CENTRE NATIONAL D'ÉTUDES SPATIALES

Les radiomètres microondes en projet pour les prochaines générations de satellites météorologiques opérationnels

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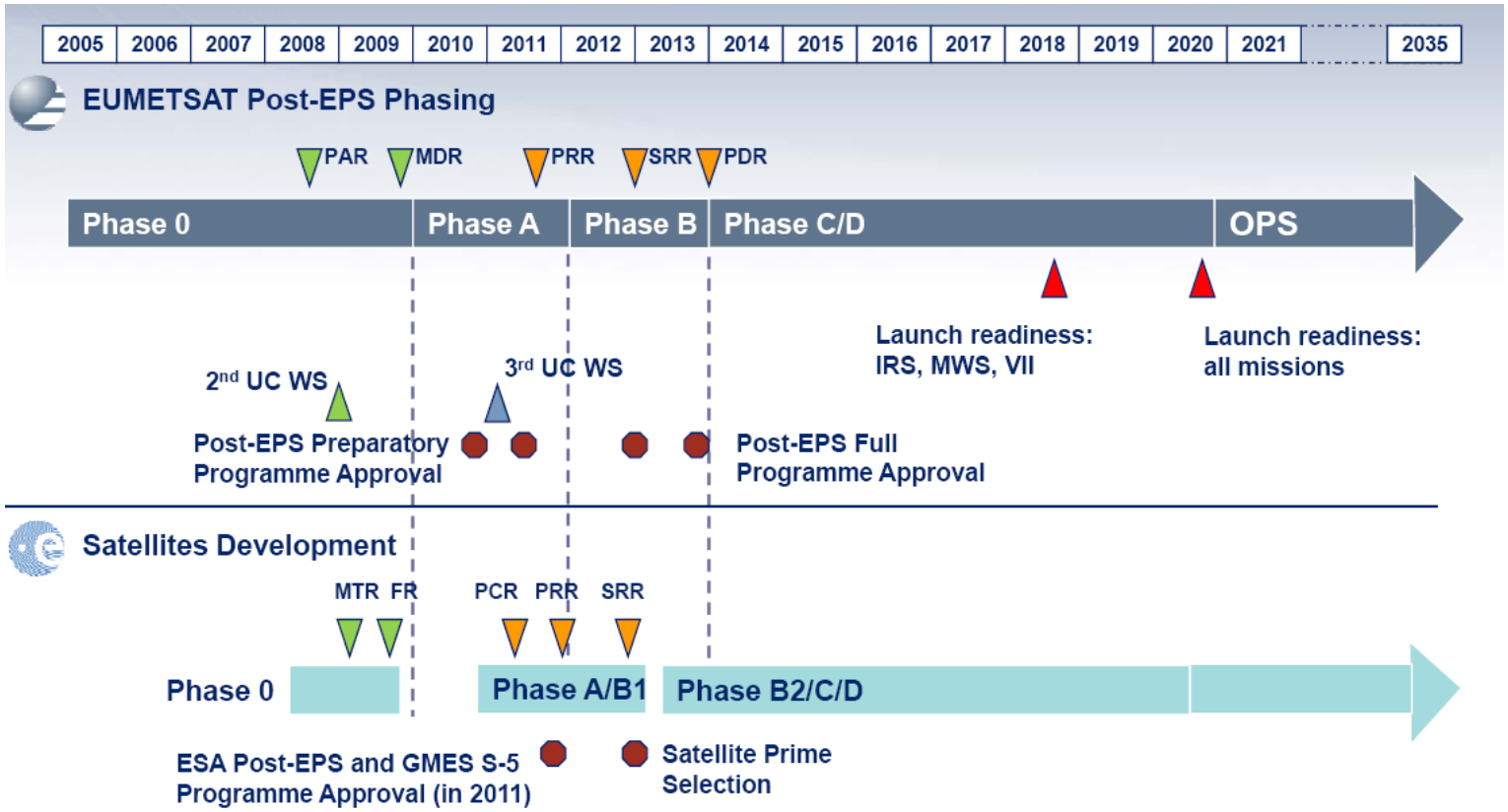
Sommaire

