SPONGE

Spaceborne Observations to Nourish the GEMS/Water Global Network

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GEMS Water
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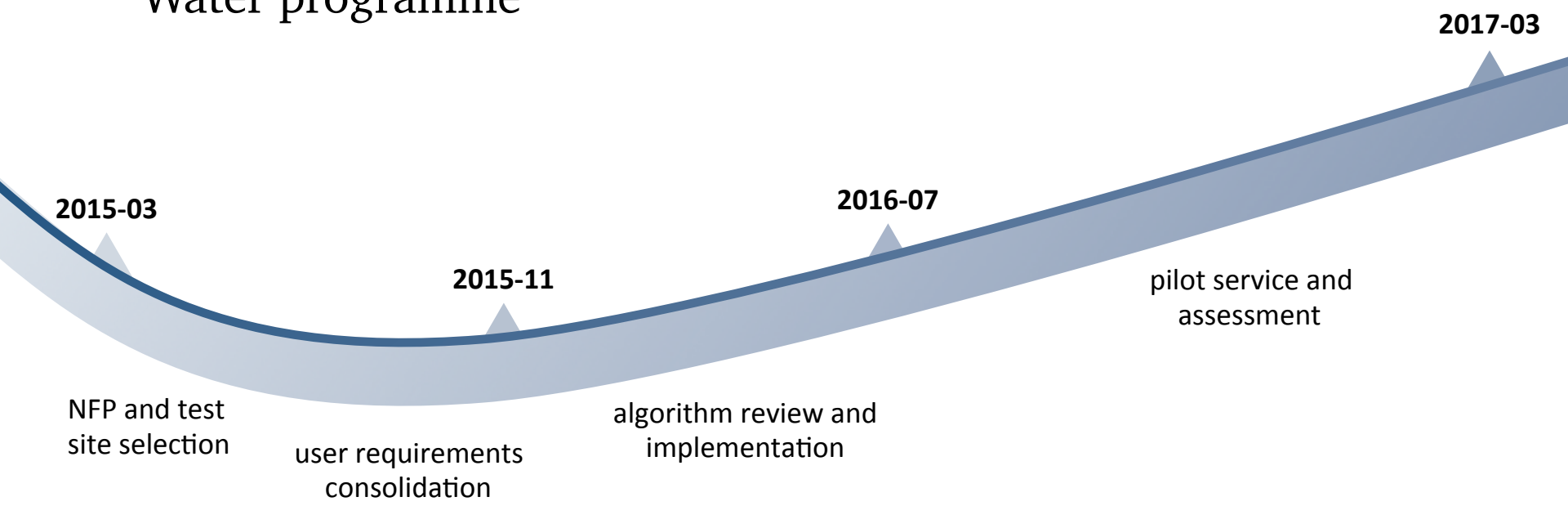
Project Overview

- 2-year ESA DUE Innovators III project
- Aims to demonstrate how Sentinel-2 and other current sensors can contribute water quality information for UNEP's GEMS/ Water programme



SPONGE Collaboration Framework

EO Service Requirements • *In Situ Measurement Requirements* • *In Situ Measurements* • *EO Products*

GEMS/Water Data Centre

GEMS Water

gemstat

bfg

National Focal Points

SYKE Finland

CSIR Ghana

Universidad Rafael Landívar Guatemala

Japan

Tanzania

Earth Observation Services

Odermatt & Brockmann

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EO Service Requirements • *In Situ Measurement Requirements* • *In Situ Measurements* • *EO Products*

GEMS/Water Data Centre

- Parameters of interest
- Proxies for SDG determinants
- Trophic state classifications
- Pollution hot spots
- GEMStat diagram types
- Data formats and delivery

National Focal Points

Finland Ghana Guatemala Japan Tanzania

- Monitoring sites
- Description of local WQ issues
- Cyanobacteria identification
- Improved monitoring efficiency
- Adoption of EO techniques

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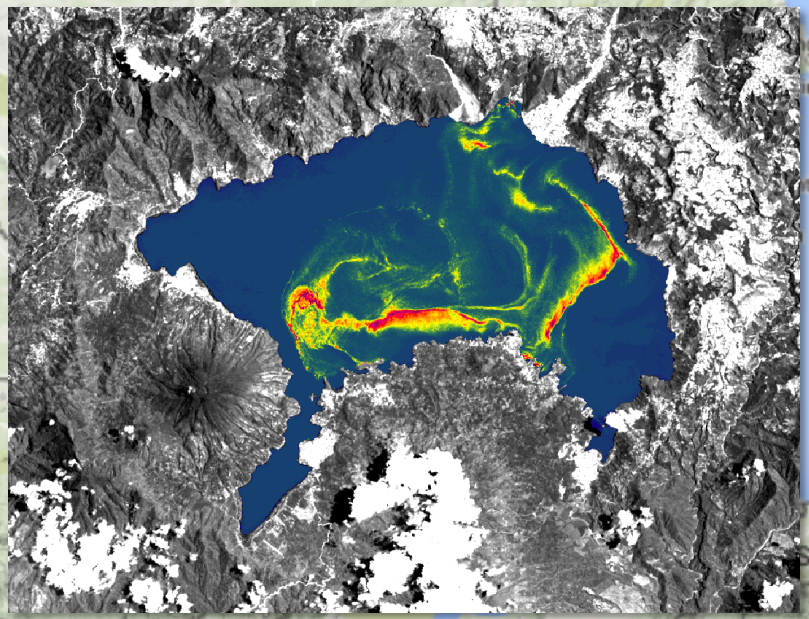
Test Site Examples: Guatemala

