

Global Mercury Observation System (GMOS)



Mariantonio Bencardino on behalf of the **CNR-IIA** team

with the participating contributions from:

APLBA, Associação dos Pesquisadores do Experimento LBA

AU, Aarhus University

AU IOM, Anna University Institute for Ocean Management

CONICET-Instituto de Investigaciones en Biodiversidad y Medio Ambiente

CVGZ, Global Change Research Institute

EPA, Environmental Protection Agency

HZG, Helmholtz-Zentrum Geesthacht

IFREMER, Institut Francais de Recherche pour l'Exploitation de la MER

IGCAS, Institute of Geochemistry, Chinese Academy of Science

INTEC, Instituut voor Toegepast Technologisch Onderzoek

IVL, Swedish Environmental Research Institute

JME, Japan Ministry of Environment

JRC, Joint Research Centre

JSI, Jožef Stefan Institute

MU, Macquarie University, Sydney, Australia

NILU, Norwegian Institute for Air Research

SAWS, South African Weather Service

SPBSU, St. Petersburg State University

UJF-LGGE, Université Joseph Fourier

UNAM, Universidad Nacional Autònoma de México

UNIVE, University Ca' Foscari of Venice

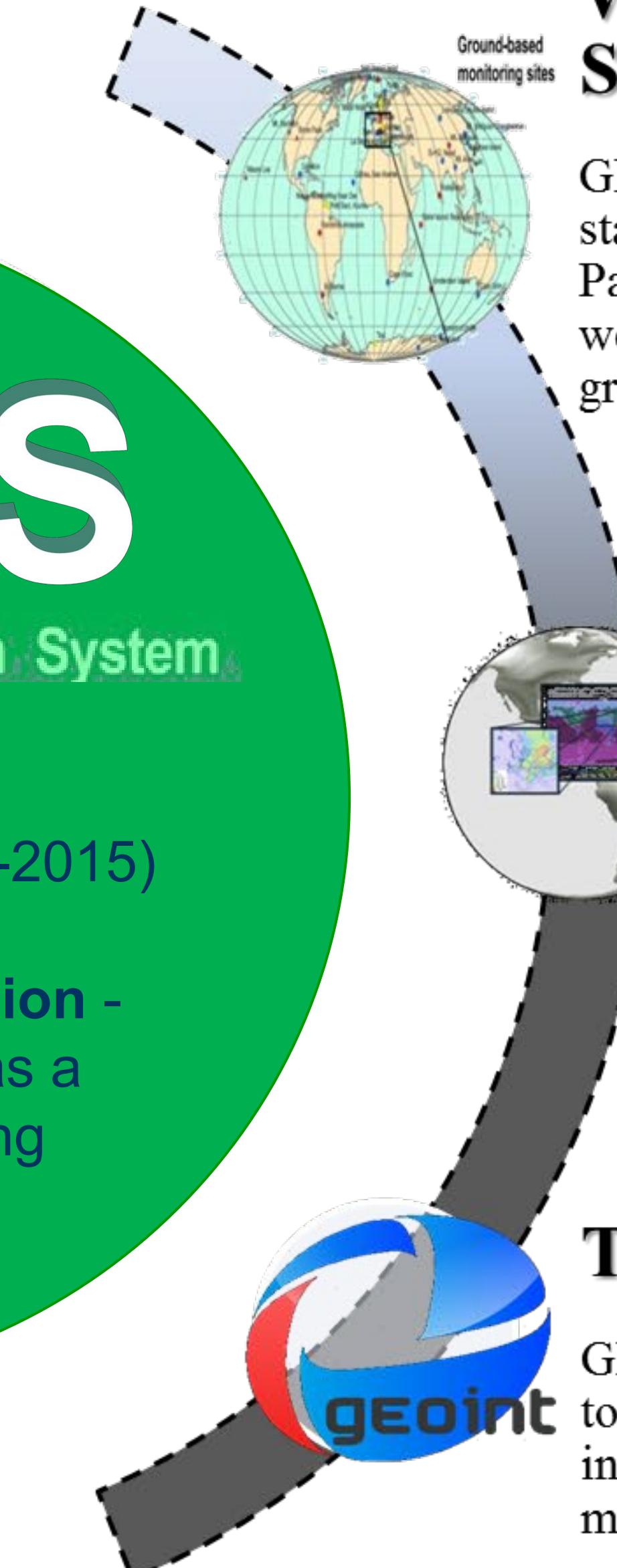
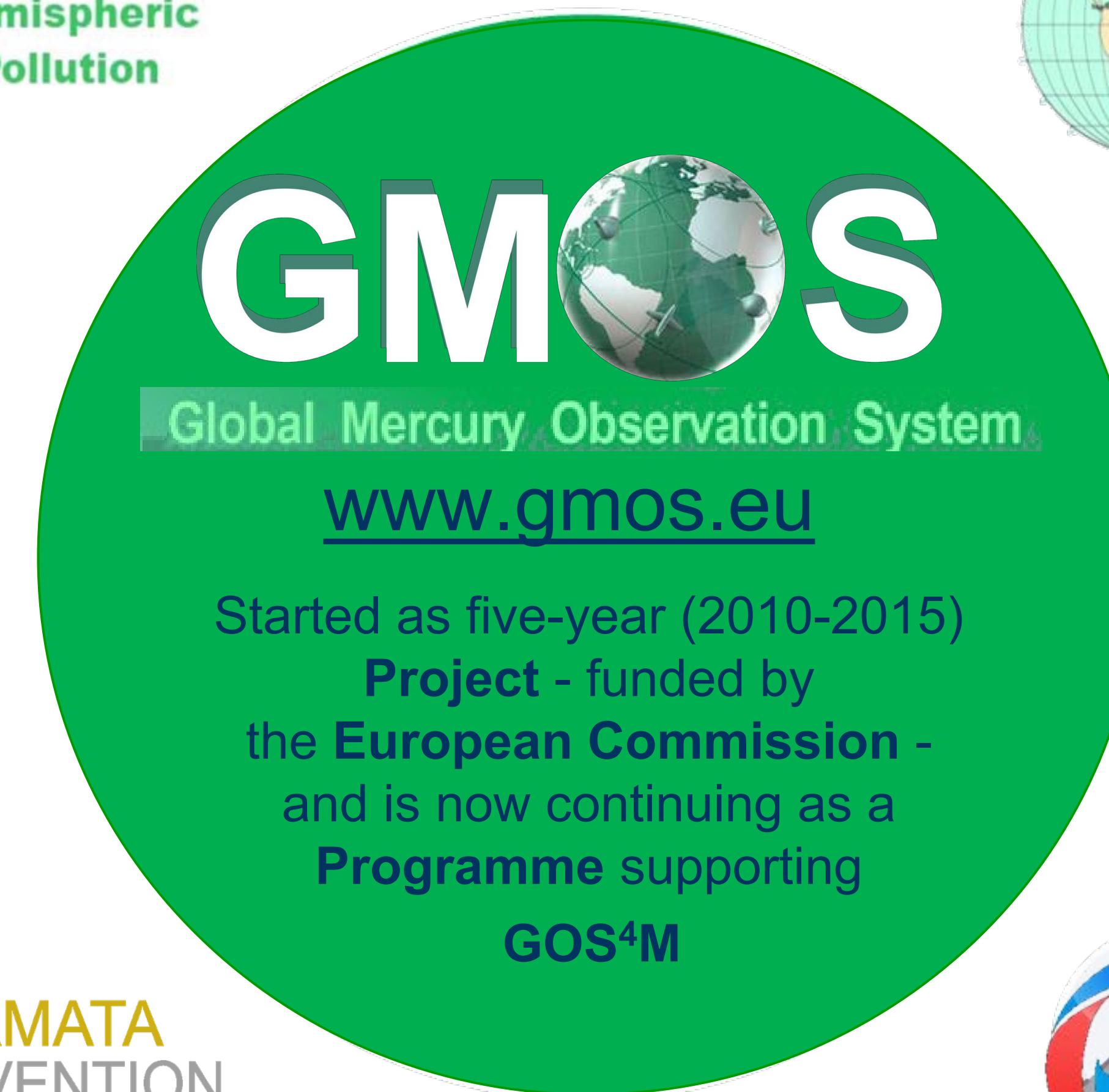
UoW, University of Washington

UoY, University of York

The International Framework



Task Force on Hemispheric Transport of Air Pollution



WORLDWIDE OBSERVATION SYSTEM

GMOS includes ground-based monitoring stations, ship-based measurements over the Pacific and Atlantic Oceans, European Seas, as well as aircraft-based measurements from the ground to the lower stratosphere

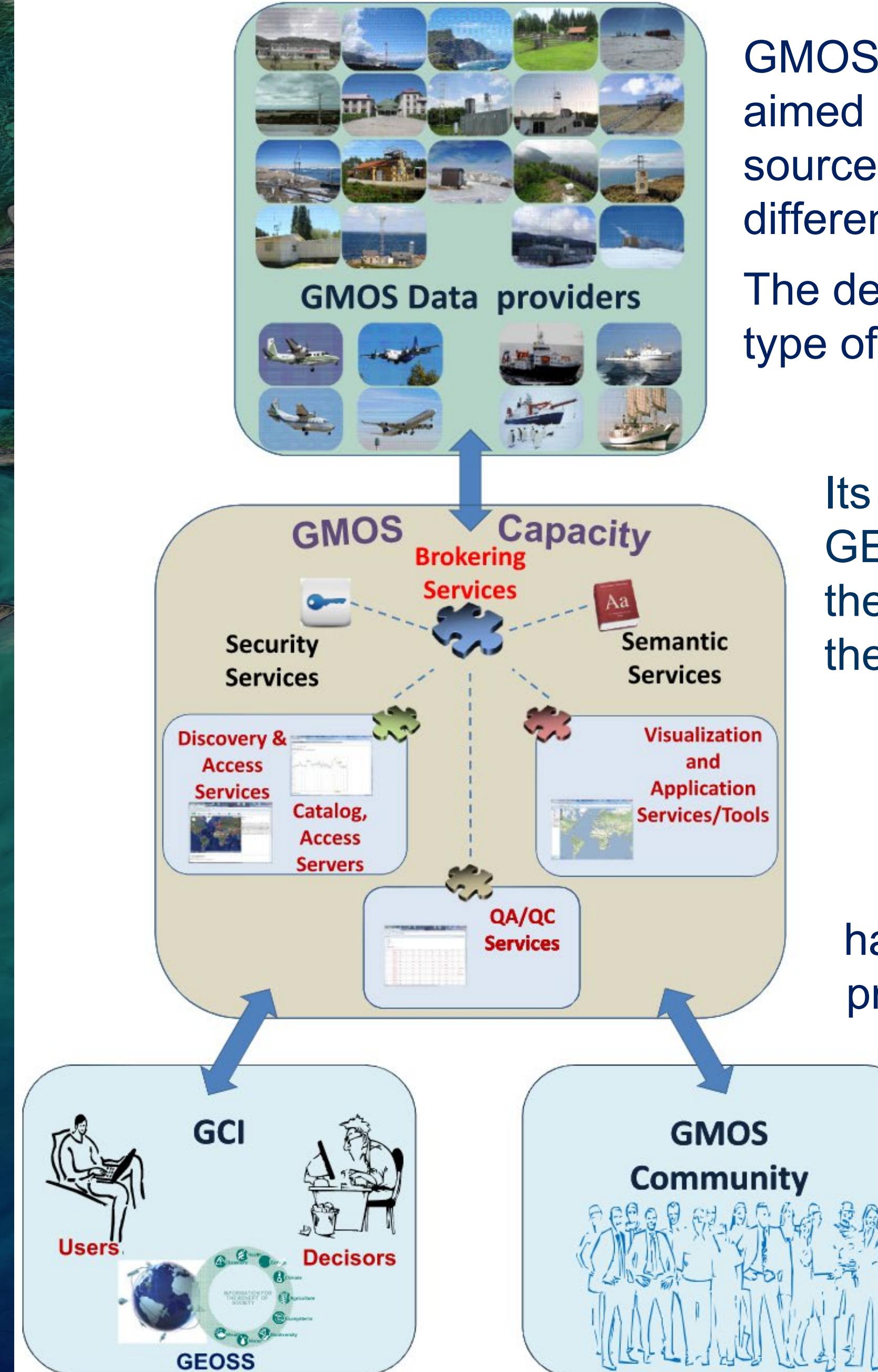
MODELLING

GMOS data are used to test regional and global scale atmospheric mercury models, which can then be used for determining mercury deposition to ecosystems and the current state of atmospheric mercury contamination.

