Bundesministerium für Verkehr und digitale Infrastruktur

mFUND
Das Startkapital für die Mobilität 4.0

# Sentinel-based atmosphere products to assess the effect of traffic emissions on the air quality in Germany (S-VELD)

BMVI Workshop:
Data to support monitoring and policy decisions for climate protection in the transport sector

Online, 4 Aug 2021

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DLR

IVU Umwelt GmbH
Umweltplanung - Informationssysteme

Freie Universität Berlin

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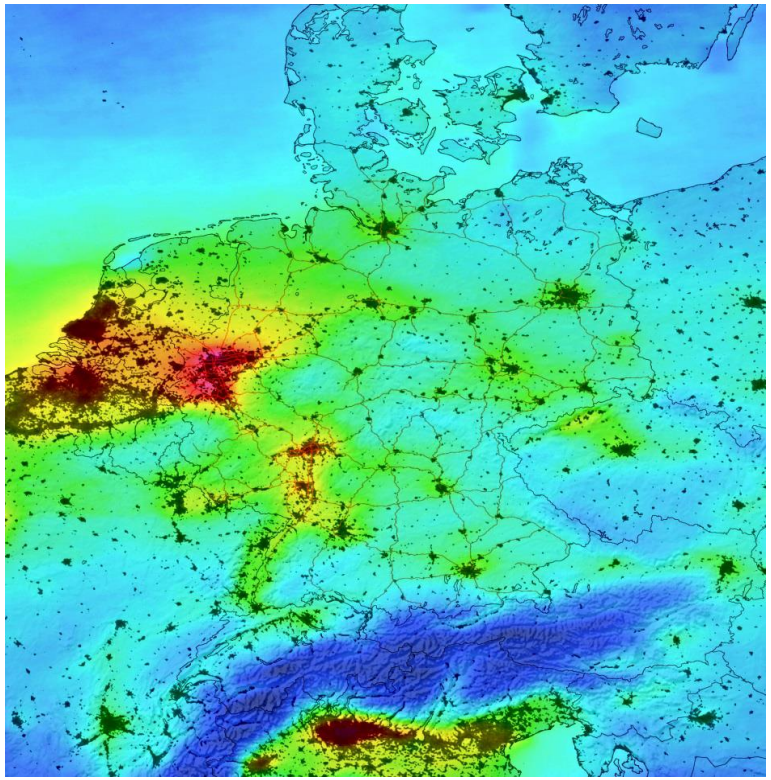
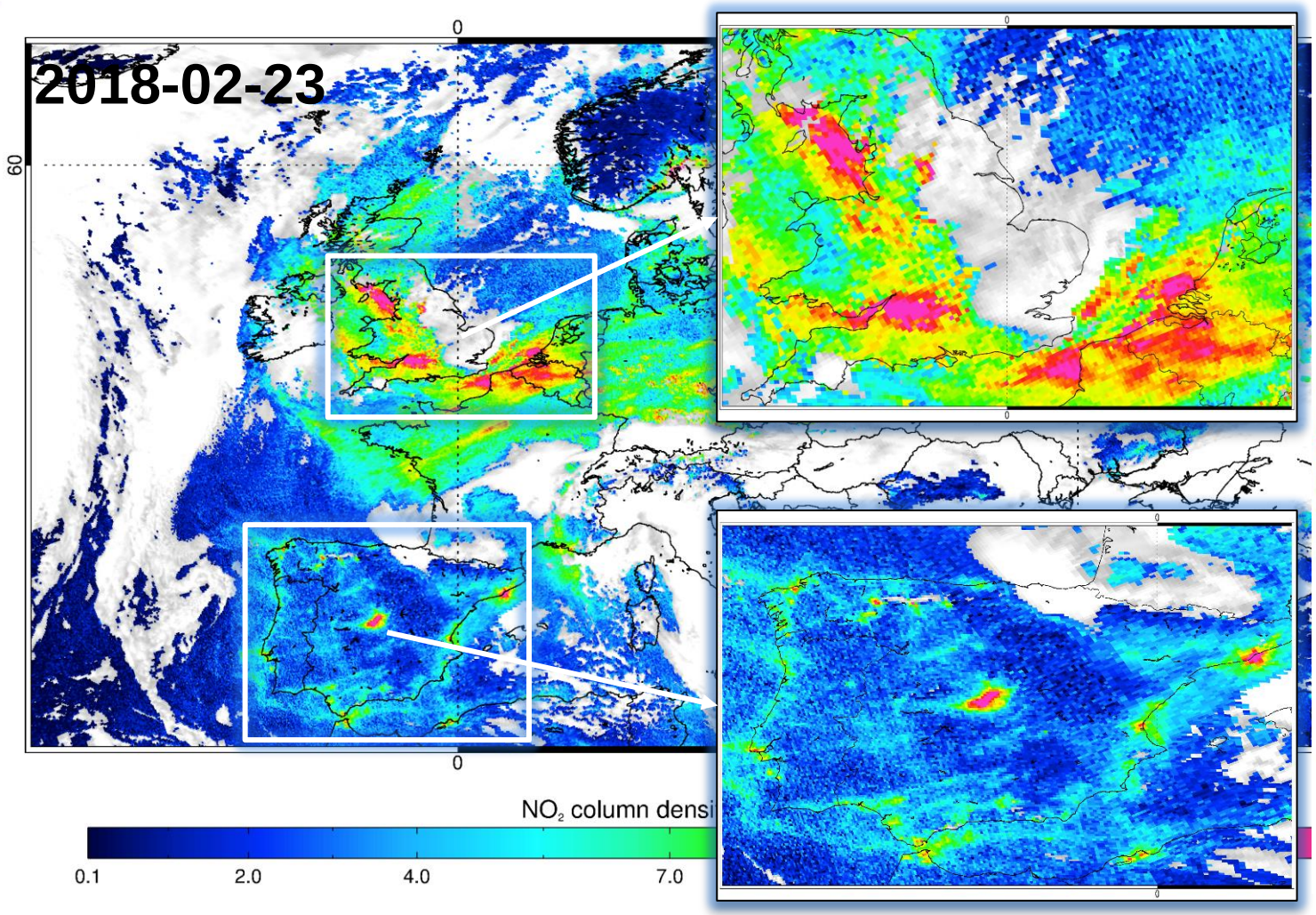
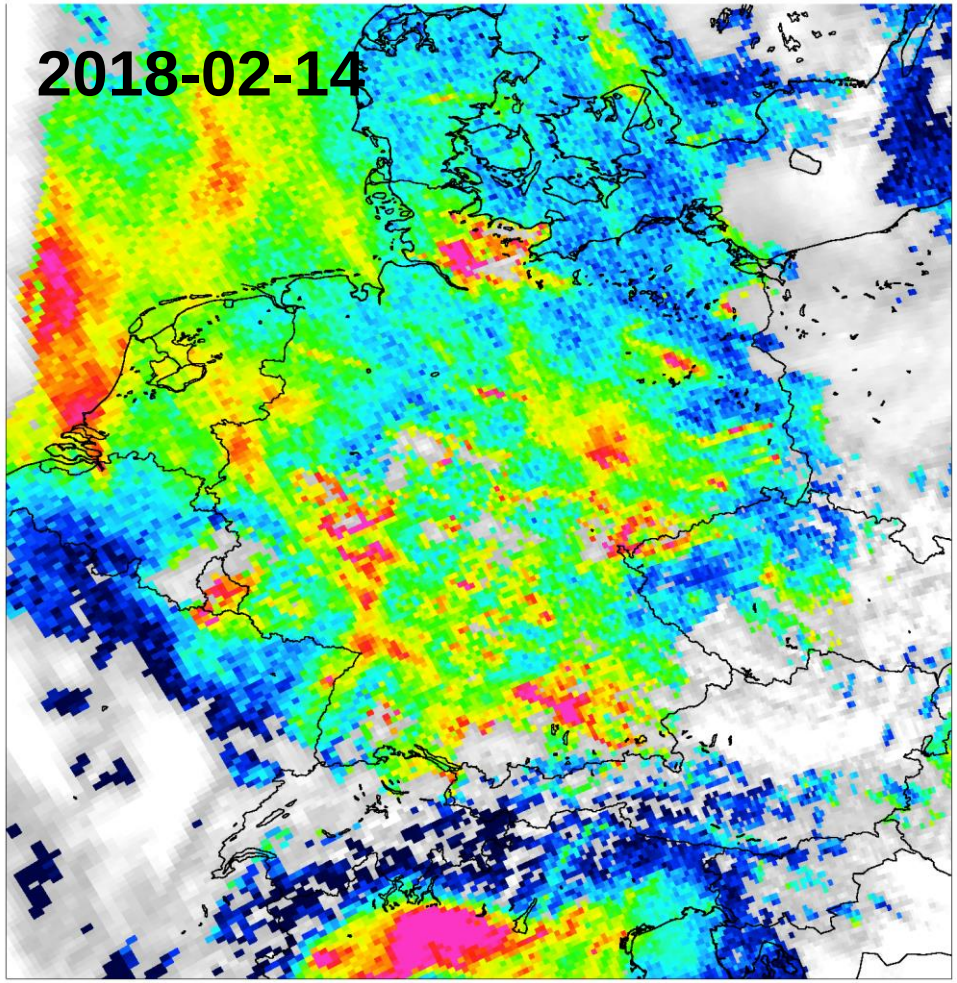
# S-VELD – Main goal

