Author reply to the review by Referee #3 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 would like to thank the reviewer for taking the time to review our manuscript. It is apparent the reviewer is well versed on the topic and clearly points out one of our short comings in the manuscript of not explicitly making our results clear.

# General comments

There are several main concerns we will address in sequence, reviewer comments are in italics:

1. *This paper is based upon a fundamental misunderstanding of the nature of eddy covariance measurements of surface-atmosphere exchange. It assumes that surface fluxes of scalars are carried only by 'turbulent' (incoherent) motions. Waves are assumed to carry no scalar flux and so an elaborate methodology is applied to separate and remove the waves from the turbulence. In fact, both waves and turbulent motions are capable of transferring scalars between the surface and an atmospheric level at which an eddy flux instrument is located.*

   We the authors agree that both waves and turbulent motions are capable of transferring scalars between the surface and an atmospheric level at which an eddy flux instrument is located. In the manuscript we state that we are only assessing errors in turbulence statistics and turbulent fluxes. We state on p. 5152 line 24-27 "Our study assesses the magnitude of the overestimation (inflation) in turbulence statistics and errors in turbulent flux calculations (hereafter any reference to fluxes refers to turbulent fluxes) on two nights in contrasting atmospheric conditions". We proceeded to use fluxes in reference to strictly turbulent fluxes throughout the rest of the text. We will change all the instances of fluxes to turbulent fluxes.

2. *I think the misunderstanding comes from the assumption that in a wave, the vertical velocity and the scalar concentration must be in quadrature. This is only true of an ideal inviscid wave or in certain circumstances of a wave in a fluid of constant viscosity. When the atmospheric wave is either: non-linear, interacting with turbulence, interacting with canopy drag, in a horizontally inhomogeneous mean field or affected strongly by buoyancy forces, then the quadrature relationship need not hold. In that case, because the wave motions are generally of large amplitude and more coherent than the turbulence, the wave can make a significant contribution to the transport of the scalar and removing it will compromise the measurement of biological exchange. Conversely, if*

*the wave makes only a small or zero contribution to the budget, there is no need to remove it from the eddy covariance signal.*

*The problem posed by waves is a different one than addressed here. Because the eddy covariance averaging time is generally only a few wave periods, the possibility of only catching a fractional part of a wave period in the averaged covariance is high and, unless the resulting mismatch is captured in the storage term the budget will be in error.*

*However, the errors in the storage term calculation are of a different order to those of flux calculation. I agree with the authors that the wave signal needs to be separated from the turbulence signal to calculate some aspects of turbulence and wave dynamics but it most emphatically should not be separated when calculating the scalar flux.*

In the manuscript we do not address the issue quadrature to determine phase relationships, though this is something that must be assessed case by case. However, we mention the short-lived non-linear nature of waves on p. 5153 line 25, and the problem of capturing partial wave cycles in flux calculations on p. 5161 line 1-6. In our revisions we will discuss quadrature and emphasize the importance of another study looking to assess the overall impact on budgets by assessing the impact of waves on both the flux calculation and the storage term, as van Gorsel et al., 2010 showed the storage term can be impacted by the presence of waves, to better understand exchange processes. We the authors wish to highlight the contribution of the work to modeling efforts, where characterizing true turbulent components and indicating wave implications could produce more robust parameterizations.

In addition to addressing these issues the authors present a restructured data selection section, with added processing for large amplitude "wave-like" events. 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.