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UTJECAJ EKSTREMNIH TOPLINSKIH PRILIKA NA SMRTNOST U HRVATSKOJ

IMPACT OF EXTREME THERMAL CONDITIONS IN CROATIA

Ksenija Zaninović

DHMZ

Meteorološki izazovi 2: Meteorologija u fokusu javnosti
Zagreb, 6.3.2012.

Motivation

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- Identification of the meteorological basis for the development and the establishment of the national **H**eat **H**ealth **W**arning **S**ystem (HHWS).

- Implementation of public health actions for mitigation of the consequences and the protection of the population.

Objective

- Determination of criteria for heat related mortality in different climate regions of Croatia.
- Climatological analysis of heat waves (frequency, intensity and duration) in order to assess the vulnerability of the population.
- Estimation of changes in mortality based on projected conditions in future climate.

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Period
1983-2008.

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Thermal environment

Tmax, Tmin, Tmean

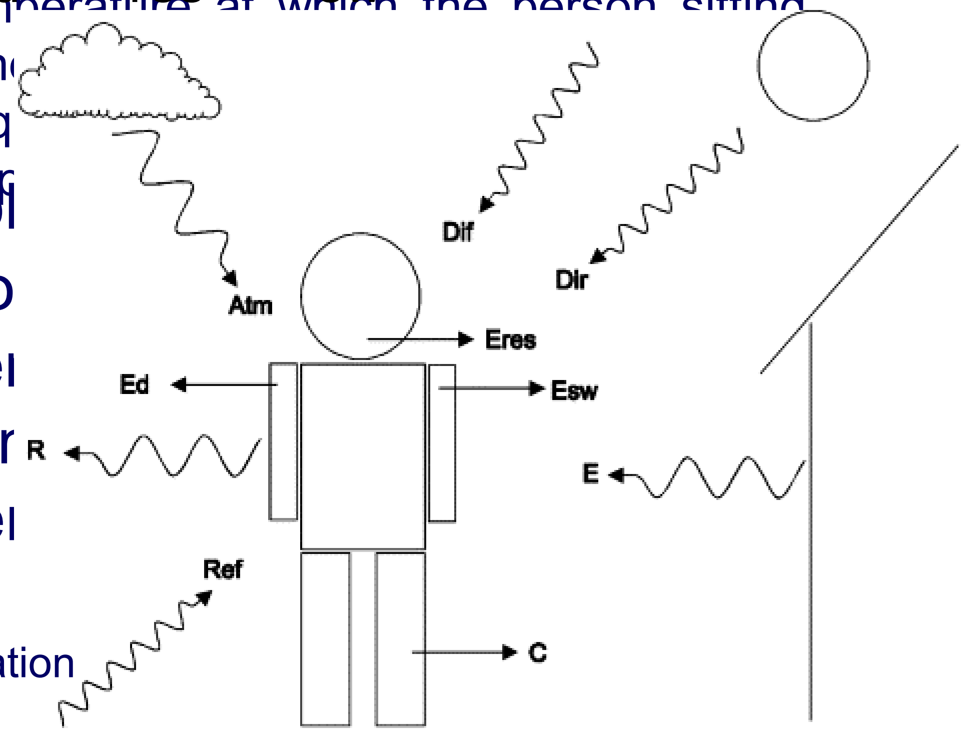
Physiologically **E**quivalent **T**emperature (PET at 2 p.m.)
(Mayer and Höppe, 1987, Höppe, 1999)

$$M + W + R + C + E_d + E_{res} + E_{sw} + S = 0$$

PET equivalent to the air temperature at which the person sitting indoors (work activity 80 W, h... mean radiant temperature eq... velocity 0.1 m/s, water vapour p... as in real outdoor conditions.

PET (°C)	Grade of pl...
< 29	no...
29–35	moder...
35–41	stron...
> 41	extre...

M - metabolic rate
W – work rate
R – total body radiation
C – convective heat transfer
Ed – latent enery flux by vapour diffusion through skin
Eres – enery flux by respiration
Esw – latent energy flux by sweat evaporation
S – storing of energy in the body



Adaptation to previous thermal conditions

$$Tha = Th + \frac{1}{3}\left(PET_{F41} - Th\right)$$ (Koppe and Jendritzky, 2005)

Tha – adapted threshold
Th – absolute threshold
PET_{F41} – PET smoothed with onefold Gaussian filter of 41 days

Relative threshold – PET smoothed with backward Gaussian filter of 41 days that have 30 significant filter weights

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Mortality

Heat-related mortality - deaths which would not have occurred in the absence of heat stress (McMichael et al., 1996).

Estimation of expected mortality – 183 day two band Gaussian filter

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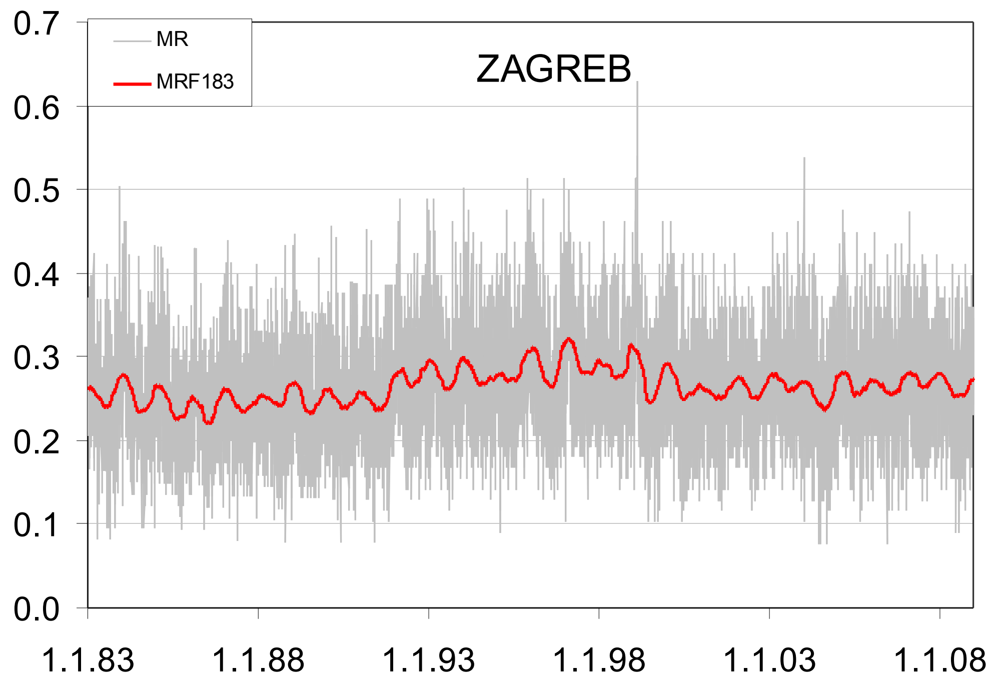
Mortality deviation MRdev (%)



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Climate change modelling

RegCM3 (ICTP, Trieste) forced by global atmosphere-ocean circulation model ECHAM5-MPIOM

Horizontal resolution 35 km
23 vertical levels with the model top at 100 hPa

Downscaling for 3 periods
P0: 1961-1990
P1: 2011-2040 ← IPCC SRES A2 emission scenario
P2: 2041-2070

Temperature correction between station altitude and model grid height with 0.65°C / 100 m

Wind speed reduced to the height 1.1 m, the center of gravity of human body (Matzarakis et al., 2009)

