ProGIRH-DLR

REMOTE SENSING OF WATER QUALITY IN THE MANTARO RIVER BASIN THROUGH SPACEBORNE AND GROUND-BASED ACQUISITION OF MULTI- AND HYPERSPECTRAL DATA

DETECCIÓN REMOTA DE LA CALIDAD DEL AGUA EN LA UNIDAD HIDROGRÁFICA DEL RÍO MANTARO A TRAVÉS DE LA ADQUISICIÓN ESPACIAL Y TERRESTRE DE DATOS MULTI- E HIPERESPECTRALES

ANA - Seminario Internacional
“Nuevas tecnologías para la protección de los recursos hídricos”

DLR

Ian Somlai, Remote Sensing Technology Institute (IMF), 13.01.2023

Background

- Peru has severe water availability problems, aggravated by climate change
- GIZ funded project to improve the *"Multisectoral management of water resources in the Mantaro River basin“ (ProGIRH)*
- Peruvian national water authority (ANA) supported by DLR-IMF Team to establish remote sensing monitoring of water resources
- Motivation: to establish a self-dependent and locally managed long-term observation of water quality and availability

The Mantaro River basin (source: www.ana.gob.pe)

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Sentinel-2 MSI image of Lake Chinchaycocha (Junín)

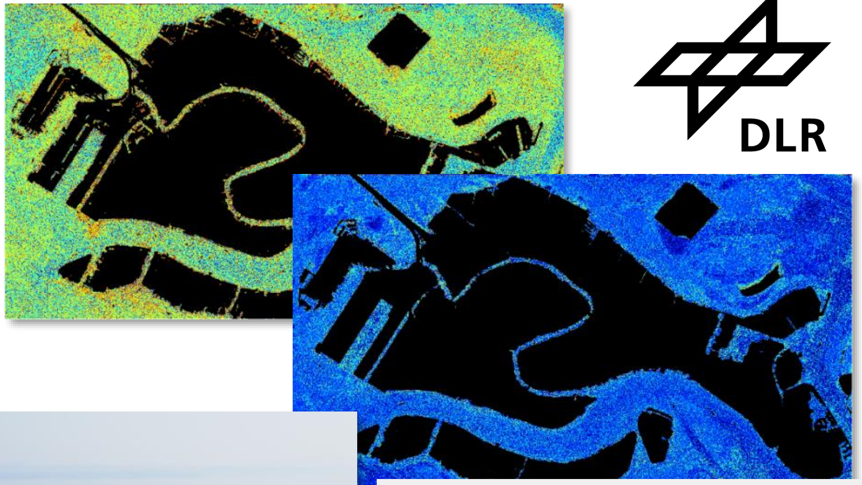
PlanetScope image of lakes Lasuntay and Huacracocha and the city of Huancayo

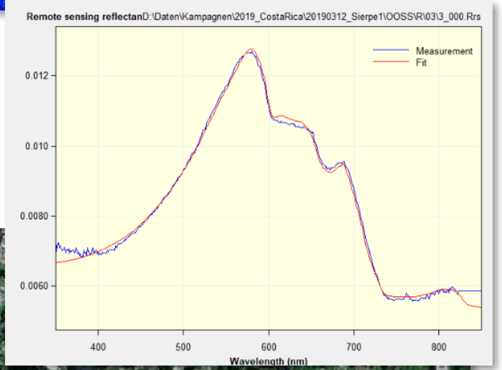
Requirements

- Development of concepts to improve and complement existing monitoring systems through remote sensing methods
- Development and introduction of tools to improve databases for decision-making
- Capacity building

Group Validation

- Principal research topic: remote sensing of inland waters
- Validation of satellite data and model results for water quality parameters
- Development of radiative transfer models for water (WASI)
- Conduction of field campaigns
- Development of instrumentation for field measurements





