WORLD METEOROLOGICAL ORGANIZATION
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COMMISSION FOR BASIC SYSTEMS
OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

EXPERT TEAM ON SATELLITE SYSTEMS
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ARCHITECTURE FOR CLIMATE MONITORING FROM SPACE

Contribution to the physical view of the architecture

(Submitted by J. Lafeuille, WMO Secretariat)

Summary and Purpose of Document

This document recalls the CGMS action, supported by WMO, to evaluate how the "CGMS baseline" plans will contribute to the physical implementation of the Architecture for Climate Monitoring from Space. For this evaluation, WMO was tasked by CGMS to propose a template for mapping the "CGMS baseline" against the ECVs. This template, filled with tentative information, was sent to CGMS members to be reviewed and updated. It is provided in the Appendix.

Once completed, it is expected that the mapping will:
- provide visibility on the operational/sustained missions coordinated by CGMS, and their potential value for climate monitoring,
- stimulate the registration of corresponding ECV datasets in the ECV inventory initiated for the Architecture,
- highlight the "missed opportunities", i.e. situations where there are plans for sensors but no plan yet to exploit these sensors to generate climate data sets.

Within the strategy towards an Architecture for Climate Monitoring from Space, this exercise is expected to be a useful complement to the current ECV inventory initiated by CEOS, CGMS and WMO.

ACTION PROPOSED

The Expert Team is invited:
- review and comment the preliminary mapping of the CGMS baseline against the ECVs,
- provide guidance on how to document the value of the CGMS baseline, including plans for delivering FCDRs, as a contribution to the architecture for climate monitoring from space,
- provide guidance on further steps to be taken for advancing the physical definition of the Architecture, for instance in focusing on some example missions.

APPENDIX: CGMS baseline mapping template (an updated version will be tabled at ET-SAT-8)

REFERENCES:
- Strategy towards an Architecture for Climate Monitoring from Space
- CGMS baseline for operational/sustained missions

Contribution to the physical view of the architecture

Background

1. At the 39th meeting of the Coordination Group for Meteorological Satellites (CGMS-39, St Petersburg, 3-7 Oct 2011), based on the outcome of ET-SAT-6, CGMS Members have adopted the "*CGMS Baseline for the operational contribution to the GOS*"[1], which documents the future satellite missions to be implemented by CGMS Members in an operational or sustained framework, and with a long-term perspective. This was an important milestone. The action to "*Coordinate the implementation of the CGMS baseline missions*" is now the first task in the CGMS High Level Priority Plan 2013-2017. In order to monitor the implementation of this baseline, a mapping of CGMS Members' plans against the baseline is kept under review. The CGMS Working Group on Operational continuity and contingency planning (CGMS WG III) uses this mapping to evaluate risk of gaps or other long-term planning issues.

2. In addition, at its fortieth meeting (CGMS-40, Lugano, 5-9 Nov 2012), CGMS agreed to evaluate how these baseline plans would contribute to the physical implementation of the Architecture for Climate Monitoring from Space. Recommendation 40.40 states: *"CGMS Members, through WG III, to evaluate the CGMS baseline in the light of the [climate monitoring] architecture strategy with a view to populate the space segment physical view of the architecture and identify gaps and scenarios to address them"*.

3. During the Climate and Space Week (Geneva, 18-22 Feb 2013) a report on the ECV dataset inventory was presented to the meetings of the CEOS-CGMS-WMO Architecture team and the CEOS Working group on Climate. WMO and NOAA pointed out that an inventory of climate monitoring contribution at the sensor level could be a useful complement to the ECV dataset inventory to identify the gaps in the overall chain (See Figure 1).