THE INTEROPERABLE SYSTEM

GMOS developed an interoperable system to facilitate the sharing of information, including measurement databases and modelling results, with major stakeholders, policymakers and the public.

The GMOS Information & Communication Technologies System



GMOS network provides to the community an ICT System aimed to share information and data coming from different data sources (measurements, sensors, models, ecc) requiring a different information structure to be stored and used.

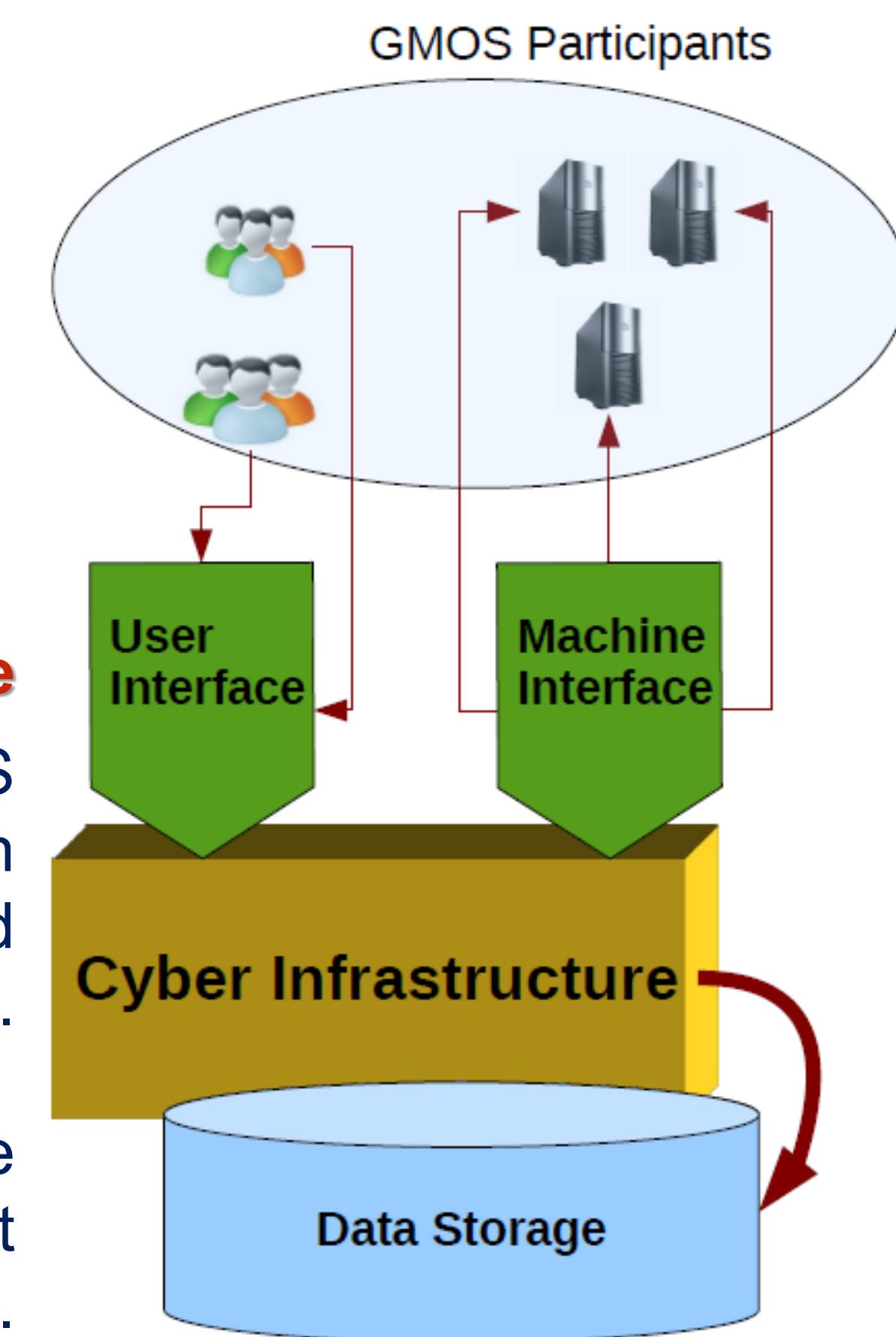
The design of GMOS ICT System is oriented to manage both type of data in a single infrastructure.

Its architecture provides interactions between the GEOSS Common Infrastructures (GCI), the GMOS Community, and the GMOS monitoring network.

The Cyber Infrastructure

It manages and stores data and is the core of GMOS having a simple Web Interface through which users can produce metadata (following INSPIRE scheme), upload data, and assign rights to their data.

The Cyber Infrastructure plays an important role about data integration through different GMOS partner and users.





