

A scenic view of a university campus featuring a large pond in the foreground, a green lawn, and several buildings, including a prominent brick tower and a stone building with a steeple. The sky is blue with light clouds.

Interrogating new science with low cost monitoring approaches: needs, pitfalls, and opportunities

Richard Peltier, MPH, PhD

University of Massachusetts, USA

18 May 2023

rpeltier@umass.edu

A long, long, long time ago (for sensors, at least)



The first air sensors for consumer use

This system, called "Lambda Sond," will be on every 1977 Volvo 240 series car sold in California. The California Air Resources Board is very impressed. They've called it "virtually pollution free..."



DRIVE A CAR THAT IMPRESSES PEOPLE WHO AREN'T EASILY IMPRESSED.

safety standards for cars in the future. It was no accident that the government selected Volvo for this safety program. Of all the cars involved in preliminary crash-testing, Volvo showed significantly greater potential for occupant protection than any car in its class.

G.M. AND FORD

Between them, G.M. and Ford have bought 13 Volvos to study and analyze. After years of following the "bigger is better" philosophy, they're introducing "trim, sensibly-sized" cars. Maybe they feel there's something to be learned from a company that's been making trim, sensibly-sized cars for 50 years.

THE STATE OF CALIFORNIA

California has the strictest automobile emissions requirements in the nation. And they get stricter all the time. While some car makers were loudly protesting that these requirements could not be met, Volvo was quietly working on a new type of emissions control system that would not only meet these standards, but exceed them. This system, called "Lambda Sond," will be on every 1977 Volvo 240 series car sold in California. The California Air Resources Board is very impressed. They've called it "virtually pollution free... the most significant step ever made in the battle to develop clean automobiles."

VOLVO OWNERS

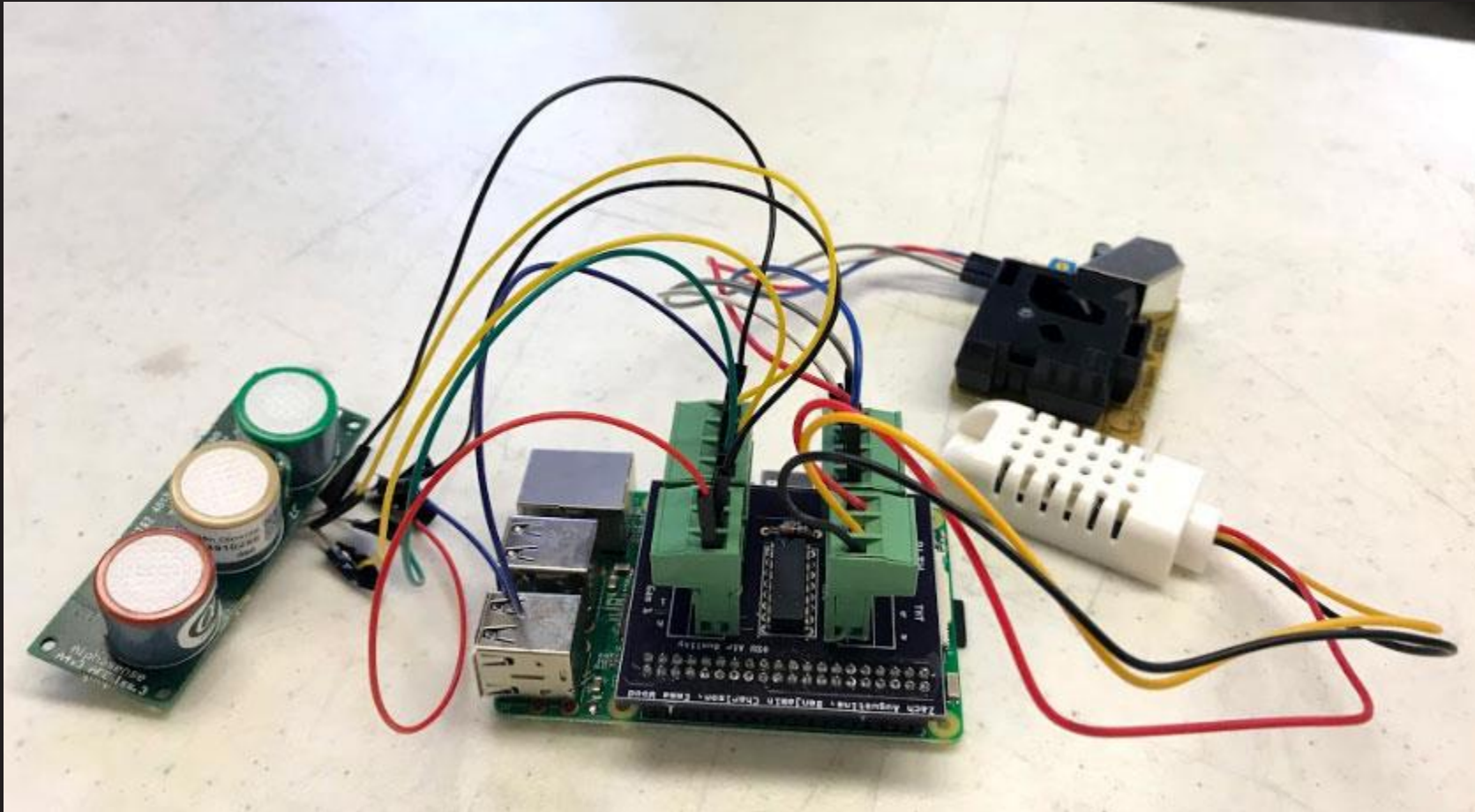
The ultimate test of any car is how the owner feels about it. Volvo owners seem to be happier than the owners of other cars. In fact, when new Volvo owners were asked in a recent nationwide survey how they felt about their cars, more of them said they were "completely satisfied" or "very satisfied" than did the owners of any car made by G.M., Ford, Chrysler or American Motors. Now that you know who's impressed with Volvos, you can take a test drive and impress the most important person of all: yourself.



