

Development of an optimal calibration strategy for trace gas measurements

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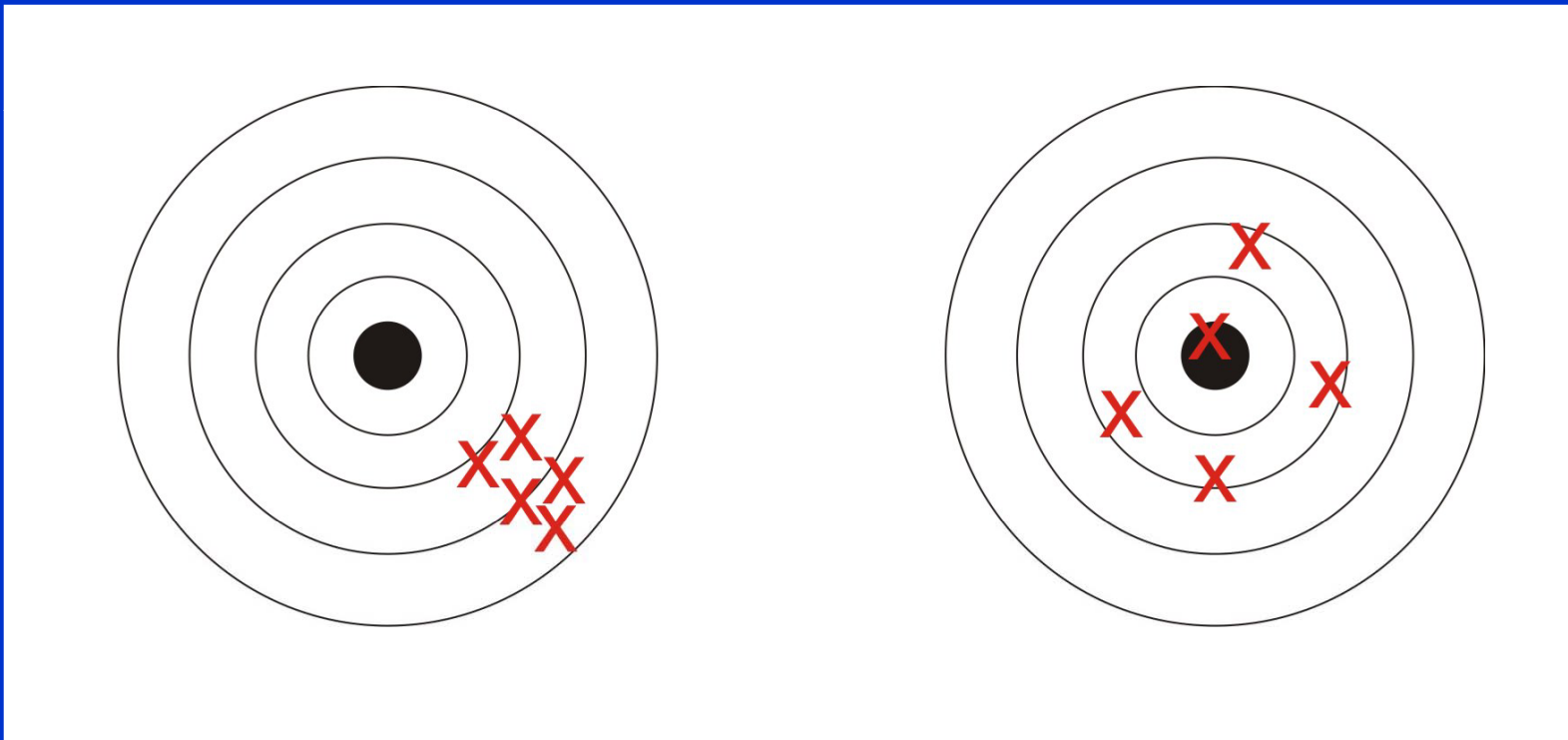
Outline

- Structure of a measurement program
- What measurements might tell us
- Example of one such program
- Call for help

