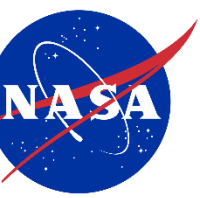
An aerial photograph of a coastline. On the left, a large, dark, rocky landmass meets the water. The water is a vibrant turquoise color near the shore, transitioning to a deep blue further out. White surf is visible where the water meets the shore and in the distance. The overall scene is dynamic and natural.

# Low-Cost Sensor Integration into City Scale Air Quality Forecasts

**Dr. Carl Malings**

NASA Goddard Space Flight Center & Morgan State University  
GESTAR II Cooperative Agreement



**Part 1: WMO Low-Cost Sensor Applications Report**

**Part 2: Ongoing Air Quality Forecast Project in  
Rio de Janeiro, incorporating Low-Cost Sensors**

# **Integrating Low-cost Sensor Systems and Networks to Enhance Air Quality Applications**

**GAW Report No. 293**

**Presented by Dr. Carl Malings**

**Morgan State University & NASA Goddard Space Flight Center**

**on behalf of the editors, authors, and contributors**



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# Executive Summary

- Despite challenges, low-cost sensors (LCS) represent a key tool for filling gaps in existing global and local air quality monitoring networks and contributing information for policy-relevant air quality products.
- Methods that use networks of LCS with tens to hundreds of sensors and combine LCS data with other information sources can provide a deeper insight into the causes and consequences of poor air quality.
- Known LCS data quality limitations should be explicitly accounted for in such application methods.
- LCS networks require physical and cyber infrastructure, technical capacity, community involvement, and institutional and financial support for effective sustained operations leading to positive societal impacts.



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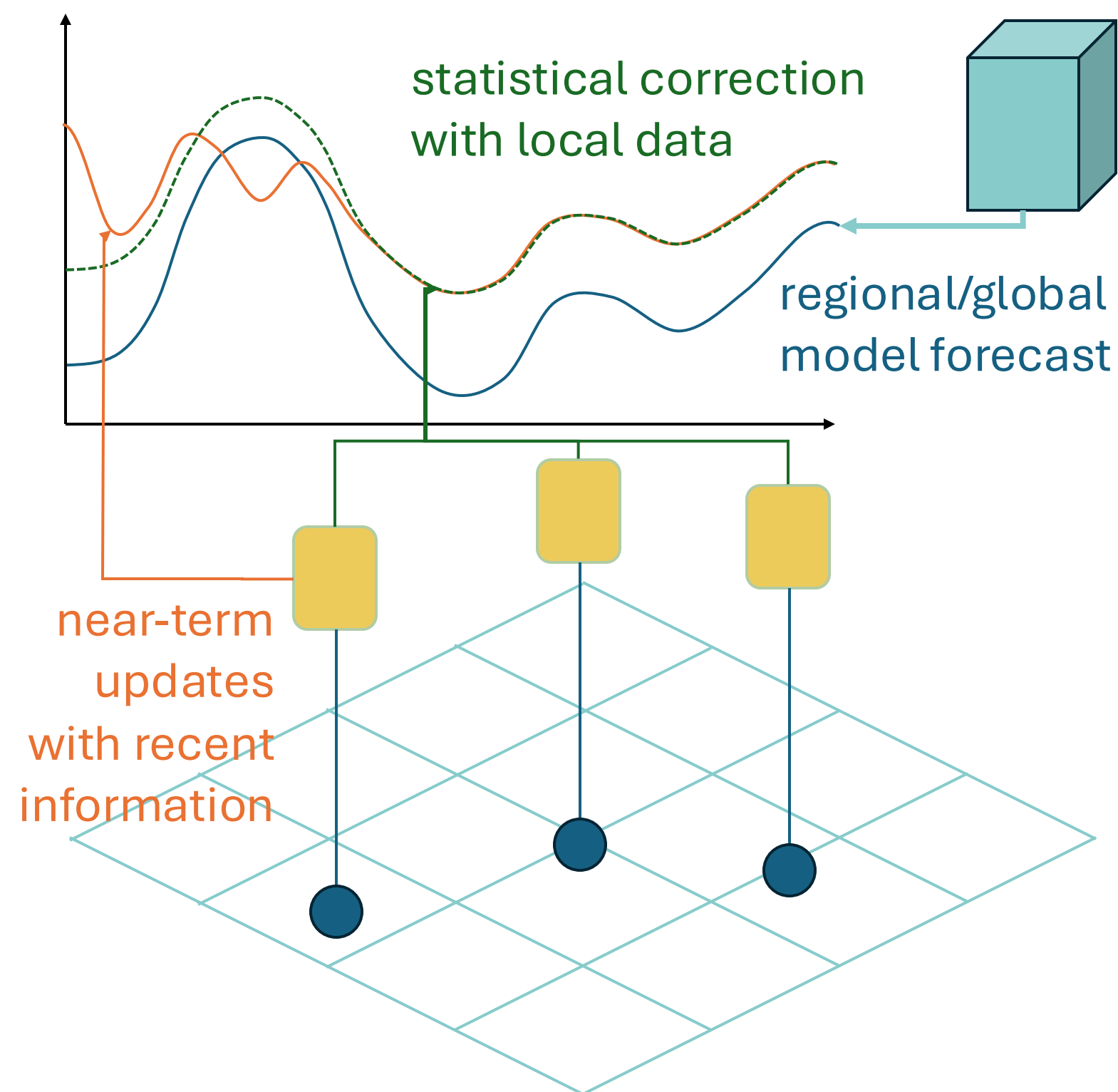
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## Integrating Low-cost Sensor Systems and Networks to Enhance Air Quality Applications



# Chapter 7: Air Quality Forecasting

- LCS networks can improve **short-term, localized forecasting** from regional or global air quality models, supporting advisories and warnings.
- Characterizing **uncertainties** in LCS data, including connections to meteorological factors, are key to their use in forecasting.
- LCS can provide data for **evaluating model forecasts** where RGM networks lack coverage.
- Latency, quality (i.e., accuracy and uncertainty) and **spatial representativity** of the LCS data are key factors for long-term performance forecast evaluations or near-real time validation.



