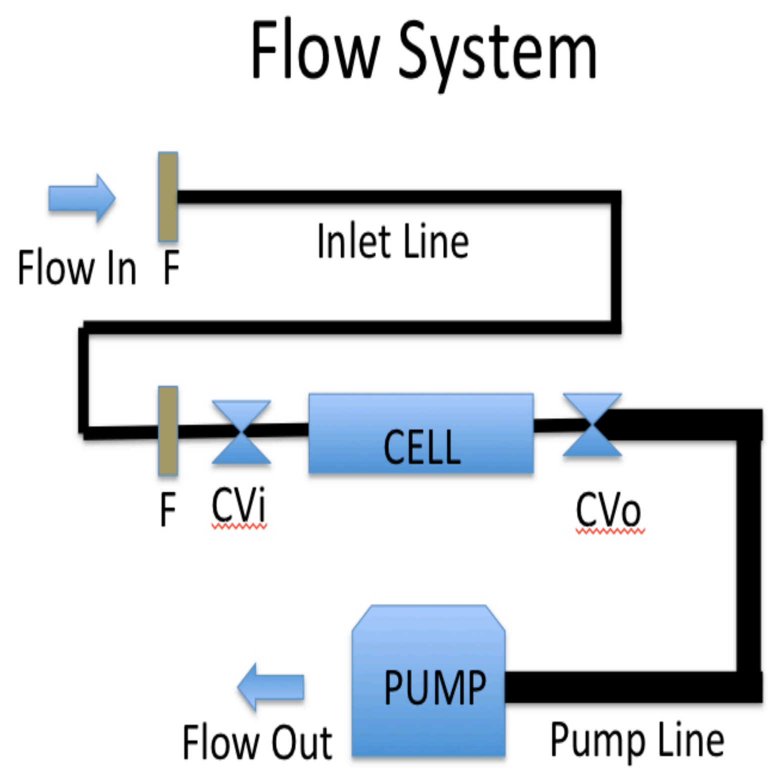
Technical issues related to using the ARI mini for eddy covariance or chamber measurements

Topics

– Relationship between flow rate, time constant and sample pressure.
– Real-time water corrections to obtain real-time dry air mixing ratios.
– Data integration issues
– Value of Team Viewer
– Input from group

Flow Rate and Response Time

- Three fundamental quantities: τ , P_c and Φ.
- Two constraints – inlet and outlet valves
- So, one can choose two variables freely. Third variable is determined by:



$$\tau\ (s) \sim 0.072 * P_c(Torr) * V_c(l) / \Phi(slpm) \qquad (1)$$

Working with Equation (1)

$$\tau \text{ (s)} \sim 0.072 * P_c(\text{Torr}) * V_c(\text{l}) / \Phi(\text{slpm}) \qquad (1)$$

- P_c is measured continuously (20 to 50 Torr)
- V_c is constant (0.5 liters)
- τ can be measured by flow switching (0.1 to 5 sec)
- Φ can be measured with flow meter (0.1 to 20 slpm) [It is useful to have a flow meter available]

Small τ is critical for eddy covariance; small Φ is often critical for chambers.

How to set control valves for low flow

- With low flow both valves are operated as critical orifices
  - CV_i controls the flow rate, Φ
  - CV_o controls time response, τ
  - Pressure follows from Equation (1)

