Observations of Licor Issues
Stratus Cruise
October 2007

*Surface contamination of the optics.
There are two obvious sources of gunk collection on the optical windows of the LI7500: sea salt and ship exhaust. Are they important? Please examine Fig. 1 which shows the time series of CO2 from our open path instrument on JD

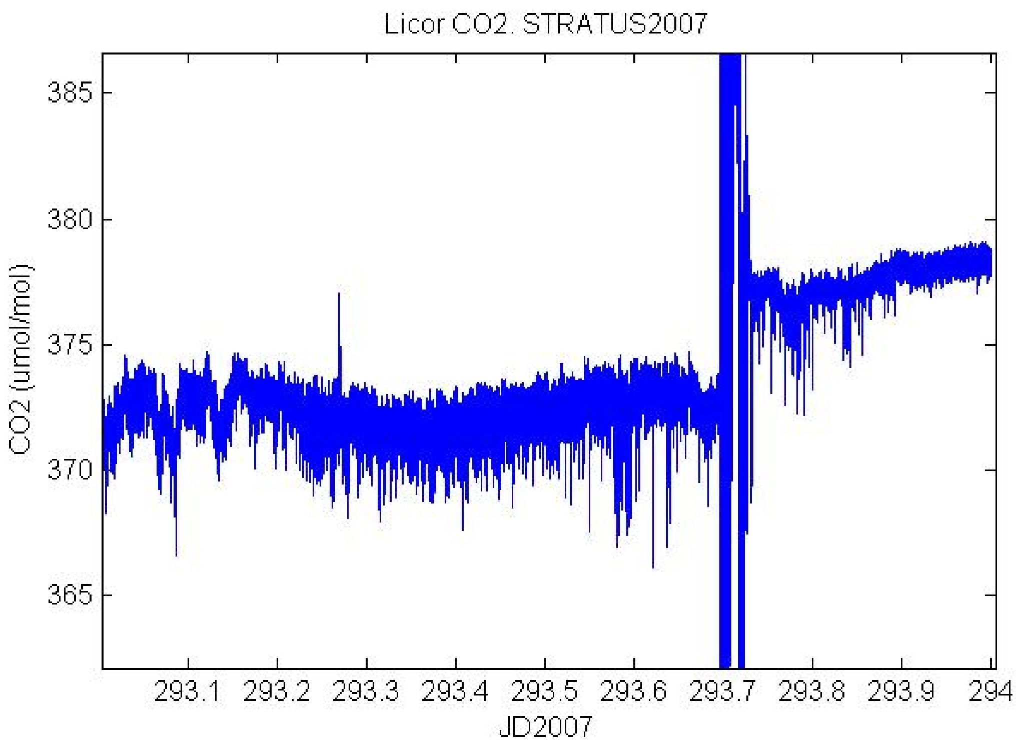

Figure 1. Time series of CO2 from PSD open path LI-7500.

In this example the water washers were run for 10 sec at 293.7. This causes invalid data for several minutes but notice the change in the values after cleaning. Not only does the mean value change (increase) but the noise level is significantly reduced. Why? Not sure but suspect it is interaction of humidity variations and the microcrystals of salt on the optics. The second example is from JD 296 when the ship made several maneuvers later in the day that cause an exhaust plume to drift over the sensors. Here there are transients caused by the exhaust at roughly 296.6, 296.7, and 296.8. The first causes an obvious drop in mean CO2; the effects of the next two are less apparent. The fourth spike is associated with another washing, which restores the CO2 to its previous values. Conclusions: a) ship exhaust quickly contaminates the windows and b) the effects seem to be alleviated by washing.

