Global vertical profiles of tropospheric NO_2 from cloud-sliced TROPOMI observations

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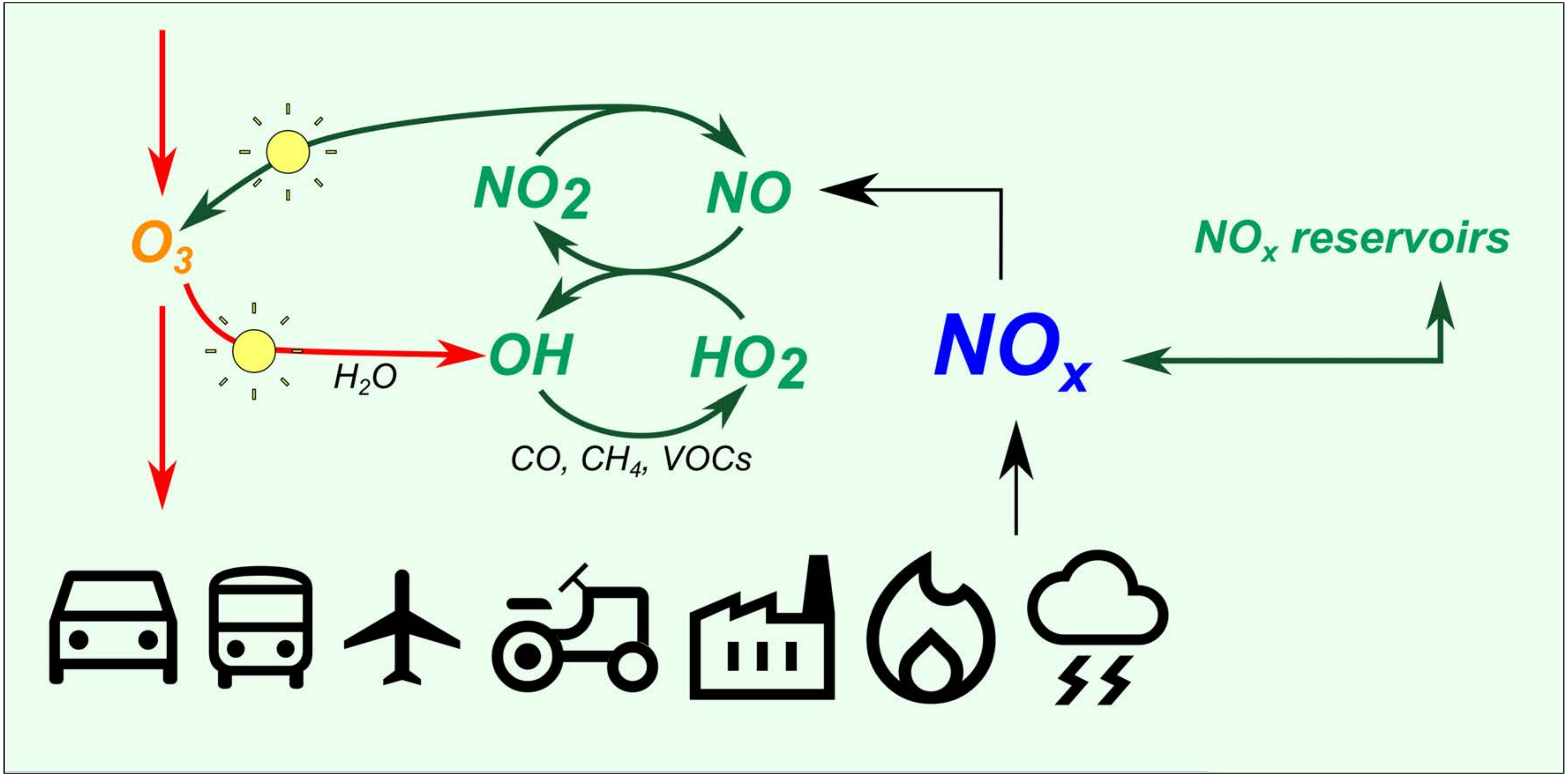
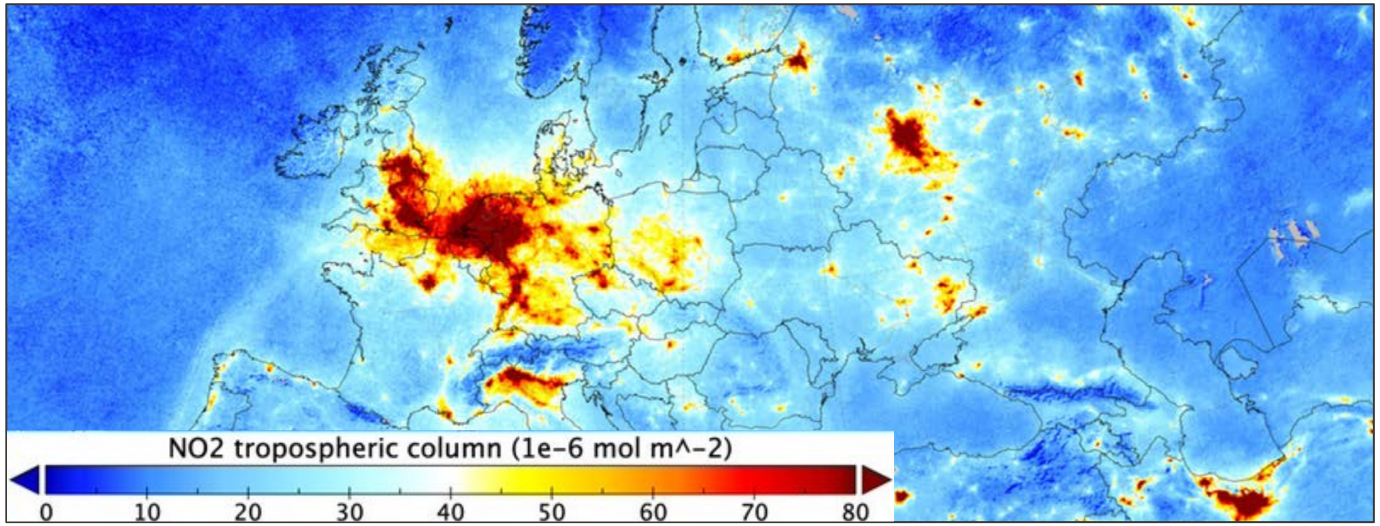
The importance of NO_x in the troposphere