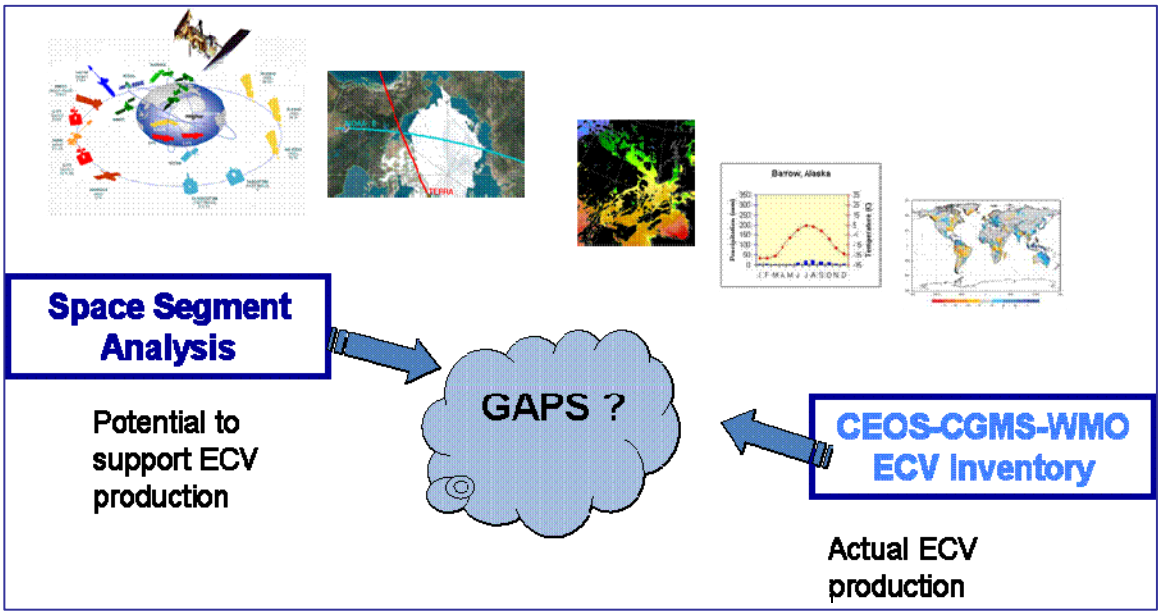


Figure 1: Gap analyses from both ends (From Lafeuille, J. and Wooldridge, C., Contribution to macroscale space –segment definition, Climate and Space Week)

[1] See CGMS-39 Final Report, Annex 6, pages 124-125. The CGMS baseline is also available on line on the WMO Space Programme website: http://www.wmo.int/pages/prog/sat/documents/CGMS_Baseline-operational-contribution-to-GOS-CGMS39-2011.pdf

4. Following these discussions, WMO was tasked by CGMS WG III to propose a template to be used by CGMS Members for mapping the "CGMS baseline" against the Essential Climate Variables (ECVs). "Mapping" means here identifying, for each mission in the "CGMS baseline", its actual or potential contribution to the generation of ECVs products, i.e. Thematic Climate Data Records (TCDRs).

5. The draft mapping, provided in the Appendix, consists of a set of tables where the nominal missions in the CGMS baseline are listed in the first column on the left. The last two columns on the right shall contain: (i) the list of ECVs that a mission could potentially contribute to, and (ii) contributions actually recorded in the ECV product inventory. There are four tables in total:

I. Geostationary constellation
II. Core meteorological missions in 3 sun-synchronous orbits (a.m., p.m., e.m.)
III. Other weather/climate missions in low Earth orbits
IV. Data collection and space weather missions in low Earth orbits.

ECV mapping and contribution to the climate monitoring architecture

6. Once reviewed and completed by space agencies, the consolidated outcome of this mapping will first provide visibility on the current and planned contribution of operational/sustained missions to the Architecture. In some cases, it may shed light on existing or planned TCDRs that are not yet captured in the ECV inventory, thus encouraging their registration in the inventory.

7. Another expected benefit of the mapping could be to highlight the potential contribution of missions to climate monitoring for which there are currently no plans to process the sensor data to the level of ECV products (TCDR). This situation may be identified in the Architecture as a gap.

8. However, the availability of Fundamental Climate Data Records (FCDR) is not only a precondition for the generation of ECV products. Some FCDRs (e.g., MW or IR brightness temperatures, GNSS bending angles) are also increasingly recognized as being of direct value for climate applications, for example when assimilated within modelling frameworks. Sustaining the operation of certain sensors and delivering the corresponding FCDRs may therefore be regarded as a contribution to the Architecture in its own right and documented accordingly, in addition to the current ECV inventory.

