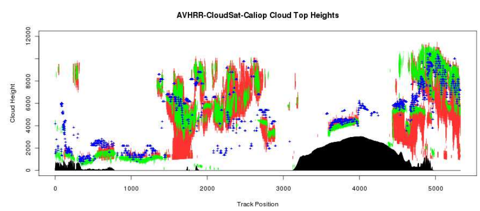

Figure 4: Cross section plot of matched AVHRR (NOAA-18, 27 July 2007 at 06:12 UTC) and CloudSat/CALIPSO results along the matchup track (in km). Red = CloudSat cloud mask, Green = CALIPSO cloud mask, Blue = AVHRR CTH retrievals.