Atmos. Meas. Tech. Discuss., 5, C3861–C3868, 2013
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Atmospheric Measurement Techniques Discussions

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Interactive Comment

Interactive comment on "Simulation of SEVIRI infrared channels: a case study from the Eyjafjallajökull April/May 2010 eruption" *by* A. Kylling et al.

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Received and published: 12 February 2013

Overall response to interactive comments from the Referees

We thank the referees for constructive comments to our manuscript. While revising the manuscript, an error in the calculation of the optical properties of the ash particles surfaced. This error led to a factor 3 too large ash absorption optical depth. The correction of this error has drastically improved the agreement between the simulated and measured brightness temperature differences (Figs. 6 and 7). In addition to this

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Interactive Discussion

Discussion Paper

correction, numerous changes have been made as suggested by the referees. Some of these changes were suggested by two or more of the referees. They are addressed first and referred to in the individual answers to the referees.

1. All three referees have questioned the use of a constant water vapour profile over the whole domain. As mentioned in the manuscript this was done for technical reasons. While revising the manuscript simulations were made with a one-dimensional code that allow the variation of water vapour to be included. Simulations with a fixed water vapour profile and one with water vapour from the ECMWF were compared. Brightness temperature differences in the $\pm$1.5 K range were found between the two simulations. The 10.8-12.0 μm brightness temperature difference is on average overestiamted by 0.2 K using a constant water vapour profile. The impact of using a constant water vapour profile is discussed in the revised manuscript.

2. Referees #2 and #3 questions the use of constant liquid and ice water cloud radii. In the revised manuscript we have adopted the parameterisations used by Bugliaro et al. (2011). The effect of including liquid and ice water cloud parameterisations for the effective radii is readily seen in the revised left panel of Fig. 6. The impact is largest for high ice clouds where a fixed effective radii may overestimate the brightness temperature by up to about 15 K. For brightness temperature differences used for ash discrimination, bottom panel Fig. 7, the difference between using fixed effective radii and the above mentioned parameterisation is small. The paragraph describing the choice of effective radii has been rewritten to reflect the changes in the approach. In addition, the description of the optical properties of ice clouds have been clarified, including the citation of the correct Yang et al. (2005) paper.

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3. Emissivity was set to a fixed value of 1 in the original manuscript. In the revised manuscript the emissivity has been taken from Borbas and Ruston (2010). The use of this emissivity atlas resulted in a decrease of the brightness temperature of about 0.5 K over ocean regions. The largest decrease of 4 K was seen over the Sahara. The use of the emissivity atlas is mentioned in the revised manuscript.

4. Table 1, the text where appropriate, and all relevant figures have been updated to reflect the changes due to the points mentioned above.

Response to interactive comments from Referee #2

Two concerns:

a) Concerning the use of fixed liquid and ice water cloud effective radii, please see overall response above.

b) Concerning the use of a fixed water vapour profile, please see overall response above.

Minor comments:

1. We have split section 5 into two as suggested.

2. We have removed the phrase “shadow effects” and rephrased this part. It now reads: “Simulations were also made using the so-called independent pixel

approximation (IPA) instead of the fully 3-D radiative transfer modeling. In the two simulations different clouds (or different parts of the clouds) or the ground are effectively emitting radiation towards the instrument, thus causing differences in the brightness temperature of up to ± 25 K".

3. Several questions are asked within the point labelled "p. 7785".

   - It is beyond the scope of this paper to give an estimate of the goodness of the a priori ash retrieval. Such an estimate would require independent measurements of which few are available. A description of the method used for the a priori ash retrieval and comparison with independent measurements is given by Prata and Prata (2012). This paper is referenced in the manuscript. We have added a sentence on page 7785 stating: "Methodology, results and validation for the Eyjafjallajökull eruption is given by Prata and Prata (2012)."
   - Concerning the evaluation of mass columns Prata and Prata (2012) have compared lidar measurements with SEVIRI retrievals for a few cases during the Eyjafjallajökull eruption. They makes the following statement about the validation of SEVIRI ash retrievals: "this is an ongoing exercise and definitive conclusions about the accuracy of these satellite retrievals cannot yet be made".
   - The retrieved effective radius is not used in the inversion process, only the retrieved mass loading. We thus prefer to use the simulated FLEXPART ash distribution as input to the radiative transfer simulations as it provides more information than an effective radius does.
   - The initial ash retrievals use the same optical constants as the simulations presented in the manuscript. This information has been added to the manuscript under subsection 3.1 "Volcanic cloud".

