

Answers to the reviewers

Dear reviewers, thank you for reviewing the manuscript so carefully and for valuable suggestions of how to increase the quality of the manuscript. In the following, we respond to your questions and suggestions point by point.

Reviewer 1

SPECIFIC COMMENTS

Page 4698 line 18: How dense is the canopy (LAI)? This is important for understanding how easily turbulence can penetrate through the canopy.

The plant area index is now added to the site description.

Page 4699 line 11: What was the tube diameter and material?

The information is added to the instruments and set-up section (2.2)

Section 3.4: The storage change term (Aubinet et al. (2012), chapter 1, first term in Eq. (1.24a)) should be calculated from the measured CO₂ concentration profile and its magnitude and evolution during a jet period should be discussed. Now the effects of changes in CO₂ storage are discussed in several parts of the manuscript, but they are not quantitatively determined. I would add discussion about the storage change term also in section 4.2 and other parts of the manuscript where the accumulation of CO₂ below the EC measurement level is discussed.

The storage change term is calculated from the profile data and the results were added to the results section (3.4). In section 4.2, the changes of the storage change term during jet periods are now discussed.

Page 4705 line 8: Friction velocity threshold is site specific (see for instance Barr et al., 2013) and thus a threshold estimated for one site cannot be used at another. Please estimate the threshold for your site or express clearly that the value used (0.17 m/s) may not be the right value for this site since it is taken from another study.

We changed the manuscript text accordingly

Page 4705 lines 16-17: This can be said based on Fig.7 only if the data shown in the bottom part of the figure is normalised with the corresponding variance of w . If the data is not normalised, then the relative contribution of small eddies to the power spectral density is difficult to assess based on Fig. 7 alone.

The spectrogram was not normalized by the variance of w . Normalized vertical wind velocity spectra were added to figure 7 (corresponding to a one-hour data block measured before, during, and after the jet event). The spectra support the results from the spectrogram. Additionally, a short paragraph was added to the data processing section (2.3) describing the calculation of the spectra.

Section 3.5.3: I would add a paragraph or two showing a comparison between the two EC systems during a jet period and outside a jet period. In an ideal case the CO₂ fluxes from these two systems should be equal, whereas in a case when the two measurement levels are decoupled from each other the turbulent fluxes might not agree.

A paragraph in which the differences between the upper and the lower EC-systems are analyzed was added to the results section (3.5.3). Figures 8 and 9 now include data from the upper and the lower EC-systems.

Page 4709 lines 16-26: Is this significantly different from what Mahrt et al. (2010) described?

Yes, it is significantly different from what Mart 2010 described. While Mahrt described drainage flows and the growth of a cold pool on a gentle (1.3 – 5.3 °) slope, our data and the results of Zhou and Chow (2012, 2013) represent drainage flows on much steeper slopes with more momentum. This allows the overshooting of the point of neutral buoyancy and the development of the respective counter flow. Mahrt describes the growth of the cold pool and how the cold pool stops the drainage flow once it reaches the measurement location.

Figure 7: Please consider adding a third subplot which shows the power spectral density normalised with the corresponding variance of w . It would help in assessing the relative contribution of each frequency to the total variance of w

Three plots have been added to figure 7 representing the power spectra of the vertical wind speed for the jet period and one hour before and after the jet. Caption and discussion were changed accordingly

TECHNICAL CORRECTIONS

Page 4703 lines 1-2: Mention that these values for the vertical wind are given in a coordinate frame which is perpendicular to gravity, not to ground.

Done

Page 4708 lines 6-7: Please reformulate this sentence. The CO₂ flux is not necessarily small at night. Furthermore, the word “small” is a relative term and it should be mentioned to what the fluxes are compared with. I guess the meaning of this sentence is to say that under these conditions the EC fluxes represent the fluxes at the atmosphere-biosphere interface.

Thank you, done

Figures 2 & 3 & 4: Please add in the captions of these figures that the data shown is given in coordinate frame which is perpendicular to gravity, not to the ground.

Done

Figures 2 & 3 & 4 & 5: Would it be possible to remove the grey background from these figures?

