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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Constraints on methane emissions in North America from future geostationary remote sensing measurements" *by* N. Bousserez et al.

Anonymous Referee #2

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The study by Bousserez et al. explores the benefit of a geostationary observer with spectral coverage in the shortwave (SWIR) and/or thermal infrared (TIR) for surface flux inversion of CH4. To this end, the flux error reduction is assessed by feeding a Bayesian inversion frame work with the sampling patterns and measurement errors of several low-Earth-orbit and geostationary configurations. The geostationary SWIR+TIR configuration shows the best error reduction suggesting that inverting weekly-to-monthly fluxes on the scales of several ten kilometers is possible.

The study is of interest to the atmospheric sciences, it is generally well written. Therefore, it is suitable for publication in ACP after considering my comments:

1. General comment: In my opinion the general drawback of the approach is that model resolution is still coarse in time (weekly, monthly) and space (several ten kilometers) in comparison to the expected geostationary sampling resolution (1 hour, 4 km2 in geostationary configuration) and density. Diurnal cycle information available from the 1 h repeat cycle of the geostationary configurations, for example, is not exploited (and not discussed). Probably the diurnal cycle in the model is simply imposed. Other studies focusing on the high-resolution aspects (such as Rayner et al, AMT, 2014) should be cited.

Further, the model study assumes ideal measurements exhibiting purely random error characteristics. Likewise, transport model error is implemented by inflating the random errors. While these approximations might be adequate for a first assessment of sounding capabilities, I would argue that it is necessary to discuss these drawbacks and assumptions in the conclusion or discussion section.

2. Section 2.3: What are the "observations" exactly?

- Is it the modelled CH4 concentration field averaging-kernel weighted as GOSAT, TES, or a SWIR+TIR instrument would deliver it? Or do you really use CH4 concentrations retrieved from GOSAT or TES? If the former, do you use a single (typical) averaging kernel or do you consider dependencies on geometry, surface temperature etc.? If the latter, how do you deal with the fact that the measured and modelled concentration fields do not match? This needs some clarification.

- I do not understand the role of an SVD of the posterior covariance? Why do you need it and how does it decorrelate error correlations between the layers?

- Is it correct that you sample the modelled concentration field according to the GOSAT, TES, SWIR+TIR sampling patterns and then, remove all cloud-contaminated scenes based on the GEOS-CHEM cloud fraction? Please consider clarifying the text.

- Do you consider that footprint size for a satellite observer, in particular a geostationary

one, depends on distance from the subsatellite point? Are the 4 km2 geostationary resolution representative for the subsatellite point? What is it at higher latitudes?

- Showing maps of exemplary “observations” could help illustrate constraint density and patterns.

3. Figure 3: Why do most regions show zero error reduction? Is it because the prior error covariance is defined relative (40%) wrt. to the prior fluxes which are small for large parts of the continent (figure 1)? If so, is this a reasonable setup of the inversion method? It essentially puts a hard constraint on regions with zero prior fluxes (to remain zero).

4. Section 3.2: Would a uniform bias in the boundary conditions not be a very benign scenario? If the incoming airmasses have 2% high-biased methane and the outflow airmasses have the same 2% high-bias, the intra-domain fluxes would need little adjustments (unless there is a strong gradient between the boundaries). How would a bias in the zonal gradient between Eastern and Western boundaries affect intra-domain fluxes?

5. Technical comments

P19020,l2: under sampling -> undersampling

P19022,l6: providing -> provided

P19022,l16: Calling the analysis vector x_a could be misleading to many readers who are used to terminology with subscript a indicating “a priori”. But, your choice.

P19024,l3: inline citation: citep -> citet

P19030,l18: On a weekly -> On weekly

Flux figures: Units “per grid cell” are not easy to interpret since grid cell area depends on latitude. Consider replacing “per grid cell” by “per square meter” units.

Figure 6: Axes labels are small and faint.

Figure 7: Consider replacing figure 7 by zooms on the relevant regions. Axes labels are too small.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 19017, 2015.