Overview of the ClimaProof results: Climate change projections for Western Balkan – challenges for road infrastructure development

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AGENDA

- **Climate and Climate Change in the Western Balkan region**
- **ClimaProof Dataset and Tools**
- **Climate indicators: Theory and Examples**

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Climate and Climate Change in the Western Balkan region

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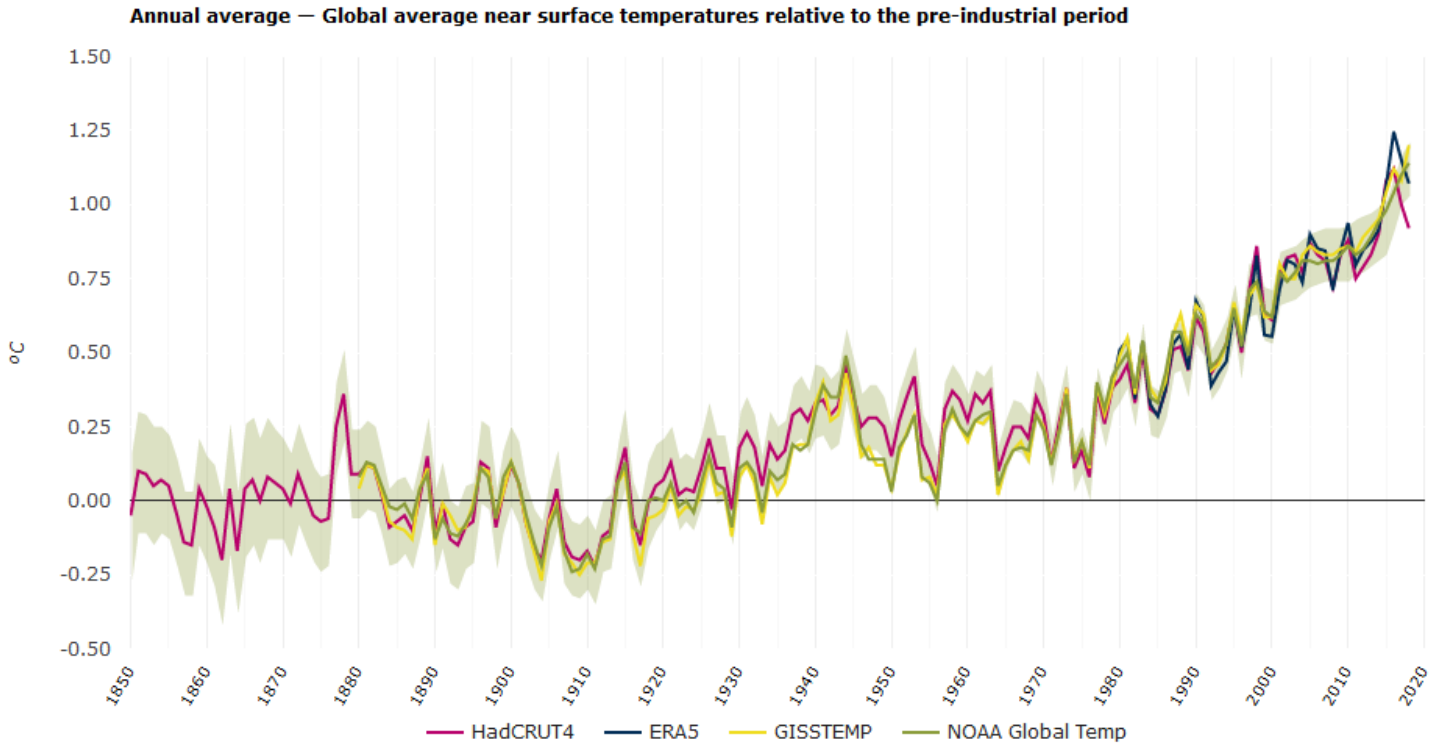
Global Temperature Change



Data sources:

- Global Surface Temperature Anomalies and Annual Global (land and ocean combined) Anomalies (degrees C) provided by **National Oceanic and Atmospheric Administration (NOAA)**
- Annual Global (Land and Ocean) temperature anomalies – HadCRUT (degrees Celsius) provided by
- NASA – Goddard Institute for Space Studies Surface Temperature Analysis (GISTEMP) provided by **NASA**
- ERA-Interim provided by **European Centre for Medium-Range Weather Forecasts (ECMWF)**

EEA, 2020

https://www.eea.europa.eu/data-and-maps/indicators/global-and-european-temperature-9/assessment

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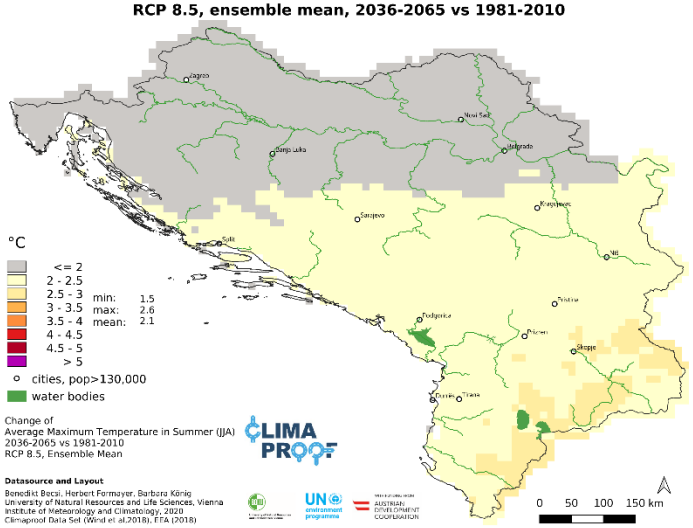
Change of Average Temperature (Tmax JJA, Tmin DJF)

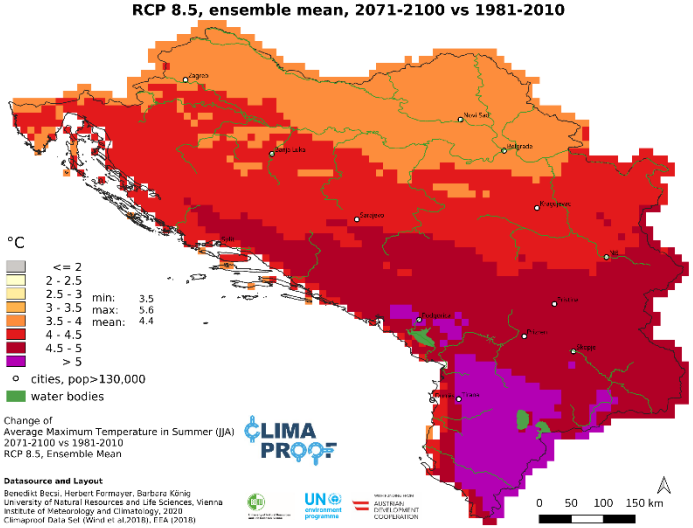
Change of Average Maximum Temperature in Summer

