Underestimation of Sulfur Concentrations During High Loadings and Humidity Conditions in the Eastern US

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Issue

The sulfur concentration measurement from the Teflon filter in the IMPROVE Module A sampler can be underestimated by over a factor of 2 (Figure 1). This bias occurred only at Eastern US sites and was most severe during the summers of 1992-94 on days with the highest sulfur loadings coinciding with high humidity. Table 1 list the sites where this bias was found to occur.

Cause

The exact cause of the sulfur underestimation has never been fully explained. However, analysis of data from IMPROVE and from a special study at Great Smoky Mountains in the of summer 1994 indicates that the problem is produced by a combination of very high relative humidity, sulfur present predominantly as hygroscopic sulfuric acid, and high filter face velocities. With these conditions, some of the sulfate may migrate away from the center of the filter and perhaps even be lost from the filter.

Long Term Solution

In 1995, the filter mask was removed from most Eastern US sites. This increased the filter size from 2.2 cm^2 to 3.5 cm^2 and reduced the filter face velocity by 35%. This has nearly eliminated the problem, but several significant sulfur and sulfate differences were observed at Washington DC even with unmasked filters. On 8/16/95, significant differences were also observed at four sites after the mask was removed.

The filter size was also increased at sites which had no indication of a sulfur underestimation, but have high mass loadings (Table 2). This was done to prevent any possible sulfur losses and minimize clogging of the Teflon filter.

Recommendations for Data Analysis

It is recommended that data analysts use the sulfate ion measurements, divided by 3, from the IMPROVE Module B nylon filter instead of the sulfur mass measurement from module A for time periods before the Teflon filter size was increased at the sites listed below (Table 1)

