

Vaisala Xweather Hyperlocal Air Quality Forecast

Street-by-street view of urban air quality for healthier cities

Net sales in 2022

514.2
MEUR

12%

of net sales
invested
into R&D

2,200+

employees
worldwide

25+

offices in

17

countries

300+

product
families

Business
in over

150

countries

Employee
engagement index

4.2 / 5

100%

renewable
electricity



9 out of 10 people worldwide breath polluted air

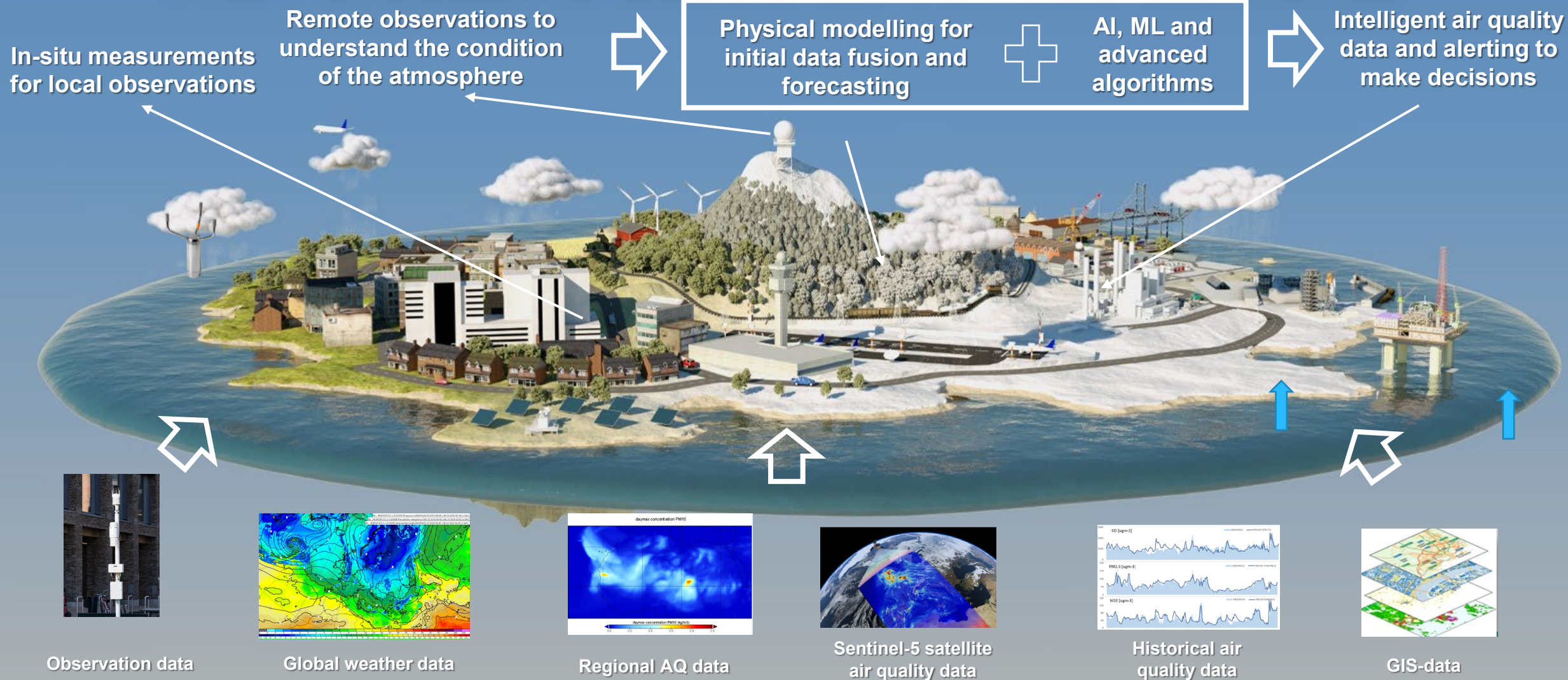
4th most common reason for death after high blood pressure, smoking and nutrition

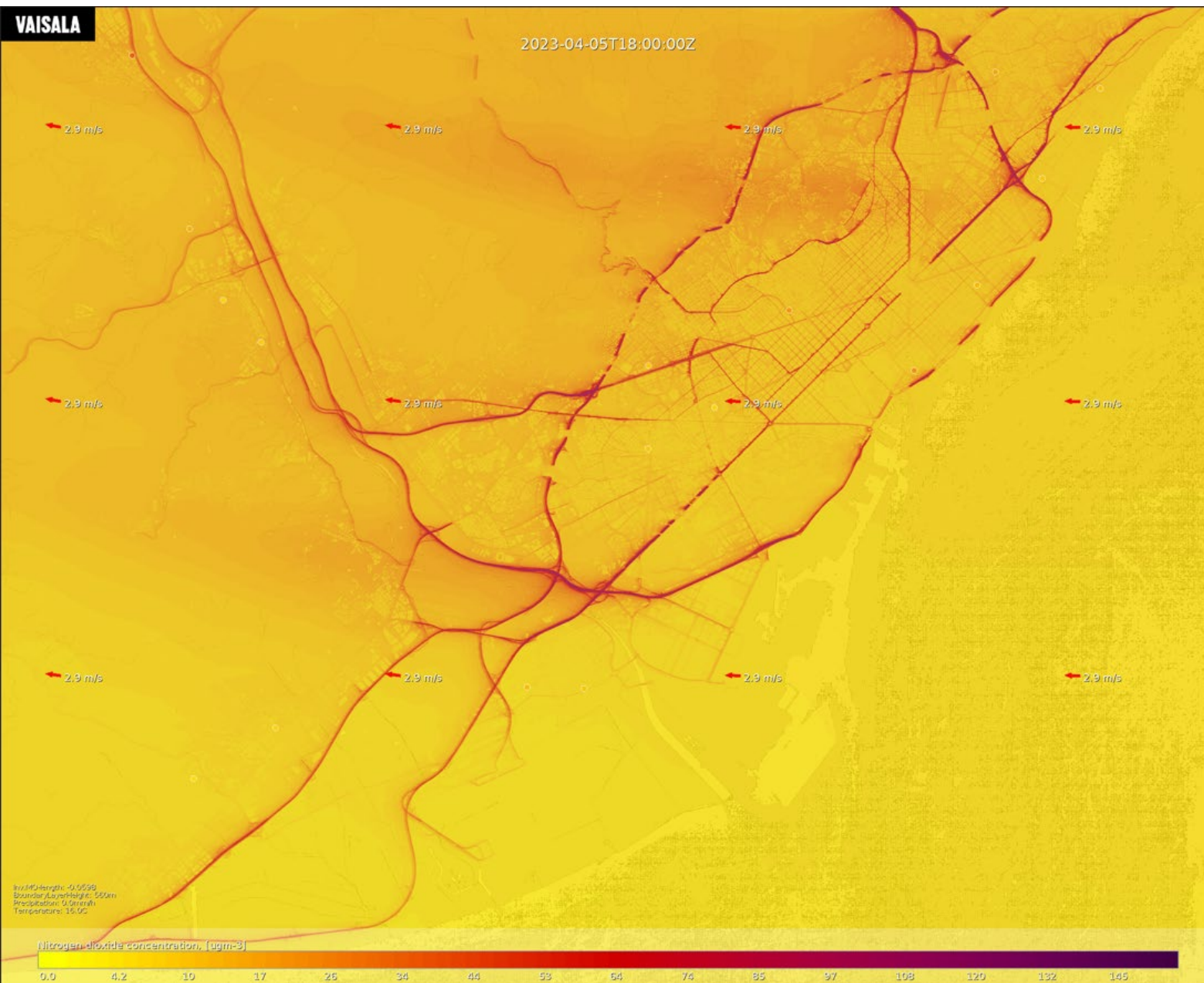
Ambient air pollution contributes to
5.4% of all deaths worldwide

