Assessment of FCI data onboard Meteosat-12 at ECMWF

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FCI / Meteosat-12 overview

EUMETSAT's Meteosat Third Generation Imaging satellites carry the Flexible Combined Imager (FCI) instrument which is the upgraded continuation of the Meteosat Second Generation (MSG) SEVIRI instrument. The primary goal with FCI is to provide continuity to SEVIRI 0° operational service.

Infrared radiances: At ECMWF, we use the Level-2 All-Sky Radiance (ASR) product, providing continuous full-disk infrared observations every 10 minutes, at a spatial resolution of 16x16 pixels (32x32 km at nadir).

Visible reflectances: Given the suite of visible channels, FCI Level-1c data are also attractive for developing ECMWF's capabilities for the monitoring and assimilation of visible reflectances, an area of active research at ECMWF and elsewhere.

Spectral response functions: FCI & SEVIRI

Solar channels: 8 (FCI), 3 (SEVIRI)

- FCI instruments will operate additional spectral bands in the visible blue and green wavelengths (444 and 510 nm) and short-wave infrared as shown in Figure 1.

Thermal channels: 8 (FCI), 8 (SEVIRI)

- FCI has similar channels in the thermal infrared to SEVIRI, with central wavelengths slightly shifted and a smaller bandwidth to better isolate the spectral signature of the atmospheric components.

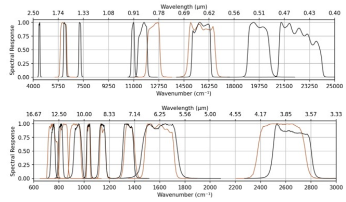


Fig. 1: SRFs for each of FCI (black line) and SEVIRI (brown line): solar channels (top) and thermal channels (bottom).

FCI visible reflectances (0.64 µm)

Monitoring in the IFS: FCI assessment against SEVIRI

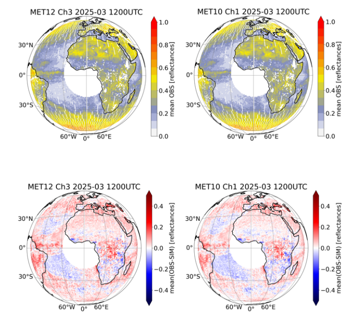


***Fig. 2**: Monthly means of observed 0.64 µm reflectances (top row) and monthly means of first guess departures in the IFS (bottom row) for FCI (left) and SEVIRI (right) images. The red (blue) shading shows where the IFS has reflectances that are too low (high) compared to the observations.*

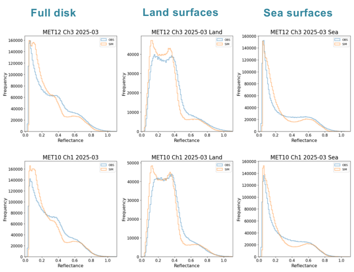
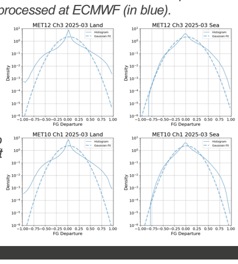


***Fig. 3**: Reflectance histograms for the 0.64 µm channels onboard FCI (Meteosat-12, top row) and SEVIRI (Meteosat-10, bottom row) based on IFS model fields compared to observations as pre-processed at ECMWF (in blue).*

Fig. 4: First guess departures based on IFS model fields and 0.64 µm reflectances from FCI (top) and SEVIRI (bottom) stratified according to surface type (land/left and sea/right).



- The fast NN-based forward model MFASIS as implemented in RTTOV-14 (Hocking et al., 2025; Scheck et al., 2016) is used in this study for computing cloud affected reflectances based on model profiles from the global IFS model. These are compared to visible reflectances at 0.64 µm from FCI (Meteosat-12) and SEVIRI (Meteosat-10). The observations are used at original full resolution and averaged at approx. 80 km.
- The comparisons shown are based on one month 14th March to 11th April 2025 using hourly imagery. Quality control is applied and exclude data with large solar and satellite zenith angles, sun glint regions, sea ice and other surface and BRDF related aspects.
- Monthly mean first-guess departures on the map offer initial insights into typical regional model biases. Overall, the magnitude of differences is similar for FCI and SEVIRI (0.64 µm). However, some systematic biases are evidenced over some areas (e.g., Africa), possibly related to shortcoming in the specification of BRDF surface reflectances.
- The overall shape of observed reflectance histogram is well reproduced in the simulation (Fig. 3).
- Statistics of reflectance difference between model and observation (Fig. 4) for 0.64 µm show a nearly symmetric and unbiased behaviour. Results for FCI and SEVIRI are broadly similar.
- The study of reflectance histograms and first guess departures stratified by surface type (land, sea) represents a first step toward a situation-dependent analysis of biases.
- This study lays the groundwork for routine operational monitoring of visible reflectances in the IFS and provide guidance regarding the expected performance of MFASIS-NN observation operator and the requirements for data screening.