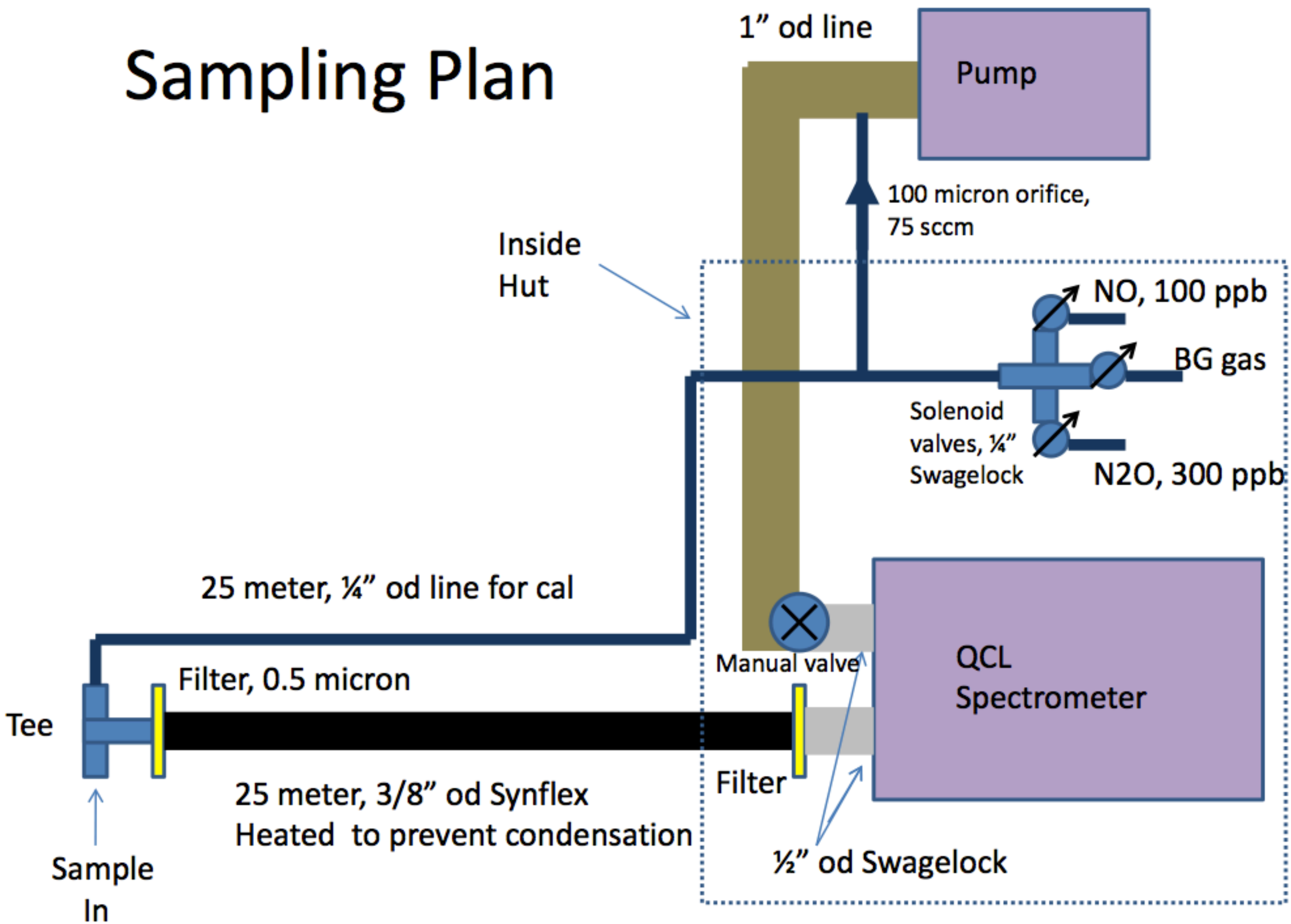
- Practical Procedure #1
  - Open CV_o completely.
  - Adjust CV_i to set the desired flow rate, Φ (do not need flow meter).
  - Adjust CV_o to set the cell pressure, P_c, to its desired value. This will also set τ but the cell pressure is easier to monitor.

- Practical Procedure #2
  - Turn on pressure lock
  - Adjust CV_o to set the desired flow rate, Φ (requires flow meter).

How to set control valves for high flow and fast time response

- CV_o must be wide open (and tubing to pump must be large diameter, 25 mm ID)
  - This implies: $\tau(s) \sim V_c(l) * [60/S_p(lpm)]$
  - Typically S_p ~ 500 lpm so that $\tau(s)$ ~ 0.06 s
- Adjust CV_i to set P_c and Φ
  - Might be necessary to set P_c lower than optimal
- Helpful inlet hints:
  - Use at least 9 mm OD tubing on inlet
  - Keep inlet filters clean; use parallel filters

