

How the risk of heat waves will change in the future decades in Croatian cities?



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REGION	Maximum temperature [°C]			Minimum temperature [°C]		
	35.2	36.7	38.8	20.1	21.2	22.9
Osijek	33.7	35.1	37.1	20.2	21.3	22.9
Zagreb	34.5	35.9	38.0	20.0	21.1	22.7
Karlovac	32.1	33.4	35.4	17.0	18.0	19.6
Gospic	32.7	33.9	35.5	22.7	23.7	25.1
Rijeka	35.5	36.9	39.0	20.5	21.6	23.1
Knin	33.9	35.1	36.7	25.8	26.8	28.2
Split	32.3	33.2	34.7	25.4	26.3	27.6
Dubrovnik						

1 CROATIAN OPERATIONAL HEAT WAVE ALARM

- According to Zaninović and Matzarakis (2014)
- Mortality data (1983-2008)
- Meteorological data – parameters that are regularly forecasted
- Heat cut point was defined (threshold for increased mortality)

3 RISK LEVELS

- (1) MODERATE RISK – temperature higher than 96.5 percentile
- (2) HIGH RISK – temperature higher than 98.5 percentile
- (3) VERY HIGH RISK – temperature higher than 99.5 percentile

If the criteria for T_{max} and T_{min} are simultaneously met, the degree of risk raises to a higher level. Also, the degree of risk raises to a higher level if the temperature exceeds threshold for more than four consecutive days.

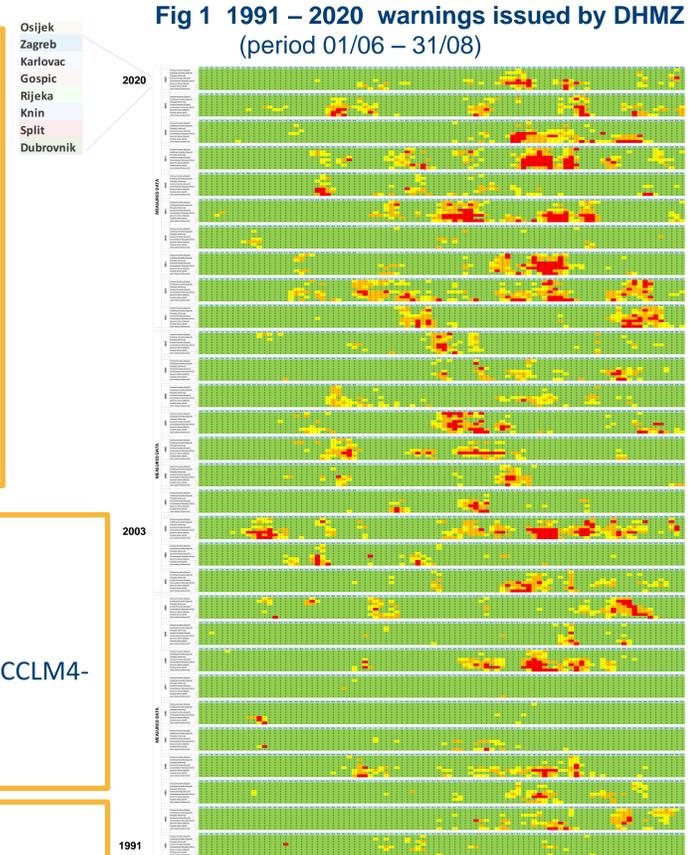


Fig 1 1991 – 2020 warnings issued by DHMZ (period 01/06 – 31/08)

2 CLIMATE SIMULATIONS

- Daily T_{max} and T_{min} from regional climate model historical and scenario simulations from the EURO-CORDEX ensemble at 0.11° spatial resolution were extracted for 8 locations in Croatia
- Two greenhouse gas concentrations scenarios were considered, RCP4.5 & RCP8.5
- ensemble includes a total of 9 simulations → 3 RCMs driven by 3 CMIP5 global climate models (GCMs)
- RCMs: DHMZ-RegCM4-2, SMHI-RCA4 and CLMcom-CCLM4-8-17
- GCMs: CNRM-CM5, EC-EARTH and HadGEM2

