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# Recent extreme drought events in the Amazon rainforest: assessment of different precipitation and evapotranspiration datasets and drought indicators

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**Table S1: Total area affected by drought stress in million km² (and %) by drought index (MCWD, scPDSI and RAI) and intensity (moderate, severe and extreme) across the 10 datasets evaluated in our study (rows) for the years 2005 and 2010.**

| | | Year | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2005 | 2005 | 2005 | 2010 | 2010 | 2010 |
| Metric | Dataset | $rMCWD < -2.5$ (extreme) | $rMCWD < -2.0$ (severe) | $rMCWD < -0.5$ (moderate) | $rMCWD < -2.5$ (extreme) | $rMCWD < -2.0$ (severe) | $rMCWD < -0.5$ (moderate) |
| rMCWD | CHIRPS | 0.1 (2%) | 0.4 (7%) | 3. (51%) | 0.1 (1%) | 0.6 (10%) | 3.7 (63%) |
| rMCWD | CRUNCEP | 0.2 (3%) | 0.6 (10%) | 3. (51%) | 0.2 (3%) | 0.3 (6%) | 3.4 (58%) |
| rMCWD | ERA5 | 0.1 (1%) | 0.2 (3%) | 2.2 (37%) | 0.1 (2%) | 0.8 (14%) | 4.2 (70%) |
| rMCWD | GLDAS | 0.2 (3%) | 0.5 (9%) | 2.8 (46%) | 0.3 (6%) | 0.9 (14%) | 3.6 (60%) |
| rMCWD | GPCC | 0.1 (2%) | 0.5 (9%) | 2.8 (46%) | 0.2 (4%) | 0.6 (9%) | 3. (51%) |
| rMCWD | TRMM6 | 0. (1%) | 0.3 (5%) | 2.7 (45%) | 0.2 (3%) | 0.7 (12%) | 4.4 (74%) |
| rMCWD | TRMM7 | 0.1 (2%) | 0.4 (7%) | 2.6 (45%) | 0.2 (4%) | 0.5 (9%) | 3.8 (64%) |
| rMCWD | GSWP3 | 0.1 (2%) | 0.5 (9%) | 2.6 (44%) | 0.2 (4%) | 0.5 (8%) | 3.2 (54%) |
| rMCWD | WATCH_WFDEI | 0.1 (2%) | 0.6 (9%) | 2.6 (45%) | 0.2 (4%) | 0.4 (7%) | 3.1 (51%) |
| | | $rscPDSI < -2.5$ (extreme) | $rscPDSI < -2.0$ (severe) | $rscPDSI < -0.5$ (moderate) | $rscPDSI < -2.5$ (extreme) | $rscPDSI < -2.0$ (severe) | $rscPDSI < -0.5$ (moderate) |
| rscPDSI | CHIRPS | 0. (0%) | 0.2 (3%) | 4. (67%) | 0.1 (1%) | 0.5 (9%) | 3.8 (64%) |
| rscPDSI | CRUNCEP | 0. (0%) | 0.1 (2%) | 3.1 (52%) | 0. (1%) | 0.4 (7%) | 3.6 (60%) |
| rscPDSI | ERA5 | 0. (0%) | 0.1 (1%) | 4.4 (75%) | 0. (0%) | 0.4 (7%) | 4. (67%) |
| rscPDSI | GLDAS | 0. (0%) | 0.2 (3%) | 2.6 (43%) | 0.2 (4%) | 1.1 (18%) | 4.6 (77%) |
| rscPDSI | GPCC | 0. (0%) | 0.3 (6%) | 3.5 (58%) | 0. (1%) | 0.3 (5%) | 3.5 (59%) |
| rscPDSI | TRMM6 | 0. (0%) | 0.2 (3%) | 3.8 (64%) | 0. (1%) | 0.4 (7%) | 3.8 (64%) |
| rscPDSI | TRMM7 | 0. (0%) | 0.2 (3%) | 3.8 (64%) | 0. (1%) | 0.4 (7%) | 3.8 (64%) |
| rscPDSI | GSWP3 | 0. (0%) | 0.3 (6%) | 3.5 (59%) | 0. (0%) | 0.3 (5%) | 3.6 (61%) |
| rscPDSI | WATCH_WFDEI | 0. (0%) | 0.3 (6%) | 3.5 (59%) | 0. (0%) | 0.2 (4%) | 3.5 (59%) |
| | | $rRAI < -2.5$ (extreme) | $rRAI < -2.0$ (severe) | $rRAI < -0.5$ (moderate) | $rRAI < -2.5$ (extreme) | $rRAI < -2.0$ (severe) | $rRAI < -0.5$ (moderate) |
| rRAI | CHIRPS | 0. (0%) | 0.3 (5%) | 3.7 (63%) | 0. (0%) | 0.2 (3%) | 4.1 (70%) |
| rRAI | CRUNCEP | 0. (0%) | 0.1 (2%) | 2.6 (43%) | 0. (0%) | 0.1 (2%) | 4. (67%) |

