THE IMPACT OF THE SECA ON MEASURED CONCENTRATIONS
A MEASURABLE IMPACT?

Ministry of Infrastructure and Water Management:
• Verify the impact of SECA on SO₂ (and preferably PM) with AQ measurements;
• For the whole period (2007-2015) for Rotterdam and Amsterdam.

www.researchgate.net/publication/325528302_the_impact_of_a_seca_on_measured_so2_concentrations_a_case_study_from_the_ports_of_amsterdam_and_rotterdam

• Recent work: Ni and V trends

• Methodology demonstrated at one monitoring site
STUDY AREA
SECA AND NON-SECA CHANGES

Study period 2005-2015:
• Port extension, coast reinforcement (2008-2013);
• Emission reduction at a refinery and some other plants (2008, 2009);
• Emission inventory method changed to AIS based (2007/2008);
• Economic crisis and upswing; changing ship types;
• Background $\text{SO}_2$ became too low to be reliably monitored.

Look at timing and wind angles!
EMISSIONS

• Based on Dutch national emission inventory
• Shipping: adapted for pre-AIS years by correlating CO₂ emission with ‘Cargo handled’ and ‘#Port calls’; remaining issue AIS coverage further inland

Table 2 SO₂ emissions (kton/y) in the port of Rotterdam area; bold: change related to SECA measures

<table>
<thead>
<tr>
<th>Year</th>
<th>Total land sources</th>
<th>% change</th>
<th>Total marine shipping</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>33.3</td>
<td></td>
<td>6.4*</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>33.9</td>
<td>2%</td>
<td>6.8*</td>
<td>6%</td>
</tr>
<tr>
<td>2007</td>
<td>31.3</td>
<td>-8%</td>
<td>5.8</td>
<td>-15%</td>
</tr>
<tr>
<td>2008</td>
<td>24.7</td>
<td>-21%</td>
<td>4.3</td>
<td>-26%</td>
</tr>
<tr>
<td>2009</td>
<td>19.4</td>
<td>-21%</td>
<td>4.5</td>
<td>5%</td>
</tr>
<tr>
<td>2010</td>
<td>15.3</td>
<td>-21%</td>
<td>2.1</td>
<td>-53%</td>
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<tr>
<td>2011</td>
<td>15.0</td>
<td>-2%</td>
<td>1.8</td>
<td>-14%</td>
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<tr>
<td>2012</td>
<td>15.8</td>
<td>5%</td>
<td>1.7</td>
<td>-6%</td>
</tr>
<tr>
<td>2013</td>
<td>13.0</td>
<td>-18%</td>
<td>1.5</td>
<td>-12%</td>
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<tr>
<td>2014</td>
<td>12.6</td>
<td>-3%</td>
<td>1.7</td>
<td>13%</td>
</tr>
<tr>
<td>2015</td>
<td>13.9</td>
<td>10%</td>
<td>0.7*</td>
<td>-59%</td>
</tr>
</tbody>
</table>

* Data adapted from Marin, see annex 2
DISENTANGLING TRENDS

Industrial SO$_2$-contributions Hoek van Holland

mean (µg m$^{-3}$)}

SO$_2$-contribution
DISENTANGLING TRENDS

SO2

- Sea (north-west)
- Shipping (south-west)
- Entrance port (west)
- All other

Concentration (µg.m⁻³)

SECA step

- pre SECA
- 2007
- 2010-1
- 2010-2
- 2015
DISENTANGLING TRENDS

**Nickel**
- Sea (north-west)
- Shipping (south-west)
- Entrance port (west)
- All other

**Vanadium**
- Sea (north-west)
- Shipping (south-west)
- Entrance port (west)
- All other
CHANGE OF FUEL TYPE?

![Graph showing changes in fuel type over time for different categories like Sea (north-west), Shipping (south-west), Entrance port (west), and All other. The graph indicates a trend with concentration ratios varying over the years 2003-2015.](image-url)
CHANGE OF FUEL TYPE?

Fuel samples

<table>
<thead>
<tr>
<th>Year</th>
<th>MDO</th>
<th>HFO</th>
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<tbody>
<tr>
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<td>11</td>
<td>23</td>
</tr>
<tr>
<td>2007</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td>2008</td>
<td>13</td>
<td>21</td>
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Fuel samples

<table>
<thead>
<tr>
<th>Year</th>
<th>% S</th>
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</thead>
<tbody>
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<td>2006</td>
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<tr>
<td>2007</td>
<td>2</td>
</tr>
<tr>
<td>2008</td>
<td>1</td>
</tr>
</tbody>
</table>
V WET DEPOSITION

Bergambacht
(25-50 km downwind of the port)
A MEASURABLE IMPACT!

• Expected stepwise concentration behavior in the ‘shipping-specific’ wind angles
• T-test in 1-3 wind angles at 4 sites (9 cases Rotterdam & 5 cases in 4 sites in Amsterdam)
• Mainly significant results; further inland (narrow wind angles) some insignificant
RELATIVE IMPORTANCE

• Combined modeling and monitoring exercise:
  • Measured SO$_2$ at port monitoring site
  • Measured SO$_2$ background
  • Calculated (Gaussian plume model) industrial contribution at port monitoring site
  • Difference is assume to be shipping

• Limitations: uncertainties play a substantial role at low concentrations
CONCLUSIONS

- All SECA steps have a significant impact on SO$_2$ in wind angles specific for shipping
  - Pre SECA: shipping stronger source than local industries; 2015 equal contributions
  - SO$_2$ contribution from shipping in Hoek van Holland 18 $\rightarrow$ 5 µg. m$^{-3}$

- Impact on total PM can’t be shown with AQ measurements
- Impact on aerosol can be seen from heavy metal concentrations
  - V strong reductions: 30 $\rightarrow$ 2 ng.m$^{-3}$
  - Ni 17 $\rightarrow$ 3 ng.m$^{-3}$

- Impact visible in the port area and beyond
Acknowledgements:
- The routine air quality monitoring and data analysis is financed by the local and regional authorities.
- The ministry of Infrastructure and Environment and the Port of Rotterdam have contributed financially to studies based on these data.
- Emre Ozdemir (DCMR) and Simran Thakur (WUR) for work on the heavy metal data.