A pollutant emission model for ships and its application in air quality modelling

SCC2016

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7. November 2016

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Zentrum für Material- und Küstenforschung

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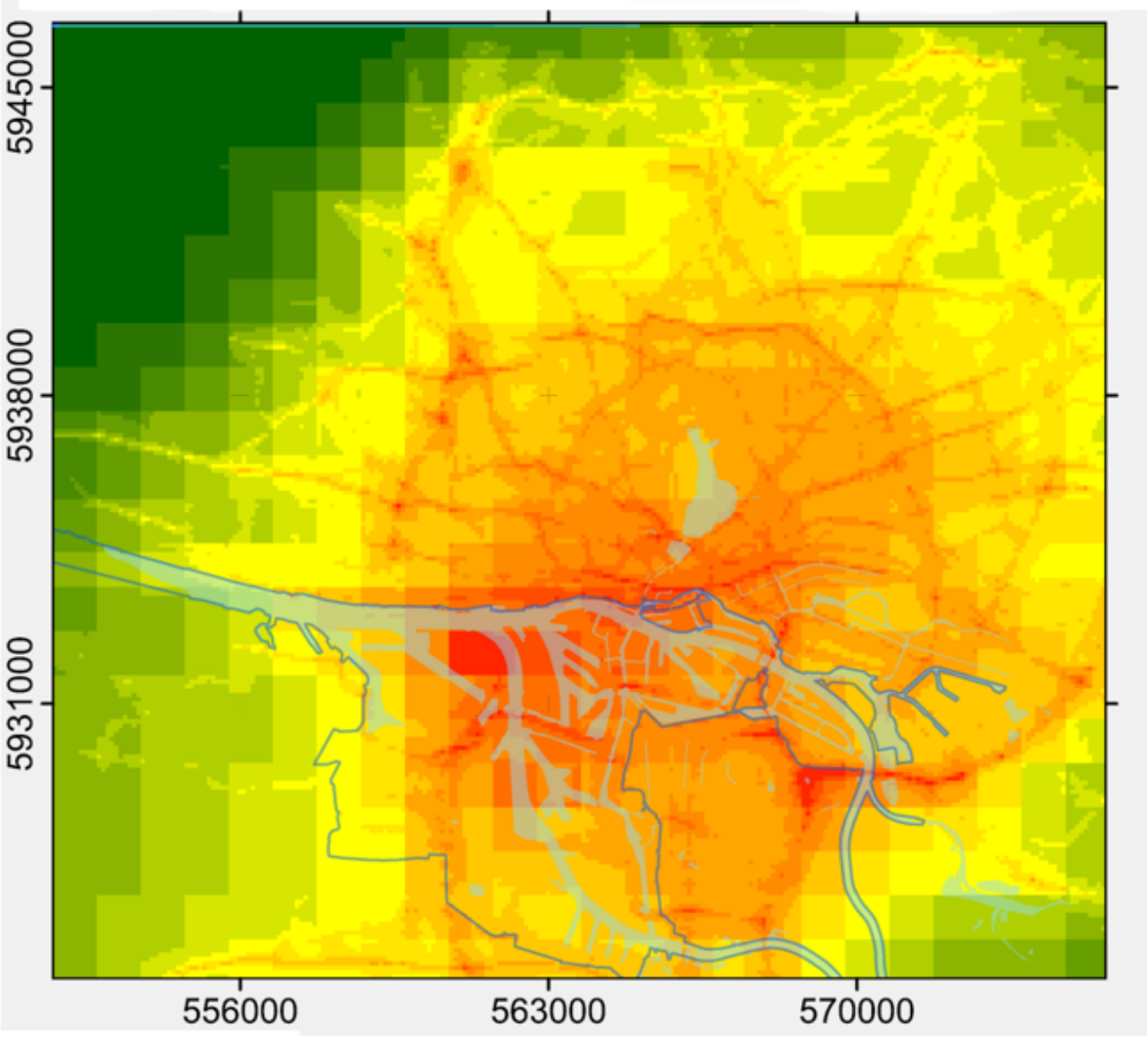
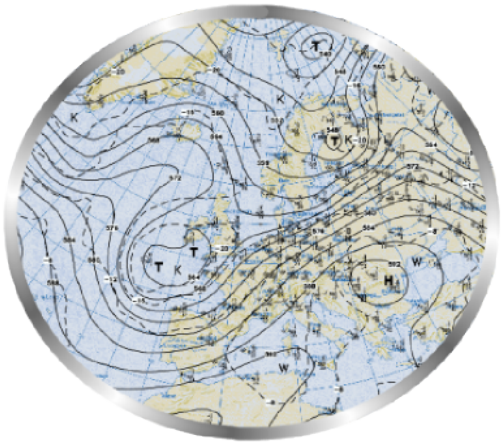
Air Quality Map

