Change of winter climate indicators over the Carpathian Basin

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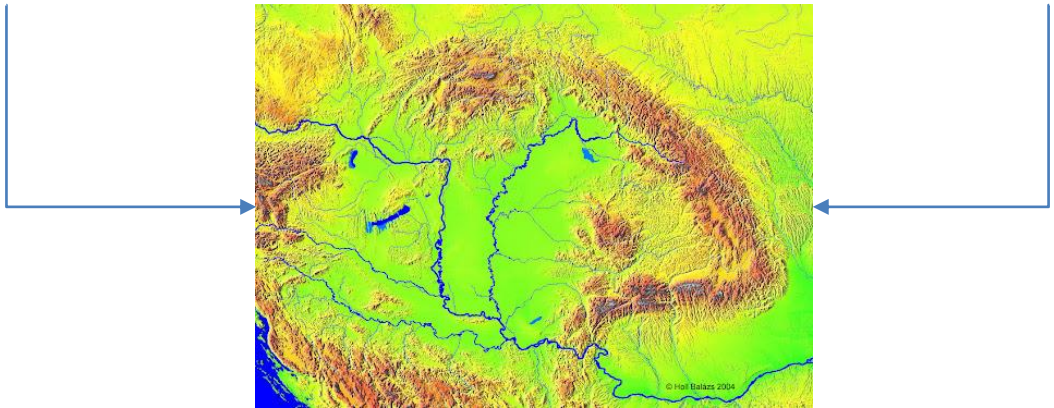
Fog

- Hard to predict: large variability
- Clouds close to the ground, low visibility (+compound drizzling)
- Traffic disruption on road & air
- Low-lying areas,
  lower wind speed,
  river valleys
  → cold-air pool (inversion)

Freezing rain

- Hard to predict: large variability
- Layer of ice on surfaces (+compound wind, snow)
- Damage trees & infrastructure, road accidents, bone injuries
- Warm-air masses + sub-freezing inversion layer



Data

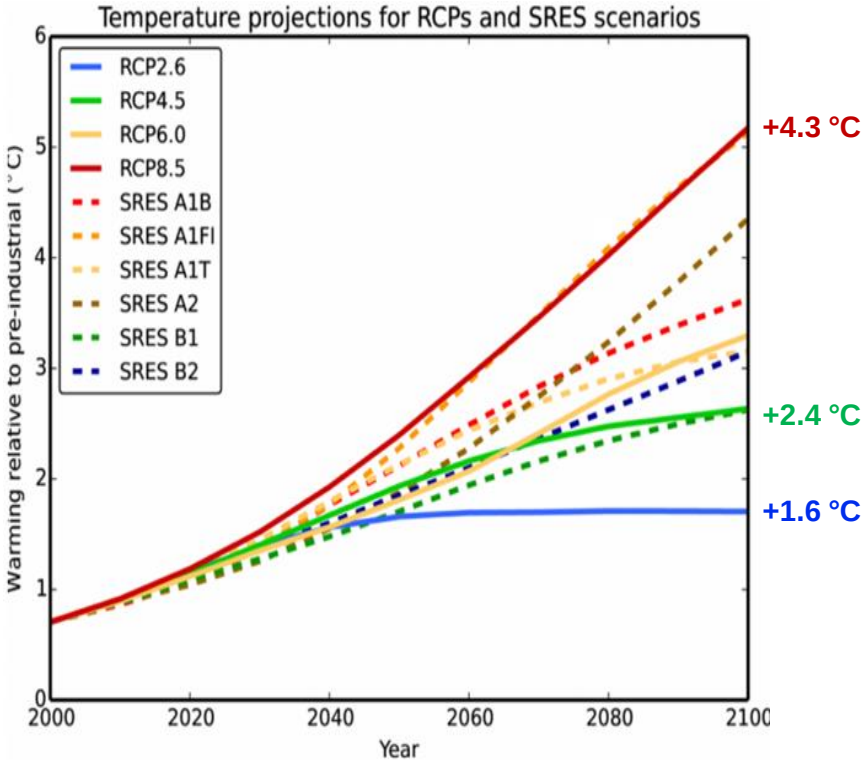
- **Observations:**
  HUCLIM – 0.1°, homogenized *daily* observations for Hungary, 1971/2001-2022
  Tave, Tmin, relative humidity, wind speed → **fog**