Eddy covariance flow scheme

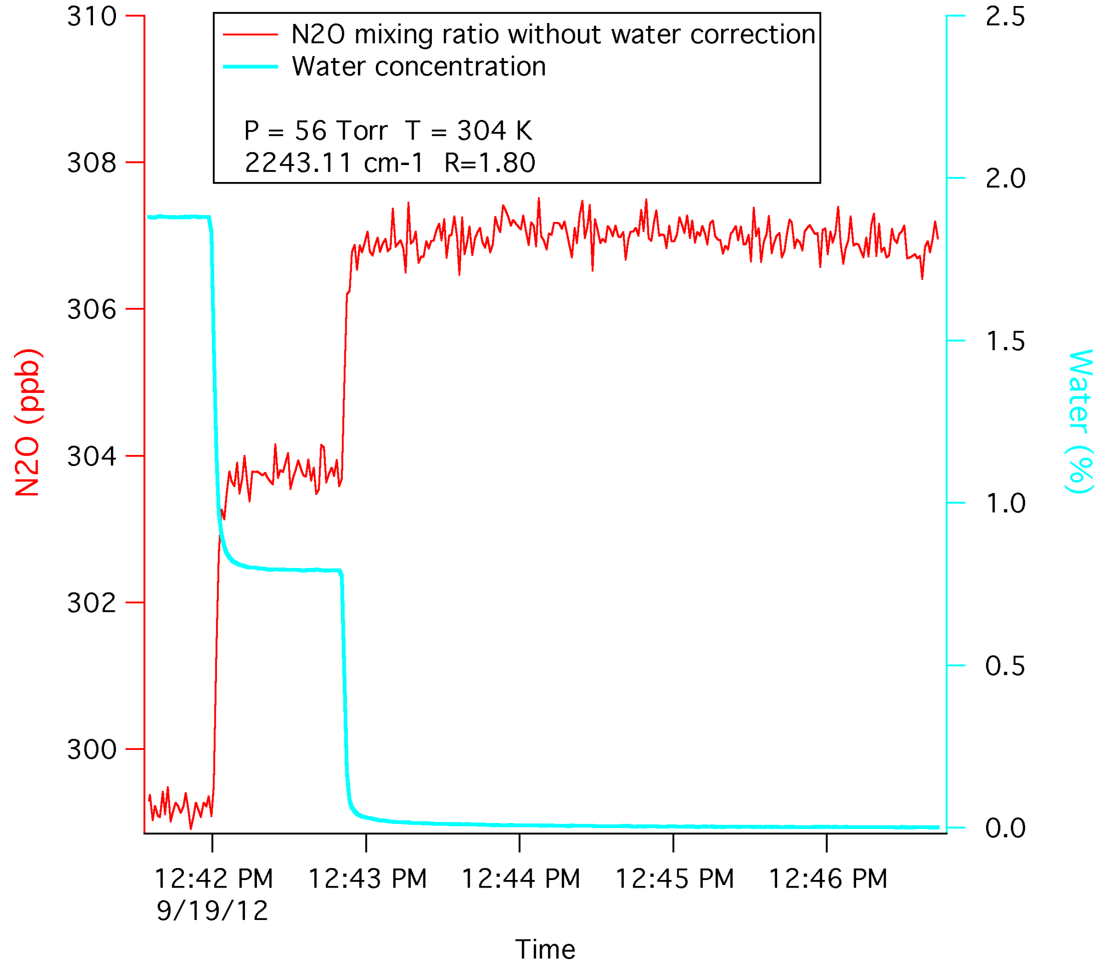


Real Time Water Correction

- Both eddy covariance and chamber measurements desire dry air mixing ratios
- This can be accomplished with Nafion dryer or dry ice trap before instrument but…
  - Expensive
  - Imperfect, failure prone
  - Prevents recirculation experiments
- By measuring water vapor mixing ratio we report dry air MR even though we measure wet air