| Metric | Dataset | | | | | |
|---|---|---|---|---|---|---|
| rRAI | ERA5 | 0. (0%) | 0.1 (2%) | 3.5 (60%) | 0. (0%) | 0.3 (5%) | 4.6 (78%) |
| rRAI | GLDAS | 0. (0%) | 0.1 (2%) | 2.2 (37%) | 0.3 (5%) | 0.7 (12%) | 4.5 (75%) |
| rRAI | GPCC | 0. (0%) | 0.3 (6%) | 3.1 (52%) | 0. (1%) | 0.2 (3%) | 3.4 (57%) |
| rRAI | TRMM6 | 0. (0%) | 0.1 (1%) | 3.1 (52%) | 0. (0%) | 0.2 (3%) | 4.3 (72%) |
| rRAI | TRMM7 | 0. (0%) | 0.2 (3%) | 3.6 (60%) | 0. (0%) | 0.3 (5%) | 4. (68%) |
| rRAI | GSWP3 | 0. (0%) | 0.3 (5%) | 3.1 (53%) | 0. (0%) | 0.2 (3%) | 3.7 (63%) |
| rRAI | WATCH_ WFDEI | 0. (0%) | 0.3 (6%) | 3.3 (56%) | 0. (0%) | 0.2 (3%) | 3.4 (58%) |

**Table S2: Total area affected by drought in million km² (and %) by drought index (MCWD, scPDSI and RAI) and intensity (moderate, severe and extreme) across the 10 datasets evaluated in this study (rows) for the year 2016. TR6, GSW and WAT are missing from this calculation as their timespan ends before 2016.**

| Metric | Dataset | 2016 | 2016 | 2016 |
|---|---|---|---|---|
| | | $rMCWD < -2.5$ (extreme) | $rMCWD < -2.0$ (severe) | $rMCWD < -0.5$ (moderate) |
| rMCWD | CHRIPS | 0.4 (7%) | 0.8 (14%) | 2.2 (38%) |
| rMCWD | CRUNCEP | 0.3 (4%) | 0.6 (10%) | 2.3 (38%) |
| rMCWD | ERA5 | 0.6 (10%) | 1.1 (18%) | 2.5 (43%) |
| rMCWD | GLDAS | 0.8 (13%) | 1.3 (21%) | 3.7 (63%) |
| rMCWD | GPCC | 0.5 (8%) | 0.8 (14%) | 2.8 (48%) |
| rMCWD | TRMM7 | 0.5 (8%) | 0.7 (13%) | 3. (50%) |
| | | $rscPDSI < -2.5$ (extreme) | $rscPDSI < -2.0$ (severe) | $rscPDSI < -0.5$ (moderate) |
| rscPDSI | CHRIPS | 0.1 (1%) | 0.7 (11%) | 3.6 (61%) |
| rscPDSI | CRUNCEP | 0.1 (2%) | 0.8 (14%) | 4.3 (72%) |
| rscPDSI | ERA5 | 0.1 (1%) | 0.7 (11%) | 2.8 (47%) |
| rscPDSI | GLDAS | 0.8 (14%) | 2.3 (40%) | 4.3 (73%) |
| rscPDSI | GPCC | 0.1 (2%) | 0.9 (16%) | 4.6 (78%) |
| rscPDSI | TRMM7 | 0.3 (6%) | 0.9 (15%) | 3.7 (63%) |
| | | $rRAI < -2.5$ (extreme) | $rRAI < -2.0$ (severe) | $rRAI < -0.5$ (moderate) |

| rRAI | CHRIPS | 0. (0%) | 0. (0%) | 0.8 (14%) |
|------|--------|---------|---------|-----------|
| rRAI | CRUNCEP | 0. (0%) | 0. (0%) | 0.8 (13%) |
| rRAI | ERA5 | 0. (0%) | 0. (0%) | 0.7 (13%) |
| rRAI | GLDAS | 0.3 (4%) | 0.8 (13%) | 3.6 (61%) |
| rRAI | GPCC | 0. (0%) | 0. (0%) | 1.6 (27%) |
| rRAI | TRMM7 | 0. (0%) | 0. (0%) | 1.4 (23%) |

