Reviewer 1:

This manuscript describes the aggregation of ecosystem respiration data from air warming experiments across arctic and alpine tundra warming manipulations. Efforts to aggregate data from similar groups of experiments run by PIs distributed across institutions and nations is extremely valuable to facilitate synthesis, model comparison, and identify gaps. Thus, I think this database is a valuable contribution to the literature. There are several other chamber-based flux aggregation products which the authors mention in their next steps as a goal to facilitate integration. I believe it would be worth explicitly mentioning and distinguishing these in the introduction or description and structure sections. A few aggregated datasets of which I am aware are ABCFlux (ambient only), COSORE (global, focused on continuous, not necessarily aggregated for experimental manipulations), and the ITEX Ecosystem carbon flux dataset. Additonally, are all the sites in TrundraFlux listed in Vogt et al 2025. ARGO: ARctic greenhouse Gas Observation metadata version 1? If not, adding entries there would be a good way to build on existing resources and reduce diverging aggregation efforts.

Overall, this paper is well written with informative graphics and descriptions of the data structure. I feel I have a good grasp of what I expect to find in the dataset and how it is organized.

Response: We thank the reviewer for their positive and constructive feedback on our manuscript and the TundraFlux database. We also appreciate the suggestions regarding related synthesis efforts and metadata initiatives.

We agree that providing additional context on existing chamber-based flux synthesis efforts helps position the TundraFlux Database within the broader data landscape. We have therefore added a short paragraph describing ABCFlux and COSORE, and clarifying how TundraFlux complements these existing resources, to Section 2.1, 'Scope and Purpose', in the 'Description and Structure' section. This paragraph covers **L173-183**:

"*Several related chamber-based flux synthesis efforts already exist, including the Arctic-Boreal Chamber Flux Database (ABCFlux; Virkkala et al., 2022), which focuses on ambient CO_2 flux observations across Arctic and boreal ecosystems, and COSORE (Bond-Lamberty et al., 2020), which compiles continuous soil respiration and soil–atmosphere greenhouse gas flux measurements across ecosystems worldwide. The TundraFlux Database complements these efforts by specifically compiling Reco observations from both ambient and experimentally manipulated tundra ecosystems.*"

We also now explicitly mention these databases in the discussion of future integration efforts, where it now reads:

" *Finally, we aim to link the TundraFlux Database with other available databases on terrestrial carbon fluxes (Table S1), including the Tundra Trait Team database (Bjorkman et al., 2018), the*

Manipulation Experiments Synthesis Initiative (MESI; Van Sundert et al., 2023), COSORE (Bond-Lamberty et al., 2020), and the ABCflux database (Leffler et al., 2025; Virkkala et al., 2022). Although integration remains challenging due to differences in data formats, identifiers, and metadata standards, establishing common protocols will be crucial to advance syntheses across databases." **L390-395**

Furthermore, we added a **new Table S1** in the supplements:

Table S1: Comparison of the TundraFlux Database with related databases and synthesis initiatives relevant to tundra ecosystem research. The table highlights the primary scope of each resource and illustrates how TundraFlux complements existing databases by providing harmonized ecosystem respiration (R_{eco}) observations from both ambient and warming experiments in Arctic and alpine tundra ecosystems.

Database	Reference	Primary scope / distinction
Tundra Trait Team	Bjorkman *et al.* 2018, *Glob. Ecol. Biogeogr;* https://doi.org/10.1111/geb.12821	Plant trait database for tundra species. Contains vegetation trait information but no ecosystem carbon flux measurements.
COSORE	Bond-Lamberty *et al.* 2020, *Glob. Change Biol*; https://doi.org/10.1111/gcb.15353	Global compilation of continuous/automated soil respiration and soil greenhouse gas flux measurements. Emphasizes high-frequency temporal observations rather than tundra-specific ecosystem respiration syntheses.
ABCFlux	Virkkala *et al.* 2022, *Earth Syst. Sci. Data;* https://doi.org/10.5194/essd-14-179-2022	Arctic–boreal carbon flux database containing multiple carbon flux components across ecosystems, primarily under ambient conditions. Not specifically focused on tundra ecosystem respiration or experimental warming manipulations.
Manipulation Experiments Synthesis Initiative (MESI)	Van Sundert *et al.* 2023, *Glob. Change Biol;* https://doi.org/10.1111/gcb.16585	Global compilation of terrestrial climate-change experiments (e.g., warming, nutrient addition, CO_2 enrichment). Documents experimental manipulations and associated metadata rather than harmonized tundra Reco measurements.
TundraFlux	Schwieger et al., 2026, DOI: 10.5281/zenodo.17976235	Tundra-specific ecosystem respiration database integrating ambient and experimental warming (open-top chambers) across studies with standardized environmental and experimental metadata.