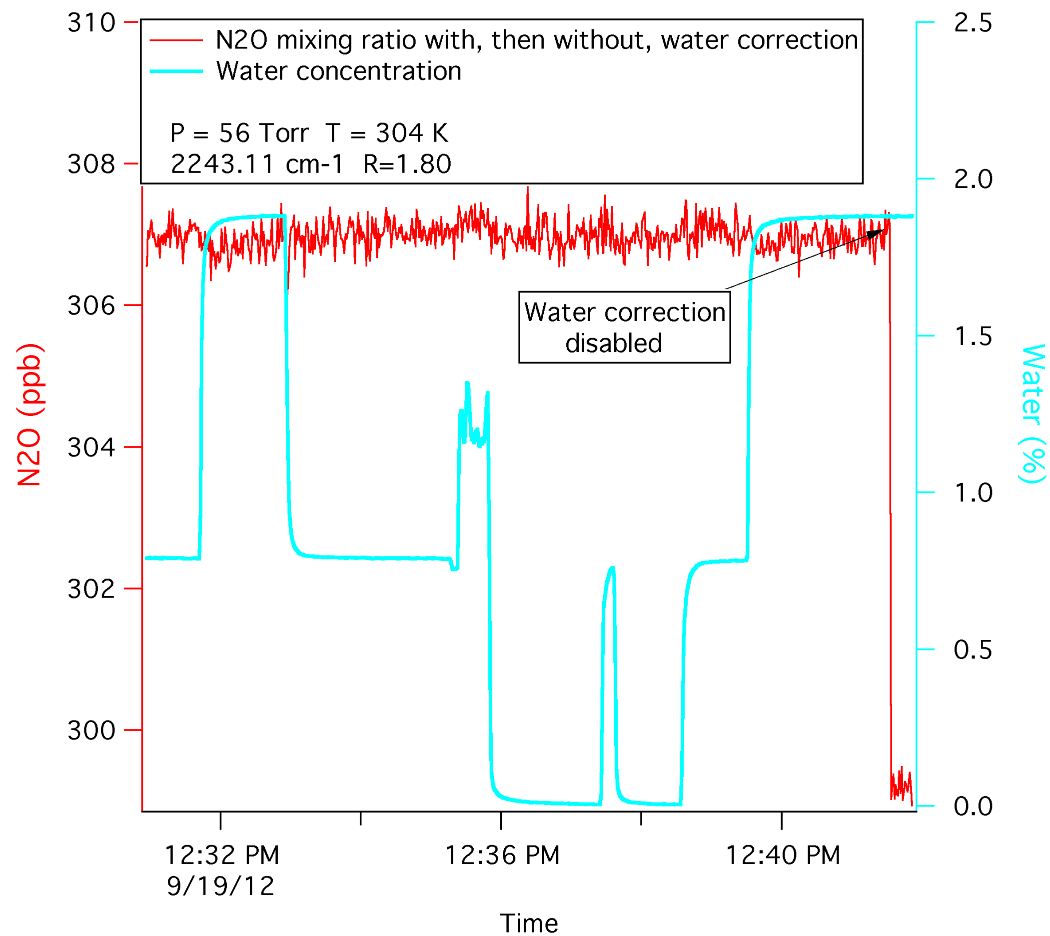
Usual Effect of Water on Measured N_2O Mixing Ratio

- Software reports the true MR not the dry MR
- Variation is greater than pure dilution



