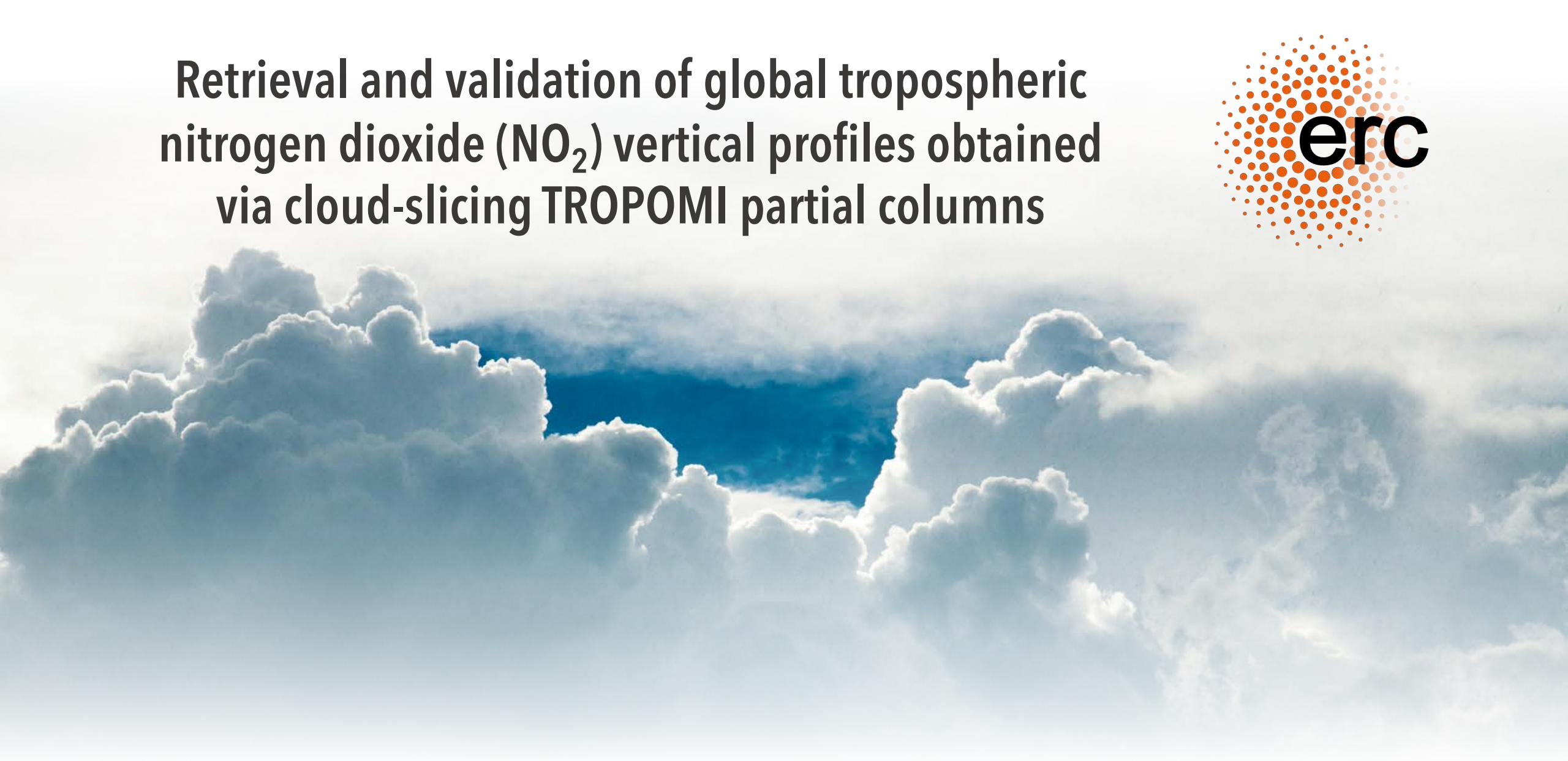
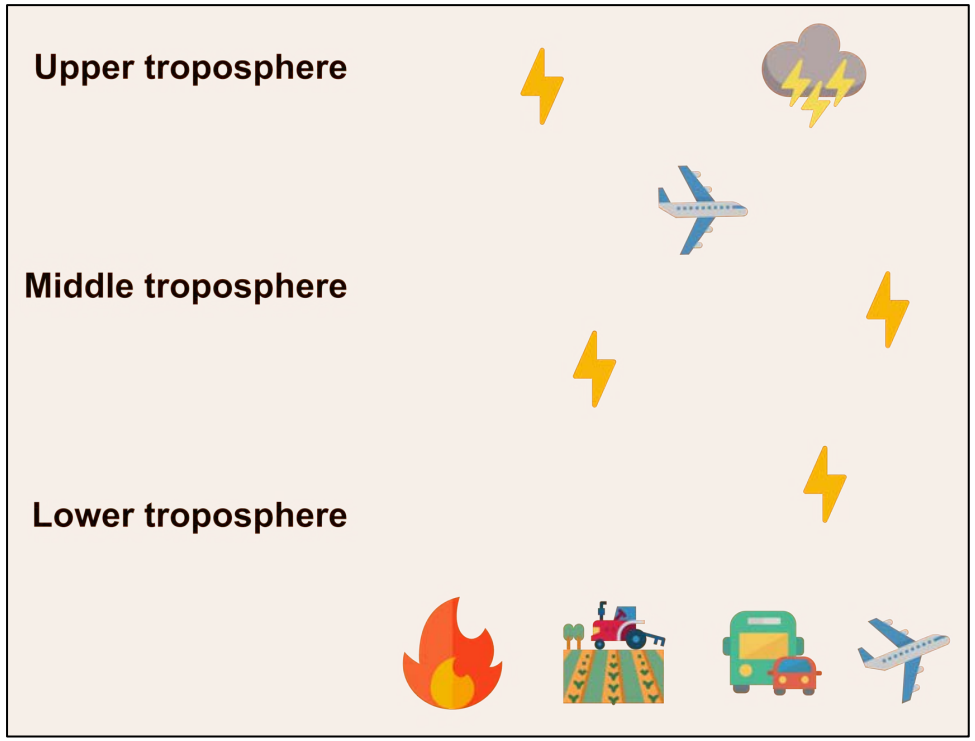
Retrieval and validation of global tropospheric nitrogen dioxide (NO_2) vertical profiles obtained via cloud-slicing TROPOMI partial columns

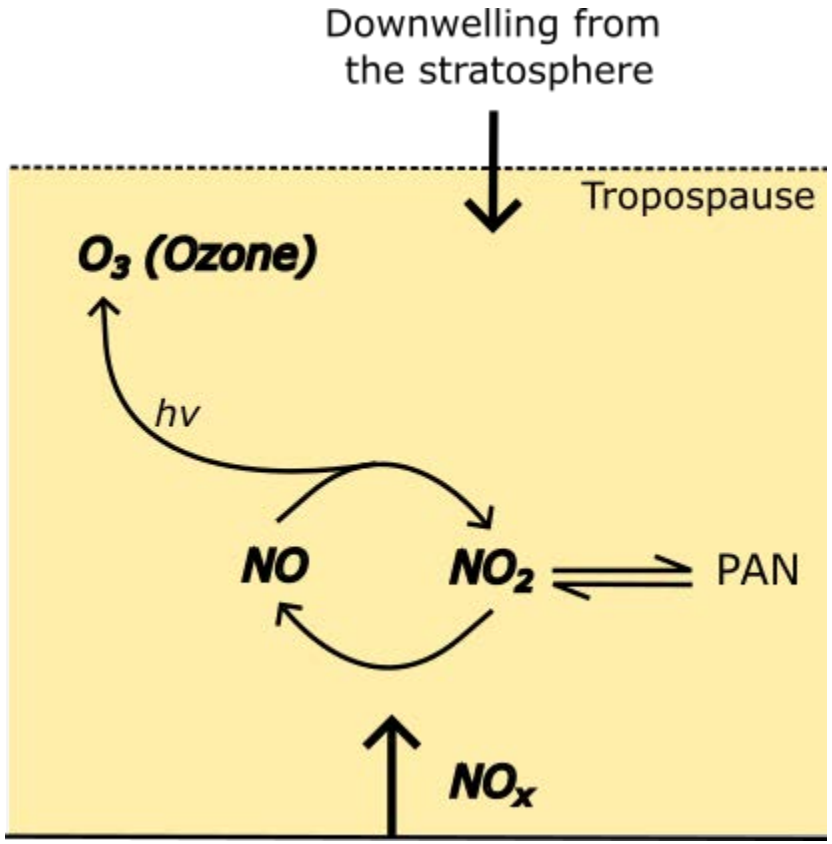


Rebekah P. Horner
(rebekah.horner.20@ucl.ac.uk), Eloise A. Marais, Nana Wei, NASA DC8 Science Teams

EGU General Assembly 2023

NO_x in the troposphere

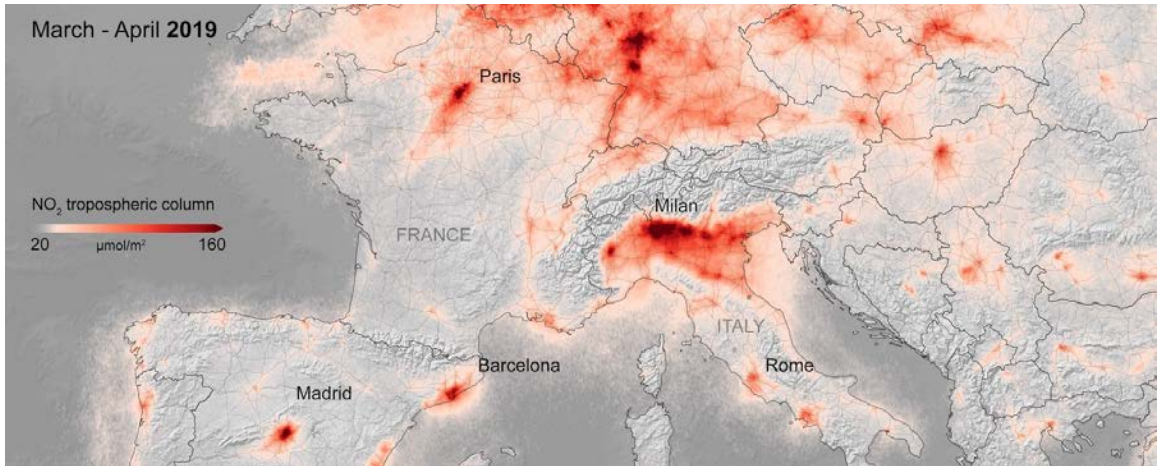




NO_x has a large influence on **tropospheric ozone** → The troposphere is **predominantly NO_x-limited** and the persistence of NO_x increases with altitude

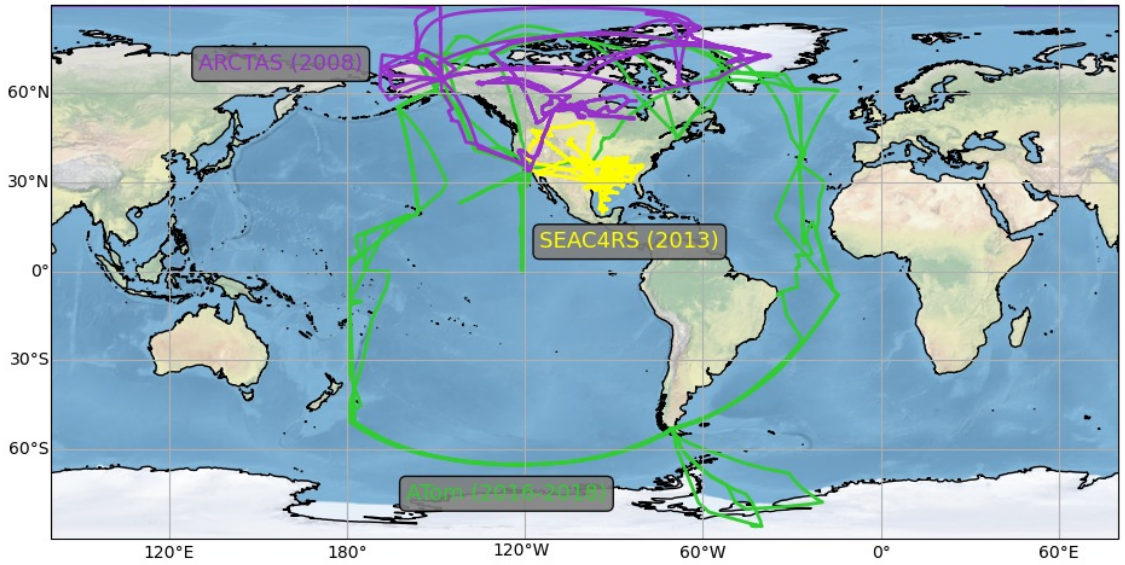
Limitations of the current NO_2 observation network

Satellite data (TROPOMI)

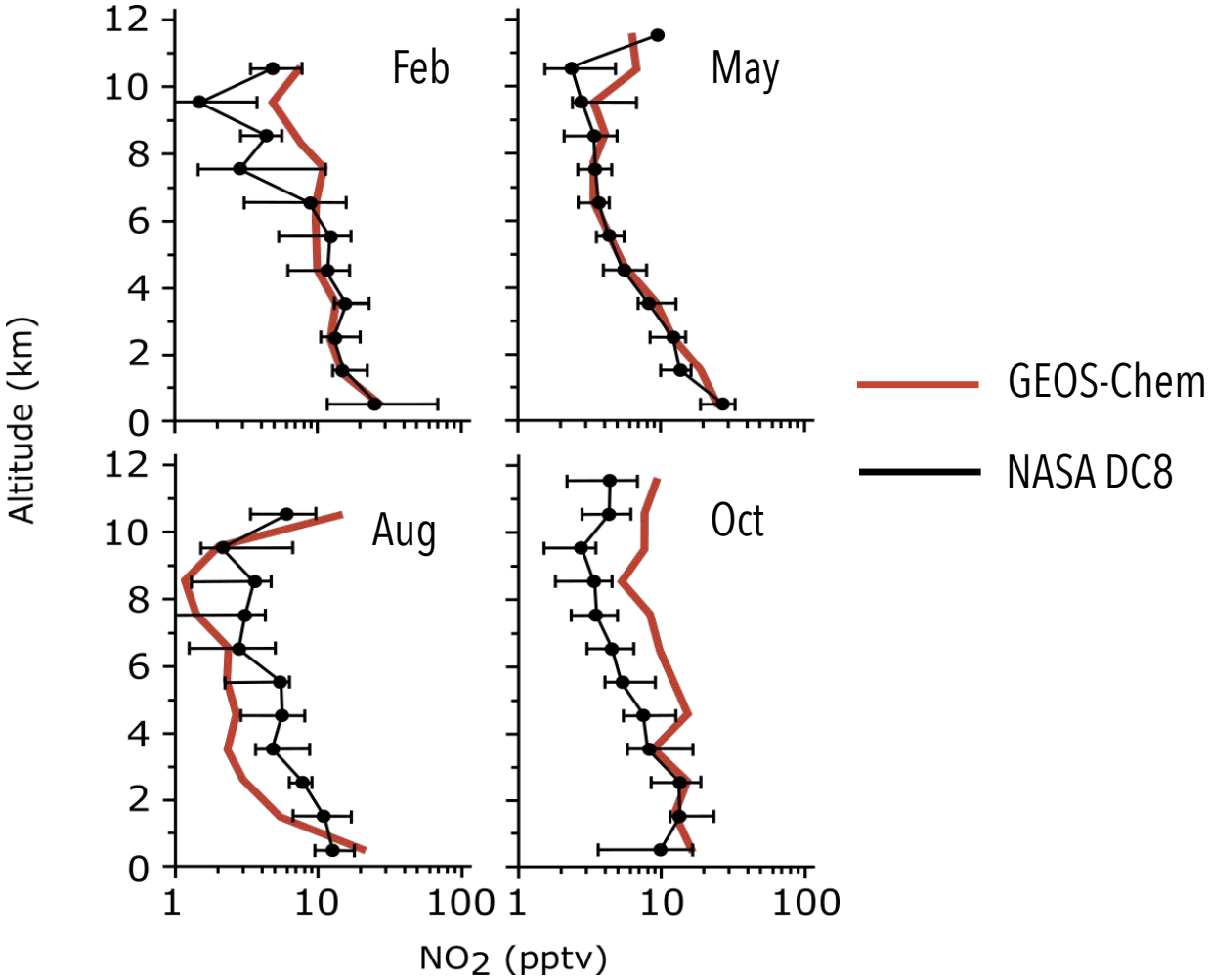


[ESA, 2020]

Aircraft data (NASA DC8)

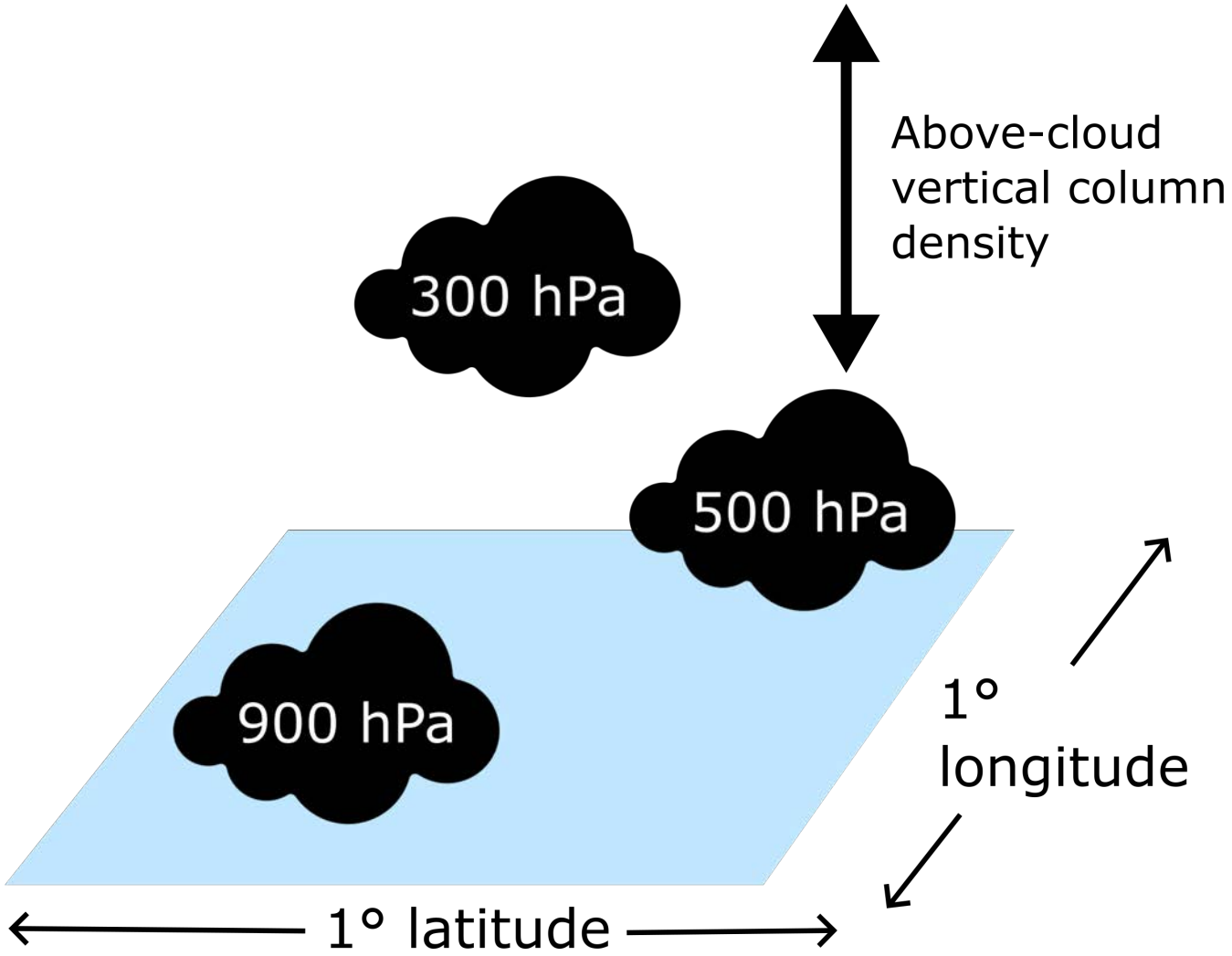


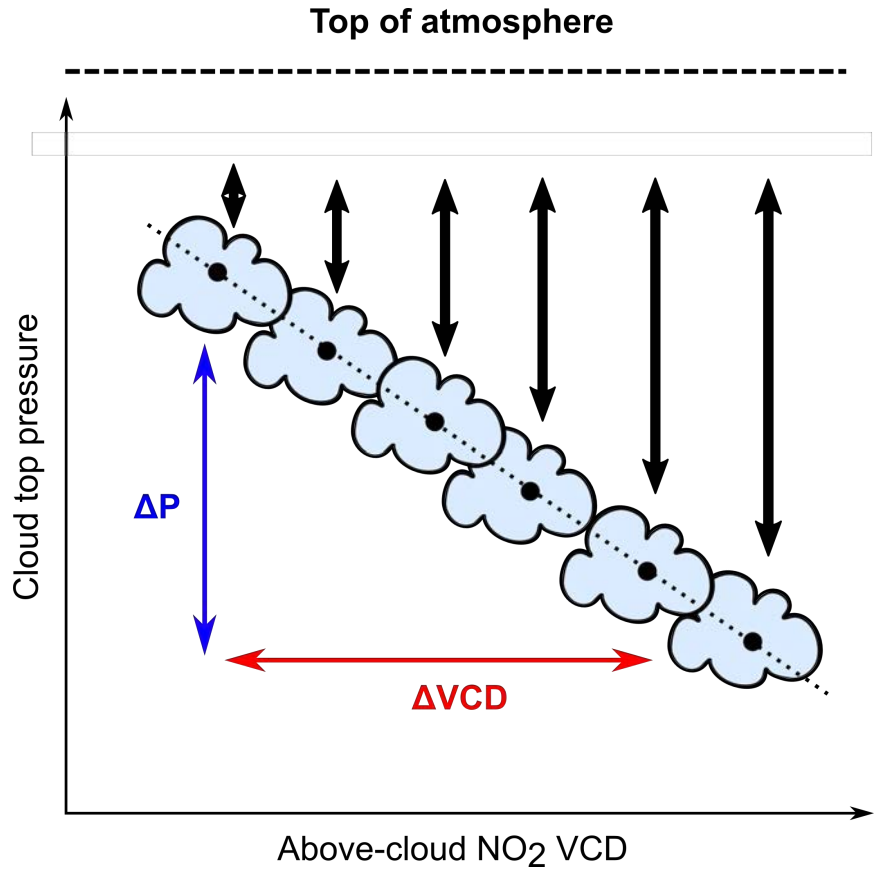
Models misrepresent tropospheric NO_2



[Shah et al., 2022]

Using the cloud-slicing technique to retrieve NO_2 data from satellites



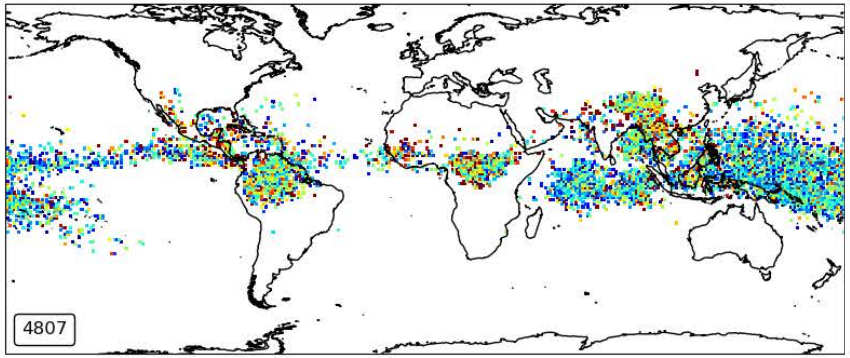


$$NO_2\ VMR \propto \frac{\Delta VCD}{\Delta P}$$

NO_2 vertical profiles from cloud-slicing of TROPOMI data

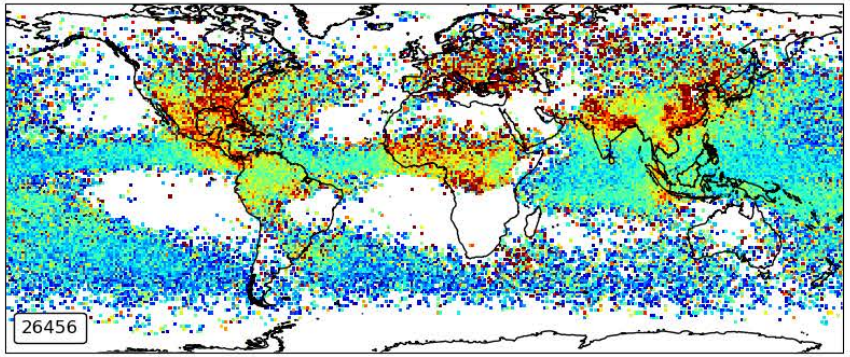
Multiyear seasonal mean for JJA 2018-2021 at a resolution of 1° x 1°

9-12 km (320-180 hPa)



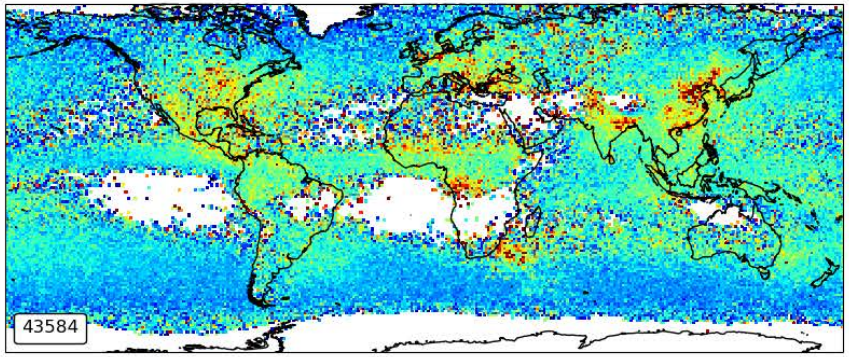
7% coverage

6-9 km (450-320 hPa)



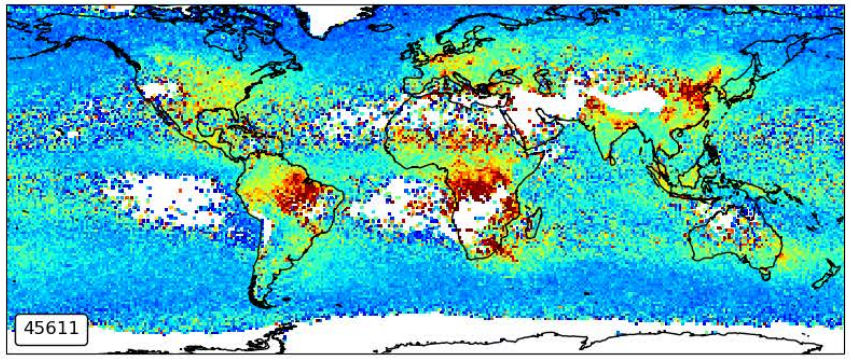
41% coverage

4-6 km (600-450 hPa)



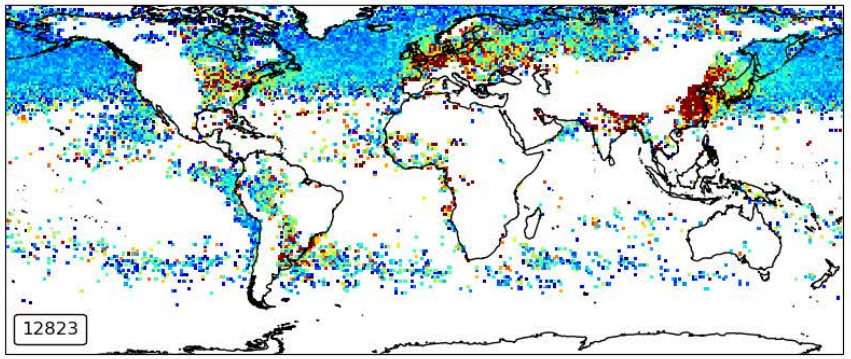
67% coverage

2-4 km (800-600 hPa)



70% coverage

< 2 km (1100-800 hPa)



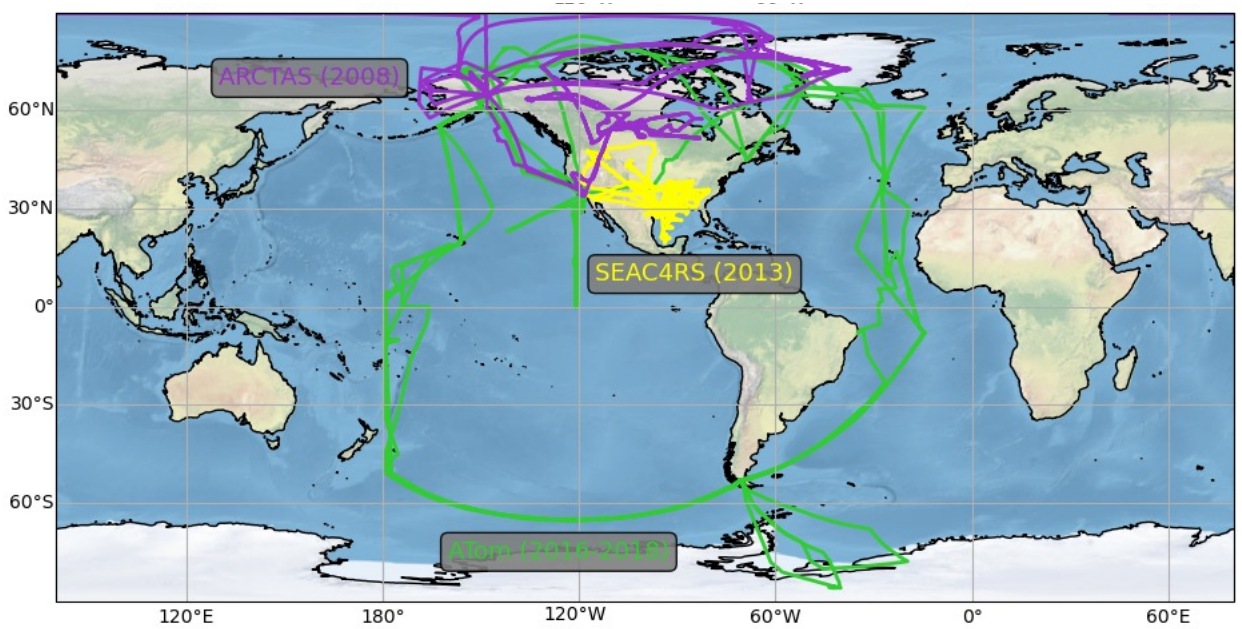
20% coverage

Deriving NO_2 concentrations from NASA DC8 aircraft campaigns

SEAC⁴RS – Central US, summer 2013

ATom – Remote Pacific & Atlantic, once in all 4 seasons from 2016 to 2018

ARCTAS – Canada & Arctic Circle, spring and summer 2008

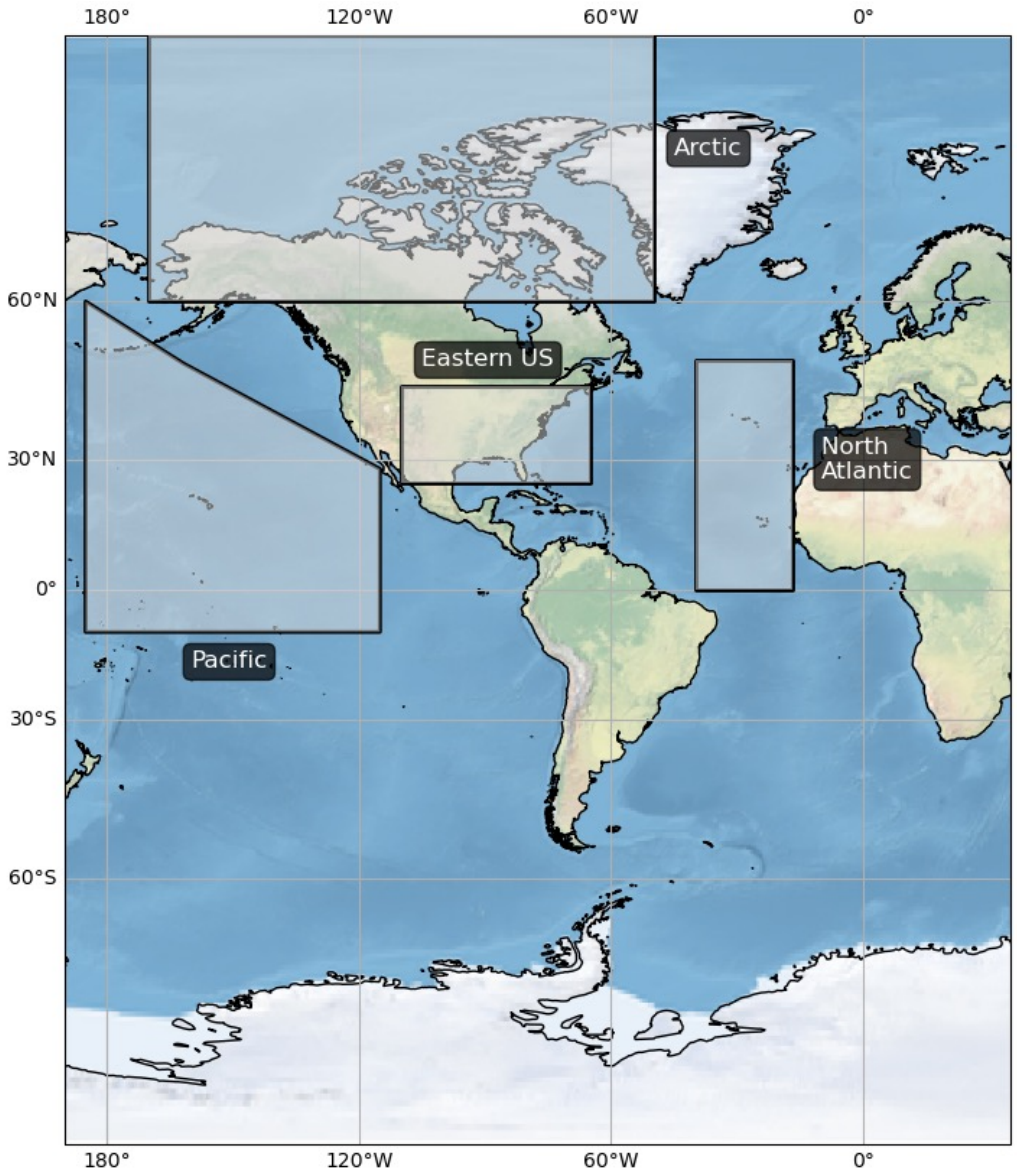


$$PSS = \frac{[NO]}{[NO_2]} \approx \frac{j_{NO_2}}{k_1[O_3] + k_2[HO_2]} \approx \frac{j_{NO_2}}{k_1[O_3]}$$

Aircraft measurements are only used when:

- The **local solar time** is similar to the **TROPOMI overpass time**
- The NO concentrations are more than **2 times the instrument detection limit**

Intercomparison of cloud-sliced, aircraft and modelled NO_2



Emissions data

NASA meteorology

GEOS-Chem

2° x 2.5°

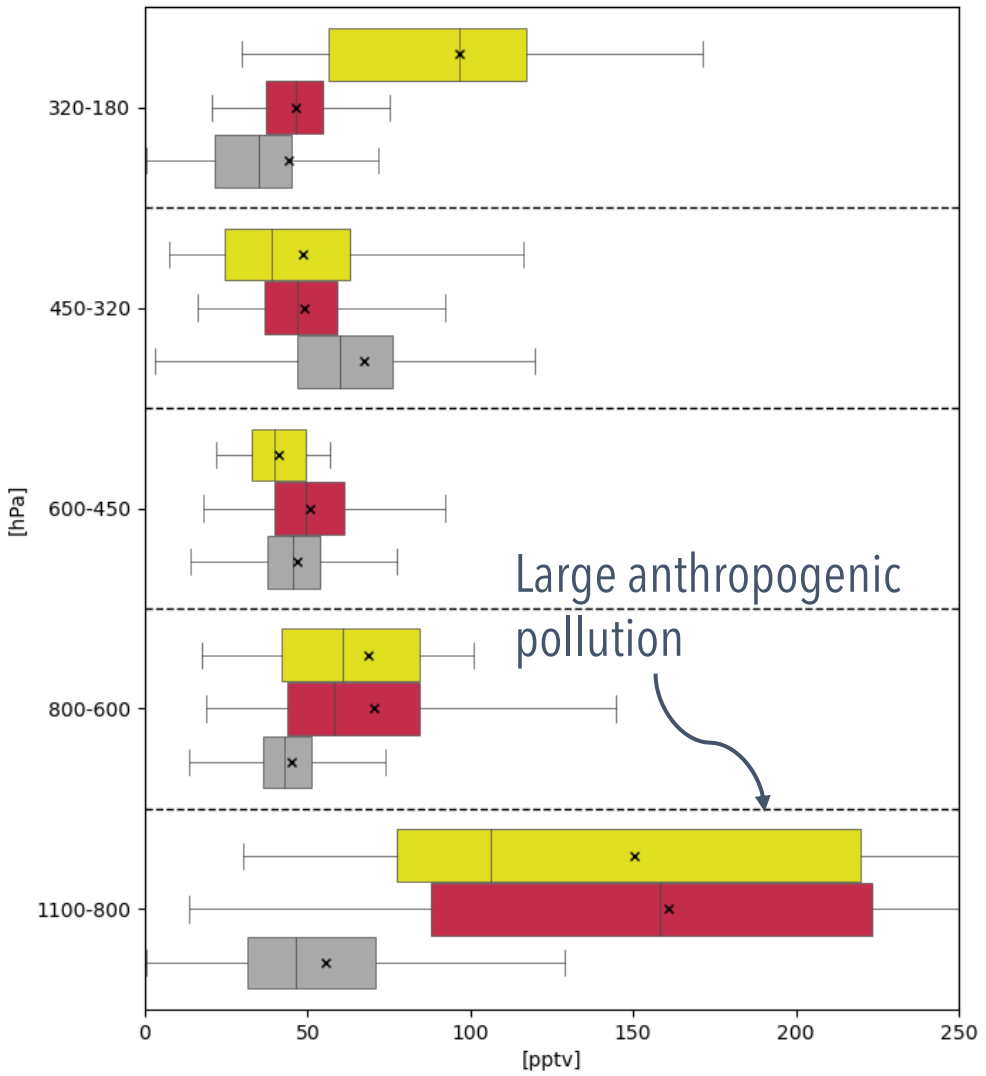
v13.3.4

Seasonal multiyear means 2015-2019

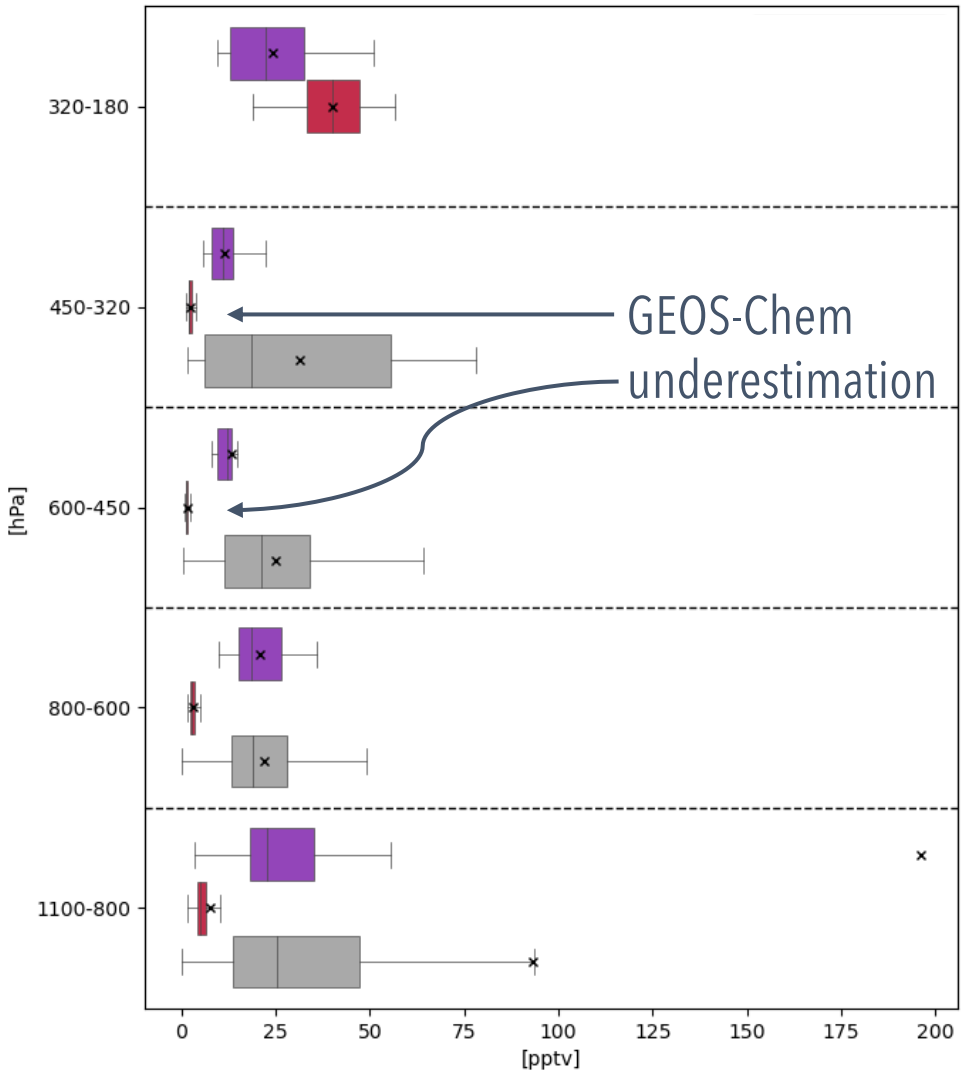
TROPOMI NO_2 **cloud-slicing** is compared to **NASA DC8** measurements and simulations from the **GEOS-Chem** model regions with aircraft observations at 5 altitude ranges

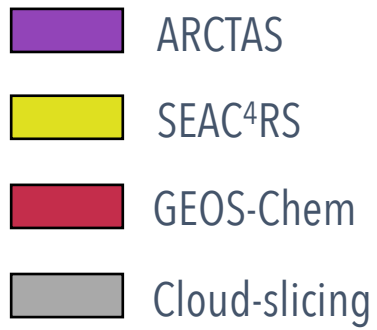
Vertical profiles of tropospheric NO_2 over terrestrial regions

