Review of "Monitoring aerosols over Europe: an assessment of the potential benefit of assimilating the VIS04 measurements from the future MTG/FCI geostationary imager" by Descheemaecker et al, 2018

This paper discusses the assimilation of Aerosol Optical Depth (AOD) into the MOCAGE aerosol model using observations simulated from the future Flexible Combined Imager which will be flown on board the Meteosat Third Generation (MTG) satellite using a 3D-var approach. A Nature Run (NR) with the MOCAGE model is set-up to generate the "truth". The quality of this run for surface aerosol concentrations is verified using ground-based observations. The NR shows a low bias with respect to the ground-based measurements which is quite typical of global aerosol models. The NR is then used to generate the synthetic observations of AOD to be then assimilated. To ensure the robustness of OSSE results, 4 control runs (CRs) are also set-up. While the underlying model is the same as in the NR, the CRs different in either initialization or in the aerosol parameterizations/localizations of the emissions. This is to obviate the problem of using the same model to perform the NR and the subsequent assimilation and have at least a (small) ensemble of runs to judge the quality of the assimilation. The experiments with assimilation of the synthetic measurements (Assimilation Runs, ARs) are closer to the NR than the CRs, indicating a successful assimilation. The ARs are also compared with ground-based particulate matter (PM) observations. Results show that the assimilation of the simulated AOD reduces the error with respect to independent surface-based observations, even if the underestimation is still present.

The paper is interesting and illustrates an important application of geostationary satellite retrievals for aerosol assimilation which should become more prominent in the future as more geostationary satellites around the world will carry advanced imagers. These datasets will complement those from polar-orbiting satellites to provide high-resolution and high-frequency data on the state of the atmospheric particulate fields.

I have a few questions/comments, which should be addressed before the manuscript can be published.

Major comments:

1. The procedure to create the synthetic datasets it not clear. What is clear is that a lot of effort and time has gone into this part of the work, but then the procedure is introduced in what it looked to me a chaotic way. First you talk about the Monte Carlo approach to calculate the radiances, then you mention a global sensitivity analysis whose purpose is not clear, then you mention the use of the OPAC tables. I was not sure whether the AODs were retrieved from the simulated FCI radiances and how. I really got lost in this section. Please rewrite it all keeping in mind that most readers are not familiar with how to create a synthetic AOD dataset. Give enough details, but do not get carried away.

2. At the end of section 3, you conclude that only a few profiles can be assimilated over the continent. This is an important result but at the same time undermines the concept of the paper which is to highlight the usefulness of the high temporal resolution data from the geostationary sensors. Besides, it is important to keep the study realistic, but with an OSSE you can go wild and seek to demonstrate the untapped potential of the instrument. For example, what would happen if you were able to use the full temporal resolution of the

instrument and not only hourly data? Have you thought of these issues? What is completely unrealistic and what is pushing the limit of the technology? I do not feel you had the time to address these important questions. While this may be subject of future work, you need to comment on this and add your insight.

3. You only selected one wavelength (444nm). I am sure this was due to the amount of work needed to generate the synthetic dataset but your choice needs to be better justified as it is rather limiting.

4. In some parts the paper reads too academic. For example, the long list of verification metrics including the formulas is not needed. Please change that.

5. For all figures, particularly the PM maps, the legends have to be bigger.

6. Some of the tables can be eliminated. I found table 3 particularly cumbersome. Please consider presenting the information in a more concise way.

Other comments:

Page 2

Line 20: please use also this reference. Peuch, V. and Engelen, R.: Towards and operational GMES Atmosphere Monitoring Service, ECMWF Newsletter, 132, 20–25, 2012.

Page 3

Line 20: Please expand the overview of the OSSE approach and provide more references.

Page 5

Line 10: are 6 bins used for all aerosols, including sulphates, nitrates etc?

Line 23: “parameterized” instead of “made”

Page 6

Line 9: Please add Benedetti et al, 2009 (Benedetti, A., Morcrette, J.-J., Boucher, O., Dethof, A., Engelen, R., Fisher, M., Flentje, H., Huneeus, N., Jones, L., Kaiser, J., et al.: Aerosolanalysis and forecast in the European centre for medium-range weather forecasts integrated forecast system: 2. Data assimilation, Journal of Geophysical Research: Atmospheres (1984–2012), 114, 2009) to the reference list for the AOD assimilation approach.

Line 18. Is the computation of the optical properties performed online or off-line and tabulated in a look-up table.

Page 7

Lines 10-30. Please rewrite in a less academic way. Maybe you do not need to put formulas for all of the metrics.

Page 8.

Line 7. This is not useful, please explain what 1-5 means.

Line 12: remove “a bit”. The underestimation of PM in global aerosol models is a general problem, due to unresolved emissions and coarse resolution. Even a resolution of 0.2 does not allow to resolve all the regional and urban pollution features.

Line 30. It is unusual that AOD is overestimated. The explanation on page 9 line 10 is unlikely.

Page 9

Line 23: why was only one wavelength selected, and why the 444nm?

Referring to the general comments this section is not clear to me and would benefit from substantial rewriting.

Page 13

Lines 24-32. You are effectively saying that your experimental set-up is not adequate to explore the potentiality of the instrument due to limited spatial resolution. This is actually not ideal for an OSSE. Would it be possible to run the model at higher resolution or downscale somehow the synthetic AOD? I am not suggesting this extension for this study, but perhaps for a follow-on.

Page 14

Line 5. Please explain how convergence is connected to thinning. Usually thinning is applied to avoid using correlated observations in the assimilation, without accounting for the correlation errors (off-diagonal elements of the R matrix).

Line 18. Use another adjective instead of “great”.

Line 19. I missed the supplementary material. Was it accessible?

Page 16

Line 8-9. Where does the improvement in the vertical profile come from? AOD does not contain information in the vertical distribution of the aerosols.

Section 6.

The conclusions are fine but this is where you should elaborate more what you would do to extend this study. For example you could comment on trying to increase the resolution of the model to produce synthetic measurements that are closer to the future capabilities of FCI (or something along these lines).