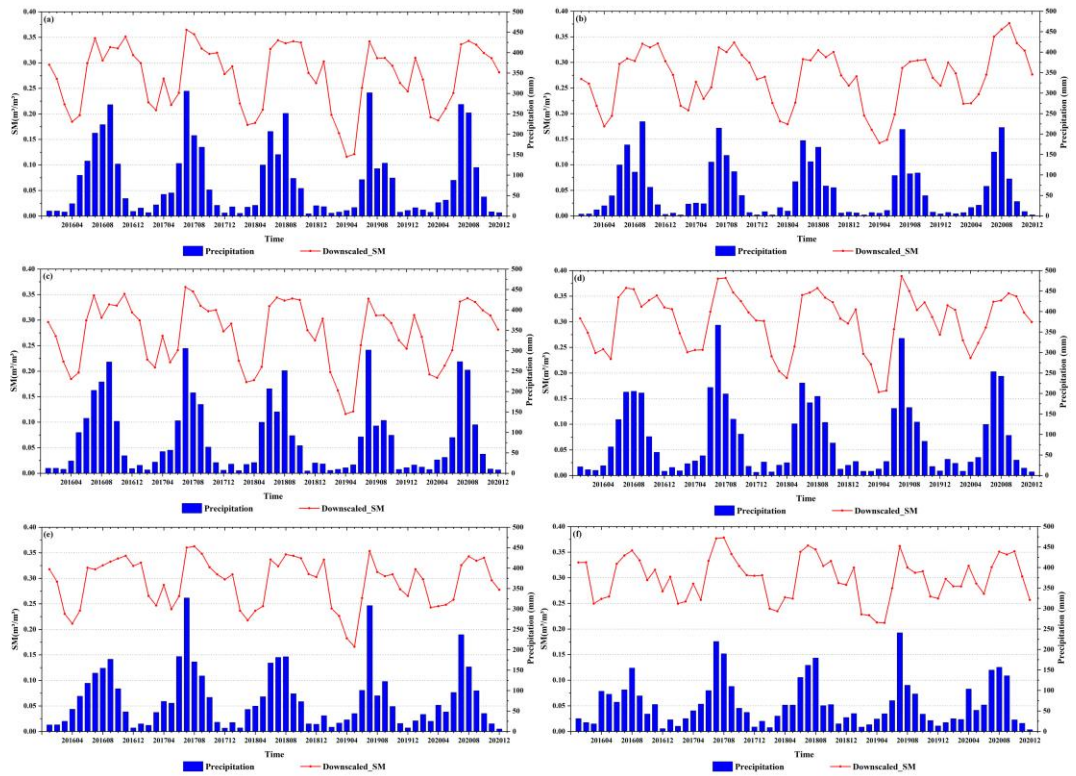
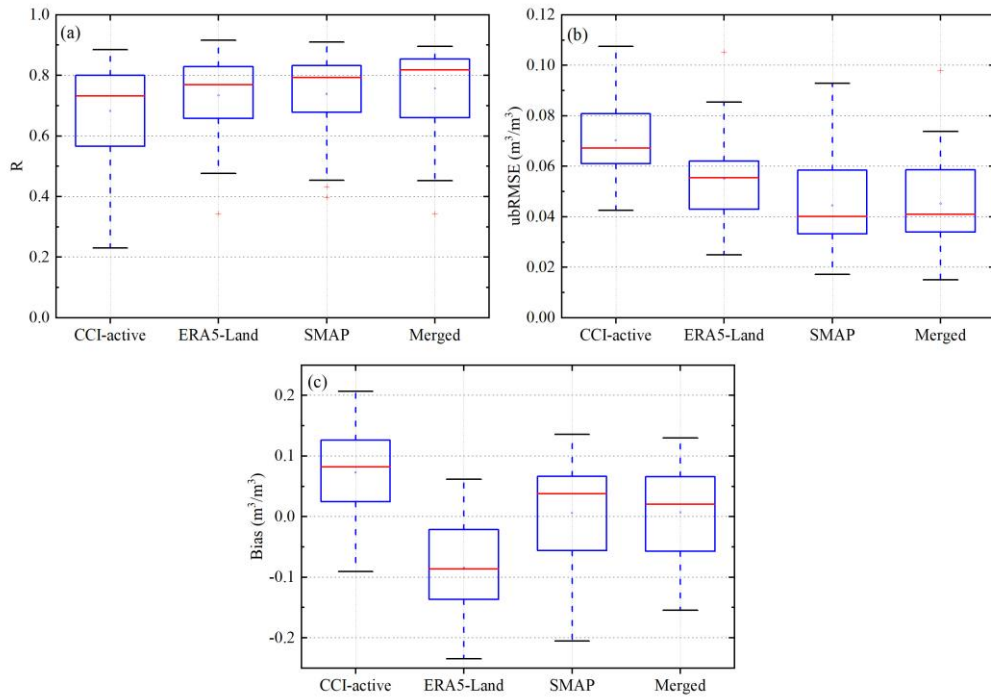


**Figure S1.** The spatial distribution of the cross-correlation of three SM products: (a) ERA5-Land-GLDAS; (b) ERA5-Land-SMAP; (3) GLDAS-SMAP. The pixels lacking significant correlation (at 95% confidence level) were set as null value.

