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METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Effect of ship fuel sulphur reductions in the Baltic Sea area in 2010

Jukka-Pekka Jalkanen



Baltic Sea cooperation for reducing ship and port emissions through knowledge- & innovation-based competitiveness

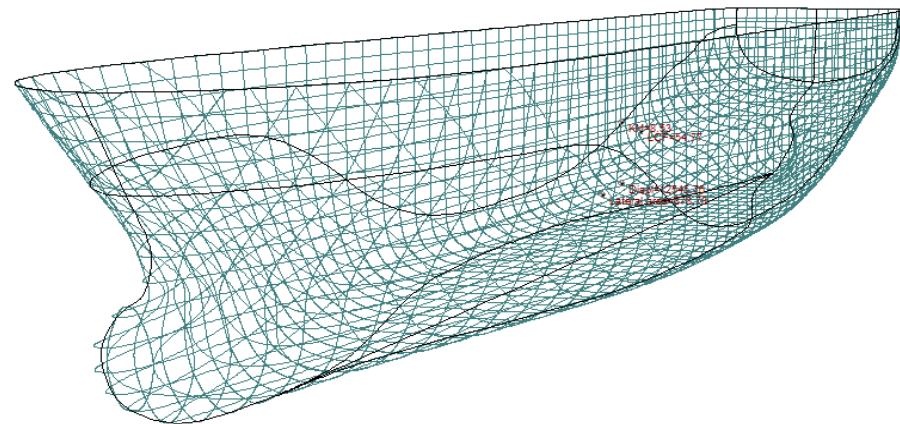
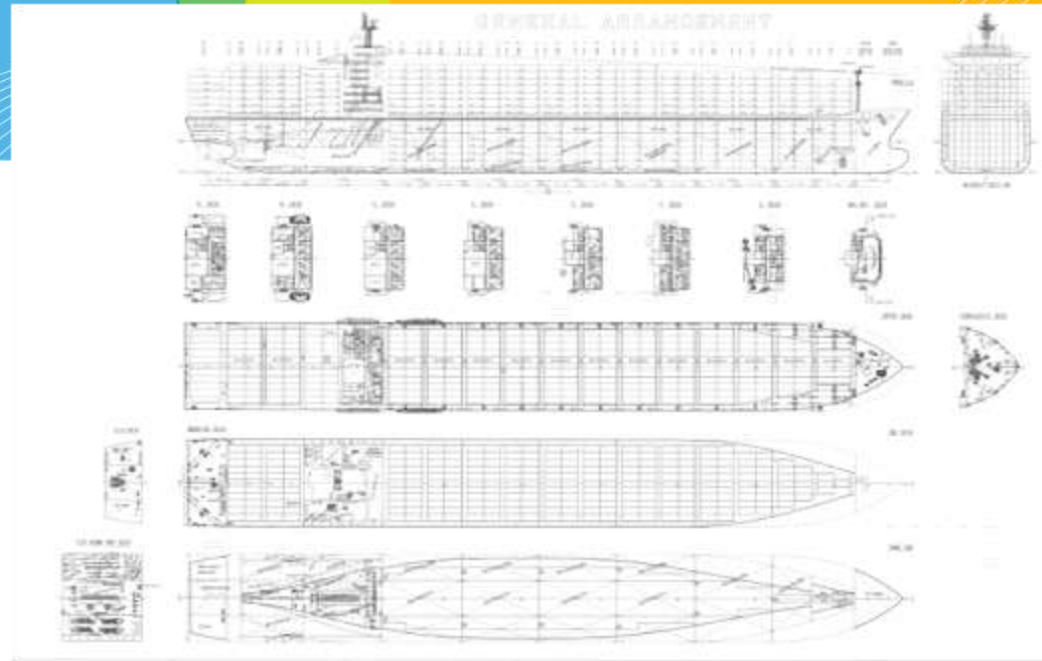


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What is needed

- **Activity data**
- **Ship details**
 - Technical database
 - **IHS Fairplay Ltd**
 - Clarkson Research Ltd.
 - **Fuel types**
 - **Emission abatement**
 - **Experimental emission factors**
- **Emission model**





Activity data

• Automatic Identification System

- Vessel identification
- Geographical location
- Speed
- Course

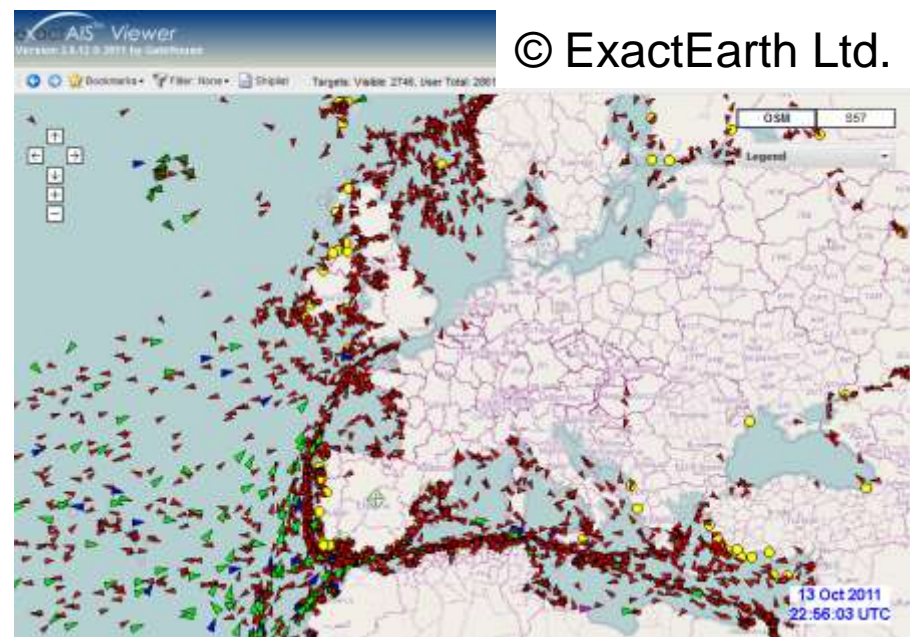
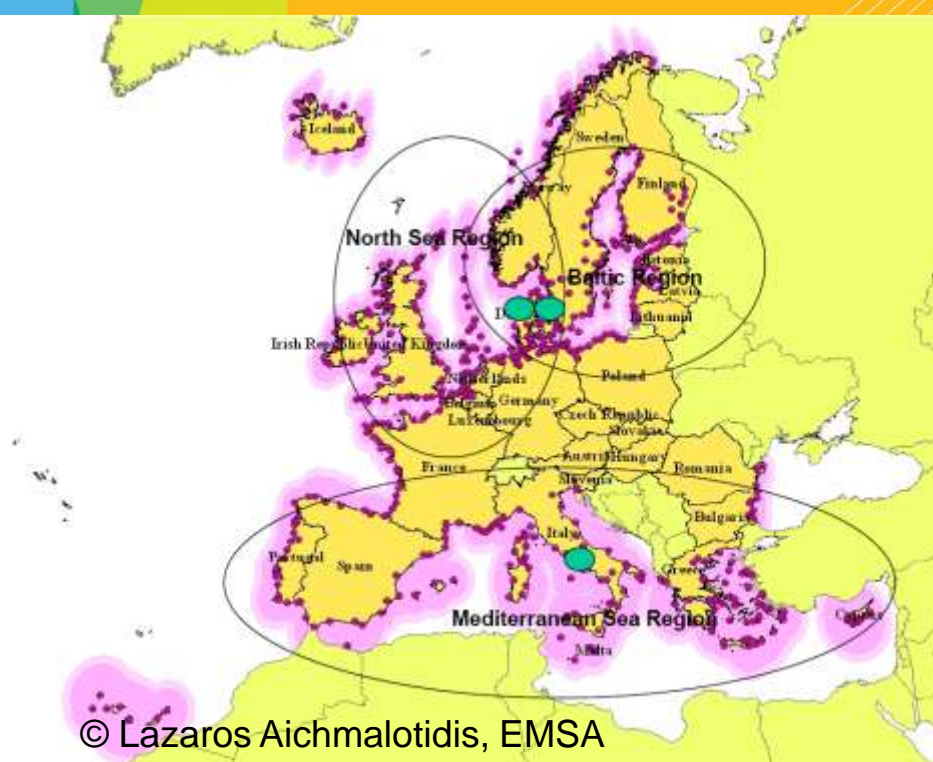
• Terrestrial AIS network

