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Super-Resolution based Deep Downscaling of Precipitation

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Downscaling is widely used to improve spatial resolution of meteorological variables. Broadly there are two classes of techniques used for downscaling i.e. dynamical downscaling and statistical downscaling. Dynamical downscaling depends on the boundary conditions of coarse resolution global models like General Circulation Models (GCMs) for its operation whereas the statistical model tries to interpret the statistical relationship between the high-resolution and low-resolution data (Kumar et. al. 2021). With the rapid development of deep learning techniques in recent years, deep learning based super-resolution (SR) models have been designed for image processing and computer vision, for increasing the resolution of a given image. But many researchers from other fields have also adapted these techniques and achieved state-of-the-art performance in various domains. To the best of our knowledge, only a few works exist that have used the super-resolution methods in climate domain, for deep downscaling of precipitation data.

These super-resolution approaches mostly use convolutional neural networks (CNN) to accomplish their task. In CNN when we increase the depth of the model then there is a chance of information loss and error propagation (Vandal et.al.2017). To reduce this information loss, we have introduced residual-based deep downscaling models. These models have multiple residual blocks and skip connections between similar types of convolutional layers. The long skip connections in the model helps to reduce information loss in the network. These models take as input, data that is pre-upsampled by linear interpolation, and then improve the estimates of the pixel values.

In our experiments, we have focused on downscaling of rainfall over Indian landmass (for Indian summer monsoon rainfall) and for a region in the USA spanning the southeast CONUS and parts of its neighboring states that are present between the longitude 70^0 W to 100^0 W and latitude 24^0 N to 40^0 N. The precipitation data for this task is collected from the India Meteorological Department (IMD), Pune, India, and NOAA Physical Science Laboratory. We have examined our model's predictive behavior and compared it with the existing super-resolution models like SRCNN and DeepSD, which have been earlier used for precipitation downscaling. In the DeepSD model, we have used the GTOPO30 land elevation data provided by USGS along with the precipitation data as input. All these models are trained and tested in both the geographical regions separately and it is found that the proposed model performs better than the existing models on multiple accuracy measures like PSNR, Correlation Coefficient, etc. for the specific region and scaling factor.