7 million premature deaths worldwide per year

US\$ 5 trillion in welfare losses and **US\$ 255 billion in lost income**

AQ Forecast is based on various elements

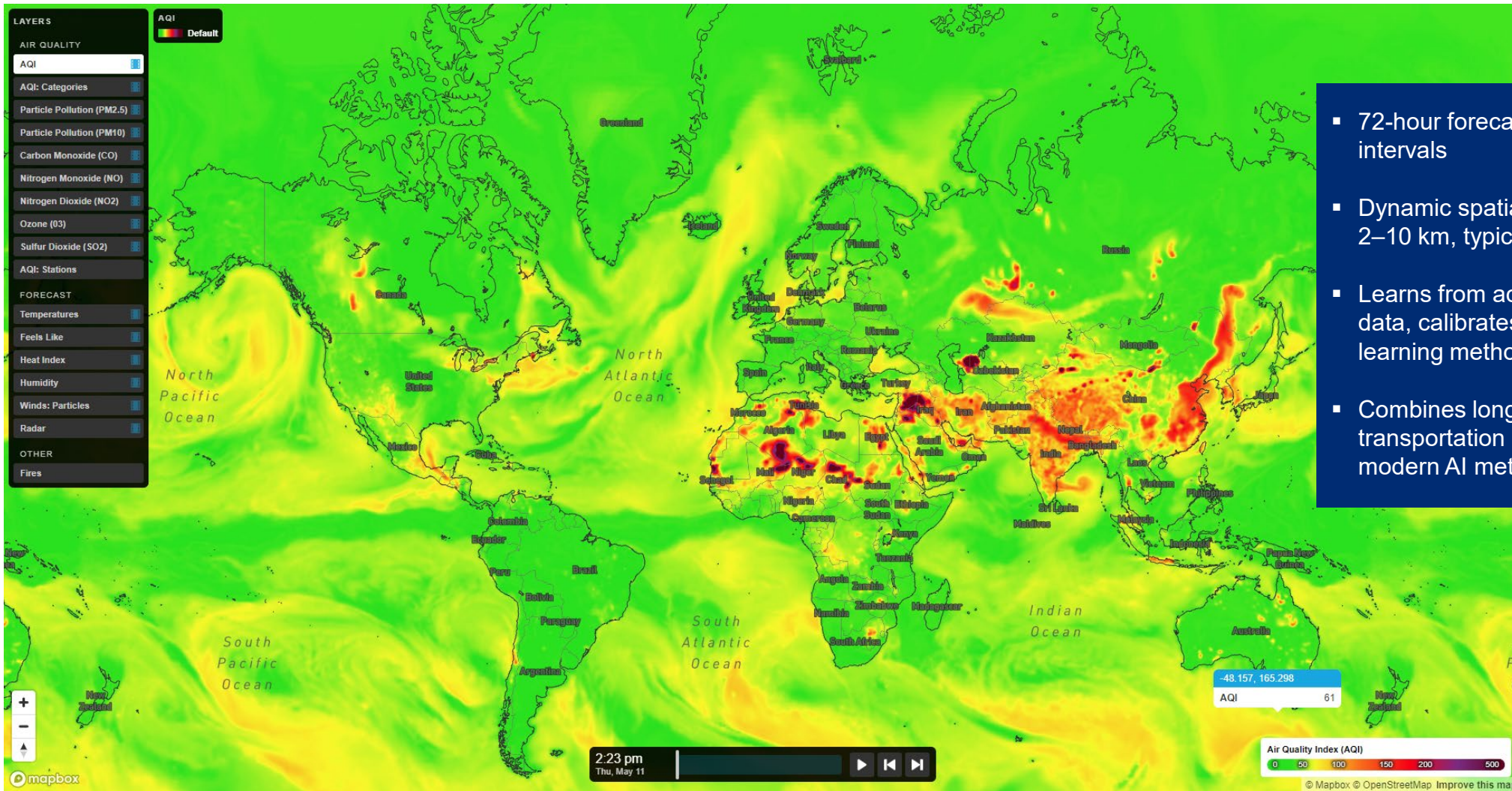




With current breakthroughs in data fusion and machine learning, we can now forecast air quality in urban environments with unprecedented accuracy

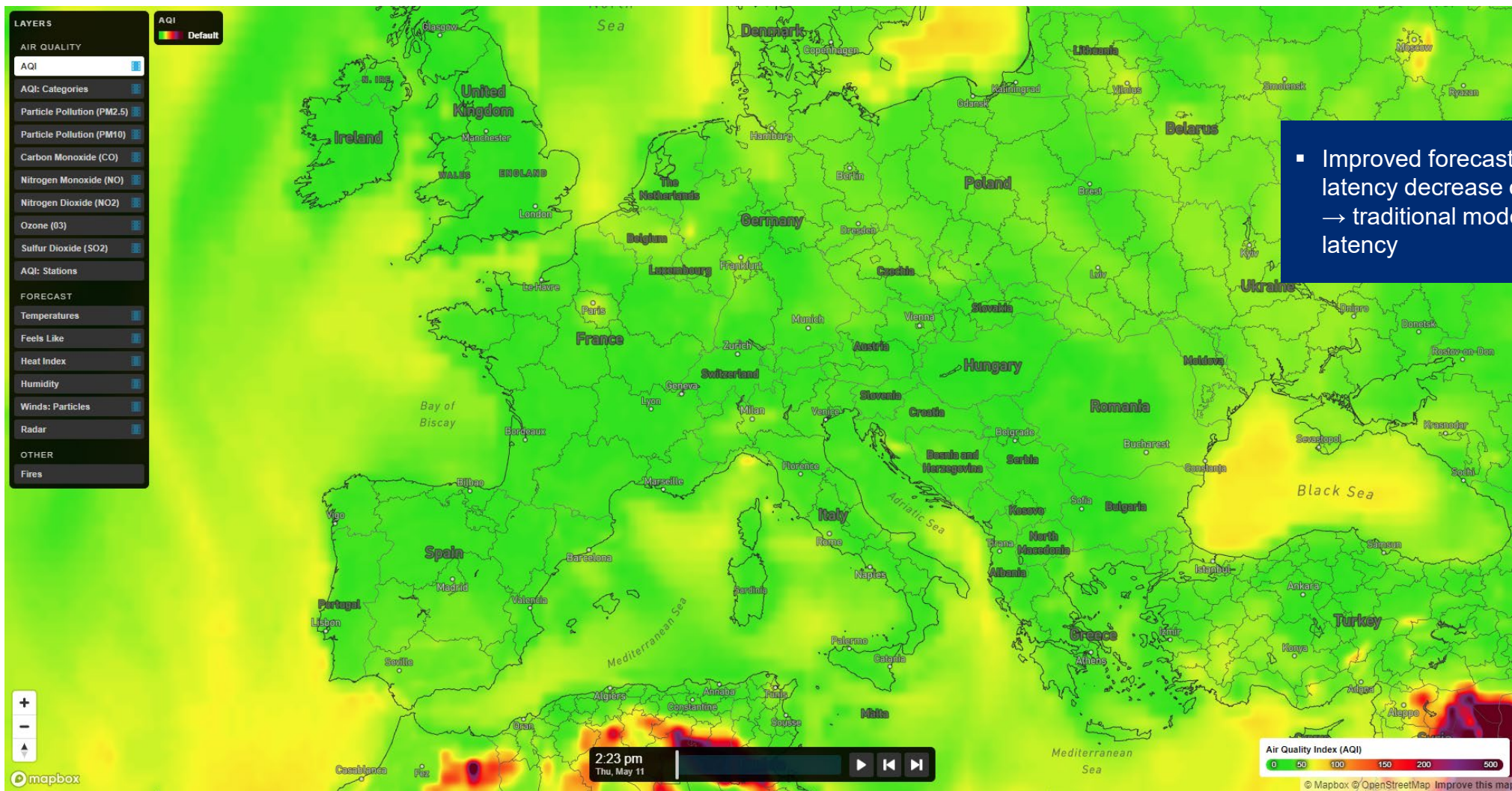
- Local levels of different pollutants
- Real-time view and forecasts
- Hyperlocal resolution to identify problem areas

Global forecast with unprecedented accuracy

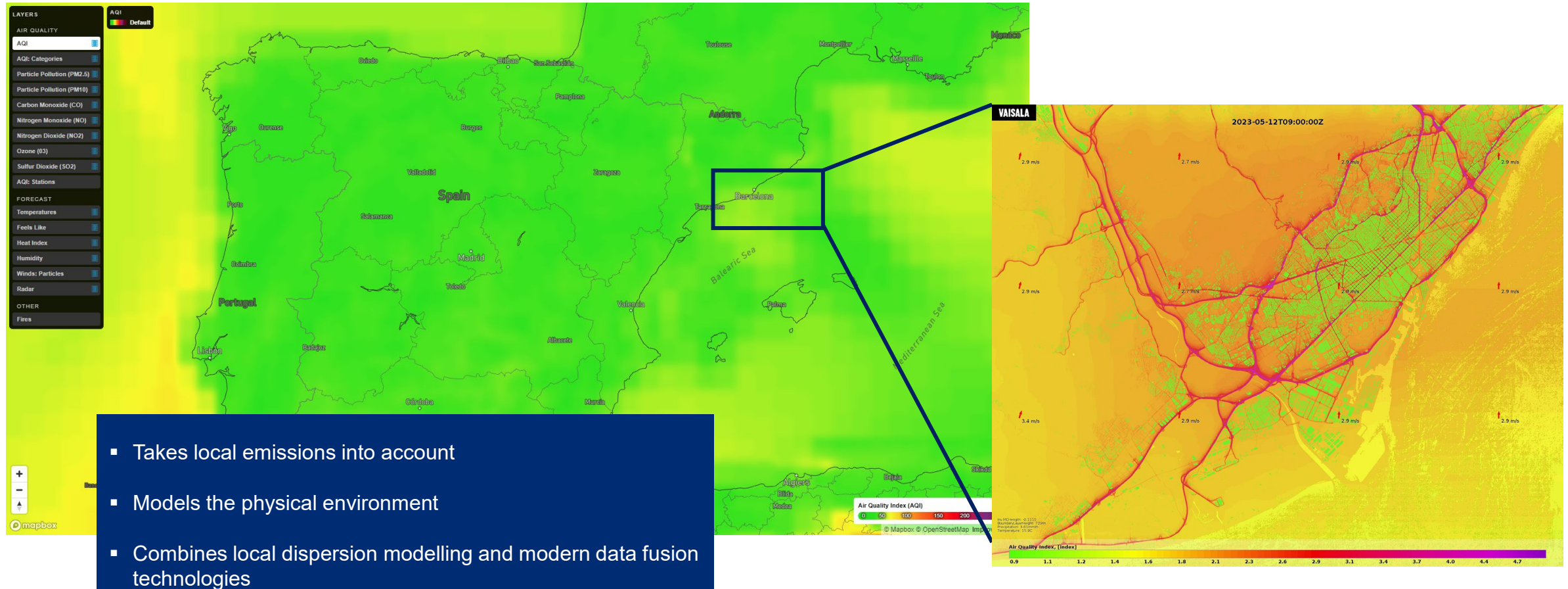


- 72-hour forecast in 1-hour intervals
- Dynamic spatial resolution from 2–10 km, typically 5 km
- Learns from actual measurement data, calibrates itself by machine learning methods
- Combines long range transportation modelling and modern AI methods

