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

Experiment	Background wind	Mountain height (h_0, km)	Domain length (L)
CTLa	W0	0.01	$0.5L_0^*$
CTLb	W0	0.01	L_0
CTLc	W0	1.0	L_0
Exp1a	W1	0.01	L_0
Exp1b	W1	0.01	$1.25L_0$
Exp1c	W1	0.01	$1.5L_0$
Exp2	W2	0.01	L_0
Exp3	W3	0.01	L_0
Exp4	W1	1.0	L_0
Exp5	W2	1.0	L_0
Exp6	W3	1.0	L_0
Exp7	W2	2.0	L_0

Background winds

Winds	$\lvert V_0 \rvert$ (m s^{-1})	ψ_0 (°)	$\lvert V_z \rvert$ (s^{-1})	χ_0 (°)
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

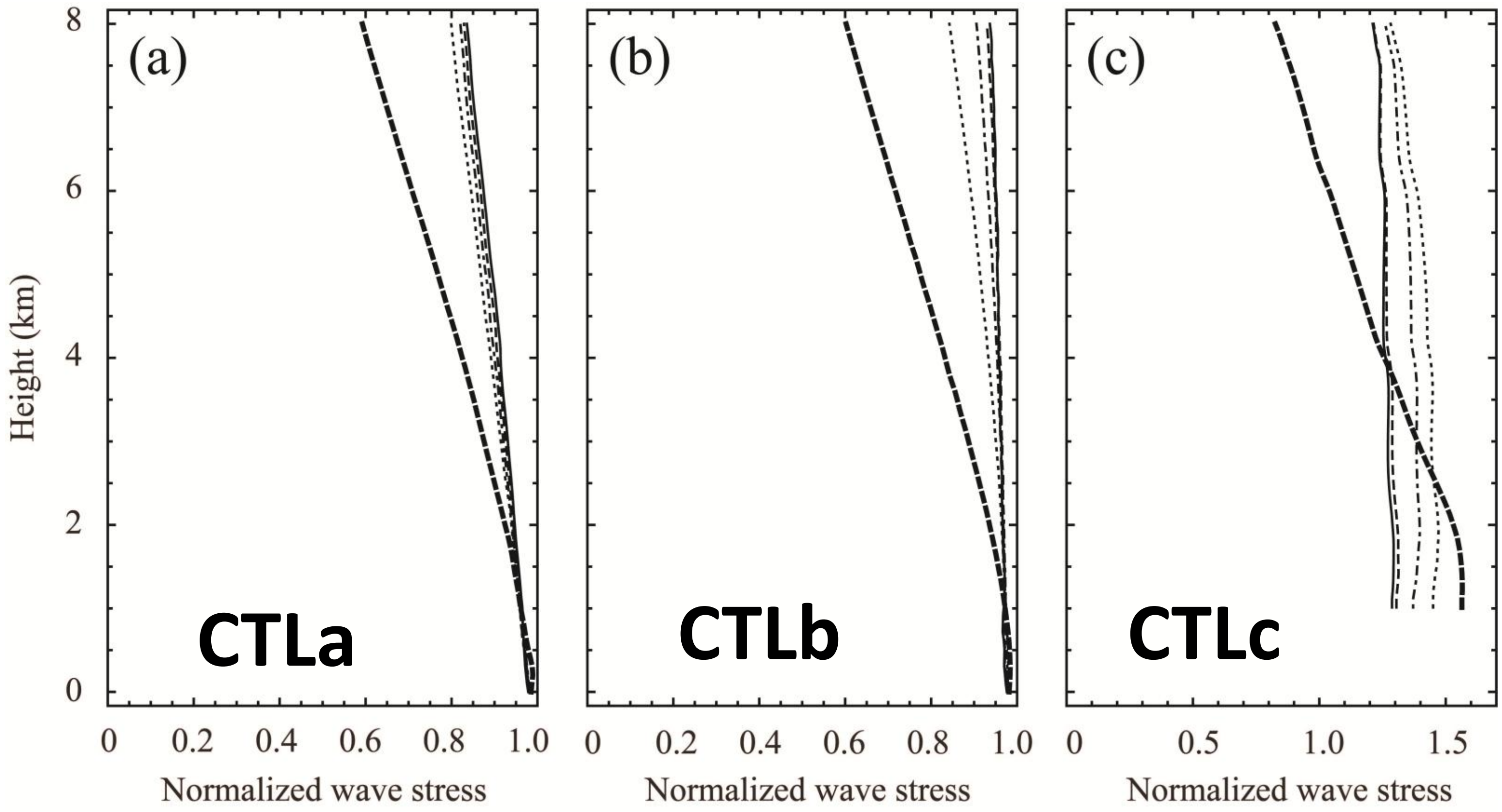


Figure 1

Linear wave momentum flux

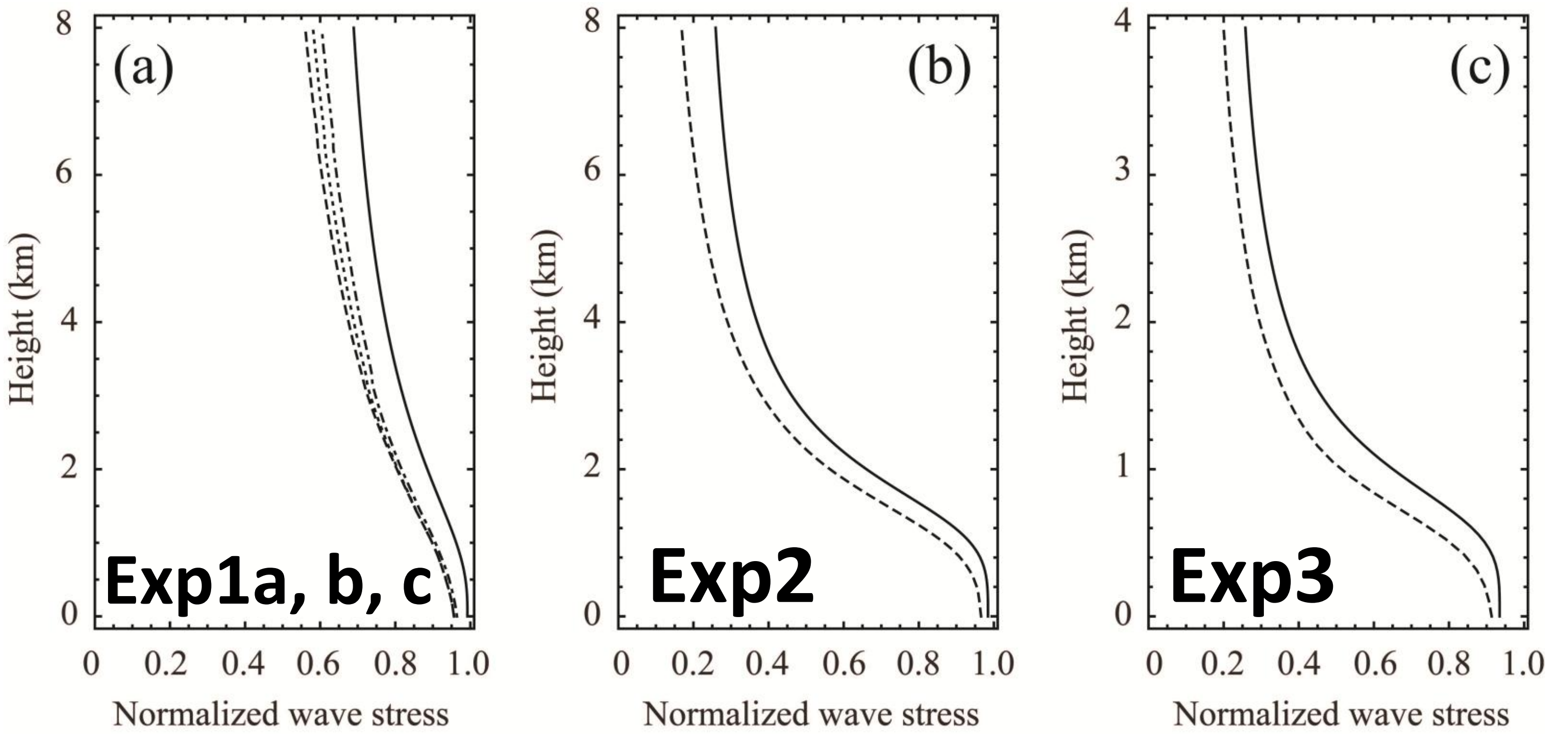


Figure 2

Linear wave stress divergence

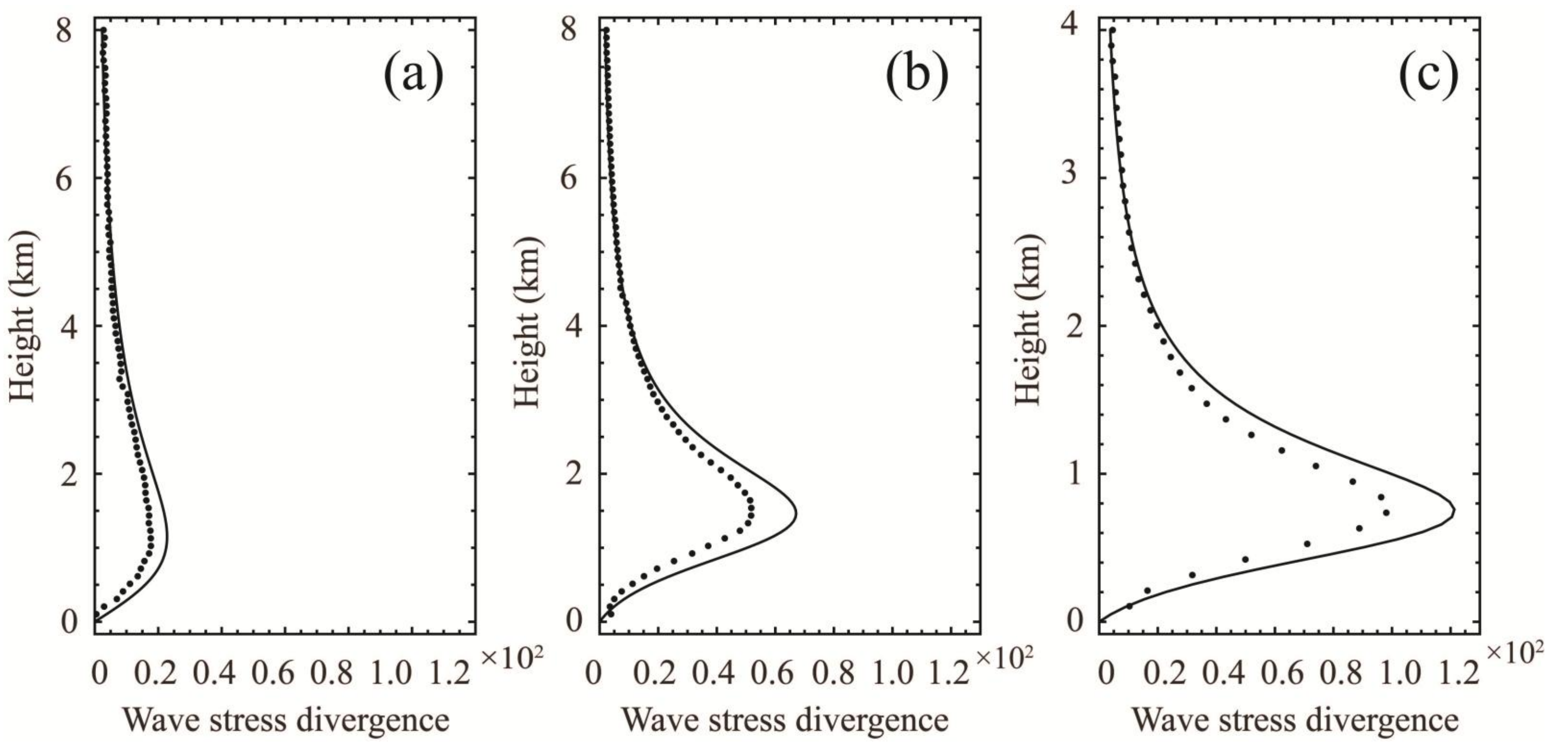


