LATENT NEURAL PROCESSES

A NEW PARADIGM FOR MULTIVARIATE CLIMATE DOWNSCALING

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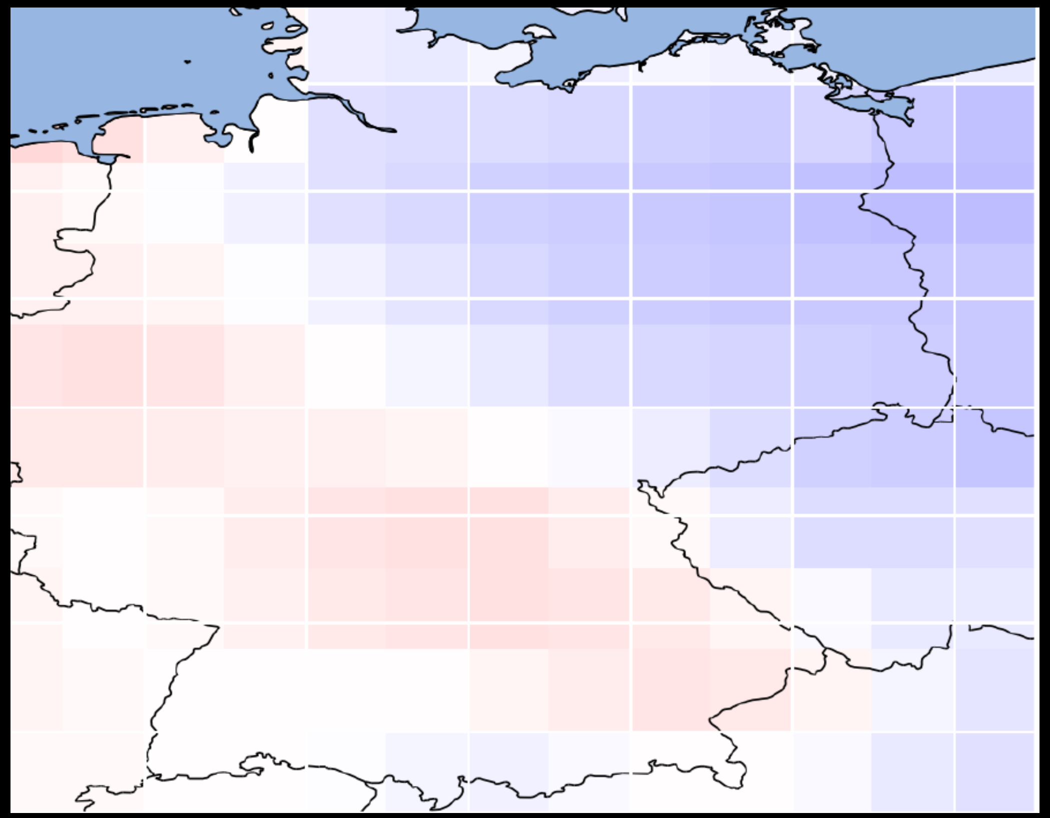
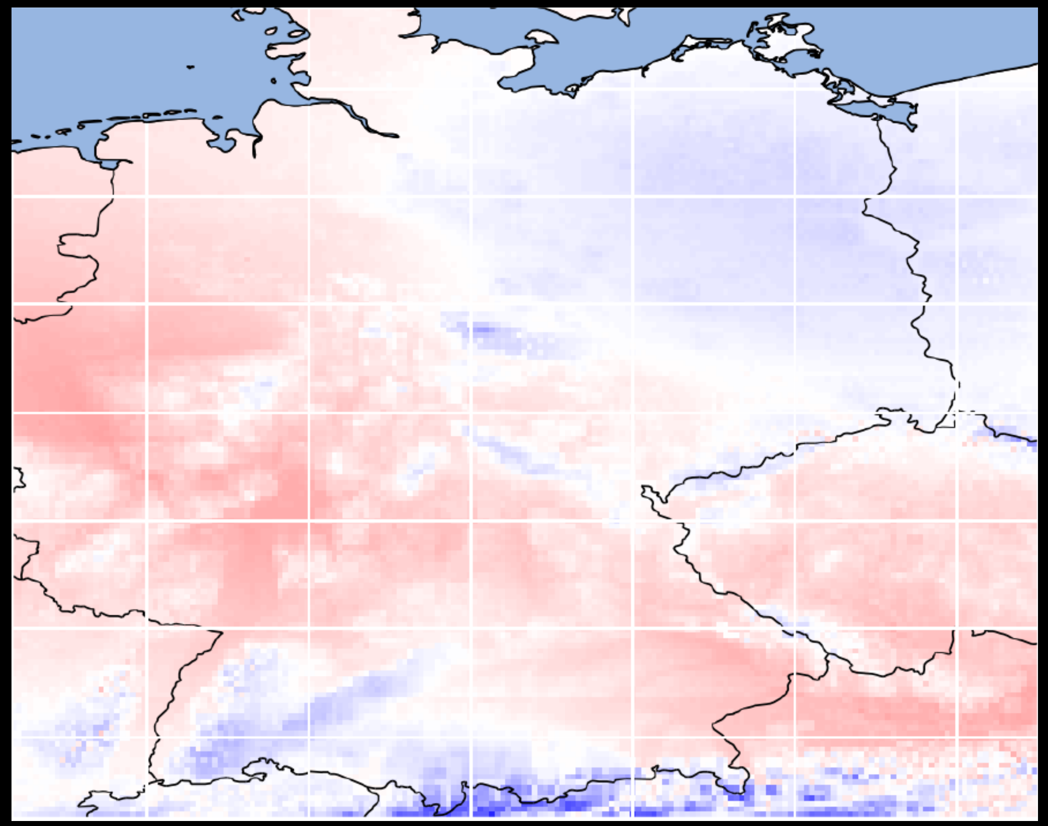
CLIMATE DOWNSCALING: PATHWAY TO IMPACT

