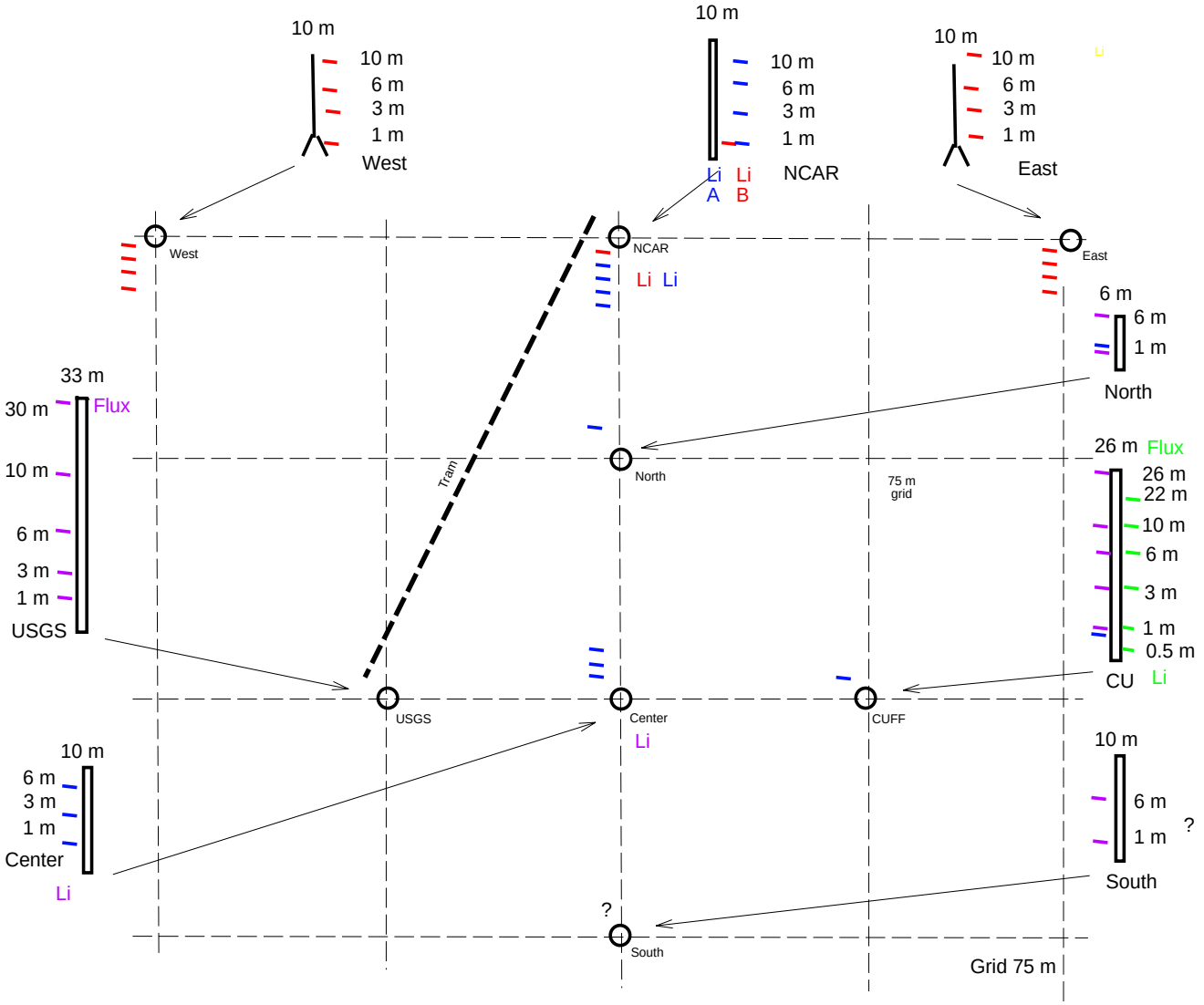
NIWOT02: Hydra/Licor Report

A.C. Delany and Tim Lowry Version, 13 Jan''03

The NIWOT02 program was established to investigate the advective flux of CO2 within a forest canopy, especially under nocturnal stable conditions. Towers were erected to augment the existing CUFF and USGS structures to enable additional profiles and transects of CO2 mixing ratios to be measured.

