Freie Universität Berlin

Development of Cloud Optical Properties During Cloud Life-Cycles

J. Slobodda[1], R. Preusker[1], J. Fischer[1]

1 Institute for Space Sciences, Freie Universität Berlin

E-Mail: jennifer.slobodda@wew.fu-berlin.de

1. Introduction

Geostationary Satellites provide a good opportunity to retrieve cloud properties and monitor their evolution due to their high temporal resolution. Examinations of this time series give information of the development of the cloud itself.

For our study we use the SEVIRI (Spinning Enhenced Visible and InfraRed Imager on Meteosat Second Generation) visible and near infrared channels to retrieve cloud optical depth (COD) and effective radius (Reff) of convective cells over Europe. This retrieval is applied to time series of SEVIRI images of convective cells so that we can examine the development of its properties over time.

2. Method

The cloud retrieval we used is based on the radiative transfer scheme Matrix Operator Model (MOMO; [1]) as forward operator for the calculation of look-up tables and the optimal estimation method is utilized for the inversion. Thereby the cloud is treated separately from the surrounding atmosphere and the ground below. The measured radiance is corrected for the atmosphere above the cloud and during the inversion an effective surface is utilized which contains an correction factor for the atmosphere between the cloud and the surface. This method is described by Walther and Heidinger 2012 [2]. The retrieved values are used for case studies on the development of cloud optical properties during the life-cycle of a convective cell. The cells for these studies are assumed to be high enough to contain only ice particles at their top. Thus only look-up tables for ice particles are used though the retrieval also works for liquid water.

The case studies are divided into two parts. For the first one histograms of the frequency distribution of COD and Reff values were calculated once per hour to get an impression of the development of COD and Reff during the formation and growth of convective cells. For the second part a single cell is tracked over several SEVIRI images and the development of mean values of cloud properties is examined especially whether there are certain dependancies. The tracking algorithm is based on the detection of maximal overlap of an identified cell in two successive images and follows closely the work of Williams and Houze 1986 [3]. The identification of individual cells is carried out according to brightness temperature (BT) thresholds from channel 10.8µm. For the following results the threshold was set to 245K. Variation of the threshold is possible and the quantitative effects on the results have to be estimated. Other possibilities of identification e.g. by COD thresholds shall also be tested.

