Analysis of compound events in the Carpathian Basin with special focus on concurrently hot and dry conditions

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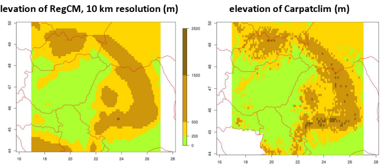
SUMMARY

Climate models project a general temperature increase and substantial changes in the annual distribution of precipitation for the Carpathian Basin (e.g. Pieczka et al., 2018). The change of either of these climatic elements alone could have negative effects on the social-ecological system, but if we consider their simultaneous changes – which is often the case as they are inter-linked through various meteorological processes – the overall impact can be even more severe.

Our research group completed RegCM4.3 simulations at 50 km horizontal resolution using ERA-Interim reanalysis data, HadGEM2-ES (Collins et al., 2011) and MPI-ESM-MR (Stevens et al., 2013; Jungclaus et al., 2013) global model outputs as initial and lateral boundary conditions (ICBC) for the entire MED-44 CORDEX area covering the extended Mediterranean region of Europe (30°-50°N, 10°W-45°E) for both validation and projection purposes. The simulations were further downscaled to 10 km horizontal resolution for a smaller domain covering Central Europe with special focus on the Carpathian Region (Pieczka et al., 2017).

In the first steps of our study, we analyse the climate of the Carpathian region based on observed and modelled climate data with multivariate statistics, including probability distribution functions, with special focus on compound events. To find such events/conditions, 10 km horizontal resolution gridded data are used: (i) the Carpatclim database (Szalai et al., 2013) that contains daily values of several meteorological parameters, and (ii) regional climate model simulation outputs produced by our experiments with the RegCM model.

elevation of RegCM, 10 km resolution (m) **elevation of Carpatclim (m)**



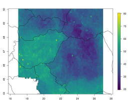
The regional climate model RegCM applied in this study is a 3-dimensional, sigma-coordinate, primitive equation model. RegCM stems from the National Center for Atmospheric Research/Pennsylvania State University (NCAR/PSU) Mesoscale Model version MM4 (Dickinson et al., 1989; Giorgi, 1989). It was originally developed by Giorgi et al. (1993a, 1993b) and later modified and improved by Giorgi and Mearns (1999) and Pal et al. (2000). The latest version of this model is RegCM4, the model specification is available in Elguindi et al. (2011). Currently, it is available from the ICTP (Abdus Salam International Centre for Theoretical Physics), Trieste, Italy.

Carpatclim is a high resolution homogeneous gridded database covering 1961–2010 for the Carpathian Region with 0.1° horizontal resolution, and containing all the major surface meteorological variables (Szalai et al., 2013, Spinoni et al., 2015). Daily temperature and precipitation datasets were downloaded from the Carpatclim portal covering the entire domain (i.e. 44°N–50°N, 17°E–27°E) for the present analysis.

HOW DRY IS THE REGION?

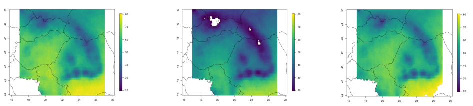
In general, the **driest season** of the year is **winter**, implying less precipitation in winter months compared to the other months. Altogether **10 months** (mostly in the winter half-year) can be found in the entire period of 1961–2010 when there were **no precipitation** during an entire month in some parts of the Carpathian region.

The wettest months are usually in late spring, early summer. However, these greater precipitation amounts originate mostly from convective events, therefore, dry days often occurs in summer. We analyze here how often days without precipitation occur in summer:



First percentile with daily precipitation > 0 mm
In Carpatclim data
-> note that there are outstanding values in some points (wrt. surroundings)
-> inhomogeneity: artificial differences at the two sides of the borders (despite using MASH homogenization)
Possible reasons: Different method at observations? Different precision?
Is it related to station density?

Different threshold (0.1 mm) is used for model data due to „drizzle effect"



in ERA-Interim-driven simulation | in MPI-ESM-MR-driven simulation | in HadGEM2-ES-driven simulation

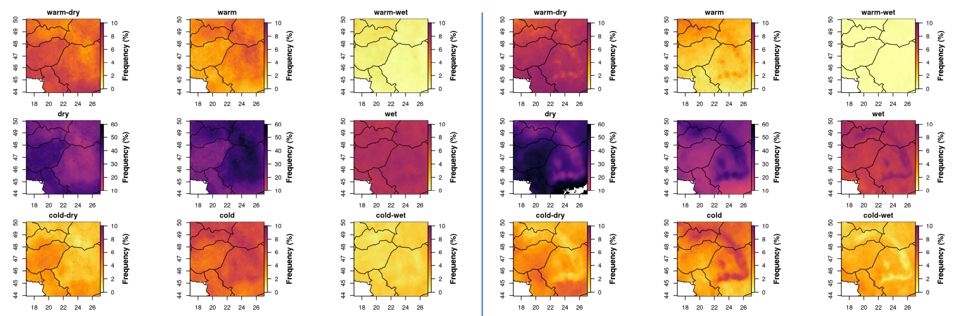
-> the effect of orography is highlighted much more than in Carpatclim

HOW ARE EXTREMES IN ONE (T OR P) AND TWO VARIABLES (T AND P) RELATED TO EACH OTHER (IN SUMMER)?

