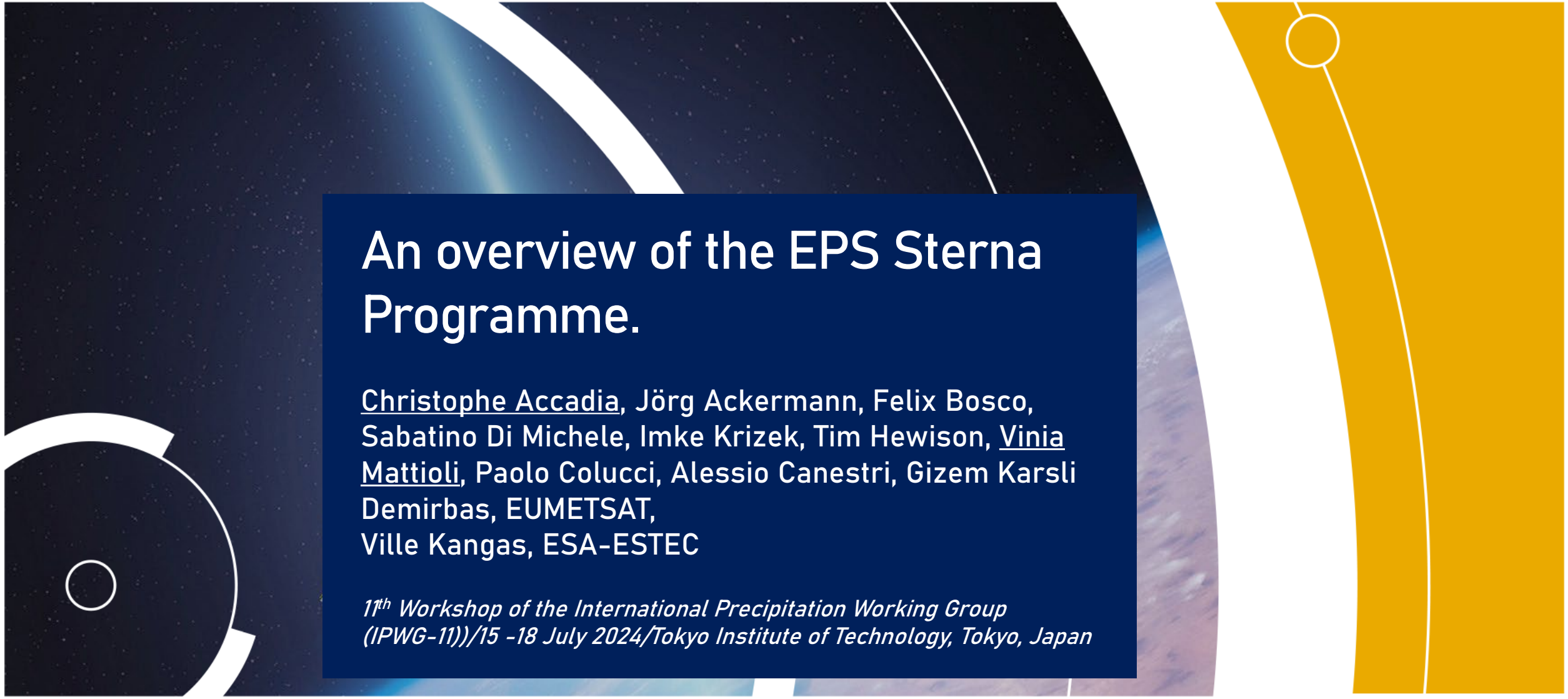


An overview of the EPS Sterna Programme.

Christophe Accadia, Jörg Ackermann, Felix Bosco, Sabatino Di Michele, Imke Krizek, Tim Hewison, Vinia Mattioli, Paolo Colucci, Alessio Canestri, Gizem Karsli Demirbas, EUMETSAT,
Ville Kangas, ESA-ESTEC

11th Workshop of the International Precipitation Working Group (IPWG-11))/15 -18 July 2024/Tokyo Institute of Technology, Tokyo, Japan

Agenda

Key Programmatic Features of EPS-Sterna

Objectives

Constellation Architecture

Overall System Overview

Expected Benefits of the EPS Sterna Constellation

Status of EUMETSAT activities and roadmap to approval

Key programmatic features of EPS-Sterna

- EUMETSAT identified a constellation of small microwave sounding satellites, complementing the reference EUMETSAT Polar System (EPS-SG) /Microwave Sounder (MWS), as a potential additional contribution to the realisation of the WMO Integrated Global Observation System (**WIGOS) Vision 2040,** in line with **objective 4 of the EUMETSAT strategy "Destination 2030".**

- EPS-Sterna will be a **EUMETSAT programme**; EUMETSAT will be responsible for the overall system, the development and provision of the ground segment, the procurement of the launch services, the LEOP, the system operations including the management of the constellation.

- The EPS-Sterna **space segment will be procured in cooperation with ESA**. It will capitalise on the experience from the ESA mission **Arctic Weather Satellite (AWS)** which is a technology demonstrator to be flown this year in July. Minor modifications are expected for the constellation.

- A successful outcome of the AWS in-orbit demonstration in 2024-2025 would represent an opportunity to expand the products envelope of the EPS-SG mission for its users, by implementing the **EUMETSAT Polar System Sterna.**

- **EPS-Sterna overall operational mission duration will be 13 years with the initial constellation expected in 2029.**

Objectives

- To expand and complement the microwave sounding observations from the EUMETSAT EPS-SG, the NOAA JPSS and the CMA FY polar-orbiting, meteorological satellites.

