CU LED-CE-DOAS and MAX-DOAS: diurnal cycles, vertical profiles and air-sea fluxes of glyoxal

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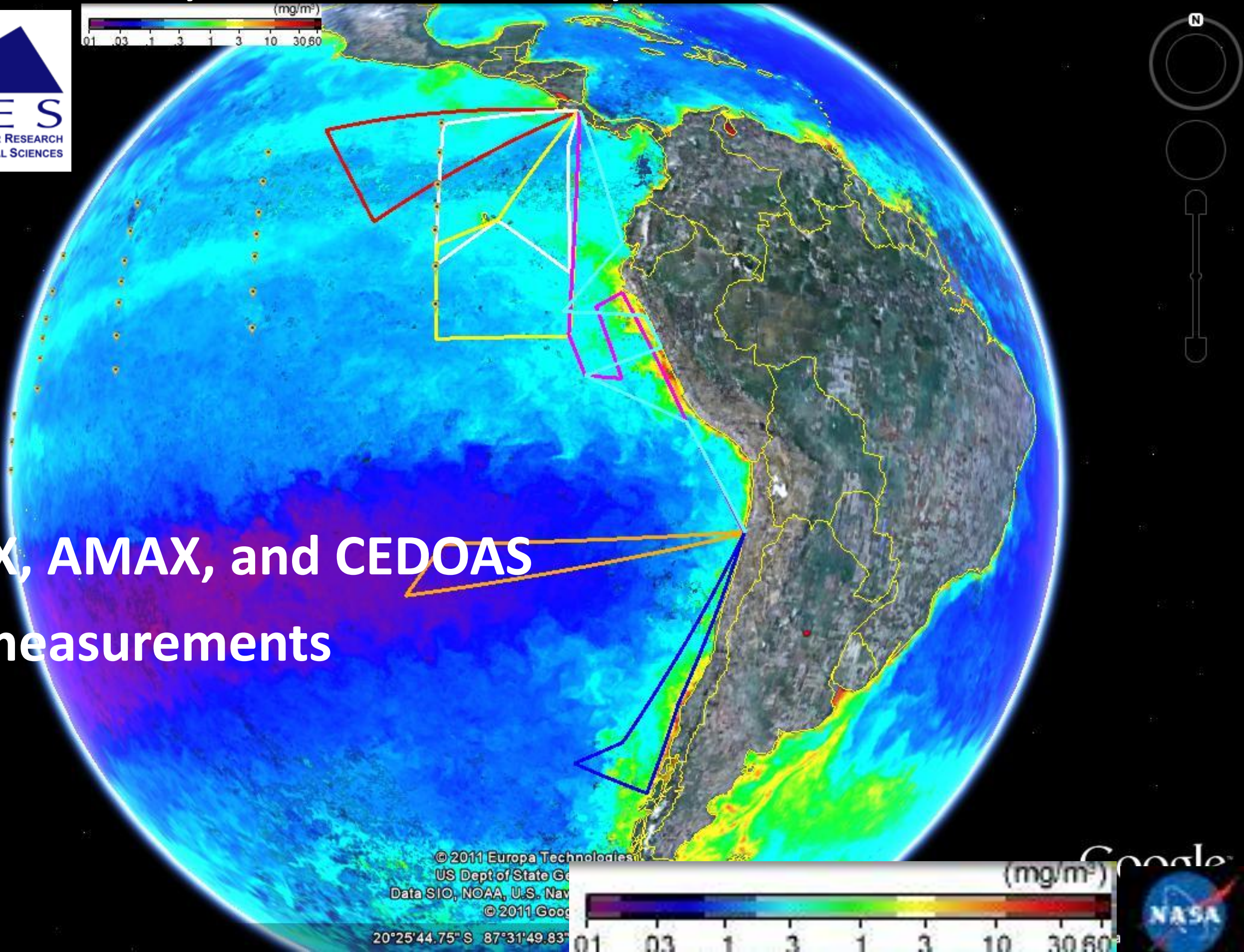
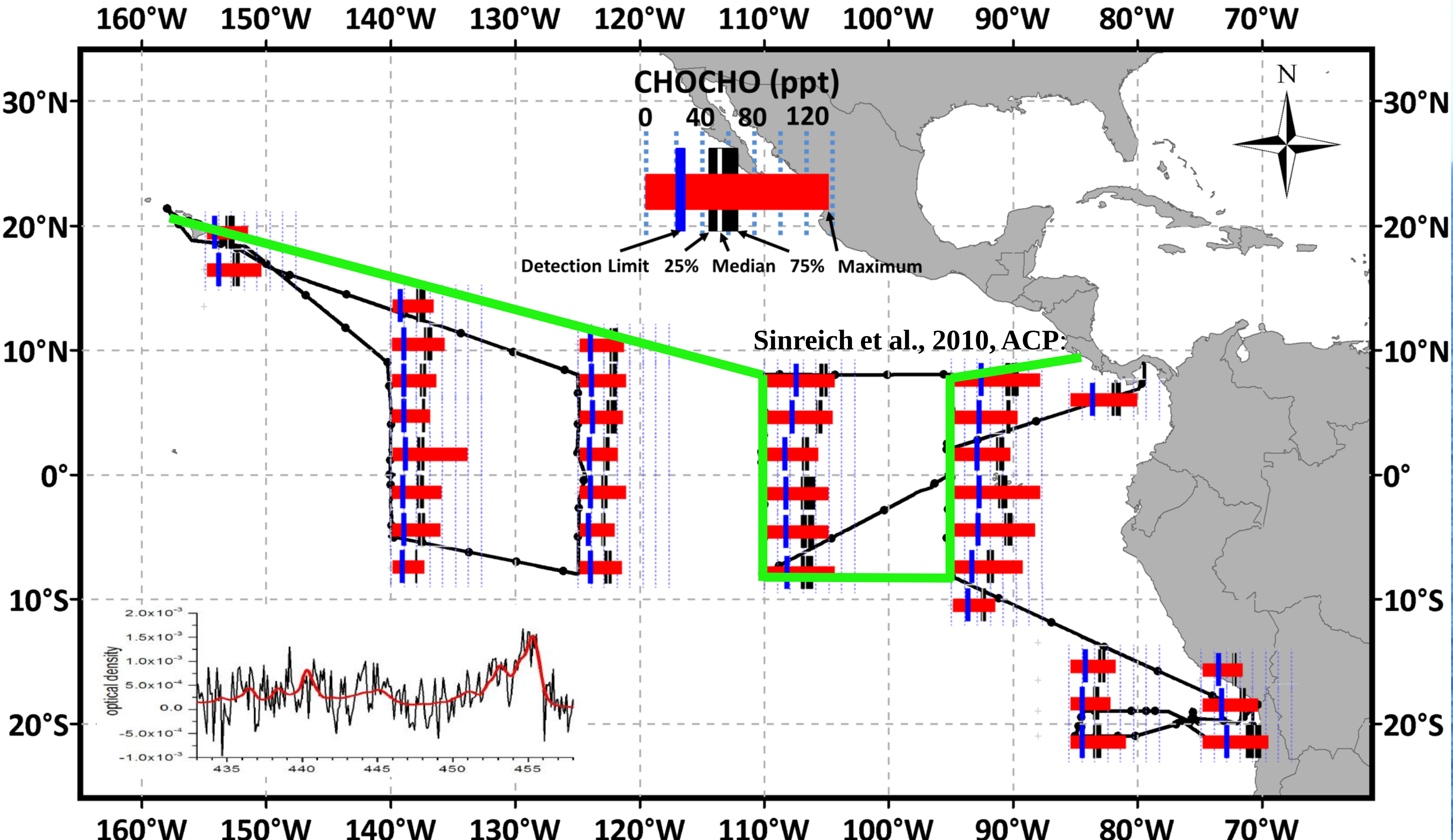
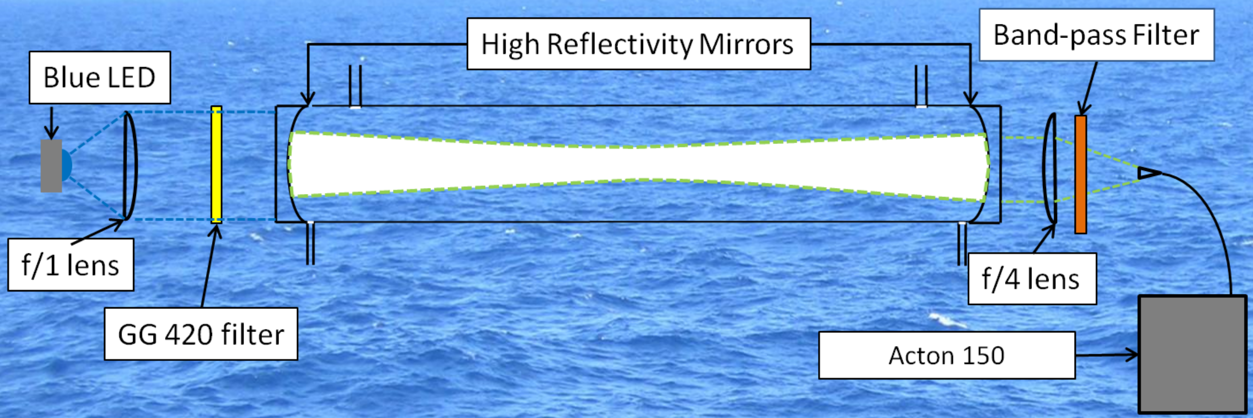


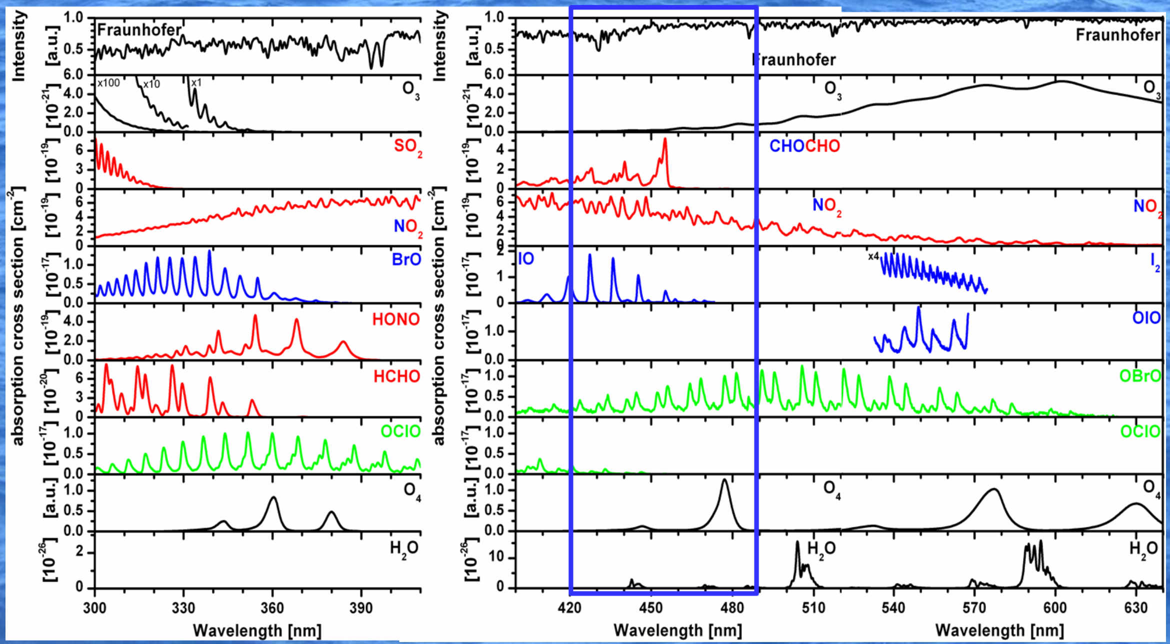
- CE-DOAS
  - TORERO set up
  - Preliminary data
- Case Study RF17: SMAX, AMAX, and CEDOAS
- Eddy Covariance Flux measurements
  - Method
  - Preliminary results



- MAX-DOAS data from four cruises in 2008-2009
- MAX- DOAS - Daytime only data
- What is the diurnal cycle?

