



GCOS STEERING COMMITTEE

THIRTIETH SESSION

GCOS SC-30, 7–8 December 2022

Virtual Session

GCOS Workplan 2023

1. Overview of GCOS Activities in 2023

A detailed workplan and allocation of responsibilities is given in Table 3

The main activities of GCOS in 2023 are:

1. Address the GCOS IP actions, that have GCOS as an implementer and are detailed in Table 2;
2. Update OSCAR/RRR with the ECV requirements from IP and the ECV fact sheets;
3. ECV Rationalization;
4. Support task team on Adaptation;
5. Support task team on the Earth's cycles;
6. Organize Joint Panel Meeting 2023 (26-30 June);
 - a. Theme 1 – Rationalization;
 - b. Theme 2 – Earth Cycles (TBD);
 - c. Theme 3 – Cross-panel actions in GCOS IP (TBD based on Table 2);
7. Support to GCOS panels and GCOS SC, preparation of meetings and reporting;
8. Support to WMO and participation in relevant Standing Committees and Expert Teams on behalf of GCOS;
9. Support task team on the implementation of the GSRN.

Additional activities include:

- Respond to relevant recommendations to the JSG-GCOS

Other tasks can be grouped in the following:

- Communications
- Liaise with Partners
- Administrative tasks
- Preparation and presentation of input at the meetings of WMO and IOC Governing bodies

In addition, there are specific tasks of the panels, including addressing the IP actions relative to each panel and panel task teams. These tasks will not be included here but will be the responsibility of the GCOS Sec and the panels.

Table 1. Main activities of the GCOS Secretariat

2023	GCOS IP	Update of RRR	Update ECV fact sheets	ECV Rationalization	Adaptation	Earth's cycle TT	Task Team on GSRN	GCOS JPM 23	GCOS SC 31	GCOS Meetings	External Meetings (including co-sponsors statutory meetings)								
Jan	Prepare timeline for selected actions	Insert in RRR new GCOS requirements	Discuss changes	Establish and support task team	Case studies finalized		Support Task Team	Meeting with chairs											
Feb	Work on actions		Request input from panel and update fact sheets		Consult with the relevant organisations to determine their needs and expectations										GHG Symposium				
Mar														Meeting with chairs		CBS LC and RWC workshop (Q1 or Q2?)			
Apr																	Tentative: Meeting with GSRN LC		
May														Prepare agenda/meeting		WMO Cg 19 (22/5-0)2/6			
Jun	Check Status of actions	1 st proposal to JPM	Prepare workshop with organization implementing adaptation (Q1 2024)				JPM	JPM (26-30/6)	WMO EC-77 (5-6 June)	IOC General Assembly									
July	Work on actions	Continue work																	
Aug																			
Sep																GSRN Plenary		GSRN (26-27/9)	
Oct																	Prepare agenda and decisions		WCRP Conf
Nov	Summarize progress and prepare follow up for 2024								UNFCCC-COP 28 (6-17/11)	GRUAN (TBD)									
Dec	Present to SC		Present to SC for approval	Present to SC for approval				SC Meeting	SC(TBD)										
2024	Continue			Continue	Continue	Continue	Continue												

2. Work Plan for 2023: Major tasks

2.1 GCOS Implementation Plan

Table 2 lists the actions where GCOS is the implementer. They have been divided in 3 major groupings:

- Actions that will start in 2023 (green):
- Actions that are ongoing and will extend to future years (pink)
- Actions that will not be started before 2024

For each of these actions, the GCOS Secretariat lead(s) have been identified. During January, the GCOS Sec will prepare and propose a timeline for the specific action. In June, progress will be checked within the GCOS Secretariat. At the end of November, the GCOS Secretariat will prepare a short report on progress on actions and a timeline for 2024. This will be presented at the SC.

Table 2. GCOS IP actions where GCOS is the implementer (detailed in section 2.10)

IP Action	Activity	GCOS Sec Lead	Comments	Timeline
Action A1	1. Undertake an assessment of current levels of funding support for global in situ networks delivering relevant in situ ECV data, including cal/val measurements, and identify those in situ networks with immediate or short-term problems around adequacy and sustainability of funding	Caterina, Antonio, Belen, Tim	Each of the GCOS Sec will work on the network in their domain, with the help of panels. (For reporting to the JPM). 1 st step: Develop a proforma (January 2023)	2023
	2. Identify entities that can provide support for the networks identified as at risk in Activity 1.	Caterina, Antonio, Belen, Tim		2024
	3. Advocate with funding agencies to support identified networks	GCOS Director		2025-
Action B1	1. Continue development of GRUAN.	Caterina/Tim		Ongoing
	2. Implement the GSRN.	Caterina/Tim		Ongoing
	4. Develop further the concept of a reference network tier across all earth observation domains.			2024+
Action B2	2. Consideration of alignment of GSN and GUAN with GBON.	Tim	Probably not happening next year	Ongoing
Action B9	Improve estimates of latent and sensible heat fluxes and wind stress	Belen, Caterina, Antonio		Ongoing
Action B10	1. Continue to periodically review observations of the Earth's energy, water, carbon cycles to identify gaps and areas of high uncertainty.		This will probably be a joint activity with WCRP	2023
	2. Review consistency of the underlying observations.			
	3. Develop plans to address the gaps identified in (1), if feasible			
Action C1	1. Review existing monitoring standards, guidance and best practices for each ECV, ensuring these reflect current state-of-the-art. Maintain a repository of this guidance for ECVs.	Antonio, Caterina, Belen, Tim	Each of the GCOS Sec will work on the ECVs in their domain, with the help of panels. Create a proforma	2023: start identifying way forward 2024: start work
	2. Ensure the development of monitoring standards, guidance and best practices, including intercomparison procedures, for			2025

