CGMS-50-CGMS-WP-15
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Prepared by CGMSSEC
Agenda Item: Plenary (Information docs)

Provided for information to Plenary

Status of implementation of CGMS High Level Priority Plan (2021-2025)

This working paper provides the status of implementation of CGMS High Level Priority Plan (2021-2025). It incorporates inputs from:

- WG I, II, III and IV Chairs and rapporteurs
- CGMS Space Weather Coordination Group
- International Science Working Group chairs and rapporteurs
- GSICS project
- SCOPE-CM project
- CEOS-CGMS Joint Working Group on Climate

The colour coding in the table corresponds to the following:

Green: Priority is reflected in ongoing CGMS actions
Yellow: Actions have been defined associated to the priority, but progress is limited
Red: No actions associated with the priority can be identified or major obstacles is hindering progress

Action/Recommendation proposed:

This is an information document, supporting the annual process for revision of the HLPP

Plenary is invited to note the status of implementation of the HLPP 2021-2025.

This document presents the status of implementation of the CGMS High-Level Priority Plan (2021-2025), as agreed by CGMS at its 49th virtual Plenary Session 19-21 May 2021. The document has been reviewed on the occasion of the CGMS-50 virtual working group meetings in April-May 2022.

Inputs have also been provided by Chairs, co-chairs and rapporteurs from CGMS Plenary working groups I, II, III and IV as well as the CGMS Space Weather Task Team, gathered through the inter-sessional activities, as well as from International Science Working Groups (through WG-II), the joint CEOS-CGMS Working Group on Climate and other non-plenary working groups reporting to CGMS.

The table present the targets according to the logic of the CGMS end-to-end systems. A colour coding indicates the overall progress of achievement of the target:

ACHIEVED	Target has been achieved, will be proposed for removal from HLPP
	Priority is reflected in ongoing CGMS actions
	Actions have been defined associated to the priority, but progress is limited
	No actions associated with the priority can be identified or major obstacles is hindering progress

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1	**Operational Continuity and Contingency Planning**	**WG-III**		
1.1	Mitigate the impact of identified degradation or loss of capabilities of the CGMS baseline and ensure appropriate contingency measures are in place, in particular to:		WG-III at its Risk Assessment Workshop in February 2022 identified mitigating actions to address loss of CGMS baseline capabilities. The outcome of the Risk Assessment was presented to all CGMS WGs to consider opportunities to mitigate identified risks. (Associated actions are recorded).	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.1.1	Ensure continuity of passive microwave imager measurements		WG-III recognized the need for a long-term plan for ~6 GHz frequency microwave imaging in at least one LEO orbit for all weather sea surface temperatures. Recommended mitigating actions included ensuring data availability from HY-2B, continue to work towards having 6 GHz data from two orbits (consistent with section 1.2.2), and NOAA to provide an update on SSMI status and possible follow-on. ESA and EUMETSAT are to confirm plans for the Copernicus CIMR mission. It will be investigated whether the current and planned µwave constellation provides adequate support for precipitation measurements, as these measurements depend mainly on frequencies around 90 GHz. 2022 Risk assessment: Low risk of not meeting the CGMS Baseline commitment; however, sensor performance requirements for different environmental parameters vary; ~6 GHz frequency microwave imaging critical for all weather SSTs, and >90 GHz frequency critical for precipitation. Recommend action for ESA to report on plans for the CIMR (Copernicus Imaging Microwave Radiometer) Mission.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.1.2	Ensure long-term continuity of the Early Morning orbit, in particular for IR/MW sounding and IR/VIS imaging for NWP and nowcasting		The official announcement of China's decision for FY-3E in EM orbit was made by CMA during the 17th WMO Congress. Following this official announcement, CGMS actions are being defined to ensure the full integration of the FY-3E satellite in the overall GOS. 2022 risk assessment: CMA confirmed the plan to fly FY-3J in the EM orbit as a successor to F3-E. The continuity in the EM orbit is therefore confirmed.	
1.1.3	Ensure continuity of Precipitation Radar measurements;		2022 Risk assessment: Low risk of not meeting the CGMS Baseline commitment. FY-3I now provides continuity beyond FY-3G. NASA and JAXA have an action to confirm plans beyond the GPM Core.	
1.1.4	Ensure continuity of Scatterometer measurements		2022 Risk Assessment: Low risk of not meeting the CGMS Baseline commitment. FY-3J now provides coverage beyond FY-3E in the early morning orbit. ISRO to confirm plans beyond OceanSat-3A.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.1.5	Ensure continuity of Radio Occultation Measurements with required quantity, geographical coverage and temporal sampling for numerical weather prediction and for ionospheric monitoring		2022 risk assessment: The CGMS Baseline commitment is not being met until 2024 until Metop-SG launches, and there is a high risk of not meeting the commitment from low inclination orbits in the later part of the decade as there are no plans for a follow-on to COSMIC-2. There is inconsistent coverage from polar and high inclination orbits throughout the period (commitment for number of occultations can be met, but not the geographic distribution or performance to meet NWP requirements). Commercial operators could offer some risk mitigation (would need to ensure compliance with national and international mandates and policies). An HLPP objective (1.2) already exists to advance the atmospheric Radio Occultation constellation, with the long-term goal of providing 20000 occultations per day on a sustained basis; consider an additional recommendation for tropical missions to carry RO sensors.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.1.6	Ensure continuity of Coronagraph and Plasma Analyser observations through exploitation of scientific space weather missions for operational gap filling		2022 risk assessment: Increasing risk of a gap in the early part of the decade and long term continuity at L1. SOHO operating well past design life; increasing risk of a gap until GOES-U and SWFO-L1 are launched. CGMS Members to invited to propose near-term alternative data sources for consideration as gap mitigation in event of loss or degradation of current L1 capabilities prior to SWFO-L1 data availability. WGIV to consider recommended gap mitigation observation requests and develop plans to ensure near real-time access to those data. Recommend action for NOAA to review additional ground resources needed to track STEREO-A and PUNCH to provide additional coverage in the near-term.	
1.2	Advance the response to the WIGOS 2040 vision for space, by the implementation of new capabilities beyond the CGMS baseline		CGMS continues its efforts to extend its response to the WIGOS vision.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.2.1	Work towards establishing optimum constellations for new observations introduced in the CGMS baseline: - Short Wave IR Spectrometers for monitoring of Greenhouse Gases (CO2 and CH4); - Multi-viewing, multi-channel, multi- polarisation imaging for aerosols; - UV limb sounding spectrometry for profiles of Ozone and trace gases;		- CGMS contribution to SWIR spectrometer constellation for emission monitoring is being coordinated by the JWGClimate - The capabilities of the CGMS baseline for aerosol measurements will be assessed. - The capabilities of the CGMS baseline for monitoring of minor trace gases will be assessed. Concrete actions to be discussed	
1.2.2	Advance the new generation of GEO satellites, including advanced imaging, lightning mapping and IR sounding for the whole geostationary ring;		The definition of GEO-XO and of Himawari-8/9 follow-on are in progress	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.2.3	Work towards operational hourly daytime UV/VIS mapping of air quality from geostationary orbit;			
1.2.4	Work towards ensuring optimised High Spectral resolution IR measurements from LEO and GEO orbits to improve time sampling, spatial and spectral resolution and timeliness of observations, including the deployment of HSIR instruments across the GEO ring as per WIGOS vision 2040;	WG-II, -III, ITWG	Actions not well defined. Analysis of the current plans and gaps required	
1.2.5	Work towards optimising the distribution of planned scatterometer missions across different polar and inclined non synchronous orbits to achieve the 6-hour sampling requirement of the WIGOS and resolve diurnal variations;			
1.2.6	Work towards ensuring low frequency microwave imagery for all-weather SST and ice monitoring from at least 2 sun-synchronous orbits			

