Understanding nocturnal mixing in cleared areas: Mechanisms of turbulent exchange during nearly calm conditions.

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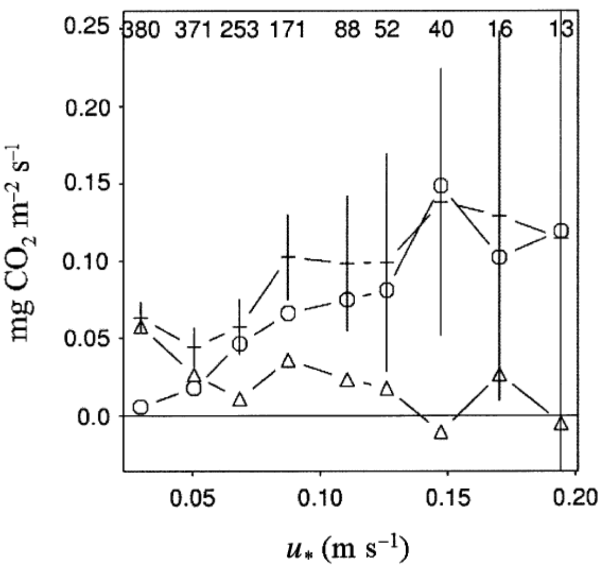
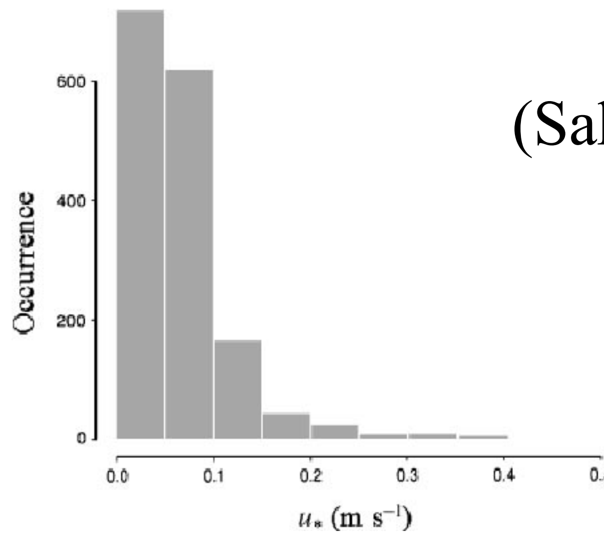
Objective: To show that usually discarded turbulent data from weak mixing conditions, can provide useful information regarding nocturnal surface fluxes.

To do that, we will look at data from The km 77 pasture/agricultural site.

- Deforestation leads to enhanced radiative loss at the surface, forming a strongly stable layer at nighttime;
- Nocturnal turbulent mixing is extremely reduced at the site.





(Sakai et al., 2004)

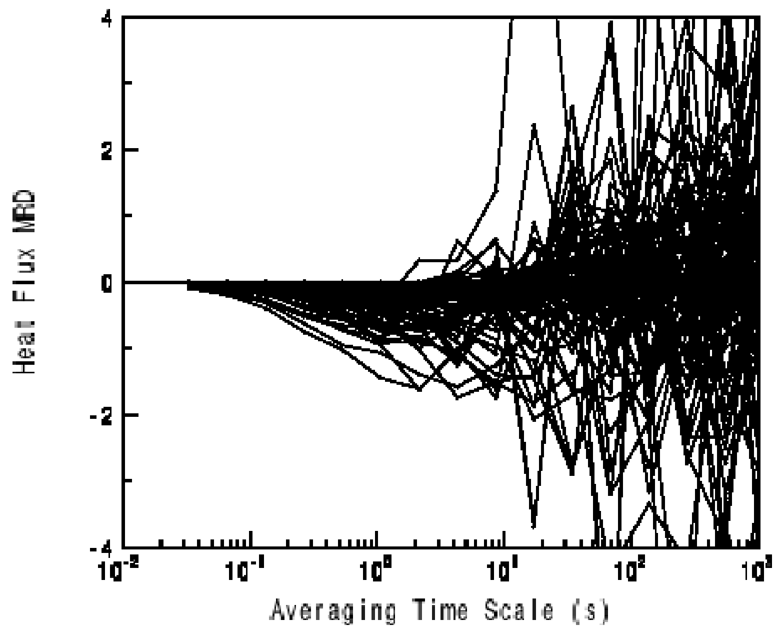
u_*<0.2 m/s during 98% of the time;
u_*<0.08 m/s during 82% of the time;