Measuring the composition of air

- Precision vs. Accuracy

Precision vs. Accuracy



Measuring the composition of air

- Precision vs. Accuracy
- Differential measurements

Benefits of differential measurements

Initial Group

1001 Women

Final group

1002 Women

Benefits of differential measurements

Initial Group

1001 Women

Final group

1002 Women

Absolute changes

Initial # women: 1001

Final # women: 1002

Change in women: 0.1%

Benefits of differential measurements

Initial Group

999 Men
1001 Women

Final group

999 Men
1002 Women

Benefits of differential measurements

Initial Group

999 Men
1001 Women

Final group

999 Men
1002 Women

Differential changes

Initial gender diff: 2
Final gender diff: 3
Change in gender diff: 33%

Benefits of differential measurements

Initial Group

999 Men
1001 Women

Absolute changes

Initial # women: 1001
Final # women: 1002
Change in women: 0.1%

Final group

999 Men
1002 Women

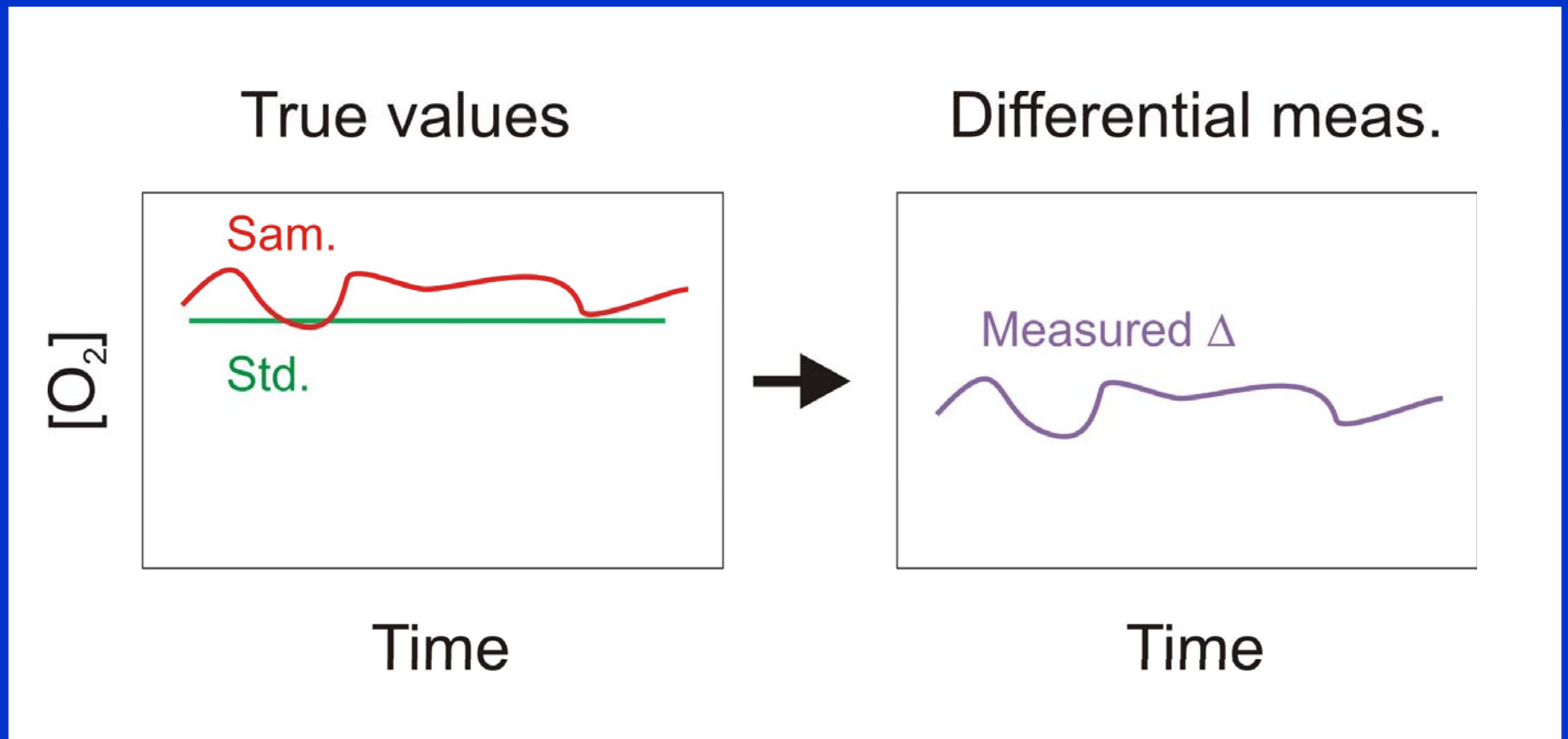
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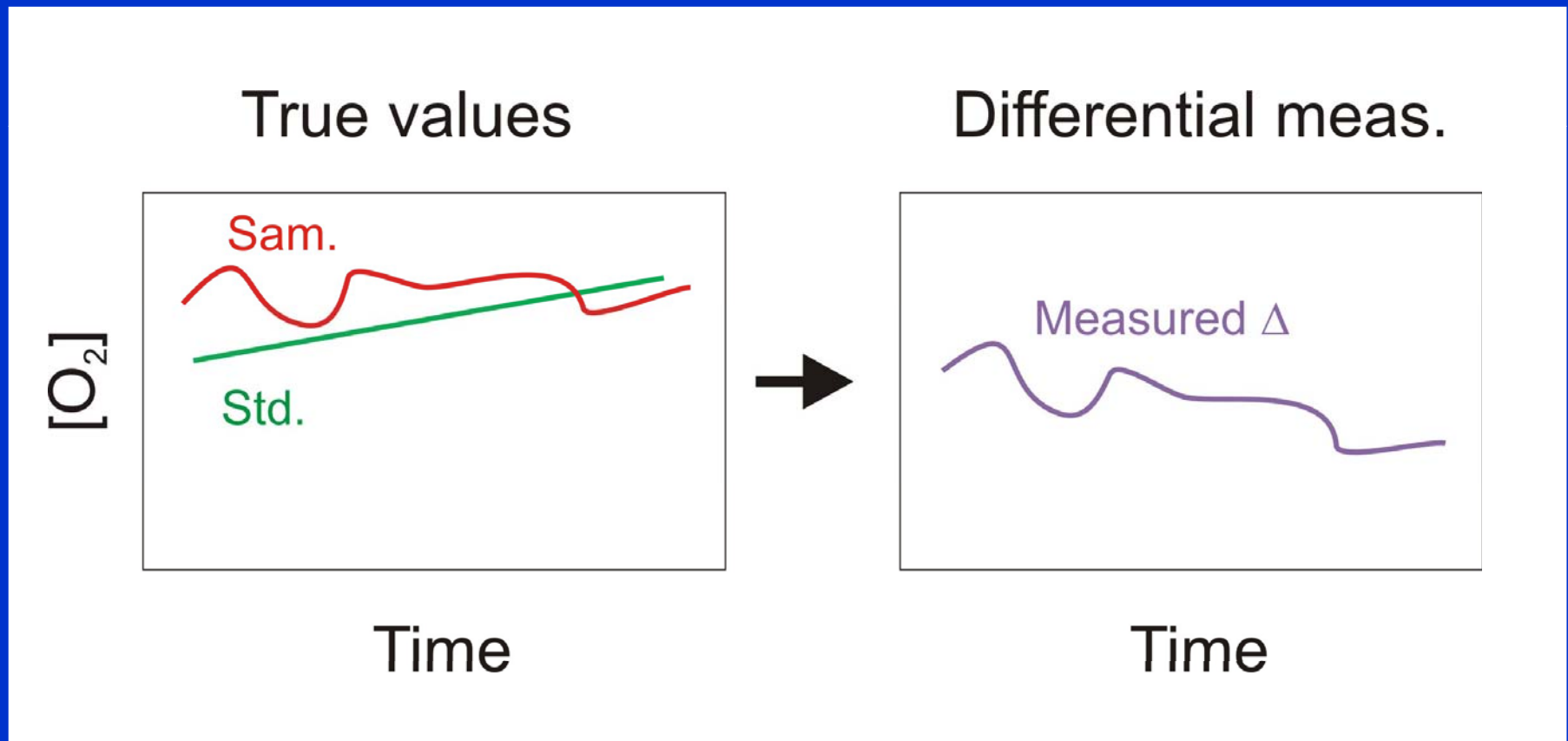
Measuring the composition of air

- Precision vs. Accuracy
- Differential measurements
- Measure samples relative to “standards”

