Supplementary Material: Dust Induced Atmospheric Absorption Improves Tropical Precipitations In Climate Model

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This Supplementary material consists of 4 figures and 1 table

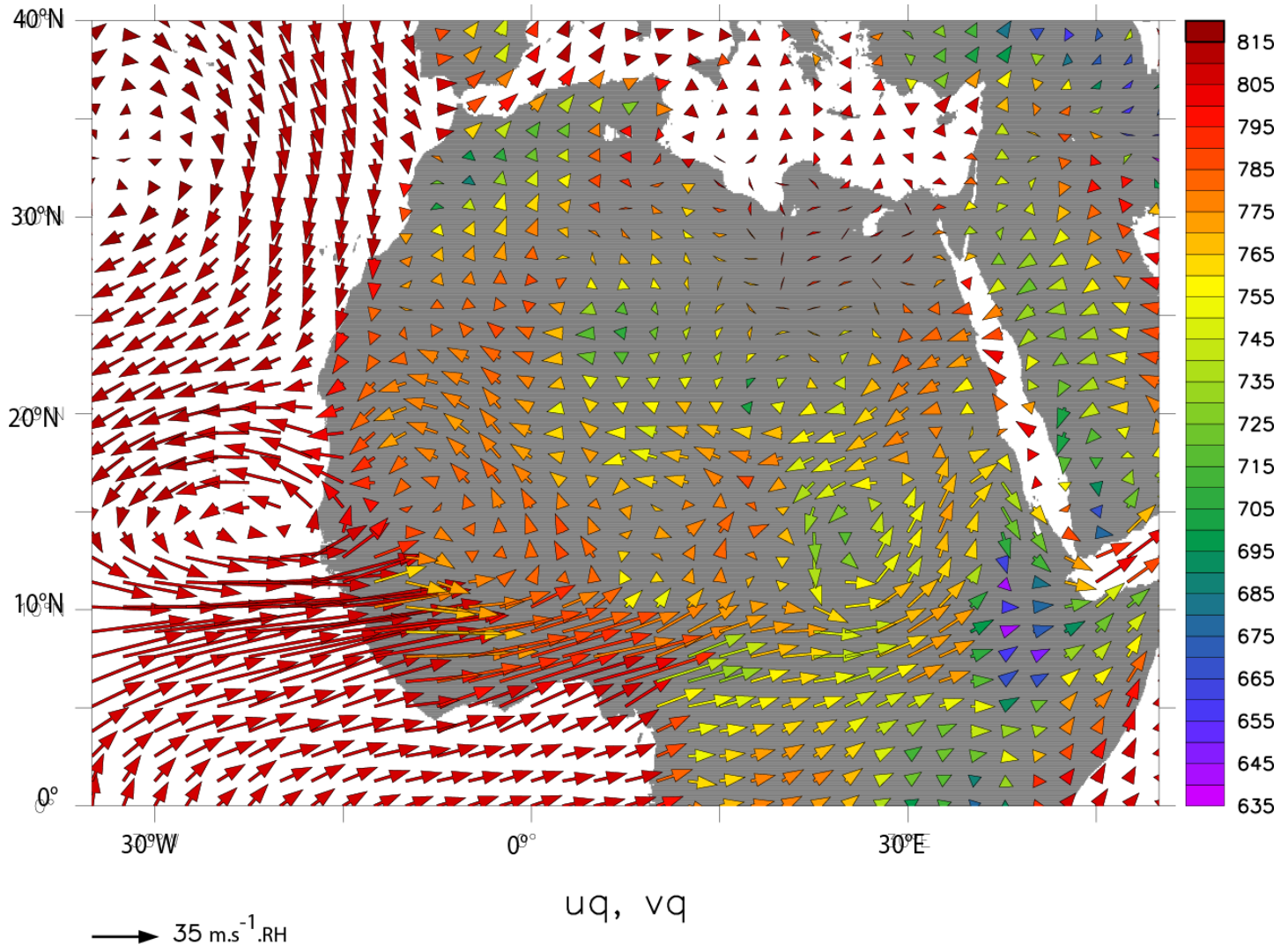

Figure S1. 30-year average difference in flux of relative humidity (Dust – No Dust) for the months JJAS at 800mb over oceanic regions (the height of the transport in mb is indicated by the color bar). The units for arrows are m.s^{-1}.RH, where RH indicates relative humidity in percent.

