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Equivalent resolutions of a grid-point and a spectral transform global atmospheric model

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Resolution can be a determining factor in model climate statistics, especially properties other than the time-mean. Establishing equivalent resolutions between models is an important component of climate model intercomparisons. Resolution itself might explain some of the shortcomings in current climate models. We establish the equivalent resolutions for two very different dynamical cores: one spectral transform and the other finite volume. These are established over a range of resolutions employed today for climate models. The shape as a function of wavenumber of the linear response functions of discrete numerical operators can be very different for different numerical schemes, especially at the smaller resolved scales. This makes it difficult to establish equivalent resolutions from such first principles for the climate model application. The minimum grid lengths are not necessarily relevant. Therefore we base our comparison on the characteristics of free, unforced motions, due in large part to the dynamical component driven by the parameterized processes and explicit dissipation. The comparison is done in the context of the Aqua Planet Experiment (APE) intercomparison. The different dynamical cores are coupled to the CAM3 parameterization suite. We demonstrate the resolution equivalences for a number of key model fields. These include growth of a perturbation in a baroclinicly unstable flow, meridional structure of eddy kinetic energy and eddy temperature variance, mean meridional eddy transports, characteristics of tropical wave propagation, and PDFs of precipitation in the tropics and in mid-latitudes. We conclude that the 2 degree finite volume model is equivalent to T42 spectral transform model, and 1 degree is equivalent to T85.