THE SCIPPER PROJECT

EMERGE

Maritime air emissions and enforcement: The SCIPPER and EMERGE projects

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Presentation at the
ERMES Plenary
May 26, 2021

ermes

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nr.814893

Background

Emission Control Areas (ECAs) in EU waters

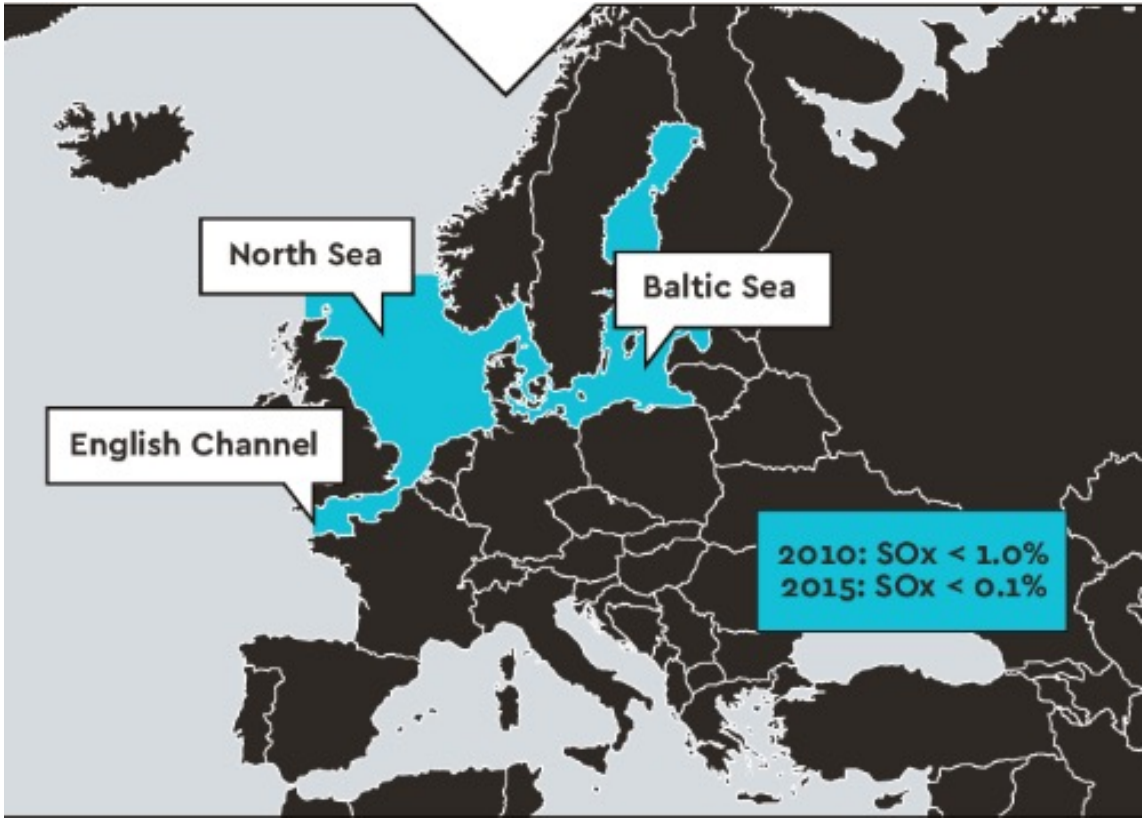
- Baltic Sea
- North Sea
- English Channel

Limits

- 1.1.2015 ECAs: 0.1% max FSC
- 1.1.2020 Globally: 0.5% max FSC
- 1.1.2021 Baltic and North Seas ECAs:
  NO_x Tier III for vessels keeled 1.1.2016 on

Developments

- On-going discussion for inclusion
  of the Mediterranean Sea as a SO_x - ECA



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Response

Some options to meet new emission standards:

- Low sulfur fuel and NO_x aftertreatment
- Heavy fuel and both NO_x and SO_x aftertreatment (scrubbers)
- LNG
- Other fuels, like methanol, electrification, etc.
- …

Higher costs may motivate wrong-doing

Main Question to be responded by SCIPPER:

How will authorities make sure that correct fuel / proper aftertreatment are being used?

?

