Modellierung der atmosphärischen Deposition von partikulär gebundenem Stickstoff und Schwefel in deutschen Küstenregionen unter besonderer Berücksichtigung von Schiffsemissionen

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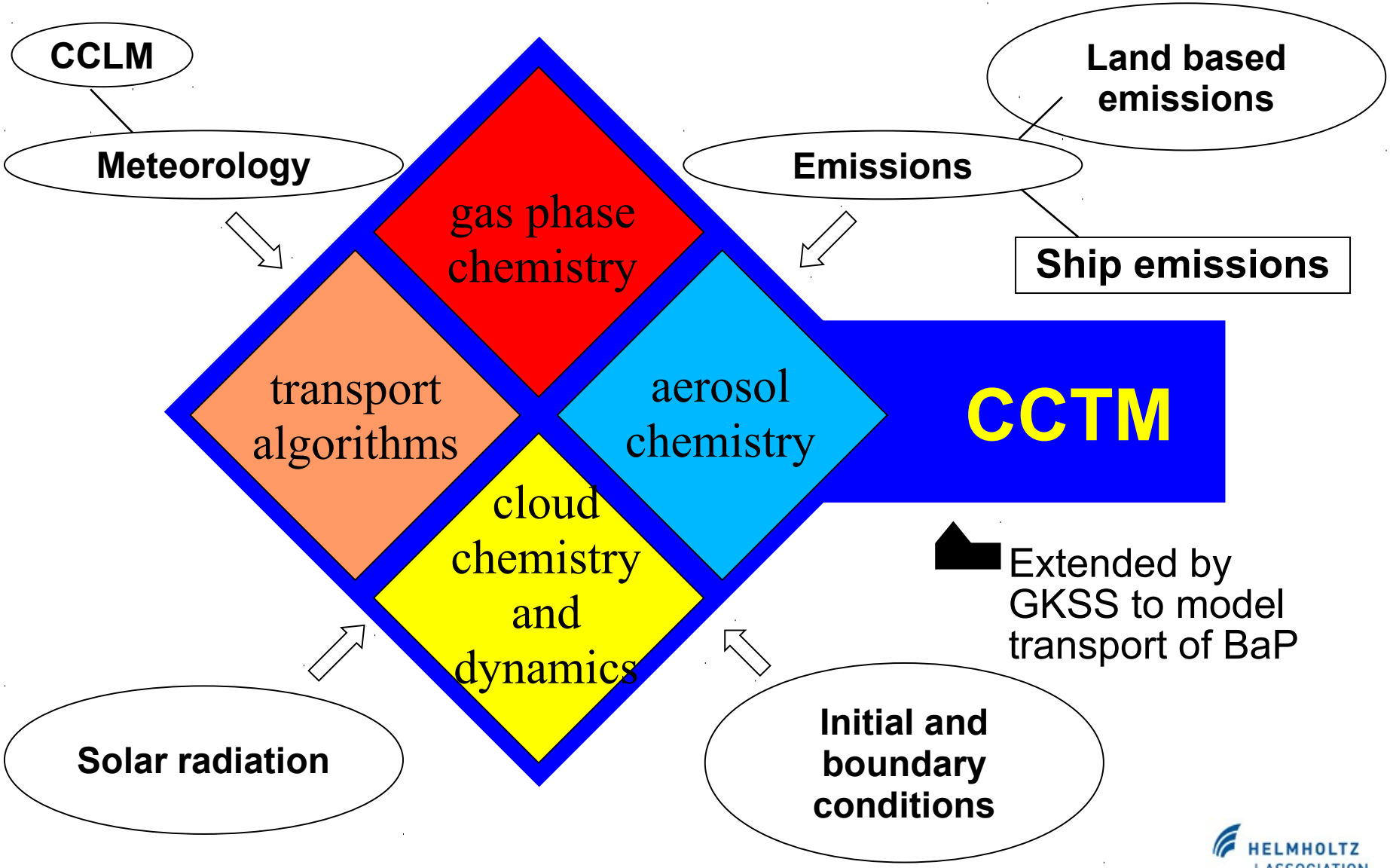
Motivation

- Schiffe stellen die billigste Möglichkeit dar, Güter über weite Strecken zu transportieren.
- Mehr als 90% aller Güter weltweit werden mit Schiffen transportiert mit einer jährlichen Zunahme von ca. 3%.
- Schiffe benutzen niederwertigen Treibstoff mit hohem Schwefelgehalt (Schweröl)
- Schiffe haben möglicherweise in einigen Regionen einen hohen Einfluß auf die Luftqualität und Depositionen von Säurebildnern und Nährstoffen

Überblick

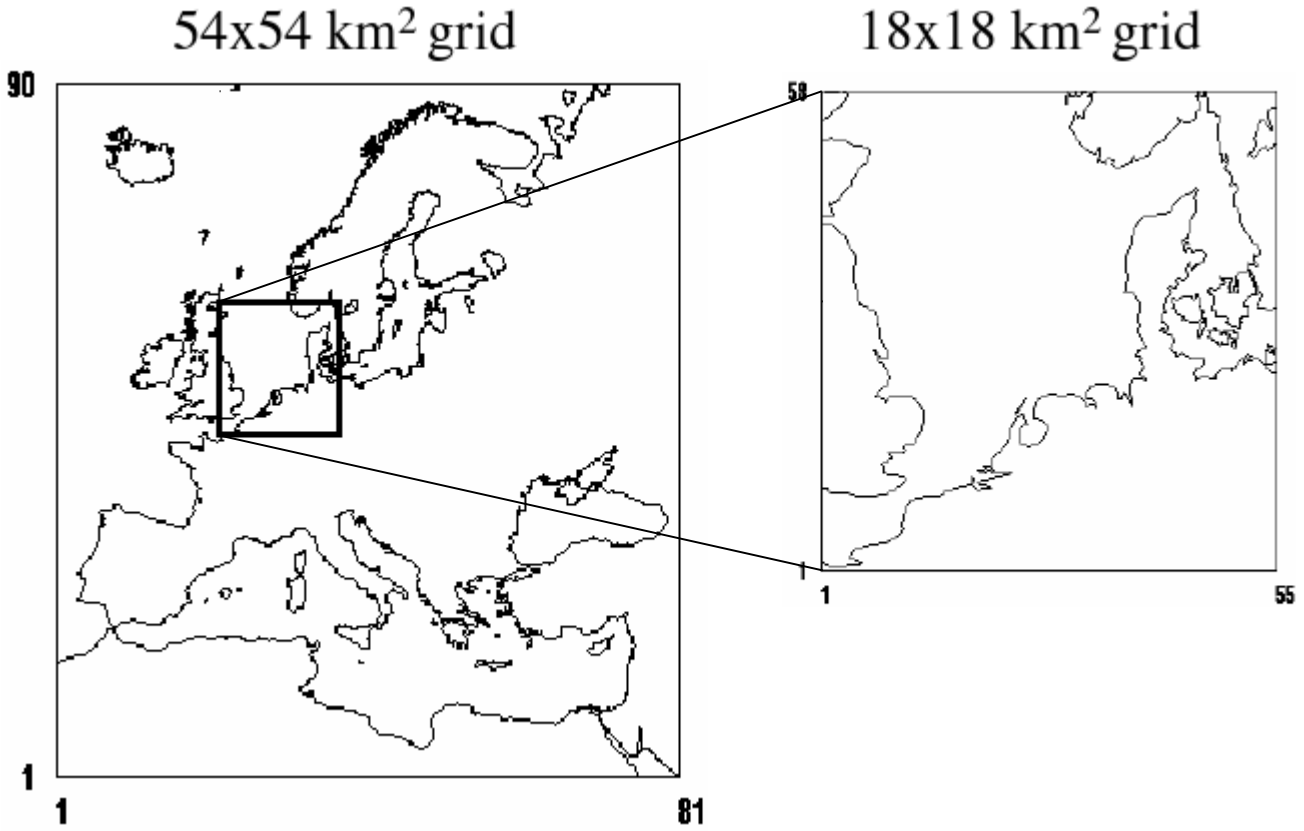
- Model System
- Schiffsemissionen
- Luftverschmutzung in Küstenregionen
- Depositionen
- Effekt von Schwefelreduktion im Treibstoff
- Zusammenfassung

