

# Emission Monitoring Mobile Experiment (EMME): an overview and results of the St. Petersburg megacity campaigns of 2019-2020 (Russia)

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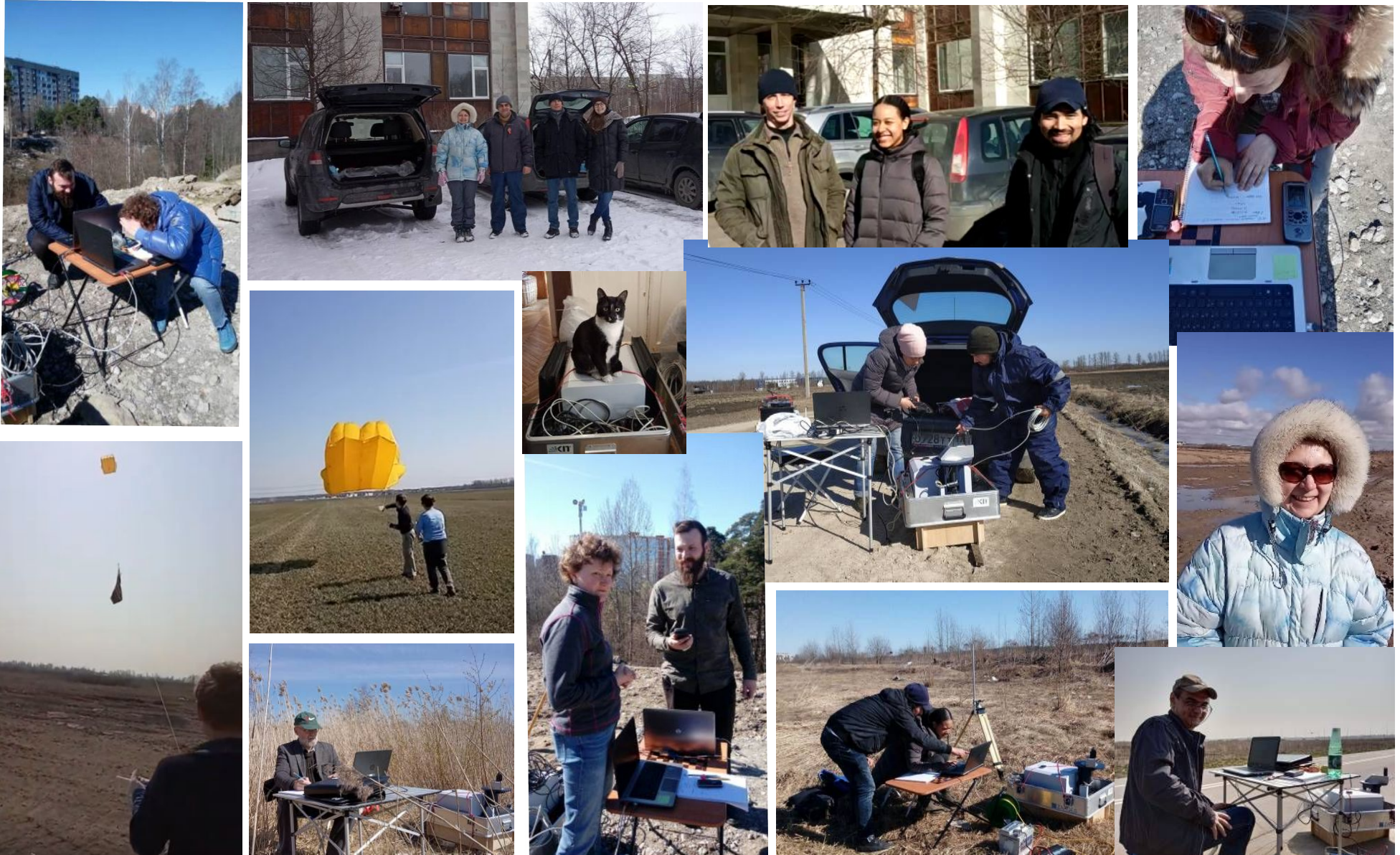
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# The goal of EMME

- Making a lot of photos/hours of video ;-)



# The goal of EMME

► to estimate the emission of CO<sub>2</sub>, CH<sub>4</sub>, CO and NO<sub>2</sub> for St. Petersburg – a megacity with a population of ~ 5.4 million (7.5 million - unofficial info)

EMME city campaign was carried out:

- in March-April of 2019, 11 days of field measurements;
- in March-early May 2020, 6 days (**3 days out of quarantine and 3 days during the COVID-19 quarantine**).