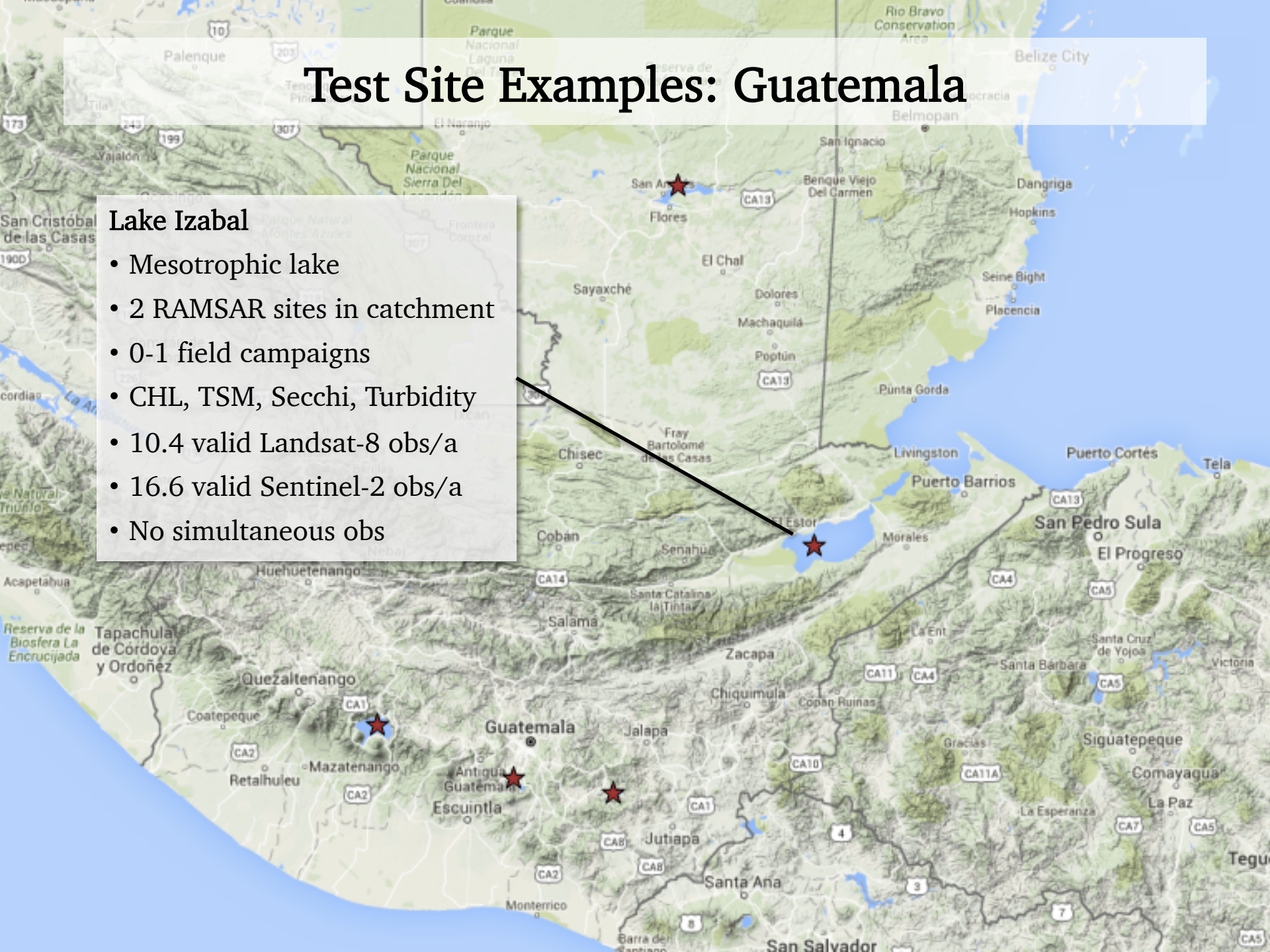
Test Site Examples: Guatemala

Lake Atitlan – GEMStat site

- Mesotrophic lake
- Drinking water source under increasing agricultural press.
- 6 field campaigns, 3 sites
- CHL, TSM, Secchi, Turbidity
- 14.1 valid Landsat-8 obs/a
- 22.6 valid Sentinel-2 obs/a
- 1.8 valid simultaneous obs/a



Test Site Examples: Guatemala



Lake Izabal

- Mesotrophic lake
- 2 RAMSAR sites in catchment
- 0-1 field campaigns
- CHL, TSM, Secchi, Turbidity
- 10.4 valid Landsat-8 obs/a
- 16.6 valid Sentinel-2 obs/a
- No simultaneous obs

SPONGE Collaboration Framework

EO Service Requirements • *In Situ Measurement Requirements* • *In Situ Measurements* • *EO Products*

