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METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

EMERGE

# Global ship emissions

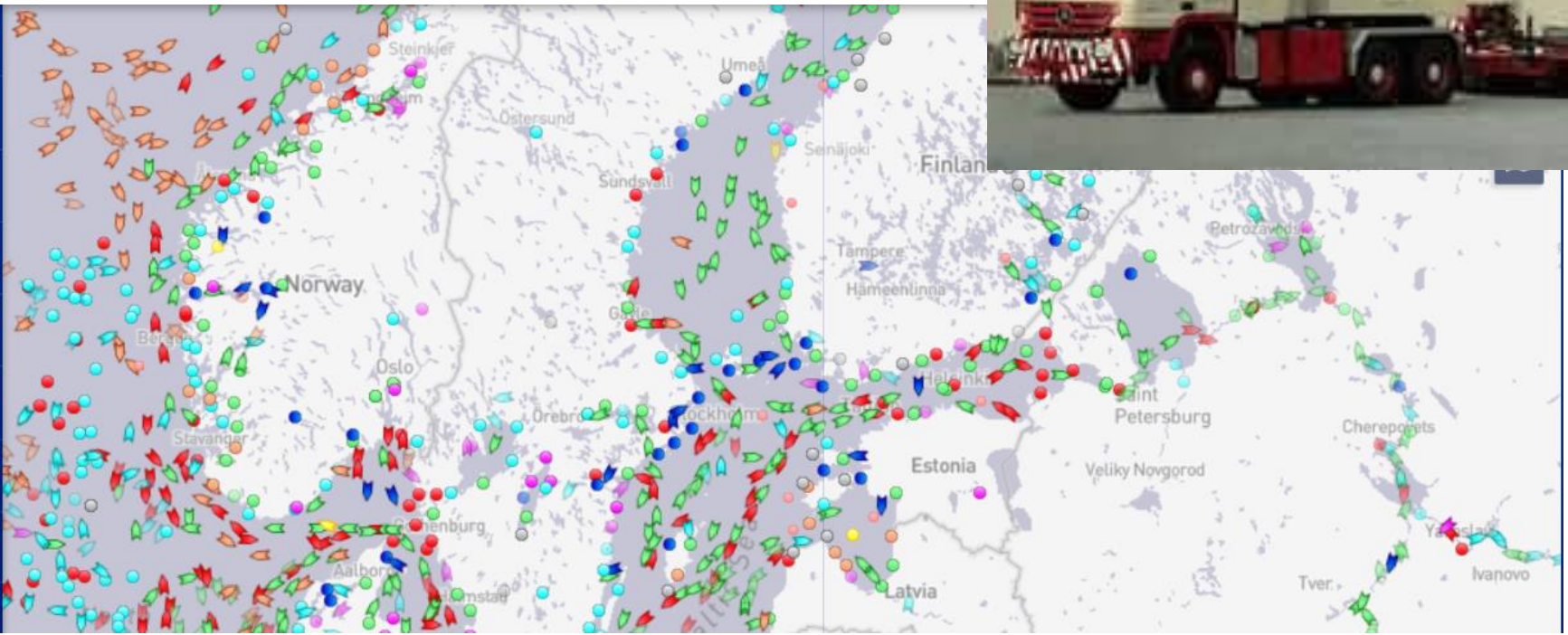
Jukka-Pekka Jalkanen
Elisa Majamäki
Lasse Johansson
Tiia Grönholm
Androniki Maragkidou

EU STRATEGY FOR THE BALTIC SEA REGION
FLAGSHIP

# Outline

- Why bother with ship emissions?
- Modeling of ship emissions
- Air emissions, discharges, underwater noise
- Example applications
  - Global methane emissions
  - Import/Export emissions
  - Impact of ambient conditions to fuel consumption
  - Track record
- Challenges and limitations

