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Projected changes in heat waves and cold waves indices in Romania over the period 2021-2100

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Motto:

Get used to 'extreme' weather, it's the new normal

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General information

- Research in climatology focused in the latest decades on climate change and especially on changes in extreme weather events.
- Among them, heat waves and cold waves are among the most studied.
- Since climate change is already affecting large areas worldwide, it is important to study in details the future evolution of these changes at regional and local scale.

Aims of the study

The aims of this study are:

- to analyse changes of heat waves and cold waves indices over the period 2021-2100;
- to compare the results got for the future period with the historical period.

Data used

- Modelled data of **daily maximum (TX) and daily minimum (TN) temperature** was extracted from EURO-CORDEX Project database over the period 2021-2100 calculated for five weather stations in Romania (fig. 1);
- The period 2021-2100 divided into **three sub-periods**:
  - 2021-2040
  - 2041-2070
  - 2071-2100
- **Five regional climate models** (ALADIN, REMO, RACMO22E, RCA4, and WRF331F) were considered;
- **Scenario RCP 4.5.**

Data used

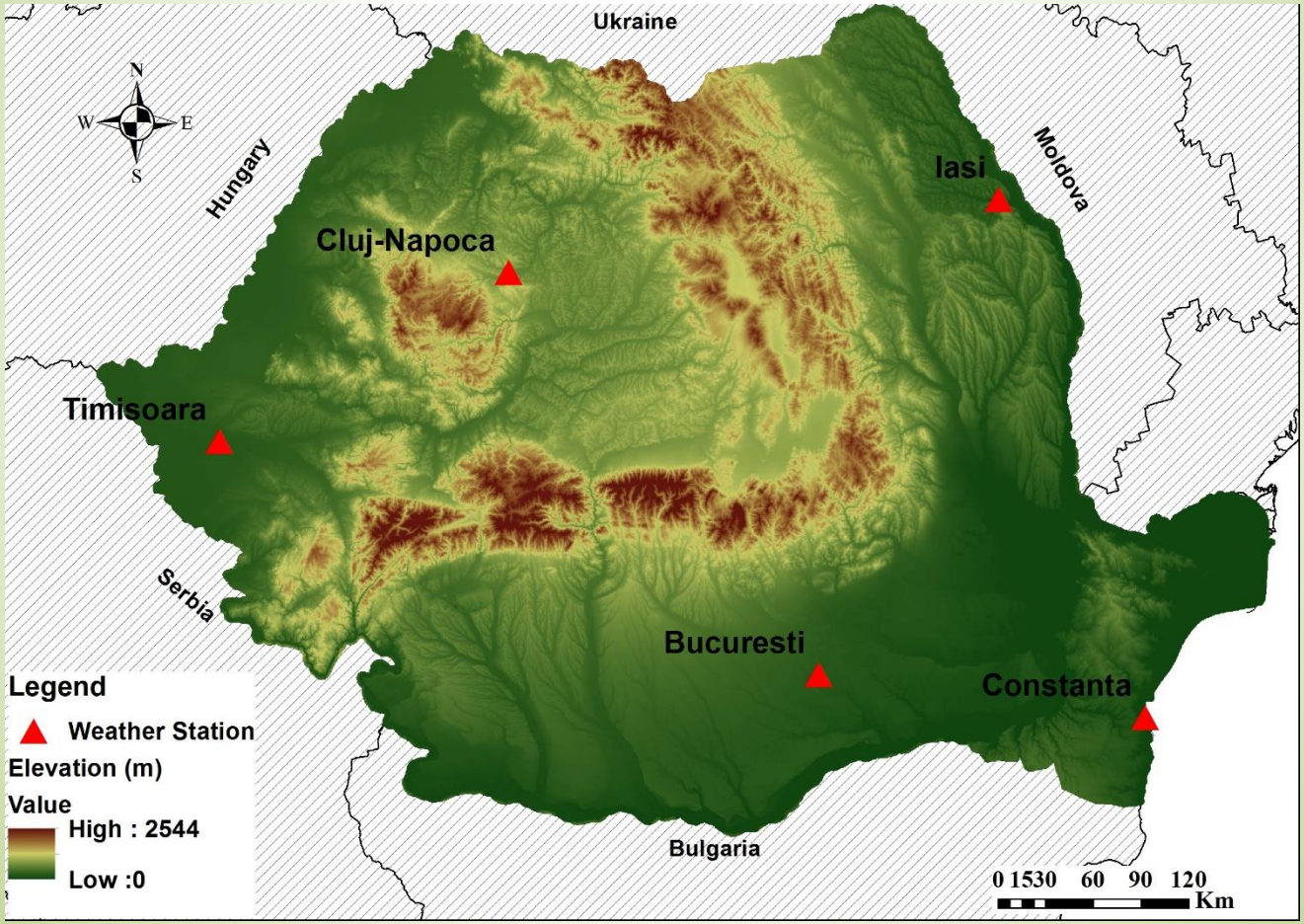


Fig. 1. Location of the weather stations considered

Data used

- The six RCMs had available data at the spatial resolution of 0.1°.
- Both HWs/WSs and CWs/CSs were detected based on each modeled data sets, but the further statistical analysis was performed based on the average value of all models.
- This procedure is commonly used at international level as each model seems to underestimate or overestimate data for one or more seasons or for the entire year.
- Under these circumstances, the use of an average value diminishes the bias introduced by one model or another.

Methods

- ✓ Reference period: 1961-1990;

- ✓ **Events identification:**
  - heat waves were detected based on **excess heat factor** (Alexander and Harold, 2016) over the extended summer season (May-September);
  - cold waves were detected based on **excess cold factor** (Alexander and Harold, 2016) over the extended winter season (November-March);

- ✓ A set of **10 indices** recommended by ETCCDMI:
  - five indices for heat waves: EHF-HWN, EHF-HWD, EHF-HWF, EHF-HWM, EHF-HWA;
  - five indices for cold waves: ECF-CWN, ECF-CWD, ECF-CWF, ECF-CWM, ECF-CWA.

