- **Meteosat Third Generation (MTG)**
- **Direct Fire Emissions using FREM**
  - Geostationary Network
  - High Latitude (Polar Orbiting)
- **Sentinel-3 Active Fire**
- **Example of Air Quality Model Evaluation**

M. Wooster, W. Xu, W. Maslanka, J. He, Z. Liu,
M. Grosvenor, T. Wainright, G. Roberts

KING'S College LONDON
University of London

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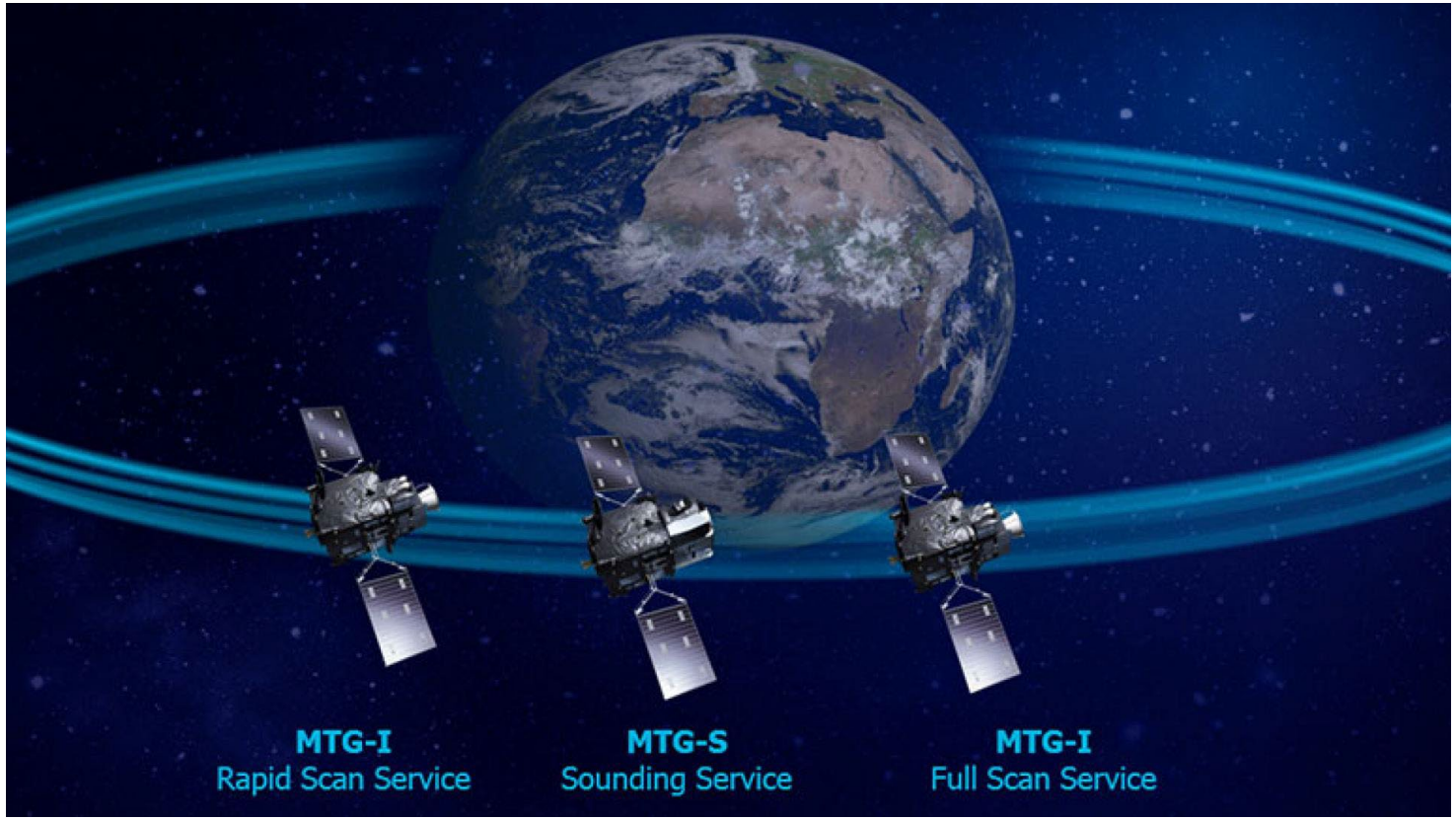
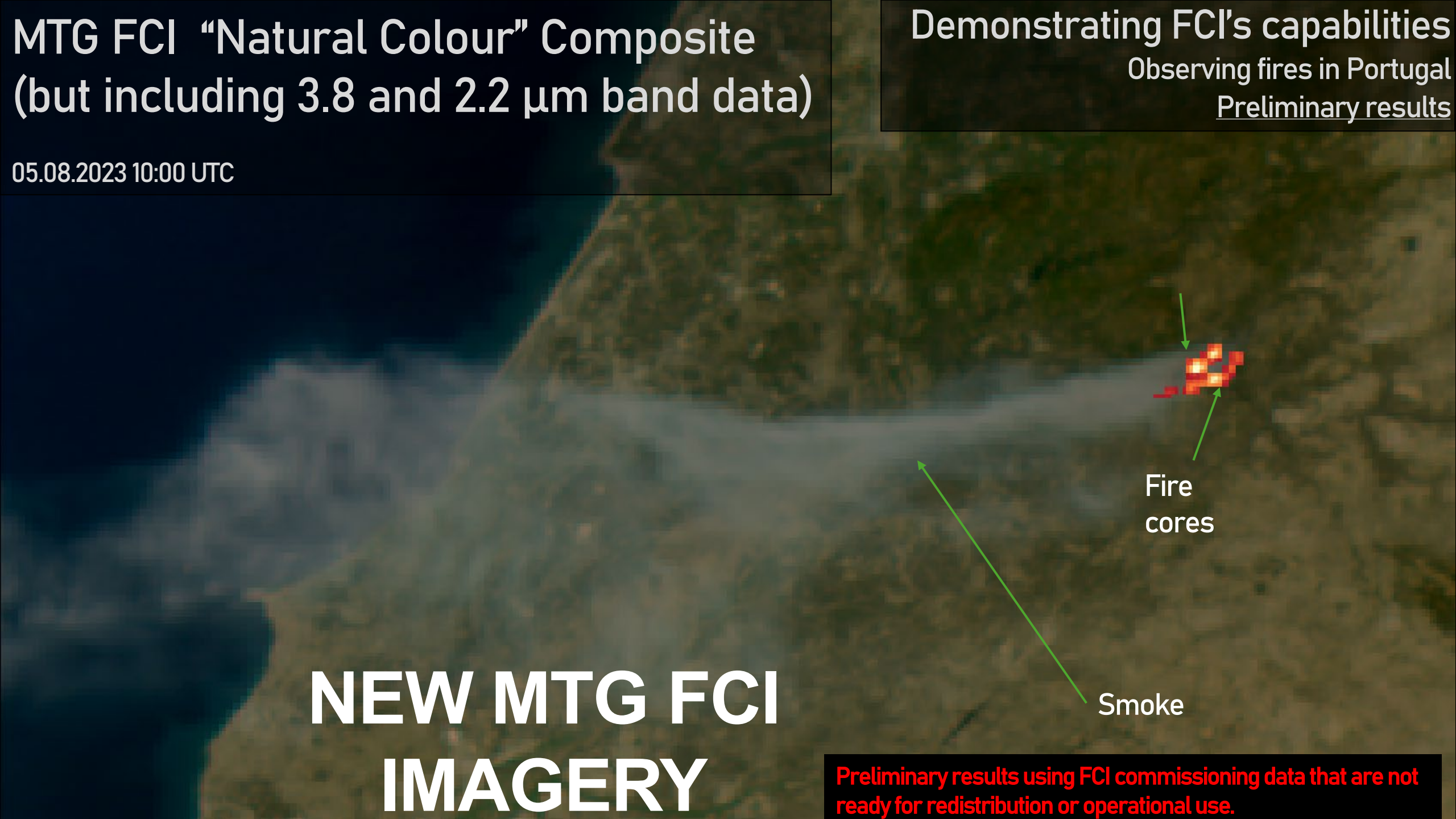
Meteosat Third Generation




MSG SEVIRI “Natural Colour” Composite
(but including 3.8µm band data)
05.08.2023 10:00 UTC
MSG vs MTG
Comparison
CURRENT MSG
SEVIRI IMAGERY


MTG FCI "Natural Colour" Composite
(but including 3.8 and 2.2 µm band data)
05.08.2023 10:00 UTC
Demonstrating FCI's capabilities
Observing fires in Portugal
Preliminary results
Fire
cores
Smoke
NEW MTG FCI
IMAGERY
Preliminary results using FCI commissioning data that are not
ready for redistribution or operational use.

