Getting started with EarthCARE

Product selection, browsing, access, and tools

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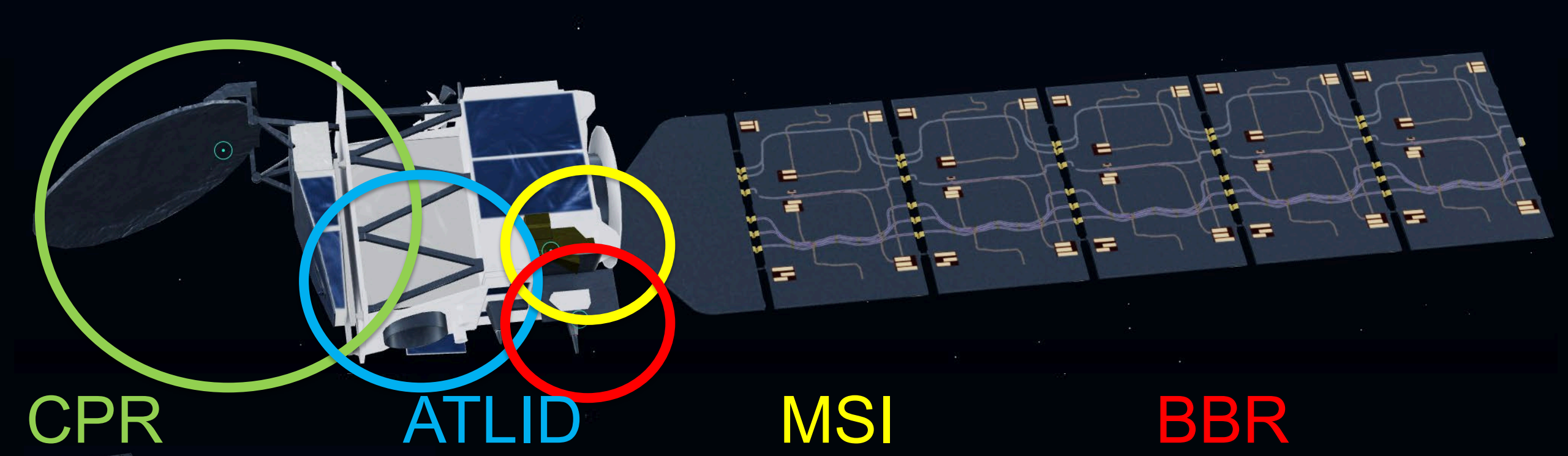
Overview

- EarthCARE scientific data production models (ESA & JAXA)
- Selecting EarthCARE data products
- Browsing & quicklooks
- Access & downloading
- I/O and basic plotting tools

Important links

- EarthCARE Science
https://www.earthcarescience.net/
- ESA Earth Online Portal
https://earth.esa.int/eogateway/missions/earthcare
- JAXA EarthCARE
https://www.eorc.jaxa.jp/EARTHCARE
- AMT Special Issue on EarthCARE algorithms & data products (pre-launch)
amt.copernicus.org/articles/special_issue1156.html
- 2nd In-Orbit Validation Workshop (March 2025)
www.earthcare-validation-2025-2.org/
- Science and Validation Workshop (December 2025)
www.eorc.jaxa.jp/EARTHCARE/event/ws2025/



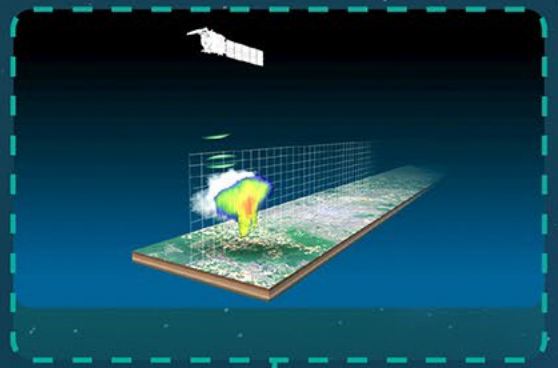
CPR ATLID MSI BBR

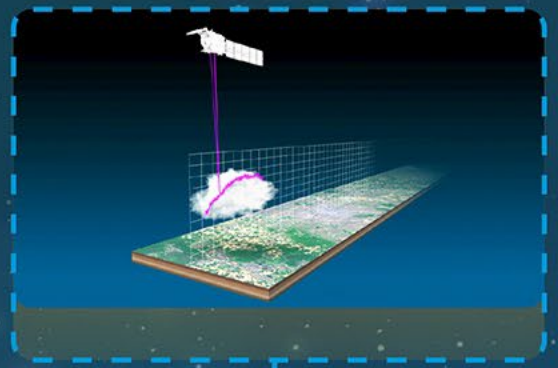
- Earth Cloud and Radiation Explorer (EarthCARE) launched 29 May 2024
- Commissioning Phase ended December 2024
- L1 data products released January 2025
- L2a & 2-instrument L2b products released March 2025
- **3+ instrument L2b products to be released in Q4 2025**