	those ECVs where such guidance does not exist.			
	3. Review and revise the climate monitoring guidance in the WIGOS manual to bring it in line with the updated guidance developed in this Action.			
	4. Review the GCOS climate monitoring principles.	Antonio, Caterina, Belen, Tim	Panels should review this. Collaborate with Dave.	2023: review 2024: update principles
Action D1	1. Draft requirements for the activities of Global Climate Data Centres and identify the relevant internationally agreed standards.	Caterina	Collaborate with Dave, Omar and Peer. (Discuss at JPM?)	2023
	2. Develop any new standards as required.			2024
	3. Implement the agreed-upon requirements at all global data centres.			2025-
	4. Advocate for implementation of the WMO Unified Data Policy to foster a free and unrestricted exchange of available data.	Antonio, Belen, Caterina, Tim, GCOS director		Ongoing
Action D2	1. Identify ECVs for which adequate global centres do not exist or are insufficiently supported and facilitate and support the creation or improvement of global data centres for these ECVs.	Antonio, Belen, Caterina, Tim	Each of the GCOS Sec will work on the ECVs in their domain, with the help of panels	2023-start auditing 2024-
	2. Promote regional data centres, their interoperability, where possible, synchronisation of their data holdings, and the provision of data in their archives to global data centres.	TBD		Ongoing
Action E1	1. Undertake at least one regional GCOS Workshop each year.			2024 or 2025, depending on funding
	2. Report regional needs and issues to the UNFCCC, WMO and other relevant stakeholders.			After workshop
Action E2	1. Encourage the development of national coordination of climate observations (e.g. national GCOS programs). a) Collect annual reports of these programmes; b)-d)	Belen (Svenja)	Start looking at existing Focal Points	a) 2023 b-d: 2024-
	2. Engagement of National GCOS Focal Points: a) Revise terms of reference (ToR) for National GCOS Focal Points b) Increased nomination of National GCOS Focal Points.	Belen	Roles of GCOS FP and GCOS National Coordinators. Investigate and propose SC one role if adequate	a) propose a TOR to SC by end of 2023 b) 2024-
Action E3	Enhance support for national climate observations	GCOS Director, GCOS SC members		Ongoing
Action F1	1. Identify the higher resolution observations of ECVs to support the Climatic Impact-Drivers (CIDs) identified in the IPCC AR6 and develop plans to address the priority needs. (see IPCC WGI AR6 Figure SPM.9).	Svenja		2023: scoping out 2024: start work
Action F4	1. Audit existing GCOS ECVs to identify those that are urban-relevant and produce updated requirements where needed.			2024

	2. Identify new urban-relevant products and define their requirements.			2025
Action F5	4. Improve and coordinate measurements of relevant ECVs at anthropogenic emissions hotspots (large cities, powerplants) to support emission monitoring and the validation of tropospheric measurements by satellites.	Antonio		2023: Start assessment 2024: continue

2.2 ECV Requirements

- Update of the RRR with GCOS Requirements: The GCOS Sec will start including the GCOS IP ECV requirements into OSCAR/RRR. If the variable already exists in the RRR, the process consists in simply updating the existing requirements with the new one. However, if the name is different or the variable is not in OSCAR, approvals from JET-OSDE is required.
- Update of ECV fact sheets: The existing ECV fact sheets need to be updated with new values of the requirements. Many new ECV products have been introduced in the GCOS IP. Update will require consultation with the panel regarding the data sources.

2.3 ECV Rationalization

Following the 29/1 from the SC29 and 29/4, the Steering Committee agreed to work towards presenting the ECV in a rationalized form, with similar ECV Products grouped together under one ECV and tasked the GCOS Secretariat, in consultation with the panel chairs to propose a new grouping of ECVs. The GCOS Secretariat will establish a task team with 1 or 2 members from each panel, with the task to:

- a) Identify the main scope of rationalizing the ECVs;
- b) Define the possible groupings;
- c) ECV Products: check whether ECV products are necessary and which of them are repeated in different domains;
- d) Formalize the process of adding ECVs and ECV products to the existing one;
- e) Present a first proposal for discussion at the JPM and a final proposal for SC-31;
- f) Prepare a follow-up paper to Bojinski et al. 2014 to be published in BAMS.

2.4 Adaptation

This task depends on the decision at the SC-30. It is proposed that the GCOS Secretariat consults with the relevant organizations to determine their needs and expectations and subsequently prepares a workshop with organizations implementing adaptation to be held in Q1 2024.

2.5 Earth's cycles

Work on Earth's cycle will be done in collaboration with WCRP. Details will be added once an initial meeting with experts, to better define GCOS role will take place.

2.6 Joint Panel Meeting 2023

In order to facilitate the cross-cutting work of the panels, a joint panel meeting with the 3 panels will take place on 26-30 June 2023. The meeting will consist in 3 days for the individual panels and 2 days of cross-cutting topics.

2.7 Support to Panels and Steering Committee

In addition to the above the Secretariat will support the panels as needed and also prepare and report on the Steering Committee meeting. Actions and tasks from the SC-30 will be added after the SC-30.

2.8 Support to WMO activities

There are several links to WMO activities that the GCOS Secretariat need to follow, such as:

- Preparation for Congress, where the WMO/NMHS actions will be presented to Members – Side event(?)
- Activities related to JET-OSDE: this includes giving input for the evolution of the RRR that is going to take place
- Tiered networks
- Participation in WMO GHG monitoring infrastructure initiative

2.9 Support of the GCOS Surface Reference Network Task Team

The GCOS Secretariat supports the TT-GSRN. In 2023 this will mainly consist in supporting the establishment of the GSRN Pilot network and progressing/monitoring the establishment of the Lead Center.

Activity	Tasks	Responsibility								Milestone	Notes
		SC Chair	Anthony	Antonio	Caterina	Belén	Tim	Magaly	Intern*		
Adaptation	Organize a series of consultation with stakeholders									August 2023	Specific plan depends on decision at SC-30
Earth's cycle Task Team	Establish task team									February 2023	Specific plan depends on decision at SC-30
	Support task team										
Joint Panel Meeting	Develop agenda in consultation with panel co-chairs	X	X	X	X	X	X			March 2023	
	Arrange logistics			X	X	X		X			
	Celebrate the JPM	X	X	X	X	X	X	X			June 2023
GSRN TT	Continue support to GSRN Task Team				x		x	x		Ongoing	
Support to WMO	INFCOM		x	x	x					Ongoing	
	SC-ON			x	x					Ongoing	
	SERCOM (?)		x							Ongoing	
	GAW				x					Ongoing	
	WMO Hydro and GTN-H			x						Ongoing	
	GCW			x		x				Ongoing	
	SC-MINT						x			Ongoing	
	SC-ON TT on tiered network				x					Ongoing	
Comms	JET-OESDE-RRR				x					Ongoing	
	Web site							x	X	Ongoing	
Liase with Partners	Twitter					x			X	Ongoing	
	GEO		x	x						Ongoing	
	GOOS					x				Ongoing	
	WGClimate		x	x	x	x				Ongoing	
	EUMETSAT		x	x	x					Ongoing	
	ESA		x	x	x					Ongoing	
	Copernicus		x	x	x					Ongoing	
	WCRP		x	x	x	x				Ongoing	
	IPCC	x	x	x	x	x				Ongoing	
	UNFCCC	x	x	x	x	x				Ongoing	
Admin	GCOS National Coordinators (including annual meetings)			x	x	x	x			Ongoing	(Switzerland, Germany, Austria, Ireland and more)
	Fund Raising	x	x							Ongoing	
	Financial Monitoring		x						x	Ongoing	
	Reporting		x						x	Ongoing	
	Admin Support								x	Ongoing	

