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METHANE-To-Go-Europe: an upcoming airborne field campaign in the Netherlands, Italy and Balkan states

- *CH_4, N_2O and SO_2 emissions from on-/off-shore natural gas and oil operations, power plants, smelters, waste and agriculture*

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Motivation

Methane (CH_4) is a well-mixed greenhouse gas that is ~80 times more potent than carbon dioxide (CO_2) on a timescale of 20 years and in focus of current mitigation strategies trying to reduce global warming since its lifetime is shorter (~10 years) in comparison to CO_2 (~100 years). Various oil and gas exploration regions have been identified by the United Nations Environmental Program (UNEP) as target for CH_4 studies. Besides the Persian/Arabian Gulf, Gulf of Mexico, Gulf of Guinea, and the North Sea, **one of these selected regions is the Balkan**. The latter is of special interest, because it is also well-known for heavy pollution (e.g. SO_2) and bad air quality. Here we introduce the **METHANE-To-Go-Europe project**, which is funded by the German Aerospace Center (DLR) and a replacement for the originally UNEP-funded **METHANE-To-Go project** (as announced in the abstract), which has been postponed due to the difficult political situation in the Arabian Gulf.

→ **A better quantification of anthropogenic CH_4 and SO_2 (and N_2O) emissions from pronounced European sources and their contribution to the atmospheric composition is needed for the development of successful mitigation strategies in Europe.**

The METHANE-To-Go-Europe Field Campaign

Targeting the Netherlands, Italy and the Balkan states

The field experiment aims to carry out **airborne in situ measurements of the greenhouse gases** CH_4 and nitrous oxide (N_2O), and a number of further trace species (SO_2, CO, NO and aerosols) **to quantify the emission rates from on-/off-shore natural gas and oil operations, outstanding power plants, smelters, and pronounced waste and agricultural sources**. In addition, emissions from larger cities in the selected target regions (Netherlands/Italy/Balkan) are of interest (e.g. Rotterdam, Naples and Belgrade). These emission rates will be compared to current emission inventories. Furthermore, **satellite validation is envisaged** with the TROPOspheric Monitoring instrument (**TROPOMI**) on Sentinel-5P (focusing on SO_2). The Balkan region is high-lighted as the European region with the strongest and most uncertain anthropogenic SO_2 sources.

Trace Gas / Aerosol Instrumentation and Modeling

Instrument	Species/Parameter	Measurement Technique
Dual QCLs* Aerodyne	CH_4, CO_2, CO, C_2H_6, N_2O, H_2O	Laser absorption Spectroscopy
PICARRO	CH_4, CO_2, CO	Cavity Ring-down Spectroscopy
IT-CIMS	SO_2	Ion-Trap Chemical Ionization Mass Spectrometry
ECO Physics TR	NO, NOy	Chemiluminescence Technique
Aerosol	Vol.- & non-vol. particles	Condensation Particle Counters plus Thermodenuder
MET PACKAGE	Wind (3-d), T	5 hole probe

*(Kostinek, Roiger, et al., AMT, 2019, https://doi.org/10.5194/amt-12-1767-2019)

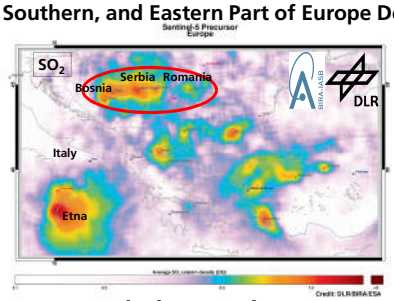
The operation of a novel dual Quantum Cascade Laser **(QCL) instrument** (Kostinek et al., 2019*) based on laser absorption spectroscopy to measure CH_4, N_2O and CO, and related trace gases as CO_2 and ethane (C_2H_6) is foreseen. The latter gases can be used to distinguish between different CH_4 sources (flaring, venting and combustion). An **ion-trap chemical ionization mass spectrometer** (IT-CIMS) is envisaged for the measurements of SO_2. Both instruments operate with a high precision/accuracy and a temporal resolution of 0.5 to 1s (corresponding to 50-200 m). In addition, measurements of nitrogen oxides (NO, NOy) and aerosols and other trace gases are planned to pinpoint different sources, and simulations with **particle dispersion models** for flight planning and post analyses (HYSPLIT), WRF-Chem and MECO(n) (MESSy-fied ECHAM and COSMO/MESSy models nested n times).