**Methods S1:**

To (1) identify potential biases between datasets and (2) to enable a comparison of drought classifications between $r$MCWD and $a$MCWD (SI Fig. 1) we calculated the empirical cumulative density functions (CDF). More specifically we used a Gaussian CDF which we applied to both the relative and absolute MCWD anomalies:

$CDF(N(\mu, \sigma), x) = CDF(N(0, \sigma), x) = CDF(N(\sigma), x) = \frac{1}{2} Erfc\left(-\frac{x}{\sqrt{2}\sigma}\right)$ where Erfc denotes the complementary error function. Parameter σ was obtained by fitting the CDF against the points of the empirical CDF of the datasets using *Mathematica's NonlinearModelFit* package. Fitting this CDF to the $a$MCWD anomalies resulted in $\sigma_{aMCWD} \approx 52.95$ and (by definition) $\sigma_{rMCWD} = 1$.

We then defined our relative drought intensity thresholds of $r$MCWD anomaly to be $X_r$: $\{-2.5\ (Extreme), -2.0\ (Severe), -0.5\ (Moderate)\}$ and solved for corresponding quantile set $Q$: $q_i$ with $q_i = \frac{1}{2} Erfc\left(-\frac{x_i}{\sqrt{2}}\right) \forall x_i \in X_r$ resulting in $Q = \{0.006, 0.023, 0.31\}$. We then applied each $q \in Q$ to the CDF of the $a$MCWD anomaly and obtained the corresponding absolute thresholds $X_a = \{-132\ mm, -106\ mm, -26\ mm\}$ to the relative thresholds $X_r =: \{-2.5, -2.0, -0.5\}$ (See also colored rectangles in Figure S1). Hence, extreme drought stress as defined by a $r$MCWD anomaly less than -2.5 corresponds to an $a$MCWD anomaly of less than -132mm.
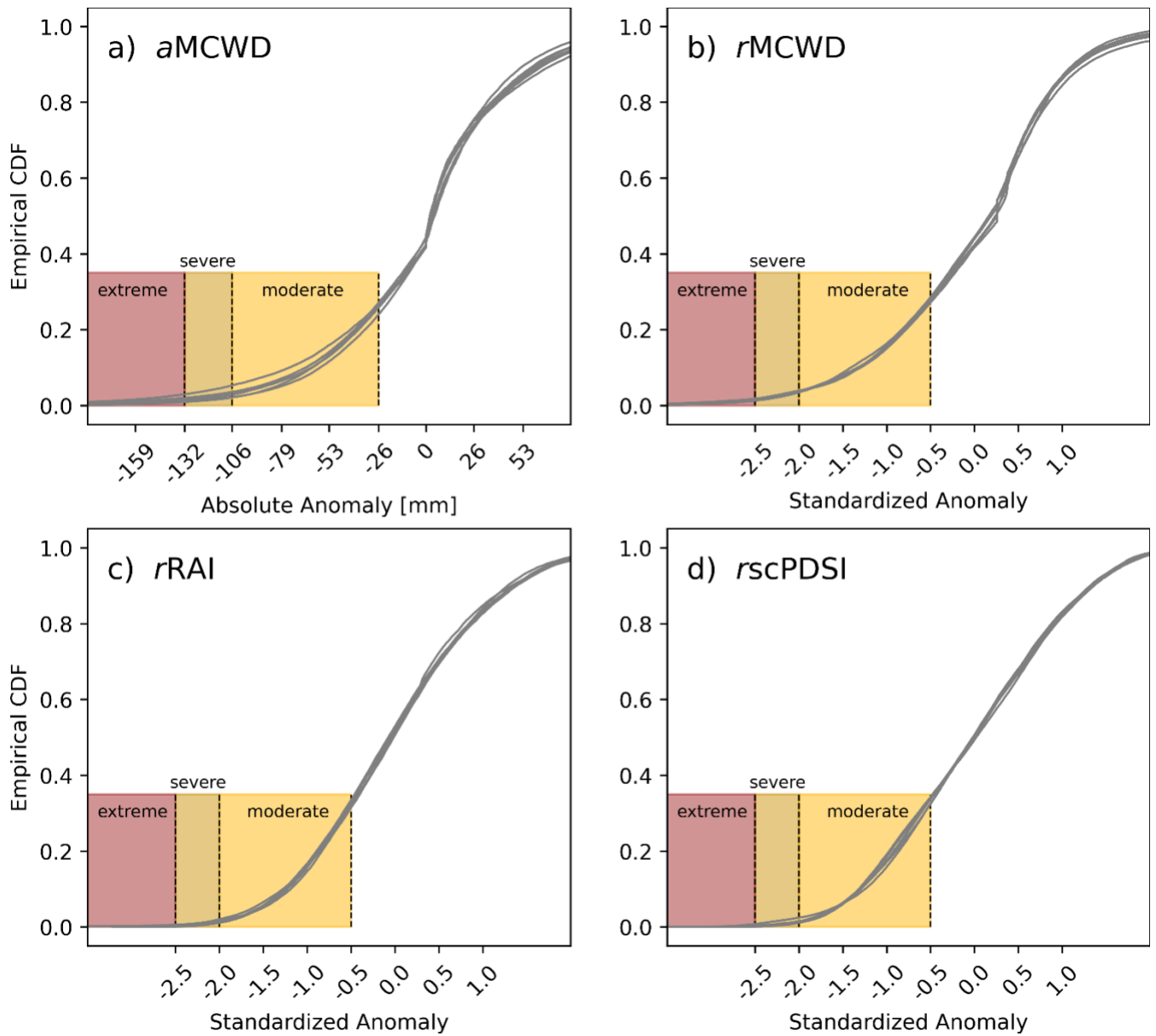
**Figure S1: Empirical cumulative distribution functions (CDFs) of the drought indices used in this study (a: *a*MCWD, b: *r*MCWD, c: *r*RAI, and d: *r*scPDSI). CDFs are calculated based on yearly values from 2000 to 2016 across all gridcells of the Amazon rainforest. Gray lines represent the CDFs of each dataset considered in this study.**
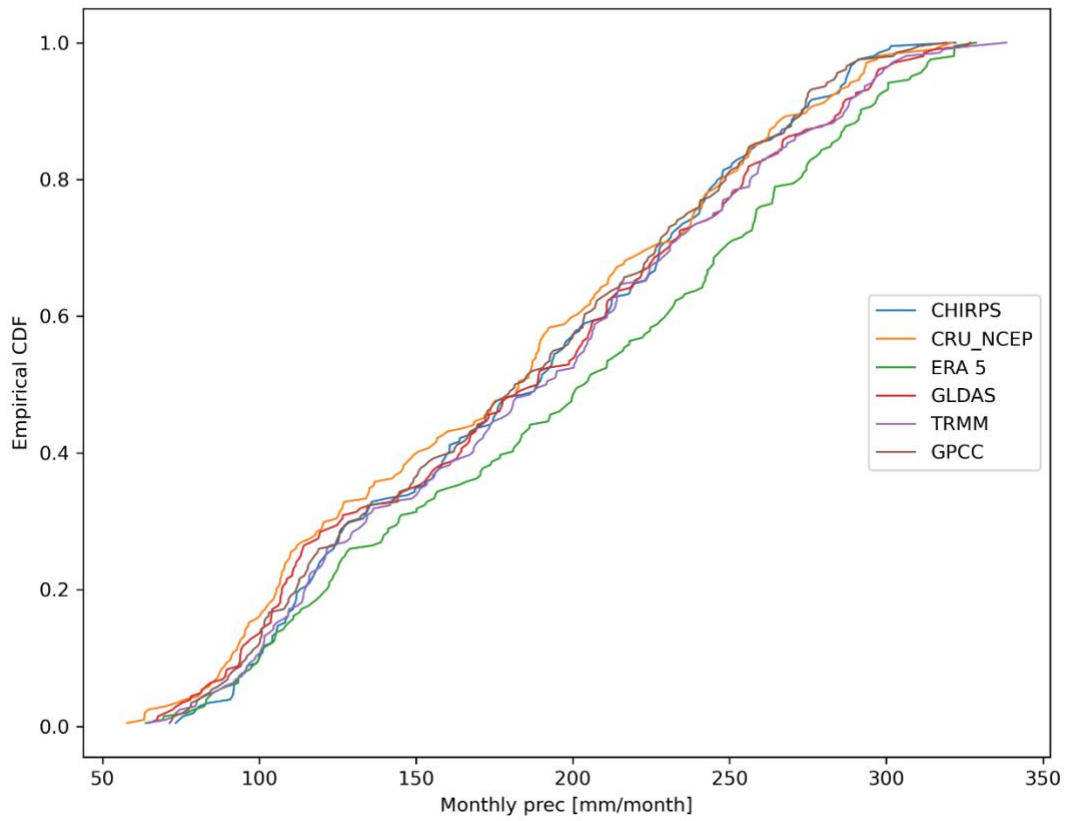
**Figure S2: Empirical cumulative distribution functions (CDFs) of monthly precipitation of six of the datasets used in this study across all gridcell of the Amazon basin. Only datasets that include the full period from 2001 to 2016 are displayed.**