RCP 8.5, ensemble mean, 2036-2065 vs 1981-2010



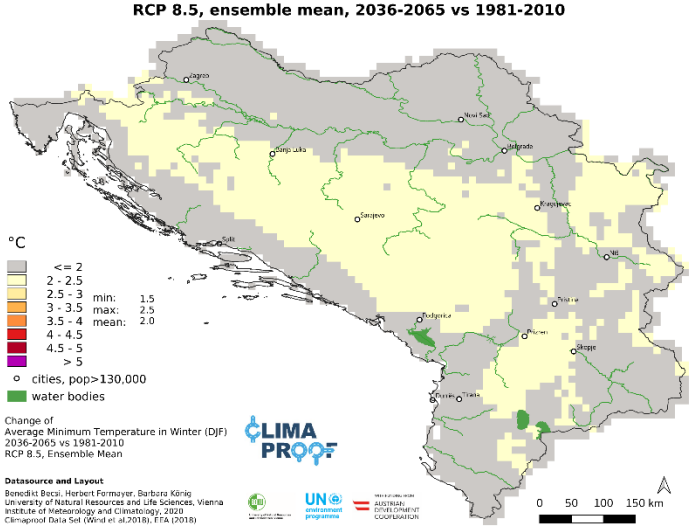
Change of Average Maximum Temperature in Summer

RCP 8.5, ensemble mean, 2071-2100 vs 1981-2010



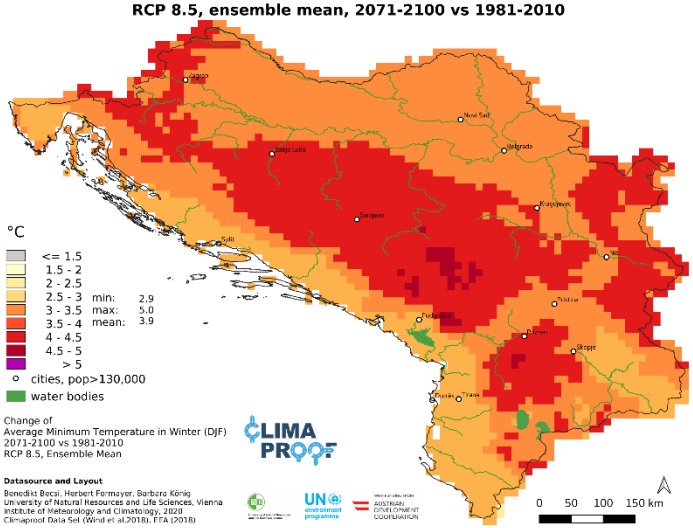
Change of Average Minimum Temperature in Winter

RCP 8.5, ensemble mean, 2036-2065 vs 1981-2010

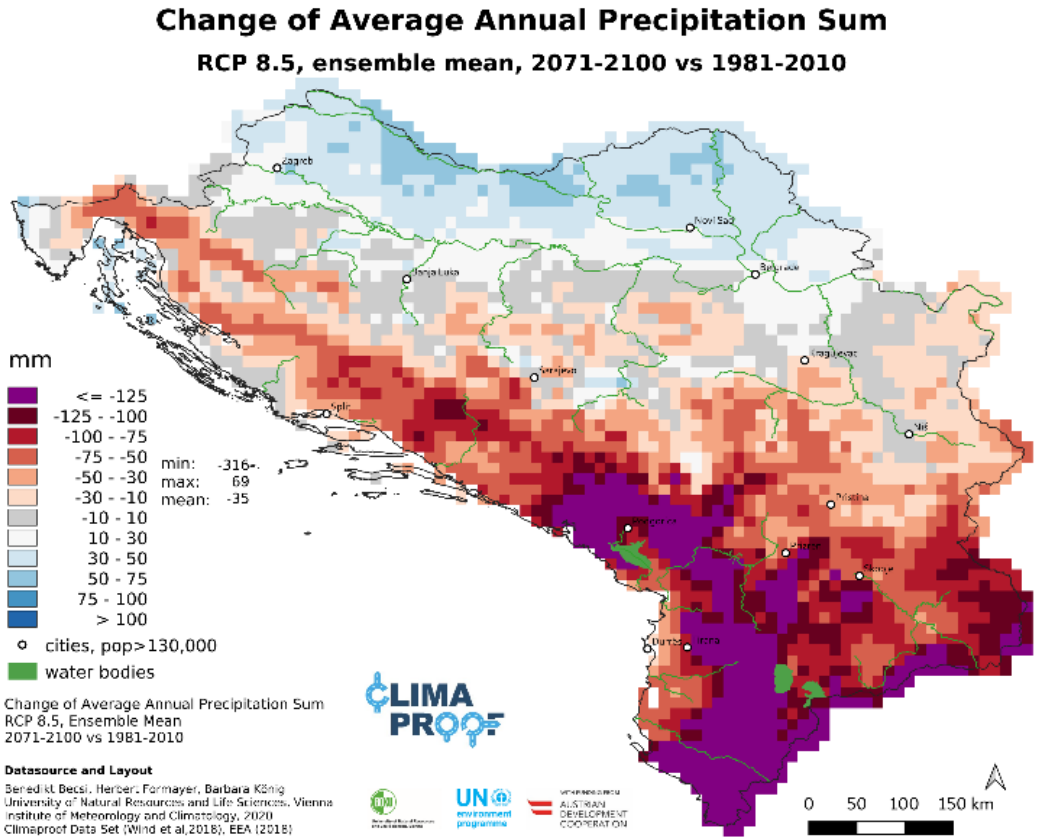


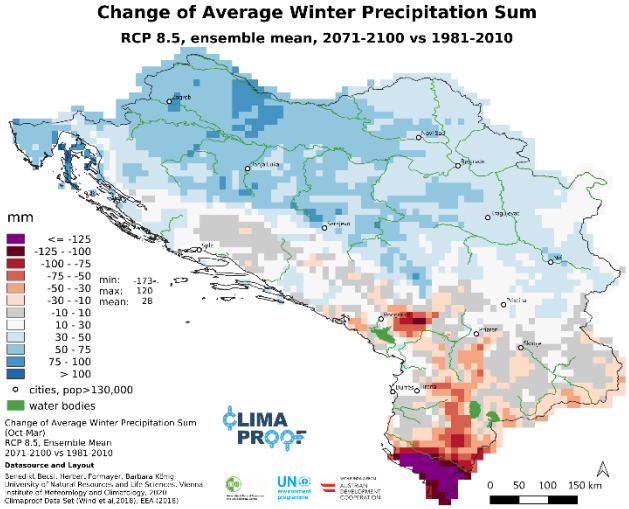
Change of Average Minimum Temperature in Winter