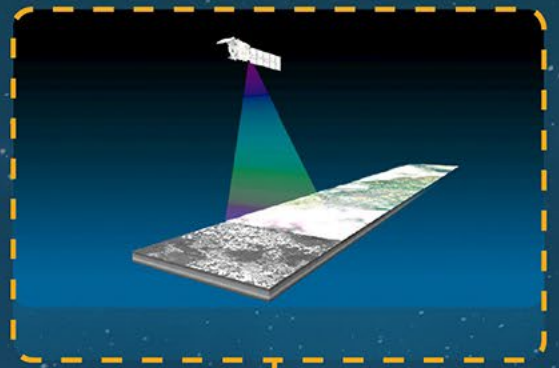
precip clou aerosols radiation

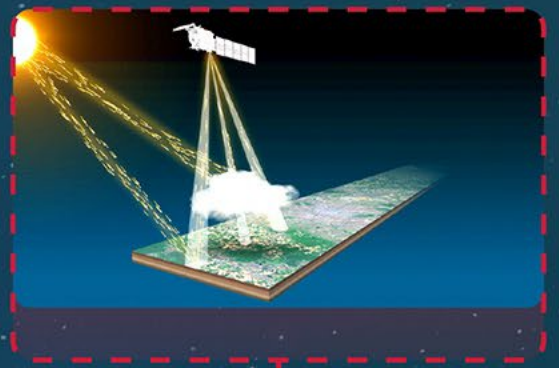
ESA | JAXA earthcare

EarthCARE data processing









Cloud Profiling Radar Level-1b (JAXA)

- Radar reflectivity
- Doppler velocity profiles

Atmospheric Lidar Level-1b (ESA)

Attenuated backscatter in

- Raleigh channel
- Co-polar Mie channel
- Cross-polar Mie channel

Multispectral Imager Level-1b (ESA)

- Top-of-atmosphere radiances for solar channels
- Top-of-atmosphere brightness temperatures for thermal channels

Broadband Radiometer Level-1b (ESA)

- Filtered top-of-atmosphere shortwave radiance
- Filtered top-of-atmosphere total wave radiance

EarthCARE production models

- Paper describing ESA & JAXA science data processing chains: doi.org/10.5194/amt-17-839-202
- Product naming convention: [INSTRUMENTS]-[NAME]
  - C-NOM (CPR Nominal, L1)
  - A-EBD (ATLID Extinction, Backscatter & Depolarization ratio, L2a)
  - ACM-RT (ATLID-CPR-MSI Radiative Transfer, L2b)
- L1 products are common to ESA & JAXA:
  - JAXA: CPR L1 product
  - ESA: ATLID, MSI and BBR L1 products & auxiliary products
- ESA L2 products
- JAXA L2 products

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Atmospheric Measurement Techniques
Open Access
EGU

X-MET

B-SNG
(pixel-level)

The EarthCARE mission: science data processing chain overview

X-JSG X-NOM A-NOM M-RGR B-NOM
(various scales)

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Figure 3. The JAXA EarthCARE Production Model shows all JAXA data products and ESA's level 1 and BBR level 2b products. Level 2 products and their retrieval algorithms (L2a, L2b) are described in this *AMT* special issue according to Table 2 (L2a) and Table 4 (L2b).

Selecting EarthCARE L2 data products

What kind of data do you want?

Measurements

Which instruments?

CPR

CPR-only
C-NOM (L1)
C-FMR (Z, PIA)
C-CD (V_D, V_S)

w/ ATLID & MSI
ACM-CAP

ATLID

ATLID-only
A-NOM (L1)
A-EBD

w/ CPR & MSI
ACM-CAP

MSI

MSI-only
M-RGR

w/ CPR & MSI
ACM-CAP
(solar and TIR channels at nadir)

BBR

BBR-only:
B-NOM (domain-averaged)
B-SNG (pixel-level)

Calculated & corrected w/ MSI & ATLID
BM-RAD
BMA-FLX

Detection & Classification

What geometry?

