Institute of Coastal Research

Research Unit *Biogeochemistry in Coastal Seas*

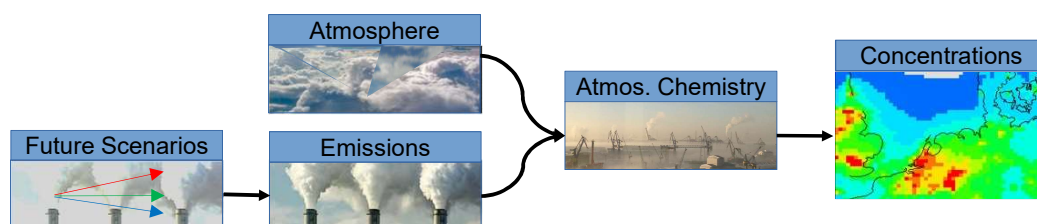## How shipping impacts coastal air quality
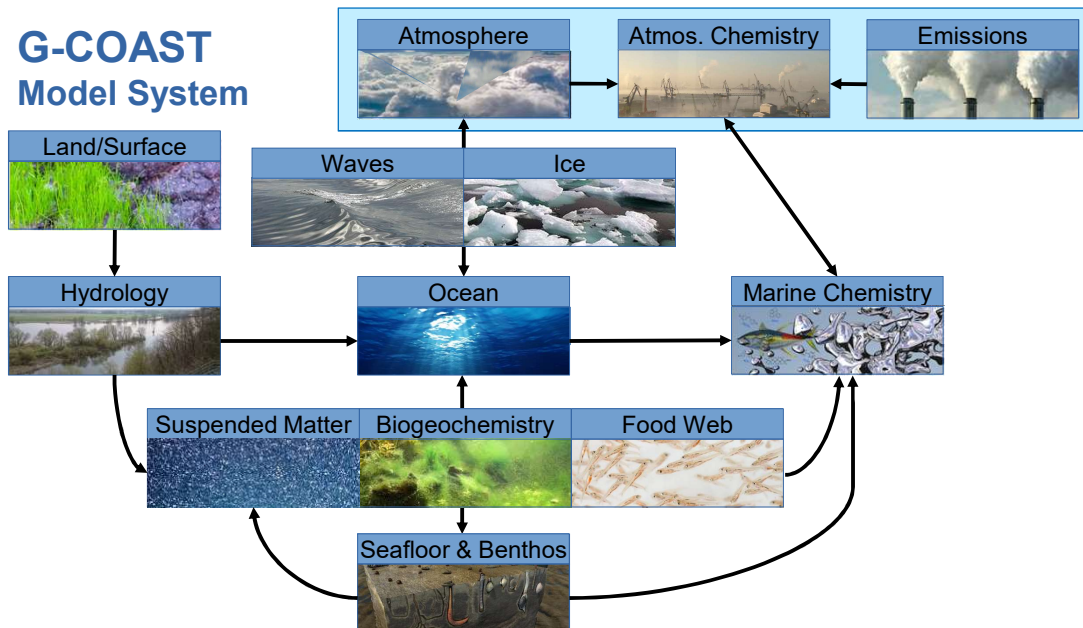
Dr. Volker Matthias

RU 2   Topic 2

Introduction

- North European coasts are intensively used areas

- Pressures arise from emissions to air
  - poor air quality
  - deposition of acidifying and eutrophying substances

