

## ***Interactive comment on “Multichannel analysis of correlation length of SEVIRI images around ground-based cloud observatories to determine their representativeness” by J. Slobodda et al.***

**J. Slobodda et al.**

jennifer.slobodda@wew.fu-berlin.de

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Dear Reviewer, we like to express our thanks to the reviewer and their helpful comments, which helped to improve the present work.

For a small summary, the following major changes to the manuscript were performed:

- Extension of the abstract to make the purpose of the paper clearer
- Adding the citation of Schutgens 2009
- Adding information on the fields of view of ground-based instruments in comparison

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to the satellite field of view

This study aims to study how representative cloud observations at single ground sites are for their surrounding area. This work is of relevance to evaluation of clouds in models, or SEVIRI retrievals against ground station data. The authors perform the study by considering temporal correlation among instantaneous SEVIRI cloudy radiances in an area of 300 by 300 km. They show that 1) visual and near IR radiances are correlated over much shorter distances than IR radiances (1 km vs 20 km) and argue this has consequences for the sort of evaluation that is possible (cloud optical thickness and effective particle size for visual and near-IR or cloud top height for IR). They also show that daily averages increase these correlations and allow evaluation of regional models (grid resolutions up to 70 km).

**General comments** The purpose and context of the paper would become clearer if the authors are more specific about strategies for evaluating models against observations. Their paper seems to advocate correlating individual model values and observations. Given the statistical description of clouds in many models, a comparison of the statistical properties (monthly mean and standard deviation of optical thickness, particle size and cloud top height) might be sufficient. Such a comparison does not require the rather strict demands on proximity that their study reveals. I assume that the authors decided to use radiances instead of retrieved properties in their analysis due to errors in the latter that might further reduce correlations? It would be good if they could discuss this briefly. > Thank you for pointing out this shortcoming. We expanded the abstract by the following sentences: ‘Comparing radiances has the advantage that this property directly depends on the cloud physics and is directly measurable. Thus we avoid errors arising from a cloud property retrieval. The usage of satellite data enables the examination of a broad region around a measurement site without needing a lot of instruments that cover the same area as several SEVIRI pixels. To avoid errors between different measurement techniques between ground- and satellite-based instruments only satellite data are used to estimate cloud variability as an indicator for

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the representativeness of a point measurement.'

Specific comments

p. 5770, l. 6: Please remove "the one of".

> We removed "the one of"

p. 5770, l. 8: Maybe replace "the characteristic" by "a characteristic"? No radius has been defined yet.

> We changed "a" to "the"

p. 5770, Abstract: nowhere do the authors mention what property is actually studied. Presumably this is channel radiance.

> We changed the first sentence to: p.5770: "Images of measured radiance in different channels of the geostationary Meteosat-9 SEVIRI instrument during the year 2012 are analyzed with respect to the representativeness of the observations of eight cloud observatories in Europe (e.g. measurements from cloud radars or microwave radiometers)."

p. 5770, l. 11: Visual channels contain mostly information on COT. I would not call COT a microphysical property; it refers to the full extent of a cloud and is a function of not only individual droplet properties (e.g. size) but also total number.

> You are right, this is misleading. It should be macro- as well as microphysical properties. We changed: p.5770, l11: "...which respond to cloud physical properties ..."

p. 5770, l. 17: Consider rephrasing "The results show good comparability between regional forecast models...". The authors have not done any comparison with models. I suggest "Our results suggest it should be possible to compare instantaneous cloud observations from ground sites to regional forecast models".

> We rephrased the sentence. p. 5770, l. 17: "The results suggest the possibility

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of comparisons between instantaneous cloud observations from ground sites and regional forecast models..."

p. 5772, l. 6-13: Schutgens & Roebeling JAOT 2009 studied the impact of cloud inhomogeneity on SEVIRI evaluation with ground-based microwave radiometers. They were able to make error estimates for various sources (parallax effect, time integration, sub-pixel inhomogeneity, etc) and suggested optimal averaging times for comparison. I think this paper should be mentioned in this or the following paragraph.

