Universität Bremen

Institut für Umweltphysik

FB Physik / Elektrotechnik

Applying the S4 NO_2 breadboard algorithm to GEMS data

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S4 NO_2 breadboard algorithm

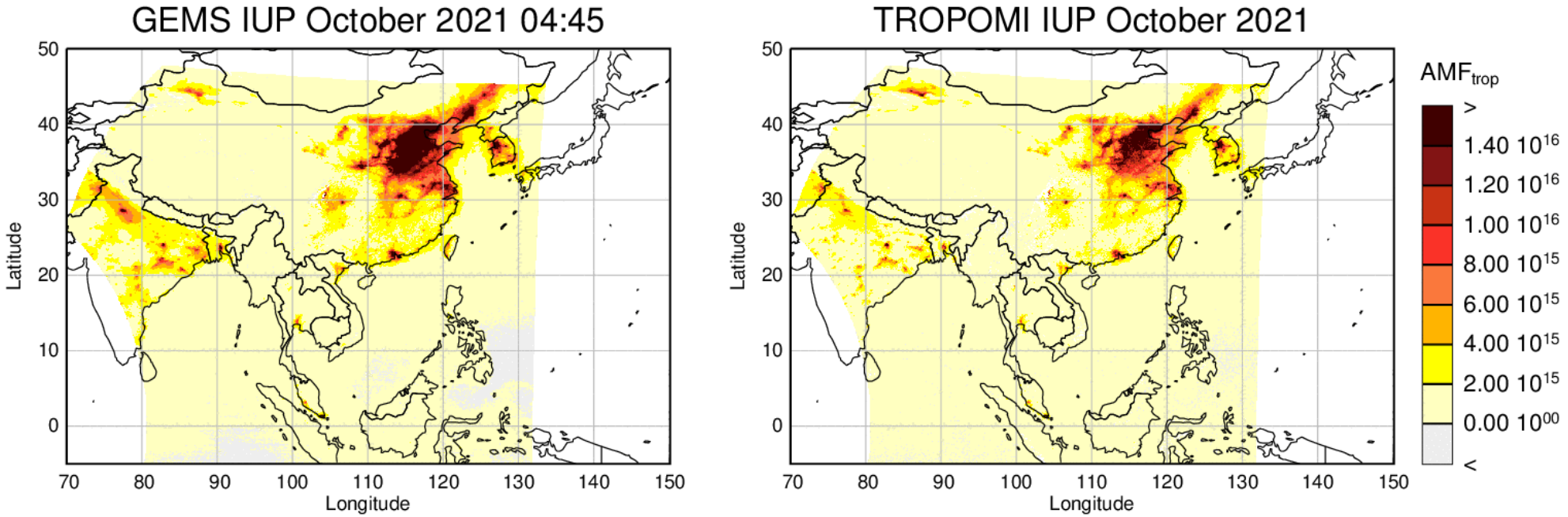
Mission

- Sentinel 4 is the European geostationary satellite
- Launch 2024, coverage Europe

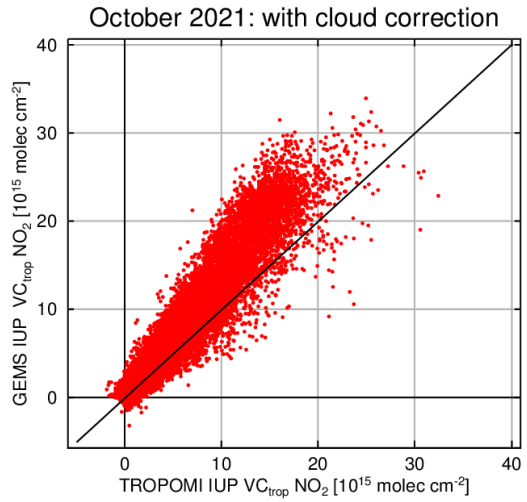
S4 NO_2 Algorithm

- DOAS NO_2 retrieval
- 405 – 485 nm
- Stratosphere from STREAM (Beirle et al., 2016)
- NO_2 *a priori* from TM5
- OMI surface reflectivity
- Cloud correction using lv2 cloud data
- No aerosols
- No BRDF

=> Idea: Test algorithms on GEMS data

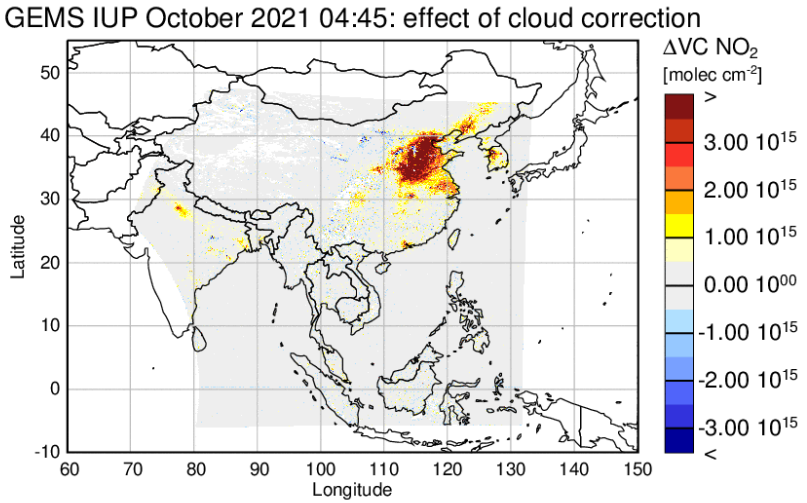


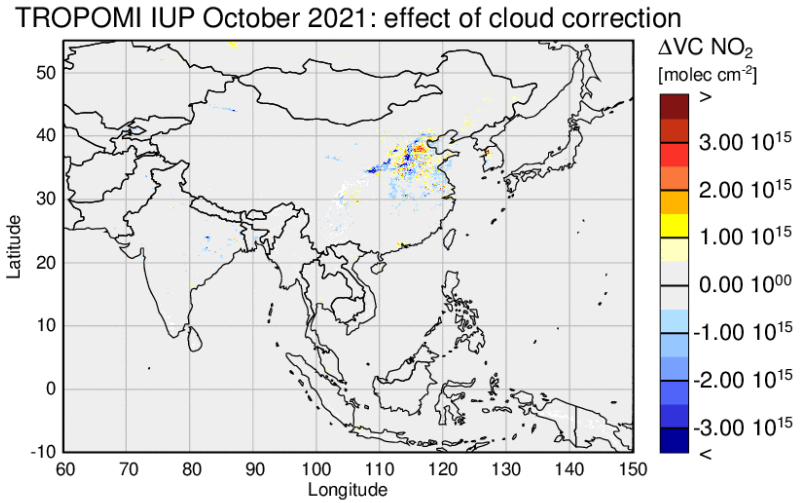
- Very similar patterns
- Very similar NO_2 levels
- But is that really good agreement?
  - GEMS overestimation
  - Significant scatter



Why no better agreement with TROPOMI?

