The SCIAMACHY cloud products derived using the semi-analytical cloud retrieval algorithm

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ABSTRACT

The paper is aimed to the presentation of the semi-analytical cloud retrieval algorithm developed at Bremen University. The algorithm is capable to derive the cloud top height using SCIAMACHY measurements in the oxygen A-band. The cloud optical thickness is derived from measurements outside gaseous absorption bands. The notion of the phase index is introduced and used to identify ice clouds. SCIAMACHY data for years 2004 and 2005 are analyzed. The global cloud properties as obtained from SCIAMACHY measurements are discussed.

1 INTRODUCTION

A new Semi-Analytical CloUd Retrieval Algorithm (SACURA) for the cloud liquid water path (LWP) and the droplet effective radius (DER) determination presented here is based on the asymptotical solution of the radiative transfer equation for a special case of disperse media, having a large optical thickness. This solution was obtained by Germogenova [1] for plane-parallel turbid slabs. Such an approach has already been used in a number of studies [2, 3]. The difference with our technique is that the asymptotical solutions are further simplified such that the inverse problem is reduced to the solution of a single transcendent equation. This allows us to speed up the retrieval process significantly without the substantial loss of the accuracy of the retrieved parameters. The algorithm is restricted to the case of optically thick clouds (the optical thickness $\tau \geq 5$). Apart DER and LWP, we also retrieve the cloud optical thickness, the cloud albedo and the columnar concentration of droplets. The cloud top height is derived from

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measurements in the oxygen absorption A-band as recommended by Yamamoto and Wark[4]. Finally, the cloud thermodynamic state is obtained using different spectral signatures of liquid water as compared to ice in the spectral range 1550-1670nm [5]. The detailed description of SACURA is given in [6].

2 RESULTS OF RETRIEVALS

Results of retrievals of cloud top height (CTH) using SCIAMACHY oxygen A-band measurements are shown in Figs. 1 and 2 for years 2004 and 2005. We also show the temporal behavior of the average values of CTH for three latitudinal belts located at 30N-60N (northern belt), 30S-30N(tropical belt), 30S-60S(southern belt) in Fig.3. It follows from the analysis of these figures that the general structure of the CTH distribution is the same for both years. However, some regional differences are seen. In particular, the clouds are generally higher in year 2005 as compared to 2004 in the region of the Golf of Mexico. This can be related to the higher activity of hurricanes in that area in the year 2005 as compared to year 2004. It follows that high clouds are present around tropics with the average CTH of 9 km. Clouds are lower for the southern and northern belts with the average height of 6km. Interestingly, CTH is more uniform for the northern belt as compared to the southern belt. This can be related to the difference in the distribution of land and ocean in southern and northern hemispheres. We also see a high cloud activity in the Pacific region.

