

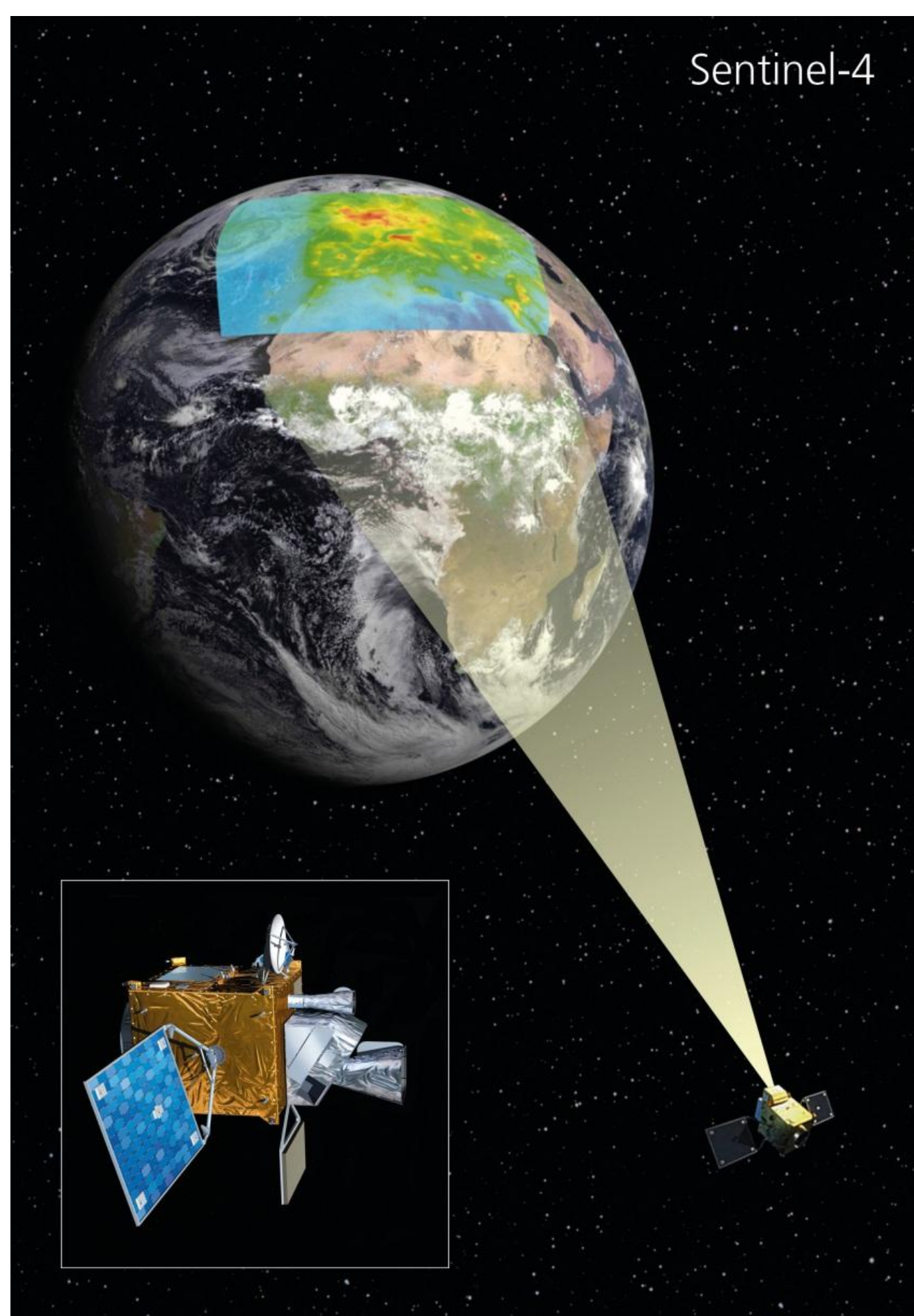
The operational cloud product from Sentinel-4/UVN on MTG-S1

1. Sentinel-4

- ❖ Copernicus atmospheric mission
- ❖ Platform: MTG-S
- ❖ Instrument: UVN
- ❖ objective: **air quality monitoring**
- ❖ **geostationary** orbit
- ❖ **hourly** temporal resolution
- ❖ coverage: Europe
- ❖ spatial resolution: 8 x 8 km²
- ❖ spectral coverage: UV-VIS-NIR
- ❖ spectral resolution: 0.12-0.5 nm
- ❖ Launch: July 2025
- ❖ L2 Status: Commissioning

