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Glyoxal tropospheric vertical column retrievals from S5p/TROPOMI observations

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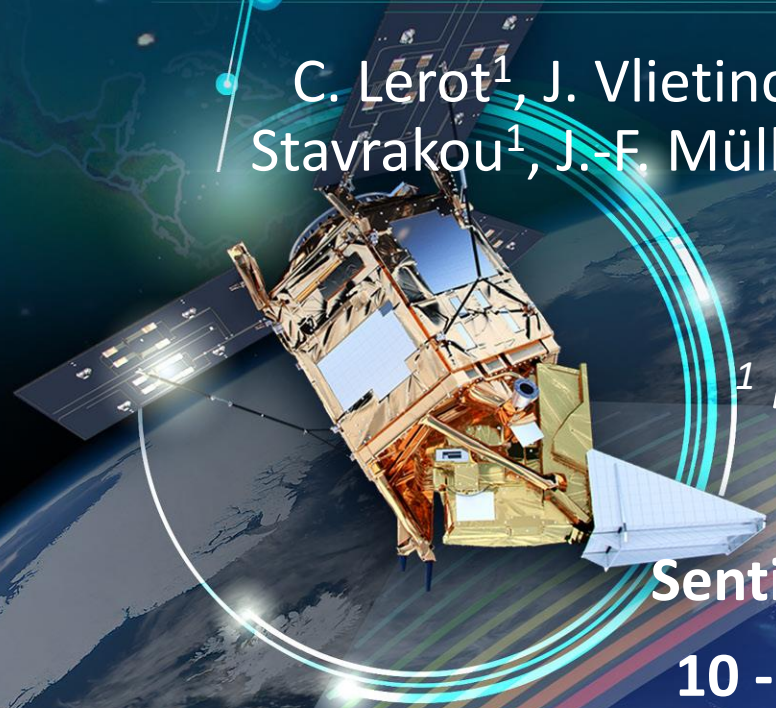
[1] BIRA-IASB; [2] AWI; [3] IUP-UB; [4] S&T



Sentinel-5P Mission:5 years anniversary

10 - 14 October 2022 | Taormina, Italy

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Glyoxal retrievals from TROPOMI

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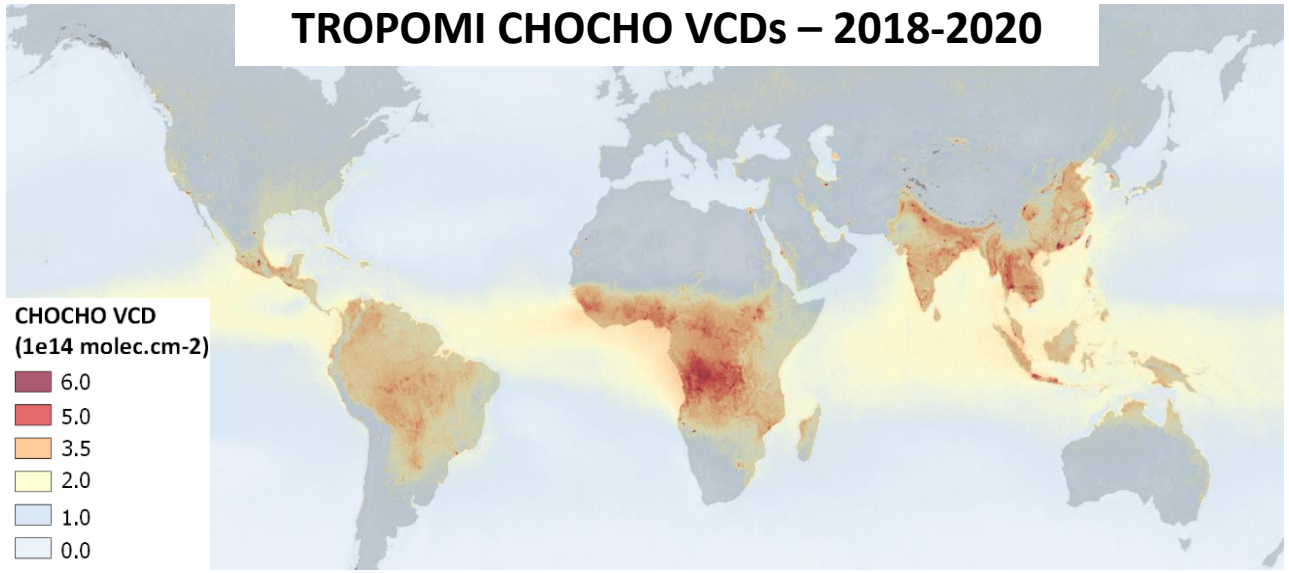
- Sources:
  - Oxidation of other NMVOCs (from natural or human emissions)
  - Direct emissions (combustion processes)

→ Information on NMVOC emissions and SOA budget.

TROPOMI CHOCHO VCDs – 2018-2020



1. DOAS spectral fit: SCD retrieval
2. AMF computation
3. Background/destriping correction

- Glyoxal tropospheric columns can be retrieved from TROPOMI using a DOAS approach in the visible spectral range (435-460 nm).
- Low optical depth → Requires averaging to extract meaningful signals.
- Algorithm further developed and product characterized within the GLYRETRO project (ESA S5p+I). Data available @ https://glyretro.aeronomie.be

Lerot et al., AMT, 2021

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Inter-satellite consistency

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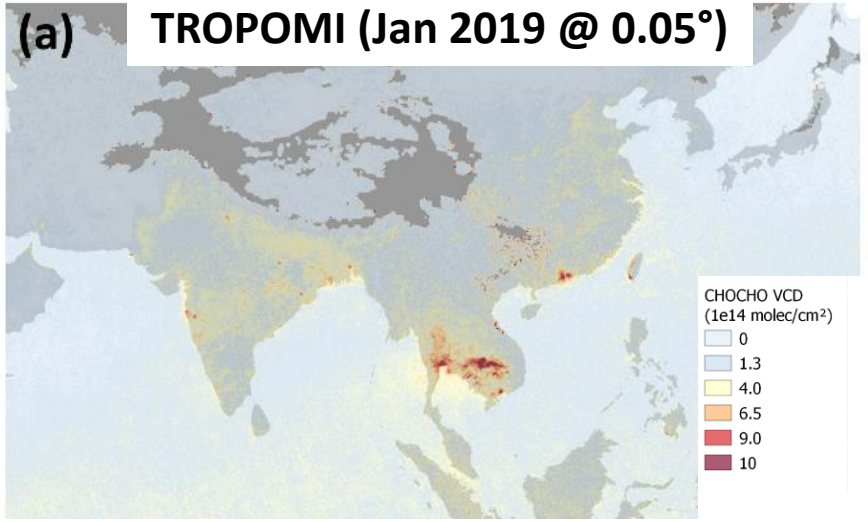
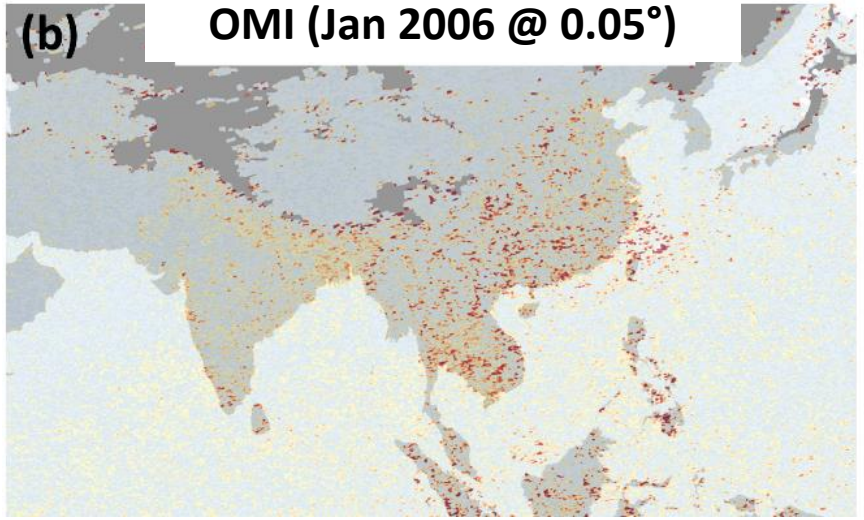
- Glyoxal algorithm applied to different sensors with consistent DOAS settings:
  - Scientific product TROPOMI [ESA innovation project] (2018-present)
  - Scientific product OMI (2005-2018)
  - GOME2A/B operational records [AC-SAF] (2007-2017/2013-2020)