# Core instruments

- ▶ **two portable Bruker EM27/SUN** FTIR spectrometers (KIT&UoB, COCCON network) – CO<sub>2</sub>, CH<sub>4</sub> and CO TC measurements;
- ▶ **OceanOptics HR4000Vis** spectrometer - mobile DOAS observations of NO<sub>2</sub> tropospheric vertical column;
- ▶ **GNSS receivers** – geographic location info;
- ▶ **3 vehicles** – for the transportation of the scientific equipment.



# Auxillary instruments

- ▶ **sample bags+sampling devices** for in-situ analysis of CO<sub>2</sub>, CH<sub>4</sub>, CO, N<sub>2</sub>O, H<sub>2</sub>O, NO<sub>2</sub>, NO and O<sub>3</sub> concentrations (Los Gatos Research and ThermoScientific gas analyzers);
- ▶ **lifter kite** for elevated air sampling;
- ▶ **Reinhardt meteostation** – p, T, wind speed&direction, etc;
- ▶ 4 car batteries, 2 invertors, 2 electric blankets, 3 laptops, etc.

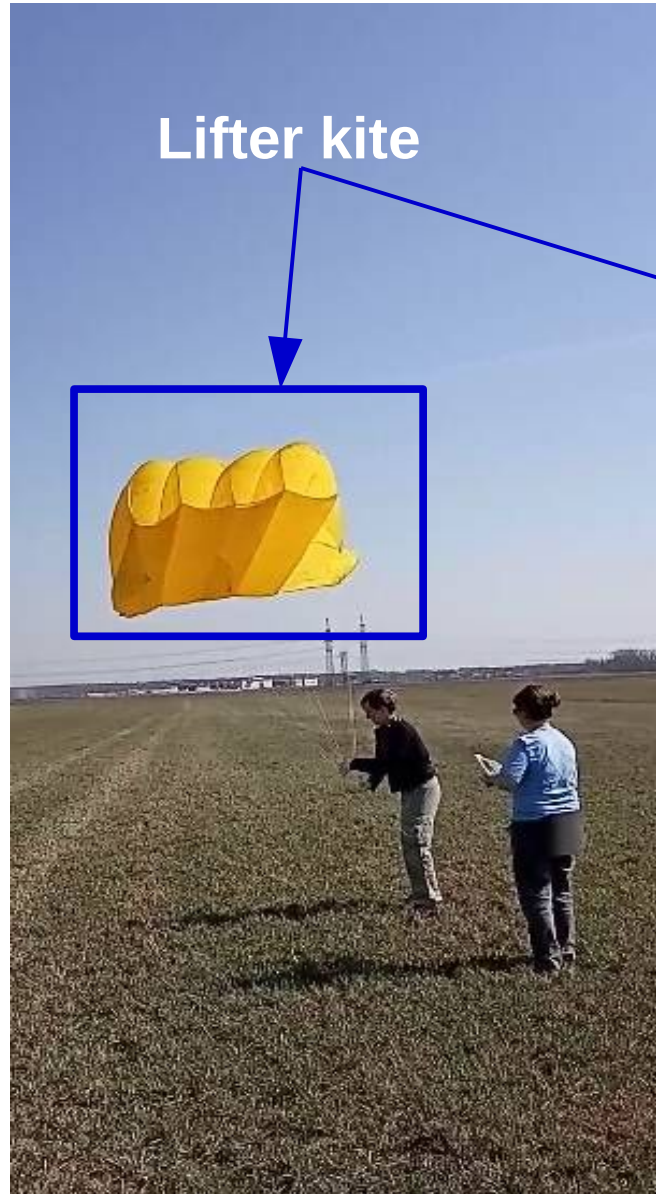
# Concept of EMME (1)