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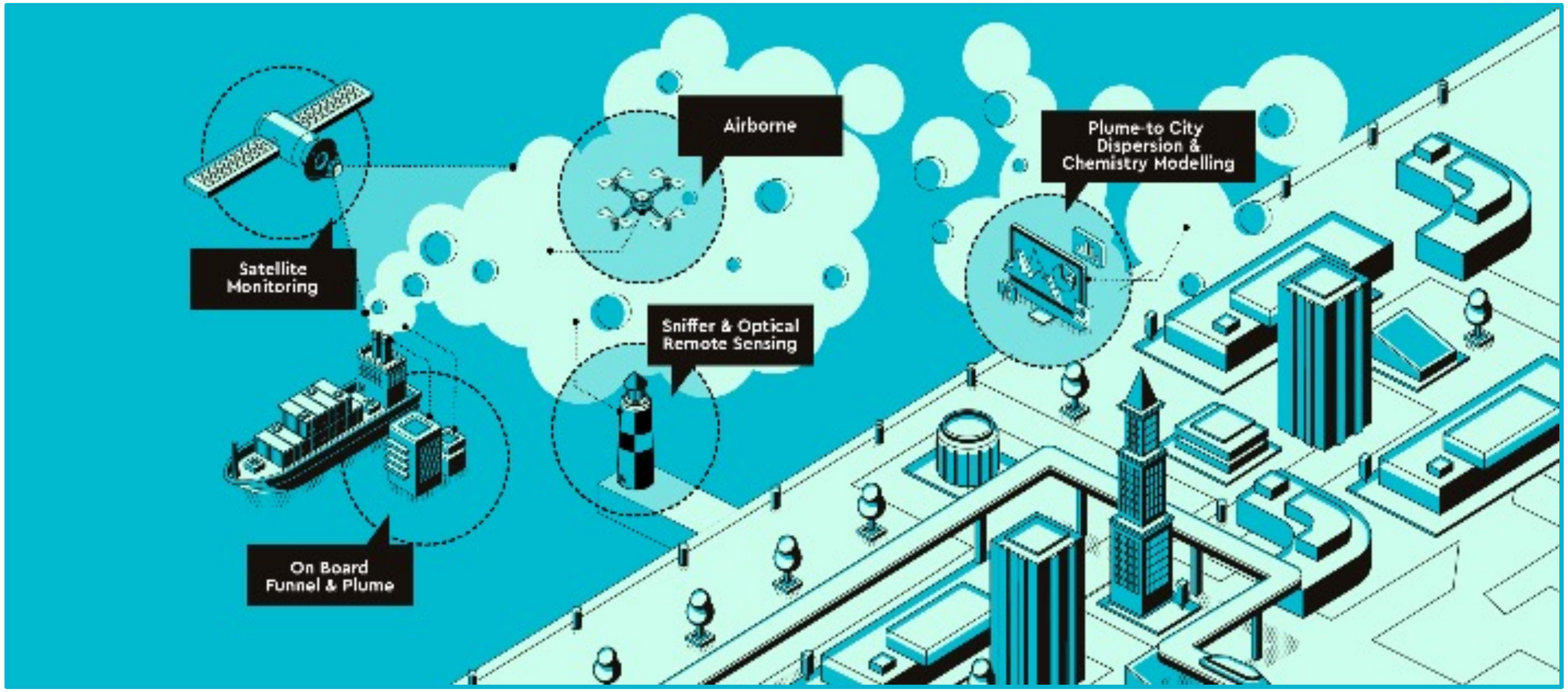
Concept

Real-world deployment of various monitoring techniques

Implementation of 5 experimental campaigns at different locations



- ❑ Application / validation / comparison of various emission measurement and monitoring techniques for emission standards compliance checking purposes
- ❑ Determination of the impact of shipping on air quality at coastal and harbor level