Figure 3

Nonlinear wave momentum flux

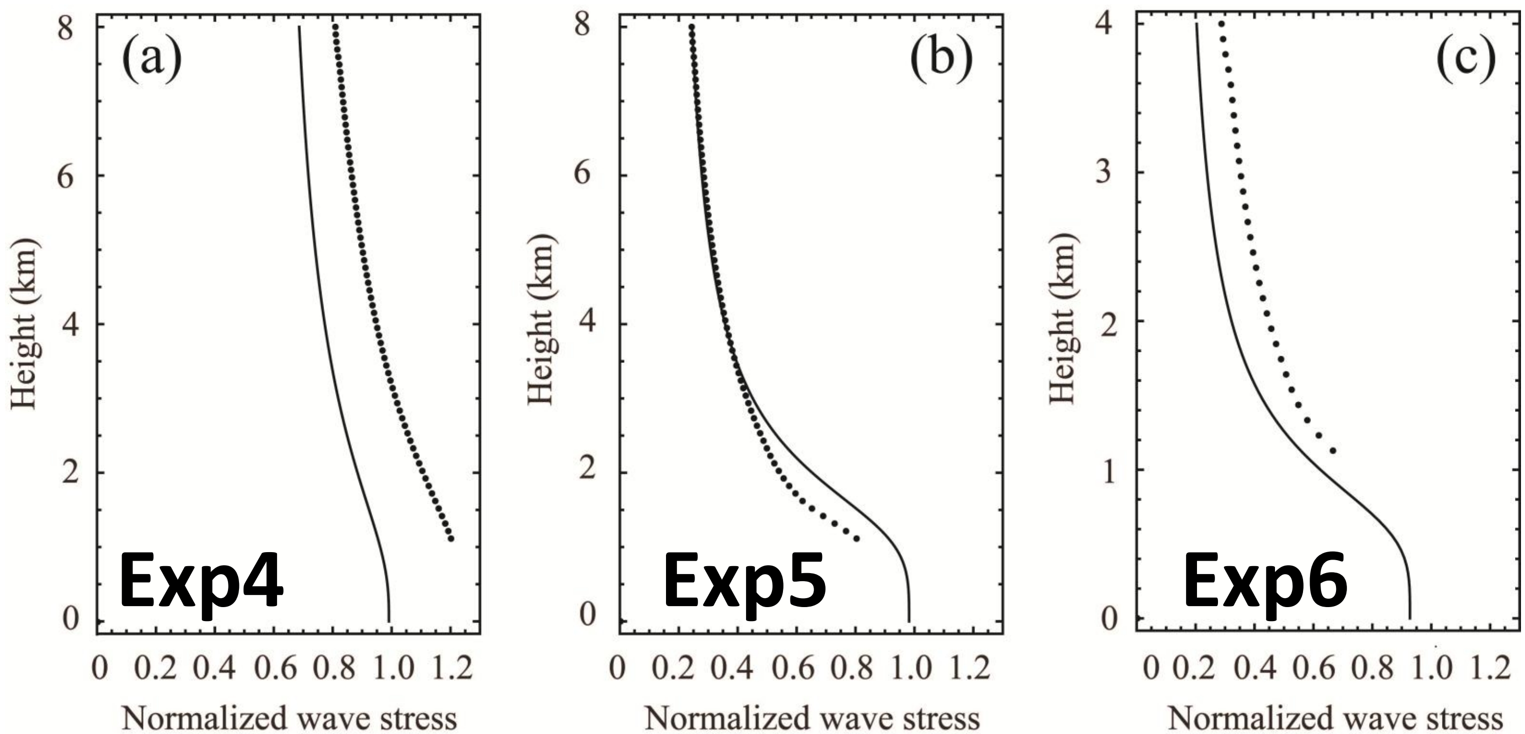


Figure 4

Nonlinear wave stress divergence

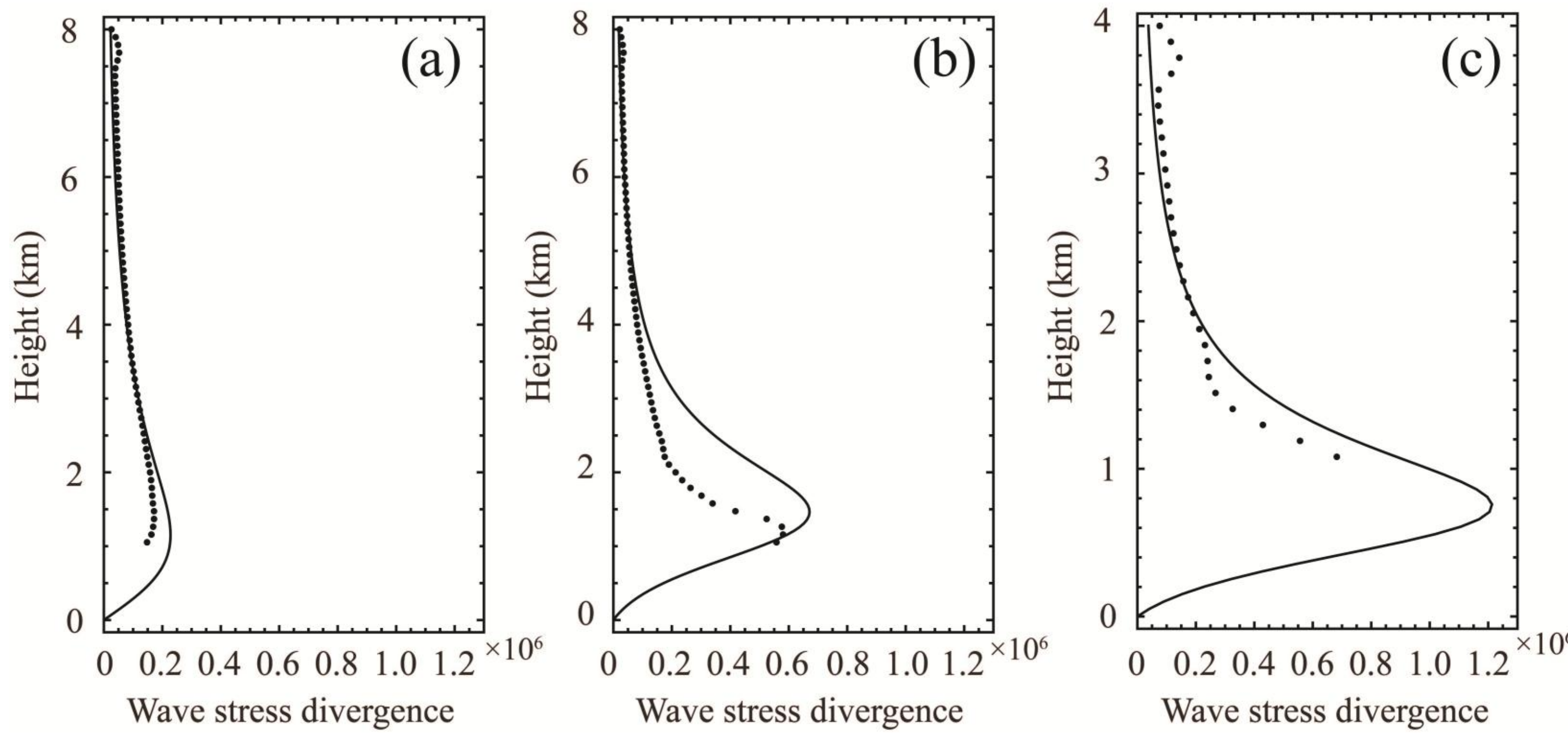
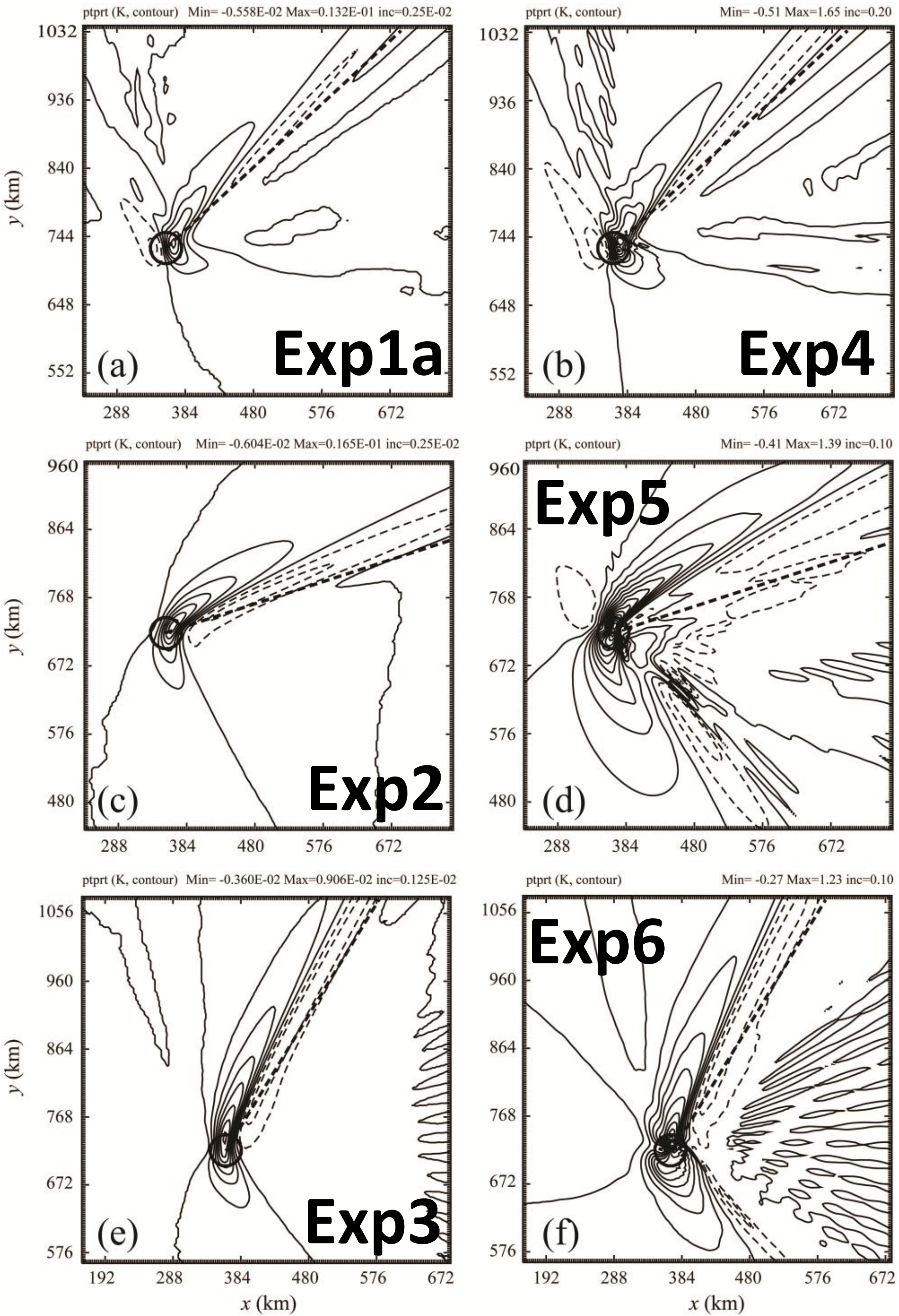