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.2.7	Establish observational requirements for microwave observations (sounder and imager) for precipitation and perform gap analysis against CGMS baseline;	WG-III,-II, IPWG	Actions should be placed on IPWG	
1.2.8	Work towards increasing geographical resolution and coverage for altimetry measurements, including very high latitudes;		Altimetry coverage for arctic sea-ice at very high latitudes is currently provided by R&D missions (CRYOSAT-2 and ICESAT) for which continuity is not currently assured. At CGMS-50 ISRO will present plans for altimetry missions and ESA will present plans for the operational Copernicus mission CRISTAL.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.2.9	Advance the atmospheric Radio Occultation constellation, with the long-term goal of providing 20000 occultations per day on a sustained basis	WG-III,-II, IROWG	IROWG recommends targeting 20,000 globally distributed observations per day with uniform spatial and local time coverage, noting that both the equatorial and polar components of the COSMIC-2 mission are required for operational NWP. Recent studies show that substantial increases in NWP accuracy and climate monitoring utility are obtained for increases in the number of RO profiles to at least 20,000/day (corresponding to around 4 M bending angles per day), and beyond, not approaching saturation at 20,000 per day. The status remains unchanged: the target number of occultations will not be met with existing operational missions or those in the implementation stage. Current estimates for operational missions, including the COSMIC-2 equatorial mission, are for approximately 12,000 occultation profiles per day starting in 2022 with the launch of EPS-SG. However, only 5,500 are from satellites providing global coverage (EPS, EPS-SG, Feng-Yun and JASON-CS/Sentinel-6). The COSMIC-2 mission profiles are all below about 40 degrees latitude. Source: WMO/OSCAR (courtesy of C. Marquardt, EUMETSAT). To mitigate the risk of a gap after COSMIC-2, all operators should consider flying RO instruments on any planned low-inclination mission.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
			RO: Recommend operators to fly RO instruments for all missions in drifting orbits to mitigate the risk of gaps beyond the middle of the decade. Input from IROWG: The 20 000 target is well established and has already been endorsed by CGMS. And the assessment of the current and near future situation - with quite some gaps in coverage (especially in local time) at latitudes beyond 40° latitude - is still valid.	
1.2.10	Work towards operational 3D wind profile observations from space-based lidar;		AEOLUS follow-on under consideration by ESA and EUMETSAT	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.2.11	Move towards an operational space weather monitoring capability from the Lagrangian Point L-5	SWCG	The need to expand to the L-5 orbit has been established by NOAA's NSOSA study, which noted the benefit of off-Sun-Earth axis solar observations. Space Weather cooperation between NOAA and ESA has been assigned, including instrument exchanges for Vigil and SWFO. Vigil mission is in extended B1 phase, subject to support from ESA ministerial 2022.	
1.2.12	Establish the operational framework for the provision of magnetometer data from LEO orbit;	SWCG	Operational need has not yet been demonstrated, but a clear interest has been stated in survey and from scientific community.	
1.2.13	Investigate continuous space weather observations from lunar orbit for terrestrial and future lunar space weather services as well as for heliophysics research, complementing the geostationary and L1 measurements.	SWCG	Lunar Gateway demonstration mission with ESA and NASA payloads under development for launch in 2024. NOAA MoA with NASA has been signed on SW services in support to future lunar operations.	

Commented [MR1]: Other subjects for consideration in HLPP:

Adding auroral monitoring capabilities

Investigate impact on future SW observation due to increased demand on SW services by SSA and STC

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.3	**Ensure long-term continuity of OSCAR/Space as a primary tool to support the CGMS Risk assessment and the WMO Rolling Review of Requirements including gap analysis against observing system requirements for satellite data and make OSCAR/Space the primary repository for WIGOS satellite metadata records generated by CGMS operators**	**WG-III**		
1.4	**Assess impact and benefits of CGMS satellite missions**			
1.4.1	Support satellite impact studies, including in particular impact of data latency and the impact of the Early Morning orbit;		The preparation process for the next WMO impact workshop in 2020 has started and CGMS has provided inputs to the science questions for the workshop, to ensure that impact of data latency is adequately addressed.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.4.2	Develop capacity to assess socio-economic benefits of CGMS satellite missions;			
1.5	**Identifying partnership opportunities on space and ground segments and establish CGMS coordinated mechanisms;**		Partnership on LEO ground segments being implemented by EUMETSAT and NOAA for Metop-SG and JPSS. It should be noted that this target applies strongly to the CGMS engagement in Space Weather and NOAA is actively pursuing Ground Segment partnerships for the SWFO-L1 mission.	

2	**COORDINATION OF SATELLITE SYSTEMS AND OPERATIONS**	**WG-I**		
2.1	**Coordination/Optimisation of data collection systems**	**WG-I**		
2.1.1	Complete SWOT (strengths, weaknesses, opportunities, and threats) analysis for DCS (Data Collection Service)		SWOT under preparation for CGMS-50	
2.1.2	Assess DCS status and evolutions including International channels, taking into account requirements of tsunami alert systems and in-situ ocean observations (e.g. buoys), and assess the utilisation of International DCS channels;		Considered work in progress noting the information in DCS Task Group status report.	
2.1.3	Establish International DCP design standards taking into account requirements of tsunami alert systems and in-situ ocean observations (e.g. buoys) and lessons learned from the development of High Rate DCPs. This standard would allow the use by all agencies and also as an international standard;		The DCS Task Group are coordinating the elaboration of the user requirements, the technical specifications, and potential applications for a new DCP Standard including a section on DCP formats. The specification is initially based on ESA study. It is planned to organise a workshop with the 5 core manufacturers to discuss easily implementable solutions to achieve this. Status is considered to be "yellow" as the topic to be further developed through dedicated working team and focused Inter-Sessional activities.	

Commented [KN2]: DCS items updated with inputs from Nick Coyne

Commented [MR3R3]: OK

2.2	**Radio Frequency (RF) Protection**	**WG-I**		

Commented [KN4]: RF protection items updated with inputs from Markus Dreis

Commented [KN5]: In addition, a "Task Group on RFI detection, monitoring and mapping" has been formed

2.2.1	Facilitate an effective preparation of national and ITU-R regional groups' positions for the World Radiocommunication Conference (WRC) 2023 favourable for the CGMS-related issues, in particular but not exclusively with regard to the: - Establishment of a new frequency allocation to EESS (passive) in the bands 239.2-242.2 GHz and 244.2-247.2 GHz under agenda item 1.14 to cover and protect planned and future passive microwave sensors for ice cloud measurements; - Recognition to the extent possible of the need for protection of the band 6425-7125 MHz or to find, if possible, complementary frequency resources for SST observations to compensate for the increased interference potential due to the identification of the band for IMT 5G mobile (agenda item 1.2); - Protection of the band 1695-1710 MHz (used for LEO broadcast to user stations) from planned new frequency usage by commercial		This topic needs to be kept in the HLPP for securing adequate information flow inside CGMS on national and regional level preparatory activities (as well as the dedicated report from SFCG activities provided by CGMS Liaison representative in SFCG) Rewording proposed to better reflect the CGMS priorities for WRC 23.	