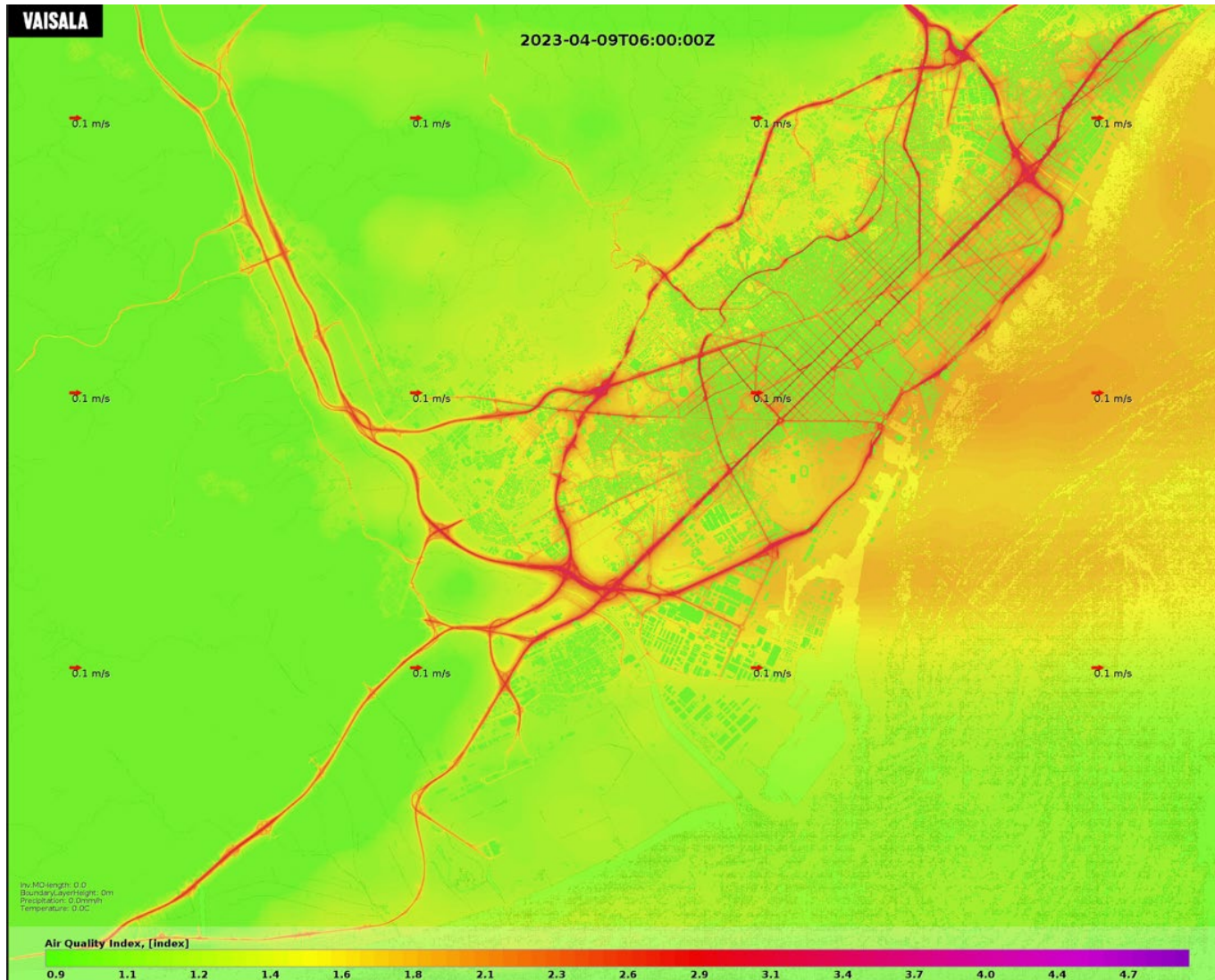
Continental forecast with outstandingly short latency



Regional forecast with unprecedented resolution



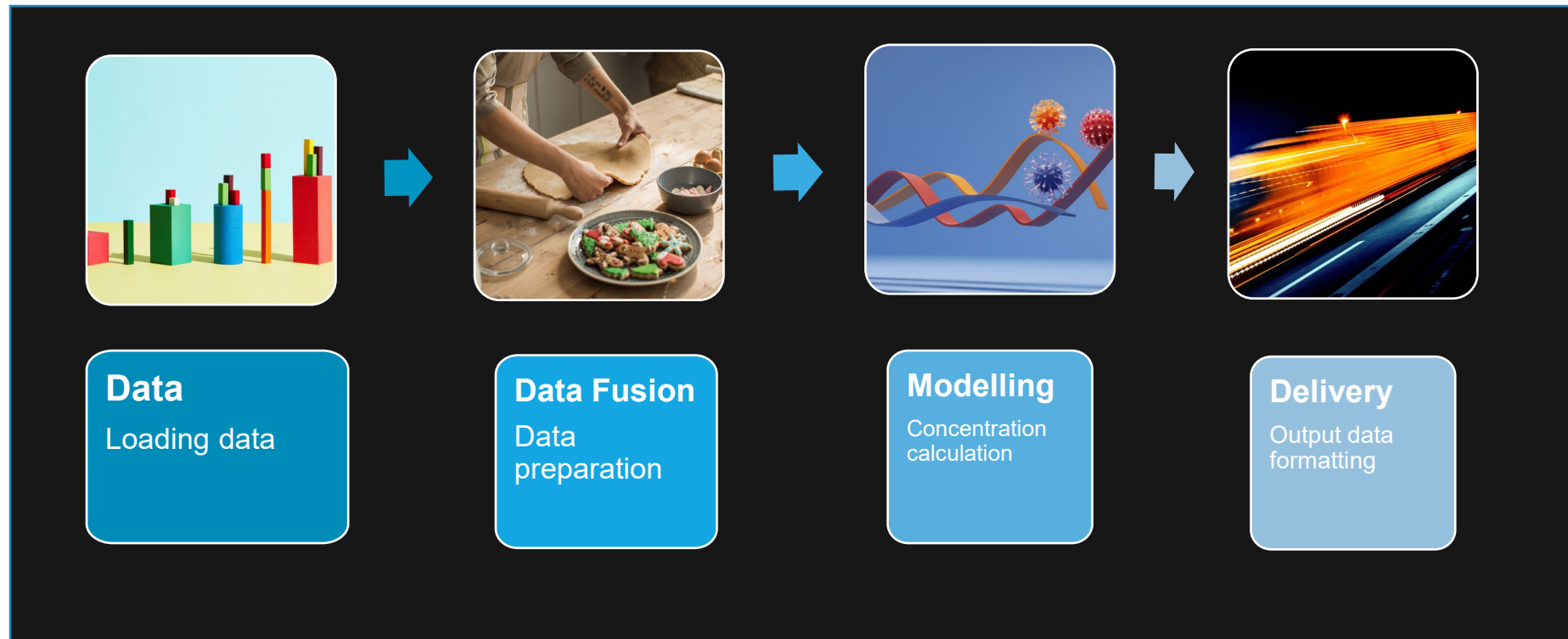
Hyperlocal forecasting



- Real-time view and 72-hour forecast of the air quality index and individual levels of CO, NO, NO₂, O₃, SO₂, PM_{2.5}, and PM₁₀ levels in urban environments with **15-meter hyperlocal resolution.**
- Data fusion combines multiple datasets and information sources:
 - OpenStreetMap, satellite images, ground elevation data, chemical transport models, real-time traffic data
- Automatically adaptive dispersion and emission source modelling
- The solution can be setup without prior knowledge of local emission sources.