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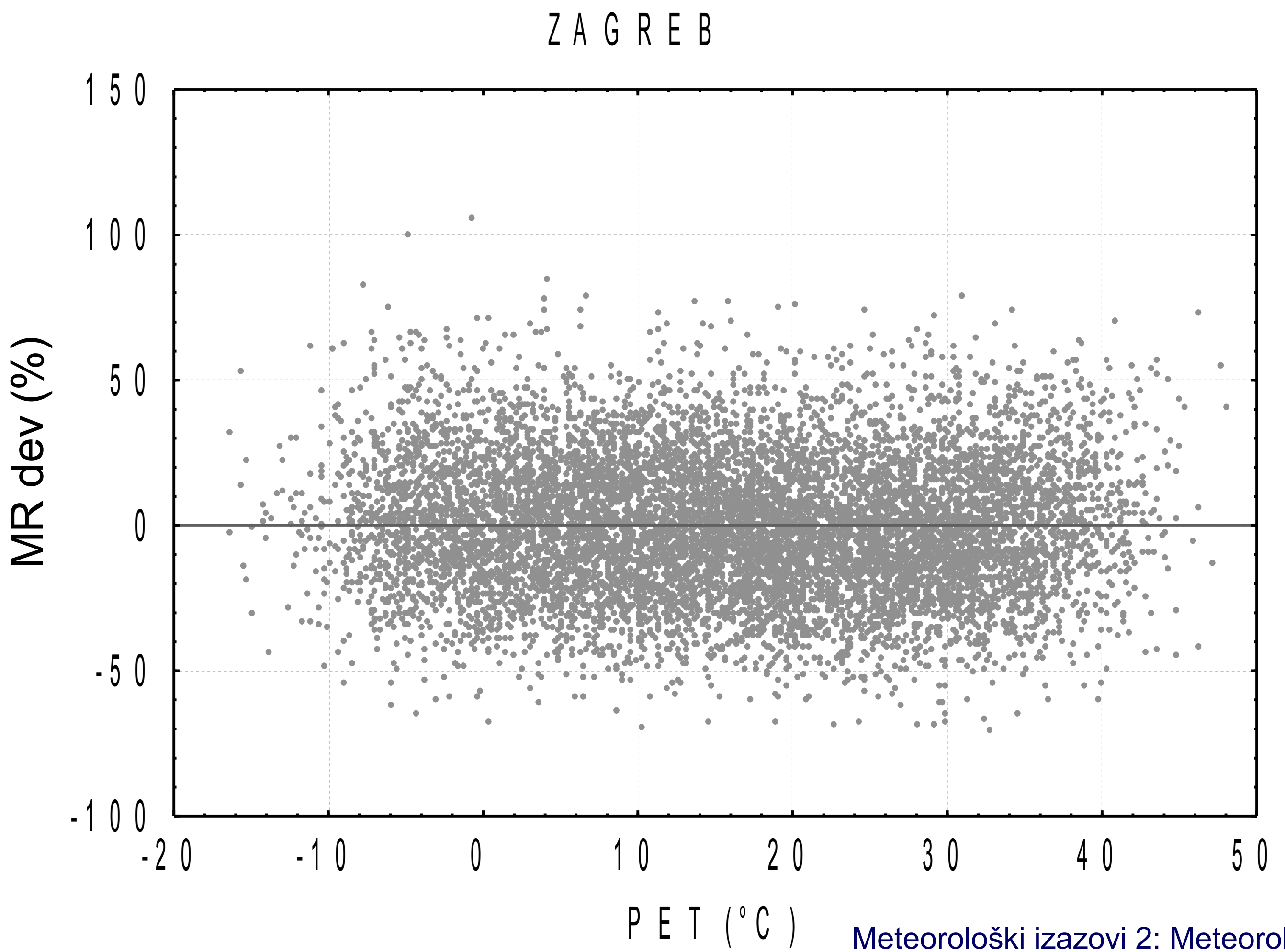
Determination of threshold for increased mortality – **heat cut point**

Temperature – MR dev scatter plot



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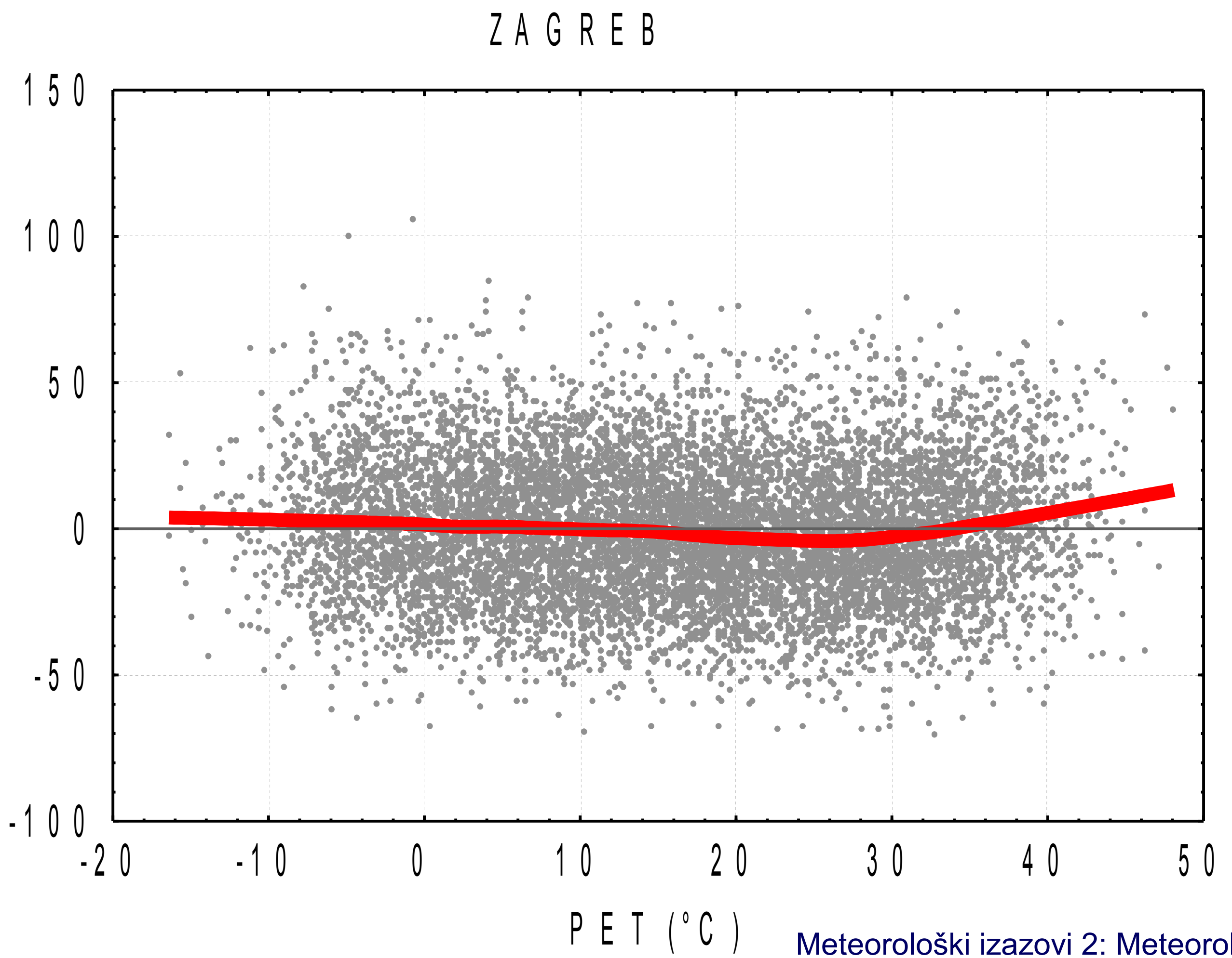
Locally **W**eighted **S**catter plot **S**moothing (Lowess smoothing) – fitting the subsets of data



