

*[Water Resources Research]*

Supporting Information for

**The complementary relationship (CR) of evaporation: a calibration-free diagnostic and benchmarking tool for large-scale terrestrial evapotranspiration modeling**

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## **Introduction**

This file contains two Tables and seven Figures. Table S1 is for multiyear mean annual  $ET_{wb}$  rates and linear trends in annual values during different periods. Table S2 displays summary performance statistics of the 18 HUC2-averaged annual ET time series from nine ET products during the full and GRACE periods. Figures S1 and S2 illustrate the evaluations of linear trends for the overlap of model and GRACE periods of the HUC2-averaged annual ET rates from nine ET products. Figures S3 and S4 illustrate the same evaluations of linear trends for the HUC6-averaged annual ET rates during the full and the model-overlap periods, respectively. Figures S5 and S6 display time series and interannual variability of HUC2-averaged annual ET rates from nine products and  $ET_{wb}$  during the full and GRACE-overlap periods, respectively. Figure S7 presents averages of several statistical metrics (for NSE median is used) of the modeled annual ET time-series for the 18 HUC2 basins during the full model and GRACE-overlap periods.

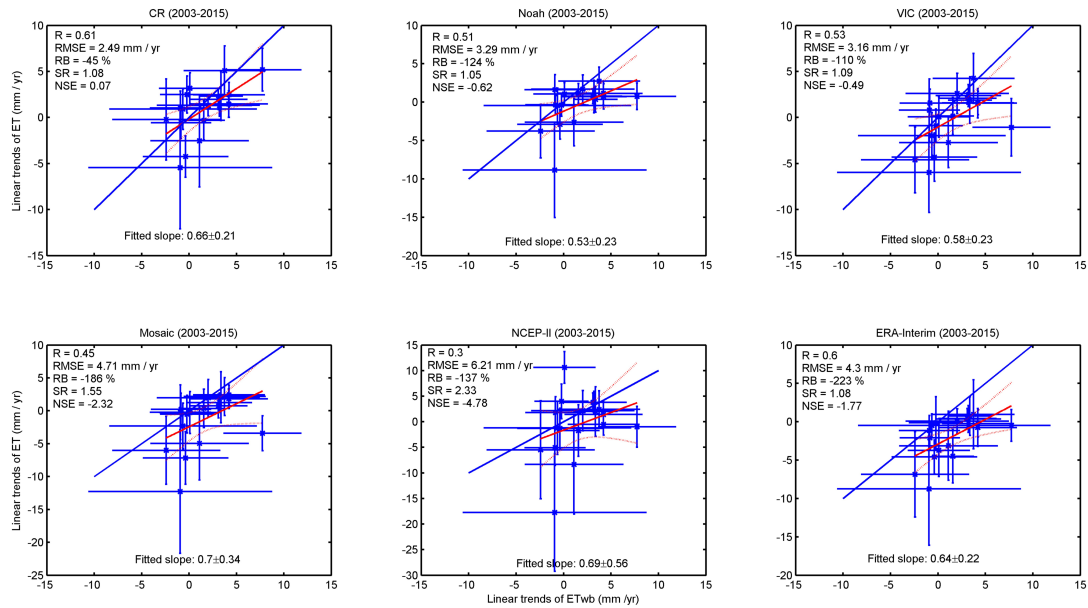
**Table S1.** Arithmetic averages and standard deviations (with the plus/minus sign) of the water-balance derived multiyear mean annual ET rates ( $ET_{wb}$ ) for the 18 HUC2 and 327 HUC6 basins across CONUS. The linear trends (with their standard errors) in the annual  $ET_{wb}$  values are also displayed for the different periods considered.