- Slant column fit: similar
- Stratospheric correction: similar approach
- Surface reflectance: same climatology
- Atmospheric profiles: both from TM5
- Clouds:
  - TROPOMI: FRESCO wide + cloud fraction from NO_2 lv2 file
  - GEMS: O2-O2 from GEMS cloud lv2 file





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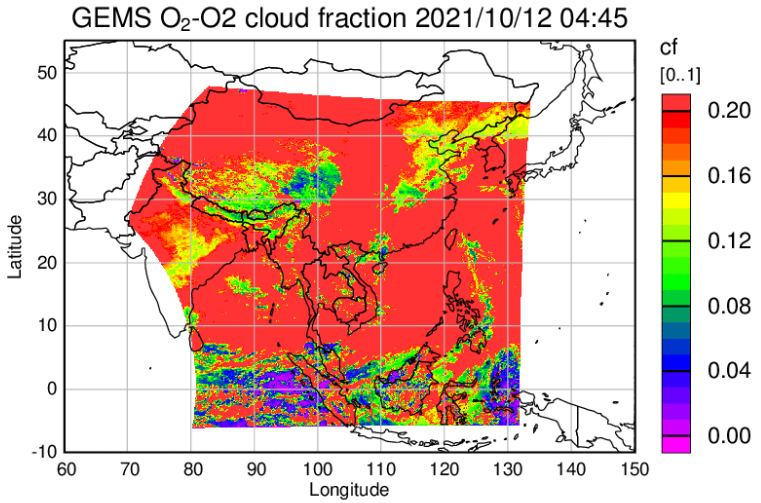
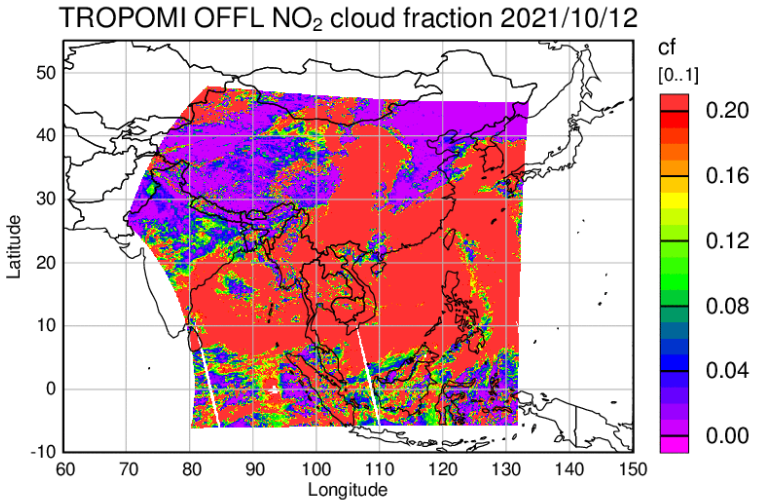
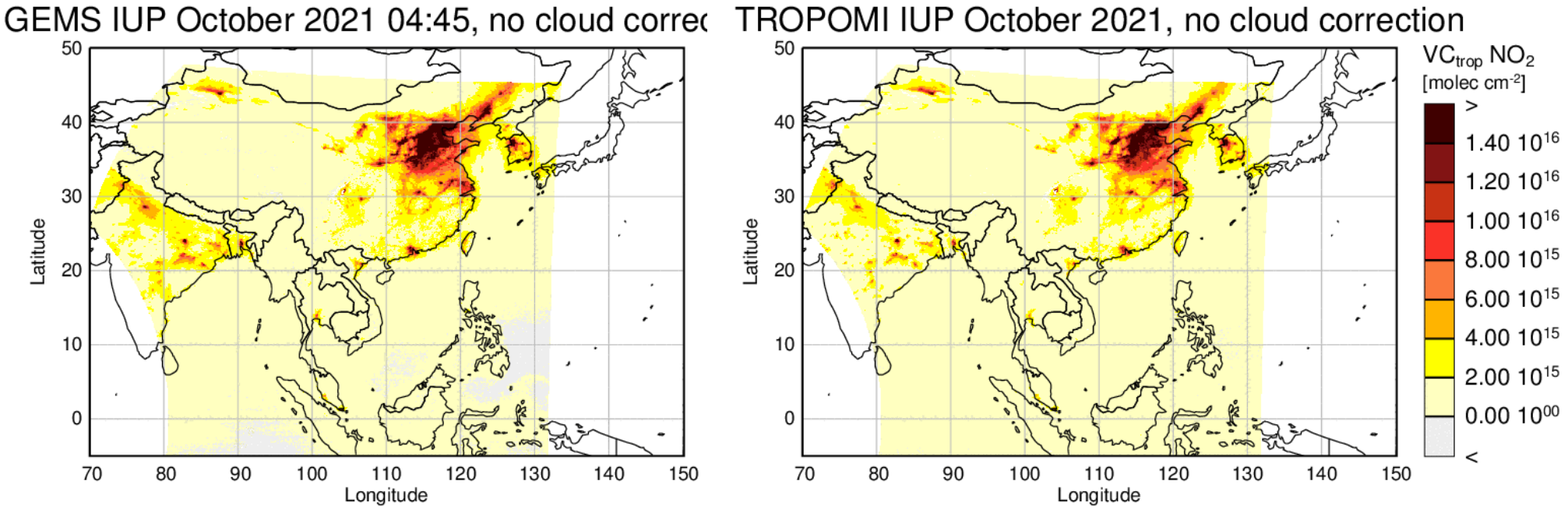
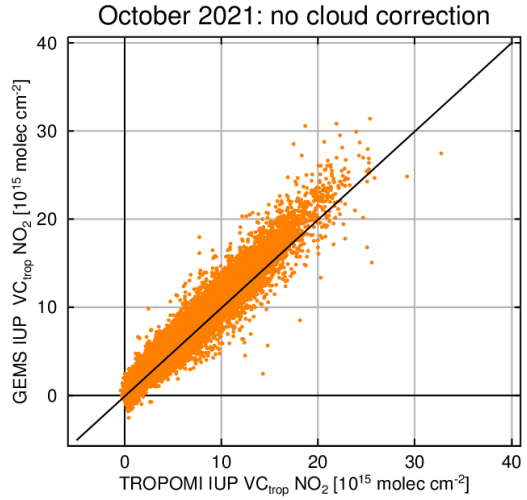




