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FMI/Air Quality modelling

Research Manager,
Ari Karppinen
12/2021

https://en.ilmatieteenlaitos.fi/atmospheric-dispersion-modelling-group

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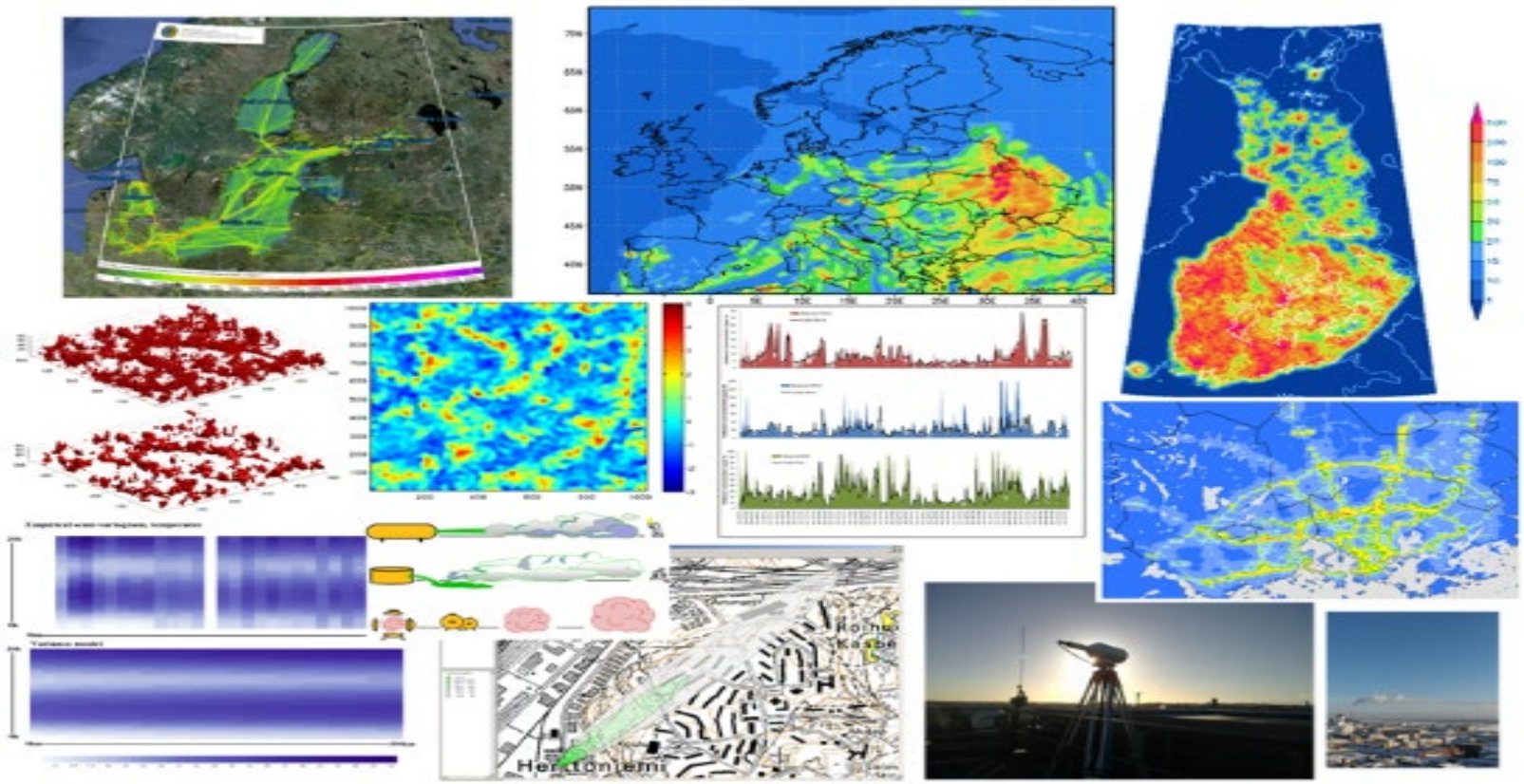
+ Prof. Jaakko Kukkonen (EU/EMERGE)
+ Prof. Jouni Jaakkola(Health, Epidemiology)

NOTE! In addition to these people, there is also the ”FMI Air Quality expert Sevices group”: ” https://en.ilmatieteenlaitos.fi/air-quality-services” (katja.loven@fmi.fi)

Atmospheric Dispersion Modelling

~30 researchers



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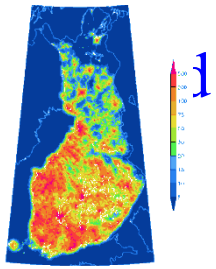
Emphasis on specific research areas

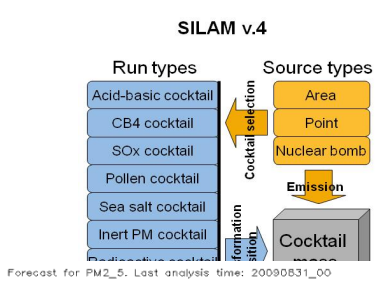
- Computational fluid dynamics
- Accidents involving hazardous materials
- Local air quality modeling
- Regional air quality modeling
- Air quality forecasts
- Environmental information fusion service
- Surveying maritime emissions
- Urban boundary layer network

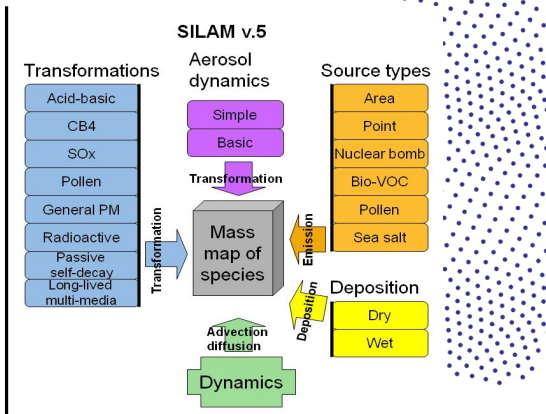
AQMg : the aims

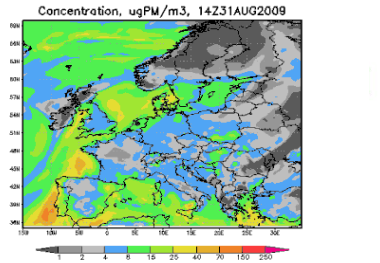
1. **Development and evaluation of air quality models : from microscale to global scale**
2. Integration of meteor l i l models (including cli l dispersion models
3. Efficient use of all av measurement information
4. Application of models, and dissemination of information:

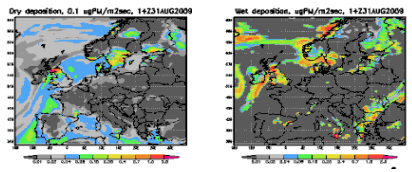
   co-op: with other FMI groups/units!

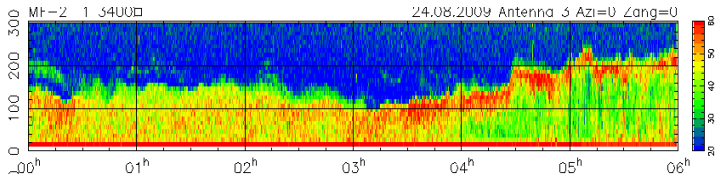


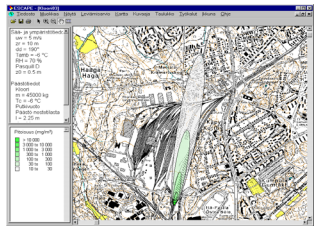


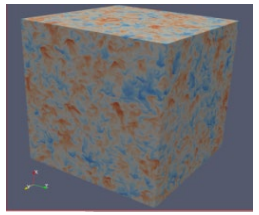


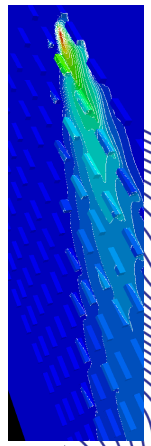












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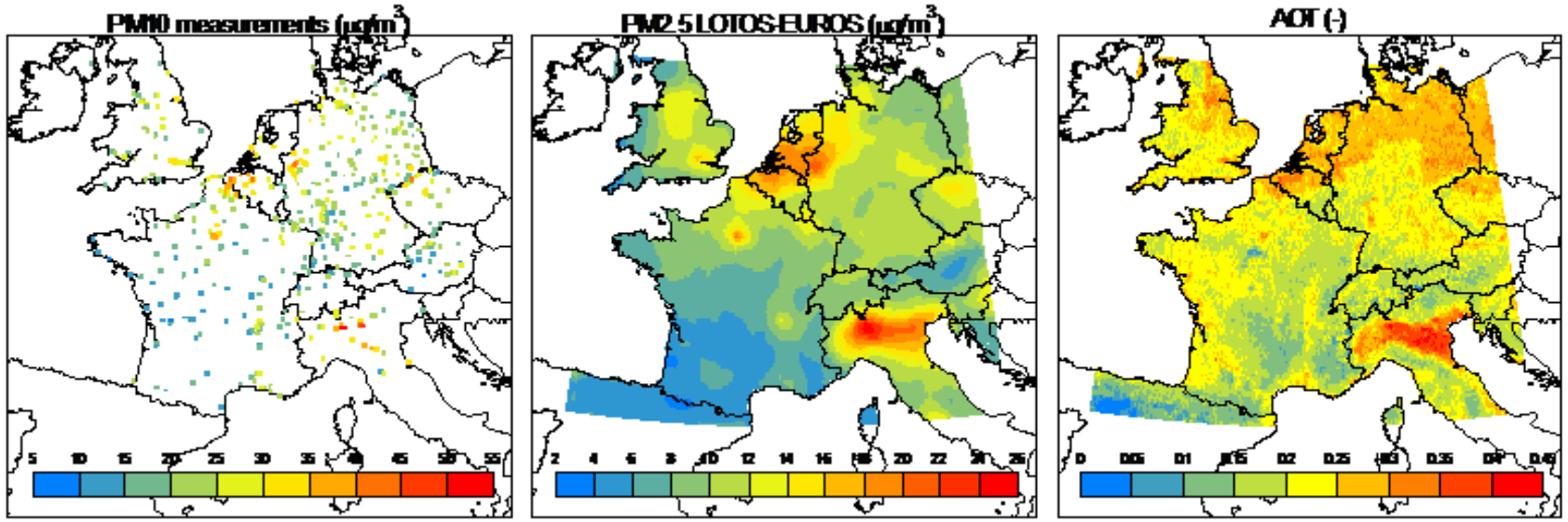
Integrated use of models and data

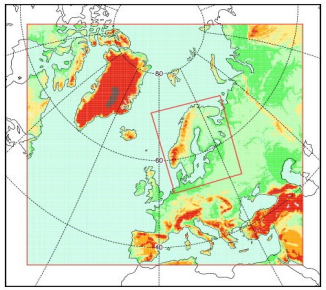


Monitoring Models Satellite

Goal: operational system taking into account all sources of information (EnFuser/SILAM)

Modelling system - FMI

Weather prediction models

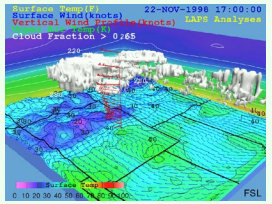


ECMWF

HIRLAM (7.5)

HARMONIE (2.5)

Harmonie (1.0)



Dispersion models - long-range, regional

SILAM **LRT**, meso-scale, radioactivity , **pollen**

Aerosol process models:

SALSA(UH,UKU,FMI)
SILAM-APMs

EnFuser (data fusion)

Dispersion and effects models – urban, local

CAR-FMI, roadside

UDM-FMI, urban

OSPM (NERI), street canyon

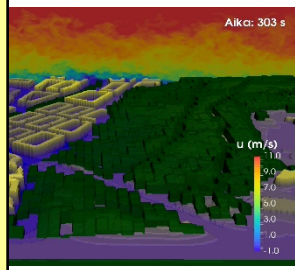
BUOYANT, fires

ESCAPE, chemical accidents

PALM, LESCAPE

EXPAND (FMI, YTV) population exposure

MPP-FMI, Meteorological pre-processing model



AQ measurements

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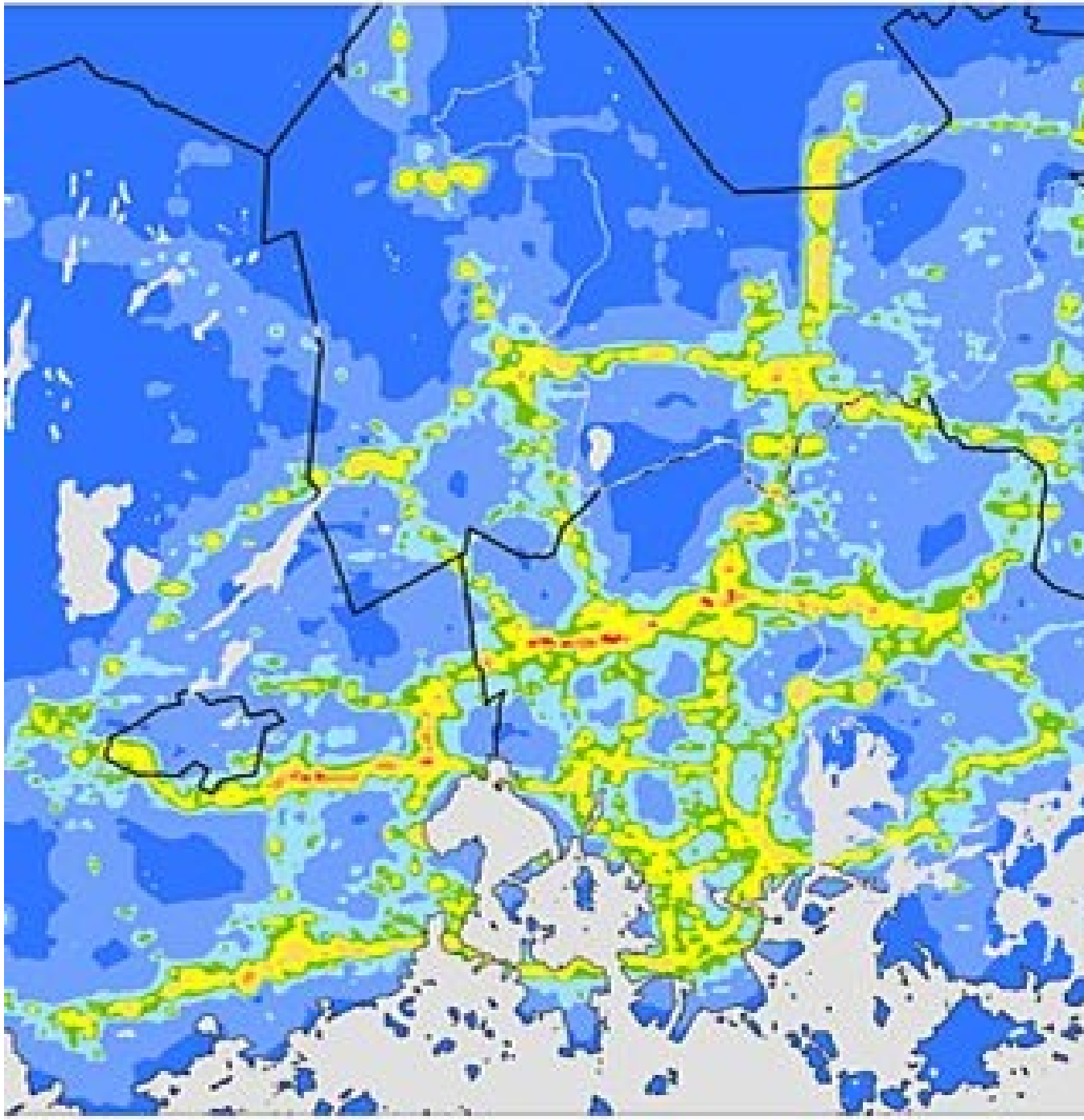
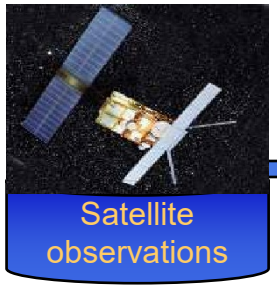
Open road line source model, CAR-FMI

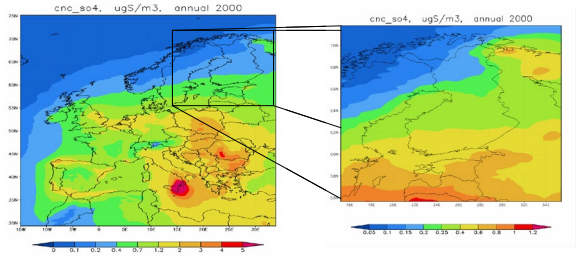
CAR-FMI (Contaminants in the Air from a Road; Härkönen 2002) is a Gaussian finite line source dispersion model i.e., a plume model for an open road network. Road is treated as a straight line of finite length.