Dr. Peter Gege | Dr. Ian Somlai | Stefan Plattner | Thomas Schwarzmaier

The principle of aquatic remote sensing

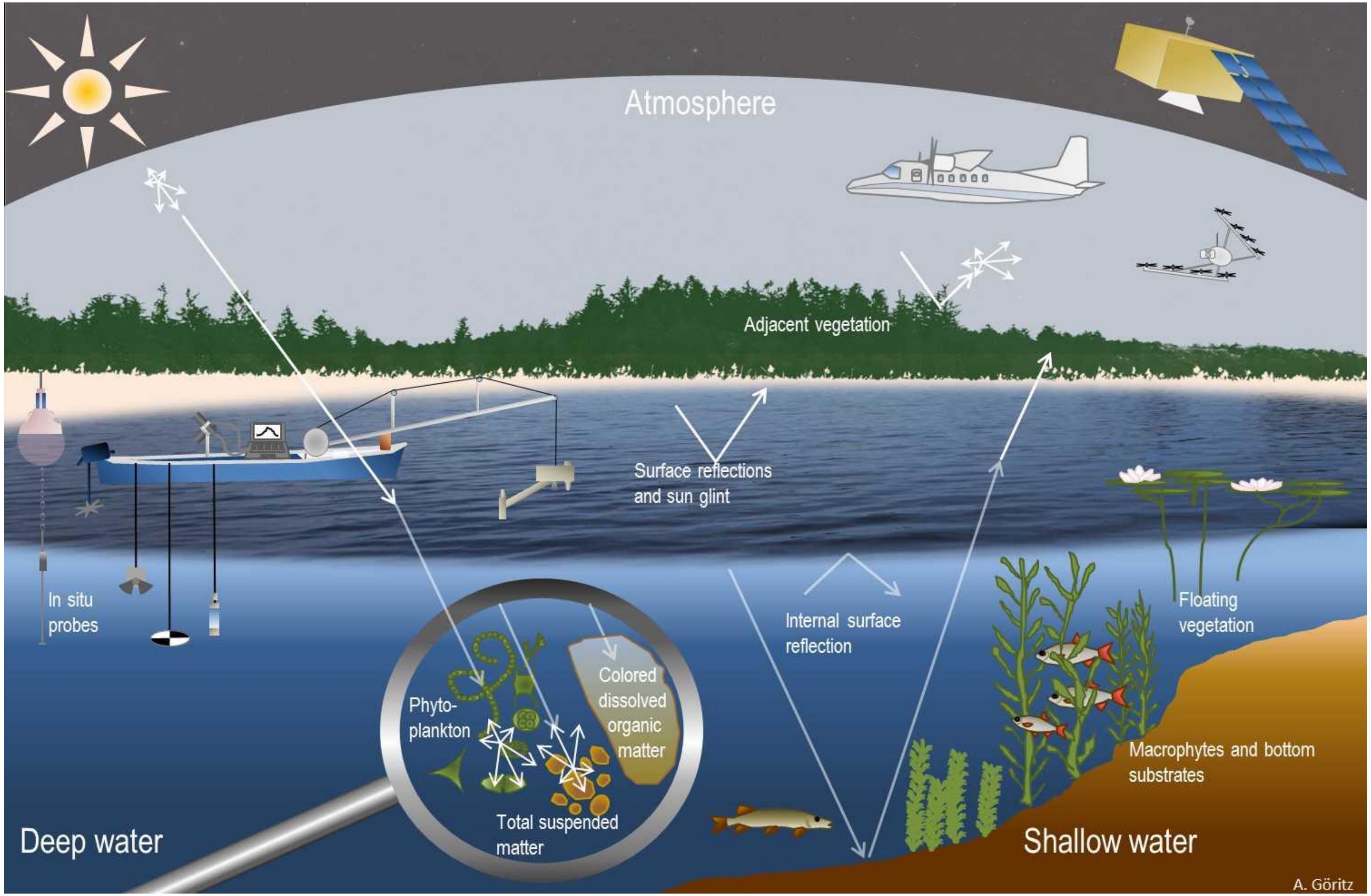
Courtesy: C. Giardino (CNR)

The principle of aquatic remote sensing

Which major groups of constituents are typically discriminated in aquatic remote sensing?

→ Phytoplankton (Chl-a)
→ Colored dissolved organic matter (CDOM)
→ Total suspended matter (TSM)

+ Bathymetry (shallow waters)



Reflectance spectrum

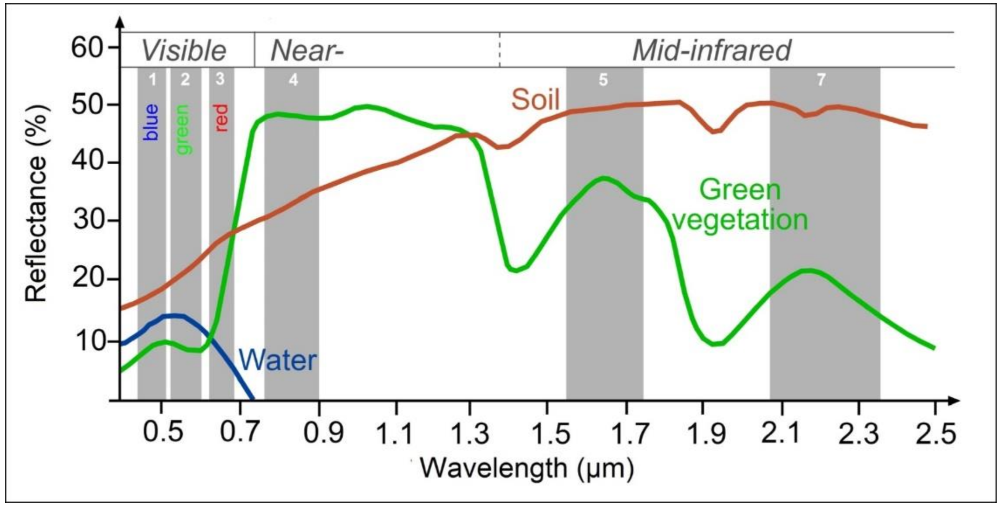
What does the human eye see?

