

Author reply to the review by Referee #2 of the manuscript:

“On the impact of atmospheric waves on fluxes and turbulence statistics during nighttime conditions: a case study”

by Durden et al.

We the authors would like to thank the reviewer for their insightful comments and suggestions to improve the manuscript. We implemented all of the grammatical suggestions and figure corrections suggested in the revised manuscript. We also addressed the structure of the manuscript to make the data selection process more evident and to enhance the discussion of the results. Additional nights, ranging from 22 April, 2009 to 31 March, 2010, were processed for identification of large amplitude “wave-like events” to present a better representation of “wave-like” phenomena at our site. We also added a better description of the nighttime conditions leading to the propagation of the wave cases analyzed by providing the gradient Richardson number and the Brunt-Vaisala frequency. The reviewers comments are cited in italics.

General comments

We acknowledge that the inclusion of many nocturnal phenomena in the introduction and the manner in assessing that data may introduce some confusion; however, we felt it was important to demonstrate the use of a microbarograph to help identify nocturnal phenomena that may impact fluxes. In the revised manuscript, we have pointed out that each phenomenon, whether it is a density current, a gravity wave, or a nocturnal low-level jet interacts with turbulence and fluxes in its own unique way. The detection of “wave-like events” is a precursor to classifying the events as gravity waves; the positive identification of a wave in a turbulence/ eddy flux signal relies upon the phase relationship of w and T from the sonic anemometer (presented in Fig. 4) and u and pressure. The quadrature spectra are used to derive the phase relationships between the variables for the identified wave frequencies. The rationale behind the use of a microbarograph at the surface to identify the waves lies in the fact that the microbarograph signal contains significantly less noise than the sonic anemometer data with the addition of static pressure disks to the microbarograph setup reducing the dynamic pressure fluctuations.

We recognize the omission of the sensible and latent heat fluxes leads to a title that may be construed as too general. Sensible and latent heat fluxes are similar to CO₂ through their interaction with the wave. The phase relationships between the variables of the covariances (e.g. w and T, w and H₂O, w and CO₂) are similar (i.e. -90° and 90° out of phase); therefore, the results are similar to those for CO₂. We will address this issue by adding figures for H and LE.

Specific Comments

1. *Page 5154, line 5: If the wavelet analysis is already applied, why the backward wavelet analysis is not used to estimate wave-like perturbations? Which kind of filter is used for the band-pass filtering?*

The wavelet analysis was applied only to the pressure data during the first identification phase. The frequencies/periods of the waves were determined from the wavelet analysis of the pressure; then, the waves were band passed from the eddy covariance data using a ramped Butterworth filter. We adapted a program to perform each task; however, the process could be streamlined using a method similar to Hauf et al., 1996.

2. *Page 5154, line 13: Did you use for detrending and band-pass filtering the entire time series or from the start time to the end of the wave episode?*

Both the detrending and band-pass filtering were performed on the entire 4 hour time series. The detrending was necessary for the band-pass, and the entire time series was used so that the edge effects of the filter could be removed, which is addressed in the next question.

3. *Page 5154, line 16: Did you apply any kind of window during band pass filtering to minimize side lobe level?*

The time series selected for each case was 4 hours with the wave centered in the middle; therefore, after the band-pass, only the two hours in the middle were used for calculations

while removing one hour at the beginning and end of the time series to remove side effects caused by the filter. Also, the filter linearly ramped to reduce the edge effects.

4. *Page 5156, line 7: The authors restrict the analysis to waves with a period less than 30 min. However, the impact of larger waves is included by averaging of turbulence statistics over large periods. How it could be done, when these waves are already band-passed filtered?*

The study was focused on waves with periods of less than 30 minutes, so during the detection of events using the microbarograph data the frequencies corresponding to periods less than 3 minutes and greater than 30 minutes were filtered to detect the waves. Figure 1 below demonstrates the resultant pressure signal that was used in conjunction with the wavelet plots during the identification phase with 2σ (green) and 3σ (blue) plotted over the bandpassed pressure signal. During the processing of the eddy covariance data just the bands identified as corresponding to the wave were removed from the signal, i.e. frequencies corresponding to 3- 11 minute periods for 20090423. The premise of this study is to identify wave contributions that occur if processing eddy covariance data in a routine way, leading to partial wave cycles being included in the calculations leading to some errors.