9. It may be recalled that, in addition to defining a set of core missions in geostationary and Low Earth Orbit, the CGMS baseline contains cross-cutting considerations on contingency planning, inter-calibration, data availability and dissemination, which also play an important role for climate monitoring.

Possible elements of the "Physical architecture"

10. The architecture for climate monitoring from space should provide a reference framework for coordinated efforts of space agencies, climate data centres and scientific groups, to ensure that the appropriate satellite missions will be implemented and the corresponding data will be exploited in a consistent fashion to meet the needs of climate monitoring and applications. The report on Strategy Towards an Architecture for Climate Monitoring from Space recalls that "an architecture typically describes the structure of a system as reflected in its building blocks, their relationships to each other, and to the environment". It furthermore defines a logical view of the architecture illustrated by Figures 2 and 3 below. As concerns the physical view of the architecture the same report suggests that for each of the ECVs it should contain requirements, current implementation status, and planned contributions, as indicated in Table 1. ET-SAT may wish to discuss the practicality of this approach and consider how it can be followed or adapted in order to reflect the plans of WMO Members (through their satellite operators) for sustained provision of FCDRs, which often support different ECVs.

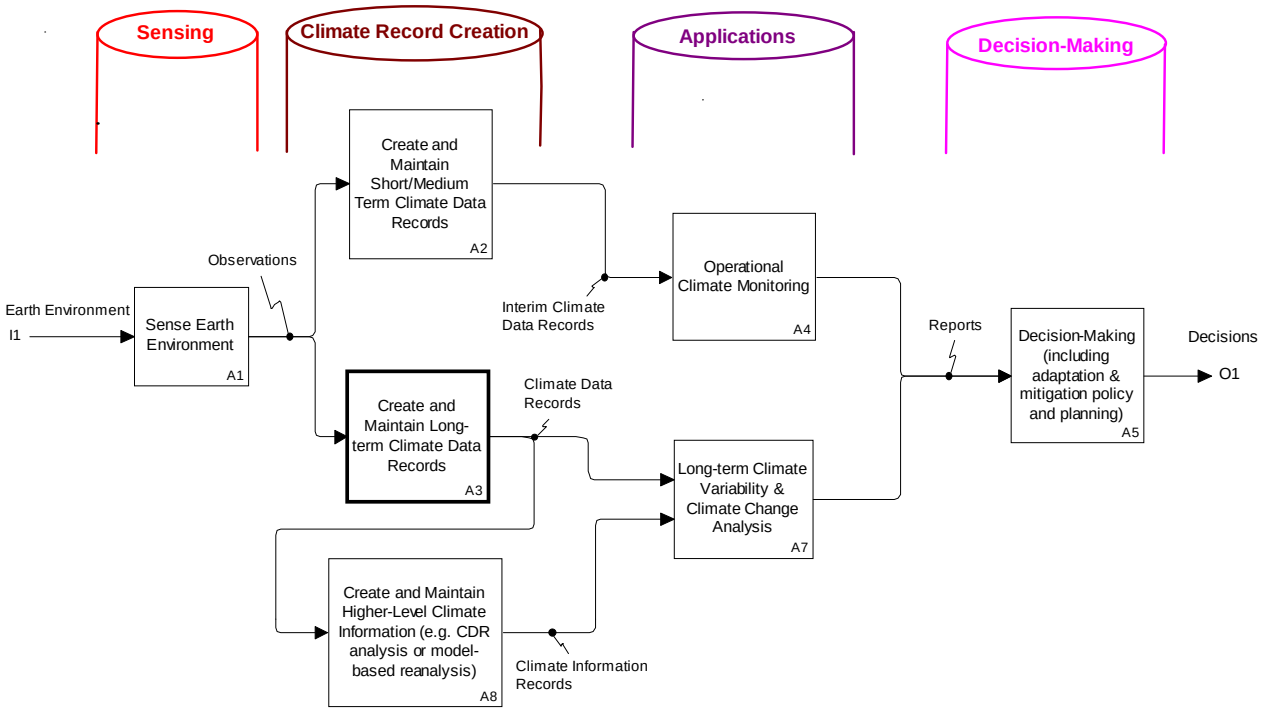
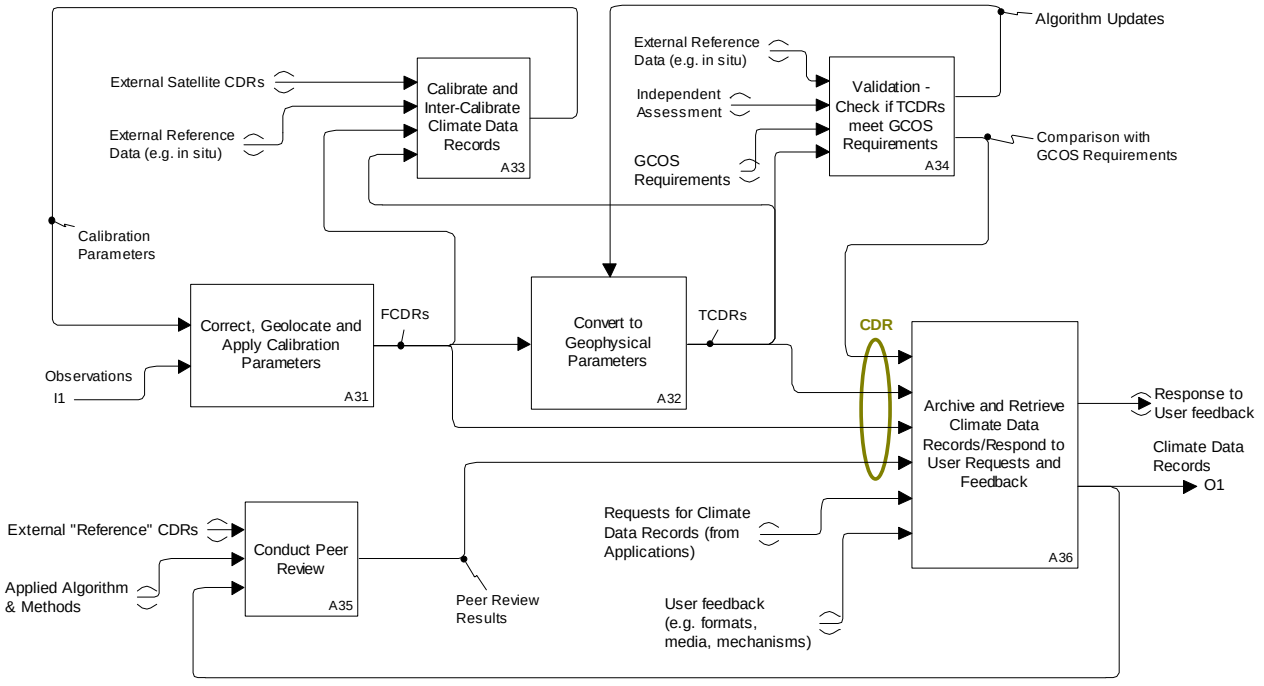


