

SEICOR - Ship Emission Inspection with Calibration-free Optical Remote sensing



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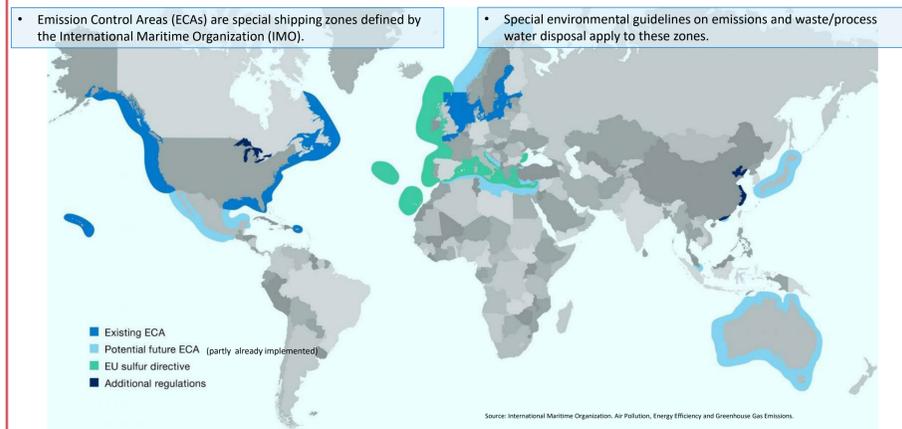


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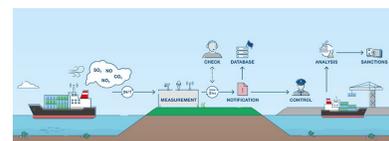
SEICOR – a Federal Ministry for Economic Affairs and Climate Action (BMWK) funded project (03SX583A) - aims at developing a system for automated long-term surveillance of emissions from ships and other, similar sources. The new system will cover all parts of the measurements, from the instrument over data analysis of the emission factors to direct generation of warnings in case of high emissions. An automated reporting to the authorities, port operators and / or ship owners is planned. Here we present some technical details of the demonstrator and first results of the test campaign which takes place since April 8, 2025 in Wedel at the river Elbe in Germany.

Introduction

- Ship emissions of SO_x and NO_x (sum of NO and NO₂) are a significant source of air pollution
- National and international regulations are in place to limit emissions (see map below) - The following new areas will require ships to comply with reduced emissions limitations: Mediterranean Sea (SO_x), Canadian Arctic (NO_x and SO_x), Norwegian Sea (NO_x and SO_x)
- Monitoring is challenging and regularly used in situ instruments are dependent on favourable winds and need regular calibration
- Active optical remote sensing such as Differential Optical Absorption Spectroscopy (DOAS) can be used to measure ship emissions independent of wind and without frequent calibration procedures
- The capabilities of active DOAS to measure ship emissions have been shown in *Krause et al. 2021* and SEICOR builds on and improves these methods



Standard Ship Fuel / Emission Control



- The exhaust plume from the ships made its way to the shore with the air flow
- In-situ measuring station determines the increase in pollutants in the exhaust gas plume
- The sulfur content of the ship's fuel, for example, is estimated from the measurement data

Advantage:

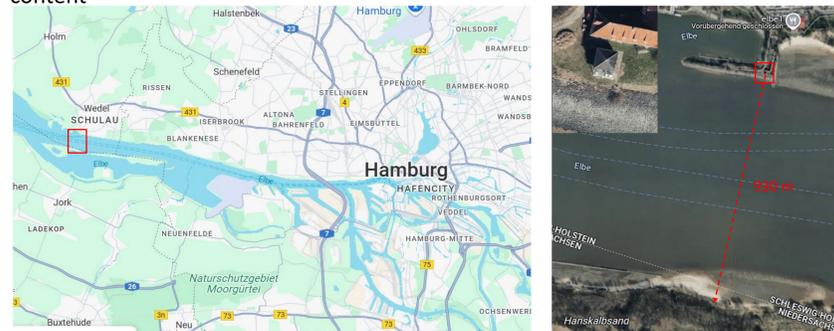
- "Standard" in-situ measuring instruments can be used
- Various gases measurable