*We would like to acknowledge the expertise and efforts of the many authors, editors, and contributors who made this report possible.*

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**Integrating Low-cost Sensor Systems and Networks to Enhance Air Quality Applications**

Collection(s)	Technical > Specialized programme publications
Author(s)	World Meteorological Organization (WMO); United Nations Environment Programme (UNEP); International Global Atmospheric Chemistry project (IGAC)
Published by	WMO
Published in	Geneva
Year published	2024
Summary	Low-cost air quality sensor systems (LCS) are emerging technologies for policy-relevant air quality analysis, including pollution levels, source identification, and forecasting. This report discusses LCS use in networks and alongside other data sources for comprehensive air quality applications, complementing other WMO publications on LCS operating principles, calibration, performance assessment, and data communication.

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# Scaling Data Fusion Tools to Support Local Air Quality Managers in Latin America

**Carl Malings**

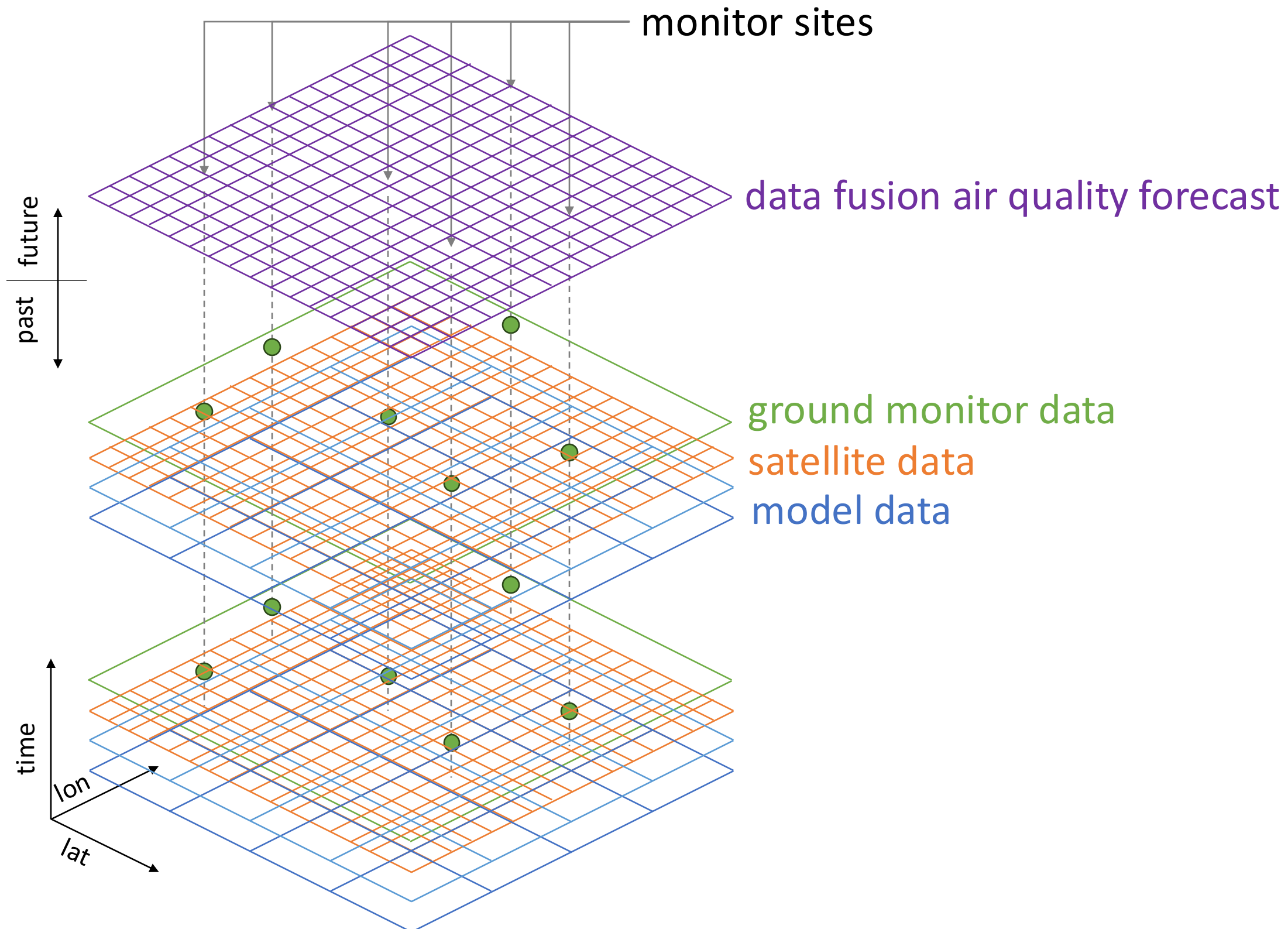
*Morgan State University & GESTAR-II cooperative agreement*

*NASA Global Modeling and Assimilation Office*

Project Team: Nathan Pavlovic, Daniel King, Bryan Duncan, Megan Damon, Sina Hasheminassab, Daniel Westervelt, Sebastián Diez, Colleen Rosales, Russ Biggs, Felipe Mandarino, Vicente Lorca



