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S1 Comparison between observational data products

Figure S1: Comparison across observational data products of GHA rainfall climatologies. All three climatologies are calculated over the period 2001-2021 to accommodate the later start of the GPCP and IMERG datasets (see main text Table 1).

S2 Vertical structure of $h_s - h^*$

Figure S2: 2-dimensional histogram of $h_s - h^*$ across years by pressure level. Darker colors mean more years have a given average seasonal $h_s - h^*$ at a given pressure level.
S3 Comparison between reanalyses

Figure S3: Comparison across reanalysis products of 1981-2021 GHA rainfall climatologies. CHIRPS observations are in black.
Figure S4: Comparison across reanalysis products of GHA climatological average instability (a.), $h_s - h^*$ (b.), and its components (c.-e.). Shading shows the 0.1-0.9 inter-quartile range for each reanalysis product. $h^*$ is calculated at 650 hPa.
S4 Rainfall distributions by $h_s - h^*$

Figure S5: Figure as in main text Figure 3, but using March-April-May (MAM) and October-November-December (OND) as seasonal definitions instead of the local onset and demise of the long and short rains, as is often done in the literature. Results are qualitatively similar, but three-monthly averages cover both wet and dry periods; fewer grid-cell days in the sample have $h_s - h^* > 0$ than when using local seasonal definitions.
Figure S6: Figure as in main text Figure 3, but using daily maximum $h_s - h^*$ (calculated from 3-hourly data) instead of daily mean $h_s - h^*$. Using higher-frequency data emphasizes that some amount of instability is necessary for rain to fall in a given location on a given day, and that if $h_s - h^*$ is higher, the probability of rainfall increases. Note that, similar to Figure 3, across both seasons about 99.7% of grid cell days have maximum 3-hourly $h_s - h^*$ between -22 and 7.5 kJ/kg; values in bins beyond those limits for panels d. - g. are calculated from very small sample sizes.
S5  Spatial correlations of $h^*$

Figure S7: Seasonal average correlation between GHA double-peaked region mean $h^*$ and $h^*$ at all other locations in the wet season and across all days. Seasons are defined using the average onset and demise across the double-peaked region, shown in green. Hatching obscures regions with insignificant correlations, as determined using a two-sided t-test with a threshold of $p=0.05$, with a correction for multiple testing applied (Wilks, 2016), using a False Discovery Rate of 0.2.
Figure S8: Daily correlation between GHA double-peaked region mean $h^*$ and $h^*$ at all other locations in the wet season and across all days. Seasons are defined using the average onset and demise across the double-peaked region, shown in green. Hatching obscures regions with insignificant correlations, as determined using a two-sided t-test with a threshold of $p=0.05$, with a correction for multiple testing applied (Wilks, 2016), using a False Discovery Rate of 0.2.
S6 Verification of interannual changes

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Figure S9: Linear correlations between changes in double-peaked region $P$ and $h_s - h^*$ (top 3 rows) or area fraction unstable (bottom 3 rows), for interannual changes in MAM (left 3 columns) or OND (right 3 columns), calculated using all reanalysis and rainfall data products used. Darker colors indicate stronger correlations.

References