FCI infrared radiances (6.3 and 7.35 µm)

Monitoring in the IFS: FCI assessment against SEVIRI

- Focus on clear-sky radiances from two water vapour sensitive infrared channels (6.3 and 7.35 µm; hourly data; 75 km spatial resolution).
- FCI monitored in operations since March 2025 and has demonstrated consistent performance over time with a bias and standard deviation that remain relatively stable.

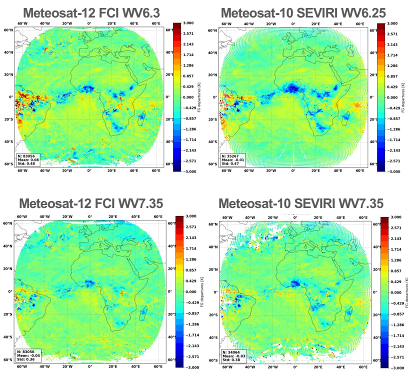


***Fig.5**: Mean first-guess departure (K) statistics for the upper-level (top row) and mid-level (bottom row) tropospheric water vapour channel on FCI (left) and SEVIRI (right) over the period 5th March 2025 to 20th March 2025 for clear-sky scenes.*

Upper-level tropospheric water vapour channel (6.3 µm for FCI and 6.25 µm for SEVIRI):

- Clear-sky scene selection: SEVIRI ASRs *include* low clouds but FCI ASRs *exclude* low clouds.
- Larger first-guess departures bias is observed for FCI compared to SEVIRI similar channel.

Mid-level tropospheric water vapour channel (7.35 µm):

- Similar spectral channel and same data selection for both SEVIRI and FCI.
- Local differences in mean first-guess departures.
- Overall bias and standard deviation are consistent between SEVIRI and FCI.

Assimilation in the IFS: FCI and SEVIRI performance comparison

- Initially, use the same observation errors for FCI as diagnosed with Desroziers approach for SEVIRI.

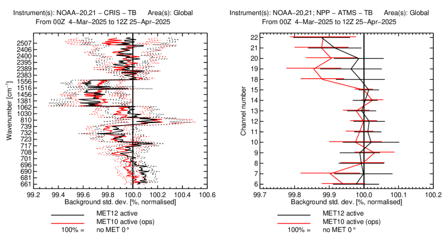


***Fig.6**: Comparison of the impact of adding Meteosat-10 SEVIRI (red – as in current operations), or Meteosat-12 FCI (black) as the Meteosat Prime 0° mission, relative to a control scenario with no Meteosat Prime 0° satellite, from 4th March to 25th April 2025, against CrIS (left) and ATMS (right) observations.*

- Against IR sounders, the addition of either SEVIRI or FCI shows similar impact.
- The addition of Meteosat-10 SEVIRI results in a positive impact against ATMS channels 18 to 20 while Meteosat-12 FCI has a neutral impact on the same channels.
- As the generation of ASR products differs between SEVIRI and FCI, applying SEVIRI's observation errors and data selection criteria may result in underutilising FCI's full potential and performance. Further studies to refine these parameters will ensure better utilisation of FCI water vapour channels in the IFS, maximising their contribution to the system's performance.

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Outlook

- FCI ASR will replace SEVIRI ASR in ECMWF operations later this year.
- Preparatory and research work to support monitoring of visible reflectances in IFS will continue, aiming at operational monitoring of FCI visible reflectances alongside other GEOS/LEOS satellites in the upcoming IFS cycle 50r1 (Q4 2025).

Future work

- FCI **infrared window channel** assessment and its operational activation. Aim to include the skin temperature (SKT) increments into the coupled atmosphere-ocean system to improve the representation of the ocean surface in the ocean model and potentially improve ocean atmosphere forecasts directly through the SKT information.
- Assessment of **observation errors** for infrared channels.
- Address remaining challenges to enable successful assimilation of visible observations, including observation operator refinements, observation error modelling, and the role of model errors and biases.