Changes in CSN Uncertainty Calculations and Impacts on Reporting

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Overview

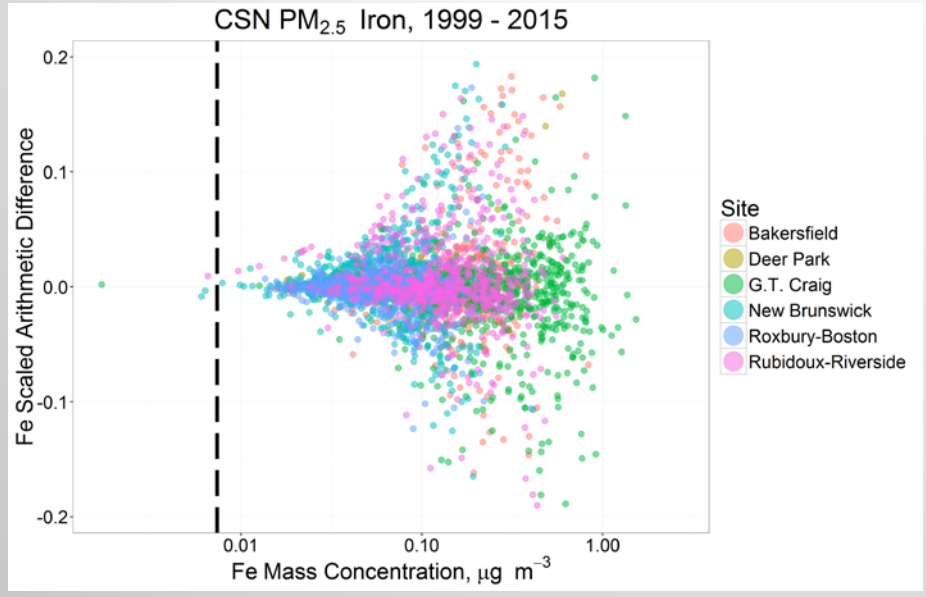
- What sources of uncertainty are included?
- Model for CSN uncertainty estimates
- Using collocated measurements to evaluate uncertainty estimates
  - The shape of uncertainty
- Updated CSN uncertainty estimates
- Differences between old and new uncertainty estimates

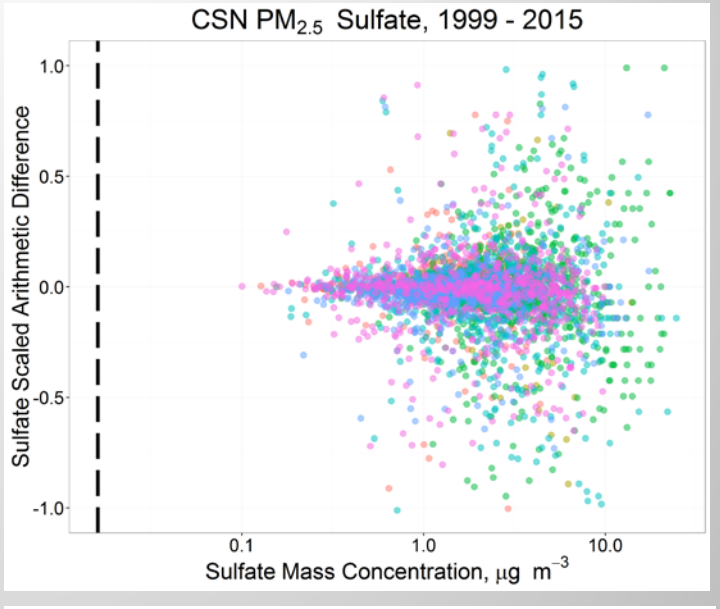
Uncertainty Estimates

- No absolute standards for particulate matter measurements exist.
- Uncertainties only account for the repeatability or precision of the measurements
    - they do not account for the accuracy.
- CSN uncertainties estimate one standard deviation of the measurements
- Uncertainties can be based on
    - propagating estimates of sources of uncertainty,
    - empirical observations such as collocated measurements, or
    - a combination of both techniques.