FCI FRP-PIXEL First Detection of Athens fire @ *12:00* UTC

UTC Local Time GMT+0100 (British Summer Time)

LATITUDE	LONGITUDE	BRIGHT_TI4	SCAN	TRACK	ACQUIRE_TIME	SATELLITE	INSTRUMENT	CONFIDENCE	VERSION	BRIGHT_TI5	FRP	DAYNIGHT
38.18	23.8	308	616	1267	2024-08-11 13:25:00	Met9	SEVIRI	58	1.0NRT	303	61.4	D
38.21	23.86	334	615	1269	2024-08-11 13:25:00	Met9	SEVIRI	98	1.0NRT	303.3	537.4	D
38.26	23.77	331.4	614	1267	2024-08-11 13:25:00	Met9	SEVIRI	93	1.0NRT	302.7	481.1	D
38.26	23.81	335.4	614	1268	2024-08-11 13:25:00	Met9	SEVIRI	86	1.0NRT	302.7	700.3	D
38.22	23.74	321.4	615	1266	2024-08-11 13:40:00	Met9	SEVIRI	73	1.0NRT	299.6	265.4	D
38.21	23.86	335.2	615	1269	2024-08-11 13:55:00	Met9	SEVIRI	98	1.0NRT	307.3	735.2	D

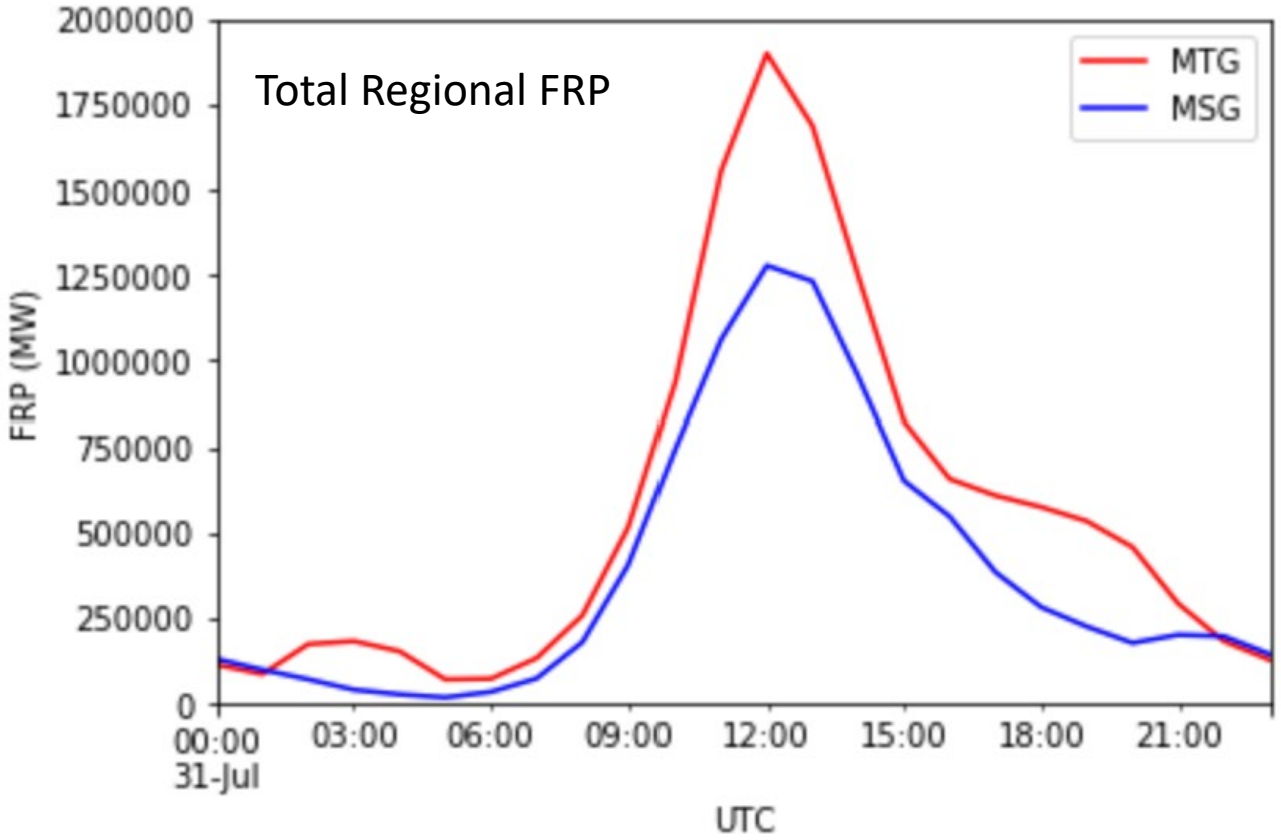
FILTER BY nothing ... All fields All dates

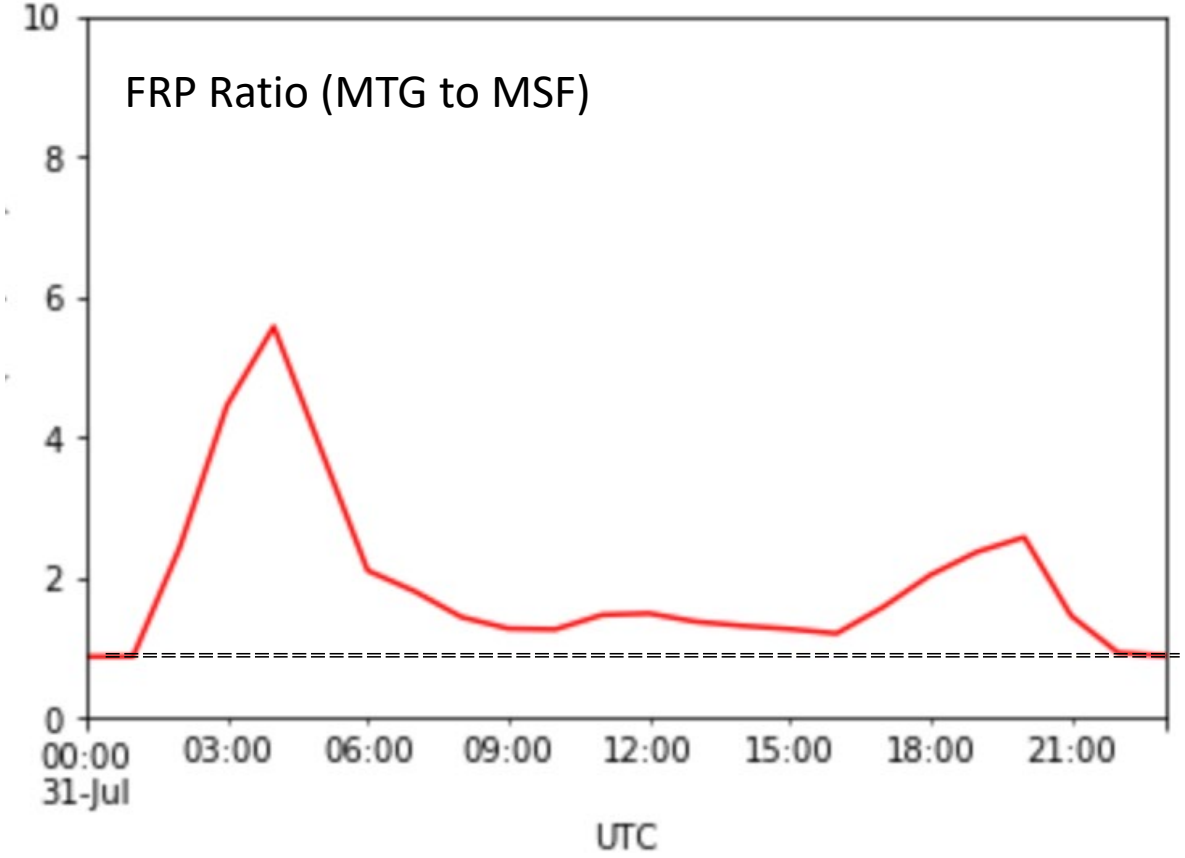
- FCI detected Fire @ **12:00** UTC @ **40 MW**
- VIIRS confirmed @ **12:06** UTC @ **34 MW**
- SEVIRI detected Fire @ **13:25** UTC **Saturated**