**Figure S3: Pairwise scatterplots (blue points) of the nine precipitation datasets in this study for the rMCWD anomaly of 2005. The black dashed line is the 1:1 line and the red solid line is the linear model fit based on the blue points.**

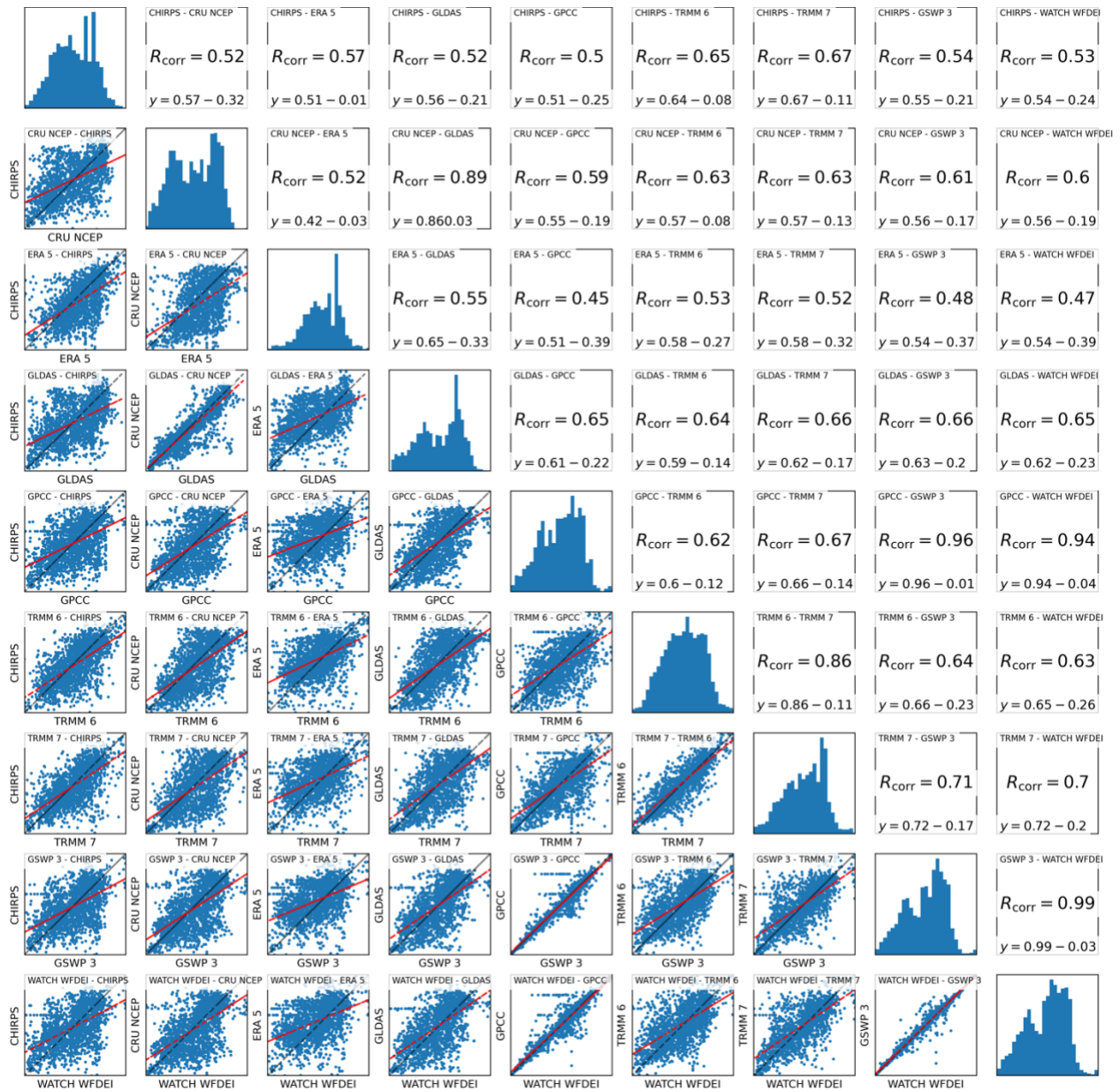|  | CHIRPS - CRU NCEP | CHIRPS - ERA 5 | CHIRPS - GLDAS | CHIRPS - GPCC | CHIRPS - TRMM 6 | CHIRPS - TRMM 7 | CHIRPS - GSWP 3 | CHIRPS - WATCH WFDEI |
|---|---|---|---|---|---|---|---|---|
| | $R_{corr} = 0.25$ | $R_{corr} = 0.47$ | $R_{corr} = 0.51$ | $R_{corr} = 0.21$ | $R_{corr} = 0.28$ | $R_{corr} = 0.29$ | $R_{corr} = 0.16$ | $R_{corr} = 0.15$ |
| | $y = 0.23 - 0.57$ | $y = 0.48 - 0.65$ | $y = 0.54 - 0.42$ | $y = 0.23 - 0.41$ | $y = 0.27 - 0.86$ | $y = 0.29 - 0.63$ | $y = 0.17 - 0.58$ | $y = 0.16 - 0.48$ |

