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# A study of surface semi-geostrophic turbulence: freely decaying dynamics

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In this study we give a characterization of semi-geostrophic turbulence by performing freely decaying simulations for the case of constant uniform potential vorticity, a set of equations known as the surface semi-geostrophic approximation. The equations are formulated as conservation laws for potential temperature and potential vorticity, with a nonlinear Monge–Ampère type inversion equation for the streamfunction, expressed in a transformed coordinate system that follows the geostrophic flow. We perform model studies of turbulent surface semi-geostrophic flows in a domain doubly periodic in the horizontal and limited in the vertical by two rigid lids, allowing for variations of potential temperature at one of the boundaries, and we compare the results with those obtained in the corresponding surface quasi-geostrophic case. The results show that, while the surface quasi-geostrophic dynamics is dominated by a symmetric population of cyclones and anticyclones, the surface semi-geostrophic dynamics features a more prominent role of fronts and filaments. The resulting distribution of potential temperature is strongly skewed and peaked at non-zero values at and close to the active boundary, while symmetry is restored in the interior of the domain, where small-scale frontal structures do not penetrate. In surface semi-geostrophic turbulence, energy spectra are less steep than in the surface quasi-geostrophic case, with more energy concentrated at small scales for increasing Rossby number. The energy related to frontal structures, the lateral strain rate and the vertical velocities are largest close to the active boundary. These results show that the semi-geostrophic model could be of interest for studying the lateral mixing of properties in geophysical flows.