Response to Referee 2 - Jono Conway:

General Response: We thank Jono Conway for his very valuable comments which helped significantly to improve the representation of the results and the informative value of the figures. We revised figures 2, 3, 4, 5, 6, 7, 8, 9 and 10. All suggested figure improvements and adjustments have been made and checked for consistency. Used colours are now colour-blind friendly. Additionally, added three new figures:

- new Figure 2 describing the multi flux decomposition,
- new Figure 3 showing the time series of air temperature, wind and the classification scheme for katabatic and disturbed conditions.
- new figure 13 showing the divergences of the vertical and horizontal heat fluxes.

Furthermore, we added a new table showing estimates on flux footprint area and spitted the original table 1 in two tables – table 2 and table 3.

In the following we respond to all comments and provide the revised figures the responses are referring to at the end of the document.

General comments

1. The manuscript would benefit from the addition of some context for the general meteorological conditions during campaign, especially timeseries of temperature and wind speed/ direction during the 5 selected days. This would provide the reader with a more intuitive introduction to the meteorology between relationships are discussed in later figures. These figures should also include an indication of time periods defined as 'katabatic' and 'disturbed' as this is unclear.

Response: We agree and have now added the time series of temperature anomalies, the wind velocity, deviation of wind direction from 200° (prevailing Katabatic wind direction) and the classification between katabatic and disturbed flows for two of the measurement days to demonstrate conditions during katabatic and disturbed situations. We decided not show the data for all five days as this would make the figure too unclear.

2. In the discussion section, the authors should reflect further on the (potential) implications for measurements and modelling of turbulent heat fluxes, wind speed and air temperature distributions on other glaciers. Along with this the authors could provide more recommendations for future research.

Response: Yes, we agree with the referee and will add a discussion on implications for modelling an measuring the distribution of turbulent heat fluxes, temperature and wind speed. A postdoc based at Innsbruck is currently doing 240m and 48m resolution LES simulations of these days with WRF which will allow us to include some specific experiences relevant to combining and comparing measurements such as these with modelling efforts. In terms of future research, we now include lessons learned from our instrumental campaign and some specific research goals we would want to explore in a follow up campaign if funding were available.

3. Specific comments to improve the paper are provided below, but in general the paper is very well written, and figures well presented. My only concern with the analysis presented is the use of ratios to normalise temperature and wind speed in Figure 6, 7 and Table 1, and I would suggest the authors instead use anomalies (in K and ms-1, respectively). This is especially important for temperature, where the fractional difference for the same change in temperature (in C) become smaller as daily mean temperature (in C) increases. If the authors wish to retain the current method, the theoretical basis for using ratios needs more explanation. The discussion of

temperature differences between sites and situations is also very hard to compare with the current figures (see specific comments), but a change to anomalies and addition of timeseries of from each site should address this. While the use of scatter plots makes it a little hard to interpret the density of data in certain figures, the ability to use colour warrants this approach. For some figures (Fig 9 and 10), histograms added along the x and y axes would enable the reader to see differences in the distribution that are discussed in the text (e.g. https://matplotlib.org/3.1.0/gallery/lines_bars_and_markers/scatter_hist.html).

In short, with some changes to clarify ambiguities of method and the presentation of additional results to support some statements, this manuscript will make a good addition to the literature.

Response: We followed Jono Conway suggestion to use anomalies and adapted Figure 6 and 7, as well as statistics shown in table 1. We further followed the suggestion to add histograms to figures 7, 9 and 10 which much better describe the distribution of the data and allows a better comparison between the data (i.e. between station or flow types). Figures are shown further below under specific comments.

Specific comments:

- 41 – the sensitivity of melt rate to air temperature is not only controlled by net longwave and turbulent heat flux, but also controlled by snowfall-albedo feedbacks – consider changing "controlled" to 'strongly affected' or similar.

Response: yes, we agree. We replace "controlled" by "strongly affected".

- 48 – 'several studies' – worth adding additional references to this sentence or rewording.

Response: we reworded the sentence.

- 49 – "near-surface warming" – it is unclear what is meant here – the katabatic models discussed in the previous sentence predict enhanced turbulent heat fluxes due to increased wind speed, not temperature. Please revise.

Response: to be clear that these are different processes we changed the corresponding sentences to read: *Zhong and Whiteman (2008) claim that near-surface warming induced by katabatic flow could also be caused by along-slope warm-air advection, while Pinto et al., (2006) identify the entrainment of potentially warmer air down to the surface driven by stronger turbulent mixing. Furthermore, some studies highlighted the effect of katabatic flows in laterally decoupling the local atmosphere from its surrounding, thus lowering the climatic sensitivity of glaciers to external temperature changes (Shea and Moore, 2010; Sauter and Galos, 2016; Mott et al., 2019).*

- 122 – please list the model numbers of the other instrumentation, including the young anemometers, the 2d sonic anemometer and the air temperature, rh and pressure sensors. Please also note if the t/rh sensors were passively or actively ventilated and if any corrections were made to raw data aside from the eddy-covariance data.

Response: yes, we add the model numbers and the information that the RH/T sensor was actively ventilated.

- 127 – it would be useful to expand further on the choice of 1-minute averaging period, as this departs significantly from often-used averaging periods of ~30 minutes. Perhaps present some of the analysis mentioned or comment on the effect of the short averaging period on, e.g. average heat fluxes.

Response: We have now added a plot showing the results of the MRD which highlights our choice of the averaging time, and have expended the text to provide more information.

The turbulence data were processed as follows: multi-resolution flux decomposition (MRD) was used to determine the optimal averaging time for the turbulence data (Vickers and Mahrt, 2003). MRD works as a wavelet transform that decomposes the signal into dyadic scales while preserving Reynolds averaging rules. The appropriate averaging time is usually taken to be that time scale at which the contribution to the flux (at its inter-quantile ranges) first crosses over zero (Vickers and Mahrt, 2003). The MRD analysis of the heat flux for the four examined stations during the period of the campaign (Figure 2) shows that due to its stable nature, the dominant turbulent contribution to the flux comes at scales smaller than 1 min, while the scales larger than 1 min already show a strong contribution of the (sub)mesoscale motions. The exception here is station TT1 which exhibits a higher median contribution to the turbulent flux up until a 5 min scale. Following the approach of Vickers and Mahrt (2003) however, we choose the appropriate averaging time scale to be that where the upper quantile crosses over zero, for comparability reasons we therefore block average the data from all stations with an averaging time of 1 minute

- 147-155 – please clarify the criteria used to define katabatic vs disturbed conditions as there are several different versions given in this paragraph and the figure captions – i.e. did disturbed situation require wind shift from just W/NW or also E sector?