CRU NCEP - ERA 5: $R_{corr} = 0.13$, $y = 0.15 - 0.96$
CRU NCEP - GLDAS: $R_{corr} = 0.36$, $y = 0.41 - 0.58$
CRU NCEP - GPCC: $R_{corr} = 0.42$, $y = 0.52 - 0.22$
CRU NCEP - TRMM 6: $R_{corr} = 0.37$, $y = 0.38 - 0.8$
CRU NCEP - TRMM 7: $R_{corr} = 0.28$, $y = 0.3 - 0.66$
CRU NCEP - GSWP 3: $R_{corr} = 0.41$, $y = 0.47 - 0.36$
CRU NCEP - WATCH WFDEI: $R_{corr} = 0.41$, $y = 0.47 - 0.26$

ERA 5 - GLDAS: $R_{corr} = 0.41$, $y = 0.42 - 0.44$
ERA 5 - GPCC: $R_{corr} = 0.2$, $y = 0.22 - 0.39$
ERA 5 - TRMM 6: $R_{corr} = 0.21$, $y = 0.2 - 0.88$
ERA 5 - TRMM 7: $R_{corr} = 0.23$, $y = 0.22 - 0.65$
ERA 5 - GSWP 3: $R_{corr} = 0.1$, $y = 0.1 - 0.62$
ERA 5 - WATCH WFDEI: $R_{corr} = 0.08$, $y = 0.08 - 0.54$

GLDAS - GPCC: $R_{corr} = 0.38$, $y = 0.4 - 0.26$
GLDAS - TRMM 6: $R_{corr} = 0.22$, $y = 0.2 - 0.92$
GLDAS - TRMM 7: $R_{corr} = 0.33$, $y = 0.31 - 0.61$
GLDAS - GSWP 3: $R_{corr} = 0.37$, $y = 0.37 - 0.4$
GLDAS - WATCH WFDEI: $R_{corr} = 0.29$, $y = 0.29 - 0.37$

GPCC - TRMM 6: $R_{corr} = 0.35$, $y = 0.3 - 0.91$
GPCC - TRMM 7: $R_{corr} = 0.54$, $y = 0.47 - 0.6$
GPCC - GSWP 3: $R_{corr} = 0.84$, $y = 0.8 - 0.24$
GPCC - WATCH WFDEI: $R_{corr} = 0.79$, $y = 0.74 - 0.17$

TRMM 6 - TRMM 7: $R_{corr} = 0.58$, $y = 0.6 - 0.23$
TRMM 6 - GSWP 3: $R_{corr} = 0.35$, $y = 0.39 - 0.3$
TRMM 6 - WATCH WFDEI: $R_{corr} = 0.33$, $y = 0.37 - 0.23$