- To improve accuracy of **global Numerical Weather Prediction models** by increasing the number of microwave sounding observations by providing atmospheric water vapour and temperature profiles in clear and cloudy air;

- To contribute to **Nowcasting applications** at high latitudes through an increase in the frequency of microwave observations;

- The channels' selection and the temporal/spatial coverage can contribute to **global precipitation monitoring**

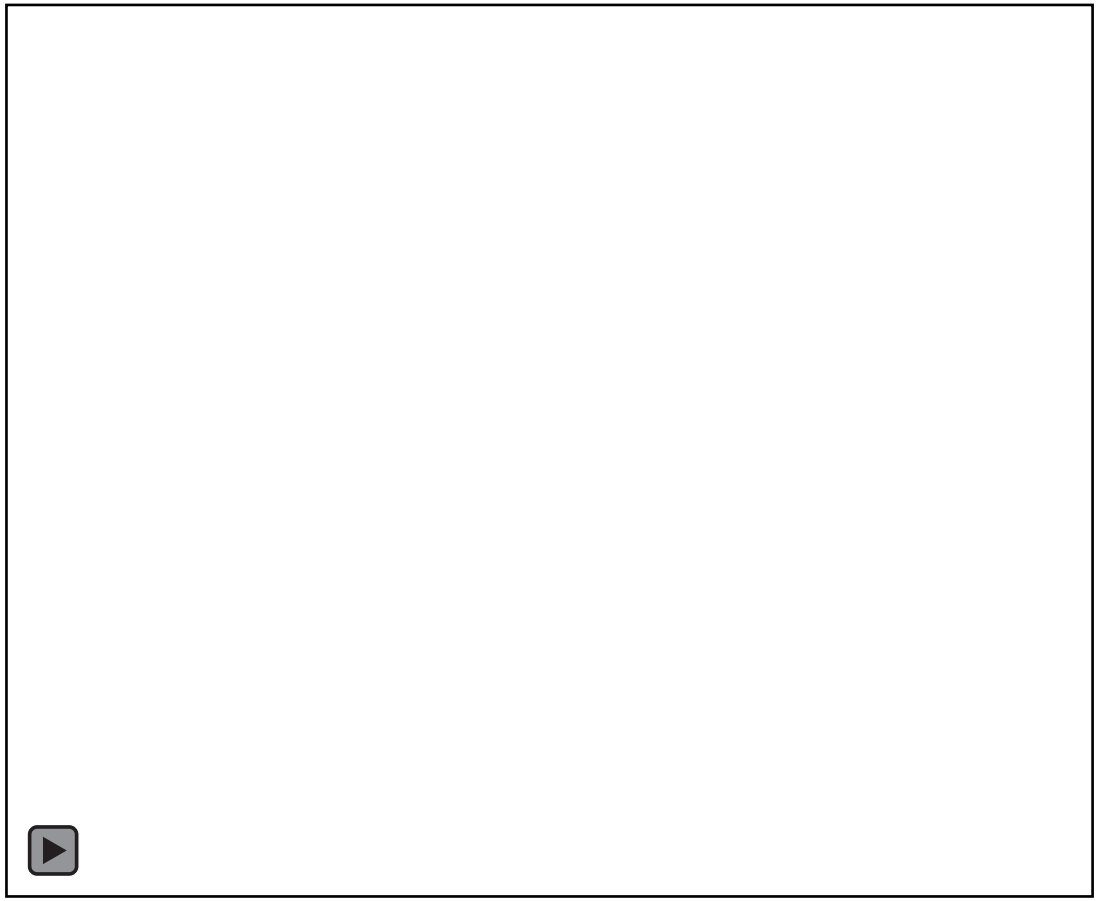
- To contribute to **climate monitoring** by adding to the existing record data with increased spatio-temporal sampling.

Constellation Architecture

- The Time-to-Coverage requirement is the “driver” of the constellation. It’s the time required to cover 90% of the globe with Sterna observations.

- The Sterna constellation shall achieve 90% of global coverage over the repeat cycle in 5 hours (T), 4 hours (O), 3 hours (B).

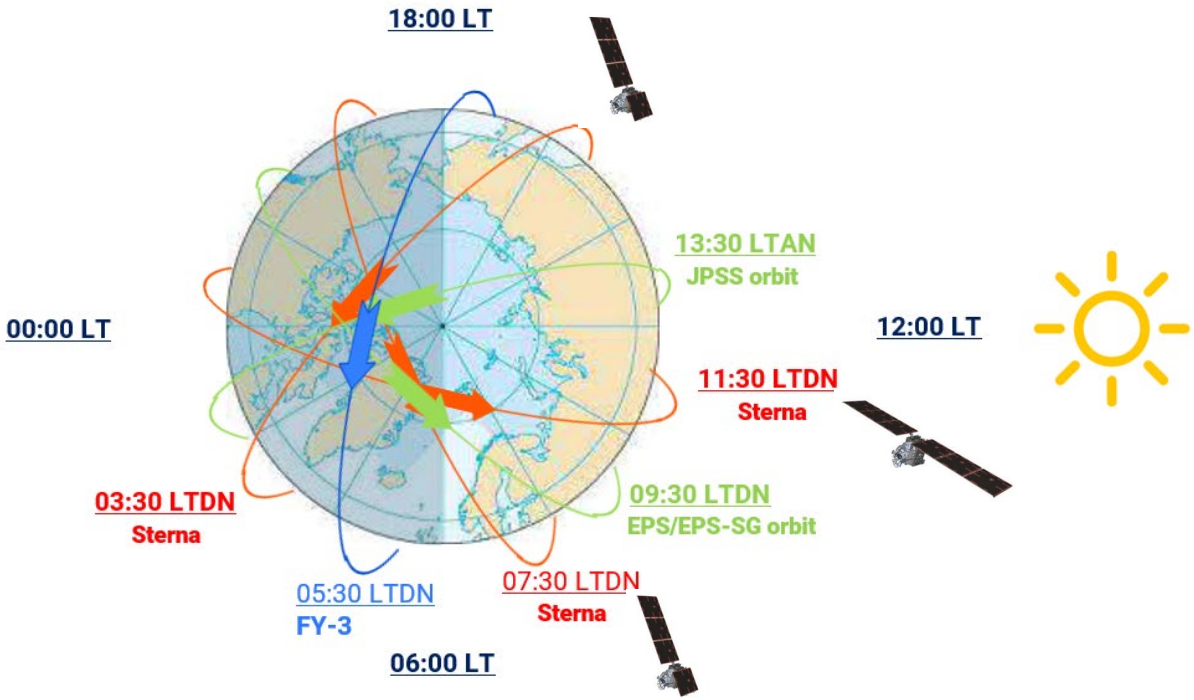
  - **3 Sun Synchronous orbits at 595 km altitude;**
  - **Inclination: 97º-98º**
  - **Repeat cycle per individual satellite: 9 days;**
  - **Number of satellites of initial full constellation: 6;**
  - **2 Satellites per each orbital plane phased at 180º**