Mission Flights

Flights are planned with the research aircraft Falcon-20 of the DLR during three weeks in **October-November 2020**. From the home base in Oberpfaffenhofen near Munich (Germany), flights with overnight stops in the target regions are foreseen to perform detailed local flights.

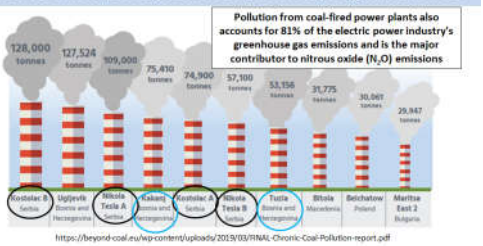
DLR research aircraft Falcon-20

Flight region: Northern, Southern, and Eastern Part of Europe Depending on the Present Weather Situation



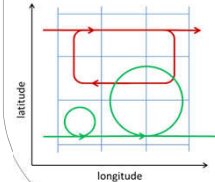
In 2016, 16 of the power plants in the Balkan region emitted as much sulfur dioxide (SO_2) pollution as the entire fleet of the EU's 250 coal power plants.

Balkan: coal-fired power plants belong to the top SO_2 emitters in EU

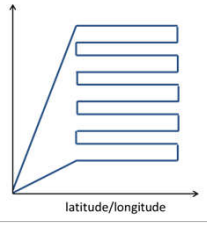


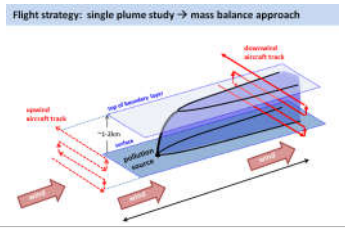
Flight Strategy and Present Knowledge on the Trace Gas Distribution (CH_4, N_2O, and SO_2) in the Balkan Region

- The proposed campaign includes both **survey flights** in the northern, southern and eastern part of Europe, as well as **single plume study flights** focusing on the emissions from single point sources as e.g. power plants. The emission fluxes will be estimated and compared to current emission inventories. Furthermore, **satellite validation** is envisaged with the TROPOMI instrument on Sentinel-5P (focus on SO_2).
- There is a **lack of detailed airborne CH_4 and N_2O measurements in Europe (compared to the U.S.)** and the contribution from this region to the global CH_4 and N_2O mass balance is presently unknown. **Rudimentary knowledge on the SO_2 distribution** from satellite measurements (OMI and TROPOMI) is available, however no detailed airborne data set from the Balkan region exists, which e.g. determines the export and import of SO_2 pollution to Serbia.



For satellite validation narrow spirals (diameter ~5-10 km) **up to 12 km altitude** envisaged. Pixel size is 3.5 x 7 km².





Romania (& border to Serbia) hot spot of CH_4 from natural gas. Large uncertainties in present CH_4 inventories → METHANE-To-Go-Europe can contribute to reduce uncertainties

The METHANE-To-Go-Europe Team

- The Institute of Atmospheric Physics (**PI: Dr. Anke Roiger; co-PI: Dr. Heidi Huntrieser**) at the German Aerospace Center (DLR) are coordinating and conducting the field experiment (in close cooperation with the DLR Department of Flight Experiments) and performing the main data analysis.
- Validation of TROPOMI products are conducted in cooperation with the DLR Remote Sensing Technology Institute (Dr. Diego Loyola and Dr. Pascal Hedelt).
- Contact to local scientists in Serbia, Romania and Croatia has been initiated. The collaboration and support from the local partners is essential and key for the success of the project. Joint data analysis and publications are envisaged. We are also open for further collaborations with local scientists.

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