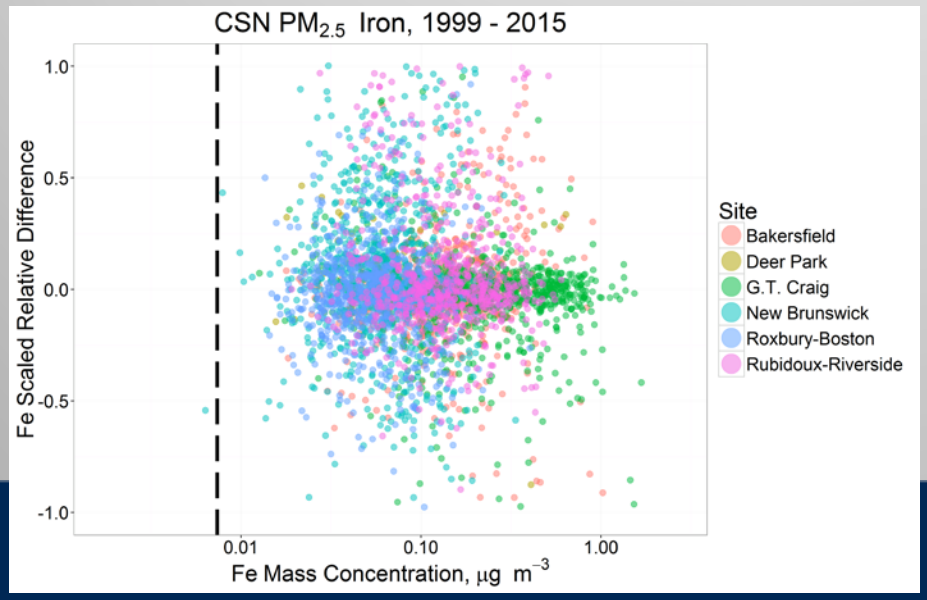
Arithmetic & Proportional Uncertainty Components