Complementarity with EPS-SG and JPSS

- **Orbits selected in order to minimize the global time-to-coverage of Sterna + EPS-SG + JPSS**

- LTDN 03:30, 07:30, 11:30 – complementary to EPS-SG and JPSS

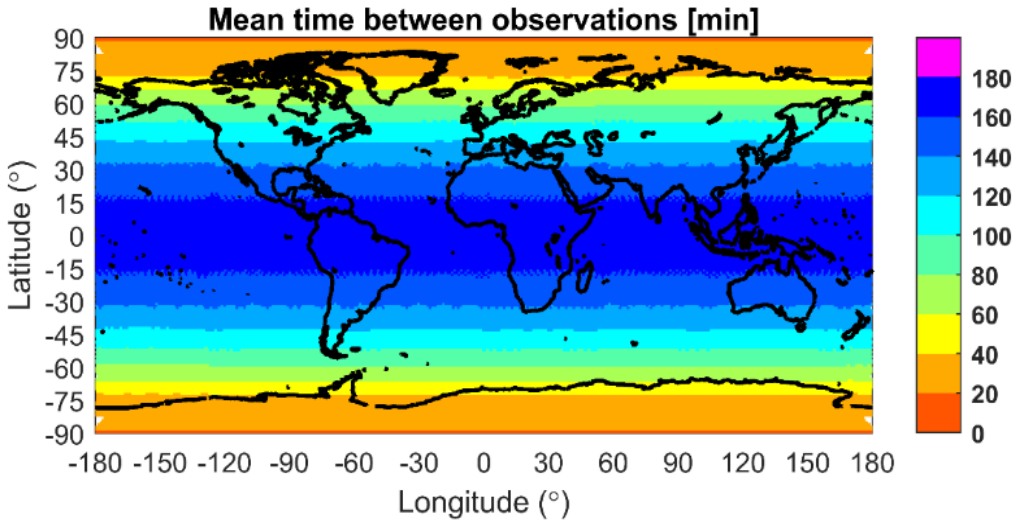


Constellation performance:

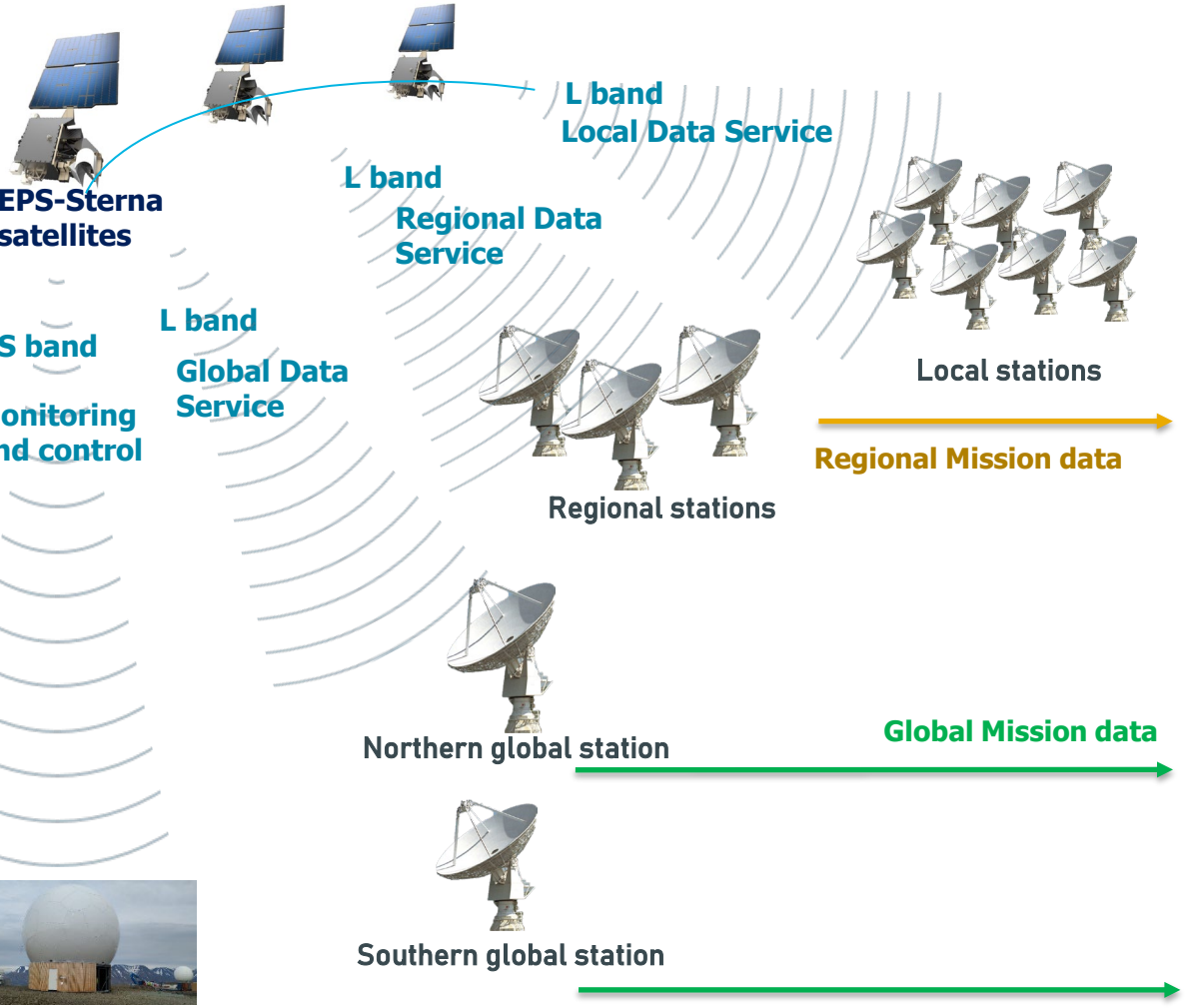
Time to achieve 90% coverage:

- **EPS-Sterna only: 3.1-4.7 hours;**
- **EPS-Sterna + EPS-SG +JPSS: 2.4-3.8 hours.**

Mean time between observations (with 6 satellites): **20 min-3 hours.**

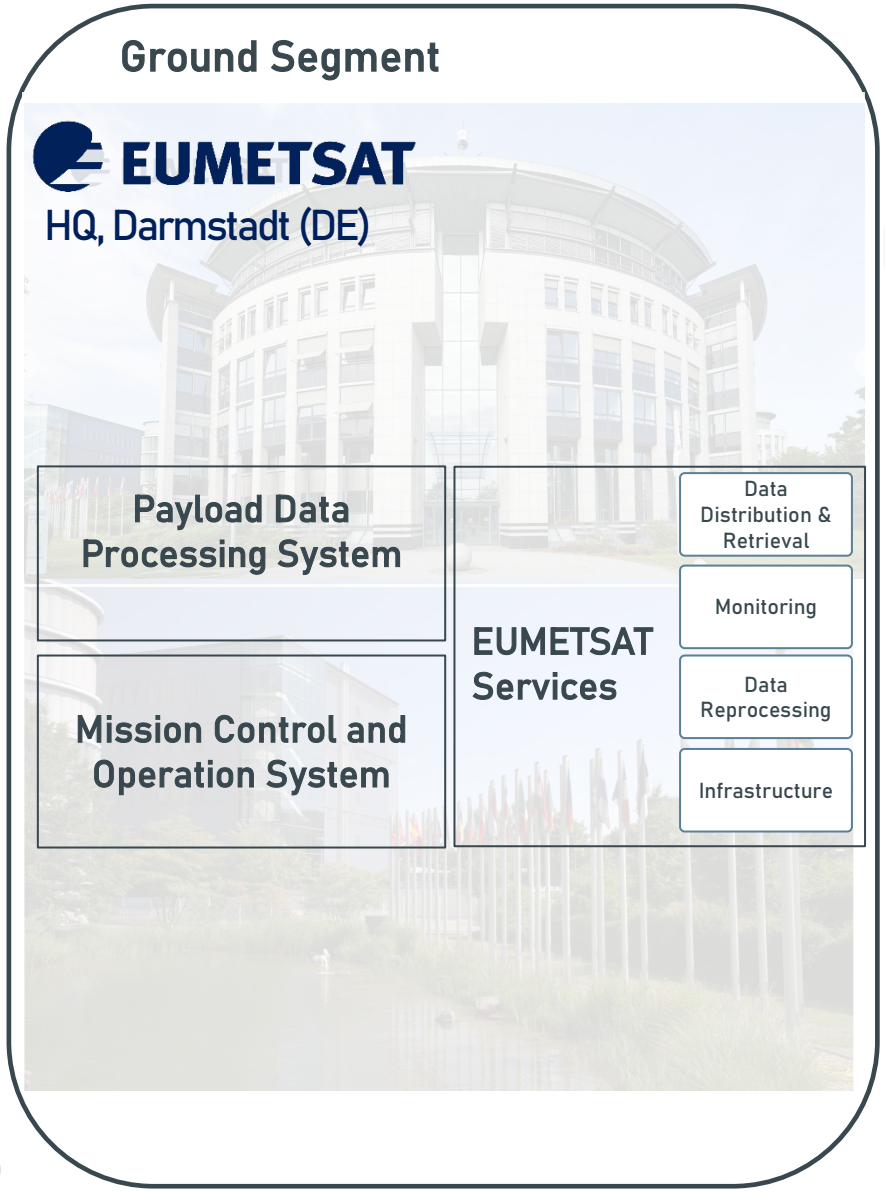


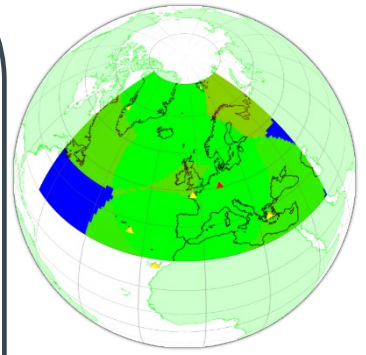
Overall System Overview



TT&C Station
Existing stations
Svalbard (NO)

Timeliness of global mission products:
threshold: 75 min(50%) 100 min (80%);
breakthrough: 45 min (50%), 75 min (80%)
Regional : 20 min (T), 15 min (B)





Regional mission coverage

Satellite & Payload Overview

- **Spacecraft**– three axis stabilised with electric propulsion:
  - Mass: ca. 135 kg;
  - Volume: 1.1x 0.7 x 0.8m;
  - Power (nominal): ca. 143 W;
  - Science data : L band (1.707 GHz);
  - Command and Control: S band (2.230/2.053 GHz).