Light Emitting Diode Cavity Enhanced DOAS (CU LED-CE-DOAS)





420-490nm,

R(460nm) =0.999965

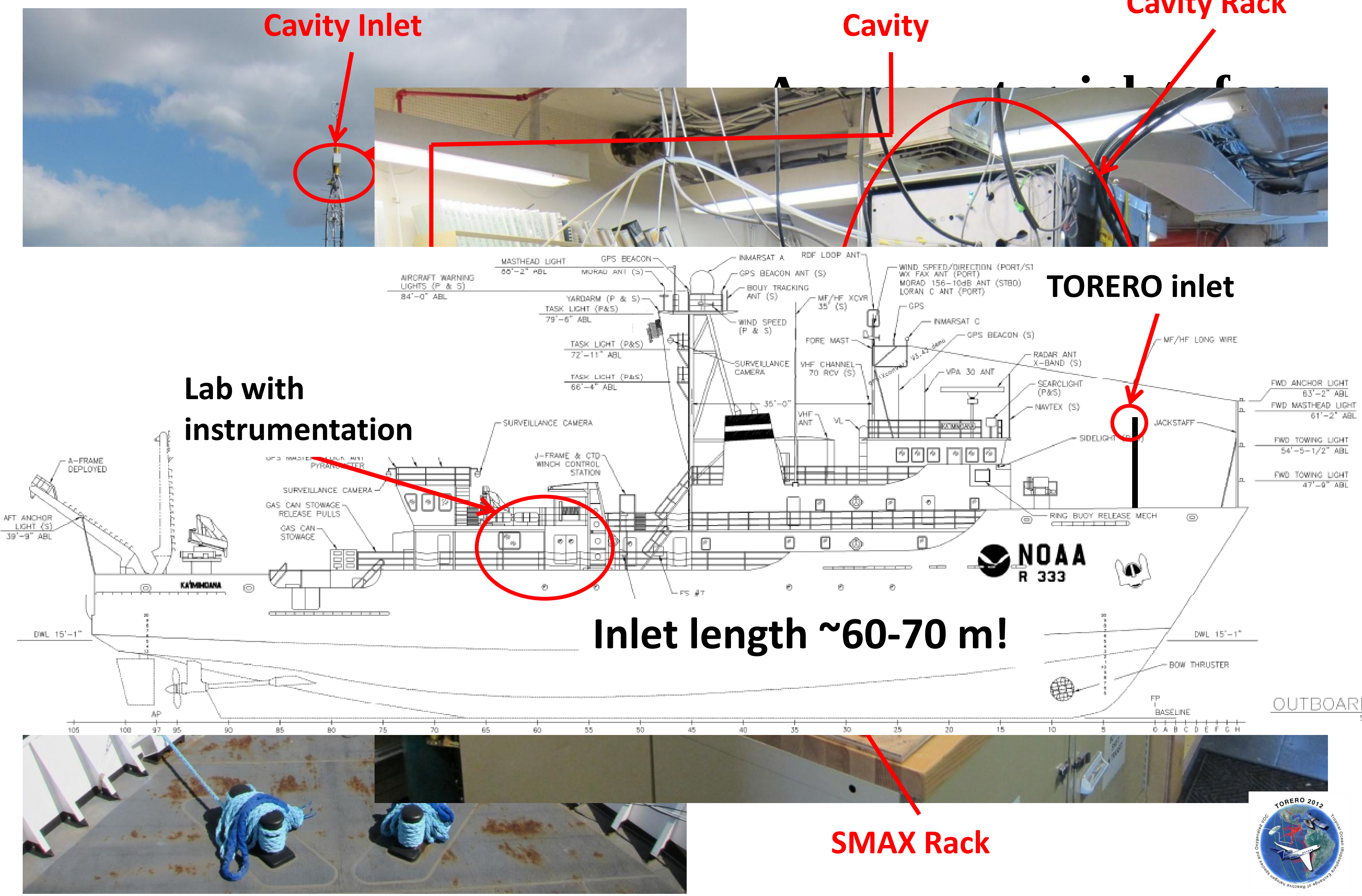
L_{eff}= 15-20 km

Acton 150

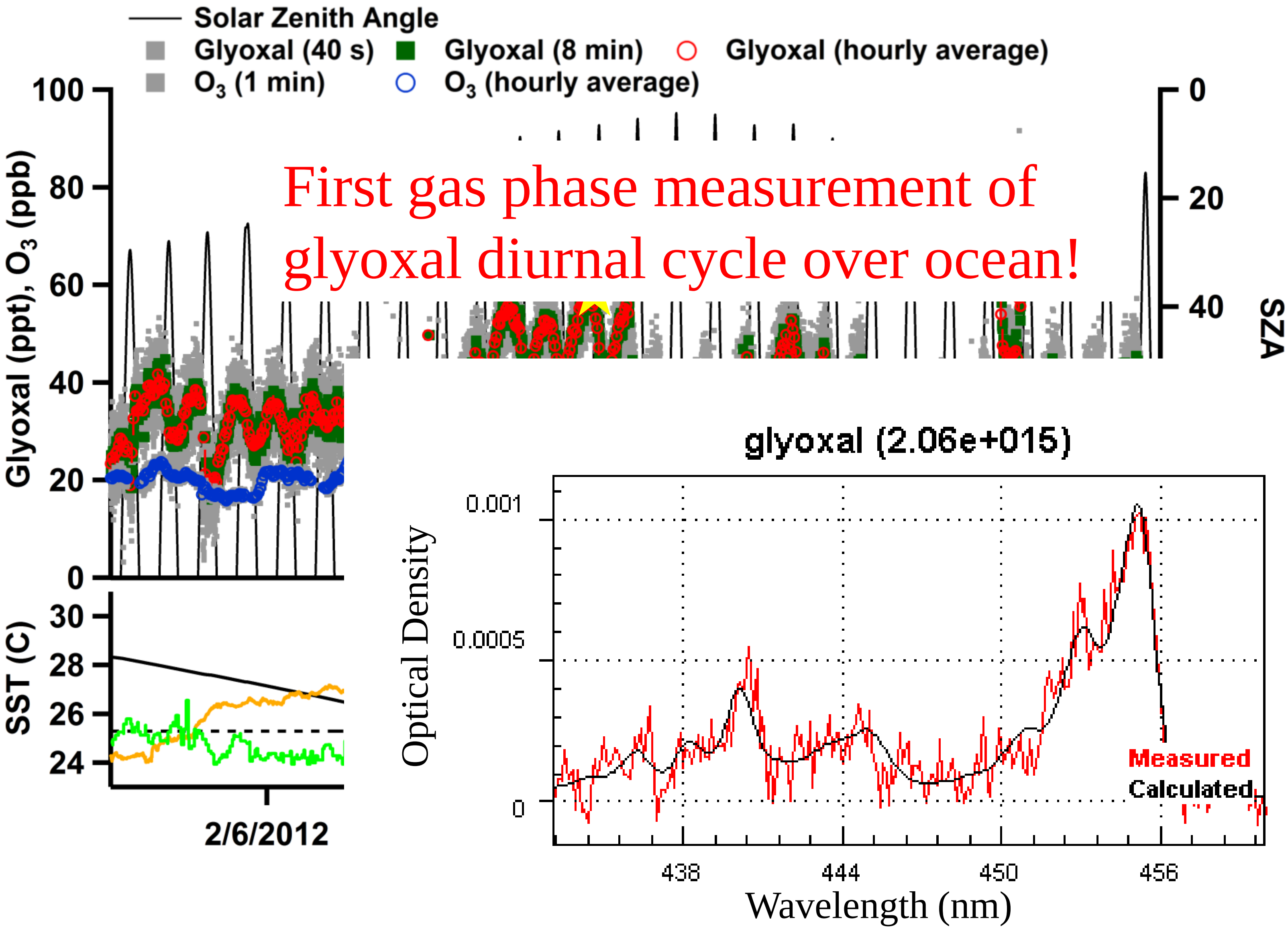
0.5 nm FWHM

Thalman and Volkamer, 2010, AMT

Setup for TORERO



Glyoxal Time Series

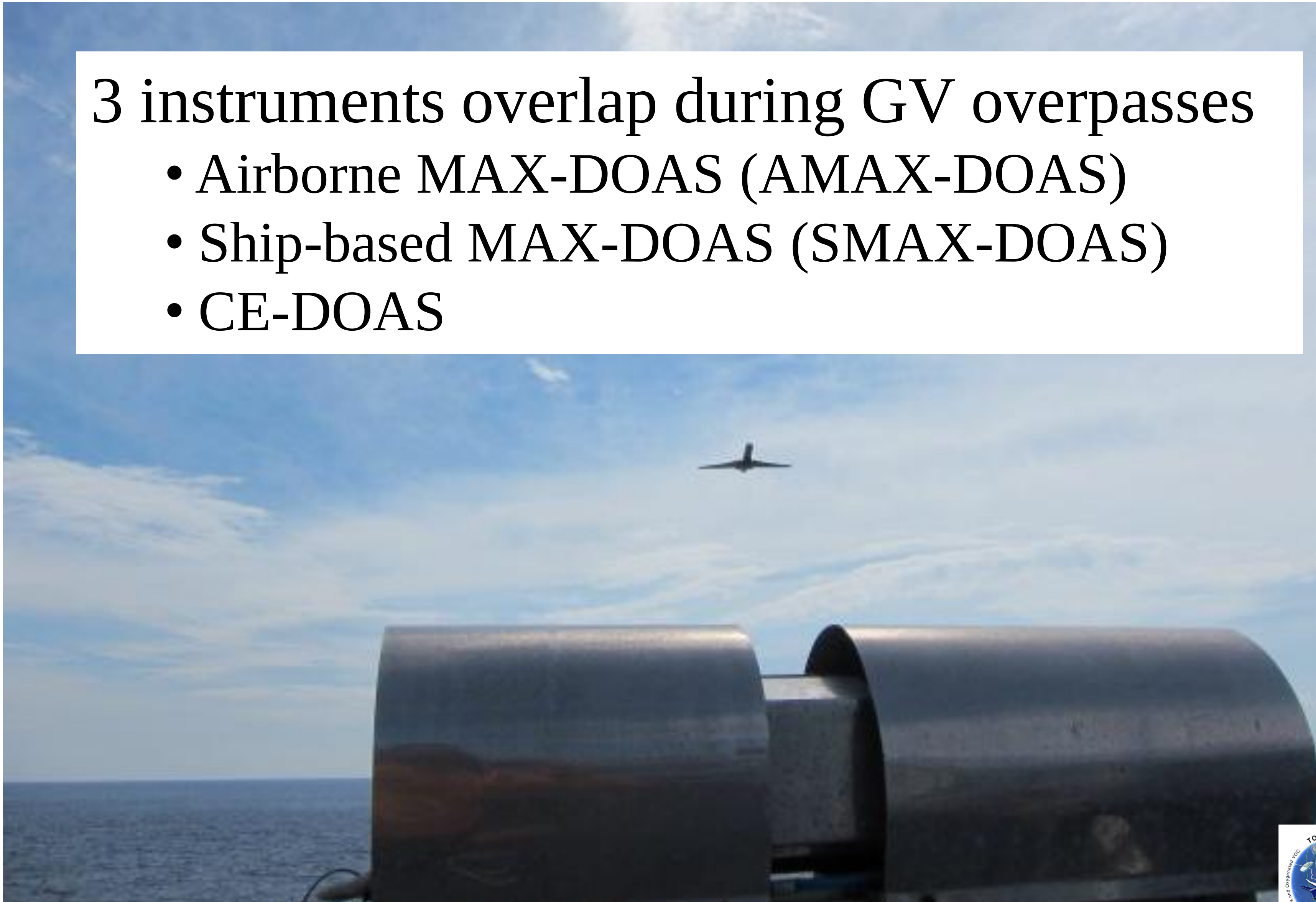


First gas phase measurement of glyoxal diurnal cycle over ocean!

MAX-DOAS telescope aboard KA

3 instruments overlap during GV overpasses

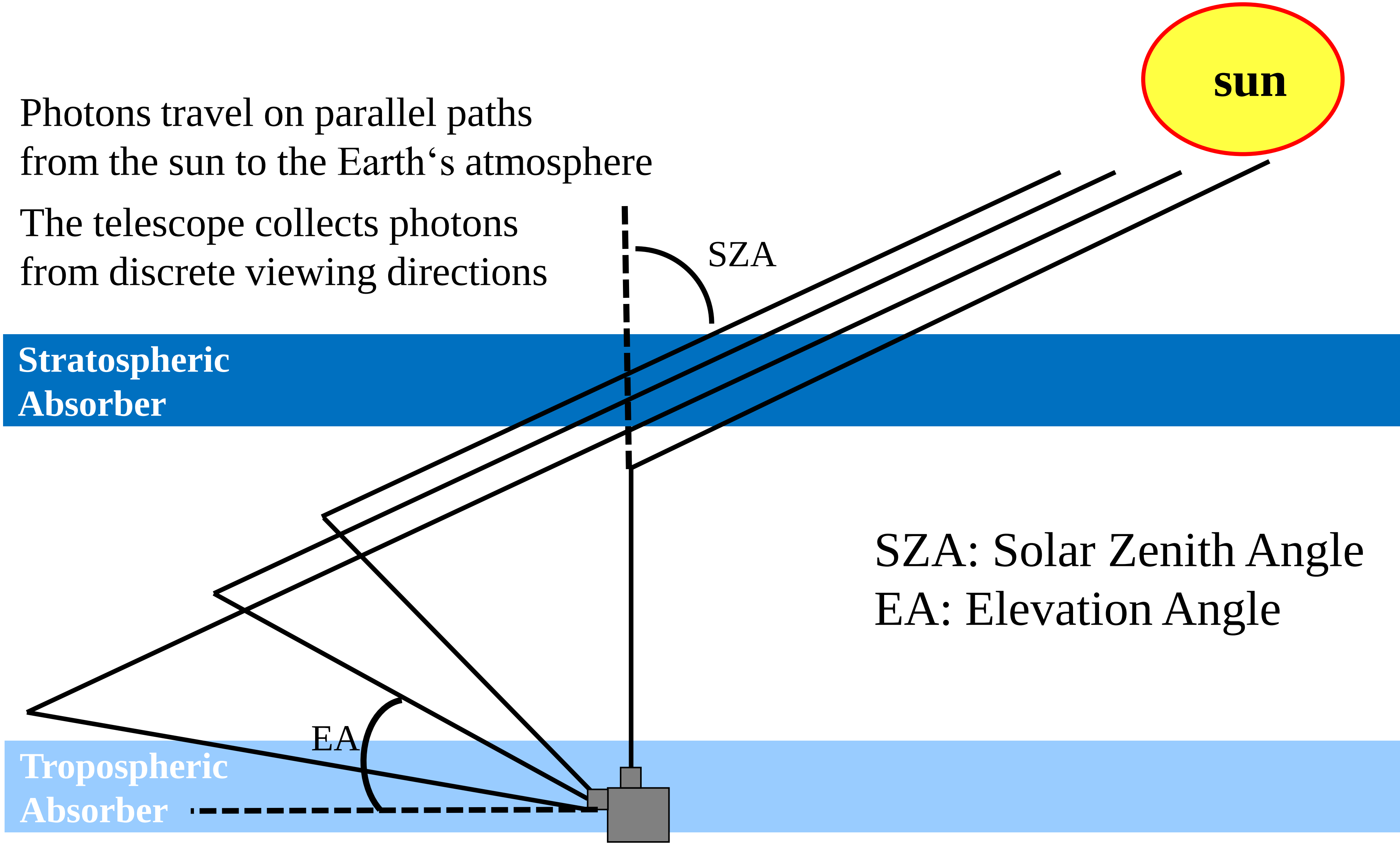
- Airborne MAX-DOAS (AMAX-DOAS)
- Ship-based MAX-DOAS (SMAX-DOAS)
- CE-DOAS



