Long-term EC and Reflectance Trends in IMPROVE Laboratory Data

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Objectives

- Identify other evidence of downward EC trends
- Examine trends in laboratory EC measurements (prior to data processing)
- Comparison EC trends with trends in filter darkness, τ_R[a]:

$$\tau_R = -\ln\left(\frac{R_{final}}{R_{int}}\right)^*$$

The ratio of initial (*int*) and final reflectance (R)

Evidence favors long-term reduction in EC 20 over past 20 years

- Many SIPs implemented emission reductions for PM_{10} (after 1987) and $PM_{2.5}$ (after 1997), including EC sources
- Fraction of EC is some emissions is reduced, especially engine exhaust
- Other long-term BC and EC data measurements indicate reductions

BC trends in Los Angeles

(Reflectometer, with mass absorption efficiency determined by against GRALE and PACs thermal method)

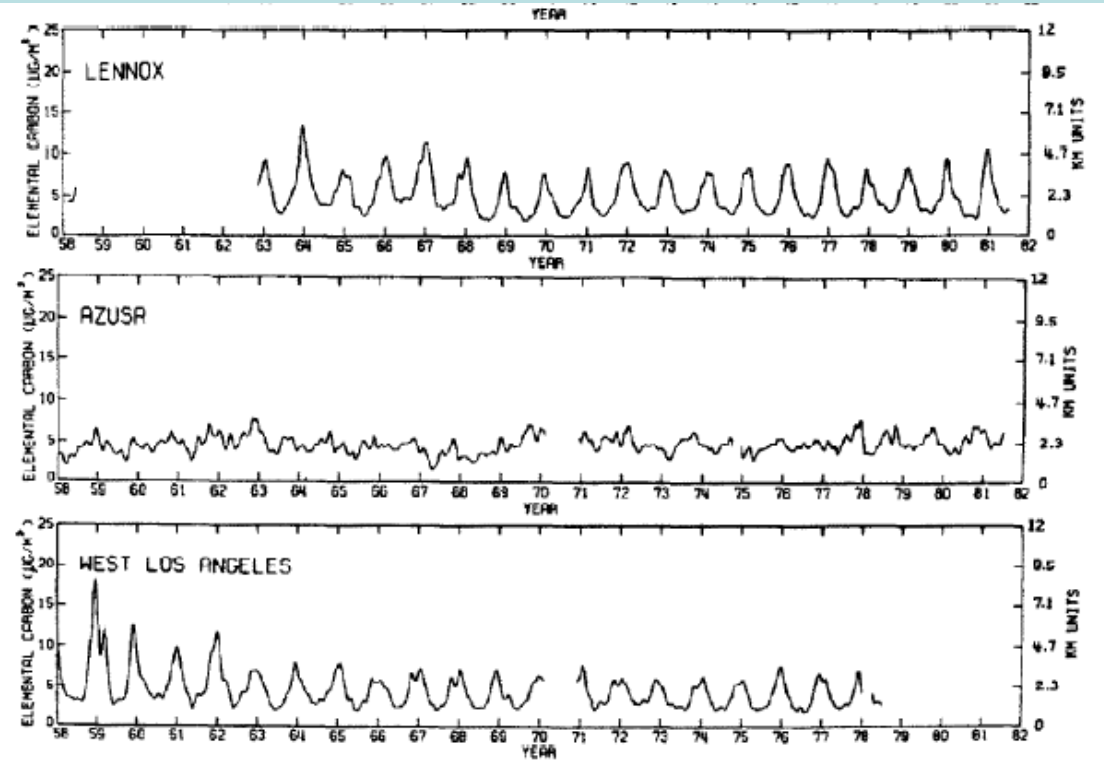


Fig. 7. Trend in elemental carbon concentration and Km values.

during the Portland Aerosol Characterization Study (PACS) (Watson, 1979). It was found that the PACS samples lost about 20% of their total C loading during a storage period of 3 years. Thus organic C concen-

Cass, G.R.; Conklin, M.H.; Shah, J.J.; Huntzicker, J.J. (1984). Elemental carbon concentrations - Estimation of an historical data base. Atmos. Environ., 18 (1): 153-162.

EC Trends at Whiteface Mountain

(TOT on deposits removed from cellulose fiber filters)

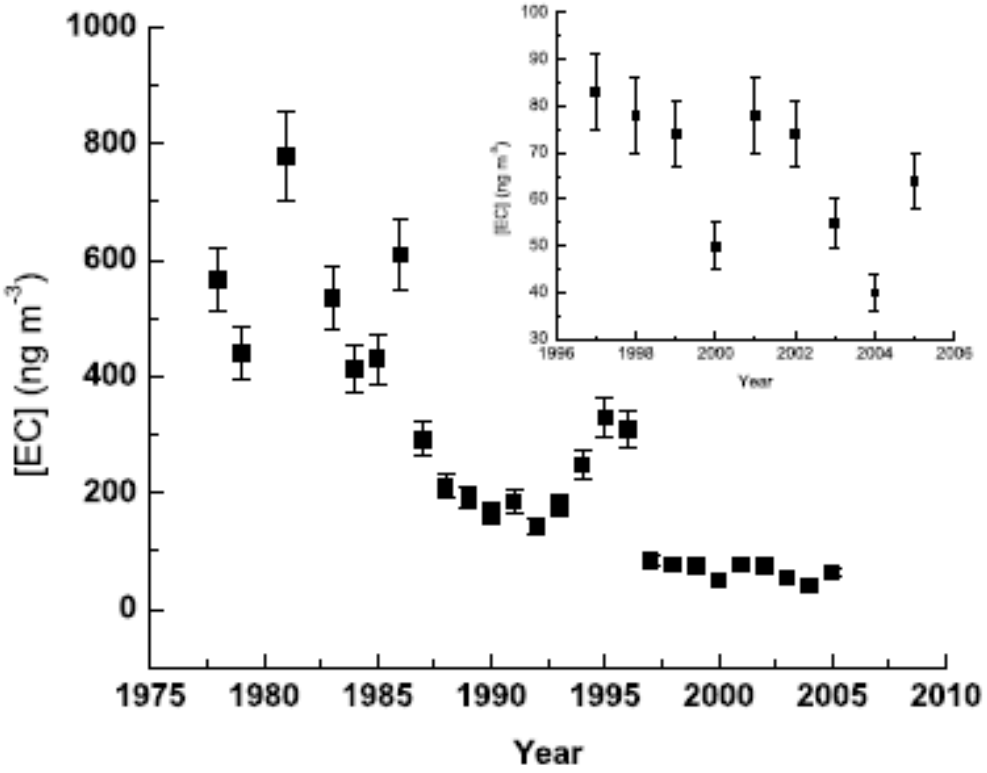


Figure 2. Annual atmospheric elemental carbon concentrations measured at Whiteface Mountain from 1978 to 2005. Inset shows the concentrations for the 1997–2005 period on an expanded scale.

Husain, L.; Khan, A.J.; Ahmed, T.; Swami, K.; Bari, A.; Webber, J.S.; Li, J.J. (2008). Trends in atmospheric elemental carbon concentrations from 1835 to 2005. *J. Geophys. Res. -Atmospheres,* ***113(D13)***

BC Trends at Mace Head

(Aethalometers, changed in 1996. Mass absorption coefficients related to French two-step method)

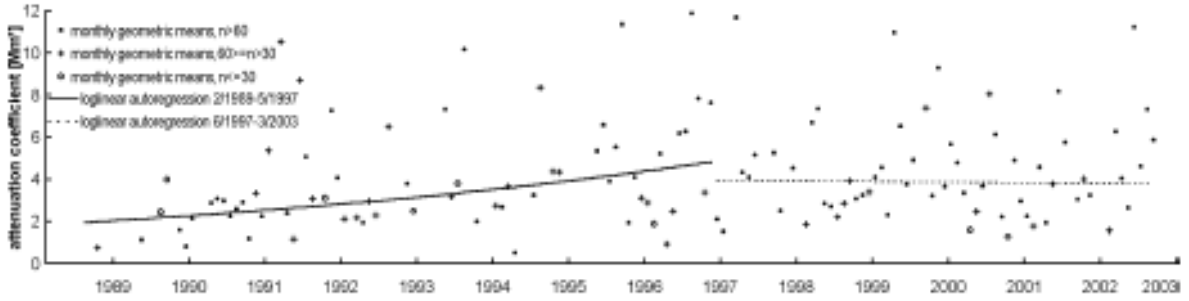


Fig. 13. Monthly geometric means of the *continental* sector aerosol attenuation coefficients with trend lines determined by autoregression analysis. The number of hourly values is represented by *n*. Values denoted by a cross are monthly geometric means calculated from less than 60 hourly values. Open circles denote means calculated from less than 30 hourly values. The markers on the abscissa denote the middle of each year (30 June).

