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HONO retrievals over biomass burning regions from satellite UV and IR measurements

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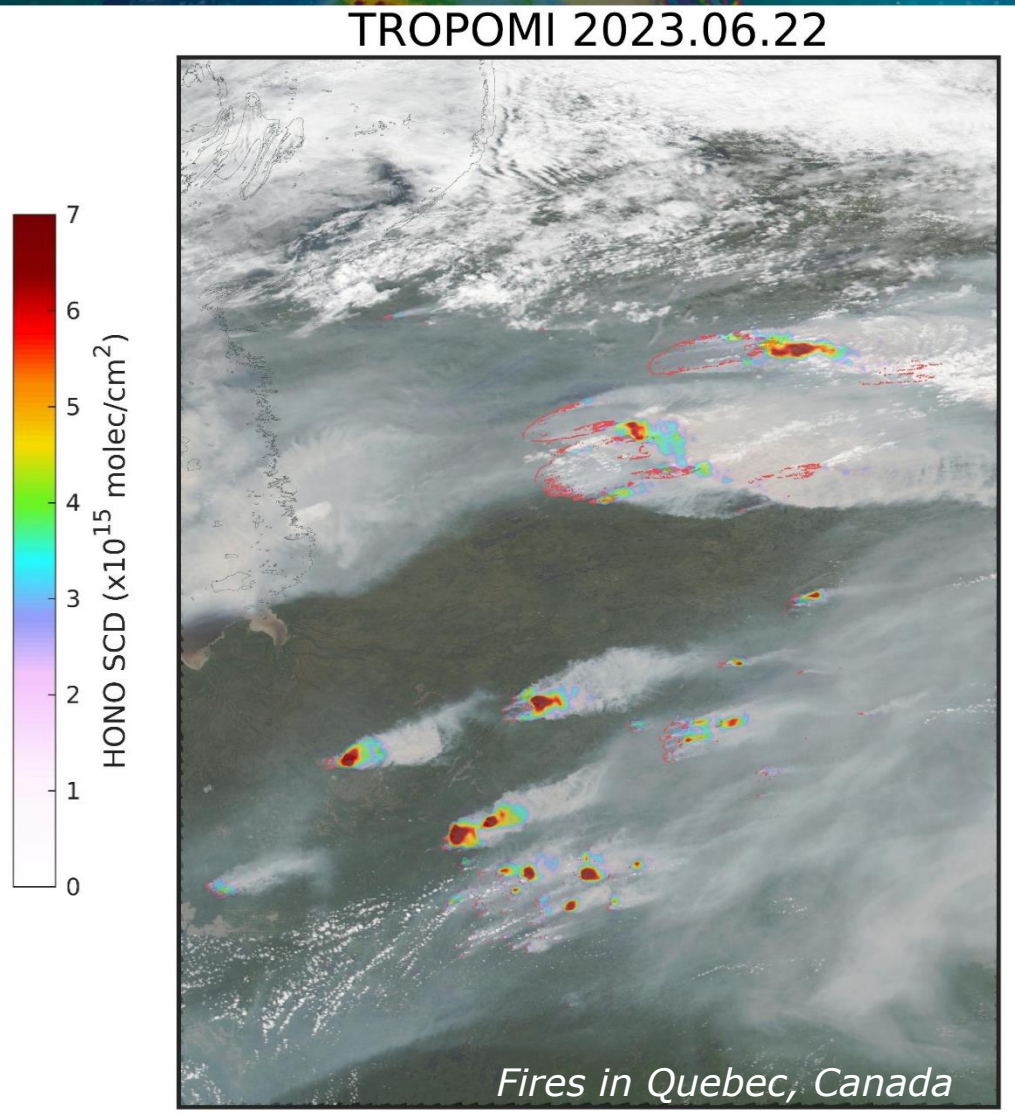
Pyrogenic HONO



- HONO is directly emitted from fires, mostly during flaming combustion.
- HONO is an important source of reactive oxidants.

$$HONO + h\nu \longrightarrow NO + OH$$

- Short atmospheric lifetime ~15-30 minutes.
- Possible large impact of pyrogenic HONO on oxidative plume chemistry and ozone production.
- Global detection of pyrogenic HONO using satellite UV and IR instruments (Theys et al., 2020; De Longueville et al., 2021; Dufour et al., 2022).

⇒ **need for further development of satellite HONO products, intercomparison and validation.**

TROPOMI and IASI HONO retrievals

Spectral fitting

- TROPOMI (337-375 nm): HONO SCD based on Covariance-Based Retrieval Algorithm (COBRA).
- IASI (1210-1305 cm^{-1}): HONO hyperspectral range index (HRI).

$$HRI = \frac{k^T S^{-1}.(y - \bar{y})}{\sqrt{k^T S^{-1} k}}$$

Detection flag and outliers filtering

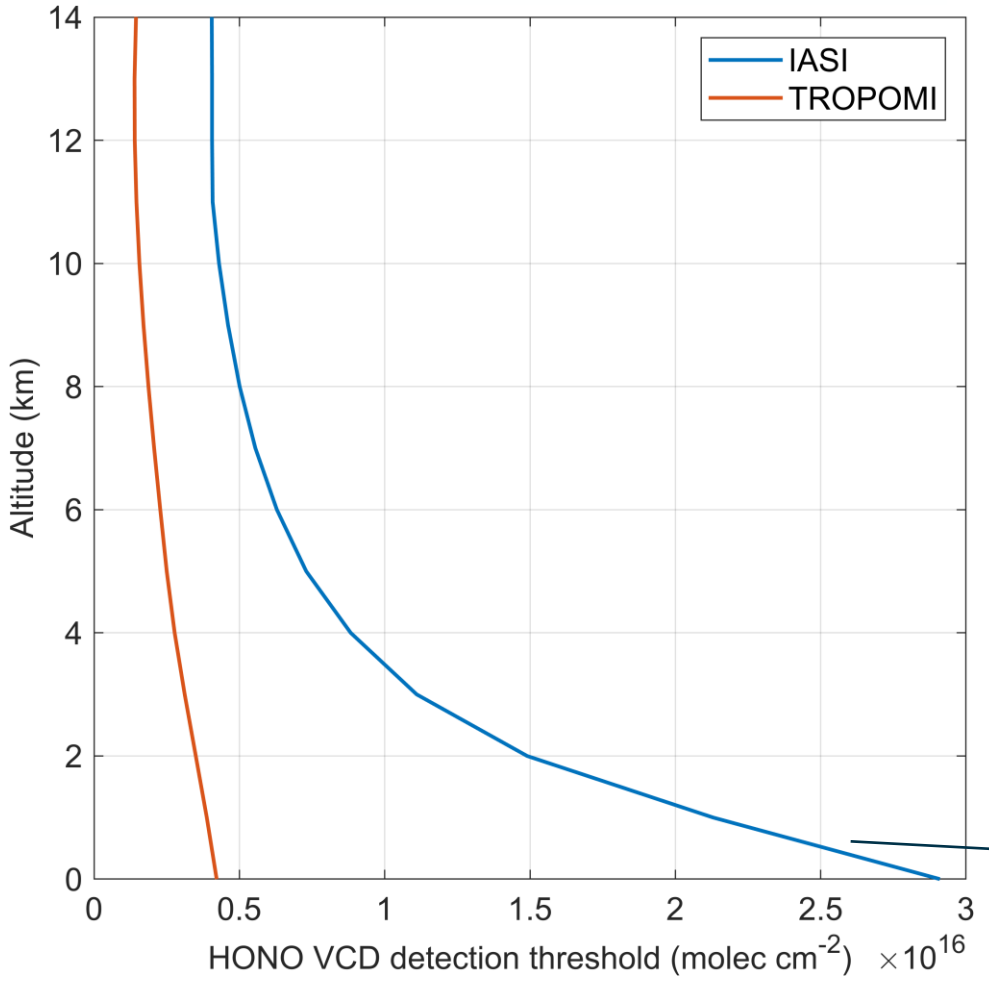
Radiative transfer modeling → HONO vertical columns

- TROPOMI: AMF calculation for prescribed plume heights and aerosol conditions.
- IASI: Neural network-based retrieval approach (ANNI).
  HONO VCD for prescribed plume heights + AvK and complete uncertainty budget.