Methods

Definitions of HWs and CWs indices (after Alexander and Harold, 2016)

Index	Definition	Units
Heat waves indices		
EHF_HWN	The annual **number of individual HWs** calculated based on EHF that occur in each extended summer (May-Sept)	Events
EHF_HWF	The **number of days** that contribute to HWs as identified by EHF_HWN	Days
EHF_HWD	The **length of the longest HW** identified by EHF_HWN	Days
EHF_HWM	The **mean magnitude of all HWs** in a year identified based on EHF	$°C^2$
EHF_HWA	The **peak daily value in the hottest HW** calculated based on EHF	$°C^2$
Cold waves indices		
ECF_CWN	The annual **number of individual CWs** calculated based on ECF that occur in each extended winter (Nov-Mar)	Events
ECF_CWF	The annual **number of days** that contribute to CWs as identified by ECF_CWN	Days
ECF_CWD	The **length of the longest CW** identified by EHF_CWN	Days
ECF_CWM	The **mean magnitude of all CWs** identified by ECF_CWN calculated based on ECF	$°C^2$
ECF_CWA	The **lowest daily value in the coldest CW** calculated based on ECF	$°C^2$

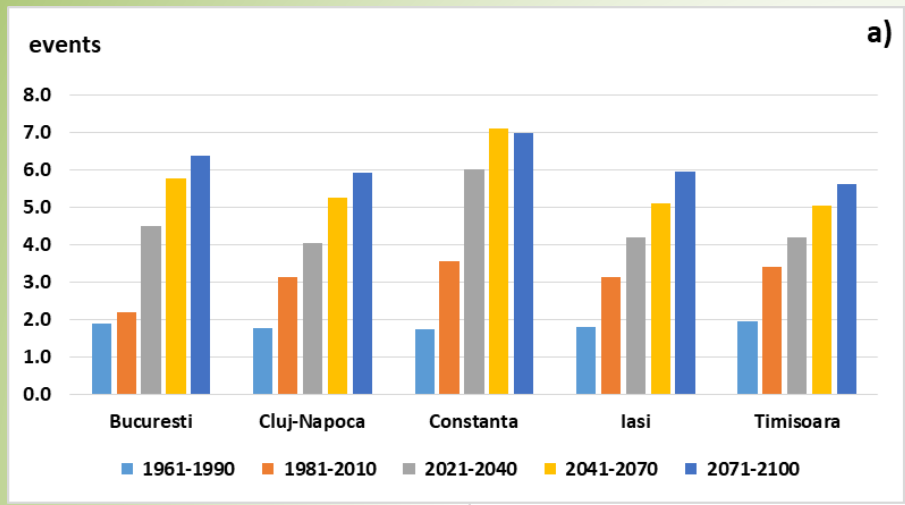
Bias correction

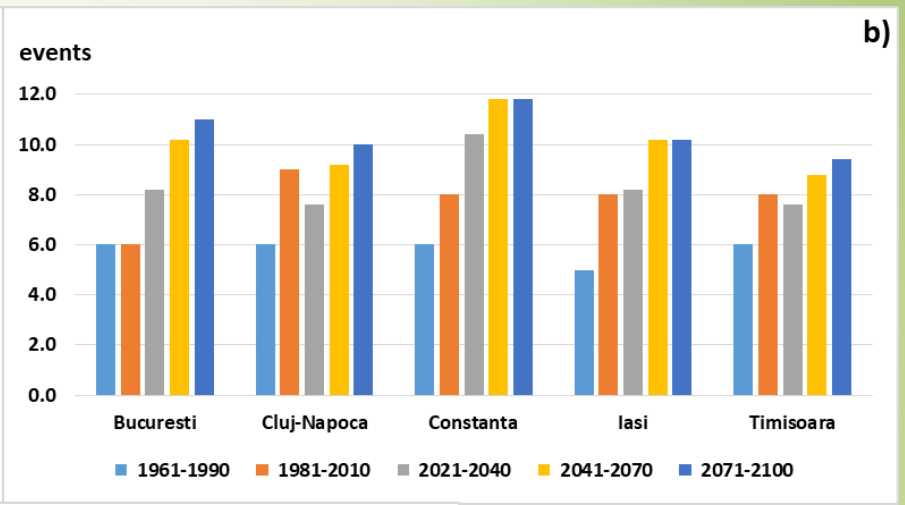
- Using the observed values of corresponding variables, over a 30-year common period (1971-2000), in the five locations, statistical bias corrections were applied on RCMs results following the approach of quantile mapping presented in Piani et al. (2010) and Raisanen and Raty (2013).
- The correction function was defined according to the difference between cumulative density functions, derived from observed and RCMs values of the analysed variables.
- It was assumed that temperatures data follows a normal distribution. The correction function was then applied on raw RCMs output over all analysed periods that cover both historical and scenario part of RCMs integrations.

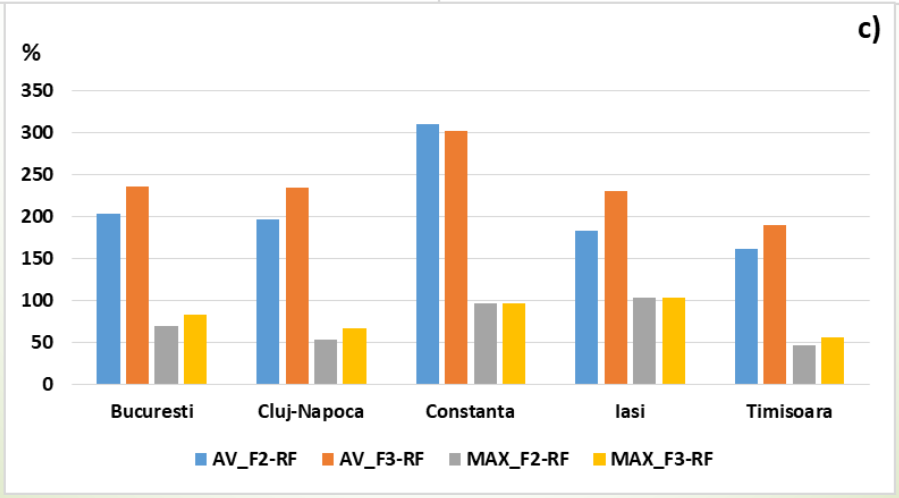
Methods

- ✓ The indices for observed and modelled data were calculated by employing ClimPACT2 software.
- ✓ We compared the average values of the historical reference period (1961-1990) with those obtained for the three sub-periods for the moderate scenario (RCP 4.5).
- ✓ We considered for each index three approaches:
  - ✓ Mean multiannual value;
  - ✓ Maximum multiannual value;
  - ✓ Change compared to the reference period.

