EarthCARE ESA Data Products

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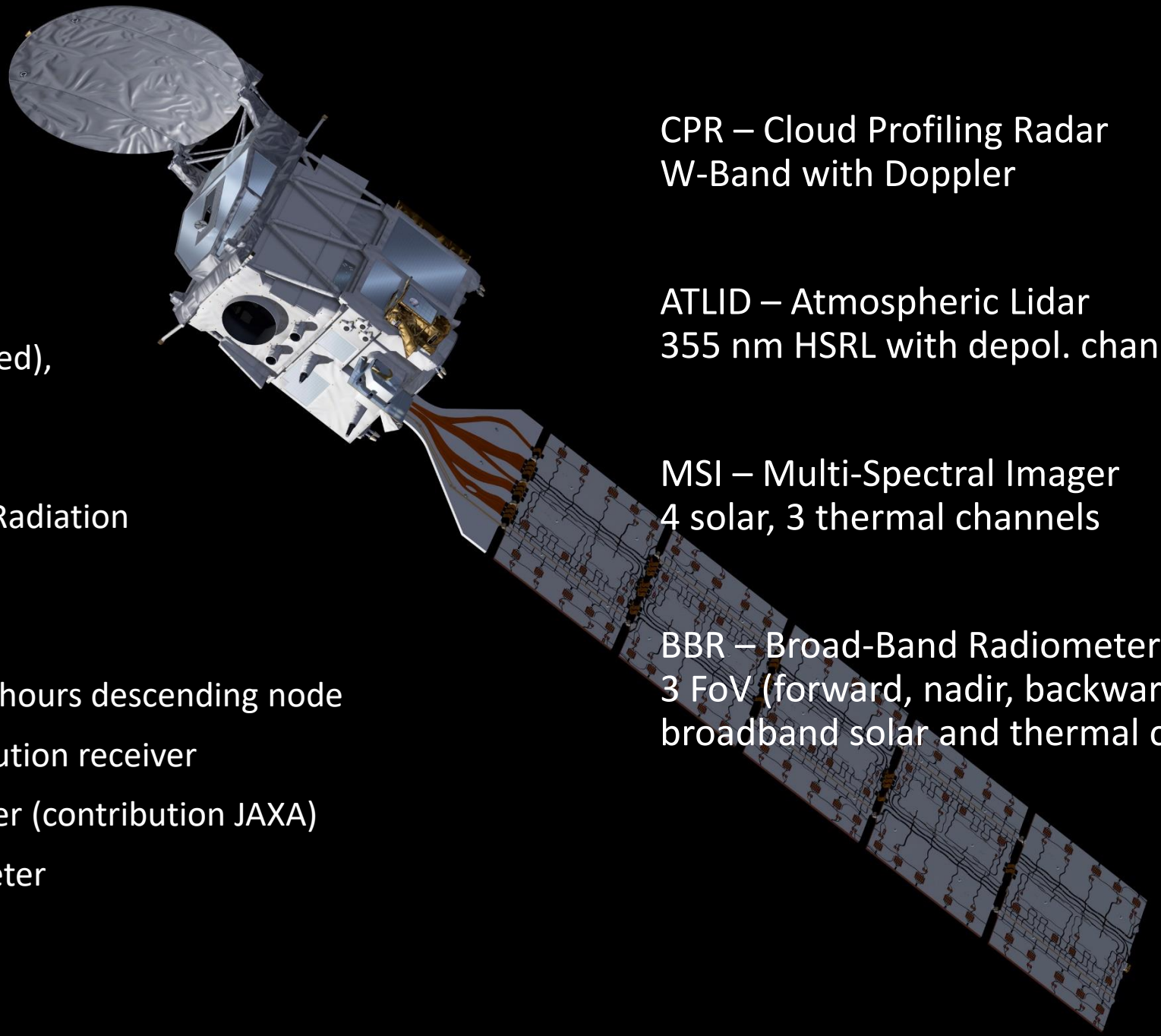
EarthCARE

Observations:

- Cloud profiles (ice, liquid, mixed), cloud coverage, precipitation
- Aerosol profiles
- Broad-band Solar & Thermal Radiation

Satellite and Payload

- Sun-sync. orbit at 393 km, 14:00 hours descending node
- UV Lidar with high spectral resolution receiver
- W-band Cloud Radar with Doppler (contribution JAXA)
- Imager and Broad-Band Radiometer
- Launch October 2023

