City of Minneapolis – Network Quality Control: Our route to confidence and source apportionment for the Total Volatile Organic Compounds (TVOC) sensor data

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MPCA / City of Minneapolis project summary

Project goals	Measure air quality pollutants of specific concern where it matters to local communities	Take measurements necessary for development of mitigation plans and measure the impact any mitigation might have		Engage with local communities affected by air pollution
QC goals	Measure VOCs accurately for the duration of the project	Identify which VOCs are present at each location		Understand the impact pollution is having on the local community
Criteria goals	**Show repeatability** between all AQMesh instruments.	Show that AQMesh **agrees with PAMS (Photochemical Assessment Monitoring Station)**	**Identify hyper-local pollution events** within the data collected	**Calibrate AQMesh TVOC readings** using TO-15 samples
Approach	Use co-location of all instruments to show they read the same as one another	Short term co-location of all instruments with PAM and single, long-term co-location with PAMS	Use network calibration method (long-distance scaling) to separate pollution scale	Match VOC sources to sensor responses via source apportionment to apply optimal correction factors

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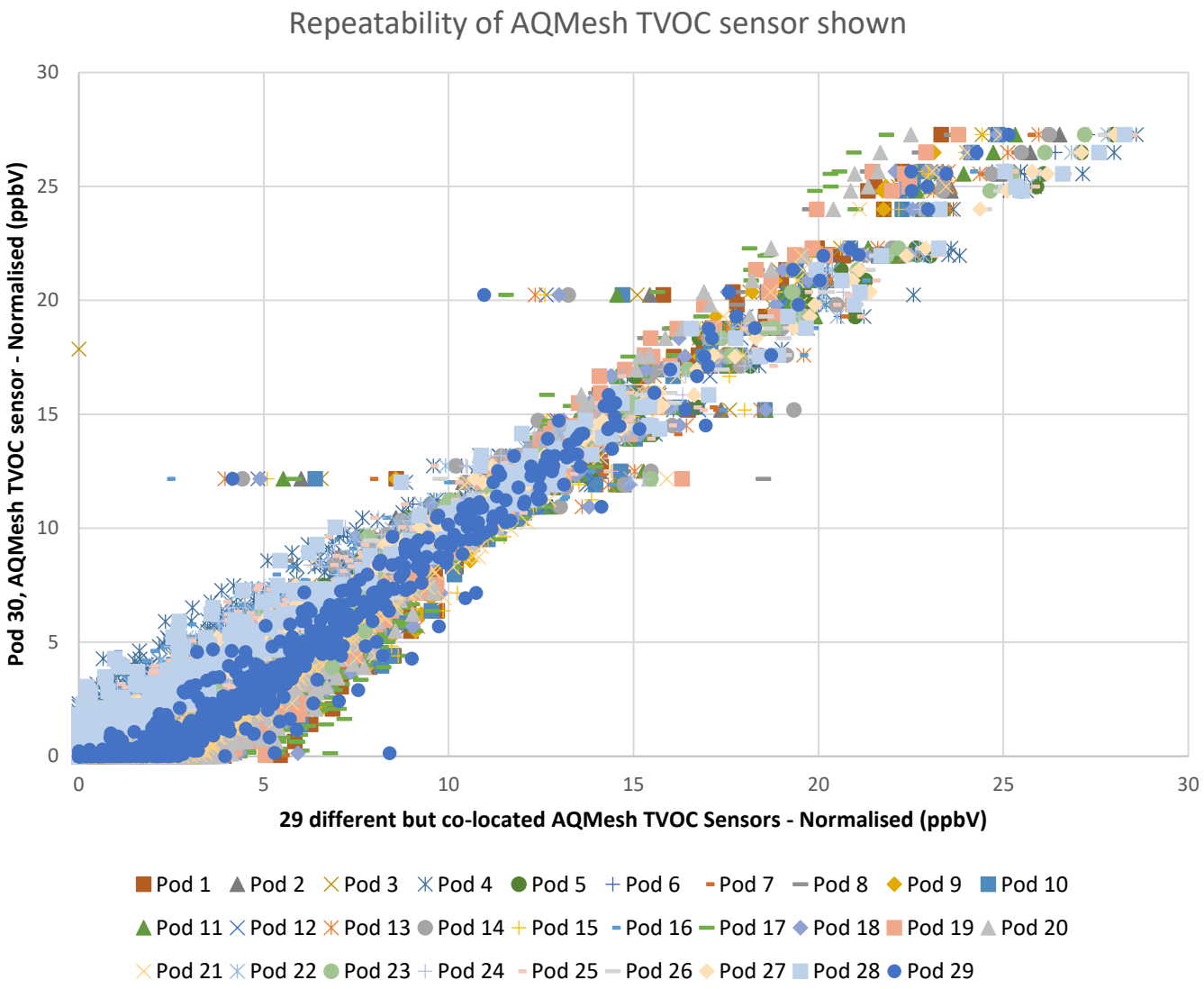
Proving repeatability through linearity comparisons



