An update on trends in surface radiation over the U.S. as determined from the seven SURFRAD BSRN sites

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Data are from the U.S. SURFRAD BSRN Surface Radiation Budget Network

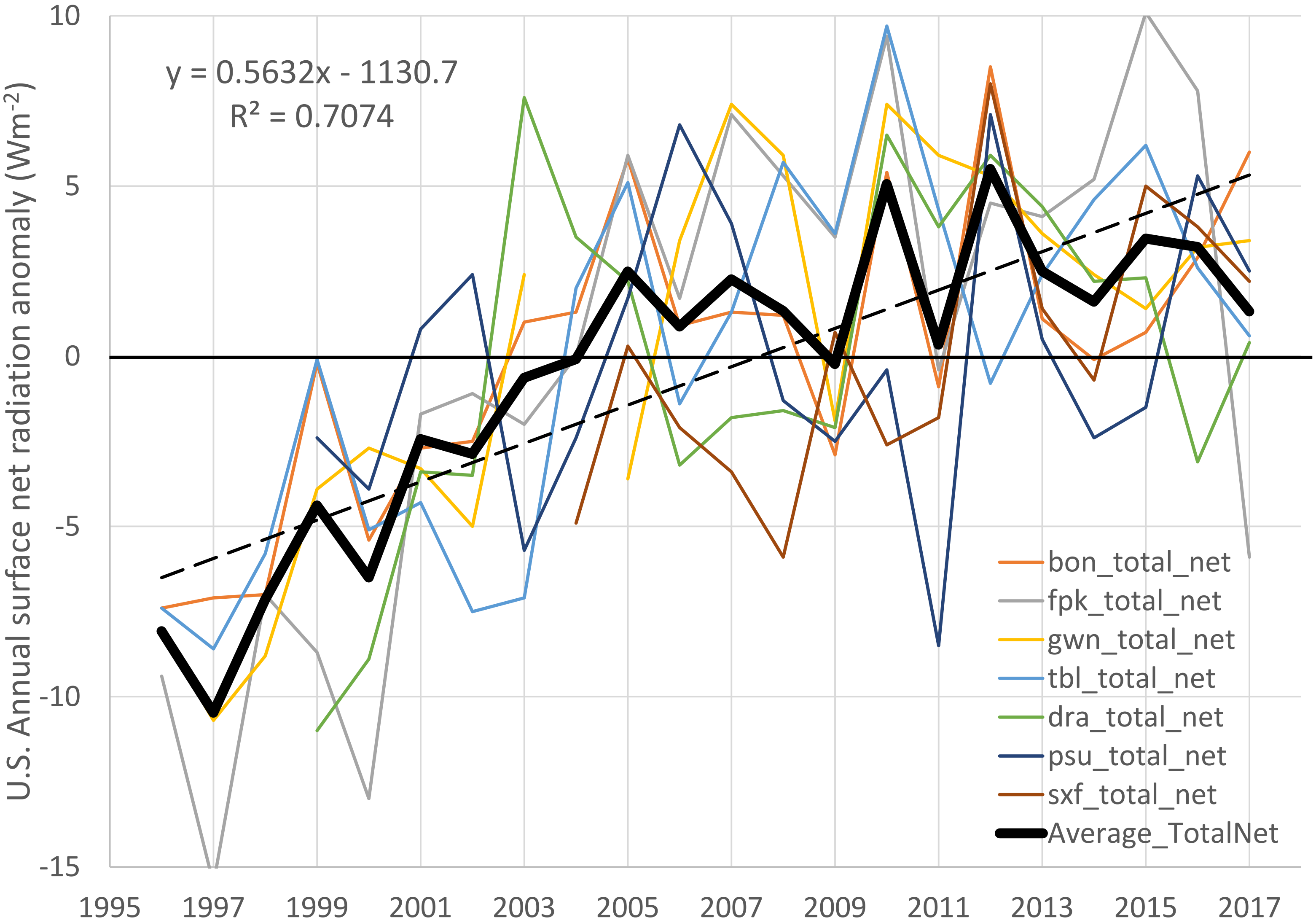
Began operations on 1 Jan. 1995

Trend Analysis

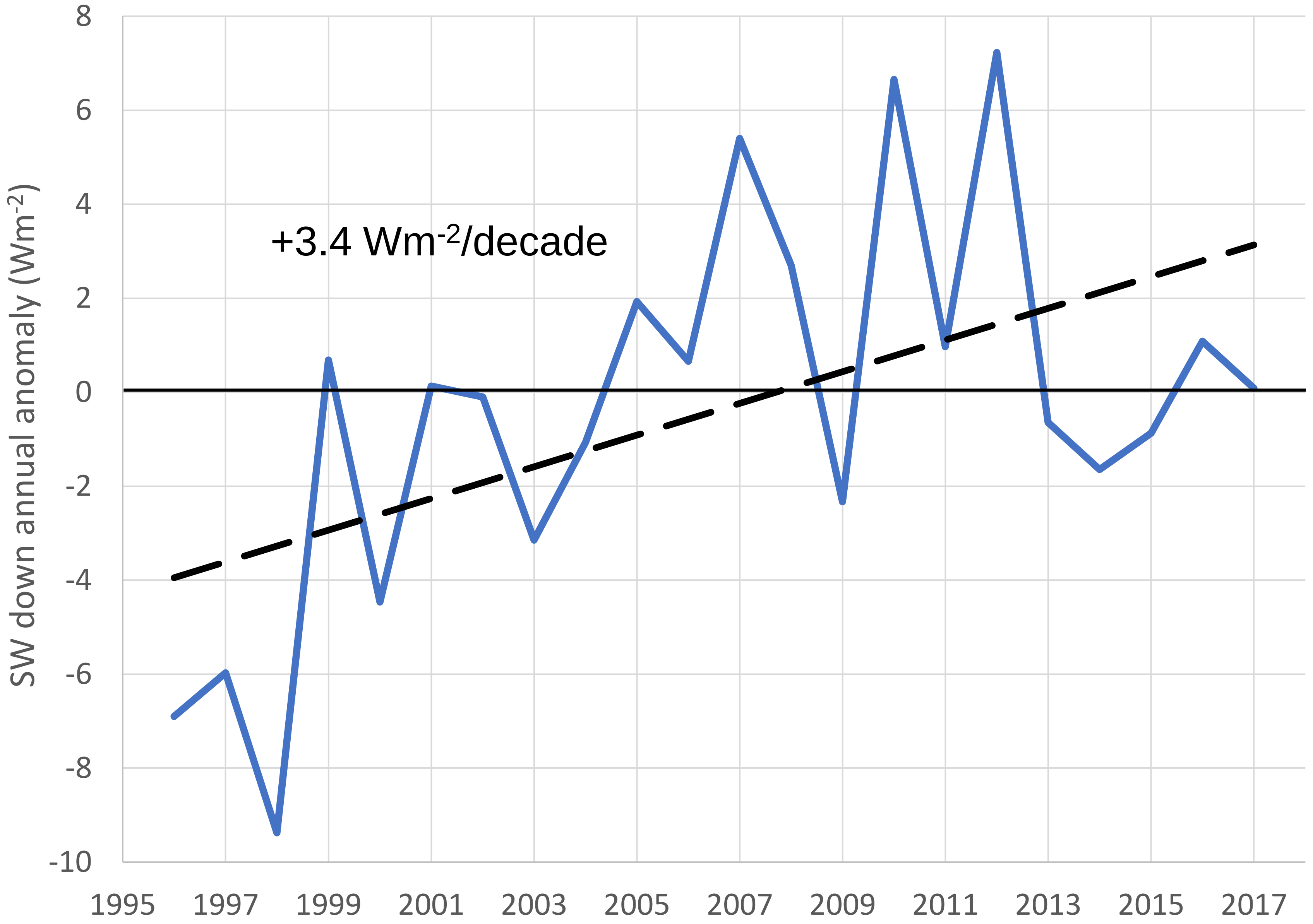
- Monthly averages computed for each station
- Annual averages computed from monthly means
- Station annual averages were normalized to zero by computing annual anomalies from their long-term mean
- The average of all stations’ anomalies for each year is considered a proxy for the U.S.

