Ship emission modeling

Jukka-Pekka Jalkanen

Air Quality research

Building blocks of ship emission modeling

© Lazaros Aichmalotidis, EMSA

- **Ship activity, identity**
  - Automatic Identification System (AIS)
    - Terrestrial AIS-network
      - EMSA SafeSeaNet
    - Satellite-AIS
      - Commercial providers
- **Ship technical data**
- **Emission model**
  - **S**hip **T**raffic **E**mission **A**ssessment **M**odel (STEAM)
  - Jalkanen et al, Atmos. Chem. Phys., 9 (2009) 9209-9223
  - Jalkanen et al, Atmos. Chem. Phys., 12 (2012) 2641-2659.
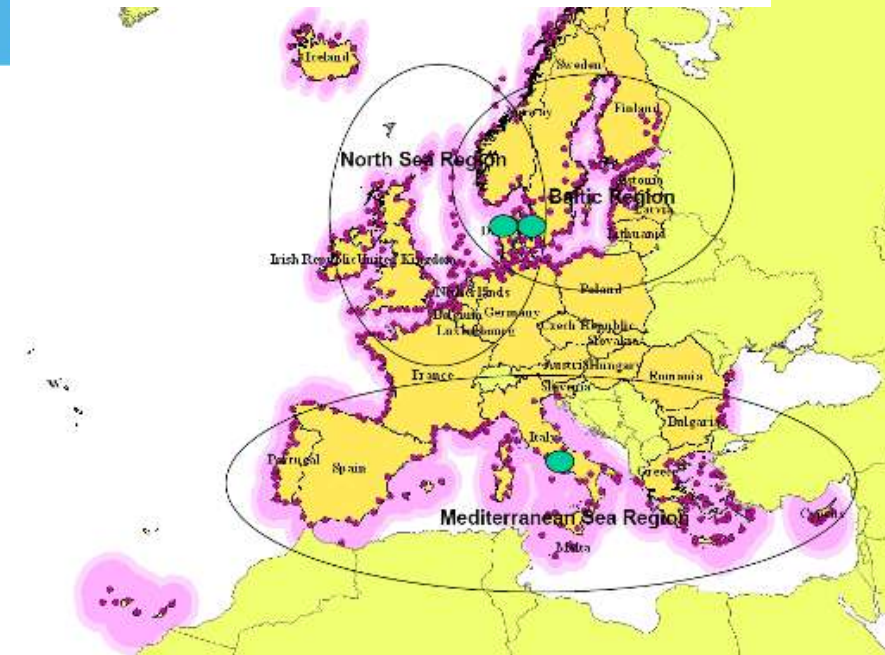
Based on sat-AIS data from exactEarth

Google earth
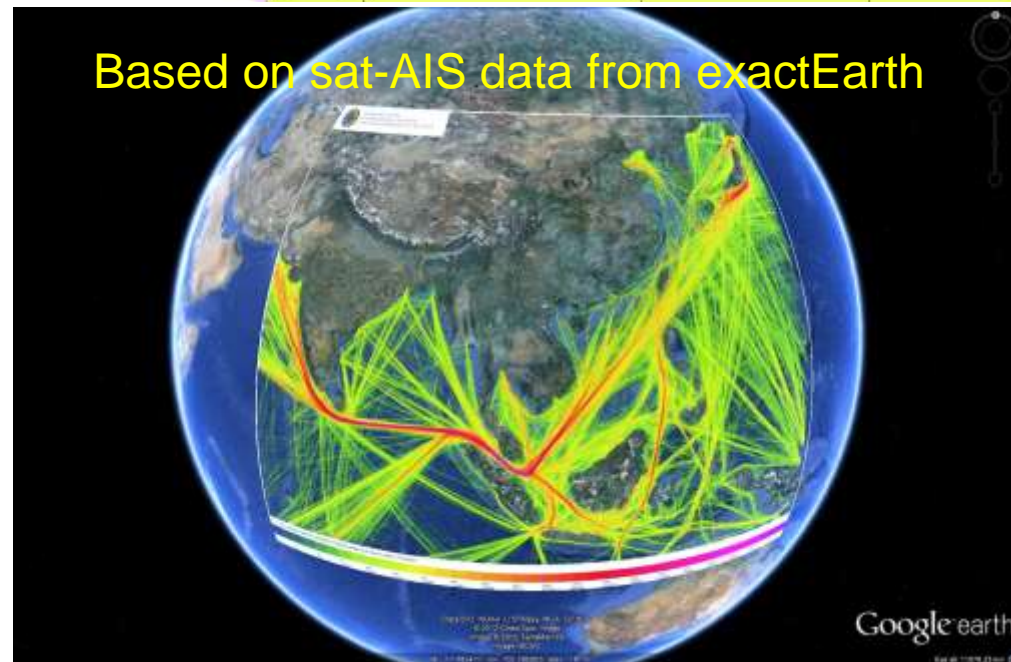
AIS-data from SafeSeaNet

- **Automatic transponder system, mandatory for ships > 300 GT**
  - Position update every two seconds
- **SafeSeaNet: Position update every 5-6 minutes**
  - Over 1000 000 000 position reports/year(!)
- **Use of AIS is voluntary for small vessels**
- **EMSA-FMI cooperation**
  - Pilot study 2009
  - MoU 2012-
- **SafeSeaNet AIS data is a very useful resource**
  - **Long term trends in traffic activity, emissions**
  - **Large research potential in Air Quality, Environment, Economic, Statistical studies**

Emission modeling with AIS data makes ship emissions one of the best known emission sectors

Image © Vroon Offshore Services

Example of a 300 GT vessel "VOS Ruler"
Length: 36.3 m
Breadth: 8 m
Draught: 3.55 m

