

Interactive comment on “Atmospheric carbon cycle dynamics over the ABoVE domain: an integrated analysis using aircraft observations (Arctic-CAP) and model simulations (GEOS)” by Colm Sweeney et al.

Anonymous Referee #1

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The authors discuss recent aircraft observations of trace gases across Alaska and northern Canada and compare these observations against simulations from the GEOS model.

This manuscript is partly a data description paper, partly a model evaluation paper, and partly a paper on trace gas fluxes. I think that a data description paper and model development/evaluation paper would be better-suited for a different journal. At the conclusion of the study, I am not sure what new information we have learned about greenhouse gas sources and sinks from the region. This study seems to reiterate what

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we already know – that greenhouse gases exhibit patterns in the atmosphere across North American high latitudes and that atmospheric models can reproduce at least some of these patterns.

Relatedly, I think this manuscript needs a more novel message. I do not think it is sufficient to describe patterns in aircraft observations across northern Canada and Alaska, nor is it sufficient to show that atmospheric models can reproduce at least some of the patterns in those observations. The authors argue that the analysis in this manuscript highlights the potential of the observations to inform surface fluxes, and the authors use a single set of flux estimates to evaluate this question. In fact, a number of studies have used aircraft and tower-based observations across high latitudes to inform surface fluxes (e.g., Pickett Heaps 2011, Chang et al. 2014, Karion et al. 2016, Miller et al. 2016, Zona et al. 2016, Commane et al. 2017, Hartery et al. 2018). Furthermore, existing studies have shown that models can capture spatial and temporal patterns in greenhouse gas fluxes at high latitudes (including models that use GEOS meteorology, e.g., Pickett-Heaps et al. 2011).

It would have been more interesting if the authors would have used these observations to inform surface fluxes instead of commenting on the possibility of doing so. For example, the authors could either estimate fluxes using aircraft observations or evaluate several bottom-up estimates of greenhouse gas fluxes (e.g., from recent bottom-up model inter-comparison projects like the Wetland And Wetland CH₄ Inter-Comparison Of Models Project (WETCHIMP), Multi-scale Synthesis and Terrestrial Model Intercomparison Project (MsTMIP), or TRENDY models).

Feedback on specific sections of the manuscript:

Introduction: To date, multiple studies have used atmospheric observations from Alaska and/or Canada to evaluate greenhouse gas fluxes across the region (e.g., Pickett Heaps et al. 2011, Chang et al. 2014, Karion et al. 2016, Sweeney et al. 2016, Zona et al. 2016, Miller et al. 2016, Hartery et al. 2018, Commane et al. 2017, Thomp-

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son et al. 2017, Floerchinger et al. 2019). At present, the introduction does not cite any of these studies. I think it's important to cite at least a few of these references, explain what scientific questions these studies were able to answer, and point out which questions remain largely unanswered. The authors point out that top-down studies can be impacted by atmospheric transport errors, but the authors cite studies focused on other regions of the globe, not one of the many studies focused on Alaska and northern Canada.

Lines 195 - 240: The authors compare the magnitude of the bottom-up fluxes used in the GEOS model against a handful of recent studies. There are far more studies that have analyzed carbon dioxide and methane fluxes across the study region than described in the comparison here (see references in previous comments). This material also feels like it would be better suited for a results and/or discussion section; one could evaluate the magnitude of the fluxes using ABoVE aircraft observations and bring in existing studies to provide context on the results of this evaluation.

Section 2: At present, the methods section describes the aircraft flights and the GEOS model simulations, but the methods section does not describe any kind of analysis. I.e., based on the methods section, it is not clear what the authors intend to do with these aircraft observations or model simulations. I think this feeds into my previous comment that the manuscript needs a stronger purpose that drives toward a novel conclusion about greenhouse gas fluxes. I think that including analysis methods in this section would give the reader a stronger preview of where the manuscript is headed and what the authors intend to do with these data and model simulations.

Section 3.1.1: This section provides a broad description of the aircraft flights. I would start the results section by discussing a scientific result. The material in this section almost feels like it would be better suited for a methods section describing the frequency and locations of aircraft flights.

Line 376: Again, I think a number of studies focused on high latitudes have already

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shown the utility of using aircraft observations to evaluate surface fluxes and surface flux models. I would try to ask more novel and focused questions either about the information content of existing atmospheric observations or about surface fluxes.

Minor comments: Line 169: Make sure to put the "2" in "CO₂" in subscript.

Figure 1: Why are the different flight tracks shown in different colors? What do those colors mean? This information is explained in the Figure 2 caption, but it would be useful to explain these features within the caption for figure 1 (or within a legend).

Figures 4 and 5: What is the takeaway message of this figure? I would recommend adding this information to the caption. Each of these figures contains many panels, and I was not sure what message I should take away as a reader.

Make sure to put the "2" and "4" in "CO₂" and "CH₄" in subscript throughout the references section.

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