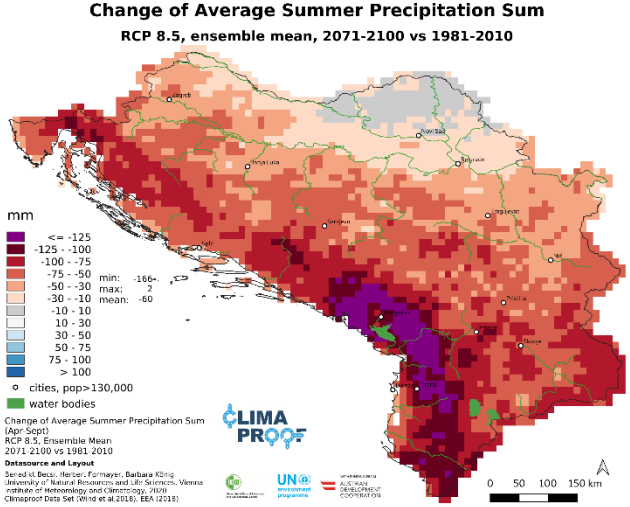
RCP 8.5, ensemble mean, 2071-2100 vs 1981-2010



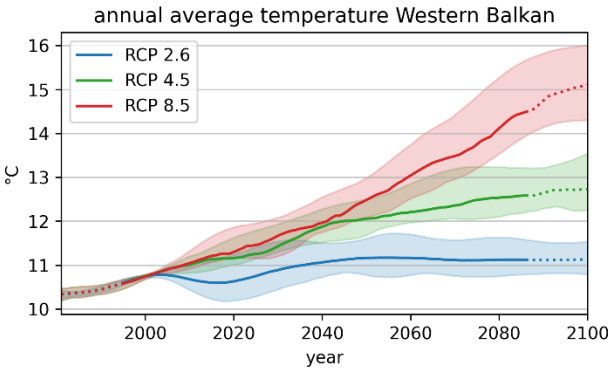
Change of Precipitation

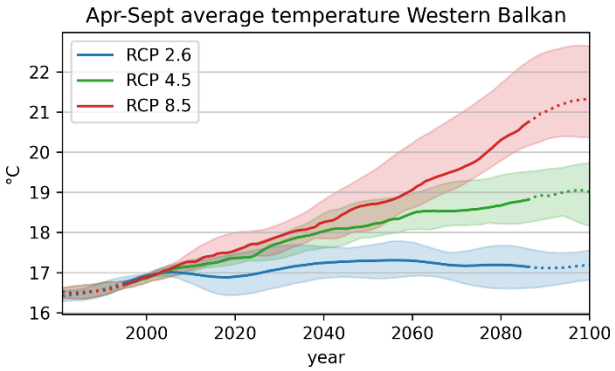


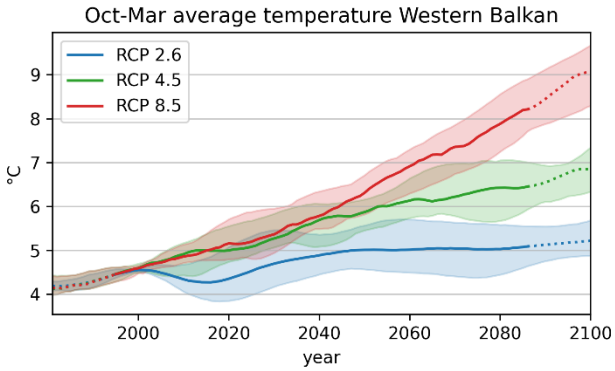


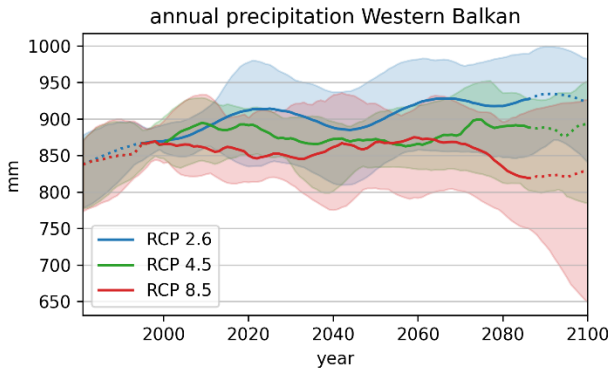


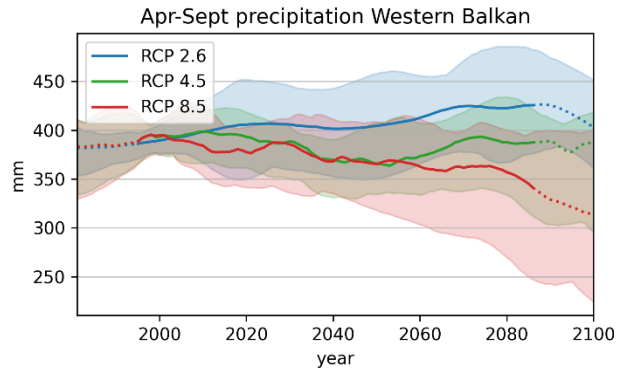
Temperature and precipitation change WB

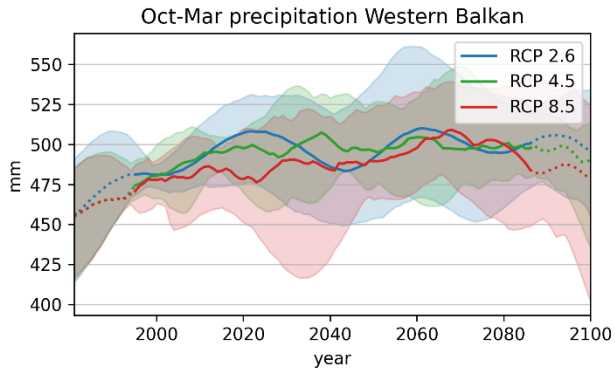












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ClimaProof Dataset and Tools

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Data base – Model data

- Euro-Cordex[1] (40) and Med-Cordex[2] (4), Resolution 0.11°
- Fully-coupled model by the University of Belgrade, Resolution 0.44°
- 6 GCMs, 13 RCMs
- RCP2.6 (6), RCP4.5 (18), RCP8.5 (16)

[1] https://euro-cordex.net [2] https://www.medcordex.eu/

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Data base – Observational data

