

FCI view on Fires

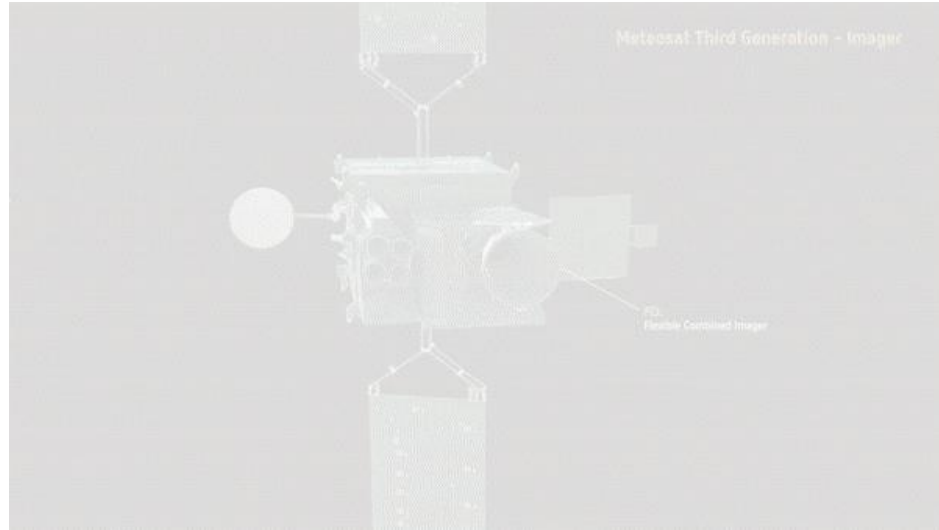
Exploring the fire monitoring detection





- Fire parameters?
- What to use to detect fires?





- The FCI imager is one of the two main payloads onboard the Meteosat Third Generation Imaging (MTG-I) satellites.

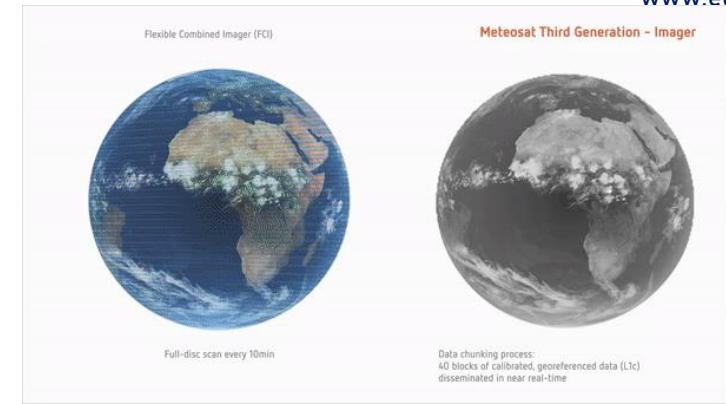
- First FCI on MTG-I1: **full disk scanning service (FDSS)** with **10min** temporal resolution.
- Second FCI on MTG-I2: **rapid scanning service (RSS)** over Europe with **2.5min** temporal resolution.



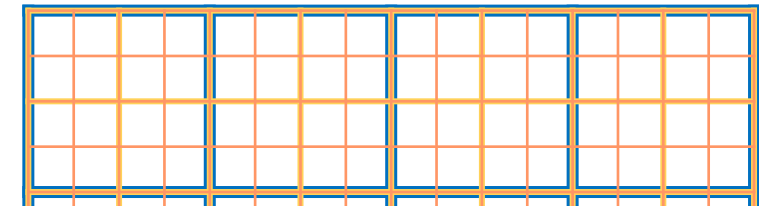
The entire fire cycle can be observed by FCI with unprecedented temporal detail!

FCI – Overview – A big step forward!