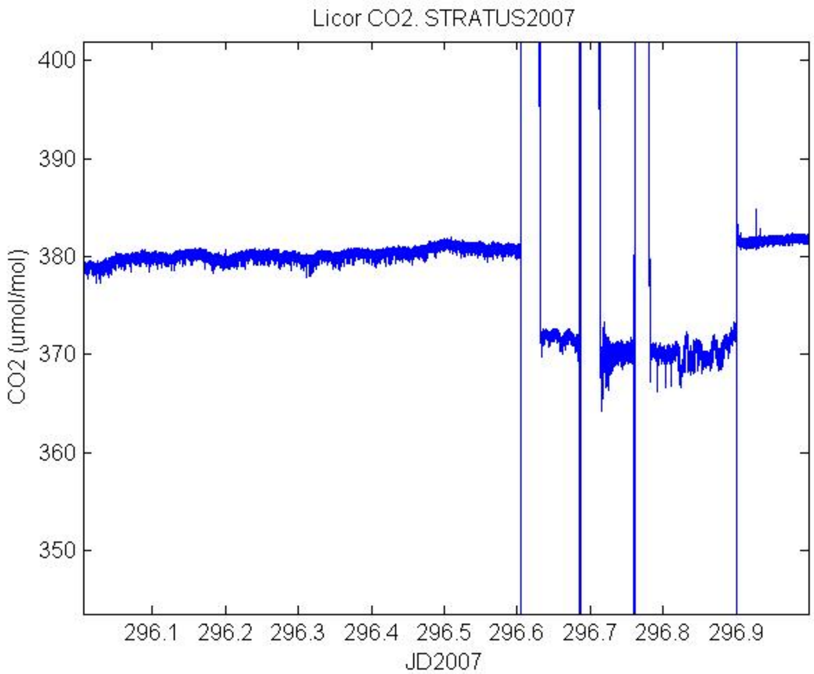

Figure 2. Time series of CO2 from PSD open path LI-7500 showing ship plume effects and recovery due to washing.

Right now we have three LI-7500's up: open (open and exposed), sample (in a tube with strong ventilation), and null (in a tube with weak ventilation through a mixing volume). The open unit is washed daily while the other two are not. Fig. 3 shows a 1-hr time series

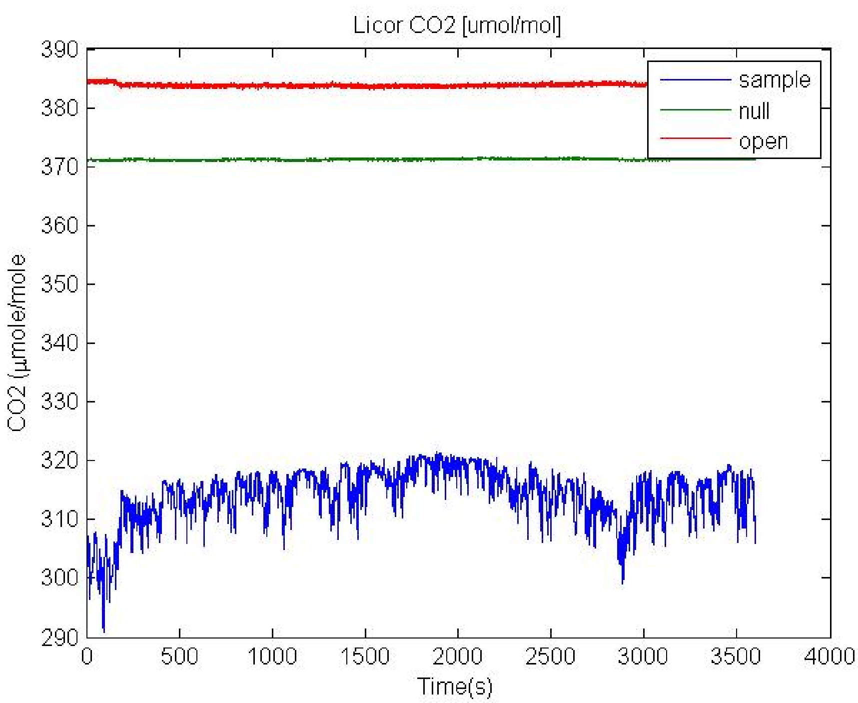

Figure 3. Time series of CO2 from three LI-7500's: sample – blue line; null – green line; open - red line.

for CO2 from the three units. The sample unit is obvious in severe distress with a poor mean reading and way, way too much noise. This could be because the unit is experiencing some hardware problems or it could be the effects of accumulated contamination. Right now we don't know, but will try to diagnose the issue by washing it when we can get to it (maybe the end of the cruise). This unit does not indicate noticeably degraded performance for water vapor but the significance of that is unclear.

*Sample and Null Filter Behavior
The sample/null approach is our approach for a more robust and weatherproof CO2 measurements. We need to characterize the filter function for the sample unit and we need to be able to ensure that the null removes most of the real atmospheric variations above the frequency where the motions affect the CO2 signal. The water vapor signal is a good way to look at the sample filter function (Fig. 4). In this case the sample unit is about 20% more sensitive than the open unit (thus the constant offset at low frequency). The filter effect of the ventilation is seen as relatively reduced signal as frequency increases.