VOLVO
The car for people who think.

© 1977 VOLVO OF AMERICA CORPORATION. LEASING AVAILABLE. CAR and DRIVER

They're here!



And There!

Aerosol and Air Quality Research, 20: 254–270, 2020
Copyright © Taiwan Association for Aerosol Research
ISSN: 1680-8584 print / 2071-1409 online
doi: 10.4209/aaqr.2018.12.0485



Evaluation of Nine Low-cost-sensor-based Particulate Matter Monitors

Jiayu Li^{1#}, Simar K. Mattewal^{1,2#}, Sameer Patel^{1,3}, Pratim Biswas^{1*}

¹ *Aerosol and Air Quality Research Laboratory, Department of Energy, Environmental and Chemical Engineering, Washington University in St. Louis, St. Louis, MO 63130, USA*

² *Indian Institute of Technology Delhi, New Delhi 110016, India*

³ *University of Colorado, Boulder, CO 80309, USA*

Atmos. Meas. Tech., 12, 4643–4657, 2019
<https://doi.org/10.5194/amt-12-4643-2019>
© Author(s) 2019. This work is distributed under the Creative Commons Attribution 4.0 License.



Atmospheric
Measurement
Techniques
Open Access
EGU

Characterising low-cost sensors in highly portable platforms to quantify personal exposure in diverse environments

Lia Chatzidiakou^{1,*}, Anika Krause^{1,*}, Olalekan A. M. Popoola¹, Andrea Di Antonio¹, Mike Kellaway², Yiqun Han^{3,4,5}, Freya A. Squires⁶, Teng Wang^{4,7}, Hanbin Zhang^{3,5,8}, Qi Wang^{4,7}, Yunfei Fan^{4,7}, Shiyi Chen⁴, Min Hu^{4,7}, Jennifer K. Quint⁹, Benjamin Barratt^{3,5,8}, Frank J. Kelly^{3,5,8}, Tong Zhu^{4,7}, and Roderic L. Jones¹



ELSEVIER

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint



Full length article

Can commercial low-cost sensor platforms contribute to air quality monitoring and exposure estimates?



Nuria Castell^{a,*}, Franck R. Dauge^a, Philipp Schneider^a, Matthias Vogt^a, Uri Lerner^b, Barak Fishbain^b, David Broday^b, Alena Bartonova^a

^a *NILU – Norwegian Institute for Air Research, Kjeller, Norway*

^b *Faculty of Civil and Environmental Engineering, Technion – Israel Institute of Technology, Haifa, Israel*



ELSEVIER

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres



Validating novel air pollution sensors to improve exposure estimates for epidemiological analyses and citizen science



Michael Jerrett^{a,*}, David Donaire-Gonzalez^b, Olalekan Popoola^c, Roderic Jones^c, Ronald C. Cohen^d, Estela Almanza^e, Audrey de Nazelle^f, Iq Mead^g, Glòria Carrasco-Turigas^b, Tom Cole-Hunter^b, Margarita Triguero-Mas^b, Edmund Seto^h, Mark Nieuwenhuijsen^b

And everywhere!

Note: Please be cautious and check with your supplier if this product is for virus protection purposes and if the coronavirus (COVID-19) will affect your order.