Clouds & precipitation

Feature mask:
Radar-only:
C-CLD
Composite:
ACM-COM
Synergistic:
ACM-CAP
Cloud-top phase:
M-COP
Aerosols:
A-ALD
M-AOT
AM-ACD

Clouds

Passive:
M-COP
Lidar-only:
A-ICE (ice clouds)
Radar-only:
C-CLD
Composite:
ACM-COM
Synergistic:
ACM-CAP

Profiling

Feature mask:
A-FM
C-FMR + C-CD
Cloud class'n:
A-TC* + C-TC
AC-TC
Precipitation class'n:
C-TC
AC-TC
Aerosol class'n:
A-TC
AC-TC

Clouds & aerosols

Passive:
M-COP & M-AOT
Lidar-only:
A-ICE & A-EBD*
Composite:
ACM-COM
Synergistic:
ACM-CAP

Retrievals

Of what?

Aerosols

Passive:
M-AOT
Lidar-only:
A-EBD*
Synergistic:
ACM-CAP

Radiation

Fluxes & heating rates:
ACM-RT
Radiative closure:
ACMB-DF

*when using **A-TC** and **A-EBD** for aerosols, use variables with suffix `low_resolution`; these variables use the most along-track averaging to remove lidar noise

EarthCARE datafile naming conventions

ECA_EXAE_ATL_NOM_1B_20250601T131853Z_20250601T144838Z_05735E

mission (always ECA)

production centre
(EX for ESA, JX for JAXA)

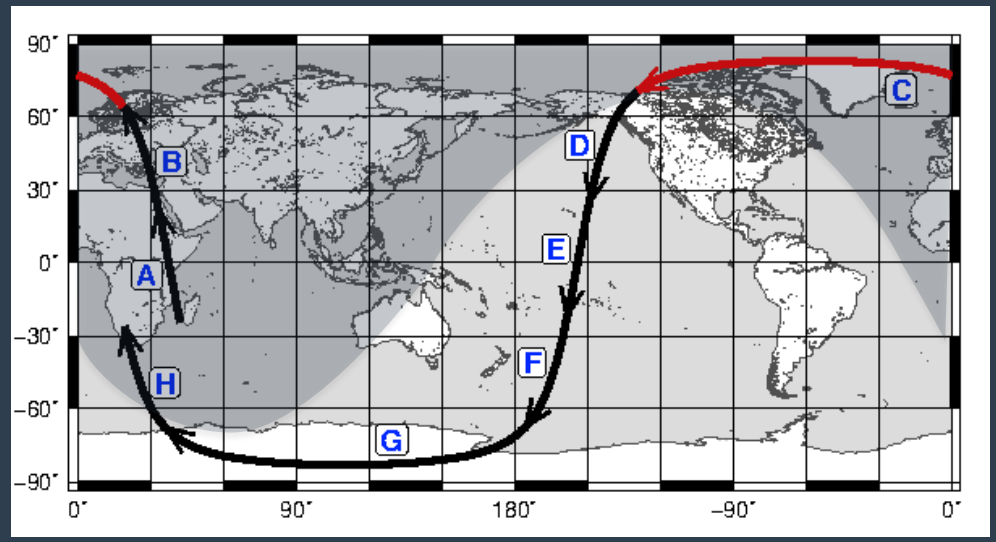
expanded product name of form
XXX_YYY_LL

product baseline (starting from AA
minor increment→AB ; major increment→BA)

