Generative machine learning emulation of precipitation (and more?) from a km-scale regional climate model

Henry Addison, University of Bristol, Interactive AI Centre

High-resolution climate simulations are very valuable for understanding climate change impacts and planning adaptation measures. This has motivated use of regional climate models at sufficiently fine resolution to capture important small-scale atmospheric processes, such as convective storms. However, these regional models have very high computational costs, limiting their applicability. We present a novel application of a generative machine learning model, a diffusion model, to skilfully emulate precipitation simulations from such a high-resolution model over England and Wales at much lower cost. This emulator enables stochastic generation of high-resolution (8.8km), daily-mean precipitation samples conditioned on coarse-resolution (60km) weather states from a global climate model. The output is fine enough for use in applications such as flood inundation modelling. The emulator produces precipitation predictions with realistic intensities and spatial structures and captures most of the 21st century climate change signal. We show evidence that the emulator has skill for extreme events up to and including 1-in-100 year intensities. Potential applications include producing high-resolution precipitation predictions for large-ensemble climate simulations and downscaling different climate models and climate change scenarios to better sample uncertainty in climate changes at local-scale.