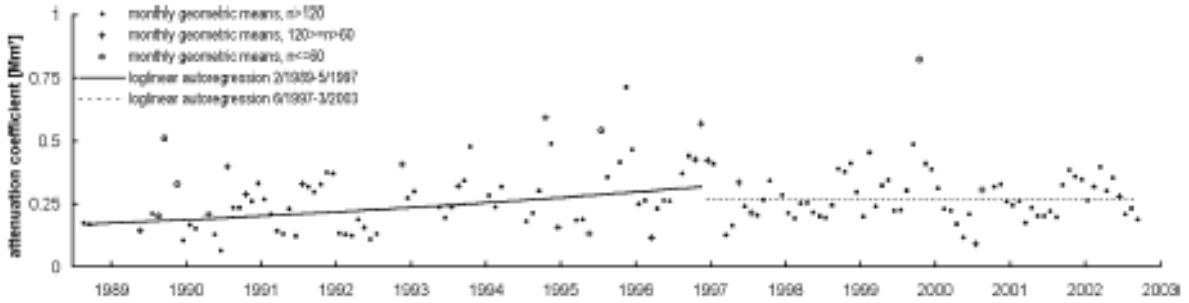


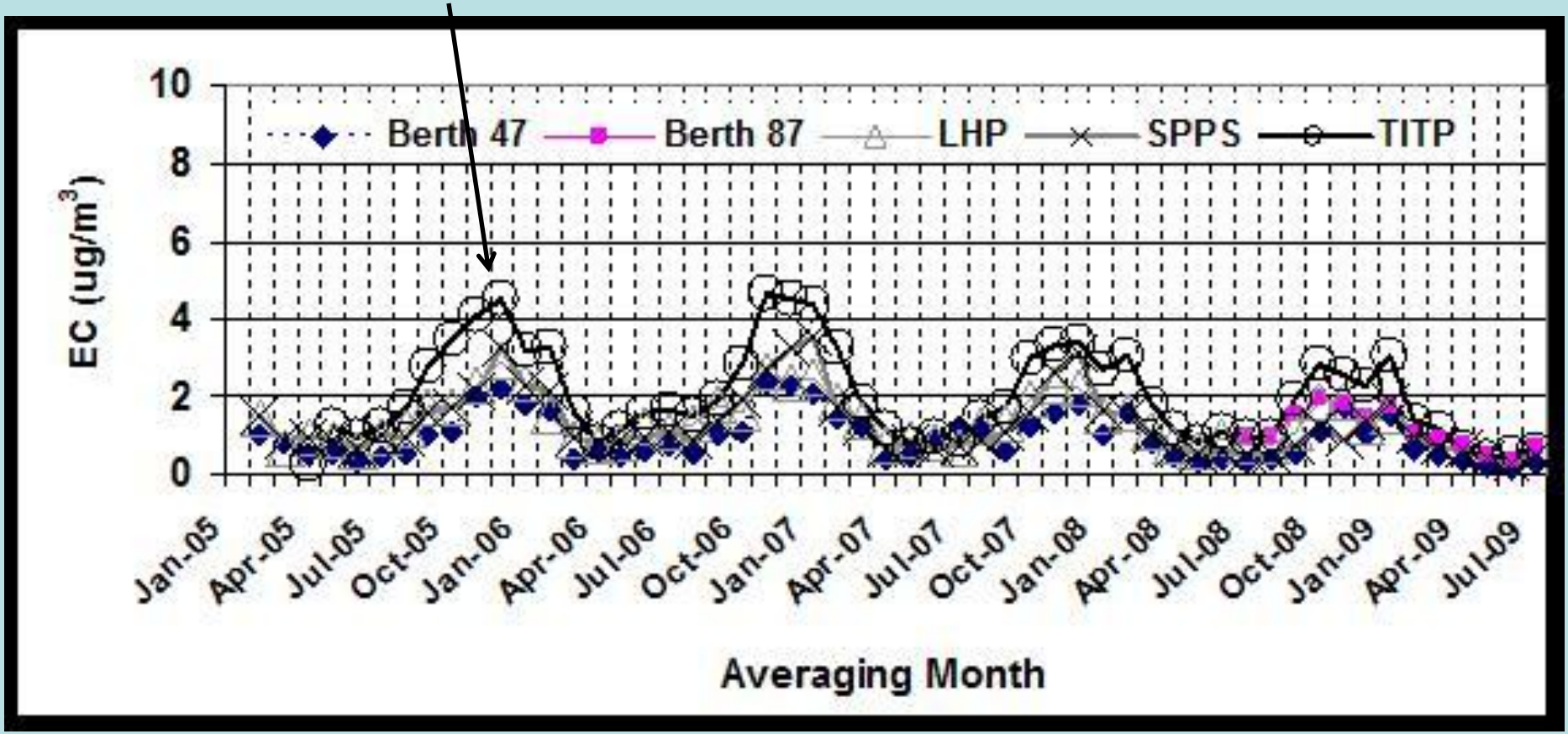
Fig. 14. Monthly geometric means of the *marine* sector aerosol attenuation coefficients with trend lines determined by autoregression analysis. The number of hourly values is represented by n. Values denoted by a cross are geometric means calculated from less than 120 hourly values. Open circles denote means calculated from less than 60 hourly values. The markers on the abscissa denote the middle of each year (30 June).

Junker, C.; Jennings, S.G.; Cachier, H. (2006). Aerosol light absorption in the North Atlantic: trends and seasonal characteristics during the period 1989 to 2003. *Atmos. Chem. Phys.*, ***6: 1913-1925.***

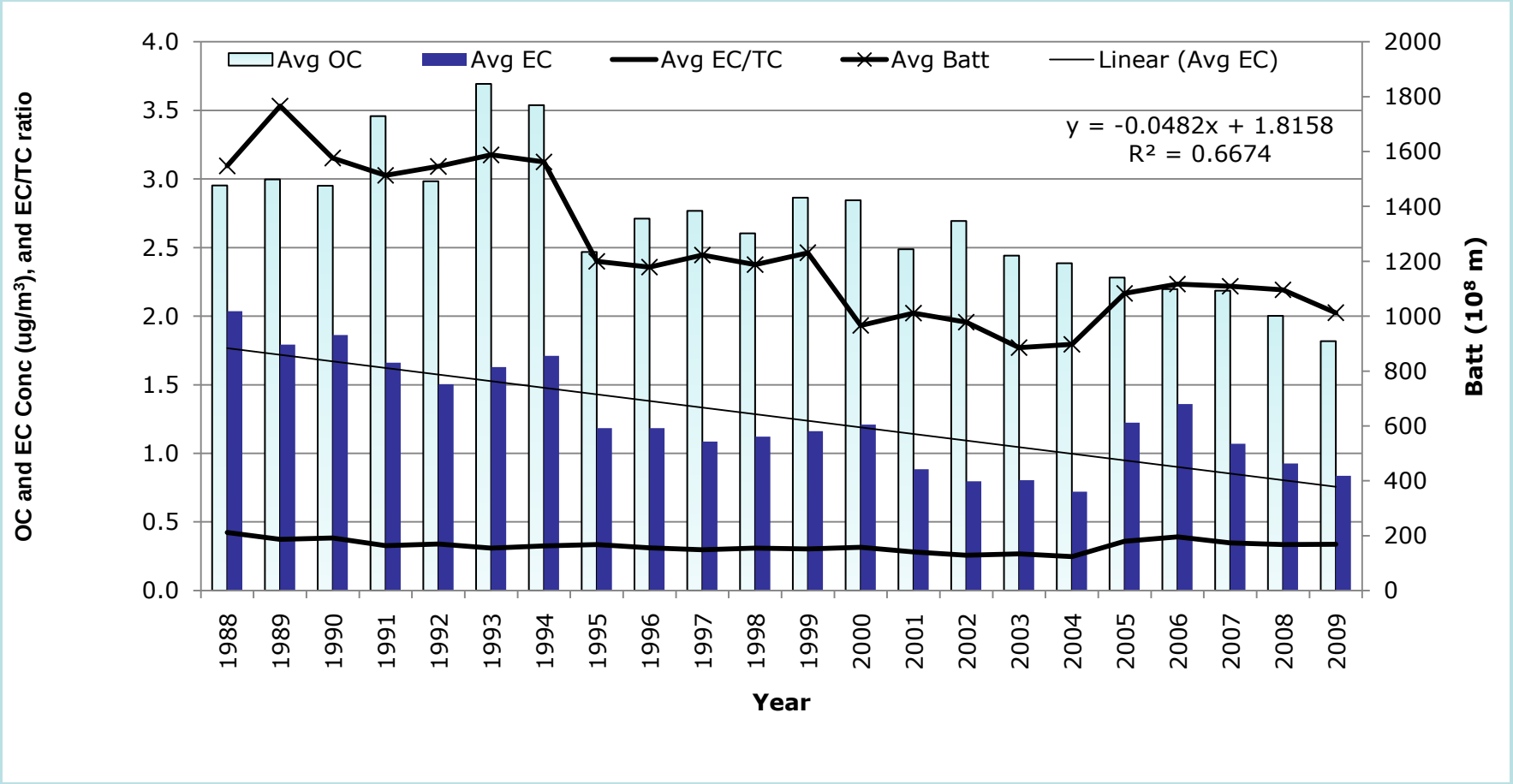
EC Trends at Port of Los Angeles

(IMPROVE TOR)