Response: disturbed situation also include flow from easterly sector, but these were very rare. Now the analysis of horizontal heat flux and horizontal heat flux divergence was limited to the small wind sector of 290°+/- 30° which is flow along the transect (see revised methods below). This is also indicated in Figure 2 and 8. *We added the following criteria:* The classification varies for averaging time periods of 1 and 30 minutes. The data analysis based entirely on 1-minute averages used the following classification (as applied in Figure 2): (1) Pure katabatic conditions are defined as flows with persistent flow direction from southwest (defined as 200° at station TT3) and wind velocities larger than 3 m/s. (2) Disturbed conditions are defined by a deviation of wind direction of more than 40° and less than 100° from the dominant katabatic flow direction. This limits the flow sector to +/- 30° from the flow perfectly aligned with transect. Following these criteria, the analysis of turbulence data was performed for the following five days: 4, 5, 11, 15 and 20 August (referred to as day 1-5). During these days, persistent katabatic flow was disturbed by westerly winds or up-valley flows (strong shift of the dominant wind direction during the day from southwest to the westerly or easterly wind sector). Data used for the 30 minute-averaged profiles were classified using the following criteria: Pure katabatic flows are defined as flows with persistent flow direction from southwest (defined as 200° at station TT3) and wind velocities larger than 3 m/s for the entire 30-minute averaging time period. All other flows were classified as disturbed flows without lower limit of wind direction. Note that the upper turbulence sensor (CSAT, level 2) at TT2 was not working until 7 August, due to a faulty cable which had to be replaced. During this period turbulence profiles were analyzed for stations TT1 and TT3.

- please define whether 'time periods' on line 149 means 1-min or 30-min periods.

Response: it refers to each 1-minute average.

- Line 150 says that disturbed required WD shift of >50 degree over 30 mins, yet Figure 2 has many disturbed situations with average WD around 200 degrees?
- Figure 2 caption says katabatic required consistent WD during 30-min period – are there time periods that are excluded from the analysis as they do not fit either criteria?

- Are the data sub-set solely on one station (tt3), or classified individually based on WD at each station?

Response: the subsets are classified based on the wind direction and velocity measured at TT3. This has now been more clearly stated in the text and the deviations for stations other than TT3 were discussed (see above).

- Perhaps adding a timeseries of each case-study day, showing periods defined as katabatic and disturbed at TT3 would be useful.

Response: we fully agree that as it is stated in the text is confusing. We revised the method section to be clearer about the two different classification schemes used for analysis based on 1-minute averages and on 30-minute averages. Two slightly different schemes are used to allow a stricter classification for smaller averaging times as we expect more homogenous flow conditions during shorter time periods. We further show a time series now demonstrating the stricter classification scheme (see above).

- 223 – 'Flux footprints tend to be smaller during disturbed situations." Figure 3 shows a larger overall footprint area – perhaps worth clarifying that footprints for individual periods are smaller but the more varied orientation during disturbed conditions results in a larger overall footprint, if this is the case.

Response: Yes, we agree and added this to the text and have also added the information on the actual area enclosed by the footprints for the different conditions. We have also calculated the area enclosed by the footprints for the different conditions and stations. Increasing the roughness from 0.004 to 0.01 results in a decrease of footprint sizes that depends on the flow conditions, but is consistent between the stations. For katabatic flow the footprint size is 88 % of the original, and for the disturbed: 79 %. We now provide the areas of the footprint for two different roughness lengths:

Table 1: Estimates on flux footprint area in m^2 for surface roughness of z0 = 0.004 m and z0 = 0.01 m. Flux footprint areas are provided for disturbed and katabatic flow conditions and for the three transect stations TT1, TT2 and TT3.

With z0 = 0.004

	TT1	TT2	TT3
katabatic	$2.88 *10^3$	$2.31*10^3$	$3.43*10^3$
disturbed	$6.35*10^3$	$6.5*10^3$	$8.42*10^3$

With z0 = 0.01

	TT1	TT2	TT3
katabatic	$2.5 *10^3$	$2.04*10^3$	$3.03*10^3$
disturbed	$5.01*10^3$	$5.1*10^3$	$6.67*10^3$

(decrease of footprint size with increasing roughness between 0.004 and 0.01 is Katabatic: 88 % of the original, disturbed: 79 %)

- 227 – Do you think the different instrumentation contributes significantly to the differences observed between level 3 and the lower two levels?

Response: We have now skipped this part of the text as wind data in the original version had some errors. Now, there is no strong increase in wind velocity between level 2 and 3.

- 227 – Do you mean a secondary larger-scale wind system above level 2? If so, please clarify.

Response: This part is skipped from the text as wind data in the original version had some errors. Now, there is no strong increase in wind velocity between level 2 and 3.

- 234 – “This extreme increase of wind speed with height is confirmed by preliminary numerical simulations (not shown)”. As the reader cannot assess this without presenting the data, please remove or modify this sentence.

Response: we agree, we removed this sentence.

- 259 – ‘higher streamwise momentum fluxes” please revise – I presume you mean “larger negative streamwise momentum fluxes”?

Response: yes, we agree, we revised this part accordingly.

- 268 – ‘on 2018-08-20’ – I presume you mean on all case-study days? Please revise

Response: thanks! Yes, this is true – we revised it.

- 277 – ‘the temporal variability of flux profiles increased significantly for disturbed situations’ – it is very hard to assess this statement from Figure 5 – please add further statistics to describe the mean and variability of the fluxes or reword.