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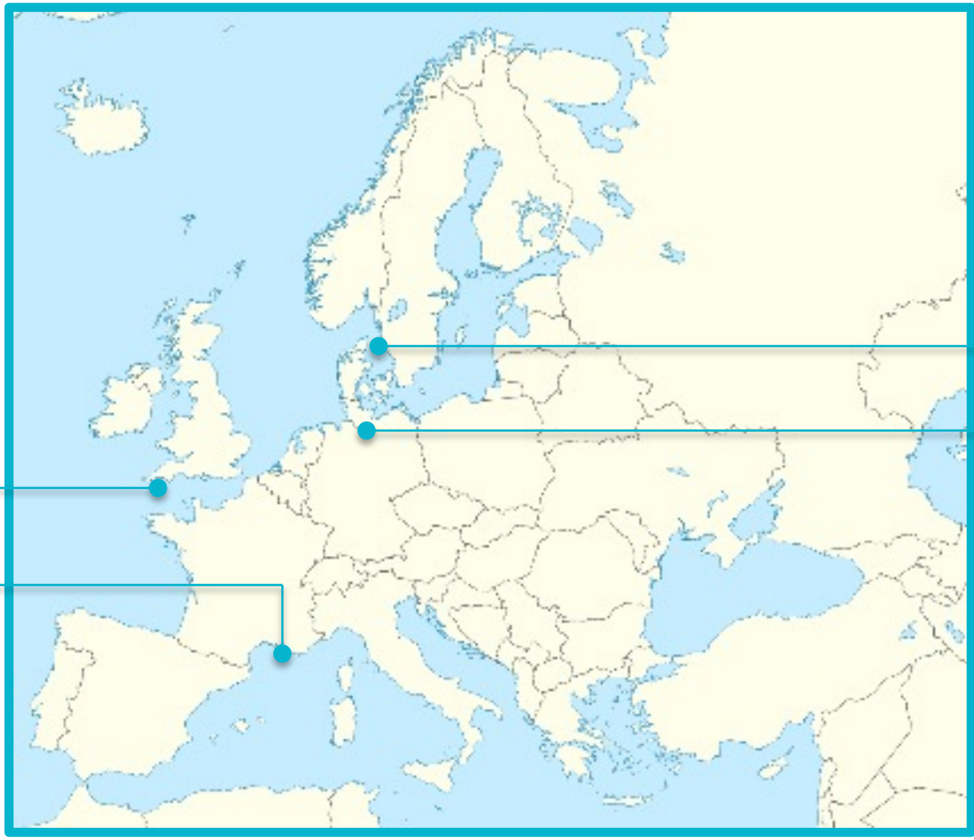
Experimental Campaigns Overview

C5

Western English channel (EN)

C1 C4

Marseille (FR)



C2

Gothenburg (SE) to Kiel (DE)

C3

Hamburg (DE)

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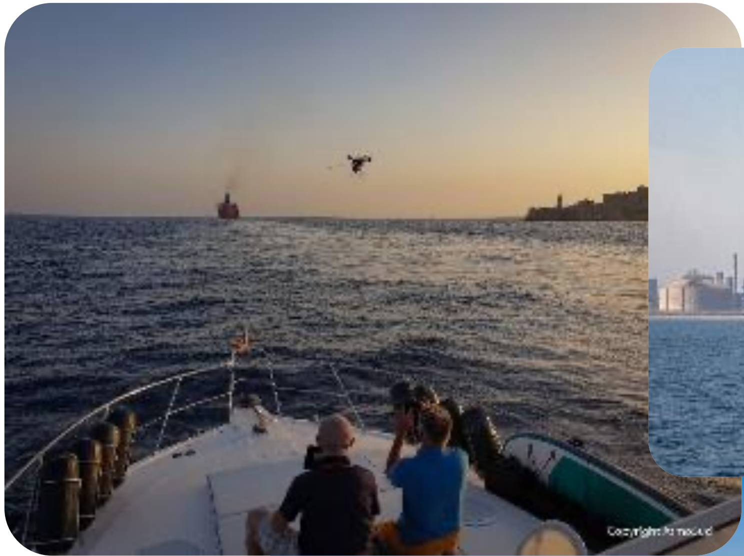
Measurement Campaigns

C1 Implementation of Measurement Campaign in Marseille



- ❑ Remote compliance monitoring of FSC in ships in and outside the port before global FSC regulations
- ❑ First assessment of state-of-art remote and UAS comparability
- ❑ Assessment of state-of-art remote techniques including uncertainty characterization
- ❑ Input to AQ emissions before global FSC regulation