Period	Average annual $ET_{wb}$ (mm yr <sup>-1</sup> )		Linear trend (mm yr <sup>-1</sup> )	
	HUC2	HUC6	HUC2	HUC6
1979–2015	554 ± 209	597 ± 239	0.24 ± 1.41	0.29 ± 1.98
1980–2015	554 ± 209	597 ± 238	0.22 ± 1.52	0.31 ± 2.09
1981–2012	552 ± 207	594 ± 236	-0.69 ± 1.66	-0.82 ± 2.32
1982–2011	552 ± 207	594 ± 236	-0.48 ± 1.59	-0.66 ± 2.38
2003–2015	550 ± 213	591 ± 238	1.55 ± 2.59	2.39 ± 5.77
2003–2012	549 ± 215	590 ± 240	2.27 ± 8.57	0.3 ± 11.35
2003–2011	544 ± 208	584 ± 233	-0.78 ± 7.17	-0.18 ± 11.73

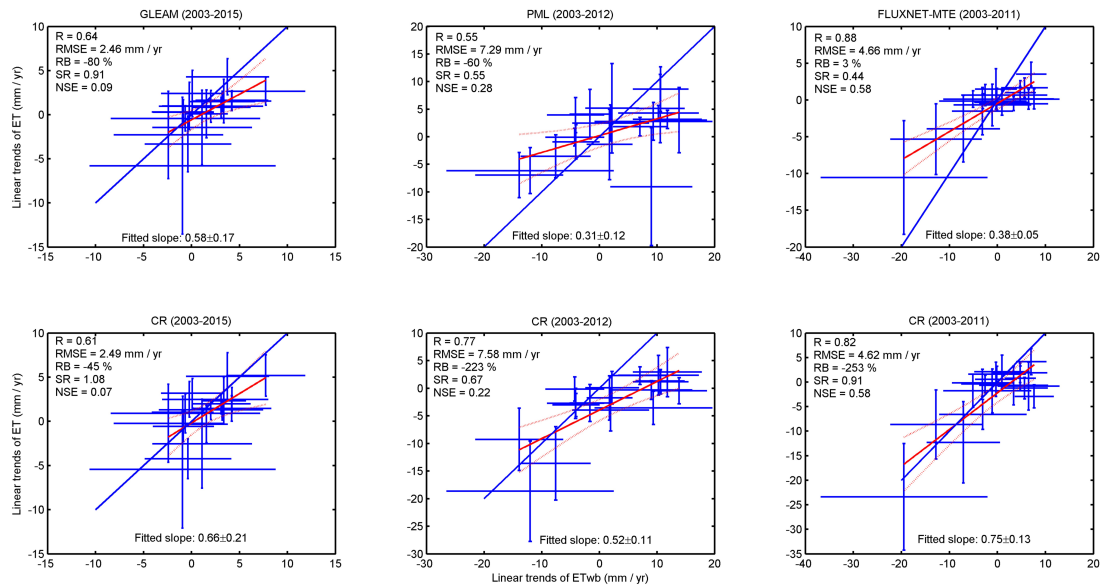
**Table S2.** Arithmetic averages (plus/minus standard deviation) of performance statistics from the 18 HUC2 annual ET time-series during the full and GRACE model periods. For NSE the median is applied due to frequent large negative values. Outstanding values in each category are emphasized.

Products	Full period					GRACE period				
	R	RMSE	RB	SR	NSE	R	RMSE	RB	SR	NSE
CR	0.47±0.22	<b>74.3±22.4</b>	<b>-3±13</b>	52±16	<b>-0.06</b>	0.44±0.32	<b>67.9±24.8</b>	-3±15	60±24	<b>-0.42</b>
Noah	<b>0.58±0.17</b>	111.0±34.7	-19±7	42±12	-1.38	<b>0.58±0.24</b>	100.0±33.5	-18±7	49±13	-3.36
VIC	0.55±0.16	135.3±88.6	-18±10	50±13	-2.15	0.33±0.36	126.1±86.2	-17±10	59±23	-1.81
Mosaic	0.53±0.25	114.0±69.3	15±15	<b>69±20</b>	-0.67	0.46±0.33	116.1±76.8	16±16	83±35	-1.97
NCEP-II	0.31±0.16	314.3±115.6	57±27	149±53	-28.4	0.25±0.38	360.0±134.0	68±31	<b>113±52</b>	-75.8
ERA-Interim	0.40±0.24	137.9±61.0	22±11	<b>67±34</b>	-2.38	0.42±0.34	111.0±64.9	17±11	73±37	-3.30
GLEAM	0.56±0.16	84.9±36.3	<b>-1±14</b>	49±20	-0.15	<b>0.57±0.26</b>	75.5±37.5	<b>-0.3±14</b>	60±30	-0.49
PML	0.26±0.36	94.9±34.2	-11±10	55±28	-1.1	0.37±0.39	88.5±31.9	-10±11	78±49	-1.19
FLUXNET-MTE	0.37±0.33	80.9±36.8	-6±9	25±9	-0.28	0.54±0.40	<b>63.1±34.0</b>	-4±10	32±18	-0.51

