Surface-level NO2 Prediction using Machine Learning on Sentinel-5P TROPOMI Satellite Observations and CAMS European Air Quality Reanalysis Dataset

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Background and Research Goal

NO2 is a harmful pollutant in the atmosphere, which requires close monitoring at surface level. NO2 prediction schemes exist, which apply machine learning on the TROPOMI NO2 column and additional variables as well as in-situ data to predict surface-level NO2 [1]. The Sentinel-5P satellite delivers daily measure-ments of tropospheric NO2 on an unprecetended scale. At the same time the European CAMS air quality reanalyses delivers high-quality models of the atmospheric state on different altitudes. Hereby the CAMS model already represents atmospheric conditions and processes which determine NO2 distribution within the atmosphere [2].

This study explores the potential of machine learning to learn **dependence between columnar quantity and ground-level concentrations as displayed by CAMS model**. We investigate how this learned dependence ican be employed for the prediction of NO2 conentrations based on S-5P TROPOMI NO2 column measurements as input to the prediction model.

Data and Methods

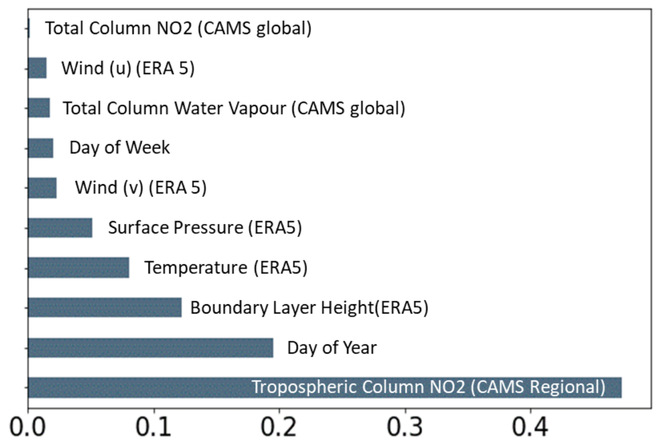
1. Determine CAMS NO2 column based on altitude layers of the CAMS Regional Air Quality Reanalysis

$$NO2\ Column_{CAMS} = \sum_{atm.\ layer=l0}^{l5000} NO2_{\ CAMS} \times layer\ thickness$$

2. Train ML Model with CAMS NO2 Level 0 as target y
3. Model learns the relation between CAMS NO2 column and CAMS NO2 Level 0 (under consideration of additional variables)
4. Surface NO2 is predicted using the ML model on the S5P NO2 as input variable (X)

NO2 Prediction-Model Evaluation

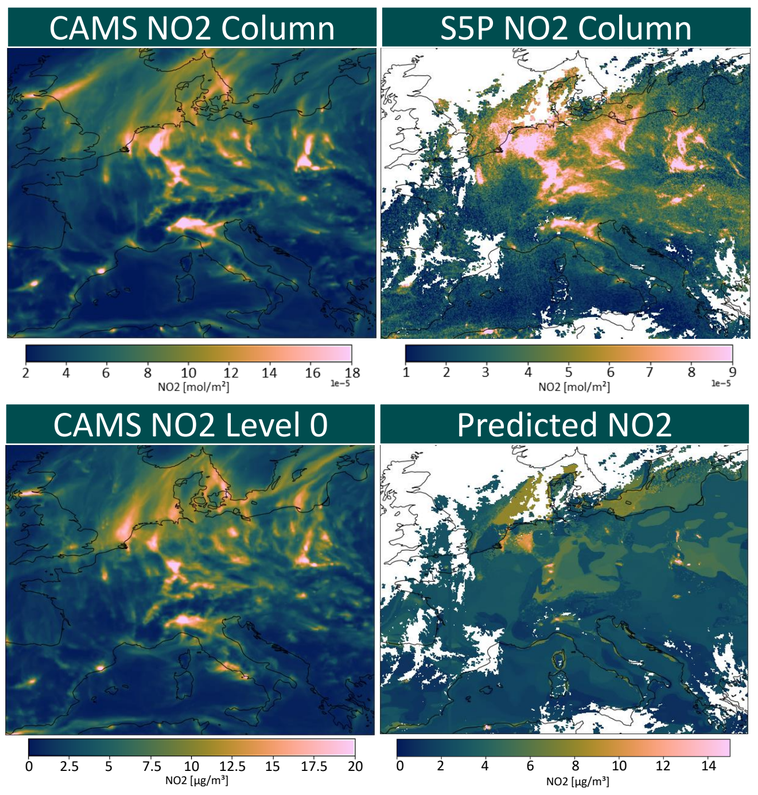
The model is trained and validated over a study perod of 6 months. 154 daily datasets are used for training the model, 29 daily sets for validation.
The validation on independent scenes reveals a correlation of 0.66 between the predicted surface NO2 and the CAMS surface NO2. Main cause of deviation is hereby a difference of order of magnitude between CAMS NO2 column and TROPOMI NO2column.