21 plumes measured by drones

30 plumes measured by a sniffer boat & 17 for intercomparison on SO_2 and NO_x

Air quality measurements at harbor sites

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Measurement Campaigns

FSC and NO_x emissions detection in Marseille

Sniffer boat

- Prior to the Sulphur cap application
- Measurements to be repeated after the global new limits' enforcement

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Measurement Campaigns

C3

Implementation of Measurement Campaign in Wedel/Hamburg

- Participation from NL, SE, DK, DE
- 5 Sniffer | 1 LASER-spectrometer
  2 UAS | 4 Particle sizers
  2 DOAS | 2 Aethalometers
  6 AIS | 5 Meteo stations

- > 500 allocated plumes from 256 different ships (fixed sniffers)
- 65 plumes from 53 different ships (UAS measurement)
- 55 fuel samples from 32 selected vessels (waterways police Hamburg)
- 19 comparison experiments with artificial plumes (SO_2-CO_2 and NO-CO_2)
- Detailed scientific analysis in progress

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Methods Overview (On-going assessment)

Technique	On-Board	Small UAV	Patrol-Vessel	Aircraft/Large UAV	Fixed Station	Fixed station	Optical - Satellite
Method	**Sensors**	**Sniffers**				**Remote Optical**	
Most widespread detection techniques	SO_x (IR or DOAS) NO, NO_2 (Electrochem.) CO_2 (NDIR) BC/PN (various)	SO_2 (Electrochem., DOAS) NO, NO_2 (Electrochem.) CO_2 (NDIR)	SO_2 (UV Fluorescence) NO, NO_2 (CLD) PN (CPC) CO_2 (NDIR, CRDS)			SO_2 (DOAS, IR Iradiance) NO_2 (DOAS)	NO_2, SO_2 (DOAS)
Experience	Yes, Scrubber vessels	DK, FI, EMSA	DE, FR, SE	EMSA, BE, FI, (SE)	DE, NL, SE, DK, FI	DE	FI, GR, NL
Flexibility in terms of monitoring location	On-board	Yes (restrictions)	Yes (restrictions)	Yes (restrictions)	No	No	No (5.5×3.5 km^2, depends on pass)
Open Sea surveillance	Yes	No	Yes	Yes	No	No	Yes
Availability of results	Can be on-line	Immediately	Immediately	After landing	Immediately	Immediately	Post-processing
Suitable sites	vessels	line of sight (smaller harbour, canal, …)	ports, busy lanes	coast and open sea	major shipping lane (harbour, canal, pole, bridge,…)		Away from other major sources
Operation time	24/7 (automated)	daylight	24/7	daylight	24/7 (automated)	24/7 (automated)	daylight/weather
Resources (cost, personnel)/vessel	High	Low-Medium	Medium	High	Low	Low	Medium (currently processing-tedious)