## ► mobile monitoring – the combined approach

EM27/SUN #80 - crew #1



EM27/SUN #84 - crew #2





# Concept of EMME (2)

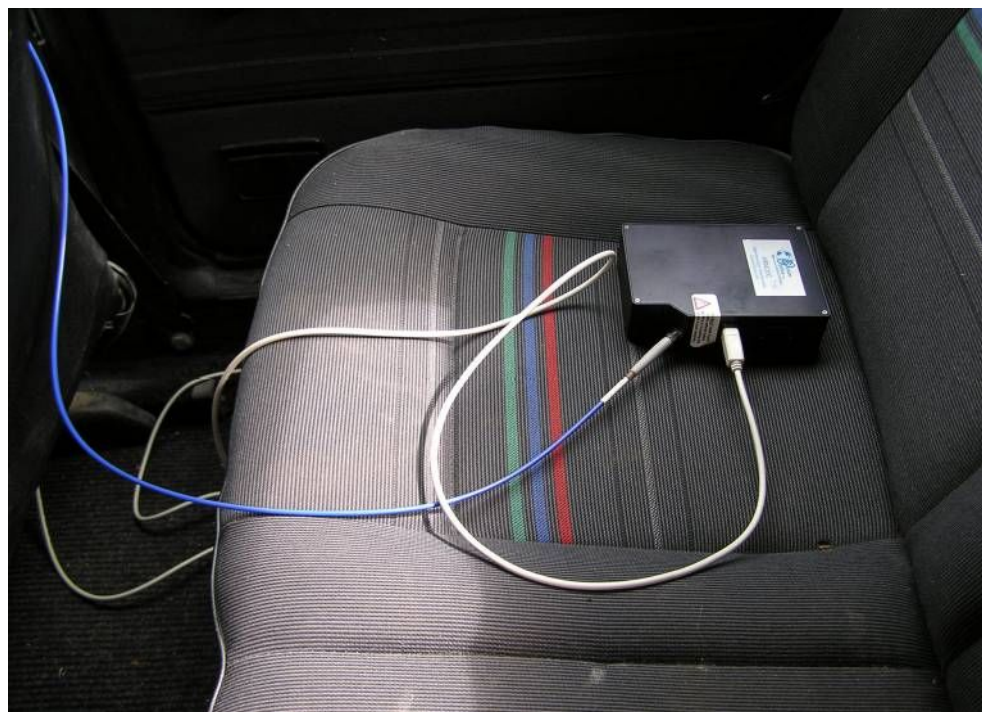
- ▶ mobile monitoring – real-time detection of **NO<sub>2</sub> city plume**



OceanOptics HR4000Vis grating spectrometers: zenith-sky scattered solar radiation measurements.

Processing software: WinDOAS

Output: NO<sub>2</sub> tropospheric vertical column



# Concept of EMME (3)

## ► the combined approach based on:

**Hase** et al.: Application of portable FTIR spectrometers for detecting greenhouse gas emissions of the major city Berlin, Atmos. Meas. Tech., 8, 3059-3068, *doi:10.5194/amt-8-3059-2015*, 2015.

**Ionov** et al.: 2015: Quantification of NO<sub>x</sub> emission from St.Petersburg (Russia) using mobile DOAS measurements around entire city. Int. J. Remote Sensing, 36, 9, 2486–2502, *https://doi.org/10.1080/01431161.2015.1042123*, 2015.

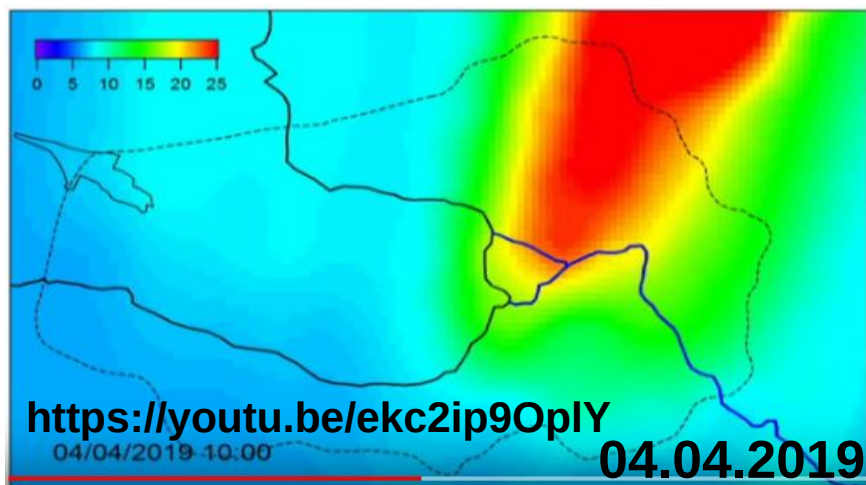


# Concept of EMME (4)

## ► preparatory stage (autumn 2018 – winter 2019)

The set of 21 points for possible up- and downwind positioning of two EM27/SUNs has been checked during the preparatory stage of EMME. Observational points are mostly located near the St. Petersburg ring roadway.