Figure 1. Array of stations at the Niwot Ridge site.



Hydra A ISSF 7000 Li

A1	1 m	NCAR
A2	6 m	
A3	3 m	
A4	10 m	
A5	6 m	Center
A6	3 m	
A7	1 m	
A8	1 m	North
A9	1 m	CUFF

A1 / A4 were reversed before 15:00, 5 Sep''02

Hydra B ISSF 7000 Li

B1	1 m	NCAR
B2	10 m	West
B3	6 m	
B4	3 m	
B5	1 m	
B6	10 m	East
B7	6 m	
B8	3 m	
B9	1 m	

CUFF 6251 Li

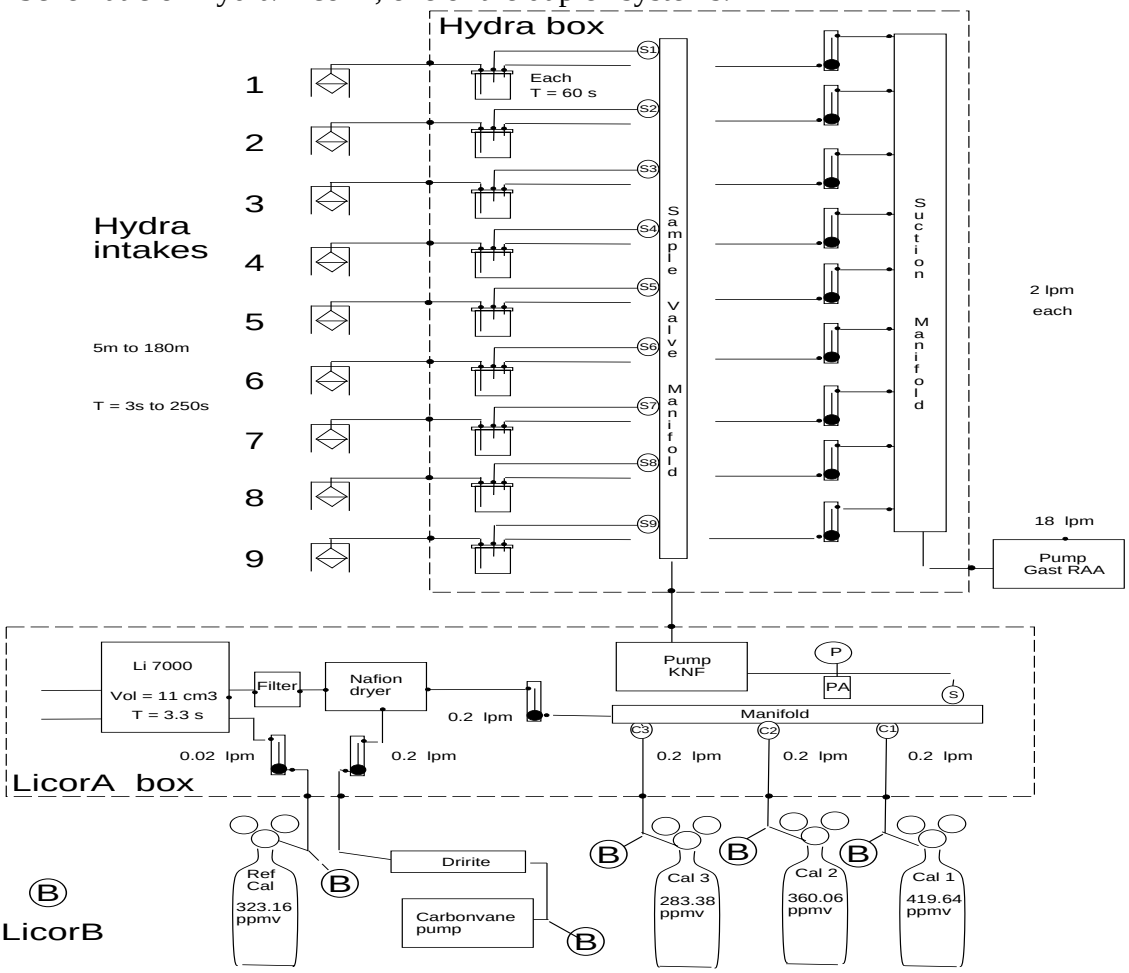
0.5 m	CUFF
1 m	
3 m	
6 m	
10 m	
22 m	

USGS 6251 Li

1 m	USGS
3 m	
6 m	
10 m	
30 m	
1 m	CUFF
3 m	
6 m	
10 m	
26 m	
1 m	? South
6 m	

The Hydra was installed at the NCAR base and 18 lengths of 3/8 Decabond tubing were laid to inlets at the different towers.

Figure 2. Schematic of Hydra/LicorA, one of the duplex systems.



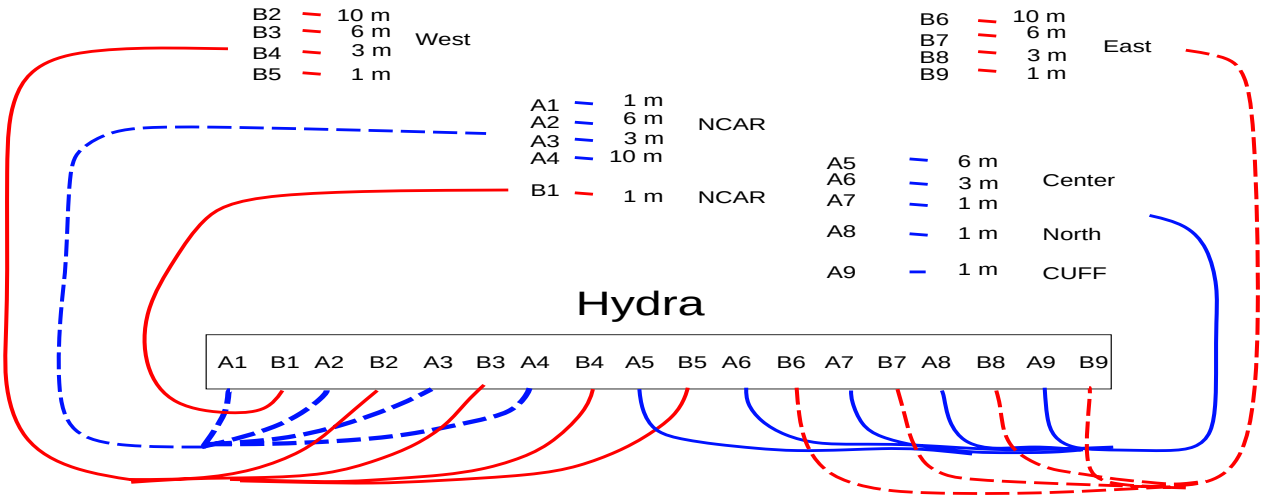
The Hydra is essentially a duplex system with two sets of nine sample air streams supplying two separate Licor 7000 closed path infrared absorption CO2 analyzers. The designation used is Hydra/Licor A and Hydra/Licor B. Each of the two systems is represented by the above schematic.

Each of the nine individual sample air streams is drawn from its specific intake position through a 2” diameter 1.0 um Gelman PTFE filter housed in a cut-off plastic bottle with an insect screen across the opening. The air travels the 5 to 200 meter length of the 3/8” Decabond tubing to the Hydra inlet. A strain relief arrangement holds the eighteen tubes to allow their configuration and to avoid their crimping. Figures 3 and 4 illustrate the configuration of the Hydra inlets.