All grey backgrounds have been removed from the figures in the revised manuscript except for figure 5

Reviewer 2

Mixed tenses (past and present) are used throughout the manuscript and occasionally present tense is used to describe the observations at the field site during this study. This implies that you believe your findings over 17 specific nights are valid for all nights in any given year. Please use past tense only when discussing your observations.

The tenses are more consistent now and whenever observations from the field are described, past tense is used.

SPECIFIC COMMENTS

Page 4696, line 7: add “, then” after the word “site”

Done.

Page 4696, lines 19 -20: “::: eddy-covariance data presenting higher quality. This was particularly indicated by spectral analysis and stationary tests.” This statement seems vague. Thus, I suggest to specifically name what components of the EC data were improved in quality.

The sentence is more precise now and the components with improved quality are named.

Page 4697, line 3: remove comma after word “turbulence”

Done.

Page 4697, line 20: “It plays a major role:::” , What is “it” specifically?

The ‘it’ was replaced by ‘This, intermittent turbulence...’

Page 4697, line 27: “:::intermittent turbulence in very complex terrain”. The word “very” is qualitative, please define the terrain in more quantitative terms.

The term ‘very’ was removed from the text and a reference to figure 1 was added so the reader can estimate the complexity of the terrain.

Page 4697, line 28 and page 4698, line 1: Is there a reference for this preliminary study?

The preliminary study was a Diploma Thesis written in German, therefore I don’t think it makes much sense to cite it here.

Page 4698, line 6: define “SODAR” as this word is first encountered on this line.

Done.

Page 4698, line 12: remove “SODAR” definition

Done.

Page 4698, lines 17-18: are these trees deciduous? Evergreen? This could impact turbulence depending on seasonal phenology of the trees.

The trees are evergreen coniferous trees with a plant area index (PAI) ranging between 2.75 m² m⁻² in February and 5 m² m⁻² in September. During the experiment the PAI was roughly 4 m² m⁻². The information was incorporated into the site description.

Page 4699, line 13: Is the sample air stream pulled by a pump through the 15m length tubing? How was condensation in the tubing addressed?

The information is added to the instruments and set-up section (2.2)

Page 4699, line 18: “negative influence of ground clutter” What does this mean specifically?

The additional noise from reflections of sound at surfaces (mountain face and forest canopy) results in a bad signal to noise ratio and leads to larger uncertainties in the determination of wind components. The sentence was changed into ‘... ground clutter namely, a bad signal to noise ratio, ...’

Page 4699, line 20: replace “used.” With “used –“

Changed accordingly

Page 4700, line 27: “::: and backscatter are available.” Do you mean “were used”?

Was changed to ‘...were calculated’.

Page 4702, lines 9-10: “stable boundary conditions prevailed throughout the entire nights”. Do you mean “night” singular or are you referring to all nights of the 14 events?

During all 14 nights stable boundary conditions prevailed. The text was changed to make it clearer.

Page 4704, line 24: define ITC

The definition of the ITC (integral turbulence characteristics) was added in section 2.3 where it is mentioned for the first time.

Page 4709, line 19: “It flows:::.” replace “It” with exact word

‘It’ is replaced by ‘The air’....

TECHNICAL COMMENTS

Page 4697, lines 10 -11: “:::while gravity waves are usually caused by topographic changes or irregularities of the canopy top”. There is no discussion within the manuscript about why gravity waves could be ruled out, thus a couple of sentences to this effect may be of value.

With the used measurement setup it is not possible to rule out gravity waves as a source for nocturnal turbulence. In fact, it is most likely that gravity waves also induce nocturnal turbulence at the site. Nevertheless, the used setup was able to detect low-level jets and above canopy drainage flows and only these are presented and discussed. Therefore, we believe that the way we address gravity waves is a good one.

Page 4703, lines 23 – 24: CO₂ mixing ratios are also a function of photosynthesis, which is not occurring during these nighttime events.

The sentence was changed to:

During the nights, when photosynthesis is absent, carbon dioxide typically accumulated at the surface of the forest as a result of nocturnal respiration of the soil and vegetation.

A few sentences in the site description (section 2.1) or in the data selection (section 2.4) sections discussing precipitation/storm events or lack thereof should be included.

Two sentences about precipitation and storm events are included in the site description.

Again, we appreciate the careful work of both reviewers, thank you!