3 METHOD

- Operational heat wave alarm (HWA) was applied for 3 future periods: P1 (2021-2050), P2 (2031-2060) and P3 (2041-2070) in comparison to historical period P0 (1991-2020)
- Summer season from 1 Jun to 31 Aug was considered
- Results were summarized as ensemble of 9 members

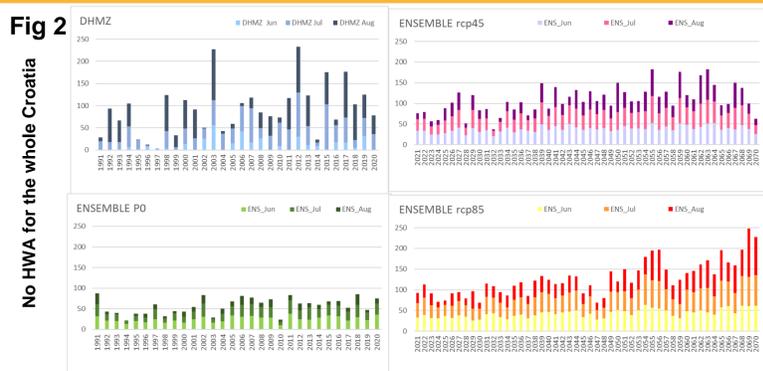
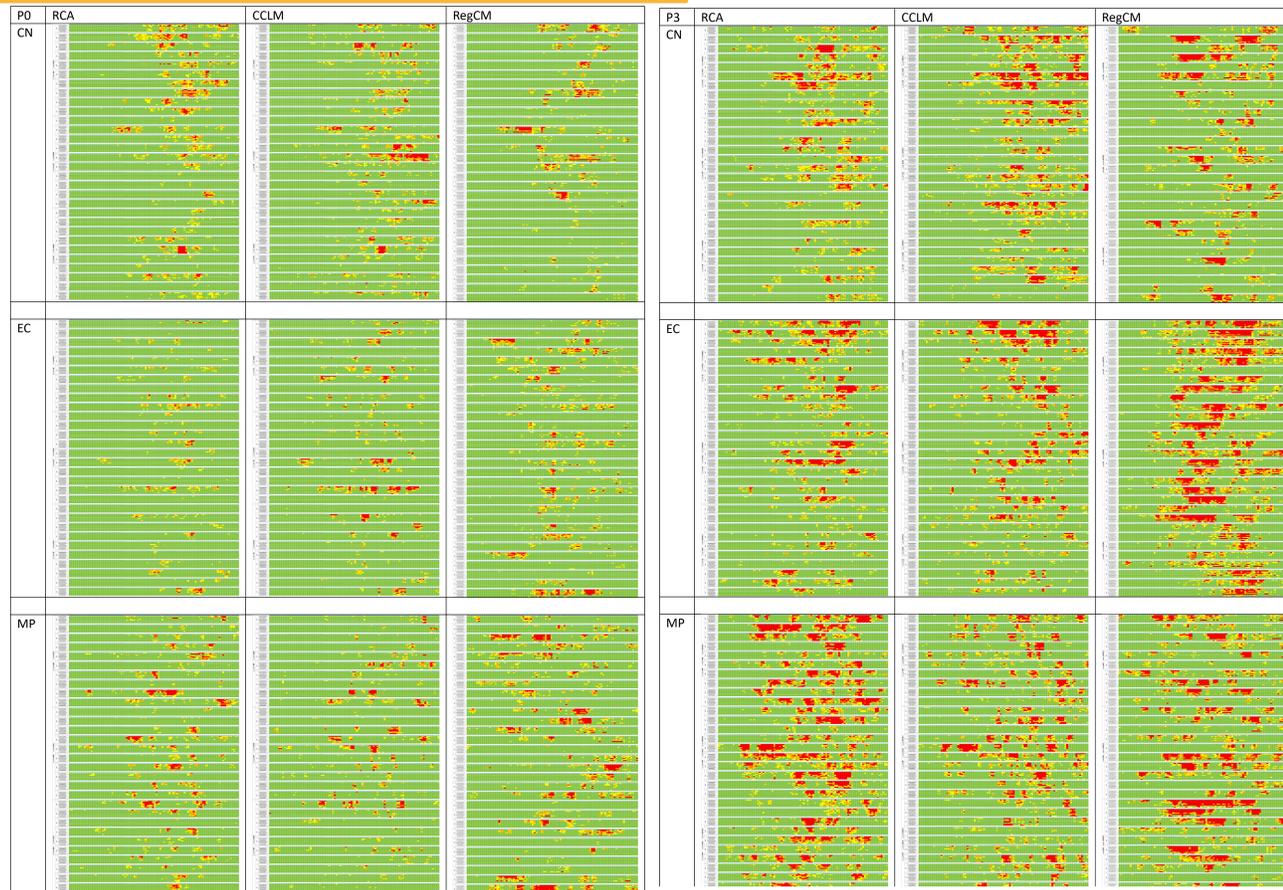