# Why bother?



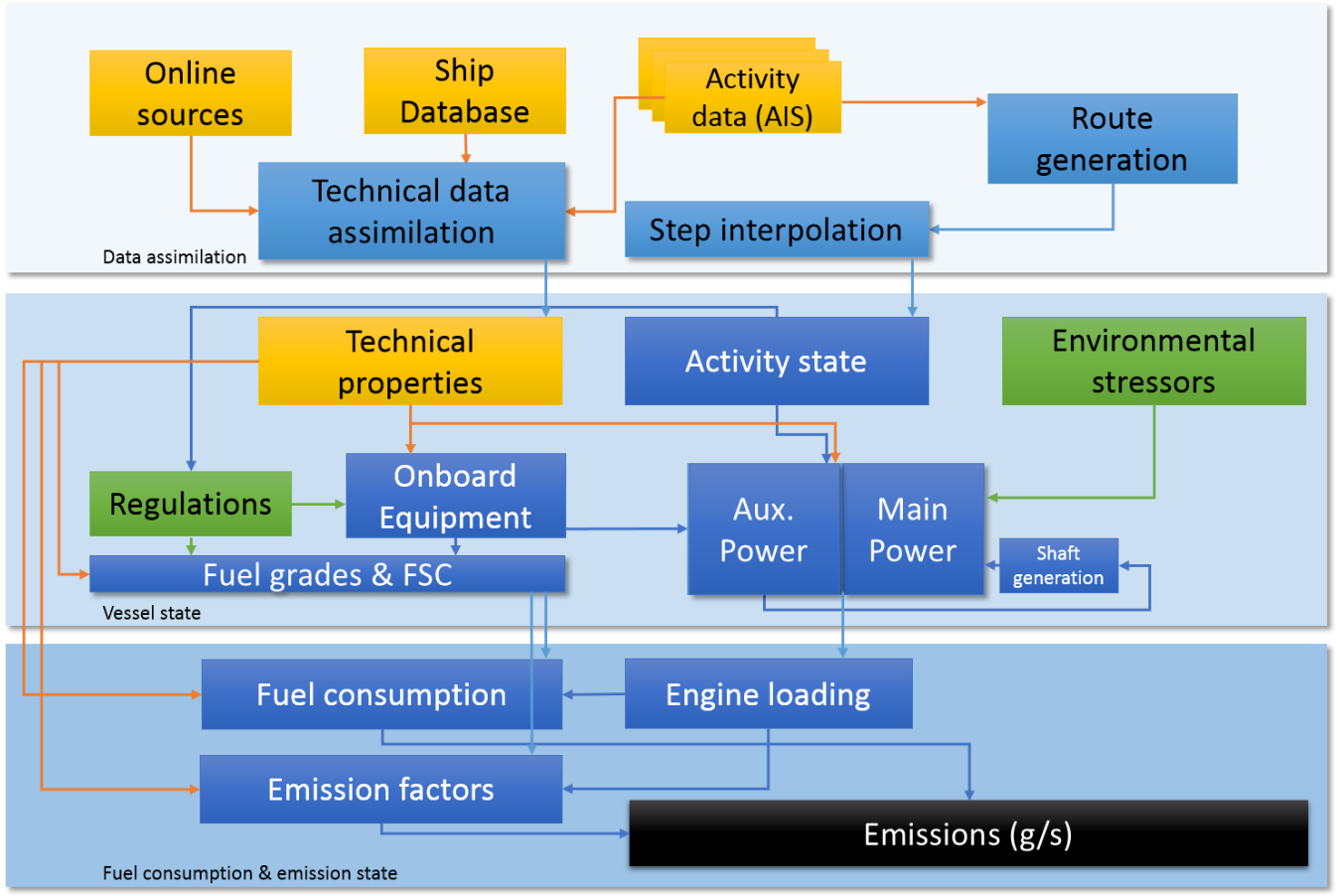

Wärtsilä RTA-96-C
Height 13.5 m, mass 2300 tonnes
Power 80 000 kW
Consumption 171 g/kWh > 3 liters/sec

Car tank of 60 liters will drive this 20 sec

# Short introduction to Ship Traffic Emission Assessment Model (STEAM)

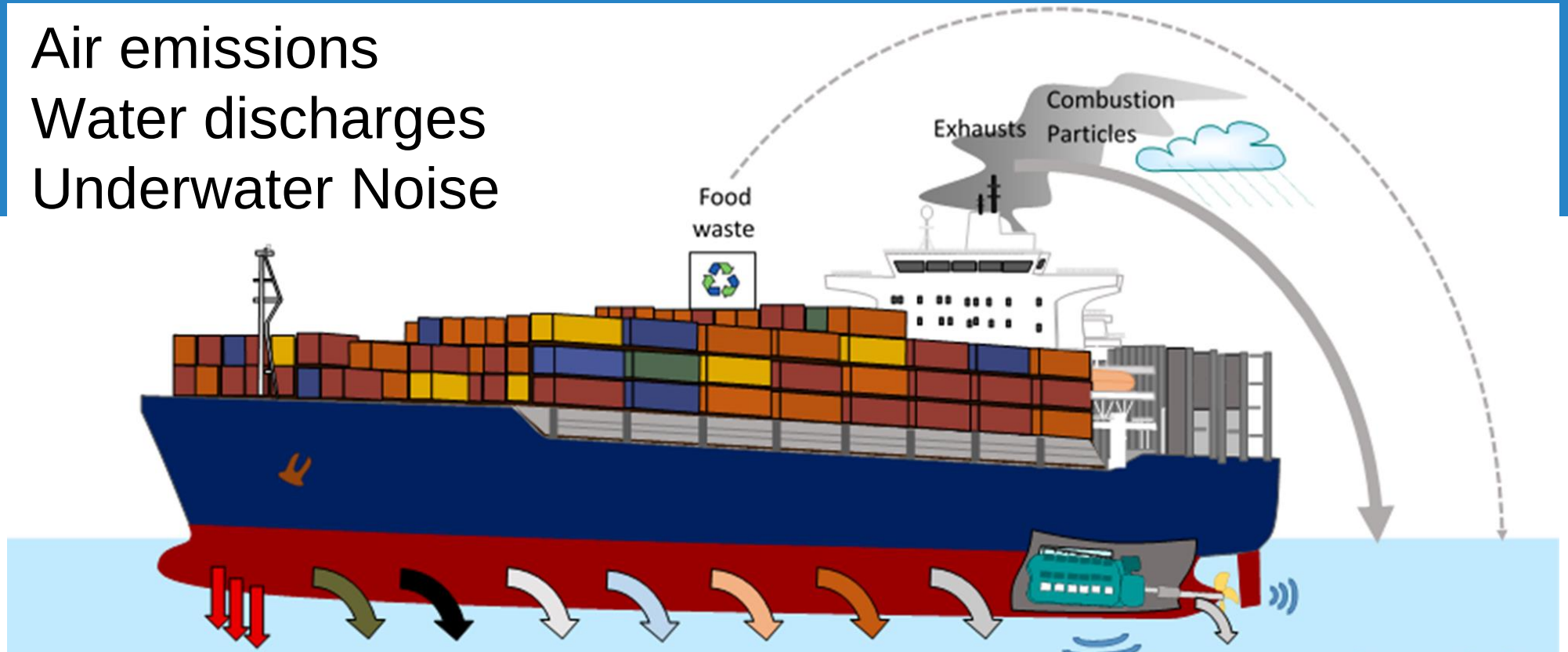
- FMI, in-house development since 2007
- Input data sources
  - Automatic Identification System (transponder)
    - Own antenna
    - National networks
    - HELCOM
    - Orbcomm Ltd.
  - LRIT, VMS, departure/arrival times
  - Minimum: Timestamp, location, identity
- Technical description of the global fleet
  - S&P Global, bespoke data
- Optional:
  - Meteorological, oceanographical data for performance prediction
    - Wind dir/speed, wave height/direction, sea currents, ice cover, salinity, water temperature...

