CONDITIONAL PROBABILITIES OF TRANSITIONS FROM ARID TO HUMID ENVIRONMENT AND VICE VERSA IN EUROPE DURING 1766-2015

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ABSTRACT

Currently, there are changes in the hydrological system, mostly of Europe affected by droughts. Recent reconstructions on historical precipitation and temperature fields can be used for determination of impacts of meteorological, hydrological and agricultural droughts. These reconstructions are available for European continent in gridded form (Casty et al., 2007). Aridity index, defined as a fraction of potential evapotranspiration and precipitation, can be used for characterization of humid – arid and dry – wet region. It represents the ratio between energy availability and water availability. This study deals with conditional probabilities of transitions from humid to arid and vice versa. The aridity index was used to determine the transitions on annual basis for the European continent for 1766-2015. The probabilities were calculated for each year, and for 10-year, 20-year and 30-year periods. It is shown that the recent droughts followed the drying of substantial part of Europe starting in 2014 (Hanel et al., 2018). The changes are more pronounced in Northern and Central Europe.

ARIDITY INDEX AND ITS TRANSITION PROBABILITIES

The Aridity index (AI) represents the relative water and energy availability in the hydrological system of a catchment. The climate is assessed according to AI. Aridity index was defined as potential evapotranspiration limited by water availability, the amount of water. If evapotranspiration is limited by energy availability, then AI >1 corresponding to a humid catchment (a). If evapotranspiration is limited by water availability, then AI <1 and arid catchments (b). We study transitions between individual periods (1-year, 10-year, 20-year, 30-year).

where PET and P are in units mm/year. PET is the maximum amount of water that can be taken away from the system by unlimited amount of water. If evapotranspiration is limited by energy availability, then AI >1 corresponding to a humid catchment (a). If evapotranspiration is limited by water availability, then AI <1 and arid catchments (b).

STUDY AREA AND INPUT DATA

The used data describe the whole Europe, for the period 1950-2015 three data sets are compared:
A. CRU data (P, Q, CRU, CRU) (Casty et al., 2007)
B. GRUN data (Q, PET, ECAD) (Ghiggi et al., 2020)
C. E-OBS data (Q, PET, E-OBS) (Gudmundsson, 2019)
D. MEAN of data layers GRUN and E-OBS

where Q is runoff. The subscripts (CRU, GRUN, E-OBS) indicate the origin of the data (P, Q, PET) from the input data files CRU (Casty et al., 2007), GRUN (Ghiggi et al., 2020), E-OBS (Gudmundsson, 2019).

RESULTS

Histograms of 10-year IA values for all data sets

- most values occur around the value one
- most values are on the line between wet and dry catchment

Fig. 1: Histograms of 10-year IA values for all data sets (CRU, CRU, GRUN, Q, OBS) for the period 1950-2015.

- transitions to arid catchment, especially in recent decades
- the biggest changes in Central Europe

Fig. 3: Left column: plotted transitions of 10-year periods of CRU data. Right column: plotted transitions of 10-year periods of E-OBS data. All maps are drawn for the period 1950-2015 (excluding the last five years).

Fig. 2: Plotted 10-year periods for mean of data layers GRUN and E-OBS for the period 1950-2015.

- small values are on the line between wet and dry catchment

Fig. 4: Plotted 10-year periods for three sets of data (CRU, CRU, GRUN, E-OBS) for the period 1950-2015.