- Use of Sentinel satellite data to improve the understanding and modelling of air pollution from road traffic in Germany (and surrounding countries)
  - ➢ Planning basis (city/regional) for public/local authorities
- The Copernicus Sentinel Instruments provide daily $NO_2$ and PM information with a high spatial resolution from space
- Combination of Sentinel data with emission- and air quality modelling
  - ➢ *Bottom-up* emission estimates based on BMVI traffic data (BASt)
  - ➢ *Top-Down* emission estimates using Sentinel-data and AQ models



# Tropospheric $NO_2$ from Sentinel-5P

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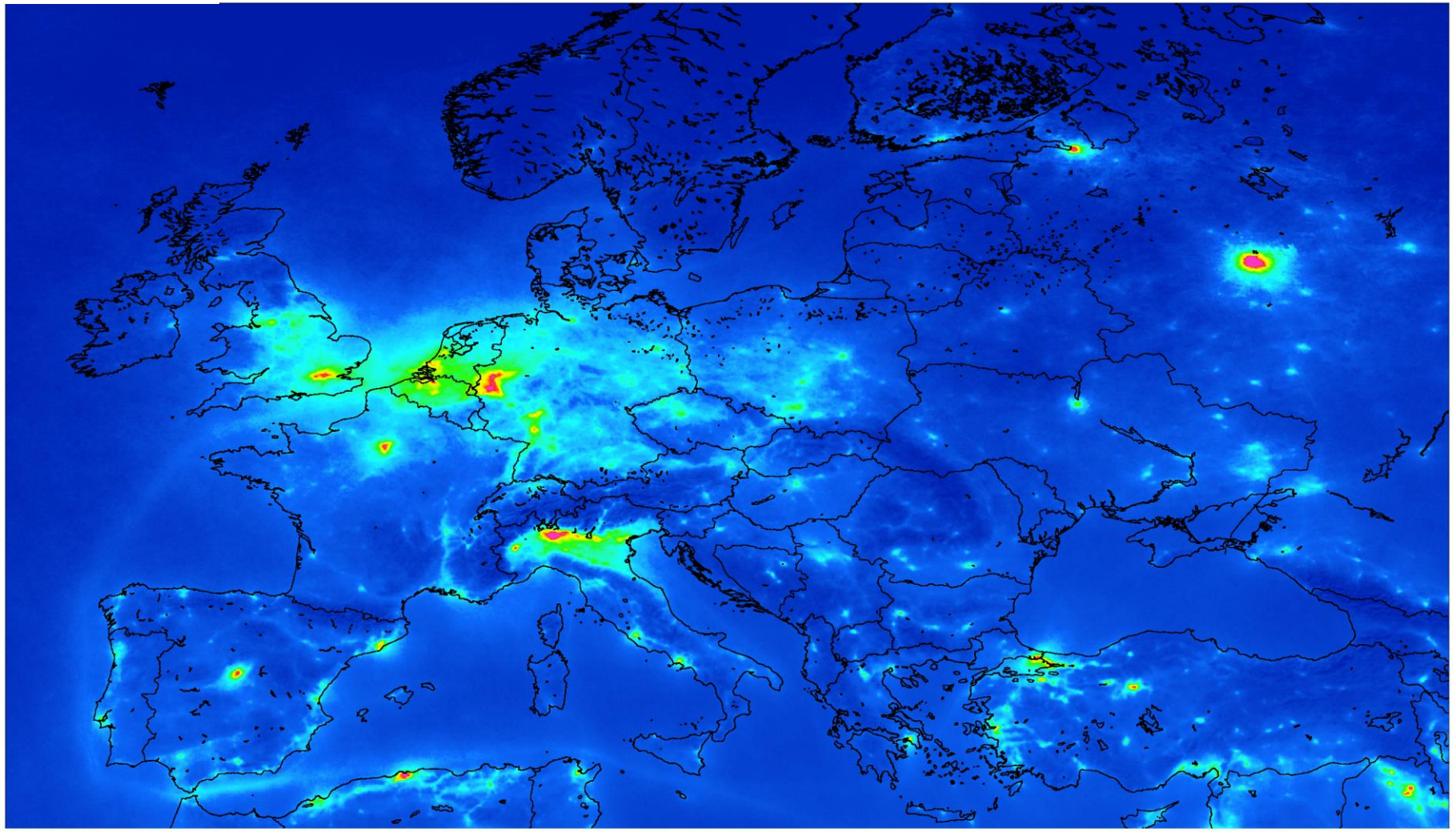
# Troposphärisches $NO_2$ from Sentinel-5P



