Cloud top retrievals using the CO_2-slicing method on IASI data

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The cloud top temperature and height (CTTH) retrieval based on polar orbiter data developed within the SAFNWC (Satellite Application Facility) project aims at nowcasting applications. The main use of this product is in the analysis and early warning of thunderstorm development and the height assignment for aviation forecasting. The product may also serve as input to mesoscale models for use in nowcasting in general, or as input to other satellite retrievals used for nowcasting. The IASI part of the SAFNWC CTTH retrieval will also be used to build up cloud climatologies within the Climate Monitoring SAF.

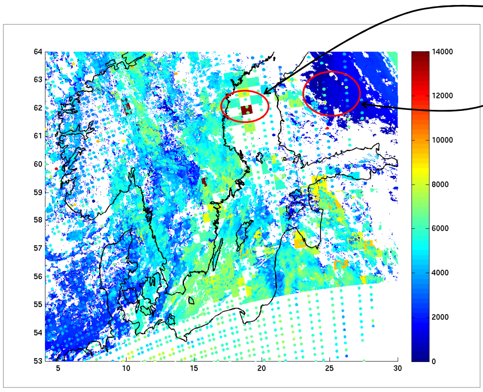
The role of the IASI CTTH

For the SAFNWC, CTTH derived from AVHRR data has been the operational method. The IASI instrument with its sounding channels and high spectral resolution provides the possibility for applying the radiance rationing technique, also known as the CO_2-slicing technique. This technique applies to single layers of high semi-transparent clouds. The radiance rationing technique using IASI data will be implemented as a complement to the AVHRR algorithm. There will also be a combined product using the strong parts of both techniques.

The CO_2 slicing method

For IASI CTTH retrievals the radiance rationing technique, or CO_2-slicing algorithm, is used. This algorithm utilises the fact that different CO_2-channels are sensitive to radiation from different altitudes.

In a first step a cloud top pressure (CTP) is derived for each individual CO_2-channel from the best fit between the calculated and measured radiances. After this a weighted average is made to obtain the final CTP. The cloud top temperature and height can then be calculated, as well as an estimation of the effective cloud cover.



Example where IASI CTTH can improve the AVHRR retrievals

Example where IASI CTTH has problems with low clouds the AVHRR retrievals can improve the IASI product

Figure 1. An example showing a scene from 20081018, 19:55 (start of AVHRR scan). The IASI retrieved cloud top height (sparse circles) is plotted on top of the AVHRR retrieved cloud top height (dense pattern).

The CO_2 slicing method, theory

The apparent cloud properties for each CO_2-channel are retrieved separately for the current FOV by calculating a ratio difference, RD_k, according to:

$$RD_k = \frac{I_k - I_{k,clr}}{I_{ref} - I_{ref,clr}} - \frac{I_{k,cld,lev} - I_{k,clr}}{I_{ref,cld,lev} - I_{ref,clr}}$$

where I_k and I_{ref} are the measured radiances for CO_2-channel k, and the reference channel *ref*, respectively. The clear radiances, *clr*, and the cloudy radiances for all pressure levels, *cld,lev*, are the calculated radiances for all CO_2-channels and the reference channel. The final cloud top pressure for channel k is obtained from the level with the minimum value of the ratio difference RD_k.

Validation

Validation has been made against the CALIOP lidar on CALIPSO and the cloud radar (CPR) on CloudSat in the so called A-train constellation. They provide a very accurate high resolution dataset which is very useful for validation. The disadvantage with this dataset is that the only simultaneous overpasses with the MetOp-satellite are at high latitudes, typically between 72-75 degrees latitude (south and north).

Comparisons to the cloud radar at the Lindenberg measurement site in Germany has also been made for a mid-latitude validation.

High-latitude example

One example from 20081018 16:44 (start time of the IASI scene) is presented in Figure 2. This comparison is made along the CALIPSO track. Note that one IASI footprint may be compared to several CALIOP and CPR footprints due to the different horizontal resolution. Figure 2 shows that the IASI retrievals (red) agree fairly well with CALIOP (black) and the CPR (blue) cloud top estimates in the first half of the coinciding track. The mean difference is 735 m. In the second half the cloud situation is more complicated and the difference is larger, 1523 m.

Cloud top estimates from AVHRR (green) show a similar behaviour in the first half, with a mean difference of 657 m. The second half shows the same behavoiur as IASI, with a mean difference of 2351 m.

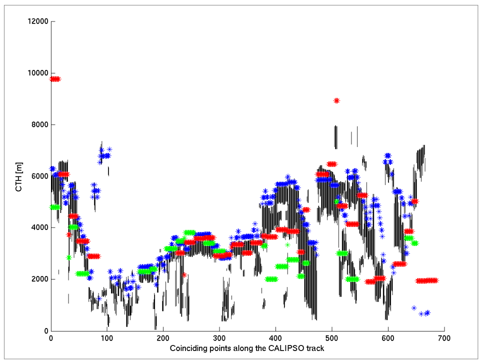


Figure 2. Clouds from CALIOP (black lines from cloud top to base) and cloud top heights from CPR (blue), AVHRR (green) and from IASI (red) derived with the CO_2-slicing algorithm. Data points are along the CALIPSO track.

Mid-latitude validation example

IASI CTTH is compared to the Lindenberg cloud radar observations over four months, August to November 2008. IASI FOVs closer than 10 km to the Lindenberg site is compared to the cloud radar observation closest in time to these FOVs. This results in 31 cases. Figure 3 shows the IASI and AVHRR vs Lindenberg cloud top heights.

The rms difference for all cases:	1561 m
For high clouds (above 4000 m):	1467 m
For low clouds (below 4000 m):	2218 m

The same values for the AVHRR retrievals at the same times over the Lindenberg station is:

The rms difference for all cases:	1379 m
For high clouds (above 4000 m):	1820 m
For low clouds (below 4000 m):	889 m

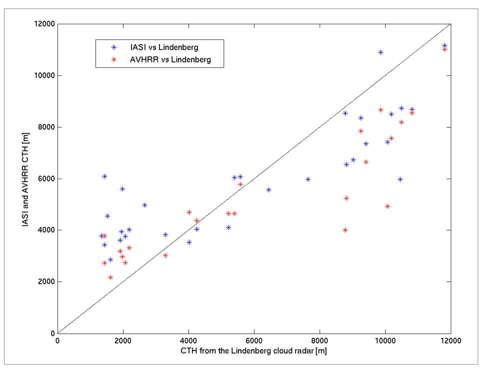


Figure 3. IASI (blue) and AVHRR (red) estimated cloud top heights as a function of the Lindenberg cloud radar estimates.