The feature importance of the model prediction reveals the high importance of the CAMS Regional Total column along with Day of Year and meteorological variables.

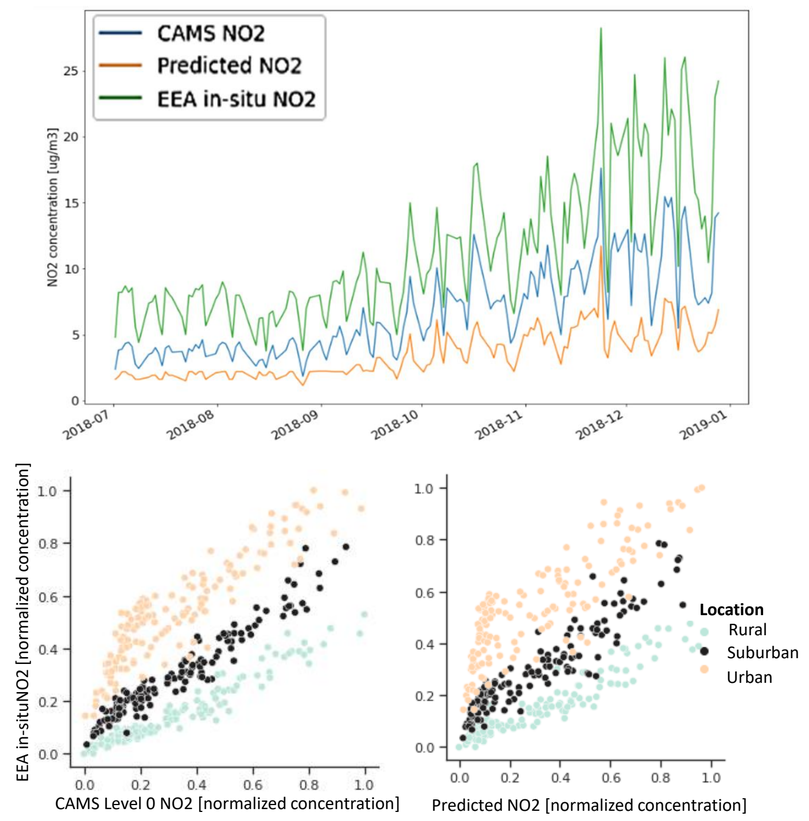
Results of NO2 Prediction

Exemplary NO2 Prediction Map (bottom right) for one validation date (2018/10/13) and comparison to CAMS model and TROPOMI NO2 column.



Validation with EEA in-situ data

The S5P-based NO2 prediction, CAMS-based Level0 NO2 and NO2 in-situ measurements of 2095 EEA stations are compared across the study time (6 months):



Main Findings – and plans for the upcoming development of the research

- NO2 predictions **distinct localization** of surface NO2 hotspots. **Patterns** agree with in-situ and CAMS surface NO2; **Magnitude** of NO2 concentrations deviates.
- While **preserving the complex relation** between column and surface NO2 given by CAMS, the S5P NO2 column adds value by high **spatial resolution** and gives a direct link to **real-world measurements**.
- Drawback of this approach is **the uncertainty in the CAMS NO2 column**. A more sophisticated approach for determining, e.g. by applying an averaging kernel [3] will be subject in the future course of this work.
- Future plans lead to the extension of **testing time** and the inclusion of **more variables** to increase learning quality of the ML model.

References:

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For further information feel free to reach out!
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