sensing start-time of form
YYYYMMDDTHHMMSSZ

processing time of form
YYYYMMDDTHHMMSSZ

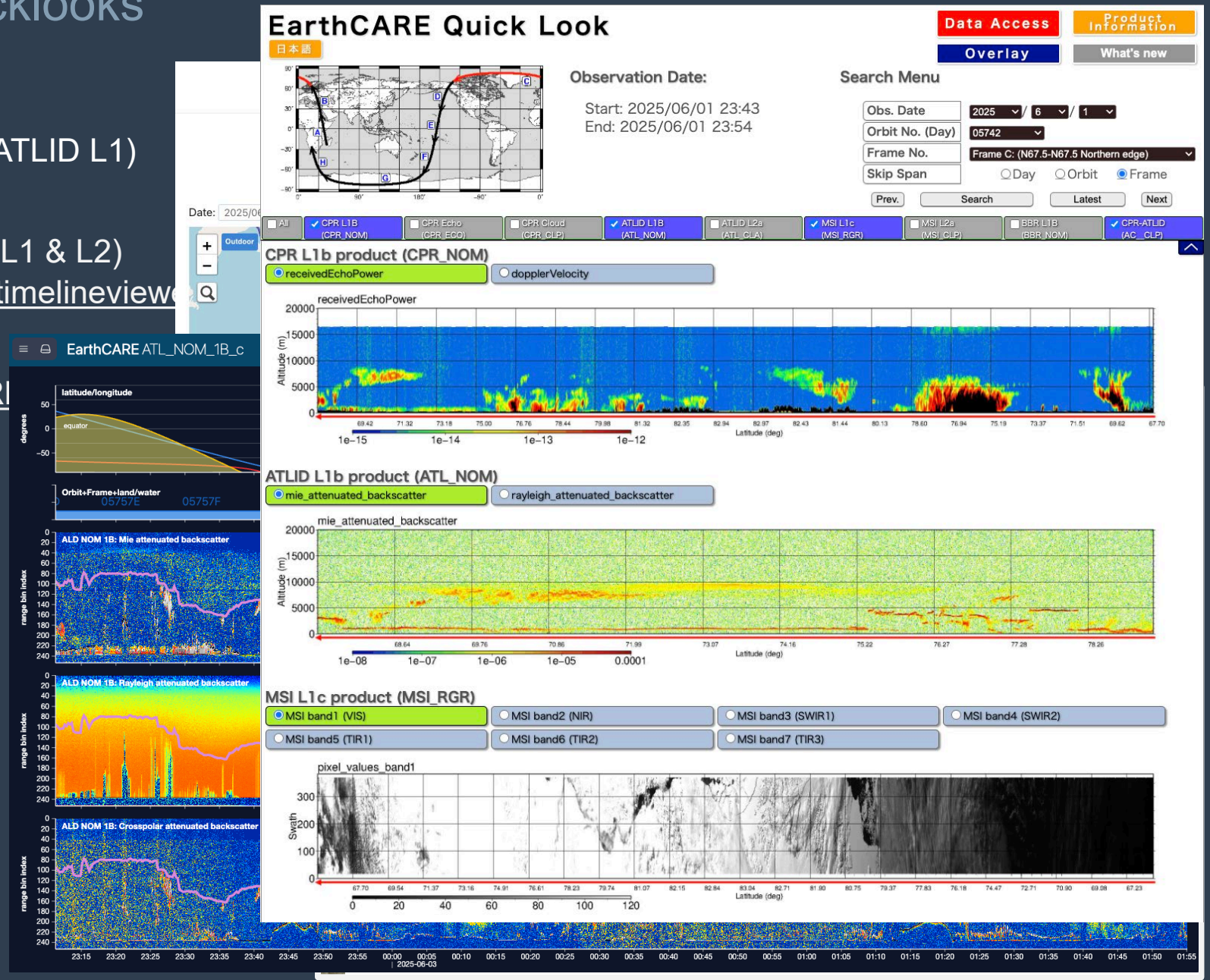
orbit number
& frame



- All EarthCARE data are divided into 8 “frames” per orbit
  - Allows for very easy sub-sampling:
    - A & E are always equatorial (night & day, respectively)
    - C is boreal, G is austral
    - B & H are night-time extratropics;
      D & F are day-time extratropics
- Sun-synchronous: A frames cross the equator around 02:00 local solar time;
E frames cross the equator around 14:00 local solar time
- Each data product comprises
  - a netCDF4/HDF5 file (*.h5) containing the data (in the “ScienceData” group)
  - an XML header file (*.HDR) containing orbital/frame metadata, a list of inputs files & configuration settings

Discovery, browsing and quicklooks

- Timeline viewers
  - EarthCARE Imagery Portal (CPR & ATLID L1)
    web.meteo.mcgill.ca/EarthCARE/
  - EarthCARE Timeline Viewer (ATLID L1 & L2)
    portal.maap.eo.esa.int/ini/earthcare/timelineview
  - JAXA Quicklook (L1 & L2)
    https://www.eorc.jaxa.jp/EARTHCARE
- ESA Orbit Prediction Tool
  evdc.esa.int/orbit/
- Global Stratospheric Aerosol Watch
  aerosolstrato.projet.latmos.ipsl.fr/



