

# Answers to Referee 2: Turbulence measurements with a tethered balloon

CANUT Guylaine<sup>1</sup>, COUVREUX Fleur<sup>1</sup>, LOTHON Marie<sup>2</sup>, LEGAIN Dominique<sup>1</sup>, PIGUET Bruno<sup>1</sup>,  
LAMPERT Astrid<sup>3</sup>, and MOULIN Eric<sup>1</sup>

<sup>1</sup>CNRM-GAME (Météo-France and CNRS), Toulouse, France

<sup>2</sup>Laboratoire d'Aérodynamique, University of Toulouse, CNRS, France

<sup>3</sup>Institute of Flight Guidance, TU Braunschweig, Hermann-Blenk-Str. 27, 38108 Braunschweig, Germany

*Correspondence to:* CANUT Guylaine  
(guylaine.canut@meteo.fr)

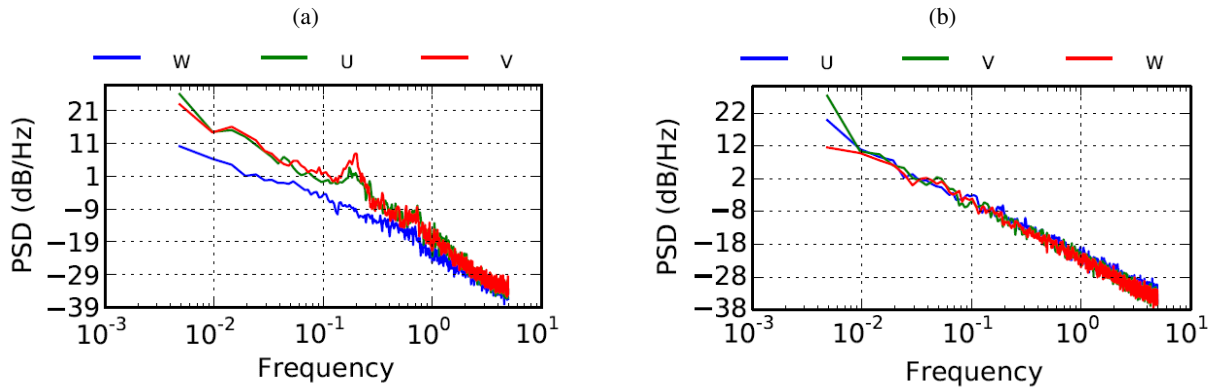
The authors would like to thank the anonymous reviewer for his/her suggestions and relevant remarks. The text from the review is given in black and the answers in red.

## 1 Referee 2

I found the subject of this paper extremely interesting and timely. Very recently I was discussing observed turbulence profiles in the atmospheric boundary layer with a colleague. As neither of us were aware of how these measurements were originally performed, we speculated on how they might have acquired them with the technology available at the time and discussed how one might be able to make improved measurements with the technology that is currently available. One of the concepts that we discussed was very similar to the system discussed in this manuscript. I am happy to see that such a concept has been developed. The possibilities of this measurement system are very exciting. This system makes it possible to deploy sonic anemometers in relatively fixed locations quickly and inexpensively. I had the same principal concerns as the first referee, even before I had read that review. While I agree with the main points, I believe that the system discussed is a significant improvement in the ability to directly measure atmospheric turbulence and is well worth publishing.

Therefore I recommend that the manuscript should be considered for publication if the authors are willing to perform major revisions. Regarding the technical content of the manuscript: The claims of the originality of mounting a turbulence probe on a tethered balloon in the abstract are obviously too general. The capabilities of the new system needs to be discussed in relation to previous balloon-based turbulence measurement platform discussed in Lapworth and Mason (1988). Their system used three propeller anemometers, therefore the 3D sonic anemometer should easily outperform the Lapworth and Mason's system in more than the total weight, such as frequency response and minimum detectable velocity, etc. The validation of the balloon-mounted system needs a more direct comparison with a tower-mounted sonic anemometer. It should not be necessary to have the turbulence probe mounted to tethered balloon in order to validate the system. It can easily be accomplished by mounting your system to a tower or tripod while still allowing it to pivot and move in the wind. It should be located within a few meters of a fixed 3D sonic anemometer at the same height above the surface. It wouldn't be necessary to mount the two instruments very high above the surface, perhaps just 2 or 3 meters. The two instruments need only measure essentially the same flow, making it obvious whether or not the motion correction is working correctly. While such a comparison would not be exercising the ability of the inertial GPS motion sensor for large scale motions, it is likely that it is more difficult correct for the small scale motions than it is the large motions due to the movement of the balloon.

Editorial concerns: This manuscript needs a thorough copy edit by a native English speaker. There are numerous grammatical and spelling errors throughout the manuscript as well as several instances where words were used incorrectly. For example, the word "weighted" was used instead of "weighed" on page 2, left column, line 16 and elsewhere in the manuscript. Page 4, right column, Line 8: You refer to potential temperature as  $t$  when  $\theta$  is used elsewhere.



**Figure 1.** PSD of TS: (a) the raw anemometer measurement; (b) the computed wind.

## 2 Answers

We appreciate that the referee considers our research topic and sensor as interesting. We would like to thank the referee again for the encouragement to submit an improved revised version. Many answers given to the first referee can improve the manuscript as you suggest. We completely modified the abstract to indicate that this is the first time that a sonic anemometer is embarked above a tethered balloon. The previous attempt of turbulence measurement by a tethered balloon used a propeller anemometer. We propose the following abstract:

*This study presents the first deployment in field campaigns of a turbulence probe built around a sonic anemometer and an inertial motion sensor and suspended below a tethered balloon. This system allows to measure at high frequency the temperature and the horizontal and vertical wind to estimate the turbulent heat fluxes, momentum fluxes as well as turbulent kinetic energy in the lower part of the boundary layer. It has been validated during three campaigns with different convective boundary-layer conditions using turbulent measurements from atmospheric towers and aircrafts.*

Also, we added in the manuscript more details on the accuracy of the GPS-INS and sonic given by the manufacturers. The maximum sampling rate of the inertial-GPS motion is 100hz. Our onboard acquisition system records at 10 Hz both the Inertial-GPS motion/altitude sensor and the sonic anemometer.

As you suggested, we conducted a series of test to assess the capability on this system to remove the motion of the anemometer to compute accurately the wind fluctuations at a frequency suitable for turbulence studies. In June 2010 the system was suspended below a gantry and left oscillating starting at  $30^\circ$  from the vertical; and we verified that the oscillation was not visible in the computed wind. As a routine monitoring, for each flight we compare the PSD of the raw and corrected wind components. Figure 1 is an example during the test flight in Lannemezan, on August 30 2010 between 14 and 15 h UTC: on the left hand side the raw anemometer measurement, with a clear peak at the modal oscillation frequency of the system (0,2 Hz), on the right hand side the computed wind which exhibits a very linear spectrum. We propose to insert this figure as an annex to a revised manuscript.

We take your Editorial concerns into account. We will improve the paper and a native English speaking professional will revise the manuscript. We corrected "weighed" on page 2, and also we standardized on all the text the notation of the potential temperature to  $\theta$ .