	satellite systems (agenda item 1.18) or from possible high-altitude platform stations as IMT base stations (HIBS) in the neighbouring band (agenda item 1.4); - Establishment of recognition and protection of sensing frequencies for space weather observations (agenda item 9.1 Topic A).			
2.2.2	In the general ITU framework, triggered by ITU-R Resolution 731, regarding the establishment of sharing conditions between active and passive services in bands above 71 GHz, to ensure protection of passive sensing bands, in particular in bands in which all emissions are prohibited (Radio Regulations Footnote 5.340).		Some countries in ITU are using the inconsistencies in Resolution 731 to undermine the status of the purely passive bands in RR FN 5.340 (all emissions are prohibited) to justify use of these bands by active service with all its negative consequences in terms of interference. It will be important that CGMS members urge their national regulatory authorities, when establishing new regulations for use of active services and applications, to appropriately taken into account the protection requirements of passive sensors and that the bands listed in RR FN 5.340 will not be opened for a shared use with active services.	
2.3	**Direct Broadcast Systems and Data Processing**		Propose to add “Provide coordinated CGMS inputs to WMO on satellite and instrument identifiers for data representation and metadata within the WIS” under this heading, as it is addressed in WG-I TG on Satellite Data and Codes, as well as “Develop efficient standardized data handling for high-resolution imaging and hyperspectral instruments”	

2.3.1	Ensure the ease of use of satellite-derived data and products, disseminate in one of the standard formats, as specified in the CGMS LRIT/HRIT Global Specification and the WMO Manual on Codes. Once the use of netCDF with the CF convention are captured in the WMO Manual on Codes, ensure compliance with this for satellite-derived data and products disseminated in netCDF.		Work has progressed, see the status report provided by EUMETSAT on dedicated paper for CGMS-48, containing also the outcome of specific work achieved by the WG-I participants through dedicated Inter-Sessional meetings. A dedicated CGMS "liaison officer" agreed at CGMS-47. The role is to coordinate with the CF community to concentrate efforts and views of the different CGMS members aiming at contributing to the evolution of these standards by actively participating in the related CF meetings. Topic is proposed to be further developed through the Task Group of Satellite Data and Codes (TGSDC), which will interact with the CF Conventions Committee, the CF Standard Names Committee, and the CF Governance Panel.	
2.3.2	Facilitate the transition to new LEO direct readout systems (JPSS, FY-3, Meteor-M, Metop-SG);		The initial nine Best Practices now published in *CGMS Agency Best Practices in support to Local and Regional Processing of LEO Direct Broadcast data* (CGMS/DOC/18/1008274) were introduced and endorsed through CGMS-44, CGMS-45 and CGMS-46. As a result of the ongoing work, supported by WG-I dedicated Inter-Sessional meetings, one new Best Practice, *BP.10 Monitoring of the Direct Broadcast Downlink* and an update to the existing BP.04 and BP.09 were endorsed at CGMS-48. In preparation for CGMS-50, an editorial update was made to BP.04 to include a wording on user friendly interface. **Any concrete actions apart from the efforts on the Best Practices?**	

Commented [KN6]: Remark from Antoine that "the JPSS2 and FY-3E spacecraft compliance to the DB best practices are now part of the NOAA and CMA BP documents. The yearly update and peer review process is allowing to update the documents as spacecraft are launched / decommissioned."

So this is a regular effort for the agencies.

2.3.3	Advance the implementation of the CGMS Agency Best Practices in support to Local and Regional Processing of LEO Direct Broadcast data for operational satellites and complete a SWOT (strengths, weaknesses, opportunities, and threats) analysis for the Direct Broadcast;		Maturity of the existing BPs considered achieved. To review and support the implementation of the BPs, WG-I has established a peer review process between the agencies operating LEO satellites with Direct Broadcast capability. The outcome of the peer review is reflected through the *Implementation of CGMS best practices for LEO direct broadcast data* documents prepared by each agency. These documents were exchanged and actively reviewed and discussed between CMA, NOAA and EUMETSAT prior to being published for the CGMS-48 WG-I meeting. The review covered not only the documents, but where relevant also a verification of the availability or content of resources listed in the document. Progress on the *Implementation of CGMS best practices for LEO direct broadcast data* will be presented by each of the agencies in the CGMS-50 WGI meeting. In preparation for CGMS-50, the Task Group on Direct Broadcast Systems has performed am extensive SWOT analysis on Low Latency Data Access from LEO meteorological satellites and the outcome will be presented in CGMS-50 WGI.	
2.4	**Operational issues related to Space Weather**			
2.4.1	Evaluate existing operational space weather products and services in support of CGMS members' spacecraft operations and recommend additional services as appropriate	WG-I, SWCG	Will be addressed in intersessional work with SWCG. SW is an agenda item for SpaceOps March 2023.	

Additional activity areas of WG-I, that could at some point be considered for inclusion in the HLPP. The status is:

Coordination of LEO Orbits

Concept for Best Practices for the Coordination of Data Acquisition for Low Earth Orbit Satellite Systems will be presented by the the Task Group on the Coordination of LEO Orbits for discussion in CGMS-50 WGI

Space Debris and Collision avoidance

Task Group on Space Debris and Collision Avoidance has been formed and will present a report in CGMS-50 WGI to discuss possible Best Practices on Collision Avoidance

Commented [KN7]: In addition, there is the:

- Coordination of LEO Orbits

For this, a Proposed Best Practices for the Coordination of Data Acquisition for Low Earth Orbit Satellite Systems will be presented by the the Task Group on the Coordination of LEO Orbits in CGMS-50 WGI

- Form a Task Group on Space Debris and Collision Avoidance to produce a Best Practice on Collision Avoidance

Task Group on Space Debris and Collision Avoidance has been formed and will present a report in CGMS-50 WGI

Commented [MR8R8]: Reflected in revised text

3	**COORDINATION OF DATA ACCESS AND END-USER SUPPORT**	**WG-IV**	**It is proposed in CGMS-WP-26 to reorganize the priorities to better reflect the new working structure of WG-IV.**	
3.1	**Support the user-provider dialogue on regional/continental scales through regional coordination groups maintaining requirements for dissemination of satellite data and products through the various broadcast services;**		To be addressed by TG on User Readiness Regional coordination groups on data requirements are established in all WMO regions (RA I to RA VI), and those groups are very active. As reported in CGMS-48, the results from joint meetings and user surveys in RA II and RA V are useful for policy makers of satellite product development, data dissemination and user training. A user survey for RA-III and –IV is being completed by WMO, results will be available in the course of 2022.	

3.1.1	Consider the full range of user capabilities (ranging from advanced Short range NWP to more conventional nowcasting) when planning data utilisation, products generation and dissemination strategies, in particular for the new geostationary satellites;		To be considered in the review of Best Practices for User Readiness (move to 3.2)	

3.1.2	Establish a sustained interaction with the operational nowcasting communities with a view to fully utilise the commonality of the future geostationary imagers and sounders.		The responsibility for the priority is between agencies and nowcasting communities, not between Agencies. However, it is recognized that Agency interaction would facilitate further progress and some activities are happening here as well. Looking at some the key players with key current and future capabilities it seems this is progressing reasonably. Whilst some interactions exist, also in the context of the EUMETSAT MTG IRS Mission Advisory Group, a sustained regular interaction across all CGMS members planning to launch geo-satellites with hyperspectral infrared capabilities has not yet been established. Focus of SCOPE-Nowcasting Pilot Project 1 in RA II (Asia) and RA V (South-West Pacific) Note however that SCOPE-Nowcasting has been inactive since 2019 Activity to be coordinated with WGII, no progress so far.	