TROPOMI: Theys et al., 2021, 2024 (in preparation), IASI: Franco et al., 2024.

TROPOMI and IASI HONO retrievals

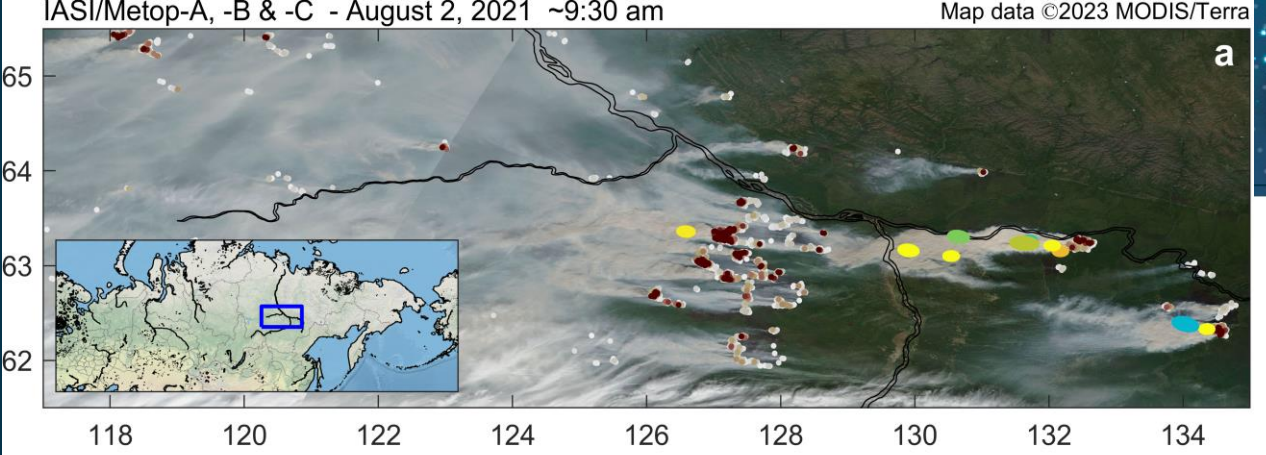
HONO detection threshold of IASI and TROPOMI vs. altitude of fire plume



- TROPOMI more sensitive to HONO than IASI, especially for low plume heights.
- IASI almost insensitive to the presence of smoke aerosols (=> large source of errors for TROPOMI).
- Complementary overpasses.
  IASI: morning and evening,
  TROPOMI: afternoon.

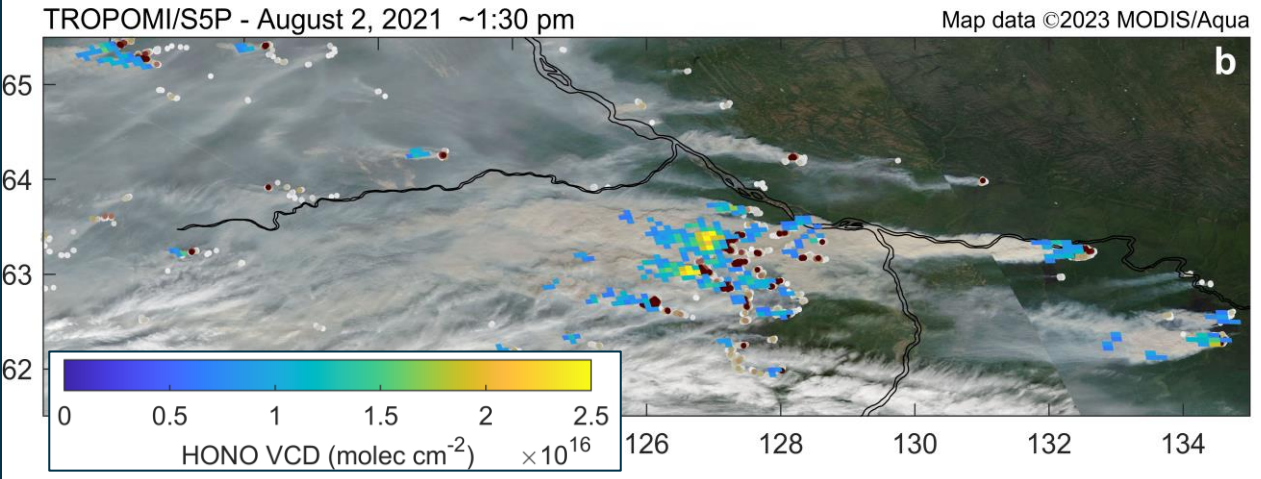
Higher detection threshold due to weaker thermal contrast

Comparison TROPOMI-IASI



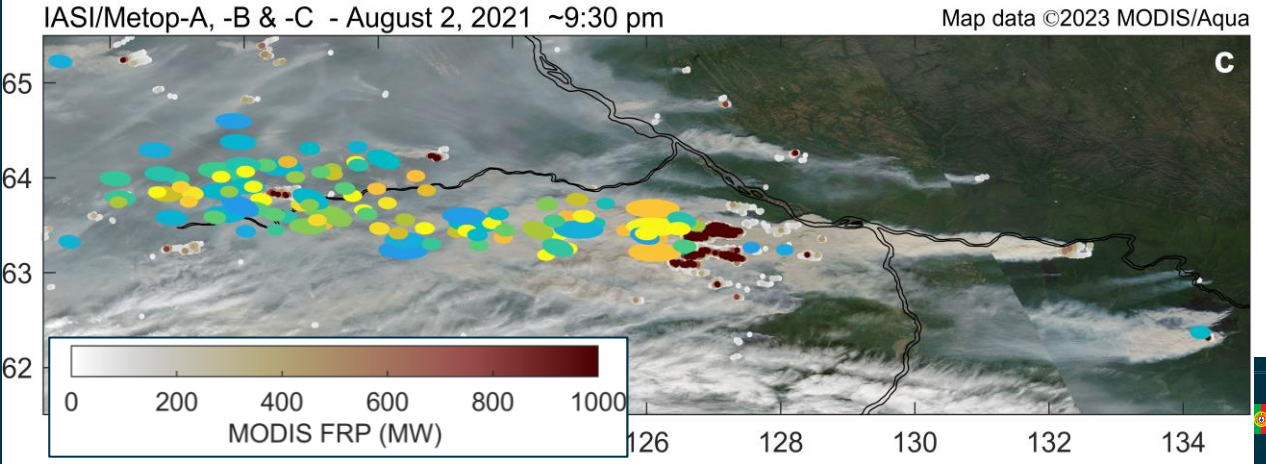
IASI ~9:30 am
MODIS/Terra (~10:30 am)

Yakutian Fires, Siberia – August 2, 2021



TROPOMI ~1:30 pm
MODIS/Aqua (~1:30 pm)

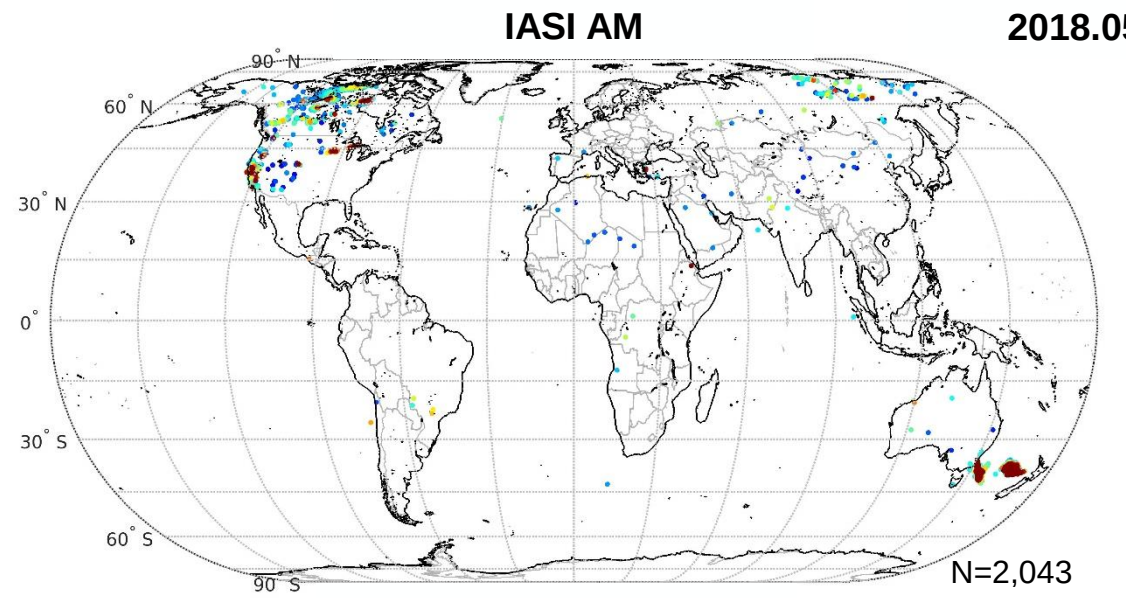
→ Detection of HONO in smaller fire plumes and in proximity to fire sources

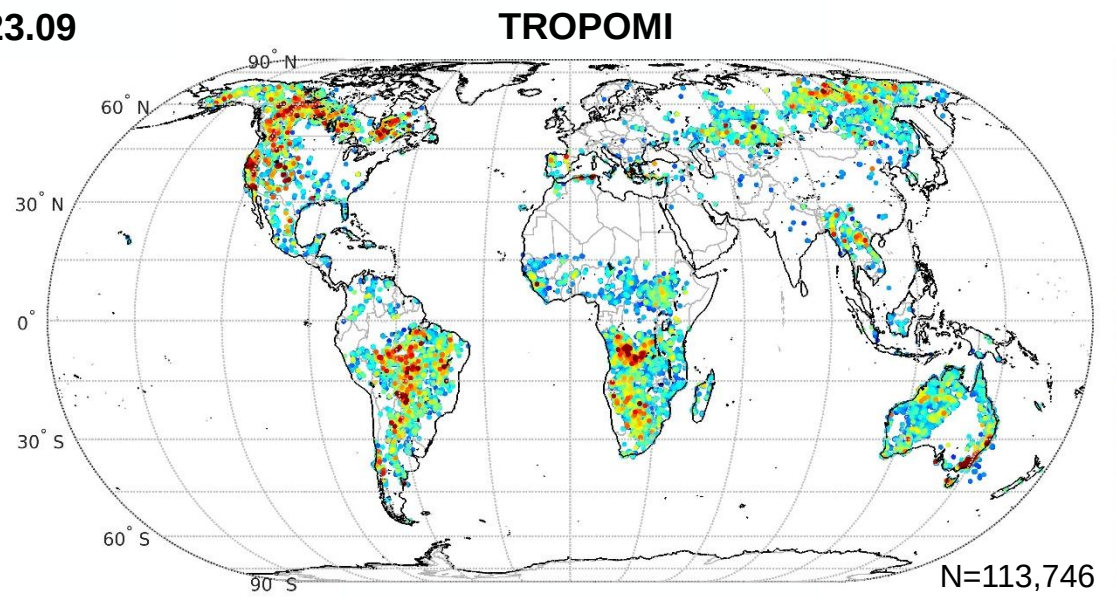


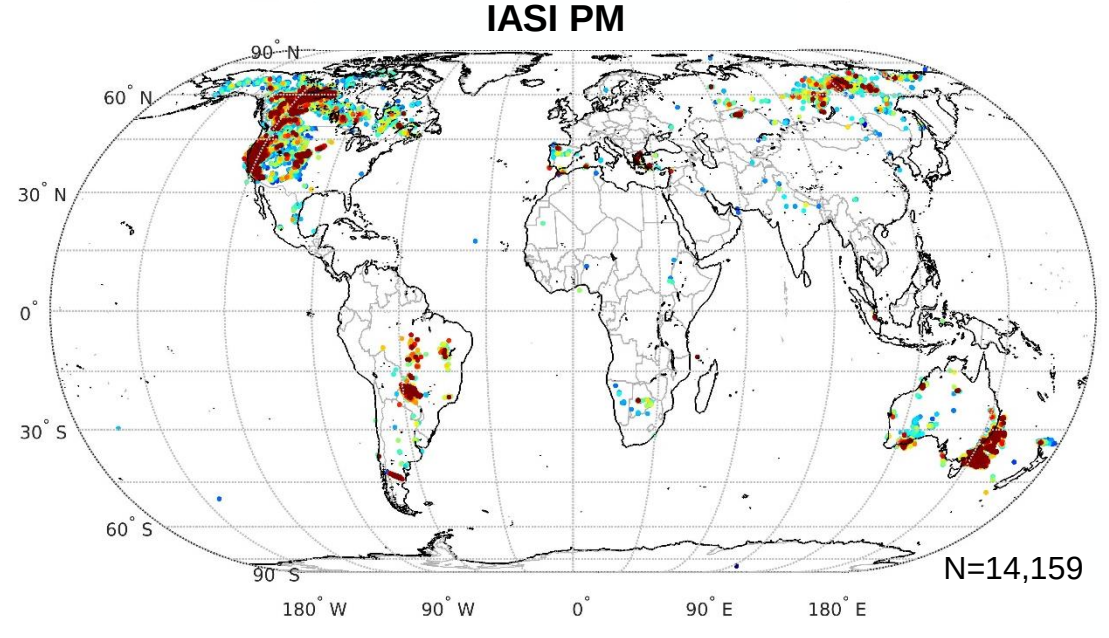
IASI ~9:30 pm
MODIS/Terra (~10:30 pm)

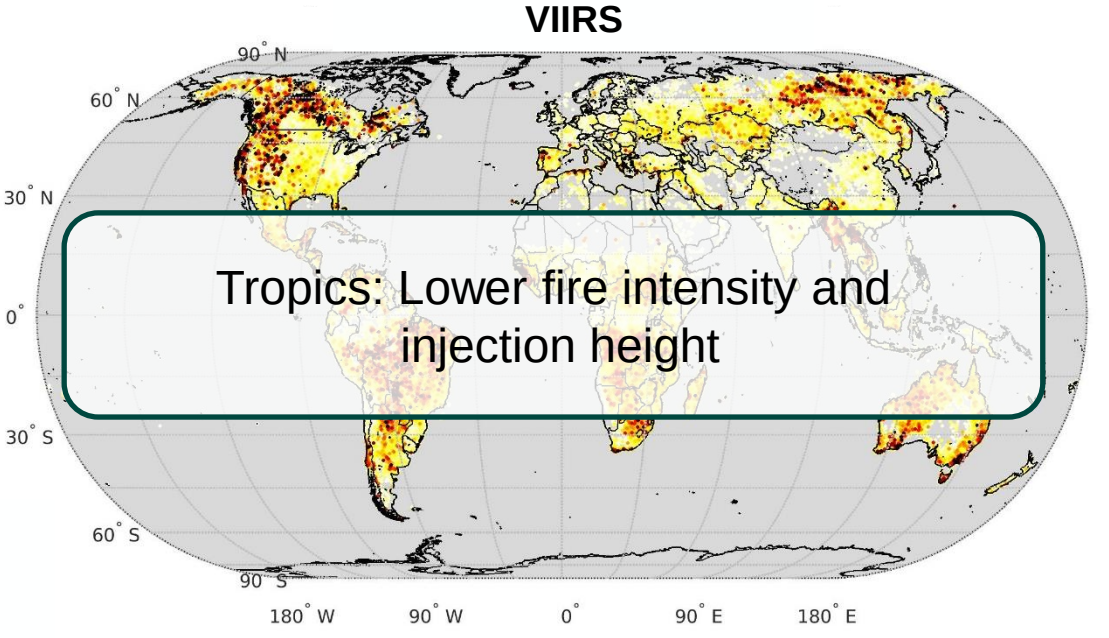
→ Detection of HONO along long-range transport and from secondary formation

Comparison TROPOMI-IASI

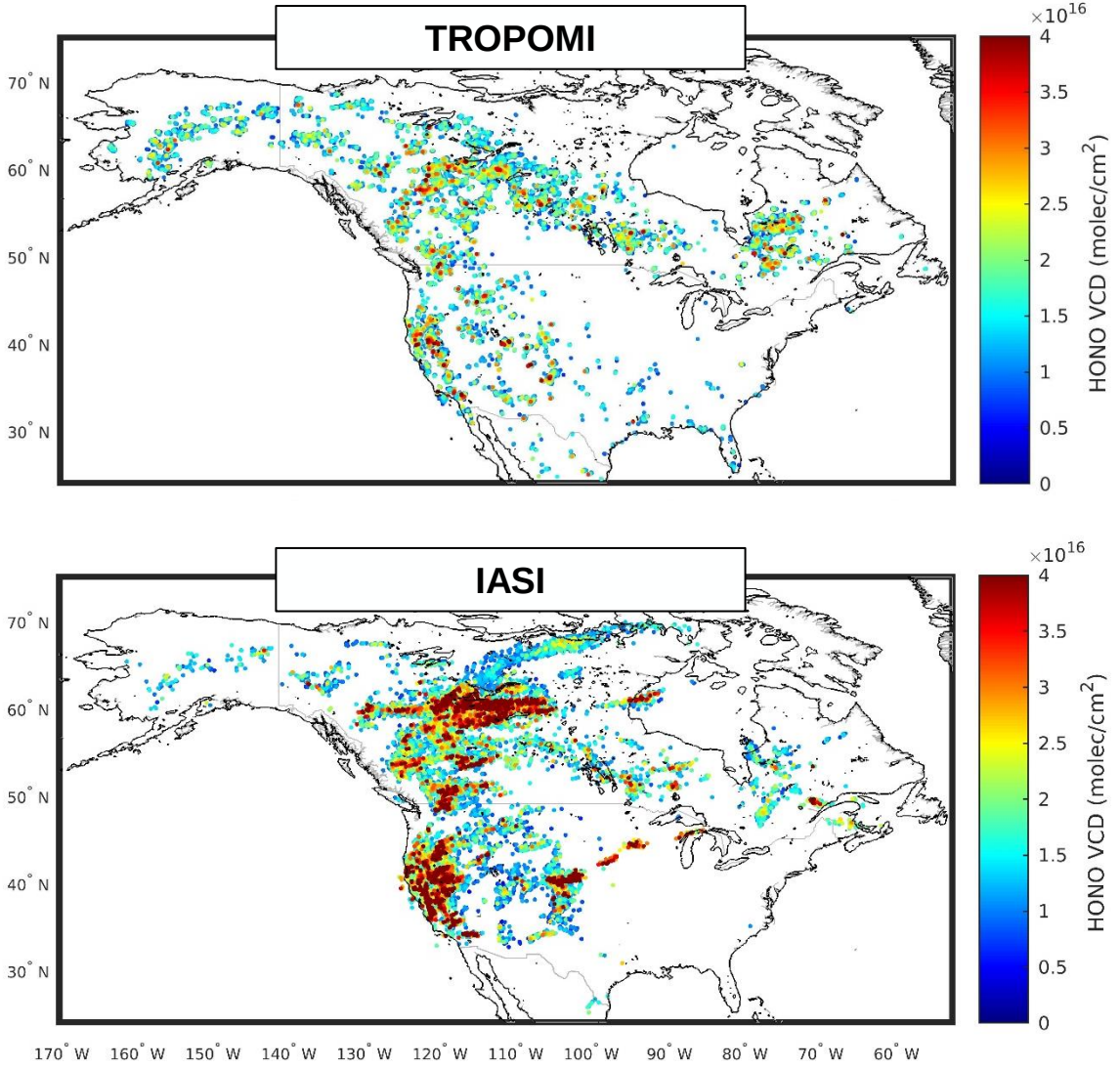


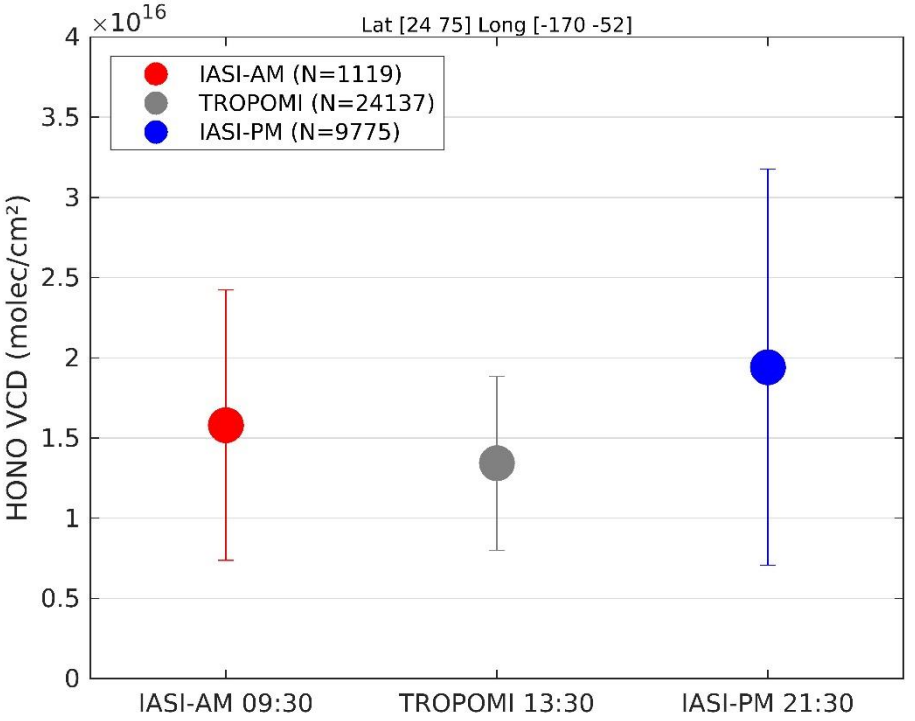






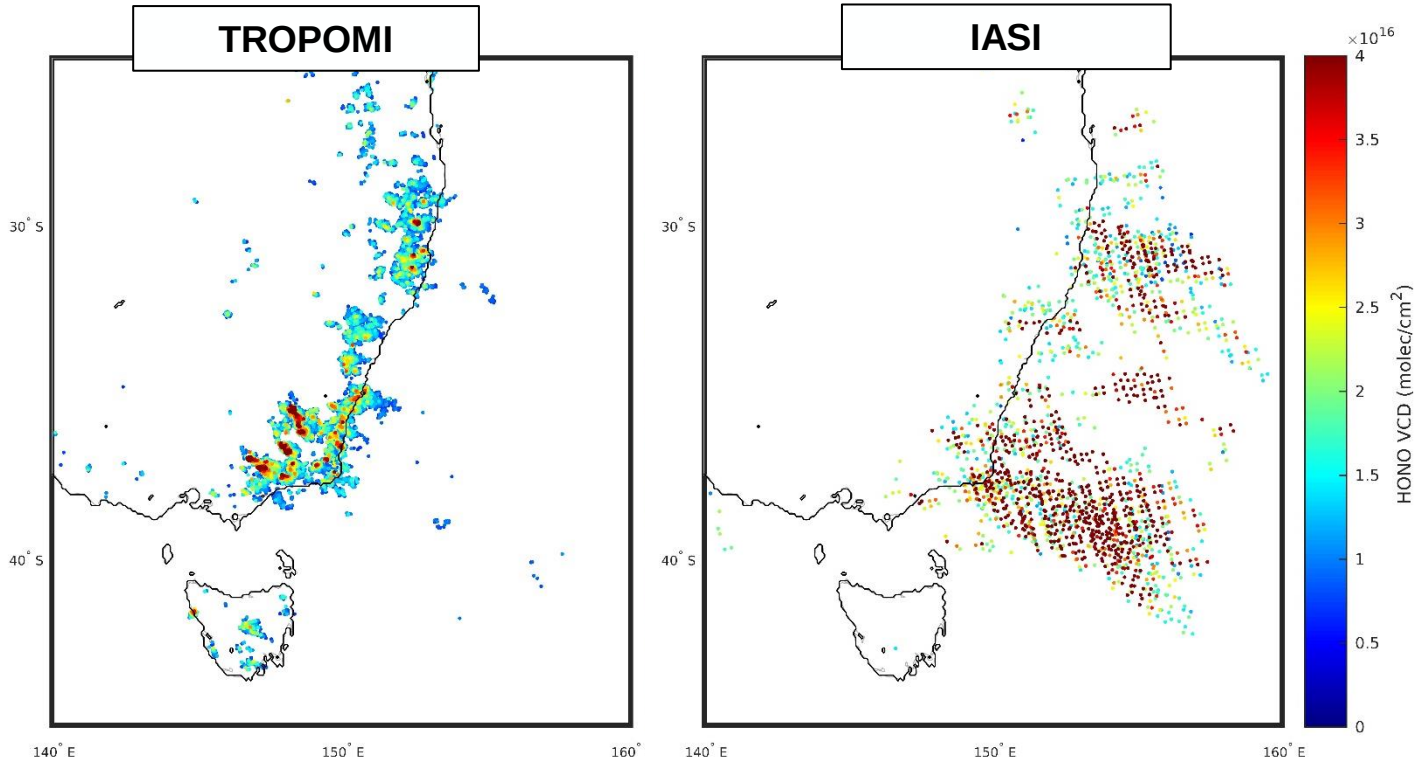
Comparison TROPOMI-IASI

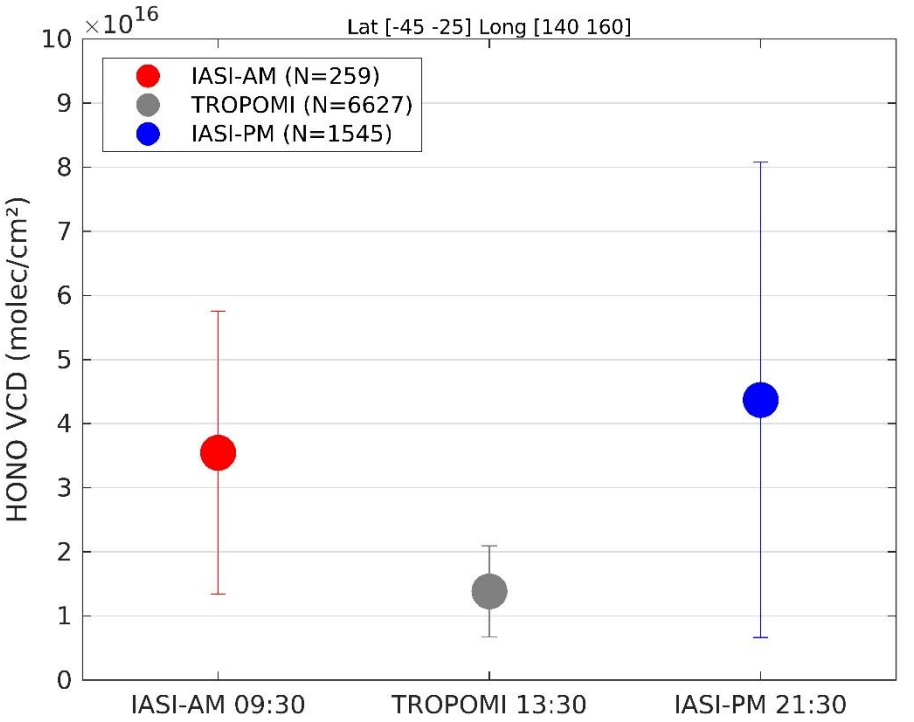




- HONO VCDs: same order of magnitude.
- Nighttime HONO larger than daytime HONO (photochemistry).
- Transport events seen in IASI data.

Comparison TROPOMI-IASI

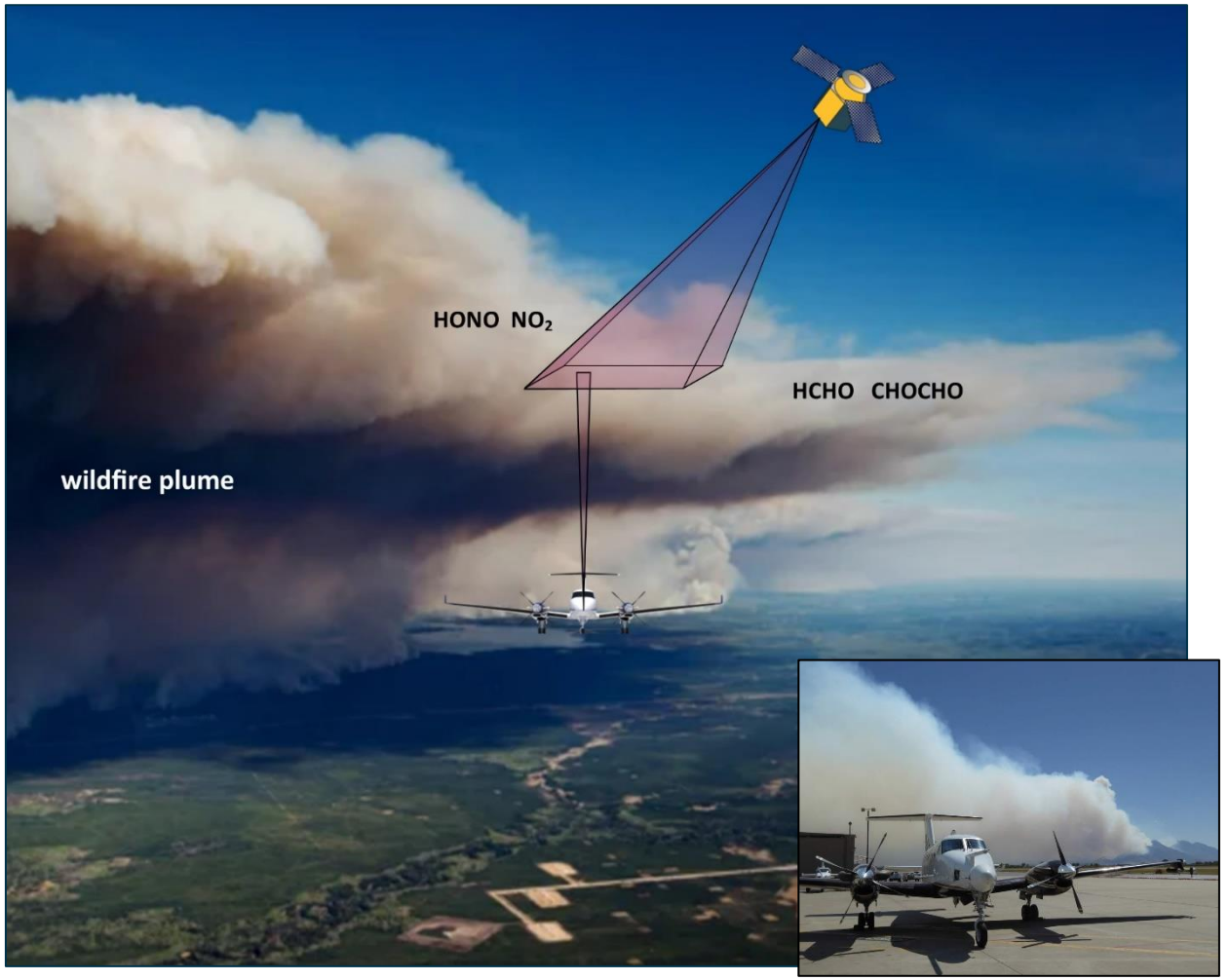




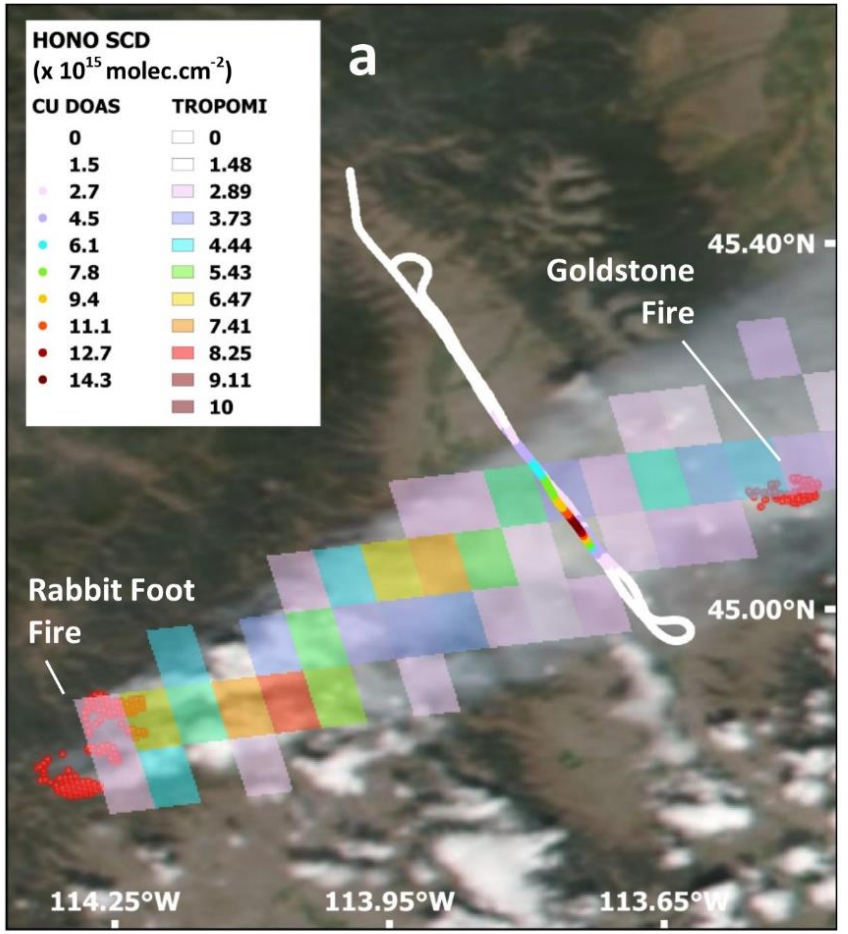
East Australia: large discrepancy between TROPOMI and IASI
(both magnitude and location of the HONO detections).

TROPOMI validation

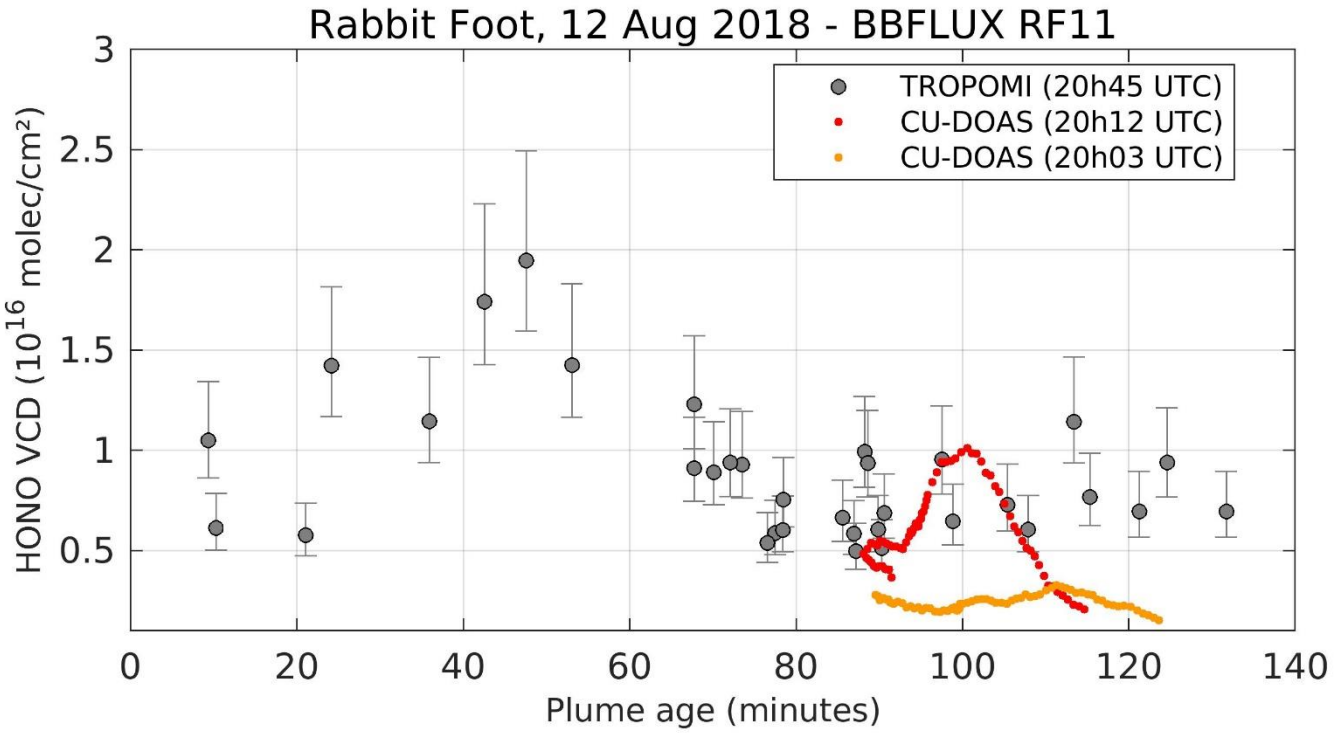
Comparison against aircraft measurements (BB-FLUX)



Rabbit Foot fire (US): 12 August 2018



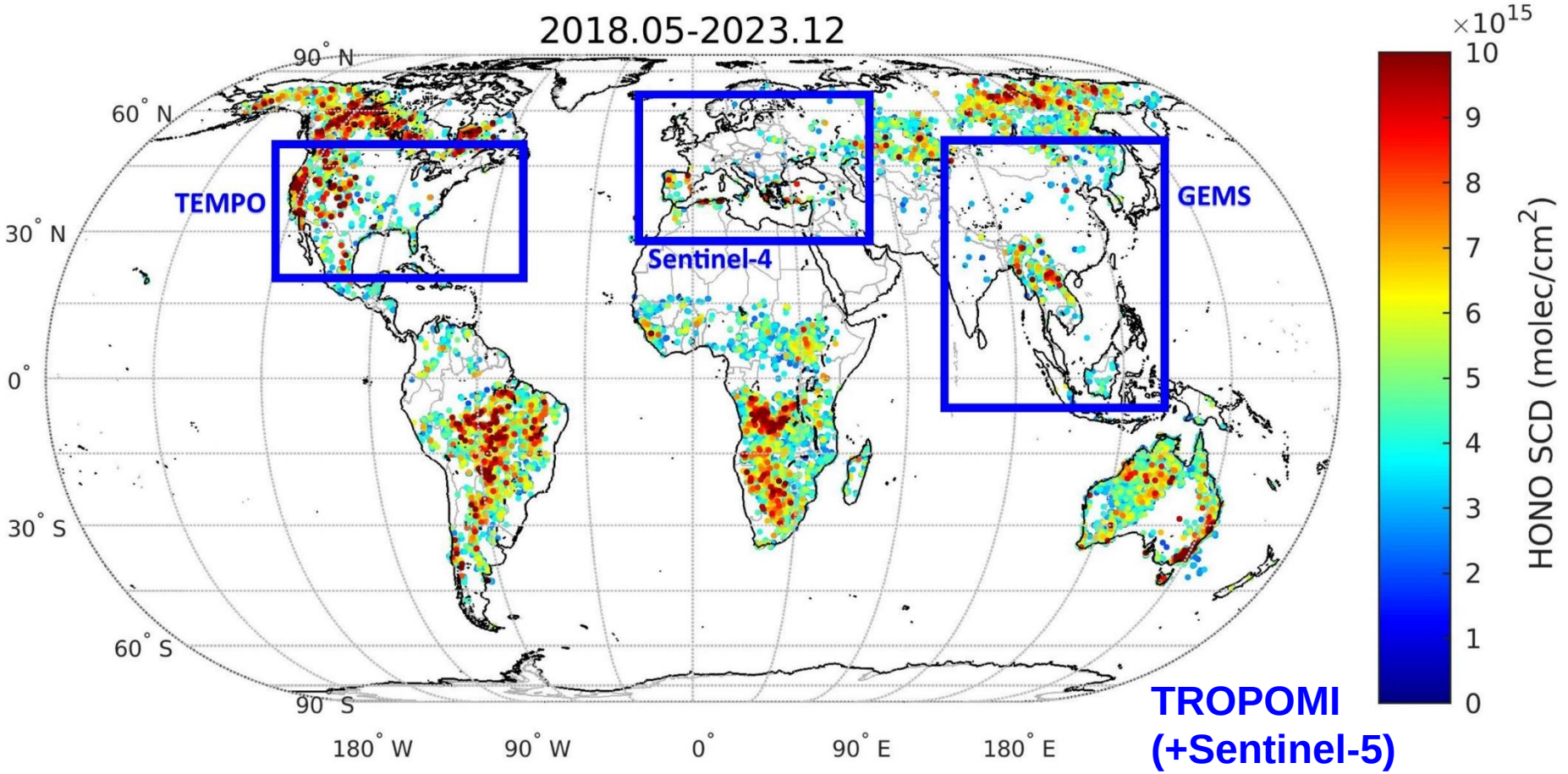
Comparison against aircraft measurements (BB-FLUX)