However, we are unsure which dataset the reviewer is referring to when they mention the **ITEX Ecosystem carbon flux dataset**. We assume that the reviewer might be referring to the dataset used in Maes, et al. 2024: *Environmental drivers of increased ecosystem respiration in a warming tundra* (https://doi.org/10.1038/s41586-024-07274-7). In section 3 of the manuscript, 'Applications of the TundraFlux database', specifically 3.1 'Identifying magnitude and drivers of ecosystem respiration response to warming through meta-analysis' (**L266–271**), we state that we are using 136 datasets from 56 OTC experiments at 28 tundra sites worldwide. This represents 60% of the data in the TundraFlux Database. The data used in this paper can be accessed via the citation provided in our manuscript.

Regarding the representation of TundraFlux within the metadata compilation by Vogt et al. (2025) (ARGO: ARctic greenhouse Gas Observation metadata version 1; https://essd.copernicus.org/articles/17/2553/2025/), the TundraFlux database was not included because the dataset is not yet publicly available. However, we hope that the database can contribute to future ARGO releases once TundraFlux is openly accessible after acceptance. More broadly, facilitating integration into existing synthesis platforms and community efforts such as ARGO, ABCFlux, and COSORE is one of the key motivations behind publishing the TundraFlux Database.

Some detailed, line-by-line comments

Data sources:

Table S1: do some of these come from databases (eg: LTER for CiPEHR and Toolik sites)? It would be helpful to add these links to the table as well. I think it would be additionally helpful to identify which of these sites originates from the establishment of ITEX.

Response: Thank you for this comment.

Whenever available and applicable, co-authors and data contributors were encouraged to provide links to related datasets and publications in what is now **Table S2 (previous Table S1)**. We updated the reference column with new links to datasets from Cambridge Bay and the Iceland CRUST site.

Concerning links to LTER, the CiPEHR data included in the TundraFlux Database were compiled and filtered specifically for this synthesis effort and therefore do not correspond exactly to previously published datasets available. Here, we present a subset of the data that can be found at LTER. The data we included in our database are nighttime R_{eco}, as stated in (**L235-239**):

"*All experiments measured daytime R_{eco} using dark or opaque chambers, except for the CiPEHR site in Alaska (ALA_1), where automated chambers continuously measured CO_2 respiration using clear chambers. To obtain comparable respiration estimates for this site, we extracted only night-time fluxes, defined by photosynthetically active radiation (PAR) values below 5 µmol m^{-2} s^{-1}, as these best approximated dark chamber conditions. These night-time measurements were therefore used as the site's Reco values.*"

We have added a link to the original, unfiltered CiPEHR data (https://www2.nau.edu/schuurlab-p/data.html), which can be accessed in what is now Table S2 (previously Table S1) of the supplements.

Regarding our data connections to ITEX, many of the warming experiments included in TundraFlux use open-top chambers (OTCs) and are conceptually aligned with the International

Tundra Experiment. However, because participation in ITEX is voluntary and there is no strict formal definition of membership, it is difficult to unambiguously classify sites as ITEX sites. We would therefore like to avoid making definitive classifications and instead clarify the relationship of these experiments to the broader ITEX framework where appropriate.

Table S2: not sure how useful Nobs is other than to show generally large vs small datasets. Instead perhaps adding the frequency/interval of measurement or mode of measurement such as manual vs automated.

Response: Thank you for the comment. We had indeed the intention to show the magnitude of larger vs smaller datasets within the database in this table. We now added the measurement frequency in what is now **Table S3 (previously Table S2)** of the supplements, which is estimated from the mean interval between consecutive daily averaged observations per site-year: Daily (≤1.5 days), Weekly (2–8.5 days), Bi-weekly (8.5–16 days), Monthly (16–35 days), or Irregular (>35 days). We also added a column with the number of raw observations (N Raw Obs.) before daily averaging to show readers how many individual measurements underlie each daily average

Only one site currently has automated chambers in the database, i.e. CiPHER (ALA_1 in our database) , which is stated in **L235-236** of the manuscript as:

"All experiments measured daytime Reco using dark or opaque chambers, except for the CiPEHR site in Alaska (ALA_1), where automated chambers continuously measured CO_2 *respiration using clear chambers."*

We have therefore not added information on the mode of measurement in in Table S3 (former Table S2).