In middle of terminal



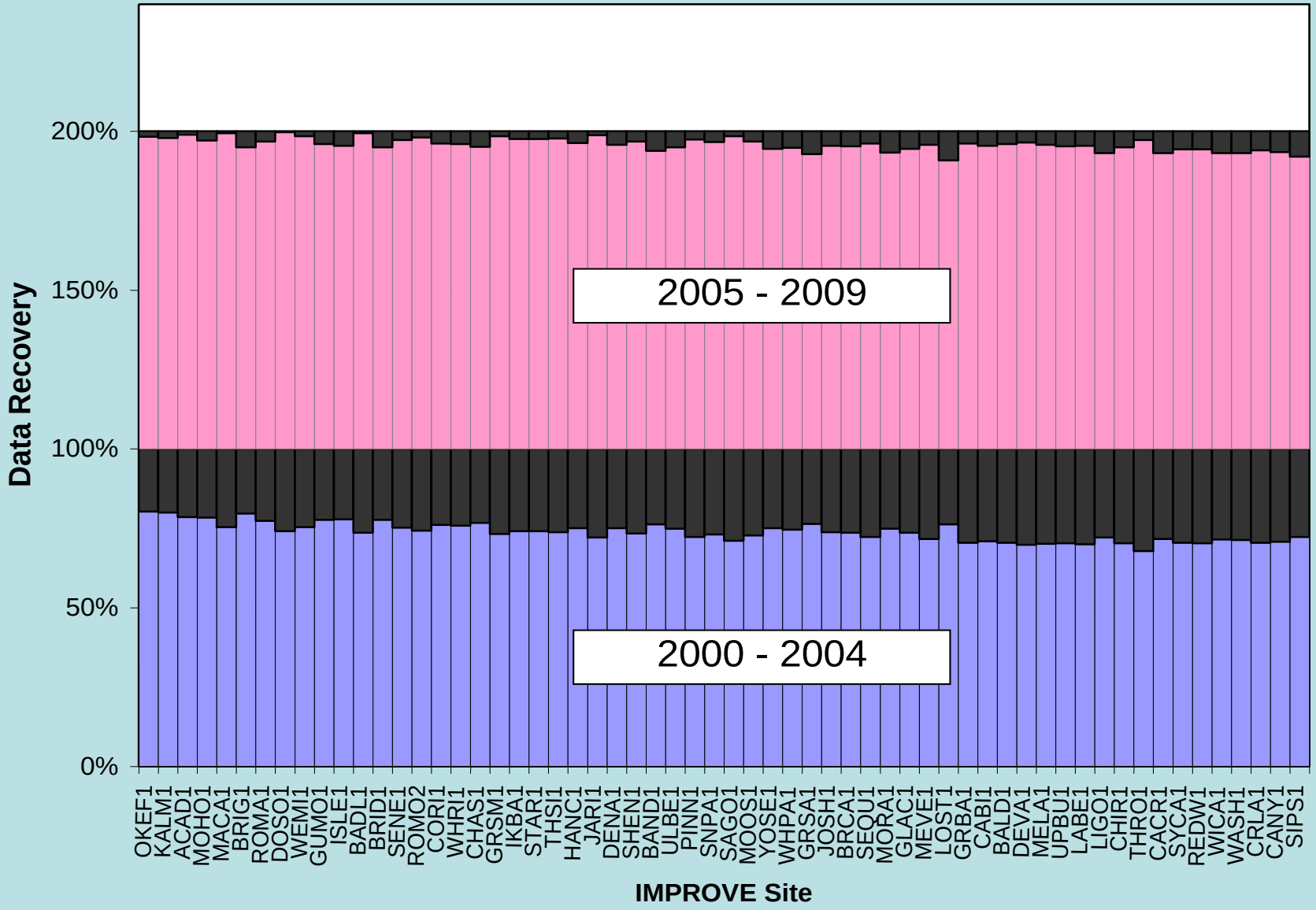
IMPROVE OC,EC, b_{att}, and EC/TC trends at WASH1



Sources of Data

- Data were retrieved from DRI data bases (uncorrected data)
- Pre-2005 data were reprocessed for negative OP and only includes those with digitized thermograms
- Post-2005 data contain initial, minimum, and final reflectance and transmittance

60 sites selected based on data availability



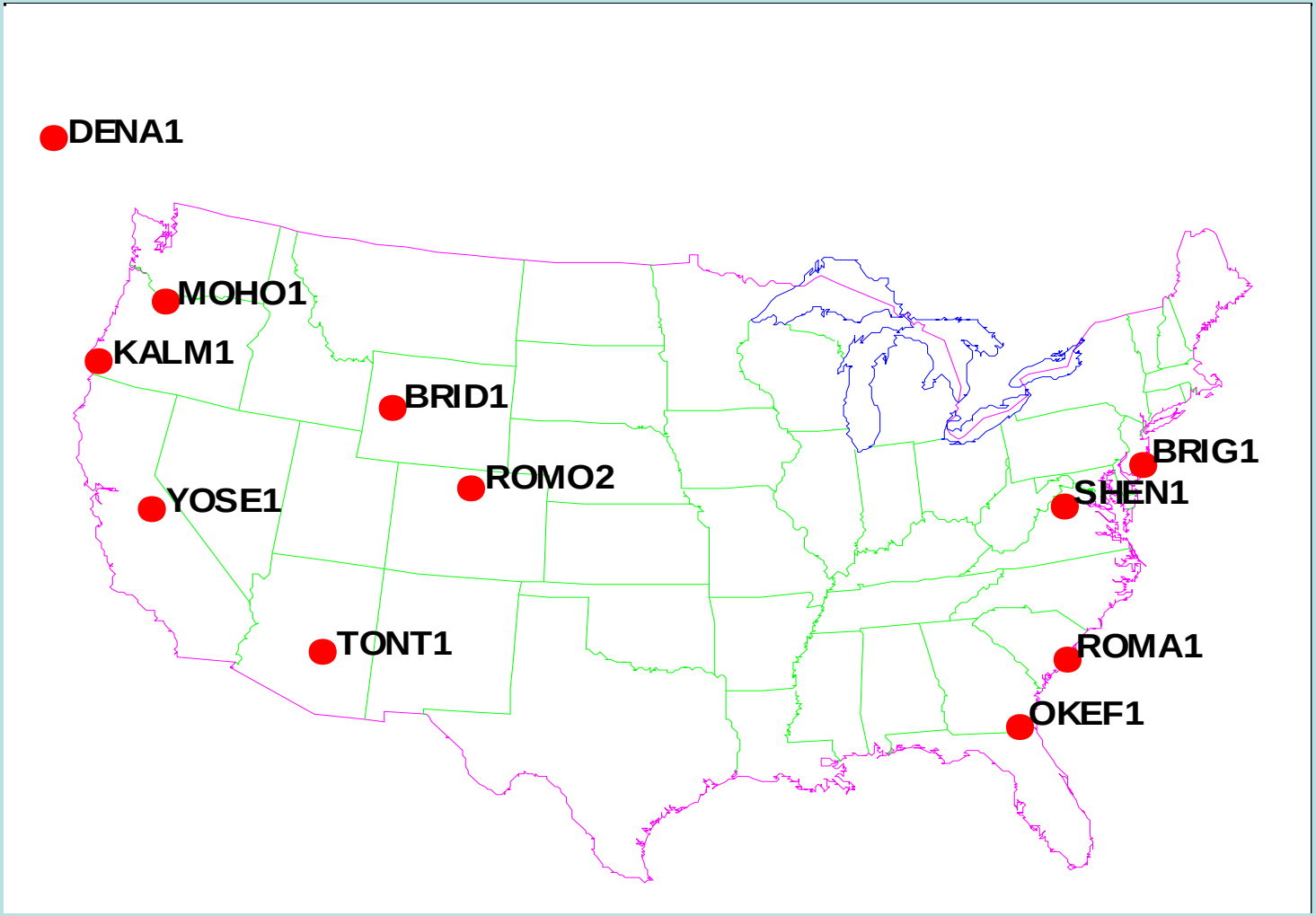
95% of data retrieved for 2005 – 2009; 70 – 80% data retrieved for 2000 - 2004

Data were divided into quarters t to minimize seasonal influences

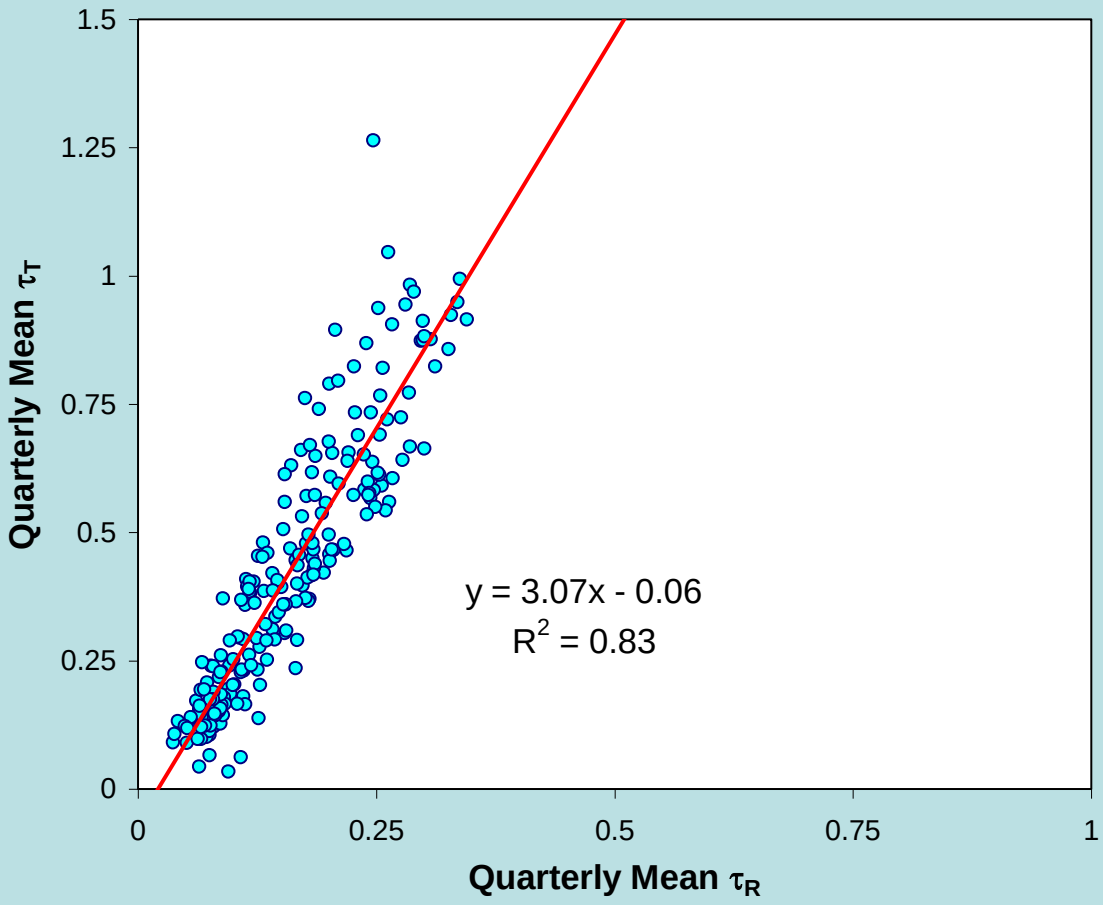
- Contain at least 16 of the ~30 samples for each quarter, including mean, median, low (20%) and high (80%) data

