

We would like to thank the handling editor Donatella Zona for the final comments and suggestions on our revised manuscript “Winter GHG fluxes in a sub-alpine grassland”. We believe the comments improved the manuscript considerably. Here, we respond to all general and specific comments (regular font is the reviewer’s comments, italic font represents our answer).

Abstract:

1., 1.23) “2010/2011”

This implicates that the winter season in Davos commonly starts in November and lasts until April the following year. Therefore it is referred to as the winter season 2010/2011 as done in previous papers for other years, e.g. Merbold et al. 2012.

2., 1.26 and 1.30) 50%

We gave the 50 % as an average value to make a clear statement in the abstract. In the manuscript, particularly Table 2 shows an underestimation of the gradient measurements ranging between 40 and 60 % compared to the EC measurements.

3., 1.35, 36) (1st Dec – 31st Mar, 121 days)

This definition was moved and is now directly stated after the second objective in the revised manuscript

4., 1.44) g CO₂

We decided to keep the numbers as stated in the revised manuscript since we are focusing on comparing the three GHGs with each other. Currently no standard exists on which unit to use and statements in other papers vary (g CO₂, g C-CO₂, μmol CO₂ etc.). However we believe that the numbers given in our paper (g CO₂, g CH₄ and g N₂O) are most suitable for comparison of the contribution of each greenhouse gas to the total balance.

5.) shortening the abstract and avoid redundancy, e.g. no driver for CO₂ could be detected.

In order to shorten the abstract and avoid redundant information we rephrased the last subsection. “Further investigations on the GHG exchange of grasslands in winter are needed in order to (1) deepen our currently limited knowledge on the environmental drivers of each GHG, (2) to thoroughly constrain annual balances, and (3) to project possible changes in GHG flux magnitude with expected shorter and warmer winter periods.”

Introduction:

6., 1.76) profound

We agree with the comment of the editor that in some ecosystems the uncertainties on the controls of CO₂ exchange remain large. However since we highlight the major

processes, e.g. photosynthesis and respiration for CO₂, we believe that there exists a much better understanding of the processes driving CO₂ exchange than on the processes driving methane exchange. Therefore we chose the word “profound” strengthening the discrepancies in understanding.

7., l. 91) here you use CO₂-C, to make comparison easier with your values use same units (better CO₂-C everywhere?)

We agree with this statement and converted the values given by e.g. Jones et al. 1999, Fahnestock et al. 1999, Clein and Schimel 1995) to g CO₂ instead of giving g C-CO₂. Further we refer to Björkman et al. 2010b that summarizes the results of several studies on winter CO₂ efflux. The reported values ranged between 0.7 – 770 g CO₂ m⁻² yr⁻¹. We adjusted these values in the re-revised version of the manuscript.

8., l.324) receive

This is the appropriate term according to two native speakers who read the manuscript prior to resubmission.

Results:

9., l.365) “increase from the soil to the snow surface”

Correct. We would like to thank the editor for this comment and changed the wording in the re-revised version.

10., l-409) significant relationship

This sentence was changed to: “In addition, soil temperatures at 3 cm depth showed a weaker but still significant relationship with CO₂ emissions ($r^2 = 0.32$).

Discussion:

11., l.550) of

This was removed in the revised manuscript.

12., l.566) Q10 specification

Monson et al. report the R_T which is analogous to the Q10 in metabolic studies. The value reported in this study was as high as 5.76×10^5 , for a temperature range from -0.8 to 0.4°C. Which is very similar to the temperature range shown in our study.

13., l.603) did you test this at different time scales? not only half-hour but also longer time scale (monthly for example)

We tested this relationship also at different time scales showing no improvement the correlation. In general we believe that a relationship between soil moisture and methane flux in alpine grassland is difficult to detect since the changes in soil moisture are very small. Further we believe the soil conditions being close to water

saturation due to the permanent snow cover and temperature near the freezing point leading to a permanent water input.

14., 1.618) fertilizer composition

We were unable to determine the concentrations of either NO_3^- or NH_4 , since the fertilization event took place without a notification prior to the management application.

15., 1.660) careful statement

We agree with the editor on this statement and changed the sentence accordingly.

16., 1.675) how the soil temperature in these compare, maybe you should mention how different they were? also maybe worth addition to Fig. 8?

Unfortunately we do not have such temperature measurements from the forest and we can only hypothesize lower temperatures in the forest due to strongly reduced snow cover.

17., 1.680) it would be helpful if you mention how the range of winter emissions compares with the summer ones, so that it is more clear the relevance of measuring winter (most reviewers asked about the relevance of your work) and if your winter results do not change the summer results very much

Due to the management activities and the private use of the land we were unable to measure summer GHG exchange. Concerning the relevance of our work we strongly refer to our objectives, which focused on the comparison of contrasting measurement techniques and the identification of drivers of GHG exchange during winter. Further CO_2 losses were in the same order of magnitude as reported for a sub-alpine grassland in Central Switzerland (Merbold et al. 2012). Therefore we assume a similar contribution of the winter CO_2 exchange to the annual budget of 3-25%.

18., 1.687) gradient approach

Here we refer to all manual gradient measurements presented in the results, which were not based on the non-correctly functioning automatic gradients. We included the word "manual" in the re-revised version of the manuscript.