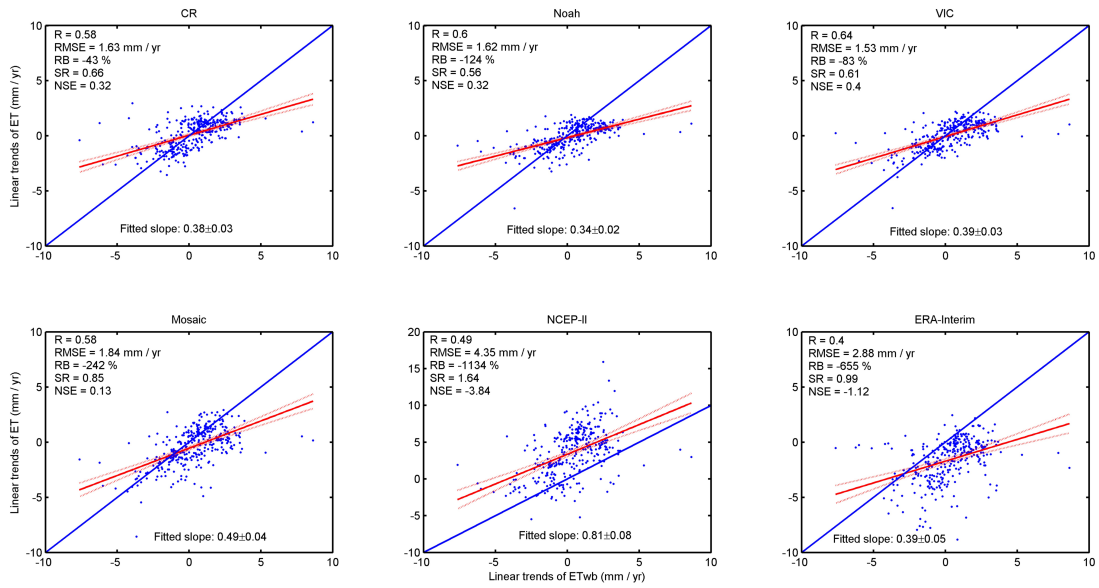
*Note.* The units of RMSE, RB, and SR are mm yr<sup>-1</sup>, %, and %, respectively; R and NSE are dimensionless.