- Eleven sites had valid Q2, Q3, and Q4 from 2000 – 2009 (10-year period) and valid Q1 from 2001 - 2009 (Most Q1 data in 2000 were missing)

Eleven sites with sufficient samples in each quarter (2000 – 2009)



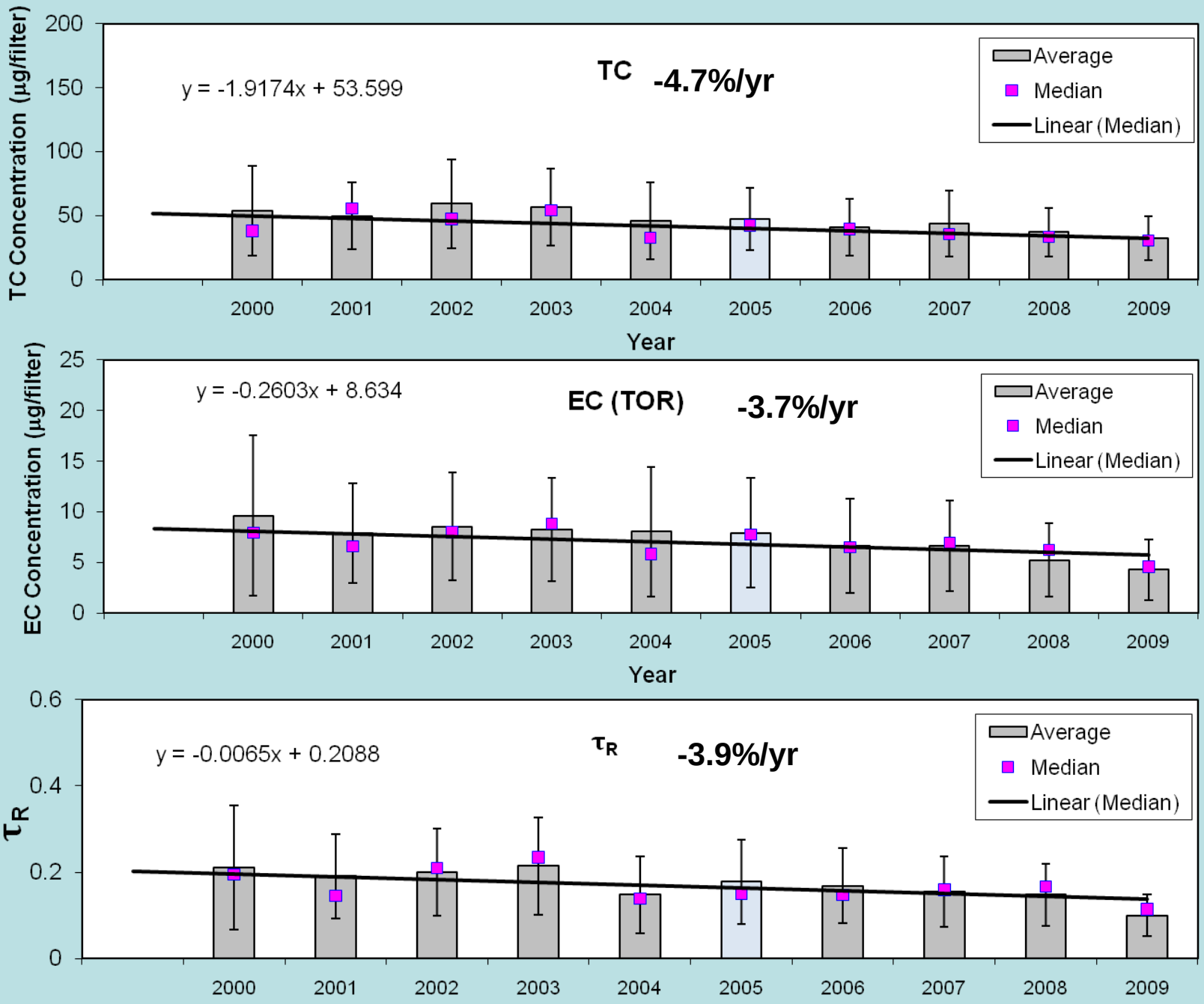
τ_R is linearly related to τ_T



*Include all valid quarterly means from the 11 sites selected

(2005 – 2009 where transmittance data are available)

Q4 (Oct, Nov, Dec)

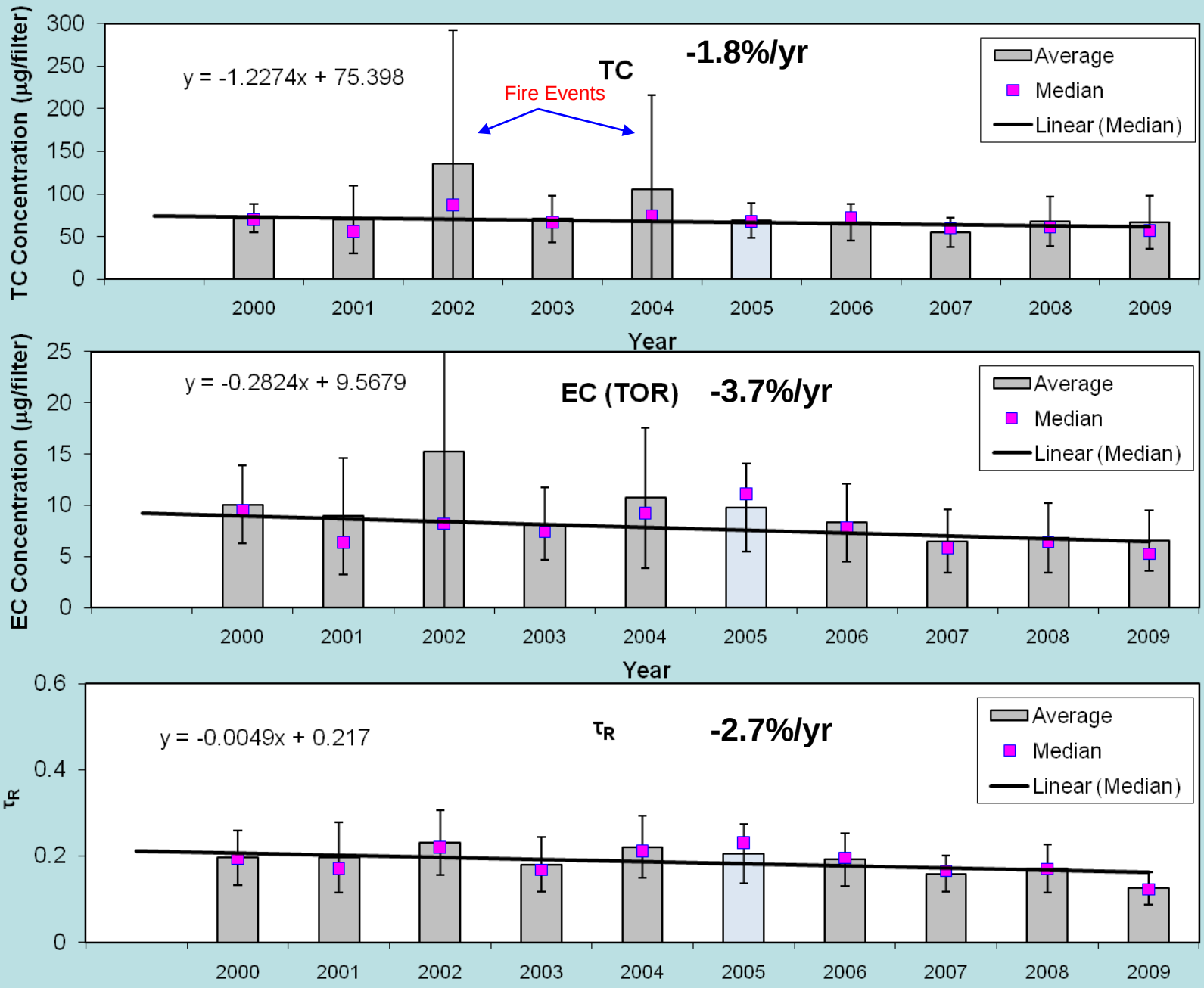


Based on average, standard deviation and median of quarterly mean across 11 sites

$\tau_R = -\ln(R_{final}/R_{int})$; slope divided by the average of yearly median concentration for Q4

Pale grey data point indicates changeover to DRI Model 2001 analyzers

Q3 (Jul, Aug, Sep)