- TROPOMI has better S/N ratio, spatial resolution and provides huge amount of obs.

→ Much more details in the retrieved glyoxal fields.





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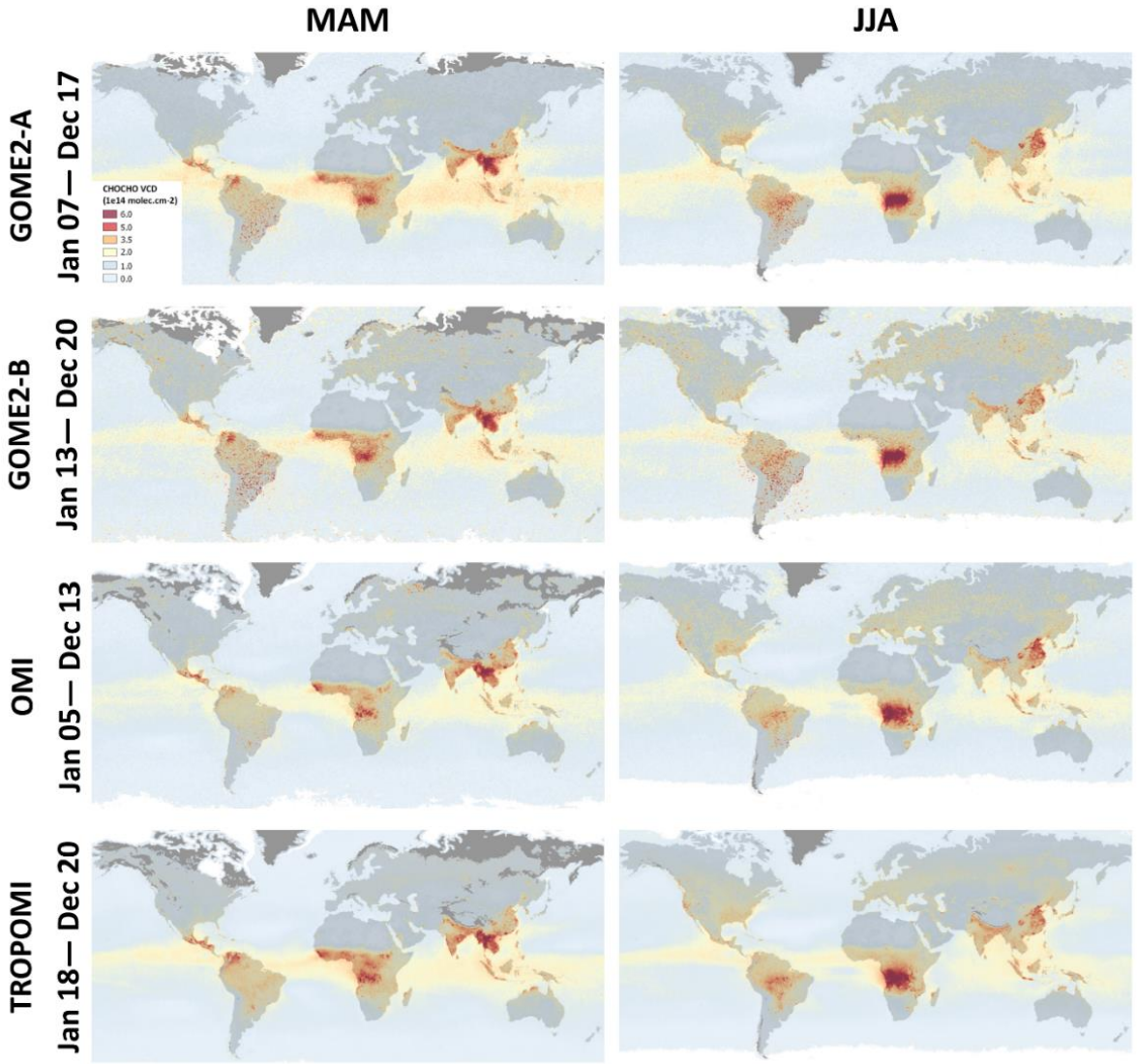
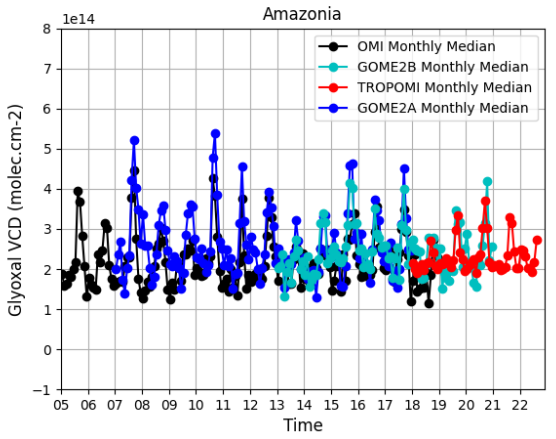
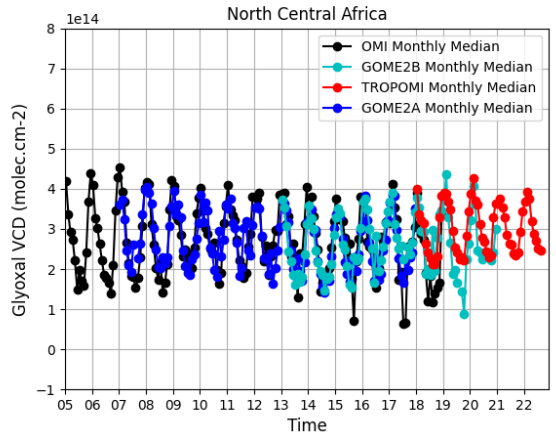
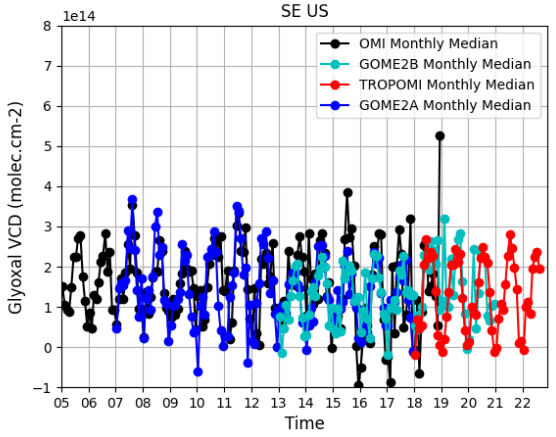
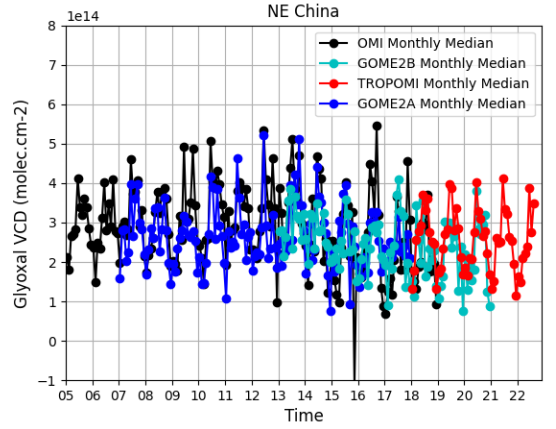
Inter-satellite consistency