- The traffic volume of the road during one hour is assumed constant and thus the traffic emissions can be interpreted as a finite line source. The model computes an hourly time-series of the pollutant dispersion for CO, NO, NO2, NOx, O3, PM2.5, and C_6H_6 concentrations with input information from
- the locations of the line sources and receptor points
- the hourly average traffic volumes and speeds of the line sources
- the emission factors
- the hourly, daily, monthly, yearly time-series of the meteorology and the background concentration.



SILAM now





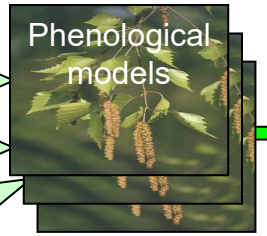
AQ products

http://silam.fmi.fi

Phenological observations

Aerobiological observations

Physiography, forest mapping



SILAM
CTM model

EVALUATION:
NRT model-measurement
comparison

Online AQ monitoring

Aerobiological observations

CLRTAP/EMEP
emission data

AROME

HIRLAM-MBE

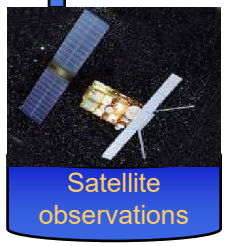
HIRLAM-RCR
NWP model

WRF

TVM

Global
boundary cond.
+
own simulations

Meteorological
data: ECMWF



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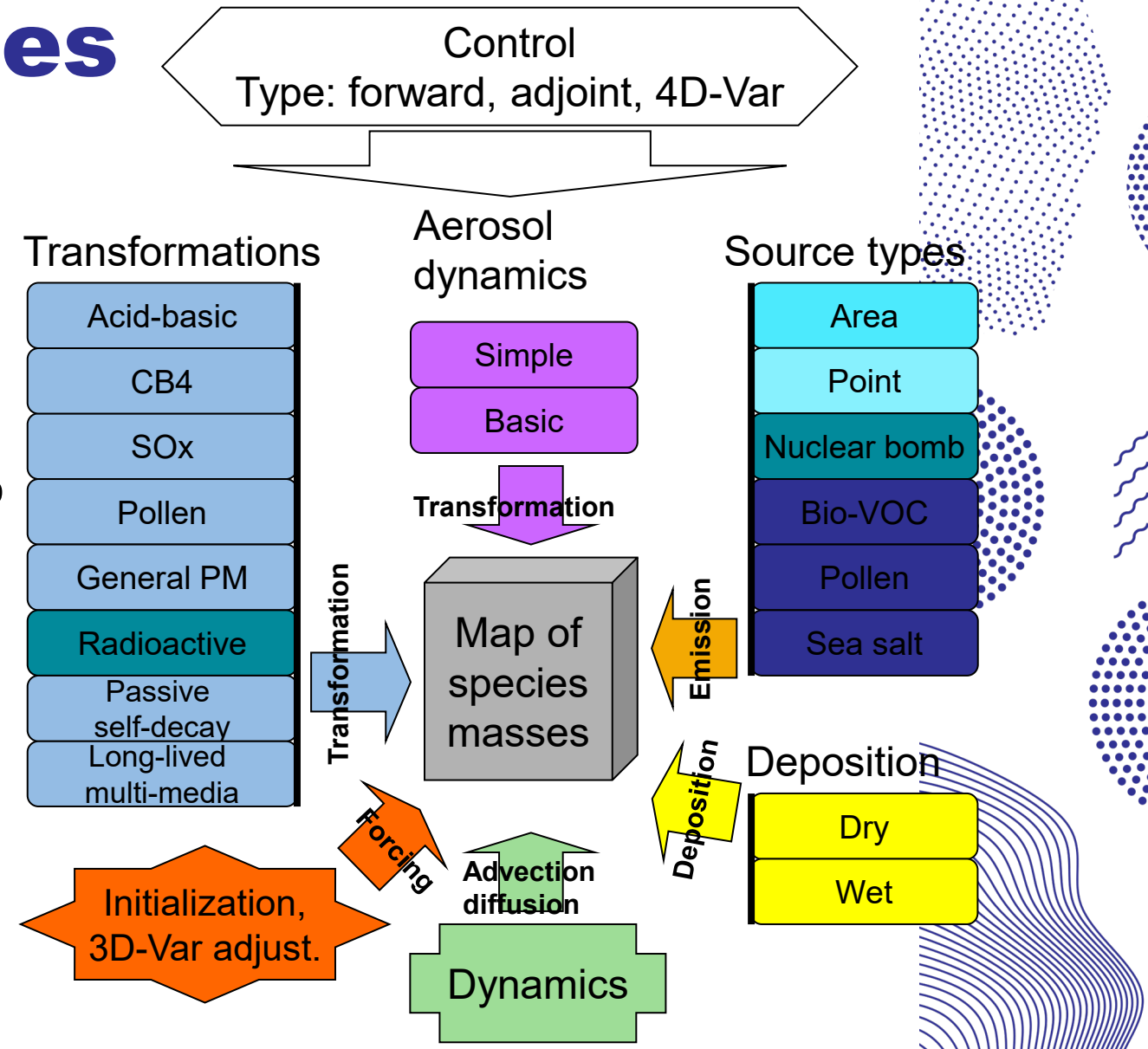
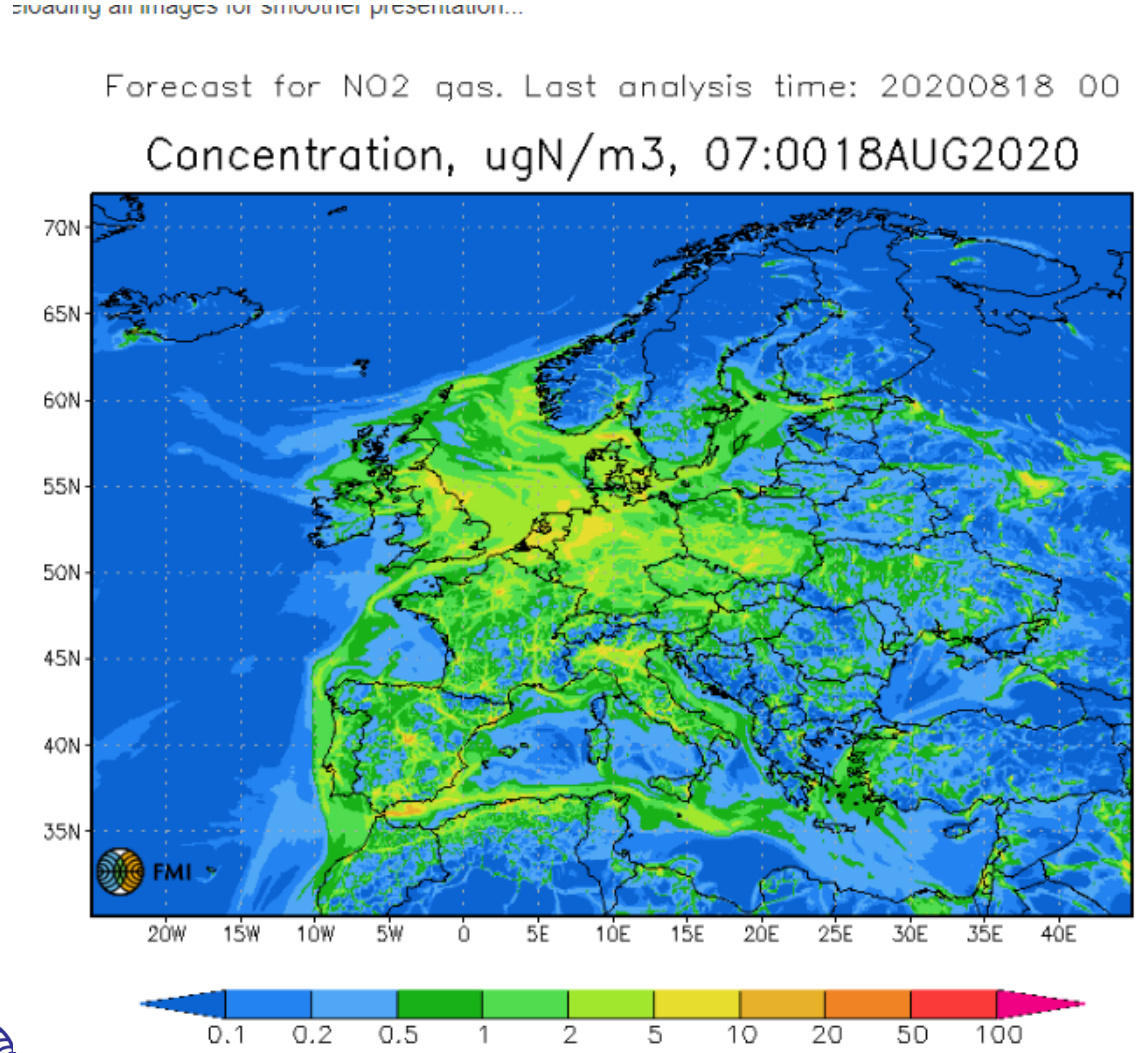
SILAM v.5: modules and capabilities

- Modules
  - 8 chemical and physical transformation modules (6 open for operational use),
  - 6 source terms (all open),
  - 2 aerosol dynamics (one open)
  - 3D- and 4D- Var
- Domains: from global to beta-meso scale (~1km resolution)
- Meteo input:
  - ECMWF
  - HIRLAM, AROME, HIRHAM, ECHAM, and any other who can write GRIB-1 or GRIB-2
  - WRF



European AQ forecast (SO2, NO, NO2, CO, O3, PM10, PM2.5)

see also : http://silam.fmi.fi/



Concentrations and depositions:

CO | NO | NO2 | O3 | SO2

PM10 | PM2.5 | AQI

Tropospheric column:

AOD | O3 | NO2 | SO2

Meteorological parameters:

ABL height

Height:

Surface

Region:

Europe

Hour: 27

Rewind

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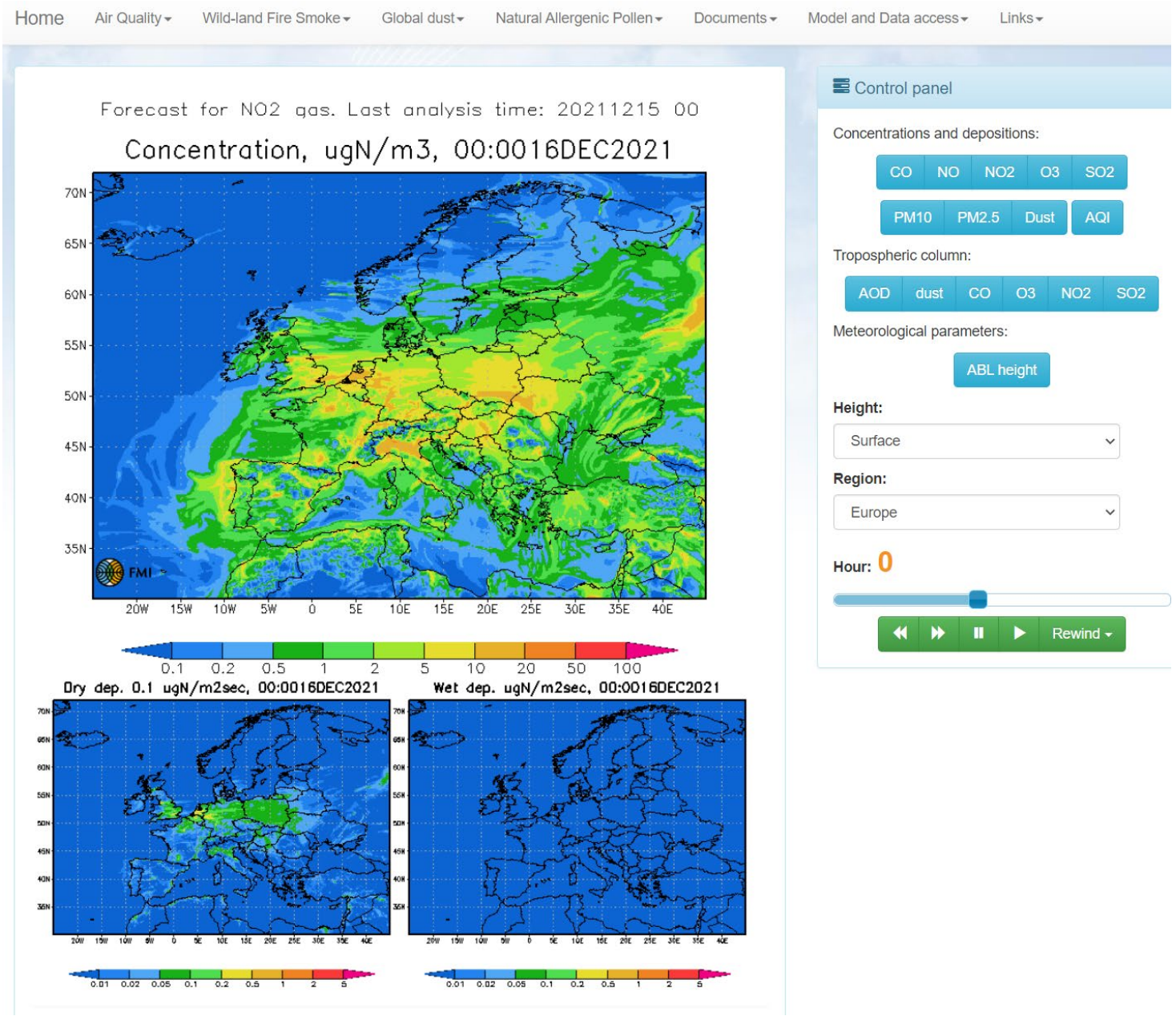
Global AQ forecast
(SO2, NO, **NO2**, CO, O3,
PM10, **PM2.5**)
see : http://silam.fmi.fi/



