Supporting Information for "Linking Atmospheric Cloud Radiative Effects, Tropical Precipitation, and Column Relative Humidity"

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Text S1: Regions of the Tropics and Distributions of CRH

The latitude and longitude boundaries for the six tropical regions used in the main text are recorded in Tbl. S1. The regions were selected to give a range of underlying sea surface temperature (SST) and column relative humidity (CRH) distributions (see Fig. S1). The Indo-Pacific warm pool, south Pacific convergence zone, Pacific ITCZ and Atlantic ITCZ regions are characterized by time-mean low-level moisture convergence which favors deep

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convection. In contrast, the Atlantic and Pacific cold tongue regions are characterized by cold upwelling SSTs and are situated under the descending branch of the Hadley cells. The cold SSTs and subsiding motion both tend to suppresses deep convection and favor the formation of marine stratocumulus clouds.

Probability density functions (PDFs) of column relative humidity (CRH) are included in the six panels of Fig. S1. The CRH appears to follow a bimodal distribution, with a "humid peak" near 80% and a "dry peak" near 40%. The Indo-Pacific and ITCZ regions have a single mode near the humid peak, while the cold tongue regions have a single moad near the dry peak. Only the SPCZ region exhibits the bimodal behavior of the wider tropical belt.

Text S2: Comparing the Precipitation Models of Rushley et. al. (2018)

Fig. S2 shows the TRMM precipitation rate binned by the CRH for each of the six regions of the tropics. The dashed and dotted lines show the V5 and V7 models of precipitation presented by Rushley et. al. (2018). The models use the same exponential form with different coefficients to predict precipitation as a function of CRH as

$$P_{V5} = 4.07 \times 10^{-5} \exp(16.12 \times \text{CRH}) \text{ mm day}^{-1}, \tag{1}$$

and

$$P_{V7} = 6.89 \times 10^{-5} \exp(14.72 \times \text{CRH}) \text{ mm day}^{-1}. \tag{2}$$

As in Fig. 1.a from the main text, the mean TRMM precipitation rate more closely follows the V7 model, while the V5 model tends to overestimate the precipitation rate.

Figs. S3 and S4 show the TRMM annual mean precipitation rate as well as the precipitation rate estimated from CRH using one of the two models. Consistent with previous results, the V5 model tends to overestimate the precipitation rate, while the V7 model is more similar to the values from TRMM.

References

Rushley, S. S., Kim, D., Bretherton, C. S., & Ahn, M.-S. (2018, January). Re-examining the non-linear moisture-precipitation relationship over the tropical oceans. *Geophys. Res. Lett.*, *45*(2), 1133-1140. doi: 10.1002/2017GL076296