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4. We want to simulate the two channels typically used for ash discrimination, that is the 10.8 and 12.0 μm channels. The model may of course also simulate the 8.7 μm channel. That channel may, however, be affected by SO_2 absorption.

5. It is H_2SO_4 which is meant here. This has been clarified in the manuscript.

6. The outcome of the evaluation is already mentioned in the Introduction. To avoid repetition we have hence removed the sentence starting with "Evaluation of the ..."

7. Ash particles are generally not spherical. However, optical properties (single scattering albedo, phase function) of realistic non-spherical ash particles for refractive index values applicable in the IR, are, to the authors knowledge, not available. Calculations of such optical properties are extremely time-consuming. They have been made for refractive index values applicable to the solar part of the spectrum for a few sizes. For simulations such as those presented here, optical properties are needed for a number of sizes, which increases the computational burden considerably.

8. To quote wiktionary: "voxel: the three-dimensional analogue of a pixel; a volume element representing some numerical quantity, such as the colour, of a point in three-dimensional space, used in the visualisation and analysis of three-dimensional (especially scientific and medical) data". We give no further explanation of voxel in the mansucript.

9. In the revised manuscript the effective radius of meteorological clouds is varied, please see overall response above.

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10. The impact of using a constant water vapour profile for the whole domain has been estimated in the revised manuscript, please see overall response above.

11. The impact of water vapour on the BTD for ash has been investigated by Yu et al. (2002). In the revised manuscript we have added water vapour to the list of factors that affect the ash signal. Also please see overall response above to water vapour profile assumption.

12. We certainly agree and have added ash mineral composition to the list of factors that affect the ash signal.

13. In response to the referee's comments We have changed the wording from

    > As noted above, pixels containing ash are identifed by negative 10.8–12.0 μm brightness temperature differences (Prata,1989).

    to

    > The presence of ash reduces the 10.8–12.0 μm brightness temperature differences. As noted above, pixels containing ash are identifed by negative 10.8–12.0 μm brightness temperature differences (Prata,1989).

14. Yes, it is Fig. 6 that is referred to. A reference to Fig. 6 has been added.

15. There is no one-to-one correspondence between optical depth or ash concentration and the cutoff value (see for example Fig. 2 of Wen and Rose (1994)

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or Fig. 2 of Prata and Prata (2012)). Different ash concentrations (or optical depths) may give the same brightness temperature difference depending on the altitude of the ash cloud and on the size distribution, viewing geometry and more. The detection of thin ash layers depends also on these factors. It is noted that according to Prata and Prata (2012) "...the accuracy is highest where the volcanic cloud is semi-transparent ($\tau(\lambda) \approx 1-3$) ...". A comprehensive study of all the factors that affect volcanic ash retrievals is beyond the scope of the present manuscript.

16. Please see overall response above to the assumption of a constant water vapour profile and the correction of the Mie calculations.

17. This paragraph has been rewritten based on the changes to the manuscript described above in the overall response to the referees.

18. For high mass loading the ash cloud will become opaque regardless of the size of the ash particles. Thus the BTD will be small for high mass loadings. See also Fig. 2 of Prata and Prata (2012).

19. Due to the improvement in the agreement between the simulations and the measurements this section has been fully rewritten.

20. The word "shadow" has been removed from the abstract and conclusions. The corresponding sentences have been rephrased.

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21. We have omitted the word “complete” in the revised manuscript.

22. Fig. 1 has been redone in logarithmic colour scale as suggested by the referee.

23. Fig. 6 (left): The Figure has been revised and the black circle enclosing the red filling has been removed. Thus the red dots are truly red.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 7783, 2012.

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