The sample streams are drawn into the Hydra interior through 3/8” teflon tubing leading into 2 liter glass containers with bored-out Parker bulkheads fitted though the stainless steel lids. The sample air enters at the bottom of the container and is drawn out from the top via the Omega floating ball flow control gauge. Each set of nine flow control gauges is connected to a 2” PVC suction manifold aspirated by a Gast RAA sequence dual piston pump. All eighteen sample air streams are drawn continuously and are adjusted to an identical flow rate of 2 ambient lpm. The residence time of the buffer volumes was ~ 1 minute.

From each of the nine buffer volumes a 1/4” teflon tube allows sample air to be taken from the center. The 1/4” sample tubes run to the nine-ganged air sample manifold. Each manifold serves one Licor 7000.

Figure 3 The Hydra inlet



NB on Sept 05 inlets swopped
A1 changed from Hydra A, NCAR 10m to 1m
A4 changed from Hydra A, NCAR 1m to 10m

As of Sep 05

A1	A2	A3	A4	A5	A6	A7	A8	A9
NCAR	NCAR	NCAR	NCAR	Center	Center	Center	North	CUFF
1 m	6 m	3 m	10 m	6 m	3 m	1 m	1 m	1 m

B1	B2	B3	B4	B5	B6	B7	B8	B9
NCAR	West	West	West	West	East	East	East	East
1 m	10 m	6 m	3 m	1 m	10 m	6 m	3 m	1 m

Figure 4 a and b. Hydra interior and view of Hydra during deployment

As the tubing lengths from the various inlet stations to the Hydra/Licor system ranged from 5 m to 180 m, the delay times for the sample air needed to be determined.

Figure 5. Plot of estimated inlet lengths and measured delay times.

