Supplementary Materials:.

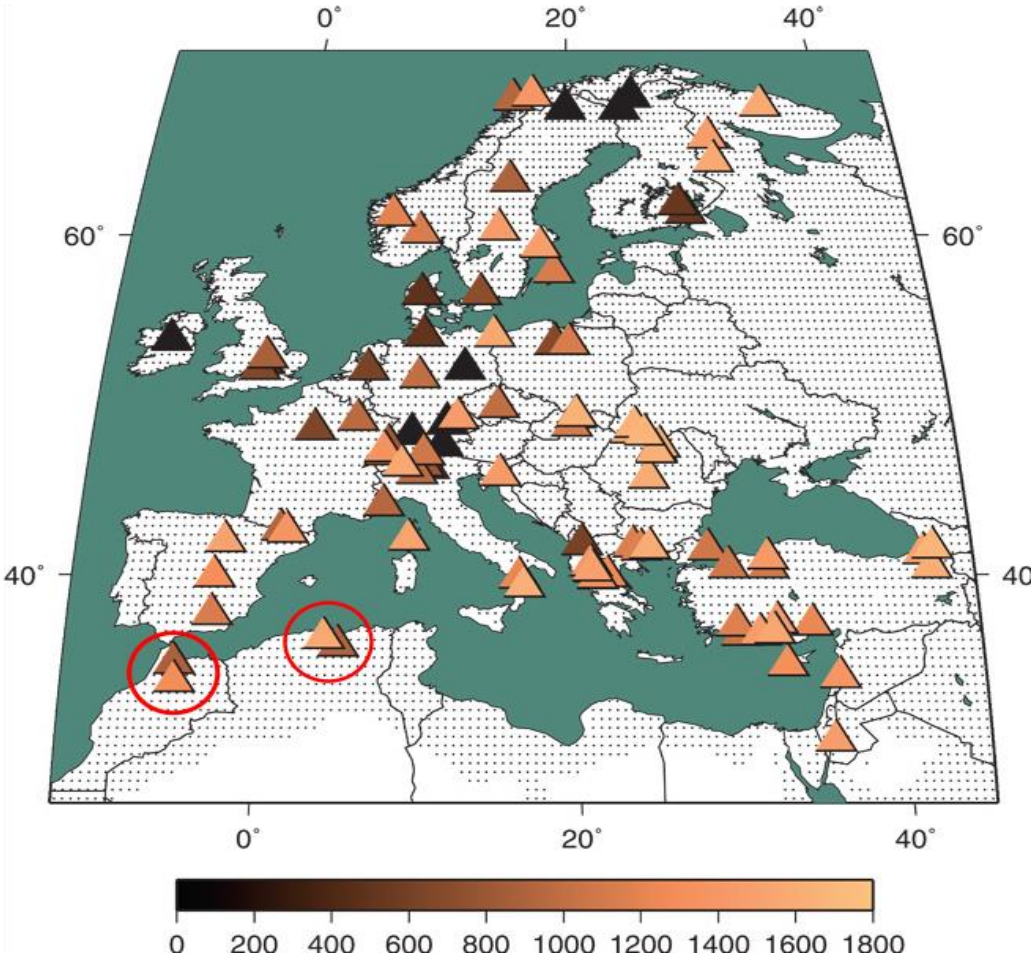

Figure S1. Locations of tree ring chronologies in the North African region of Old World Drought Atlas (OWDA). Colors and triangles indicate approximate start dates of various chronologies. Dark brown triangles circled in red represent two grid points (Algeria and Morocco), corresponding to sites were reconstructions of the OWDA are available in the region (map source: [34]).

.

Table S1. Correlation coefficients between calculated PDSI from Coupled Model Intercomparison Project (CMIP5) models and reconstructed from OWDA (none are significant).

