Supplementary Material for
"Elusive drought: Uncertainty in observed trends and short- and long-term CMIP5 projections"

by B. Orlowsky and S. I. Seneviratne

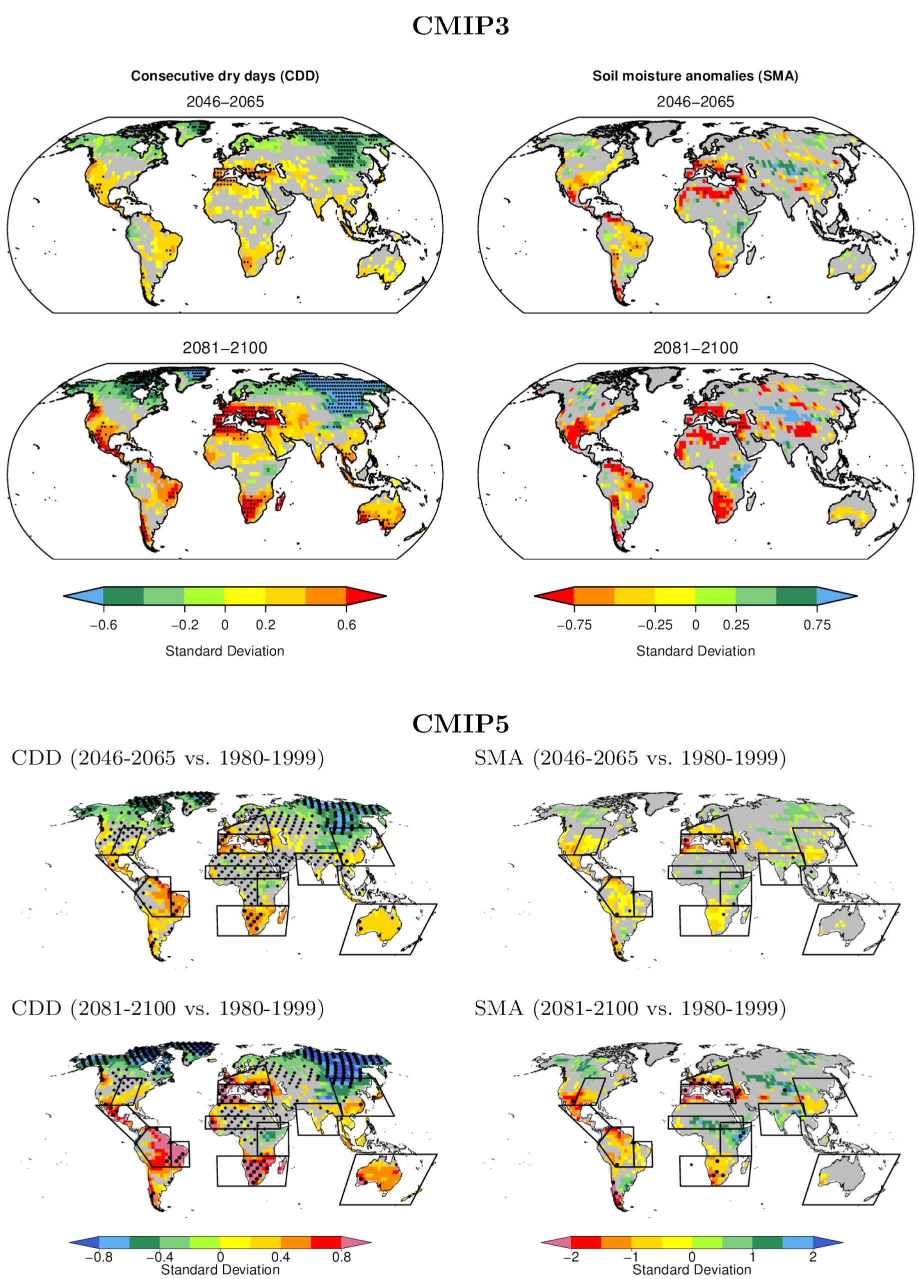

Figure S1: Changing drought projections in CMIP3 and CMIP5.
CMIP3 panels (see Orlowsky and Seneviratne, 2012, for details): Adapted from Fig. SPM5.1 of the SREX Summary for Policymakers (IPCC, 2012), the maps display multi-GCM averages of multi-year average changes

between present-day (1980-1999) and two future periods (2046-2065 and 2081-2100) in units of standard deviations. Future periods are simulated assuming the SRES-A2 emission scenario (Nakicenovic and Swart, 2001). Left: Changes in the annual maximum lengths of Consecutive Dry Days (CDD, meteorological drought); Right: Changes in average Soil Moisture Anomalies (SMA, soil moisture (agricultural) drought). Colour shading indicates at least 66% of the GCMs agreeing on the sign of change, additional stippling (black dots) indicates 90% agreement. Grey shading indicates GCM agreement on the sign below 66%. Contributing GCMs are listed in Tab. S1.

