Gap Analysis for Integrated Atmospheric ECV CLImate Monitoring:

Initial input from WP1 to the gap analysis and impacts document

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Nature: R

Dissemination level: PU

GAIA-CLIM: Gap Identification Template[1])

Guidance: Please adhere to this template and keep the inputs concise. Please provide longer explanatory remarks not in the summary table but in a separate document as input to the GAID with reference to the Gap Identifier (G<workpackage origin>.<gap number>) [Gap6.99, G2.40, G2.41 are examples. These are hypothetical gap as could be identified e.g. through the WP6 user survey, external documents as well as WP deliverables)]

Gap Identifier G<wp>.<no>	**Gap Type** [2])	**Keywords** [3]) [Up to 10 (max)]	**ECV(s)** [Specify if not generic]	**Gap Description** (<100 characters)	**Trace** (both underlying WP deliverable(s) as well as external papers, reports etc)	**Gap Impacts** (Bulleted summary)	**Envisaged Remedy** (including timescale and cost estimate if possible)	**Remedy addressed in GAIA-CLIM** (Yes/No)
G1.1	**Technical / Organizational**	**Reference Networks, Baseline Networks, comprehensive observation system.**		**Missing agreement for levels of data and associated names across domains**	**D1.3 , recent meetings of GCOS AOPC panel, Seidel et al. BAMS (2009).**	• **No effort has been made to define and broadly agree amongst global stakeholders the measurement and network characteristics underlying a posited system of systems approach to Earth Observation.** • **Different domains use distinct conventions and conflate labels**	**Remedy: Canvas stakeholders on suitability of adopting task 1.1 outcomes** **Timescale: years** **Cost estimate: low**	**Partially**
G1.2	**Technical**	**Measurement maturity assessment**		**Need to assess suitability of measurement maturity assessment**	**D1.3**	• **Ensure viability of Task 1.2 activities to determine data tiers.**	**Remedy: Testers from task 1.2** **Timescale: months** **Cost estimate: none**	**Yes**
G1.3	**Coverage (spatial and temporal)**	**Reference Networks, Baseline Networks, comprehensive observation system.**		**Missing evaluation criteria for assessing existing observing capabilities.**	**D1.1**	• **No effort has been made to define and broadly agree amongst global stakeholders the measurement and network characteristics underlying a posited system of systems approach to Earth Observation.**	**Remedy: enhanced coordination amongst global stakeholders** **Timescale: uncertain;** **Cost estimate: uncertain**	**yes**
G1.4	**Coverage (spatial and temporal)**	**Geographical observation gaps and redundancies**		**Lacking of a comprehensive review of current sub-orbital observing capabilities for**	**D1.4, D1.6, D1.8**	• **Mapping of current observing capabilities has been carried out by each network under an uncoordinated effort across**	**Remedy: enhanced coordination amongst global stakeholders like GCOS, GEOSS, GAW, and**	**yes**

				all the study of ECVs in atmospheric, ocean and land domains		the community measuring ECVs.	the federated networks adhering to this programs Timescale: uncertain Cost estimate: requires further plans and investigation	
G1.5	Coverage (spatial and temporal)	Geographical observation gaps, redundancies		Lacking of unified tools showing all the existing observing capabilities for measuring ECVs with respect to satellite spatial coverage.	D1.4, D1.6, D1.8	No available tools able to map sub-orbital measurement capabilities along with satellite spatial to measure for the most of the ECVs at once, but quite often there are non tolls mapping all the sub-orbital measurement capabilities even for just one ECVs	Remedy: enhanced coordination among the main international initiatives like GCOS, GEOSS, GAW, …. Timescale: uncertain Cost estimate: uncertain	Yes
G1.6	Coverage (spatial and temporal)	metadata		Lacking of a common effort in metadata harmonization	D1.4, D1.6, D1.8	Different metadata format are adopted among the different networks making the data harmonization effort at the global scale and n the different observation domain challenging.	Remedy: WMO to push all the observing networks to conform to WIGOS standards. Timescale: starting from 2018 when WIGOS-OSCAR will be fully operational; Cost estimate: requires further plans and investigation	A significant effort will be done in WP1 following the international initiatives dealing with this gap.
G1.7	Coverage (spatial and temporal)	Observation Gaps		Need for a scientific approach for the assessment of gaps in the existing networks measuring ECVs.	D1.9	Assessment of gaps has been often performed without a scientific basis or using sparse approach never applied in an extensive way. It does not exist a comprehensive scientific approaches to assess the gaps in the current observing capabilities of the system of systems.	Remedy: closer cooperation between measurement community, geo-statisticians and modelers to design different solution to assess the gaps and then to inter-compare the elaborated approached to provide robust and reliable solutions. Timescale: uncertain Cost estimate: uncertain	Yes for a subset of ECVs
G1.8	Coverage (spatial and temporal)	Observation Gaps		Evaluation of the effect of missing data or missing in temporal coverage of full traceability data provided by ground-based networks	D1.9, Whiteman et al., 2011	• There are only a few quantification of the effect of temporal sampling in the determination of atmospheric variability. • Prevents full traceability of both the model/assimilation	Remedy: use of geo-statistical approaches to assess this effect; Research to characterize model-observation differences with focus on enhancing representation of	Yes for a subset of ECVs. WP4, but also Task 1.4 and 1.5 will provide a relevant