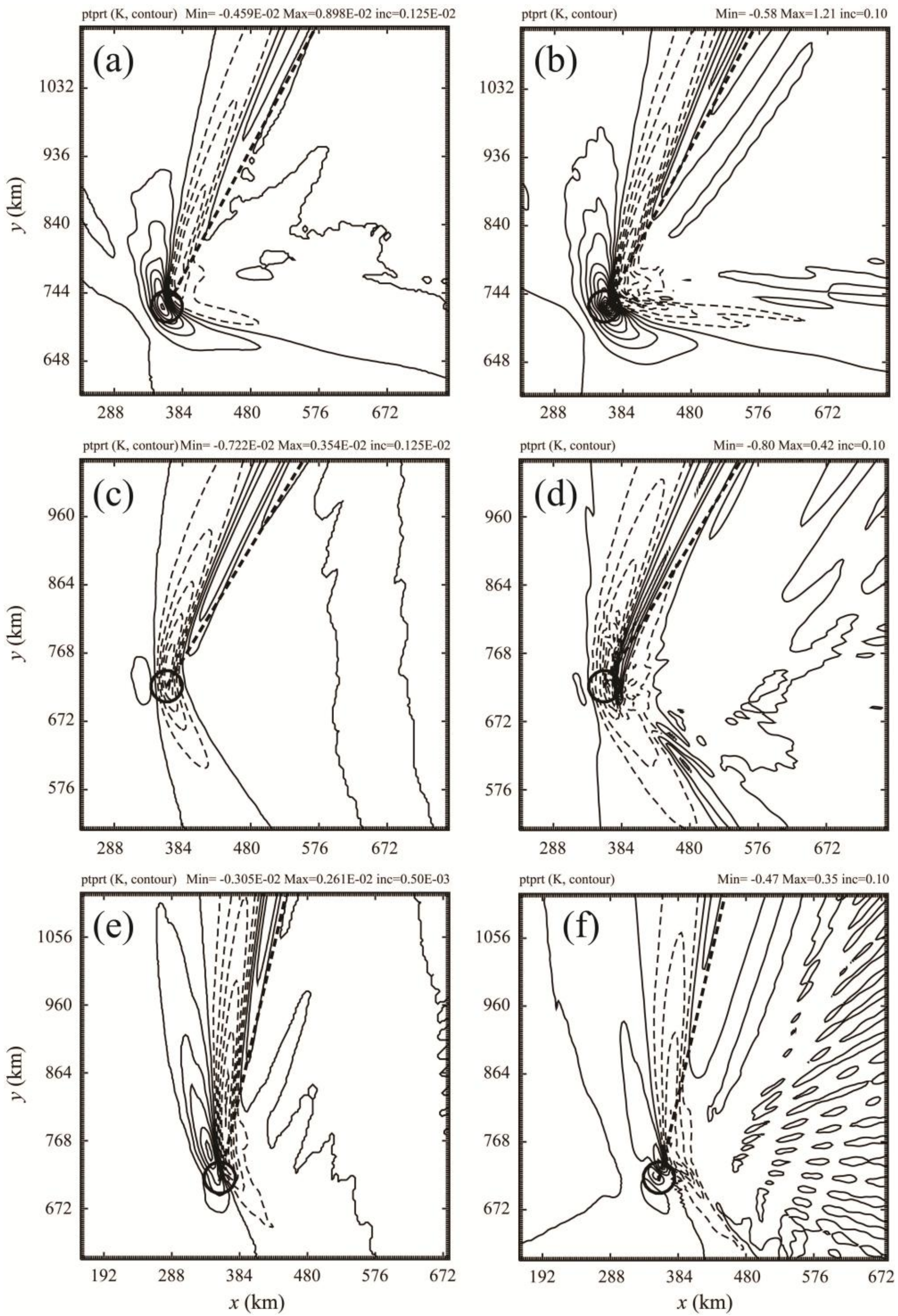
Figure 5



Potential temperature perturbation at z =1.5km

Left: linear
Right: nonlinear

Figure 6



Potential temperature perturbation at z =3.0km

Left: linear
Right: nonlinear

Figure 7

