Fire emissions in SEEDS

Jenny Stavrakou
Glenn-Michael Oomen
Jean-François Müller

SEEDS
Sentinel EO-based Emission and Deposition Service

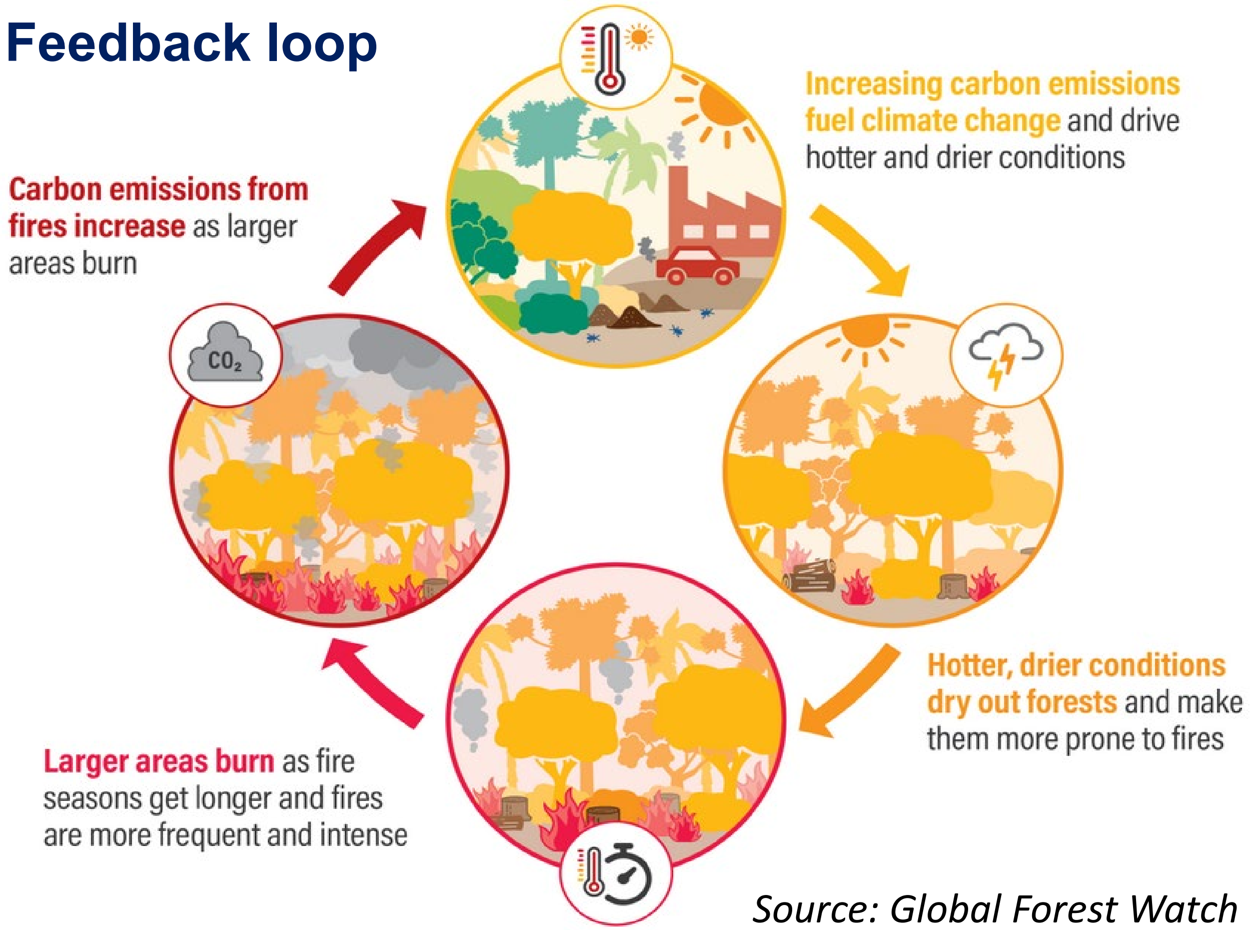
BIRA-IASB

tropo.aeronomie.be
Tropospheric Chemistry Modeling Unit

Warming climate causes increased fire risk

- ✓ Longer fire seasons
- ✓ Expansion of fire-prone areas
- ✓ 2021: one of the most intense fire seasons since two decades in Europe
- ✓ Heatwaves and droughts drive massive wildfire outbreaks