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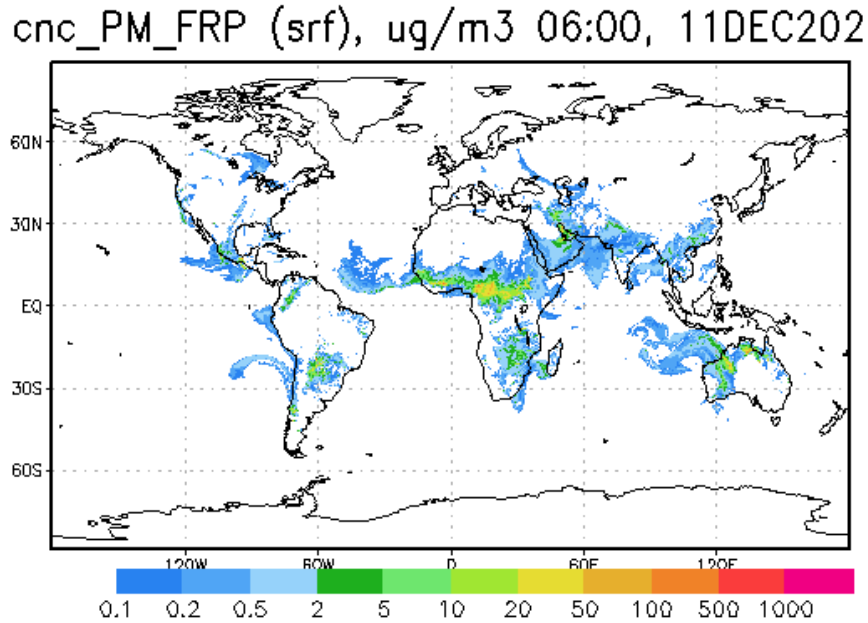
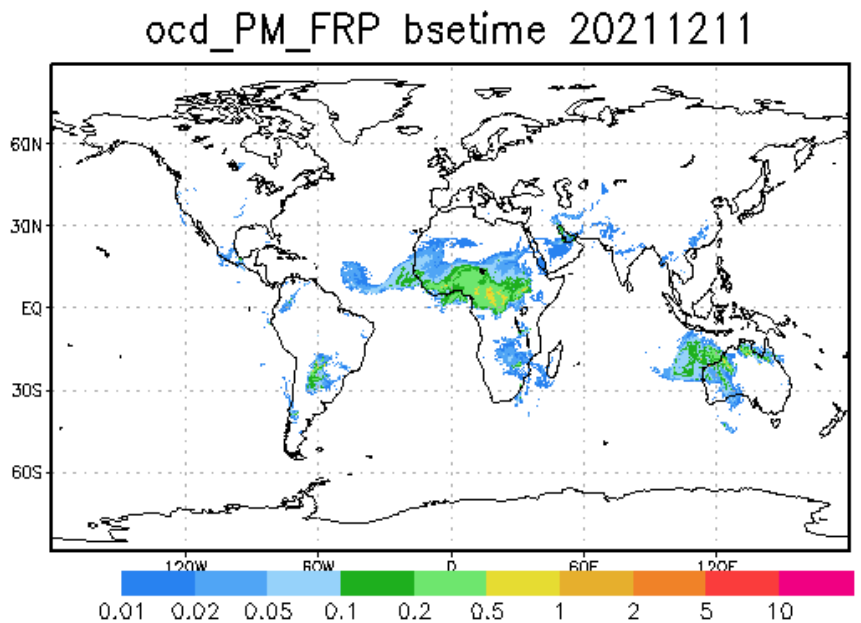
Forest fires,
volcanoes,
etc…





CAMS: Copernicus Atmosphere Monitoring service

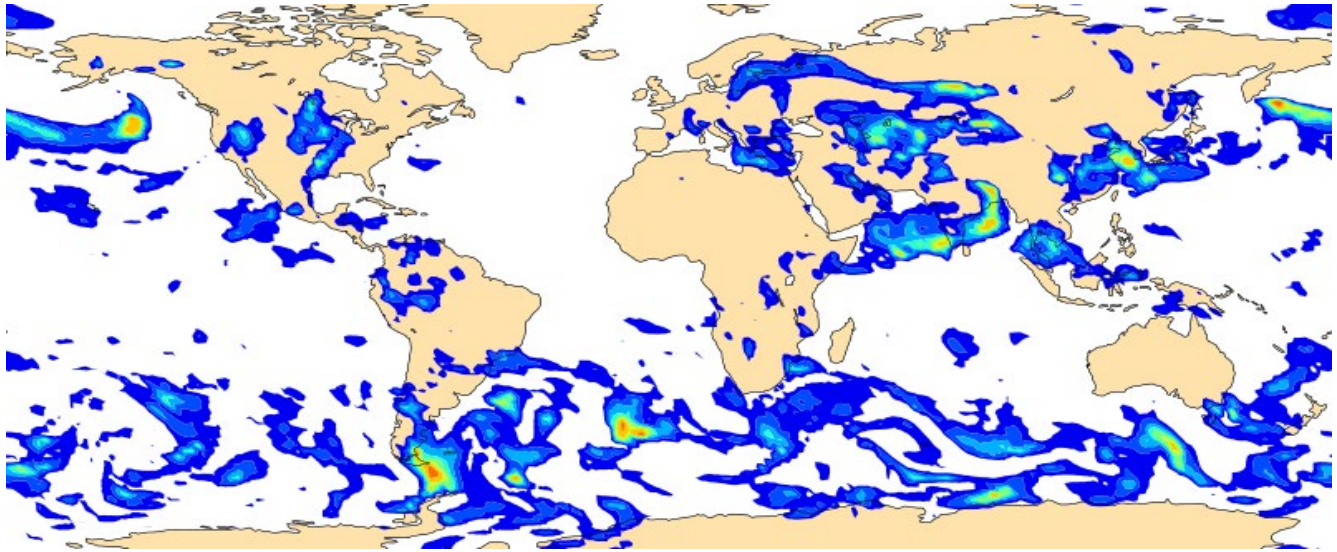
(https://atmosphere.copernicus.eu/)

+ Clearly largest forecasting ensemble up to date, for main gaseous and PM pollutants

+ A concerted effort with a better overall reliability and versalitility

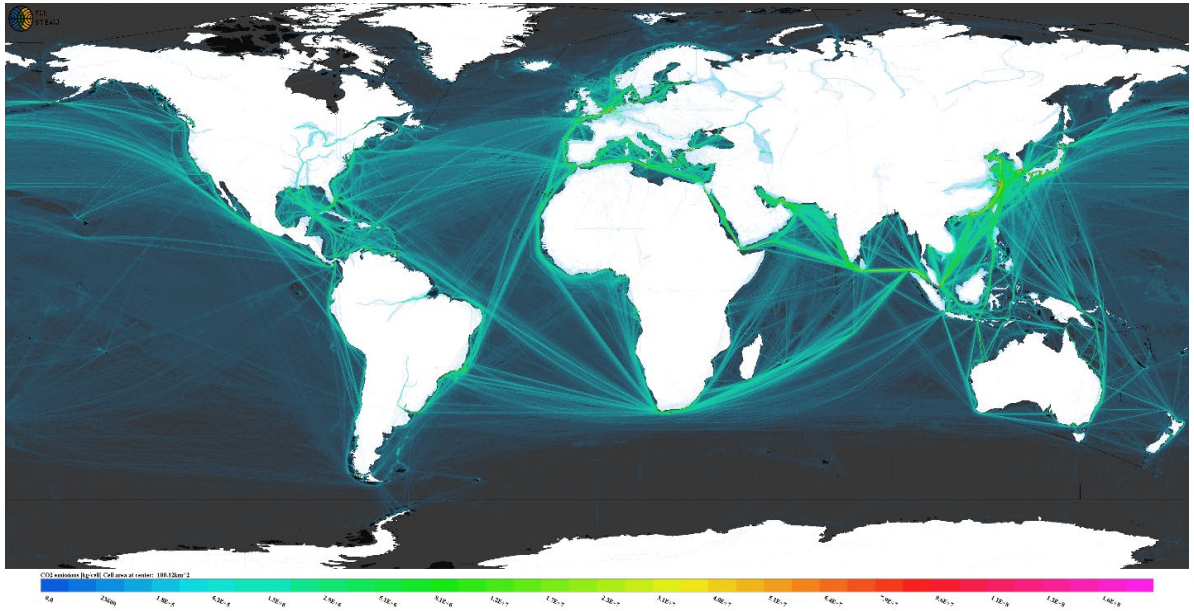
- Can still be improved: mass closure of PM, non-antropogenic PM

- Structure and treatments of models are variable (e.g. data assimilation, evaluation)



Example:
Global forecasts of aerosol concentrations - sulphates

Global Shipe Emsission modelling (STEAM 2)



CO_2 emissions from global shipping

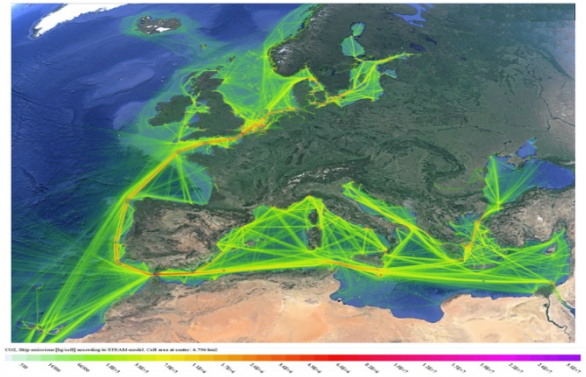
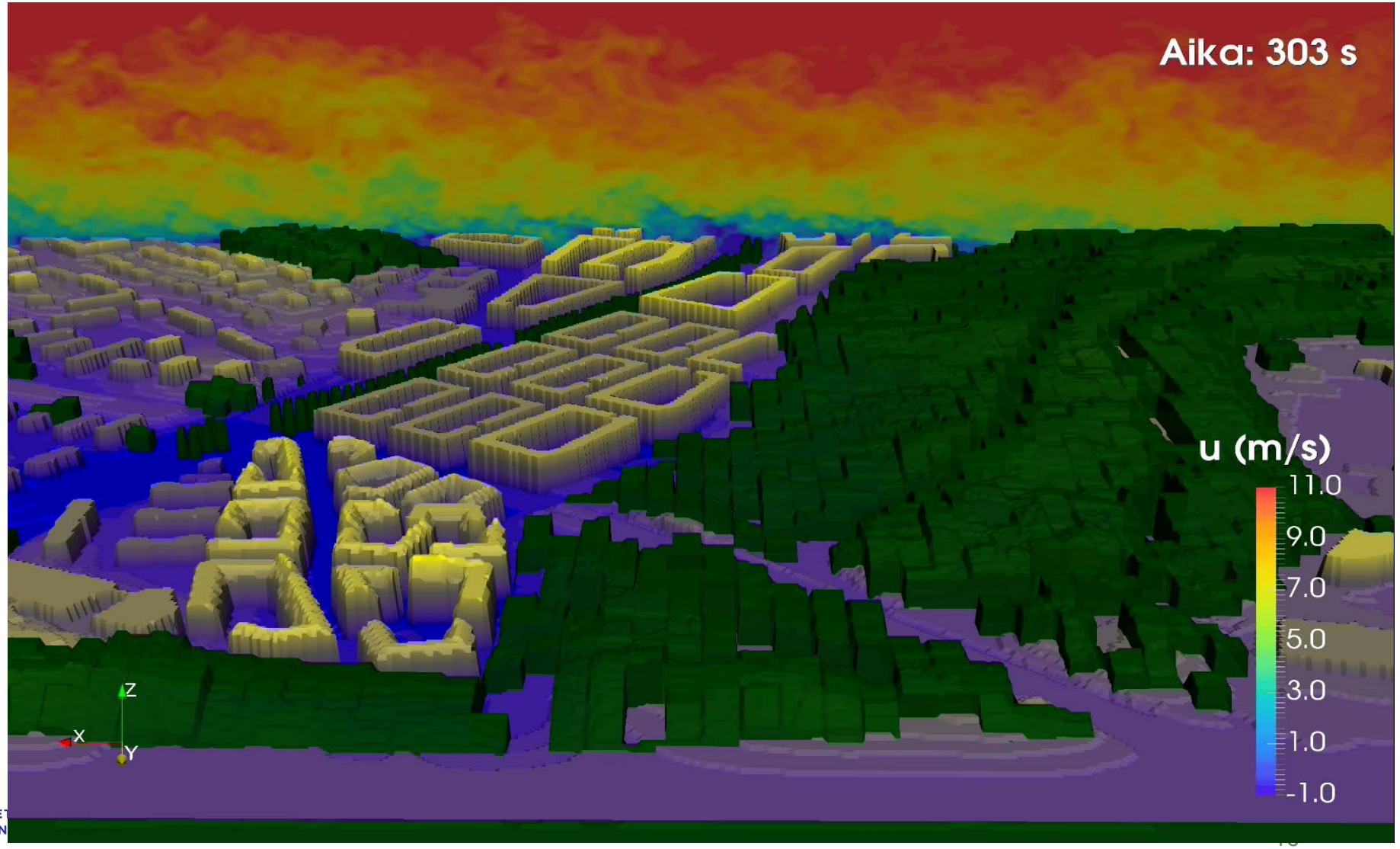


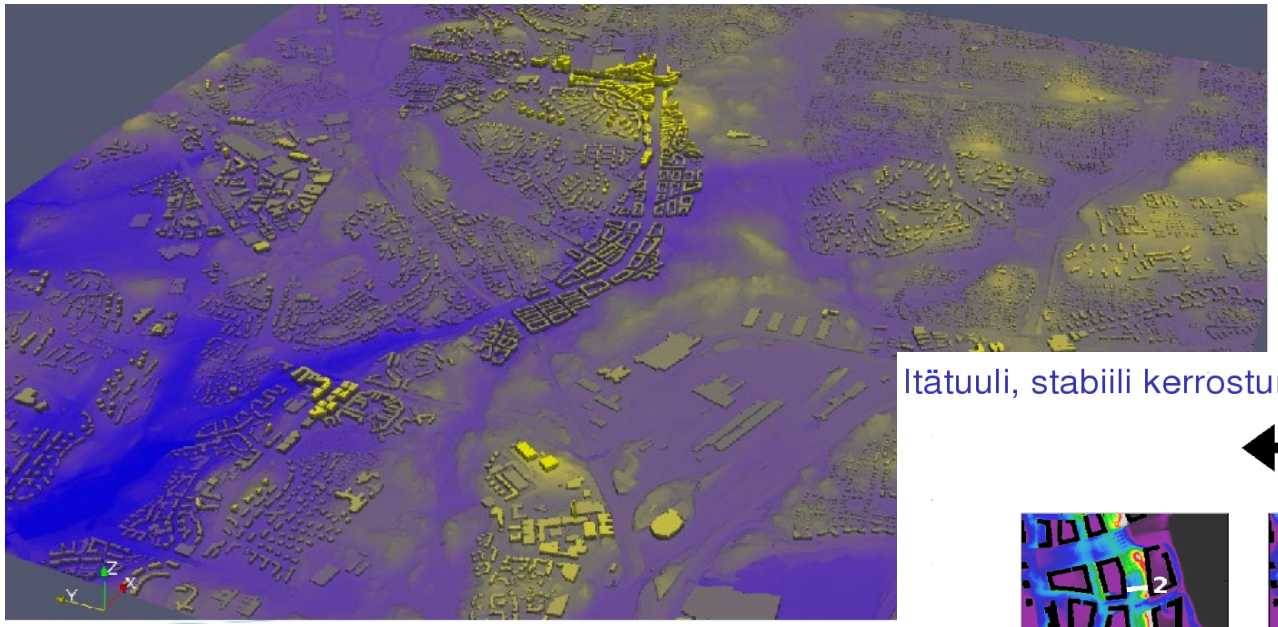
Figure 2. Predicted geographic distribution of shipping emissions of CO_2 in Europe in 2011. The colour code indicates emissions in relative mass units per unit area.

Jalkanen, J.-P., L. Johansson, and J. Kukkonen, **2016**. A comprehensive inventory of ship traffic exhaust emissions in the European sea areas in 2011. Atmos. Chem. Phys., 16, 71–84, 2016. http://www.atmos-chem-phys.net/16/71/2016/acp-16-71-2016.pdf.

