Characterizing the climatological distribution of rain frequency and intensity

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Motivation and objectives

Precipitation is inherently intermittent, and when it does rain, it can rain hard or lightly. It is often quantified by its mean, its frequency, or the intensity of extremes, but these provide a limited view of precipitation. The distribution of precipitation in terms of rain rate provides a more complete description, but cannot be readily visualized in multiple spatial or temporal dimensions.

Here we develop metrics describing key characteristics of the distribution of daily precipitation that enable us to investigate in observations and model simulations:

- How heavy is rain when it falls?
- How does this vary in space, and across the seasonal cycle?
- How robust are these characteristics across observational datasets, and how do they compare with a climate model?

Conclusions

Rain frequency peak follows mean precipitation, while rain amount peak does not. In the zonal mean, rain amount peak varies little with latitude compared to total precipitation. The rain amount width varies inversely with total precipitation.

GPCP 1DD, TRMM 3B42, and CESM1 agree qualitatively on the patterns of variation of rain amount, rain frequency peak, and rain amount width. They differ on the magnitude of the rain amount peak and width. GPCP and TRMM disagree on the spatial pattern of rain frequency peak.

These results show that further study of observations is necessary to advance our understanding of the distribution of precipitation, and to confidently validate precipitation in climate models.

Results

Metrics, Seasonal cycle, Variation with latitude

Fig. 1: The climatological distribution of global, annual mean (a) rain amount and (b) rain frequency from GPCP 1DD from October 1996 – October 2015. The red asterisk denotes the rain amount peak in (a) and the rain frequency peak in (b). In (a), the horizontal line indicates the width of the rain amount distribution. In (b), the dry-day frequency is given in the top left.

Fig. 2: (a) Climatological zonal, annual mean rain amount (mm) distribution from GPCP 1DD. The black curve shows the rain amount peak at each latitude, smoothed with 3 successive application of a 1-2-1 filter. (b) As in (a) but for total precipitation (mm/d) from the same dataset.

Fig. 3: Climatological zonal, annual mean rain amount (mm/d) distribution from GPCP 1DD for ocean (top) and land (bottom) separately, stratified by 3-month seasons.

Fig. 4: Maps of climatological annual mean (top) rain amount peak, (second row) rain frequency peak, (third row) rain amount width and (bottom) rain frequency width (%) from (left) GPCP 1DD, (center) TRMM 3B42, and (right) CESM1.

Fig. 5: Comparison between climatological zonal annual mean distributions of (top) rain amount (mm/d) and (bottom) rain frequency (%) between (a, d) GPCP 1DD, (b, e) TRMM 3B42 (coarsened to one-degree resolution), and (c, f) CESM1.

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