Figure 2: Decomposition of the 4 Pillars, with a focus on "Climate Record Creation and Preservation" and "Applications". (From “Strategy towards an architecture for Climate Monitoring from Space, p.31).



Recursive Process - Re-processing Synchronised with Reanalysis (where appropriate)

Figure 3: Decomposition of "Create and Maintain Long-term Climate Data Records" (expanding function A3 of Fig. 1). (From “Strategy towards an architecture for Climate Monitoring from Space, page 31). The delivery of FCDRs is represented by Box A31.

Table 1: Proposed elements of the physical view of the architecture
(Adapted from "Strategy towards an architecture for Climate Monitoring from Space, p.32).

ECV-specific Requirements	e.g. ECV identifier, accuracy, spatial and temporal resolution, stability, coverage, etc.

Current Implementation Status for each ECV	e.g.: - Sensor/Satellite data set(s); - Stewardship arrangements for each of the functions in the logical architecture; - Achieved performance (uncertainty, stability, etc); - Record length; - Access arrangements (formats, distribution mechanisms, etc);
Planned Contributions for each ECV	Similar items, e.g.: - Planned sensor/Satellite data set(s); - Planned stewardship arrangements for each of the functions in the logical architecture; - Planned performance (uncertainty, stability, etc); - Planned record length; - Planned access arrangements (formats, distribution mechanisms, etc);

Conclusion

11. ET-SAT is invited to :
- review and comment the preliminary mapping of the CGMS baseline against the ECVs,
- provide guidance on how to document the value of the CGMS baseline, including plans for delivering FCDRs, as a contribution to the architecture for climate monitoring from space,
- provide guidance on further steps to be taken for advancing the physical definition of the Architecture, for instance in focusing on some example missions.