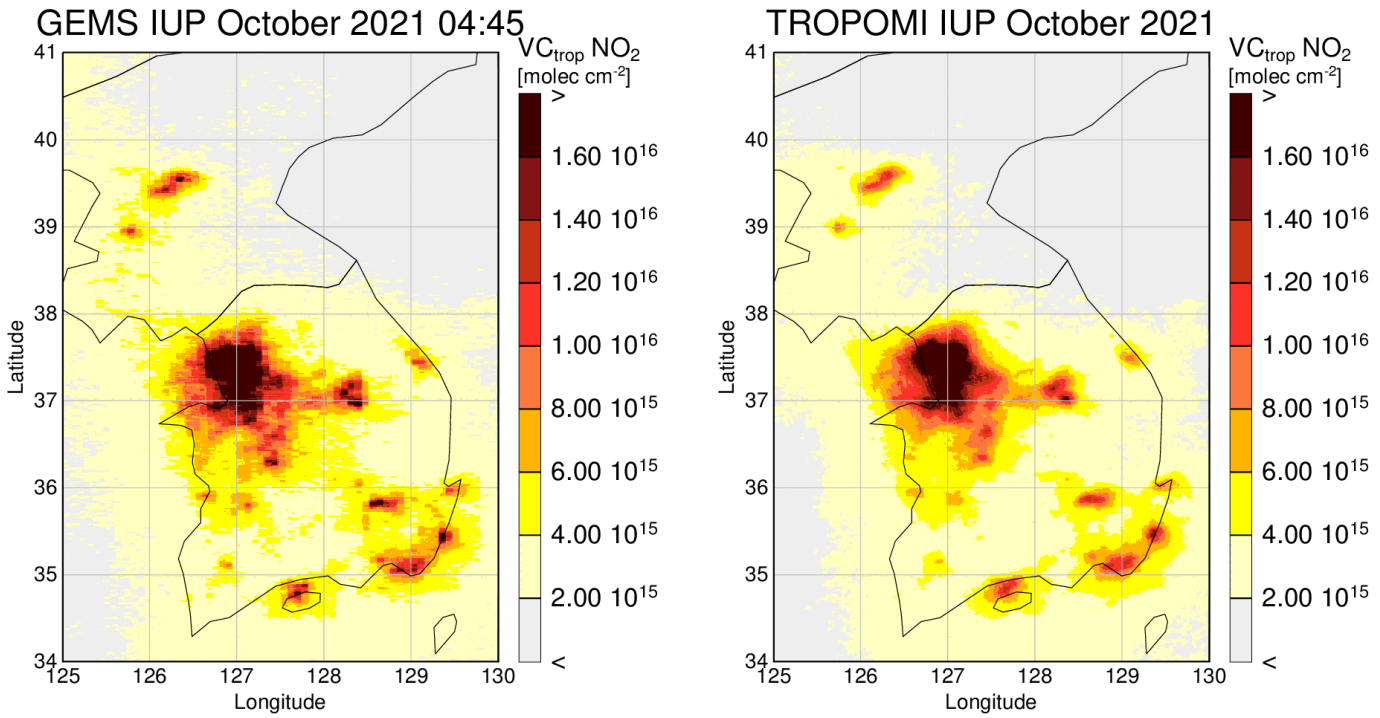


- Cloud correction switched off
- Only using filtering on cloud radiance fraction:
  - TROPOMI: <= 50% CRF
  - GEMS: <= 60% CRF



A few percent GEMS overestimation remain

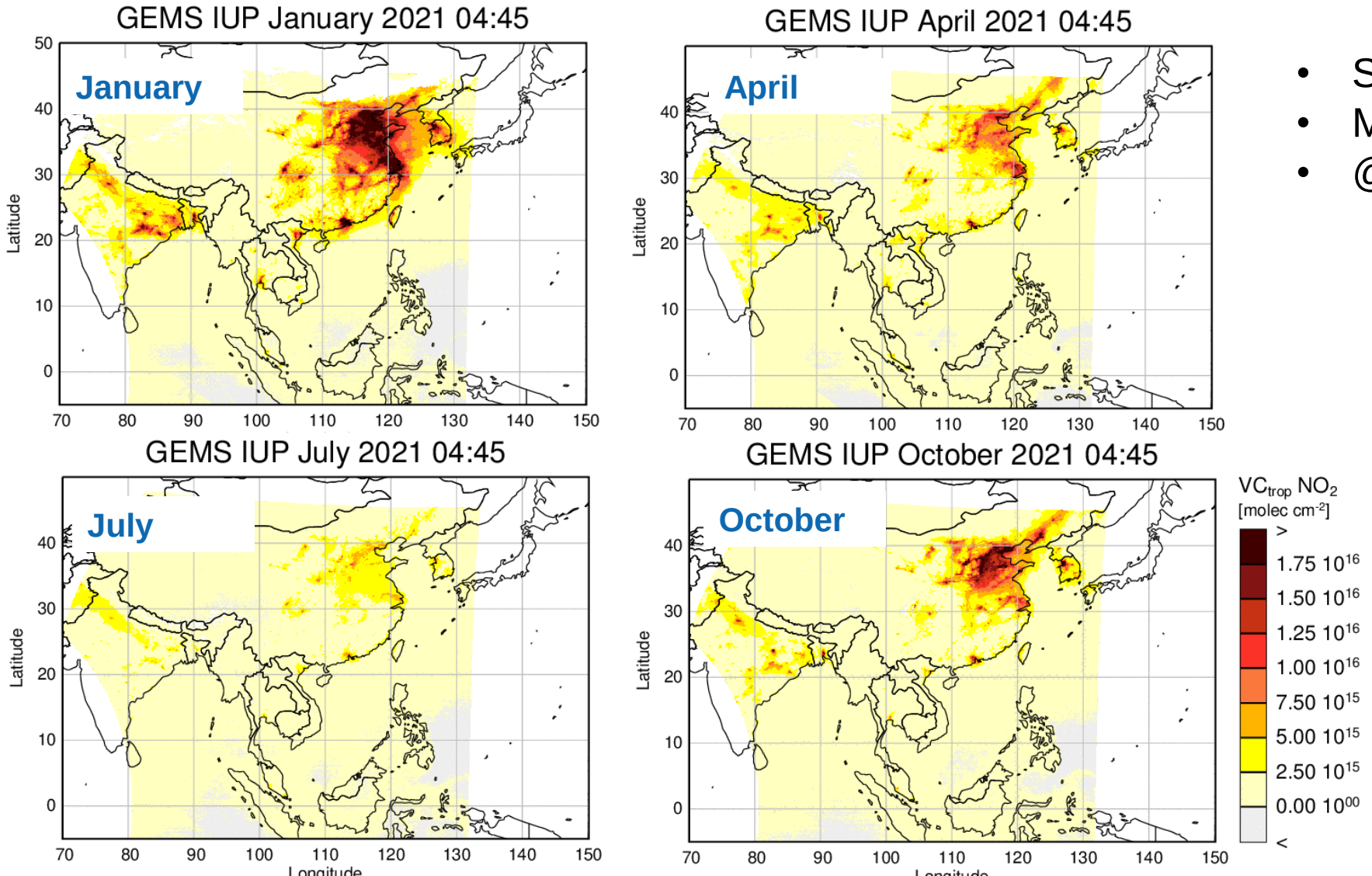
Oversampling



Data was sampled at 0.01° resolution

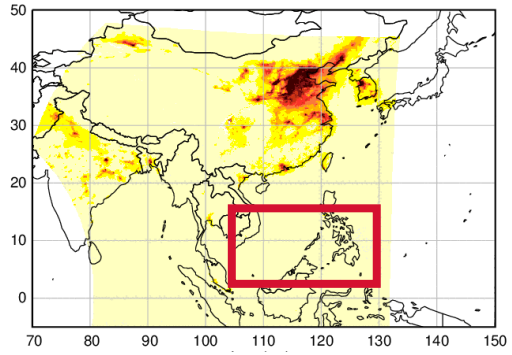
- Sampling pattern remains visible in GEMS averages
- Less smoothing, no oversampling

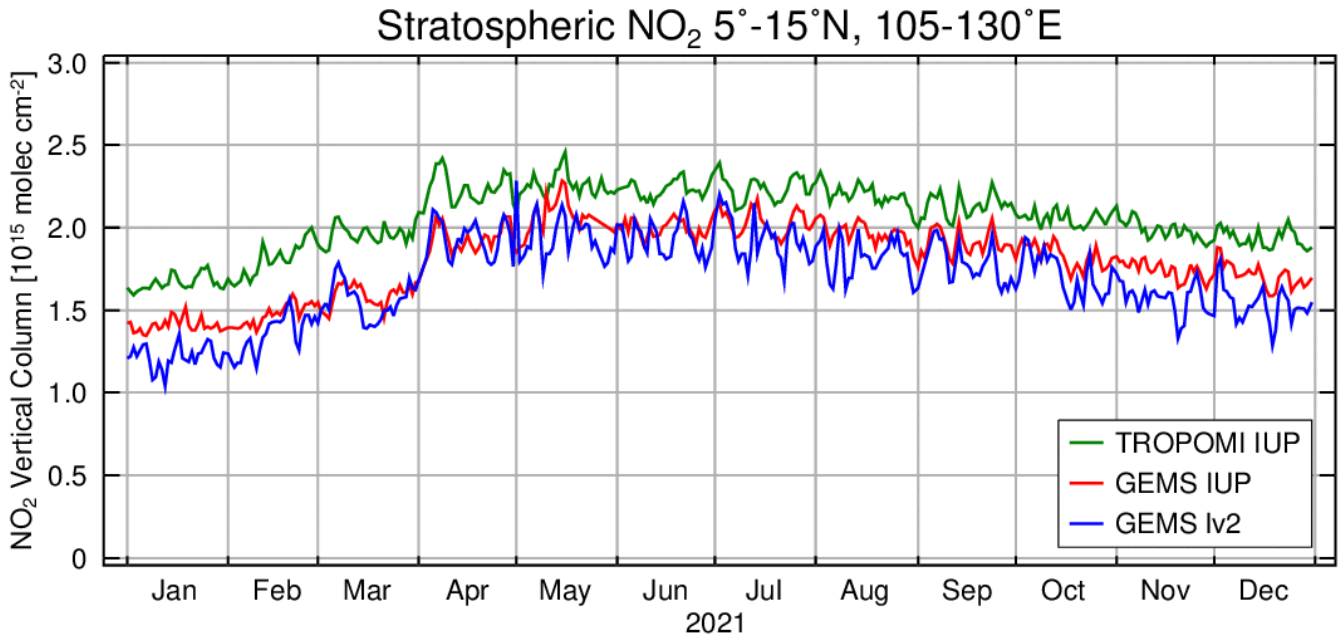
GEMS tropospheric NO_2 examples



- S4 algorithm
- Monthly average
- @ 04:45 UTC

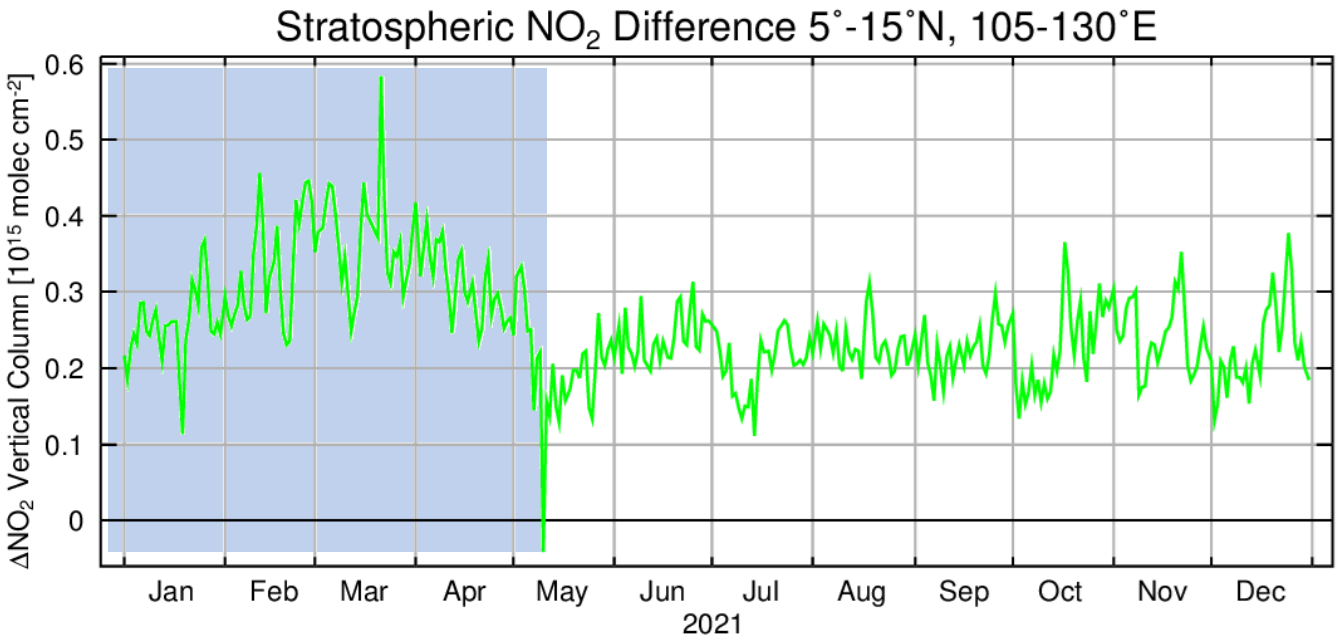
How stable is GEMS NO_2?





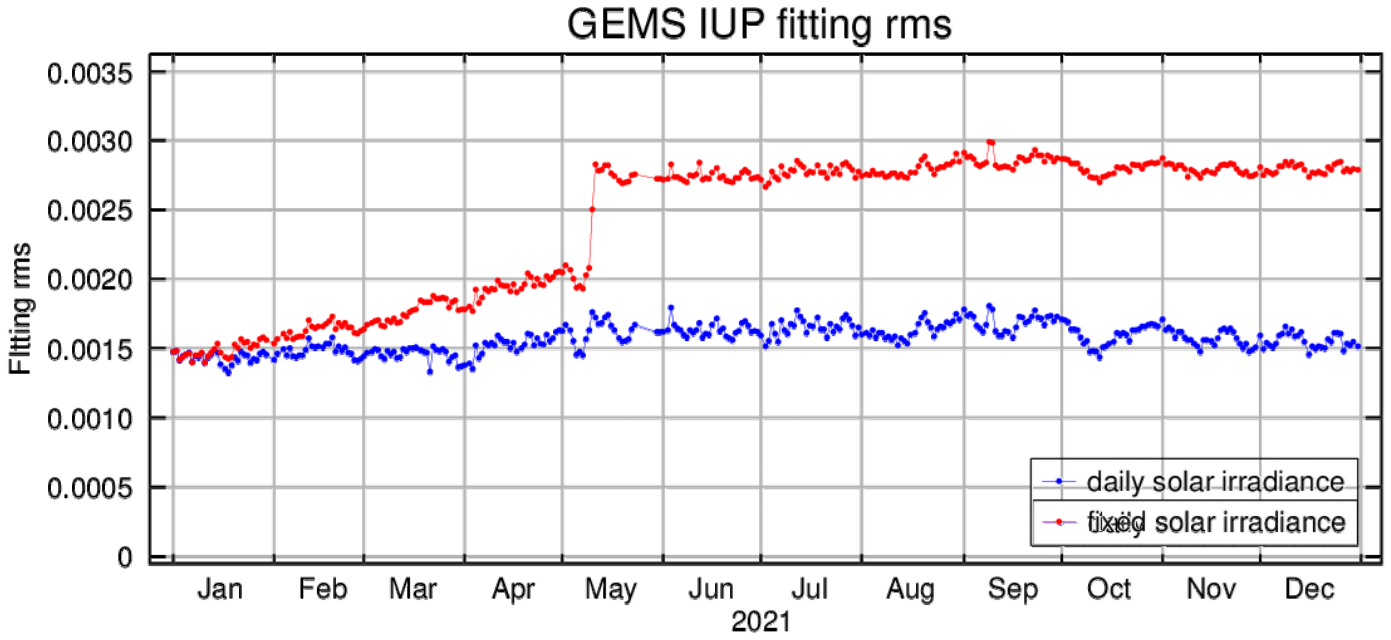
One year of data over relatively unpolluted region
Only 04:45 UTC data used from GEMS
Stratospheric AMF applied to slant columns
=> good agreement, small offset to TROPOMI, more noise in lv2 data

How stable is GEMS NO_2?



- Difference between GEMS and TROPOMI is small (2–3x10^{14} molec cm^{-2})
- Variations until May 10, constant afterwards

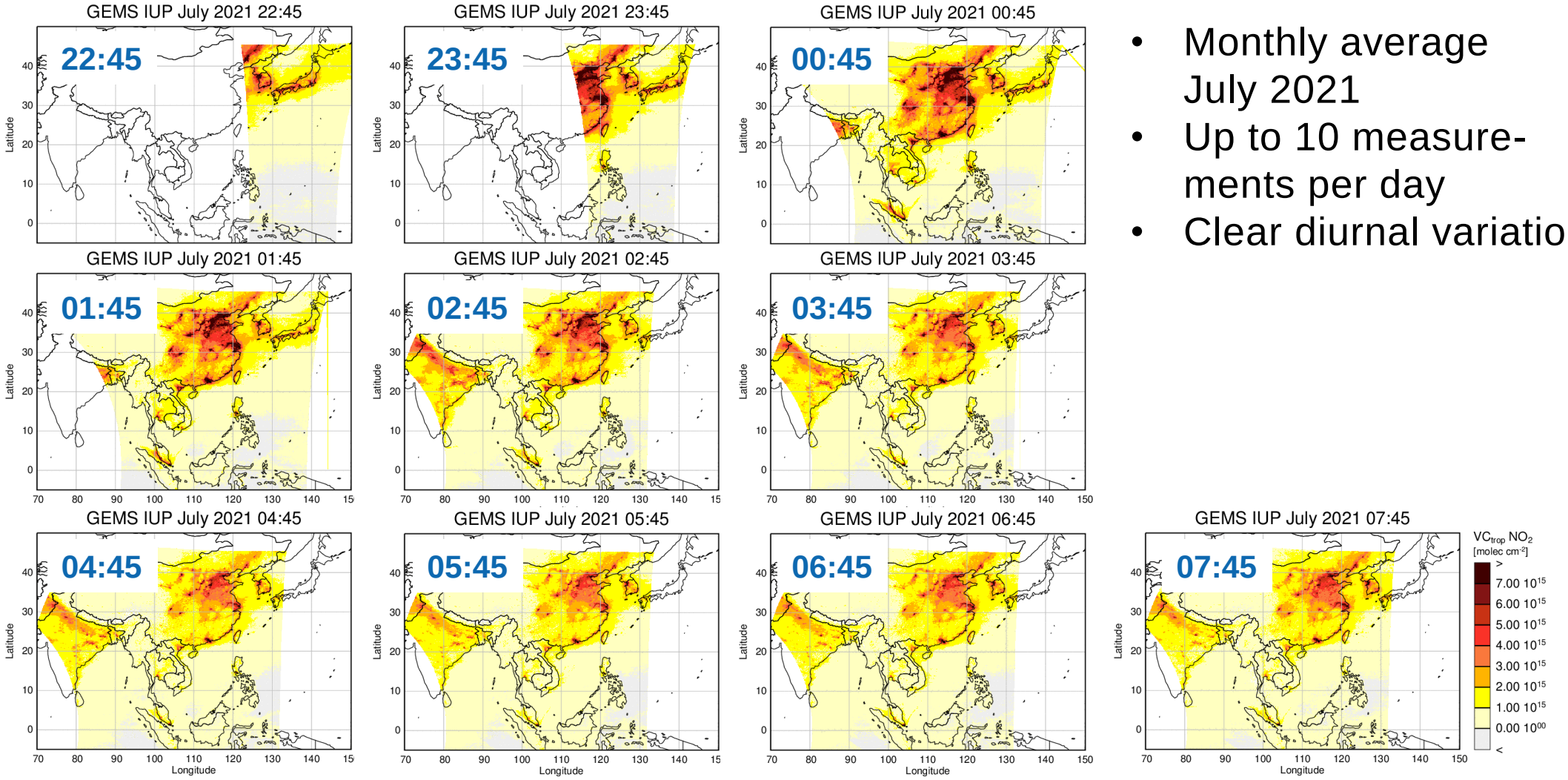
How stable is GEMS NO_2?



- Evaluation of fitting RMS for 04:45 UTC
- Very constant over time with daily irradiance
- Increase in RMS with fixed irradiance until May 10, constant afterwards

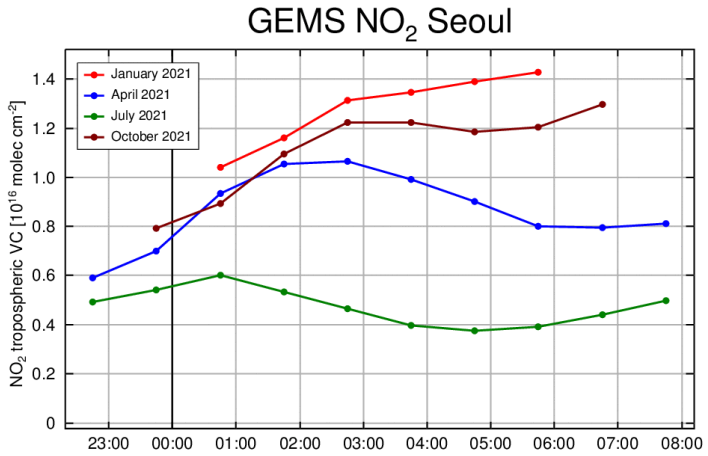
=> something changed in the instrument, operation or lv1 data