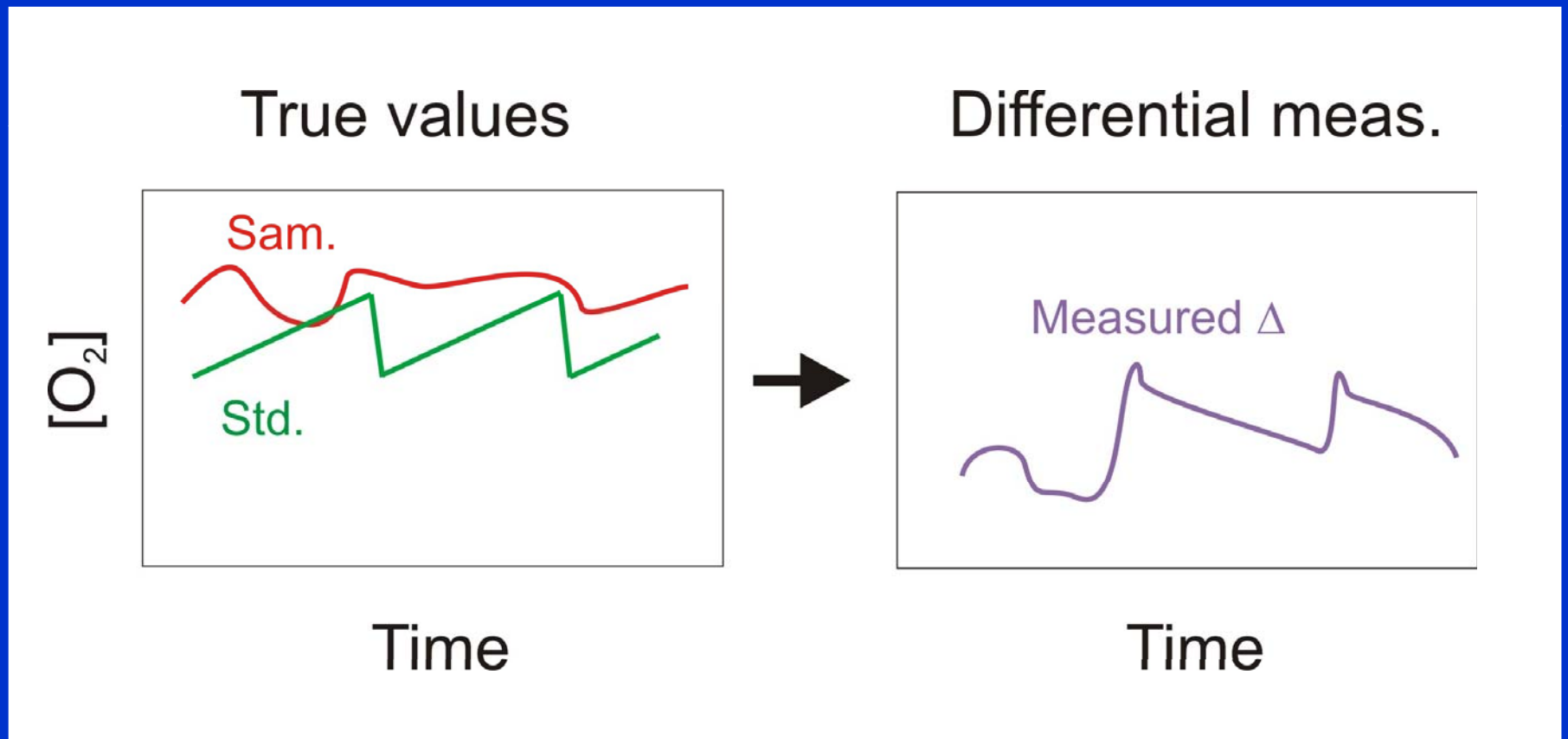
Challenges of differential measurements



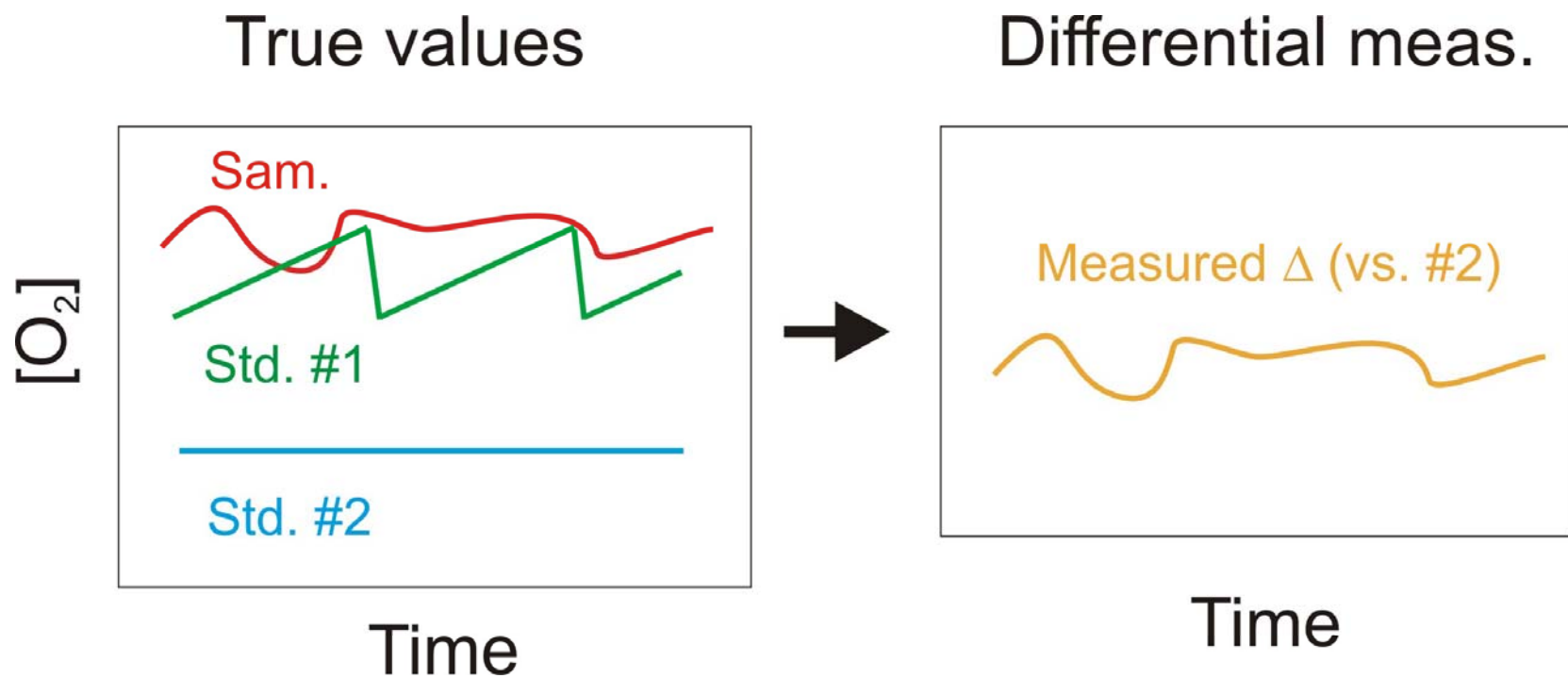
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