Dataset	Variables used within the Project	Horizontal Resolution	Expansion of original dataset	Download
Carpatclim (Szalai et al, 2013; European Commission JRC, 2013)	tasmax, tasmin, pr, rsds, sfcWind, hurs	0.1°	44°N - 50°N, 17°E - 27°E	http://www.carpatclim-eu.org/
Danubeclim (Szalai et al, 2013; European Commission JRC, 2015)	pr	0.1°	Serbia, Montenegro and Srpska Republic	http://www.carpatclim-eu.org/danubeclim
E-OBS (Haylock et al, 2008; ECA&D, 2018)	tasmax, tasmin	0.25°	25°N -75°N 40°W-75°E	https://www.ecad.eu/download/ensembles/download.php
CHIRPS (Funk et al, 2015)	pr	0.05°	50°N - 50°S, 180°W - 180°E	http://chg.ucsb.edu/data/chirps/
ERA5 (C3S, 2017)	sfcWind (calc. from u and v), hurs (calc. from mean temperature and dew point temperature)	0.28°	global	https://cds.climate.copernicus.eu/cdsapp#!/home
SARAH-2 (Pfeifroth et al, 2017)	rsds	0.05°	65°N - 65°S, 65°W - 65°E	https://doi.org/10.5676/EUM_SAF_CM/SARAH/V002

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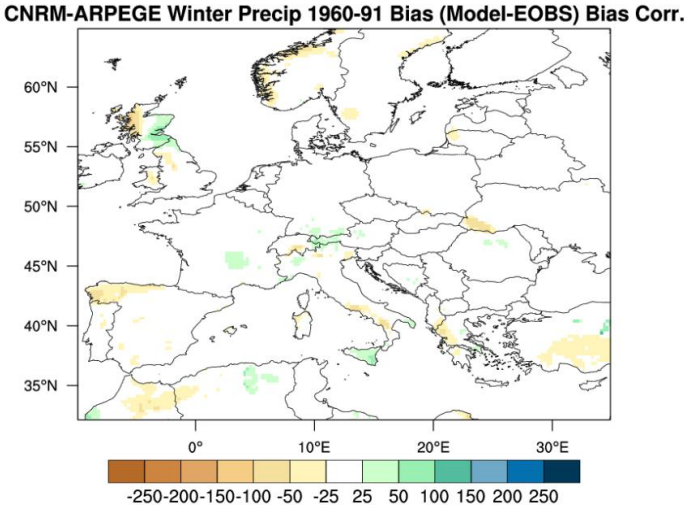
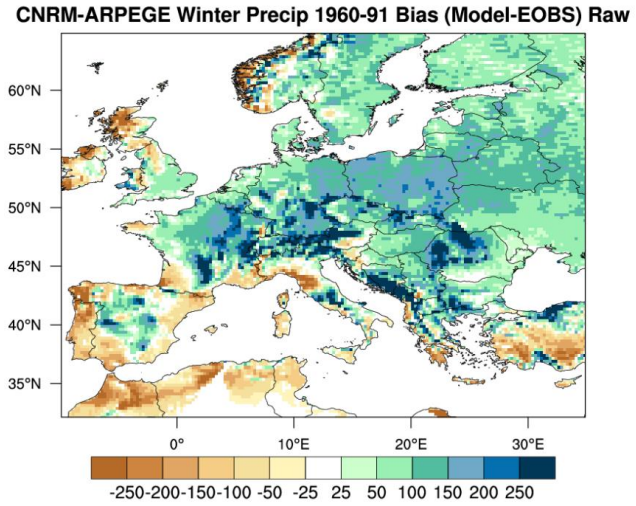
Ensemble of bias-corrected Climate Scenarios

Scaled-Distribution Mapping

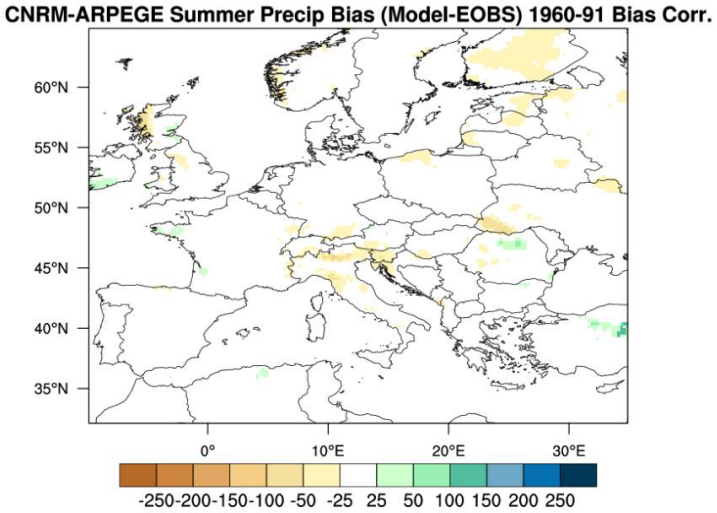




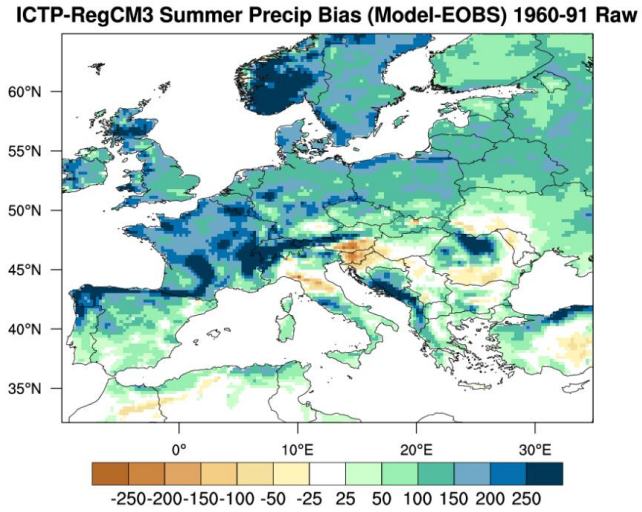
Precipitation-bias in RCMs

Left: bias corrected

Right: raw data



(up: ALADIN
down: RegCM3)



CCCA Dataserver

https://data.ccca.ac.at/group/climaproof

(Account required)

Available data:

- Bias corrected model data
- Regridded original model data (for the ICC-OBS Tool)
- Observational data (used for bias correction)
- Topography data of the common grid (0.1°)
- High resolution topography data (0.01°) for downscaling