						quantity and also the observational dataset	"observation operators" Timescale: uncertain Cost estimate: uncertain	contribution to this gap.
G1.9	Spatial coverage; vertical resolution	Carbon monoxide, TCCON, profiles, FTIR	Carbon monoxide	Limited availability of quantitative profiles of carbon monoxide	D1.2	Large uncertainty in top-down global and regional CO inventories Insufficient verification of vertical information in satellite products	Remedy: uncertain Timescale: uncertain Cost estimate: uncertain	No
G1.10	Uncertainty	Reference Networks, Baseline Networks, comprehensive observation system.		Traceable uncertainty estimates	D1.3, Immler et al., AMT 2010	Limited availability of traceable uncertainty estimates propagates to applications that use model or reanalysis fields. Progress here is critical for establishing the scientific basis for using such fields as a transfer standard in satellite dataset characterization and other activities, and for assessing the cost-effectiveness of potential observing system enhancements.	Remedy: Mix of operational improvements in observing systems; better characterization of model-based & assimilation-based uncertainty Timescale: uncertain Cost estimate: uncertain.	Partly
G1.11	Coverage (spatial and temporal)	Operational observing systems		Traceable uncertainty estimates from baseline and comprehensive networks	D1.1, D1.4, , Immler et al., AMT 2010	Datasets from baseline and comprehensive networks provide valuable spatio-temporal coverage, but often lack the characteristics needed to facilitate traceable uncertainty estimates. Essential contribution to make progress on G1.10	Remedy: Identify scope for baseline and comprehensive networks leverage expertise from reference networks, including adopting elements of best practice from reference networks, and/or facilitating reprocessing that iteratively improves dataset quality. Timescale: uncertain Cost estimate: uncertain	WPs 1,2 and 3.
G1.12	Uncertainty	model-based uncertainty, assimilation-based uncertainty		Propagate uncertainty from well-characterized locations and parameters to other locations and parameters.		Limited knowledge about how to propagate uncertainty from well-characterized locations and parameters to other locations and parameters. Essential contribution to make progress on G4.1.	Remedy: modelling studies to characterize propagation of uncertainty in models and assimilation systems. Timescale: uncertain Cost estimate: uncertain	Task 1.4 and Task 1.5 show some potential to address this gap.

G1.13	**Coverage (spatial and temporal)**	**Water vapour**		**Water vapor measurements with the lidar and microwave radiometer are often provided in a sparse way and under an uncoordinated effort**	**D1.1, D2.1**	**• Several stations are routinely performing water vapor measurements with the microwave radiometer and with the Raman lidar (column and profiles) often at the same site exploiting also this synergy, but they are often not coordinated loosing their powerful observing capability at a large scale.**	**Remedy: Agree on a federated approach like those already partly established for the aerosol network most of which are also in charge for water vapor measurements using Raman lidar and microwave radiometer. Timescale: uncertain Cost estimate: low-moderate**	**No**
G1.14	**Spatial and temporal coverage**	**Aircraft, E-AMDAR, IAGOS**	**Temperature profile, wind profile, ozone profile, water vapour profile**	**There is currently limited aircraft data in Eastern Europe.**		**Missing aircraft information in the in Eastern Europe.**	**If suitable airlines can be identified it may be possible to include them in the E-AMDAR program.**	**No**
G1.15	**Spatial and temporal coverage**	**UV-visible spectroscopy, NDACC, PANDORA**	**Ozone (total column)**	**Northern Hemisphere bias in NDACC and PANDORA network sites distribution**	**D1.1, D2.1**	**The lack of coverage in space and time limits the potential of the network for global studies such as latitudinal dependencies and global trend studies, satellite validation and long-term assessment of ECV.**	**Develop strategies for network extension, and long-term preservation of data and measurement capabilities.**	**Yes, in terms of the development of strategies for network extension**

Notes

[1]**)** Gaps are assumed to be supported by **full text entries in the underlying WP deliverables** indicated in the column 'Trace' (a suggested full text format is provided below)

[2]**) Proposed Gap Types** (either scientific, technical, organizational), please complete the following list of gap types if necessary. Note: Gap type will be used to help organizing the table with collected gaps: coverage(horizontal); coverage (vertical); coverage (temporal) or 'missing data'; resolution (vertical); uncertainty large (systematic); uncertainty large (random); uncertainty unknown (systematic); uncertainty unknown (random); …

[3]**)Proposed Keywords**, please complete the following list of keywords if necessary. Keywords will facilitate search tools for the gaps related to e.g. any networks, techniques:

[measurement technique(s)], [network(s)], relative uncertainty, absolute uncertainty, error budget, smoothing error, retrieval, calibration, representativity, etc.

G1.1 Missing agreement for levels of data and associated names across domains

Gap Type: Technical/organizational

Gap keywords: Reference Networks, Baseline Networks, comprehensive observation system.

