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Investigation of the stretching of pollutant clouds during climate change in an ensemble approach

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The change in the intensity of the atmospheric large-scale spreading events is investigated during century-long time-intervals characterized by global mean surface temperature changes of 3.5–6 °C using an ensemble of 110 and 35 climate realizations produced by the PlaSim and the CESM climate models. The intensity of the spreading is characterized by a measure introduced in the context of chaotic systems, called topological entropy. Pollutant clouds typically stretch in an exponential manner in time, and in the atmospheric context the topological entropy corresponds to the stretching rate of the length of the pollutant clouds. Therefore, the stretching rate is closely related to the unpredictability of the spreading and the complexity of the structure of the pollutant cloud. An overall decrease in the areal mean of the stretching rate is found to be typical in the ensembles of climate realizations of both models. It results in that the mean length of 10-day-old pollutant clouds decreases on average by a factor of 1.7 by the end of the investigated time-intervals implying that the intensity of the spreading, and, therefore, the typical extension of a polluted region from a pollution event becomes smaller. Furthermore, a strong correlation is found between the time series of the ensemble mean values of the stretching rate and the absolute value of the relative vorticity, respectively. The ensemble approach also provides an opportunity to investigate the relationship in a single time instant. The ensemble-based correlation coefficient determined for each year also confirms the link between the two quantities. The results draw attention to the fact that as a consequence of the climate change the intensity of the atmospheric spreading also changes. Based on the obtained relationship, the intensity of the spreading in an arbitrary climate realization can be estimated by using only the ensemble means of the relative vorticity data of a climate model.