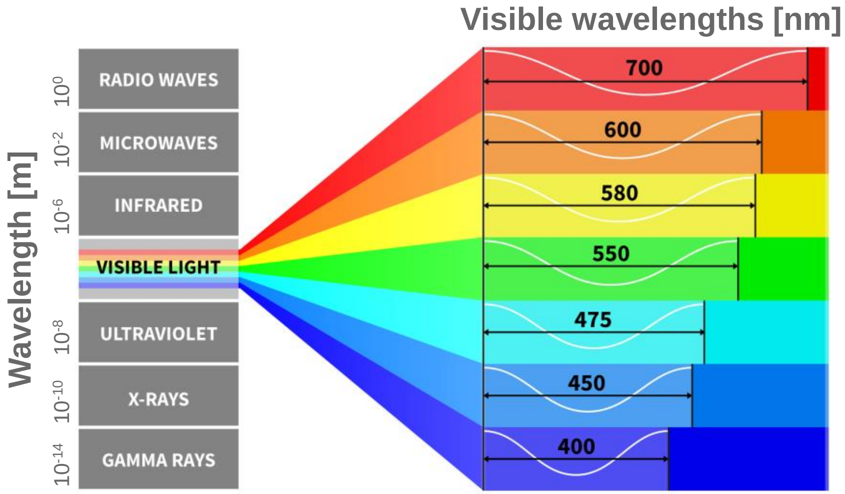
- Every material reflects / absorbs electromagnetic radiation differently
- Visible spectrum represents only a short wavelength range

- Reflected light defines a material specific spectral signature = <u>spectrum</u>

→Reflectance spectrum contains information about material properties!
(not restricted to VIS)

[1]





[2]

[1] justledus.com
[2] bceye.com

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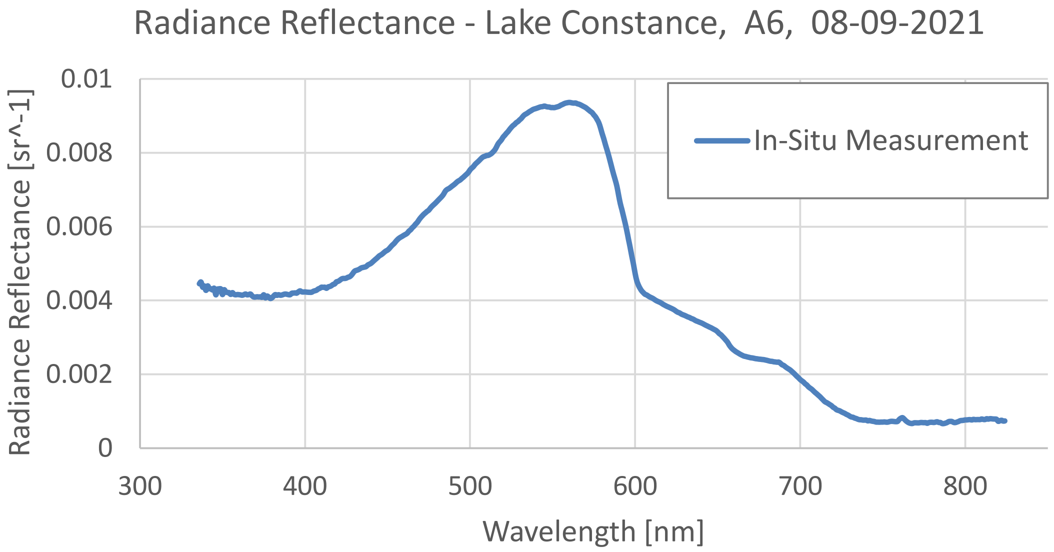

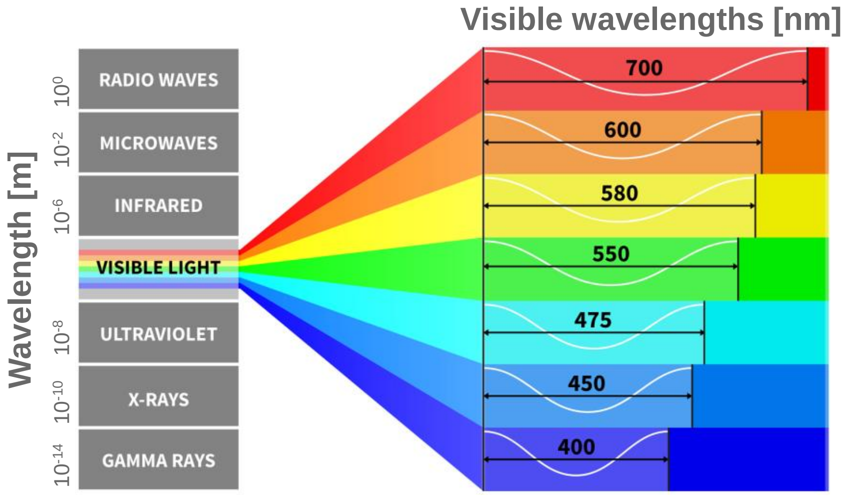

[2]