1. Co-location of all 30 instruments gives direct comparison of all sensors. Regression plots (LEFT) use hourly averaged data.

2. Linearity shows sensor **repeatability** - a vital stage in small sensor network deployment.

3. Calibration of sensor outputs to the group average normalises data.

This three-stage approach allows uniform correction factors to be applied across the network.

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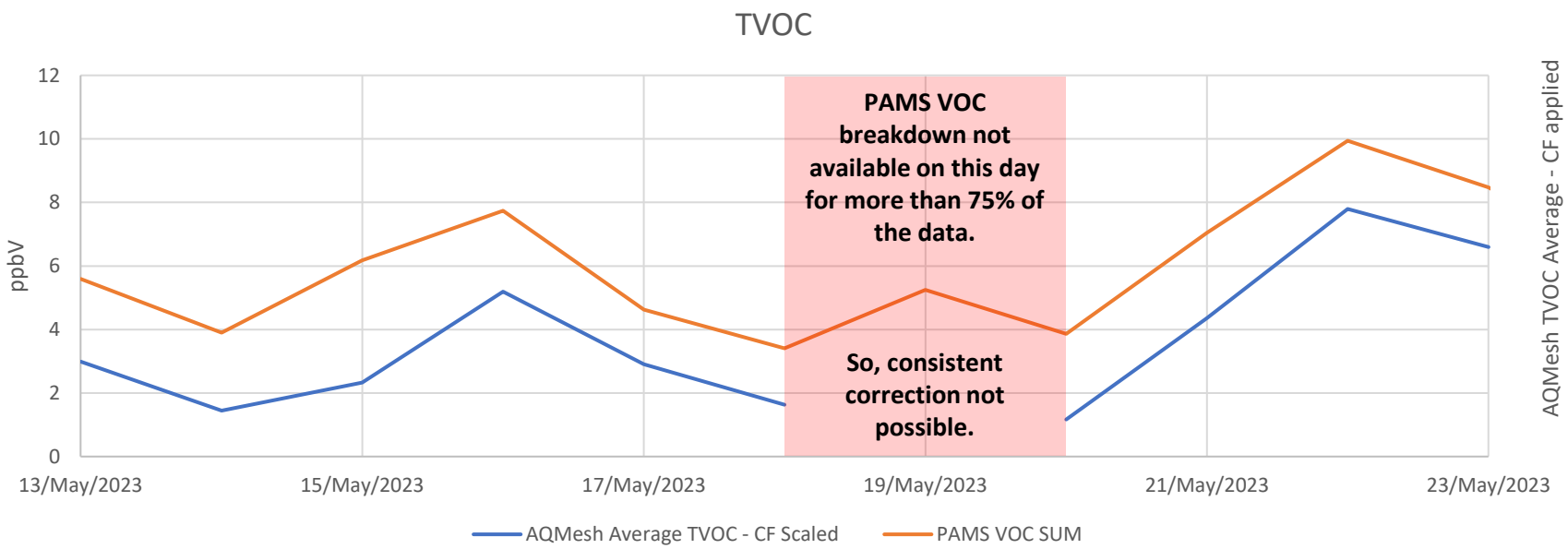
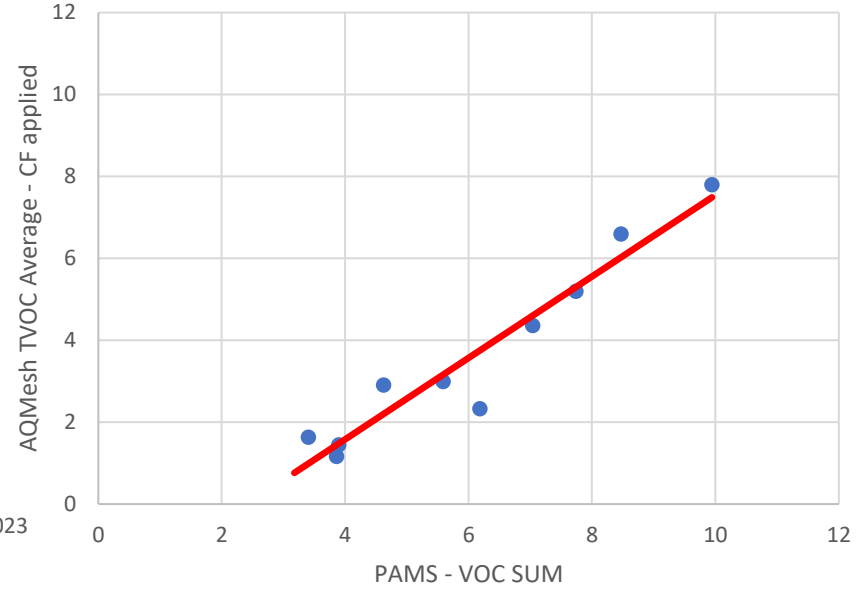
Co-location with PAMS – correction factors applied