Feedback loop



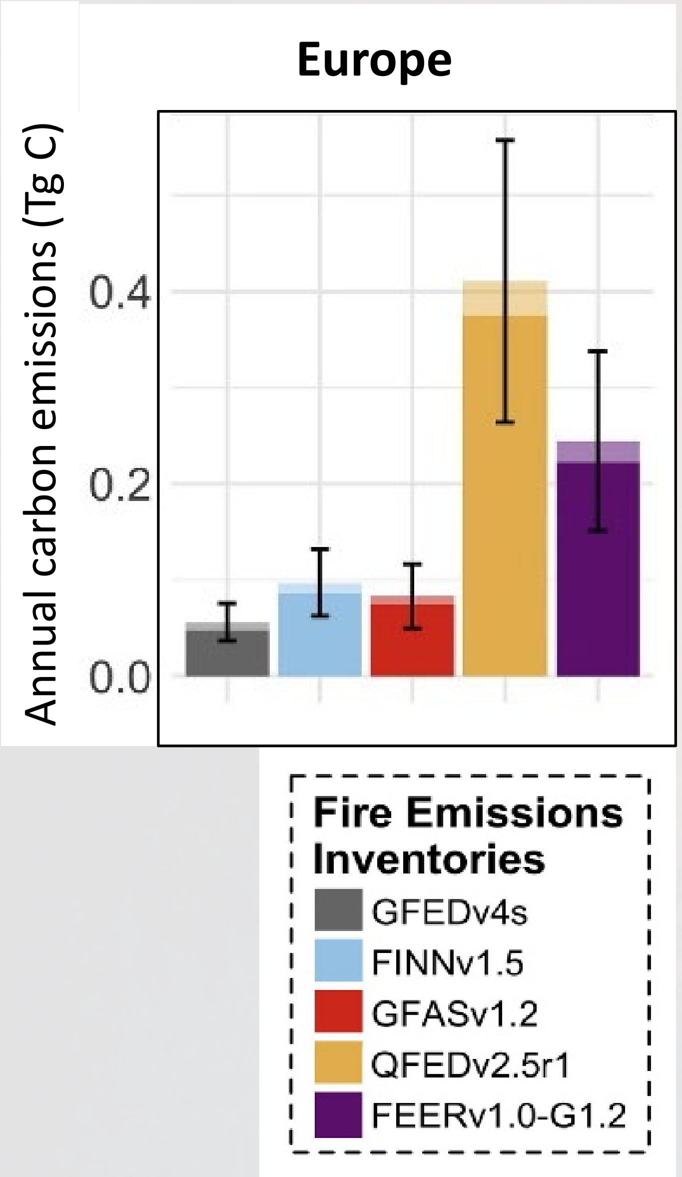
Source: Global Forest Watch

Australian fires in 2019

- ✓ Important concern for air quality

VOCs → aerosols / ozone → climate

Large differences between inventories

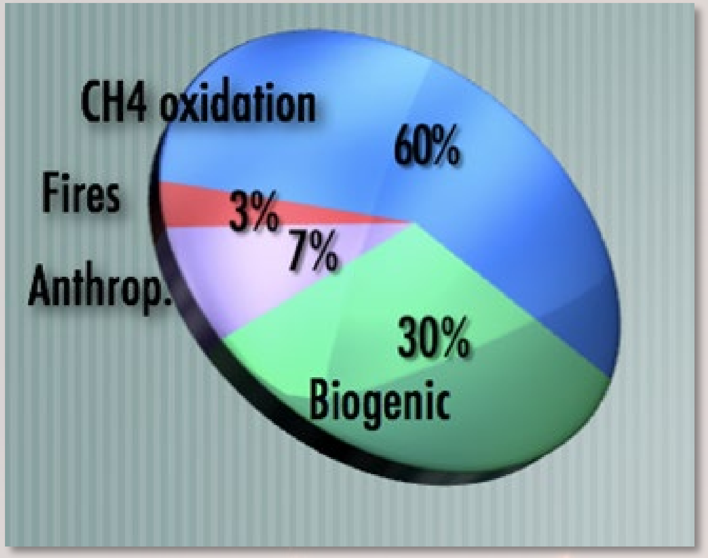


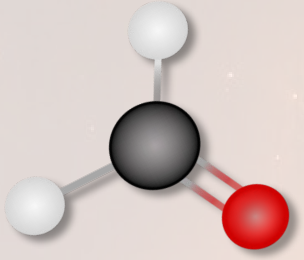
BB datasets	Relies on
GFED4s	MODIS burnt area + MODIS active fires (for small fires)
FINN	MODIS active fire counts + MODIS active fires
GFAS	Assimilated MODIS FRP
FEER	As in GFAS, constrained by MODIS AOD
QFED	FRP fire products, constrained by MODIS AOD
SEEDS	Top-down, uses chemical observations of HCHO

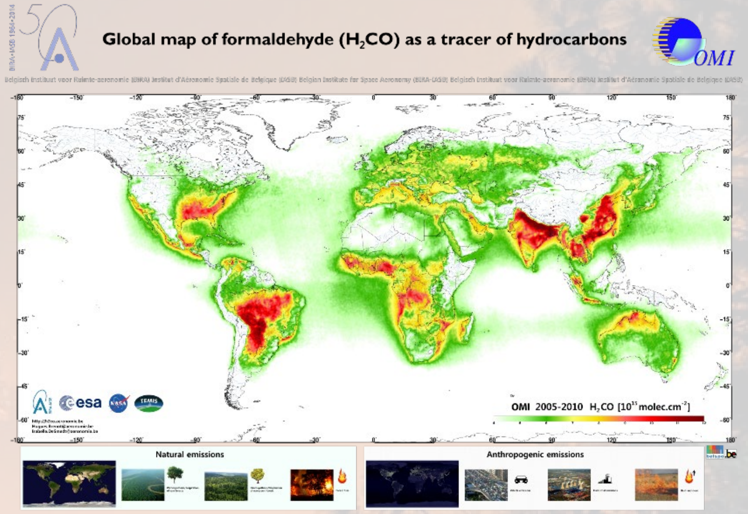
- Uncertainties could be due to detection of area burnt, FRP, emission factors, biome types, fuel consumption, difficulty to account for understory fires
- Factor of ~4 between the global emission estimates
- QFED and FEER much higher than other datasets
- Satellite HCHO data offer an alternative way to constrain biomass burning emissions

Formaldehyde as a proxy for VOC emissions

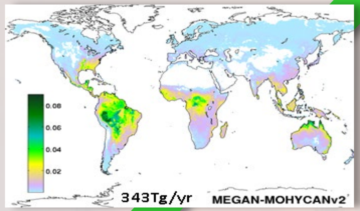
Short-lived intermediate in the oxidation of the majority of VOCs

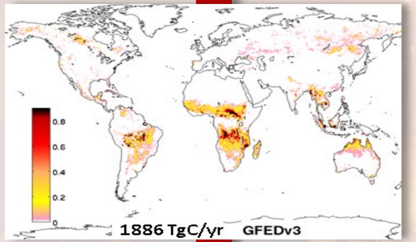


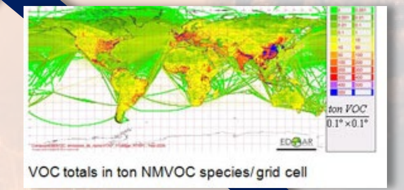




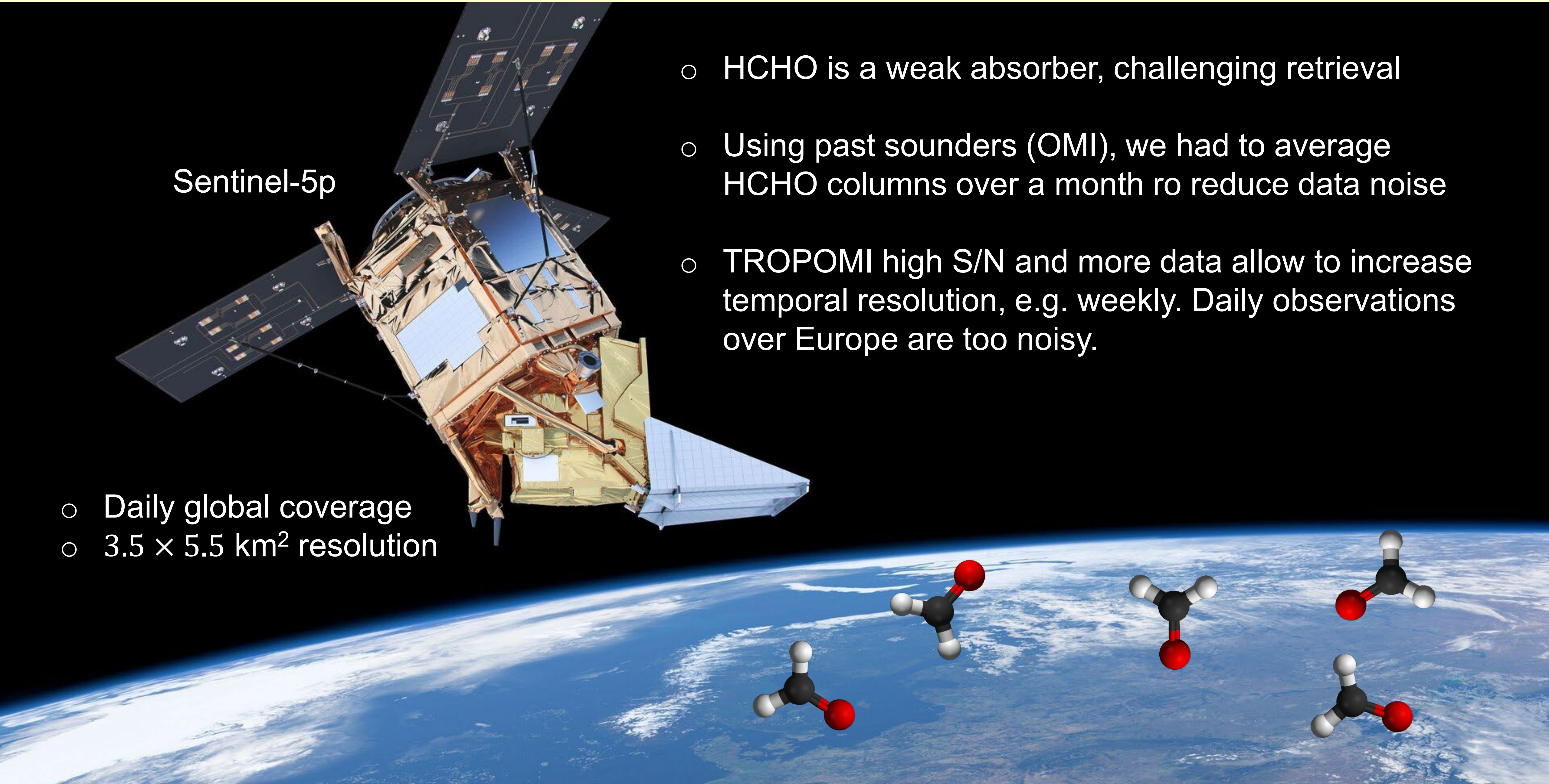
Strong potential to constrain emissions
(Palmer et al. 2003, Millet 2008, Stavrakou 2009, Barkley et al. 2013, Marais et al. 2014, Bauwens et al. 2016, and many others!)







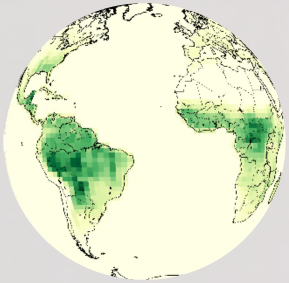
Formaldehyde observations from Sentinel-5p



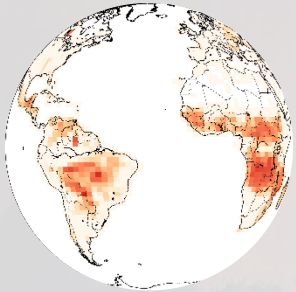
- HCHO is a weak absorber, challenging retrieval
- Using past sounders (OMI), we had to average HCHO columns over a month ro reduce data noise
- TROPOMI high S/N and more data allow to increase temporal resolution, e.g. weekly. Daily observations over Europe are too noisy.