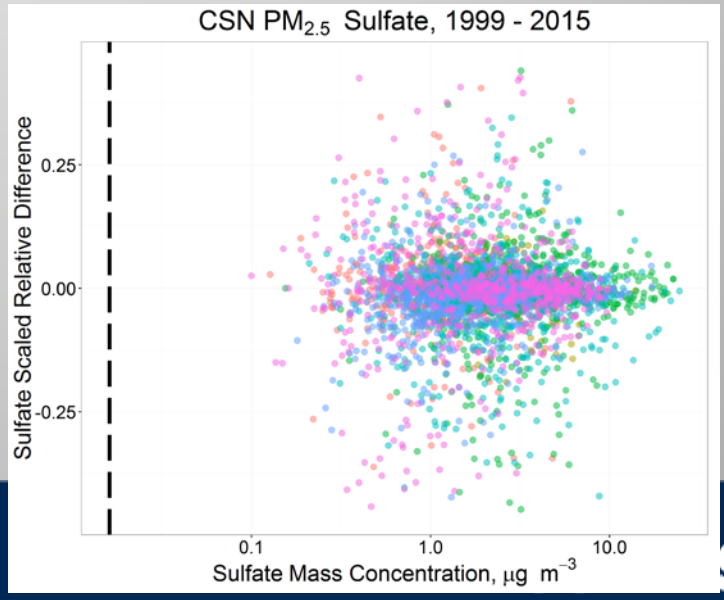
$$\frac{C_1 - C_2}{\sqrt{2}}$$





$$\frac{C_1 - C_2}{\sqrt{2}\bar{C}}$$

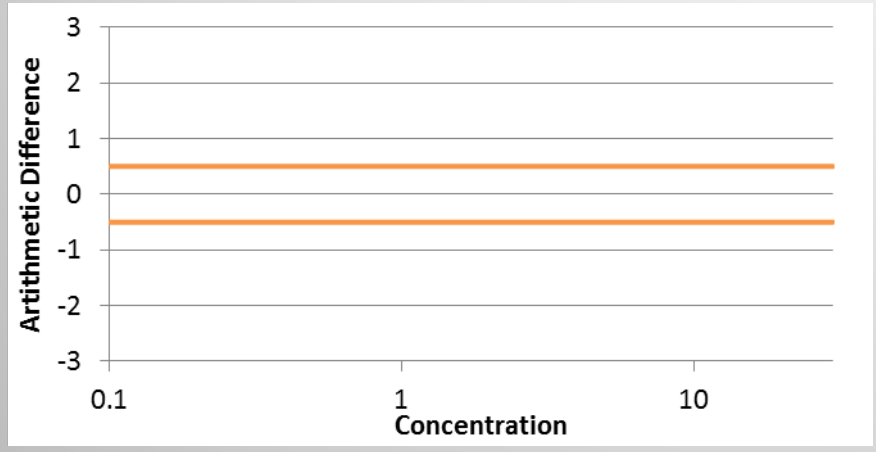


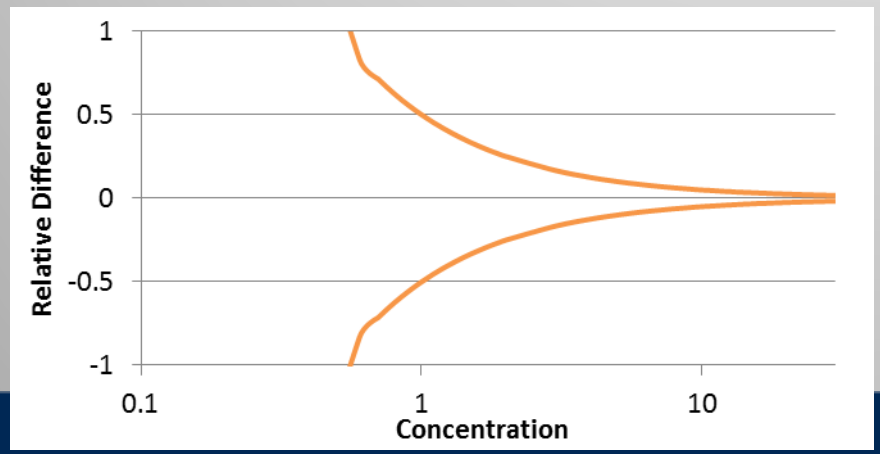


New Uncertainty Estimates

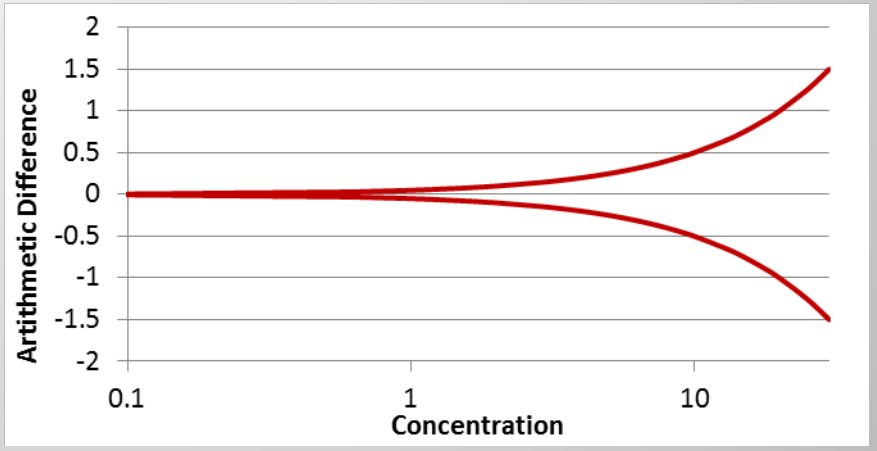
$$Uncertainty = \sqrt{\left(Unc_{Additive}\right)^2 + \left(Unc_{Multiplicative} * Conc.\right)^2},$$

