The Norwegian air quality service: Model forecasting

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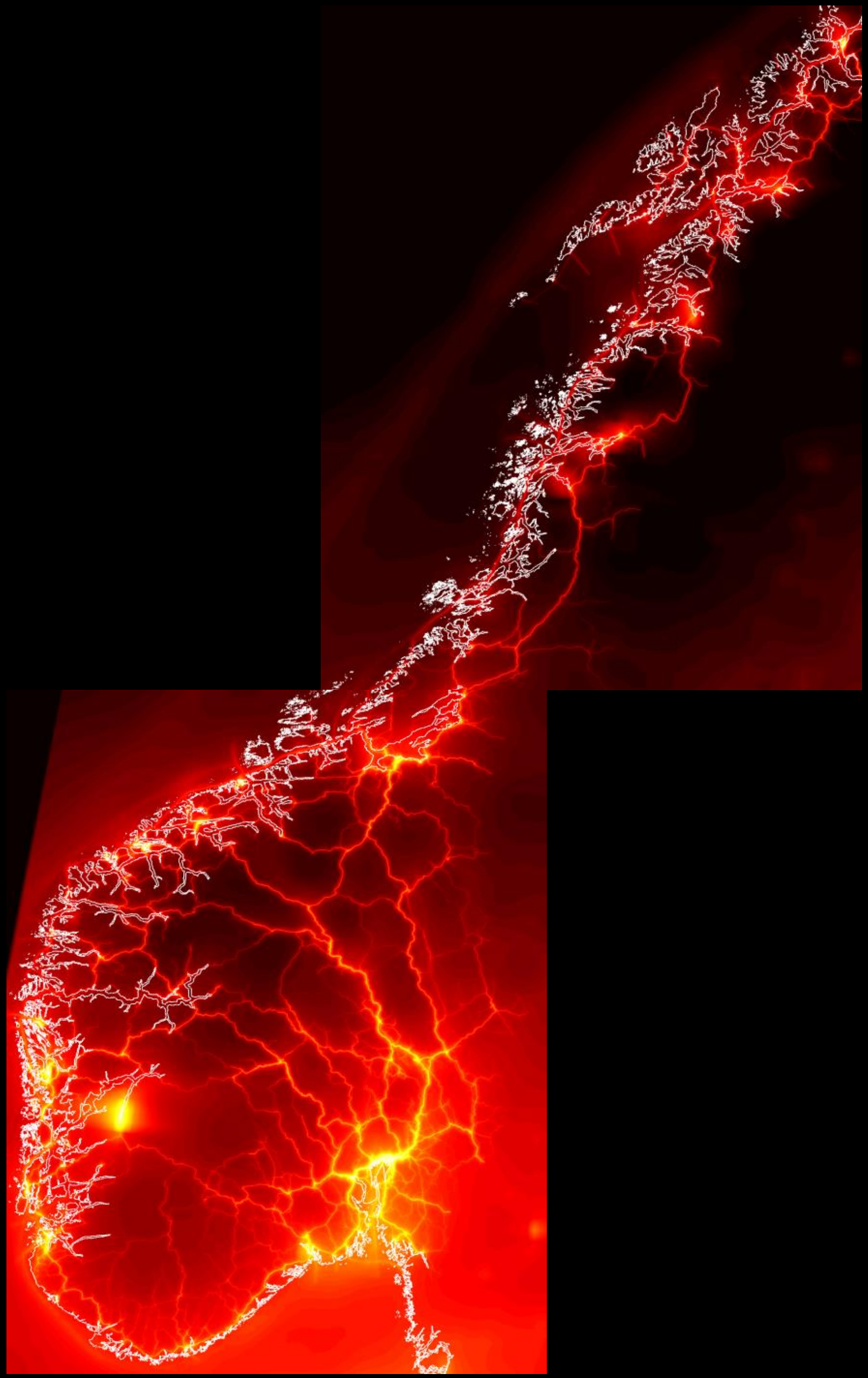
17 September workshop held at the Road Traffic Authorities (SVV) at Brynseng

Ambition

- To provide a national air quality modelling system to support both local and national authorities in their air quality obligations
- The modelling system will be used, and be useful, for the following applications
  - Air quality forecasting
  - Short term air quality measures
  - Long term air quality planning
  - Providing information and awareness to the public
- Because such a system must work on the local level then involvement of local authorities is essential



Content

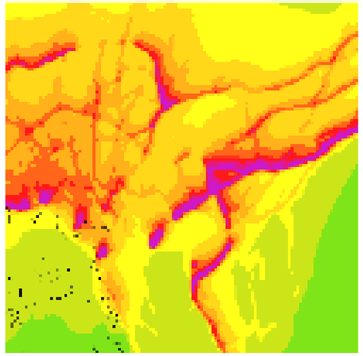
- Short background to modelling
- Description of the modelling system
- Emissions
- Model implementation
- Comparison to measurements
- Uncertainty
- Ongoing developments
- How can local authorities improve their air quality forecasts?

Background

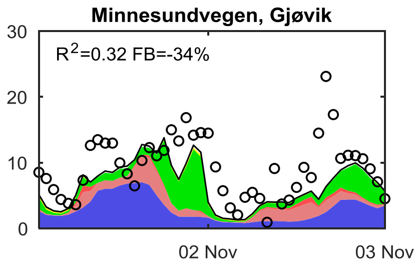
Modelling and monitoring?

- Monitoring provides the 'true' air quality at a single point in space and can tell us things we don't know
- There are between 60 and 80 active monitoring sites in Norway

- Modelling is based on 'what we do know' and is more uncertain than monitoring
- Modelling allows complete spatial coverage (around 20 million grids)
- Modelling can be used for planning and forecasting



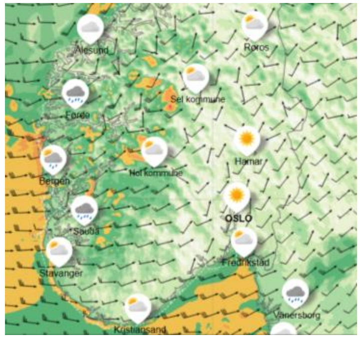
- Uncertainties in modelling are estimated by comparison with measurements
- But a measurement site may not represent the same area as a model



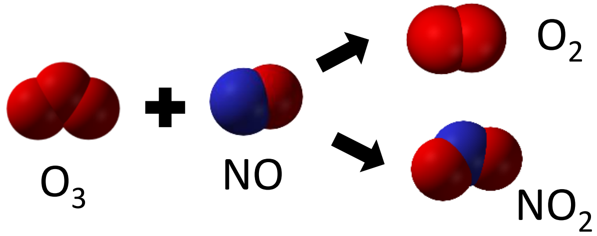
http://www.ielverum.no/nyheter/daarlig-luftkvalitet-og-forbud-i-oslo-i-elverum-er-luftkvaliteten-god

What makes an air quality forecast?

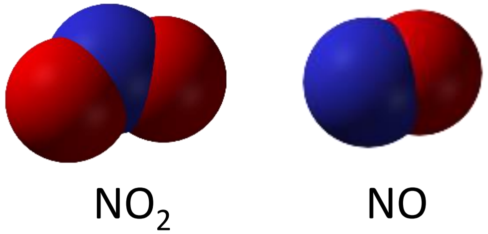
- Meteorology
  - Meteorological models provide forecasts required for the air quality model
  - Important are wind speed and direction, atmospheric stability, mixing height and precipitation
  - An air quality forecast is no better than the meteorology it uses
- Emissions
  - Emissions from all known sources distributed in time and space
  - An air quality forecast is no better than the emissions it uses
- An air quality model
  - Combines meteorology with emissions, transporting and dispersing these emissions
  - Chemical reactions
- Interpretation and communication



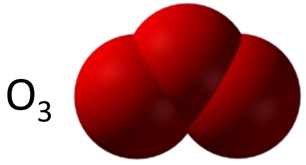
Pollutants and sources



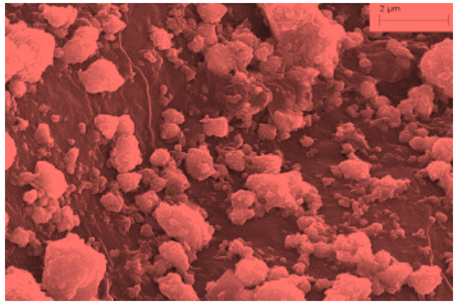
- **NO_2 (nitrogen dioxide)** emitted during combustion (traffic, industry). NO_2 can be emitted directly or is formed when NO (nitrogen oxide) reacts with O_3 to form NO_2 after a number of minutes. Most NO_x (NO_2 + NO) is emitted as NO



- **O_3 (ozone)** created naturally over longer time scales but also enhanced, or depleted, through emissions. This is a long transport pollutant and important for making NO_2 from NO



- **PM_{10} and $PM_{2.5}$** are particulate matter less than 10 and 2.5 µm. Particles greater than 10 µm are not easily inhaled into the lungs. PM has many sources but in Norway PM is dominated by long range transport, road dust and wood burning

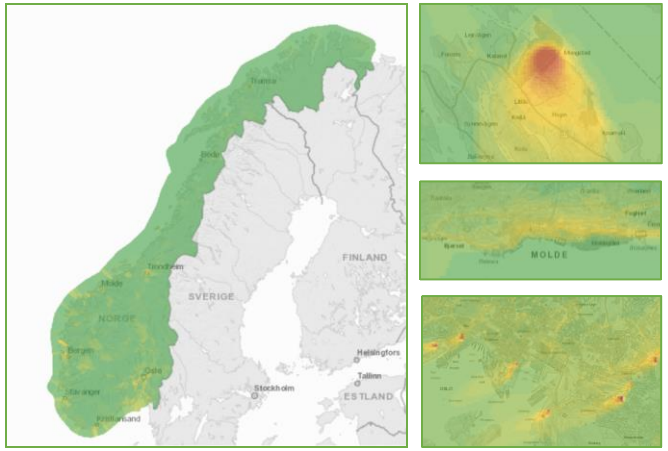


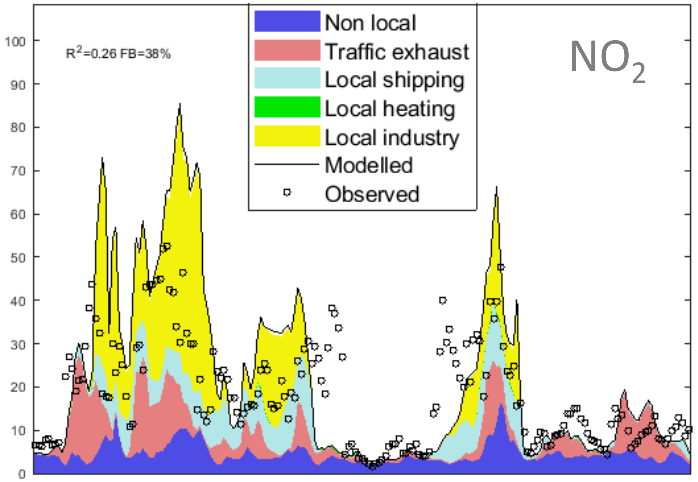
https://cen.acs.org/articles/91/web/2013/11/Trees-Capture-Particulate-Matter-Road.html

Description of the modelling system

What does the forecasting system deliver

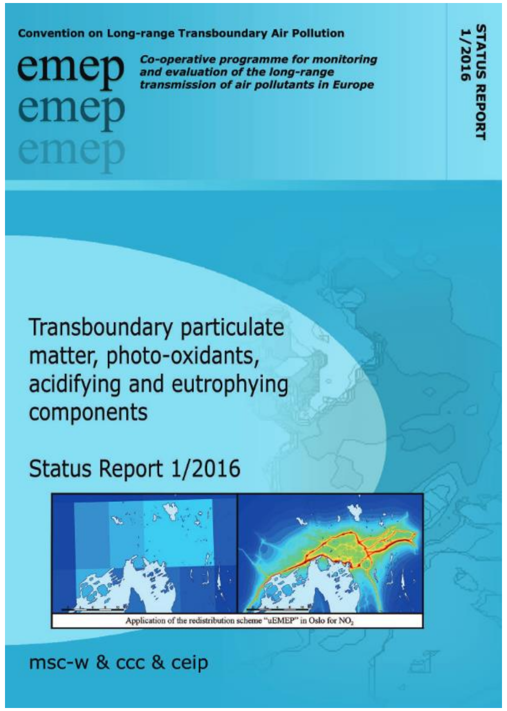
- 2 day hourly forecasts for all of Norway at 500 – 50 m for the pollutants PM_{10}, $PM_{2.5}$, NO_2 and O_3
- A forecasted Air Quality Index (AQI) for all of Norway for each forecast hour. AQI is a combined pollutant health index
- Local source contribution for each pollutant:
  - Traffic exhaust
  - Traffic non-exhaust (mostly road dust)
  - Shipping emissions (exhaust only)
  - Industrial emissions
  - Residential wood combustion
  - Other sources (mostly non-local contributions)





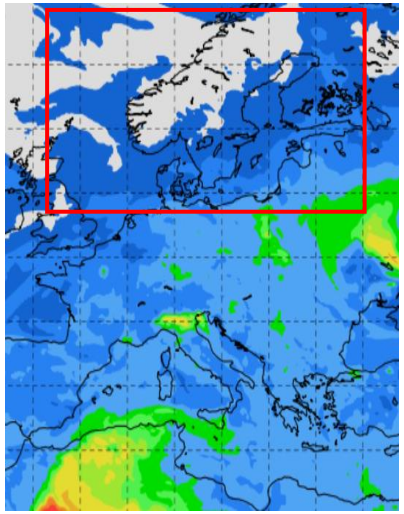
What is EMEP?

- **EMEP** stands for the **E**uropean **M**onitoring and **E**valuation **P**rogramme and is part of the Convention on Long-range Transboundary Air Pollution (CLRTAP)
- **‘The EMEP model’** is the chemical transport model used within this programme to calculate pollutants globally, in Europe and now in Norway. It has been developed at MET
- **‘uEMEP’** (urban EMEP) is the fine resolution dispersion model that calculates concentrations on ‘subgrids’ from 250 – 50 m in size within the EMEP model

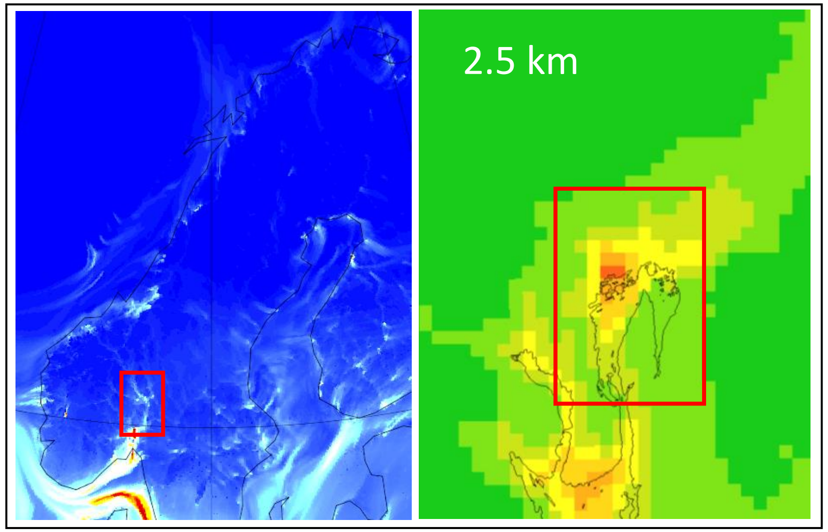


http://emep.int/publ/reports/2016/EMEP_Status_Report_1_2016.pdf

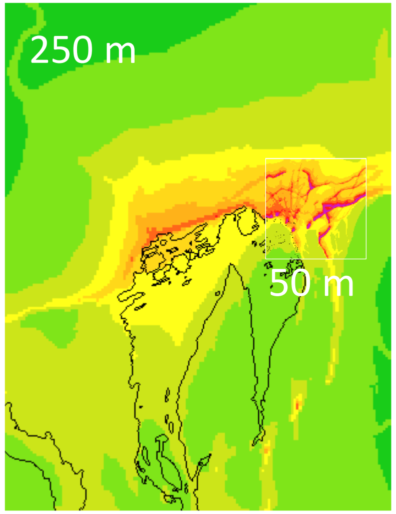
Overview of modelling in the forecast system



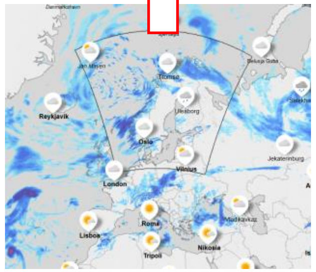
EMEP model for Europe



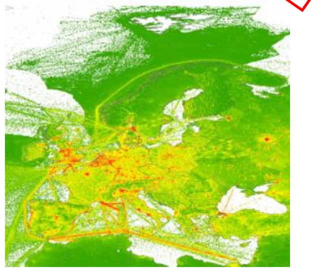
EMEP model for Norway



uEMEP



ECMWF global meteorology



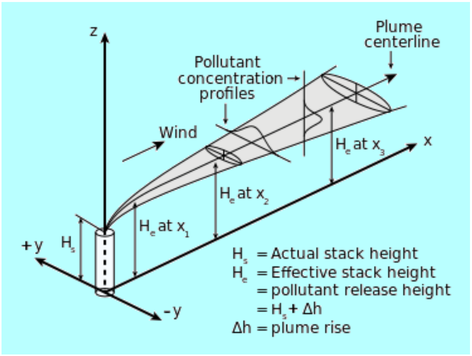
CAMS European emissions

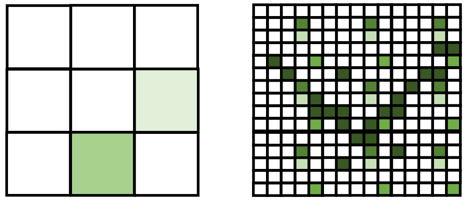
AROME meteorology

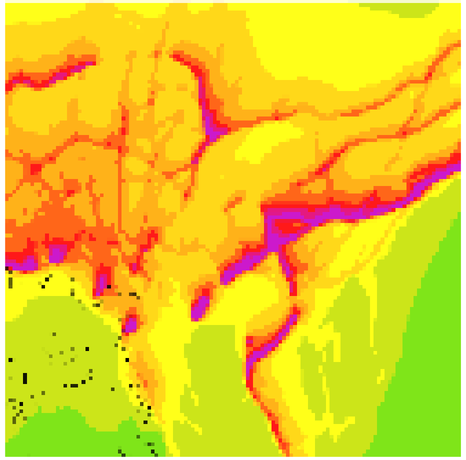
Local emissions

uEMEP

- uEMEP is based on Gaussian plume modelling
- It places emissions into **sub-grids** (grids much smaller than the EMEP grid) and calculates each sub-grid emission contribution to all other sub-grids within a 10 x 10 km^2 region
- Smallest sub-grids are 25 m, used to calculate concentrations at monitoring sites
- The largest subgrid is 250 m
- A chemistry scheme is used only for $NO_x/O_3/NO_2$

