

MODELLING OF BENZO(A)PYRENE CONCENTRATIONS IN NORTH SEA COASTAL AREAS: CONTRIBUTION OF SHIP EMISSIONS

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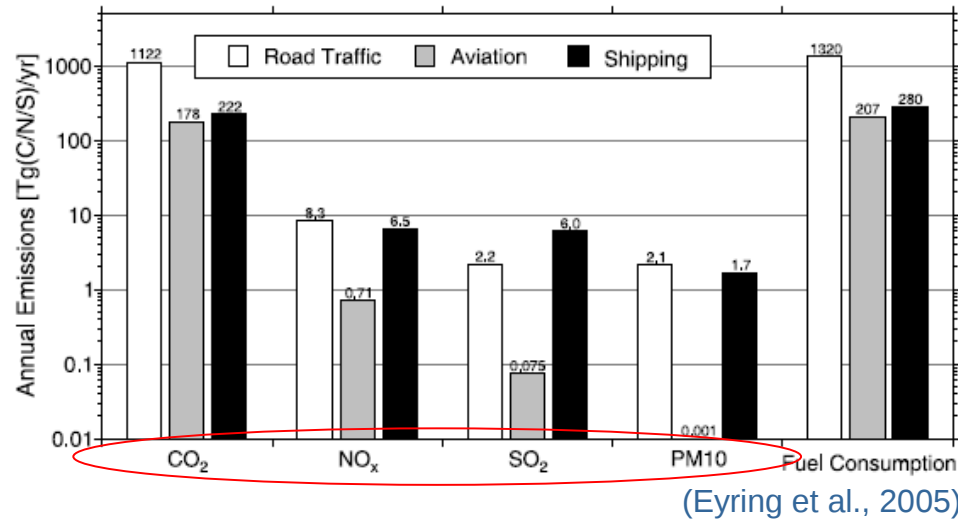
GKSS Research Center Geesthacht, Germany

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Modelling
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- Introduction
- Model system
- Ship emissions
- CMAQ results
- Conclusion

Ship emissions – other studies

Transport-related annual emissions and fuel consumption

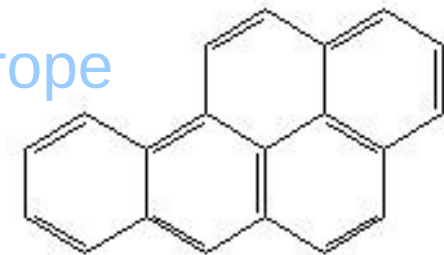


Ship contribution to national emission inventories

Country	NO _x Emission Contribution	Country	SO ₂ Emission Contribution
Malta	38 %	Malta	16 %
Cyprus	24 %	Denmark	15 %
Denmark	20 %	Sweden	13 %
Sweden	16 %	Netherlands	13 %
Greece	15 %	Cyprus	10 %
Portugal	14 %	Norway	9 %
Netherlands	13 %	Portugal	9 %
Finland	13 %	Belgium	9 %

Benzo(a)pyrene (BaP)

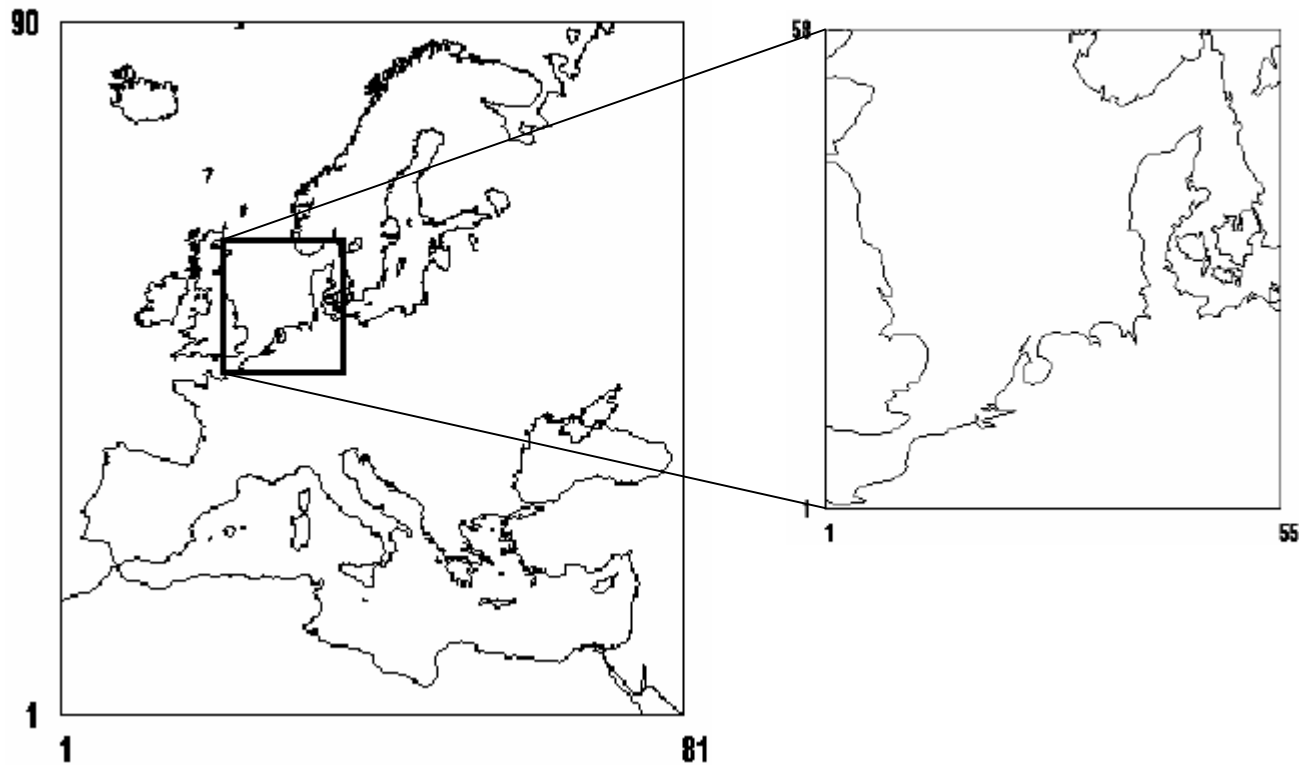
- Polycyclic aromatic hydrocarbon (PAH)
→ BaP marker substance
- Originates primarily from incomplete combustion of oil, wood and coal
- Temperatures prevailing in Middle Europe
→ bound to particles
- Lipophilic, persistent organic pollutant
- Bioaccumulative pollutant
- Carcinogenic
- EU target limiting value: $1 \text{ ng} \cdot \text{m}^{-3} \cdot \text{a}^{-1}$



