EGU23-6993, updated on 27 Apr 2024
https://doi.org/10.5194/egusphere-egu23-6993
EGU General Assembly 2023

Using infrasound from explosions for probing internal gravity waves in the middle atmosphere

Ekaterina Vorobeva[1,2], Jelle Assink[3], Igor Chunchuzov[4], Toralf Renkwitz[5], Patrick Espy[1], and Sven Peter Näsholm[2,6]

[1]Department of Physics, Norwegian University of Science and Technology, Trondheim, Norway
[2]NORSAR, Kjeller, Norway
[3]R&D Seismology and Acoustics, Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands
[4]Obukhov Institute of Atmospheric Physics, Moscow, Russia
[5]Leibniz Institute of Atmospheric Physics, University of Rostock, Kühlungsborn, Germany
[6]Department of Informatics, University of Oslo, Oslo, Norway

This study uses ground-based recordings of low-frequency, inaudible acoustic waves (infrasound) to probe the wind and temperature fluctuations associated with internal gravity waves breaking in the middle atmosphere. Building on the approach introduced by Chunchuzov et al., the recorded waveforms are used to retrieve the effective sound speed fluctuations in an inhomogeneous atmospheric layer of infrasound backscattering. The retrieval procedure was applied to infrasound from controlled blasts related to the disposal of military explosives in Hukkakero, Finland and recorded at the IS37 station in Norway over a four-year period from 2014 to 2017. Our findings indicate that infrasound scattering occurs in the lower mesosphere between 50 and 75 km in altitude in a region where gravity waves interact due to strong nonlinear effects and form thin layers with strong wind shears. The retrieved effective sound speed fluctuations were then analysed in terms of the vertical wave number spectra. The analysis revealed that the spectra follow a k_z^{-3} power law that corresponds to the "universal" saturated spectrum of atmospheric gravity waves within $k_z \in [2.1\cdot10^{-3}; 2.7\cdot10^{-2}]$ cycles/m. Based on this wavenumber range, we estimate the outer and inner vertical scale of atmospheric inhomogeneities that infrasound is sensitive to as L_{inner}= 33 – 37 m, L_{outer} = 382 – 625 m.

Furthermore, the spectra of the retrieved effective sound speed fluctuations were compared to theoretical linear and nonlinear gravity wave saturation theories as well as to independent wind measurements made by the Saura MF radar near the Andøya Space Center in Norway. The comparison showed a good agreement in terms of the amplitude and slopes of the vertical wavenumber spectra in both cases. The overall agreement allows us to suggest that the Saura radar and infrasound-based effective sound speed profiles represent the low- and high-wavenumber regimes of the same "universal" gravity wave spectrum. These results illustrate that the use of infrasound makes it possible to probe fine-scale motions that are not well captured by other techniques. The latter suggests that infrasound observations can be used as a

complementary technique to probe internal gravity waves in the middle- and upper atmosphere.