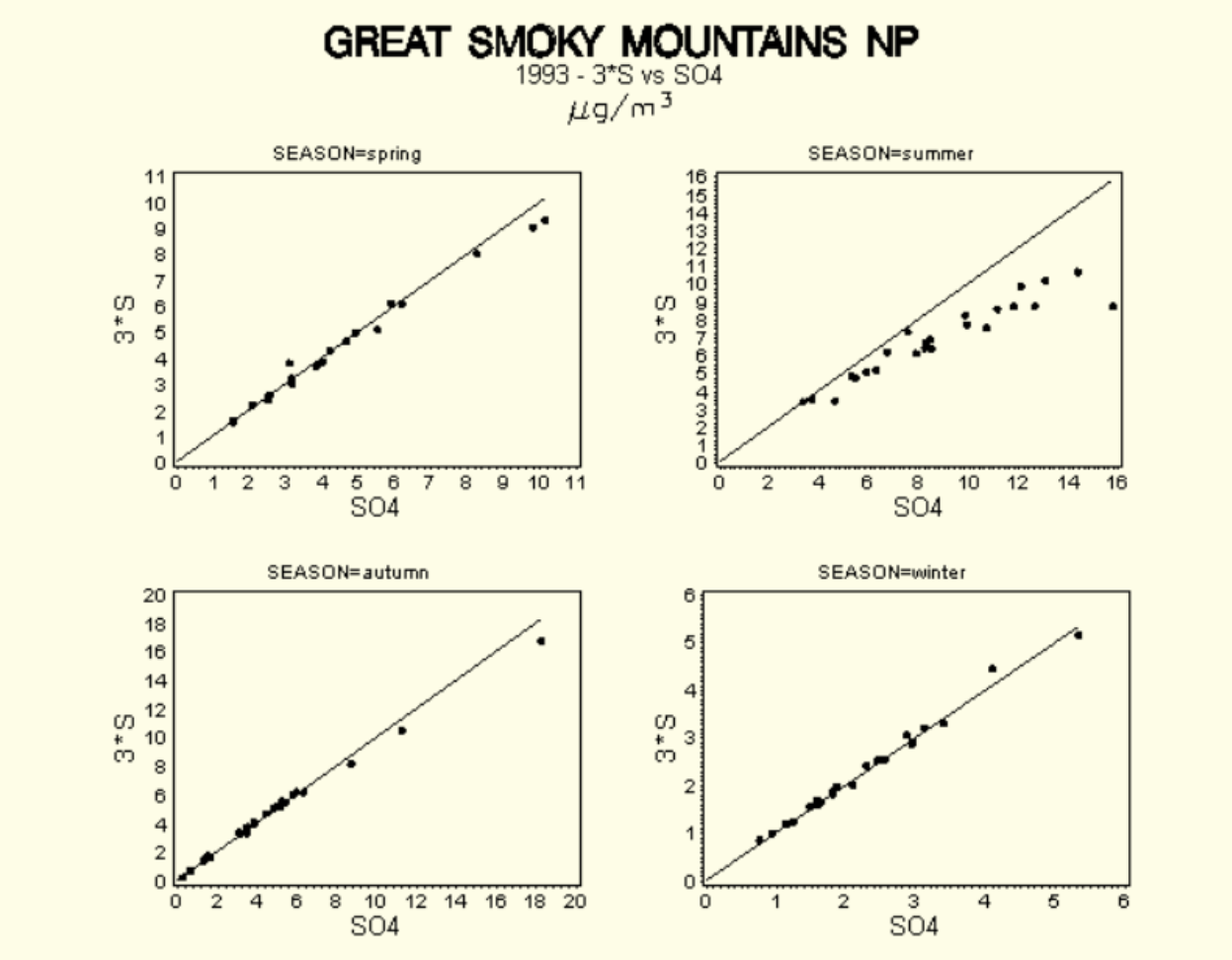

Figure 1. Scatter plots of Great Smoky Mountain, TN, National Park sulfate (SO4) against sulfur scaled by 3 (3*S) for each season during 1993. The SO4 and 3*S should fall along the 1 to 1 line as they do during spring, autumn and winter. During the summer months the 3*S severely underestimates the SO4 at concentrations above 5 micro-g/m3.

Table 1. Monitoring sites impacted by the sulfur underestimation problem and dates when the Teflon filter was increased from 2.2 sq. cm to 3.5 sq. cm.

Site	Site Name	Sulfur Bias	Nylon Filter clogging during 1998	Filter Size Increase Date

Code				
LYBR	Lye Brook, VT WA	YES	NO	4/95
ACAD	Acadia, ME NP	YES	NO	4/95
BRIG	Edwin B. Forsyth, NJ NWR	YES	YES	5/95
DOSO	Dolly Sods, WV, WA	YES	YES	4/95
SHEN	Shenandoah, VA, NP	YES	YES	4/95
JEFF	James River Face, VA, WA	YES	YES	4/95
GRSM	Great Smoky Mnt, TN, NP	YES	YES	4/95
SHRO	Shinning Rock, NC, WA	YES	YES	4/95
UPBU	Upper Buffalo, AR, WA	YES	NO	5/95
MACA	Mammoth Cave, KY, NP	YES	YES	4/95
SIPS	Sipsey, AL, WA	YES	YES	5/95
ROMA	Cape Romain, SC, NWR	YES	YES	8/98
OKEF	Okefenokee, GA, NWR	YES	YES	8/98
CHAS	Chassahowitzka, FL, NWR	YES	YES	8/98
EVER	Everglades, FL, NP			8/98

Table 2. Monitoring sites with a 3.5 sq cm filter and no evidence of sulfur underestimation in their time series.

Site Code	Site Name	Filter Size Increase Date
MOOS	Moose Horn, ME, WA	7/98
GUMO	Guadalupe MNT, TX, NP	4/01
BIBE	Big Bend, TX, NP	4/01
SEQU	Sequoia, CA, NP	5/98
SAGO	San Gorgonio, CA, WA	4/95
CACR	Caney Creek, AR	4/01
HEGL	Hercules-Glades, MO	4/01
WIMO	Wichita Mountains, OK	5/01
PUSO	Puget Sound, WA	3/98