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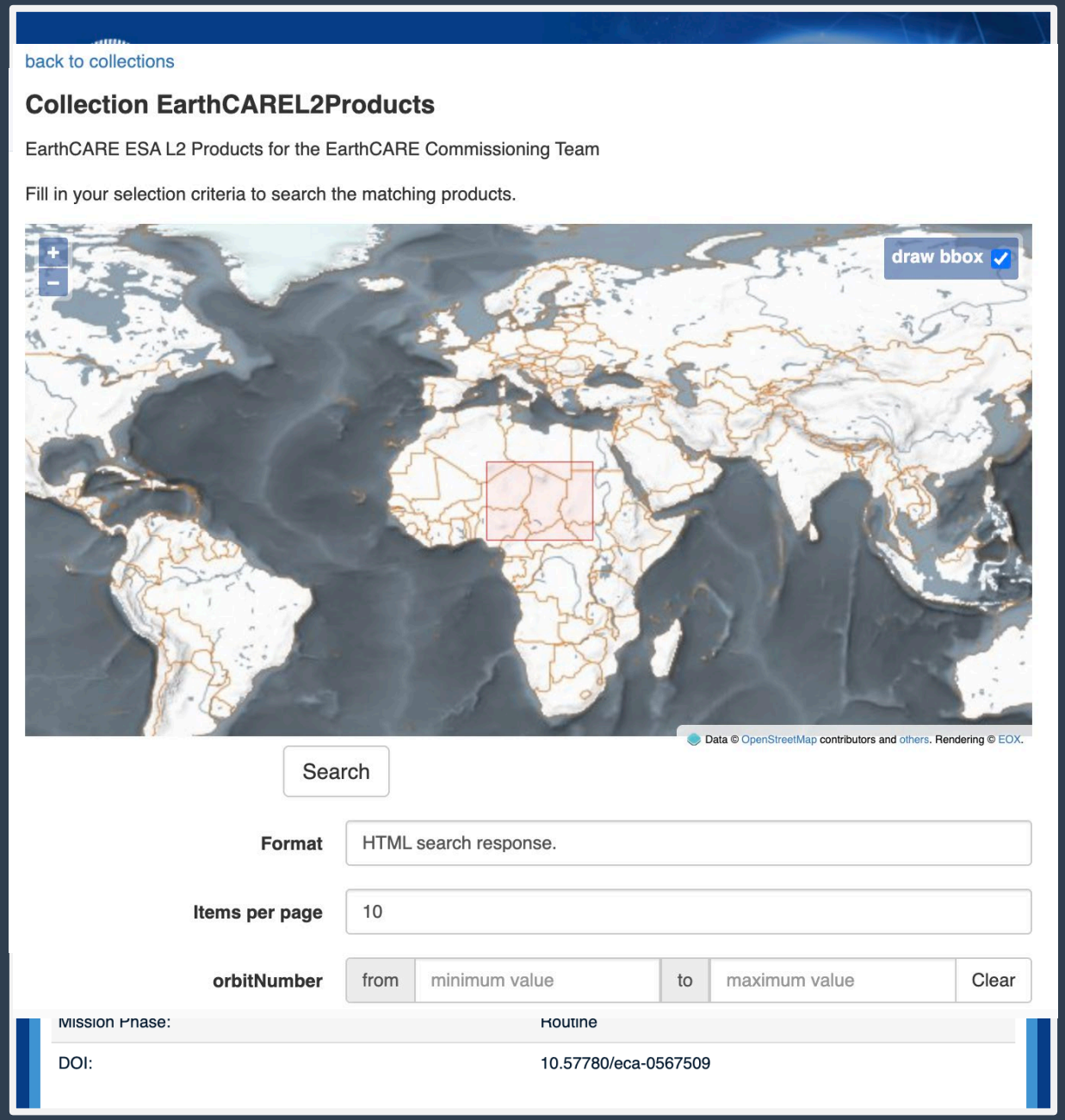
Access and downloading