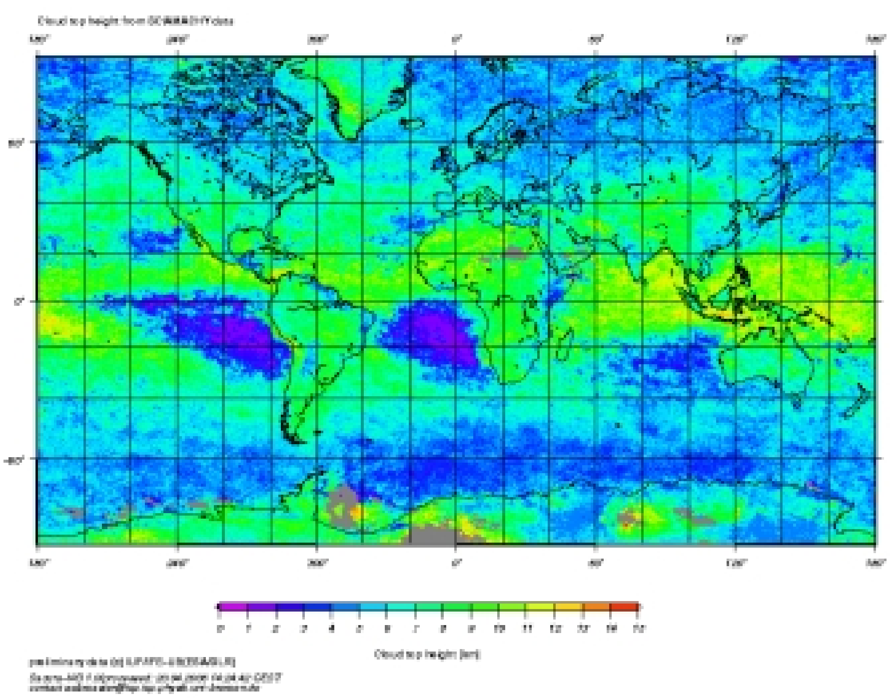

Fig.1. The average cloud top for year 2004 as retrieved by SACURA using SCIAMACHY. The data averaged on 0.2*0.2 degree grid.

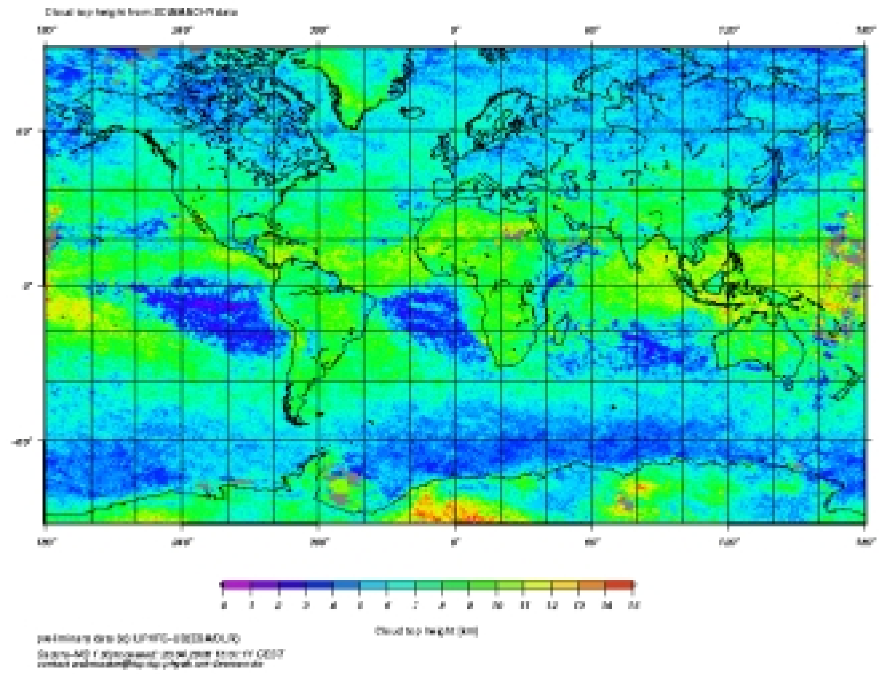

Fig.2. The same as in Fig.1 except for the year 2005.

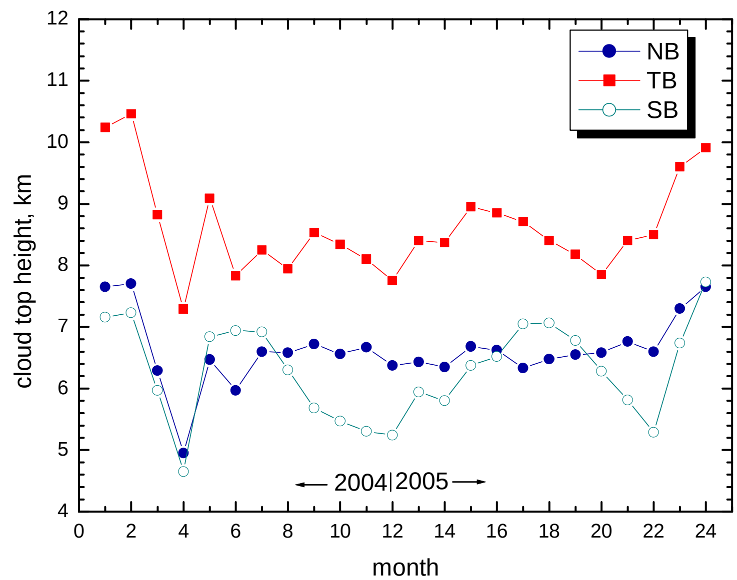

Fig.3. The temporal trend of the global average cloud top height as derived from SCIAMACHY using SACURA for the northern belt (NB), the tropical belt (TB), and the southern belt (SB). Only thick cloud systems are taken into account. The results for years 2004 and 2005 are shown in the figure.

