# Impacts of stochastic physics on tropical variability in models

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## 1. Introduction

Low resolution atmospheric models generally have less tropical variability on time scales of several days than is observed (e.g. [1]). Stochastic physics (SP) may reduce this bias by increasing the variability in the simulated tropical convection. SP has already been shown to improve NWP skill and reduce some biases in the mean state [2,3]. Here we quantify the impact of SP on tropical variability in the ECMWF seasonal forecasting system (System 4). We also quantify the impact on simulating tropical precipitation extremes, which have large societal impacts [4].

## 2. Data

- We use seasonal hindcasts of daily-mean precipitation from System 4 and compare these with equivalent hindcasts with the SP schemes deactivated (DET).
- These begin on May 1 and Nov 1 of each year between 1998–2010 and we use hindcast months 2–7 to sample all calendar months equally.
- 10 ensemble members are used so that sampling variability is small.
- System 4 uses two SP schemes: the Stochastically Perturbed Parametrization Tendencies Scheme (SPPT) and the Spectral Stochastic Backscatter Scheme (SPBS) [2]. Comparing with hindcasts with just one of SPPT or SPBS activated indicates that most of the effects of SP are due to SPPT (not shown).

We also compare the model output with the observational GPCP 1DD and TRMM 3B42 V7 datasets. Note that these show considerable differences in the estimated precipitation amounts in individual heavy rainfall events, suggesting there is considerable uncertainty in the true variability, so comparisons with the model data should be made cautiously.

## 3. Impact on the standard deviation of precipitation

- Fig. 1a shows that SP increases the standard deviation of daily-mean tropical precipitation in System 4 relative to DET by up to 1–2mm/day, particularly in the west Pacific and in South America.
- SP also causes substantial decreases in the extratropical standard deviation.
- Fig. 1b shows that System 4 generally exhibits lower variability than GPCP in the tropics, so SP makes the variability in System 4 more consistent with GPCP, particularly over equatorial landmasses and the tropical Pacific.
- SP increases the positive bias in standard deviation over the ocean around the Maritime Continent, however.

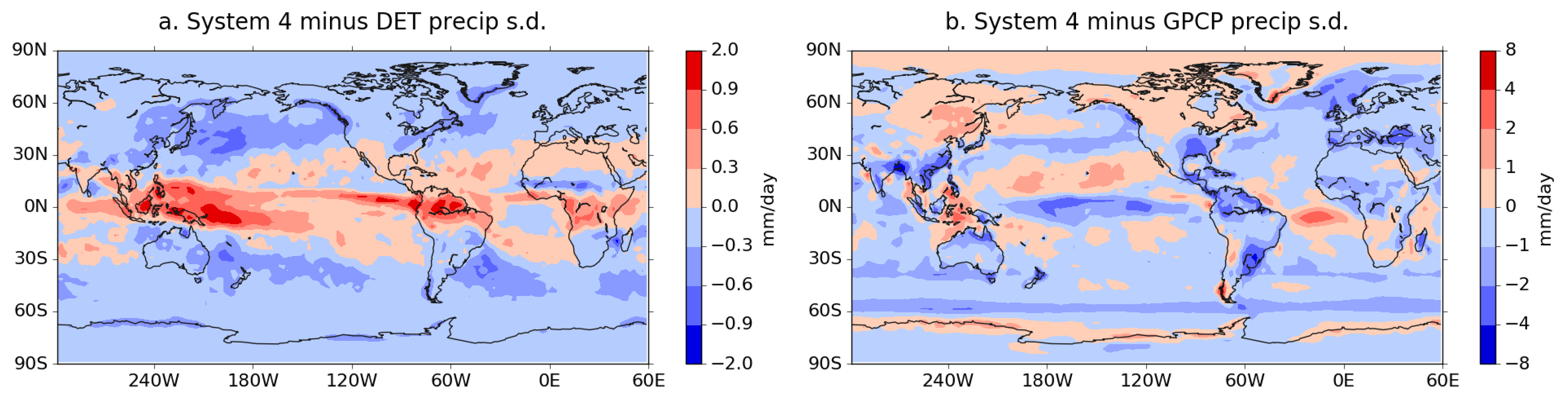


Figure 1: Differences in the standard deviation of daily mean precipitation between System 4 and DET in (a) and between System 4 and GPCP in (b).