Ready to Ship **In Stock** **Fast Dispatch**

Custom pm1.0 Analog output fine module laser dust particle sensor for pm10 or pm2.5 pm25

2 - 99 Pieces	100 - 499 Pieces	>=500 Pieces
\$71.30	\$65.40	\$60.40

\$25.00 OFF Order more than \$359.00 | [Get Coupon](#)

Benefits **Pro** US \$100 OFF [Apply now >](#)

Quantity: Pieces

Samples: \$72.00/Piece | 1 Piece (Min. Order) | [Buy Samples](#)

2 Pieces **\$142.60**
Ship to [United States](#) **Free shipping**
by [Express](#) ...

Processing Time **15** days

Shipping time **9-25** days

Total \$142.60

[Start Order](#)

[Leave Messages](#)

[Contact Supplier](#)

[Call us](#)

[Add to cart](#)

Gold Supplier

[Guangzhou Logoele Electronics T...](#)

Kecheer Moniteur de qualité de l'air 3 en 1
Détecteur de CO2/RH/Temp multifonction pour l'intérieur et l'extérieur avec écran numérique couleur 3,5"

75,99 €
Livraison GRATUITE (0.01€ pour les livres) en point retrait. Détails
Juin en France métropolitaine
Détails

En stock.
Quantité: 1

[Ajouter au panier](#)

Plus: 75,99 €
Tous les prix incluent la TVA.

Livraison GRATUITE (0.01€ pour les livres) en point retrait. Détails

- Écran couleur TFT HD de 3,5" : affichage en temps réel de l'heure, de la date, du CO2, de la température et de l'humidité relative. L'écran a un grand angle de vue jusqu'à 160°, ce qui est très facile à lire.
- Fonctions d'enregistrement des données: Avec jusqu'à 65 534 groupes de stockage de stockage maximal, pratique pour rechercher les données historiques stockées par le système.
- Technologie de détecteur semi-conducteur: surveillance de la qualité de l'air dans votre environnement avec une grande précision, détection en temps réel du CO2, température et humidité relative.
- Apparence simple et élégante: le moniteur de qualité de l'air a une petite taille et un design épuré et s'adapte parfaitement à n'importe quelle maison avec n'importe quel style décoratif. Style autonome, pas de montage nécessaire.
- Large application : convient pour une utilisation dans la voiture, la chambre, le salon, le bureau, la salle de classe, la bibliothèque, etc.

[Voir plus de détails.](#)



大気質モニター多機能室内大気汚染セン
サPM2.5 PM10 CO2ホルムアルデヒド
(HCO) TVOC検出器 楽器
Brand: GXT

Price: ¥20,028

- 新しい設計: それは各ガスの平均値を提供することができ、リアルタイムデータは不安定性のために存在する長期的な監視が存在します。
- 多機能: 二酸化炭素 (CO2)、ホルムアルデヒド (HCHO)、揮発性化合物 (TVOC)、粒子物質 (PM2.5 / PM10) の空気を正確に検出することができます。
- 簡単に操作: このエアモニタは、機能ボタンを押すだけで操作が簡単で、読みやすく、アラーム音のサポートがお知らせください。
- 通知: 屋内テスト時にドアとウィンドウを開けることをお勧めします。ホルムアルデヒドTVOC CO2をテストするのは約60分です。

¥20,028

Your selected delivery location is beyond seller's shipping coverage for this item. Please choose a different delivery location or purchase from another seller.

[Deliver to United States](#)
[Add to Cart](#)

Share this item [Email](#) [Facebook](#) [Twitter](#) [WhatsApp](#)

Have one to sell?
[Sell on Amazon](#)

Atmotube PRO Portable Luftqualitätsmonitor für Außen- und Innenanwendungen [PM, VOC, Formaldehyd, Temperatur, Luftfeuchtigkeit und Luftdruckmesser]

Preis: 189,90 €
Preisangaben inkl. USt. Abhängig von der Lieferadresse kann die USt. an der Kasse variieren. Weltinformationen.

Marke: Atmotube
173 Sternebewertungen

Stromquelle: Batteriebetrieben
Anzahl der Batterien: 1 Lithium-Polymer Batterie erforderlich (inbatterien).
Aufbau: RGB LED Indikator
Maximale Lagertemperatur: 55 Grad Celsius
Spezifikation erfüllt: Co, Rohc, Fc
Obere Temperaturstufe: 45 Grad Celsius

Info zu diesem Artikel

- **ECHTZEITIGER LUFTQUALITÄTS-TRACKER** - Überwacht ständig die Umgebung und misst präzise eine Vielzahl von Feinstaub, flüchtigen organischen Verbindungen (VOC) wie Aceton, Methanol, Formaldehyd und schädlichen Gasen.
- **PM SENSORS** erkennt PM1-, PM2.5- und PM10-Schadstoffe wie Staub, Pollen, Ruß und Schimmelpilzsporen.
- **PORTABLE & WEARABLE:** Kompaktester Luftqualitäts-Tracker, der sicher an einer Tasche oder einem Gürtel befestigt werden kann. Mit einer Akkulaufzeit von bis zu 7 Tagen können Sie ihn überall hin mitnehmen und die Luftverschmutzung in oder außerhalb Ihres Hauses testen.
- **MEHRZWECK:** Der Atmotube Pro-Luftqualitätsprüfer enthält auch eine Wetterstation mit Sensoren für Luftdruck, Temperatur und Luftfeuchtigkeit für den Innen- und Außenbereich.
- **MOBILE APP:** Die benutzerfreundliche Oberfläche zeigt die Luftqualitätswerte an und hilft dabei, den Messwert und die persönliche Luftpunktzahl zu verfolgen. Wenn die Luftqualität einen bestimmten Punkt unterschreitet, erhalten Sie sofortige Alarme.



