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A Conditional Generative Adversarial Network for Rainfall Downscaling

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Predicting extreme precipitation events is one of the main challenges of climate science in this decade. Despite the continuously increasing computing availability, Global Climate Models' (GCMs) spatial resolution is still too coarse to correctly represent and predict small-scale phenomena as convection, so that precipitation prediction is still imprecise. Indeed, precipitation shows variability on both spatial and temporal scales (much) smaller than the current state-of-the-art GCMs resolution. Therefore, downscaling techniques play a crucial role, both for the understanding of the phenomenon itself and for applications like e.g. hydrologic studies, risk prediction and emergency management. Seen in the context of image processing, a downscaling procedure has many similarities with super-resolution tasks, i.e. the improvement of the resolution of an image. This scope has taken advantage from the application of Machine Learning techniques, and in particular from the introduction of Convolutional Neural Networks (CNNs).

In our work we exploit a conditional Generative Adversarial Network (cGAN) to train a generator model to perform precipitation downscaling. This generator, a deep CNN, takes as input the precipitation field at the scale resolved by GCMs, adds random noise, and outputs a possible realization of the precipitation field at higher resolution, preserving its statistical properties with respect to the coarse-scale field. The GAN is being trained and tested in a "perfect model" setup, in which we try to reproduce the ERA5 precipitation field starting from an upscaled version of it.

Compared to other downscaling techniques, our model has the advantage of being computationally inexpensive at run time, since the computational load is mostly concentrated in the training phase. We are examining the Greater Alpine Region, upon which numerical models performances are limited by the complex orography. Nevertheless the approach, being independent of physical, statistical and empirical assumptions, can be easily extended to different domains.