Correlation test	CCSM4		MPI-ESM-P		CESM1 (mean)		Reconstructed PDSI	
	Algeria	Morocco	Algeria	Morocco	Algeria	Morocco	Algeria	Morocco
CCSM4	1	1	0.04	0.03	0.08	0.13	0.05	0.07
MPI-ESM-P			1	1	0.16	0.11	–0.005	0.03
CESM1 (mean)					1	1	0.04	0.06
Reconstructed PDSI							1	1

Table S2. Correlations between North Atlantic Oscillation (NAO) index and winter (DJFMA) precipitation for observations, reanalysis, and CMIP5 models over the three periods (1979–2005, 1850–1950, 850–1850). (Red indicates significance, with a p-value <0.05).

NAO		WEST		CENTER		EST	
	DATA	COR	P value	COR	P value	COR	P value
Recent Period	Dalware	-5.17×10^{-01}	1.47×10^{-03}	-4.54×10^{-01}	6.22×10^{-03}	1.23×10^{-01}	4.83×10^{-01}
	GPCC	-5.13×10^{-01}	1.64×10^{-03}	-4.62×10^{-01}	5.24×10^{-03}	2.06×10^{-01}	2.34×10^{-01}
	20c RE	-7.13×10^{-01}	1.54×10^{-06}	-6.43×10^{-01}	3.05×10^{-05}	-3.87×10^{-01}	2.17×10^{-02}
	CCSM4	-5.27×10^{-01}	2.31×10^{-03}	-9.92×10^{-02}	5.96×10^{-01}	2.72×10^{-01}	1.39×10^{-01}
	MPI ESM	-2.92×10^{-01}	1.10×10^{-01}	2.01×10^{-01}	2.79×10^{-01}	2.68×10^{-01}	1.45×10^{-01}
	IPSL LR	-3.74×10^{-01}	3.85×10^{-02}	-1.32×10^{-02}	9.44×10^{-01}	3.10×10^{-01}	9.01×10^{-02}
	GISS	3.05×10^{-02}	8.71×10^{-01}	1.73×10^{-01}	3.53×10^{-01}	2.18×10^{-01}	2.38×10^{-01}
	BCC	-4.49×10^{-01}	2.13×10^{-02}	-3.67×10^{-01}	6.49×10^{-01}	-2.61×10^{-01}	1.98×10^{-01}
	CESM1	2.57×10^{-02}	8.91×10^{-01}	2.50×10^{-02}	8.94×10^{-01}	-1.45×10^{-01}	4.35×10^{-01}
Past century	Dalware	-4.55×10^{-01}	1.94×10^{-06}	-1.29×10^{-01}	2.02×10^{-01}	2.99×10^{-01}	2.52×10^{-03}
	GPCC	-4.43×10^{-01}	4.02×10^{-06}	-1.29×10^{-01}	2.01×10^{-01}	3.38×10^{-01}	5.91×10^{-04}
	20c RE	-6.65×10^{-01}	4.63×10^{-14}	-4.66×10^{-01}	1.02×10^{-06}	-2.77×10^{-01}	5.28×10^{-03}
	CCSM4	-2.16×10^{-01}	2.97×10^{-02}	1.00×10^{-01}	3.19×10^{-01}	3.38×10^{-01}	5.55×10^{-04}
	MPI ESM	-4.96×10^{-01}	1.32×10^{-07}	-1.71×10^{-01}	8.72×10^{-02}	1.72×10^{-01}	8.51×10^{-02}
	IPSL LR	-1.60×10^{-01}	1.10×10^{-01}	1.65×10^{-01}	9.85×10^{-02}	3.68×10^{-01}	1.51×10^{-04}
	GISS	-1.77×10^{-01}	7.71×10^{-02}	8.73×10^{-02}	3.85×10^{-01}	3.08×10^{-01}	1.75×10^{-03}
	BCC	7.89×10^{-02}	4.33×10^{-01}	8.48×10^{-02}	3.99×10^{-01}	1.20×10^{-01}	2.31×10^{-01}
	CESM1	-1.23×10^{-01}	2.22×10^{-01}	9.09×10^{-04}	9.93×10^{-01}	3.36×10^{-02}	7.40×10^{-01}
Past millennia	CCSM4	-2.60×10^{-01}	$5.92 \times$	$-1.84 \times$	$5.60 \times$	$1.66 \times$	$1.30 \times$