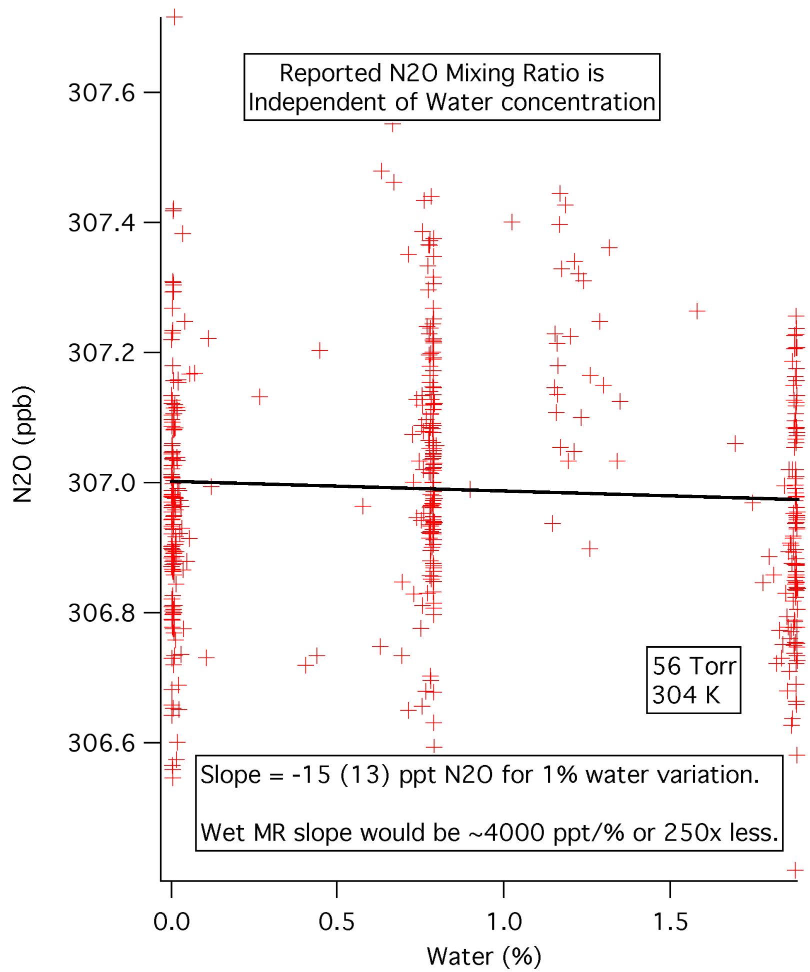
Effect of Water on Measured N_2O Mixing Ratio with Software Correction

- TDLWintel uses measured water to correct for water dilution and water spectral broadening
- Slows down fitting a bit



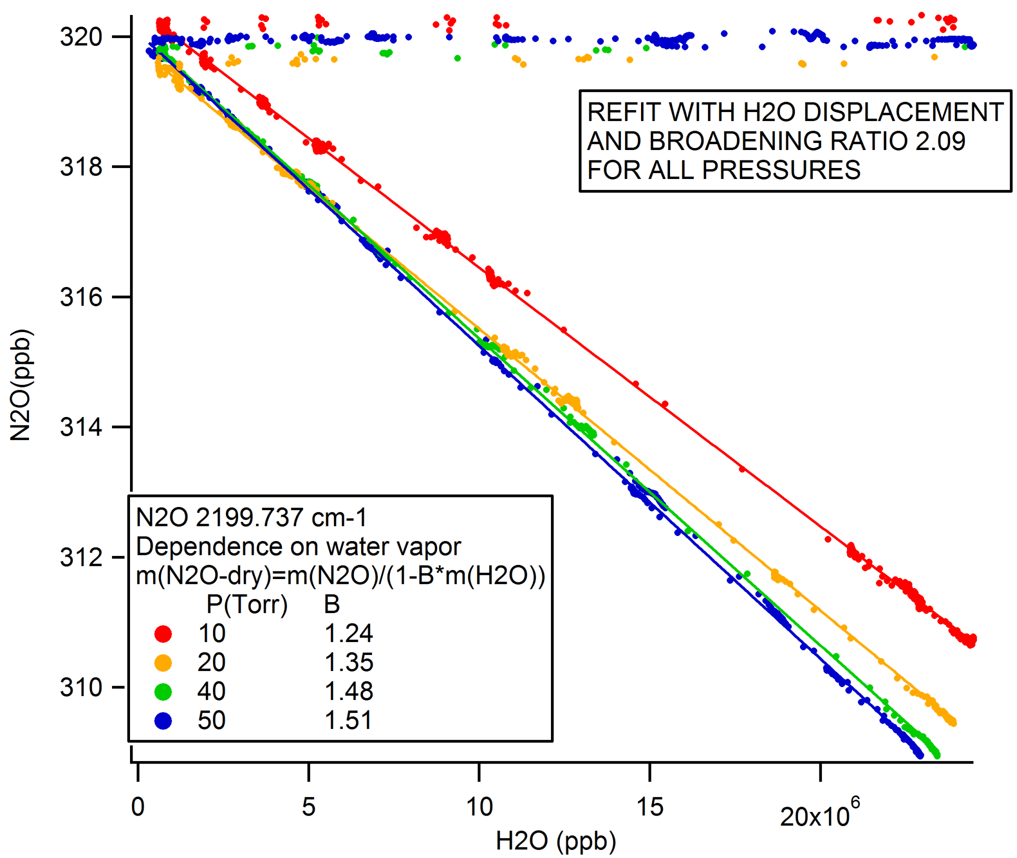
Dry Air Mixing Ratio Shows No Correlation with Water