❖ Copernicus L2 data products:

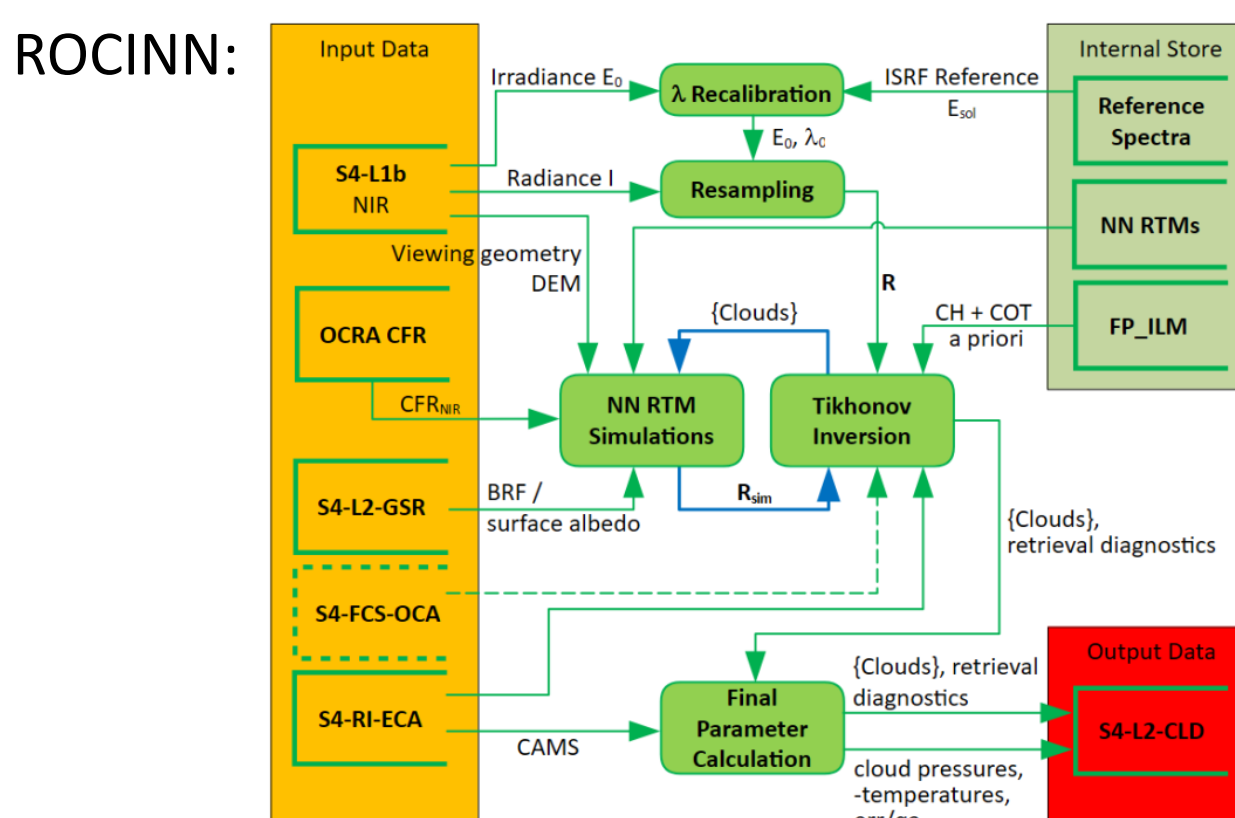
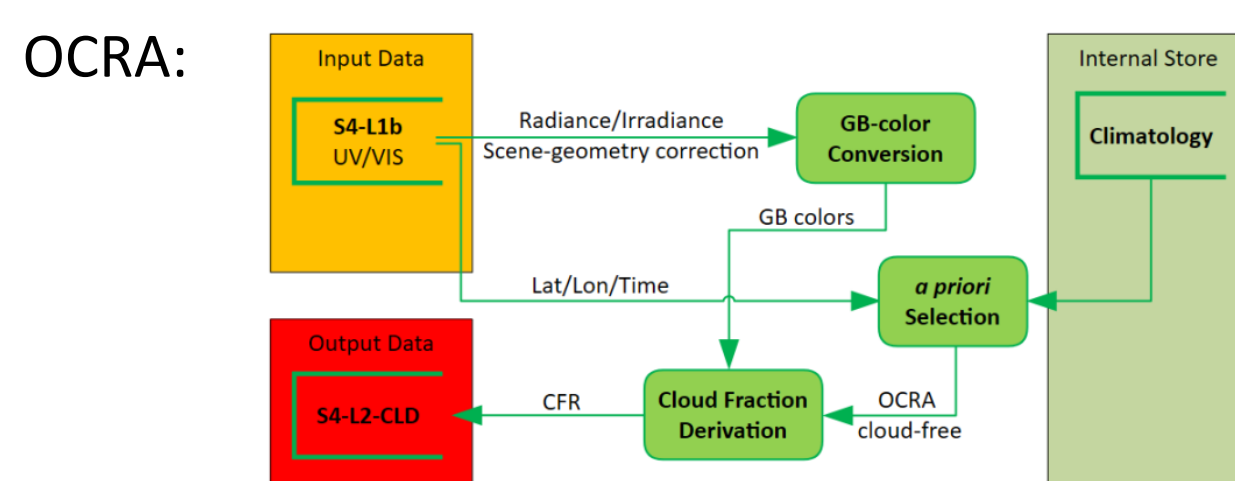
- Total Ozone
- Tropospheric Ozone
- Nitrogen Dioxide
- Sulfur Dioxide
- Formaldehyde
- Glyoxal
- **Clouds**
- Aerosols
- Surface properties
- Auxiliary Information