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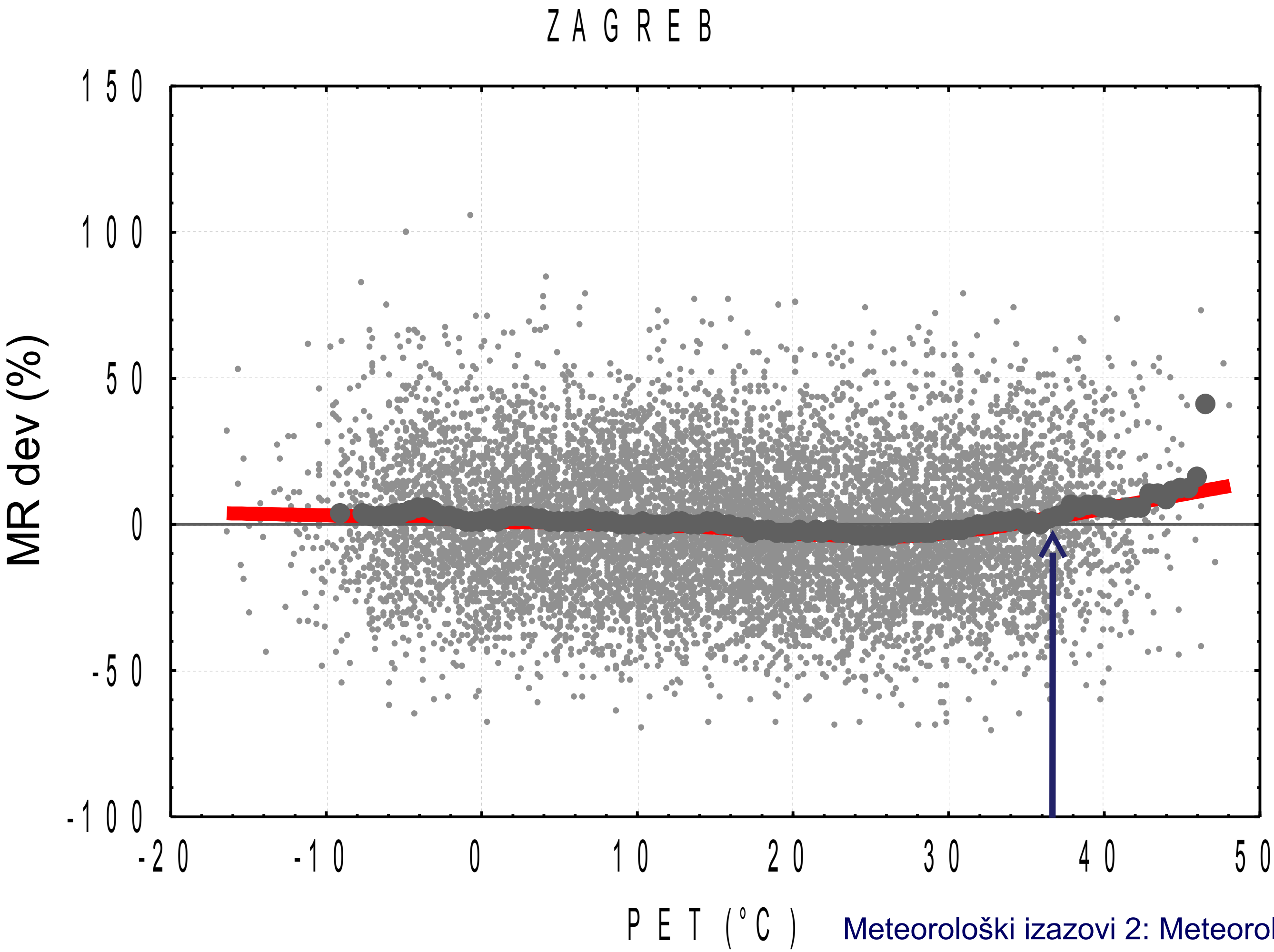
Temperature thresholds (heat cut point HCP) - centre of the first 3°C temperature bands for which MRdev were significantly higher (p=0.05) than the mean MRdev of the entire series

Average MRdev at successive 3°C temperature bands at increments of 0.5°C



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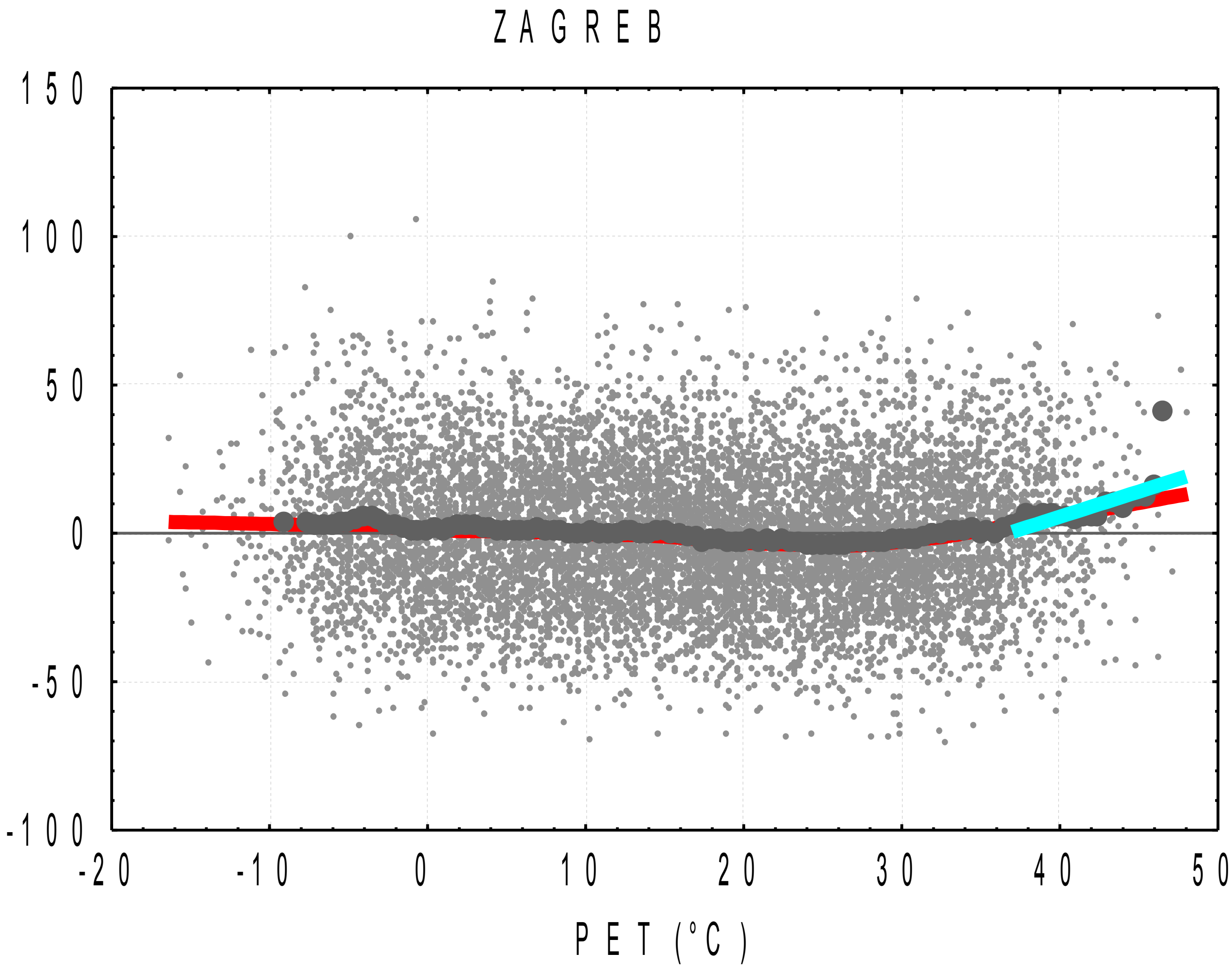
Regression line MRdev – temperature