Response: we have to admit that this is not very clear and removed this sentence.

- Figure 6 – consider moving TT3 to the x axis on these plots as it is functioning here as a common variable (hence is more like the ‘independent’ variable).

Response: we revised figure 6 now showing kernel distributions for all stations for katabatic and disturbed conditions. We revised the text accordingly.

- Figure 6 – it is hard to assess the density of points in the scatter plot – consider using a transparency for the points so that more dense data shows as darker shades.

Response: Please see comment above.

- Figure 6 – the colour scale for disturbed conditions would be better to avoid white tones as the are hard to read. Scale used in Figure 9 would be better.

Response: please see comment above.

- 308-332 – there are many statements in this section at are not clearly supported by the data presented in Figure 6. The addition of timeseries of WD/WS and temperature from multiple sites would be of great benefit here.

Response: we are now showing the time series of 2 days, for stations TT1 and TT3. We now also show the mean temperature anomaly for each station and condition.

- 310 – “significant increase in the near-surface air temperature of several degrees (Fig. 6d-f)” – this cannot be ascertained from the current figure 6 as the units are normalised. Please use anomalies as suggested in general comments section or provide additional results to support this statement.

Response: we now show the anomalies indicating the change in temperature which provides a clearer picture.

- 314 – “Local air temperatures at the higher altitude station TT4 showed the lowest sensitivity to changes in wind direction at TT3
- .” It is unclear how the data support this statement – please clarify and revise.

Response: this is shown by the smallest temperature anomaly for disturbed flow. We revised the text accordingly:
Local air temperatures at the higher altitude station TT4 showed the lowest sensitivity to changes in wind direction at TT3, which is reflected by the smallest mean temperature anomaly for disturbed flows. Wind direction data at TT4 (not shown) suggest that the katabatic flow seemed to persist at the higher-altitude station TT4 when at the same time all transect stations already evidenced a westerly flow. Data thus suggest that the station TT4 was more sheltered from westerly flows than stations located at lower parts of the glacier.

- 315 – "The katabatic flow seemed to persist at the higher altitude station TT4 when at the same time all transect stations already evidenced a westerly flow (Fig. 6b)." It is unclear how the data support this statement – please clarify and revise.

Response: Yes, it is true the figure 6 does not show this because we always show the wind direction deviation based on TT3 measurements. As we want to stick with that we changed the sentence now to:
Wind direction data at TT4 (not shown) suggest that the katabatic flow seemed to persist at the higher-altitude station TT4 when at the same time all transect stations already evidenced a westerly flow.

- 317 – "Air temperatures at the glacier tongue (WT1) appeared to be strongly affected by up-valley flows (Fig. 6f)." It is unclear how the data support this statement – please clarify and revise.

Response: we removed this sentence.

- 326 – "explain a larger spatial variability of the air temperature" – It is unclear how the data support this statement – please clarify and revise.

Response*:* We agree with the Referee that spatial differences are quite similar between the two flow conditions. We therefore decided to remove this sentence.

- 329 – Are the cooler temperatures during katabatic flows affected by diurnal changes in temperature? Ie. are katabatic conditions more common during cooler periods at night time?

Response: Our analysis is only focused on the daytime hours, as mentioned in the text, and therefore we only examine daytime temperatures. We do also observe katabatic flows in the afternoon – we can therefore not link cooler air temperatures to diurnal changes.

- Table 1 – what is UT ?

Response: We thank the referee for detecting this inconsistency – UT is named V elsewhere in the text - *wind velocity component along the transect V (wind speed component along the Transect)*

- 342 – 'all four turbulence stations' do you mean 'all three turbulence stations' or 'all 6 turbulence sensors'. Also please list what height data is from

Response: We revised the text now referring to three across glacier transect stations. We also added a more detailed list of heights etc.
Each tower measured wind properties at three heights above the ice surface (1.7 m (level 1) and 2.35 m (level 2) and 2.9 m (level 3)), as well as air temperature, relative humidity and pressure at level 1. The temperature and humidity sensors were actively ventilated. At the four turbulence towers (TT1-TT4) the wind sensors at level 1 and 2 were Campbell CSAT3 sonic anemometers, sampling at a frequency of 20 Hz, while as the fifth tower (WT1), with at these levels was recorded with two Young anemometers. At all towers the level 3 wind sensor was a two-dimensional sonic anemometer. Air temperature, relative humidity and air pressure was measured at each station at measurement level 1 with a 1-minute resolution.

- showed small spatial differences' – this is very hard to interpret from Figure 7 – a histogram of differences between fluxes at different stations would support this.

Response: we now add histograms to Figures 7. The distributions nicely show that spatial differences of turbulent heat fluxes are particularly small for disturbed flows and are higher for katabatic flows.

- 362 – "despite significantly higher air temperatures observed at TT1" – this is not shown and needs to be supported by additional results – perhaps a histogram of temperature differences between each site in different conditions.

Response: a histogram of air temperatures is now shown in Figure 7. Additionally, mean anomalies of air temperature are given for TT1 and TT3 showing higher air temperature anomalies at TT1 for disturbed situations.

- Figure 8 – does this figure include all periods from the 5 days, or only disturbed periods? Please clarify in the caption. Please also add units and level used for HA calculation.

Response: we revised Figure8 accordingly.

- 423 – "Similar to heat advection, peak vertical turbulent heat fluxes coincided with peak V-component at the centerline." - to what extent is this due to the correlation between mean wind speed and vertical fluxes? Please discuss.

