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Circulation controls of the spatial structure of maximum daily precipitation over Poland

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Among forecasts made on the basis of global and regional climatic models is one of a high probability of an increase in the frequency and intensity of extreme precipitation events. Learning the regularities underlying the recurrence and spatial extent of extreme precipitation is obviously of great importance, both economic and social.

The main goal of the study was to analyse regularities underlying spatial and temporal variations in monthly Maximum Daily Precipitation Totals (MDPTs) observed in Poland over the years 1956-1980. These data are specific because apart from being spatially discontinuous, which is typical of precipitation, they are also non-synchronic.

The main aim of the study was accomplished via several detailed goals:
• identification and typology of the spatial structure of monthly MDPTs,
• determination of the character and probable origin of events generating MDPTs, and
• quantitative assessment of the contribution of the particular events to the overall MDPT figures.

The analysis of the spatial structure of MDPTs was based on 300 models of spatial structure, one for each of the analysed sets of monthly MDPTs. The models were built on the basis of empirical anisotropic semivariograms of normalised data.

In spite of their spatial discontinuity and asynchronicity, the MDPT data from Poland display marked regularities in their spatial pattern that yield readily to mathematical modelling.

The MDPT field in Poland is usually the sum of the outcomes of three types of processes operating at various spatial scales: local (<10-20 km), regional (50-150 km), and supra-regional (>200 km). The spatial scales are probably connected with a convective/ orographic, a frontal and a 'planetary waves' genesis of high precipitation. Their contributions are highly variable. Generally predominant, however, are high daily precipitation totals with a spatial extent of 50 to 150 km connected with mesoscale phenomena and the migration of atmospheric fronts (35-38%). The spatial extent of areas of high local-scale precipitation usually varies at random, especially in the warm season. At supra-local scales, structures of repetitive size predominate.

Eight types of anisotropic structures of monthly MDPTs were distinguished. To identify them, an analysis was made of semivariance surface similarities. The types differ not only in the level and direction of anisotropy, but also in the number and type of elementary components, which is evidence of genetic differences in precipitation. Their appearance shows a significant seasonal variability, so the most probable supposition was that temporal variations in the MDPT pattern were connected with circulation conditions: the type and direction of inflow of air masses. This hypothesis was validated by testing differences in the frequency of occurrence of Grosswetterlagen circulation situations in the months belonging to the distinguished types of the spatial MDPT pattern.