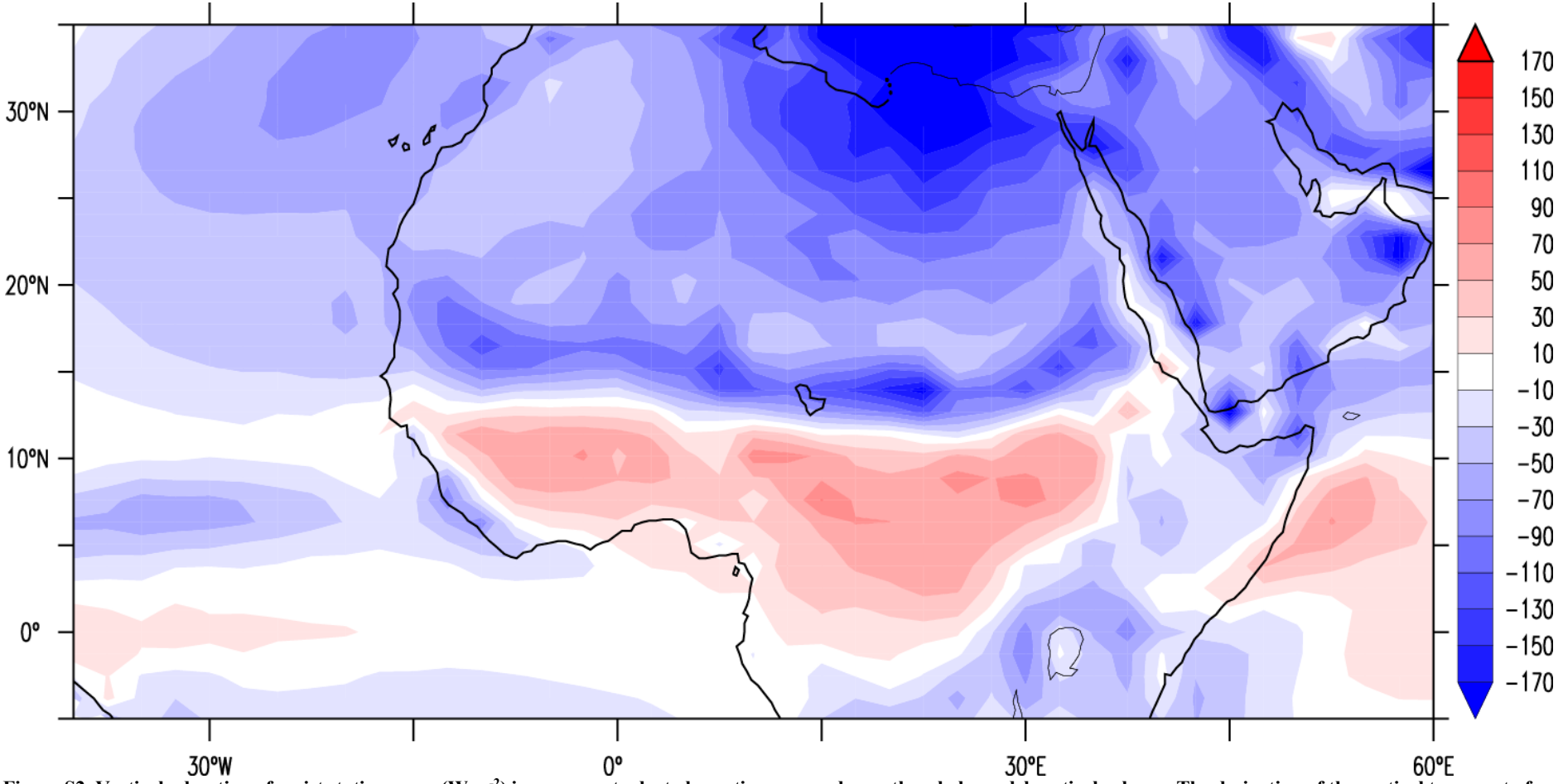

Figure S2. Vertical advection of moist static energy (W.m^{-2}) in response to dust absorption summed over the whole model vertical column. The derivation of the vertical transport of energy is estimated in explained in the section Methods. See Fig 9b of Hill et al. (2017).

