

Microwave Sounder (MWS) Product Formats and Test Datasets

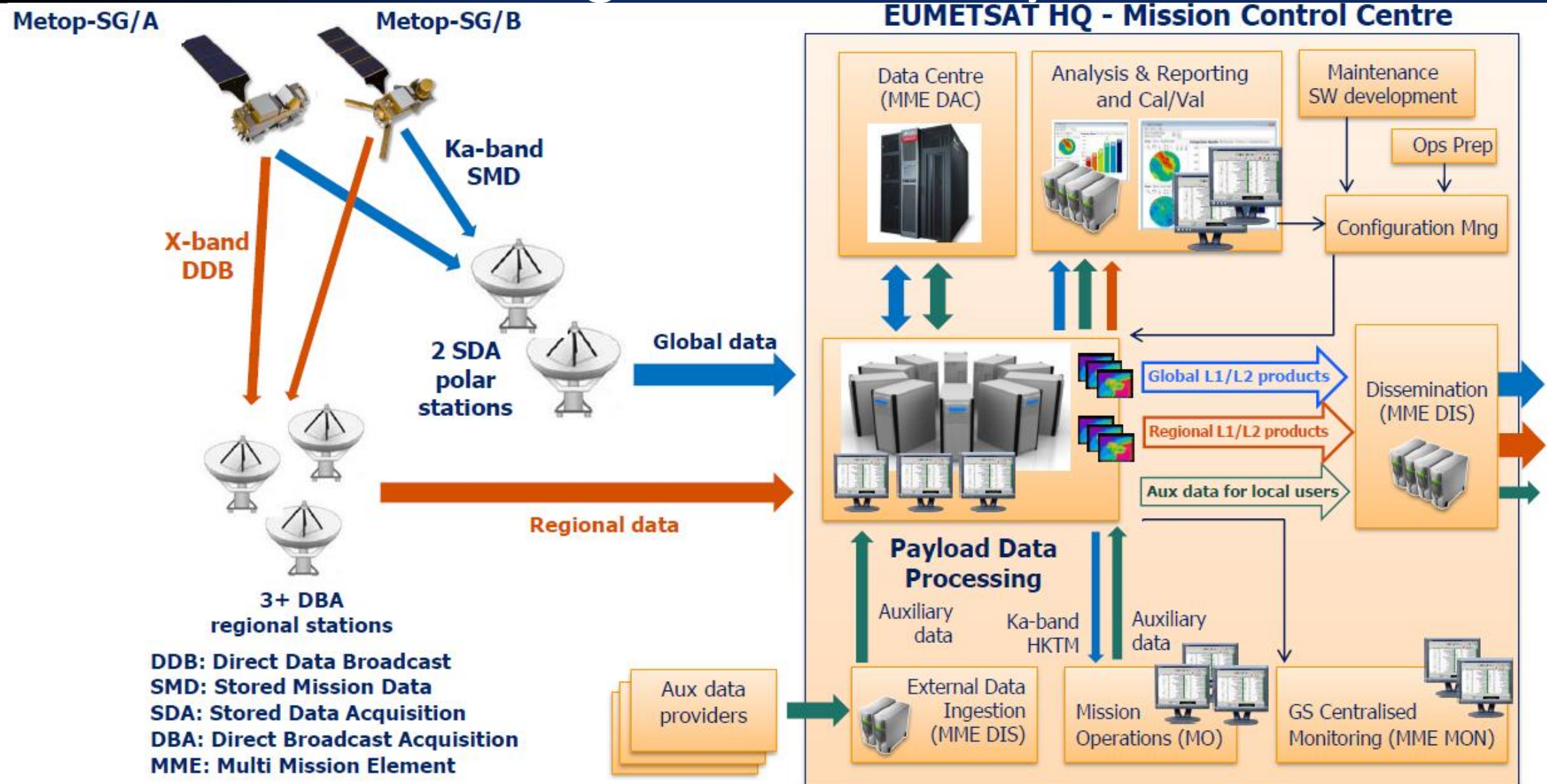
User Preparation Webinar on EPS-SG Microwave and
Submm Sensors, 11 October 2021



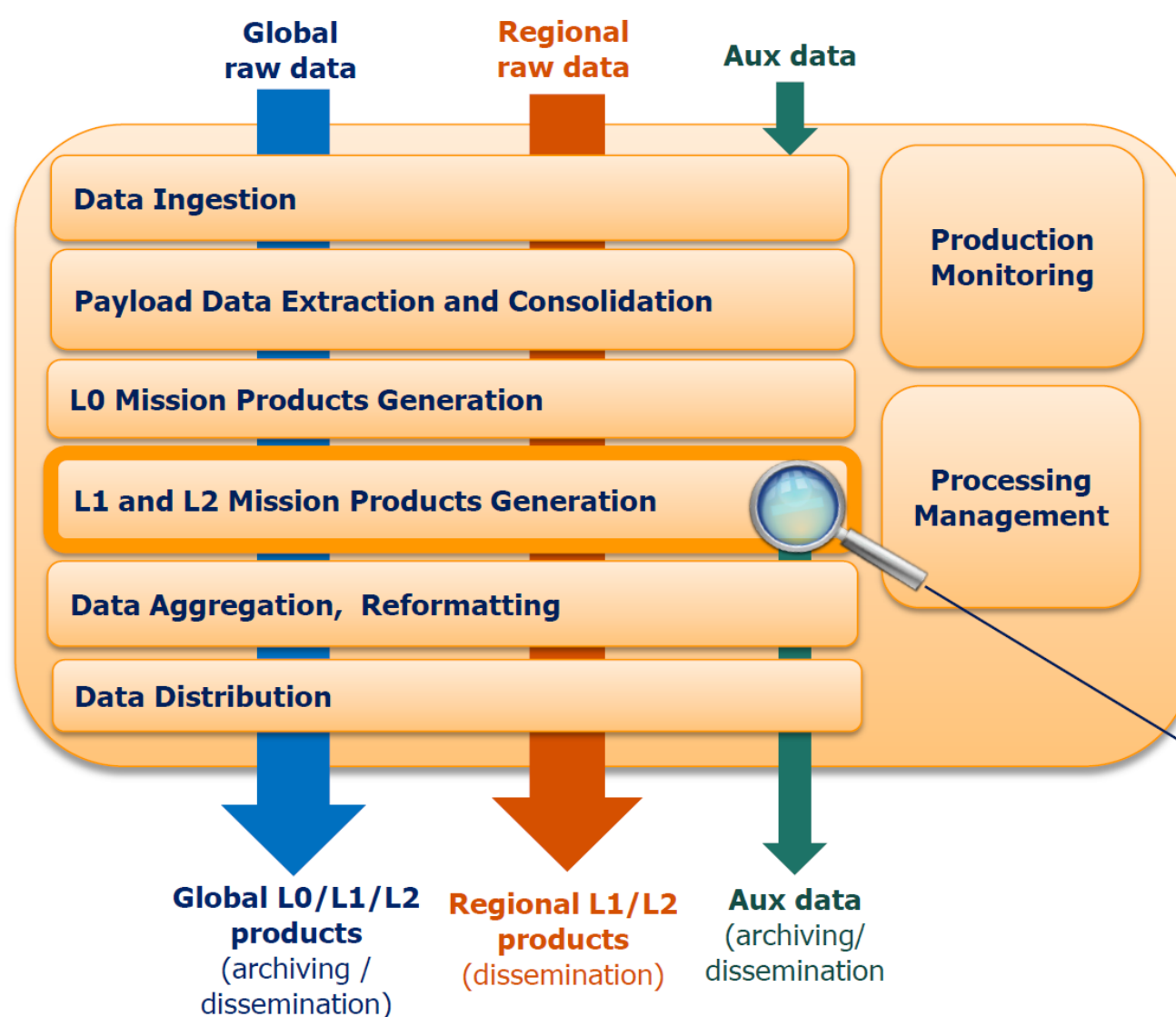
Contents

- Introduction to EPS-SG data acquisition and processing
- MWS product formats description
- EPS-SG dissemination strategy
- MWS reference L1B and L2 test datasets

EPS-SG Data Acquisition and NRT Processing (Product Generation-Archiving-Dissemination) at EUMETSAT HQ



Payload Data Processing: functional breakdown



Inner functional breakdown of the **Payload Data Processing** function with main NRT data flows

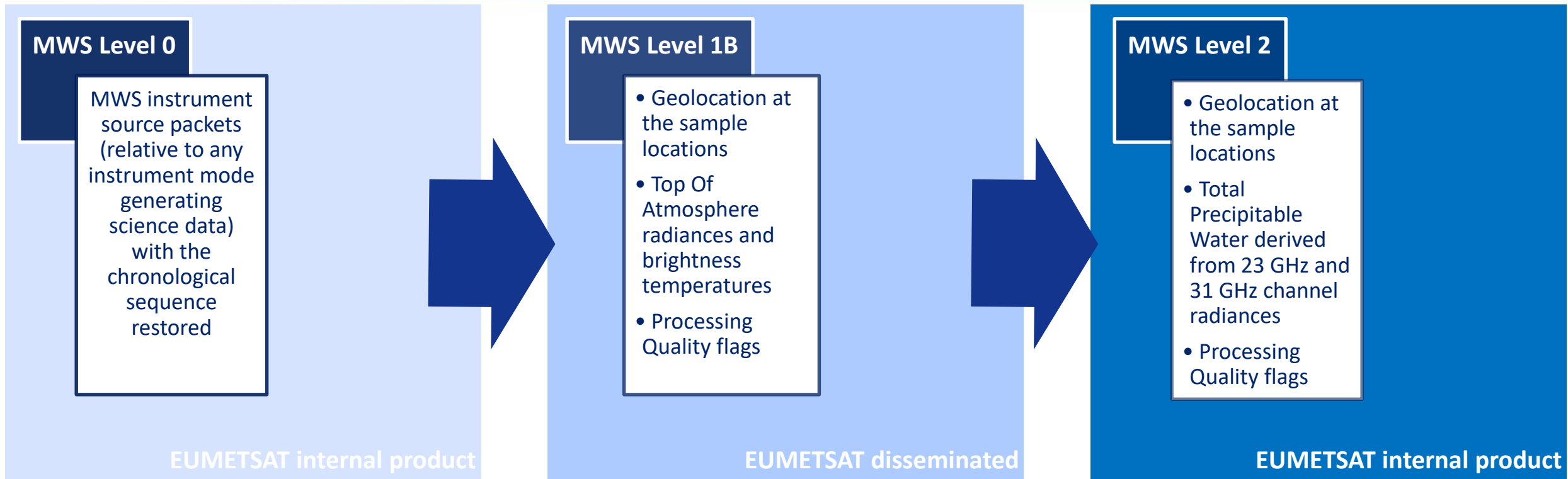
Native product format: **NetCDF-4** (enhanced data model) for all products

Some products will be reformatted in **BUFR** before dissemination

L1/L2 Product Generation Functions (PGFs) for all Metop-SG instruments and L1/L2 products

