PROGRAMME OF THE EUROPEAN UNION

co-funded with

Two years of Copernicus Sentinel-3 (CS3) Near Real Time (NRT) Fires by EUMETSAT

Lessons learned & new developments

7th Sentinel-3 Validation Team Meeting 2022

18-20 October 2022 | ESA-ESRIN | Frascati (Rm), Italy

Julien Chimot[1], Martin Wooster[2], Weidong Xu[2], Andrea Meraner[1], Sauli Joro[1], Bojan Bojkov[1]

1 EUMETSAT

2 King's College London (KCL)

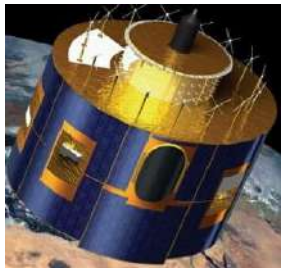
European portfolio for Level 2 (L2) NRT Fires

Expertise support regularly provided to operational air quality & climate services with ECMWF

Primary needs are both air quality / population health / aviation & security + land surface monitoring

LandSAF + EUMETSAT Central Facility (CF) – NRT (<< 3h), 7/7 days, 24h led by EUM operators & System Engineers.

European NRT satellite Fires providers



MSG SEVIRI

OFRaP-CS3

NRT FRP Since 2020 by EUMETSAT CF

Assimilation under analyses by ECMWF/CAMS

MTG FCI

EPS-SG MetImage

FIR (Bayesian detection) – EUMETSAT CF

FRP (Pixel & Gridded) – LandSAF
Fire weather index, Fire emissions

Fire User Communities

Copernicus Services

Emergency centres

Internal Fire service collaboration

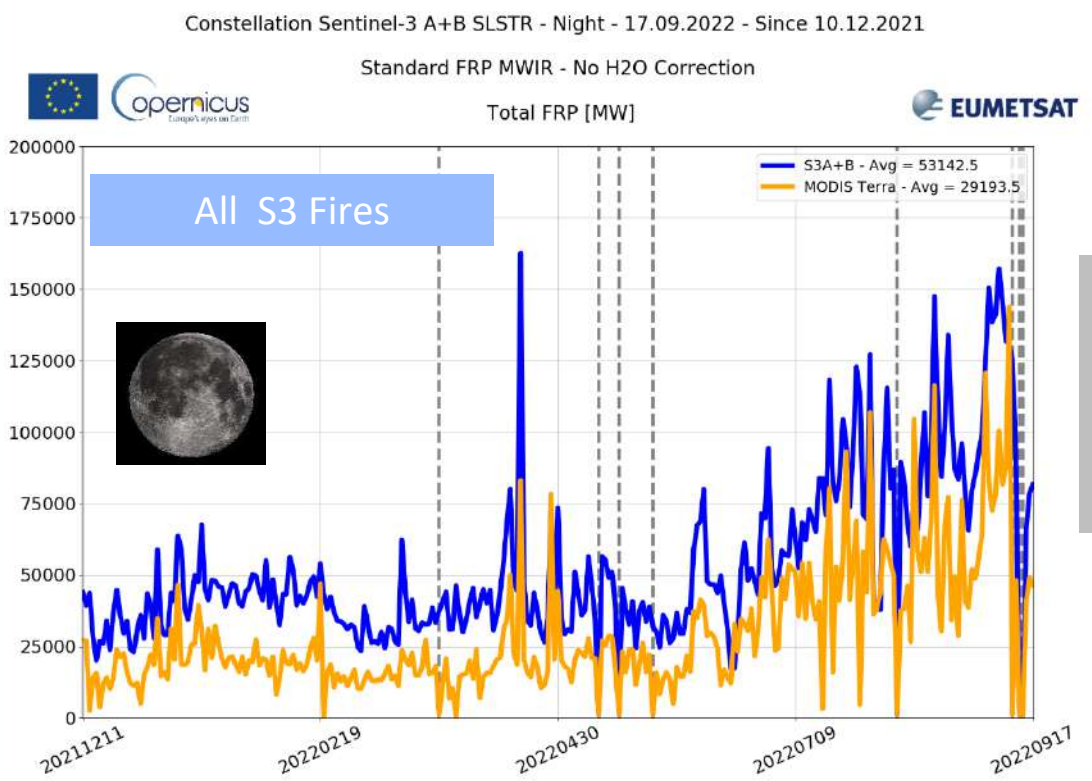
OFRaP-CS3 – Optimized Fire Radiative Power for Copernicus Sentinel-3

- EUMETSAT – exclusive mandate from Copernicus & Europe for the NRT Atmospheric portfolio (including fires)
  - Supporting Global Fire Assimilation Service (GFAS) procured by the Copernicus Atmospheric Service (CAMS)
- King's College London (KCL – Prof. Dr. M. Wooster & W. Xu)
  - Reference night-time algorithm (Thermal), since 2012
  - GFAS evolutions for multiple satellites
- EUMETSAT has developed the operational OFRaP-CS3 processor 2 years ago!
  - Started with precursor v1.0 elements delivered in 2019 by ESA / S3 MPC
  - Enhanced baseline developed by EUMETSAT leading to processor v2.0
  - Collection 1.0 in March 2020 – Collection 2.0 Day-Time since December 2021.

2020 Q2	2020 Q3	2021 Q2	2021 Q4
Collection 1	Collection 1.1	Collection 1.2	Collection 2
Additional EUMETSAT developments	High-latitude improvements	Small hot-spots Night	**Day-time**
- Very hot sports (**SWIR** module) – 1 km - **Thermal** - warm water outliers removal	Twilight removal	- New baseline: "**Alternative Thermal**" (KCL request) - SWIR module extended to 500 m	

Night-Time algorithms

- **1st thermal Fire algorithm**:
  - Standard – Based on S7 detector grid – low dynamic range – grid co-registered with all channels – high measurement reliability – distortion at swath edges
  - Much higher capability than MODIS Terra for small / weak hot-spots – Time series highly consistent