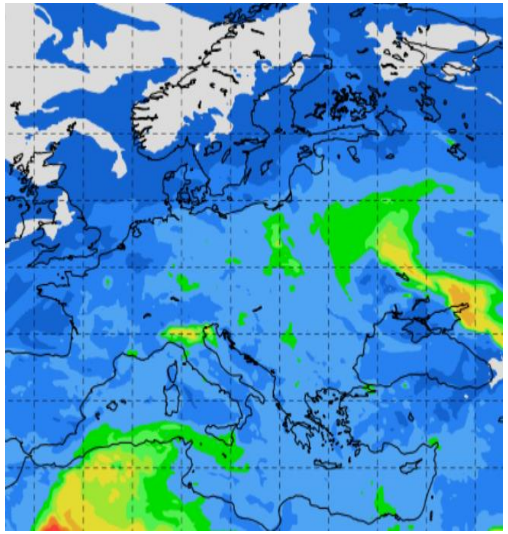


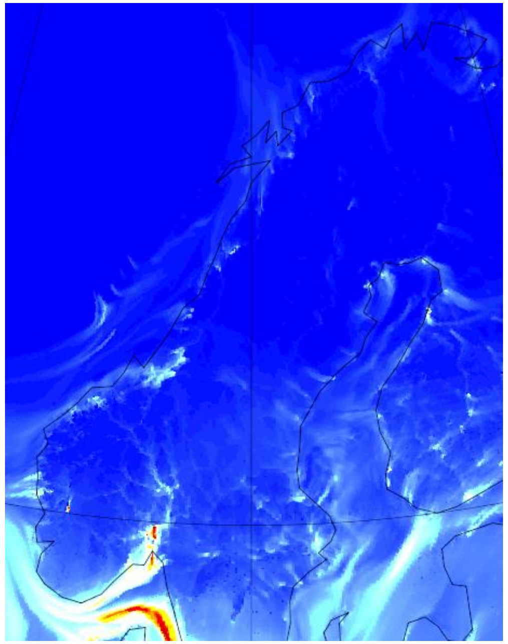




The EMEP model

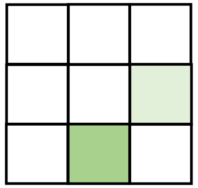
- The EMEP model is used to calculate concentrations for Europe (15 km) and provides boundary conditions for the Norwegian calculation
- The EMEP model is applied over Norway (2.5 km) using the meteorological data from the Arome-MetCOOP model (the same model that provides forecast information for Yr)
- Within the EMEP model is a routine that calculates how much the emissions from each grid contribute to it and its surrounding grids (‘**local fraction’**)
- The ‘local fraction’ information allows us to place the high resolution uEMEP anywhere within EMEP by replacing the **‘local region’** EMEP grids with uEMEP **‘local’** sub-grids and avoid **double counting** of emissions



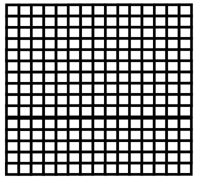


Terms and concepts

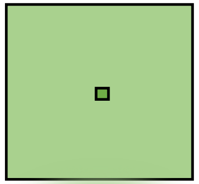
- **‘Grid’** is the calculation grid for EMEP (2.5 km for Norway)



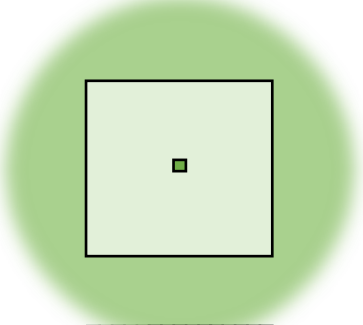
- **‘Sub-grid’** is the uEMEP emission and concentration grid that is much smaller than the EMEP grid (250 – 50 m)



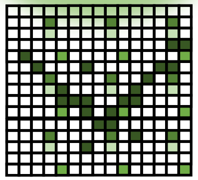
- **‘Local region’** is the area surrounding an uEMEP sub-grid where the uEMEP calculations are done (10 x 10 km^2)



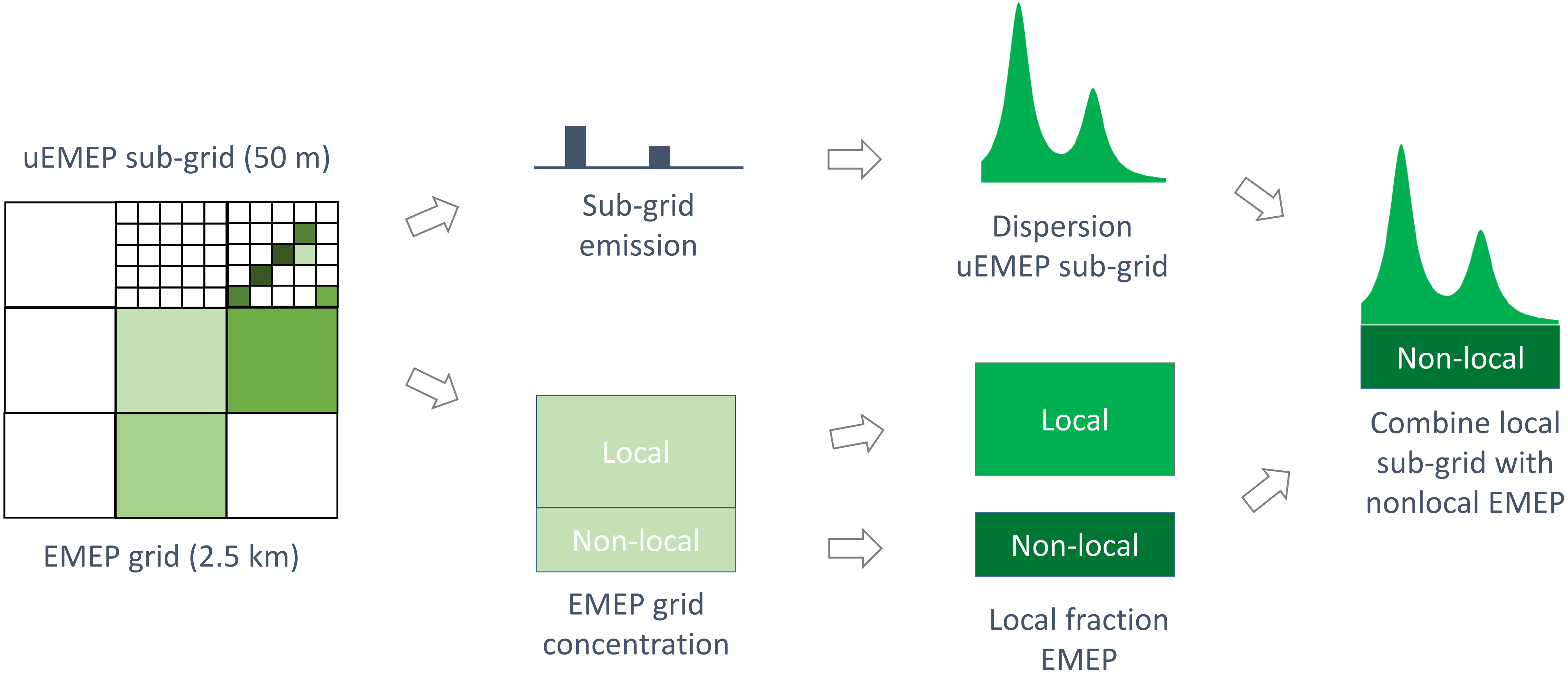
- **‘Non-local’** includes all EMEP modelled concentrations originating from emissions outside the local region **and** not included in uEMEP



- **‘Local’** means all uEMEP modelled concentrations from emissions within the ‘local region’



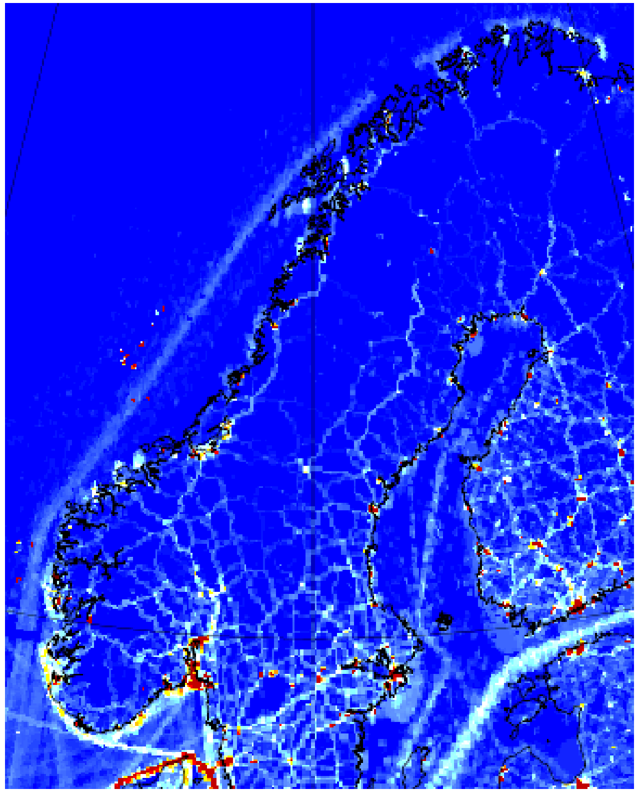
How uEMEP replaces EMEP grids with uEMEP sub-grids



Emissions

EMEP emissions

- EMEP uses emissions from all sectors based on the European emissions inventories developed for CAMS (Copernicus Atmosphere Monitoring Service)
- These emissions are provided at 7 x 7 km^2 for all of Europe and disaggregated for use in Norway
- In addition separate emissions for shipping are provided by FMI, Finland, based on AIS data (Automatic Identification System)
- These emissions are currently not the same as the subgrid emissions used in uEMEP and will be replaced soon



NOx emissions used in EMEP

uEMEP emissions

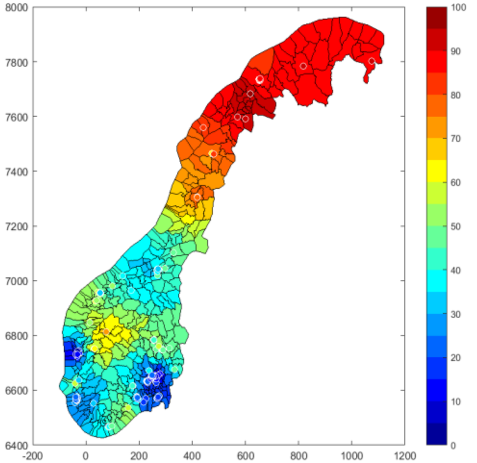
- uEMEP calculates the most important emissions sources in Norway for high resolution modelling. These are:
  - Traffic exhaust (per road segment)
  - Traffic non-exhaust (per road segment)
  - Shipping emissions (250 m grid)
  - Residential wood burning emissions (250 m)
  - Industrial emissions (per industry)
- All other emissions are calculated on the larger scale using EMEP





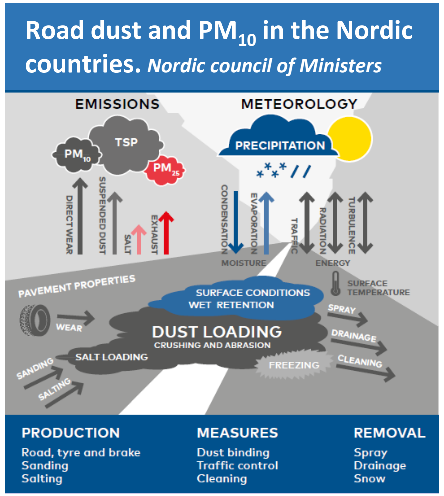
Traffic data and emissions

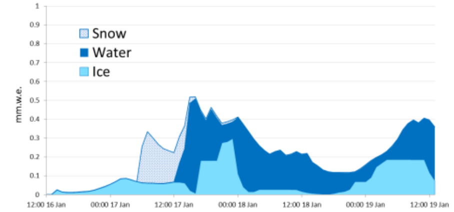
- Road traffic and road network data is taken from NVDB for state roads and from SSB traffic modelling for municipal roads
- In all roughly 700 000 road segments are used containing 8 million individual road links
- NO_x emission factors are set everywhere to the national average, based on total road traffic emissions for Norway (SSB)
- One single time profile for all traffic is currently used
- NORTRIP road dust emission model is used for all roads
- Studded tyre share is derived from ~ 200 counting sites across the country (SVV) from 2017 and distributed to each municipality
- All emissions within tunnels exit at tunnel portals

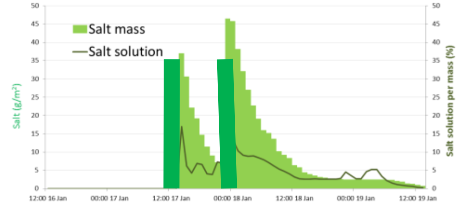


Road dust emissions

- PM emissions from road, tyre and brake wear, as well as road salt, are calculated using the NORTRIP road dust emission model
- Calculates the road surface conditions and the accumulation of wear particles on the road surface
- Calculates the direct emission from studded tyres and the suspension of the road dust particles
- Salting and dust binding are included in the model but these activities are unknown. Salting activities are estimated based on a set of salting rules and snow ploughing automatically occurs above a snow depth threshold
- No information on dust binding activities is available and it is not currently applied in the model







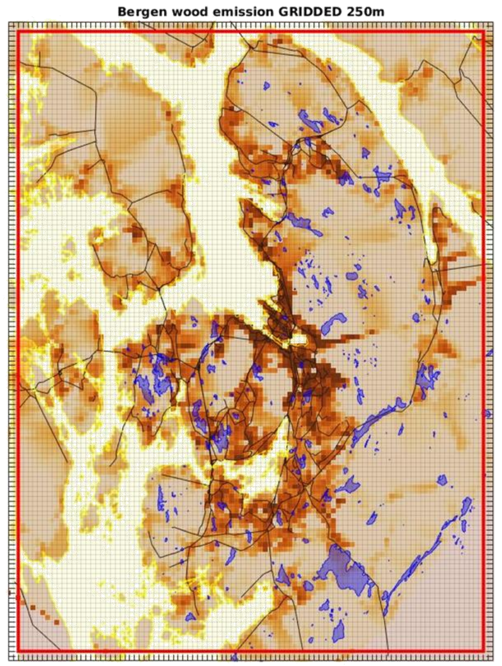
Shipping emissions

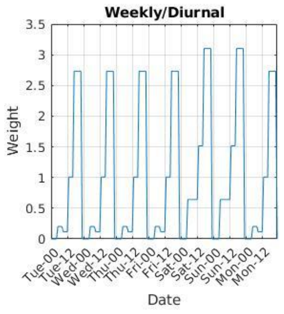
- AIS data (Automatic Identification System) is used for positional and movement information to determine exhaust emissions for shipping (kystverket.no)
- It is assumed that while AIS is turned on then the ships motors, or generators, are working. Emissions are determined from boat/engine type and speed
- Errors occur where land line electricity is available
- Heights of the emissions are not included in the AIS data
- Current dataset in uEMEP is from 2015 and constant in time. These will be updated using 2017 data with time variation where applicable

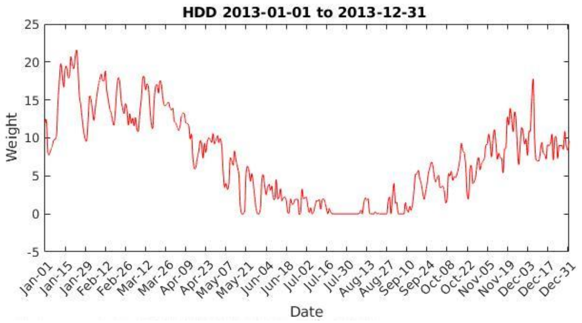
https://kart.kystverket.no/
https://www.tu.no/artikler/bergen-havn-far-sin-forste-stikkontakt-for-skip/193813

Residential wood burning emissions

- New wood burning emission data has been provided by NILU (MetVed model)
- Uses a range of new data sources to better distribute wood burning emissions on a 250 m grid for all of Norway
- Uses ‘heating degree days’ (temperature dependency) to adjust the emissions on a daily basis







* Images supplied by Susana López-Aparicio, NILU

Industrial emissions

- Emission data for 300 industrial sites are available through Statistisk sentralbyrå (SSB) and Miljødirektoratet (www.norskeutslipp.no)
- Only total annual emissions are provided
- For PM only total particle emissions are provided (size unspecified)
- Lacking metadata (emission height, flow rate, temperature, detailed position of emission sources etc.) and temporal profiles
- Effective mission height set to 80 m for all industries

http://nordnorskdebatt.no/article/enig-tro-saltfjellet-faller
https://www.sa.no/nyhet/borregaard/miljo/na-skal-lufta-i-sarpsborg-bli-renere-takket-vare-denne-milioninvesteringen/s/5-46-421438

Model implementation

Model implementation: pollutants and sources

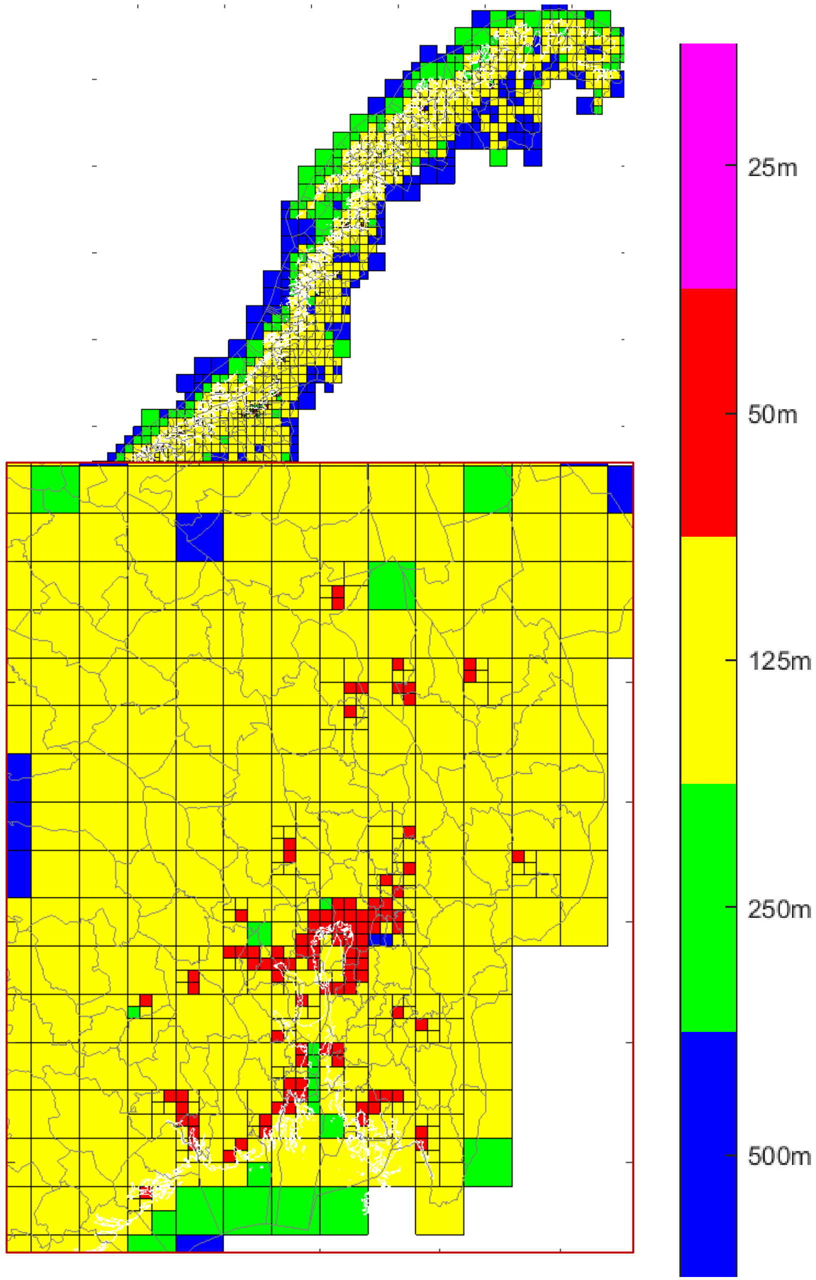
- uEMEP calculates the following pollutants
  - NO_x and NO_2
  - O_3
  - PM_{10} and $PM_{2.5}$
- For each of these pollutants the fractional contribution of each source is calculated and provided
  - Traffic exhaust
  - Traffic nonexhaust (road dust)
  - Shipping
  - Residential wood burning
  - Industry
  - Non-local contribution

