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Rapid propagation of Tsunami-induced gravity waves across the atmosphere

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We present theoretical and numerical results on large-scale gravity waves that are forced by Tsunamis at the sea surface and subsequently travel rapidly across the atmosphere until they are detectable by remote sensing in the ionosphere an hour or so after their launch. The theoretical possibility of this phenomenon has been known for some time, but only in recent years has detailed data become available that confirms this effect. This has potential impact for remote sensing applied to Tsunami detection as well as to other near-ground processes.

Solving this detailed wave problem requires technology somewhat beyond the standard ray-tracing familiar from wave drag parametrizations, as there is no usable scale separation in the vertical. Our method combines Laplace transforms in time with Fourier transforms in the horizontal, which allows us to satisfy the vertical radiation condition correctly, takes into account back-reflection at the tropopause as well as the influence of wind shear, and provides detailed information about the structure of the first arriving waves at 100 km altitude or so.

One unexpected outcome is that there is a clearly observable forerunner wave that arrives at the ionosphere in a manner of minutes, which is an acoustic-gravity wave, so its dynamics goes beyond anelastic models and requires the fully compressible Euler equations instead. These results will be illustrated in a number of idealized examples.