Results: HWs indices

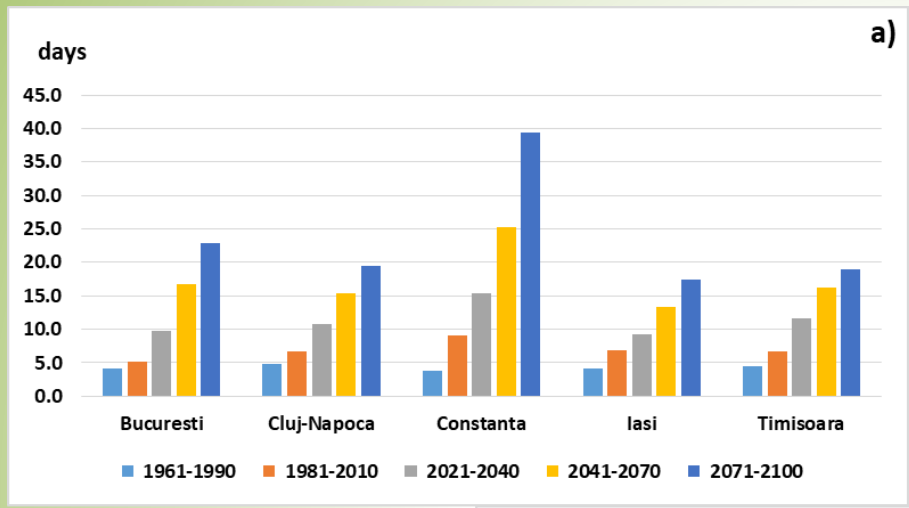


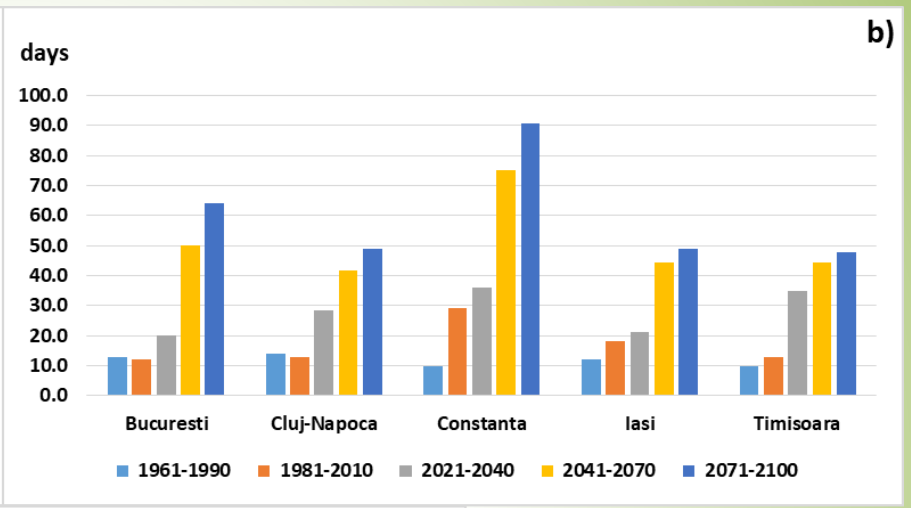


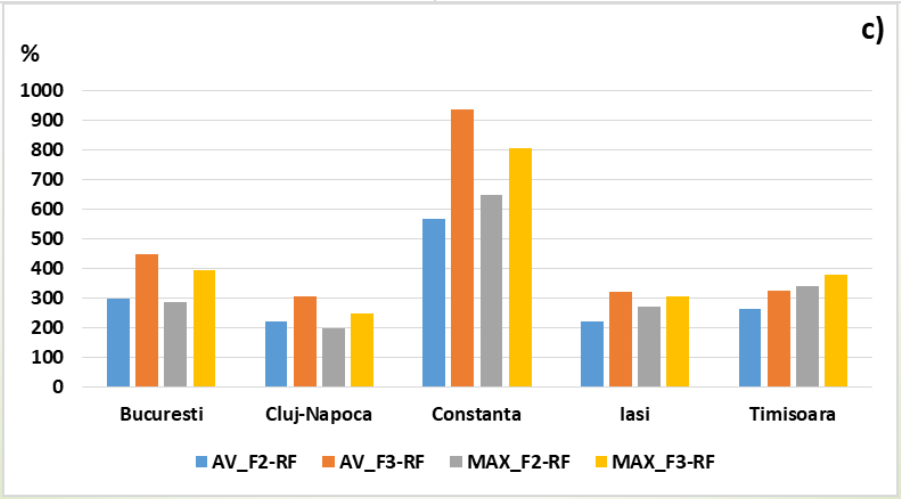


EHF-HWN: a. mean annual number of events; b. maximum annual number of events; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