Model implementation: tiling

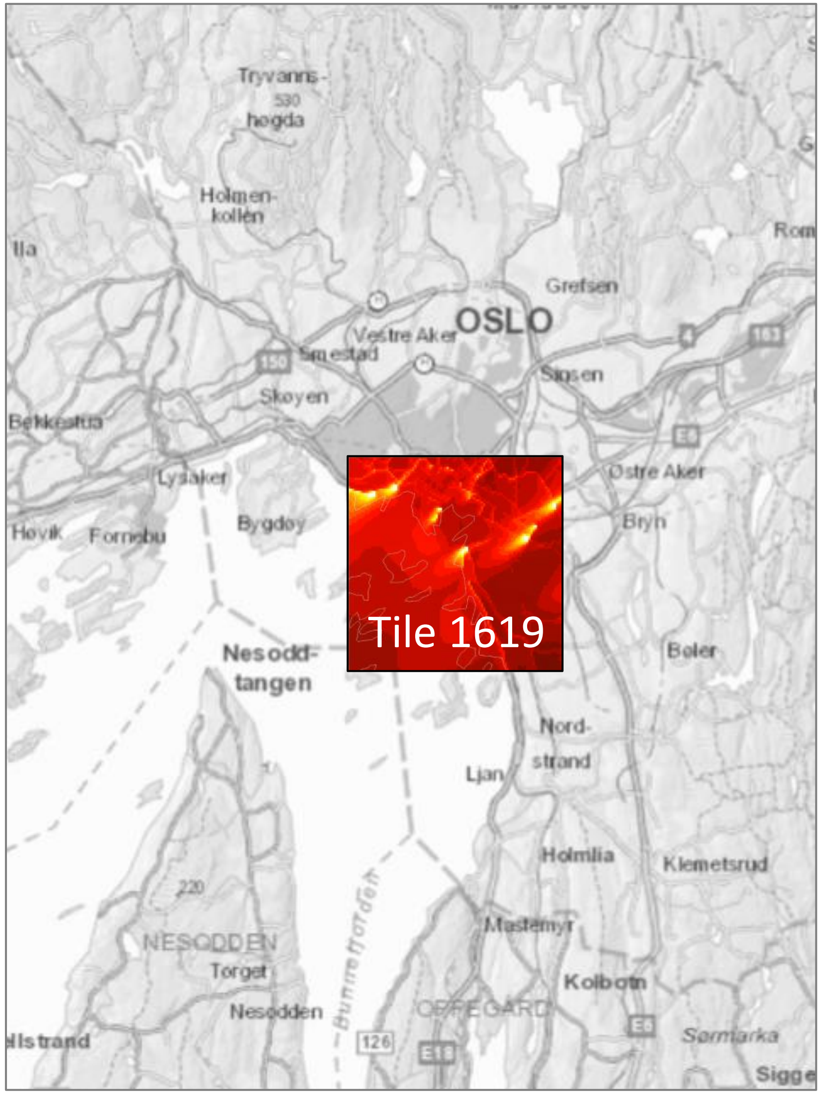
- It is not possible, or necessary, to calculate concentrations at 50 m resolution for all of Norway
- uEMEP covers the entire country at a range of resolutions and uses tiling to achieve this
- Grid resolution is set by rules within 5 x 5 km^2 tiles

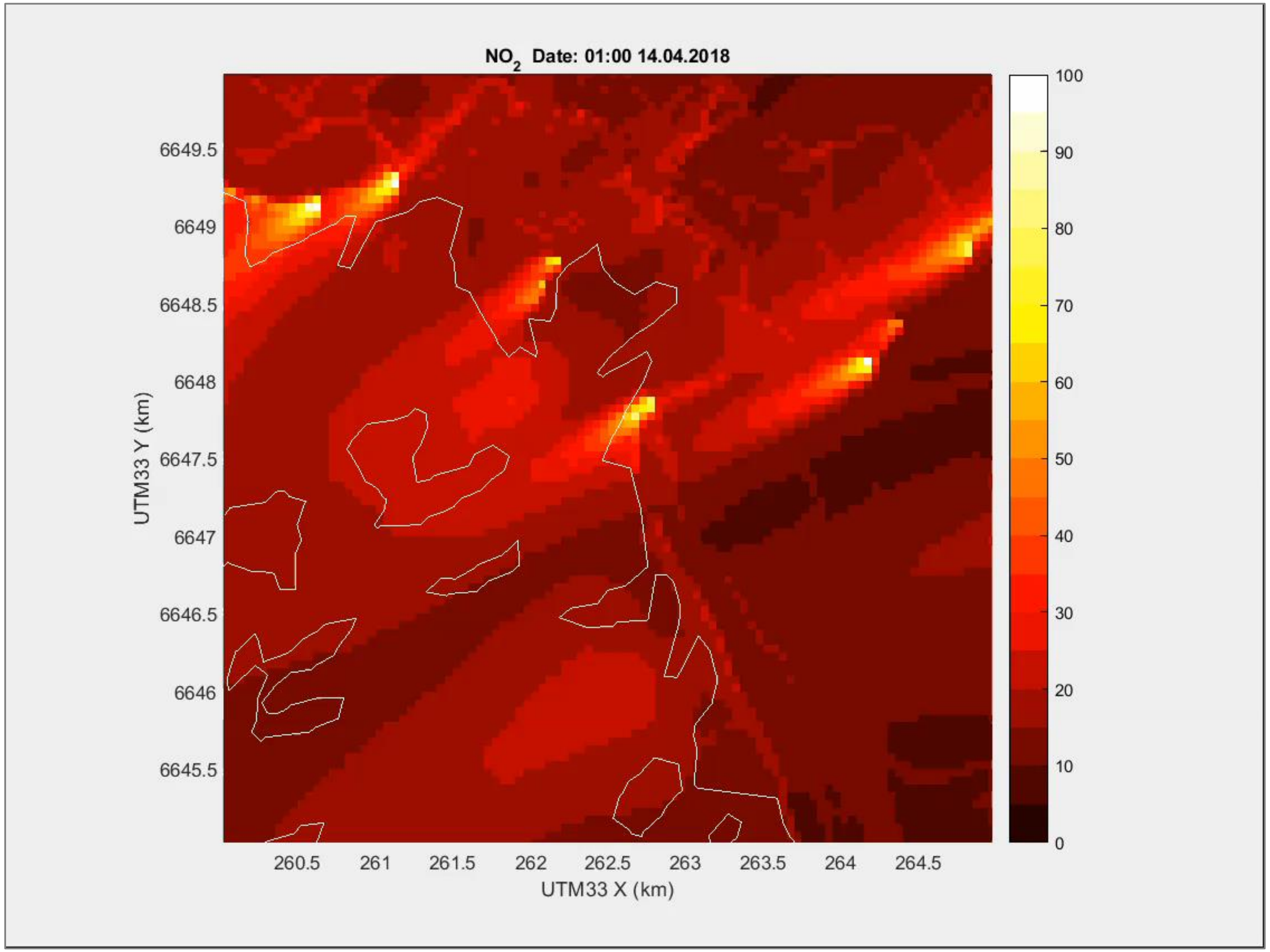
500 m: No emissions and population < 2 inhab./km^2
250 m: Traffic < 1000 veh.km/day and population < 2 inhab./km^2
125 m: 2 inhab/km^2 < population < 200 inhab./km^2
50 m: population > 200 inhab./km^2
25 m: surrounding all measurement sites

- Tiles with the same resolution are aggregated, up to 40 x 40 km^2, resulting in 1864 individual tiles

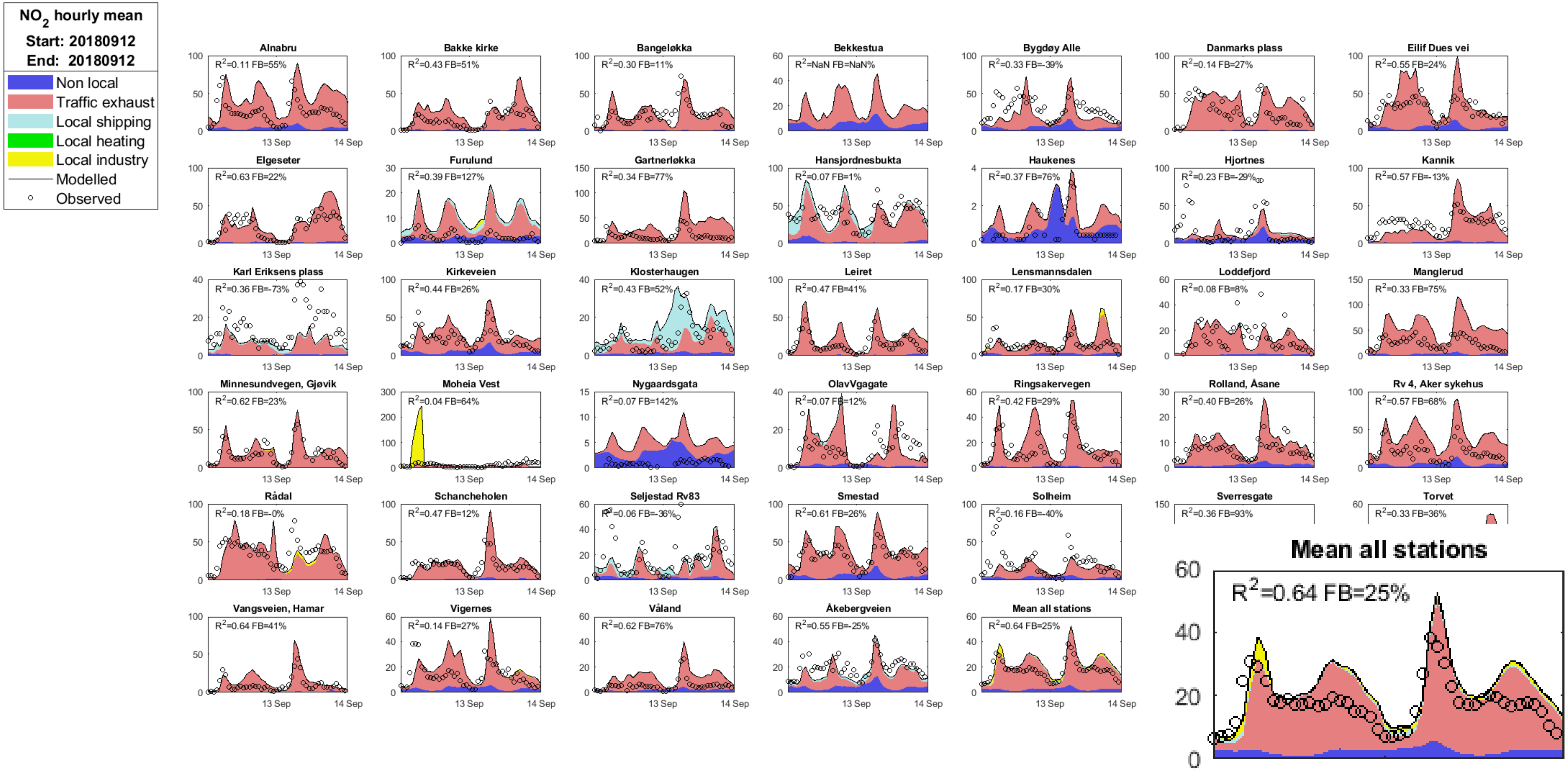


Example calculation : Tile 1619, 5 x 5 km^2, 50 m resolution

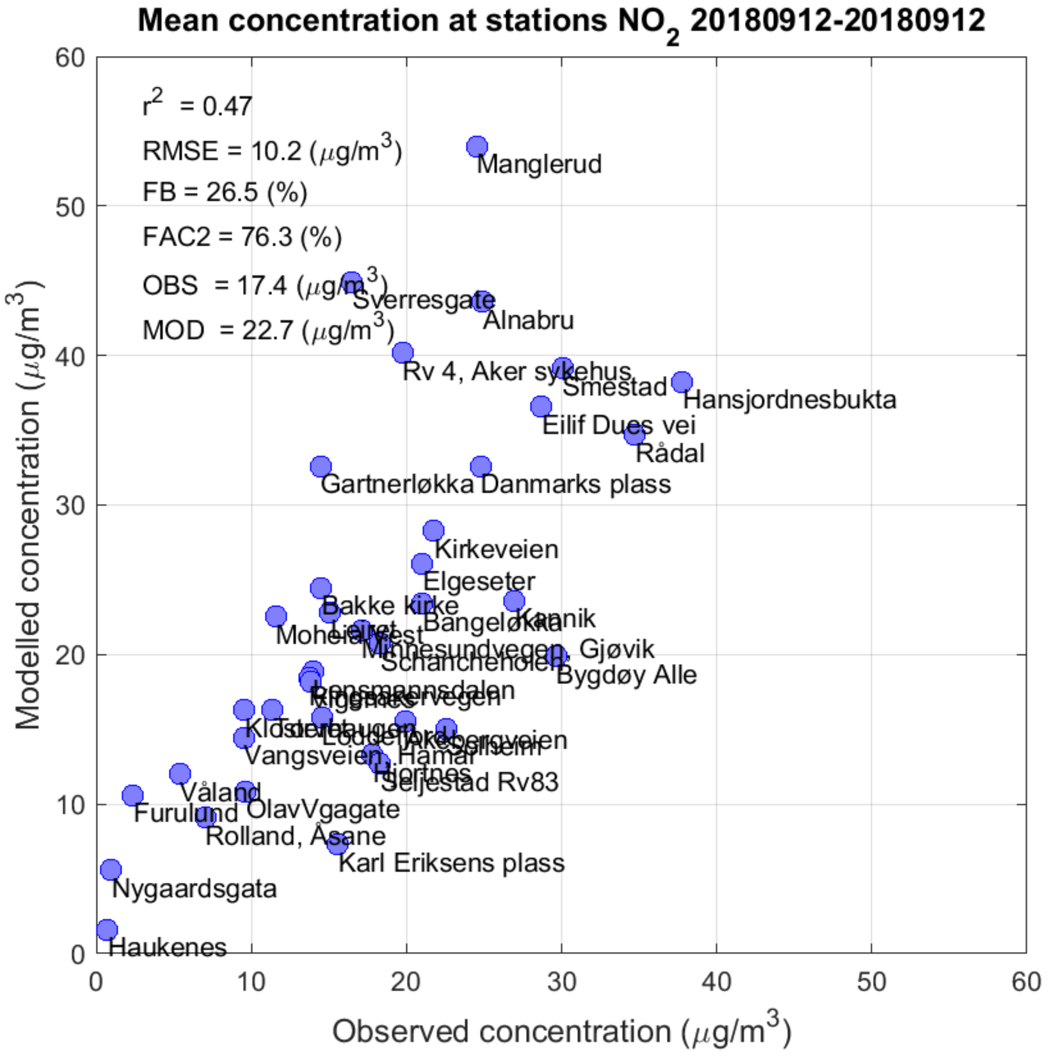




Example calculation : NO_2 forecast 12 September 2018, hourly



Example calculation : NO_2 forecast 12 September 2018, mean

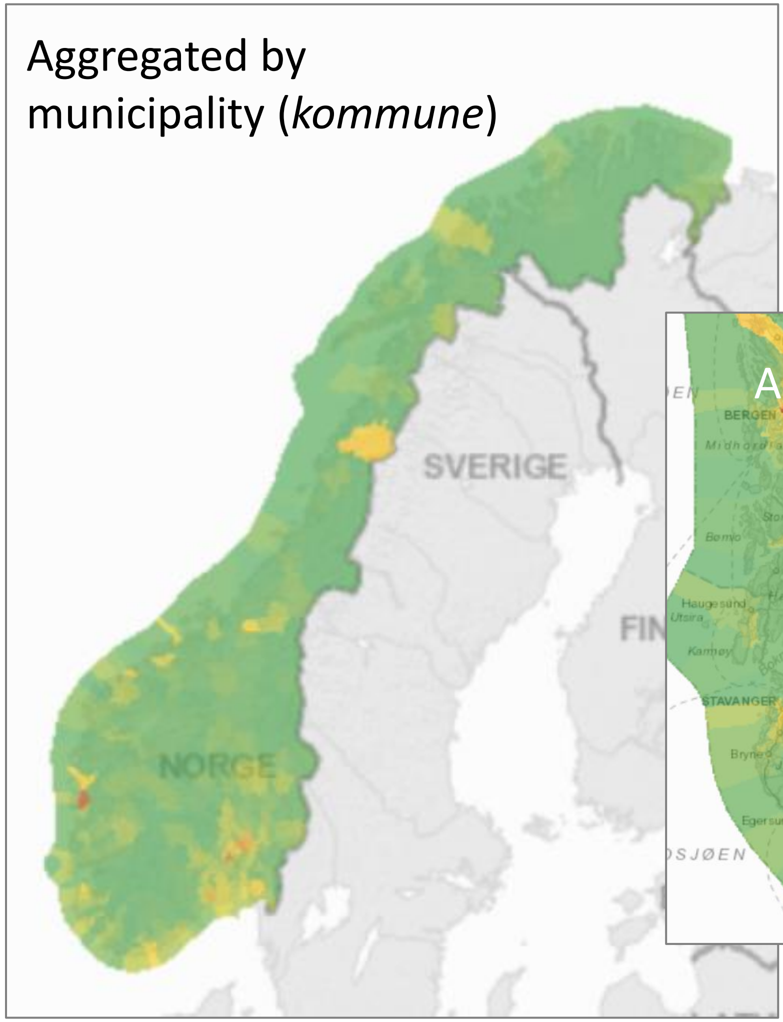


Forecast maps

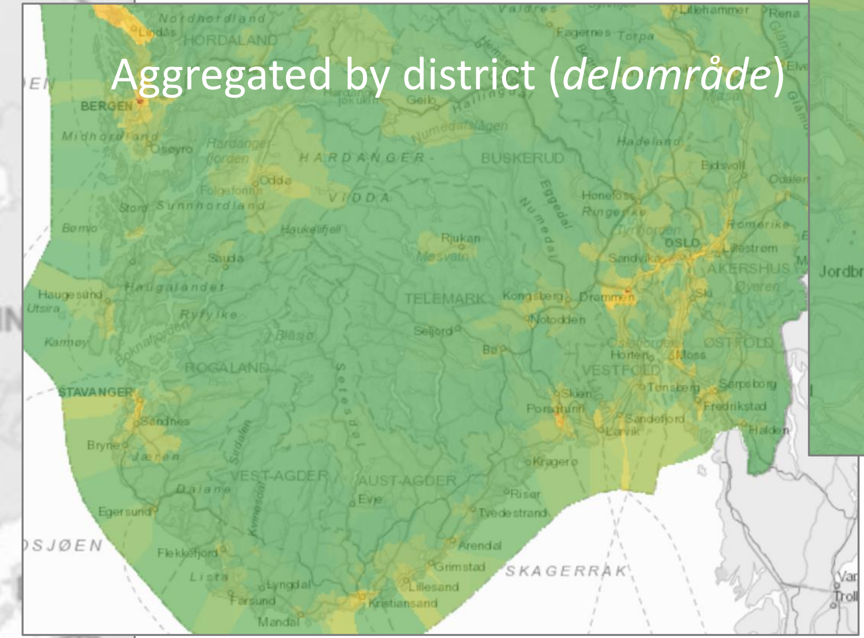
- A web mapping service (WMS) will provide access to the forecast maps
- A preliminary version is currently available as stand alone (not part of the web portal)
- Different aggregations are presented at different scales
  - At large scale a value is given to each municipality (*kommune*)
  - At medium scale a value is given to each district (*delområde*)
  - At fine scale the individual grids are shown
- The colour scale follows the AQI levels for each pollutant (hourly)