5. *Page 5158, line 25: The inflation for averaging times longer than the period of wave event observed for 23 April is shown in Fig. 5. Did the authors observed the inflation of turbulence statistic for 3 December?*

Inflation of the turbulence statistics was observed on 3 December, 2009, but the percent inflation was much smaller, in part due to the greater amount of turbulence present. The average turbulent kinetic energy inflation can be observed in Fig. 7.

6. *Fig. 2: Add units to colorbar. Are the peaks located outside the cone of influence? The sentence "Increases in wavelet ..." is not a figure title, move it to the text.*

We did not include the cone of influence since the periods important for the study don't approach the size of the time series, where the periods of interest are less than 30 minutes and the total length of the time series is 6 hours. Therefore only a very small fraction of the graph in the top corners of the graphs would be outside the cone of influence. We added units to the colorbar.

All other minor comments were implemented directly. We hope that all of your comments and concerns have been addressed. We thank you for your contributions to improving this work. If questions or concerns linger we are happy to address them.

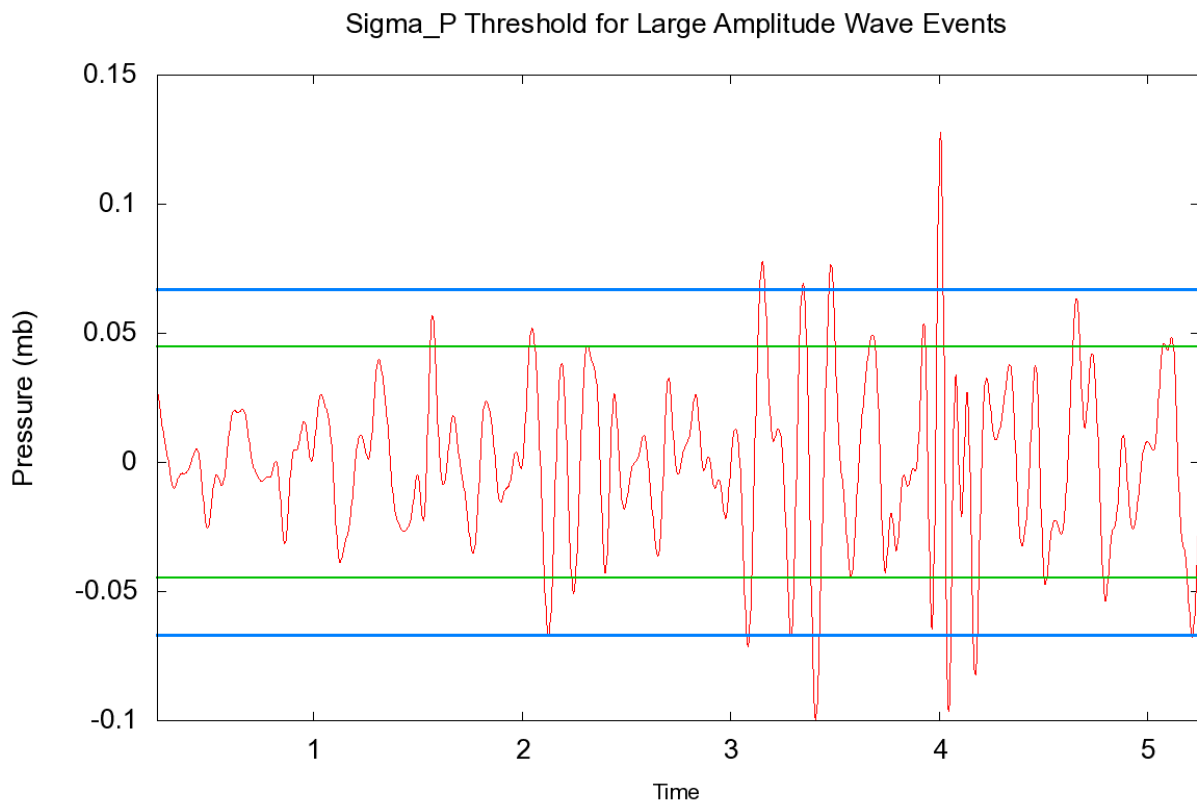


Figure 1 Bandpassed pressure signal used for the identification of large amplitude wave-like events using $3\sigma_p$ (blue line).