Solution details

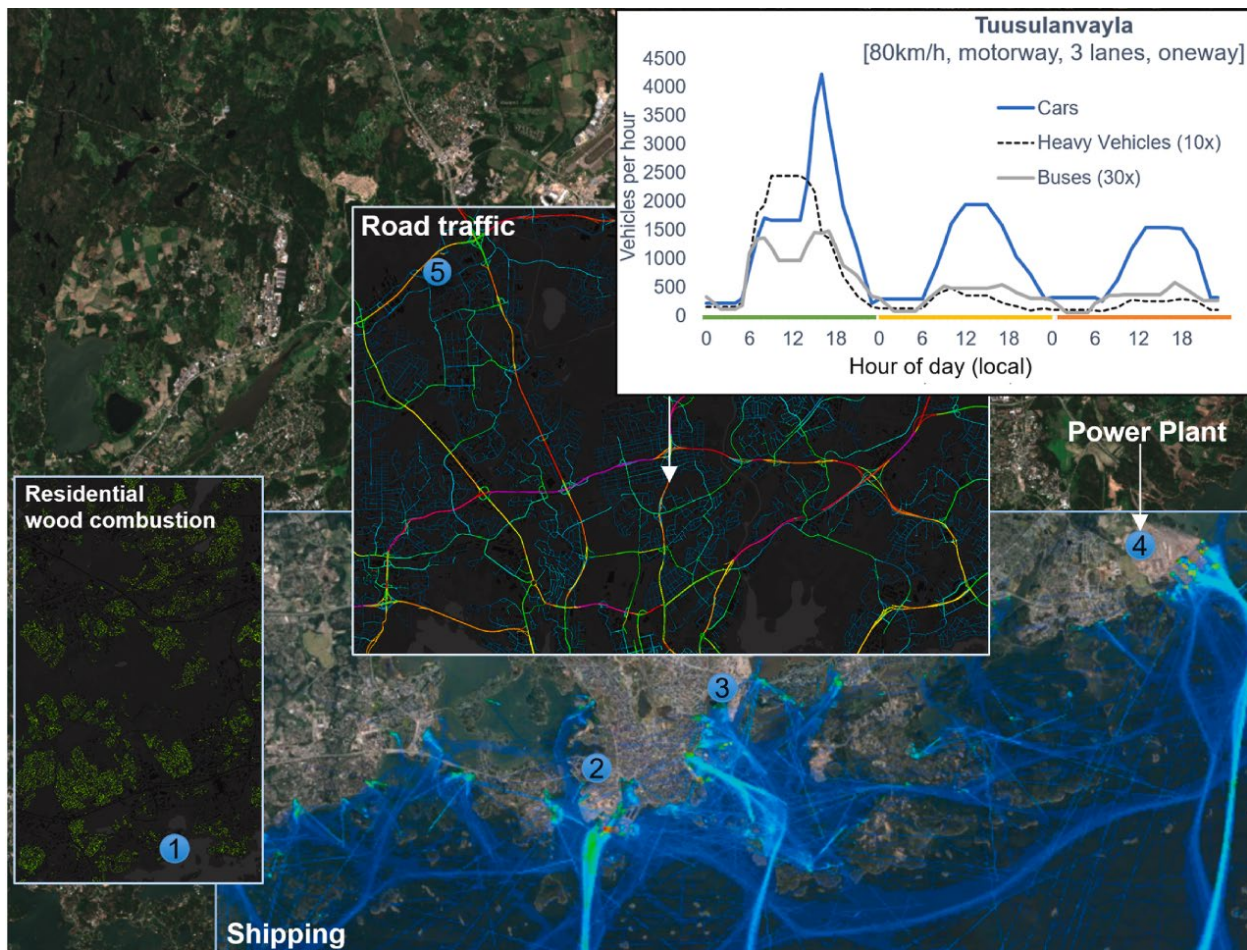
Proactive insights for real-time air quality problems



Static and dynamic data — global and local



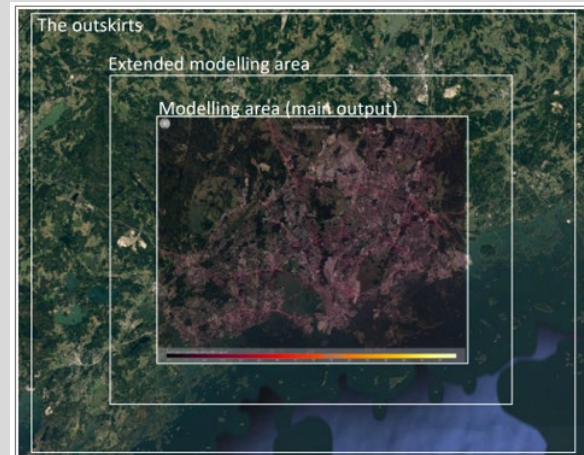
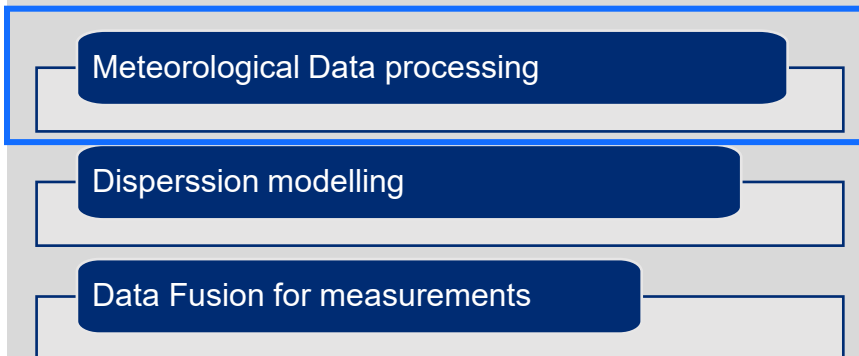
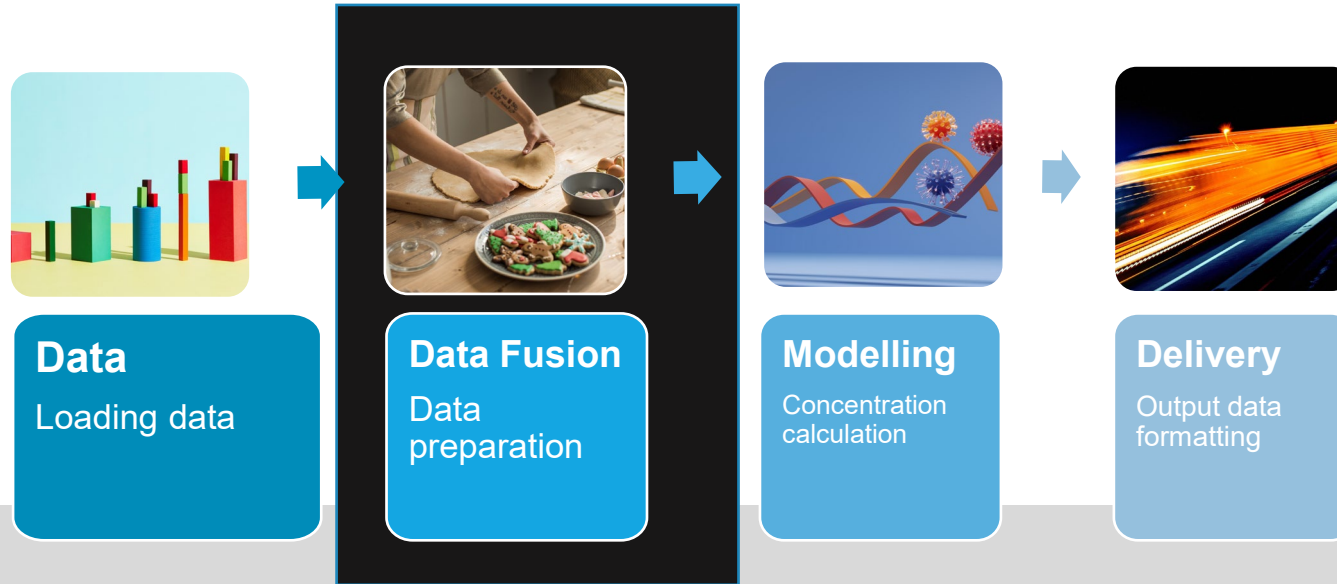
Emission inventories details



From: L. Johansson et al. "An operational urban air quality model, based on dispersion modelling and data assimilation" in Environmental modelling and software. Elsevir: <https://www.sciencedirect.com/science/article/pii/S1364815222001657>

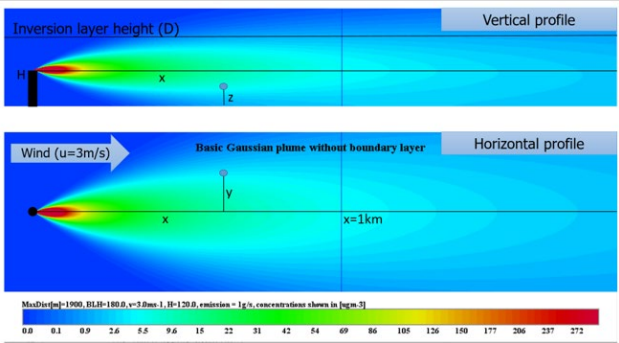
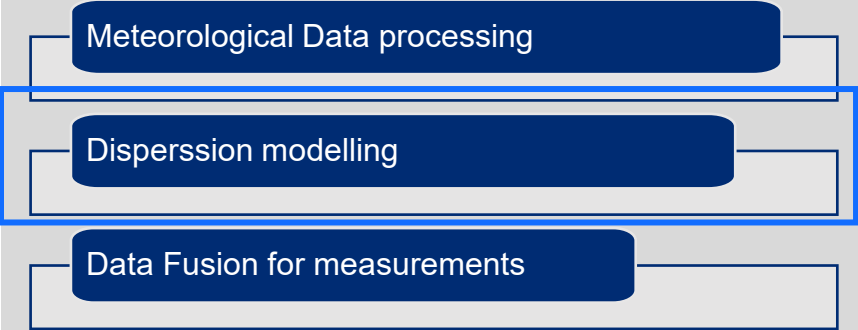
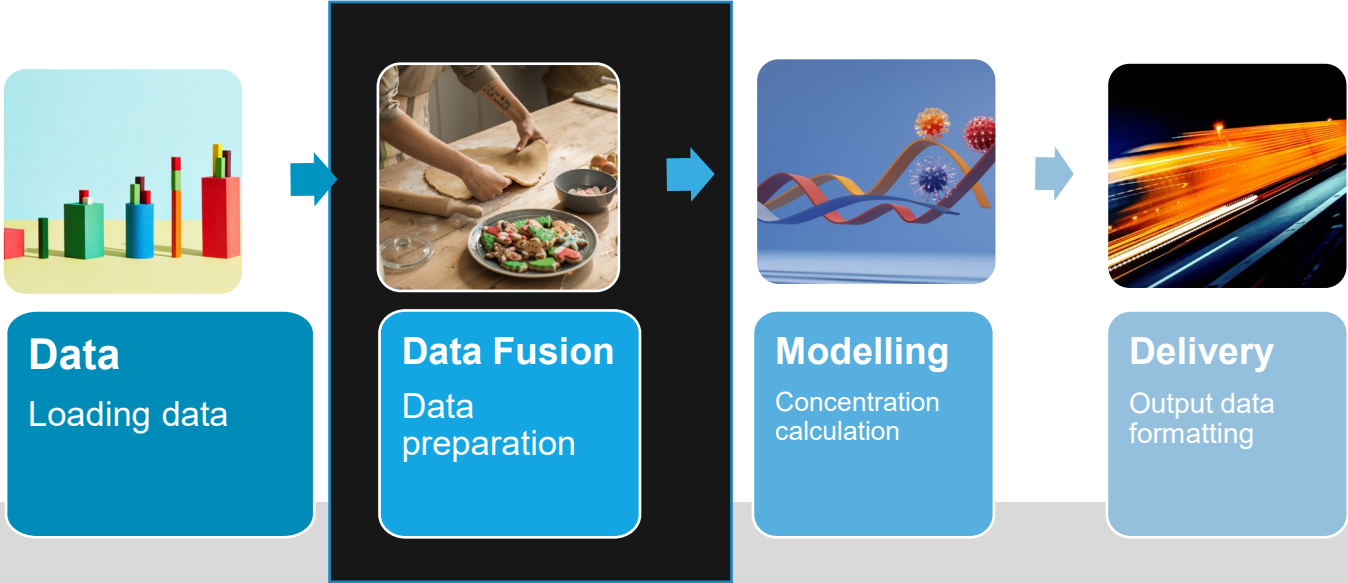
- Urban source categories vary depending on several factors: location, weather, main activities, etc
- Gridded annual or monthly emission data set are used
- Temporal profile to sequence emission release rate is defined
- Example for Helsinki Metropolitan Area is presented in the left