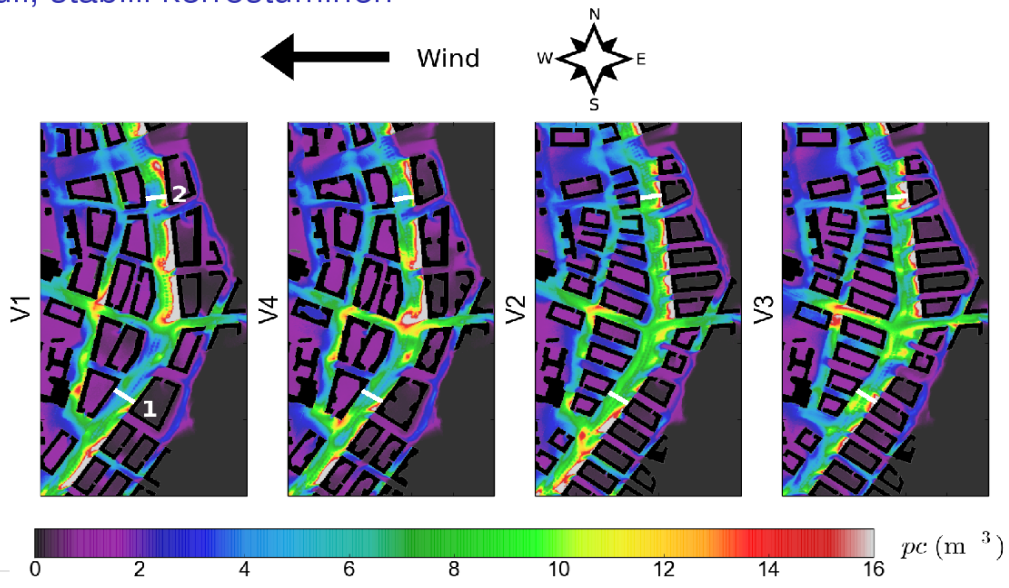
LES-modeling for Helsinki City / *New boulevards*

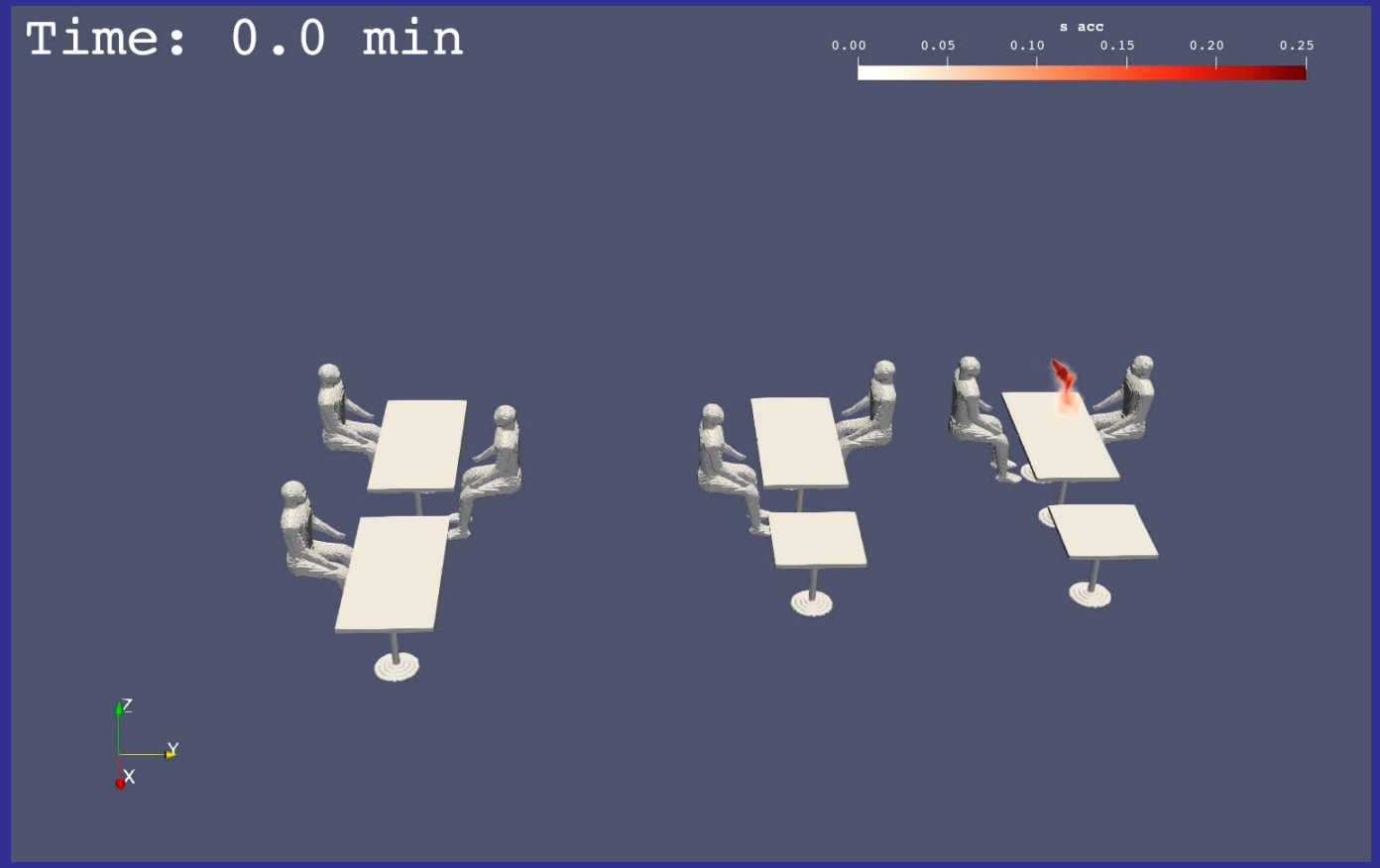


LES-modeling for Helsinki City / New boulevards



Itätuuli, stabiili kerrostuminen

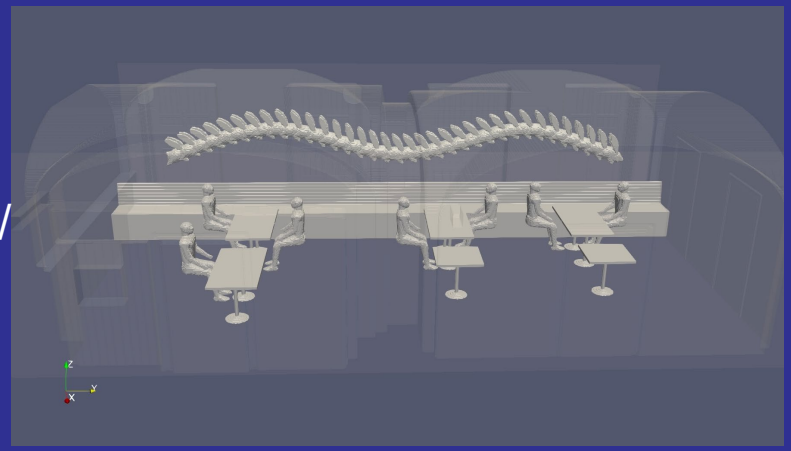




BF/TUPA

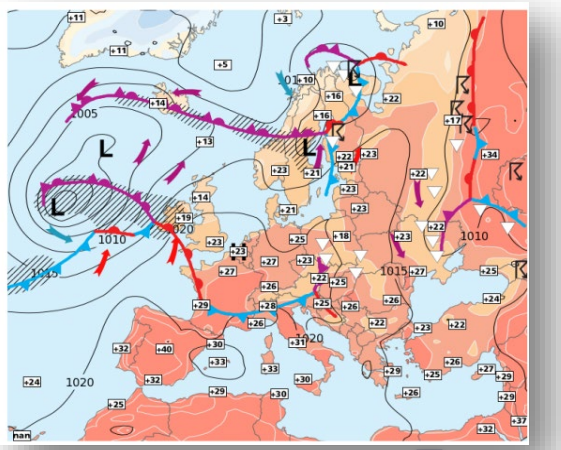
Ultima Fiasco /Henri Alen

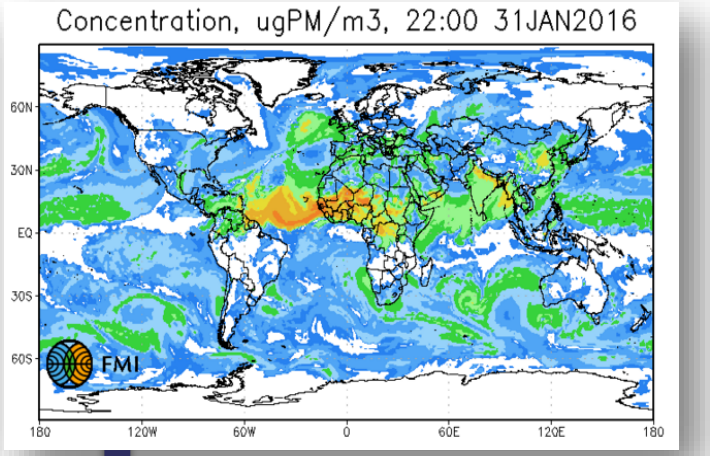
(esim. https://rbdesign.fi/tupa-tutkimushanke/



ENFUSER system –very briefly

- **Local scale, adaptive dispersion modelling with data fusion**
  - Portable (fast setup with global & open access data)
- **Designed to be computationally light-weight** providing real-time output with forecasts
  - 13x13m /1h resolution, output (24h timespan) updated **each hour**
  - CFD not (yet) possible in this context, uses Gaussian plume & puff modelling (ongoing work for utilizing pre-computed flow fields)
  - NO2, PM2.5, PM10, O3 and AQI
- **Speciality: High utilization of measurement data**
  - Calibration: hundreds of thousands of AQ measurements used.
  - Real-time adaptation with data fusion algorithms
  - Modelled data also used as input
    - Regional AQ models in particular

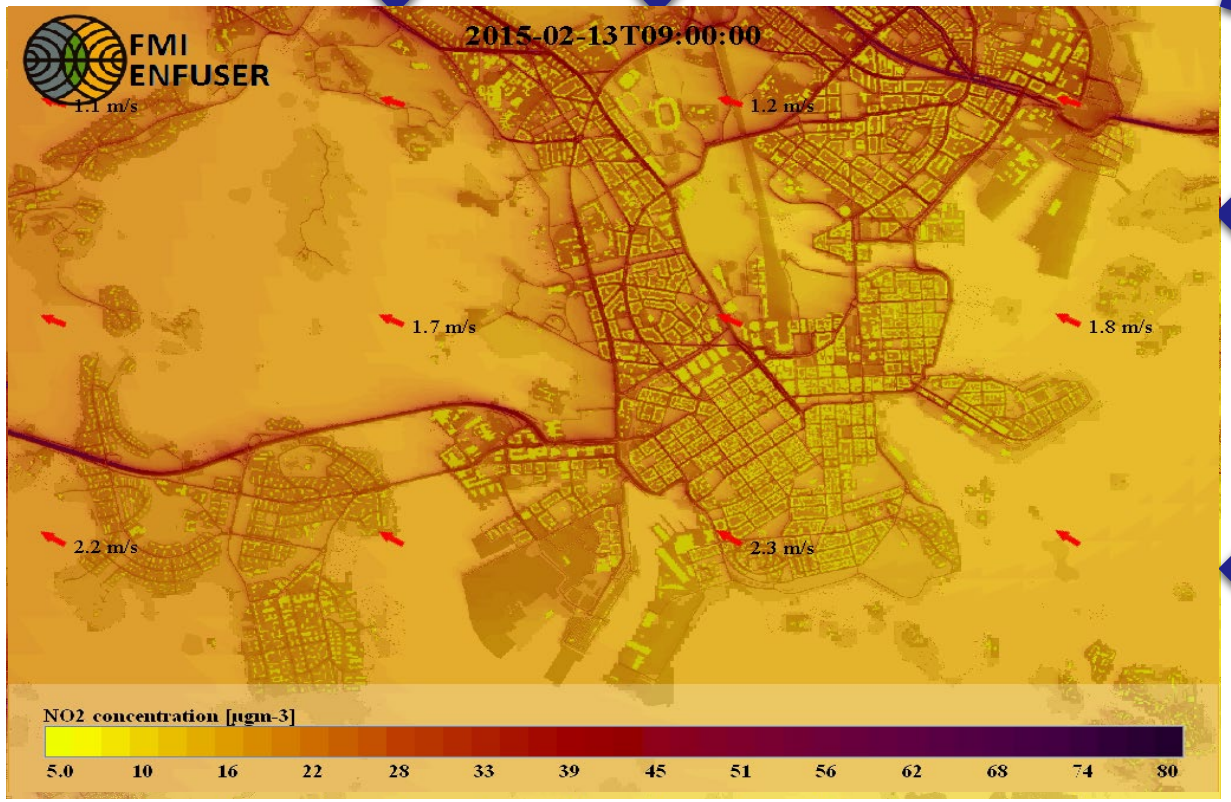




Weather data (HIRLAM)

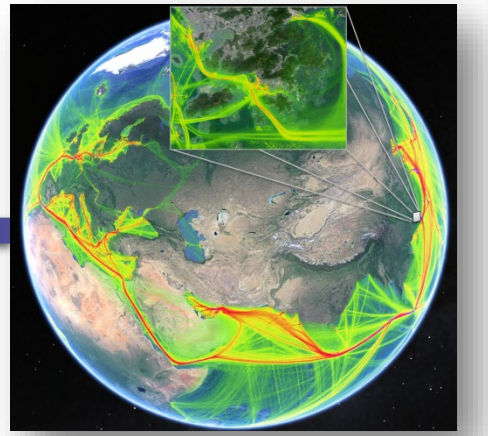
Regional AQ (SILAM)