- Internship finishing on 28 February 2023

2.10 2022 GCOS Implementation Plan Actions as mentioned in Table 2

Action A1: Ensure necessary levels of long-term funding support for in situ networks, from observations to data delivery	
Activities	<ol style="list-style-type: none"> 1. Undertake an assessment of current levels of funding support for global in situ networks delivering relevant in situ ECV data, including cal/val measurements, and identify those in situ networks with immediate or short-term problems around adequacy and sustainability of funding - by end of 2023. 2. Identify entities that can provide support for the networks identified as at risk in Activity 1. 3. Advocate with funding agencies to support identified networks.
Issue/Benefits	<p>Not all in situ networks have the assurance of the long-term support needed to ensure the continuity and development of long-term time-series needed for climate monitoring. Although progress has been made, some networks are still supported by short- and fixed-term funding or have inadequate funding support. This action aims to make progress in addressing this issue by improving the sustainability of in situ measurement programs.</p> <p>Improved funding support for networks performing measurements of ECVs would improve our ability to undertake long-term monitoring of the changing climate system. This informs climate assessments such as IPCC and WMO annual reports. Furthermore, it is essential for climate services, adaptation activities and mitigation efforts. Sustained in situ observations provide critical input to reanalyses and aid satellite cal/val activities, especially as new missions/instruments are launched.</p>
Implementers	From 1 to 3: GCOS , WMO, NMHSs, Research organizations, Academia, Funding agencies
Means of Assessing Progress	<ol style="list-style-type: none"> 1. Initial inventory of the funding profile for identified in situ networks that provide ECVs, considering adequacy and sustainability of funding support. Findings are to be prepared by all GCOS panels and consolidated in the form of a GCOS report by the end of 2023. The report should provide a current health snapshot of financial support for the networks. 2. Regularly reassess and report in future GCOS Status Reports progress towards sustainable funding for those networks designated in the initial report as inadequate or at risk. 3. Number of in situ networks for which funding support as a whole has been improved.
Additional Details	GCOS panels should inventory key current in situ networks and ascertain their levels of support, and barriers to their full implementation, and highlight examples of existing sustainable solutions. NMHSs, research performing organizations and other public and private funders should then take the outcomes of these assessments and attempt to remedy issues raised. A final assessment will then be made at the end of the IP / Status report cycle.
Links with other IP Actions	<p>All ECV need sustained support, but this GCOS IP has identified the following actions:</p> <p>B4: in situ observations of atmospheric composition ECVs.</p> <p>B6 and B7: expansion and integration of the global ocean observing system, including observations of biogeochemical/biological parameters.</p>

Action B1: Development of reference networks (in situ and satellite Fiducial Reference Measurement (FRM) programs)	
Activities	<ol style="list-style-type: none"> 1. Continue development of GRUAN. 2. Implement the GSRN. 3. Better align the satellite FRM program to the reference tier of tiered networks and enhance / expand FRM to fill gaps in satellite cal/val. 4. Develop further the concept of a reference network tier across all earth observation domains. 5. Establish a long-term space-based reference calibration system to enhance the quality and traceability of earth observations. The following measurables are to be considered: high-resolution spectral radiances in the reflected solar (RS) and infrared (IR) wave bands, as well as GNSS radio occultations.
Issue/Benefits	<p>The principal benefits of reference quality networks / measurements are:</p> <ul style="list-style-type: none"> • Well characterised measurement series that are traceable to SI and/or community standards with robustly quantified uncertainties that can be used with confidence. • Improved instrument performance that transfers down to other broader global regional and national networks. • Characterisation of wider networks, especially of measurement quality. • Robust calibration/validation of satellite data. • Improved process understanding and model validation. <p>However:</p> <ul style="list-style-type: none"> • Although GRUAN has been successfully implemented since 2005, it remains far from globally well distributed. • There is no Global Surface Reference Network, as yet. • The FRM programs of satellite agencies have been carried out independent of broader concerns around tiered network design, yet these measurements should be sustained as part of reference networks and not be funded or considered separately from broader observational strategies. There is also a need to undertake additional FRM measurements to fill critical cal/val capability gaps for some ECVs. • Whilst several in situ networks are considered to be of reference quality, as yet, apart from GRUAN, there are no additional GCOS recognized global reference networks. • Enabling traceable Earth observations from satellites will improve the accuracy and quality of many ECV data sets. In addition to meeting crucial inter-calibration needs, this effort will aid in better understanding climate relevant processes and their spectral signatures.
Implementers	<ol style="list-style-type: none"> 1. Lead Centre (DWD), GCOS, WMO, NMHS. 2. GCOS, Lead Centre (CMA), WMO, NMHS. 3. Space agencies, WMO, GCOS, Funding agencies. 4. GCOS, WMO, NMHS, Research organizations. 5. Space agencies.
Means of Assessing Progress	<ol style="list-style-type: none"> 1. Number of certified GRUAN stations and geographical distribution of stations; number of data products; data usage measured through citations. 2. Operational GSRN (for an initial set of stations focussing on temperature and precipitation). 3.