  ERA5-Land reanalysis – 0.1°, *hourly* data, 1971-2022
  T2m, total precipitation, snowfall → **freezing rain**

- **Simulations**: 6 Euro-CORDEX RCMs – 0.11°

RCM\GCM	CNRM-CM5	EC-EARTH	NorESM1-M
ALADIN63	x		
CCLM4-8-17		x	
HIRHAM5		x	
RACMO22E	x		
RCA4			x
REMO2015			x

daily data: Tave, Tmax, Tmin, RH, WS, TP, SF
1971-2100 (historical runs)
RCP2.6, RCP4.5 & RCP8.5 scenario runs

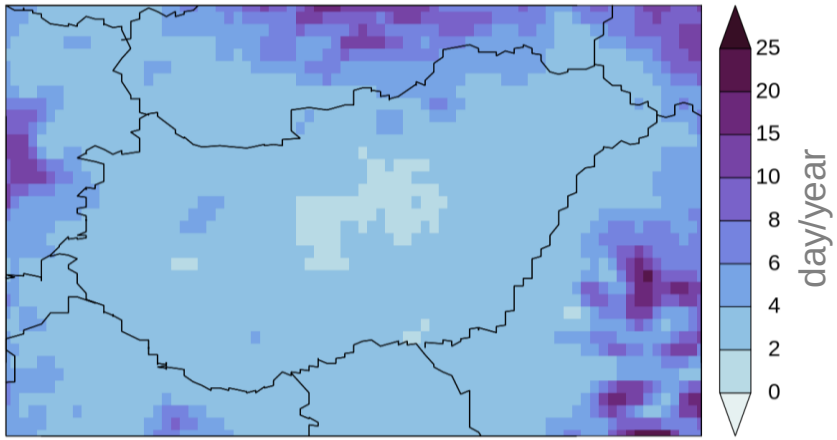


Freezing rain 1

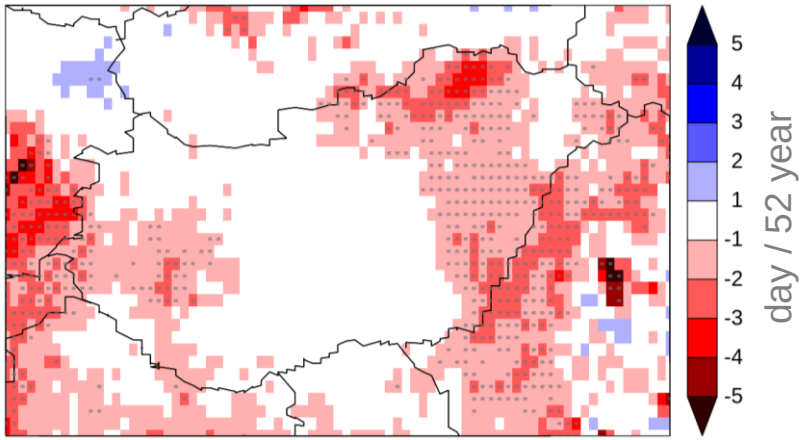
0) No available gridded reference data set
hourly data in reanalysis ←→ daily data in simulations

1) Definition: **days with freezing rain**
= **hourly Rain > 0.5 mm** (total precipitation – snowfall) &
hourly T2m < 0 °C for any 6 hours within a day

Annual mean value, 1971-2022



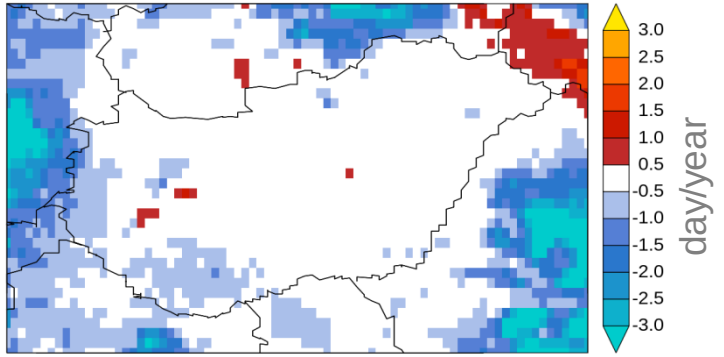
Fitted linear trend, 1971-2022



2) Find any 2-3 combinations of **daily Rain, Tmax, Tmin**
best fitting for 3 stations in Hungary
(on the basis of Taylor-diagram for 1971-2022)