Table S4: Is the Daily_% the percent of days in a year with measurements? So 0.5% would be and average of 1.8 days of measurement over the years measured?

Response: Yes, we see the confusion. The "Daily_%" column does not represent the percentage of days in a year with measurements. Instead, it reflects the proportion of total observation days contributed by each site relative to the full dataset (i.e., across all sites combined).

Specifically, we first aggregate the data to unique site–day combinations with R_{eco} measurements and then count the number of days per site. The percentage is then calculated as:

total number of measured days per site / total number of observed days across all sites × 100.

Thus, the values are intended as a relative weighting of sampling effort across sites, not as within-year sampling frequency.

We changed the column name from ‘Daily_%’ to ‘Site_contribution_%’ and edited the caption of what is now **Table S5 (previous Table S4)** to:

”*Table S5: Number of years R_{eco} was measured and number and percentages of total observed site–day records (i.e. summed daily observations), by site and region.* “ to improve clarity.

Use country codes that match a standard. I believe Fluxnet currently uses: ISO-3611-2: https://fluxnet.org/data/fluxnet2015-dataset/known-issues/. I think using standardized names reduces guessing and makes it easier to link with other products.

Response: We thank the reviewer for the helpful reference and agree that standardized codes are preferable to uncontrolled country names. In our dataset, we use **ISO 3166-1 alpha-3** (three-letter codes, e.g., NOR=Norway, SWE=Sweden), which is a widely recognized ISO standard. FLUXNET uses the same standard but alpha-2, which means only two letters (e.g., NO=Norway, SE=Sweden). We think that alpha-3 codes offer a readability advantage in research contexts, as they are more immediately recognizable without requiring a lookup table. Further, since sites are linked via site IDs, plot IDs, and coordinates rather than country codes, we do not expect any compatibility issues with FLUXNET or other datasets. However, we would be willing to switch to ISO-3611-2 using the two-letter code if the reviewer or editors feel this would support wider usability of the database.

Reviewer access URL for code, readme, data dictionary did not work (page not found error from Zenodo)

Response: Our apologies for this inconvenience. We provide an updated link for the reviewers in the new uploaded manuscript.

Text:

Line 128: Suggestion not starting the paragraph with ‘its’. Instead something like: ‘Ecosystem respiration plays a central role… making it important to predict… ‘

Response: Thank you for the recommendation. We changed the sentence, it now reads:

”*Ecosystem respiration plays a central role in the global carbon cycle, making it essential to predict how Reco responds to climate change. However, accurately forecasting the extent, as well as the spatial and temporal variability of these responses, remains a major scientific challenge (Karhu et al., 2014; Maes et al., 2024; Rustad et al., 2001; Schuur et al., 2022; Sulman et al., 2018; Virkkala et al., 2021).*” **L129-132**

Line 135: It would be useful to briefly describe the OTC method.

Response: Thank you for the comment. We described the OTC method in the methods in section 2.2 Data sources and data collection, but we agree, an earlier introduction may indeed benefit readers to better understand the scope of the TundraFlux database. Therefore, we moved the description to **L135-142** of the introduction, which now reads as follows:

"Here, we present the TundraFlux Database, which contains R_{eco} measurements derived from open-top chamber (OTC) warming experiments. These experiments use small greenhouses to passively increase air temperatures during the snow-free season while allowing relatively free entry of precipitation (Hollister et al., 2023; Marion et al., 1997; Welker et al., 1997). OTCs are commonly used to simulate climate warming at a plot-scale in low-stature Arctic and alpine tundra systems, e.g., in the International Tundra Experiment network (ITEX; https://www.gvsu.edu/itex/; Henry and Molau, 1997; Hollister et al., 2023). These experiments provide a unique opportunity to analyse patterns and drivers of CO_2 respiration under warming conditions across bioclimatic gradients, which arise from differences in climate, vegetation, and soil characteristics (Maes et al., 2024).“

Line 169-171: Are these metadata time-varying if the experiment is multiple years long? Or are they site-specific and temporally fixed?

Response: This is indeed an important question. The metadata is site-and-plot specific but not strictly temporally fixed, and the linkage year (flux_year) may not equal the measurement year. The metadata measurement year is not always identical to the flux year (in which Reco is measured). In some cases, the closest available metadata measurement is associated with a given flux year. In Maes et al., 2024, we assessed whether mismatching of R_{eco} with environmental driver data from different measurement years influenced the results through performing a sensitivity analysis, that is, rerunning the meta regression models on the basis of several restrictive sample size scenarios (Supplementary Fig. 4 and Supplementary Discussion 4 in Maes et al 2024).

