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Atmospheric Measurement Techniques Discussions

AMTD

2, C186–C194, 2009

Interactive Comment

Interactive comment on "The benefit of limb cloud imaging for tropospheric infrared limb sounding" *by* S. Adams et al.

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We thank the reviewer for his comments. They will help to clarify the discussion of several points. We have taken all points into account and we will give a point-to-point response below. We show the changed paragraphs and all changes are written in bold and italics.

Specific:

p. 592, l. 4: This sentence is a compromise between giving some technical motivation and still being well focused on the cloud topic. The instrument concept is based on S/N requirements and the need to reduce instruments complexity. The solution described in Friedl-Vallon et al. 2005 is optimized accordingly. Having the general design, the maximum size of a pixel can be determined. The reviewer is correct that the vertical pixel size is driven by the requested vertical resolution for the dynamics mode. In the horizontal, however, the size of the super-pixels of chemistry and dynamics mode are much larger than the Haidinger fringes and accordingly smaller pixels have to be introduced.

We thought this is interesting information. However, it is not relevant for the purpose of this paper. Since the reviewer feels that it is confusing, we decided to drop the point. The text now reads:

“A detailed technical description of such an instrument is given by Friedl-Vallon et al. [2005]. The instrument parameters studied here are chosen in accordance with the mission requirements defined in the PREMIER assessment report [ESA, 2008]. The size of a single detector pixel corresponds to 500 m in the vertical and 4 km in across-track direction. This is smaller than required for most scientific purposes. As a result the raw-data rate of such an instrument is about 100 Mbyte/s and thus too large to be sent down to ground completely. The problem is solved by combining several of the detector pixels to form respective super-pixels in three scientific measurement modes (Table 1):”

p. 592, l. 10-20: The description of the modes is based on the instrument concept of the original PREMIER proposal. The concept presented in the ESA mission assessment report has evolved from this initial concept. Nevertheless the actual instrument parameters studied here are in accordance with the mission requirements defined in the PREMIER assessment report. In consequence, the basic results and conclusions remain valid also for the modified instrument concept.

We will add this statement (including the reference to the mission assessment report) to the text (see above).

p. 593, l. 25: We change the text to make it clearer that there are uncertainties in case of thin clouds:

"Only by combining the two methods we can estimate the benefits of the LCI more realistically. Still, in case of thin clouds the uncertainties might be even larger than indicated by the differences between the results of the two methods."

p. 594, l. 22: The Global-merged IR Brightness Temperature Data which was provided by the NASA GES DAAC is only a 2-D data product. From the brightness temperature we calculated the cloud top heights. In order to get a 3-D cloud model we assume a vertical resolution to 0.5 km because this is the finest vertical resolution of the measurement modes. In this case the spatial resolution of the cloud model is comparable with the one of the LCI mode.

To clarify this point the text now reads:

"Here we use a 2-D composite of IR brightness temperatures measured with the operational geostationary weather satellites. The composite offers a spatial resolution of $\sim$4 km and a temporal resolution of at least 1 hour as well as a coverage of nearly the entire globe ($\sim$60° N – 60° S) [Janowiak et al., 2001]. The brightness temperatures are assumed to be the temperatures of the cloud tops which are matched to local ECMWF temperature profiles to obtain the cloud top height. The result is a nearly global map of cloud top heights. Because only the cloud top heights are available and not the complete 3-D cloud structure, we assume that the cloud extends down to the ground. The spatial resolution of the resulting cloud topography is 4 km horizontally. In the vertical we need to discretize to 0.5 km steps, since this is the vertical sampling of the LCI mode. This sampling is finer than the accuracy of the inferred altitudes. However, since we only need generally realistic cloud topography, this oversampling is justified for the purpose of this paper."

p. 596, l. 6: We add three references for the quoted numbers of cloud sensitivity and give a more detailed explanation about the retrieval of the IWC threshold in the text. The minimum IWC presented in our COSMO-EU data set is 8.36442*10-12 kg/kg.

Fischer, H., M. Birk., C. Blom, B. Carli, M. Carlotti, T. von Clarmann, L. Delbouille, A.

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Dudhia, D. Ehhalt, M. Endemann, J. M. Flaud, R. Gessner, A. Kleinert, R. Koopman, J. Langen, M. López-Puertas, P. Mosner, H. Nett, H. Oelhaf, G. Perron, J. Remedios, M. Ridolfi, G. Stiller, and R. Zander: MIPAS: an instrument for atmospheric and climate research, Atmos. Chem. Phys., 8, 2151-2188, 2008.

Höpfner, M.: Study on the impact of polar stratospheric clouds on high resolution mid-IR limb emission spectra, J. Quant. Spectrosc. Radiat. Transfer, 83, 1, 93-107, 2004.

Spang, R. et al. ESA Technical Note: Retrievability of MIPAS cloud parameter, Contract No.:20601/07/I-OL, ESA-ESRIN, 2008.

