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Improving cloud retrievals for accurate detection of ship NO_2 plumes from S5P-TROPOMI

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The TROPOMI and OMI satellite sensors provide an exciting perspective on the sources, dispersion, and fate of air pollution emitted by the international shipping industry. Recently it proved possible to detect plumes of NO_2 from individual ships with high-resolution measurements from TROPOMI, especially when observed under sun-glint conditions. In principle, this allows the quantification of NO_x emissions from ocean-going ships, but an outstanding scientific question is under which atmospheric conditions ship plumes are best detected. The effects of viewing geometries, local wind speed, partial cloud cover, emission strength as well as chemical boundary conditions on NO_2 plume detectability are still a challenge to understand.

Here we investigate TROPOMI's ability to detect NO_2 pollution from the international shipping sector under different measurement conditions, and we compare it to that of its predecessor OMI. Uncertainties in cloud properties – and thereby in the resulting Air Mass Factors – are one of the leading sources of uncertainty in the TROPOMI NO_2 retrieval. These become increasingly important when investigating small NO_2 enhancements close to the Earth's surface in partly cloudy scenes, i.e. thos from shipping.

We examine for the first time the new TROPOMI-FRESCO+DDS algorithm which uses a wider spectral window for the O_2-A band than the original FRESCO+, increasing its sensitivity to low clouds. We cross-evaluate the resulting cloud properties against the operational TROPOMI-FRESCO+, VIIRS and OMCLDO2 algorithms on a pixel-by-pixel basis. This comparison reveals it is likely that FRESCO+ cloud heights are biased high by around 100hPa, leading to an overestimated AMF and thus low biased NO_2 columns for (partially) cloudy scenes. We explore the AMF correction based on FRESCO+DDS to improve the operational TROPOMI NO_2 retrieval for ship plume detection and discuss implications for the detection of COVID-19 associated reductions in shipping, and hence pollution levels over European seas.

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