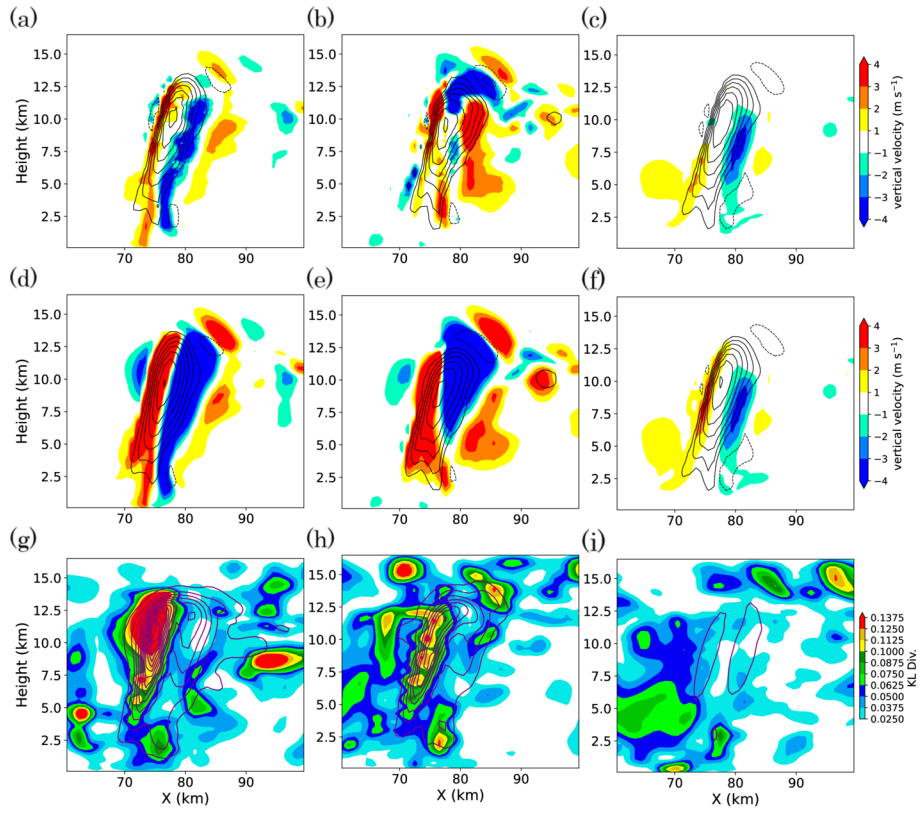
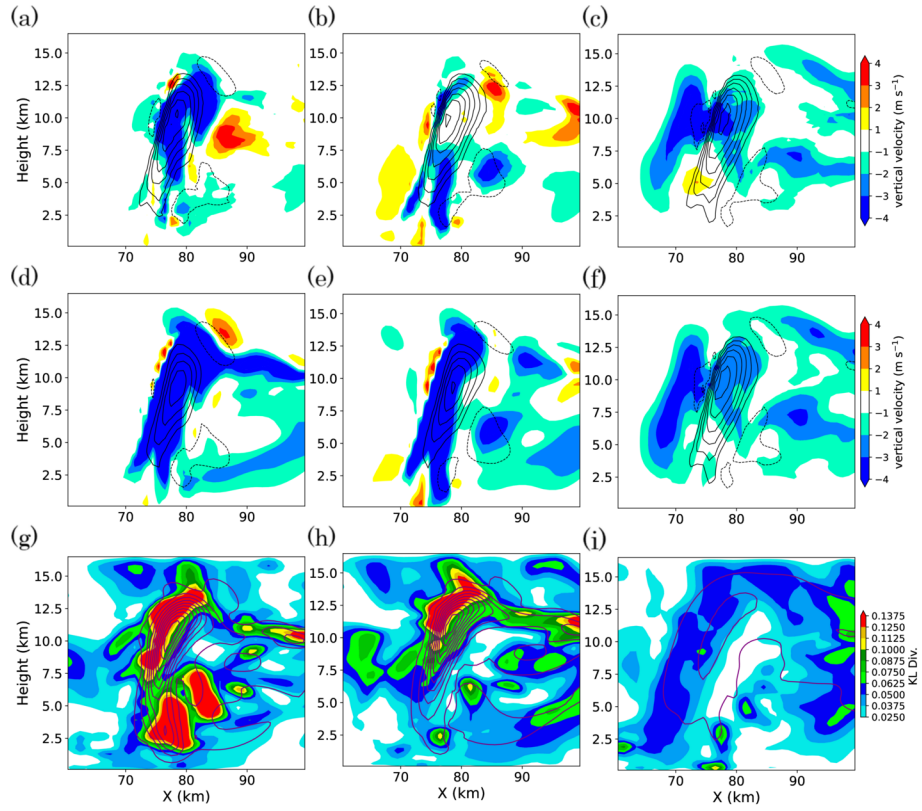


**Figure 4.** Vertical cross sections at  $Y = 80$  km of (a-c) analysis ensemble mean and deviation from the nature run, (d-f) first guess ensemble mean and deviation from the nature run, and (g-i) first guess ensemble spread and KL divergence, of vertical velocity at 00:50:00, for (a,d,g) 5MIN-3D, (b,e,h) 5MIN-4D, and (c,f,i) 30SEC cases respectively. Black contours in (a-f) indicate ensemble mean of vertical velocity with contour interval of  $5 \text{ m s}^{-1}$ . Red contours in (g-i) indicate first guess ensemble spread of vertical velocity with contour interval of  $0.5 \text{ m s}^{-1}$ .



**Figure 9.** Same with figure 4 but for the experiments with background wind perturbation. Purple contours in (g-i) indicate first guess ensemble spread of vertical velocity with contour interval of 1 m s<sup>-1</sup>.



**Figure 10.** Same with figure 9 but for the experiments with background stability perturbation.