AQ measurements

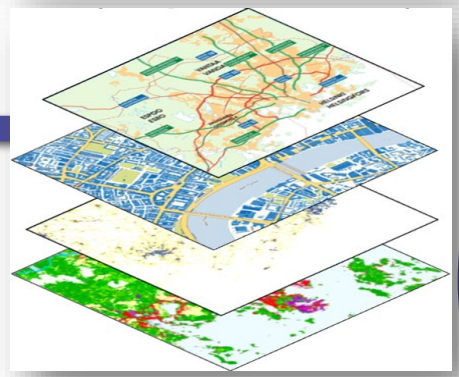


FMI-ENFUSER modelling system

Supporting emission inventories



GIS-data

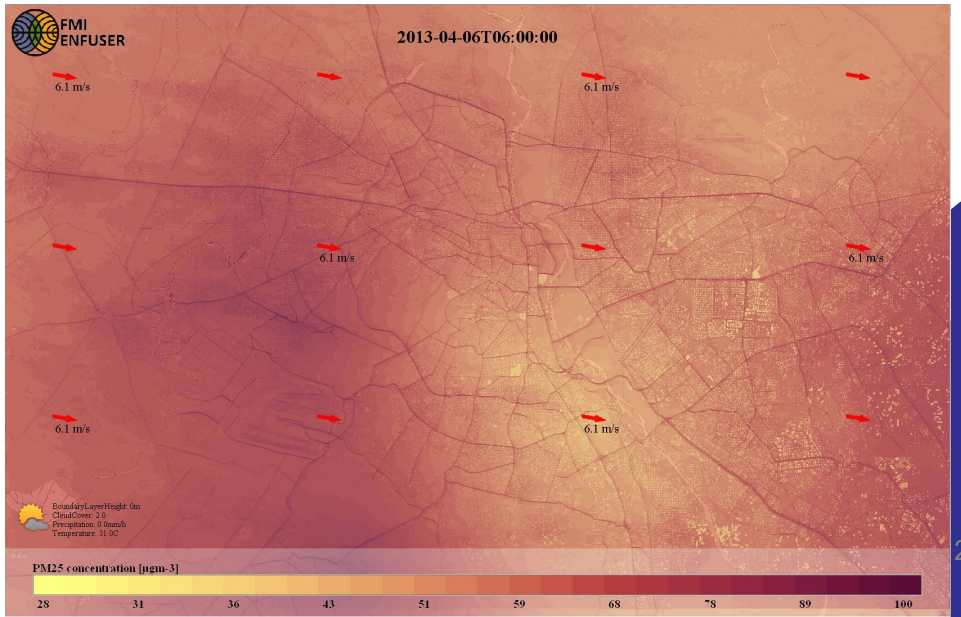


ENFUSER regions

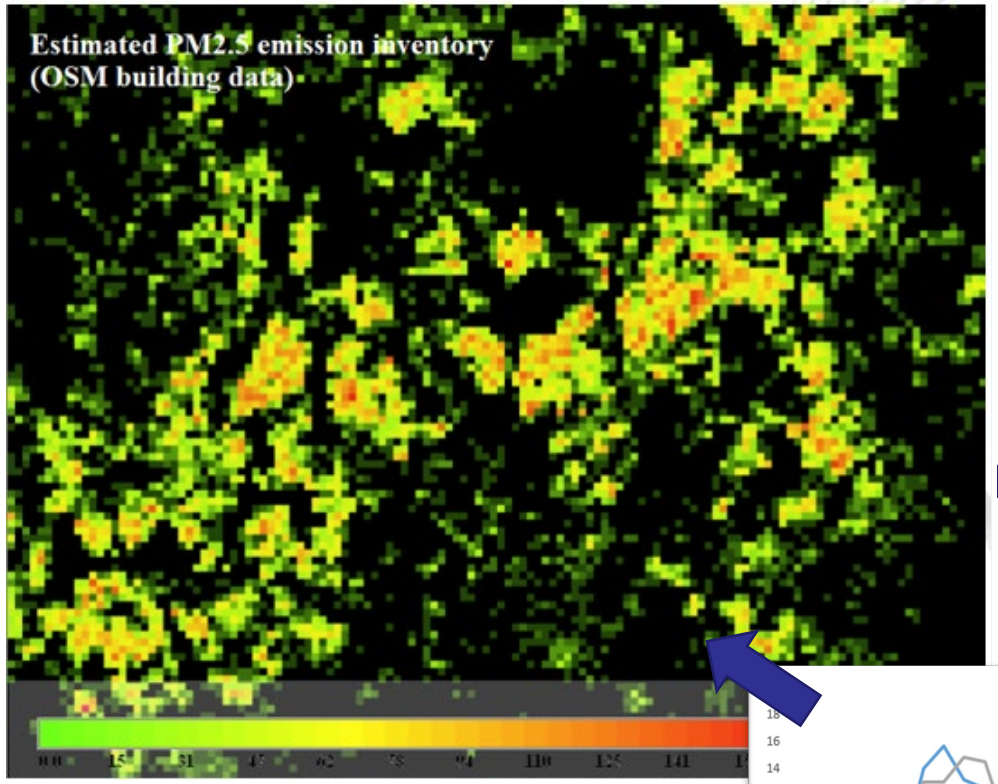
- **Provides hourly high-res AQ information for the Helsinki Metropolitan area**
  - Updated data every hour) as a part of CITYZER platform
  - PM2.5, PM10, NO2, O3, AQI)
  - Feeds information to metro displays (02/2018)

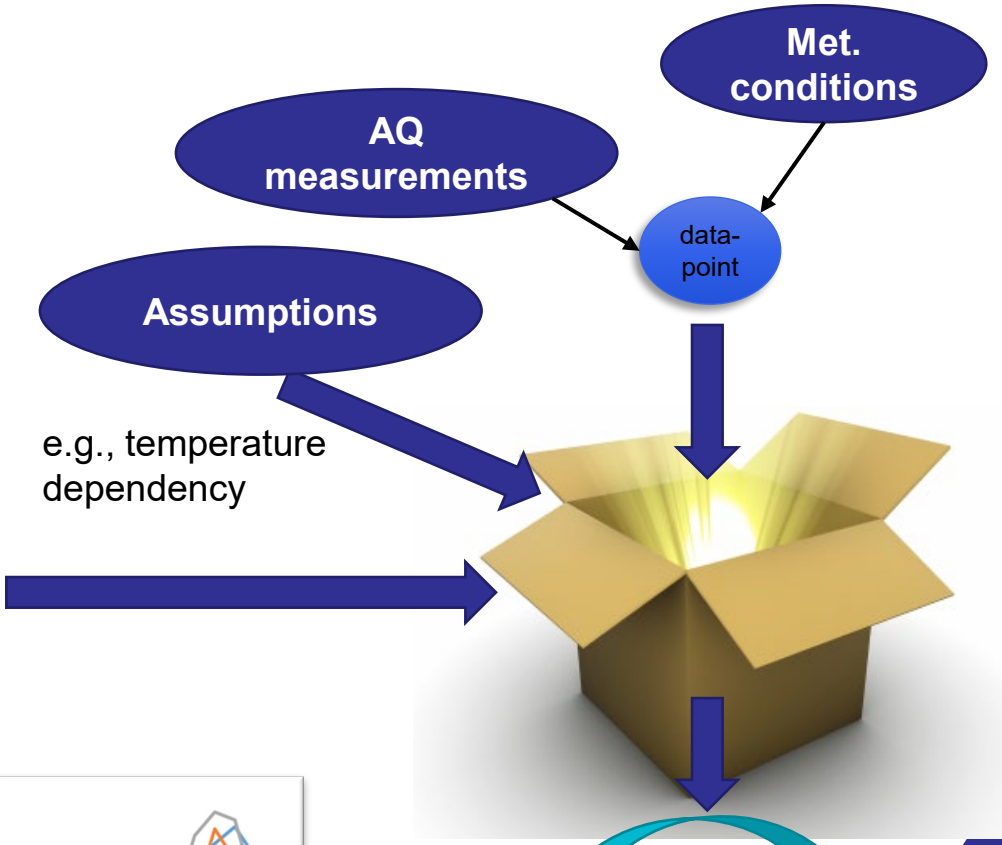
- **ENFUSER has already been demonstrated in**
  - Langfang, China
  - Delhi, India

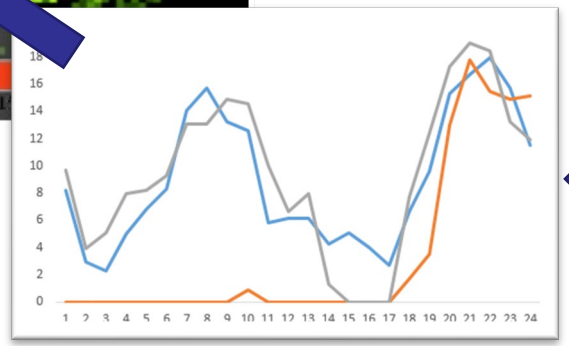
- **Nanjing Air Quality Testbed**
  - Ongoing project (2017-2019)
  - Same capabilities as in Helsinki



Emission source calibration example







Emission factors and temporal profiles

EnFuser: Applications

Added value when provided with a measurement network

- From a collection of points into full area coverage
  - Continuous quality control for sensors
  - Tool for analyzing optimal locations for **additional** sensors

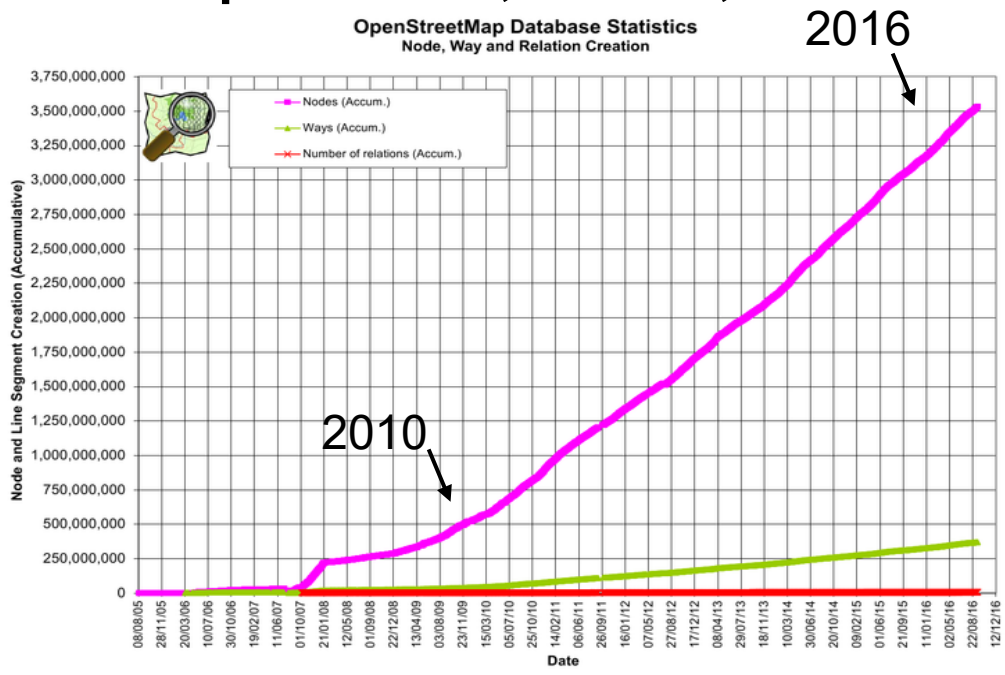
Tool for decision making

- Automatic warnings, pre-emptive administrative actions

- **Indoor air control**
  - Intelligent indoor air control management (3D) in e.g., large office
  - buildings
- **Personal exposure estimation**
  - GPS-based tracking of exposure
    - Health business?
  - High res annual averages => real estate market?
- **Navigators with emphasis on cleaner air**
  - **https://green-paths.web.app/?map=streets**

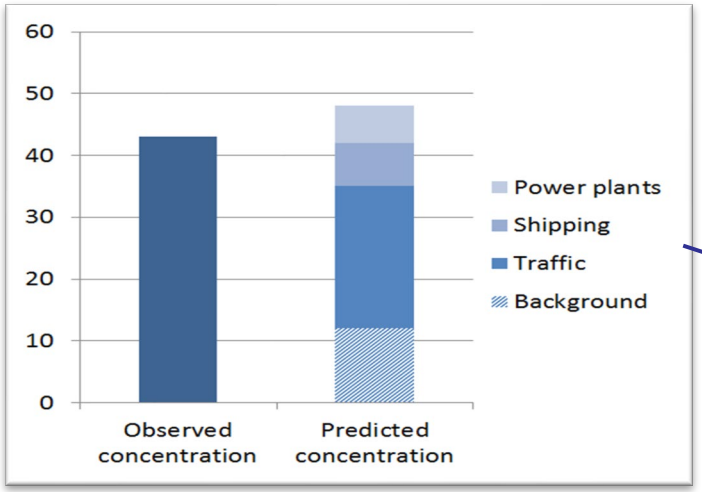
GIS-data and emission inventories

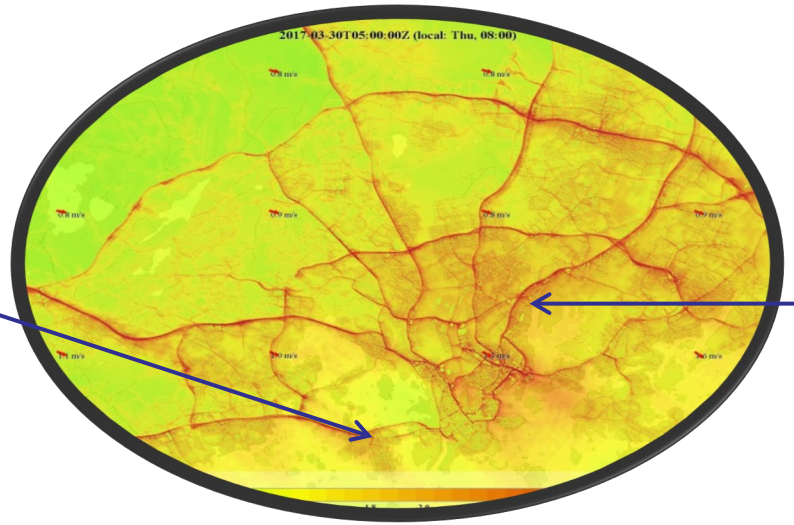
- **Provides ENFUSER with open-access, globally available description of the modelling environment**
  - Used in local source appointment & emission factor assignment during calibration
- **The content of OSM has increased strongly recent years**
- **Includes: road network structure, public transport routes, tunnels, traffic lights, buildings and landuse**
- **Refinements and additions**
  - Elevation data from SRTM
  - Satellite image analysis
  - Custom vehicle patterns for roads

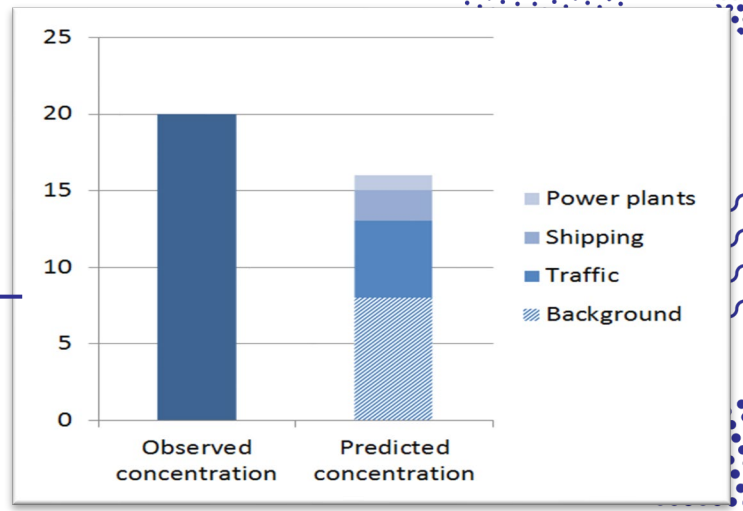


Data fusion in ENFUSER is kind of a voting system

Measurement 1: ” we could reduce the regional background or traffic emissions a bit to reach a nice agreement.”







Measurement 2: ”No way! I’d get even larger errors here. Rather, we need to increase something. Is your sensor working?”