Rain > 1, 2, 3 mm	Tmax < 1, 2, 3 °C Tmax > 0, 1, 2 °C	Tmin < 0, -1, -2 °C

Mean annual difference (6H – DAILY), 1971-2022

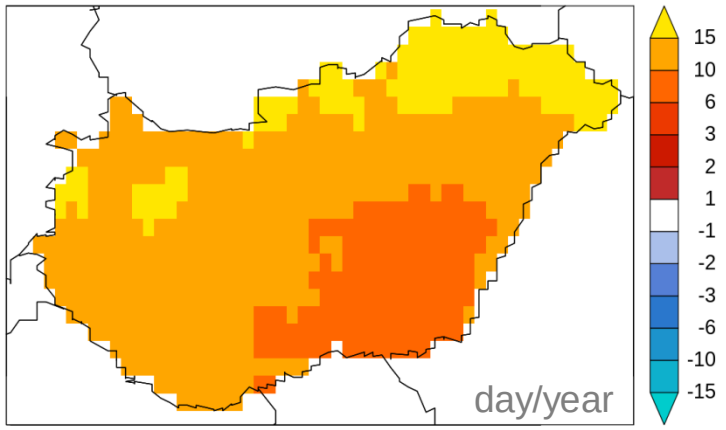


Freezing rain 2

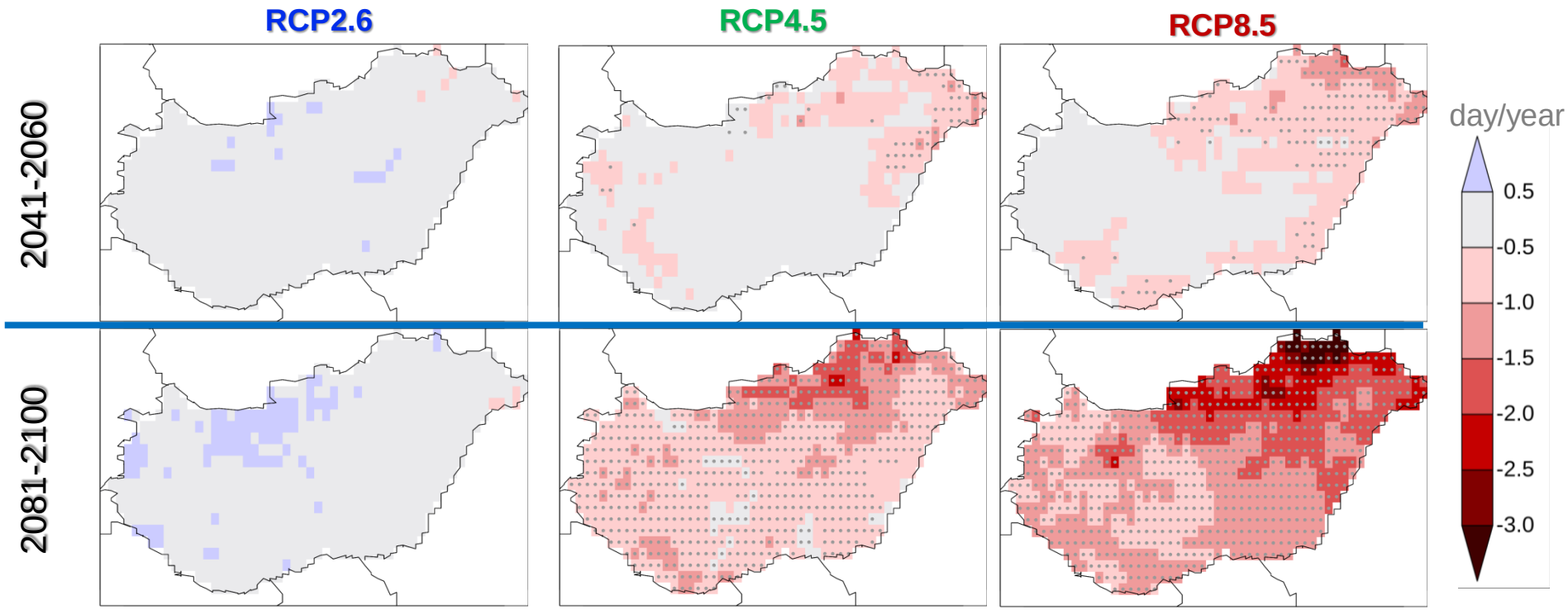
3) Calculate index from simulations → validation:
omit 1 model simulation (RACMO22E) out of
the 6 RCM-simulations