- EUMETSAT
- NOAA/DoD
- Japon

Projets Eumetsat

- EPS-SG
- Premier tir décalé en octobre 2019



Post-EPS Candidate Missions

Mission	Approach
High-Resolution Infrared Sounding	Phase 0 Study by ESA and CNES, Phase A study by CNES (IASI-NG)
Microwave Sounding	Phase 0/A Studies by ESA, Accommodation of ATMS (NOAA)
VIS/IR Imaging	Phase 0 Study by ESA, Accommodation of DLR *METimage*
Scatterometry	Phase 0/A Studies by ESA
Radio Occultation Sounding (RO)	Phase 0/A Studies by ESA
Nadir viewing UV/VIS/NIR/SWIR Sounding (UVNS)	GMES Sentinel-5 accommodation
Microwave Imaging - Precipitation and Cloud	Phase 0/A studies by ESA
Multi-viewing, -channel, -polarisation Imaging (3MI)	Phase 0/A studies by ESA
Radiant Energy Radiometry (RER)	Accommodation of CERES (NOAA)
Low Light Imager (LLI)	Accommodation of LLI (NOAA)
Space Environment Monitor for NPOESS (SEM-N)	Accommodation of SEM-N (NOAA)
Data Collection System	Accommodation of ARGOS (CNES)
Search & Rescue	Accommodation SAR (COSPAS SARSAT / NOAA)
Radar Altimetry (ALT)	GMES Sentinel-3, JASON f/o
Dual View Radiometry (DVR)	GMES Sentinel-3
Ocean Colour Imaging (OCI)	GMES Sentinel-3
Microwave Imaging - Ocean and Land	Phase 0 Study by ESA, not retained, demonstration by SMOS for 1.4 GHz
Doppler Wind Lidar (DWL)	Not retained, demonstration by ADM
Aerosol Profiling Lidar (APL)	Not retained, demonstration by ADM
Cloud and Precipitation Profiling Radar (CPR)	Not retained, demonstration by EarthCare
Total Solar Irradiance Monitoring (TSIM)	Not retained, one instrument on NOAA satellite sufficient
Limb Infra-Red Sounding (LIR)	Not retained - lack of operational demonstration
Limb Millimetre-Wave Sounding (MMW)	Not retained - lack of operational demonstration
Differential Absorption Lidar (DIA)	Not retained - lack of operational demonstration

EPS versus Post-EPS: mission evolution

Instrument	Metop	Post-EPS
IASI / IRS	645 to 2760 cm^{-1} NEΔT 0.1 - 0.6 K (<2400 cm^{-1}) $\Delta\nu$ = 0.35 - 0.5 cm^{-1} pixel size 12 km	645 - 2760 cm^{-1} NEΔT $\leq$ 0.5 NEΔT(IASI) $\Delta\nu \leq 0.5\ \Delta\nu$(IASI) pixel size 12 km
AHVRR / VII - *METimage*	6 channels: 0.58 - 12.5 µm	≥ 20 channels: 0.41 - 14.2 µm spatial sampling 500 m, 2 solar channels sampled at 250 m
AMSU - MHS / MWS	15 + 5 channels: 23.8 - 190 GHz	33 channels (incl. low priority): 23.8 - 229 GHz

Instrument	Post-EPS
MWI	up to 28 channels: 18.7 - 668 GHz spatial resolution 50 km at low frequencies to 7 km at high frequencies
3MI	12 channels: 342 - 2130 nm multi-channel, multi-viewing, multi-polarization Spatial sampling 4 km
RER	3 broad spectral bands angular sampling ≥ 3 views spatial resolution 20 km
LLI	one broad-band channel 0.4 - 1.1 µm

Phase 0 Concepts
Payload vs. Satellite Configurations

Payload	Single	Dual		Rationale For Allocation
VII	x	x		
LLI	x	x		Essential co-registration with VII
IRS	x	x		Essential co-registration with VII
MWS	x	x		Same need date as VII and IRS
MWI-P	x		x	
MWI-C	x		x	
SCA	x		x	
3MI	x	x		Essential co-registration with VII
S5/UVNS	x	x		Essential co-registration with VII and IRS
RER	x	x		Essential co-registration with VII
RO	x	x	x	On both satellites to increase number of occultations
ARGOS	x		x	Could be on either satellite
S&R	x		x	Could be on either satellite
SEM	x		x	Could be on either satellite