Nur noch 2 auf Lager

Menge: 1

[In den Einkaufswagen](#)

[Jetzt kaufen](#)

Sichere Transaktion

Verkauf und Versand durch Alibaba.com. Für weitere Informationen, Impressum, AGB und Widerrufsrecht klicken Sie bitte auf den Verkäufernamen.

Kauf abgedeckt durch den Käuferschutz von Amazon

[Auf die Liste](#)



Click to open expanded view

EXCLUSIVE UP TO 10% OFF

FREE delivery: June 28 - 29 Details

Save Extra with 3 offers

No Cost EMI: Avail No Cost EMI on select cards for orders above ₹3000 | Details

Cashback: 5% back with Amazon Pay ICICI Bank credit card for Prime members. 3% back for others. Get up to 7600 back on card approval | Details

[See 1 more](#)

10 Days Returnable
Amazon Delivered
No-Contact Delivery

In stock.

noke Particle Sensor

Share [Email](#) [Facebook](#) [Twitter](#) [Pinterest](#)

Quantity: 1

[Add to Cart](#)

[Buy Now](#)

Secure transaction

[Select delivery location](#)

[Add to Wish List](#)



Creality Ender 5 Plus 2021 Version 3D Printer with BL...
★★★★☆ 52
₹47,499.00

Epidemiology (in one slide)

- Exposure linked to health outcomes.
- Exposure only *estimated* from central monitors.
- Lots of exposure misclassification.
- Uncertainty → controversy.
- Controversy → ineffective policy

Is Air Pollution Regulation Too Stringent?*

Joseph S. Shapiro
UC Berkeley
and NBER

joseph.shapiro@berkeley.edu

Reed Walker
UC Berkeley
and NBER

rwalker@berkeley.edu

December 2020

The New York Times

E.P.A. to Disband a Key Scientific Review Panel on Air Pollution



The Guardian

'Modern air is too clean': the rise of air pollution denial

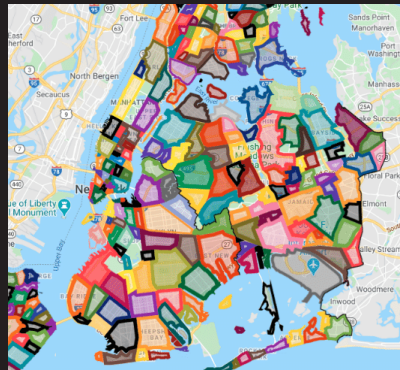
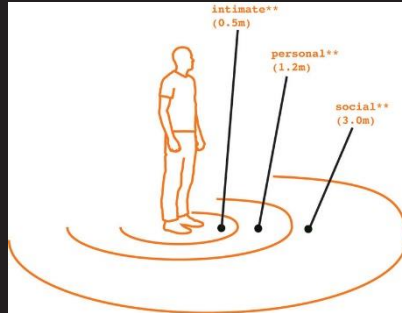
ical risk data

US sceptics are questioning the science behind air pollution and mortality, a trend that is starting to appear in countries where the air is much more toxic

Janssen, Stijn, et al. "Spatial interpolation of air pollution measurements using CORINE land cover data." *Atmospheric Environment* 42.20 (2008): 4884-4903.

Mancuso et, 2012.