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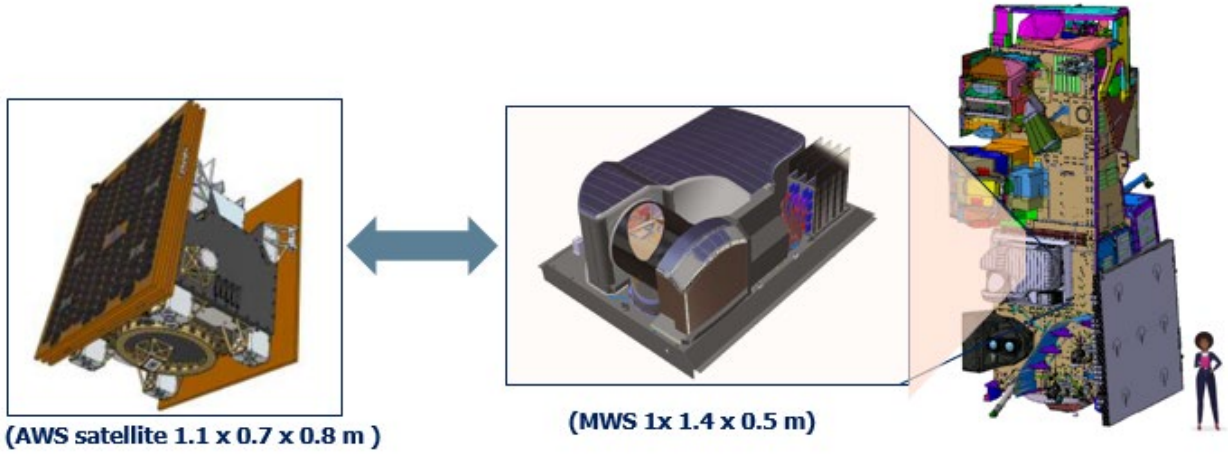
- **Payload** : Passive Microwave Radiometer 19 channels:
  - Mass: 30 kg (MWS on EPS-SG ca.150 kg);
  - Power: ca. 35 W (MWS ca.120W);
  - Data rate: 60 kbps;
  - Scan rate 45 RPM, scan angle ˝54.42ş
  - Swath ~ 2000 Km.

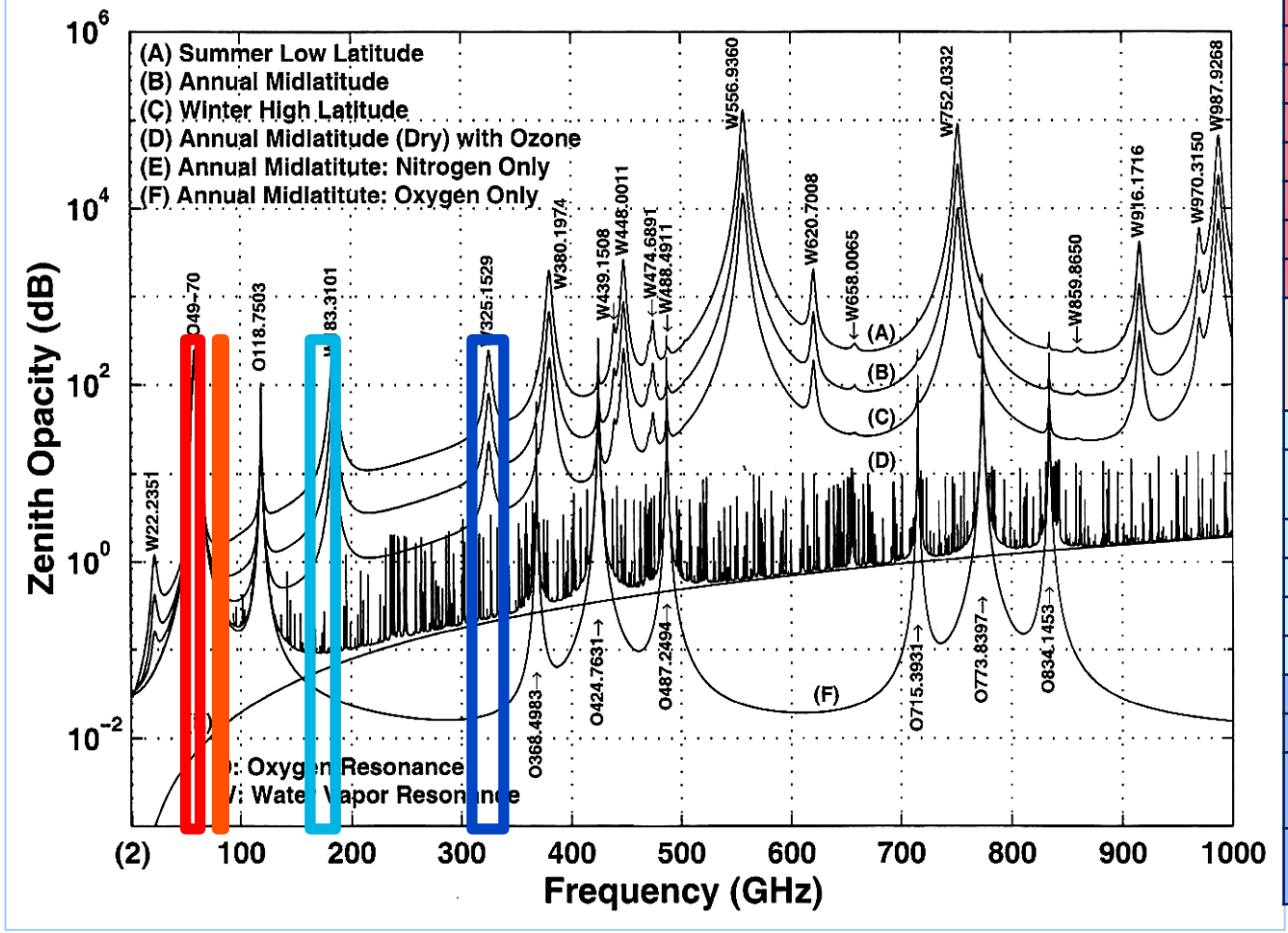


(AWS satellite 1.1 x 0.7 x 0.8 m)

(MWS 1x 1.4 x 0.5 m)