FCI FRP-PIXEL Prototype @ LSA_SAF

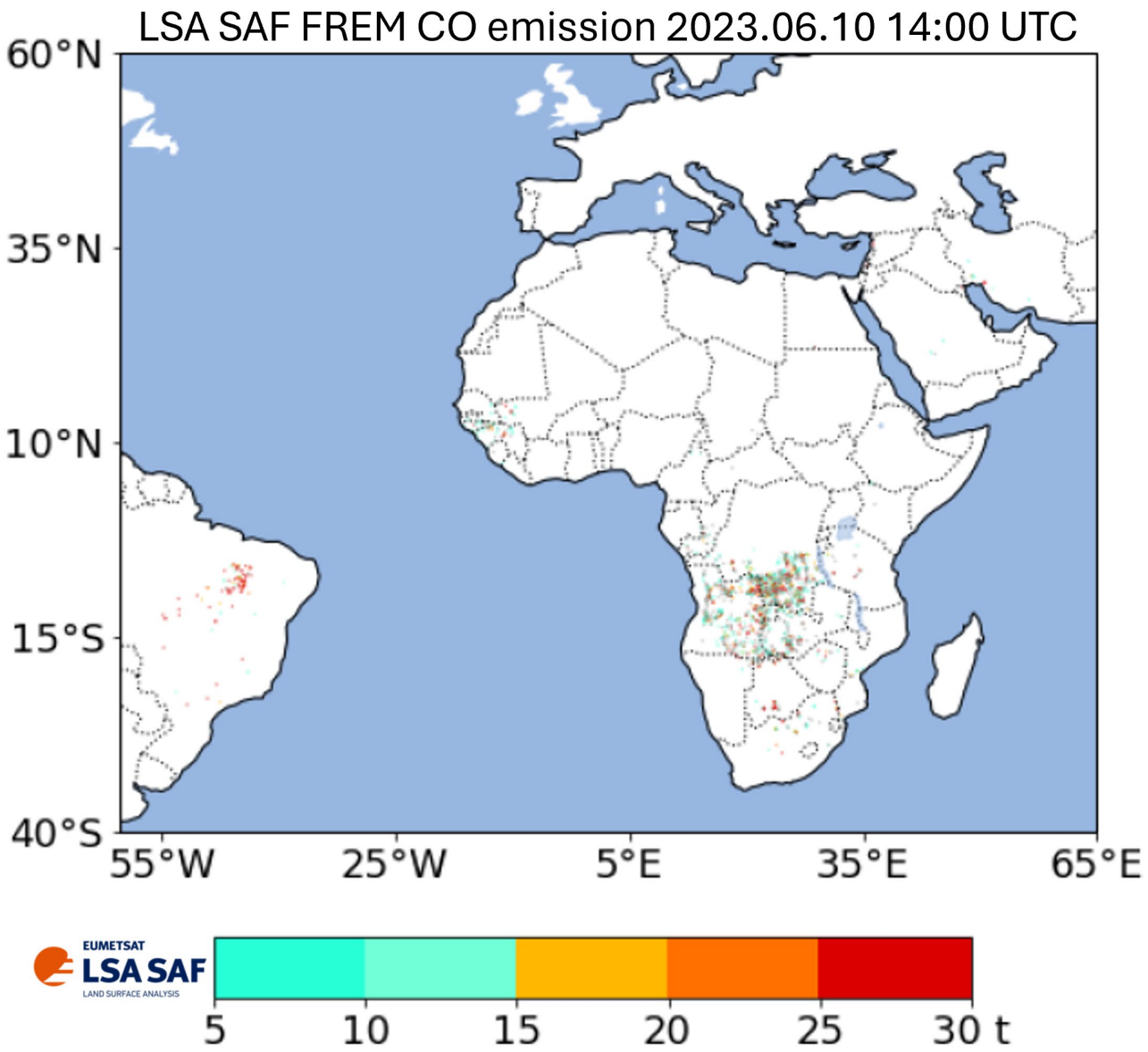

#1 Scroll (0.022...
MTG FCI
MWIR-LWIR Brightness
Temp. Difference
(1 km Data)
Southern Africa
13:00 UTC; 31 July 2024

MTG FCI-derived FRP Diurnal Cycle vs MSG





Direct Fire Emission Estimation from Geostationary Observations

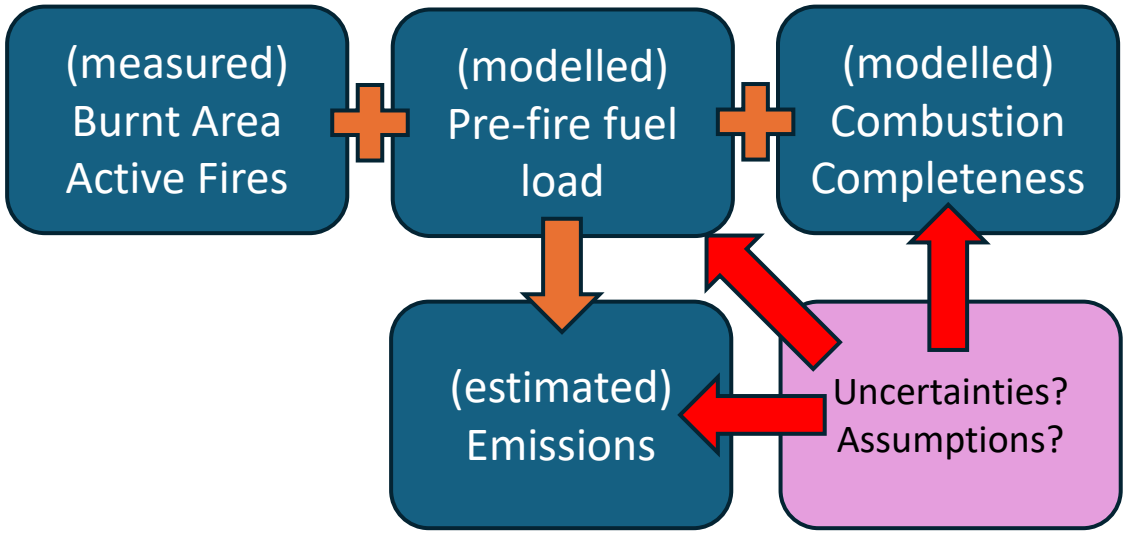


Estimating Fire Emissions

Different ways of estimating fire activity and associated emissions of gases and aerosols using Earth Observation.

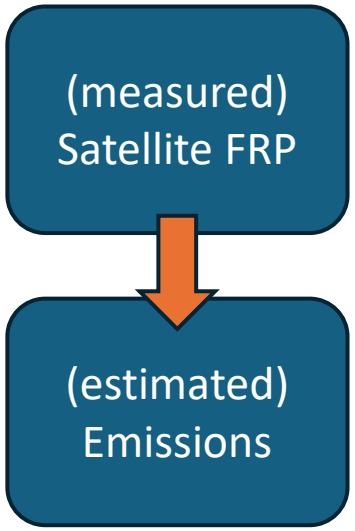
- Only way to effectively get information at regional / national / global scales consistently, and at temporal resolutions needed

Bottom-Up



GFED, GFAS, FLAMBE, FINN

Top-Down



FEER, FREM

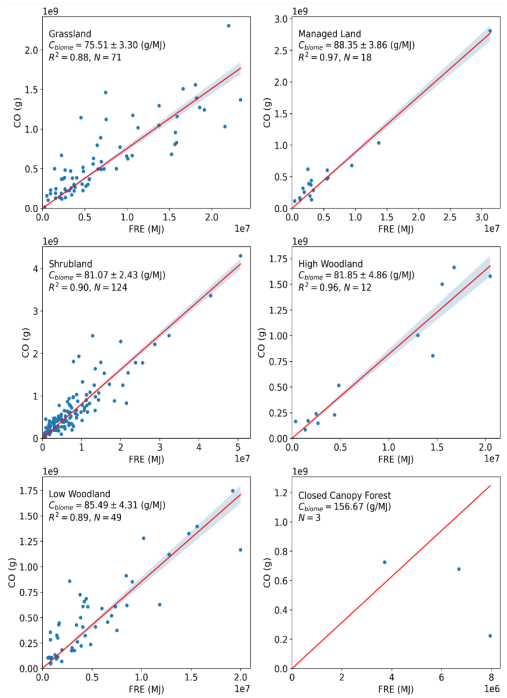
Quantified Uncertainties

Based on Observations so Very Limited Assumptions

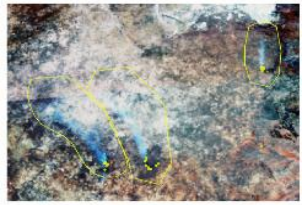
Will Maslanka | William.maslanka@kcl.ac.uk | NCEO King's College London