Two recent studies show that turbulent fluxes in very stable conditions can be found through the multiresolution decomposition:

Mahrt and Vickers: Extremely weak mixing in stable conditions, *Boundary Layer Meteorology*, in press.

Vickers and Mahrt: A solution for flux contamination by mesoscale motions with very weak turbulence, *Boundary Layer Meteorology*, in press.

This is achieved through the decomposition of the fluxes between turbulence and larger-scale.
The turbulent portion is well-organized and relates very well to vertical gradients.
The mesoscale fluxes are more erratic.

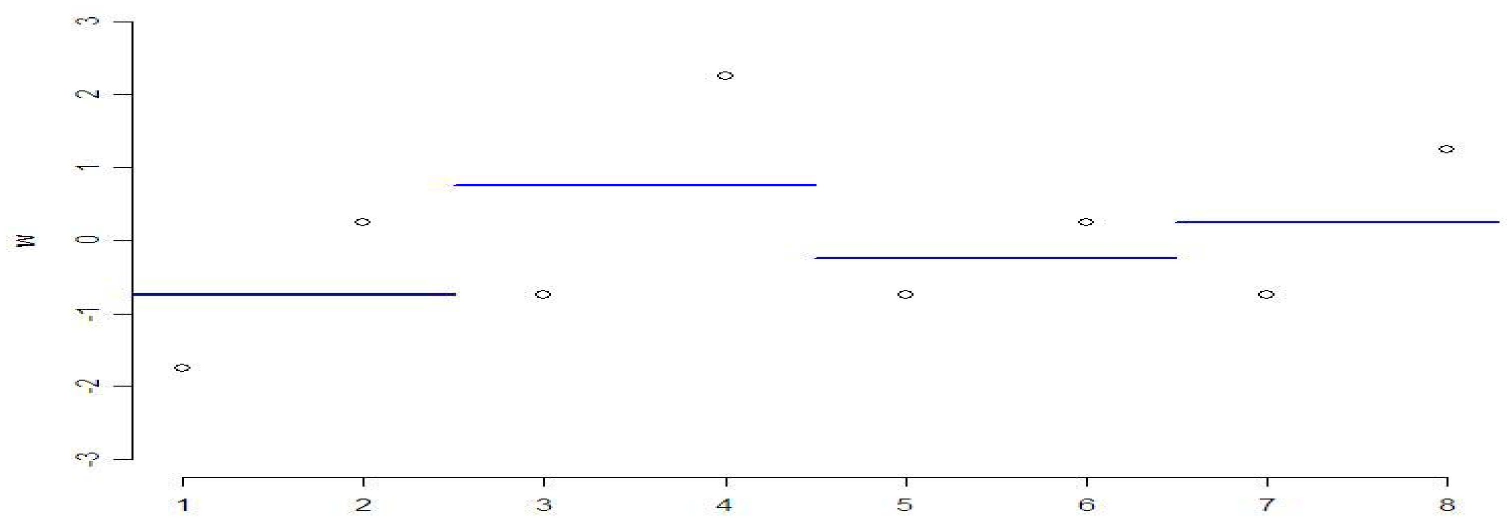


(Vickers and Mahrt, in press)

IMPORTANT: For geophysical purposes, like determining the energy budget or respiration rates, both the turbulent and mesoscale fluxes matter!