Results: HWs indices

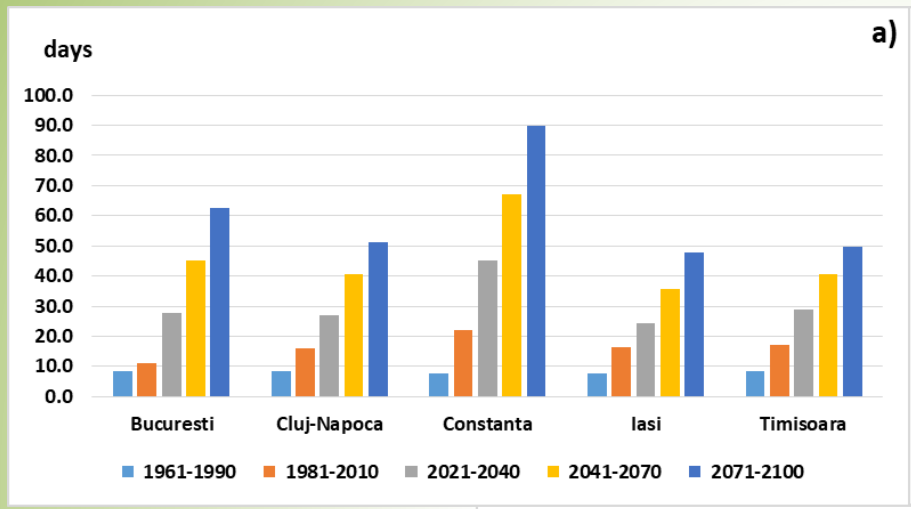


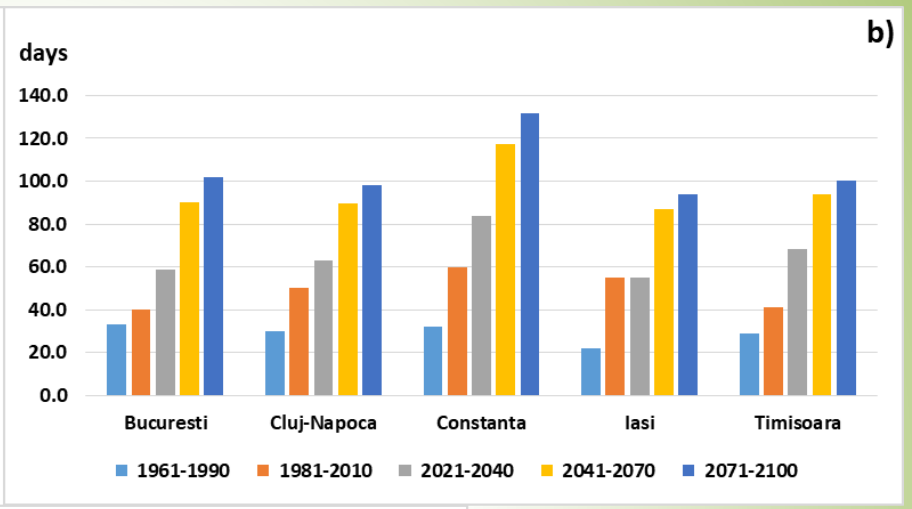


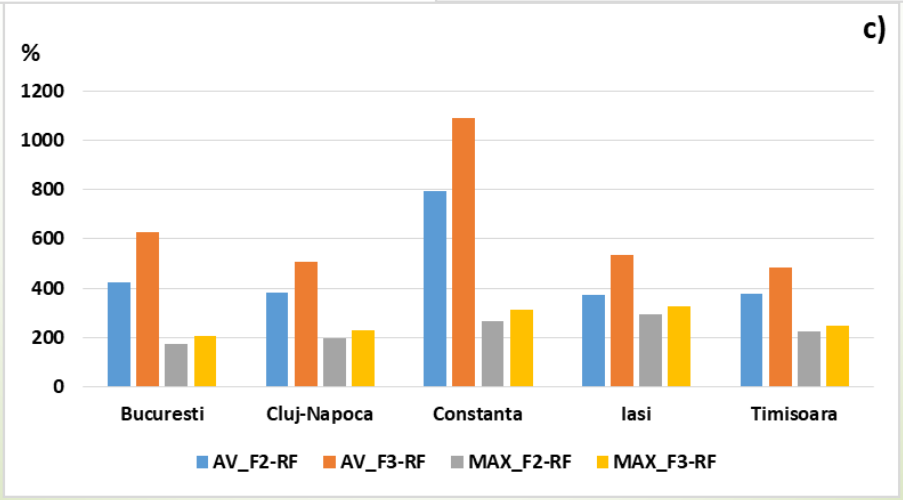


EHF-HWD: a. mean annual number of days; b. maximum annual number of days; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

Results: HWs indices

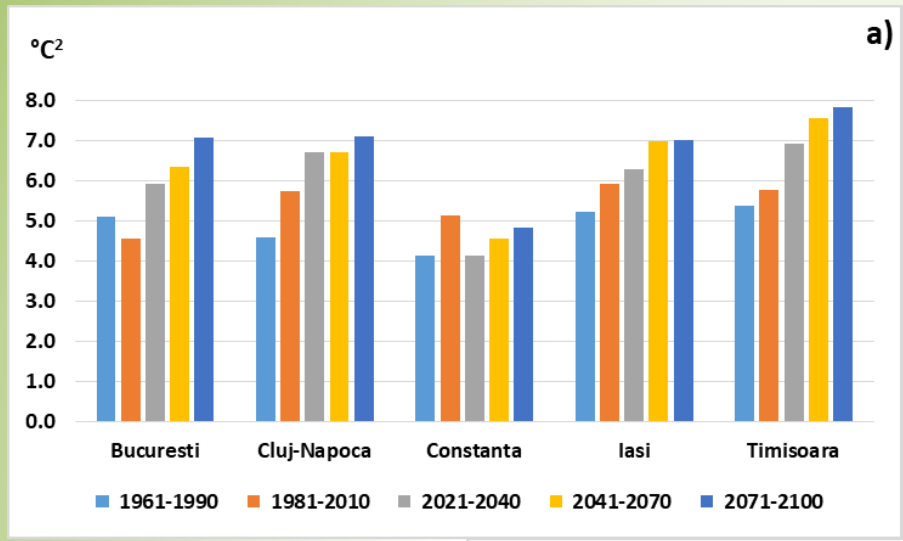


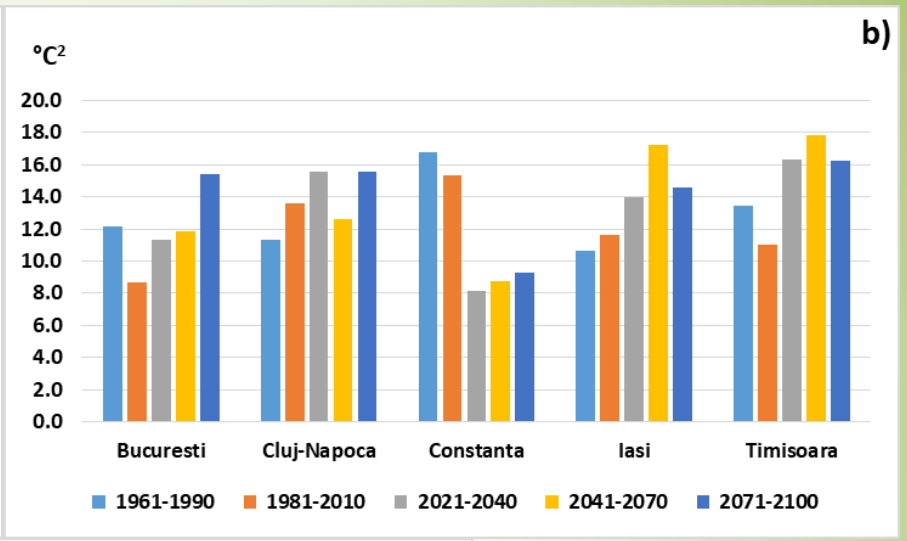


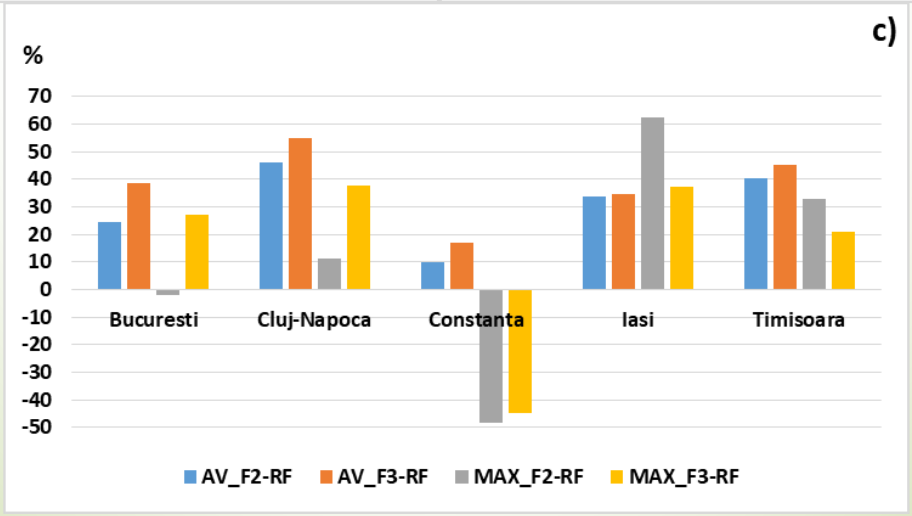


EHF-HWF: a. mean annual number of days; b. maximum annual number of days; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