The average phase index, which is equal to the ratio of reflectances R(1550nm) / R(1670nm) is presented in Fig. 4 for the year 2005. The blue color on this figure corresponds to the ice reflective properties either deposited on the ground (see, e.g., the region of Greenland) or in the atmosphere. Results shown in Figs. 2 and 4 correlate. Clearly, this must be the case because the tops of high clouds are composed mostly of ice. Also we have found that the SCIAMACHY – derived water vapor map for year 2004 [7] shows features, which are present in the cloud top height results (see Figs. 1,5). Such a correlation must exist on general grounds.

Other cloud products including the cloud optical thickness, cloud liquid water path, cloud effective radius, and cloud fraction are given at the SACURA-dedicated website *www.iup.physik.uni-bremen.de/sacura*. The cloud fraction is derived using the optical cloud recognition algorithm (OCRA) as described in [8]. OCRA is based on the analysis of reflectances as measured by SCIAMCHY polarization measurement devices (PMDs). PMDs have higher resolution as compared to SCIAMACHY states used in the cloud retrieval algorithm. This enables the determination of the cloud fraction using the color space technique presented in [8]. Retrievals for partially cloud covered ground scenes are treated in the framework of the independent pixel approximation [9].

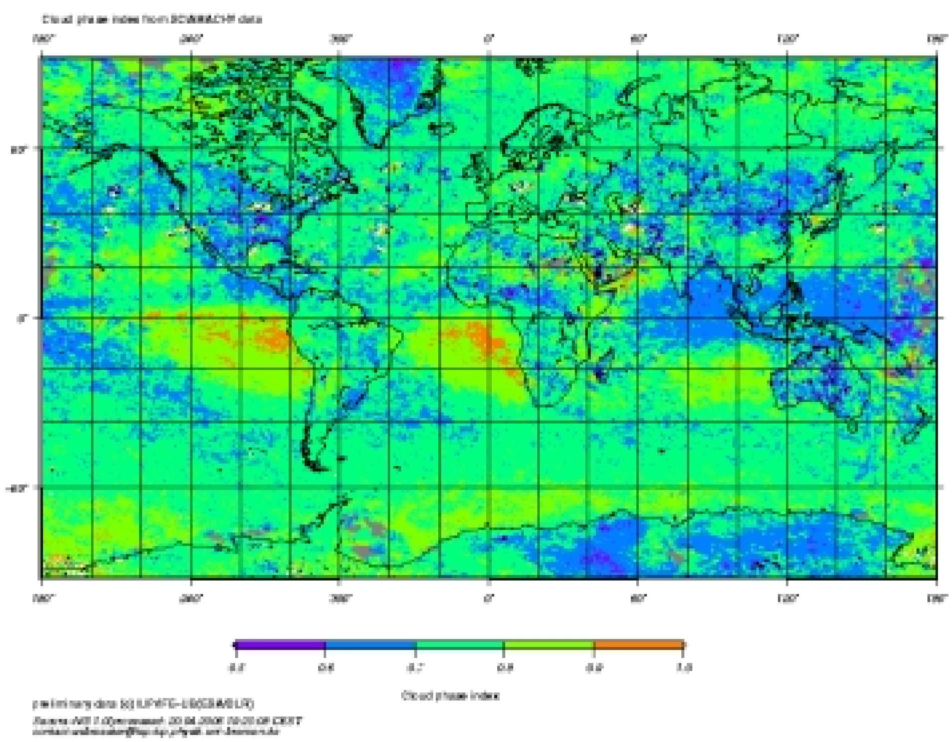

Fig. 4. The phase index map for the year 2005.