The multiresolution decomposition

(Howell and Mahrt, 1995; Vickers and Mahrt, 2003)



w=(1, 3, 2, 5, 1, 2, 1, 3) $\langle w_n \rangle = 2.25$

w=(-1.25, 0.75, -0.25, 2.75, -1.25, -0.25, -1.25, 0.75) $\langle w_n \rangle = (0.5, -0.5)$

w=(-1.75, 0.25, -0.75, 2.25, -0.75, 0.25, -0.75, 1.25) $\langle w_n \rangle = (-0.75, 0.75, -0.25, 0.25)$

$$\left(D_w\right)_n = \overline{\left\langle w_n \right\rangle^2}$$

multiresolution spectra

$$\left(D_{w\phi}\right)_n = \overline{\left\langle w_n \right\rangle \left\langle \phi_n \right\rangle}$$

multiresolution cospectra

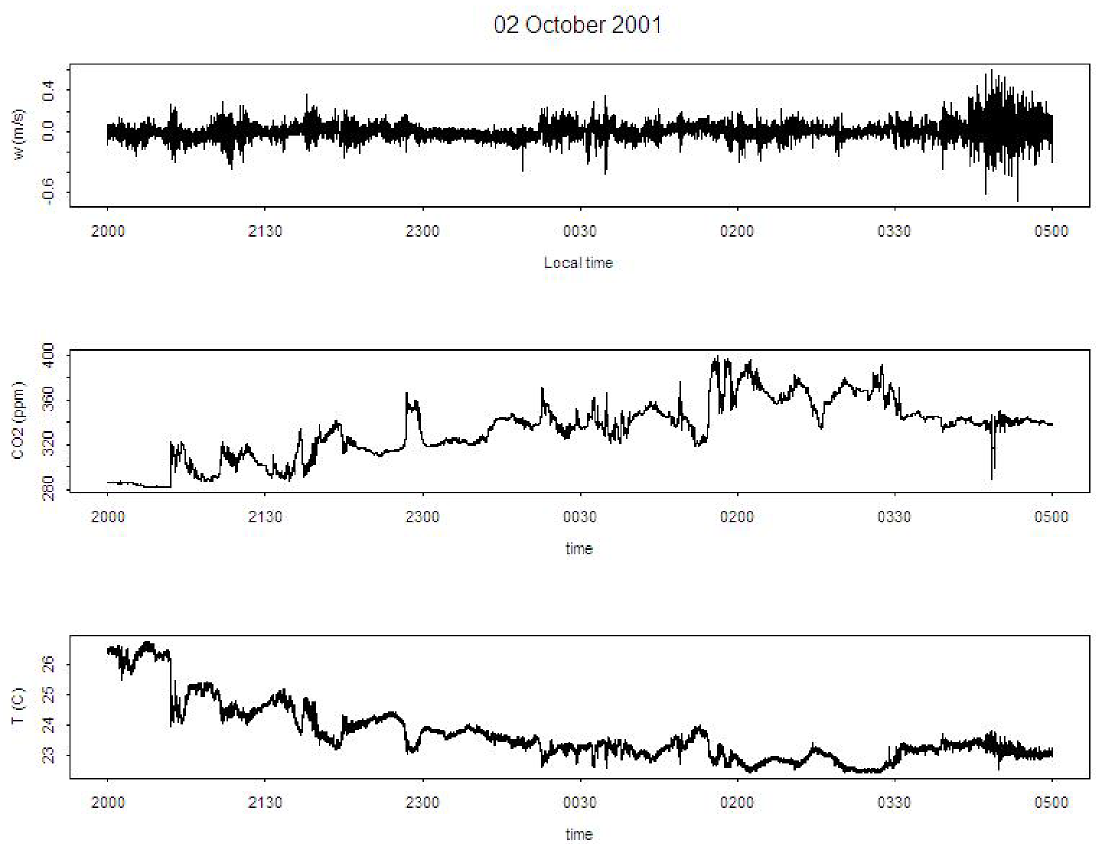
Important remarks

- The multiresolution cospectra, integrated up to a window size *m*, is precisely equal to the eddy covariance flux within that window;