Increase in mortality MRdev / 1°C



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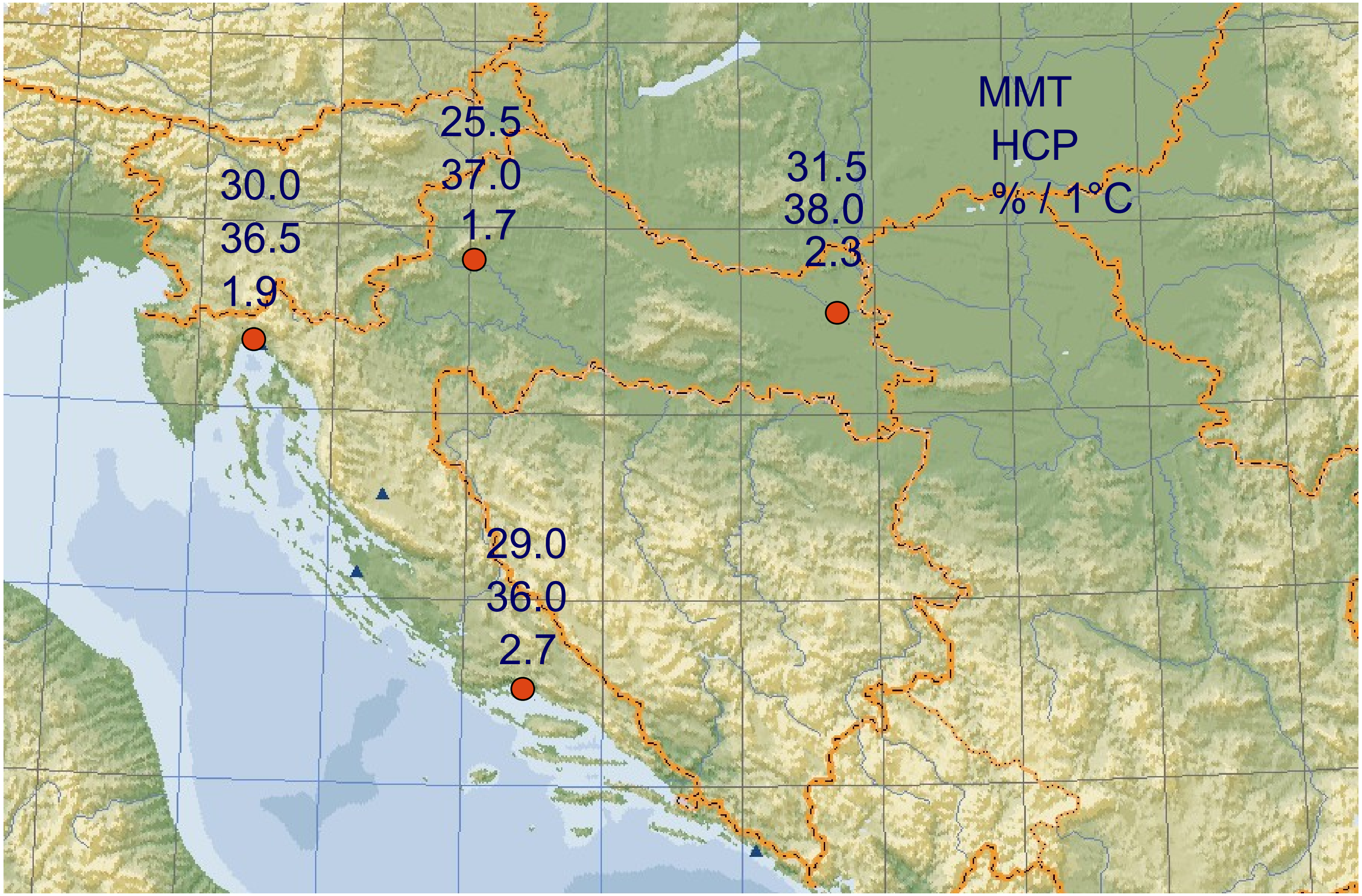
Minimum mortality temperature MMT (°C)
Heat cut point HCP (°C)
Increase of mortality per each °C (MR dev % / 1°C)



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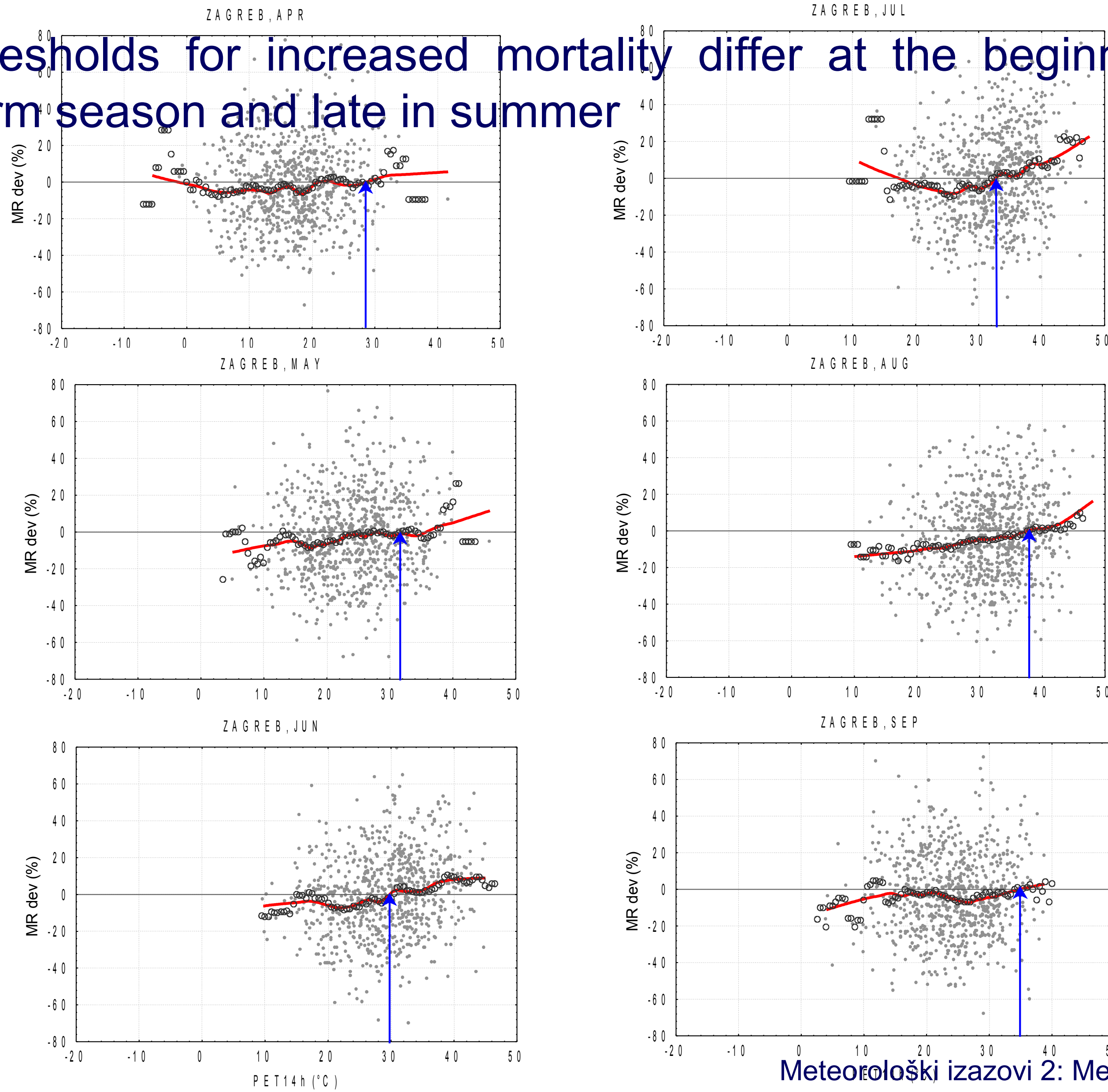
Thresholds for increased mortality differ at the beginning of warm season and late in summer



PET at 2 p.m.