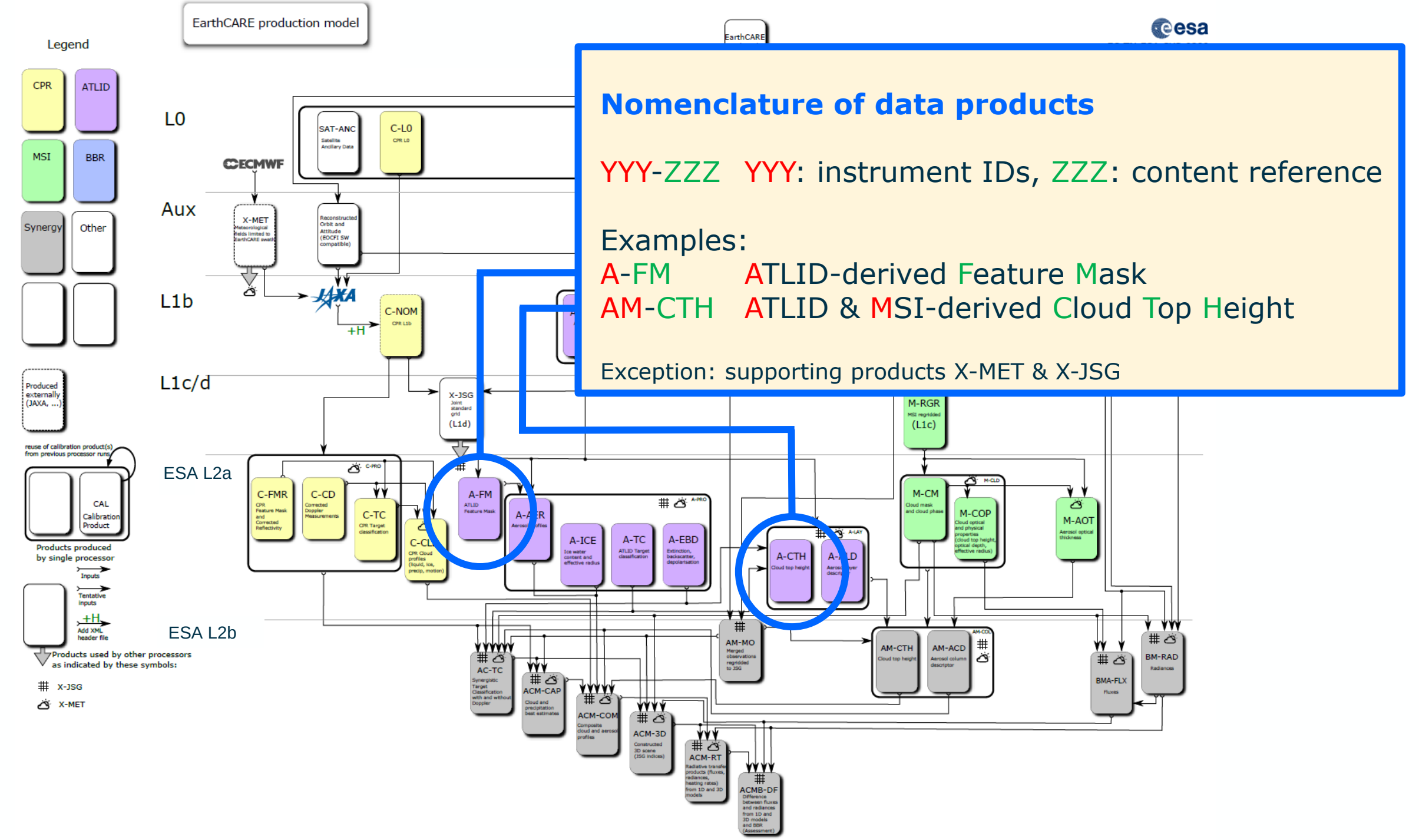


CPR – Cloud Profiling Radar
W-Band with Doppler

ATLID – Atmospheric Lidar
355 nm HSRL with depol. channel

MSI – Multi-Spectral Imager
4 solar, 3 thermal channels

BBR – Broad-Band Radiometer
3 FoV (forward, nadir, backwards),
broadband solar and thermal channel



Nomenclature of data products

YYY-ZZZ YYY: instrument IDs, ZZZ: content reference

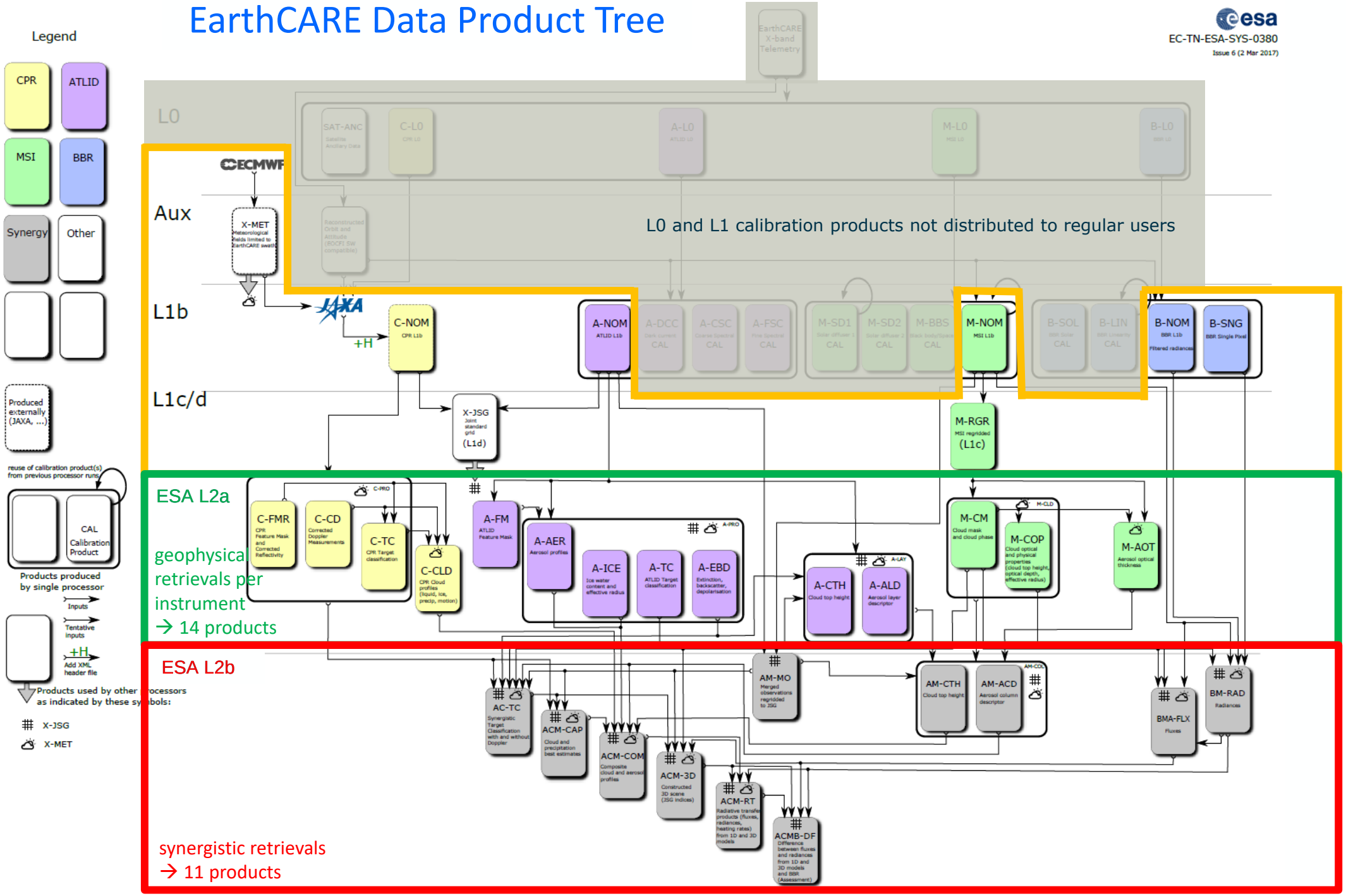
Examples:

A-FM ATLID-derived Feature Mask

AM-CTH ATLID & MSI-derived Cloud Top Height

Exception: supporting products X-MET & X-JSG

EarthCARE Data Product Tree

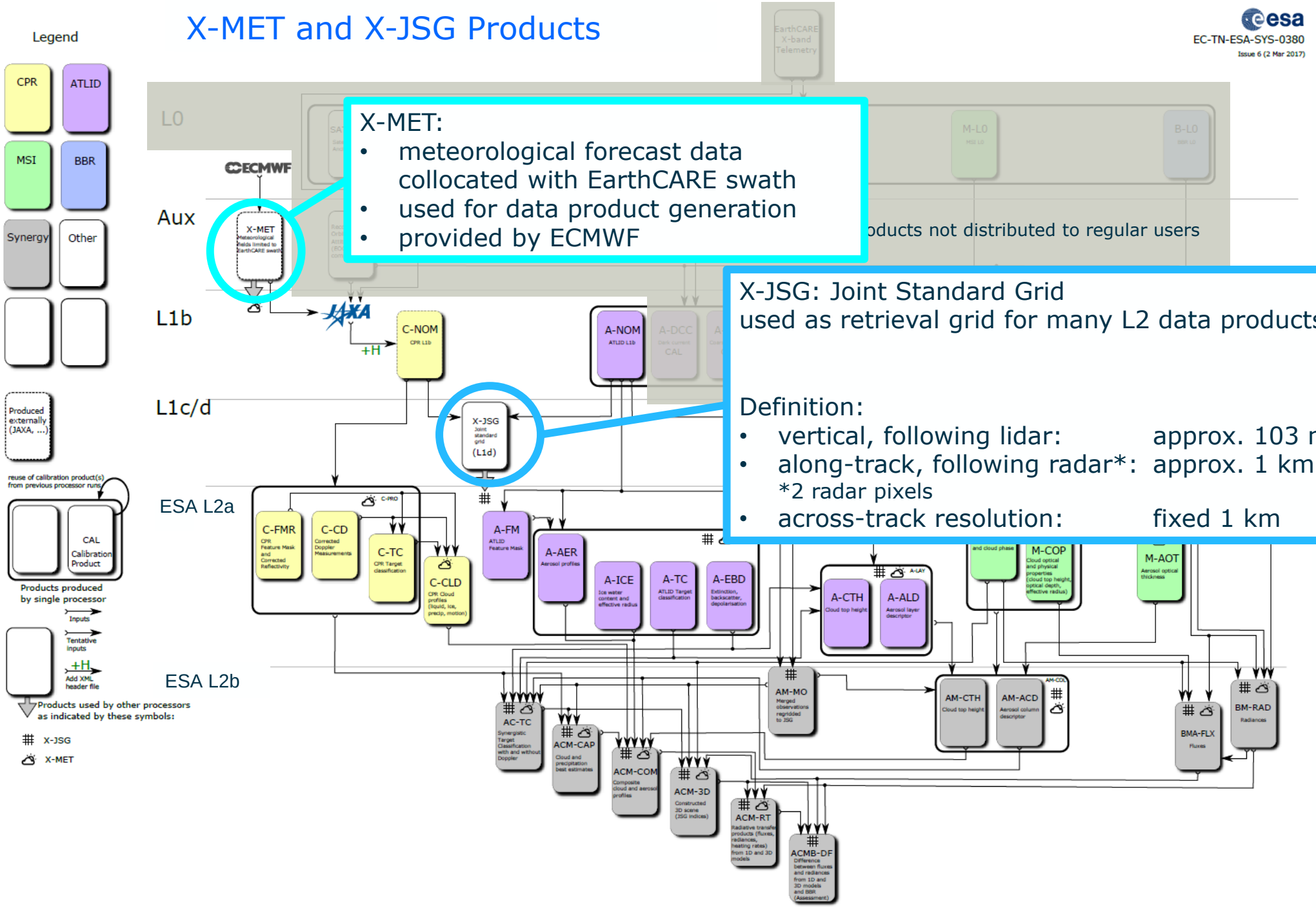


ESA data products will be produced operationally by the ESA ground segment located at ESRIN.

JAXA data products fall in two categories: **Standard Products**: produced and released by JAXA Mission Operation System: (1) CPR echo and cloud products; (2) ATLID feature & target mask, aerosol & cloud products, PBL height; (3) MSI cloud products; (4) CPR-ATLID synergistic cloud products; (5) CPR-ATLID-MSI synergistic cloud products; (6) Four-sensor synergy radiative products. **Research Products:** processed by either JAXA/EORC or co-operating Japanese Laboratories, are single or multi-sensor cloud, aerosol, precipitation, snow and air motion products.

X-MET and X-JSG Products

esa
EC-TN-ESA-SYS-0380
Issue 6 (2 Mar 2017)



X-MET:
- meteorological forecast data collocated with EarthCARE swath
- used for data product generation
- provided by ECMWF

X-JSG: Joint Standard Grid
used as retrieval grid for many L2 data products

Definition:
- vertical, following lidar: approx. 103 m
- along-track, following radar*: approx. 1 km
  *2 radar pixels
- across-track resolution: fixed 1 km

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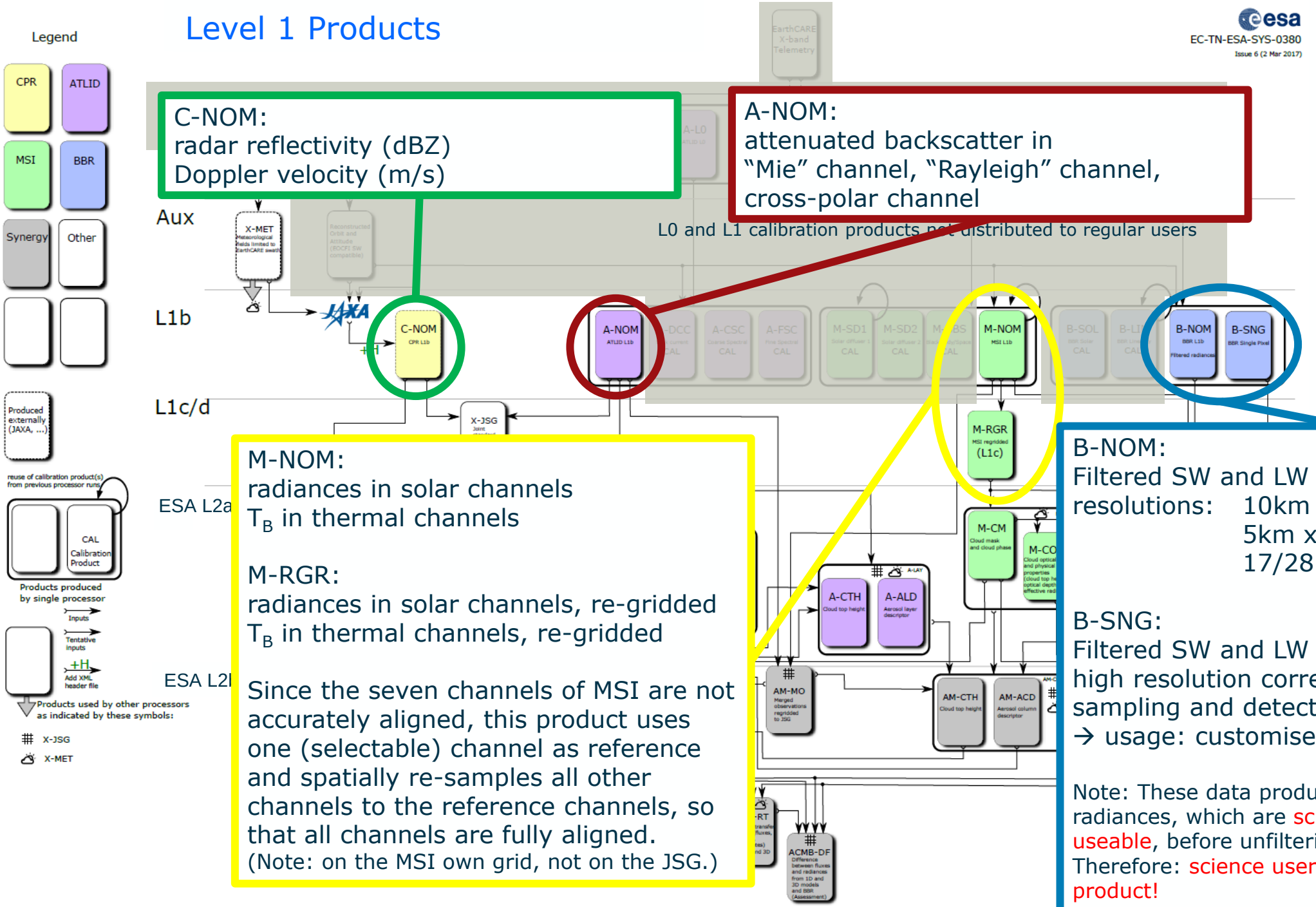
Research Products: processed by either JAXA/EORC or co-operating Japanese Laboratories, are single or multi-sensor cloud, aerosol, precipitation, snow and air motion products.

