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Atmospheric Measurement Techniques Discussions

Interactive comment on "Global cloud top height retrieval using SCIAMACHY limb spectra: model studies and first results" *by* K.-U. Eichmann et al.

Anonymous Referee #3

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General

The manuscript describes the determination of cloud top height from SCIAMACHY limb observations between 2003 and 2012. The detection method is based on the change of a colour ratio with tangent height, the so-called colour index ratio. The colour index ratio is compared against a pre-defined threshold for cloud detection. This method is theoretically substantiated by radiative transfer calculations. The resulting cloud top height climatology is compared to SICAMACHY nadir and co-incident MIPAS/Envisat cloud top distributions. Further, the influence of aerosol from major volcanic eruptions is discussed. The paper is logically structured and clearly written. It broadens the dataset of global information on cloud top heights which is, especially for thin clouds, still relatively sparse. Further it demonstrates the information content of limb-observations on

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aerosols from volcanic eruptions. Thus, I recommend the work for publication in AMT after addressing/clarification of the comments listed below.

Major comments

P8309, chapter 4 Model simulations: These simulations have been performed for a very limited subset of possible cloud scenes. E.g. only one kind of cirrus cloud particles has been taken into account. Could you explain, why this restricted amount of simulations should be representative for the large global variability of macro- and microphysical cloud parameters?

An empirical colour index ratio limit of 1.4 has been used for cloud top detection. However, I would like to have seen some examples on how the global distributions vary when changing this values within some reasonable boundaries.

In favour of the applied detection method it is argued that 'Due to the use of ratios the radiance calibration was not necessary as all multiplicative and height-independent calibration errors cancel out.' However, I would like to see at least a list of possible known issues with the measurements which could have an influence on the cloud detection scheme.

Specific comments

P8303L3, P8338, 'Figure 2 gives a schematic view of the limb geometry':

The tangent points in the figure are positioned exactly in the vertical. However, there is some horizontal displacement due to the limb-scanning. How large is this and could it be indicated in the Figure?

P8306L27, 'Mie scattering':

With this term scattering would restricted to spherical particles only but cirrus clouds are definitely no Mie scatterers.

P8307L17:

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Please define ‘h’ and ‘l’ clearly – high and low wavelengths or frequencies?

P8307L23:

This is similar to a gradient, why would it not be adequate to attribute the ratio to an altitude between z_th and z_th + delta z_th rather than to z_th?

P8308L2, ‘where the cloud top z_ct is within the field of view’:

The cloud top can also be slightly above the field of view, just not reaching the FOV of the following tangent height.

P8308L5, ‘as all multiplicative and height-independent calibration errors cancel out’:

It would be good to state also which known instrumental errors of SCIAMACHY are still relevant here.

P8311L23:

Please indicate the source of the single-scattering properties of the cirrus clouds. Are those assumed to be randomly oriented? I would be interesting also to test different sizes and a size-distribution of particles.

P8312L1, ‘A total aerosol optical thickness. . .’:

Could you be a bit more specific about the range of realistic aerosol optical thicknesses and their variability to be able to judge on the validity of the used values.

P8312L7, ‘In Fig. 6 calculated colour index ratios are shown’:

Are those the colour index ratios at the position of the clouds? Please specify.

P8312L23, ‘But a CTH at 3 km was not detectable’:

This test has not been shown as a figure and described above. It should be made clear that this is not visible from Fig. 6. It would be good to show a corresponding figure, e.g. in a supplement.

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P8313L8, ‘The influence of CTH changes on the CIR theta was also tested’:

This is a bit a strange order since now the tests of CTH changes are described. It would perhaps make more sense to mention these tests before (at least before the previous paragraph).

P8313L8, ‘clouds down to the Earth’s surface’:

Have mountains been excluded from the could-detection?

P8317L12, ‘The fractions are calculated by comparing the number of clouds in that layer with the number of all measurements.’:

Is this really a cloud fraction or rather a ‘cloud-top fraction’? How do you count tangent altitudes below a cloudy altitude: cloud-free or excluded from the calculation? The explanation should be more detailed here.

P8318L1, ‘But CALIPSO detected no enhancement of cloud fractions over Northern Africa, which indicates that SCIAMACHY possibly detected an enhanced aerosol layer in this region.’:

Could you confirm this by using the CALIPSO aerosol product?

P8318L5, Fig. 9c: ‘The cloud fraction in the northern hemisphere’:

In Fig. 9c north of 70deg N there are very high cloud fractions which are not visible at other altitudes (orange-red colours). Might this be a measurement issue?

P8318L20, ‘The global colour index ratio’: How was this determined / which tangent altitudes were used?

P8322L2, ‘We have used a MIPAS verification dataset with measurements from January 2008 to March 2012.’:

Why have you not used the whole overlapping MIPAS and SCIA period?

P8322L14, ‘This is the region where the lowest possible MIPAS tangent heights were

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at about 10 km, which can partly explain the differences.':

I don't understand how this explains the differences at around the 12 km and the 14-16 km SCIAMACHY CTH block in Fig. 14.

P8323L24, 'It has to be noted that the very high CTHs at the end of 2011 were only detected with SCIAMACHY. But also MIPAS measured higher clouds on average during this period.':

This is not clear. How does the comparison look like in this period/latitude range for the co-incident observations?

P8324L24, 'The volcanoes emitted sulphur dioxide into the troposphere . . .':

However, direct emission of SO2 into the lower stratosphere cannot be excluded (see e.g.: Pumphrey et al., 2015 (www.atmos-meas-tech.net/8/195/2015/), Höpfner et al., 2015 (www.atmos-chem-phys.net/15/7017/2015/)).

P8327L21, 'be explained by differences in the tangent height steps':

Could you suggest other reasons? E.g. the setting of the cloud threshold parameters in case of MIPAS and SCIAMACHY and sensitivity issues between mid-IR and NIR/vis?

Technical comments

'limb state', 'measurement state':

The term 'state' is used but has not been defined clearly. It should be clear what is different from a limb-scan.

P8312L23: 'clouds tops' -> 'cloud tops'

P8314L26: 'it leave' -> 'it leaves'

P8317L23: 'at the height range': Which range?

P8318L27: '1551 / 1090 nm' -> '1551 nm / 1090 nm' , also @ P8319L2.

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P8321L23: ‘blue dashed line’

Really blue? Isn’t it more black or dark violet?

P8336: Please indicate the date of the orbit in the caption.

P8352: Could you indicate the eruption dates in the figure?

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 8295, 2015.