Ship technical data

- **Physical dimensions; Hull form**

- **Powering; <u>all</u> installed engines, generators**

  - No boiler data used → Aux engine usage

- **Emission abatement, emission certificates**

- **Fuel type; sulphur content; specific consumption**

- **Current legislation; ECAs, directives, IMO Tiers**

- **Engine load vs fuel consumption/emissions; power transmission**

- **Propellers**

- **Capacity; reefer containers, cabins**

- **Each vessel handled as unique case**

  - No averages, compromises, shortcuts

- **All information may not be available!**

- **Combination of different data sources**

  - IHS Fairplay

  - Other classification societies

 - Ship owners

  - Engine manufacturers

  - …
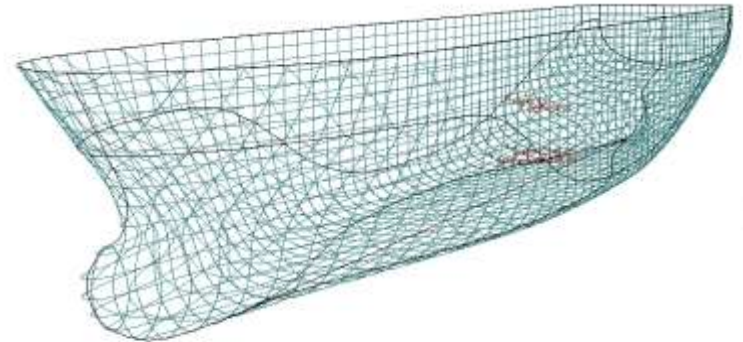
Emission model properties

- **Based on water resistance calculations**

  - Effects of wind, waves, sea currents, ice, shallow water can be included explicitly. FMI has access to all relevant datasets.

- **Transparent, documented and detailed enough to gain acceptance among ship owners**

- **Can be applied anywhere in the world as long as good quality AIS data is available**

- **Includes emissions from ships at berth**

  - Same approach regardless of scale; Harbors → Global coverage

  - Specific fuel consumption, emissions depend on engine load

- **Pollutants: NO_x, SO_x, CO, CO_2, Particulate Matter**

  - PM chemical components: EC, OC, Ash, hydrated SO_4

Geographical distribution of emissions

CO_2 emissions from all ships, 2011
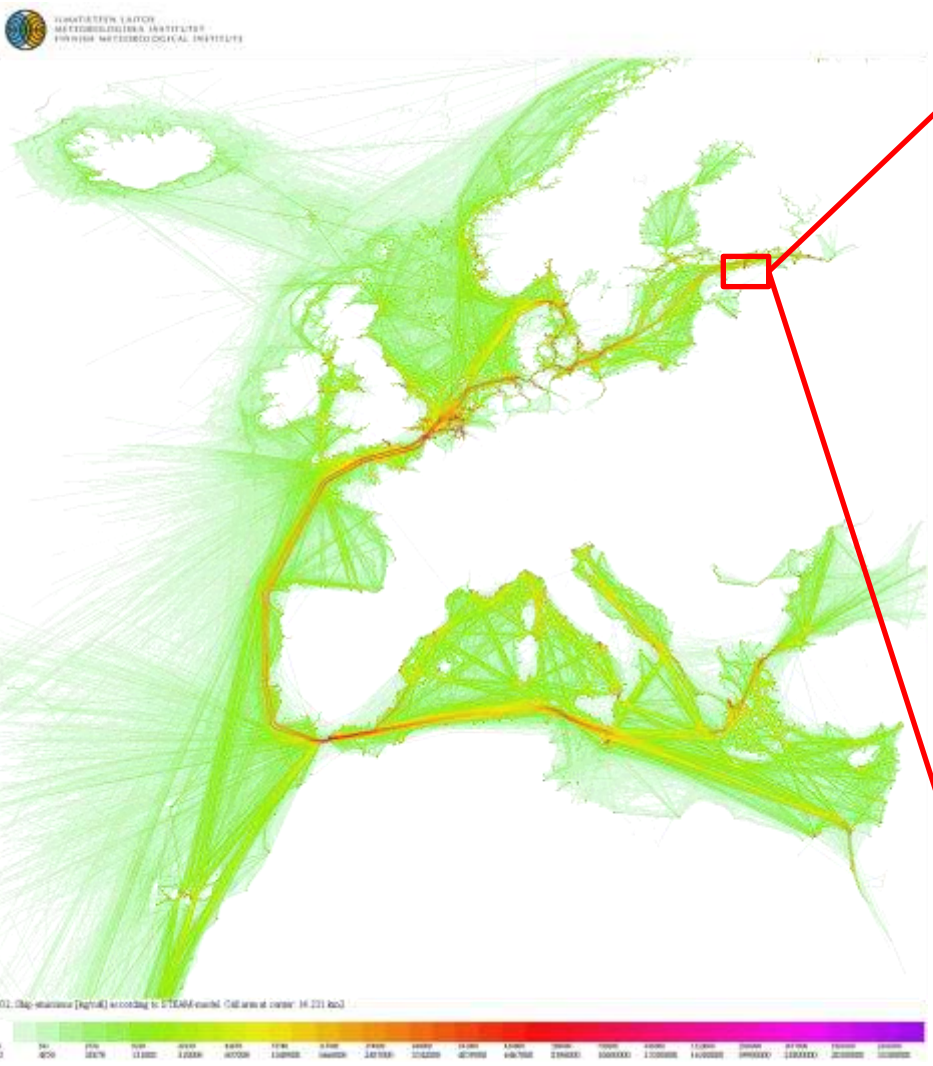
CO_2 from ships at Tallinn harbor, 2011
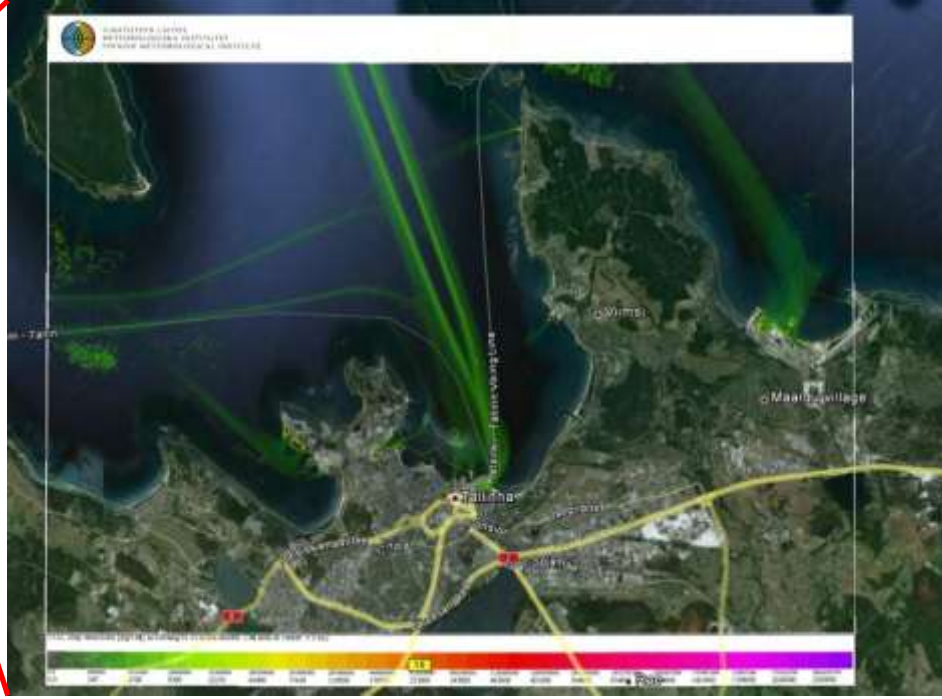
Emissions inside harbor areas are included