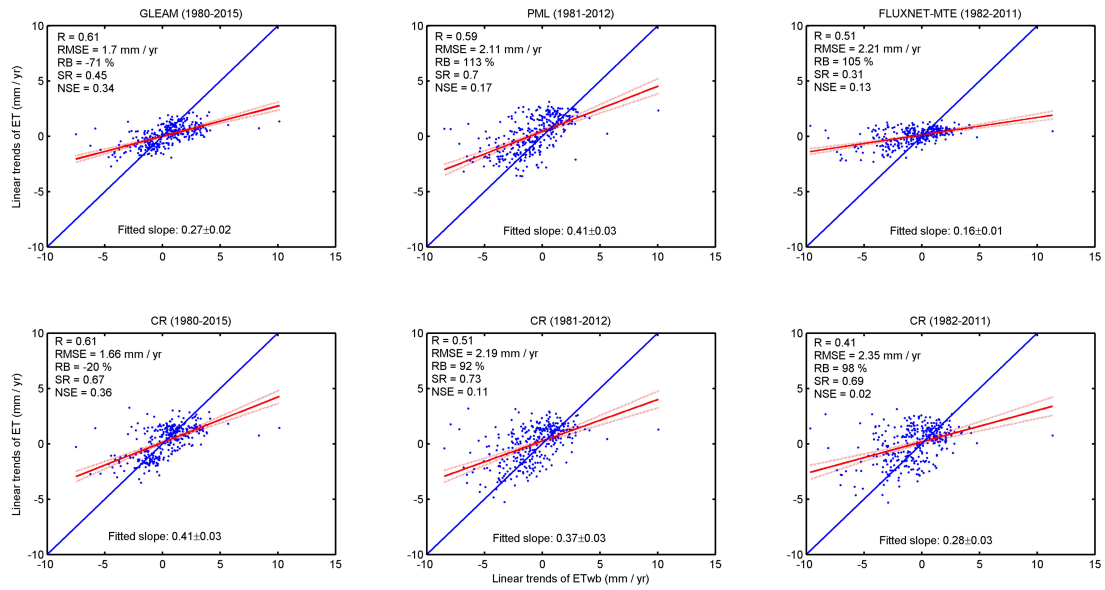
**Figure S1.** Regression plots of the linear trend values in HUC2-averaged annual ET rates (mm yr<sup>-1</sup>) from CR, Noah, VIC, Mosaic, NCEP-II, and ERA-Interim against those found in the water-balance  $ET_{wb}$  data over the whole GRACE period of 2003–2015 period. The length of the whiskers denotes the standard error in the estimated slope value. The strips around the fitted lines (red) denote the 95% confidence intervals and the long blue line represents a 1:1 relationship.



**Figure S2.** Regression plots of the linear trend values in HUC2-averaged annual ET rates ( $\text{mm yr}^{-1}$ ) from GLEAM, PML, and FLUXNET-MTE against those found in the water-balance  $ET_{wb}$  data over the overlaps with that of GRACE data (shown in parenthesis). For comparison, the regressions for the CR ET rates over the same periods are also displayed. The length of the whiskers denotes the standard error in the estimated slope value. The strips around the fitted lines (red) denote the 95% confidence intervals and the long blue line represents a 1:1 relationship.