Level 1 Products



C-NOM:
radar reflectivity (dBZ)
Doppler velocity (m/s)

A-NOM:
attenuated backscatter in
"Mie" channel, "Rayleigh" channel,
cross-polar channel

M-NOM:
radiances in solar channels
T_B in thermal channels

M-RGR:
radiances in solar channels, re-gridded
T_B in thermal channels, re-gridded

Since the seven channels of MSI are not accurately aligned, this product uses one (selectable) channel as reference and spatially re-samples all other channels to the reference channels, so that all channels are fully aligned.
(Note: on the MSI own grid, not on the JSG.)

B-NOM:
Filtered SW and LW radiances
resolutions: 10km x 10km (standard)
5km x 10km (small)
17/28km x 10km (full)

B-SNG:
Filtered SW and LW radiances
high resolution corresponding to along-track sampling and detector resolution
→ usage: customise spatial resolution

Note: These data products contain filtered radiances, which are scientifically not directly useable, before unfiltering has happened.
Therefore: science users advised to use BM-RAD product!

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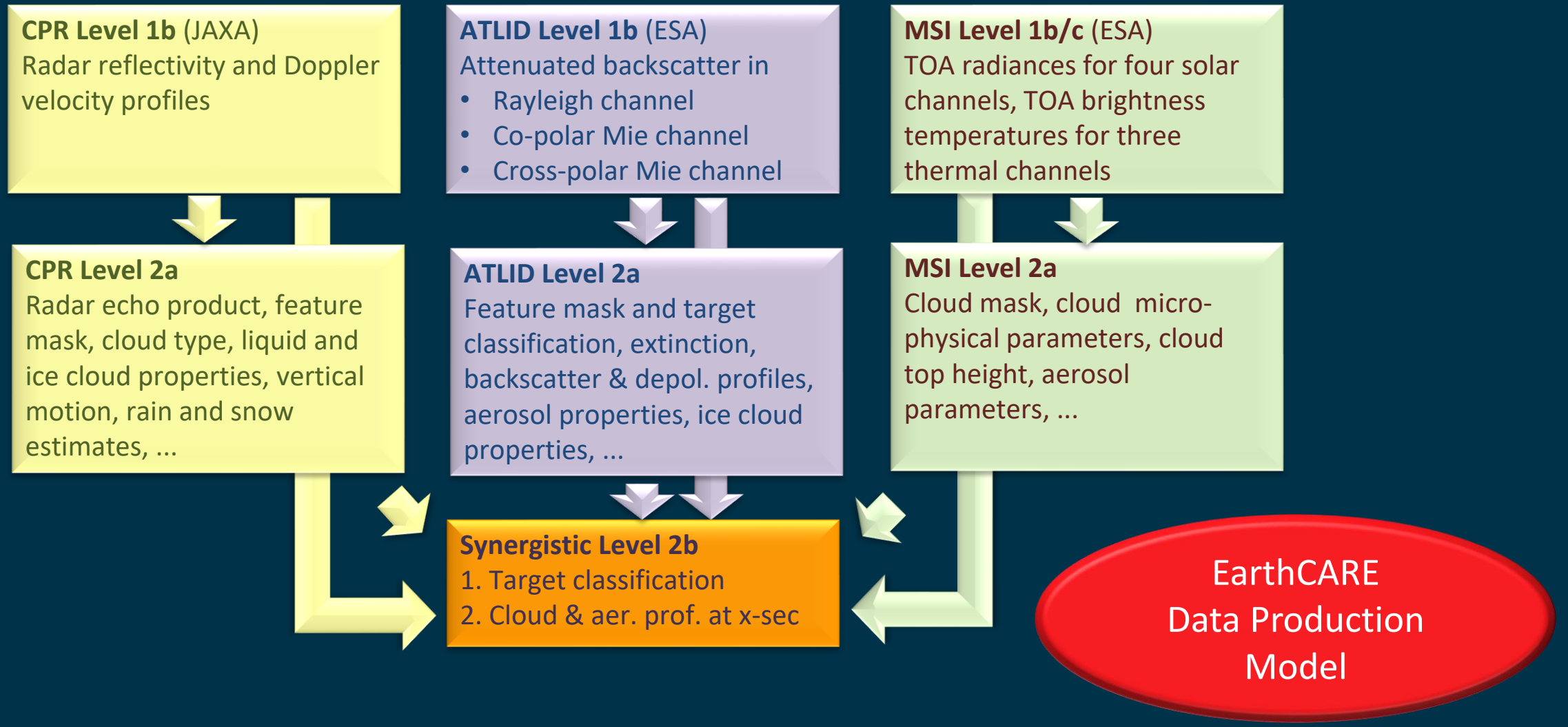
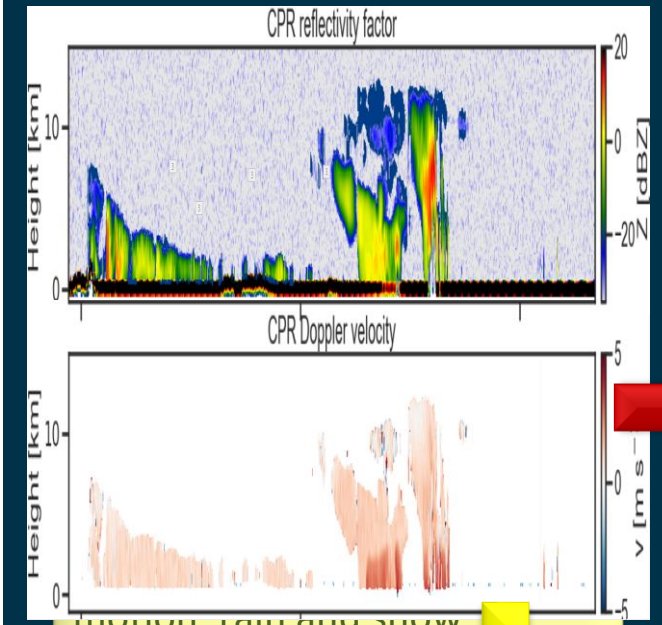
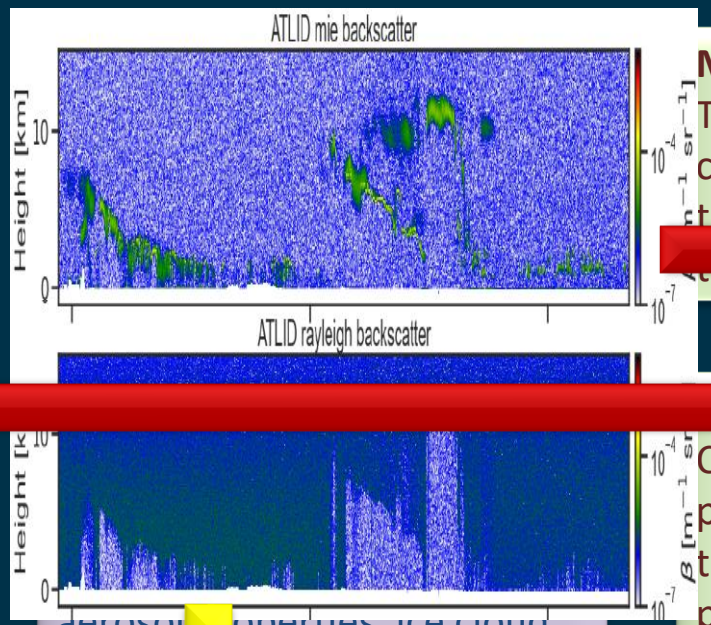
(1) CPR echo and cloud products; (2) ATLID feature & target mask, aerosol