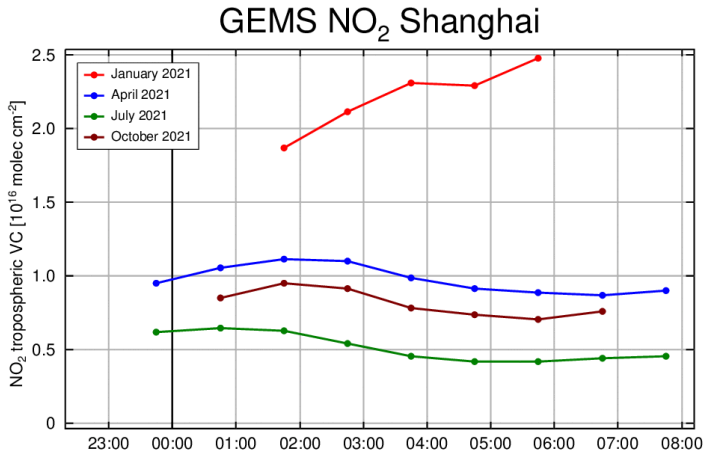
GEMS NO_2 diurnal variation

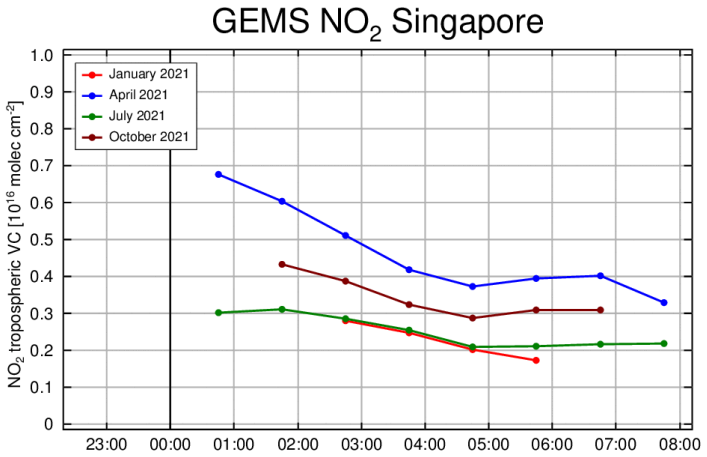


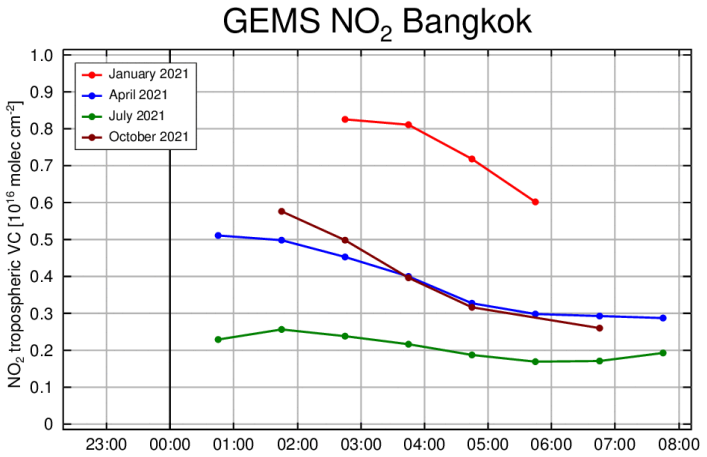
- Monthly average July 2021
- Up to 10 measure-ments per day
- Clear diurnal variation

GEMS tropospheric NO_2 diurnal variation





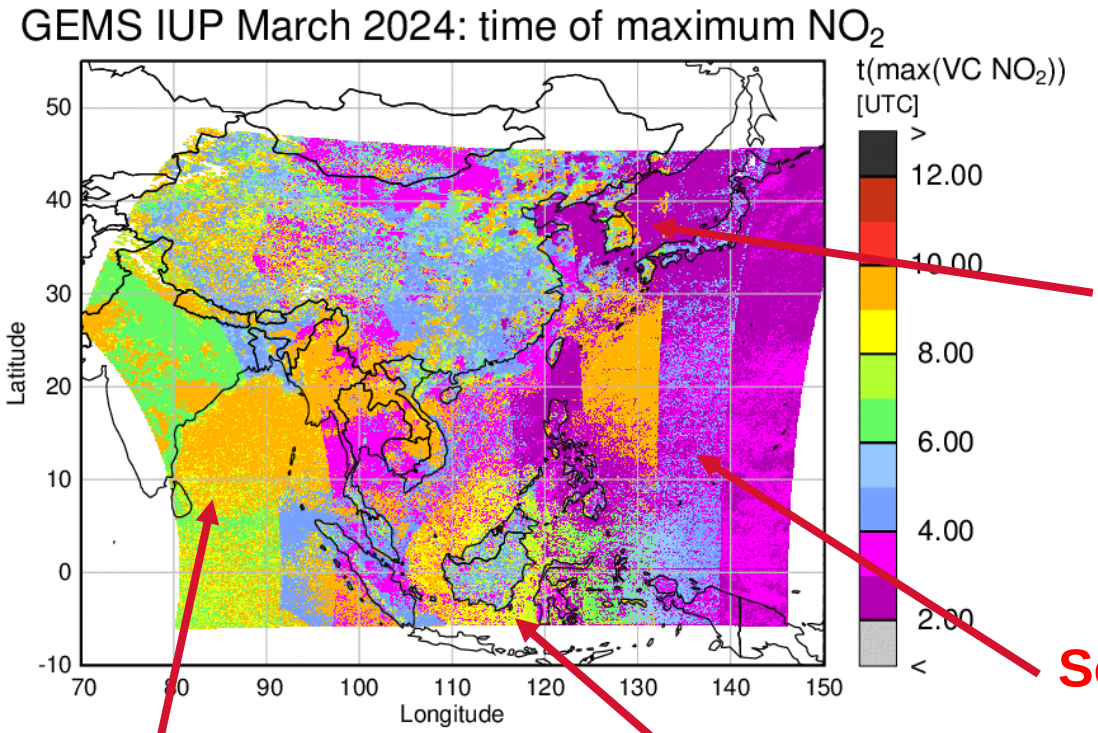




- Smooth diurnal variations
- Depend on location
- Depend on season

- Times are UTC
- Coverage depends on position in GEMS FOV
- Less measure-ments in winter