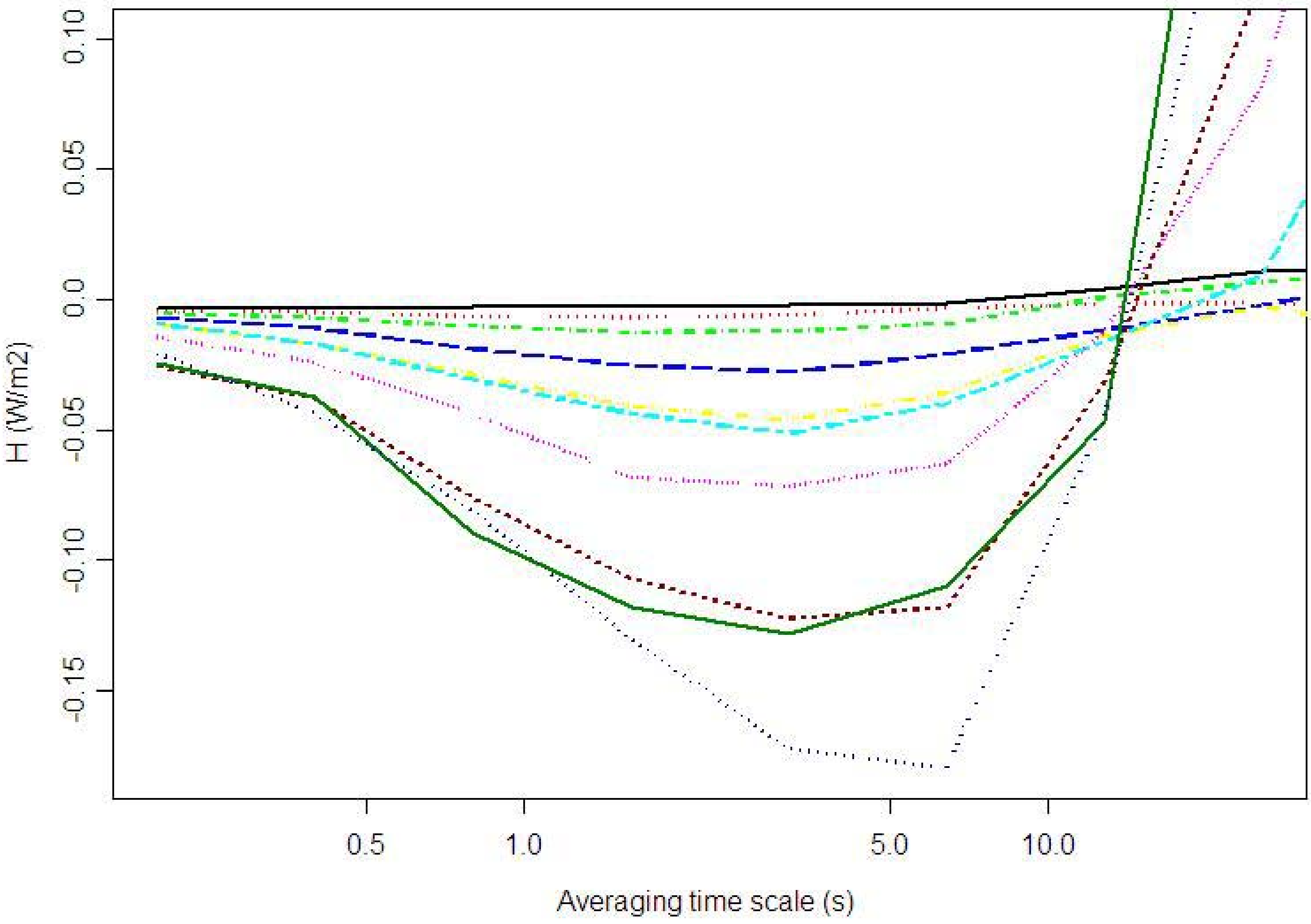
- Multiresolution cospectra can be interpreted in terms of wavelets.