CPR Level 1b (JAXA)
Radar reflectivity and Doppler velocity profiles
ATLID Level 1b (ESA)
Attenuated backscatter in
• Rayleigh channel
• Co-polar Mie channel
• Cross-polar Mie channel
MSI Level 1b/c (ESA)
TOA radiances for four solar channels, TOA brightness temperatures for three thermal channels
CPR Level 2a
Radar echo product, feature mask, cloud type, liquid and ice cloud properties, vertical motion, rain and snow estimates, ...
ATLID Level 2a
Feature mask and target classification, extinction, backscatter & depol. profiles, aerosol properties, ice cloud properties, ...
MSI Level 2a
Cloud mask, cloud micro-physical parameters, cloud top height, aerosol parameters, ...
Synergistic Level 2b
1. Target classification
2. Cloud & aer. prof. at x-sec
EarthCARE Data Production Model





MSI Level 1b

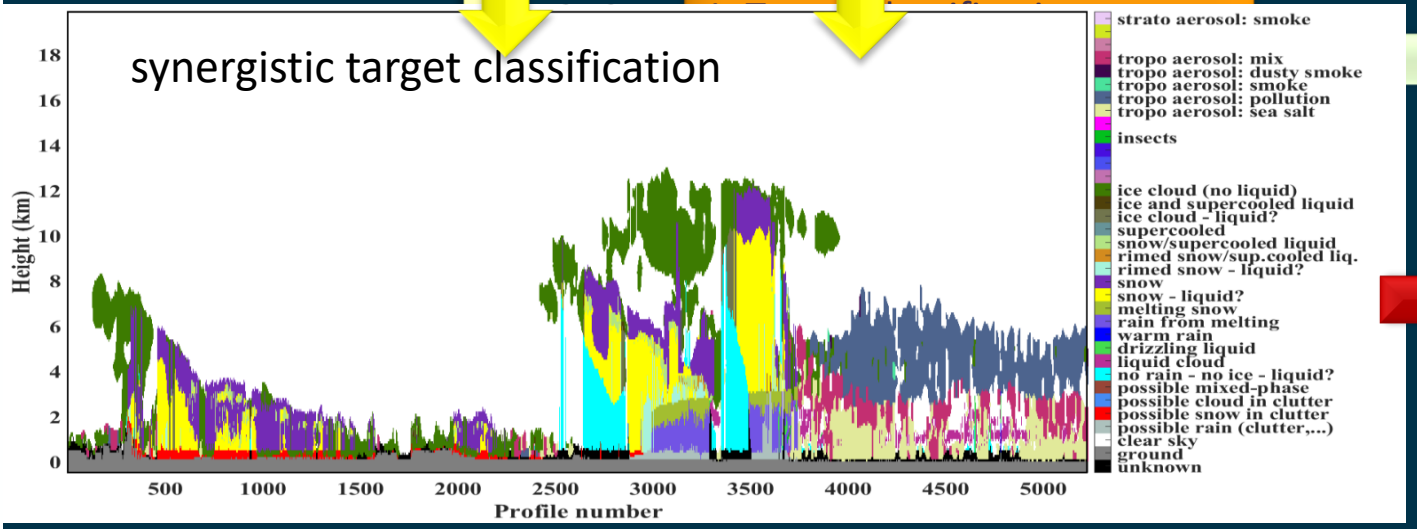
TOA radiance
channels, TOA
temperature
thermal chan

motion, rain and snow
estimates, ...

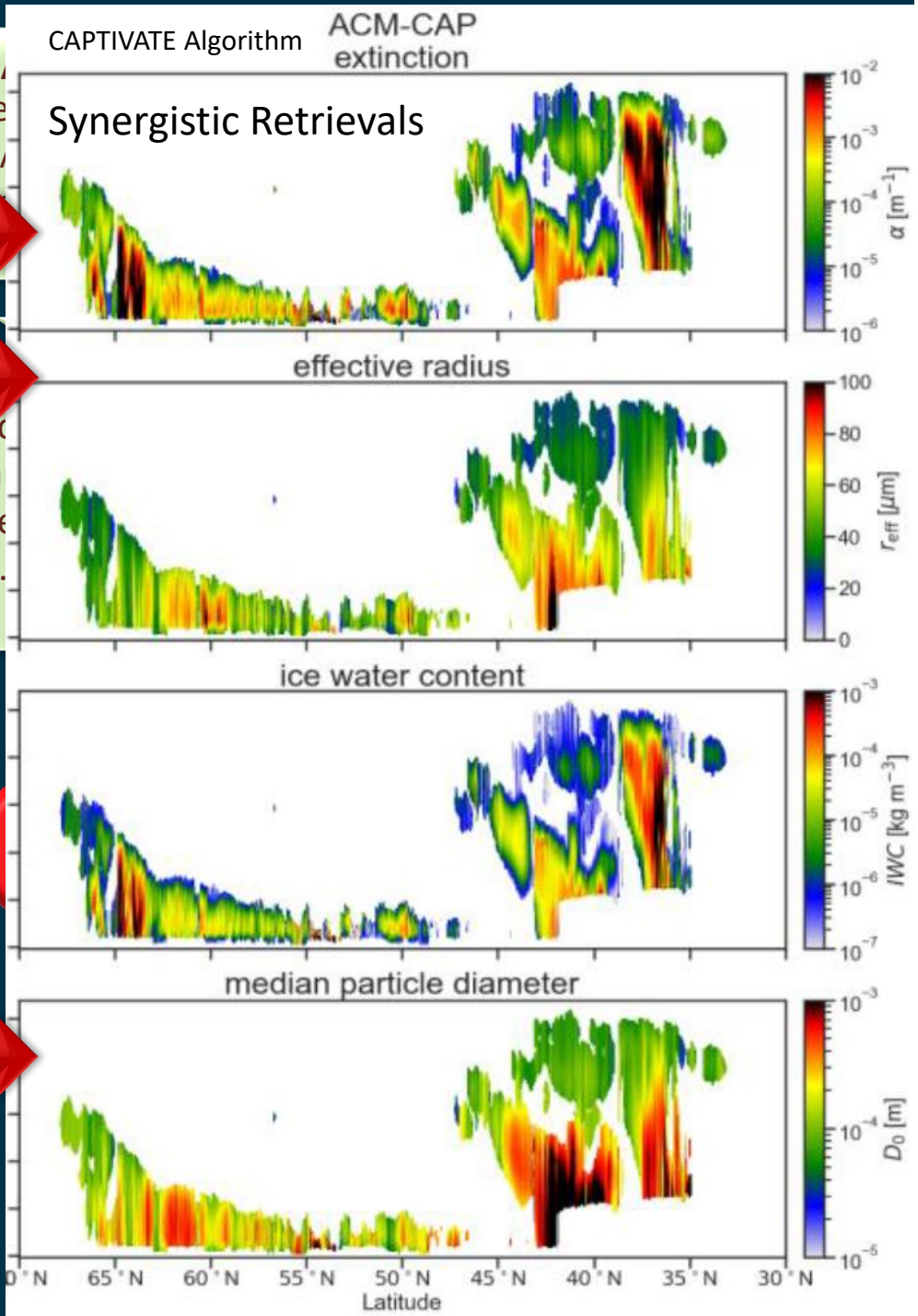
aerosol properties, ice cloud
properties, ...