3.2	**Prepare operational users for new generation of meteorological satellites through user readiness programmes, with coordinated contributions from CGMS members**		To be addressed by TG on User Readiness	
3.2.1	Review the Best Practices for Achieving User Readiness for New Meteorological Satellites, taking into account lessons learnt from recent new satellites programmes and advance the implementation of the best practices;		A related WGIV action response will be discussed at CGMS-49, addressing the future evolution of the WMO "Guidelines on Best Practices for Achieving User Readiness for New Meteorological Satellites". Review has been initiated, also involving the WMO Expert Team on Satellite Systems and Utilization (ET-SSU)	
3.2.2	Provide up-to-date Information on these topics, to be synthesized and maintained by WMO in the SATURN portal, dynamically linked to resources of CGMS members, including the new generation of GEO satellites as well as new LEO satellites.		Continuous update of SATURN information to be included in Best Practice, by a to-be-established inter-sessional sub-group. Until the Best Practice sub-group is established, the target will be kept open. SATURN content updates provided for MTG and EPS-SG.	

3.3	**Support the coordination of the operational Digital Video Broadcast (DVB) satellite services for the Americas, Africa, Europe and the Asia Pacific regions;**		The communication satellite broadcast systems GEONETCast Americas, EUMETCast, CMACast and HimawariCast are well established and coordinated systems, and no significant issues are observed. Reporting on the broadcast systems were provided in CGMS-50 WG-IV meeting	
3.4	**Increase access to, and use of, data from R&D and pre-operational missions, including space-weather missions;**		TG on Data Access/Exchange EUMETSAT, supported by CGMS members, is actively increasing access of such data to its member states, and to other CGMS members through bilateral arrangements. It should however be noted, that the bilateral agreements for R&D satellites do not always allow unrestricted re-distribution for operational use. There are ongoing activities, no specific issues reported.	

3.5	**Investigate the feasibility of utilizing existing dissemination systems for meteorological information in helping to mitigate disasters;**		The utilization of existing dissemination systems for disaster mitigation purpose is well established but still has room for expansion. The on-demand Rapid Scanning services of CMA, JMA and KMA are using existing dissemination systems for supporting disaster preparedness.	
3.6	**Increase operational access to data and products in support to the ocean user community;**		Ocean is addressed in the regional dialogues, but there is a need for a better dialogue with the global ocean community. The future mechanism for structured dialogue between CGMS and the ocean community is still to be defined. Will be discussed in the Ocean session at the CGMS-50, after which concrete actions can be defined by WG-IV. KMA has implemented an L-band Direct Broadcast service on GEO-KOMPSAT-2A, providing meteorological and marine data for reception by ships. Even though there is still no coordinated interaction with this community in place, the ocean user community benefits from evolutions in existing data access mechanisms.	

3.7	**Utilise operationally the WIS infrastructure for satellite data provision and discovery**		Limited progress in the operational use of WIS 1.0 for satellite data and products. Reports from the Joint WGI-WGIV cloud and big data service session suggest that the WIS 2.0 is evolving into a heterogeneous set of data access mechanisms, each one optimised for its purpose and all complementing each other. The goal is to best serve the users' and providers' needs. Cloud services play an increasing but not the only role. It is important that CGMS operators position themselves in this development Proposed to amend target to refer to WIS 2.0: **Ensure the WMO Information System (WIS) 2.0 suitability and usage for satellite data discovery and provision** To be addressed by TG on Data Access/Exchange	
3.8	**Provide coordinated CGMS inputs to WMO on satellite and instrument identifiers for data representation and metadata within the WIS**		Addressed in TG on Satellite Data and Codes **Proposed to move to WG-I**	

3.9	**Harmonise the metadata (e.g. quality descriptors) and format of products to be exchanged, in adherence to the Service and Discovery metadata standards formulated in the context of WIGOS/WIS**			
3.9.1	Support WIGOS in the definition of harmonized product metadata for satellite data and implement for CGMS missions;		TG on Metadata The CGMS Task Force on Metadata Implementation has worked on the WIGOS Standard Assessment. The recommendations available from CGMS-TFMI-WIGOS-Standard-Review were approved. An extension of the work plan regarding the assessment of the WIGOS Metadata Representation Format was endorsed. Documentation is published.	
3.9.2	Promote the product metadata standards within ocean communities, such as on SST, ocean colour, ocean vector surface wind and ocean surface topography, to facilitate common data representation and near-real time exchange. This must be done in dialogue with the relevant CEOS Virtual Constellations.		To be addressed by TG on Metadata	

3.10	Document current data formats for space weather observations		This topic is now addressed within SWCG, and WGIV involved in joint sessions and when needed. SWCG TG on User Access to be established. Propose to move to SWCG, to be addressed by the new TG on User Access.	
3.11	Ensure the timely access to and global exchange of space weather data of CGMS Members, including instruments hosted on third-party satellites		Latency for RO for ionospheric monitoring is being addressed. Data access and latency issues will be addressed by SWCG TG on User Access. Propose to move to SWCG?	
3.12	Ensure the timely access to and exchange of near-real-time scatterometer data, share access to calibration and validation information across CGMS agencies		TG on Data Access/Exchange This should be refined to match the objectives of WGIV	
3.13	Improve the exchange of characterisation data (incl apodization) for geostationary and low Earth orbit hyperspectral infrared instruments		Proposed to reword to: **Improve the access to characterisation data (incl apodization) for geostationary and low Earth orbit hyperspectral infrared instruments** To be addressed in review of BP on User Readiness	

3.14	Develop efficient standardized data handling for high-resolution imaging and hyperspectral instruments		Some progress in the context of the NETCDF activities. Propose to move to WG-I to be addressed by WG-I TG on Satellite Data and Codes	
3.15	Explore options for optimal data exchange of advanced data from new generation GEOs, in consultation with the global NWP centres through GODEX-NWP		No progress, GODEX-NWP has not yet defined requirements To be addressed by TG on Data Access/Exchange	
3.16	Develop Best Practices for Global Data Exchange		To be addressed by TG on Data Access/Exchange	
3.17	Develop Best Practices for Operational User Notifications		To be addressed by TG on User Readiness	
3.18	Develop Best Practices for Cloud Services Interoperability		Cloud Services Expert Group established and working well. Best Practices to be further considered based on recommendation from Cloud Expert Group Workshop given at CGMS-50 WG-IV	

4	**ENHANCE THE QUALITY OF SATELLITE-DERIVED DATA AND PRODUCTS**	**WG-II (Supported as appropriate by ISWGs and GSICS project)**	**Status below is provided based on information from the ISWGs that have met since last CGMS. A complete status of implementation of the proposed targets in the product area will be gradually established by WG-II, the ISWGs (during their cycle of meetings) and the GSICS project.**	
4.1	**Establish within GSICS a fully consistent calibration of relevant satellite instruments across CGMS agencies, recognising the importance of collaboration between operational and research CGMS agencies;**			
4.1.1	Maintain within GSICS a framework for inter-calibration of hyper-spectral sounders;	GSICS	Implemented and provides input to the annual GSICS. observing system report. Interoperability within GSICS framework ongoing.	
4.1.2	Establish within GSICS a consistent inter-calibration for thermal IR channels using hyper-spectral sounders as reference. The implementation will be done successively by the individual satellite operators	GSICS		