GEMS/Water Data Centre

- GEMStat standard methodologies
- Data submission procedures

National Focal Points

Finland Ghana Guatemala Japan Tanzania

- Satellite overpass calendars
- EO-specific sampling guidelines

Earth Observation Services

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Lake Pyhäjärvi Acquisition Calendar

L-8 (189) | L-8 (190) | L-8 (191) | L-8 & S-2

S-2 (122) | S-2 (079) | S-2 (022)

Apr 16

Mo	Tu	We	Th	Fr	Sa	So
				01	02	03
04	05	06	07	08	09	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

May 16

Mo	Tu	We	Th	Fr	Sa	So
						01
02	03	04	05	06	07	08
09	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Jun 16

Mo	Tu	We	Th	Fr	Sa	So
		01	02	03	04	05
06	07	08	09	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

Jul 16

Mo	Tu	We	Th	Fr	Sa	So
				01	02	03
04	05	06	07	08	09	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Aug 16

Mo	Tu	We	Th	Fr	Sa	So
01	02	03	04	05	06	07
08	09	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Sep 16

Mo	Tu	We	Th	Fr	Sa	So
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

Overview of Planned In Situ Measurements

Country	Water body name	Type	CHL	TSS	CDOM	Turbidity/ Secchi Depth	Derived Nutrients (CHL)	Derived DOC (CDOM)
Finland	Lamposaarenselkä	L	4		4	cit.		
	Lammin Pääjärvi	L	5		5	5		
	Puruvesi	L	2		2	2		
	Säkylän Pyhäjärvi	L	auto.		6	auto.		
	Vanajanselkä	L	auto.		auto.	auto.	auto.	auto.
Ghana	Volta	R	12	12		12		12
	Weija	R	12	12		12		12
	Bosomtwe	R						
	Barekese	L						
	Pra	I						
Guatemala	Atitlan	L	12	12		12		
	Amatitlan	L	20	20		20		
	Ayarza	L						
	Peten Itza	L						
	Izabal	L						
Japan	Kasumigaura	L	120	120		120	120	60
Tanzania	Kagera	I	12	12		12		12
	Tanganyika	L	12	12		12		12
	Victoria	L	12	12		12		12
	Malagarasi	I	12	12		12		12
	Ruvu	I	12	12		12		12

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GEMS/Water Data Centre

GEMS Water
gemstat
bfg

National Focal Points

SYKE Finland
CSIR Ghana
Universidad Rafael Landívar Guatemala
Japan
Tanzania

- Data and metadata submission

- Fast delivery for cal/val tasks
- Quality control
- Ingestion in GEMStat

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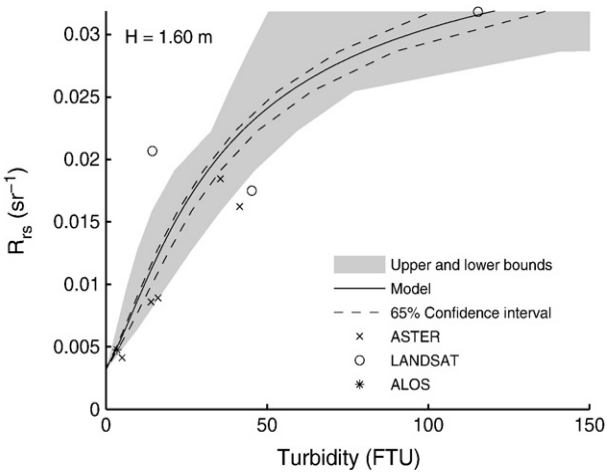
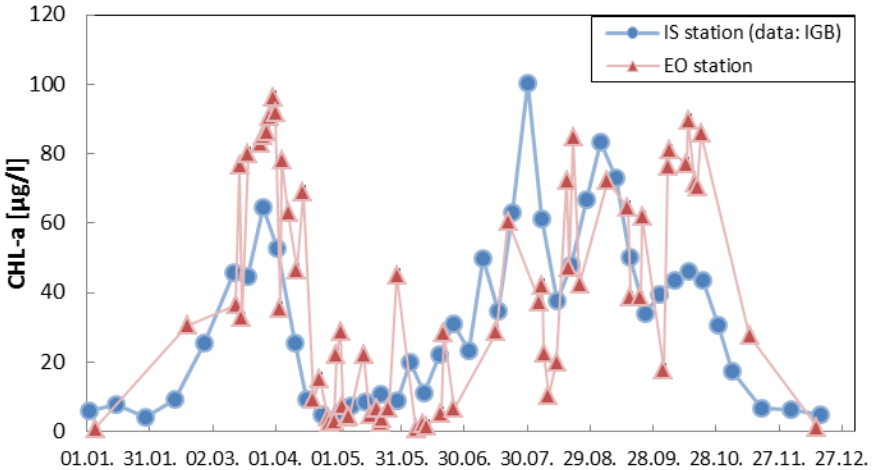
Product Validation Approaches