CMAQ Modelling System



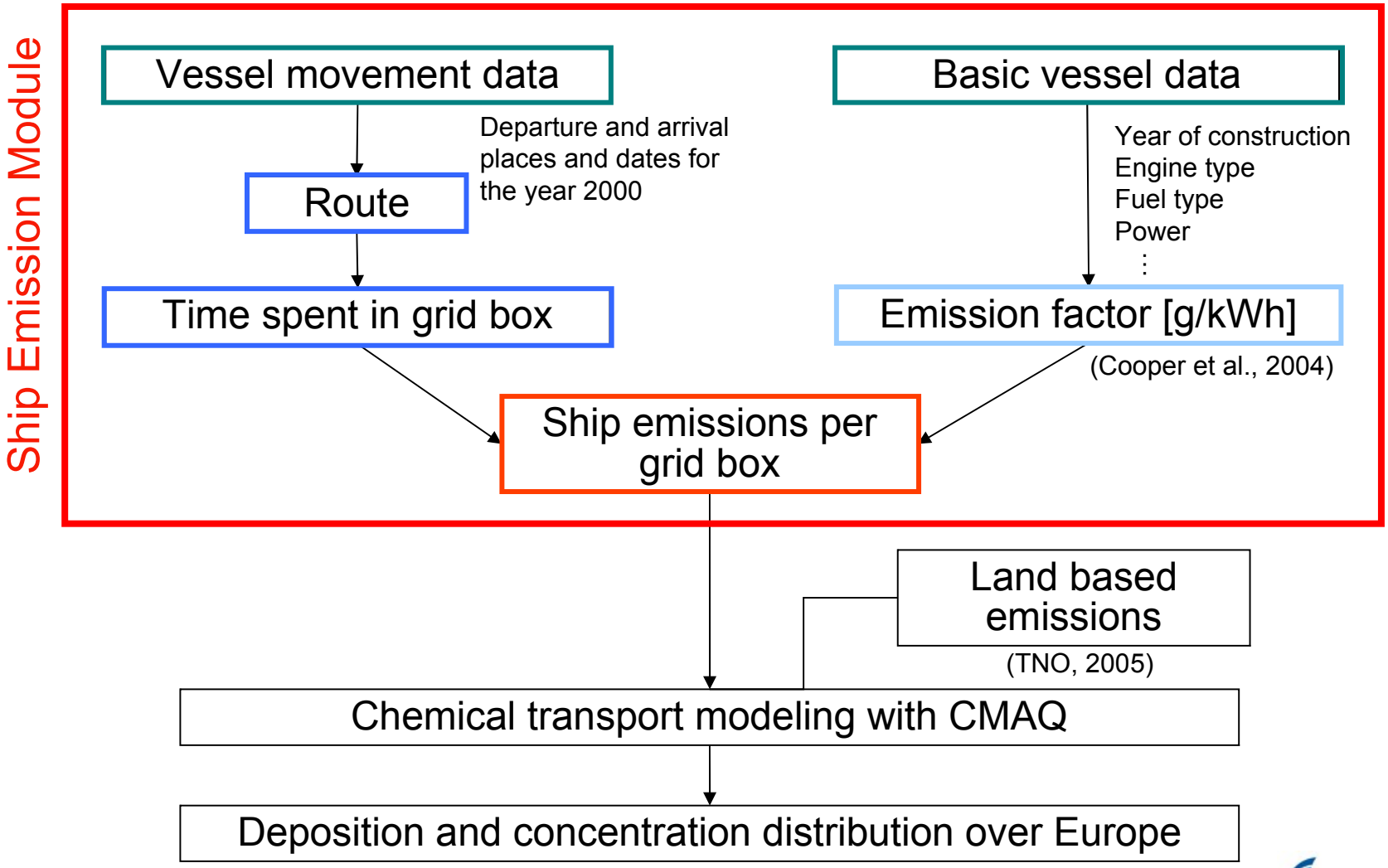
Model and Setup

Model domain:



- 30 vertical layers up to 100 hPa

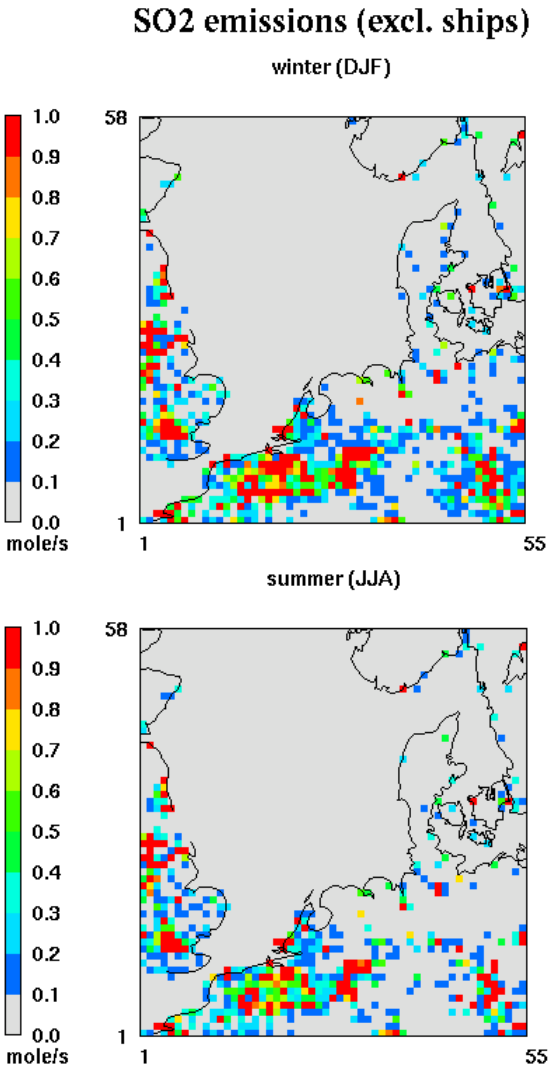
Calculation of ship emissions in NW Europe