- Local/Ports:
 - Dedicated base station
 - National AIS network
 - Regional server
- Regional
 - HELCOM: Baltic Sea
 - OSPAR: North Sea

• Global: Sat-AIS

High traffic zones

Ground level interference





Ship details

- **Vessel identification**
 - Name, IMO, MMSI
- **Ship type**
- **Physical dimensions**
 - LOA, LBP, B, T, DWT, GT
- **Build year**
- **Hull type; Monohull, catamaran...**
- **Bow bulb?**
- **Main and Aux engine setup**
 - Number of engines
 - Installed kW, RPM, make, model
 - Engine stroke type
 - Shaft Generator(s)
 - Fuel consumption
- **Power transmission: Mechanical, Electric**
- **Propellers, thrusters, rudders**
 - Number, type, RPM, diameter
- **Hull blueprints**
 - Hull angles (ice class)
- **Experimental emission factors**
- **Abatement techniques**
- **Capacity**
 - Passenger: Cabins
 - Containerships: Reefer containers
- **All information may not be available!**
- **Combination of different data sources**





Fuel

IMO

SOx Emission Control Area

- Baltic Sea (05/2006), North Sea/English Channel (11/2007), North America

Marine fuel sulphur content, MARPOL Annex VI

- **Russian ratification 04/2011**
- SECA
 - 05/2006: 1.5 %
 - 07/2010: 1.0 %
 - 01/2015: 0.1 %
- EU-waters
 - Passenger vessels, 2006: 1.5 %
 - Currently under revision
- Global limits
 - Present: 4.5 %
 - 01/2012: 3.5 %
 - 01/2020: 0.5 %

Sulphur directive, 2005/33/EC, under revision

- 0.1 % from 01/2010 while in port

Impact on SOx, PM emissions

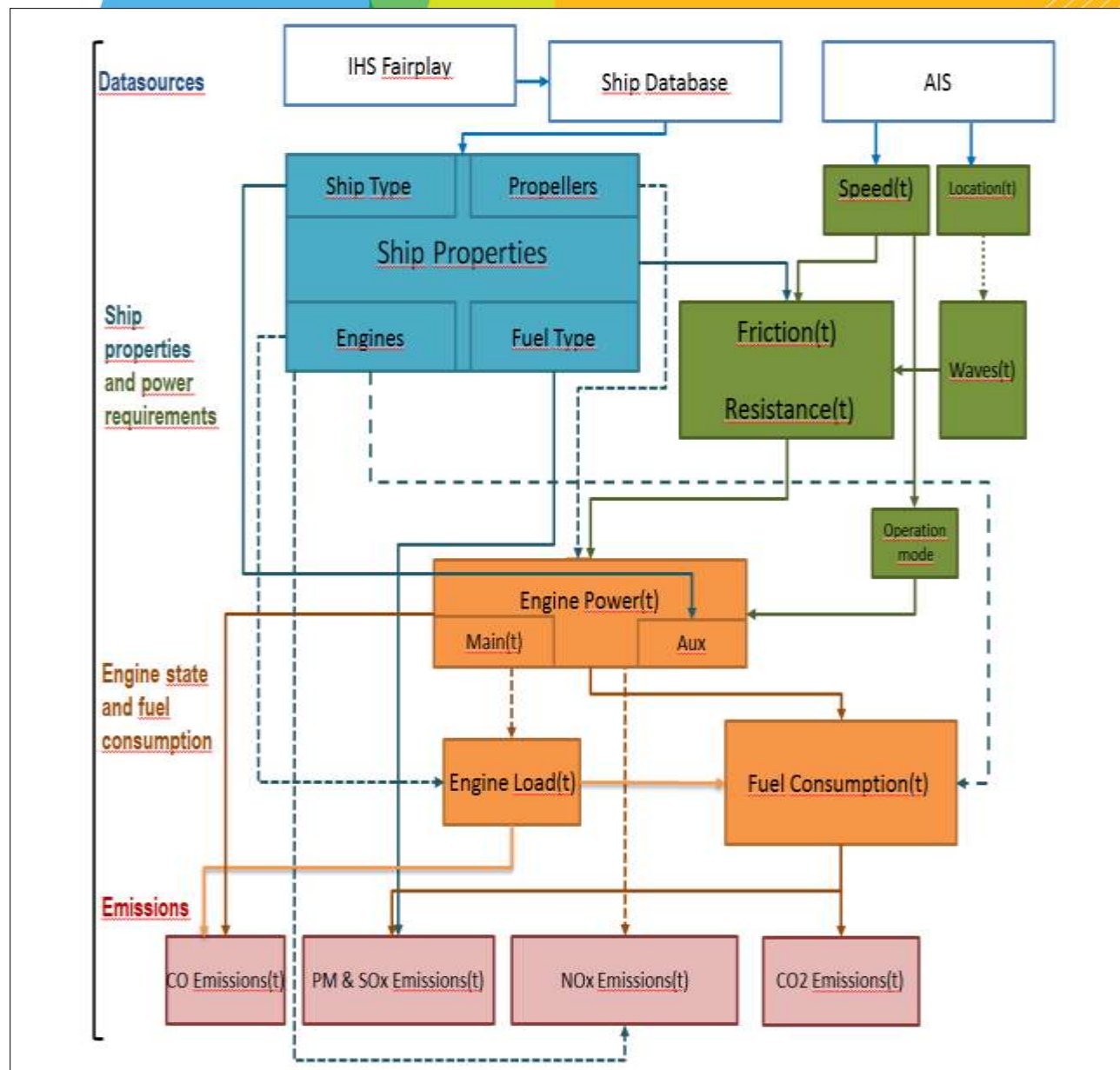
- **LNG**
 - Duel-Fuel: <20 % engine load → Diesel
- **Biofuels**
 - Emissions?
- **Nuclear power**
 - Icebreakers
 - Naval vessels
 - Commercial traffic?
- **Sailboats...**