Matchup Analyses

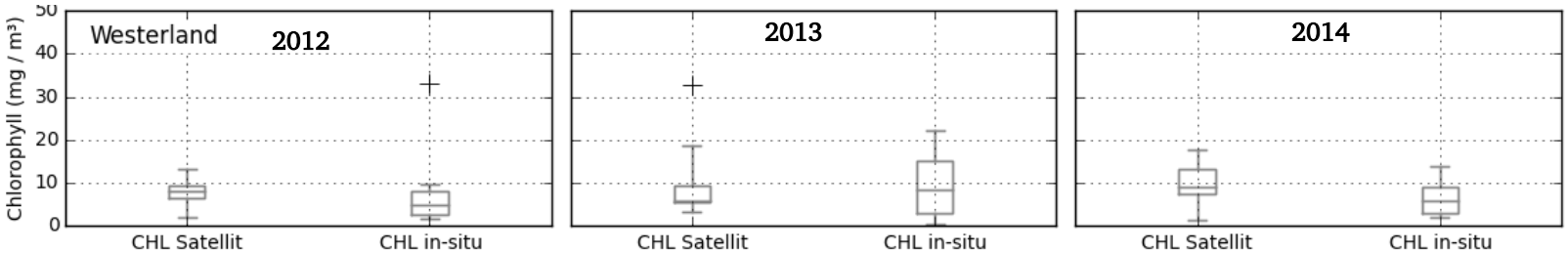
Bootstrap example from Volpe et al. (2011)



