Supplement of Hydrol. Earth Syst. Sci., 22, 241–263, 2018
https://doi.org/10.5194/hess-22-241-2018-supplement

Hydrology and Earth System Sciences
Open Access

Supplement of

A Climate Data Record (CDR) for the global terrestrial water budget: 1984–2010

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Supplement I.

Precipitation:

(1) Satellite remote sensing

The CSU product (Bytheway and Kummerow, 2013) is actually the TRMM TMPA Data Set (1998-2010, (Huffman et al., 2007;Huffman et al., 2010)) accumulated rainfall with uncertainty estimates by referencing to the National Centers for Environmental Prediction (NCEP) Stage IV radar data set (Lin and Mitchell, 2005), which is a 3-hourly, 0.25° gridded product available from 50°N−50°S.

(2) In situ observation

The GPCC product (Schneider et al., 2014) is gridded rain gauge-analysis from in-situ observations which are collected by the World Meteorological Organization (WMO) at monthly, 0.5°. A number of approximate 67000 ground gauge stations over the globe are interpolated in GPCC.

(3) Hybrid data sets

The PGF dataset used in this study, which is an updated version of the PGF described in (Sheffield et al., 2006), provides near-surface meteorological data for driving land surface models and other terrestrial modeling systems. For the precipitation, the PGF combines reanalysis from National Centers for Environmental Prediction - National Center for Atmospheric Research (NECP-NCAR), satellite remote sensing from TRMM and Global Precipitation Climatology Project (GPCP), gauge observation from Climate Research Unit (CRU), and then disaggregates in time and space. The dataset is currently available at 0.25 degree, 3-hourly globally for 1948-2010.

CHIRPS (Funk et al., 2014) combines reanalysis from Climate Forecast System Version 2 (CFSv2), satellite remote sensing infrared (IR) from Climate Prediction Center (CPC) and National Climatic Data Center (NCDC), satellite remote sensing precipitation from TRMM, monthly precipitation climatology (CHPClim) with ground observations from a variety of sources. CHIRPS is currently available at 0.05° resolution from 1981 to near present at quasi-global (50°N−50°S, 180°N−180°S). In this study the global monthly CHIRPS at 0.5° is applied in order to keep a uniform spatial and temporal resolution with other products.

Evapotranspiration:

(1) Land Surface Model (LSM)

Forced by the near-surface meteorological variables from PGF mentioned above, the gridded runoff is simulated using the macro-scale land surface model VIC version 4.0.6 Full Energy Mode that is an updated version from (Sheffield and Wood, 2007) at 0.25 degree, 3 hourly over the land from 1948 to 2010. The VIC model has been applied for global analysis of drought as well in other applications at regional to continental scales (Maurer et al., 2002;Zhu and Lettenmaier, 2007;Sheffield et al., 2013;Nijssen et al., 2014;Troy et al., 2011;Nijssen et al., 1997;Maurer et al., 2001;Nijssen et al., 2001b;Nijssen et al., 2001a;Tang et al., 2010). The VIC model applied in this study has been calibrated over 43 well-distributed major global basins against the measured streamflow data from Global Runoff Data Center (GRDC, http://grdc.bagf.de). Given the extensive application of VIC in continental to global scale studies, we have confidence that it represents well the terrestrial water budget fluxes.

Un-calibrated CLM v3.5 (Dickinson et al., 2006) and NOAH v3.4 (Chen et al., 1996) are also forced by the same meteorological forcing from PGF at 1 degree, 3 hourly over the land for 1948-2010.

(2) Reanalysis

ERA-Interim (Simmons et al., 2006), which is a global atmospheric reanalysis from 1979 with a spatial resolution of approximately 80 km (T255 spectral), is provided by the European Centre for Medium-Range Weather Forecasts (ECMWF) and continuously updated at near real time.

MERRA (Rienecker et al., 2011), provided by NASA's Global Modeling and Assimilation Office (GMAO), applies the state-of-the-art GEOS-5 data assimilation system by "integrating a variety of observing systems with numerical models to produce a temporally and spatially consistent synthesis of observations and analyses of variables not easily observed" at a variety of spatial and temporal resolutions from 1979 to near present (http://gmao.gsfc.nasa.gov/research/merra/intro.php).