		10^{-07}	10^{-02}	10^{-01}	10^{-01}	10^{-07}
MPI ESM	-4.64×10^{-01}	1.40×10^{-54}	-1.06×10^{-01}	8.09×10^{-04}	7.18×10^{-03}	2.32×10^{-02}
IPSL LR	-3.30×10^{-01}	8.74×10^{-27}	2.86×10^{-02}	3.67×10^{-01}	3.12×10^{-01}	3.67×10^{-02}
GISS	-1.10×10^{-01}	5.12×10^{-04}	1.38×10^{-01}	1.16×10^{-05}	1.38×10^{-01}	1.16×10^{-05}
BCC	-1.99×10^{-01}	2.30×10^{-01}	3.35×10^{-02}	2.89×10^{-01}	3.35×10^{-02}	2.89×10^{-01}
CESM1	-3.95×10^{-02}	2.13×10^{-01}	1.60×10^{-02}	6.14×10^{-01}	-2.48×10^{-014}	9.94×10^{-01}

Table S3. Correlations between West Mediterranean Oscillation (WeMO) index and winter (DJFMA) precipitation for observations, reanalysis, and CMIP5 models over the three periods (1979–2005, 1850–1950, 850–1850). (Red indicates significance, with a p-value <0.05).

WeMOI		WEST		CENTER		EST	
	MODEL	COR	P value	COR	P value	COR	P value
Recent period	Dalware	−3.34 × 10^{-01}	4.98 × 10^{-02}	−1.22 × 10^{-02}	9.45 × 10^{-01}	−1.37 × 10^{-01}	4.33 × 10^{-01}
	GPCC	−3.19 × 10^{-01}	6.21 × 10^{-02}	−1.00 × 10^{-01}	5.66 × 10^{-01}	−1.45 × 10^{-01}	4.06 × 10^{-01}
	20c RE	−6.51 × 10^{-01}	2.30 × 10^{-05}	−5.16 × 10^{-01}	1.50 × 10^{-03}	−3.85 × 10^{-01}	2.22 × 10^{-02}
	CCSM4	−4.41 × 10^{-01}	1.29 × 10^{-02}	−1.96 × 10^{-01}	2.91 × 10^{-01}	5.71 × 10^{-03}	9.76 × 10^{-01}
	MPI ESM	−5.30 × 10^{-01}	2.19 × 10^{-03}	−2.66 × 10^{-01}	1.48 × 10^{-01}	−2.60 × 10^{-01}	1.58 × 10^{-01}
	IPSL LR	−4.71 × 10^{-01}	7.45 × 10^{-03}	−2.39 × 10^{-01}	1.95 × 10^{-01}	−7.73 × 10^{-02}	6.79 × 10^{-01}
	GISS	1.77 × 10^{-02}	9.25 × 10^{-01}	−2.11 × 10^{-01}	2.53 × 10^{-01}	−5.32 × 10^{-02}	7.76 × 10^{-01}
	BCC	−6.83 × 10^{-02}	7.40 × 10^{-01}	8.74 × 10^{-02}	6.71 × 10^{-01}	3.18 × 10^{-01}	1.14 × 10^{-01}