Summary of MWS (Start of Phase A)

Post-EPS

- 118 GHz channels removed (was priority 3)
- Additional channels around 50 GHz and 229 GHz channel have been kept (were priority 2)

Channel name	Frequency (GHz)	Utilisation
MWS-1	23.8	Water-vapour column
MWS-2	31.4	Window, water-vapour column
MWS-3	50.3	Quasi-window, surface emissivity
MWS-4	52.8	Temperature profile
MWS-5	53.246±0.08	Temperature profile
MWS-6	53.596±0.115	Temperature profile
MWS-7	53.948±0.081	Temperature profile
MWS-8	54.4	Temperature profile
MWS-9	54.94	Temperature profile
MWS-10	55.5	Temperature profile
MWS-11	57.290344	Temperature profile
MWS-12	57.290344±0.217	Temperature profile
MWS-13	57.290344 ±0.3222±0.048	Temperature profile
MWS-14	57.290344±0.3222±0.022	Temperature profile
MWS-15	57.290344±0.3222±0.010	Temperature profile
MWS-16	57.290344±0.3222±0.045	Temperature profile
MWS-17	89	Window
MWS-27	164-167	Quasi-window, water-vapour profile
MWS-28	183.311±7.0	Water-vapour profile, precipitation
MWS-29	183.311±4.5	Water-vapour profile
MWS-30	183.311±3.0	Water-vapour profile
MWS-31	183.311±1.8	Water-vapour profile
MWS-32	183.311±1.0	Water-vapour profile
MWS-33	229	Quasi-window water-vapour profile

Summary of MWI

Channel name	Frequency (GHz)	Polarisation
MWI-5	18.7	V, H
MWI-6	23.8	V, H
MWI-7	31.4	V, H
MWI-8	50.3	V, H
MWI-9	52.61	V, H
MWI-10	53.24	V, H
MWI-11	53.75	V, H
MWI-12	89	V, H
MWI-14	118.7503±2.0	V
MWI-15	118.7503±1.6	V
MWI-16	118.7503±1.4	V
MWI-17	118.7503±1.2	V
MWI-18	166.9	V
MWI-19	183.31±8.4	V
MWI-20	183.31±6.1	V
MWI-21	183.31±4.9	V
MWI-22	183.31±	
MWI-23	183.31±	

- Still waiting feedback, whether to include sounding channels around 50 GHz as an option to be studied

- 100.49 GHz channel removed (was priority 2)
- Expecting to modify 118 GHz and 183 GHz channels
  - Currently 4 channels @ 118 GHz and 5 channels @ 183 GHz
- Up to 89 GHz V & H, above 89 GHz only V polarisation
- An option to build 18.7 GHz channel as a Radio Frequency Interference (RFI) tolerant channel will be studied