Varslings-klasser	**Forurensnings-nivå**	**Helserisiko**	**PM_{10}** *Døgn* ($\mu g/m^3$)	**$PM_{2,5}$** *Døgn* ($\mu g/m^3$)	**PM_{10}** *Time** ($\mu g/m^3$)	**$PM_{2,5}$** *Time** ($\mu g/m^3$)	**NO_2** *Time* ($\mu g/m^3$)	**SO_2** *Time* ($\mu g/m^3$)	**O_3** *Time* ($\mu g/m^3$)
	Lite	Liten	<30	<15	<50	<25	<100	<100	<100
	Moderat	Moderat	30-50	15-25	50-80	25-40	100-200	100-350	100-180
	Høyt	Betydelig	50-150	25-75	80-400	40-150	200-400	350-500	180-240
	Svært høyt	Alvorlig	>150	>75	>400	>150	>400	>500	>240

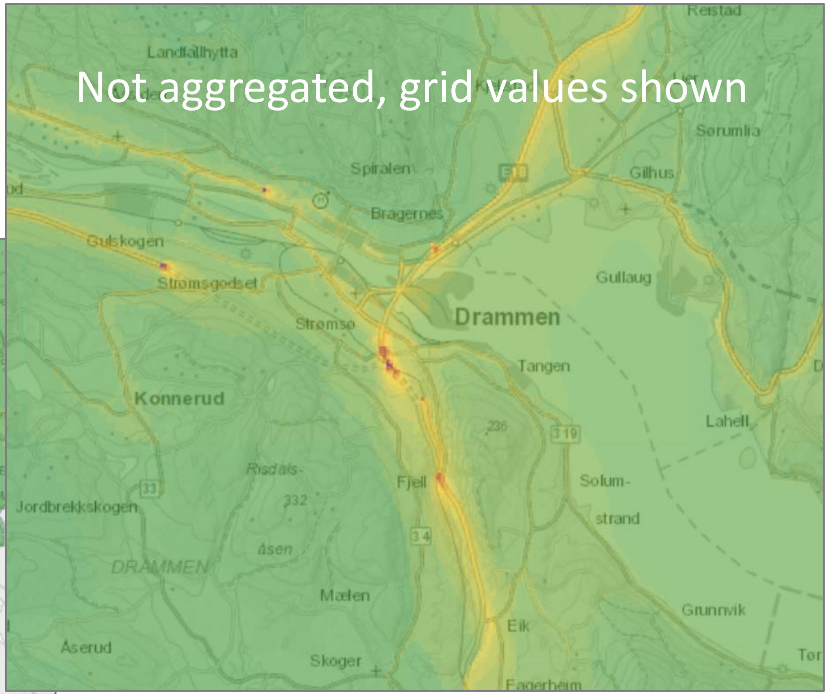
Model visualisation: map levels



Aggregated by municipality (*kommune*)

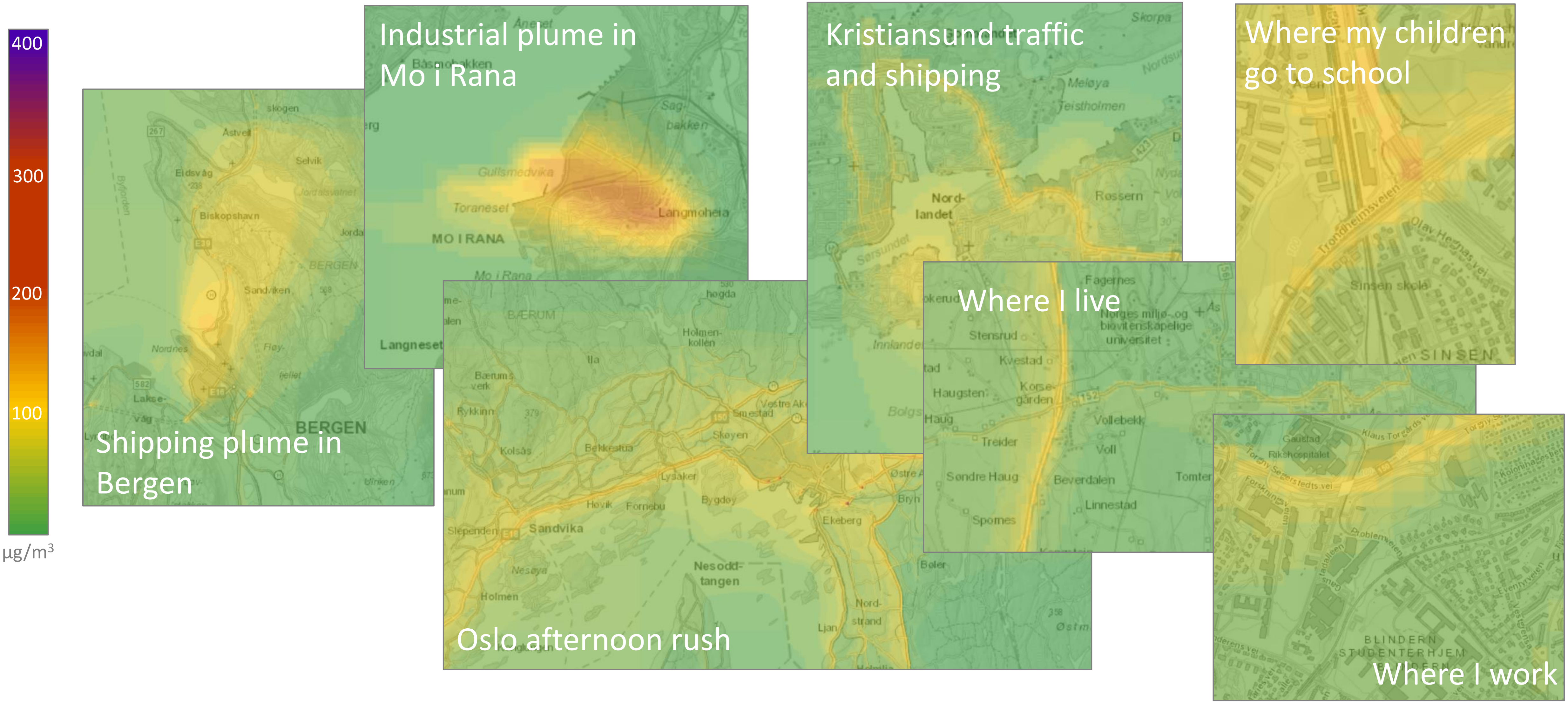


Aggregated by district (*delområde*)



Not aggregated, grid values shown

Model visualisation: some NO_2 examples



Some limitations

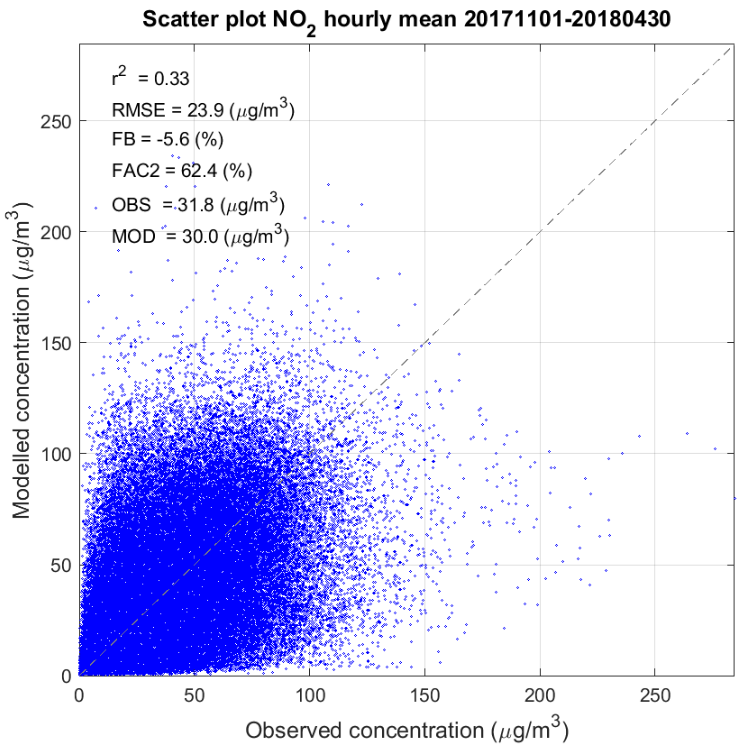
- Does not include buildings or other obstacles
- Meteorology is based on 2.5 km grids so details within these grids, e.g. due to variation in terrain, obstacles, are not represented
- Some emissions lack details, e.g. industry, and many have never been validated
- There is some significant uncertainties in the traffic data. SSB data for municipality roads is modelled and has a higher uncertainty than the NVDB traffic data. NVDB traffic data itself has also shown inconsistencies and gaps in data
- The uEMEP calculation region is limitted to 10 x 10 km^2 (4 x 4 EMEP grids). For some industrial sources with large plumes this is not large enough

Comparison to measurements

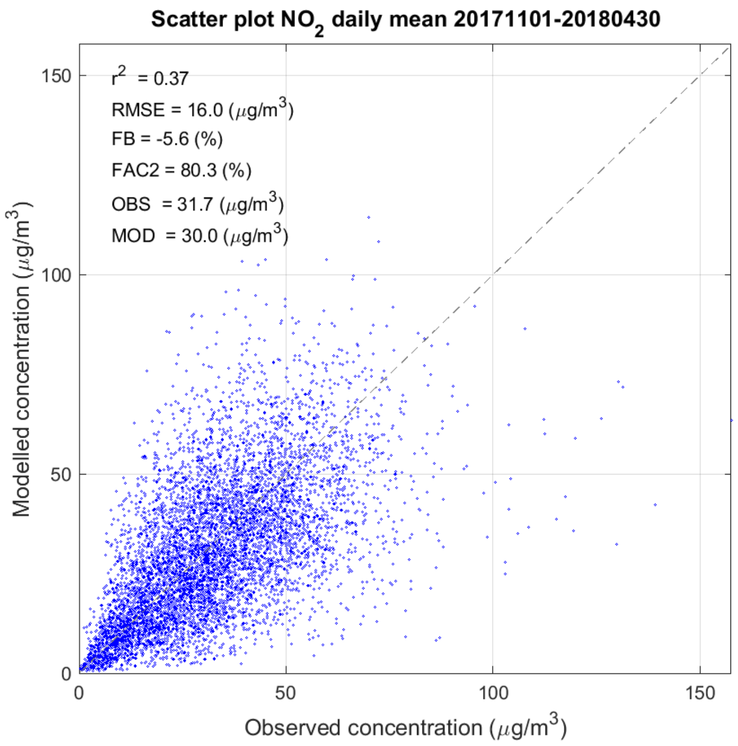
Overview

- The concentrations from the previous winter season (1 November 2017 to 30 April 2018) have been calculated at all measurement sites
- The calculations are made every day and the first day of the forecast is shown
- Pollutants calculated are PM_{10}, $PM_{2.5}$, NO_2 and O_3
- Shown are:
  - scatter plots of all stations and all hours/days
  - mean source contributions for each station
  - daily cycles for each station
  - selected individual station time seiries
  - an assessment of uncertainty

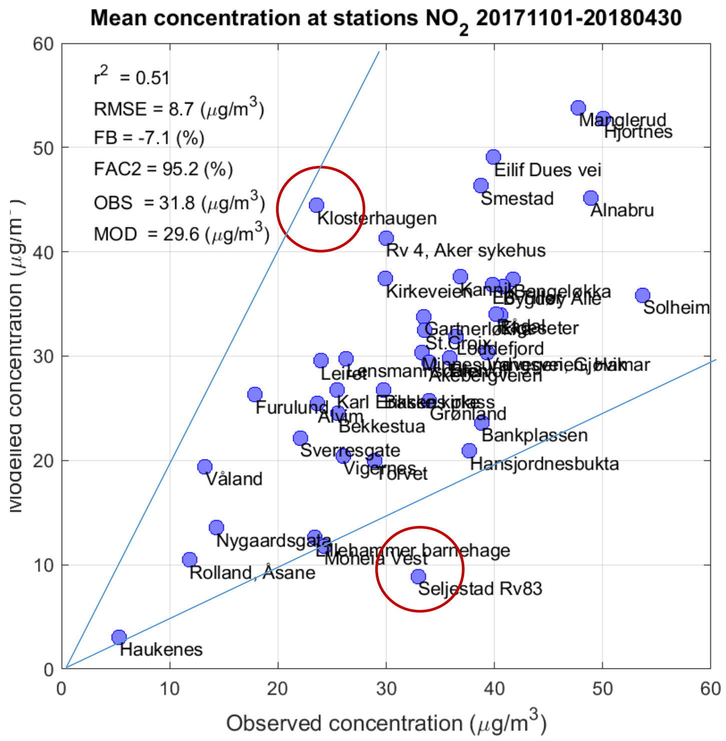
NO_2 scatter plots (42 stations)



All stations hourly mean

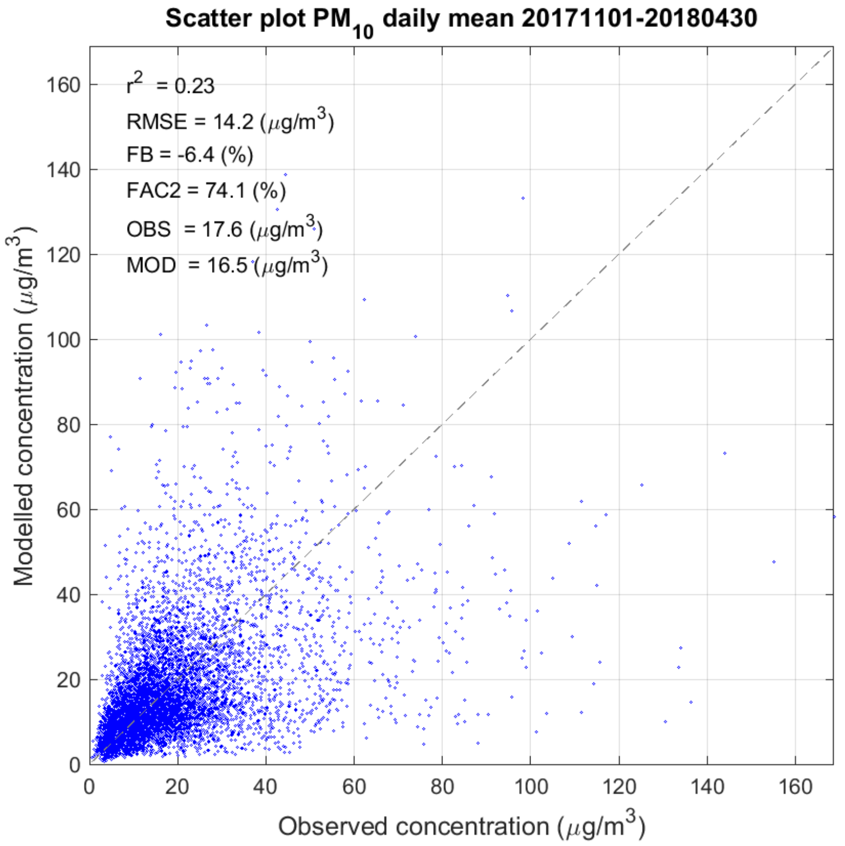


All stations daily mean

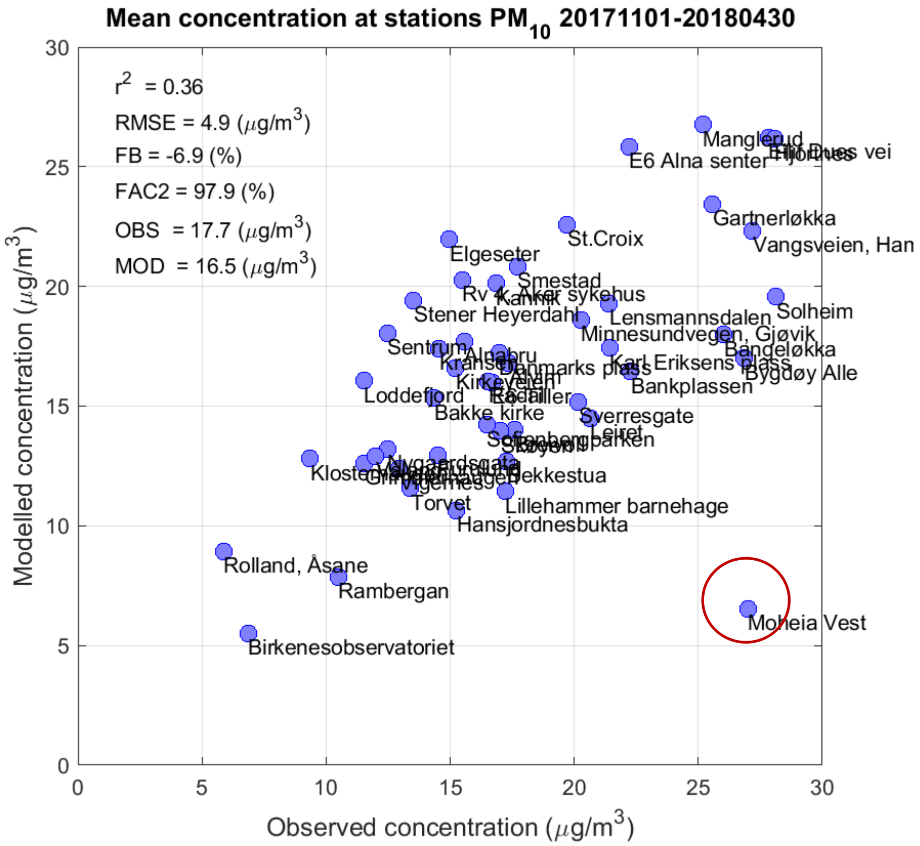


All stations season mean

PM_{10} scatter plots (49 stations)