Land-based Monitoring Sites



DATABASES

GMOS



Oceanographic Campaign Measurements



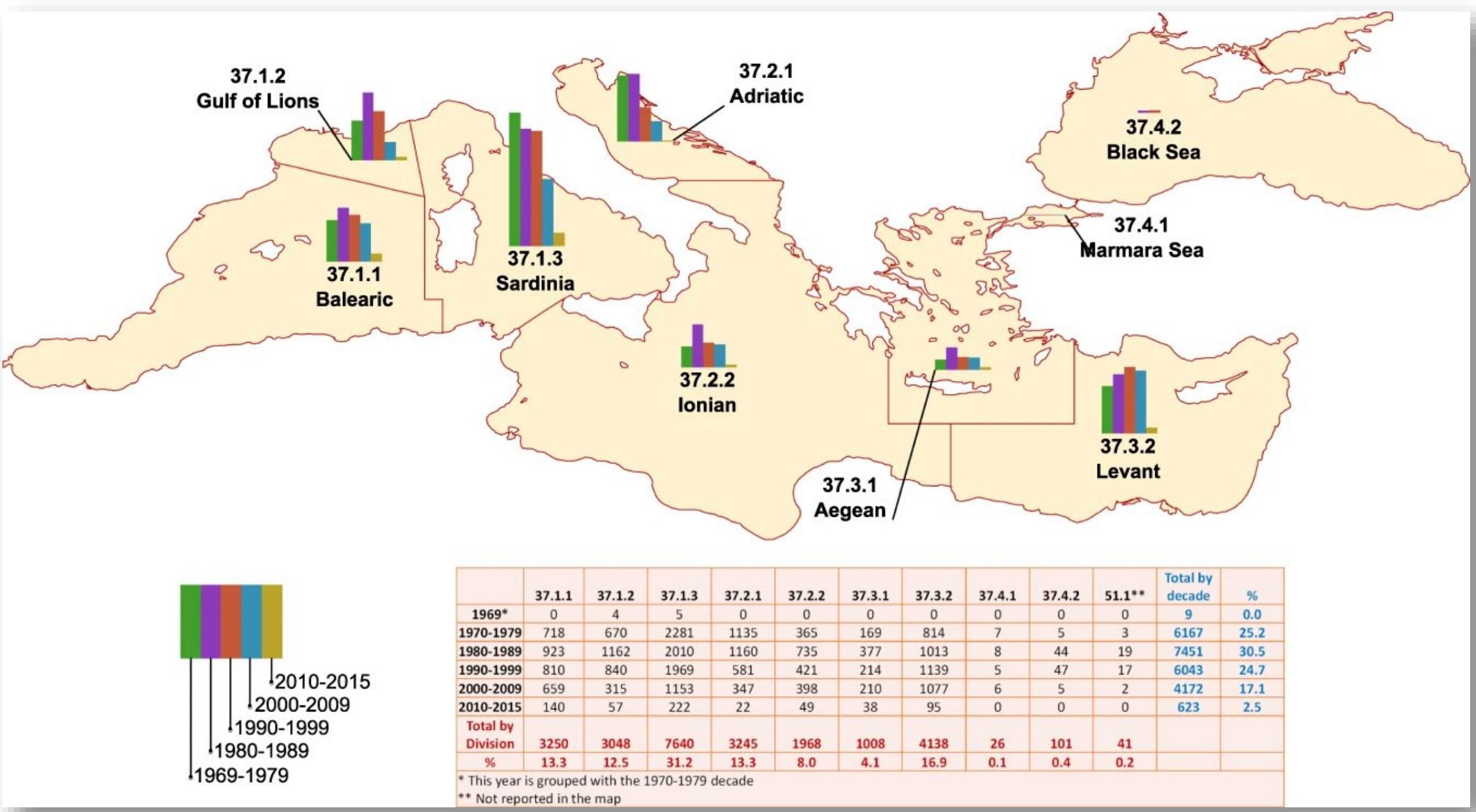
Passive Network



Aircraft Measurement Campaigns



Work in progress: Database on Marine and Freshwater Biota



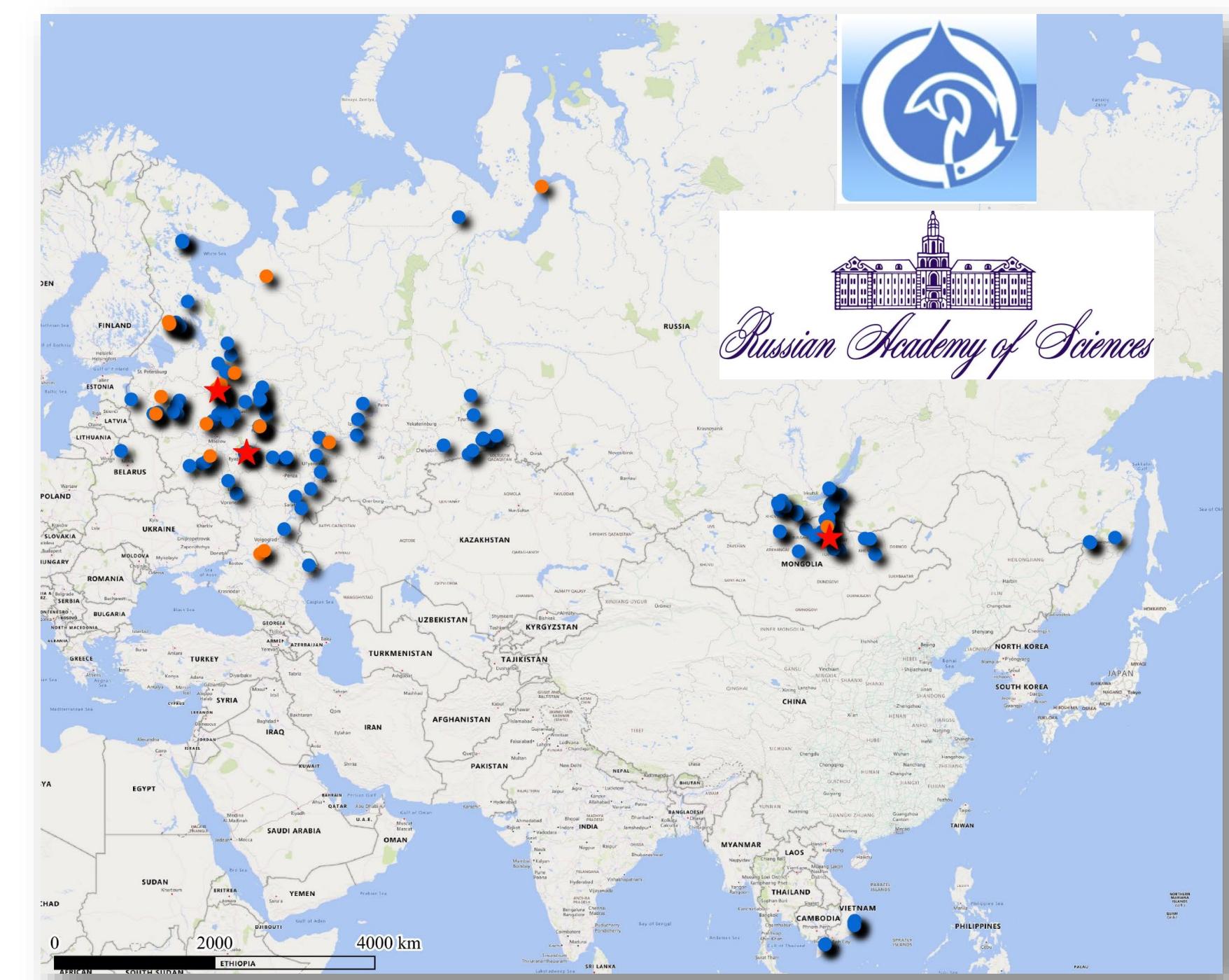
Mercury in Marine Biota provided by Cinnirella et al., 2019

Forty years of biota monitoring in the Mediterranean basin. Existing peer-reviewed literature and datasets on mercury concentration in marine flora and fauna (Animal, Plants and Chromista Kingdoms) have been retrieved for a total of 24,465 records from 539 sources.

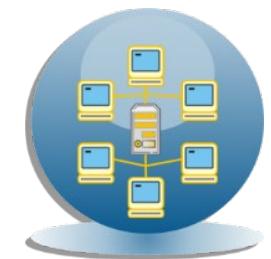
Mercury in Freshwater Biota provided by Komov et al., 2014, 2016

Since 1989

5000 fish specimens were analyzed from 102 lakes and 35 rivers of Russia, Mongolia, Belarus, and Vietnam, by the Papanin Institute for Biology of Inland Waters, and the Russian Academy of Sciences.



SERVICES



G-Data Acquisition

User Amore francesco Logout | List source View Logs

Data Sources

Name	Station Code	Organization	Country	Data Selection
Amsterdam Island	AMS	LGGE-UGF	TAAF	Data Selection
Calhau Sao Vincente	CAL	University of York/NMIG	Cape Verde	Data Selection
Cape Point	CPO	SAWS	South Africa	Data Selection
Dumont d'Urville	DDU	CNR-IIA; LGGE-UGF	Antarctica	Data Selection
Dome-C, Antarctica	DOC	CNR-IIA; LGGE-UGF	Antarctica	Data Selection
Ev-K2	EVK	CNR-IIA	Nepal	Data Selection
Longobucco	LON	CNR-IIA	Italy	Data Selection
Manaus	MAN	LBA	Brazil	Data Selection
Mace Head	MHE	Helmholtz-Zentrum Geesthacht	Ireland	Data Selection
La Seyne-sur-Mer	LSM	IFREMER	France	Data Selection
Station Nord	STN	Aarhus University	Denmark	Data Selection



G-Stat

STATISTICS

sd.liia.cnr.it/geoint/publicpage/GMOS/statistics/gmmostat.zul

Bencardino Mariantonio Logout Report GMOS-CI Home

DO NOT TOUCH

Data Sources

Name	Station Code	Organization	Country	First Meas	Last Meas	Last Update
Alert	ALE	Environment Canada	Canada			
Amsterdam Island	AMS	LGGE-UGF	TAAF (France)	2012-10-27 00:00:00	2015-11-08 23:55:00	2015-11-11 15:52:47.0
Auchencorth Moss	ACM	CEH	United Kingdom			
Bariloche	BAR	Inibioama-Conicet	Argentina	1999-12-31 00:03:40	2019-09-25 11:25:00	2019-11-19 14:34:29.0
Calhau Sao Vincente	CAL	Cape Verde	UoY/NMIG	1118-11-13 15:30:00	2020-03-26 20:30:00	2020-03-27 23:12:53.0
Cap Ferrat	CFE	IFREMER	France			
Cape Grimm	CGR	IVL	Australia	NO DATA	NO DATA	NO DATA

aqp-16-11915-2016.pdf | gdqm.png | statistic_on.png | printpdf.png | Report (1).pdf | humans_on.png

It is a GMOS **web-component** designed to collect data coming from GMOS stations. It permits automatic data integration on the GMOS Cyber Infrastructure.

The G-DQM system is a **web-based service** with real-time adaptive monitoring procedures aimed at preventing the production of poor-quality data



G-Data Quality Management System

sta in Arrivo Abstract Submission DATA SOURCE

sd.liia.cnr.it/gdqm/user/usermainpage.zul

Bencardino Mariantonio Logout Parameters

Data View

Set Automated Flag | Reset Automated Flag | Save Manual Flag | Set Null Manual Flag

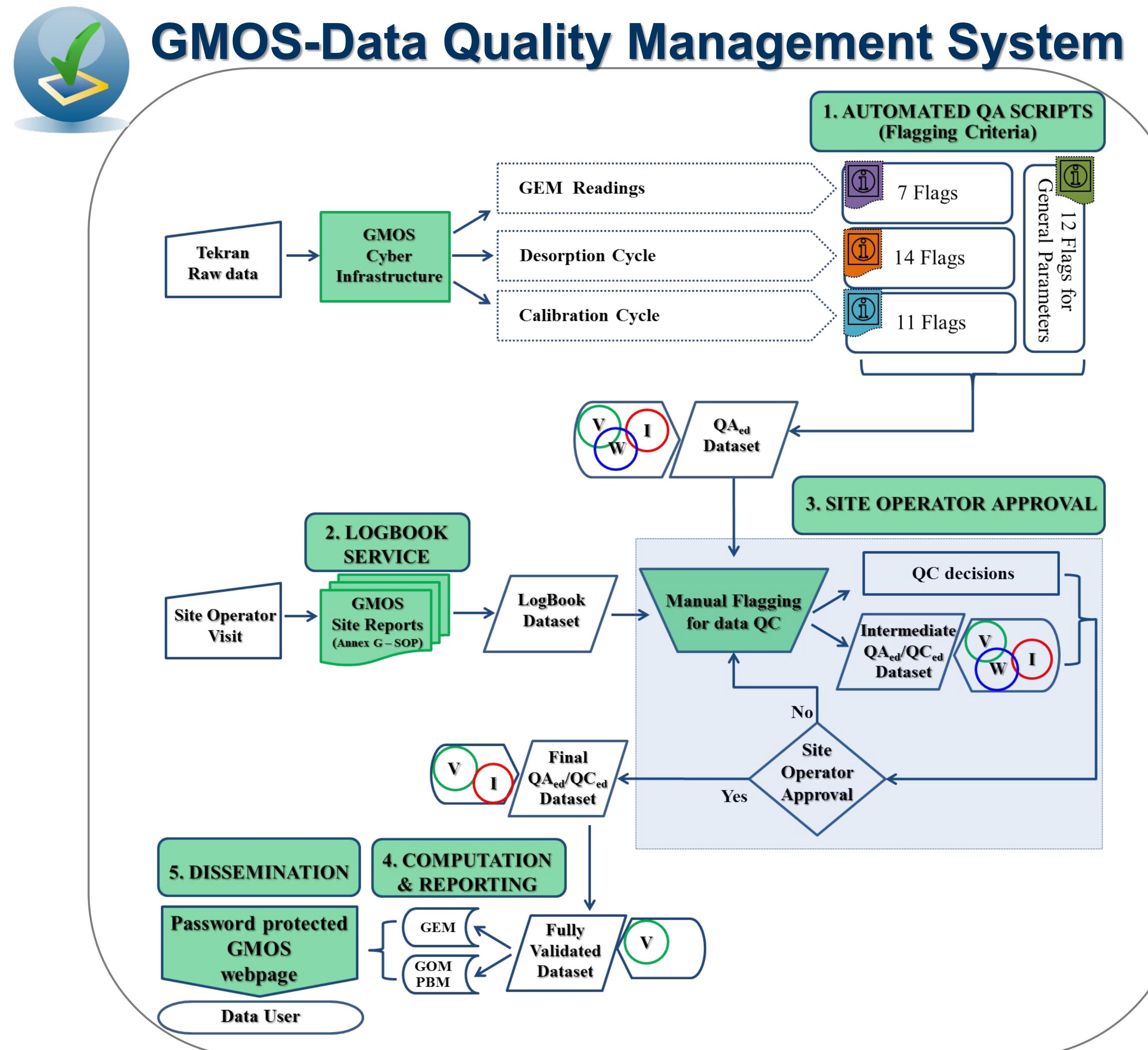
Date and Time Type C Stat AdTim Vol BI BIDev Area Ng/m³ Automated Flag Manual Flag

ID	Date and Time	Type	C	Stat	AdTim	Vol	BI	BIDev	Area	Ng/m ³	Automated Flag	Manual Flag
9423	1-giu-2012 10:00:01	CONT	B	OK 0	300.0	4.91	0.129	0.039	22215.0	1.039	IVT	IVT
9424	1-giu-2012 10:05:01	CONT	A	OK 0	300.0	4.71	0.129	0.046	13724.0	1.067	WK2	WK2
9425	1-giu-2012 10:10:01	CONT	B	OK 0	300.0	4.92	0.129	0.049	22117.0	1.582	IVT WK2	OKM
9426	1-giu-2012 10:15:01	CONT	A	OK 0	300.0	4.75	0.129	0.042	14009.0	1.127	WV5 WK2	WV5 WK2
9427	1-giu-2012 10:20:01	CONT	B	OK 0	300.0	4.95	0.129	0.045	23547.0	1.84	IVT WK2	IVT WK2
9428	1-giu-2012 10:25:01	CONT	A	OK 0	300.0	4.78	0.13	0.057	14908.0	1.143	WV5 WK2	WV5 WK2
9429	1-giu-2012 10:30:01	CONT	B	OK 0	300.0	4.98	0.13	0.038	23873.0	1.682	IVT WK2	IVT WK2
9430	1-giu-2012 10:35:01	CONT	A	OK 0	300.0	4.81	0.13	0.042	14725.0	1.122	WV5 WK2	WV5 WK2
9431	1-giu-2012 10:40:01	CONT	B	OK 0	300.0	4.93	0.13	0.056	22590.0	1.593	IVT WK2	IVT WK2
9432	1-giu-2012 10:45:01	CONT	A	OK 0	300.0	4.88	0.13	0.054	14798.0	1.115	IVT WK2	IVT WK2
9433	1-giu-2012 10:50:01	CONT	B	OK 0	300.0	4.98	0.13	0.042	23742.0	1.08	IVT WK2	
9434	1-giu-2012 10:55:01	CONT	A	OK 0	300.0	4.78	0.13	0.044	16259.0	1.174	WV5 WK2	
9435	1-giu-2012 11:00:01	CONT	B	OK 0	300.0	4.97	0.13	0.045	23489.0	1.655	IVT WK2	
9436	1-giu-2012 11:05:01	CONT	A	OK 0	300.0	4.81	0.13	0.096	16141.0	1.23	WV5 WK2	

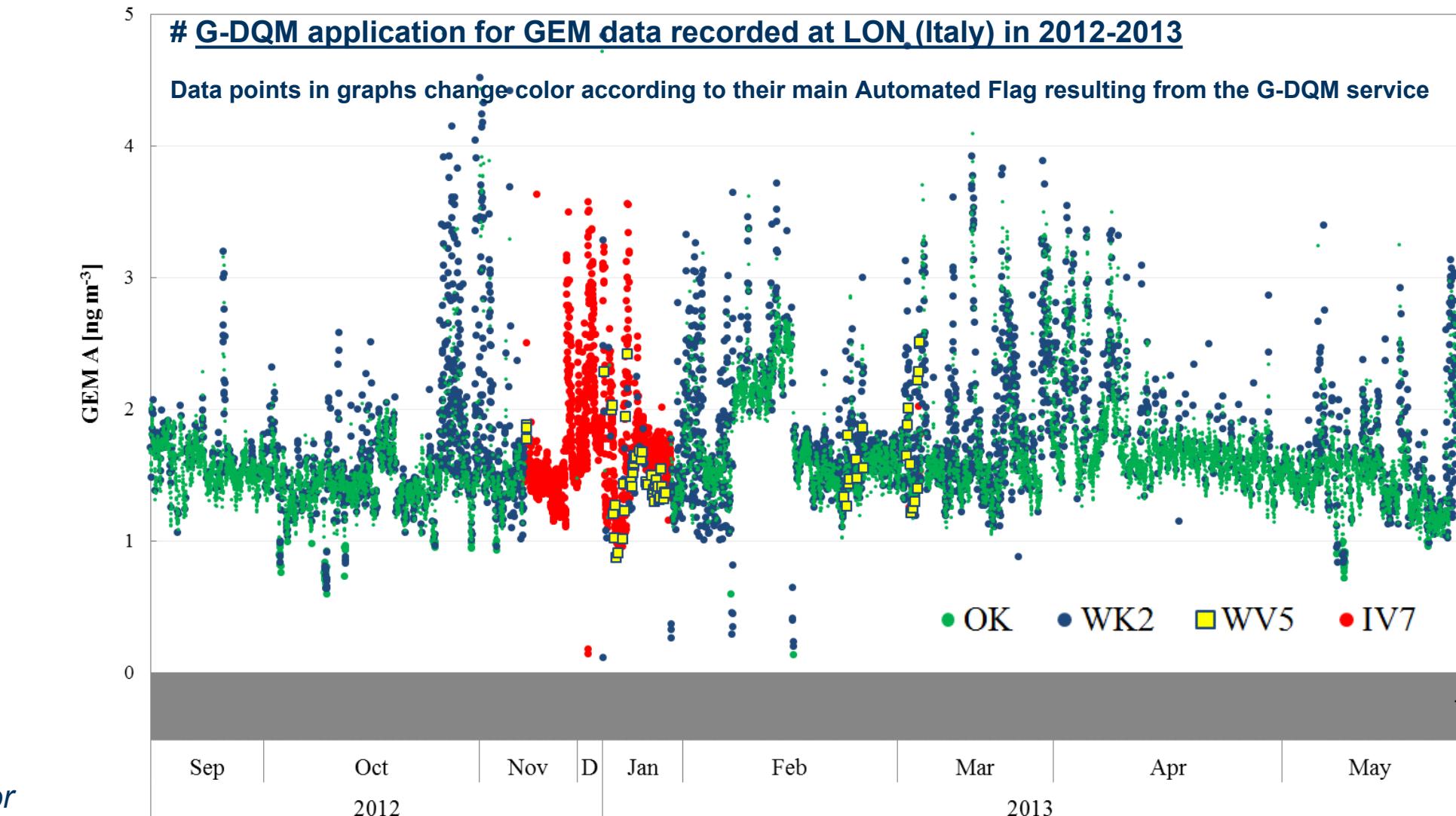
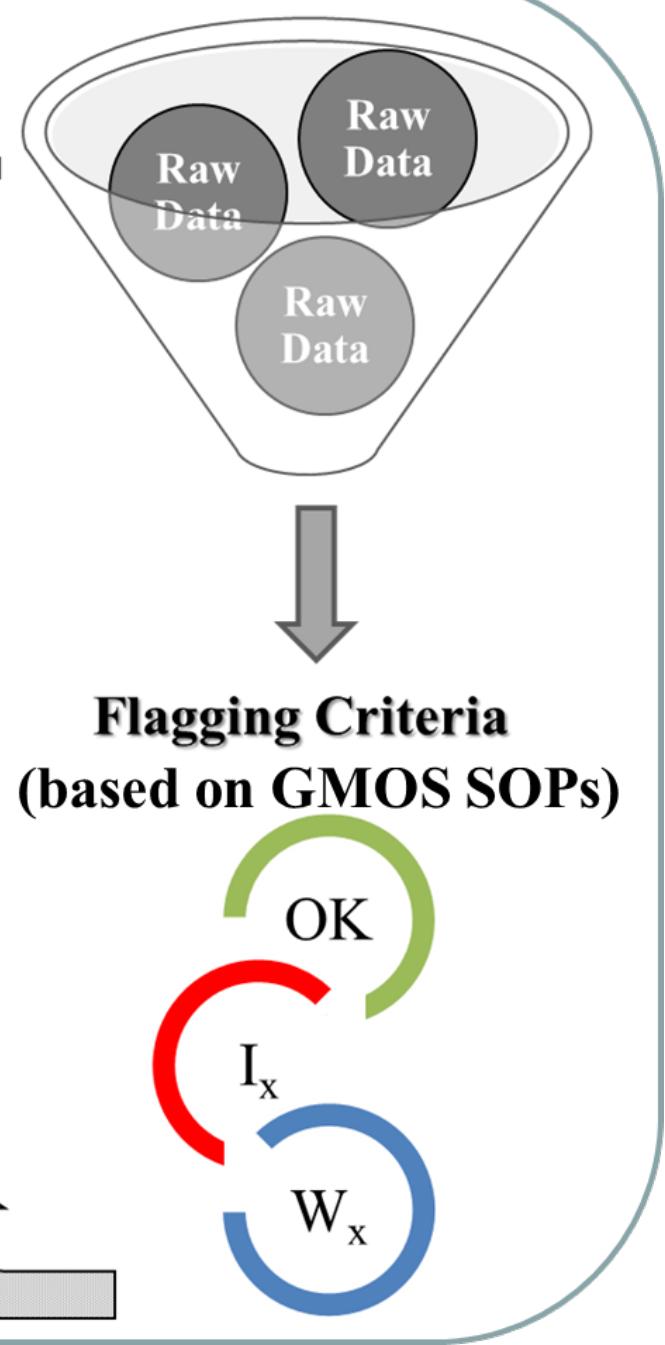
G-Stat is **web-based service** each night (UTC Rome) upload statistics about the last acquired measurement for each GMOS stations

*D'Amore, F., Bencardino, M., Cinnirella, S., Sprovieri, F., & Pirrone, N. (2015). Data quality through a web-based QA/QC system: implementation for atmospheric mercury data from the global mercury observation system. *Environmental Science: Processes & Impacts*, 17(8), 1482-1491.

GMOS-Data Quality Management System



Date	Time	Typ	C	Stat	AdTim	Vol	Bl	BIDev	MaxV	Area	ng/m3	Automated Flag
8/7/2012	15:00:00	CONT A	OK	0	300	4.98	0.096	0.078	0.11	69197	2.698	W _x
8/7/2012	15:05:00	CONT B	OK	0	300	5	0.096	0.057	0.123	105947	3.188	W _x
8/7/2012	15:10:00	CONT A	OK	0	300	5	0.097	0.075	0.11	64483	2.506	W _x
8/7/2012	15:15:00	CONT B	OK	0	300	5	0.097	0.084	0.123	115426	3.474	OK
8/7/2012	15:20:00	CONT A	OK	0	300	5	0.097	0.042	0.11	68667	2.669	OK
8/7/2012	15:25:00	CONT B	OK	0	300	4.99	0.097	0.08	0.124	112975	3.4	I _x
8/7/2012	15:30:00	CONT A	OK	0	300	5	0.097	0.082	0.111	67968	2.642	I _x
8/7/2012	15:35:00	CONT B	OK	0	300	4.99	0.097	0.062	0.125	115421	3.474	OK
8/7/2012	15:40:00	CONT A	OK	0	300	5	0.098	0.1	0.111	75448	2.932	I _x
8/7/2012	15:45:00	CONT B	OK	0	300	5	0.098	0.075	0.125	121046	3.642	W _x
8/7/2012	15:50:00	CONT A	OK	0	300	5	0.098	0.07	0.112	71704	2.788	W _x
8/7/2012	15:55:00	CONT B	OK	0	300	5	0.098	0.066	0.124	117140	3.525	OK
8/7/2012	16:00:00	CONT A	OK	0	300	5	0.098	0.088	0.111	66353	2.58	OK
8/7/2012	16:05:00	CONT B	OK	0	300	5	0.098	0.062	0.124	112641	3.389	I _x
8/7/2012	16:10:00	CONT A	OK	0	300	5	0.098	0.083	0.11	58405	2.271	W _x
8/7/2012	16:15:00	CONT B	OK	0	300	5	0.098	0.072	0.123	105796	3.183	I _x
8/7/2012	16:20:00	CONT A	OK	0	300	5	0.098	0.048	0.11	67993	2.643	OK
8/7/2012	16:25:00	CONT B	OK	0	300	4.99	0.098	0.085	0.123	102309	3.079	I _x
8/7/2012	16:30:00	CONT A	OK	0	300	5	0.099	0.073	0.11	63127	2.454	OK
8/7/2012	16:35:00	CONT B	OK	0	300	4.99	0.099	0.063	0.124	101409	3.052	OK
8/7/2012	16:40:00	CONT A	OK	0	300	5	0.099	0.047	0.111	56470	2.195	OK



* D'Amore, F., Bencardino, M., Cinnirella, S., Sprovieri, F., & Pirrone, N. (2015). Data quality through a web-based QA/QC system: implementation for atmospheric mercury data from the global mercury observation system. *Environmental Science: Processes & Impacts*, 17(8), 1482-1491.