(3) Satellite remote sensing

GLEAM estimates the ET by calculating all the components of evapotranspiration ($ET = E_t + E_i + E_b + E_s + E_w$): transpiration ($E_t$) interception loss ($E_i$), bare soil evaporation (E_b), sublimation (E_s), and open water evaporation (E_w), based on the Priestley–Taylor equation and the Gash analytical model (Miralles et al., 2011b;Miralles et al., 2011a;Miralles et al., 2014). GLEAM v2 is applied in this study from http://www.gleam.eu/#home.

SRB-CFSR-PM and SRB-CFSR-PT (Vinukollu et al., 2011) estimate the evapotranspiration using Penman-Monteith (PM), and Priestly-Taylor (PT), which are forced by the Surface Radiation Budget (SRB) and the surface meteorology from Climate Forecast System Reanalysis(CFSR).

Similarly to SRB-CFSR-PM and SRB-CFSR-PT, SRB-PGF-PM and SRB-PGF-PT estimate the evapotranspiration using Penman-Monteith (PM) and Priestly-Taylor (PT) as well, but are forced by the Surface Radiation Budget (SRB) and the surface meteorology from Princeton Global Forcing (PGF).

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Supplement II.

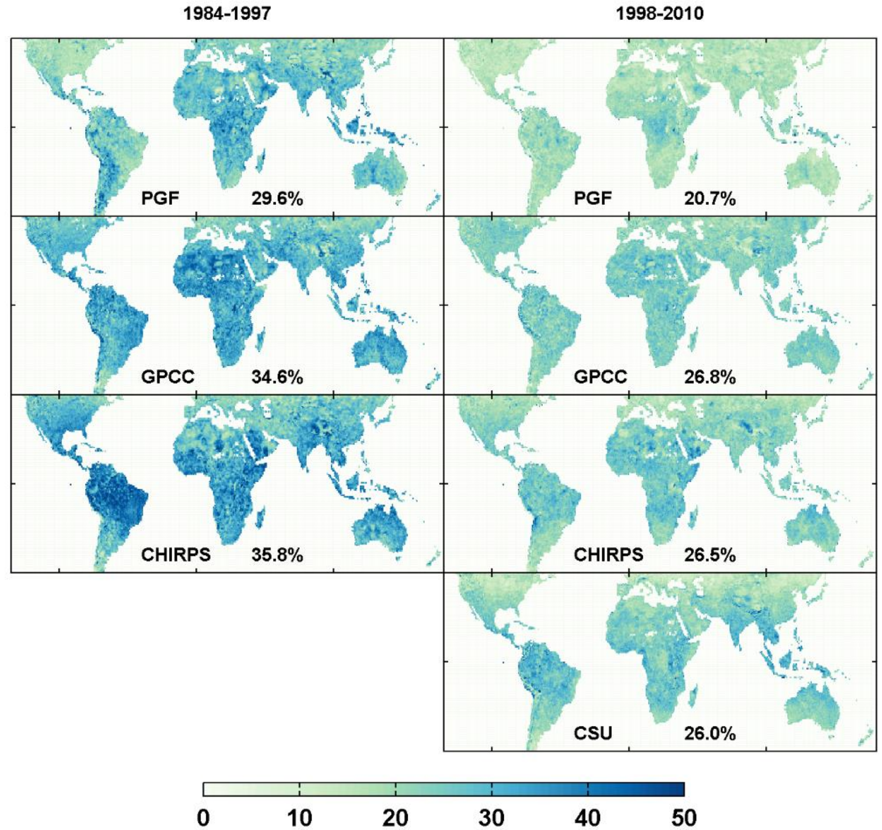

Figure S1. Monthly mean merging weights for the precipitation products during 1984-1997 (first column) and 1998-2010 (second column); CHIRPS and CSU only cover the quasi global region between 50°N- 50°S. For those regions outside 50°N-50°S, only PGF and GPCC were merged and the merging weights for PGF and GPCC are 50%, 50% respectively; The number listed on each sub-panel are the mean merging weight for each precipitation product. So as in Figure S2 and Figure S3, but for evapotranspiration and $TWSC$.

