Characterization of spatial and temporal variability of HONO from wildfires using TROPOMI and GEMS
(preliminary results)

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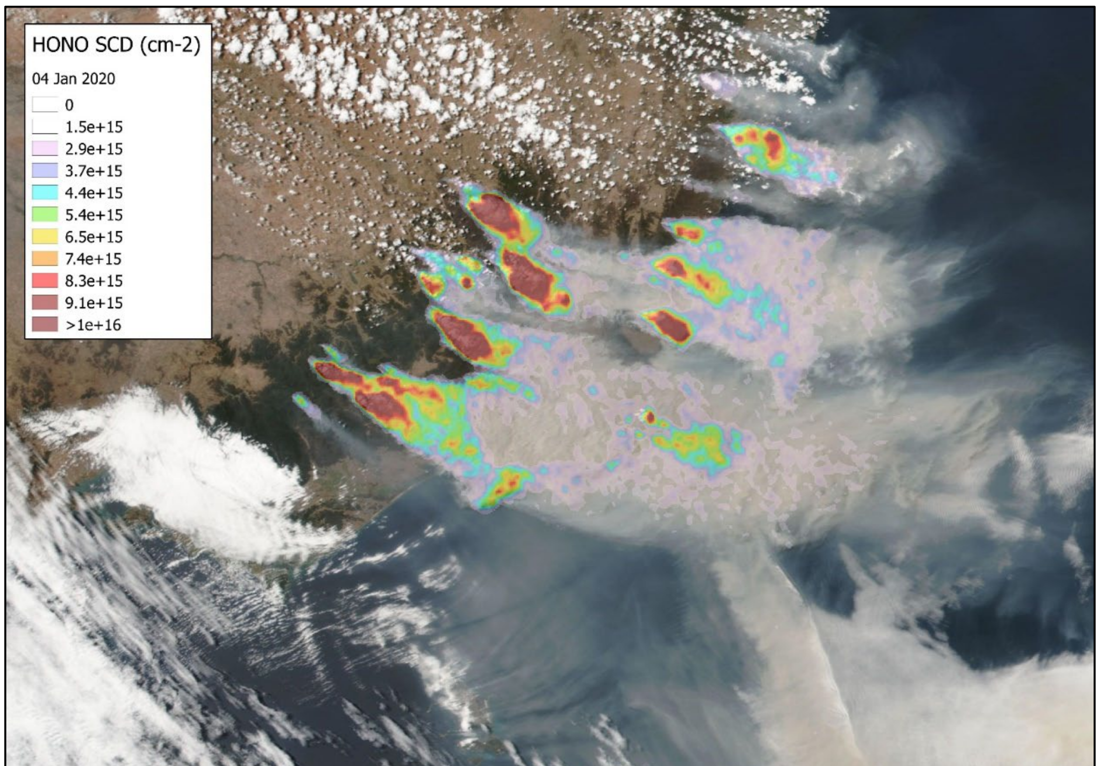

TROPOMI HONO observations over fires in Victoria and New South Wales (Australia)

Atmospheric HONO

- HONO is a source of hydroxyl radical (OH).

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

→ enhanced VOC oxidation

→ secondary organic aerosol formation & aging

→ ozone formation

- HONO emission budget and formation mechanisms are poorly constrained => impact on tropospheric chemistry remains uncertain.

- Until recently, measurements of HONO mostly using in-situ and spectroscopic techniques from instruments on the ground or onboard aircrafts

Detection and mapping of pyrogenic HONO is possible using high spatial resolution instruments like TROPOMI

nature geoscience
ARTICLES
https://doi.org/10.1038/s41561-020-0637-7
Check for updates

Global nitrous acid emissions and levels of regional oxidants enhanced by wildfires

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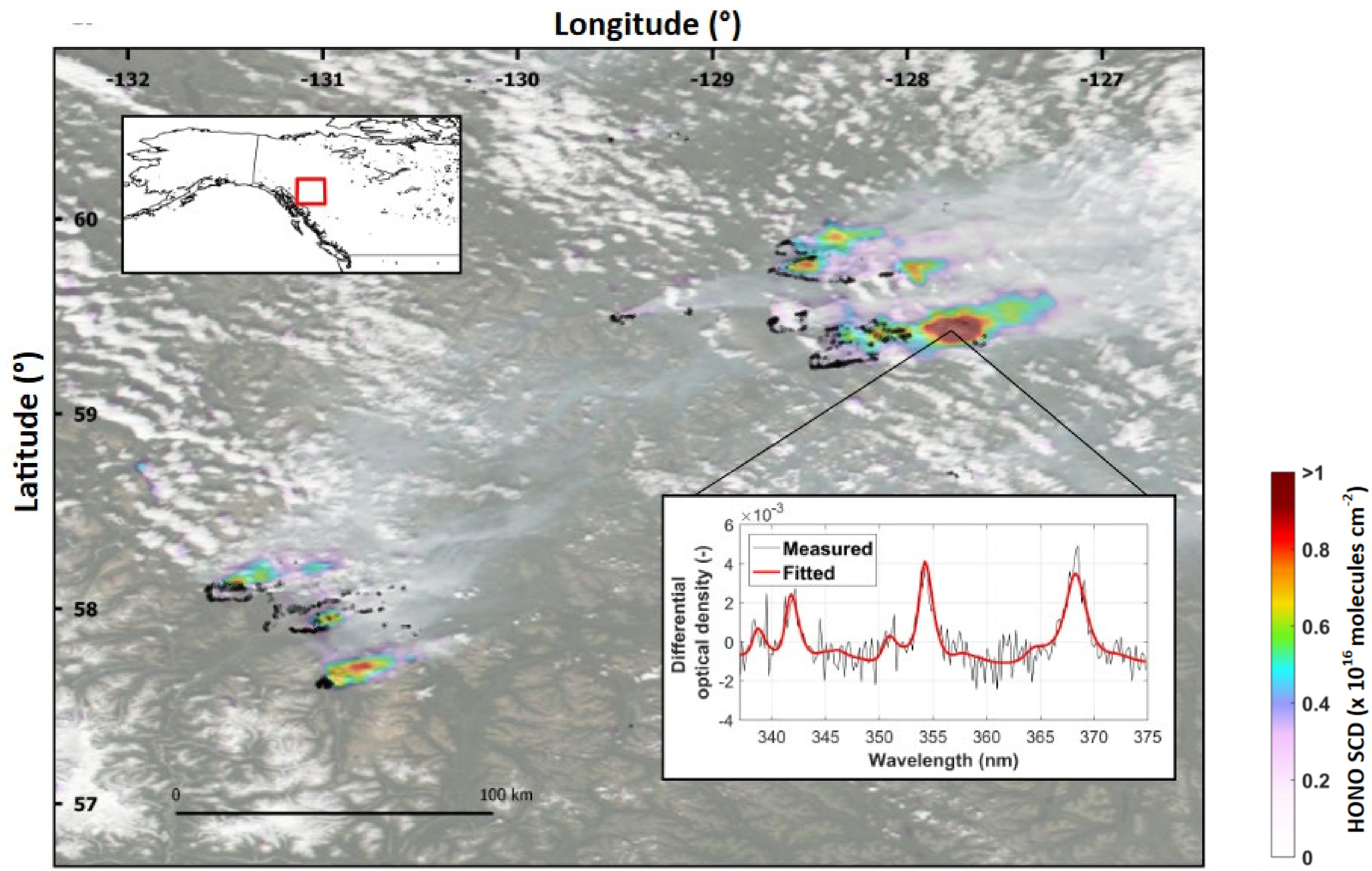