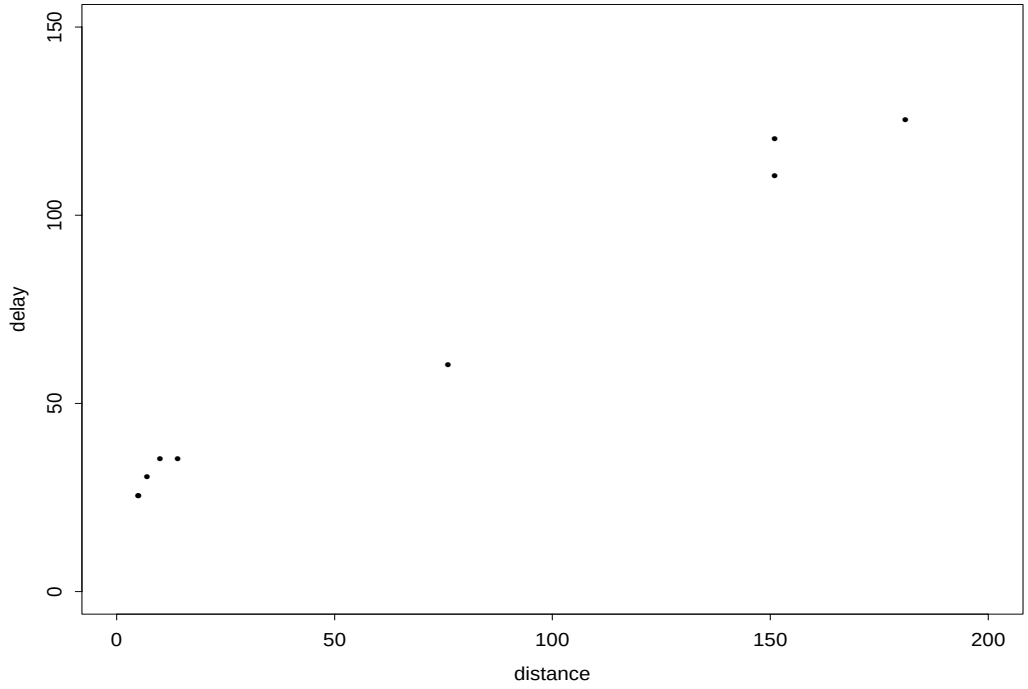


Table 1 The delay times for the Hydra inlets

Licor Inlet	Location Height		Estimated Distance,m	Measured Delays, s	Calculated Delay, s
A1	NCAR	1m	5	25	25
A2	NCAR	6m	10	35	35
A3	NCAR	3m	7	30	30
A4	NCAR	10m	14	35	38
A5	Center	6m		~	120
A6	Center	3m		~	115
A7	Center	1m	151	110	110
A8	North	1m	76	60	60
A9	CUFF	1m	181	125	125
B1	NCAR	1m	5	25	25
B2	West	10m		~	133
B3	West	6m		~	130
B4	West	3m		~	125
B5	West	1m		~	120
B6	East	10m		~	133
B7	East	6m		~	130
B8t	East	3m		~	125
B9	East	1m	151	120	120

The two Licor 7000's were installed in separate weather-proof containers and connected to reference and calibration gas cylinders and the dry air supply. The configuration of the Licor analyzer and the supporting systems is illustrated in Figure 2.