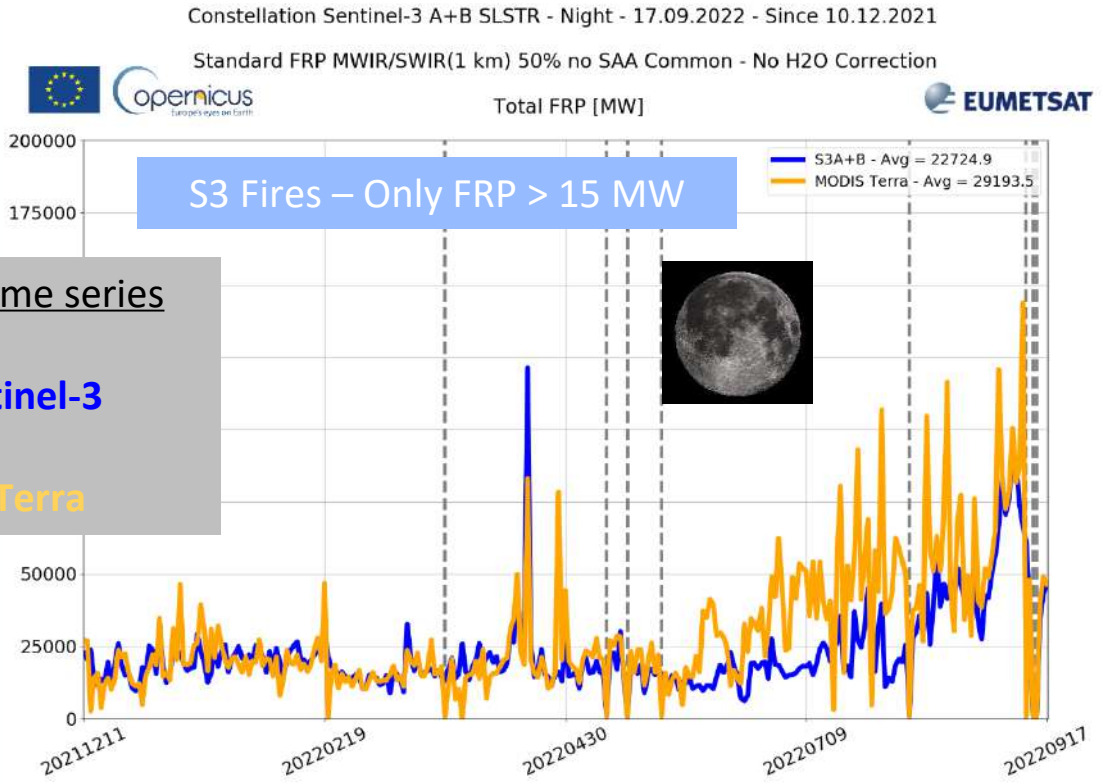


Global FRP time series

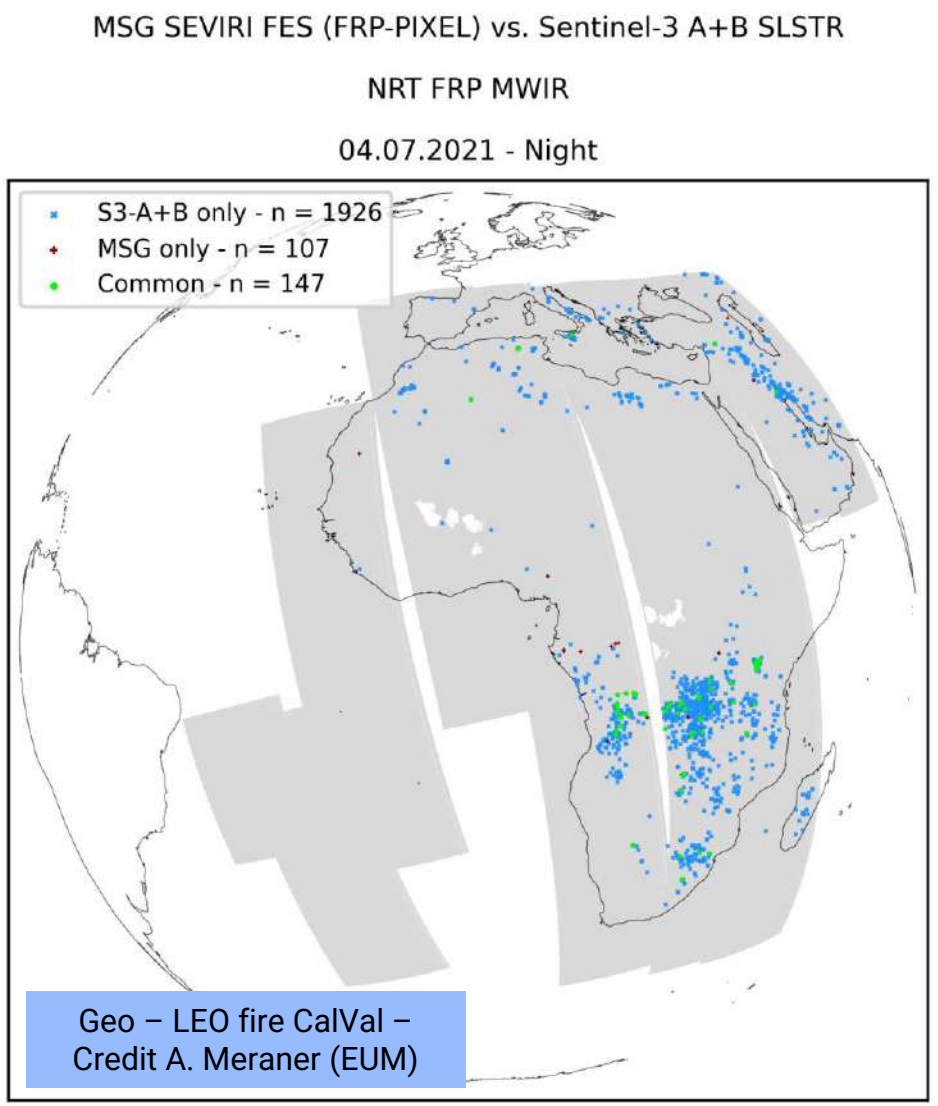
NRT Sentinel-3

vs.

MODIS Terra



Night-Time algorithms



Geo – LEO fire CalVal – Credit A. Meraner (EUM)

- GEO – LEO collocation methodology designed & implemented by A. Meraner (EUMETSAT):
  - Satpy / Pytroll - Stringent 1-to-1 pixel threshold.
- MSG *vs.* SLSTR Active Fire scores:
  - **~60% (± 10%)** MSG hot-spots common with SLSTR
  - **~9%** SLSTR common with MSG
- MSG *vs.* MODIS Active Fire scores:
  - **~32%** MSG hot-spots common with MODIS (Terra, Aqua)
  - **~23%** MODIS (Terra, Aqua) common with MSG.
- OFRaP-CS3 = higher Probability Of Detection than MODIS (MSG Reference).
- MODIS = higher Precision (MSG Reference) => OFRaP-CS3 higher probability of weak hot-spots.
  - Good - Further confidence needed.
- Waning: activation scores strongly vary per minimum fire threshold.

Night-Time confidence class

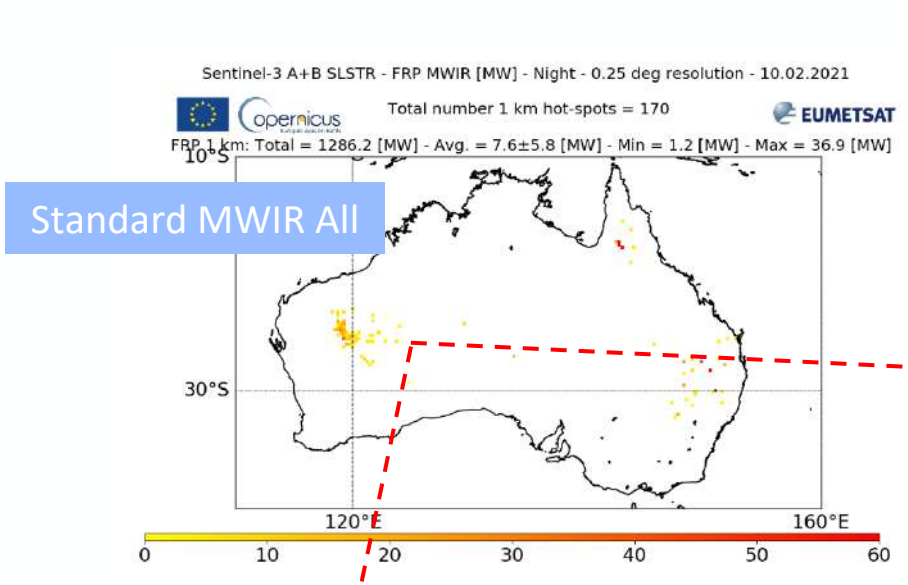
FRP_NR.001.01
X Standard FRP MWIR
Australia

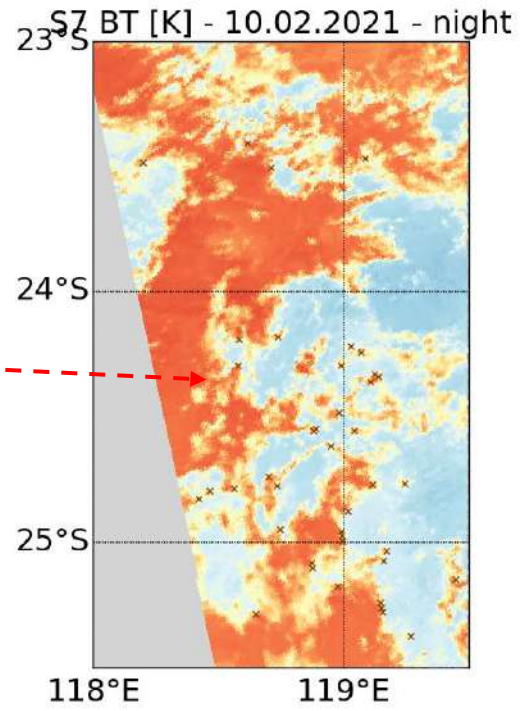
- Between 10-20% of false alarms due to missed cloud-edges.

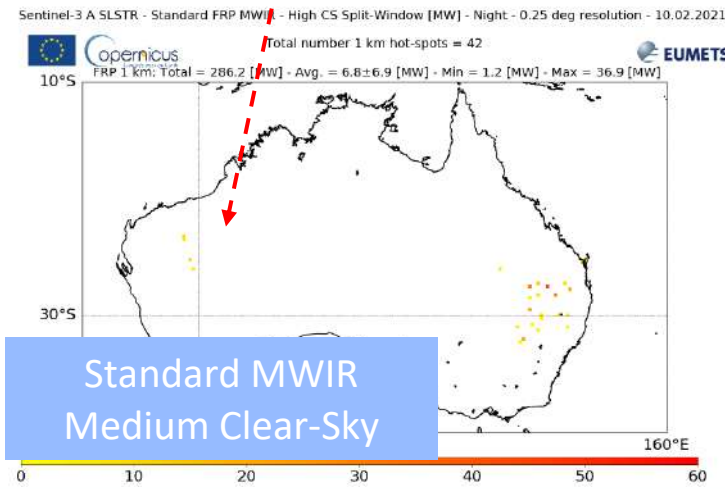
- **Potential root-causes:**
  - S7-S8 off-set
  - Weak cloud-tests.

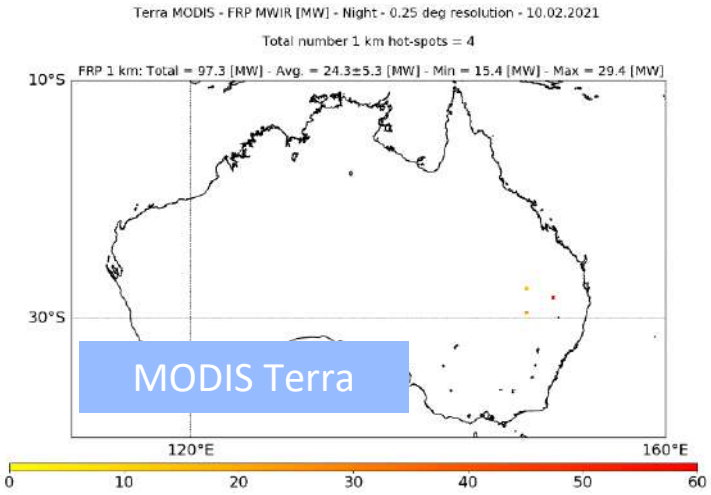
- Since May 2021 (Coll 1.2) - Clear-Sky split window: 11-12 µm: Ackerman *et al.* 2006, Godin 2014), A. Bozzo (EUM Cloud Expert)