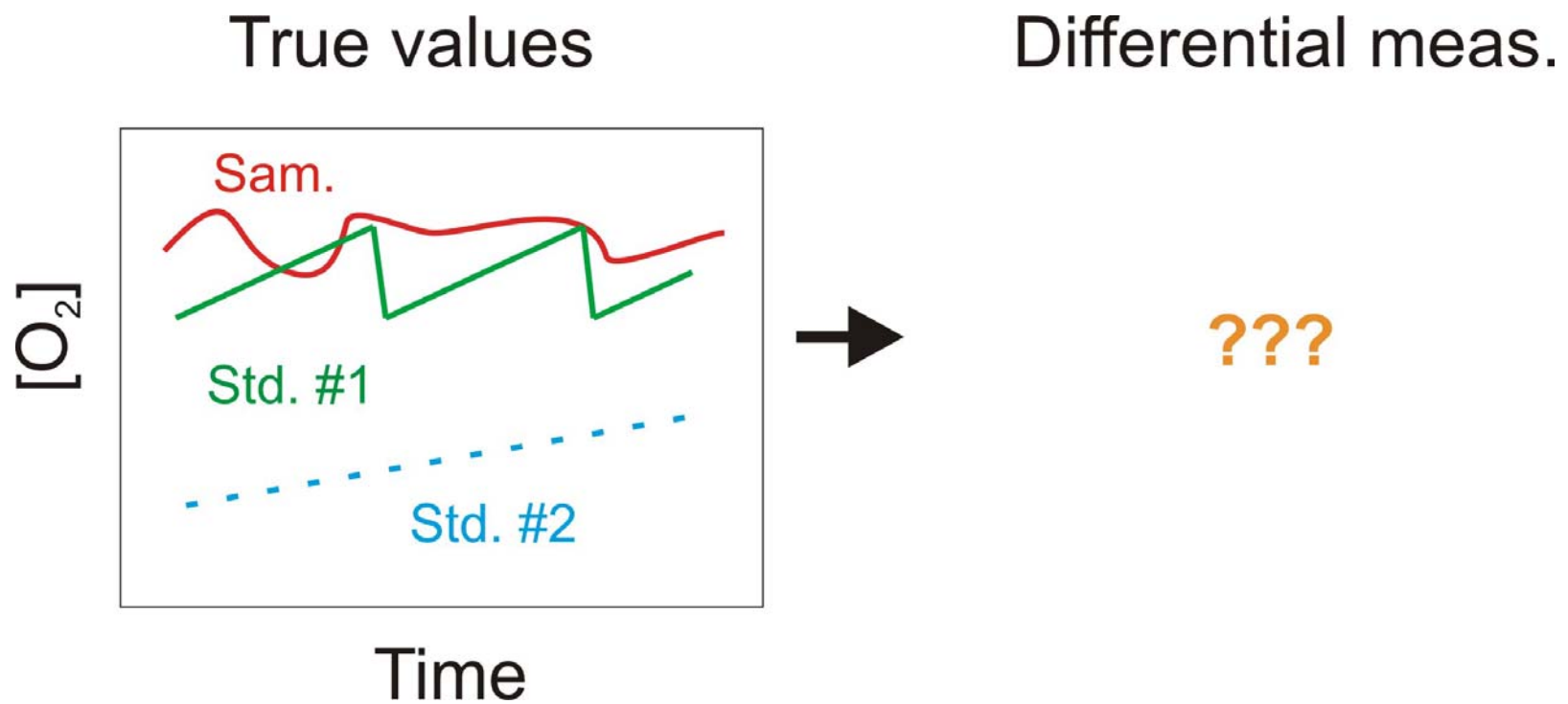
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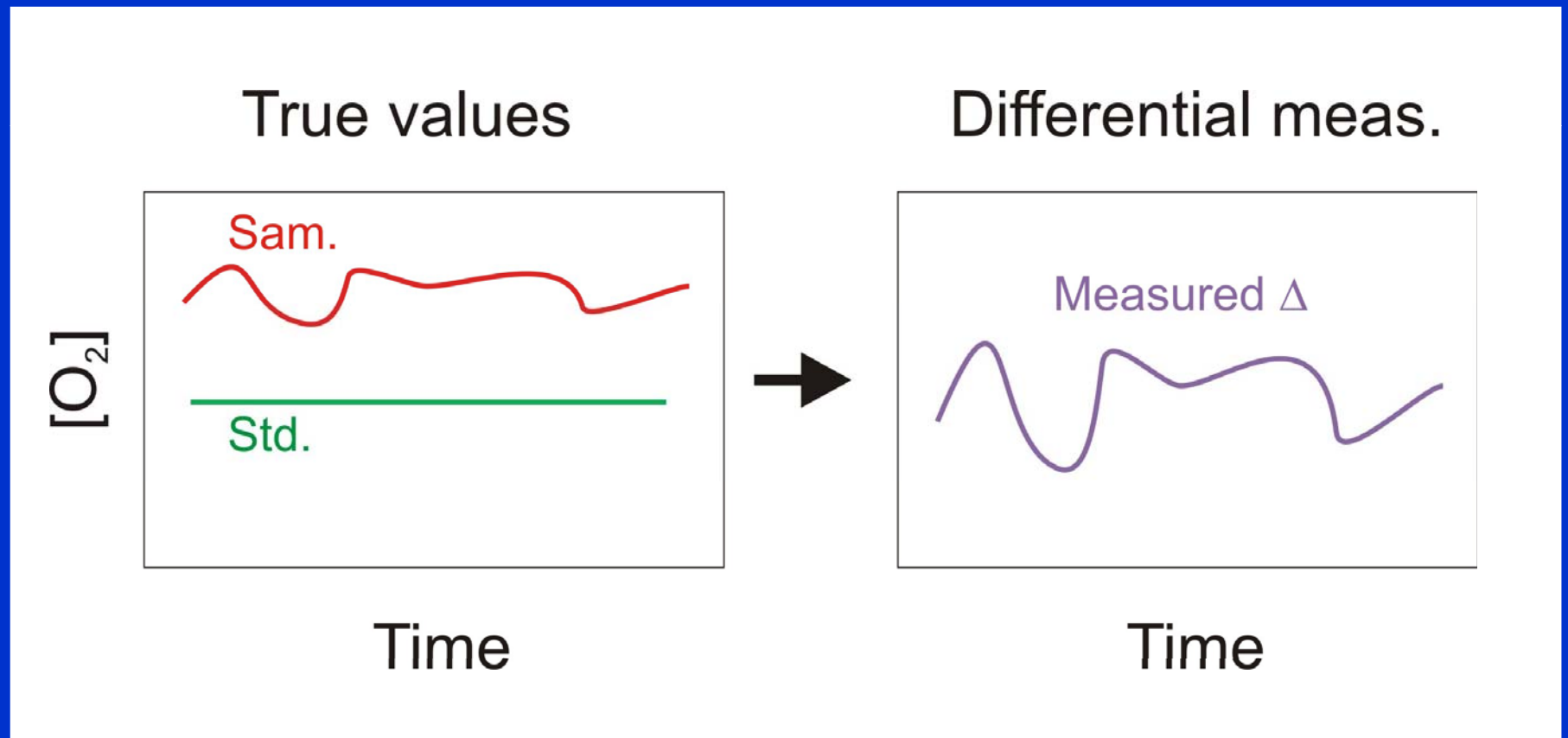
Challenges of differential measurements