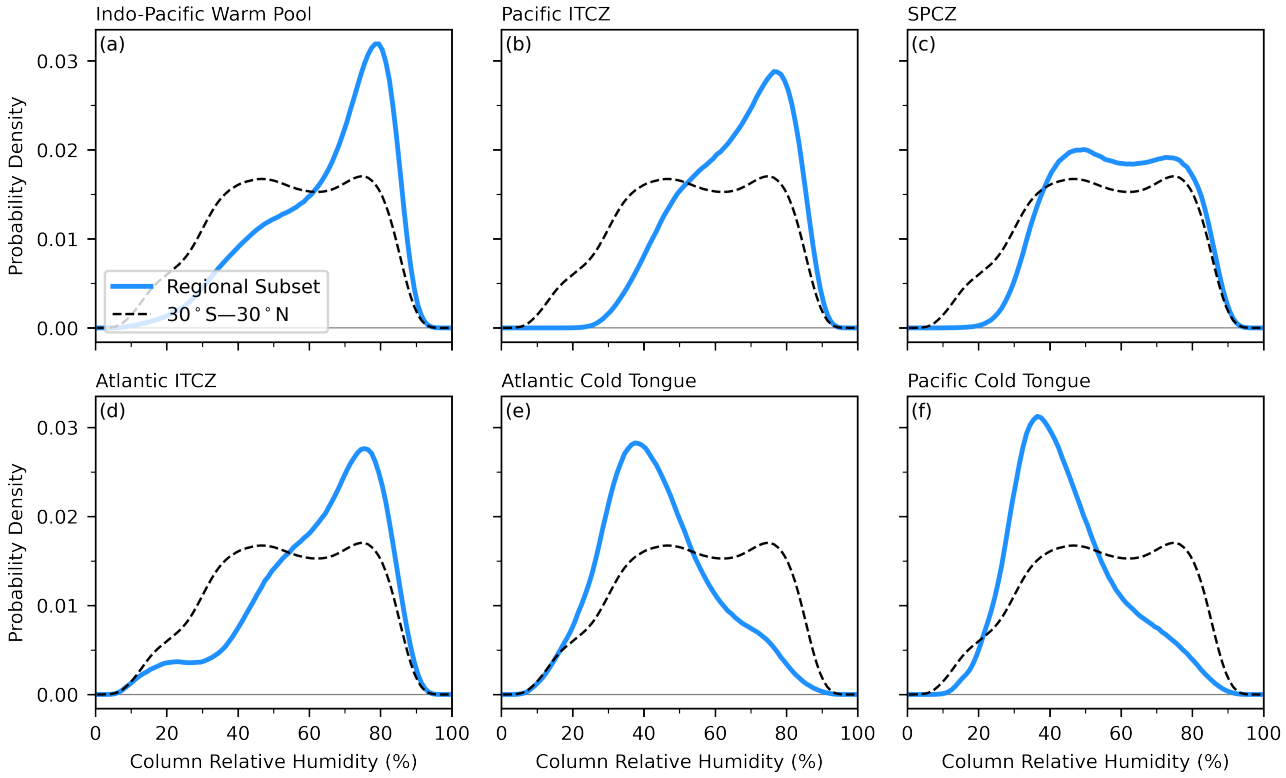

Figure S1. **(a)** Probability density functions of column relative humidity for the Indo-Pacific warm pool (red line) and over the entire 30°S-30°N tropical belt. **(b)-(f):** same as **(a)**, but for, respectively, the pacific ITCZ, the SPCZ, the Pacific cold tongue, the Atlantic ITCZ, and the Atlantic cold tongue.

Table S1. Pearson's R^2 correlation between ACRE calculated from CERES observations and ACRE estimated from ERA5 CRH at monthly and daily time-scales for each of the six tropical sub regions. Also included are the latitude and longitude boundaries for each region.

	Regional Extent	Monthly R^2	Daily R^2
Indo-Pacific Warm Pool	70°E-170°W, 20°S-20°N	0.775	0.624
Pacific ITCZ	150°E-100°W, 0°-15°N	0.753	0.569
SPCZ	150°E-130°W, 30°S-0°	0.616	0.486
Pacific Cold Tongue	130°W-95°W, 30°S-0°	0.56	0.39
Atlantic ITCZ	55°W-15°E, 5°S-15°N	0.653	0.507
Atlantic Cold Tongue	40°W-20°E, 30°S-5°N	0.515	0.421