Cloud mask, c
physical para
top height, ae
parameters, .

Synergistic Level 2b



CAPTIVATE Algorithm



acknowledgements: KNMI, LATMOS, ECMWF

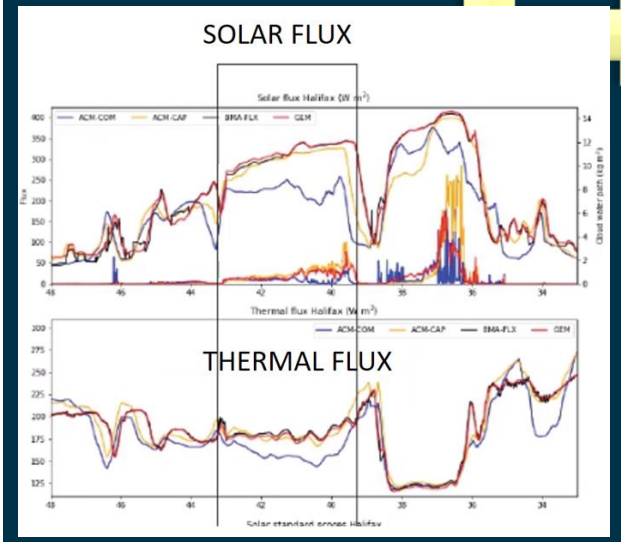
CPR Level 1b (JAXA)
Radar reflectivity and Doppler velocity profiles

CPR Level 2a
Radar echo product, feature mask, cloud type, liquid and ice cloud properties, vertical motion, rain and snow estimates, ...

ATLID Level 1b (ESA)
Attenuated backscatter in
- Rayleigh channel
- Co-polar Mie channel
- Cross-polar Mie channel

ATLID Level 2a
Feature mask and target classification, extinction, backscatter & depol. profiles, aerosol properties, ice cloud properties, ...

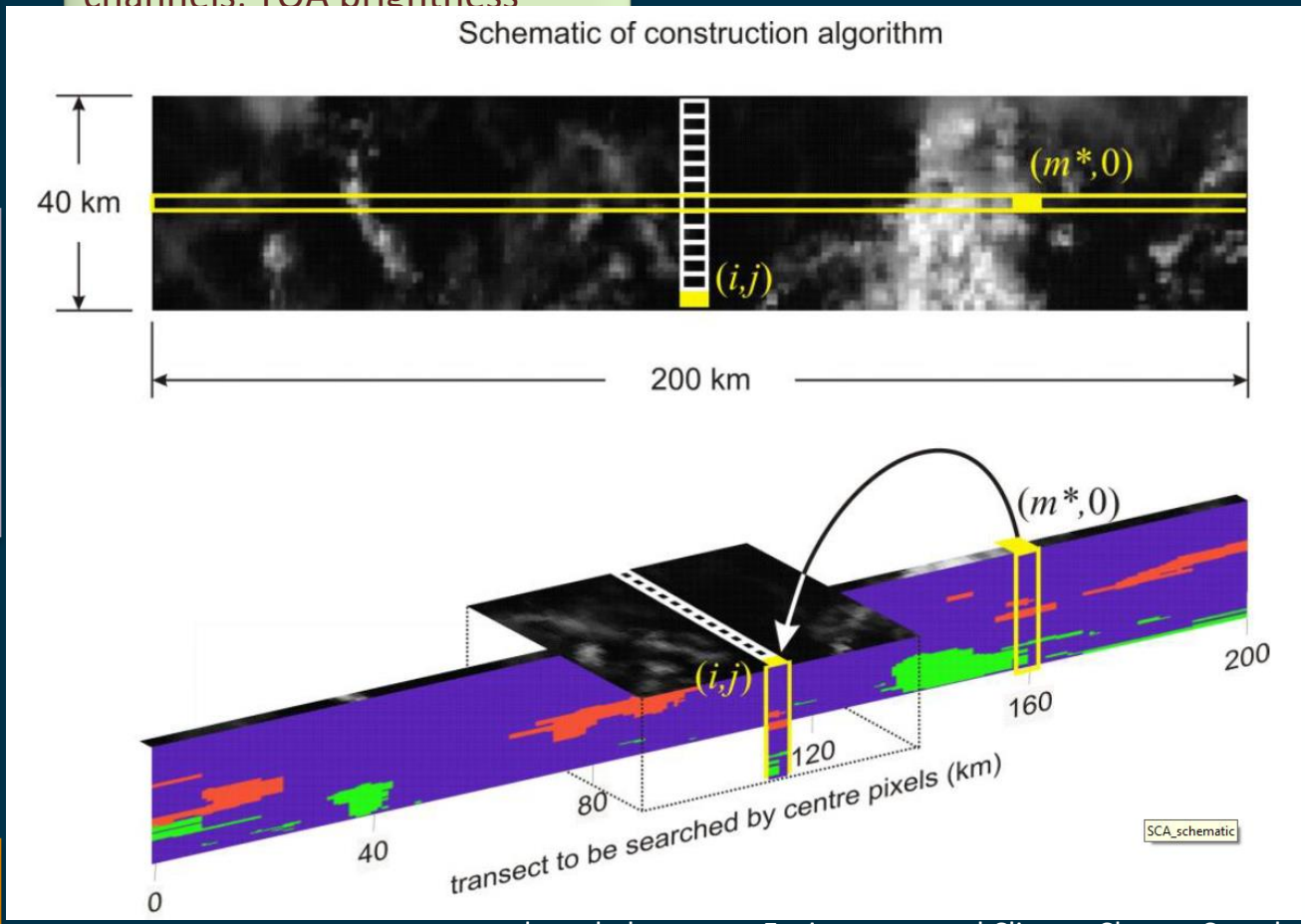
MSI Level 1b/c (ESA)
TOA radiances for four solar channels, TOA brightness



Synergistic Level 2b
1. Target classification
2. Cloud & aer. prof. at x-sec

3D Scenes Construction
Expand syn. retrievals across-track using MSI; ≈40km wide

Radiative Transfer Products
calculated radiances, fluxes, heating rate profiles



acknowledgements: Environment and Climate Change Canada

CPR Level 1b (JAXA)
Radar reflectivity and Doppler velocity profiles

ATLID Level 1b (ESA)
Attenuated backscatter in
- Rayleigh channel
- Co-polar Mie channel
- Cross-polar Mie channel

MSI Level 1b/c (ESA)
TOA radiances for four solar channels, TOA brightness temperatures for three thermal channels

BBR Level 1b (ESA)
Filtered TOA short-wave and total-wave radiances

CPR Level 2a
Radar echo product, feature mask, cloud type, liquid and ice cloud properties, vertical motion, rain and snow estimates, ...