Measuring the composition of air

- Precision vs. Accuracy
- Differential measurements
- Measure samples relative to “standards”
- Instrumental response

Impact of instrumental non-linearity



Metric

Precision & Accuracy

Constraints

Instrument time is precious

Standard air is precious

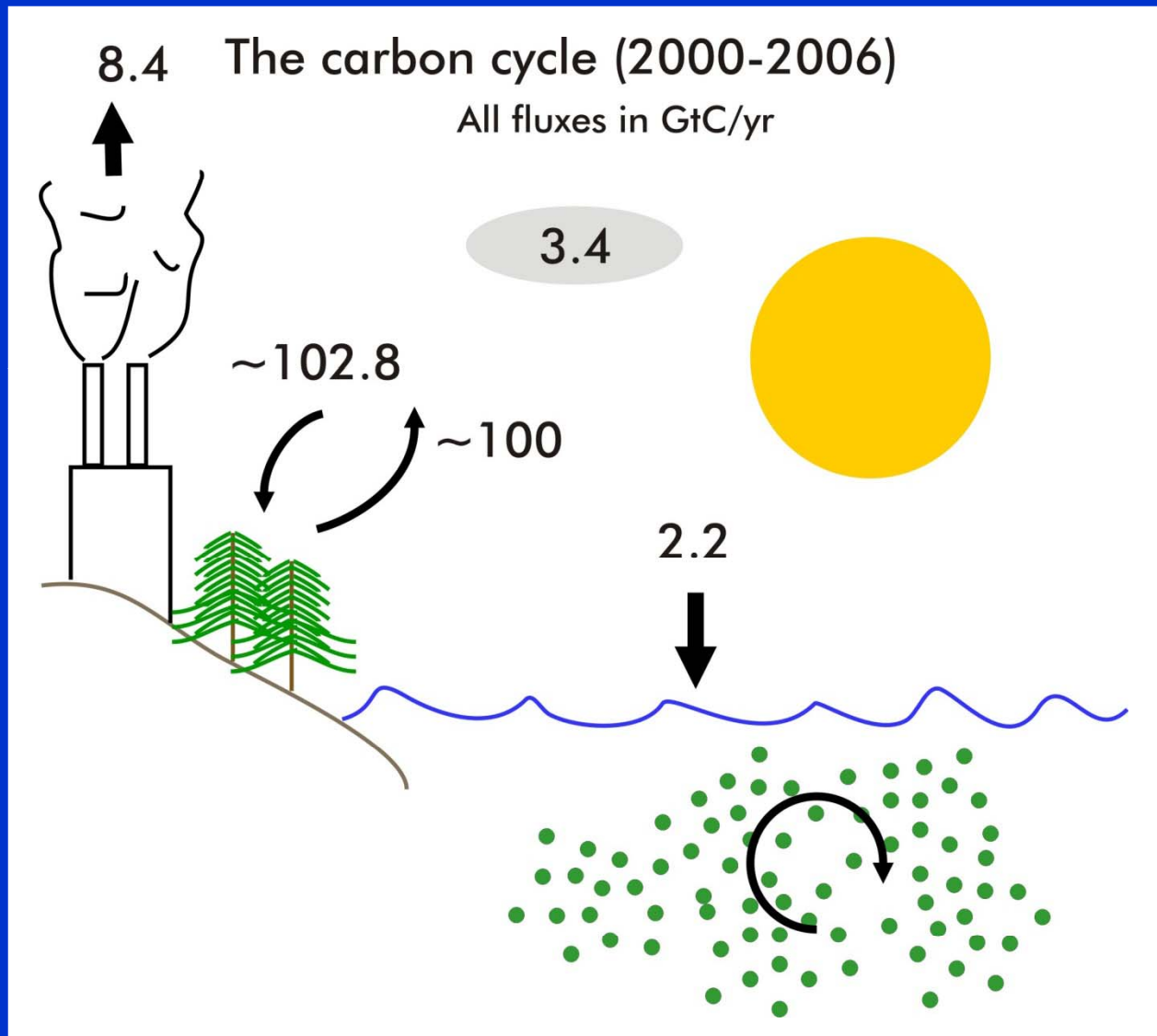
In summary:

Optimally combine many analyses of many standards to create a virtual standard against which all samples are measured.

