**Atmospheric
Chemistry
and Physics**
Discussions

Interactive comment on "Investigation of error sources in regional inverse estimates of greenhouse gas emissions in Canada" *by* E. Chan et al.

Anonymous Referee #2

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This paper provides some evaluations of the errors in a regional iňĆux inversion model for different provinces in Canada, including the impacts of the errors from the Bayesian optimization method, prior iňĆux distribution and the atmospheric transport model, as well as their interaction. The work contributes the understanding of components of inversion problems. However, there are some major issues should be addressed.

General comments:

(1) This study used fossil fuel CO_2 emissions as target. However, CO_2 also has land and ocean sink, and land-use change emissions, which are significant compared to

fossil fuel CO_2. This study did not account for these emissions. This study used the CarbonTrack simulation as the synthetic observation which probably has accounted for all emissions and sink (right?), while the FLEXPART simulation used for the inversion did not account for the land and ocean sink (right?), which would lead to a mismatch between the simulated concentrations by FLEXPART and CarbonTack. This is major issue that hinders the robustness of the interpretation of the "posterior error" and mismatch between the obs and simulation.

(2) What is the average footprint (emission sensitivity) coverage? This paper did not show. The inversion domain should be largely determined by the footprint coverage, while the authors seem to choose the domain according to census. Does footprint of the three stations in ON province covers ON well? EGB and DOW stations are so close. Why not locate one of them in another place in ON? How about the uncertainty reduction for the emissions in each sub-region after inversion?

(3) The synthetic observation at each station simulated by the CarbonTracker model is the average value in the whole grid cell (1 deg by 1 deg). However, the Prior and Posterior modeled value by the FLEXPART is the concentration value at the exact location of the obs station. So, there is a representation error between the synthetic obs and modeled obs, which would lead to bias in interpreting the inversion results.

(4) The CO_2 concentrations at all four sites in SK/AB were almost identical to the background concentrations in spring and summer (Figure 3). It means the pollution signals were weak, which could lead to weak constraint on estimating the monthly and annually emissions in SK/AB. In the Table 2, CT2010 inventory (used a priori) is larger by ∼20% than the CT2011 (used as target) for SK/AB. In Figure 4, the "Annual Error" (relative percentage difference of the posterior estimates from the target flux) is also ∼20% by both MCMC and CFM methods. It seems suggest that the inversion has not done substantial adjustments of emissions.

(5) When the number of sub-regions increased, the sub-region domain became

smaller. Some sub-regions cover one, two or three grid cells (0.2*0.2). There are some approximation and errors when converting from the footprint value in grid cell to sub-regions. Does this issue contribute the large variety of inversion results with various numbers of sub-regions and negative posteriori values in some sub-regions close to the stations?

(6) P22728, L15- P2279, L2: Does the simplification treatment of σ_e^2 and σ_prior^2 affect significantly the posterior emissions? In this study, the prior errors were assigned constant for all sub-regions, which would lead to large prior error for small emission in one sub-region and small prior error for large emission in other sub-region. In this sense, emission values in some sub-regions could be changed easily by the inversion while some would be not.

Specific comments:

P2221, L17: What is value for "majority"?

P22722, L1: How did the authors do that "the gridded fluxes were aggregated into sub-regions to be optimized as shown in Fig. 2"? Some gridded fluxes cross over more than one sub-region.

P22723, L4: why "5 day" was used as transport history? CO2 is long-lived species. Is a longer backward simulation better?

P22724, L19-20 and rest text: why the year 2009 was used for simulation in this study? The paper used CT2011 as the target year.

P22731, P7-11: The explanation seems be not robust. Many factors could contribute to the mismatch. Does the land sink contribute to the mismatch? Or "representation error" I mentioned above? Or the different resolutions in two simulations (1 vs. 0.2)?

P22738, L1 and in main text: why not show the "not shown"?

P22738, L20-23: what is the Logic behind this claim?

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