Benzo(a)pyrene

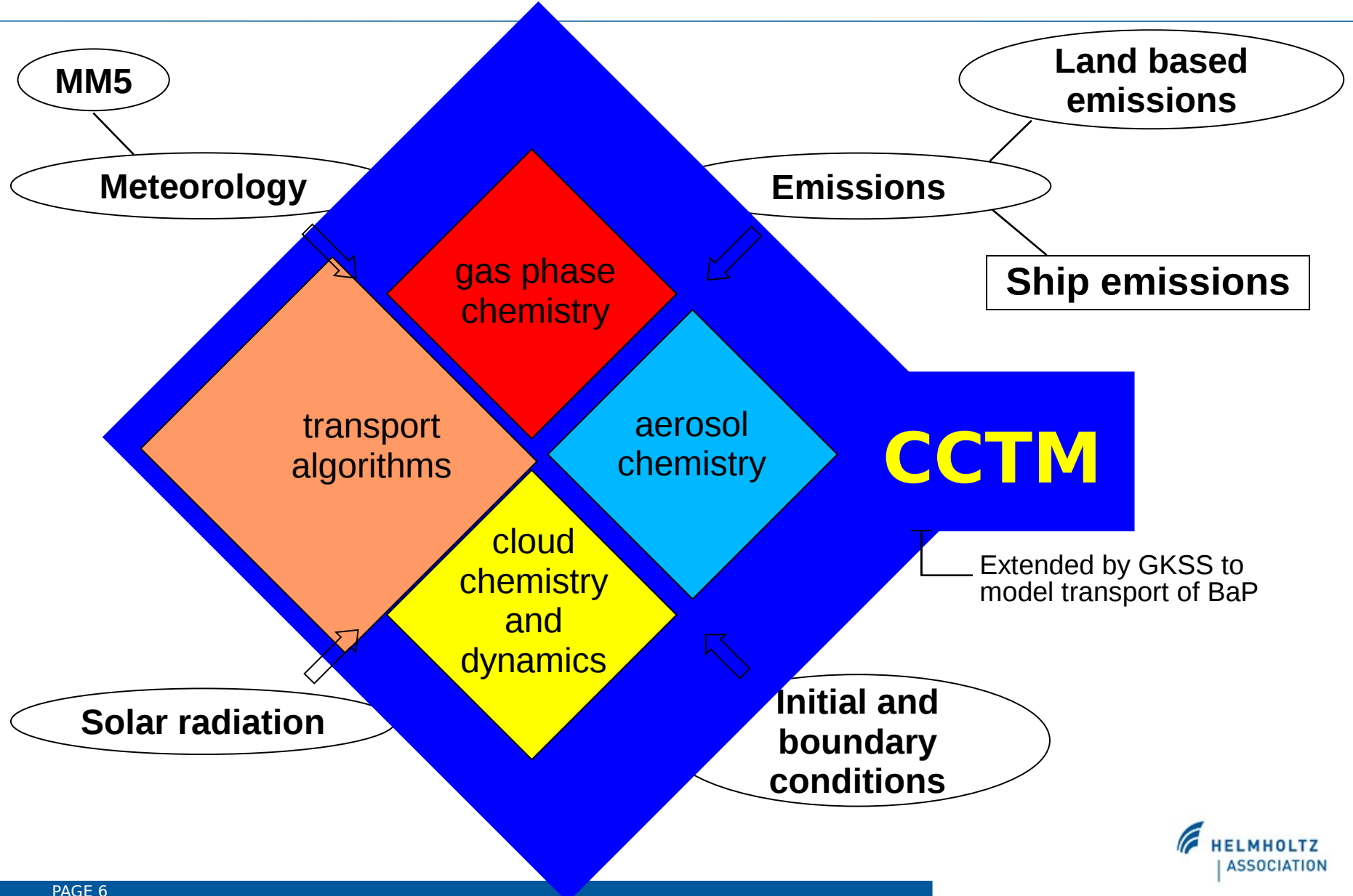
Model and Setup

- Community Multiscale Air Quality modelling system (**CMAQ**), developed by the US EPA for SO_2 , NO_x , O_3 and particulate matter (PM)
- Model domain: $54 \times 54 \text{ km}^2$ grid $18 \times 18 \text{ km}^2$ grid