Example results

- **Ship emission totals**
  - 131 Mt of CO_2 in 2011
- **Geographical distribution of pollutants (maps+gridded datasets)**
  - Significant impact on research!
- **Emissions classified by flag, ship type, age group**
- **Policy impact on ship emissions**

EMSA – FMI Pilot
Application of STEAM
to the North Sea Area

NO_x from ships Oct 2009

Jukka-Pekka Jalkanen
Air Quality Research
Finnish Meteorological Institute
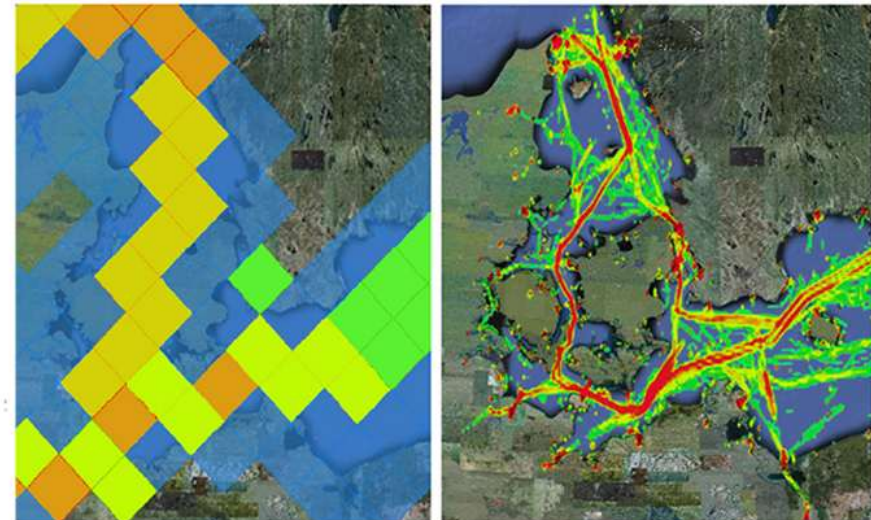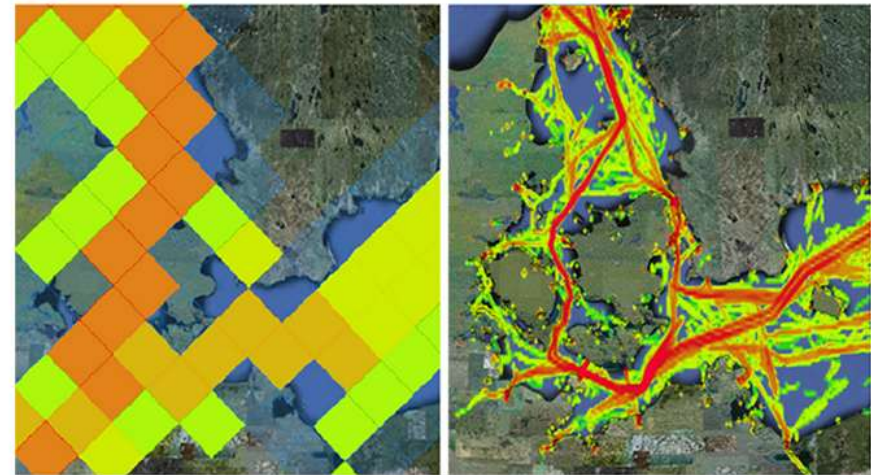
Emissions by ship type, SafeSeaNet area, 2011