Climate model **resolution is too low** to produce accurate local scale predictions. To mitigate this, **statistical downscaling techniques** are routinely applied to increase the spatial and temporal resolution of projections.

Low resolution model output





High resolution downscaled prediction

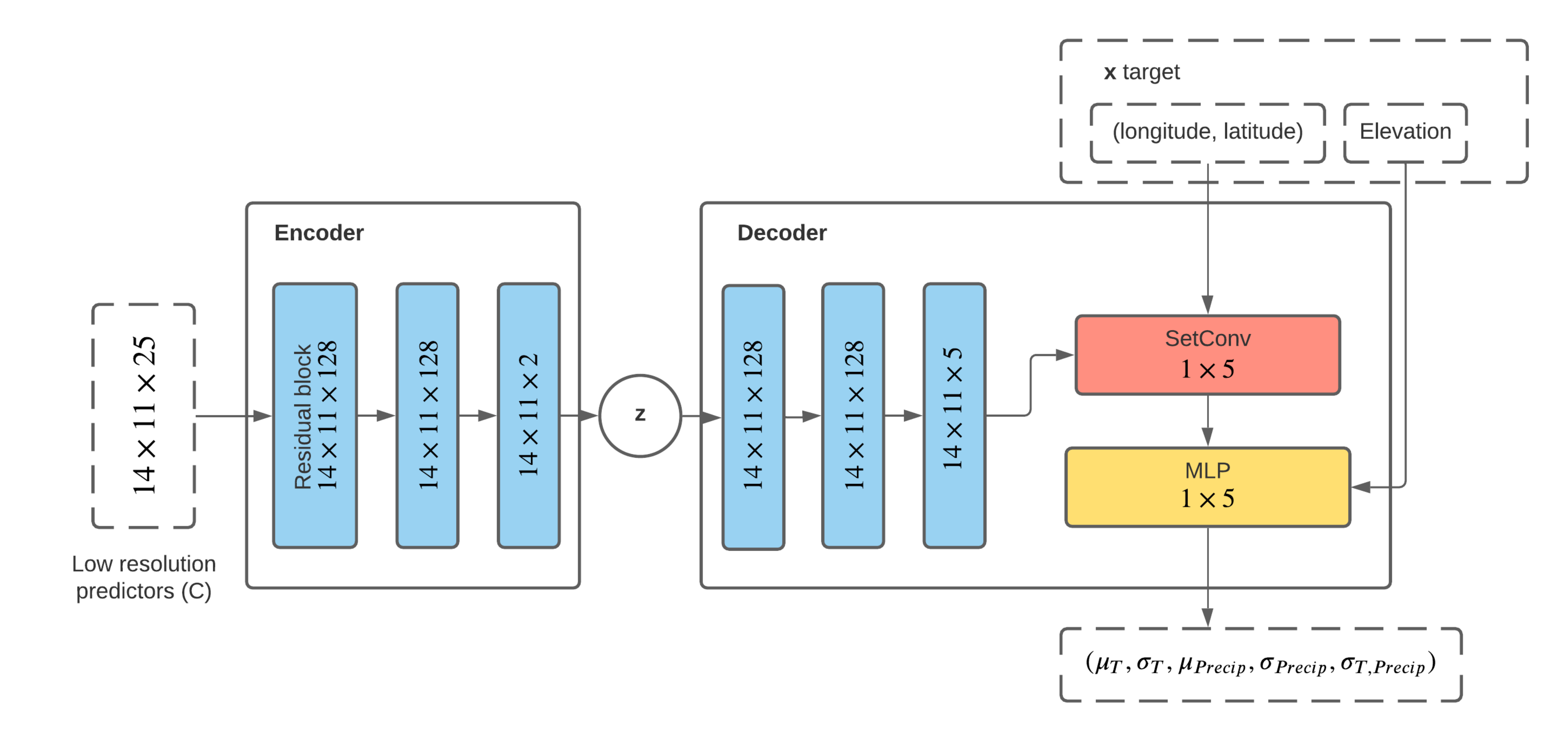
Downscaling techniques are required for any local climate impact study.

LIMITATIONS IN EXISTING MULTIVARIATE DOWNSCALING MODELS

- Make predictions at a list of sites determined at training time
- Unable to consistently quantify uncertainty

Question: is it possible to train a deep learning model for multivariate downscaling that can make predictions at arbitrary locations and quantify uncertainty in those predictions?