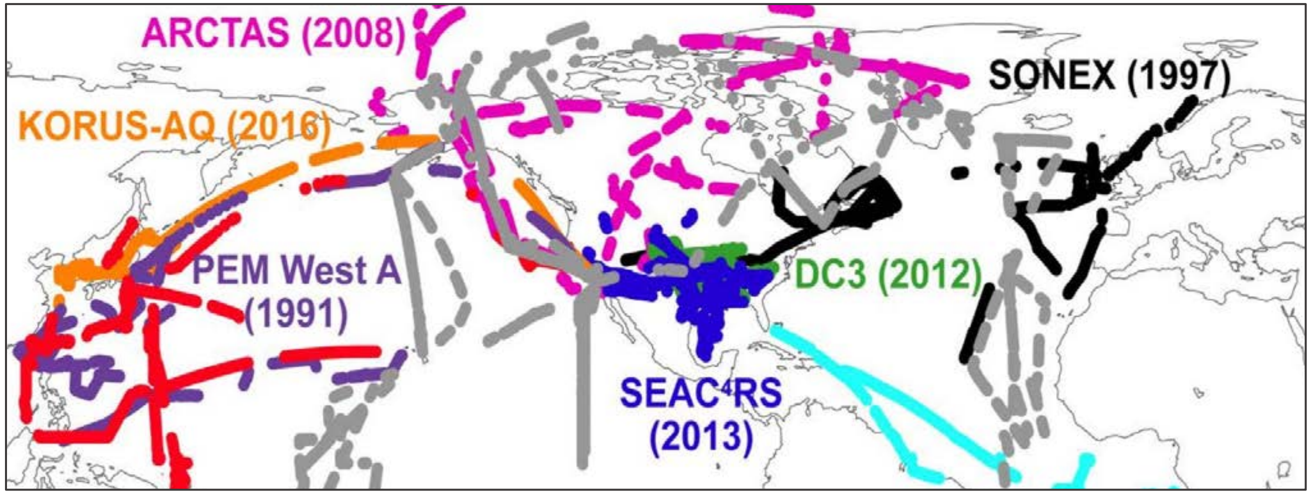


Why do we use cloud-slicing?

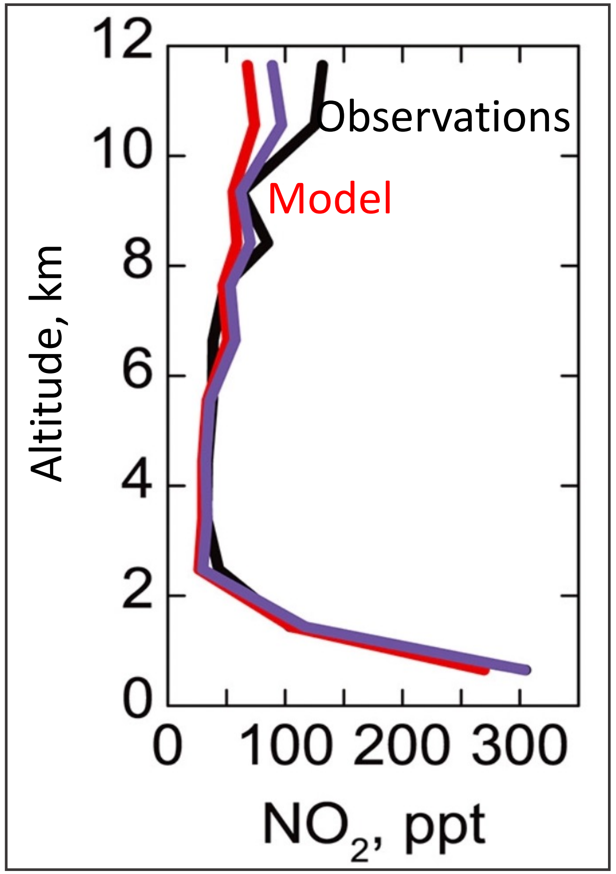
TROPOMI NO_2 column – April to September 2018



NASA DC-8 aircraft flight tracks



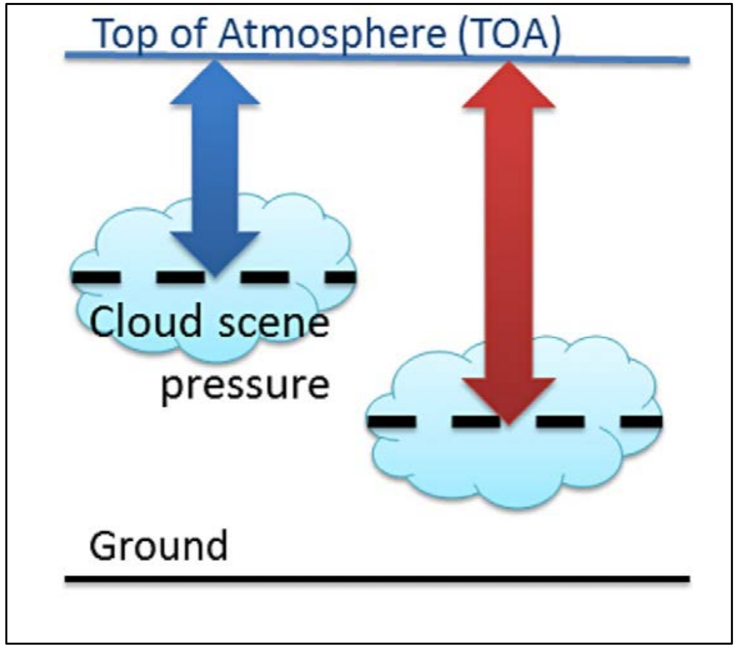
Modelled NO_2 vertical profile

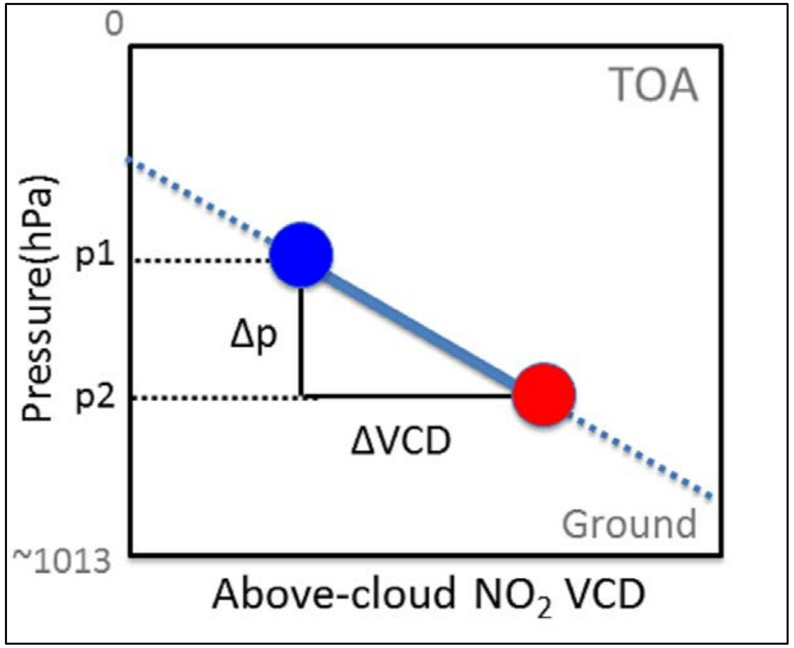


(Silvern et al., 2018)

TROPOMI data retrieval and the cloud-slicing technique

Derives the NO_2 volume mixing ratio using partial NO_2 columns above optically thick clouds.





