GAIA-CLIM WP1.2
“Mapping geographical capabilities”

Lead: CNR

Involved: BIRA, MO, BKS, KNMI, FMI, UNIBRE, MPG, UHEL

Start: month 1; Complete: month 18

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This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 640276.

WP1.2: Objectives

- To provide a geographical identification, at European and at the global scale, of current surface-based, balloon-based and airborne observing capabilities on an ECV by ECV basis for parameters which can be obtained using space-based observations from past, present and planned satellite missions.

- Preparation for the creation of a “Virtual Observatory” of ground based and satellite data by establishing common formats for metadata.

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Task 1.2: Geographical capabilities mapping

- Review at the global scale of 54 plausible networks and 2 aircraft permanent infrastructures for EO Characterisation
- Complete discovery metadataset (ISO19115 format) collected for all the stations belonging to 49 of the 54 networks.
- Observation metadata format identified for the VO: Unified metadata format (UMF) with conversion tool to WIGOS, CFNetCDF and NASA-Ames formats.
- Data and metadata test cases provided for EARLINET, NDACC ozonesondes, GRUAN.

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Maturity matrix collection

In addition, the discovery metadataset includes the scores of all the maturity matrices (e.g. deliverable D1.3) collected for each of the reviewed networks:

- Collected scores are representative of the level of maturity of each network (i.e core stations and operations).

- A further granuality of the assessment would be possible but not practical within the time and resource constraints available.

- It has not been possible to classify a small number of additionally identified potential target networks using the MMA. In most cases this was because network PIs have not yet been forthcoming with the required information to complete the assessment. However, overall about 75% of the expected assessments have been successfully collected and statistically investigated.

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Maturity Matrix Assessment: statistics

The maturity matrix assessment applied to the networks reviewed under Task 1.2 shows an overall medium-high level of maturity (scores > 4) in the following categories of the maturity matrix:

- Metadata: improvements must still be targeted at the creation and curation of collection level information (e.g. enhanced or complete discovery metadata);
- Sustainability: continued operations can be envisaged given national and international funding;
- Documentation: improvements required towards the adoption of formal measurement user guidance, the regular update by data providers with instrument/method of measurement updates and/or new validation results, the availability in peer-reviewed literature of measurement description and examples of data usage;

The reviewed networks have an overall medium level of maturity (scores 3 - 4) in the following categories:

- Uncertainty: robust uncertainty quantification and comparability must be improved to be considered reference quality measurements; more mature approach is adopted in the frame of networks measuring aerosols, water vapour and ozone;
- Public access, feedback and update: heterogeneous scenario, a large effort must be spent to assess shortcomings in user feedback mechanisms and version control.