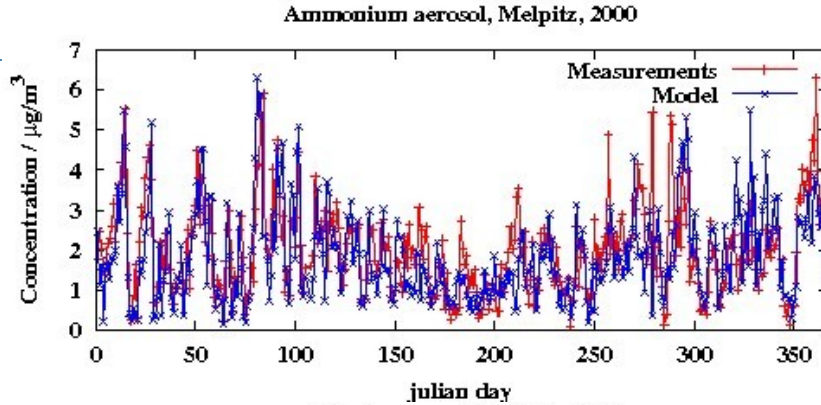


- 30 vertical layers up to 100 hPa

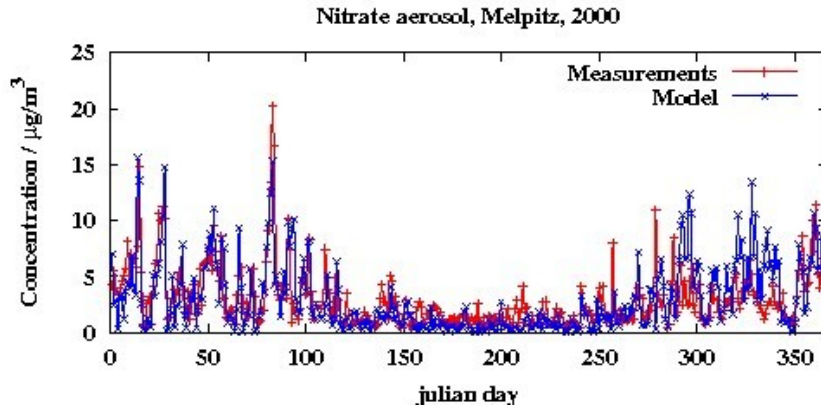
CMAQ Modelling System



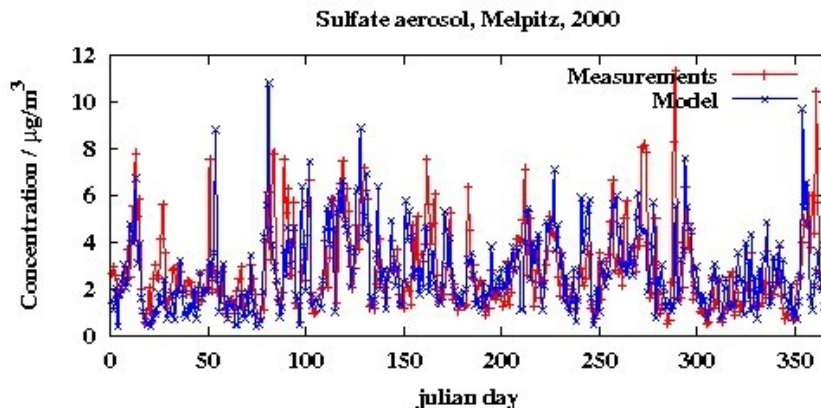
NH_4



NO_3



SO_4



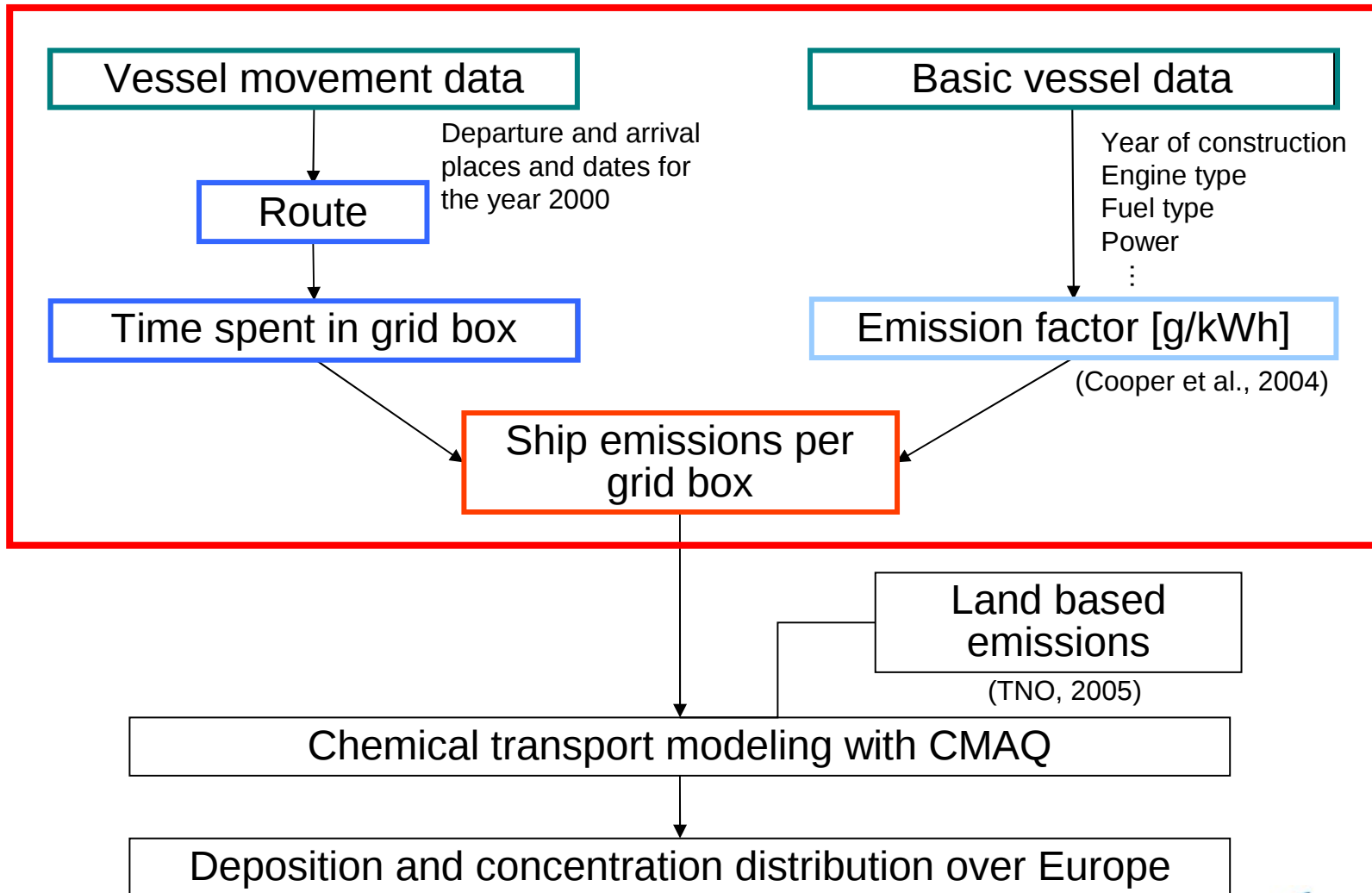
sec. inorganic aerosol
Melpitz/Germany, 2000