Fire Radiative Energy EMissions (FREM) Method

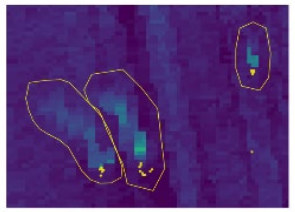
Emissions are derived from coefficients linking FRE directly to amount of atmospheric species (TPM and CO) for different biomes - Nguyen et al. (2023)



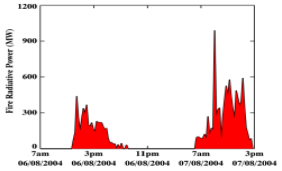
VIIRS RGB



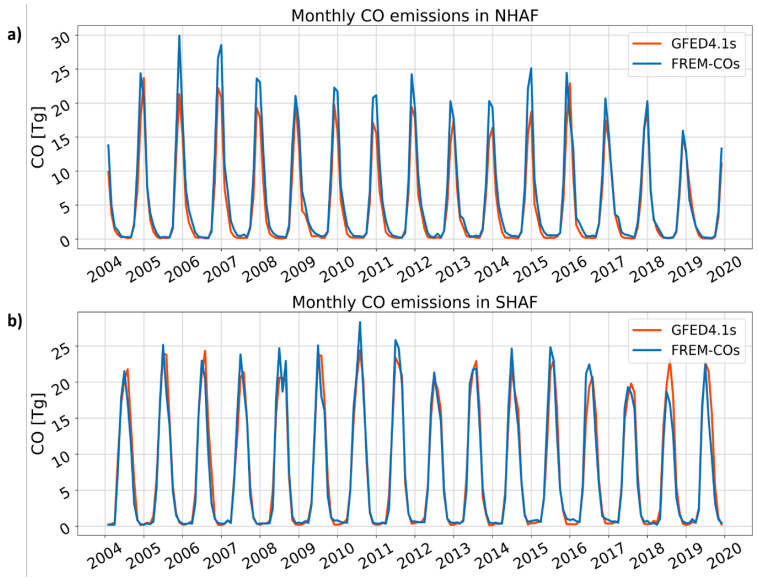
Sentinel-5P TCCO



MSG FRE



- Applied to LSA SAF FRP-PIXEL record (2004-2019) used over Africa
- Very close to GFED4.1s - derived using completely different datasets and methods



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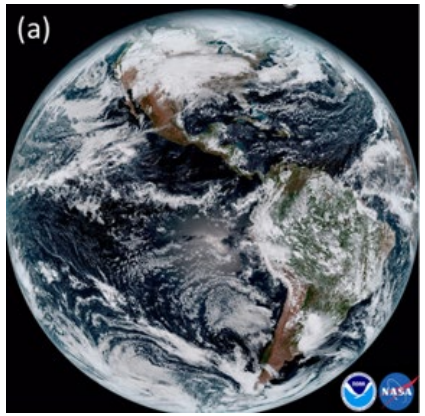
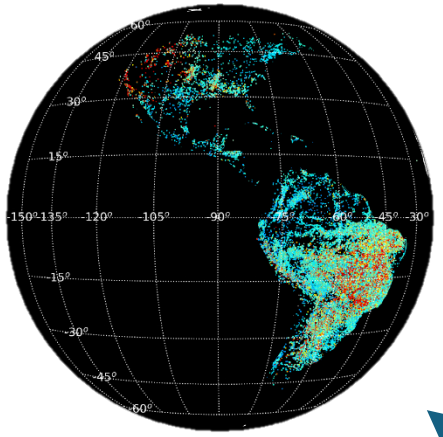
“FREM” Smoke Emissions Products from MSG

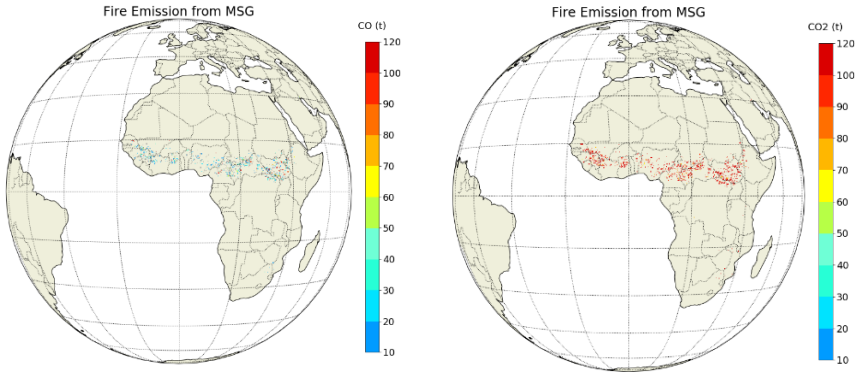
Meteosat 11



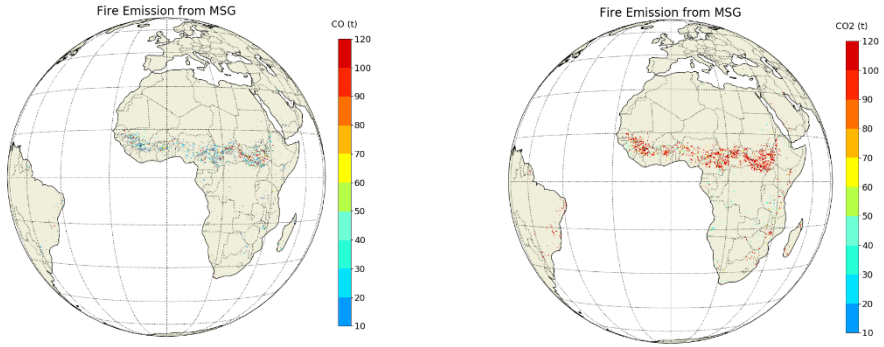
FRP-PIXEL



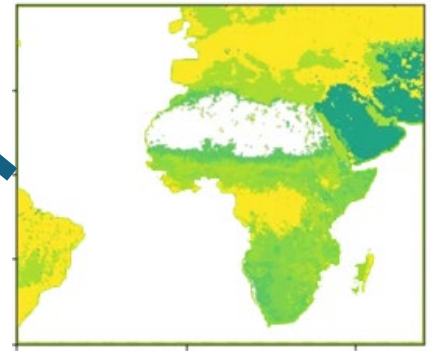
Fire Emission (Hourly)



Fire Emission (Daily)



Fire Emission Coefficients in 0.1˚ gird



Fire Emission : CO, CO_2, CH_4, N_20, TPM, $PM_{2.5}$, Total Carbon, Dry Material

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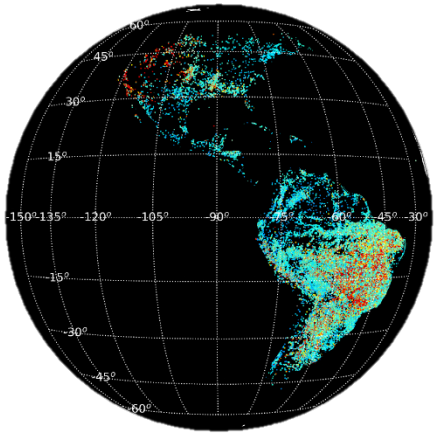
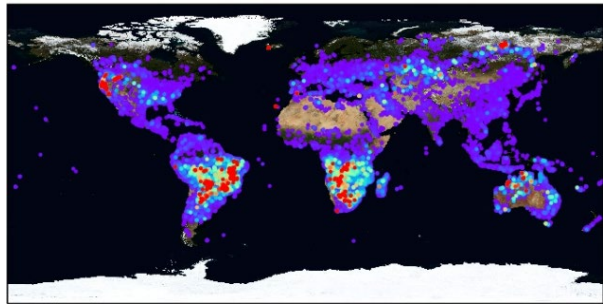
Extending to GOES and Himawari Satellites

