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Observations and modelling of atmospheric rotors

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Atmospheric rotors are often connected with severe turbulence and intense up- and downdrafts near the ground in mountainous regions. Pioneering investigations of the phenomenon date back to the 1930s, while the major elements of its current understanding were obtained through dedicated field campaigns in the 1950s (Mountain Wave Project), 1970s (near the Colorado Rockies) and 2000s (Sierra Wave Project and Terrain-induced Rotor Experiment, T-Rex), as well as through high-resolution idealized numerical simulations. It is now well established that atmospheric rotors are embedded in non-hydrostatic flow, and that they are linked on one side to large-amplitude lee waves in the atmosphere aloft, and on the other to wave-induced separation of the boundary layer from the ground.

A few recent findings concerning atmospheric rotors are presented:

1. The intensity of turbulence within rotors is comparable to that in hydraulic jumps and in mid-tropospheric wave-breaking regions. Rotors react quickly to mesoscale forcing and may move steadily against the background wind on the lee side of a mountain as they dissipate. Supporting evidence includes Doppler cloud radar measurements made in 2006 in the lee of the Medicine Bow Mountains (Wyoming, USA). These observations are interpreted with the aid of mesoscale numerical simulations.

2. The complexities inherent to a valley environment may considerably affect the normal development of rotors. Examples from a few case studies of the T-Rex campaign, held in 2006 in Owens Valley in the lee of the Sierra Nevada (California, USA), are provided.

3. Even when the primary mountain wave propagates vertically and is essentially hydrostatic, rotors may occur underneath a secondary wave disturbance resembling an undular bore. This finding is supported by idealized simulations of linearly stratified and vertically uniform flow over a mountain.