Estimating lockdown-induced NO_2 changes in Europe

Copernicus Atmosphere Monitoring Service (CAMS)

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S5P NO2 EUROPEAN LOCKDOWN OVERVIEW

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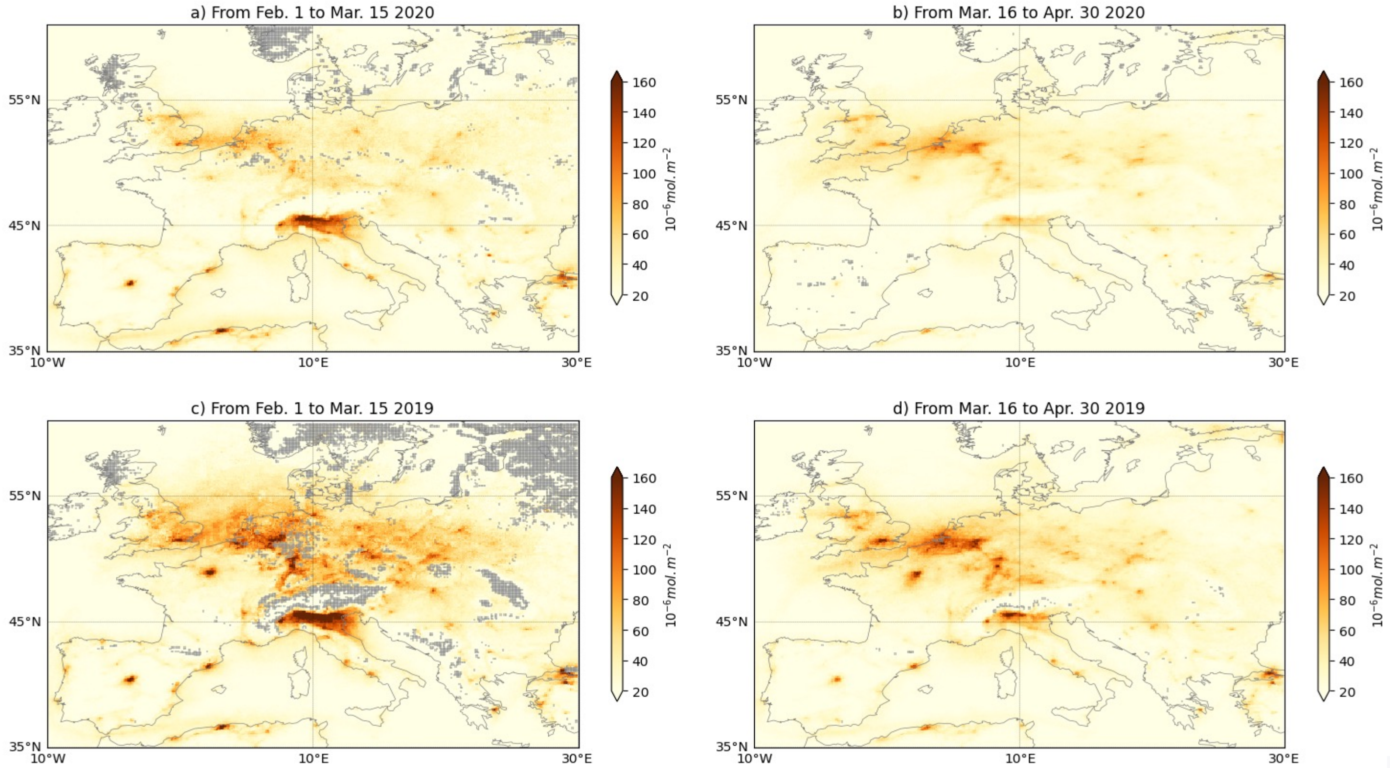
Before Lockdown