4.1.3	Establish a consistent inter-calibration for solar channels using instruments with adequate in-orbit calibration and vicarious methods as reference. The implementation will be done successively by the individual satellite operators.	GSICS	The lunar irradiance and DCC (Deep Convective Cloud) have been suggested by GRWG as targets to transfer the NPP-VIIRS reference calibration for the solar reflective bands. The results have been demonstrated by most satellite agencies, the approach for implementation is still under discussion. It is imperative to stress the need to use the same solar spectrum for inter-comparing sensors based on radiance units. The MODIS, NPP-VIIRS, and N20-VIIRS sensors use the Neckel&Labs, MODTRAN 4.3, and Thuillier 2003 solar spectra, respectively. The GSICS-recommended NOAA NPP-VIIRS V2 calibration reference will use the Thuillier solar spectrum. This multiplicity is confusing. The GSICS VIS/NIR and UV groups have tasked the CU/LASP solar group to prepare a paper (contact: Peter Pilewskie peter.pilewskie@lasp.colorado.edu) to establish a high resolution solar reference spectrum anchored to the newly launched ISS/TSIS-1 sensor. This will be in coordination CEOS WGCV IVOS group.	
4.1.4	Establish a common reference solar spectrum with appropriate spectral coverage and spectral resolution and develop common methods and tools for on-ground calibration and characterisation and inter-calibration of UV-Vis- NIR SWIR spectrometers	GSICS		

4.1.5	Establish a methodology to characterise microwave instruments for O2 absorption channels through the SNO and RTM modelling. The implementation will be done successively by the individual satellite operators;	GSICS	NEW	
4.1.6	Establish mechanisms for cross-calibrating scatterometers across the constellation.	GSICS	NEW	
4.2	**Establish commonality in the derivation of satellite products for global users where appropriate (e.g., through sharing of prototype algorithms);**			

4.2.1	Establish commonality in the derivation of AMV products for global users where appropriate (e.g., through sharing of prototype algorithms) and consider backwards compatibility when designing AMV algorithms for the 16-channel imagers, so that present state-of-the-art algorithms can be applied to old imagery.	IWWG	Implementation of new AMV BUFR et sequence and Common QI by space agencies is partially completed. EUMETSAT, KMA, JMA and the NWCSAF/HRW have included the Common QI into their algorithm repositories. NOAA still has to complete their integration of Common QI. NOAA, EUMETSAT, KMA and the NWCSAF/HRW have implemented the use of new AMV BUFR sequence. The scope of 4th AMV Intercomparison has been presented at IWW15 and co-chairs coordinated the preparation of the study last fall. NWCSAF, EUMETSAT, JMA, KMA, NOAA, CPTEC/INPE have sent AMVs datasets, ISRO, CMA, BoM may submit AMVs until the end March 2022. W-Madison/CIMSS (Dave Santek) performing the analysis with NWCSAF (Javier Garcia-Perreda). Results are expected by IWW16 (spring 2023)	
4.2.2	Investigate the best configurations to be used by the AMV producers for use in global and regional NWP models respectively, and clearly define the appropriate requirements for each of them;	IWWG	M. Forsythe (MET Office) compiled the best configurations to be used by AMV producers for Global NWP models in a short document that is accessible on IWWG website. This document will be updated regularly following the evolution of users' needs and satellite capabilities.	

4.2.3	Assess value of derivation of winds from GEO Hyperspectral IR	IWWG	The potential of 3D winds extracted from Hyperspectral IR sounders can be estimated from existing demonstration 3D AIRS/CrIS (CIMSS/NOAA/NASA) and 3D IASI winds (EUMETSAT) that can be made available to the user community. For a better estimation of 3D winds from a Geostationary Hyperspectral IR sounder instrument, NOAA is discussing the possibility of generating 3D AMVs from GEOS-5 for use in OSSEs.	
4.2.4	Establish a coherent development of volcanic ash products and applications with close user community coordination;	WG II	WG II will discuss the way forward for Ash Product development, updated intercomparisons and definition of suitable parameters for end user applications with SCOPE-NWC, IAW and ICAO."	
4.2.5	Develop best practices for evaluation and validation of cloud properties	ICWG	ICWG proposes to modify to: Assess the cloud properties generated from the geostationary and polar orbiting imagers and pursue best practices that lead to improved consistency and accuracy across the globe and the geo-ring.	

4.2.6	Establish together with the user community a commonly agreed approach for retrieval of Principal Component scores and associated parameters from hyperspectral infrared data, minimizing information loss including the mutually acceptable update strategy for the principal component basis and to implement such an approach in a coordinated manner.	ITWG	At ITSC-23 EUMETSAT (Tim Hultberg) presented the latest results of the hybrid PC compression approach. EUMETSAT is preparing to implement IASI PCC Basis v2.01 in August 2022, with the following improvements: • Full matrix noise normalisation • Optional filtering of instrument artifacts not common to all satellites, pixels and CCDs • Subspace (instead of affine subspace) – not centered around mean spectrum • 153 million base spectra: 74 days of reprocessed IASI-A (2008-2019) 48 days of IASI-B (2013-2019) • Adding data from recent events: Calbuco and Raikoke volcanoes; Australian wild fires At ITSC-23 ECMWF (Cristina Lupu) presented a poster titled "The assimilation of EUMETSAT reconstructed radiances for IASI data compression". ECMWF conducted assimilation trials with the operational 4D-VAR using IASI radiances reconstructed from hybrid PC scores with the same approach used currently for conventional IASI radiances (same channels, observation error matrix and RTTOV). • A comparison between the mean and standard deviation of the background departures for original and reconstructed IASI radiances was performed. Reconstructed radiances show small differences in the mean but marked reduction in the standard deviations of the background departures. The biases are generally unchanged and comparable data volumes pass the cloud detection algorithm. • The conventional vs. reconstructed radiance experiments display very similar patterns of temperature and humidity	

			analysis increments structures, indicating that the assimilation of either conventional radiances or reconstructed radiances results in similar adjustments of the background fields. • The results obtained from the assimilation of IASI reconstructed radiances in a depleted observing system are very encouraging in terms of analysis and forecast impacts. • They show the possibility of an alternative route to radiance assimilation for the exploitation of data from high spectral resolution infrared sounders in NWP. During the ITWG interim meetings of spring 2022, CIMSS/SSEC/UW-Madison (Dave Tobin) presented an update on "Prototyping the EUMETSAT Hybrid PCA Technique for CrIS: Preliminary Results and Next Steps". • CIMSS/SSEC has developed a CrIS PC compression approach following the hybrid PC approach currently used for IASI data, where a static PC database is determined and distributed to trial users, and PC scores and outlier spectra for each granule are computed and distributed. • The prototype is based on a large representative set of spectra. This current study uses (TBR) 3 randomly selected spectra from each 4-scan SCRIF file from Julian days 001, 090, 180 and 270 of year 2019 (~32,400 spectra). • The leading 150 (TBR) PCs are retained. • These global PCs are "static" and distributed to trial users along with the global mean spectrum. • The PC score volume is less than 10% of the volume of the equivalent radiances.	

			• CIMSS/SSEC has shared the software for generating the PC basis coefficients and the PC scores, and has distributed samples of the PC scores and reconstructed radiances. • Will plan to add a software toolkit to CSPP for CrIS PC compression and reconstruction.	
4.3	**Foster the continuous improvement of products through validation and inter-comparison through international working groups and SCOPE-type mechanisms;**			
4.3.1	Apply the IPWG validation protocol (as defined on its web page) to precipitation combination datasets generated using multiple satellite and in-situ data sources, and expand the number of participating agencies to broaden the validation domain	IPWG	The South Korean validation website is up and running. It has been presented to the IPWG community during one of the virtual sessions IPWG did hold in 2021. Regarding a potential future validation site over Israel, this is an interesting testbed for estimating rainfall over complex terrain. However, attempts to contact the initial points of contact have been unsuccessful to date.	

4.3.2	Provide a SCOPE-CM Implementation Plan following the agreed new concept by 2020;	WG II	WP on SCOPE-CM phase III will be discussed at CGMS-48. A small task team composed of representatives from NOAA, EUMETSAT and WMO have considered the way forward for SCOPE-CM and proposes to conclude all Phase-II activities and then adopt a new approach for SCOPE-CM, i.e, to focus on production of CDRs responding to gaps identified by JWGClimate. WG-II supported this proposal, which then will be detailed with updated strategy, Agenda and Terms of Reference for SCOPE-CM.	

4.3.3	Conduct an inter-comparison study between the different methods to derive level 2 data from infrared hyperspectral sounders, recognising that there are several software packages available utilizing AIRS/IASI/CrIS data.	ITWG	At ITSC-23 NOAA (Tony Reale) presented "Enterprise Comparison of Atmospheric Profiles Derived Polar Satellite and GNSS Constellations ". The presentation described the features of the NOAA Products Validation System (NPROVS). NPROVS routinely compiles daily datasets of collocated radiosonde, dropsonde, numerical weather prediction (NWP) and satellite sounding product observations. These datasets are sub-divided for Conventional and Special radiosonde observations. These collocations are primarily used to monitor satellite derived soundings from multiple product suites and support of scientific algorithm development. NPROVS supported satellites, sensors, and products relevant to this comparison include: S-NPP and NOAA-20: CrIS/ATMS NUCAPS/HEAP from NOAA MetOp-B/C: IASI/AMSU NUCAPS/HEAP from NOAA; IASI Level 2 from EUMETSAT Aqua: AIRS Level 2 from NASA • Results comparing NOAA (NUCAPS), EUMETSAT IASI L2, and NOAA (MiRS) MW-only soundings from MetOp-B were provided; mismatch among these data are minimal lending high confidence. • Results comparing GNSS COSMIC-2 versus GRAS retrievals were provided; mismatch among these data is larger (than for polar satellites) lending moderate confidence. • Overall, enterprise assessment differences among polar satellites appear larger (despite smaller mismatch) than for GNSS.	

			NPROVS data, results, and documentation are available at https://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/	
4.3.4	Through the International Cloud Working Group, collaborate with SCOPE-Nowcasting to explore the use of agency cloud products in Nowcasting applications;	ICWG	Link between ICWG and SCOPE-Nowcasting has now been established, through the SCOPE-NWC lead Mike Pavolonis/NOAA	
4.4	**Maintain, enhance and improve the methods to describe the error characteristics of satellite data and products.**			

4.4.1	Establish a common vocabulary and methodology with appropriate error propagation to include the errors associated with validation data (e.g. radiosonde temperature, water vapour, precipitation and winds).	ITWG	From the ITWG International Issues and Future Systems Working Group, the last action on this topic was for Christoforos Tsamalis (Met Office) to provide input to Mikael Rattenborg. This was completed and reported at ITSC-22. No updates are available following ITSC-23. From the ITWG Climate Working Group, this topic was discussed at ITSC-23 in the context of allowing users to better understand and trace uncertainties when interpreting long time series (e.g., ECVs). It was noted that when reporting climate trends, the climate community addresses statistical uncertainties in trends associated with the lengths of observations and magnitudes of variability in time series. On the other hand, the satellite CDR community addresses calibration uncertainty, or stability, of time series in trend detection. This led to a new recommendation from the Climate Working Group as shown below. Recommendation Climate-11 to satellite data product developers: Report statistical uncertainties of the CDR trends together with the calibration uncertainties	

4.4.2	Agree on standardized procedures to derive NedT estimates for microwave sounders, and include such estimates in the disseminated BUFR data.	ITWG	At ITSC-23 the ITWG International Issues and Future Systems working group noted that a recent paper by Yang and Yang is currently under review, and this includes comparisons of different NedT algorithms (Yang and Yang, 2021, "A New Algorithm for Determining the Noise Equivalent Delta Temperature of In-orbit Microwave Radiometers", IEEE Transaction on Geoscience and Remote Sensing). The group reiterated that websites with timeseries of instrument performance indicators such as the NOAA/NESDIS ICVS (Integrated Calibration/Validation System) monitoring are an invaluable resource for data users, including for NWP and reanalysis applications. The group would greatly appreciate such monitoring to be available from other space agencies.	
4.5	**Strengthen interaction with users in selected thematic areas by establishing a close relation with them as beta-testers and foster optimum use of satellite data.**			

4.5.1	Report on the progress within the Nowcasting community toward the use of hyperspectral sounders and work toward common products to serve the requirements of the global community.	WG II	The value of hyperspectral infrared has been discussed at the EUMETSAT Nowcasting Workshop in 2017 follow up with a report that was prepared in 2018 and update in 2019 by Hazardous Weather Testbed group. In addition, FY-4A/GIIRS has been launched and data is now available routinely and with sufficient quality to explore the value of the data in Nowcasting. At the joint WG II/III session OSSEs for Assessment of Hyperspectral Infrared Measurements from Geostationary Orbit was presented by NOAA. In addition, EUMETSAT has been using polar orbiting data to demonstrate the potential value of hyperspectral IR from GEO. Further discussions are anticipated at the special HSIR session at CGMS-48 Plenary	
4.5.2	Enhance the use of satellite precipitation datasets through an IPWG-led user workshop where training on visualization and analysis tools will be one of the topics.	IPWG	A telecon was held early December 2021 with the VLab in order to organize a joined session on training during the next IPWG meeting in June 2022 in Fort Collins, CO. During this telecon, the objectives of this future session have been identified. In the next months, a more precise agenda for this session will be defined with the VLab	
4.5.3	Foster the coordinated development of novel products and applications of the new generation of geostationary imagers, initially for the areas of fire, aerosols and flood-mapping.	WG-II	Collaboration on flood mapping is progressing well between NOAA and CMA. In addition the flood mapping was discussed at CGMS-48 WG-II meeting establishing links with CEOS and the WMO Flood Forecasting Initiative. Roshydromet also presented promising high resolution flood mapp0ing results that could be used as independent validation. Hence, in summary flood mapping is progressing well. Limited progress and collaboration was presented in other areas.	