Time Series Comparison

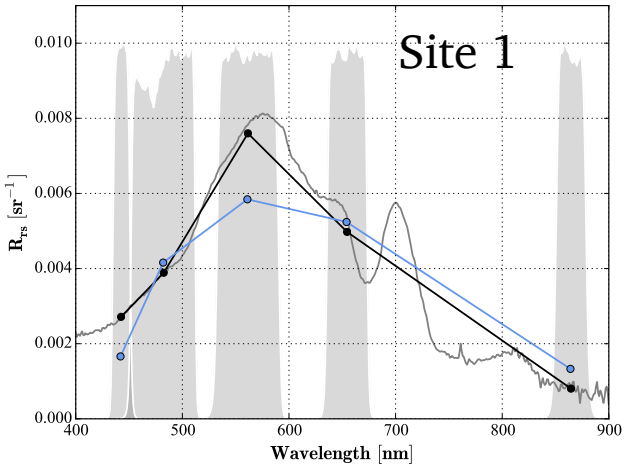


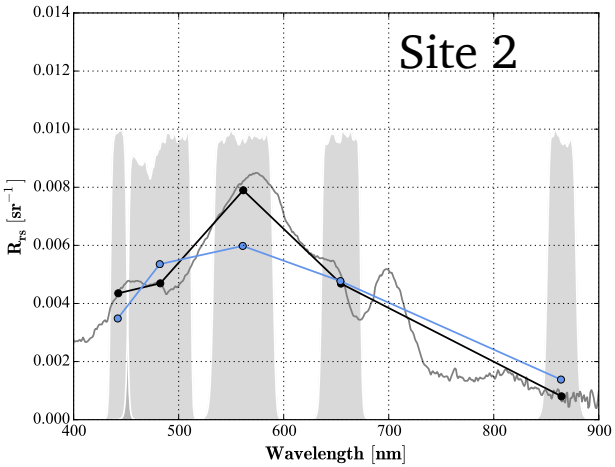
Histogram and Data Range Statistics

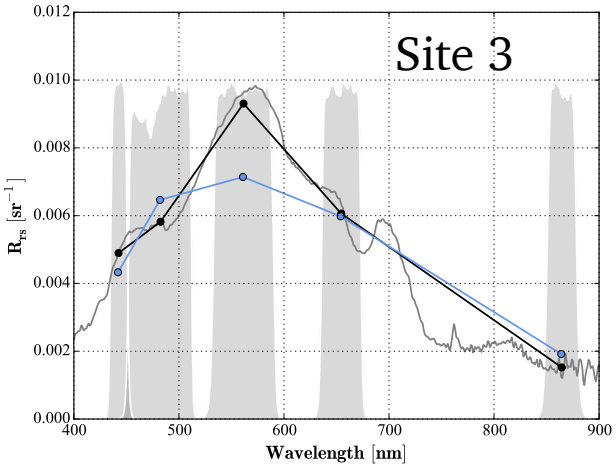


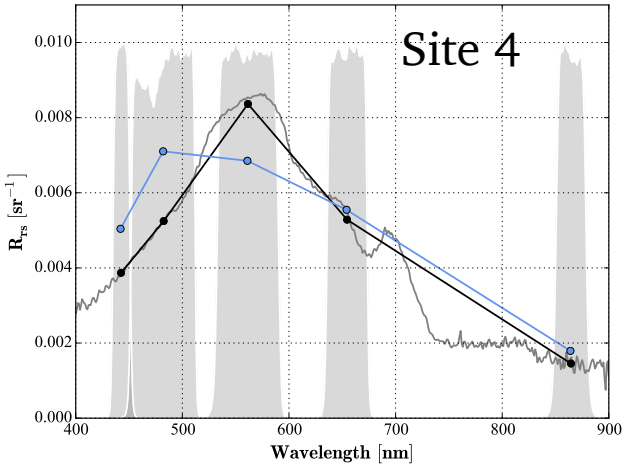
Lake Kasumigaura: Acolite R_{RS}

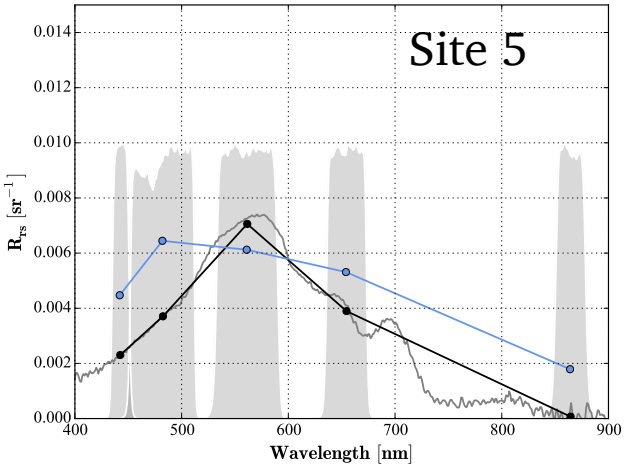
Data of January 13, 2016; in situ measurements by Bunkei Matsushita, Univ. Tsukuba











Acolite is provided by Vanhellemont & Ruddick, RBINS

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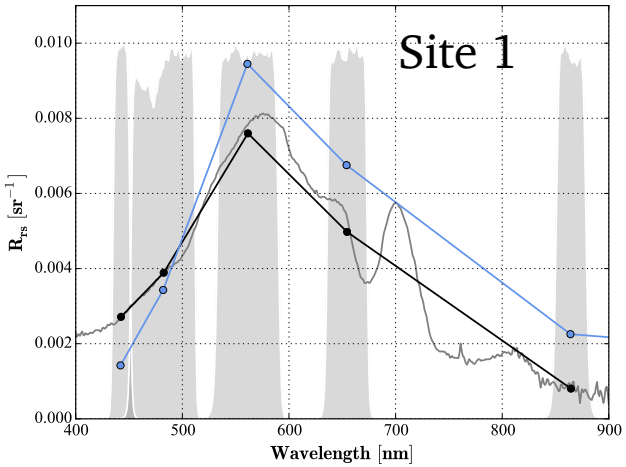
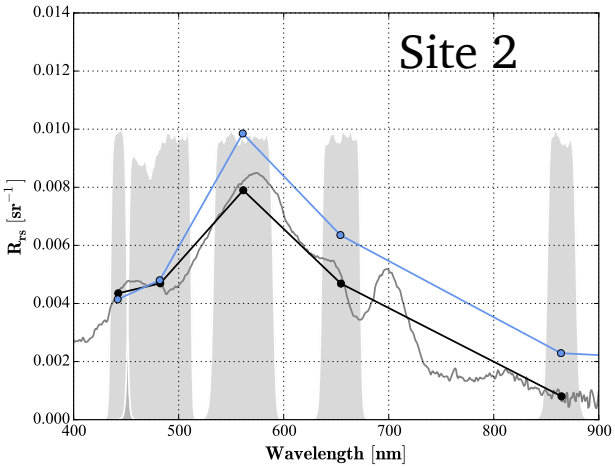
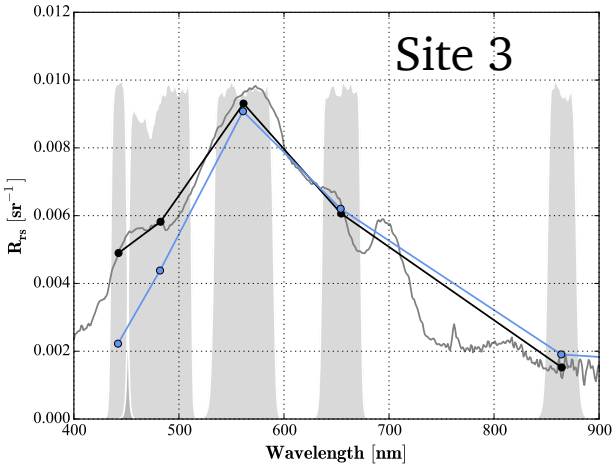
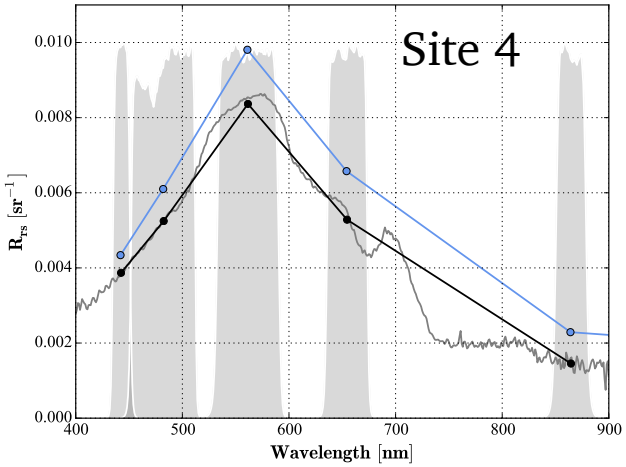
Lake Kasumigaura: OPERA R_{rs}