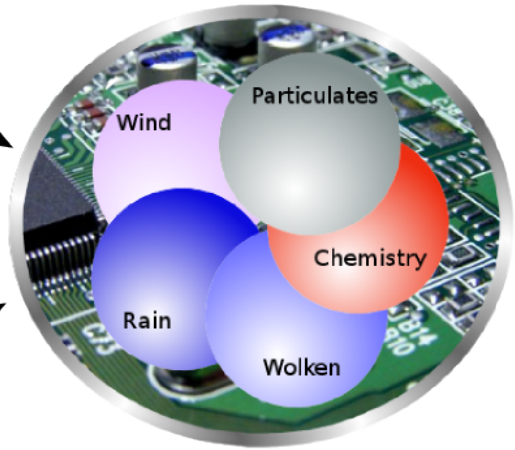


Modelling System

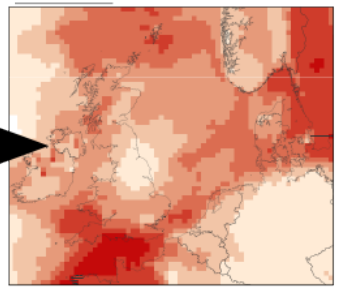
meteorology model

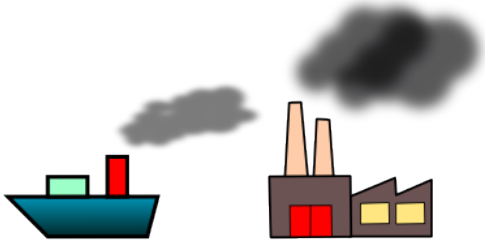


chemistry-transport model



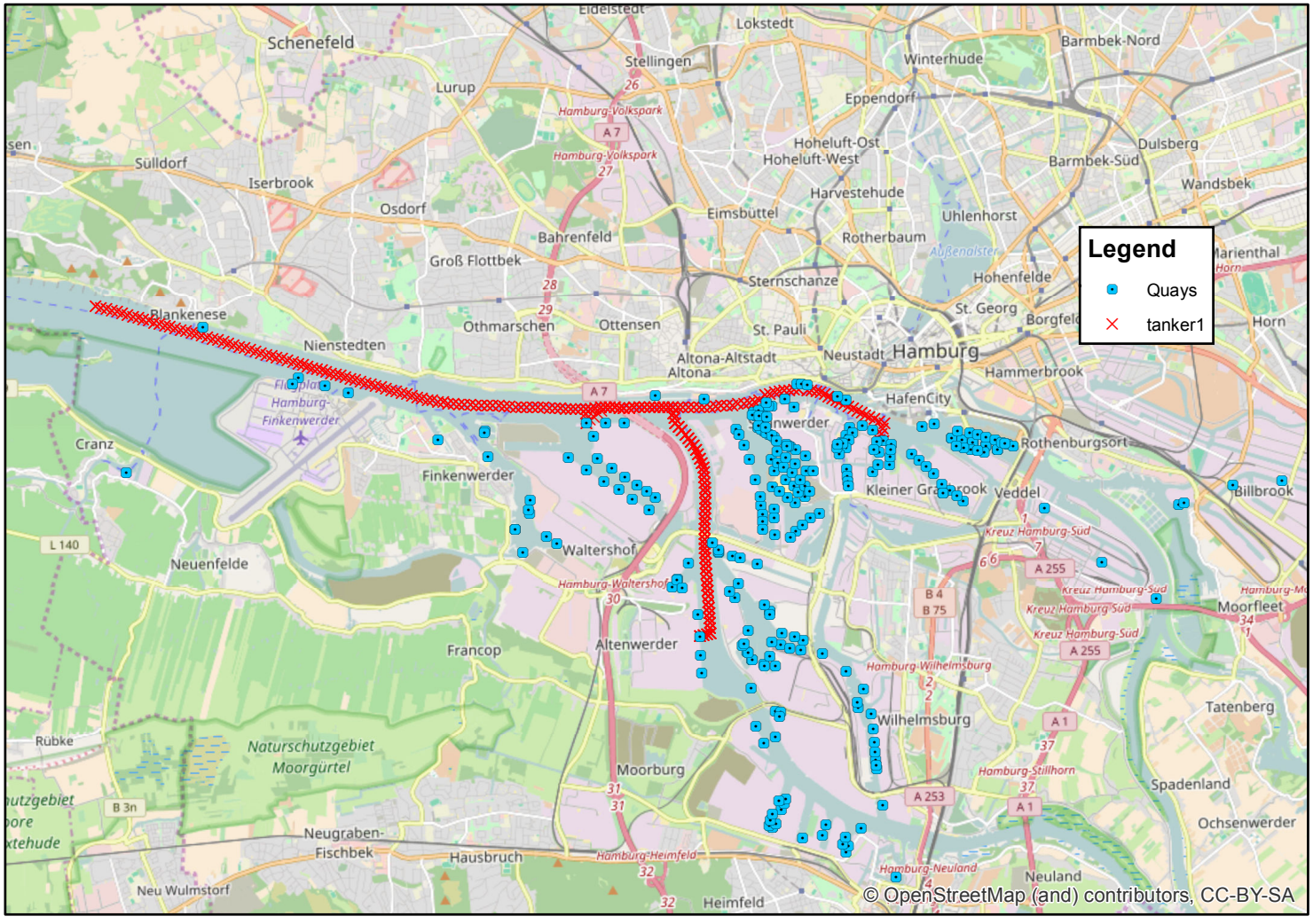
concentrations





emission model

Ship track


Legend
Quays
tanker1
Schenefeld
Lurup
Stellingen
Lokstedt
Winterhude
Barmbek-Nord
Eppendorf
Hoheluft-Ost
Hoheluft-West
Barmbek-Süd
Dulsberg
Wandsbek
Sülldorf
Iserbrook
Osdorf
Harvestehude
Eimsbüttel
Uhlenhorst
Bahrenfeld
Rotherbaum
Groß Flottbek
Sternschanze
Hohenfelde
St. Georg
Blankenese
Othmarschen
Ottensen
St. Pauli
Nienstedten
Altona-Altstadt
Altona
Neustadt
Hamburg
Hammerbrook
HafenCity
Finkenwerder
Cranz
Rothenburgsort
Kleiner Grasbrook
Veddel
Billbrook
Neuenfelde
Waltershof
Francop
Altenwerder
Moorfleet
Tatenberg
Wilhelmsburg
Rübke
Naturschutzgebiet
Moorgürtel
Moorburg
Spadenland
Ochsenwerder
Neugraben-
Fischbek
Hausbruch
Neu Wulmstorf
Heimfeld
Neuland
A 7
A 1
A 253
A 255
B 4
B 75
B 3n
L 140
Hamburg-Volkspark
Hamburg-Waltershof
Hamburg-Wilhelmsburg
Hamburg-Stillhorn