- Recommendations to Users:
  - 40% => Medium clear-sky confidence



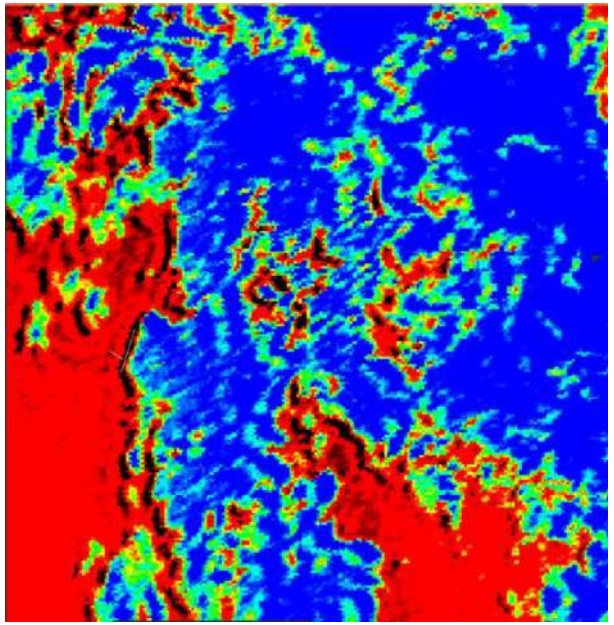






Night-Time algorithms

- **2nd thermal Fire algorithm**:
  - Alternative - F1 detector grid, after S7 sub-sequent detection - Xu *et al.*, 2021
  - F1 = high dynamic range – pixels not co-registered with other channels – low distortion at swath edges – high number of outliers (due to slow detector response)
  - High risk of false alarms minimized thanks to the EUMETSAT F1 shooting mask (developed internally)
  - Reduced FRP dependence on viewing scanning angles

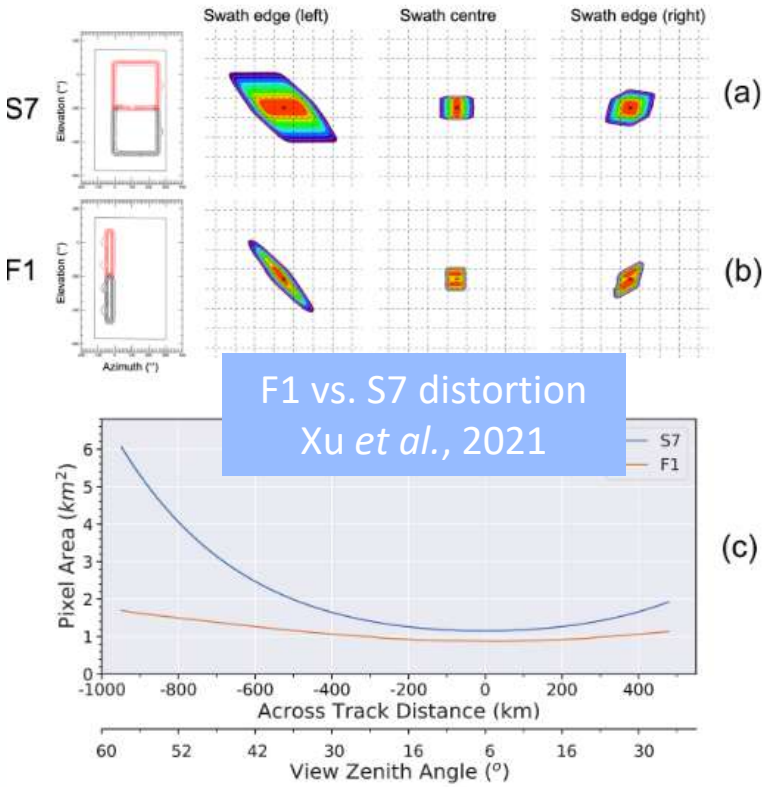


F1 Brightness Temperature (BT)

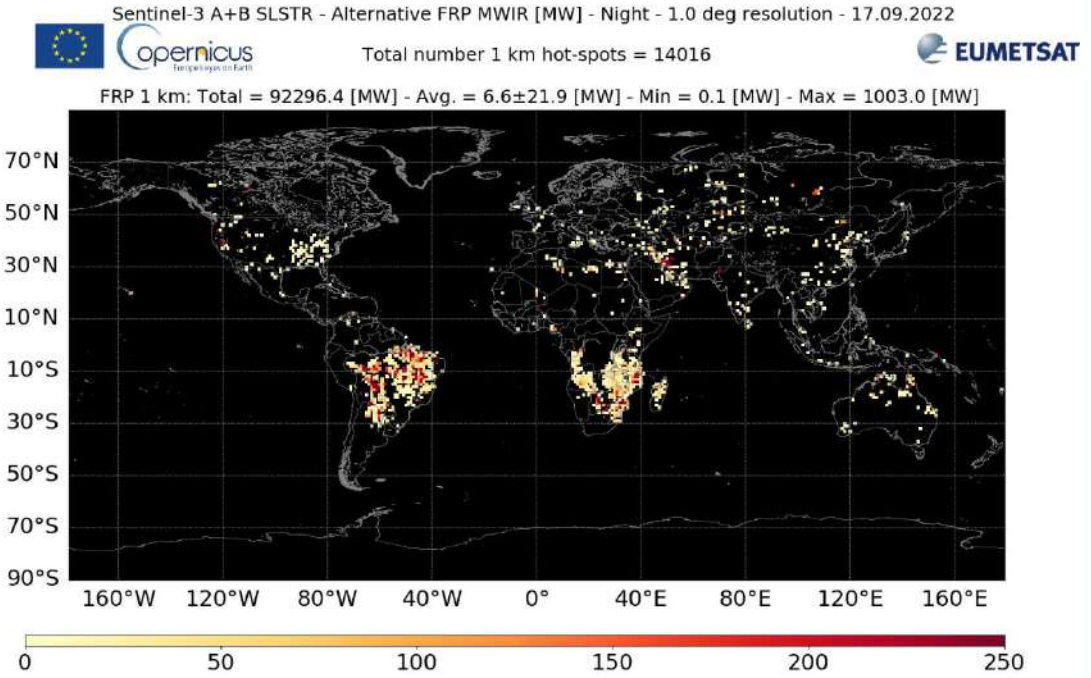
-- BT ~ 273 K (Clouds)