(S. Choi et al., 2014)

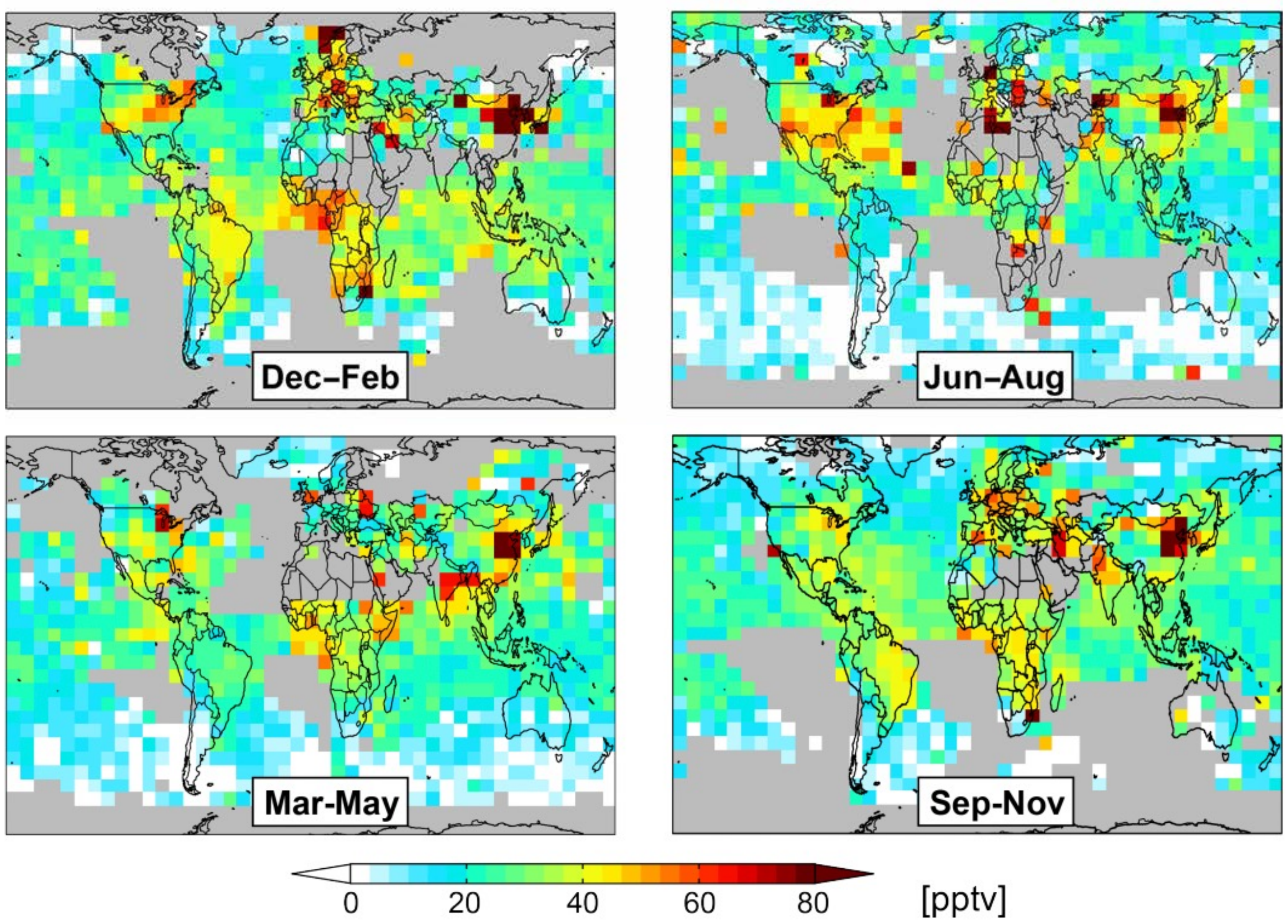
$$\boldsymbol{NO_2\,VMR} = \frac{\Delta \boldsymbol{VCD}}{\Delta \boldsymbol{p}}\,\frac{k_B\,g}{R_{air}}$$

Previous cloud-slicing of satellite data

OMI = Ozone Monitoring Instrument

- OMI has a horizontal resolution of 13 km x 24 km.
- TROPOMI has a horizontal resolution of 5.6 km x 3.5 km since August 2019.

Seasonal mean upper tropospheric NO_2 from NASA OMI with a spatial resolution of 5° x 8° (2005-2007).

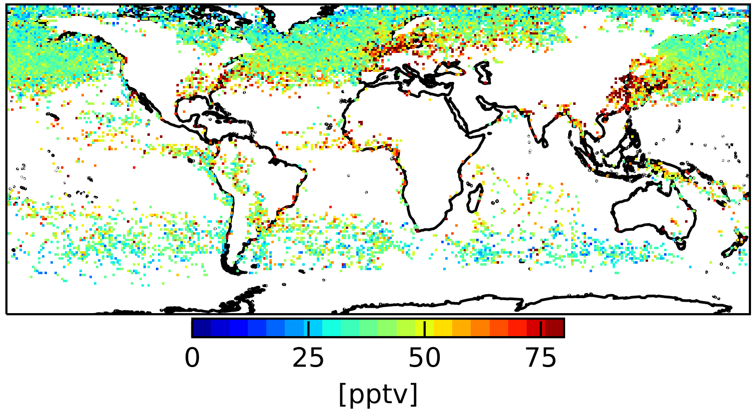


(Marais et al., 2018)

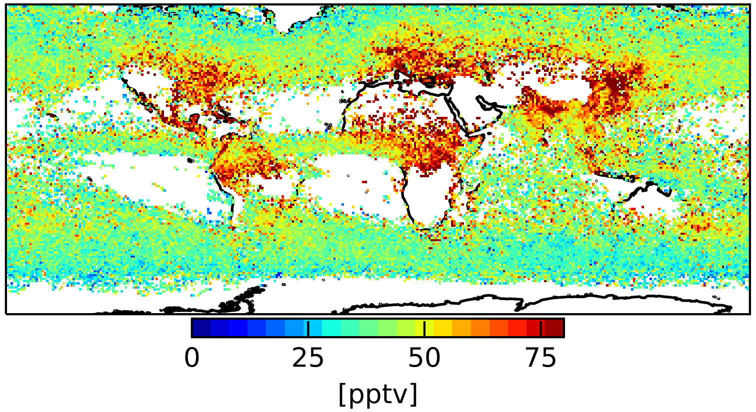
TROPOMI vertical columns from cloud-slicing

Mean TROPOMI NO_2 for Jun-Aug 2019 with a resolution of 1° x 1°.