Hamburg-Heimfeld
Hamburg-Neuland
Kreuz Hamburg-Süd
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AIS data

- IMO number.
- Ship type.
- Position (lat, lon) ca. every 10 sec.
- Time stamp.
- Speed over ground.
- Course over ground.

At the moment, we have only historical data with hourly resolution.

HPA data table

- time of entering the port area
- time of leaving the port area
- time of arriving at the quay
- time of departing from the quay
- quay identifier
- ship info
  - unique IMO number
  - shiptype: container, general cargo, tanker, bulk,...
  - shipsize in grosstonnage

Additional info about the engines of the vessels are obtained from an IHS Fairplay data base directly or using class medians.

Three types of activities

sailing

- line source emissions
- energy specific emission factors ($\frac{\mathrm{g}}{\mathrm{kWh}}$)
- calculate load from speed over ground
- fixed loads for auxiliary engines

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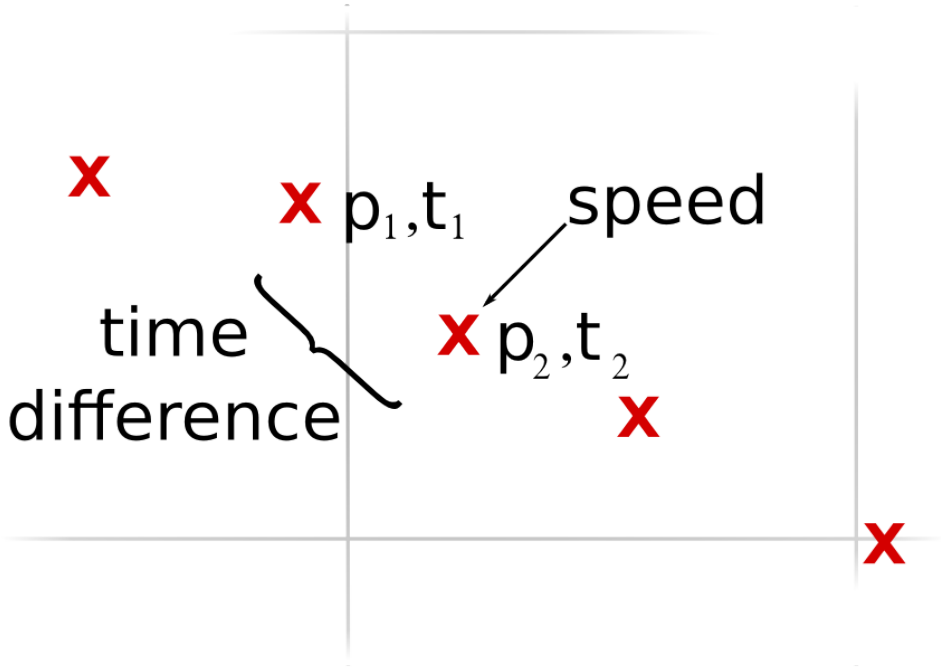
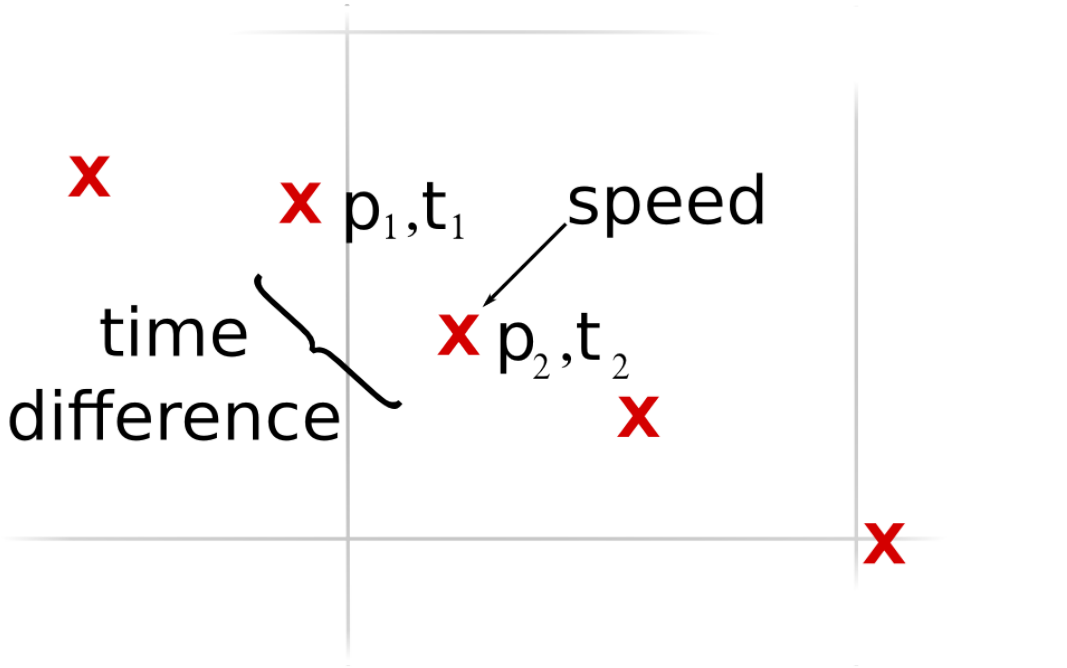
berthing