Comparison Type	Comparison Method	PreScaled ("out of box")	Correction Factors applied
Linearity	R^2	0.68	0.92
Bias	Slope	1.30	0.99
Bias	Offset	-2.16 ppb	-2.40 ppb
Error	RMSE	1.60 ppb	2.50 ppb
Completeness	% Capture	97.69 %	

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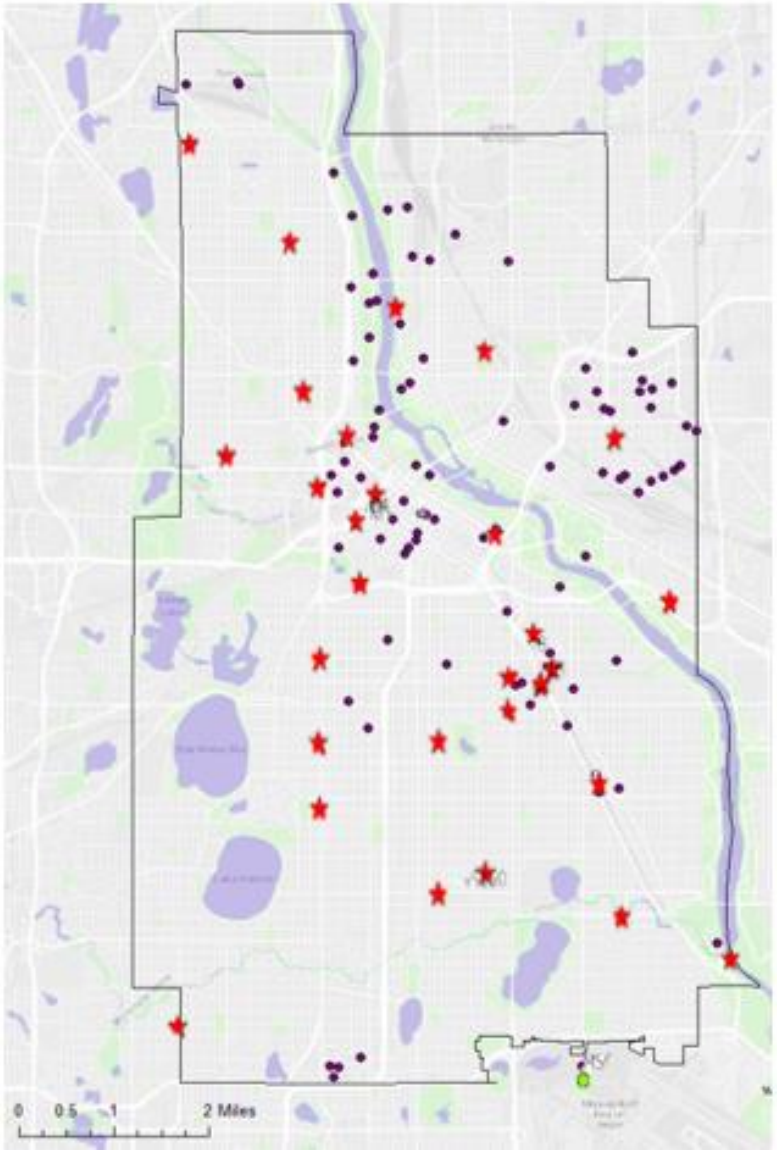
MPCA / City of Minneapolis Deployment