## 4. Impact on the frequency of light and heavy rainfall

Fig. 2a shows the frequency distribution of daily-mean rain rates in System 4, DET, GPCP and TRMM between 10S–10N in 2.5°x2.5° grid boxes. For rates below 30mm/day, GPCP and TRMM agree closely on the frequency.

- Both System 4 and DET have a higher frequency of rain rates below 20mm/day and a lower frequency between 20–45mm/day than observed, shown more clearly in fig.2b.
- The biases in this range are generally smaller in System 4 than in DET, indicating that SP is improving the frequency distribution.
- SP also increases the frequency of higher rain rates, with the frequency in System 4 lying between the observational estimates in GPCP and TRMM at rates above 45mm/day.

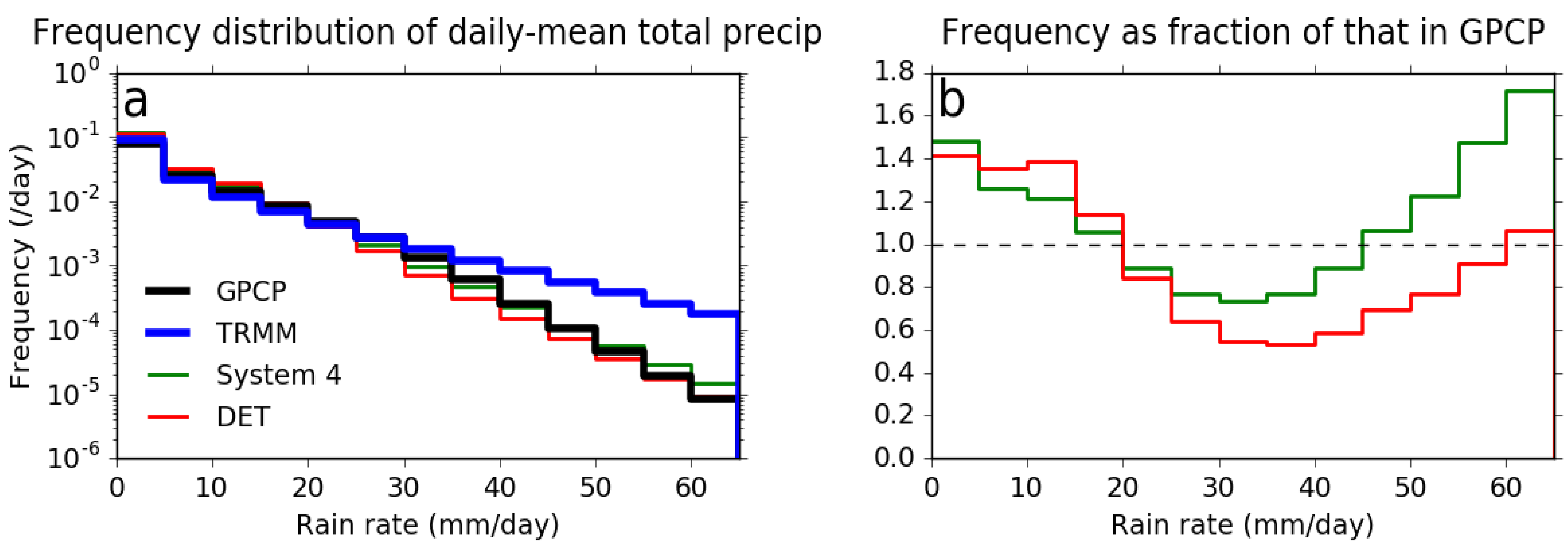


Figure 2: (a) shows the frequency distribution of rain rates in the observational and model datasets, for daily-mean precipitation between 10S–10N in 2.5°x2.5° grid boxes. (b) shows the ratio of the frequencies in the model datasets to that in GPCP.

## 4. Summary and key points

- Stochastic physics generally increases the standard deviation of tropical precipitation in System 4 and reduces biases with respect to observational datasets.
- Stochastic physics improves the frequency distribution of tropical rainfall rates, reducing the excess of light rainfall events and increasing the frequency of heavy rainfall events.

References
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