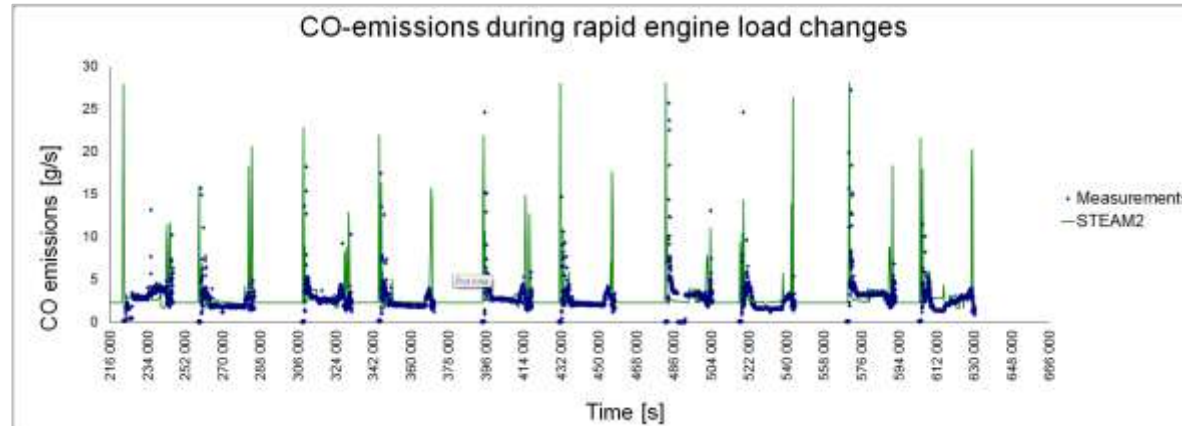
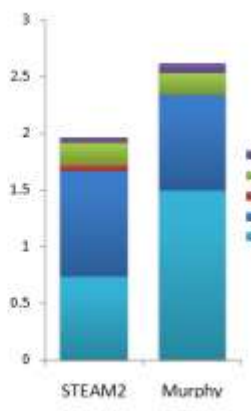
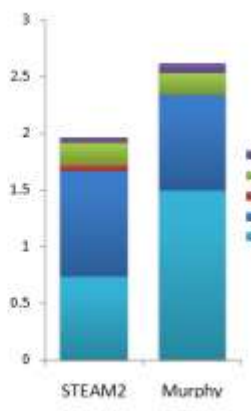
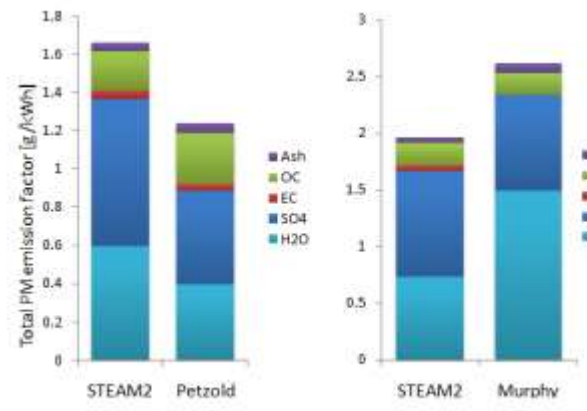
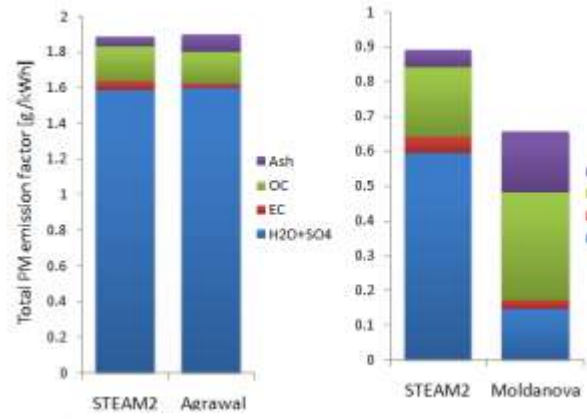
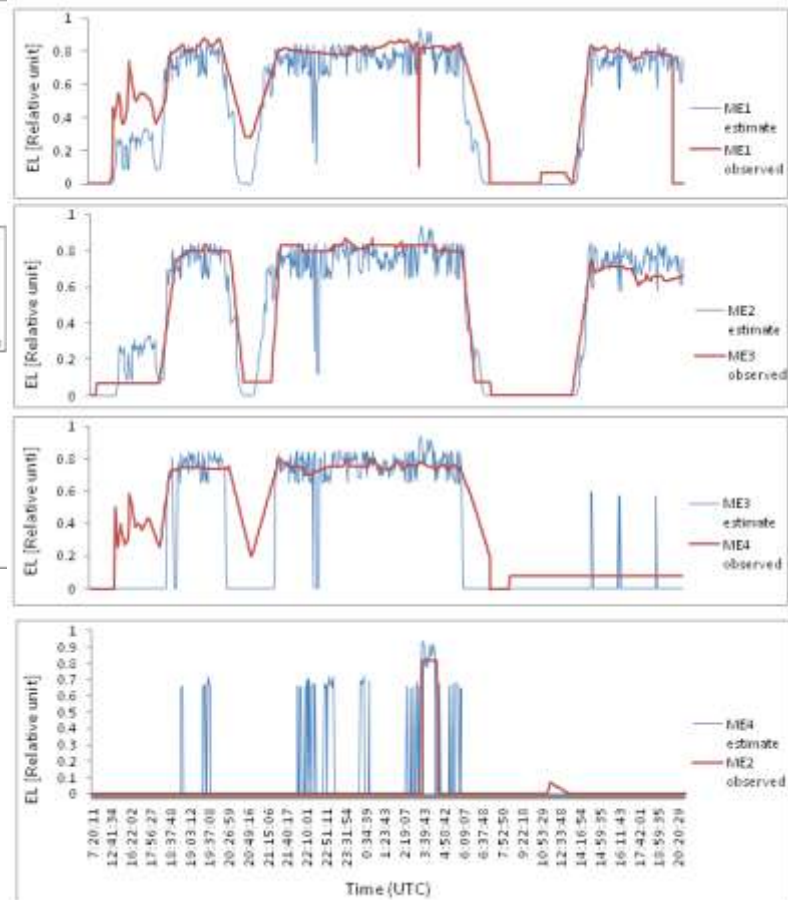
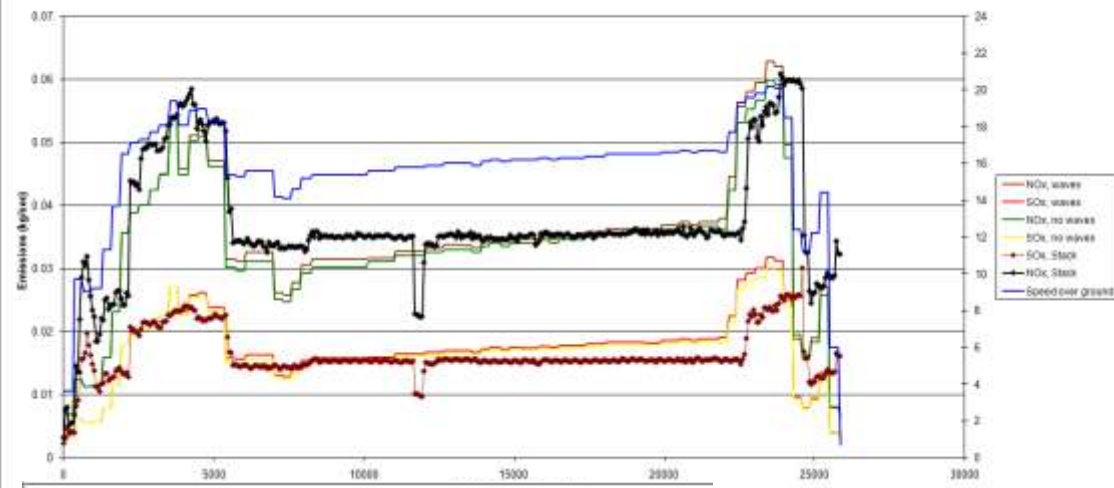