	<p>a) Alignment of FRM programs into the tiered network of networks concept;</p> <p>b) Additional FRM measurements to fill gaps to support satellite cal/val of ECVs such as Above Ground Biomass, albedo, FAPAR, LAI and burned area.</p> <p>4. Inventory of (potential for) global reference networks across atmosphere, ocean and terrestrial.</p> <p>5. Implementation of CLARREO pathfinder, TRUTHS and Prefire. Plans for long-term follow-on missions to the short-term (~1 year) pathfinder missions (CLARREO and Prefire) and long-term continuous measurements.</p>
<p>Additional Details</p>	<p>Reference-quality measurements must be traceable to SI or community recognised standards and have their uncertainties fully quantified following the guidance laid out by BIPM. Measurements across a reference network must be metrologically comparable.</p> <p>1. GRUAN is envisaged as a global network of eventually 30-40 measurement sites. As of August 2021, GRUAN comprises 30 sites, 12 of which have been officially certified. However, few GRUAN stations exist in several geographical regions (e.g. Africa, South America). There is also substantial work required to expand the number of GRUAN Data Products including from a range of ground-based remote sensing and in situ balloon-borne techniques. The WG-GRUAN is supported by, and reports to, AOPC who should continue to oversee progress. Regular Implementation and Coordination Meetings should continue. Efforts should be made to better integrate GRUAN into WIGOS operations.</p> <p>2. A task team has been created under GCOS and SC-ON / SC-MINT to work towards the implementation of the GSRN. The GSRN should measure both near-surface atmospheric ECVs and site-relevant terrestrial ECVs and therefore the network will be overseen jointly by AOPC and TOPC from GCOS. CMA has agreed to host the Lead Centre for the GSRN. The GSRN TT, together with CMA, is expected to develop a proposal for the initial composition of the GSRN and start operations for the selected pilot stations by 2024.</p> <p>3. Integration of FRM program measurements and associated support into long-term reference quality observing programs and networks assuring long-term cal/val operations. Including the provision of new FRM measurement programs and supporting infrastructure to fill critical current gaps in ECV satellite cal/val such as:</p> <ul style="list-style-type: none"> • Networks in high and low above-ground biomass regions; • Ground-based in situ measurements of above-ground biomass and vegetation dynamics following FRM protocols (Dunanson et al., 2021); • Ground-based time-series in situ measurements of surface albedo, FAPAR and LAI with their uncertainties; • An open-access network of sites for burned area products. <p>4. There are known networks and activities that produce reference quality measurements, i.e. BSRN, GAW networks. Efforts should be made to better recognize these as global reference networks. The panels will plan how to implement other reference networks across all domains.</p> <p>5. Spearheading spectral RS and IR measurements are the following space missions: CLARREO pathfinder will measure spectral (350 – 2300 nm) radiances and reflectances in the visible and near-IR (NASA; launch in 2023); Prefire will measure spectral (5-45 μm) far-IR emissivity (NASA; launch in 2022); Forum will measure spectral far-IR outgoing radiation (ESA; launch in 2026); and TRUTHS will measure spectral RS (ESA; launch in 2029). It is essential that Space agencies consider long-term follow-on missions to the short-term pathfinder missions (CLARREO and Prefire). This should draw upon GSICS.</p>

Links with other IP Actions	<p>C2: Improvements to satellite data processing depends on the availability of reference observations.</p> <p>D4: Improve access to co-located satellite and reference quality in situ observations.</p>
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Action B2: Development and Implementation of the Global Basic Observing Network (GBON)	
Activities	<ol style="list-style-type: none"> 1. Implementation of initial GBON and the associated SOFF mechanism to fill long-standing gaps to globally monitor climate over land and oceans. 2. Consideration of alignment of GSN and GUAN with GBON. 3. Planning the development of GBON and SOFF to cover more marine, hydrological, and atmospheric composition observations.
Issue/Benefits	<p>To date the GBON has been scoped by and adopted by WMO members along with the associated SOFF mechanism. However, the network has yet to be formally implemented and monitoring and enforcement mechanisms put in place. The use of the SOFF to fill persistent gaps has yet to start. If successful, given potential overlaps with GSN and GUAN, the implications for the future of those GCOS networks has yet to be fully evaluated.</p> <p>Furthermore, the initial implementation of GBON is focussed on requirements for NWP and reanalyses and an extension is required in future to ensure that GBON also meets the broader needs for climate monitoring and adaptation. This needs an expansion of the observational variables supported by GBON and can be supported through, for example, inclusion of daily and monthly summary reports. The GBON effort and associated SOFF, if fully implemented, would represent a step-change in the ability to monitor surface and upper-air atmospheric ECVs on a sustained basis. Benefits will include more complete sampling of many GCOS ECVs over land, ocean and the cryosphere, and filling gaps that exist over several geographical regions. The GBON network, if fully implemented, would meet the stated requirements for ECV monitoring for those ECVs it measures.</p>
Implementers	<ol style="list-style-type: none"> 1. WMO, GCOS, GOOS, NMHS. 2. GCOS, WMO, NMHS. 3. WMO, GCOS, GOOS, NMHS.
Means of Assessing Progress	<ol style="list-style-type: none"> 1. Number of GBON stations (including marine platforms in Exclusive Economic Zones (EEZs)), their geographical completeness and their continuity of data provision to data centres as well as over the WIS. 2. Assessment by GCOS of the continued relevance and role of GSN and GUAN at such time as GBON is considered to be fully implemented in its first phase with recommendations to GCOS Steering Committee. 3. GBON scope expanded to incorporate additional ECVs which are then observed on a sustained basis as part of GBON expanded operations.
Additional Details	<ol style="list-style-type: none"> 1. In collaboration with WMO, ensure the full implementation of GBON and the associated SOFF mechanism to fill long-standing gaps to monitor climate over land and oceans. In particular, ensure that: <ul style="list-style-type: none"> • The initial GBON as adopted at WMO Extraordinary Congress in 2021 is implemented in full, including both surface and upper-air components; • GBON surface stations are encouraged to submit monthly and daily summaries in addition to synoptic reports; • The SOFF is used to target areas of data sparsity over land and EEZs and ensure continuity of capability.

	<p>2. After 2-3 years of operation, consider the relationship of GBON to GSN and GUAN. Does GBON fulfil all aims of GSN and GUAN or is there value in retaining GSN and GUAN as independent network designations? If they are retained: are any changes required to GSN and GUAN aims and governance accordingly? AOPC to report to GCOS SC in 2024/2025.</p> <p>3. WMO envisages that GBON will expand to cover other domains. GCOS to take an active role in the continued evolution of the GBON network to ensure that climate needs are adequately accounted for. Progress to this end is to be assessed in the next GCOS status report.</p>
Links with other IP Actions	<p>B4: The extension of GBON (Activity 3) will benefit expansion of in situ monitoring of atmospheric composition ECVs.</p> <p>B8: The extension of GBON (Activity 3) will benefit the coordination of N₂O observations.</p> <p>C4: The implementation of GBON will benefit reanalysis.</p>

Action B10: Identify gaps in the climate observing system to monitor the global energy, water and carbon cycles	
Activities	<ol style="list-style-type: none"> 1. Continue to periodically review observations of the Earth's energy, water, carbon cycles to identify gaps and areas of high uncertainty. 2. Review consistency of the underlying observations. 3. Develop plans to address the gaps identified in (1), if feasible.
Issue/Benefits	<p>This action will implement an objective approach to identifying gaps and major uncertainties in the global climate monitoring system.</p> <p>The energy, water and carbon cycles and their closure/imbalance are fundamental to understanding current climate state and change, and improved observations of the cycles will lead to improved climate projections and reduced model biases.</p>
Implementers	From 1 to 3: GCOS , Research organizations, Funding agencies, WCRP.
Means of Assessing Progress	<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> a) Periodic assessments of each cycle and its components at least as part of the Status Report (about every five years); b) Periodic reviews of suitability of existing ECV structure to monitor energy, water and carbon cycles at least as part of the Status Report. 2. Periodic assessment of consistency of the underlying ECVs. <p>1. Include plan to address the main issues for the next GCOS Implementation Plan.</p>
Additional Details	<p>GCOS has reviewed how well the existing structure of ECVs monitors these cycles and their components. This has revealed significant gaps in observations and highlighted areas of highest uncertainty – this information will be used to guide developments and improvements to the observing system.</p> <p>Expert teams reviewing observations of the cycles will report on gaps and major uncertainties for inclusion in the next GCOS Status Report. They will develop plans to address these issues in subsequent Implementation Plans.</p> <p>See also Section 2.4 in this GCOS IP for more details and references.</p>
Links with other IP Actions	<p>This action indirectly links with many others but in particular with:</p> <p>B3: Better EEI measurements.</p> <p>B4: In situ GHG observations.</p> <p>B8: Coordinate observations and data product development for ocean CO₂.</p> <p>C5: Activity 2 (estimation of aboveground biomass).</p>