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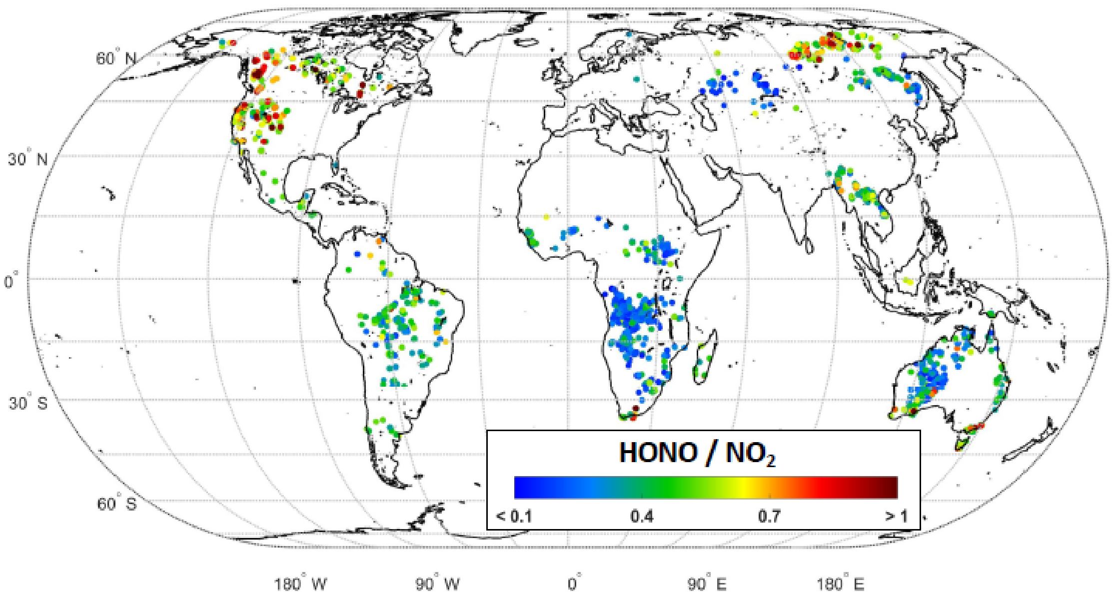
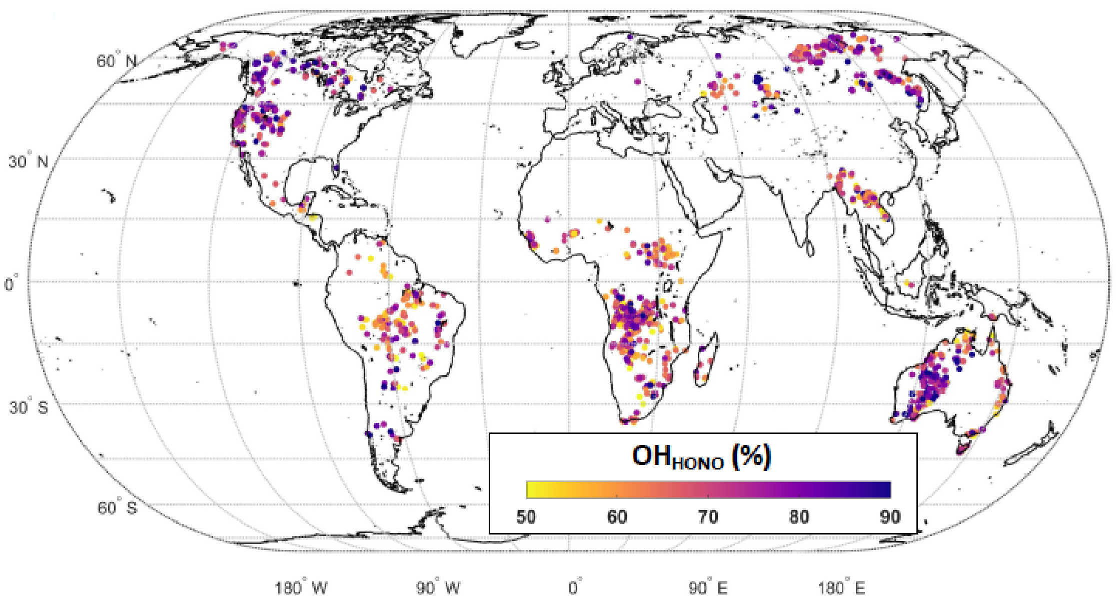
First global survey

May 2018-Apr 2019



$HONO/NO_2$ (proxy of HONO production)

- Strong dependence with ecosystem type.
- Larger than previous estimates by a factor of 2-4.



OH production by HONO photolysis

- Dominant in fresh BB plumes, about 2/3 of total OH production.
- Possible large impact of HONO on oxidative plume chemistry and ozone production.

Points addressed in this presentation

— Can we improve the HONO spectral fitting? A better sensitivity would allow studying a wider range of fires.

— Can we retrieve HONO from geostationary instrument like GEMS (1h resolution)?

— What information can be obtained by studying jointly temporally-resolved HONO, NO_2 and fire activity data from space? This is relevant for improved representation of pyrogenic HONO emissions in air quality models.

Spectral fitting improvement

Covariance-based retrieval algorithm (COBRA) Theys et al., ACP, 2021

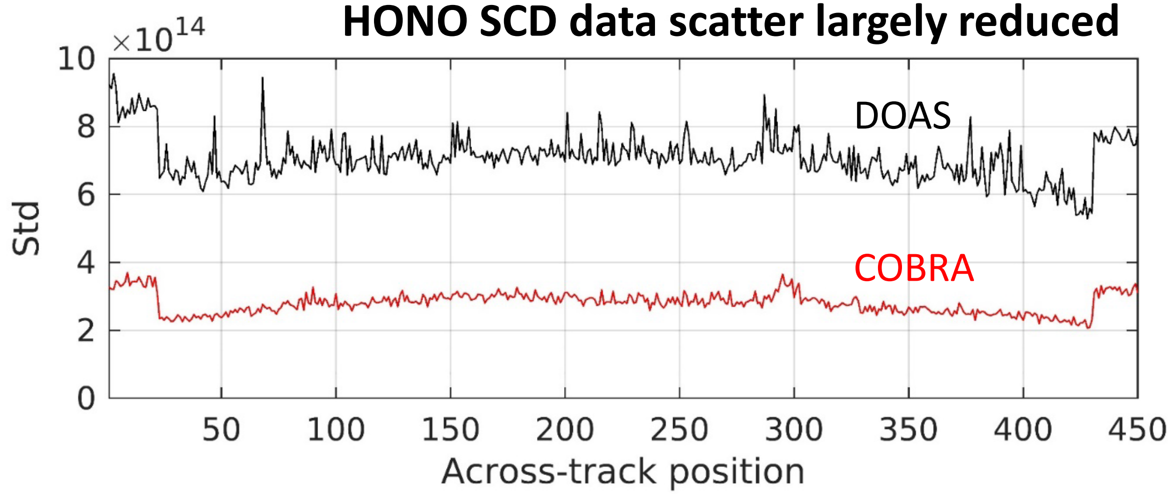
$$y = k.SCD + y_{bkg} + \epsilon$$

y: -log(I/Io) (I, Io: wvl calibrated spectra)
k, SCD: cross-section and slant column of HONO
y_{bkg}: optical depth without contribution from HONO
ϵ : measurement noise

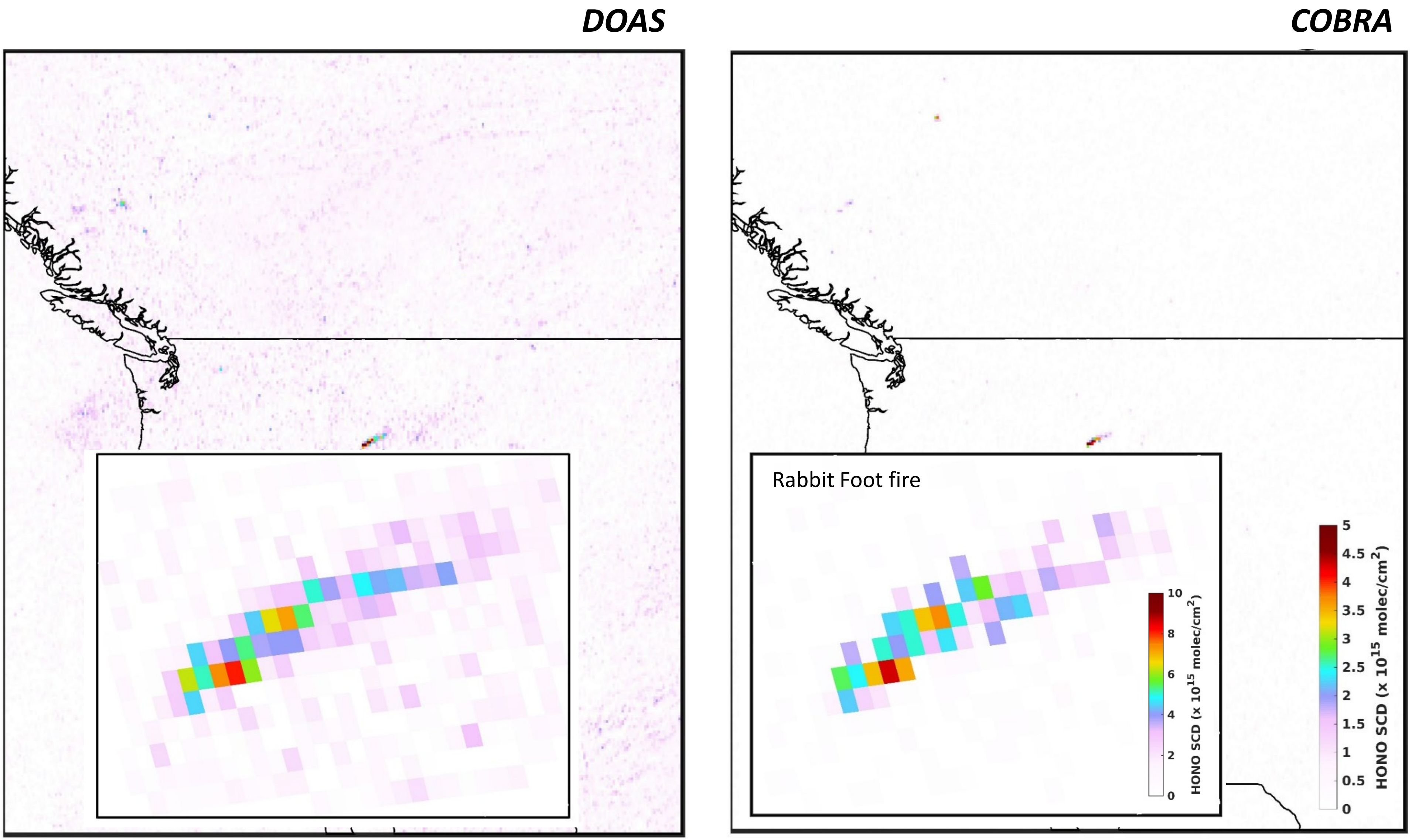
y_{bkg} statistical characterization from a set of HONO-free spectra by S and $\bar{y}$ (covariance matrix and mean spectrum)

$$\rightarrow \boxed{\widehat{SCD} = (k^T S^{-1} k)^{-1} . k^T S^{-1} . (y - \bar{y})}$$

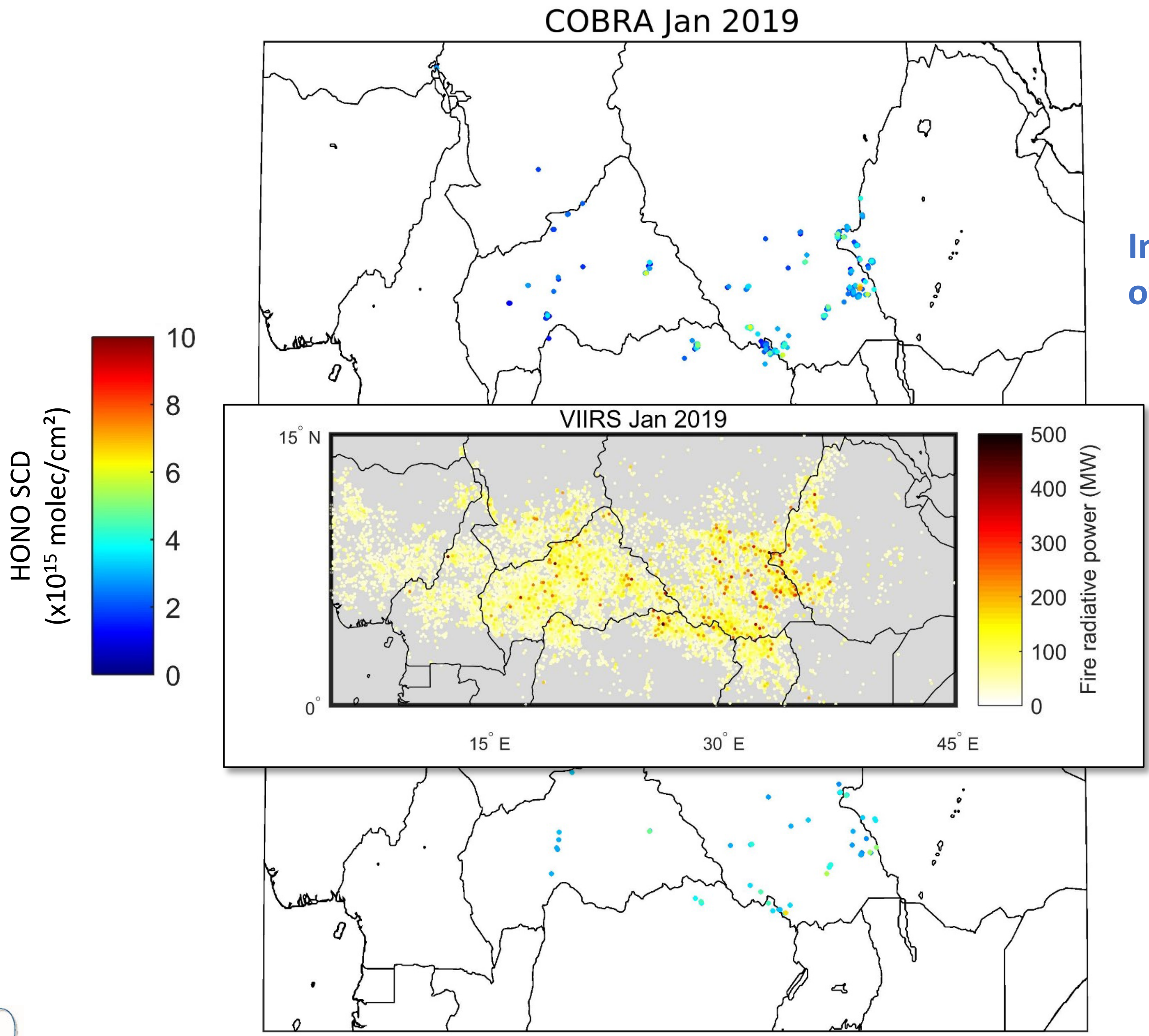
HONO SCD data scatter largely reduced



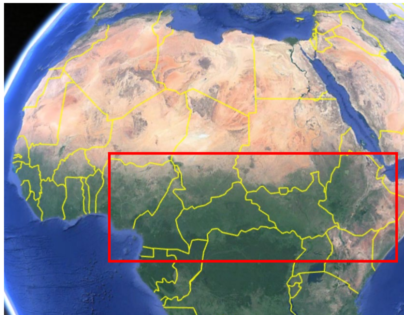
Spectral fitting improvement



12 August 2018



Improved detection of HONO



Geostationary HONO observations

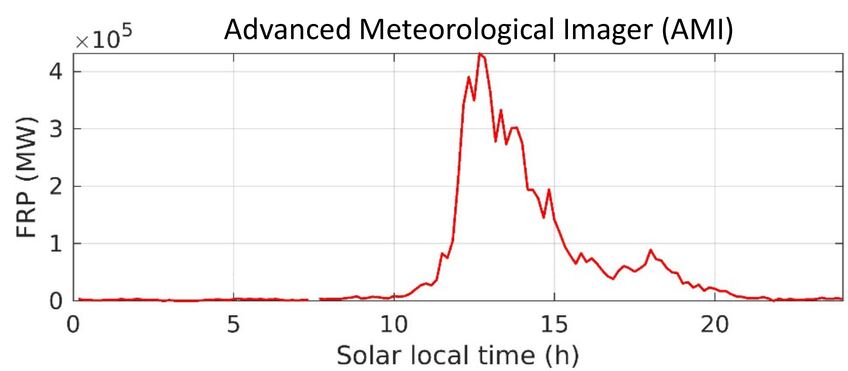
Investigation of South East Asia burning season (agricultural and forest fires)

- March-April 2021

Atmospheric products from GEMS hourly sampling (+TROPOMI)

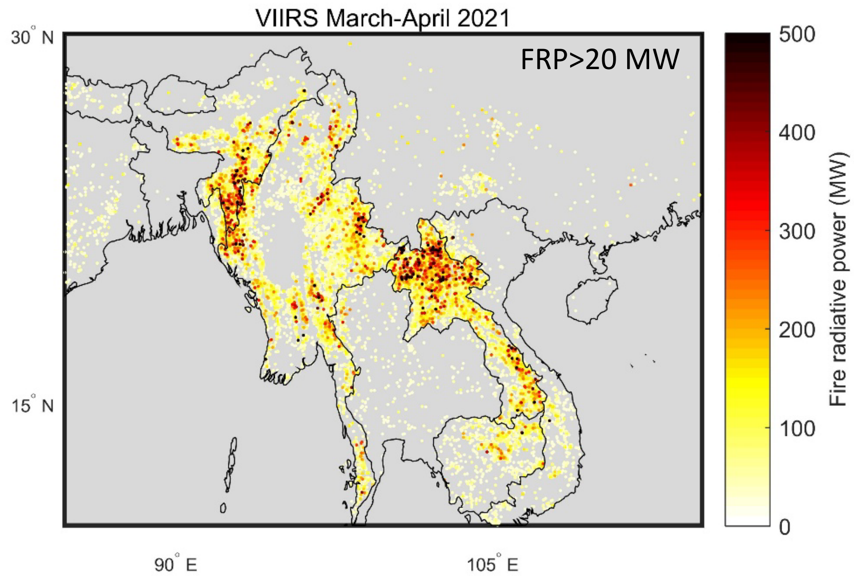
- HONO SCD (COBRA)
- NO_2 VIS SCD background corr. (oper.)

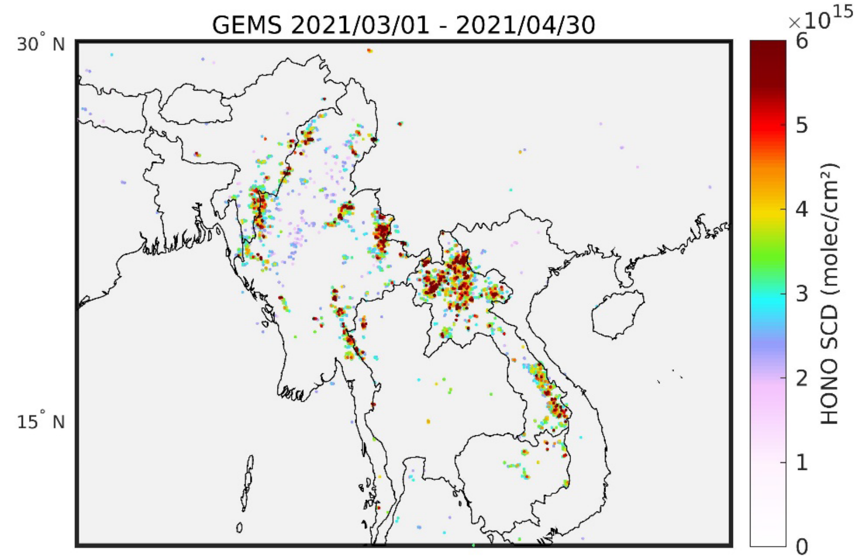
Fire Radiative Power (FRP) product from AMI/GEO-KOMPSAT-2A 10 minutes sampling (+VIIRS/S-NPP)

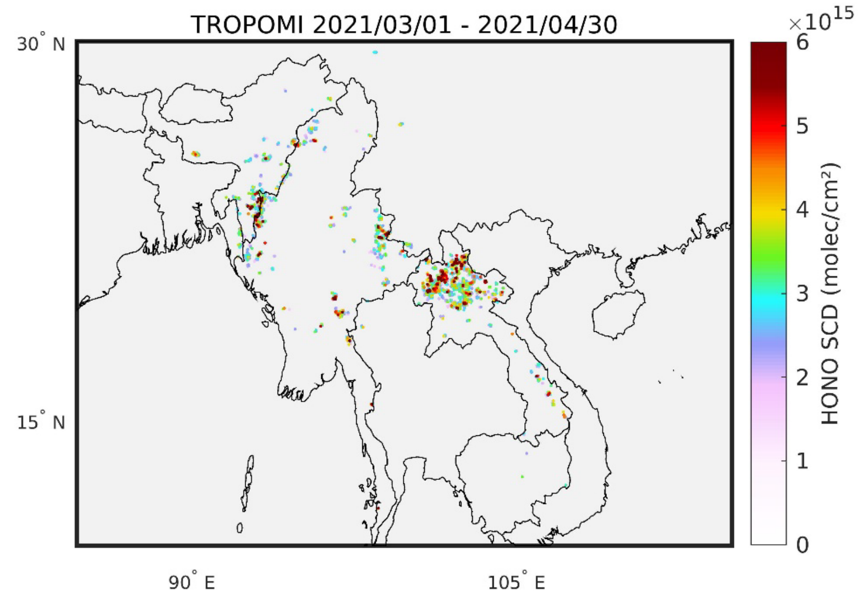


Acknowledgements: NMSC of KMA

Geostationary HONO observations







- Good spatial match between FRP-based fire locations and pixels with confident HONO detection.
- Many more HONO detections with GEMS compared to TROPOMI, in part due to better temporal sampling.

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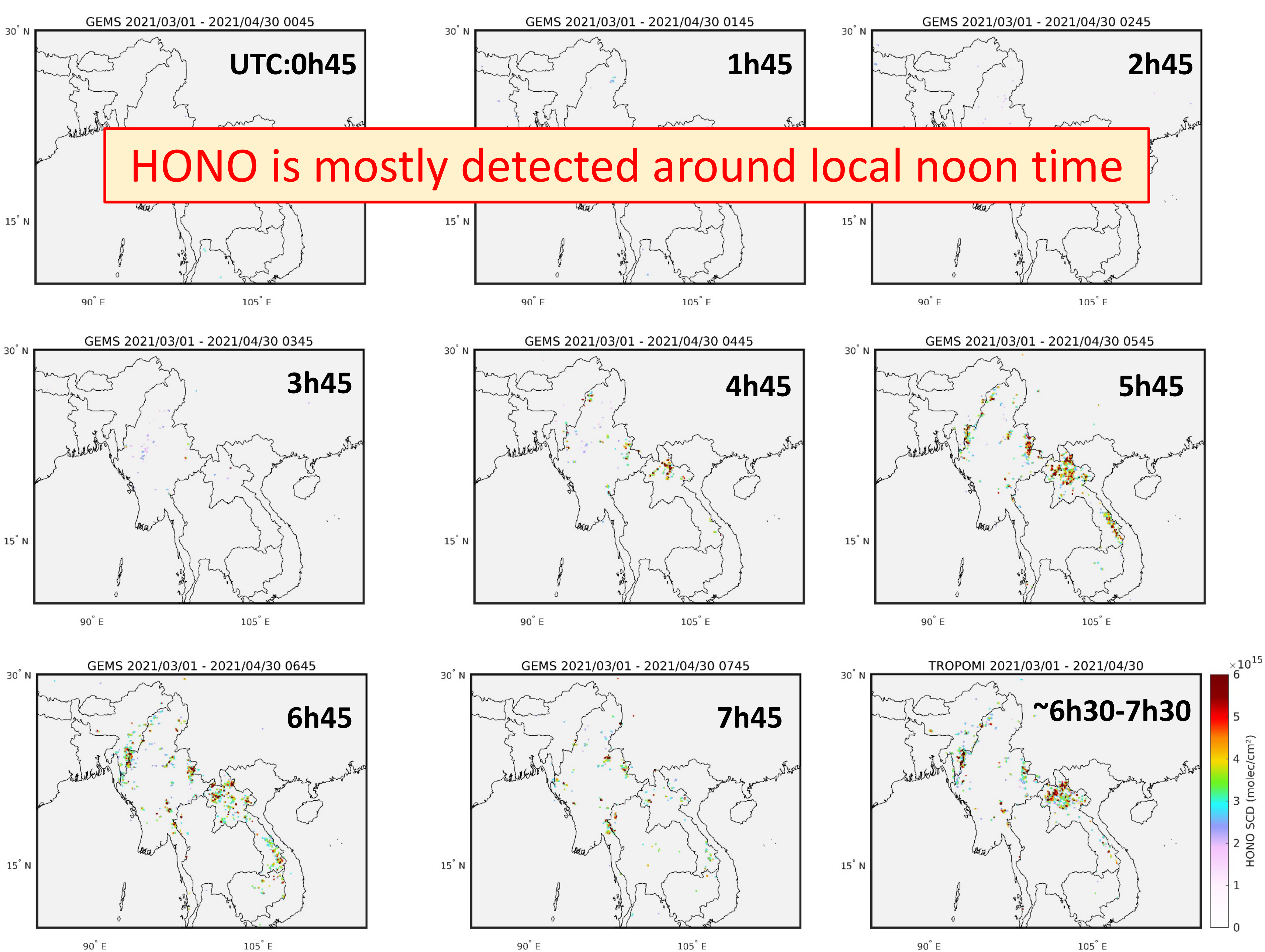
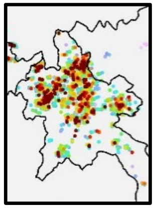
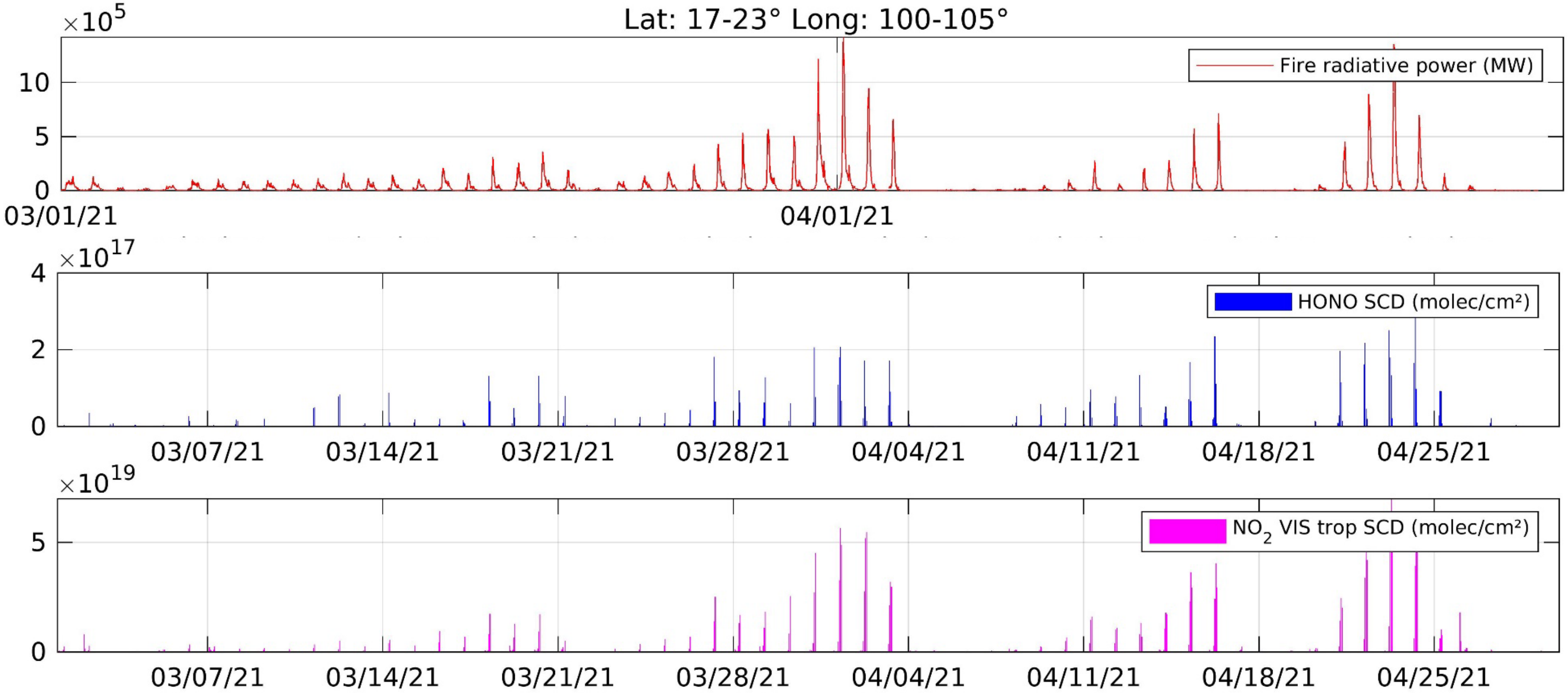
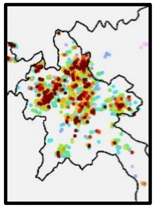

GEMS 2021/03/01 - 2021/04/30 0045
UTC:0h45
GEMS 2021/03/01 - 2021/04/30 0145
1h45
GEMS 2021/03/01 - 2021/04/30 0245
2h45
HONO is mostly detected around local noon time
GEMS 2021/03/01 - 2021/04/30 0345
3h45
GEMS 2021/03/01 - 2021/04/30 0445
4h45
GEMS 2021/03/01 - 2021/04/30 0545
5h45
GEMS 2021/03/01 - 2021/04/30 0645
6h45
GEMS 2021/03/01 - 2021/04/30 0745
7h45
TROPOMI 2021/03/01 - 2021/04/30
~6h30-7h30
30° N
15° N
90° E
105° E
$\times 10^{15}$
HONO SCD (molec/cm²)
0
1
2
3
4
5
6

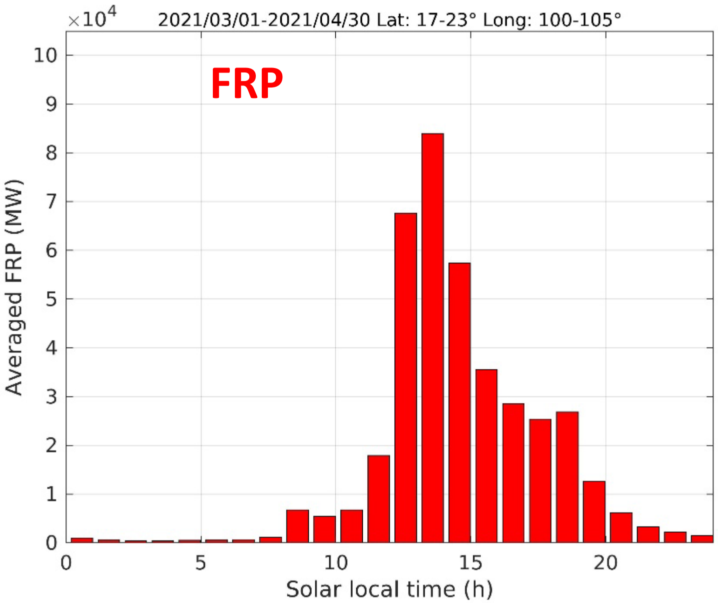
Time evolution - North Laos

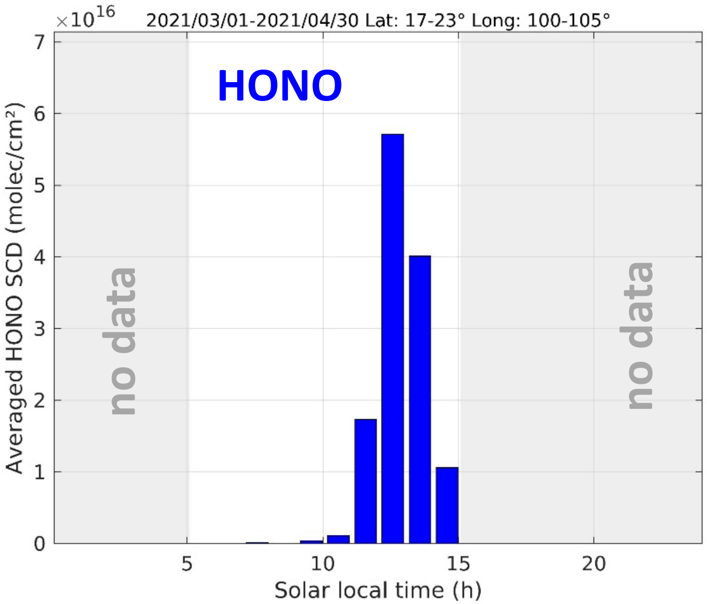




Time evolution - North Laos

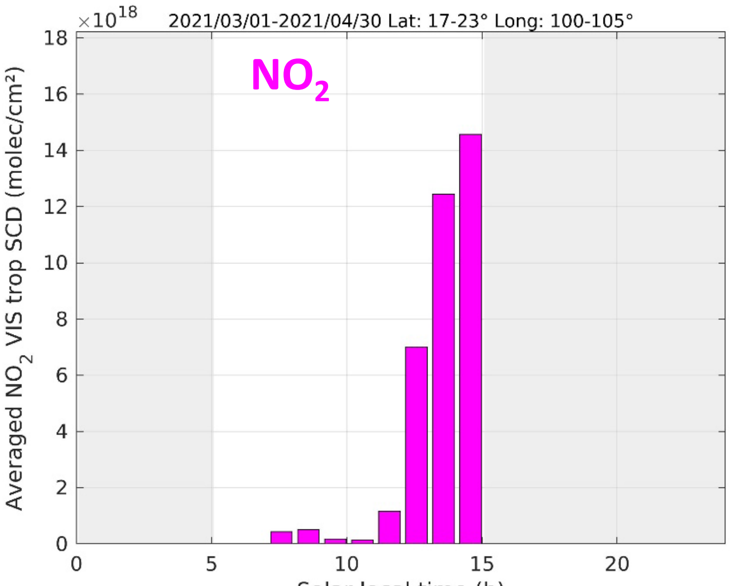




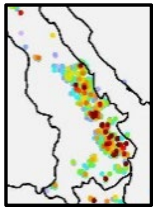


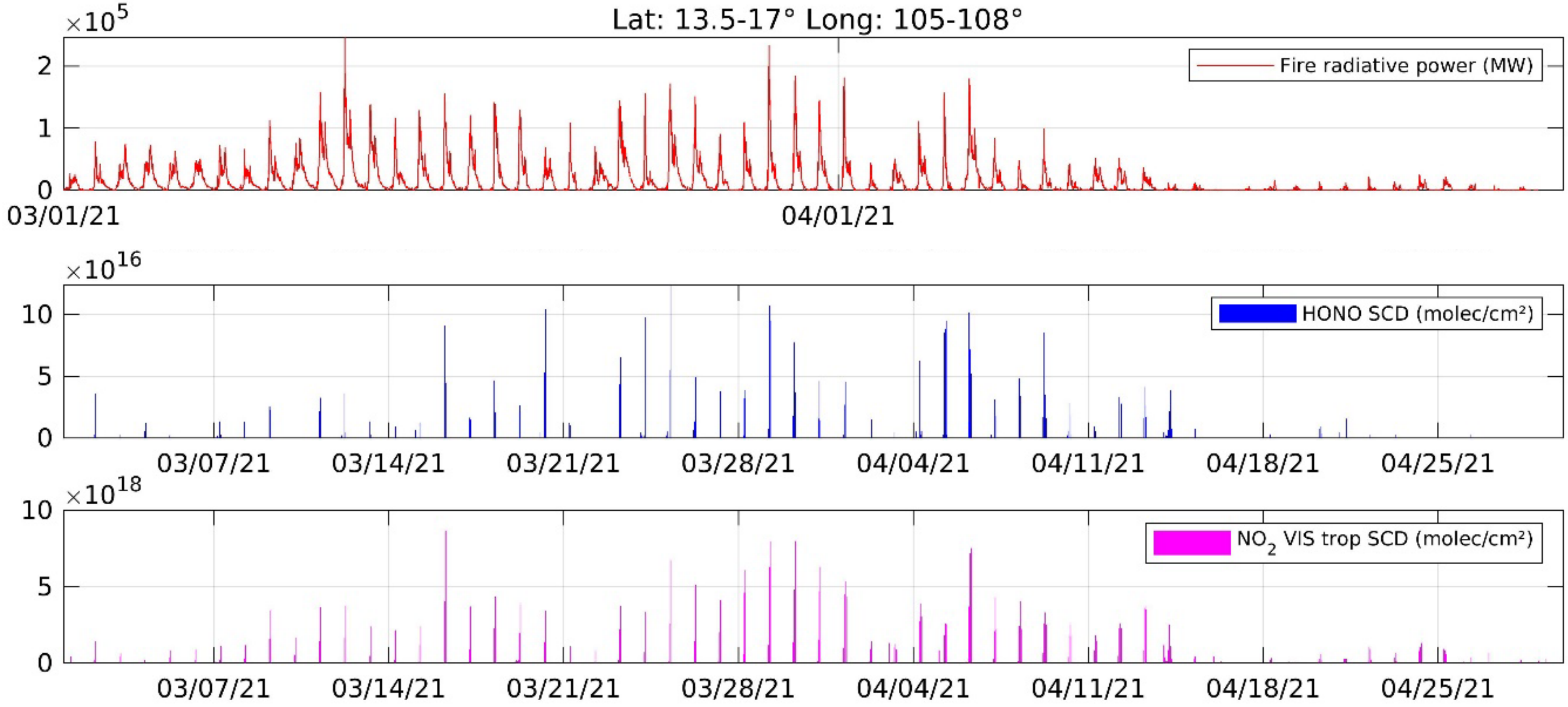
- HONO emissions strongest during flaming combustion?