U.S. total surface net radiation annual anomalies

SW↓ - SW↑ + LW↓ - LW↑



U.S. short wave down annual anomalies



Martin Wild's 2012 review of observed dimming and brightening at the surface

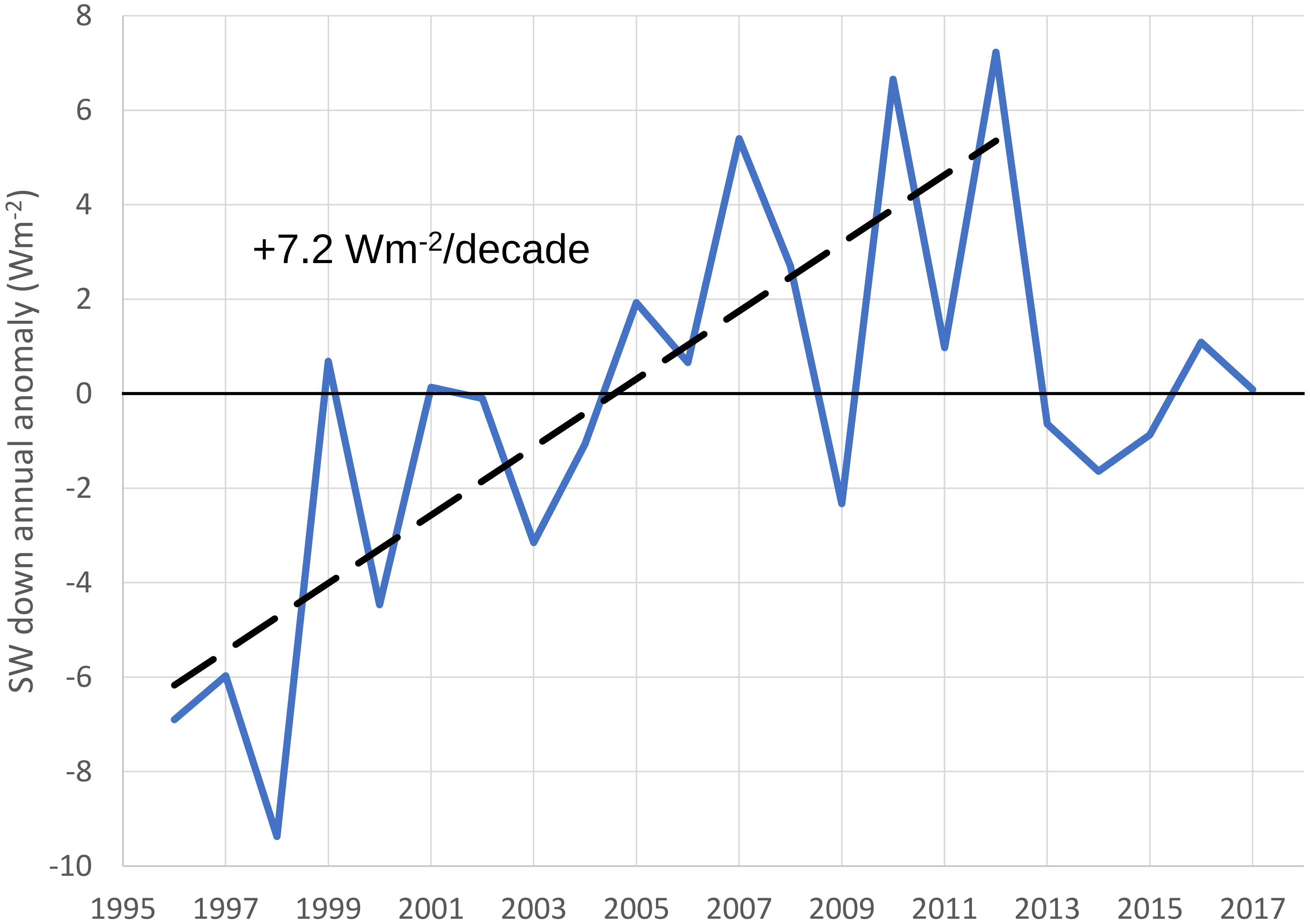
— SURFRAD ——

	1950s-1980s	1980s-2000	after 2000
USA	-6 ↘	5 ↗	8 ↗
Europe	-3 ↘	2 ↗	3 ↗
China/Mongolia	-7 ↘	3 ↗	-4 ↘
Japan	-5 ↘	8 ↗	0 →
India	-3 ↘	-8 ↘	-10 ↘

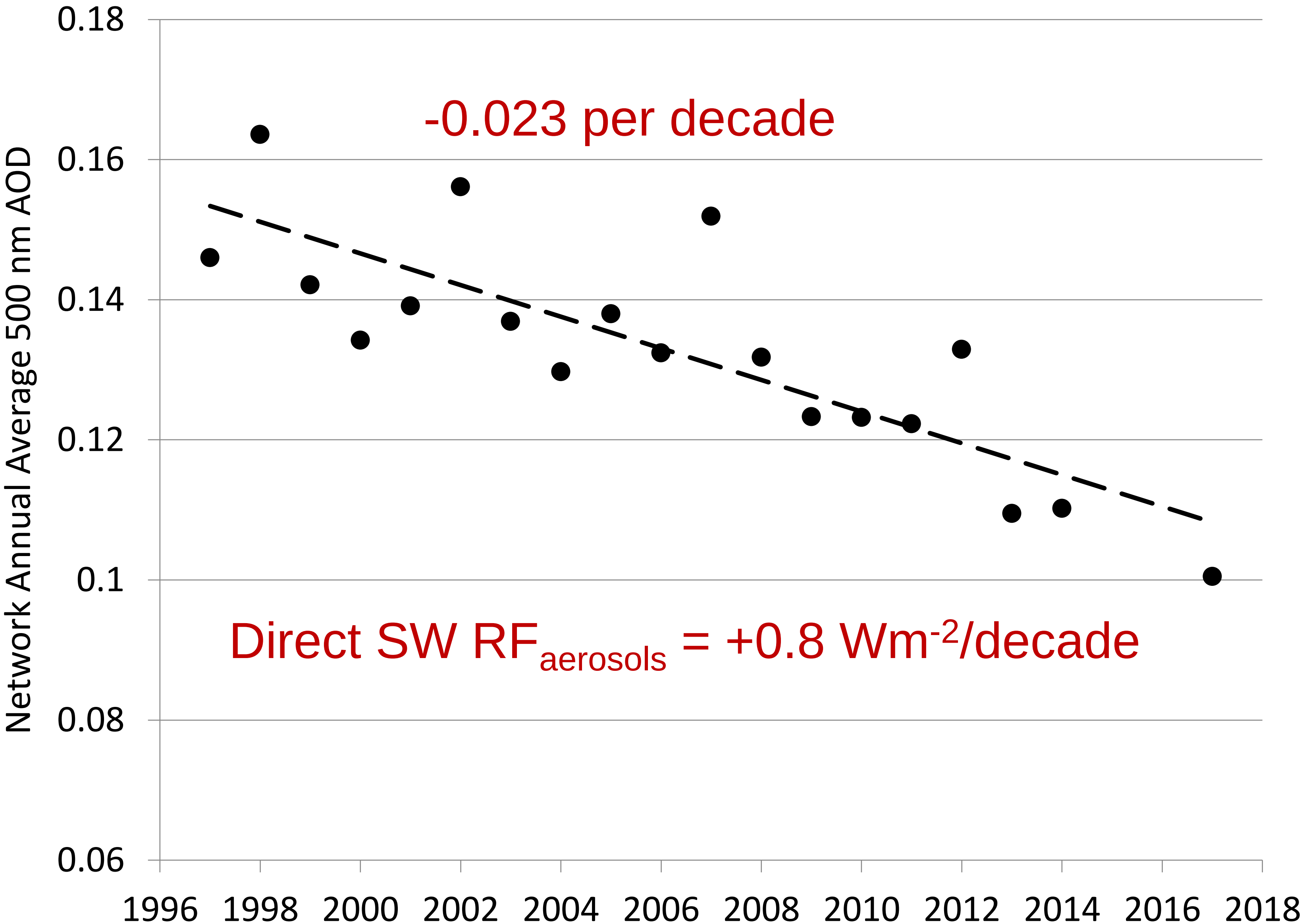
Trends in Wm^{-2}/decade

From: Wild (2012) Enlightening Global Dimming and Brightening, https://doi.org/10.1175/BAMS-D-11-00074.1