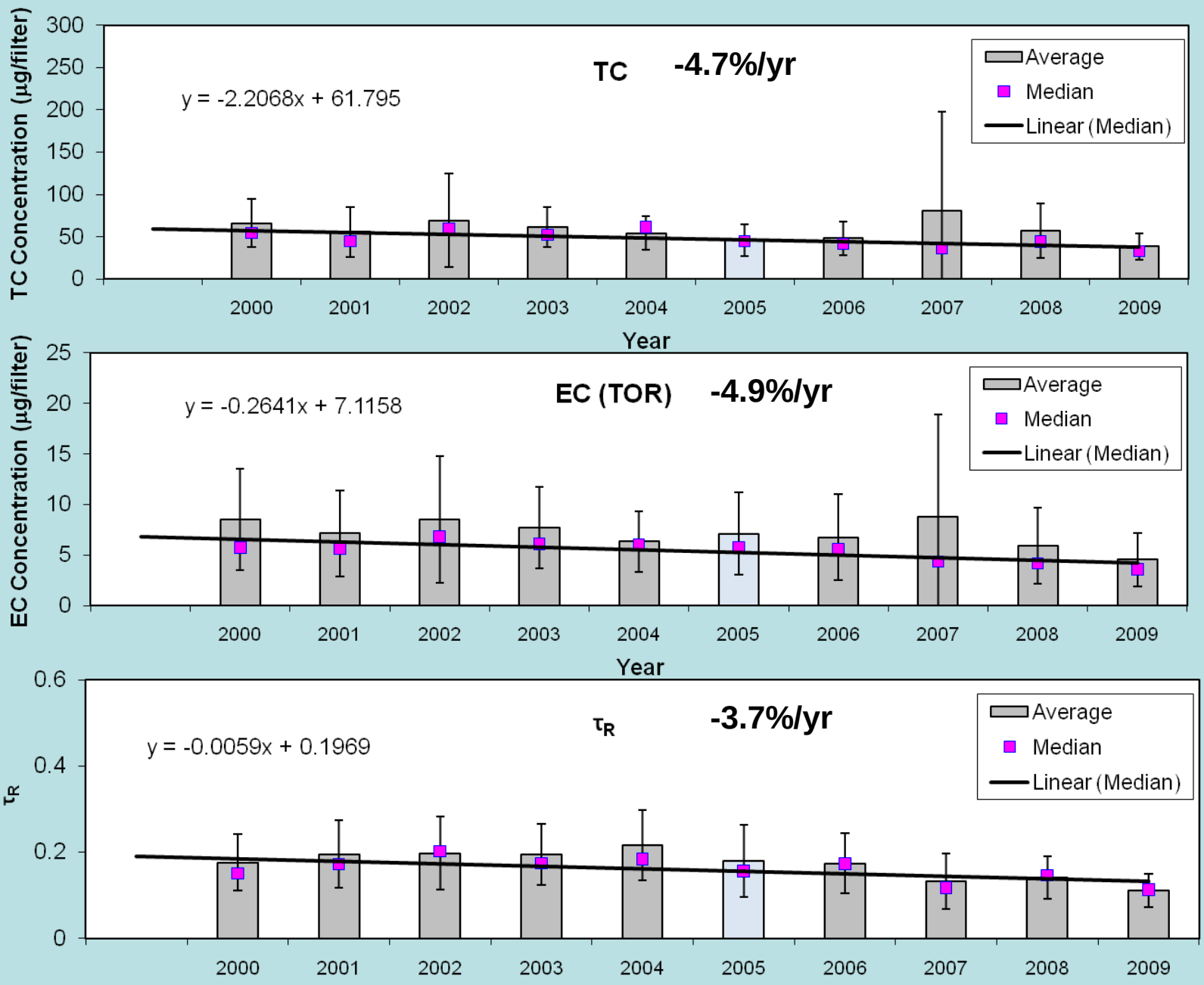


Based on average, standard deviation and median of quarterly means across 11 sites

$\tau_R = -\ln(R_{final}/R_{int})$; slope divided by the average of yearly median concentration for Q3

Pale grey data point indicates changeover to DRI Model 2001 analyzers

Q2 (Apr, May, Jun)

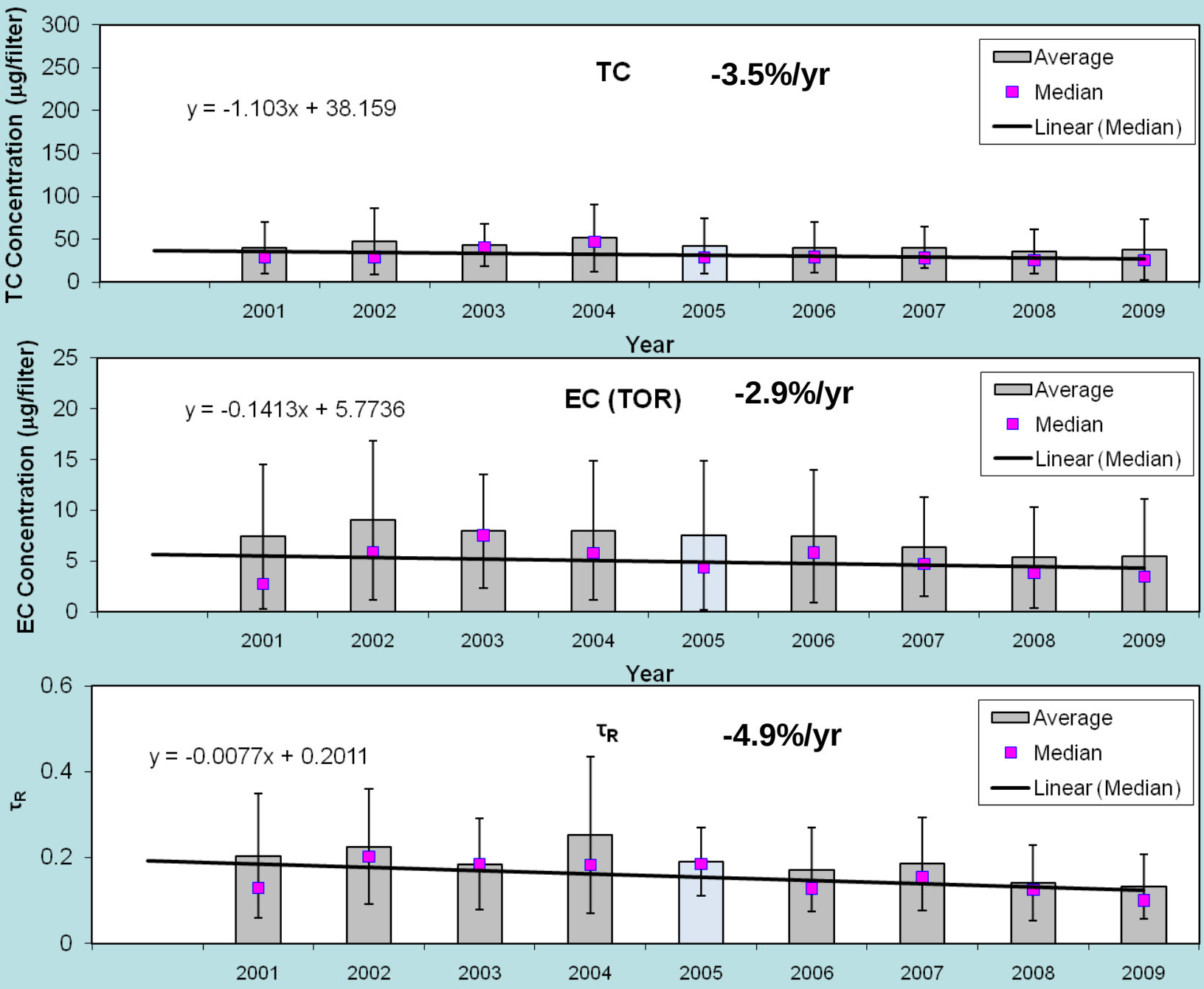


Based on average, standard deviation and median of quarterly means across 11 sites

$\tau_R = -\ln(R_{final}/R_{int})$; slope divided by the average of yearly median concentration for Q2

Pale grey data point indicates changeover to DRI Model 2001 analyzers

Q1 (Jan, Feb, Mar)