- point source emissions
- fuel specific emission factors ($\frac{\mathrm{g}}{\mathrm{kg}}$)
- data about fuel consumption from surveys

Load based emissions



Load based emissions



$$E(v, p_2, t_2) = (\frac{speed}{speed_{max}})^3 MCR_{max} \Delta t EF + E_{aux}$$

Aulinger, A., V. Matthias, M. Zeretzke, J. Bieser, M. Quante, Backes, A. 2016: The impact of shipping emissions on air pollution in the greater North Sea region – Part 1: Current emissions and concentrations. Atmos. Chem. Phys., 16, 739-758.

Fuel based emissions at berth

Survey on board 175 seagoing ships

- fuel consumption at berth (fc in $\frac{\mathrm{kg}}{\mathrm{h}}$).
- ratio of boiler usage (r).
- fuel specific emission factors for auxiliary engines and boilers (EF_{aux}, EF_b in $\frac{\mathrm{g}}{\mathrm{kg}}$).

Hulskotte, J. H. J., H. A. C. Denier van der Gon, 2010: Fuel consumption and associated emissions from seagoing ships at berth derived from an on-board survey. Atmos.Environ., 44, 1229-1236.

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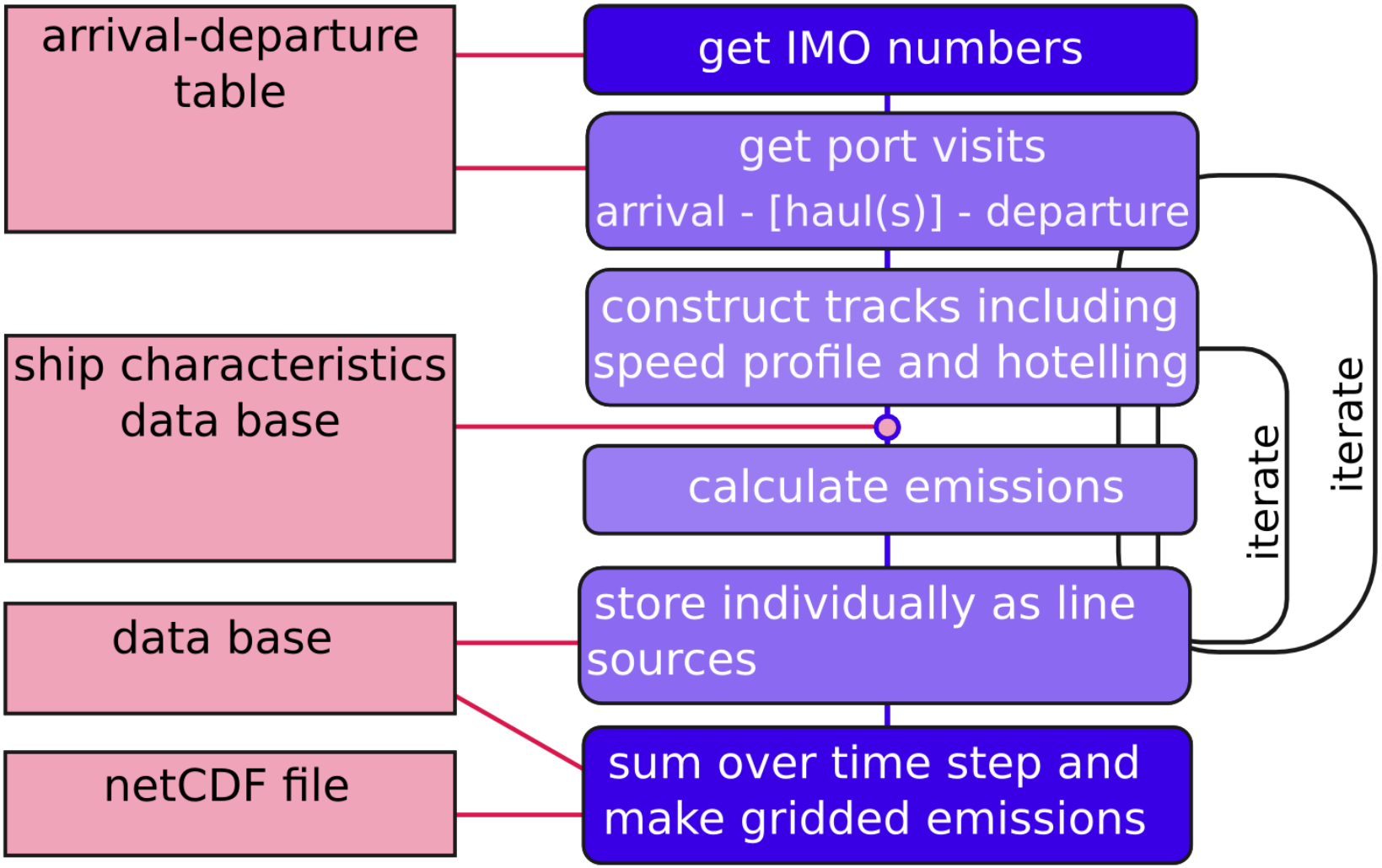
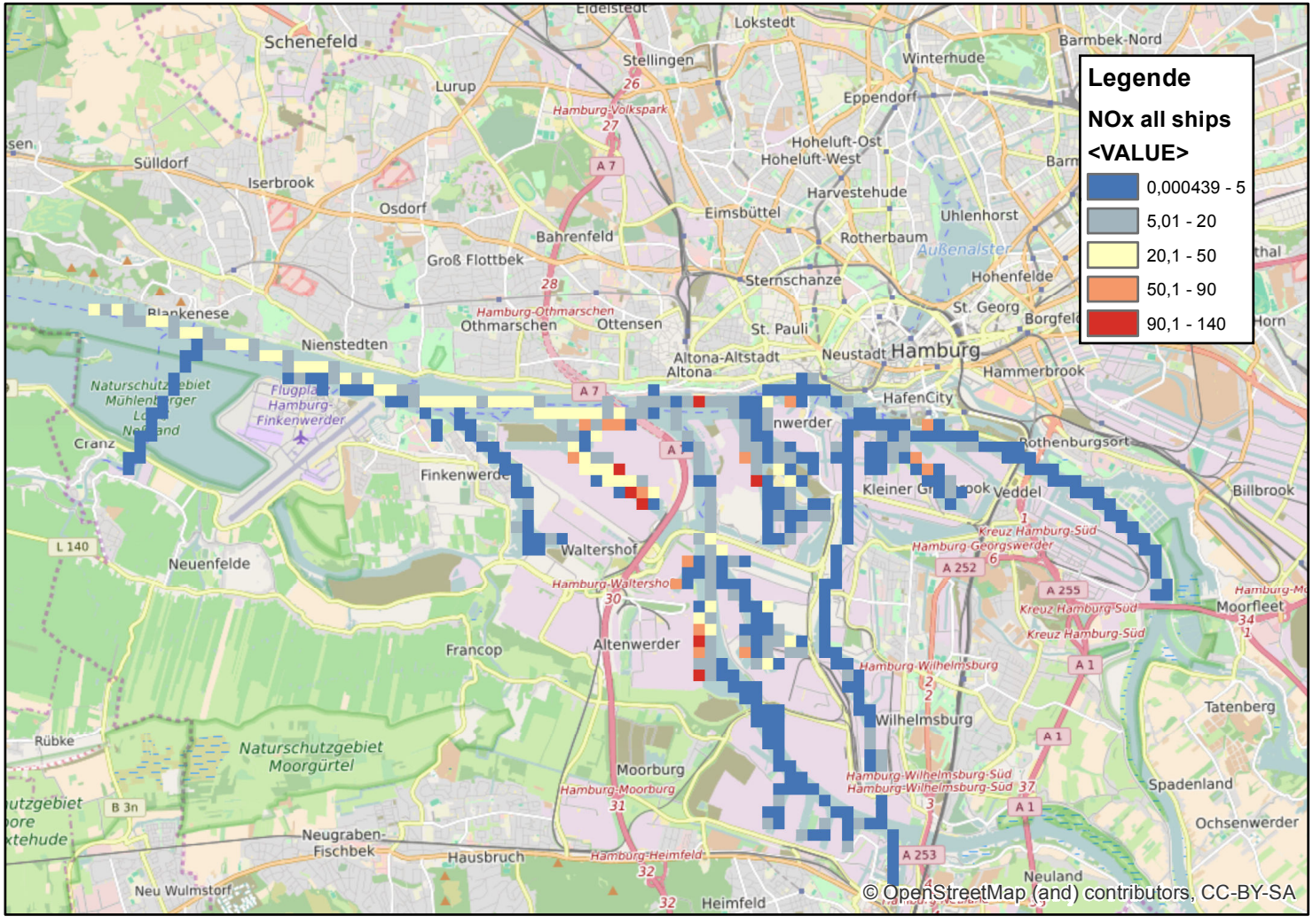
$$E(v, q, t_1, t_2) = (rEF_b + (1 - r)EF_{aux})fc\Delta t$$

Hulskotte, J. H. J., H. A. C. Denier van der Gon, 2010: Fuel consumption and associated emissions from seagoing ships at berth derived from an on-board survey. Atmos.Environ., 44, 1229-1236.

