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Kinematic vorticity number – a tool for estimating circulations and cyclone sizes

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Extra-tropical cyclones play an important role in the heat and moisture transport between the (sub)tropics and the poles. The effectivity of this process depends on the circulation, the system's speed as well as the size of the cyclones. Although extra-tropical cyclones can clearly be seen on satellite images, it is a challenge to extract them from the flow field. Whereas various methods generally based on vorticity or geopotential height data have been published for the estimation of cyclone properties, the estimation of their sizes is still a challenge. Especially in a shear-dominated flow, these methods give different results. The aim of this work is the application of mathematical definitions that allow the identification of cyclone sizes even in shear-dominated regions. Mathematical basis is the velocity gradient tensor that describes the properties of the flow field around a local point. This tensor can be decomposed into the sum of a symmetric strain-rate tensor and an antisymmetric vorticity tensor. Parameters based on the invariants of the velocity gradient tensor like the kinematic vorticity number relate the rotation and deformation of the flow field. A vortex is then defined as a region in the flow field where the rotation prevails over the deformation.

In the presented work, the kinematic vorticity number is tested in idealized 2D and real cases concerning its ability to identify cyclone sizes. Therefore, the 3D geopotential height fields were investigated with help of the kinematic vorticity number. Furthermore, a comparison between the proposed method and other methods will be presented.