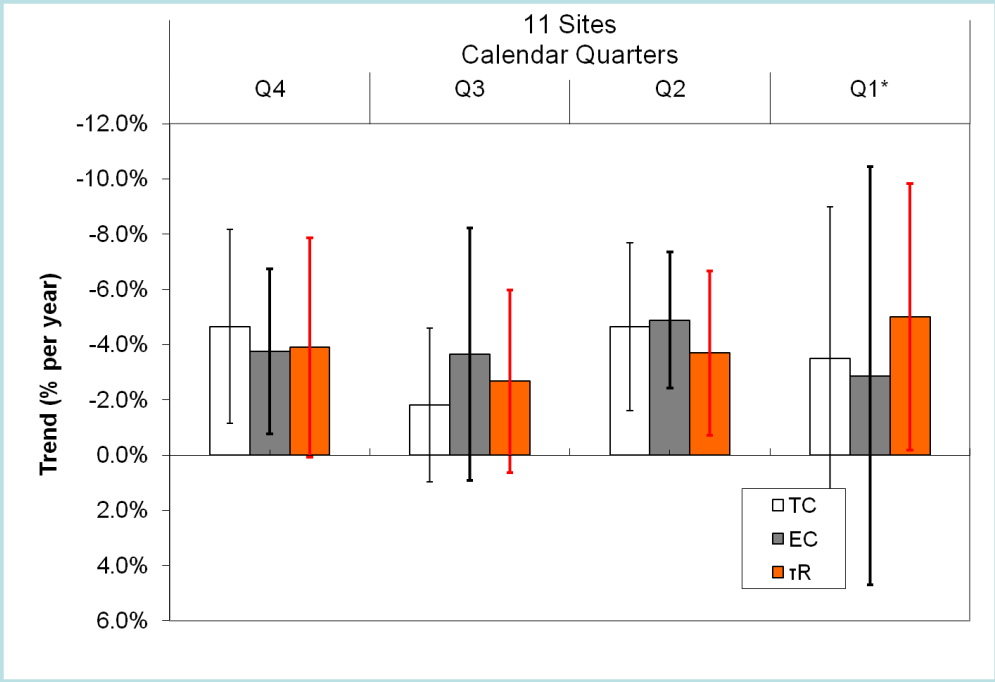


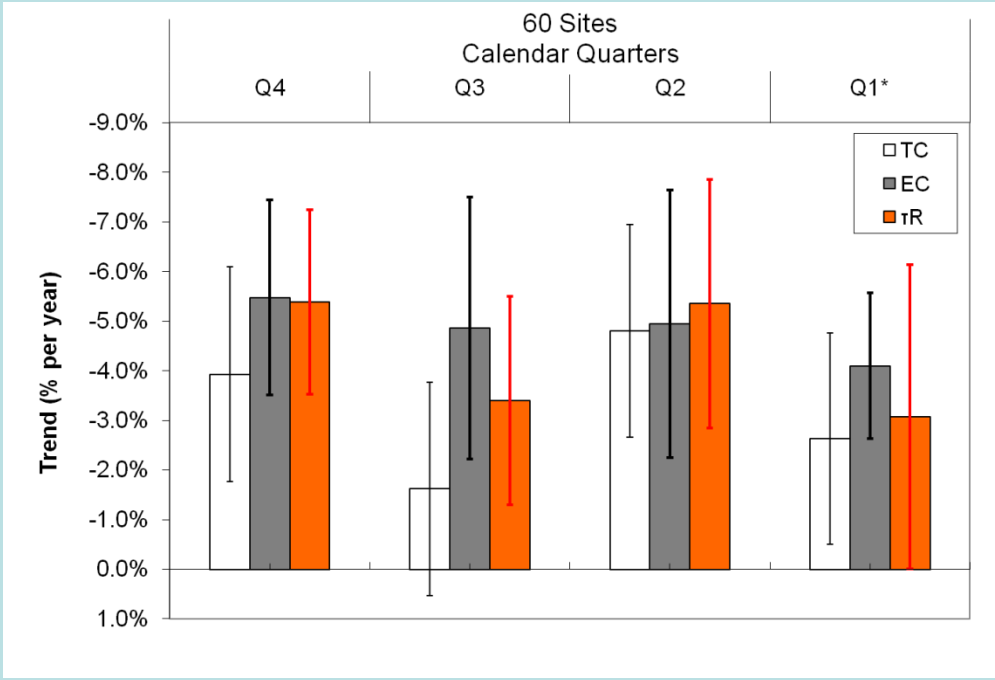
Based on average, standard deviation and median of quarterly means across 11 sites

$\tau_R = -\ln(R_{final}/R_{int})$; slope divided by the average of yearly median concentration for Q2

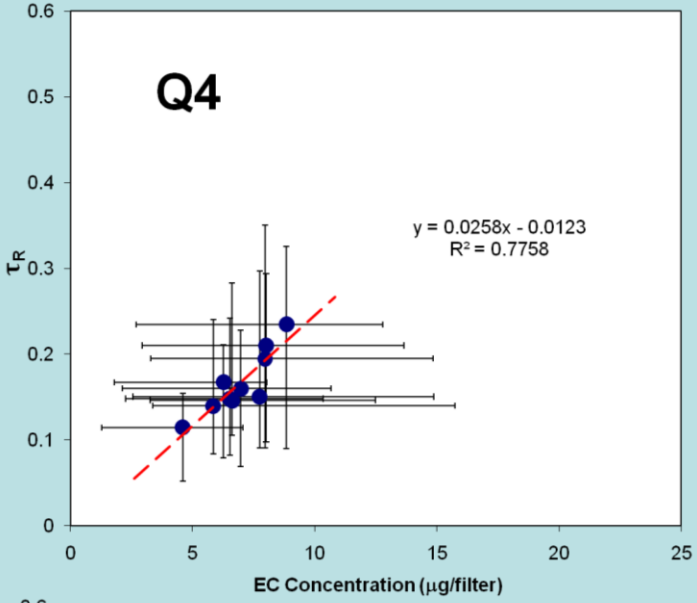
Pale grey data point indicates changeover to DRI Model 2001 analyzers

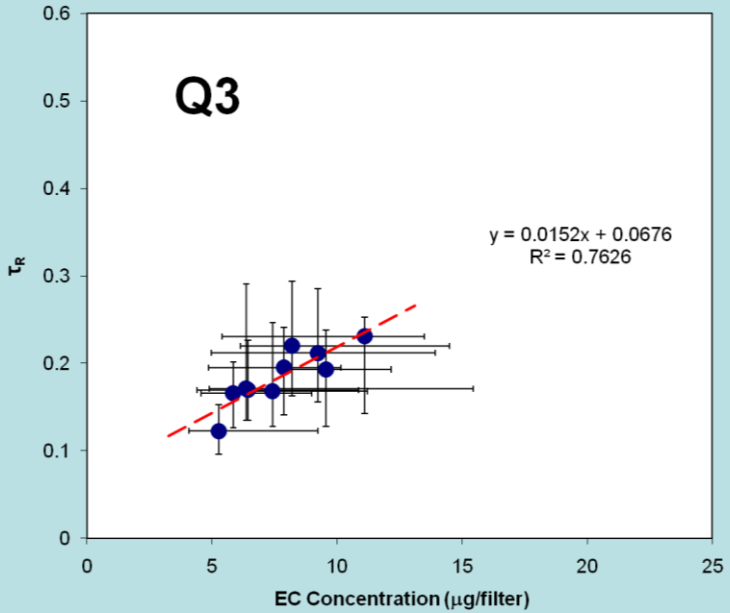
Average (standard deviation) of quarterly changes at 11 and 60 sites

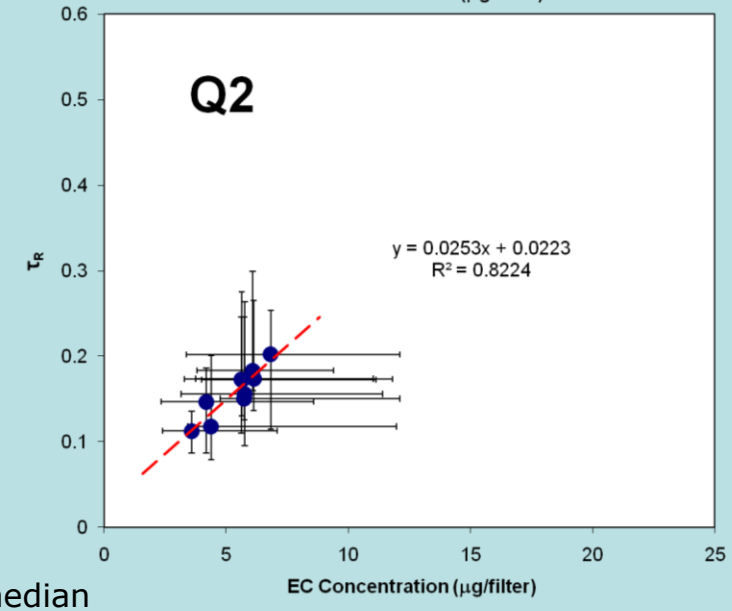


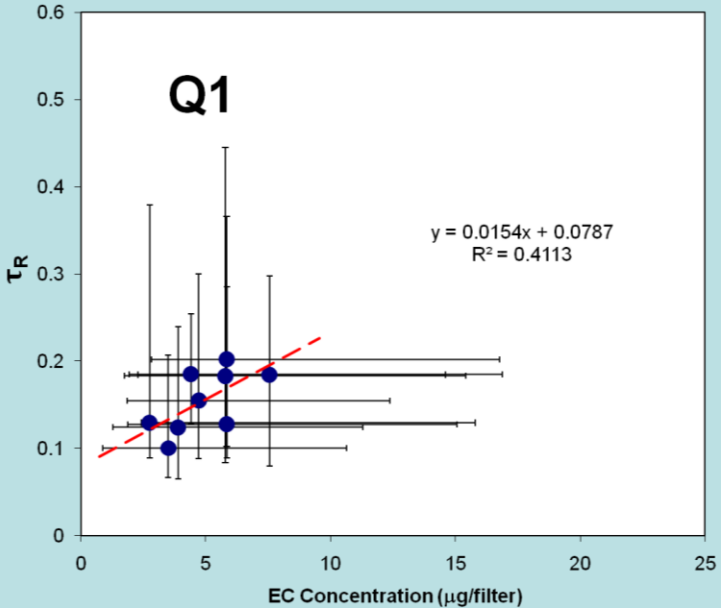


EC/τ_R correlation are $0.76 < R^2 < 0.82$ for Q2-Q4. Q1 ($R^2 = 0.41$)