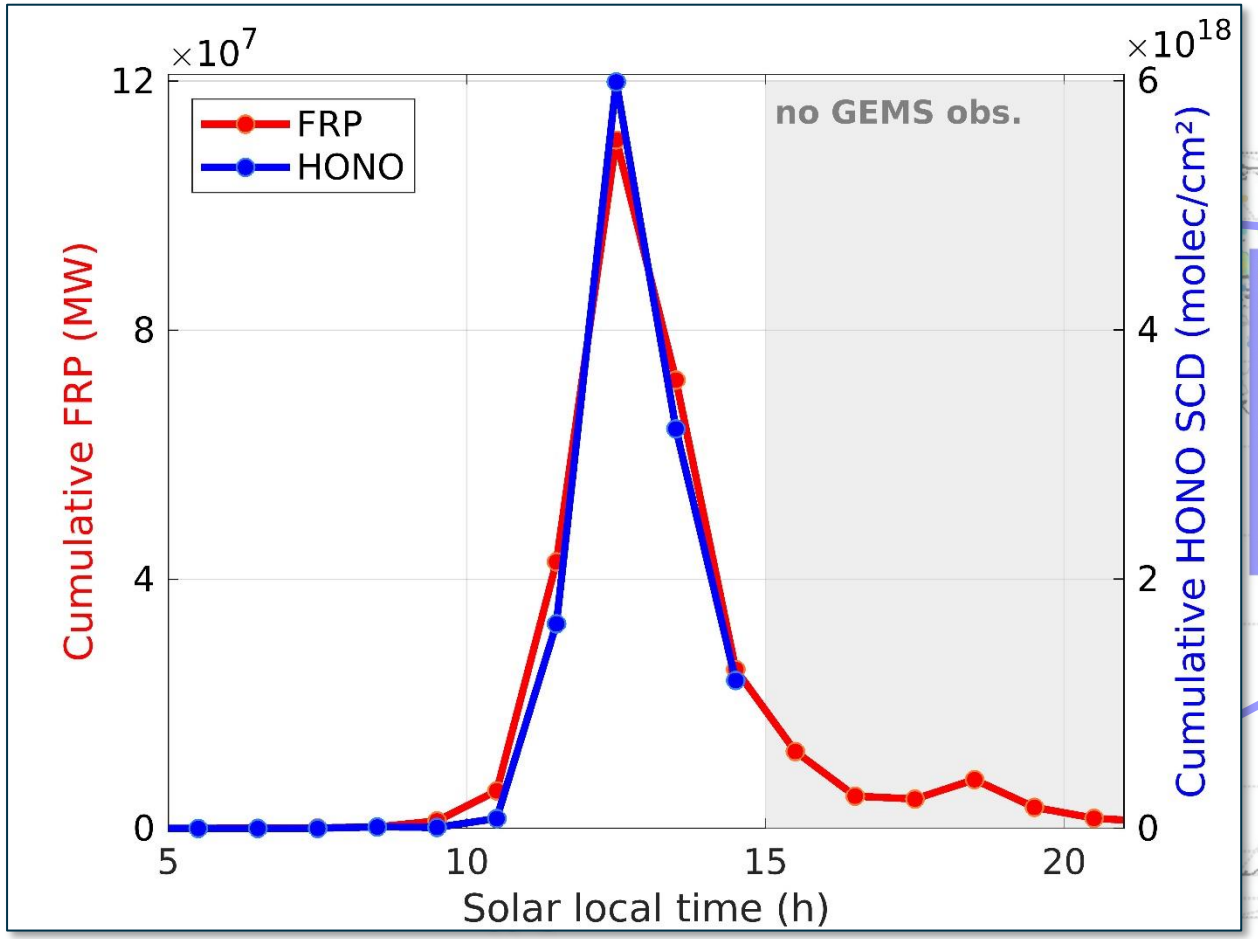
AMF calculation:

- AOD: 7.5 ± 1
- SSA: 85 ± 2.5 %
- Plume height: 3 ± 1 km
- Albedo: 5%
- No cloud.
- Observation geometry: pixel dependent.