Action C1: Develop monitoring standards, guidance and best practices for each ECV	
Activities	<ol style="list-style-type: none"> 1. Review existing monitoring standards, guidance and best practices for each ECV, ensuring these reflect current state-of-the-art. Maintain a repository of this guidance for ECVs. 2. Ensure the development of monitoring standards, guidance and best practices, including intercomparison procedures, for those ECVs where such guidance does not exist. 3. Review and revise the climate monitoring guidance in the WIGOS manual to bring it in line with the updated guidance developed in this Action. 4. Review the GCOS climate monitoring principles.
Issue/Benefits	<p>Many ECVs have standards, guidance and best practices that, when followed, ensure consistency between the observations which is necessary to ensure that the global datasets meet user requirements. However, monitoring standards for some ECVs are missing and need to be established, and for others they are either substantively dated or not fit-for-purpose.</p> <p>Improvements in observations and their consistency across countries and regions would lead to more accurate observations, predictions/projections, and warnings and would thus improve adaptation planning.</p>
Implementers	From 1 to 4: GCOS , GOOS, WMO, Copernicus, satellite agencies.
Means of Assessing Progress	<ol style="list-style-type: none"> 1. Unified repository of standards, guidance, and best practices for all observations of atmospheric, oceanic and terrestrial ECVs by time of next status report. 2. New monitoring standards, guidance, and best practices for ECVs where this is identified as absent or requiring updates. 3. WMO adopts revisions to WIGOS regulatory materials to ensure they meet climate needs as articulated in the unified repository. 4. Review and undertake revisions to GCOS Monitoring Principles to align with outcomes of activities 1-3 by time of next status report.
Additional Details	<p>For 1 and 2:</p> <p>Guidance for collecting observations of ECVs is incomplete, particularly in the terrestrial domain. Therefore, the first step is to identify gaps in the guidance, or where guidance is outdated, and provide up-to-date guidance that covers siting, observations, data collection, processing, and QA/QC. Any new guidance should be based on existing guidance where this exists and is appropriate: Where possible, this can include ballpark costs and manpower requirements for implementation, operation and maintenance of ECV observations. The WIGOS manual guides NMHS in making observations. However, the current guidance on climate observations is inadequate and unclear. It should therefore be revised to be consistent with ECV requirements.</p> <p>3. The GCOS Climate monitoring principles were adopted in the 1990s. They need to be reviewed and updated as appropriate in light of new methods, insights and best practices.</p>
Links with other IP Actions	Best practices, guidance and standards are relevant for most of the Actions in themes A, B, C, D and F.

Action D1: Define governance and requirements for Global Climate Data Centres	
Activities	<ol style="list-style-type: none"> 1. Draft requirements for the activities of Global Climate Data Centres and identify the relevant internationally agreed standards. 2. Develop any new standards as required. 3. Implement the agreed-upon requirements at all global data centres.

	4. Advocate for implementation of the WMO Unified Data Policy to foster a free and unrestricted exchange of available data.
Issue/Benefits	<p>It is vital that all users have unrestricted access to well-documented, historical and near-real-time climate data and associated metadata, including relevant documentation. However, despite various efforts to implement appropriate data stewardship and sharing standards, such “free and open” access to well-maintained data archives is not available consistently across all data centres and data types.</p> <p>This action aims to improve the situation by encouraging global climate data centres with global-scale data holdings to agree on and implement relevant standards. Open exchange of easily accessible and findable data, particularly well-maintained long-term time series, will improve the completeness and accuracy of the data and metadata necessary for climate science, climate adaptation activities, and climate change mitigation planning.</p>
Implementers	From 1 to 4: GCOS , WMO, Global Data Centres.
Means of Assessing Progress	<p>For 1 and 2:</p> <p>Published GCOS document defining requirements and standards for data and metadata.</p> <p>3. GCOS to periodically audit climate data centres for compliance with the requirements and availability of all applicable mandatory metadata as defined in the WIGOS Metadata Standard. GCOS to develop implementation plans as required.</p> <p>4. Increased number and volume of ECVs for which data is exchanged according to the WMO Unified Data Policy.</p>
Additional Details	<p>1. Working with existing data centres, GCOS should coordinate the development of an agreed set of requirements with respect to data centre activities such as processing, quality controlling, archiving, and distribution of climate-related observations of the atmosphere, land, and ocean. These should be general enough to be widely used but also specific enough to be directly applicable to climate data. They should emphasize the FAIR principles; comply with existing standards of the WMO, World Data System, and other international bodies; ensure interoperability between data and metadata stored at different centres; ensure consistency with WMO systems (e.g., OSCAR), especially for ECVs; contribute to the implementation of the new WMO Unified Data Policy; and call for free and open data policies.</p> <p>This activity involves the development of standards in areas where adequate standards currently do not exist. One such area is the development of standards for compiling and managing collection-level metadata, i.e., metadata that provides the data user information about the data that is needed for assessing the data’s utility for a particular purpose as well as for acquiring and processing the data. Such metadata standards are particularly lacking for the terrestrial domain. GCOS, alongside other relevant bodies, should develop such standards and coordinate their implementation.</p> <p>2. Once all necessary requirements and standards have been developed, an implementation plan needs to be developed that outlines how GCOS will facilitate and encourage the implementation of these standards. Implementation activities may include (1) coordination with funding agencies to ensure that funding is available to data centres that need to upgrade their infrastructure or undertake significant amounts of work in order to meet the requirements; (2) the development and distribution of relevant training materials for data centre personnel; and (3) the establishment of a mechanism for determining and tracking progress towards implementation of the requirements globally.</p> <p>3. The stewardship of GCOS related data sources should be assessed on a regular basis according to the requirements and standards identified in Activities 1 and</p>