Variable	Unit
tasmax	°C
tasmin	°C
pr	mm
rsds	W/m²
sfcWind	m/s
hurs	%

User Guide: https://github.com/boku-met/climaproof-docs

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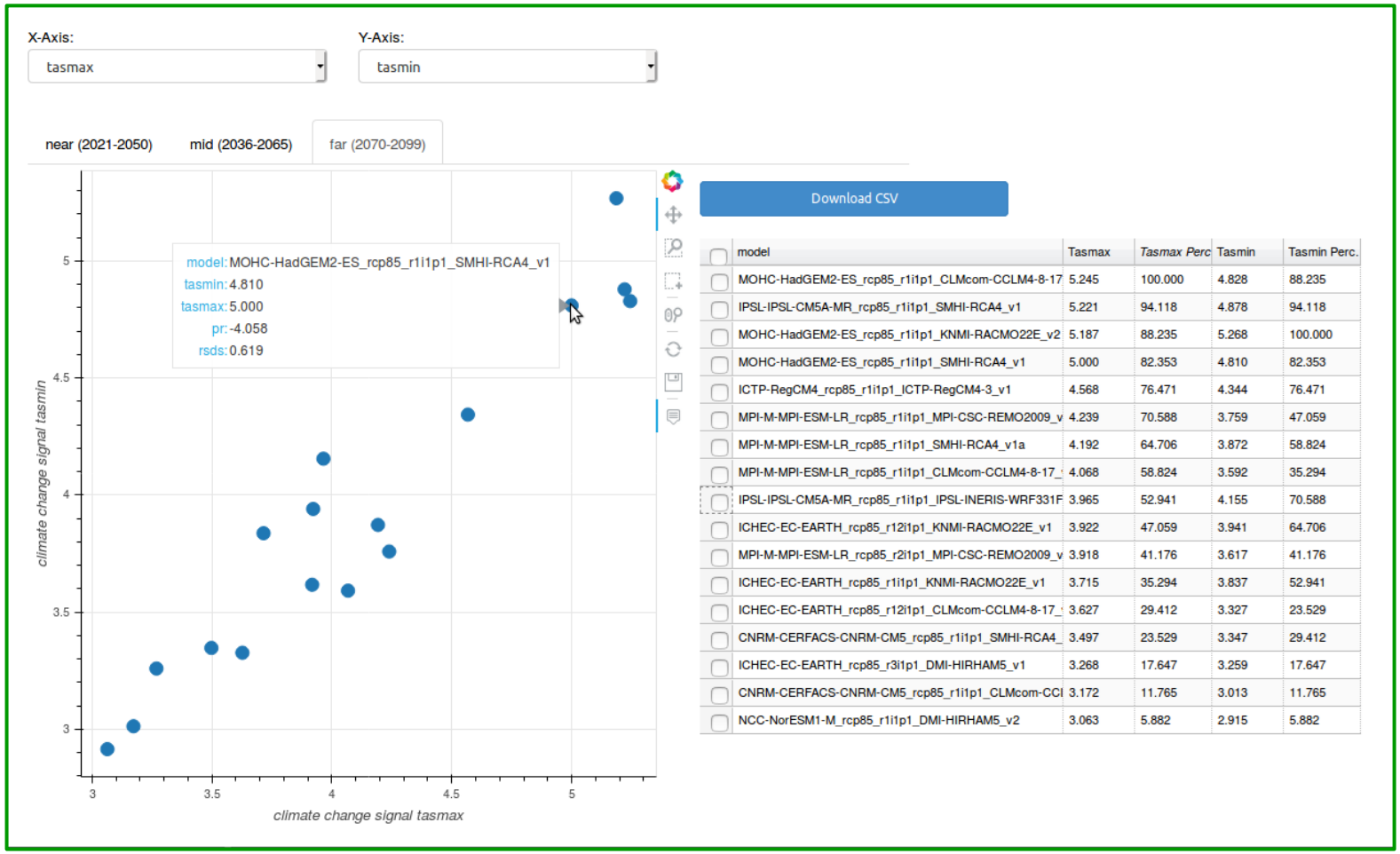
Model Selection Tool

https://github.com/boku-met/climaproof-tools



model	Tasmax	*Tasmax Perc*	Tasmin	Tasmin Perc.
MOHC-HadGEM2-ES_rcp85_r1i1p1_CLMcom-CCLM4-8-17	5.245	100.000	4.828	88.235
IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4_v1	5.221	94.118	4.878	94.118
MOHC-HadGEM2-ES_rcp85_r1i1p1_KNMI-RACMO22E_v2	5.187	88.235	5.268	100.000
MOHC-HadGEM2-ES_rcp85_r1i1p1_SMHI-RCA4_v1	5.000	82.353	4.810	82.353
ICTP-RegCM4_rcp85_r1i1p1_ICTP-RegCM4-3_v1	4.568	76.471	4.344	76.471
MPI-M-MPI-ESM-LR_rcp85_r1i1p1_MPI-CSC-REMO2009_v	4.239	70.588	3.759	47.059
MPI-M-MPI-ESM-LR_rcp85_r1i1p1_SMHI-RCA4_v1a	4.192	64.706	3.872	58.824
MPI-M-MPI-ESM-LR_rcp85_r1i1p1_CLMcom-CCLM4-8-17_	4.068	58.824	3.592	35.294
IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_IPSL-INERIS-WRF331F	3.965	52.941	4.155	70.588
ICHEC-EC-EARTH_rcp85_r12i1p1_KNMI-RACMO22E_v1	3.922	47.059	3.941	64.706
MPI-M-MPI-ESM-LR_rcp85_r2i1p1_MPI-CSC-REMO2009_v	3.918	41.176	3.617	41.176
ICHEC-EC-EARTH_rcp85_r1i1p1_KNMI-RACMO22E_v1	3.715	35.294	3.837	52.941
ICHEC-EC-EARTH_rcp85_r12i1p1_CLMcom-CCLM4-8-17_	3.627	29.412	3.327	23.529
CNRM-CERFACS-CNRM-CM5_rcp85_r1i1p1_SMHI-RCA4_	3.497	23.529	3.347	29.412
ICHEC-EC-EARTH_rcp85_r3i1p1_DMI-HIRHAM5_v1	3.268	17.647	3.259	17.647
CNRM-CERFACS-CNRM-CM5_rcp85_r1i1p1_CLMcom-CCI	3.172	11.765	3.013	11.765
NCC-NorESM1-M_rcp85_r1i1p1_DMI-HIRHAM5_v2	3.063	5.882	2.915	5.882