TROPOMI NO2 time averages

During Lockdown

2020

2019



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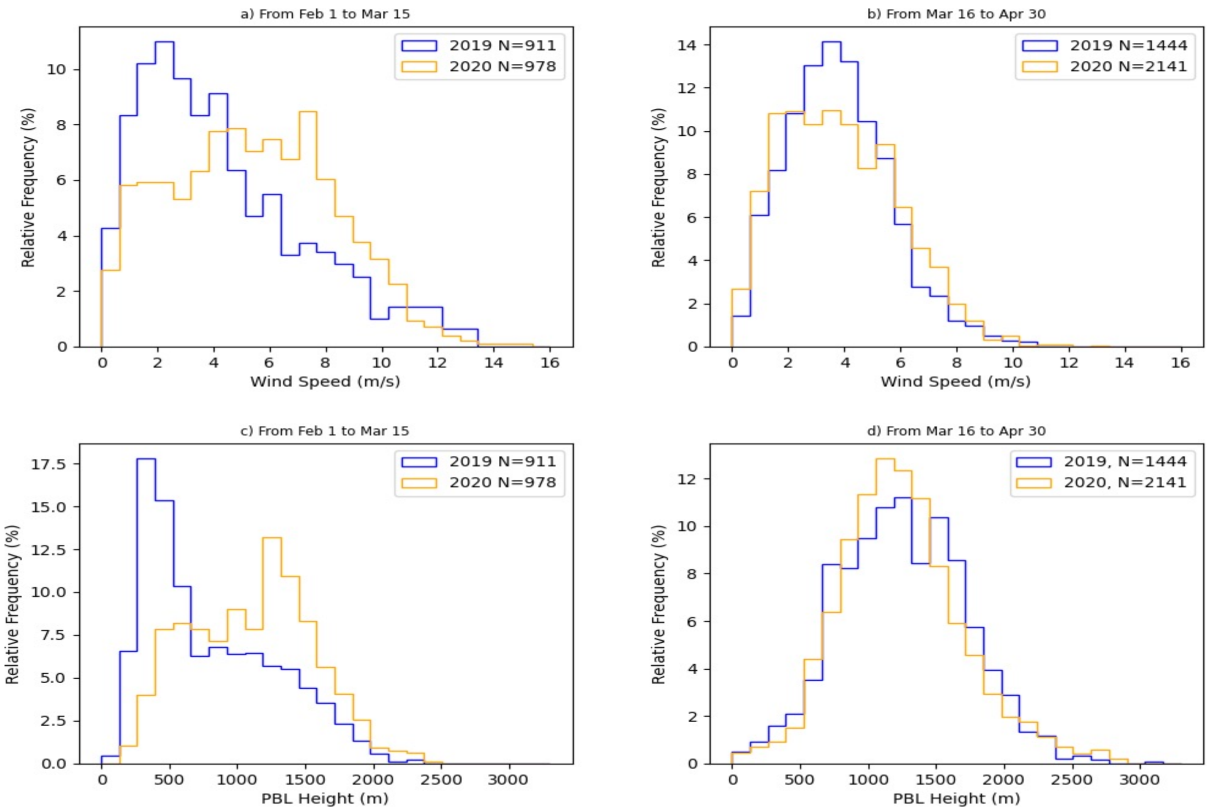
2019-2020 DISTRIBUTION OF WEATHER PARAMETERS

Before lockdown | During lockdown

Windspeed

PBLH



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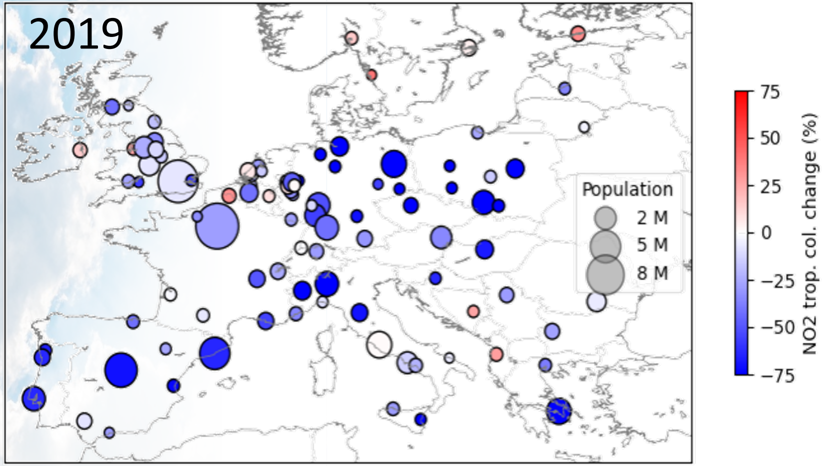
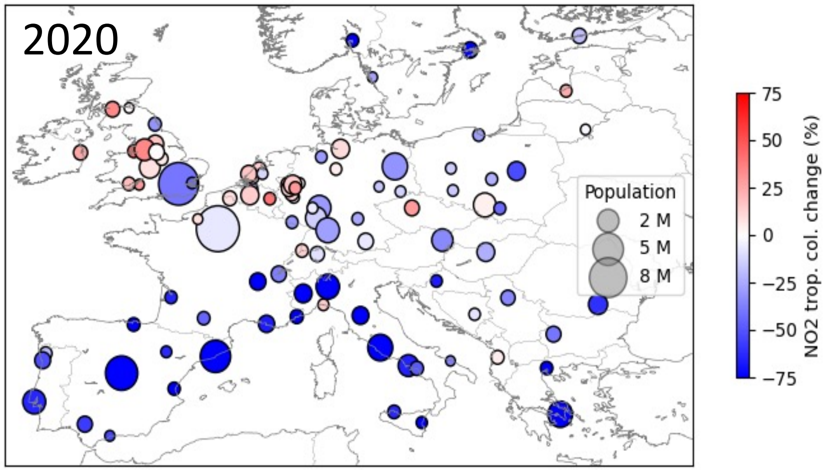
NON-WEATHER NORMALIZED ESTIMATES