	<p>2. Internationally agreed-upon standards for the assessment of the maturity of data repositories exist with the CoreTrustSeal of the International Science Council's World Data System or the WMO Stewardship Maturity Matrix for Climate Data (SMM-CD) and could be utilized for this purpose if the working groups developing the data centre requirements decide to include them.</p> <p>4. At the most recent Congress WMO adopted its Unified Data Policy which places a requirement on Members to share historical data holdings. Activity is now required to enable the sharing of these historical data via documented routes to recognised global and regional repositories. GCOS, working with WMO must develop guidance and support and integrate requirements into relevant technical regulations.</p>
Links with other IP Actions	<p>Action D1, D2 and D3 are interconnected and pursue a common goal of preserving and providing access to ECV data in Global Data Centres, including interoperability.</p> <p>D5: data rescue is connected to data sharing of historical data.</p>

Action D2: Ensure Global Climate Data Centres exist for all in situ observations of ECVs	
Activities	<ol style="list-style-type: none"> 1. Identify ECVs for which adequate global centres do not exist or are insufficiently supported and facilitate and support the creation or improvement of global data centres for these ECVs. 2. Promote regional data centres, their interoperability, where possible, synchronisation of their data holdings, and the provision of data in their archives to global data centres.
Issue/Benefits	<p>The aim of this action is to ensure that all available observations for each ECV/ observation type are distributed from integrative data centres that meet the requirements established in Action D1. Data centres do not exist for every ECV and the continued existence of some of those that do exist is not assured due to the lack of long-term funding. This action addresses this issue and targets specifically in situ data.</p>
Implementers	<p>From 1 to 2: GCOS, WMO, GOOS, NMHS, National agencies, Funding bodies.</p>
Means of Assessing Progress	<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> a) List of climate data centres, identifying those in need of additional support followed by annual reports by GCOS panels on data centres at risk; b) List of ECVs for which no data centre exists, followed by annual updates on progress towards filling the identified gaps. 2. Establishment of a functional network of regional data centres for all ECVs of relevance in the region and their synchronisation with global data centres.
Additional Details	<ol style="list-style-type: none"> 1. Global Climate Data Centres need to maintain and construct long-term time series of ECV data and to archive and disseminate these time series for the long term, at least several decades following the requirements established as part of Action D1. The maintenance of these data centres requires long-term assured funding. <p>The first step is to identify all existing data centres and the status of their funding. ECVs for which data centres are missing need to be identified, and the relevant GCOS panels should advocate for the establishment of the missing centres. GCOS should also make a clear case for adequate funding of data centres and the benefits that will accrue.</p> <p>For example, sustained funding is urgently needed for the Global Ocean Data Analysis Project (GLODAP), where ocean biogeochemistry data is collected and stored. Despite a recent increase in the quantity of these observations GLODAP is a largely unfunded community effort. Such a situation is unsustainable, and</p>

	<p>there is a significant risk that the effort will diminish or disappear in the next few years.</p> <p>Following an initial assessment of adequacy, it is necessary to continuously review the health of the network of global data centres. GCOS panels should annually review the status of global data centres within their domain and highlight any issues so that these can be remedied.</p> <p>2. The Global data centres are part of a network of data centres that include regional data centres and in some cases the observation networks. These need to be integrated into a global system to improve data exchange and data availability. They should also follow the requirements developed in Action D1. Sustainable funding of regional data centres and observation networks is key. Working with Regional Associations and Regional WIGOS Centres, GCOS should advocate for regional level data collection and curation which may then be passed on to the extent possible for inclusion in global data centre collections. This action focuses on in situ data. Information about satellite-based climate data records can be found in the ECV inventory.</p>
Links with other IP Actions	Action D1, D2 and D3 are interconnected and pursue a common goal of preserving and providing access to ECV data in Global Data Centres.

Action E2: Promote national engagement in GCOS	
Activities	<ol style="list-style-type: none"> 1. Encourage the development of national coordination of climate observations (e.g. national GCOS programs). <ol style="list-style-type: none"> a) Collect annual reports of these programmes; b) Promote the benefits of national coordination; c) Support the development of new national climate observing programmes, including bi-lateral programmes to develop and support national GCOS activities; d) Inclusion of national climate observations needs in WMO technical regulations and guides. 2. Engagement of National GCOS Focal Points <ol style="list-style-type: none"> a) Revise terms of reference (ToR) for National GCOS Focal Points; b) Increased nomination of National GCOS Focal Points.
Issue/Benefits	<p>National programmes provide the information needed to support adaptation and mitigation and can be focussed on specific issues of national importance. Some countries have established national GCOS programmes or national climate observing programmes in their territories to monitor climate and climate change. These programmes are important to focus effort within a country, identify national priorities and, where appropriate, report issues and needs internationally to potential donors.</p> <p>Where national resources for climate observations are very limited, national climate observing programmes can aid in requesting support, resources and capacity development. National GCOS programmes can also provide the reporting on observations to the UNFCCC required for national communications.</p> <p>These actions will better inform the global system of local needs and link local observing systems with international support and capacity development. They can also provide some capacity development, explain the needs and uses of climate data and help ensure that countries have access to all the data.</p> <p>Most WMO members respond positively to guidance and standards mandated in the WMO technical regulations. Updating these technical regulations to adequately capture national climate data needs will provide the means to unambiguously define Members obligations regarding collecting/sharing climate data.</p>

	GCOS National Focal Points should be the point of contact between GCOS and all national climate observations, especially those observations made outside of the NMHS. However, many countries do not have a focal point, current lists of focal points are out of date and their ToR need updating.
Implementers	From 1 to 2: GCOS , Parties to the UNFCCC, NMHS, Academia; WMO.
Means of Assessing Progress	<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> a) Number of national climate coordination programs b) Revised WMO technical regulations. 2. <ol style="list-style-type: none"> a) Revised ToR for National Focal Points; b) Number of active National GCOS Focal Points.
Additional Details	<ol style="list-style-type: none"> 1. A few countries have national GCOS programmes. Others have similar climate monitoring programmes. GCOS should support the development of these programmes and encourage the spread of best practices to other countries. GCOS needs to inventory those national programmes that exist, collect recent reports, and identify contacts. Support and guidance to the development of new programmes can be given. If there is sufficient interest, workshops to exchange best practices and experiences can be held. 2. GCOS needs to revitalise the national GCOS focal points, starting by developing a revised ToR. The GCOS focal points should coordinate with all bodies producing climate data, and not just NMHS. New ToR for the National GCOS Focal Points should emphasise this role outside of the NMHS and other state bodies. Currently most of the existing focal points are within NMHS and the need to link to all climate observations is not recognised. If there is a national climate observing system the Focal Point should be a link to that programme as well. Once the ToR are revised and agreed, nominations for the role should be requested from all countries. The GCOS Secretariat will need to support Focal Points, exchanging information and ideas to develop national observation systems and increase communication.
Links with other IP Actions	Actions E1 and E3.