- 8 channels in the solar VIS-NIR domain (0.4μm - 2.2μm), 1km spatial resolution at nadir (FDHSI).
- 8 channels in the thermal IR domain (3.8μm - 13.3μm), 2km spatial resolution at nadir (FDHSI).
- 4 channels are also available at higher spatial resolution (HRFI):
 - VIS0.6 and NIR2.2: 0.5km (nadir)
 - IR3.8 and IR10.5: 1km (nadir)



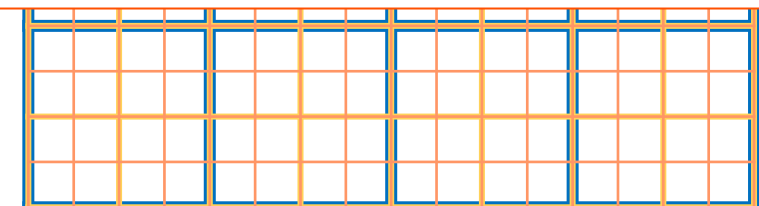
2 km 1 km 0.5 km



No.	Central λ / μm	λ width / μm	Resolution / km	No.	Central λ / μm	λ width / μm	Resolution / km
1	0.44	0.06	1.0	9	3.80 🔥	0.40	2.0/1.0
2	0.51	0.04	1.0	10	6.30	1.00	2.0
3	0.64	0.05	1.0/0.5	11	7.35	0.50	2.0
4	0.86	0.05	1.0	12	8.70	0.40	2.0
5	0.91	0.02	1.0	13	9.66	0.30	2.0
6	1.38	0.03	1.0	14	10.50 🔥	0.70	2.0/1.0
7	1.61 🔥	0.05	1.0	15	12.30	0.50	2.0
8	2.25 🔥	0.05	1.0/0.5	16	13.30	0.60	2.0



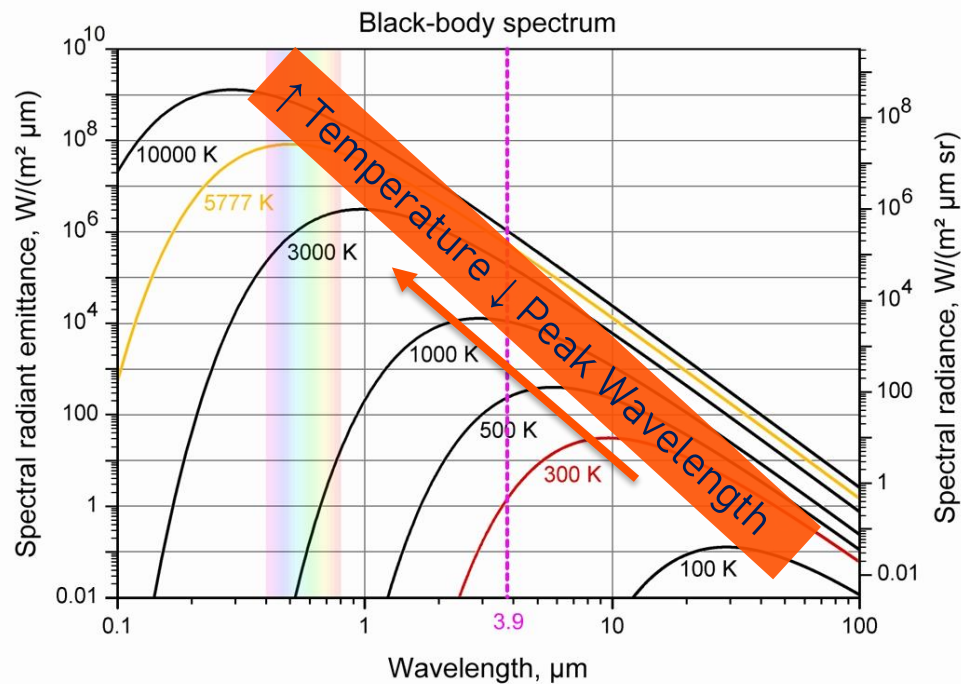
Fires and hotspots can be observed by FCI with unprecedented spatial detail!