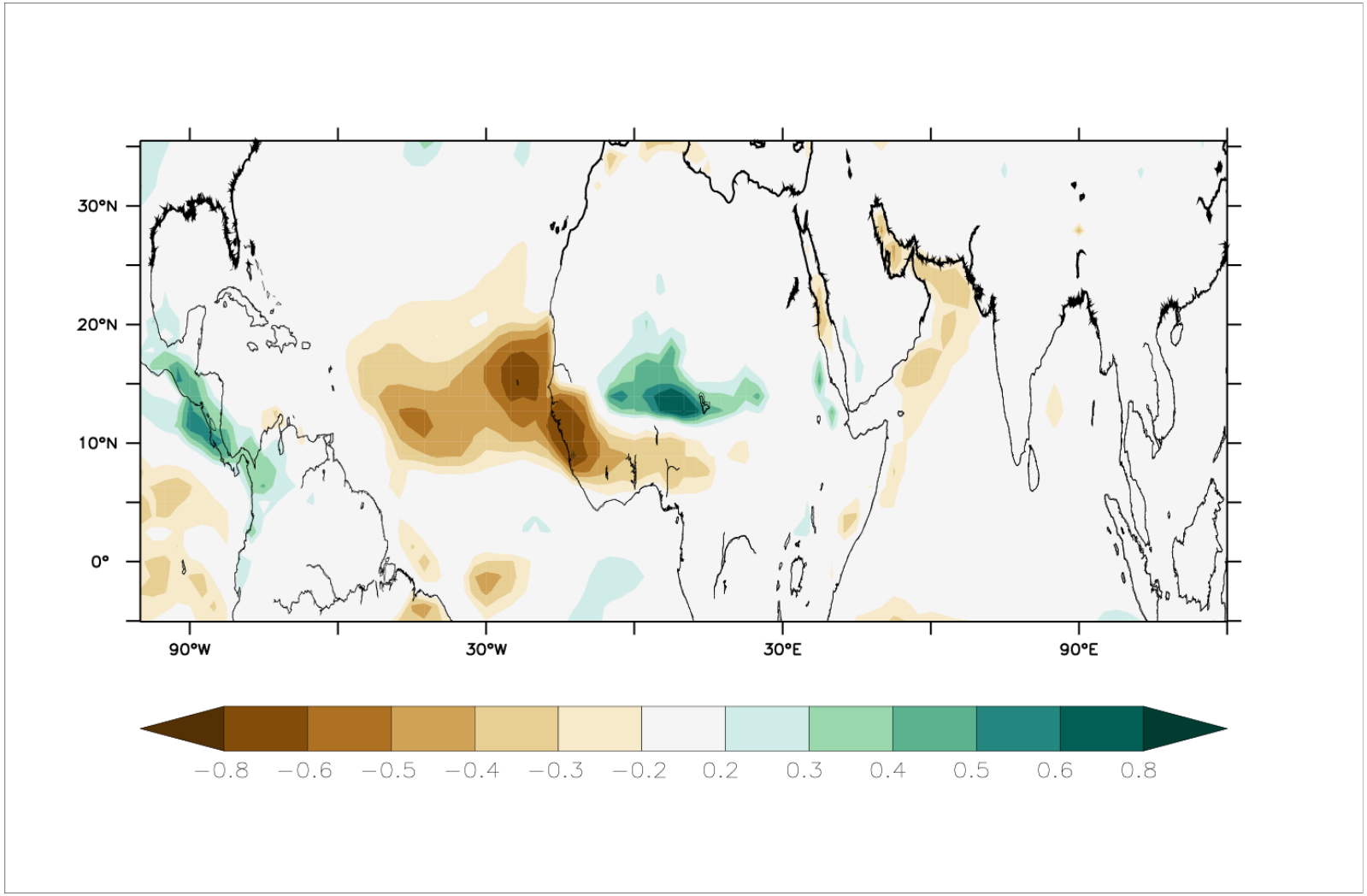

Figure S3. Difference in annual mean evaporation (mm.day^{-1}) for the 30-year period (1985-2014) showing the evaporation increase over the Sahel due to dust absorption.

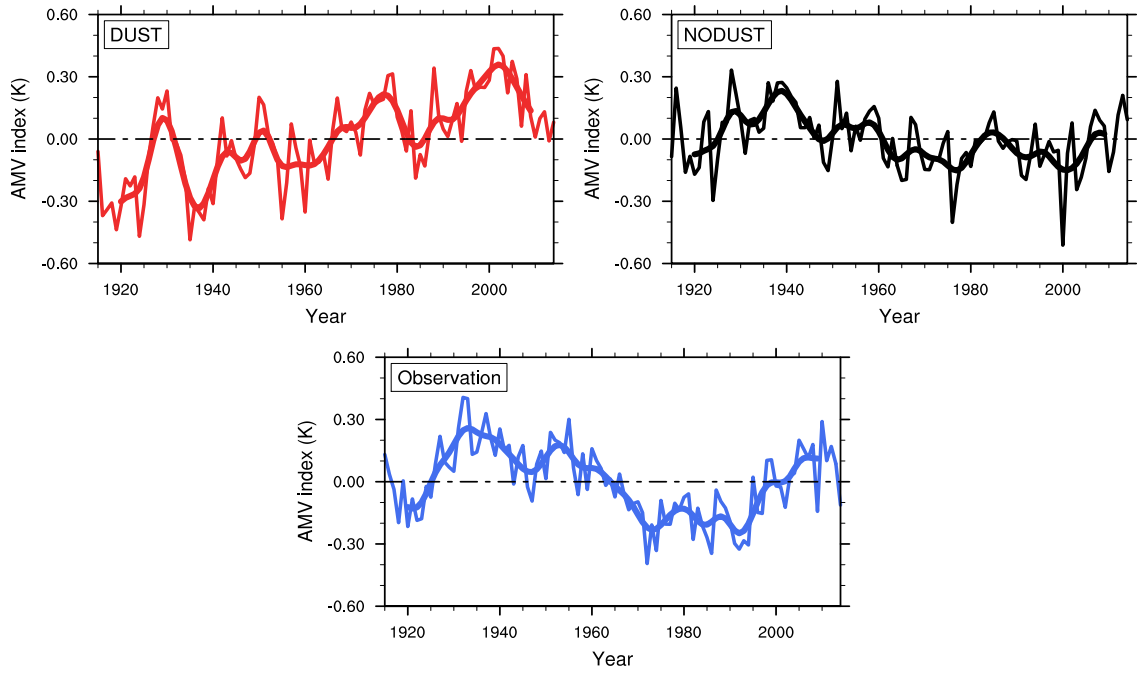

Figure S4. Representation of the Atlantic Multidecadal Variability (AMV) evolution. Time evolution of the AMV index over the 1915-2014 period from the simulation including interactive dust (top left), the simulation without dust (top right) and the ERSSTv5 observational dataset (Huang et al., 2017) (bottom). The AMV index is defined as the monthly anomaly over the North Atlantic Ocean, with the response from the external forcings removed (Deser et al., 2010). The external forcing are estimated by the average SST between -60°N and 60°N(Trenberth and Shea, 2006). A lanczos low-pass filter with a cutoff period of 10 years is applied to the AMV index (thicker line).