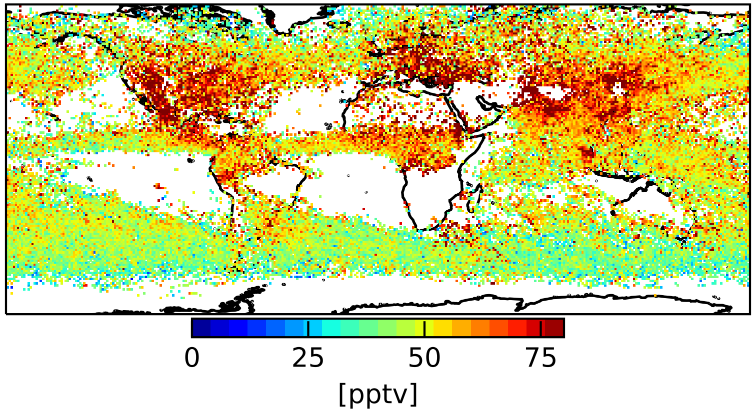
800-1100 hPa: 17.4% filled



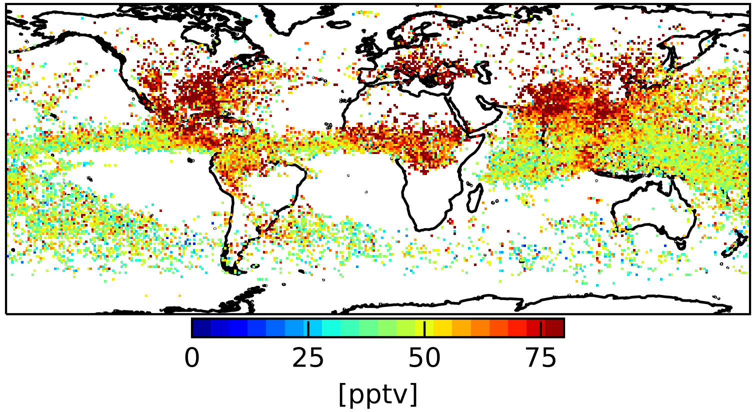
600-800 hPa: 55.0% filled



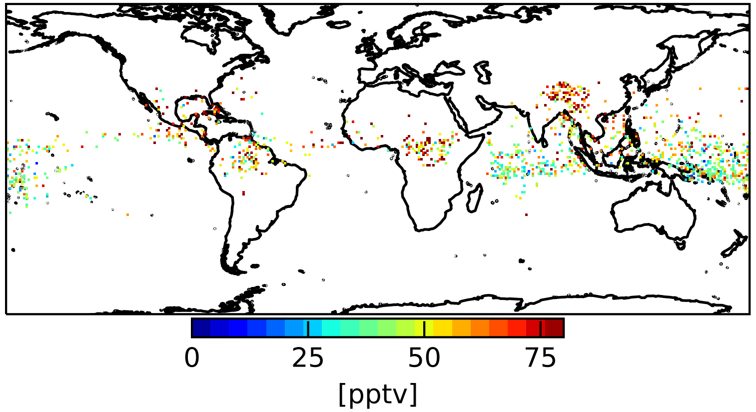
450-600 hPa: 49.0% filled



320-450 hPa: 20.4% filled



180-320 hPa: 1.68% filled

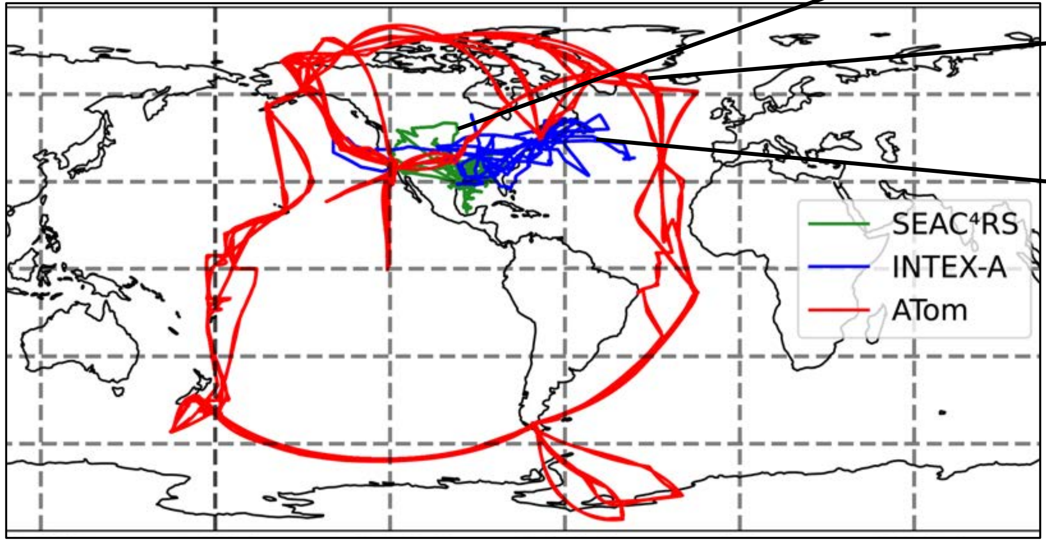


Datasets used in tropospheric vertical profiles

TROPOMI aboard Sentinel-5P

2 retrieval products from TROPOMI (*TROPOMI 1* & *TROPOMI 2*)