	CESM1	−1.34 × 10^{-01}	4.71 × 10^{-01}	−2.49 × 10^{-01}	1.77 × 10^{-01}	−2.45 × 10^{-01}	1.85 × 10^{-01}
Past century	Dalware	−4.88 × 10^{-01}	2.60 × 10^{-07}	−4.48 × 10^{-02}	6.58 × 10^{-01}	1.28 × 10^{-01}	2.06 × 10^{-01}
	GPCC	−5.04 × 10^{-01}	9.09 × 10^{-08}	−6.20 × 10^{-02}	5.40 × 10^{-01}	1.11 × 10^{-01}	2.70 × 10^{-01}
	20c RE	−4.41 × 10^{-01}	4.42 × 10^{-06}	−4.19 × 10^{-01}	1.40 × 10^{-05}	−2.36 × 10^{-01}	1.80 × 10^{-02}
	CCSM4	3.70 × 10^{-01}	1.42 × 10^{-04}	1.81 × 10^{-01}	7.00 × 10^{-02}	6.84 × 10^{-02}	4.97 × 10^{-01}
	MPI ESM	−5.46 × 10^{-01}	3.63 × 10^{-09}	−4.72 × 10^{-01}	6.10 × 10^{-06}	−2.72 × 10^{-01}	5.87 × 10^{-03}
	IPSL LR	−2.21 × 10^{-01}	2.65 × 10^{-02}	1.53 × 10^{-02}	8.79 × 10^{-01}	−8.65 × 10^{-02}	3.90 × 10^{-01}
	GISS	3.91 × 10^{-01}	5.30 × 10^{-05}	2.36 × 10^{-01}	1.76 × 10^{-02}	1.39 × 10^{-01}	1.67 × 10^{-01}
	BCC	−8.11 × 10^{-02}	4.20× 10^{-01}	−1.30 × 10^{-01}	1.95 × 10^{-01}	−1.15 × 10^{-01}	2.54 × 10^{-01}
	CESM1	7.61 × 10^{-02}	4.52× 10^{-01}	−3.72 × 10^{-04}	9.97 × 10^{-01}	1.45 × 10^{-01}	1.51 × 10^{-01}
Past millennium	CCSM4	−2.88 × 10^{-01}	1.31 × 10^{-02}	−1.23 × 10^{-01}	9.10 × 10^{-05}	−7.76 × 10^{-02}	1.41 × 10^{-02}
	MPI ESM	−5.47 × 10^{-01}	5.89 × 10^{-79}	−4.08 × 10^{-01}	2.33 × 10^{-41}	−2.20 × 10^{-01}	1.79 × 10^{-12}
	IPSL LR	−3.39 × 10^{-01}	2.88 × 10^{-28}	−1.77 × 10^{-01}	1.67 × 10^{-08}	−1.55 × 10^{-01}	7.93 × 10^{-07}
	GISS	3.44 × 10^{-01}	3.03 × 10^{-29}	2.45 × 10^{-01}	3.39 × 10^{-15}	2.45 × 10^{-01}	3.39 × 10^{-15}
	BCC	5.23 × 10^{-01}	2.23 × 10^{-71}	4.31 × 10^{-01}	1.24 × 10^{-46}	4.31 × 10^{-01}	1.24 × 10^{-46}
	CESM1	4.96 × 10^{-02}	1.17 × 10^{-01}	3.33 × 10^{-02}	2.93 × 10^{-01}	5.56 × 10^{-02}	7.92 × 10^{-02}