Conceptual schema of STEAM




Johansson et al, Atm. Env., 2017

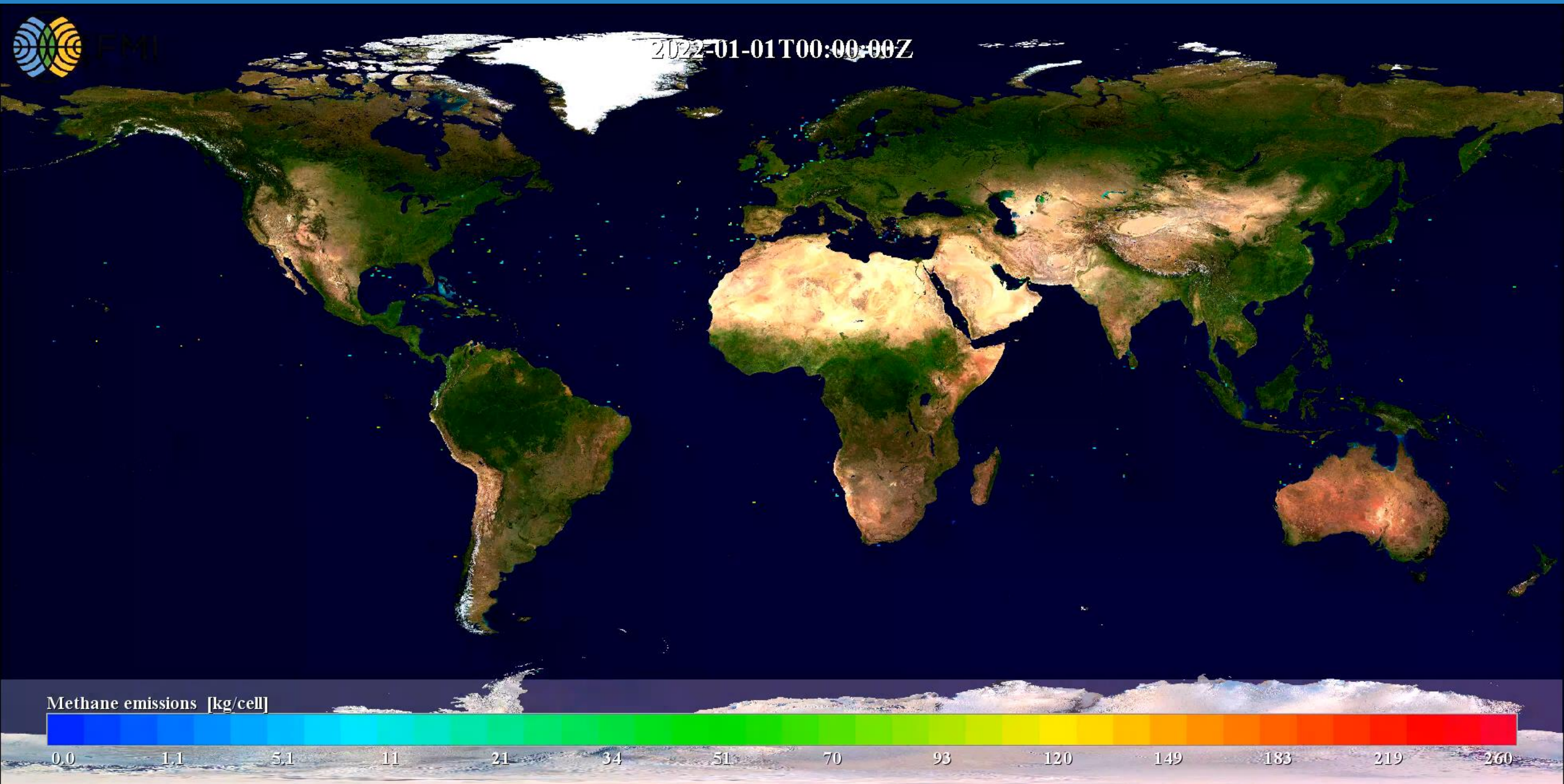
# Air emissions
# Water discharges
# Underwater Noise