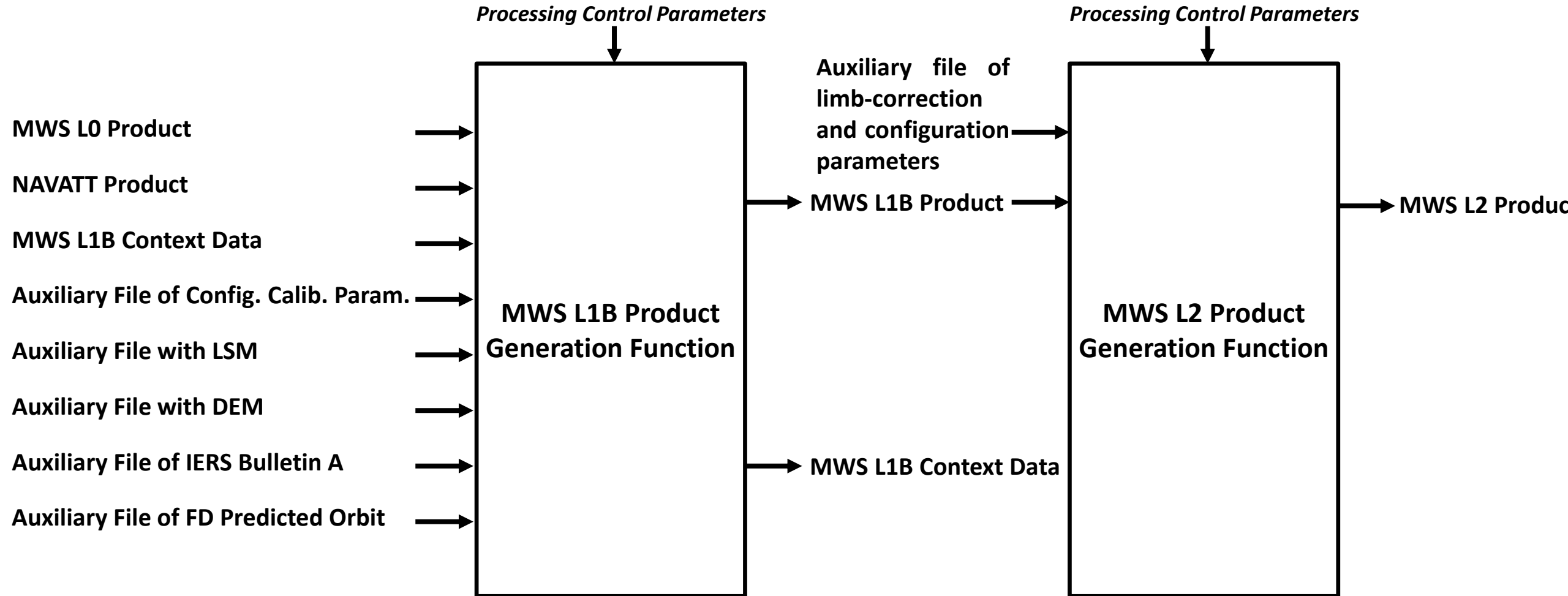


Introduction to MWS data processing: L0/L1/L2 products



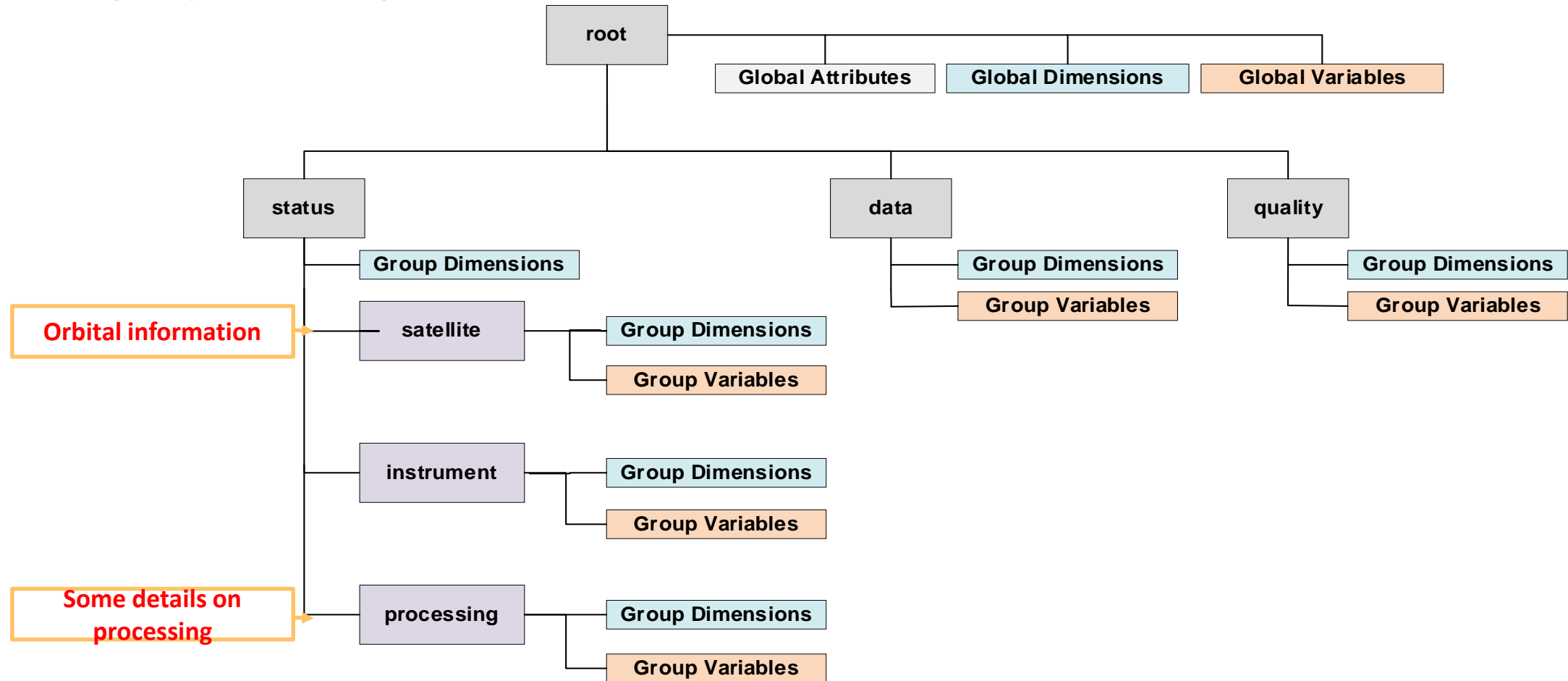
- Native Format: NetCDF-4
- Product Size / Orbit
 - Level 0 : about 34 MB / orbit
 - Level 1B : about 81 MB / orbit
 - Level 2 : about 36 MB / orbit

MWS data processing: L1B / L2 dataflow



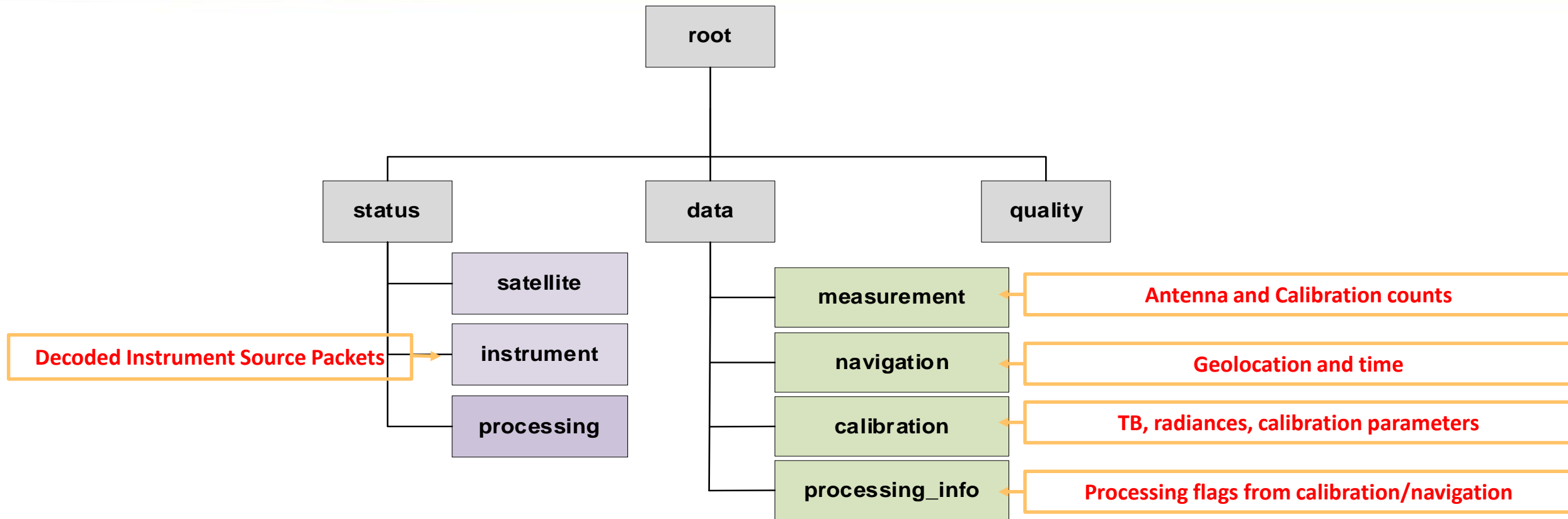
Product format: NetCDF-4 structure of EPS-SG products

Native product files are in NetCDF-4 format where data and metadata are organized into groups and subgroups following the Climate and Forecast metadata (CF) conventions



Structure common to all EPS-SG products

Product format: EPS-SG MWS L1B: groups and variables



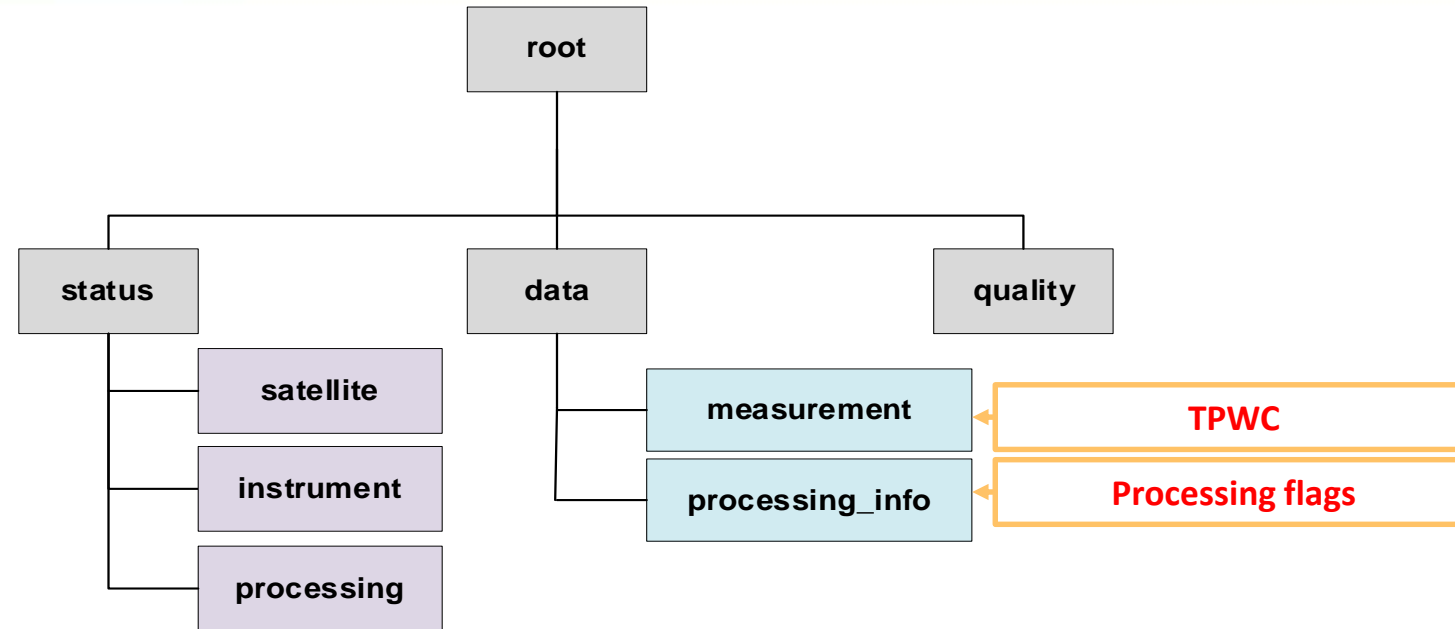
Further details are given later when showing the MWS L1B test dataset