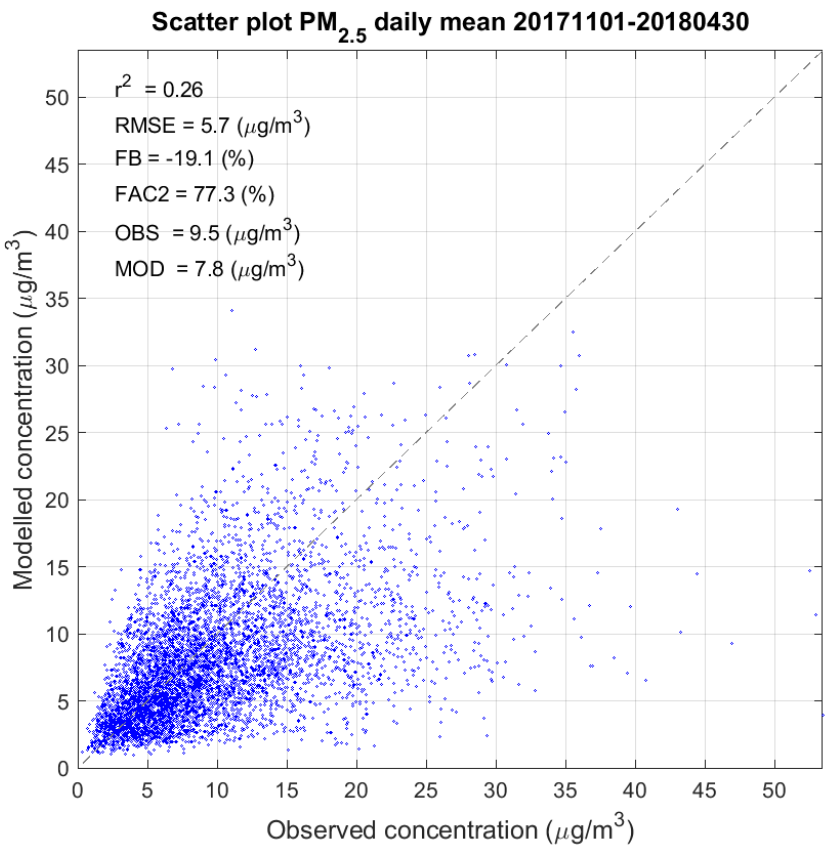


All stations daily mean

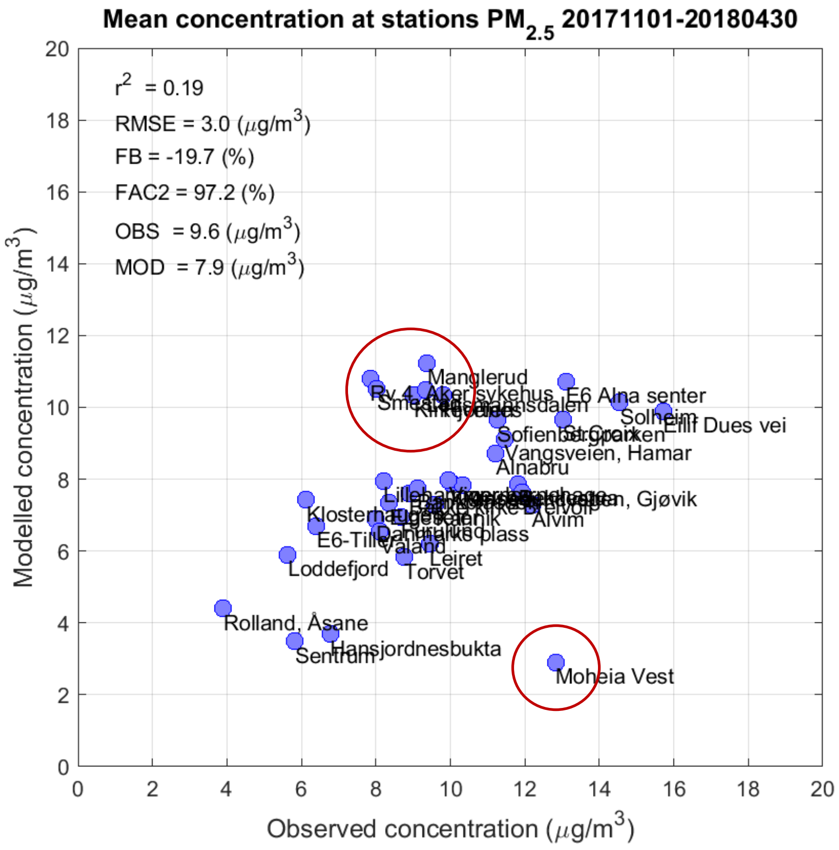


All stations season mean

PM$_{2.5}$ scatter plots (36 stations)

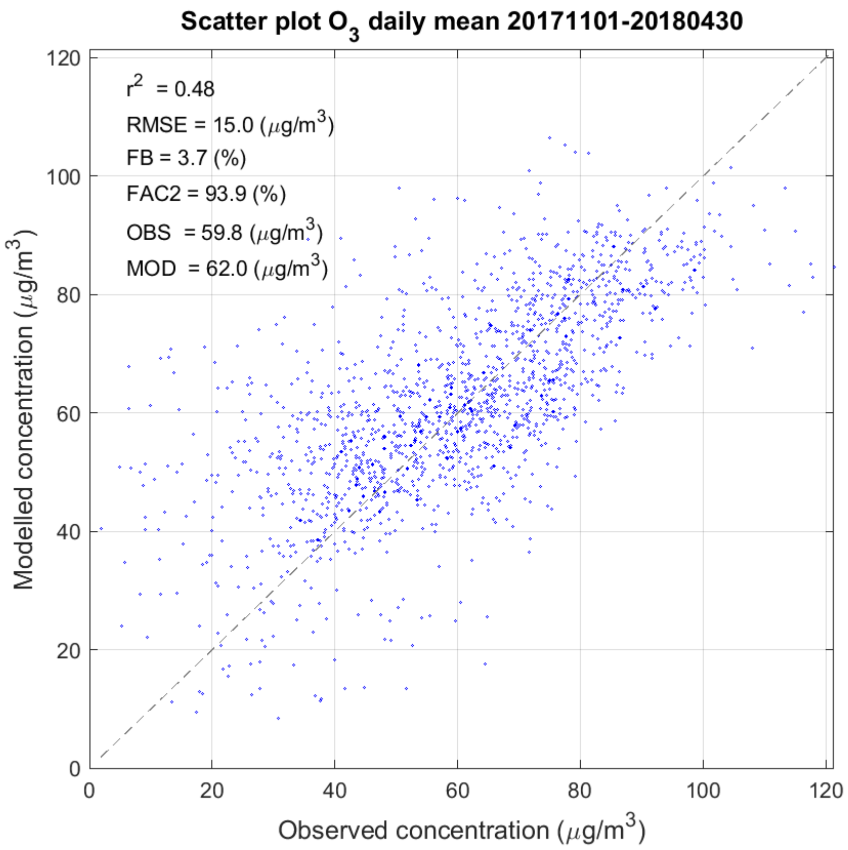


All stations daily mean

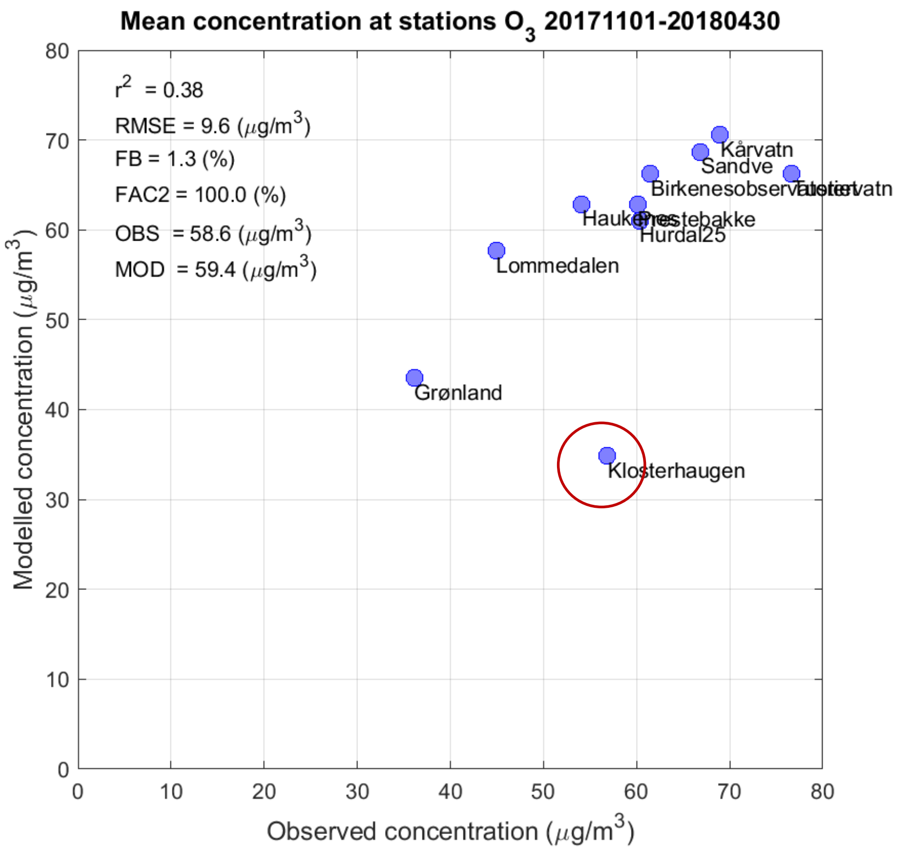


All stations season mean

O_3 scatter plots (10 stations)