ECV(s): all

Trace (external refs): D1.3 , recent meetings of GCOS AOPC panel, "Seidel, D. J. et al (2009), Reference Upper-Air Observations for Climate: Rationale, Progress, and Plans. Bulletin of the American Meteorological Society, 90, 361–369, doi:10.1175/2008BAMS2540.1"

Gap Description

Despite the existence of groups such as GEOSS with the System of Systems implicit in its name little to no effort has been made to define and broadly agree amongst global stakeholders the measurement and network characteristics underlying a posited system of systems approach to Earth Observation. Within the peer reviewed literature explicit reference to a tiered network of networks approach is, to our knowledge, limited to Seidel et al., 2009.

Gap Impacts

Such a tiered set of networks approach is necessary to make sense of the mosaic of observational capabilities at our disposal and use the right measurements for the correct application. This also impact the associated names across domains that use distinct conventions and conflate labels.

Gap Remedy

Define tiers of current existing capabilities that may define fitness-for-purpose for different application areas of candidate sub-orbital measurement programs to understand and ultimately constrain satellite measurements.

G1.2 Need to assess suitability of measurement maturity assessment

Gap Type: Technical

Gap keywords: Measurement maturity assessment

ECV(s): all

Trace (external refs): D1.3

Gap Description

The determination of data tiers requires the use of objective criteria to assess the maturity of the components of the system of systems. This can be effectively implemented through the definition of the measurement system maturity matrix (SMM) as a tool to assess various facets of the maturity of a measurement. The matrices assess to what extent measurement best practices have been met and hence the extent to which the measurement system may be applicable to a given application area.

Gap Impacts

The definition of SMM is a pre-requisite to ensure viability of Task 1.2 activities and allow a smart analysis of the geographical mapping of the sub-orbital measurement capabilities.

Gap Remedy

A remedy will be available in the short term within GAIA-CLIM through the assessment and the test of the approach elaborated in task 1.1 using task 1.2 members who are also the leaders of existing networks; they will serve as self-evaluators for the first stage related to an internal assessment of the SMM. In a second stage an external assessment will be performed before the delivery of D1.3 at month 9.

G1.3 Missing evaluation criteria for assessing existing observing capabilities

Gap Type: Coverage (spatial and temporal)

Gap keywords: Reference Networks, Baseline Networks, comprehensive observation system.

ECV(s): all

Trace (external refs): D1.1

Gap Description

It is necessary to clearly define measurement capabilities tiers that individual sub-orbital observational programs can be placed into so that users can use the measurements appropriately and with confidence. It is then necessary to create criteria which are as objective as possible by which to designate a given candidate measurement series or measurement program into the most appropriate tier and to map these capabilities in various ways that can aid end users to make informed and appropriate decisions and analyses. So far, no effort has been made to define and broadly agree amongst global stakeholders the measurement and network characteristics underlying a posited system of systems approach to Earth Observation.

Gap Impacts

Definition of measurement capabilities tiers for the individual sub-orbital observational programs and of evaluation criteria for their assessment can maximize the return-on-investment of the currently available and future sub-orbital observational capabilities portfolio.

Gap Remedy

An enhanced coordination amongst global stakeholders is required to come up with shared evaluation criteria for the assessment of the existing observing capabilities.

G1.4 Lacking of a comprehensive review of current sub-orbital observing capabilities for all the study of ECVs in atmospheric, ocean and land domains.

Gap Type: Coverage (spatial and temporal)

Gap keywords: Observation gaps, redundancies

ECV(s): all

Trace (external refs): D1.4, D1.6, D1.8

Gap Description

In the past, a relevant effort has been spent to perform a review of the observing capabilities on an ECV basis, within each specific sector of the community performing atmospheric measurements. This has allowed to achieve in a few cases also excellent results in the review of the observing capabilities for the measurement of a single ECV (e.g. ARGO for the ocean variables). Nevertheless, for most of the of ECV, the existing review are incomplete due to the lacking of a coordinated effort and a federated approach among the networks measuring the same ECV. In addition, a comprehensive review of current sub-orbital observing capabilities for all the ECVs listed by GCOS for the atmospheric, ocean and land domains, made available all together in one repository, is missing.

Gap Impacts

The elaboration of suitable validation strategies for the current and upcoming satellite missions strongly requires an extensive review of the existing sub/orbital measurements capabilities. The evaluation of the geographical gaps (and/or redundancies) in the observing system represents the first mandatory step towards the full exploitation of system of observation systems.

Gap Remedy

An enhanced coordination amongst global stakeholders like GCOS, GEOSS, GAW, and the application of a federated approach among all the networks joining these international initiatives and science programs might allow to start a process that could strongly enhance the use of sub-orbital capabilities for satellite validation and modelling evaluation/assimilation, fostering the exchange of expertise among the different networks and generating a virtuous loop to increase the data quality and traceability. An existing example, though still under development, is represented by GALION (GAW LIdar Observation Network) and more in general by the aerosol network participating into the GAW program.

G1.5 Lacking of unified tools showing all the existing observing capabilities for measuring ECVs with respect to satellite spatial coverage.

Gap Type: Coverage (spatial and temporal)

Gap Keywords: Observation gaps, redundancies

ECV(s): all

Trace (external refs): D1.4, D1.6, D1.8

Gap Description

A unified tool able to visualize all the sub-orbital observing capabilities of measuring ECVs at the global scale with respect to spatial and temporal coverage of the current and the future satellite mission is indeed missing. Several tools are already available for several networks of the global observing system but all of them are designed on the basis of very specific needs, using different logics, tools, and typically including just one ECV an d only one or a small subset of the networks at the global scale.