CMIP5 panels: the respective analyses from the CMIP5 ensemble. Colours and shading and colour stippling like in the top maps. Stippled grey shading (black diamonds) indicates consistent small changes (at least 66% of the GCMs display changes smaller than half a standard deviation).

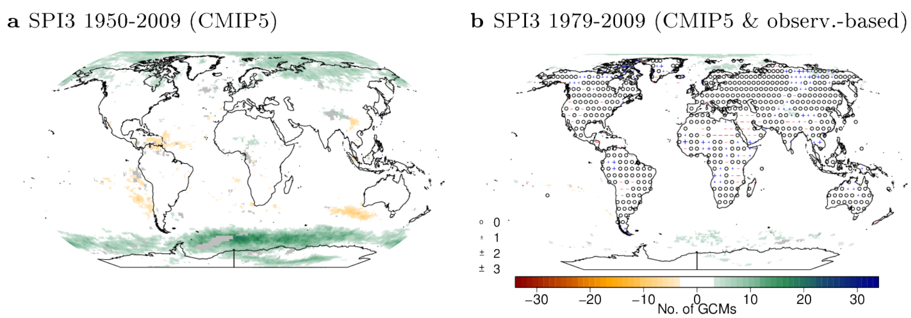

Figure S2: Consistency of drought trends in two observational periods (observations and CMIP5 GCM simulations) for SPI3. Colour shading is applied if the significant trends (evaluated at the 0.5 % significance level) across the CMIP5 ensemble are all of the same sign and indicates the number of GCMs with significant trends (green-blue for positive, orange-red for negative trends). White indicates regions where at least 90 % of the GCMs show no significant trends (consistently no change). All other areas are grey. Symbols in **(b)** show the same for three observational SPI3 datasets. "o": none of the three datasets shows a significant trends; blue "+" and red "−" indicate purely significant positive/wetting and negative/drying trends, respectively; the size of the symbol indicates the number of agreeing observation-based datasets (see legend at **b**).

Table S1: Climate research centres contributing to the IPCC AR4, their Global Climate Models (GCMs) from the IPCC AR4 ensemble (CMIP3), their horizontal resolution and the drought indicators calculated from them. SMA: Soil Moisture Anomalies (see Sect. 2 in the main text); CDD: Consecutive Dry Days (e.g. Alexander et al., 2006; Orlowsky and Seneviratne, 2012).

Institution	Model	Resolution	Indicators
Bjerknes Centre for Climate Research	BCCR-BCM2.0	T63	CDD
Canadian Centre for Climate Modeling and Analysis	CGCM3.1-T47	T47	CDD
Météo-France/Centre National de Recherches Météorologiques	CNRM-CM3	T63	CDD
CSIRO Atmospheric Research	CSIRO Mk3.0	T63	CDD
CSIRO Atmospheric Research	CSIRO Mk3.5	T63	CDD
NOAA/Geophysical Fluid Dynamics Laboratory	GFDL-CM2.0	144×90	CDD, SMA
NOAA/Geophysical Fluid Dynamics Laboratory	GFDL-CM2.1	144×90	CDD, SMA
NASA Goddard Institute for Space Studies	GISS-ER	72×46	CDD, SMA
Instituto Nazionale di Geofisica e Vulcanologia	INGV-ECHAM4	320×160	CDD, SMA
Institute for Numerical Mathematics	INM-CM3.0	72×45	CDD, SMA
Institute Pierre Simon Laplace	IPSL-CM4	96×72	CDD, SMA
Center for Climate System Research (University of Tokyo)	MIROC3.2-medres	T42	CDD, SMA
Meteorological Institute of the University of Bonn	ECHO-G	T30	CDD, SMA
Max Planck Institute for Meteorology	ECHAM5/MPI-OM	T63	CDD, SMA
Meteorological Research Institute	MRI-CGCM2.3.2	T42	CDD, SMA
National Center for Atmospheric Research	CCSM3	T85	CDD, SMA
National Center for Atmospheric Research	PCM	T42	CDD, SMA
Hadley Centre for Climate Prediction and Research, Met Office	UKMO-HadCM3	T63	SMA
Hadley Centre for Climate Prediction and Research, Met Office	UKMO-HadGEM1	T63	SMA

