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Gravity Waves in the Tropical UTLS: New Insights from Aeolus Wind Profiling Data

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The European Space Agency's Aeolus satellite mission, launched in 2018, provides global wind profiling using a Doppler lidar instrument ALADIN. In this study, we examined ALADIN's ability to capture and resolve internal gravity waves (IGWs) in the upper troposphere and lower stratosphere (UTLS). To derive the IGW-induced perturbations in the vertical profiles of ALADIN's horizontal line-of-sight (HLOS) quasi-zonal wind velocity at ~1 km vertical resolution, we subtract the Aeolus-derived "background" wind profiles from the individual measurements. Through a spectral analysis of these data, we then derive the IGW kinetic energy and dominant vertical wavelength in the UTLS over the entire Aeolus mission lifespan.

This study represents the first attempt to reconstruct the global distribution of IGW activity using the global wind information exclusively provided by the Aeolus mission. The analysis reveals the well-known IGW sources such as orography, polar vortex dynamics and tropical convection. Here we focus on the tropical UTLS region, where ALADIN has an extended stratospheric coverage. The analysis reveals a previously undocumented spot of enhanced IGW activity in the UTLS, recurring above the Indian Ocean during Boreal Summer. The IGW activity spot is shown to slowly migrate from eastern Africa to the Pacific maritime continent during the June-December period.

The Aeolus-derived distribution and seasonal variation of IGW activity were cross-validated using the global temperature profiling by EUMETSAT radio-occultation (RO) satellites. The RO data were resampled to ALADIN resolution and spectrally analyzed in the same way as it was done for ALADIN wind data. The derived IGW potential energy data confirm the seasonal/zonal variation of IGW activity observed by ALADIN, in particular the eastward migration of the IGW activity hotspot, presumably linked to convection within the MJO (Madden-Julian Oscillation). The results suggest that the interannual variation of the IGW kinetic and potential energies in the UTLS is modulated by the Quasi-Biennial Oscillation, whereas the MJO-related waves can be characterized by shorter vertical wavelengths.

Another important finding enabled by the joint analysis of the Aeolus wind and RO temperature data is the evidence for a strong IGW generation by the Smoke-Charged Vortex (SCV) produced by the 2019/20 Australian megafires. Overall, with this study we point out the potential of Aeolus wind profiling to improve our understanding of atmospheric dynamics, particularly in the UTLS region.