Figure S1. Monthly dust emission fluxes together with the soil moisture over each region averaged from 2013 to 2017. Seasonal fluxes of dust emissions are shown as black lines. The correlation coefficients (*r*) between the dust emission fluxes and soil moisture are also shown as inset.
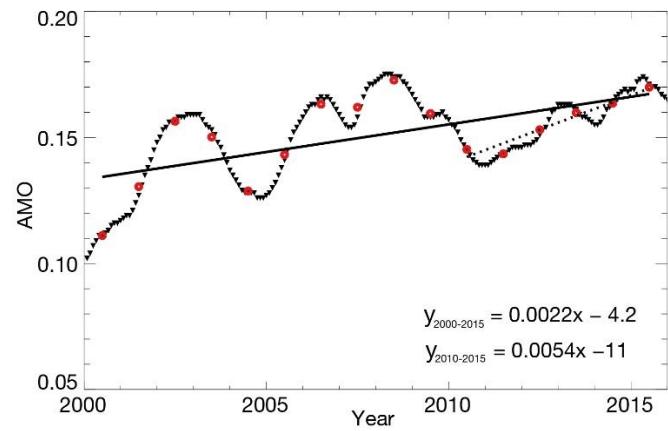
Figure S2. Time series of Atlantic Multidecadal Oscillation (AMO) during 2010-2015 together with the linear trends over the periods $2000 - 2015$ and $2010 - 2015$. The black triangles and red circles represent monthly and annual mean, respectively.
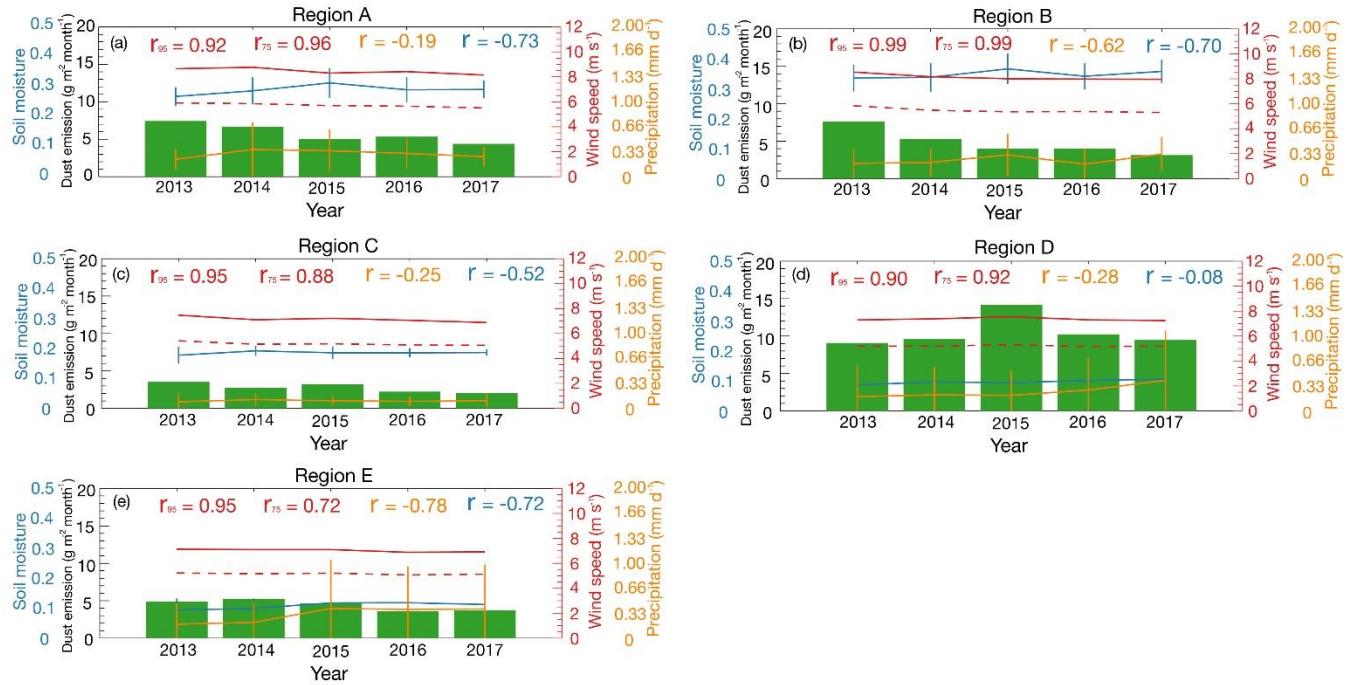
Figure S3. Annual dust emission fluxes together with the 95th percentile wind speeds (red lines), the 75th percentile wind speeds (red dotted lines), precipitation (yellow lines) and soil moisture (blue line) over each region from 2013 to 2017. The correlation coefficients (*r*) between the dust emission fluxes and different meteorological variables are also shown as inset.
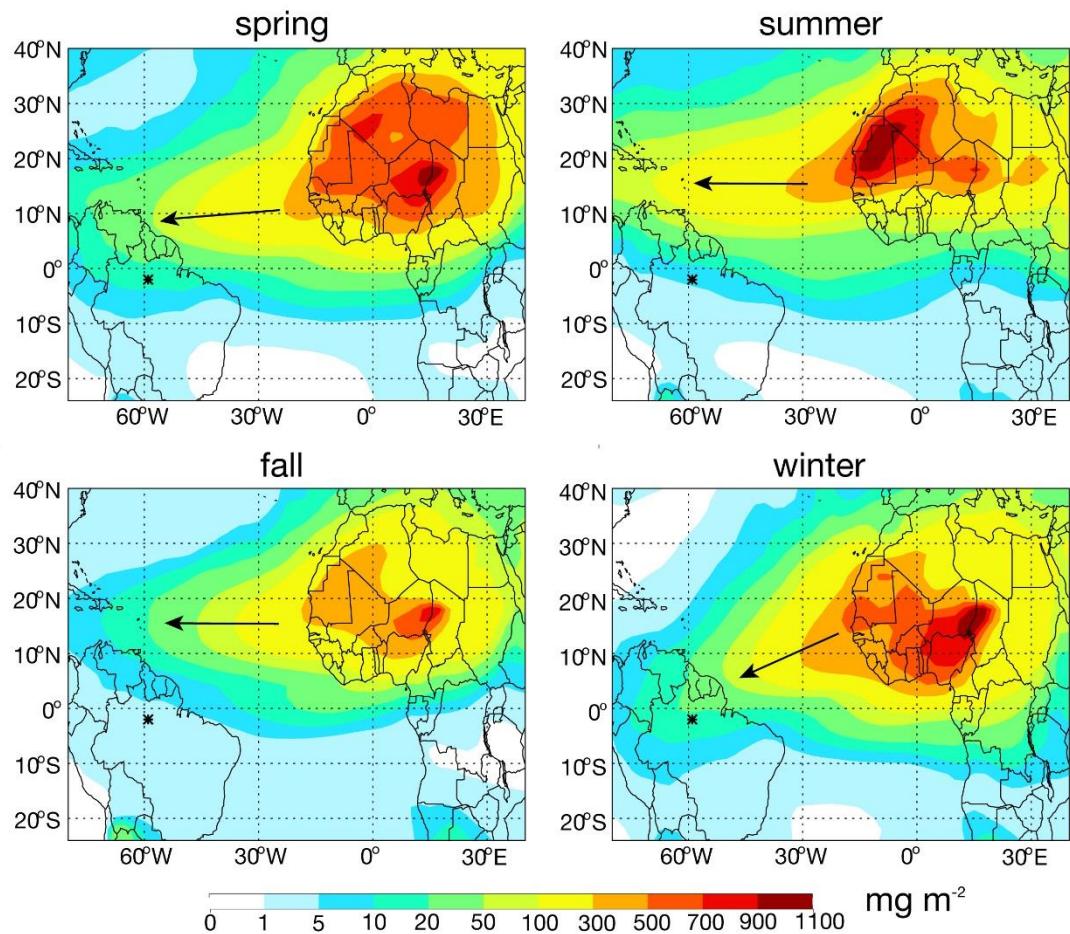
Figure S4. Simulated dust column burden averaged from 2013 to 2017 over the region between $80° \text{W} - 40° \text{E}$ and $25° \text{S} - 40° \text{N}$. The location of ATTO site is marked as black asterisk and the transport paths of dust in four seasons are marked by black arrows.

