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The fractal nature of clouds in global convection-resolving simulations and satellite data

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Recent years have seen an increase in the production of global convection-resolving (or at least convection-permitting) atmospheric simulations. These simulations are very realistic when compared to observations. A good example of this can be seen in images of simulated cloud condensate fields, rendered in such a way that they can be directly compared to satellite images of the Earth (e.g. Fig 2, Stevens et al, 2019). While it can be difficult at first glance to distinguish between model and observed data, on closer inspection, the satellite image can often be identified. We seek to quantify these visual similarities and differences between models and satellite data. We do this by computing the fractal dimension of clouds.

It has long been known that clouds in observations exhibit self-similarity across scales ranging from 1 to 1000 km (Lovejoy, 1982), i.e. they are fractals, but it is not known if models can reproduce this behaviour. We demonstrate the fractal nature of clouds simulated by high-resolution model simulations completed as part of the DYAMOND intercomparison project (Stevens et al, 2019). We compute the fractal dimension of the simulated clouds, and compare this to the dimension measured using Himawari satellite data. This enables us to quantify the fidelity of the multi-scale structure of convection and convective organisation across model simulations. Only by quantifying the difference between models and observations can we assess the degree to which a high-resolution model can 'stand in'for observations, and thereby be used to help us understand the real atmosphere.

Lovejoy (1982). Science, 216(4542), 185–187. DOI: 10.1126/science.216.4542.185

Stevens et al, (2019), Progress in Earth and Planetary Science, 6(61), DOI: 10.1186/s40645-019-0304-z

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