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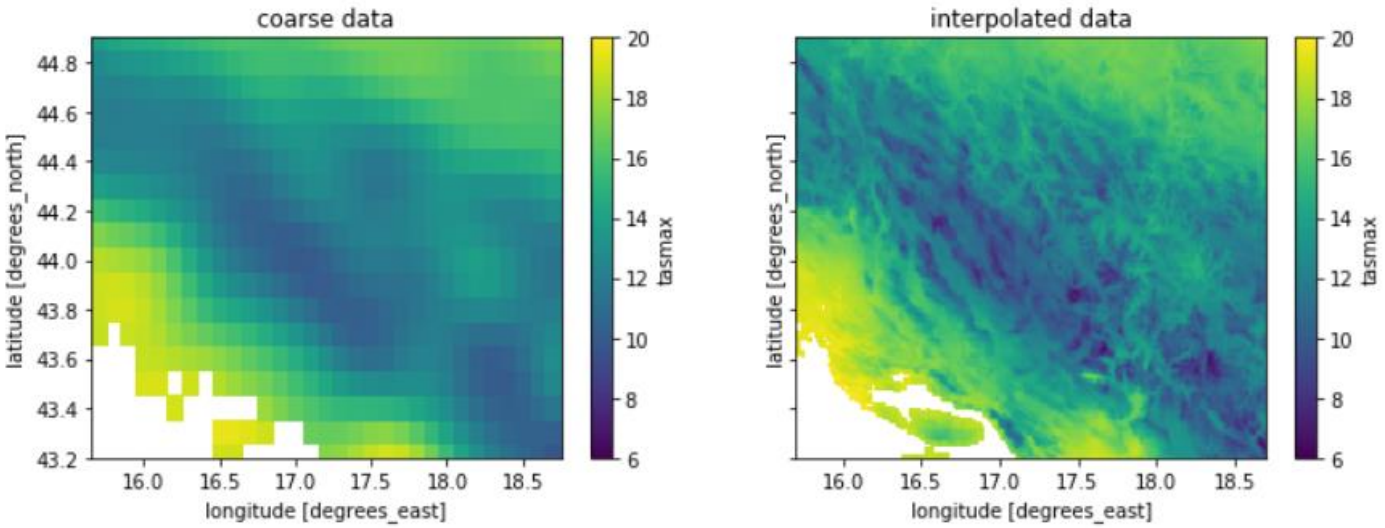
Downscaling Tool

https://github.com/boku-met/climaproof-tools

- For applications that need a higher horizontal resolution
- Easy-to-use tool to **downscale model and observational data** from default (0.1°) to high resolution (0.01°)



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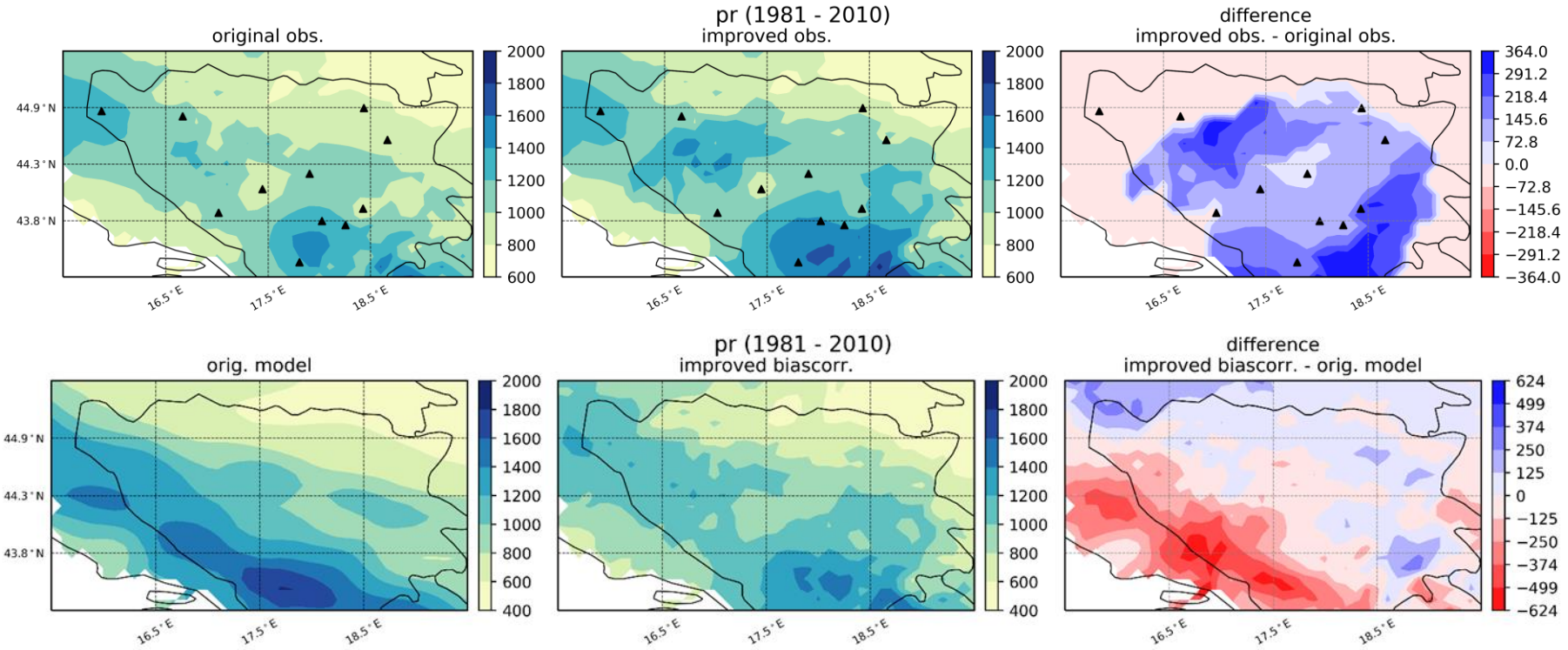
ICC-OBS tool

https://github.com/boku-met/ICC-OBS

Improving bias-corrected **C**limate **C**hange scenarios with local **OBS**ervational data

- Observational Data of 11 Stations for the period 1981-2010
- Interpolation with idw (min. 3 neighbours, 100km radius)



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Upcoming: New global observational dataset

Dataset	Variables	Horizontal Resolution	Expansion of dataset	Download
CHELSA	tasmax, tasmin, tas, pr	1-arc-second (0.00833°)	global	https://chelsa-climate.org/downloads/

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Climate indicators

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Climate indicators

- Climate indicators can increase the relevance of climate data for certain applications
- Expert/practitioner knowledge required
- Impact chains connect specific effects with climate parameters