Product format: EPS-SG MWS L1B coded into BUFR

MWS BUFR tables are almost finalized

References	Element	Variable(s) from NetCDF
0 08 070	TOVS/ATOVS product qualifier	2 (signifies L1B)
0 01 033	Identification of originating/generating centre	254
0 01 034	Identification of originating/generating sub-centre	0
0 01 007	Satellite identifier	/spacecraft
0 02 019	Satellite sensor indicator	/instrument
0 25 061	Software identification and version number	status/processor_version, /mission_type
0 05 040	Orbit number	/orbit_start
2 01 133	Change data width	
0 05 041	Scan line number	n_scans index
2 01 000	Change data width	
0 05 043	Field of view number	n_fovs index
301011	Year	/data/measurement/mws_scantime_utc
	Month	/data/measurement/mws_scantime_utc
	Day	/data/measurement/mws_scantime_utc
301012	Hour	/data/measurement/mws_scantime_utc
	Minute	/data/measurement/mws_scantime_utc
2 07 003	Increase scale, reference value and data width	
0 04 006	Second	/data/measurement/mws_scantime_utc
2 07 000	Cancel increase in scale, reference value and data width	
3 01 021	Latitude	/data/navigation/mws_lat
	Longitude	/data/navigation/mws_lon
102002	Repeat 2 descriptors 2x	
021166	landFraction	/data/navigation/mws_surface_type
010001	heightOfLandSurface	/data/navigation/mws_terrain_elevation
2 02 126	Change scale	
0 07 001	Height of station	/data/navigation/mws_space_craft_altitude
2 02 000	Change scale	
0 07 024	Satellite zenith angle	/data/navigation/mws_satellite_zenith_angle
0 05 021	Bearing or azimuth	/data/navigation/mws_satellite_azimuth_angle
0 07 025	Solar zenith angle	/data/navigation/mws_solar_zenith_angle
0 05 022	Solar azimuth	/data/navigation/mws_solar_azimuth_angle

Product format: EPS-SG MWS L2: groups and variables

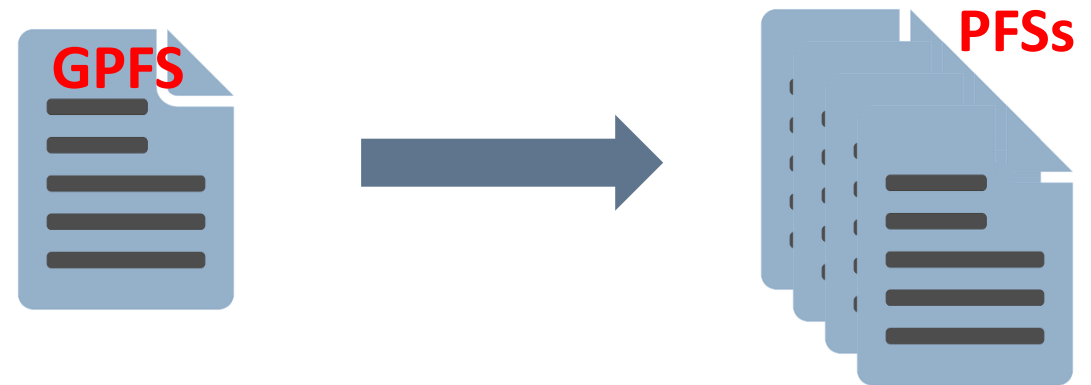


Further details are given later when showing the MWS L2 test dataset

Where to find all information on product formats?

- Format and content of products generated by the different mission Product Generation Functions (PGFs) within the EPS-SG ground segment are given in specific **Product Format Specification** (PFS) documents. For MWS, users should refer to :
 - ✓ **L1B**: *EUM/LEO-EPSSG/SPE/14/777550* available at: eumetsat.int/media/44139
 - ✓ **L2** : *EUM/LEO-EPSSG/SPE/14/777687* available at: eumetsat.int/media/44138
- In addition, conventions for naming, format and metadata for all products in native format (NetCDF-4 following the CF conventions) as generated by the ground segment are given in the **Generic Product Format Specification** (GPFS):
 - ✓ **GPFS**: *EUM/LEO-EPSSG/SPE/13/702108* available at: eumetsat.int/media/46295

The GPFS is the main document applicable to all PFSs!



Product format: Naming of EPS-SG MWS L1B/L2 products

MWS Level 1B

W_XX-EUMETSAT-Darmstadt,SAT,SGA1-MWS-1B-RAD_C_EUMT_20210609091004_G_O_20070912070128_20070912084321_T_N____.nc

MWS Level 2

W_XX-EUMETSAT-Darmstadt,SAT,SGA1-MWS-02-TPW_C_EUMT_20210611120755_G_O_20070912070128_20070912084321_T_N____.nc

pflag_country_organisation_location_datadesignator_spacecraft_instrument_processinglevel_type_oflag_originator_generationtime_missiontype_environment_sensing-start_sensing-end_dispositionmode_processingmode

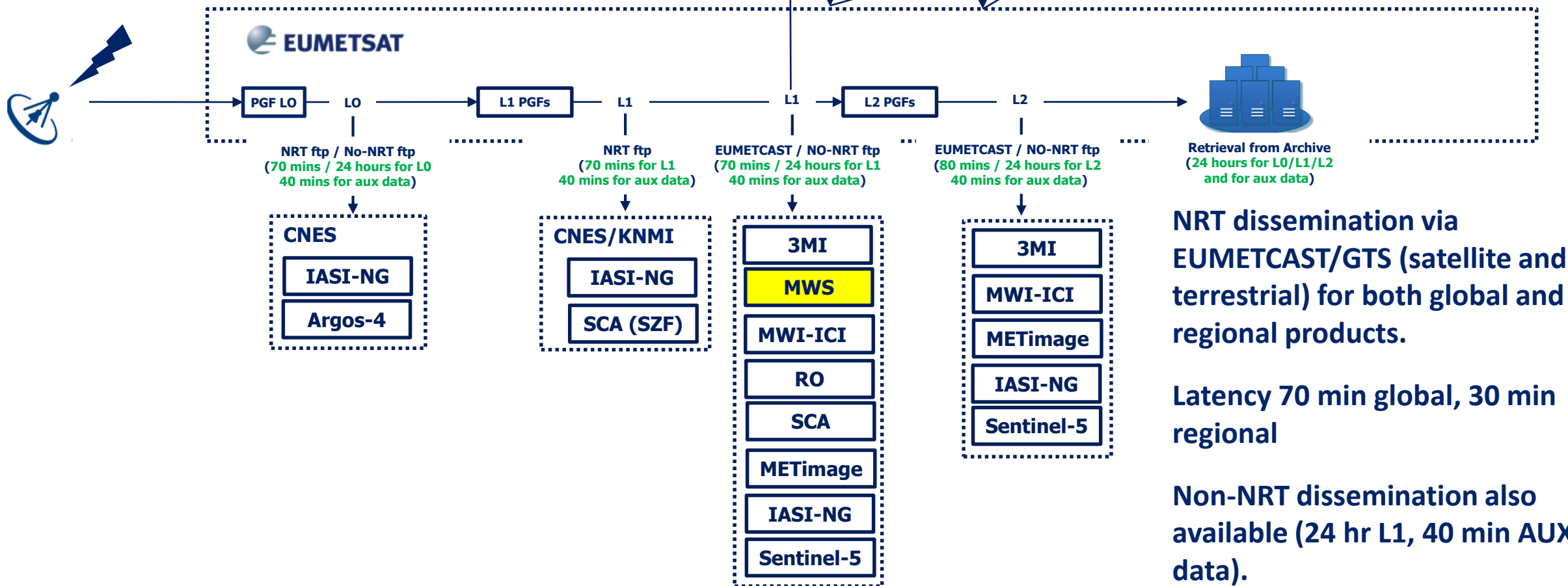
EPS-SG Global Dissemination Operations Baseline at EUMETSAT HQ

L1 and L2 products exchanged between EUMETSAT and NOAA via JEUNO (Joint EUMETSAT and NOAA Operational Infrastructure for Satellite Data Exchange)

Jeuno Gateway
NOAA



Satellite Application Facilities (SAFs) are specialized processing centers in charge of the generation of some of the Level 2 products and higher level by processing the inputs disseminated by EUMETSAT Central Processing Centre. The SAF centers are part of the EPS-SG system although they are designed, developed and deployed outside EUMETSAT, as part of other programs, too. The product processed by the SAF will be disseminated by EUMETSAT End Users in NRT once received by EUMETSAT HQ, and will be also available for offline retrieval from the archiving. The SAF product will be archived in the SAF premises, but they will be available for End Users in the EUMETSAT catalogue to be retrieved offline.



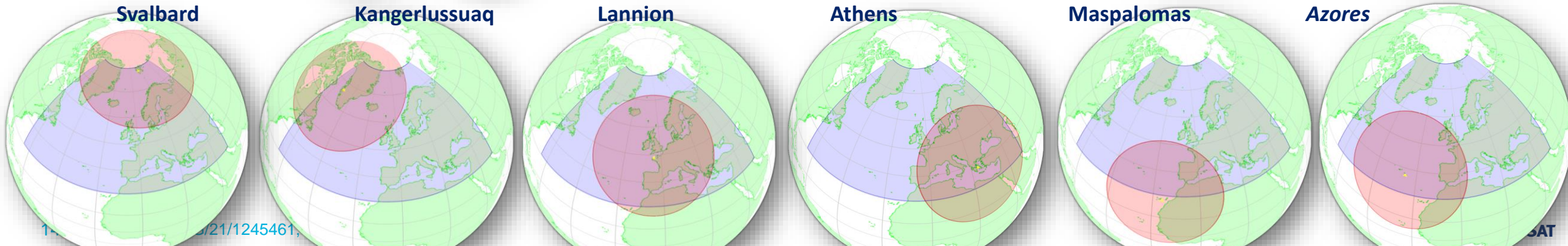
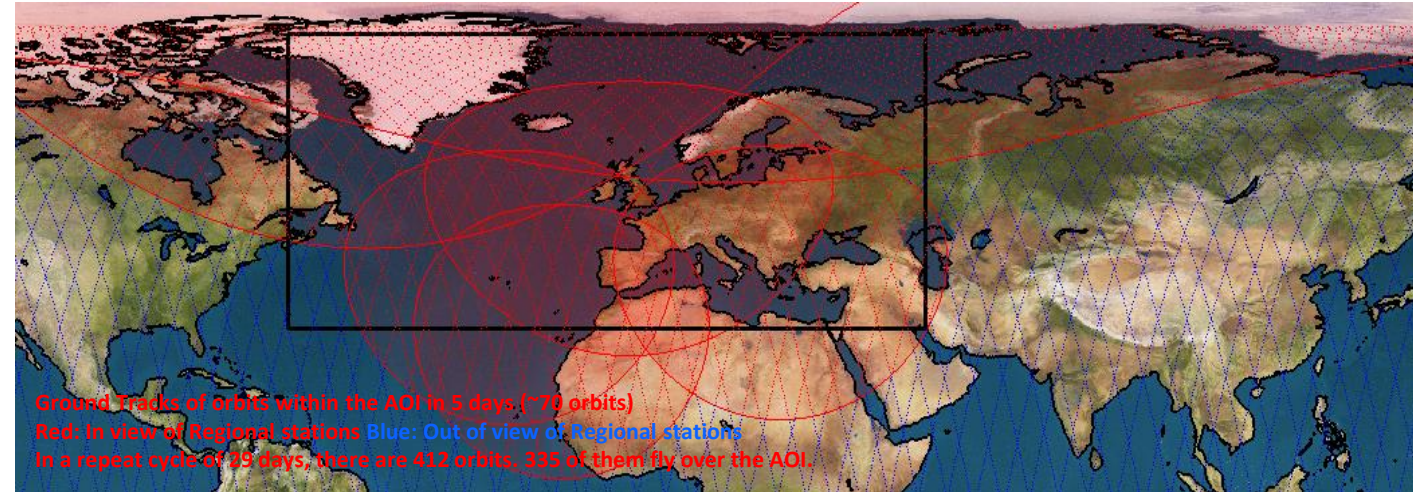
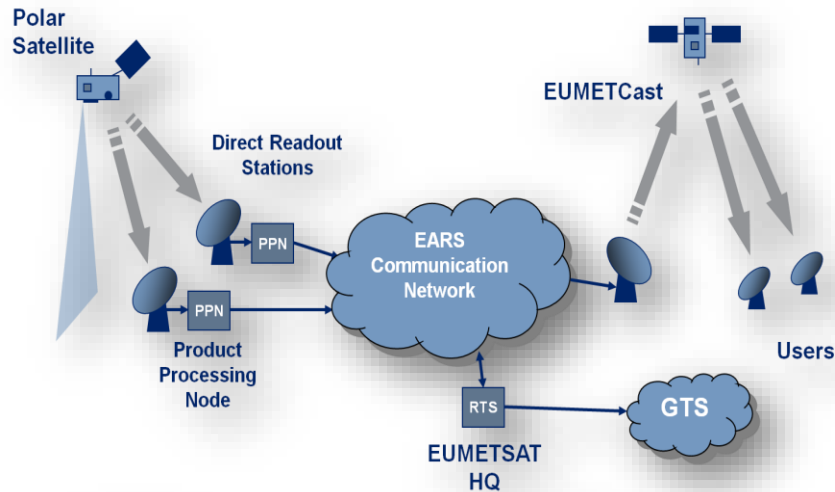
NRT dissemination via EUMETCAST/GTS (satellite and terrestrial) for both global and regional products.