Emission model

- **STEAM (Ship Traffic Emission Assessment Model)**
- **Aim: General applicability, regardless of scale**
 - Local-Regional-Global
- **Vessel resistance modeling**
 - Sea ice
 - Currents
 - Waves
 - (Wind)
- **Emission abatement included**
- **Need to know what, where and on which engines these are installed**



J.-P. Jalkanen, L. Johansson, J. Kukkonen, A. Brink, J. Kalli, and T. Stipa, Extension of an assessment model of ship traffic exhaust emissions for particulate matter and carbon monoxide, *ACPD*, 11 (2011) 22129-22172.



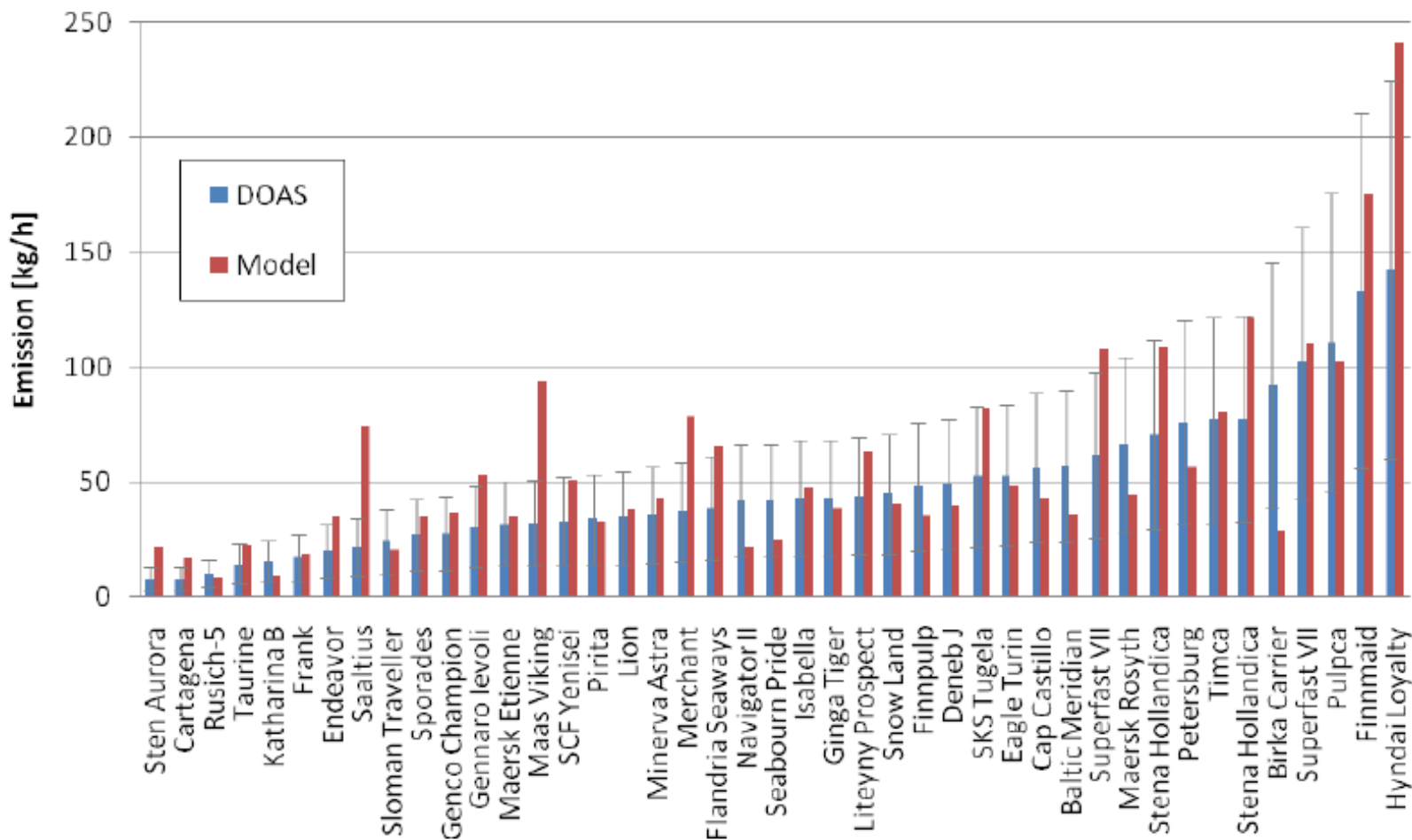
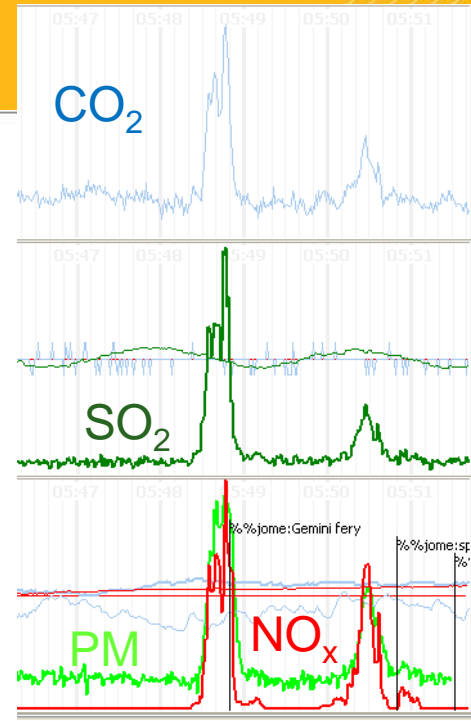
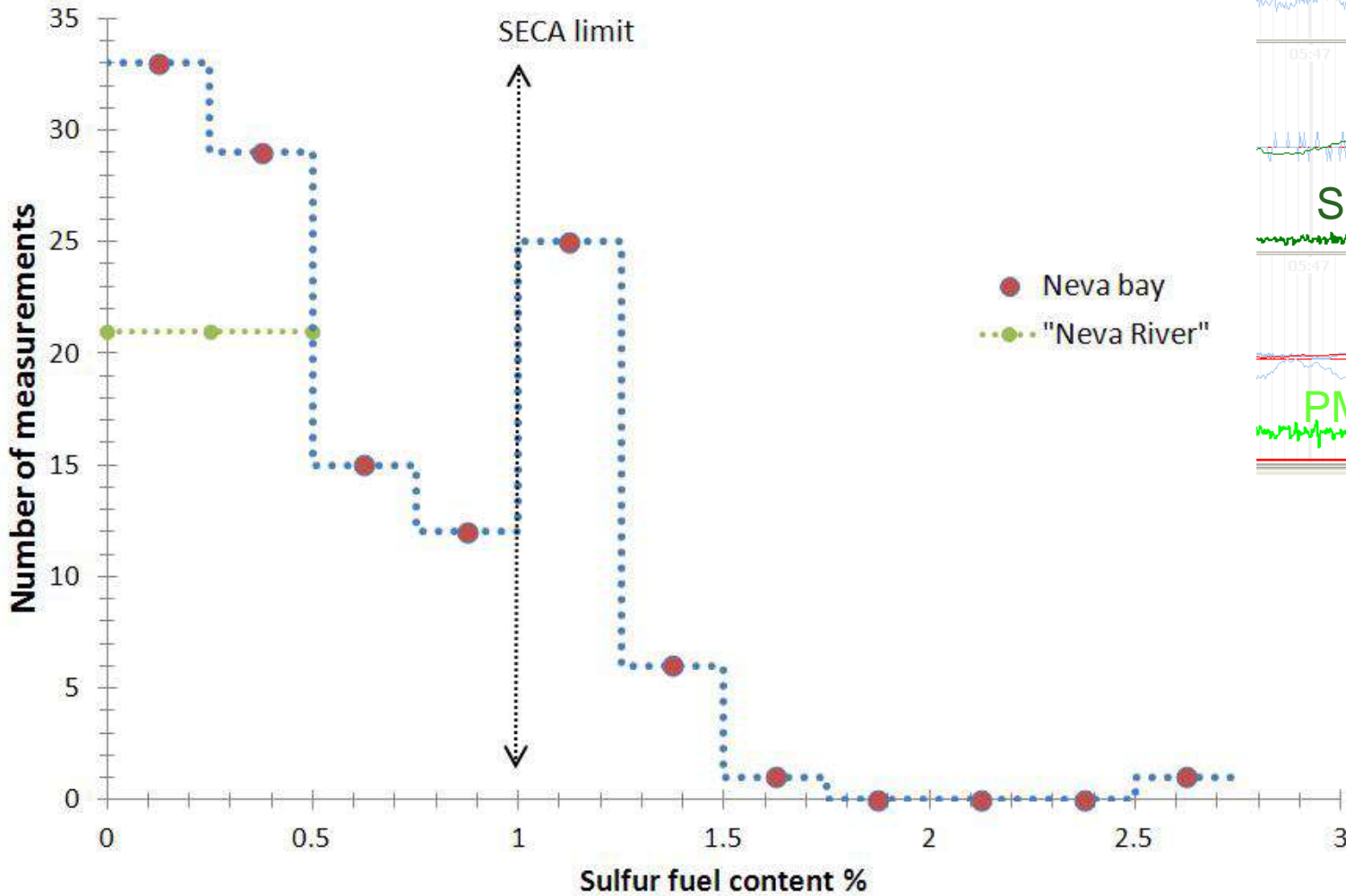