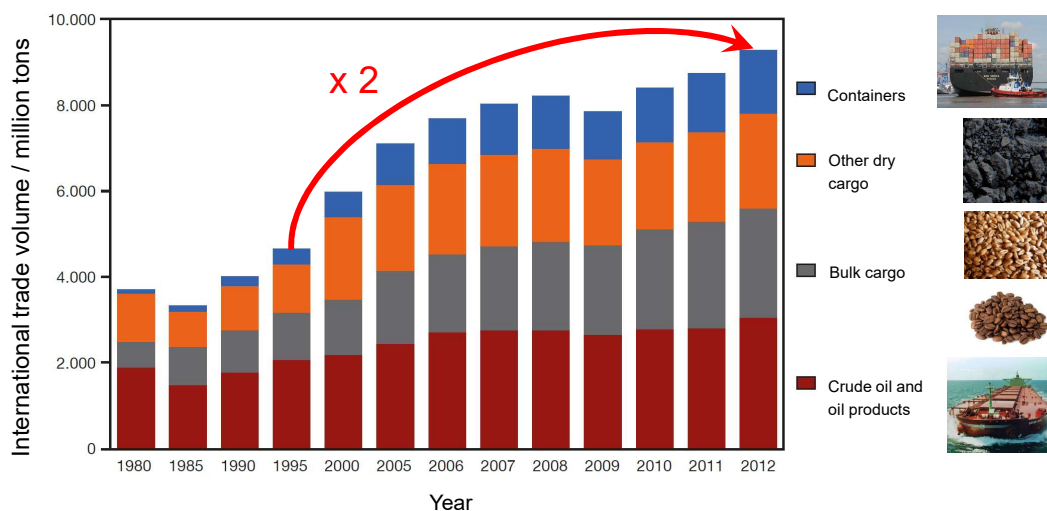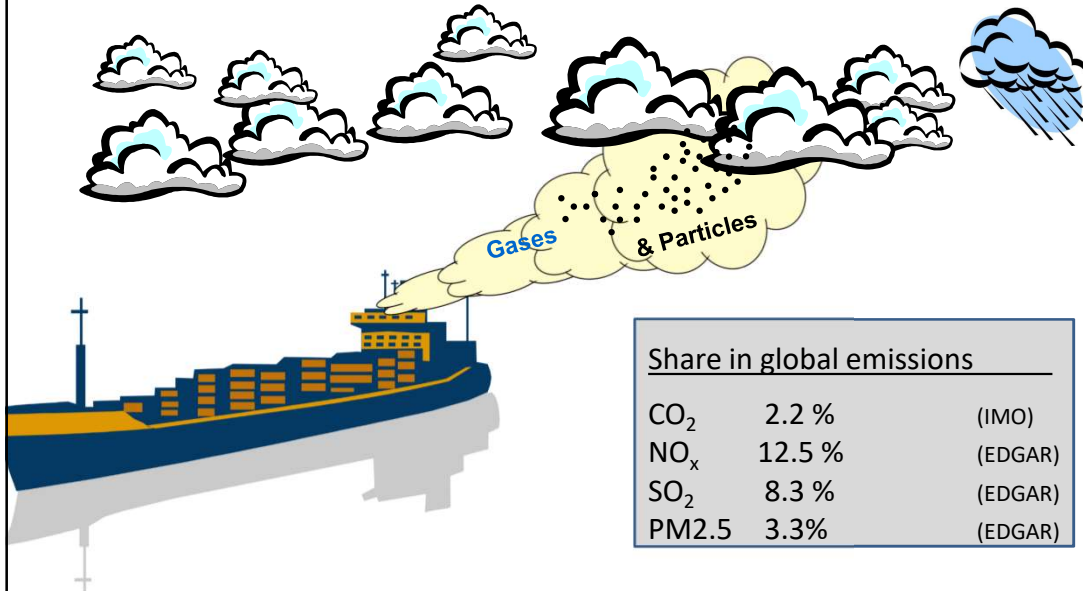- The impact is studied with state of the art modelling systems

Atmosphere → Atmos. Chemistry → Concentrations

Future Scenarios → Emissions →

Atmospheric chemistry in G-COAST

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

G-COAST Model System

Atmosphere — Atmos. Chemistry ← Emissions

Land/Surface

Waves — Ice

Hydrology — Ocean — Marine Chemistry

Suspended Matter — Biogeochemistry — Food Web

Seafloor & Benthos

Global transport with ships

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Centre for Materials and Coastal Research