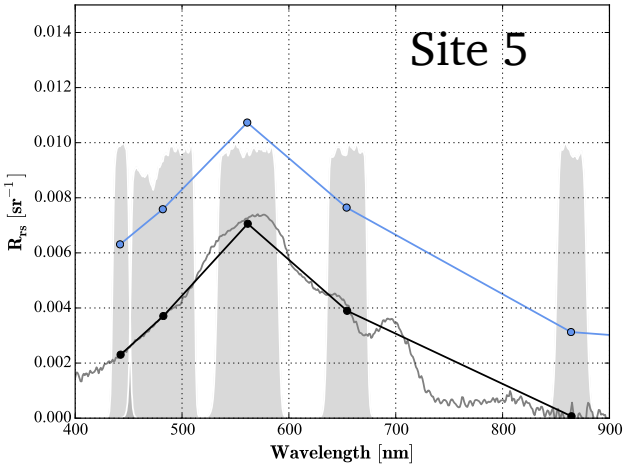
Data of January 13, 2016; in situ measurements by Bunkei Matsushita, Univ. Tsukuba











OPERA products provided by De Keukelaere, Sterckx & Knaeps, VITO

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EO Service Requirements • *In Situ Measurement Requirements* • *In Situ Measurements* • *EO Products*

GEMS/Water Data Centre

GEMS Water
gemstat
bfg

- Optical parameters in map format
- Cal/val results
- Evaluation of SDG determinant proxies
- Definition of methodological standards

