We thank the reviewer for his careful reading of the article. His constructive comments should undoubtedly contribute to improving the paper.

Follows a point-by-point response to the referee's remarks.

- **The referee states that the title of the paper is misleading because we do not present turbulence data.** It is correct that we do not present turbulence measurements as the oscillating motions of balloons does not allow direct observations of turbulence. However, the paper presents methods for detecting turbulence based on estimates of the local stratification. The underlying assumption of such an approach is similar to that of Thorpe's detection (Thorpe, 1977) or to detection methods based on the Ri criterion: in case of unstable flow, i.e. when $Ri < 1/4$ or $\theta_z \leq 0$, the flow is assumed to be turbulent. It is true that these conditions may be the cause of turbulence - in the initial phase of an instability - before turbulence develops. However, the statistics on which stratification is estimated, correlations or covariances, are calculated over one-hour time segments. It appears very unlikely that an unstable flow could persist for such a time without generating turbulence.. Therefore, we believe that the detection of neutral or even unstable stratification is, or has been recently, associated with turbulent episodes. We therefore think that the current title is appropriate.

- **About the lack of other evidence of turbulence**: our first attempt to detect turbulence was to look for high-frequency excesses of variance or a high-frequency spectral signature of the measured fluctuations. This method was unsuccessful. We believe this is because the high frequency variance is dominated by the natural oscillations of the balloon. The sampling period of measurements is 30 s, i.e. $f_{Nyquist} = 1/60$ Hz. The oscillation periods of the balloon vary around 220 s, i.e. $f_{NBO} \approx f_{Ny}/3.5$. We found that the variability of measured quantities in this narrow frequency domain is dramatically affected by balloon oscillations (see the *w* spectrum of Fig.6). This point is discussed in the paper (lines 199-203 and 401-404). Therefore, we turned to statistical methods to detect the effects of turbulence from sensors that do not measure turbulence directly.

  Despite the fact that we cannot directly measure the turbulence intensity from measurements under SP balloons, we show that the vertical temperature gradients estimated by statistical methods from TSEN measurements are consistent with the RACHuTS measurements. Also, observing $\omega_{NBO} < \omega_B < N$, as modeled by Podglagen et al. (2016, see the supplementary information) gives confidence in the estimates of the vertical gradients since ω_{NBO} and *N* depend on them (Eqs. 1 and 2). Therefore, we are confident about the estimates of vertical gradients and correlations revealing periods with little or no stratification of the flow.

- **About the lack of relationship between the times and places where turbulence occurs and the synoptic conditions**: the objective of the paper is clearly methodological and we did not investigate for the causes of turbulence occurrences. We have only mentioned the fact that the frequency of occurrence of turbulence is about 5% in the average and is not uniform around the globe. It appears to be greater over convective areas such as the maritime continent. Such an assertion is justified by the following figure which shows the positions of the turbulence detections (Ri method) as green dots for the 8 flights of the C0 campaign. At the present stage, this result is qualitative and need to be deepened. Following the suggestion of the reviewer we have included this figure in the new version of the paper. The exploitation of the Strateole-2 data set with the presented methods is the subject the PhD thesis of one of the co-authors (C.P.).

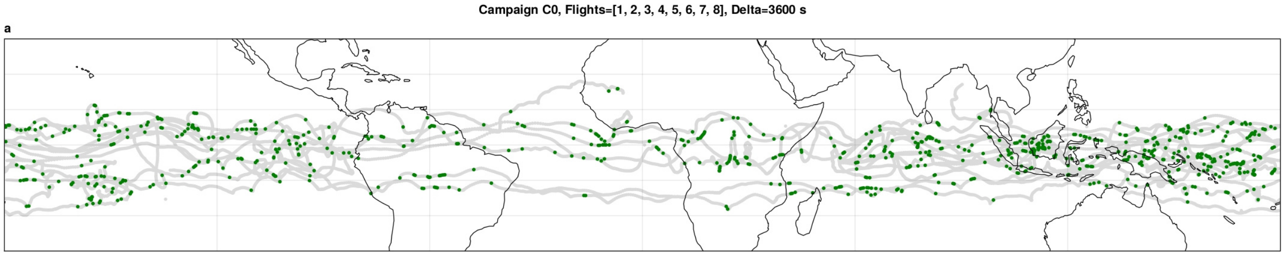

Fig. 3.1 Positions of the turbulence detection for the height flights of the C0 campaign.

- **About the assumption that layers with neutral stratification are turbulent**: There is no doubt that instability precedes the development of turbulence. We agree that this instability condition (Ri < 1/4) may be due to dynamic processes such as waves or shear, and not to turbulence. But such instability cannot persist and will necessarily generate turbulence. Therefore, if unstable, or neutral, stratification is observed, either turbulence is developed or it will develop. Since the statistics are based on one-hour segments, we favor the first hypothesis.

  We modified the sentence of line 205 to precise this point: "A consequence of turbulence is to restore stability from a preceding unstable state of the flow, which is achieved by locally mixing the fluid" and added a sentence: : "Note that neutral or even unstable stratification conditions may precede turbulence, but such conditions cannot persist and will cause turbulence."

- **About the impact of turbulence on vertical transport**: the question of the impact of turbulence on the vertical transport is the major motivation for turbulence study. This does not imply that we can answer this question with this article, which is only methodological. An estimate of vertical transport will have to rely on a physical model constrained by observations. The fact that we detect turbulence in the average for about 5% of the time does not allow us to quantify the vertical transport. The question of the impact of turbulence on transport is the central question of the PhD thesis of C.P..

