Machine learning emulation of a local-scale UK climate model

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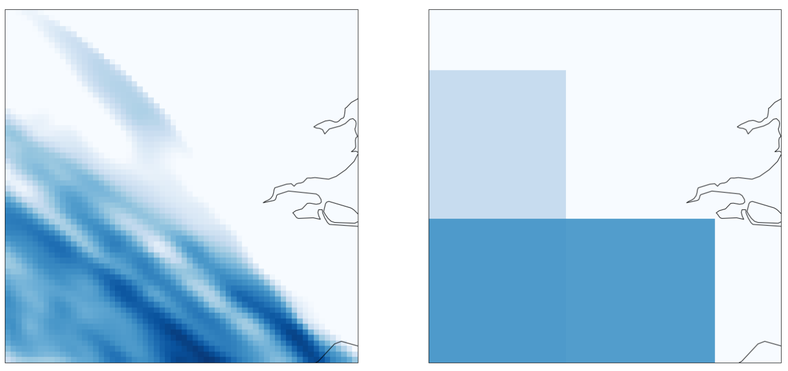
Introduction

Local-scale precipitation projections are important for adapting to future changes to the climate but are expensive to create with physics-based simulations. Statistical downscaling from low-resolution simulations is a cheaper approach and machine learning offers the potential for detailed, stochastic samples with realistic spatial structure.

Approach

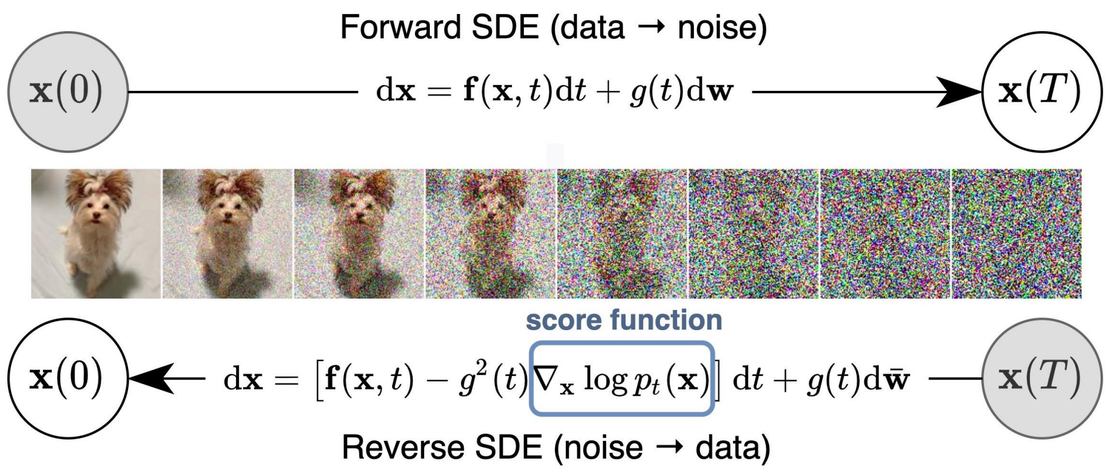
- Met Office's UKCP18 dataset includes projections from 2.2km-resolution, regional climate model. Restricting to London region.



Example daily precipitation projection at a single timestamp in full resolution (left) and coarsened to match a 60km-resolution global model (right).

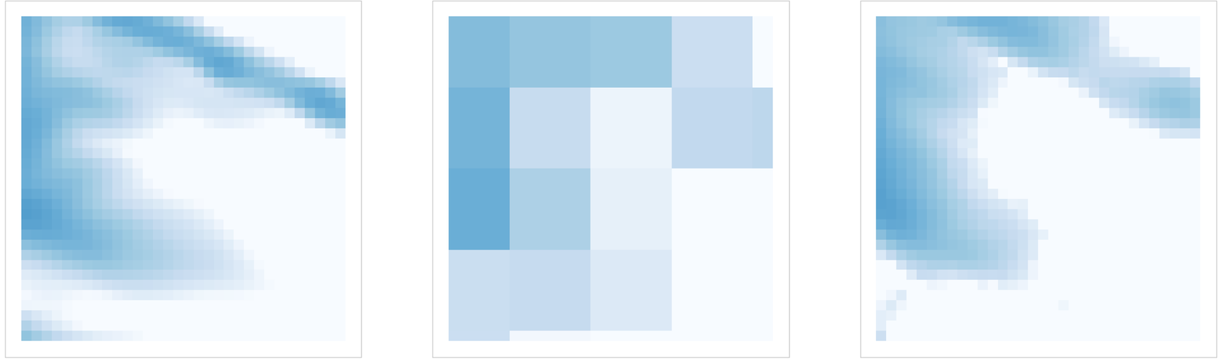
- **Score-based generative models** have worked well for related problems for natural images such as **super-resolution** and offer a good trade-off over expense, sharpness and diversity of samples.

From Figure 1 of [1]: "Transforming data to a simple noise distribution can be accomplished with a continuous-time SDE. This SDE can be reversed if we know the score of the distribution at each intermediate time step."



Progress

Proof-of-concept: Score-based generative model predicting high-resolution daily precipitation from coarsened version of itself.



Full-resolution daily precipitation from physics-based simulation (left), 8x coarsened version used as conditioning input (middle), sample (right).

Conclusion

My work demonstrates the potential of score-based generative models for faster computation of high-resolution precipitation projections. This paves the way for exploration of more climate scenarios at high resolution than is feasible with physics-based simulations alone.

Next steps

- **Condition on variables that cause rain and are represented well in low-resolution global models**
- Evaluate how well **extreme precipitation** is represented in climatological statistics and for individual events
- Samples conditioned on variables from different, coarse climate model ensembles, rather than coarsened high-resolution data
- Sub-daily frequency and sample sequences

References

[1] Yang Song, et al. Score-Based Generative Modeling through Stochastic Differential Equations. *International Conference on Learning Representations,* 2021.
[2] Kendon, E. J. et al. Update to the UKCP Local (2.2km) projections. Science report, Met Office Hadley Centre, Exeter, UK, 2021.
[3] Met Office Hadley Centre. UKCP18 Local Projections at 2.2km Resolution for 1980-2080. Centre for Environmental Data Analysis, 2019.
[4] Ravuri, Suman, et al. Skilful precipitation nowcasting using deep generative models of radar. *Nature*, 2021.

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Further information

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