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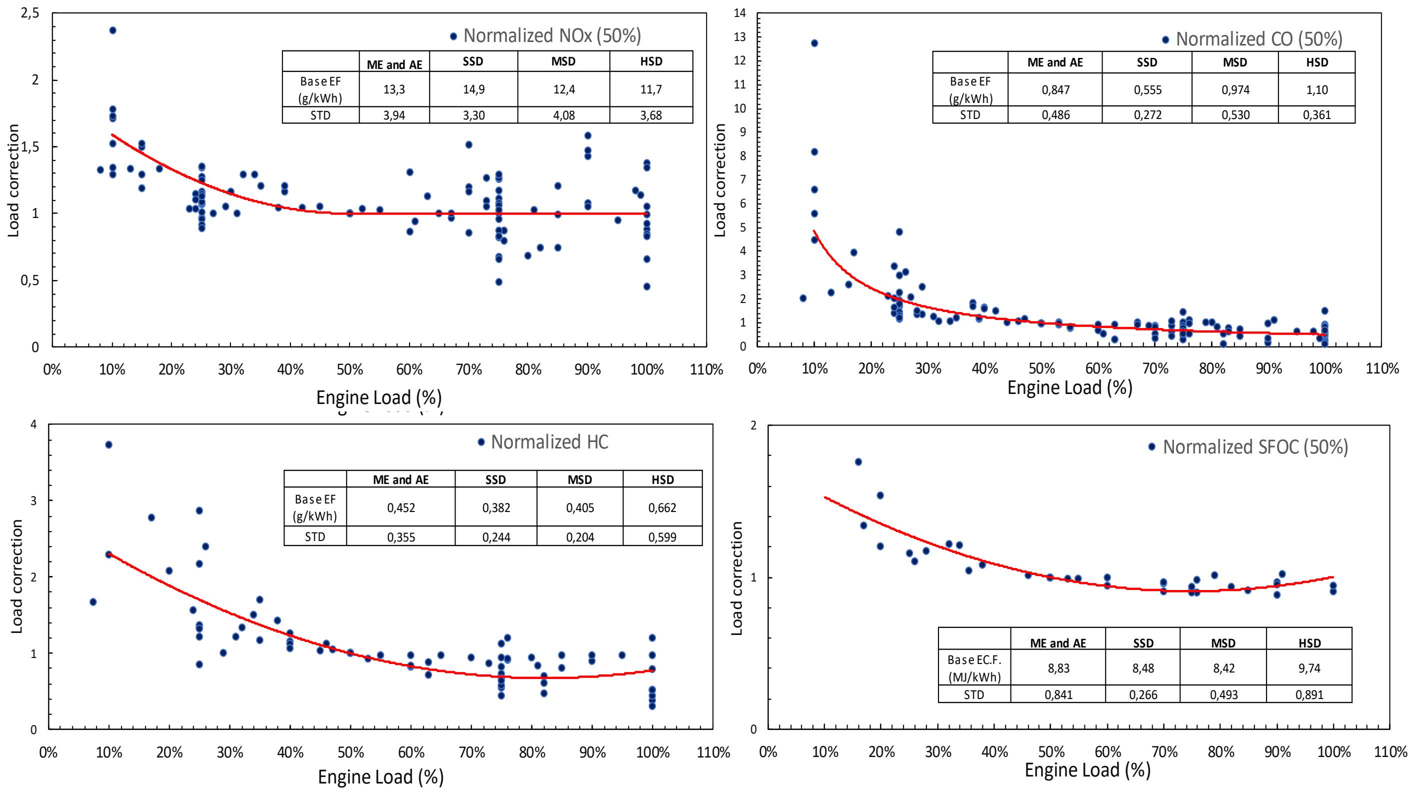
Update of EFs for Ships

Load-dependent EFs development



- ❑ NO_x EFs are higher for slow speed engines
- ❑ CO and HC are higher for high-speed engines
- ❑ EFs are in general high at low load areas and decreased with the load increase
- ❑ For some pollutants and SFOC, full load emissions and EC are again increased
- ❑ New set of EF to be used for:
  - ❑ EEA/EMEP AEIG
  - ❑ STEAM Model

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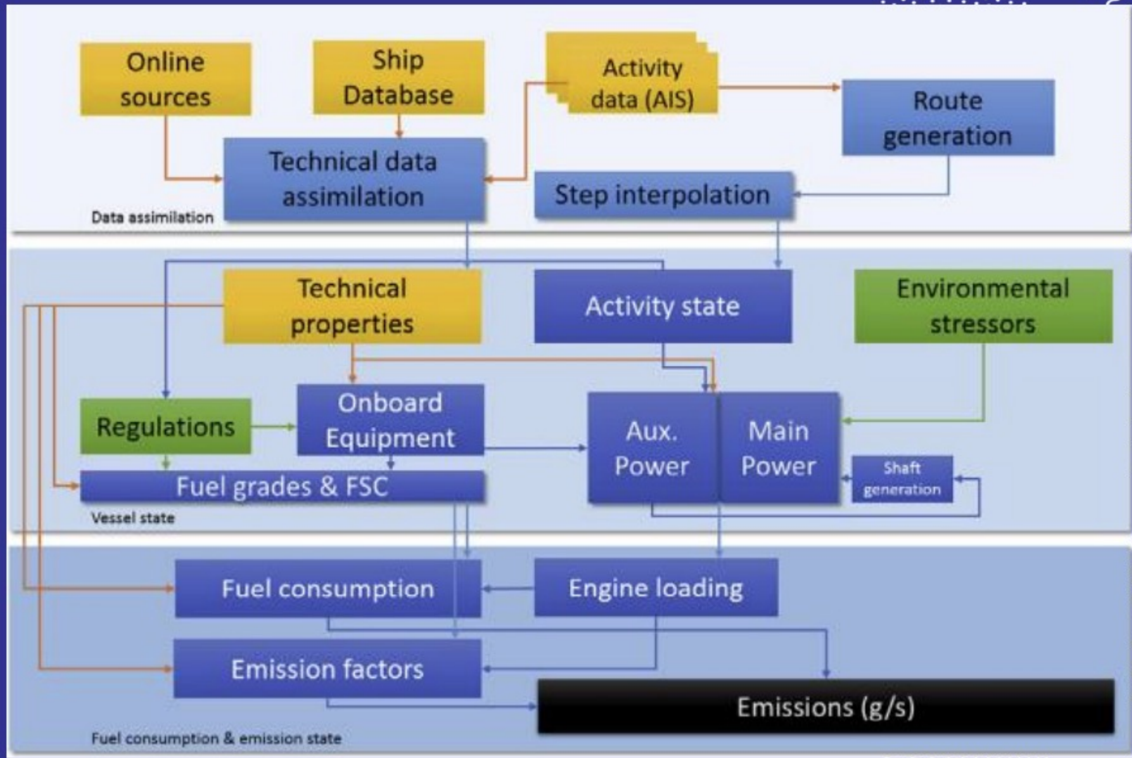
STEAM model outline