ATLID Level 2a
Feature mask and target classification, extinction, backscatter & depol. profiles, aerosol properties, ice cloud properties, ...

MSI Level 2a
Cloud mask, cloud micro-physical parameters, cloud top height, aerosol parameters, ...

BBR Level 2a
Unfiltered top-of-atmosphere radiances, short-wave and long-wave fluxes
BBR Level 2b: enhanced products using MSI

Synergistic Level 2b
1. Target classification
2. Cloud & aer. prof. at x-sec

EarthCARE Data Production Model

3D Scenes Construction
Expand syn. retrievals across-track using MSI; ≈40km wide

Radiative Transfer Products
calculated radiances, fluxes, heating rate profiles

Assessment
Comparison of calculated fluxes and radiances to BBR observations

Retrievals and “Closure”

Example of work in progress

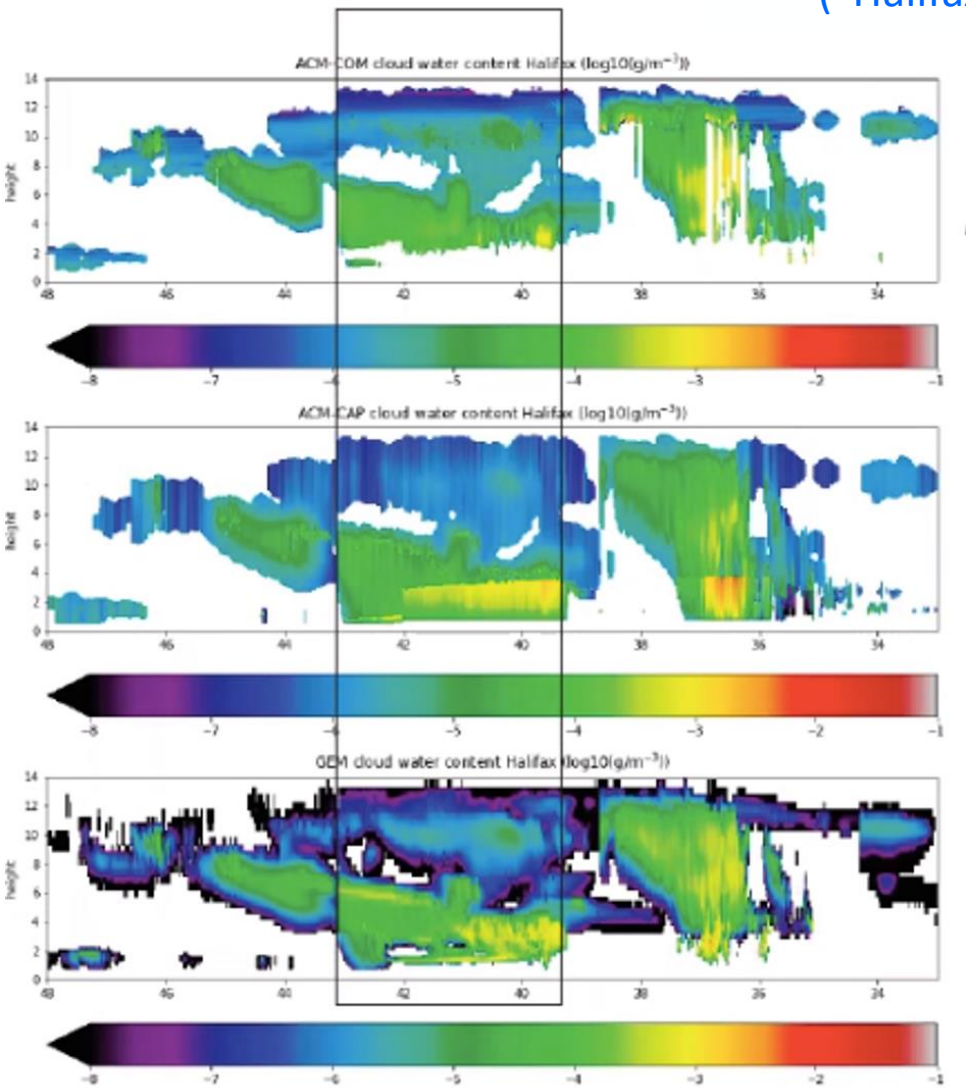
Reconstructed cloud scene based on radar-only + lidar-only + imager-only cloud retrievals (“Composite” product)
FLUX IN BLUE

Synergistically retrieved cloud scene, CAPTIVATE algorithm (Opt. Estimation with complex state vector)
FLUX IN YELLOW

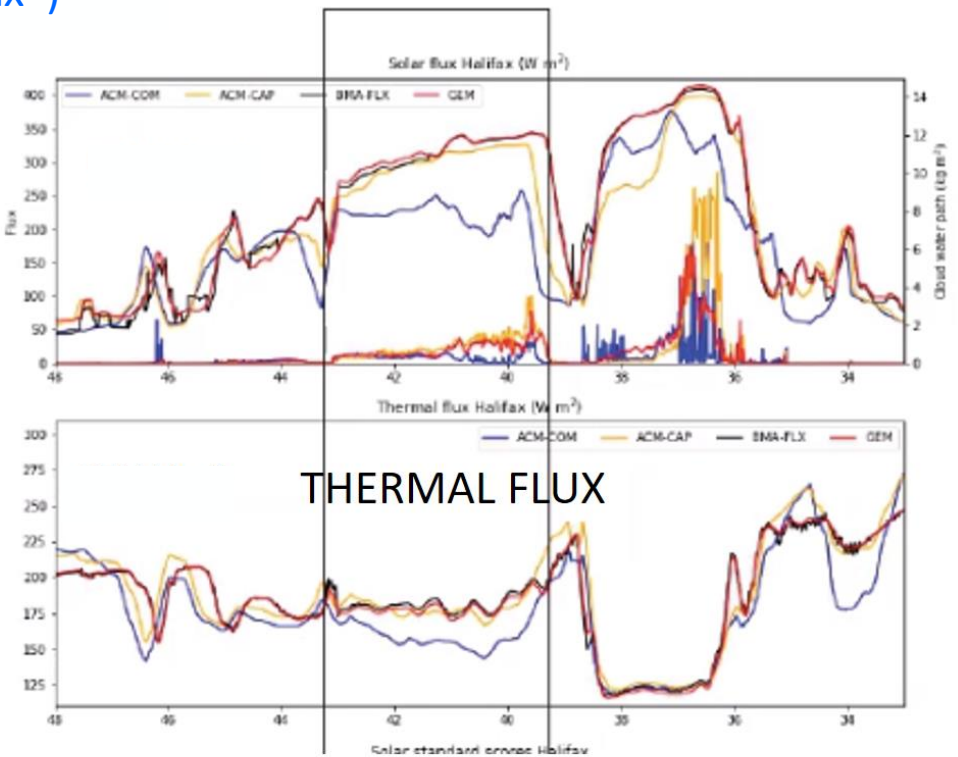
Model truth (Canadian Weather Model GEM)
FLUX IN RED