Tankers:
- Represent 8.4% of all ships
- Carry 35% of cargo payload
- Emit 19% of CO_2 and 22% of PM
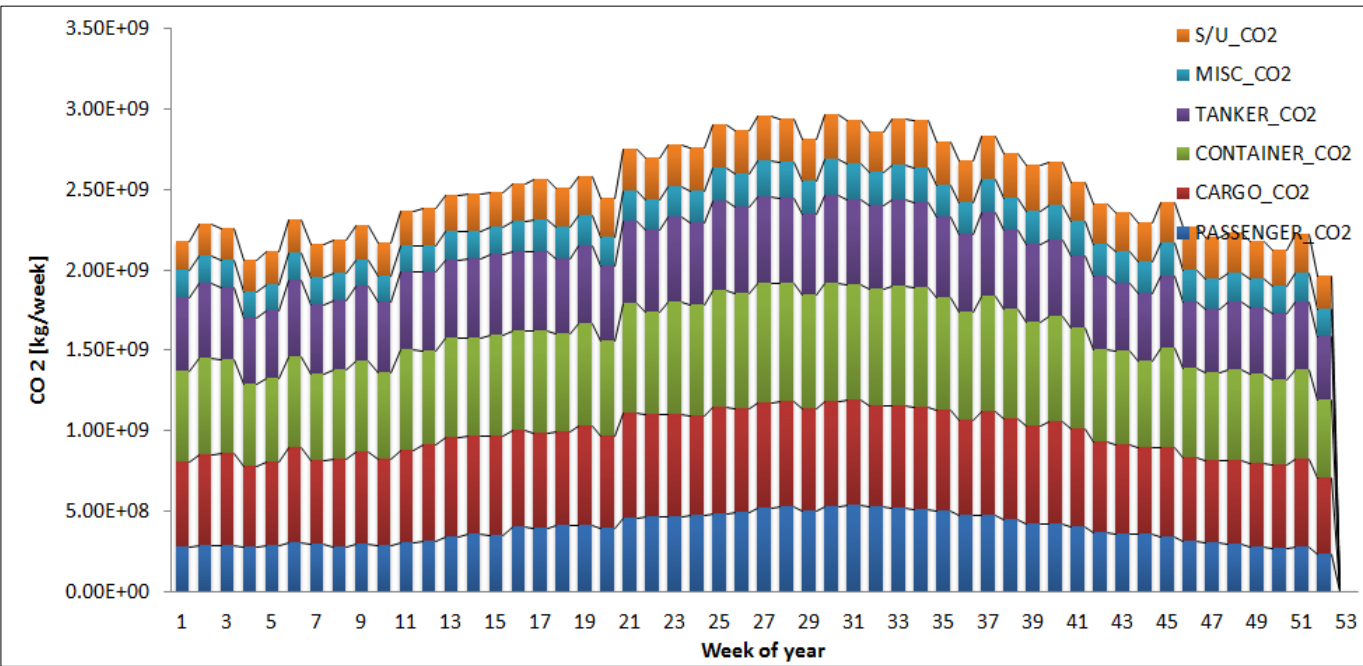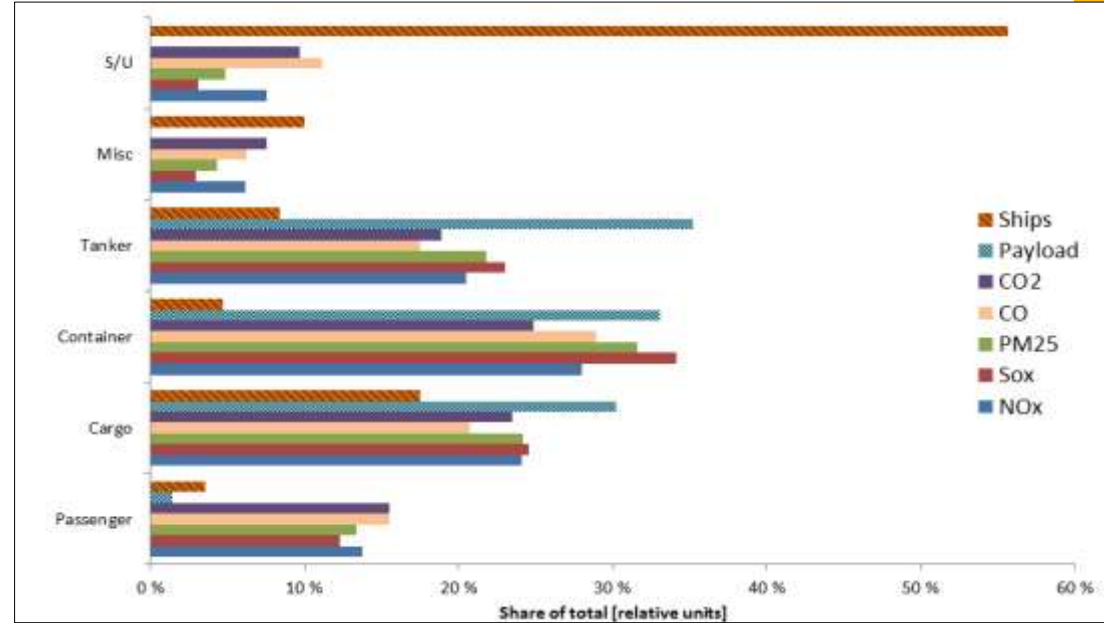
Differences to previous ship emission inventories

- **Based on actual ship activity**
  - No need to guess shipping routes
  - No bias towards certain ship types
  - Avoid averages
- **All relevant legislation included**
- **Speed – resistance - power**
- **Emissions from ships at berth included**
- **Weather effects can be included**

- **Same approach regardless of scale**
  - Local harbor – Global
- **Cost effective approach**
  - Large parts can be automated
- **Can be verified with experiments**
  - Ship by ship approach
  - Satellite observations
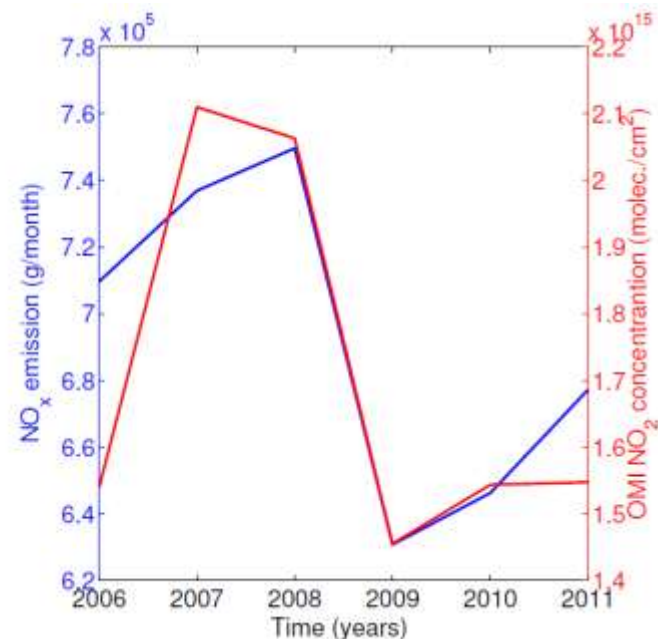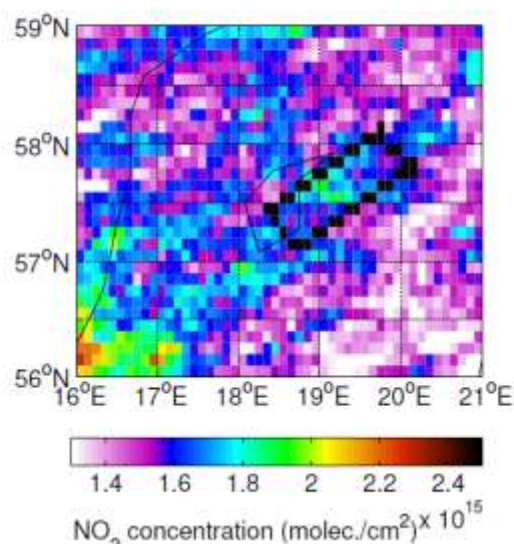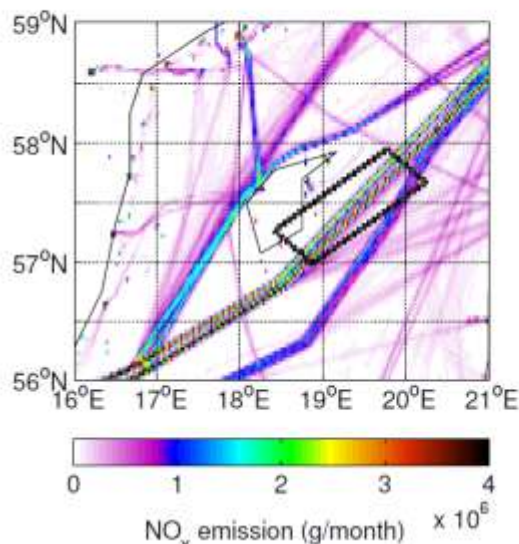
Thank you for your attention