- Conical scanning at 53°
- +/- 60° around orbital plane

Summary of ICI

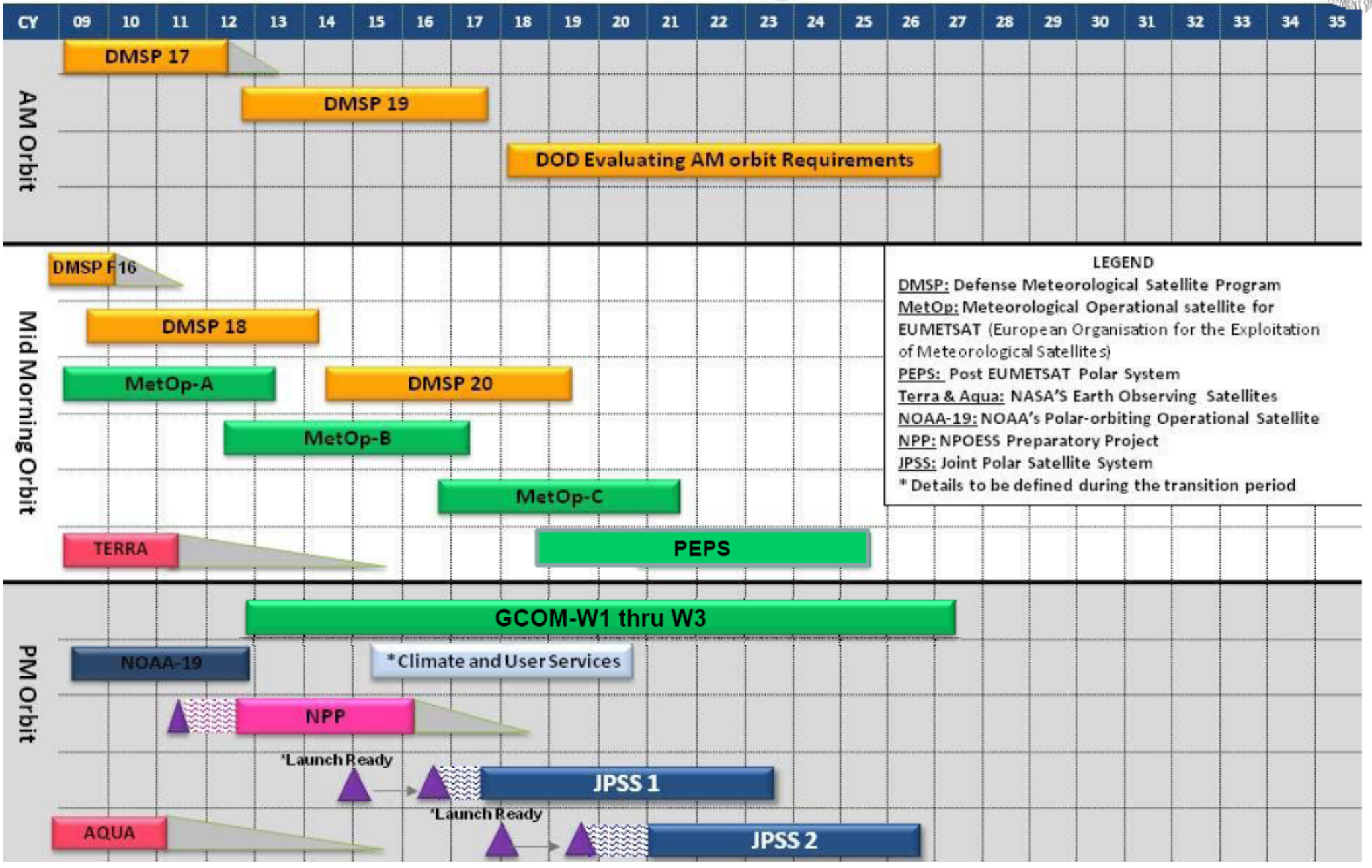
Channel name	Frequency (GHz)	Polarisation (T/G)
MWI-19	183.31±8.4	45°/V
MWI-22	183.31±3.4	45°/V
MWI-23	183.31±2.0	45°/V
MWI-24	243.2±2.5	45° / V, H
MWI-25	325.15±9.5	45°/V
MWI-26	325.15±3.5	45°/V
MWI-27	325.15±1.5	45°/V
MWI-29	448±7.2	45°/V
MWI-30	448±3.0	45°/V
MWI-31	448±1.4	45°/V
MWI-32	664±4.2	45° / V, H

- No changes to channel complement
- Polarisation options will be studied in Phase A

NPOESS Restructure

- Acquisition responsibilities will be shared
  - NOAA/NASA responsible for the PM orbit – to be called Joint Polar Satellite System (JPSS)
    - Joint in JPSS is in reference to our international partnerships
  - DoD responsible for the early AM orbit – DMSP then Defense Weather Satellite System (DWSS)
  - Agencies will share a common ground system to be managed by NOAA/NASA
  - Agencies will share data from each orbit to meet the national need for weather and climate information
- Mid morning orbits covered by EUMETSAT
- Observations planned in the PM orbit for NPOESS are maintained
  - VIIRS, CrIS, ATMS, OMPS, and CERES/ERBS remain
  - AMSR sensor data from Japanese GCOM satellite to replace MIS for microwave imaging/sounding
  - Accommodations for TSIS and User Services (SARSAT, ADCS, Direct Readout)
- Continue plan for operational use of NPP data (PM orbit) with an October 2011 launch readiness date
- NASA Science Mission Directorate Division and Transition Team has been formed