All channels have the same reference grid



- **More sensitivity** with IR3.8 channel for sub-pixel signals/fires
- **Larger dynamic range** to maximise detection performance (with double detector array)
- **More channels** for fire intensity (IR3.8, NIR2.25, NIR1.6)
- Main instrument improvements on FCI compared to SEVIRI:
 - Better spatial resolution
 - -> from 3km to 1km (9 times more pixels!) for 3.8 μ m channel
 - -> from 3km to 500 m (36 times more pixels!!) in the near-IR region
 - **Higher saturation** brightness temperature -> from ~335K to ~490K (TBC)
 - **Less CO₂ absorption** and **limb cooling** for 3.8 μ m channel (central wavelength shift from 3.9 μ m to 3.8 μ m)
 - **Higher radiometric resolution** for 3.8 μ m channel -> from 10 bits to 13 bits (10 bits to 12 bits improvement for rest of the channels)
 - **Less “blinding”** effect -> from spinning to 3-axis stabilised platform



- Planck/Wien's law:
the hotter the object (🔥), the shorter the wavelength at which it emits the most
- Typical 🔥 temperature: 600K-1300K
→ ~ 3.9 μm is the most suitable wavelength range!
 - Highest emission
 - Highest sensitivity to sub-pixel fires
- But hot(ter) fires will appear also in the NIR range



Fire RGB Visualisation Techniques: Fire Temperature RGB

- “Classic” Fire Temperature RGB:
 - Combination of 3.8, 2.2 and 1.6 to show fire temperature in classic RGB scheme
 - New for EUM-GEO, heritage from e.g. VIIRS and ABI

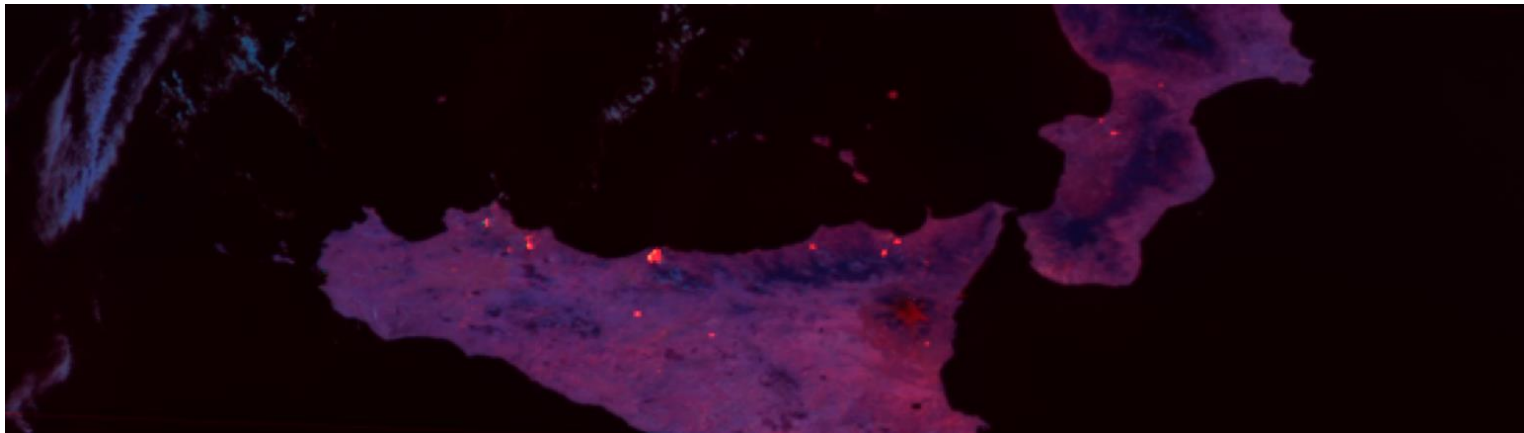
Quick Guide:

https://resources.eumetrain.org/rgb_quick_guides/quick_guides/FireTemperatureRGB.pdf

... or search for “fire temperature rgb eumetrain”

Colour	Channel [µm]	Physically relates to	Smaller contribution to the signal	Larger contribution to the signal
Red	IR3.7	(Fire) temperature <i>Cloud top microphysics</i>	Cold land surfaces <i>water, snow/ice, cold clouds</i>	Low fire temperature, hot spots <i>Warm land surfaces</i>
Green	NIR2.25	Fire temperature <i>Land type, cloud top particle size</i>	<i>Green vegetation, water, snow/ ice, large cloud particles</i>	Medium fire temperature, <i>Dry grass, bare ground, small cloud particles</i>
Blue	NIR1.6	Fire temperature <i>Land type, cloud top phase</i>	<i>Green vegetation, water, snow/ice, ice clouds</i>	High fire temperature <i>Dry vegetation, bare ground, water clouds</i>