4) Projection results: median change
bias correction: standardization with ref. 2001-2022
significance at 0.1 level (3 out of 5 model simulations)

Validation (MODEL – OBS): 2001-2022



Projected change compared to 2003-2022



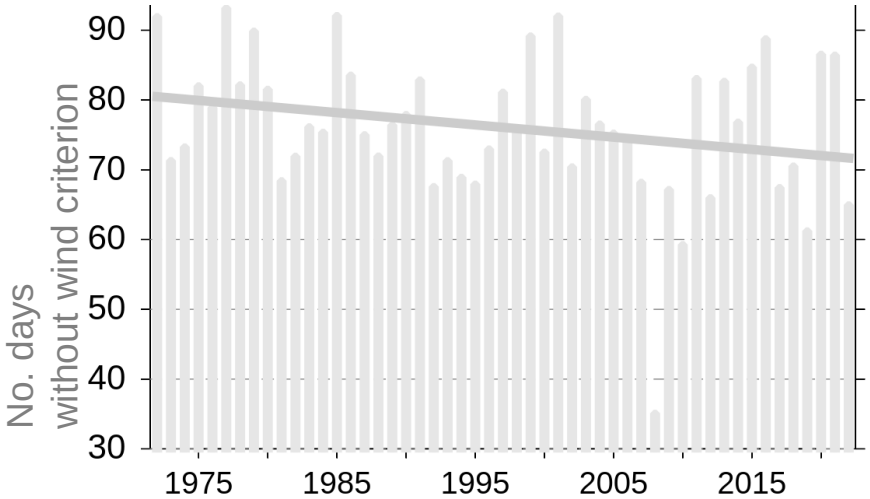
Fog 1

0) Fog climatology (1961-1990): 5 SYNOP-stations located below 200 m
occurring from October-March: 44-54 days

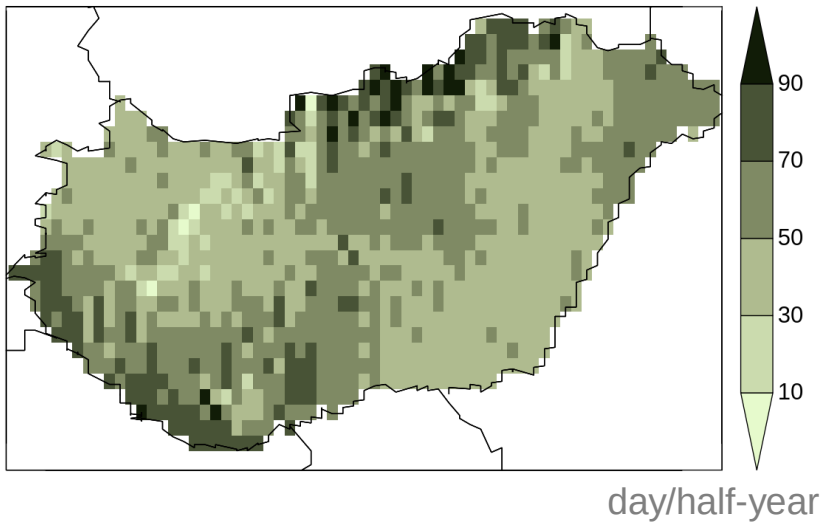
1) **Days with tendency to fog** :
calculate daily dew-point temperature: Td = Tave+RH/5–20 (Lawrence, 2005)

criterion No.1: cold&humid morning (Td≈c during the night): **Tmin(t) - Td(t-1) < 1 °C**
criterion No.2: close to saturated state (Td≈c) : **RHmax = (Td+20)·5–Tmin > 98%**
criterion No.3: low wind speed (data availability from 2001): **WS < 9 km/h**