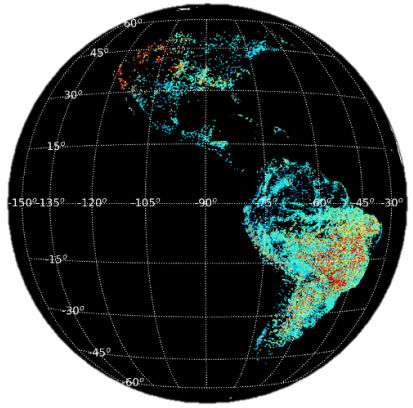
GOES



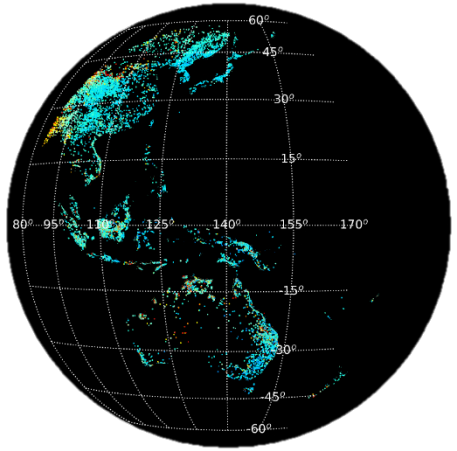
FEER-Equivalent FREM Coefficients



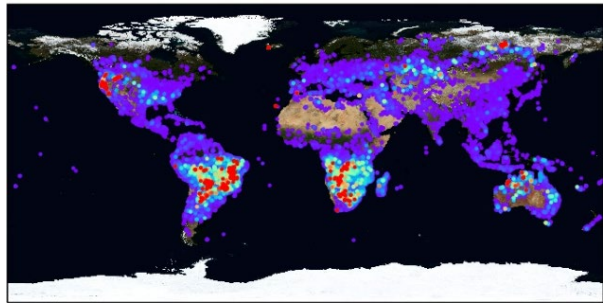
Fire Emissions (Sept. 2024)



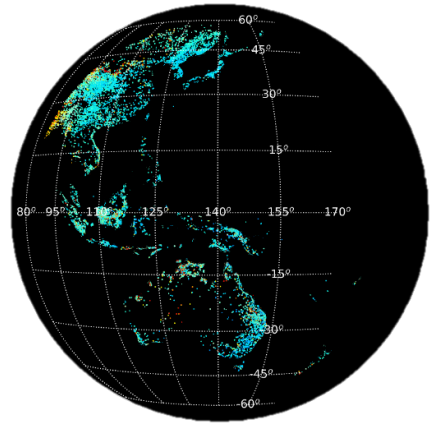
Himawari



FEER-Equivalent FREM Coefficients



Fire Emissions (Mar. 2025)



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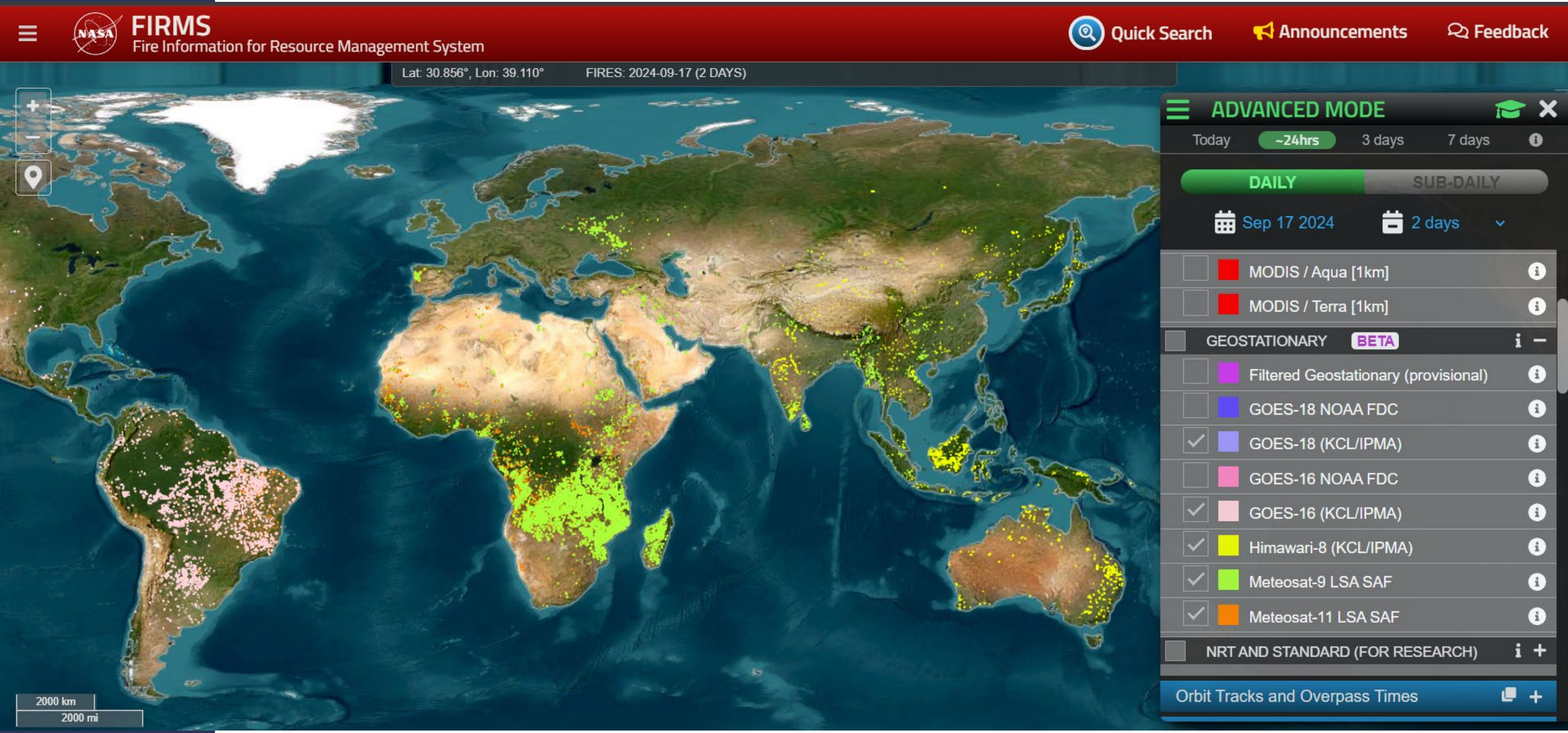

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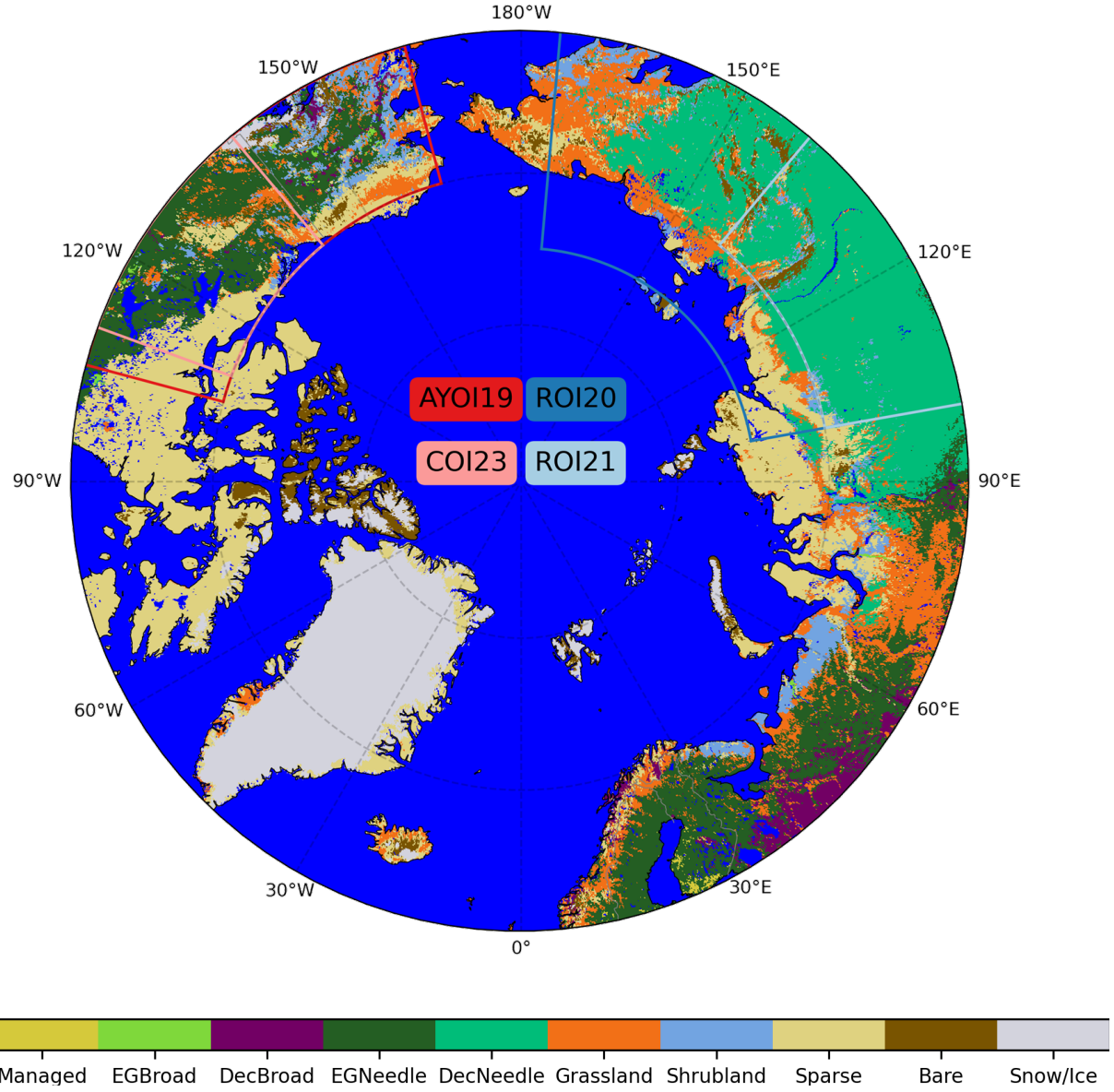
Natural Environment Research Council