Table S4. Correlations between Mediterranean Oscillation (MO) index and winter (DJFMA) precipitation for observations, reanalysis, and CMIP5 models over the three periods (1979–2005, 1850–1950, 850–1850). (Red indicates significance, with a p-value <0.05).

MOI		WEST		CENTER		EST	
	DATA	COR	P value	COR	P value	COR	P value
Recent period	Dalware	-3.11×10^{-01}	6.91×10^{-02}	-1.49×10^{-02}	9.32×10^{-01}	1.89×10^{-01}	2.77×10^{-01}
	GPCC	-3.33×10^{-01}	5.08×10^{-02}	-3.34×10^{-02}	8.49×10^{-01}	2.01×10^{-01}	2.46×10^{-01}
	20c RE	-6.34×10^{-01}	4.40×10^{-05}	-5.85×10^{-01}	2.27×10^{-04}	-2.51×10^{-01}	1.45×10^{-01}
	CCSM4	-6.42×10^{-01}	9.84×10^{-05}	-1.38×10^{-01}	4.61×10^{-01}	3.85×10^{-01}	1.69×10^{-02}
	MPI ESM	-6.38×10^{-01}	1.14×10^{-04}	-4.20×10^{-01}	1.86×10^{-02}	-5.93×10^{-02}	7.51×10^{-01}
	IPSL LR	-5.26×10^{-01}	2.35×10^{-03}	-1.62×10^{-01}	3.85×10^{-01}	3.38×10^{-01}	6.25×10^{-02}
	GISS	-2.42×10^{-01}	1.90×10^{-01}	-1.38×10^{-01}	1.90×10^{-01}	3.72×10^{-01}	4.60×10^{-01}
	BCC	2.84×10^{-01}	1.60×10^{-01}	1.48×10^{-01}	4.71×10^{-01}	-1.48×10^{-02}	9.43×10^{-01}
	CESM1	-2.17×10^{-01}	2.41×10^{-01}	-2.72×10^{-01}	1.39×10^{-01}	-1.67×10^{-02}	9.29×10^{-01}
Past century	Dalware	-5.01×10^{-01}	1.12×10^{-07}	-1.59×10^{-01}	1.13×10^{-01}	2.83×10^{-01}	4.28×10^{-03}
	GPCC	-5.01×10^{-01}	1.08×10^{-07}	-1.63×10^{-01}	1.04×10^{-01}	2.84×10^{-01}	4.14×10^{-03}
	20c RE	-5.07×10^{-01}	7.14×10^{-08}	-3.92×10^{-01}	5.43×10^{-05}	-1.45×10^{-01}	1.50×10^{-01}
	CCSM4	-5.63×10^{-01}	8.62×10^{-10}	-9.10×10^{-02}	3.65×10^{-01}	4.88×10^{-01}	2.27×10^{-07}
	MPI ESM	-5.90×10^{-01}	8.59×10^{-11}	-5.44×10^{-01}	4.23×10^{-09}	-3.63×10^{-02}	7.18×10^{-01}
	IPSL LR	-5.00×10^{-01}	1.02×10^{-07}	-2.47×10^{-01}	1.26×10^{-02}	2.67×10^{-01}	7.02×10^{-03}
	GISS	-3.54×10^{-01}	2.76×10^{-04}	-1.01×10^{-01}	3.13×10^{-01}	2.71×10^{-01}	6.18×10^{-03}
	BCC	3.97×10^{-02}	6.93×10^{-01}	-4.04×10^{-02}	6.88×10^{-01}	-6.57×10^{-02}	5.14×10^{-01}
Past millennium	CESM1	2.32×10^{-02}	8.19×10^{-01}	4.73×10^{-02}	6.40×10^{-01}	1.07×10^{-01}	2.88×10^{-01}
	CCSM4	-4.00×10^{-01}	8.37×10^{-40}	-1.29×10^{-01}	4.26×10^{-05}	3.13×10^{-01}	3.43×10^{-24}
	MPI ESM p	-5.82×10^{-01}	1.21×10^{-91}	-4.87×10^{-01}	8.65×10^{-61}	1.36×10^{-01}	1.57×10^{-05}
	IPSL LR	-4.83×10^{-01}	1.50×10^{-59}	-1.88×10^{-01}	2.08×10^{-09}	3.65×10^{-01}	6.33×10^{-33}
	GISS	-4.86×10^{-01}	1.59×10^{-60}	-2.75×10^{-01}	9.19×10^{-19}	-2.75×10^{-01}	9.19×10^{-19}
	BCC	-4.85×10^{-01}	4.38×10^{-60}	-2.42×10^{-01}	9.04×10^{-15}	-2.42×10^{-01}	9.04×10^{-15}
	CESM1	-1.36×10^{-02}	6.68×10^{-01}	-2.64×10^{-02}	4.04×10^{-01}	-5.70×10^{-02}	7.19×10^{-02}

Table S5. Correlations between U850 index and winter (DJFMA) precipitation for observations, reanalysis, and CMIP5 models over the three periods (1979–2005, 1850–1950, 850–1850). (Red indicates significance, with a p-value <0.05).