4.5.4	Provide support to users in the WMO Application Areas, including for agricultural, hydrology, marine/ocean and other applications and, where appropriate, identify and follow-up on opportunities by other entities (e.g. CEOS led activities).	WG-II		
4.6	**Foster and support research regarding enhanced radiative transfer capabilities, recognising the paramount importance of radiative transfer developments for satellite products**			

4.6.1	Continue support for line-by-line (LBL) reference model development and enhanced characterization of spectroscopy to ensure that product development teams and users of level 1 data have access to the latest updates in LBL forward modelling and the uncertainties involved.	ITWG	Following ITSC-23 the ITWG Radiative Transfer and Surface Modeling Working Group provided the following information about specific requests for support. **LBL modeling** 1. Continuous support for line-by-line modeling should be guaranteed. The community needs the development of competing line-by-line codes. There are concerns that line- by-line models are not flexible enough to accommodate the use of line parameters from alternative databases. For instance, LBLRTM uses line mixing coefficients that are not compatible with the GEISA line parameters because the LBLRTM line mixing coefficients are based on HITRAN line data. 2. Although the semi-empirical MTK_CKD model is perhaps adequate for many applications, there is still the need for a physically based representation of the water vapour continuum absorption which should eventually be implemented in state-of-the-art LBL models. 3. Further research is needed into the modeling of line mixing processes for CO2, CH4, N2O and to a lesser extent water vapor. This is especially true for the 4μm absorption band of CO2. 4. The effects of pressure and Doppler line broadening should be modelled using a better representation of the line shape than the Voigt profile. Proposed replacements to the Voigt profile will require different broadening coefficients for all the molecules and consequently the need for significant updates to LBL models.	

			5. To allow the exploitation of spectral regions affected by non-LTE effects, it is important that these effects are accurately represented in LBL codes. In parallel, efficient representations of non-LTE effects should also be sought for implementation in fast RT models. **Spectroscopy** 1. A strong emphasis should put on the continuous support of theoretical and laboratory spectroscopic studies. It is crucial that a compilation of basic line parameters is maintained. 2. It should be assessed if there is a requirement to introduce more molecular species, including isotopes, and understand what accuracies are required. 3. It should be assessed if there is any requirement regarding the precision of the spectroscopic parameters 4. Using the synergy between the IR and the UV/Vis some inconsistencies have been observed in the retrieval of ozone profiles which could attributed to an inconsistency of the precision of the spectroscopic parameters between the 2 spectral ranges. Inconsistency problems have also been observed for SO2. 5. Promote research into spectroscopy of higher frequency microwave channels up to 664GHz. 6. Line shapes of water vapor broadening for trace gases need improvement. 7. Regarding the database of cross sections, in general, we have access to the absorption coefficients for a set of pressure and temperature. The experience gained with IASI suggests that we should address the following points:	

			a) The number of temperature and pressure values available in databases may not be sufficient to ensure that the error made when interpolating to the actual temperature and pressure is smaller than the noise of the instrument. b) Even if the spectral variation is low, cross section measurement have not been done using the best spectral resolution (especially in the center of the absorption band). • Some measurements have been done with an instrumental noise which was too high resulting in negative absorption coefficients. **Spectroscopic databases** The present status of the atmospheric databases is the result of numerous studies performed during the last 20 years in several dedicated spectroscopic laboratories all over the world. International cooperation contributed to the establishment of a number of spectroscopic databases for atmospheric applications. These include: • GEISA under the responsibility of N. Jacquinet-Husson and R. Armante from LMD, Palaiseau, France. The last update has been done in 2011 (Jacquinet-Husson, N. and others, 2011), the next one is planned for the end of 2015. • HITRAN under the responsibility of Phillips Laboratory, Cambridge, USA (Rothman et al., 2013). • MIPAS specifically dedicated to satellite experiments in the Earth's atmosphere (Flaud, 2003). • BEAMCAT, for millimeter and sub-millimeter wave propagation in the Earth's atmosphere (Feist, 2004).	

			• JPL Catalog (Pickett et al., 1998) of microwave to sub-millimeter transitions. It mostly contains rotational transitions of a few hundred molecules which can be potentially observed in the Earth's atmosphere or in the atmosphere of other planets. It also features molecules present in the Inter Stellar Medium (ISM) or in Circum Stellar Envelopes (CSE) of late type stars. It comprises a small, but increasing, number of entries for infrared transitions. • CDMS Catalog (Müller et al., 2001, 2005). Like the JPL catalogue, it mostly contains rotational transitions of molecules important for the ISM or CSEs. Some of the molecules are of course also relevant for application in Earth's atmosphere or in the atmosphere of other planets and a number of entries are for infrared transitions of such molecules. Of all the databases listed above, GEISA and HITRAN are of primary importance for data assimilation. Finally, the VAMDC consortium (http://www.vamdc.eu/) aims at being an interoperable e- infrastructure that provides the international research community with access to a broad range of atomic and molecular data. .	

4.6.2	Perform validation and intercomparison of LBL models/spectroscopy to assess the impact of spectroscopic uncertainties and the differences between line-by-line and fast radiative transfer models.	ITWG	At ITSC-23 a presentation was given by Thibault Delahaye (Laboratoire de Météorologie Dynamique/IPSL) et al. titled "*CO2 spectroscopy in 4A/OP: new developments and applications to satellite missions*". This presentation described the development and validation of a new CO2 full line-mixing algorithm and software package. This is required by missions including IASI in order to retrieve CO2 concentration by inversion of infrared spectra using radiative transfer-based algorithms. This method fundamentally relies on the precision of CO2 molecular spectroscopy knowledge. The authors presented the status of the CO2 spectroscopy and its implementation and validation in the radiative transfer software 4A/OP.	

4.6.3	Through coordination between IPWG, ITWG and ICWG, continue to improve microwave radiative transfer models to include complex surfaces (e.g., snow, desert, etc.) and scattering atmospheres (e.g., frozen hydrometeors) to support improved algorithm development for current and future sensors.	WG II	This is always an ongoing topic and challenge but we are pleased to report some headway in 2019-2020. IPWG was able to identify "champions" to represent the precipitation community within ICWG and ITWG because of mutual interests in the focus topics such as radiative transfer and land surface modelling. For the next two years, we expect that Dr. Benjamin Johnson (NOAA/Joint Center for Satellite Data Assimilation) will provide IPWG linkage to ICWG. Dr. Philippe Chambon, IPWG co-chair participates at ITWG. A common forum of discussion between IPWG and ITWG on scattering atmospheres and radiative transfer was held at ECMWF in February 2020 (4th workshop on assimilating satellite cloud and precipitation observations for NWP). In the program of IPWG10, Dr Alan Geer was supposed to present the outcomes of this workshop to the IPWG community to improve the coordination on observation operators, but this will now occur in 2021. The ISWG's need a dedicated financial commitment from CGMS to allow the co-chairs to attend the meetings of IPWG, ICWG and ITWG. The current budgets are very minimal and as used to support participation by 1 or 2 people at the individual ISGW meetings in order to bolster a broader participation. We request that a formal commitment be made by CGMS for co-chair participation at upcoming ISWG's.	
4.7	**Stimulate trade-off analyses for the development of future passive sounding instruments**			

4.7.1	Conduct studies to investigate the technical feasibility to reduce the field of view sizes for future microwave sounders to keep in line with the spatial resolution expected for future global NWP models.	WG II	For EPS-SG, EUMETSAT has concluded that no major improvements for MWS can be anticipated (over current microwave state-of-the-art sounders) within known technical limitations. For the foreseeable future, no significant improvements are expected for the CGMS baseline." However, it should also be noted, that for ongoing considerations of microwave constellations and miniaturisation of microwave instruments, the continued trade-off studies are essential.	