Sterna spectral bands and Channels

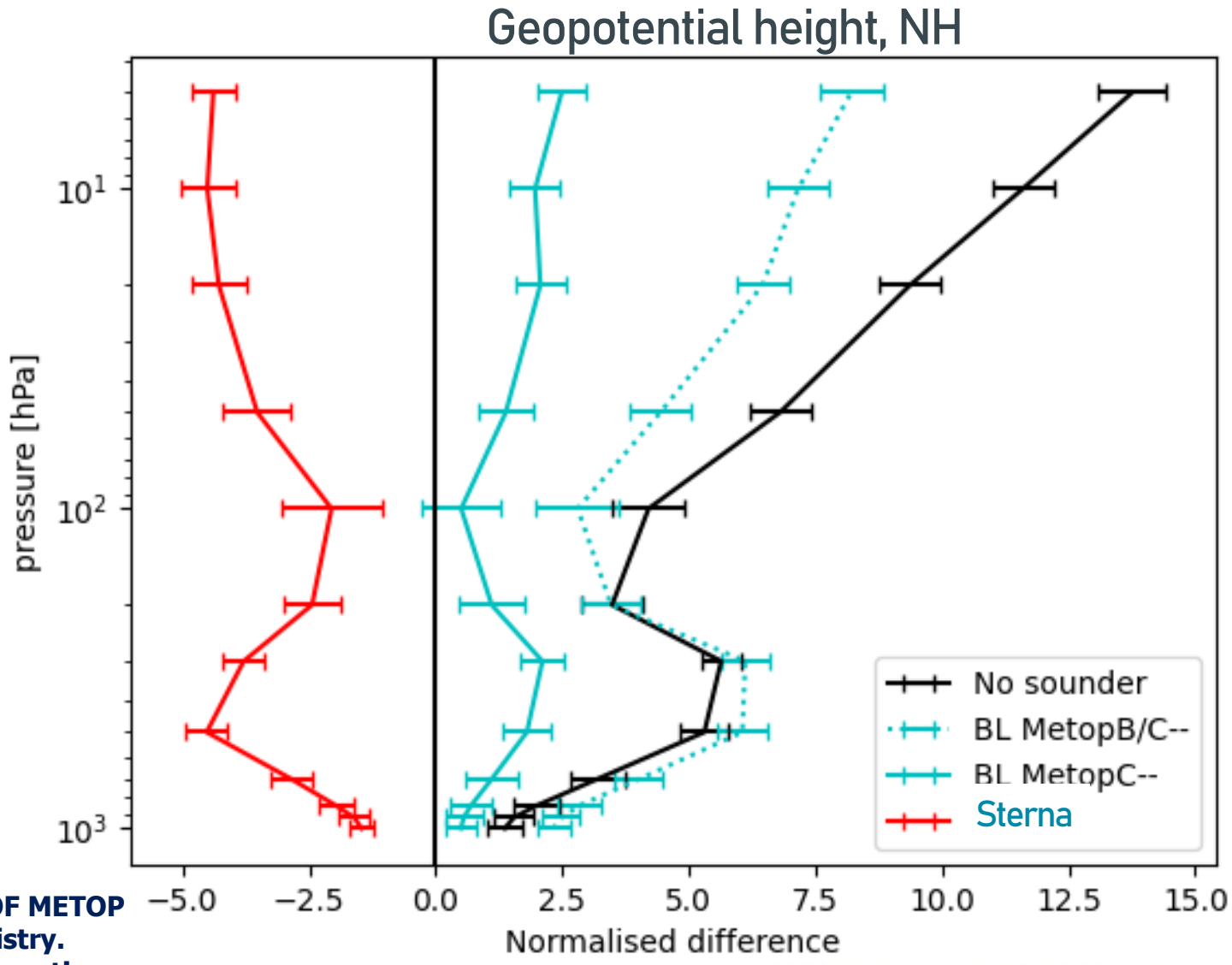
Atmospheric spectrum in the MW/Sub-mm range (Klein and Gasiewski, 2000)



Channel name	Centre Frequency [GHz]	Bandwidth [MHz]	NEΔT [K]	footprint size [km]	
STERNA-11	50.3	180	<0.6	≤ 40 km (±25%)	Temperature Sounding
STERNA-12	52.8	400	<0.4		
STERNA-13	53.246	300	<0.4		
STERNA-14	53.596	370	<0.4		
STERNA-15	54.4	400	<0.4		
STERNA-16	54.94	400	<0.4		
STERNA-17	55.5	330	<0.5		
STERNA-18	57.290344	330	<0.6		
STERNA-21	89	4000	<0.3	≤ 20 km (±25%)	Window and Cloud detection
STERNA-31	165.5	2800	<0.6	≤ 10 km (±25%)	Window/humidity sounding
STERNA-32	176.311	2000	<0.7		Humidity sounding
STERNA-33	178.811	2000	<0.7		
STERNA-34	180.311	1000	<1		
STERNA-35	181.511	1000	<1		
STERNA-36	182.311	500	<1.3		
STERNA-41	325.15±1.2	(2x) 800	<1.7	≤ 10 km (±25%)	Humidity sounding/cloud detection
STERNA-42	325.15±2.4	(2x) 1200	<1.4		
STERNA-43	325.15±4.1	(2x) 1800	<1.2		
STERNA-44	325.15±6.6	(2x) 2800	<1		

Expected Benefits of the EPS-Sterna Constellation - NWP

- NWP Impact assessments confirm that impacts on global NWP are substantial (the order of one Metop satellite).
- Additional substantial impacts expected on regional, short-range forecasts and Nowcasting.
- Performance/measurement accuracy are drivers of the magnitude of impacts - Meeting instrument performance specifications is important.