- Quality control
- Release in GEMStat if compliant

National Focal Points

SYKE Finland
CSIR Ghana
Universidad Rafael Landívar Guatemala
Japan
Tanzania

- Limited exchange of preliminary products

- Service assessment

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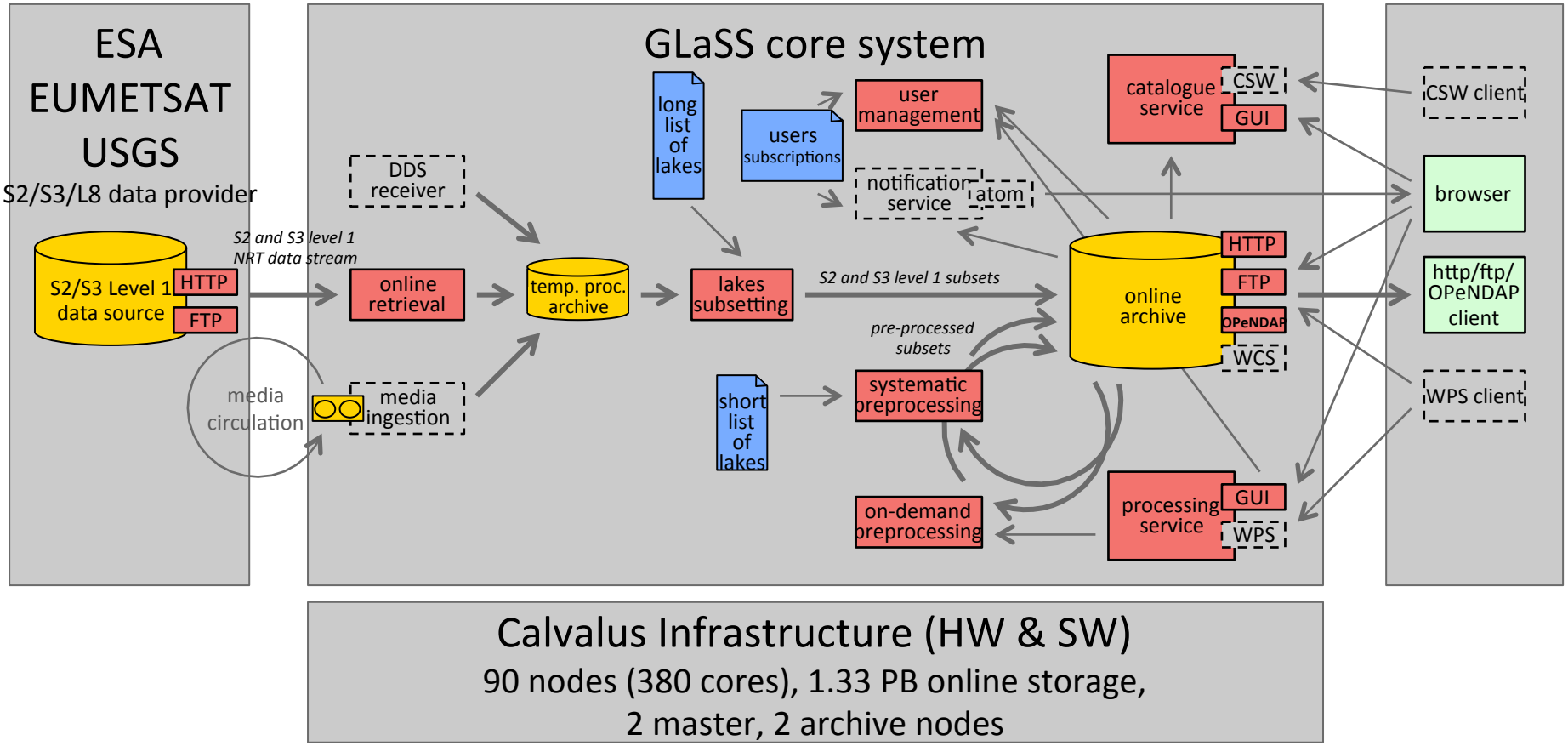
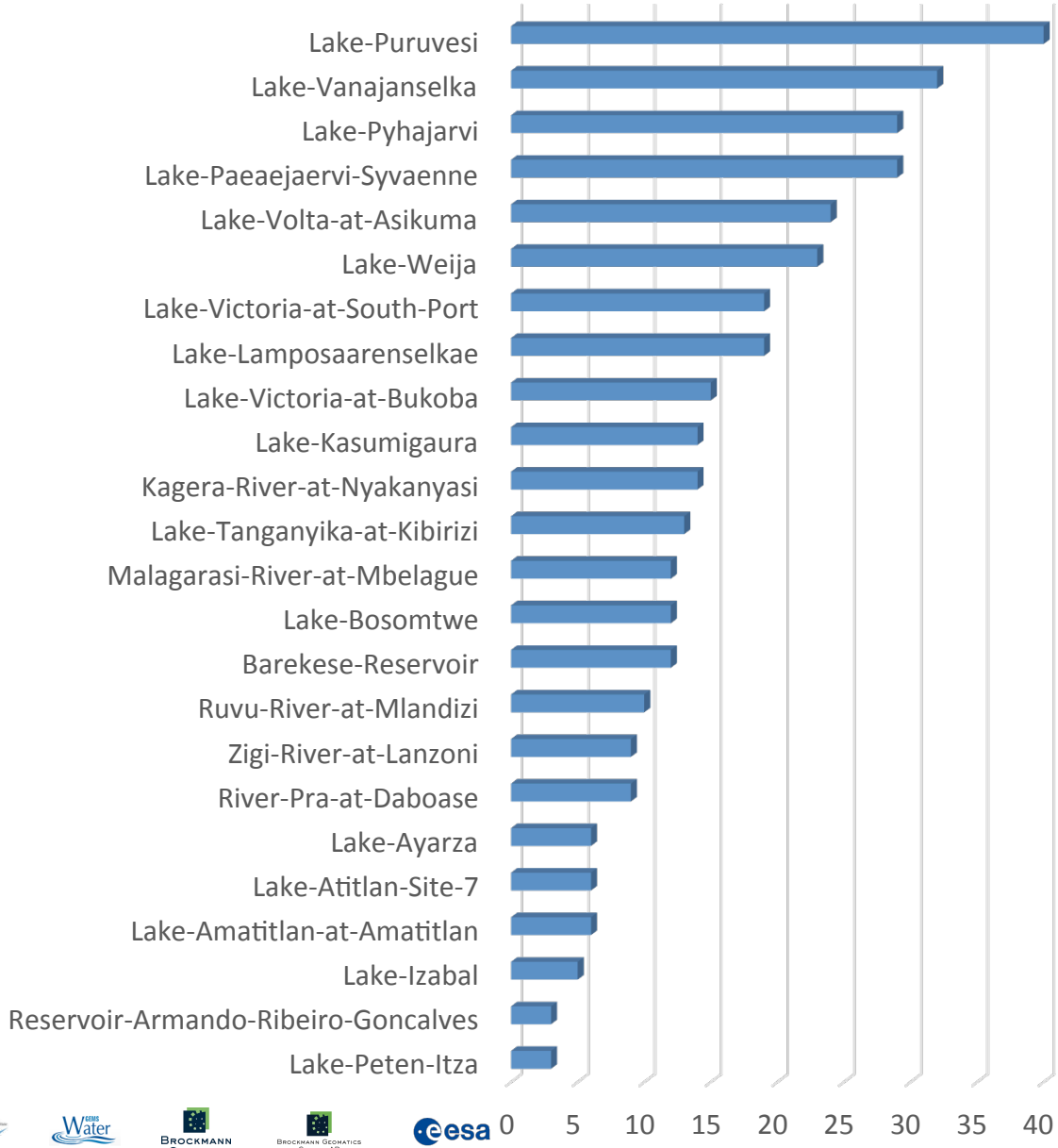
Data Access and Processing



Number of S-2 Products per Lake (April 2016)