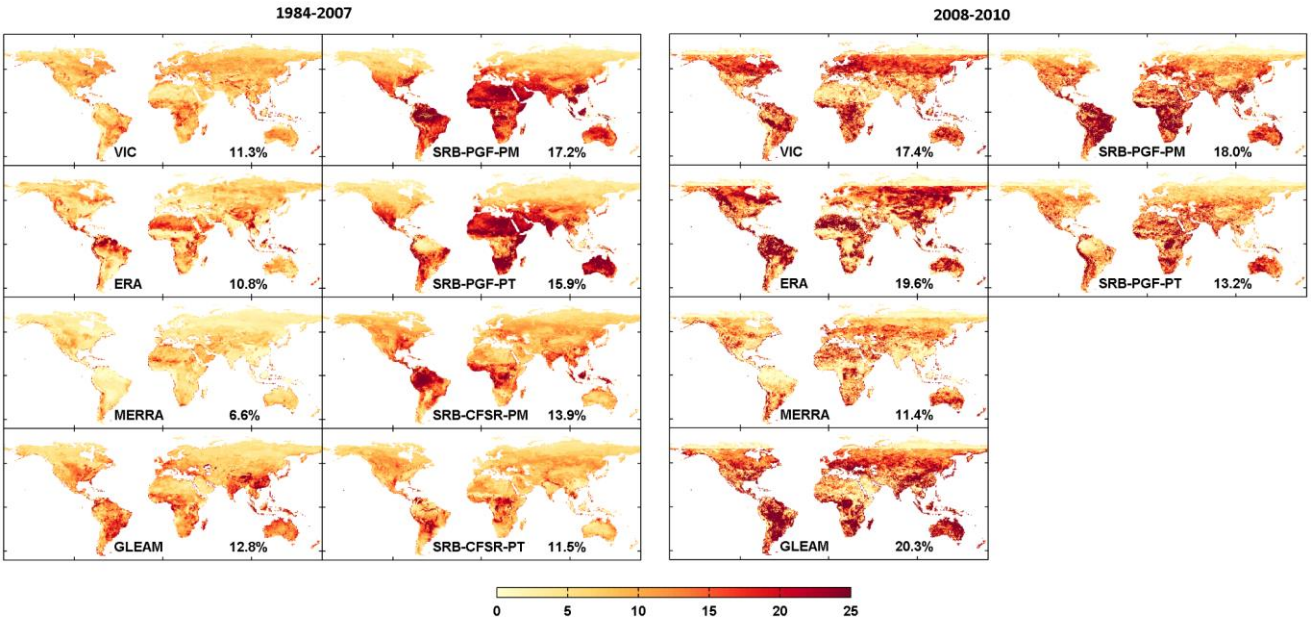

Figure S2. Monthly mean merging weights for the evapotranspiration products during 1984-2007 (left panel) and 2008-2010 (right panel)*;* Greenland and Antarctica excluded, the same for Figure S3