MAY 27.5

AUG 37.0

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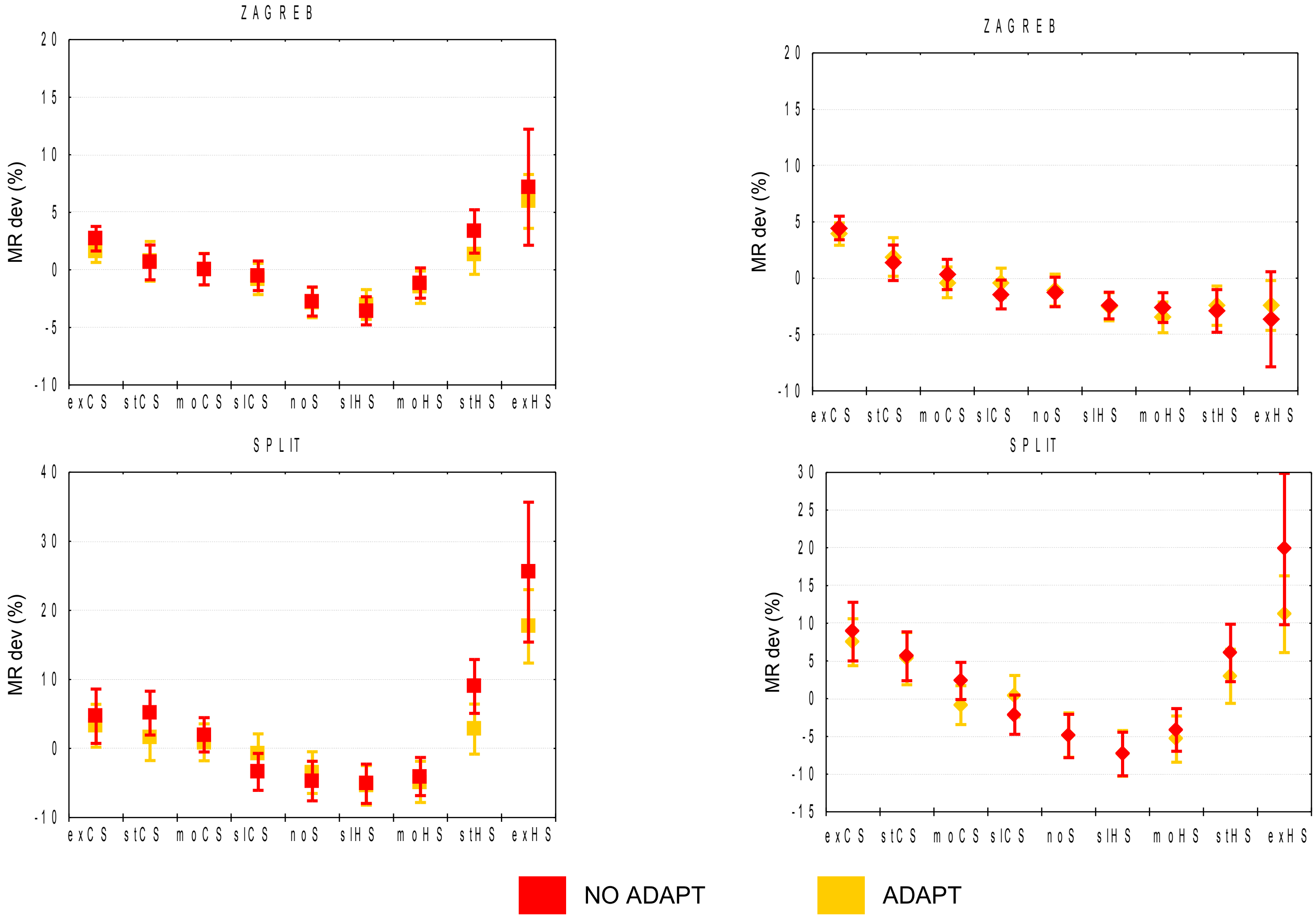
Mean mortality for grades of thermal stress – PET at 2 p.m.

no lag

7-day lag



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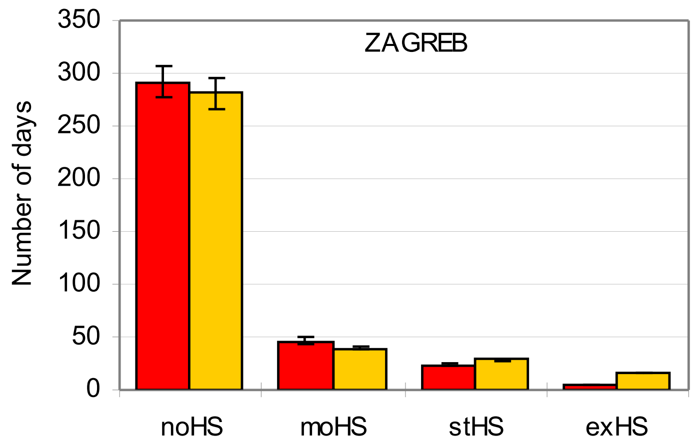
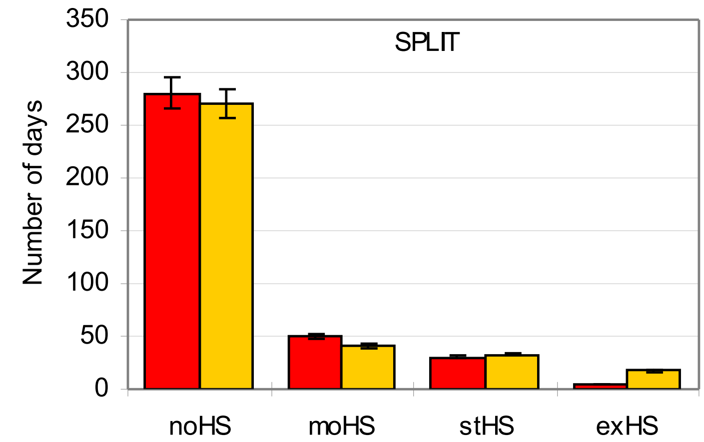
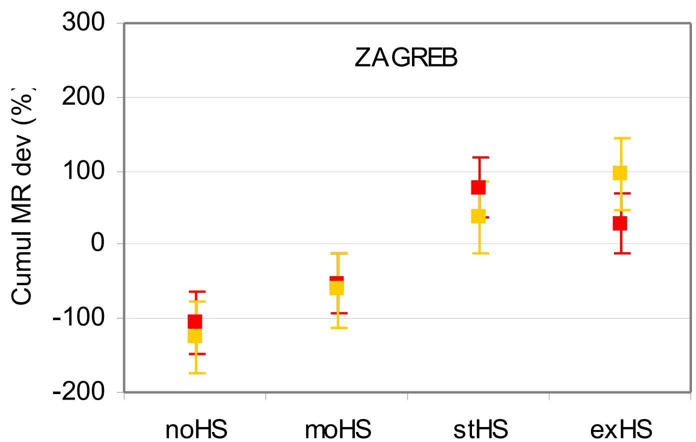
Vulnerability

