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Internal gravity waves generation by isolated topography in the laboratory: Lee waves and lee mountains

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The internal wave field associated with steady flow past stationary isolated obstacles is studied in the laboratory in a recirculating stratified shear flume tank. The complete steady span-wise averaged wave field is determined using the synthetic schlieren technique. Typically, the obstacles are two-dimensional segments of cylinders, which are chosen in an attempt to satisfy the requirements for linear behaviour in the wave field. Such obstacles are predicted by linear theory to induce a steady (in the obstacle frame) lee wave field, with perturbations localized above, and slightly downstream of the obstacle, thus implying a relatively small dominant value of the streamwise wavenumber component. This is unsurprising, as the spectral response to an isolated obstacle is strongly peaked at small streamwise wavenumbers.

However, the observed wave field exhibits some non-trivial differences from the predicted behaviour. Although the induced vertical wavenumber of the perturbation is quite similar to the theoretical predictions, the observed streamwise wavenumber is substantially larger than predicted, or equivalently, the lee waves are observed to be more strongly tilted downstream than predicted. This tilting appears to be a consequence of the tendency of the fluid in the lee of the obstacle to oscillate strongly vertically, as if it were passing over a sequence of "lee mountains". Considering such virtual lee mountains as part of the topographic forcing appears to lead to closer agreement between linear theory and experimental observation. We explore the role of these virtual lee mountains by introducing physical low-level obstacles in the lee of the primary mountain, focussing on the effect such physical lee obstacles have on the observed lee wave flow at higher levels.