Table S1. Annual dust emission fluxes (g month^{-1} m^{-2}) over different source regions in northern Africa[a].

Year	Region A	Region B	Region C	Region D	Region E
2013	7.4	7.6	3.6	9.1	4.9
2014	6.7	5.3	2.8	9.6	5.3
2015	5.0	4.0	3.2	14	4.6
2016	5.3	4.0	2.2	10	3.6
2017	4.4	3.1	2.0	9.5	3.7
Mean±std[b]	5.8±1.3	4.8±1.8	2.8±0.64	11±2.1	4.4±0.74

[a] Region A: $15° \text{W} - 10° \text{E}$, $21° \text{N} - 35° \text{N}$; Region B: $10° \text{E} - 25° \text{E}$, $25° \text{N} - 35° \text{N}$; Region C: $25° \text{E} - 35°$ E, $15° \text{N} - 32° \text{N}$; Region D: $12.5° \text{E} - 23° \text{E}$, $13° \text{N} - 21° \text{N}$; Region E: $17° \text{W} - 5° \text{W}$, $15° \text{N} - 21° \text{N}$.
[b] standard deviation

Table S2. Seasonal dust deposition (Pg a^{-1}) as well as the ratio of deposition to total emission over northern Africa, AOaTP[a] and the Amazon Basin during 2013 − 2017.

Region	Spring		Summer		Fall		Winter	
	Dep	Ratio	Dep	Ratio	Dep	Ratio	Dep	Ratio
northern Africa	0.51±0.090	54%	0.38±0.10	64%	0.26±0.055	60%	0.44±0.085	48%
AOaTP	0.073±0.031	7.7%	0.079±0.034	13%	0.063±0.019	15%	0.18±0.034	20%
Amazon Basin	0.015±0.0064	1.6%	0.0089±0.045	1.5%	0.0022±0.0010	0.51%	0.015±0.0033	1.6%

[a] Atlantic Ocean along the transport path, over the region between 20° − 50° W and 5° S − 25° N.

Table S3. Dust emission (Pg a^{-1}) from northern Africa and its lifetime (d) along the trans-Atlantic transport during January − April of 2014 − 2016.

year	January		February		March		April	
	emission	lifetime	emission	lifetime	emission	lifetime	emission	lifetime
2014	0.68	1.4	1.2	1.5	0.97	1.8	0.75	1.8
2015	1.5	1.5	0.92	1.4	1.5	1.6	1.2	1.9
2016	0.78	1.4	0.95	1.7	1.0	1.7	0.68	1.8