Internship Subject: Environmental conditions favouring tropospheric gravity waves trapping, a waveguide climatology

Internship

4- to 6-months internship, for M1/M2/end-of-studies internship. No follow-up PhD subject.
Nature of the subject: observations/theory.

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Meteorology - Wave theory - Observations - Data analysis

Waves constitute a major and ubiquitous component of atmospheric flows, from planetary-scale Rossby waves down to gravity waves with wavelengths of the order of a few kilometers. High-resolution modeling of the atmosphere on one hand, and the availability of novel observations from both satellites and field campaigns, on the other, is renewing the interest in internal gravity waves. They remain difficult to observe globally, because of their fine scales and because their most conspicuous signature is on a field difficult to observe: vertical velocity (see in-situ measurements in Figure 1). A strong motivation to better quantify and understand the gravity wave field stems from the dynamical and thermodynamical impacts of vertical velocity in a stratified medium, in particular for nonlinear processes. A clear visible signature of gravity waves occurs when water vapor condenses in the cold phases of the waves, yielding banded cloud patterns that can be detected in visible or infrared satellite imagery (as in Figure 1b).

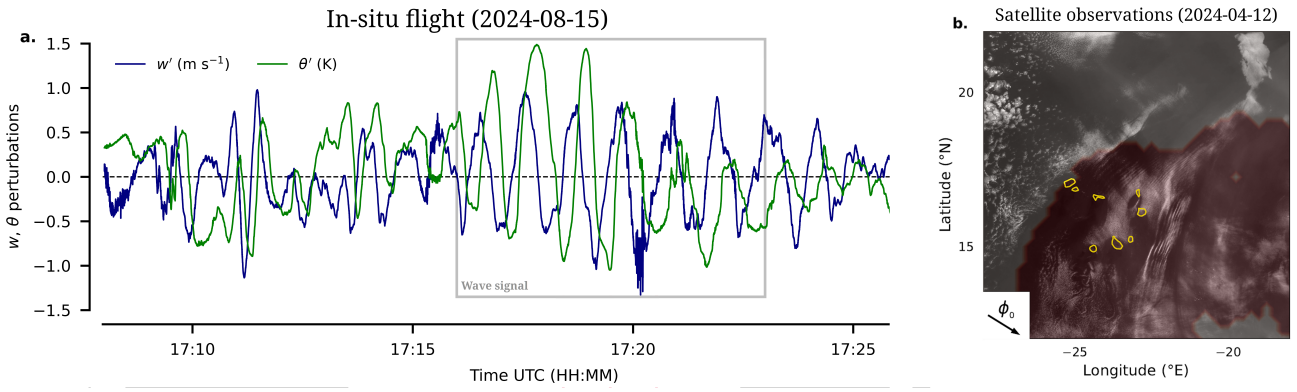

Figure 1: Illustration of (a) in-situ measurement of Gravity Waves (GW) from a field campaign near Cape Verde. The multiple instruments allow for an extensive characterization of the wave. Satellite observations (b) are more widespread but more limited in resolution, instrument variety and sensitivity. Here cloud bands are present (black-and-white satellite image) above Cape Verde (coastline in yellow). The GW signature occurs within the assessed waveguide, from TraLI (red overlay). Figures and full details in Biagioli et al. (2026).

This internship will investigate specifically the occurrence of trapped Gravity Waves in the troposphere. In a way analogous to the laser cavity in optics, the atmospheric wind and stratification profiles can induce layers that

inhibit the vertical propagation of waves, confining internal gravity waves vertically: either between the surface and an evanescent layer, or in a propagative layer encapsulated between two evanescent layers. Both the extent of horizontal and the characteristics of the resonant modes are heavily influenced by the characteristics of the waveguide, which can be maintained over large spatial and temporal scales. Extended horizontal propagation provides an opportunity for observing such waves, as multiple wavelengths are frequently present. The large-scale nature of the factors defining the waveguide implies that coarse resolution knowledge of the flow could be sufficient to detect the occurrence of trapped waves.

The internship builds on recent work that analyzed a well-documented case of trapped waves in the mid-troposphere over the Atlantic Ocean (Figure 1a, see also Biagioli et al., 2026). Based on this case study, we proposed a simple diagnostic (TraLI, or *Trapping Likelihood Index*) characterizing the atmospheric ability to act as a waveguide, calculated from ERA-5 reanalysis data (the potential waveguide is illustrated in red in Figure 1b). The initial goal of the internship would be to characterize the evolution of the potential for trapping, temporally and spatially, and investigate favoured resonant modes. Several directions will be considered, combining observations and theory, including:

- Investigation and characterization (frequency of occurrence, wavelengths, orientation) of trapped gravity waves in visible and infrared geostationary imagery (following Vicari et al., 2024).
- Comparison to the Trapping Likelihood Index to characterize its predictive skill.
- Estimation of expected wave characteristics, based on theory and the characteristics of waveguides calculated from ERA5.
- Theoretical investigation of potential implications of these trapped waves for nonlinear processes, namely the radiative budget or the organization of convection.

References

Biagioli, G., Aubel, A., Plougonven, R., and Bony, S. (2026). Observed large-scale trapping of gravity waves within the free troposphere. *EGUsphere*, 2026:1–30.

Vicari, R., Stephan, C. C., Lane, T. P., and Huang, Y. (2024). Analysis of trapped small-scale internal gravity waves automatically detected in satellite imagery. *Journal of Geophysical Research: Atmospheres*, 129(4):e2023JD038956. e2023JD038956 2023JD038956.