Daily means

	Bias/ $\mu\text{g}/\text{m}^3$	Corr
NH_4	-0.14	0.63
NO_3	0.04	0.67
SO_4	-0.08	0.55

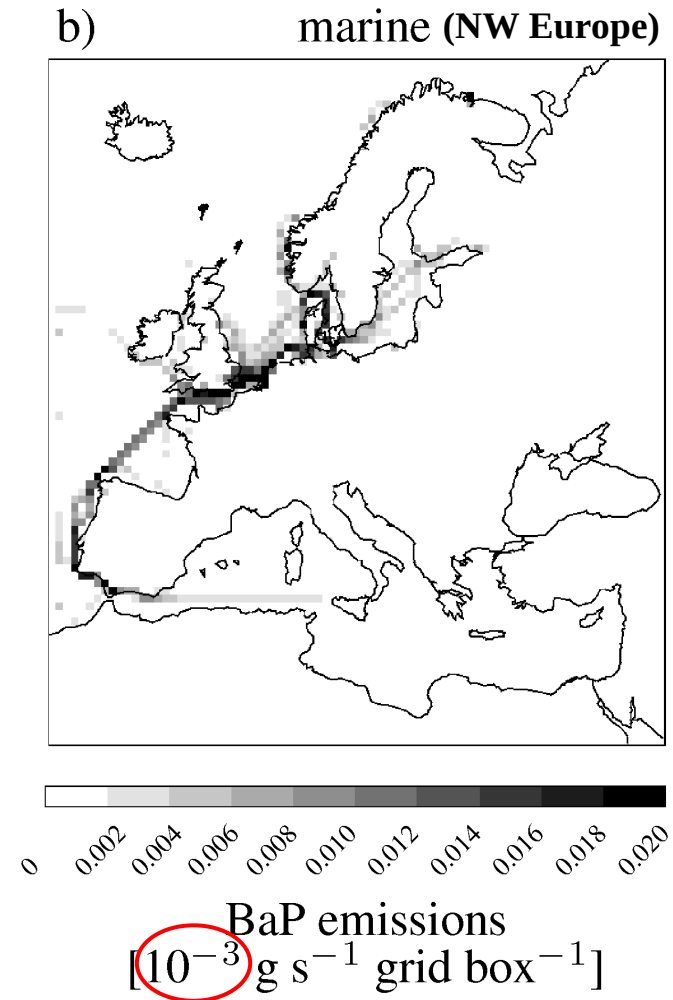
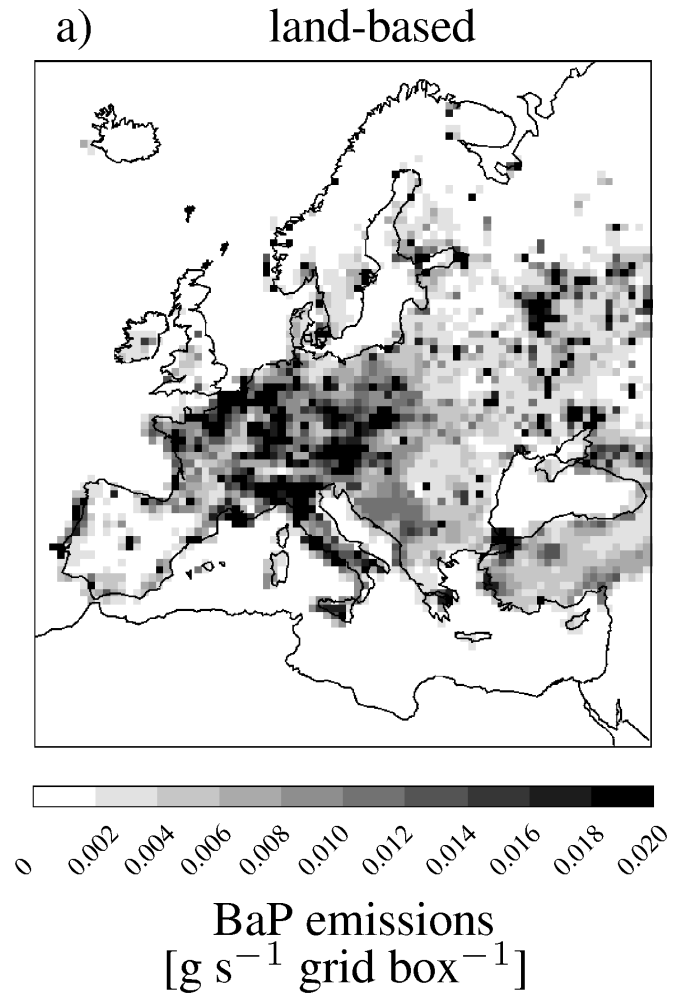
BUT: total PM10 is under-estimated by 30 – 50 %

(Matthias, ACP 8, 5077 (2008))