- Dependence of dry air mixing ratio is too small to measure
- Reduced by at least 250x
- Independent of cell pressure



Dry Air Mixing Ratio Eliminates Pressure Dependence

- Simpler correction methods depend on pressure
- Using proper spectral model provide pressure independent correction factor



Water Broadening Correction Factors

- Correction factor is interpreted as the ratio of the water broadening coefficient to that of the air broadening coefficient
- Usually not known from literature
- Since the pressure broadening is a function of spectral line – correction factors must be determined for each spectral line

Experimental Water Broadening Ratios

N2O	Frequency (cm-1)	CF	Instrument
	2243.11	1.80	Julich
	1275.49	1.53	IMK6
	2237.66	1.704	IMK6
	~1275	1.9	ZALF
	2199.74	2.1	VTI1
	2199.74	2.1	VTI2

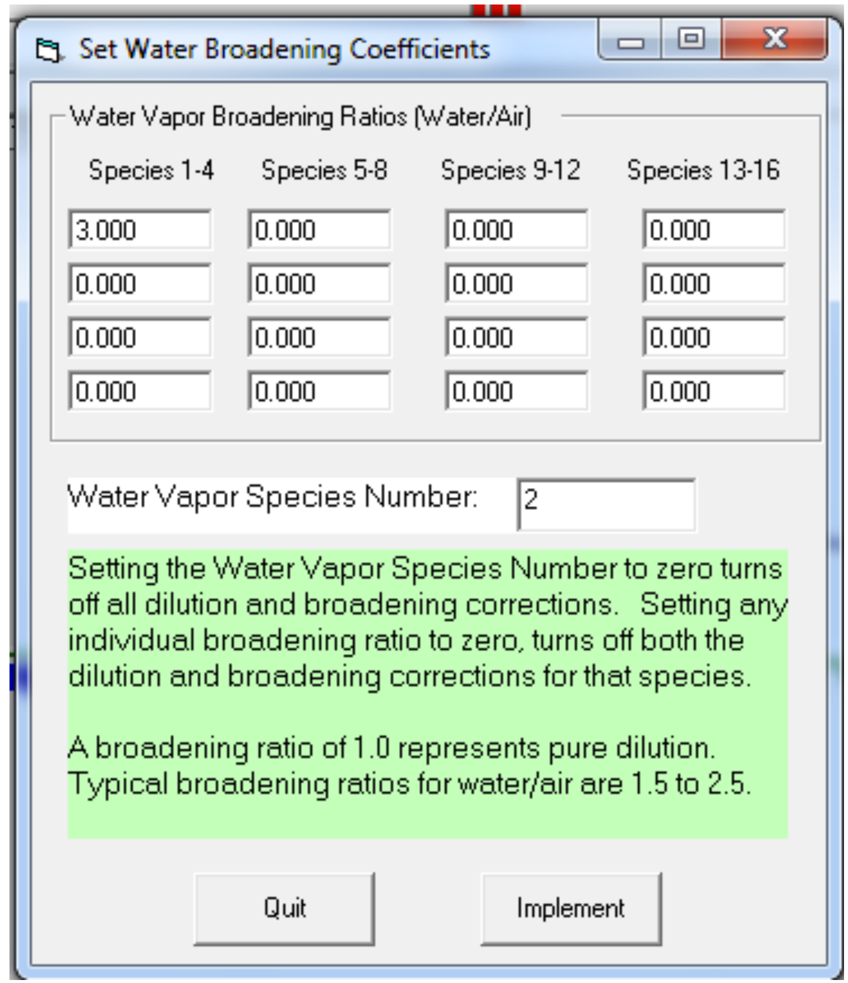
CH4	Frequency (cm-1)	CF	Instrument
	1276.85	1.55	Julich
	~1275	1.9	ZALF