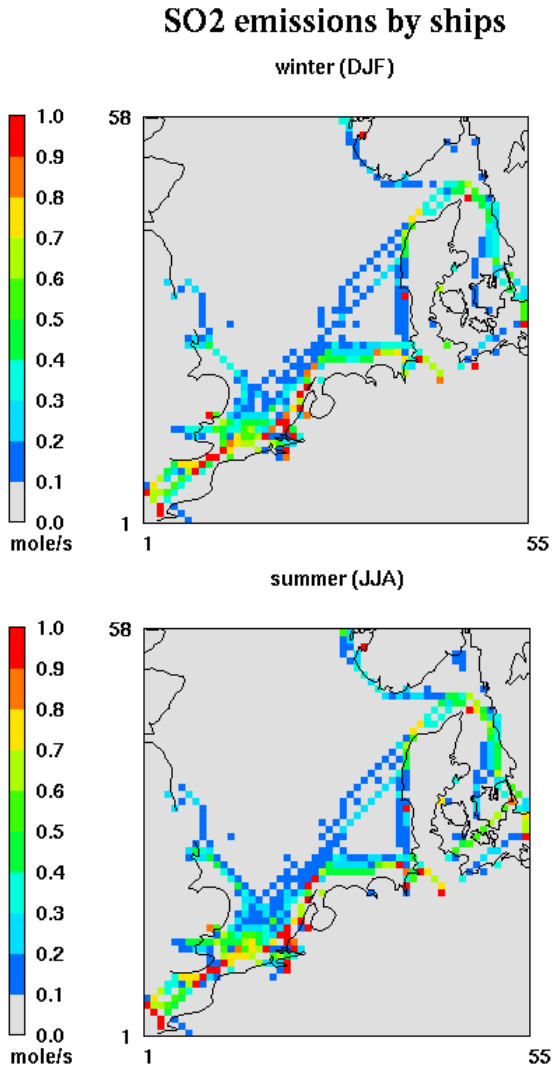


Emissions

$SO_{2,}$ NO_x

SO_2 emissions

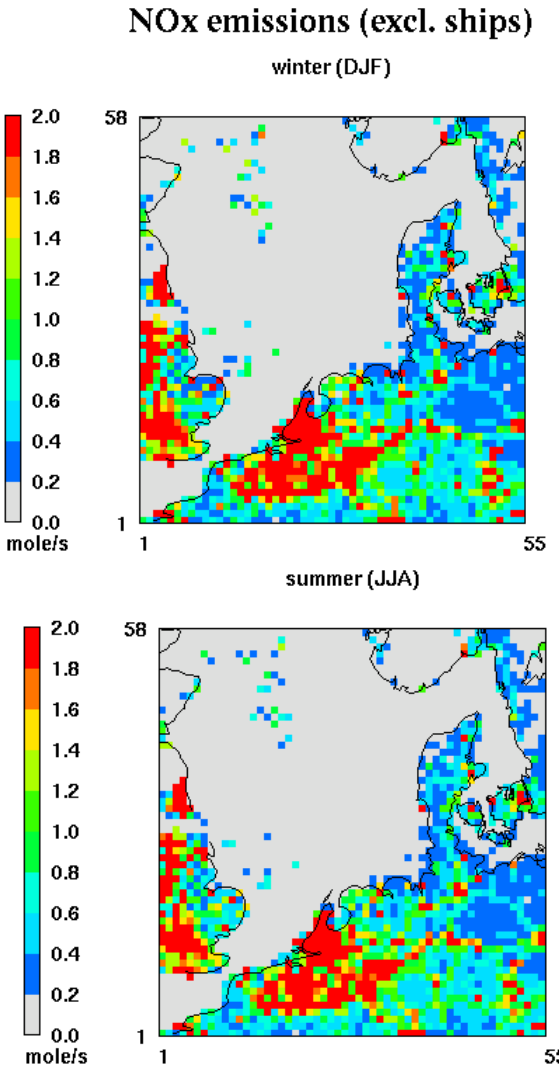


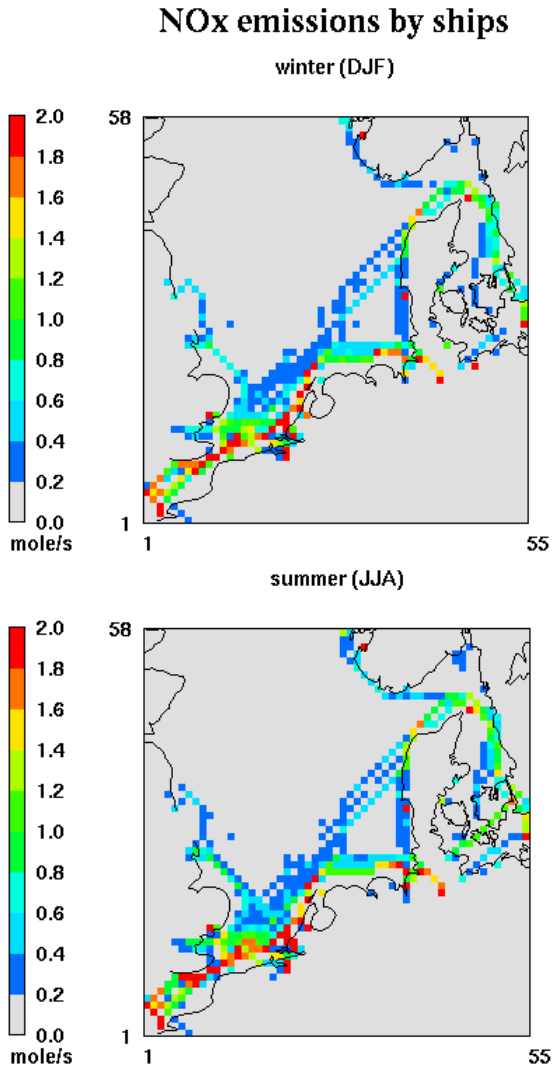


+19 %

+30 %

NO_x emissions