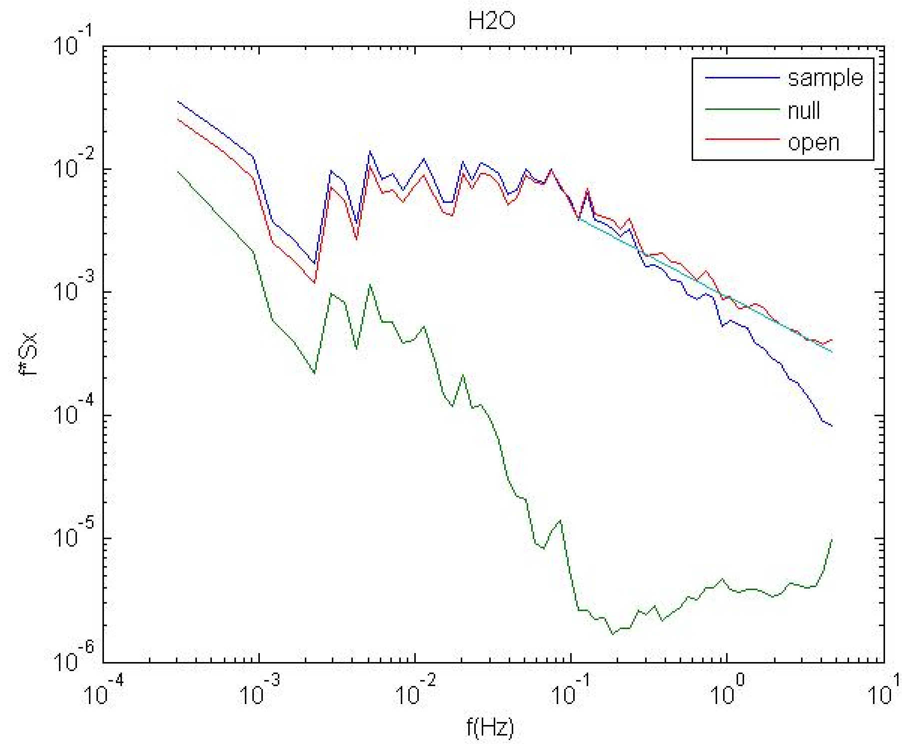

Figure 4. Variance spectra for the water vapor signals; one hour of data. The short green straight line is the -5/3 inertial subrange slope.

Another way to illustrate this is with the frequency response spectrum (ratio of variance spectra of the sample or null to the open path). In Fig. 5 we have used the correlation ratio (Cxy/ Sx) where x is the open signal and y is the other signal.