Latency 70 min global, 30 min regional

Non-NRT dissemination also available (24 hr L1, 40 min AUX data).

MWS Regional Dissemination – EARS stations

The aim of the EUMETSAT Advanced Retransmission Service (EARS) is to improve (wrt the global dissemination) the timeliness of sounder, scatterometer and imager data from the EUMETSAT Metop and NOAA satellites. This is done to better suit the needs, over a specific Area of Interest (AOI), of the operational regional NWP short-range forecasting and nowcasting applications. The location of the AOI extends from 30 to 80 deg North and from 50 deg East to 65 deg West, mainly covering Europe and the North Atlantic. AOI data (95%) are delivered to users within 30 minutes of sensing. To cover the AOI, a network of Direct Broadcast Acquisition (DBA) stations within this area is needed. When a satellite is visible by the X-band antenna of the DBA station, data are received and then transmitted in real-time to EUMETSAT Headquarters for processing and retransmission to end users via EUMETCast/GTS.



Online access to data



Product Navigator

navigator.eumetsat.int

Explore our catalogue,
and data collections



EUMETView

view.eumetsat.int

View, animate and
interact with satellite
imagery



EUMETSAT Data Store

data.eumetsat.int

Download near real-time
and historical Meteosat &
Metop data



EUMETSAT Data Center

eumetsat.int/eumetsat-data-centre

Order past data and generated
products from EUMETSAT



Data Tailor

eumetsat.int/data-tailor

Learn more about our new
data customization toolbox



EUMETCast

eumetsat.int/eumetcast

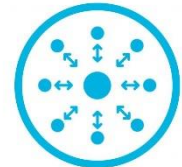
Learn more about data from the
Metop and NOAA satellites directly
to user reception station



Metop Direct Dissemination

eumetsat.int/direct-dissemination

Learn more about our push
delivery service



Global Telecom System (GTS)

eumetsat.int/global-telecommun

Learn more about the GTS,
used to receive, send and relay
weather data and products

MWS reference test datasets

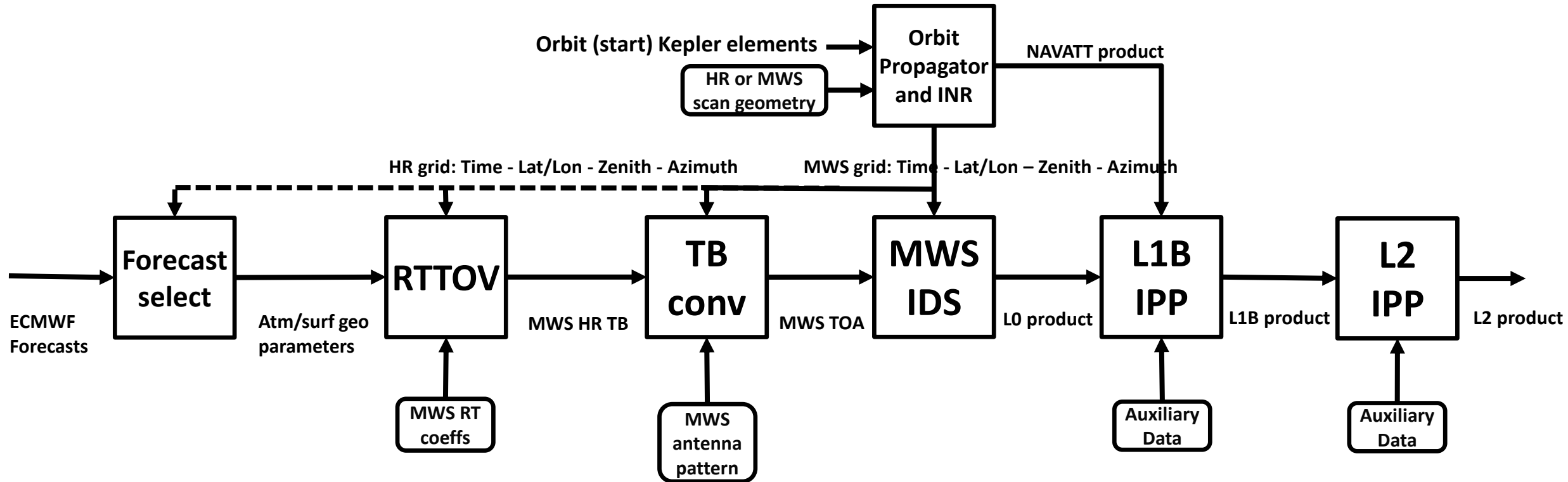
Version 1

- Already available through EUMETSAT website <https://www.eumetsat.int/simulated-epssg-mws-test-data>
- Nominal scenario, single orbit, compliant with PFS V3D

Version 2

- Close to be publicly released
- nominal plus various non-nominal processing scenarios, compliant with PFS V4A
- **Four full orbits (three consecutive)**
 1. 2007/09/12 07:01:27 - 08:43:21 METOP-A orbit 4654
 2. 2007/09/12 08:43:21 - 10:22:25 METOP-A orbit 4655
 3. 2007/09/12 10:22:25 - 12:04:08 METOP-A orbit 4656
 4. 2008/02/23 08:46:26 - 10:25:01 METOP-A orbit 6985

MWS reference test datasets: generation structure



INR: Image Navigation and Registration

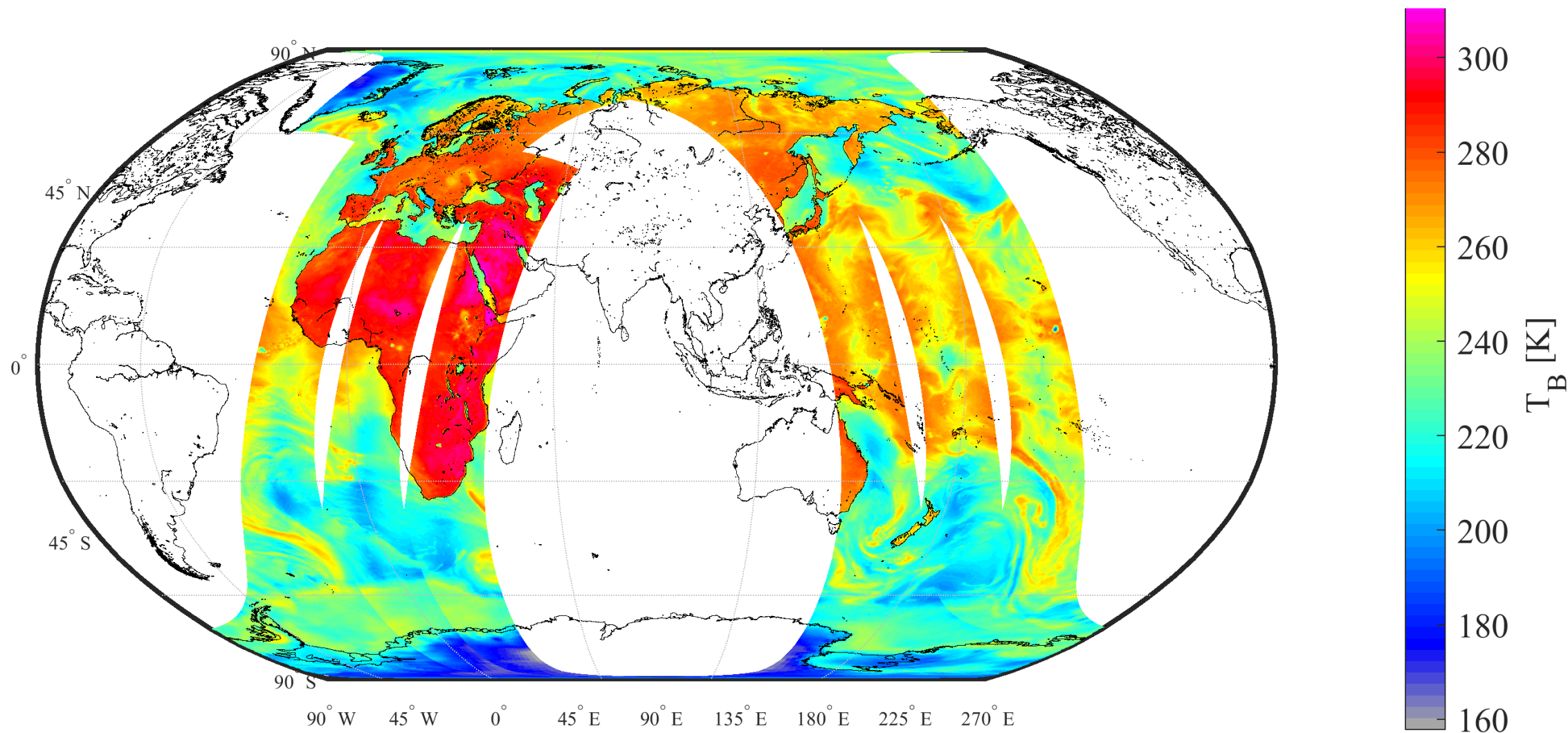
IDS: Instrument Data Simulator

IPP: In-house Prototype Processor

HR: High Resolution TOA: Top-of-Atmosphere

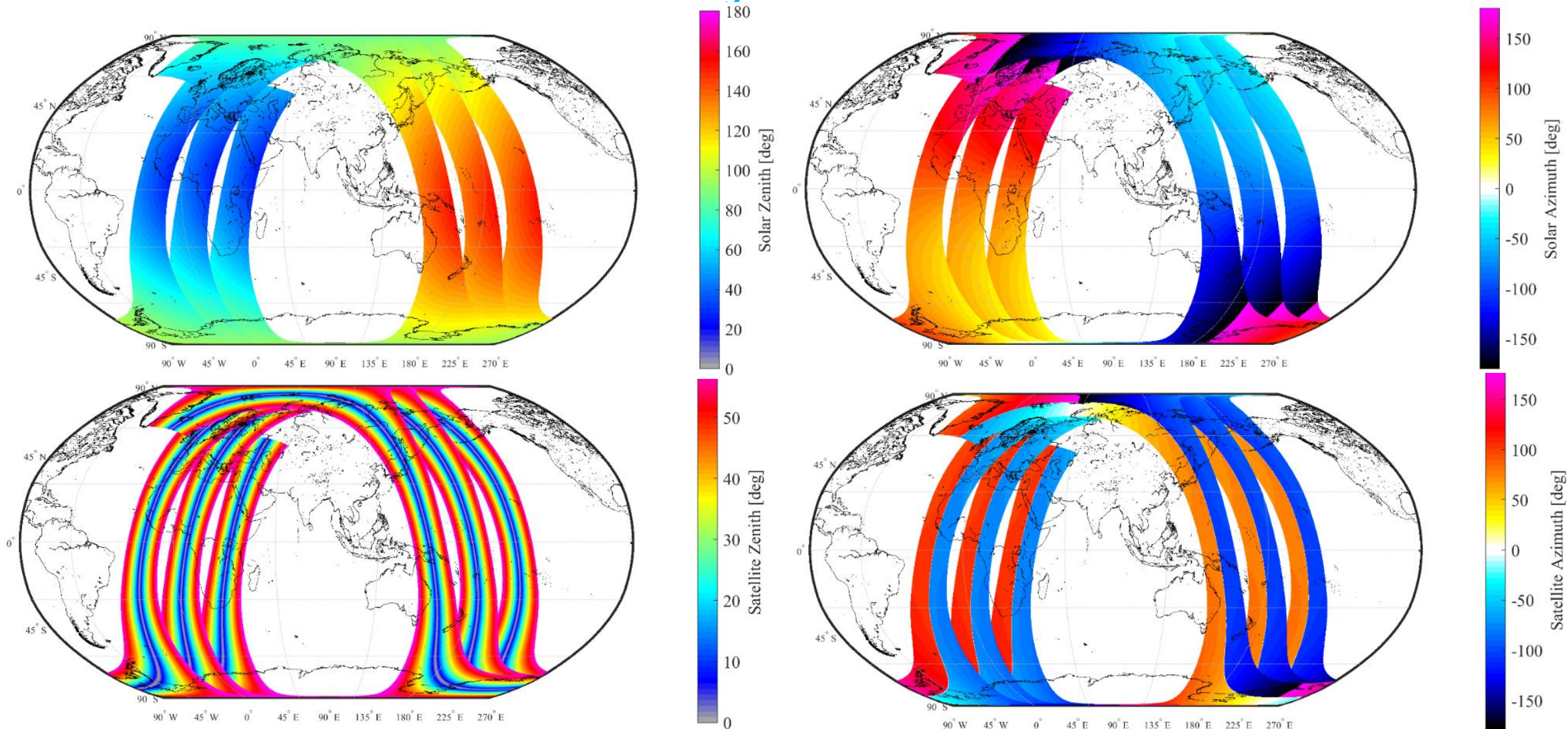
MWS L1B Reference Test Data: L1B product

