MTG FCI instrument and services

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outlines

• MTG introduction
• FCI instrument
• FCI applications
• RSS channel selection
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Meteosat Third Generation: Mission

- **Primary mission:** support nowcasting/ Short Range Forecasting of high impact weather
  - Continuity and enhancement of MSG imagery
  - Addition of a new lightning imaging capability
  - New, innovative infrared hyper-spectral sounding
- **Secondary mission:** air quality monitoring over Europe
  - Synergy between Sentinel-4, IRS and imagery
MTG-I imaging mission

- Imagery mission implemented by two MTG-I satellites
- Full disc imagery every 10 minutes in 16 bands
- Fast imagery of Europe every 2.5 minutes
- New Lightning Imager (LI)
- Start of operations in 2021
- Operational exploitation: 2021-2042
MTG-S sounding mission

- Hyperspectral infrared sounding mission
- 3D weather cube: temperature, water vapour, O3, every 30 minutes over Europe
- Air quality monitoring and atmospheric chemistry in synergy with Copernicus Sentinel-4 instrument
- Start of operations in 2023
- Operational exploitation: 2023-2042
Meteosat Third Generation (MTG) full operational configuration

- **MTG-I** Rapid Scan Service
- **MTG-S** Sounding Service
- **MTG-I** Full Scan Service
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• RSS channel selection
From MVIRI through SEVIRI to FCI on MTG

1 = VIS0.6
2 = WV6.2
3 = IR10.8
From MVIRI through SEVIRI to FCI on MTG
From MVIRI through SEVIRI to FCI on MTG

Solar channels provided in 0.5 km / 1.0 km resolution

Thermal channels provided in 1 km / 2 km resolution
FCI preliminary SRFs vs SEVIRI FM4

- VIS0.4
- VIS0.5
- VIS0.6
- VIS0.8
- VIS0.9
- SEVIRI VIS0.6
- SEVIRI VIS0.8
- NIR1.3
- NIR1.6
- NIR2.2
- SEVIRI NIR1.6
- IR3.8
- WV6.3
- WV7.3
- IR8.7
- IR9.7
- IR10.5
- IR12.3
- IR13.3
- SEVIRI IR3.9
- SEVIRI WV6.2
- SEVIRI WV7.3
- SEVIRI IR8.7
- SEVIRI IR9.7
Sampling Distance

MSG spatial resolution Full Disk

3 km
Sampling Distance

MTG spatial resolution Full Disk Thermal

3 km

2 km
Sampling Distance

MTG spatial resolution Full Disk Solar Channels and High Res Thermal

3 km

1 km
Sampling Distance Issues

Have a common reference grid for all these different resolutions!
Spatial resolution and True colour RGB

**Application:**
Weather forecasts for public
Quicklooks for forecasters

courtesy D. Rosenfeld, Univ. Jerusalem
SEVIRI to FCI Performance Enhancements

SEVIRI
- 15 min full disc repeat cycle
- SNR 1.2 to 10.1
- NEdT 0.25 to 1.8K
- IR3.9 up to 335K
- 1.0 km HRV
- 3 km non-HRV

FCI
- 10 min full disc repeat cycle
- SNR 12 to 40
- NEdT 0.1 to 0.3K
- IR3.8 up to 450K
- FDHSI:
  - 8 x 1 km channels
  - 8 x 2 km channels
- HRFI:
  - 2 x 0.5 km channels
  - 2 x 1 km channels
SEVIRI to FCI Data Collection Differences

SEVIRI
- Continuous E to W scan
- S to N motion between swaths
- Swath width 9km
- Time between points either side of swath boundary 0.6s

FCI
- Alternate E to W then W to E scans
- S to N motion between swaths
- Swath width 180km (excluding overlap)
- Time between points either side of swath boundary 0 to 20s max at equator
- Reversal of detector order for yaw flip, but not scan pattern.
FCI units are being produced