Now, let's apply it to the very stable data from km 77

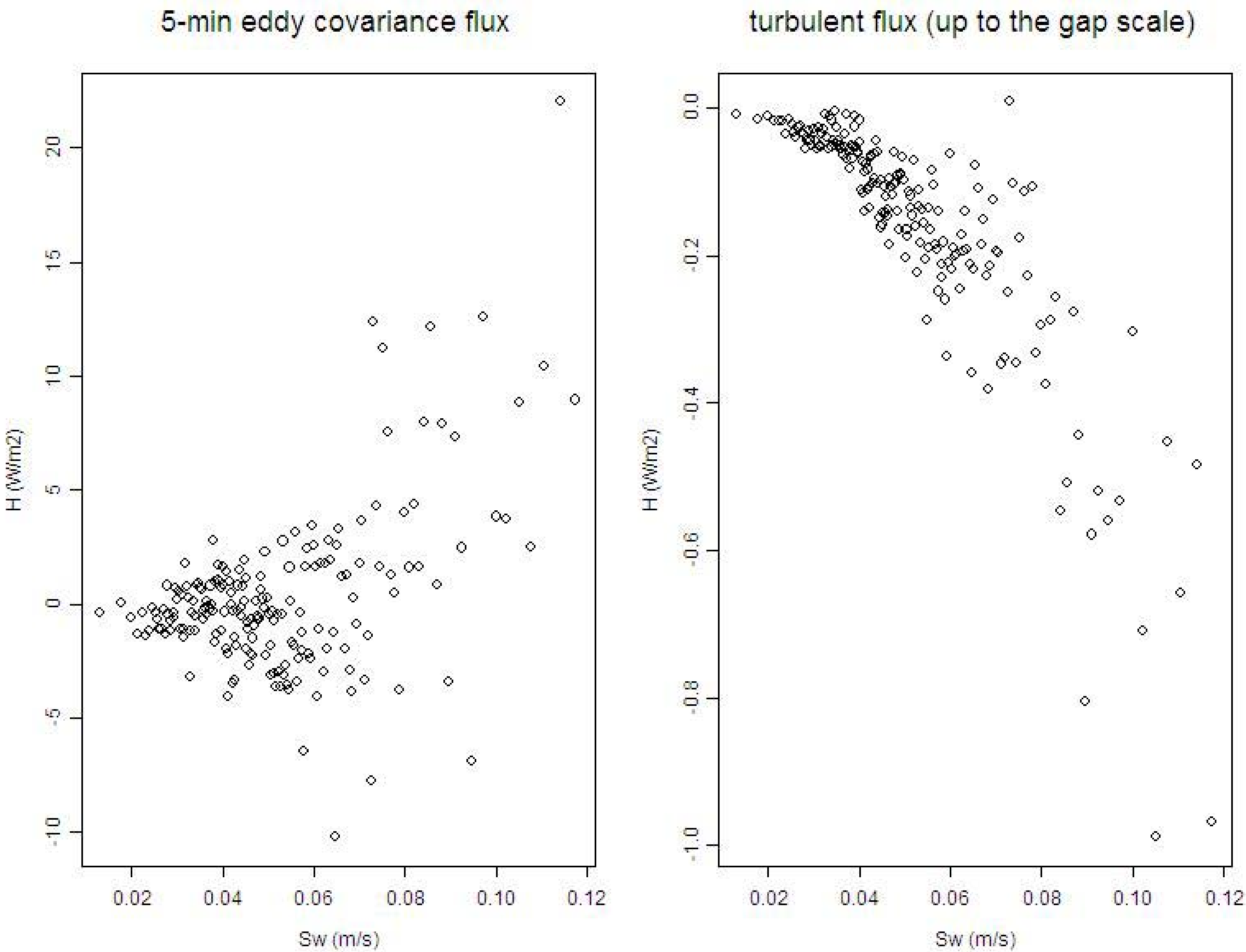
- Data from 26 nights in October 2001;
- The technique was applied to initial windows of 13 minutes;
- The windows were then shifted by 1 minute, and the process was repeated.