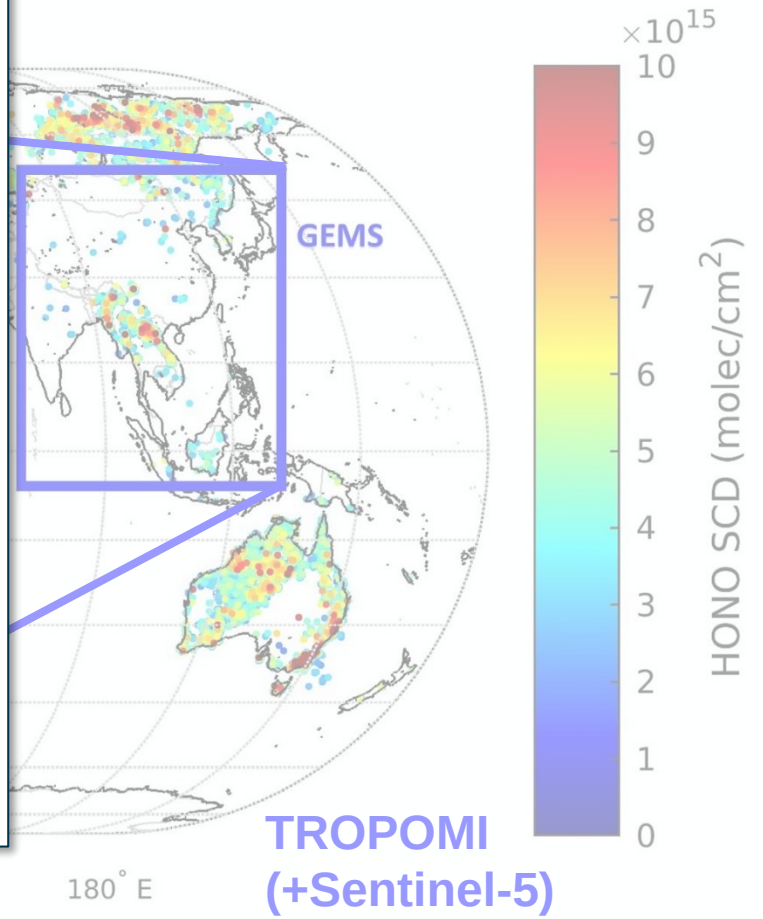
Towards HONO UV constellation



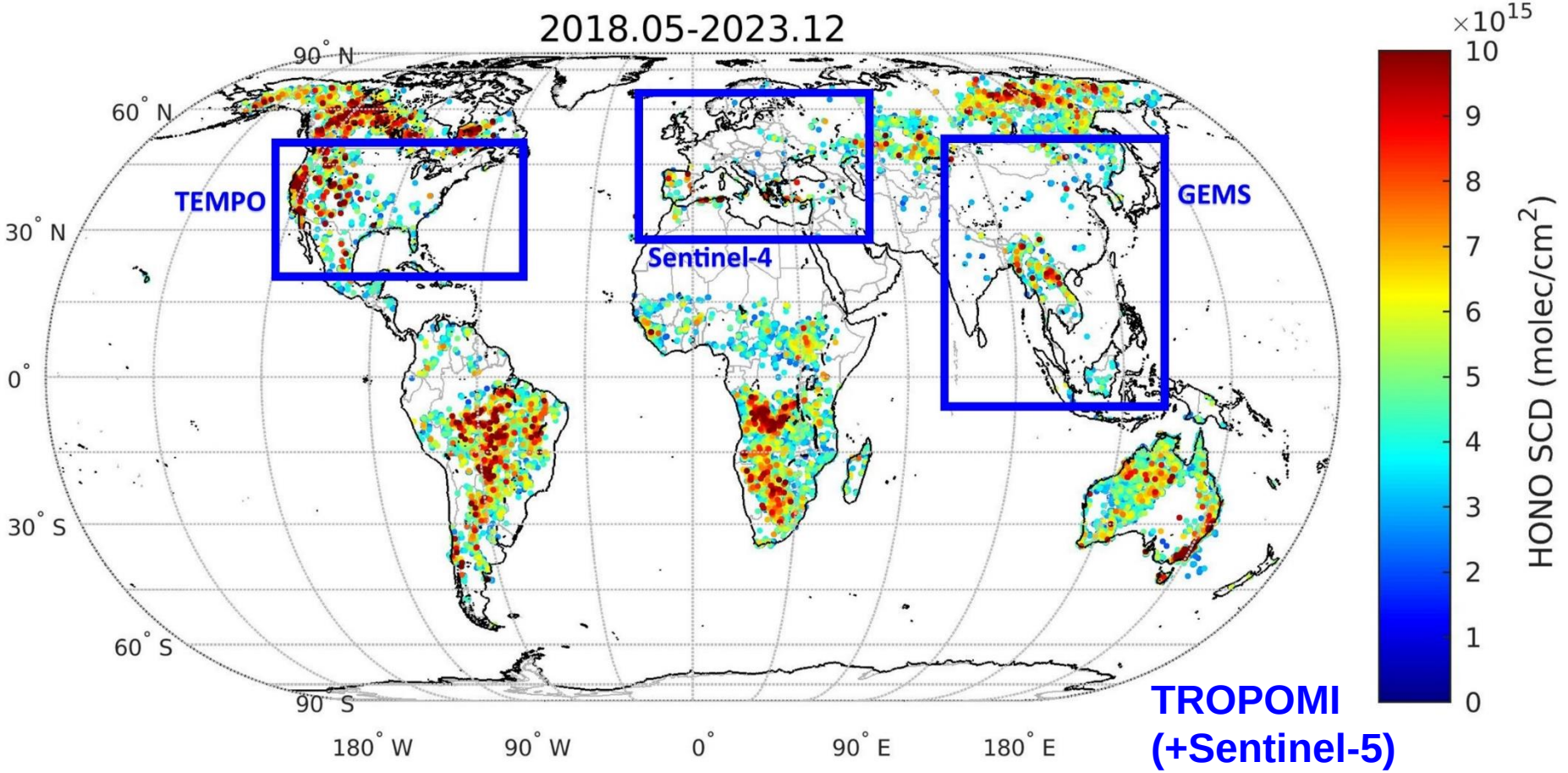
Towards HONO UV constellation



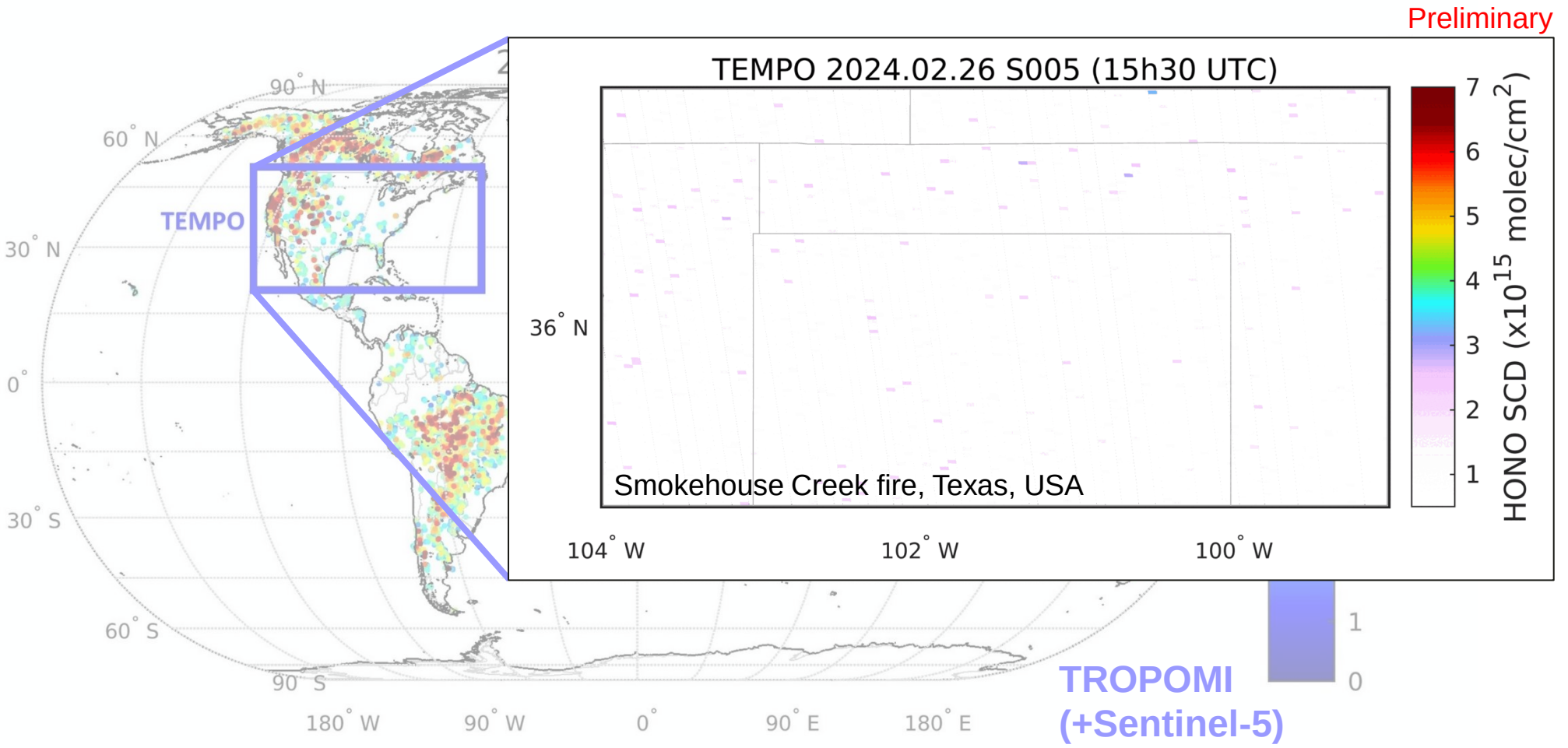
FRP product from AMI/GEO-KOMPSAT-2A



Towards HONO UV constellation



Towards HONO UV constellation



Conclusions

- TROPOMI and IASI observations of HONO over many fire locations worldwide.
- Retrieved HONO vertical columns of the same order of magnitude. Discrepancies are primarily due to differences in horizontal-temporal sampling and vertical sensitivity.
- Aircraft and TROPOMI HONO VCD measurements agree reasonably well, but satellite AMF uncertainties are very large.
- Promising results using geostationary observations (GEMS and TEMPO).
- More research needed on retrievals, validation, interpretation of the results, as well as modelling.

ESA DINAR project:

Development and **I**nterpretation of improved **N**itrous **A**cid **R**etrievals

- Webpage: http://hono.aeronomie.be
  - TROPOMI L2 HONO data (May 2018 – April 2024).
  - IASI L2 HONO data (Jan 2007 – Feb 2024; MetOp-A, -B, -C).
  - Documentation (ATBD, Validation Report, Science Roadmap, etc).

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