Surface flow pattern

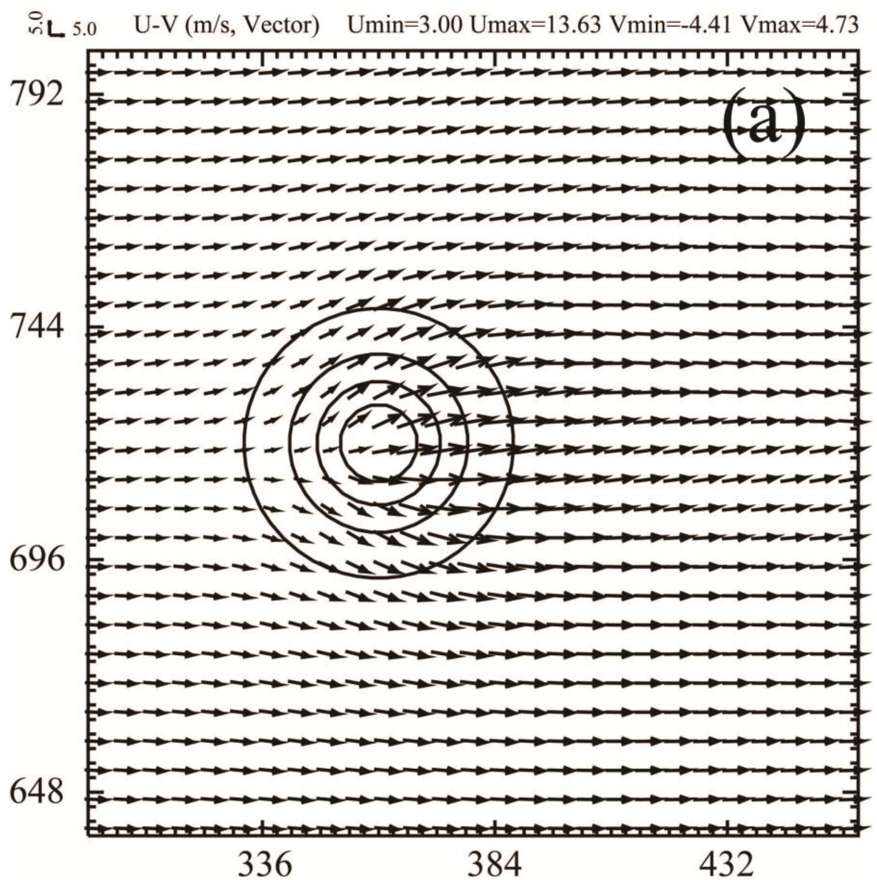


Figure 8a: Exp4

Surface flow pattern

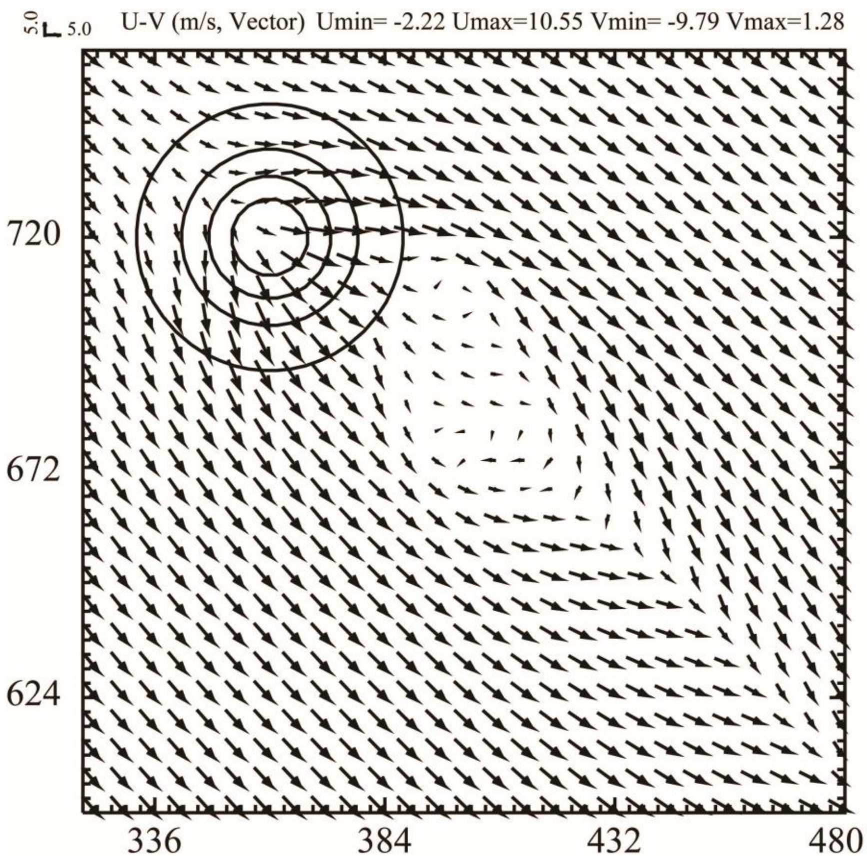


Figure 8b: Exp5

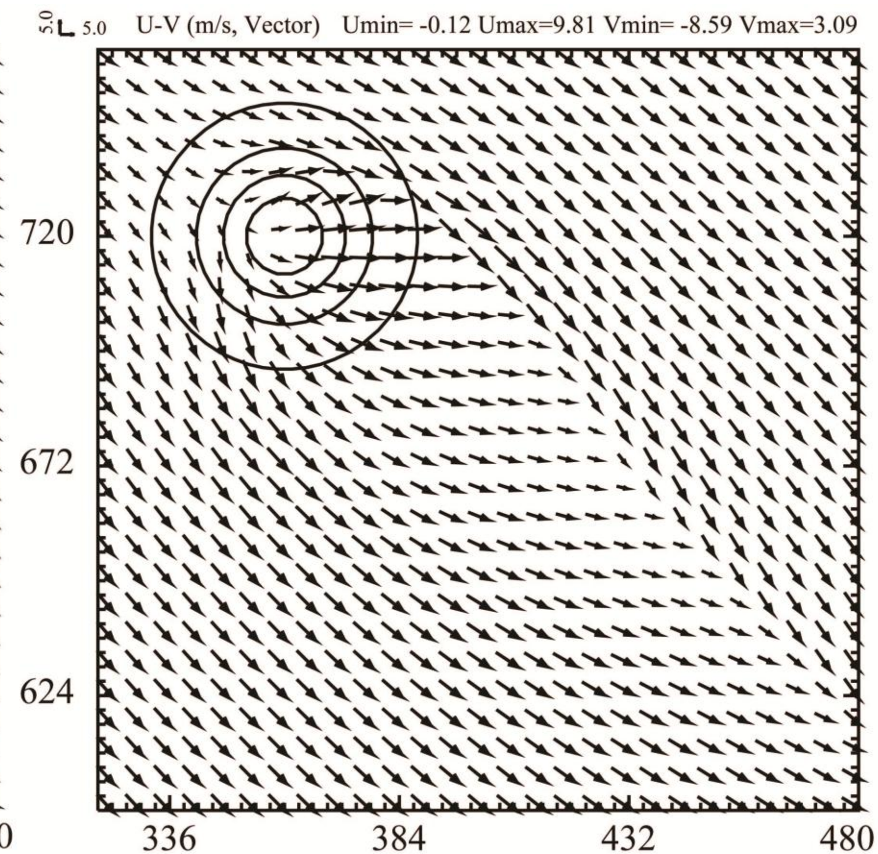


Figure 8c: Exp6

