CGMS-51-CGMS-WP-07
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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 (2022-2026)

This working paper provides the status of implementation of CGMS High Level Priority Plan (2022-2026). 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 2022-2026.

This document presents the status of implementation of the CGMS High-Level Priority Plan (2022-2026), as agreed by CGMS at its 50th Plenary Session 15-17 June 2023 at WMO, Geneva. The document is submitted to review on the occasion of the CGMS-51 working group meetings 24-28 April 2023 at EUMETSAT, Darmstadt, Germany.

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 2023 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. As of 2023 there is 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 status of 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 continuity of Precipitation Radar measurements;		2023 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.	
1.1.3	Ensure continuity of Scatterometer measurements		2023 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
1.1.4	Ensure continuity of Radio Occultation Measurements with required quantity, geographical coverage and temporal sampling for numerical weather prediction and for ionospheric monitoring		2023 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 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.	
1.1.5	Ensure continuity of Coronagraph and Plasma Analyser observations through exploitation of scientific space weather missions for operational gap filling		Increasing risk of a gap in the early part of the decade and long term continuity at L1. Increasing risk of a gap until GOES-U and SWFO-L1 are launched as SOHO operating well past design life, but additional ground resources used to track STEREO-A may mitigate that risk in the event of SOHO loss before 2024. **SWCG suggests to include L1 magnetometry**	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.2	Advance the response to the WIGOS 2040 vision for space, by the implementation of new capabilities beyond the CGMS baseline		CGMS reviews its response to the WIGOS vision annually, based on the WMO Gap Analysis.	

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;		It is now confirmed that GEO-XO and Himawari-8/9 follow-on will be manifesting Hyperspectral IR sounders **Propose to replace “IR” by “Hyperspectral IR”**	

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		ESA to confirm CIMR mission under Copernicus	

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1.2.7	Establish observational requirements for microwave observations (sounder and imager) for NWP and precipitation and perform gap analysis against CGMS baseline;	WG-III,-II, IPWG, ITWG	Actions should be placed on IPWG and ITWG **IPWG proposes to add: "For precipitation, develop a benchmark to conduct comprehensive assessments of current and future scenarios for the CGMS baseline"**	
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-51 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	
1.2.11	Work towards operational infrared/µwave limb sounding for climate monitoring and NWP applications		**To be discussed whether this should continue to refer to both IR and µwave**	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.2.12	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	
1.2.13	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.	
1.2.14	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.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
1.2.15	Work towards auroral monitoring capabilities			
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**			

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
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.	
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.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
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)		The SWOT analysis has been completed. Further work building on the SWOT analysis is ongoing. **Reword target to: Build on the work of the SWOT analysis on the DCS from Geostationary Meteorological satellites, and particularly progress on the five proposals for further work (covering RFI Mitigation incl creation of an RFI DCS register), joint DCS PR materials, DCS introduction video, manufacturer workshop, discoverable information).**	
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.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
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. Progress has been made on the definition of an Enhanced DCP standard. A manufacturers workshop was held at the Satcom Form in 2022. Further intersessional meetings with manufacturers have taken place. A draft EDCP standard has been produced. There are still refinements needed but the main elements have been defined. Additional sessions will be needed to finalise the EDCP standard. Status is considered to be "yellow" as the topic to be further developed through dedicated working team and focused Inter-Sessional activities.	
2.2	**Radio Frequency (RF) Protection**	**WG-I**		

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
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);		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.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
	- Protection of the band 1695-1710 MHz (used for LEO broadcast to user stations) from planned new frequency usage by commercial 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	Within 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.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
NEW	**Proposed new target:** Pursue the establishment of a set of best practices for the RFI detection, monitoring, and mapping based on the common aspects of the approaches already adopted by CGMS members.			
2.3	**Data acquisition and Data Processing, (Low Latency Data Access / Satellite Data and Codes)**		Reworded to align with WG-I organization.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
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.	WG-I	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.	