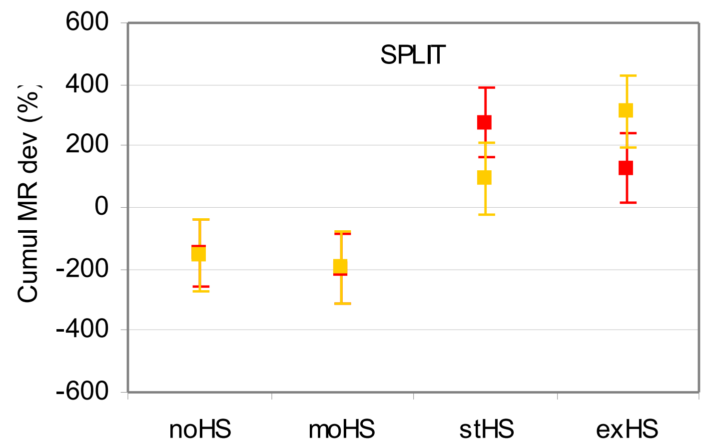
Frequency of grades of thermal stress





Sensitivity to thermal stress





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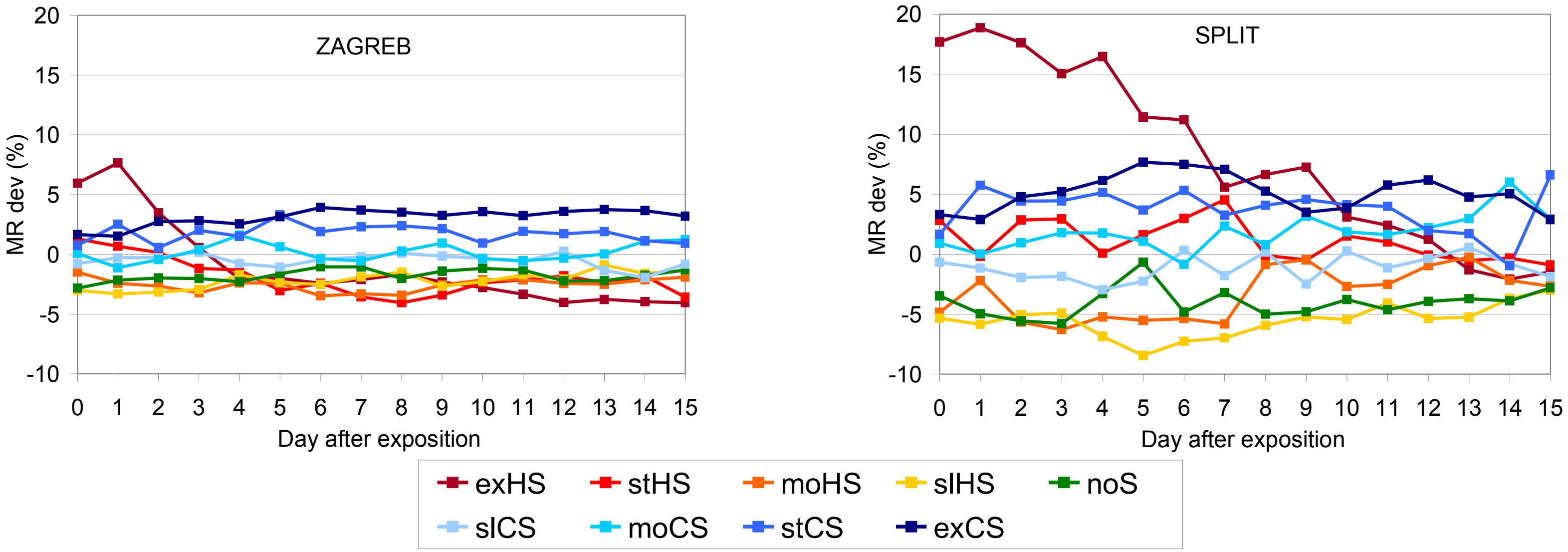
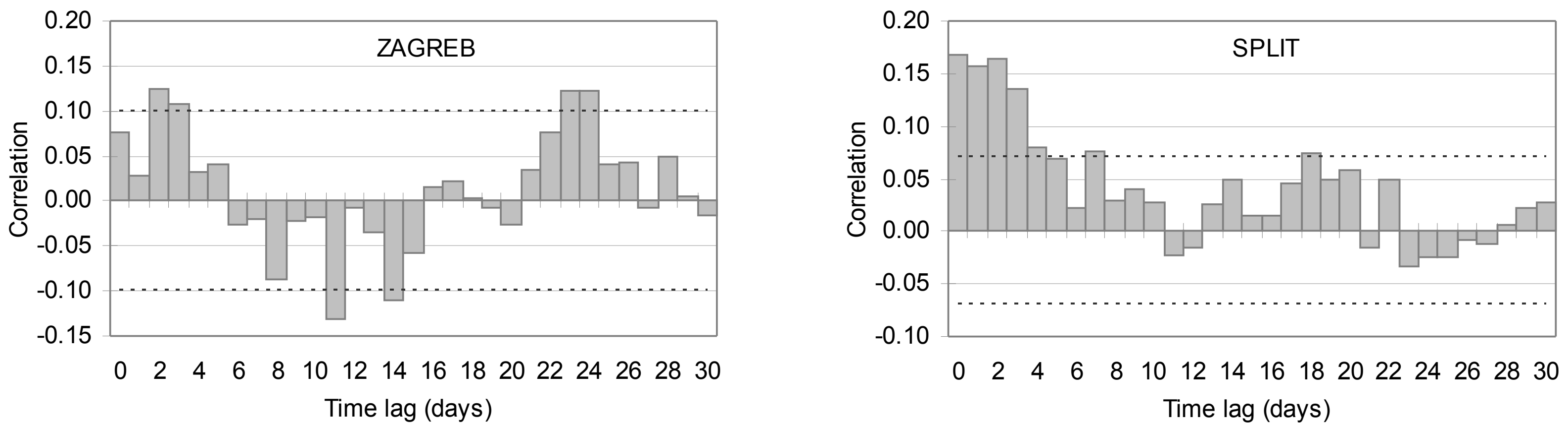
Displacement of mortality – harvesting effect

Mean mortality per grades of thermal stress up to 15 days after exposure



Correlations between PET (> HCP) and mortality rates with lags 0–30 days.



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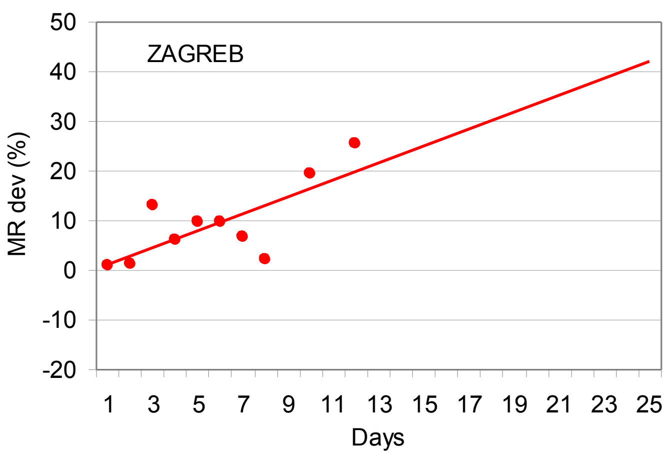
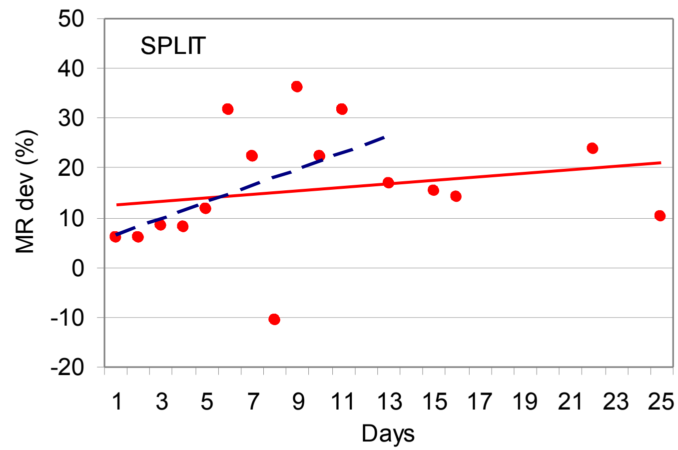
Persistence of heat waves