Jukka-Pekka Jalkanen

with contributions from

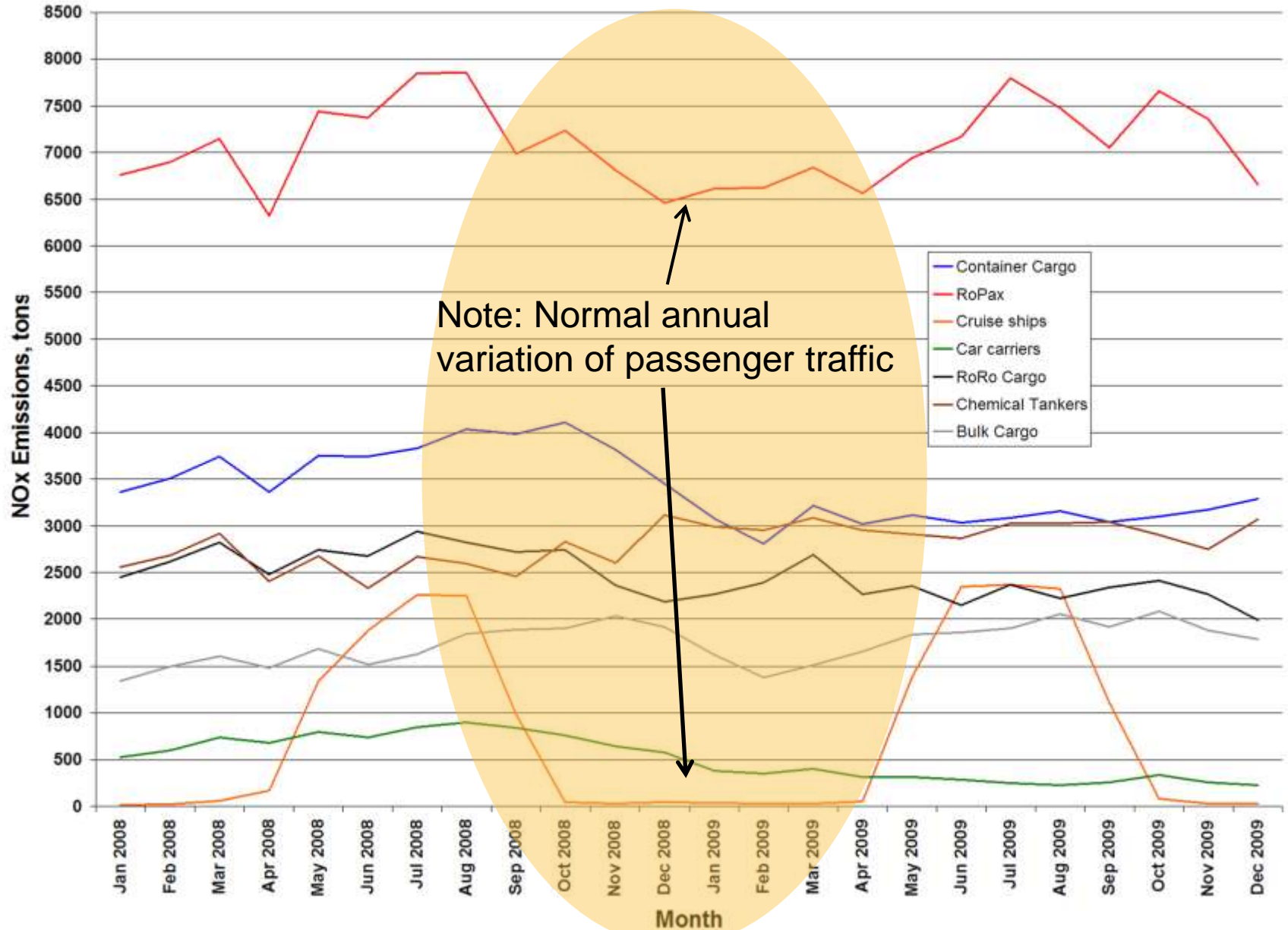European Maritime Safety Agency
European Space Agency
exactEarth Ltd.
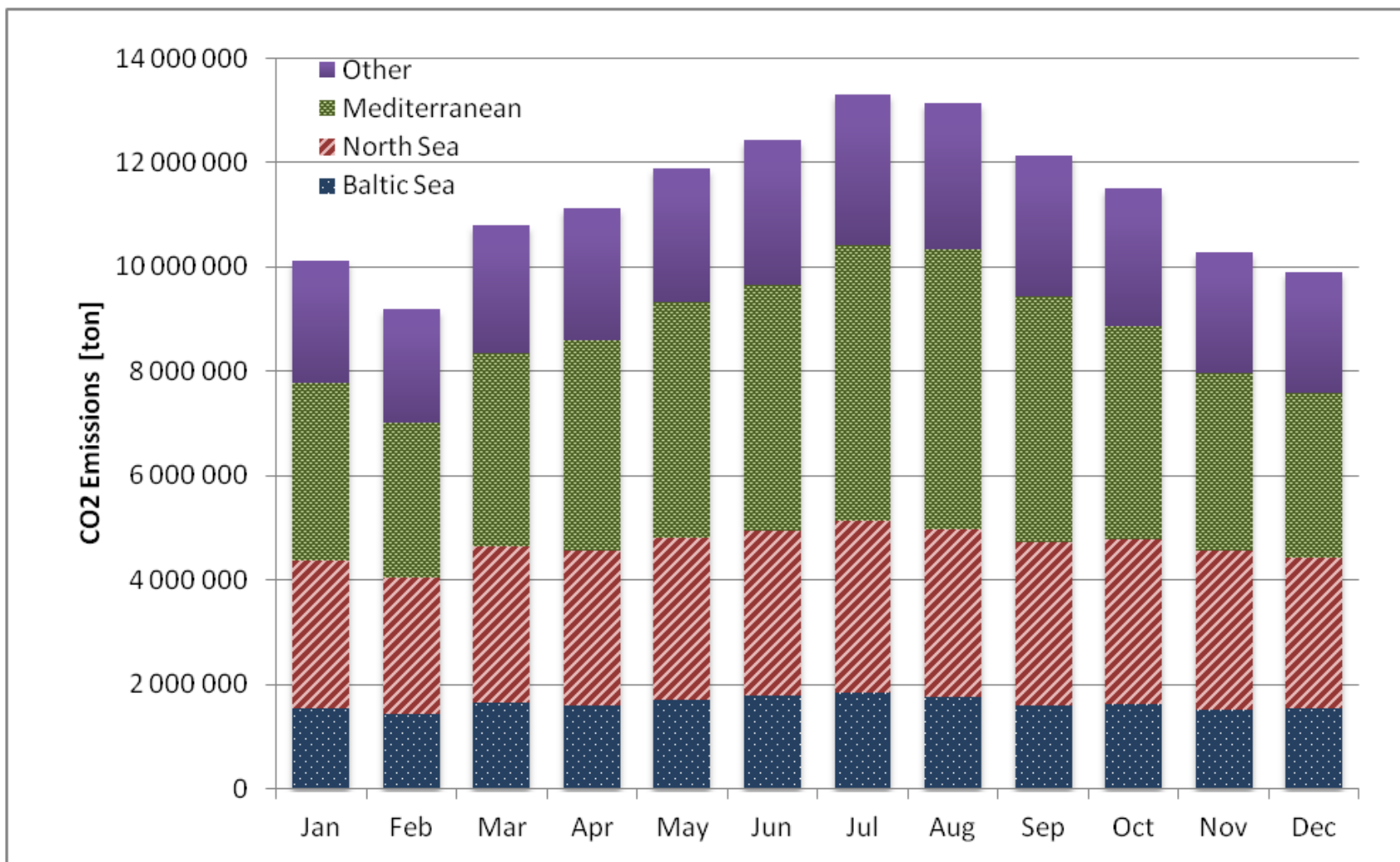HELCOM member states