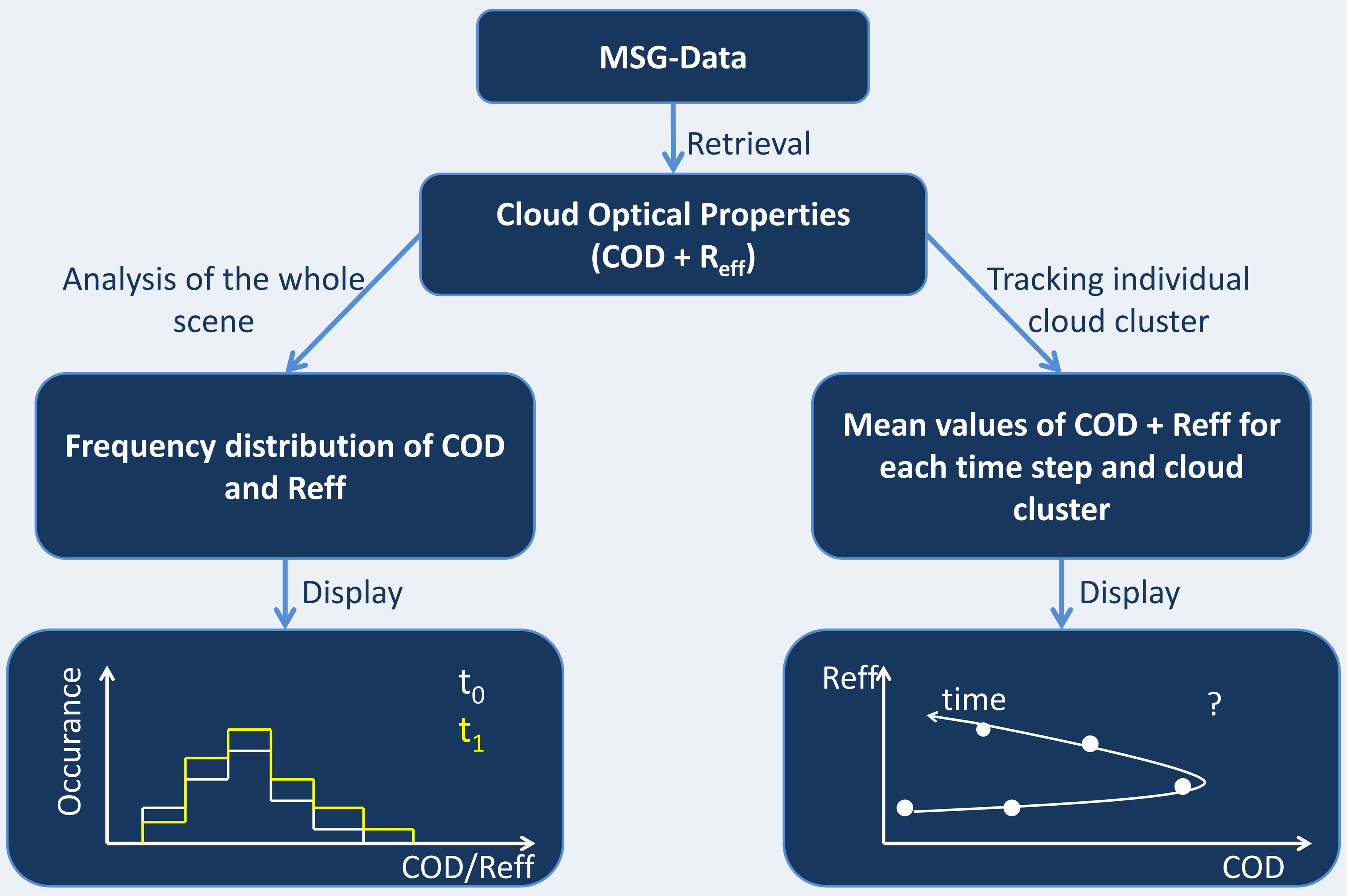

Figure 1: Schematic structure of the method used to analyze the development of optical cloud properties during the life-cycle of convective cells.

3. Case Study

For the case study convective cells over Europe were chosen that pass ideally over a ground-based cloud observatory like Jülich or Leipzig.

One such cell passed Jülich on the 23/05/2012. The histogram in the right panel of Figure 2 shows a constant increase of COD over the day. The values from the MODIS instrument fit well into the time series of SEVIRI instruments for 12.30UTC but are higher for 10.45UTC.

The left panel shows a decrease in Reff in the first time steps and than a clear increase of values around 18µm -20µm with a small shift to higher values from 13UTC to 16UTC, indicating an increase of Reff in convective cells that are already dissolving. The higher numbers of large Reff values in the morning originate from the southern part of the cloud system that is already decaying while the northern part is growing. The effect of growing Reff at the end of the life-cycle is also visible in the left panel of Figure 3. The other two panels show other cells. For the middle panel an isolated cell over France was examined. It shows quite constant values of Reff except for the increase in the end. The right panel illustrates the complexity of cells that involve splitting and merging events. The decrease in COD with time for all shown cases arises from an increasing number of pixels with low COD in the growing cirrus shield around the center of the cell.