Increase in mortality with duration of period with PET>HCP

17%/10d

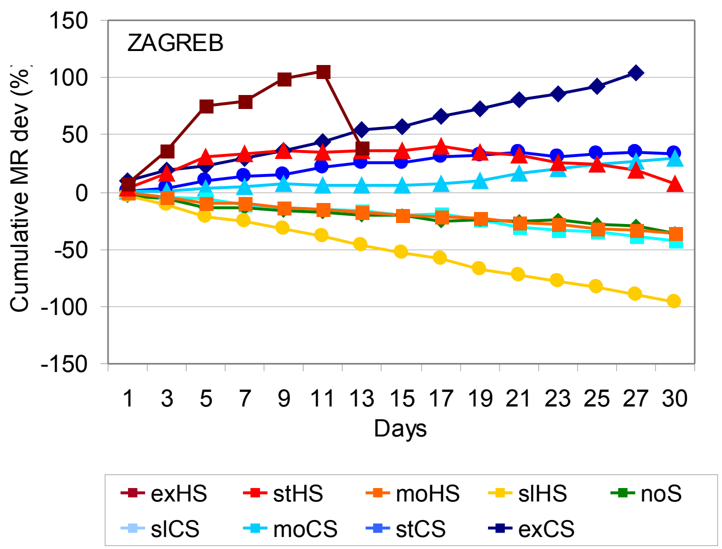


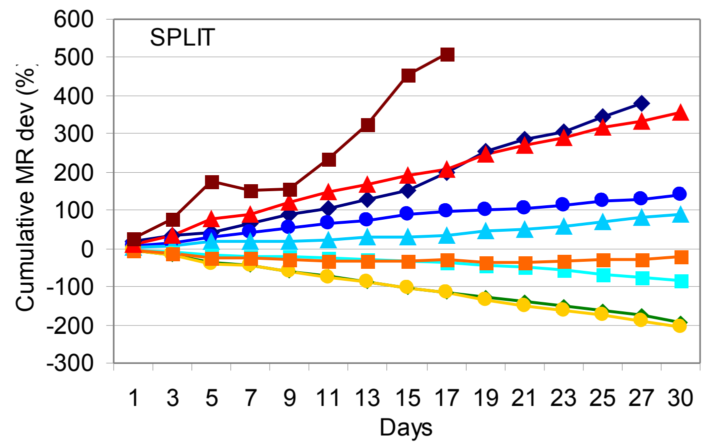


3%/10d

17%/10d

Cumulative mortality per grades of thermal stress





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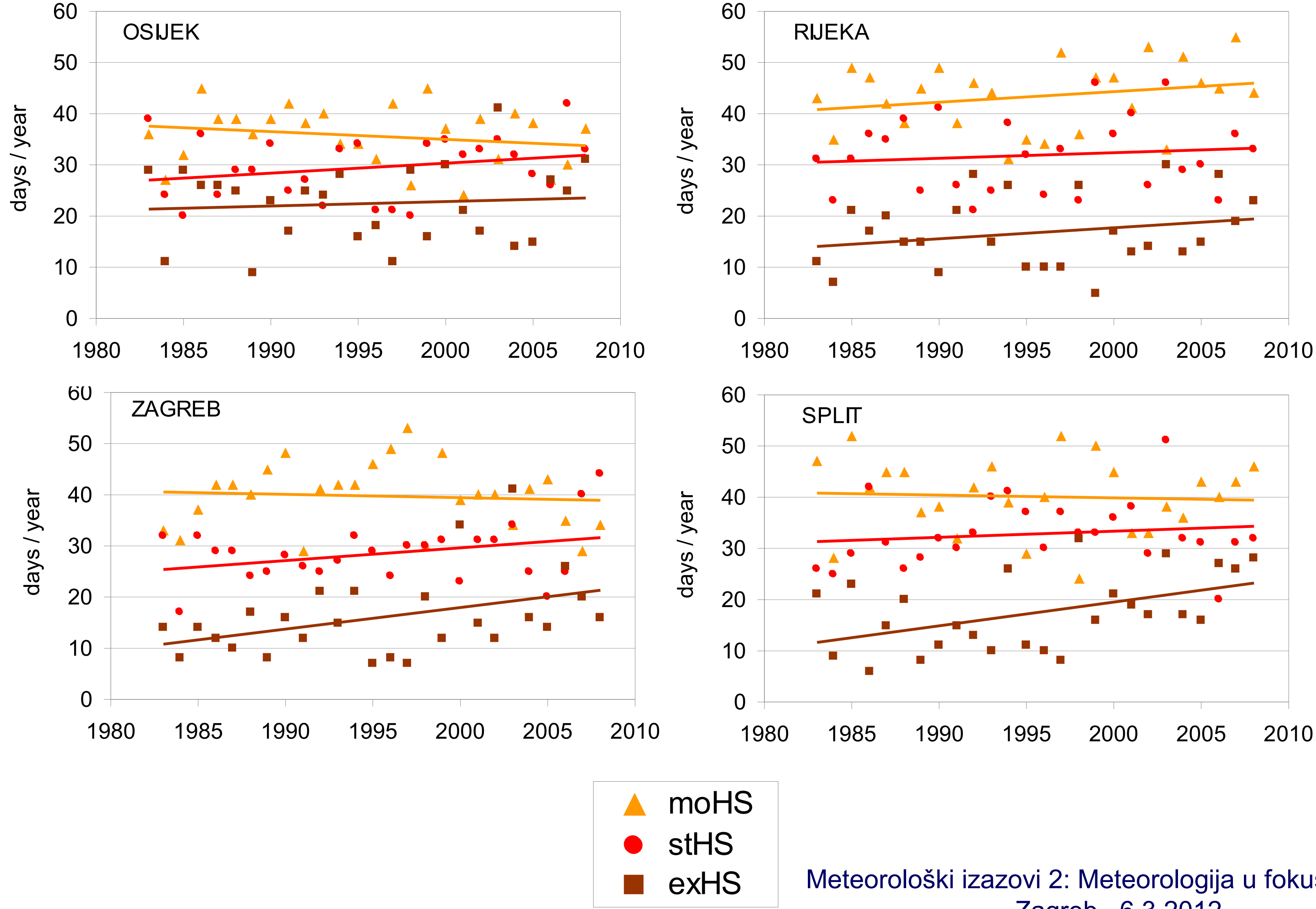
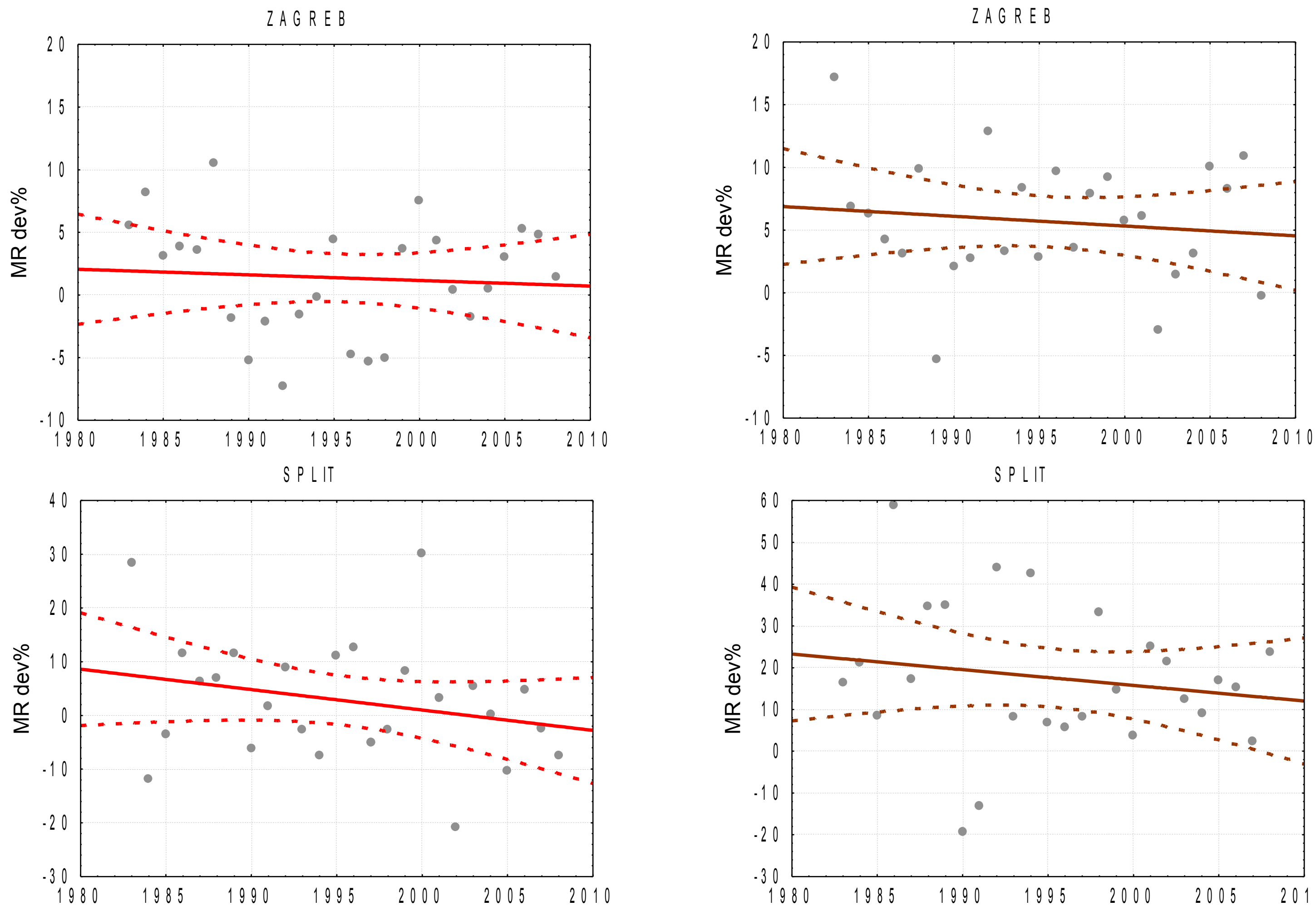
Trends in number of days with different grades of thermal stress (PET at 2 p.m.)