Finnish Transport Safety Agency
SAMBA, SNOOP, BSR InnoShip project partners
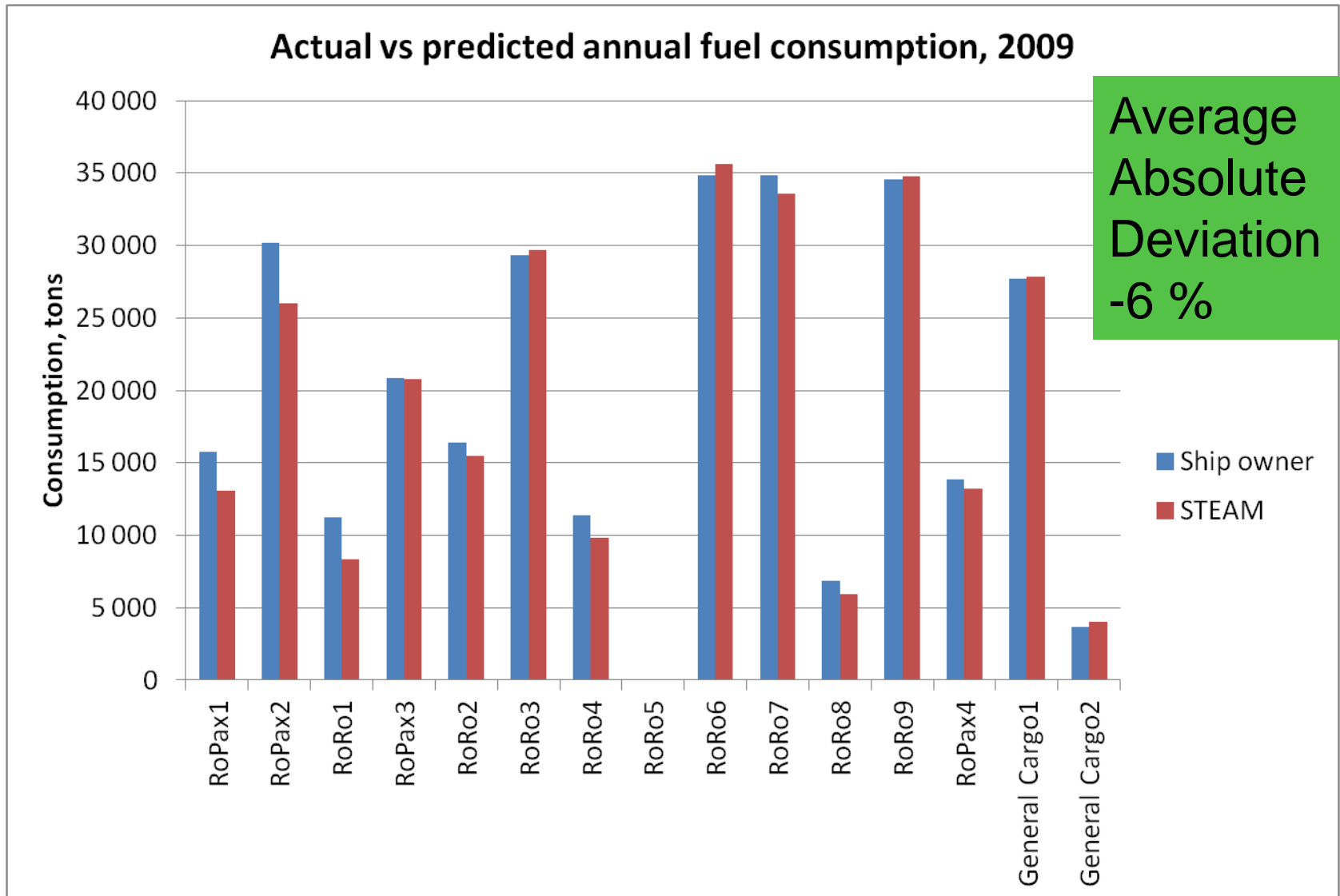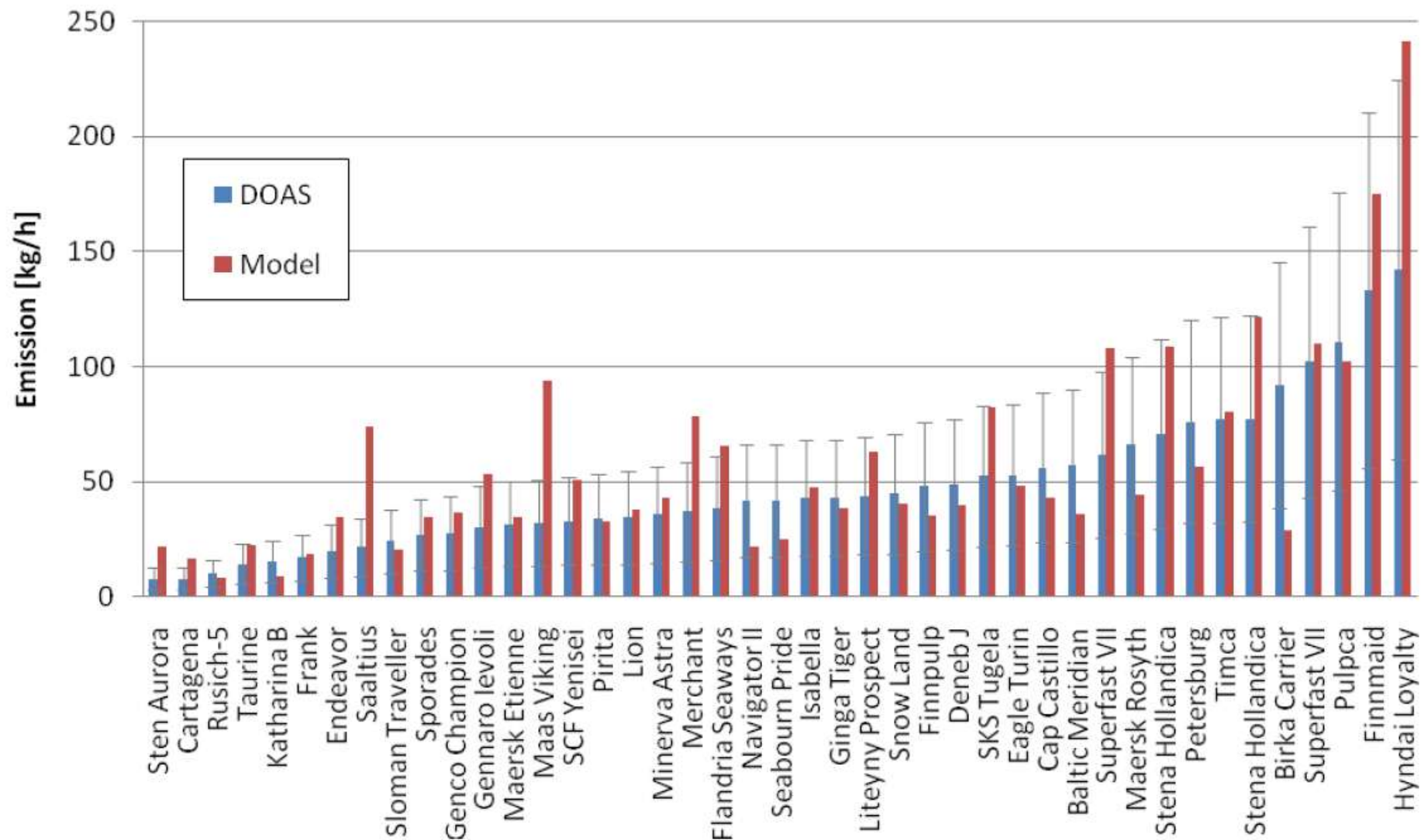
Emissions vs. economic activity, Baltic Sea