5	**ADVANCING THE ARCHITECTURE FOR CLIMATE MONITORING FROM SPACE (THROUGH THE JOINT CEOS-CGMS WORKING GROUP ON CLIMATE)**	**Joint CEOS-CGMS Working Group Climate (WG Climate)**		
5.1	Update ECV Inventory of Climate Data Records, Gap Analysis and Coordinated Action Plan (CAP) of CEOS and CGMS and report on status of the implementation of the CAP (This target is cyclic and all three parts are covered every year including endorsement by CEOS and CGMS);		Updates of the ECV Inventory will be done annually, the next version 3.0 was closed off on 28 February 2019. Generic parts of gap analysis will be repeated every year to monitor progress, specific ECV analysis will be for selected ECVs each year. Selection depends on existing known gaps and topics of specific interest for CGMS and CEOS agencies. Due to pandemic situation in 2020 and 2021 the gap analysis on the ECV Inventory version 3.0 had been delayed but will be finalized with the CEOS SIT Technical Workshop in Q3/2021. In parallel the upcoming version 4.0 of the ECV Inventory will be closed off during summer 2021,	

5.2	Report to and interact with the UNFCCC Subsidiary Body for Scientific and Technological Advice – Research and Systematic Observation (SBSTA-RSO) to foster usage of satellite data in the context of the Paris Agreement, in particular results from the operational GHG monitoring system. (This target is also part of the cyclic regular annual reporting);			
5.3	Respond to the GCOS IP after new versions of it issued by GCOS (every 5 years). Provide support to GCOS for the GCOS status report (1 year ahead of the new GCOS IP);		JWGClimate plans to update GCOS on status of space agency activities in 2022 in time for the next GCOS adequacy report.	
5.4	JWGClimate Task Team on GHG monitoring to coordinate the specific CGMS contributions to the operational GHG constellation, covering activities on mission coordination, inter-calibration, product prototyping, data distribution, exchange, formatting, and on training and outreach;		CGMS WG PoC had been identified in spring 2021 in order to coordinate with CEOS and CGMS bodies within the WGClimate Task Team. Tasks will be identified during a targeted Task team meeting. Note that the task team had been expanded by additional members from the in-situ community.	

5.5	Foster the implementation of the architecture for climate monitoring from space by strengthening the analysis of use cases for climate data records to increase usage in climate services and science.		WGClimate #10 meeting has agreed a way forward for further case studies. WMO Space Programme has indicated to lead this activities togehter with NASA and specific proposals had been discussed at WGClimate #11, 4-6 September 2019, Anchorage, Alaska, USA. In summer 2020 a call for proposal had been published. Until now, 7 use cases had been collected. Currently, further measures are under implementation to encourage agencies and their climate communities to submit use cases. Resolution 6.1(5)/1 (Cg-18) „Implementation of the Architecture for Climate Monitoring from Space", which has been drafted with the input of WGClimate, will be considered by WMO Members at the 18th World Meteorological Congress in June 2019. The resolution describes the progress with implementation of the Architecture for Climate Monitoring from Space	
5.6	JWGClimate to publish updated definitions for the Fundamental, Thematic, and Interim Climate Data Record.			

6	ADVANCE OPERATIONAL SPACE WEATHER MONITORING FROM SPACE	SWCG		
6.1	Coordinate CGMS activities and align priorities with the space weather user community, in particular the ICAO Space Weather Centres, ISES, WMO ET-SWx and the UNCOPUOS STSC		Several ICAO SWC members are participating in SWCG and are also members of ISES. ISES is invited to give presentation at SWCG. UNCOPUS STSC ET on SW successfully concluded its activities, and a (non-consensus) recommendation was for WMO, ISES and COSPAR to initiate an activity to improve coordination. WMO Expert Team is currently being established.	
6.2	Investigate feasibility of a consistent inter-calibration for energetic particle measurements using instruments with adequate in-orbit calibration and vicarious methods, using GSICS methodology as reference.		The task group on inter-calibration of high energy particle sensor had several teleconferences, and set up a campaign period for data exchanging, and did inter-calibration by each members. The group also wrote a draft of white paper about high energy particle observation and its inter-calibration to get feedback from GSICS EP members. GSICS EP will consider a SW subgroup at its upcoming meeting 10-12 may. Target should be revised based on the outcome of this discussion.	
6.3	Advance the integration of Space Weather coordination activities into the relevant CGMS working groups;		The integration of Space Weather activities in relevant CGMS WGs is progressing well. SWCG rapporteurs participate in relevant Intersessional activities to ensure coordination: Joint session with WG-I and -IV, GSICS discussions, participation in annual CGMS Risk Assessment workshop.	

6.4	In coordination with IROWG establish requirements for and recommend an implementation of an optimised system for radio occultation observations for ionosphere monitoring.		Progress is being made in the development of advanced methods to reduce residual effects of the ionosphere on atmospheric retrievals and an increasing number of receivers are able to collect ionospheric data, for example, the extension of GRAS RO profiles into the ionosphere under testhas been implemented for on Metop first generation satellites, soon later to be complemented by Metop second generation ionospheric RO data. End-user utilization of ionospheric RO is increasing, with COSMIC-2 ionospheric data starting to be integrated into SWPC models. Furthermore, efforts are now on-going under SWCG leadership to reduce end-to-end data and product median latencies to at or below 30 minutes with a plan of action identified in CGMS-48-EUMETSAT-WP-06. Meeting with IROWG planned for 6 May 2022	

7	**OUTREACH AND TRAINING**			
7.1	**Engage in communication and outreach activities to promote EO and Space Weather observations benefits.**	**Plenary**		
7.2	**Training**	**Plenary /VLab**		
7.2.1	Continue to foster optimum use of satellite data for weather forecasting, climate applications, and environmental assessments including hazardous events such as volcanic ash and flooding;			

7.2.2	Update and develop new training material where necessary, and in collaboration with partner organisations such as Collaboration among Education and Training Programmes (COMET), Committee on Space Research (COSPAR), the CEOS Working Group on Capacity Building and Data Democracy (WGCapD) and the CEOS-CGMS Joint Working Group on Climate; disseminating such material through the WMO-CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (VLab);		Significant progress in the training material provided by the VLAB.	
7.2.3	Provide shared, regular support to funding the VLab Technical Support Officer function through the WMO VLab Trust Fund, and to the VLab Centres of Excellence as per agreed expectations.		Funding is still secured for the TSO only on an ad-hoc, non-sustained basis. WMO still seeking additional voluntary contributions from CGSM members:	

7.3	**User Conferences** Conduct regional satellite users conferences to (i) share experience and foster the exchange of ideas; (ii) promote better access, and improve the utilisation of, existing satellite data and products; (iii) prepare the user community on new satellite systems' data products and services; (iv) engage with the user community on the application of new Climate Data Records, supported by the CEOS-CGMS Joint Working Group on Climate; (v) gain user feedback on data, product and system real-world application; (vi) engage young people entering the field; (vii) other items as appropriate.	**Plenary**	Series of Asia-Oceanic conferences and NOAA satellite users' conferences are continuing. In spite of COVID-19, the 11th Asia-Oceanic Conference was held in Beijing Oct 2021 as a hybrid event and conducted a series of virtual Community Meetings in Oct 2020.	