- Daily global coverage
- 3.5×5.5 km^2 resolution

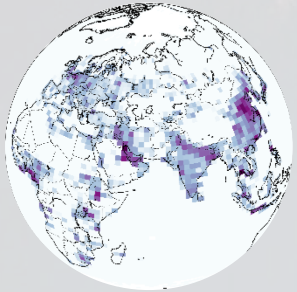
From bottom-up to top-down emissions through MAGRITTE



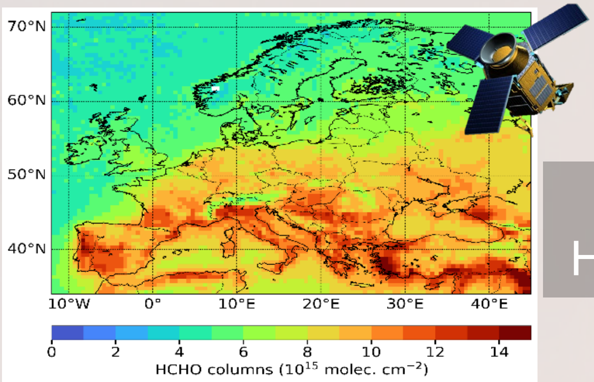
biogenic emissions



fire emissions



anthropogenic emissions



TROPOMI HCHO columns

Inversion constrained by weekly-averages

MAGRITTE
chemistry-transport model and its adjoint

Iterative minimization algorithm

Top-down biogenic isoprene fluxes

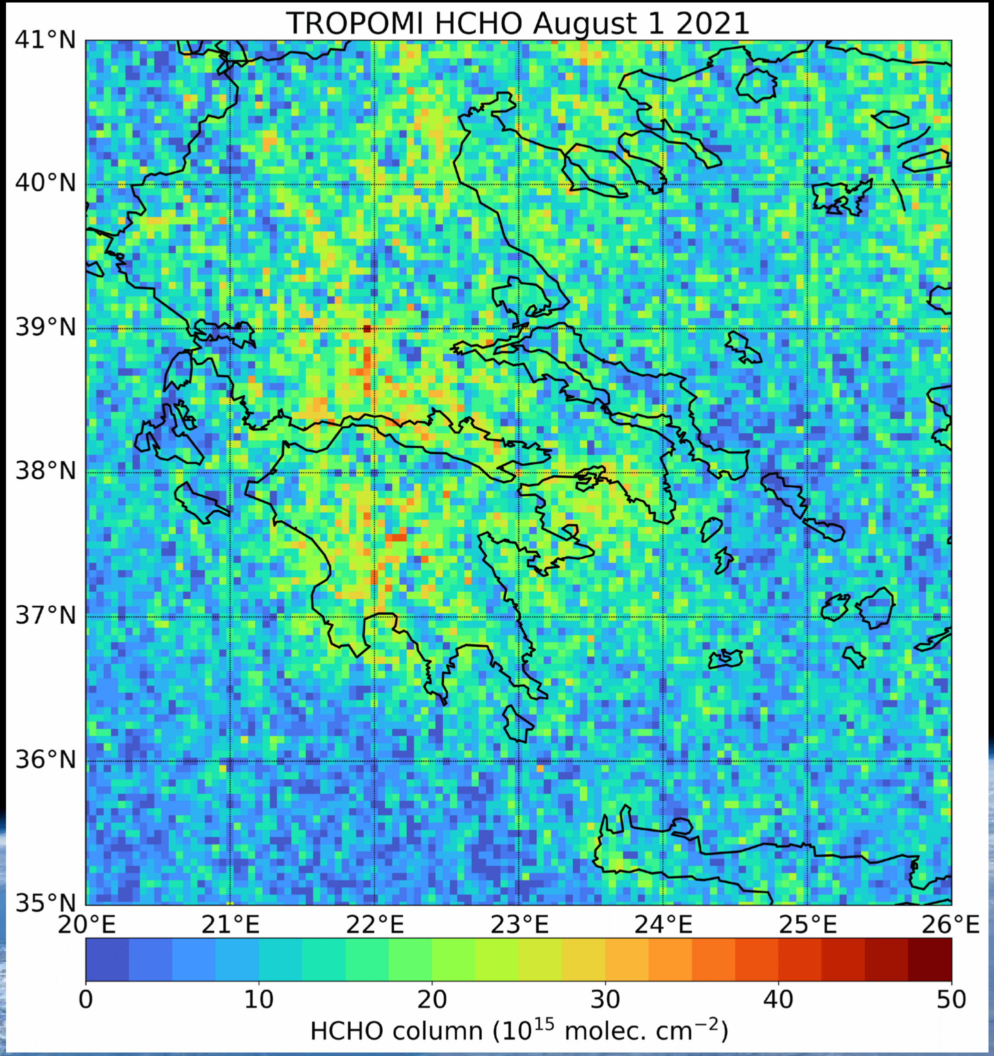
Top-down biomass burning fluxes

Top-down anthropogenic fluxes

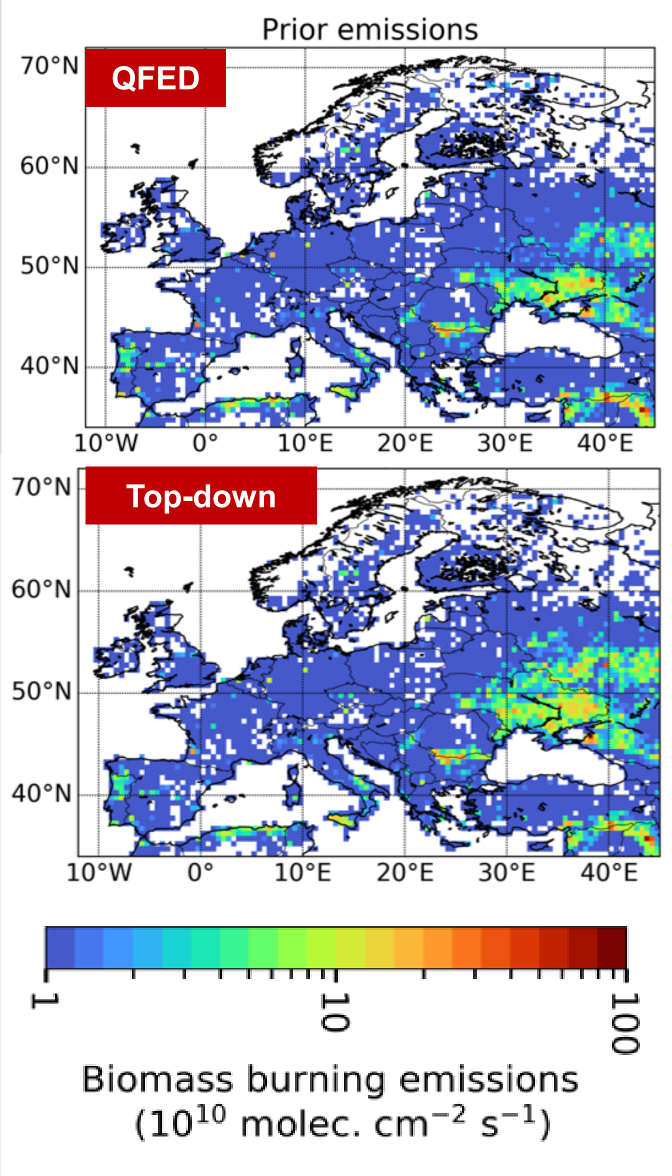
- ❑ 40 VOCs emitted by fires and their chemical oxidation mechanism
- ❑ QFED a priori fire dataset, emission factors from Andreae (2019)