LCS to Improve Scale



1m

Personal
Monitoring

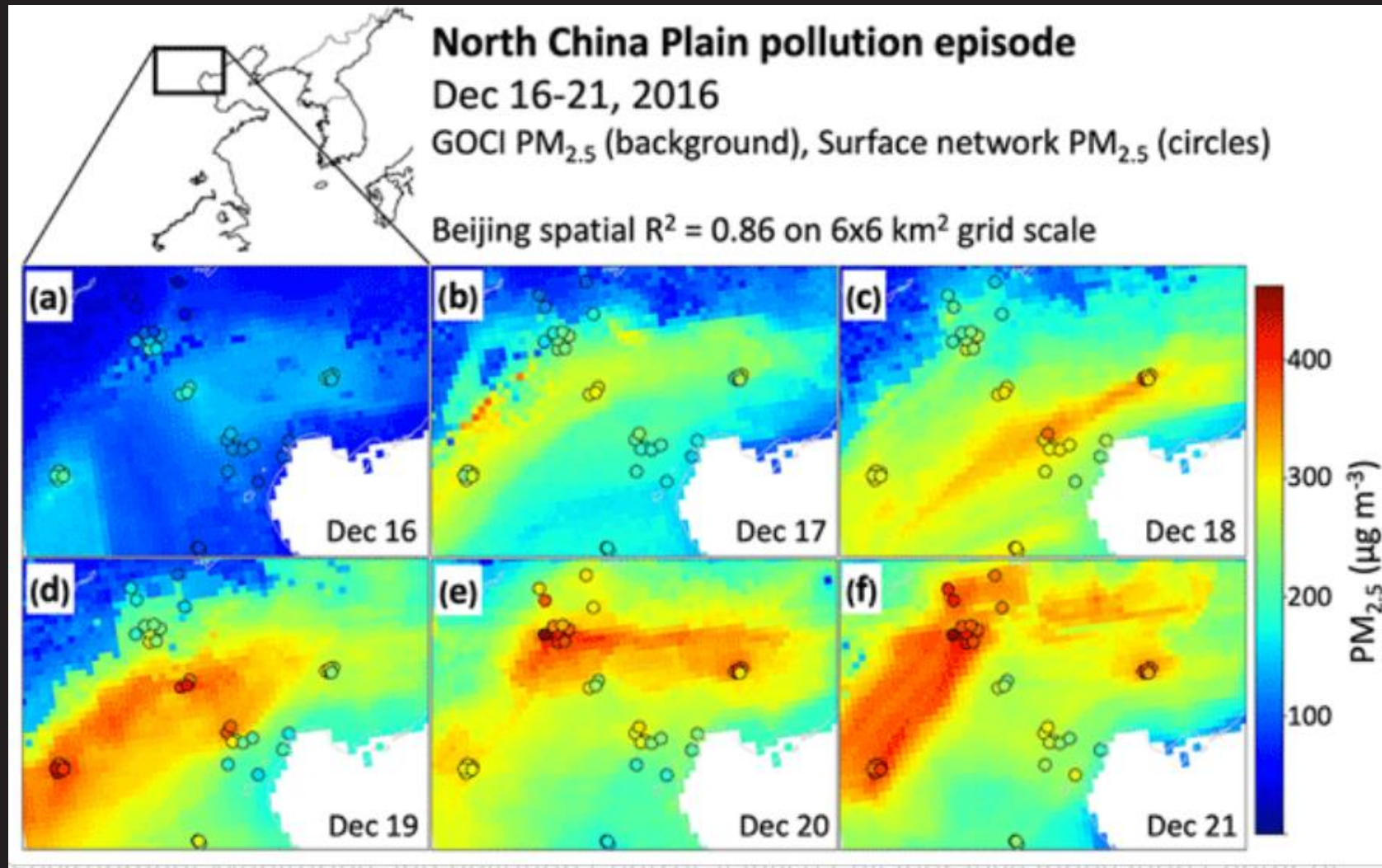
1 km

Current LCS

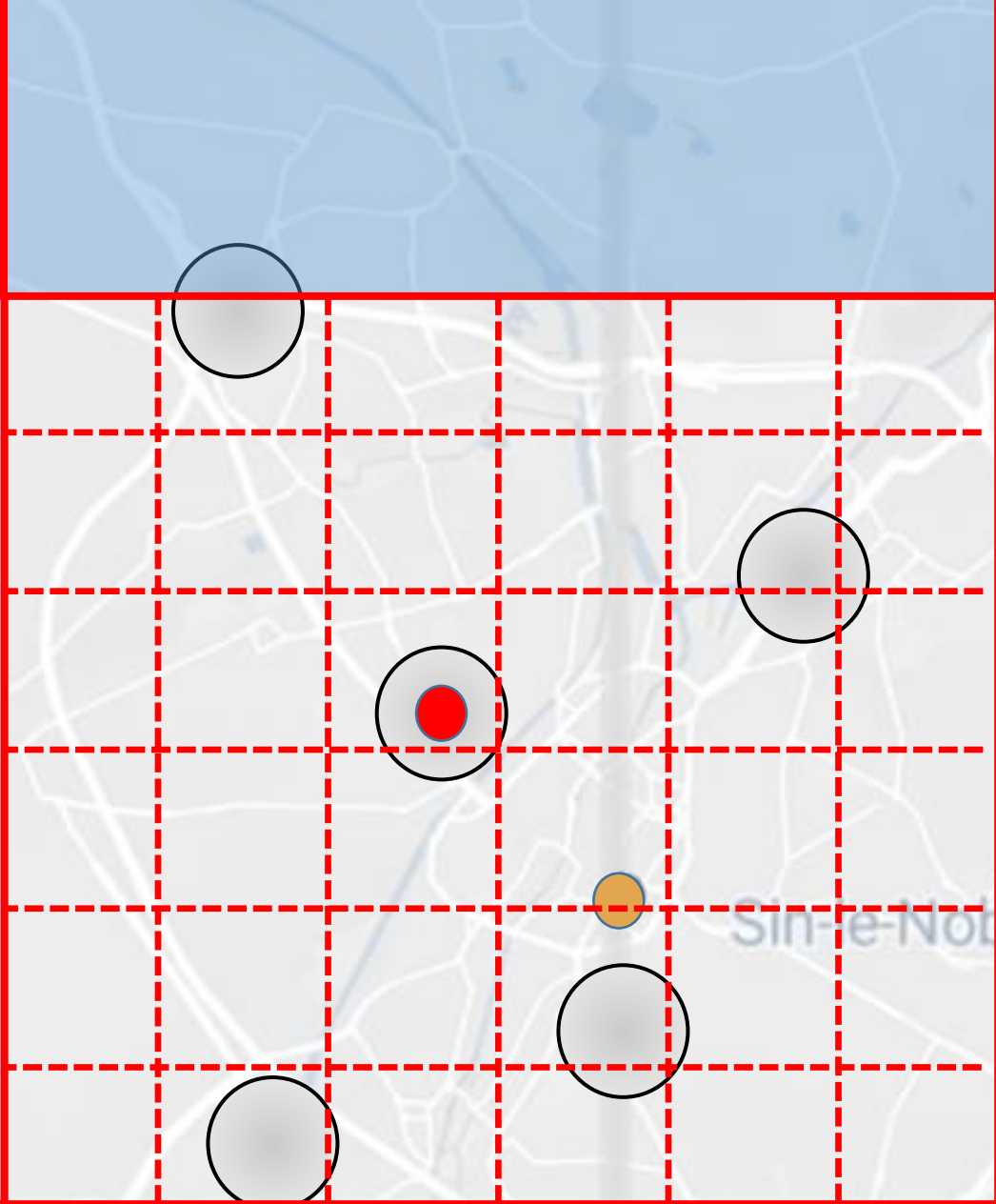
10-100 km

Reference
Monitors

Satellite retrieval and LCS?



Godault



Sin-e-Notre

From openaq.org

Douai Region

LCS Needs

- Take more risks, admit & accept failures
- Common QA/QC approaches