NASA DC-8 aircraft campaigns



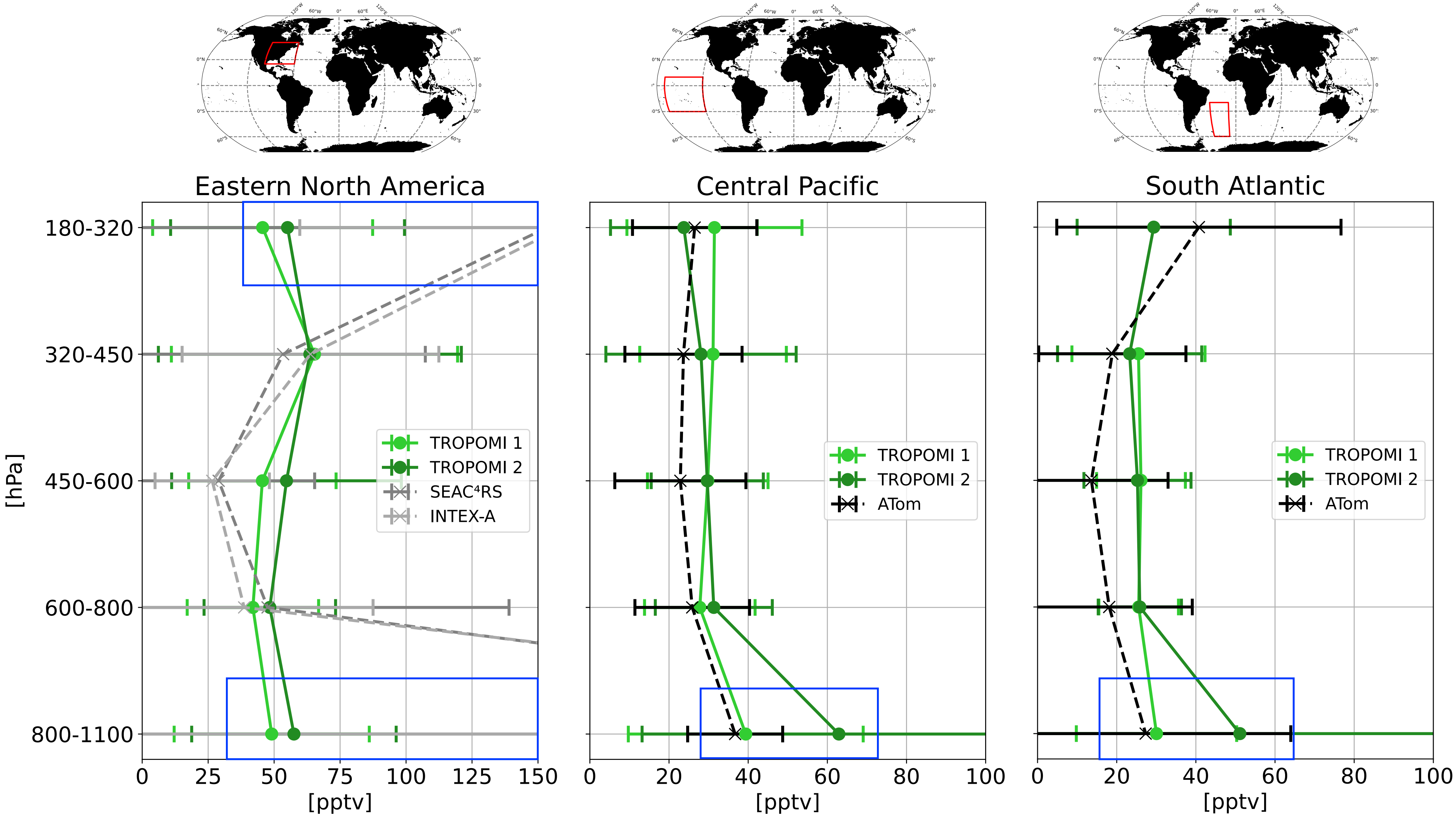
SEAC^{4}RS - Summer 2013

ATom - ATom-1 (Jul-Aug 2016), ATom-2 (Jan-Feb 2017), ATom-3 (Sep-Oct 2017), and ATom-4 (Apr-May 2018)

INTEX-A - Summer 2004

Multi-year tropospheric vertical profiles from TROPOMI

June to August: 2018 to 2021



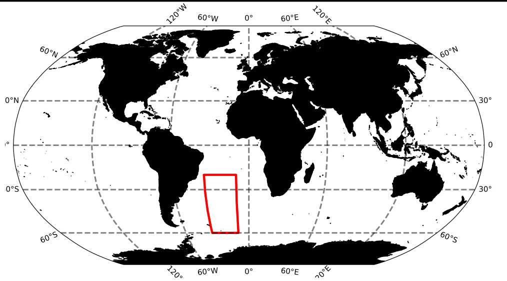
Over North America:

- > 350 pptv difference in the boundary layer.
- Decreases between 180 and 320 hPa to < 110 pptv.

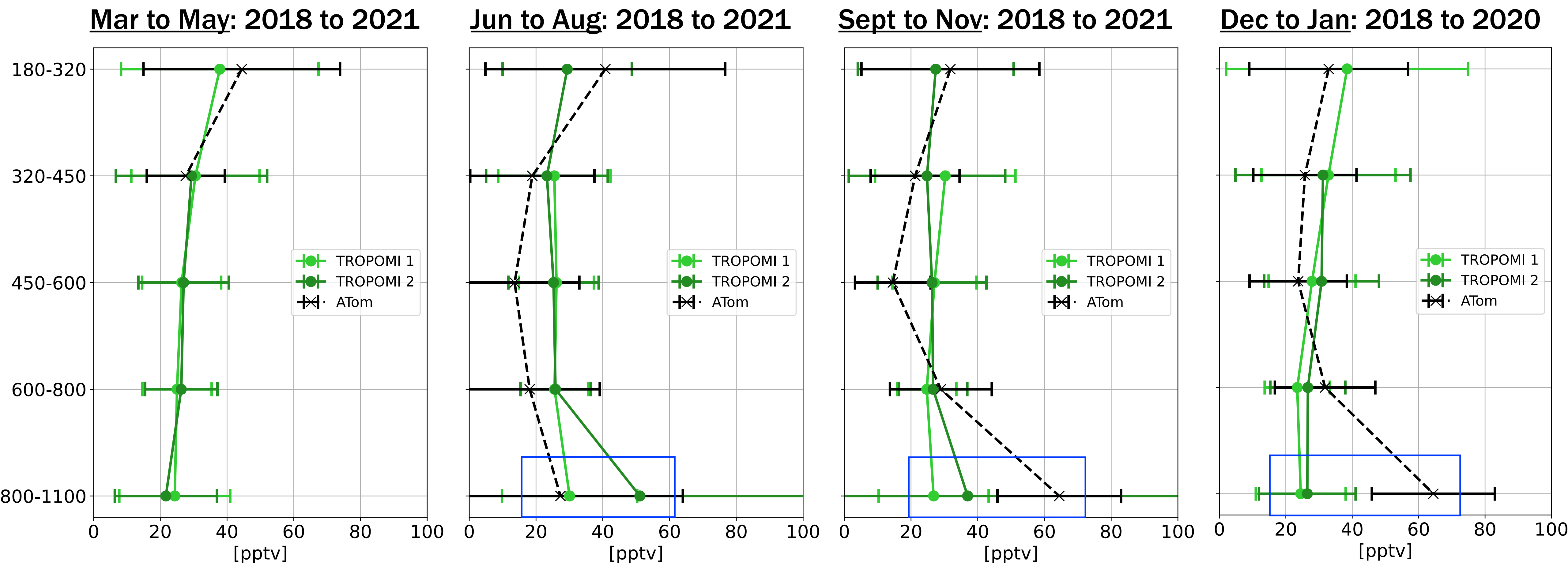
Over the oceans:

- < 30 pptv difference in the boundary layer.
- Discrepency of 10 pptv between 180 and 320 hPa.

Comparison of seasonal vertical profiles to ATom measurements

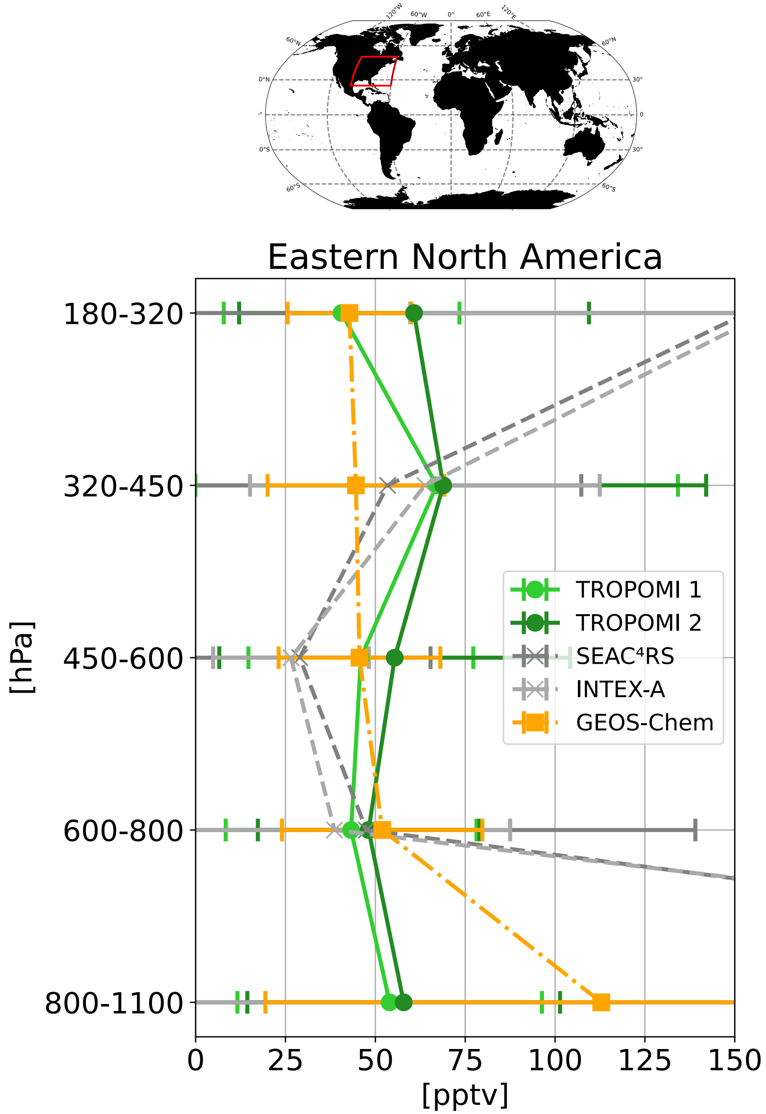


This technique enables us to obtain information on the composition of the troposphere where aircraft observations are lacking.



Summary

Jun - Aug 2019



- Provides a method for creating vertical profiles from global cloud-sliced satellite data.
- Reasonable agreement in most areas of the globe between TROPOMI and aircraft observations between 180-800 hPa.
- Enables analysis of vertical distribution of NO_2 in areas where aircraft observations are sparse.

Next steps:

1. Use GEOS-Chem to attribute any other uncertainties.
2. Continue to test the robustness of these results.
3. Identify whether the cloud-slicing technique is functional in the boundary layer.

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