**Europe**

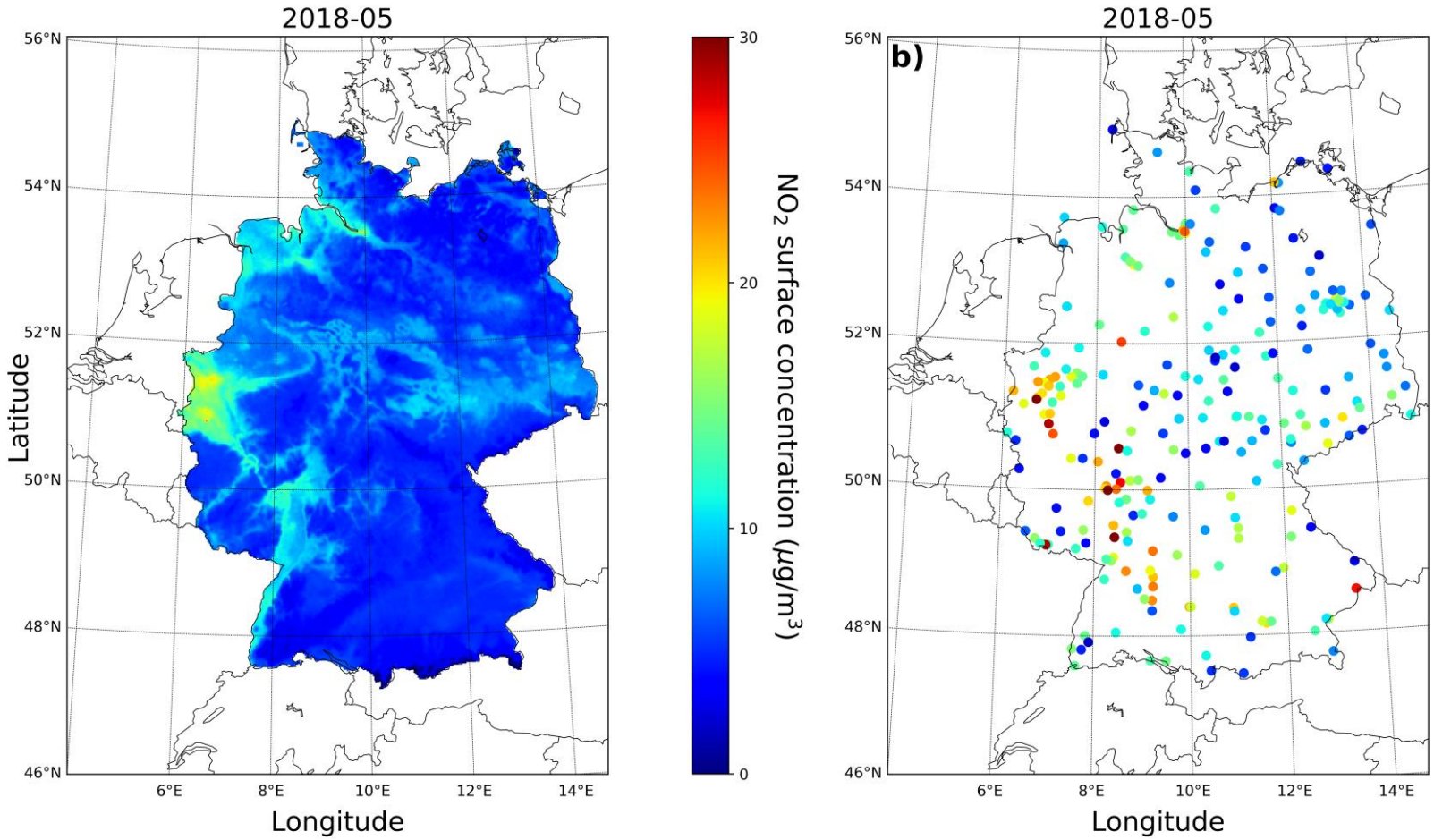
**2018-2020**

$NO_2$ column density [$10^{15}$ molec/cm$^2$]

0.0 10.0

# Surface $NO_2$ Concentrations from S-5P

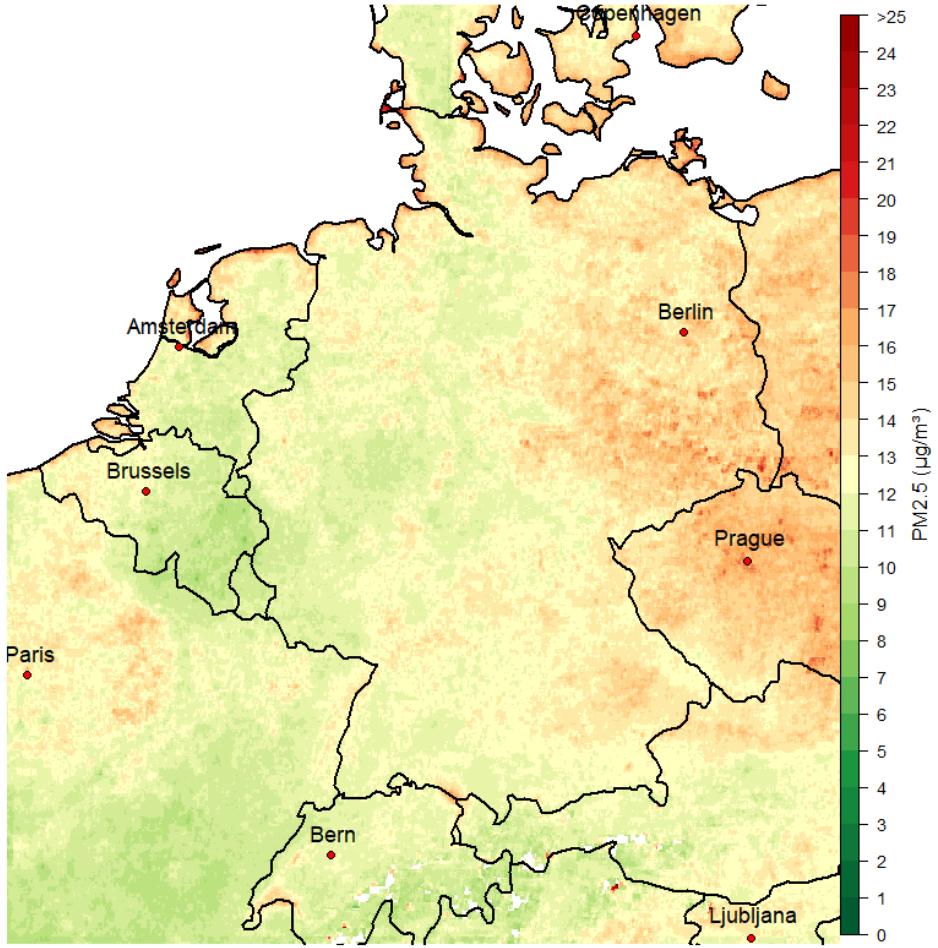
- Monthly averaged surface $NO_2$ conc. over Germany with 2 km spatial resolution.
- Machine learning approach based on S-5P $NO_2$ data und meteorological parameters
- Validation with in-situ $NO_2$ measurements