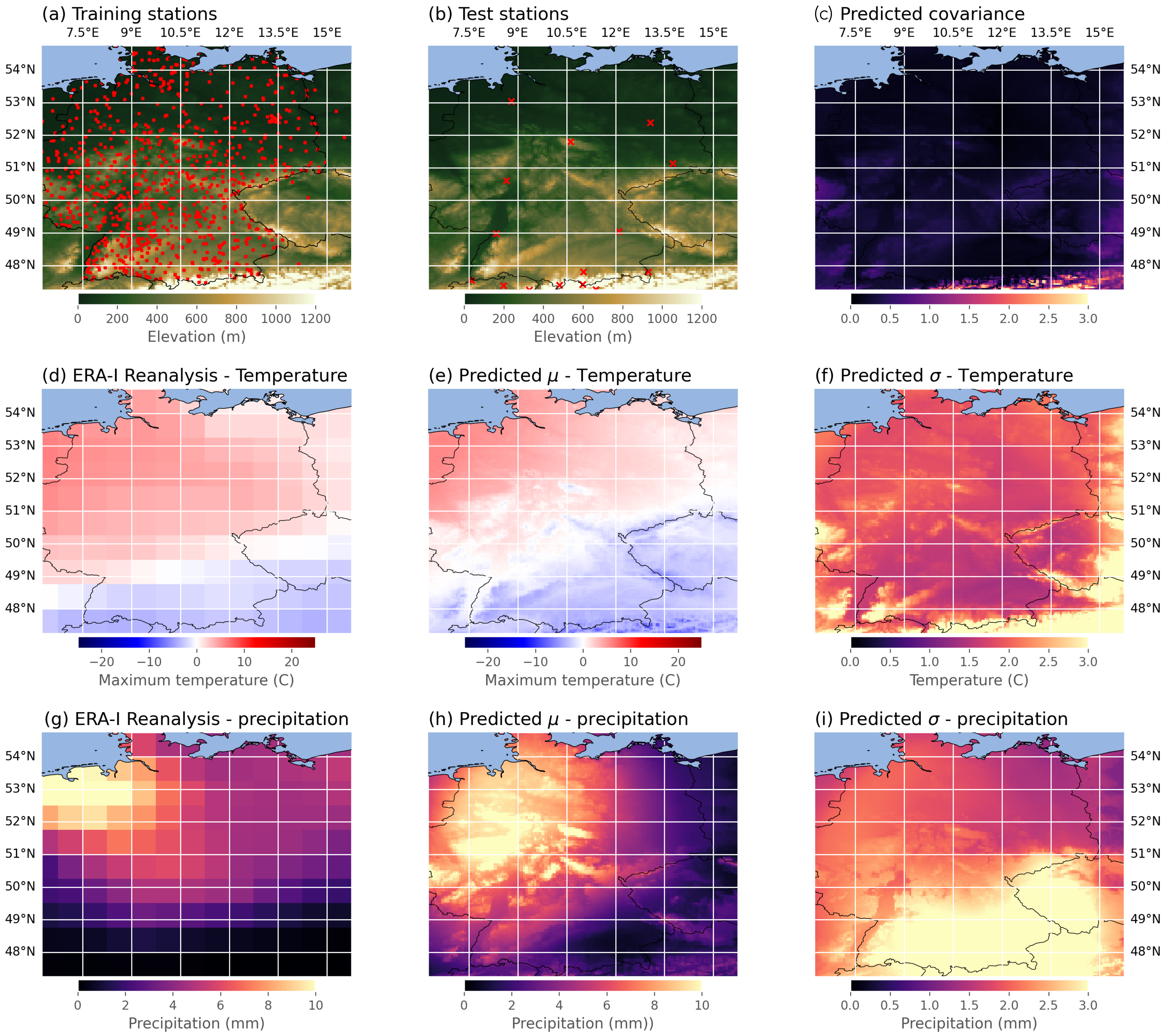
SOLUTION: CONVOLUTIONAL LATENT NEURAL PROCESSES (CONVLNP)



Learn a mapping from low resolution model output to a posterior stochastic process that can be queried at an arbitrary location

$$p_\theta(\{\mathrm{y}^{(t)}\}_{t=1}^{T} \mid \{\mathrm{x}^{(t)}\}_{t=1}^{T}, C) = \int p_\theta(\mathrm{z} \mid C) \prod_t \mathcal{N}(\mathrm{y}^{(t)}; \Sigma^{(t)}(\mathrm{x}^{(t)}, \mathrm{z}; C), \mu^{(t)}(\mathrm{x}^{(t)}, \mathrm{z}; C))dz$$

RESULTS



METRIC	CONVLNP	BASELINE
MAXIMUM TEMPERATURE		
MAE (C)	**1.95**	2.33
PEARSON	**0.96**	**0.96**
CMD	**1.29E-4**	6.43E-4
DOF BIAS	**0.02**	0.16
PRECIPITATION		
MAE (C)	**2.51**	2.64
SPEARMAN	**0.64**	**0.64**
CMD	**0.02**	0.06
DOF BIAS	**1.79**	2.24
MULTIVARIATE		
CORRELATION BIAS	**0.08**	0.15

SUMMARY

- We present a new model for multivariate climate downscaling using a convolutional latent neural process.
- Demonstrate that this model can generate spatially coherent predictions with robust uncertainty estimates at arbitrary locations, outperforming a transfer learning baseline.
- This work has clear pathway to impact for generating local climate projections at any set of locations, regardless of whether training data are available.