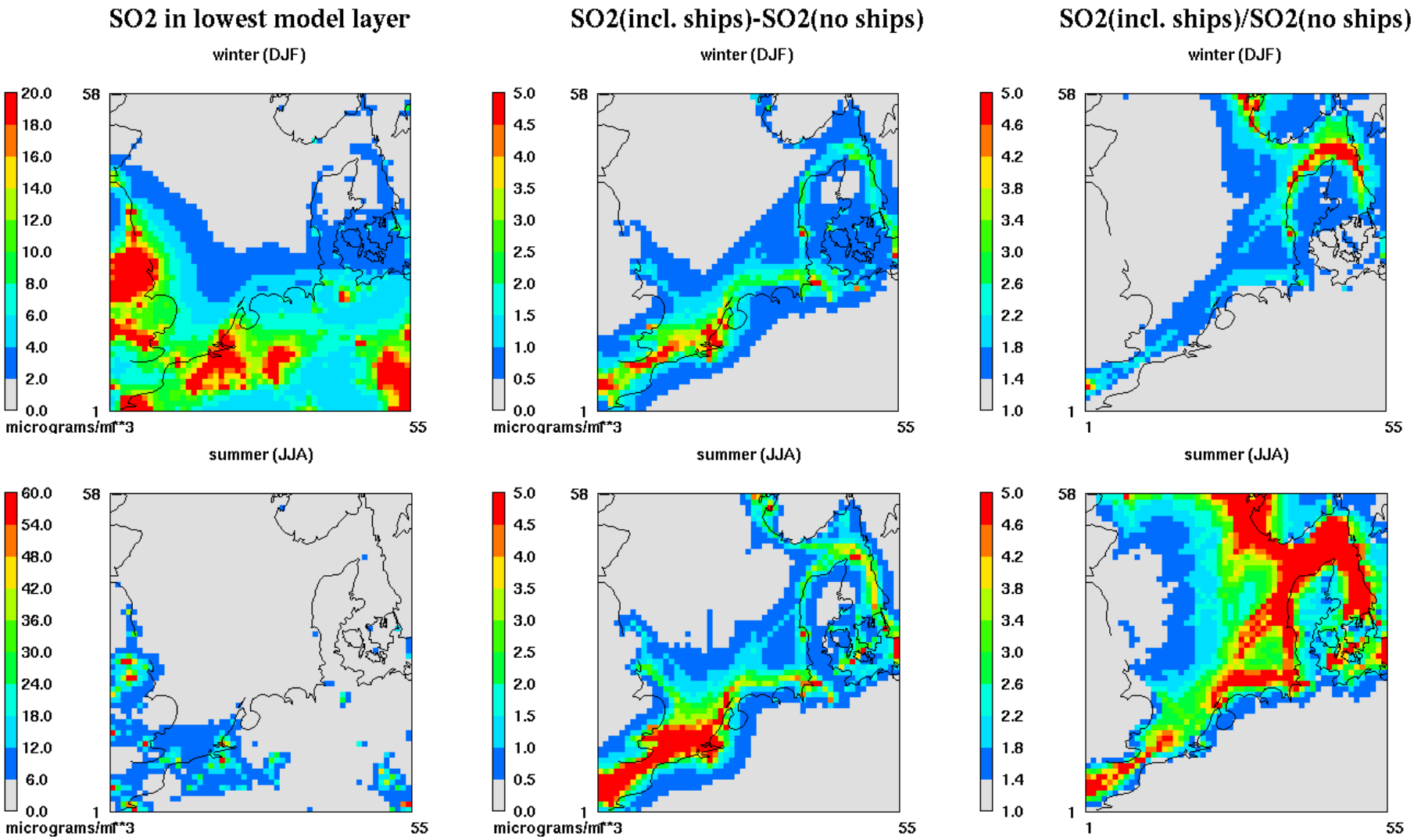
+18 %

+23 %

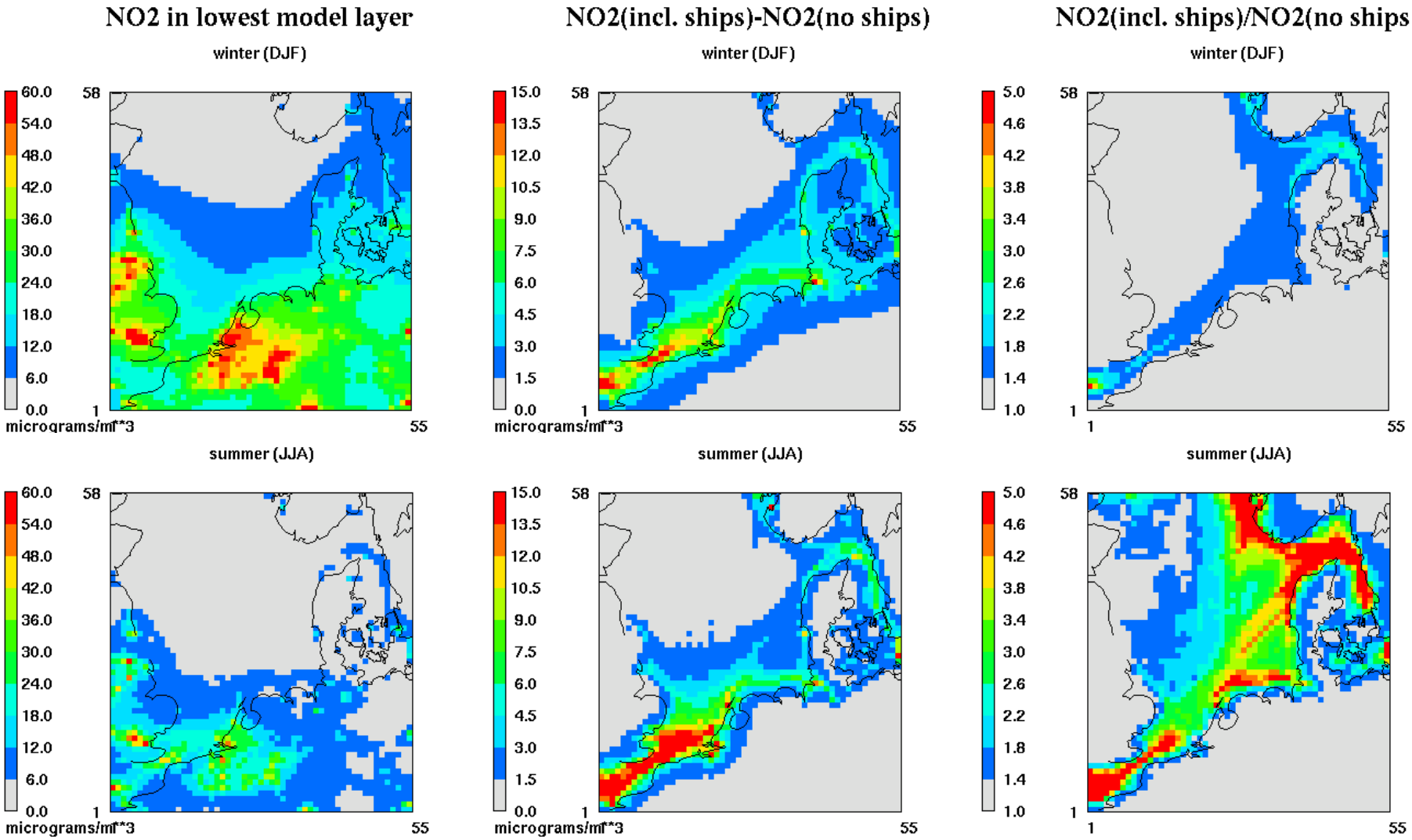
Concentrations (gases)

SO_2, NO_2

SO_2 concentration



NO_2 concentration



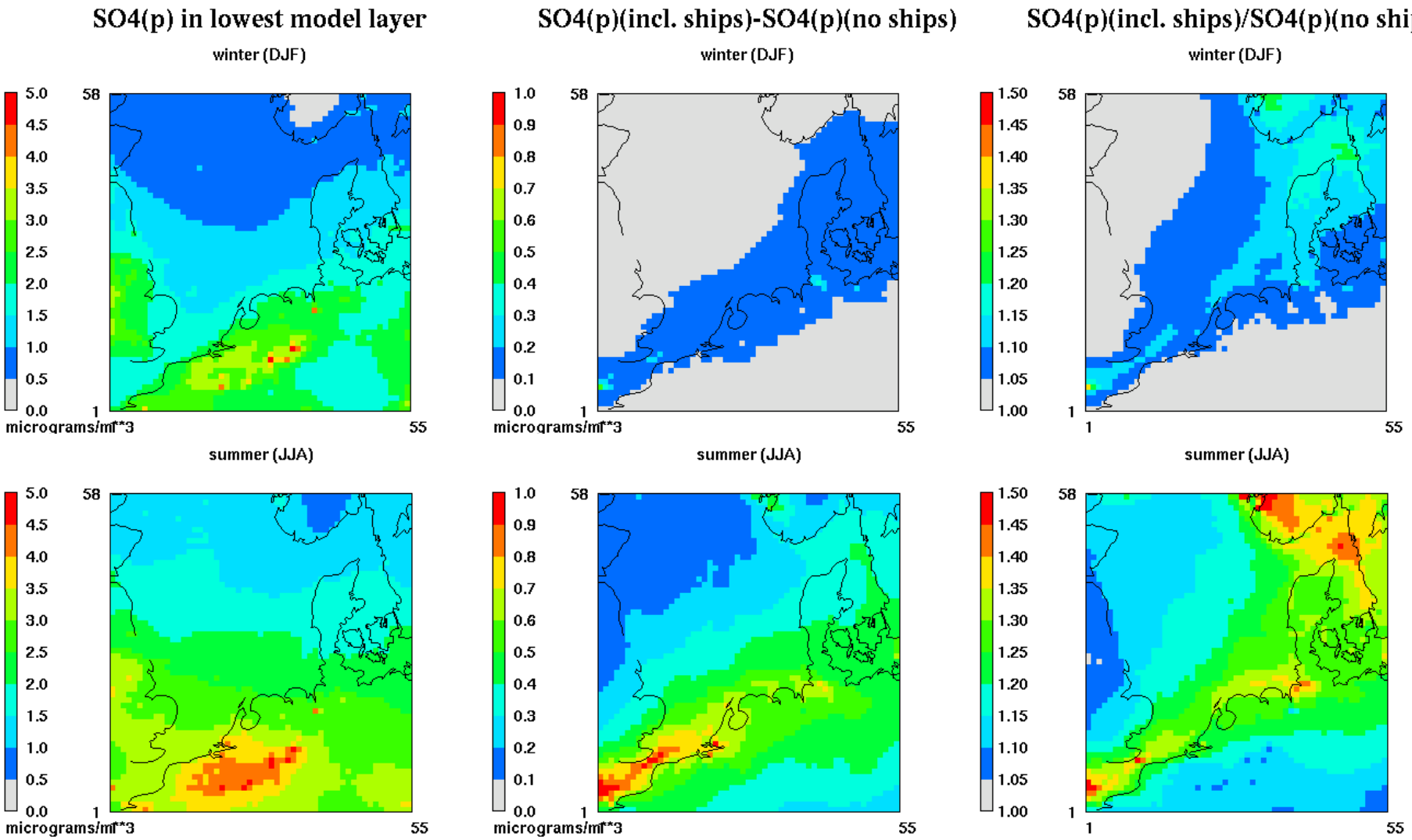
Concentration (aerosols)