MWS Channel 17 – Three consecutive orbits



MWS L1B Reference Test Data: L1B product

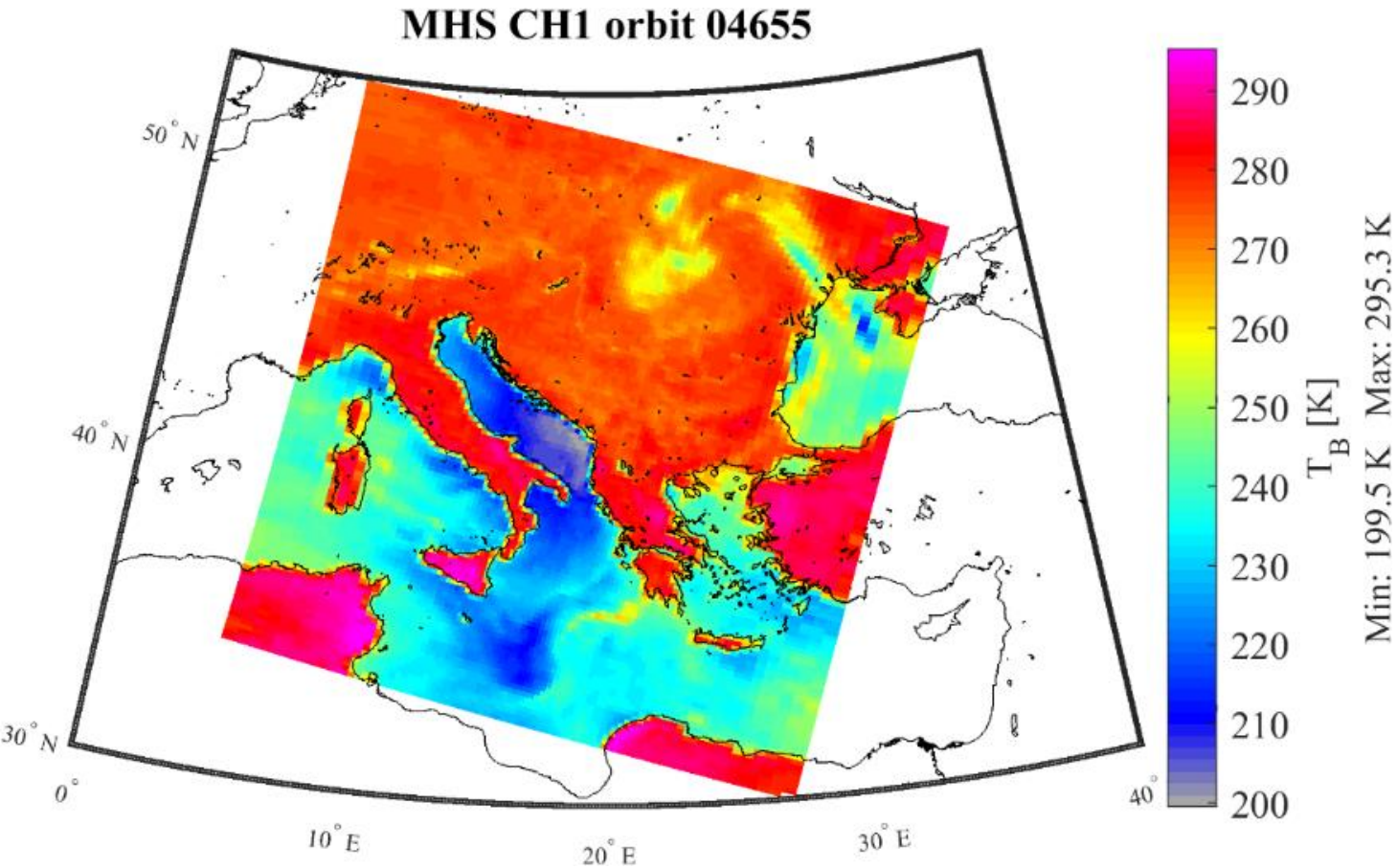
MWS Angular Relations



MWS L1B Reference Test Data: L1B product vs. MHS

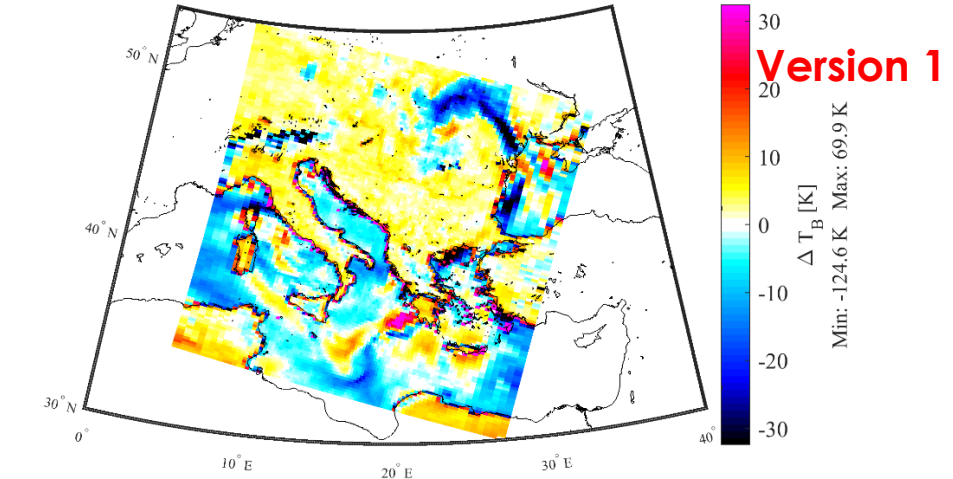
MWS Channel 17

Real

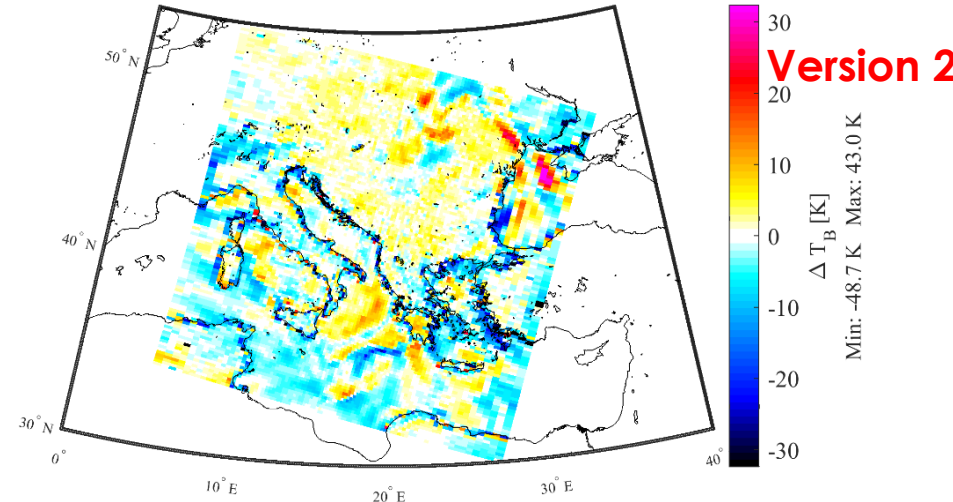


Test Data MWS L1B TB minus MHS

TB HRES CH17 minus MHS CH1 orbit 04655



TB HRES CH17 minus MHS CH1 orbit 04655

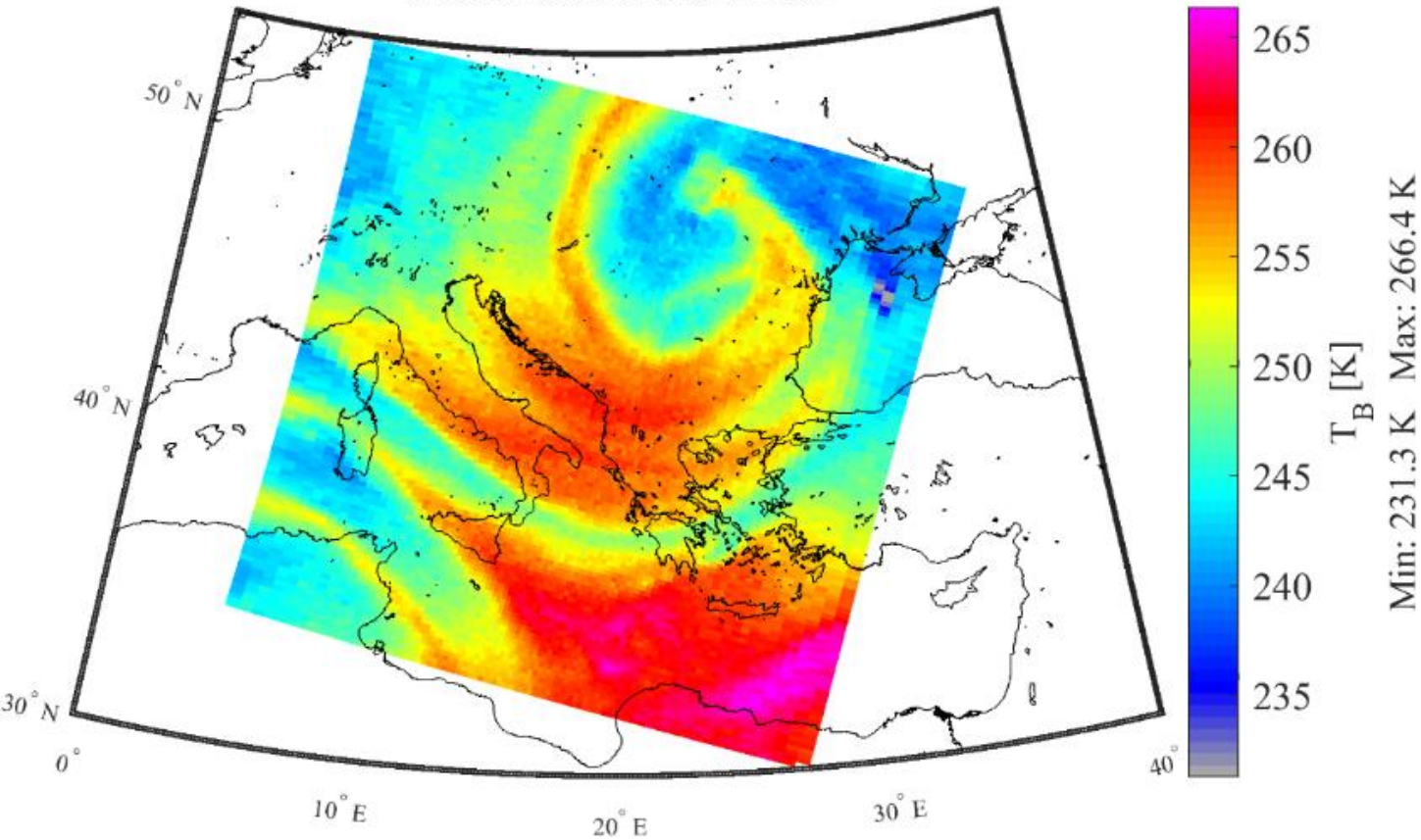


MWS L1B Reference Test Data: L1B product vs. MHS