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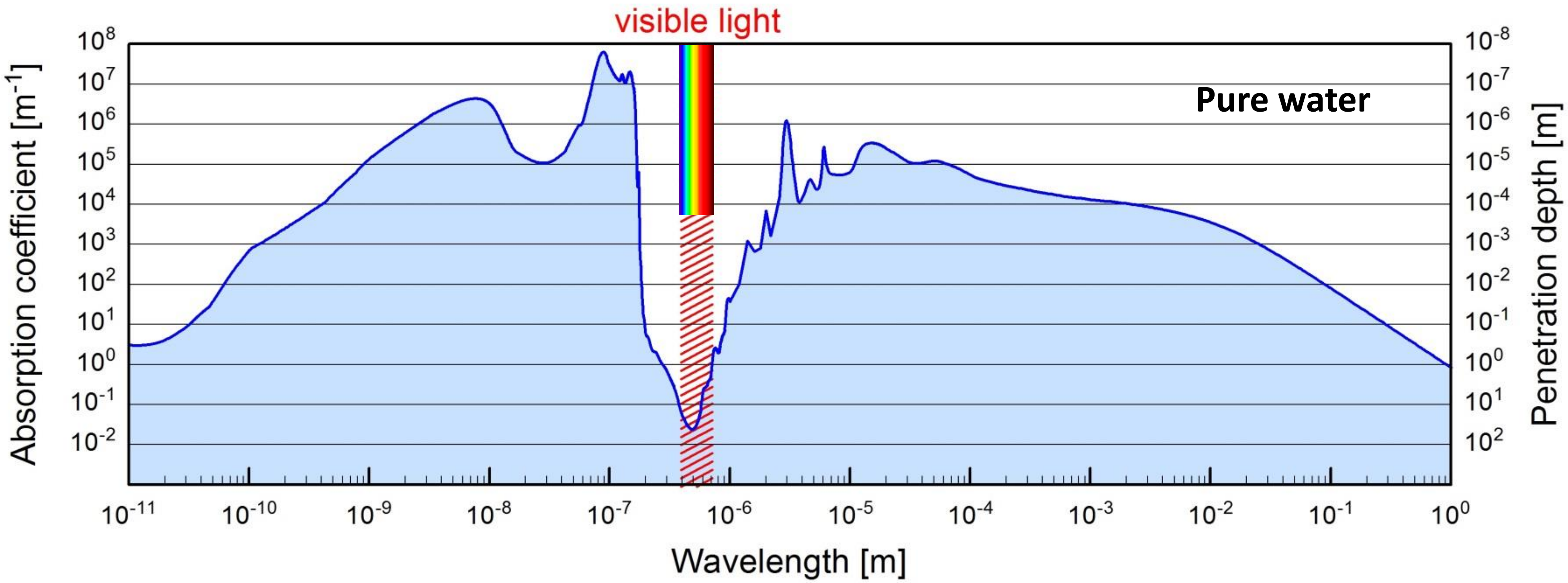
Spectral information in water colour



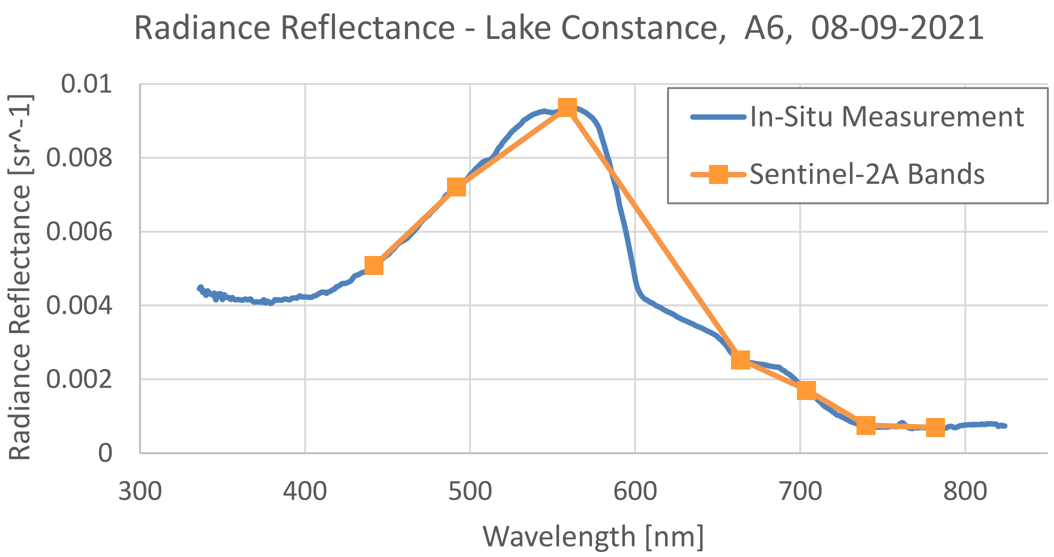
- Visible light bears information about the upper water layer (order of 10 m) and (in shallow waters) the bottom
- The other wavelengths can be used to derive information about the surface (skin temperature, waves) and the reflected light (useful for atmosphere correction)

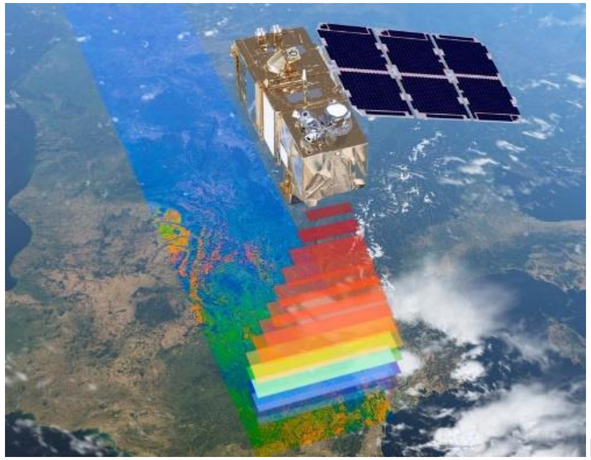
Reflectance spectrum

What does an optical satellite sensor see?

- Reflected light coming from large areas on the planet's surface and propagating through the atmosphere
- Each image pixel contains one reflectance spectrum
- Number of bands and spectral properties defined by sensor

→ Multi- and hyperspectral sensors





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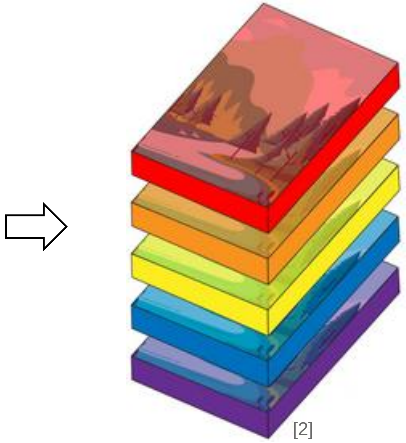


[2]

[1] www.dlr.de/content/de/artikel/news/2015/20150623_landbeobachtung-4-0-sentinel-2a-gestartet_14001.html
[2] www.edmundoptics.eu/knowledge-center/application-notes/imaging/hyperspectral-and-multispectral-imaging

Multi- and hyperspectral sensors

RGB

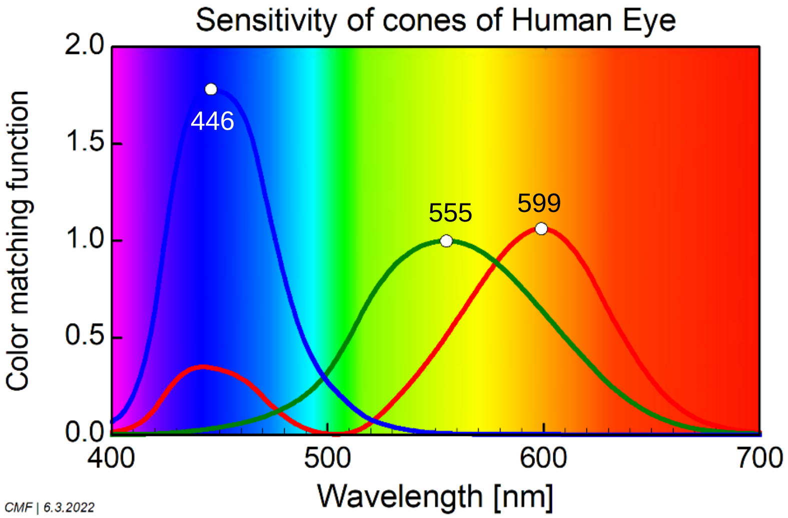
- 3 bands (red, green, blue)
- Sensitivity similar to human eye
- Example: camera

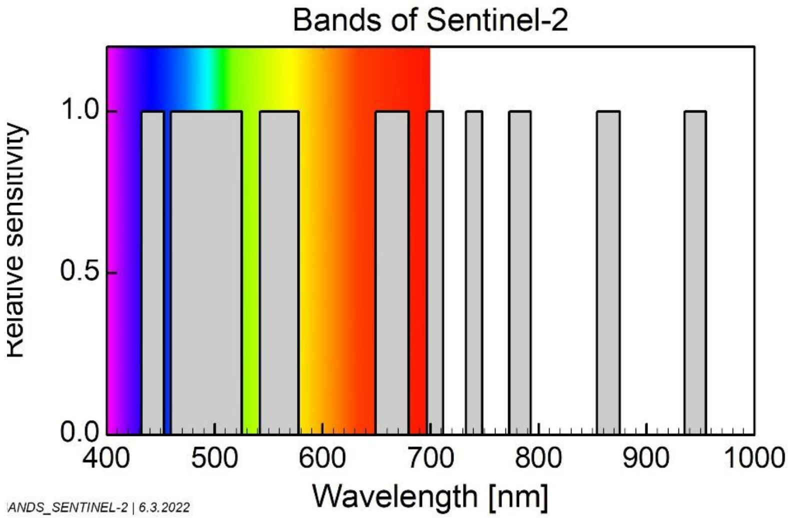
Multispectral

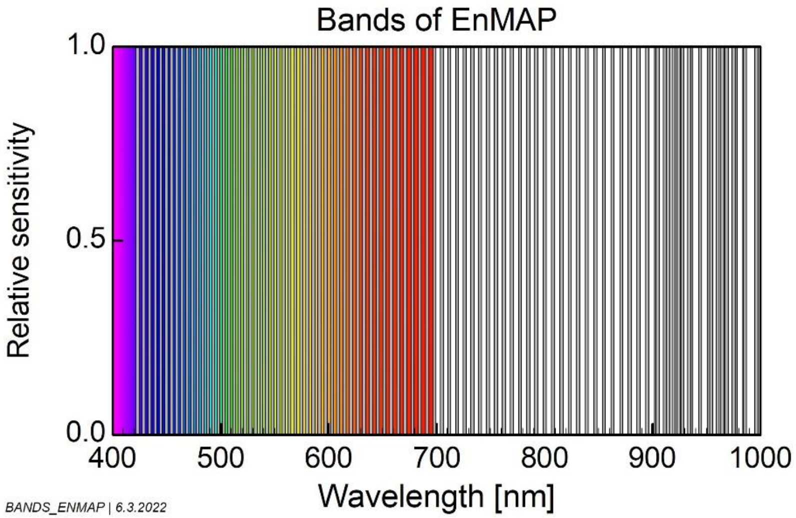
- Few bands separated by gaps
- Examples: Sentinel-2/3, Landsat-8/9, Planet SuperDove, PeruSAT-1

Hyperspectral

- Many narrow contiguous bands
- Examples: EnMap, DESIS, PRISMA







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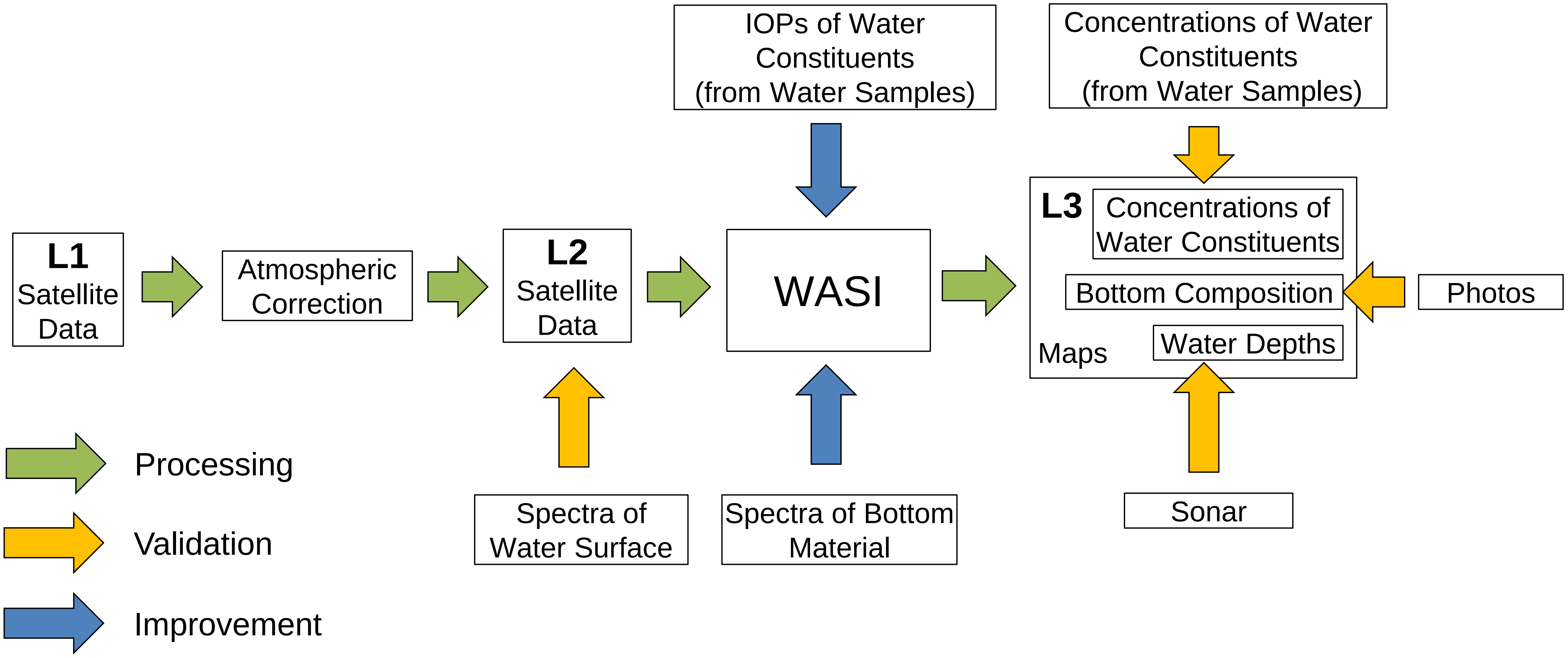
Processing, Validation and Improvement Workflow



Project Goals & Structure

- Development of concepts to improve and complement existing monitoring systems through remote sensing methods
- Development and introduction of tools to improve databases for decision-making
- Capacity building

Covered in 4 work packages:

Concept development, capacity building and scheduling

- Workshops for know-how transfer, capacity building (hands-on!), data analysis and results evaluation

Adaptation of data processing software

- Determination of regional optical properties
- In-situ measurements: spectral (water and substrate) and depth
- Water samples for laboratory analysis

Set-up of a processing environment for satellite data

- Protocols for access, (pre) processing and data analysis of different instruments/satellites