## ► ► a day before

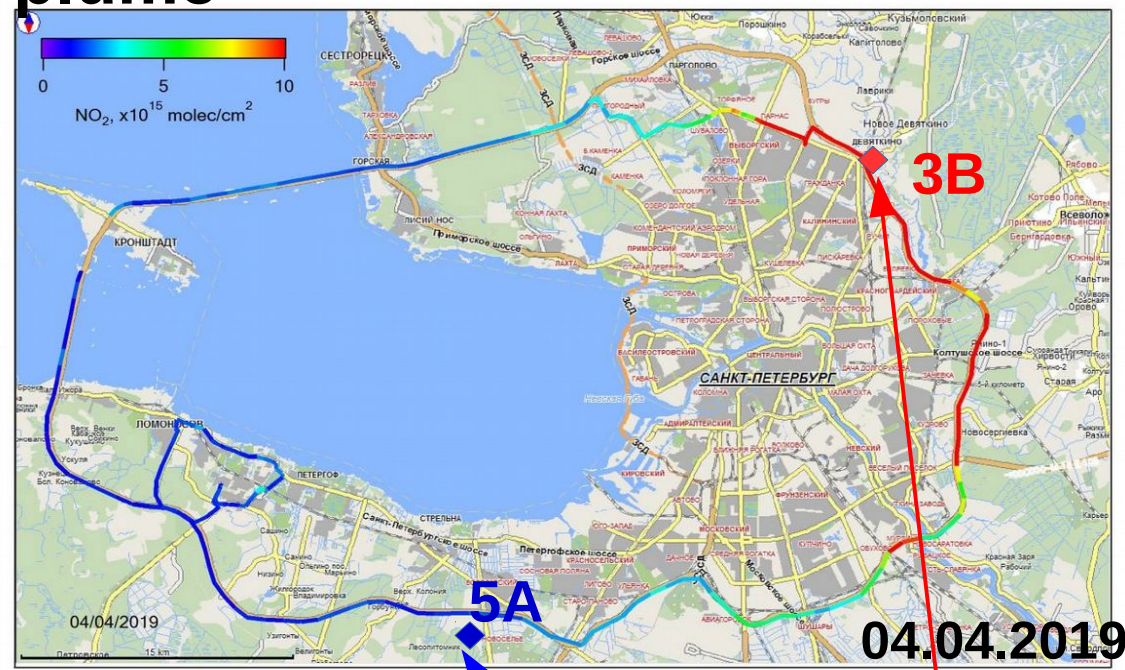


The position of St. Petersburg NO<sub>2</sub> plume was forecasted using the HYSPLIT\* dispersion model.

The forecast made it possible to identify preliminary up- and downwind locations of measurement points for two mobile crews carrying Bruker EM27/SUN FTIR spectrometers.

\*See references

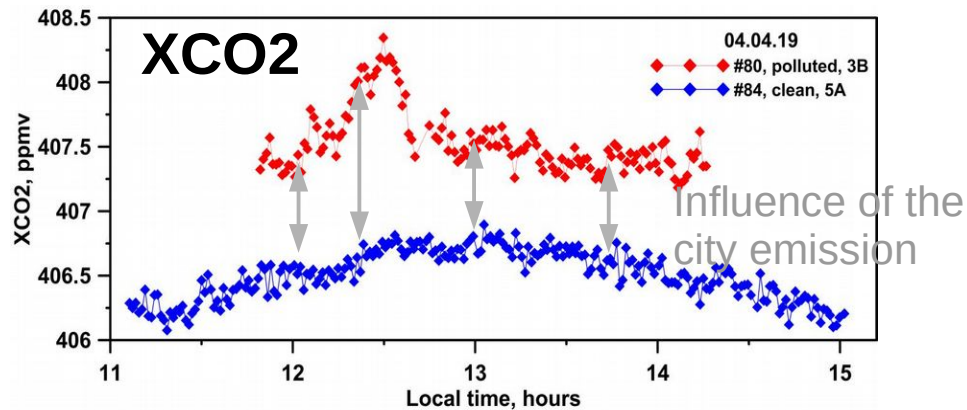
## ► ► ► mobile DOAS monitoring – real-time detection of NO<sub>2</sub> city plume



