Assimilation of atmospheric infrasound data to constrain tropospheric and stratospheric winds

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Abstract

This data assimilation study exploits acoustical infrasound from explosions to probe an atmospheric wind component from the ground up to stratospheric altitudes. Planned explosions of old ammunition in Finland generate transient infrasound waves that travel through the atmosphere. These waves are partially reflected back towards the ground from stratospheric levels, and are detected at a receiver station located in northern Norway at 178 km almost due north from the explosion site. The difference between the true horizontal direction towards the source and the backazimuth direction (the horizontal direction of arrival) of the incoming infrasound wave-fronts, in combination with the pulse propagation time, are exploited to provide an estimate of the average cross-wind component in the penetrated atmosphere. We perform offline assimilation experiments with an ensemble Kalman filter and these observations, using the ERA5 ensemble reanalysis atmospheric product as background (prior) for the wind at different vertical levels. We demonstrate that information from both sources can be combined to obtain analysis (posterior) estimates of cross-winds at different vertical levels of the atmospheric slice between the explosion site and the recording station. The assimilation makes greatest impact at the 12 − 60km levels, with some changes with respect to the prior of the order of 0.1 − 1.0 m/s, which is a magnitude larger than the typical standard deviation of the ERA5 background. The reduction of background variance in the higher levels often reached 2−5%. This is the first published study demonstrating techniques to implement assimilation of infrasound data into atmospheric models. It paves the way for further exploration in the use of infrasound observations – especially natural and continuous sources – to probe the middle atmospheric dynamics and to assimilate these data into atmospheric model products.