Ref	**Target**	**Primary responsible for target in CGMS**	**Summary/highlights of progress as reported for CGMS-49**	**Overall Status**
2.3.2	Facilitate the transition to new LEO direct readout systems (JPSS, FY-3, Meteor-M, Metop-SG);	WG-I	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. **Propose to reword:** To address technical and operational aspects of direct broadcast services (present and future) of mutual or global interest for the CGMS agencies, including facilitating transition to new LEO direct broadcast systems.	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
NEW	**Proposed new target:** Explore improvements to LEO satellite systems low latency data access from both a global and regional perspective, harnessing common emerging technologies and taking account of the evolution of the commercial and agency space systems.	WG-I		

Ref	**Target**	**Primary responsible for target in CGMS**	**Summary/highlights of progress as reported for CGMS-49**	**Overall Status**
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-51 WGI meeting. The Task Group on DB Systems and Coordination of LEO orbits have worked together on a SWOT analysis for low latency data access. This will be presented to CGMS-52 WGI, along with a proposal to merge the two groups and their best practices into a single "Low Latency Data Access Task Group	

Ref	Target	Primary responsible for target in CGMS	Summary/highlights of progress as reported for CGMS-49	Overall Status
2.3.4	Establish Best Practices for the Coordination of Data Acquisition for Low Earth Orbit Satellite Systems and report on implementation	WG-I	**Propose to replace 2.3.3 and 2.3.4:** Merge the LEO (Global) and DB (regional) best practices into a single "Low Latency Best Practices" containing common best practices for both regional and global missions, as well as specific best practices for direct broadcast and global missions.	
2.3.5	Provide coordinated CGMS inputs to WMO on satellite and instrument identifiers for data representation and metadata within the WIS	WG-I	The Group continues to encourage WMO to ensure that OSCAR/Space includes references to the Common Code Table entries used for satellite identifiers (table C-5) and instruments (C-8). At the last OSCAR/Space workshop it was confirmed that these changes would be included in the forthcoming update to OSCAR/Space. Between CGMS 51 and CGMS 52, the Task Group will continue work on implementation of WIGOS station identifiers for satellite platforms, and providing subject matter expertise to WMO Expert Teams.	

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2.3.6	Develop efficient standardized data handling for high-resolution imaging and hyperspectral instruments	WG-I	The Task Group has worked with the WMO Secretariat and the WMO Expert Team on Data Standards (ET-Data) and its Task Team on Table Driven Code Forms (TTTDCF) on the development of a number of new BUFR encoding sequences and Common Code Table entries. In each case, the Task Group acts as a reference group of experts who are invited to consider and endorse relevant proposals going through WMO's approval process. Between CGMS 51 and CGMS 52, the Task Group will continue work on coordinating format standardisation for satellite data.	
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.	
2.5	**Space Debris and Collision Avoidance**			
2.5.1	Establish Best Practices on Collision Avoidance and Debris Mitigation and report on implementation	WG-I		

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.	

3.1.1	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. WMO has discussed the maintenance of the SATURN portal and will report to WG-I	

3.2.3	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			
3.2.4	Improve the provision to users of characterisation data (incl apodization) for geostationary and low Earth orbit hyperspectral infrared instruments			
3.2.5	Develop Best Practices for Operational User Notifications			
3.3	**Coordinated global data exchange**			

3.3.1	Develop Best Practices for Global Data Exchange			
3.3.2	Explore options for optimal data exchange of advanced data from new generation GEOs, in consultation with the global NWP centres through GODEX-NWP			
3.3.3	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-51 WG-IV meeting	
3.4	**Coordination with WMO Information Systems (WIS) and WIGOS**			

3.4.1	Ensure the WIS 2.0 usage 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. To be addressed by TG on Data Access/Exchange	
3.4.2	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			

3.4.3	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.	
3.5	**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.	

3.6	**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.	
3.7	**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. 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.	

3.7.1	Ensure the timely access to and exchange of near-real-time scatterometer data, share access to calibration and validation information across CGMS agencies			
3.7.2	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.			