- Data harmonization/standardization
- Move beyond PM.
- Type 1 fun.



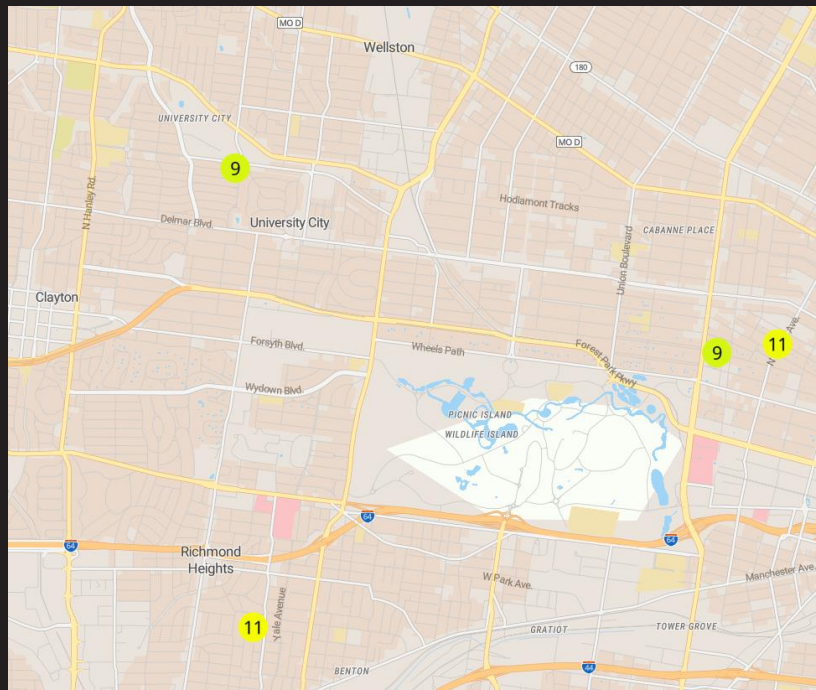
LCS Pitfalls

- Measurement uncertainty
 - Exposure misclassification
 - Technical interferences
- Underestimated costs, data overflow
- Long term drift
- Understanding indoor AQ/invasive data collection
- For most, no DMS