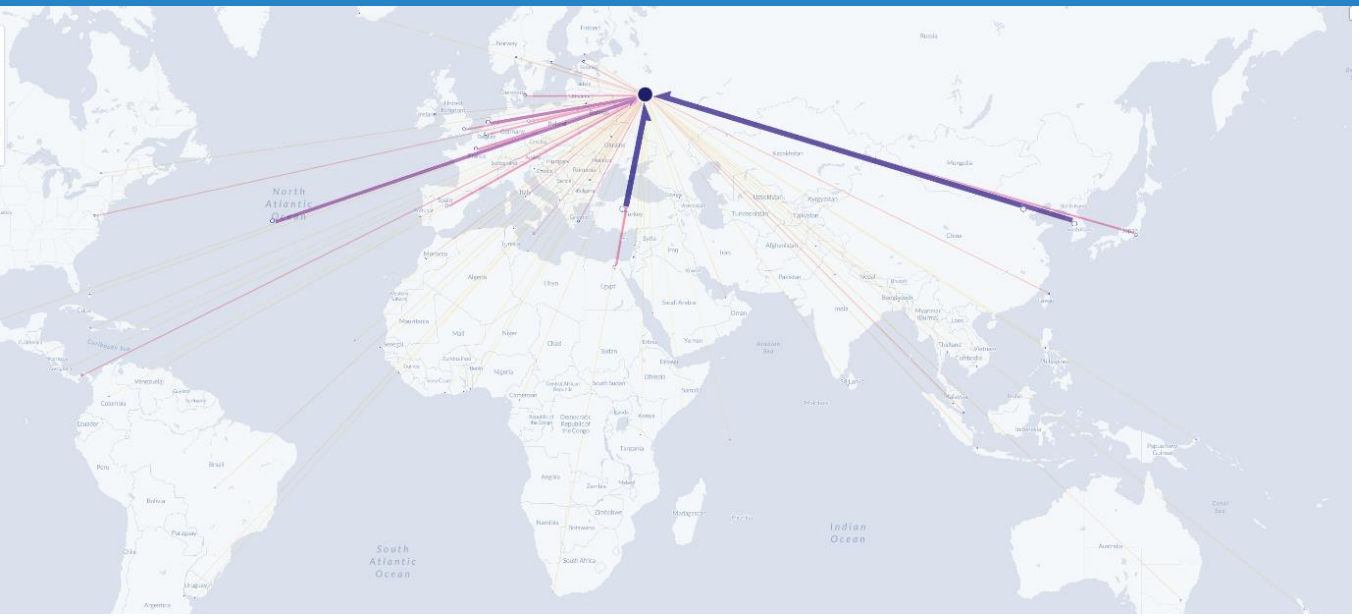

| | Biofouling & Antifouling | Ballast water | Black water | Grey water | Tank cleaning | Cooling water | Scrubber water | Bilge water | Noise | Stern tube oil | Atmos. deposition | Food waste |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acidifying substances | | | | | | | x | | | | x | |
| BOD/COD | | x | x | x | | | | | | | | x |
| Halocarbons, POP | | x | | | | | | | | | | |
| Hydrocarbons, PAH | | x | | x | x | | x | x | | x | x | |
| Litter, PM | | | | | x | | | | | | x | x |
| Metals | x | | | x | | x | x | x | | x | | |
| NIS | x | x | x | x | | | | | | | | |
| Nutrients, N, P | | x | x | x | x | | x | x | | | x | x |
| Energy/noise | | | | | | | | | x | | | |
| Shipping regulations | AFS | BWMC | MARPOL Annex IV | MARPOL Annex IV | MARPOL Annex I | | *MARPOL Annex VI* | MARPOL Annex I | | MARPOL Annex I | MARPOL Annex VI | MARPOL Annex V |

Jalkanen et al, Ocean Science, 2021

# Example: Hourly methane ($CH_4$) emissions



# Import/Export emissions




Global runs, shipping between any two countries

For all pollutants, fuel consumed

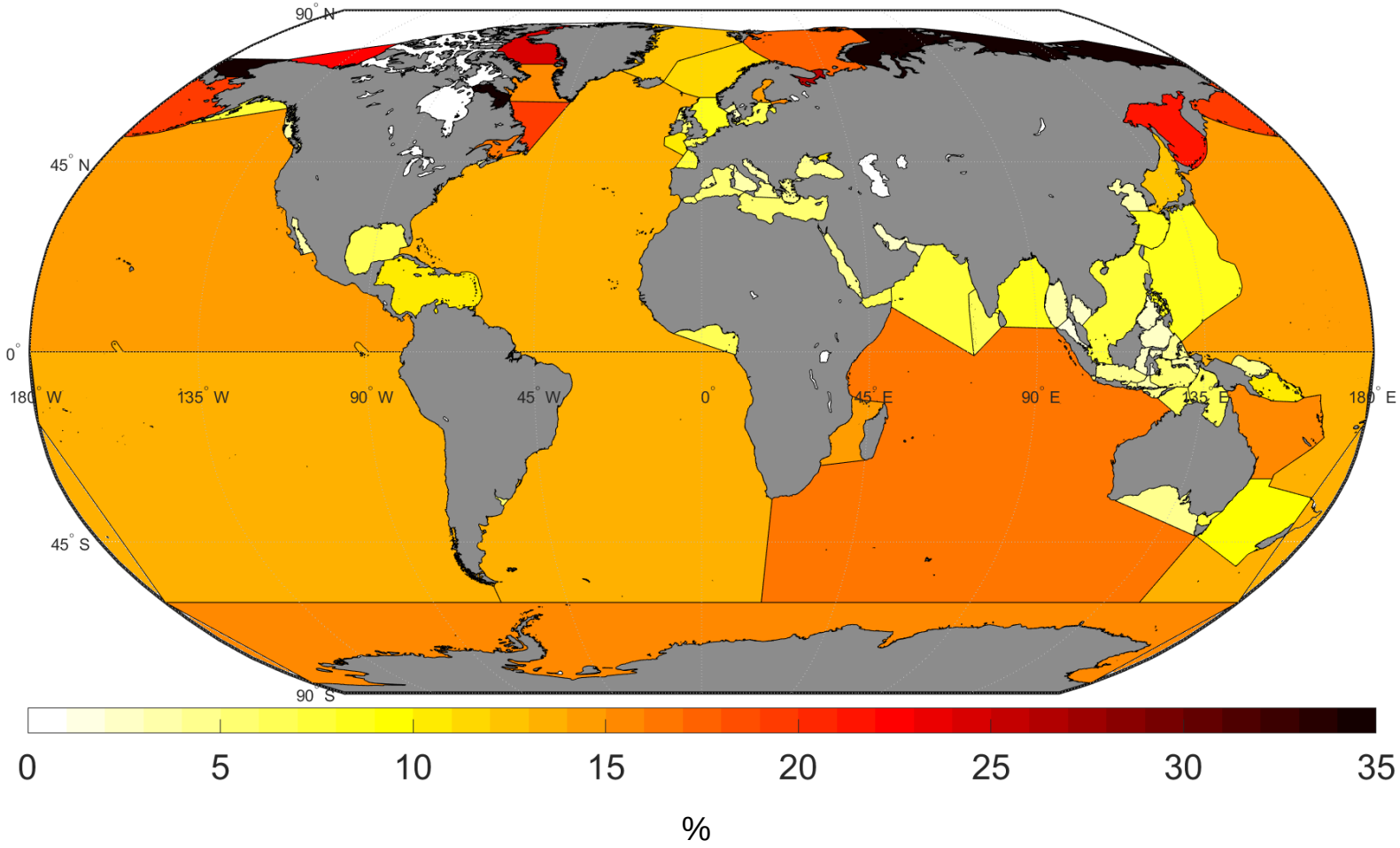
Any vessels operating between the two countries

