REMOTE SENSING OF SURFACE AND CLOUD-TOP PRESSURE FROM MERIS MEASUREMENTS IN THE OXYGEN A BAND

Lindstrot, R., Fischer, J., and Preusker, R.

Institut für Weltraumwissenschaften, Freie Universität Berlin, Germany

1. INTRODUCTION

Due to their diversity and complexity, clouds are still a major source of uncertainty in the simulation of climate development (e.g. [1], and citations therein). 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 CO_2 Slicing, are based on the exploitation of the thermal emission of the cloud in the thermal infrared spectral region (e.g. [2]), providing accurate results in case of high clouds but suffering from a reduced sensitivity in the lower atmosphere. In the frame of this work, 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 ([3], [4]). A similar approach is exploited for the retrieval of surface pressure in case of clear sky measurements.

2. THE OXYGEN A BAND METHOD

The mass of oxygen along the path of reflected sunlight is derived from measurements inside the absorption band. Since oxygen is well mixed in the atmosphere, the traversed mass of air can directly be determined, allowing for the retrieval of cloud-top pressure in case of measurements above clouds, as illustrated in figure 1. The determined mass of air additionally depends on the length of the photon path inside the cloud that can be estimated from the cloud optical thickness, and the surface brightness, available from globally mapped albedo data ([5]).

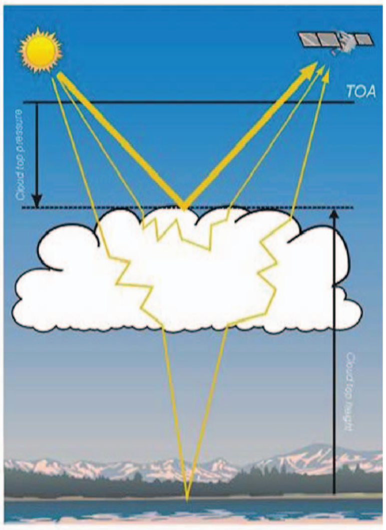

Figure 1: Schematic light path at 0.76µm above clouds as observed by MERIS.

3. APPLICATION TO MERIS MEASUREMENTS

Since the launch of ENVISAT on March 1st, 2002, measurements inside the O_2 A band are available from MERIS and operationally used for the retrieval of cloud properties like optical thickness and height within ESA´s ground segment. In a validation study using airborne LIDAR measurements recorded during a flight campaign in 2004, a cloud-top pressure accuracy of 25hPa was found in case of single-layered boundary layer clouds ([6], see figure 2).

In case of clear sky, the MERIS measurements inside the oxygen A band can be used for a retrieval of surface pressure above land surfaces ([7]). Due to the comparatively weak effect of aerosol scattering on the measured oxygen transmission for a surface albedo between 0.1 and 0.4, the surface pressure above land surfaces can be determined with an accuracy of ~10hPa in case the temperature profile is known to a sufficient degree. The derived surface pressure can be an important tool for the cloud detection in satellite imagery and is used for the empirical correction of instrumental stray light within MERIS ([8]).

The two retrieval algorithms are presented and case studies and validation results are shown. An outlook on future work and algorithm improvements is given, including e.g. the treatment of multilayered clouds by a synergetic usage of MERIS and AATSR on ENVISAT.

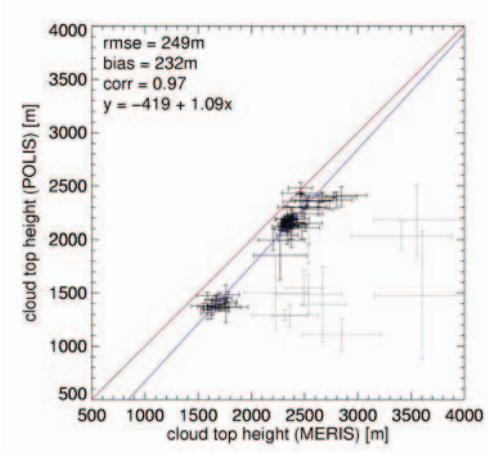

Figure 2: Scatterplot of cloud-top height derived from MERIS and LIDAR measurements. Grey crosses mark cases with cirrus above low-level clouds.

4. REFERENCES

[1] Randall, D., R. Wood, S. Bony, R. Colman, T. Fichefet, J. Fyfe, V. Kattsov, A. Pitman, J. Shukla, J. Srinivasan, R. Stouffer, A. Sumi, and K. Taylor, 2007: *Climate Models and Their Evaluation. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[2] Menzel, W. P., R. A. Frey, B. A. Baum, and Z. H., 2006: Cloud top properties and cloud phase algorithm theoretical basis document. Algorithm Theoretical Basis Document MOD04, Cooperative Institute for Meteorological Satellite Studies, Universityof Wisconsin.

[3] Fischer, J. and H. Grassl, 1991: Detection of Cloud-Top Height from Backscattered Radiances within the Oxygen A Band. Part 1: Theoretical Study. J. Appl. Meteor., 30, 1245–1259.

[4] Preusker, R. and R. Lindstrot, 2009: Remote sensing of cloud-top pressure using moderately resolved measurements within the oxygen A band - a sensitivity study. J. Appl. Meteor. Climat., 48, 1562 – 1574.

[5] Muller, J.-P., R. Preusker, J. Fischer, M. Zuhlke, C. Brockmann, and P. Regner, 2007: ALBEDOMAP: MERIS land surface albedo retrieval using data fusion with MODIS BRDF and its validation using contemporaneous EO and in situ data products.IGARSS International Geoscience and Remote Sensing Symposium 2007, 2404–2407.

[6] Lindstrot, R., R. Preusker, T. Ruhtz, B. Heese, M. Wiegner, C. Lindemann, and J. Fischer, 2006: Validation of MERIS cloud top pressure using airborne lidar measurements. J. Appl. Meteor. Climat., 45, 1612 – 1621.

[7] Lindstrot, R., R. Preusker, and J. Fischer, 2009: The retrieval of land surface pressure from MERIS measurements in the oxygen A band. J. Atmos. Oceanic Technol., 26, 1367 – 1377.

[8] Lindstrot, R, Preusker, R. and Fischer, J., 2009: The empirical correction of stray light in the MERIS oxygen A band channel, *submitted to J. Atmos. Oceanic Technol.*