Exploiting spatial and spectral patterns in satellite imagery for long-term fog monitoring

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ABSTRACT

Accurate and efficient satellite-based fog detection is desired for various research and operational applications. However, conventional retrievals still suffer from limited detection skill and require expert knowledge to interpret available products. In particular, the distinction between low clouds and fog as well as a diurnally consistent detection remain challenges. On the other hand, recent advances in spatial, temporal and spectral resolution of satellite observations give rise to more datadriven methods to exploit the wealth of data efficiently. Here, we apply neural networks to investigate if a satellite-based fog detection algorithm can be diurnally consistent without having to neglect spectral information from thermal emissive channels with solar component. The two considered network types, a multi-layer perceptron and a fully convolutional neural network (CNN), are further compared to test if a CNN can exploit spatial structures to achieve a better performance. We use cropped images from the Geostationary Operational Environmental Satellite - 3rd generation (GOES-16) with a focus on the Atacama Desert. By choosing this study region, algorithm development and testing benefit from a rather homogeneous surface in time and space, excluding substantial seasonal effects on reflection and emission due to a vegetation cycle. Additionally, the variety of fog types is limited and spatially constraint within this region. However, an application to other sensors (e.g. Meteosat Second and Third Generation) is envisioned for the future to facilitate long-term studies for climate change and variability analysis. For training and validation of the neural networks, we created a novel ground-based reference fog data set which is based on in-situ leaf wetness sensor measurements refined with additional meteorological station data. These data were obtained from a station network deployed across the Atacama Desert by the Collaborative Research Center "Earth – Evolution at the Dry Limit" (https://sfb1211.uni-koeln.de/) of the German Science Foundation (DFG SFB1211).