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MAPPING OF CGMS MEMBERS' PLANS AGAINST THE CGMS BASELINE (13/05/2013)

(Circulated to CGMS Members for updating)

The purpose of this document is two-fold:

1. **To map the plans of CGMS Members against the "CGMS Baseline for the operational contribution to the GOS" adopted by CGMS-39 [2].**

   The first task listed in the CGMS High Level Priority Plan is to "*Coordinate the implementation of the CGMS baseline missions*". Action 40.34 requests "*All CGMS Members to review and update their contribution to the mapping of CGMS mission plans against the CGMS baseline, and inform WMO accordingly*". This mapping will be used by the CGMS Working Group III to evaluate risk of gaps or other long-term planning issues.

   In the present document, the operational or sustained missions of CGMS members are "mapped" to the various capabilities of the "baseline". This mapping is split into four tables:

   I. Geostationary constellation
   II. Core meteorological missions in 3 sun-synchronous orbits (a.m., p.m., e.m.)
   III. Other weather/climate missions in low Earth orbits
   IV. Data collection and space weather missions in low Earth orbits

   The baseline is recalled in the first column, there is then one column for each satellite series. **Please review, update and complete the columns corresponding to the missions your organization is responsible for.** For future capabilities, please indicate in brackets the expected year of operational availability if it is different from the year of launch (e.g. planned in-orbit storage).

2. **To map these plans with the Essential Climate Variables (ECV) and the ECV dataset inventory undertaken for the Architecture for Climate Monitoring from Space**

   This responds to Recommendation 40.40: *"CGMS Members, through WG III, to evaluate the CGMS baseline in the light of the [climate monitoring] architecture strategy with a view to populate the space segment physical view of the architecture and identify gaps and scenarios to address them"*.

   For this purpose, two columns have been added on the right of the tables. One is to indicate the ECVs supported by each of the missions. As a starting point, tentative ECVs have been listed there. Please review this tentative list of ECVs and highlight the ECVs that your missions have the potential to measure (or contribute to measure). You can add ECVs if they are not yet listed [3]. In the last column, please indicate references of the relevant ECV

[2] See CGMS-39 Final Report, Annex 6, pages 124-125. The CGMS baseline is also available on line on the WMO Space Programme website: http://www.wmo.int/pages/prog/sat/documents/CGMS_Baseline-operational-contribution-to-GOS-CGMS39-2011.pdf

[3] The official list of GCOS ECV is on : :http://www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables

datasets (FCDR or TCDR) if such datasets have been registered in the ECV inventory already.

The consolidated outcome of this mapping to the ECVs should enable to acknowledge the planned contribution of operational/sustained missions to the climate monitoring architecture, and to highlight the "missed opportunities", i.e. the potential contributions to climate monitoring for which there is still no plan, and/or that are not yet captured in the ECV inventory.

Contact information

Please indicate:

Your Name	
Your agency	
Your function	
Your email:	
Comments	
Date	

Once you have reviewed and completed the tables contained in the following pages, please send back this document to jlafeuille@wmo.int

If you have any question, please feel free to contact me.

Thank you very much for your cooperation !

Jérôme Lafeuille
WMO Space Programme
Rapporteur for CGMS WG III

WMO CGMS

I. Geostationary constellation

Missions/ Agencies	*Planned implementation*	GOES-W NOAA	GOES-E NOAA	Meteosat EUMETSAT	Elektro Roshydromet	FY-2, FY-4 CMA	INSAT IMD	FY-2, FY-4 CMA	COMS, Geo-Kompsat KMA	MTSAT/ Himawari JMA	Main potentially supported ECVs (Tentative)	References in the ECV inventory (When available)
On at least 6 GEO locations :		**135° W**	**75° W**	**0°**	**76° E**	**86.5° E**	**93.5° E**	**105° E**	**128° E**	**140° E**		
Advanced VIS/IR imagery, (<= 2km resol, ≥ 16 channels, <=15 min)	*2 in 2015 6 in 2017 7 in 2018 8 in 2020*	ABI >=2016 (2017)	ABI >=2020 (2021)	FCI >=2017 (2018)	MSU-GSM >=2018 (2019)	AGRI >=2017 (2018)		AGRI >=2015 (2016)	AMI >=2017 (2018)	AHI >=2015 (2016)	Cloud properties Wind speed & direction, Sea surface temperature Snow cover, Aerosols, Albedo Surface radiation budget, Water vapour, Precipitation Soil moisture Fire disturbance	
IR Sounding hyperspectral on some positions	*4 in 2015, 5 in 2017*	Sounder (mitigation) until 2018	Sounder (mitigation) until 2020	IRS >=2019 (2020) Hyper-spectral	HIS >=2018 (2019) Hyper-spectral	GIIRS >=2017 (2018) Hyper-spectral.	Sounder	GIIRS >=2015 (2016) Hyper-spectral			Air temperature Water vapour Cloud properties Wind speed & direction Surface radiation budget, Albedo, Ozone Precipitation CO_2 CH_4 NO_2, SO_2, CO	
Lightning detection	*2 in. 2015, 3 in 2016 5 in 2017 6 in 2020*	GLM >=2016 (2017)	GLM >=2020 (2021)	LI >=2017 (2018)	LM >=2018 (2019)	LMI >=2017 (2018)		LMI >=2015 (2016)				
Data collection	*At least 6*	DCIS	DCIS	DCS	DCS	DCS	DCS	DCS	?	DCS		
Space Environment Monitoring	*3 present, 5 in 2015 7 in 2017*	SEM/MAG SEISS	SEM/MAG SEISS		GGAK	SEP >=2017 (2018)		SEP >=2015 (2016)	? >=2017 (2018)	>=2015 (2016) (house keeping purpose)		

Launch date
(Operational availability)

Missions/ Agencies		GOES-W NOAA	GOES-E NOAA	Meteosat EUMET SAT	Elektro Roshy dromet	FY-4 CMA	INSAT IMD	FY-4 CMA	COMS KMA	MTSAT/ Himawari JMA	Main potentially supported ECVs (Tentative)	References in the ECV inventory (When available)
On selected positions only:		**135° W**	**75° W**	**0°**	**76° E**	**86.5° E**	**93.5° E**	**105° E**	**128° E**	**140° E**		
Earth radiation budget				? >=2020	ERBR >=2018 (2019)						Earth radiation budget Surface radiation budget	
High spectral resolution UV sounding				Sentinel-4 >=2018 (2019)							Ozone, other GHG Aerosols	
Solar activity		SUVI	SUVI		GGAK >=2018 (2019)			SXEUV >=2017 (2018)	? >=2017 (2018)			

II. Core operational meteorological missions in 3 sun-synchronous orbits (a.m., p.m., e.m.) and with Direct Broadcast

	Missions / Agencies	METOP, METOP-SG EUMETSAT	Meteor M, MP Roshydromet	FY-3 CMA	SNPP, JPSS, NOAA/NASA, then NOAA	GCOM-W JAXA [1]	FY-3 CMA	DMSP NOAA/ DOD [2]	Main potentially supported ECVs (Tentative)	References in the ECV inventory (When available)
Orbit (typical ECT)		9:30 desc	9:30 desc	10:00 desc	13:30	13:30	14:00	17:30		
Multispectral VIS/IR imagery	(a.m.)	AVHRR, Metimage	MSU-MR KMSS >=2013	MERSI-2					Cloud properties Sea surface temperature Snow cover Aerosols, Surface radiation budget Albedo Leaf Area Index Ocean colour Ozone	
	(p.m.)				VIIRS		MERSI-2			
	(e.m.)									
IR hyper-spectral sounders (at least a.m. and p.m.)	(a.m.)	IASI, IASI-NG	IKFS >=2013	HIRAS >=2016					Air temperature Water vapour Cloud properties Ozone Earth radiation budget, Albedo	
	(p.m.)				CrIS		HIRAS <=2014			
MW sounders	(a.m.)	MWS >=2020	MTVZA >=2013	MWHS, MWTS					Temperature Water vapour Precipitation Cloud properties	
	(p.m.)				ATMS		MWHS MWTS			
	(e.m.)							?		
MW imagers – some polarimetric	(a.m.)	MWI, ICI >=2022	? >=2013	MWRI					Precipitation Sea surface temperature Sea ice Snow cover	
	(p.m.)					AMSR-2 [3]	MWRI			
	(e.m.)							?		