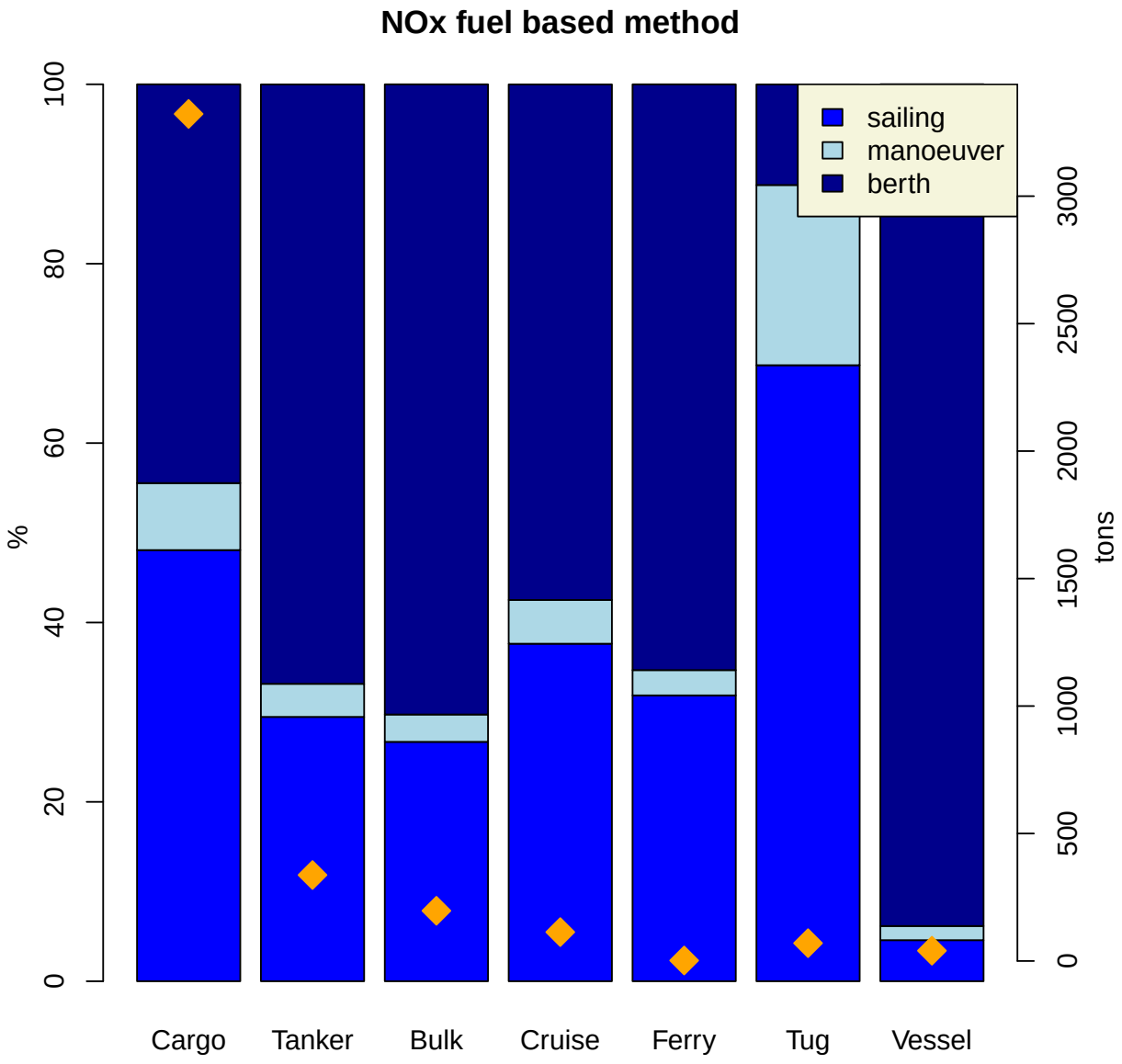
Model scheme



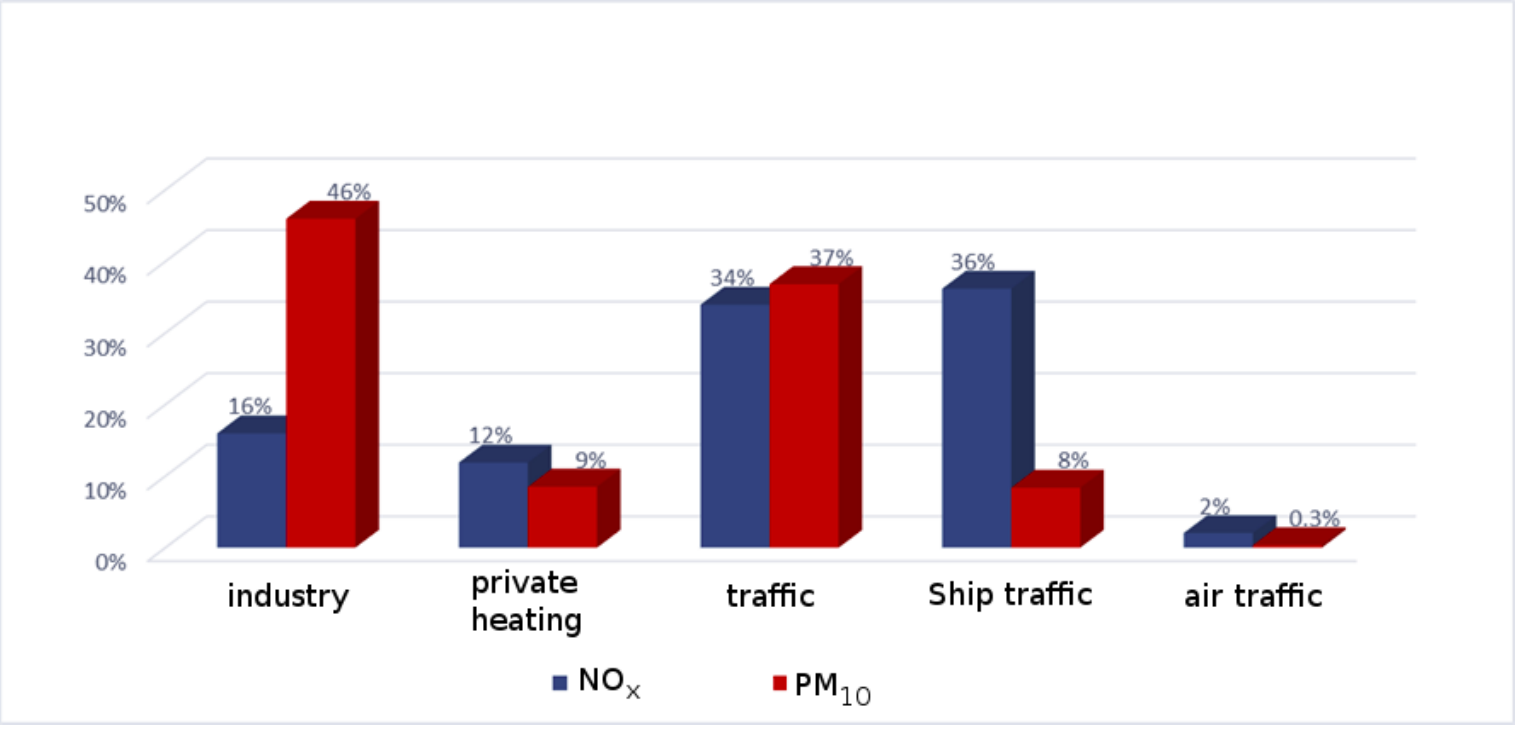