CO2	Frequency (cm-1)	CF	Instrument
	2242.91	2.50	Julich

CO	Frequency (cm-1)	CF	Instrument
	2199.93	2.1	VTI1
	2199.93	2.1	VTI2

Water Broadening: Software Details

- Must specify a correction factor for each molecule
- Must specify species number that corresponds to water vapor
- Select this menu under: Edit\Water Broadening…



Eddy Covariance Data Integration Issues

- Eddy covariance depends on observing fast correlations between wind speed and mixing ratio
- QCL data must be sufficiently fast
- QCL and sonic must be perfectly synchronized
- Potential Obstacles:
  - No man should wear two watches
  - Speed of QCL computer?
  - QCL is not a clock – data rate can jitter

Two Approaches to Data Integration for Eddy Covariance

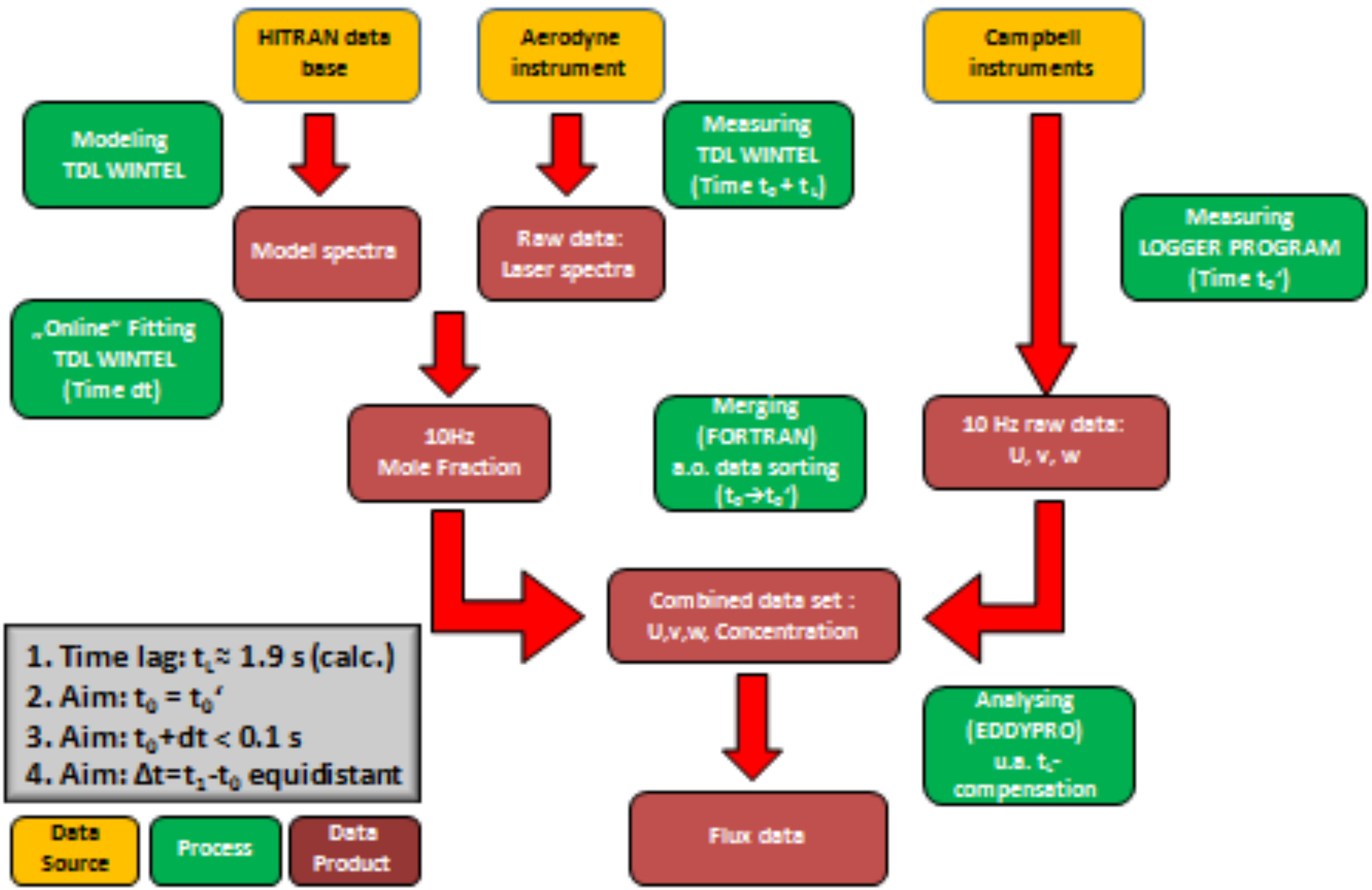
- Approach #1 (hard drive, recommended):
  - Save Campbell data to data logger
  - Save Aerodyne data to hard drive
  - Integrate data sets during post processing
  - Calculate flux with Eddy Pro
- Approach #2 (RS232):
  - Save Campbell data to data logger
  - Send Aerodyne data to data logger via RS232
  - Calculate flux with Eddy Pro