- Using “before-during” estimate i.e. subtract [1Feb:15Mar] to [16Mar:30Apr]
- Select urban areas >0.5M : 100 across Europe
- Significant reductions in 2019! Stronger than in 2020 in many areas.

a) Satellite "Before-During" Estimates:
OBS[16Mar2019:30Apr2019] - OBS[1Feb2019:15Mar2019]



b) Satellite "Before-During" Estimates:
OBS[16Mar2020:30Apr2020] - OBS[1Feb2020:15Mar2020]



NON-WEATHER NORMALIZED ESTIMATES 2

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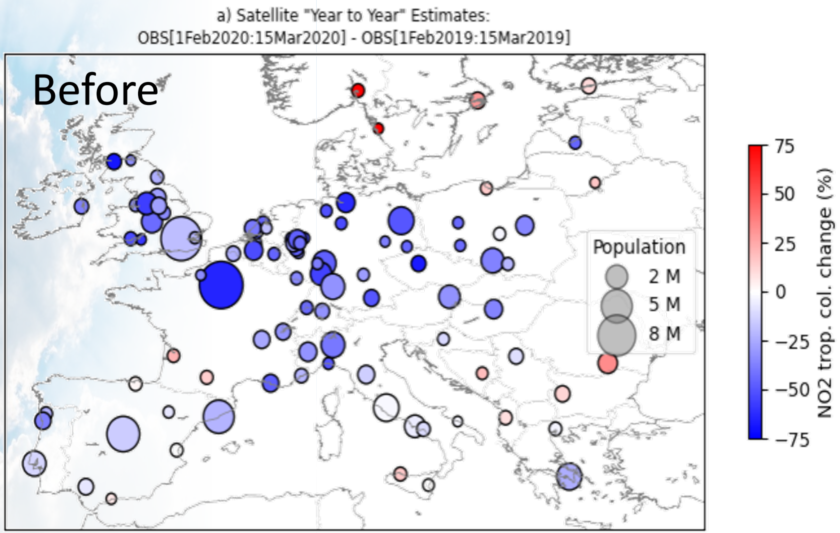
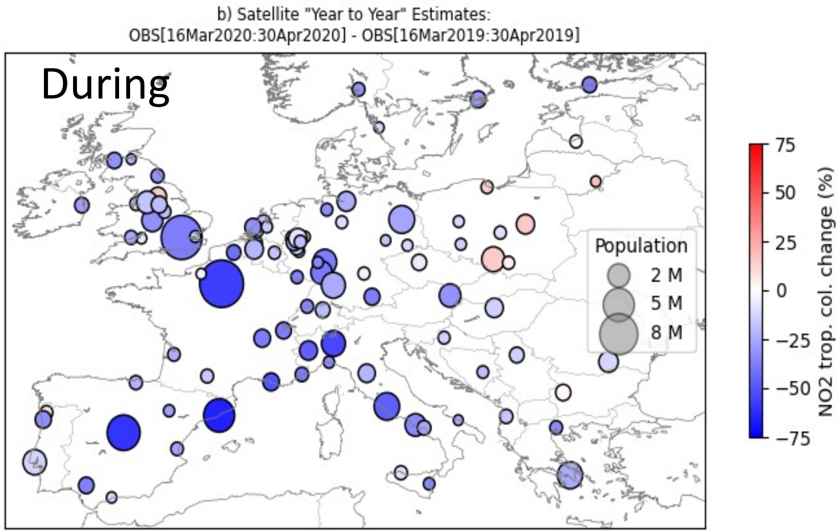
- Using "year1-vs-year2" estimate for the same period of year: i.e. subtract [2019] to [2020]
- Significant reductions before lockdown! Stronger in certain areas as well.