MAX-DOAS: Multi-Axis DOAS

Photons travel on parallel paths
from the sun to the Earth‘s atmosphere

The telescope collects photons
from discrete viewing directions

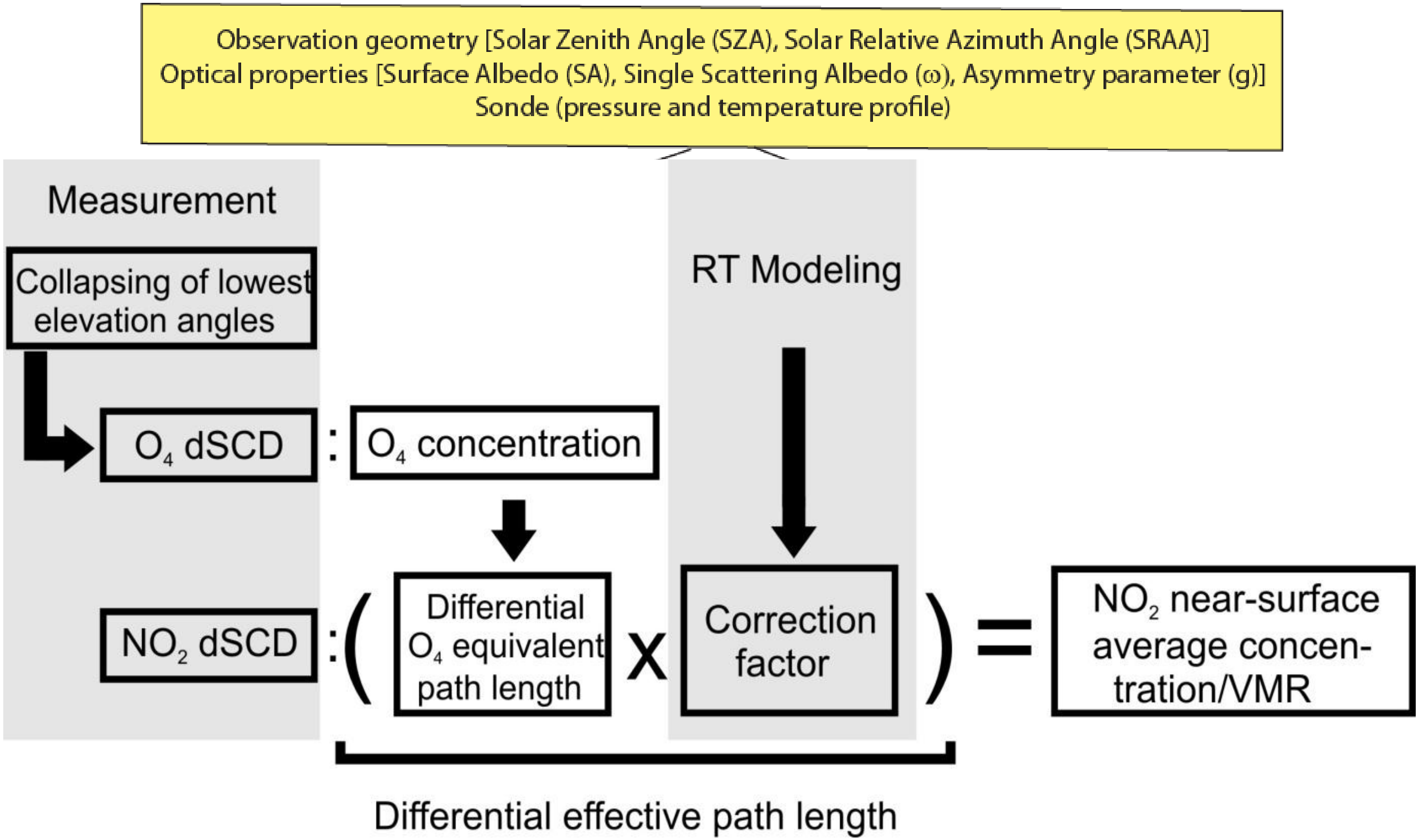


SZA: Solar Zenith Angle
EA: Elevation Angle

Single-scattering approximation

The lower the Elevation Angle the longer the light path through the BL

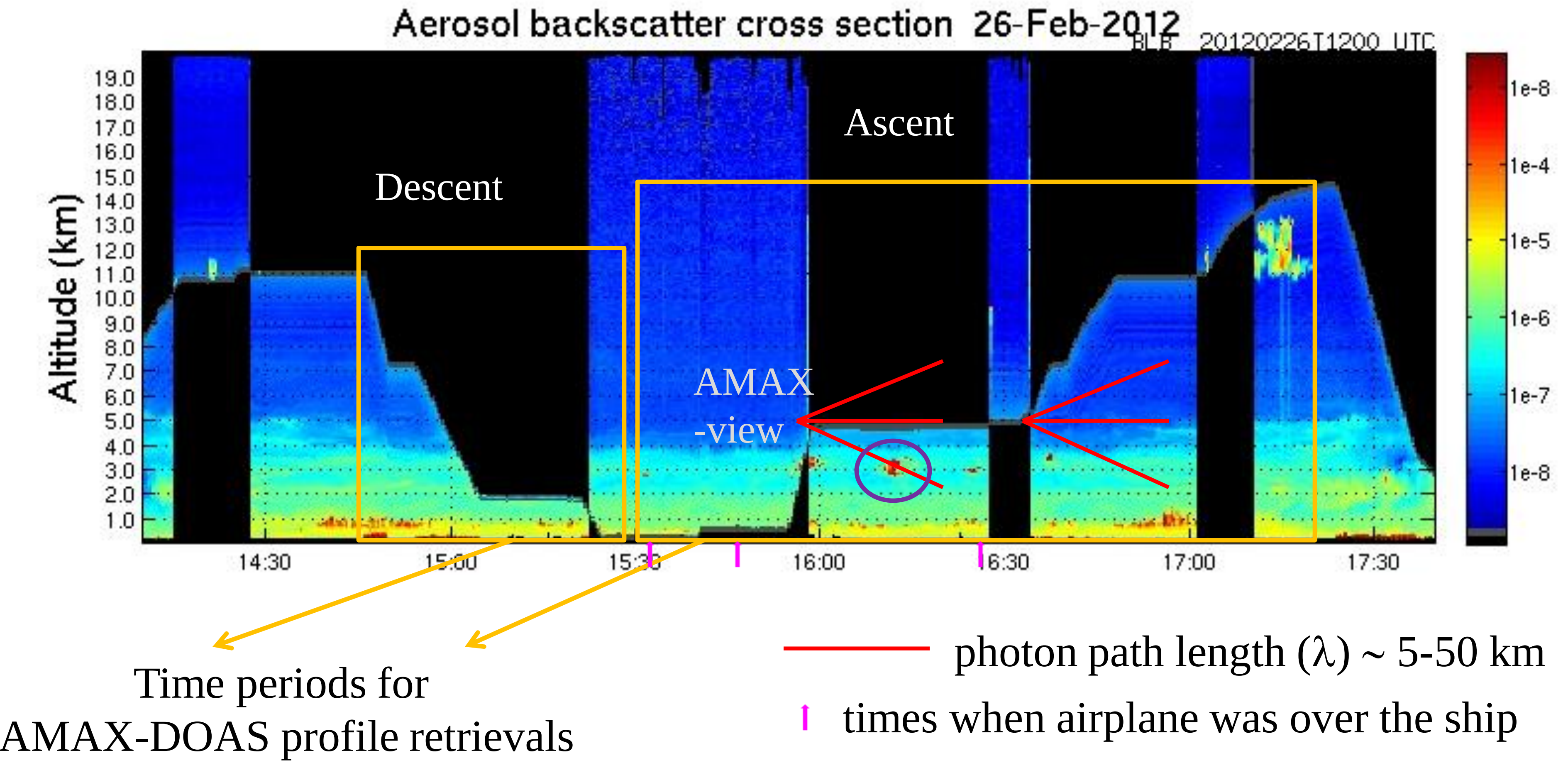
Vertical profile retrieval method



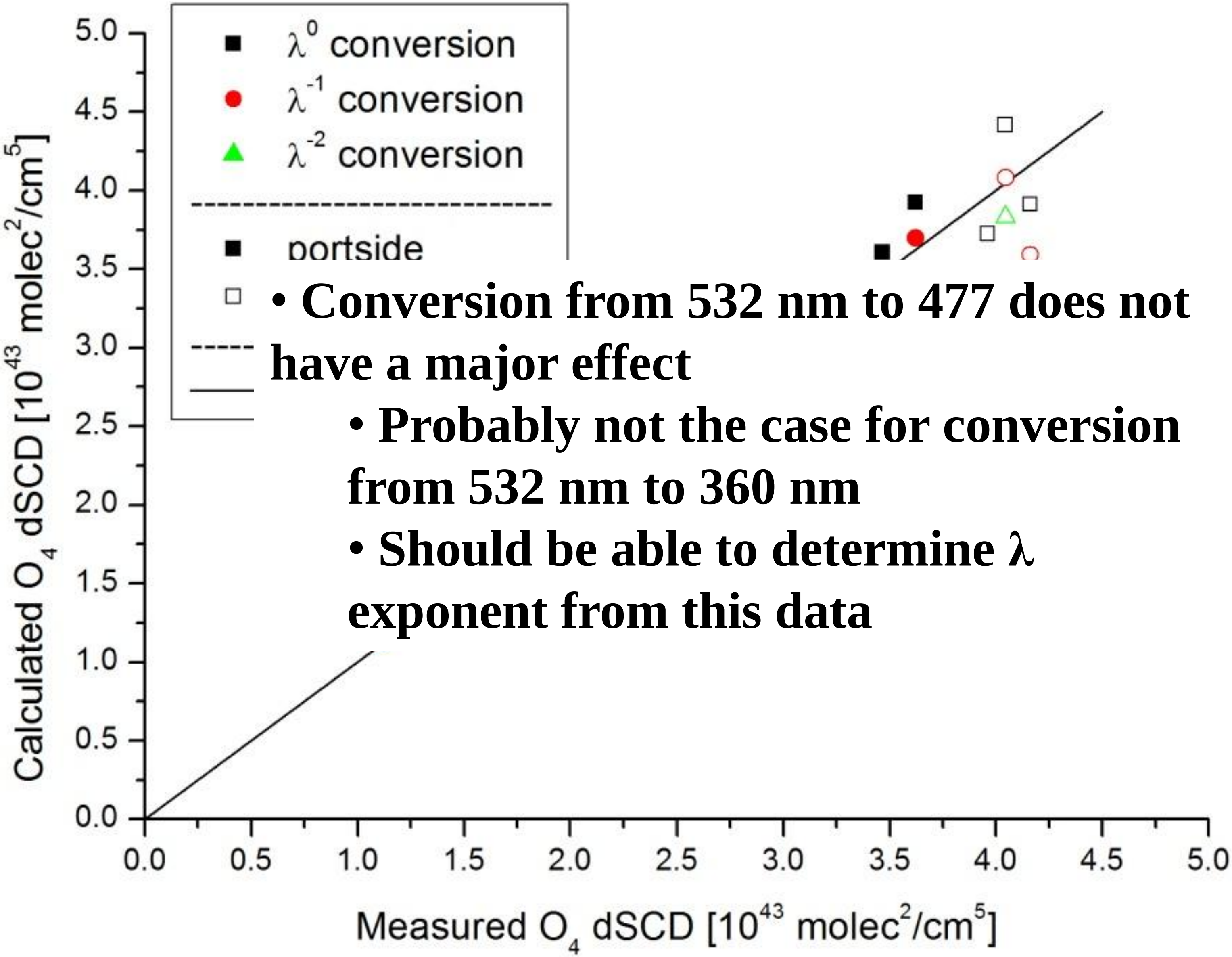
Relies on "collapsing" of O_4 dSCDs under elevated aerosol load conditions

Sinreich and Volkamer, in prep

RF17: HSRL Curtain

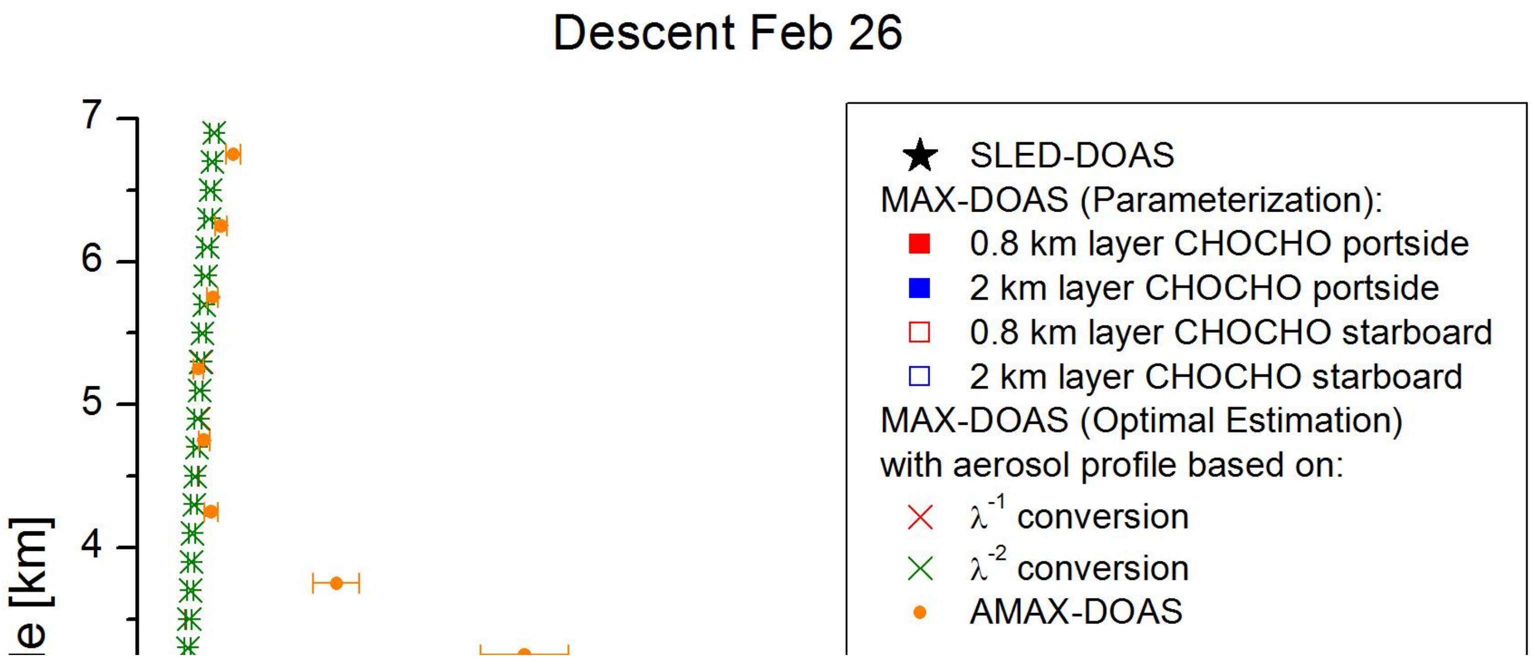


RF17: O_4 dSCD Comparison

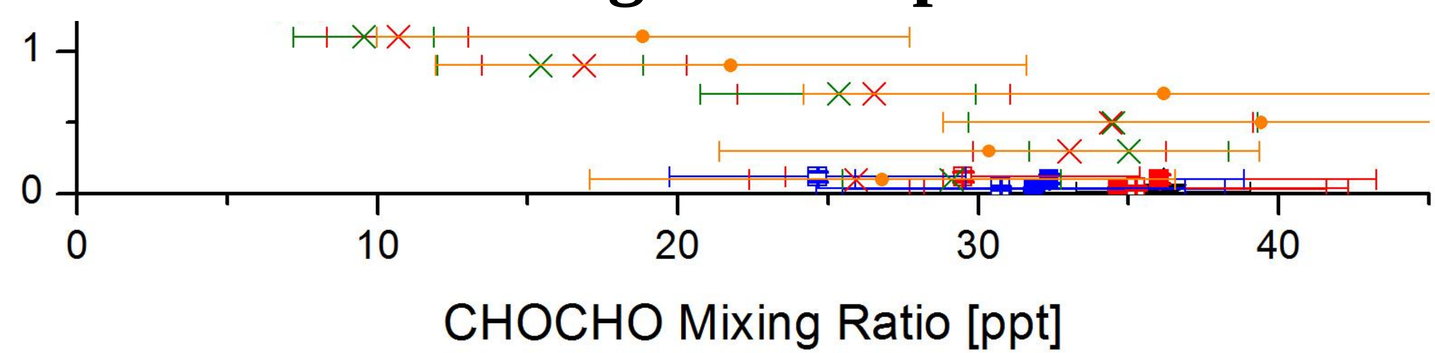


- **Conversion from 532 nm to 477 does not have a major effect**
  - **Probably not the case for conversion from 532 nm to 360 nm**
  - **Should be able to determine λ exponent from this data**

RF17: Glyoxal VMR Comparison



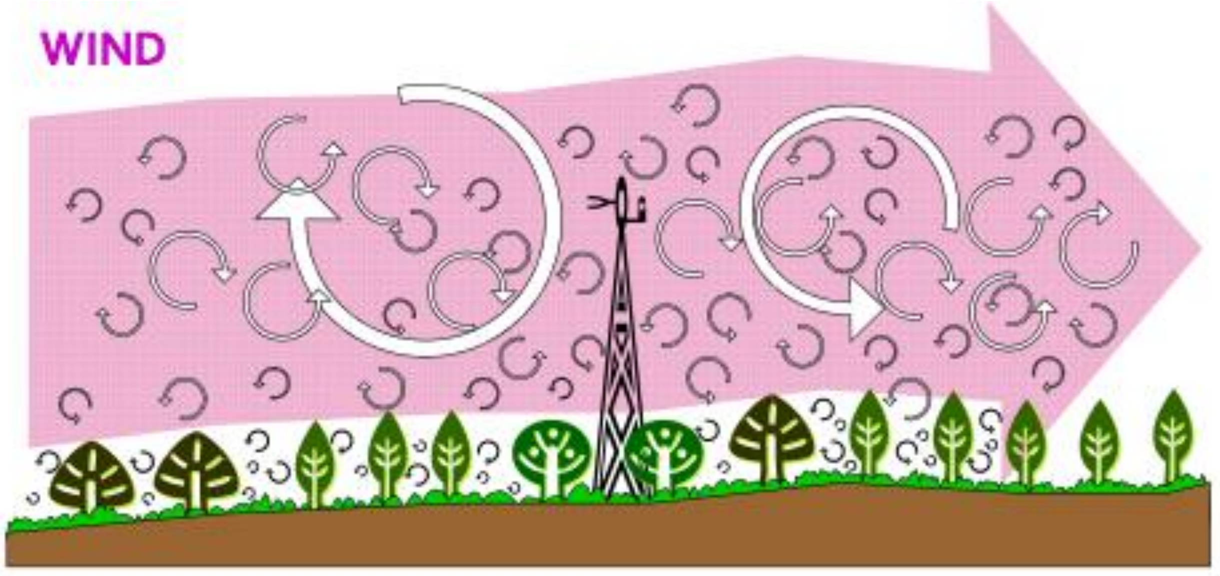
Vertical profile information can help with the assessment of source apportionment and flux measurements are a good compliment to this!



Eddy Covariance Flux Measurements

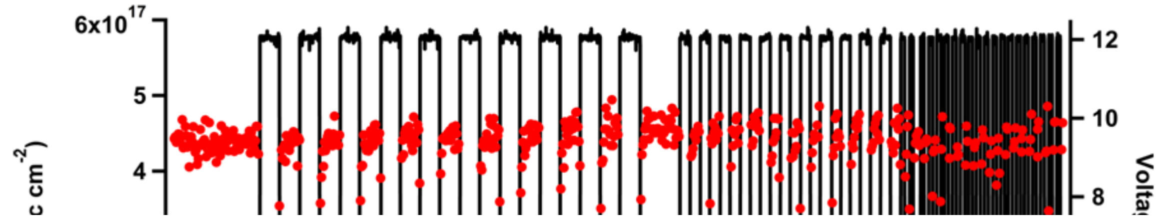
- Allow to measure vertical gas fluxes in the MBL
    - Facilitate understanding of air-sea exchange of measured species

- Require fast response measurements of wind velocities and the concentration of the desired analyte
    - Flux is the covariance of the vertical wind velocity and concentration of analyte