# Air Quality Data Fusion – Methodology



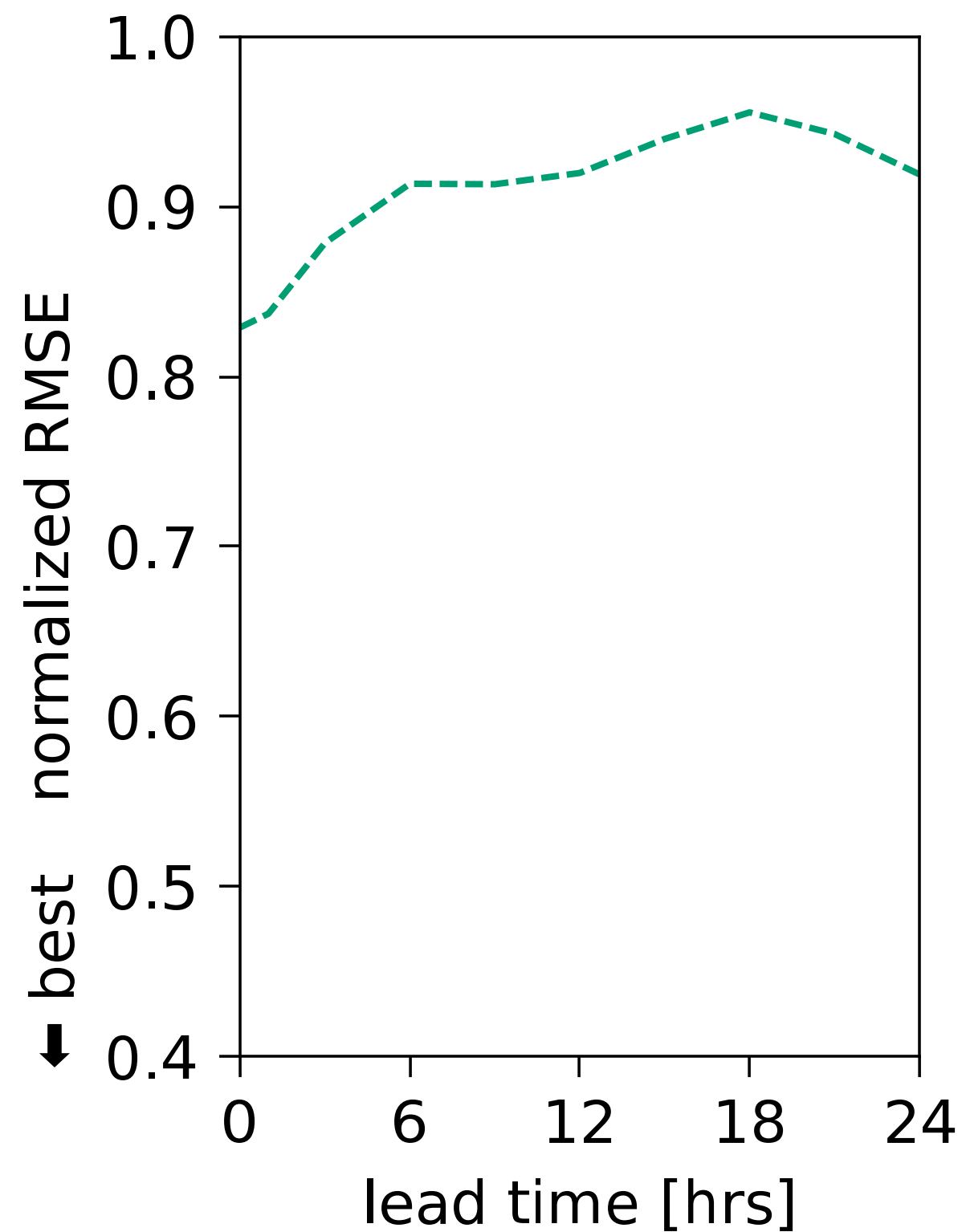
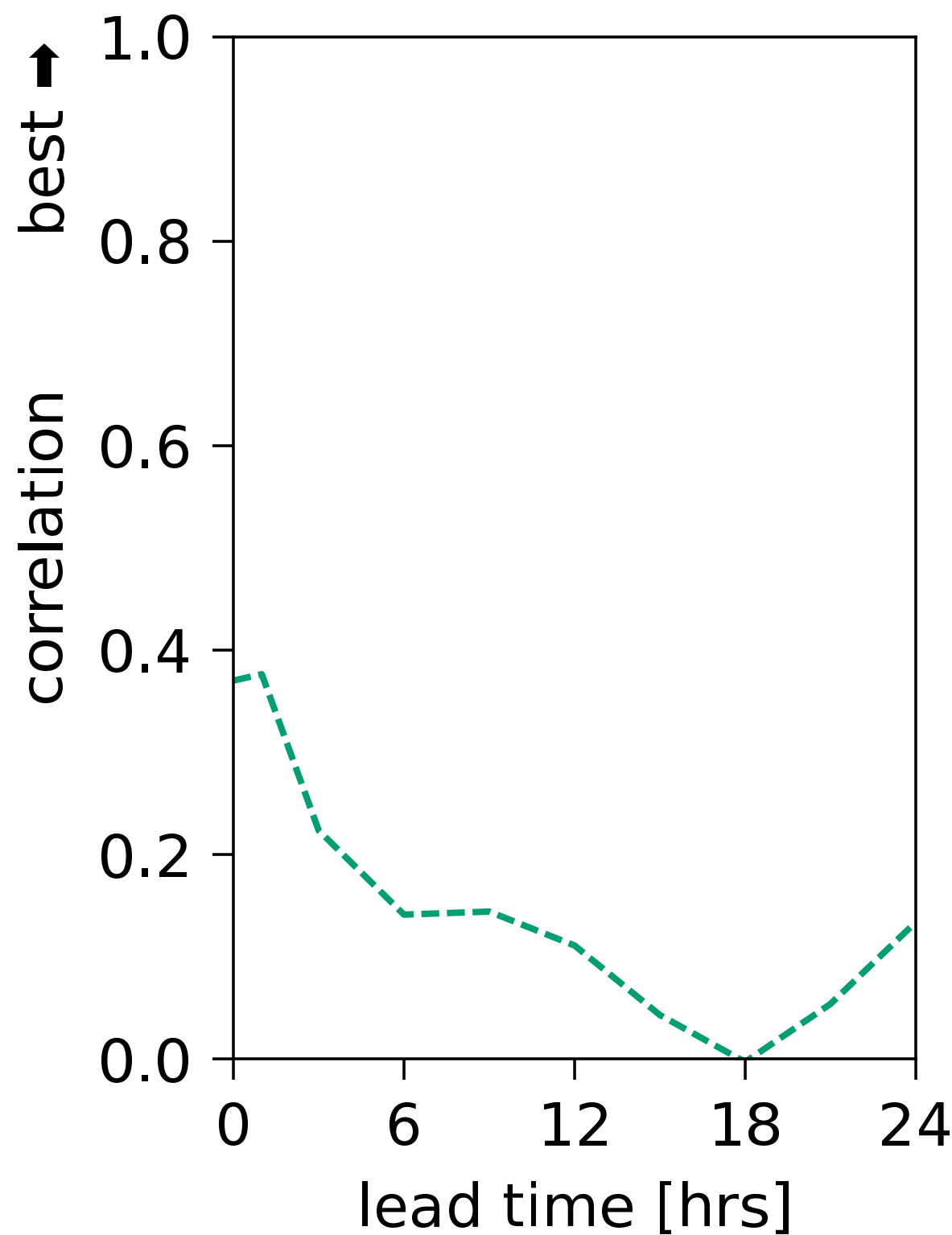
Combine model (NASA GEOS-CF), satellite (TROPOMI, MODIS, VIIRS), and local air quality monitor data to produce regional air quality forecasts using uncertainty-aware data fusion