Response: we revised the discussion of correlations between HA, wind and vertical turbulent heat fluxes: *We are interested in the efficiency of the horizontal heat transport to warm near-surface air layers and thus to indirectly promote turbulent heat exchange towards the ice surface contributing to the surface energy balance. We therefore analyzed the relationship between horizontal heat advection HA (TT1-TT2 and TT2-TT3), the vertical turbulent heat flux and the V-component along the transect, illustrated in Fig. 9. Additionally, correlation coefficient R between those variables are provided (Table 1). Note that for this analysis we considered only data for the 60° wind sector (see methods, disturbed conditions). Consistent with small correlations between air temperature and $\overline{w'T'}$, correlations between HA and $\overline{w'T'}$ are rather small for all stations. Highest correlation was found at TT3 (0.31). Peak vertical turbulent heat fluxes coincided with peak V-component at the centreline. Correlation coefficients $R_{(w'T',UT)}$ were higher between TT2 and TT3 (0.56). Turbulent heat fluxes showed slightly smaller mean values at TT1 (Figure 9b), coinciding with significantly smaller wind speeds (Figure 9a). Furthermore, the correlation between wind speed and vertical turbulent heat flux at the peripheral station was smaller (-0.5) than at the centreline (-0.62). Thus, at the centerline (TT3) strong winds not only promote stronger heat advection (Figure 9a) but also promote maximum downward turbulent heat exchange (Figure 9b). Heat advection appears to enhance turbulent heat exchange towards the glacier surface by enhancing near-surface temperature gradients. Consequently, at the glacier centreline (TT3) stronger winds enhance both the heat advection and the turbulent heat exchange.*

- 424 – "Correlation coefficients R(w´T´,UT) were high between TT1-TT2 and TT2-TT3 station pairs with a slightly higher value for stations closer to the centerline." It is unclear how this relates to the data presented in Table 1. Please revise.

Response: please see the revised text above.

- Figure 9 - consider adding histograms to each axis. It is currently very difficult to compare the distribution of points between different conditions and sites.

Response: we added histograms to Figures 9 and 10. We now show heat advection as a function of V component and vertical heat flux. Showing both stations in one plot allows a much better comparison of the distribution of the data. In Figure 10 we now present all stations in one plot. Panel c additionally presents the data from station TT3 but for katabatic and disturbed situations to allow a direct comparison.

- 509 - The steep moraine sides are likely to play a role in the sheltering of the site closest to the glacier margin, especially considering the sharp slope transitions and short distances involved. Thus, the flow hitting the glacier edge may not be well developed and still be affected by lee-side flow separation etc, reducing its ability to influence the stable glacier boundary layer. This may be worth discussing further here.

Response: we thank Jono Conway for his thoughtful comments and revised the conclusion now reading: *The topographic setting which is typical for alpine glaciers are likely to play a significant role in the sheltering of the site closest to the glacier margin. Steep moraine sides and sharp slope transitions at the glacier margin strongly affect the local boundary layer flow (i.e. lee-side flow separation) reducing the ability of the flow hitting the glacier edge to influence the stable glacier boundary layer. Contrary, well developed flows at the glacier line and associated higher wind speeds appear to promote turbulent mixing close to the surface allowing the rush-in of high-speed fluid from the outer region into the near-surface atmospheric layer, as shown by Mott et al., (2016) for a wind tunnel experiment with warm air advection over a melting snow surface.*

- 528 – as the study only presents data from 5 days, it would be more meaningful to say "during five days that displayed a distinct disruption of down-glacier flow during a three-week period in summer 2018." Or similar.

Response: we followed this suggestion and revised this part of the manuscript.

- 541 – 'induced by strong westerly winds' – while this makes sense, the origin of the flow is still speculative so please revise.

Response: we revised this paragraph not speculating about the origin of the flow.

- 552 – 'At the peripheral areas stronger exposure' – shouldn't this be 'weaker exposure'.

Response: Yes, we changed that to weaker exposure.

- 552 – As wind direction is not presented for TT1 it is impossible to assess if the 'preservation of a very-shallow low-level katabatic jet' is supported by the results. Figure 1 shows the WD is aligned at all levels at TT3 during disturbed situations – in order to support a katabatic jet at TT1 the wind direction would need to be maintained down-slope. The BL could still be decoupled at TT1 because of the strong thermal stratification, but this does not necessarily mean that a katabatic jet will exist at TT1. Please revise.

Response: Yes, the referee is right at this point and we try to be more clear that the turbulence data (positive momentum fluxes) indicate a wind jet below the lowest measurement level but data do not allow to distinguish between a glacier flow or slope flow*: At the peripheral area weaker exposure to the westerly winds might promote the preservation of a very shallow low-level jet which potentially decouples near-surface turbulence from higher atmospheric levels (Parmhed et al., 2004). Although no wind direction measurements are available at heights below 1.7 m, positive momentum fluxes at the lowest measurement height indicate the existence of such a shallow low-level jet height which might be connected to a glacier flow or a thermal flow originating from the moraine slopes.*

- 575 – "the frequency of such flows at other glaciers is not known" – this comment highlights that fact that the frequency of these flows has not been presented in the current study. This would be an easy and useful addition to the results.

Response: During the entire 3 weeks of data 20 % of the data fulfilled the conditions of disturbed conditions. 45% of the data is categorized as katabatic conditions. We added this information to the method section.

Editorial comments:

- Temporal changes

Response: we changed change to changes.

- 121 – 'while as the fifth tower (WT1), with at these' –> 'while at the fifth tower (WT!), these'

Response: thanks, we revised this.

- 125 – suggest changing 'methodology' to 'data processing'

Response: we changed methodology to data processing and also change turbulence towers to instrumentation

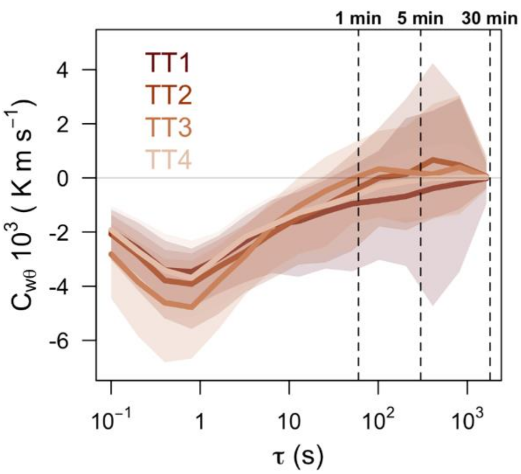


Figure 2: Multi-resolution flux decomposition of buoyancy flux as a function of time scale t for the four examined stations.