"In addition, for the COSMO-EU IWC data (where minimum/maximum IWC values of around 10-11 kg/kg respectively can be found) the LOS is considered to be "cloudy" if the integrated IWC along the entire LOS path exceeds at least 5*10-2 g m-2. This threshold is based on radiative transfer calculations for large database of modelled cloud spectra with the KOPRA radiative transport model including single scattering effects (Höpfner, 2005) together with measurements of MIPAS instrument (Fischer et al., 2008). Results for the ESA study on MIPAS cloud parameter retrieval [Spang et al., 2008] can be interpreted, that a limb ice water path of 5*10-2 g/m2 could be detectable in the IR spectra under certain conditions (e.g. in the tropopause region with its current extremely low background aerosol load). This threshold results in an effective IWC of 10-6 for a 50 km limb cloud path. Therefore only those ice-water path values are included which show clouds with sufficient optical thickness."

p. 596, l. 10-17: Both the FOV and the satellite shift are included in the simulation. For better understanding we made some changes in the text:

"While one interferogram in the D-mode is being measured, for example, the satellite moves 8 km and therefore the signal is integrated over this distance. Therefore the motion of the satellite as well as the FOV has to account for in the simulation. The method is described in following paragraph. We now compare cloud characteristics for the D-mode and the C-mode against the simulated measurements of the LCI, using

LCI as a standard. In order to downscale the very high spatial resolution of the LCI to the lower resolution of the D-mode and the C-mode, the corresponding number of observations are combined in all three dimensions. The combination of corresponding number of observations in the vertical and the across-track direction accounts for the various FOVs. The combination of observations along track includes the shift of the volume due to of the motion of the satellite in the simulation. The resulting measurement volume is the new observation of the respective lower resolution measurement mode."

p. 597, l. 23: In order to clarify the statement "their emissions" we changed the text:

"According to Kerridge et al. [2004] the optical thin clouds, which are in particular subvisible cirrus, are not detected by the nadir sounding geostationary weather satellites because the emissions resulting from their low optical depth relative to the strong emissions from the ground and altitudes below the level of interest do not induce a clear signal at the sensor."

p. 597, l. 25…p. 598, l. 5: We meant opaque in limb direction. The text reads now:

"In order to validate the simulated distributions of the opaque clouds in limb direction we compare them with the zonal averages of accumulative opaque cloud distributions measured with the limb sounding Stratospheric Aerosol and Gas Experiment (SAGE) 1997/98 (Figure 3) [Wang et al., 2003]. Simulated and measured cloud distributions are similar in general, but the cloud occurrences simulated with the LCI for winter 2005/06 show an underestimation of about 20 % with respect to the cloud occurrences measured with SAGE."

p. 597, l. 25: We make a reference to chapter 4.3:

"With an instrument measuring only at C-mode resolution a great many profiles were not usable for trace gas retrieval. This problem is discussed in more detail in section 4.3."

p. 602, l. 23: This statement is not described in Kerridge et al., 2004. They describe only that the clouds are generally underestimated with the BT method because the optically thin clouds are not detected in nadir direction. You are right that this sentence is misleading. Therefore we change the text to clarify the statement.

“The big differences in the two cloud data sets in Figure 7 result from the differences in the applied cloud data of the two methods. The method for deriving the BT cloud data seems to underestimate the occurrences of high altitude clouds compared to the COSMO-EU results, which are restricted to a mid-latitude region. The method is most sensitive and optimised to optically thick clouds (section 3.1). Optically thin cloud in the nadir direction will result in a significant underestimation of the real CTH due penetrating radiation by lower altitudes and surface emissions through the cloud. In consequence the BT clouds distribution will underestimate in a certain extent the cloud occurrence with respect to height [Kerridge et al., 2004]. However, the cloud extent, especially the small cloud fields, is reproduced more realistically. In contrast to this, the COSMO-EU data seem to show a more realistic cloud amount because of the representation of the high altitude and optically thin clouds. On the other hand, the cloud occurrence simulated from the COSMO-EU data compares better to the SAGE data, presumably due to the representation of the optically thin clouds. But due to the lower spatial resolution of the COSMO-EU data (7 km grid size) the cloud cover is too homogeneous and too many cloudy pixels are simulated for the high spatial resolution of the LCI.”

Technical:

Figures 7-9: We replace LME with COSMO-EU in all figures.

p. 596, l. 3: changed

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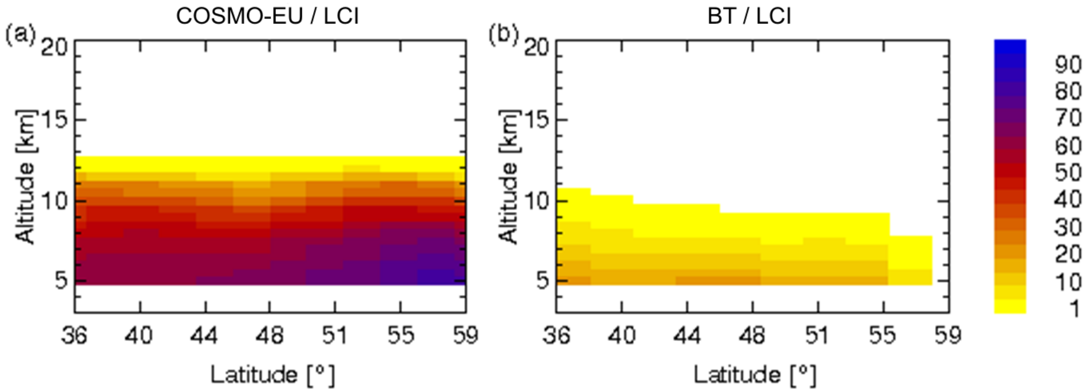