We recognize that a dedicated metadata measurement year column would clarify this, and we have added this as the coloumns **'veg_survey_year'** (i.e., the year in which the vegetation measurements of the 'plant_metadata_plot' dataset were taken) and **'soil_survey_year'** (i.e., the year in which the soil measurements of the 'soil_metadata_plot' dataset were taken) to the database to make the temporal relationship between flux data and metadata explicit. We updated the data dictionary in what is now **Table S4 (previously Table S3)** accordingly.

Line 232-235: Restricting the NEE fluxes to night-time only is a reasonable approach. However, I wonder what the data source was for the CiPEHR data because Reco (extrapolated from night to day using a temperature-response function) is included in the datasets in the BNZ LTER data catalog: https://www.lter.uaf.edu/data/data-detail/id/481.

There are also some respiration measurements during and from the end of the growing season. Not sure if they are included?

https://www.lter.uaf.edu/data/data-detail/id/611

https://www.lter.uaf.edu/data/data-detail/id/572

https://www.lter.uaf.edu/data/data-detail/id/652

Response: The CiPEHR data included in the TundraFlux Database were compiled and filtered specifically for this synthesis effort and therefore do not correspond exactly to previously published datasets available through the Bonanza Creek LTER data catalog. In particular, we compiled only **measured ecosystem respiration data** relevant to the scope of this study and excluded modeled respiration products. Because TundraFlux integrates curated subsets and additional auxiliary datasets from multiple sources, there is not always a one-to-one correspondence between the datasets included here and externally archived products.

Regarding the datasets suggested by the reviewer, some of these measurements may overlap temporally with the data included in TundraFlux. However, our synthesis specifically focuses on ecosystem respiration measurements from open-top chamber (OTC) warming experiments, as described in **L184–186**:

"*The TundraFlux Database compiles in-situ measurements of daily-aggregated terrestrial ecosystem-level CO_2 fluxes (g C-CO_2 m^{-2} day^{-1}) from Arctic and alpine tundra ecosystems to assess warming effects on ecosystem CO2 respiration (Reco). We compiled data from experiments that used open-top chambers (OTCs) from across the Arctic and alpine tundra biome.*"

Datasets outside this scope were therefore not included.

Line 262: I think this sentence has a word missing

Response: Yes, indeed. We changed the sentence to*:*

"The TundraFlux Database is based on a global synthesis of how ecosystem respiration in Arctic and alpine tundra responds to experimental warming (Maes et al., 2024)." **(L266-267)**

Line 288: perhaps cite Schadel et al 2018 Divergent patterns of experimental and model-derived permafrost ecosystem carbon dynamics in response to Arctic warming as an example?

Response: Thank you for pointing us towards this publication that describes the possible divergence of model results from field experiments and highlights the need to align field-based warming measurements from, for example, the TundraFlux Database with model simulations. We added it in **L292**.

Line 295: Remove 'while' to start with The TundraFlux Database? I think it's important to point out, as you do, that the imbalance is a reflection of the field rather than a limitation of the

TundraFlux data aggregation effort. In a sense, these aggregation efforts allow us to see the imbalance more clearly.

Response: Thank you for pointing this out. We changed the sentence and it now reads:

" *The TundraFlux Database inherently reflects a sampling imbalance in the field, particularly the underrepresentation of key Arctic regions such as the Canadian High Arctic archipelago and Siberia (López-Blanco et al., 2024; Metcalfe et al., 2018; Virkkala et al., 2019; Fig. 1A, Table S5). Still it represents the most comprehensive effort that is currently available of Reco data from warming experiments in the tundra.*" **(L299-302)**

Line 372: and/or air vs soil warming as the CiPEHR experiments show that the effects of snow-fences carry over into the summer because the warming soil profile is cumulative. And air warming in summer can alter winter conditions as shifts in vegetation can alter soil conditions (eg: Heather Kropp et al 2021 Environ. Res. Lett.)

Response: That is an interesting point. We added this to the sentence, which now reads:

" *This will enable us to distinguish between the effects of summer (OTC) and winter (snow fences) warming on Reco, as well as the combined effects of these treatments (Hermesdorf et al., 2024). It will also allow us to account for cross-seasonal carry-over and the effects of coupled air-soil warming, whereby winter soil warming persists into summer and summer air warming can indirectly modify winter soil conditions via changes to vegetation (Kropp et al., 2020)."* **(L380-384)**