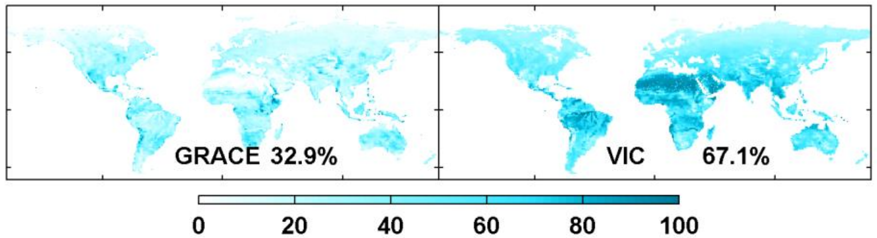

Figure S3. Monthly mean merging weights for $TWSC$ products during 2003-2010

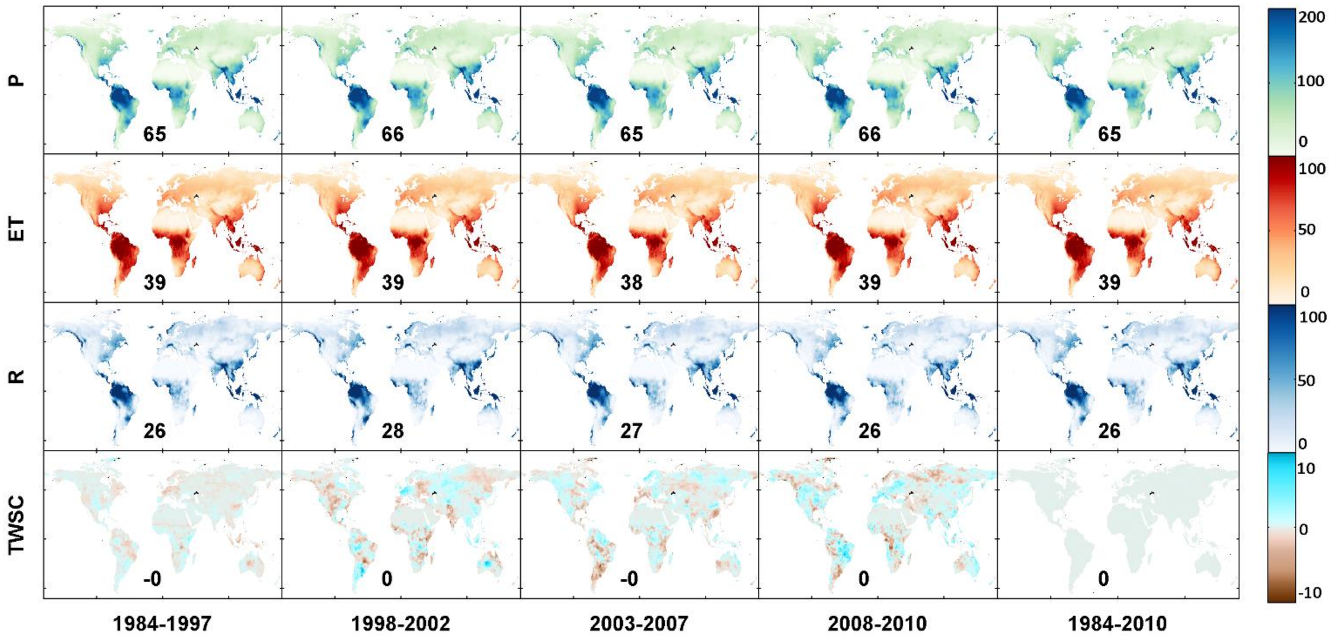

Figure S4. Monthly mean (mm/month) of different water budgets (from the first row to the bottom: precipitation, evapotranspiration, runoff, total water storage change) after water balance constraint throughout different periods (from the left to the right: 1984-1997, 1998-2002, 2003-2007, 2008-2010, and 1984-2010); The imbalance after water budget constraint is zero for each grid cell

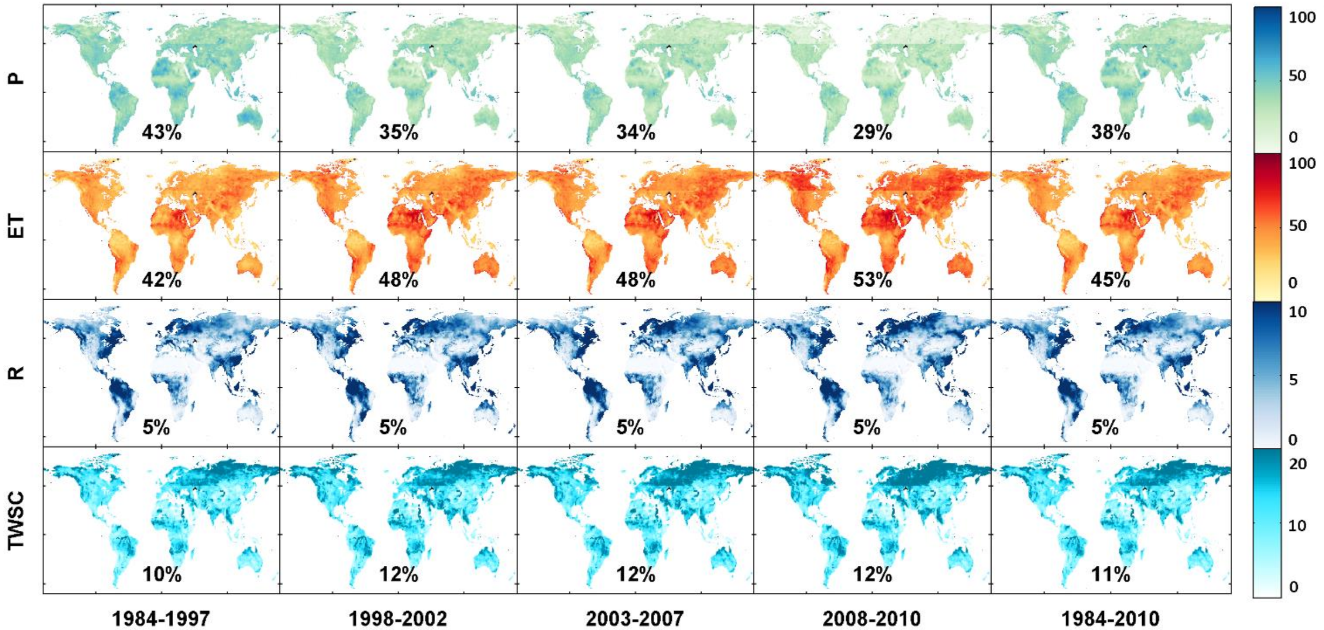

Figure S5. The imbalance/non-closure attributions (%) to different water budget variables (from the first row to the bottom: precipitation, evapotranspiration, runoff, total water storage change) throughout different periods (from the left to the right: 1984-1997, 1998-2002, 2003-2007, 2008-2010, and 1984-2010)

