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Gravity waves in the southern polar night jet region: A case study on propagation and origin

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Satellite and super-pressure balloon observations display a band of enhanced gravity wave momentum flux (GWMF) around 60°S associated with the winter polar night jet. Though this structure is reproduced in high-resolution analysis fields of the ECMWF's Integrated Forecast System (IFS), it is not found in several state-of-the-art climate simulations. In general, the generation processes contributing to the gravity wave activity in this region are still not well understood. Especially, GWMF signatures remote of orography in the lower stratosphere of the southern mid-latitudes are not explained with by recent studies of gravity wave sources and propagation. Naturally, coarse setups as used for climate simulations rely greatly on parametrising small-scale processes such as gravity waves and hence lack the ability to reproduce their effects.

We present a case study on gravity wave propagation pathways and sources contributing to a large pattern of enhanced GWMF several 100 kilometres southeast of New Zealand over the Pacific Ocean. Using an analysis cube-based sinusoid fitting approach, we identify gravity waves in high-pass filtered IFS temperature fields of 1 August 2014. Full, three-dimensional wave vectors as well as additional characteristic parameters, such as GWMF, are calculated from the fits at 25 km altitude. The calculated wave parameters are then used to initialize the GROGRAT ray-tracer and follow the propagation paths back to the most likely sources of the waves.

We find that stratospheric gravity waves in our case are forced by various processes. The orography of New Zealand presents a significant but not the dominant source. Non-orographic gravity wave sources over the Tasmanian Sea contribute the remaining flux. In addition, we see a far lateral propagation, of often more than 1000 km. Other than reasoned in former studies, the lateral propagation takes place below 15 km altitude, before the waves "shoot up" into the stratospheric jet. This propagation may explain the displacement of observed GWMF maxima poleward against the dominant source regions. In general, our results support the pressing necessity to improve gravity wave parametrisations by incorporating lateral propagation.