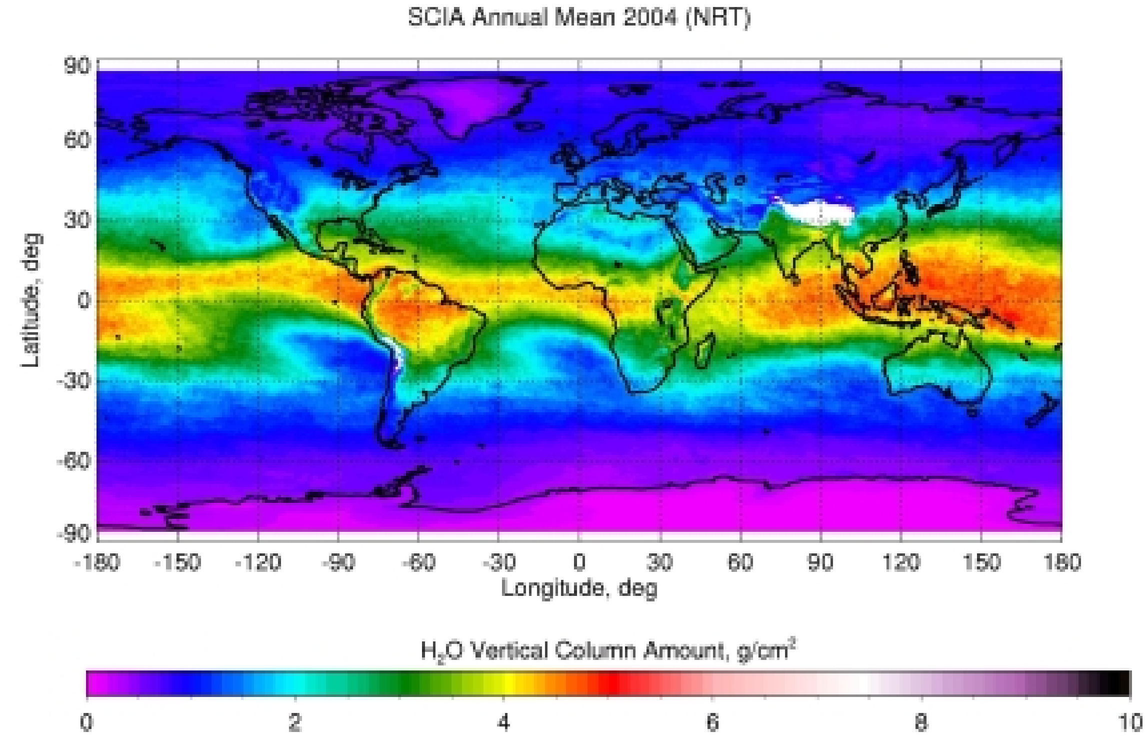

Fig.5. The water vapor map for year 2004 as derived from SCIAMACHY measurements for cloudless conditions (courtesy of S. Noël).

3 CONCLUSION

We presented here the analysis of selected cloud products as derived from SCIAMACHY measurements over cloud fields for years 2004-2005. In particular, the spatial distributions of the cloud top height and the cloud phase index are presented. The results for the cloud top height are in a good correspondence with those obtained from other instruments such as MODerate resolution Spectrometer (MODIS) (http://modis.gsfc.nasa.gov). The estimated accuracy of the cloud top height product is around 0.5km as derived from comparisons with infrared measurements [10]. Currently, SACURA does not distinguish water and ice clouds. All retrievals are performed in the assumption of a single homogeneous water cloud. In future, we plan to introduce two retrieval chains – one for water clouds and yet another one for ice clouds. The selection of pixels will be based on the analysis of the phase index (see Fig.4). The snow/cloud discrimination is planned to be performed using a combination of oxygen A-band and infrared SCIAMACHY measurements. SACURA is used to account for cloudiness in the ozone concentration retrievals based on the analysis of the solar backscattered light in the Huggins bands[11].

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