-- BT ~298 K

-- large F1 outliers



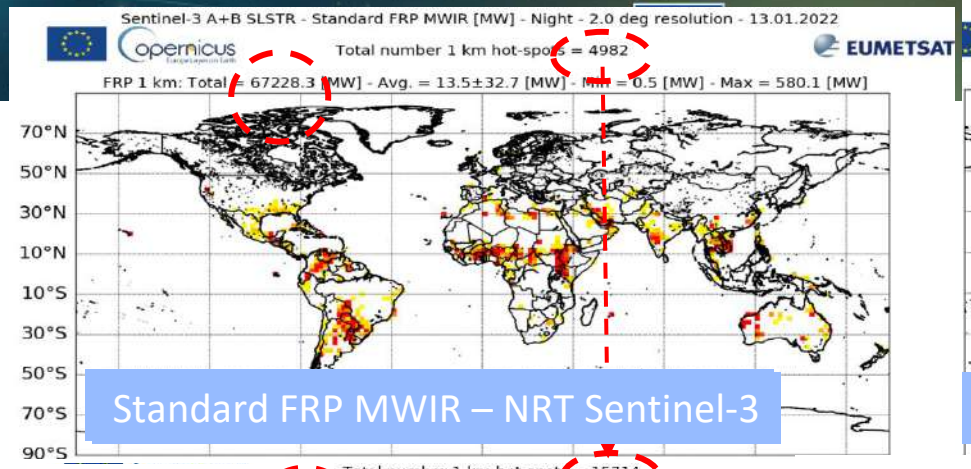
F1 vs. S7 distortion
Xu *et al.*, 2021

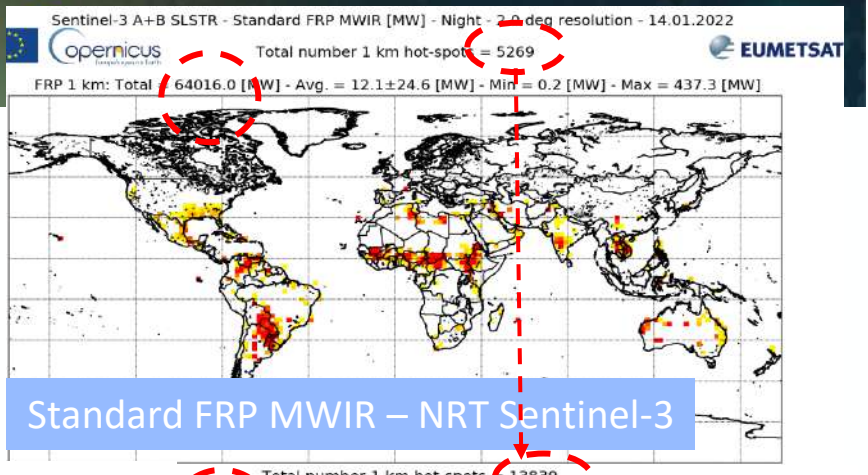


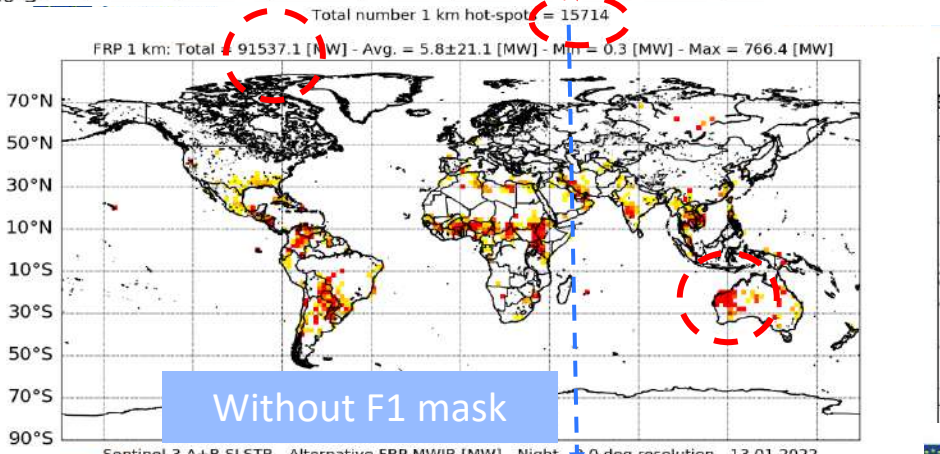
Alternative FRP MWIR – NRT Sentinel-3

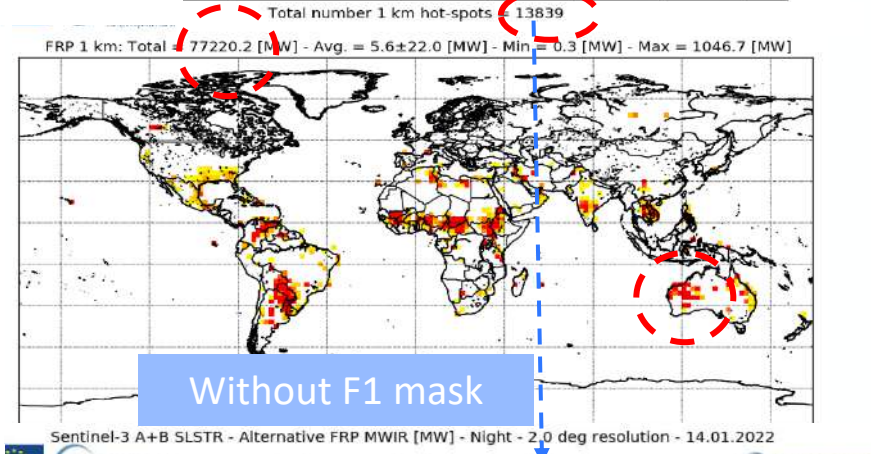
Night-Time algorithms

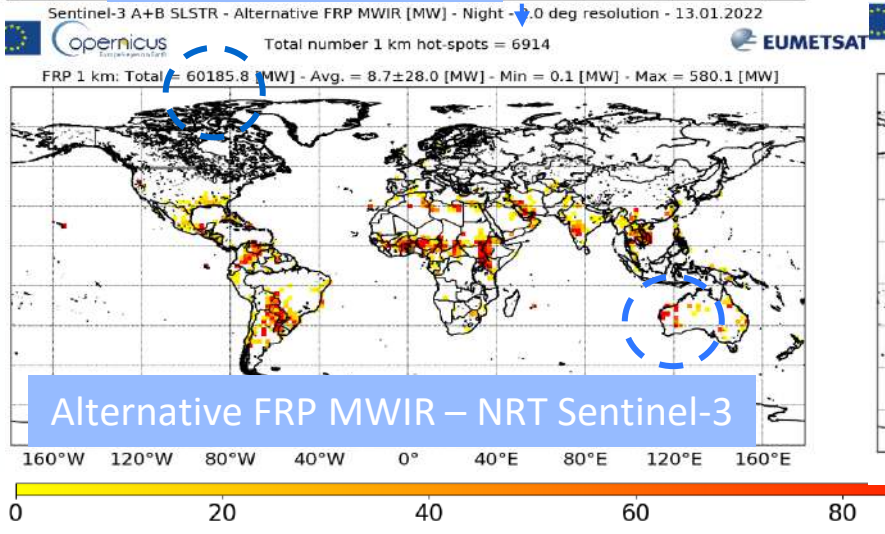
- Without the F1 over-shooting mask:
  - x3-x4 increased hot-spot number (night-globally)
  - Considerably higher than ~30% in Xu et al., 2021.
- Alternative MWIR:
  - ~20%:30% increased hot-spot number (in line with Xu *et al.*, 2021)
- Confidence classes are missing.
- Revision of F1 mask on-going:

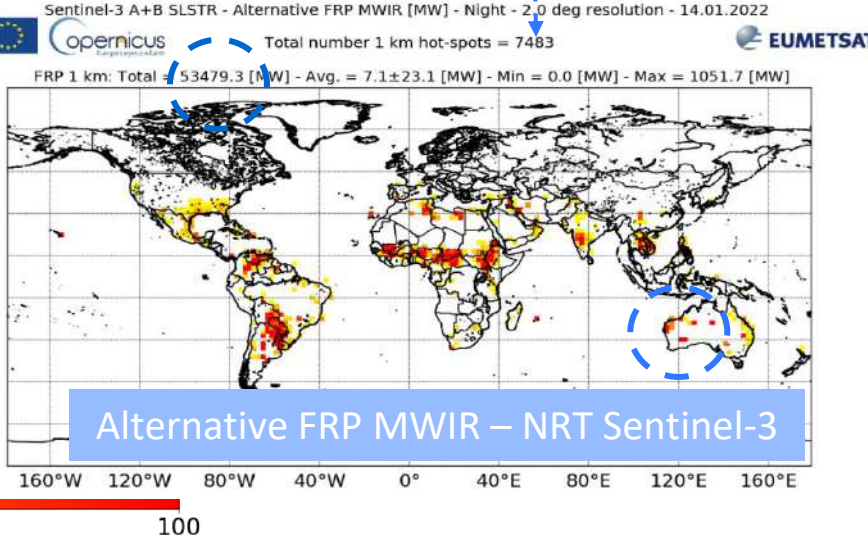




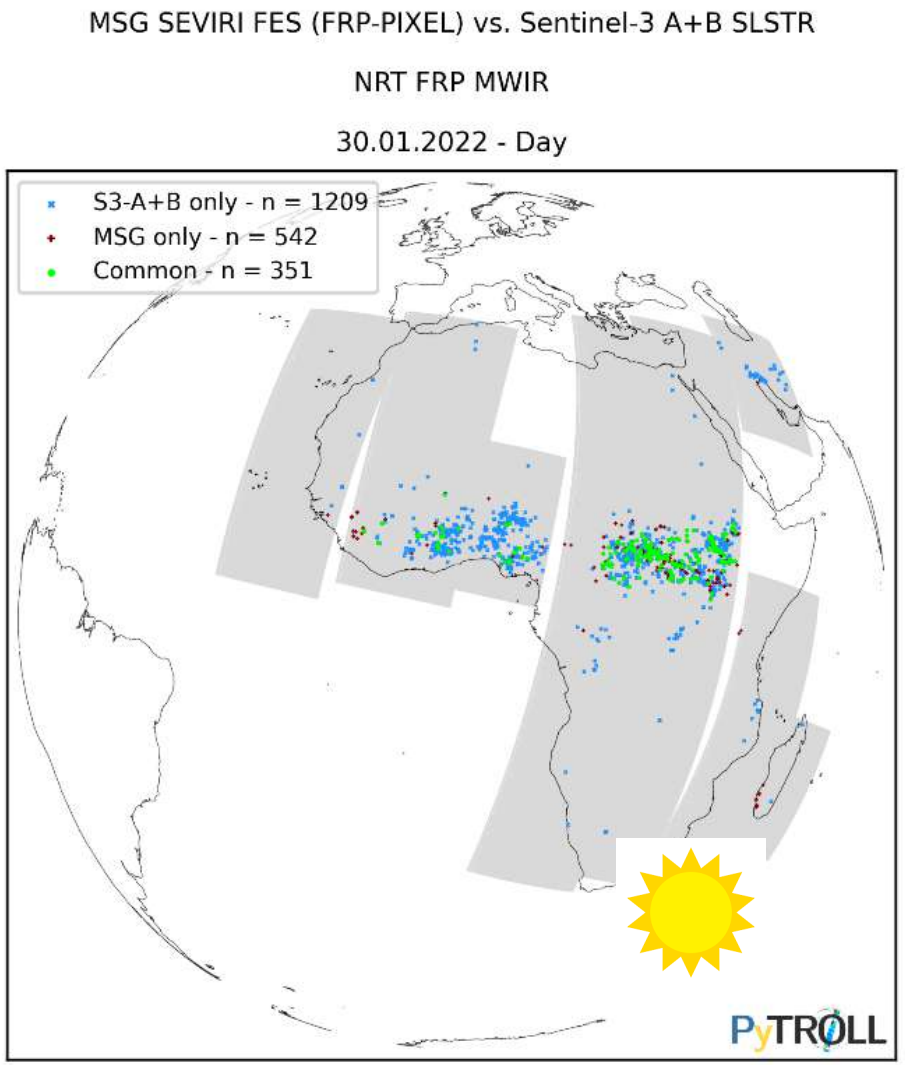






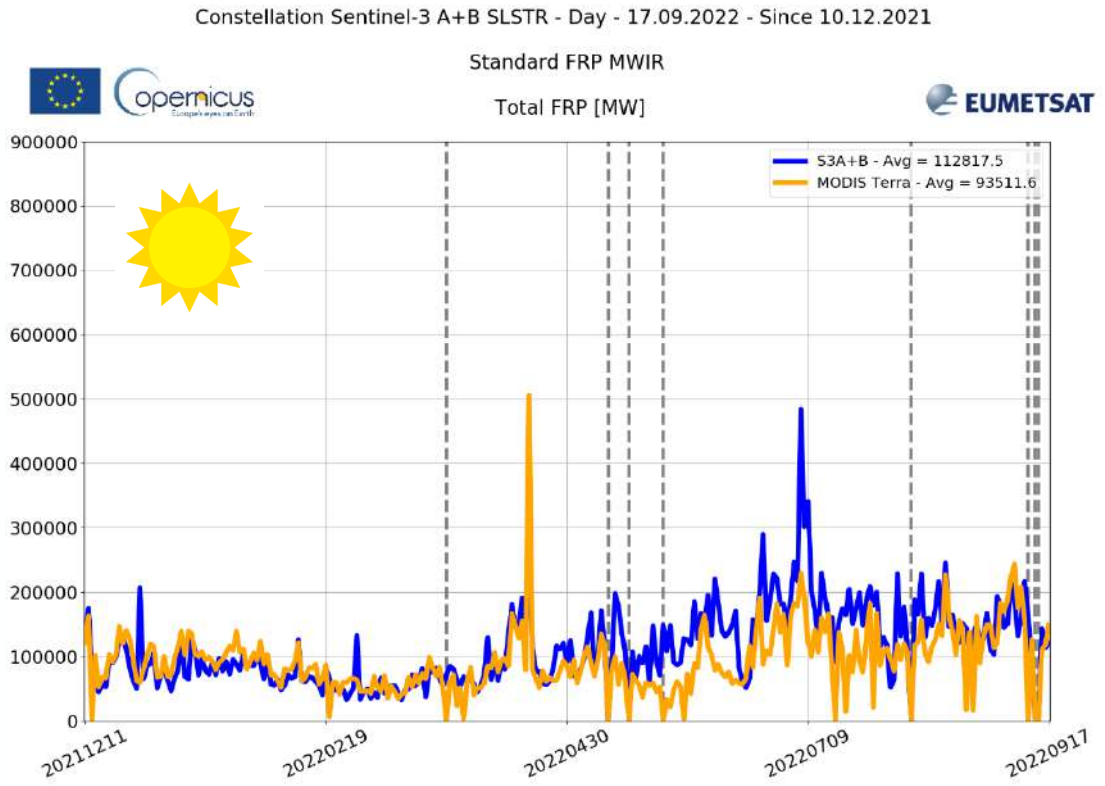


Day-Time



opernicus EUMETSAT LSA SAF LAND SURFACE ANALYSIS EUMETSAT

- Virtual F3 channel – F1 remapping into S7 Field Of view:
  - Avoiding frequent S7 saturation; Accounting for FOV size differences, Linear weights between F1 and S7 BT (smooth transition), F1 under/over-shooting excluded (see ATBD)
- Provisional:
  - Restricted weak hot-spots at this stage - Improvements in future Collection 2.1
- ~30%:40% MSG common with SLSTR:
  - Very similar to MODIS Prob. Detection (A. Meraner GEO-LEO CalVal).



Global FRP time series

NRT Sentinel-3 vs. **MODIS Terra**

Summer 2022 – North America - Wildfires

Day & Night

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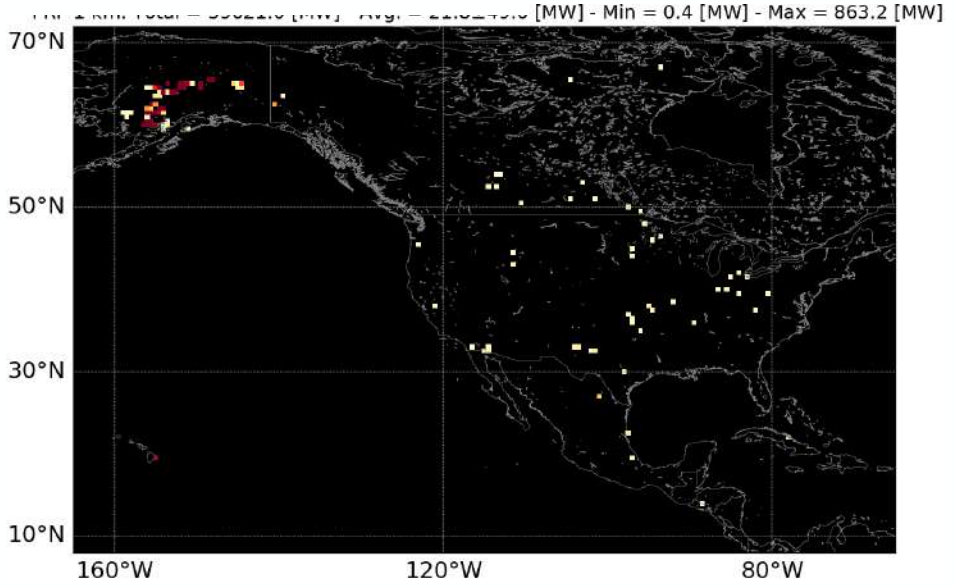
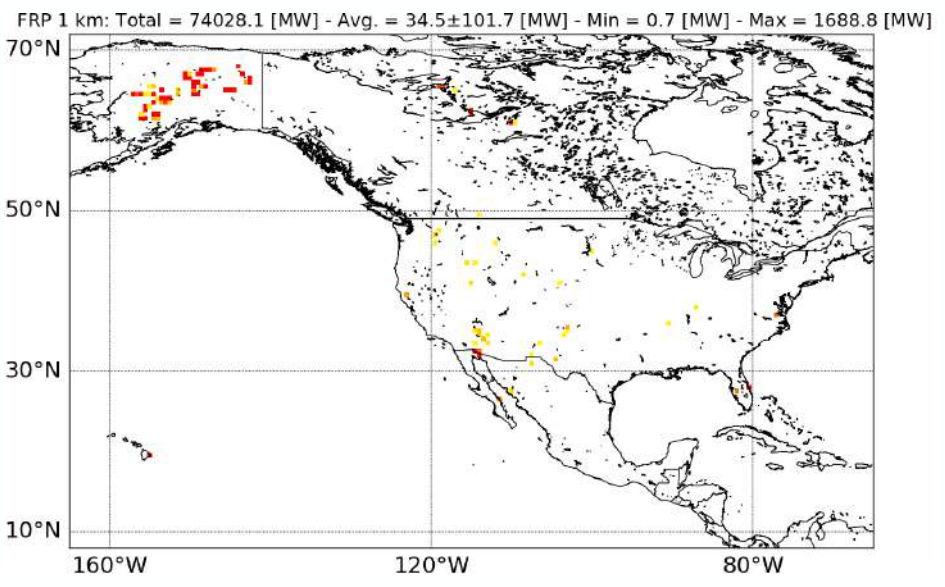
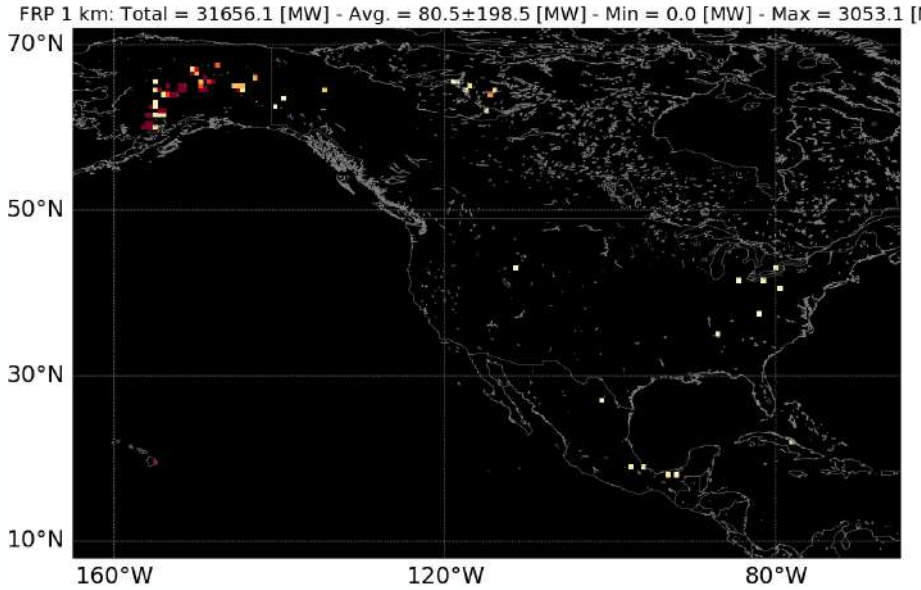
01.07.2022

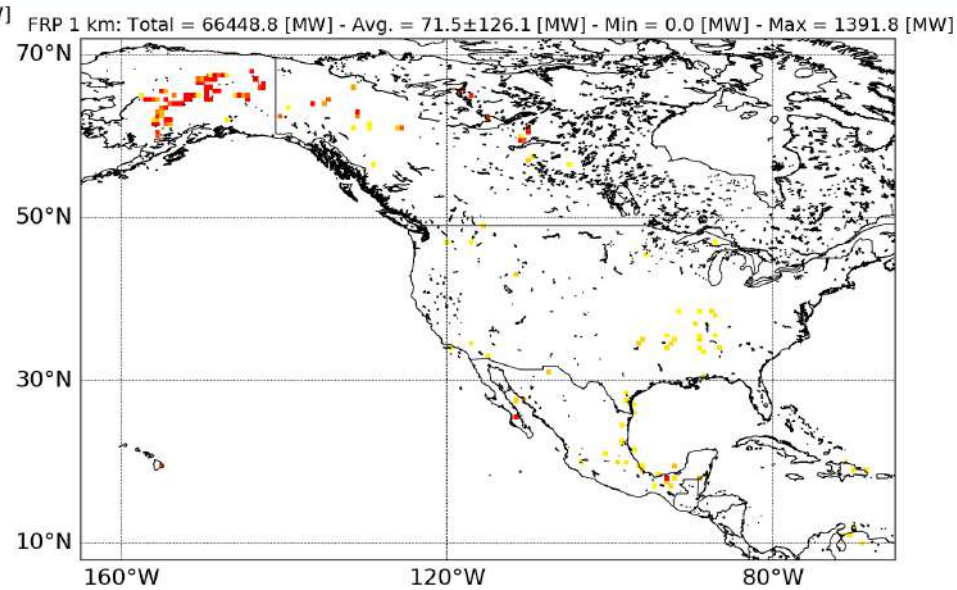
Near Real Time Sentinel-3 Collection 2.0





MODIS Terra (NASA)





Fire Radiative Power [MW]

Summer 2022 – Siberia - Wildfires

Day & Night

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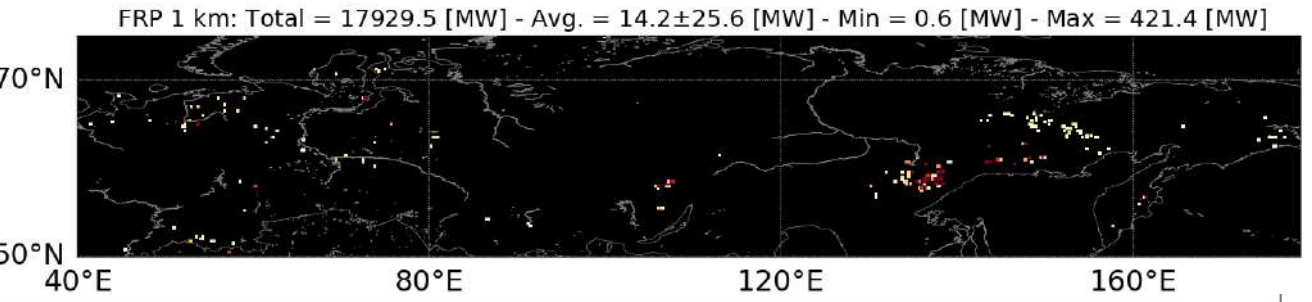
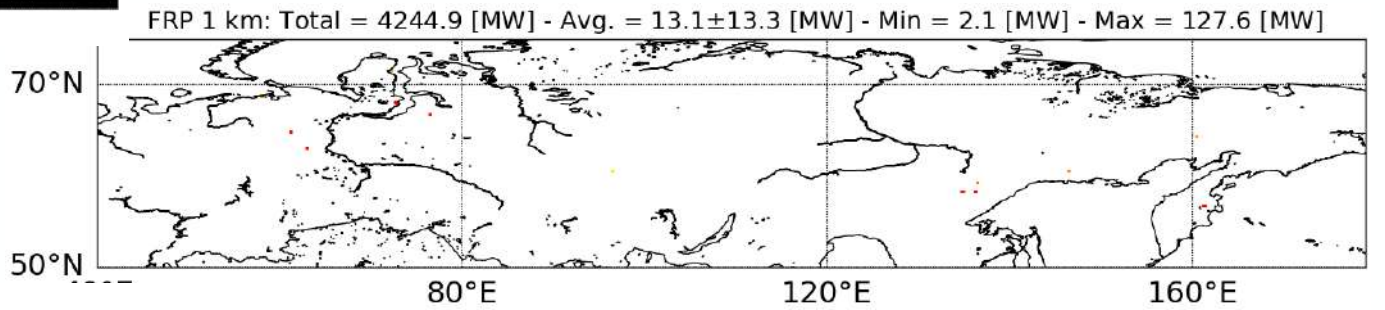
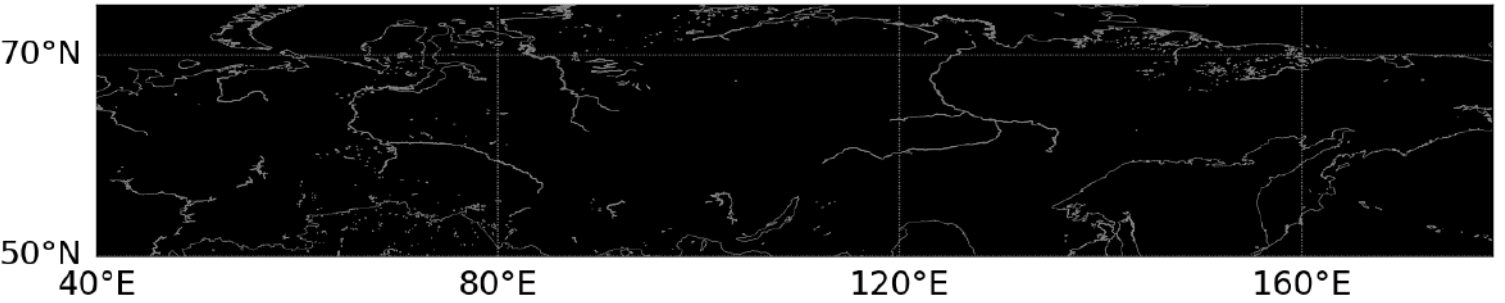
20.07.2022

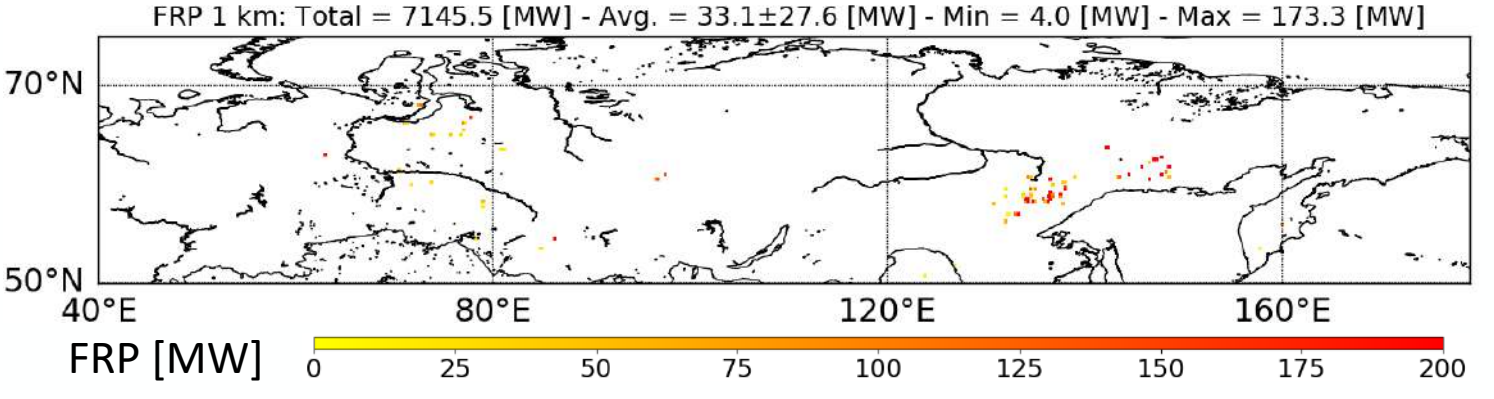


OFRaP-CS3 - NRT S3
Coll 2.0

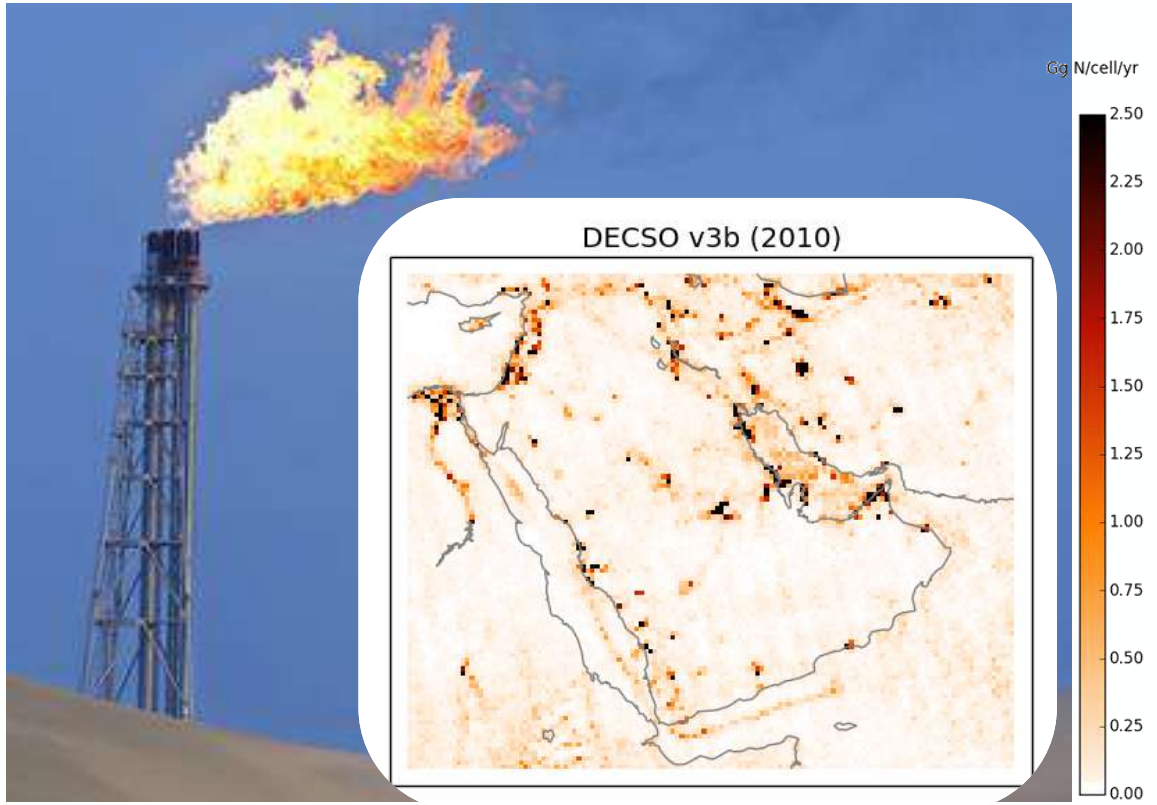




MODIS Terra (NASA)



- Increasing interest in NRT gas flare monitoring.