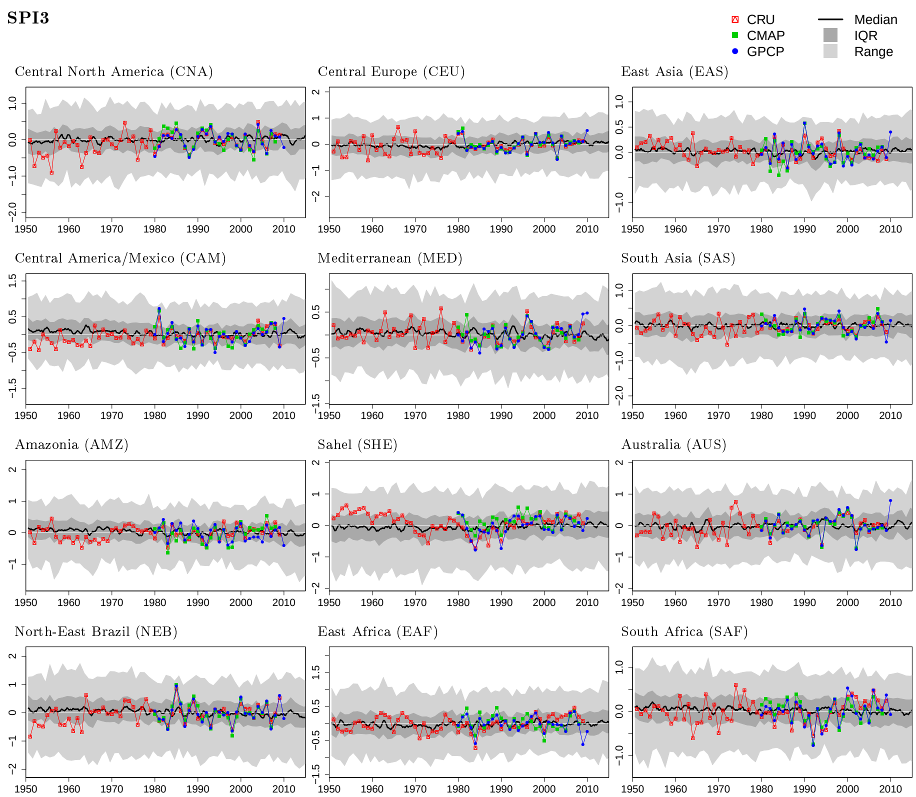

Figure S3: Observed and CMIP5 simulated SPI3: Annual averages of SPI3 values from three observational datasets (coloured lines) and median, inter-quartile range and total range across the CMIP5 ensemble (black line, dark grey and grey shading, respectively). Until 2005, CMIP5 data come from the historical simulations, after-wards, projections for the RCP8.5 GHG concentrations scenario are used. SPI3 values are calculated w.r.t. the 1979–2009 period for all datasets.

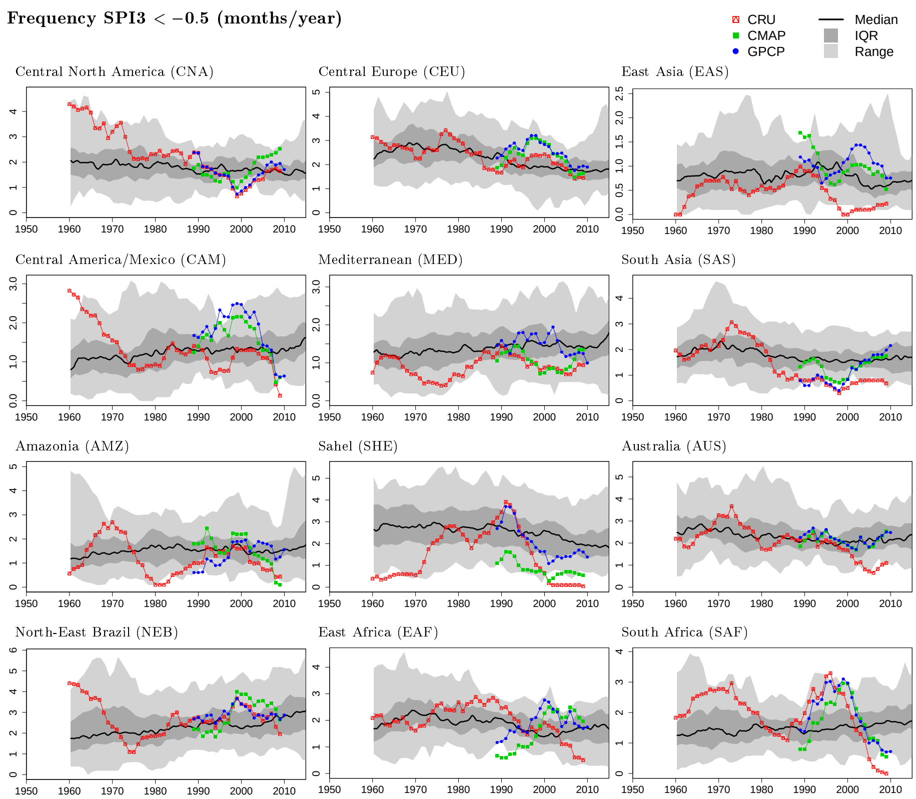

Figure S4: As Fig. S3, for the occurrence frequencies of "mild drought" (SPI3< −0.5) in observation-based datasets and CMIP5 simulations, derived from 10-year moving windows. Frequencies are given as months/year.