Continuity of Polar Operational Satellite Programs



LEGEND

DMSP: Defense Meteorological Satellite Program

MetOp: Meteorological Operational satellite for EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites)

PEPS: Post EUMETSAT Polar System

Terra & Aqua: NASA'S Earth Observing Satellites

NOAA-19: NOAA's Polar-orbiting Operational Satellite

NPP: NPOESS Preparatory Project

JPSS: Joint Polar Satellite System

* Details to be defined during the transition period

NPOESS/JPSS Program Development

- Payloads:
  - OMPS
    - OMPS F2 rework and retest to clean debris and broken wire completed
  - CrIS
    - CrIS thermal vacuum completed with no significant issues, on plan to June Pre-ship review (PSR) held 15-16 June, delivery to NPP by July
  - VIIRS
    - VIIRS F1 integration completed on NPP
    - VIIRS F2 schedule erosion continues
  - ATMS
    - ATMS F1 integrated on NPP
    - ATMS F2 moderate schedule erosion
- Ground
  - Ground System Interface Test completed March 25.
- Climate and User Services
  - TSIS, SARSAT, ADCS and Direct Readout missions will be accommodated by the JPSS Program.

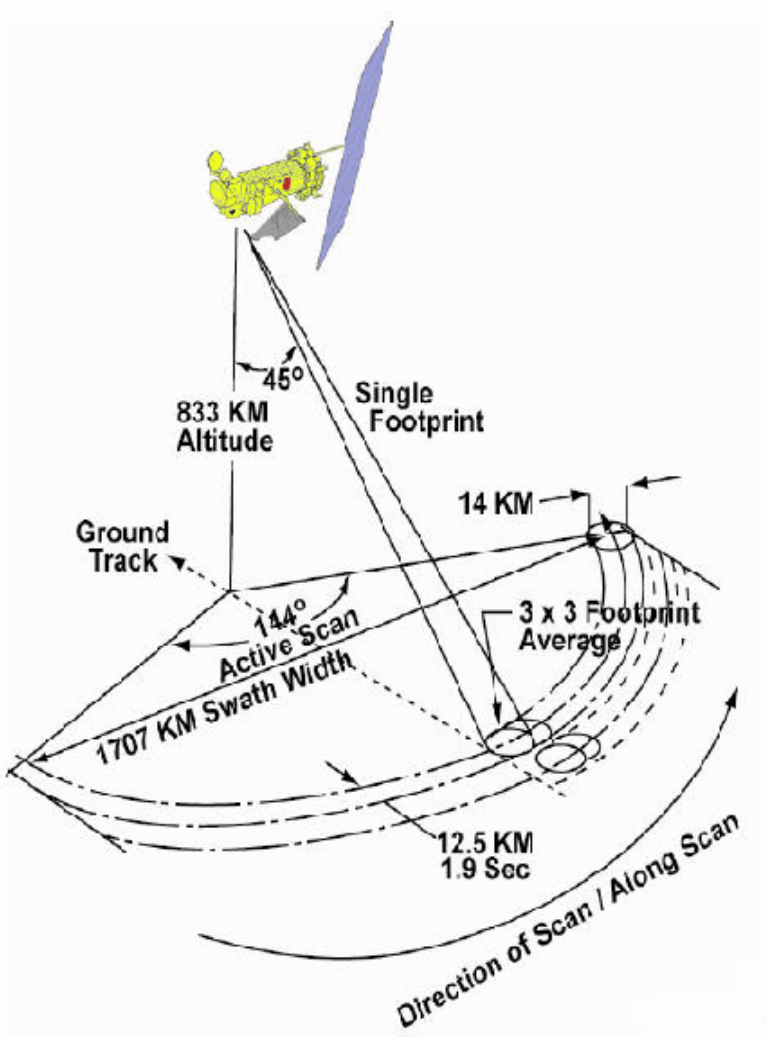
DoD (AM orbit)