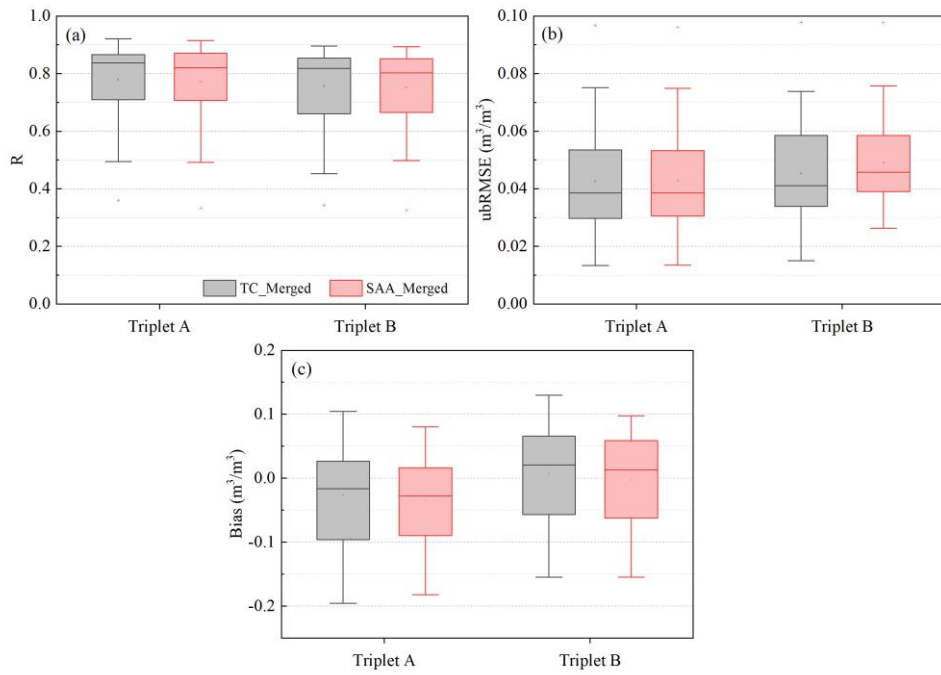


**Figure S2.** Temporal variations of downscaled SM and CHIRPS precipitation at representative site: (a) No.8 Station (100°34'E, 25°50'N, 1438.4m); (b) No.10 Station (101°52'E, 25°44'N, 1120.2m); (c) No.11 Station (101°32'E, 25°1'N, 1772.0m); (d) No.13 Station (102°41'E, 25°1'N, 1892.4m); (e) No.23 Station (102°33'E, 24°21'N, 1636.7m); (f) No.34 Station (103°23'E, 23°23'N, 1300.7m).



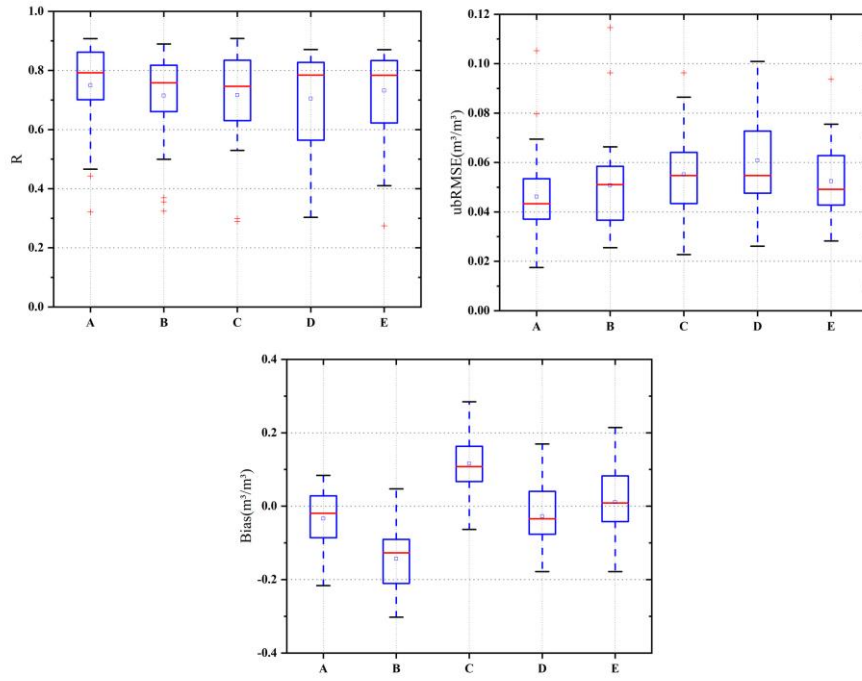


**Figure S3.** The evaluation of SM datasets using in situ observations for validation.



**Figure S4.** The evaluation of SM datasets merged by TC and simple arithmetic averaging (SAA) for two triplets using in situ observations for validation. Triplet A includes SMAP, ERA5-land and GLDAS and Triplet B includes CCI-active, ERA5-Land and SMAP.





**Figure S5.** Performance evaluation of the downscaling algorithms under different input schemes using in situ observations. The downscaling algorithm was run under five different input schemes as follows: scheme A: leave LST out, input NDVI, surface albedo, elevation, and soil texture; scheme B: leave NDVI out, input LST, surface albedo, elevation, and soil texture; scheme C: leave surface albedo out, input LST, NDVI, elevation, and soil texture; scheme D: leave elevation out, input LST, NDVI, surface albedo and soil texture; scheme E: leave soil texture out, input LST, NDVI, surface albedo, and elevation.