TRMM 7 - GSWP 3: $R_{corr} = 0.49$, $y = 0.53 - 0.26$
TRMM 7 - WATCH WFDEI: $R_{corr} = 0.47$, $y = 0.51 - 0.18$

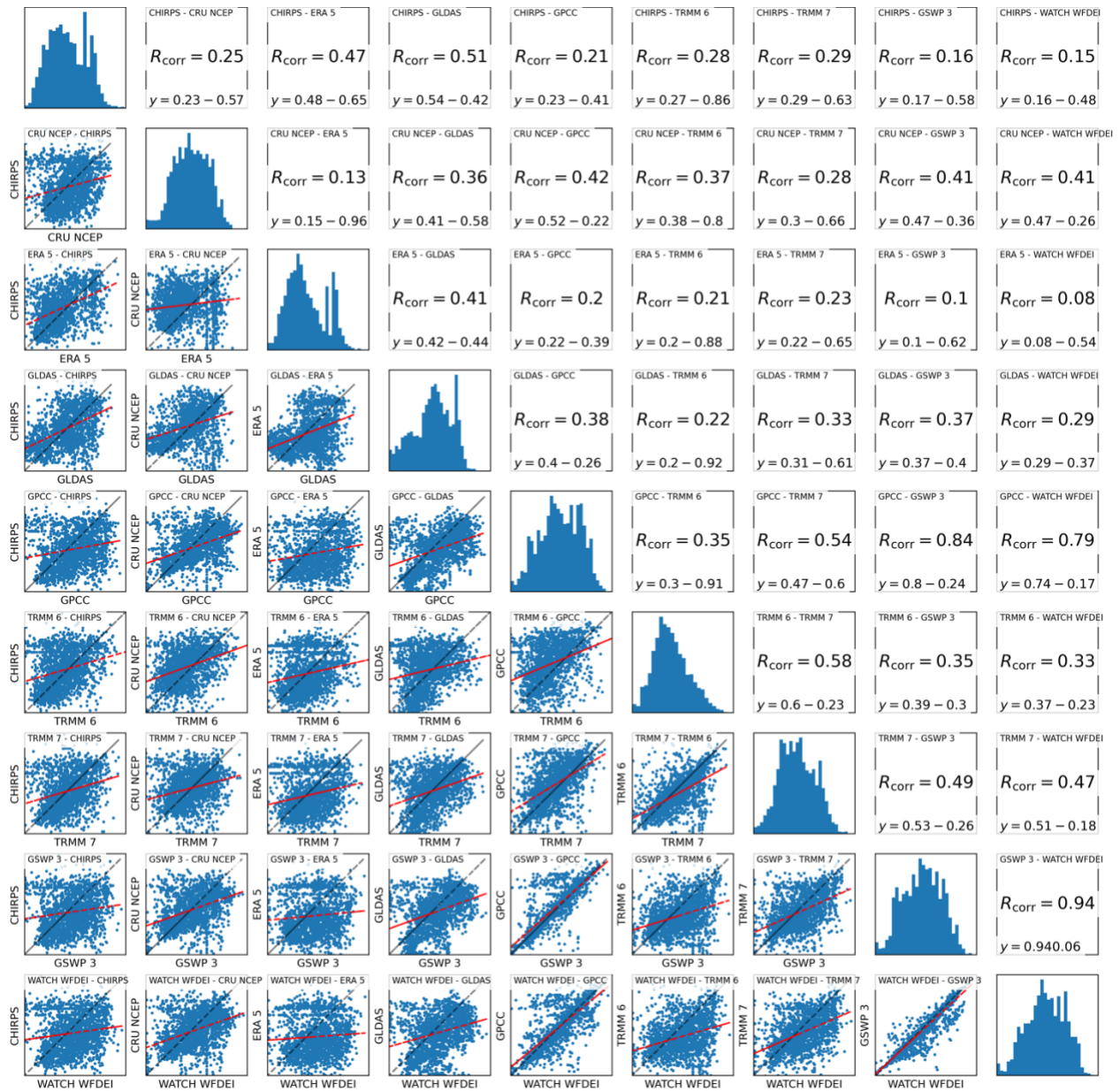GSWP 3 - WATCH WFDEI: $R_{corr} = 0.94$, $y = 0.940.06$