Locations of #84 (point 5A) and #80 (3B) FTIR EM27/SUN spectrometers

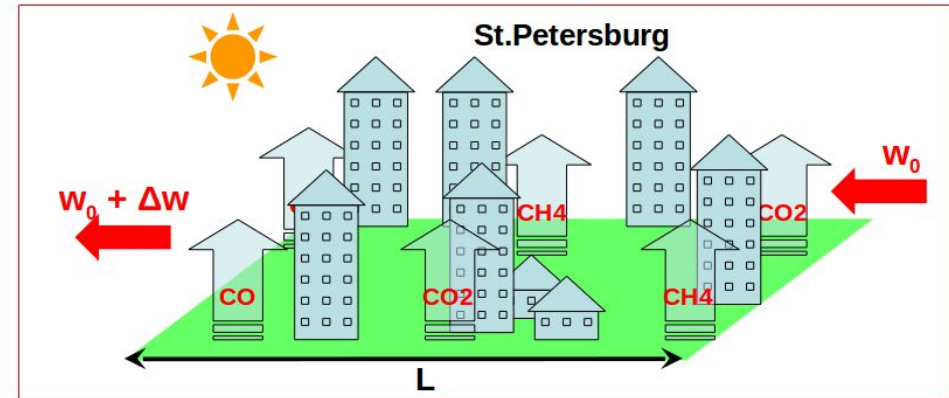
# Area fluxes of the city center

- **down-** and **upwind** Xgas for **polluted** and **clean** locations



+

- ► **Box model (mass balance approach)**



- ► ► **Area fluxes of the city center (2019), t/(km<sup>2</sup>·yr):**

CO2	89 000 ± 28 000	~31000**
CH4	135 ± 68	~25**
CO	251 ± 104	~410**
NOx	66 ± 28	~69**

*\*\*2017 official inventory for Saint Petersburg*

Results of EMME 2019 have been submitted to AMT (discussion phase):