The data fusion algorithm is a process where the voting converges into conclusion. The conclusion also includes ’relability penalties’ to input providers that contradict the concensus

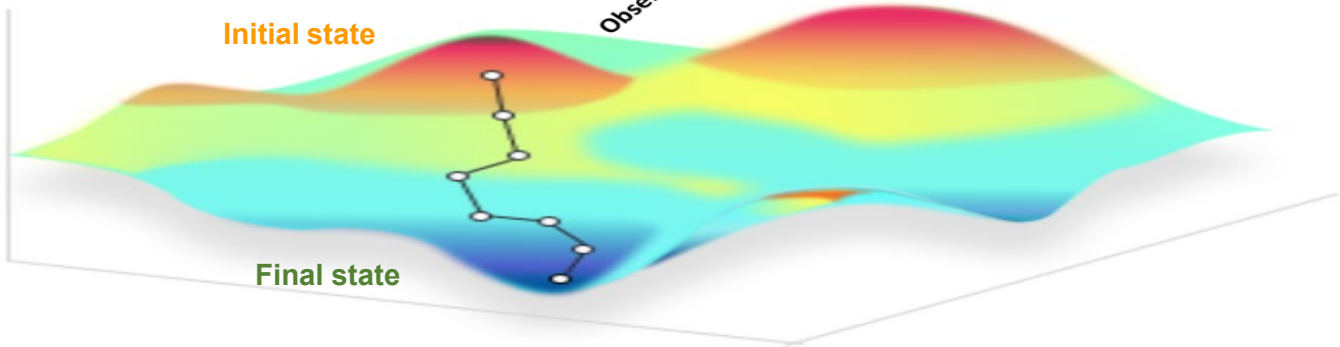
Technically, the data fusion is a gradient descend -algorithm

Main iteration (adjustments)

Em. category 1	a11	a12	a13	a14	a15
Em. category 2	a21	a22	a23	a24	a25
Em. category 3	a31	a32	a33	a34	a35
Em. category 4	a41	a42	a43	a44	a45

Penalty iteration (for each main iteration step)

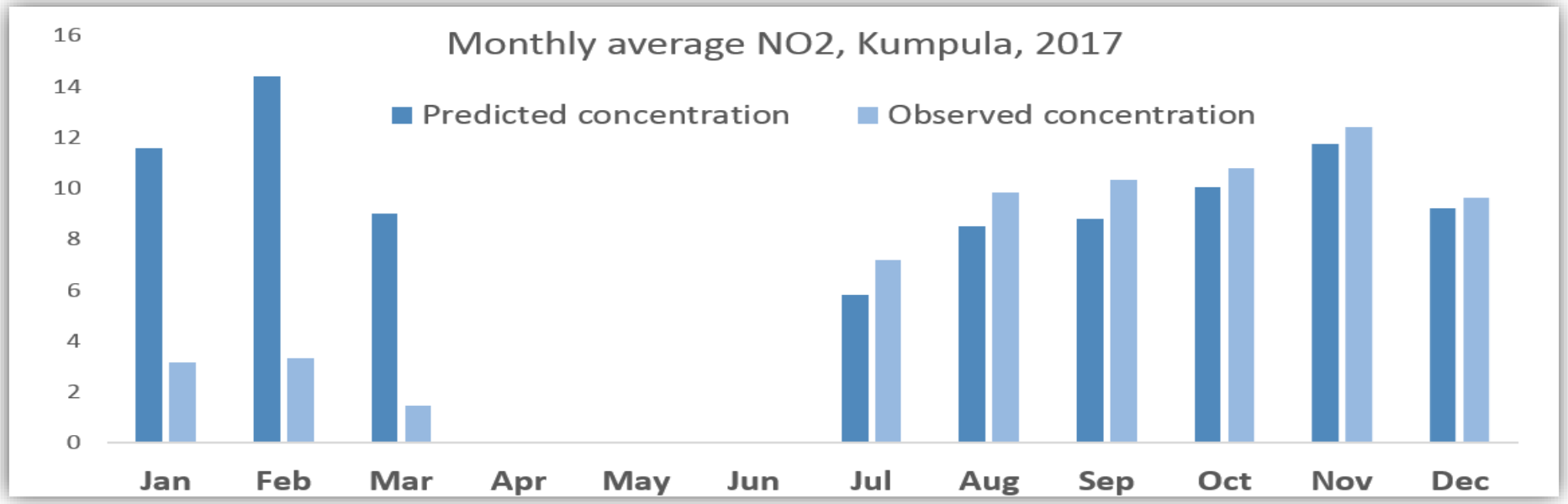
Observation 1	1	2	4	8	16
Observation 2	1	2	4	8	16
Observation 3	1	2	4	8	16
Observation 4	1	2	4	8	16
Observation 5	1	2	4	8	16



- Minimize sum of squared weighted errors (wSSE)
- -Evaluate this at the initial state, then reduce wSSE step by step

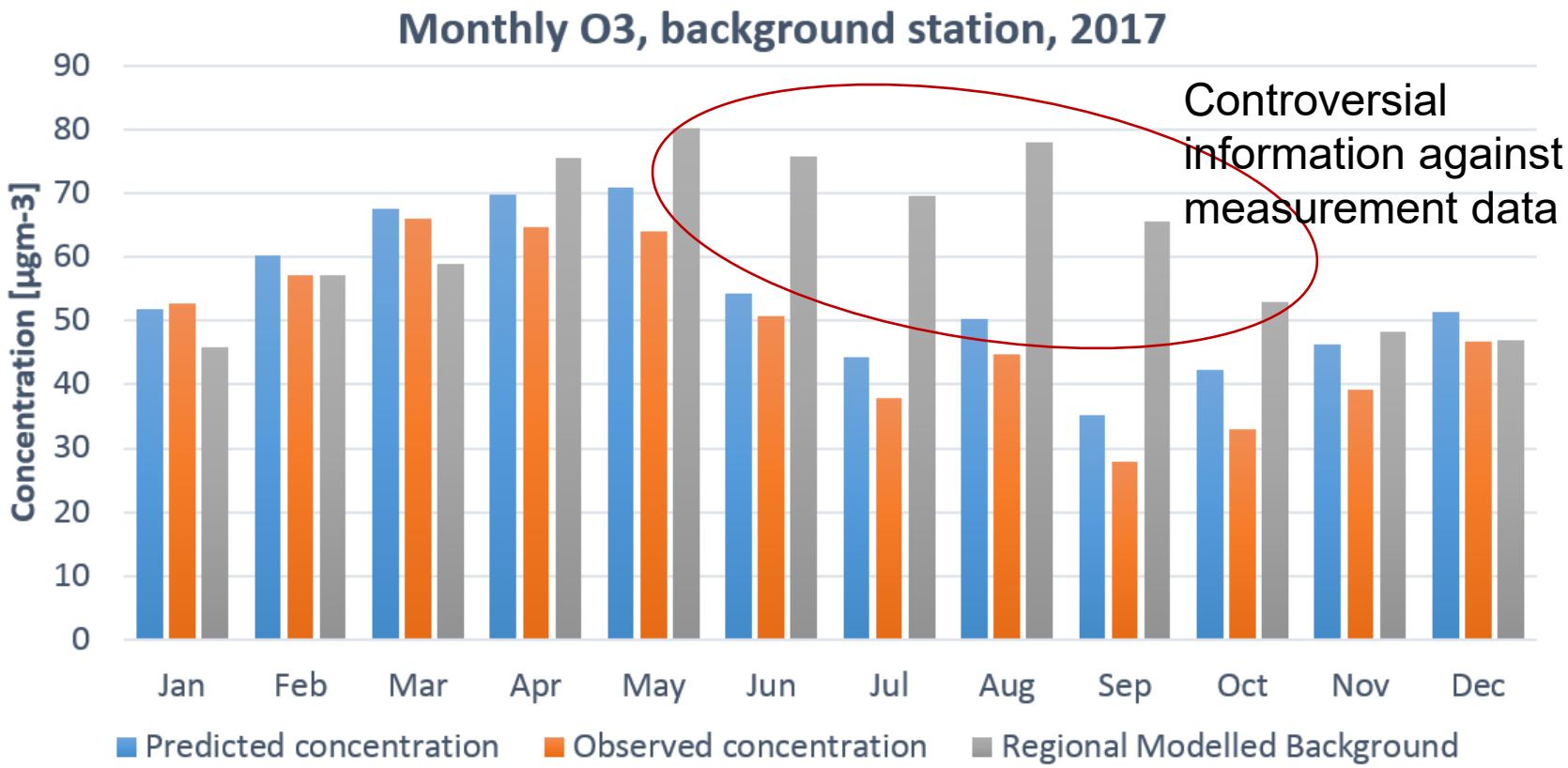
Urban background station was also revealed to be malfunctioning

- **Kumpula, the operator when contacted was unaware of this**
- **January to March –data was filtered out, but not because the model prediction errors were particularily high**
  - **This measurement site voted background concentration up**, but this was in conflict with the concensus



The monthly NO2 averages (measured and observed) for a station in Kumpula, Helsinki in 2017.

Utilization of measurement data: ”correction of background”

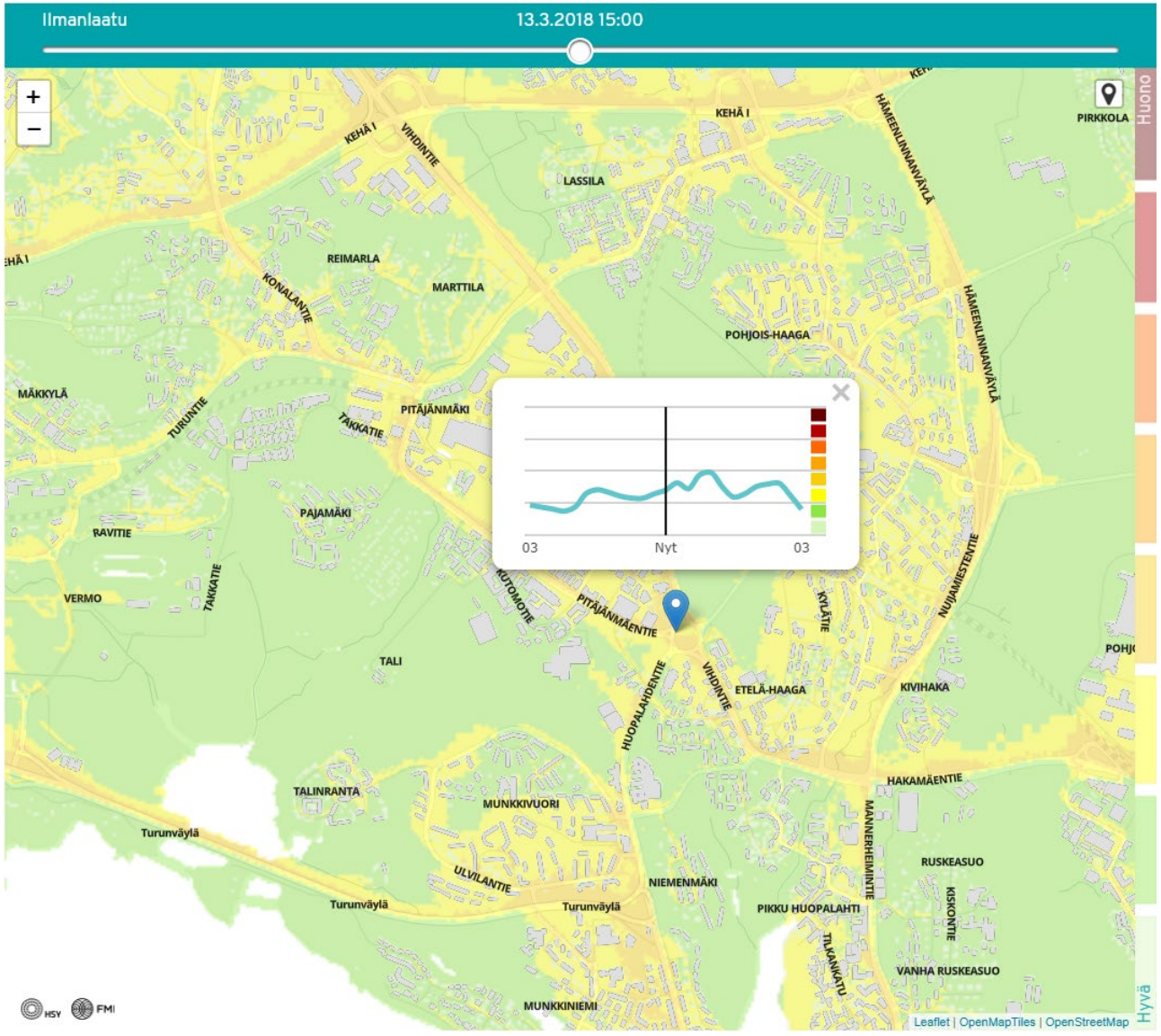


Accessing AQ model data

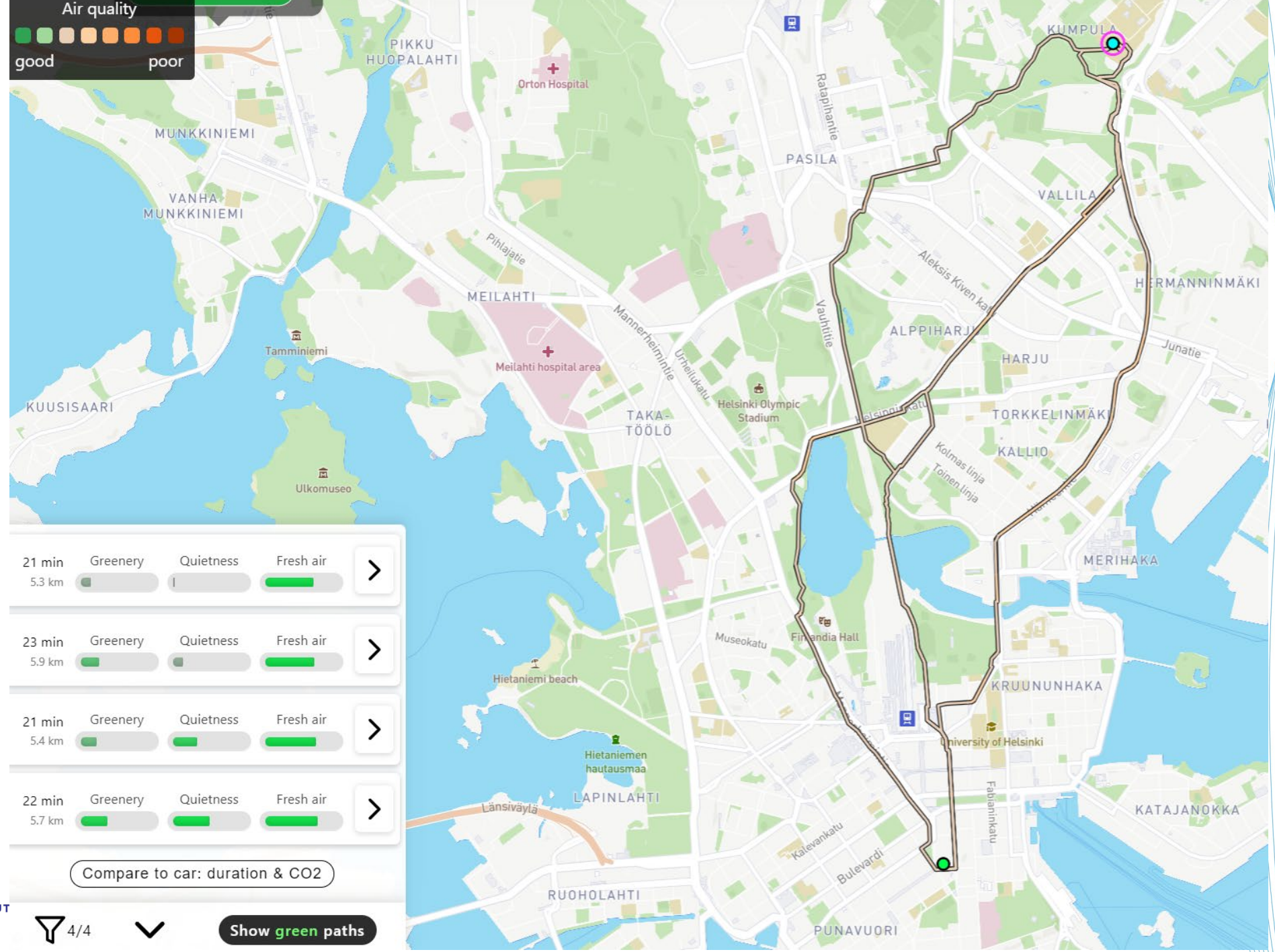
Real time information on Helsinki air quality has been made available since 6.3.2018.