- Baffles assy, courtesy APCO
- Structure assy, courtesy EADS
- Optical Bench, courtesy EADS
- Calibration Mechanism, courtesy SEN
- MND, courtesy AMOS
- BB, courtesy ABB/MICOS
- Cooler Assy, courtesy ALAT
- NIR DA, courtesy SOF
- VISDA, courtesy E2V/JOP
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FCI applications – Nowcasting and risk monitoring

- Cloud and moisture (imagery + products)
- Convection
- Wind
- Hurricane/storm intensity
- Land surface temperature
- Fire
- Total Precipitable Water
- Rainfall rate
- Snow cover
- Smoke, dust, volcanic ash
- Flooding
- Aviation
Benefits just from the FCI...

- New channels (0.444 µm and 0.51 µm) will support true colour images and permit surpassing current aerosol retrievals especially over land – also an important contribution to air quality monitoring.

- The 0.91 µm channel will provide during daytime total column precipitable water especially over land surfaces.

- The 1.375 µm channel will improve detection of very thin cirrus clouds not seen by the current system. If not detected, errors are introduced in all clear sky products.

- The 2.26 µm channel will provide the capability for an improved retrieval of cloud microphysics.

- The higher spatial resolution (1 km and 2 km) of the 3.8 µm channel will improve fire detection and, via its extended dynamical range (from 350 K to 450 K), the quality of products.

- To improve the convection detection through the shorter repeat cycle and better spatial resolution.
FCI L2 products HQ (produced by EUMETSAT)

- Atmospheric Motion Vectors
- All Sky Radiance
- Cloud Mask
- Clear Sky Reflectance Map
- Cloud Analysis (CTTH, Cloud Type)
- Fire
- Global Instability Index
- Optimal Cloud Analysis
- Total Ozone Column
- Volcanic Ash
outlines

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## One instrument – Two missions

<table>
<thead>
<tr>
<th></th>
<th>Full Disc Hyper-Spectral Imagery</th>
<th>High Resolution Fast Imagery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral</td>
<td>16 channels</td>
<td>4 channels</td>
</tr>
<tr>
<td>Repeat cycle</td>
<td>10 min</td>
<td>2.5 min</td>
</tr>
<tr>
<td>SSD VNIR</td>
<td>1 km</td>
<td>500 m</td>
</tr>
<tr>
<td>SSD IR</td>
<td>2 km</td>
<td>1 km</td>
</tr>
<tr>
<td>MTF @ Nyquist</td>
<td>0.15 &lt; MTF &lt; 0.3</td>
<td>~ 0.3</td>
</tr>
<tr>
<td>SNR @ ρ=0.01 VNIR</td>
<td>&gt; 20</td>
<td>&gt; 12 for VIS0.9</td>
</tr>
<tr>
<td>NEdT @ Tref IR</td>
<td>&gt; 12 for VIS0.9</td>
<td>0.1-0.3 K</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 K for Fire</td>
</tr>
<tr>
<td>Radiometric accuracy</td>
<td>&lt; 5 %</td>
<td>&lt; 0.7 K</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VIS0.6 &amp; NIR2.2 &lt; 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IR3.8 &amp; IR10.5 &lt; 1K</td>
</tr>
<tr>
<td>Lifetime &amp; Availability</td>
<td>8.5 years &amp; &gt; 96%</td>
<td>8.5 years &amp; &gt; 96%</td>
</tr>
</tbody>
</table>

*courtesy ESA*
The Flexible Combined Imager (FCI) on Meteosat Third Generation (MTG) can support 2 alternative and distinct missions:

(1) Full Disc (FD) High Spectral Resolution Imagery (FDHSI) in support of the Full Disc Scanning Service (FDSS), or (2) High Spatial Resolution (HR) Fast Imagery (HRFI) in support of the Rapid Scanning Service (RSS)

For a given spacecraft, it will be decided to pick one or the other. MTG-I1 is expected to perform FDSS (although it may be decided otherwise before launch).