MWS Channel 23

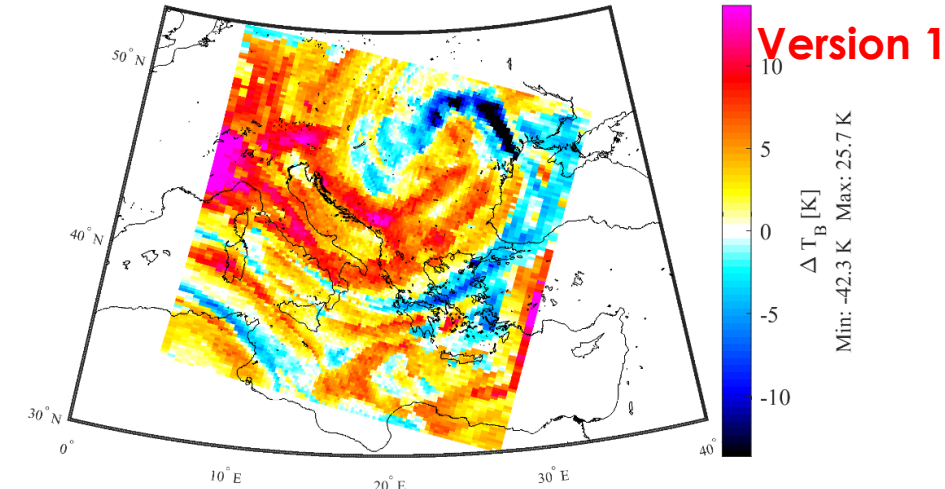
Real

MHS CH3 orbit 04655

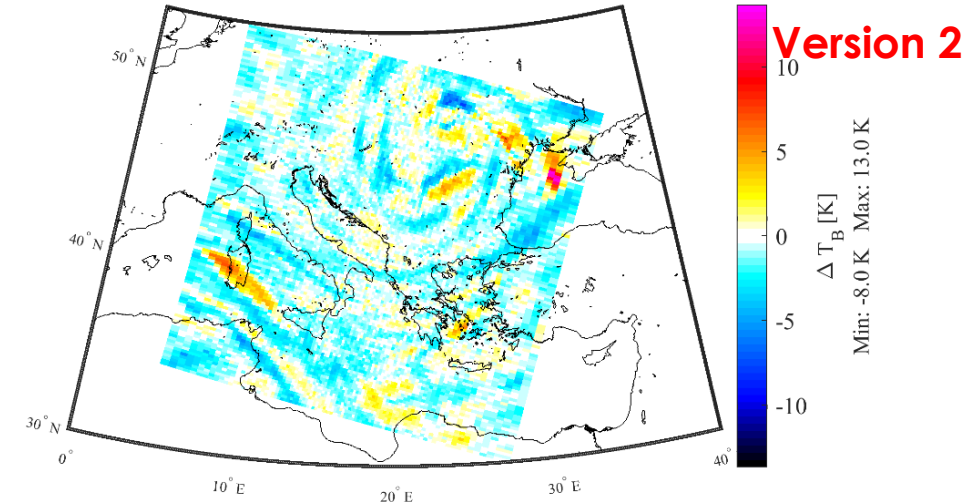


Test Data MWS L1B TB minus MHS

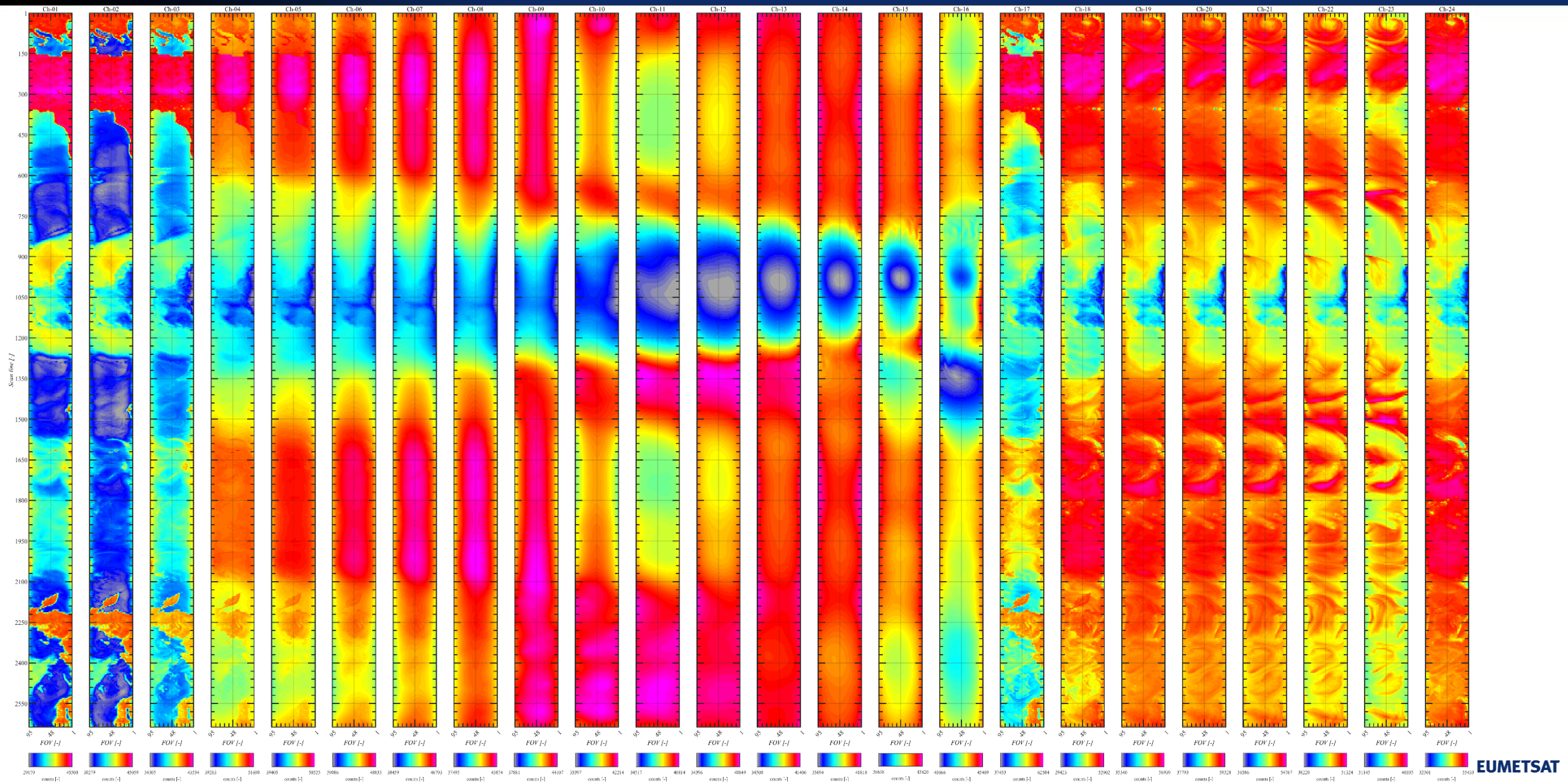
TB HRES CH23 minus MHS CH3 orbit 04655



TB HRES CH23 minus MHS CH3 orbit 04655



MWS Instrument Source Packets: simulated Earth view counts



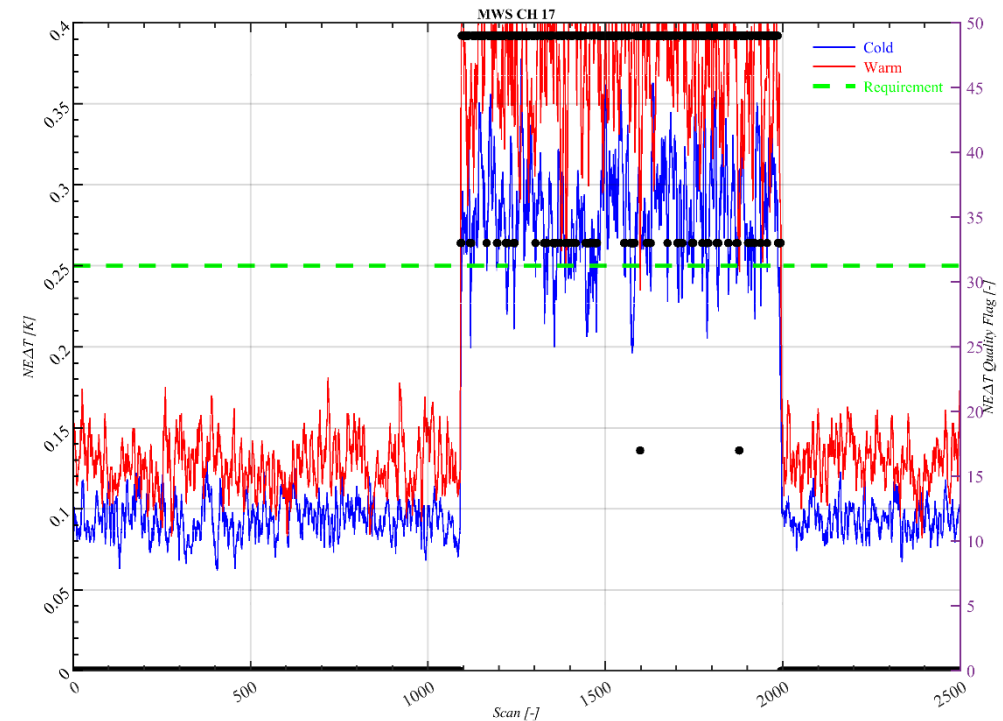
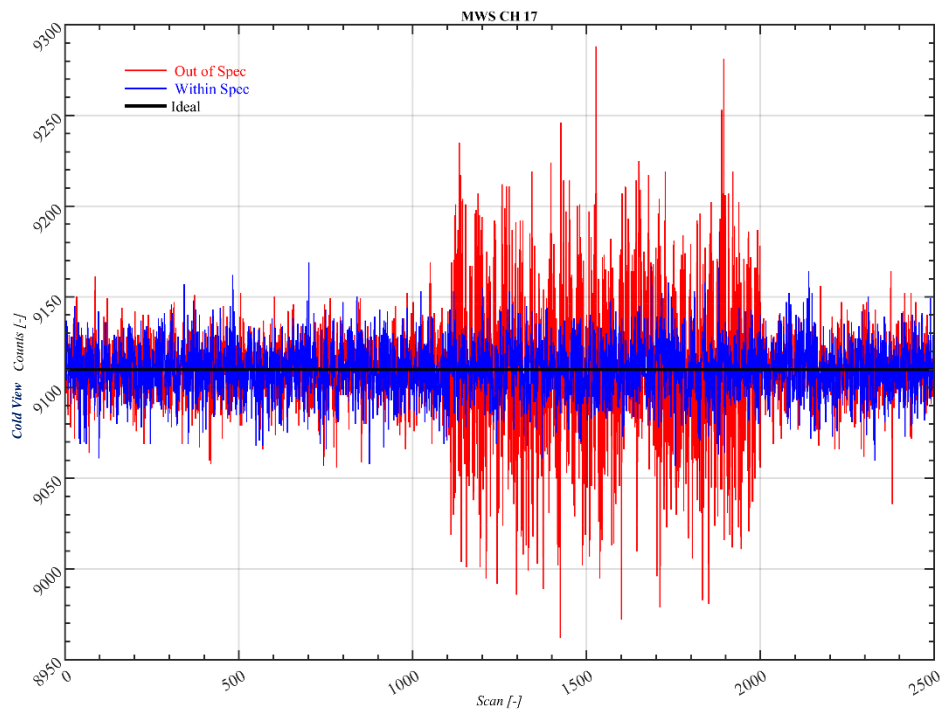
MWS L1B Reference Test Data: non-nominal conditions