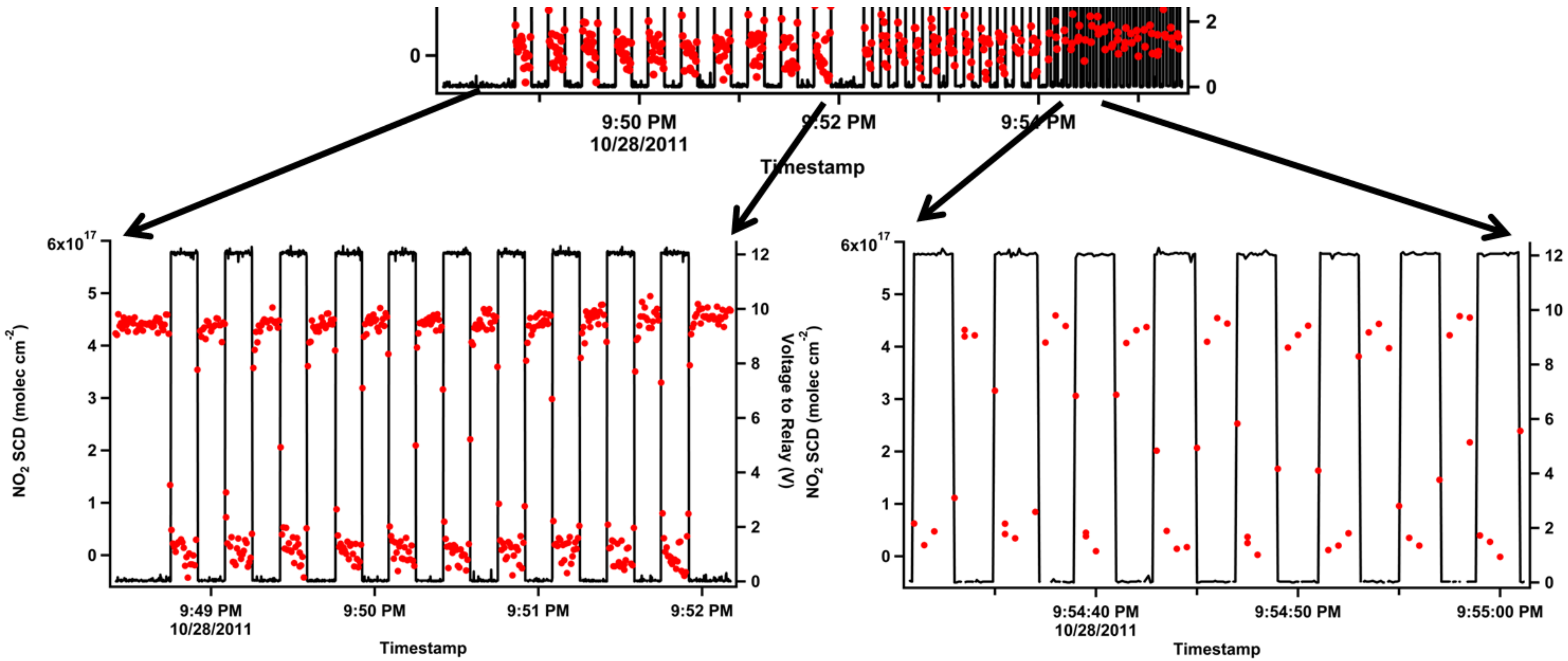


G. Burba and D. Anderson. “A Brief Practical Guide to Eddy Covariance Flux Measurements,” 2005

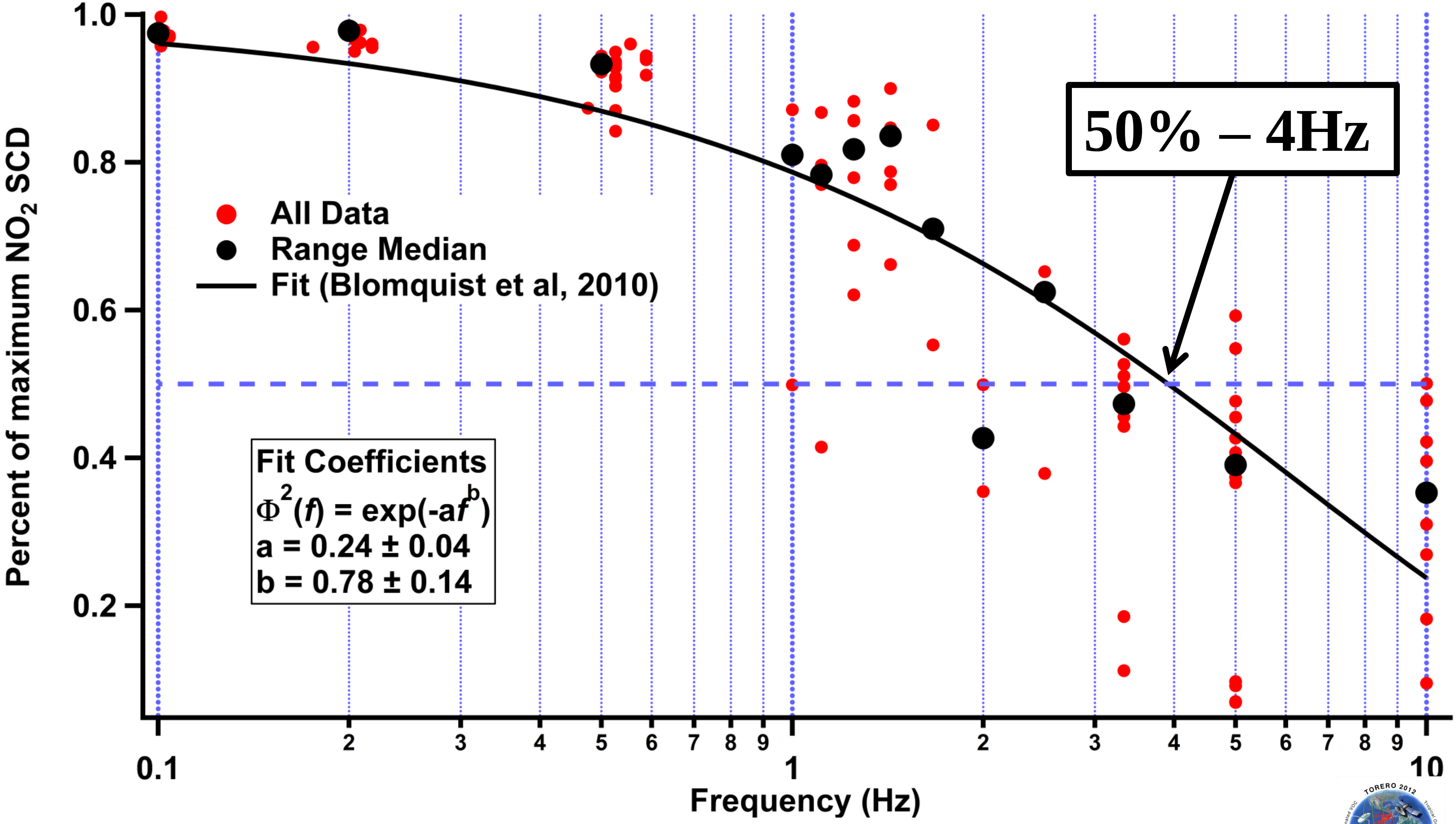
Laboratory tests



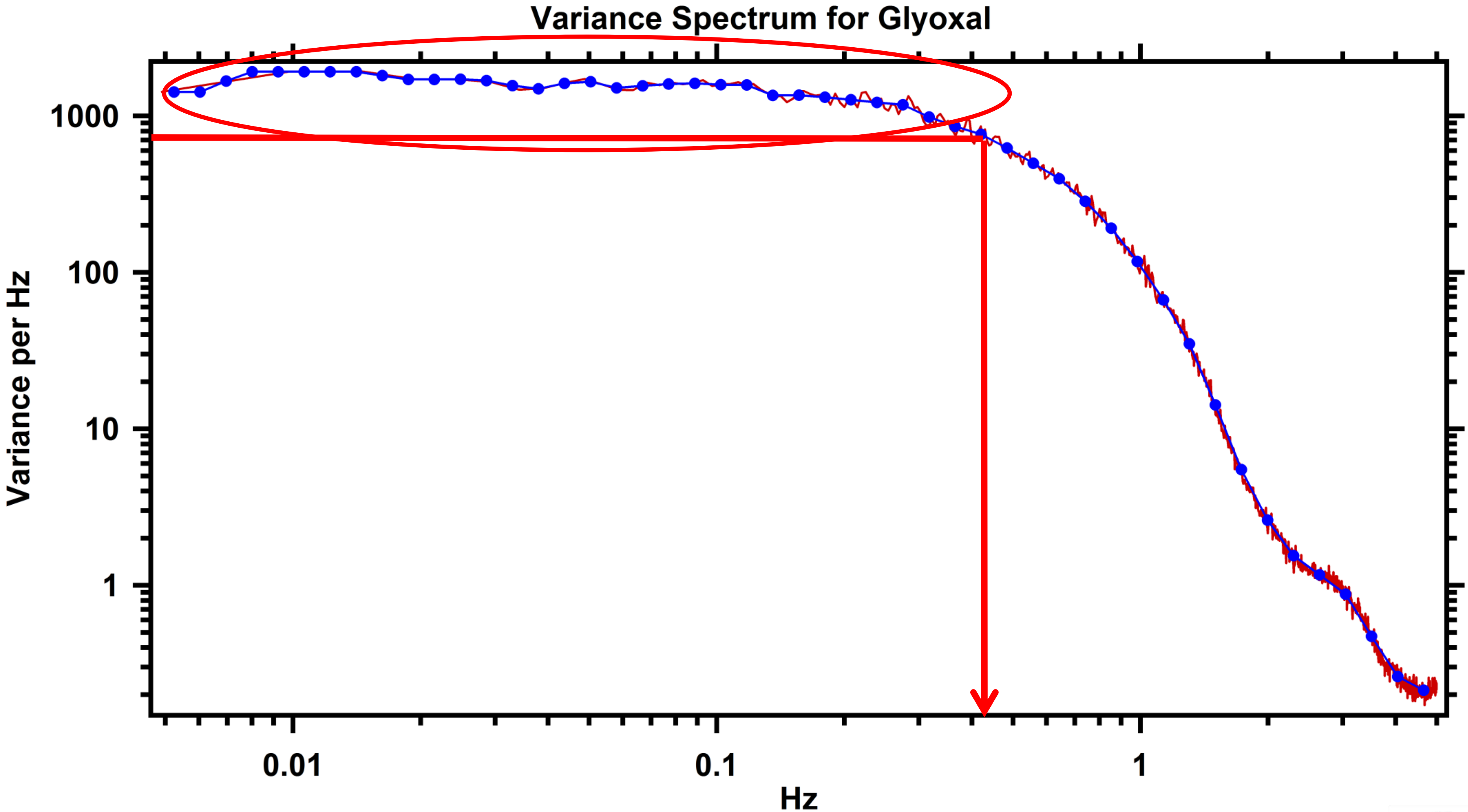
- Looking for the frequency at which the NO_2 signal is at 50% of the maximum



Fast sensor: Time constant



Fast Sensor: White Noise



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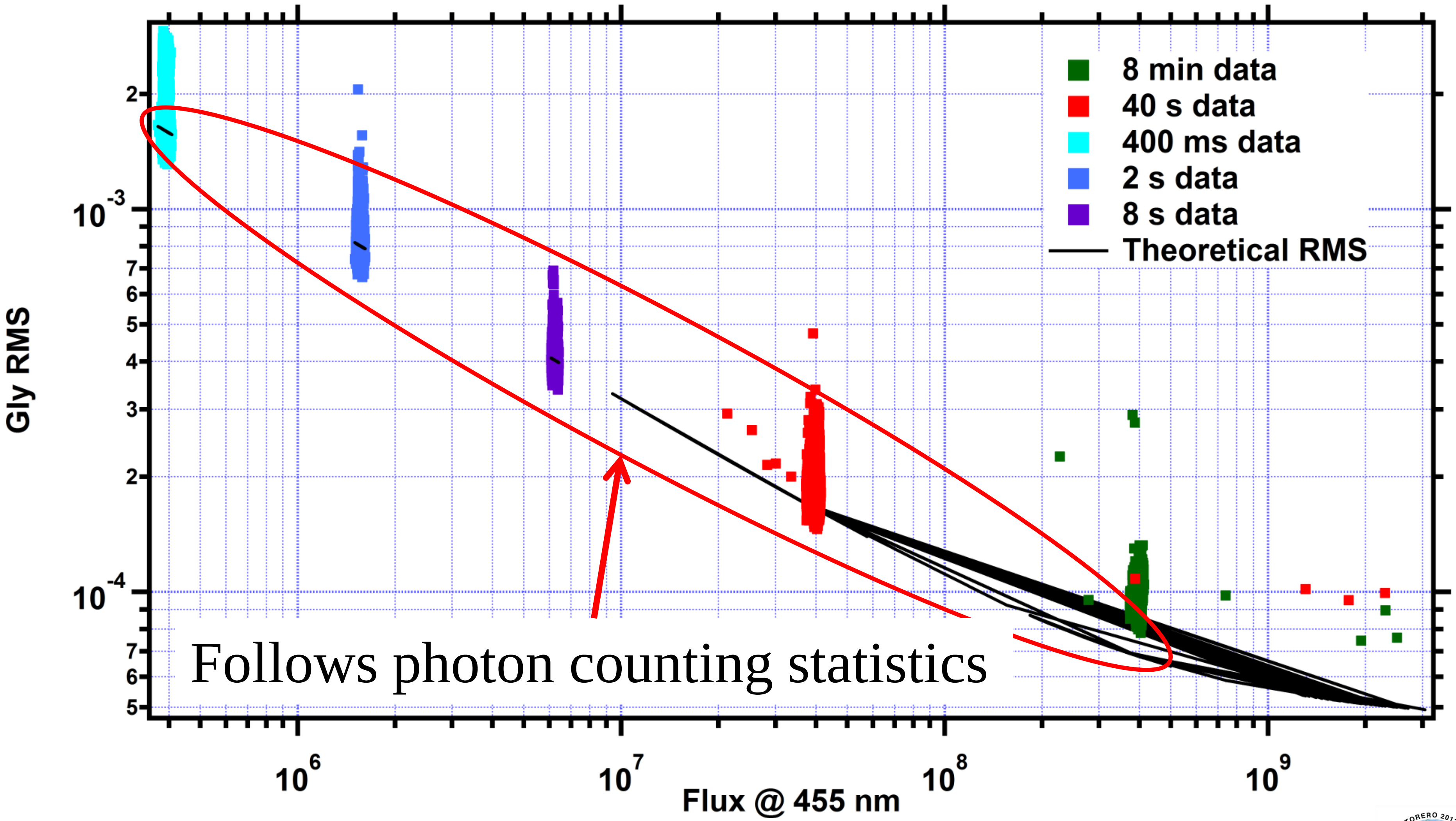