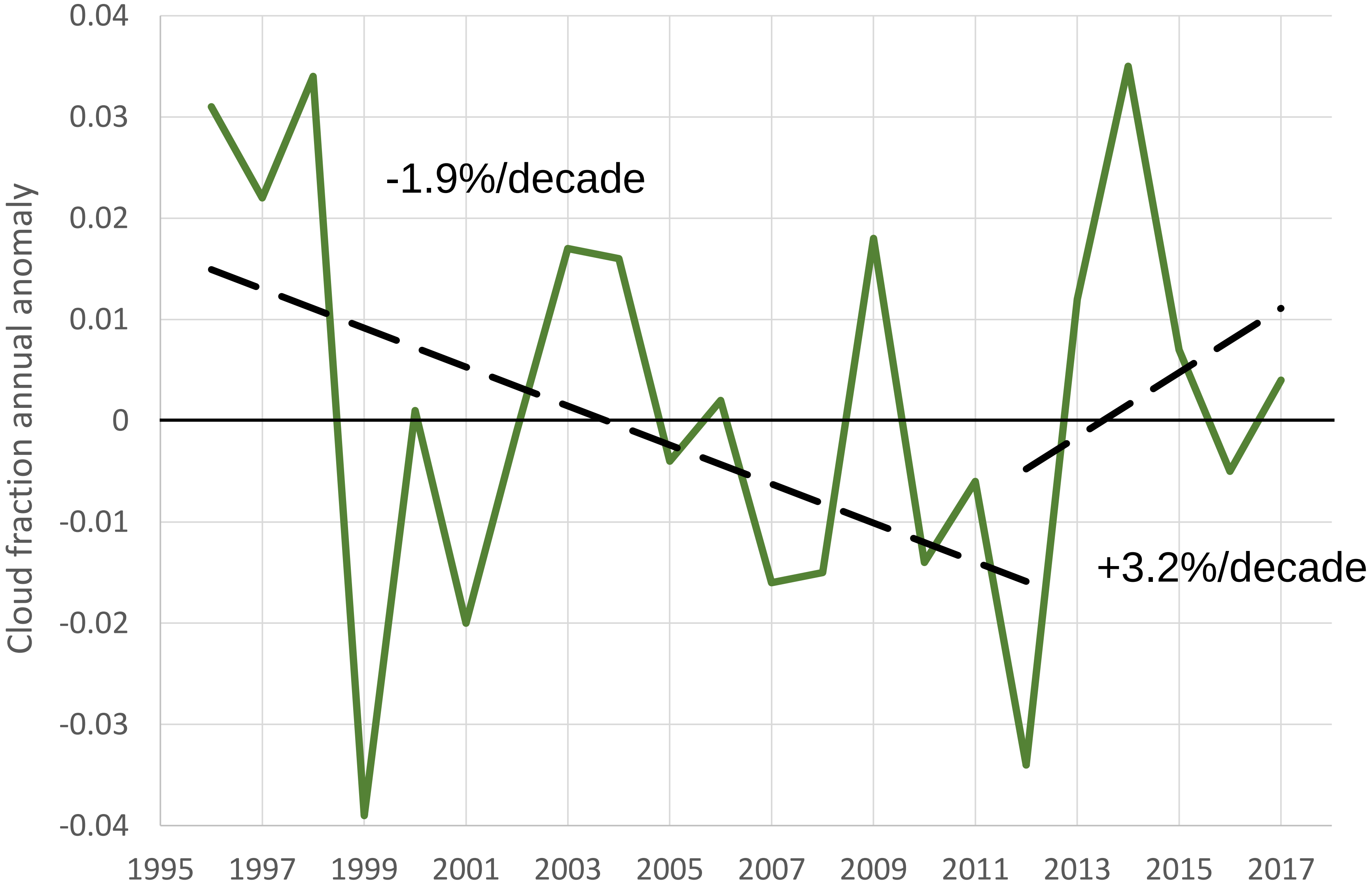
U.S. short wave down annual anomalies



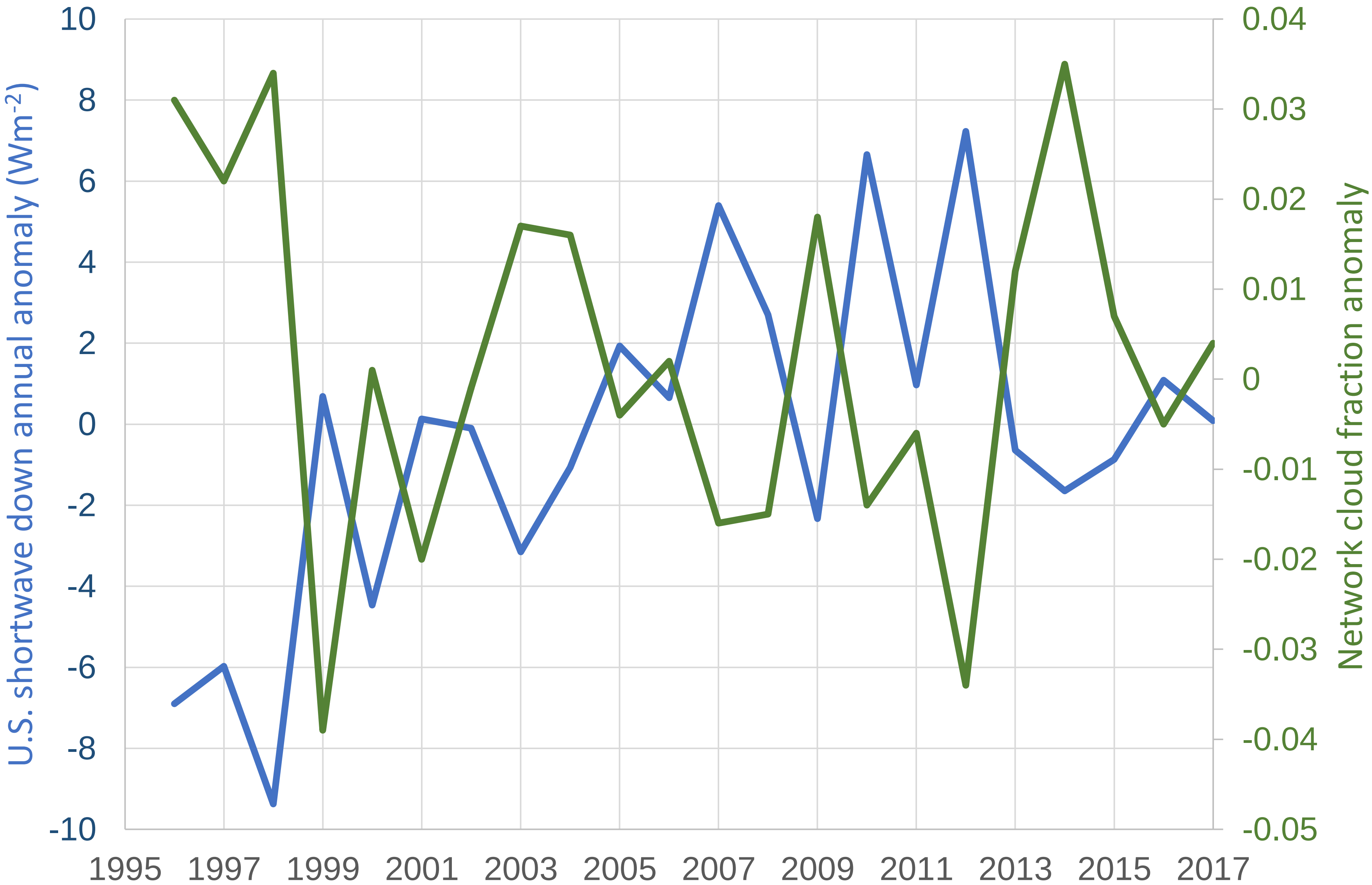
U.S. average annual 500 nm Aerosol Optical Depth