Accessible from:
ilmanlaatukartta.hsy.fi

Or
www.hsy.fi/fi/asukkaalle/ilmanlaatu/Sivut/ilmanlaatukartta.aspx



Green paths



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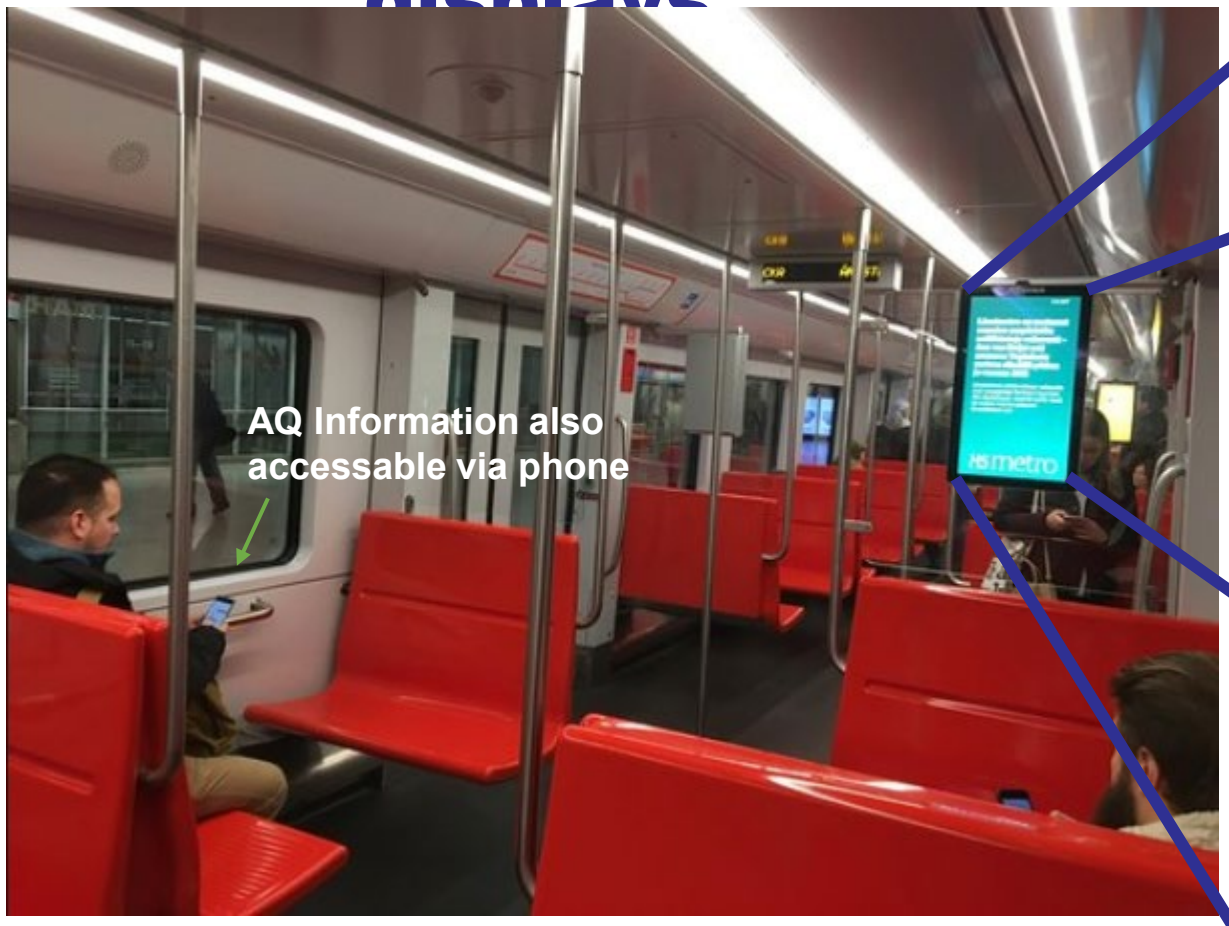
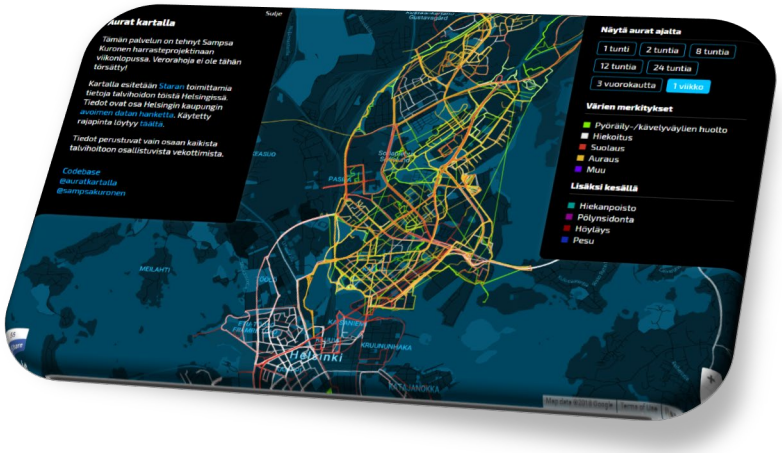
Real-time information feed in metro displays

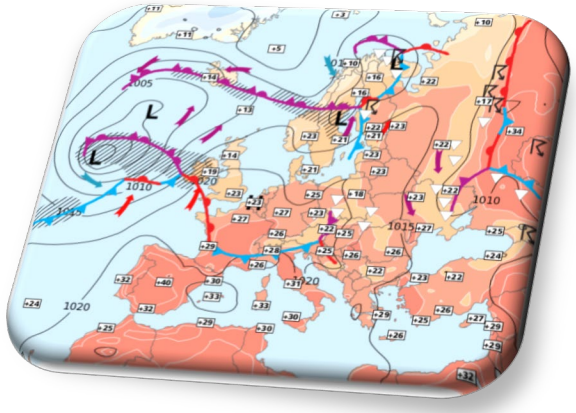


Further Development

Real-time traffic congestion data, source Here.com
=> traffic flow speed adjustments



Extraction of real-time sanding, salting, dust binding and cleaning activities.
=> Improved PM10 modelling?



High resolution meteorology HIRLAM data too coarse for coastal reagion such as Helsinki

Other

- Utilization of AQ sensor data
- Measured BLH data
- Power plant emissions
- Airport emissions
- Construction sites and PM10

EnFuser :status in Helsinki

- **Real-time local scale air quality modelling service has been established in Helsinki region**
  - Speciality: high utilization of measurement data
    - More measurement locations => better adaptibility
  - Portable system: a similar setup in progress in Nanjing, China
- **Performance evaluation done for 2017-19**
  - Agreement with seasonal/annual averages is high (R2 > 0.8)
  - Agreement with hourly PM10 is acceptable, but could still be improved
- **Use of measurements in modelling is beneficial, yet challenging**
  - Measurements affected by wide range of local specialities
  - Quality of measurements must be considered

1. Kouznetsov, R.: A note on precision-preserving compression of scientific data, Geosci. Model Dev., 14, 377–389, https://doi.org/10.5194/gmd-14-377-2021, 2021.

2. Kuittinen, N., Jalkanen, J.-P., Alanen, J., Ntziachristos, L., Hannuniemi, H., Johansson, L., Karjalainen, P., Saukko, E., Isotalo, M., Aakko-Saksa, P., Lehtoranta, K., Keskinen, J., Simonen, P., Saarikoski, S., Asmi, E., Laurila, T., Hillamo, R., Mylläri, F., Lihavainen, H., Timonen, H., Rönkkö, T., *"Global particle number emissions from shipping equal all continental anthropogenic sources"*, *Environ. Sci. Technol.* 2021, 55, 1, 129–138, https://doi.org/10.1021/acs.est.0c03627

3. Backman, J., Schmeisser, L., & Asmi, E. (2021). Asian emissions explain much of the Arctic Black Carbon events. Geophysical Research Letters, 48, e2020GL091913, https://doi.org/10.1029/2020GL091913

4. Evangeliou, N., Platt, S. M., Eckhardt, S., Lund Myhre, C., Laj, P., Alados-Arboledas, L., Backman, J., Brem, B. T., Fiebig, M., Flentje, H., Marinoni, A., Pandolfi, M., Yus-Dìez, J., Prats, N., Putaud, J. P., Sellegri, K., Sorribas, M., Eleftheriadis, K., Vratolis, S., Wiedensohler, A., and Stohl, A.: Changes in black carbon emissions over Europe due to COVID-19 lockdowns, Atmos. Chem. Phys., 21, 2675–2692, https://doi.org/10.5194/acp-21-2675-2021, 2021.

5. Sari Repka , Anne Erkkilä-Välimäki, Jan Eiof Jonson, Maximilian Posch, Janne Törrönen, Jukka Pekka Jalkanen, "Assessing the costs and environmental benefits of IMO regulations of ship-originated SOx and NOx emissions in the Baltic Sea", Ambio, https://doi.org/10.1007/s13280-021-01500-6, 2021

6. Michael Gauss, Jerzy Bartnicki, Jukka-Pekka Jalkanen, Agnes Nyiri, Heiko Klein, Hilde Fagerli, Zbigniew Klimont, Airborne nitrogen deposition to the Baltic Sea: past trends, source allocation, and future projections, Atmos. Env., 253 (2021) 118377, https://doi.org/10.1016/j.atmosenv.2021.118377

7. Jalkanen, J.-P., Johansson, L., Wilewska-Bien, M., Granhag, L., Ytreberg, E., Eriksson, K. M., Yngsell, D., Hassellöv, I.-M., Magnusson, K., Raudsepp, U., Maljutenko, I., Styhre, L., Winnes, H. and Moldanova J., "*Modeling of discharges from Baltic Sea shipping*", Ocean Science, 17, 699–728, 2021, https://doi.org/10.5194/os-17-699-2021

8. Hellsten, A., Ketelsen, K., Suehring, M., Auvinen, M., Maronga, B., Knigge, C., Barmpas, F., Tsegas, G., and Moussiopoulos, N., Raasch, S. A Nested Multi-Scale System Implemented in the Large-Eddy Simulation Model PALM model system 6.0. Geoscientific Model Development, 14(6), 3185-3214, https://gmd.copernicus.org/articles/14/3185/2021/, 2021.

9. Moldanová, J., Hassellöv, I.-M., Matthias, V., Fridell, E., Jalkanen, J.-P., Ytreberg, E., Maljutenko, I., Tröltz, J. and Quante, M., "Framework for the environmental impact assessment of operational shipping", AMBIO, https://doi.org/10.1007/s13280-021-01597-9

10. Rafael A.O. Nunes, Maria C.M. Alvim-Ferraz, Fernando G. Martins, Fátima Calderay-Cayetano, Vanessa Durán-Grados, Juan Moreno-Gutiérrez, Jukka-Pekka Jalkanen, Hanna Hannuniemi, Sofia I.V. Sousa, Estimating the health and economic burden of shipping related air pollution in the Iberian Peninsula, Environment International, Volume 156, November 2021, 106763, https://www.sciencedirect.com/science/article/pii/S0160412021003883

11. Martin Saliba; Francelle Azzopardi; Rebecca Muscat; Marvic Grima; Alexander Smyth; Jukka-Pekka Jalkanen; Lasse Johansson; Alan Deidun; Charles Galdies; Tonio Caruana; Raymond Ellul, Trends in vessel atmospheric emissions in the central Mediterranean over the last ten years and during the Covid-19 outbreak, *J. Mar. Sci. Eng.* 2021, *9*(7), 762; https://doi.org/10.3390/jmse9070762

12. Pekka Koivisto, Tomi Honkanen, Mikko Auvinen, Antti Hellsten, and Kimmo Kahma, Effect of Viscosity and Scale on the De/Anti-icing Fluid Flow-off, published Online in AIAA Journal, 18 Aug 2021 https://doi.org/10.2514/1.J060164

13. Geels, C., Andersson, C, Winter, M, Jalkanen, J-P, Brandt, J, Frohn, LM, "Projections of shipping emissions and the related impact on air pollution and human health in the Nordic region", Atmos. Chem. Phys., 21, 12495–12519, 2021, https://doi.org/10.5194/acp-21-12495-2021

14. Zorzetto, E., Peltola, O., Grönholm, T. and Katul, G.G., "Intermittent surface renewals and methane hotspots in natural peatlands", Boundary-Layer Meteorology, 2021, 180:407-433. https://doi.org/10.1007/s10546-021-00637-x

15. Ilja Maljutenko, Ida-Maja Hassellöv, K. Martin Eriksson, Erik Ytreberg, Daniel Yngsell, Lasse Johansson, Jukka-Pekka Jalkanen, Mariliis Kõuts, Mari-Liis Kasemets, Jana Moldanova, Kerstin Magnusson, Urmas Raudsepp, Modelling spatial dispersion of contaminants from shipping lanes in the Baltic Sea, Environmental Pollution, Volume 173, Part A, December 2021, 112985, https://doi.org/10.1016/j.marpolbul.2021.112985

16. Daniel A. Schwarzkopf, Ronny Petrik, Volker Matthias, Markus Quante, Elisa Majamäki and Jukka-Pekka Jalkanen, "A Ship Emission Modeling System with Scenario Capabilities", Atmospheric Environment: X, Volume 12, December 2021, 100132

17. Panu Karjalainen, Kimmo Teinilä, Niina Kuittinen, Päivi Aakko-Saksa, Hannu Vesala, Rasmus Pettinen, Sanna Saarikoski, Jukka-Pekka Jalkanen, Hilkka Timonen, Real-world particle emissions and secondary particle formation from a diesel oxidation catalyst and scrubber equipped ship operating in a SECA area, Env. Poll, Environmental Pollution, Volume 292, Part A, 1 January 2022, 118278, https://doi.org/10.1016/j.envpol.2021.118278

18. Grönholm, Tiia, Mäkelä, Timo, Hatakka, Juha, Jalkanen, Jukka-Pekka, Kuula, Joel, Laurila, Tuomas, Laakso, Lauri, Kukkonen, Jaakko, "Evaluation of methane emissions originating from LNG ships based on the measurements at a remote marine station", *Environmental Science & Technology* 2021, 55, 20, 13677-13686. https://doi.org/10.1021/acs.est.1c03293

19. Jari Walden, Liisa Pirjola, Tuomas Laurila, Juha Hatakka, Heidi Pettersson, Tuomas Walden, Jukka-Pekka Jalkanen, Harri Nordlund, Toivo Truuts, Miika Meretoja, and Kimmo K. Kahma, "Measurement report: Characterization of uncertainties in fluxes and fuel sulfur content from ship emissions in the Baltic Sea", Atmos. Chem. Phys., 21, 18175–18194, https://doi.org/10.5194/acp-21-18175-2021, 2021

20. Thomas Foken, Wolfgang Babel, J. William Munger, Tiia Grönholm, Timo Vesala and Alexander Knohl, "Selected breakpoints of net forest carbon uptake at four eddy-covariance sites", Tellus B: Chemical and Physical Meteorology, 2021, 73, 1, 1-12. https://doi.org/10.1080/16000889.2021.1915648

21. tropical high-altitude site of Chacaltaya using WRF-FLEXPART and cluster analysis. *Atmos. Chem. Phys.*, 21, 16453–16477, 2021, https://doi.org/10.5194/acp-21-16453-2021

22. Kadantsev, E., Mortikov, E., Zilitinkevich S.: The resistance law for stably stratified atmospheric planetary boundary layer (PBL). *Quarterly Journal of the Royal Meteorological Society*, 147(737), 2233-2243, 2021, https://doi.org/10.1002/qj.4019

23. Achilleas Grigoriadis; Sokratis Mamarikas; Ioannis Ioannidis; Elisa Majamäki; Jukka-Pekka Jalkanen and Leonidas Ntziachristos, "Development of exhaust emission factors for vessels: A review and meta-analysis of available data", Atm. Env. X, Volume 12, December 2021, 100142, https://doi.org/10.1016/j.aeaoa.2021.100142

24. Fatahi, Y., Kouznetsov, R., and Sofiev, M.: Effect of accounting for public holidays on skills of atmospheric composition model SILAM v.5.7 (2021) Geosci. Model Dev., https://gmd.copernicus.org/articles/14/7459/2021/, 14, 7459 – 7475, https://doi.org/10.5194/gmd-14-7459-2021