Total NO_x emissions by ships 2013



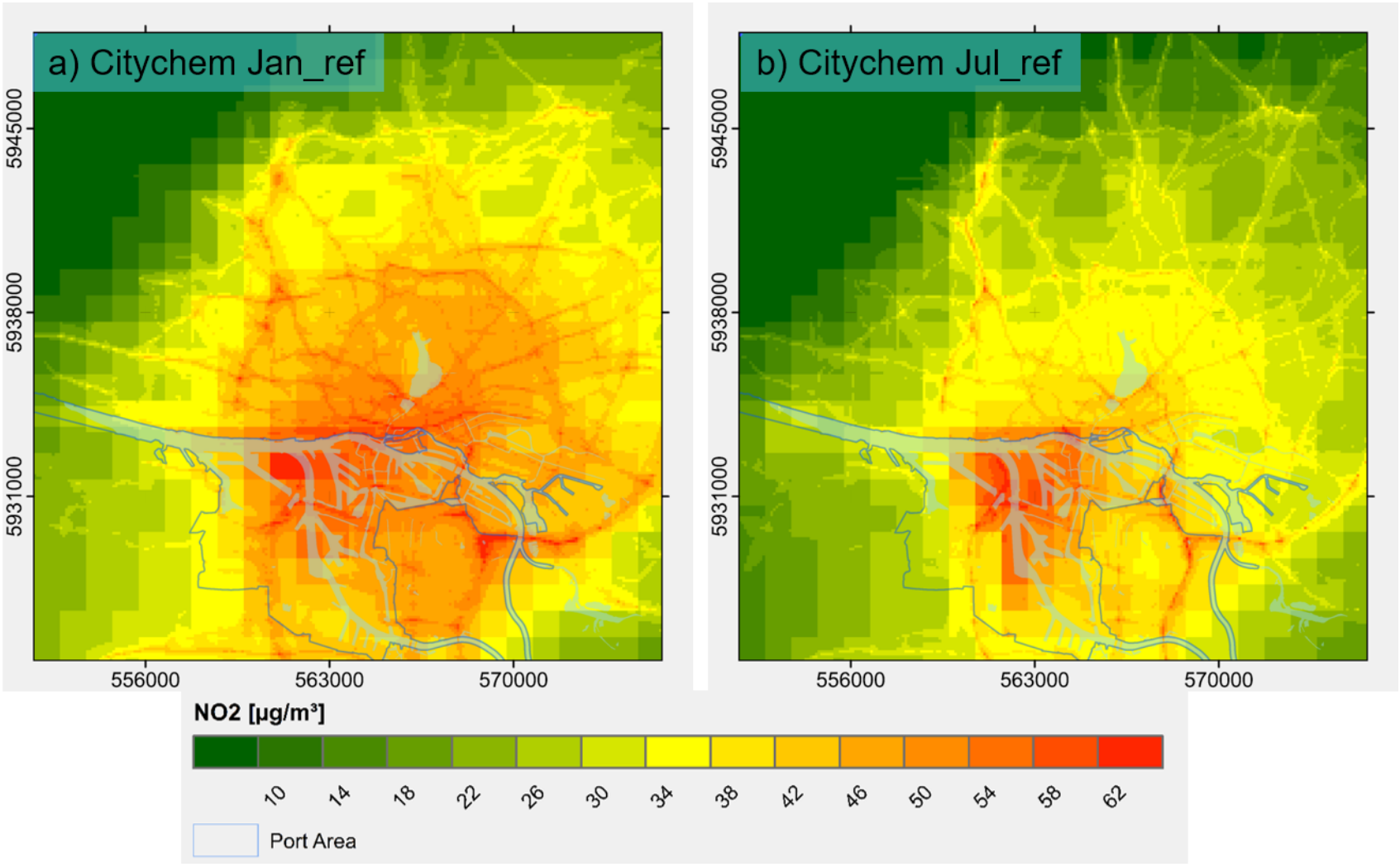
NO_x emissions per activity and ship type