High Latitude FREM



FREM Approach: Method and Data

Fire Radiative Energy Emissions (FREM)

- Based on Fire Radiative Power (FRP) timeseries
- v1: relates Geostationary FRE to TPM (Africa)
- v2: method improved, also relates Geostationary FRE to CO (Africa)

Adapted FREM (Latitudes ≥ 60°N)

- Swap Geostationary FRE for Polar Orbiter FRP
- Orbital convergence provides many samples per day

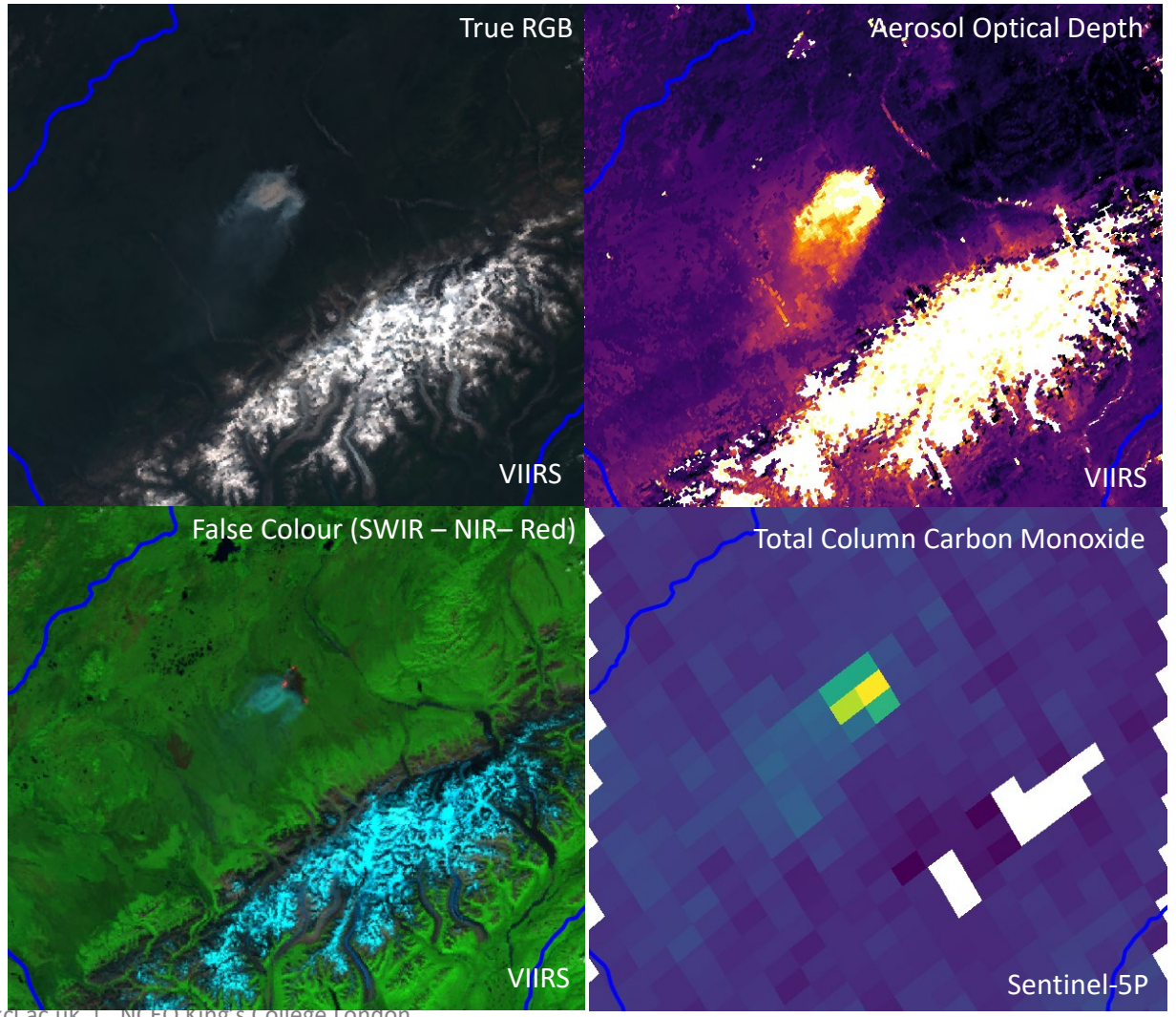
Data Used

VIIRS (S-NPP)
Plume and Fire Identification

Sentinel-5P
Carbon Monoxide Observations

GFAS v1.4
MODIS + VIIRS Hourly FRP

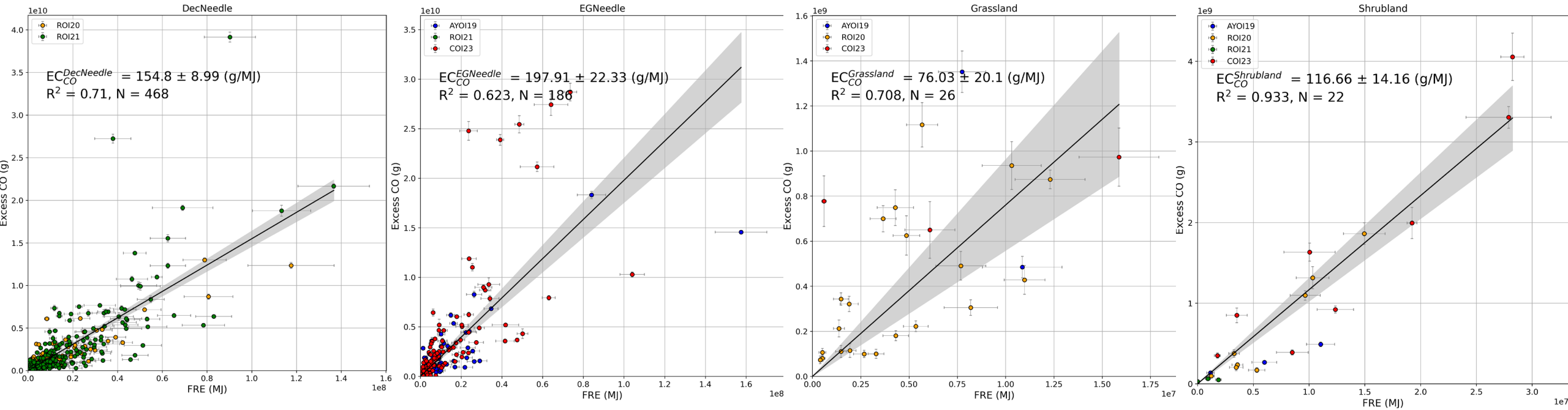
CCI 2018 Land Cover + Köppen-Geiger classes
Aggregated Biomes



High Latitude FREM Emission Coefficients

Four biomes across the combined ROIs (covers 95% of FL Emissions)

- Deciduous Needleleaf Forest (DecNeedle)
- Evergreen Needleleaf Forests (EGNeedle)
- Grasslands
- Shrublands



Plots show relation between total CO emission from a fire (y-axis) and Fire Radiative Energy (x-axis).