Range			Gamma
273	333	K	0.4
0	100	%	1
0	75	%	1




Interpretation

1	warm fire, hot spot
2	very warm fire
3	hot fire
4	extreme intense fire
5	burn scars (day)
6	land surface (day)
7	water, snow, ice, night-time
8	water cloud (day)
9	ice cloud (day)



Fire RGB Visualisation Techniques: True Color + Fire Temp

- True-/Geo-Color in background + Fire Temp representation blended on top
- Fire Temperature Representation:
 - Addition of $3.8\mu\text{m}$ BT + $2.2\mu\text{m}$ Refl
 - Colourisation using Red-to-Yellow colorbar: 330  430
- Blending of True Color with Fire Temp needs a fire mask!
 - Simple fire detection using thresholds on $3.8\mu\text{m}$, $10.5\mu\text{m}$ and $0.6\mu\text{m}$
- Preliminary, further tuning and enhancement needed
 - developments will be pushed to Satpy asap!

Advantages compared to Fire Temperature RGB:

- Easier interpretation of background for better situational awareness
- Smoke is much more visible (wind direction!)
- Clouds are more visible and easier to interpret
- ...

Disadvantages:

- Requires solid fire mask for blending (integration of L2?)
- Burn scar age not interpretable
- ...





Scenario: You are in charge of giving the flight routes and dump locations for aerial firefighting in your country? Based on SEVIRI data, think of the flight routes from the sea to the fires (avoiding smoke if possible), and locate the water dump locations (based on the location of most intense fires)?

Focus on the advanced **spatial**, **spectral** and **radiometric** resolution of FCI:

- **Spatial resolution** benefits:
 - the shape of the fires, fire fronts and burn scars
 - detection of smallest fires
- **Spectral resolution** benefits:
 - information about the fire intensity (indication of most active fires, ie fire fronts) with additional NIR 2.25 channel → Fire Temperature RGB
 - better smoke detection through additional VIS0.4 and VIS0.5 channels → True Colour RGB
- **Radiometric resolution** benefits:
 - better fire intensity information → Fire Temperature RGB
- **Temporal resolution** benefits:
 - fire intensity dynamics (fires intensifying / diminishing)
 - fire front dynamics (direction of fire spread / low level winds)
 - fire initiation (quicker initial detection)
 - smoke dynamics (smoke spread and thickness monitoring)
 - wind dynamics (tracking the smoke and surrounding clouds advection (rate))

SEVIRI Natural Color 3km Fire Temperature 3km (3.8 μ m)

05.08.2023 10:00 UTC

MSG-SEVIRI
For comparison

Smoke?



Water fetch area
for airplanes

Intense fires at
the core?





Scenario: You need to send ground troops to clear the vegetation in front of the fires to stop its spread. Based on one SEVIRI image available, where would you send firefighters, to which side of the fire?

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SEVIRI Natural color 3km

Fire Temperature 3km

(3.8 μ m)

18.03.2023 15:45 UTC

Demonstrating FCI's capabilities

Observing fires in the sub-Saharan region

Preliminary results





Scenario: You gave a lecture on Fire Temperature RGB using the imagery below. Now you need to answer the question from the student: “Why NIR1.6 channel is used at all, while it seems that NIR2.25 captured all the hotter fires, even at higher resolution of 500 m? We could add another channel instead, that would eg show a smoke signal (eg VIS0.4).”

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FCI IR3.8 1km
22.09.2023 10:40 UTC
273-333K, 0.4 Gamma

Demonstrating FCI's capabilities
Observing Fires in Botswana
Preliminary results



FCI NIR2.2 500m

22.09.2023 10:40 UTC

0-100% Refl

Demonstrating FCI's capabilities

Observing Fires in Botswana

Preliminary results



FCI NIR1.6 1km

22.09.2023 10:40 UTC

0-75% Refl

Demonstrating FCI's capabilities

Observing Fires in Botswana

Preliminary results



FCI Fire Temperature RGB 500m
22.09.2023 10:40 UTC

Demonstrating FCI's capabilities
Observing Fires in Botswana
Preliminary results



FCI True Color 0.5km
Fire Temperature 0.5km
22.09.2023 10:40 UTC

Demonstrating FCI's capabilities
Observing Fires in Botswana
Preliminary results