Large-scale data fusion for your city

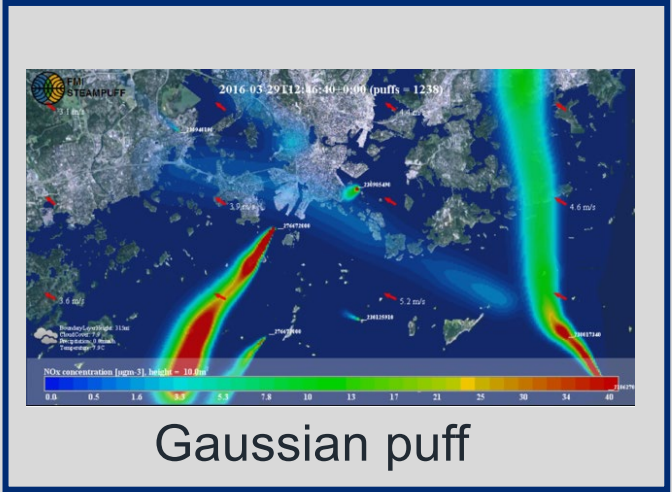


- Meteorological data over the modelling area
- Duration of the modelling task

Large-scale data fusion for your city

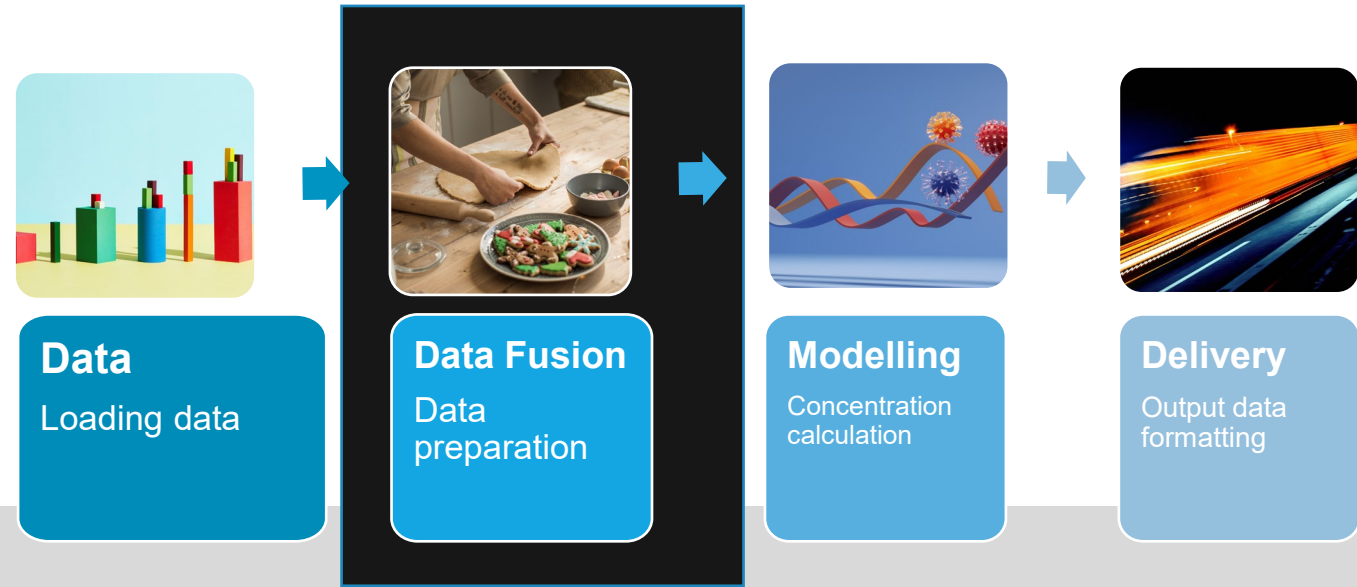


Gaussian plume



Gaussian puff

Large-scale data fusion for your city



- Meteorological Data processing
- Dispersion modelling
- Data Fusion for measurements**

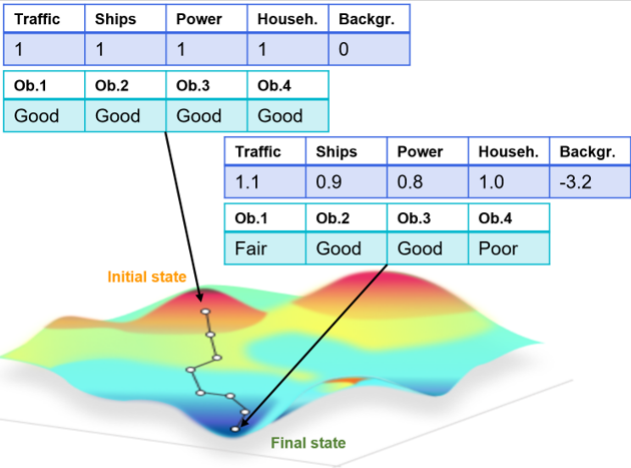
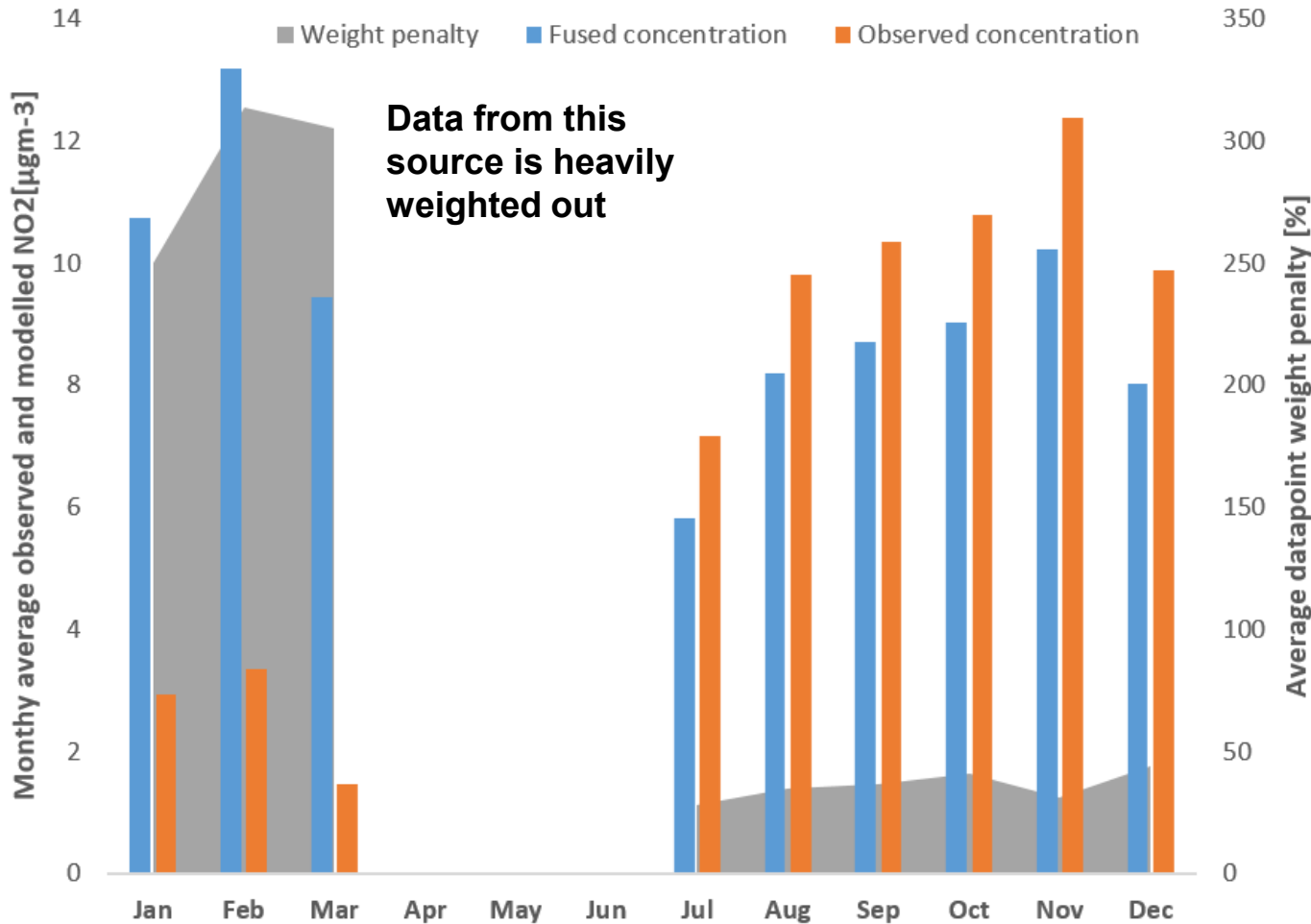