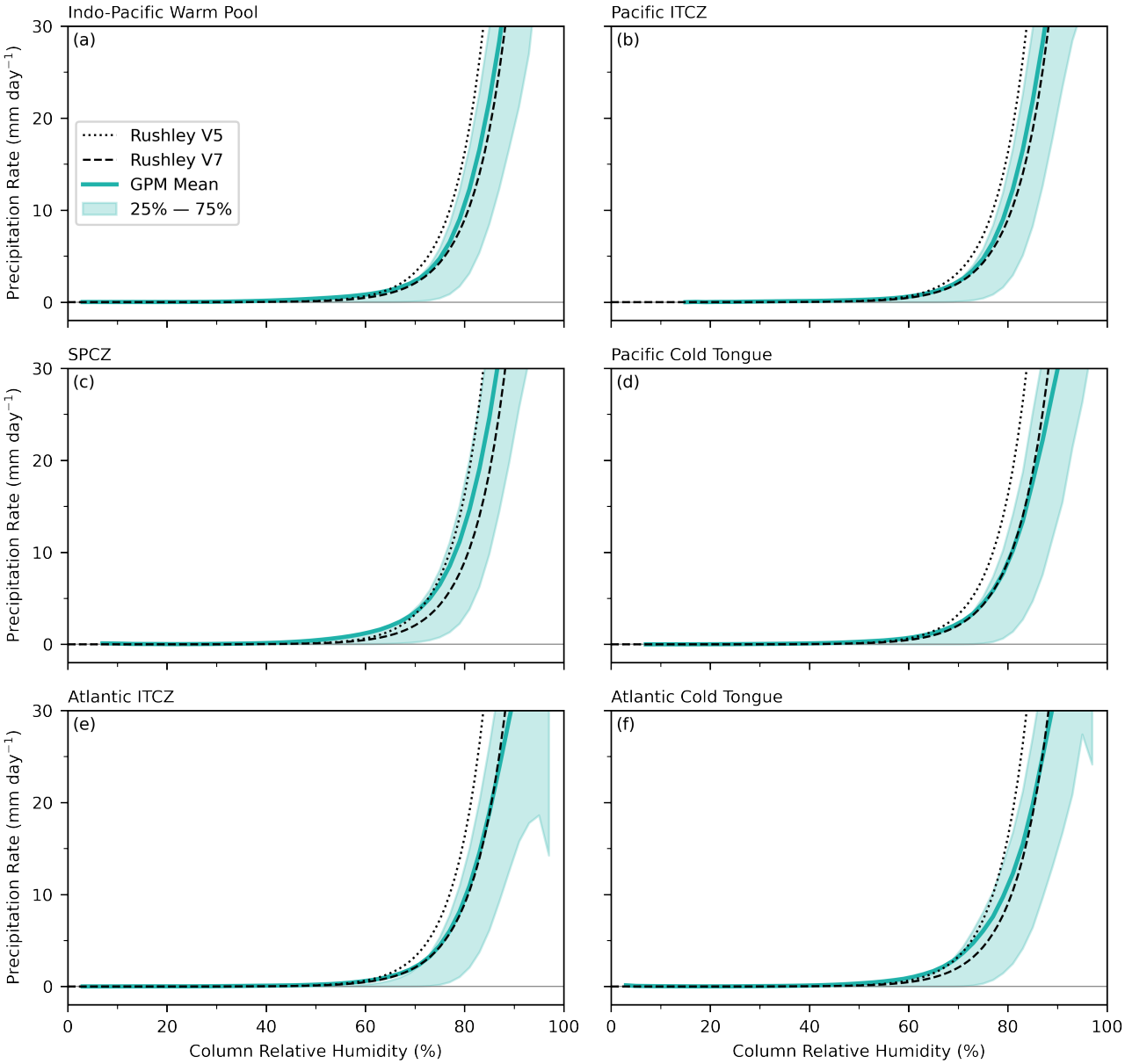

Figure S2. **(a)** TRMM precipitation rate binned by CRH for the Indo-Pacific warm pool, as well as curves showing the precipitation rate predicted by the V5 and V7 models of Rushley et al. (2018). Shaded region shows the 25th to 75th percentiles. **(b)-(f):** same as **(a)**, but for, respectively, the pacific ITCZ, the SPCZ, the Pacific cold tongue, the Atlantic ITCZ, and the Atlantic cold tongue. Reversal of the 25th percentile curve in panels e and f occurs at the tail of the CRH distribution, where the small number of grid cells prevents the calculation of meaningful statistics (see Fig. S1).