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Climate indicators

Climate Event	Climate Parameter	Indicator / Unit	Effects on infrastructure
Extreme Rainfall events (local or regional)	**Pr**	maximum precipitation intensity/day or per several days	Flooding of road surface Erosion of road embankments Weakening of the road embankments and road foundation due to standing water Landslides and mudflows Loss of road structure integrity Overloading of drainage systems Damage to energy supply and communication Traffic hindrance and safety (aquaplaning)
Seasonal or annual rainfall (sum)	**Pr**	mm/3month, mm/season, mm/year	Structural integrity of roads, bridges and tunnels (soil moisture levels) Damage of the road base due to standing water Risk of floods, landslides and slope failures (if change in precipitation pattern)
Max Temperature/ Heatdays	**Temp.**	Average max T in 24h Max Temp	Pavement integrity (Rutting, cracking and blow-ups of asphalt; migration of liquid bitumen) Thermal expansion in bridge expansion joints and pavements
Drought	**Temp & Pr**	Drought duration: Number of consecutive dry days and days/year	Increased risk of wildfires threatening transport infrastructure Threats from areas deforested by wildfires (decreased soil integrity) Increased generation of smog
Thaw/ Frost-Thaw Cycle	**Temp**	Number of days with 0°C crossing	Cracking due to weakening of the road base Increased demand for reconstruction Increases risk of stone chipping
Extreme wind speed (storm surge, worst gales and wind gusts)	**Wind**	max. speed km/h; m/s	Threat to stability of bridges Damage to signs, lightings etc Trees, windmill, noise barriers and trucks falling on the road Reduced vehicle control

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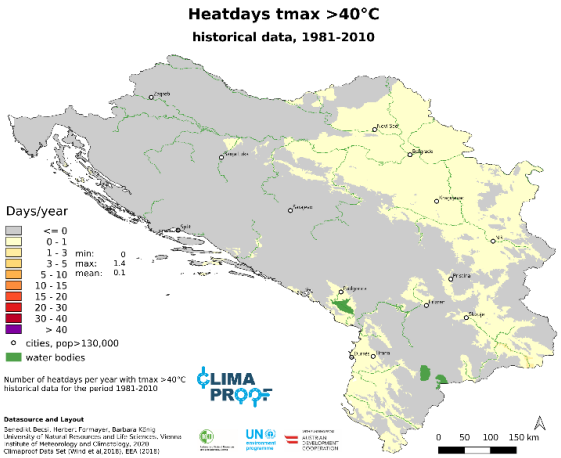
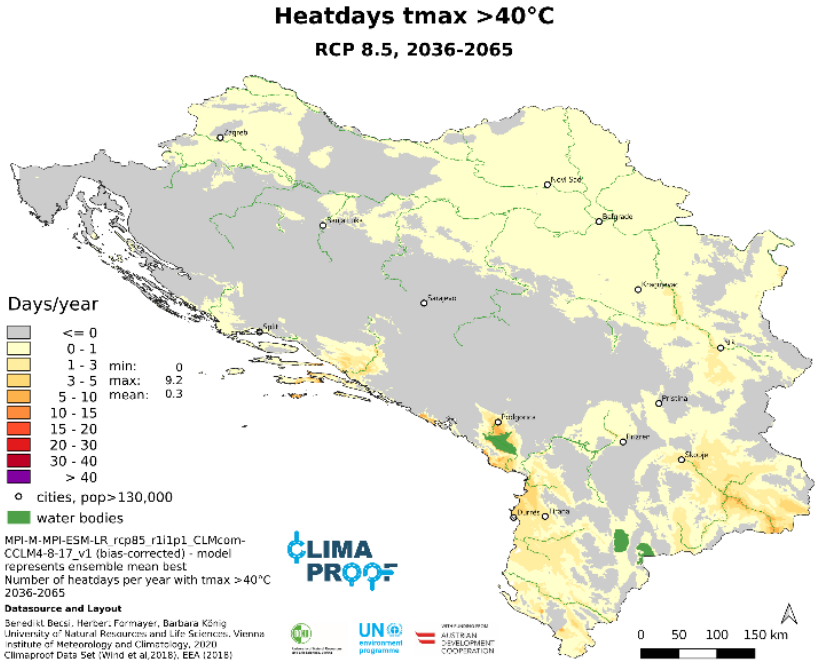
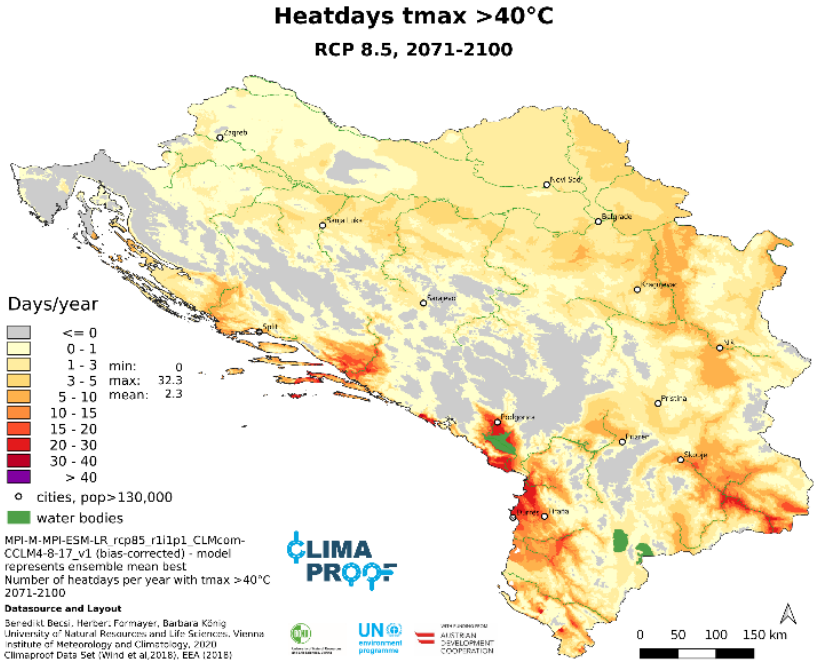
Example 1:
Heatdays with tmax >40°C
(model closest to RCP8.5 ensemble mean)