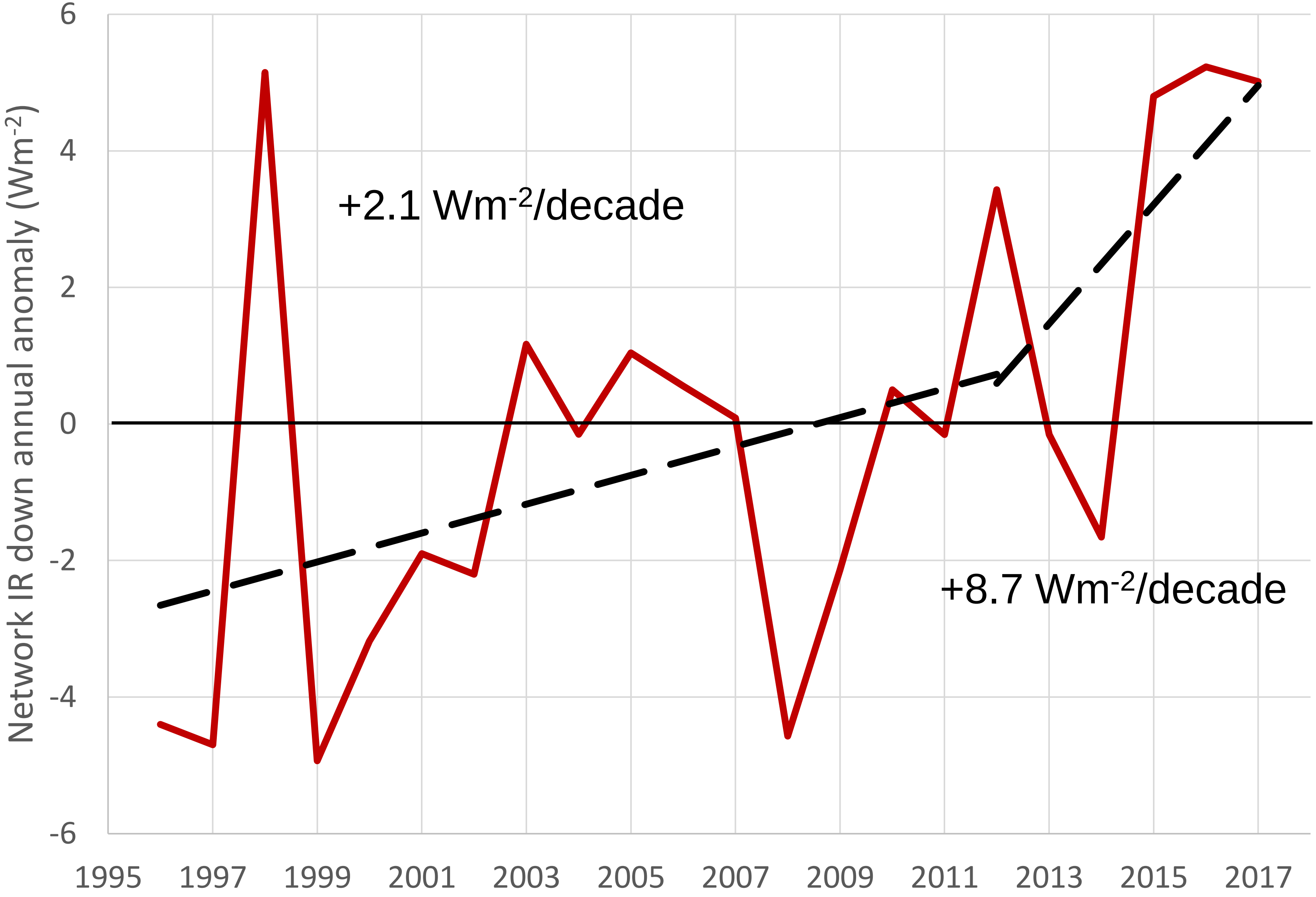
U.S. sky-cover annual anomalies



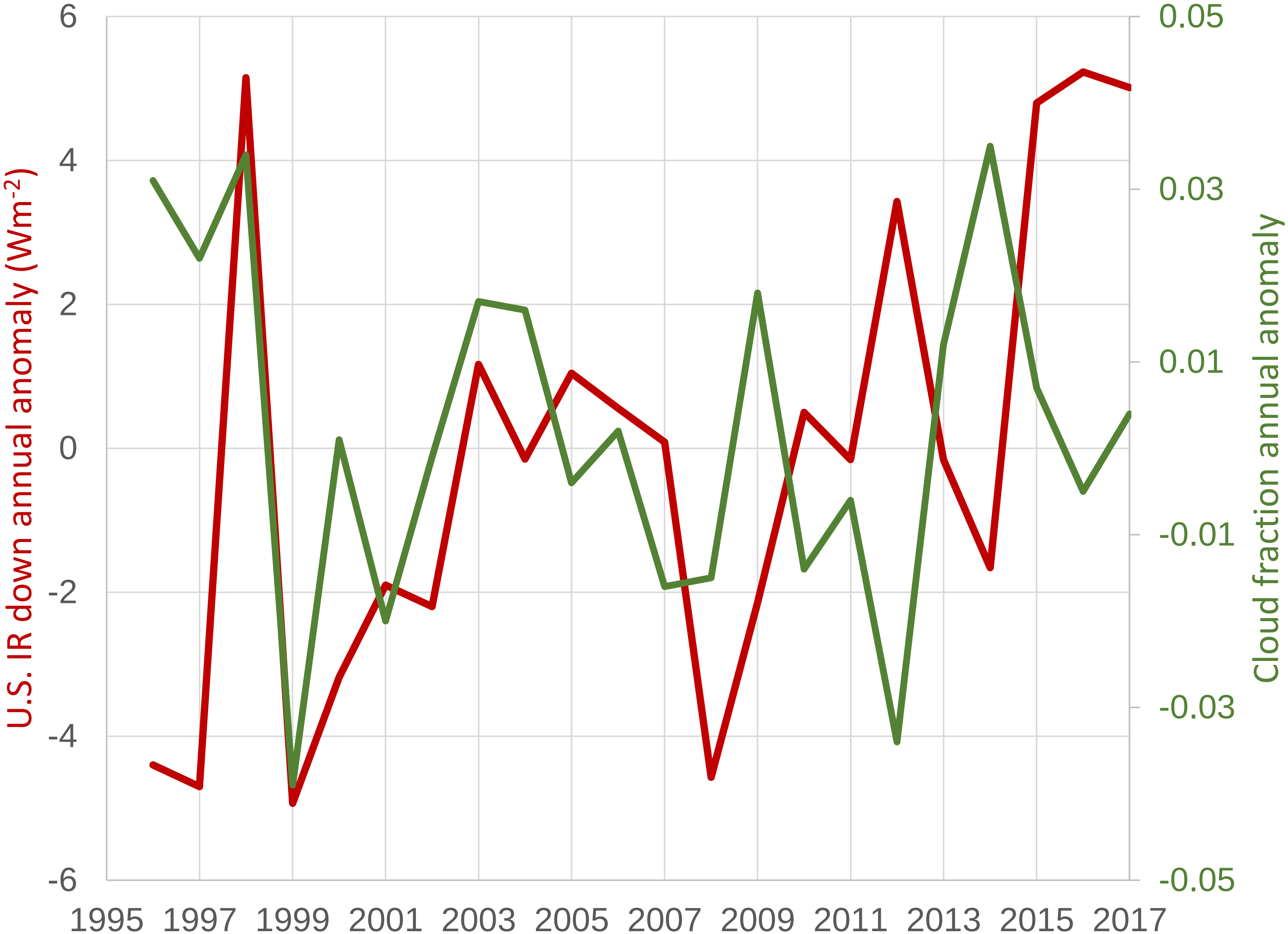
Shortwave and sky cover annual anomalies anticorrelated



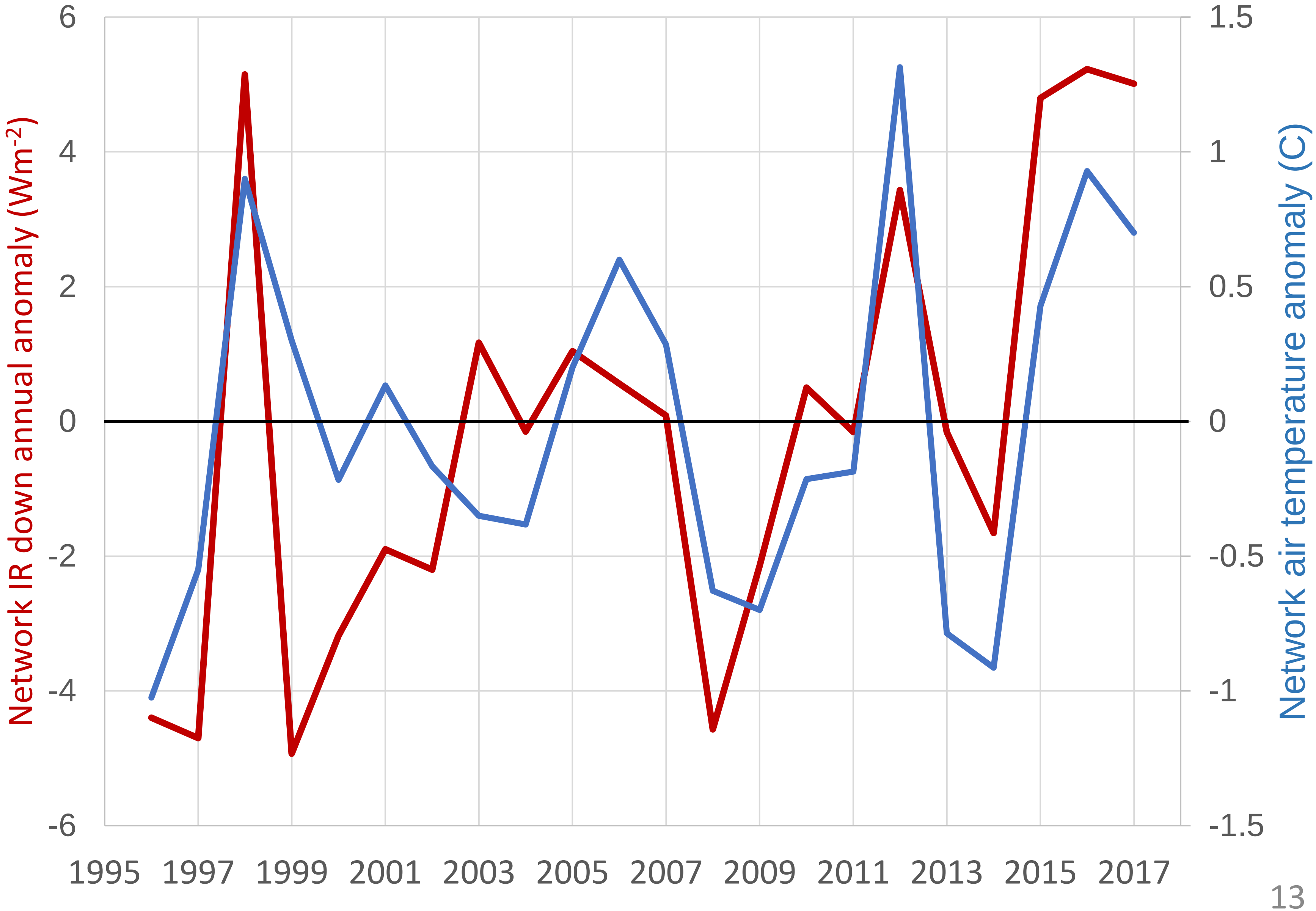
Long wave down annual anomalies



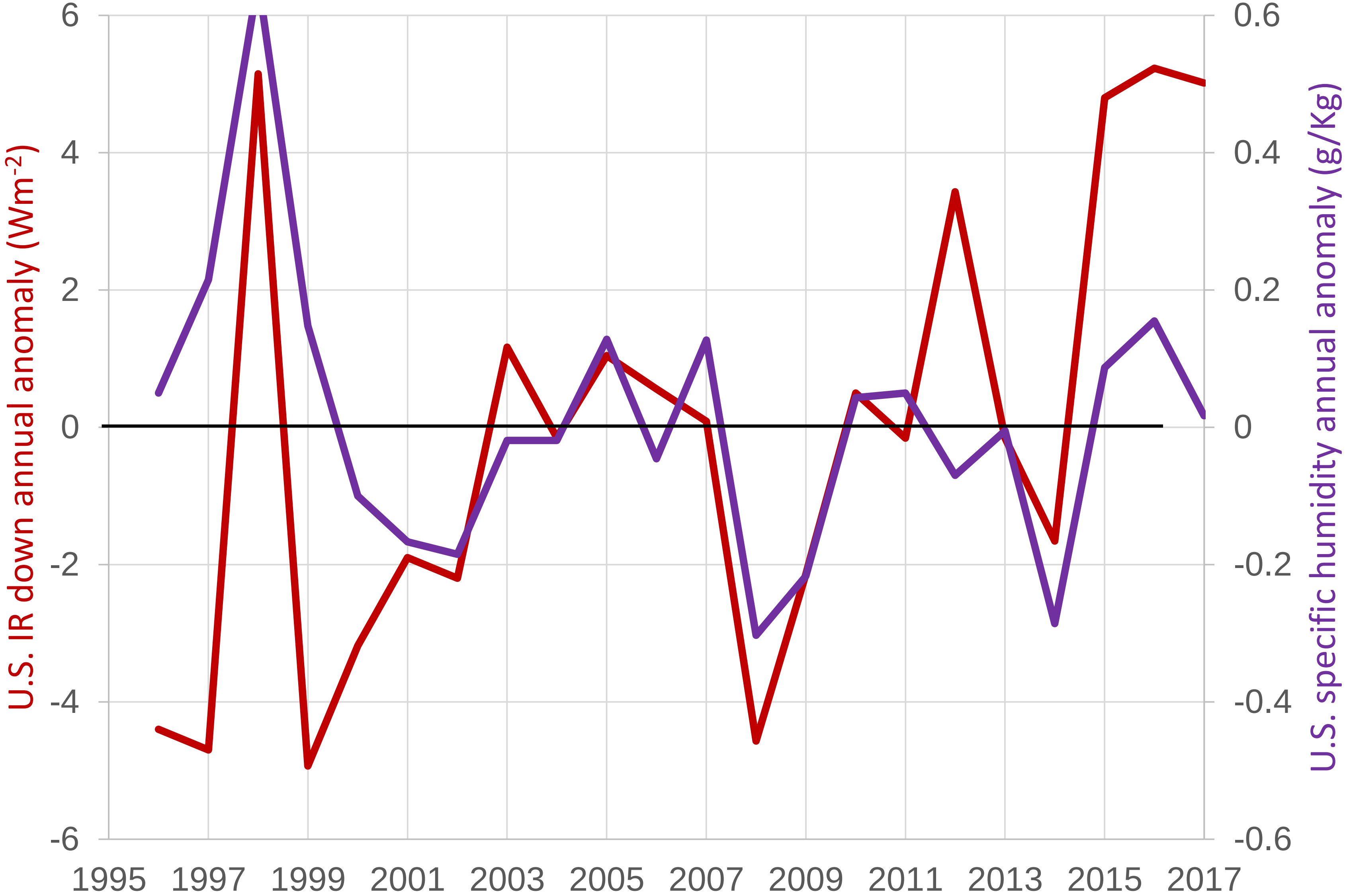
Long wave down and cloud fraction annual anomalies