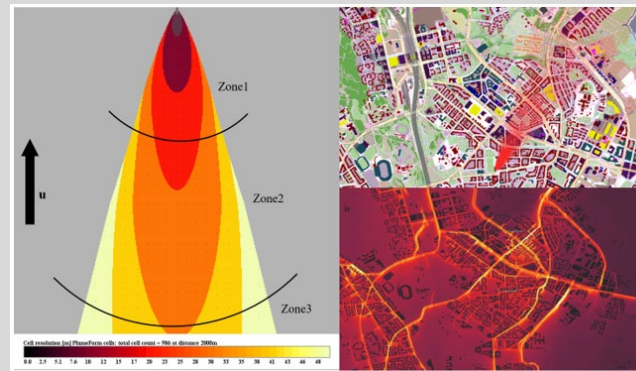
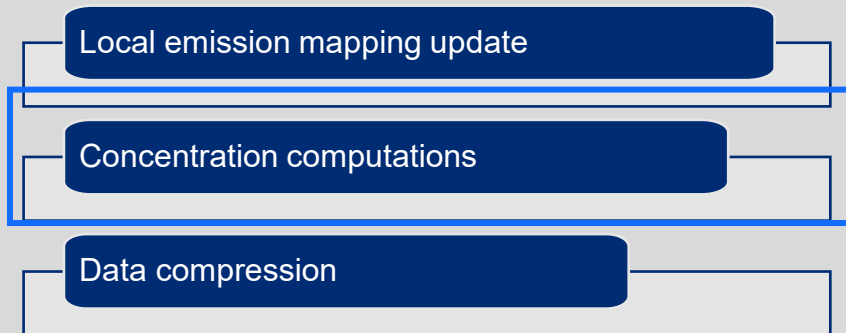
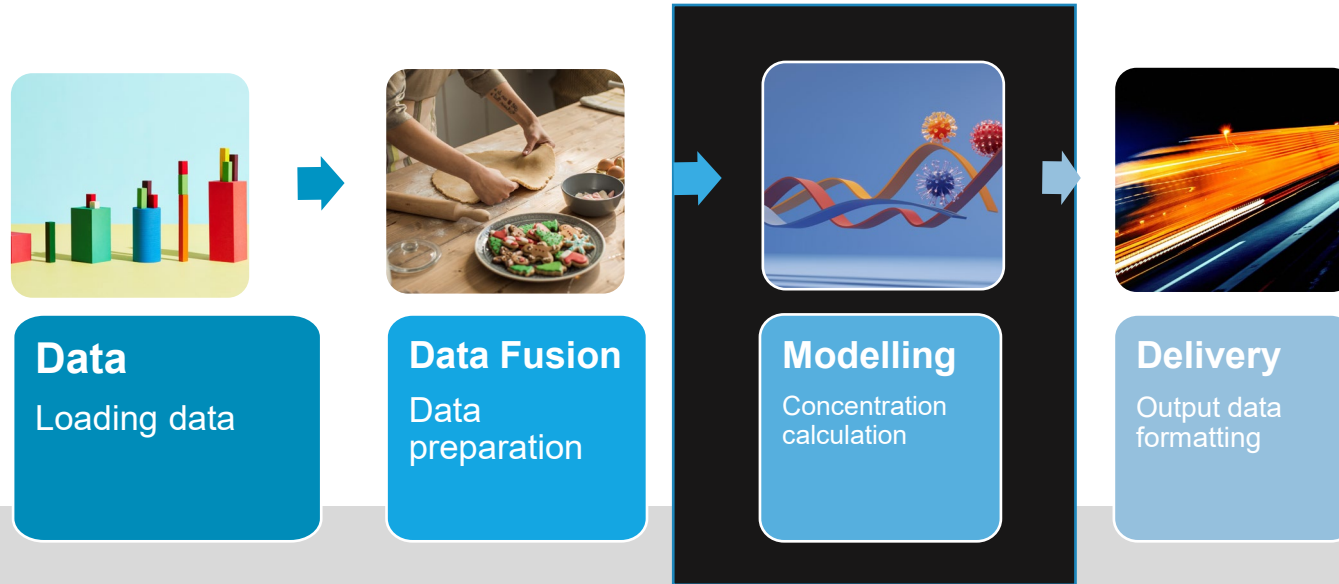
Figure 10: Illustration of the data fusion gradient descend algorithm. Starting from an initial, unadjusted state, the iterations proceeds to find directions in which the rate of improvement is highest, and then takes a step along that direction. When there are no directions that provide improvements the iteration terminates at a final state.

Quality of observations is evaluated in real time



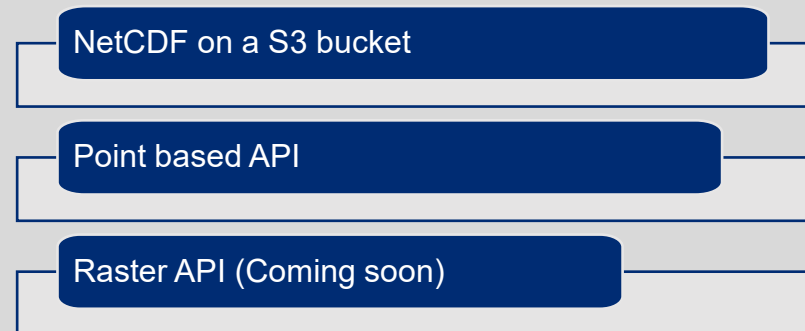
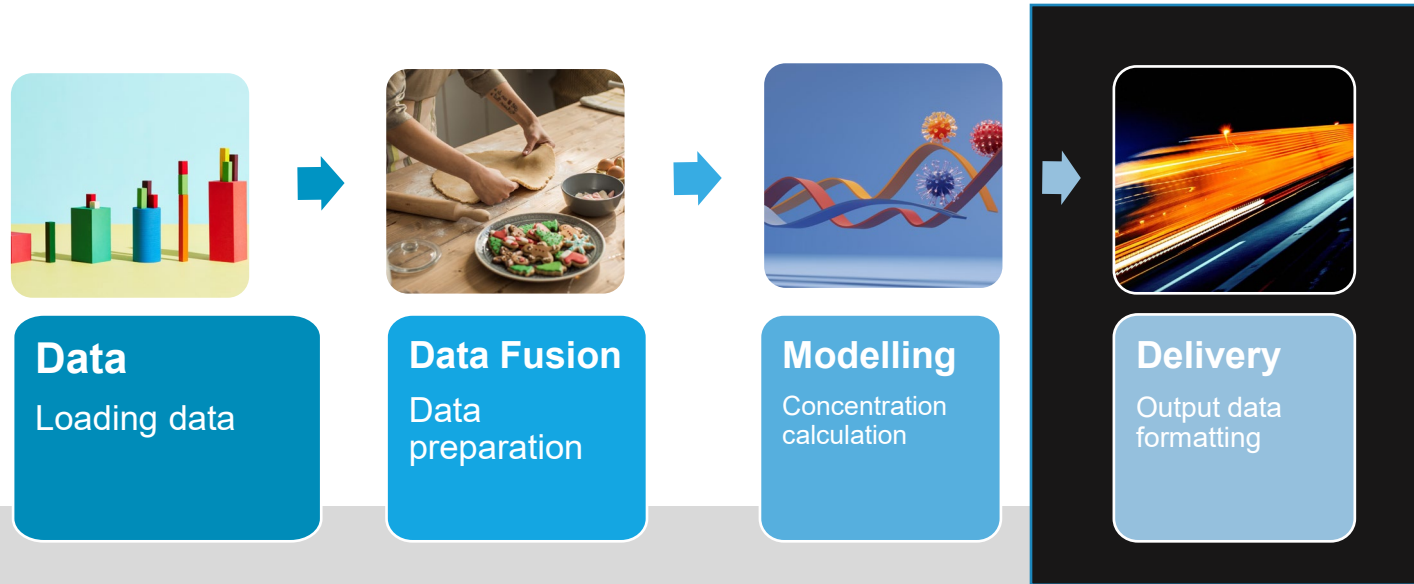
- Even the highest quality measurement stations can malfunction.
- Large scale data fusion provides multiple different sources as alternative data sources
- Vaisala Hyperlocal Air Quality Forecast can automatically filter data that is not in-line with other AQ information evidence

Most advanced air quality forecast



- Gaussian plume used for close by emission sources
- Puff dispersion are stock on top of plume
- Data fussion based adjustments aplied

