Example of Intercomparison Discrepancy

Both measurements have been verified and validated and the difference cannot be reconciled.

\[
E[\text{Air}_1] = \mu_{\text{species}} + \delta_{\text{cal}} + \delta_{\text{IntComp}}
\]

Total Intercomparison Unc \(\text{Unc}_1\) = \(\sum_n \left| \frac{\text{Air}_1 - \text{wavg}}{n} \right|\)

Total Intercomparison Unc \(\text{Unc}_1\) = 10.6

Additional IntComp Bias = \(\hat{\delta}_{\text{IntComp}} = 10.6 - 6 = 4.6\)

PI uncertainties

\(u_{\text{PI}_1} = \pm 6\)  \(u_{\text{PI}_2} = \pm 12\)

\[
\text{wavg} = \frac{\frac{1}{u_{\text{PI}_1}^2} (\text{Air}_1) + \frac{1}{u_{\text{PI}_2}^2} (\text{Air}_2)}{\frac{1}{u_{\text{PI}_1}^2} + \frac{1}{u_{\text{PI}_2}^2}}
\]

if Total IntComp Unc < PI Unc.
then no adjustment is required
(could occur with more than 2 aircraft)
Uncertainty Estimates

- **Within-instrument uncertainty (bias + precision)**
  - Source: PI, calibration data
  - Form: % of reading or constant value, 2-sigma interval
    - internal estimate of random uncertainty from intercomparison (Chen)

- **Between-instrument uncertainty (potential additional bias)**
  - Source: Panel, intercomparison data
  - Form: additional bias component estimated for each instrument
    - average abs(difference between measurement and weighted mean)
      - similar to the two aircraft difference plot (Parrish)
    - internal estimate from distribution of differences of time averaged means (new plot)
  - Result: Each instrument receives a proportional allocation of unexplained instrument-to-instrument difference based on PI uncertainties (or internal random estimates if PI uncertainty is not available)

- **Unified Data Base Total Measurement Uncertainty (bias + precision)**
  - Source: Panel, intercomparison data
  - Form: RMS combination of bias and precision for each instrument, 2-sigma
    \[ u_{TMU} = \sqrt{(\delta_{cal} + \delta_{IntComp})^2 + \sigma^2_{e}} \]
  - Apply TMU error bars to regression plot to confirm coverage of the 1:1 expected line (Chen)
**Adjusted Error Bars Result**

<table>
<thead>
<tr>
<th></th>
<th>Air1</th>
<th>Air2</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI uncertainty</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Est. Additional Bias</td>
<td>4.6</td>
<td>9.3</td>
</tr>
<tr>
<td>Total IntComp Uncertainty</td>
<td>10.6</td>
<td>21.3</td>
</tr>
</tbody>
</table>

Approach is equitable, objective, data-driven and conceptually satisfies the panel’s deliberations.

Need to test on actual data and verify statistical properties.
### Example with 3 Aircraft

<table>
<thead>
<tr>
<th></th>
<th>Air1</th>
<th>Air2</th>
<th>Air3</th>
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</thead>
<tbody>
<tr>
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<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Est. Additional Bias</td>
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<tr>
<td>Total IntComp Uncertainty</td>
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<td>29.8</td>
<td>12.7</td>
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</tbody>
</table>

![Graphs showing data for three aircraft](image.png)