Overall inter-satellite consistency within 5e13 molec/cm² (<20%)

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Product validation

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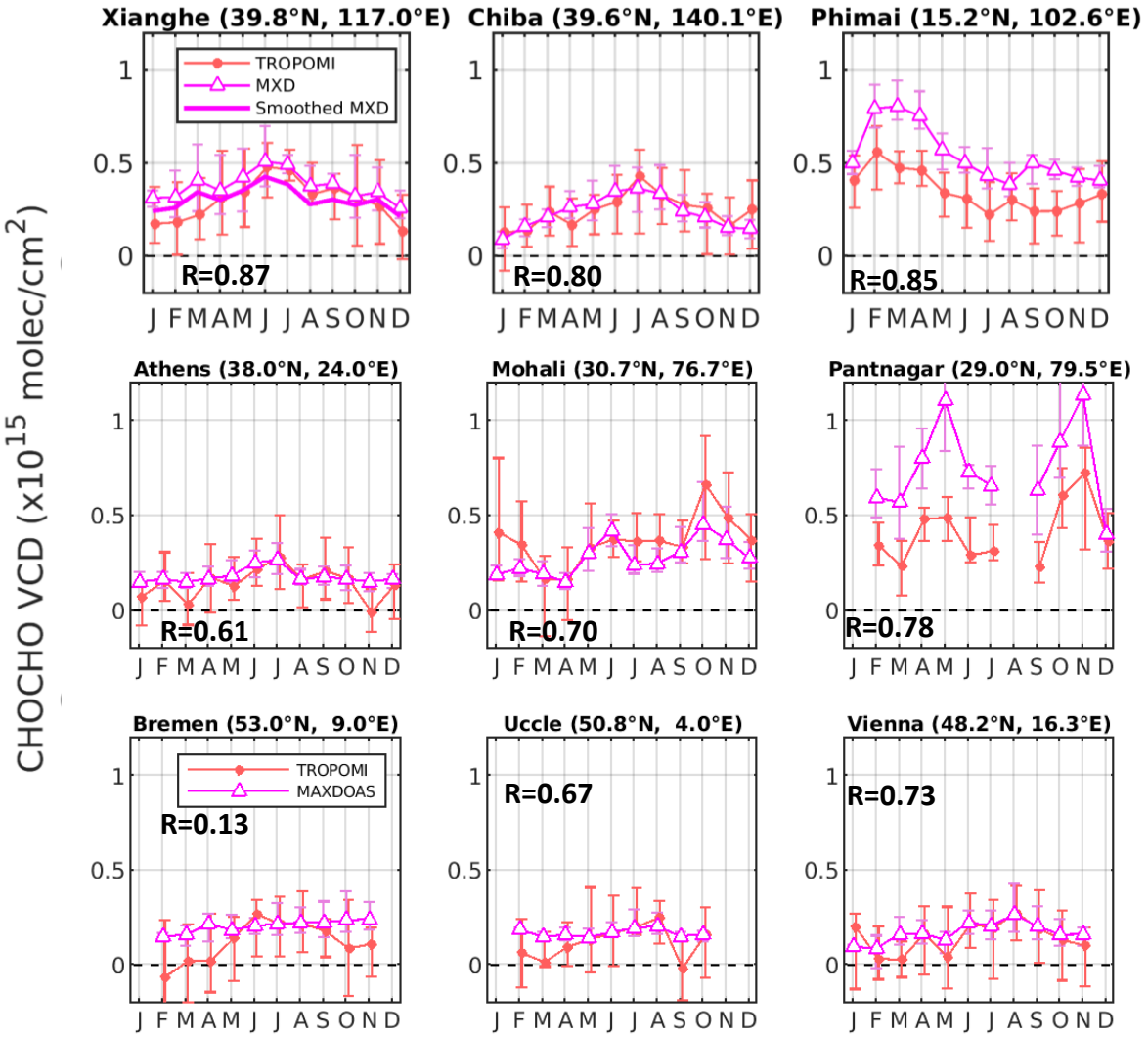
- MAX-DOAS validation based on 9 stations in Asia and Europe. Overpass radius: 20 km; overpass time: 1.5h
- Consistent TROPOMI and MAX-DOAS seasonal cycles. Indication for a negative bias during wintertime at mid/high latitude (e.g. Bremen).
- Large biases in Phimai and Pantnagar not fully understood. Related to different MAX-DOAS retrieval strategies?

Correlation coefficient/Bias (x10^{14}molec.cm-2)

	Xianghe	Chiba	Phimai	Athens	Mohali	Pantnagar	Bremen	Uccle	Vienna
R	0.87	0.80	0.85	0.61	0.70	0.78	0.13	0.67	0.73
Bias	-0.8	+0.1	-2.0	-0.4	+0.6	-3.5	+0.9	-0.5	-0.3



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Tracking VOC emissions from fires

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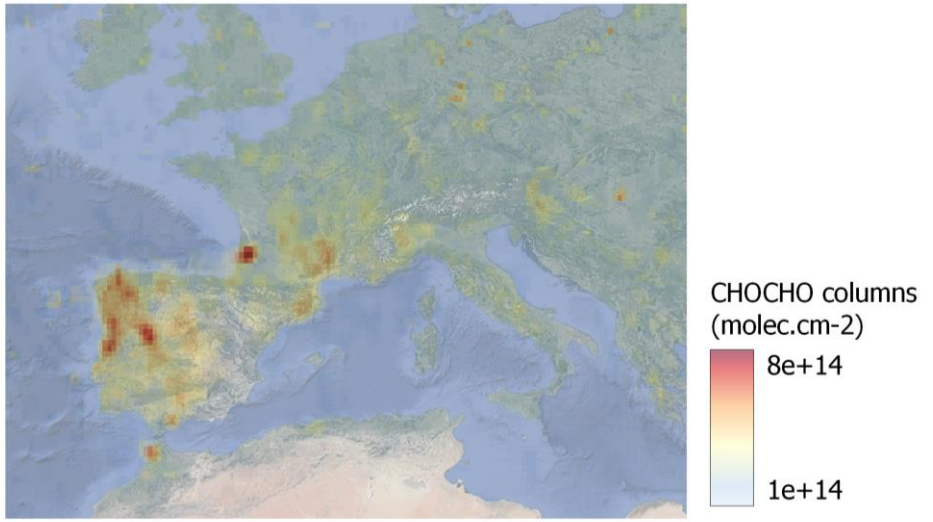
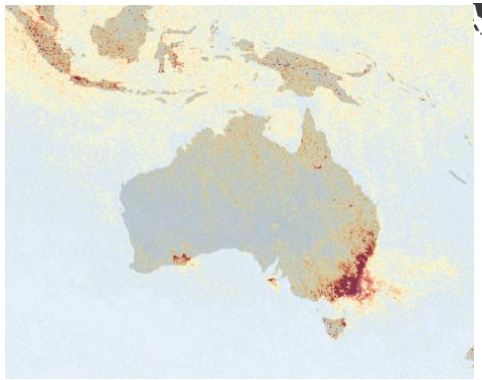
- Wildfires emit large amounts of pollutants and aerosols, including VOCs.
- Climate change leads to more frequent and more intense wild fires → huge impact on ecosystems and air quality.
- Not only a local issue: enhanced CHOCHO and HCHO signals are sometimes observed at long distances from fire sources (Alvarado et al., ACP, 2020).