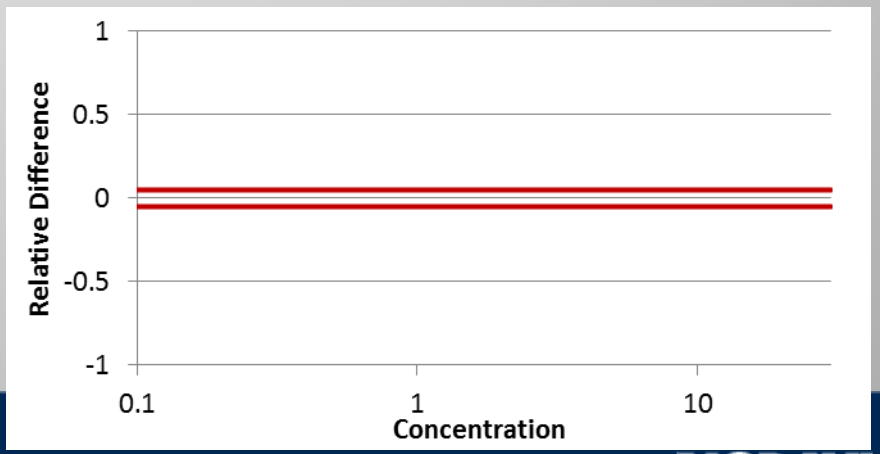
Additive Uncertainty Term





Multiplicative Uncertainty Term





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Additive and Multiplicative Uncertainty Estimates

$$Uncertainty = \sqrt{\left(Unc_{Additive}\right)^2 + \left(Unc_{Multiplicative} * Conc.\right)^2},$$

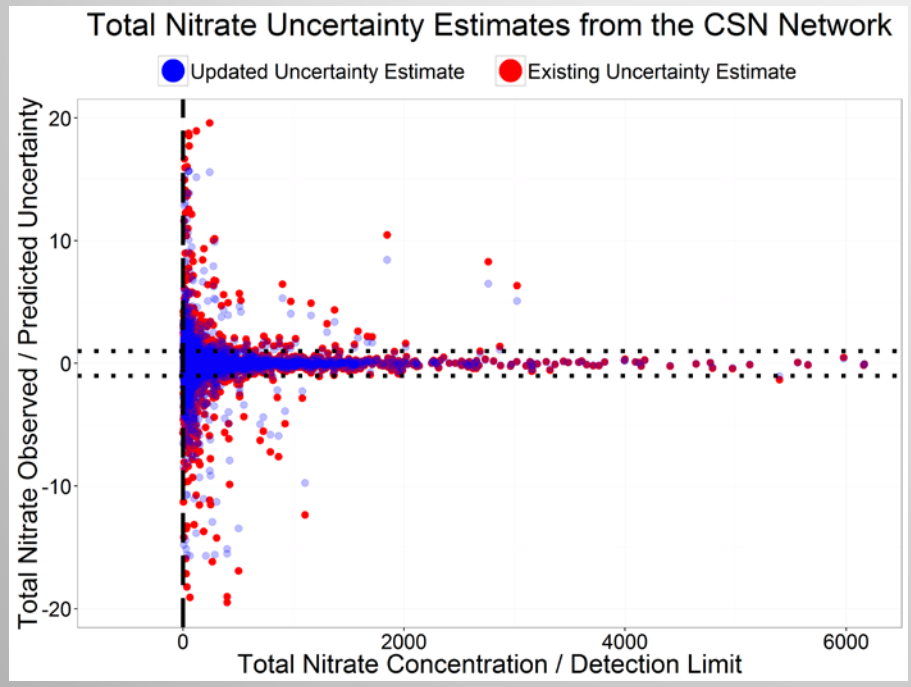
- The form of the equation has stayed the same, the only change is in the source of the additive and multiplicative uncertainty terms.