Trends in mortality

strong heat stress | extreme heat stress



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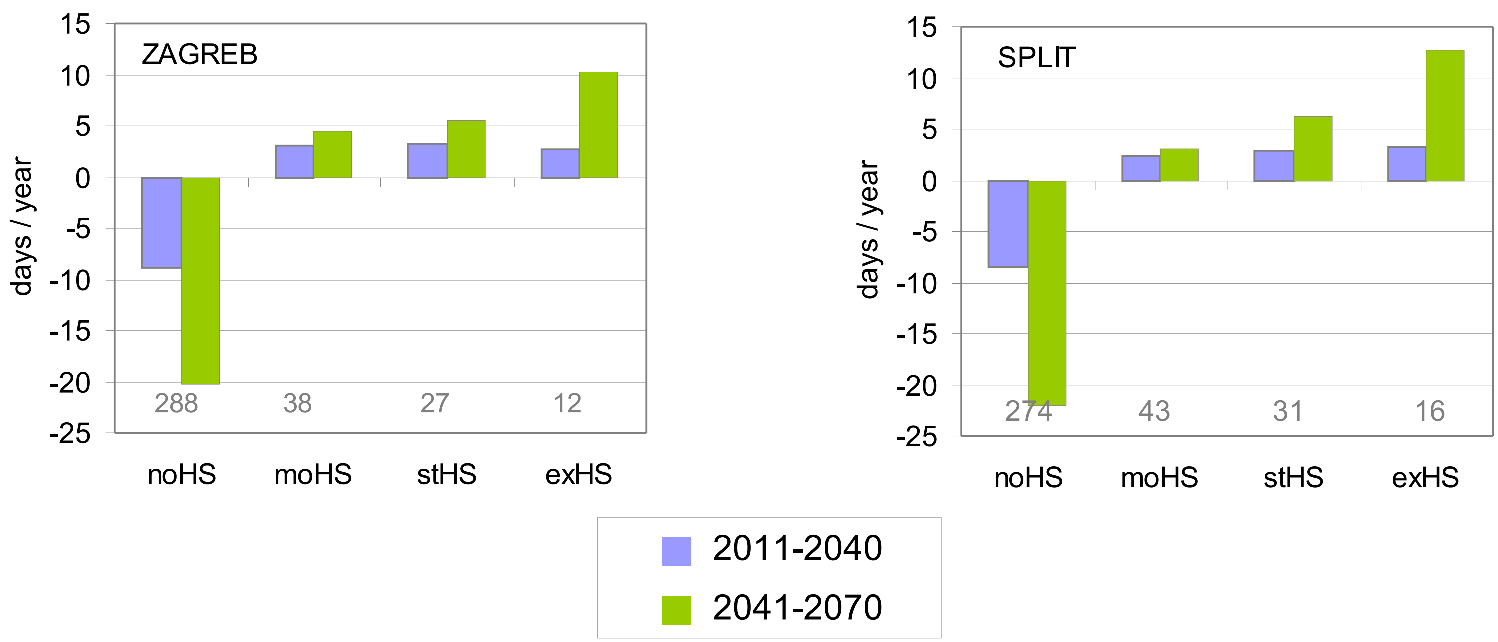
Climate change scenarios

Changes in number of days per grades of thermal stress for 2011-2040 and 2041-2070 related to 1961-1990



stHS	1.9-3.6	3.6-7.8
exHS	2.0-3.3	9.8-12.7

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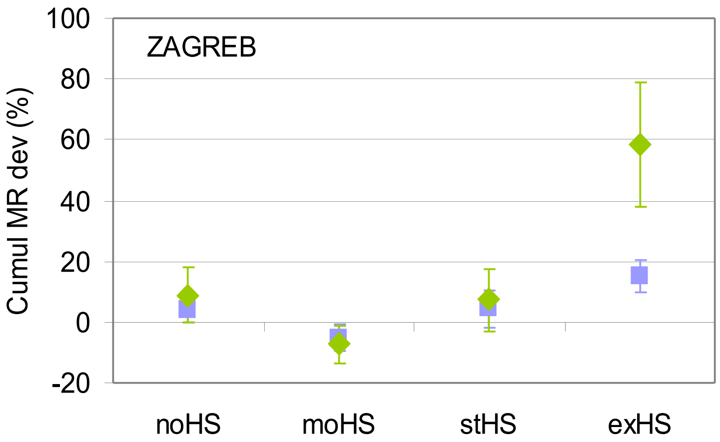
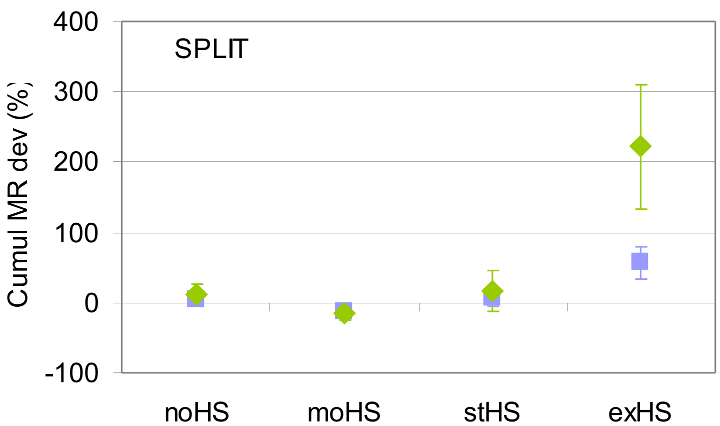
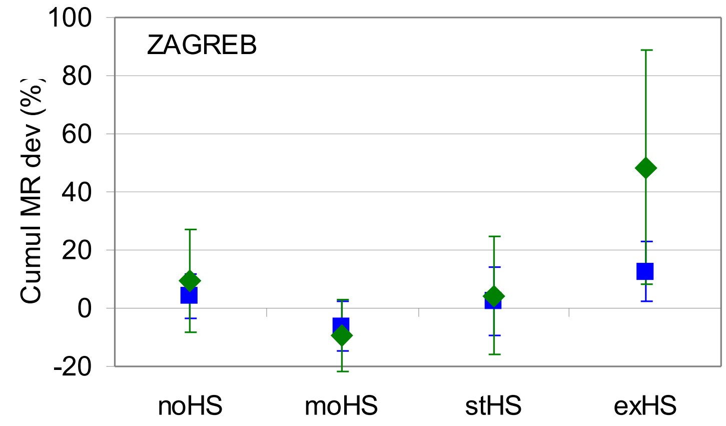
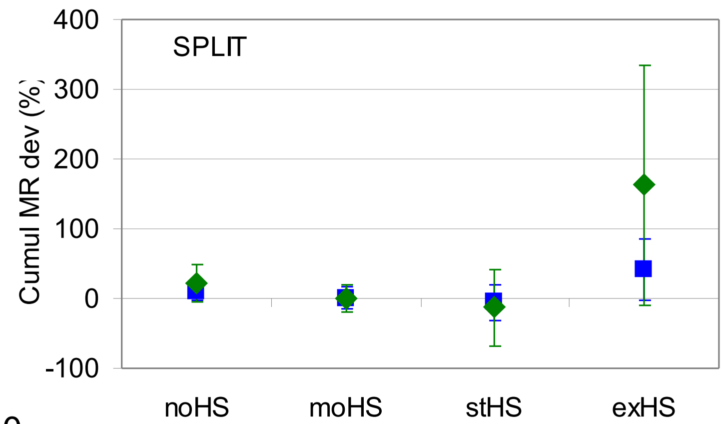
no long-term adaptation
MR dev 1983-2008





with long-term adaptation
MR dev 2008





2011-2040
2041-2070

exHS	no long-term adaptation	with long-term adaptation
2011-2040	15-57	12-42
2041-2070	58-222	48-162

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Conclusions

- Relation between mortality and thermal environment has U shape
- Geographical differences in temperature thresholds with the higher values in the continental climate, than in the coastal area (PET>36°C exceeds body temperature)
- The mortality increases by ~2% per 1°C increase in PET
- Temperature thresholds at the beginning of the warm season lower then on it's end (differences up to 10°C for PET)
- Heat related mortality occurs for strong and extreme heat stress
- Mortality increases up to 3-5 days after exposure, after that decrease mostly bellow expected values (harvesting effect)
- Prolonged heat stress causes significantly higher mortality than one-day heat stress
- In spite of increasing number of days with heat stress in the analyzed period, mortality declined due to long-term adaptation
- In the future climate periods, a strong heat stress will no longer cause increased mortality, for extreme heat stress the total mortality would increase for 12–42% in the period 2011–2040 and 48–162% in the period 2041–2070, and even more if the long-term adaptation were not included
- The results build a good basis for the forecast of the risks of heat waves

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