ACCOUNTING FOR WEATHER VARIABILITY

Machine Learning: Weather Normalization Methodology

- **Training Set**
- ECMWF NWP operational forecasts:
  - 10m wind speed and direction,
  - planetary boundary layer height
  - 2m temperature
  - surface relative humidity
  - geopotential at 500hPa
  - Date information
- CAMS regional 3D NO_2 forecasts
- S5P NO_2 columns or surface NO_2 (*target*)

Gradient boosting Regressor
Hyperparameter tuning (grid search)
with cross-validation (5 k-fold)

Simulate "business as usual" (BAU) S5P NO_2 columns or surface NO_2

Evaluation with **Test Set**

Calculate 2020 estimates:
Rea l– BAU

WEATHER NORMALIZED ESTIMATES (SATELLITE)

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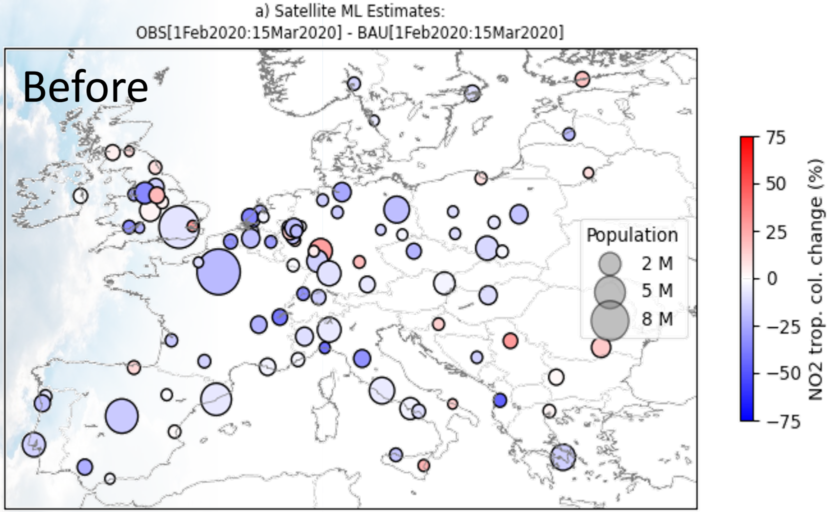
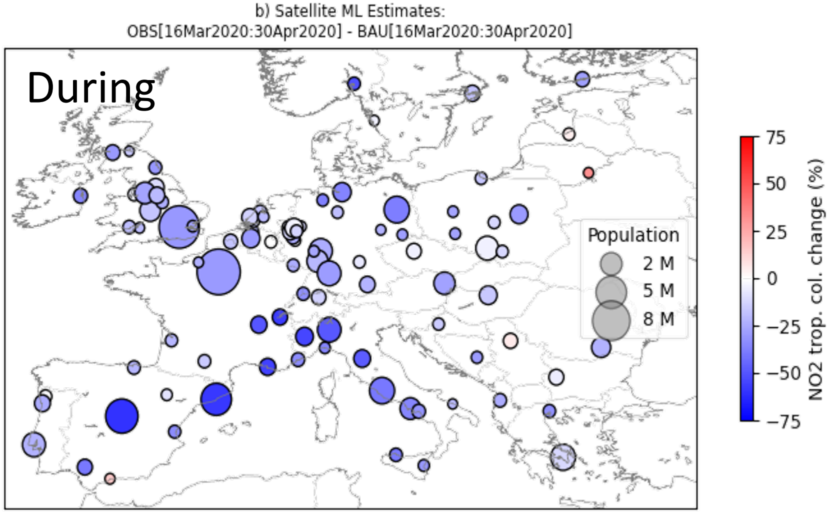
- Lower reductions in the period before lockdown
- Caveat: ML model is not perfect and cannot fully represent the anomaly