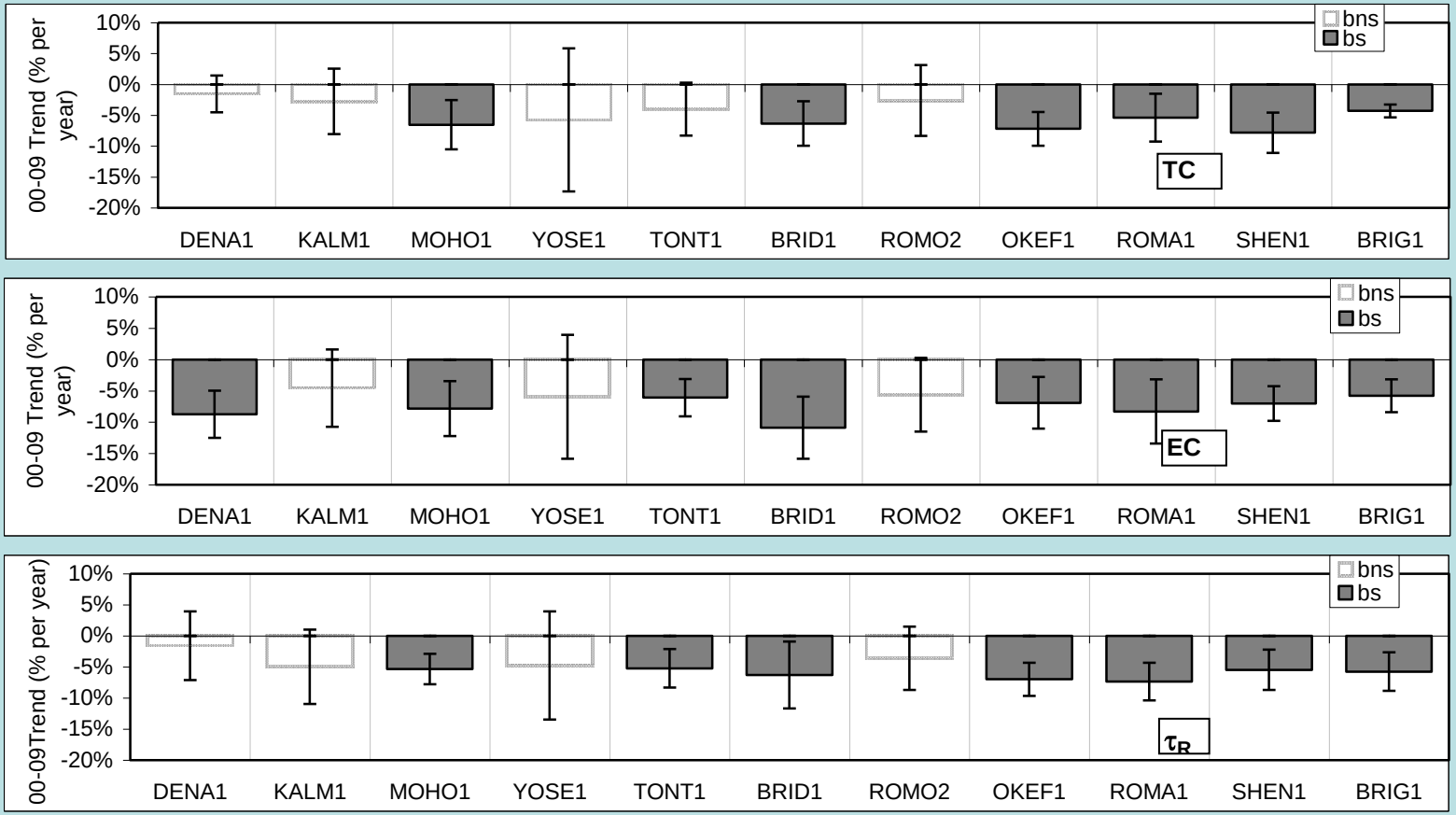






11-site median

Trend variation by site (Q4 [Oct, Nov, Dec])

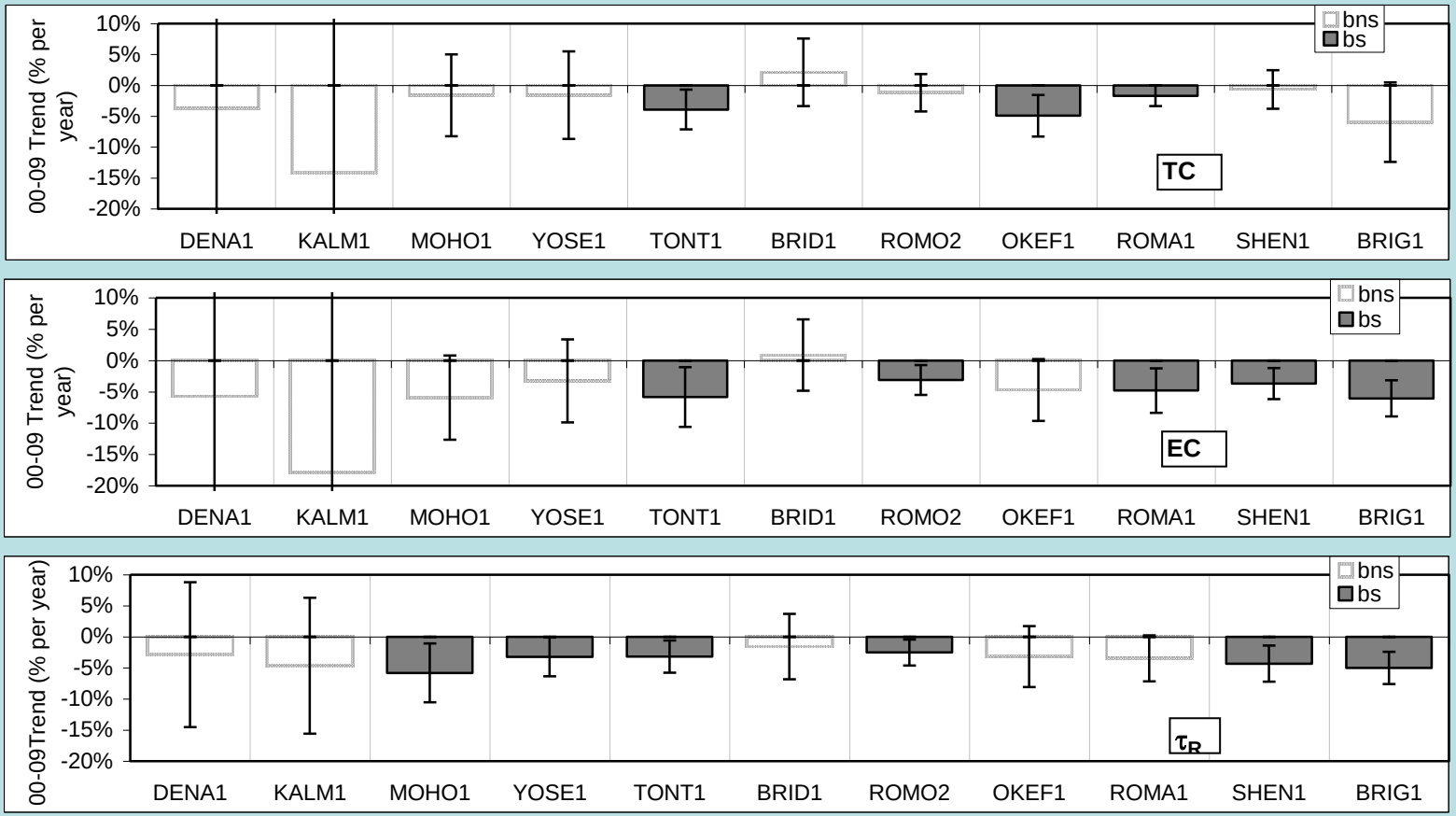


Error bars indicate 90% confidence interval; hollow bars indicate insignificant trends

Sites are grouped from northwest to southeast

Slope is divided by median (Q4) by site over 10 years

Trend variation by site (Q3 [Jan, Feb, Mar])