Low-Cost Sensor Integration Strategy:

- Generate initial city-scale forecast with model, satellite, and regulatory-grade monitor data
- Refine forecast locally using recent, nearby low-cost sensor data (following city-specific low-cost sensor calibration)

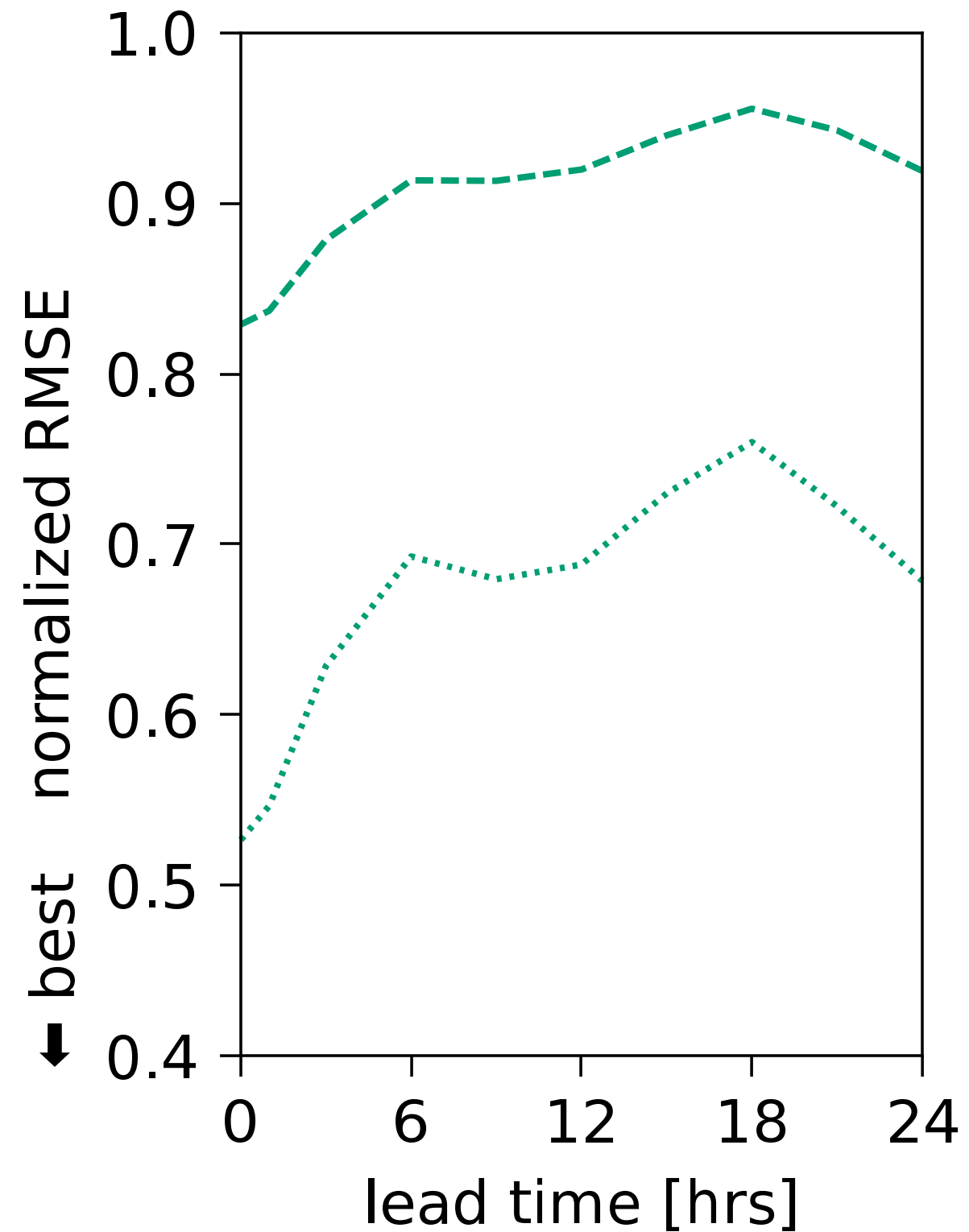
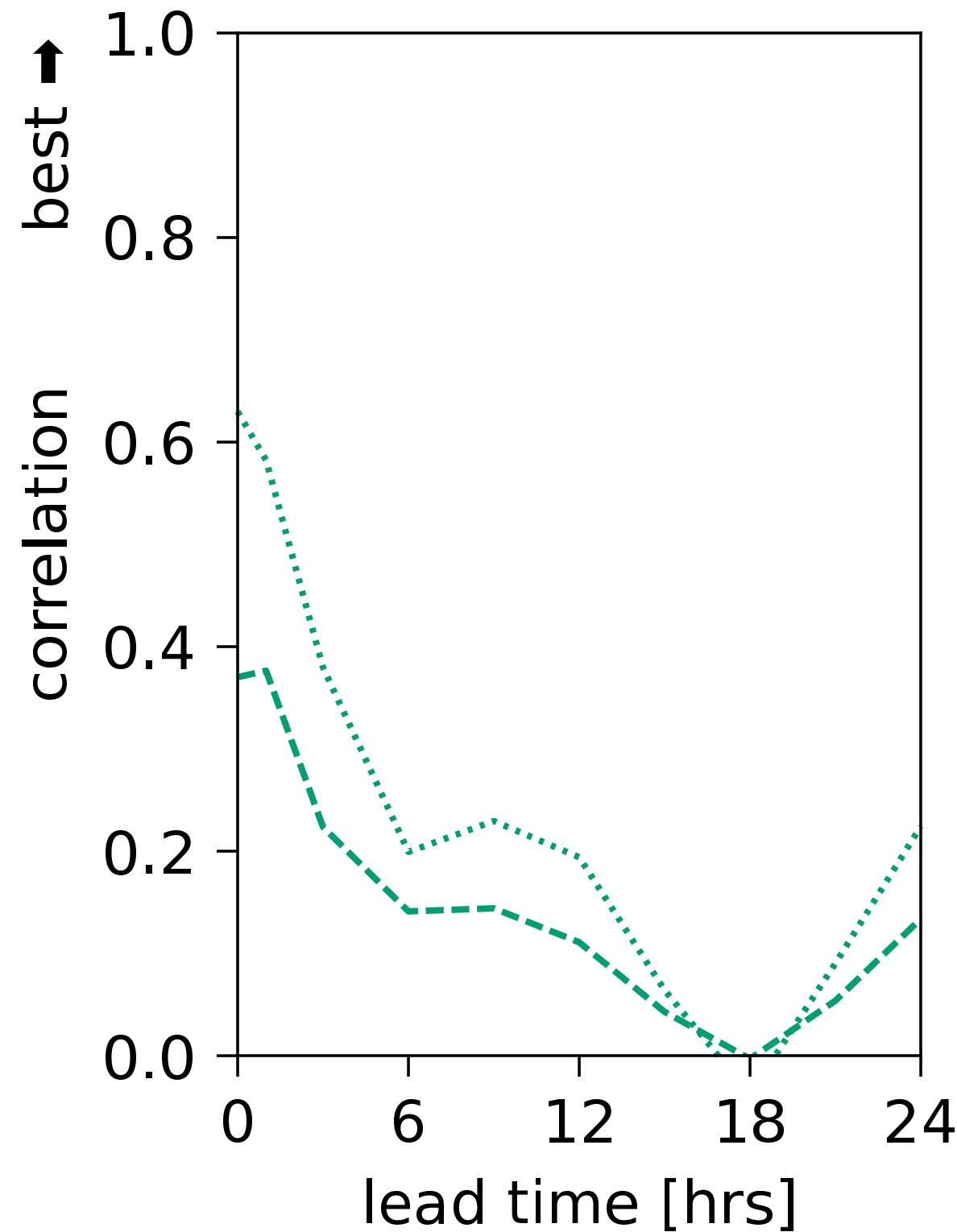
Source: [Malings et al., 2024](#)