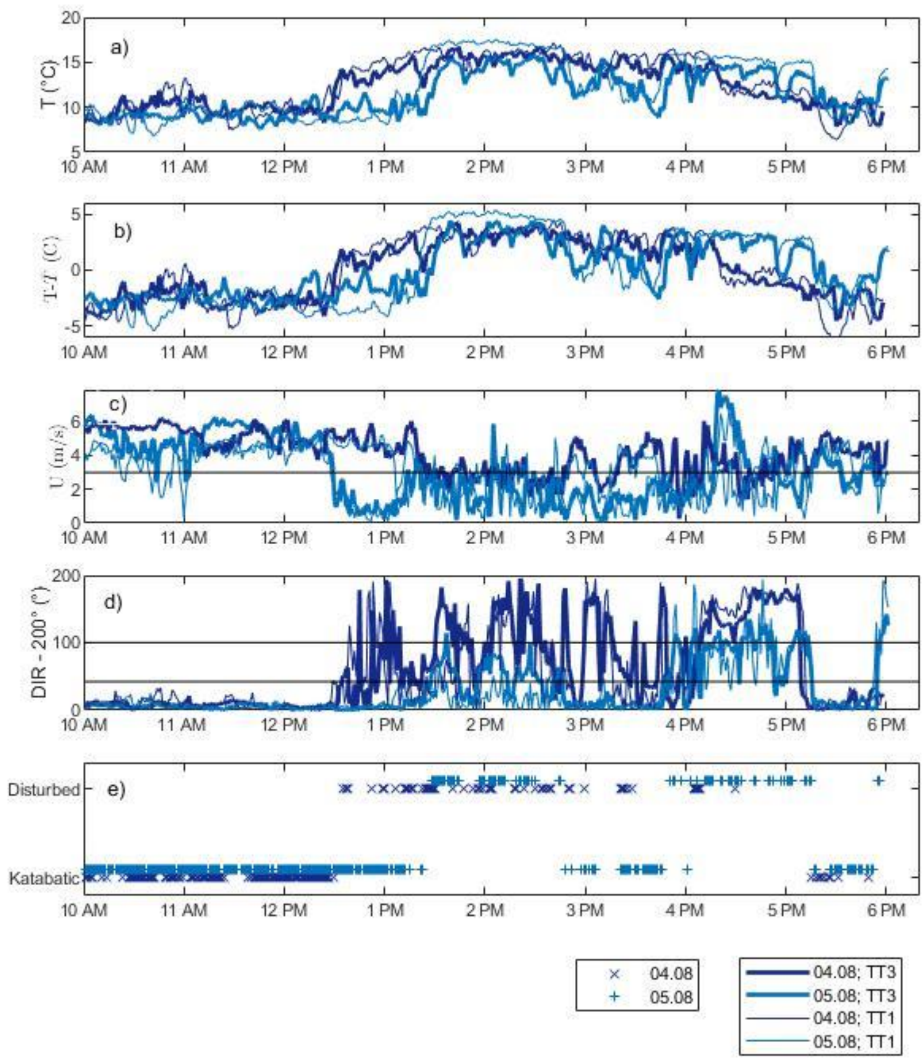


Figure 3: 1-minute averages of a) air temperature, b) air temperature anomalies, c) wind velocity, d) wind direction deviation from the prevailing katabatic wind direction (200°) and e) of classification of katabatic and disturbed flow based on station TT3. Solid line indicate the lower limit of 3 m/s for katabatic flow classification in c) and the lower and upper limit of the deviation of wind direction from dominant katabatic flow direction to be classified as disturbed flow in d). Data is shown for days 1 and 2 (04.08 and 05.08).

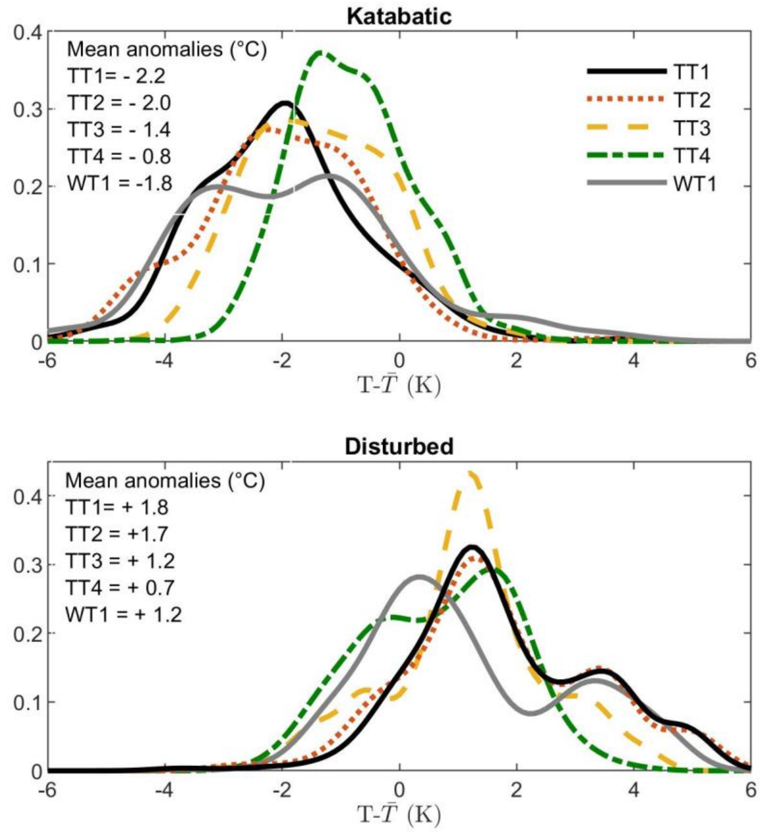
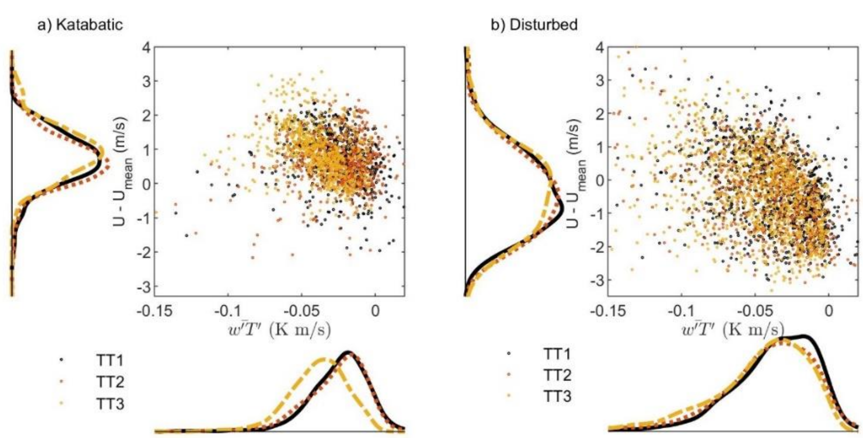