What this means for the Space Segment and Level-0 to Level-1 processing:

→ **FDSS**: The full Earth disk is acquired, transmitted and processed every 10 minutes
→ **RSS**: The Northern quarter disk is acquired, transmitted and processed every 2.5 minutes

The only difference between the two services in practice is the scan law.
One instrument – Two missions

In both FDSS and RSS services, **17 Level-0 channels** are acquired and transmitted to ground:

- FDVIS0.4 at 1 km
- FDVIS0.5 at 1 km
- HRVIS0.6 at 0.5 km
- FDVIS0.8 at 1 km
- FDVIS0.9 at 1 km
- FDNIR1.3 at 1 km
- FDNIR1.6 at 1 km
- HRNIR2.2 at 0.5 km
- HRIR3.8 at 1 km (cold channel)
- FAIR3.8 at 1 km (warm channel)
- FDIR6.3 at 2 km
- FDIR7.3 at 2 km
- FDIR8.7 at 2 km
- FDIR9.7 at 2 km
- HRIR10.5 at 1 km
- FDIR12.3 at 2 km
- FDIR13.3 at 2 km
One instrument – Two missions

In both FDSS and RSS services, **20 Level-1c TOA radiance products** are produced by the Level-0 to Level-1c operational processor (IDPF-I) and archived:

**16 FD Level-1c Products:**

- FDVIS0.4 at 1 km
- FDVIS0.5 at 1 km
- FDVIS0.6 at 1 km (from HRVIS0.6 MTF-filtered and down-sampled)
- FDVIS0.8 at 1 km
- FDVIS0.9 at 1 km
- FDNIR1.3 at 1 km
- FDNIR1.6 at 1 km
- FDNIR2.2 at 1 km (from HRNIR2.2 MTF-filtered and down-sampled)
- FMIR3.8 at 2 km (from HRIR3.8/FAIR3.8 merged & MTF-filtered and down-sampled)
- FDIR6.3 at 2 km
- FDIR7.3 at 2 km
- FDIR8.7 at 2 km
- FDIR9.7 at 2 km
- FDIR10.5 at 2 km (from HRIR10.5 MTF-filtered and down-sampled)
- FDIR12.3 at 2 km
- FDIR13.3 at 2 km
One instrument – Two missions

...and

4 HR Level-1c Products:
HRVIS0.6 at 0.5 km
HRNIR2.2 at 0.5 km
HMIR3.8 at 1 km (from HRIR3.8/FAIR3.8 merged)
HRIR10.5 at 1 km

Note that in a given service, all of the above-mentioned Level-1c products (FD and HR) have the same spatial coverage and temporal resolution.
One instrument – Two missions

What it means for the baseline Level-1c (our current given mandate) dissemination to operational users and SAFs (via EUMETCast):

FDSS: Only the 16 FD products are disseminated

RSS: Only the 4 HR products are disseminated

What it means to EUMETSAT in-house Level-2 operational processor (L2PF):

FDSS: Only the 16 FD products are ingested and processed

RSS: No mandate to do anything!
One instrument – Two missions

RSS mission

<table>
<thead>
<tr>
<th>Level-0</th>
<th>L1c archived</th>
<th>L1c disseminated</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 channels</td>
<td>16 FD channels</td>
<td>Ø</td>
</tr>
<tr>
<td></td>
<td>4 HR channels</td>
<td>4 HR channels</td>
</tr>
</tbody>
</table>

2.5 min
One instrument – Two missions

FDSS mission

<table>
<thead>
<tr>
<th>Level-0</th>
<th>L1c archived</th>
<th>L1c disseminated</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 channels</td>
<td>16 FD channels</td>
<td>16 FD channels</td>
</tr>
<tr>
<td>4 HR channels</td>
<td></td>
<td>Ø</td>
</tr>
</tbody>
</table>
FCI dissemination is costly!

- Three products are the main contributors to the EUM dissemination
- FCI represents half of the bandwidth
- 4 High Resolution channels (HR) = 16 Normal Resolution (NR) channels
FCI dissemination is costly!