- NO_2 peak is shifted in comparison to HONO and FRP.



Time evolution - South Laos





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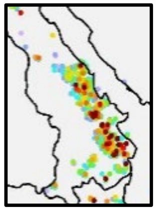
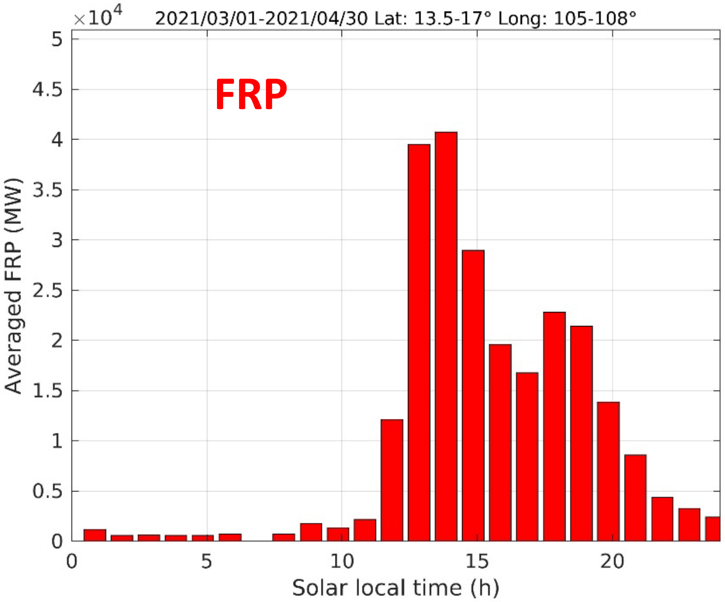
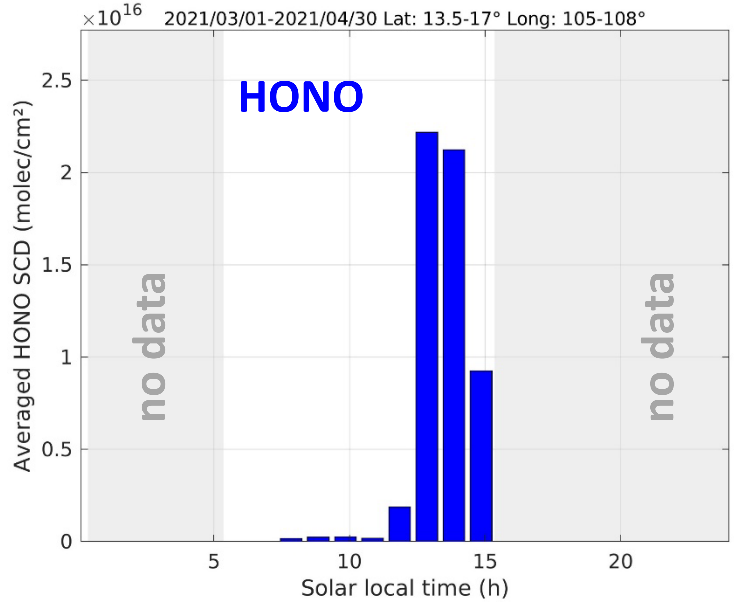
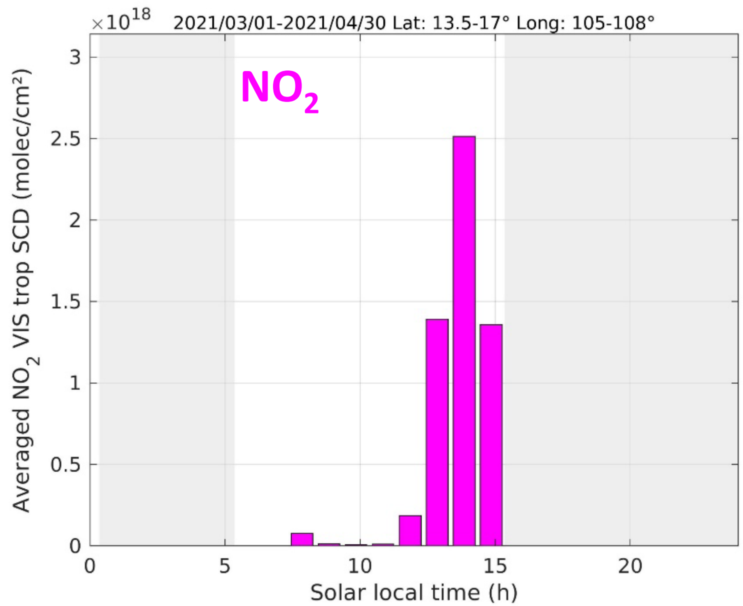
Time evolution - South Laos









Conclusions

- Covariance-Based Retrieval Algorithm (COBRA) scheme improves significantly the detection of HONO.

- GEMS HONO retrievals are promising
  - Consistent with TROPOMI and similar retrieval quality.
  - Detection directly over fire locations and mostly around noontime.

- Time evolution of HONO compared to GEMS NO_2 and AMI FRP
  - HONO emitted at first stage of the fires (flaming combustion).
  - NO_2 and HONO peaks are not occuring at the same time.

Perspectives: DINAR project

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

- Development of HONO VCD product from UV-vis sensors (TROPOMI, OMI, GEMS)
  - spectral fitting (SCDs)
  - radiative transfer in smoke plumes (AMFs)
- Development of HONO VCD product from TIR sensors (IASI, GIIRS)
- Cal/Val activities
- Interpretation and modelling
- Dissemination of output data sets

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