Figure 6: Anomalies of air temperatures from mean daytime air temperature at the respective stations TT1, TT2, TT3, TT4 and WT1 are shown for katabatic and disturbed conditions.



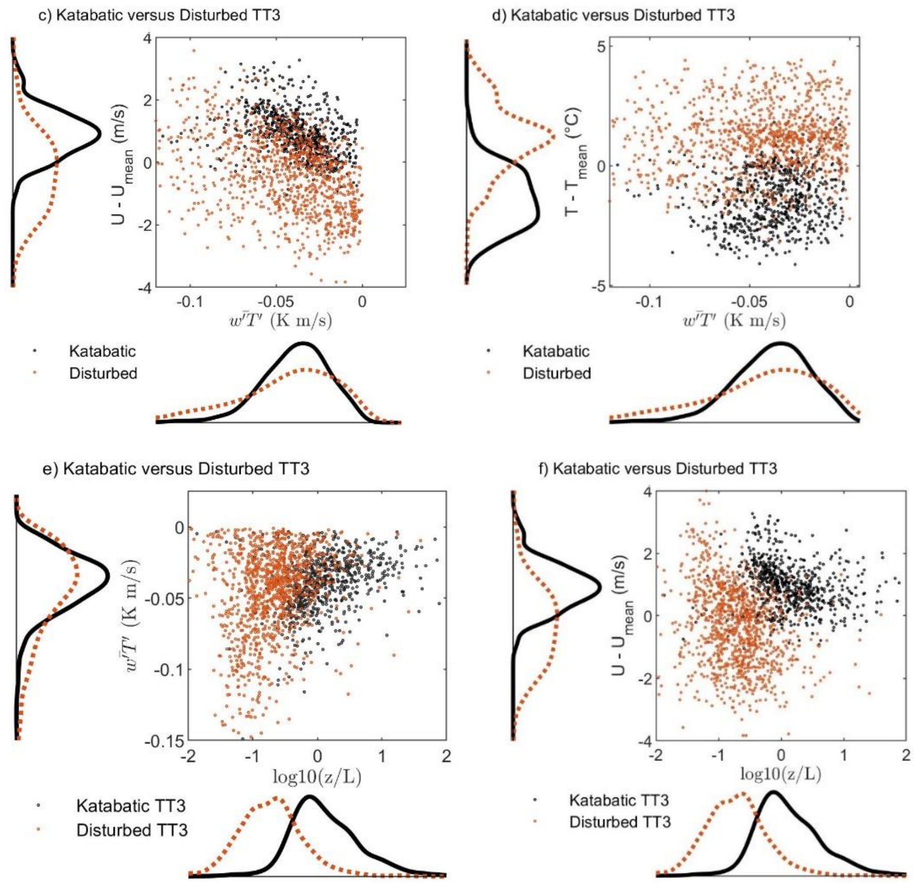


Figure 7: Vertical heat flux plotted against anomalies of wind speed from mean daytime wind speed shown for stations TT1 –TT3 for katabatic conditions *a) and disturbed* conditions *(b). Vertical turbulent heat flux plotted against anomalies of wind speed from mean daytime wind speed (c) and against anomalies of air temperature from mean daytime air temperature (d) shown for station TT3 for katabatic and disturbed* conditions*. Logarithm of Stability parameter z/L plotted against Vertical turbulent heat flux (e) and normalized wind speed (f) measured at TT3 during katabatic and disturbed flows.*