Two Approaches to Data Integration: Pros and Cons

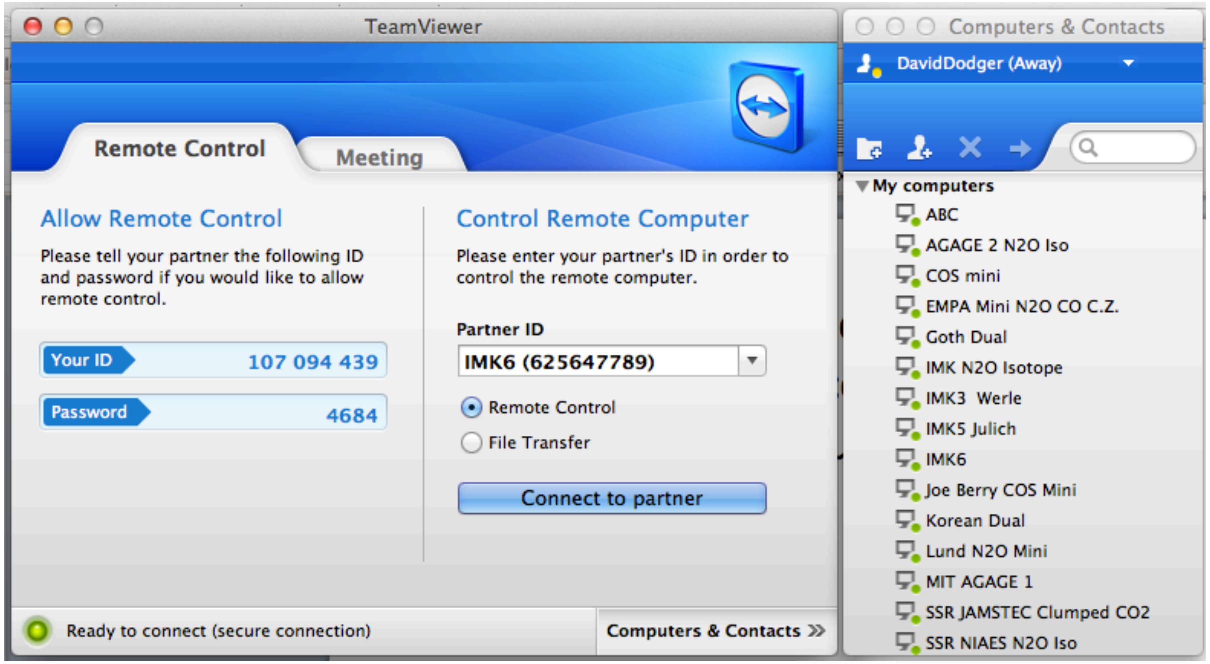
- Approach #1 (hard drive, recommended):
  - Requires decent synch between Campbell and QCL
  - Allows careful handling of subtle timing issues
  - Eliminates RS232 cable from QCL to data logger

- Approach #2 (RS232):
  - Requires software on the data logger to read RS232
  - Provides real time and simplified data integration
  - Sweeps subtle timing issues under the rug

Data Processing Scheme



Team Viewer



- Remote control software
- By far, the best way for us to help you succeed
- Secure

- Also very useful to you
- Obstacles:
  - Internet connection
  - Network Administration

You will get more help if you find a way to use TeamViewer!

User Input

- What have we missed that we should talk about?