Simulations of gravity waves generated in directional flows over an isolated orography
Outline of the draft

• Section 1: Introduction
• Section 2: Setup of experiments
• Section 3: Results
• Section 4: Conclusions
## Setup of experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Background wind</th>
<th>Mountain height ((h_0, \text{km}))</th>
<th>Domain length ((L))</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTLa</td>
<td>W0</td>
<td>0.01</td>
<td>0.5L_0^*</td>
</tr>
<tr>
<td>CTLb</td>
<td>W0</td>
<td>0.01</td>
<td>L_0</td>
</tr>
<tr>
<td>CTLc</td>
<td>W0</td>
<td>1.0</td>
<td>L_0</td>
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<tr>
<td>Exp1a</td>
<td>W1</td>
<td>0.01</td>
<td>L_0</td>
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<tr>
<td>Exp1b</td>
<td>W1</td>
<td>0.01</td>
<td>1.25L_0</td>
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<tr>
<td>Exp1c</td>
<td>W1</td>
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<td>W2</td>
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<tr>
<td>Exp3</td>
<td>W3</td>
<td>0.01</td>
<td>L_0</td>
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<td>W1</td>
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</tr>
<tr>
<td>Exp6</td>
<td>W3</td>
<td>1.0</td>
<td>L_0</td>
</tr>
<tr>
<td>Exp7</td>
<td>W2</td>
<td>2.0</td>
<td>L_0</td>
</tr>
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</table>
Background winds

| Winds | $|V_0| (\text{m s}^{-1})$ | $\psi_0 (\degree)$ | $|V_z| (\text{s}^{-1})$ | $\chi_0 (\degree)$ |
|-------|----------------------|--------------------|----------------------|--------------------|
| W0    | 8                    | 0                  | 0                    | —                  |
| W1    | 8                    | 0                  | 0.005                | 90                 |
| W2    | 8                    | -45                | 0.005                | 90                 |
| W3    | 8                    | -45                | 0.01                 | 90                 |
Results

• a. model verification (Fig. 1)
• b. momentum flux and its vertical divergence
  linear waves (Figs. 2, 3)
  nonlinear waves (Figs. 4, 5)
• c. wave structure
  pt fields at 1.5 and 3.0 km (Figs. 6, 7)
  surface flow pattern and vorticity (Figs. 8, 9)
  TKE in y-z cross section (Fig. 10)
• d. discussions: lee vortex shedding (Fig. 11)
Model verification

Figure 1
Linear wave momentum flux

Figure 2
Linear wave stress divergence

Figure 3
Nonlinear wave momentum flux

Figure 4
Nonlinear wave stress divergence

Figure 5
Potential temperature perturbation at z = 1.5km

Left: linear
Right: nonlinear

Figure 6
Potential temperature perturbation at $z = 3.0\text{km}$

Left: linear
Right: nonlinear

Figure 7
Surface flow pattern

Figure 8a: Exp4
Surface flow pattern

Figure 8b: Exp5

Figure 8c: Exp6
Surface vertical vorticity

Figure 9a: Exp4
Surface vertical vorticity

Figure 9b: Exp5
Figure 9c: Exp6
TKE in the y-z plane at 80 km downstream of the mountain

Figure 10
Evolution of the vertical vorticity at the surface for Exp7

Figure 11
Conclusions

• For linear waves, the simulated wave momentum flux show fairly good agreement with that obtained from linear theory.

• The numerical results of nonlinear waves differ from their analytic counterparts significantly.
Conclusions (cont.)

• The incident flow of which the wind speed increases with height is prone to climb over the mountain. Wave-breaking is suppressed, with weak vertical vorticity generated in the mountain wake.

• The flow tends to go around the mountain when the wind speed decreases with height in the lower levels. Intense vertical vorticity are created downwind of the mountain in association with strong turbulent dissipation.
Conclusions (cont.)

• The directional wind shear results in the development of asymmetric perturbations about the upstream flow, which could induce the formation of lee vortex shedding for sufficiently high mountains.