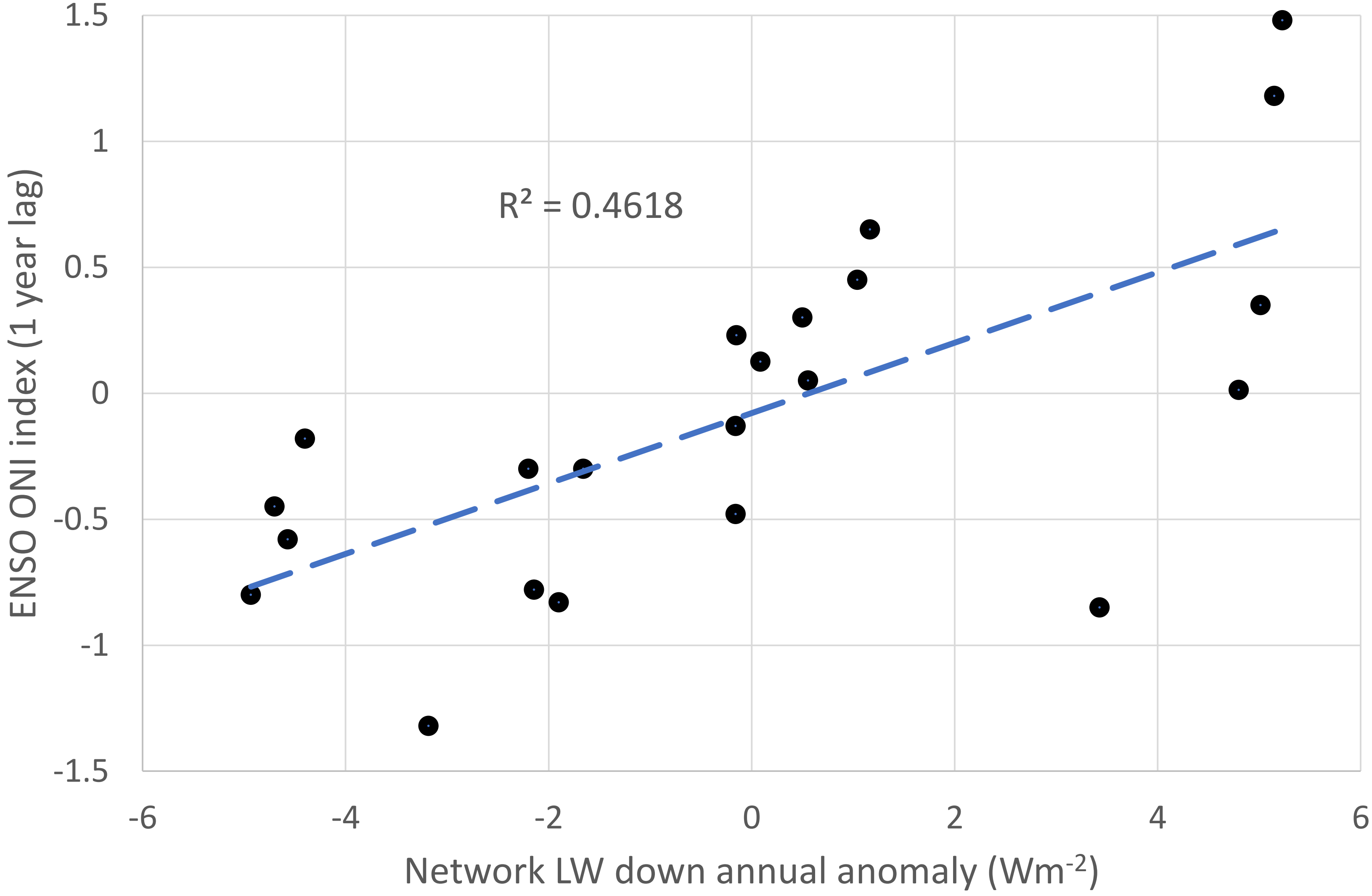
Long wave down and air temperature annual anomalies



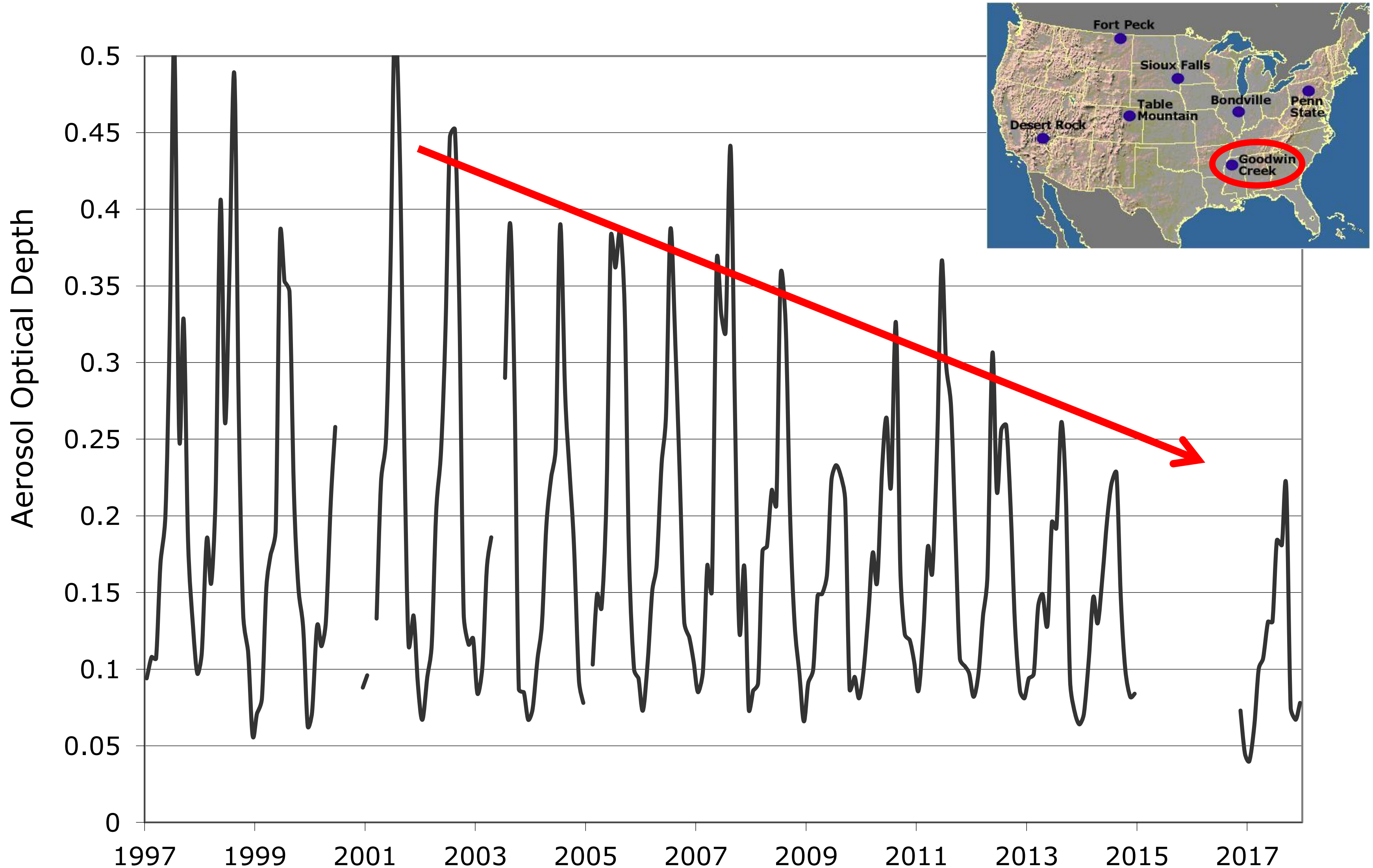
Long wave down and specific humidity annual anomalies