Daily N emission estimates constrained by satellites

DECSO algorithm from KNMI

Bas Mijling , Ronald van der A, KNMI

Heating flames due to flammable gas disposed at the tip industrial Gas Flaring (GF) released:

between 2003 and 2012 ˜304 Tg CO_2 yearly

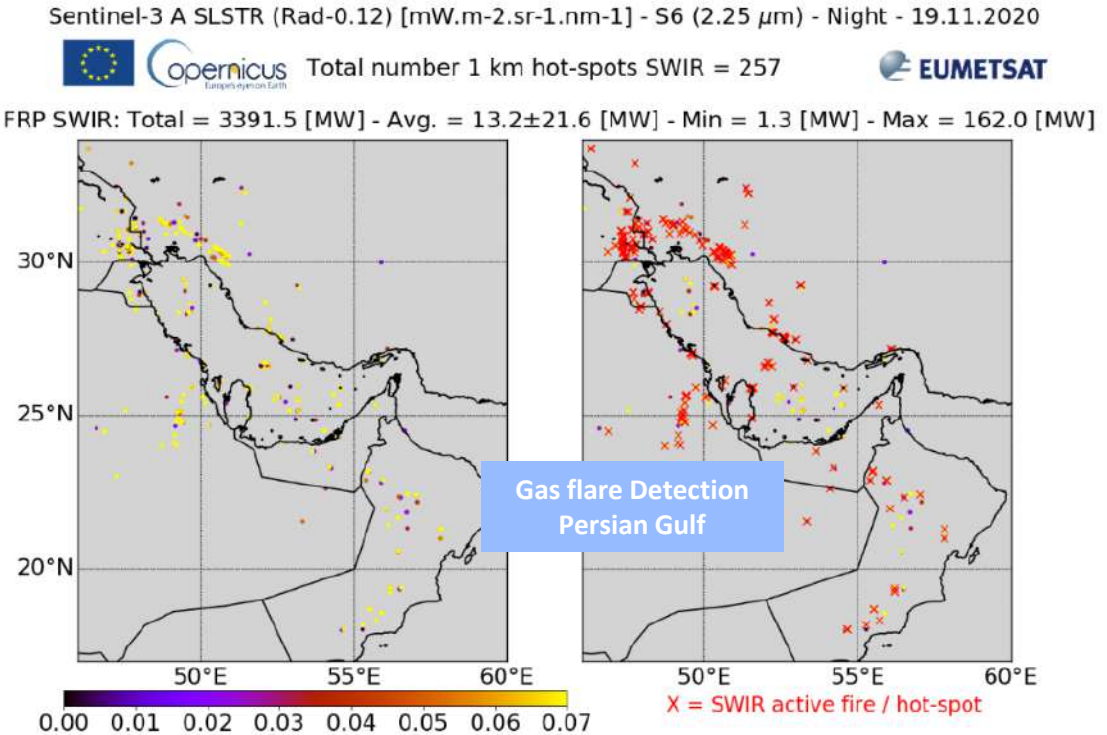
270 and 210 Gg of BC in 2005 and 2010, respectively.

Contribute to half the near-surface BC concentration in the Arctic.

Olivier *et al.* (2014)

Klimont *et al.* (2017)

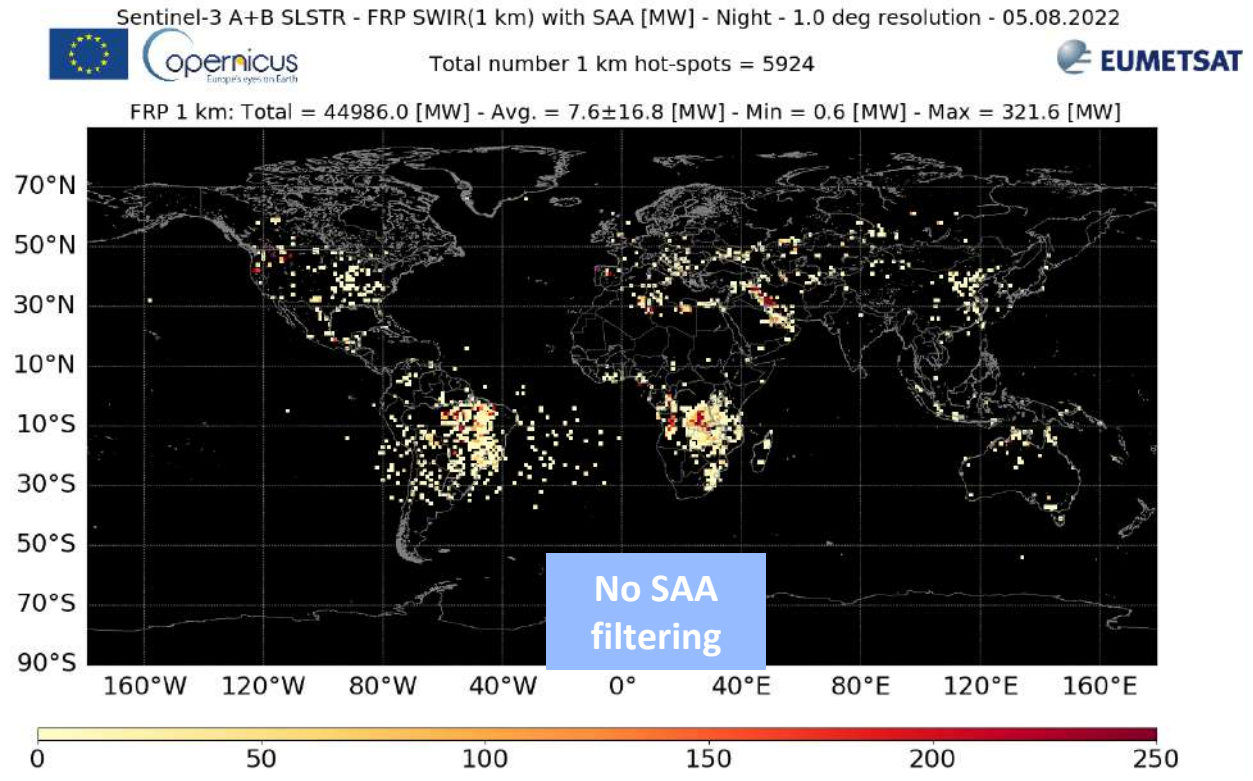
Stohl *et al.* (2013)