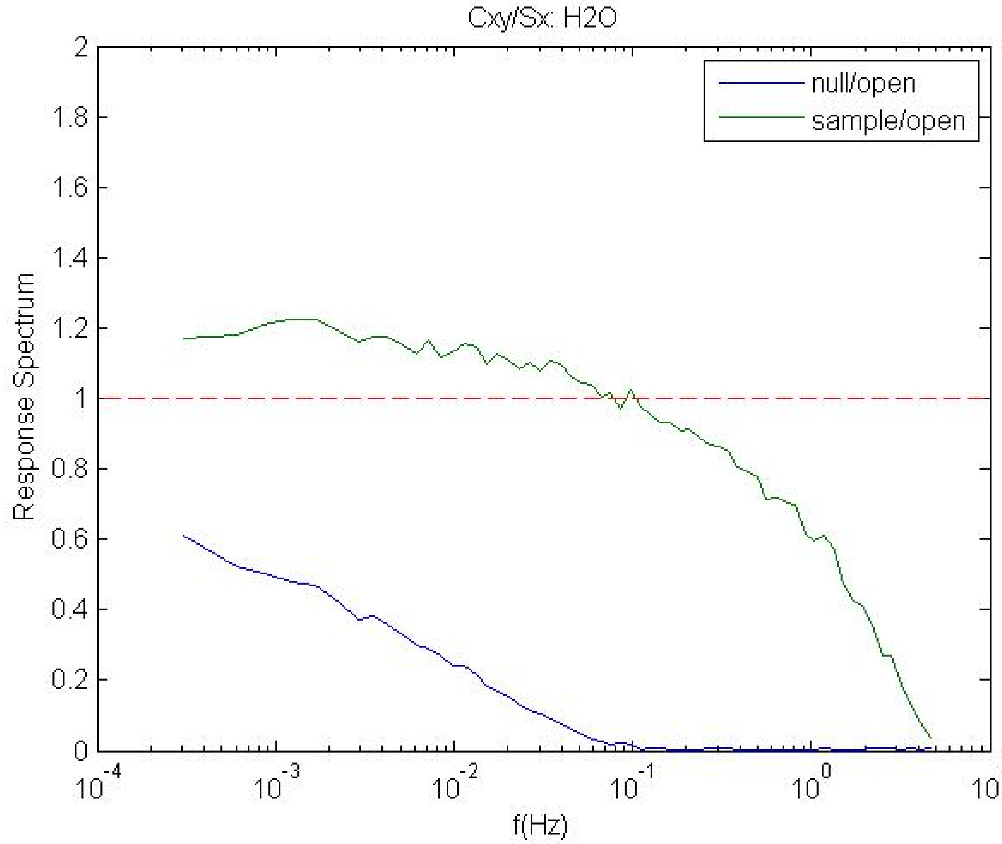

Figure 5. Ratio of cross correlation of null (blue) and sample (green) with the open signal divided by the open variance spectrum.

At low frequency the ratio is 1.2, which is the ratio of water vapor fluctuation sensitivities of the two devices. The decrease with frequency is a combination of uncorrelated noise, spatial separation, and the ventilation filter function. This graph suggests the filter for the sample sensor has a characteristic frequency of about 0.4 Hz. It is more difficult to characterize the cutoff frequency of the null system. I don't think it behaves like a simple filter. It looks like most of the signal is gone by 0.02 Hz. We put a flow restrictor on the hose several days ago but I haven't looked carefully enough to say if that changed things. Fig. 6 is an example of humidity time series. You can see the fine structure has been removed by the filter volume. Also, the null and the open agree well for mean humidity with the Vaisala unit. You can also see the sample unit has slightly more variability than the open unit – the ratio of 1.2 referred to above. Furthermore, the ratio of mean humidity of sample to open is 1.22. This implies that, in this particular case, the humidity error of the sample unit is in gain instead of offset.

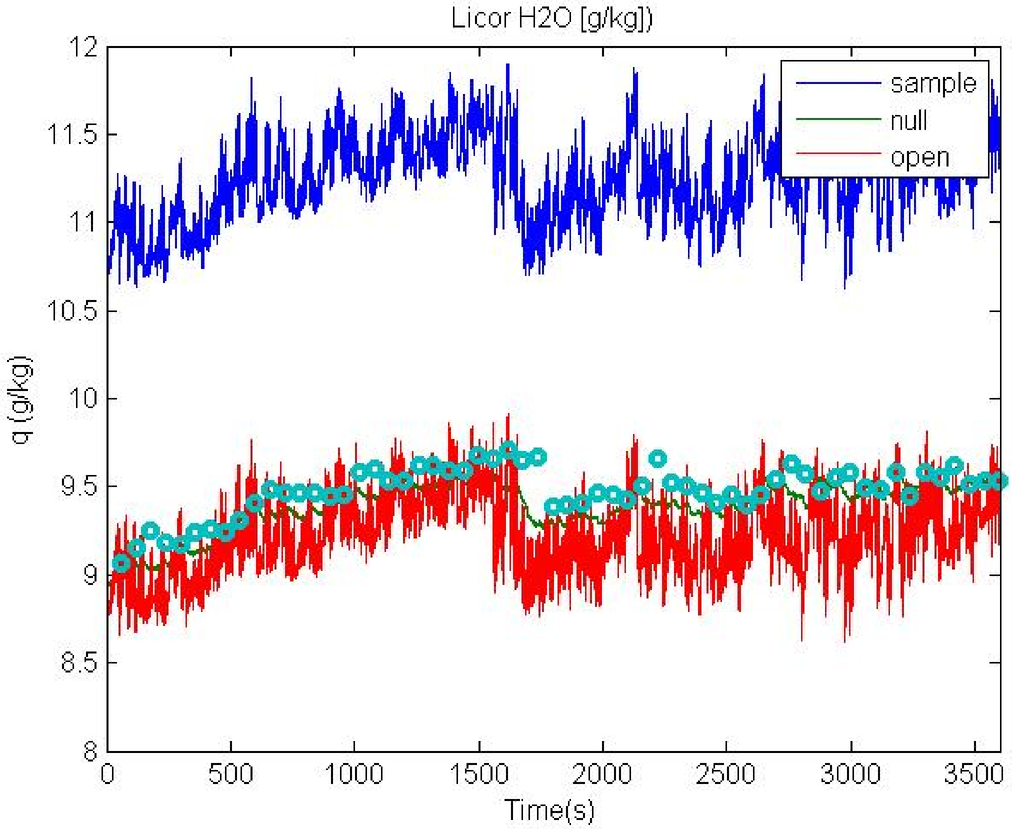

Figure 6. Time series of specific humidity from LI-7500 (sample – blue; open –red' 'null - green) and Vaisala HMP325 (circles) .