**Surface $NO_2$ from S-5P $NO_2$ data (May 2018)**

# PM surface concentrations

- Yearly/seasonal PM surface concentrations (PM 2.5 & PM 10) based on satellite data with km-scale resolution
- Aerosol data (AOD) von MODIS, Sentinel-3 und -5P
- Semi-empirical approach using key meteorological parameters (humidity and boundary layer height).
- Correction/verification of PM surface concentrations using in-situ measurements




**PM 2.5 Ensemble from MODIS and S3 aerosol data (2018)**

Handschuh et al. 2020
http://dx.doi.org/10.1117/12.2574020

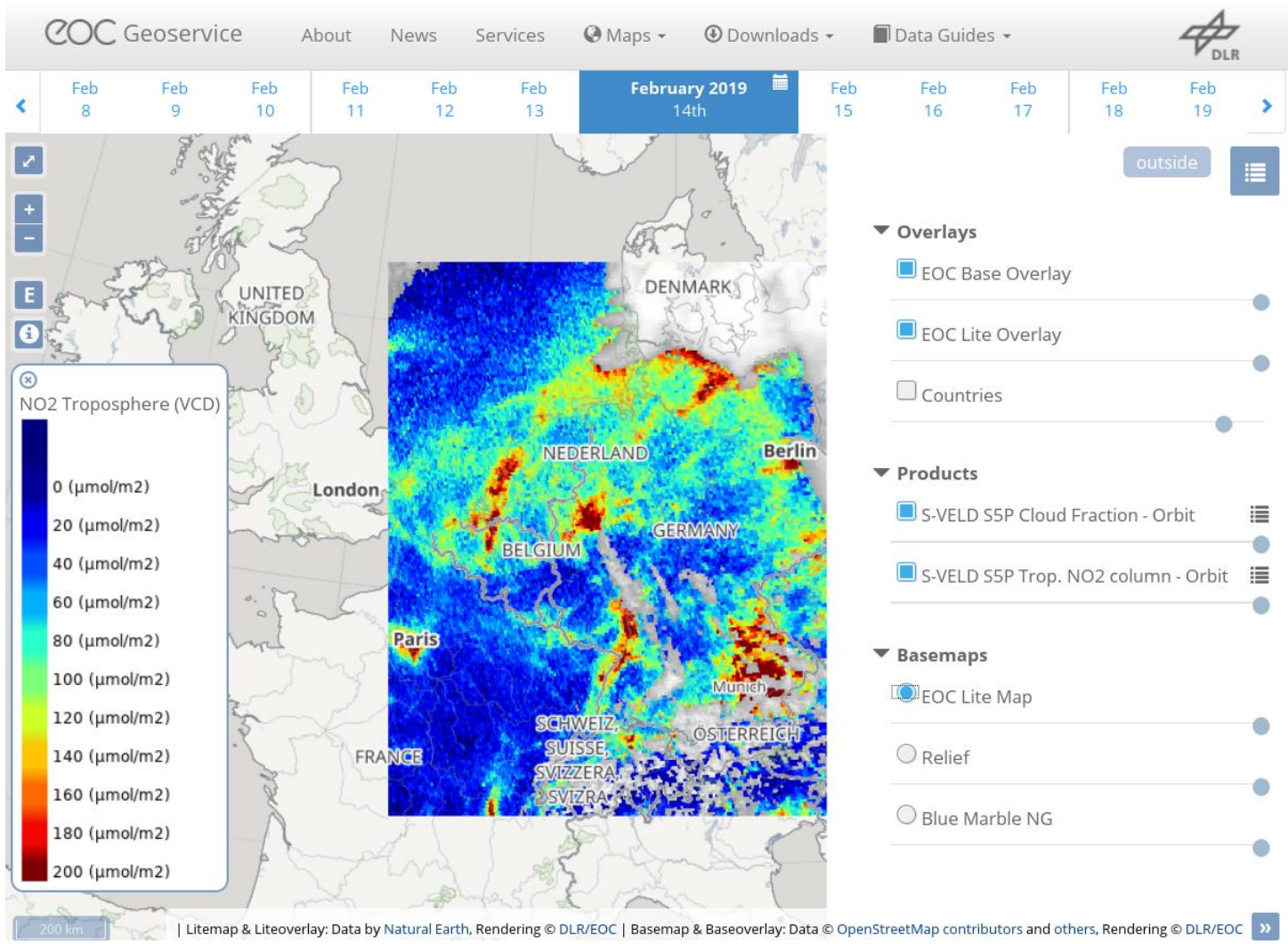
# EOWEB GeoPortal - Geoservice

## S-VELD $NO_2$ und PM products

Daily and monthly averaged $NO_2$ und PM maps & data

Interoperable data discovery, viewing, and download

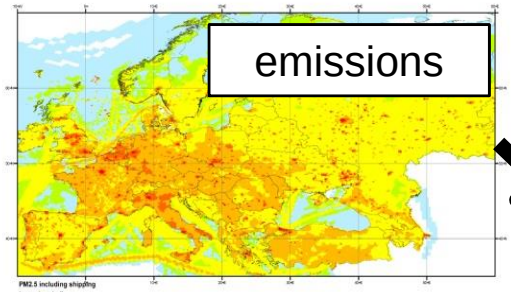
Collection Metadata in mCLOUD



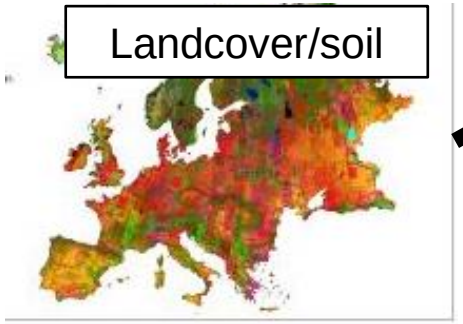

https://atmos.eoc.dlr.de/sveld/data

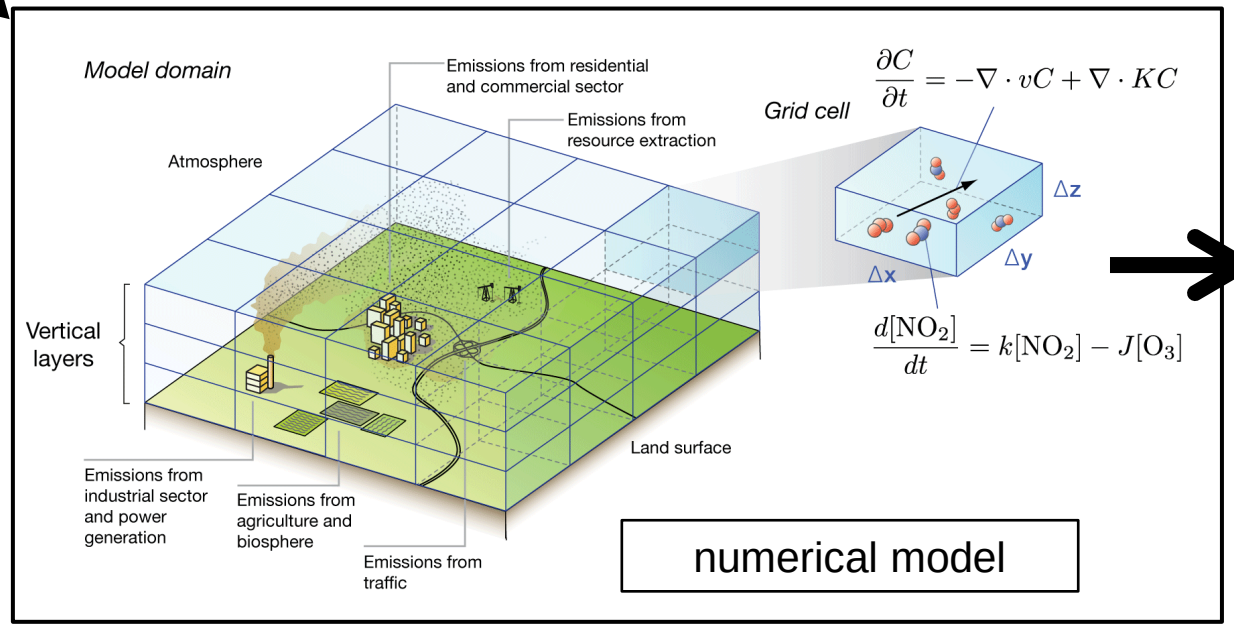
# Deriving Emissions from Sentinel-5P data

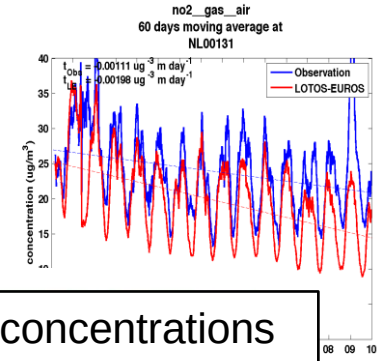
## Chemistry Transport Models provide link between emissions and concentrations