This example:
Emissions from import ship traffic to Russia

| Country | Export, $10^6$ tonnes of $CO_2$ | Import, $10^6$ tonnes of $CO_2$ | $CO_2$, $10^6$ tonnes, 50% |
|---|---|---|---|
| **Estonia** | 0.79 | 1.21 | 1.0 |
| **Latvia** | 0.47 | 0.43 | 0.45 |
| **Lithuania** | 0.54 | 0.61 | 0.58 |
| **Poland** | 1.05 | 1.20 | 1.13 |
| **Germany** | 5.11 | 4.72 | 4.92 |
| **Denmark** | 2.95 | 2.65 | 2.8 |
| **Sweden** | 3.15 | 3.13 | 3.14 |
| **Finland** | 1.61 | 1.65 | 1.63 |
| **Russia** | 10.05 | 8.40 | 9.23 |
| **Baltic Sea countries** | 25.7 | 24.0 | 24.9 |

# Ambient effects; Magnitude and spatial variation

Average increase in $CO_2$ emissions (%) in 2014-2021

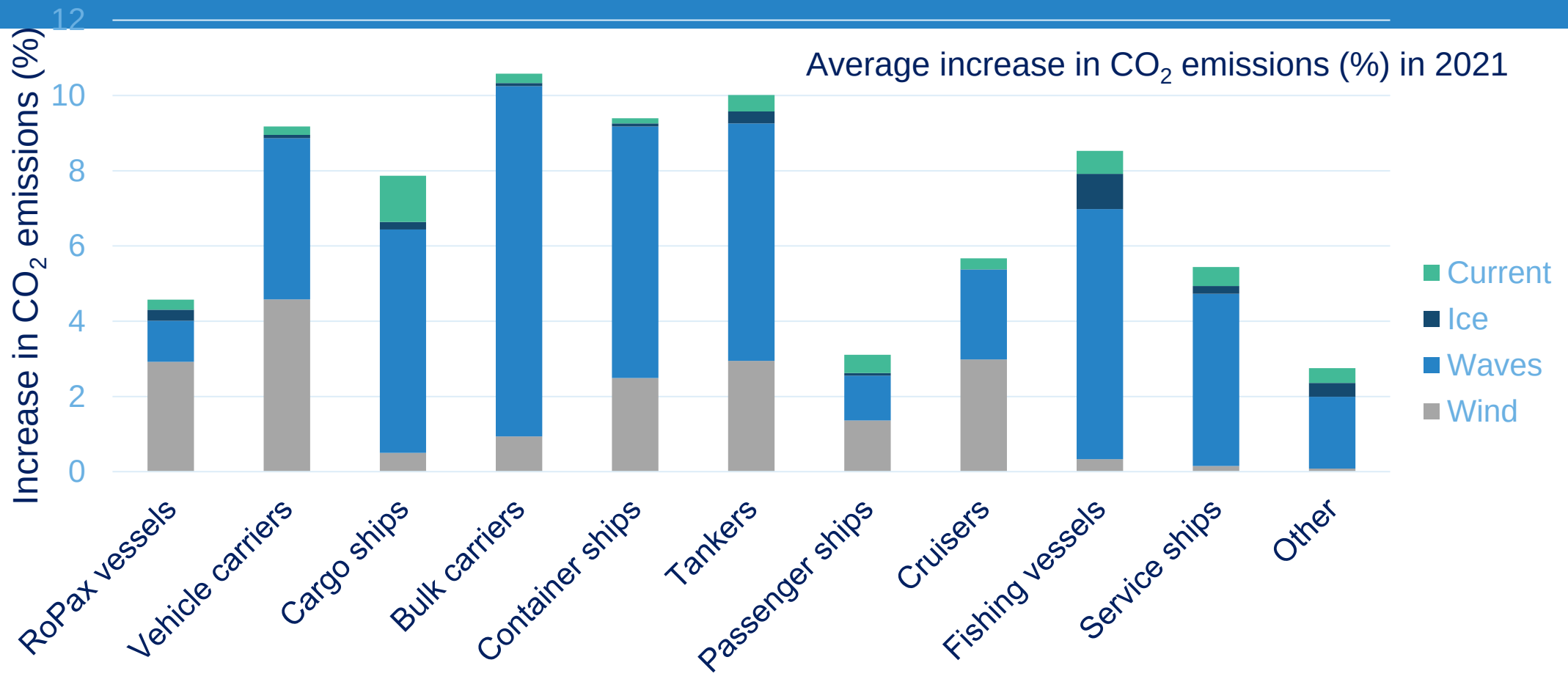



Compare this with

IMO GHG4:
+10% near coastlines
+15% elsewhere

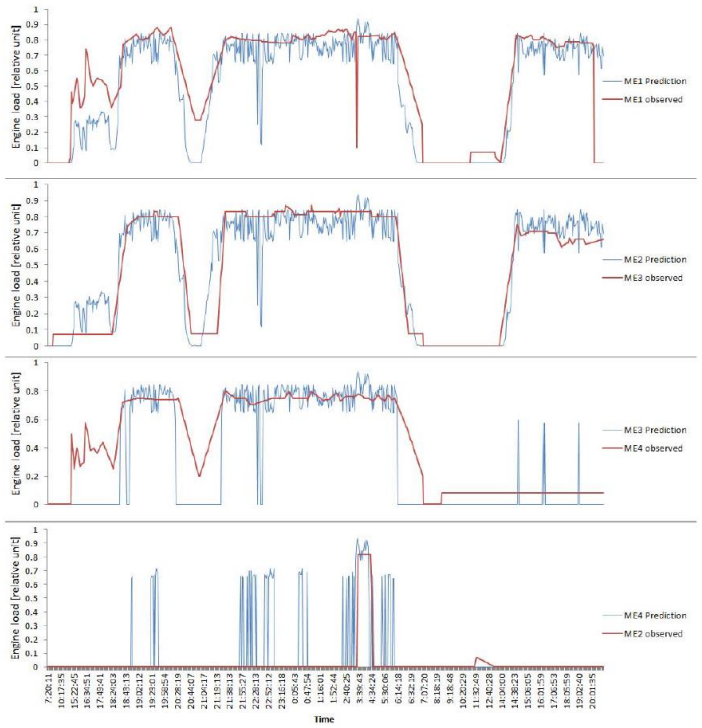
Biofouling: +9%

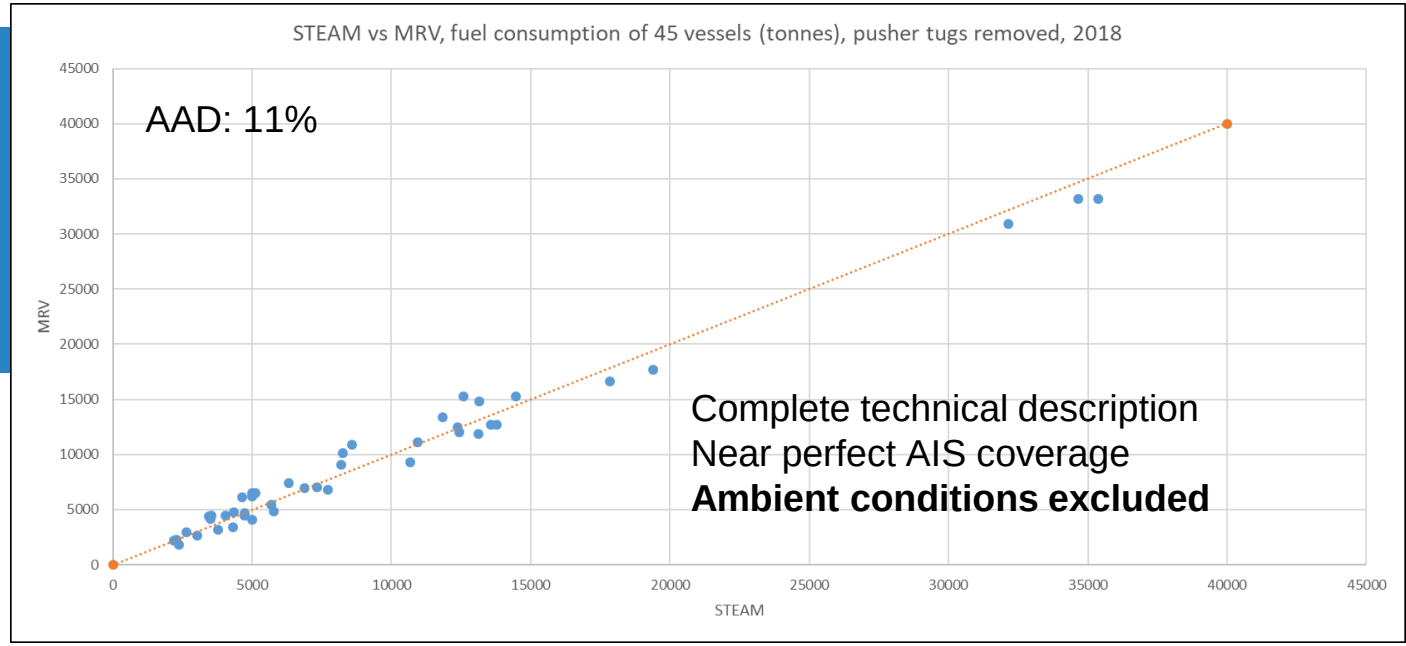
# Impacts of ambient conditions on $CO_2$ emissions