Air permitted facilities

AQMesh

- AQMesh data will be supplemented with SPODs for TO-15 collection for VOC data

- TO-15 samples will be lab analysed for a suite of 62 different VOCs
  - Initially from alongside the AQMesh units
  - Later from elsewhere in the city
  - TO-15 samples will be collected at 30 locations, once per month, for 21 months

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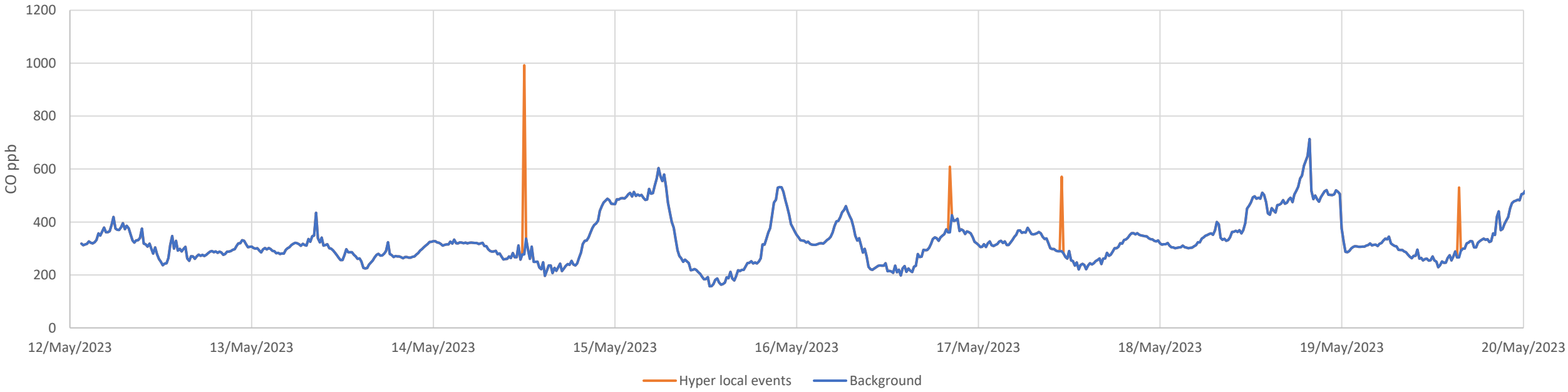
Identifying hyper-local events

What is Long Distance Scaling (LDS)?

- A network calibration methodology which uses a statistical process to separate hyper-local events from the regional or background response
- The background pollution response is comparable over much greater distances, allowing comparison and calibration
- Calibration factors can be applied to the full data set as the sensor response is linear

We remove the oranges so we can compare apples to apples.