Disadvantage:

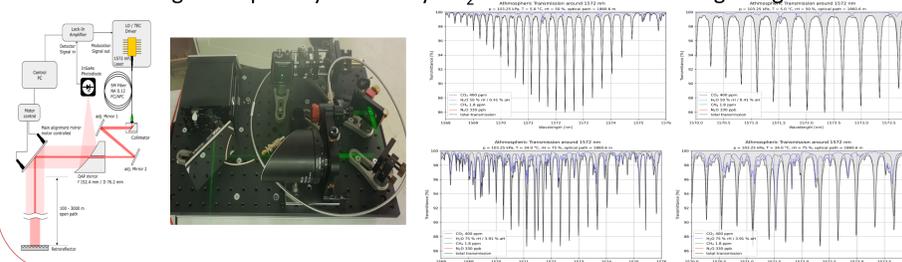
- Dependence on the wind direction → small number of measurable ships
- Chemical conversion between the emission and the measurement location → errors, for example with NO_x emissions
- influence of other sources
- Only for clearly separated ships

Measurement site and Instrument

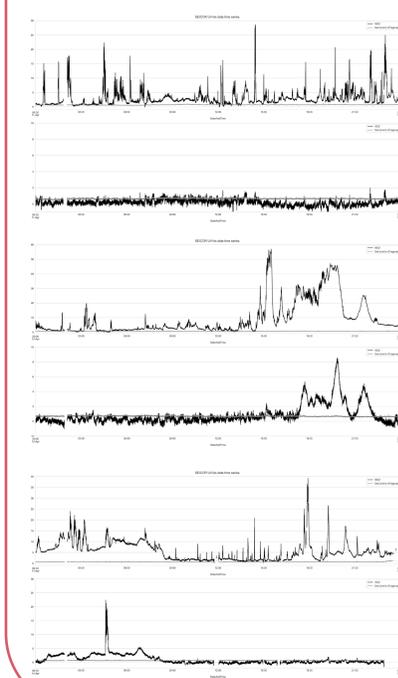
- The first SEICOR demonstrator was set up on the river Elbe in Wedel, Germany 10 km downriver of the port of Hamburg
- The river Elbe serves as the entrance route to the port and inland and sea ships pass the measurement site regularly, standard instrumentation from the BSH (German Federal Maritime and Hydrographic Agency) can be used for validation
- The instrument sends out a beam of light in different wavelength-regions that is reflected by retro-reflectors and records the spectra of the reflected beam
- The new system is a combination of a UV/vis and an IR system and will measure all necessary gas species (NO, NO₂, SO₂, CO₂)
- CO₂ will be used as a proxy for the amount of burnt fuel and can be used to calculate emission factors, e.g. for SO₂ where the regulations are based on limits for fuel sulphur content



Scheme and foto of the new developed IR channel (NIR TDLAS Spectrometer): the figures on the right side show simulated transmission spectra for different weather conditions in Wedel illustrating the capability to identify CO₂ in the selected wavelength region.



First results



- First results (DOAS real time analysis) of the UV/Vis part of the SEICOR instrument
- Three consecutive days from April 11 to April 13, 2025 are shown
- Small peaks in NO₂ and SO₂ can be assigned to passing ships using AIS data recorded at the same time illustrating the good coverage independent of weather conditions
- Meteorological data are recorded to identify other sources as in this case plumes from a nearby power plant in the afternoon of April 12 and the morning of April 13

Outlook

- Optimization of the CO₂ infrared channel and first analysis of results is ongoing and will be finished in the next weeks
- Additional IR laser for measuring NO will be added soon

Acknowledgements / References

Krause, K., Wittrock, F., Richter, A., Schmitt, S., Pöhler, D., Weigelt, A., & Burrows, J. P. (2021). Estimation of ship emission rates at a major shipping lane by long-path DOAS measurements. *Atmospheric Measurement Techniques*, 14, 5791–5807. doi:10.5194/amt-14-5791-2021

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Supported by:

