A combined line-point-source model for ship emissions in the port of Hamburg, Germany

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Data and set-up

Ship activities

Emission calculation

Results

Outlook
Port of Hamburg
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,…

Additional info about the engines of the vessels are obtained from an IHS Fairplay data base.
Route points
Interpolated track
Time profile for the tracks

\[ y = \frac{1}{bx^{2a} + 1} \]
Three types of activities

sailing

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

- point/line source emissions
- energy specific emission factors ($\frac{g}{kWh}$)
- fixed loads for main and aux. engines
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berthing

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

specific NOx emission factors for E3 engines with Tier II specification

Load as fraction of MCR
Load based emissions
Load based emissions

\[ E(v, p_2, t_2) = \left(\frac{\text{speed}}{\text{speed}_{\text{max}}}\right)^3 MCR_{\text{max}} \Delta t EF + E_{\text{aux}} \]

Fuel based emissions at berth

Survey on board 175 seagoing ships

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

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

Model scheme

arrival-departure table

get IMO numbers
get port visits
arrival - [haul(s)] - departure
construct tracks including speed profile and hotelling

ship characteristics data base
calculate emissions
store individually as line sources

data base

netCDF file
sum over time step and make gridded emissions
Total $\text{NO}_x$ emissions by ships 2013
NO\textsubscript{x} emissions per activity and ship type

NO\textsubscript{x} fuel based method

- Cargo
- Tanker
- Bulk
- Cruise
- Ferry
- Tug
- Vessel

- sailing
- manoeuvre
- berth
Ship emissions compared to other emissions

- **industry**: 16% (NOx), 46% (PM10)
- **private heating**: 12% (NOx), 9% (PM10)
- **traffic**: 34% (NOx), 37% (PM10)
- **Ship traffic**: 36% (NOx), 8% (PM10)
- **air traffic**: 2% (NOx), 0.3% (PM10)
Outlook

- Evaluate further.
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- Provide tools for scenario creation.
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- Provide tools for scenario creation.
- Integrate option to create tracks from AIS signals.
- Consider emission height (and flue gas temperature).
- Make source available (GPL).