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Changes in the thermodynamic instability over the North-Atlantic European region and connection with changes in the rain showers in Romania

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The goal of this study is to analyse the main characteristic of variability (trends, shifts and variability modes given by the EOF analysis) of the observed seasonal thermodynamic instability over the North-Atlantic European region for the period 1961-2010 and to see the link with the variability of rain showers in Romania. To our knowledge this type of analysis has not been carried out until now for this area. The spring and summer seasons have been considered. Two indices quantifying the thermodynamic instability have been selected for this analysis: Best Lifted Index (lftx4) and Total Totals Index (TT). The seasonal frequency of the TT daily means exceeding 30 unities (FrTT) have been computed. The mechanisms responsible for the rain shower's variability in Romania were analysed in details using the canonical correlation analysis (CCA) and the two thermodynamic instability indices as predictors (lftx4 and FrTT anomalies). Other additional predictors such as precipitable water-PW and sea level pressure-SLP have been also considered. As a by-product, the verification of dependence between 1-hour precipitation extremes and temperature rise (Clausius–Clapeyron relation) at two Romanian stations (Baia Mare and Sibiu) has been carried out.

The results show that, in spring, the lftx4 exhibits a significant increasing trend (transition to more thermodynamic stability) over almost all Mediterranean countries and central Europe and significant decreasing (transition to instability) in northern Europe, central - southern part of the North Atlantic and north of the Black Sea. In summer the decreasing is more extended, expecially over the North Atlantic. This result is in agreement with the EOF analysis, the PC1 associated to the first EOF pattern showing a significant decreasing trend for both the seasons. The frequency of the rain showers (Fr-RS) recorded at 81 Romanian meteorological stations exhibits a significant increasing trend in both the seasons over almost the entire country that is in agreement with the increasing in the frequency of the Cumulonimbus clouds.

The CCA shows that the optimum large-scale mechanisms responsible for this behaviour in the two seasons are given by the first CCA pair with the lftx4 pattern represented by a dipole structure with a nucleus of negative anomalies (thermodynamic instability) centred over Romania. The analysis of the dependence between 1-hour precipitation extremes and temperature rise at the two Romanian stations, shows a different behaviour for the higher percentiles: the 90th percentile shows a scaling close to the Clausius–Clapeyron (CC) relation, the 99th - close to CC only for temperatures below to 100C and then a super CC scaling (close to 14% per degree), while the 99.9th exhibits a 14% scaling for all temperatures.