Global shipping NOx emissions in S5P TROPOMI data

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Miriam Latsch (mlatsch@iup.physik.uni-bremen.de)

Andreas Richter, Kezia Lange, and John P. Burrows

Miriam Latsch (mlatsch@iup.physik.uni-bremen.de)
Vienna, 27.05.2022

Institute of Environmental Physics, University of Bremen

Motivation

Background

- Nitrogen oxides are important trace gases in the troposphere
- Global shipping plays a prominent role in transporting goods around the world
- Ships emit large amounts of NOx, which affect the marine boundary layer and human health

Study aim

- Detection of shipping signals from global shipping lanes in the S5P TROPOMI NO_2 data

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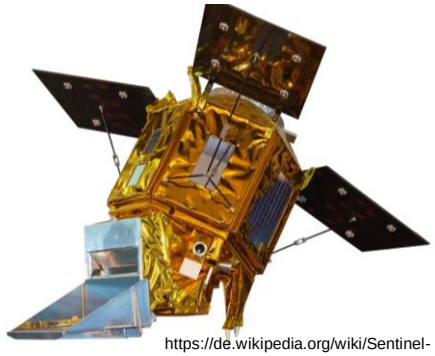
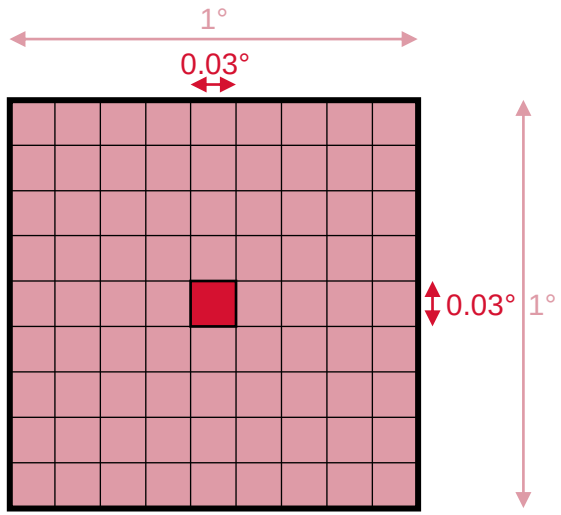
Data and filter settings

- Reprocessed consistent S5P TROPOMI NO_2 product from the Products Algorithm Laboratory (PAL) and the offline (OFFL) Level 2 NO_2 data of processor version 2.3.1
- NO_2 tropospheric slant column density (SCD) (= trop. VCD * trop. AMF)
  - SCD does not contain model information about the shipping routes



https://de.wikipedia.org/wiki/Sentinel-5P#/media/Datei:Sentinel_5P_model.jpg

- Averages on a 0.03 x 0.03 km² grid for the years from 2018 to 2021
- Filtering method to highlight the shipping lanes: averaging the neighboring pixels and subtracting this averaged value from the original pixel value with a box size of ~1° for longitude and latitude
  - Small shipping signals on a variable background
- TROPOMI surface classification mask is applied to use only pixels over water
- Only data with quality value > 0.75 and cloud fraction < 0.5 is included
- No wind speed and sun glint filtering yet



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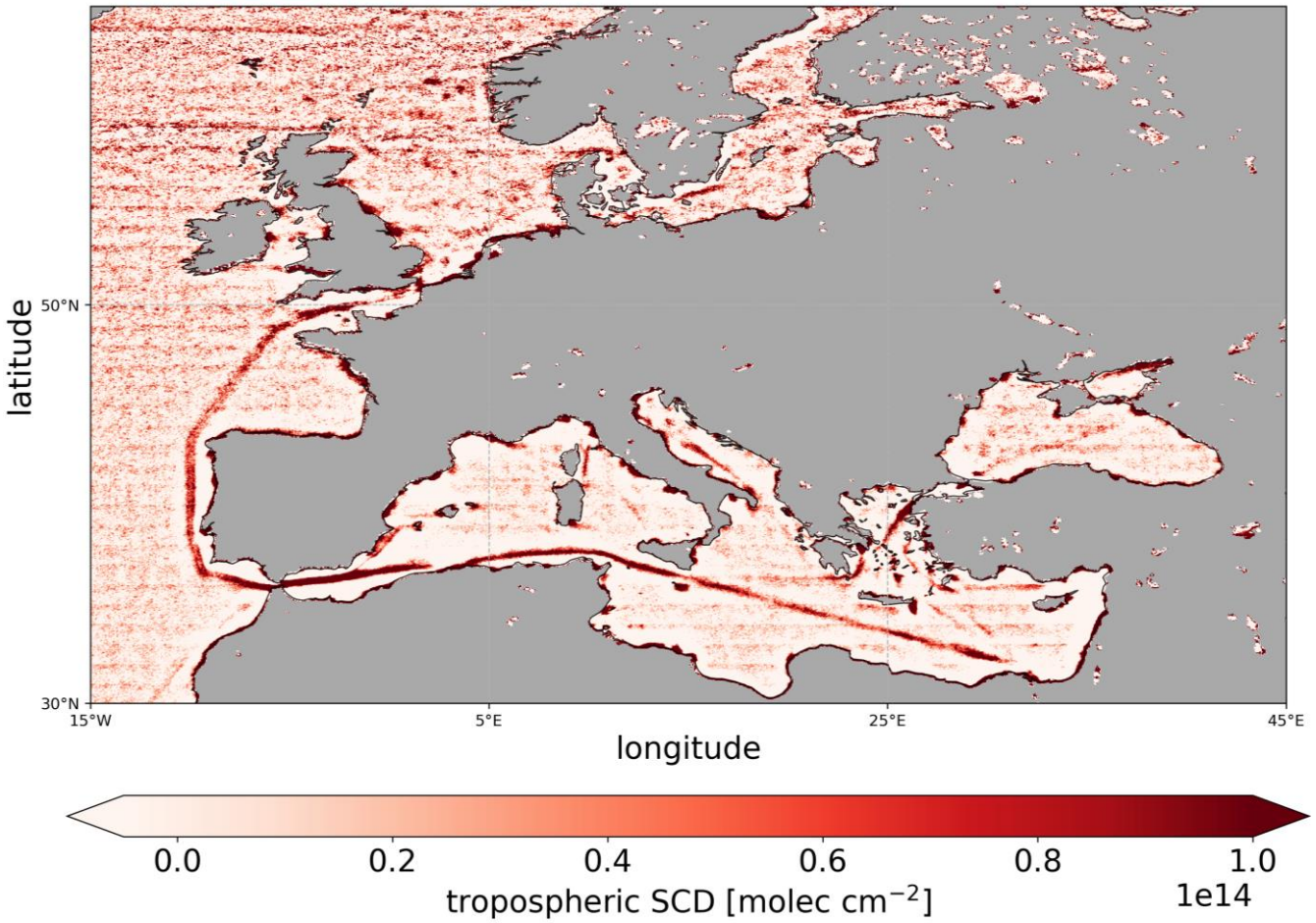
Overview – European Seas



- Very small signals below 10^{14} molecules per cm^2
- Box pattern in the operational data set, which is even more pronounced due to the filtering
- Two separated shipping lanes off the coast of southern Portugal and in the British Channel

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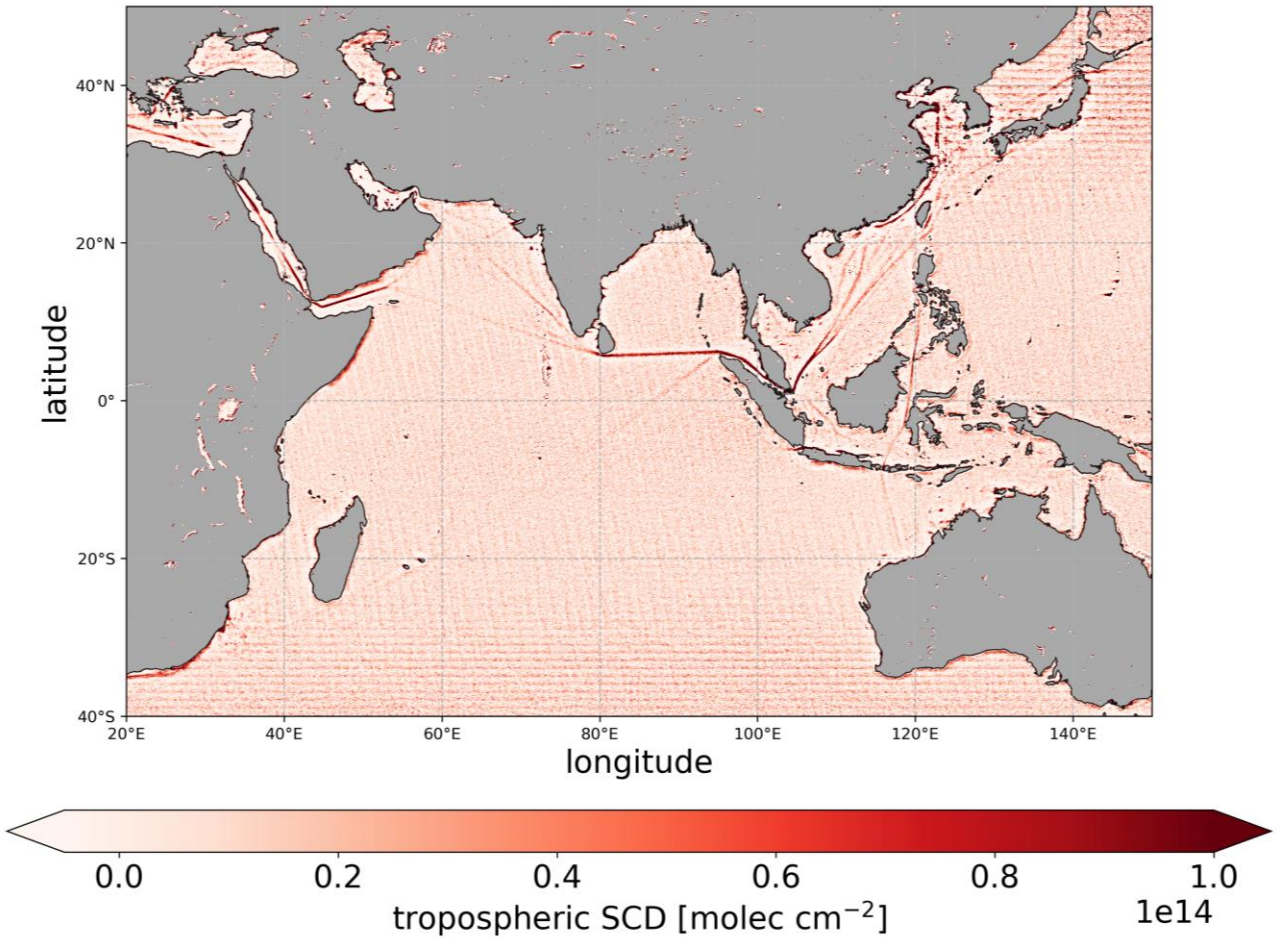
Indian Ocean and Asian Seas



- Distinct lines from
  - South Africa to Indonesia
  - the Red Sea and Persian Gulf to Singapore
  - Singapore to China in several lines, also very coastal
  - Australia straight up to the Philippines
- Box pattern in the more northern and southern regions
- Orbital structures in the tropical and subtropical region

