Downscaling climate projections to 1 km with single-image super resolution

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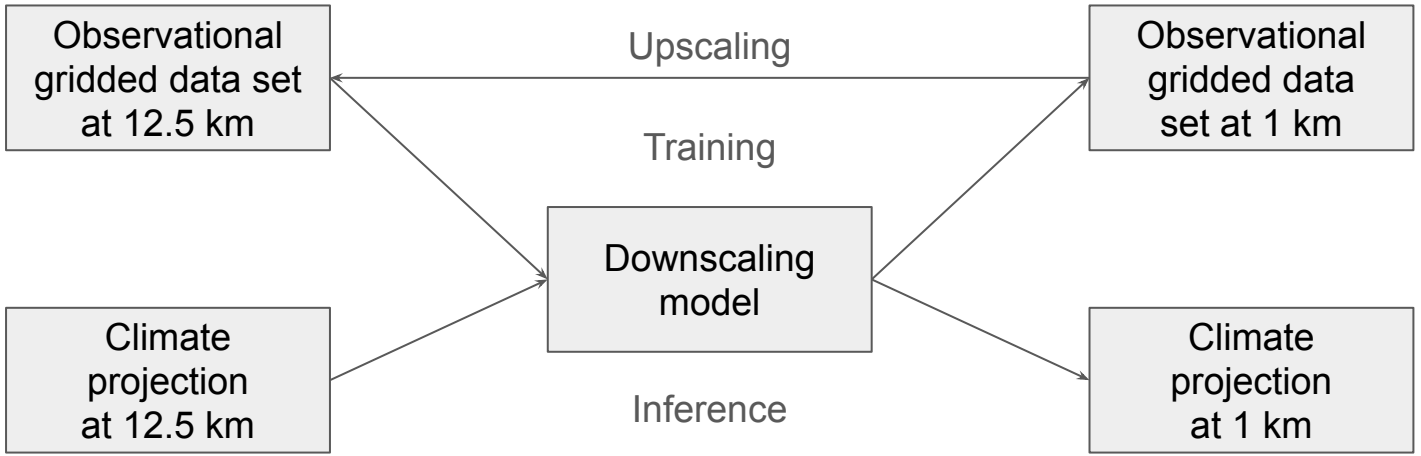
Problem

- High-resolution climate projections are essential for local decision-making.
- For example, assessment of urban heat islands or flood risks.
- However, available climate projections have low spatial resolution (e.g. 12.5 km), which limits their usability.

Single-image super resolution

- We leverage **single-image super-resolution** models to **downscale** climate projections from 12.5 km to **1-km resolution**.
- Since we do not have high-resolution climate projections, we **train** models on a high-resolution **observational gridded data set**.