3.8	**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. **GSICS to provide update**	

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	**GSICS to provide update**	
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. **GSICS to provide update**	

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	**GSICS to provide update**	
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	**GSICS to provide update**	
4.1.6	Establish mechanisms for cross-calibrating scatterometers across the constellation.	GSICS	**GSICS to provide update**	

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)	

<table>
<tr>
<td>4.2.2</td>
<td>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;</td>
<td>IWWG</td>
<td>Mary Forsythe (Met Office) created and distributed a document to the IWWG NWP community for comment on HLPP 4.2.2. Their recommendations are shown in the tables below. There is not enough information to make firm recommendations in all cases, but they have highlighted some ideas for further study. With this in mind, we propose to keep this as a living document and periodically update it based on the latest scientific information received and discussed at each IWW. A longer discussion of this HLPP will occur at IWW16 during the breakout sessions. IWW16 will address these tables and work towards a set of tests that can be performed for global, regional and nowcasting purposes.

Global NWP

<table>
<tr><td>Timeliness</td><td>Important as data later in the window has the most impact.</td></tr>
<tr><td>Target size and image interval</td><td>Best to generate AMVs with target size and interval which is optimal for the best AMV product. NWP centres can superob data, if necessary, to the resolution which is optimal for NWP. Based on recent studies this might be ~ 16x16 pixels with ~10 min interval (where available).</td></tr>
<tr><td>Grid size</td><td>Should avoid overlapping targets (to reduce correlated error). There is an open question as to whether NWP centres might benefit from maximising density after allowing for this constraint as it gives flexibility to use data at higher density in regions of interest and the potential to reduce random error through superobbing. However, there is a cost/benefit trade-off: the cost of production/storage/processing of increased volumes versus the currently unknown benefit to NWP.</td></tr>
<tr><td>Temporal frequency</td><td>Many centres assimilate data hourly in NWP so this seems like a sensible target, however, increased frequency can help to fill the spatial gaps. It may be useful to have the data every half hour, perhaps even more often. However, note caveats re cost/benefit trade-off above. May benefit from enhanced spatial/temporal products for critical events such as storms.</td></tr>
<tr><td>Derivation settings</td><td>Are there any other changes that could help to improve the spatial coverage without impacting too much the quality of the winds? Novel optical flow retrieval is potentially one option.</td></tr>
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Derivation information	Access to information from the derivation that might have skill for NWP quality control. This might include information on the correlation surface (for confidence in tracking) as well as information from the cloud analysis and height assignment steps. Request made for standardised cloud type to be made available.

Regional NWP

Timeliness	**Critical**. Some regional models cannot use data older than 50 min
Target size and image interval	Likely want a higher resolution product than for global, but not clear what will be optimal. **Might be worth trying 16x16 and smaller targets** with both **10 min and 5 min intervals** (where available). May need approaches to reduce noise (averaging correlation surfaces, clustering, filtering). Produce AMVs from high resolution channels (0.5 km, 1 km).
Grid size	Ideally set grid size to avoid overlapping targets, but otherwise the more the better. TBC if density is sufficient without overlapping targets – NWC SAF / HRW could be used to explore. May want to relax this criterion.
Temporal frequency	Probably want winds produced every **10/15 min** – should help to improve the spatial coverage even if we thin or superob to one per hour due to correlated error. May benefit from enhanced spatial/temporal products for critical events such as storms. May be useful for NWP and forecasters.
Derivation settings	Are there any other changes that could help to improve the spatial coverage without impacting too much on the quality of the winds?
Derivation information	Access to information from the derivation that might have some skill for NWP quality control. This might include information on the correlation surface (for confidence in tracking) as well as information from the cloud analysis and height assignment steps. Request made for standardised cloud type to be made available. Improving the errors is likely to be particularly important for initialising the smaller scale flow.
NWP usage	A particular challenge is how to benefit from the high-resolution information without hitting the system too hard due to correlated errors. We may want to consider back-and-forth nudging as well as variational approaches in NWP.