90 – 95 % of the international trade by ships

x 2

International trade volume / million tons

Containers
Other dry cargo
Bulk cargo
Crude oil and oil products

Year

Source: WBGU (2013)

Shipping emissions

Gases & Particles

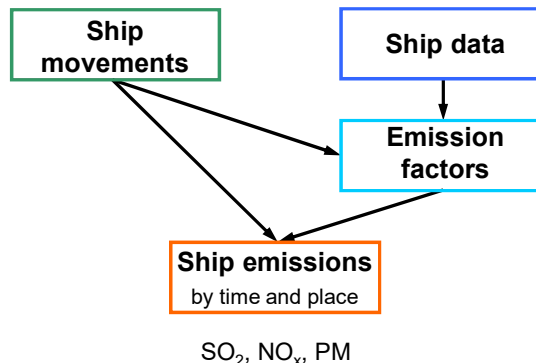| Share in global emissions		
CO_2	2.2 %	(IMO)
NO_x	12.5 %	(EDGAR)
SO_2	8.3 %	(EDGAR)
PM2.5	3.3%	(EDGAR)

Emissions in North and Baltic Seas

Example for 2012, acc. to EMEP
(in kt per year)

Ships

on North and Baltic Sea

North Sea

Baltic Sea

Industry, Residential, Traffic

in Germany

NOx   SOx

915   232

1271   381
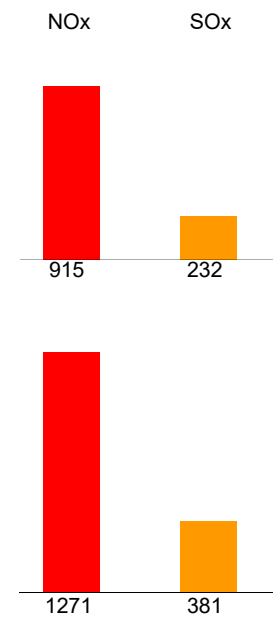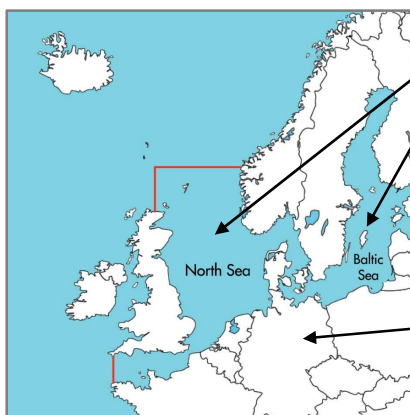
Inventory construction

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Base Case
Port areas
NOx Emission
t / a
- 0
- 0 - 100
- 100 - 250
- 250 - 500
- 500 - 750
- 750 - 1.000
- 1.000 - 2.500
- 2.500 - 5.000
- 5.000 - 6.500