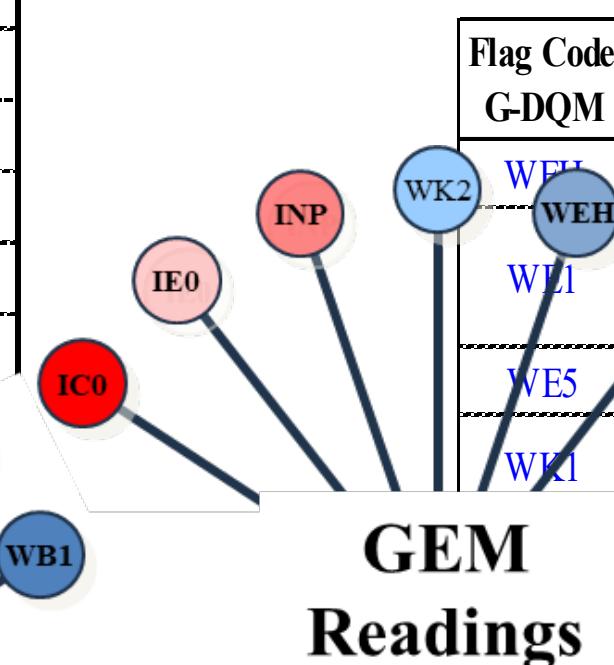
GMOS-SOPs and Data Quality Flagging



Flag Code	Flag Description	Flagging Criteria	Data Flagged	Type of Flag	#
G-DQM					
WB2	Baseline voltage change	$ \text{Baseline voltage}_i - \text{Baseline voltage}_{i-1} > 0.01$	All	F	1
WB1	Baseline Voltage Low or High	$0.01 < \text{Baseline voltage} < 0.05V$ or $\text{Baseline voltage} > 0.25V$	All	F	2
IB0	Baseline Voltage too Low	Baseline voltage $< 0.01 V$	All	F	3
WB3	Baseline Deviation High	Baseline deviation $> 0.10V$ for 5 consecutive readings	All	F	4
IB5	Baseline Deviation too High	Baseline deviation $> 0.15V$	All	F	5
IDL	Below Detection Limit	Hg concentration $< 0.1 \text{ ng m}^{-3}$	All	F	6
WM2	Multiple Peaks Detected	Status = M2 (multiple peaks)	All	F	7
IM3	Multiple Peaks Detected	Status $> M2$ (multiple peaks)	All	F	8
WOL	Overload	Status = OL (overload)	All	S	9
WV5	Questionable Sample Volume	$0.05 < (\text{Volume}_{\text{meas}} - \text{Volume}_{\text{exp}})/\text{Volume}_{\text{exp}} \leq 0.07$	All	S	10
IV7	Sample Volume	$ (\text{Volume}_{\text{meas}} - \text{Volume}_{\text{exp}})/\text{Volume}_{\text{exp}} > 0.07$	All	SS	11
WTG	Time Gap	Sampling time _i - Sampling time _{i-1} $> 2 * \text{Ad Time}$	IDL		

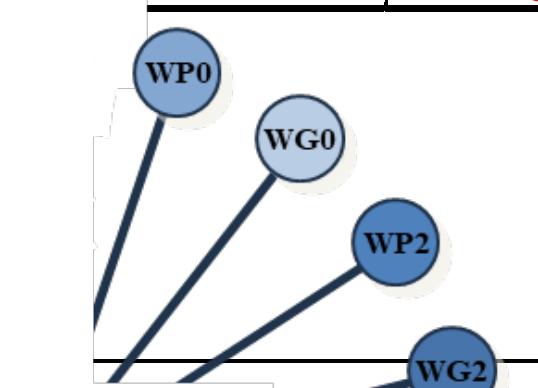


General Parameters

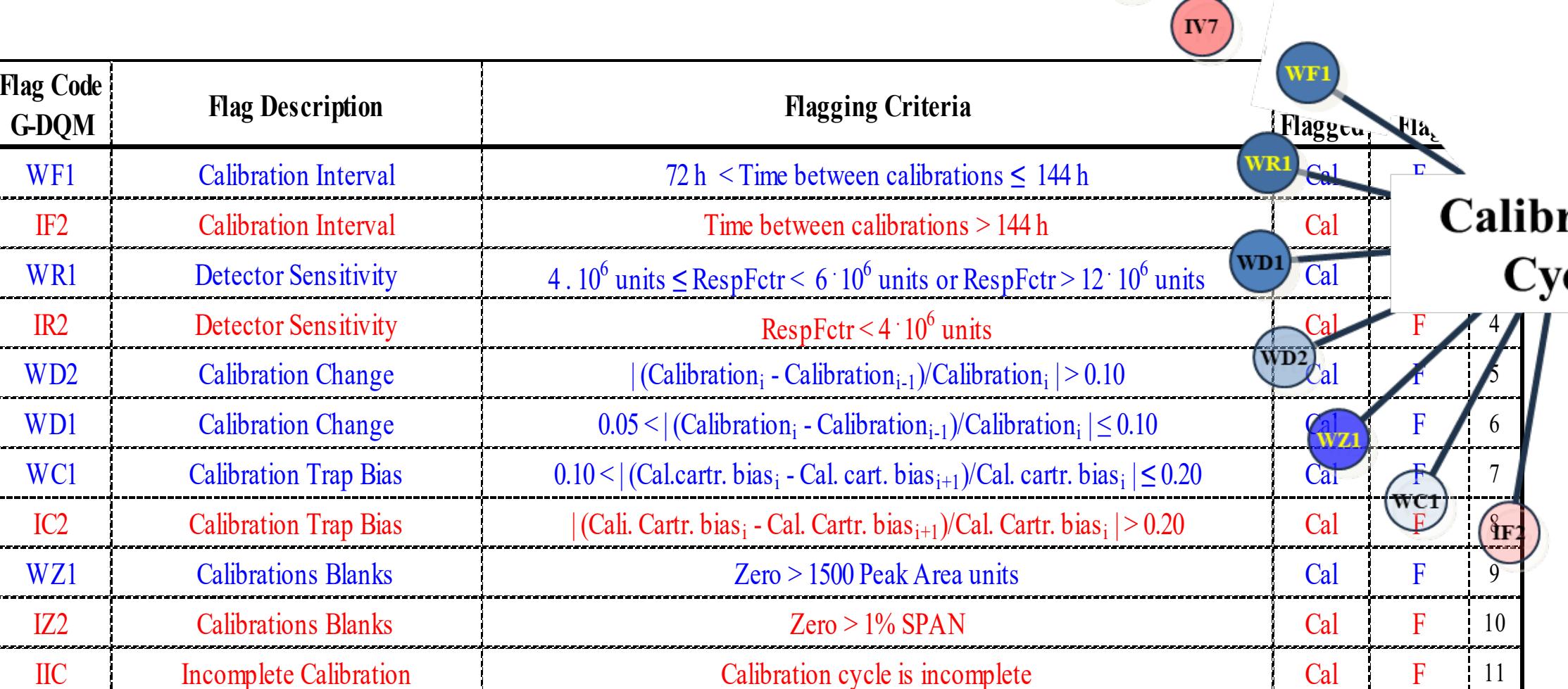


GEM Readings

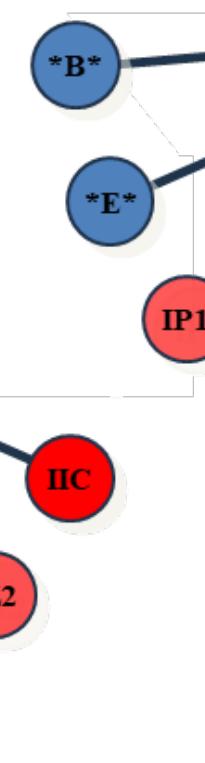
Flag Description	Flagging Criteria	Data Flagged	Type of Flag	#
Hg concentration high	GEM concentration $> 4.0 \text{ ng m}^{-3}$	GEM	F	1
WEL Hg concentration low	GEM concentration $< 1.0 \text{ ng m}^{-3}$ for same cartridge $(< 0.2 \text{ ng m}^{-3} \text{ for polar sites})$	GEM	SS	2
S WES cartridge > 50%	$ (\text{GEM}_i - \text{GEM}_{i-1})/\text{GEM}_i > 0.5$ for the same cartridge	GEM	F	3
A/B cartridge difference 10% to 20%	$0.10 < (\text{Air cartridge bias}_i - \text{Air cartridge bias}_{i-1})/\text{Air cartridge bias}_i \leq 0.15$	GEM	F	4
A/B cartridge difference > 15%	$ (\text{Air cartridge bias}_i - \text{Air cartridge bias}_{i-1})/\text{Air cartridge bias}_i > 0.15$	GEM	F	5
peak	Status = NP (no peaks)	GEM	F	6
negative GEM values	Following desorption first two GEM data are not considered representative	GEM	F	7