TROPOMI observations - 12-17 July 2022



2020 bushfires in Australia

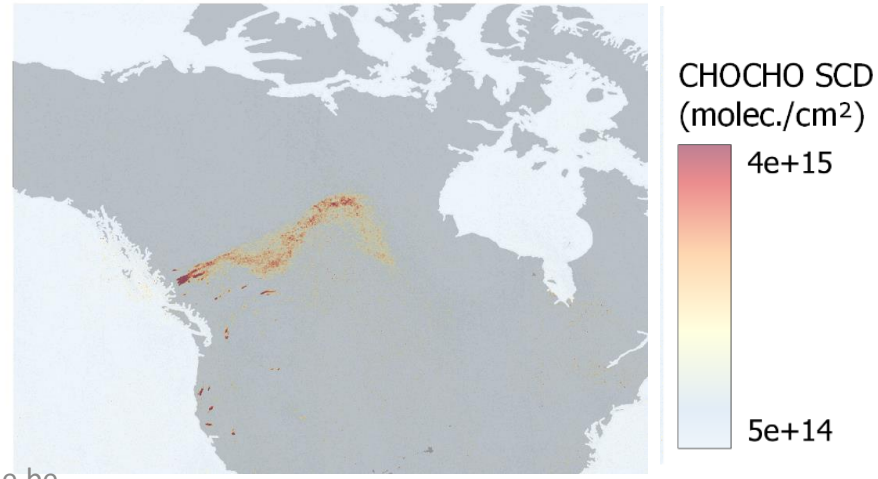
CHOCHO VCD

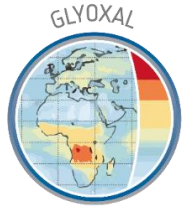


VIIRS FRP

© FIRMS

Canadian wildfires
CHOCHO SCDs (10/08/2018)





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Spatial distribution of glyoxal and formaldehyde

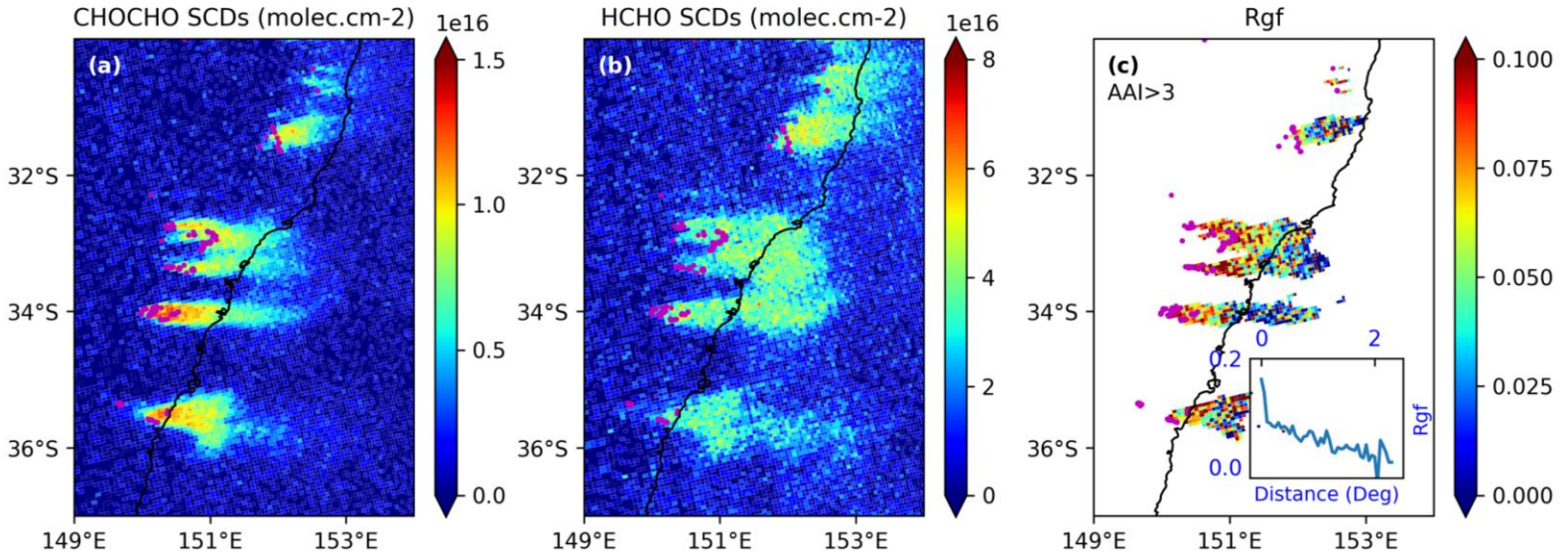
co-funded with esa

Australian wildfires – 05/12/2019

- Direct emissions from fires larger for CHOCHO than for HCHO

→ Clear CHOCHO hot spots near the fire sources.

→ The CHOCHO/HCHO ratio (Rgf) typically has maximum values near the fires and decreases downwind.



Note: Differences of sensitivity between Visible and UV spectral ranges are accounted for by computing Rgf as:

$$R_{gf} = \frac{SCD_{CHOCHO}}{SCD_{HCHO}} \times \frac{SCD_{NO2}(UV)}{SCD_{NO2}(Visible)}$$