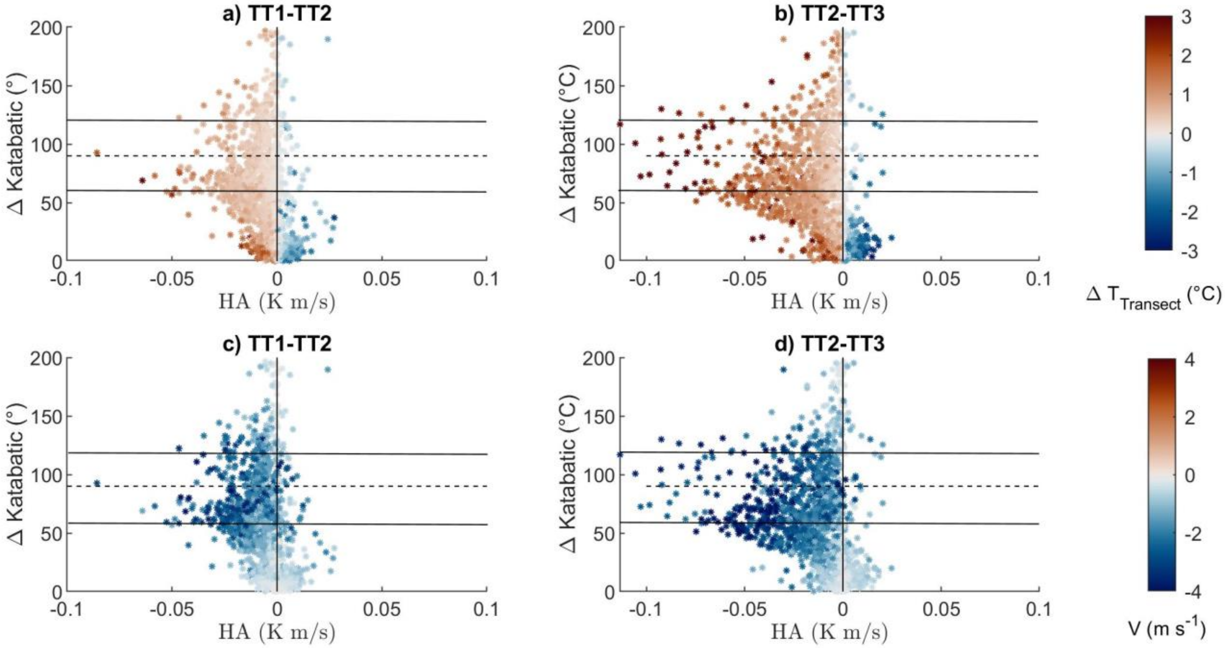


Figure 8: *Horizontal advection of heat (HA) calculated between stations TT1 and TT2 (a) and TT2 and TT3 (b) from the first level above ground are plotted against deviation from katabatic wind direction for 5 selected days with periods of clear deviation from the dominant katabatic flow direction. Colour codes indicate the measured air temperature difference between stations TT1 and TT2 and TT2 and TT3 (a, b) and the wind velocity component along the transect V (wind speed component along the Transect) (c, d). Note that all data (katabatic and disturbed flows) are shown here. Positive values of air temperature difference indicate higher air temperatures at the station closer to the glacier margin. Negative wind velocity component indicate wind from station TT1 to TT3. The dashed line indicates the deviation of the wind direction 90 degree from the dominant katabatic flow which is the orientation of the transect. The solid lines indicate the 60° wind sector the heat advection analysis for disturbed situations is based on.*

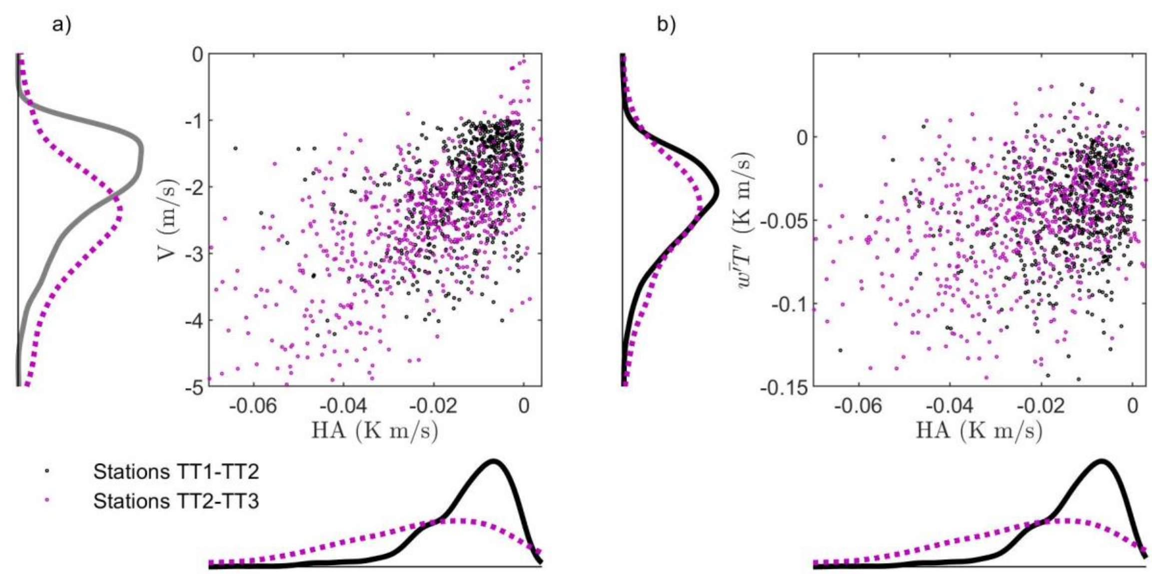


Figure 9: *Horizontal advection of heat (HA) between stations TT1 and TT2 and TT2 and TT3 plotted against measured wind speed component along the transect V (a) and turbulent vertical heat flux (b). Note that for this analysis we considered only data with evidence of horizontal heat advection along the transect (U-component along the transect larger than 1 m/s and positive air temperature differences).*

