Analyzing scales of precipitation in general circulation models and observations

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General circulation models (GCMs) have been criticized for failing to represent observed scales of precipitation, particularly in the tropics where simulated rainfall is often said to be too light, frequent and persistent. Previous assessments have used temporally or spatially averaged precipitation, which offers little actionable information for model developers, since the physics-dynamics interactions that produce precipitation occur at the native gridscale and timestep.

We introduce a set of diagnostics (ASoP1) to compare the spatial and temporal scales of precipitation across GCMs and observations, which can be applied to data ranging from the gridscale and timestep to regional and sub-monthly averages (Klingaman et al., 2017). When applied to data from ten GCMs, ASoP1 diagnostics reveal that far from the “dreary” persistent light rain implied by daily mean data, on the native timestep and gridscale most GCMs produce a broad range of intensities (1-100 mm day^{-1}; Figure 1, top panel). Several GCMs, including the Met Office Unified Model (MetUM), show quasi-random behaviour that may alter the spectrum of atmospheric waves. Averaging to a common spatial (~600 km) or temporal (3 hr) resolution reduces inter-model variability, demonstrating that averaging masks intrinsic model behavior (Figure 1, bottom panel).

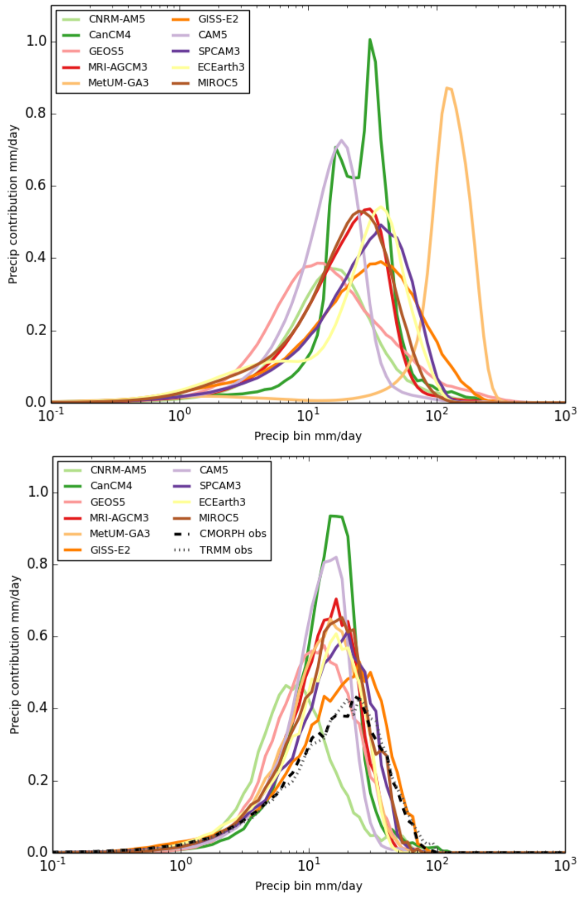

Figure 1: Histograms of the contributions from each bin of precipitation intensity to the total precipitation, computed across a Warm Pool domain, using data from (top) the native horizontal grid and timestep and (bottom) 3 hr and 600 km averages. See Klingaman et al. (2017) for full details of data and computation method.

To further explore intermittent MetUM timestep precipitation and connect it to longer- and larger-scale biases, we analyze MetUM simulations at a range of horizontal resolutions, including ~16 km simulations with and without a deep convective parameterization (Martin et al., 2017). With parameterized convection, intermittency is largely insensitive to resolution and timestep length, as are larger- and longer-scale variability. Switching off the parameterization results in very persistent but very sporadic rainfall. On the ~100 km scale, the spectra of oceanic 3-hr and daily mean rainfall in the parameterized configurations agree well with satellite-derived rainfall estimates. At ~10 day scales, the spectra indicate a lack of intra-seasonal variability. Over tropical land, MetUM often underestimates daily mean rainfall (related to a poor representation of the diurnal cycle) and lacks sub-seasonal variability.

References for further information on this work

Klingaman NP, Martin GM and Moise AF, 2017: ASoP (v1.0): A set of methods for analyzing scales of precipitation in general circulation models. *Geosci. Model Dev.*, 10, 57-83, doi:10.5194/gmd-10-57-2017.

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