U850		WEST		CENTER		EST	
	DATA	COR	P value	COR	P value	COR	P value
Present period	20c RE	3.84 × 10^{-01}	2.50 × 10^{-02}	1.82 × 10^{-01}	3.02 × 10^{-01}	7.53 × 10^{-02}	6.72 × 10^{-01}
	CCSM4	7.04 × 10^{-01}	9.91 × 10^{-06}	6.59 × 10^{-01}	5.63 × 10^{-05}	2.10 × 10^{-01}	2.56 × 10^{-02}
	MPI_ESM	7.25 × 10^{-01}	3.89 × 10^{-06}	5.95 × 10^{-01}	4.17 × 10^{-04}	1.84 × 10^{-01}	3.22 × 10^{-02}
	IPSL_LR	4.08 × 10^{-01}	2.26 × 10^{-02}	5.00 × 10^{-01}	4.20 × 10^{-03}	9.48 × 10^{-02}	6.12 × 10^{-01}
	GISS	5.56 × 10^{-01}	1.15 × 10^{-03}	5.56 × 10^{-01}	5.41 × 10^{-02}	8.91 × 10^{-02}	6.34 × 10^{-01}
	BCC	1.26 × 10^{-01}	5.41 × 10^{-01}	1.26 × 10^{-01}	7.53 × 10^{-01}	−9.17 × 10^{-03}	9.65 × 10^{-01}
	CESM	6.50 × 10−01	7.56 × 10^{-05}	5.21 × 10^{-01}	2.66 × 10^{-03}	3.09 × 10^{-01}	4.04 × 10^{-02}
Past century	20c RE	1.81 × 10^{-01}	7.10 × 10^{-02}	7.98 × 10^{-02}	4.30 × 10^{-01}	7.47 × 10^{-02}	4.60 × 10^{-01}
	CCSM4	6.80 × 10^{-01}	5.55 × 10^{-15}	5.53 × 10^{-01}	2.02 × 10^{-09}	1.12 × 10^{-01}	2.64 × 10^{-01}
	MPI ESM	7.16 × 10^{-01}	4.16 × 10^{-17}	6.82 × 10^{-01}	4.05 × 10^{-15}	2.67 × 10^{-01}	6.87 × 10^{-03}
	IPSL LR	1.45 × 10^{-01}	1.47 × 10^{-01}	1.79 × 10^{-01}	5.27 × 10^{-02}	1.04 × 10^{-02}	9.17 × 10^{-01}
	GISS	5.42 × 10^{-01}	4.94 × 10^{-09}	3.45 × 10^{-01}	4.14 × 10^{-04}	2.11 × 10^{-01}	3.39 × 10^{-02}
	BCC	-1.98 × 10^{-02}	8.44 × 10^{-01}	−6.07 × 10^{-02}	5.46 × 10^{-01}	−7.17 × 10^{-02}	4.76 × 10^{-01}
	CESM	7.07 × 10^{-01}	1.48 × 10^{-16}	6.11 × 10^{-01}	1.11 × 10^{-11}	2.78 × 10^{-01}	4.80 × 10^{-03}
Past millennium	CCSM4	6.54 × 10^{-01}	2.21 × 10^{-12}	5.97 × 10^{-01}	9.70× 10^{-98}	1.41 × 10^{-01}	8.01 × 10^{-06}
	MPI ESM	2.63 × 10^{-01}	2.48 × 10^{-13}	2.45 × 10^{-01}	1.06 × 10^{-11}	6.75 × 10^{-02}	6.72 × 10^{-01}
	IPSL LR	7.31 × 10^{-01}	2.53 × 10^{-15}	7.31 × 10^{-01}	2.49 × 10^{-69}	1.31 × 10^{-01}	7.66 × 10^{-05}
	GISS_	6.27 × 10^{-01}	3.00 × 10^{-11}	6.27 × 10^{-01}	9.87 × 10^{-21}	1.92 × 10^{-01}	9.17 × 10^{-10}
	BCC	6.70 × 10^{-01}	3.29 × 10^{-13}	5.04 × 10^{-01}	1.09 × 10^{-65}	1.51 × 10^{-01}	2.27 × 10^{-30}
	CESM1	2.53 × 10^{-02}	1.47 × 10^{-16}	2.71 × 10^{-03}	9.32 × 10^{-01}	4.82 × 10^{-02}	1.28 × 10^{-01}