Sensible heat flux results

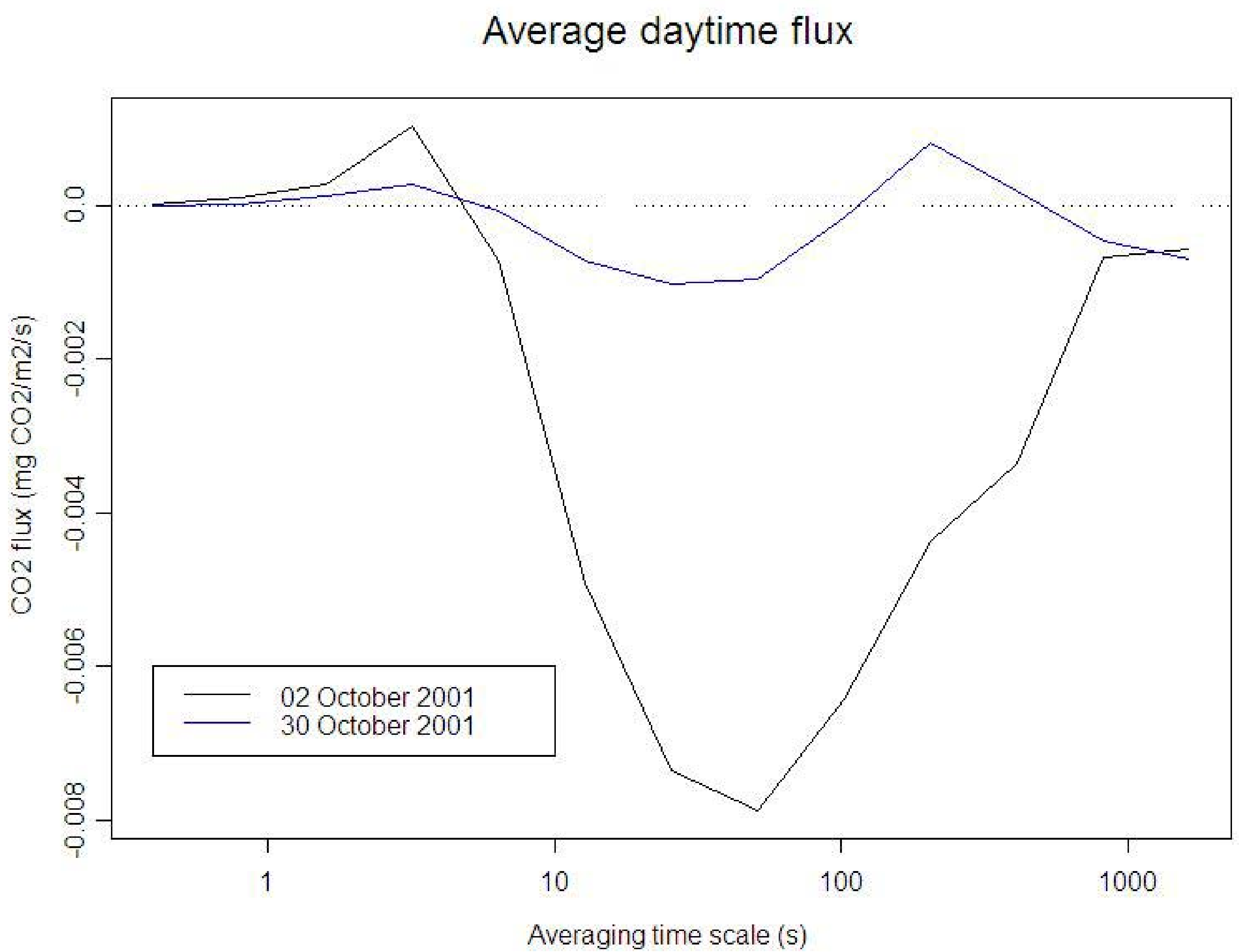


How do fluxes relate to turbulence intensity?