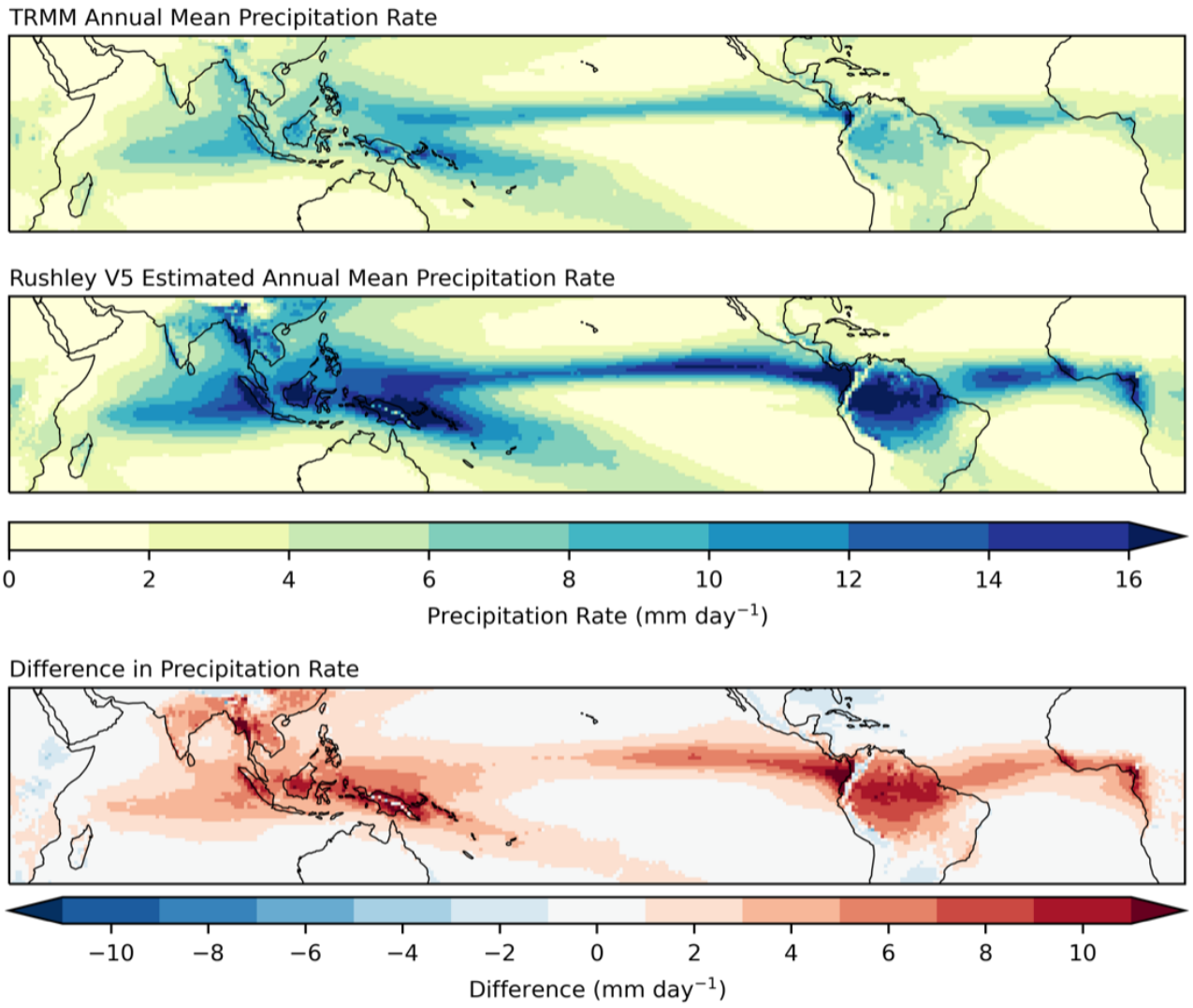

Figure S3. **Top:** 2001-2019 annual mean precipitation rate from TRMM. **Middle:** 2001-2019 annual mean precipitation rate estimated using ERA5 CRH and V5 model from Rushley et al. (2018). **Bottom:** Difference between **Middle** and **Top**.