Sulfate

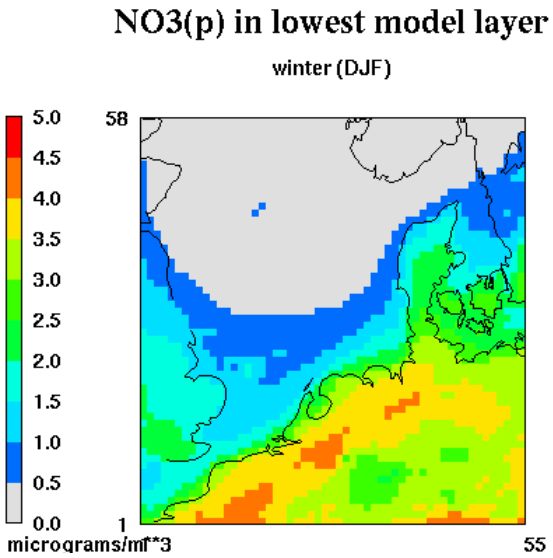
Nitrate

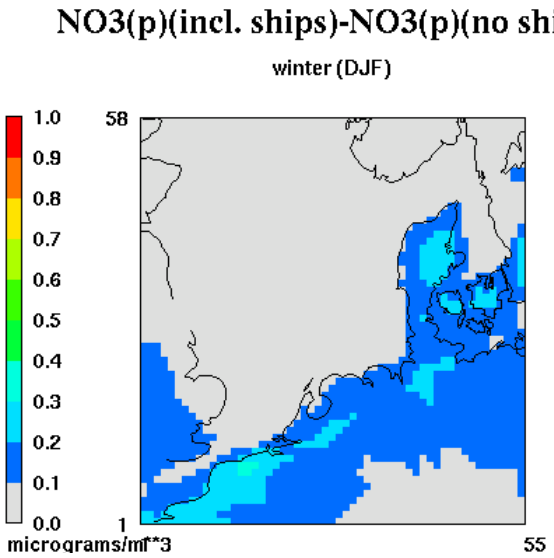
Ammonium

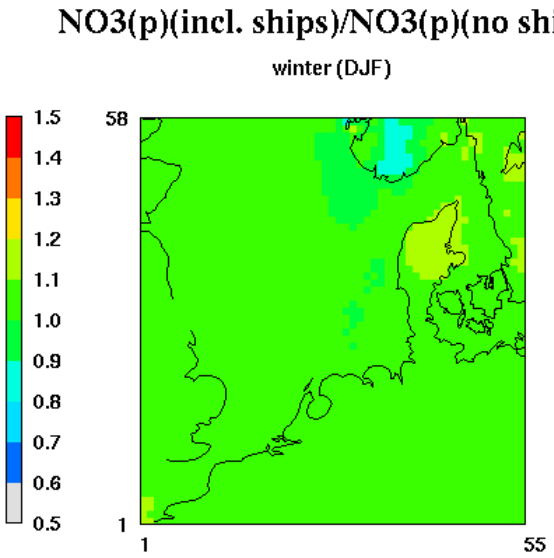
Sulfate aerosol concentration

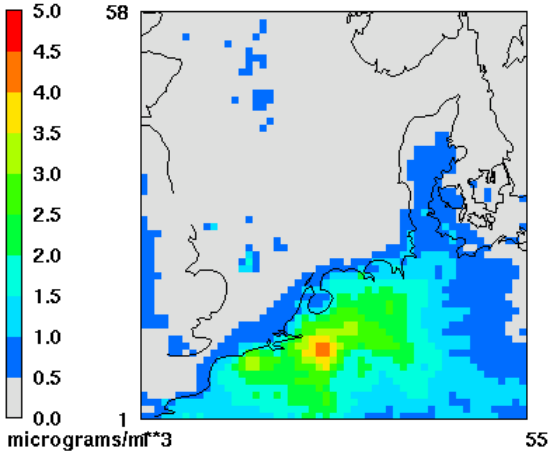


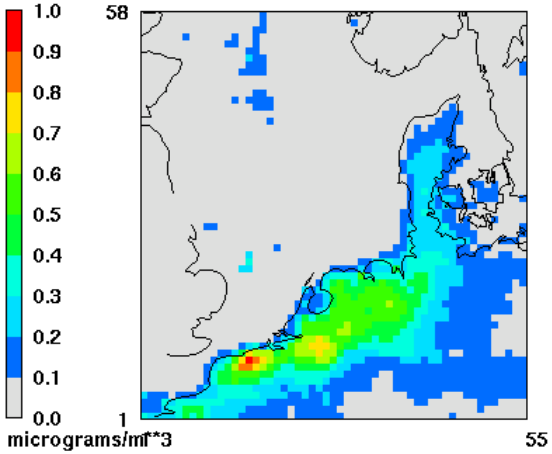
Nitrate aerosol concentration

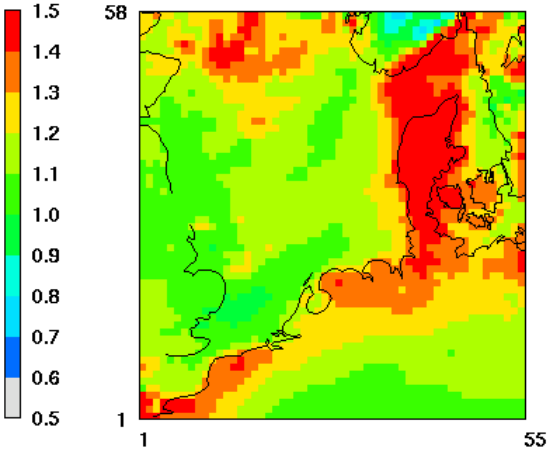




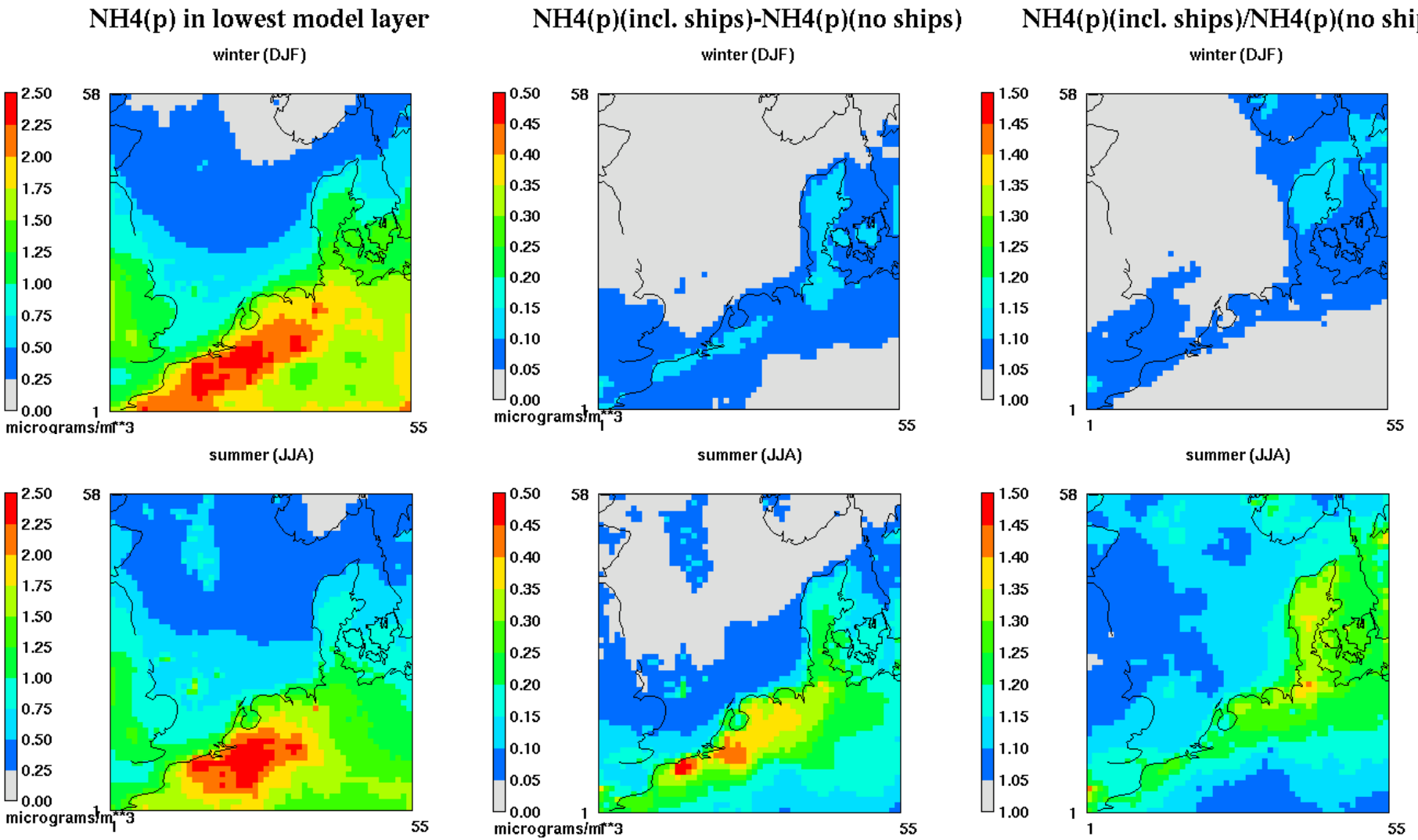




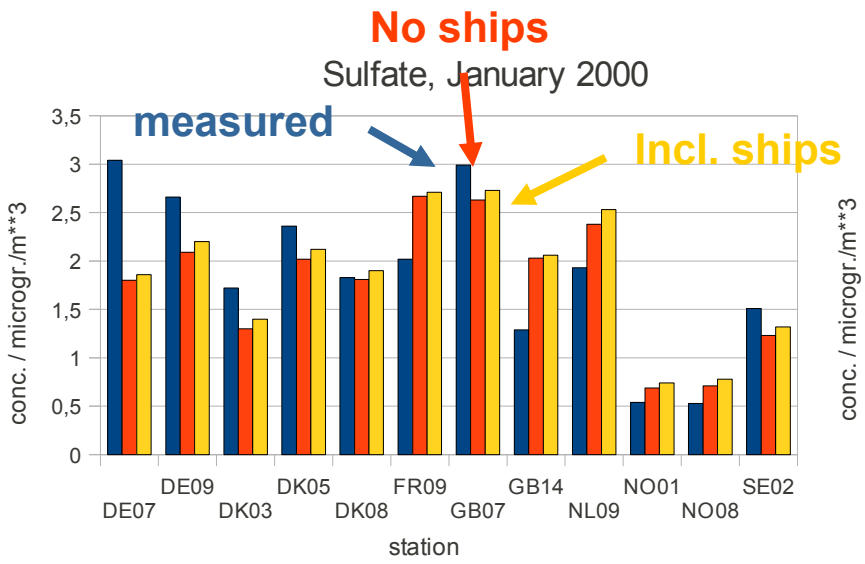


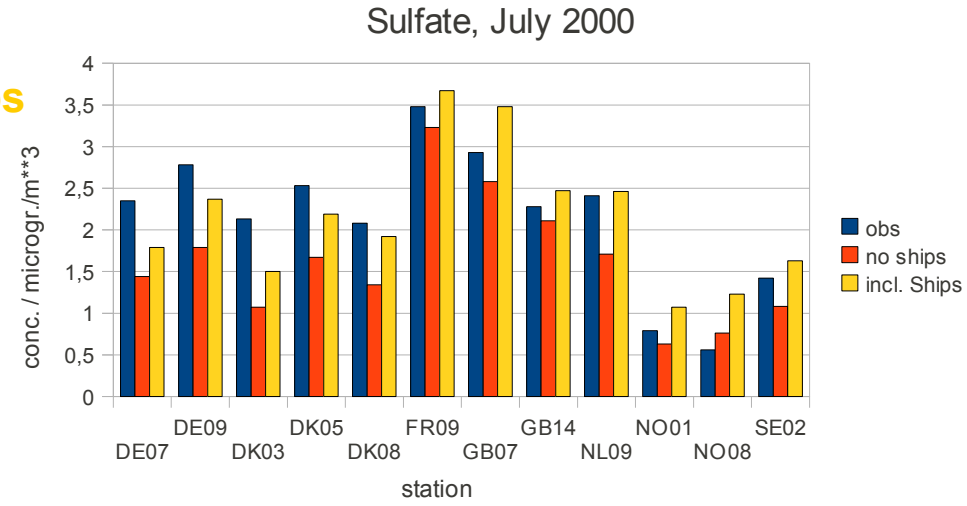


Ammonium aerosol concentration



Comparison to measurements





Comparison to measurements reveals better results if ship emissions are included

Effect is larger in summer compared to winter

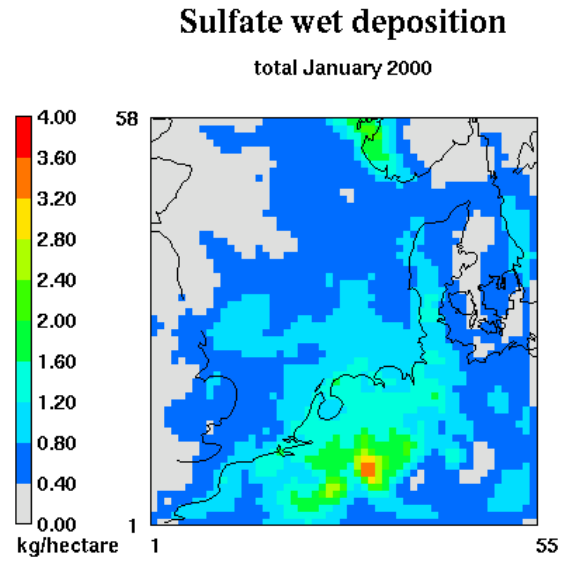
Wet deposition (from aerosols)