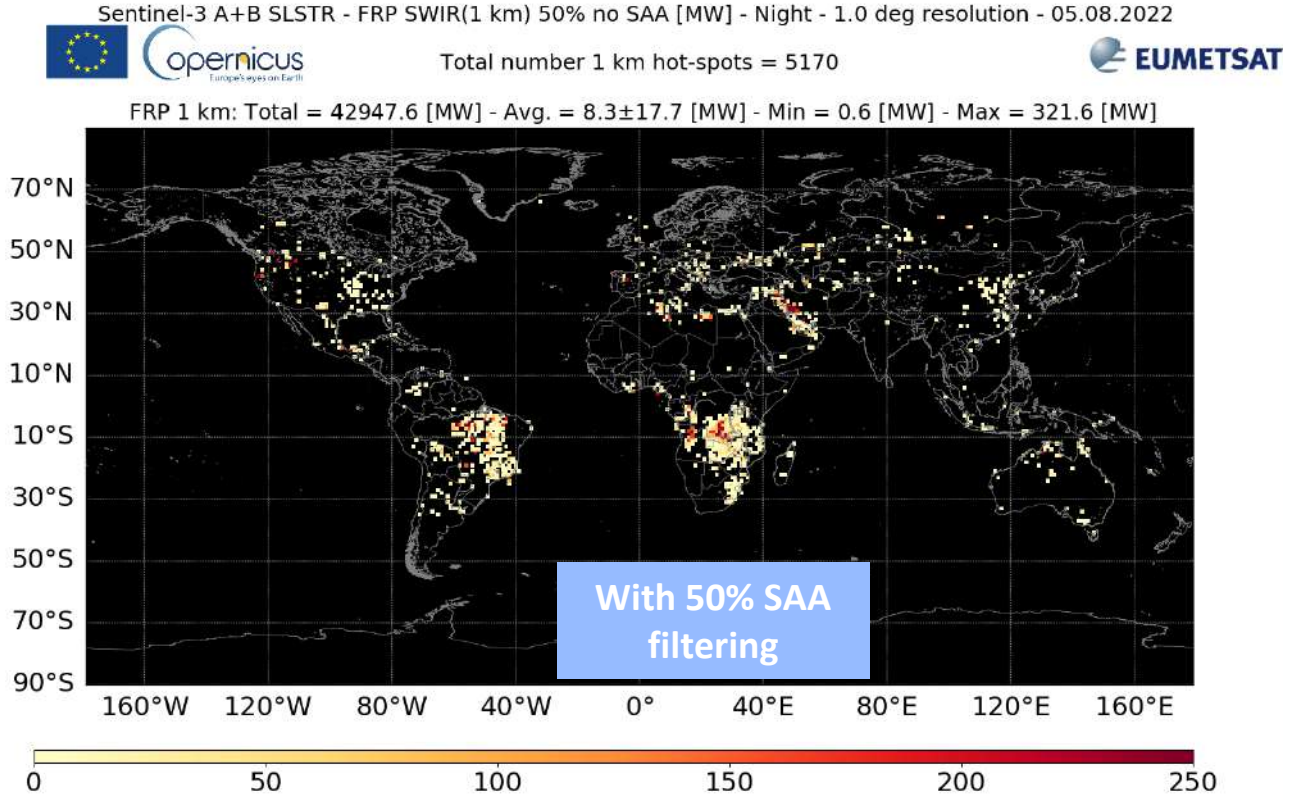


Gas flare Detection Persian Gulf

South-Atlantic filtering

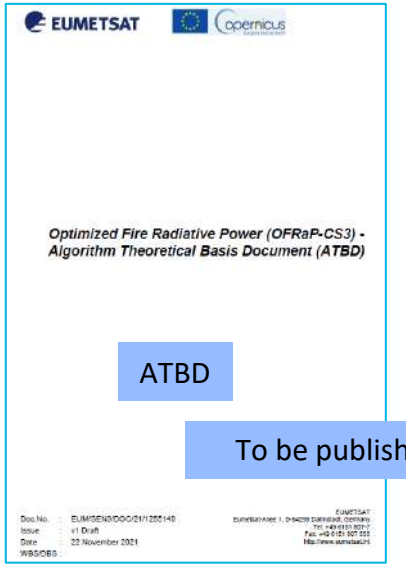
- NRT South-Atlantic Anomaly (SAA) detection – Persistency analyses (spectral / spatial):
  - ~10% FRP SWIR caused by SAA – Recommended confidence threshold > 50%.

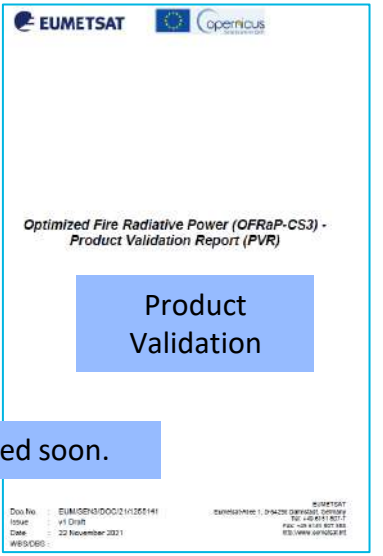




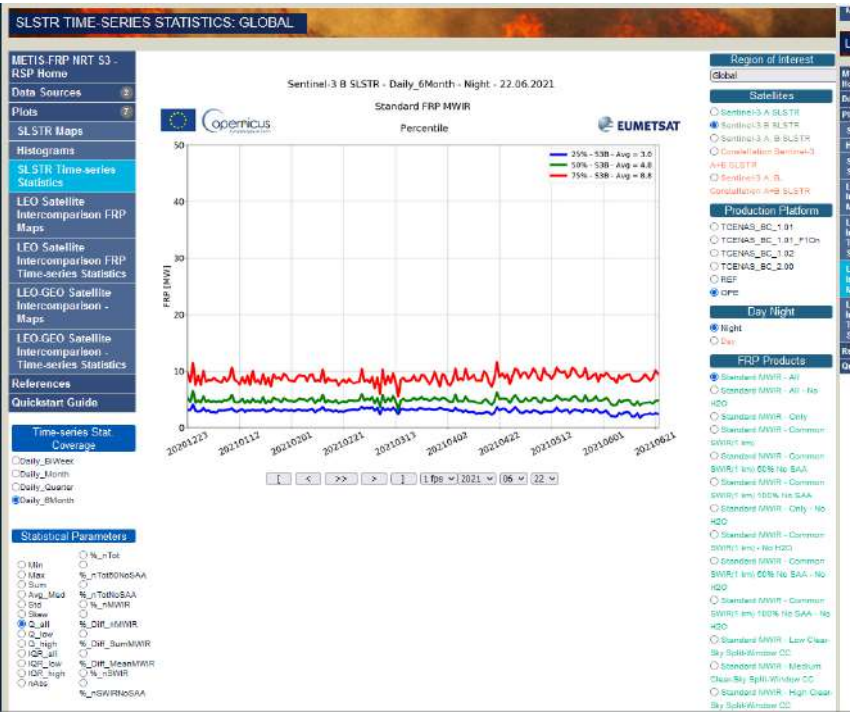
- **Public quality monitoring under preparation => METIS**
  - Internal – Public release under preparation (very soon)
- **Public access to products: EUMETSAT data tailor**

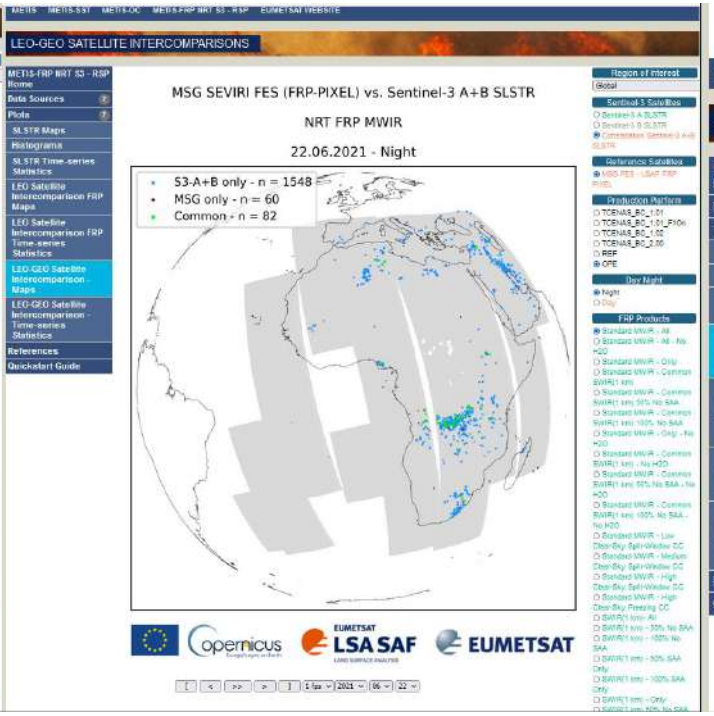
- Websites (under major updates in the next weeks):
  - OFRaP-CS3 processor: https://www.eumetsat.int/S3-NRT-FRP
  - NRT Fires Collection 2: https://www.eumetsat.int/release-collection-2-s3-nrt-fire-radiative-power
  - Sentinel-3 Atmospheric composition (NRT): https://www.eumetsat.int/atmospheric-composition
  - METIS – Daily maps: https://metis.eumetsat.int/frp/index.html

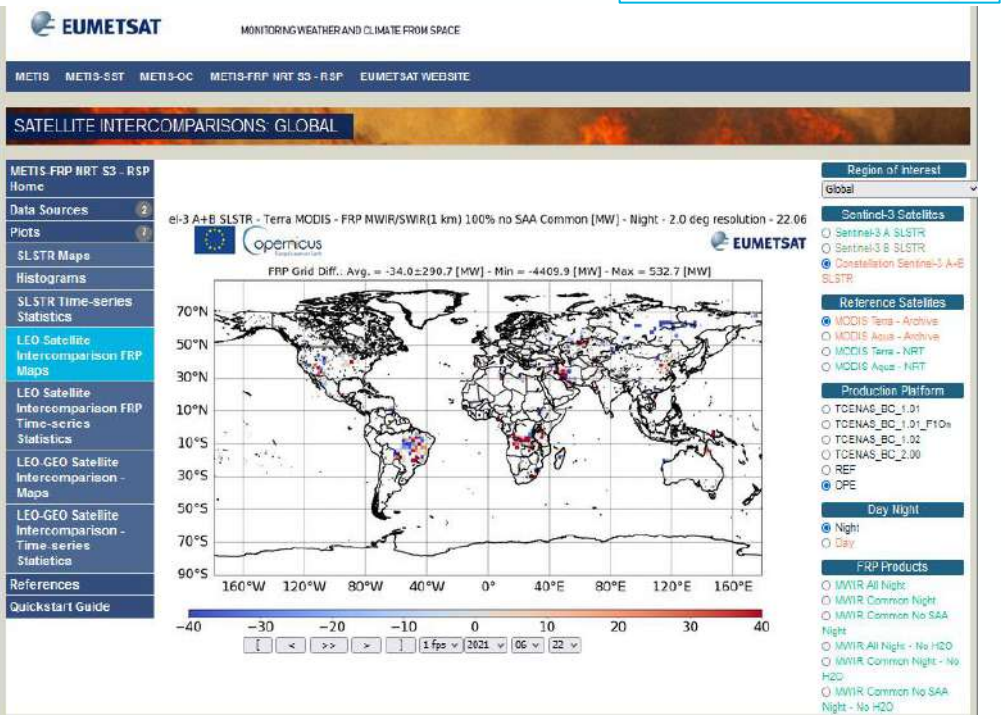




To be published soon.







Way forward

EUMETSAT is leading the NRT Copernicus Sentinel-3 L2 Fire product
night-time since 2020 - day-time since 2021.

- Publicly available from EUMETSAT Data Store https://data.eumetsat.int/search
- Multiple algorithms + confidence classes.
- Documentation Collection 2.0 https://www.eumetsat.int/release-collection-2-s3-nrt-fire-radiative-power
- Internal Validation monitoring
- **Coordination with users and new requests for evolved product content (smaller size, new format, etc…):** *e.g.* NILU, NASA, EFFIS, ECMWF/CAMS
- Active support to preparation of Global Fire Assimilation Service (GFAS).

Strong partnership with King's College London (KCL) + LandSaf (IPMA) being renewed for MSG, Sentinel-3, MTG.