- **About the turbulent fraction of the atmosphere**: the turbulent fraction in the UTLS is very poorly known. The few estimates from radiosondes or instrumented aircraft suggest values between 0 (no detection at all) and about 5%. It is difficult to compare these values because they are based on instruments with different sensitivities.

  Beyond an average value for the tropical UTLS, we found that the spatial distribution of turbulent events around the globe is far from uniform. The differences are very large since the turbulent fraction can be higher than 20% in some regions and almost zero in others. Interestingly, these inhomogeneities provide information on the mechanisms behind these turbulent episodes.

  In addition, the Lagrangian observations enabled by SPBs provide information on the lifetime of turbulent events. This parameter is crucial in some models (Alisse & Haynes) to quantify the turbulent transport.

- **line 60**: Indeed, there are many studies of turbulence from aircraft measurements. We added a reference to a recent work (Dörnbrack et al. 2022) with numerous references. However, to our knowledge, these studies do not involve tropical UTLS (with the exception of Podglajen et al., 2017, who used data obtained above &the ceiling of most research aircraft). Note that the current lack of turbulence measurements in that region is a major motivation for the present research (lines 33-35).

- **Table 1**: All balloons carry TSEN sensors. This has been specified in the legend of Table 1.
- **line 115**: Following the remark of the reviewer, the sentence has been modified: "… which we degraded to about 30 m in order to (1) improve the raw 1-m accuracy of the altitude measurements and (2) achieve similar vertical resolution from the TSEN and RACHuTS measurements (since the amplitude of the balloon oscillations is typically +/- 15 m)."
- **line 152**: The following figure (Fig. 3.2) shows the relative variations of volume of a Strateole-2 balloon during a two and a half month flight.

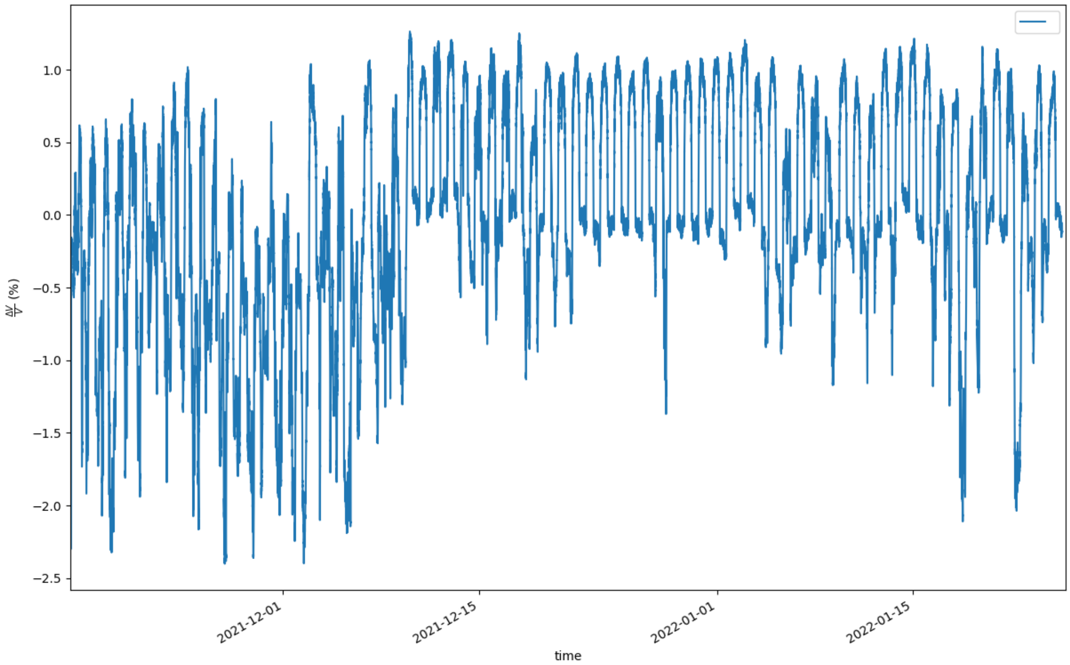

Fig. 3.2 Time series of the relative variations of the balloon volume during a flight.

The volume of the balloon varies by less than 3% peak to peak, the variations of diameter are thus lower than 1%. This precision has been added in the paper. The volume variations are mainly due to the diurnal cycle of the solar heating.

- **Fig. 8**: The large orange polygon extending to the left of -10 K/km represents the histogram of vertical temperature gradients for the only time intervals during which the flow is detected as turbulent. The green histogram (the color has been corrected) corresponds to the cases when the flow is stable.
- **line 395**: As suggested, we have removed the word "mainly" in the sentence.
- **line 404**: In the initial phase of this study, we looked for a high frequency signature as a proxy for turbulence, excess of variance or spectral signature. This method proved unsuccessful because the high frequency fluctuations ($N/2\pi < f < 1/60$ Hz) are affected by the natural oscillations of the balloon.

  However, it is planned for the next Strateole-2 campaign to perform fast (1s) velocity measurements with a sonic anemometer. This instrument, called VATA, is currently under development. These measurements should allow to directly measure turbulence.

- **line 424**: As suggested, we have included in the paper the plot of the positions of the turbulence detections (Ri method) for the 8 flights of the C0 campaign (Figure 3.1). The study to determine the origins of instabilities is ongoing.