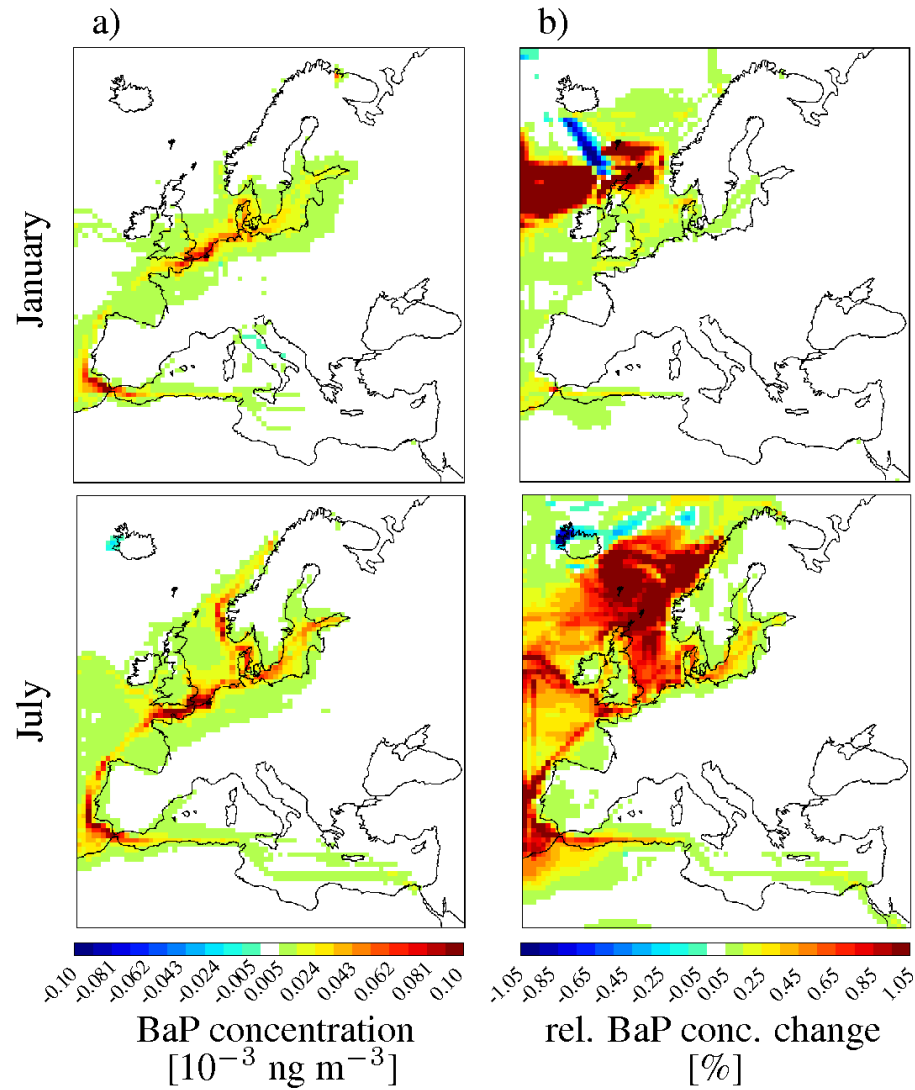


BaP Emissions

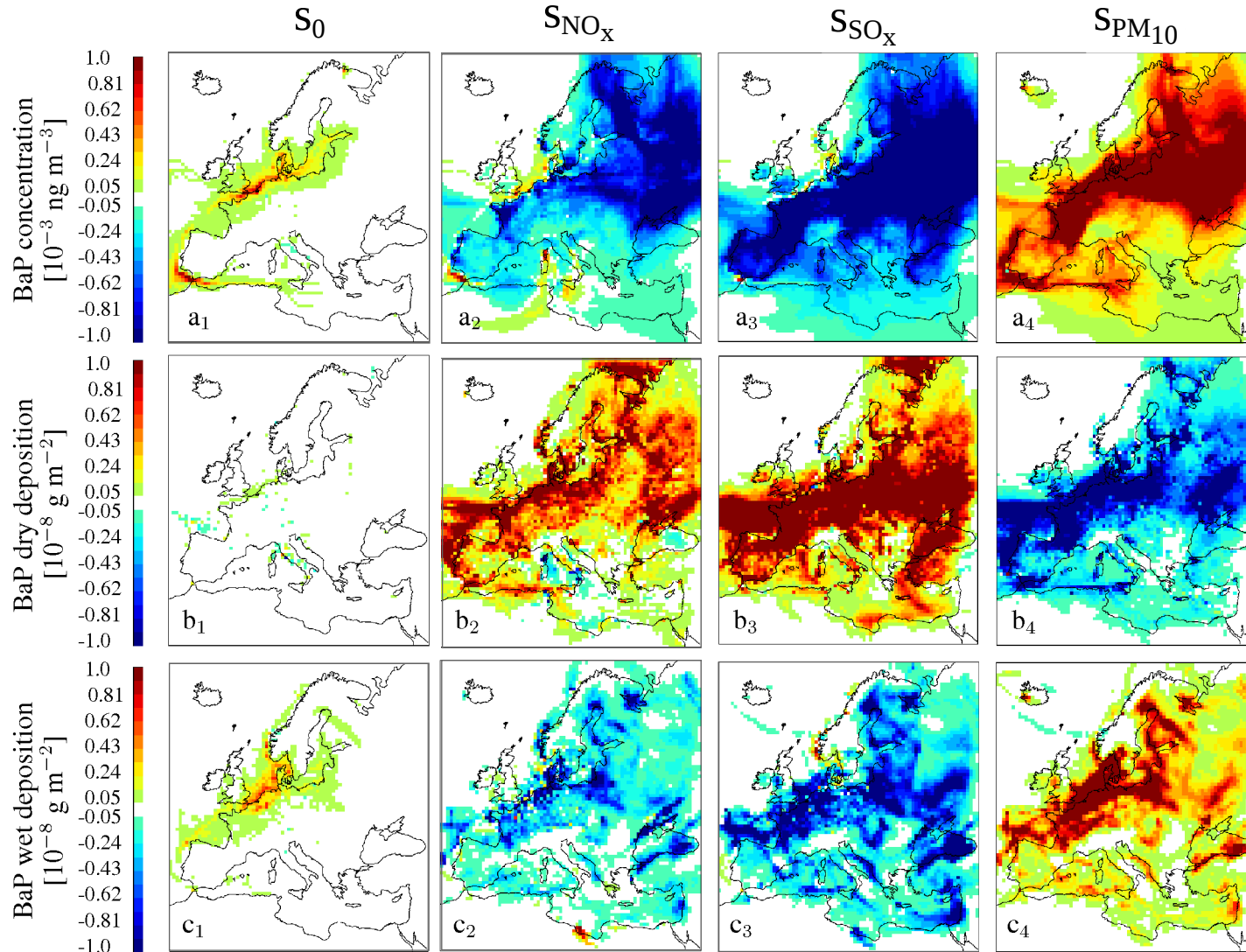
January 2000



Results: BaP Concentration



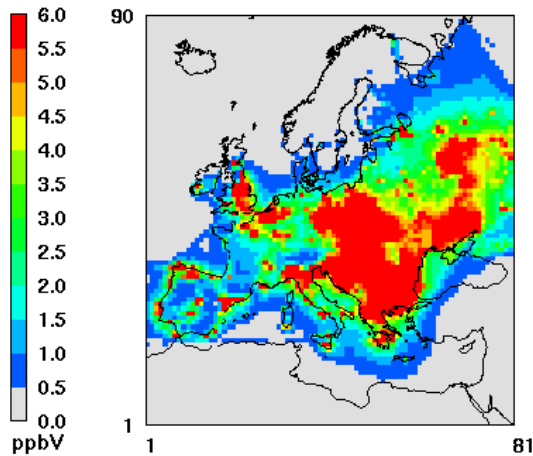
Sensitivity study for January– BaP Concentration and Deposition



Impact of Ships on SO_2 and $\text{SO}_4(\text{p})$ January and July

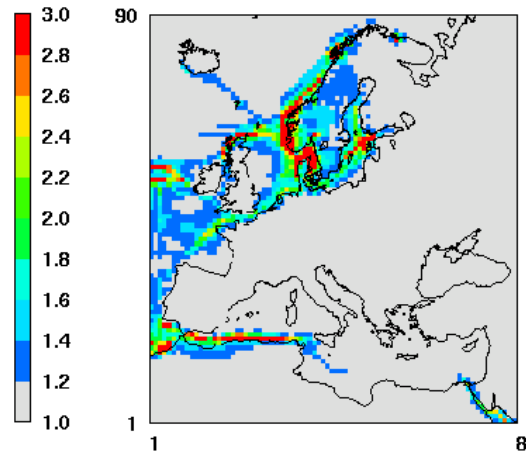
SO_2 January 2000

average concentration