# Results of Past Work (using London NO<sub>2</sub> data)



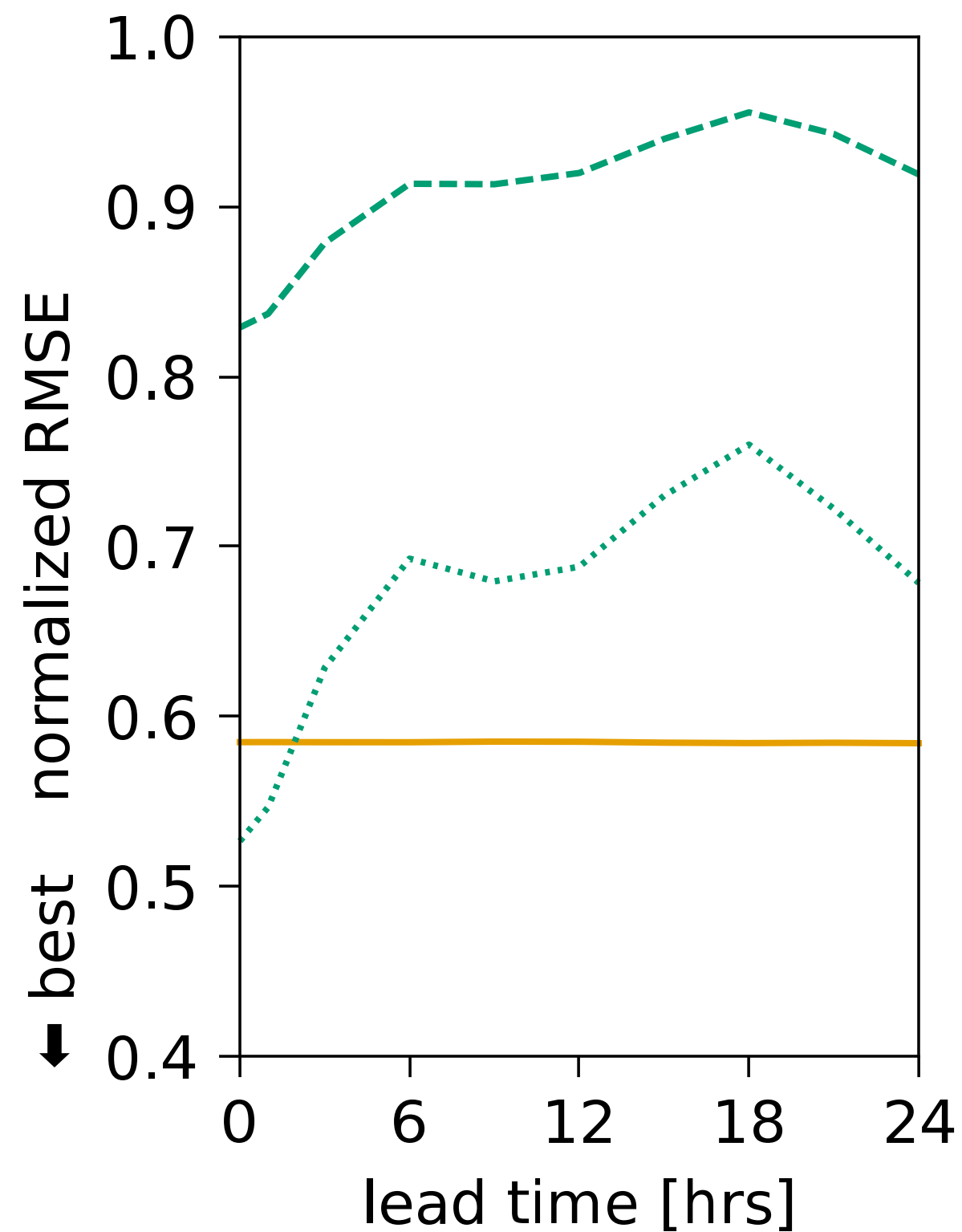
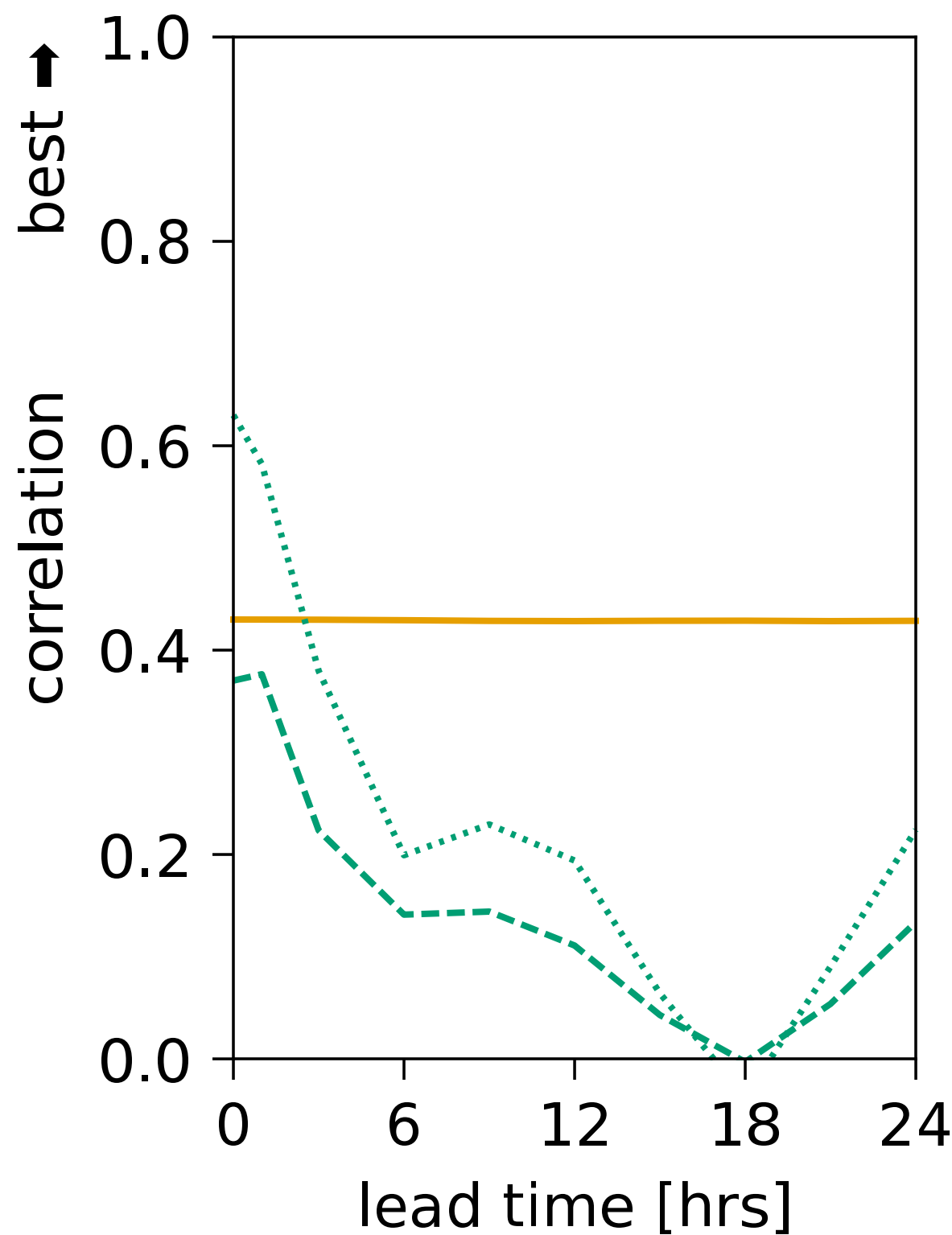
--- Regulatory Monitor persistence forecast