Results: HWs indices

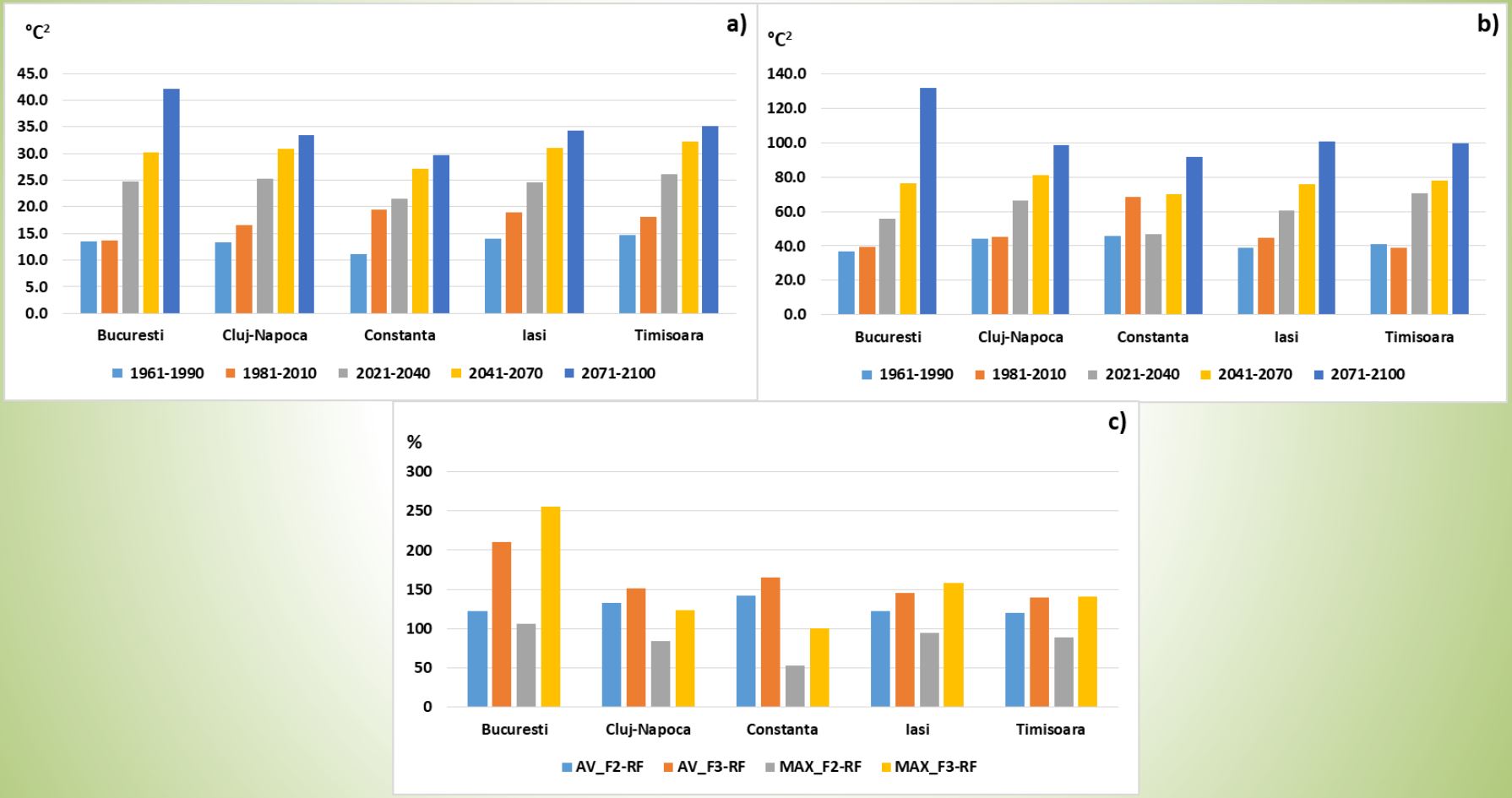






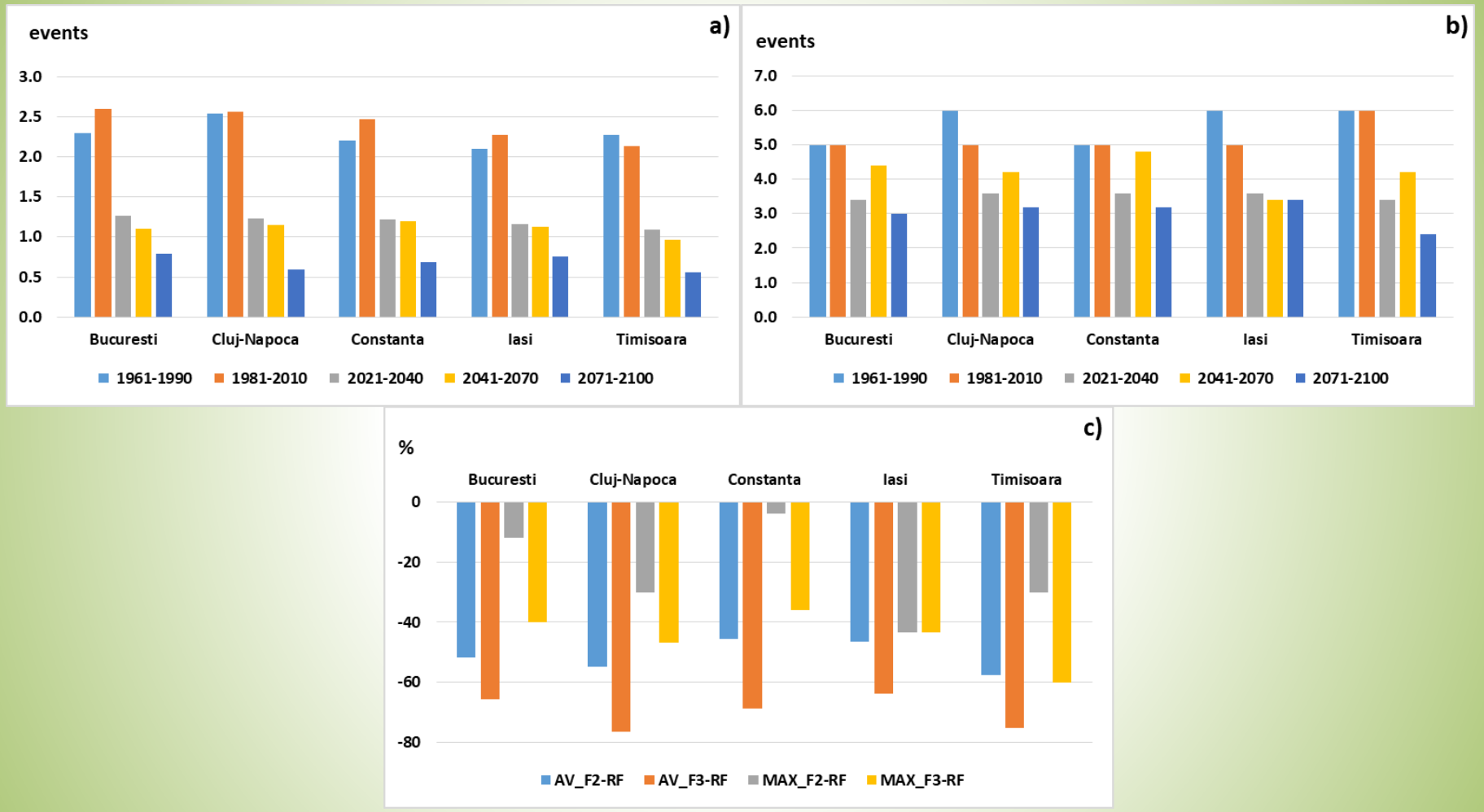
EHF-HWM: a. mean annual magnitude; b. maximum annual magnitude; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

Results: HWs indices



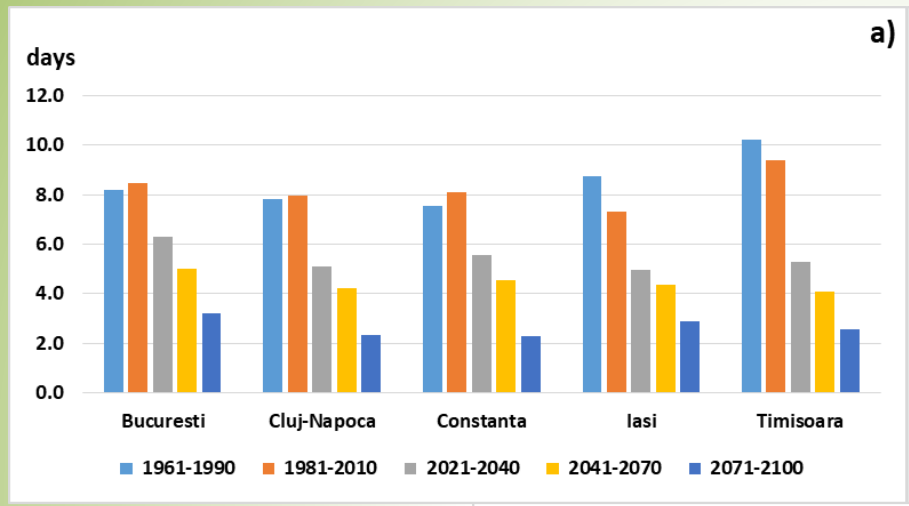