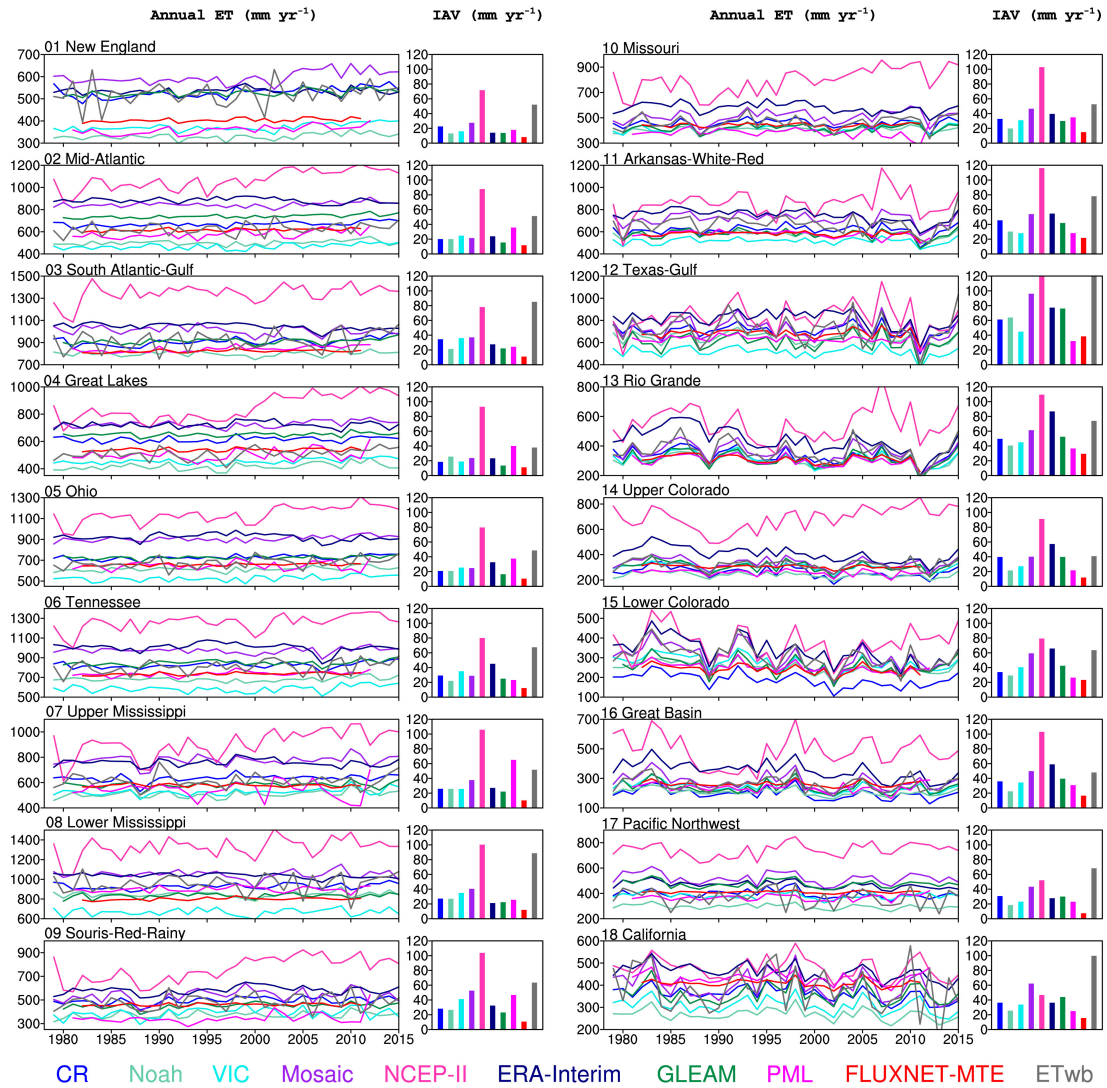


**Figure S3.** Regression plots of the linear trend values in HUC6-averaged annual ET rates ( $\text{mm yr}^{-1}$ ) from CR, Noah, VIC, Mosaic, NCEP-II, and ERA-Interim against those found in the water-balance  $ET_{wb}$  data over 1979–2015. The number of data points prohibits the use of whiskers for the standard error in the estimated slope value. The strips around the fitted lines (red) denote the 95% confidence intervals and the long blue line represents a 1:1 relationship.