Eddy Covariance Calculations

<u>5 Step Program</u>

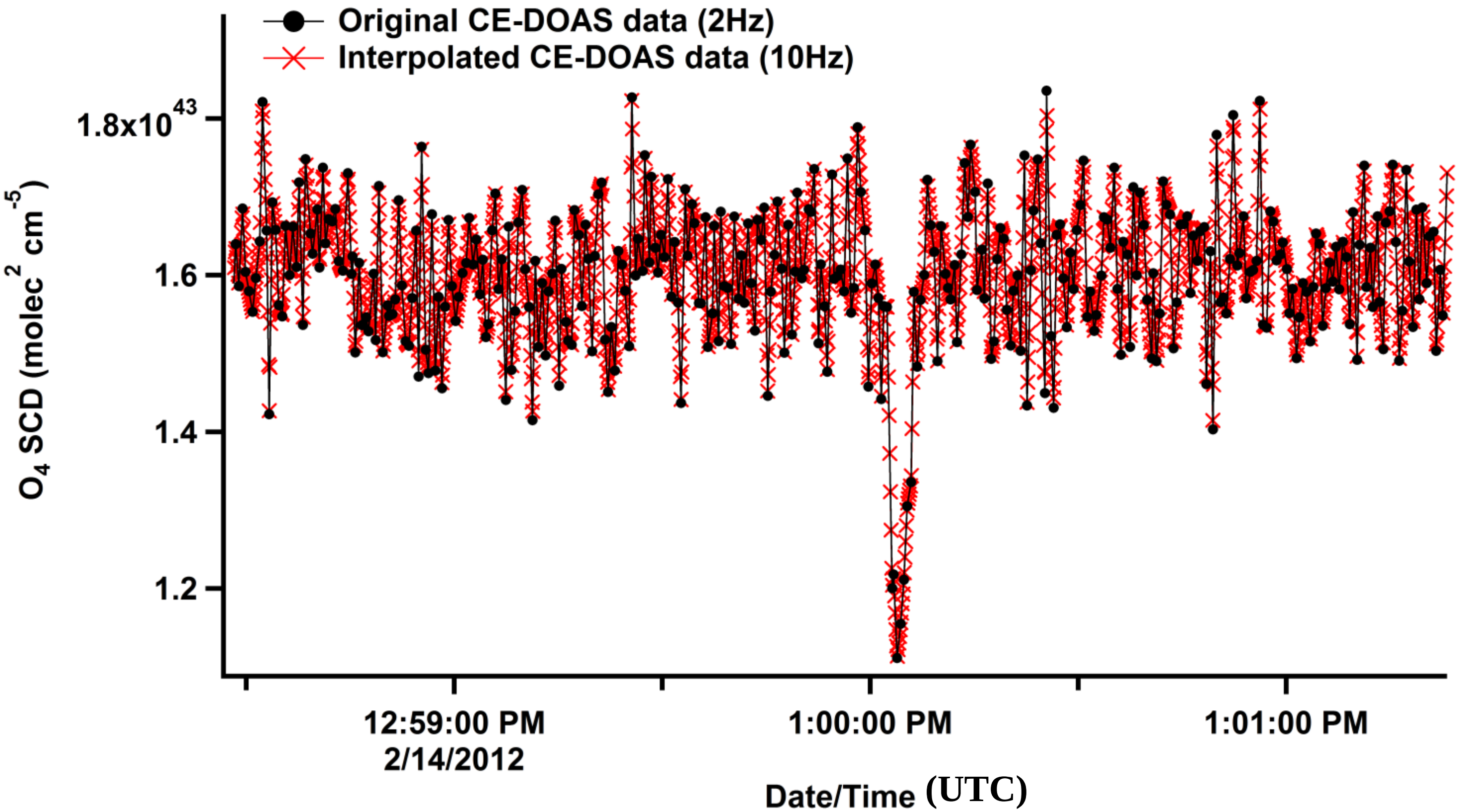
1) Correct wind data to compensate for motion of the measurement platform
2) Interpolate the measured analyte concentration onto the timestamp for the wind data
3) Relative wind analysis and phase correction
4) Calculate 10 minute flux averages and statistics for the time series
5) Apply additional filters to remove any “bad” 10 minute averages and then calculate 1 hour averages