EHF-HWA: a. mean annual amplitude; b. maximum annual amplitude; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

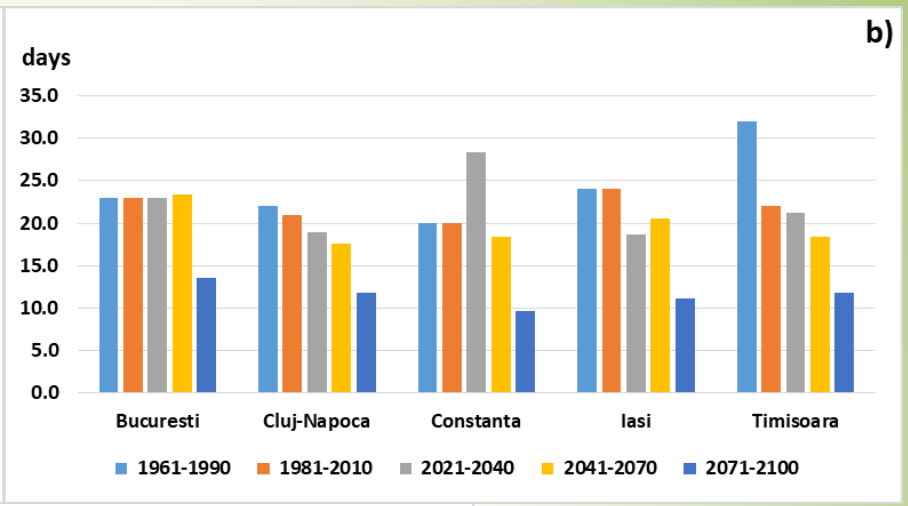
Results: CWs indices

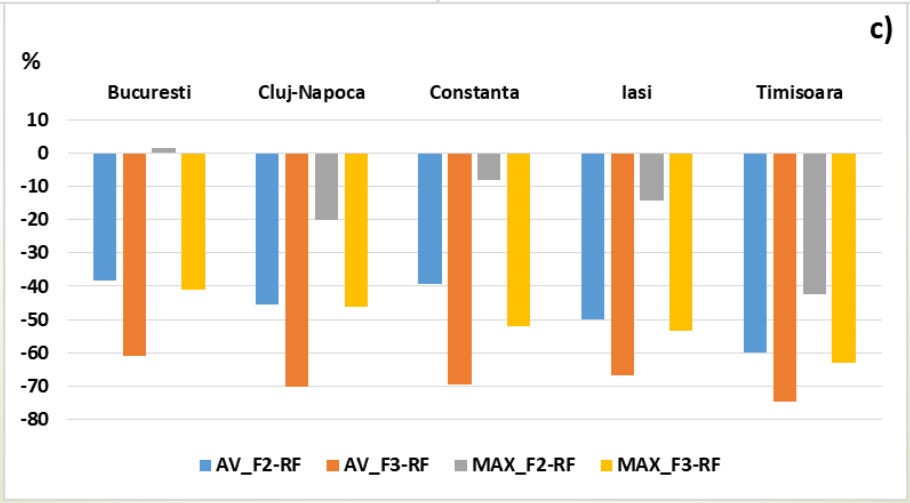


ECF-CWN: a. mean annual number of events; b. maximum annual number of events; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