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Maturity matrices

Measurement type		surface	profile	profile	column	column	column	surface	profile	column	profile	surface	surface	column	column	column	column	profile	surface	profile	In situ & tower	column	surface	surface	profile	profile, column	profile, column	profile	profile	column	surface	aircraft	profile	surface	surface	surface	profile	column	column	column	profile	surface	column, profile
ECV		AEROSOL, NO2	AEROSOL	AEROSOL	AEROSOL, WATER VAPOR	AEROSOL, WATER VAPOR	AEROSOL, WATER VAPOR	TEMPERATURE	TEMPERATURE, SALINITY	AEROSOL,O3	AEROSOL	AEROSOL	AEROSOL	WATER VAPOR	AEROSOL, WATER VAPOR	AEROSOL	WATER VAPOR	TEMPERATURE, WATER VAPOR	TEMPRATURE	TEMPERATURE, WATER VAPOR	CO, CO2, CH4	WATER VAPOR	AEROSOL	TEMPERATURE, WATER VAPOR	AEROSOL	TEMPERATURE, WATER VAPOR	CO,CH4, NO2,O3 ,WATER VAPOR	WATER VAPOR	O3	O3	O3	O3	TEMPERATURE, WATER VAPOR	TEMPERATURE	CO2	O3	AEROSOL,NO2,O 3,TEMPERATURE ,WATER VAPOR	AEROSOL,CO2,C O,CH4,NO2,O3,T EMPERATURE, WATER VAPOR	WATER VAPOR	AEROSOL	CO2,CH4	O3	TEMPERATURE, WATER VAPOR	O3
	Security	1	1	5				5			5			1	4		5			4		1	5			5						4	?		2			5		1		
	Portability and Numerical Reproducibility	1	1	6				4			6	5		1	6		6			3		1				3	4	3				3	?		5	6		5	2	5		
	Software Documentation	2	2	6				5		6	6	5		1	6		6		5	5		1				3	4	4				5	5		5	6		4	2	2	4	4
SOFTWARE READINESS	Coding standards	3	5	6				6	6		6	3						3	5	6							2	4	3				6	5		6			5	3	5	5	4
	Programmatic support	6	6	6	5	5	5	6	6	6	6	6	5	6	5	5	5	5	6	5	5	6	5	4	5	6	4	4	5	4	4	4	5	6	3	5	4	5	6	2	3	3	4	4
	Scientific / expert support	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	4	4	4	5	5	5	4	5	2	5	6	4	5	5	5	3	4	4	5	4	5	6	5	5	3	5	3
SUSTAINABILITY	Siting environment	5	5	5	6	6	6	4		6	5	6	6	6	6	5	6	4	3	5	5	6	6	5	6	6	4	5	5	5	5	5	3	3	5	5	5	6	6	3	5	4	4	4
	Public and commercial exploitation	4	4	4	5	5	5	6	3	3	4	5	4	6	2	2	4	3	3	5			6	4	3	3	5	6					3	3		6	2	5	6	3	6			6
USAGE	Research	5	3	5	5	5	5	6	5	5	5	6	6	6	4	5	5	4	4	5	5	5	6	2	2	6	5	6	5	5	5	5	4	2	2	5	4	5	6	4	5	4	5	6
	Long-term data preservation	5	5	6	5	5	5	5			6	5	5	6	3	5	3	3	2	2	5	5	5	6	6	4	6	5	5	5	5	5	4	3	4	5	5	3	5	5	3	4	4	6
	Version control	3	3	6	5	5	5	6			6	4	5	6	3	6	3	2	2	1	1	5	6	3	6	5	5	4	3	4	2	4	3	3	2	4	4	3	6	6	2	5	6	4	4
	Updates to Record	4	5	5	6	6	6	6	6	6	5	4	5	6	3	4	6	6	6	1	1	6	5	5	6	2	6	6	4	5	5	5	6	6	6	6	5	6	6	6	6	5	6	4
	User Feedback Mechanism	4	4	6	5	5	5	5	4		6	2	5	6	2	2	6	3	3	2	6	6	3	2	5	4	4	6	4	4	4	4	2	2	6	6	4	5	6	3	6	4	5	6
PUBLIC ACCESS, FEEDBACK, AND UPDATE	Public Access/Archive	4	6	6	5	6	6	4	6	6	6	5	6	6	4	5	6	6	6	1	1	6	6	1	6	4	4	5	6	4	5	6	5	6	6	6	5	6	6	5	6	5	6	5
	Routine Quality Monitoring	4	4	5	6	6	6	5	6	6	5	5	6	5	5	5	6	5	5	2	4	6	6	2	5	4	4	6	4	5	6	4	5	5	4	6	5	6	6	5	6	3	4	5
	Uncertainty quantification	5	5	5	3	3	3	5	2		5	5	5	5	3	2	3	3	3	3	4	5	4	1	6	4	4	4	2	1	2	1	3	3	2	4	4	3	5	5	3	4	5	6
	Comparability	4	4	4	5	5	5	5	3	6	4	5	6	4	3	5	3	3	3	6	5	5	6	2	3	4	3	5	4	3	4	3	3	3	2	2	4	5	5	4	4	3	4	4
UNCERTAINTY CHARACTERISATION	Traceability	4	5	5	5	5	5	6	4	6	5	5	5	4	4	4	4	3	3	3	5	5	5	1	3	3	4	5	3	3	4	3	4	5	3	2	2	5	6	4	5	4	5	4
	Formal Measurement series User Guidance	4	4	5	5	5	5	5	4	6	5	5	6	4	4	4	6	3	3	3	2	5	6	2	3	3	2	6	3	3	4	3	3	3	2	2	2	5	6	4	5	4	5	4
	Formal Validation Report	4	4	6	5	4	4	6	4	5	6	6	5	5	4	5	6	3	3	3	5	5	6	1	2	3	2	5	3	4	4	4	4	5	4	2	2	5	6	4	5	4	5	4
DOCUMENTATION	Formal description of measurement methodology	3	5	5	6	6	6	6	6	5	5	3	5	5	3	5	6	3	3	1	4	5	6	1	5	4	3	5	3	3	4	3	3	5	3	2	2	5	6	4	5	4	5	4
	File level	5	5	5	5	5	5	5	5	5	5	3	5	5	4	5	5	4	5	4	5	5	5	4	5	5	4	5	2	3	4	3	2	4	5	2	3	4	5	3	4	3	4	3
	Collection level metadata (including change records)	5	5	6	3	3	3	6	6	6	6	4	2	6	6	6	6	5	6	5	3	6	6	4	5	3	6	6	4	5	6	5	3	4	3	4	5	5	6	3	4	4	5	4
METADATA	Standards	5	6	6	4	4	4	5	6	6	6	3	5	6	6	6	6	5	6	6	6	6	6	5	6	6	6	6	5	6	6	6	2	3	4	4	4	5	5	4	5	4	5	5
NETWORK		ACTRIS surface	ACTRIS profiles	ADNET	AEROCAN	AERONET_PHOTONS	AGSNET_CSIRO	AMeDAS	ARGO	BSRN	EARLINET	EMEP	EPA	EUREF	EUROSKYRAD	GAWPFR	GPSMET	GRUAN	GSN	GUAN	ICOS (including InGOS)	IGS	IMPROVE	MESONET	MPLnet	MWRnet	NDACC	NOAA ESRL WV profiles	NOAA ESRL O3 profiles	NOAA ESRL O3 dobson	NOAA ESRL O3 in-situ	NOAA ESRL O3 aircraft	RAOB	RBSN	SCRIPPS CO2 program	SHADOZ	SKYNET	SMEAR	SUOMINET	SURFRAD	TCCON	TOLNET	USCRN	WOUDC