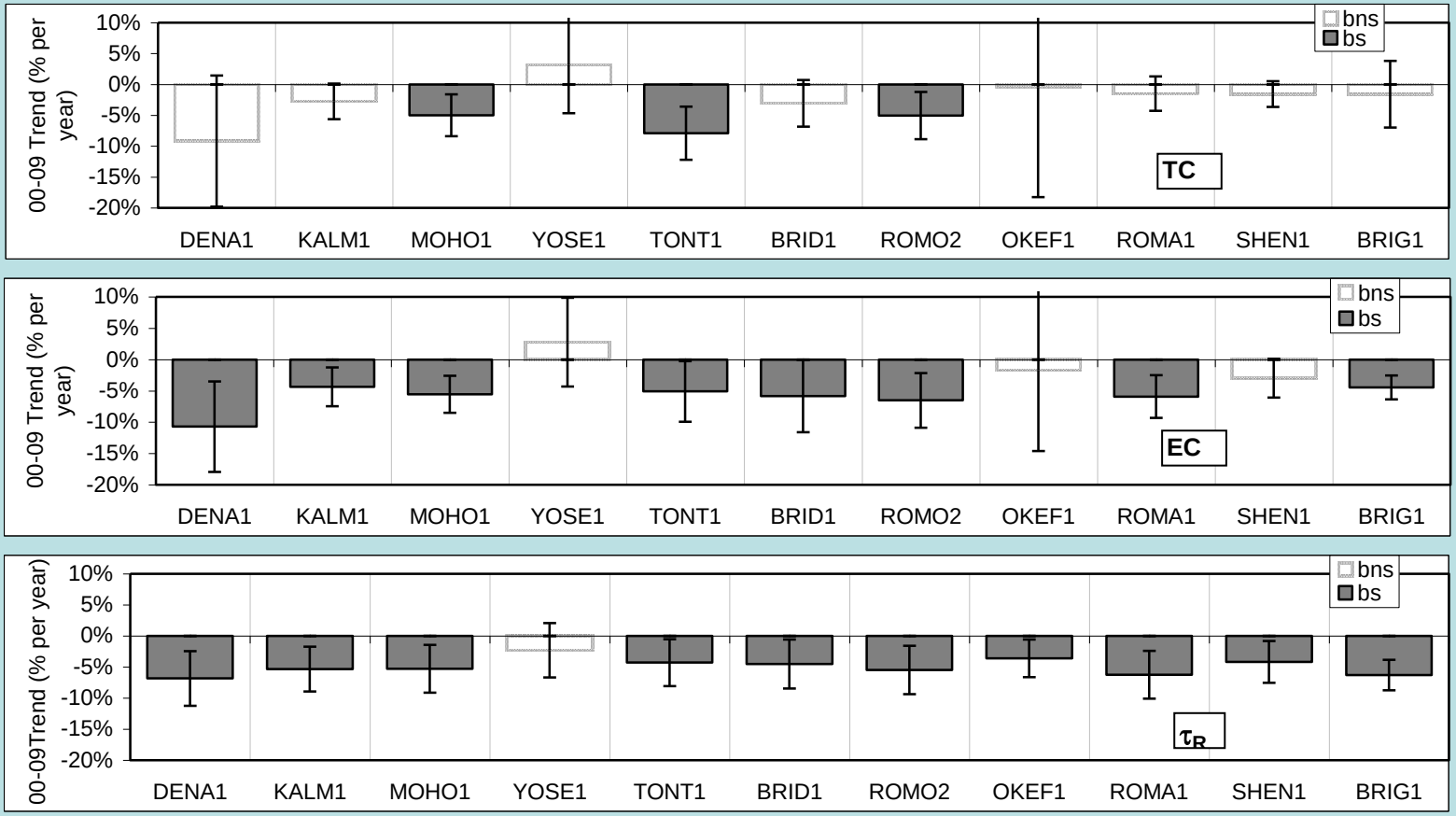


Error bars indicate 90% confidence interval; hollow bars indicate insignificant trends

Sites are grouped from northwest to southeast

Slope is divided by median (Q4) by site over 10 years

Trend variation by site (Q2 [Apr, May, Jun])

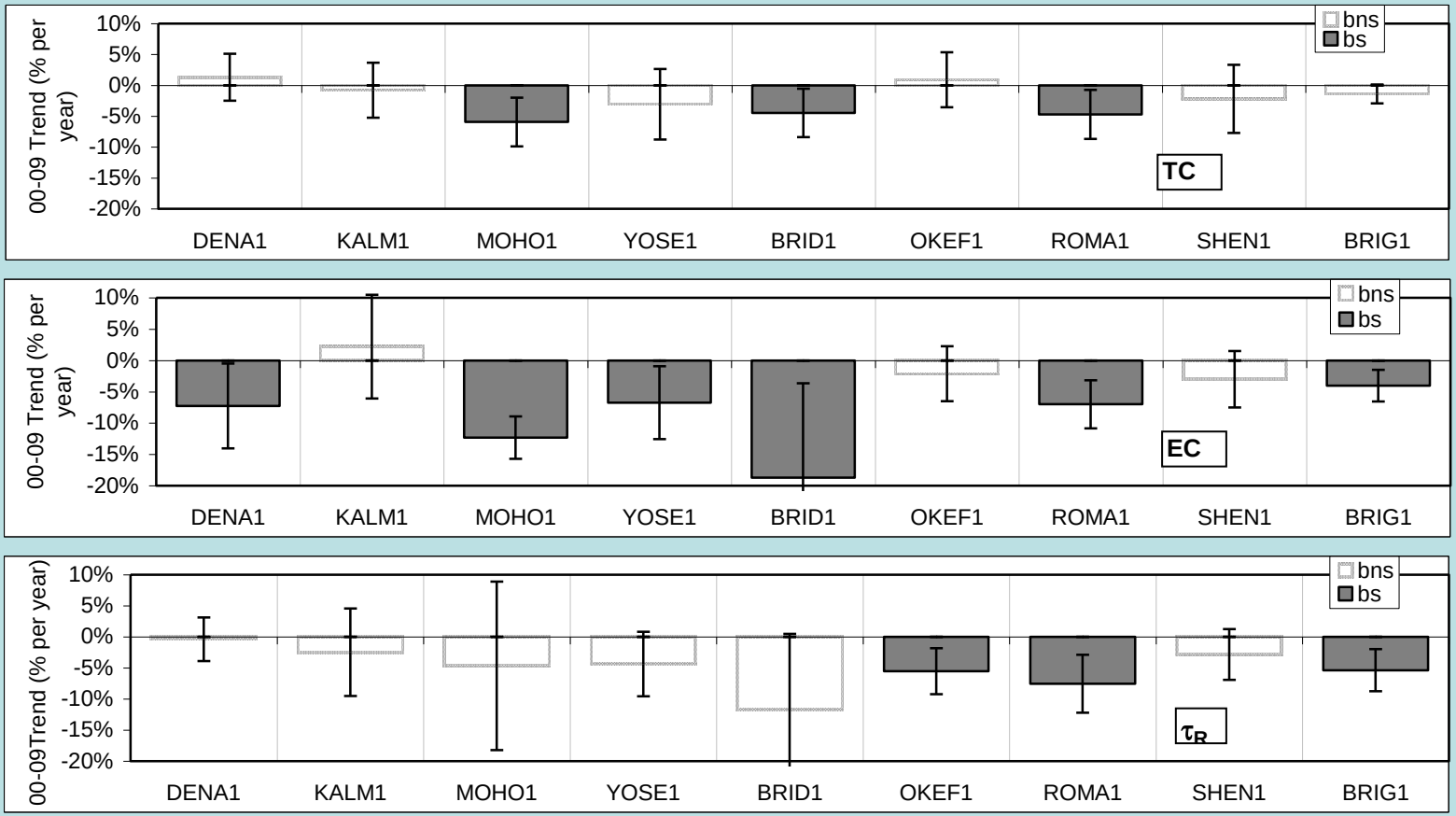


Error bars indicate 90% confidence interval; hollow bars indicate insignificant trends

Sites are grouped from northwest to southeast

Slope is divided by median (Q4) by site over 10 years

Trend variation by site (Q1 [Jul, Aug, Sep])



Error bars indicate 90% confidence interval; hollow bars indicate insignificant trends

Sites are grouped from northwest to southeast

Slope is divided by median (Q4) by site over 10 years

Western sites report 40 – 80% lower EC with higher decreasing trend (5 to 10% per year)

2000 - 2009 Trend		TC				EC				τ_R		
		Mean (µg/filter)	Trend/yr	90% CI		Mean (µg/filter)	Trend/yr	90% CI		Mean (µg/filter)	Trend/yr	90% CI
4 Eastern Sites	Q4	70.1	**-4.8%**	1.6%		13.0	**-7.1%**	3.3%		0.28	**-7.0%**	2.5%
	Q3	73.7	**-3.3%**	2.2%		10.7	**-4.6%**	2.7%		0.23	**-4.0%**	3.1%
	Q2	70.6	**-2.9%**	1.9%		11.1	**-4.4%**	2.8%		0.25	**-5.3%**	2.9%
	Q1*	76.5	**-3.2%**	3.2%		15.0	**-5.0%**	2.5%		0.32	**-6.6%**	4.3%
7 Western Sites	Q4	28.1	-4.5%	4.0%		3.5	**-7.3%**	4.1%		0.10	**-4.6%**	4.5%
	Q3	58.3	-1.6%	4.2%		6.2	**-4.6%**	3.9%		0.16	**-2.8%**	2.5%
	Q2	38.7	**-5.1%**	2.0%		3.8	**-5.1%**	1.8%		0.12	**-4.7%**	3.2%
	Q1*	18.6	-2.8%	4.1%		2.4	**-9.8%**	6.0%		0.10	-4.8%	7.2%

Q1 contains the most missing data in all cases

EC and τ_R decreased at 3 – 5% per year from 2000 – 2009 (-2 to 5% per year for TC)

2000 - 2009 Trend		TC				EC				τ_R		
		Mean (µg/filter)	Trend/yr	90% CI		Mean (µg/filter)	Trend/yr	90% CI		Mean (µg/filter)	Trend/yr	90% CI
11 Sites	Q4	41.1	**-4.7%**	3.5%		6.9	**-3.8%**	3.0%		0.17	-3.9%	4.0%
	Q3	67.4	-1.8%	2.8%		7.7	-3.7%	4.6%		0.18	-2.7%	3.3%
	Q2	47.5	**-4.7%**	3.0%		5.4	**-4.9%**	2.5%		0.16	**-3.7%**	3.0%
	Q1*	31.5	-3.5%	5.5%		4.9	-2.9%	7.6%		0.15	**-5.0%**	4.8%
60 Sites	Q4	36.8	**-3.9%**	2.2%		5.5	**-5.5%**	2.0%		0.15	**-5.4%**	1.9%
	Q3	63.1	-1.6%	2.1%		7.2	**-4.9%**	2.6%		0.17	**-3.4%**	2.1%
	Q2	44.4	**-4.8%**	2.1%		5.3	**-4.9%**	2.7%		0.15	**-5.4%**	2.5%
	Q1*	26.9	**-2.6%**	2.1%		4.2	**-4.1%**	1.5%		0.14	**-3.1%**	3.1%

Q1 contains the most missing data in all cases

Conclusions

- Declining trends of 2 – 5% are found for TC, EC, and τ_R during 2000 – 2009 and at 11 to 60 individual sites

- Trends in spring and summer (Q2 and Q3) may be influenced by large fire events (τ_R is saturated)

- Change of carbon analyzer in 2005 does not seem to alter the EC or τ_R trend for the unprocessed data