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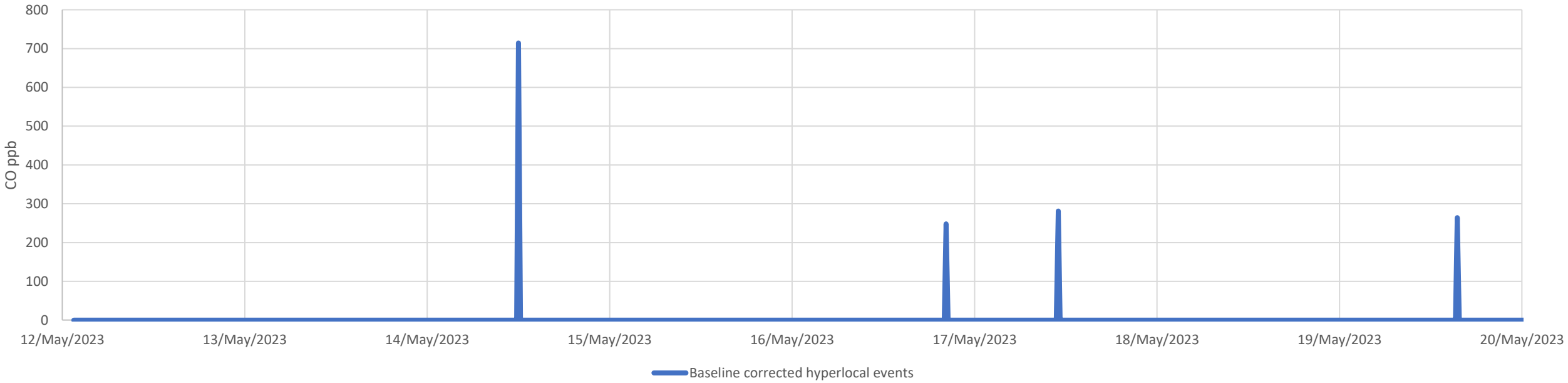
How much measured pollution is coming from that source?

How Long Distance Scaling (LDS) helps further

- LDS separates the hyper-local event data from the background pollution levels
  - Background level is subtracted from the hyper-local data set to show <u>just</u> the pollution from local sources at that point
  - Better assessment of pollution created by that source alone, so decision making on pollution mitigation and source apportionment is much more reliable



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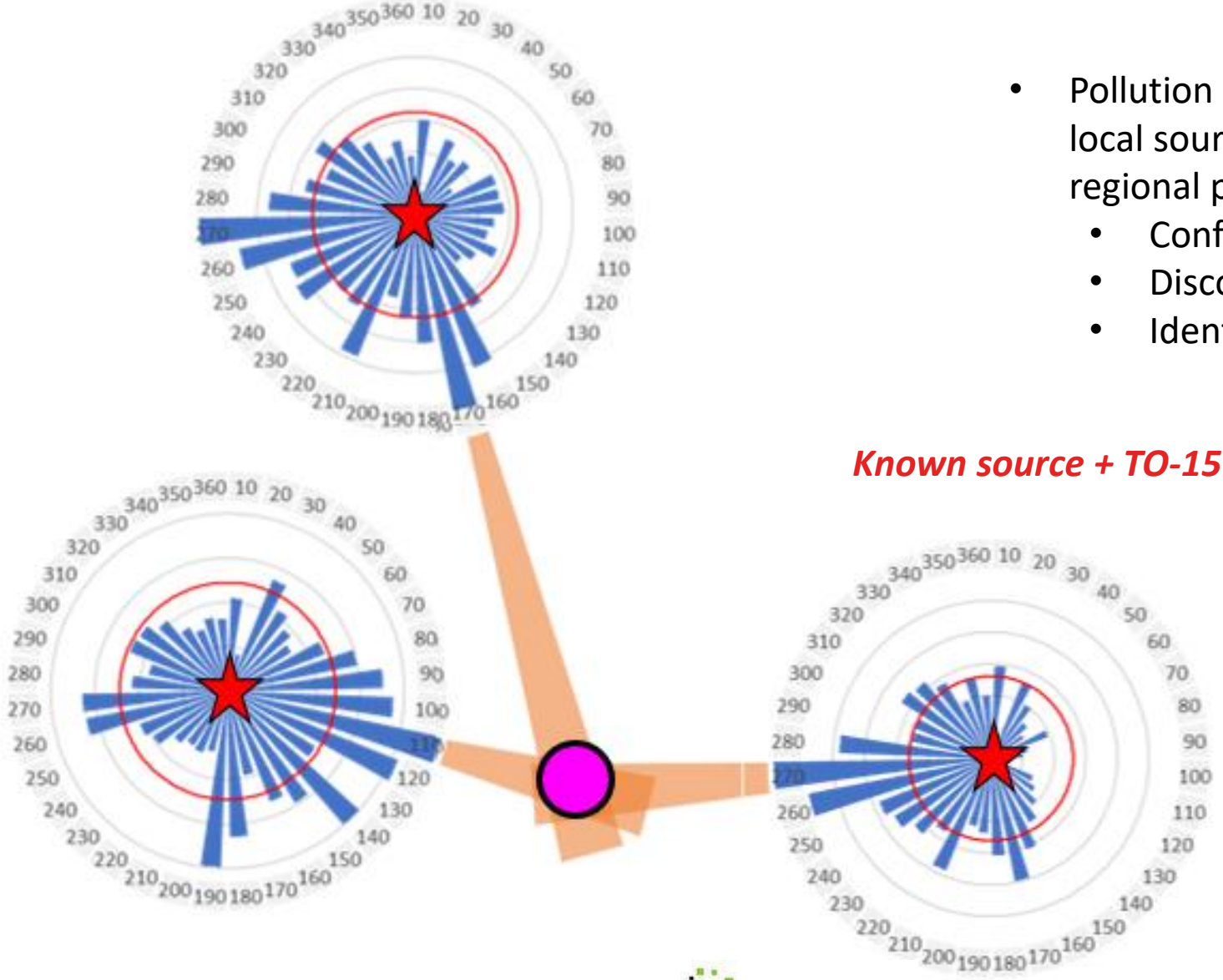
Identifying VOC sources using pollution rose analysis