The maturity assessments carried out above were performed under the auspices of GAIA-CLIM, http://www.gaia-clim.eu/page/maturity-matrix-assessment, in September 2016. They assess certain quantifiable aspects of typical measurement system maturity across each network for those ECVs and associated measurement systems that are relevant to GAIA-CLIM, www.gaia-clim.eu.

Users should be aware that this is a first effort to systematically quantify measurement system performance. Redundant assessments suggest a minimum uncertainty arising from assessor-to-assessor variations in any category of at least 1 score. Although the assessment may be useful to certain applications; at this time and until it is more broadly tested it should not constitute a primary or unique decision-making tool.

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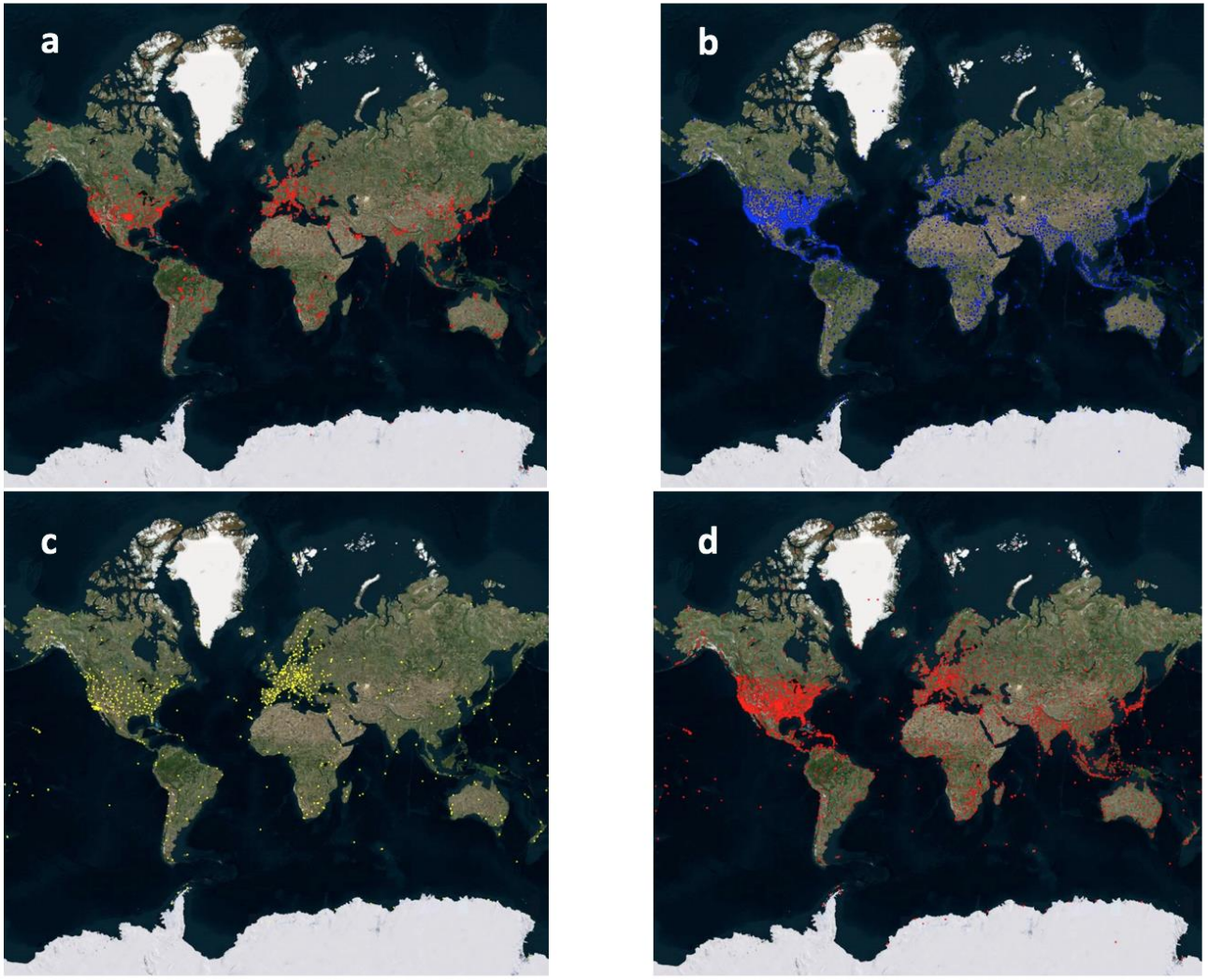
Maturity of existing capabilities