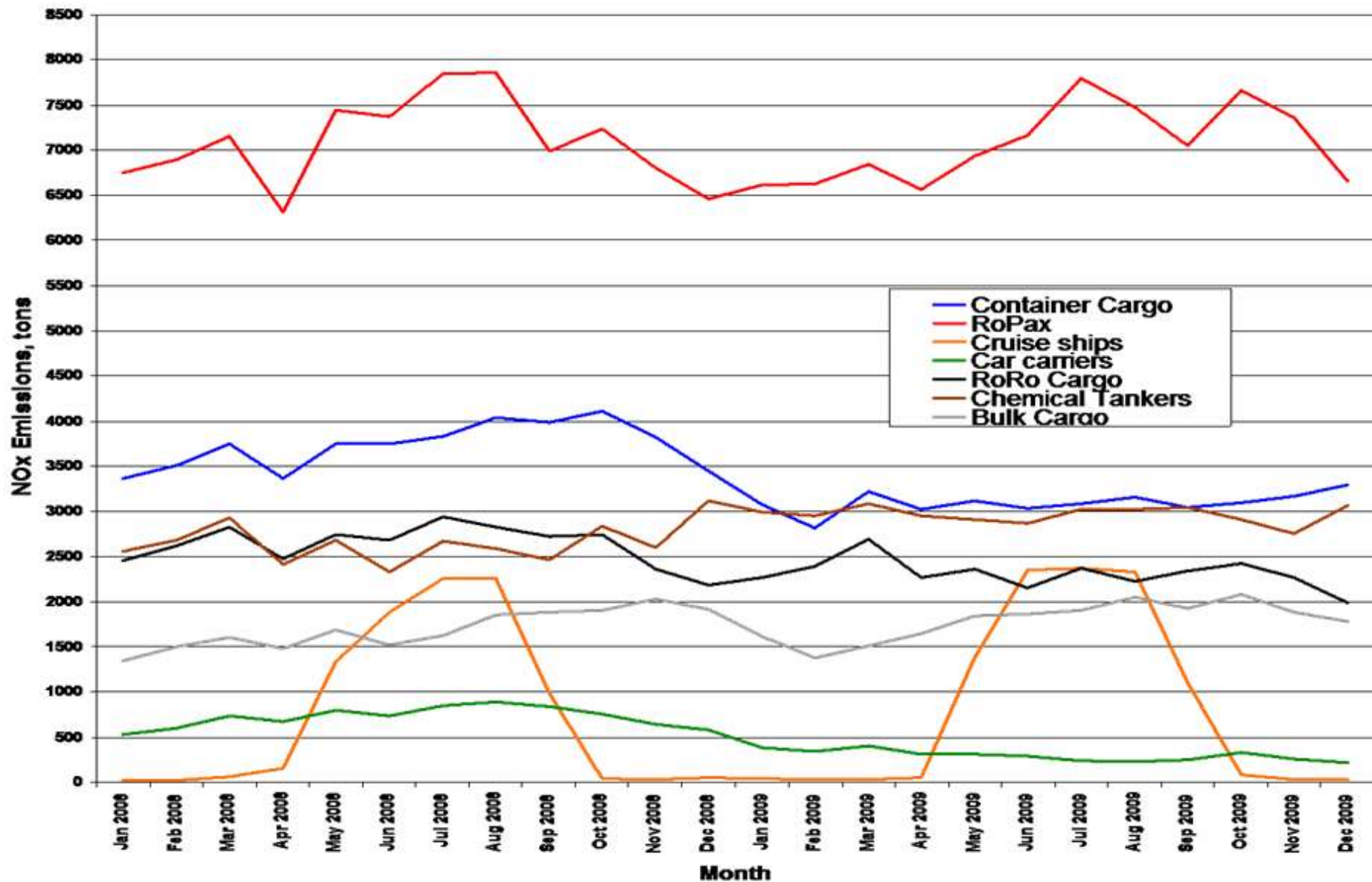
Fig. 13. Comparison of SO₂ emission rates obtained by optical measurements (DOAS) and the FMI-Steam model, for ships on the Baltic and North Sea during 2008 and 2009, respectively. The measurement error bars correspond to 40 % uncertainty.