Ship movements

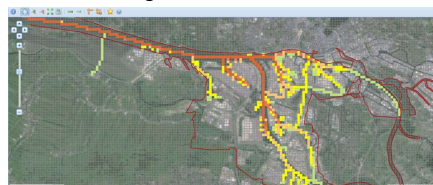Ship data

Emission factors

Ship emissions
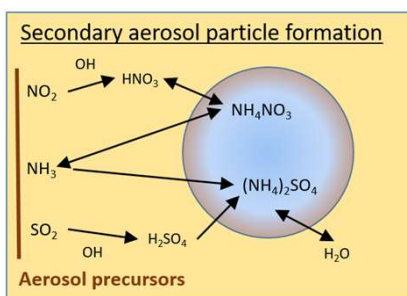by time and place

SO_2, NO_x, PM
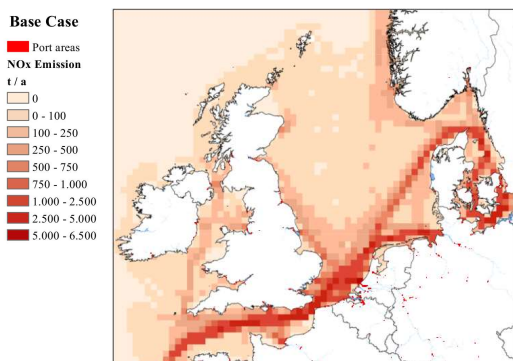
- Emission inventories for the sea and for ports
- Use of AIS ship position data
- Scenario construction (Emission control areas)
- Cooperations with BSH and Hamburg Port

Port of Hamburg

Aulinger et al., 2016

The role of ammonia in particle formation

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Secondary aerosol particle formation

NO_2 → (OH) → HNO_3 → NH_4NO_3

NH_3

SO_2 → (OH) → H_2SO_4 → $(NH_4)_2SO_4$ → H_2O
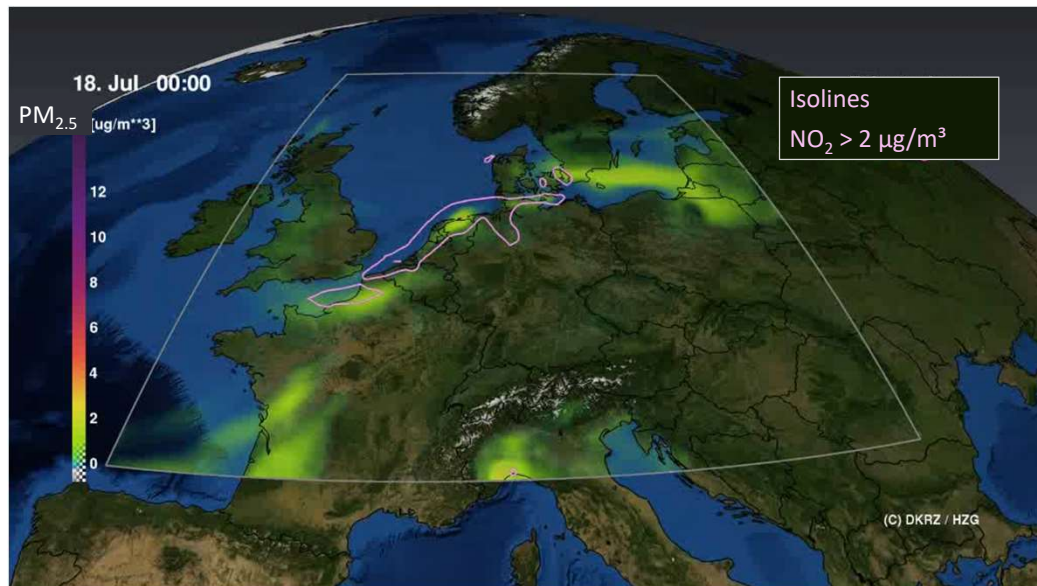
Aerosol precursors

- Ammonia is a key player in secondary aerosol formation ($PM_{2.5}$)
- High emissions around the North Sea
- Development of detailed spatio-temporal profiles for ammonia emissions
- Improved CTM results compared to observations

Spring   Summer   Autumn   Winter

t/ season
- 200
- 350
- 500
- 650
- 800
- 1000
- > 1000
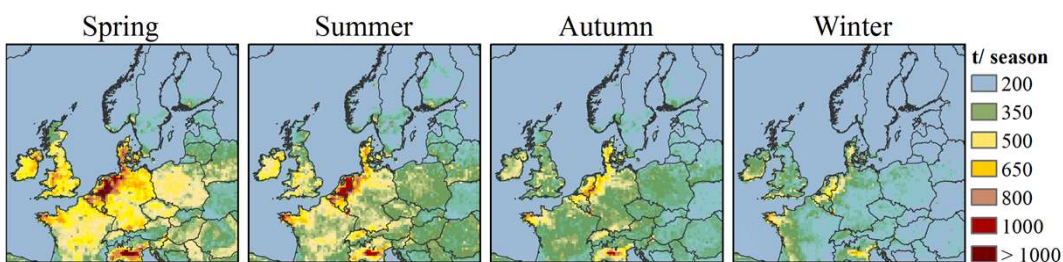
Seasonal dependence of ammonia emissions