III. Other weather/climate missions in low Earth orbits

Missions / Agencies	Required capability	METOP, METOP-SG EUMETSAT	Meteor M, MP Roshydromet	FY-3 CMA	Sentinel-3 EU/ESA/ EUMETSAT [1]	Landsat LDCM NASA/ USGS ?	Oceansat ISRO [1]	SNPP, JPSS, PFF NOAA	GCOM-W JAXA [1]	FY-3 CMA	DMSP NOAA/DOD [2] ???	Jason NASA, NOAA, CNES, EUMETSAT	COSMIC NOAA, USAF, NSPO	Main potentially supported ECVs (Tentative)	References in the ECV inventory (When available)
Orbit (typical ECT)		9:30 desc	9:30 desc	10:00 desc	10:00 desc	10:00 desc	12:00	13:30	13:30	14:00	17:30	66° incl.	Constellation		
Scatterometers	At least 2 orbital planes	ASCAT, SCA	SCAT >= 2015				OSCAT							Wind speed and direction Soil moisture	
Altimeter constellation	At least a.m., p.m. plus a reference mission in precision, inclined orbit		? >=2014		SRAL >=2014		?					Poseidon-3		Sea level Sea state	
Radio occultation (For 10000 occultation/day)	At least a.m., p.m., plus a constellation in appropriate orbits	GRAS, RO	Radiomet >=2015	GNOS >=2013			ROSA Continued?			GNOS >=2014			IGOR, Tri-G	Temperature Water vapour	
Broadband Vis/IR radiometer	At least a.m. , p.m			ERM				CERES Continued?						Earth radiation budget	
Total solar irradiance sensor	At least one			SIM				TSIS >=2016 Continued?						Earth radiation budget	
Atmospheric composition (contribution)	At least a.m. , p.m	Sentinel-5 >=2020	? >=2015	TOU, SBUSOMS				OMPS		TOU, SBUSGAS				Ozone Other GHG	

WMO CGMS

Narrow-band Vis/NIR imagers (ocean colour and vegetation)	At least one in a.m.		OCS, SZS >=2015		OLCI >=2014			?						Ocean colour FAPAR Leaf area index	
High-resolution multi-spectral Vis/IR imagers	Constellation preferably in a.m. orbit	?				ETM+								Land cover Snow cover	
IR dual-angle view imager	At least one in a.m.				SLSTR >=2014									Sea surface temperature	

IV. Data collection and space weather missions in low Earth orbits

Missions / Agencies	Required capability	METOP, METOP-SG EUMETSAT	Meteor M, MP Roshydromet	FY-3 CMA	Sentinel-3 EU/ESA/ EUMETSAT	Landsat LDCM NASA/ USGS ?	Oceansat ISRO [1]	SNPP, JPSS, PFF NOAA	GCOM-W JAXA [1]	FY-3 CMA	DMSP DWSS NOAA/ DOD [2]	Jason NASA, NOAA, CNES, EUMETSAT	COSMIC NOAA, USAF, NSPO	Main supported ECVs
Orbit (typical ECT)		9:30 desc	9:30 desc	10:00 desc	10:00 desc	10:00 desc	12:00	13:30	13:30	14:00	17:30	66° incl.	Constel-lation	
Particle detection (electrons, protons, ions, neutrons) and/or electron density	At least a.m., p.m	?	GGAK-M >=2013	SEM, SES				SEM-N		SEM	SEM-N ?		VIDI	
Magnetic field	At least a.m., p.m			?				?		?				
Solar monitoring	At least two			?						?				
Data Collection System		?	SSPD >=2013					?						

[1] Mission operated in a "sustained" mode by R&D agencies.
[2] United States DOD mission, data available to civilian users by NOAA.
[3] No Direct Broadcast from JAXA's GCOM-W