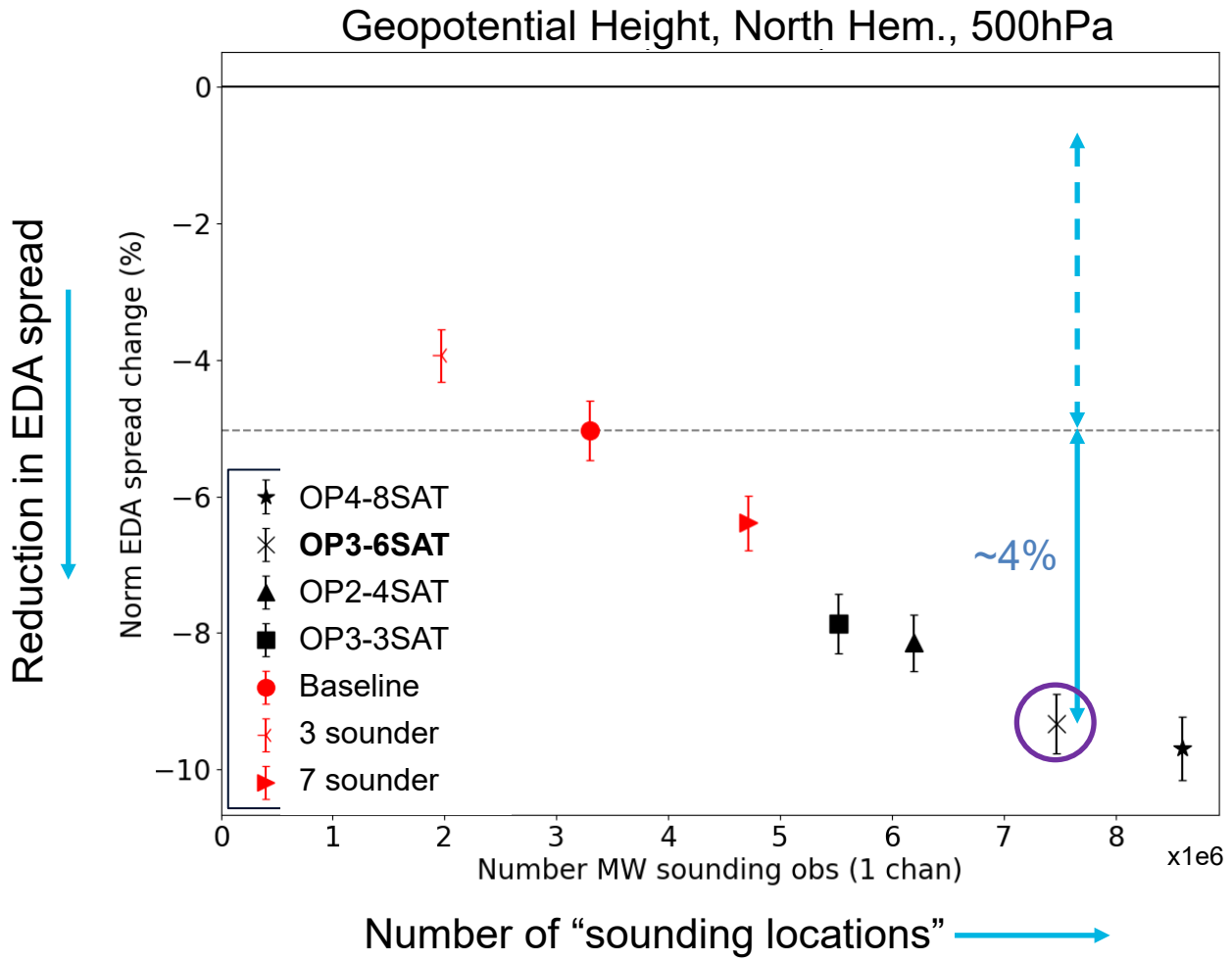
IMPORTANT NOTE: EDA METRIC DOES NOT FULLY CAPTURE LOSS OF METOP
e.g. land surface parameters, surface winds, atmospheric chemistry.
Also need high performance platforms for essential calibration information.

Benefit from adding more MW observations

www.eumetsat.int

8-28 July 2019

- Additional MW data continues to reduce EDA spread i.e. improve uncertainties
- Reference (6 sat) Sterna constellation performs very well
- Results with simulated data consistent with results from existing real data



Significant additional impact from adding Sterna constellations to baseline observing system

- **OSSE NWP impact study – see Talk 9.6**: *A global Observing System Simulation Experiment to evaluate the impact of the EPS-Sterna constellation of microwave sounders, by P. Chambon - CNRM, Météo-France*