**Figure S4: Pairwise scatterplots (blue points) of the nine precipitation datasets in this study for the rMCWD anomaly of 2010. The black dashed line is the 1:1 line and the red solid line is the linear model fit based on the blue points.**
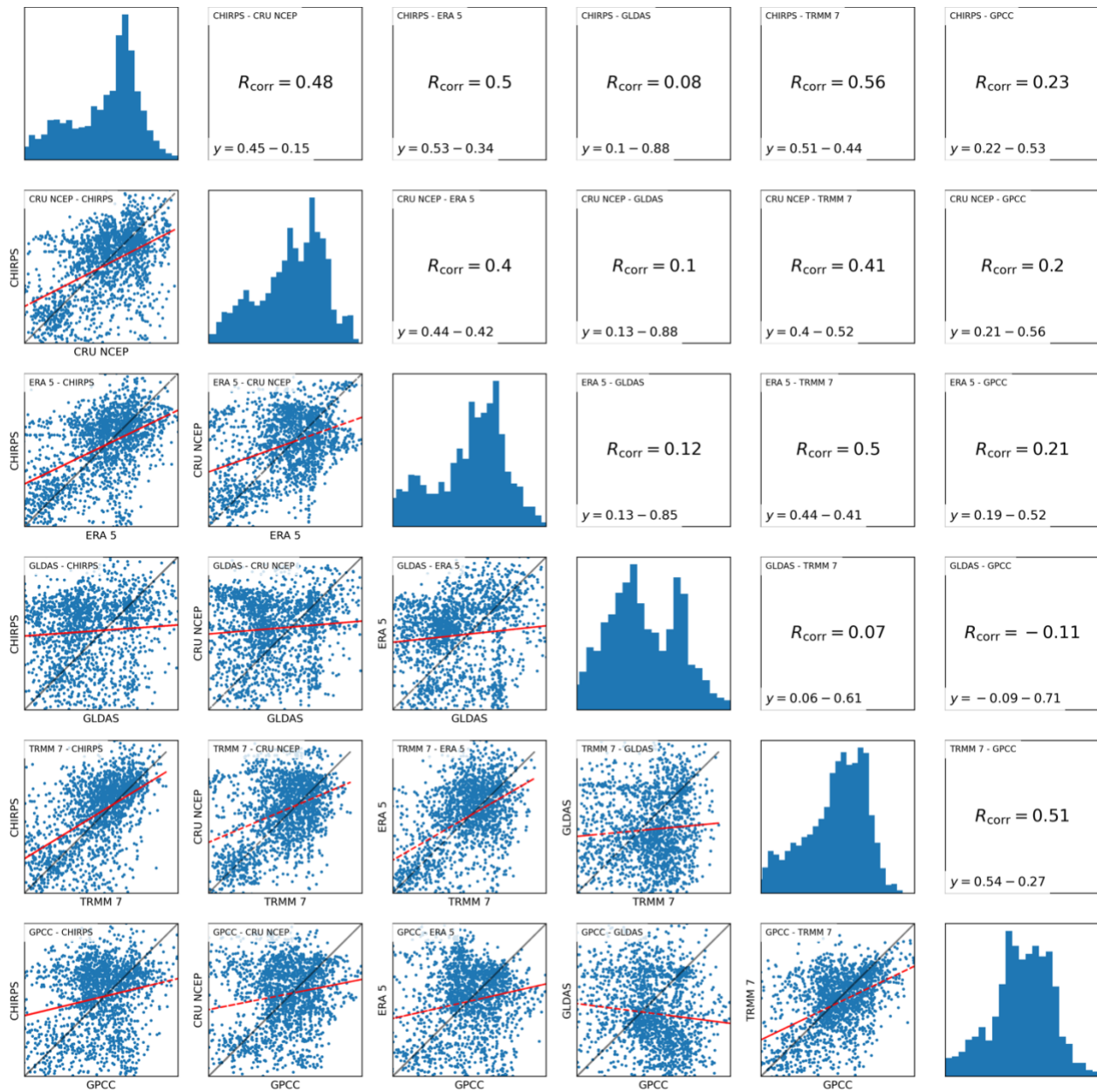
**Figure S5: Pairwise scatterplots (blue points) of the six precipitation datasets in this study for the rMCWD anomaly of the year 2016. The black dashed line is the 1:1 line and the red solid line is the linear model fit based on the blue points.**