The STEAM model

– Overall structure



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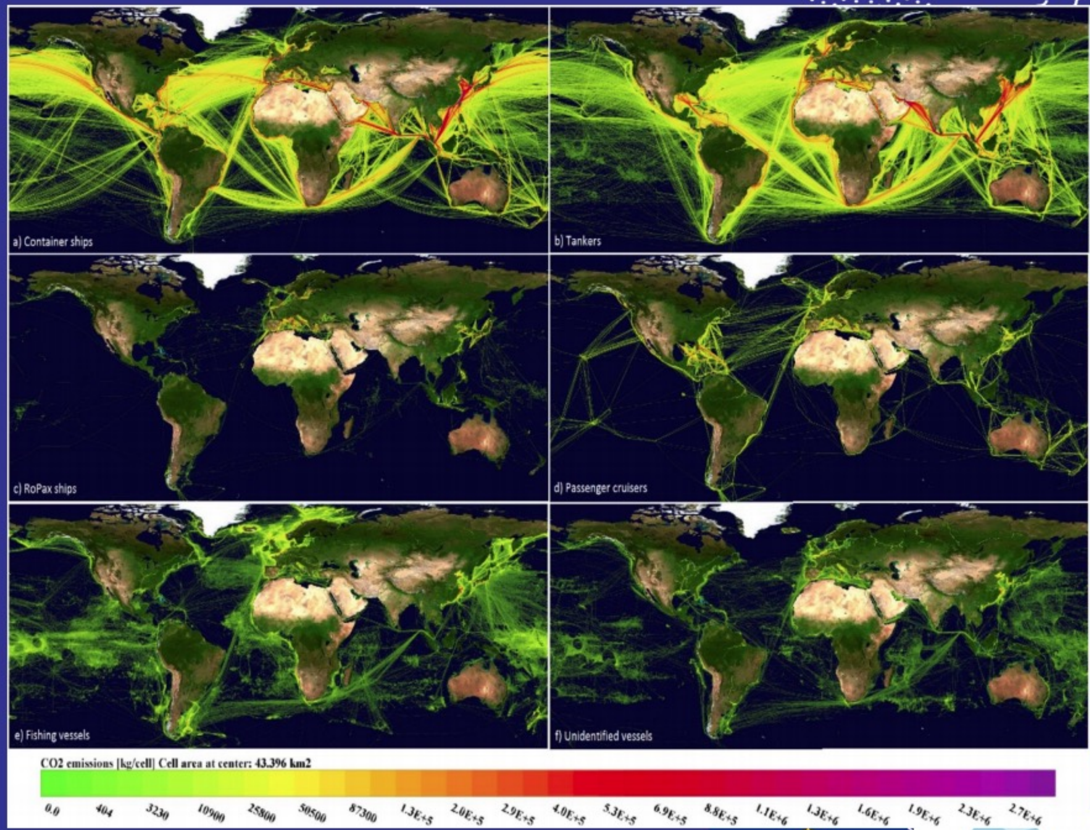
Global marine emissions by STEAM

Example results on the predicted global shipping emissions

Figures show the shipping emissions of CO_2 (kg/area) for various categories of ships (container ships, tankers, RoPax, passenger cruisers, fishing vessels, unidentified vessels)

These results were computed based on 8 billion position reports from over 300 000 vessels.

