TC-2023-1

Reply document

Atmospheric drivers of melt-related ice speed-up events on the Russell Glacier in Southwest Greenland

Reply to minor revisions of editor Kristin Poinar in July 2023.

We thank the handling editor, Kristin Poinar, for her useful comments and improvement suggestions. The four comments are addressed in the document below with our reply in blue.

A. Reviewer comment C3 has two parts - "what" and "why". The "what" is not addressed in the revision / addition to the end of the paragraph, but it is addressed in existing text in the middle of the paragraph. If the authors flipped around the paragraph, it would be clearer. Roughly, I suggest:

- First sentence as is

- Next, the sentences that describe SOMs and Lagrangian trajectory analysis

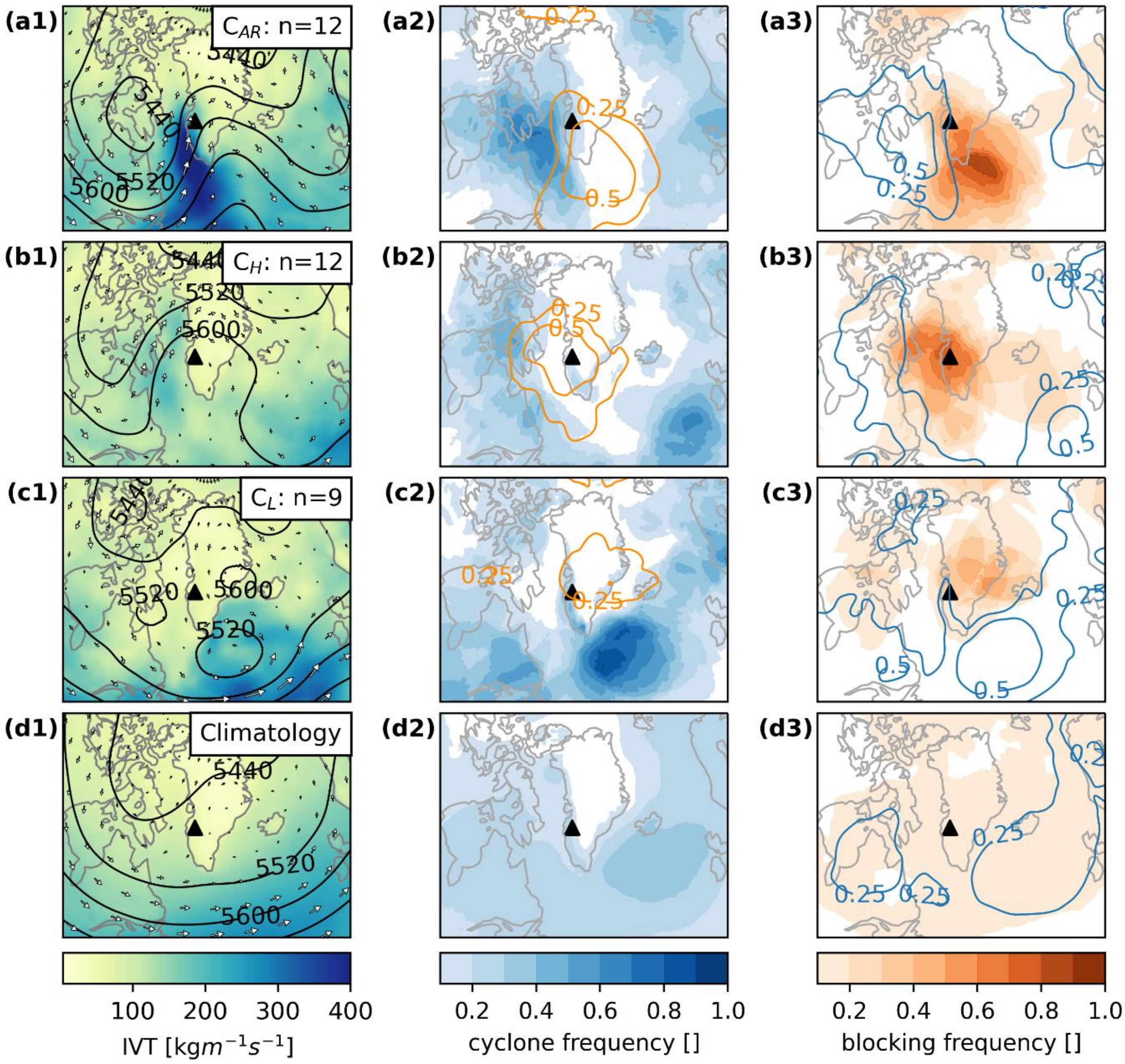
- Finally, current sentences 2-3, which state the research goals