# Results of Past Work (using London NO<sub>2</sub> data)



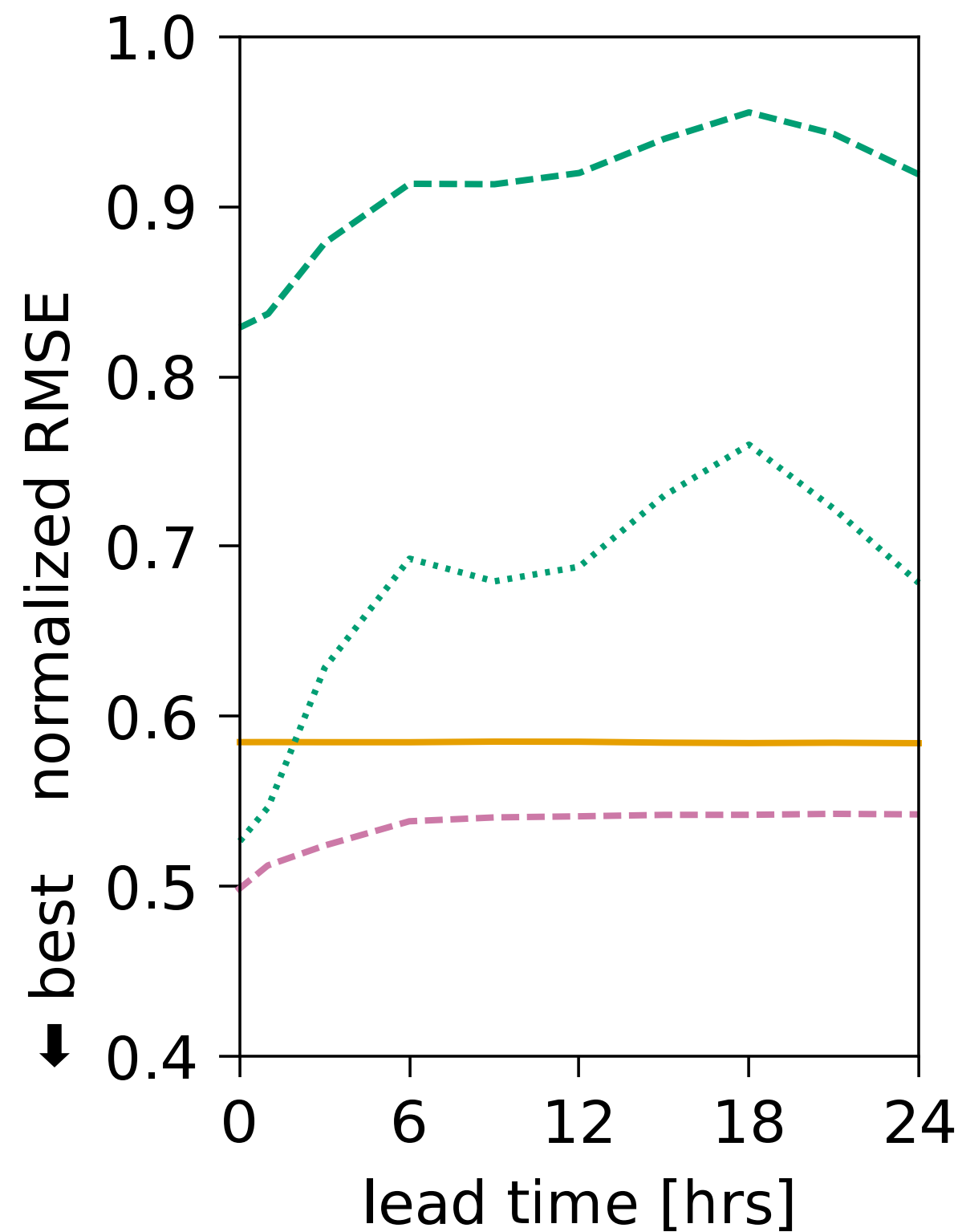
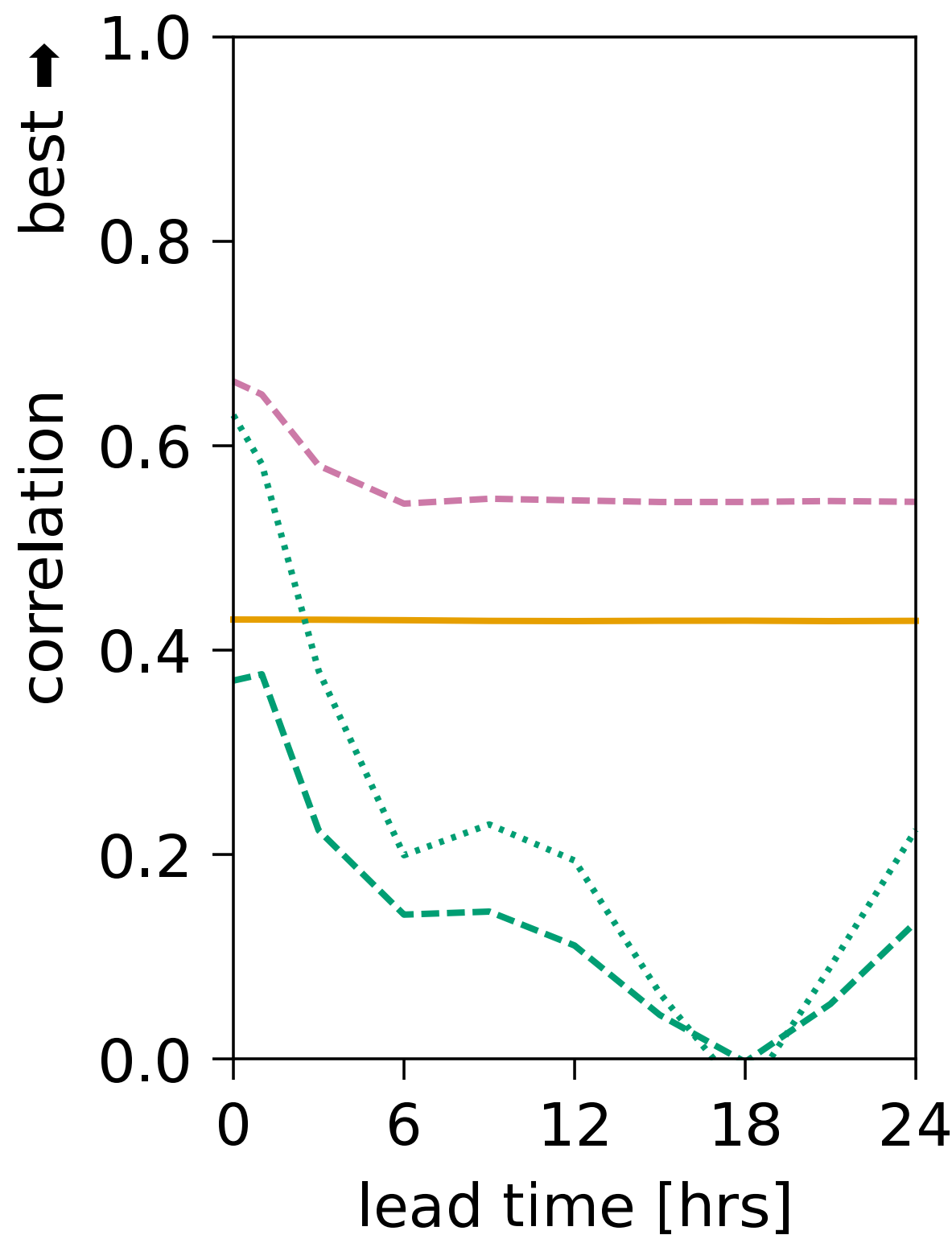
- Regulatory Monitor persistence forecast
- ..... Low-Cost Sensor persistence forecast