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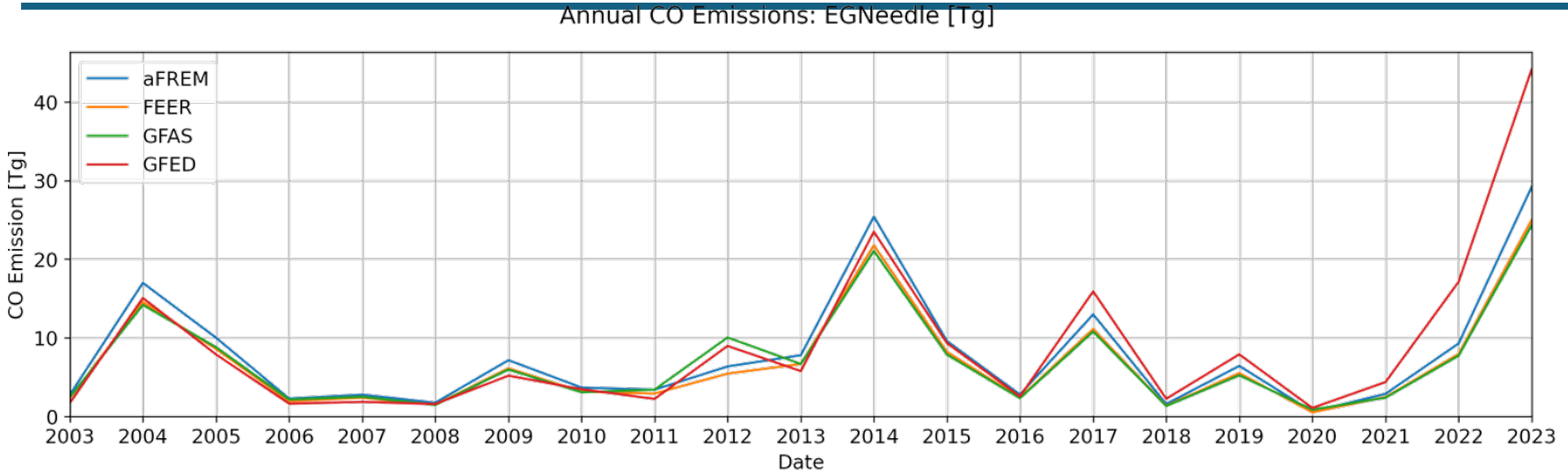
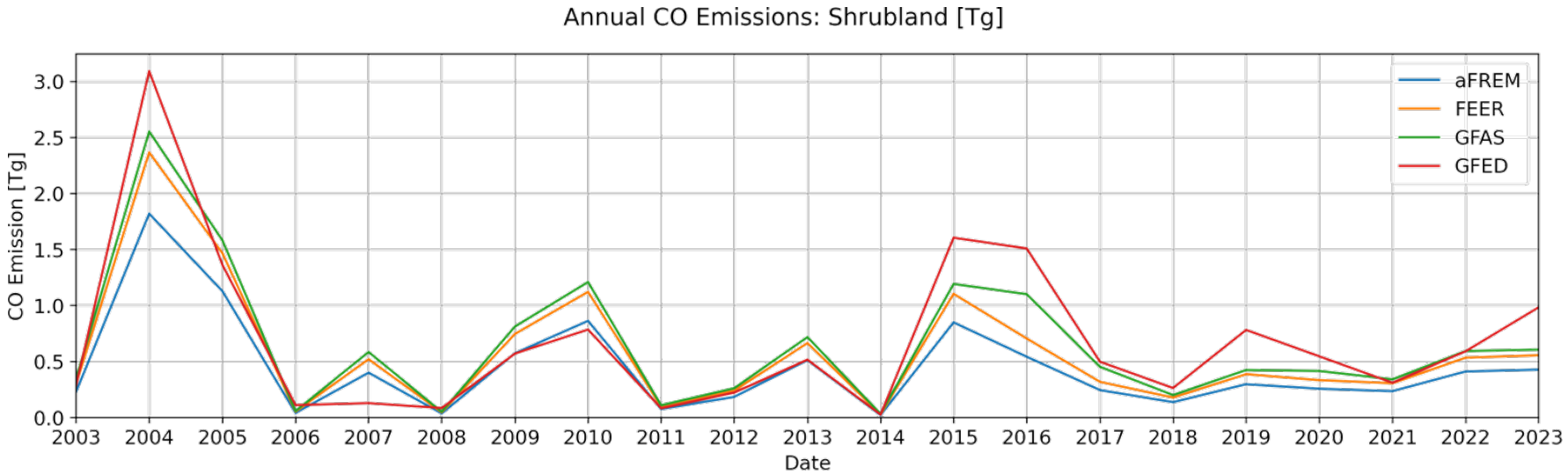
Fire Emissions Inventory Intercomparison



EGNeedle

- Alaska / Canada Dominated
- ≈ 85% w.r.t. GFED
- ≈ 118% w.r.t. GFAS
- ≈ 117% w.r.t. FEER

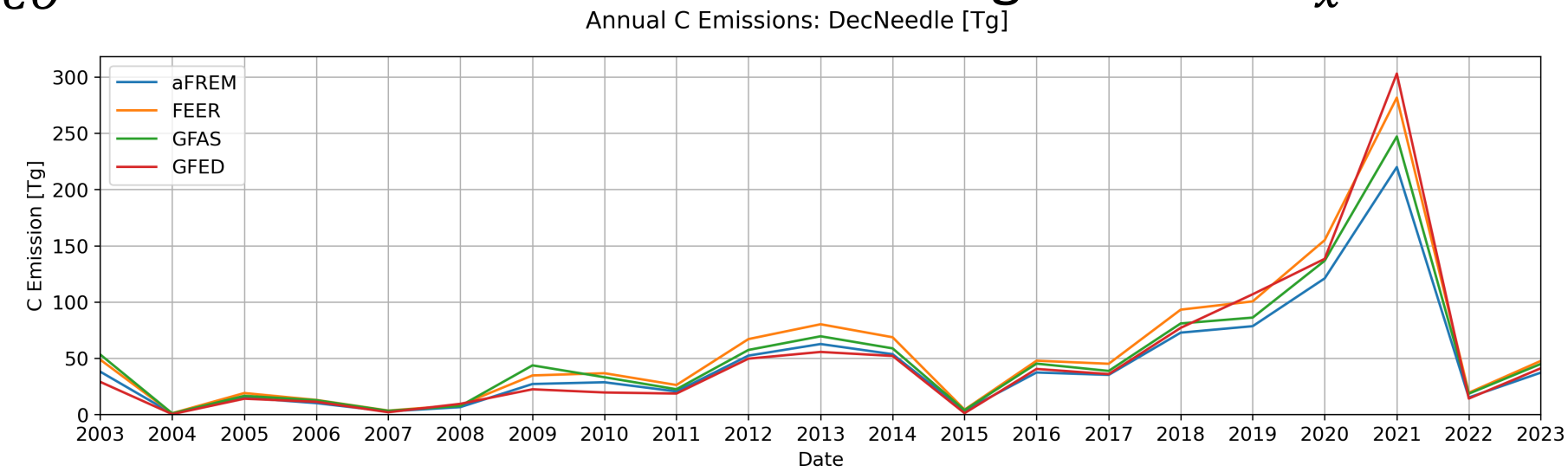


Shrubland

- Alaska / East Siberia
- ≈ 64% w.r.t. GFED
- ≈ 70% w.r.t. GFAS
- ≈ 77% w.r.t. FEER