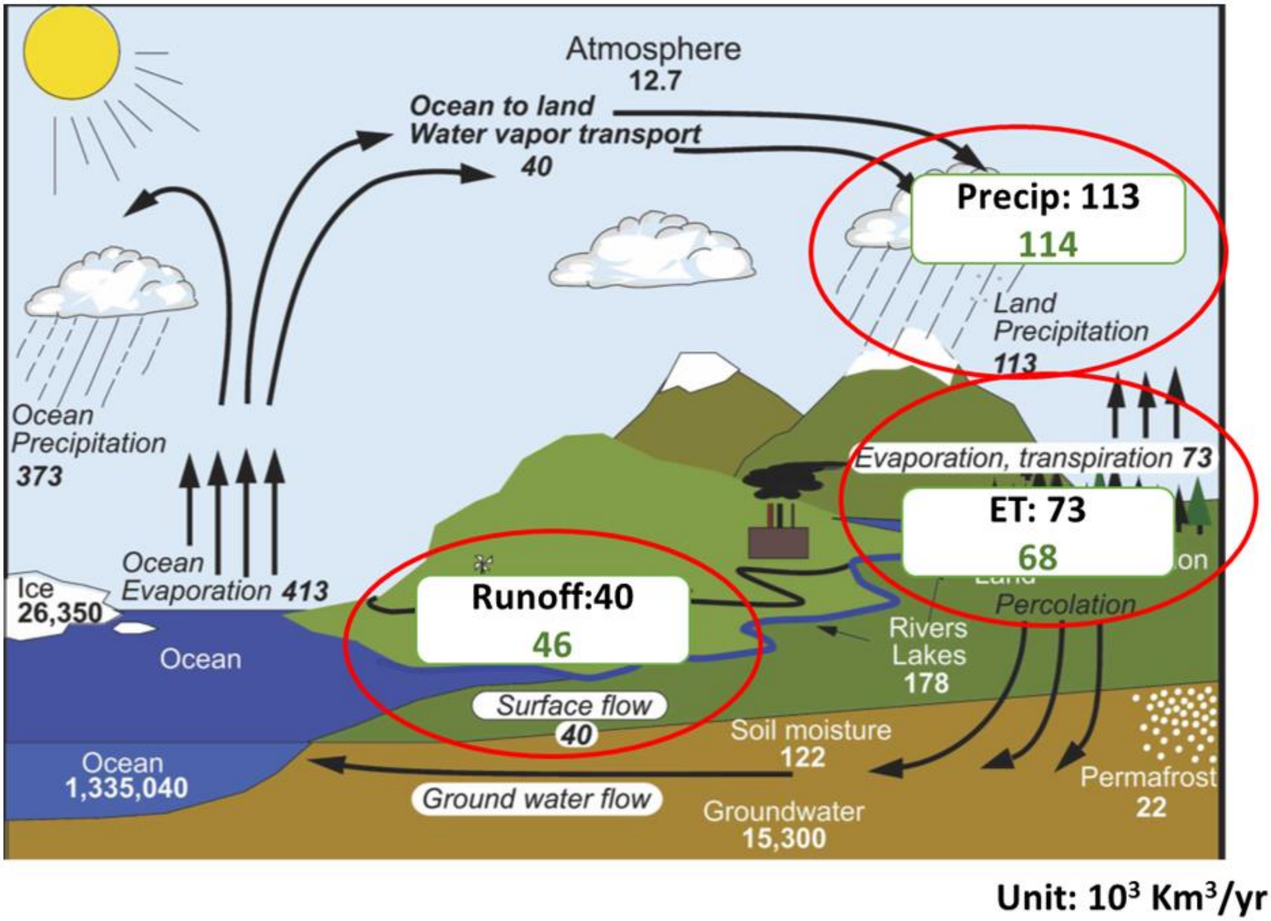

Figure S6 Comparison with Trenberth et al .2007 (This figure was modified from Trenberth et al. 2007)

Category	Description	Standardized Precipitation Index (SPI)
D0	Abnormally Dry	-0.5 to -0.7
D1	Moderate Drought	-0.8 to -1.2
D2	Severe Drought	-1.3 to -1.5
D3	Extreme Drought	-1.6 to -1.9
D4	Exceptional Drought	-2.0 or less