Action E3: Enhance support for national climate observations	
Activities	<ol style="list-style-type: none"> 1. Identify additional sources of support for climate observations. 2. Identify national needs for network support that will not be addressed by WMO's GBON and SOFF. 3. Publicise these to potential donors and try to mobilise the resources needed.
Issue/Benefits	<p>In countries with limited resources, it is often difficult to maintain long-term systematic climate observations, due to competing priorities. The WMO GBON and SOFF have been established to address this need for climate and meteorological observations: however, there are many ECVs that will not be addressed via these mechanisms, for many years to come, if ever.</p> <p>The GCOS Cooperation Mechanism was established to assist countries in developing their climate observation capacity. In recent years donations to the GCM have been limited and it has focussed on supporting radiosondes – this will now be covered by GBON and the SOFF.</p> <p>While the GCM should try to address other ECVs it should also return to its original concept: identifying national needs and international assistance available.</p>

Implementers	From 1 to 3: GCOS , National governments, Funding Agencies.
Means of Assessing Progress	<ol style="list-style-type: none"> 1. List of additional donors. 2. List of national network support needs. 3. <ol style="list-style-type: none"> a) Increase in national network support; b) Funds raised by the GCM.
Additional Details	<ol style="list-style-type: none"> 1. An inventory of potential donors should be established and maintained. Pro-actively engage with the potential donors to explore additional funding models/streams. 2. There are many needs for support to observations. Based on the regional workshops (E1) and national engagement (E2) as well as an understanding of the major gaps identified in the GCOS Status Report, a list of specific proposals to improve observing networks can be established. 3. Fundraising for the GCM should recommence. This will require clarity on how it will supplement the SOFF for climate observations, the benefits of the observations and how they provide global goods. In parallel, matching of countries to donors can also provide the required resources.
Links with other IP Actions	Actions E1 and E2.

Action F1: Responding to user needs for higher resolution, near real time data	
Activities	<ol style="list-style-type: none"> 1. Identify the higher resolution observations of ECVs to support the Climatic Impact-Drivers (CIDs) identified in the IPCC AR6 and develop plans to address the priority needs. (see IPCC WGI AR6 Figure SPM.9). 2. Improve biomass, land cover, land surface temperature, and fire data with sub-annual observations and improved local detail and quality. 3. Increase temporal resolution of surface air temperature, soil moisture and precipitation to capture both climate and human-induced changes and extremes. 4. Include daily averages with the monthly CLIMAT reports for land surface stations (GSN/RBON).
Issue/Benefits	<p>High-resolution and near-real time information of ECV-based climate information at global, regional and local scales allows planning to consider the full range of possible impacts.</p> <p>High-resolution data (in space and time), which, for many ECVs are currently not available, will allow rapid monitoring of changes in the climate system. This will allow the tracking of sustainable mitigation and adaptation measures. Improved high-resolution and near-real-time ECV data will allow improved understanding of CIDs.</p> <p>Whilst monthly CLIMAT reports have been available for many decades, the option to include daily averages has not been implemented operationally across the GSN/RBCN networks although it was approved by WMO in 2015. Daily averages would allow users to monitor the Regional/National impact of climate change, including an assessment of extremes.</p>
Implementers	<ol style="list-style-type: none"> 1. GCOS, Research organizations, Academia, WMO. 2. Space agencies. 3. NMHS, WMO. 4. WMO, NMHS.

Means of Assessing Progress	<ol style="list-style-type: none"> 1. Inventory of improvements to ECVs needed to inform CIDs (e.g. spatial and temporal resolution, latency, uncertainty and data stewardship) and plans for priority actions. 2. <ol style="list-style-type: none"> a) Availability of key terrestrial ECVs at resolutions of 10-30 m stored in long term archives; b) Availability of Near Real Time (NRT) sub-annual data for critical land changes and to identify extremes stored in long term archives. 3. Availability of temperature, precipitation and soil moisture at higher temporal resolution stored in long term archives. 4. Increased availability of CLIMAT reports with daily averages.
Additional Details	<ol style="list-style-type: none"> 1. CIDs are physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems and are thus a priority for climate information provision. Sustainable adaptation and mitigation planning and management need high-resolution data and in near real time to monitor critical changes in CIDs as they occur and so allow adaptation responses to be implemented. This includes the need for systematic data for land changes (land cover/use, fire, biomass), hydrological conditions (runoff, soil moisture), cryosphere data (e.g. sea ice, ice sheets, permafrost, snow, glaciers), atmospheric data (e.g. temperature and precipitation and related extremes such as droughts, floods, heavy storms and cyclones, heat waves etc.), and oceanic data (e.g. marine extremes, ocean warming, ocean acidification, and oxygen depletion) to be available in timely and easy-accessible manner. Often, consistency across spatial and temporal scales is needed, as well as consistency among multi-variable sources. Existing data streams for ECVs informing CIDs need to evolve to increase regional (e.g. national) and local detail and quality and aim for much faster data delivery than available today. The various data streams should be provided in integrated, consistent ways so the various user and expert communities can use and combine them for their purposes. GCOS should make sure that the ECV requirements are updated accordingly. 2. and 3. The GCOS expert panels have already identified some specific high-resolution, near real time datasets that have been requested by users and that the existing monitoring systems are able to support within the next 5 years. 3. When implemented GBON will deliver higher resolution spatial and temporal data record for most land surface stations and some marine platforms. Where stations report on an hourly basis it will be possible to construct both monthly and daily CLIMAT reports for those stations which do not compute/report the CLIMAT operationally.
Links with other IP Actions	<p>B2: GBON.</p> <p>C4: develop regional reanalysis; reduce data latency. Reanalysis is important for responding to user needs for higher-resolution data. Observations in this action will benefit reanalysis.</p> <p>D2: availability of data in archives.</p> <p>D3: easy accessibility of data.</p>

Action F4: Improve climate monitoring in urban areas	
Activities	<ol style="list-style-type: none"> 1. Audit existing GCOS ECVs to identify those that are urban-relevant and produce updated requirements where needed. 2. Identify new urban-relevant products and define their requirements. 3. Develop plans to address the urban monitoring requirements identified in Activities 1 and 2.