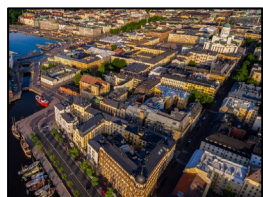
Delivering local insights for your city



Strong scientific foundation

Xweather hyperlocal model has been developed in partnership with leading meteorological agencies, research institutes, and universities

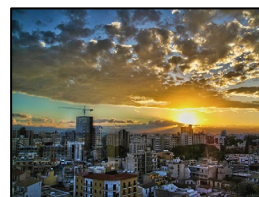
TESTBED PROJECTS & VALIDATIONS



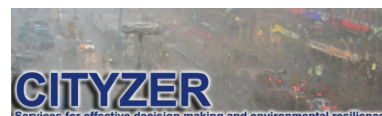
Helsinki, Finland



Nanjing, China



Nicosia, Cyprus



SELECTED PAPERS

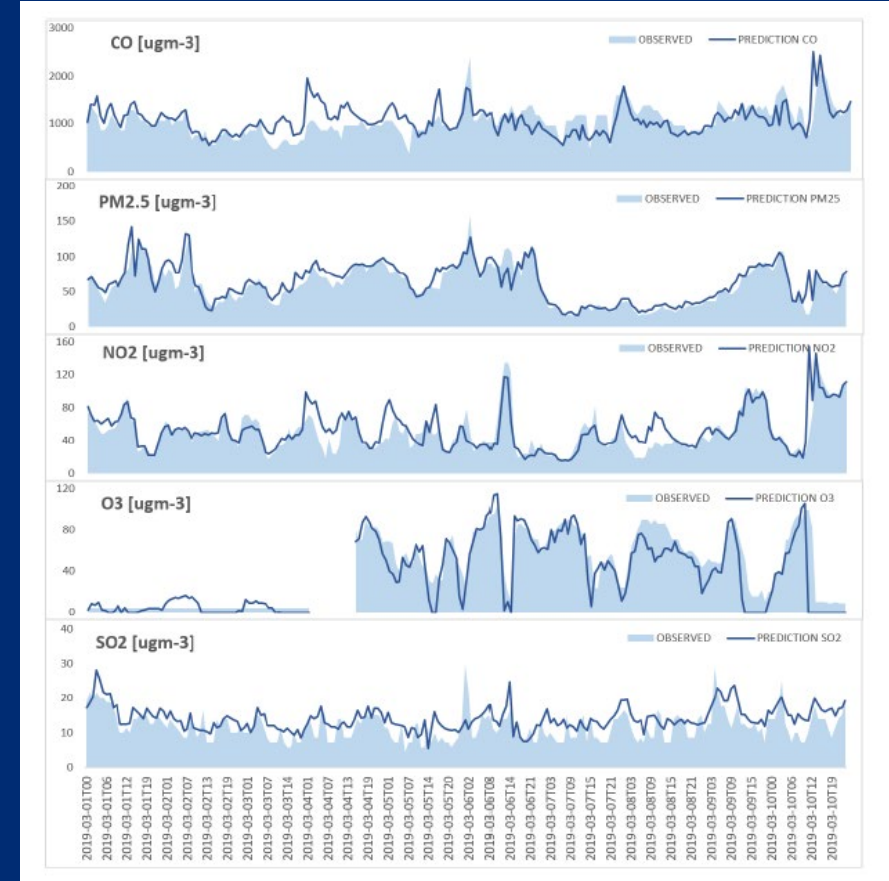
- Johansson, L., Karppinen, A., Kurppa, M., Kousa, A., Niemi, J. Description of an operative local scale air quality model FMI-Enfuser (Part 1), to be submitted to Environmental Modelling and Software, 2021.
- Johansson, L., Kurppa, M., Karppinen, A., Kousa, A., Niemi, J. Evaluation of an operative local scale air quality model FMI-Enfuser (Part-2), to be submitted to Environmental Modelling and Software, 2021.
- Johansson, L., Epitropou, V., Karatzas, K., Karppinen, K., Wanner, L., Vrochidis, S., Bassoukos, A., Kukkonen, J. and Kompatsiaris, I. Fusion of meteorological and air quality data extracted from the web for personalized environmental information services. Environmental Modelling & Software, Elsevier, 64 (2015) 143-155.

SELECTED CONFERENCE PAPERS

- Poom, A., Helle, J., Willberg, E., Toivonen, T., Poom, A., Willberg, E., Toivonen, T. and Helle, J., 2021. Examining environmental exposure during travel-routing tool and population-level analysis. In The 17th International Conference on CUPUM-Computational Urban Planning and Urban Management.
- Mensink, C. and Volker, M., Air Pollution Modeling and its Application XXVII, Springer International Publishing, doi:10.1007/978-3-662-63760-9, 2021.
- Johansson, L., Karppinen, A. and Loven, K., Evaluation of Air Quality Using Dynamic Land-use Regression and Fusion of Environmental Information, Proceedings of the 2nd International Workshop on Environmental Multimedia Retrieval, Pages 33-38, ACM New York, NY, USA, ISBN: 978-1-4503-3558-4, 2015.
- Karppinen, A. and Johansson, L. "Fusion of Air Quality Information: Evaluation of the Enfuser-Methodology in Finland and a Case Study in China." International Technical Meeting on Air Pollution Modelling and its Application. Springer, Cham, 2016.
- L. Johansson and A. Karppinen, Demonstration of real-time air quality modelling systems – Helsinki and Nanjing testbeds, 11th International conference on air quality – Science and Applications, ISBN: 978-1-5272-2150-5, DOI: 10.18745/PB.19829, Spain, 2018.
- Johansson, L., A service platform based on a low-cost, dense air quality monitoring network and the fusion of environmental information, Korea-Austria Energy & Environment Forum - Bioenergy, Air Quality and Machine Learning, November 23-24, 2017, Vienna, Austria
- Laakso, M. and Johansson L., New tools for Air quality modelling and forecasting: compact Sensors Combined with a data fusion model with forecasting capabilities, National Air Quality Conference, Austin, Texas, January 2018.

Proven performance

- The Xweather air quality model is scientifically peer-reviewed and has a strong academic research group behind it
- The Xweather productized version of the model runs live projects comparing observations with hyperlocal model results in three diverse cities
- Each pollutant component is validated individually
- The model's predictions closely match the observations, and quality can be enhanced by adding more sensors



Model prediction versus measurements of hourly concentration of CO, PM_{2.5}, NO₂, O₃, and SO₂ for a station in Nanjing Center, China for 10 days in March 2019.

How can air quality data be used in your city?

From reactive to proactive



Monitoring



Mitigation



Warnings



Smart city

**With better information,
people become more
aware, active, and
committed.**

Air quality forecast allows cities to ACT



Proactive and pre-emptive health care



Intelligent traffic management



Smart urban planning for cities



Anticipating effects of fire forest



Polution control in industries (ports, airports, mines)



Mobility



Use case details

Air quality forecast allows individuals to act proactively

- Anticipate hospitalization due to bad air quality events
- Warnings to vulnerable groups:
 - People with respiratory illnesses
 - Schools, kindergartens
 - Communities exposed to pollution



Proactive and pre-emptive health care



Intelligent traffic management



Smart urban planning for cities



Anticipating effects of fire forest



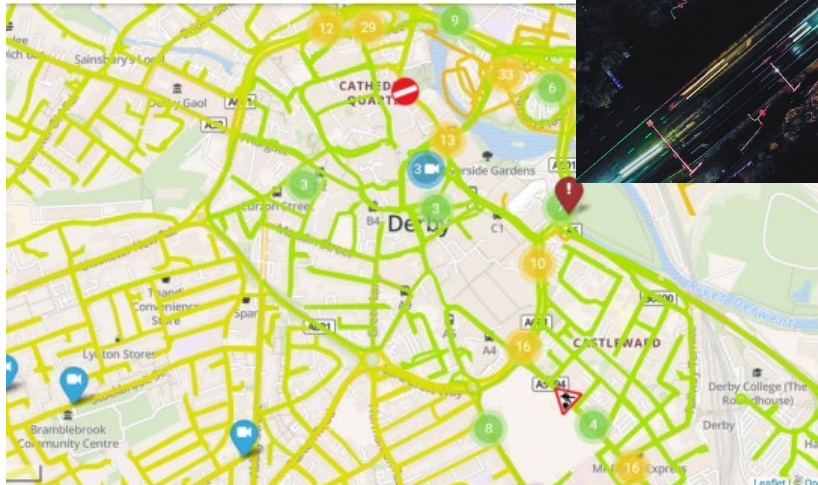
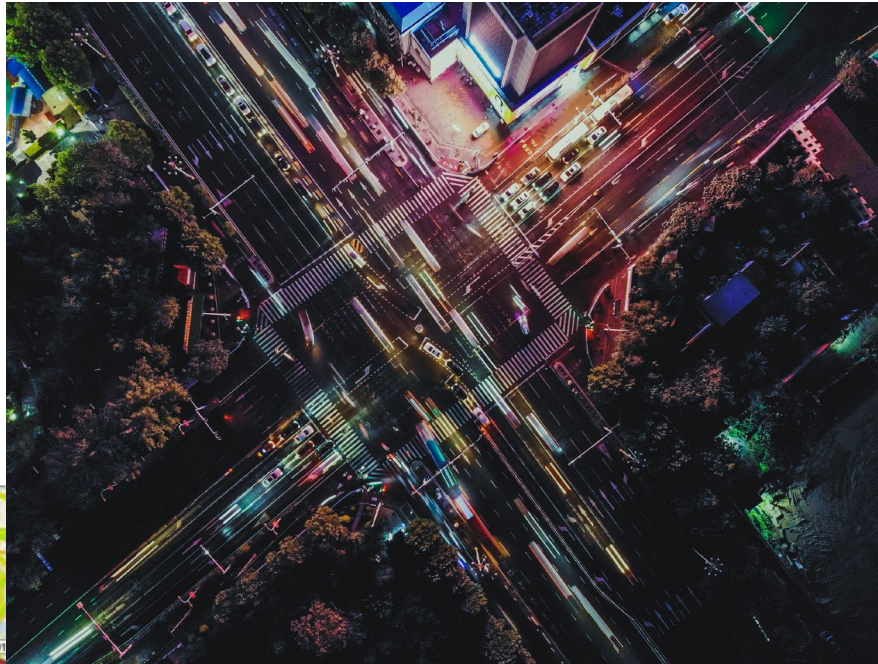
Polution control in industries (ports, airports, mines)