Test cases

ID	Scenario	Level 0 Data Forcing
Nominal /ideal cases		
Test_Scenario_011	Nominal / ideal Processing: NRT Global – orbit 1	-
Test_Scenario_012	Nominal / ideal Processing: NRT Global – orbit 2	-
Test_Scenario_013	Nominal / ideal Processing: NRT Global – orbit 3	-
Test_Scenario_014	Nominal / ideal Processing: NRT Global – orbit 4	-
Nominal /perturbed case (orbit 2)		
Test_Scenario_010	Nominal / perturbed Processing: NRT Global	Added noise (within specs) to cold/warm/Earth counts
Degraded cases (orbit 2)		
Test_Scenario_062	Degraded because of degraded antenna counts	Corrupted half scan of Earth antenna counts
Test_Scenario_063	Degraded because of degraded calibration (cold or warm) counts	3 out of 5 cold views of Ch. 17 forced to drift
Test_Scenario_064	Degraded because of degraded PRT counts	PTR counts forced to drift, 2 groups (1-2, 3-5)
Test_Scenario_065	Degraded because of degraded instrument temperature	Hacked thermistor counts resulting in degraded instrument temperature
Test_Scenario_066	Degraded because of excessive NEDT noise	Added noise (out of specs) to cold/warm/Earth counts of Ch. 1 and Ch. 17
Special case (orbit 2)		
Test_Scenario_071	Moon contamination of the cold views	Hacked ISP time stamp, Moon-affected cold view counts inflated

MWS L1B Reference Test Data: non-nominal conditions

Nominal/non-nominal perturbed case: simulation of NE Δ T
MWS #17



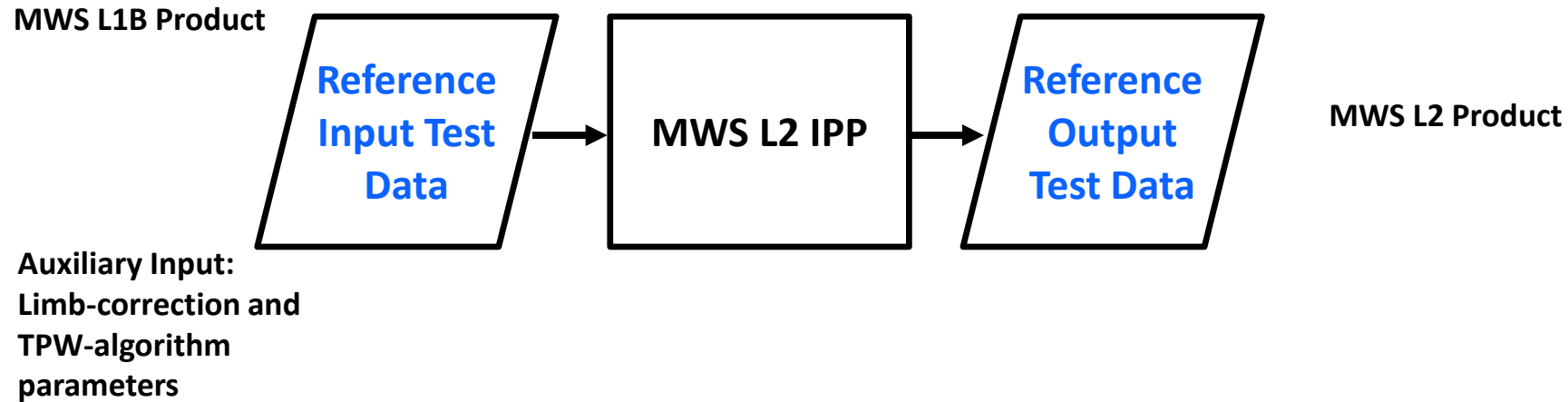
MWS L2 OP Reference Test Data: L2 product

MWS Level 2

- Internal product
- Main content:
 - total precipitable water (TPW), obtained from MWS channel 1 and 2 (23.8 GHz, 31.4 GHz)
 - Limb-corrected brightness temperature for all channels
- TPW can support temp.-difference based cloud detection in METimage data
- Processing functionalities, auxiliary data and format specified in L2 PGS, ADS and PFS

MWS L2 OP Reference Test Data: L2 product

- L2 directly obtained from L1B test data



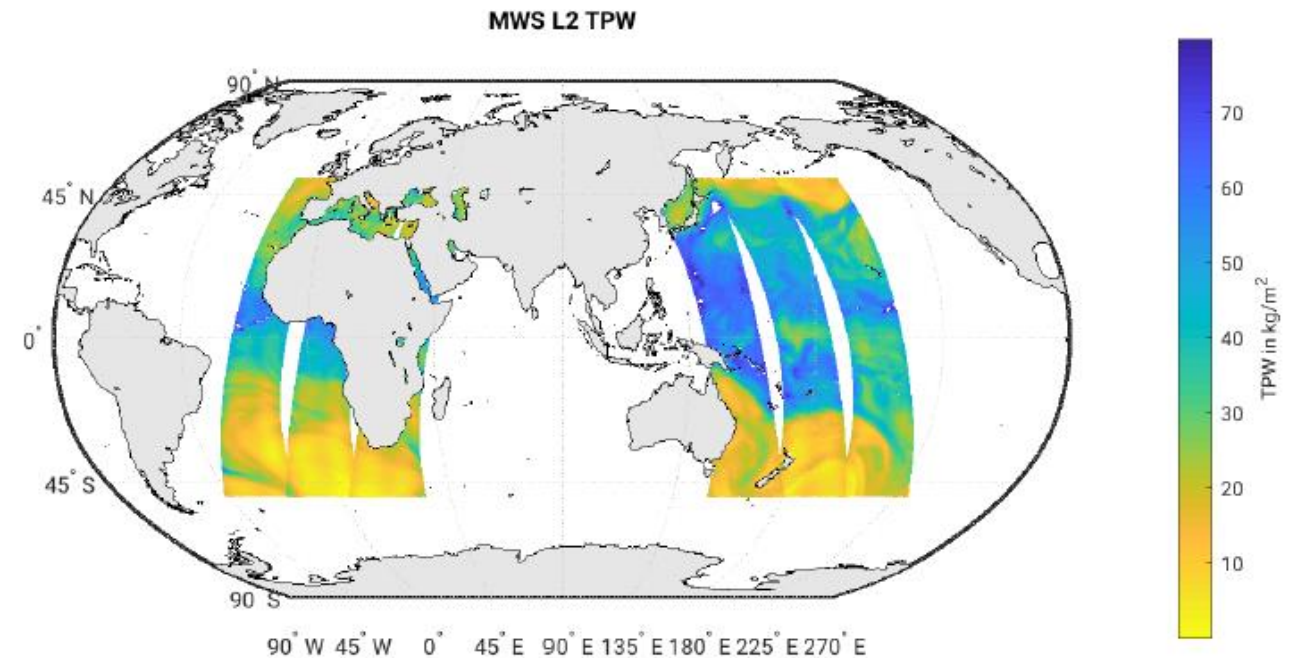
Contents:

- Total precipitable water (TPW) over water surfaces in latitude band between $\pm 50^\circ$; from channel 1 and 2
- Limb-corrected T_b
- Quality indicator flags, inherited from L1B to indicate quality of calibration

MWS L2 OP Reference Test Data: L2 product

Version 2

- Compliant with **PFS V4A**
- Based on Metop-A orbits 4654, 4655, 4656 (12.09.2007), plus an additional orbit 6985 (23.02.2008)
- Scenarios:
 - Nominal
 - Orbits 4654-4656, 6985
 - (with idealised zero NedT)
 - Orbit 4655 with realistic NedT
 - Non-nominal
 - Orbit 4655:
 - degraded antenna counts
 - degraded calibration counts
 - degraded PRT counts
 - Degraded instrument thermistor counts
 - excessive NedT
 - Moon intrusion



With Quality flags inherited
from L1B processing

MWS OP Reference Test Data

Having a look into the data...

... using Panoply-software to give a quick look into the NetCDFformat

Panophy: Panophy — Sources

File

Edit

View

History

Bookmarks

Plot

Window

Help

Create Plot

Combine Plot

Open Dataset

Remove

Remove All

Hide Info

Datasets

Catalogs

Bookmarks

Name	Long Name	Type
W_XX-EUMETSAT-Darmstadt,SAT,SG...	MWS L1B Top of the Atmosphere Radiance	Local File
data	data	—
calibration	data/	—
counts_coldview_averag...	Cold view counts averaged (over scans) around current scan line	2D
counts_warmview_avera...	Warm target view counts averaged (over scans) around current...	2D
inst_temperature	Instrument temperature	1D
mean_radiance_coldview	Cold view radiance	2D
mean_radiance_warmview	Warm view radiance	2D
moon_angle_threshold	Threshold for the difference between the Moon angle and the a...	1D
mws_calibration_gain	Calibration gain	2D
mws_nedt_cold	MWS radiometric sensitivity calculated using cold view counts	2D
mws_nedt_warm	MWS radiometric sensitivity calculated using warm target view c...	2D
mws_prt_temperature	PRT temperatures	2D
mws_toa_brightness_tem...	Top of the atmosphere brightness temperature at Earth view FOVs	2D
mws_toa_radiance	Top of the atmosphere spectral radiance at Earth view FOVs	2D
nonlinearity_correction	Nonlinear correction term	2D
postdetection_amplifier_...	Post detection amplifier gain	2D
primary_calibration_first_...	a1 calibration coefficients	2D
primary_calibration_seco...	a2 calibration coefficients	2D
primary_calibration_zero...	a0 calibration coefficients	2D
prt_resistance	Calculated PRT resistances	2D
rr_radiance	Rotating reflector emitted radiance	2D
rr_temperature	Rotating reflector temperature	1D
striping_ratio_cold	Striping ratio calculated using cold view counts	1D
striping_ratio_warm	Striping ratio calculated using warm target view counts	1D
warm_target_temperature	Warm target temperature	1D
zero_radiance_count	Zero-radiance counts	2D
measurement	data/	—
navigation	data/	—
processing_information	data/	—
quality	quality	—
status	status	—
instrument	status/	—
processing	status/	—
satellite	status/	—
earth_sun_distance_ratio	Ratio of current Earth-Sun distance to mean Earth-Sun distance	—
eccentricity	Eccentricity of the orbit at epoch time [TOD]	—
epoch_time_utc	Epoch time in UTC of the orbital elements	—

Show: All variables

Variable "mws_toa_brightness_temperature"

In file "W_XX-EUMETSAT-Darmstadt,SAT,SGA1-MWS-1B-RAD_C_EUMT_20210609095009_G_D_20070912084321_20070912102225_T_N____.nc"

Variable full name: data/calibration/mws_toa_brightness_temperature

```
int mws_toa_brightness_temperature(n_scans=2637, n_fovs=95, n_channels=24);
:valid_min = 50000; // int
:valid_max = 350000; // int
:missing_value = -2147483648; // int
:units = "K";
:scale_factor = 0.001; // double
:add_offset = 0.0; // double
:long_name = "Top of the atmosphere brightness temperature at Earth view FOVs";
```