Analysis and validation of satellite data

- Validation of satellite images based on in-situ acquired data
- Remote sensing of water quality indicators and water volume

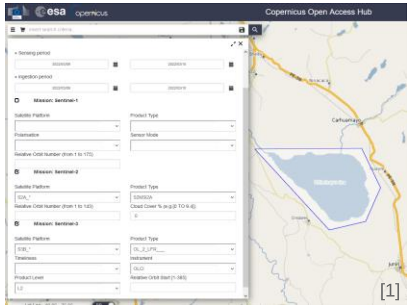
Capacity building

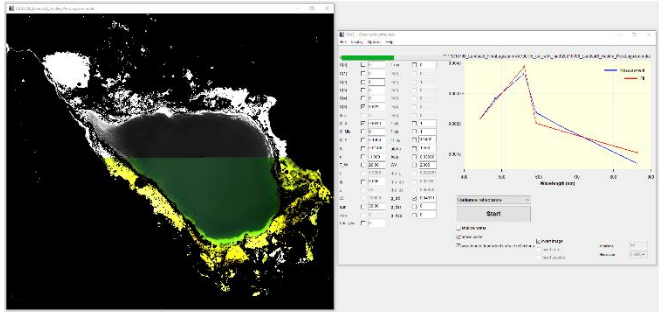
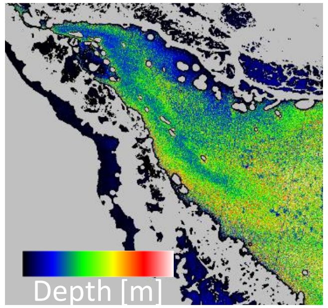
- Key for the project's success:

To establish a
<u>self-dependent</u>, <u>locally managed</u>, <u>long-term</u>
observation of water quality and availability

- Workshops / Teamwork / Know-how transfer / Collaboration / Communication / Time (!!)





- Data acquisition + processing + analysis + understanding → Dissemination, utilization, decision-making

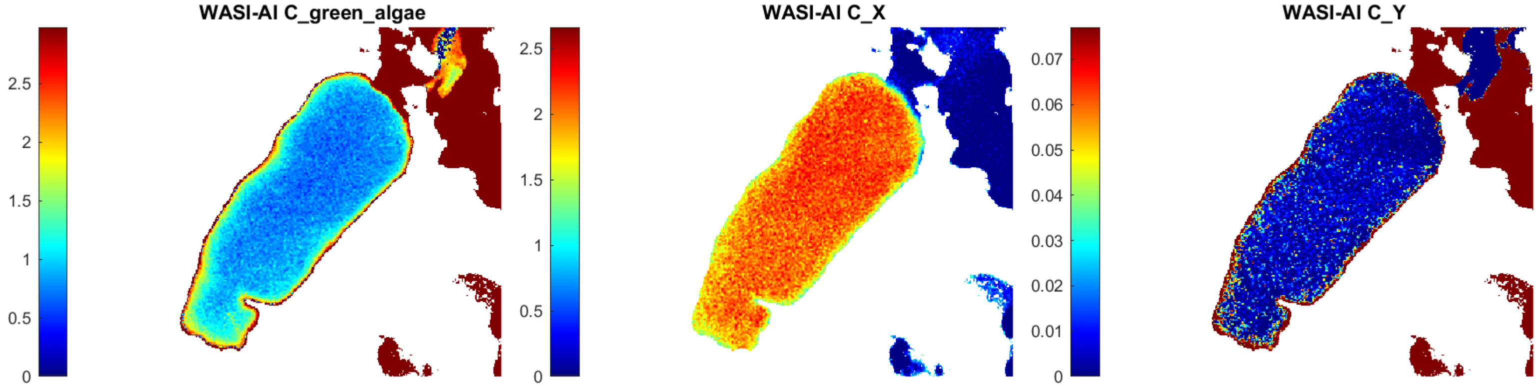
[1] https://scihub.copernicus.eu/dhus/#/home

Capacity building: Task-Force workshops

From this …

Laguna Lasuntay - PlanetScope, 16.08.2022

… to this!



Peter Gege, WASI-AI

- Search and download satellite data for Lago Junín and Lagunas Lasuntay, Huacracocha and Pomacocha
- Perform atmospheric correction and visualization of spectral reflectance data
- Data analysis to derive water constituent’s concentrations (Chl-a, TSM, CDOM) and bathymetry
- Combine all available data: in-situ radiometry + laboratory analysis of water probes + satellite data
- Results-based definition of best suited satellites for retrieval of the mentioned parameters in each water body
- Generate and export distribution maps of water constituents’ concentrations and bathymetry
- Regular online meetings, e.g. every 2 weeks, for joint work, results discussion and planning
- Prepare 1-week visit of task-force group to DLR in Q1-2023 for intensive cooperation and results generation

