What is the Impact of Common Sources of Error on Air Quality LCS Measurements Performance?

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Quantification of Utility of Atmospheric Network Technologies
(QUANT, PI Dr Pete Edwards)

- 3 sites: Manchester, London & York
- ~3 years of data
- 13 brands
- 51 devices
- ~100 gas measurements
- ~200 PM measurements

Credit: Dr Nicholas Mardsen
Potential instruments to do the job

Instrument 1
- $R^2 = 0.95$
- RMSE = 4.5
- Time res.: 1hr

Instrument 2
- $R^2 = 0.90$
- RMSE = 5.0
- Time res.: 24hs

Instrument 3
- $R^2 = 0.85$
- RMSE = 5.5
- Time res.: 30min

Instrument 4
- $R^2 = 0.80$
- RMSE = 5.0
- Time res.: 15min

Instrument 5
- $R^2 = 0.75$
- RMSE = 4.5
- Time res.: 1hr

Instrument 6
- $R^2 = 0.80$
- RMSE = 4.0
- Time res.: 24hs

Instrument 7
- $R^2 = 0.85$
- RMSE = 3.5
- Time res.: 30min

Instrument 8
- $R^2 = 0.90$
- RMSE = 4.0
- Time res.: 15min

2 Sites’ fingerprint (5yr, 1hr data)

Site 1

Site 2

2 Sites’ fingerprint (5yr, 1hr data)
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**Information content**

- Is it possible to know in advance how a LCS will perform?
- How do we now which LCS will perform best for a particular task?
- How the performance indices were obtained? Period? Site?
- And more importantly, are they comparable?
Measurement Quality = \( f(\text{Hardware}, \text{Software}) \)
Single value metrics: The Datasaurus

Same Stats, Different Graphs:
Generating Datasets with Varied Appearance and Identical Statistics through Simulated Annealing
(Matejka & Fitzmaurice, 2017)
Single value metrics: different error structure, same $R^2$ and RMSE

Reference vs. Instrument 1:
- $y = 0.55x + 7.56$
- $n = 8640$
- $R^2 = 0.93$
- RMSE = 5.1

Reference vs. Instrument 2:
- $y = 1.29x + 1.43$
- $n = 8640$
- $R^2 = 0.93$
- RMSE = 5.1

Reference vs. Instrument 3:
- $y = 1.00x + 4.67$
- $n = 8640$
- $R^2 = 0.93$
- RMSE = 5.1
Methods

“Real-world” measurements:
  o Duplicate QUANT sensors: PM2.5, NO$_2$ and O$_3$
  o Duplicate Ref grade instruments: NO$_2$ and O$_3$

Tools:
  o Single-value metrics
  o Time-series plots
  o Regression plots
  o Bland-Altman plots
  o Relative Expanded Uncertainty plots
“Real-world” instruments: LCS NO₂ and O₃

Time series & regression plots

Bland-Altman plots

REU plots
“Real-world” instruments: LCS PM$_{2.5}$
“Real-world” instruments: NO$_2$ Reference Grade

Time series & regression plots

Bland-Altman plots

REU plots
Take-home messages

• End users need to **clearly identify** the data requirements. What is the question you want to ask?

• **Single-value metrics** convey very useful information…but take proper care as they **can be misleading**

• Plot your data!!!...in as many ways as possible

• **Visualizing the data** enables the user to make **more informed decisions** about the LCS capabilities in the target range

• As **error sources** can **change** significantly for different **sites/seasons**, the LCS should ideally be tested **relevant environments**
Gracias!

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Extras


https://github.com/wacl-york/quant-air-pollution-measurement-errors
Simulated instruments: NO₂

Linear combination of arbitrary interferences:
- temperature
- ozone
- electrical noise
Session Q&A Discussion

Please submit your questions for the session speakers through Whova – on your mobile or desktop device.

Make sure to note WHOM your question should be addressed to.
Thank you for joining this session.

Please head over to the Exhibit Hall to enjoy a light, final-day lunch! During the final 20 minutes of the lunch break we will host another raffle with prizes supplied by exhibitors, so be sure to stick around!

*Please note, the Exhibit Hall will close at 1:10 PM.*

**Don’t forget about this afternoon’s activities!**

We will have a Champagne Toast in Ballroom DE at 3:30 PM. And at 4:30 PM, please join us for the International Connections Happy Hour, located at the Hilton Hotel, 168 South Los Robles Ave.