Review for egusphere-2023-732.

Main comments:
Methane leaks from the Nord Stream pipeline explosion have gained worldwide attention. Although a number of studies or reports have given estimates of methane leakage from this event, detailed data on the rate of methane leakage over time from this event are lacking. This study reconstructs vertical profiles and temporal evolution of the methane releases from the broken pipes, and simulated subsequent transport of the released methane in the atmosphere. The results show that the emission injection vertical profile and the meteorology used to drive CTM can significantly affect the methane dispersion simulations, and which in turn can seriously affect the observation-based emission inversion. Therefore, the data and the results reported by this study are important. The authors illustrate the reliability of the data by comparing the simulations with the observed increase in $CH_4$ concentration, however, the article does not give a clear conclusion on how much the concentrations modelled using the emission rates and vertical profiles given in this paper deviate from the actual observations. In addition, the writing is slightly haphazard, with some writing and formatting problems. Therefore, I would suggest that the article needs to go through a major reversion.

Specific comments:

1. Abstract, Don't divide it into so many paragraphs.

2. Lines 33-35, Please check the units, they need to be the same when comparing.

3. Line 35, what's the mean of 60%?

4. Line 43, 99, Problems with reference citation format.

5. Line 94, which product of ECMWF forecasts was used? ERA5?

6. Section 2.1, the setup of SILAM model should be added in this section, including the simulation domains, horizontal resolution, vertical layers, etc.

7. Lines 109-115, UCLALES simulations were driven using the ECMWF forecasts, however, UCLALES was run with 50 m horizontal and 10 m vertical resolution, while the forecasts are in 0.1×0.1 degrees. Does this severe mismatch in spatial resolution affect the simulation results? Why not use MEPS? It has much higher resolution of 2.5 km.

8. Line 109, Writing problems. “with temperature, humidity and wind profiles and surface variables” should be changed to “with temperature, humidity, wind profiles, and surface variables”.

9. Line 118, Writing problems. “…Observation System (ICOS) network, https://icos-cp.eu (accessed 30.11.2022).” should be changed to “Observation System (ICOS) network (https://icos-cp.eu, accessed 30.11.2022).”

10. Line 139, full name of “rhs”.

11. Line 143, Formatting issues, “$4 \cdot 10^7$” should be changed to “$4 \times 10^7$”.

12. Line 155 and the other places, Formatting of units throughout the text needs to be standardized. According to the formatting requirements of ACP, units must be written exponentially (e.g. W $m^{-2}$).

13. Table 1, Please use a 3-wire table. Horizontal lines should normally only appear above and below the table, and as a separator between the head and the main body of the table.

14. Line 260-264, It is suggested that this paragraph add a description of the total estimated leakage and a comparative analysis with existing results, rather than just describing changes in emission rates over time.

15. Lines 266-267, as shown in Figure 6, it is better to use the values of 3.0 and 0.5 km, rather than 3.5 and 1.0 km.

16. Line 275, Why is it 15km here?

17. Line 302 and the other places, problems of the date format.

18. Lines 302-306, Here, the author needs to give some descriptions about the differences between the simulation results with different vertical profiles and different model resolutions, and it is also recommended to give some quantitative analyses to clarify which vertical profile and model resolution simulation results are in better agreement with the observations.

19. Lines 309-310, remove the sentences of “Colors correspond to observation heights for each station. The line style shows different vertical distribution of the emission.” For a description of the elements in the diagram, just put it in the diagram title.

20. Figure 8, It is difficult to distinguish too many lines in the same plot, it is suggested that 1) the same site, with different heights, should be treated as different sites instead of being drawn in the same plot; 2) different colours should be used to represent different vertical profiles in the simulation results instead of using different line types; 3) the observed data can be plotted after removing the background so as to make better comparisons with the model.

21. Lines 316-317, the same as comment 19, remove the sentences of “The ICOS stations are shown with filled symbols and three-letter codes, and other stations have two-letter country prefixes. Full list of the station data and references to them can be found from supplementary materials.”

22. Line 375, Incomplete sentences.

23. Line 375, “3*x*95 kt” should be changed to “3×95 kt” or “285 kt”.