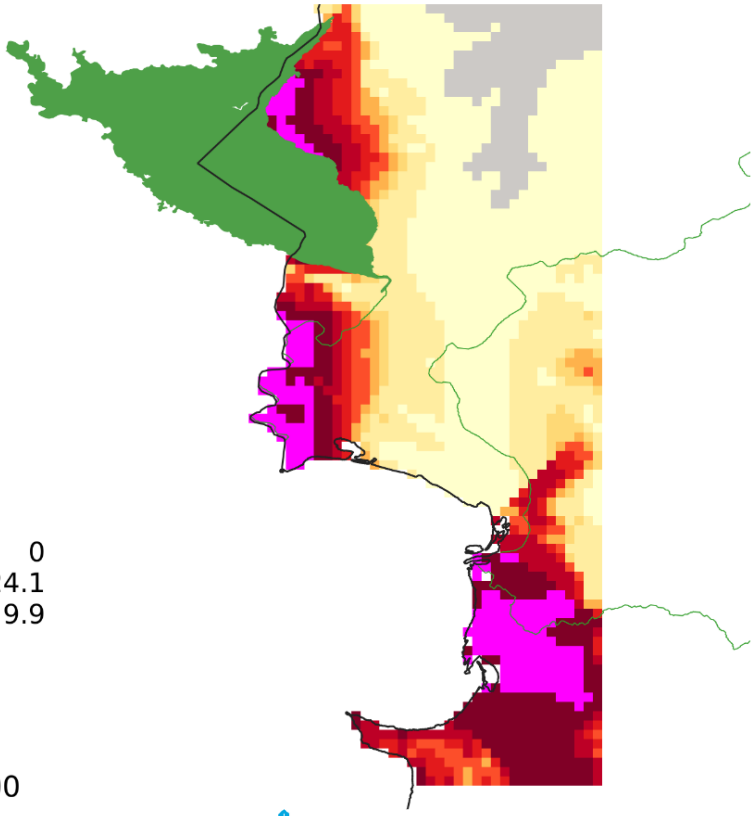






Heatdays tmax >40°C

RCP 8.5, 2071-2100



Days/year

<= 0	
0 - 5	
5 - 10	
10 - 12	min: 0
12 - 14	max: 24.1
14 - 16	mean: 9.9
16 - 18	
18 - 20	
20 - 22	
> 22	

cities, pop>130,000

water bodies

MPI-M-MPI-ESM-LR_rcp85_r1i1p1_CLMcom-CCLM4-8-17_v1 (bias corrected) - model represents ensemble mean best
Number of heatdays per year with tmax >40°C
2071-2100

Datasource and Layout

Benedikt Becsi, Herbert Formayer, Barbara König
University of Natural Resources and Life Sciences, Vienna
Institute of Meteorology and Climatology, 2020
Climaproof Data Set (Wind et al,2018), EEA (2018)

CLIMA PROOF

BOKU University of Natural Resources and Life Sciences, Vienna

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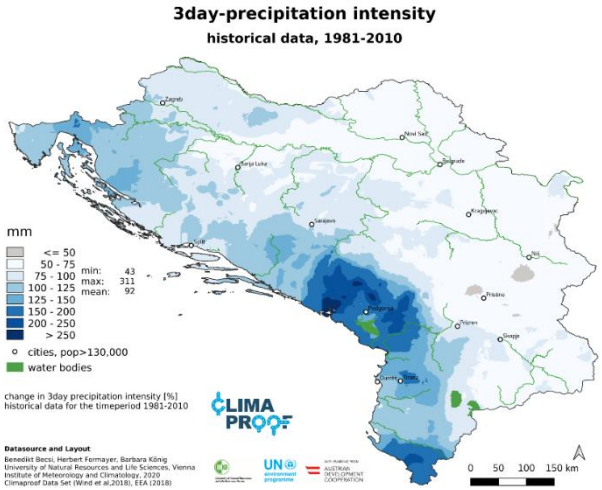
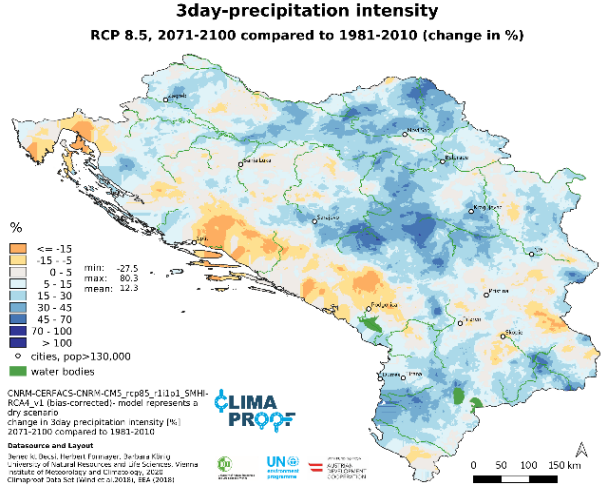
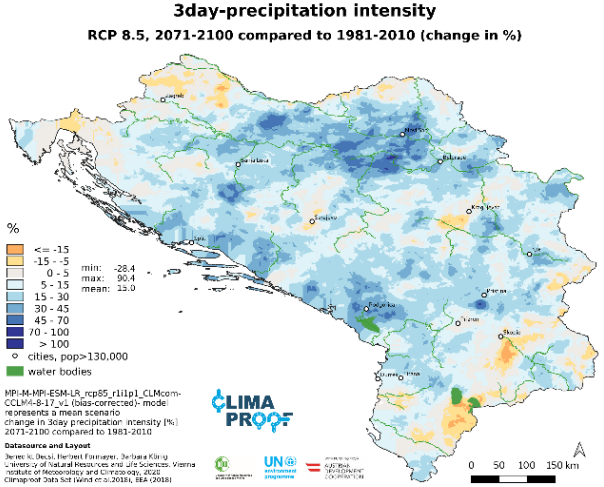
Tirana

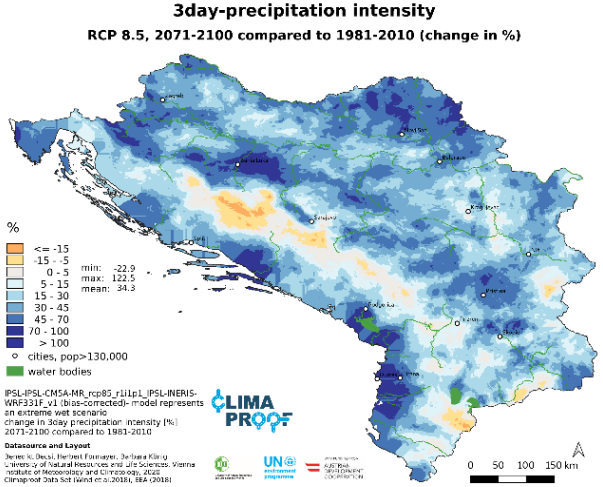
0 10 20 30 km

Example 2:
3-day extreme precipitation
different scenarios: 8.5 (dry, mean, wet)









Combination of indicators

- Climate indicators
  - Heatdays and Dry spell (concecutive dry days) – risk of forest fire
- Climate indicators and topography
  - Heavy Precipitation and topography – risk of landslides
- Climate indicators and socioeconomic data
  - Heat and age of population – risk for elderly people

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Questions

Remarks

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https://boku.ac.at/en/wau/met/forschungsthemen/klima-und-klimafolgen

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