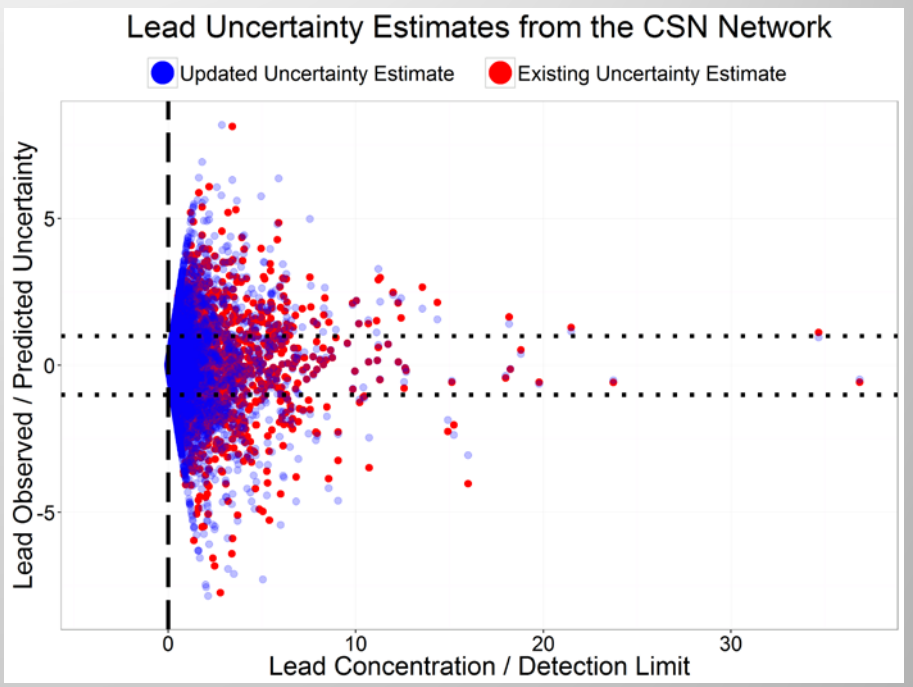
$$Unc_{Additive} = \frac{MDL}{3} = \text{standard deviation of blanks}$$

$$Unc_{Multiplicative} = \text{standard deviation of collocated measurements}$$

Differences Between Old and New Uncertainty Estimates

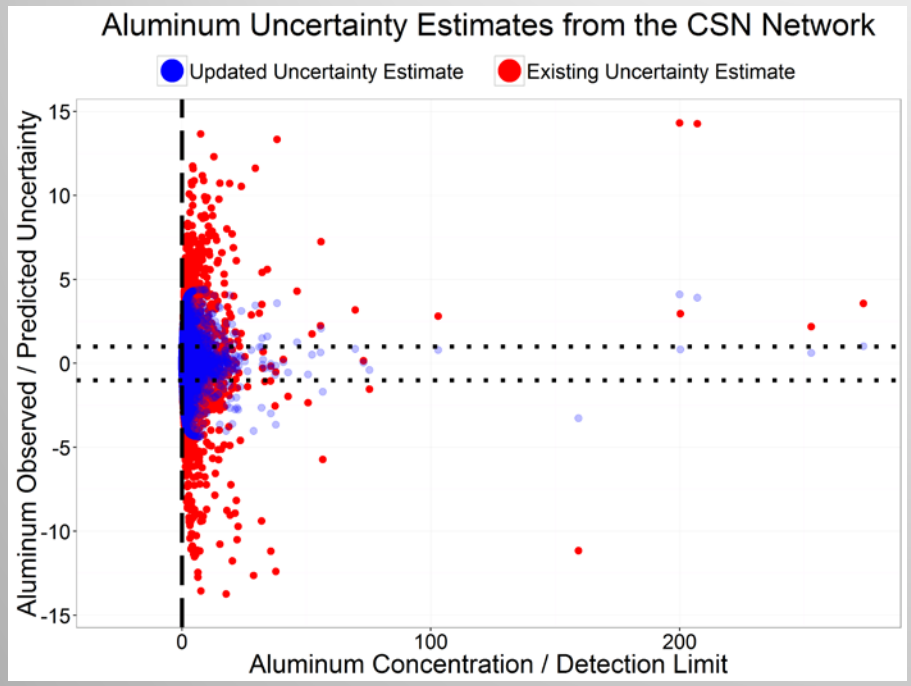
- For most species, the differences are small