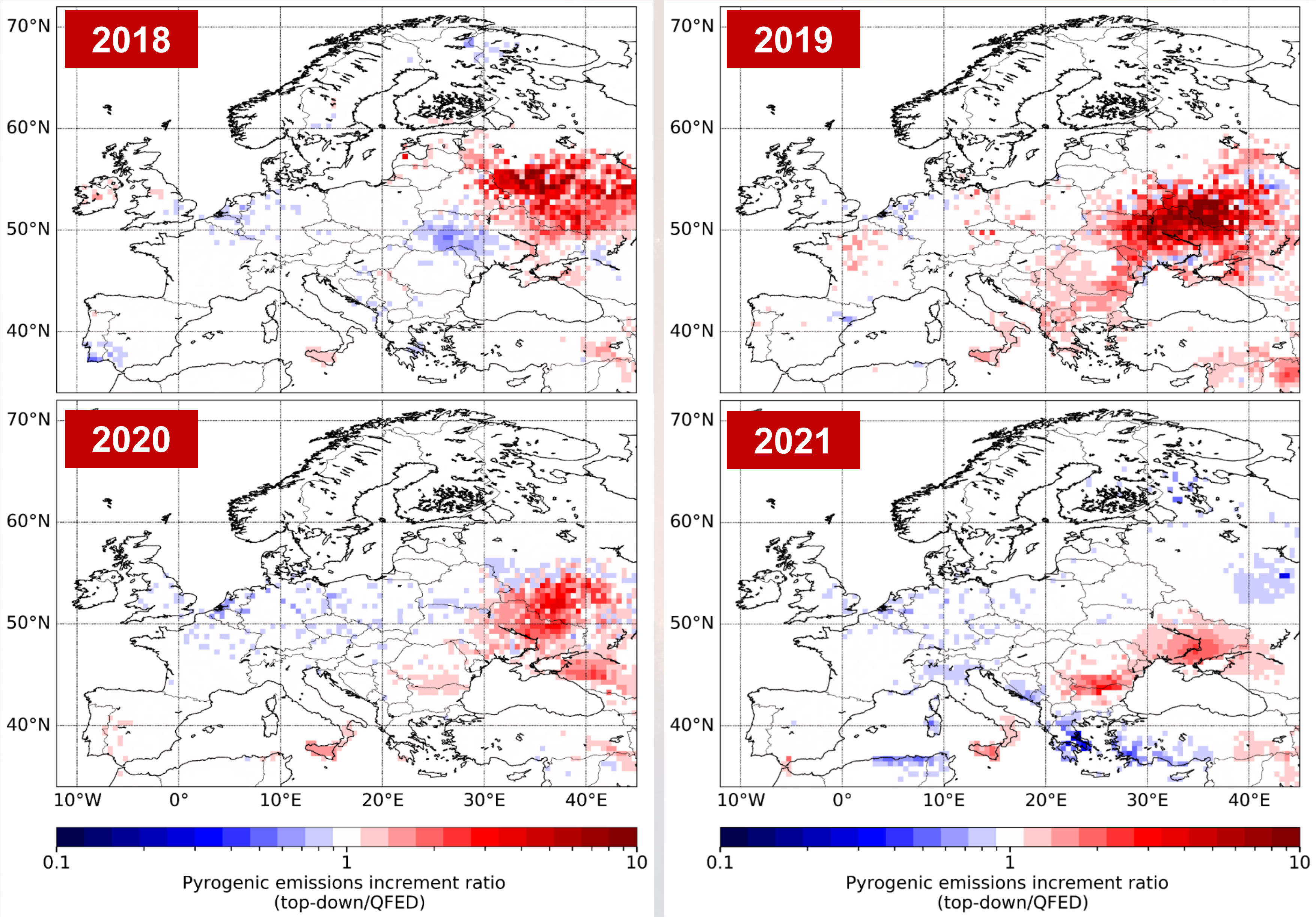
Illustration of TROPOMI HCHO columns

Greek fires in August 2021

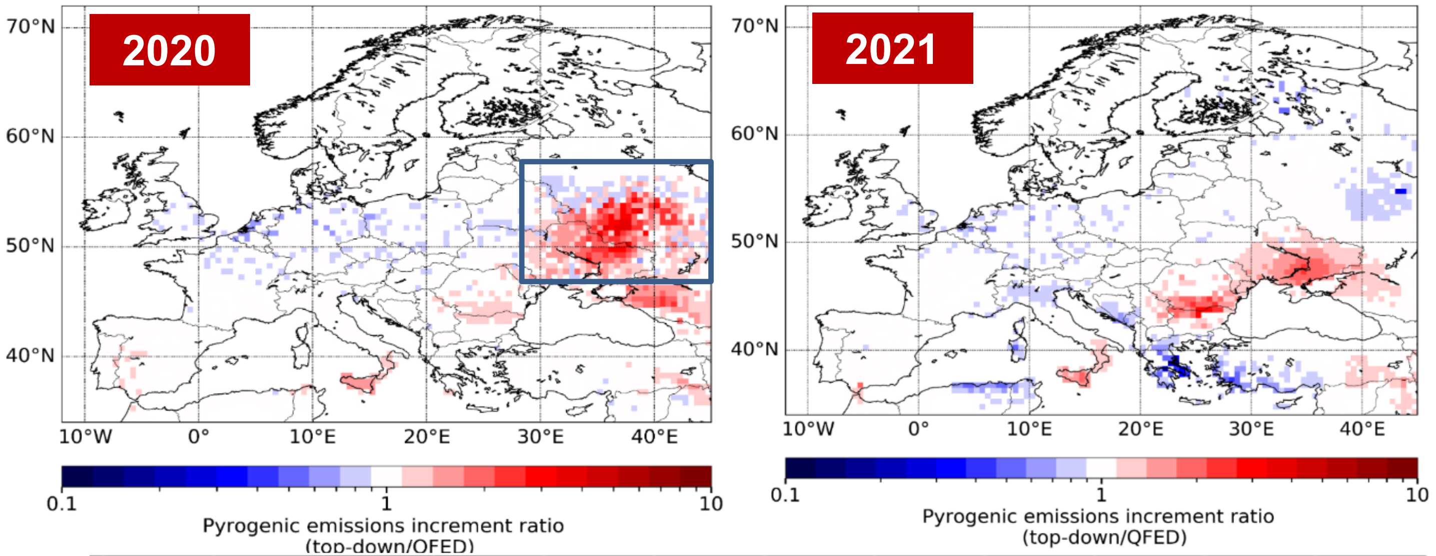


Emission increments over May-September

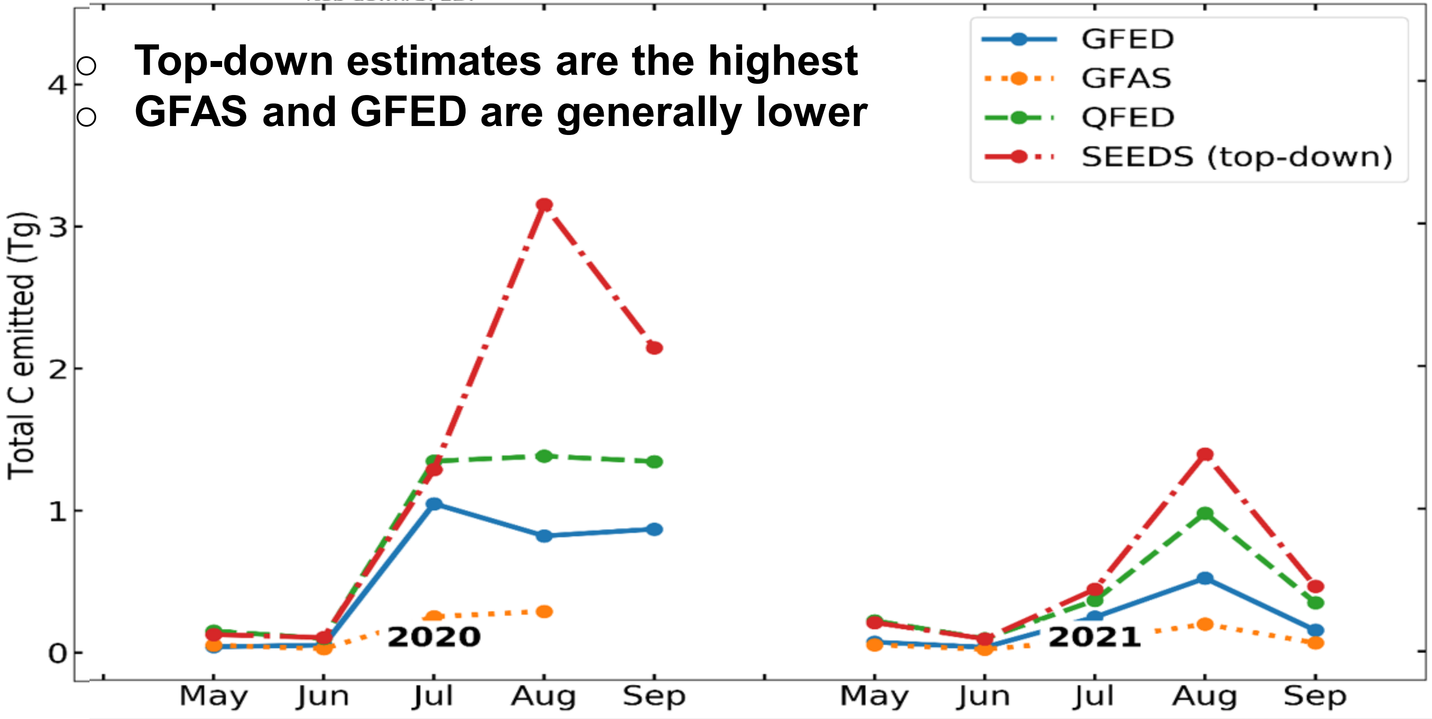




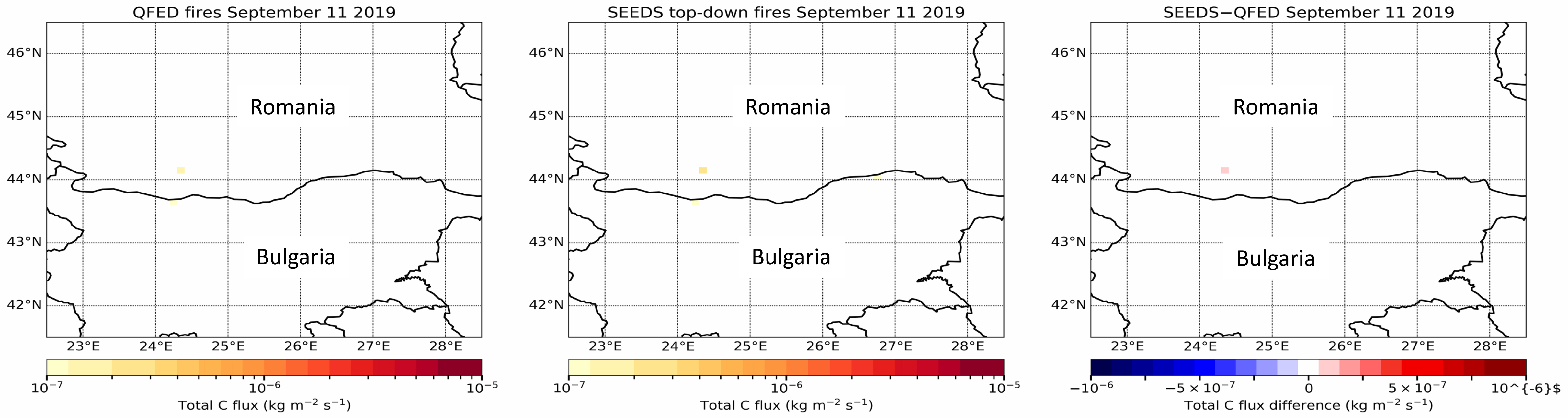
Comparison with bottom-up inventories

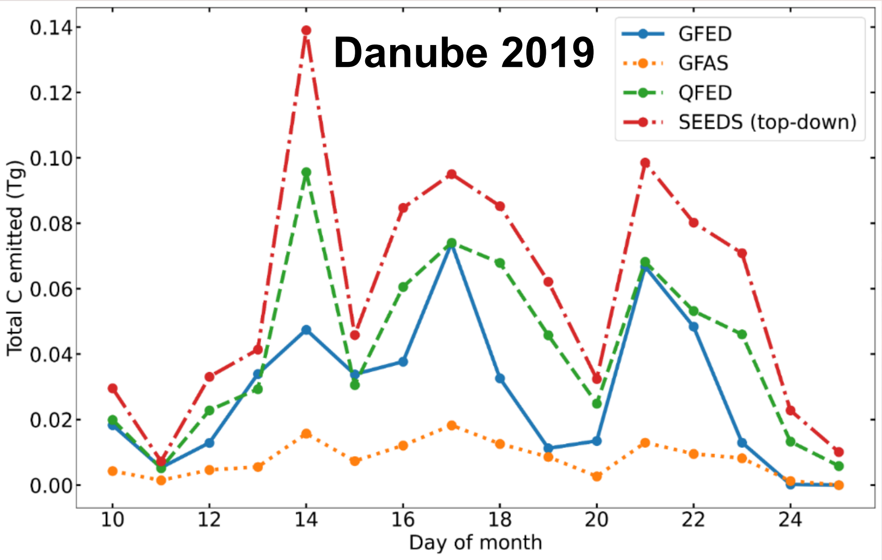


- Top-down estimates are the highest
- GFAS and GFED are generally lower



Danube fires in 2019: bottom-up vs top-down

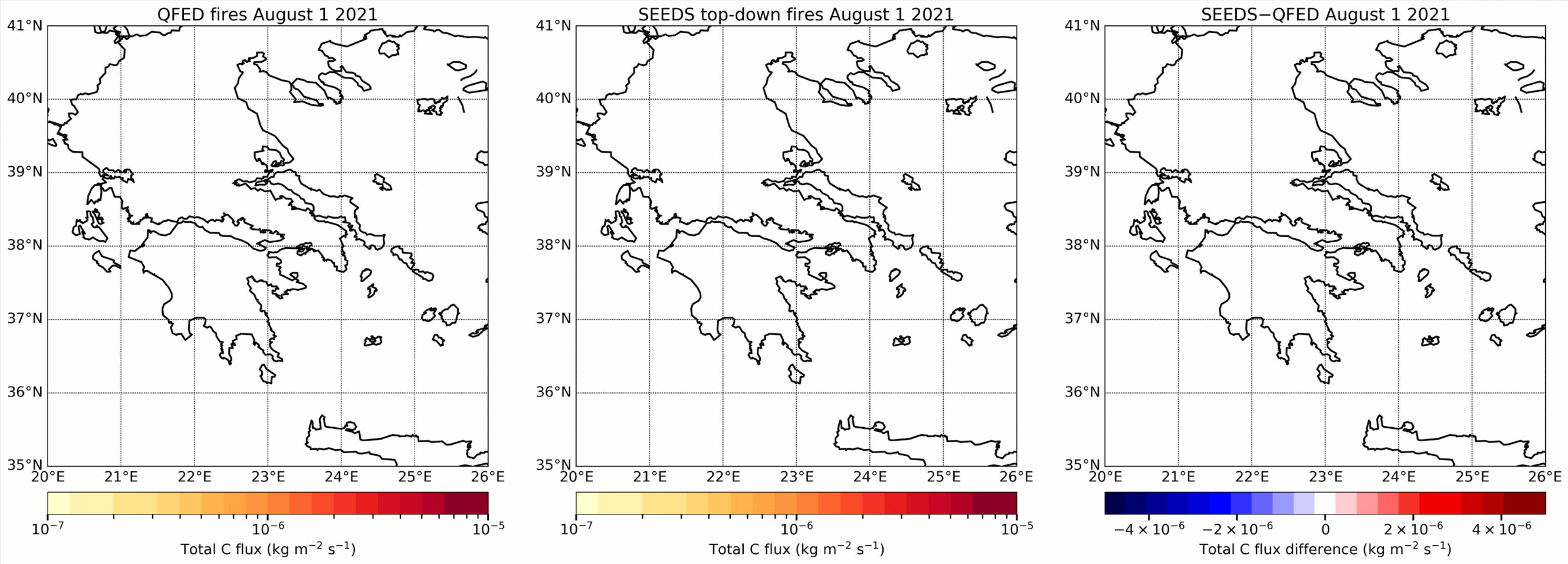


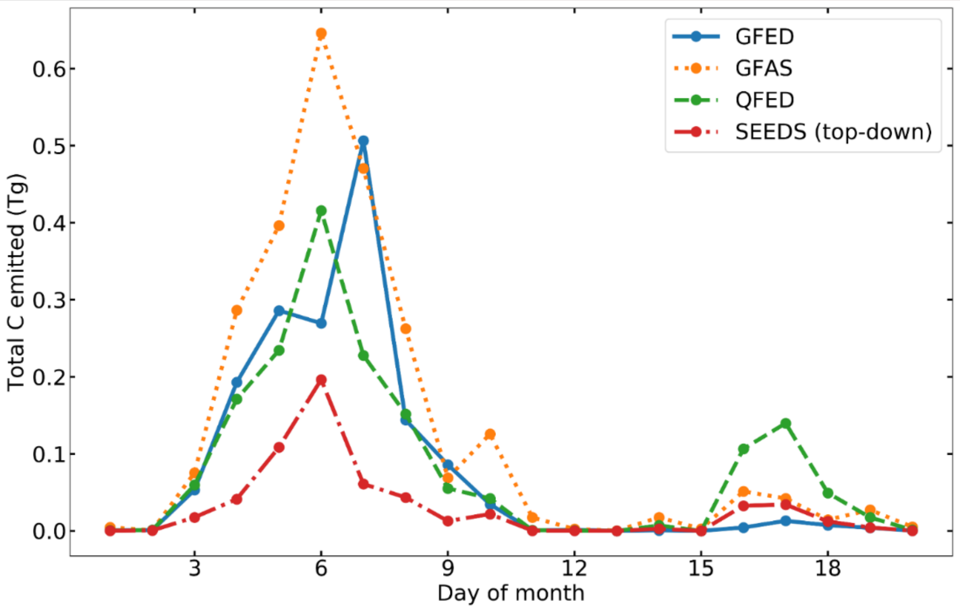


- TROPOMI data suggest increased emissions relative to QFED
- All datasets agree on the peaks on 14, 17, 21 Sep but large differences in the emission strength (up to x10)

Greek fires in 2021: an example of extreme weather

- Historic heatwave with highest temperatures reaching 47°C
- Worst heatwave since 1987





- Top-down emissions are lower than all inventories
- The peak on 6 Aug is well captured in all datasets, except for GFED
- The SEEDS peak is x2-3 lower than QFED/GFAS, could be due to the export of pollution due to strong winds

Conclusions

- Changes in emission strengths and spatial distribution, but changes in the localization of fires cannot be inferred (rely on prior biomass burning dataset)
- Uncertainties in the chemical degradation of BB VOCs in the model
- Co-occurrence of sources (fires and strong vegetation emissions) during summertime makes it difficult to separate the sources
- SEEDS top-down emissions available at 0.1°x0.1° for 2018-2021
- 2022 will become available soon

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