Geophysical Research Abstracts
Vol. 15, EGU2013-7884, 2013
EGU General Assembly 2013

Trapped lee wave drag in two-layer atmospheres

Pedro M.A. Miranda (1), Miguel Teixeira (2), and José Argain (3)
(1) University of Lisbon, IDL, Lisboa, Portugal (pmmiranda@fc.ul.pt), (2) University of Reading, (3) University of Algarve

The surface drag exerted by trapped lee waves generated in stratified flow over a 2D mountain ridge is explicitly calculated using linear theory, and compared to the drag associated with vertically propagating waves that accompany them. A two-layer atmosphere is considered, with both atmospheric layers having a constant Scorer parameter. The upper layer is assumed to be stably stratified, whereas the lower layer is assumed to be, either stably stratified, with a higher Scorer parameter (in case 1), or neutral, but capped by a sharp temperature inversion (in case 2). The wave trapping mechanisms that are active in these two cases correspond, respectively, to trapping within the lower layer or trapping at the inversion. In both cases there are also vertically propagating waves whose energy is transported in the upper layer towards infinity. The behaviour of the drag normalized by its hydrostatic single-layer reference value is investigated as a function of the flow parameters. In case 1, these are the ratio of the Scorer parameters in the two layers, a dimensionless height of the interface separating them, and a dimensional width of the mountain (quantifying non-hydrostatic effects). In case 2, the ratio of the Scorer parameters is replaced by the Froude number of the inversion. While the vertically propagating wave drag receives contributions from a continuous spectrum of relatively low wavenumbers, the trapped lee wave drag only receives contributions from higher discrete wavenumbers, satisfying a resonance condition. This allows the trapped lee wave drag to be given by a closed-form analytical expression. However, while in case 1 multiple trapped lee wave modes may exist, in case 2 only one wave mode is possible. Substantial trapped lee wave drag is only produced if either there is a considerable contrast in Scorer parameter values between the two layers (in case 1) or the inversion is strong enough (in case 2). Additionally, trapped lee wave drag is maximized for dimensionless mountain widths (normalized by the Scorer parameter in the upper layer) of order one. This condition ensures that the flow is sufficiently non-hydrostatic for the trapped lee waves to have a horizontal scale (wavelength) that roughly matches the width of the mountain. Under those circumstances, the trapped lee wave drag may be comparable, or even higher than the drag associated with vertically propagating waves, and considerably exceed the single-layer hydrostatic reference value. These results show good agreement with numerical simulations performed in linear conditions, and may have implications for drag parameterization schemes, where typically the effect of trapped lee waves is neglected.