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Remote sensing of single- and multi-layer cloud-top pressure using measurements of MERIS and AATSR onboard ENVISAT

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Due to their diversity and complexity, clouds are still a major source of uncertainty in the simulation of climate development. Precise measurements of cloud properties are therefore crucial in order to feed and validate climate models and understand the shortcomings of state-of-the-art modeling approaches. In case of cloud altitude, representing one of the most decisive parameters for the cloud radiative effect, several techniques for spaceborne remote sensing have been developed in the past decades. The most popular methods, like CO2 Slicing, are based on the exploitation of the thermal emission of the cloud in the thermal infrared spectral region, providing accurate results in case of high clouds but suffering from a reduced sensitivity in the lower atmosphere. In this framework, a different technique is applied, providing a higher accuracy in case of low clouds: MERIS measurements within the oxygen A absorption band at 0.76μm are used for the retrieval of cloud-top pressure. In a validation study using airborne lidar measurements, a MERIS cloud-top pressure accuracy of 25hPa was found in case of low, single-layered clouds whereas large errors were observed in case of optically thin cirrus residing above the observed cloud deck. In order to improve the retrieval performance in case of such multi-layered clouds, a new Optimal Estimation technique for the simultaneous detection of two cloud layers was developed, based on synergistic observations of MERIS in the near infrared and AATSR in the thermal spectral region. The unique method relies on the dramatically different sensitivity of the two instruments to optically thin cirrus, causing the MERIS-derived cloud height to be close to the lower cloud and the AATSR-derived cloud height to be close to the cirrus level. Several case studies are shown.