

The manuscript evaluates the improvement in methane inversions over China resulting from the addition of new ground-based observations. The study is thorough, novel, and well-written, addressing an important issue in methane observations and emission inversions. I recommend it for publication in AMT, subject to a few minor revisions and clarifications.

From equations 3-4, the DOFs largely depend on the relative values of the observational error and the prior error. The formulation of the observational error will therefore influence the results. I suggest providing a detailed explanation of how the observational error is calculated:

First, equation 2 for the observational error may be incorrect. According to Heald et al. (2004), Equation 2 calculates the observation error (ϵ_o), not the standard deviation of the observation error (σ_o). This appears to be a typo, but the authors should review the code to ensure the calculation is correct.

In addition, Heald et al. (2004) describe subsequent procedures: after calculating the standard deviation of the observation error, the relative residual standard deviation (RSSD) is computed by dividing the mean of the observations. The error variance for each observation is then calculated as $(y \cdot \text{RSSD})^2$. If the authors calculate the observational error based on the same procedures, I suggest the authors include these detailed steps in the manuscript.

Second, in Section 3.1 (line 310), the authors assume $\sigma_o = 65\text{ppb}$ for each new station. Based on the procedure above, it may be preferable to assume a constant RSSD for the new stations rather than a fixed σ_o . This RSSD could be estimated using the six urban sites or other methods. Then, the observational error can be calculated as the model-simulated value multiplied by the RSSD, since the model generally captures spatial and seasonal variations of CH₄. I suggest the authors test this approach, or other reasonable assumptions, for weekly or monthly observations to illustrate the potential uncertainties arising from observational error assumptions.

Other minor comments:

Line 155 (Section 2.4): Please clarify that the k-means clustering algorithm is applied to low-emission grid cells in China as well as all grid cells outside China.

Fig. 3: Consider adjusting the color scale in Fig. 3b and clarifying the units in Figure 3c (e.g., 10^6 per grid cell?).

Line 468: The improvements for coal mining and biomass burning are minimal. Is this because the a priori sensitivity for coal mining is already large, and biomass burning emissions are too small? Some explanation of sector sensitivity should be added.

Fig.1: It would be helpful to show the regional divisions directly on this figure instead of in the supplementary (e.g., by adding bold lines).

Fig. 9: The background color seems to indicate uncertainty reduction. It is unclear what the color of the circles represents. Please clarify.