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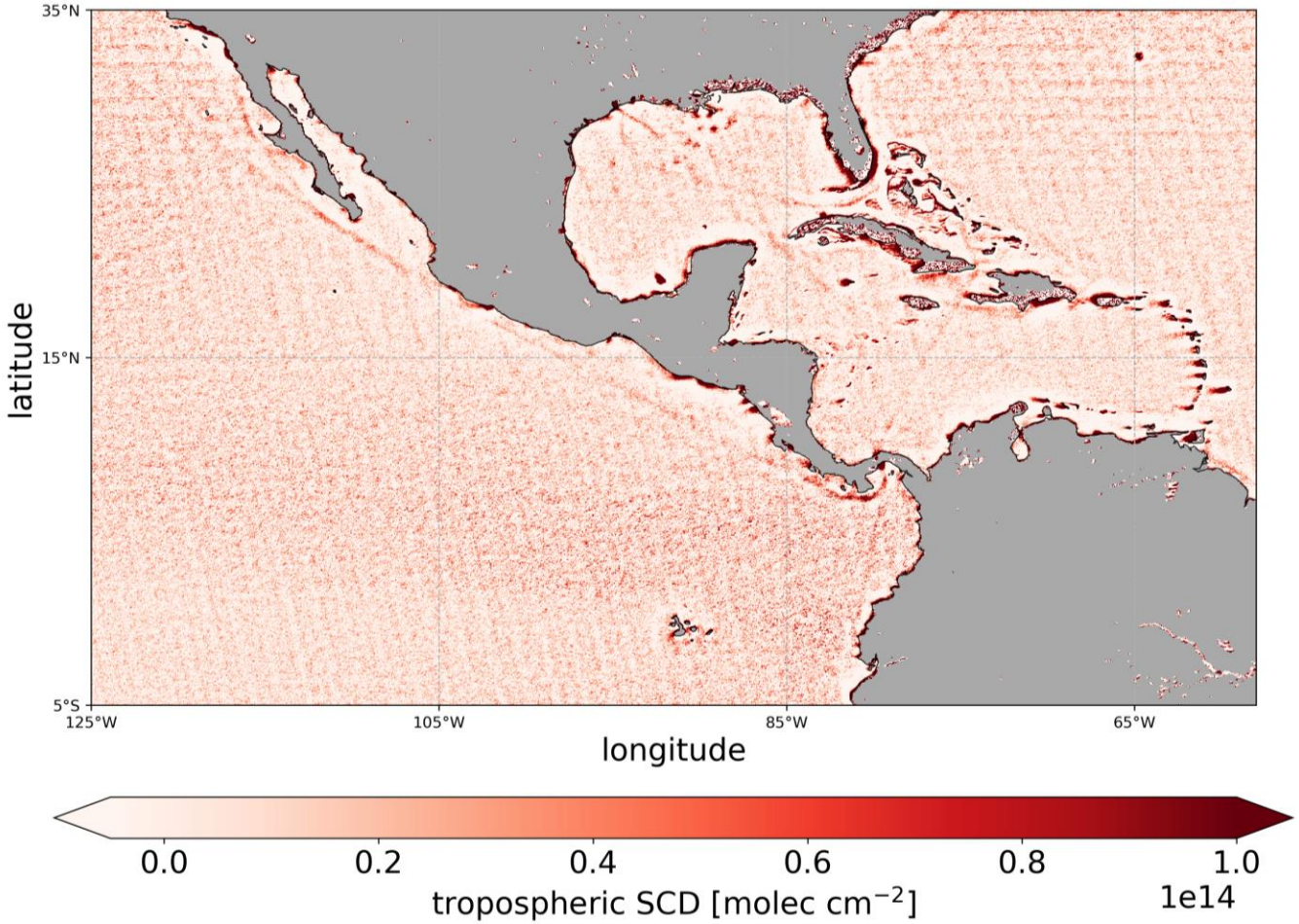
Middle America and Panama Canal



- Shipping signals from the exit of the Panama Canal to the North and to the South in the Pacific Ocean
- Some lanes in the Gulf of Mexico and the Caribbean Sea

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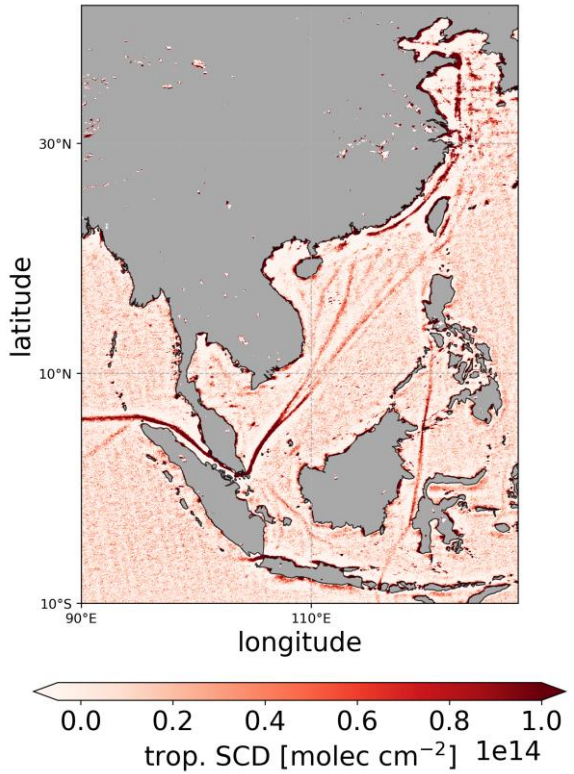
Conclusions and Outlook

- Large global shipping lanes can be seen in S5P TROPOMI NO_2 data
- The filtering method highlights the shipping lanes, but not all known lanes have been found yet
- The operational S5P TROPOMI data contains some box patterns and orbital structures that are more visible when the filtering is applied

- Some other filtering methods will be tested to detect more shipping lanes
- Sun glint and wind speed will be used for data selection
- Future work will be to quantify the NO_2 ship emissions by
  - using scene dependent appropriate air mass factors
  - comparison with model simulations



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