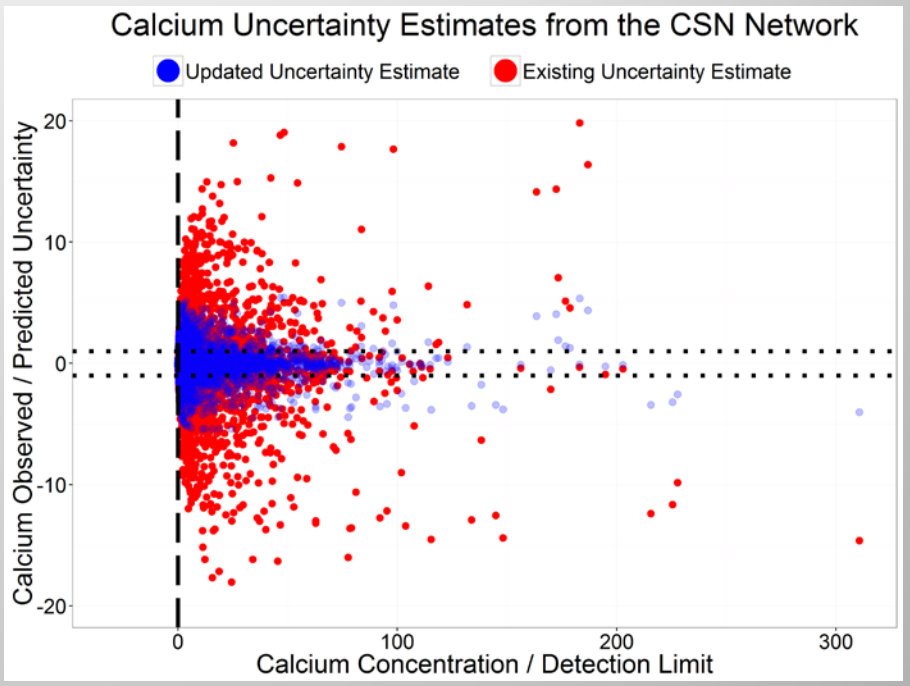




Differences Between Old and New Uncertainty Estimates

- For a few species, the new uncertainties are larger and better reflect the collocated observations





Multiplicative Uncertainty Estimated from Collocated Measurements

$$Uncertainty = \sqrt{\left(Unc_{Additive}\right)^2 + \left(Unc_{Multiplicative} * Conc.\right)^2},$$

Where $Unc_{Additive} = \frac{MDL}{3}$ = standard deviation of blanks

$Unc_{Multiplicative}$ = standard deviation of collocated measurements

$$= \frac{1}{2}\left(P_{84}(D_i) - P_{16}(D_i)\right) * 100\%,$$

where $D_i = \frac{\left(Conc._{i,Routine} - Conc._{i,Collocated}\right)/\sqrt{2}}{\left(Conc._{i,Routine} + Conc._{i,Collocated}\right)/2}$、

$P_{16}(D_i)$ and $P_{84}(D_i)$ = 16th and 84th percentiles of the collocated measurement differences

Standard Deviation of Collocated Differences

$$D_1 = \frac{(C_{i1} - C_{i2})/\sqrt{2}}{\bar{C}_i}$$

Precision Estimate 1:

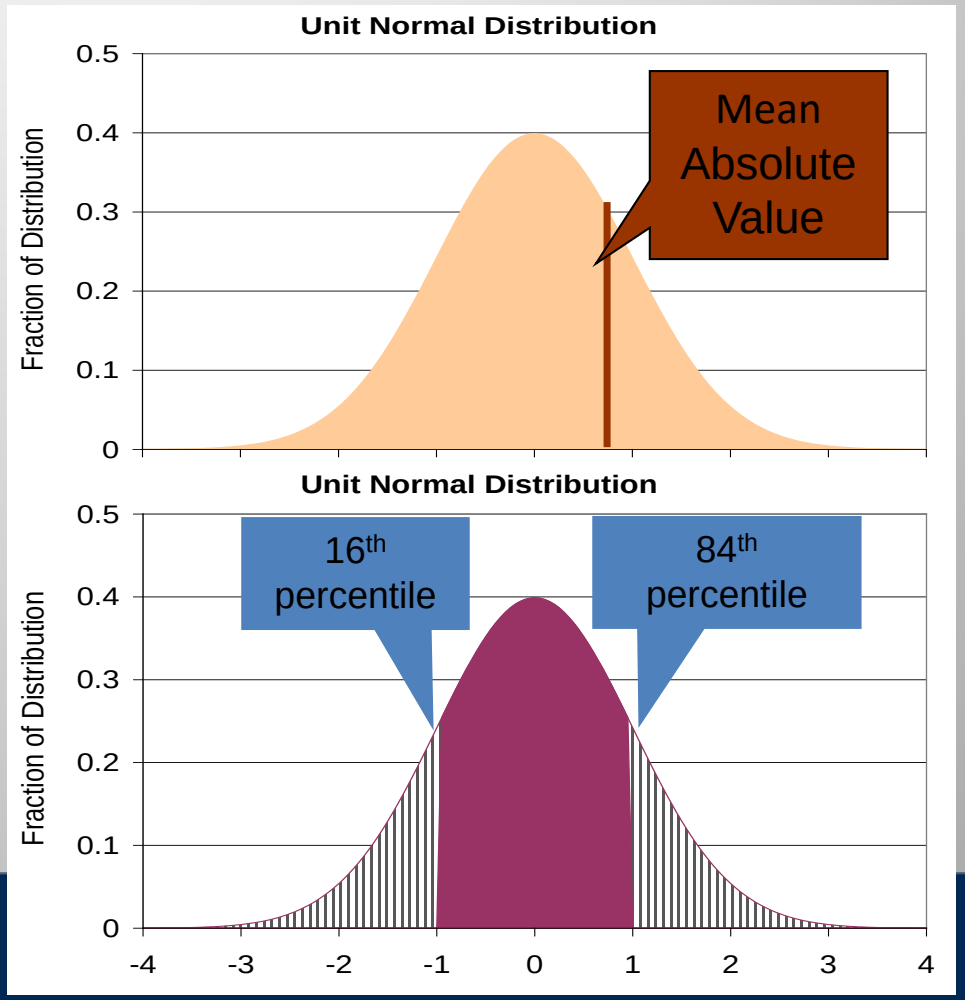
- Root Mean Square (RMS) = $\sqrt{\frac{1}{n}\sum_{i=1}^{n} D_i^2}$

Estimate 2:

- Mean Absolute Difference = $\sqrt{\frac{\pi}{2}}\frac{1}{n}\sum_{i=1}^{n}|D_i|$

Estimate 3:

- Estimate standard deviation from percentile range = $\frac{1}{2}(P_{84}(D_i) - P_{16}(D_i))$



Collocated Measurements Used to Estimate Multiplicative Uncertainty

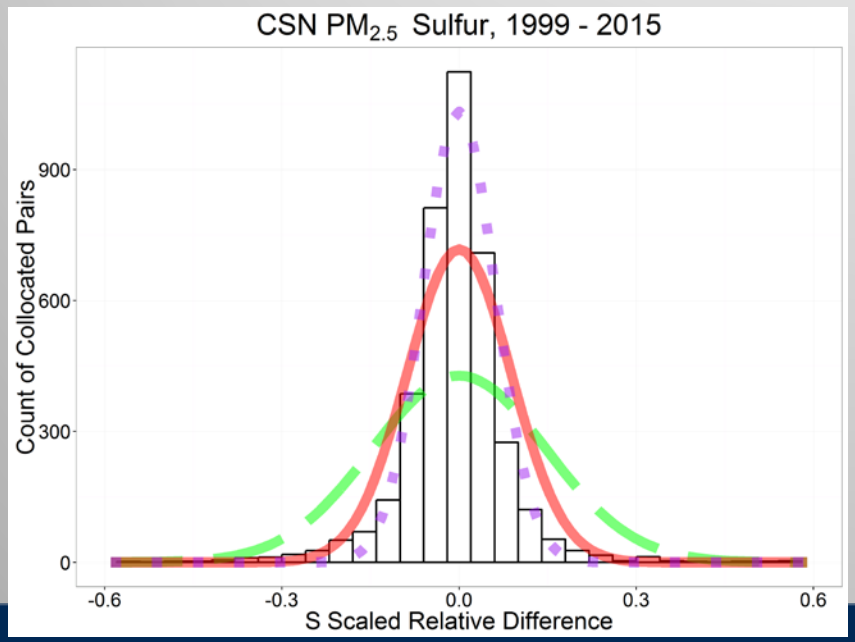
$$D_1 = \frac{(C_{i1} - C_{i2})/\sqrt{2}}{\bar{C}_i}$$