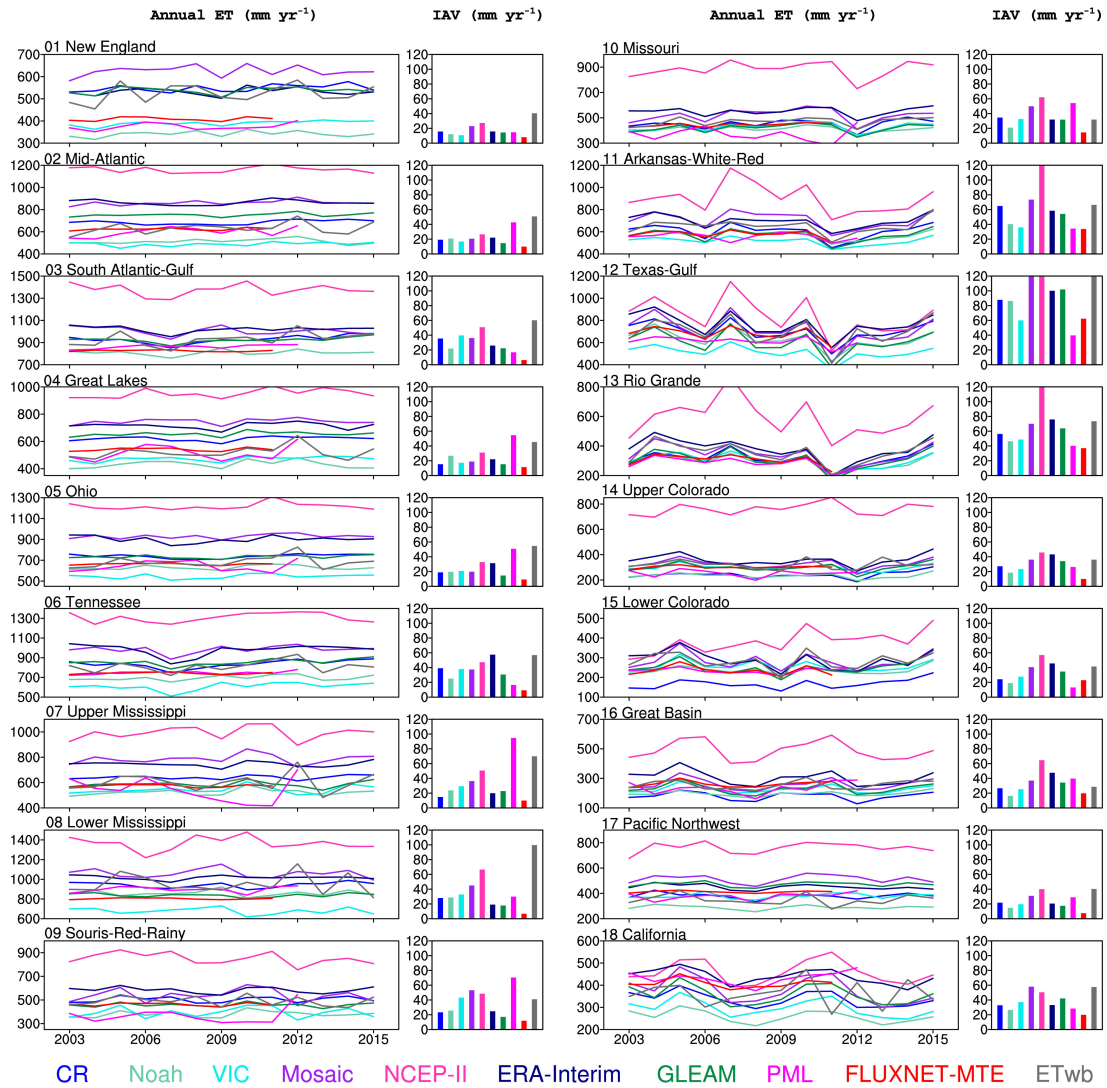


**Figure S4.** Regression plots of the linear trend values in HUC6-averaged annual ET rates ( $\text{mm yr}^{-1}$ ) from GLEAM, PML, and FLUXNET-MTE against those found in the water-balance  $ET_{wb}$  data over the available period (shown in parenthesis) of the data product. For comparison, the regressions for the CR ET rates over the same periods are also displayed. The number of data points prohibits the use of whiskers for the standard error in the estimated slope value. The strips around the fitted lines (red) denote the 95% confidence intervals and the long blue line represents a 1:1 relationship.