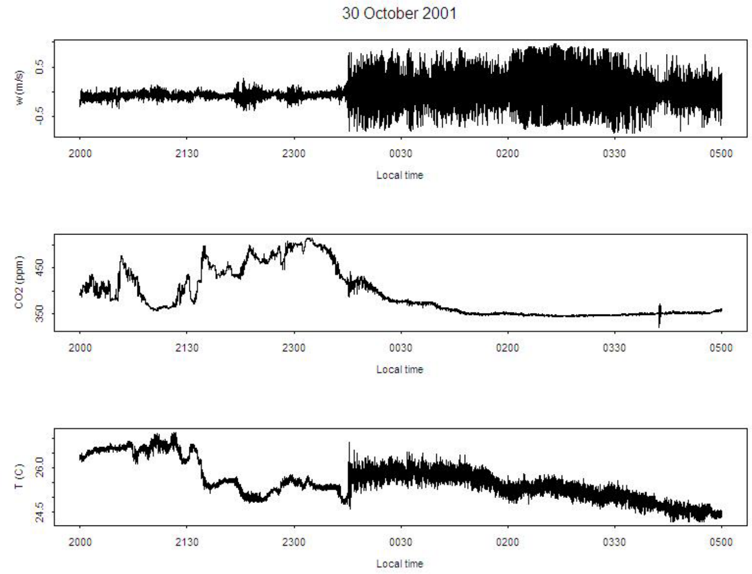


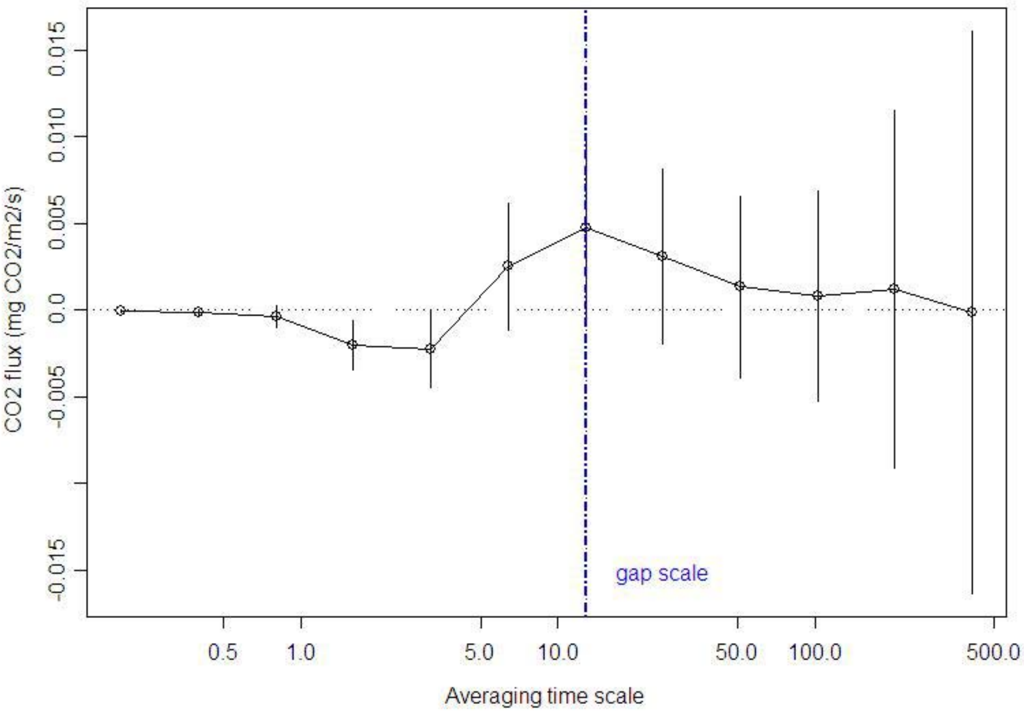
How about carbon fluxes?