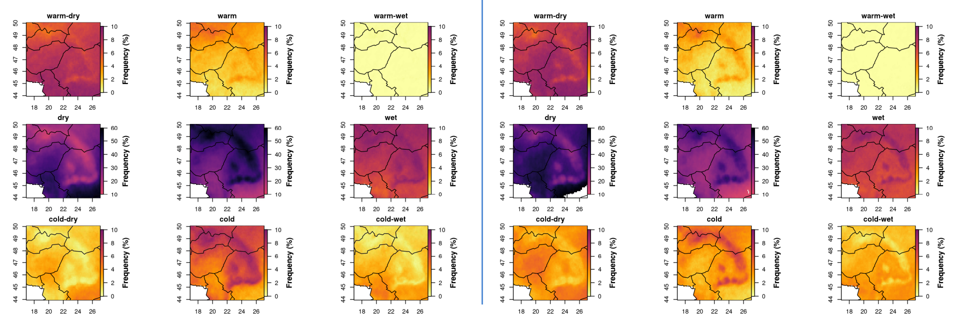
The 10th and 90th percentiles (i.e. lower and upper deciles) of temperature and precipitation have been calculated and used as thresholds to define extreme categories (cold, warm, dry, wet, and their combinations).

- values in columns/rows add up, i.e. "warm" means the category when only temperature is considered extreme, but precipitation is not
- as the lower/upper deciles are considered extreme, frequency values should be between 0% and 10% if only one variable is considered – however, notice the "dry" category, which has higher values (see explanation in the "How dry is the region?" section)
- when both variables are taken into account, the frequency value would vary between 0% and 1% if temperature and precipitation were uncorrelated (which is not the case as the figures show)

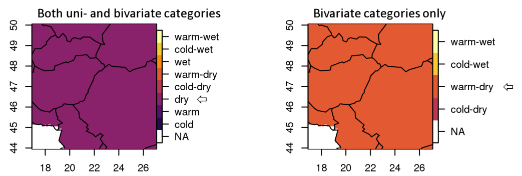
Carpatclim data, 1981–2010 **ERA-Interim-driven simulation, 1981–2000**



MPI-ESM-MR-driven simulation, 1981–2010 **HadGEM2-ES-driven simulation, 1981–2010**



Overall evaluation: Which is the dominant category in summer?

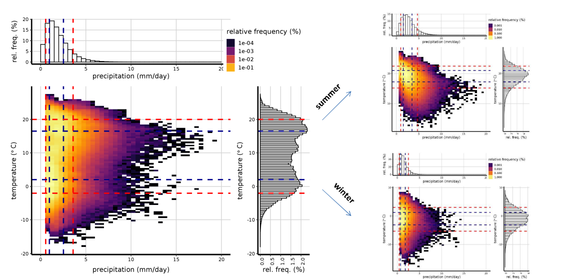


Warm and dry summer is a general feature of the Carpathian region.
Therefore, to be considered „extreme",
other attributions should be analysed simultaneously:

- The duration of period without precipitation/with low precipitation only
- Water stored in the soil (considering climatic memory)
- More specific temperature conditions

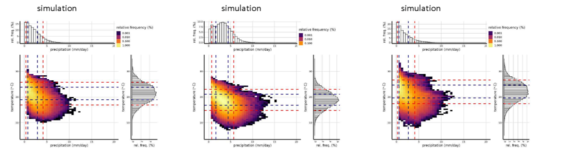
2-DIMENSIONAL HISTOGRAM OF THE REGION
(dashed lines: 10th and 90th percentile /red/, 25th and 75th percentile /blue/)

Entire year, based on monthly means from Carpatclim, 1981–2010, entire region

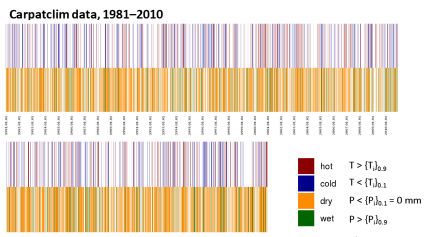


and in the model simulations, for summer

ERA-Interim-driven simulation | MPI-ESM-MR-driven simulation | HadGEM2-ES-driven simulation



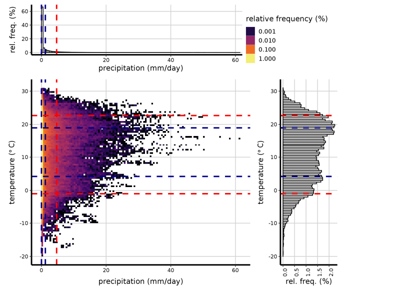
EXTREMES IN THE DAILY TIME SERIES FOR BUDAPEST (47.5°, 19.2°)



hot $T > \{T_i\}_{0.9}$
cold $T < \{T_i\}_{0.1}$
dry $P < \{P_i\}_{0.1} = 0$ mm
wet $P > \{P_i\}_{0.9}$

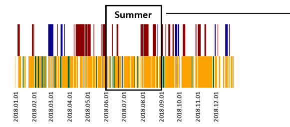
where i =1, 2, ... considering all the days within a given month

2-DIMENSIONAL HISTOGRAM OF THE SELECTED GRIDPOINT
(dashed lines: 10th and 90th percentile /red/, 25th and 75th percentile /blue/)



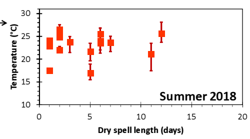
ANALYSIS APPLIED TO STATION DATA (BUDAPEST, WMO STATION ID: 12843) Last year (2018) only

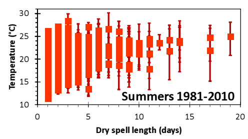
Applied thresholds are calculated from the Carpatclim data



Bivariate analysis considering
(i) the duration of dry spells and
(ii) temperature during dry spells

Maximum / Average / Minimum – of daily mean temperatures during actual dry spell





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