2) Trend should not be determined for 21 years,
but **without the wind criterion** (No.3),
the possible appearance of fog has slightly decreased



No. days from October to March, 2001/02-2021/22



Fog 2

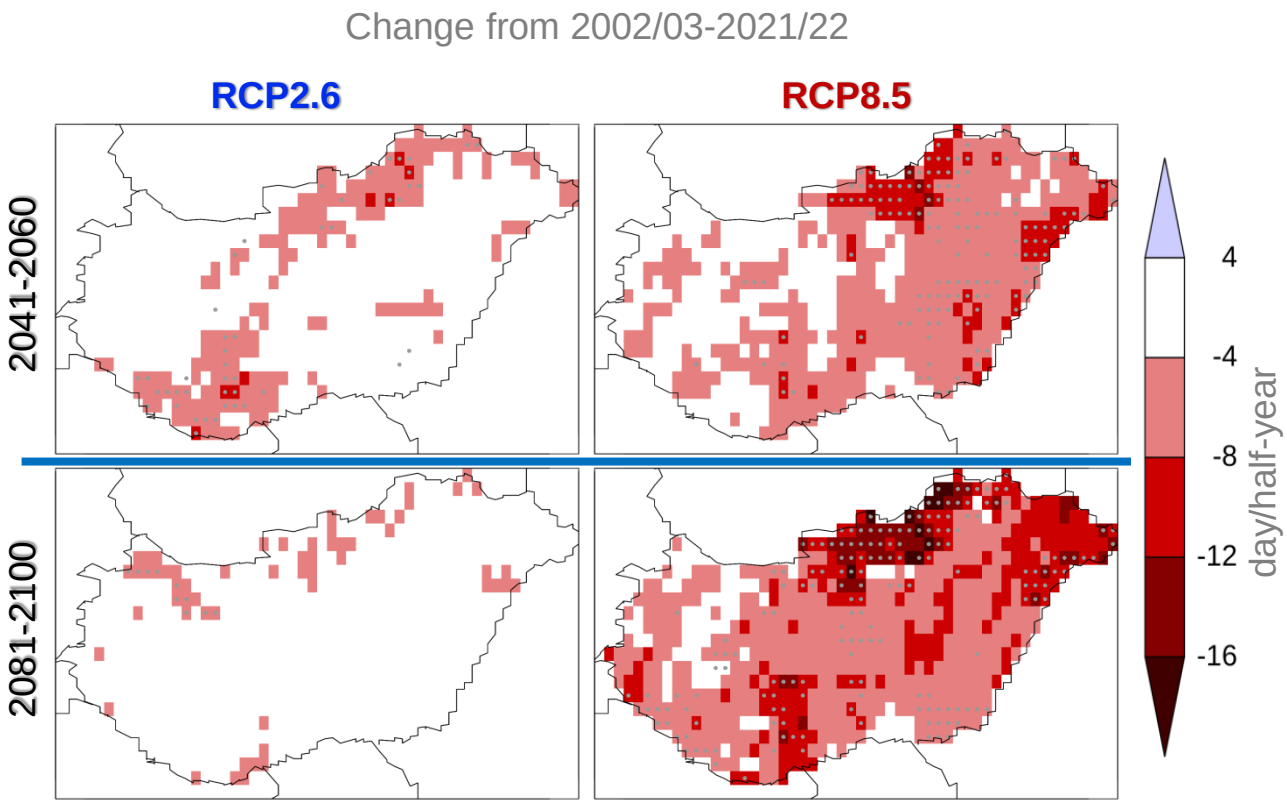
3) Calculate index from 5 simulations → validation: underestimation (keep all 5 models)

4) Future results:
median change
bias correction: standardization with ref. 2001/02-2021/22
significance at 0.1 level (3 out of 5 models)

5) What can be the cause?

RH decreases more during the day in winter → the airmass conditions close to saturated state will not last long

(low wind speed days: not changing)



Summary

- Models and methodologies can still be improved

- **Freezing rain: decrease**
  RCP8.5: <1 day/year on average (except in the mountains)
- **Fog:**
  RCP8.5: 10-30% **decrease**

- Overall, these are positive impacts of global warming in the Carpathian Basin

Thank you for your attention!

Questions? szabo.p.elte@gmail.com