Seminar on Physics and Chemistry of the Atmosphere
10.11.2023, WiSe 2023/24, IUP Bremen

Machine Learning Based Observational Cloud Products for Process-Oriented Climate Model Evaluation

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Abstract

Clouds are a long-standing large source of uncertainty in climate model (CM) projections. We introduce new methods of characterizing clouds from space with the help of machine learning (ML) and neural networks (NNs). Their purpose is to alleviate issues of available satellite products that hamper objective interpretability and comparability to CM output.
For this, an NN and a Random Forest (RF) are combined and trained on observations from both active and passive sensors to infer distributions of cloud classes defined by the World Meteorological Organization (WMO). The method is applicable even to low-resolution data such as CM output and the resulting cloud-type distributions are physically consistent. These results inspired the creation of a new Cloud Class Climatology dataset (CCClim) with the trained framework from the complete ESA Cloud_cci dataset (ESA-CCI). In addition to the cloud properties from ESA-CCI, CCClim contains daily mean values of the cloud type distributions globally at 1° resolution over a time period of 35 years. CCClim can be used to analyze cloud-related processes through the lens of major cloud types as demonstrated using several examples.
The systematic deviations between CM output and observations caused by the fundamentally different ways these data are produced are addressed by employing NN-powered generative domain adaptation (DA). This way, synthetic observations similar to those of instrument simulators can be obtained from existing CM output. The DA model is evaluated with the synthetic ESA-CCI observations it produces from ICON-A output.