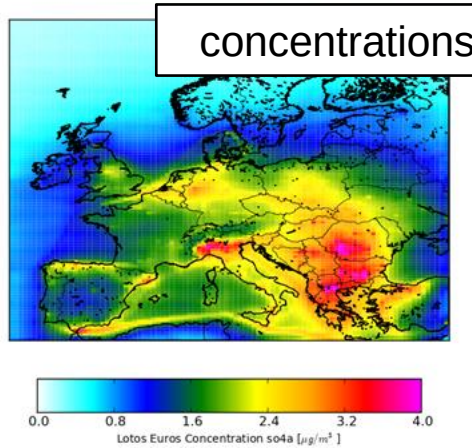







Steyn et al., 2012

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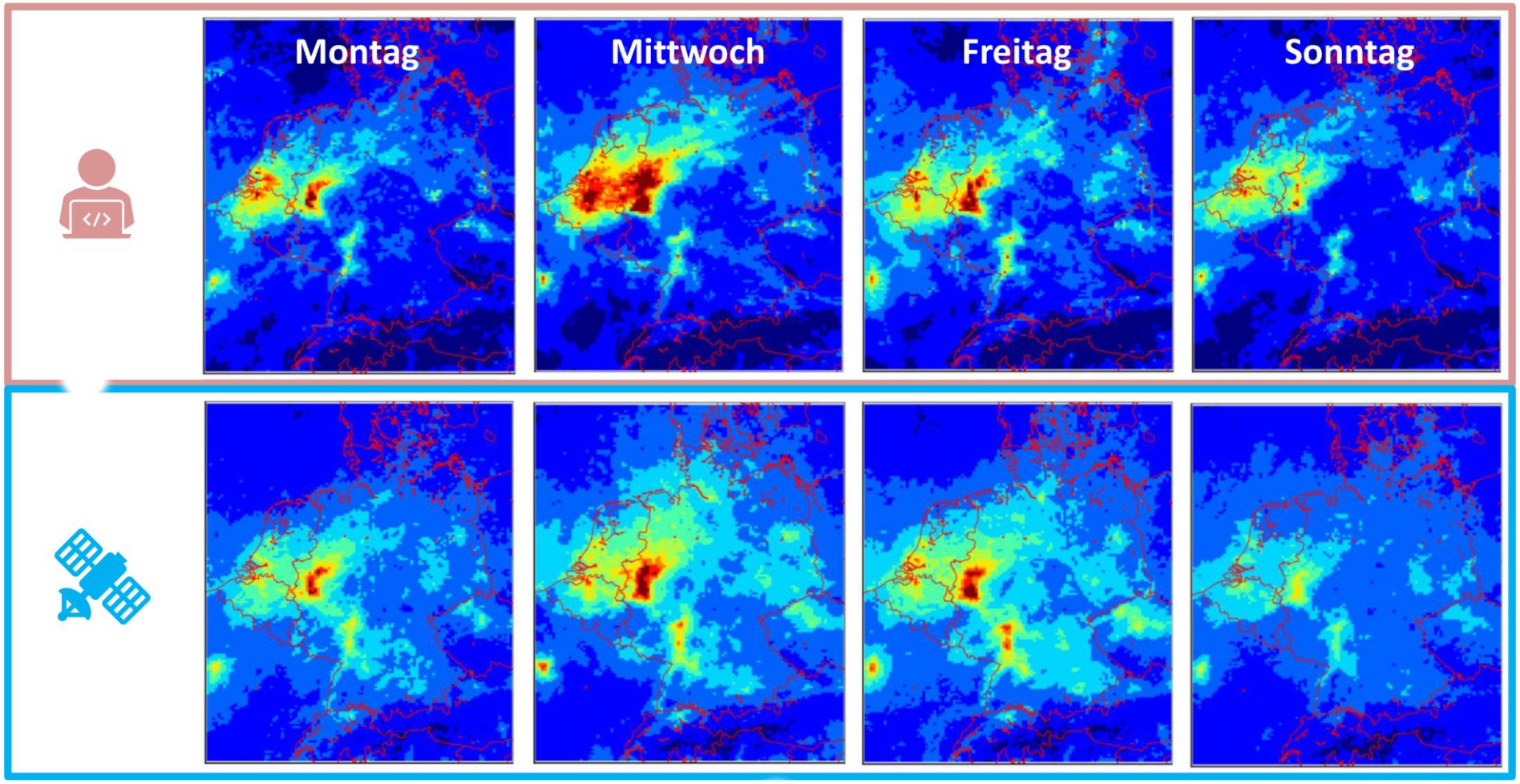
# Sentinel-5P – Model comparisons

## Tropospheric $NO_2$ Jul. – Dec. 2018

**LOTOS-EUROS Model**

**Sentinel-5P**

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# Top-Down Emission analysis