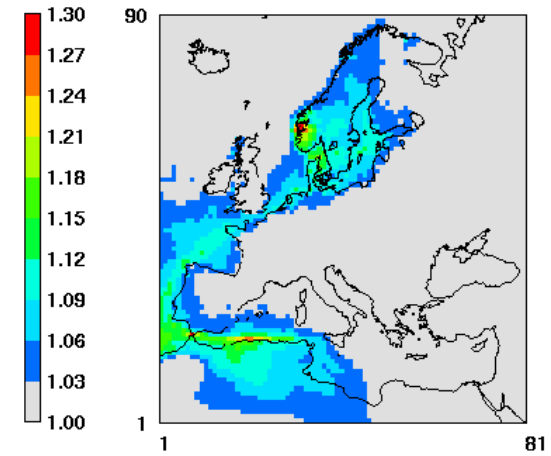
$\text{SO}_2(\text{incl. ships})/\text{SO}_2(\text{no ships})$

January 2000



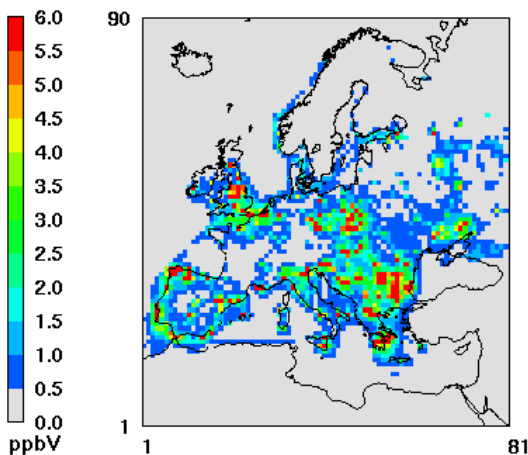
$\text{SO}_4(\text{p})(\text{incl. ships})/\text{SO}_4(\text{p})(\text{no ships})$

January 2000



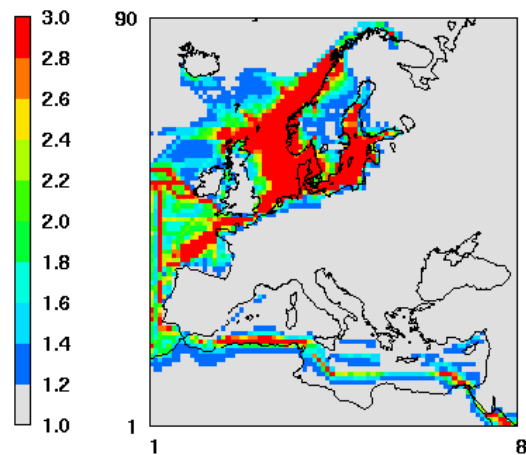
SO_2 July 2000

average concentration



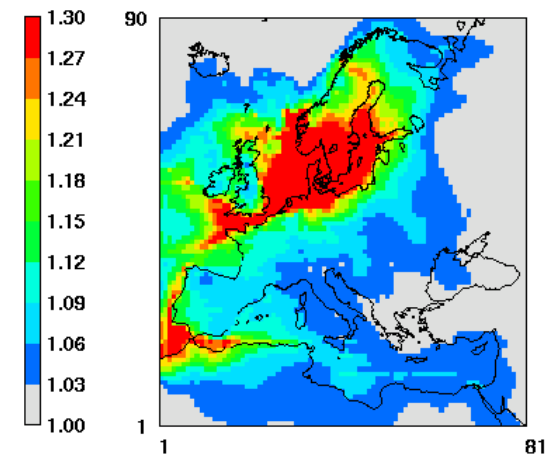
$\text{SO}_2(\text{incl. ships})/\text{SO}_2(\text{no ships})$