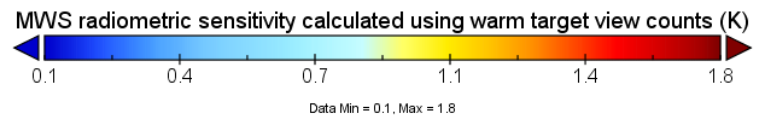
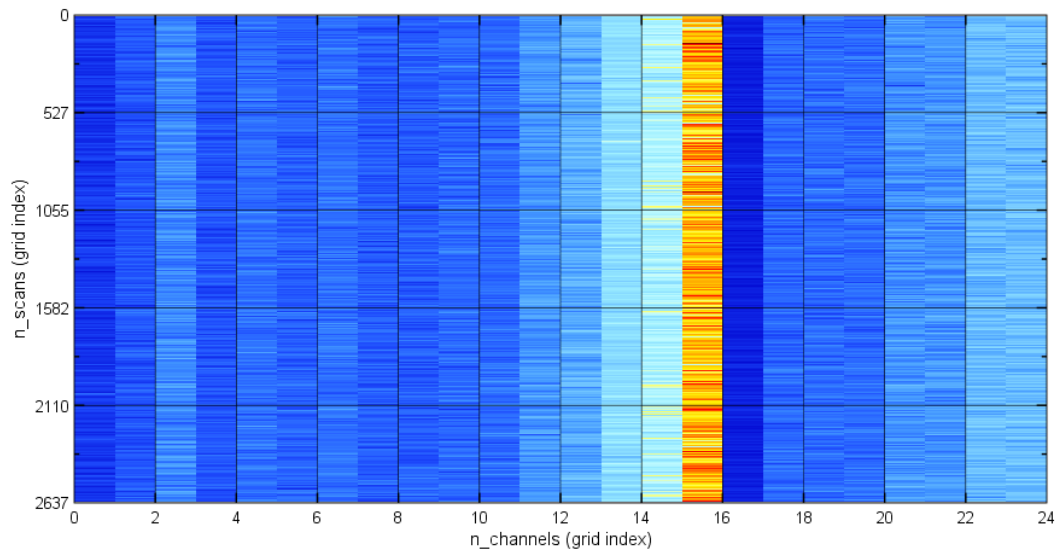
29 EUM/RSP/VWG/21/1245461, v1B, 11 October 2021

MWS L1B OP Reference Test Data: L1B product

Quality flag setting: e.g. excessive NedT

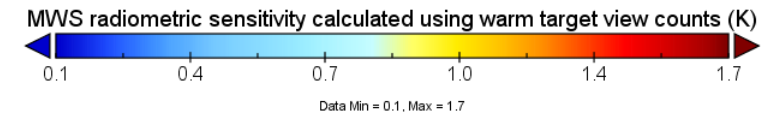
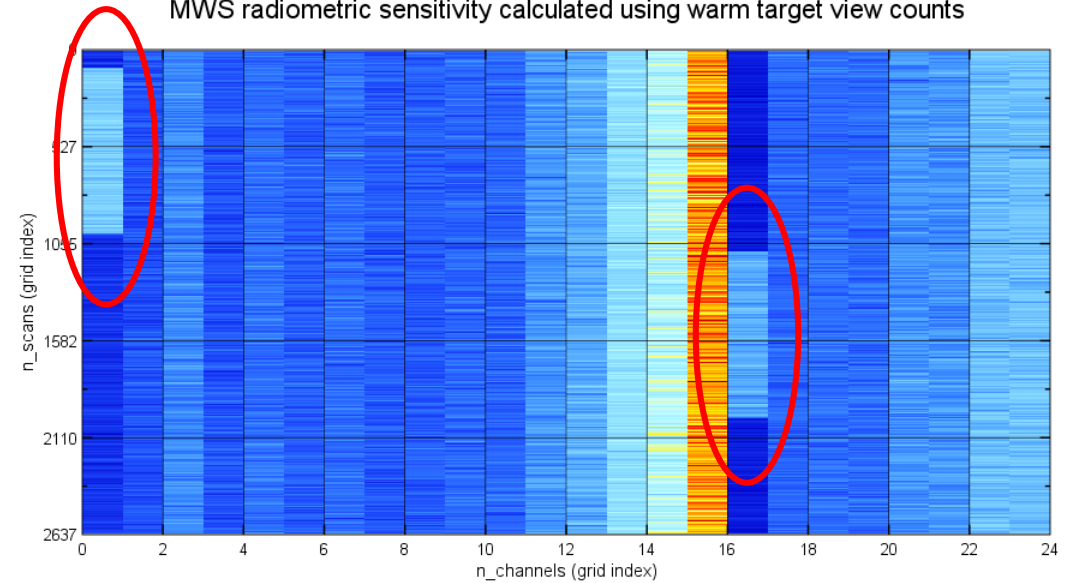
Nominal, realistic Nedt- scenario:
mws_nedt_warm

MWS radiometric sensitivity calculated using warm target view counts



Excessive Nedt- scenario:
mws_nedt_warm

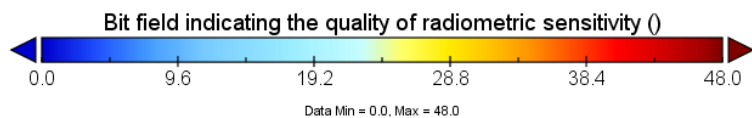
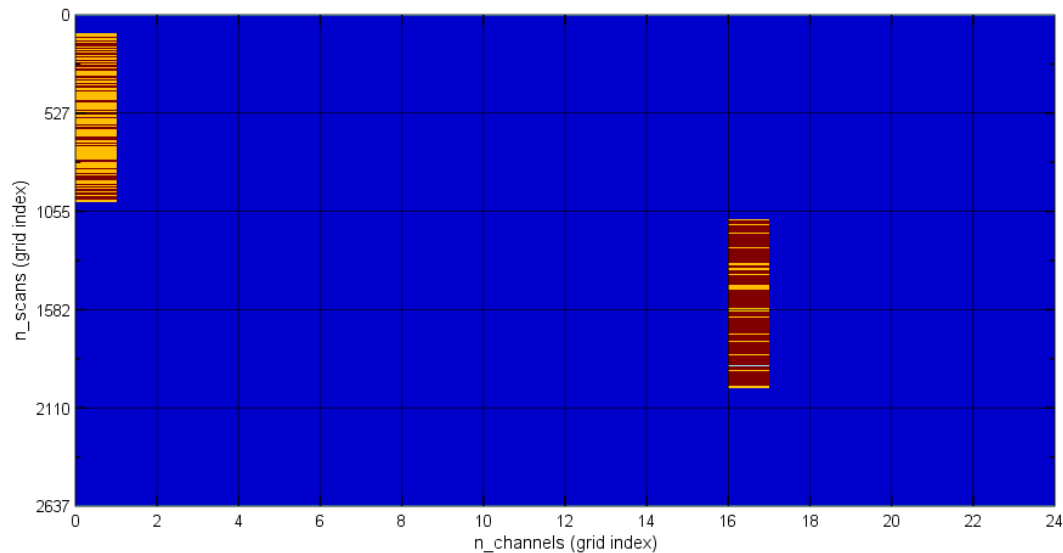
MWS radiometric sensitivity calculated using warm target view counts



MWS L1B OP Reference Test Data: L1B product

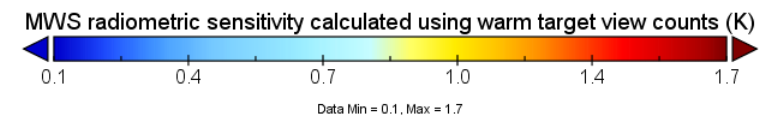
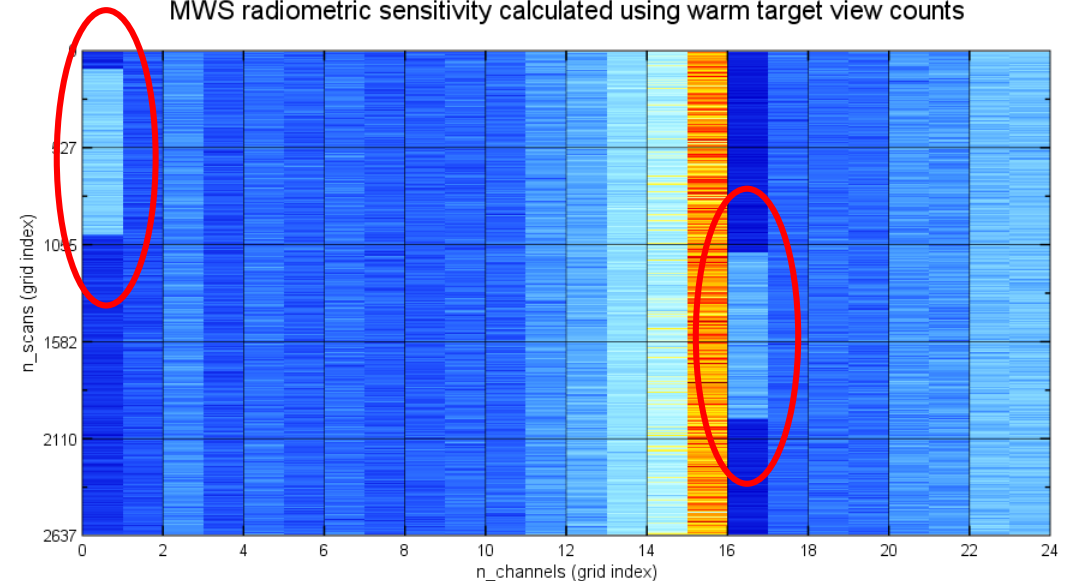
**Excessive Nedt- scenario:
mws_nedt_flag**

Bit field indicating the quality of radiometric sensitivity



**Excessive Nedt- scenario:
mws_nedt_warm**

MWS radiometric sensitivity calculated using warm target view counts



W_XX-EUMETSAT-Darmstadt,SAT,SG...

data

measurement

mws_bt_limbcorr

mws_lat

mws_lon

mws_nedt_cold

mws_nedt_warm

mws_satellite_azimuth_angle

mws_satellite_zenith_angle

mws_scantime_utc

mws_solar_azimuth_angle

mws_solar_zenith_angle

mws_surface_type

mws_terrain_elevation

mws_tpw

satellite_altitude

processing_information

mws_brightnesstemp_flag

mws_calibration_flag

mws_navigation_status

mws_nedt_flag

mws_position_flag_earthvi...

mws_scantime_quality

mws_tpw_quality_flag

quality

status

instrument

processing

creation_time_utc

satellite

Long Name

Total precipitable water content derived as a standalone retrieval...

data

data/

Limb corrected MWS brightness temperatures

Latitude corresponding to each field of view

Longitude corresponding to each field of view

MWS radiometric sensitivity calculated using cold view counts

MWS radiometric sensitivity calculated using warm target view co...

Satellite Azimuth angle corresponding to each field of view

Satellite Zenith angle corresponding to each field of view

UTC time at scan start

Solar Azimuth angle corresponding to each field of view

Solar Zenith angle corresponding to each field of view

Fraction of pixel covered by land - Low res, High res

Terrain elevation

MWS total precipitable water for every FOV

Spacecraft altitude above reference ellipsoid

data/

Bit field indicating the quality of Earth view TOA radiances and bri...

Bit field indicating the quality of the calibration

Bit field indicating the quality of the geolocation

Bit field indicating the quality of radiometric sensitivity

Bit field indicating the quality of the Earth view position

Bit field indicating a time gap around this scan

Flag indicating the quality of total precipitable water content. If t...

quality

status

status/

status/

UTC time of the start of the product creation

status/

Type

Local File

—

—

Geo2D

Geo2D

Geo2D

2D

2D

Geo2D

Geo2D

Geo2D

1D

Geo2D

Geo2D

Geo2D

1D

—

2D

2D

1D

2D

2D

1D

2D

—

—

—

—

—

Variable "creation_time_utc"

In file "W_XX-EUMETSAT-Darmstadt,SAT,SGA1-MWS-02-TPW_C_EUMT_20210611120627_G_D_20070912084321_20070912102225_T_N____.nc"

Variable full name: status/processing/creation_time_utc

```
double creation_time_utc;  
:long_name = "UTC time of the start of the product creation";  
:units = "seconds since 2020-01-01 00:00:00";  
:valid_min = -1.0E9; // double  
:valid_max = 1.0E9; // double  
:missing_value = -9.0E9; // double
```

Scalar variable has value: 4.557999e+07

Show: All variables

Create Plot

Combine Plot

Open Dataset

Remove

Remove All

Hide Info

Datasets

Catalogs

Bookmarks

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EUM/RSP/VWG/21/1245461, v1B, 11 October 2021

EUMETSAT

Summary

- MWS Level 1B and Level 2 products have been finalized both in term of processing and data format
- Structure and content of the products briefly illustrated here
- Test data are available
 - Version 1, single orbit, nominal scenario

More comprehensive:

- Version 2, four orbits (three consecutive orbits + one single orbit), nominal + non-nominal scenarios: ready and will be soon made publicly available.