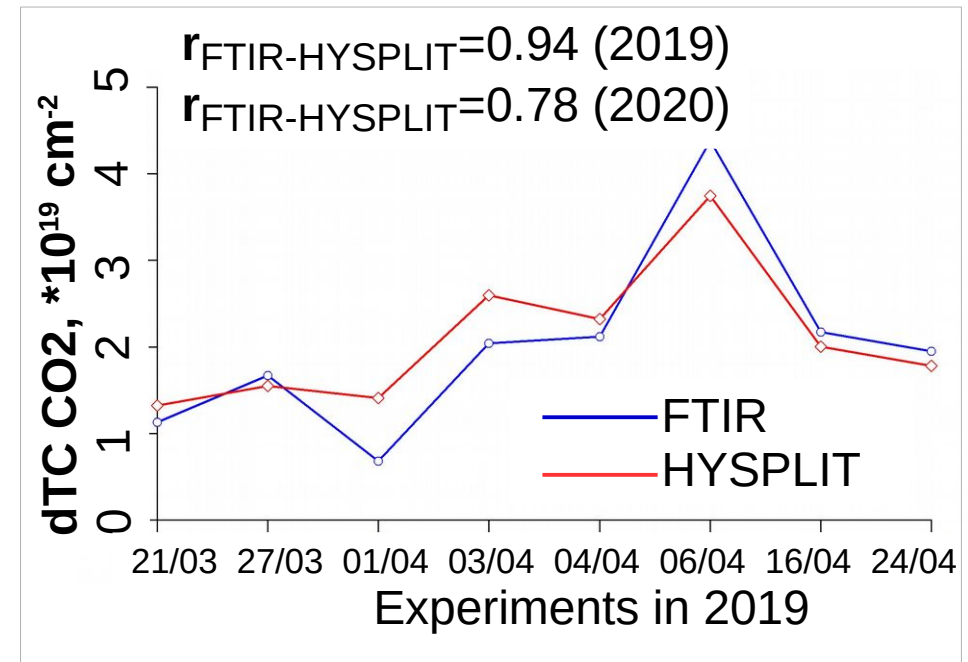
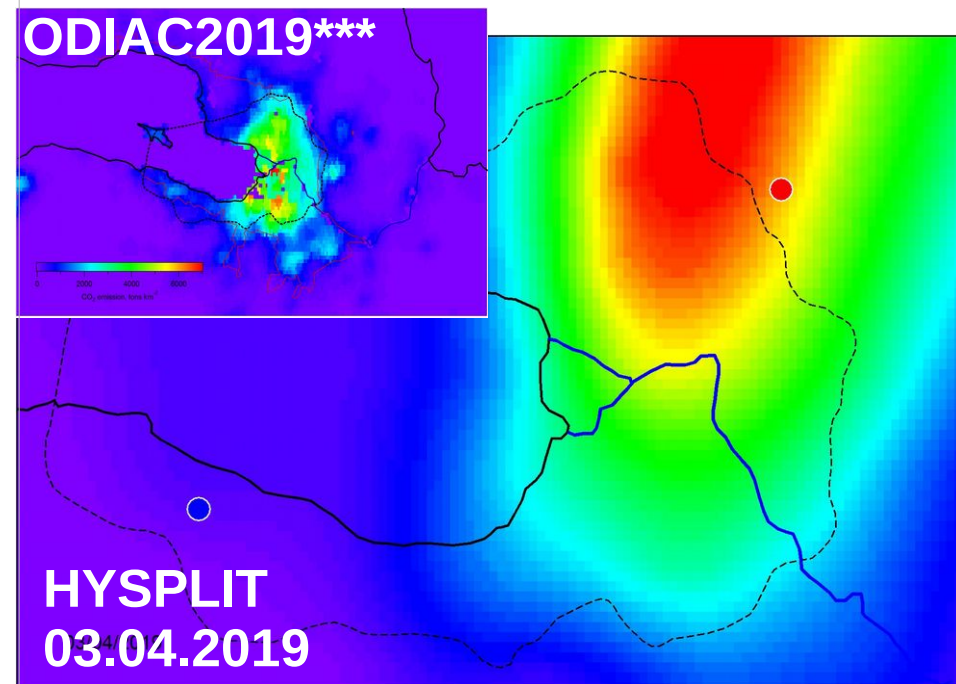
<https://www.atmos-meas-tech-discuss.net/amt-2020-87>

*\*\*See references*

# Total CO2 emission of St.Petersburg

► Evaluation of total CO2 emission of the city by coupling the EMME observations in 2019-2020 and the HYSPLIT\* simulations

ODIAC\*\*\* database was used as a priori info on the CO2 emissions



► ► Total CO2 emission of St.Petersburg, kt/yr:

**2019 75800±5400**

**2020 68400±7100 (~10% lower than in 2019)**

**~30000\*\***

\*\*2017 official inventory for Saint Petersburg

\*\*\*See references



# Summary

▶ **More than 300 photos/ ~1.5 hours of video ;-)**

▶ ▶ **Next steps:**

- further comprehensive analysis of the observational data acquired during EMME 2019&2020 campaigns;
- detailed study of the influence of the COVID-19 quarantine on CO<sub>2</sub>, CO and NO<sub>x</sub> emissions from St.Petersburg;
- evaluation of the total CH<sub>4</sub>, CO and NO<sub>x</sub> emissions of St.Petersburg using the results of EMME 2019&2020;
- preparation of an aircraft experiment for studying the 2-D cross-section of the city plume.

## ► References:

\*Draxler, R. R. and Hess, G.D.: An overview of the HYSPLIT\_4 modelling system for trajectories, dispersion, and deposition. Aust. Meteor. Mag., 47, 295-308, 1998.

\*\*Serebriisky, I.A., (Ed.): The Report on Environmental Conditions in St. Petersburg for 2017, [https://www.gov.spb.ru/static/writable/ckeditor/uploads/2018/06/29/Doklad\\_EKOLOGIA2018.pdf](https://www.gov.spb.ru/static/writable/ckeditor/uploads/2018/06/29/Doklad_EKOLOGIA2018.pdf), 2018 (in Russian).

\*\*\*Oda, T. and Maksyutov, S. (2015), ODIAC Fossil Fuel CO<sub>2</sub> Emissions Dataset (Version name: ODIAC2019), Center for Global Environmental Research, National Institute for Environmental Studies, doi:10.17595/20170411.001.18).

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# Thank you for your attention.



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