EGU24-17906, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-17906
EGU General Assembly 2024

Multifractal analysis for evaluating the representation of clouds in global km-scale models

Lilli Freischem, Philipp Weiss, Hannah Christensen, and Philip Stier
University of Oxford, Atmospheric, Oceanic and Planetary Physics, Department of Physics, Oxford, United Kingdom of Great Britain – England, Scotland, Wales (lilli.freischem@physics.ox.ac.uk)

Clouds are one of the largest sources of uncertainty in climate predictions. Emerging next-generation km-scale climate models need to simulate clouds and precipitation accurately to reliably predict future climates. To isolate issues in their representation of clouds, and thereby facilitate their improvement, km-scale models need to be thoroughly evaluated via comparisons with observations.

Traditionally, climate models are evaluated using spatio-temporally averaged observations. However, aggregated evaluation loses crucial information about underlying physical processes, such as convective updrafts, and the resulting cloud macrophysical structures. We postulate that a novel spatio-temporal evaluation strategy using satellite observations provides direct constraints on physical processes.

Here, we introduce multifractal analysis as a method for evaluating km-scale simulations. We apply it to top-of-atmosphere outgoing longwave radiation (OLR) fields to investigate structural differences between observed and simulated clouds in the tropics. For this purpose, we compute structure functions from OLR fields to which we fit scaling exponents. We then parameterise the scaling exponents to compute scaling parameters. The parameters compactly characterise OLR variability and can be compared across simulations and observations. We use this method to evaluate the ICON-Sapphire and IFS-FESOM simulations run for cycle 3 of the nextGEMS project via comparison with data from the geostationary satellite GOES-16.

We find that clouds in both models exhibit multifractal scaling from 50 to 1000km. However, the scaling parameters are significantly different between ICON and IFS, and neither match observations. In the ICON model, multifractal scaling exponents are lower than in observations whereas in IFS, they are larger. The observed differences indicate how the modelling approaches in ICON and IFS impact the organisation of clouds. More specifically, the deep convection scheme in ICON is switched off completely whereas it is still active in IFS, which could explain the difference in scaling behaviour we observed.

Our results show that spatio-temporal analysis is a promising new way to constrain global km-scale models. It can provide key insights into model performance and shed light on issues in the representation of clouds.