ANSWERS TO
Interactive comment on “Study of the overturning length scales at the Spanish planetary boundary layer” by P. López and J. L. Cano

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We thank the referee for his constructive remarks and sugestions. They are very useful in preparing a revised version of our paper. In the following, we present a response to major comments.

The manuscript deals with an interesting subject and presents a set of very high resolution methods, wind velocity and temperatura and local density.
About the wind and temperature results, maybe it could be possible to calculate the structure functions and the intermittency.

We agree that it would be interesting to analyze the relation between the Thorpe scale or the maximum Thorpe displacement and the structure functions exponents and intermittency. Really, this work has already been done. See *Turbulent intermittent structure in non-homogeneous non-local flows* by Mahjoub, O. B.; Castilla, R.; Vindel, J. M.; Redondo, J. M.. They used data from SABLES98 experimental campaign (as we do) in order to study the influence of stability on intermittency. They used SABLES98 data in order to evaluate structure functions and the scale to scale characteristics. They got differences in structure and higher order moments between stable, convective and neutral turbulence which were used to identify characteristics in turbulent intermittent mixing and velocity PDF's. These authors studied the intermittency of atmospheric turbulence in strongly stable situations which modifies the structure functions exponents. The topological aspects of the turbulence affected by stratification reduce the vertical length-scales to a maximum described by the Thorpe and the Ozmidov lenth-scales. Moreover, the paper entitled *Structure function analysis and intermittency in the ABL* by Vindel J.M., Yagüe C. and J.M. Redondo deduced that the relationship existing between the structure functions and stratification shows that as stability increases the structure functions decrease, and the same happens with the maximum Thorpe displacement and the Thorpe scale. Another of their conclusions is that the overall results show that for convective, unstable turbulence intermittency increases while neutral conditions exhibit low intermittency.
But we reaffirm that the main purpose of the article is to present the behaviour of the maximum Thorpe displacement and the Thorpe scale under different conditions in order to choose the best scale the best length scale and not seek relations with the structure functions exponents and the intermittency.

An alternative easier systems would be to present the evolution of Kurtosis in time or its statistical correlation with the Thorpe scale.

Yes, of course, it is a very interesting and easy way to do it. There are three ways of describing the intermittency: the evolution of flatness with the scale, the evolution of PDFs with the scale and the values of the absolute scaling exponents.
In the mentioned paper by Vindel J.M., Yagüe C. and J.M. Redondo, they perform an analysis of the PDFs of the horizontal velocity differences and they study the evolution of flatness. The variation of flatness with scale shows that the most stable and unstable situations have the highest values of flatness (for stably stratified flows, this happens at large scales).

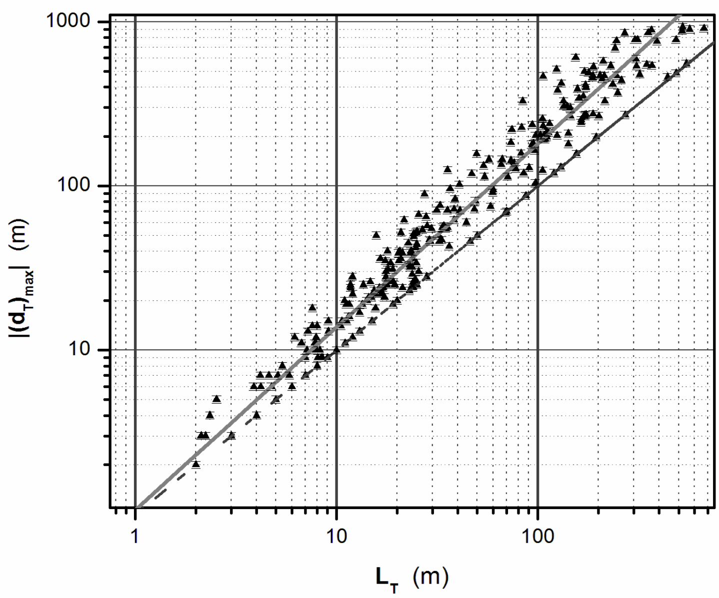
Questions and comments:

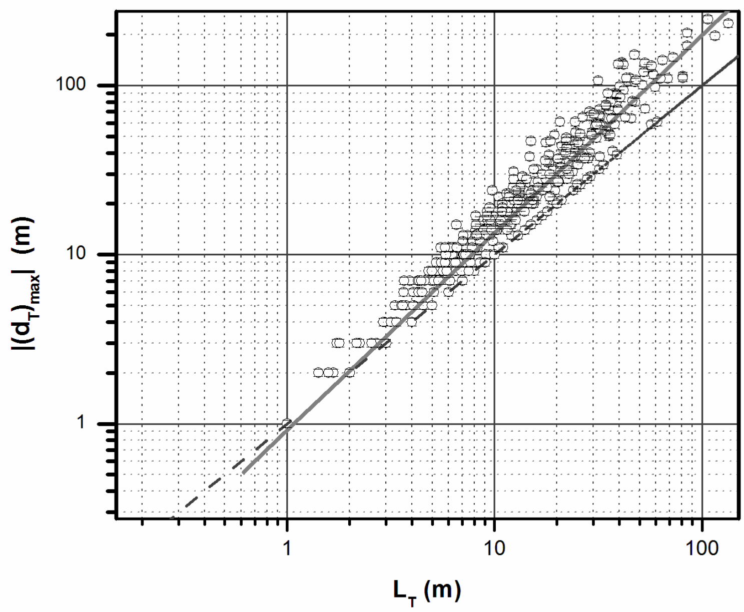
- In the figure 1: Why there is not data between aproximately 12 - 15 hours?

It is true (and also in Figure 2). There is not data between 12:00 and 15:00 hours because the team had to rest. The data were registered mainly by a tethered balloon which needs to be watched and monitored to prevent its breakage (for example, the balloon must be collected if there is a storm).

- Can you indicate the RMS error values in the figures?

Yes, I agree. You can see the error bars in the figures below (corresponding to Figure 3 and 4). Respect to figures 1 and 2, the error of Thorpe displacements is ±1 m (related to the experimental precision).





- It should be interesting to define in the paper Ozmidov scale and present some formal relationships between this scale and Elison scale and Monin-Obukhov lenghtscale.

We agree and we have initiated this study before. See *Thorpe method applied to planetary boundary layer data by* P. López González-Nieto, J. L. Cano, D. Cano and M. Tijera. By setting the buoyancy forces equal to the inertial forces, Ozmidov derived the Ozmidov length scale which would describe the largest possible overturning turbulent scale allowed by buoyancy. This scale is is helpful to estimate mixing, at least that

associated with patches of high turbulent activity. Various measurements have shown that the Thorpe scale is nearly equal to the Ozmidov scale. For example, far from the surface in wind-forced mixing layers in the seasonal thermocline the overall relationship L_T /L_O_ = 1.25 has been reported. Other results present a wider range: L_T /L_O = [0.9, 1.4] for measurements of turbulence during conditions of wear overflow. This is very important because it can be used to calculate the dissipation rate ε from L_T and the stability N^2 . Therefore, the Thorpe scales can be used to estimate rates of dissipation of turbulent kinetic energy and this is an essential result. Moreover, the length scale ratio L_T /L_O can be interpreted as a "clock", which increases monotonically as the turbulent event evolves.
The paper titled *Evolution of the Thorpe and Ozmidov scales at the lower atmospheric and planetary boundary layer* by P. López, J. L. Cano, and J. M. Redondo could be consulted in Academia.edu. This paper also analyzes the time evolution of the Thorpe and the Ozmidov scales during a day cycle. Both scales are always positive during a day cycle but they have not a similar behaviour, almost an opposite behaviour. This paper briefly mentions the Ellison scale that is another dynamical quantity used to estimate the overturning eddy size. The Ellison scale L_E is based on density ρ instead of temperature T. This length scale descriptor is the typical vertical displacement traveled by fluid particles before either returning towards their equilibrium level or mixing. It is often assumed that there is also a linear relationship between L_T and L_E, but this is not often the case $L_T \approx 1.2 L_E$.

As mentioned before, the main aim of the present paper is to choose the best length scale between the Thorpe scale and the maximum Thorpe displacement. This is the reason why we do not include relations with the Ozmidov scale, the Elison scale and Monin-Obukhov lenghtscale.

- As Thorpe scale is define here both in stable and unstaible atmosphere boundary layer conditions, the situation of convective generation of turbulence in the atmosphere, Could you define the local Rayleigh number for the situation of negative Thorpe scale?

The Thorpe scale L_T is the root mean square *(rms)* of the Thorpe displacements $(L_T)_{rms} = L_T = \langle d_T^2(z) \rangle^{1/2}$. Therefore, it is a statistical measure of the vertical size of overturning eddies and is proportional to the mean eddy size. Therefore, we deduce there is any situation of negative Thorpe scale which is always positive by definition.

- It is interesting to see in Figures 1- 2; How the large values take care in the morning and at sunset? Can you compare the evolution of the Thorpe scale in the sunny or a cloudy day because the overturning efects should be related to the solar radiation.

Yes, it is true. That is a very interesting idea to realize the same procedure with sunny and cloudy days to compare. Then, we will need to analyze the meteorological maps of campaign area and we will have a method to quantify the degree of cloudiness.