# Results of Past Work (using London NO<sub>2</sub> data)



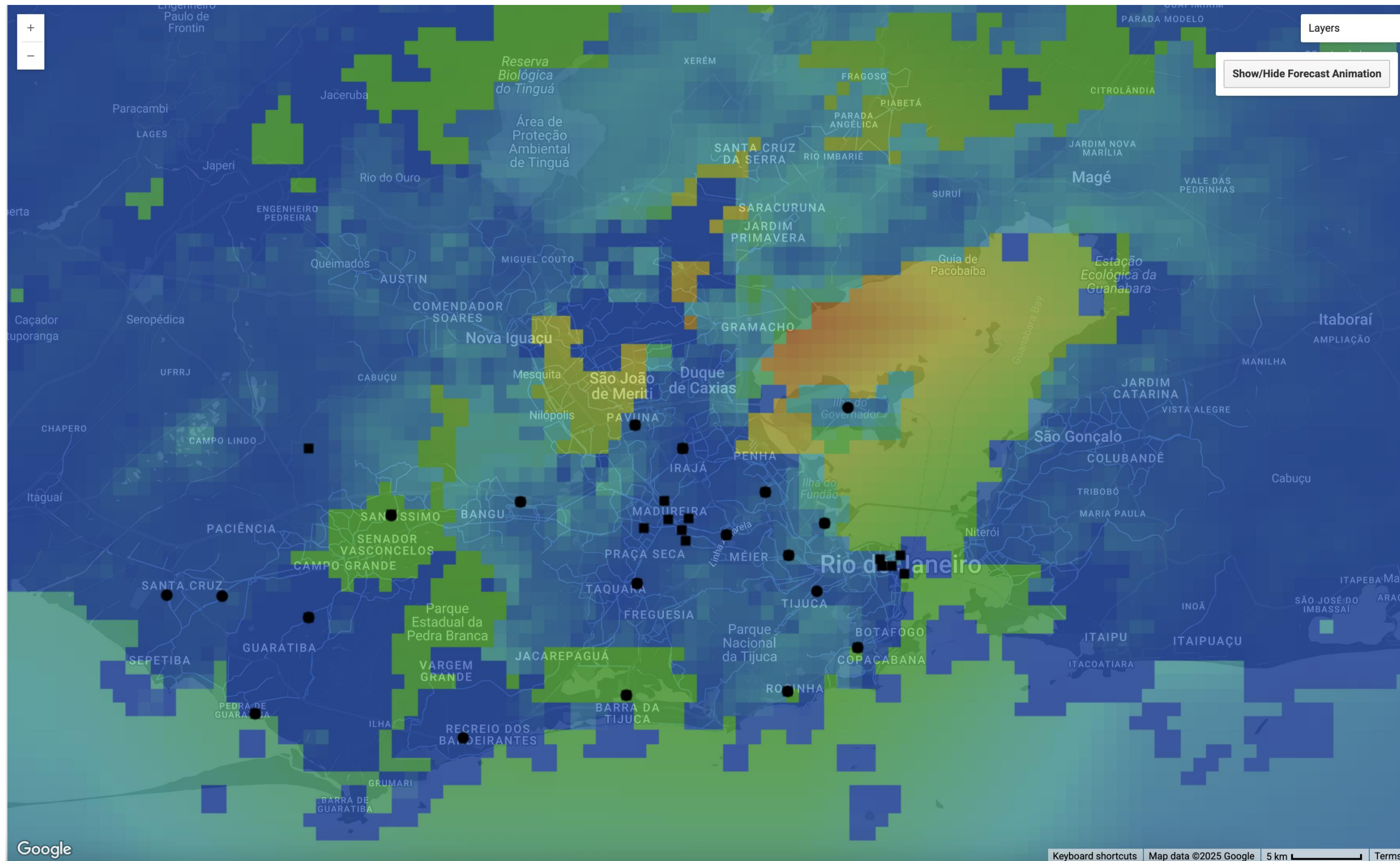
- Regulatory Monitor persistence forecast
- ... Low-Cost Sensor persistence forecast
- Data Fusion w/ non-local data (model + satellite)

# Results of Past Work (using London NO<sub>2</sub> data)



- Regulatory Monitor persistence forecast
- Low-Cost Sensor persistence forecast
- Data Fusion w/ non-local data (model + satellite)
- Data Fusion w/ local data (model + satellite + rgm + lcs)

# Operational Implementation in Google Earth Engine



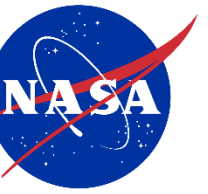
Work in Progress...

Only 1 regulatory PM<sub>2.5</sub> monitor for the city!

Recently supplemented with 25+ low-cost sensors

Local performance evaluation and calibration in progress

Preliminary qualitative assessment: more realistic PM<sub>2.5</sub> patterns when low-cost sensor data are considered.



Thank You!