Upper left panel (a), water vapour networks classified as "Comprehensive" according to the MMA for the category "Uncertainty";
upper right panel (b), networks classified as "Baseline";
lower left panel (c), networks classified as "Reference";
lower right panel (d), all the networks measuring water vapour at the global scale.

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Redundancy exercise

Compilation of the matrix for the same network by at least three persons for five networks (EARLINET, GRUAN, TCCON, AERONET, NDACC), the most well represented by the GAIA-CLIM partners.

An average uncertainty in the attribution of the maturity matrix scores among the selected compilers of ±1 for a given sub-category. This can be considered as the minimum possible quantification of the level of objectivity of the MMA.

TCCON Maturity Matrix redundancy exercise (marked fields show differences > 1)

Metadata	Documentation	Uncertainty characterization	Public access, feedback and update	Usage	Sustainability	Software (optional)
Standards 6, 4, 5, 4	Formal Description of Measurement Methodology 5, 6, 6, 3	Traceability 6, 5, 5, 5	Access 5, 5, 5, 4	Research 5, 6, 6, 5	Siting environment 4, 2, 3, 4	Coding standards 1, 5, 4, 3
Collection level 6, 4, 6, 3	Formal Validation Report 6, 5, 4, 1	Comparability 5, 5, 4, 4	User feedback mechanism 4, 4, 4, 6	Public and commercial exploitation 6, 6, 5, 5	Scientific and expert support 5, 5, 5, 3	Software documentation 4, 4, 4, 2
File level 5, 5, 5, 5	Formal Measurement Series User Guidance 6, 5, 5, 6	Uncertainty Quantification 5,4,5,5	Updates to record 4, 4, 5, 5		Programmatic support 1, 1, 2, 4	Portability and numerical reproducibility 5, 5, 3, 3
		Routine Quality Management 5, 4, 5, 3	Version control 6, 5, 6, 5			Security 1, /, 2, 1
			Long term data preservation 5, 6, 6, 4			

Scores of the four maturity matrices provided for TCCON.

Suggested rating based on results from redundancy analysis and further investigation (see comments above)

Metadata	Documentation	Uncertainty characterization	Public access, feedback and update	Usage	Sustainability	Software (optional)
Standards 5	Formal Description of Measurement Methodology 5	Traceability 5	Access 5	Research 6	Siting environment 2	Coding standards 4
Collection level 5	Formal Validation Report 5	Comparability 4	User feedback mechanism 4	Public and commercial exploitation 6	Scientific and expert support 5	Software documentation 4
File level 5	Formal Measurement Series User Guidance 5	Uncertainty Quantification 5	Updates to record 5		Programmatic support 1	Portability and numerical reproducibility 5
		Routine Quality Management 5	Version control 6			Security 1
			Long term data preservation 4			

"Official" maturity matrix provided by TCCON applying the described MMA

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Geographical analysis

Density of measurements in 1000 km by 1000 km boxes (about 10°x10° degrees at the equator) for each atmospheric ECV and by different measurement types has been calculated for the number of stations available over seven continental zones: Africa, Europe (includes European North Pole areas), Asia, North America (includes Greenland), South America, Oceania and Antarctica. The cells in red are those where a density less than 1 station per box is found.

