EGU22-12252
https://doi.org/10.5194/egusphere-egu22-12252
EGU General Assembly 2022

Stochastic downscaling of the 2m temperature with a generative adversarial network (GAN)

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Inspired by the success of superresolution applications in computer vision, deep neural networks have recently been recognized as an appealing approach for statistical downscaling of meteorological fields. While further increasing the resolution of numerical weather prediction models is computationally very expensive, statistical downscaling models can accomplish this task much cheaper once they have been trained.

In this study, we apply a generative adversarial network (GAN) to downscale the 2m temperature over Central Europe where complex terrain introduces a high degree of spatial variability. GANs are considered superior to purely convolutional networks since the model is encouraged to generate data whose statistical properties are similar to real data. Here, the generator consists of an u-shaped encoder decoder network which is capable of extracting features on various spatial scales. As a quasi-realistic test suite, we map data from the ERA5 reanalysis dataset onto a 0.1°-grid with the help of short-range forecasts from the Integrated Forecasting System (IFS) model. To increase the complexity of the downscaling task, the ERA5 reanalysis data is coarsened beforehand onto a 0.8°-grid, thus increasing the downscaling factor to 8. We evaluate our statistical downscaling model in terms of several evaluation metrics which measure the error on grid point-level as well as the quality of the downscaled product in terms of spatial variability and produced probability function. We also investigate the importance of static and dynamic predictors such as the surface elevation and the temperature on different pressure levels, respectively. Our results motivate further development of deep neural networks for statistical downscaling of meteorological fields. This includes downscaling of other, inherently uncertain variables such as precipitation, operations on spatial resolutions at kilometer-scale and ultimately targets an operational application on output data from global NWP models.