25. Brenot, H., Theys, N., Clarisse, L., van Gent, J., Hurtmans, D.R., Vandenbussche, S., Papagiannopoulos, N., Mona, L., Virtanen, T., Uppstu, A., Sofiev, M., Bugliaro, L., Vázquez-Navarro, M., Hedelt, P., Parks, M.M., Barsotti, S., Coltelli, M., Moreland, W., Scollo, S., Salerno, G., Arnold-Arias, D., Hirtl, M., Peltonen, T., Lahtinen, J., Sievers, K., Lipok, F., Rüfenacht, R., Haefele, A., Hervo, M., Wagenaar, S., Som de Cerff, W., de Laat, J., Apituley, A., Stammes, P., Laffineur, Q., Delcloo, A., Lennart, R., Rokitansky, C.-H., Vargas, A., Kerschbaum, M., Resch, C., Zopp, R., Plu, M., Peuch, V.-H., Van Roozendael, M., Wotawa, G., 2021. EUNADICS-AV early warning system dedicated to supporting aviation in the case of a crisis from natural airborne hazards and radionuclide clouds. Natural Hazards and Earth System Sciences 21, 3367–3405. https://doi.org/10.5194/nhess-21-3367-2021

26. Bousquet, J., Anto, J.M., Bachert, C., Haahtela, T., Zuberbier, T., Czarlewski, W., Bedbrook, A., Bosnic-Anticevich, S., Walter Canonica, G., Cardona, V., ElisioCosta, , Cruz, A.A., Erhola, M., Fokkens, W.J., Fonseca, J.A., Illario, M., CarlosIvancevich, J., Jutel, M., Klimek, L., PiotrKuna, , Kvedariene, V., Le, L., Larenas-Linnemann, D., Laune, D., Lourenço, O.M., Melén, E., Mullol, J., Niedoszytko, M., Odemyr, M., Okamoto, Y., Papadopoulos, N.G., Patella, V., Pfaar, O., Pham-Thi, N., Rolland, C., Samolinski, B., Sheikh, A., Sofiev, M., SuppliUlrik, C., Todo-Bom, A., Tomazic, P.V., Toppila-Salmi, S., Tsiligianni, I., Valiulis, A., Valovirta, E., Ventura, M.-T., Walker, S., Williams, S., Yorgancioglu, A., Agache, I., Akdis, C.A., Almeida, R., Ansotegui, I.J., Annesi-Maesano, I., Arnavielhe, S., Basagaña, X., Bateman, E., Bédard, A., Bedolla-Barajas, M., Becker, S., Bennoor, K.S., Benveniste, S., Bergmann, K.C., Bewick, M., Bialek, S., Billo, N., Bindslev-Jensen, C., Bjermer, L., Blain, H., Bonini, M., Bonniaud, P., Bosse, I., Bouchard, J., Boulet, L.P., Bourret, R., Boussery, K., Braido, F., Briedis, V., Briggs, A., Brightling, C.E., JanBrozek, , Brusselle, G., Brussino, L., Buhl, R., Buonaiuto, R., Calderon, M.A., Camargos, P., Camuzat, T., Caraballo, L., Carriazo, A.M., Carr, W., Cartier, C., Casale, T., Cecchi, L., Cepeda Sarabia, A.M., Chavannes, N., Chkhartishvili, E., Chu, D.K., Cingi, C., Correia de Sousa, J., Costa, D.J., Courbis, A.L., Custovic, A., Cvetkosvki, B., D'Amato, G., da Silva, J., Dantas, C., Dokic, D., Dauvilliers, Y., De Feo, G., De Vries, G., Devillier, P., Di Capua, S., Dray, G., Dubakiene, R., Durham, S.R., Dykewicz, M., Ebisawa, M., Gaga, M., El-Gamal, Y., Heffler, E., Emuzyte, R., Farrell, J., Fauquert, J.-L., Fiocchi, A., Fink-Wagner, A., Fontaine, J.-F., Fuentes Perez, J.M., Gemicioğlu, B., Gamkrelidze, A., Garcia-Aymerich, J., Gevaert, P., Gomez, M., González Diaz, S., Gotua, M., Guldemond, N.A., Guzmán, M.-A., Hajjam, J., Huerta Villalobos, Y.R., Humbert, M., Iaccarino, G., Ierodiakonou, D., Tomohisalinuma, , Jassem, E., Joos, G., Jung, K.-S., Kaidashev, I., Kalayci, O., Kardas, P., Keil, T., Khaitov, M., Khaltaev, N., Kleine-Tebbe, J., Kouznetsov, R., Kowalski, M.L., Kritikos, V., Kull, I., La Grutta, S., Leonardini, L., Ljungberg, H., Lieberman, P., Lipworth, B., Lodrup Carlsen, K.C., Lopes-Pereira, C., Loureiro, C.C., Louis, R., Mair, A., Mahboub, B., Makris, M., Malva, J., Manning, P., Marshall, G.D., Masjedi, M.R., Maspero, J.F., Carreiro-Martins, P., Makela, M., Mathieu-Dupas, E., Maurer, M., De Manuel Keenoy, E., Melo-Gomes, E., Meltzer, E.O., Menditto, E., Mercier, J., Micheli, Y., Miculinic, N., Mihaltan, F., Milenkovic, B., Mitsias, D., Moda, G., Mogica-Martinez, M.-D., Mohammad, Y., Montefort, S., Monti, R., Morais-Almeida, M., Mösges, R., Münter, L., Muraro, A., Murray, R., Naclerio, R., Napoli, L., Namazova-Baranova, L., Neffen, H., Nekam, K., Neou, A., Nordlund, B., Novellino, E., Nyembue, D., O'Hehir, R., Ohta, K., Okubo, K., Onorato, G.L., Ouedraogo, S.,Palamarchuk, J., Pali-Schöll, I., Panzner, P., Park, H.-S., Passalacqua, G., Pépin, J.-L., Paulino, E., Phillips, J., Picard, R., Pinnock, H., Plavec, D., Popov, T.A., Portejoie, F., Price, D., Prokopakis, E.P., Psarros, F., Pugin, B., Puggioni, F., Quinones-Delgado, P., Raciborski, F., Rajabian-Soderlund, R., Regateiro, F.S., Reitsma, S., Rivero-Yeverino, D., Roberts, G., Roche, N., Rodriguez-Zagal, E., Rolland, C., Roller-Wirnsberger, R.E., Rosario, N., Romano, A., Rottem, M., Ryan, D., Salimäki, J., Sanchez-Borges, M.M., Sastre, J., Scadding, G.K., Scheire, S., Schmid-Grendelmeier, P., Schünemann, H.J., Serpa, F., Shamji, M., Sisul, J.-C., Sofiev, M., Solé, D., Somekh, D., Sooronbaev, T., Sova, M., Spertini, F., Spranger, O., Stellato, C., Stelmach, R., Thibaudon, M., To, T., MondherToumi, , Usmani, O., Valero, A., Valenta, R., Valentin-Rostan, M., van der Kleij, R., Van Eerd, M., Vandenplas, O., Vasankari, T., Vaz Carneiro, A., Vezzani, G., Viart, F., Viegi, G., Wallace, D., Wagenmann, M., Wang, D.Y., Waserman, S., Wickman, M., Williams, D.M., Wong, G., Wroczynski, P., Yiallouros, P.K., Yusuf, O.M., Zar, H.J., Zeng, S., Zernotti, M.E., Zhang, L., Zhong, N.S. and Zidarn, M. (2021), ARIA digital anamorphosis: Digital transformation of health and care in airway diseases from research to practice. Allergy., doi:10.1111/all.14422

27. Bousquet, J., Pfaar, O., Agache, I., Bedbrook, A., Akdis, CA., Canonica, GW., Chivato, T., Al-Ahmad, M., Latiff, AHA., Ansotegui, IJ., Bachert, C., Baharuddin, A., Bergmann, KC., Bindslev-Jensen, C., Bjermer, L., Bonini, M., Bosnic-Anticevich, S., Bosse, I., Brough, HA., Brussino, L., Calderon, MA., Caraballo, L., Cardona, V., Carreiro-Martins, P., Casale, T., Cecchi, L., Sarabia, AMC., Chkhartishvili, E., Chu, DK., Cirule, I., Cruz, AA., Czarlewski, W., del Giacco, S., Demoly, P., Devillier, P., Dokic, D., Durham, SL., Ebisawa, M., El-Gamalt, Y,. Emuzyte, R., Gamkrelidze, A., Fauquert, JL., Fiocchi, A., Fokkens, WJ., Fonseca, JA., Fontaine, JF., Gawlik, R., Gelincik, A., Gemicioglu, B., Gereda, JE., van Wijk, RG., Gomez, RM., Gotua, M., Grisle, I., Guzman, MA., Haahtela, T., Halken, S., Heffler, E., Hoffmann-Sommergruber, K., Hossny, E., Hrubisko, M., Irani, C., Ivancevich, JC., Ispayeva, Z., Julge, K., Kaidashev, I., Kalayci, O., Khaitov, M., Klimek, L., Knol, E., Kowalski, ML., Kraxner, H., Kull, I., Kuna, P., Kvedariene, V., Kritikos, V., Lauerma, A., Lau, S., Laune, D., Levin, M., Larenas-Linnemann, DE., Carlsen, KCL., Lombardi, C., Lourenco, OM., Mahboub, B., Malling, HJ., Manning, P., Marshall, GD., Melen, E., Meltzer, EO., Miculinic, N., Milenkovic, B., Moin, M., Montefort, S., Morais-Almeida, M., Mortz, CG., Mosges, R., Mullol, J., Baranova, LN., Neffen, H., Nekam, K., Niedoszytko, M., Odemyr, M., O'Hehir, RE., Ollert, M., O'Mahony, L., Ohta, K., Okamoto, Y., Okubo, K., Pajno, GB., Palomares, O., Palkonen, S., Panzner, P., Papadopoulos, NG., Park, HS., Passalacqua, G., Patella, V., Pawankar, R., Pham-Thi, N., Plavec, D., Popov, TA., Recto, M., Regateiro, FS., Riggioni, C., Roberts, G., Rodriguez-Gonzales, M., Rosario, N., Rottem, M., Rouadi, PW., Ryan, D.,., Samolinski, B., Sanchez-Borgest, M., Serpa, FS., Sastre, J., Scadding, GK., Shamji, MH., Schmid-Grendelmeier, P., Schunemann, HJ., Sheikh, A., Scichilone, N., Sisul, JC., Sofiev, M., Sole, D., Sooronbaev, T., Soto-Martinez, M., Soto-Quiros, M., Sova, M., Schwarze, J., Skypala, I., Suppli-Ulrik, C., Taborda-Barata, L., Todo-Bom, A., Torres, MJ., Valentin-Rostan, M., Tomazic, PV., Valero, A., Toppila-Salmi, S., Tsiligianni, I., Untersmayr, E., Urrutia-Pereira, M., Valiulis, A., Valovirta, E., Vandenplas, O., Ventura, MT., Vichyanond, P., Wagenmann, M., Wallace, D., Walusiak-Skorupa, J., Wang, DY., Waserman, S., Wong, GW., Yorgancioglu, A., Yusuf, OM., Zernotti, M., Zhang, L., Zidarn, M., Zuberbier, T., Jutel, M. (2021) ARIA-EAACI care pathways for allergen immunotherapy in respiratory allergy. Clinical and Translational Allergy. v.11, 4, DOI 10.1002/clt2.12014

28. Daunys, G., Šukiene, L. Vaitkevichius, L., Valiulis, G., Sofiev, M., Šauliene, I. (2021) Clustering approach for the analysis of the fluorescent bioaerosol collected by an automatic detector. PLOIS One, https://doi.org/10.1371/journal.pone.0247284

29. Damialis, A., Gilles, S., Sofiev, M., Sofieva, V. and Kolek, F. Bayr, D. Plaza, Maria P. Leier-Wirtz, V. Kaschuba, S. Ziska, L. H. Bielory, L. Makra, L., del Mar Trigo, M. Traidl-Hoffmann, C. (2021) Higher airborne pollen concentrations correlated with increased SARS-CoV-2 infection rates, as evidenced from 31 countries across the globe. Proc. Nat. Academy of Sciense, 118, 12, doi = 10.1073/pnas.2019034118, https://www.pnas.org/content/118/12/e2019034118.

30. Petäjä T, Ovaska A, Fung PL, Poutanen P, Yli-Ojanperä J, Suikkola J, Laakso M, Mäkelä T, Niemi JV, Keskinen J, Järvinen A, Kuula J, Kurppa M, Hussein T, Tarkoma S, Kulmala M, Karppinen A, Manninen HE and Timonen H , 2021. Added Value of Vaisala AQT530 Sensors as a Part of a Sensor Network for Comprehensive Air Quality Monitoring. *Environ. Sci. 9:719567*. doi: 10.3389/fenvs.2021.719567

31. Okokon, E.O., Yli-Tuomi,T., Siponen, T., Tiittanen, P., Turunen,A.W., Kangas, L., Karppinen, A.,Kukkonen, J., Lanki, T. 2021. Heterogeneous Urban Exposures and Prevalent Hypertension in the Helsinki Capital Region, Finland. *J. Environ. Res. Public Health* .2021, 18,1196. https://doi.org/10.3390/ijerph18031196

32. Roine, E. and Atanasova, N. Vesicle-like archaeal viruses. In: Encyclopedia of Virology, 4th edition., edits. Bamford, D. and Zuckerman, M., Elsevier, London, UK. eBook ISBN: 9780128145166,Hardcover ISBN: 9780128145159

33. Demina, T. and Atanasova, N. Ecology of phages in extreme environments. In: Encyclopedia of Virology, 4th edition., edits. Bamford, D. and Zuckerman, M., Elsevier, London, UK. eBook ISBN: 9780128145166,Hardcover ISBN: 9780128145159

34. Janne Lampilahti, Hanna Elina Manninen, Katri Leino, Riikka Väänänen, Antti Manninen, Stephany Buenrostro Mazon, Tuomo Nieminen, Matti Leskinen, Joonas Enroth, Marja Bister, Sergej Zilitinkevich, Juha Kangasluoma, Heikki Järvinen, Veli-Matti Kerminen, Tuukka Petäjä, Markku Kulmala. Roll vortices induce new particle formation bursts in the planetary boundary layer. Atmos. Chem. Phys., 20, 11841–11854, 2020 https://doi.org/10.5194/acp-20-11841-2020

35. Ohata, S., Mori, T., Kondo, Y., Sharma, S., Hyvärinen, A., Andrews, E., Tunved, P., Asmi, E., Backman, J., Servomaa, H., Veber, D., Eleftheriadis, K., Vratolis, S., Krejci, R., Zieger, P., Koike, M., Kanaya, Y., Yoshida, A., Moteki, N., Zhao, Y., Tobo, Y., Matsushita, J., and Oshima, N.: Estimates of mass absorption cross sections of black carbon for filter-based absorption photometers in the Arctic, Atmos. Meas. Tech., 14, 6723–6748, https://doi.org/10.5194/amt-14-6723-2021, 2021.

36. Asmi, E., Backman, J., Servomaa, H., Virkkula, A., Gini, M. I., Eleftheriadis, K., Müller, T., Ohata, S., Kondo, Y., and Hyvärinen, A.: Absorption instruments inter-comparison campaign at the Arctic Pallas station, Atmos. Meas. Tech., 14, 5397–5413, https://doi.org/10.5194/amt-14-5397-2021, 2021

37. Helin, A., Virkkula, A., Backman, J., Pirjola, L., Sippula, O., Aakko-Saksa, P., et al. (2021). Variation of absorption Ångström exponent in aerosols from different emission sources. Journal of Geophysical Research: Atmospheres, 126, e2020JD034094. https://doi.org/10.1029/2020JD034094

38. Zilitinkevich, S., Kadantsev, E., Repina, I., Mortikov, E., and Glazunov, A.: Order out of Chaos: Shifting Paradigm of Convective Turbulence. *Journal of the Atmospheric Sciences*, 78(12), 3925-3932, 2021, https://doi.org/10.1175/JAS-D-21-0013.1

39. Aliaga, D., Sinclair, V. A., Andrade, M., Artaxo, P., Carbone, S., Kadantsev, E., Laj, P., Wiedensohler, A., Krejci, R., and Bianchi, F.: Identifying source regions of air masses sampled at the

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