Gap Impacts

A unified tool able to show at once all the existing sub-orbital capabilities can strongly help end-users in the implementation of new validation strategies and in the full exploitation of both ground based an satellite data, can inform the users on the available measurements of different ECVs and within different Earth's domain (atmosphere, land, ocean) through a quick and smart analysis of the geographical distribution of the system of networks at the global scale.

Gap Remedy

An joint effort amongst global stakeholders like GCOS, GEOSS, GAW is needed to foster the design of tools that, on the way of those already implemented in similar past initiatives carried out in the frame of the same programs, can enlarge the scope and try to encompass the whole system of observing systems.

G1.6 Lacking of a common effort in metadata harmonization

Gap Type: Metadata

Gap Keywords: Observation gaps, redundancies

ECV(s): all

Trace (external refs): D1.4, D1.6, D1.8

Gap Description

The tier designation to classify the maturity of the different networks should be a function of demonstrable measurement qualities, and this includes metadata collection and uniformity of metadata to the international standards. At present metadata are collected using many different formats and option (e.g. separate files for each measurement, unified file with general information only, reference to peer-reviewed paper, etc), or quite often are completely not available, sometimes considered somehow redundant. A large metadata harmonization across the different networks is required to enhance the full data exploitation by all end users' type and to allow a reliable and efficient reprocessing of entire data streams as necessary,

Gap Impacts

Different metadata format are adopted among the different networks making the data harmonization effort at the global scale and in the different observation domain challenging.

Gap Remedy

WMO is establishing the WIGOS-OSCAR repository based on a unified and very detailed metadata format that should be used starting from 2018 (when the WMO service will be fully operational) by all the contributing networks. WMO, in coordination with all the global stakeholders, must push all the observing networks to conform to WIGOS standards. GAIA-CLIM will start promoting a metadata harmonization network spending a significant effort in WP1 to adopt a common metadata format, following the international initiatives (including WIGOS), for all networks included in the geographical mapping of the systems of observing systems.

G1.7 Need for a scientific approach for the assessment of gaps in the existing networks measuring ECVs

Gap Type: Coverage (spatial and temporal)

Gap Keywords: Observation gaps

ECV(s): all

Trace (external refs): D1.9

Gap Description

In the past international projects and programs, the assessment of gaps within a certain network of within a subset of networks measuring the same ECV has been not always considered a priority and has been often based on studies with a limited scope, without broad scientific basis and never applied in an extensive way. It does not exist a comprehensive scientific approaches to assess the gaps in the current observing capabilities of the system of systems for the different ECVs.

Gap Impacts

Evaluation of gaps cannot be performed under the use of subjective criteria or left to the experience of a restricted team of experts but instead based on scientific approaches, based on statistical or on numerical models, able to unambiguously prove the effective needs in the current scenario of the networks measuring the ECVs at the global scale.

Gap Remedy

A closer cooperation is required between measurement community, geo-statisticians, and modellers to design different scientific-based approaches to assess the geographical gaps in the existing system of observing systems. Moreover, all the elaborated approaches should be inter-compared to ensure the robustness and the reliability of the proposed solutions.

G1.8 Evaluation of the effect of missing data or missing in temporal coverage of full traceability data provided by ground-based networks.

Gap Type: Coverage (spatial and temporal)

Gap Keywords: Observation gaps

ECV(s): all

Trace (external refs): D1.9, "Whiteman, D. N. et al (2011), The relative importance of random error and observation frequency in detecting trends in upper tropospheric water vapor, J.Geophys. Res., 116, D21118, doi:01.1029/2011DJ01661"

Gap Description

In literature, there are only a few studies presenting a quantification of the effect of temporal sampling in the determination of atmospheric variability and climate trends. One recent example is represented by the paper published by D. Whiteman et al. (JGR 2011) that provides an estimation of the number of monthly soundings of the atmosphere (affected by the measurements uncertainties) are needed to catch a climate trend in the stratospheric water vapor content over a period of 10 year. There is general lacking of organic approaches able to quantify the required temporal rate of the surface-based and sub-orbital observing capabilities for the modeling evaluation and for the assimilation of the observational dataset

Gap Impacts

The gap strongly prevents full traceability of both the model/assimilation quantity and also the observational dataset.

Gap Remedy

The use of geo-statistical approaches to assess this effect might provide significant hints to address the temporal sampling issue.

Moreover, research to characterize model-observation differences should focus on enhancing representation of "observation operators", comparison of the different approaches. The elaborated approaches must be inter-compared to reduce the uncertainties affecting the final outcome.

G1.9 Limited availability of quantitative profiles of carbon monoxide

Gap Type: Coverage (spatial and temporal)
Gap Keywords: Carbon monoxide, TCCON, profiles, FTIR
ECV(s): Carbon monoxide
Trace (external refs): D1.2

Gap Description

The review of the existing sub-orbital capabilities show how at present there is a very small amount of quantitative profiles of carbon monoxide at the global scale; most of the available measurements are columnar (e.g. TCCON) or in-situ surface concentrations.

Gap Impacts

The very limited availability of quantitative profiles of carbon monoxide provides a large uncertainty in top-down global and regional CO inventories and, therefore, insufficient verification of vertical information in satellite products

Gap Remedy

The strategy to put a remedy to this gap is quite uncertain and requires a significant effort at the global scale by all the potential actors.