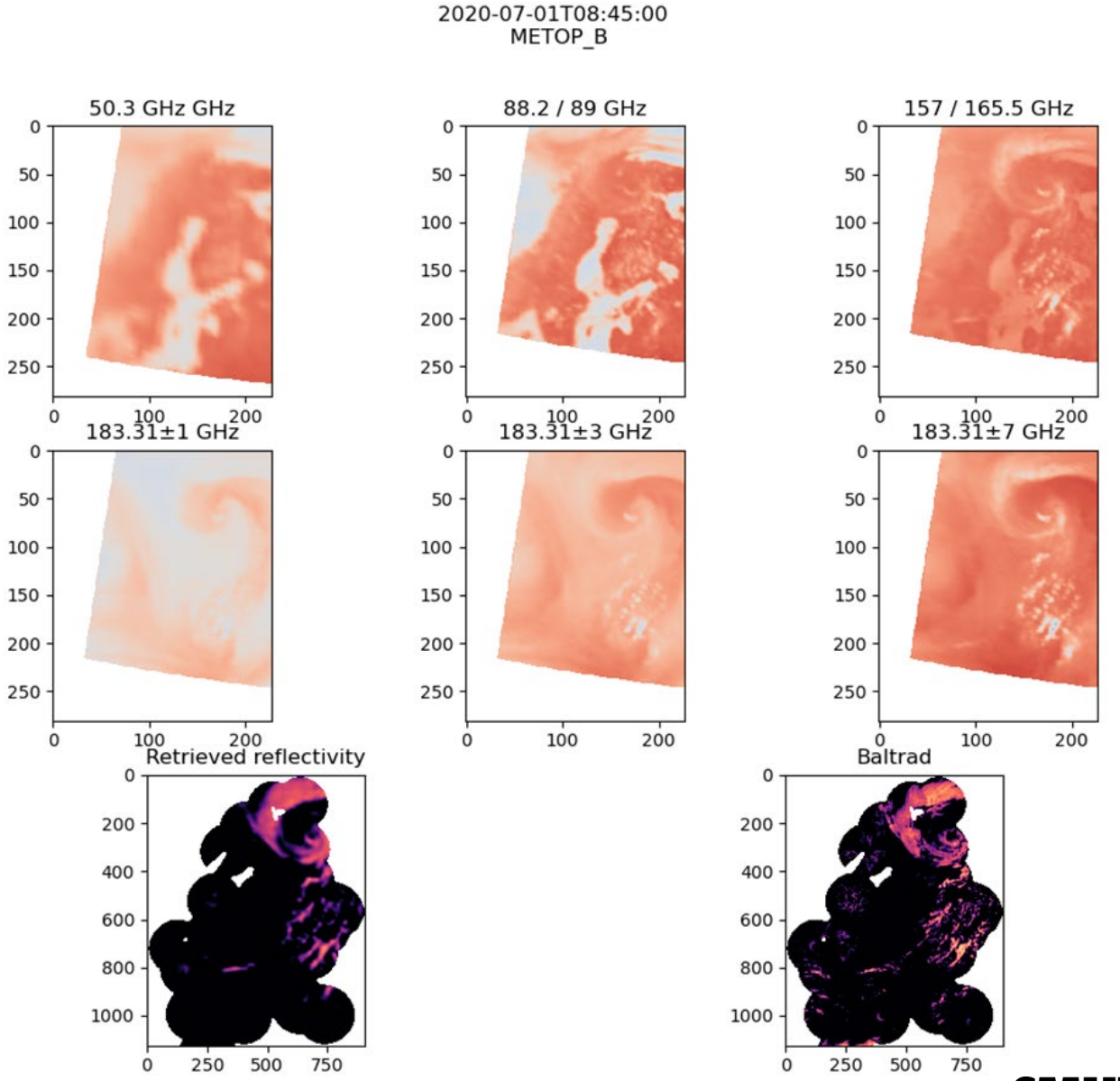
Expected Benefits of the EPS-Sterna Constellation - Nowcasting

Impact study by the Swedish Meteorological and Hydrological Institute

- Data driven Neural Network model trained to predict precipitation from the Baltic Sea Region weather radar network using passive microwave data from existing weather satellites
- More frequent nowcasting updates: including observations with an “age” of ~30 minutes for most part of the day.
- Forecasting performance: increase by about 5 – 20 % for the periods of the day where EPS-Sterna provides data

- EPS-Sterna’s frequent observations, combined with those delivered by the NOAA-EUMETSAT IJPS will provide an integrated set of microwave soundings as a key asset for nowcasting applications.

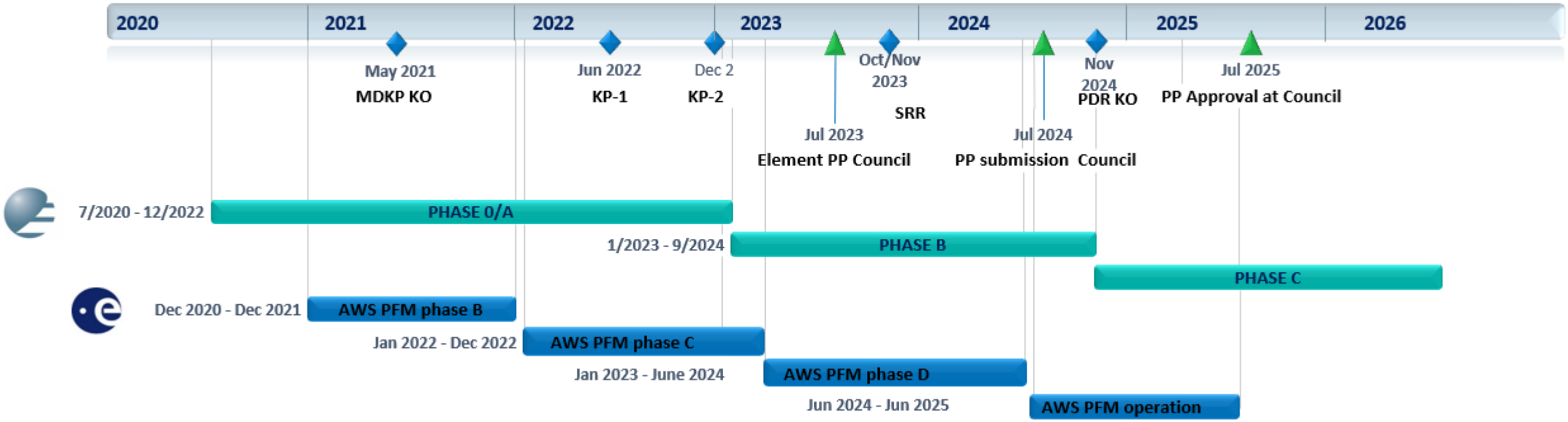
- Higher benefits at high latitudes where few conventional observations are available



Source: Rydberg et al. EUMETSAT Conference, 11-15 Sept 2023

Status of EUMETSAT activities and roadmap to approval

- Phase A completed in January 2023
- NWP impact assessment workshop held in April 2023
- Elements of Programme Proposal submitted to Council in July 2023
- Socio Economic Benefit Workshop in September 2023
- Phase B ongoing – System Requirements Review (SRR) in October 2023
- Programme Approval targeted in 2025 after the AWS in orbit demonstration.



Conclusions

- Microwave sounding is one of the primary sources of all-weather, day/night sounding information for temperature and humidity for NWP
- EPS Sterna can support global precipitation monitoring
- EPS Sterna will be complementary to EPS-SG and JPSS
- Scientific impact studies confirmed the importance of EPS Sterna
- Next steps: support the ESA evaluation of AWS data (soon!) and the EPS Sterna Programme approval, planned in 2025

Thank you! どうもありがとう!

Questions are welcome.