Carbon Emission Inventory Comparison

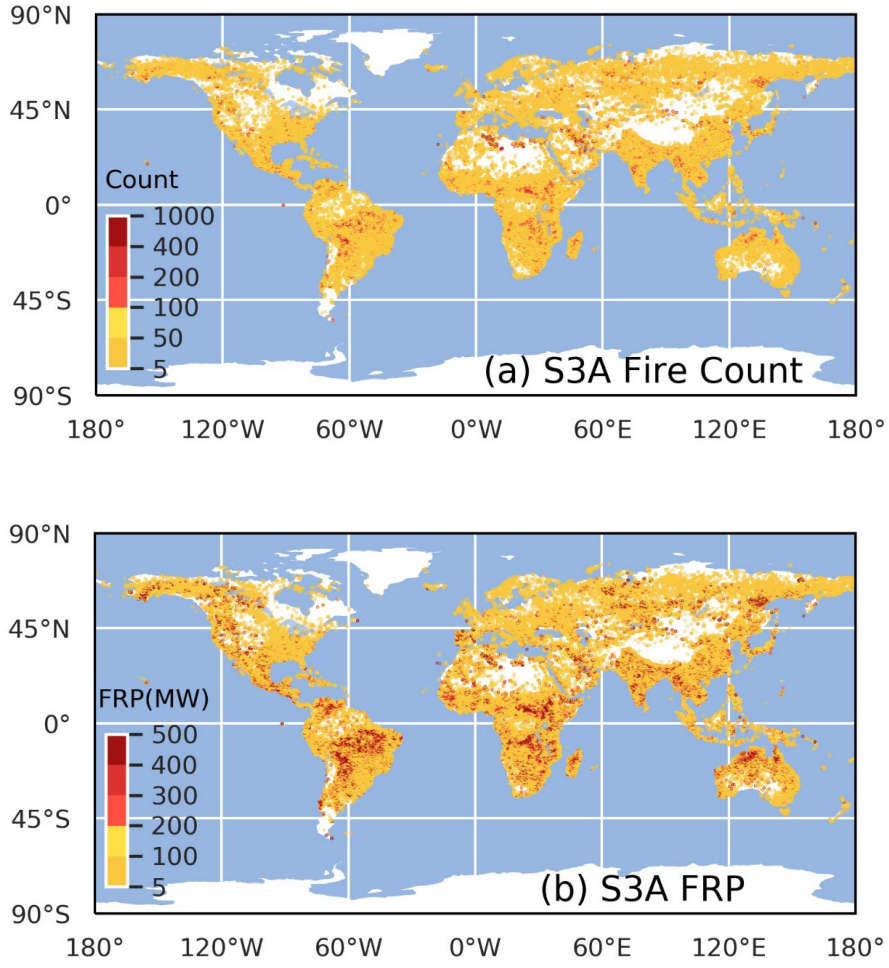
Using EC_{CO}^{biome} and Emission Factor Ratios can generate EC_{x}^{biome}



$$EC_{x}^{biome} = \frac{EF_{x}^{biome}}{EF_{CO}^{biome}} EC_{CO}^{biome}$$

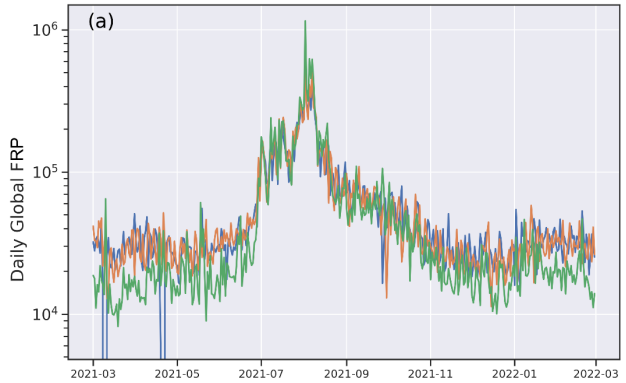
$\overline{Annual}$	DecNeedle	EGNeedle	Grassland	Shrubland
FREM	**45 Tg**	**35 Tg**	**6 Tg**	**3 Tg**
FEER	57 Tg	30 Tg	16 Tg	4 Tg
GFAS v1.2	51 Tg	31 Tg	14 Tg	3 Tg
GFED	50 Tg	31 Tg	8 Tg	2 Tg

Sentinel-3 SLSTR FRP Product

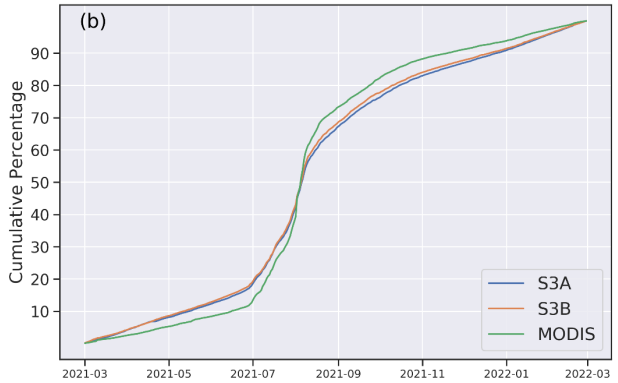


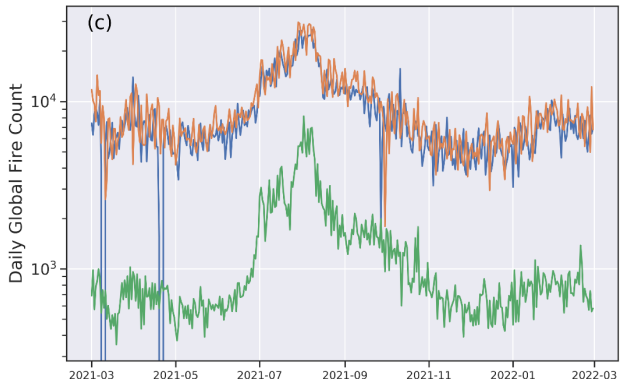
Comparison to MODIS Terra

Total Daily FRP

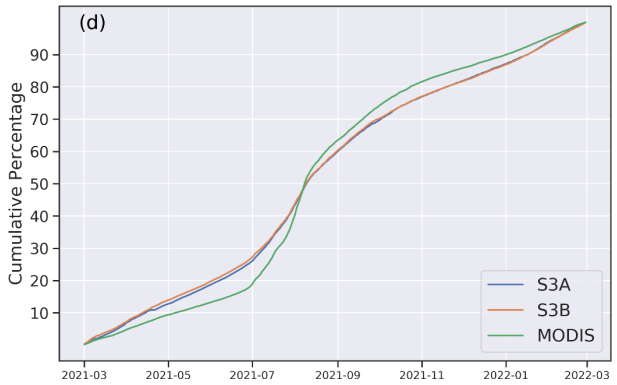


Cumulative FRP

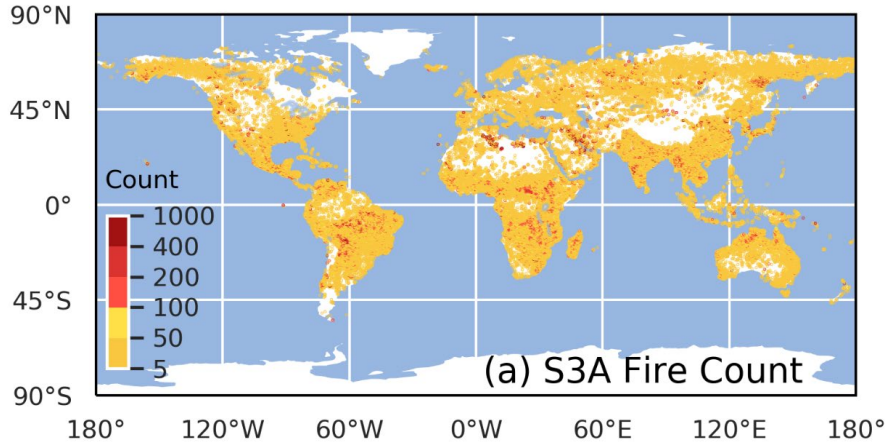


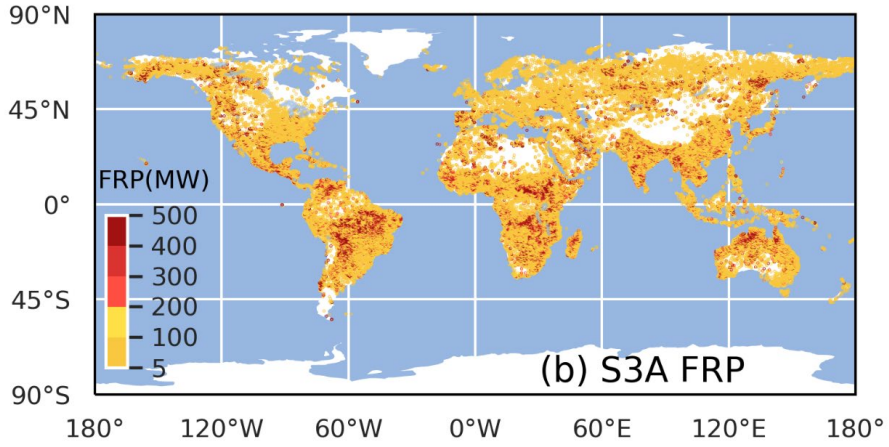


Total AF Pixel Count



Cumulative AF Pixel Count





- **NTC** night-time product available since early 2020
- **NTC** daytime product available since early 2022

PM2.5 Intercomparisons of Measurement and Models