Cloud water content

Test Scene (“Halifax”)



SOLAR FLUX

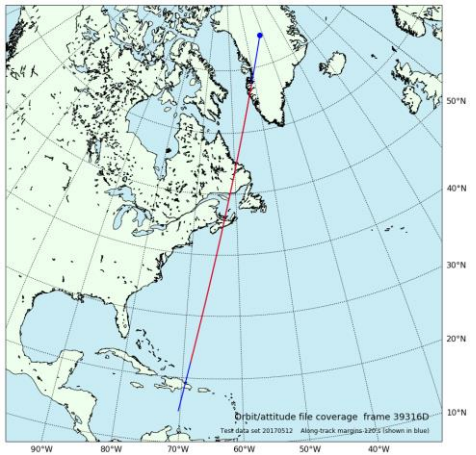


→ “Composite” clouds are too dull and too cold

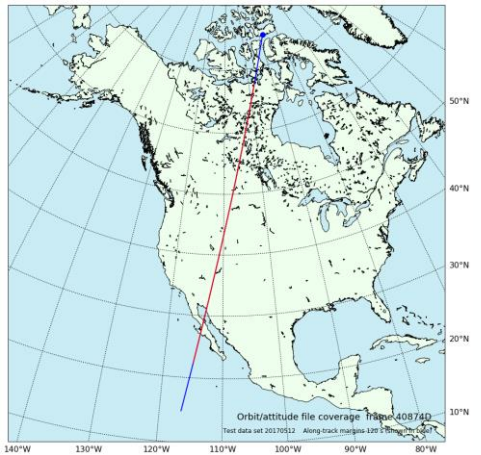
Algorithm testing

Three high-resolution scenes from the Canadian GEM model have been generated

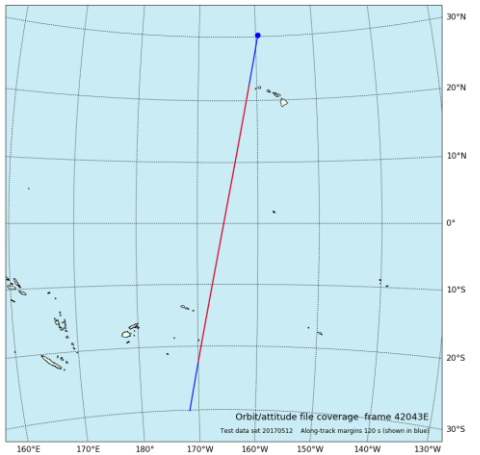
"Halifax" scene

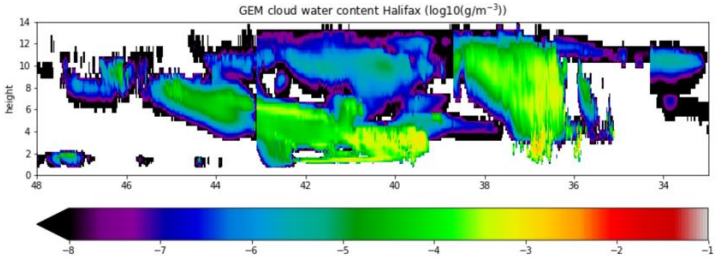


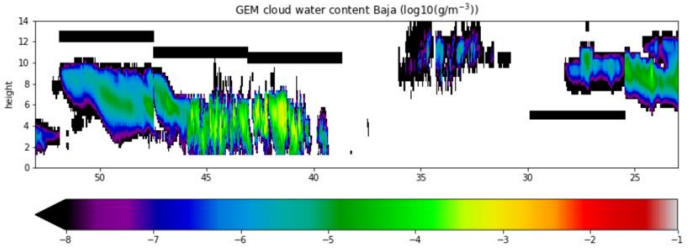
"Baja" scene

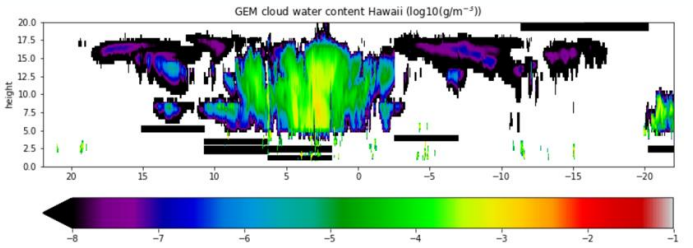


"Hawaii" scene









Test Data are available for the three test scenes
Level 2 products produced by European/Canadian team (based on simulated Level 1 data produced by science team)

Data available on ftp account – request access from ESA
However, recommended to wait for a few months until Level 1–Level 2 chain completed!

Level 1 data produced by ESA processors
A-NOM, M-NOM, M-RGR, B-NOM, B-SNG
(some issues to be resolved, not yet chained with Level 2 processors in production model)

Level 2 **Algorithm Theoretical Basis Descriptions** to be published in *Atmospheric Measurement Techniques Special Issue on "EarthCARE Level 2 algorithms and data products"* → paper submission target is June 2022

Acknowledgments

The EarthCARE Joint Mission Advisory Group

Co-chairs: *A.J. Illingworth, H. Okamoto*

Members: *L. Baldini, A. Battaglia, H. Chepfer, N. Clerbaux, J. Cole, J. Delanoë, D. Donovan, J. Fischer, S. Groß, R. Hogan, T.Y. Nakajima, T. Nishizawa, Y. Ohno, M. Satoh, K. Suzuki, N. Takahashi, U. Wandinger*

Observers: *S. Kato, G. Stephens, B. Stevens, D. Vane, D. Winker*

A. J. Illingworth *et al.*

The EarthCARE satellite: The next step forward in global measurements of clouds, aerosols, precipitation and radiation

http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-12-00227.1

Level 2 Team

- **ATLID retrievals**
  G.-J. van Zadelhoff, D. Donovan(KNMI, Netherlands)
- **CPR products**
  P. Kollias, B. Puigdomenech (McGill University, Canada); A. Battaglia (University of Torino, Italy)
- **MSI retrievals**
  A. Hünerbein, S. Bley (TROPOS, Germany); N. Docter, R. Preusker, J. Fischer (Free University of Berlin, Germany)
- **BBR radiances and estimated fluxes**
  N. Clerbaux, A. Velazquez, E. Baudrez (Royal Meteorological Institute Belgium); C. Domenech, R. Garcia Maranon (GMV Madrid), J. Fischer (Free University of Berlin, Germany)
- **Synergistic ATLID & MSI retrievals**
  U. Wandinger, A. Hünerbein, M. Haarig (TROPOS, Germany)
- **Synergistic CPR & ATLID & MSI retrievals**
  R. Hogan, S. Mason (ECMWF, UK); J. Delanoë, A. Irbah (LATMOS, France)
- **Radiation products (from retrievals) & closure**
  H. Barker, J. Cole, M. Shephard, Z. Qu (Environment and Climate Change Canada); N. Villefranque (LMD/IPSL, France)

ECMWF Assimilation

M. Janiskova, M. Fielding