The activation of the solid state optically isolated relays, which energized the solenoid valves and the sampling pump, was driven by an Opto 22 microprocessor which was commanded by the Base computer via the ADAM. The Opto 22 was only employed to translate the serial signals to TTL impulses to activate the solid state relays. Table 1 indicates a sequence of relay activation and solenoid and pump energization. Note that the timing could be readily changed to increase or decrease the duration and frequency of the sample/calibration intervals. The sequence utilized during NIWOT02 was based upon an 80 s period.

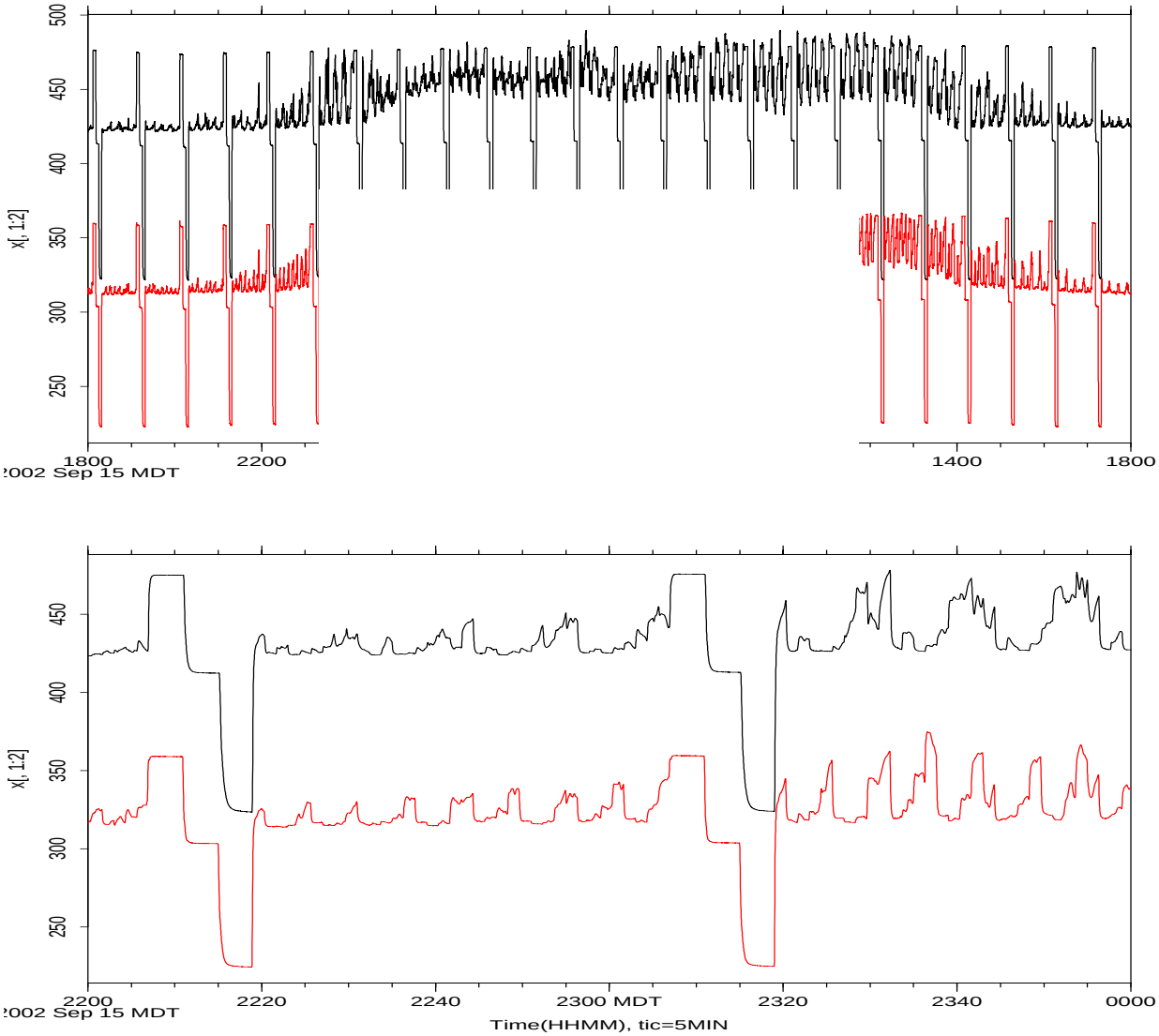
Table 2 An operational 80 second sequence of sample and calibration.