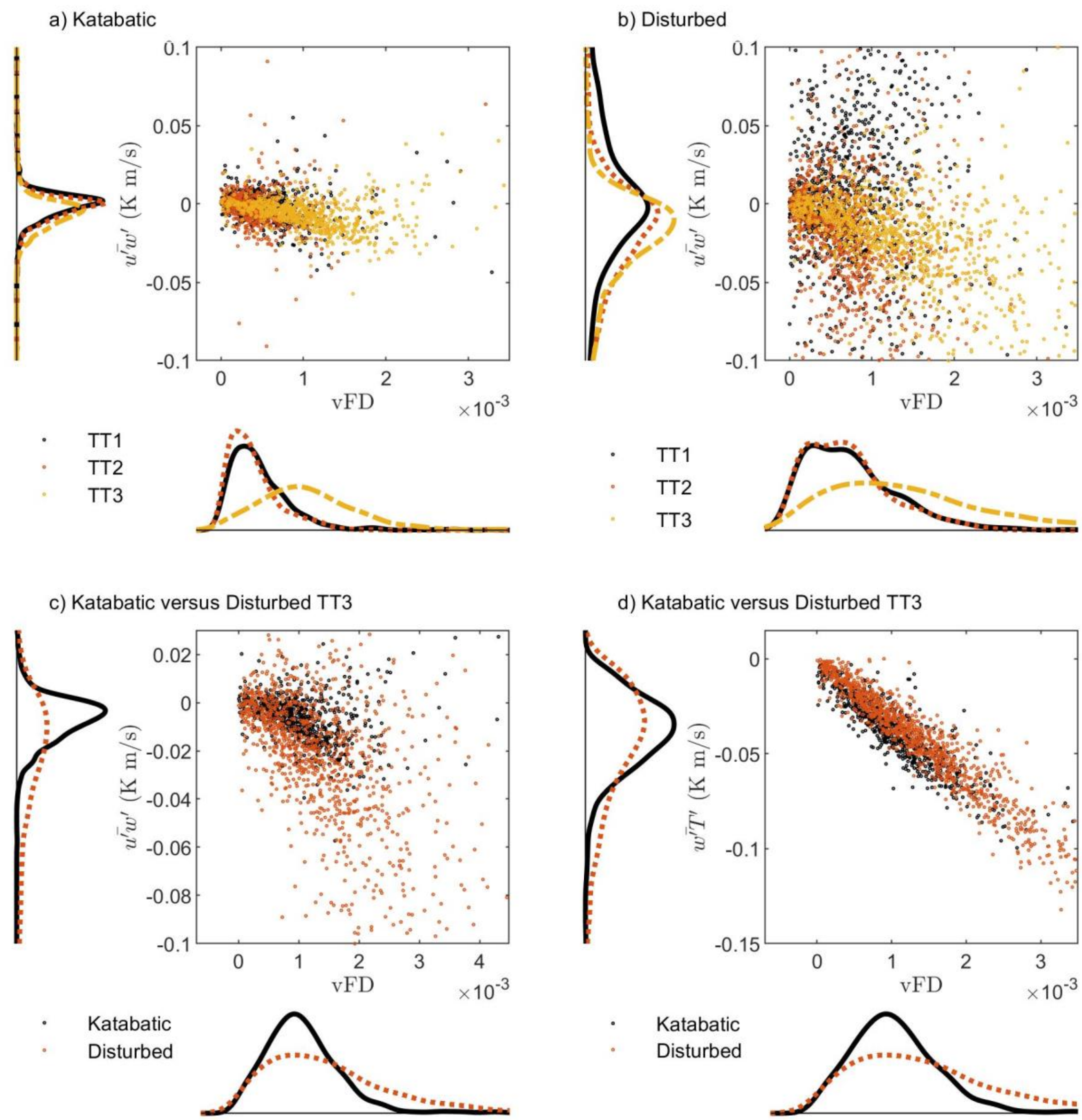


Figure 10: *Vertical flux divergence plotted against vertical momentum flux for stations TT1, TT2, TT3 are shown for katabatic (a) and disturbed* conditions *(b). To allow a better comparison of fluxes during different flow conditions the vertical flux divergenc (vFD)e is plotted against streamwise momentum flux (c) and against vertical turbulent heat flux (d) for station TT3 for katabatic and disturbed flow.*

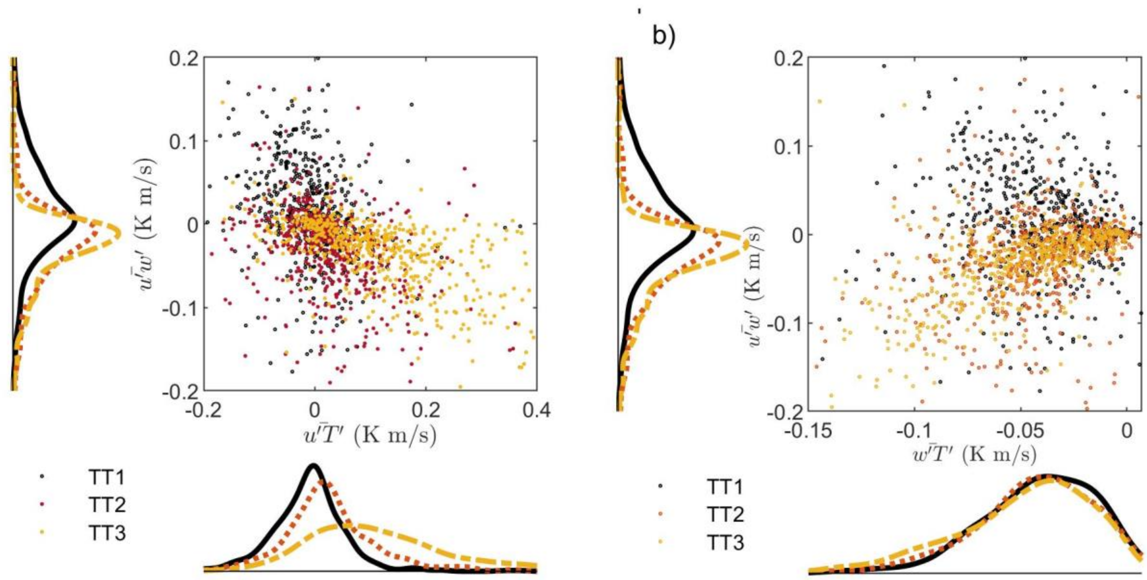


Figure 12: Streamwise horizontal turbulent heat flux plotted against streamwise momentum flux for stations TT1, TT2 and TT3 (a). Vertical turbulent heat flux plotted against streamwise momentum flux for stations TT1, TT2 and TT3 (b). Data are only shown for disturbed conditions and the 60°wind sector from 260° to 320°.

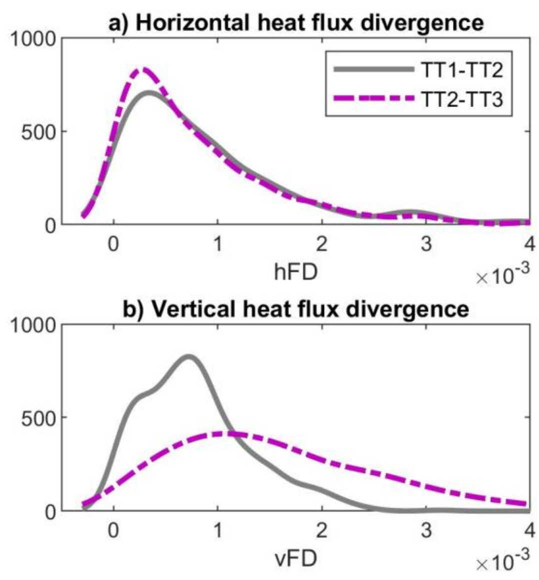


Figure 13: Kernel distribution of horizontal (hDF) and vertical (vDF) heat flux divergence shown only for disturbed situations and the wind sector 240° to 300°.