Sulfur fuel content ,(preliminary)



BSR InnoShip, sulphur content of fuel in vessels close to St. Petersburg
(Chalmers Tekniska Högskolan, J. Mellqvist)

Benefit of (relatively) long time series of AIS





Emissions from Baltic Sea shipping, 2010

Key messages

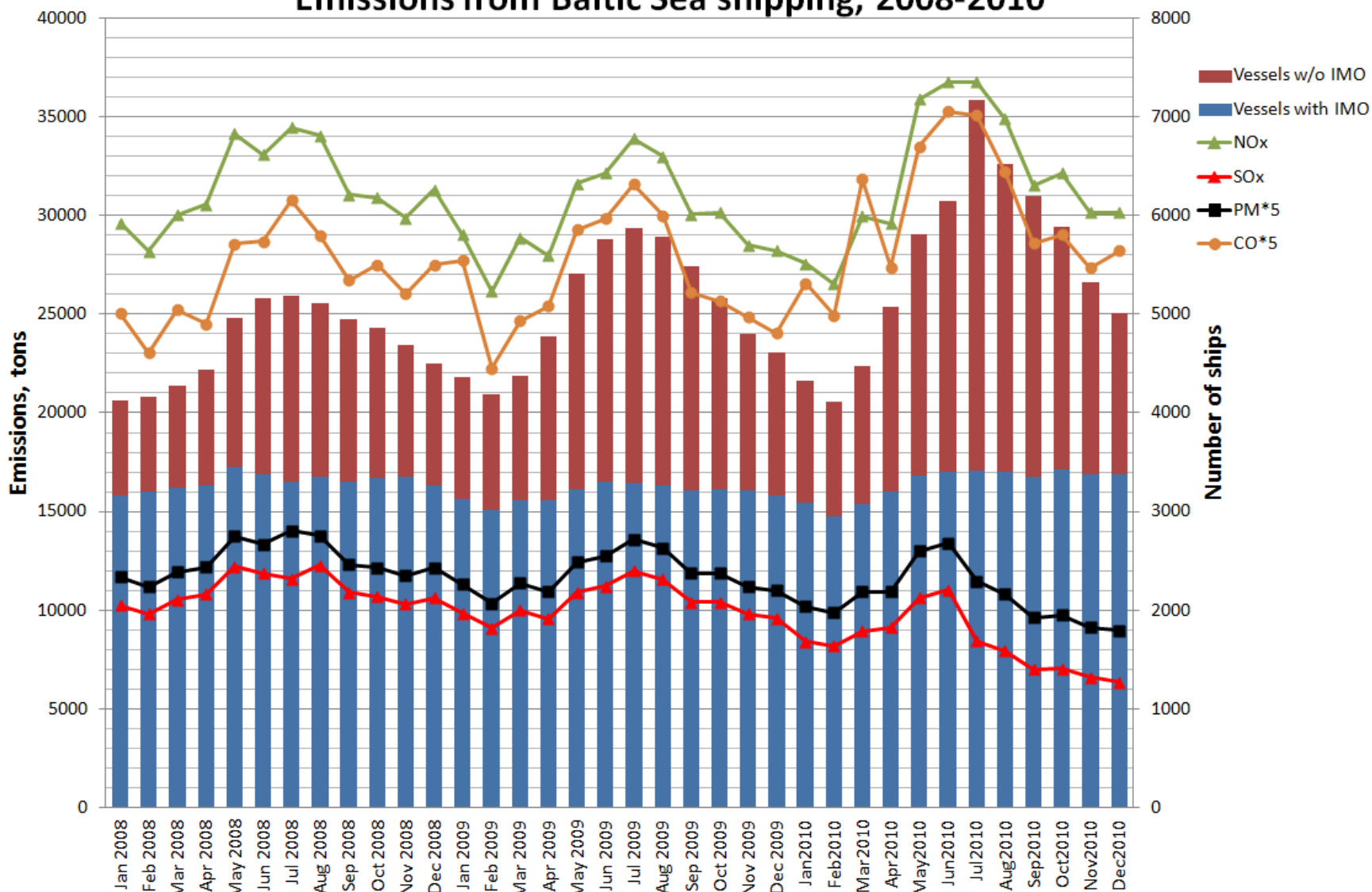
- **SO_x and particulate matter emissions from Baltic Sea shipping have decreased** by -20 % and -9.5 % to 99.5 and 25.6 kilotons.
 - **From the -20 % decrease in SO_x about one third is because of the requirement for 0.1 % S fuel use inside harbor areas.**
- Significant **increase** (+12 %) in carbon monoxide (CO) emissions was predicted because of a strong increase in the number of small vessels
- NO_x emissions have **increased** by +2.6 % to 382 kt, whereas the number of vessels has increased by +3.4 %.
 - **The NO_x emissions already surpass those before the 2008-2009 recession.**
 - Number of vessels in the Baltic Sea was 7632 (with an IMO registry number), but the number of small vessels was 2 753.
 - Increase of +3.4 % can be observed with the former and +48 % in the latter group.
- CO₂ emissions, fuel and energy consumption have all **increased** by 9 % and were 19.5 Mt, 6268 kt and 268 Petajoules.

Source: Lasse Johansson, Jukka-Pekka Jalkanen, Tapani Stipa *Finnish Meteorological Institute, "Baltic Sea ship emissions in 2010"*, HELCOM Indicator Fact Sheets 2011. Online. 30.11.2011, http://www.helcom.fi/environment2/ifs/en_GB/cover/.

Pollutant	2010	2009	Change
NO _x , kt	382.0	359.7	+2.6 %
SO _x , kt	99.5	124.3	-20.0 %
CO, kt	72.0	64.3	+12.0 %
PM*, kt	25.6	28.3	-9.5 %
of which			
Elementary Carbon, kt	2.6	2.4	+8.3 %
Organic Carbon, kt	6.6	6.2	+6.5 %
Ash, kt	1.9	1.7	+11.7 %
SO ₄ , kt	8.1	10.1	-19 %
Associated H ₂ O, kt	6.4	7.9	-19 %
CO ₂ , Mt	19.5	17.9	+9 %
Fuel, kt	6 268	5 734	+9 %
Energy use, PJ	268	245	+9 %
Vessels with IMO number	7 638	7 384	+3.4 %
Small vessels, no IMO number	2 753	1 862	+48 %

* Note, that subspecies of PM should not be added together with total PM emissions, but are alternative to each other.