Backes et al., 2016

NO$_2$ and PM$_{2.5}$ from shipping

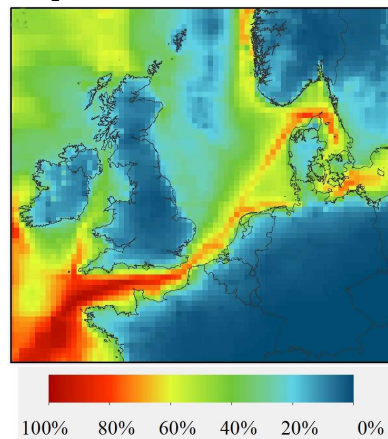## NO$_2$ from shipping

Results from a CMAQ simulation for summer 2011

Aulinger et al., 2016

NO$_2$ from shipping

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Results from a CMAQ simulation for summer 2011

Contribution of shipping to
NO$_2$ concentrations

100% 80% 60% 40% 20% 0%

Aulinger et al., 2016

Changes in NO$_2$ from shipping

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Results from a CMAQ simulation for summer 2011 and summer 2030
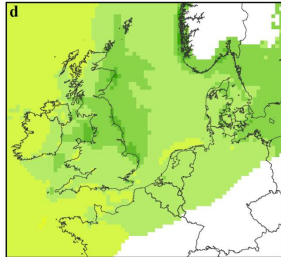
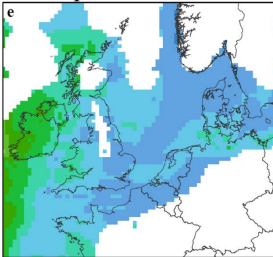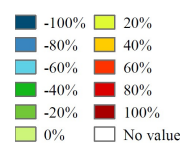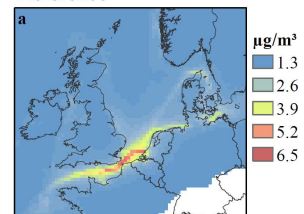No ECA
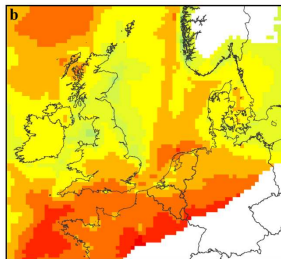
ECA 21
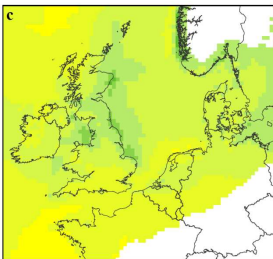
- Higher NO$_2$ from shipping in 2030 for NoECA and ECA 21
- Only full implementation of regulations will result in significant concentration reductions

- Cooperation with DNV-GL
- Influence on IMO decision for NECA in North and Baltic Sea in 2021

ECA 16

ECA opt

Reference

		µg/m³
-100%	20%	1.3
-80%	40%	2.6
-60%	60%	3.9
-40%	80%	5.2
-20%	100%	6.5
0%	No value	

Matthias et al., 2016

Interaction with stakeholders and the public

- Common projects with ports, authorities and (shipping) business partners
- Organized stakeholder dialogue
- Presenting science to the public
- Appearance in newspapers, radio and TV
- Make results available via coastMap

Related topics

- Emissions from the transport sector
- Harbour emissions and air quality in harbour cities
- Comparison of shipping impacts in Europe and China
- Agricultural emissions and the N-cycle
- The role of natural emissions for coastal air quality

Poster