July 2000



$\text{SO}_4(\text{p})(\text{incl. ships})/\text{SO}_4(\text{p})(\text{no ships})$

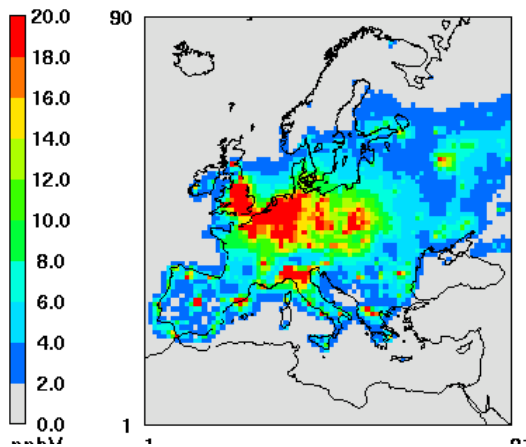
July 2000



Impact of Ships on NO_2 and $\text{NO}_3(\text{p})$ January and July

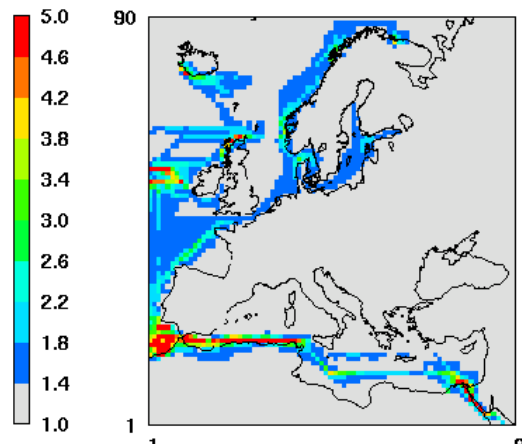
NO_2 January 2000

average concentration



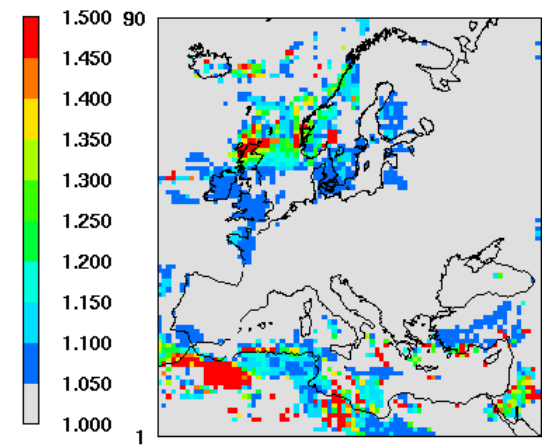
$\text{NO}_2(\text{incl. ships})/\text{NO}_2(\text{no ships})$

January 2000



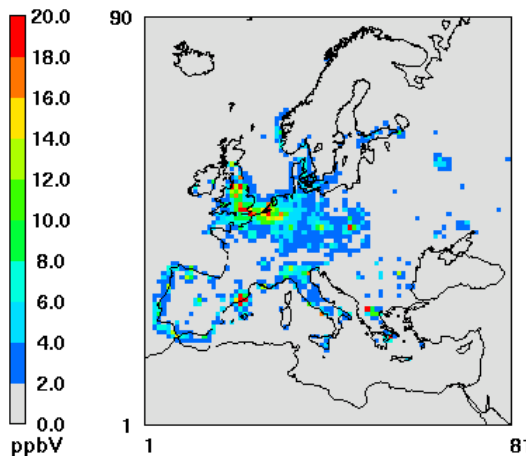
$\text{NO}_3(\text{p})(\text{incl. ships})/\text{NO}_3(\text{p})(\text{no ships})$

January 2000



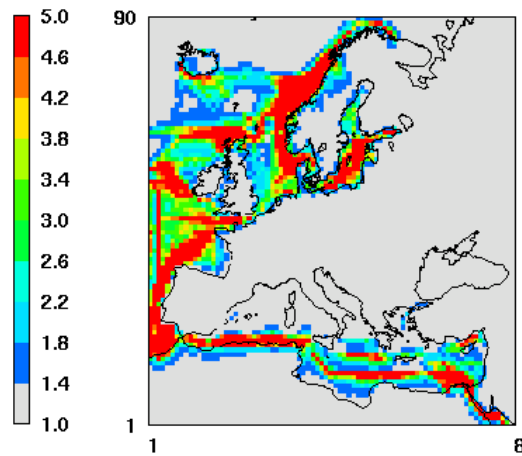
NO_2 July 2000

average concentration



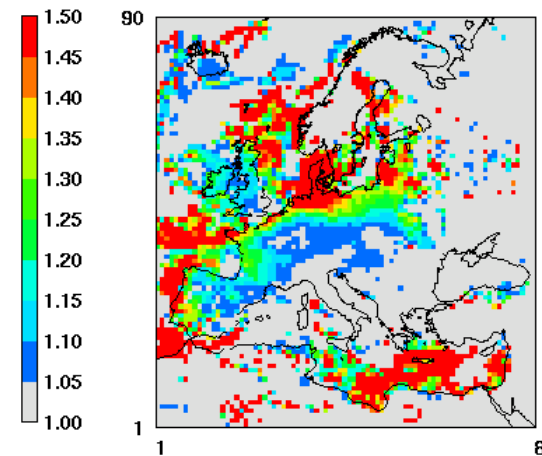
$\text{NO}_2(\text{incl. ships})/\text{NO}_2(\text{no ships})$

