

## ***Interactive comment on “Effects of interannual variability in snow accumulation on energy partitioning and surface energy exchange in a high-Arctic tundra ecosystem” by C. Stiegler et al.***

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This paper reports results from a 2-year field measurement campaign at Zackenberg, Greenland to measure seasonal time series of energy budget components in two contrasting arctic vegetation types, wet fen and dry heath tundra. The paper makes use of the fact that there was a strong contrast in snow cover between the two years to infer what changes in surface energy exchange might be expected under a warming (and higher precipitation) arctic climate. Changes in the arctic energy budget, especially those studied seasonally, are important. The variety of ecosystem types that have been measured—including in Greenland—is relatively few, making this an important contribution to our knowledge of cold land processes. The manuscript is very clearly written,

C1

well organized, and the data are well presented (but see a few comments below). The conclusions are reasonable and are supported by the data. I recommend the paper for publication with only minor revisions. In my view, the paper is very good and the detailed comments below are given as constructive suggestions to improve the final version.

General comments:

1) Figure design. The figures are very nice and clearly labeled; however, some of them are confusing to read. For example, in Figs 3a and 3b the stacked bar plots make it very hard to see the differences between sites and years. Stacked bars are difficult in general, but the large difference in the size of the trends (e.g. the tiny negative values of Rnet) make it really difficult to discern, especially in these small panels. I think the data will come across to the reader better and the paper will have better impact if you can find another way to show these data. Maybe it would be a non-stacked bar plot, a line plot, or something else. Maybe they need to be made larger so that you show only one vegetation type at a time. I understand the reasons why you laid out the panels as you did, it's just that they end up difficult to read and so the result will be better if you can revise them to show the various data values more clearly.

Secondly, the use of color is not always allowing the reader to quickly pick out what is what. Sometimes the colors are inconsistent, for example in Fig 5, H and LE are shown in red and blue, and G is in green. But in Fig 6, H and LE follow the same red and blue style, but G is now in gray. Earlier in the paper (Figs 3a and 3b), the same shades of red and blue are used instead for albedo and snow depth. I think you might be better off to remove color from most of the plots where it is possible, and reserve the use of color only where it is the best/only way to show the differences. For example, you could symbolize albedo and snow depth with black lines of different thicknesses, or using dashes. I would suggest placing all of the color figures all together out on a table and then deciding on a system so that the same type of color or symbols are used consistently, and simplify them as much as you can by not using color at all unless it is

C2

needed.

2) References. The paper does a good job of citing relevant literature overall, but its impact would be improved by making more direct comparisons to other arctic energy budget studies, especially those outside of Greenland. There are still few enough such studies that this is valuable to the scientific community to provide a bigger context for your findings. The manuscript did cite the big review paper of Eugster et al. (2000), but you didn't use that paper to actually compare the energy budget patterns you found to the patterns reported for other arctic ecosystems. At least in the North American Arctic where I have worked, there are other studies that have measured the same energy budget components and even looked at some of the same wet-dry ecosystem comparisons as you are making here. I think the paper would be stronger if it linked into the Arctic literature a little better by directly stating whether the results obtained here are consistent with or different from the values and the overall patterns found in a broader set of arctic sites. This need not be a major addition to the text, but just digging in a bit deeper for each such value or pattern that you highlight in the Discussion.

Detailed comments:

Abstract. The last part of the final sentence in the abstract is rather vague. Simply "increasing interannual variability" seems rather general and less interesting than what you actually found. I suggest thinking about how you could "sharpen" this final statement to make it more specific and impactful. I could imagine you might want to say something about how interannual climate variability (winter precip) has been shown to have different feed backs to surface energy partitioning depending on ecosystem type...

p 4, Measurements. Accepted that you are using standard CarboEurope type procedures, but can you add a citation to a paper from your flux site that explains site-specific procedures and conditions? If not, then can you please add just a brief description of key site specific information such as how data were screened (spikes, low turbulence,

C3

unfavorable meteorological conditions) and how many gaps (what percentage of the record, what percentage of the daytime values that went into the energy budget measurements, or whatever you think is relevant)? I see that you later explain that you used the MPI online gap-filling tool to do the gap filling. I am just requesting a little info to characterize data screening and the overall situation with gaps at the two towers. And any other key, site-specific information or procedures that you think are important to the reader. If all of this is summarized in a different flux paper, then it is fine to simply cite it as above, and say that those details are provided in the cited paper.

p 7, line 10-11: It is very difficult to see the negative values of Rnet in the figure because of its vertical scale and the bar type. Please see general comment above on the figures.

p 8, line 6ff: Please provide a short sentence or two explaining how the 2 study years compare to the long-term climate of the site. Which of the study years was more typical of "mean" climate conditions for this location in terms of the different seasons and meteorological variables? Which aspects were most atypical—only the low-snowfall year, or anything else?

p 12, line 4: Recommend changing "shields off" to "reflects".

p 13, Energy Budget Closure section: I suggest that you move the energy budget closure discussion somewhere further up in the Discussion section, rather than as the last item. There are two reasons for this. First, it makes the paper less impactful if the very last item discussed is a technical system-performance assessment like energy budget closure, rather than one of the main findings on your scientific questions. Second, it is arguable that the reader should know whether you think the energy closure imbalance is typical of arctic sites or is in any way a problem before reading onward to the main scientific findings. You might even put it first in the discussion, or at least somewhat closer to the beginning of the discussion, and not the very last item.

In addition, do you think that variations in the depth of permafrost may have been

C4

a source of uncertainty/error in estimating the ground heat flux and energy budget closure, and if yes, you could mention that. Finally, I suggest that you end the part about energy budget closure with a comment on how the lack of closure would (or would not) affect your findings. For example, you may believe that the H and LE fluxes are OK and that the closure error is mostly in G. Rn is not affected, and so forth. I think it would make the paper stronger if you could provide a short sentence or 2 at most that interprets what the closure error means for the results you have obtained here.

p 14, line 8: Change "discusses" to "discussed"

Some other arctic energy budget references (not exhaustive, just some close examples to what you have done here)

Sturm, M., et al. (2005). "Changing snow and shrub conditions affect albedo with global implications." *Journal of Geophysical Research-Biogeosciences* 110(G01004).

McFadden, J. P., et al. (2003). "A regional study of the controls on water vapor and CO2 exchange in arctic tundra." *Ecology* 84(10): 2762-2776.

McFadden, J. P., et al. (1998). "Subgrid-scale variability in the surface energy balance of arctic tundra." *Journal of Geophysical Research* 103(D22): 28947–28961.

Rouse, W. R. (2000). "The energy and water balance of high-latitude wetlands: controls and extrapolation." *Global Change Biology* 6: 59–68.

Lafleur, P. M. and W. R. Rouse (1988). "The influence of surface cover and climate on energy partitioning and evaporation in a subarctic wetland." *Boundary-Layer Meteorology* 44(4): 327–348.

Lafleur, P. M., et al. (1987). "Components of the surface radiation balance of subarctic wetland terrain units during the snow-free season." *Arctic, Antarctic, and Alpine Research* 19(1): 53–63.

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