We thank the editor for this comment, and restructure the paragraph as suggested:

Despite the relatively large number of studies that have focused on ice dynamics at the K-transect, systematic analysis of the links between the ice speed-up events and synoptic patterns has not been performed. In this study, we identify characteristic synoptic patterns linked to the speed-up events, based on the clustering algorithm known as self-organizing maps (SOMs). Once the patterns are identified, we apply a Lagrangian trajectory model to analyse their 5-day backward trajectories. The Lagrangian perspective is a particularly useful addition, e.g., to identify atmospheric flow features such as foehn (Elvidge and Renfrew, 2016), to understand atmospheric processes driving temperature extremes (Röthlisberger and Papritz, 2023), and to link synoptic patterns with the thermodynamic processes relevant for Arctic (Wernli and Papritz, 2018) and GrIS surface melt (Hermann et al., 2020). Here, the trajectory analysis (Sec. 4.3) provides a process-based link between the synoptic patterns (i.e., SOM clusters) during melt-induced ice speed-up events (Sec. 4.2) and the local conditions observed at the Russell Glacier (Sec. 4.4). As climate change will potentially bring substantial changes to weather systems and their variability, impacting the ice dynamics of this region, it is important to better understand current atmospheric drivers of the speed-up events in this region. This study aims to close this knowledge gap, in particular by identifying melt-induced ice speed-up events and investigating synoptic patterns that are linked to these events.

B. Figure 7: I like the addition of the wind vectors, but the black arrows disappear in the dark blue atmospheric river in the IVT map (panel a1), defeating the main purpose for their addition. The black arrows should be outlined in white, or two layers of arrows should be used: bold white arrows underneath with thinner black arrows superimposed (or vise versa). This would ensure that the wind direction arrows are visible over any IVT color.

We thank the editor this comment and changed the color to white arrays with a black outline, which improves the visibility over any IVT color.



(a1)
C$_{AR}$: n=12
5440
5520
5600
(a2)
0.25
0.5
(a3)
0.5
0.25
(b1)
C$_H$: n=12
5440
5520
5600
(b2)
0.25
0.5
(b3)
0.25
0.5
(c1)
C$_L$: n=9
5440
5520
5600
(c2)
0.25
(c3)
0.25
0.5
(d1)
Climatology
5440
5520
5600
(d2)
(d3)
0.25
100 200 300 400
IVT [kg$m^{-1}s^{-1}$]
0.2 0.4 0.6 0.8 1.0
cyclone frequency []
0.2 0.4 0.6 0.8 1.0
blocking frequency []

C. Reviewer comment C12 - The added explanation for the choice to show the 750 hPa trajectories is too long and focuses on the wrong thing. Please revise by shortening the discussion of how valuable the supplementary figures are, to give prominence to why the 750 hPa are useful (i.e. the part of the sentence with the Tedesco (2013) reference).

We thank the editor for this comment and edited the paragraph by shortening the discussion of the trajectories in the supplementary figures.

~~While air masses arriving near the surface (Fig. S1) share similar characteristics irrespective of the synoptic weather situation, as they all end in the GrIS boundary layer over ice, and are often affected by prevailing katabatic winds (Fig. S1d,e), they provide valuable information about the near-surface conditions in each cluster. Contrary to the surface trajectories, backward trajectories that started in the free atmosphere provide additional information about the large-scale flow unique to each cluster and the processes that occurred along that trajectory. Air masses arriving at around 750 hPa (Fig. 8) are able to show the development of moisture and temperature patterns that are relevant for surface melt (e.g., Tedesco et al., 2013), while those air masses arriving at 500 hPa (Fig. S2) provide additional information about higher-reaching clouds and the large-scale dynamics of the troposphere.~~

Air masses arriving in the lower troposphere at around 750 hPa (Fig. 8) are able to show the development of moisture and temperature patterns that are relevant for surface melt (e.g., Tedesco et al., 2013), as highlighted by a high moisture content of up to 6 g kg^{-1}(Fig. 8f) and the visibility of coherent trajectory-patterns (Fig. 8a-c). Thus, we primarily focus on lower tropospheric (750 hPa) trajectories, but additionally analyse the trajectories of: (i) air masses arriving at 500 hPa (Fig. S2) to get information about higher-reaching clouds and the large-scale dynamics of the troposphere, and (ii) air masses arriving at surface level (Fig. S1) to get information about the near-surface atmospheric conditions in each cluster.

D. Reviewer comment C34 - "shielding form" should be corrected to "shielding from" (typo)

We thank the editor for spotting this typo and changed ‘form’ to ‘from’.