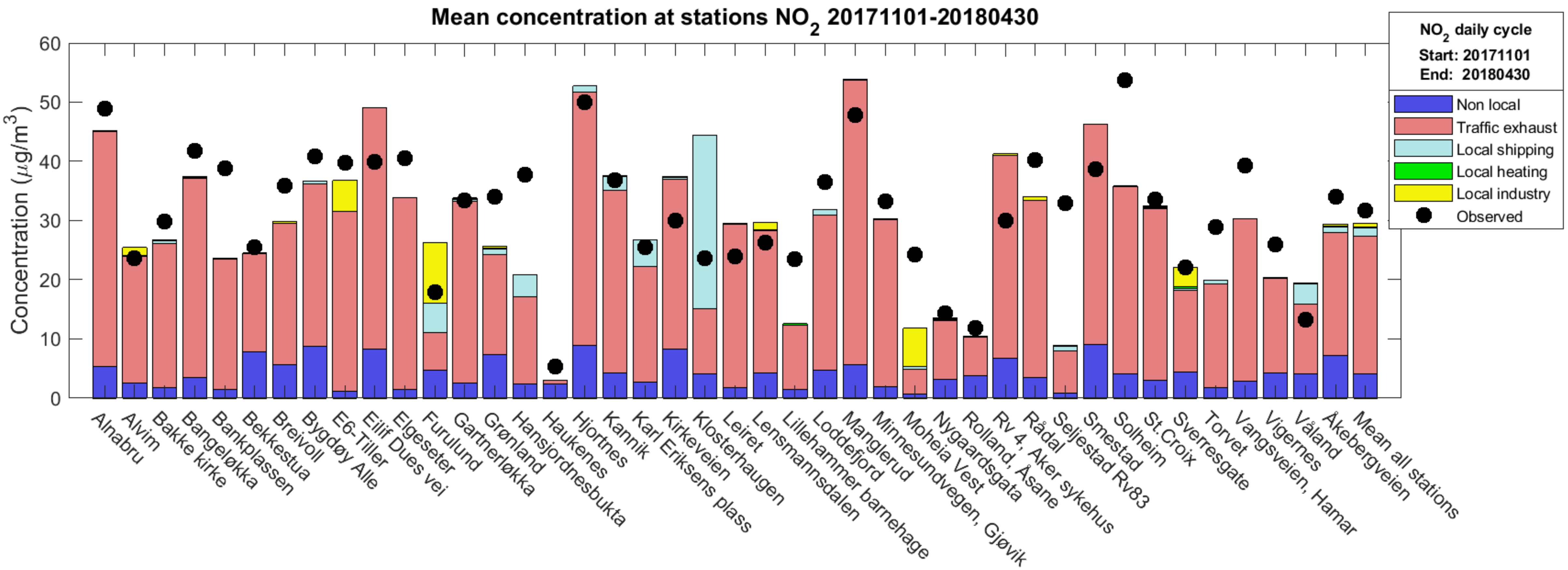


All stations daily mean

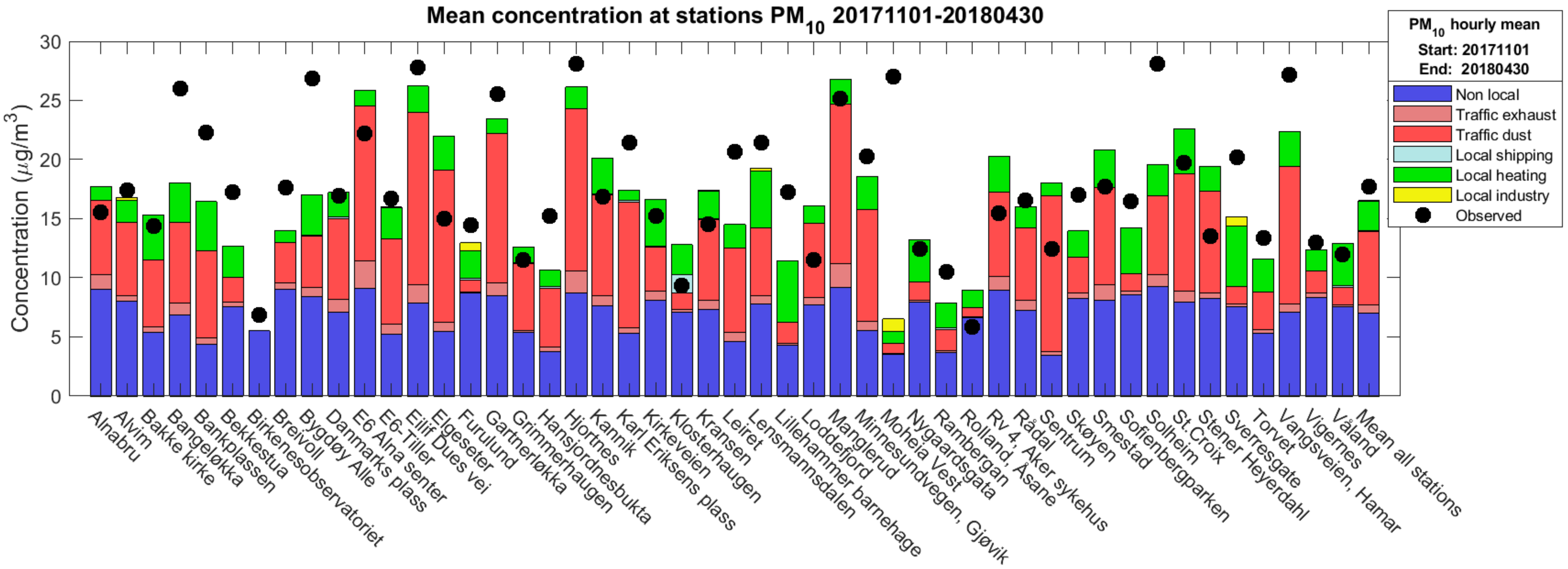


All stations season mean

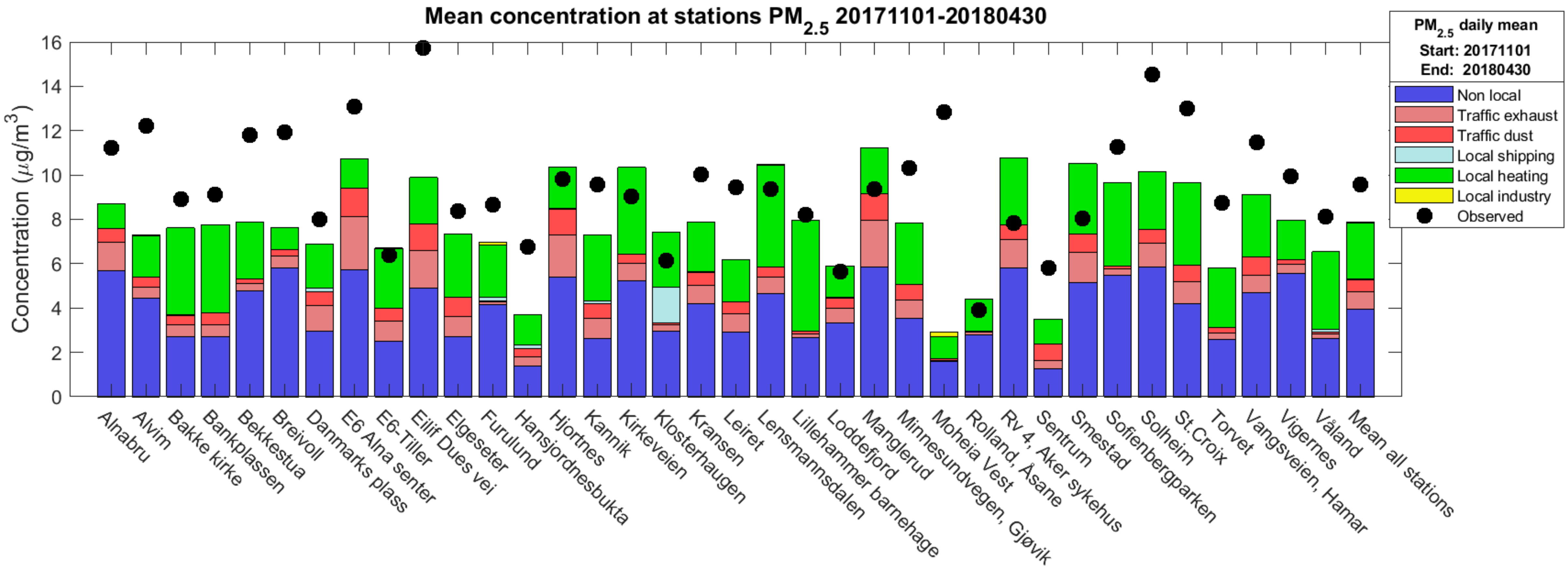
NO_2 mean source contributions



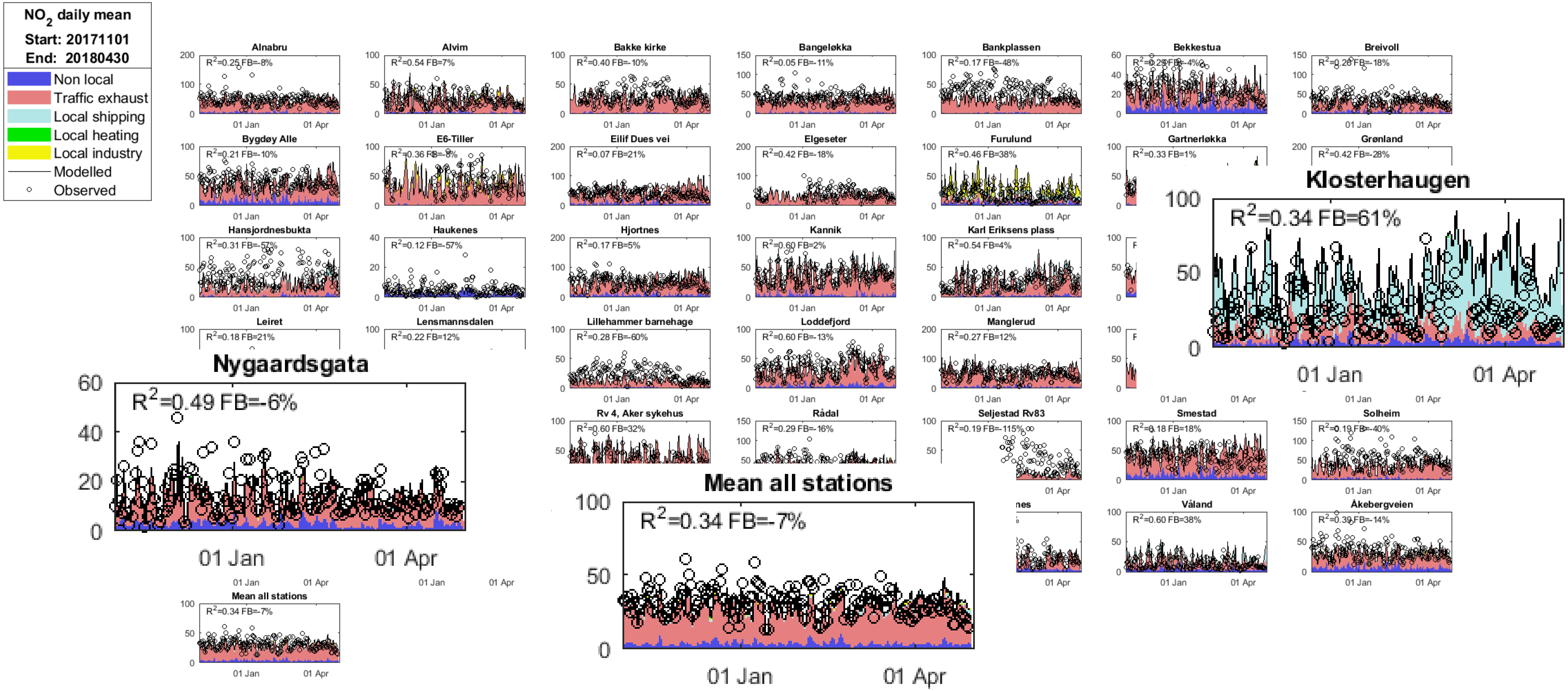
PM_{10} mean source contributions



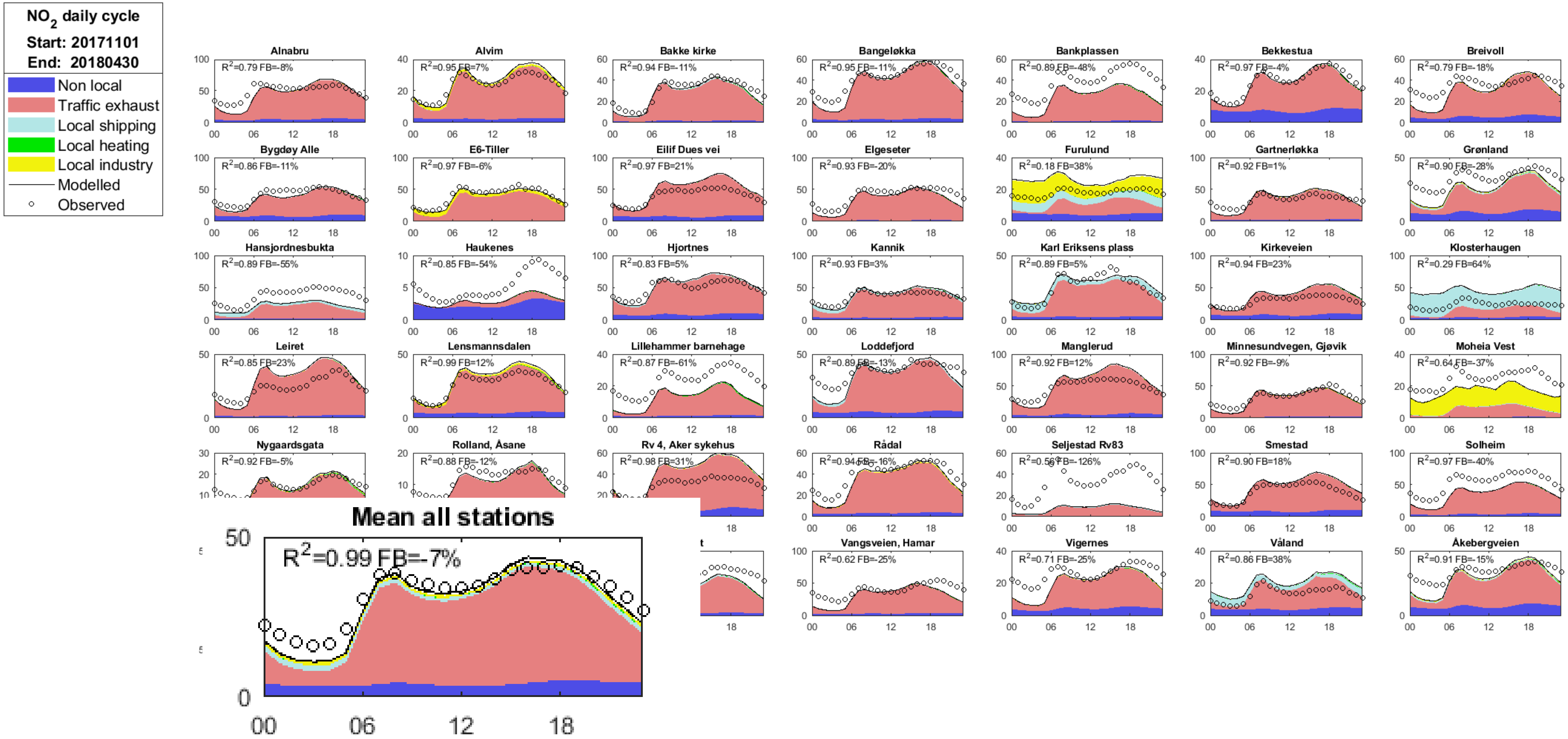
$PM_{2.5}$ mean source contributions



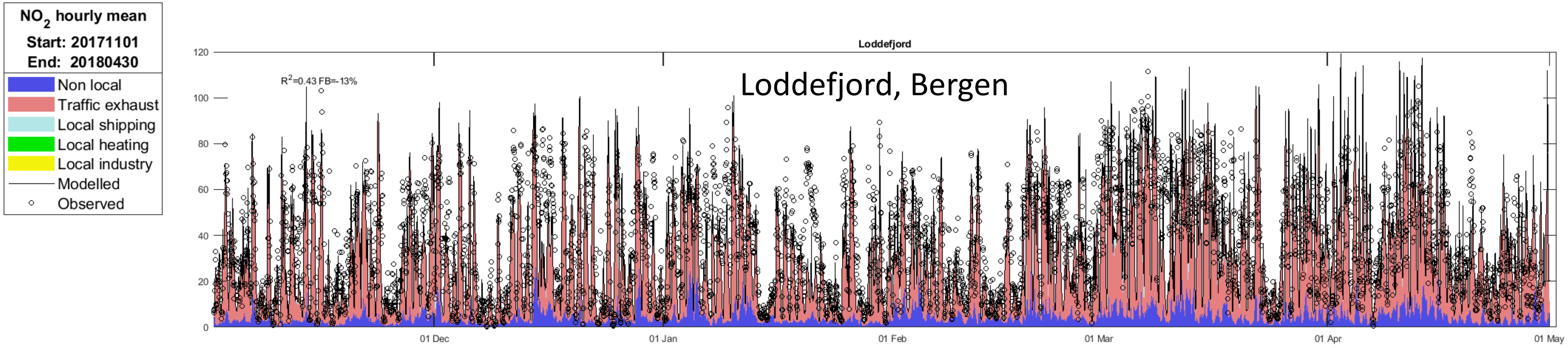
Comparison with observations: NO_2 daily mean

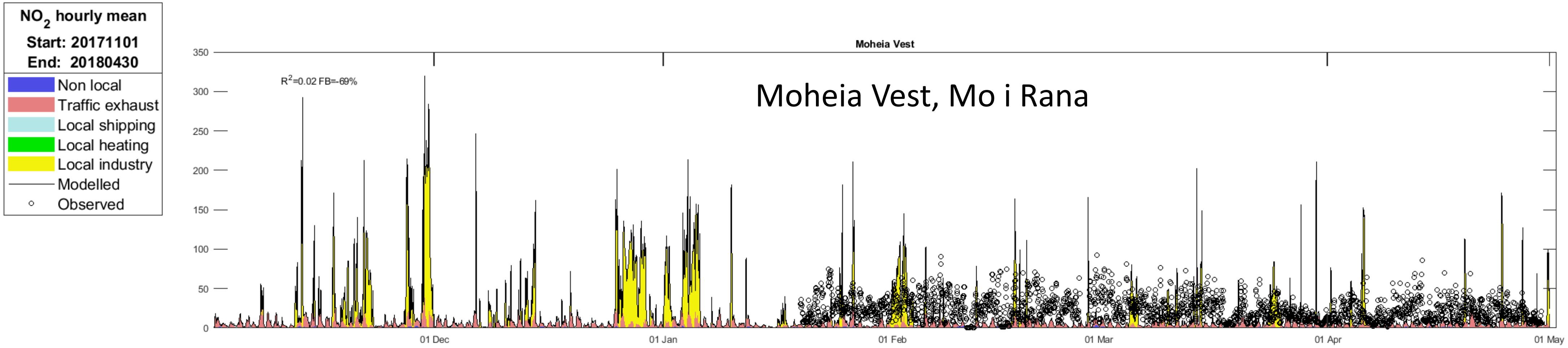


Comparison with observations: NO_2 daily cycle

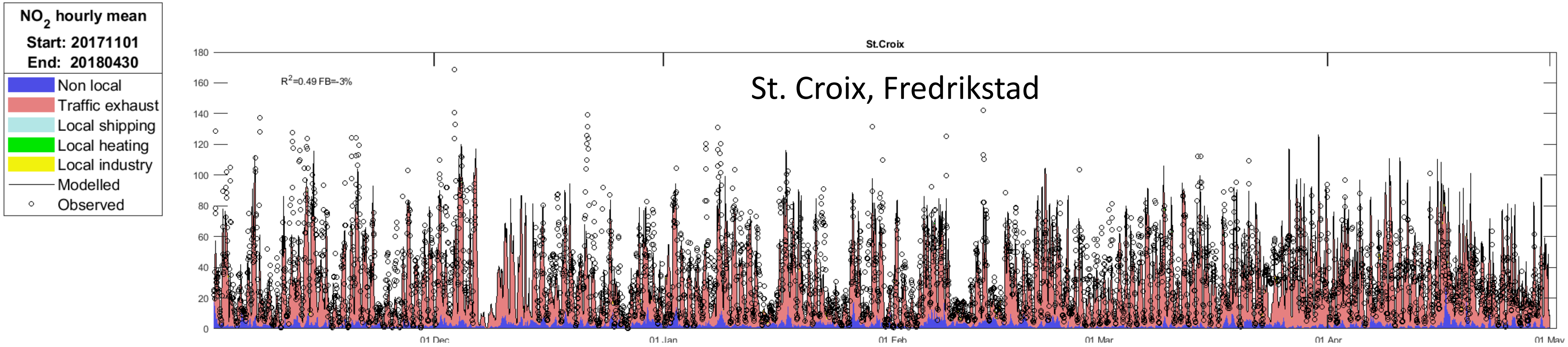


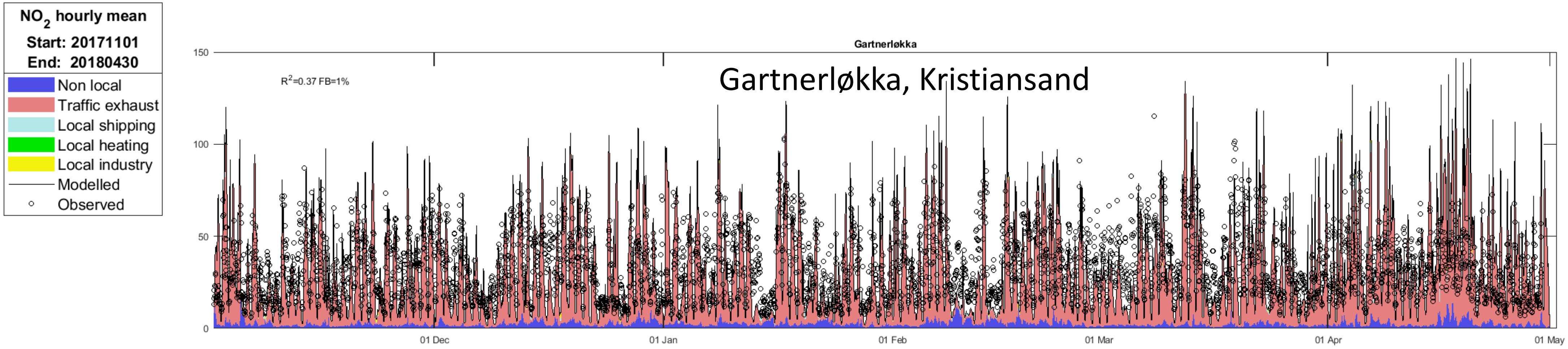
Comparison with observations: NO_2 time series



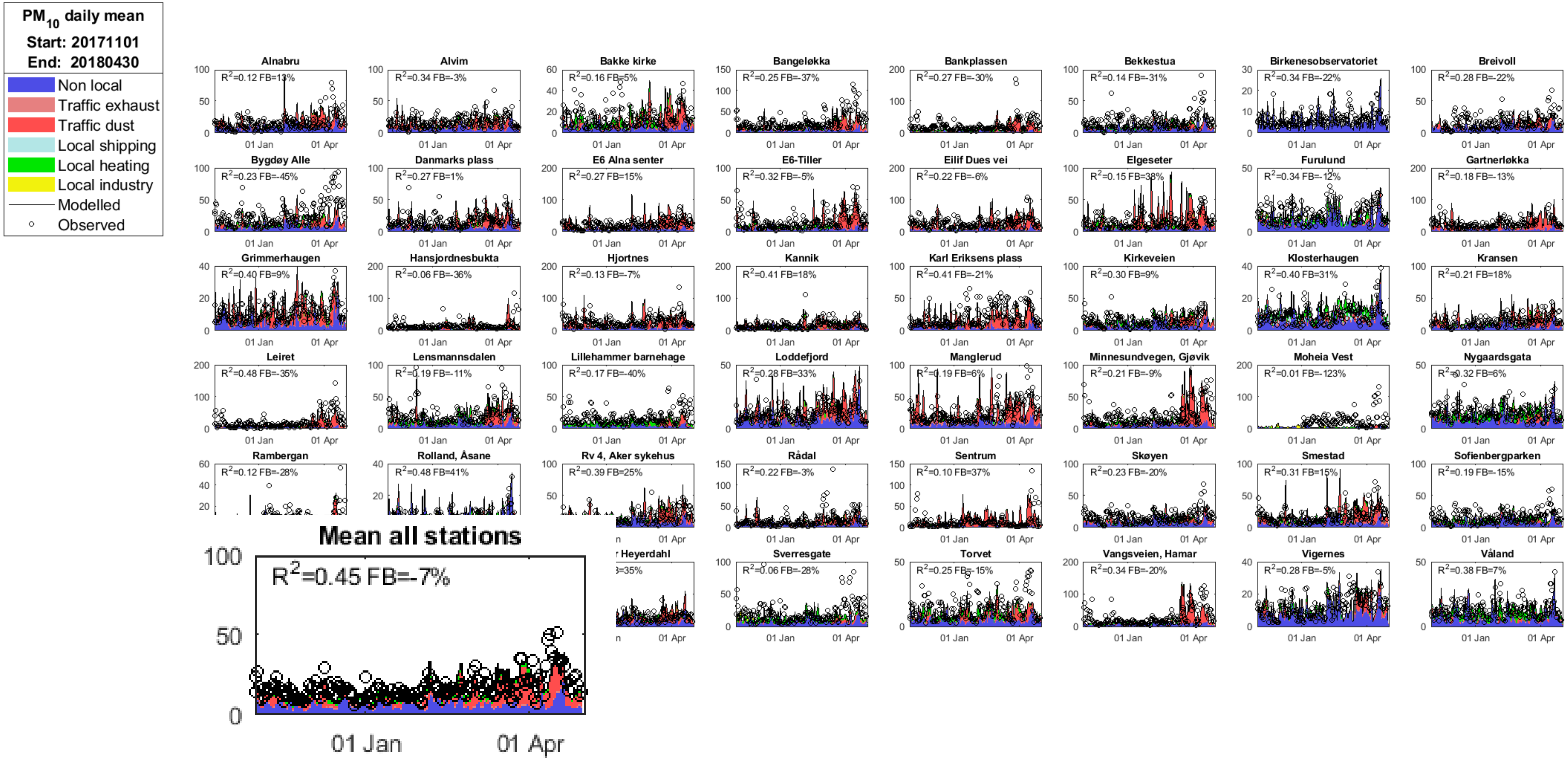


Comparison with observations: NO_2 time series

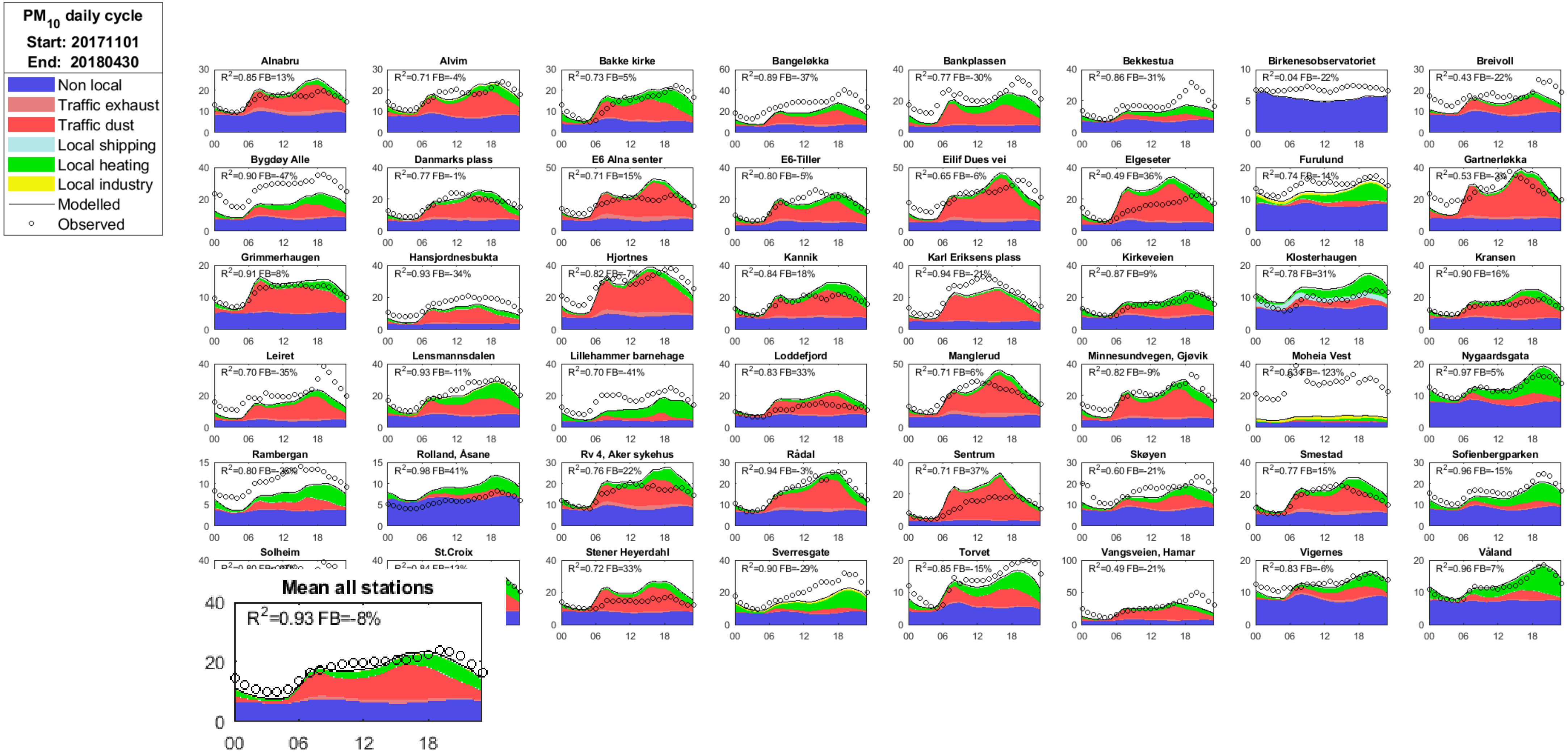




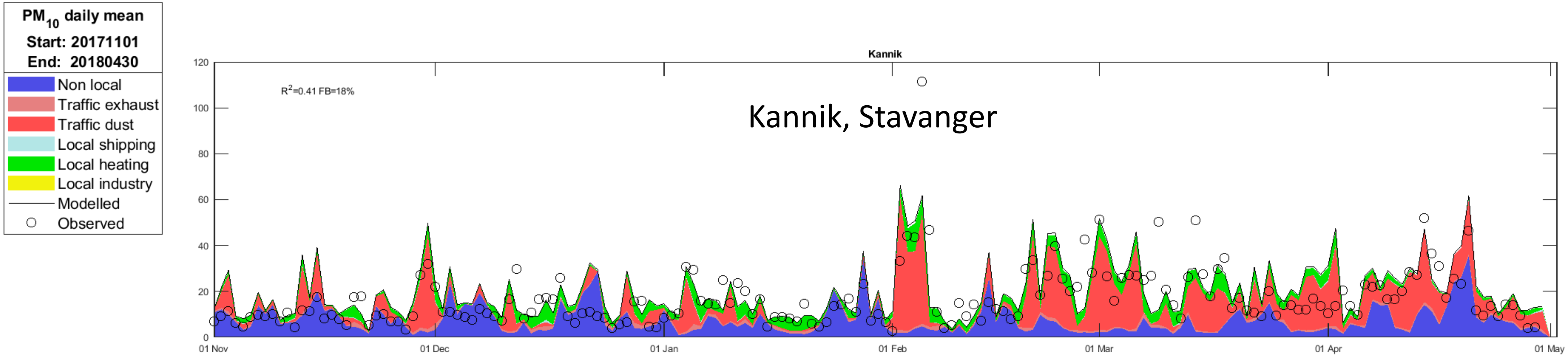
Comparison with observations: PM_{10} daily mean