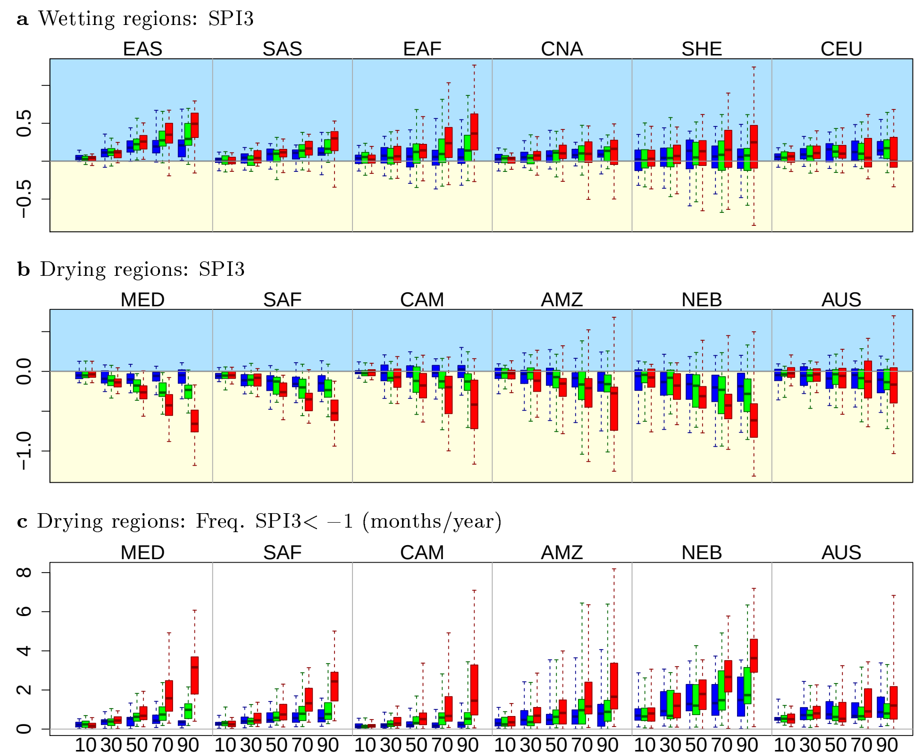

Figure S5: Future changes in SPI3. **(a)** Box plots for 20-yr average 3-month Standardised Precipitation Indices (SPI3) in regions where median SPI3 increases (wetting regions). The numbers at the bottom-most x-axis denote the central years in the 21st century of the 20-yr windows. Colours indicate the respective GHG concentrations scenario, blue: RCP2.6, green: RCP4.5 and red: RCP8.5. **(b)** like **(a)** but for regions where SPI decreases (drying regions). **(c)** Months per year in which SPI3< -1, calculated for moving 10-yr windows (same drying regions as in **(b)**). Changes are given as standard deviations w.r.t. 1979–2009 in both plots.

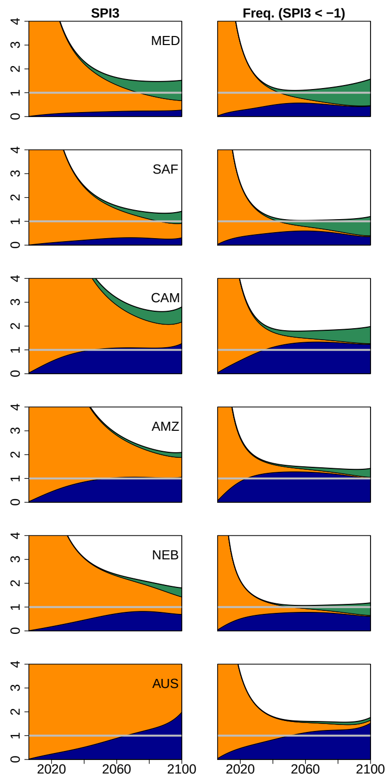

Figure S6: Fractional uncertainty, defined as uncertainty divided by the change since 2006, $F_y = \sqrt{T_y}/G_y$. Columns show F_y for magnitude and frequency (months per year with values < -1, calculated from 10-yr moving windows) of SPI3 for the analysed hot spot regions with decreasing median SPI12 (rows). Colours indicate the relative uncertainty contributions from GCM formulation (M_y, blue), internal variability (V, orange) and GHG concentrations scenarios (S_y, green). See main text for details.

References

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