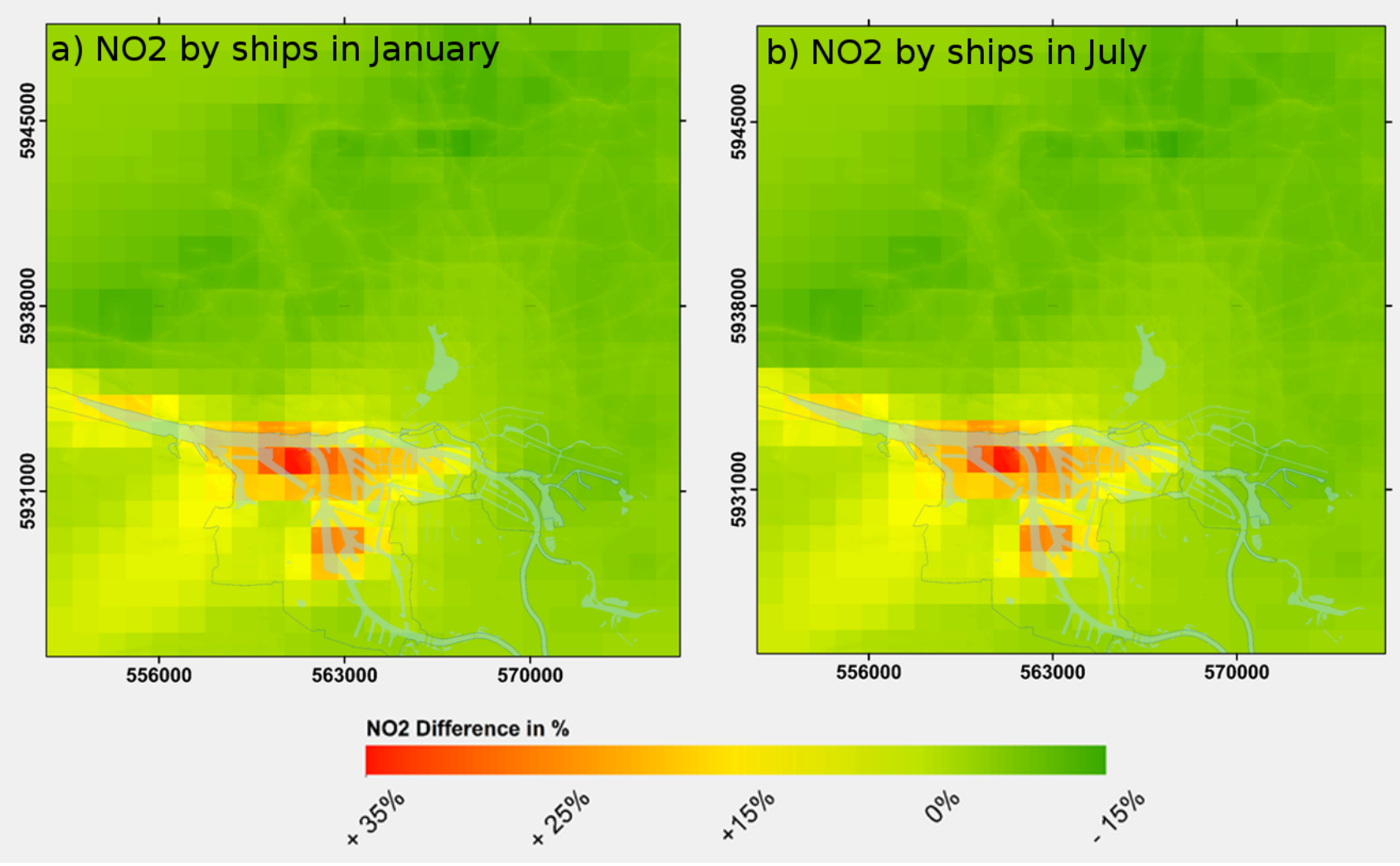
Ship emissions compared to other emissions



NO_2 concentration levels in Hamburg



Influence of ship emissions on NO_2



Outlook

- Evaluate further.

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- Provide tools for scenario creation.

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- Make source available (GPL).