G1.10 Traceable uncertainty estimates

Gap Type: Uncertainty
Gap Keywords: Reference Networks, Baseline Networks, Comprehensive observation system.
ECV(s): all
Trace (external refs): D1.3, "Immler, F. J. et al. (2010), Reference Quality Upper-Air Measurements: guidance for developing GRUAN data products. Atmospheric Measurement Techniques, 2010, 3, 1217–1231, doi:10.5194/amt-3-1217-2010"

Gap Description

Where traceable uncertainty estimates exist for a model or reanalysis quantity, it is often limited to a few locations and parameters where reference datasets are available. Comprehensiveness is lacking for extension to locations and parameters where reference datasets are not available. Limited availability of traceable uncertainty estimates propagates to applications that use model or reanalysis fields.

Gap Impacts

Progress here is critical for establishing the scientific basis for using such fields as a transfer standard in satellite dataset characterization and other activities, and for assessing the cost-effectiveness of potential observing system enhancements.

Gap Remedy

A joint effort towards operational improvements in observing systems and better characterization of model-based and assimilation-based uncertainty is the optimal approach to fix this gap.

G1.11 Traceable uncertainty estimates from baseline and comprehensive networks

Gap Type: Coverage (spatial and temporal)

Gap Keywords: Operational observing systems.

ECV(s): all

Trace (external refs): D1.1, D1.4, "Immler, F. J. et al. (2010), Reference Quality Upper-Air Measurements: guidance for developing GRUAN data products. Atmospheric Measurement Techniques, 2010, 3, 1217–1231, doi:10.5194/amt-3-1217-2010"

Gap Description

Datasets from baseline and comprehensive networks provide valuable spatio-temporal coverage, but often lack the characteristics needed to facilitate traceable uncertainty estimates.

Gap Impacts

This gap definitely impact the G.10 and its solving provides an essential contribution to make progress on G1.10.

Gap Remedy

Identify the scope of baseline and comprehensive networks, leverage expertise from reference networks, including adopting elements of best practice from reference networks, and/or facilitating reprocessing that iteratively improves dataset quality.

G1.12 Propagate uncertainty from well-characterized locations and parameters to other locations and parameters

Gap Type: Uncertainty
Gap Keywords: model-based uncertainty, assimilation-based uncertainty
ECV(s): all
Trace (external refs):

Gap Description
Limited knowledge about how to propagate uncertainty from well-characterized locations and parameters to other locations and parameters.

Gap Impacts
This gap provides an essential contribution to make progress on G1.7.

Gap Remedy
The modelling studies need to characterize propagation of uncertainty in models and assimilation systems. GAIA-CLIM Task 1.4 and Task 1.5 show some potential to address this gap.

G1.13 Water vapor measurements with the lidar and microwave radiometer are often provided in a sparse way and under an uncoordinated effort

Gap Type: Coverage (spatial and temporal)
Gap Keywords: Observation gaps
ECV(s): Water vapor
Trace (external refs): D1.1, D1.2

Gap Description
Several ground-based stations are routinely performing water vapor measurements with the microwave radiometer and with the Raman lidar technique to estimate the column water vapor content or the vertical profile of the water vapor mixing ratio or relative humidity; this is often done simultaneously with measurements of the aerosol properties.

Two of the main examples of this effort are represented by NDACC, officially performing water vapor measurements, and by EARLINET, devoted to aerosol measurements but performing water vapor measurements in several of its stations. The measurements are typically performed at this station h24 with the microwave radiometer, though different retrievals are used and a real international initiatives to coordinate this observing capability (e.g. MWRnet are still far from begin well established; on the contrary Raman lidar and DIAL measurements are performed without any coordinated effo rt and are not simultaneous, with effects on the full data exploitation.
Finally, the synergy between these two devices is highly desired to improve the 4D characterization of the atmosphere and for routinely inter-calibration procedures.

Gap Impacts

The lacking of a coordinated effort among the networks measuring water vapor using microwave radiometry and lidars does not allow to make available high quality and physically consistent datasets of measurements for the purpose of the satellite validation, modeling evaluation and to study signal of climate change in critical atmospheric regions where the water vapour is one of the most relevant ECVs, like In UT/LS.

Gap Remedy

Global stakeholders like GCOS, GEOSS, GAW should foster the adoption of a federated approach among all the networks measuring water vapor following the example of the aerosol networks most of which are already routinely performing water vapor measurements using Raman lidar and microwave radiometry.

G1.14 Water vapor measurements with the lidar and microwave radiometer are often provided in a sparse way and under an uncoordinated effort

Gap Type: Spatial and temporal coverage
Gap Keywords: Aircraft, E-AMDAR, IAGOS
ECV(s): temperature, wind, ozone, water vapor
Trace (external refs): D1.1, D1.4, D1.6., D1.8

Gap Description

The current state of the aircraft platforms routinely measuring several ECVS, like temperature, wind, ozone, water vapor using passengers aircrafts shows an impressive coverage of the northern hemisphere with a good global coverage with some missing areas, for here is currently limited aircraft data in Eastern Europe.