Tekran data output



Calibration Cycle



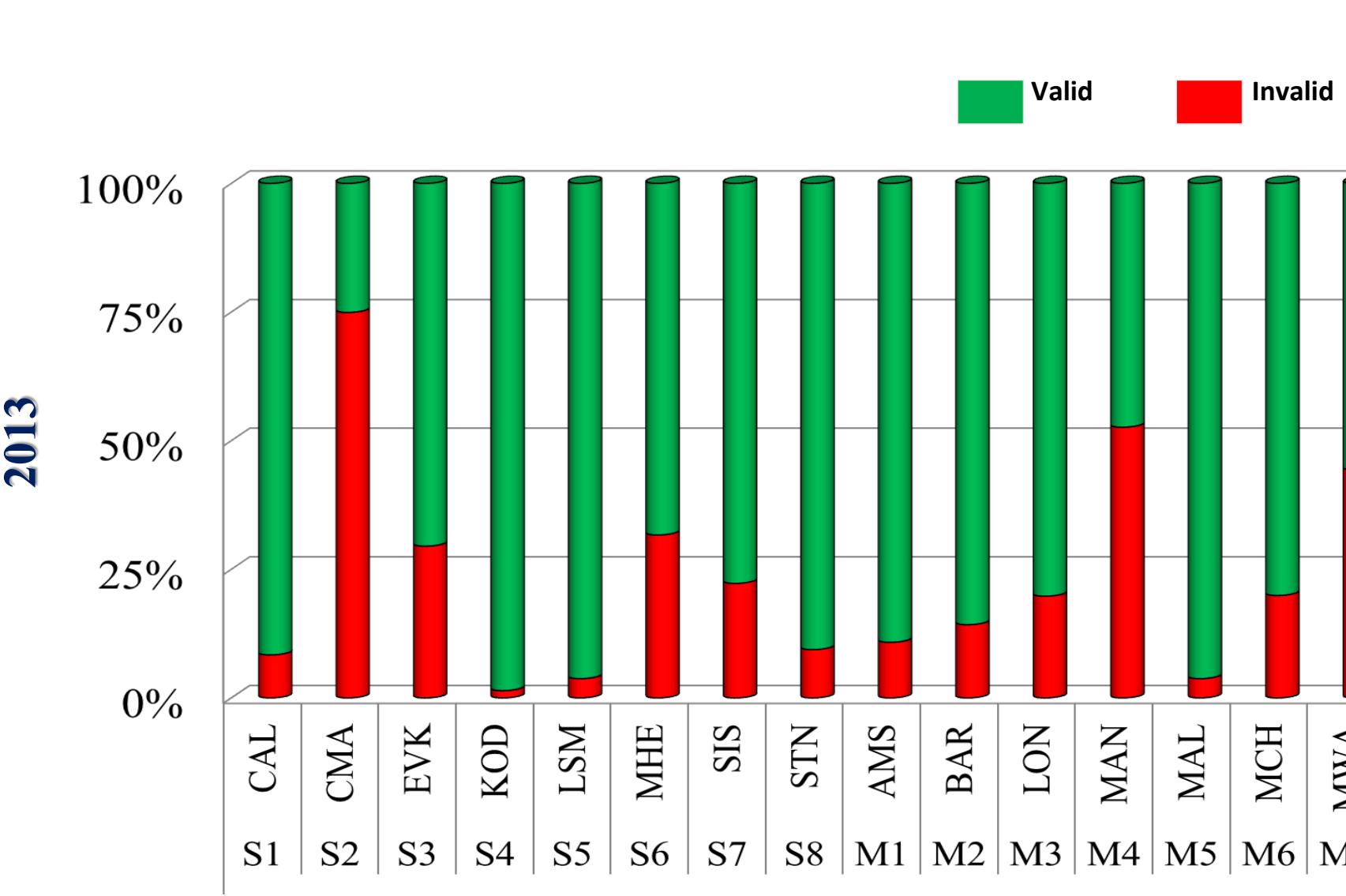
Desorption Cycle

Description		Flagging Criteria	Data Flagged	Type of Flag	#
WG2	PBM desorption questionable	E+F+G = 0	Desorp	F	1
WG0	No COM	H+I+J = 0	Desorp	F	2
IP1	PBM desorption questionable	E < 0.70(E+F+G) or F > 0.20(E+F+G) or G > 0.10(E+F+G)	Desorp	F	3
IG1	COM desorption questionable	H < 0.70(H+I+J) or I > 0.20(H+I+J) or J > 0.10(H+I+J)	Desorp	F	4
WP2	PBM negative value	E+F+G < 3°C	Desorp	F	5
WG2 IP3	GOM negative value	H+I+J < 3°C	Desorp	F	6
IP3	PBM negative value for polar sites (with highly variable data)	D+E+F+G < 4 avg(K+L)	Desorp	SS	7
IG3	GOM negative value for polar sites (with highly variable data)	H+I+J < 3 avg(K+L)	Desorp	SS	8
B	Begin of Desorp	Begin of each single Desorption Cycle	Desorp	F	9
E	End of Desorp	End of each single Desorption Cycle	Desorp	F	10
WL1	Load Cycle	Load Cycle < 1 or 2 or 3 h → GEM cycles < 12 or 24 or 36 before desorption	Desorp	SS	11
IID	Incomplete Desorp	Desorption Cycle is incomplete < 12 Step	Desorp	F	12
WS0	Speciation Blanks ©	1.67 pg m ⁻³ < Cycle © ≤ 10 pg m ⁻³	Desorp	F	13
IS1	Speciation Blanks ©	Cycle (C) > 10 pg m ⁻³	Desorp	F	14

* D'Amore, F., Bencardino, M., Cinnirella, S., Sprovieri, F., & Pirrone, N. (2015). Data quality through a web-based QA/QC system: implementation for atmospheric mercury data from the global mercury observation system. *Environmental Science: Processes & Impacts*, 17(8), 1482-1491.

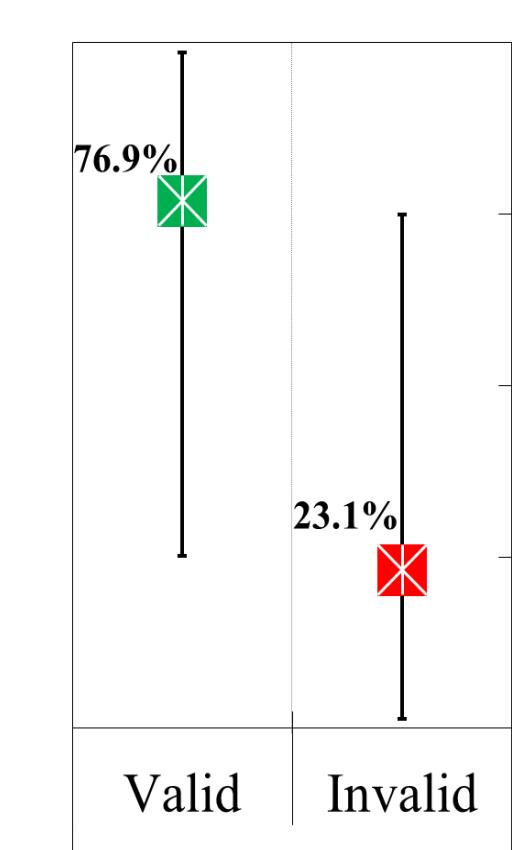
Data quality resulting from the usage of G-DQM

Share of Valid/Invalid data for TGM/GEM

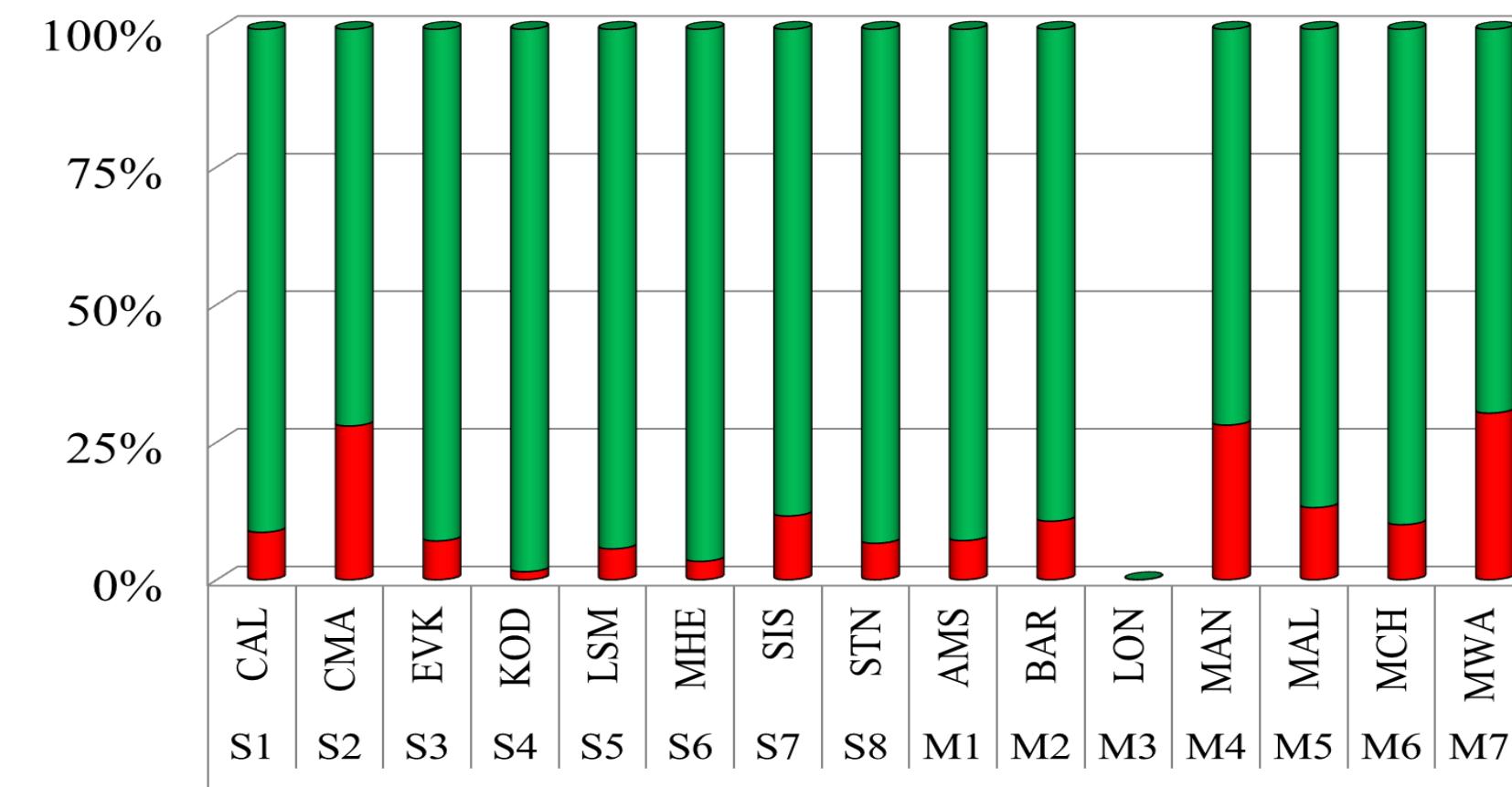


Range of values:

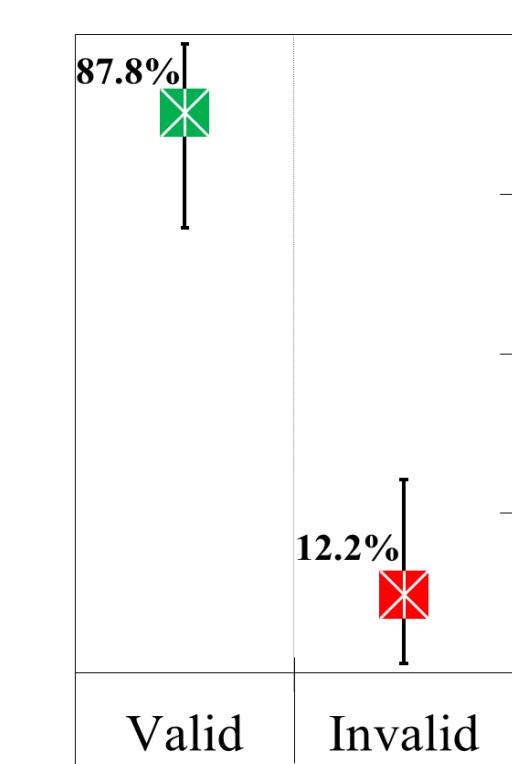
$n = 15$



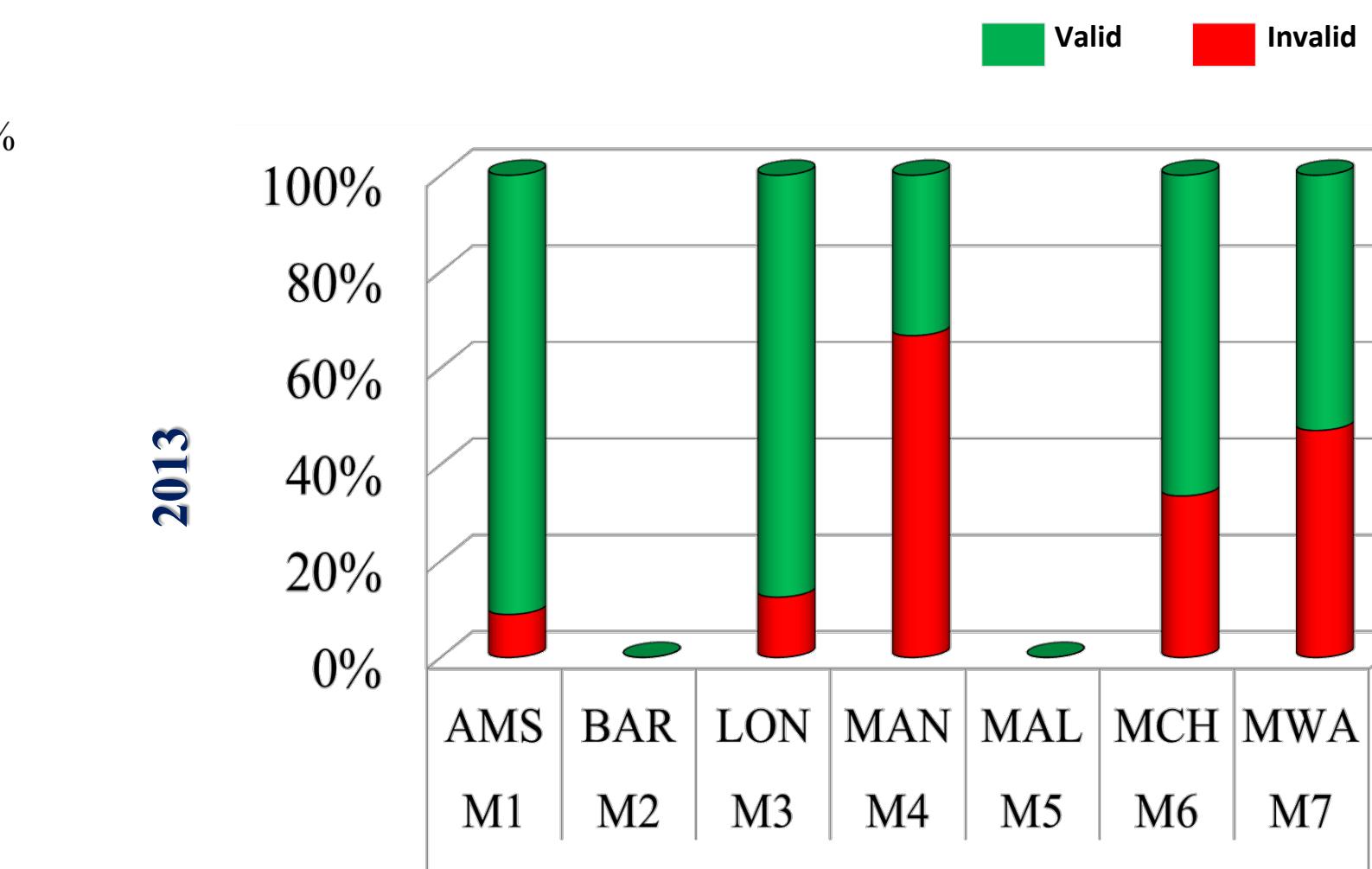
2014



$n = 14$

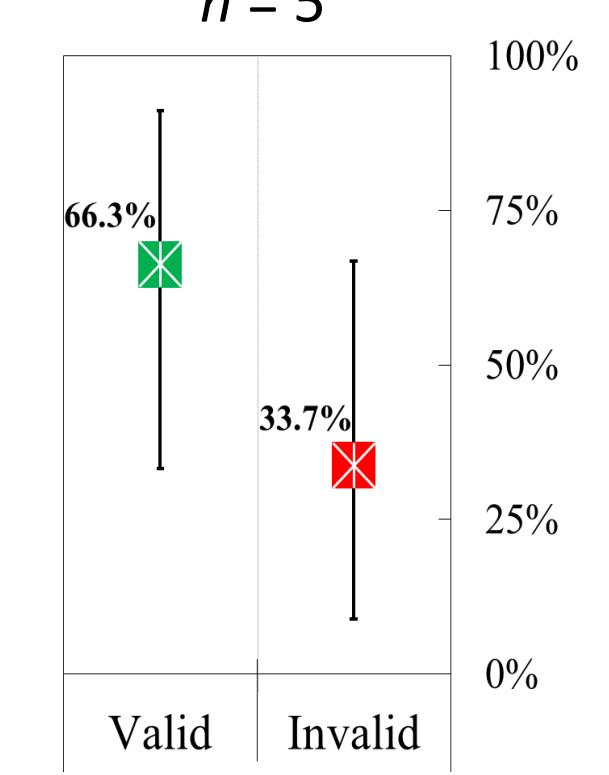


Share of Valid/Invalid data for PBM&GOM

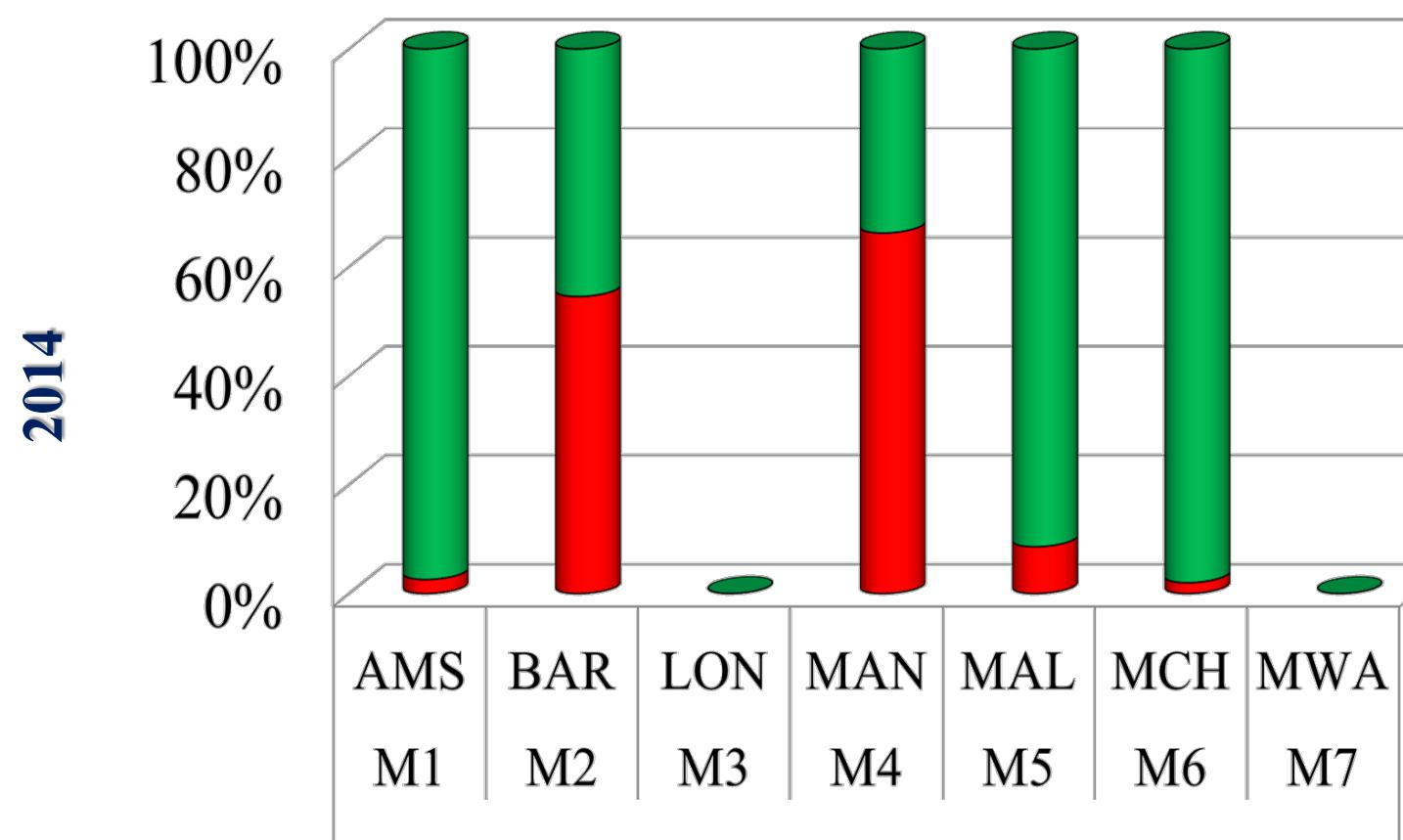


Range of values:

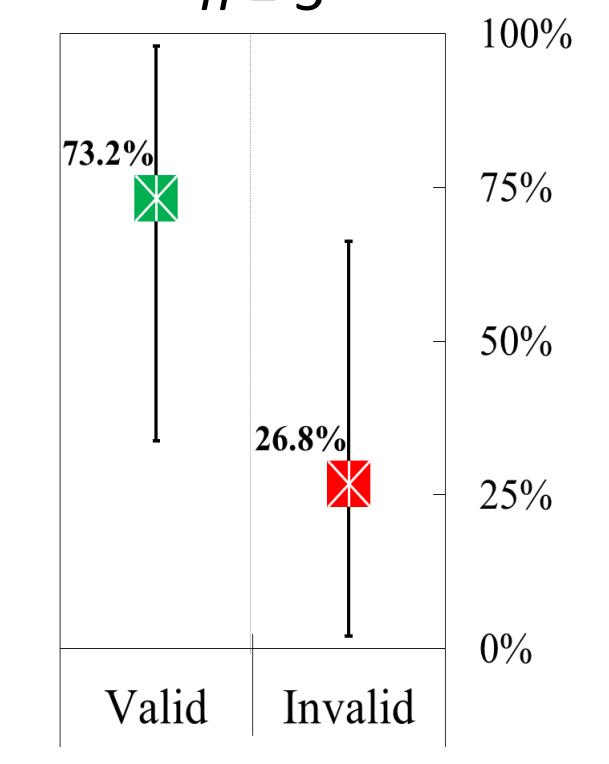
$n = 5$



2014



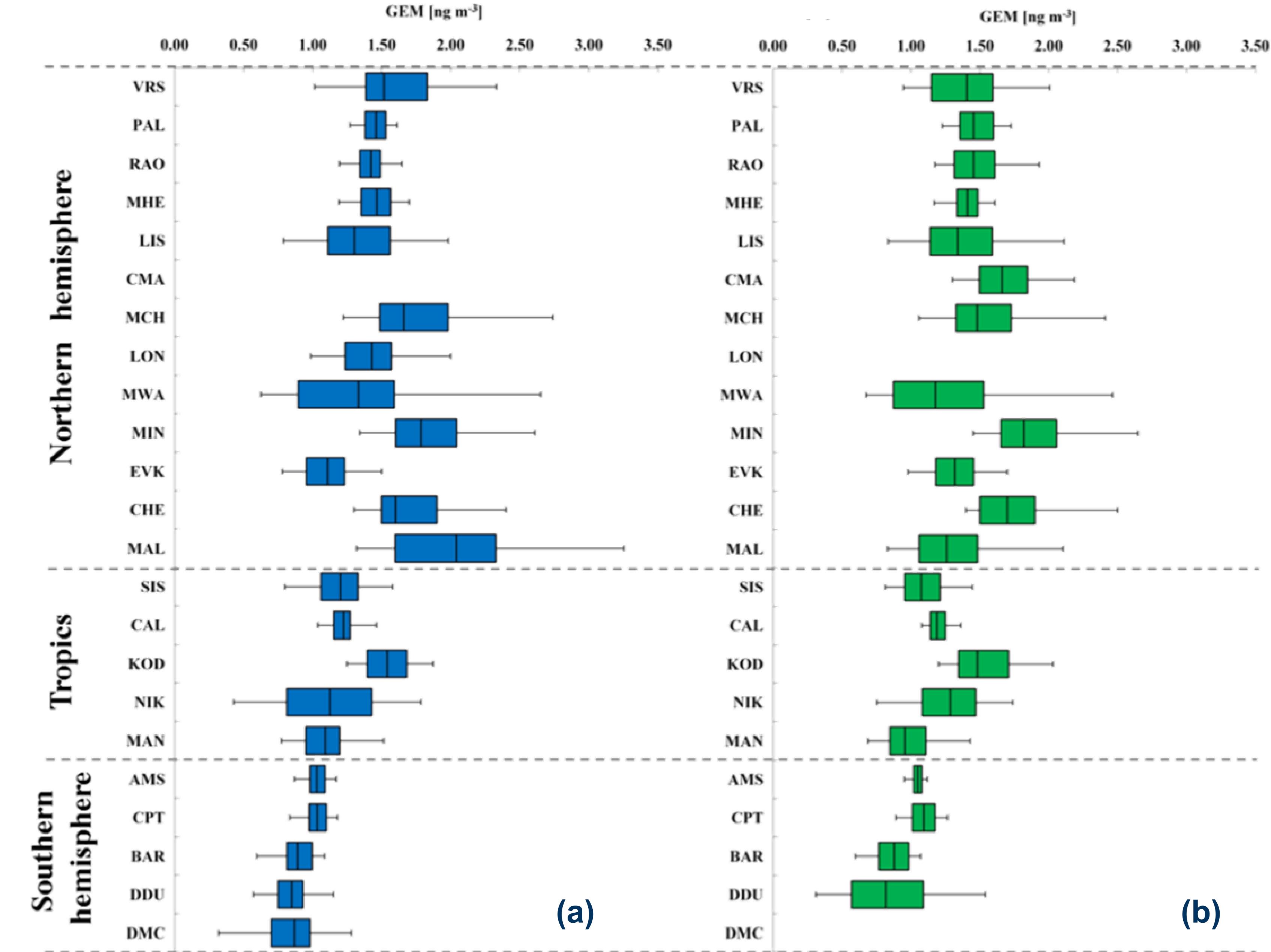
$n = 5$



*Bencardino, M., D'Amore, F., Cinnirella, S., Sprovieri, F., & Pirrone, N. (2017). Quality screening for atmospheric mercury data within the GMOS network. 13th International Conference on Mercury as a Global Pollutant - ICMGP 2017. 16 - 21 July 2017 Providence, Rhode Island, USA

Hemispheric gradient in GEM concentration for GMOS data in (a) 2013 and (b) 2014. Sites are organized by latitude.

AMAP/UN Environment 2019. Technical Background Report for the Global Mercury Assessment 2018.



The GMOS network and its data coverage

23 Partecipating Organisations from all over the world

10 stations for historical dataset (before 2010)

26 stations operating during the GMOS project (2010-2015)

22 stations still ongoing and contributing to GOS⁴M

Northern Hemisphere

Previous #15

Ongoing #12

Equator

Previous #5

Ongoing #2

Southern Hemisphere

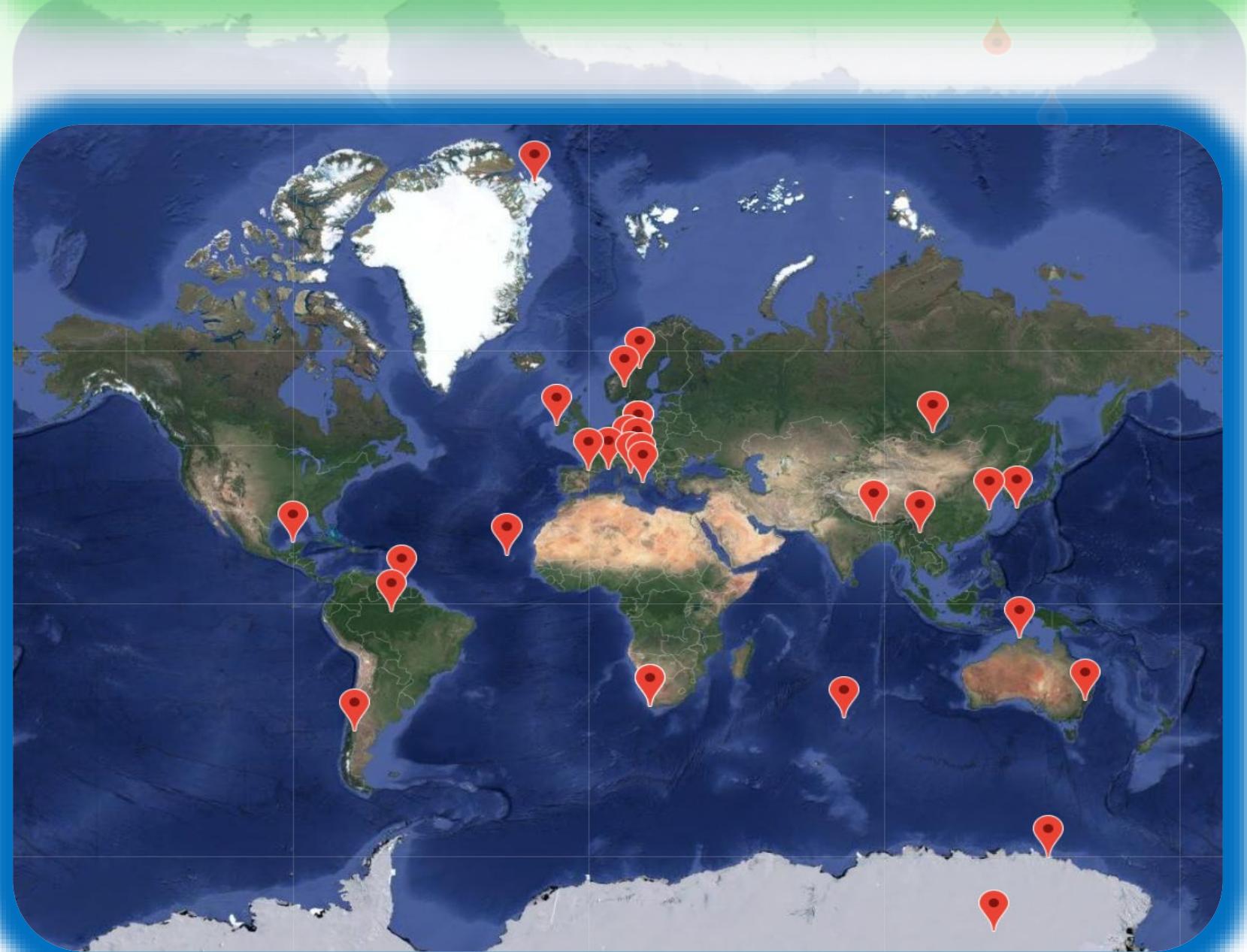
Previous #7

Ongoing #7

	Partecipating Organisation	Scientific Referent	Station Name	Station Code	Country	20	20	20	20	20	20	20
Northern Hemisphere Previous #15 Ongoing #12	AARHUS UNIVERSITY	AU	Henrik Skov Claus Nordstrøm	Station Nord	STN	Greenland						
	Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research	HZG	Ralf Ebinghaus	Mace Head	MHE	Ireland						
	Saint Petersburg State University	SPBSU	Nikolay Mashyanov	Listvyanka	LIS	Russia						
	CzechGlobe	CVGZ	Kateřina Komíková Alice Dvorská	Kresin u Pacova	KRE	Czech Republic						
	UNIVE	Carlo Barbante	Col Margherita	CMA		Italy						
	Jožef Stefan Institute	IJS	Milena Horvat Joze Kotnik	Iskrba	ISK	Slovenia						
	Ifremer	IFREMER	Daniel Cossa Joel Knoery	La Seyne-sur-Mer	LSM	France						
	IGCAS	Xinbin Feng Hui Zhang	Mt. Changbai	MCH		China						
	CNR-IIA	Nicola Pirrone Francesca Sprovieri	Longobucco	LON		Italy						
	CNR-IIA	Nicola Pirrone Francesca Sprovieri	Monte Curcio	MCU		Italy						
	IGCAS	Xinbin Feng Hui Zhang	Mt. Waliguan	MWA		China						
	NIMD	Noriuki Suzuki Nikolai Mashyanov	Minamata	MIN		Japan						
Equator Previous #5 Ongoing #2	CNR-IIA	Francesca Sprovieri	Ev-K2	EVK		Nepal						
	NIMD	Noriuki Suzuki	Cape Hedo	CHE		Japan						
	IGCAS	Xinbin Feng Hui Zhang	Mt. Ailao	MAL		China						
	JRC/UNAM	Fabrizio Sena Martha Ramirez	Sisal	SIS		Mexico						
	UNIVERSITY of York	UoY	Katie Read Luis Mendes Neves	Calhau	CAL	Cape Verde						
Southern Hemisphere Previous #7 Ongoing #7	AU IOM	Ramachandran Ramesh	Kodaikanal	KOD		India						
	INTEC	Dennis Wip	Nieuw Nickerie	NIK		Suriname						
	APLBA	Paulo Artaxo	Manaus	MAN		Brazil						
	MACQUARIE University	MU	Peter Nelson	Gunn Point	GUP	Australia						
	UNIVERSITÉ JOSEPH FOURIER	UJF-LGGE	Aurélien Dommergue Olivier Magand	Amsterdam Island	AMS	TAAF						
	South African Weather Service	SAWS	Lynwill Martin	Cape Point	CPO	South Africa						
	MACQUARIE University	MU	Peter Nelson	Glenville	GVL	Australia						
Southern Hemisphere Previous #7 Ongoing #7	INTIBIOMA CONICET	CONICET	Maria Dieguez	Bariloche	BAR	Argentina						
	UNIVERSITÉ JOSEPH FOURIER	AU	Aurélien Dommergue Olivier Magand	Dumont d'Urville	DDU	Antarctica						
	Université Joseph Fourier	AU/CNR-IIA	Aurélien Dommergue Francesca Sprovieri	Dome C	DMC	Antarctica						



**26 stations with active
instrumentation operating
during the GMOS project
(2010-2015)**



**22 stations with active instrumentation
ongoing after 2015**



**47 sites with PAS samplers
ongoing after 2015**

GMOS Project

GMOS Programme

Future planned activities

- ✓ **Facilitating cooperation of governments and institutions tracking mercury releases;**
- ✓ **Encouraging an intercomparison between existing tools aimed to quality assure and quality control (QA/QC) mercury datasets;**
- ✓ **Supporting the technological development of advanced sensors aiming to reduce the investment and running costs of long-term monitoring programmes;**
- ✓ **Creating advanced web services for using and discovering information in coherence with GEO Sharing Principles;**
- ✓ **Promoting continuous interactions and engagement of the scientific community in the policy making process.**

THANK YOU FOR YOUR ATTENTION!