2. Cloud Retrieval Algorithms at DLR

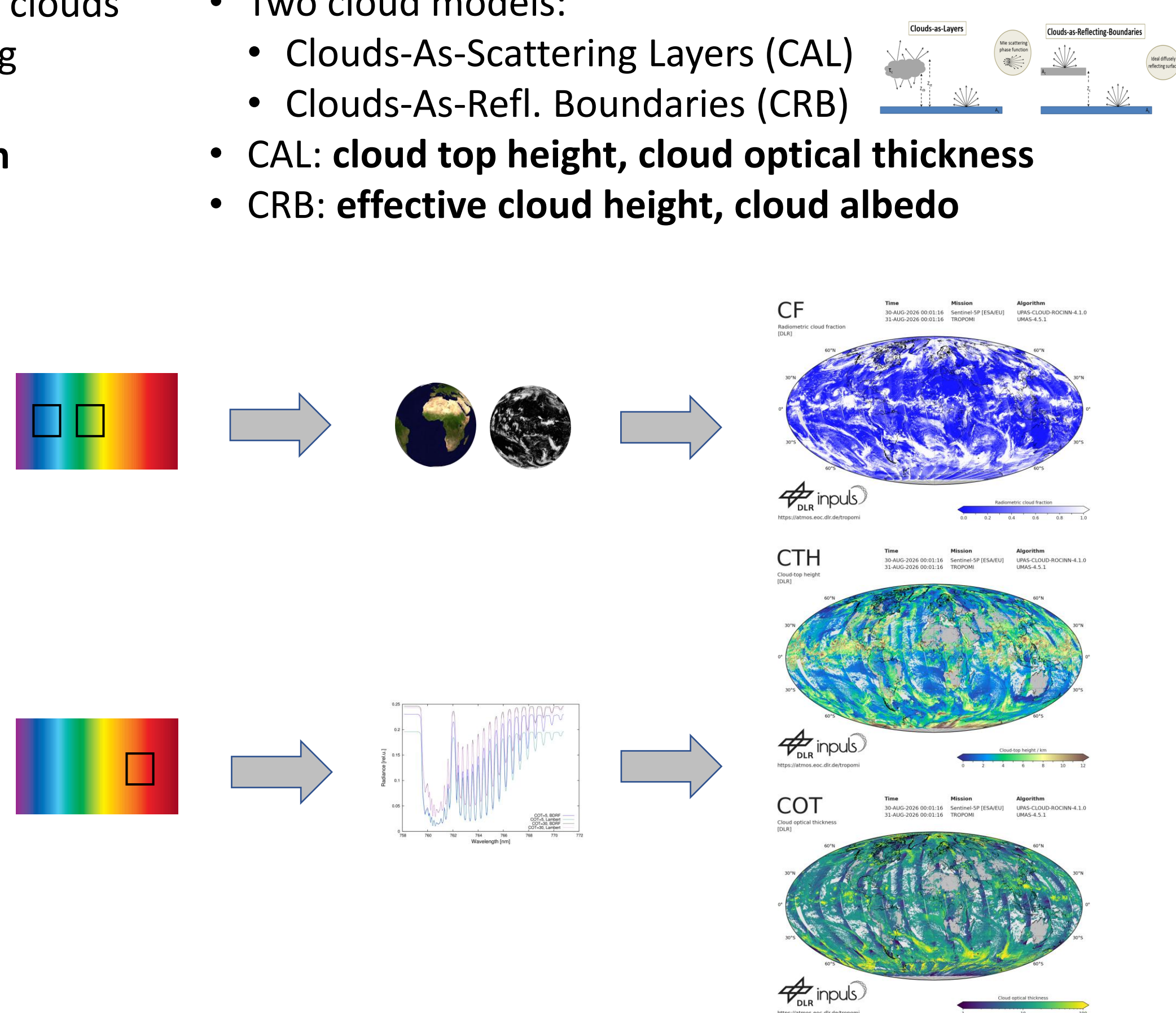
❖ OCRA (Optical Cloud Recognition Algorithm)