Mobility

Air quality forecast allows individuals to act proactively

- Traffic routing
- Health route



Proactive and pre-emptive health care



Intelligent traffic management



Smart urban planning for cities



Anticipating effects of fire forest



Pollution control in industries (ports, airports, mines)



Mobility

Air quality forecast allows individuals to act proactively

- Design city structures to support good air quality
- Avoid concentration accumulation within city structures
- Environmental justice initiative support, population exposure



Proactive and pre-emptive health care



Intelligent traffic management



Smart urban planning for cities



Anticipating effects of fire forest



Polution control in industries (ports, airports, mines)



Mobility

Air quality forecast allows individuals to act proactively

- Impact of nearby wildfires to air quality



Proactive and pre-emptive health care



Intelligent traffic management



Smart urban planning for cities



Anticipating effects of fire forest



Polution control in industries (ports, airports, mines)



Mobility

Air quality forecast allows individuals to act proactively

- Monitor of pollution levels around facilities
- Proactive actions to polluting events
- Compliance with regulation



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Proactive and pre-emptive health care



Intelligent traffic management



Smart urban planning for cities



Anticipating effects of fire forest



Polution control in industries (ports, airports, mines)



Mobility

Air quality forecast allows individuals to act proactively

- Pollution free walking and cycling routes
- Promote use of public transportation (free tickets)



Proactive and pre-emptive health care



Intelligent traffic management



Smart urban planning for cities



Anticipating effects of fire forest



Polution control in industries (ports, airports, mines)



Mobility

Air quality for Intelligent traffic management

- Traffic is the dominant source of NO₂, PM_{2.5}, and PM₁₀ pollutants in urban areas.
- In busy intersections and congested areas, populations are exposed to poor air quality.
- With air quality data from key locations, city and traffic management authorities can:
 - evaluate the severity of the situation in real time.
 - use the data as input for dynamic traffic management to reduce congestion and divert traffic from heavily affected areas



AQT530 installation in Germany

Hyperlocal concentrations provide detailed information on key pollutants and indicators of their sources enabling a proactive approach to air quality

Key Characteristics of Xweather hyperlocal air Quality



Scalable data solution, using the latest cloud architecture



Near Real-time view and **forecasts up to 72 hours ahead**



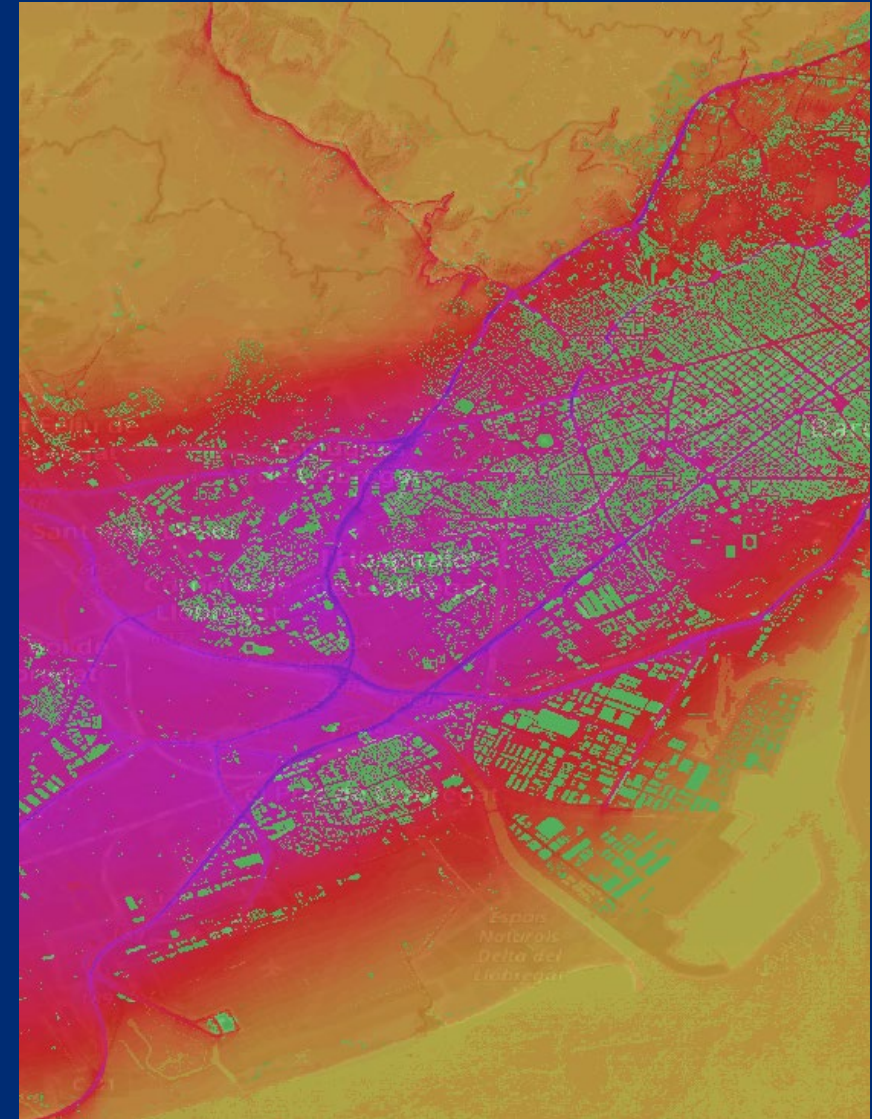
Local levels of CO, NO, NO₂, O₃, SO₂, PM_{2.5}, and PM₁₀



Hyperlocal 15-meter resolution to identify problem areas

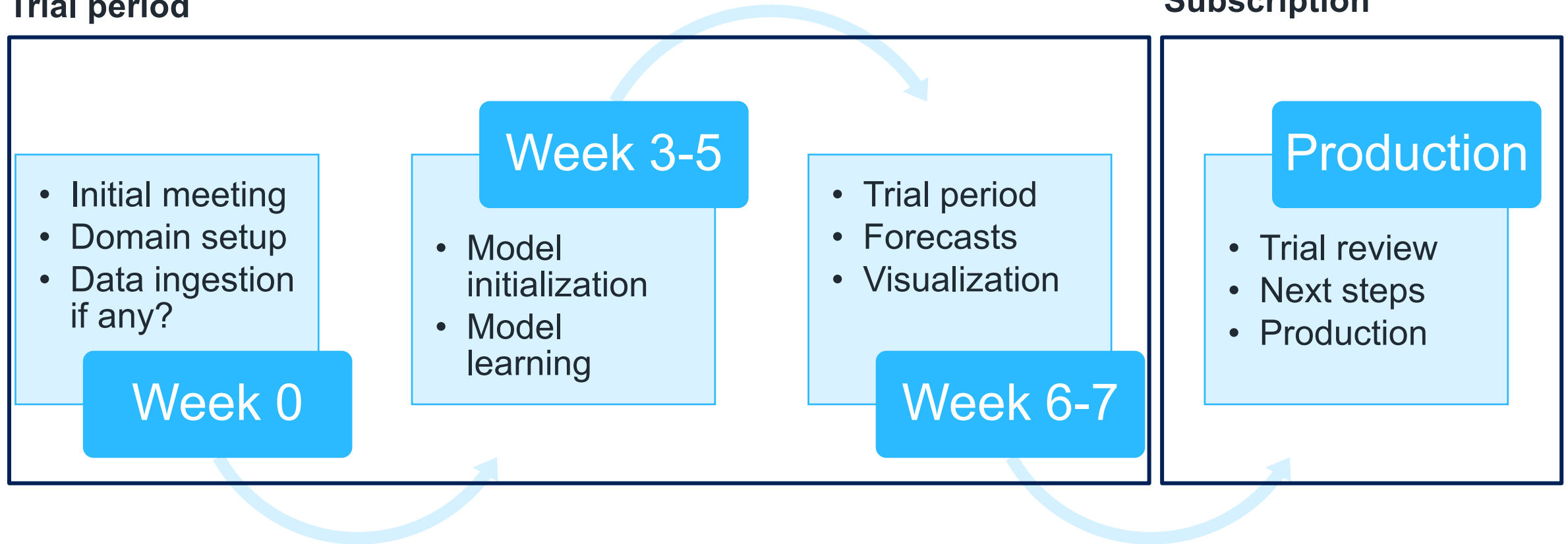


Based on physical environment model and novel AI/ML techniques



Hyperlocal Air Quality Forecast data subscription

Trial period





Thank you

