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A probabilistic method of calculating circulation-induced trends

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The water cycle in Europe has changed substantially over the past three decades. Increasing runoff is observed during winter and at northern latitudes in particular. Spring and summer months, as well as southern latitudes, are facing drier conditions. To understand what is driving large-scale changes in runoff, we look into changes in precipitation and temperature and link these to changes in atmospheric circulation. Previous studies have used the method of trend ratios (Cahynová and Huth, 2009) to attribute precipitation and temperature trends to changes in the frequency of circulation types. A trend ratio is the ratio of hypothetical trend, i.e. the trend that would result due to changes in circulation type frequency only, to the observed trend. However, the method of trend ratios has two drawbacks. First, if the observed trend is small, division by a very low value results in a meaningless trend ratio and thus requires a cut-off value to keep the trend ratio within meaningful boundaries. Second, the method does not allow a comparison of the observed trend to the spread of possible outcomes, because the method of hypothetical trends is based on a deterministic model. We propose a new, more robust method for detecting the importance of circulation-induced changes in explaining the observed trends, which has the benefit of being a non-parametric statistical test that assesses the entire range of hypothetical trends. Instead of creating a hypothetical series by replacing the observation on a given day with the long-term climatic mean of a certain month and circulation type (as in the existing trend ratio method), the new approach replaces the observation on a given day with a random sample from the distribution of the variable for the given month and circulation type. The method introduces the possibility to assign a rejection rate, thus allowing statistical significance to be assessed. We apply the method on time series of precipitation and temperature from the gridded 0.5 degree WFDEI dataset, covering Europe (40-65N, 10W-30E). The SynopVis Grosswetterlagen catalogue of circulation types for the time period 1981-2010, the same period as the climatic data, is used. The new approach is used to map in which regions and months changes in atmospheric circulation is the dominating factor controlling changes in precipitation and temperature in Europe.

References

Cahynová, M. and R. Huth (2009). Changes of atmospheric circulation in central Europe and their influence on climatic trends in the Czech Republic. Theoretical and Applied Climatology 96, 57–68. DOI:10.1007/s00704-008-0097-2.