Connecting to the real world:

Measuring O_2 and CO_2
to constrain the carbon cycle

Where does anthropogenic CO₂ end up?



Values for 2000-2006 Canadell et al. PNAS 2007

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- Record CO₂ emissions
- Measure CO₂ in the atmosphere

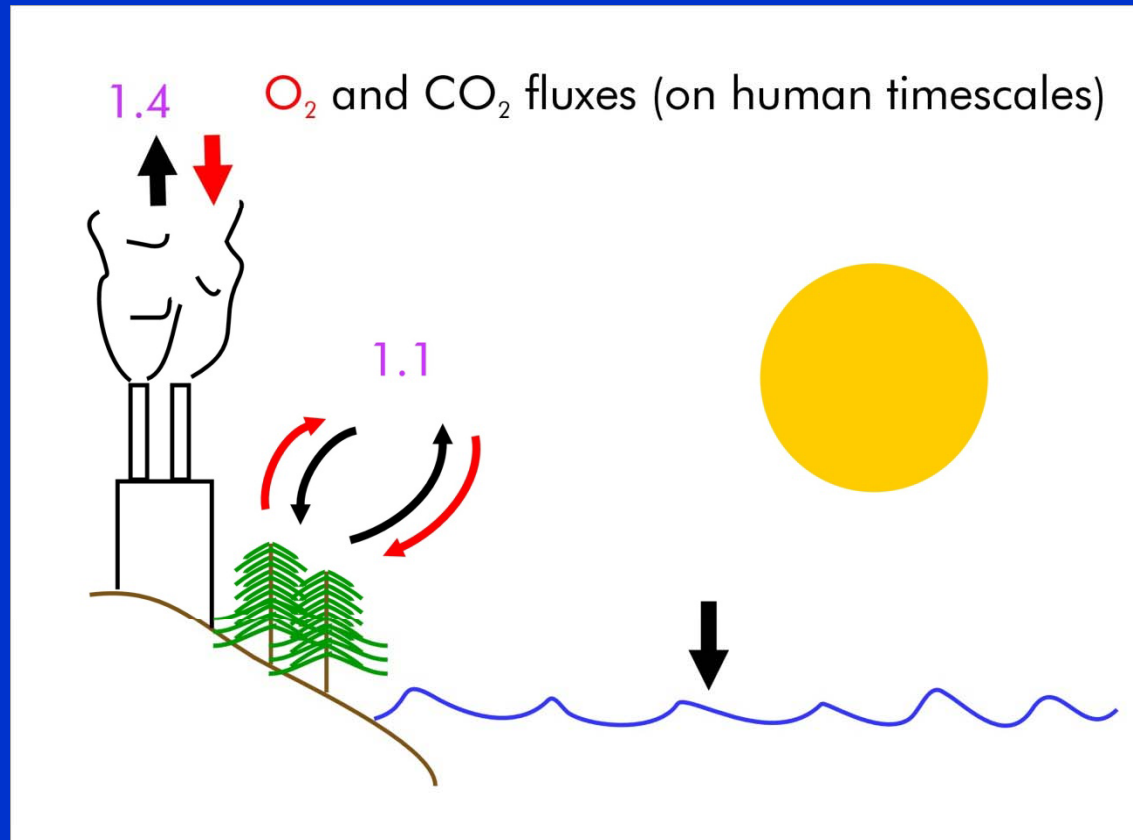
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- Infer from spatial pattern and isotopes of atmospheric CO₂
- Measure atmospheric O₂