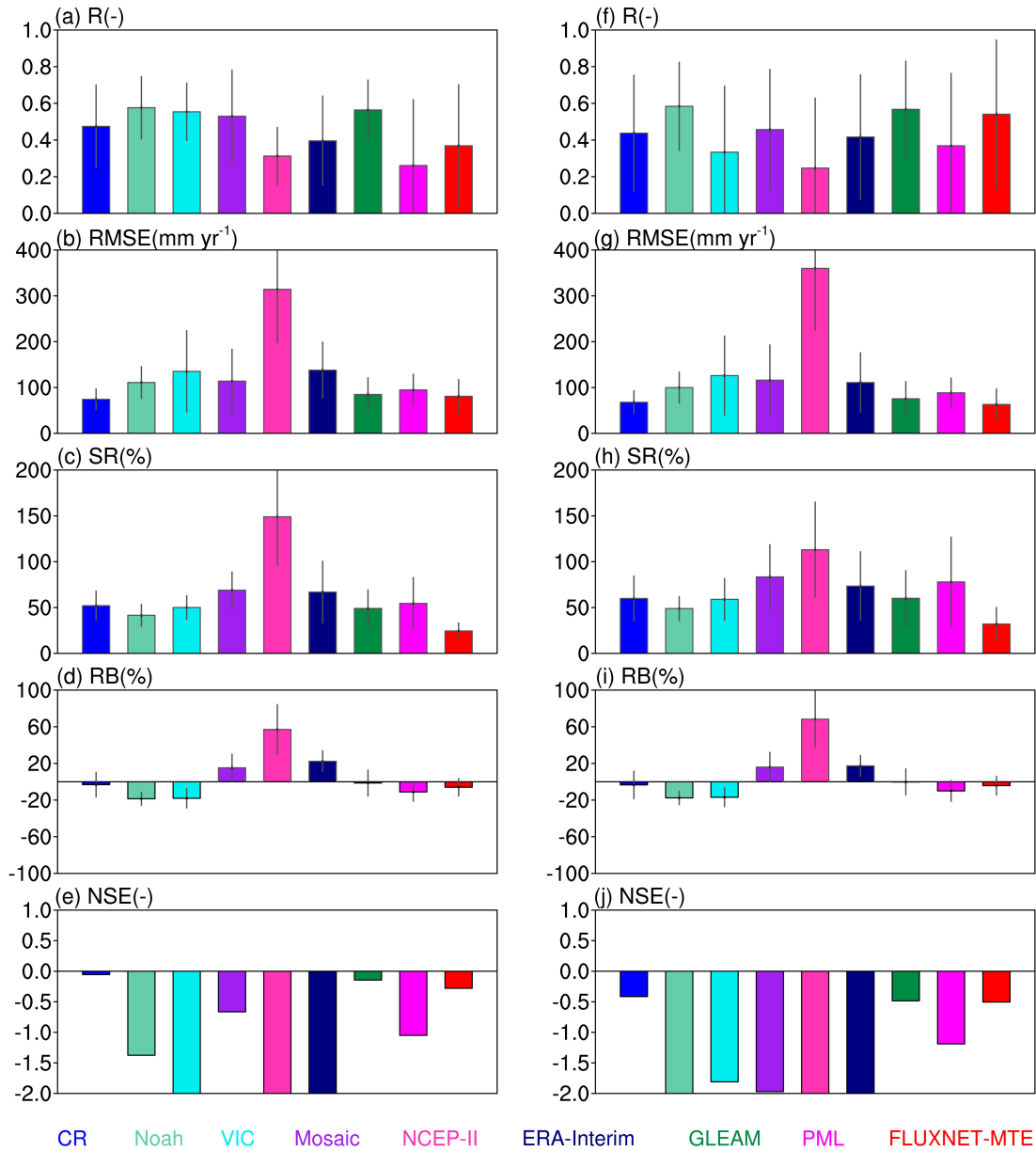




**Figure S5.** Time series and interannual variability (IAV) of the modeled and water-balance derived ( $ET_{wb}$ ) basin-averaged annual ET rates for the 18 HUC2 basins. For model periods see Table 1. IAV is represented by the standard deviation of the annual ET values.



**Figure S6.** Time series and interannual variability (IAV) of the GRACE-period (2003–2015) modeled and water-balance derived ( $ET_{wb}$ ) basin-averaged annual ET rates for the 18 HUC2 basins. Note that PML and FLUXNET-MTE ends in 2012 and 2011, respectively. IAV is represented by the standard deviation of the annual ET values.



**Figure S7.** Arithmetic averages (with error bars denoting the standard deviation) of the statistical values (R, RMSE, SR, RB) of the modeled annual ET time-series from the 18 HUC2 basins. (a-e) full model period; (f-j) overlap with the GRACE period of 2003–2015. For NSE the medians are displayed due to frequent large negative values that also prohibit the use of error bars and necessitate restricting the NSE window to [1, -2] for a meaningful visual comparison.