- Pollution rose analysis uses hyper-local data to identify local sources - without ‘noise’ - from background or regional pollution sources
  - Confirms expected sources
  - Discounts some as non-VOC producing
  - Identifies new (previously unidentified) sources

Known source + TO-15 sample + Correction factor + Hyper-local data set

= Quantitative VOC data quality

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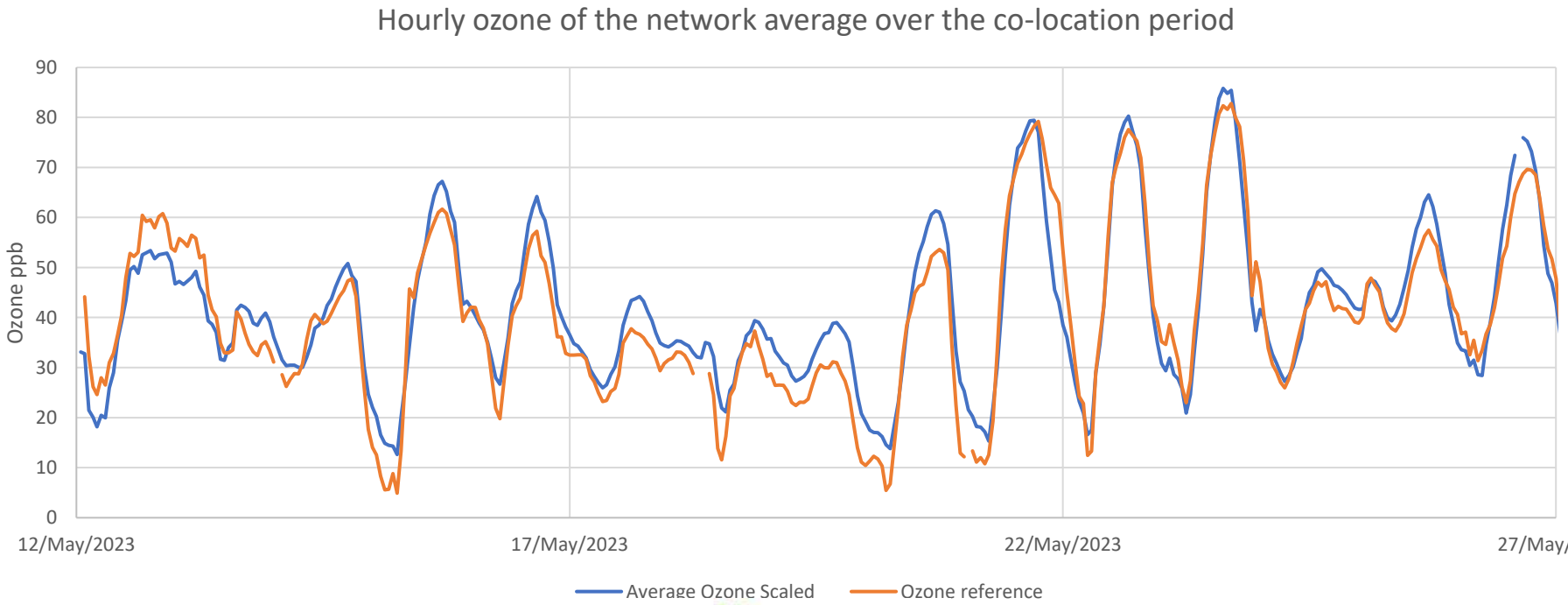
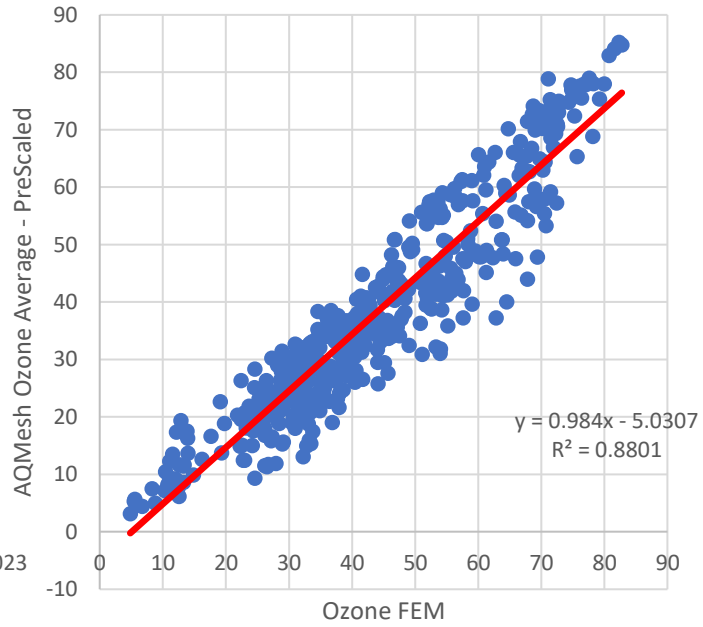
Continuous and ongoing QA/QC

To maintain confidence in the data throughout the project

1. Full time co-location of one instrument with the PAMS for long-term TVOC comparison
2. Near real-time assessment of sensor – looking for failures and potential for data points of low confidence
3. Periodic LDS to maintain network 'normalisation' of the TVOC sensor network and identify data issues

QA/QC efforts also underway for other pollutant species being measured by the AQMesh network: **ozone, NO2, CO & NO**





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Thanks to: -

- **Jenni Lansing, Senior Environmental Research Analyst, City of Minneapolis.**
- **Eric Wilcox Freeburg, Research Scientist, Minnesota Pollution Control Agency.**
- **Megan Kuhl-Stennes, Air Policy Planner, Minnesota Pollution Control Agency.**
- **Margaret McCourtney, Minnesota Pollution Control Agency.**
- **Ambilabs, AQMesh distributor for this project. Visit their booth in the exhibitor area!**

References: -

- **AQMesh Standard Operating Procedure and Operating Manual**
- **DEFRA funded, BSI Publicly Available Standard 4023**
- **USEPA Sensor Toolbox**
- **Air Quality Measurements in Kitchener, Canada - Hind A. Al-Abadleh et al, Wilfred Laurier University**
- **NPL QC report – Breathe London Pilot**
- **Scale separation method for network calibration - Professor Rod Jones, University of Cambridge**

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Questions?

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Thank you!

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