		Global Radiative Perturbation (Wm^{-2})		
		SW	LW	Net
Globe DOD (Dust Optical Depth) 550 nm = 0.0492 *This work*	Top-of-atmosphere (TOA)	-0.37	+0.24	-0.13
	Atmospheric Absorption (TOA-Surface)	+2.03	-0.41	+1.62
	Surface	-2.39	+0.65	-1.74
Yoshioka (2007)(Yoshioka et al., 2007) DOD 550 nm =0.0381	TOA	-0.92	+0.31	-0.60
	Atm. Absorption	+0.67	-0.81	-0.14
	Surface	-1.59	+1.13	-0.46
Woodward et al (2001)(Woodward, 2001)	TOA	-0.16	+0.23	+0.07
	Atm. Absorption	+1.06	-0.17	+0.89
	Surface	-1.22	+0.40	-0.82
Miller et al. (2004)(Miller et al., 2004)	TOA	-0.33	+0.15	-0.18
	Atm. Absorption	+1.49	-0.03	+1.46
	Surface	-1.82	+0.18	-1.64
Miller et al. (2006)(Miller et al., 2006)	TOA	-0.62	+0.22	-0.40
	Atm. Absorption	+0.67	-0.23	+0.44
	Surface	-1.29	+0.45	-0.84

Table S1. Dust Global Radiative Pertubation from several authors. Miller et al. (2004) also present two sensitivity runs SSA of 1.1 ω_0 and 0.9*ω_0 dust radiative effect. All values are presented as global yearly averages and compared through the different publications indicated in the first column of this Table.

References

Deser, C., Alexander, M. A., Xie, S.-P. and Phillips, A. S.: Sea Surface Temperature Variability: Patterns and Mechanisms, Annu Rev Mar Sci, 2, 115–143, 2010.

Hill, S. A., Ming, Y., Held, I. M. and Zhao, M.: A Moist Static Energy Budget–Based Analysis of the Sahel Rainfall Response to Uniform Oceanic Warming, J. Clim., 30(15), 5637–5660, doi:10.1175/JCLI-D-16-0785.1, 2017.

Huang, B., Thorne, P. W., Banzon, V. F., Boyer, T., Chepurin, G., Lawrimore, J. H., Menne, M. J., Smith, T. M., Vose, R. S. and Zhang, H.-M.: Extended Reconstructed Sea Surface Temperature, Version 5 (ERSSTv5): Upgrades, Validations, and Intercomparisons, J. Clim., 30(20), 8179–8205, doi:10.1175/JCLI-D-16-0836.1, 2017.

Miller, R. L., Tegen, I. and Perlwitz, J.: Surface radiative forcing by soil dust aerosols and the hydrologic cycle, J. Geophys. Res. Atmospheres, 109(D04203), 4085–4112, doi:10.1029/2003JD004085, 2004.

Miller, R. L., Cakmur, R. V., Perlwitz, J., Geogdzhayev, I. V., Ginoux, P., Koch, D., Kohfeld, K. E., Prigent, C., Ruedy, R., Schmidt, G. A. and Tegen, I.: Mineral dust aerosols in the NASA Goddard Institute for Space Sciences ModelE atmospheric general circulation model, J. Geophys. Res., 111(D6), D06208, doi:10.1029/2005JD005796, 2006.

Trenberth, K. E. and Shea, D. J.: Atlantic hurricanes and natural variability in 2005, Geophys. Res. Lett., 33(12), L12704, doi:10.1029/2006GL026894, 2006.

Woodward, S.: Modeling the atmospheric life cycle and radiative impact of mineral dust in the Hadley Centre climate model, J Geophys Res, 106, 18155–18166, 2001.

Yoshioka, M., Mahowald, N. M., Conley, A. J., Collins, W. D., Fillmore, D. W., Zender, C. S. and Coleman, D. B.: Impact of Desert Dust Radiative Forcing on Sahel Precipitation: Relative Importance of Dust Compared to Sea Surface Temperature Variations, Vegetation Changes, and Greenhouse Gas Warming, J. Clim., 20(8), 1445–1467, doi:10.1175/JCLI4056.1, 2007.