Emissions of each vessel can also be addressed separately -> can be evaluated against measurements



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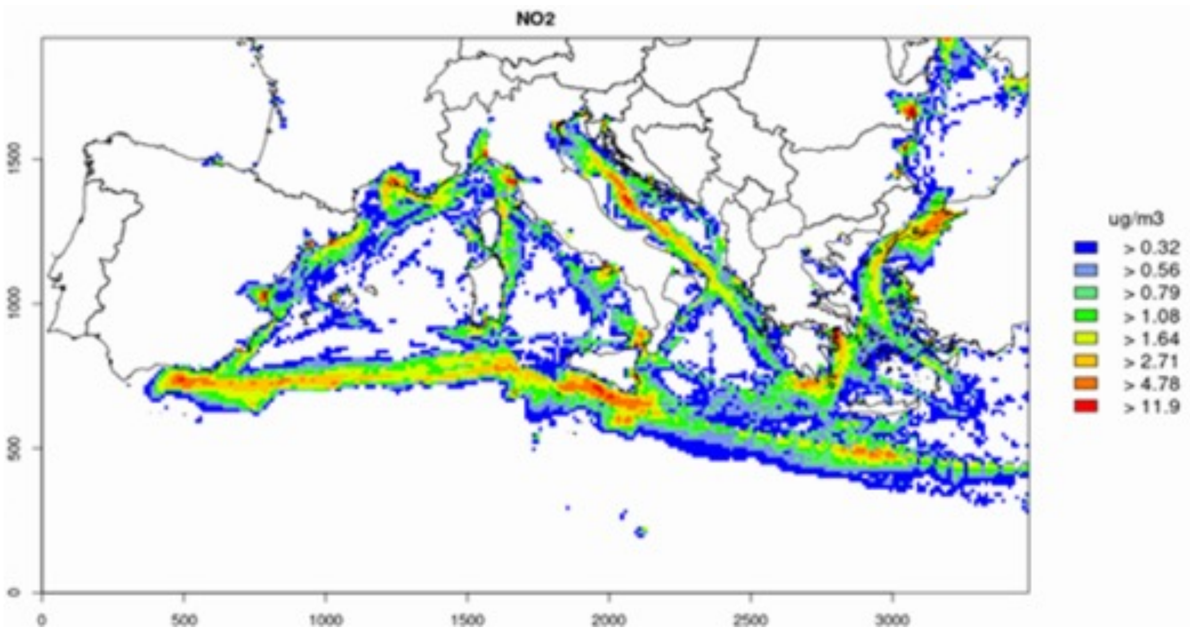
AQ simulations



- Impact of shipping on the concentration of air pollutants in the Mediterranean Sea, investigated by Chemistry Transport Model (CTM) simulations.
- Results for NO_2 concentrations in June 2015
- Calculation based on STEAM shipping emissions for 2015
- CMAQ model simulation on a 12 × 12 km^2 grid for the Mediterranean Sea
- Shipping lanes and important port areas are clearly visible

