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Modeling Convectively Induced Secondary Circulations (CISCs) in the Terra Incognita

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In numerical weather prediction models, the continuous increase of computational capacity enables grid spacings in the kilometer or even sub-kilometer range. This grid resolution is similar to the length scale of the most energetic eddies of the convective planetary boundary layer (PBL). Hence in this so-called terra incognita, convectively induced secondary circulations (CISCs) and current PBL schemes strongly interact and might cause numerical artefacts.

In this study, we use the recently developed Terrestrial System Modeling Platform (TerrSysMP) to investigate the structure and realism of simulated CISCs at these resolutions, using a set of idealized and real case studies and observations.

The simulated CISCs largely follow the behaviour predicted by the Rayleigh-Benard theory. Both in the idealized and realistic settings the spatial scales and the temporal evolution of CISCs depend on the model grid resolution; e.g. the horizontal expansion of the CISCs decrease with finer grid spacing. A modification of the Blackadar mixing length scale in the PBL parametrization scheme is an option to compensate for this dependency. The emergence and intensity of the simulated CISCs also depend on surface heterogeneity, with land-use and its impact on the sensible heat flux the dominant factor while topography plays only a minor role.