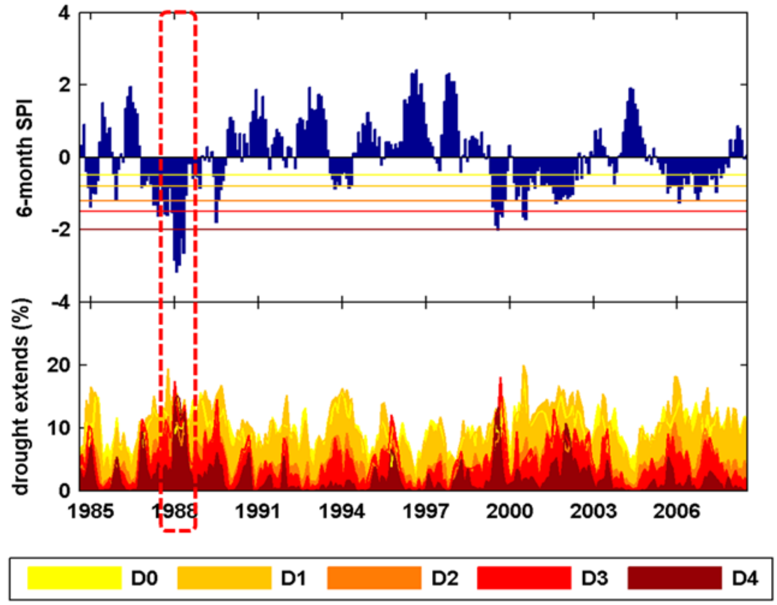

Figure S7 1998-1999 US drought captured by CDR in terms of 6-month SPI and drought extends calculated from CDR precipitation

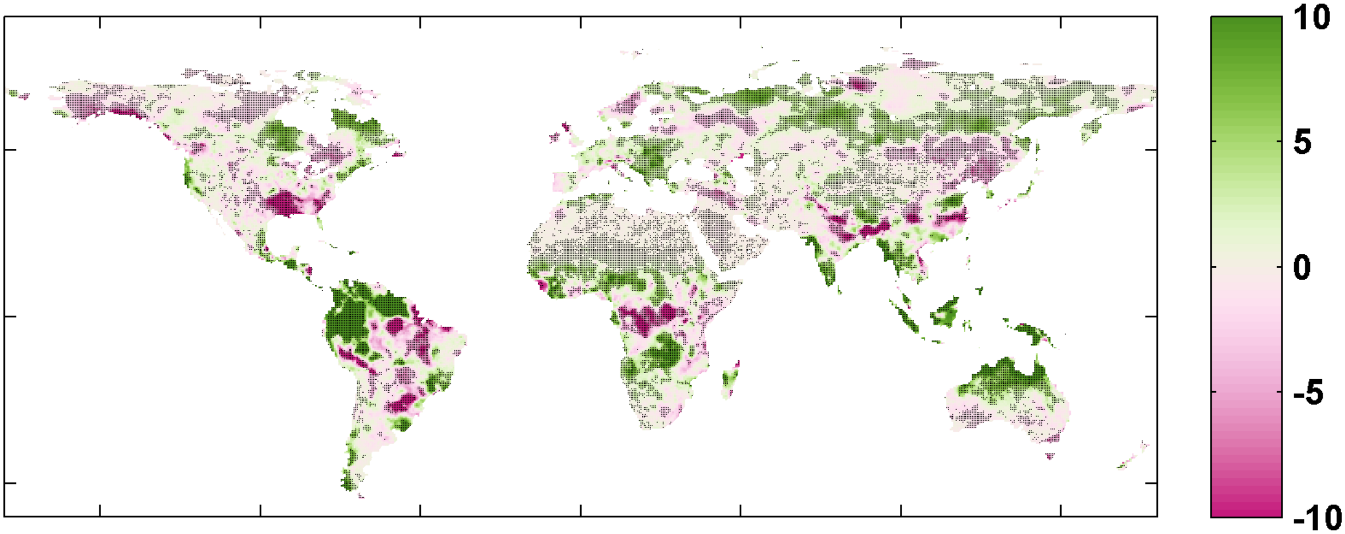

Figure S8 Inter-annual variability (mm/yr) of the available water (*P-ET*) during the CDR period 1984-2010. The black dots indicate the statistically significant trends (ρ<0.05)