Table 1. Channel Characteristics of the SSMIS Instrument (Yan and Weng 2009)

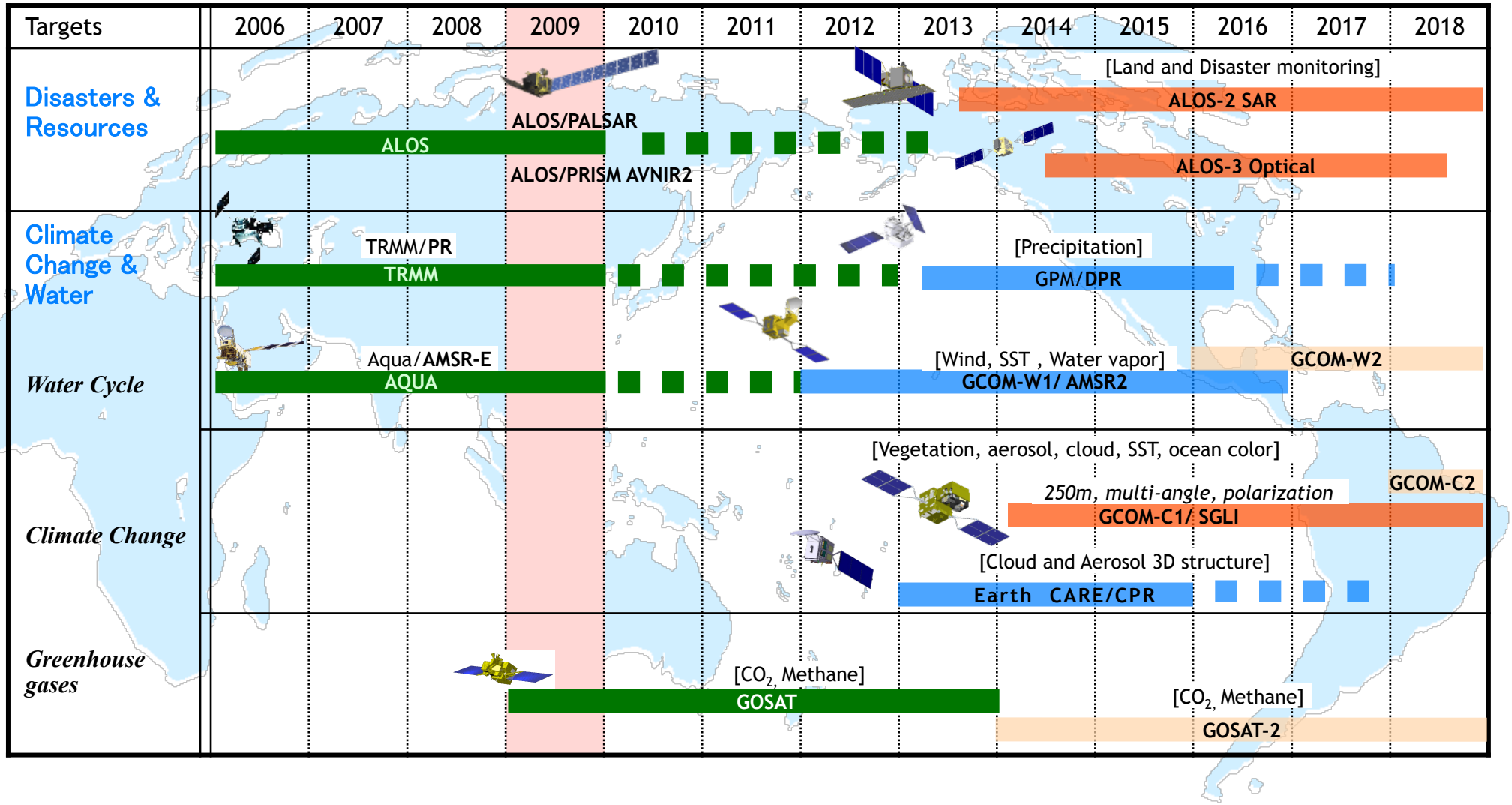
Channel	Center Frequency (GHz)	3-db Width (MHz)	Frequency Stability (MHz)	Polarization	NEΔT (K)[I]	Sampling Interval (km)[II]	Channel Application
1	50.3	380	10	V	034	37.5	LAS
2	52.8	389	10	V	0.32	37.5	LAS
3	53.596	380	10	V	0.33	37.5	LAS
4	54.4	383	10	V	0.33	37.5	LAS
5	55.5	391	10	V	0.34	37.5	LAS
6	57.29	330	10	RCP[IV]	0.41	37.5	LAS
7	59.4	239	10	RCP	0.40	37.5	LAS
8	150	1642(2)[III]	200	H	0.89	12.5	IMA
9	183.31 ± 6.6	1526(2)	200	H	0.97	12.5	IMA
10	183.31 ± 3	1019(2)	200	H	0.67	12.5	IMA
11	183.31 ± 1	513(2)	200	H	0.81	12.5	IMA
12	19.35	355	75	H	0.33	25	ENV
13	19.35	357	75	V	0.31	25	ENV
14	22.235	401	75	V	0.43	25	ENV
15	37	1616	75	H	0.25	25	ENV
16	37	1545	75	V	0.20	25	ENV
17	91.655	1418(2)	100	V	0.33	12.5	IMA
18	91.655	1411(2)	100	H	0.32	12.5	IMA
19	63.283248 ± 0.285271	1.35(2)	0.08	RCP	2.7	75	UAS
20	60.792668 ± 0.357892	1.35(2)	0.08	RCP	2.7	75	UAS
21	60.792668 ± 0.357892 ± 0.002	1.3(4)	0.08	RCP	1.9	75	UAS
22	60.792668 ± 0.357892 ± 0.0055	2.6(4)	0.12	RCP	1.3	75	UAS
23	60.792668 ± 0.357892 ± 0.016	7.35(4)	0.34	RCP	0.8	75	UAS
24	60.792668 ± 0.357892 ± 0.050	26.5(4)	0.84	RCP	0.9	37.5	LAS

