Hohenegger, C., L. Kornblueh, D. Klocke, T. Becker, G. Cioni, J. F. Engels, U. Schulzweida, and B. Stevens, 2020: Climate statistics in global simulations of the atmosphere, from 80 to 2.5 km grid spacing. *J. Meteor. Soc. Japan*, **98**, 73-91.
Special Edition on DYAMOND: The DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains
http://doi.org/10.2151/jmsj.2020-005

Plain Language Summary: General Circulation Models (GCMs) are complex tools embodying physical principles to represent the statistics of the climate system. Limitations in computer resources impose constraints on the resolution of such models and hence on the scales of the atmospheric processes that such models can explicitly represent. Both the chosen grid spacing and the employed model formulation affect the quality of a simulation. In this study, we examine the convergence behavior of a GCM by systematically varying its grid spacing. We objectively assess the convergence by comparing differences resulting from changes in grid spacing to differences resulting from using distinct model formulations. For the investigated statistics of the climate system, our study thus indicates at which grid spacing model formulation becomes more important than grid spacing.

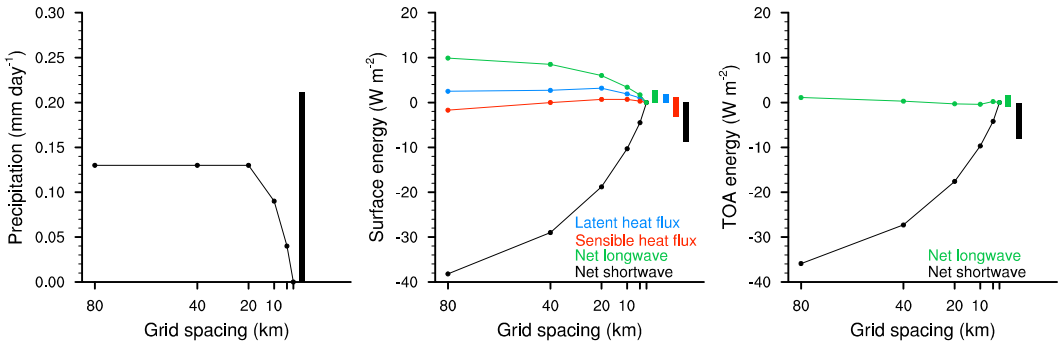

Figure 1: Resolution dependencies of global climate statistics, in a GCM using grid spacings of 80 km (on the left of the x-axis) down to 2.5 km (on the right of the x-axis), and as expressed as difference to the 2.5-km simulation. The vertical bars show one standard deviation of the corresponding global climate statistics computed from an ensemble of eight distinct global storm-resolving models. Downward energy fluxes are taken as positive except for sensible and latent heat fluxes. TOA for top-of-the-atmosphere. Global mean precipitation, for instance, seems insensitive to the grid spacing as the differences are always smaller than the spread, whereas for net shortwave radiation, resolution matters and a grid spacing of at least 5 km is required.

- Forty-day global simulations have been performed with grid spacings down to 2.5 km and compared to an ensemble of eight distinct global storm-resolving models using kilometer-scale grid spacing.
- Using our convergence metric, we find that at least a grid spacing of 5 km is sufficient to capture 26 out of the 27 investigated climate statistics.
- Refining the grid spacing moves the simulations closer to observations, but climate statistics exhibiting weaker resolution dependencies are not necessarily associated with smaller biases.