Gap Impacts

Missing aircraft information in the in Eastern Europe means an incomplete coverage of aircraft data at the continental scale that could limit the satellite validation and the modeling evaluation/assimilation.

Gap Remedy

There is real potential to identify suitable airlines that could be included and supported by the E-AMDAR program.

G1.15 Northern Hemisphere bias in NDACC and PANDORA network sites distribution

Gap Type: Spatial and temporal coverage
Gap Keywords: UV-visible spectroscopy, NDACC, PANDORA
ECV(s): ozone (total column)
Trace (external refs): D1.1, D2.1

Gap Description

NDACC and PANDORA total column ozone observation sites are mainly concentrated in Europe and the US. There is definitely a strong bias towards Northern Hemisphere mid-latitudes and a lack of measurements in Asia, the tropics and Southern latitudes.

Gap Impacts

The lack of coverage in space and time limits the potential of the network for global studies such as latitudinal dependencies and global trend studies, satellite validation and long-term assessment of ECV.

Gap Remedy

Develop strategies for network extension, and long-term preservation of data and measurement capabilities.

ANNEX 1

"Review of the current sub-orbital observing capabilities in the frame of WP1"

A subset of atmospheric, oceanic and terrestrial ECVs (Table 1) that are either currently capable of being measured from space or envisaged in funded future missions is the target of the Work Package 1 (WP1). Climate monitoring requires establishment and archiving of accurate, long-term records of the ECVs. A sufficient global coverage of surface-based and sub-orbital measurements is required to fill in knowledge gaps and to ensure a full exploitation of satellite data over a global scale.

Therein, WP1 has the objective to provide a geographical mapping of existing and planned ground-based and sub-orbital observing capabilities in the context of a system of systems.

For each measurement type (e.g. reference, baseline, comprehensive) current capabilities shall be mapped and documented, among others in terms of geo-location, vertical range and atmospheric state, but also in terms of vertical and horizontal footprints and sampling of atmospheric variability and structures. As well as mapping where, for periodic measurements (such as balloon-borne measures), when they are taken will also be mapped in terms of EO orbits.

Both as a first stage of the task 1.2 work and in support to the initial gap assessment provided in D1.1, a preliminary geographical review of the existing networks measuring the ECVs reported in Table 1 has been completed; the review include all the basic information to perform the geo-location of each site, the measured variable and the status of the metadata collection established within each networks. This information are:

a. Location_of_the station (place where the station is located)
b. Name_of_the_station (official name of the station if any)
c. Measured_ECV (measured ECV, according to the table 1)
d. Measurement_Type (in-situ surface, tower, column, profile)
e. Measurement_Technique (the technique used for the measure of ECVs, e.g. sonde, lidar, radiometer, …..)
f. Network (name of the network)
g. Latitude
h. Longitude
i. Altitude
j. Start_of_operation (when the station started to measure the related ECV)
k. PI
l. Website

Table 1. Those ECVs and additional variables for which capabilities will be classified in a system of systems approach and mapped in GAIA-CLIM.

Atmospheric	Oceanic	Terrestrial
Temperature	Sea Surface Temperature	Snow cover
Water vapour	Sea Surface Salinity	*Fraction Available Photosynthetic Absorption of Radiation*
Carbon dioxide		*Spectral albedo*
Methane		*Leaf Area Index*
Ozone		
Aerosols		
Carbon Monoxide		
Formaldehyde		
Nitrogen Dioxide		
VOCs		
Black and brown carbon		

All the above described information have been collected using the official advertising channels for each of the reviewed networks (website, official documents, mails to the PIs).

The review includes:

1. surface in-situ network (along with tower measurements),
2. surface ground based columnar networks.
3. surface ground based profiling networks.
4. airborne in situ measurements.

In Table 2, all the existing sub-orbital capabilities reviewed in this first stage are identified for each domain and for each ECV:
This preliminary geographical review provided the WP1 members with a good insight to each considered network supporting the formulation of the gaps reported in the D1.1. This geographical review will enable EO providers and users to maximize the value of existing observations and forms the basis for the mapping facility developed under Task 1.3 and to be delivered at month 24. The Table 2 will be upgraded anytime in next 18 months, before its completion and official delivery within D1.5 any missing network is missing in the mosaic of the global sub-orbital observing system will be highlighted.

Table 2: list of the sub-orbital observing capabilities reviewed in the frame of GAIA-CLIM WP1; they are identified for each domain and for each ECV; the networks with a missing reference to the website have been classified according to the description of the official reports of the GAW and of the WMO.

Atmospheric (surface-based)	**Networks**	**Techniques or measurement type**	**website**
Temperature (PROFILE)	MESONET	Acoustic Sounding Systems	www.mesonet.org
	MWRnet	Microwave radiometer	cetemps.aquila.infn.it/mwrnet/
	NDACC	Lidar (Rayleigh/Raman)	www.ndsc.ncep.noaa.gov/
	EARLINET	Lidar (Rotational Raman)	www.earlinet.org
	ARM program	Lidar (Rotational Raman)	www.arm.gov
	GRUAN	Sonde	www.gruan.org
	GUAN	Sonde	www.wmo.int/pages/themes/climate/climate_data_management_exchange.php
	RAOB	Sonde	www.raob.com
Temperature (SURFACE)	International Initiative on surface te	Surface sensors	www.surfacetemperatures.org
	GSN	Surface sensors	www.wmo.int/pages/themes/climate/climate_data_management_exchange.php
	RBSN	Surface sensors	www.wmo.int/pages/themes/climate/climate_data_management_exchange.php
	MESONET	Surface sensors	www.mesonet.org
	AMeDAS	Surface sensors	www.jma.go.jp

Atmospheric (surface-based)	Networks	Techniques or measurement type	website
Water vapour (PROFILE)	MWRnet	Microwave radiometer	cetemps.aquila.infn.it/mwrnet/
	NDACC	Lidar (Raman), microwave radiometer	www.ndsc.ncep.noaa.gov/
	EARLINET	Lidar (DIAL, Raman)	www.earlinet.org
	ARM program	Raman lidar	www.arm.gov
	GRUAN	Sonde	www.gruan.org
	GUAN	Sonde	www.wmo.int/pages/themes/climate/climate_data_management_exchange.php
	RAOB	Sonde	www.raob.com
Water vapour (COLUMN)	EPOS	GPS/GNSS	www.epos-eu.org
	IGS	GPS/GNSS	https://igscb.jpl.nasa.gov
	GPSMET	GPS/GNSS	gpsmet.noaa.gov
	SUOMINET	GPS/GNSS	www.suominet.ucar.edu
	MWRnet	Microwave radiometer	cetemps.aquila.infn.it/mwrnet/
	AERONET/PHOTONS	Sun photometer	aeronet.gfsc.nasa.gov
	SKYNET	Sun photometer	atmos2.cr.chiba-u.jp
	SURFRAD	Sun photometer	www.esrl.noaa.gov/gmd/grad/surfrad/sitepage.html
	Polar AOD network	Star photometer	www.ipy.org/index.php?ipy/detail/polar_aod/
	NDACC	FTIR, AERI, microwave radiometer	www.ndsc.ncep.noaa.gov/
	ARM	FTIR, AERI	www.arm.gov
	GRUAN	Sonde	www.gruan.org
	GUAN	Sonde	www.wmo.int/pages/themes/climate/climate_data_management_exchange.php
	RAOB	Sonde	www.raob.com
Water vapor (SURFACE)	Int. Initiative on surface temperatu	Surface sensors (?)	www.surfacetemperatures.org
	MESONET	Surface sensors (?)	www.mesonet.org
Ozone (PROFILE)	NDACC	DIAL, FTIR, microwave radiometer	www.ndsc.ncep.noaa.gov/
	Int. Ozone sonde iniziative	Ozonesondes	www.wmo.int/pages/themes/climate/climate_data_management_exchange.php
	SHADOZ	Ozonesondes	croc.gsfc.nasa.gov/shadoz
	EUBREWNET	Brewer - Dobson	www.eubrewnet.org/
	WOUDC	Brewer - Dobson	woudc.org
	NDACC	Brewer - Dobson	www.ndsc.ncep.noaa.gov/
	ARM	Ultraviolet photometry in a dual absorption cell	www.arm.gov
	NOAA ESRL		http://www.esrl.noaa.gov/
	COST Action 726	Multiband Radiometers: Harmonization of Global UVI and	http://www.cost726.org/
Atmospheric (surface-based)	**Networks**	**Techniques or measurement type**	**website**
Aerosols (PROFILE)	ADNET	variuos type	http://www-lidar.nies.go.jp/AD-Net/
	ALINE/LALINET	Backscatter lidar	http://lalinet.org/index.php/Aline/Commitment
	CISLiNet	Backscatter lidar	http://www.cis-linet.basnet.by/
	CORALNet	Backscatter lidar	http://aerocanonline.com/CoralNetwiki/index.php?
	CREST	Backscatter lidar	http://crest.ccny.cuny.edu
	EARLINET/ACTRIS	Lidar	www.earlinet.org
	GAW GALION	Various lidar types	http://alg.umbc.edu/galion/
	NDACC	sonde,backscatter lidar	www.ndsc.ncep.noaa.gov/
	MPLnet	MPL backscatter lidar	http://mplnet.gsfc.nasa.gov/