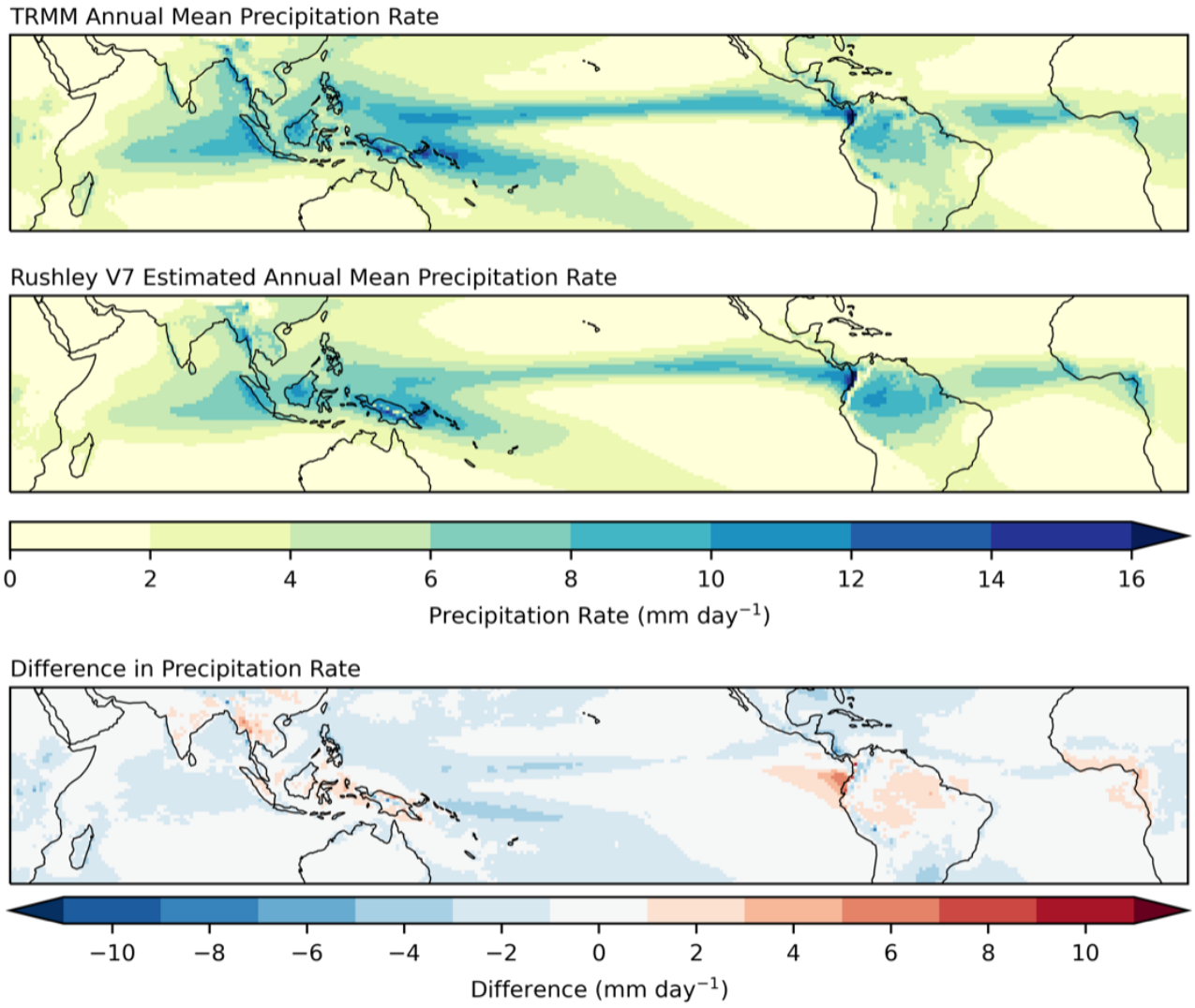

Figure S4. Same as Fig. S3, but for the V7 model from Rushley et al. (2018)