max = 40
min = 3
mean = 15.1
median = 12.5
modus = 6

Algorithm Review

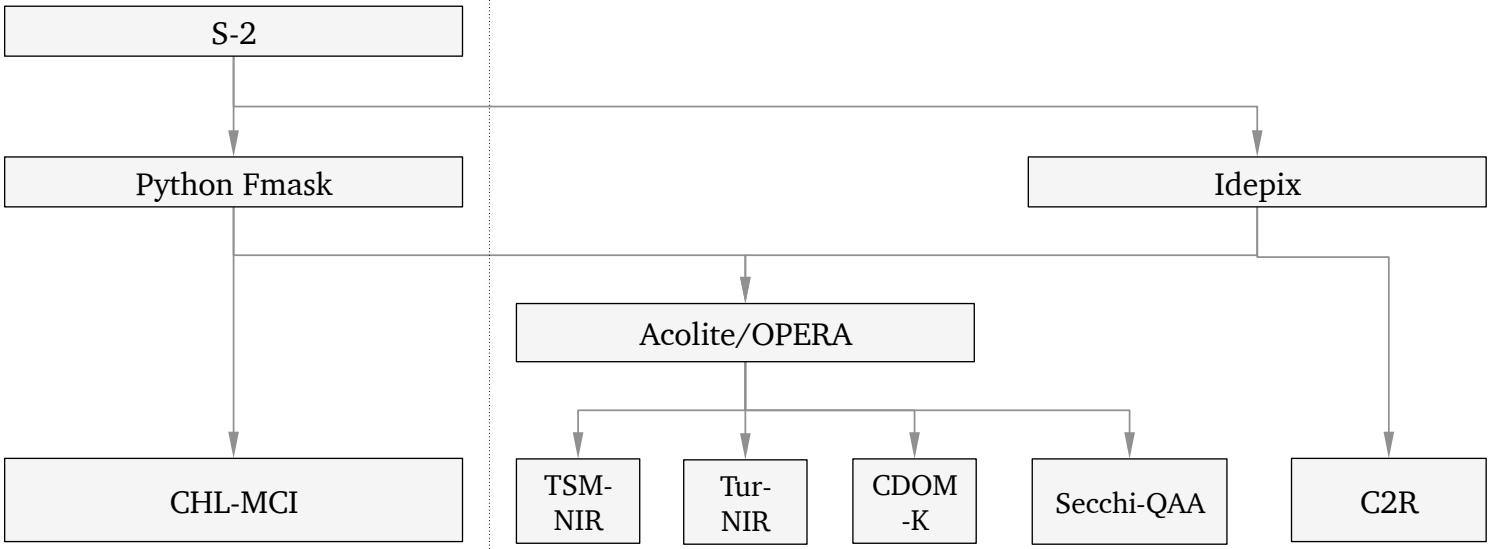
Table 1: List of algorithms that are or will be freely available in the near future for both sensors considered in SPONGE.

Task	Name	Chapter	S-2	L-8	Reference
Pixel Masking	L-8 internal	3.1	Unavailable	L1T	USGS (2015)
	S-2 internal	3.2	L1C	Unavailable	ESA (2015)
	Fmask	3.3	Python	Matlab, Python	Zhu et al. (2015)
	Modified LTK	3.4	Unavailable	Python	Wilson and Oreopoulos (2013)
	Idepix	3.5	In work	SNAP	Danne (2016)
Atmospheric correction	Sen2Cor	4.1	Python	Unavailable	Müller-Wilm (2015)
	ACOLITE	4.2	In work	IDL	Vanhellemont et al. (2014)
	OPERA	4.3	In work	In work	Sterckx et al. (2015a)
	MEETC2	4.4	Unavailable	Unavailable	Saulquin et al. (2016)
Constituent retrieval	MCI [CHL]	5.1	SNAP	Unavailable	Gower et al. (2006)
	NDCI [CHL]	5.2	SNAP	Unavailable	Mishra and Mishra (2012)
	OC3 [CHL]	5.3	SNAP/ACOLITE	SeaDAS/ SNAP/ACOLITE	Franz et al. (2015)
	TSM-NIR [TSM]	5.4	SNAP/ACOLITE	SNAP/ACOLITE	Nechad et al. (2010)
	Tur-NIR [Turbitity]	5.5	SNAP/ACOLITE	SNAP/ACOLITE	Nechad et al. (2009)
	QAA [Secchi depth]	5.6	Unavailable	Unavailable	Lee et al. (2016)
	CDOM-vis [CDOM]	5.7	SNAP	SNAP	Kutser et al. (2005)
Coupled	C2R	6.1	In work	BEAM	Doerffer et al. (2012)

Planned Sentinel-2 Processing Chain

Initial Processing Chain
Operational by the end of June

Processing Chain Evolution
Upon availability



Goals:
- *To provide a basic set of WQ parameters using only TOA radiance*
- *To facilitate generic processing and data exchange procedures*
- *To calibrate MCI for prioritized sites*

Goals:
- *To obtain accurate water-leaving reflectances for the whole vis-NIR spectrum and all sites*
- *To obtain all available WQ parameters*

Goals:
- *To improve water pixel identification (Idepix)*
- *To improve WQ parameter retrieval (C2R)*

Summary of Opportunities

- GEMS/Water's NFPs are a global network of potential users
- The NFPs (will) understand that remote sensing could complement discontinuous monitoring programmes (e.g. based on foreign aid)
- GEMStat allows for a variety of standardized methods, which is a good model for the selection of remote sensing algorithms
- SPONGE provides GEMS requirements and the corresponding blueprint for easily adoptable technologies, work procedures and interfaces

Summary of Challenges

- Cal/val is strongly limited by the NFPs work practices and resources
- S-2 is relatively new for use in a service framework, still limited in regional availability and data properties may change
- Due to the above, the SPONGE service concept may not work equally well for all regions, and only few of them may make the cut to GEMStat
- The value of the service in sites without reference data is highly uncertain