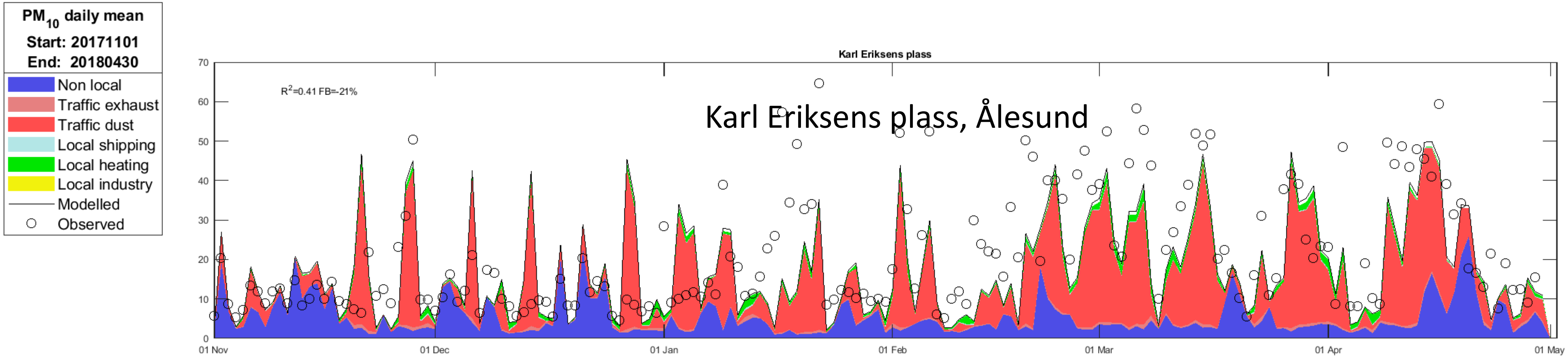


Comparison with observations: PM_{10} daily cycle

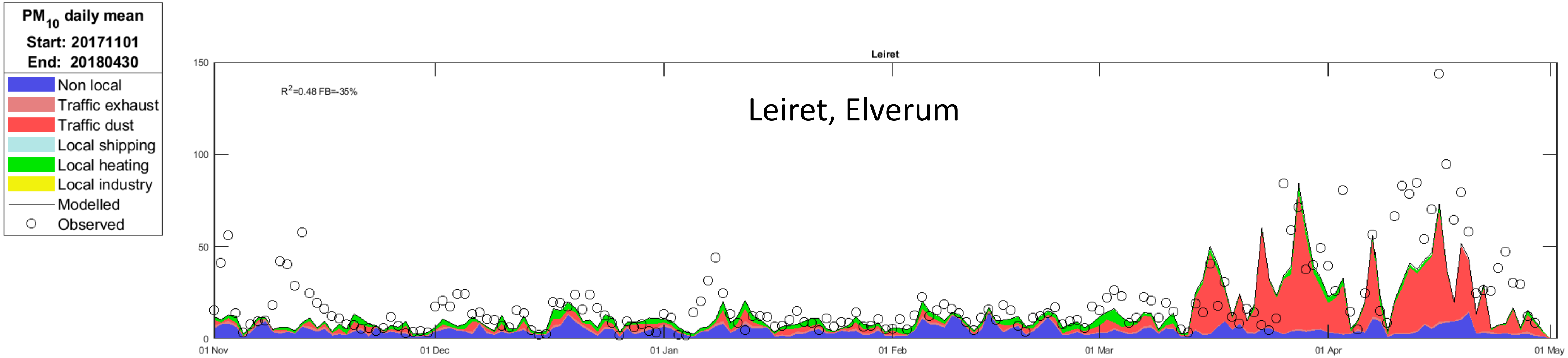


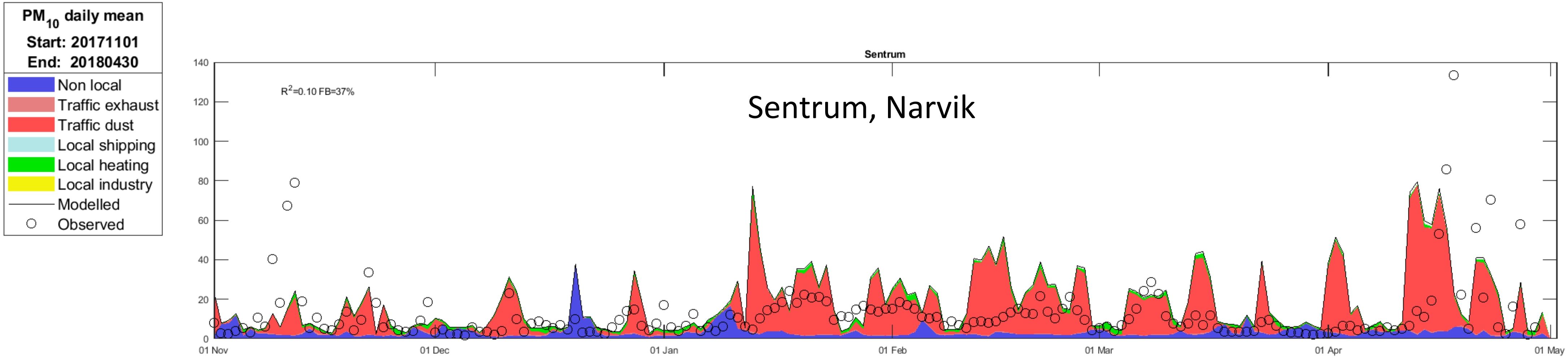
Comparison with observations: PM_{10} time series



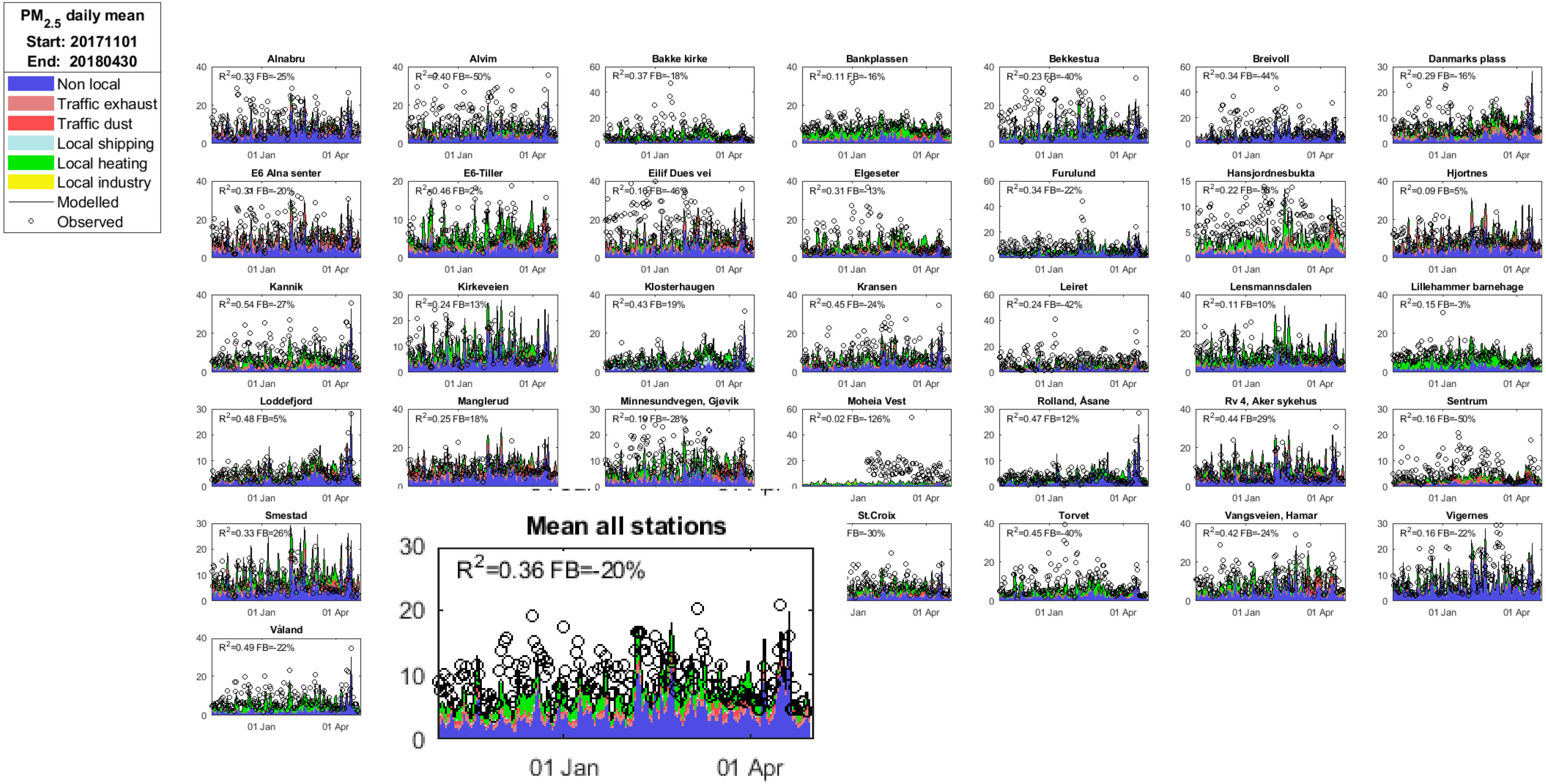


Comparison with observations: PM_{10} time series

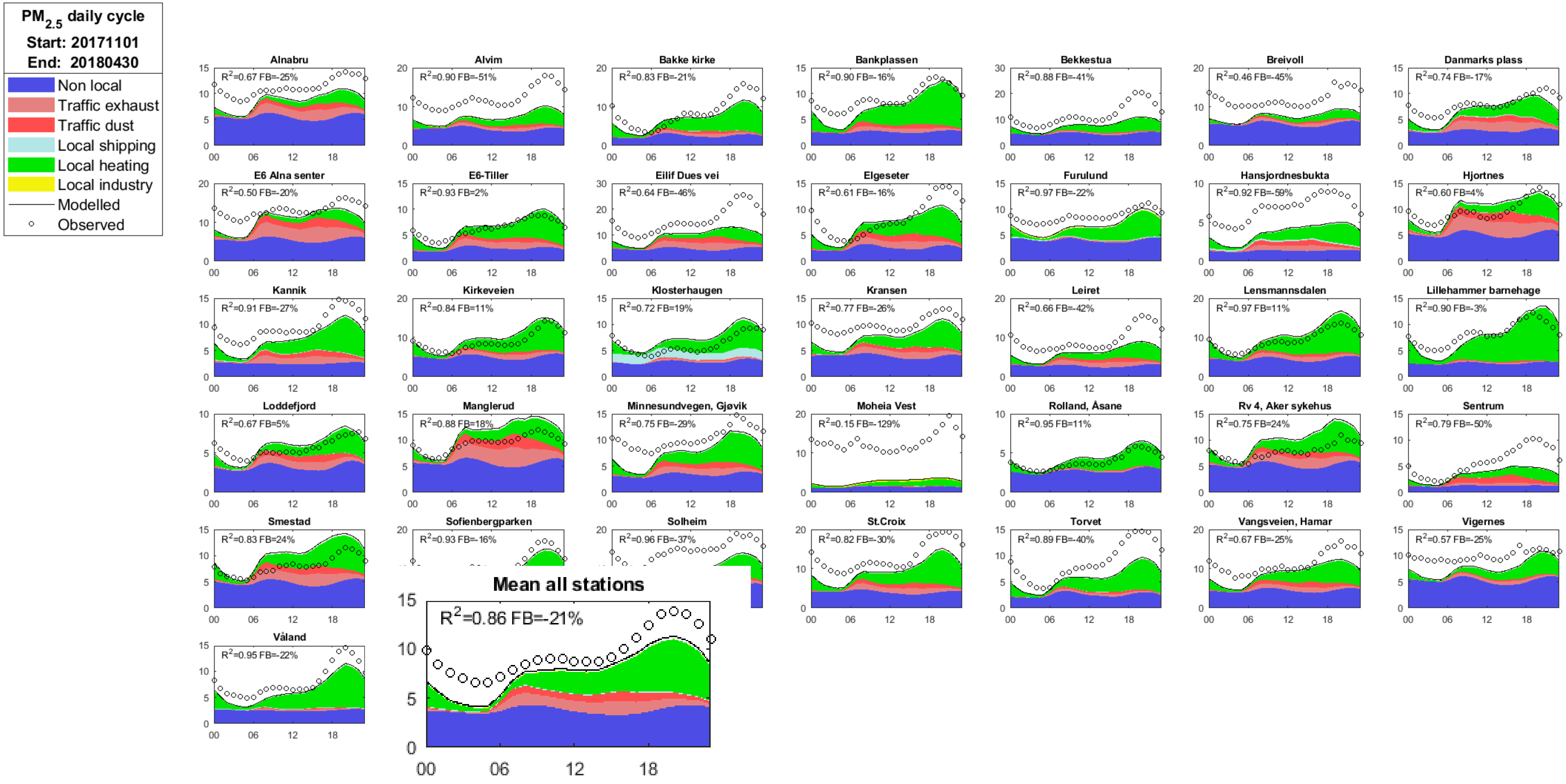




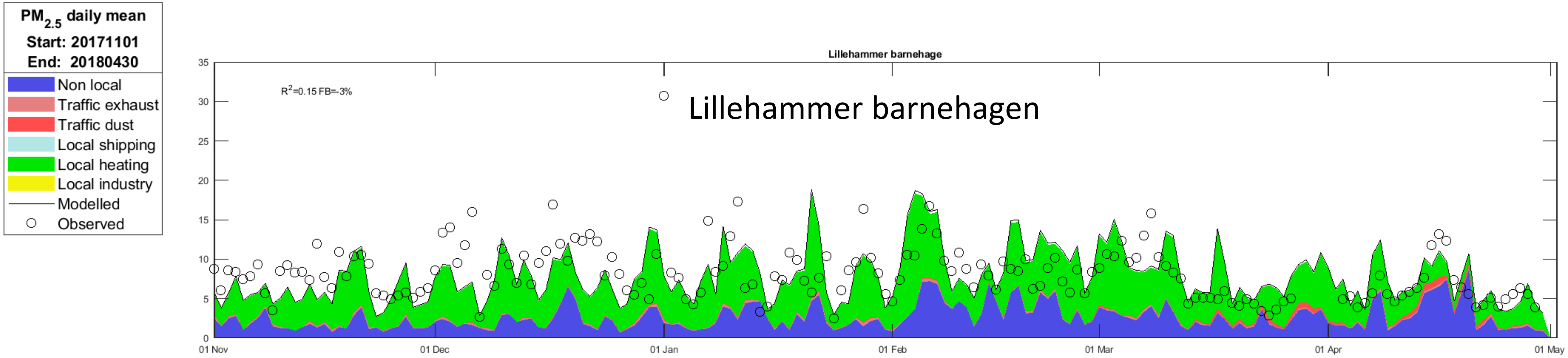
Comparison with observations: $PM_{2.5}$ daily mean

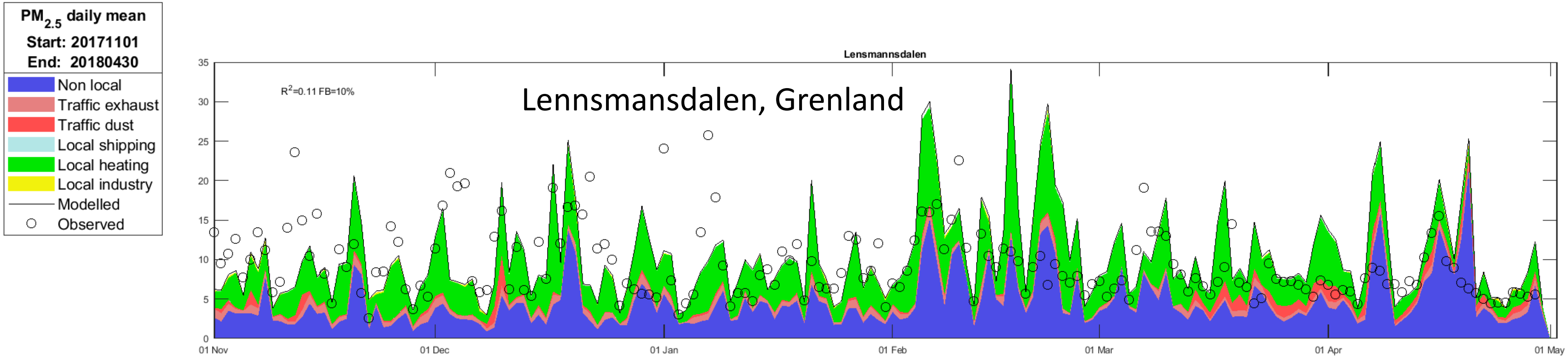


Comparison with observations: $PM_{2.5}$ daily cycle

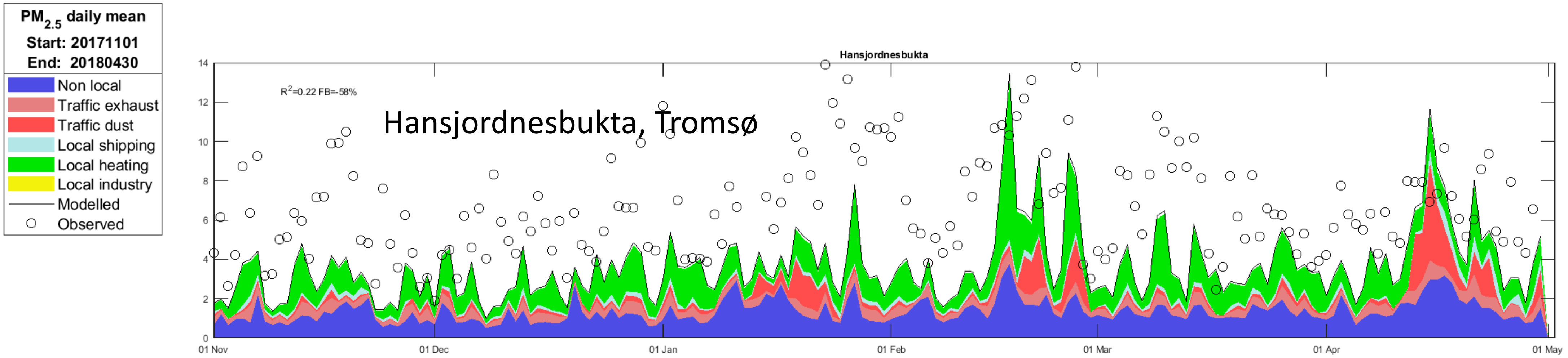


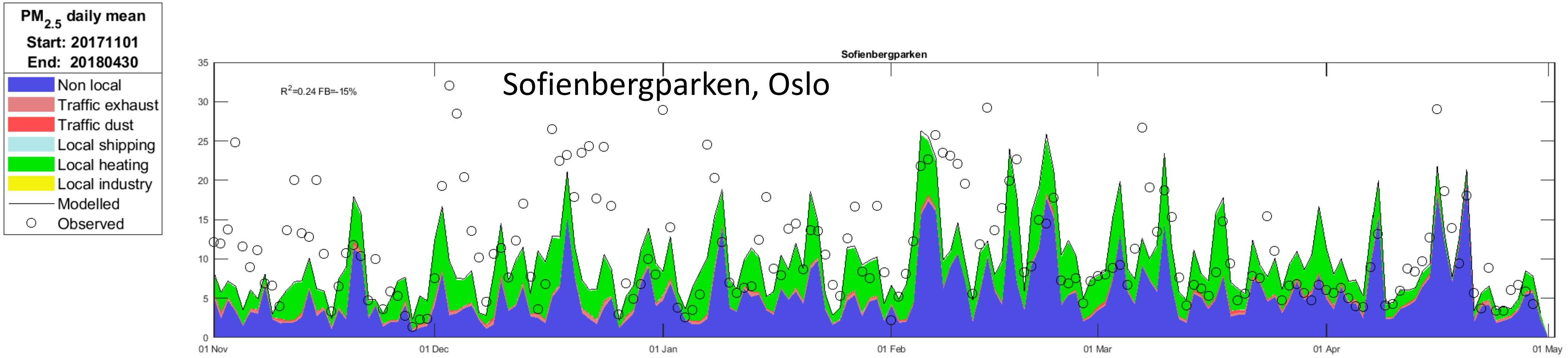
Comparison with observations: $PM_{2.5}$ time series



