Global distribution of gravity wave activity from Aeolus wind profiling

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The challenge for climate models is to take proper account of each atmospheric effect, therefore trying to minimize the biases present in the predictions. Among these effects, one type of small-scale atmospheric wave, the internal gravity waves (IGWs) are particularly hard to parametrize for current models. Since middle atmosphere dynamics are the main driver for the global atmospheric circulation, its correct understanding and depiction is a major concern.

In 2018, the European Space Agency decided to tackle this issue with the launch of a satellite, called Aeolus, with a payload consisting of ALADIN (Atmospheric LAser Doppler INstrument). The lidar measures wind velocity by sensing the Doppler spectral shift of its laser echo, scattered by the different layers of the atmosphere. The satellite is then able to provide global wind speed information from the ground up to 30km, addressing the need for a better understanding of middle atmosphere processes.

In this paper, we explore the capacities of Aeolus wind observations in capturing and resolving dynamical processes in the upper troposphere and lower stratosphere (UTLS) such as IGWs at various temporal and spatial scales. This study also includes an overview of the various instrumental and retrieval issues affecting the ALADIN wind data quality.

The perturbations in the vertical profiles of Rayleigh horizontal line-of-sight (HLOS) wind velocity, associated with IGW activity, are derived by subtracting the Aeolus-derived "background" wind profiles from the individual measurements. Then, the global distribution of the IGW kinetic energy in the UTLS and vertical wavelength is computed using Aeolus measurements over the entire mission lifespan. The derived variation of IGW activity over the Aeolus mission lifetime is analyzed in consideration of the time-varying performance of ALADIN instrument.The latter is quantified using two French ground-based Doppler wind lidars operating at a mid-latitude site (Observatoire de Haute-Provence) and at a southern tropical site (Maïdo Observatory at la Réunion island) as well as meteorological radiosoundings collocated with satellite overpasses.

These comparisons helped identify recurring perturbations in the Aeolus wind profiles signal through their frequency analysis. Taking into account these perturbations and the evolution of the instrument's performance allows for the improvement of the IGW analysis. The filtered data can then be displayed through weekly, monthly, or longer geographical visualizations.

The global spatiotemporal distribution of IGW from Aeolus observations is compared with that derived from global high-resolution temperature profiling data provided by GPS radio occultation (RO) instruments operating onboard MetOp and COSMIC-2 satellite constellations. The comparison of Aeolus and RO-derived global IGW distribution allows concluding on the capacities and limitations of Aeolus wind profiling for studying UTLS dynamics