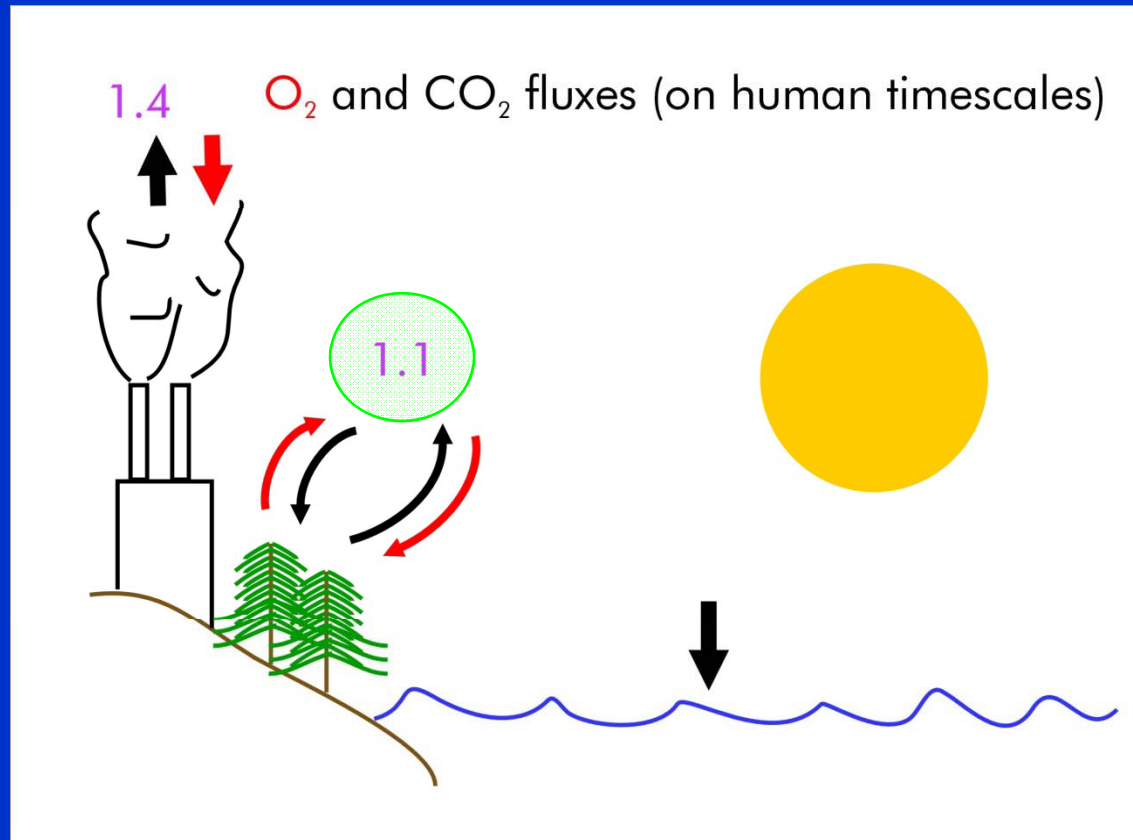
The link between O₂ and CO₂



$$\Delta\text{CO}_2 = \text{Land biota} + \text{Industry} + \text{Ocean}$$

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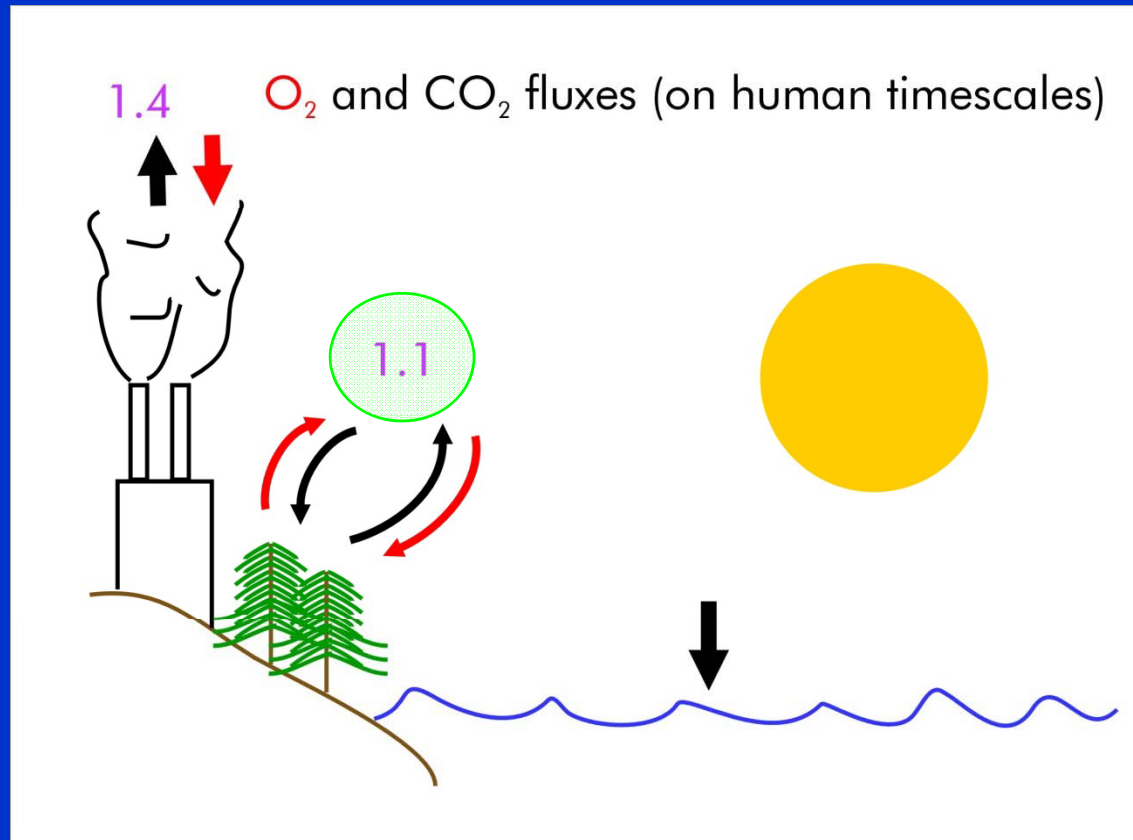
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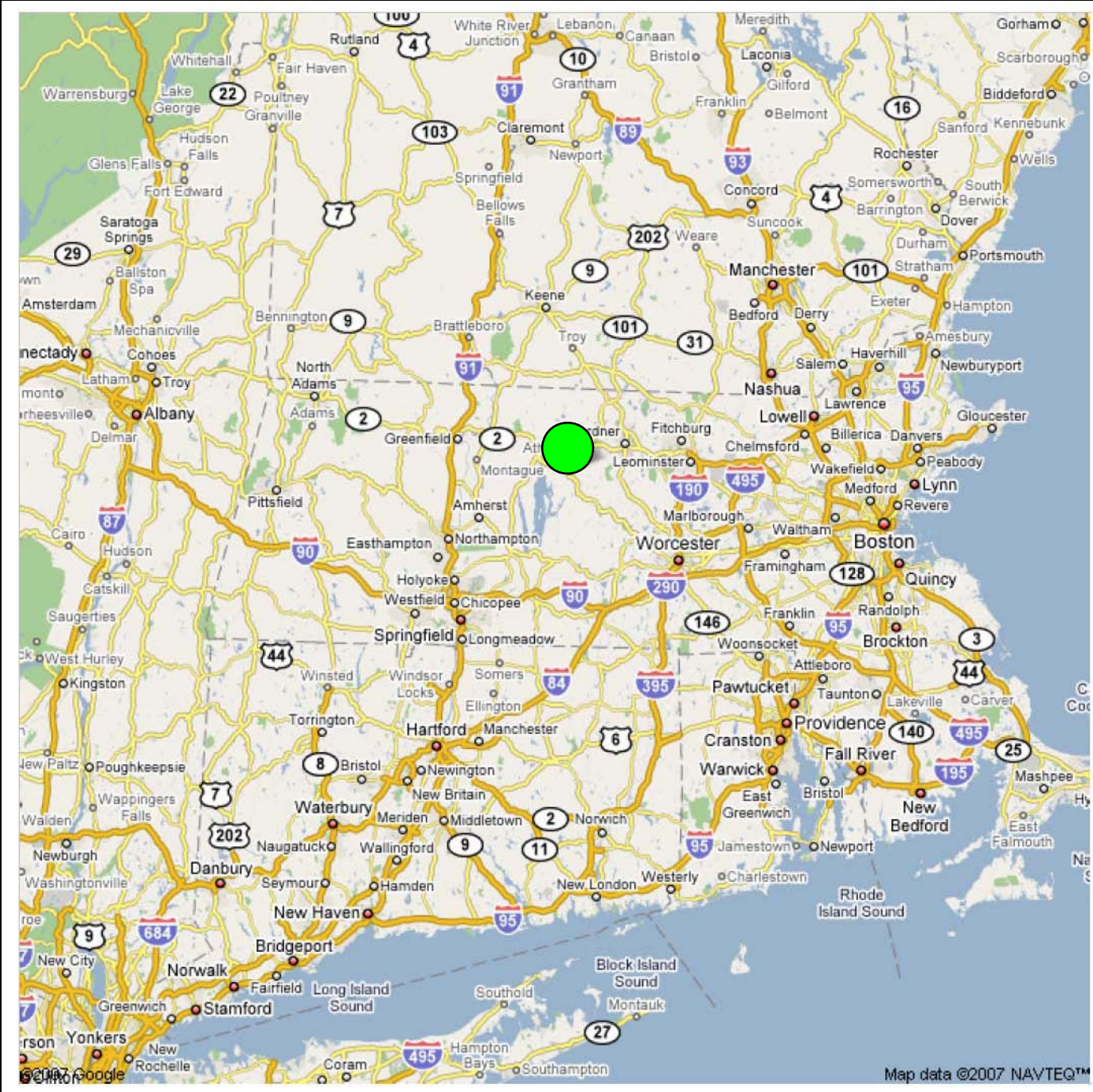
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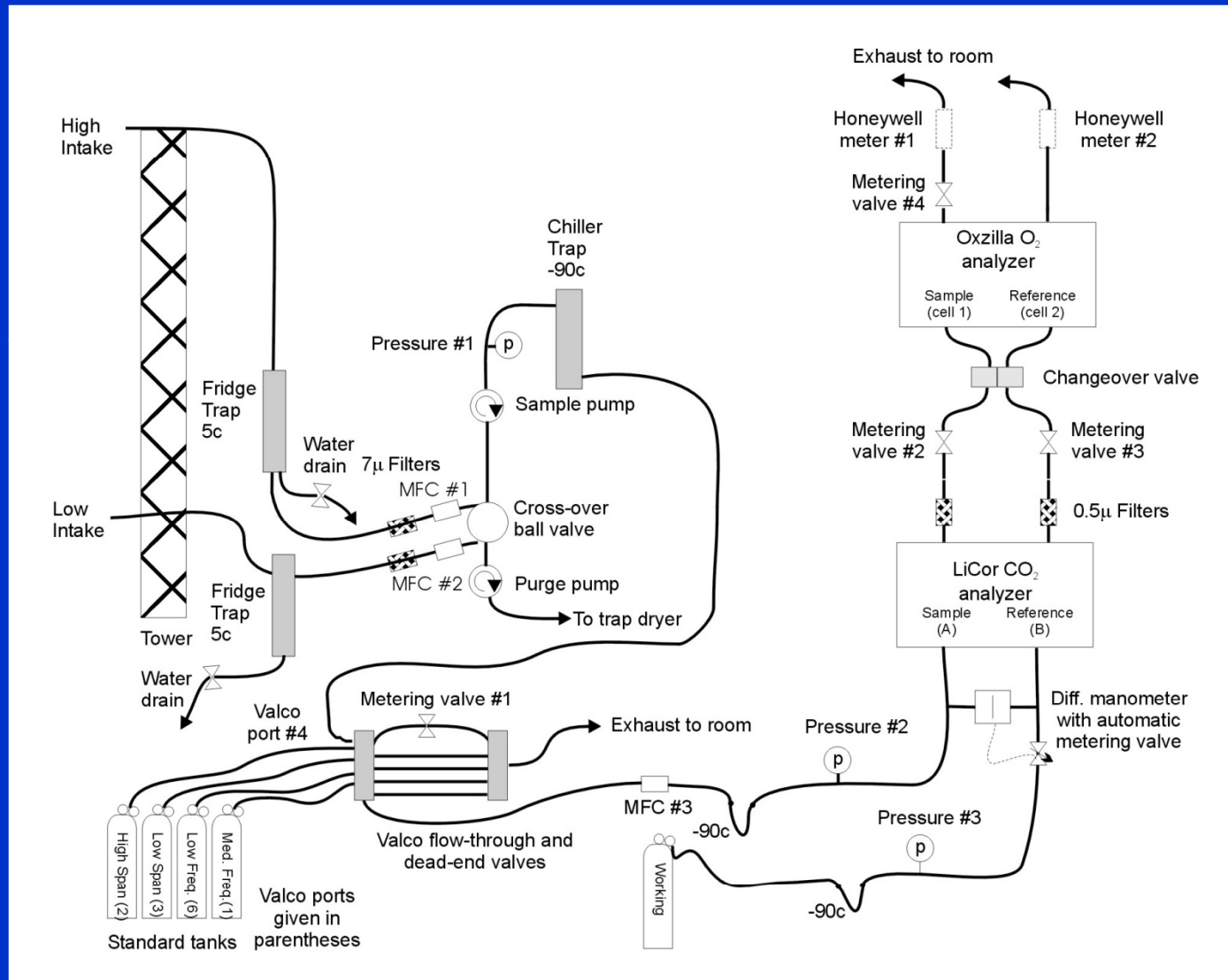