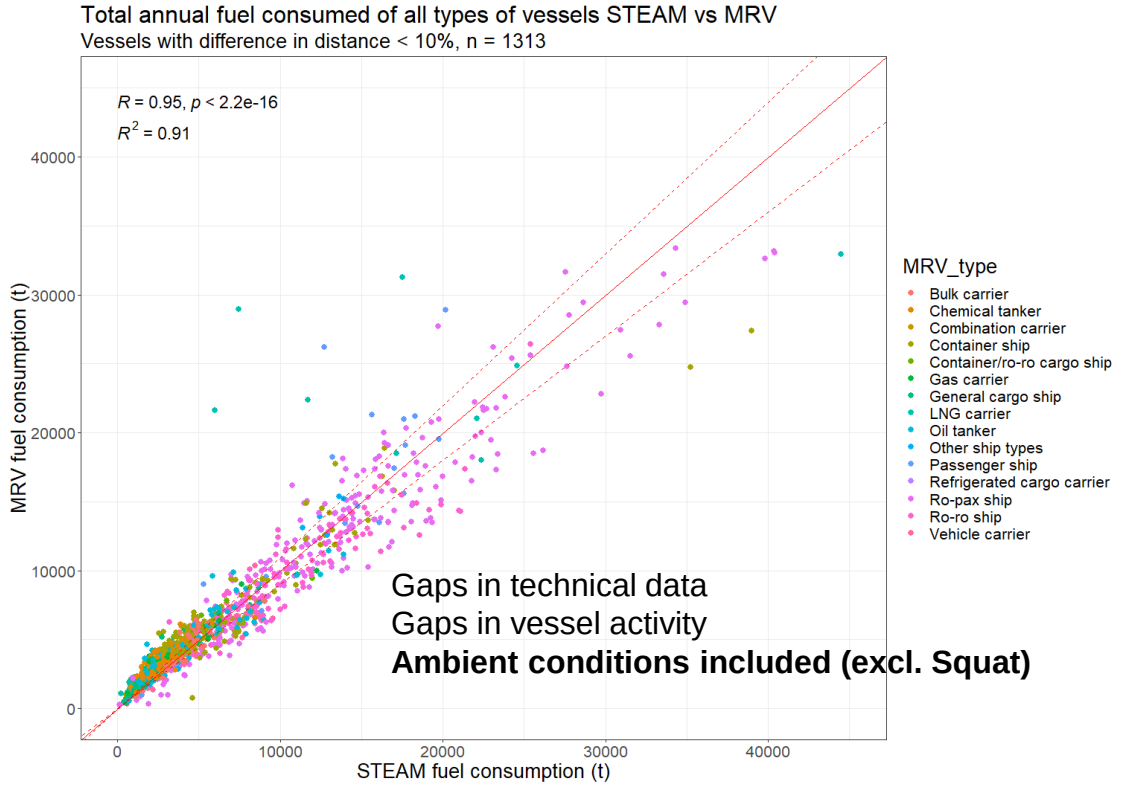


# QA/QC

- Owner fuel reporting
- EU MRV comparisons, e.g 2022
  - ΔFuel: -1.9%; Δ$CO_2$: -1.2% (>1300 ships)
- IMO Data Collection System
- Emission measurements
- Remote sensing
- Engine room data