- Color space approach in the UV/VIS
- Separation of a scene into a clear-sky background and a contribution due to clouds
- Rayleigh correction for angular viewing dependencies applied to reflectances
- Retrieval of **radiometric cloud fraction**



❖ ROCINN (Retrieval of Cloud Information using Neural Networks)

- O₂ A-band in the NIR, fitting window 758-771nm
- RTM simulations parameterized with NNs
- Two cloud models:
 - Clouds-As-Scattering Layers (CAL)
 - Clouds-As-Refl. Boundaries (CRB)
- CAL: **cloud top height, cloud optical thickness**
- CRB: **effective cloud height, cloud albedo**



3. Improved Cloud Fraction Retrieval and Comparison with FCI

- ❖ The plots on the **left** show the Sentinel-4 cloud fraction and cloud mask from OCRA without applying a Rayleigh correction

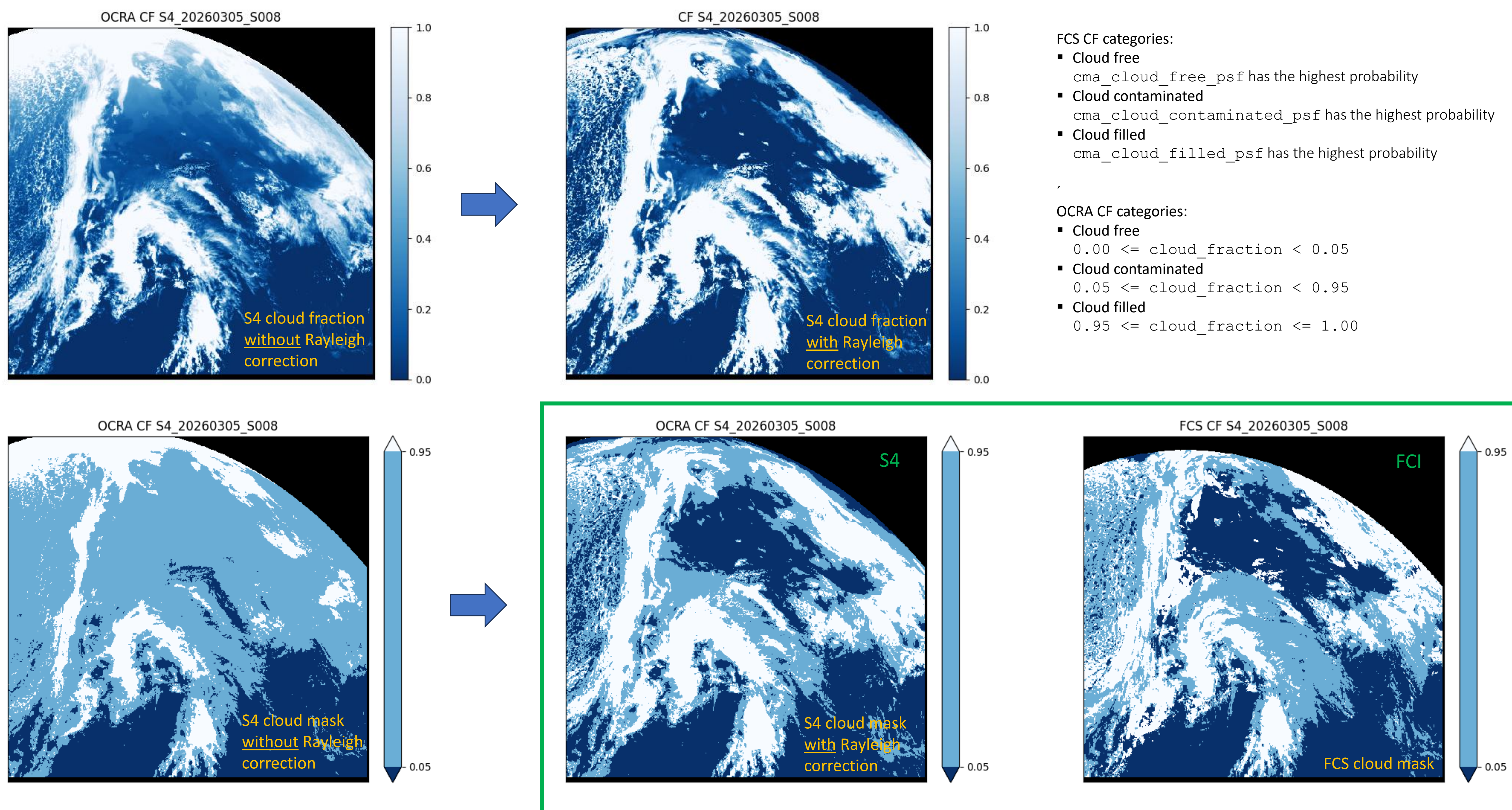
- ❖ The plots in the **middle** show the Sentinel-4 cloud fraction and cloud mask from OCRA with applying a Rayleigh correction