Google maps

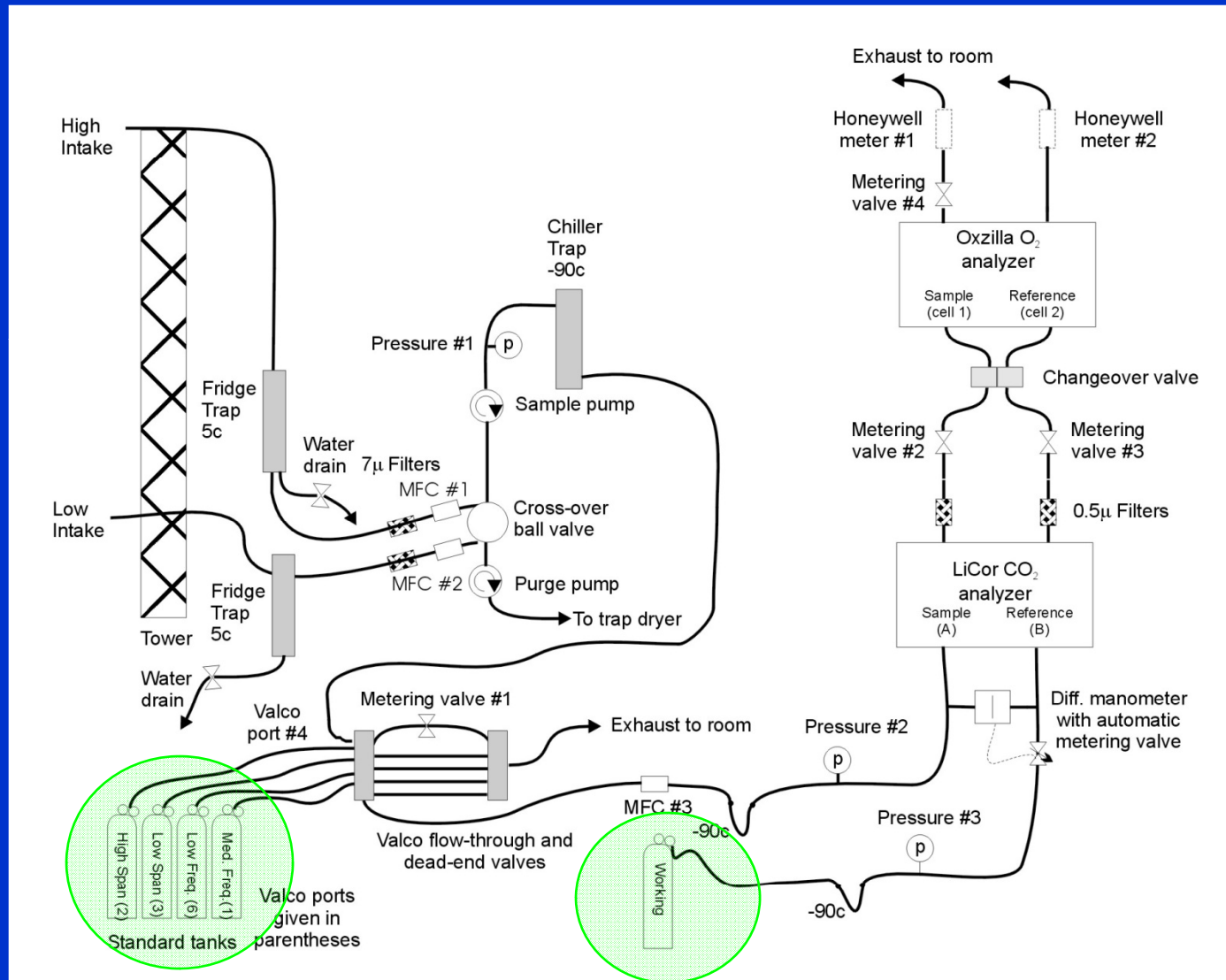




The equipment



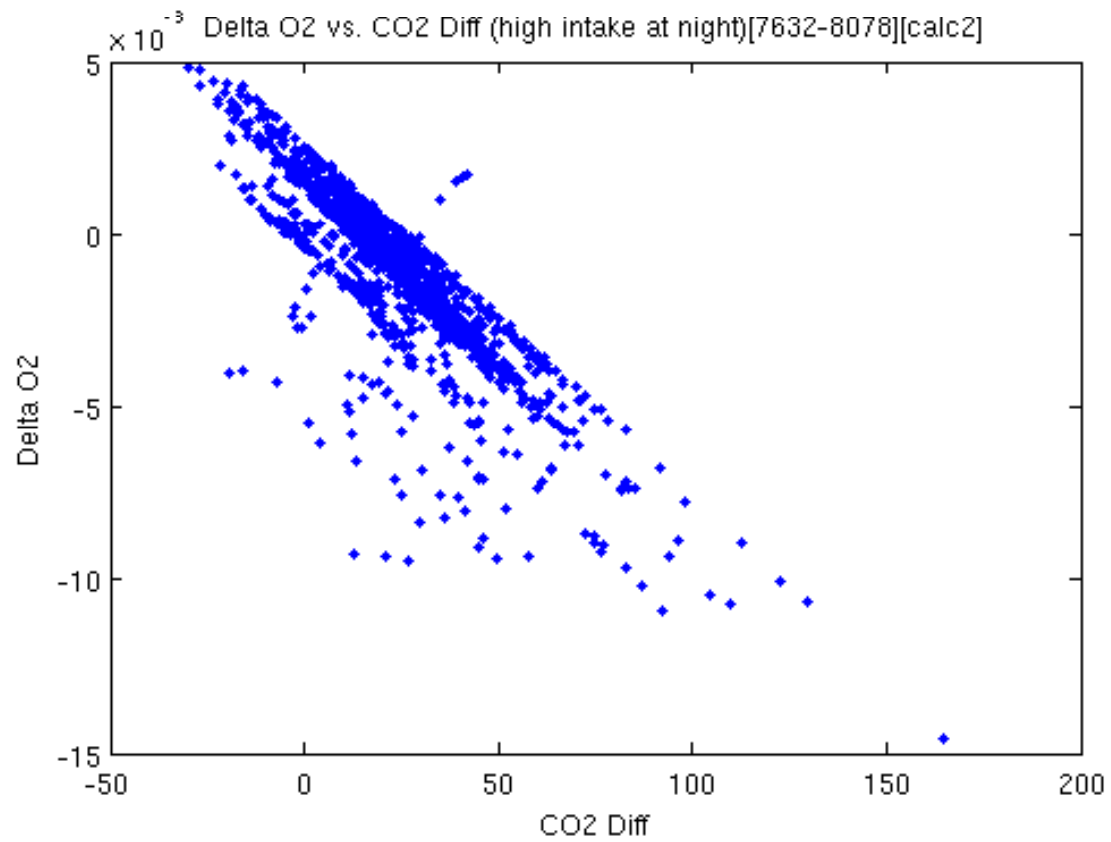
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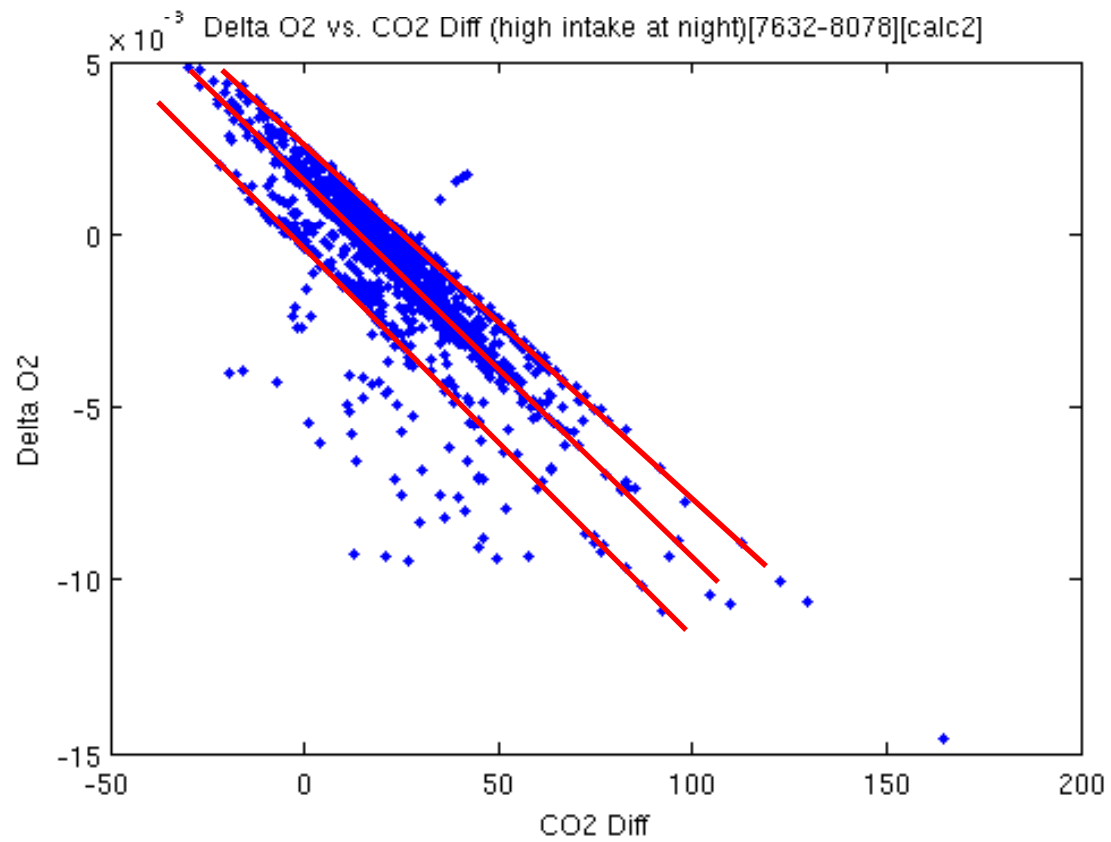




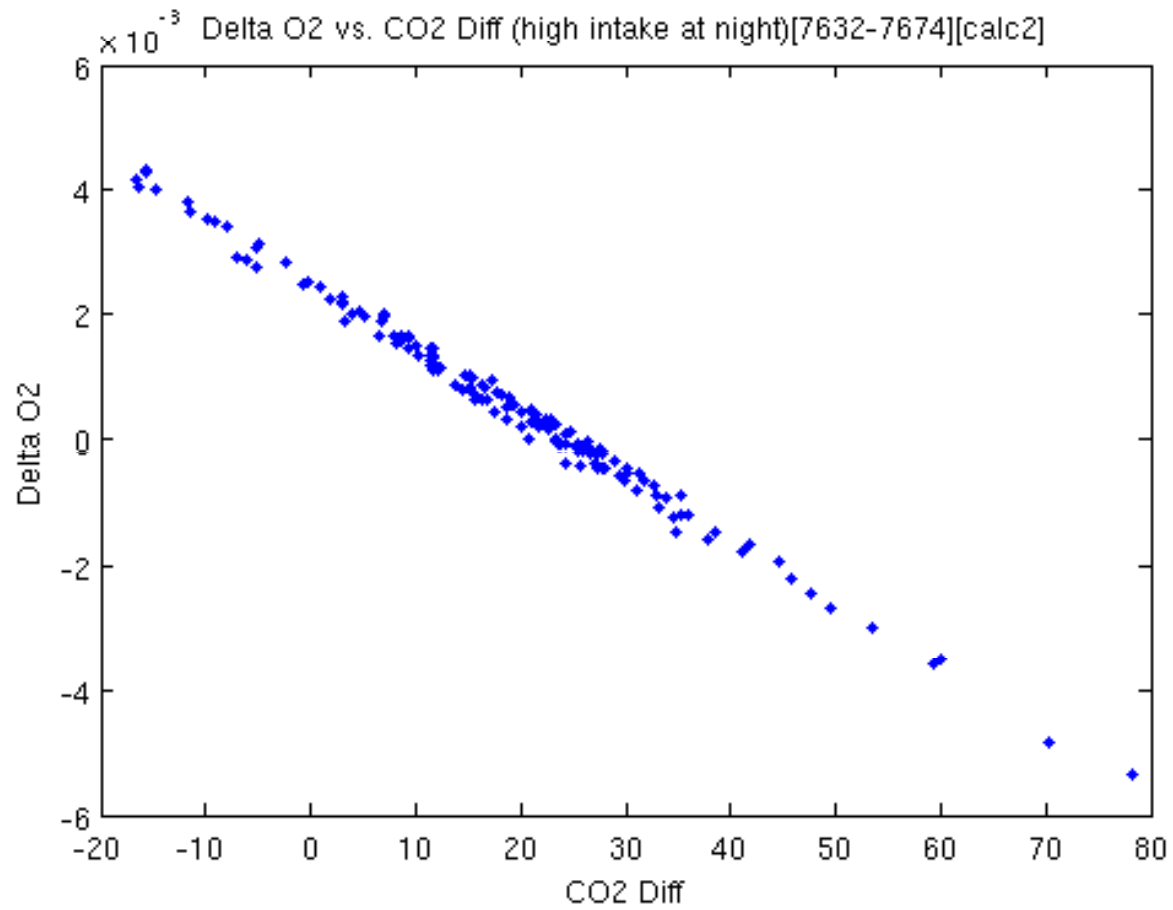
Real data



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Summary

- Important questions require excellent atmospheric measurements

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- Excellent measurements require intelligent weighting of experimental evidence

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- Important questions require excellent atmospheric measurements
- Excellent measurements require intelligent weighting of experimental evidence
- I have abundant data. Intelligence, on the other hand...

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