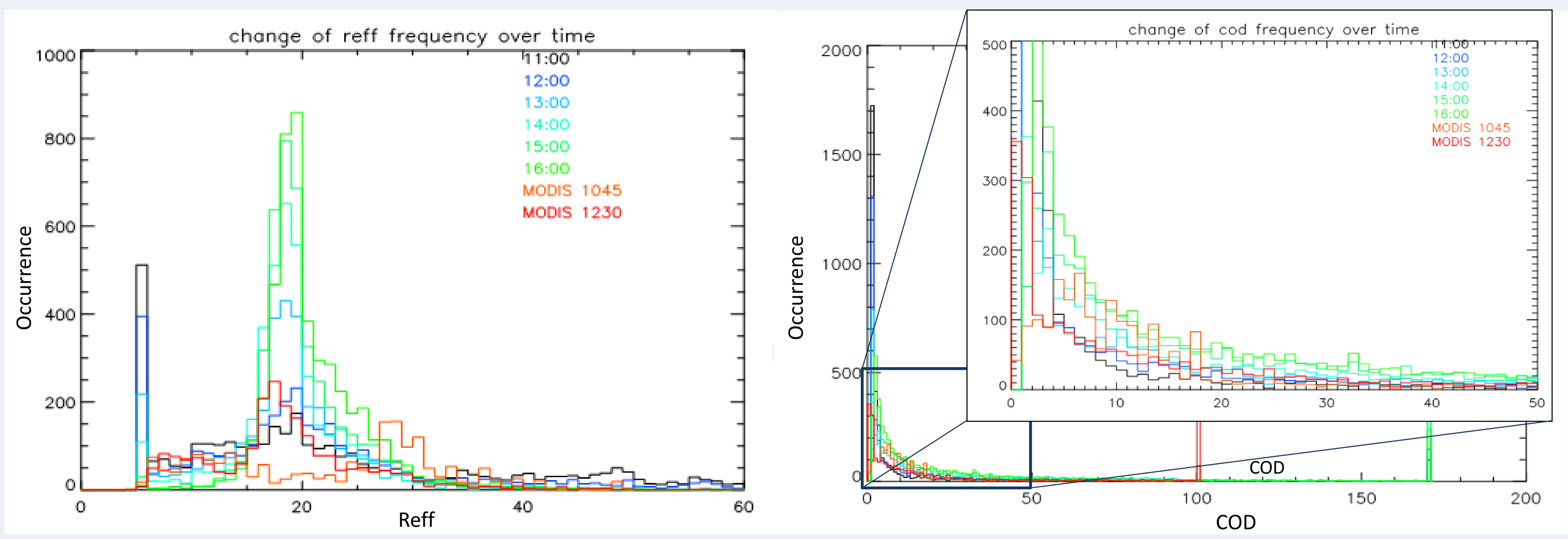

Figure 2: Histogram of Reff (left) and COD (right) in a scene over western Germany from 05/23/2012. The lines in black, blue and green show data from different images of SEVIRI and for comparisons MODIS data are included in red and orange.

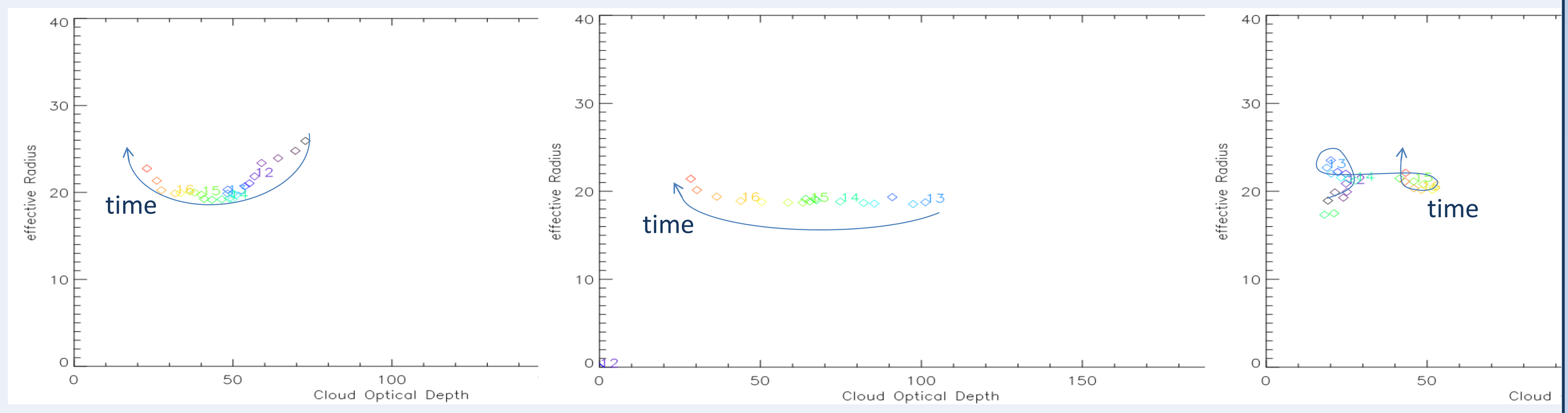

Figure 3: Development of mean values of Reff and COD during the life-cycles of three different convective cells. The left panel corresponds to the cell from 05/23/2012 that was already shown in Figure 2. The middle panel shows an isolated cell over France on 06/28/2012. The right panel illustrates the limits of the comparison when splits and mergings of cells are involved for a cell in a squall line also from 06/28/2012.

4. Outlook

- estimation of the influence of thresholds for the identification of cells on the result
- can thresholds of Reff or COD be used to identify cells?

5. Acknowledgements

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6. References

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