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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Discriminating raining from non-raining clouds at mid-latitudes using Meteosat Second Generation daytime data" *by* B. Thies et al.

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Thank you very much for your comments.

1.) The intention of the presented study is to show the potential of the new MSG SEVIRI system with its enhanced spectral resolution for an improved rain area delineation especially in comparison with existing IR retrievals based solely on IR cloud top temperature. The introduced conceptual model which has already been successfully applied for rain area delineation (e.g. Lensky & Rosenfeld 2003, Nauss & Kokhanovsky 2006) presents a more physical basis for rain area delineation in contrast to existing IR retrievals.

In general, optical rainfall retrievals consist of two parts: One part for the identification

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of precipitating cloud areas and one part for the assignment of the rainfall rates. The proposed technique for rain area delineation concerns the first step. Based on an improved rain area delineation, the second step the assignment of the associated rainfall intensity can be tackled. Concerning this topic, a separate extensive study has already been started focusing solely on a more reliable assignment of the rainfall intensity that is no longer entirely based on cloud top temperature. The reason why we did not include rainfall intensity assignment in the present study is that we wanted to focus on a valid delineation of precipitating cloud areas first.

Potential applications of a new rainfall retrieval based on the enhanced spectral resolution of multispectral satellite data of the next generation GEO systems is an improved rainfall detection in a high spatial and temporal resolution. This is of valuable benefit over oceans where radar networks are not available as well as for approaches that attempt to merge passive microwave rainfall information with higher temporal and spatial resolution observations offered by GEO systems which consider only IR cloud top temperature and suffer from the inherent drawbacks especially regarding precipitation processes in connection with extra-tropical cyclones.

It is true that microwave sensors aboard LEO systems have the advantage to be more directly sensitive to precipitation. On the other hand, retrievals based on PMW radiometers bear problems concerning the medium temporal resolution of the LEO systems and the high but in general unknown emissivity of land surfaces (Ferraro et al. 1994) that in some extent restricts their application to ocean surfaces. Therefore, rainfall retrievals based on optical sensors on GEO systems still play a very important role for quasi-continuous precipitation monitoring. Furthermore, an improved rainfall retrieval technique based on new generation GEO systems could replace the traditionally used IR cloud top temperature within hybrid PMW/IR techniques and help to enhance them.

The fact that the good validation results are obtained on a 15 minute basis without any spatial and temporal aggregation support the assumption that the achieved accura-

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cies are sufficient for the proposed applications. This is especially true, as for similar comparison studies the data are generally temporally aggregated over 3h or 24h, (e.g. validation web page of the international precipitation working group). However, the validation results of the final retrieval scheme (rain area delineation with associated rainfall intensity assignment) are necessary for a more profound statement. In this context it is intended to provide the final algorithm to the IPWG for an extensive and detailed validation.

2.) The retrieval of cloud properties (effective radius, optical thickness, liquid water path) from VIS/IR radiances is a well known and established topic. The mentioned techniques are widely validated and established. Furthermore there exist several studies concerning the comparison of the retrieved cloud properties and potential uncertainties inherent the respective retrieval algorithm (e.g. Nauss et al. 2005, Kokhanovsky et al. 2006). The reason why we did not include a discussion of the uncertainties associated with the use of VIS/IR radiance measurements for inferring cloud properties is that we are not using explicitly retrieved cloud properties for rain area delineation but focus on the information about them inherent in the VIS/IR radiances. The mentioned retrieval techniques should be seen as the physical basis that the mentioned channel combinations contain information about cloud properties. Nevertheless we are aware of uncertainties concerning the assumption of plane-parallel clouds and the negligence of 3D radiative effects.

It is true that large uncertainties are associated with the retrieving of the effective radius within the presence of ice mainly due to the unknown crystal habit. A possibility to reduce such uncertainties is the use of the particle absorption length for the characterization of ice clouds as proposed by Kokhanovsky and Nauss (2005). The fact that no operational and time-efficient retrieval technique is available for ice clouds for SEVIRI and bearing in mind the uncertainties regarding ice clouds and especially mixed phase clouds led to the decision to use VIS/IR radiances instead of retrieved cloud properties and apply a statistical approach for rain area delineation. In this context it could be

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shown that a relationship between the information about cloud properties and the rain confidence exists that can be successfully used for rain area delineation.

It is true that the information about the effective radius retrieved from VIS/IR radiance measurements is representative for the upper parts of the cloud. Nevertheless it is assumed that cloud areas with large liquid droplets and ice particles and a large cloud water path within the upper parts of the cloud are also characterised by large droplet and particle radii and a large cwp in the middle and lower portions of the cloud. Large liquid droplets and large ice particles in the upper part of the cloud be seen as a pre-condition for the formation of droplets large enough to fall as raindrops in the middle and lower portions of the cloud.

Concerning the potential bias introduced through the physical assumptions required to determine cloud properties it has to be stated that PMW based retrieval techniques also rely on physical assumptions that may introduce potential bias as well.

3.) The probability of detection (POD) and the probability of false detection (POFD) presented in form of a relative operation characteristic plot in figure 3 allows to display the performance and the uncertainty of the technique for any given scene as the POD describes the fraction of pixels that have been correctly identified by the technique and the POFD indicates the associated fraction of pixels incorrectly identified as rainfall events by the satellite algorithm for every scene. The statistics in figure 3 are calculated using the optimal confidence level for rain area delineation retrieved by maximizing the ETS. It is possible to calculate the same statistics for other confidence levels. However, it can be expected that in general the underestimation / overestimation of the classified rain area increases with increasing / decreasing confidence level used for rain area delineation.

4.) It is not our intension to imply a superiority of the proposed technique to all existing high temporal resolution rainfall products. It is however our intension to propose an improved technique for rain area delineation especially for precipitation processes in the

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mid-latitudes were existing IR retrievals show considerable drawbacks. In this context the study demonstrated the high potential offered by the enhanced spectral resolution of new generation multispectral optical satellite systems as MSG SEVIRI. As the focus lies on GEO systems we did not introduce and discuss merging PMW/IR techniques. It is true that we cannot state an improvement compared to all existing high temporal resolution rainfall products. To evaluate the new technique in this context further investigations are needed and it is intended to validate the final algorithm during extensive evaluation studies in cooperation with the working group of Vincenzo Levizzani (Italian National Research Council Institute of Atmospheric Sciences and Climate). During this validation studies special attention will be laid on a comparison with the results of CMORPH.

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