Eastern US, Jun-Aug



Arctic, Mar-May



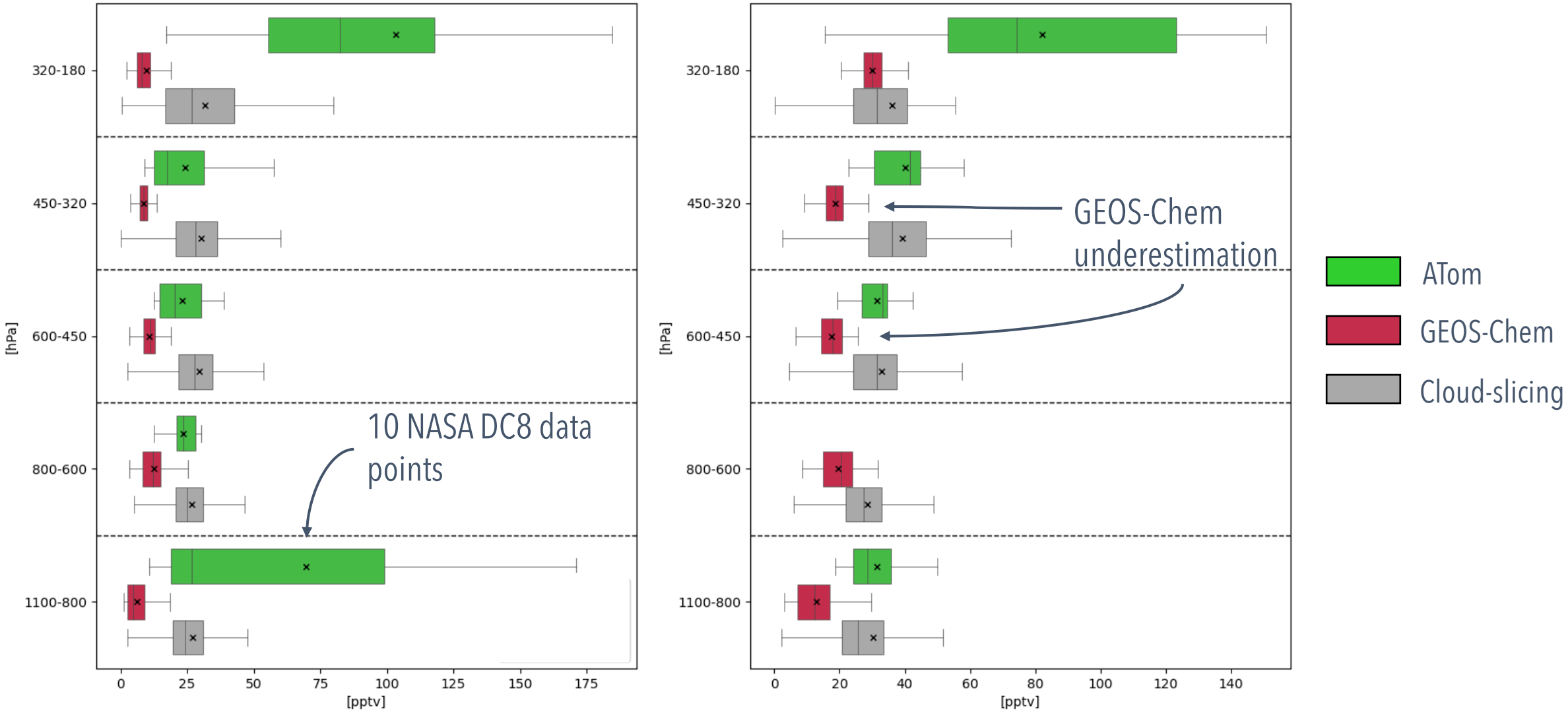


Agreement between cloud-slicing and aircraft observations in the middle troposphere and remote boundary layer

Vertical profiles of tropospheric NO_2 over marine regions

Pacific, Jun-Aug

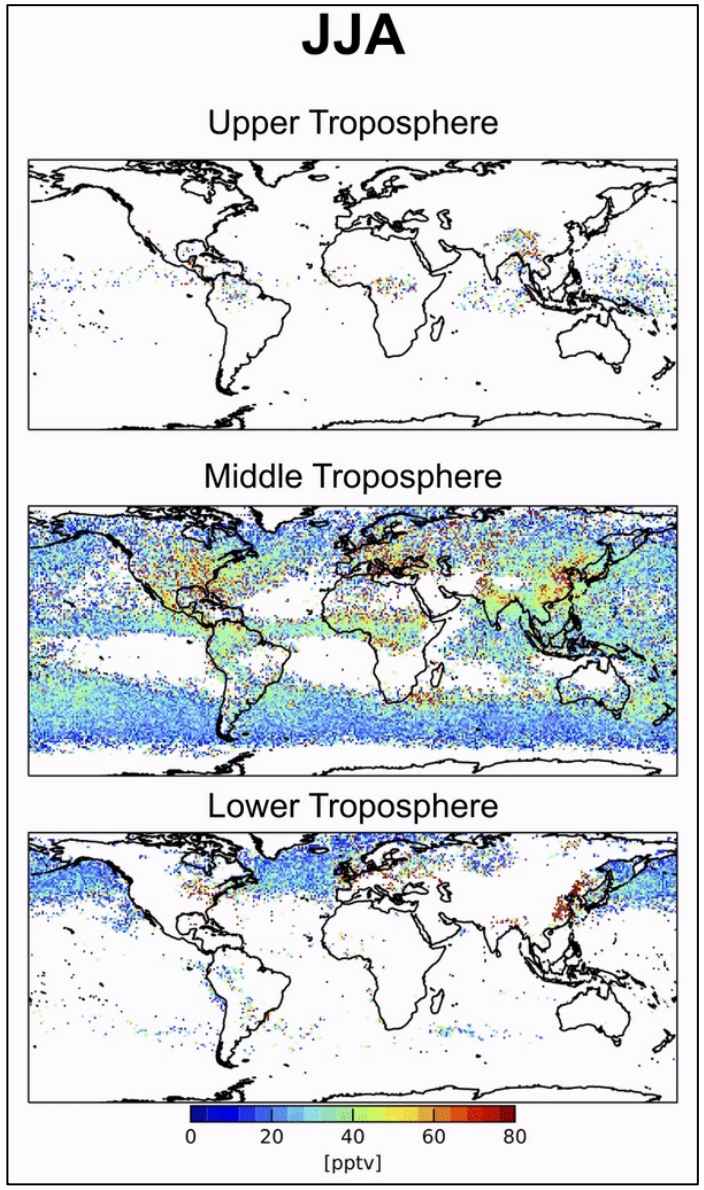
North Atlantic, Jun-Aug



Agreement between cloud-slicing and aircraft observations in the middle troposphere and boundary layer

Conclusions & next steps

- The cloud-slicing technique **improves global coverage** of NO_2 vertical profiles
- **Cloud-slicing underestimates NO_2 concentrations in the urban terrestrial boundary layer** due to large land-based anthropogenic pollution sources
- **GEOS-Chem underestimates NO_2 concentrations** in the remote troposphere by as much as 20 pptv ⟶ this can be improved by incorporating nitrate photolysis in the model



Ozone cloud-slicing

We're extending cloud-slicing to TROPOMI O_3 with promising early results!