Surface vertical vorticity

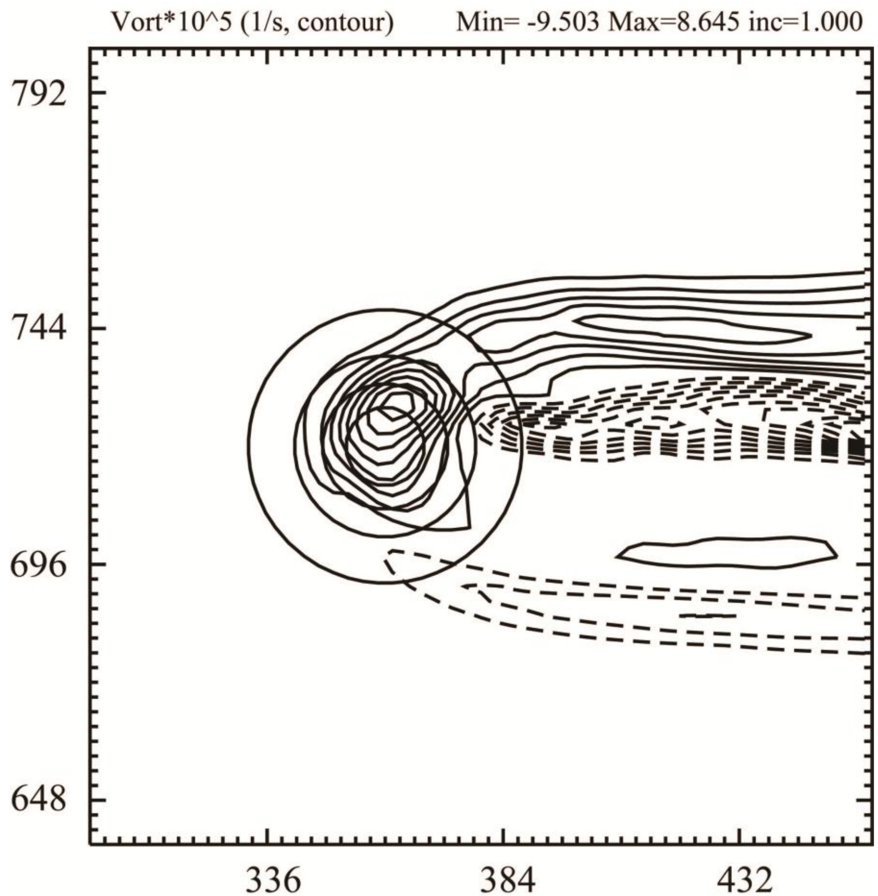


Figure 9a: Exp4

Surface vertical vorticity

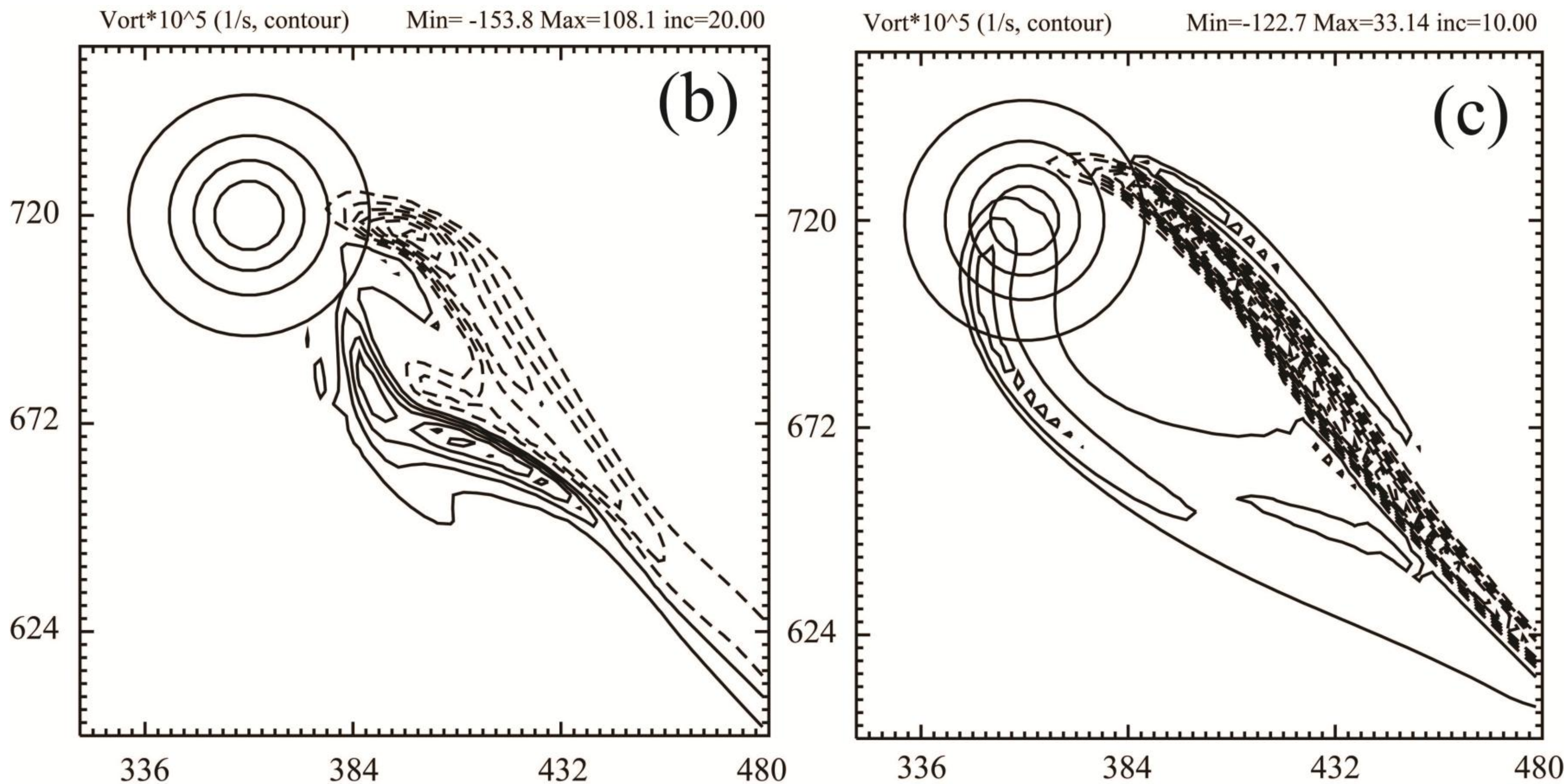
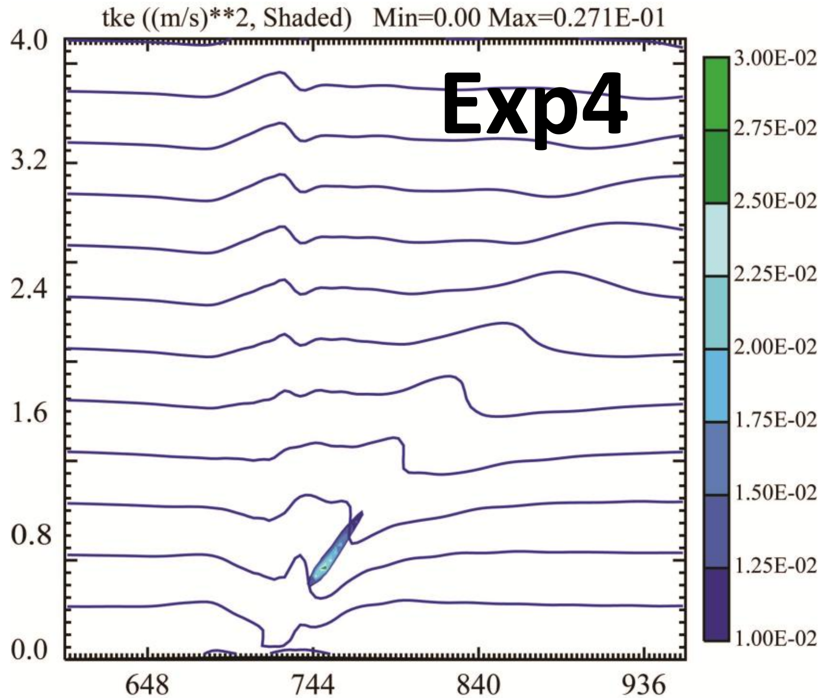
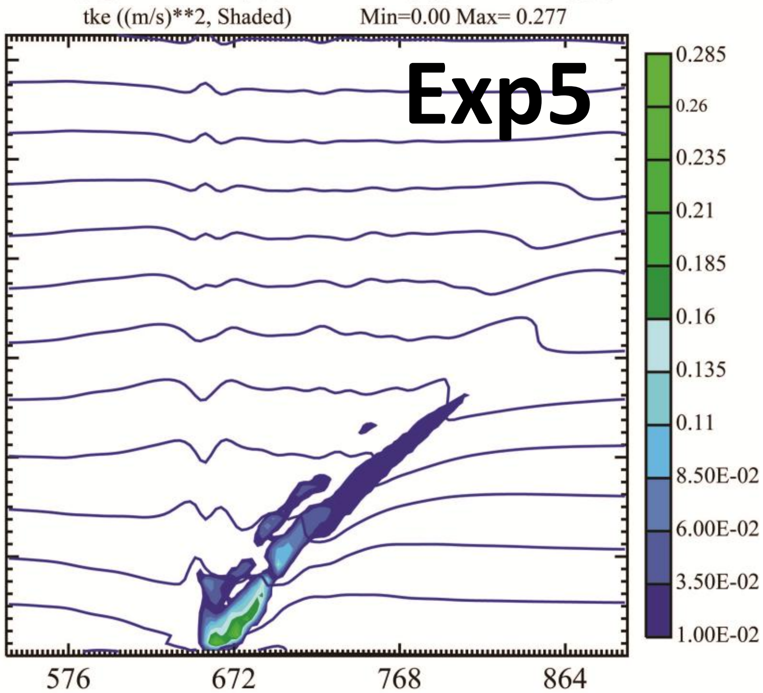