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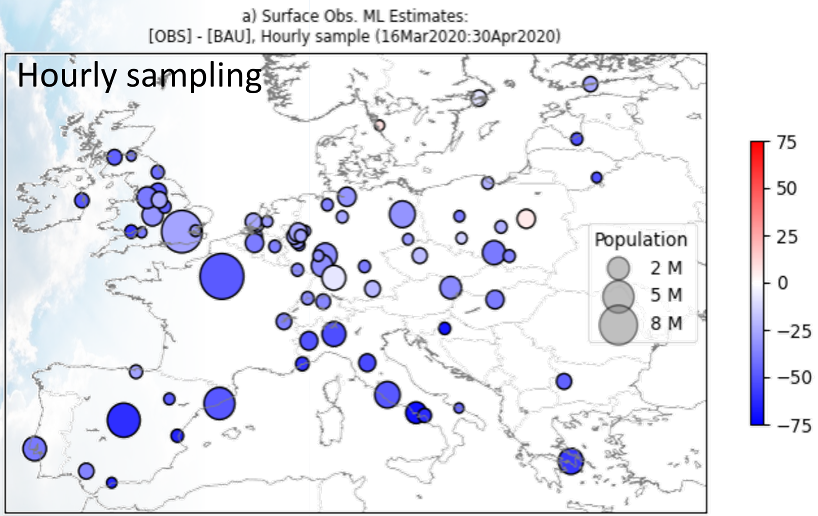
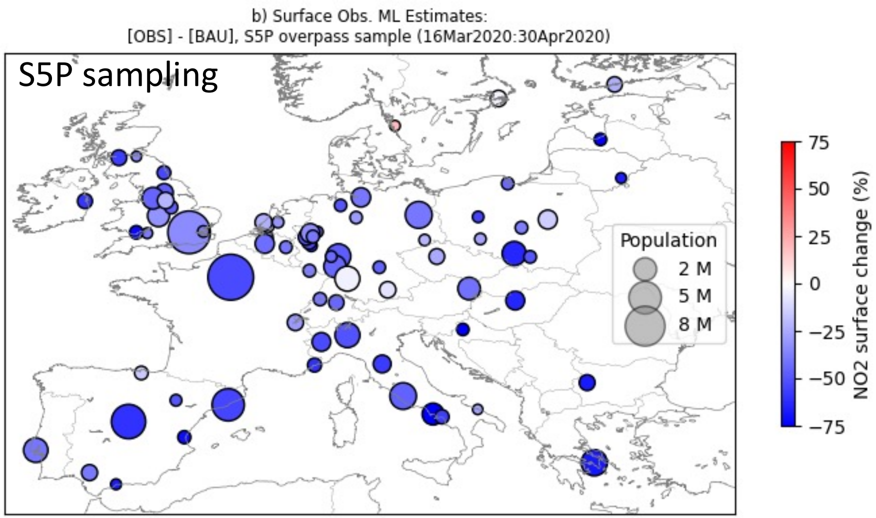
WEATHER NORMALIZED ESTIMATES (SURFACE STATIONS)

- Testing on the effect of S5P sampling versus hourly sampling

- Estimates tend to be stronger at satellite revisit times -> dependence on reduction factor and time of the day