Atmospheric (surface-based)	Networks	Techniques or measurement type	website
Aerosols (COLUMN)	ACTRIS/AERONET/PHOTONS	Sun photometer	www.actris.org
	SKYNET	Sun photometer	http://atmos2.cr.chiba-u.jp/skynet/
	GAWPFR	Precision Filter Radiometers	http://www.pmodwrc.ch/worcc/
	BoM Radiometers	CCN concentration, light scattering and absorption coefficient, inorganic components, number concentration, and condensation	
	SURFRAD	Sun photometer	http://www.esrl.noaa.gov/gmd/grad/surfrad/
	AEROCAN	Sun photometer	http://www.aerocanonline.com/
	AGSNET	Sun photometer	http://www.csiro.au/en/Research/OandA/Areas/Assessing-our-climate/Aerospan-aerosol-characterisation
	CARSNET	Sun photometer	
	GAW AOD	Sun photometer	http://www.wmo.int/pages/prog/arep/gaw/aerosol.html
	ESRL GMD	Sun photometer	http://www.esrl.noaa.gov/gmd/
	Polar AOD network	Star photometer	
	BSRN	Radiometers	http://www.bsrn.awi.de/
	SibRAD	Sun photometer	
	German AOD network	Sun photometer	
Aerosols (IN-SITU)	ACTRIS	in-situ aerosol pollutants	www.actris.org
	EMEP	in-situ aerosol pollutants	www.emep.org
	BMKG	PM10 and scattering coefficient	http://www.bmkg.go.id/BMKG_Pusat/Home.bmkg
	MMS	in-situ aerosol pollutants	
	DUSTNET	TSP mass by HiVol sampler	
	ANSTO	particulate mass, chemical speciation, optical physical properties	http://www.ansto.gov.au/
	CAPMoN	in-situ aerosol pollutants	http://www.ec.gc.ca/rs-mn/default.asp?lang=En&n=752CE271-1
	CASTNET	in-situ aerosol pollutants	http://epa.gov/castnet/javaweb/index.html
	CAWNET	PM10 (some sites include PM2.5, PM1), visibility, aerosol light absorption and aerosol light scattering.	https://www.cma.gov.cn/english/
	EANET	Acid Deposition and Oxidant Research	http://www.eanet.asia/
	EIONET	in-situ aerosol pollutants	https://www.eionet.europa.eu/
	GAW in-situ	in-situ aerosol pollutants	http://www.wmo.int/pages/prog/arep/gaw/aerosol.html
	IDAF	in-situ aerosol pollutants	http://idaf.sedoo.fr/spip.php?rubrique3
	IMPROVE	in-situ aerosol pollutants	http://vista.cira.colostate.edu/improve/
	NAPS	in-situ aerosol pollutants	http://www.ec.gc.ca/rnspa-naps/
	NIES-AGAGE-SOGE	in-situ aerosol pollutants	https://www.nies.go.jp/index-e.html
	ESRL GMD	in-situ aerosol pollutants	http://www.esrl.noaa.gov/gmd/
	IDAF (Africa)	in-situ aerosol pollutants	http://idaf.sedoo.fr/spip.php?rubrique3
	NADP	in-situ aerosol pollutants	http://nadp.sws.uiuc.edu/
	SMEAR	in-situ aerosol pollutants	https://www.atm.helsinki.fi/SMEAR/
Carbon Monoxide (COLUMN)	IG3IS (GAW)	Various tehcniques (ground-based, ships, aircraft)	https://www.wmo.int/pages/prog/arep/gaw/ghg/IG3IS-info.html
	NDACC	FTIR	www.ndsc.ncep.noaa.gov/
	TCCON	FTIR	https://tccon-wiki.caltech.edu/Sites
	ESRL GMD	surface (various types)	http://www.esrl.noaa.gov/gmd/
Carbon dioxide (COLUMN)	SCRIPPS C02 program	in-situ	http://scrippsco2.ucsd.edu/
	IG3IS (GAW)	(ground-based, ships, aircraft)	https://www.wmo.int/pages/prog/arep/gaw/ghg/IG3IS-info.html
	TCCON	FTIR	https://tccon-wiki.caltech.edu/Sites
	ICOS	laser absorption based analyzers	www.icos-ri.eu
	InGOS	Various types	www.ingos-infrastructure.eu
	RAMCES	surface (various types)	www.andra.fr
	ESRL GMD	surface (various types)	http://www.esrl.noaa.gov/gmd/

Atmospheric (surface-based)	**Networks**	**Techniques or measurement type**	**website**
Methane (COLUMN)	IG3IS (GAW)	(ground-based, ships, aircraft)	https://www.wmo.int/pages/prog/arep/gaw/ghg/IG3IS-info.html
	NDACC	FTIR	www.ndsc.ncep.noaa.gov/
	TCCON	FTIR	https://tccon-wiki.caltech.edu/Sites
	ICOS	laser absorption based analyzers	www.icos-ri.eu
	InGOS	Various types	www.ingos-infrastructure.eu
	RAMCES	surface (various types)	www.andra.fr
	ESRL GMD	surface (various types)	http://www.esrl.noaa.gov/gmd/
Formaldehyde	NDACC	MAX-DOAS, FTIR	www.ndsc.ncep.noaa.gov/
Nitrogen Dioxide (COLUMN)	IG3IS (GAW)	(ground-based, ships, aircraft)	https://www.wmo.int/pages/prog/arep/gaw/ghg/IG3IS-info.html
	NDACC	FTIR, MAX-DOAS	www.ndsc.ncep.noaa.gov/
	RAMCES	surface (various types)	www.andra.fr
VOCs (COLUMN)	NDACC	FTIR (several VOC including HCHO), MAX-DOAS (onlyHCHO and glyo	www.ndsc.ncep.noaa.gov/
Atmospheric (airborne)	**Networks**	**Techniques or measurement type**	**website**
Temperature, Water vapor, aerosol, ozone, other trace ga	E-AMDAR	in-situ	www.eumetnet.eu/e-amdar
Temperature, Water vapor, aerosol, ozone, other trace ga	IAGOS	in-situ	**www.iagos.org**
Ocean	**Networks**	**Techniques or measurement type**	**website**
Temperature and salinity	ARGO	Floats	www.argo.org
Land	**Networks**	**Techniques or measurement type**	**website**
Surface Albedo and fluxes	FLUXNET	in-situ	http://fluxnet.ornl.gov/