- ESA Online Access and Distribution System (OADS):
  - L1 products: ec-pdgs-dissemination1.eo.esa.int/oads/
  - L2 products: ec-pdgs-dissemination2.eo.esa.int/oads/
  - Searchable, or navigable by “tree”
- OADS-Download Python script:
  - github.com/koenigleon/oads-download
  - Current download limit of 3000 products/day for most users
  - Relatively simple interface, but easy to add a shell script wrapper:

```
usage: oads_download [-h] [-d DATA_DIRECTORY] [-o [ORBIT_NUMBER ...]]
[-so START_ORBIT_NUMBER] [-eo END_ORBIT_NUMBER]
[-f [FRAME_ID ...]][-oaf [ORBIT_AND_FRAME ...]]
[-soaf START_ORBIT_AND_FRAME] [-eoaf END_ORBIT_AND_FRAME]
[-t [TIME ...]][-st START_TIME] [-et END_TIME]
[-r RADIUS_SEARCH RADIUS_SEARCH RADIUS_SEARCH]
[-pv PRODUCT_VERSION]
[-bbox BOUNDING_BOX BOUNDING_BOX BOUNDING_BOX BOUNDING_BOX]
[--overwrite] [--no_download] [--no_unzip] [--no_delete] [--no_subdirs]
[-c PATH_TO_CONFIG] [--debug] [--no_log]
[-i SELECT_FILE_AT_INDEX] [-V] [--export_results] [product_type ...]
```



EarthCARE datafile structure and metadata conventions

- For all netCDF4/HDF5 files, the main scientific contents are found in the `ScienceData` group
- Each instrument has its own native resolution (at L1), but many products are available on the “Joint Standard Grid” (JSG), which combines the along-track grid of CPR and the vertical grid of ATLID:
  - CPR along-track grid with resolution ~1km (2 CPR profiles, 3 to 5 ATLID profiles)
  - ATLID vertical grid: resolution ~100m up to around 20km; ~500m from 20km to 40km
  - MSI horizontal resolution ~500m across 150km swath
- For co-aligning products on different grids, use spatial (lat/lon) coordinates rather than time: there can be differences in the time coordinates between instruments (e.g. 3s difference between ATLID and CPR due to slight off-nadir pointing of ATLID)
- Very high standard for variable naming, metadata description, etc., **but let us (L2 developers) know if something could be better described**

Basic I/O

- Python module “ectools”: bitbucket.org/smason/ectools
- Open to contributions (just ask to be added); currently widely used among L2 developers, ESA, and cal/val teams.
- Product-specific loading functions using xarray:
  - `ecio.load_AEBD(path_to_file)`
  - use wildcards to select from among multiple files
- NOTE: each product will over-run the edges of the frame boundary, but by different amounts, so you can’t rely on the `along_track` dimensions to be consistent between products

```
[30]: ecio.load_ACTC("/perm/pasm/DISC/data/L2b/AC__TC__2B", product_baseline="A[B-Z]",
                     frame_code="05*[A-H]", nested_directory_structure=True)

13 EarthCARE product files match path /perm/pasm/DISC/data/L2b/AC__TC__2B/*/*/*/ECA_EXA[B-
Z]_AC__TC__2B_*_*_05*[A-H]/ECA_EXA[B-Z]_AC__TC__2B_*_*_05*[A-H].h5; selecting -1
Selecting frame from 99 to 5044

[30]: xarray.Dataset
```

▶ Dimensions: (**along_track**: 4945, JSG_height: 242)

▼ Coordinates:

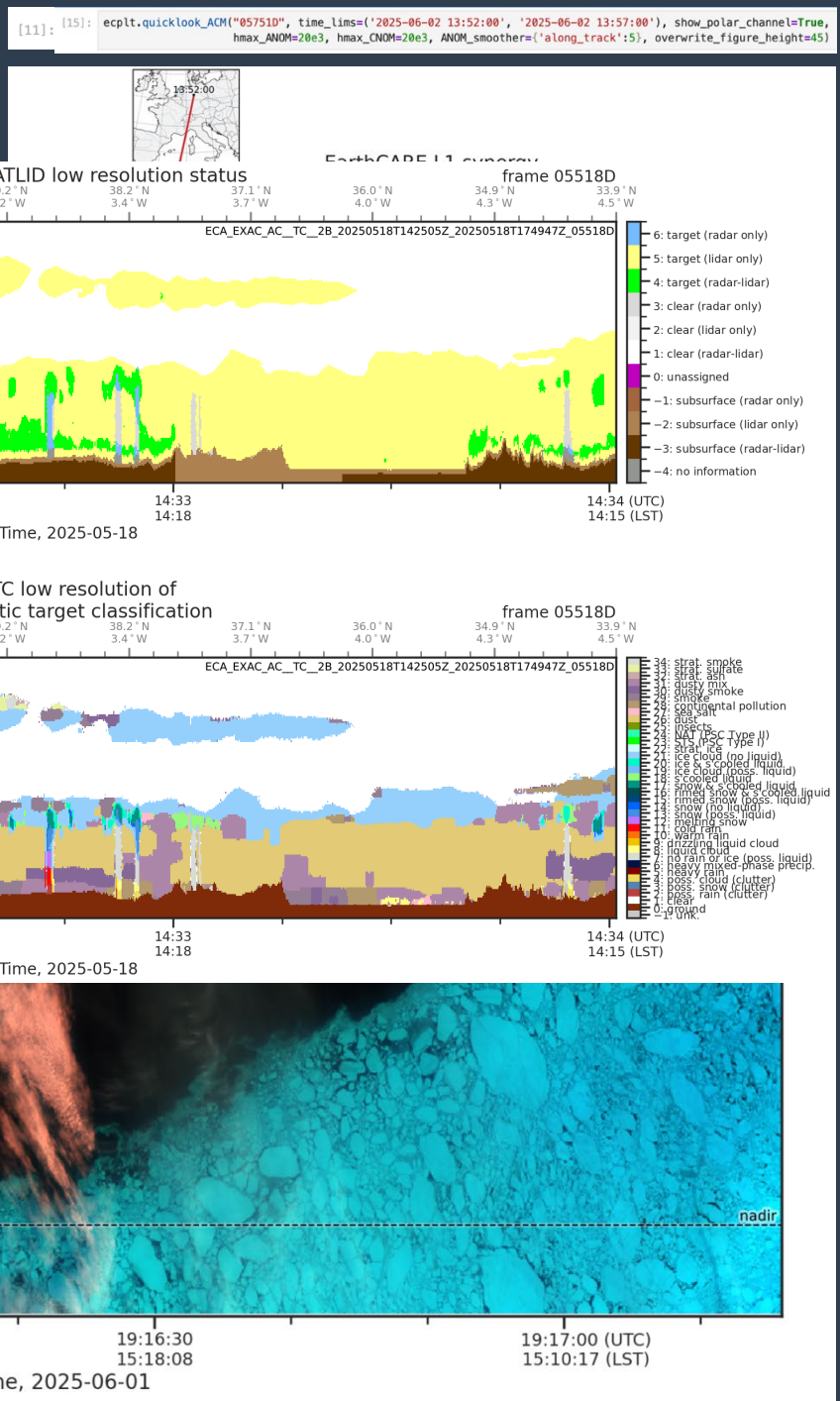
along_track	(along_track)	int64	99 100 101 102 ... 5041 5042 5043

▼ Data variables:

time	(along_track)	datetime64[ns]	...
latitude	(along_track)	float64	22.5 22.51 22.52 ... 67.48 67.49
longitude	(along_track)	float64	...
geoid_offset	(along_track)	float64	...
elevation	(along_track)	float32	...
height	(along_track, JSG_height)	float32	...
synergetic_targe...	(along_track, JSG_height)	int8	...
synergetic_targe...	(along_track, JSG_height)	int8	...
synergetic_targe...	(along_track, JSG_height)	int8	...
ATLID_target_cl...	(along_track, JSG_height)	int8	...
ATLID_target_cl...	(along_track, JSG_height)	int8	...
ATLID_target_cl...	(along_track, JSG_height)	int8	...