Budget evolution (in Mbps)

- MSG
- MTG-I1
- MTG-S1
- MTG-I2

<table>
<thead>
<tr>
<th></th>
<th>MSG</th>
<th>after MTG-I1 (IOC)</th>
<th>after MTG-S1 (POC)</th>
<th>after MTG-I2 (FOC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>39</td>
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<td></td>
<td></td>
<td>39</td>
<td>39</td>
</tr>
</tbody>
</table>
### [EURD] Evolution: proposed L1 dissemination baseline

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Previous Level 1 “baselines” existing in //</th>
<th>New unified baseline [MTGDIS]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FCI</strong></td>
<td>Council approved</td>
<td>Council Autumn 2018</td>
</tr>
<tr>
<td>FDSS</td>
<td><strong>Sat</strong> LR (jpeg, 30mn) 16 channels NR</td>
<td><strong>16 channels NR</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Ter</strong> 16 channels NR none</td>
<td>none</td>
</tr>
<tr>
<td><strong>FCI</strong></td>
<td><strong>Sat</strong> LR (jpeg, 30mn) 4 channels HR</td>
<td><strong>16 channels NR</strong></td>
</tr>
<tr>
<td>RSS</td>
<td><strong>Ter</strong> 4 channels HR none</td>
<td>4 channels HR (TBC)</td>
</tr>
<tr>
<td><strong>LI</strong></td>
<td><strong>Sat</strong> L1b events none</td>
<td>None (only L2)</td>
</tr>
<tr>
<td></td>
<td><strong>Ter</strong> none</td>
<td>none</td>
</tr>
<tr>
<td><strong>IRS</strong></td>
<td><strong>Sat</strong> none</td>
<td>300 PC per pixel</td>
</tr>
<tr>
<td></td>
<td><strong>Ter</strong> 300 PC per pixel full radiance</td>
<td>full radiance spectra (to global NWP center, if needed)</td>
</tr>
<tr>
<td></td>
<td>spectra</td>
<td></td>
</tr>
<tr>
<td><strong>UVN</strong></td>
<td><strong>Sat</strong> TBD low resolution TBD</td>
<td>None (only L2)</td>
</tr>
<tr>
<td></td>
<td><strong>Ter</strong> TBD low resolution TBD</td>
<td>6+1 products</td>
</tr>
</tbody>
</table>

- **FCI L1**: FDSS and RSS are harmonised with the same 16 channels for both (normal resolution - NR);
- Dissemination of High resolution (HR) channels to be re-assessed with experience in-orbit and evolution of technology;
- **IRS L1** timeliness improved from 30mn to 15mn
Conclusion

- The MTG system will become the cornerstone of European operational meteorology in GEO orbit.

- MTG will both ensure continuity of MSG and will enable major improvements of services.

- FCI space-segment and ground segment generate more Level-1 products than specified for a given service (FD or RSS).

- Enhanced dissemination of FCI Level-1 products in the RSS service is proposed to EUMETSAT council:
  - The 16 NR channels disseminated via EUMETCast satellite
  - The 4 HR channels disseminated via EUMETCast terrestrial

- The user community needs to prepare for the new MTG opportunities!
Backup slides
Essentially the data processing techniques applied to the SEVIRI and FCI data are similar, differing in the precise details of the algorithms.

The processing steps that can be optionally applied to the data will be flagged in the FCI level 1 dataset auxiliary data, together with an indication of the success of the processing.
SEVIRI data is provided in the so called native format – a binary representation that whilst compact needs a dedicated knowledge of the format to decode its content. For the FCI level 1c data netCDF-4 (enhanced data model) was chosen as it has the following features:

- Datasets are self describing
- Copes with large dataset sizes
- Groups allow potential for easier subsetting

The use of channel groups, swath-like data chunk files and the inclusion of suitable metadata in the archive catalogue will assist in spectral and geographic subsetting.