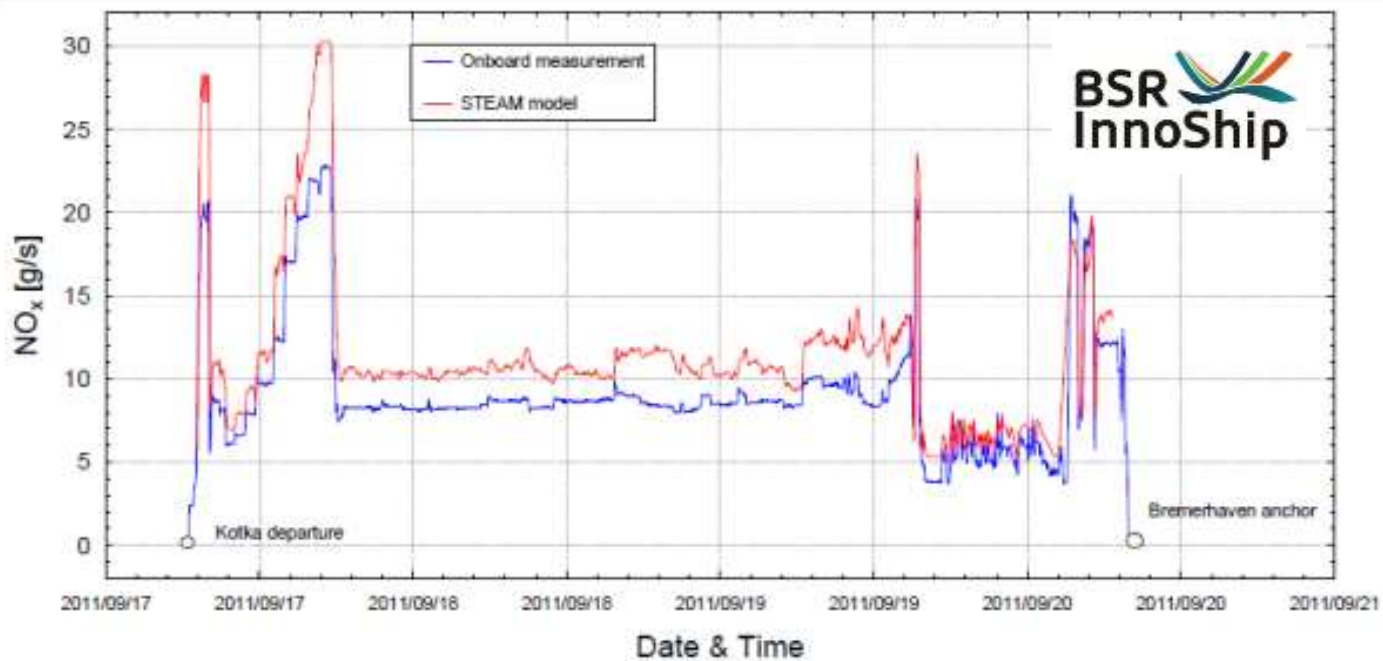# Seasonal variation of CO_2 emissions, SafeSeaNet, 2011