July 2000

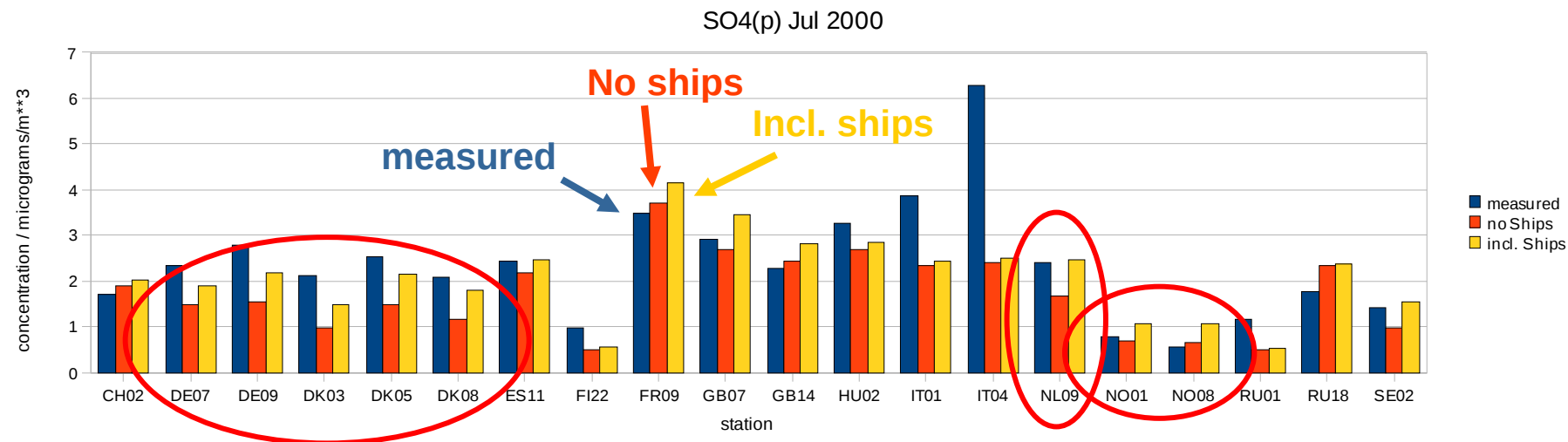
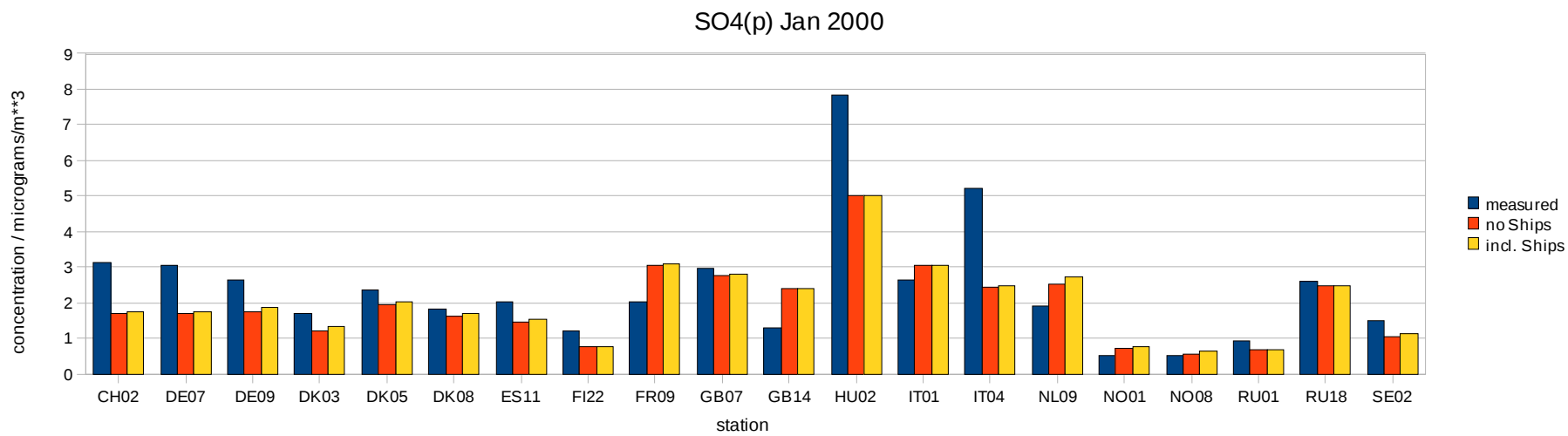


$\text{NO}_3(\text{p})(\text{incl. ships})/\text{NO}_3(\text{p})(\text{no ships})$

July 2000



Comparison of modelled SO₄(p) to EMEP stations



Significant effects of ship emissions at coastal sites

Conclusion

- **Ship emissions module:** Temporally and spatially highly resolved ship emissions for the year 2000
- First study: BaP emissions
 - Little influence on concentration distribution patterns
 - Up to 1 % (monthly average)
- Higher ship contribution in summer than in winter due to differences in residential combustion
- Emission factors with high uncertainties → further research is eligible
- Sensitivity study: additional NO_x , SO_x and PM_{10} emissions
 - Influence on the BaP concentration and deposition distributions

Outlook

- Evaluate nested grid (18 x 18 km²) for more detailed information
- Ship emission influence on concentration and deposition distributions of other pollutants, e.g. NO_x, SO₂ and particulate matter (PM) in more detail

Thank you for your attention!