Fig 2

No. HWA for the whole Croatia



Change for No. HWA for eight cities in Croatia

Table 1

ensemble RCP4.5	P0				P1				P2				P3				P1-P0				P2-P0				P3-P0			
	sum	average	min	max	sum	average	min	max	sum	average	min	max	sum	average	min	max												
Osijek	114	114	0	233	114	114	0	233	114	114	0	233	114	114	0	233	114	114	0	233	114	114	0	233	114	114	0	233
Zagreb	122	122	0	233	122	122	0	233	122	122	0	233	122	122	0	233	122	122	0	233	122	122	0	233	122	122	0	233
Karlovac	121	121	0	233	121	121	0	233	121	121	0	233	121	121	0	233	121	121	0	233	121	121	0	233	121	121	0	233
Gospic	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233
Rijeka	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233
Knin	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233
Split	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233
Dubrovnik	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233	84	84	0	233

4 RESULTS

- the total number of observed days during which there is a risk of heat wave effects on human health (regardless of the level of risk) within one year varies spatially and temporally (Fig 1).
- the total number of warnings in all eight regions together varies (Fig 2). There is an increase in the total number of warnings of 2.5 warnings per year for the whole Croatia (all 8 regions together).
- in 1991 – 2020 period, the lowest total number of warnings about the risk of a heat wave on human health was recorded in 1997 - a total of 3 warnings, with one very high risk in the area of the southern Adriatic and the interior of Dalmatia, and one moderate risk in the central Croatia. In the same period, the highest number of warnings about the risk of heat wave effects on human health was recorded in 2012 (a total of 233 warnings) and in 2003 (227 warnings were issued in all 8 regions in total)
- the model ensemble mostly underestimates the number of real warnings for the whole of

- Croatia (2/3 years have a lower number of warnings), with a smaller linear trend (increase in the total number of warnings for 0.9 warnings per year for the whole Croatia)
- Ensemble of projections for RCP4.5 scenario has an increase of warnings for 1.2 warnings per year by the end of 2070, whereas for RCP8.5 it is 2.2 warnings per year.
- Numbers of all warnings increase from present time towards the future, with the most pronounced increase in P3 (table 1)
- the change in the number of warnings by risk category (moderate, high and very high) shows that by the end of the century the number of very high risk will increase the most, especially in the east of the country (Osijek) for the RCP8.5 scenario
- Previous study with RegCM (Int J of Clim, 2020 doi:10.1002/joc.6552) showed that under current settings model has warm bias – therefore in the next step using bias corrected RegCM data can give us more realistic climate