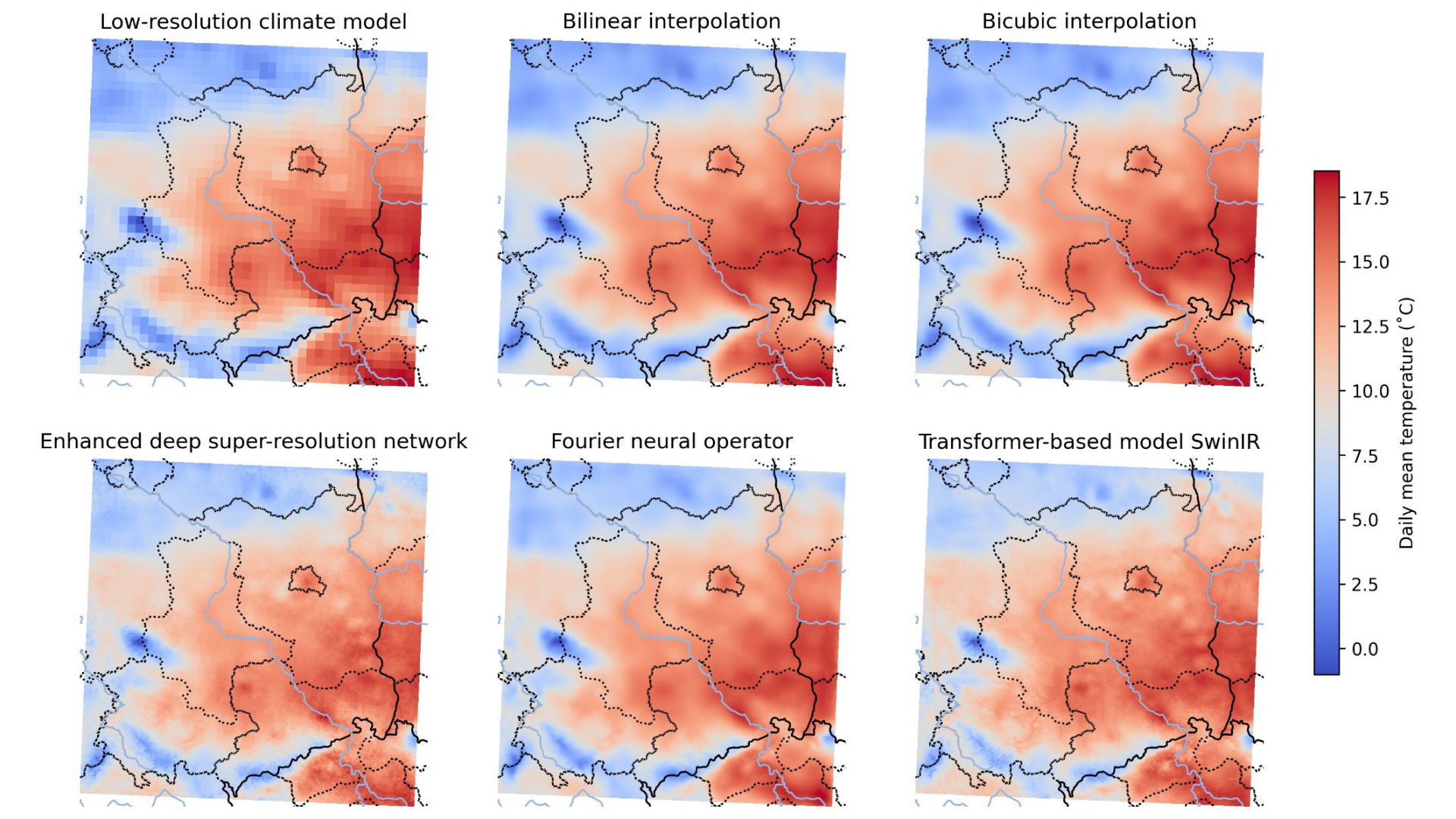


Evaluation with climate indicators

- We lack ground-truth high-resolution climate projections.
- We evaluate **climate indicators computed at weather station locations**.
- In our experiment, for daily mean temperature, we used:
  - annual mean of daily mean temperature,
  - annual growing degree days,
  - annual cooling degree days,
  - annual heating degree days.

Results: RMSE of climate indicators on the test period

Method	Annual mean of daily mean temperature (K)	Annual growing degree days (K days)	Annual cooling degree days (K days)	Annual heating degree days (K days)
Low-resolution climate model	0.88	258.58	31.30	261.00
Bilinear interpolation	0.88	256.77	30.23	265.38
Bicubic interpolation	0.87	253.69	30.34	260.30
Enhanced deep super-resolution network	0.78	241.56	30.84	233.54
Fourier neural operator	0.82	250.92	30.80	243.84
Transformer-based model SwinIR	0.77	241.30	31.02	227.90


Low-resolution climate model
Bilinear interpolation
Bicubic interpolation
Enhanced deep super-resolution network
Fourier neural operator
Transformer-based model SwinIR
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Daily mean temperature (°C)

Conclusions

- Single-image super-resolution models can downscale climate projections without increasing the error.
- Future work:
  - Assess spatial properties.
  - Quantification of predictive uncertainty.
  - Explore other climate variables.
  - Incorporate auxiliary data.
  - Experiment with diffusion models and generative adversarial nets (GANs).