Results: CWs indices

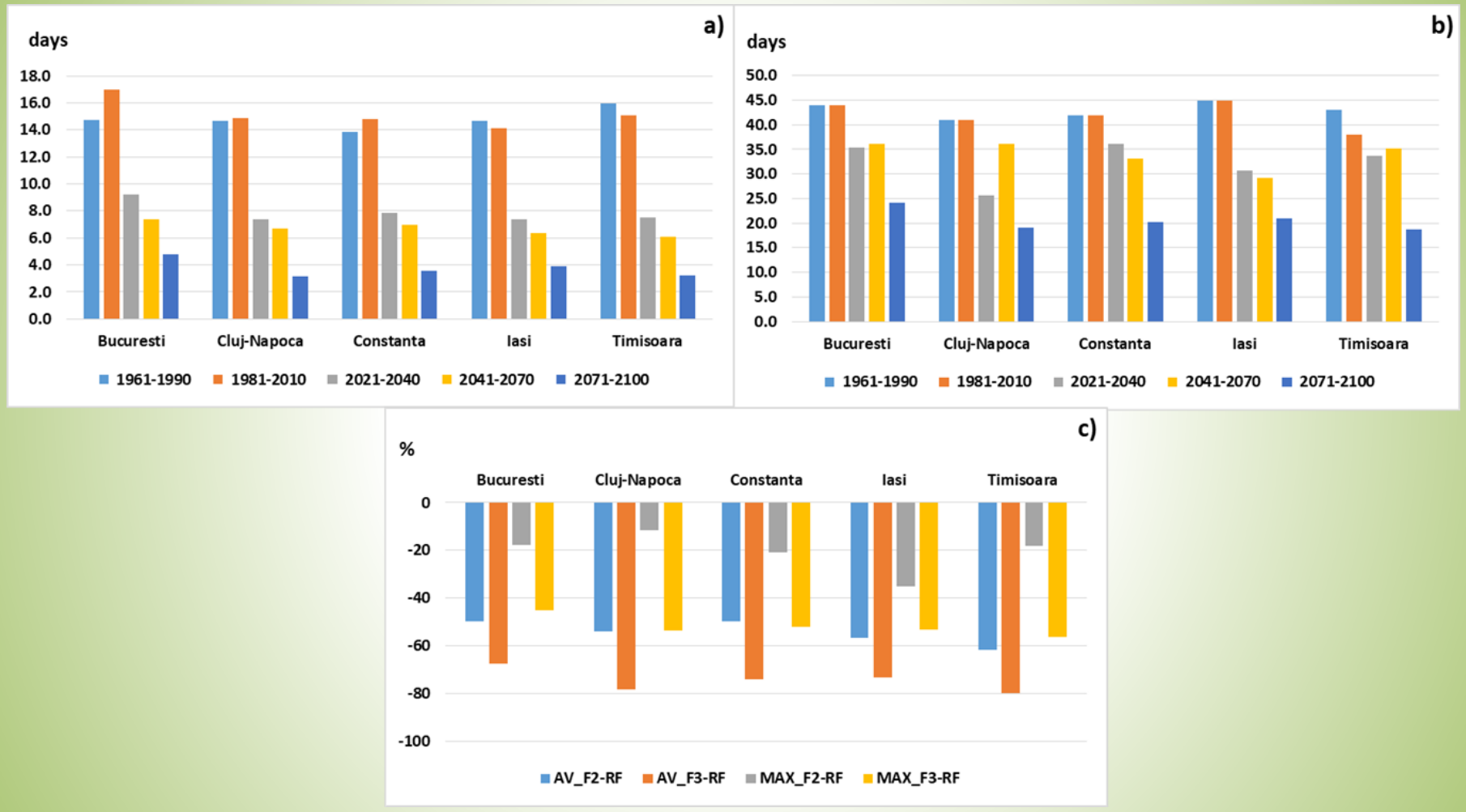






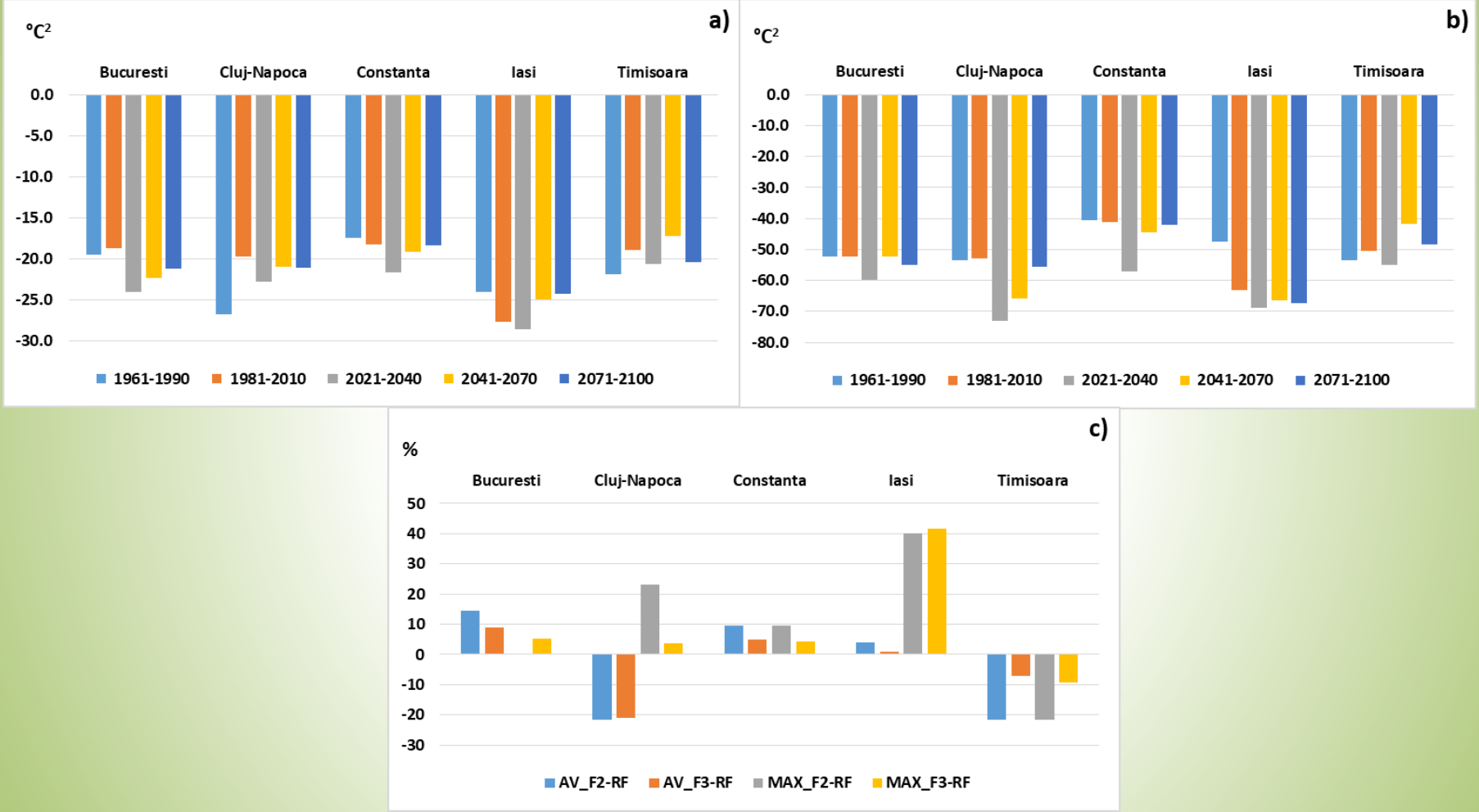
ECF-CWD: a. mean annual number of days; b. maximum annual number of days; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