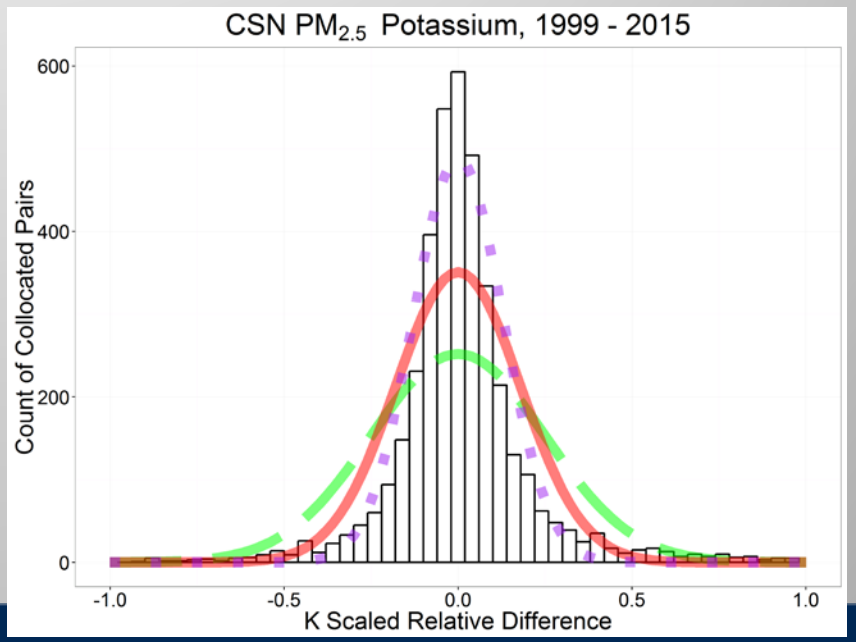
- Three different approaches to estimating the standard deviation

RMS $\sqrt{\frac{1}{n}\sum_{i=1}^{n} D_i^2}$

Mean Absolute $\sqrt{\frac{\pi}{2}}\frac{1}{n}\sum_{i=1}^{n}|D_i|$

Percentiles $\frac{1}{2}(P_{84}(D_i) - P_{16}(D_i))$





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Updated Multiplicative Uncertainties

Previously 5% for all parameters

Parameter	CSN Pairs	Updated, %
Organic Carbon	1700	9
Elemental Carbon	1695	13
Ammonium	1736	9
Sulfate	1837	6
Nitrate	1986	9
Sodium Ion	878	17
Potassium Ion	308	11
Sodium	524	16
Magnesium	131	27
Aluminum	359	32
Silicon	1173	23
Phosphorus	2	N/A
Sulfur	2157	6
Chlorine	562	37
Potassium	1481	12

Parameter	CSN Pairs	Updated, %
Calcium	1212	26
Titanium	66	17
Vanadium	14	5
Chromium	17	17
Manganese	167	14
Iron	1799	20
Nickel	31	15
Copper	787	20
Zinc	669	12
Selenium	9	12
Bromine	372	16
Strontium	6	N/A
Barium	2	N/A
Lead	35	9

New CSN Uncertainty Estimates

- are easy to understand and check
- are based on the collocated CSN measurements
- will be reviewed on an annual basis and updated, if necessary
- are easily updated using routine measurements (i.e., no special study required) when operations or instrumentation changes
  - requires approximately 1 year of data from new instrumentation or operating regime
- are based on the same approach used in the IMPROVE network
  - creates consistency between networks, which is important if data from both networks are used together