> We added a paragraph about the mentioned paper: p. 5772, l. 6-13: "Further error sources that arise during the validation of satellite data with ground-based measurements are discussed in Schutgens (2009). Therefore the authors compared LWP retrievals from SEVIRI and microwave radiometer in Northern Europe. They found that the largest errors are caused by different fields of view (between visible and near infrared channels of the SEVIRI instrument as well as between satellite pixels and the ground-based measurement instruments), collocation errors due to the parallax shift and retrieval errors induced by the assumption of plane parallel clouds."

p. 5772, Introduction: Since the authors propose to study correlations among SEVIRI pixels to understand better the usefulness of surface measurements for model evaluation, it would be good if they listed typical FOVs (field of view) of various instruments

> We added the sentence: p.5772: "A ceilometer e.g. as a field of view of only 1.8mrad (Wiegner and Geiß 2012), although the beam width of a cloud radar is wider with about 0.5° (Metek 2014) and the field of view even larger due to its ability to scan the surroundings."

p. 5772, Introduction: in GCMs, cloud at the sub-pixel level are represented in a statistical fashion, using a cloud fraction. These clouds do not need to correlate with ground sites to be considered ok, they only need to have sufficiently similar statistics (on various time scales, daily, weekly seasonally).

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> Thank you for this comment. Our focus was to study the representativeness of point measurements (which would give us vertical profiles of cloud properties) in time and space by means of satellite observations. The question is whether or not the point measurements are representative for a broader time space resolution. Still both ground- and satellite-based measurements depend on the cloud properties. Thus we hope to get some insight into the broader structure of clouds by means of satellite data to draw some conclusions for the ground-based measurements. In this study we wanted to start on the satellite based study to quantify and understand the representation. Further step would be to study in more statistical sense and also to elaborate directly with the cloud properties from the ground sites, which would be interesting for the next steps.

p. 5774, l.9: The choice of either 0.4 or 0.9 is fairly arbitrary. Is there not some way to objectively specify a correlation below which comparison becomes useless? What are typical correlations of model vs observations, when observations are close to the center of the gridbox?

> We know, that it is quite arbitrary, but I couldn't come up with a valid argument for any value. In the end I choose one I thought was reasonable. Further comparisons for different thresholds will be done future work.

p. 5775, l. 26: Presumably these time series have different timesteps. Although SEVIRI observes every 15 min, not all pixels will be cloudy/clear at the same time. How have you dealt with this and what is its impact?

> We allow up to 10% cloud-free pixels in an otherwise cloudy scene to choose it for our analysis of total cloud cover. In the half covered scenes 40-60% of the pixels are cloud-free. In both cases all pixels, that were clear in a chosen scene were set to NaN to exclude them from the analysis. Thus the timeseries for every pixel has the same length but randomly distributed NaNs. Since the distribution is random, the effect should be only noise in the correlation calculations. To eliminate clear sky pixel

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is important, because the correlation of clear sky pixel is much higher especially for shortwave channels since the albedo changes little over the year in comparison to clouds. The correlation of a combination of clear sky and cloudy pixel results in a low correlation since the differences between a timestep with clouds and one without are larger than between different clouds. We added: p.5775, l. 26: 'The cloudfree pixel in both cases are ignored for the following analysis by setting them to NaN and calculating the correlations only for pairwise complete observations.'

p. 5776, l. 1: why not use  $\rho = 1 - (\text{dist}/a)^b$  ? This makes the interpretation of a very easy.

> During the study we tried several different formulas to describe the relation of distance and correlation. One of them actually was  $1 - (\text{dist}/a)^b$ , but it gave some problems with the convergence during the calculations of the coefficients since they are not independent. Also polynomial regression didn't provide a reasonable function; at least not for a polynom of degree two. Thus we decided in the end to use  $1 - \text{dist}^b/a$ . We also mentioned the possibility to analyze  $a^{1/b}$ , which would be the same coefficient a you proposed with  $1 - (\text{dist}/a)^b$  and that we instead used  $\text{dist}^{0.9}$ , because its values seem more suited to describe representativeness.

p. 5776, l 15: global models that include aerosol and gas species are often run at even coarser resolution (100-200 km)

> We think, that this size is a bit large for the comparison of clouds, but we could still estimate the possibility of comparing these models to ground stations by regarding the whole examination area.

p. 5776, l. 19: because models may treat clouds in a statistical fashion, correlations over the size of a gridbox may not be useful to determine uncertainties. Rather you want the statistics of the clouds over the measurement site and those of the model clouds in the gridbox to be similar. It is possible to find good mean and standard deviation of e.g. cloud fraction, LWP, and CTOP while correlation is actually very low.

