18–22 September 2017, Pula, Croatia
ECSS2017-158

The sensitivity of simulated near-surface mesovortices to environmental vertical shear

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The objective of this work is to examine the sensitivity of mesovortices to the environmental vertical shear. The term mesovortices is used here to refer to a broad class of vortices in the micro-alpha to meso-gamma scale (generally several hundred to several thousand meters in size) that form along thunderstorm gust fronts. This investigation considers the separate and combined roles of the components of vertical shear normal to and parallel to the gust front. Based on prior work, front-normal shear should increase dynamic ascent ahead of and just behind the gust front and should increase the phasing of the gust front with the main updraft; front-parallel shear should enhance vertical vorticity originating as barotropic horizontal vorticity.

Experiments are conducted using a highly-idealized numerical modeling framework wherein a prescribed cold pool interacts with an updraft generated through parameterized latent heating. Both two- and three-dimensional simulations are conducted. Front-normal shear is found to be essential for mesovortex formation in these simulations as it facilitates the necessary inflection of the gust front and promotes updraft-front phasing. The pattern of vertical vorticity and vertical pressure gradient acceleration is consistent with vertical tilting of baroclinically-generated horizontal vorticity and stretching via gust front dynamics. There is no evidence in these simulations that front-parallel shear contributes to mesovortex formation through tilting of barotropic horizontal vorticity.