Results: CWs indices



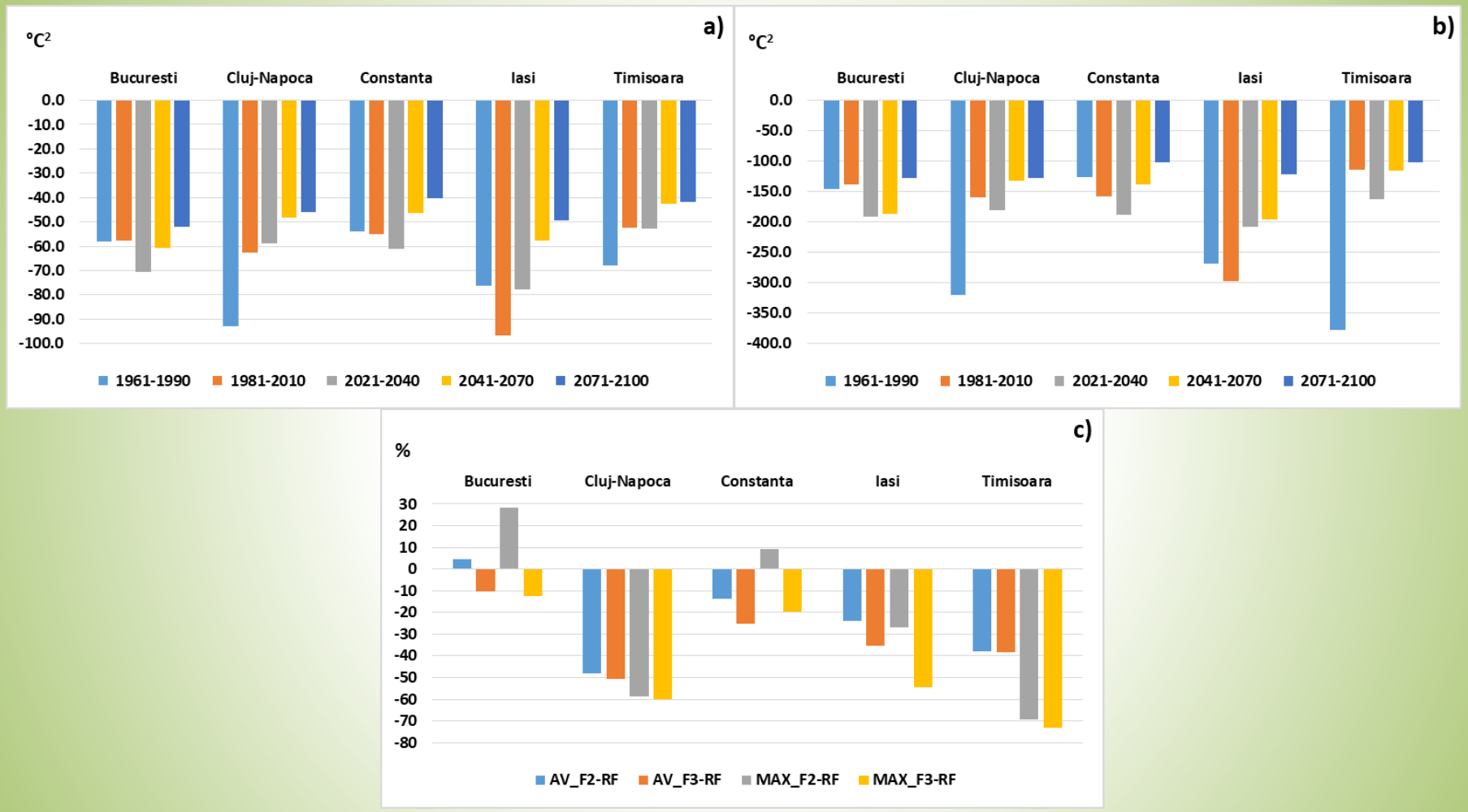
ECF-CWF: a. mean annual number of days; b. maximum annual number of days; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

Results: CWs indices



ECF-CWM: a. mean annual magnitude; b. maximum annual magnitude; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

Results: CWs indices



ECF-CWA: a. mean annual amplitude; b. maximum annual amplitude; c. changes of frequency in the future sub-periods (F2 and F3) compared to the reference period (RF).

Conclusions

✓The results of this study showed major changes for all the analysed indices, especially for the period 2071-2100, which indicated the highest changes;

✓The heat waves will increase in frequency, duration, and intensity based on moderate scenario data;

✓The cold waves are expected to become less numerous, shorter, but more intense in the extra-Carpathians region and less intense in the intra-Carpathians region.

✓These results could help authorities to adopt the most appropriate adaptation measures and to focus more on the HWs rather than in the CWs.

Acknowledgment

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Thank you very much for your kind attention!

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