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. Feng Lu (CMA) will update the community at the IWW16 on the status of 3D AMVs from the Geostationary Interferometric Infrared Sounder-2 (GIIRS-2) on FY-4B. EUMETSAT's 3D IASI AMV processor is fully developed. Production of a demonstration dataset is ongoing. Three months of data (Jan-Mar 2023) covering both North and South high latitude regions (poleward +/- 45 degrees) can be made available to the user community upon request. While not a GEO application, CIMSS, University of Wisconsin - Madison has a new funding start that will demonstrate the feasibility of tracking features in global profile of retrievals of humidity and ozone derived from AIRS and CrIS radiances on Aqua, NOAA-20, and NOAA-21 (and possible SNPP). Retrieval products will be generated using the Dual Regression (DR) method that derives atmospheric profiles, surface parameters, and cloud properties simultaneously under clear and cloudy conditions from any of the current hyperspectral infrared (IR) sounders at single field-of-view (SFOV) resolution. With three CrIS and one AIRS instrument flying in the afternoon orbit, time sequences of these global humidity and ozone profile fields enable feature tracking to determine atmospheric motion vectors (AMVs). Tracking features in retrieval fields rather than in the radiance images enables estimation of wind profiles at retrieval determined heights. This approach has been demonstrated from the successive AIRS overpasses in polar regions, but now can be tested globally.	

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." Action on WMO. **WG-II to comment**	
4.2.5	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 Geostationary ring;	ICWG	**ICWG to comment**	

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. **ITWG to comment**	
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. **IPWG proposes to reword: "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. The IPWG website is currently being transitioned, and will be updated to reflect the status of previous, current and newly added operating validation regions."**	
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. WMO to check status **WG-II to comment**	

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/ **ITWG to comment**	

4.3.4	Coordinate and improve the use of cloud properties in the high impact applications, in particular Atmospheric Motion Vectors and All-Sky Radiance Products .	ICWG	Link between ICWG and SCOPE-Nowcasting has now been established, through the SCOPE-NWC lead Mike Pavolonis/NOAA **ICWG to comment**	
4.3.5	Support the continued analysis and growth of the cloud climatology assessment data archive initiated by GEWEX and the coordinate the development and assessment of cloud climate products for the next generation of the International Cloud Climatology Project (ISCCP-NG)	ICWG	**ICWG to comment**	
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 **ITWG to comment**	

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. **ITWG to comment**	
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. Report from NOAA will be provided at WG-II. EUMETSAT relevant reports at https://www.eumetsat.int/severe-storm-forecasting-lab **WG-II to comment**	
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 session on “Training and outreach on satellite-based products to monitor weather, climate, and extreme events” was successfully coordinated at CSU/CIRA in Fort Collins, CO US in June 2022 during the IPWG-10 workshop. In addition, IPWG members have actively participated in the online Satellite Precipitation Applications Workshops co-organized with the GPM application group, and with the GPM Mentorship Program. Further discussion will take place during 2023 regarding possible training events to be coordinated with the IPWG-11 workshop.	

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 mapping 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. Fires covered by GOFC-GOLD **WG-II to comment**	
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	**WG-II to comment**	

4.6	**Foster and support research regarding enhanced radiative transfer capabilities, recognising the paramount importance of radiative transfer developments for satellite products**			

<table>
<tr>
<td>4.6.1</td>
<td>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.</td>
<td>ITWG</td>
<td>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</td>
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			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. **ITWG to comment**	

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. **ITWG to comment**	

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. **ITWG and IPWG to comment**	
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. EUM to check with Christophe Accadia on studies for EPS-Sterna Discussions foreseen at WG-II on Hyperspectral µwave **WG-II to comment**	
4.7.2	Conduct trade-off studies regarding the benefits of spectral, radiometric, and spatial resolution of infrared sounders, taking into account aspects such as scene inhomogeneity and uncertainties in spectroscopy		NOAA to check whether GEO-XO trade-off studies can be shared **WG-II to comment**	

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 (one year prior to 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	Establish a consistent inter-calibration framework in GSICS for energetic particle measurements using instruments with adequate in-orbit calibration and vicarious methods;		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	

6.5	Ensure the timely access to and global exchange of space weather data of CGMS Members, including instruments hosted on third-party satellites			

6.6	Document current data formats for space weather observations			

6.7	Investigate impact on future SW observations due to increased demand on SW services by Space Situational Awareness and Space Traffic Coordination			

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.	