Operation	Start	Stop	Δt	Pump	S	H1	H2	H3	H4	H5	H6	H7	H8	H9	C1	C2	C3
Sample Hydra 1	00 s	80 s	80 s	X	X	X											
Sample Hydra 2	80 s	160 s	80 s	X	X		X										
Sample Hydra 3	160 s	240 s	80 s	X	X			X									
Sample Hydra 4	240 s	320 s	80 s	X	X				X								
Sample Hydra 5	320 s	400 s	80 s	X	X					X							
Sample Hydra 6	400 s	480 s	80 s	X	X						X						
Sample Hydra 7	480 s	560 s	80 s	X	X							X					
Sample Hydra 8	560 s	640 s	80 s	X	X								X				
Sample Hydra 9	640 s	720 s	80 s	X	X									X			
Repeat the 12 min sampling sequence four times until 48 min, then undertake three 4 min calibrations																	
Cal 1	2880 s	3120 s	240 s												X		
Cal 2	3120 s	3360 s	240 s													X	
Cal 3	3360 s	3600 s	240 s														X
Repeat the entire 60 min sequence ad infinitum																	

As the Hydra/Licor system was duplex the two binates operated in parallel. Thus, for example, inlets A1 and B1 were sampled simultaneously and the Hi-Cal calibration for both LicorA and LicorB occurred at the same time.

The Licor 7000 yielded a serial 1 Hz data stream containing CO2 signal, optical cell pressure and temperature. This data, together with the other sensor data was time-stamped, parsed and archived on disc at the Base computer in the CUFF trailer, at the NOAA C1 site some 0.5 km from the Ameriflux tower array. An Internet connection at C1 gave access to the Base computer, allowing the data to be viewed in almost real time. The Internet connection also allowed the operational control of the solenoid sequences to be carried out.

Figure 6a and b. Examples of the NIWOT02 CO2 data. Note that the LicorA and LicorB traces are offset to avoid overlap.



The data in Figure 6 show the CO2 trace from the two Licors for an entire diurnal cycle. During the day-time, mixing ratios at the upper levels of the profiles are at the local tropospheric value of ~ 365 ppmv, with the lower levels ~ 5 ppmv greater. During the stable nocturnal conditions the mixing ratios for the upper levels increase by ~ 30 ppmv over their daytime values with the mixing ratios for the lower levels sometimes even greater by ~ 40 ppmv.

"Hydra Data-Processing Details", Sean Burns, Anthony C. Delany and Jielun Sun, 2003, January report outlines the data treatment.