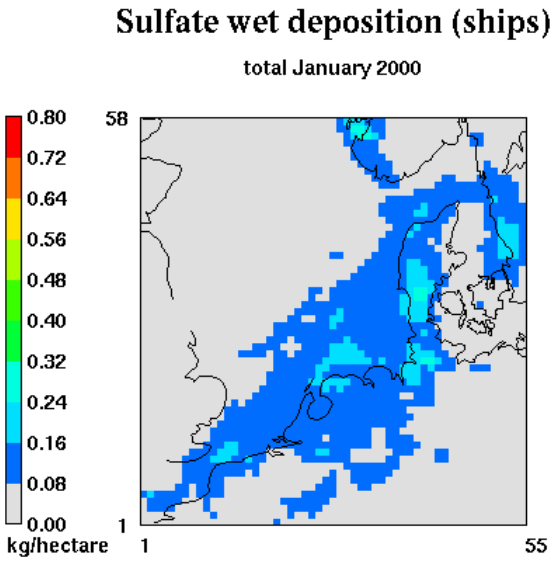
Sulfate

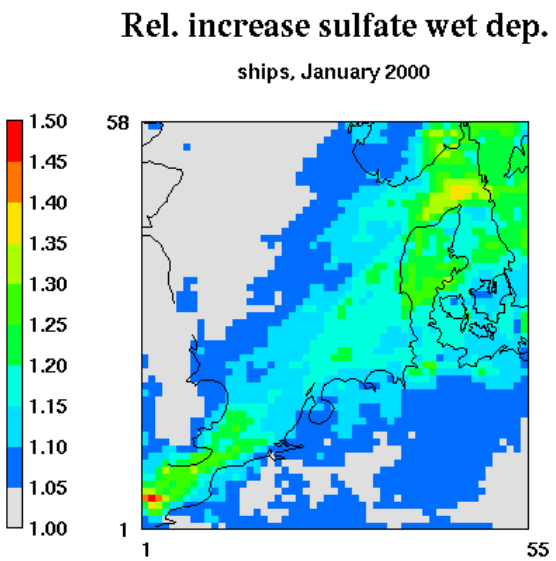
Nitrate

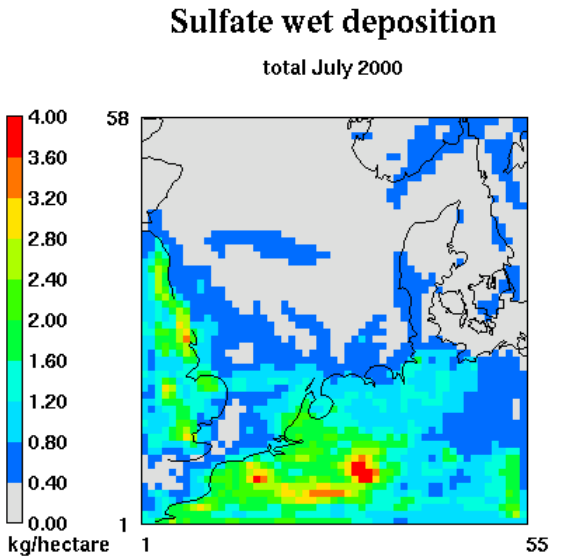
Ammonium

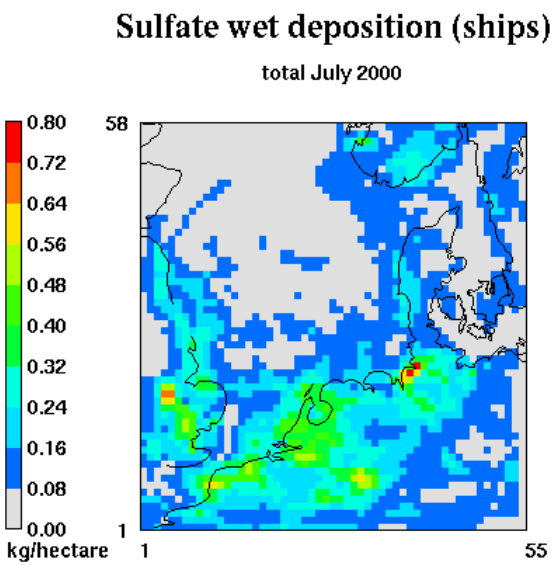
Effects on sulfate wet deposition

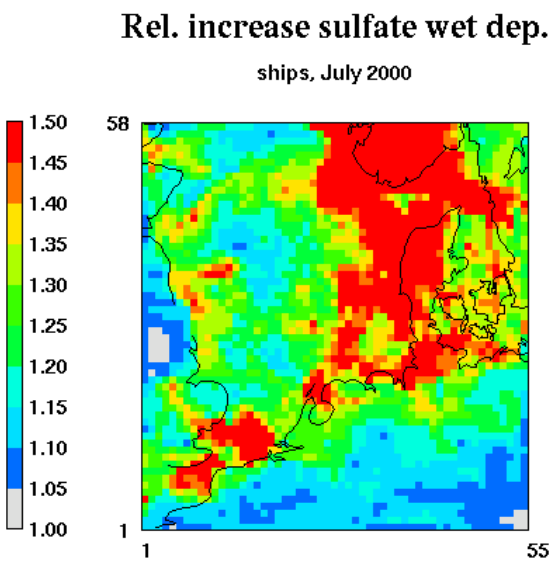




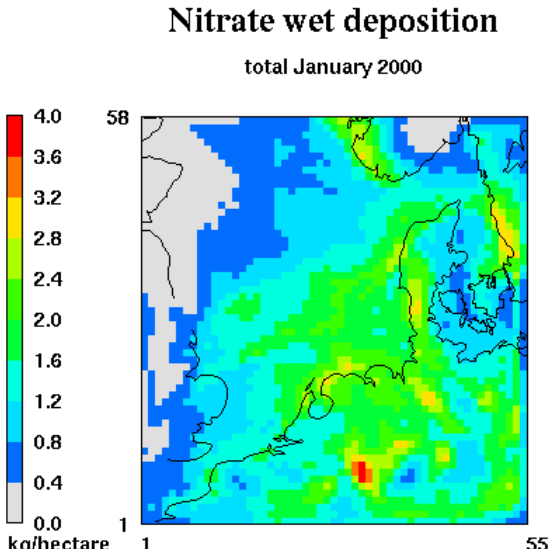


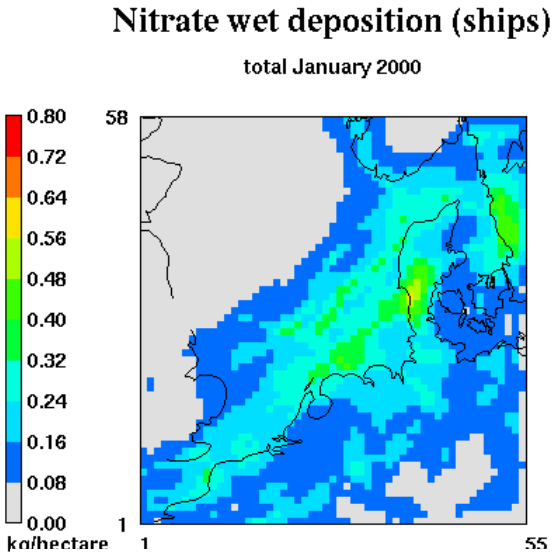


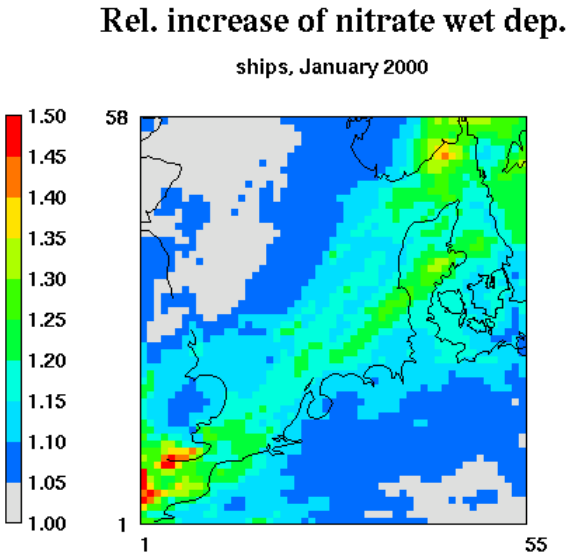


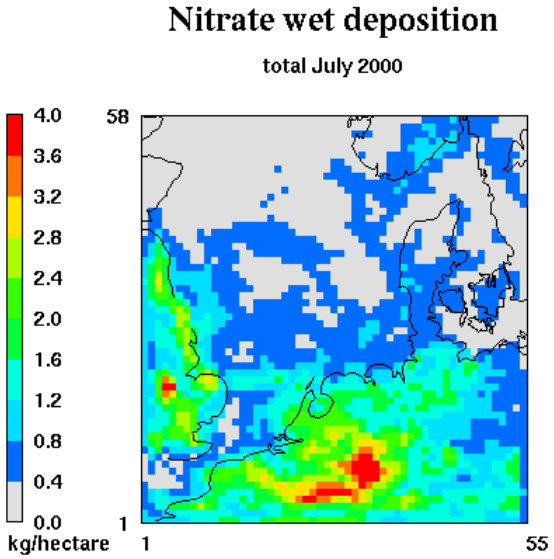


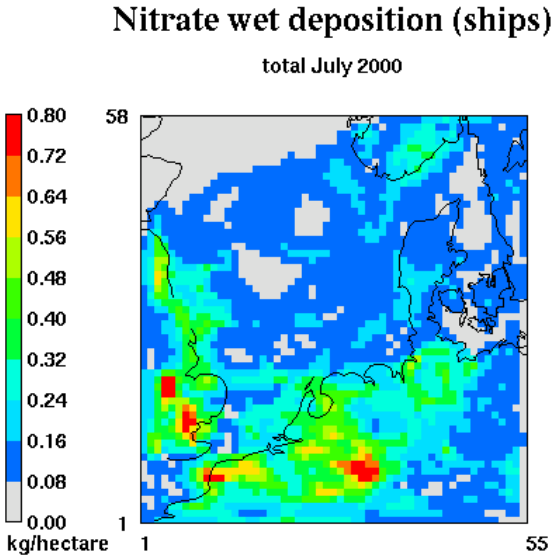
Effects on nitrate wet deposition

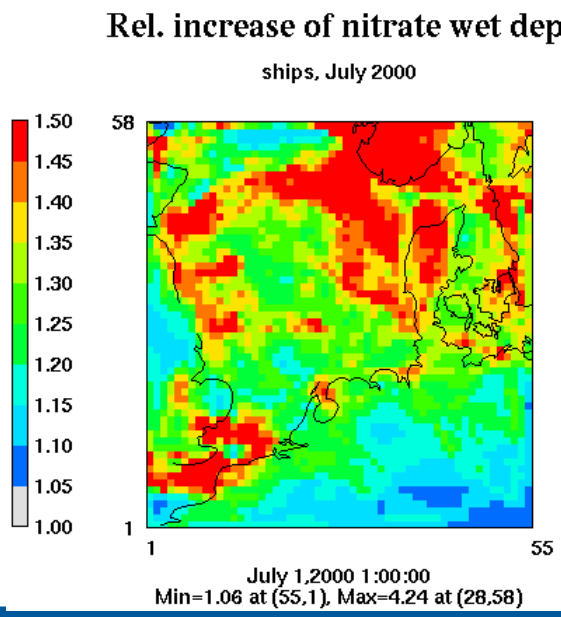




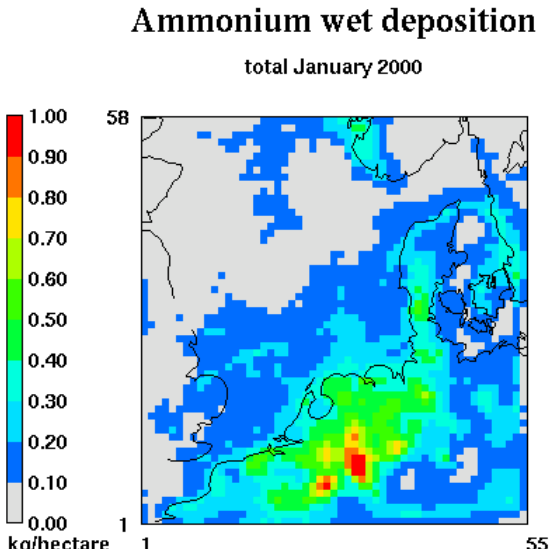


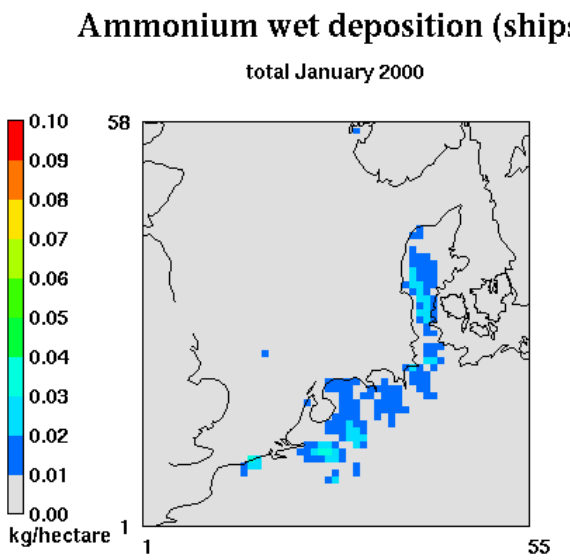


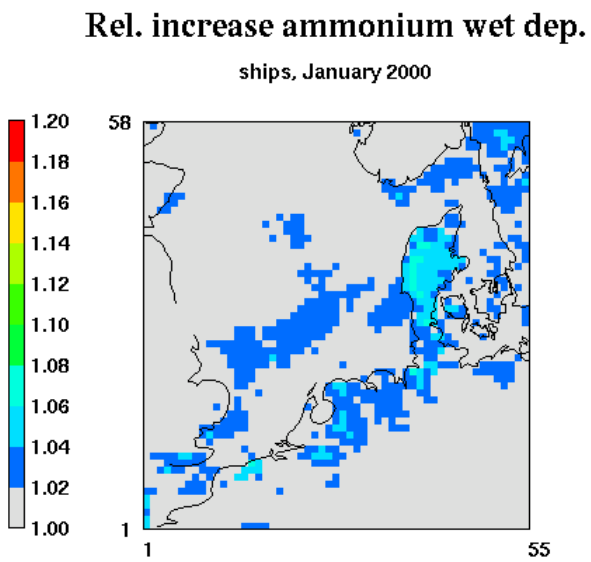


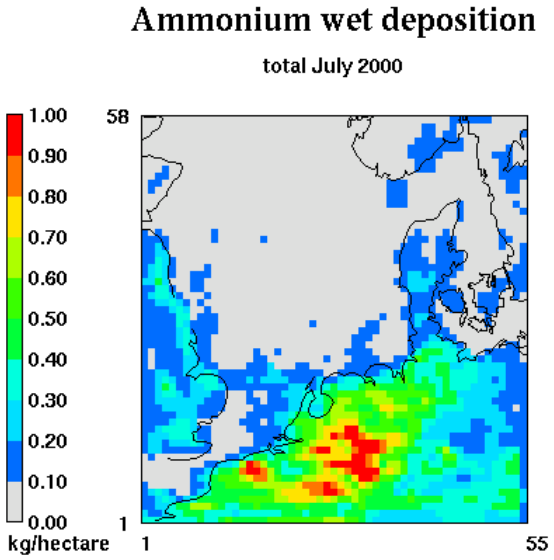


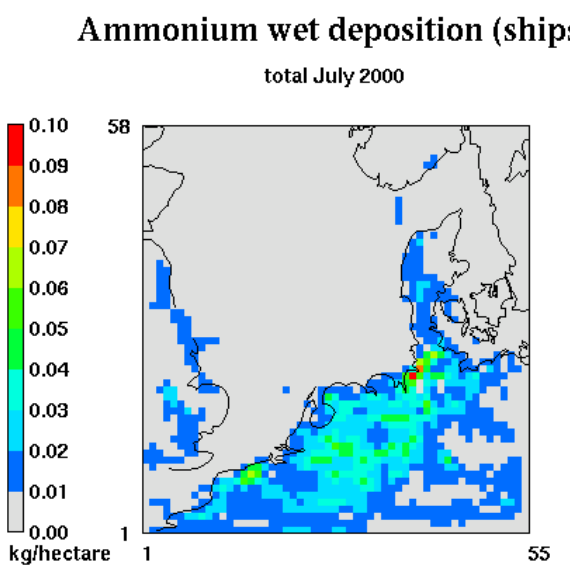
Effects on ammonium wet deposition

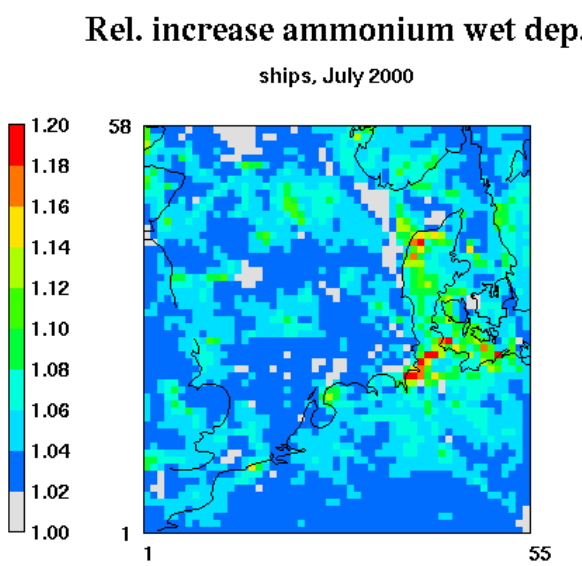




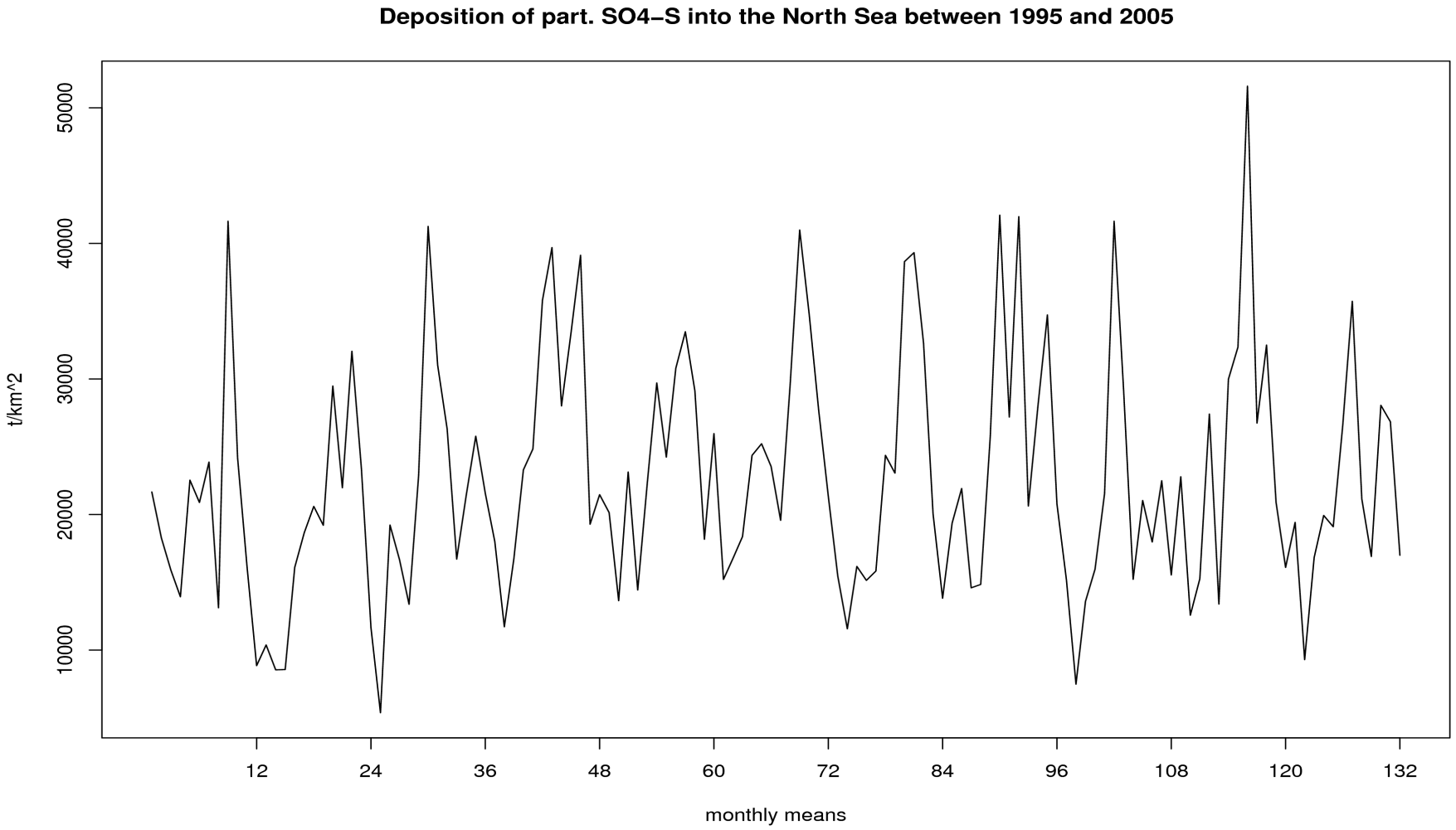




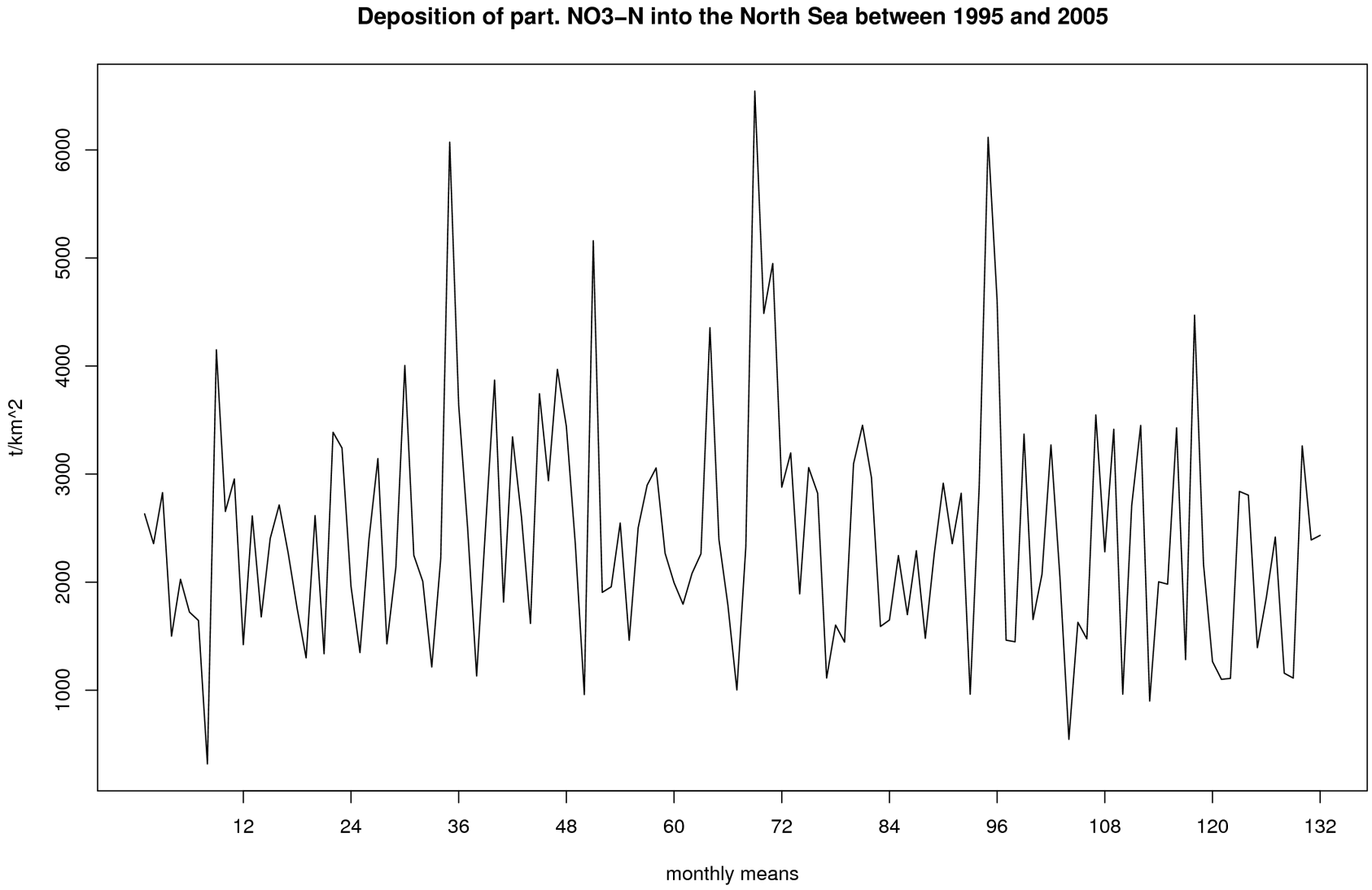




Trend of depositions into the North Sea between 1995 and 2005