	Aerosol			CO2			CO		CH4			
	column	profile	surface	column	profile	surface	profile	surface	column	profile	surface	tower
Africa	3.54	0.10	0.33	0.07	0.00	0.20	0.07	0.20	0.13	0.07	0.20	0.00
Europe	22.62	7.98	26.26	0.91	0.00	2.63	0.61	3.13	1.51	0.61	2.93	1.11
Asia	9.09	1.20	0.89	0.11	0.02	0.27	0.07	0.31	0.16	0.07	0.31	0.00
North America	19.36	0.62	112.63	0.25	0.87	1.49	1.03	14.37	0.41	1.03	1.40	0.00
South America	4.92	0.95	0.06	0.00	0.06	0.28	0.06	0.17	0.00	0.06	0.17	0.00
Oceania	4.52	0.26	4.13	0.39	0.00	1.29	0.39	1.42	0.77	0.39	1.03	0.00
Antarctica	0.98	0.24	0.33	0.00	0.00	0.16	0.00	0.08	0.00	0.00	0.08	0.00
	NO2			**O3**			**Temperature**		**Water Vapor**			
	column	profile	surface	column	profile	surface	profile	surface	column	profile	surface	tower
Africa	0.07	0.07	0.33	1.22	0.76	0.30	8.04	29.77	5.99	8.04	0.00	0.86
Europe	0.71	0.71	2.93	19.90	7.88	0.40	23.13	100.49	60.49	21.81	0.20	22.02
Asia	0.22	0.22	0.40	3.51	1.49	0.31	12.53	63.49	11.67	12.49	0.20	2.02
North America	0.08	0.08	18.79	5.00	5.33	61.06	11.60	46.98	77.29	11.93	13.34	8.01
South America	0.11	0.11	0.00	1.96	1.34	0.00	6.15	29.96	9.00	6.15	0.00	1.51
Oceania	0.39	0.39	0.26	5.03	4.13	0.39	12.64	40.64	16.26	13.16	0.52	3.74
Antarctica	0.33	0.33	0.00	2.77	1.63	0.08	1.39	7.17	1.39	1.30	0.00	0.00

Task 1.4 and task 1.5 will assess these geographical gaps on a robust scientific basis.

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Deliverables

D1.1 – Initial input from WP1 to the gap analysis and impacts document (CNR; M4)
D1.2 - Modelling studies of the impacts of gaps - experimental design (KIT; M7)
D1.3 – Report on system of systems approach adopted and rationale (NUIM; M9)
D1.4 – Review of and input to Gap Analysis and impacts document aspects relevant to WP1 (CNR; M16)
D1.5 - Summary of initial model-based study results and plans for remainder of project (KIT; M16)
D1.6 – Report on data capabilities by ECV and by system of systems layer for ECVs measurable from space. (CNR; M18)
D1.7 – Report on the collection of metadata from existing network and on the proposed protocol for a common metadata format (CNR; M18)
D1.8 – Provision of a 3D tool for the online visualization of existing measurements (CNR; M24)
D1.9 – Final version of a 3D tool for the online visualization of existing measurements (CNR; M30)
D1.10 – Report on the scientific assessment of gaps using a statistical approach based on heteroskedastic functional regression (UniBergamo; M34)
D1.11 - Report on the scientific assessment of gaps based on forward, inverse, and data assimilation modelling frameworks, (KIT, M34)

No.	Task	2015				2016				2017			
		I	II	III	IV	I	II	III	IV	I	II	III	IV
WP1	Geographical Capabilities Mapping		D				D						D
T1.1	Define system of system approach			D									
T1.2	Mapping geographical capabilities						DD						
T1.3	3D tool design for online visualisation								D		D		
T1.4	Statistical assessment of gaps												D
T1.5	Model-based assessment of gaps		D				D						D

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Outlook

- Paper by Thorne et al. close to submission in GI EGU journal (largely based on the work reported in the deliverable D1.6)

- C3S-BARON will establish this work as a permament service for Copernicus but for a restricted ensemble of networks

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QUESTIONS?

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