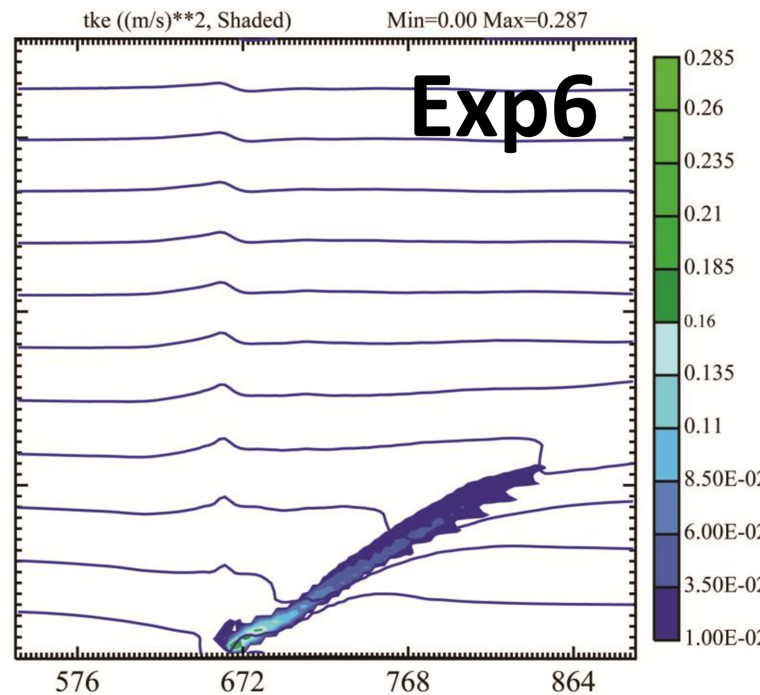
Figure 9b: Exp5 **Figure 9c: Exp6**

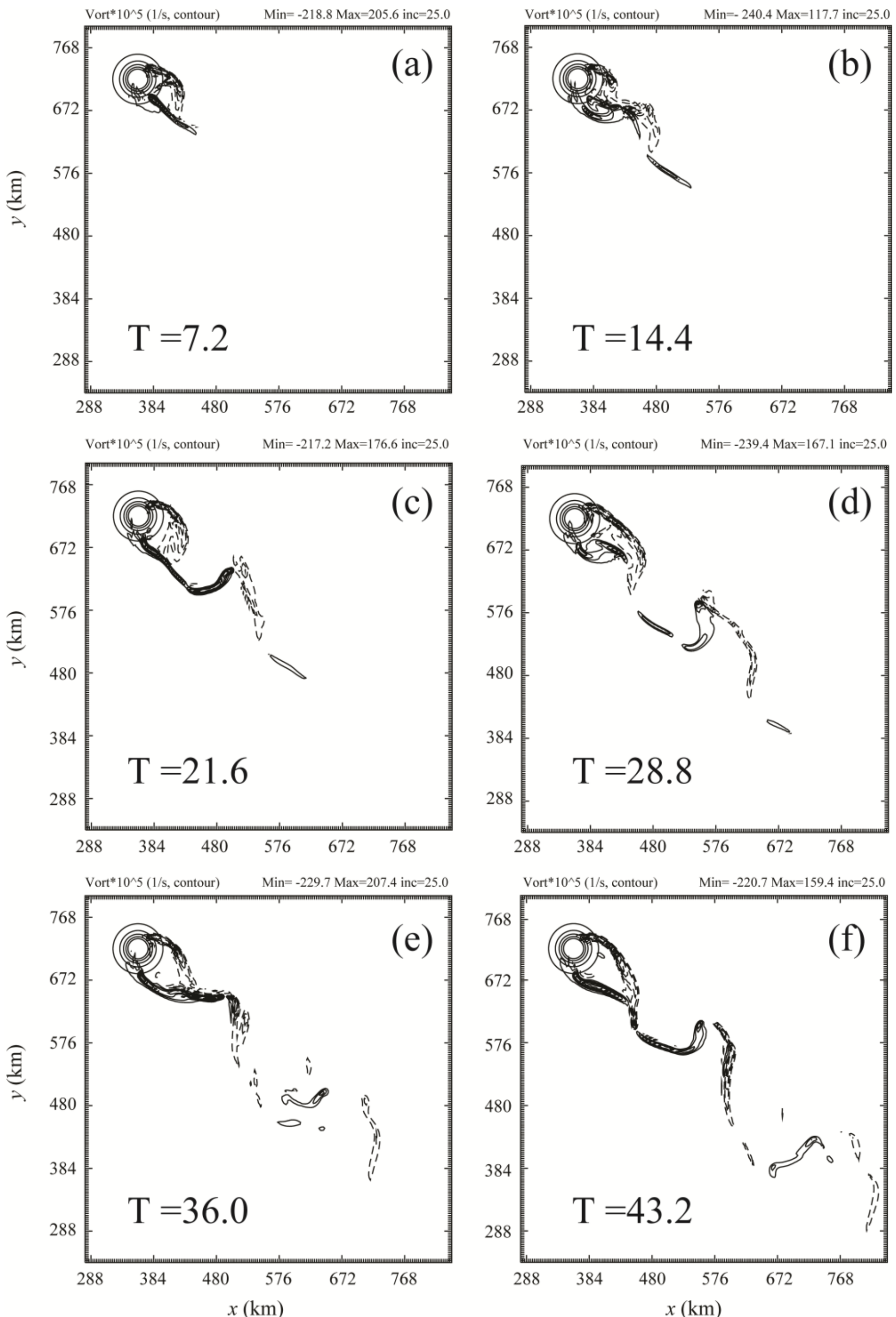


TKE in the y-z plane at 80 km downstream of the mountain

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.