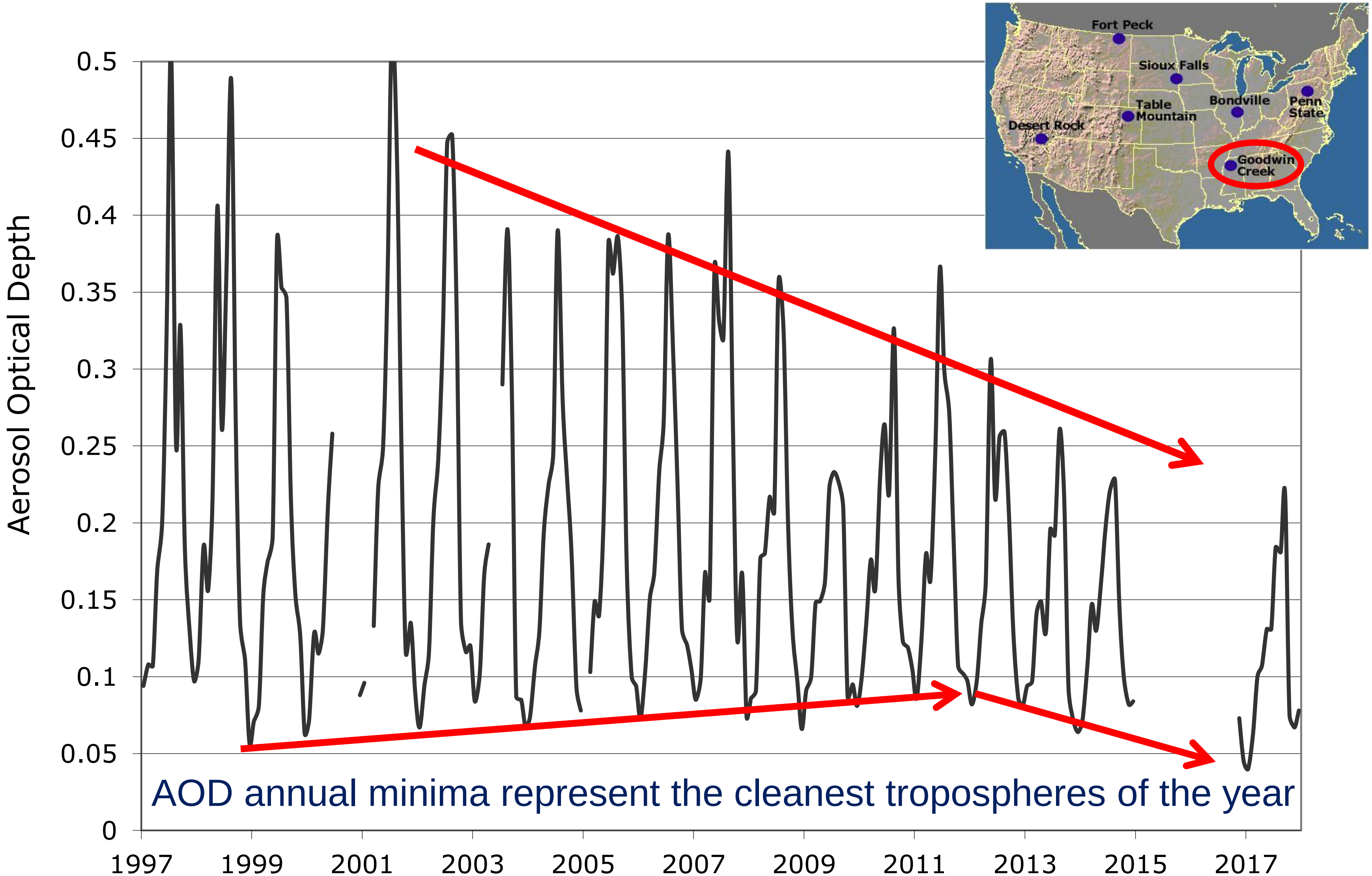
Nearly 50% of the variance of long wave down is explained by the variability of the ENSO ONI index



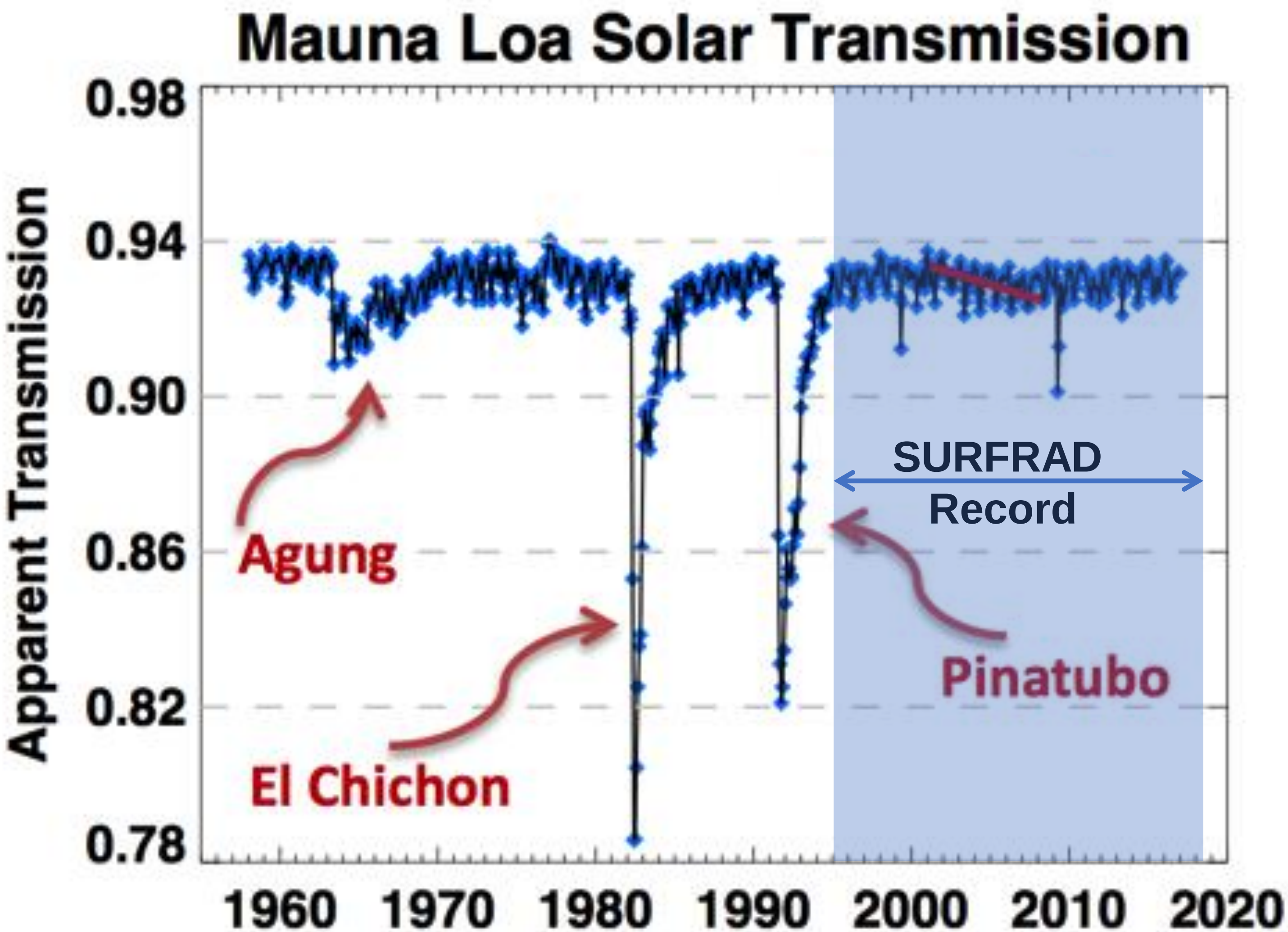
Goodwin Creek monthly average AOD at 500 nm



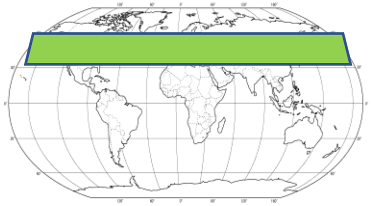
Goodwin Creek monthly average AOD at 500 nm

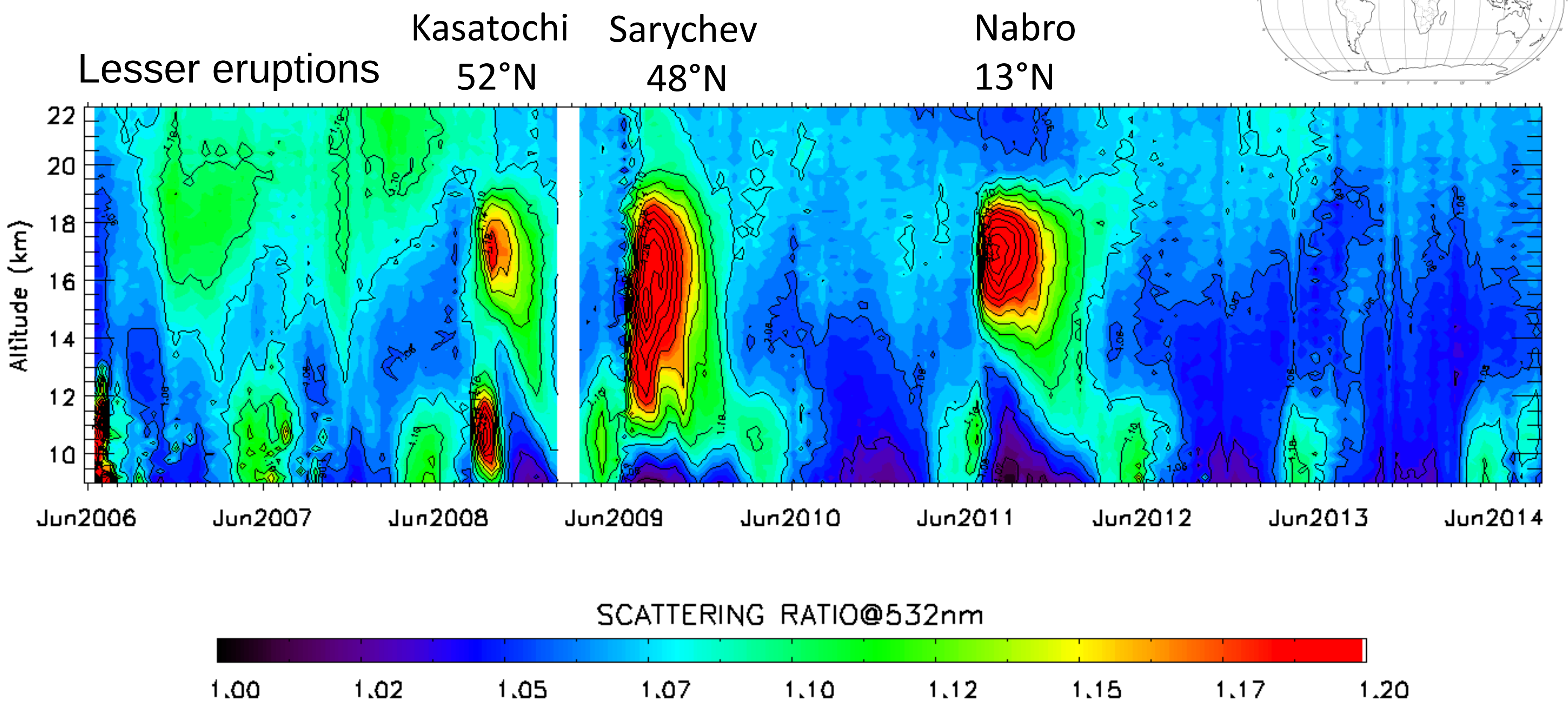


Until recently it was thought that only large tropical volcanic eruptions affected the stratosphere