Emissions from Baltic Sea shipping, 2008-2010



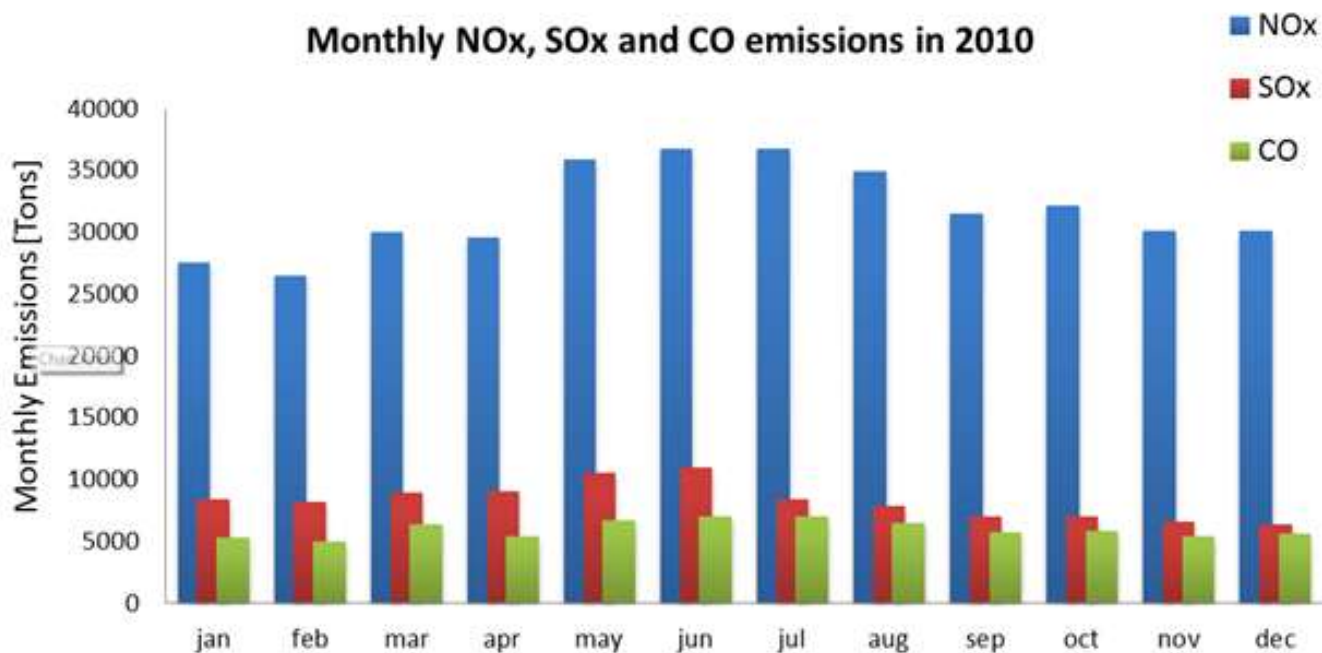
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Finnish Meteorological Institute, "Baltic Sea ship emissions in 2010", HELCOM Indicator Fact Sheets 2011. Online. 30.11.2011

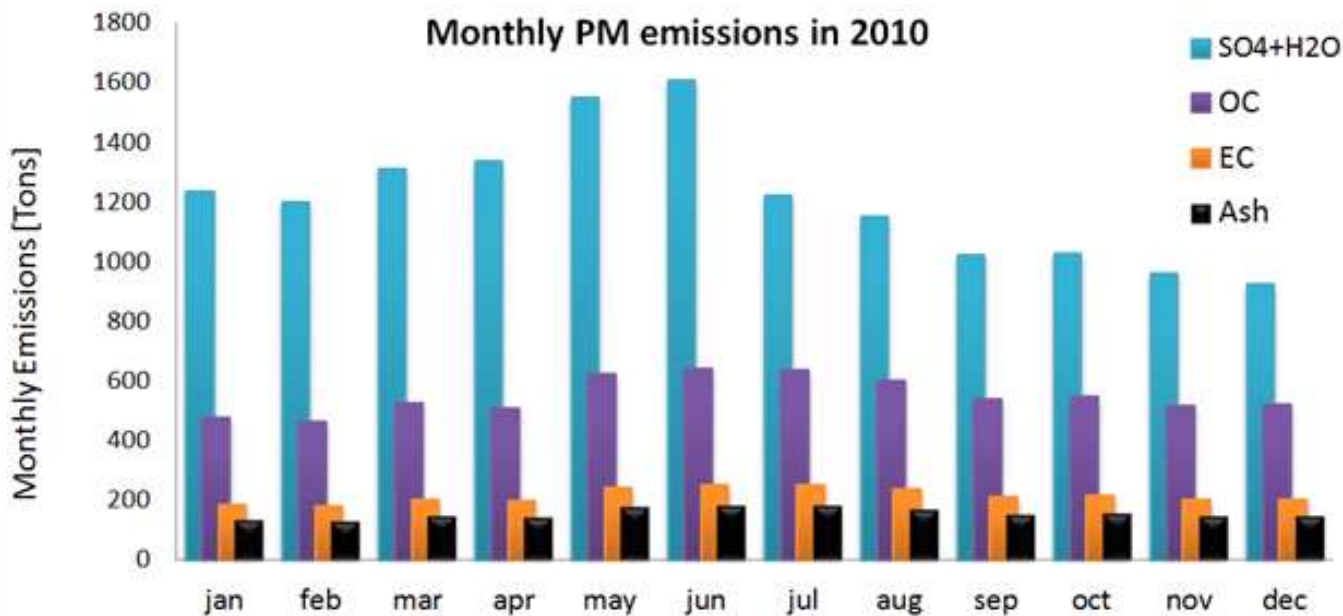


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Monthly NOx, SOx and CO emissions in 2010

