EGU23-12257
EGU General Assembly 2023

Complementary approaches in self-supervision to exploit EUREC^{4}A measurements and satellite observations for cloud systems over North Atlantic trades

Dwaipayan Chatterjee, Sabrina schnitt, Paula Bigalke, Claudia Acquistapace, and Susanne Crewell
University of Cologne, Institute for Geophysics and Meteorology, Faculty of Mathematics and Natural Sciences, Germany (dchatter@uni-koeln.de)

The cloud systems of the North Atlantic trades (NAT) have been a topic of curiosity due to significant uncertainty in their physical characteristics, physical process understanding across various spatial and temporal scales, and their impact on the regional climate system. Initial research has provided the causal link for cloud systems having distinct organizational aspects (formerly described as Sugar, Gravel, Fish, and Flower) with the net radiative flux over the region. Questions have been raised about how the changing climate will influence the frequency of occurrence of these cloud regimes and how the net radiative impact will change the regional climate system.

However, cloud systems represent a continuous spectrum where not-so-visually distinct systems also occur. Existing clustering mechanisms sort organizations into separate classes. Yet, in reality, the organization often does not align with those pre-defined classes but transitions amongst them or simply occurs in a continuous spectrum. Using two complementary neural networks in self-supervision (without human interference), we investigate the representation learning of cloud systems both in a continuous space describing a cloud system spectrum and in a discreet space aiming to identify distinct cloud systems. 50,000 GOES-ABI cloud optical depth NAT images from 2017 – 2021 covering the EUREC^{4}A study area are randomly cropped to 256 x 256 pixels and sorted/labeled by the machine.

We study the climatological representation of EUREC^{4}A's cloud patterns in the continuous embedding space. We follow the Maria S. Merian ship track inside the feature space matching the ship-based atmospheric remote sensing and ERA5 profiles with the K-nearest satellite images. This analysis examines the consistency of the environmental conditions for cloud systems identified as close to each other in the continuous feature space. We investigate the relationship between the net cloud radiative effect and the radiative flux characteristics in the continuous space, finding a strong functional relationship with the cloud system's pattern and distributions.

In the discrete space, we aim to identify the optimal number of classes that could represent the continuous space. We also aim to understand if these discrete classes correspond to the categories identified in the physical and visual space. Moreover, to better understand the decision of the neural network for a particular cloud pattern, we visualize the network's focus in the activation space. We find that different self-attention heads of the neural network learn to focus on different semantics of the cloud system distribution.

Finally, we found that different regularizations applied during the training of the network directly impact the representation learning of the cloud system, and we show how to use such regularizations to improve the understanding of cloud systems.