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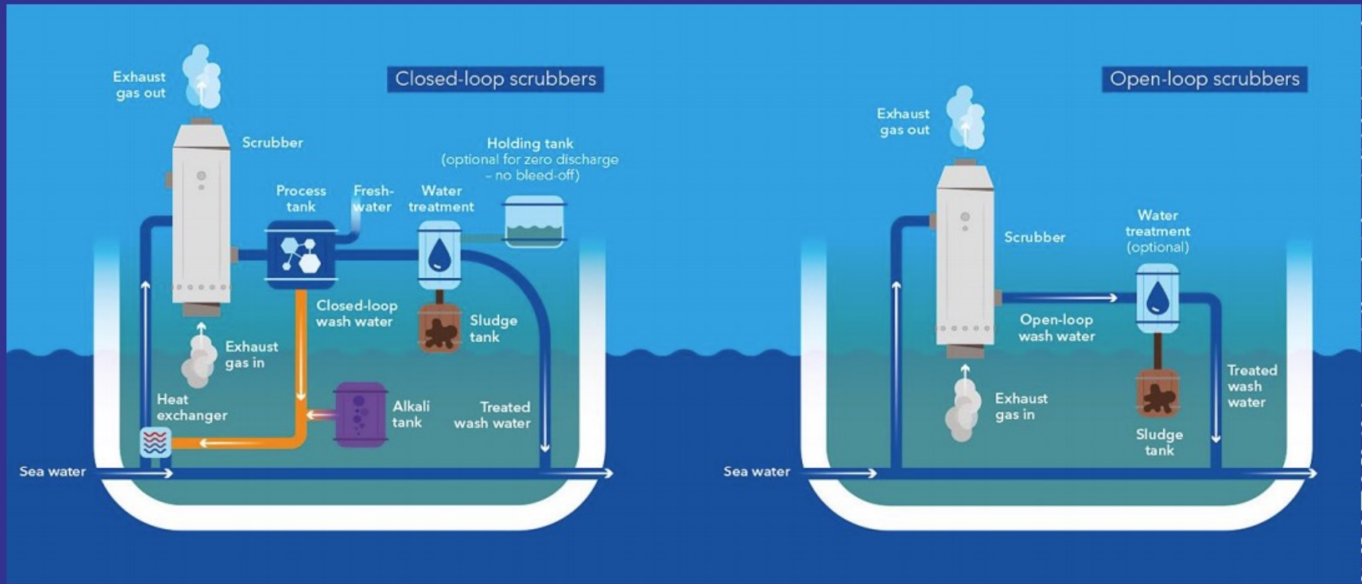
Scrubber operation



There are two main categories of scrubbers: closed- or open-loop. In open-loop scrubbers, acidic seawater is continuously discharged into the marine environment and in closed-loop ones, a smaller amount of water is released. Scrubbing SO_X with large quantities of seawater, with consequent release of wash water to the sea, may lead to substantial deterioration of marine water quality.

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Figures: Courtesy of DNV GL

Norwegian Meteorological Institute

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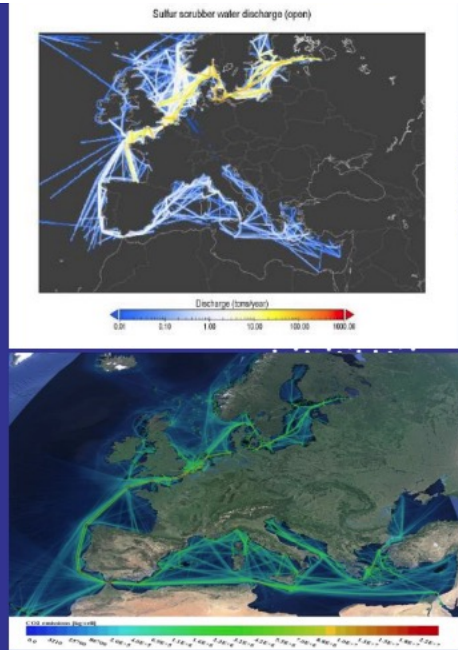
Integrated modelling

Integrated modelling of water and air

- Ship emission model STEAM: both discharges to water and emissions to air
- Dispersion of pollutants in air and water
  - Human health, climate effects, ecotoxicology
- Atmospheric models:
  - ✓ SILAM, WRF-CMAQ, CHIMERE, MEMO/MARS, etc.
- Water pollution models:
  - ✓ Currently partly separate models for dispersion and bio/geochemistry; EMERGE aims to integrate these
  - ✓ ROMS, HYCOM, Delft3D, OpenDrift; ERSEM, BFM; MERLIN-Expo, AQUATOX, MAMPEC
- Cost and benefit analysis model: GAINS model by IIASA



The predictions of the STEAM model.
Above: The predicted washwater releases to sea, from open-loop SO_x scrubbing in ships in 2016.
Below: Emissions of CO_2 from ships in 2011.
The colour codes indicate emissions in mass units (per annum) per computational grid area.

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