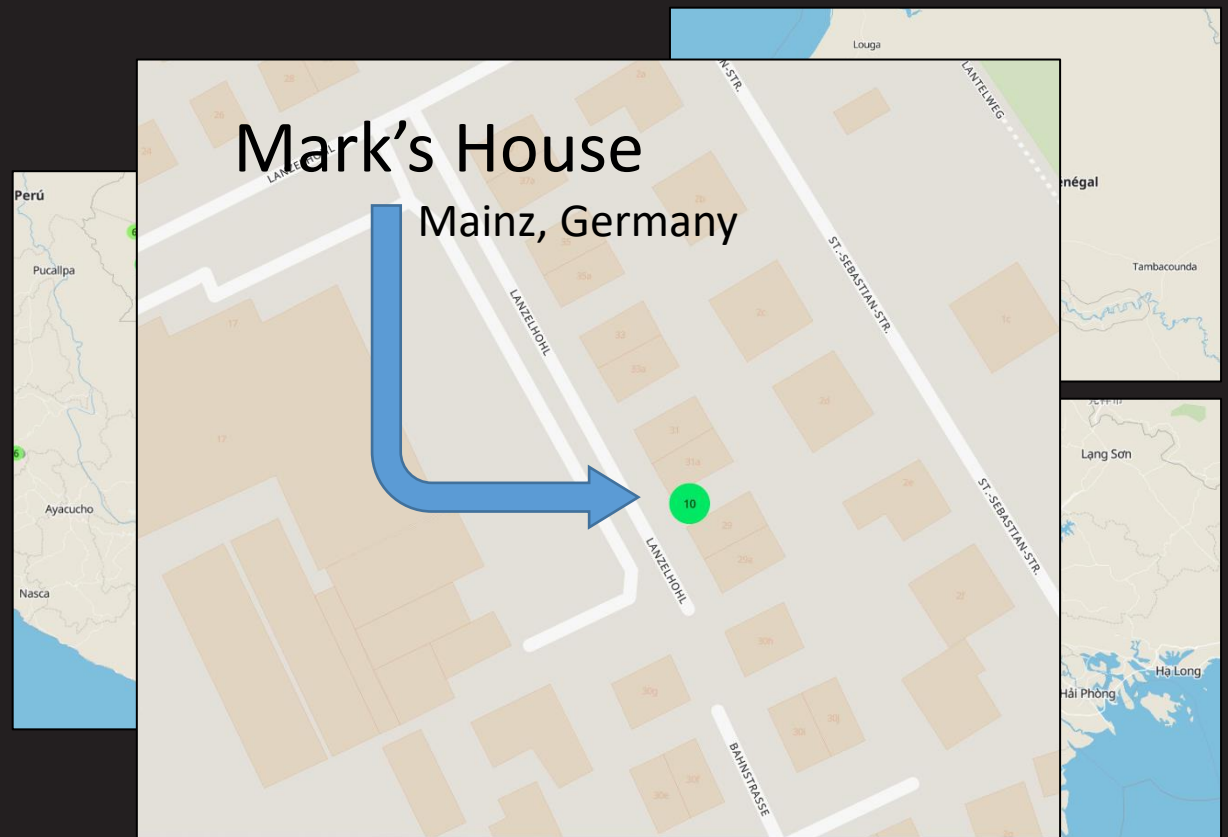


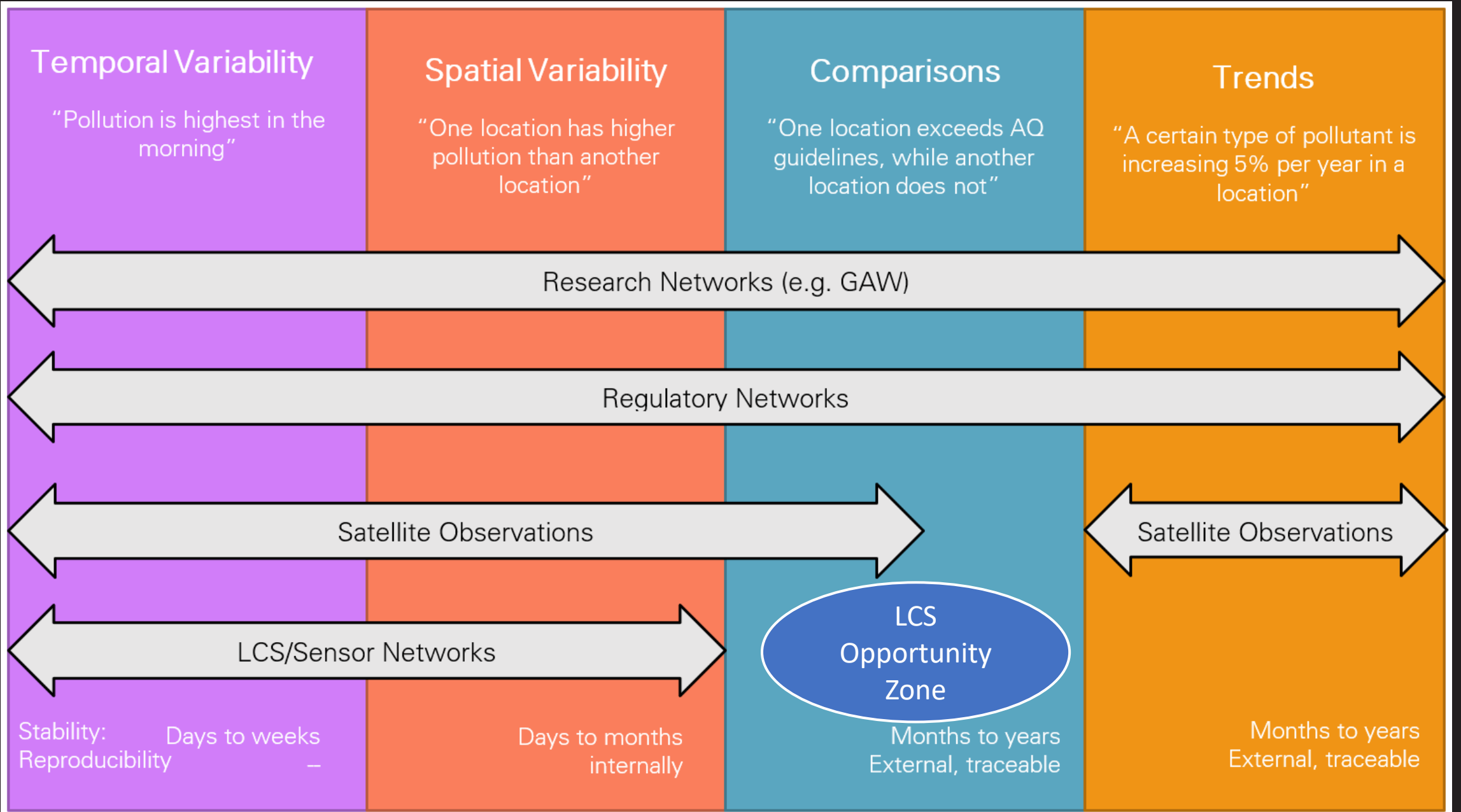
LCS successes (but be careful of ethics)