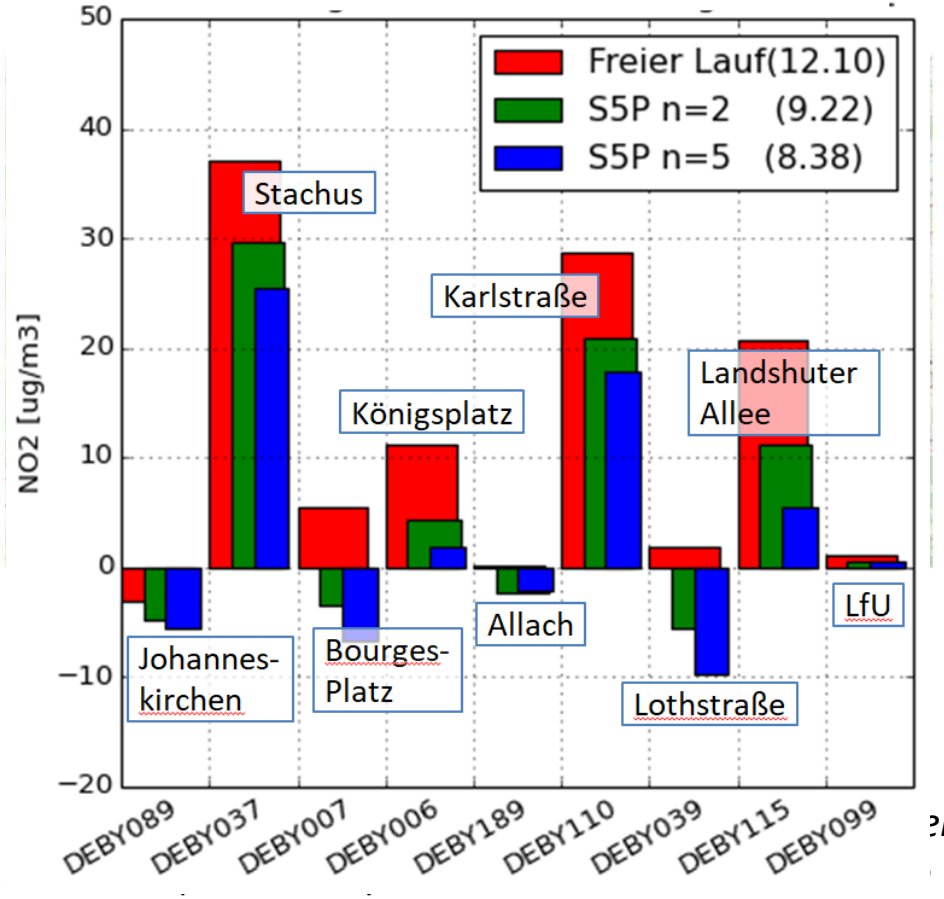
## Quantification of road traffic emissions based on inverse modelling systems

| | Scenario analysis | Data-assimilation |
|---|---|---|
| Model | POLYPHEMUS | LOTOS-EUROS |
| Technique | Localised EnKF (Offline) | EnKF (Online) |
| Meteorology | DWD - COSMO | DWD - COSMO |
| A-Priori emissions (bottom-up) | S-VELD | S-VELD |

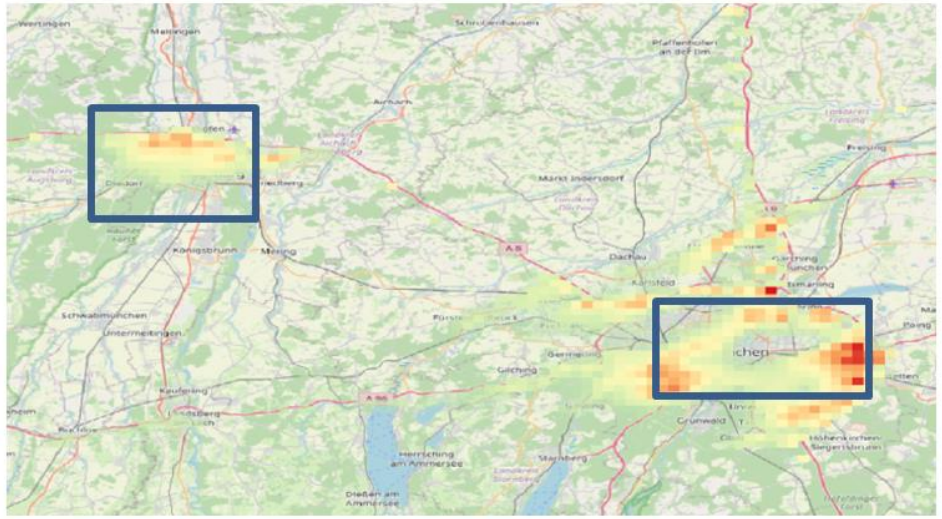
**Using two systems allows to determine the impact of model uncertainty and identify robust results.**

# First test: Top-Down emissions from Sentinel-5P $NO_2$

$NO_2$ Observations – $NO_2$ analysis




After emissions correction



NO2 [ug/m³]

30 27 23.4 19.5 15.6 11.7 7.8 3.9 0

*emission correction based on S5P $NO_2$ observations on 2nd*
*the blue rectangles only*

# Assessment of road traffic emissions and contribution to air quality in Germany

Combination and integration of emission modelling results

- Quantification of $NO_2$- und PM emissions

Separation of emissions from road traffic and other sources

Possible improvement of *bottom-up* emissions estimates from road traffic

- Road traffic induced air quality during 2018-2020

**The S-VELD approach can be applied to other (EU) countries as well**

**https://atmos.eoc.dlr.de/sveld**