Time series of the CALIOP space lidar 532 nm scattering ratio for the UTLS (30° to 60°N)





Provided by Jean-Paul Vernier, NASA Langley

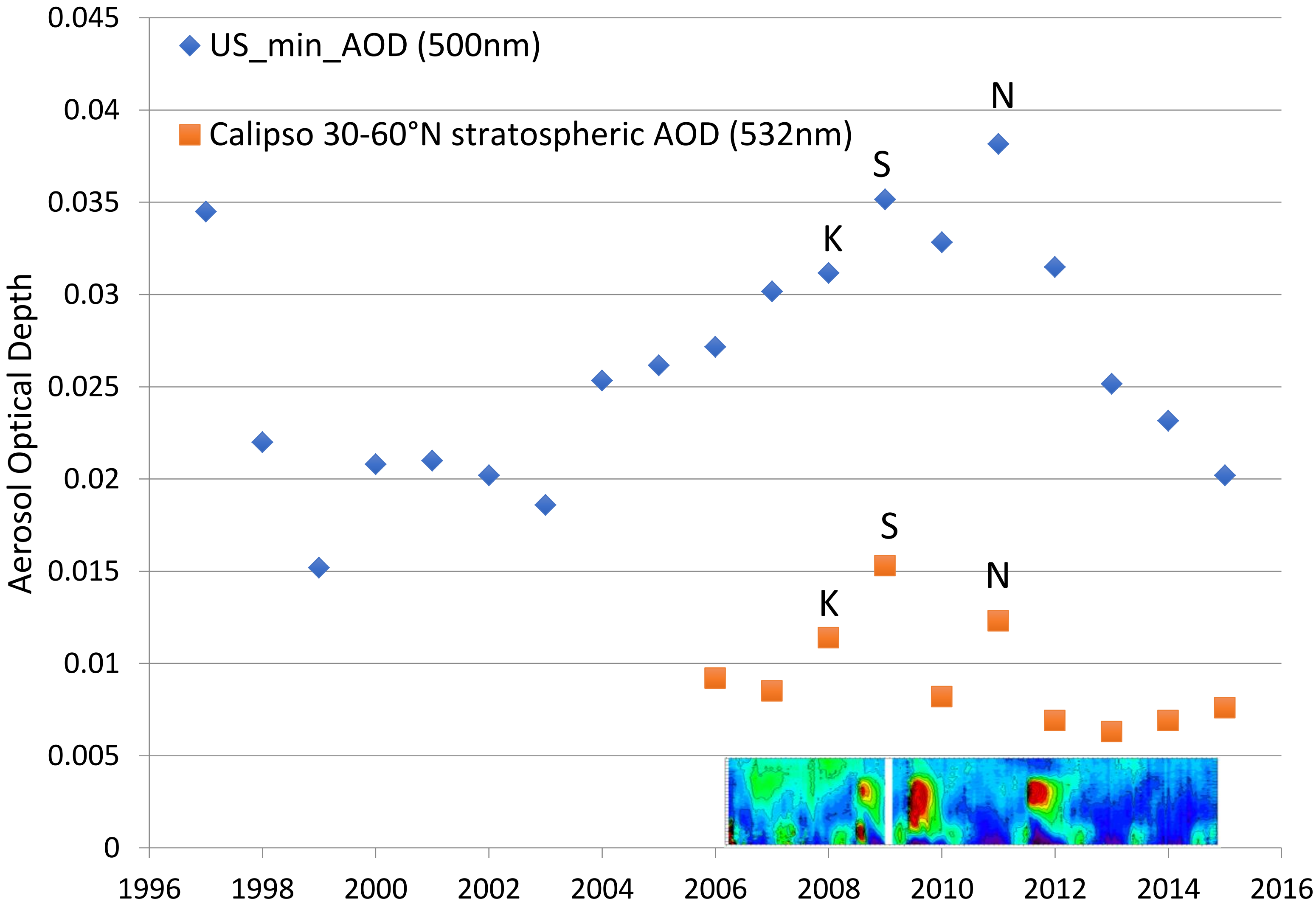
Volcanic eruptions 2000-2011

Table 1 | Volcanic eruptions in the 21th century that affect (or have the potential to affect) the aerosol loading of the stratosphere.

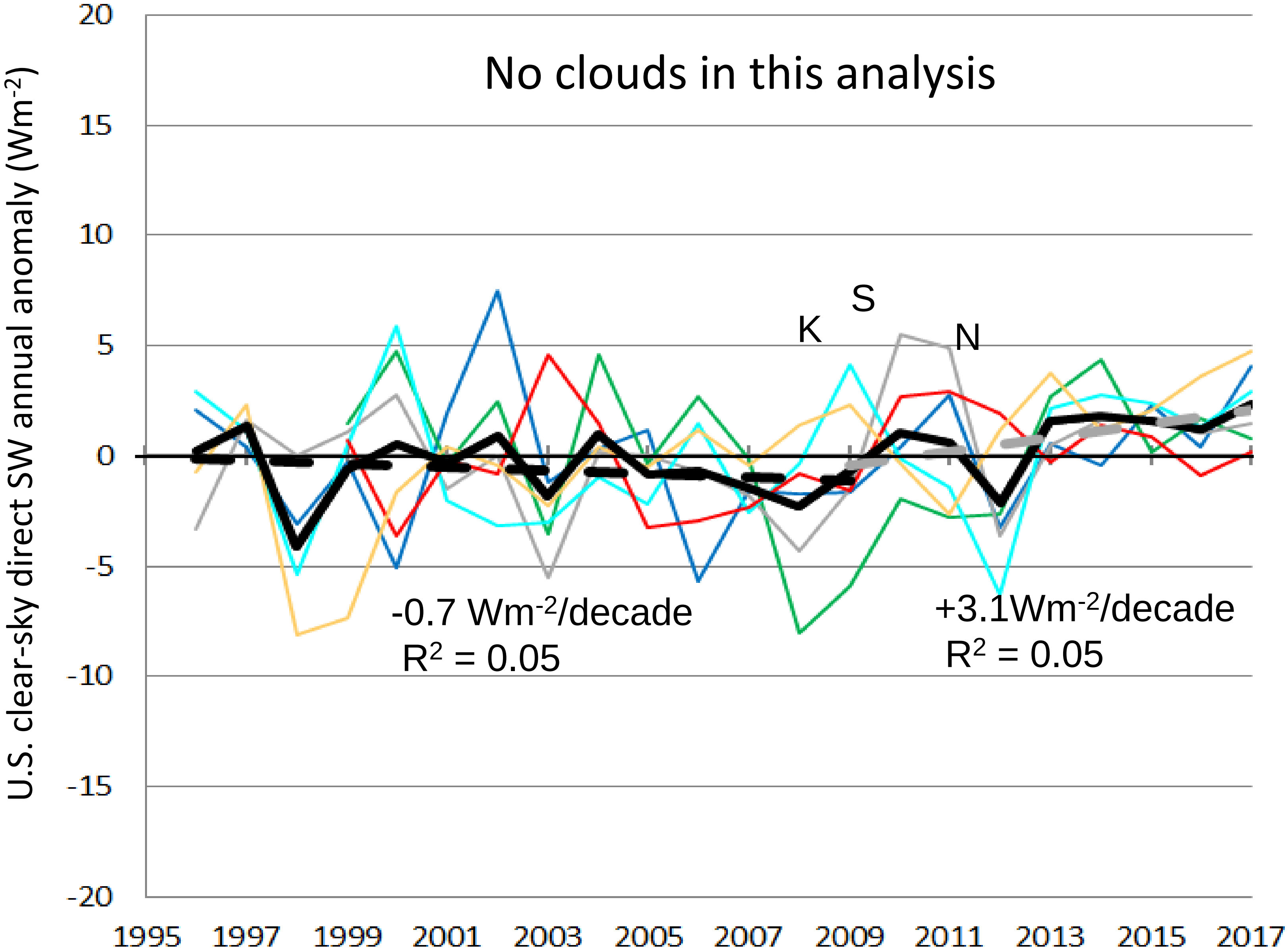
Volcano		Date	Lat.	Long.	VEI*	SO_2 (Tg)
Ulawun	Ul	29 Sep 2000	5° S	151° E	4	†
Sheveluch	Sh	22 May 2001	57° N	161° E	4	†
Ruang	Ru	25 Sep 2002	2° N	125° E	4	0.03 (ref. 50)
Reventador	Ra	3 Nov 2002	0° S	78° W	4	0.07 (ref. 50
Anatahan	At	10 May 2003	16° N	146° E	3	0.03 (ref. 50)
Manam	Ma	27 Jan 2005	4° S	145° E	4	0.09 (ref. 50)
Sierra Negra	Si	22 Oct 2005	1° S	91° W	3	†
Soufrière Hills	So	20 May 2006	17° N	62° W	3	0.2 (ref. 51)
Rabaul	Rb	7 Oct 2006	4° S	152° E	4	0.2 (ref. 50)
Jebel at Tair	Je	30 Sep 2007	16° N	42° E	3	0.08 (ref. 52)
Chaitén	Ch	2 May 2008	43° S	73° W	4	0.01 (ref. 53)
Okmok	Ok	12 Jul 2008	53° N	168° W	4	0.1 (ref. 52)
Kasatochi	Ka	7 Aug 2008	52° N	176° W	4	1.7 (ref. 52)
Redoubt	Re	23 Mar 2009	60° N	153° W	3	0.01 (ref. 54)
Sarychev	Sa	12 Jun 2009	48° N	153° E	4	1.2 (ref. 55)
Eyjafjallajökull	Ey	14 Apr 2010	64° N	20° W	4	†
Merapi	Me	5 Nov 2010	8° S	110° E	4	0.4 (ref. 56)
Grimsvötn	Gr	21 May 2011	64° N	17° W	4	0.4 (ref. 57)
Puyehue-Cordón Caulle	Pu	6 Jun 2011	41° S	72° W	5	0.3 (ref. 57)
Nabro	Na	12 Jun 2011	13° N	42° E	4	1.5 (ref. 57)