Fig. 1. Figure 7

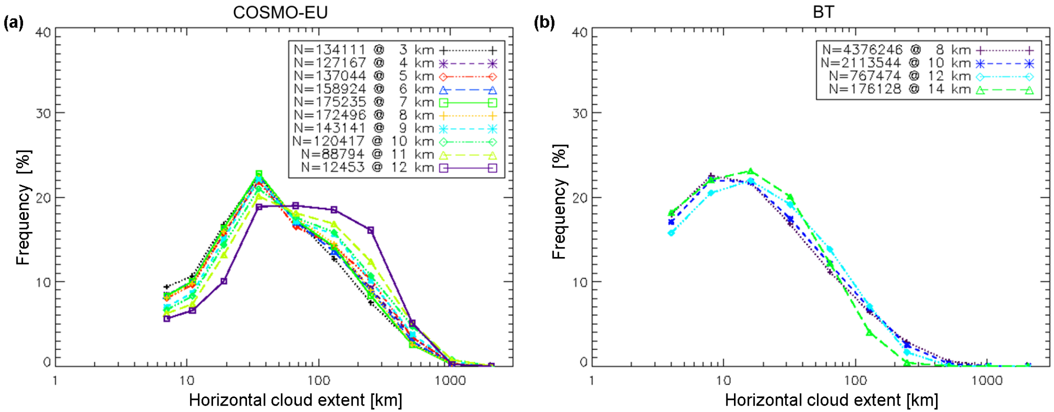

Fig. 2. Figure 8

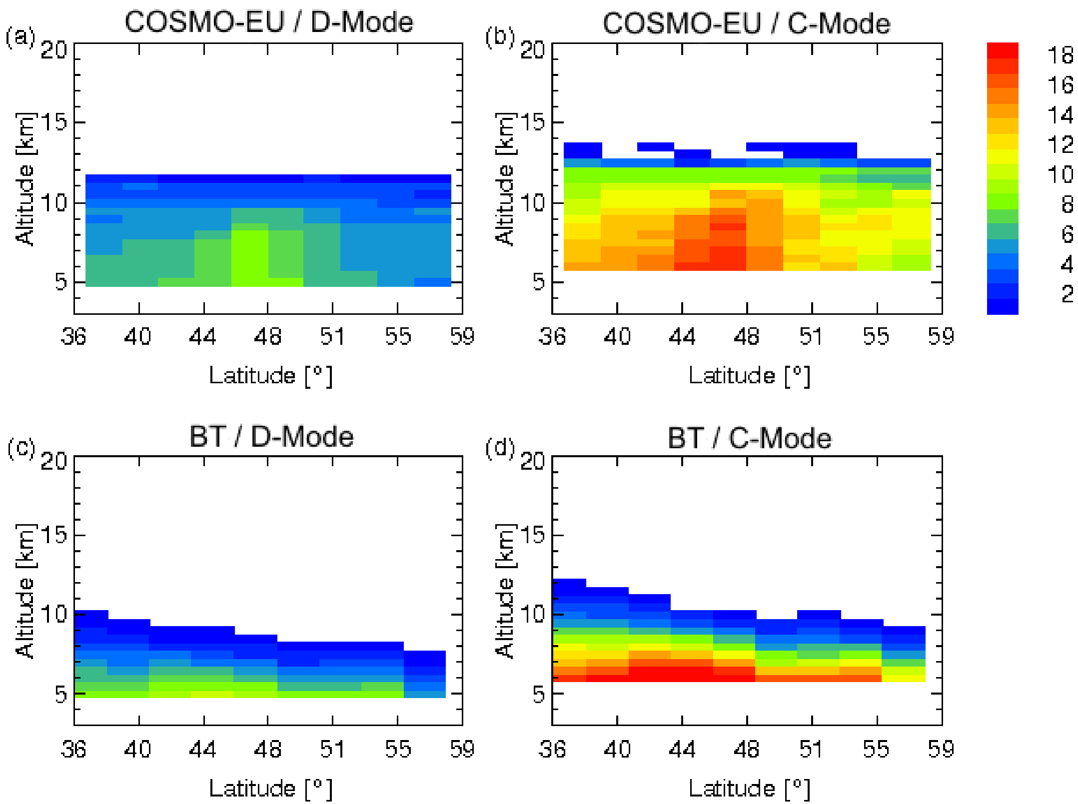

Fig. 3. Figure 9

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