Geophysical Research Abstracts
Vol. 19, EGU2017-17110-1, 2017
EGU General Assembly 2017

Cloud Detection and Cloud Top Height Determination using the Hyperspectral Imaging Spectrometer specMACS

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Diabatic heat released by clouds sometimes causes numerical weather forecast failures. Climate model predictions depend on radiative effects of tropical clouds in the trade winds. Both climate and global weather forecast models, therefore, need to be improved with respect to a proper representation of cloud microphysical and macrophysical properties. For this purpose, parameters describing the cloud geometry such as cloud fraction, cloud size and cloud top heights are important. These parameters are also important ingredients to accurately validate the results of previous and upcoming studies with cloud resolving models.

A hyperspectral imaging spectrometer (specMACS) was operated aboard the research plane HALO in the NARVAL II and NAWDEX experiments. By combining the reflected radiance of the clouds and the signal of the water vapor absorption bands in the infrared part of the solar spectrum, an effective cloud mask was developed which is prerequisite for any further analysis. The method allows detecting clouds even over the bright sunglint. As a next step, cloud top heights are determined by comparing the measured radiance within and outside of the oxygen A-band with radiative transfer model calculations. Subsequently, the calculated cloud top heights are compared to LIDAR measurements. While this method works well for plane-parallel, homogeneous clouds, 3D radiative transfer effects cause artifacts at cloud edges and in cloud free areas which can lead to strongly miscalculated cloud top heights. These effects will be assessed and also evaluated.

Deriving quantities such as cloud fraction, cloud size, and cloud structure is the basis for calculating cloud heating and cooling rates in upcoming studies.