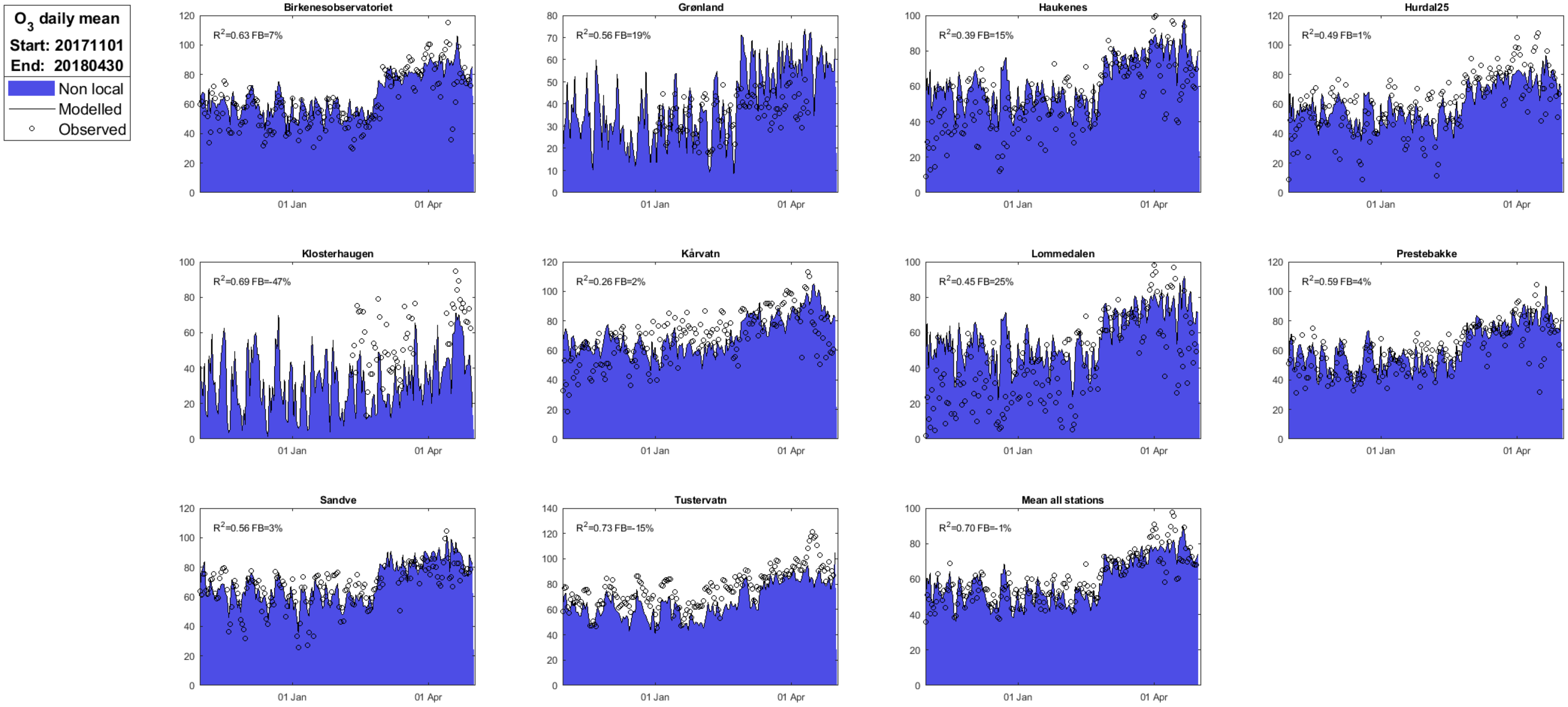


Comparison with observations: $PM_{2.5}$ time series





Comparison with observations: O_3 daily mean



Quantifying the uncertainty

Uncertainty estimates in numbers

- **FAC2:** likelihood that the predicted model concentration is within a factor of 2 of the real value for the given averaging period

FAC2	NO_2	PM_{10}	$PM_{2.5}$	O_3	Aim
Hourly mean	62%	59%	62%		> 70%
Daily mean	80%	74%	77%	94%	> 80%
Long term mean	95%	98%	97%	100%	> 95%

- **NRMSE:** the relative error for any predicted model concentration

NRMSE	NO_2	PM_{10}	$PM_{2.5}$	O_3	Aim
Hourly mean	79%	130%	106%		< 80%
Daily mean	52%	83%	71%	25%	< 60%
Long term mean	28%	29%	37%	16%	< 25%

- **NOTE:** NRMSE for hourly wind speed in AROME is around 40%

Skill of the forecast

- **Skill score:** A measure of how much better, or worse, a forecast is compared to a persistence forecast. A persistence forecast says tomorrow is the same as today, based on observations

$$Skill\ score = 1 - \frac{RMSE_{model}}{RMSE_{persistence}}$$

- A skill score > 0 means the forecast is better than persistence
- A skill score = 0.5 means the error is half that for persistence
- A perfect score = 1.0

Forecast skill score	NO_2	PM_{10}	$PM_{2.5}$	O_3	Aim
1 day (daily mean)	+ 0.25	+ 0.05	+ 0.05	- 0.50	> 0.0
2 days (daily mean)	+ 0.60	+ 0.30	+ 0.27	- 0.14	> 0.5

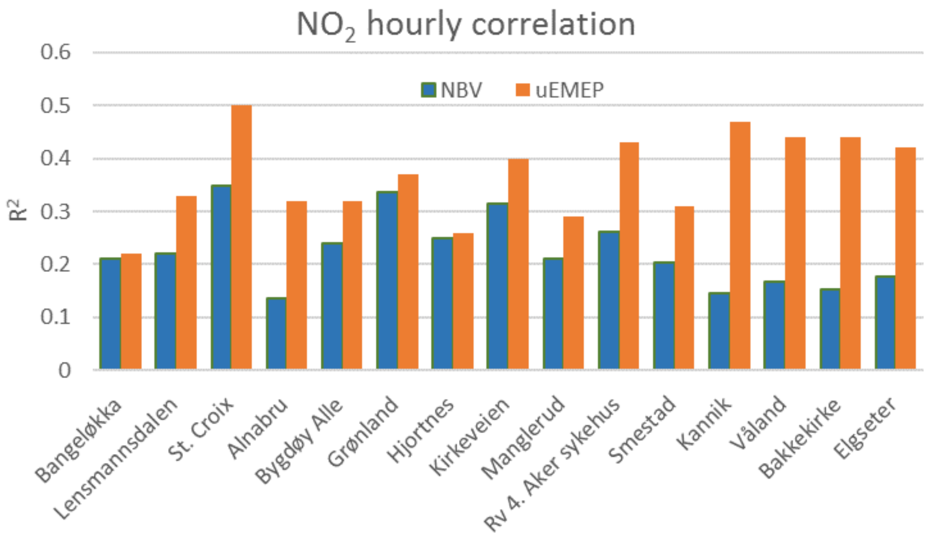
Comparison with previous modelling (NBV)

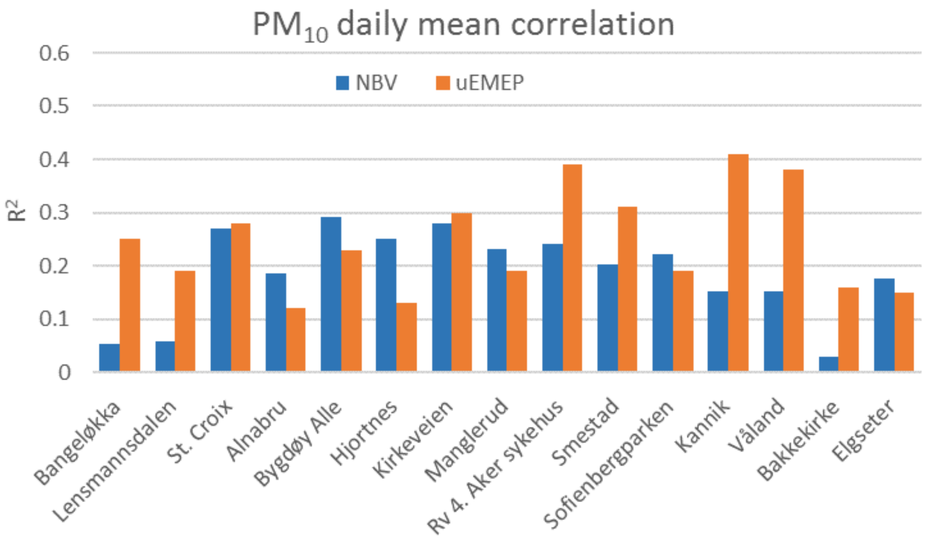
15 stations

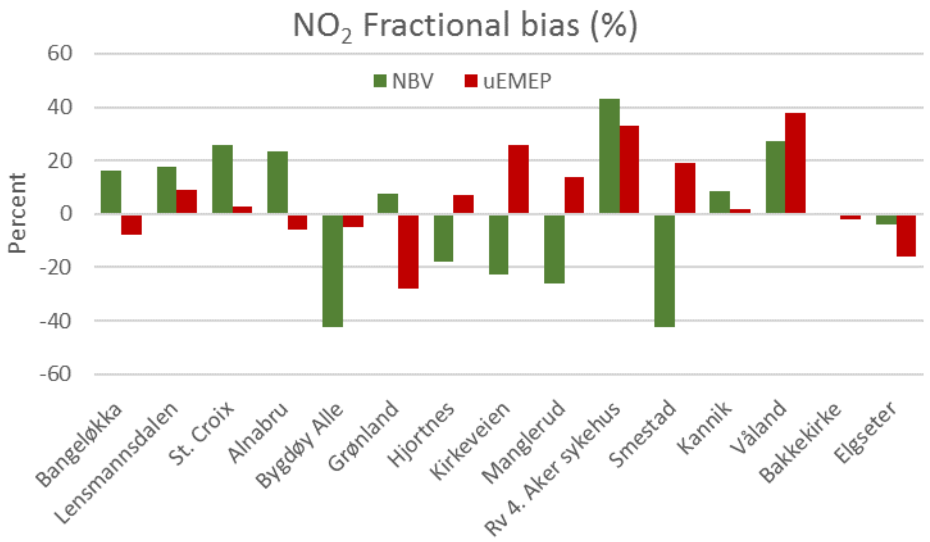
NBV: calendar year 2015
uEMEP: 6 months 2017-2018

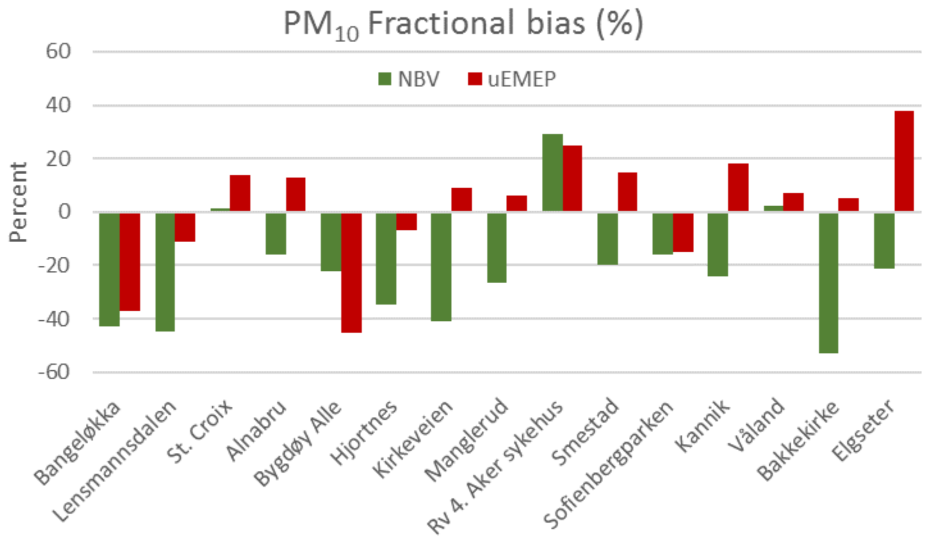
Cannot compare directly since they model different periods.

Compare statistical paramaters of correlation (R^2) and fractional bias (FB)









Main conclusions from the comparison (1)

- For all components (except ozone) the forecast is better than persistence for both forecast days
- NO_2 is modelled the best. This is largely because traffic emissions of NO_x are the best known of all the emissions
- If the measurements are considered statistically reresentative for all of Norway then we can conclude that the uncertainty in hourly NO_2 concentrations calculated by uEMEP anywhere in Norway is around 80%. For long term means this is around 30%
- Road dust is responsible for around half of the PM_{10} concentrations for the winter-spring season. It's dependence on road surface conditions makes it difficult, but not impossible, to model
- Non-local contributions to PM are significant, around 50%
- The new wood burning model from NILU performs well in many cases but underlying information, e.g. wood used on county level, can be very uncertain
- More detailed information concerning the industrial emissions is required for each of the industrial sites

Main conclusions from the comparison (2)

- There can be a number of reasons why model calculations deviate from the observations. Typically things to check are:
  - Are the traffic data correct for both light and heavy duty vehicles for nearby roads?
  - Is the studded tyre share correct for that region?
  - Are the winter maintenance practices in that region represented by the model?
  - Are there other emission source in the area not included in the emissions?
  - Is the meteorology, particularly wind speed, well represented by the model?
  - Is the siting of the station too complicated for the model?

Ongoing developments

Developments before 1 November

- Update of shipping emissions and their temporal distribution from 2015 to 2017 data
- Implementation of traffic time profiles (SVV) per county (*fylke*) for both light and heavy duty vehicles
- Update of industrial emissions and their metadata

Developments beyond 1 November

- Implementation of municipality (*kommune*) based traffic exhaust emission factors (MilDir/NILU)
- Continued improvement of industrial emissions
- Inclusion of real time observationally based temperature and precipitation fields for use with NORTRIP (as used for Yr)
- Further assessment of model results, feedback from users and improvements
- Full calender year calculations 2017, 2018

- Development of scenario calculator

How can local authorities improve their forecasts?

Topic B: What can municipalities provide?

- Information on studded tyre share beyond that gathered by SVV
- Information on the ‘real’ start and end of the studded tyre season
- Any, salting, sanding, dust binding or cleaning activities? How, how much and when. Any rules followed?
- Traffic counts in the municipality (not carried out by SVV) including heavy duty share, especially near monitoring sites
- Traffic speeds that deviate from signed speedage, areas of congestion
- Off road traffic activities, e.g. shopping centres, parking, industrial areas, other transport hubs
- Recommend to do traffic counts in front of air quality stations, if they are not available already
- Industry activity. 300 industries provided by MilDir/SSB for 2016. Are they still active?
- Information about the industries, stack heights, activity

Topic B: Studded tyre and winter maintenance data that can be provided by *kommune*

- Estimates for the studded tyre share for passenger vehicles and heavy duty vehicles
- Realistic start and stop dates of studded tyre season
- Salting, sanding, dust binding and cleaning. If yes then road type (E, R, F, K) and how often (e.g. when necessary, with what salt/binder and how much when applied)

Index	Kommunenummer	Navn	Light (%)	Heavy (%)	Start	Start full	End	End final	Salting	Sanding	Dust binding	Cleaning
1	101	Halden	21	12	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
2	104	Moss	19	11	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
3	105	Sarpsborg	20	9	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
4	106	Fredrikstad	21	12	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
5	111	Hvaler	23	18	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
6	118	Aremark	20	10	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
7	119	Marker	18	6	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
8	121	Rømskog	26	2	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
9	122	Trøgstad	16	1	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
10	123	Spydeberg	16	5	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
11	124	Askim	17	5	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
12	125	Eidsberg	17	6	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
13	127	Skiptvet	18	6	25.10.2017	07.11.2017	17.04.2017	29.04.2017				
14	128	Rakkestad	19	8	25.10.2017	07.11.2017	17.04.2017	29.04.2017				

Topic B: Industrial data that can be provided by *kommune*

- Active industries or not?
- Fugitive emissions of PM?
- Time variation (weekday only, day time only, etc.)

AnleggNummer	Navn	Driftsstatus	LokalitetNavn	Kommunenavn
1124.0001.03	Scangas LNG Production AS	Aktiv	Oljevegen 5	Sola
1001.0099.01	Glencore Nikkelverk	Aktiv	Vesterveien 31	Kristiansand
1449.0026.02	Innvik Sellgren avd. Innvik	Aktiv	INNVIKBUKTA	Stryn
1520.0002.01	Vartdal gjenvinning, Vartdal - behandling metall og EE-avfall	Aktiv	Vartdal gjenvinning	Ørsta
1228.0021.01	TiZir Titanium & Iron AS	Aktiv	Tyssedal	Odda
0814.0021.01	INEOS BAMBLE AS	Aktiv	BAMBLE Rønningen	Bamble
1119.0070.01	Norpri ex Prima	Aktiv	Næringsvegen 27, Kviamarka industriområde	Hå
0529.0007.01	Hydal Aluminium Profiler AS Raufoss	Aktiv	Bygg 232 Raufoss industripark	Vestre Toten
5001.0090.01	Rockwool, Trondheim	Aktiv	TRONDHEIM	Trondheim
0815.0020.01	Vistin Pharma avd. Gruveveien	Aktiv	Gruveveien 1	Kragerø
0403.0040.01	Hamjern støperi	Aktiv	Stangevegen 111	Hamar
0419.0006.01	Maarud AS	Aktiv	Maarudvegen 130, 2114 Disenå	Sør-Odal
0628.0005.01	Chemring Nobel AS, High Energy Materials	Aktiv	Engene	Hurum
0926.0013.01	SAINT GOBAIN CERAMIC MATERIALS AS, Lillesand	Aktiv	Birkenes	Lillesand
0710.0020.01	PRONOVA BioPharma Norge AS	Aktiv	Framnesveien 41	Sandefjord

Topic A: Look through the maps and the results and form an opinion

- You are provided with access to the map server where forecasts for the first week of September are available here

  http://uemep-wms.met.no/

  - Note that it is a little slow to start with
  - Do the results look useful for your needs?
  - Comments on the visualisation?
  - What can you see on the forecast maps that does not make sense?

- Plots presented (overview plots) in this presentation are available at:

  https://wiki.met.no/airquip/uemep_validation_2017-2018

  - Any comments to these?

Thank you

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