[I]NEΔT for instrument temperature (0°C) and calibration target (260 K) with integration times of 8.4 msec for Channels 12–16; 12.6 msec for Channels 1–7, 24; and 25.2 msec for Channels 19–23 and 4.2 msec for Channels 8–11, 17-18.

[II]Along-scan direction sampling based on 833 km spacecraft altitude.



Long-Term Plan of JAXA Earth Observation



Mission status: On orbit; Phase B~; Phase A; Pre-Phase A; Extension

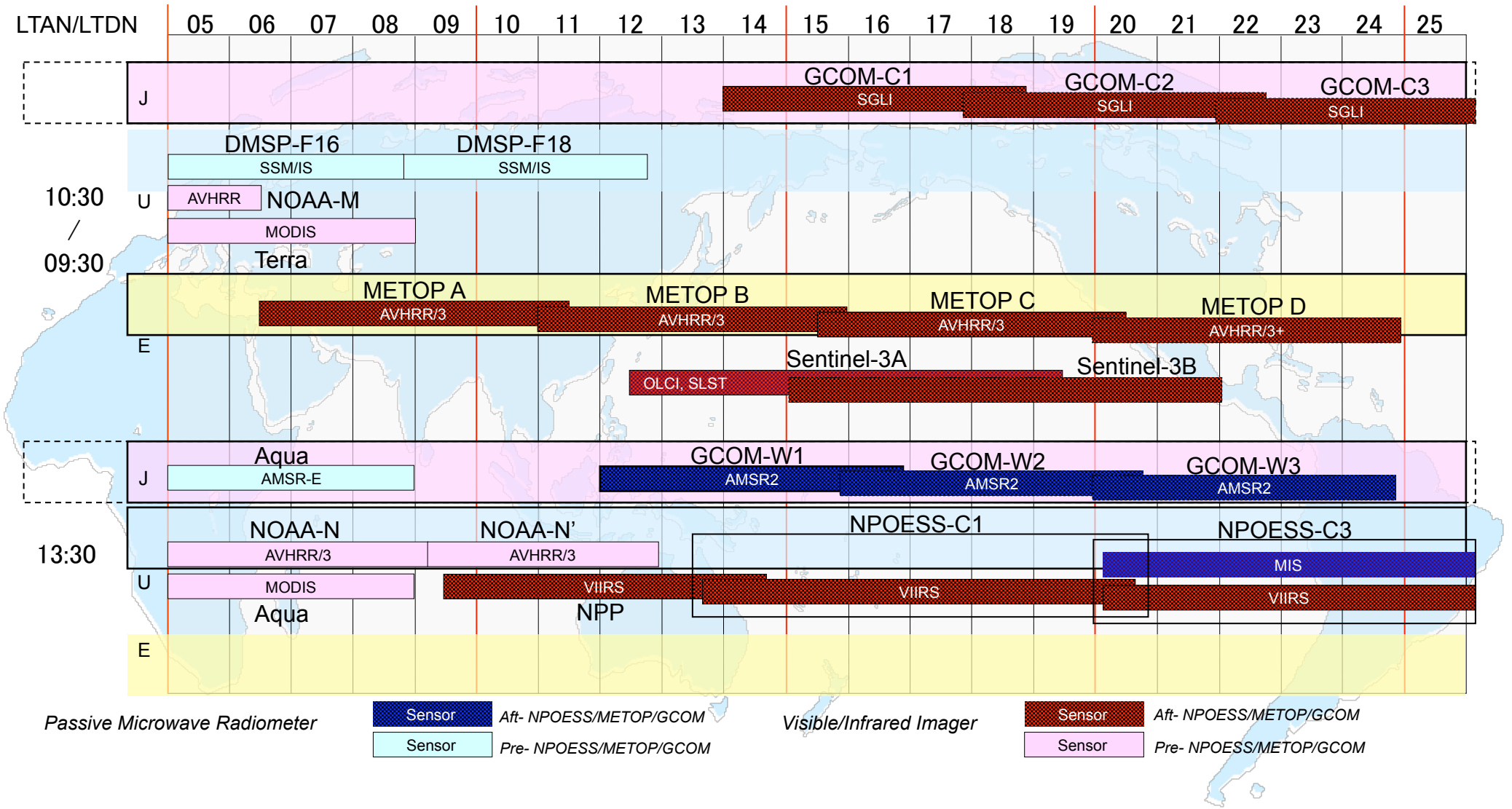
GCOM-W

- The "Global Change Observation Mission" (GCOM) for continuous global-scale observations (for 10 to 15 years) for global climate change and water circulation mechanisms.
  The GCOM mission is a two series of satellites, GCOM-W for observing water circulation changes and GCOM-C for climate changes.
- The GCOM-W with a microwave radiometer onboard will observe precipitation, vapor amounts, wind velocity above the ocean, sea water temperature, water levels on land areas, and snow depths.
  The GCOM-W1 is the first satellite for the GCOM-W series.

GCOM-W1

- The Advanced Microwave Scanning Radiometer 2 (AMSR2,) which will be loaded onto the GCOM-W1, is a sensor to observe radiometers, or microwaves emitted naturally from the ground, sea surface and atmosphere, using six different frequency bands ranging from 7 GHz to 89 GHz.
- AMSR2 will detect such weak microwaves at an altitude of 700 kilometers and measure the strength of them with a very high accuracy.
- The antenna of the AMSR2, which receives microwaves from the ground, arc scans the ground surface at a ratio of one turn every 1.5 seconds and observes an area approximately 1,450 kilometers wide in one scan. Using this scanning method, the AMSR2 can observe over 99 percent of the Earth's area in just 2 days. The diameter of the antenna is about 2 meters, making it the world's largest observation sensor aboard a satellite. The height of the rotating part is about 2.7 meters and the weight is about 250 kilograms. The AMSR2 can keep rotating such a large and heavy antenna at a speed of one turn per 1.5 seconds for 24 hours a day and more than five years without a minute of rest.

GCOM Cooperation with NPOESS and METOP



- GCOM-C/SGLI data will help fill a current gap in the NPOESS/VIIRS morning orbit, in conjunction with METOP+Sentinel.
- GCOM-W/AMSR2 data will complement NPOESS/MIS global microwave radiometry data.