- Purple Air, Clarity, Acclima, Aircube, CityLab, Luftdaten, Village Green, CairClip, and on and on...



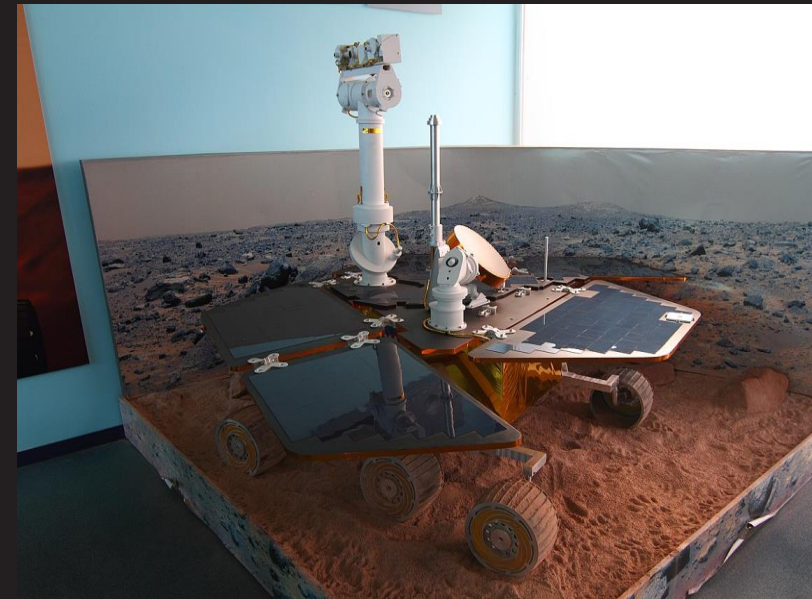
From Purple Air, 15 May 2023





LCS Opportunities (Health-focused)

- QA/QC platforms, and sensor quality leveling on the way.
- Spatial extension of ref data (with caveats)
- Education/outreach
- Peltier/Martin project – how LCS can fill gaps
- Personal monitoring + epi
- Personal monitoring + clinical
- Important for issues of justice/equity.



Acknowledgements

- World Meteorological Organization, World Health Organization, IGAC, UNEP, EMEP
- Adrian Arfire, Àlex Boso, Qingyan Fu, David Hagan, Geoff Henshaw, Rohan Jayaratne, Roderic Jones, Kerry Kelly, Vasu Kilaru, Iq Mead, Lidia Morawska, Dario Papale, Richard Peltier, Andrea Polidori, Xavier Querol, Jessica Seddon, Philipp Schneider, Oksana Tarasova, Alfred LC Yu, and Christoph Zellweger
- Núria Castell, Shih-Chun Candice Lung, Fabienne Reisen, Erika von Schneidenmesser, Matthew Parsons, Jesse Kroll, Christoph Hüglin, Tim Dye, Andrea Clements, Zhi Ning, and Michele Penza

rpeltier@umass.edu



QR Code to WMO
report 1215