- ❖ The plot on the **right** shows the FCS cloud mask from FCI for comparison. The **S4 FCS** auxiliary product regrids **cloud cover** data from FCI (Flexible Combined Imager on MTG-I) to the Sentinel-4 footprints

- ❖ As demonstrated in the green box, the Sentinel-4 cloud mask agrees very well with the FCI cloud mask

- ❖ When the Sentinel-4 cloud fraction is transferred to a ternary cloud mask (cloud free, cloud contaminated, cloud filled) with the thresholds as indicated on the right, the agreement with the FCS cloud mask is very good (in this example 76.9% of pixels from S4 and FCS have matching categories, i.e. 900.591 out of 1.171.086 pixels)

- ❖ Note that these results are **preliminary!**



- FCS CF categories:
- Cloud free
cma_cloud_free_psf has the highest probability
 - Cloud contaminated
cma_cloud_contaminated_psf has the highest probability
 - Cloud filled
cma_cloud_filled_psf has the highest probability

- OCRA CF categories:
- Cloud free
0.00 <= cloud_fraction < 0.05
 - Cloud contaminated
0.05 <= cloud_fraction < 0.95
 - Cloud filled
0.95 <= cloud_fraction <= 1.00

4. Cloud Top Height Comparison with FCI

- ❖ The **S4 FCS** auxiliary product regrids **cloud top height** data from FCI (Flexible Combined Imager on MTG-I) to the Sentinel-4 footprints