*Credit to Byron Blomquist; collaborator
*COARE model

Eddy Covariance: Interpolate data

Data measurement frequency needs to be the same as the wind sensor frequency

- CE-DOAS data: measured at 2Hz, need to interpolate to 10Hz



Eddy Covariance: Wind direction and phase correction

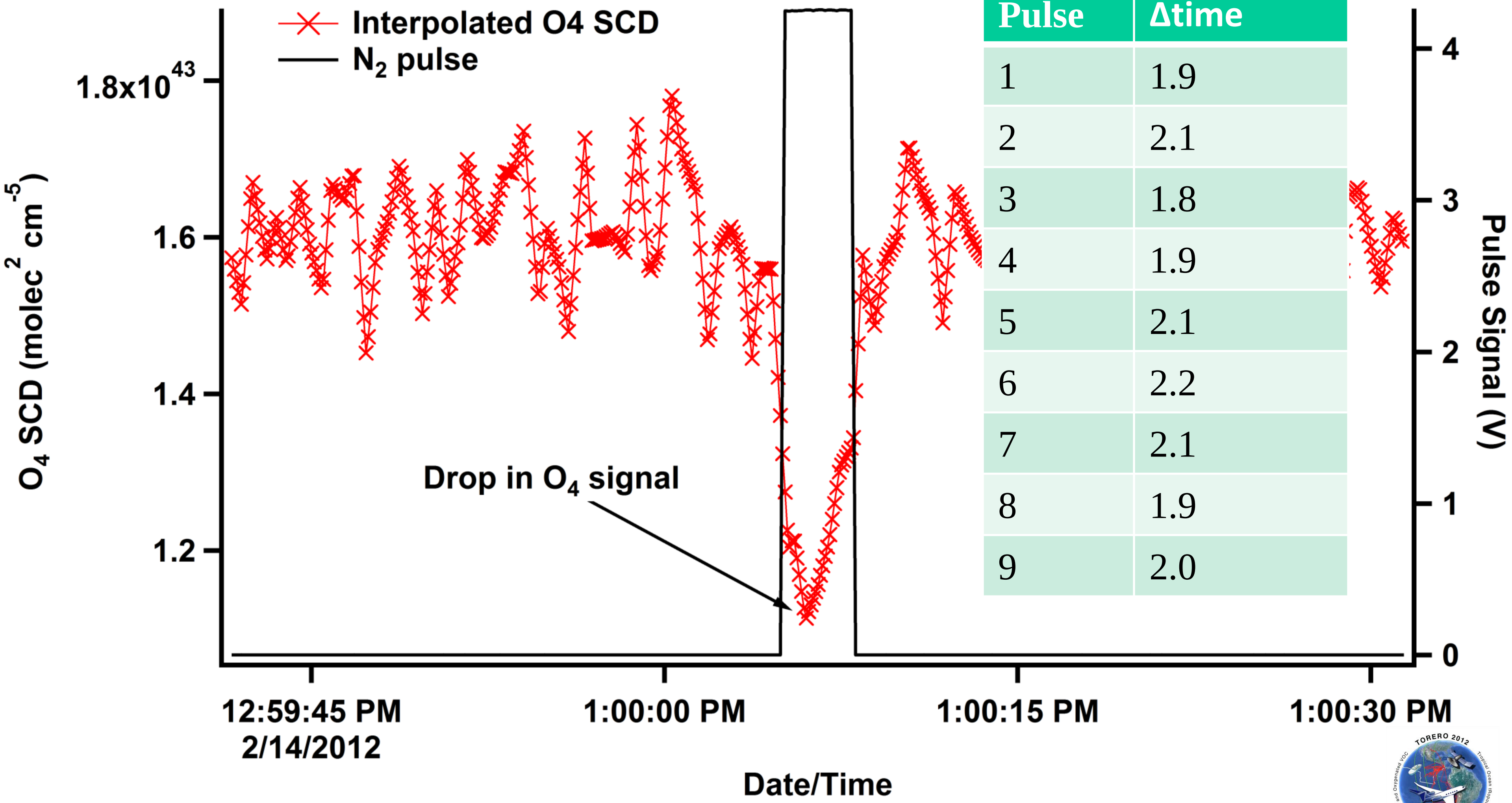
Analyze Relative Wind Direction

- Hour long segments are assessed whether they can be included in the data set based on relative wind direction
  - Needs to be ±60°

Phase Correction

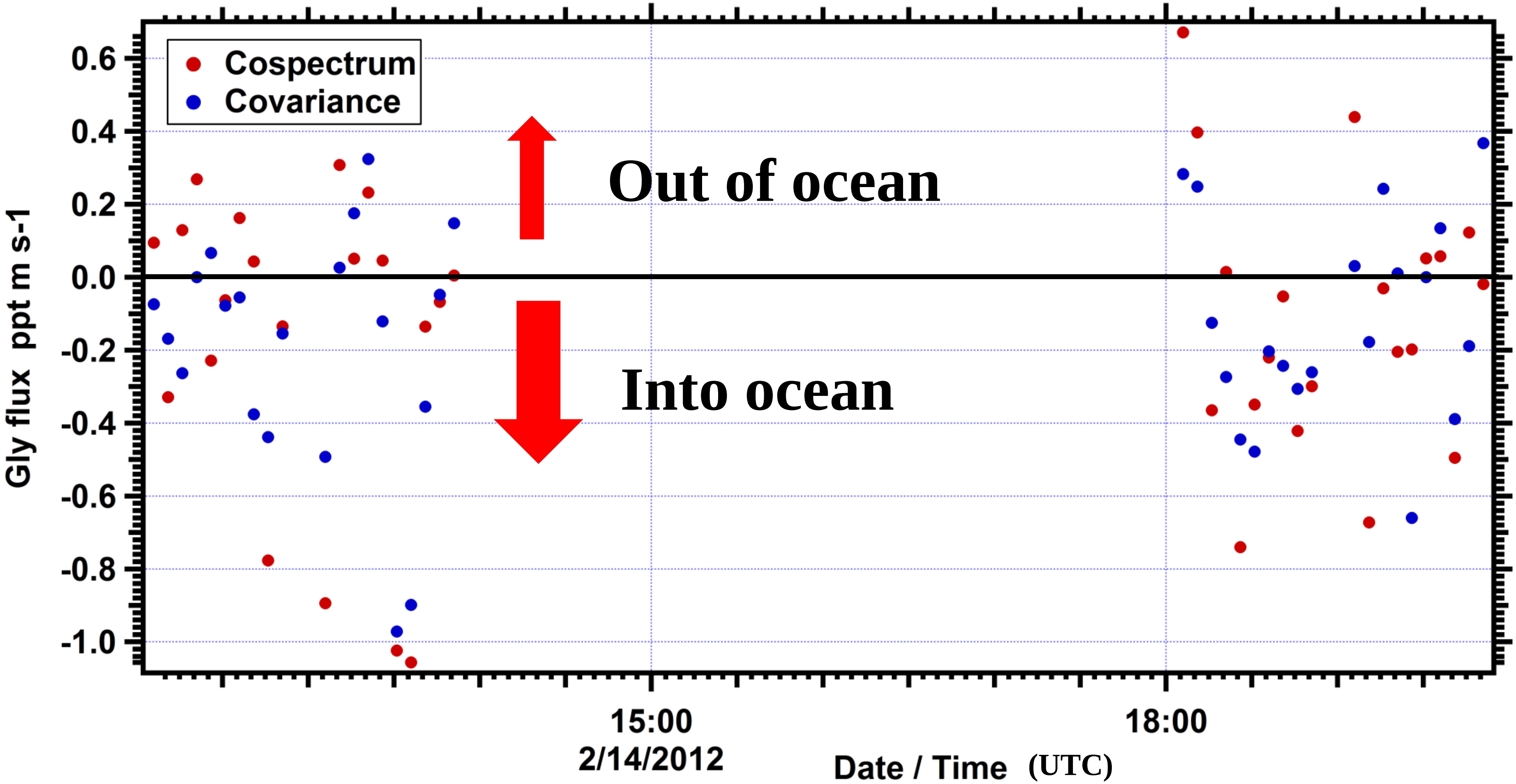
- Because the sample is drawn through an inlet, there is lag time between the wind measurements and the sample measurements
  - To account for this a fast-switching valve was connected to the sample inlet and dry nitrogen was pulsed into the line every hour
  - The pulse that triggered the valve was recorded on the wind sensor data logger and thus serves as a reference point to which the sample data can be adjusted