Issue/Benefits	<p>The majority of the human population lives in cities and urban areas, including informal settlements, are primary locations for economic and social activity, and hence these are critical locations for emissions mitigation and climate adaptation. Effective monitoring of climate relevant parameters will therefore yield substantial benefits. Such climate relevant parameters include the normal meteorological observations, but also extend to observations of other relevant variables such as pollution emissions and land use and land cover change (LULC).</p> <p>Traditional measurements of standard meteorological parameters have sought to eliminate urban influences, wherever possible, but the reality is that temperatures that are elevated by urban influence do actually represent the climatic conditions experienced by a large proportion of the global population and are especially important when considering adaptation to climate change. Sufficient standardised observations of these complex environments are required to understand the heterogeneity of urban climates, and this in turn is key to making informed adaptation decisions.</p>
Implementers	From 1 to 3: GCOS , WMO, Academia, National agencies, Research organizations, NMHS
Means of Assessing Progress	<ol style="list-style-type: none"> 1. GCOS Adaptation Task Team progress and final reports to GCOS SC. 2. Upgraded GCOS documentation (especially for TOPC and AOPC) to clearly identify existing, upgraded and new ECVs relevant to urban climate and adaptation. 3. Plans to address urban monitoring needs.
Additional Details	Processes and procedures are identified in the working documents produced by the GCOS Adaptation Task Team (GATT). Better monitoring in the urban area is also clearly needed to measure exposure to black-carbon, ozone and aerosol precursor emissions, NO ₂ . The enhancement of GCOS capability in these areas will additionally broaden GCOS engagement with stakeholders in both provision and use of the relevant observations. For example, enhancement of LULC capability for urban areas might require engagement with urban climate community and the World Urban Database and Planning Tool (WUDAPT).
Links with other IP Actions	<p>B4: expansion of atmospheric composition observations.</p> <p>F5: Activity 4 – improve measurements of relevant ECVs on large cities.</p>

Action F5: Develop an Integrated Operational Global GHG Monitoring System	
Activities	<p>The overall aim here is to develop an integrated operational global greenhouse gas monitoring infrastructure. The first steps are:</p> <ol style="list-style-type: none"> 1. Design and start to implement a comprehensive global set of surface-based observations of CO₂, CH₄ and N₂O concentrations routinely exchanged in near-real time suitable for monitoring GHG fluxes. 2. Design a constellation of operational satellites to provide near-real time global coverage of CO₂ and CH₄ column observations (and profiles to the extent possible). 3. Identify a set of global modelling centres that could assimilate surface and satellite-based observations to generate flux estimates. 4. Improve and coordinate measurements of relevant ECVs at anthropogenic emissions hotspots (large cities, powerplants) to support emission monitoring and the validation of tropospheric measurements by satellites.
Issue/Benefits	The Paris Agreement requests Parties to regularly provide estimates of anthropogenic emissions by sources and removals by sinks of greenhouse gases,

	<p>and information necessary to track progress made in implementing and achieving their nationally determined contribution under Article 4. The proposed global greenhouse gas monitoring infrastructure would support the development of these estimates (i.e. emission inventories); validate national and regional achievement of Parties' commitments in their National Adaptation Plans (NAPs); and monitor changes to the cycles of GHG that may impact the achievement of the temperature goal of the Paris Agreement.</p> <p>Monitoring of hot-spots via dedicated observations to validate specific point-source emissions and identify missing sources from emission inventories.</p> <p>Remote monitoring of atmospheric composition can quantify and identify major emission sources. Anthropogenic emission hotspots like cities and industrial facilities and power plants contribute strongly to the global GHG emissions and to emission of key ozone and aerosol precursors (SO₂, VOCs). Reliable remote observations of these emission hotspots in synergy with source detection models can contribute to verifying emission estimates and monitor and guide mitigation efforts (link to Flux ECV).</p>
Implementers	<ol style="list-style-type: none"> 1. WMO (INFCOM, GAW and IG3IS). 2. Space agencies, national agencies, Research organizations, Academia. 3. WMO (INFCOM, GAW and IG3IS), national agencies. 4. GCOS, space agencies, national agencies.
Means of Assessing Progress	<ol style="list-style-type: none"> 1. Expanded observations of GHGs, ozone and aerosol precursors, aerosols and aerosol profiles near hotspots. 2. Designs and plans for in situ and satellite observations. 3. Identification of global monitoring centres that run global Chemistry Transport Models. 4. <ol style="list-style-type: none"> a) Improved satellite retrievals in the presence of varying aerosol loadings in urban and hotspot conditions. Improved uncertainty quantification of GHG retrievals in the presence of aerosols; b) Number of emission detection studies using in situ and satellite data near hot spots.
Additional Details	<p>From 1 to 3:</p> <p>Based on an initial concept paper prepared by the WMO Secretariat entitled "A WMO-coordinated Global Greenhouse Gas Monitoring Infrastructure" and the Report from the WMO-hosted Greenhouse Gas Monitoring Workshop in May 2022, the 75th Session of the WMO Executive Council decided to proceed with the further development of the concept for a WMO-coordinated Global Greenhouse Gas Monitoring Infrastructure, building on existing WMO programmes and other regional or global infrastructure and initiatives. This infrastructure will consist of the following main elements:</p> <ol style="list-style-type: none"> a) A comprehensive global set of surface-based observations of CO₂, CH₄ and N₂O concentrations routinely exchanged in near-real time; b) A constellation of satellites to provide near-real time global coverage of CO₂ and CH₄ column observations (and profiles to the extent possible); c) A global Chemistry Transport Model (CTM) driven by output from a high-resolution global NWP model; d) Operational near-real time assimilation of the GHG observations a) and b) into CTM and routine dissemination of the output. <p>4. Hot spots include urban areas, industrial zones and individual large plants.</p> <p>4.1 Enhance observations in urban areas:</p>

	<p>a) Expand the network of GHG observations that measure around urban areas, in particular column and profile observations. These observations will support integration of satellite missions that detect and quantify sources;</p> <p>b) Ensure co-located observations of co-emitted gases (typically ozone and aerosol precursors) CO, NO₂, SO₂, VOCs.</p> <p>4.2 Ensure co-located observations of aerosols loadings and aerosol profiles in urban areas:</p> <p>a) Improve satellite retrievals in emission hotspots;</p> <p>b) Evaluate GHG retrievals in urban areas by considering varying aerosol loadings using reference observations;</p> <p>c) Focus on improving GHG retrievals and their uncertainty quantification in urban and other local hotspot cities (Action B3).</p> <p>Present challenges in monitoring emission hotspots include:</p> <ul style="list-style-type: none"> • Missing reference data sets of GHGs and other co-emitted gases and aerosols in urban areas. • Challenges in estimating GHG concentrations in the presence of varying aerosol loads. Underestimated (or overestimated) uncertainties can mislead the emission estimation. • Integration of in situ and satellite measurements. <p>In the future, measuring stable isotopes of carbon will allow separation of natural and fossil sources of GHG.</p>
<p>Links with other IP Actions</p>	<p>B3: New satellite missions.</p> <p>B4: In situ monitoring of aerosols and greenhouse gases.</p> <p>F4: Climate monitoring in urban areas.</p>