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Referee comment on amt-2021-206

Anonymous Referee #2

Referee comment on "Thermodynamic model for a pilot balloon" by Vicent Favà et al.,
Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-206-RC2>, 2021

After a nice review of the history of piball and theodolite observations for estimating wind, the authors spend 12 or so pages and 30 equations to develop a thermodynamic model for estimating the temperature differences between the environment and the balloon gas, and the ascent rate of the balloon, involving flow charts and analog resistance circuits. The hypothesis is that piball observations made in the 1950s could be improved in terms of the altitude profile of the winds if the ascent rate of the balloon was more well characterized than just the assumption of a constant 200 m/min. In the process the authors coin the term thermal jump to indicate the temperature gradient across the skin of the balloon and use Reynolds, Nusselt, and Prandtl numbers in their equations for drag. The authors believe that in particular their model could make a difference if the temperature lapse rate differed from a constant pseudo adiabatic rate and included inversions or isothermal layers. While such features are shown to make a difference in the ascent rate, it is not significant, and the ascent rate model developed was not tested against any observations, which, with modern radiosondes, would not be hard to do.

Instead for a test, the thermodynamical model is applied to wind observations from ten cases of theodolite observations from Ebro observatory in the 1950s and the wind profile derived with the new ascent rates compared with ERA5 reanalysis data. The scatter gram of U and V winds shows a linear correlation between the two, but with no indication of the size of the differences since the graphs are in standard units which are not explained. When the entire Erbo observatory data set using a constant ascent rate is compared against ERA5 the correlations are nearly the same for ascent rates between 195 and 215 m/min.

So it seems all this work, and clearly there was a lot, does not make a significant difference in the historical measurements, and the model is designed for an observation that is no longer made as we have much better systems. Further, if the authors think their model is so precise in calculating ascent rate of balloons, they should compare it to measured lapse rates of real balloons. They could easily control all the parameters going into the test: inflation gas, balloon sizes, weigh off, accounting for a small radiosonde attached. The radiosonde would provide the measured ascent rate directly for comparison with their model. Perhaps all this material could go into a report somewhere, but it certainly does not need to be published in ATM.

Here are just a few editorial comments made on reading the manuscript.

Thermal jump? – What is meant by these words referred to in several places.

169-170 ... so we carried out an interpolation process with the function of the NCL (*The NCAR Command Language*) *csa1* with 15 knots... Confusing, suggesting an interpolation in altitude but then referring to 15 knots.

185-189 redundant.

249-253 – previous table? There is no previous table. Tables should be referred to by a number.

262-269. This is a poor description, thermal jump is inappropriate. There is a temperature difference between the gas in and outside the balloon, but it should be stated much more simply. Simply put the temperature of the gas in the balloon changes the balloons volume, which changes the volume and hence mass of air displaced and this changes the buoyancy force. This is well known and can be stated quite simply.

273-274 more redundant text.

277 How is the radiative and thermal balance determined? And it only takes a few minutes. Thus are not most balloons in near thermal equilibrium with their surroundings after a few minutes?

Section 5 – This is way overdone. The simple calculations of the mass differences described by equations 5, 6, and 7 need a sentence. Then Figure 5 shows that the temperature difference between the balloon and the surroundings is about 2 C after 11 seconds. This then leads to an approximately 1/300 or 0.3% difference from assuming the balloon's temperature is ambient for a 30 g balloon. I don't see the need for such detail to be included. Also it appears the authors have not added any new information here, see how closely their measurements reproduce the literature.

326 Do the authors mean figure 5?

451 Earlier the authors assumed, line 359 and showed, figure 5, that $T_{gas} \sim T_{air}$ was within a few K. Now they characterize this difference as a thermal jump.

Figure 9. To assess the importance of the thermal jump each of the cases should be compared to a calculation with no thermal jump. Currently only one example with no thermal jump is included, but it is not even clear if this coincides with the isothermal layer or the inversion.

Figures 11 and 12. Now the results show up to a 3 K thermal jump leading to an overall height difference of about 20 m. Is this significant? And if there is no inversion layer the thermal jump is negligible. Even with an inversion it seems to remain fairly insignificant.

721-724 ..."The difference is very small, with the former being about 8 m higher than the latter at an altitude of 10 km. This extremely small difference indicates that, at least, for this kind of (30 g) balloon, the heat exchange with the surrounding air has very little effect on the ascent rate and is, therefore, virtually insignificant for calculating wind velocities at height."

Here the authors essentially agree that all this effort has led to little change in the outcome.