Eddy Covariance: Wind direction and phase correction

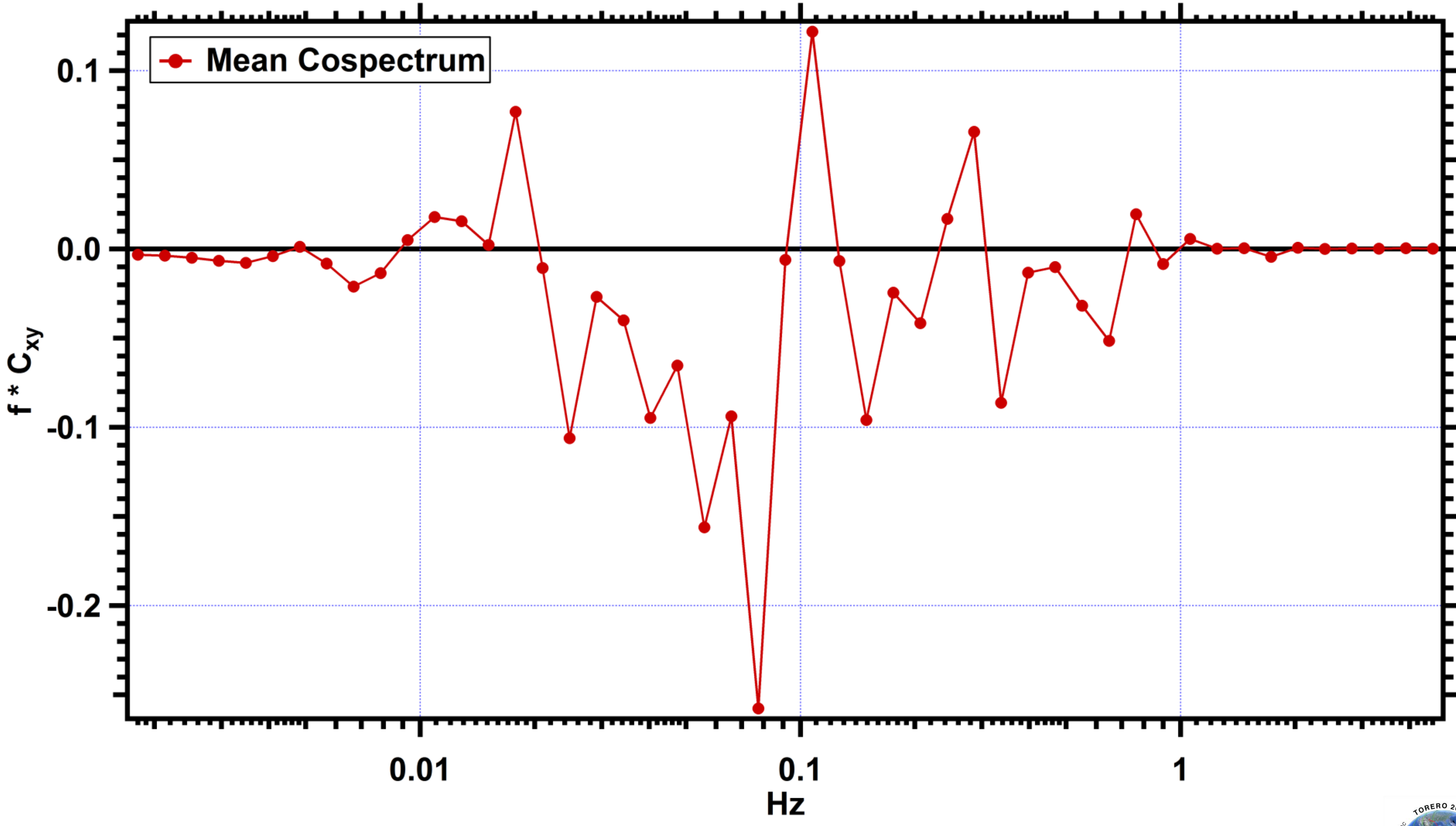


Pulse	Δtime
1	1.9
2	2.1
3	1.8
4	1.9
5	2.1
6	2.2
7	2.1
8	1.9
9	2.0

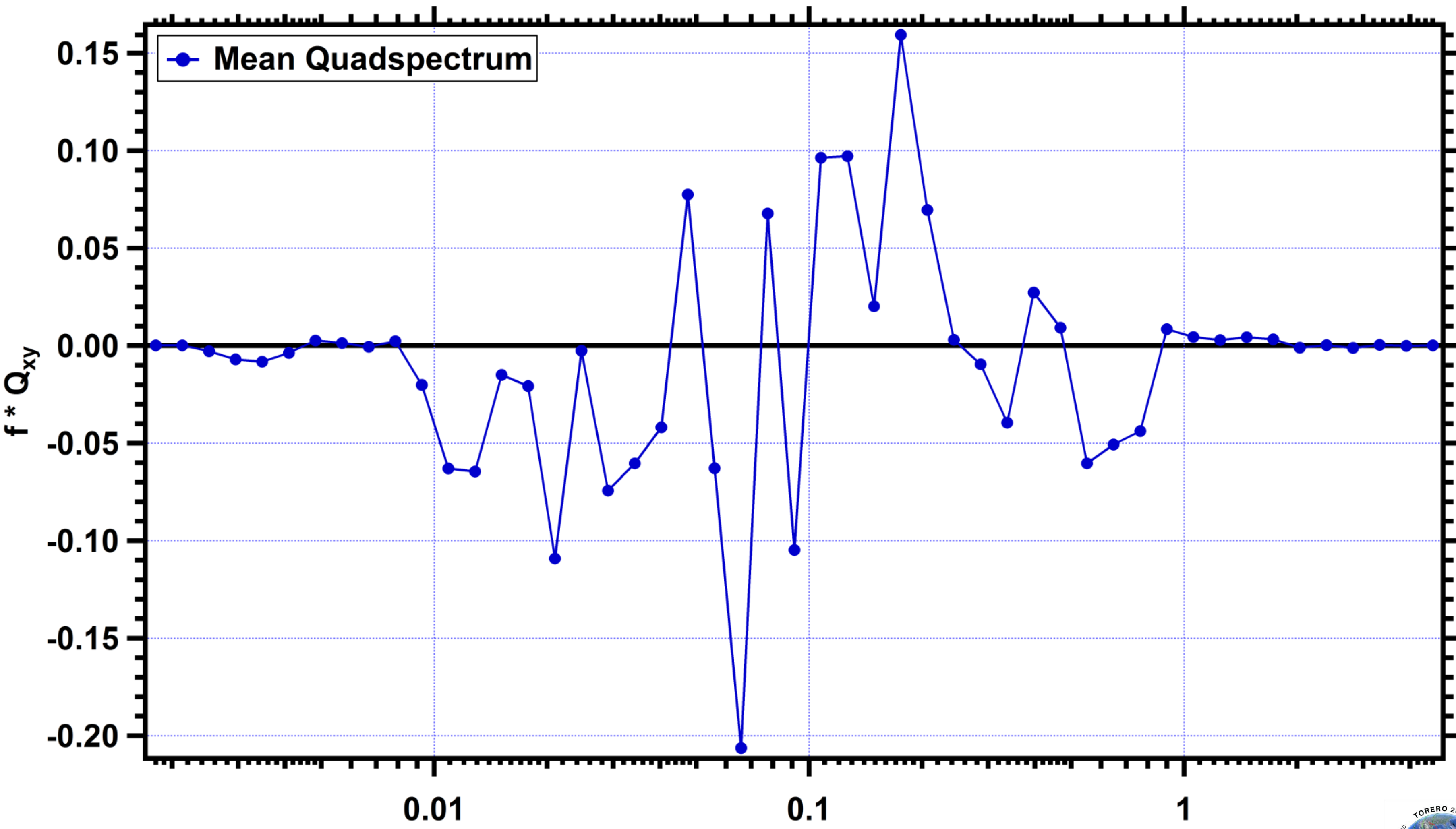
Eddy Covariance: 10 minute averages



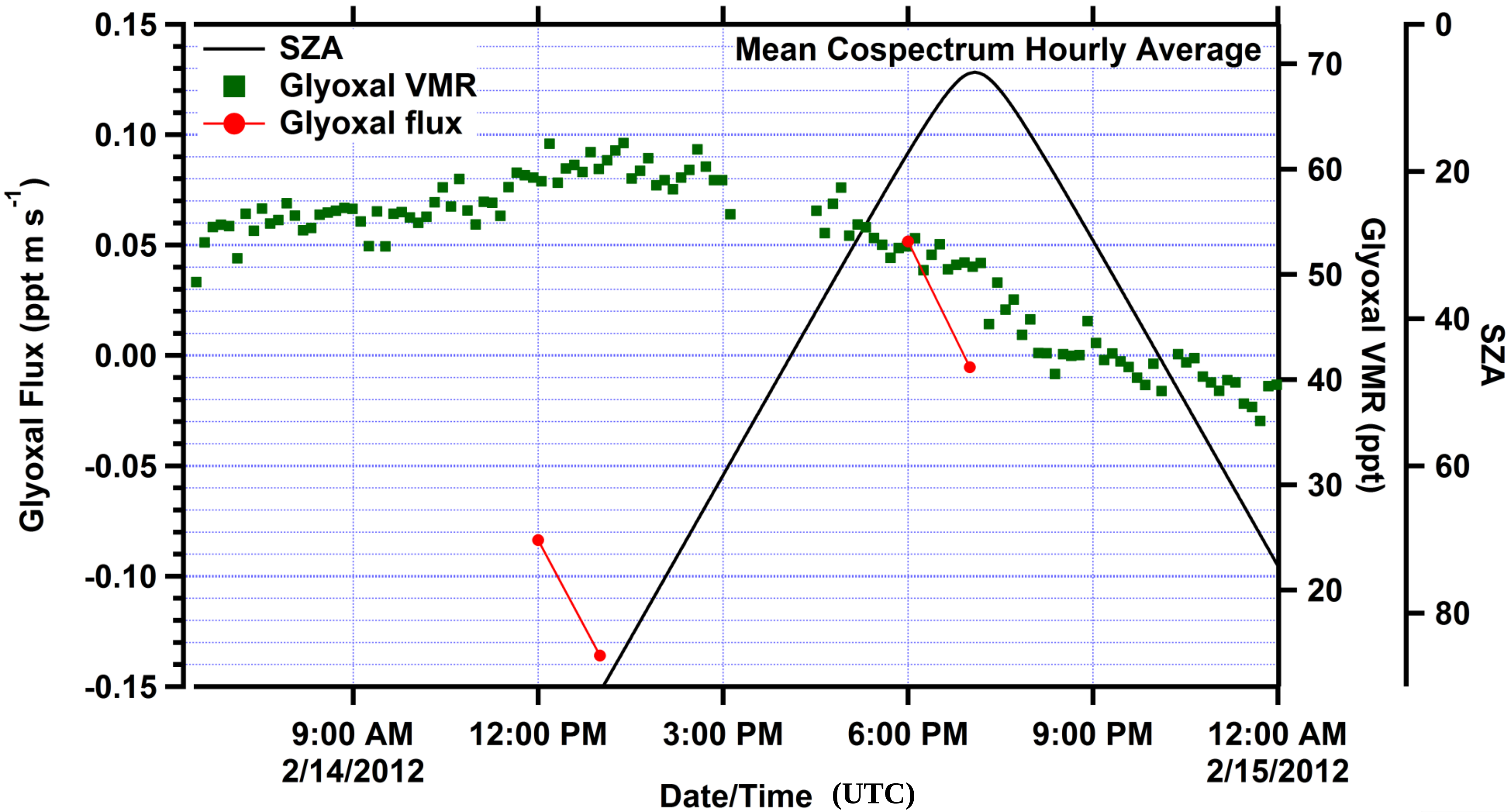
Eddy Covariance: 10 minute averages



Eddy Covariance: 10 minute averages



Eddy Covariance: Hourly averages



Summary

- Successfully built and deployed LED-CE-DOAS for ship based measurements of glyoxal
    - Able to measure the full diurnal cycle to compliment the SMAX-DOAS

- The derived glyoxal concentrations are consistent between AMAX, SMAX (parameterization method), and optimal estimation
    - Boundary layer values also agree with cavity measurements
- Doesn’t seem to be a vertical profile in the boundary layer

- CE-DOAS eddy covariance flux measurements also successful