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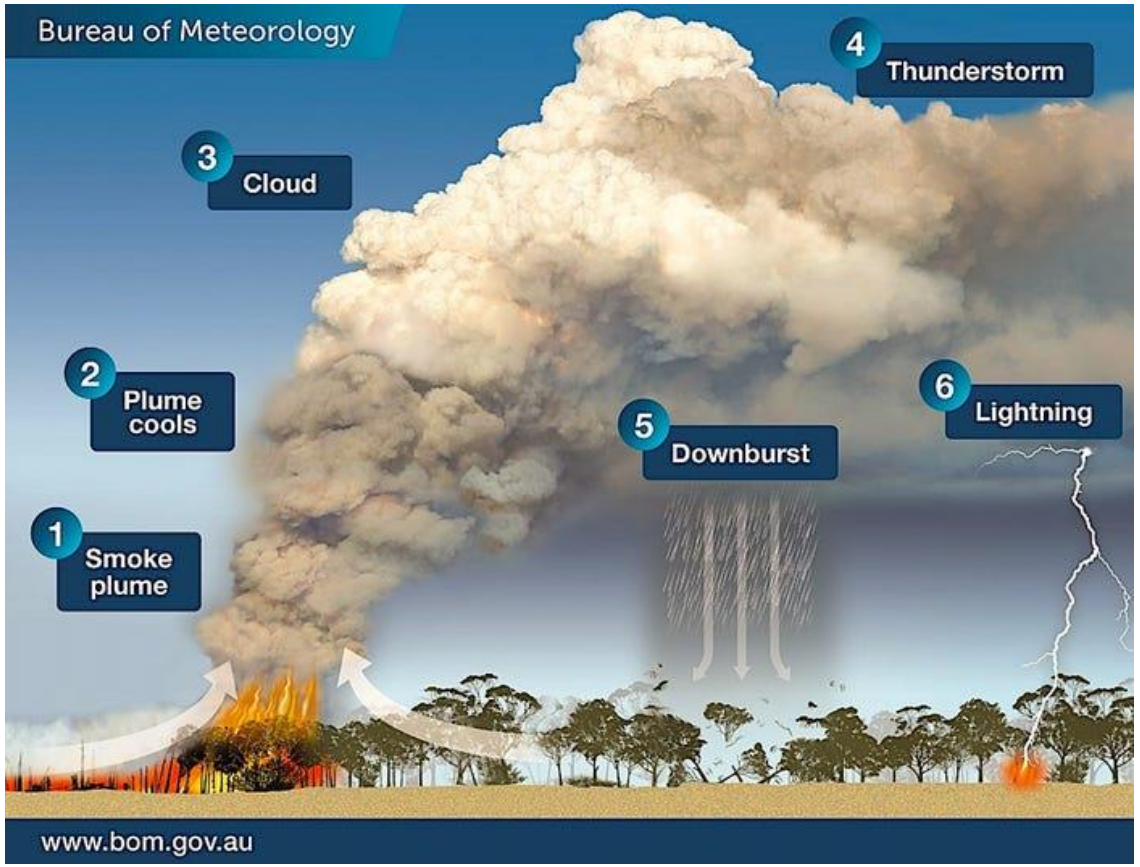
Impact of PyroCb events

- Record-breaking number of pyrocumulonimbus (PCb) formed during the 2019/2020 Australian “Black summer”.
- Such clouds form above intense heat source such as fires. Because of the strong involved convective processes, humid air condenses at high altitudes on the large amounts of injected particles.
- Occurring more and more frequently, they become a significant source of particles in the UTLS.



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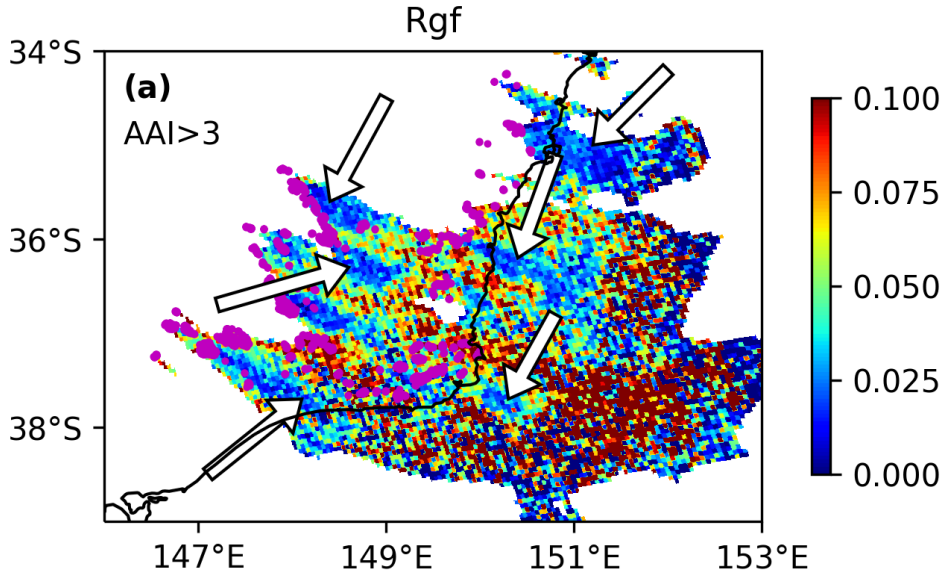
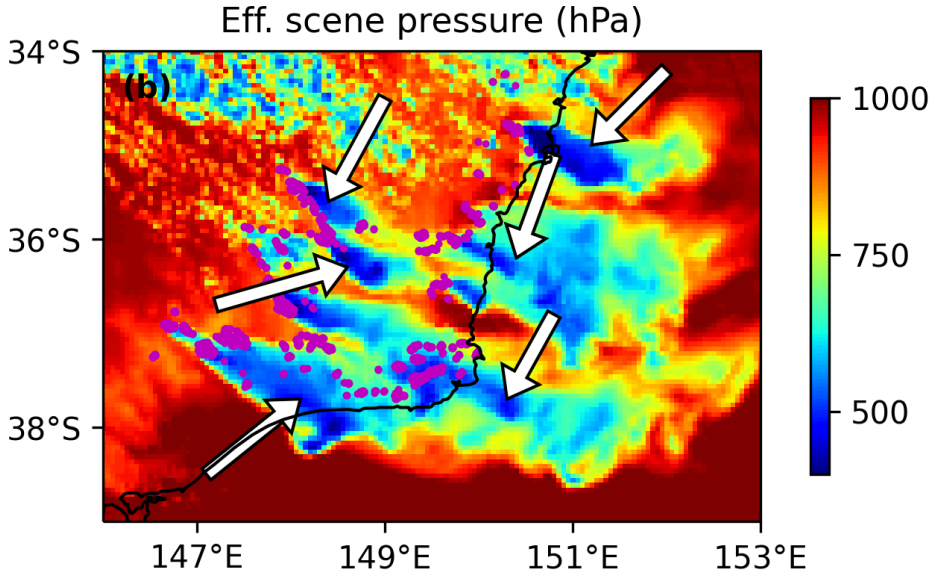
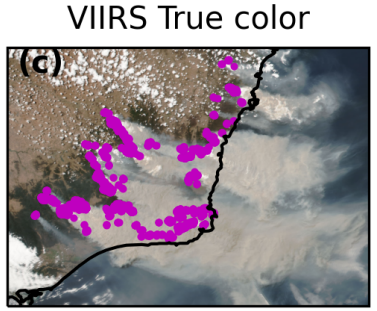
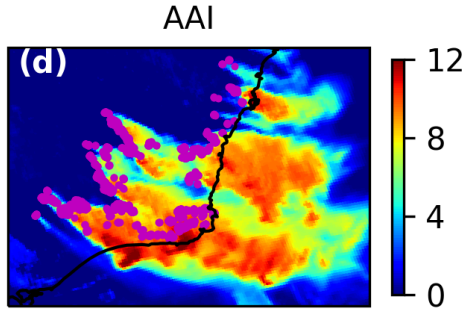
Glyoxal depletion near strong fire sources

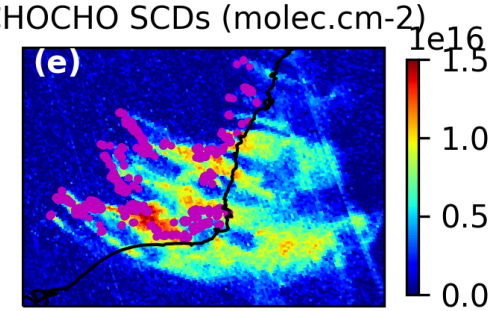
Australian wildfires – 04/01/2020

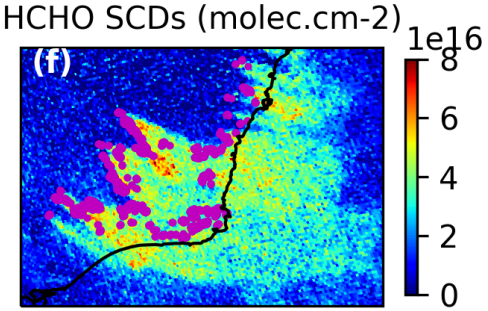












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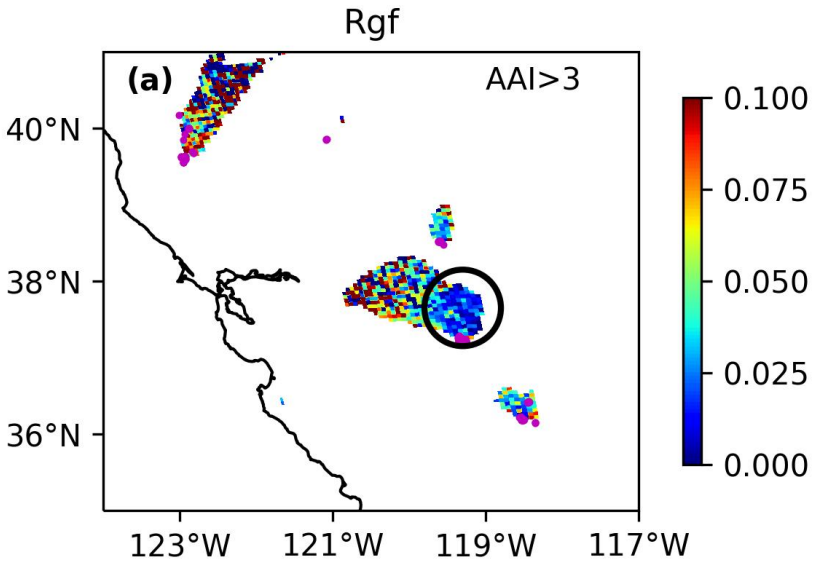
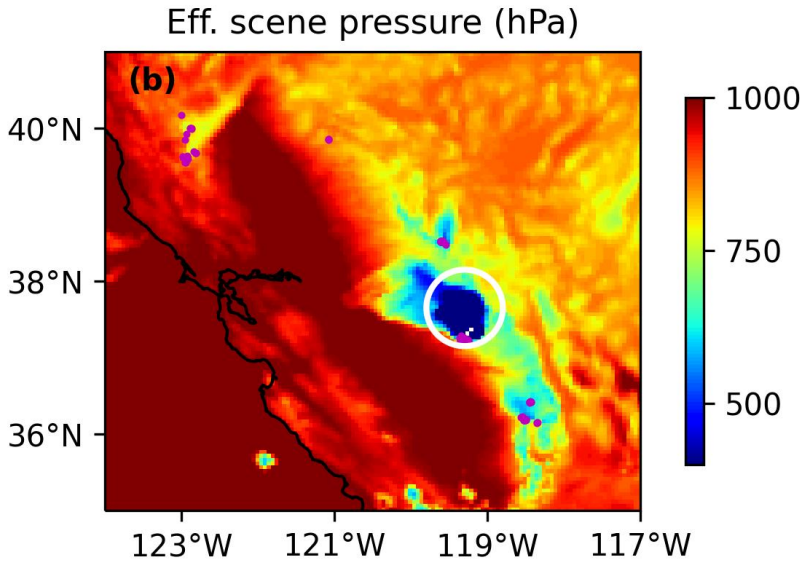
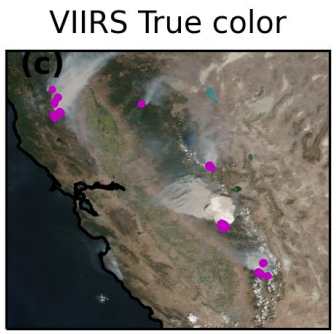
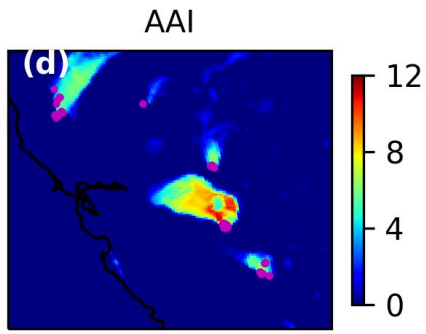
Glyoxal depletion near strong fire sources

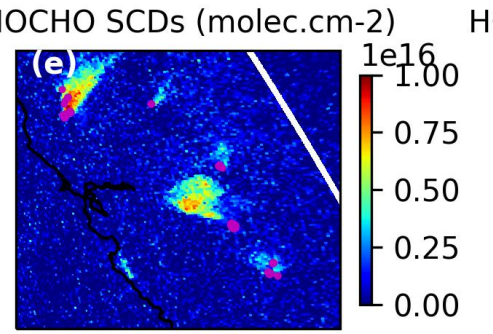
California wildfires – 05/09/2020

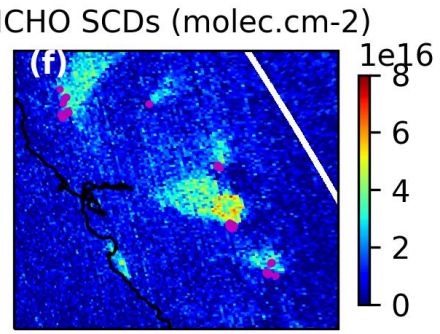












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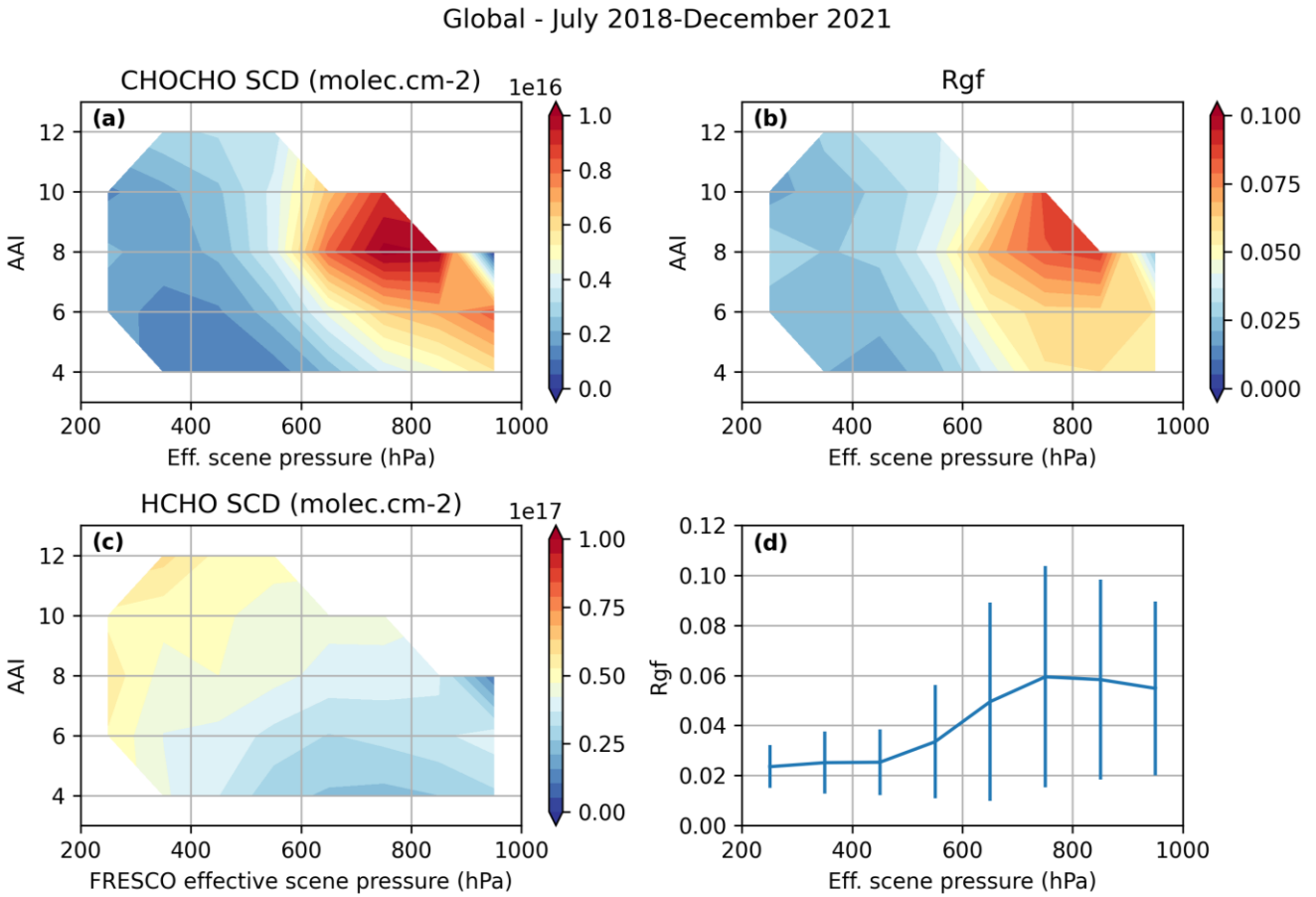
Glyoxal depletion near strong fire sources

- July 2018 – December 2021; global scale.
- Filters applied to keep TROPOMI data only near fire sources (glyoxal signal expected to be high).
- CHOCHO SCD decreases when effective scene altitude is high, as opposed to HCHO. Rgf follows the same pattern.

Glyoxal removal is very fast

→ OH oxidation, photolysis or conversion to SOA processes are too slow to explain the sudden reductions.

→ Glyoxal is likely captured in cloud droplets (high solubility) and in ice particles (high retention efficiency).



Lerot et al., in prep.

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Summary and outlook

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- The TROPOMI glyoxal product offers an additional detailed view on VOC emissions. In general, TROPOMI columns present similar variability as MAX-DOAS retrievals.
- Wild fires are important sources of pollutants, including glyoxal. In addition to tracking the transport of fire plumes, the TROPOMI high resolution allows identifying and studying smaller scale effects.
- The product is getting pre-operational with the transfer of the algorithm to the ESA PAL platform.
- Glyoxal is one of the ECV considered by the new Precursor_cci+ project:

  → Further homogenization and extension of the individual satellite data sets.

  → Development and production of merged L3 records.

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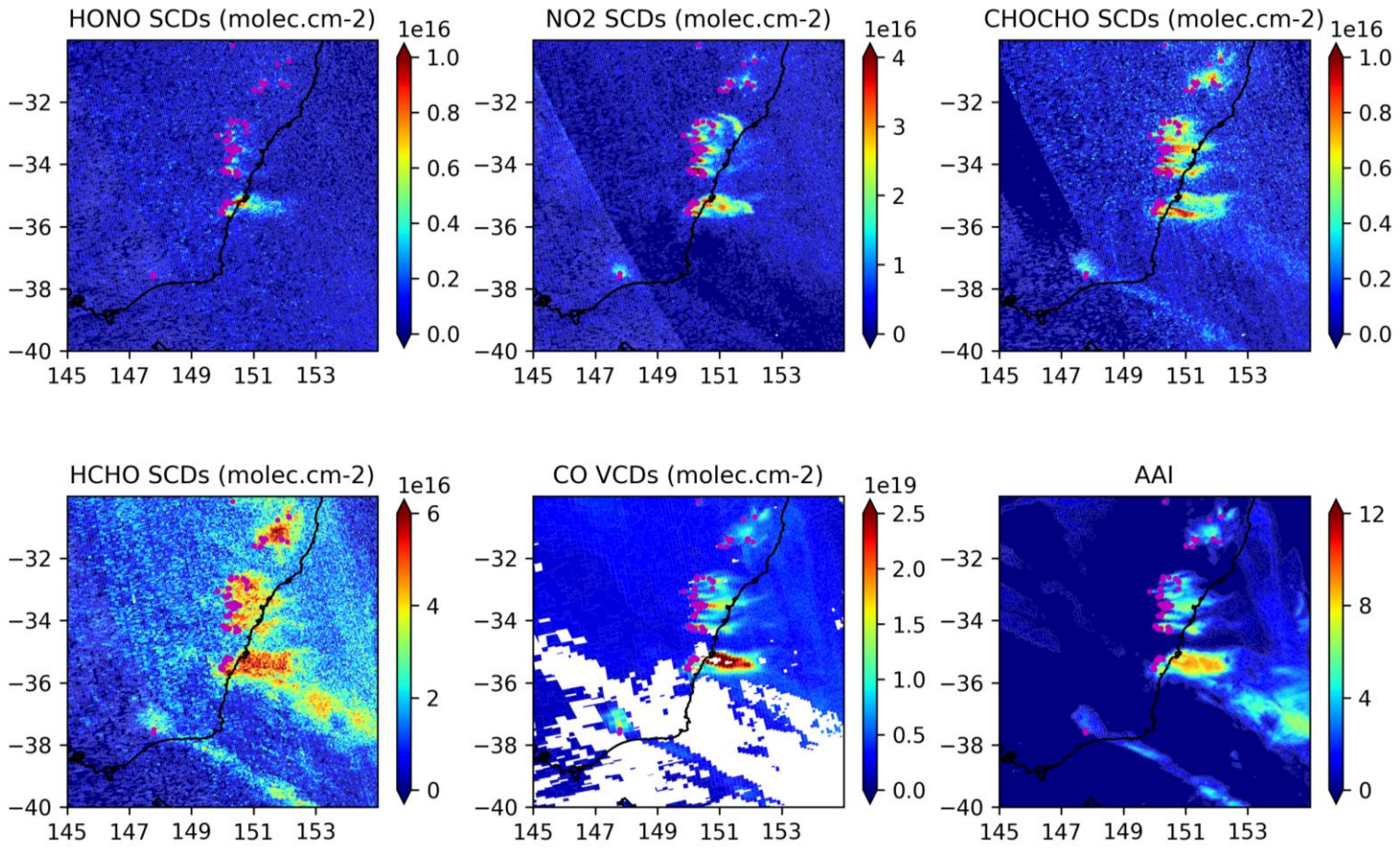
Extra slides

