

General Answer:

Thank you for your time and consideration to review the manuscript again. We are delighted to present to you the answers to the minor revisions. We have addressed all your concerns.

Reviewer 2:

The authors edited the manuscript and added new information. However, in my opinion the comparison of A-TIV with the TIV algorithm is still not detailed enough. The authors added a table showing the percentage of vacant cells and the importance of single TIVs to the A-TIV velocity estimate. However, it remains unclear how the different velocity fields agree with the reference data. I encourage the authors to add a figure comparing wind speed and wind and temperature perturbations from TIV and A-TIV and add the numbers for TIV to Table 4.

Answer:

We have added the calculation and figures of the requested TURF-T1 comparison to the appendix (Section appendix B) and have noted the quantitative difference of wind speed, wind direction of A-TIV compared to TIV in Table 4.

Reviewer 2:

I think more discussion is needed on the poor estimate of the mean wind speed. While it would be beneficial to have a spatially distributed estimate of wind velocity e.g. for the estimation of ET using energy balance models, the absolute magnitude of wind speed is of course very important too. I find it interesting that in Figure 5 the histograms of the physical and virtual TC arrays agree very well, even though the TC array is mounted 1.5 m above the ground. In the text it is stated that the sonic anemometer is also mounted at 1.5 m height. Maybe the authors could add the comparison of the TC array and sonic anemometer to their scatter plot in Figure 11 and discuss the reasons for the differences in wind speed in a bit more detail.

Answer:

The reviewer has misunderstood the mounting height of the thermocouples. It is stated clearly in the manuscript that the TC array reflects the situation 1.5 centimetre not 1.5 metre above the ground.

Reviewer 2:

The authors state in the Discussion p. 25, 362 "However, the histograms show that the distributions are not comparable, which is expected comparing a point measurement to a spatial approach." The authors should also discuss this aspect a bit more.

Answer:

We have added the following sentences to the paragraph:

“However, the histograms show that the distributions are not comparable, which is expected comparing a point measurement to a spatial approach. This means that the A-TIV is reflecting a spatial measurement whereas the other measurement methods are based on single point measurements which depend on their mounting height respectively their footprint. The direct spatial measurement of A-TIV reflects the atmospheric situation directly adjacent to the surface and hence, when compared to point measurements further away from the surface, may not reflect the same conditions.”

Reviewer 2:

Stull, 1988: “Instead of observing a large region of space at an instant in time, we find it easier to make measurements at one point in space over a long time period. Thus, the wind speed could be used to translate turbulence measurements as a function of time to their corresponding measurements in space.” The authors should discuss why this assumption does not hold in this application.

Answer:

We have added the following paragraph to the discussion section:

“The assumption from Stull, 1988 that meteorologists rather observe atmospheric conditions over longer periods of time (> several hours), than creating short observations over a large region of interest does not reflect the strategy of A-TIV applications. According to Stull, 1988 the long term point measurements can be translated to their corresponding spatial measurements as a function of time. A-TIV is a new approach in the sense that the measurement type is directly spatial and hence short term observations can immediately reflect the spatial component of turbulence. Moreover, the new type of data that is retrieved needs new spatiotemporal statistics and new analysis methods such as A-TIV for new insights into spatial turbulence.”

Some specific comments:

Reviewer 2:

P.4, line 113: Did the authors really want to refer to Section 2.5?

Answer:

We have corrected this to Section 3.2.1

Reviewer 2:

P. 5, line 120: Could the authors add the used interval settings for each flight somewhere in the text or e.g. Table 1?

Answer:

We have added the automatically selected interval settings to the table.

Reviewer 2:

P. 5, line 140: In my opinion, this sentence belongs to 2.1 since it gives information about parameters used in the TIV algorithm, which are not specific to the A-TIV algorithm.

Answer:

We have moved the following three sentences of the paragraph to the end of section 2.1.

“TIV used previously a correlation technique presented by \cite{Kaga1992} called the greyscale correlation technique which uses simple pixel by pixel subtraction to obtain a correlation value (Inagaki, 2013). The A-TIV is usually calculated using the same technique with a correlation window size of 16 x 16 pixels and a search area size of 32 x 32 pixels. These settings were previously investigated as the most accurate (Schumacher, 2019).

Reviewer 2:

P. 7, line 143: The height of the sonic anemometer should be added to Section 2.3.

Answer:

The height has been mentioned in Section 2.3 in the following sentence:

“TURF-T1 was equipped with one sonic anemometer and TURF-T2 was equipped with two sonic anemometers, one in the grass field and one in the turf (Figure~\ref{fig:experimentsites}). All anemometers were mounted at 1.5 m above ground level, sampled at 20 Hz, and were placed in the field of view of the camera. “

Reviewer 2:

P. 11, line 200: To which frequency were the other experiments subsampled?

Answer:

All experiments were subsampled in the same way. We have adjusted the sentence to:

“To evaluate in a first step the brightness temperature data captured by the infrared camera with the TC derived air temperature, the same methodology was applied to a “virtual” array taken from the brightness temperature perturbations which was sub-sampled using mean-sampling to a sampling rate of 20 Hz.”

Reviewer 2:

P. 12, line 209: I do not understand why the output frequency necessarily has to be 2 Hz due to the ten second windows in the time series.

Answer:

To retrieve lag-cross correlations of the Thermocouple signal it is necessary to retrieve chunks from the signal and correlate it. Considering 20 Hz thermal data and chunks of 10 seconds (200 datapoints) and no overlapping of the chunks, this would mean 60 measurements. However to be able to compare to A-TIV and it's subsample to 2 Hz data it is necessary to overlap the chunks to retrieve a comparable time series.

Reviewer 2:

P. 14, line 272: Reporting a p-value > 0.95 is not very common.

Answer:

This refers most likely to the answer of the major revision and not to the manuscript itself. Hence, we will take this into account for our future reporting and responses.

Reviewer 2:

P. 14, Figure 5: I again encourage the authors to add legends to their plots where needed.

Answer:

We have added a legend to the plot as per your suggestion.

Reviewer 2:

P. 18, line 281: Did the authors really want to refer to Table 1 here?

Answer:

Yes. This is to reference to the higher wind speed of the two TURF-T experiments.

Reviewer 2:

P. 18, Table 4: The mean TIV speed should be added here too.

Answer:

The TIV mean speed was added according to your above comment.

Reviewer 2:

P. 23, line 309: The wheat stubble alters the wind profile and this also affects the exchange of heat between the surface and the atmosphere.

Answer:

We have added the following sentence:

“Furthermore, the wheat stubble alters the wind profile above it more significantly compared to the smooth roughness elements of TURF-T1 and TURF-T2 which also affects the exchange of heat between the surface and the atmosphere. ”

P. 25, line 377: This sentence is not clear to me.

Answer:

We have adjusted the sentence as follows:

“The display of very small velocities (< 0.5 m/s) is also not ideal due to the a high range of extracted velocities from the multiple TIVs neglecting the display of small velocities”

P. 26, line 378: I don't really see that Figure 11 supports this claim.

Answer:

We have removed the Figure from the claim.

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