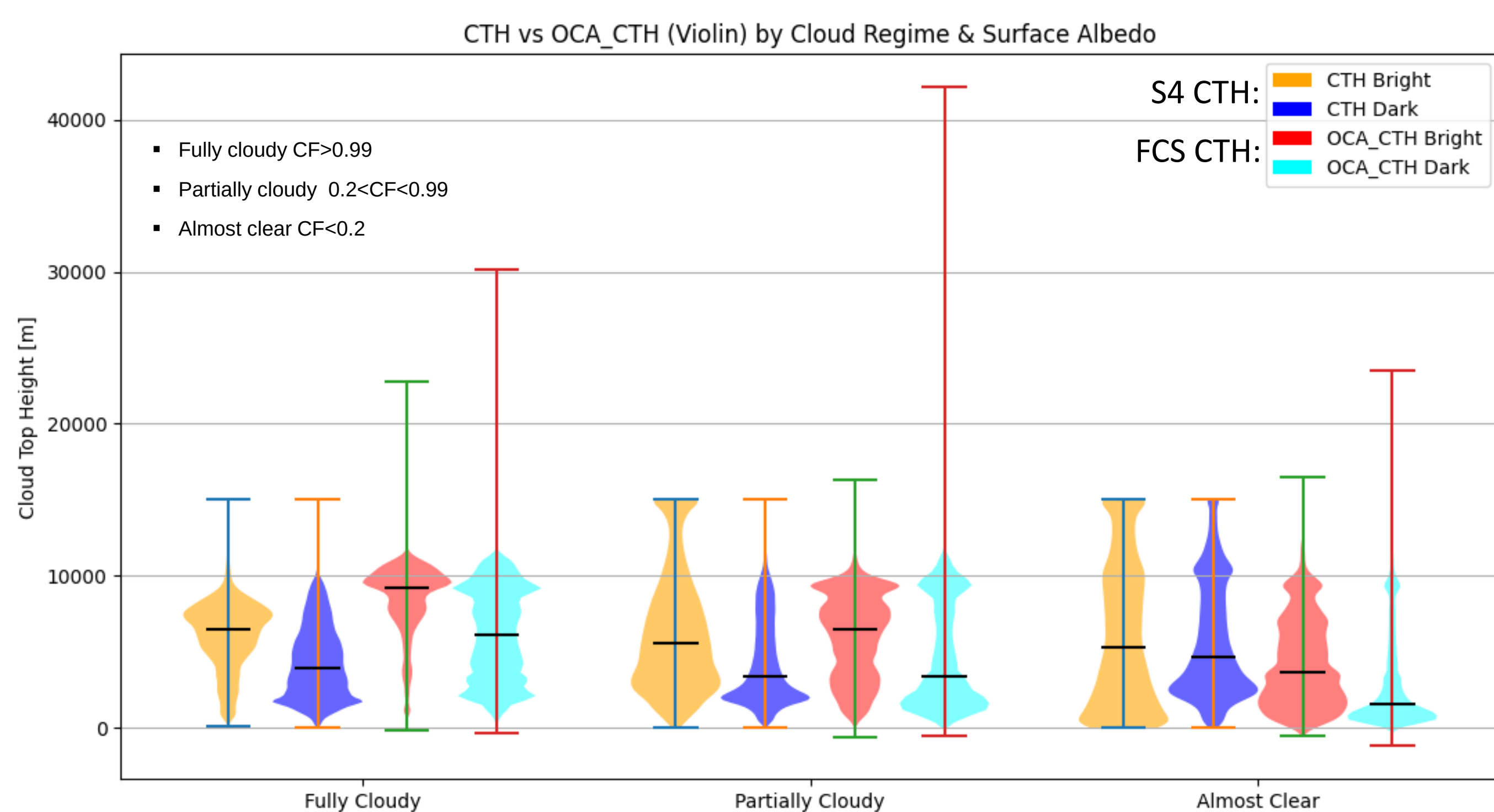
- ❖ The FCI cloud top height is compared to the cloud top height from S4

- ❖ Two different surface types are considered (Bright and Dark)

- ❖ Three different cloud coverages are considered (fully, partially, almost clear)

- ❖ The mean difference over all scenes is around 200m

- ❖ Note that these results are **preliminary!**



5. Summary and Outlook

- ❖ The operational Sentinel-4 L2 Cloud product is presented here. It is based on the algorithm pair **OCRA/ROCINN** (see box 2), which is also used operationally for TROPOMI/Sentinel-5P

- ❖ OCRA/ROCINN is well validated for **LEO** sensors and has now been adapted to a **GEO** sensor. A RTM-based Rayleigh correction for the reflectances of each pixel particularly improves cloud fraction retrievals at large viewing zenith angles (high latitudes) and at large solar zenith angles (close to the terminator)

- ❖ The main retrieved parameters are cloud fraction (from OCRA) and cloud top height, cloud effective height, cloud optical thickness and cloud albedo (all from ROCINN)

- ❖ Initial comparisons of **cloud fraction** to the FCI cloud mask show a very good agreement (see box 3)

- ❖ Initial comparisons of **cloud top height** to the FCI cloud top height show good agreement overall (see box 4). The retrieval performance depends significantly on cloud type, scene conditions and cloud coverage

- ❖ Sentinel-4 is still in **commissioning phase**. Therefore, all results shown here have to be considered as **preliminary!** Several auxiliary information, product meta data and retrieval settings still have to be refined and optimized for the operational phase