Atmospheric Measurement Techniques Discussions

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Comment on amt-2022-186

Anonymous Referee #2

Referee comment on "Electrochemical sensors on board a Zeppelin NT: in-flight evaluation of low-cost trace gas measurements" by Tobias Schuldt et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-186-RC2, 2022

I think it is a really good platform for low-cost sensors to measure the boundary layer. Please find some comments and questions below about the manuscript and methods that were used.

Time synchronization

What is LTE?

Did you apply the Savitzky-Golay filter before or after you had applied your temperature correction? How noisy were the raw data versus after this filter had been applied. Did the analyte peaks stand out prominently from the noise?

Determination of amount fractions

Not quite sure how you reached a window size of 31 seconds for the t_{90} value. Did you run the EC sensors in the laboratory under controlled conditions and then change the [NO] and [NO_2] to concentrations that you'd expect to see on the Zepplin and calculate it from there?

Was Mead et al 2013 also using these sensors on a Zepplin or aircraft? Was the concentration range in that paper the same as you'd expect for your deployment?

You use the fact that Mead et al 2013 found a t_{90} value of 21 sec for NO_2. What was Mead et al t_{90} value for NO? The manufacturer provides vastly different t_{90} for NO_2 and NO. Also do we expect that the EC sensor technology hasn't changed in ten years so you and Mead et al have the same versions of EC?

Sensor signal dependances

So you assume that an increase in NO or NO_2 from 0 ppb to 2 ppb does not cause any increase of EC. Did you check this in the lab?

Why did you not find the median NO signal (of the six NO EC) and subtract that from each NO sensor to get the 'signal primarily influenced by other factors'? I think that would be more appropriate rather than assuming a step change of the analyte concentration doesn't impact the EC output at all.

Why did you correlate WE to the change in humidity and not the humidity? Or if you wanted to use the differential, why not use that for temperature also, dT/dt? Changing the way these are plotted makes it difficult to see quickly the difference between the temperature and the humidity dependance.

Validation of ECSs performance

I think there needs to be a timeseries of the 6 NO/NO2 sensors showing how they all behaved over the duration of the flights. The slopes look good but did they start out correlated and then drift apart as they all respond differently to each interfering variable? Or were they all slightly offset and this stayed consistent throughout? Maybe add temperature and humidity onto this too, with a shared time axis.

Comparison of ECSs with the MIRO MGA

Accuracy plots are nice but please add the x-axis. Is this over time? In which case the accuracy decreases with the T,AUX and dRH/dt correction towards the end of the experiment. Or is it a shared axis with the plot below – so accuracy decreases at higher NOx (MIRO) concentrations? That seems a little odd. Why would the accuracy decrease if the reference instrument is measuring more than 125 ppb NOx? I think if this is the case a little description of why that might happen is needed.

Both the EC NO and NO_2 concentrations are overestimated (even at the higher

concentrations you mention a 30 % overestimation). Was this a consistent overestimation throughout? Did you zero the EC amount fractions to the MIRO at the beginning of the experiment? It would be interesting to see if this overestimation changed over a 20 hour flight or over the entire campaign. I was under the impression the EC drift apart over a matter of hours – days.

I know you mention that the AUX electrode is supposed to remove all impacts of variables other than temperature but I think you could write a few sentences about the NOx EC response to other gases. Did you look at how the NOx EC responded to cross interferences? Was the signal influenced by any of the other compounds measured by the MIRA? i.e. did changes in the ozone concentration cause a response in NOx EC?

Conclusions

Deviations of the sensor values to MIRO decreased from an average of 27.3 to 3.5 ppb. What is the accuracy of the MIRO? The concentrations of NOx observed by this reference instrument seem to be pretty low; the Weisweiler timeseries shows that for this flight the majority of the NOx was around 5 ppb. A deviation of 3.5 ppb is quite a lot for concentrations in this range.

I think you successfully show that you can improve the accuracy of the NO NO_2 EC sensors by correcting for temperature and humidity but I am not sure you could reliably deploy EC sensors in the Zepplin with no reference device and trust the output. It does seem to qualitatively pick up the NOx emissions from the power plant and industrial regions but there is still large amounts of uncertainty (below 5 ppb deviations between MIRO and EC increased up to 300 % and -600 %; the MIRA reported ambient NOx mixing ratios of 5 ppb for the majority of the time).

On page 11, you also say that you only ended up using sesor set up #2 for the noise plots and intercomparison with MIRA. Really, this means that 1 out of 6 EC sensors can be used on a UAV platform without a reference instrument. Or would you still advise having 6 NOx EC and then taking the best performing one?