Quality control, Fuel consumption

Actual vs predicted annual fuel consumption, 2009

Average Absolute Deviation -6 %

Berg et al, Atmos. Meas. Tech, 5 (2012) 1085-1098

NOx/SOx Emissions, All engines, RoPax, Hw-HvH, 25092009

Measurements by:
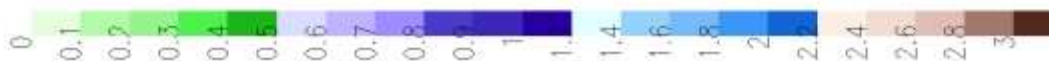Joint Research Centre,
Maritime University of Szczecin
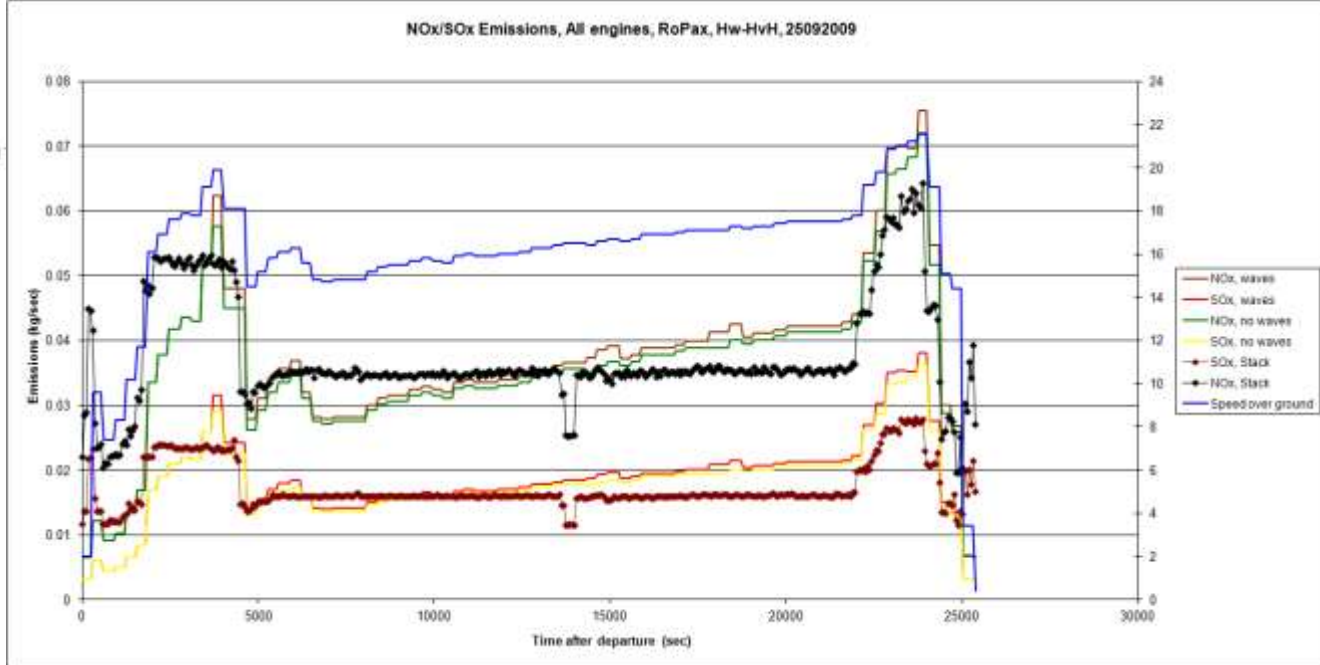
Significant wave height, 7th Oct 2007 @ 22:00 UTC
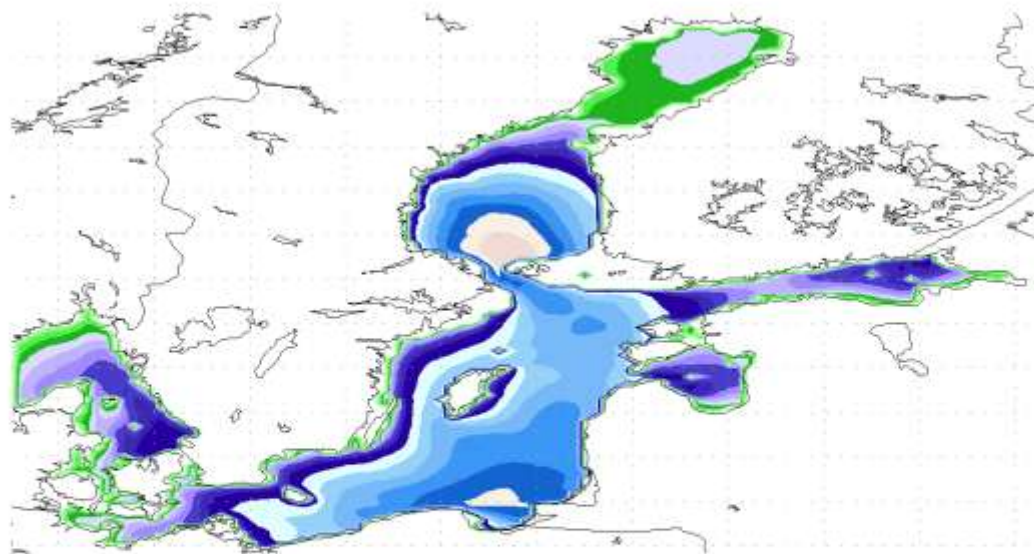
100 km

Significant wave height, m