Time of NO_2 maximum



- GEMS scan pattern can be seen
- Sea-land contrast
- Sun glint

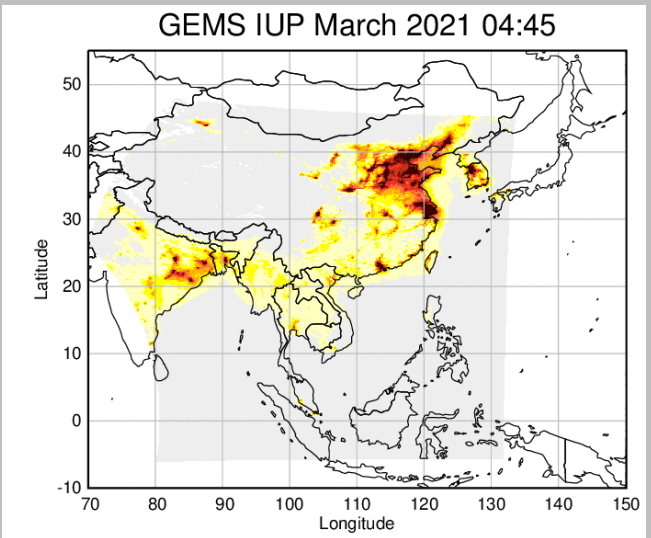
Sea-land contrast

Scan pattern

Scan pattern

Sun glint

Not seen



Need to separate **observation related effects** from **atmospheric composition effects**

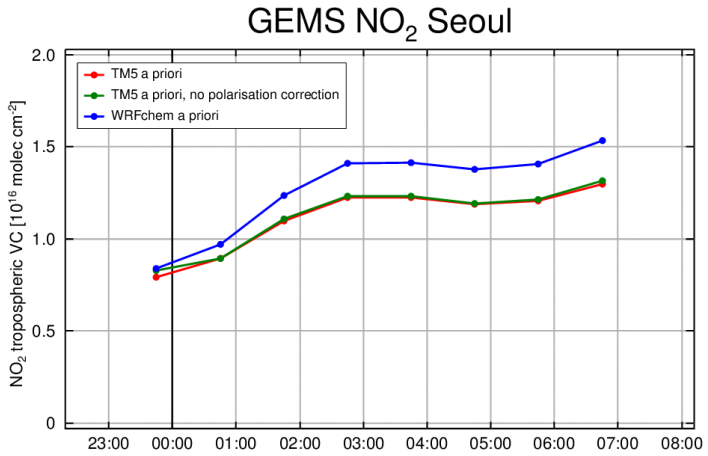
Summary and Outlook

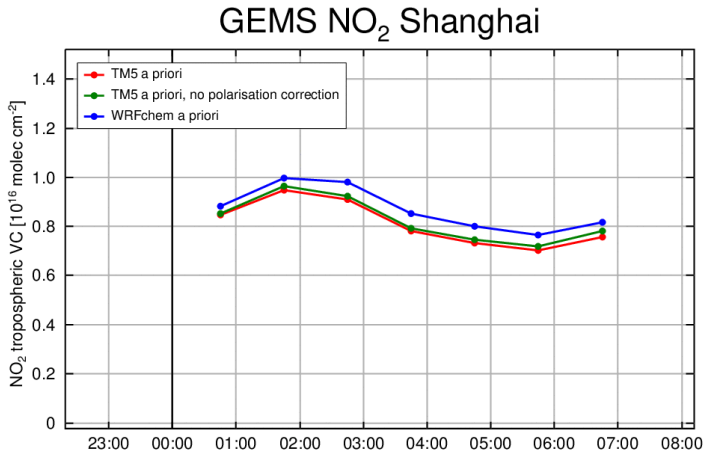
- The Korean GEMS satellite provides high resolution data over Asia with hourly resolution
- The S4 NO_2 breadboard algorithm was successfully applied to GEMS and TROPOMI data
- Excellent agreement is found between GEMS and TROPOMI data if cloud correction is not used
- Good long-term stability and consistency

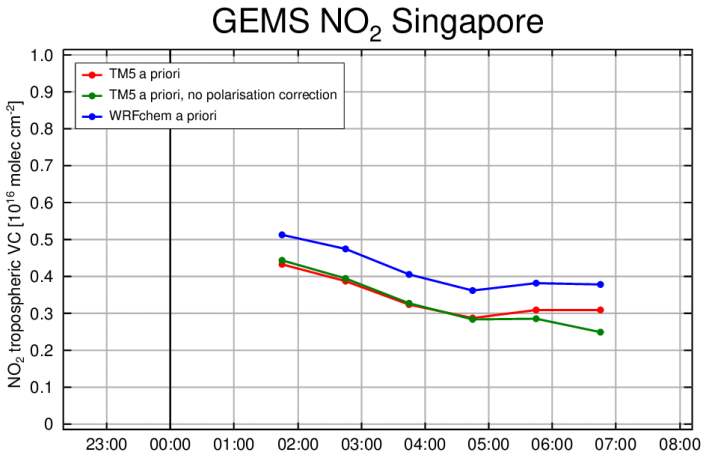
- Large and variable diurnal profiles of NO_2 are observed over source regions in Asia
- Time of maximum NO_2 columns shows many instrument and observation related patterns

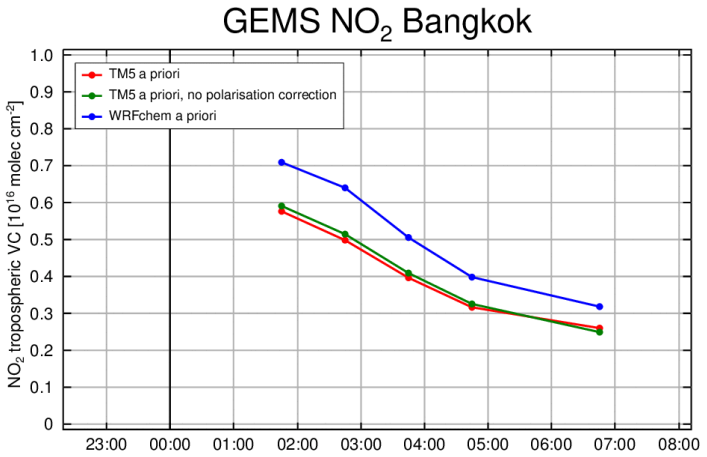
A big **Thank You** to the GMAP and GEMS teams for providing data, financial and scientific support, and an excellent collaboration atmosphere!

GEMS NO_2 diurnal variation: Sensitivity









- Correction of polarisation dependency has small impact only
- Change of a priori to high resolution WRFchem increases values and for some locations also diurnal variation