- Daytime fluxes



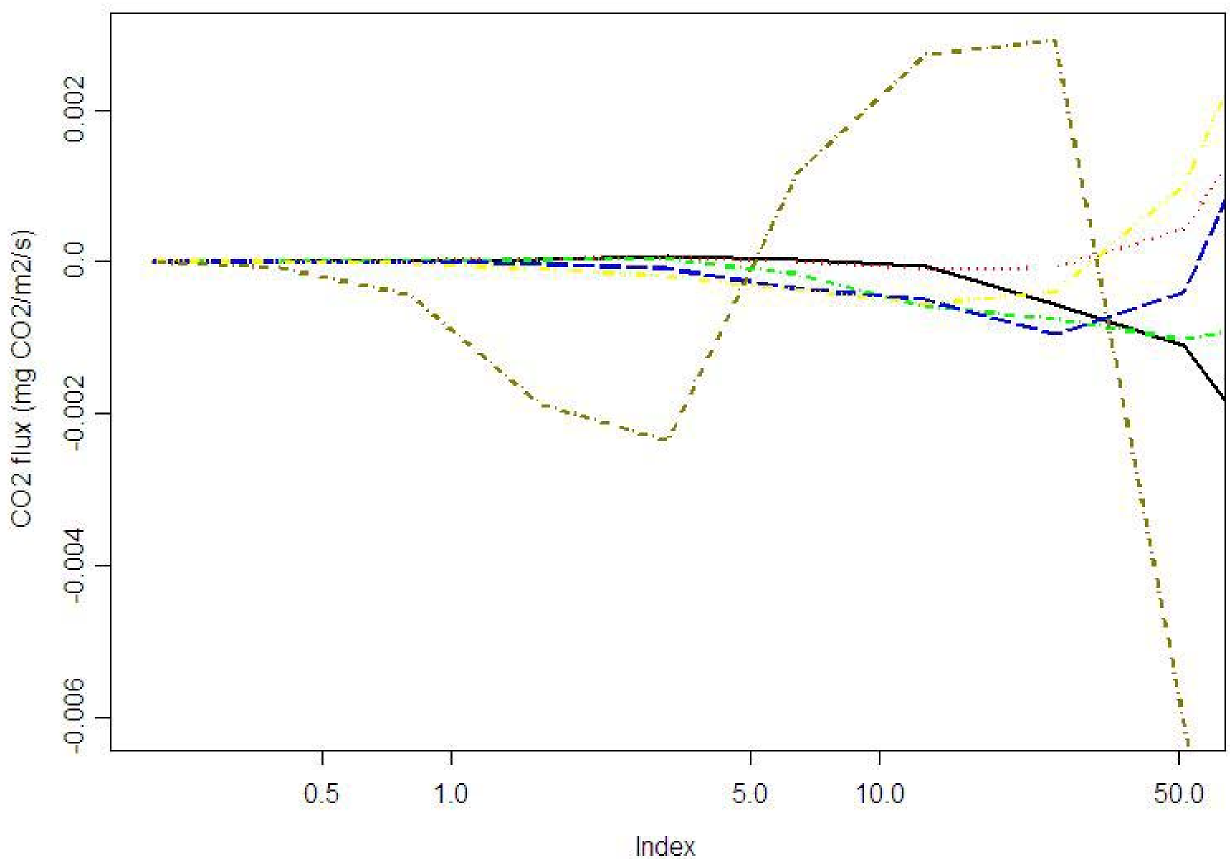
In a turbulent night:





It seems that most of the respiratory fluxes happen is scales larger than the gap, i.e., mesoscale fluxes contaminate their estimates.

What happens in the most stable cases?



It seems that the turbulent transfer gets shifted to even larger scales.

Concluding remarks

- The multiresolution decomposition provides very useful information regarding surface fluxes in very stable conditions;

- Sensible heat fluxes can be properly determined through this technique;

- Carbon dioxide fluxes are not so simple, probably due to the fact that they happen in larger scales, getting contaminated by mesoscale perturbations.