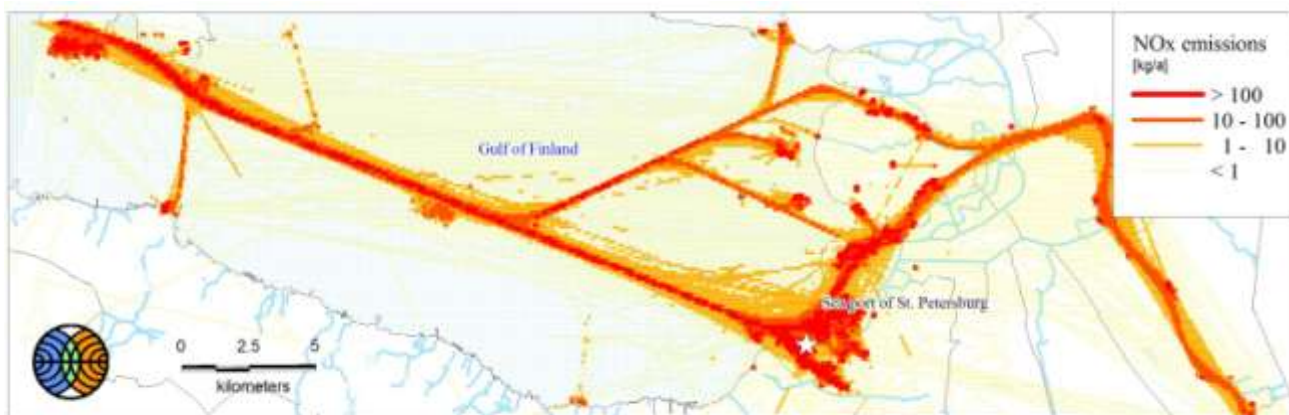


Monthly PM emissions in 2010





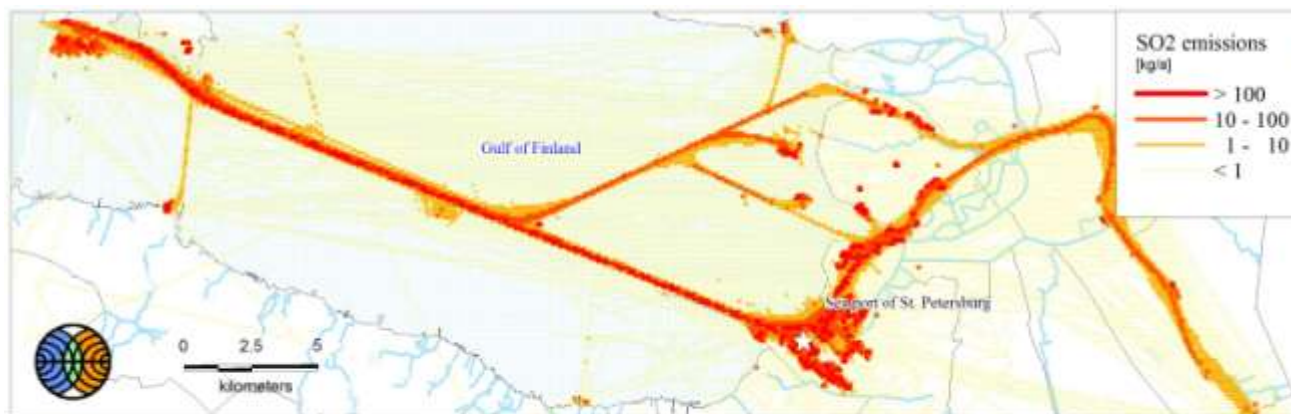
Example: St. Petersburg area, 2009



Finnish Meteorological Institute 2011

☆ = maximum = 100 tons/a

NO_x



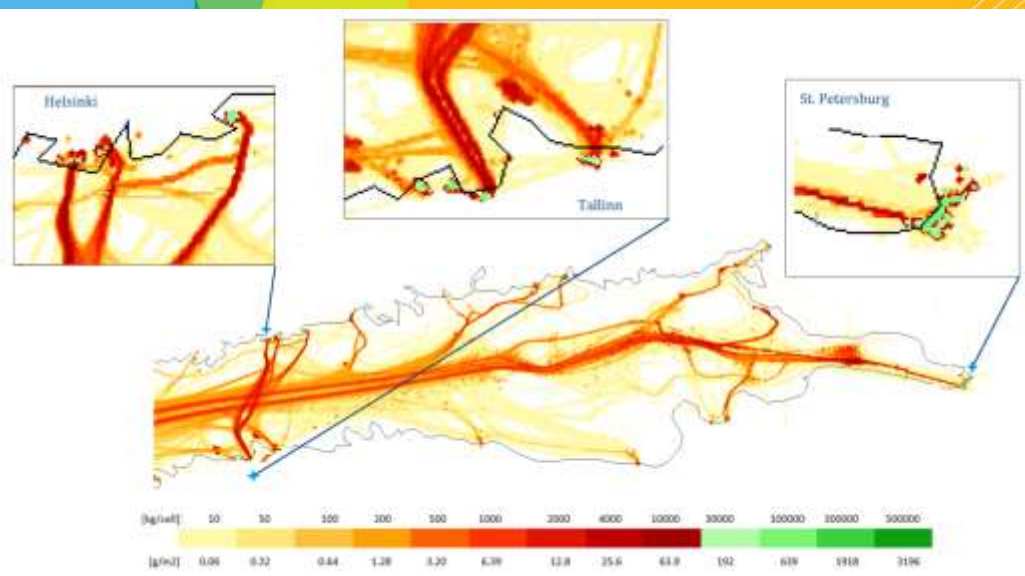
Finnish Meteorological Institute 2011

☆ = maximum = 34 tons/a

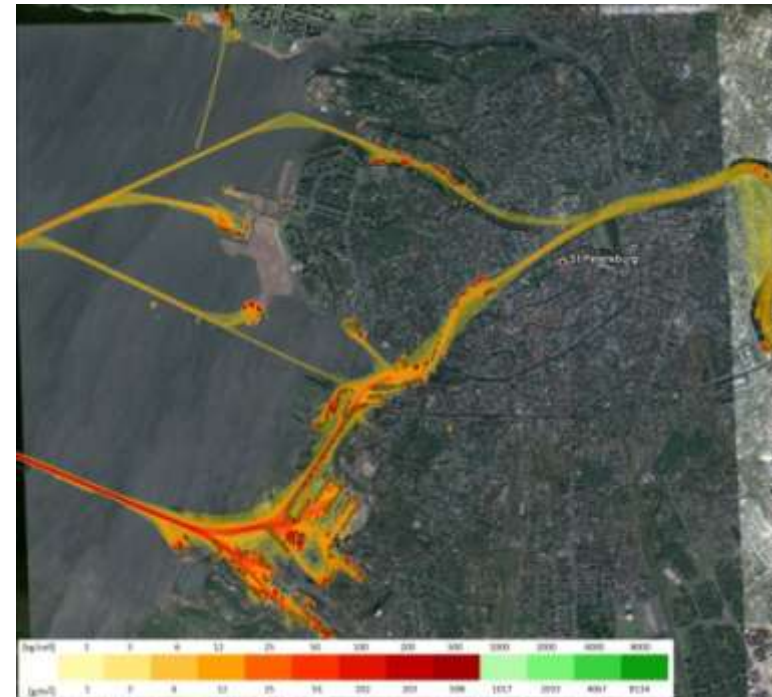
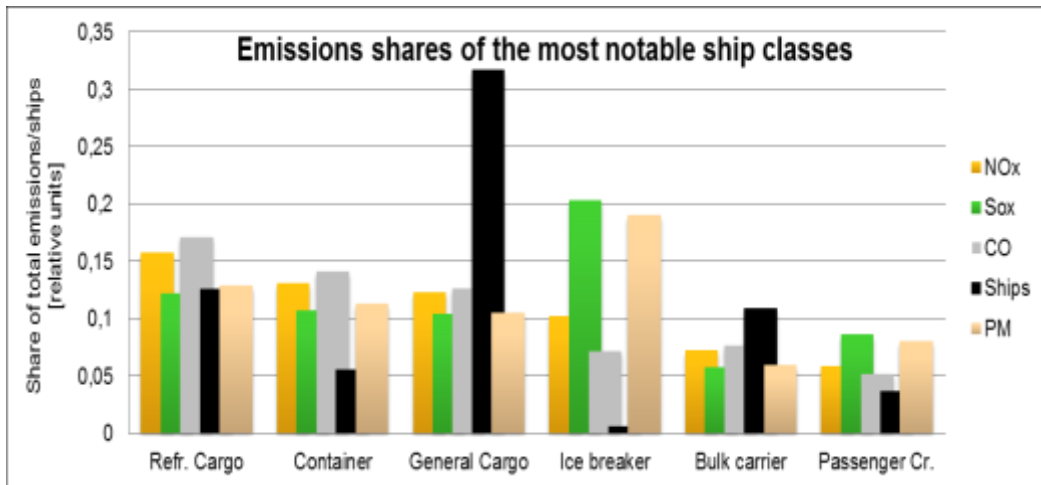
SO_x



Example: St. Petersburg, 2009



	Main Fuel	Aux Fuel	NOx	SOx	Organic C	Elemental C	Ash	SO4	CO	Travel	CO2	Ships
STEAM	22 000t	92 700t	6 170t	1 540t	130t	43t	32t	206t	1 930t	782 000km	351 000t	1865
Russian study			7 970t	1 500t					1 140t			





Thank you

Contact information

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