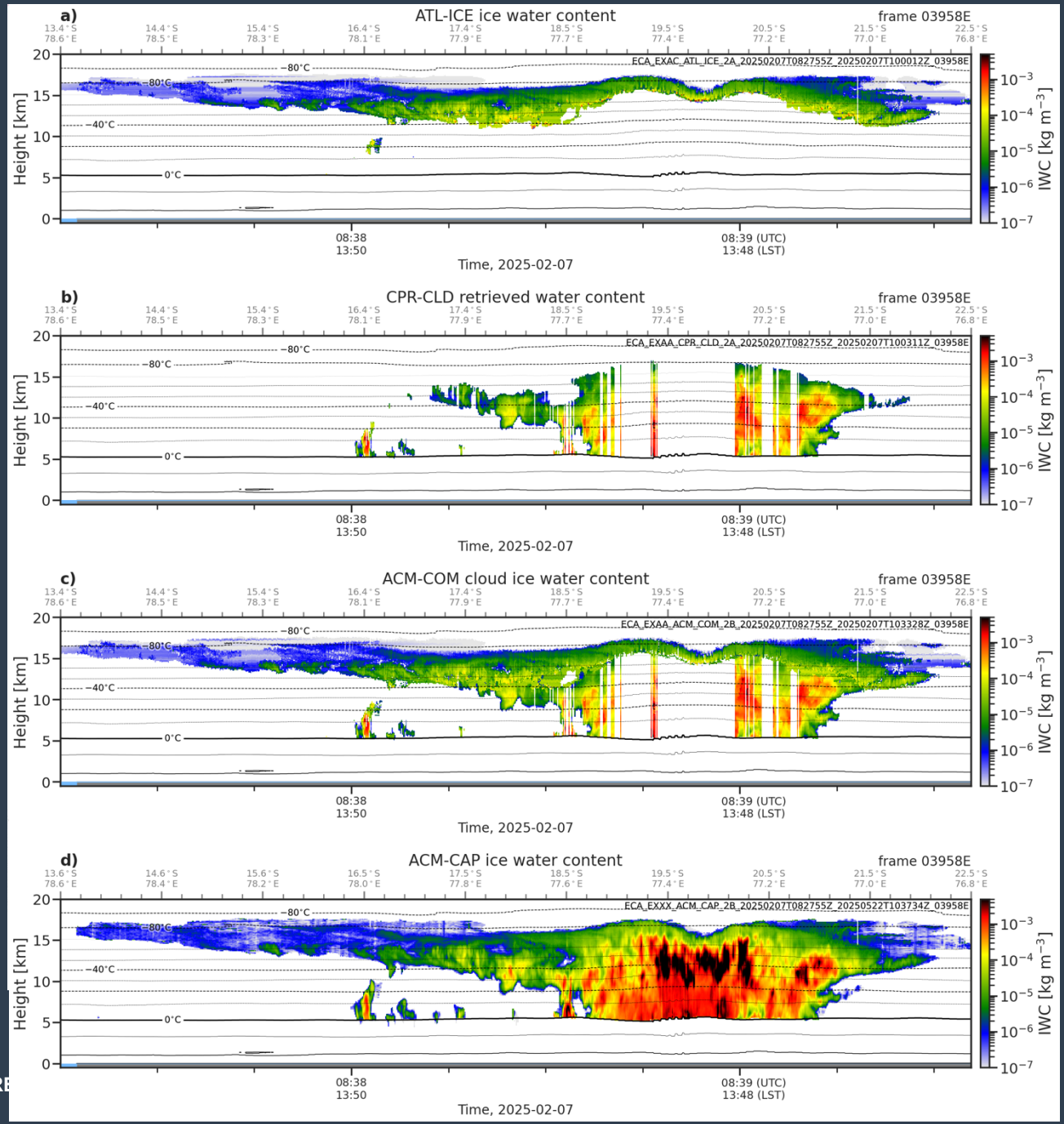
Plotting with ectools

- Consistent publication-quality aesthetic across 1D, 2D, curtain & across-swath images.
- Synergistic quicklooks:
`ecplt.quicklook_ACM( )`
  - Easy to configure to ”zoom in” on features of interest
- MSI “natural colour” images (RGB: SWIR-NIR-VIS) provide a powerful visual context for case studies
- Classification/quality status plots



Some example use-cases

- Comparing multiple products/variables to gain additional insights
- Intercomparison of retrieved quantities from different products
(e.g. A-ICE, C-CLD, ACM-COM & ACM-CAP)
- `get_XMET( )` lets you extract meteorological information from X-MET (the ECMWF forecast) onto the grid of any L2 product
  - Overlay plot with other information (temperature contours)
  - Comparison of retrievals against model cloud fields



EarthCARE is just getting started

- First L2 data released in March; synergistic retrievals and radiative closure assessment products still to be released in Q4 this year.
  - We've improved our products and processors a lot based on in-flight data and in coordination with calibration/validation campaigns
  - Also need to improve in response to exposure to scientific use:
    - So much redundancy between products and similarly-named variables—very easy to just use the first product or variable you come across and not investigate further. **We need to help with this.**
- What we're working on:
  - Product selection guides to match specific user needs to L2 products
  - Providing "cheat sheets" for L2 products to better describe caveats/pitfalls/best use of our data
- **Any feedback on products, documentation or tools are very welcome**