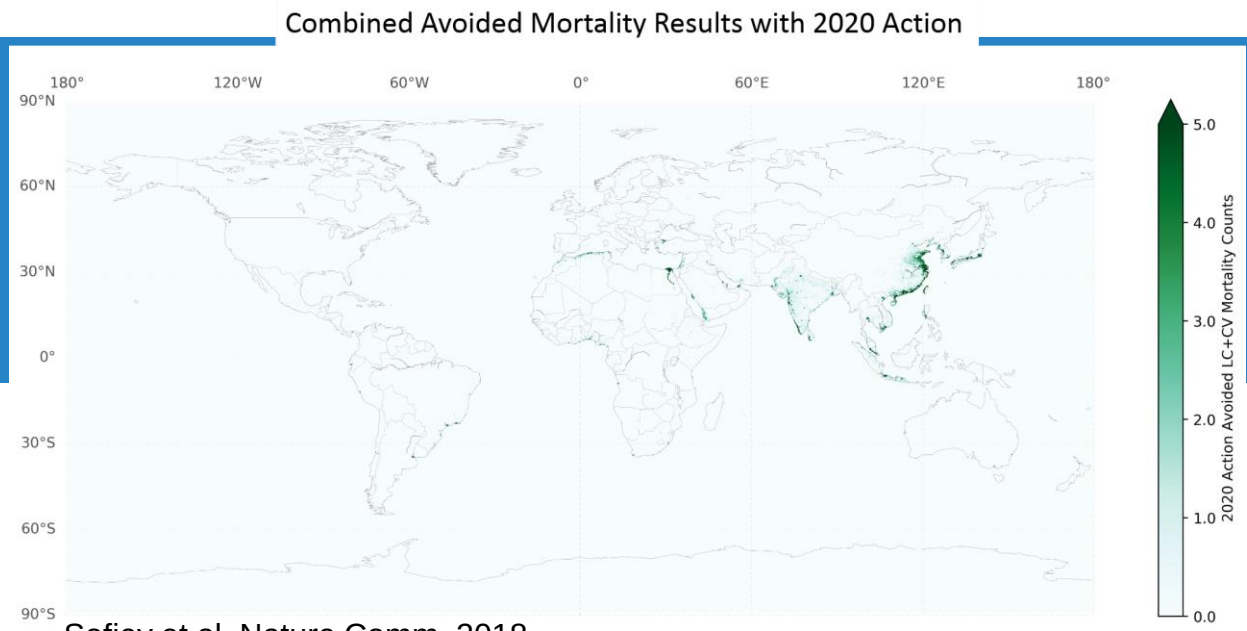


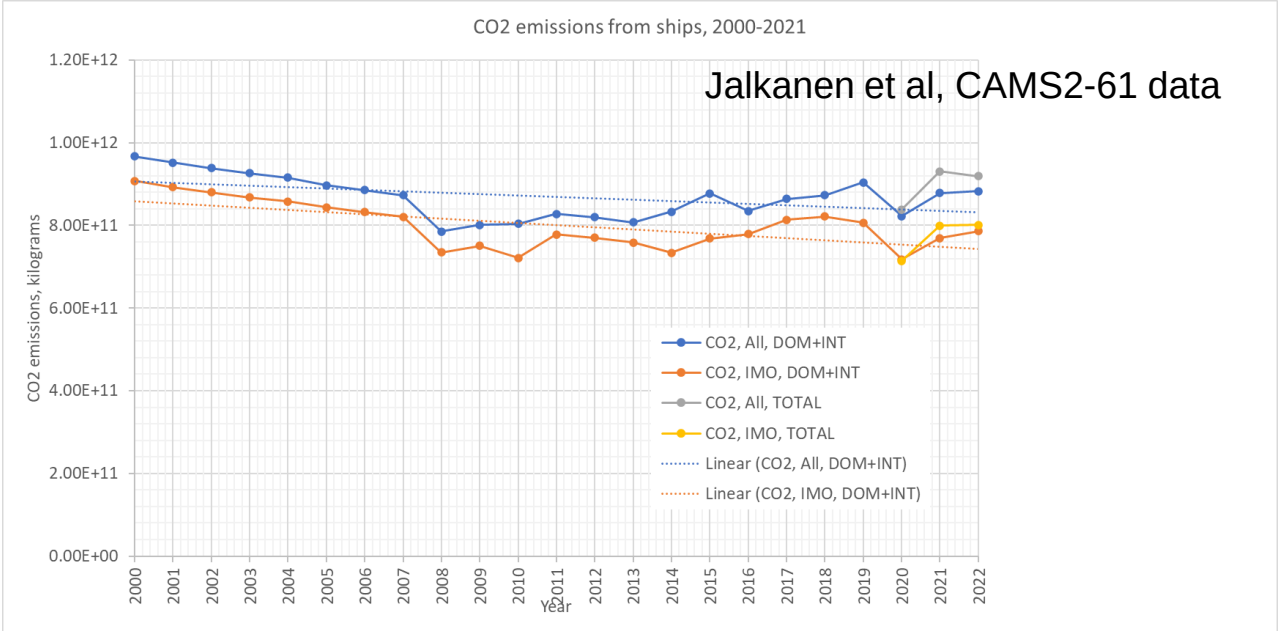



# Past applications

- New Emission Control Areas (AIR)
  - Baltic Sea, North Sea, Mediterranean Sea
- Global Sulphur cap 2020 (AIR)
  - Health & climate impact assessment
- Global GHG studies (AIR)
- Annual environmental reporting (AIR, WATER, NOISE)
  - HELCOM member states: Baltic Sea
  - EU/Global: Copernicus Atmospheric Monitoring Services
- European Maritime Transport Environmental Report (AIR, WATER, NOISE)