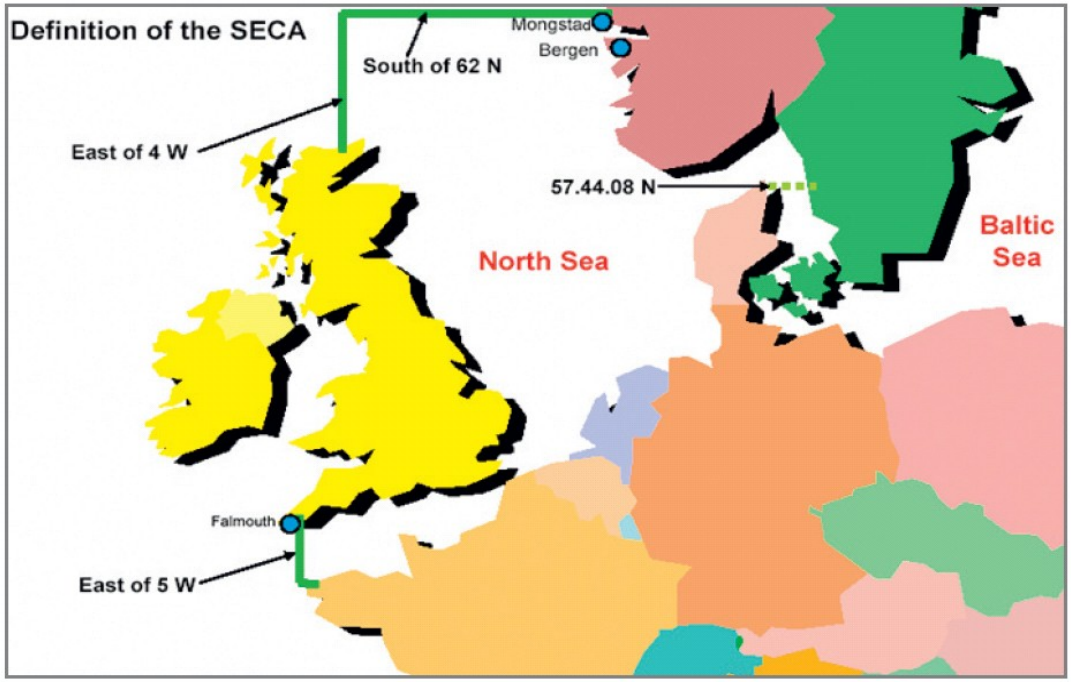
Trend of depositions into the North Sea between 1995 and 2005



Comparison between 1995 and 2005

	Sulphate-S		Nitrate-N		Ammonium-N	
tons	S	NoS	S	NoS	S	NoS
1995	20081	19897	2184	1947	909	905
2005	21402	21146	1990	1638	800	795

SO_x emission control area (SECA)



Karte: Verband Deutscher Reeder

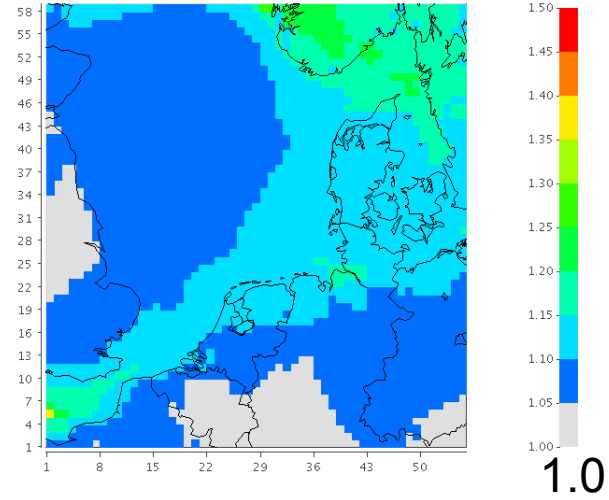
Ships have to use sulfur reduced fuels (max. 1.0% S since 1 July 2010)
SO_2 emissiones by ships are reduced by 63 % within SECAs

From 2015 on, only 0.1 % S will be allowed

Sulfur reduced fuels (1.0%) in North and Baltic Sea SECAs: Aerosol concentrations in summer

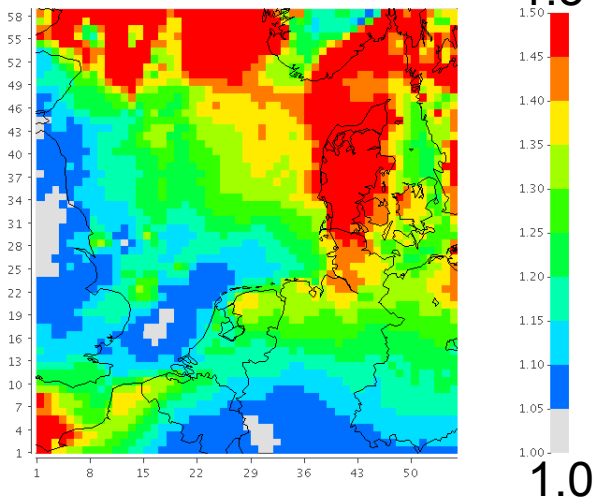
Sulfate

SO4(p)(ships 1.0% S)/SO4(p)(no ships), JJA



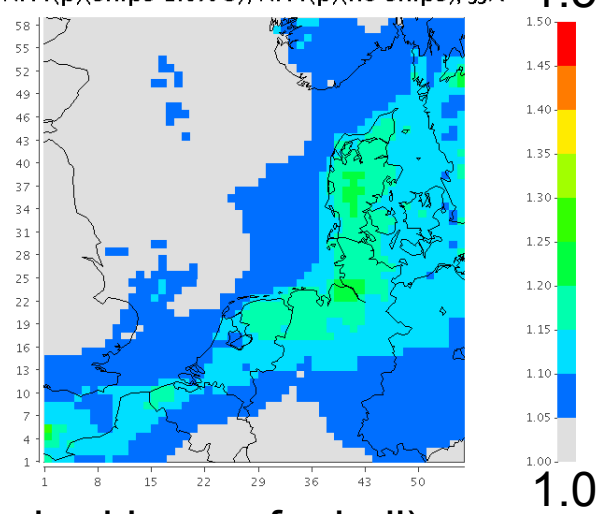
Nitrate

NO3(p)(ships 1.0% S)/NO3(p)(no ships), JJA



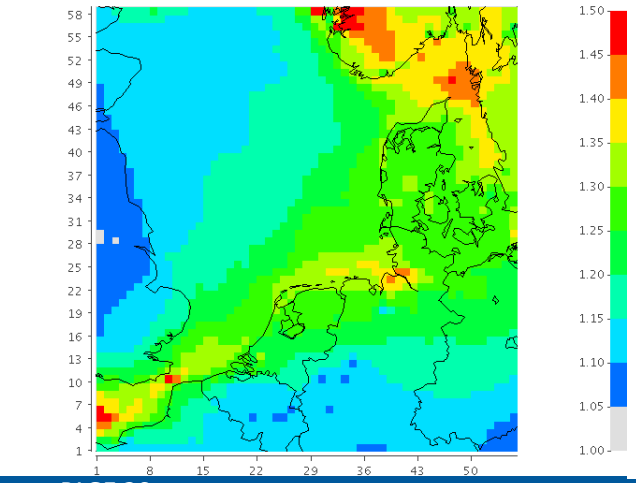
Ammonium

NH4(p)(ships 1.0% S)/NH4(p)(no ships), JJA