From Andersson et al., NATURE COMMUNICATIONS | 6:7692 | DOI: 10.1038/ncomms8692

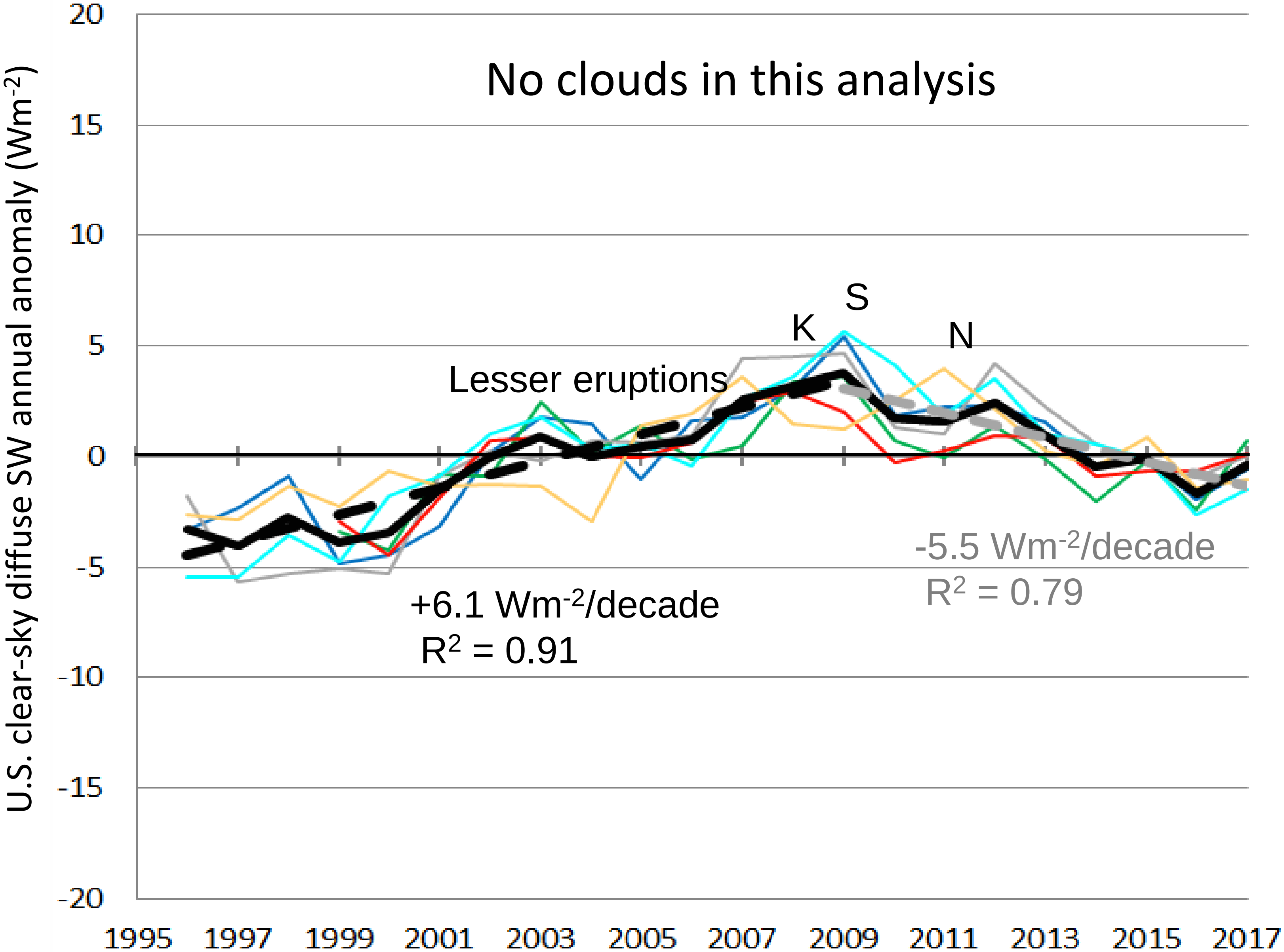
U.S. annual AOD minima and UTLS AOD from CALIOP



RadFlux: Clear-Sky-Equivalent Direct short wave

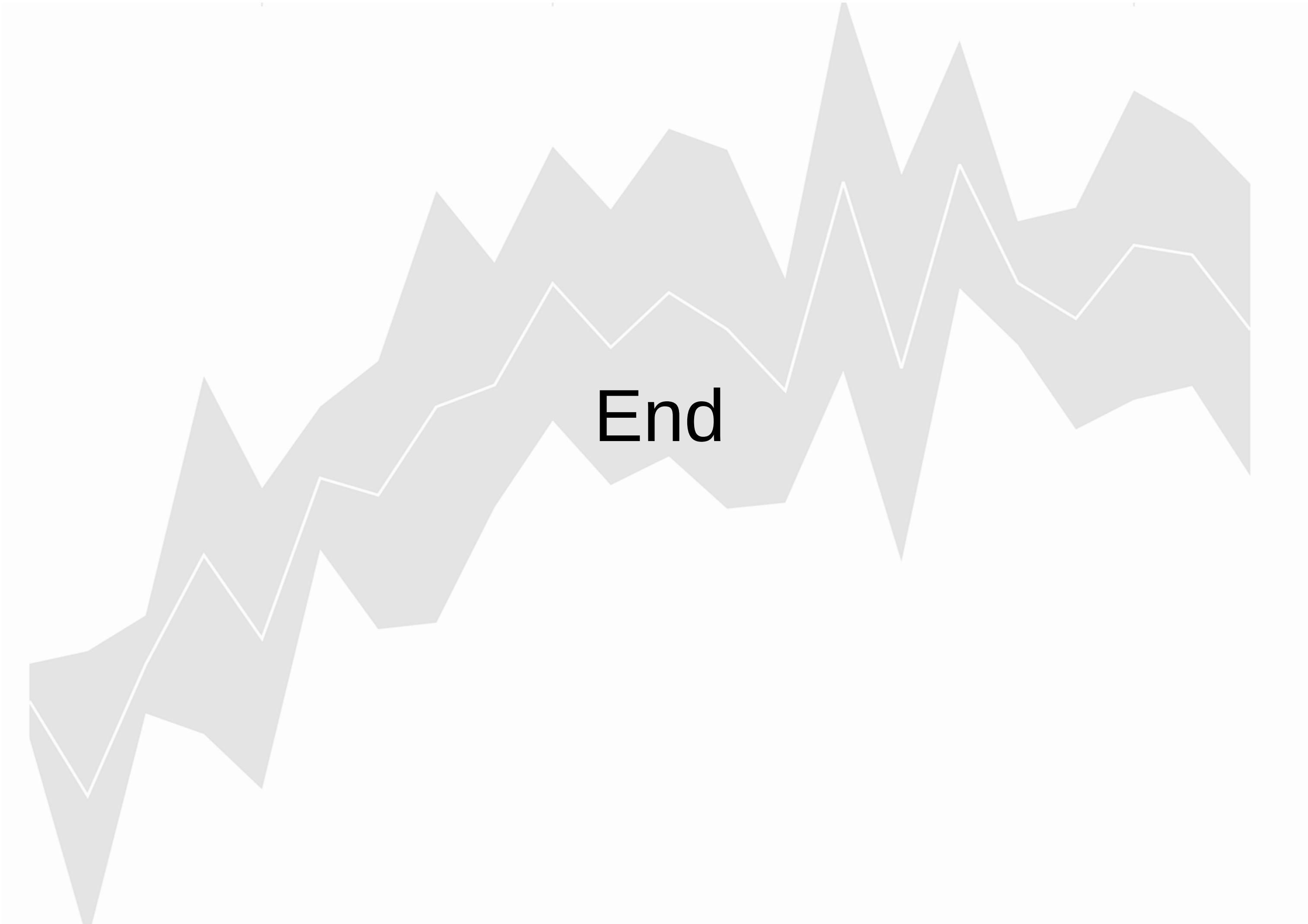


RadFlux: Clear-Sky-Equivalent Diffuse short wave



Summary

- Shortwave brightening of +7.2 Wm^{-2}/decade over the U.S. from 1996 to 2012
- Following 2012, there was a rapid return to "normalcy" –- Has brightening ended over the U.S.?
- U.S. shortwave brightening and dimming has been primarily attributed to systematic changes in cloud cover
- A systematic reduction in aerosols accounted for only a small part of the brightening
- LW down variability over the U.S. appears to be governed by surface air temperature, cloud cover, water vapor variability and ENSO
- Interannual variability of AOD minima and clear-sky diffuse seem to mimic lower stratospheric AOD variability



End