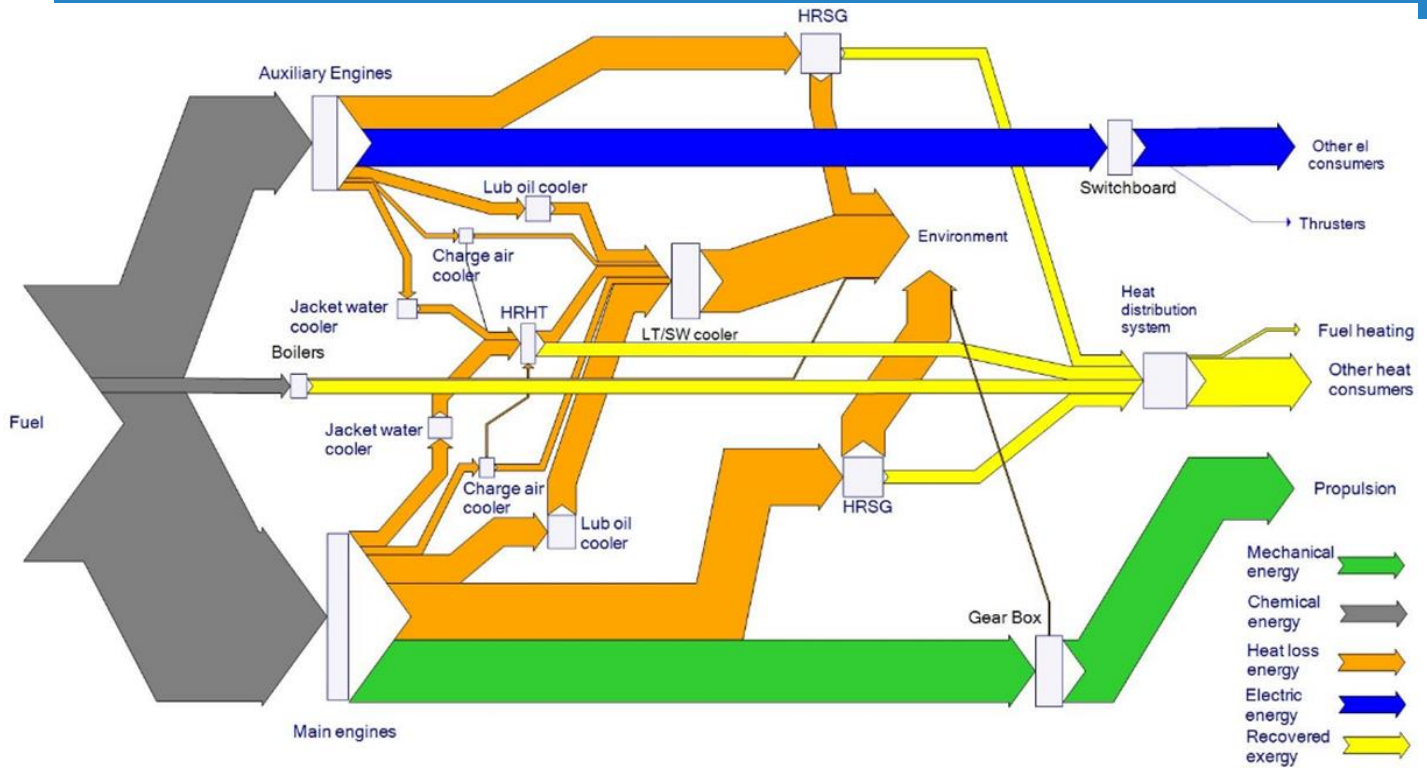



Sofiev et al, Nature Comm, 2018



# Challenges

- Incomplete, or poor-quality data
  - Activity data coverage
    - Access to various datasets (AIS, LRIT, VMS)
  - Vessel description
  - Cost of the datasets
- Energy, emissions modeling
  - Any ship, anywhere, anytime
- Validation data
  - Measurement campaigns
  - Confidential datasets
    - Engine manufacturers
    - Ship owners




Baldi et al, Proc ECOS, 2015

# Thank you

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