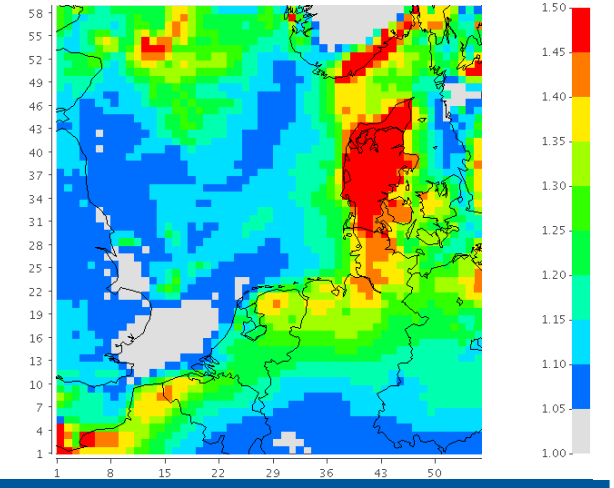


For comparison: Fuel with high sulfur content (standard heavy fuel oil)

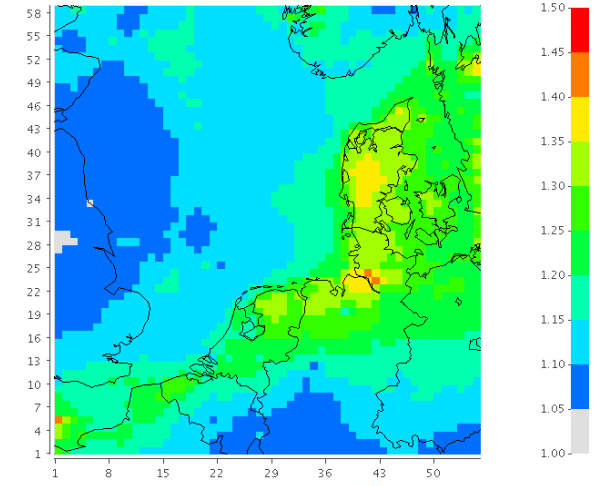
SO4(p)(incl. ships)/SO4(p) (no ships), summer (JJA)



NO3(p)(incl. ships)/NO3(p)(no ships), summer (JJA)



NH4(p)(incl. ships)/NH4(p)(no ships), summer (JJA)



Zusammenfassung

- Es wurde ein detailliertes Emissionskataster inklusive Schiffsemissionen erstellt.
- Simulationen mit dem Chemie-Transport Modell weisen auf deutlich erhöhte Schadstoffkonzentrationen in Küstenregionen in Folge des Schiffsverkehrs hin.
- Durch verstärkte Aerosolbildung kommte es zu erhöhten Depositionen von Säurebildnern und Nährstoffen (bis zu 50%).
- Schwefelarme Treibstoffe zeigen erwartete Reduktionen bei partikulärem Schwefel führen aber in manchen Regionen zu erhöhten Nitratkonzentrationen.

Publikation: V. Matthias et al. (2010): “The contribution of ship emissions to air pollution in the North Sea regions”, Environmental Pollution 158, 2241-2250