Australian wildfires – 21/12/2019



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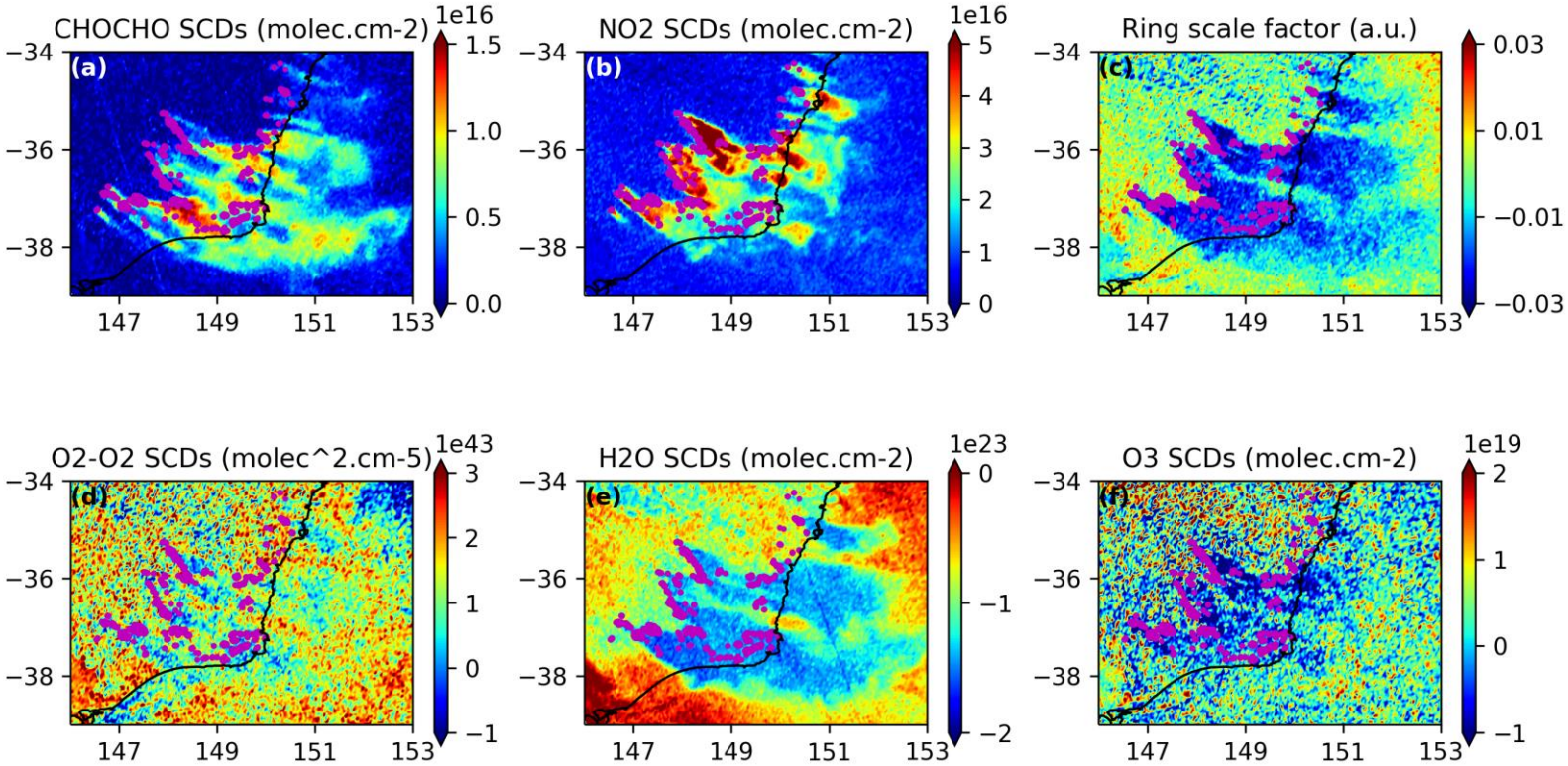
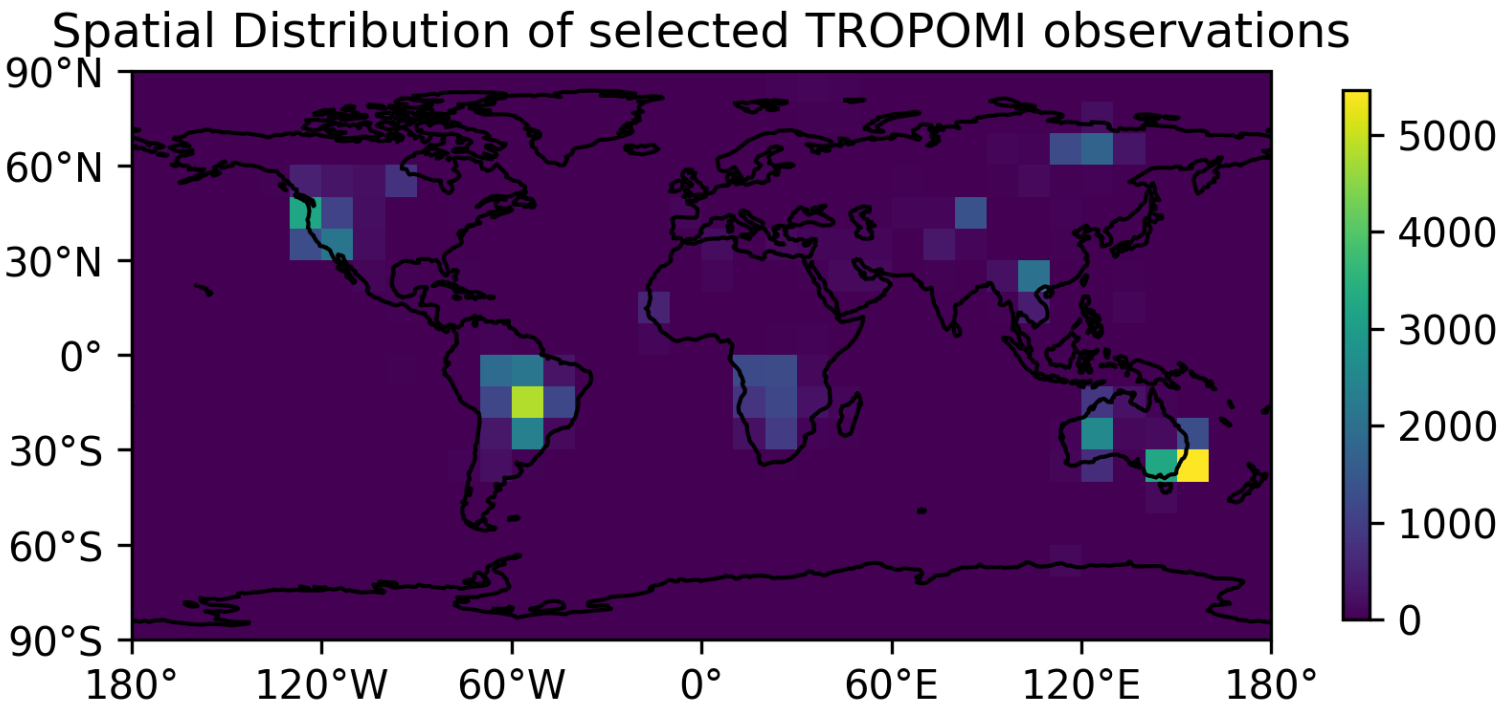
Australian wildfires – 4/01/2020




Spatial Distribution of selected TROPOMI observations
90°N
60°N
30°N
0°
30°S
60°S
90°S
180°
120°W
60°W
0°
60°E
120°E
180°
5000
4000
3000
2000
1000
0