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> Thank you for pointing out this evidence. In this study we just started with the comparison of correlations. For further investigations we keep this consideration in mind.

p. 5776, l. 23: optical depth is not a microphysical property. But really the conclusion that COT or Reff changes more than CTP i(p. 5777, l. 10) is a bit optimistic. Rather I suggest that different radiative transfer aspect cause the differences in correlations. E.g. For very similar COT and Reff, variations in cloud top height will cause shadowing and brightening which will affect the correlations. These variations in cloud top height need not be very dramatic and can be missed in IR channels.

> We changed 'microphysical properties' to 'physical properties' in p. 5776 l. 10. In p.5777 l. 10 I do not compare the correlation between different channels and make assumptions about whether COT and Reff are less homogenous than CTT, but the results suggest that one large cloud is more homogenous in terms of CTT than several separated clouds.

p. 5778, l. 19: Possibly "total cloud cover" should be replaced by "larger areas"?

> Since the whole second case of cloud amount was titled "full cloud cover" or "total cloud cover", we like to use this term in the mentioned statement, too.

p. 5778, l. 24: What "anomaly" are the authors referring to?

> It refers to the exception mentioned on p. 5777 l. 13ff. To eliminate a source of confusion, we changed "anomaly" to "mentioned exception"

p. 5780, l. 20: "Comparisons between ...especially for cloud top temperatures". This sentence suggests that the authors have actually made such a comparison. I suggest replacing "are reasonable" with "should be possible". > We changed 'are reasonable' to 'should be possible'

p. 5780, l. 26: again, an objectively determined minimum correlation would be helpful at this stage.

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> Getting an objectively minimum correlation for the definition of representativeness is not so easy. At least we checked how the results change when the effective radius is increased to correlation values of 0.8. The overall comparisons between the channels do not change. Only the radius is increased to ~3-4 times the values of dist0.9.

p. 5781, l. 6: The authors are not really considering larger timesteps (which would indicate sub-sampling of the original 15-min time series to e.g. 12 hours) but aggregates over time, in this case daily averages. The statement that models only give output every few hours appears meaningless in this context. Also, many models allow temporal means (e.g. daily or monthly) to be written to file. In this particular paragraph, I am not sure what sort of model comparison the authors are proposing: daily means from both model and observations or daily means from observations against hourly model output?

> We refer to the possibility of comparing daily means from both model data and measurements. Especially global radiation is sometimes given in mean values (3-6 hours) and this quantity is quite comparable to satellite- and ground-based measurements and strongly depends on the cloud cover.

p. 5781, l. 12: "possibilities of origins" should be replaced by "possible cases".

> We changed "possibilities of origins" to "possible cases"

p. 5781, l. 25: "blurred out" should be "smoothed out", also please remove "for the mean values".

> We changed "blurred out" to "smoothed out"

p. 5781, l. 27: Please replace "for the single stations" by "between the single stations".

> We changed "for the single stations" to "between the single stations"

p. 5782, Conclusions: Please rephrase the first sentence. It is too long and confusing.

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> We replaced the first sentence of the conclusion by: p.5782: "The correlations between time series of SEVIRI observations for 300kmx300km area surrounding eight ground-based measurement sites have been examined during this study. The comparisons have been carried out for two different amounts of cloud cover." In the next sentence we changed: "these correlations" to "the correlation".

p. 5787, caption: these measurement stations are not analysed at all.

> We changed the caption to "Map of the ground-based measurement sites and their surrounding area."

p. 5788, caption: I propose rephrasing: "Histogram of mean cloud cover from day-time SEVIRI images of the area surrounding each ground station."

> We changed the caption to "Histogram of mean cloud cover from day-time SEVIRI images of the area surrounding each ground station."

p. 5792, caption: I propose rephrasing: "Comparison of coefficients  $a$  (upper panel) and  $b$  (middle panel) as well as  $\text{dist}_{0.9}$  (lower panel) for two different cloud covers (left side: half covered scenes; right side: fully covered scenes) and for all channels (x axes) and locations (different colours, see legend)."

> We changed the caption according to your proposal and additionally the caption on p.5793 in the same manner.

Please also note the supplement to this comment:

<http://www.atmos-meas-tech-discuss.net/7/C3187/2014/amtd-7-C3187-2014-supplement.pdf>

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