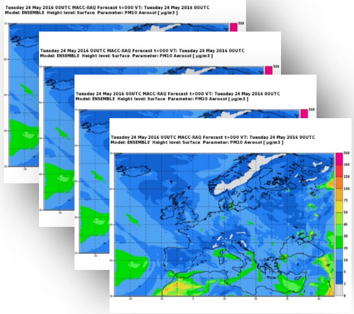




CAMS: MULTI-MODEL LOCKDOWN HINDCAST

11 models hindcasts

BAU Emissions

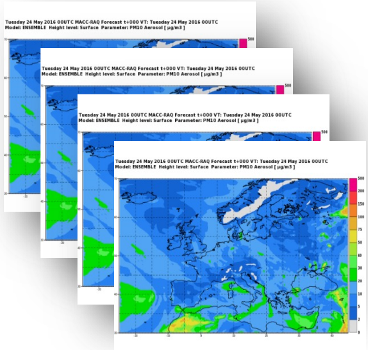


BAU Ensemble median

15 March – 30 April 2020

Surface pollution changes estimates

Factual Emissions
Using recent activity data (and ML, see Guevara et al.,



11 models hindcasts

Factual Ensemble median

CAMS REGIONAL MODEL ENSEMBLE ESTIMATES

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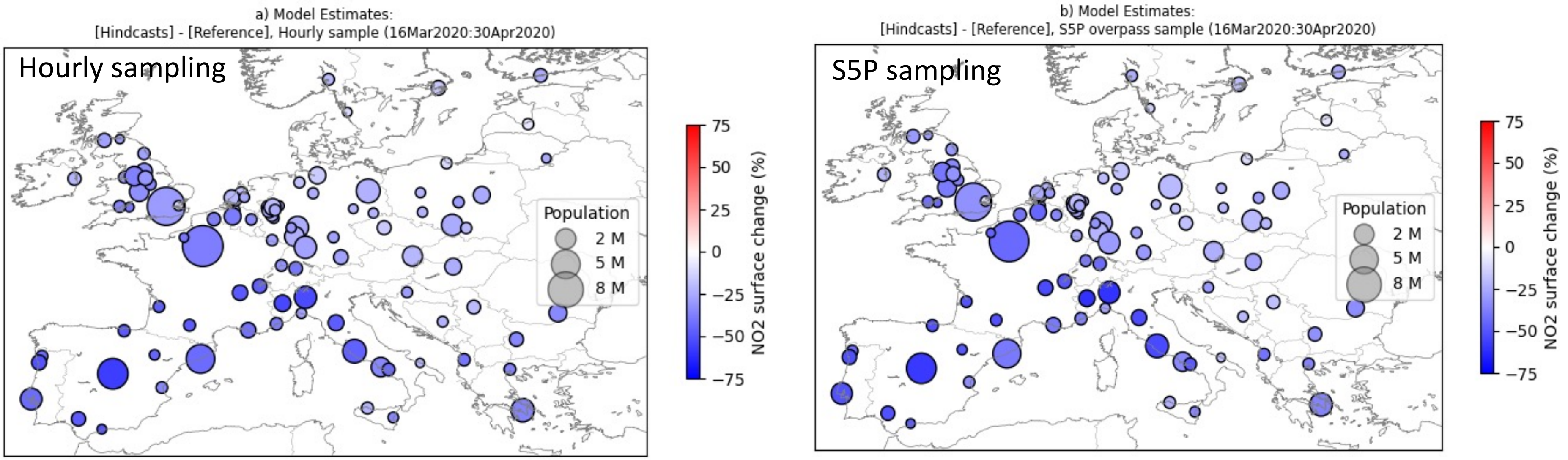
- Early version of Guevara et al.: scaling factor per sector (road, industry and aviation) per country constant for the whole period.
- No significant dependence on time sampling as emission scaling is constant over time in these simulations.



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SUMMARY OF RESULTS

	Average Changes (%)	Inter city Standard Deviation (%)
Surface stations [hourly]	-36.74	15.09
Surface stations [S5P sampling 1pm]	-43.06	18.82
CAMS model ensemble [hourly]	-30.35	10.79
CAMS model ensemble [S5P sampling 1pm]	-31.82	11.97
Satellite S5P	-22.72	15.51

- Horizontal **representativeness** issues between pixel based and stations
- **Satellite overpass sampling** tests suggest a time of the day dependence on emissions reductions (model vs surface sites)
- **Vertical sampling**: column vs surface, weaker reduction seen columns (satellite)

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CONCLUDING REMARKS

- Effects of lockdown on surface air pollution cannot be assessed correctly if weather variability and BAU emissions variability are not considered.
- When normalized with actual weather conditions, satellite-based, surface stations -based and model-based estimates provide similar country dependent variations linked with stringency of measures.
- In average the NO_2 reductions are around -30% over Europe during the most stringent phase of the 1st lockdown. Lower surface reduction are found on other pollutants (e.g. around -10% for PM), that do not have as large a contribution from transport and industrial emissions.
- Differences still exist between the type of estimates.

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