

We thank the editor and Anonymous Referee #4 for their time and careful reading of our manuscript, and for their constructive comments, which helped us improve it. Below, the referee's comments are reproduced in *italics*, followed by our responses. Changes to the manuscript are highlighted in blue in the revised version.

1 - The model assumes a vertically homogeneous thermodynamic structure. Whereas this should be a reasonable assumption for the high-frequency GW, it becomes critical for the mid- and low-frequency GW. In particular, given the fact that the saturation layer extends up to 2 km, which can be comparable with the vertical wavelength of those waves. The resulting implications for the paper should be discussed more extensively in the conclusions than the brief mentioning at line 370, see also next point.

We thank the reviewer for this comment. We agree that assuming a vertically homogeneous column is a significant simplification for the representation of low frequency waves, that have vertical wavelengths generally shorter than those of high-frequency gravity waves.

First, we want to highlight that the depth of our vertical column (L) is drawn from an exponential distribution as explained in the method. With such a distribution shape, about 15% of simulations have $L > 1$ km and fewer than 5% have $L > 1.5$ km. For most simulations, L is therefore below typical TTL gravity wave vertical wavelengths.

Still, we show in the paper that the deep columns host the longest-lived clouds which contribute disproportionately to the integrated cloud coverage. Over longer lifetimes, crystals sediment by several hundreds of meters and can cross different phases of a lower-frequency wave, and this is where neglecting vertical structure could matter most.

However, the sign of the resulting bias is not obvious to us currently :

- Crystals falling from the cold phase into a warmer phase below would sublimate earlier. In this case, the warmer phase would lead to a complete sublimation and our current model would overestimate the persistence of the longest-lived clouds. (Note that this effect may be partly offset by our assumption of spherical ice crystals: non-spherical crystals fall more slowly than spheres of equal mass, so the simulated sedimentation is likely somewhat too fast, which tends to underestimate the persistence of sedimentation-limited clouds)
- However, if the phase speed of the wave is also accounted for, Podglajen et al. (2018) showed with a vertically resolved monochromatic wave model that crystals can become localized in the cooling phase of the wave, near ice saturation. This happens where the crystals' fall speed matches the downward vertical phase speed of an upward-propagating wave. These crystals converge toward the radius at which sedimentation and phase propagation balance, so their net settling slows and they stay longer in saturated air.
- Finally, whether this localization survives the stochastic GW forcing used here is an open question. Strong GW-induced warming events could knock crystals away from the equilibrium phase. Vertical wind shear, which we also neglect, would further deform the cloud relative to the wave structure (Jensen et al., 2025).

We changed the brief statement at lines 369–372, it has been replaced by an expanded paragraph in Section 5, describing our answer to the reviewer.

2 - Is the synthetic stochastic forcing restricted to the high-frequency GWs only, what is the spectrum of this forcing? Given the fact that it depends only on standard deviation and decorrelation time, it is not obvious that lower frequencies are not present. With this the separation between high and low frequency wave forcing in the paper is somewhat arbitrary.

We thank the reviewer for this comment. We agree that the manuscript did not describe the spectral properties of the stochastic forcing clearly enough. The stochastic parameterization KP19 represents the gravity wave background between the inertial frequency f and the Brunt–Väisälä frequency N . In this range, all intrinsic frequencies contribute equally to the vertical wind power spectrum, so the w' spectrum is approximately flat. This resulting w' spectrum was computed and compared with Stratéole-2 superpressure balloon observations of gravity waves in Jensen et al. (2026, their Fig. 7). That figure shows that the KP19 spectrum, like the balloon spectrum, is approximately flat for periods between about one day and $2\pi/N$, and drops off beyond N .

Lower-frequency waves, with periods of several days, are also effectively excluded as KP19 includes a low-frequency damping that bounds the spectrum and keeps the temperature variance consistent with balloon observations. Without it, we would expect low frequencies to dominate T' .

Following the reviewer's comment, we changed Section 2.2 by adding a short description of the KP19 spectrum.

- I am wondering why no information on the vertical structure of the cirrus is presented. Given the fact that the SIP are traced in the vertical, this information should be provided by the model.

SIP altitudes are indeed tracked in the model. The main reason why we do not focus on it is that the vertical position of SIPs is only used to determine when crystals leave the ice-saturated column through sedimentation, which, together with complete sublimation, sets the cloud lifetime. The thermodynamic environment (temperature, supersaturation, and vertical wind) is homogeneous across the column (Section 2.1), so all SIPs experience the same forcing regardless of altitude. The simulated vertical distribution of ice therefore reflects only differential sedimentation: larger crystals fall faster and leave the column, while smaller ones remain near the initial layer. It does not include the effects that shape the observed vertical structure of TTL cirrus, such as vertical variations in temperature and humidity, wave phase variations with height, wind shear, or radiative and turbulent mixing. For this reason, we focused on lifetime statistics, which are the main object of the paper and for which the column-integrated approach is appropriate.

We clarified this in Section 2.1.

- Fig.4: are the units in the color bar caption for the number-size distribution correct?

We thank the reviewer for this comment. The color bar shows the number–size distribution per logarithmic radius interval, $dn/d \ln r$. Since $\ln r$ is dimensionless, its unit is indeed cm^{-3} .

We changed the label of the colorbar and changed the caption for more clarity.

- Reference list: Kärcher, B. and Corcos, M., 2025 incomplete

This was corrected.

Jensen, E. J., Corcos, M., and Kärcher, B.: Influence of variations in gravity wave properties on cirrus ice number concentrations produced by homogeneous freezing in the tropical tropopause layer, *J. Geophys. Res. Atmos.*, 131, e2025JD044467, <https://doi.org/10.1029/2025JD044467>, 2026.