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Investigation of the relationship between the intensity of pollutant spread and the vorticity during a climate change in an ensemble approach

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Numerous studies reported that the cyclonic activity and the number of cyclones have changed in the last decades. At the same time a question arises whether quantities that can be related to the cyclones — such as the intensity of the spreading of atmospheric pollutant clouds — also change during a time-interval while the climate is changing. In this study an ensemble of climate realizations are used to investigate the change in the intensity of the atmospheric large-scale transport events and its relation to the relative vorticity. In the ensemble approach, statistical measures, such as mean and standard deviation values, correlation coefficients, can be calculated at any given time instant: they are determined over the ensemble, that is, by using the results of each climate realization of the ensemble at the given time instant.

The climate realizations utilized by the pollutant spreading simulations are produced by the Planet Simulator (PlaSim) [Fraedrich 2005] intermediate complexity climate model covering a century-long time-interval characterized by an increase of the CO_2 concentration from 360 to 720 ppm. The spreading of the pollutants is simulated by the Real Particle Lagrangian Trajectory (RePLaT) model [Haszpra and Tél 2013]. For the characterization of the intensity of spreading, the so-called stretching rate is used. It is the exponent of the exponential function which describes the length of the pollutant clouds over time. The simulations show that the mean stretching rate has a zonal distribution with smaller values for the tropics and larger values for the mid- and high latitudes. The shape of the distribution does not change significantly over the investigated time-period. A general decrease of the stretching rate is found almost all over the globe except for the high latitudes of the respective winter season of the hemispheres. The zonal distribution of the relative vorticity changes similarly over time and a positive correlation coefficient is found between the two variables. The study draws attention to the fact that the changing climate may influence the intensity of pollutant transport events, and these changes can be estimated by means of other meteorological variables such as relative vorticity.

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