Capacity building: Task-Force workshops

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Task-Force Data Overview

Lugar	Fecha muestras de agua	Imagen(es) satelital(es)	Clorofila-a [µg/L] - Proveedor y origen del resultado				TSM [mg/L] - Proveedor y origen del resultado			CDOM - Proveedor y origen del resultado		
			SGS Muestra de agua	IMARPE Muestra de agua	DLR (7 estaciones) Radiometría In-Situ	ProGIRH-DLR Imagen satelital	SGS Muestra de agua	DLR (7 estaciones) Radiometría In-Situ	ProGIRH-DLR Imagen satelital	SGS [1/m]@440 [nm] Muestra de agua	DLR (7 estaciones) [mg/L] Radiometría In-Situ	ProGIRH-DLR Imagen satelital
Laguna Pomacocha	07.07.2022	PlanetScope 7.07.2022	< 3	40.59	40.5; 41.7; 42.7; 43.8; 44.0; 41.1; 42.9	Pendiente	4	3.73; 4.03; 3.6; 3.67; 3.76; 4; 3.78	Pendiente	-	2.26; 1.64; 2.43; 2.55; 2.74; 2.01; 2.39	Pendiente
Laguna Pomacocha	07.07.2022		< 3	41.54		Pendiente	5		Pendiente	-		Pendiente
Laguna Lasuntay	16.08.2022	PlanetScope 16.08.2022	< 3	43.42	-	Pendiente	< 3	-	Pendiente	X (análisis errado)	-	Pendiente
Laguna Lasuntay	16.08.2022		< 3	42.95	-	Pendiente	< 3	-	Pendiente	X (análisis errado)	-	Pendiente
Laguna Pomacocha	17.08.2022	PlanetScope, 2 escenas consecutivas pero del 18.08.2022	< 3	40.59 (!)*	-	Pendiente	4	-	Pendiente	0.0055 -> S= 0.01978 [1/λ]	-	Pendiente
Laguna Pomacocha	17.08.2022		< 3	41.54 (!)*	-	Pendiente	5	-	Pendiente	0.0074 -> S= 0.02046 [1/λ]	-	Pendiente
Huacracocha	18.08.2022	PlanetScope 18.08.2022, 2 escenas de distintos satelites	< 3	20.57	-	Pendiente	4	-	Pendiente	0.1706 -> S= 0.01916 [1/λ]	-	Pendiente
Huacracocha	18.08.2022		< 3	21.04	-	Pendiente	4	-	Pendiente	0.1784 -> S= 0.01889 [1/λ]	-	Pendiente
Chinchaycocha	24.08.2022	PlanetScope 24.08.2022 Landsat8 28.08.2022 Landsat9 20.08.20022 S2A 23.08.2022 S3A 24.08.2022 PlanetScope 25.08.2022, solo fracción del lago.	< 3	0.95	-	Pendiente	< 3	-	Pendiente	0.0140 -> S= 0.02143 [1/λ]	-	Pendiente
Chinchaycocha	24.08.2022		< 3	1.24	-	Pendiente	< 3	-	Pendiente	0.0471 -> S= 0.02216 [1/λ]	-	Pendiente
Chinchaycocha	24.08.2022		< 3	2.81	-	Pendiente	< 3	-	Pendiente	0.0131 -> S= 0.02246 [1/λ]	-	Pendiente
Chinchaycocha	24.08.2022		< 3	3.48	-	Pendiente	< 3	-	Pendiente	0.0742 -> S= 0.02227 [1/λ]	-	Pendiente
Chinchaycocha	24.08.2022		< 3	3.35	-	Pendiente	< 3	-	Pendiente	0.0867 -> S= 0.02404 [1/λ]	-	Pendiente
Chinchaycocha	25.08.2022		< 3	2.30	-	Pendiente	< 3	-	Pendiente	0.0155 -> S= 0.02331 [1/λ]	-	Pendiente
Chinchaycocha	25.08.2022		< 3	2.05	-	Pendiente	< 3	-	Pendiente	0.0844 -> S= 0.02353 [1/λ]	-	Pendiente
Chinchaycocha	25.08.2022		< 3	1.22	-	Pendiente	< 3	-	Pendiente	0.0440 -> S= 0.02070 [1/λ]	-	Pendiente

+ Bathymetry

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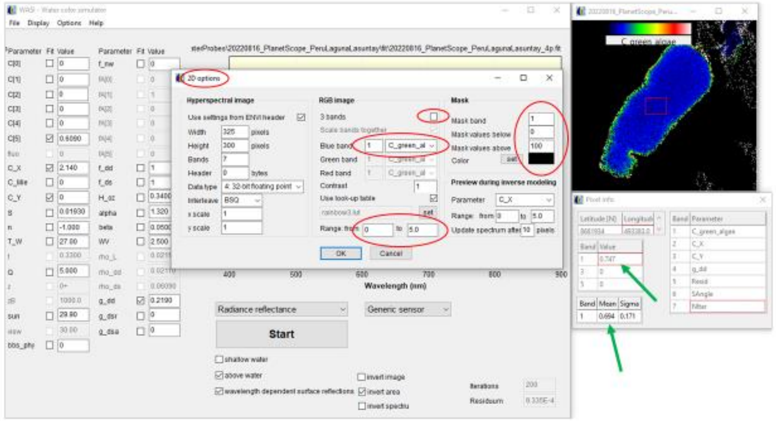
Visualize results with WASI



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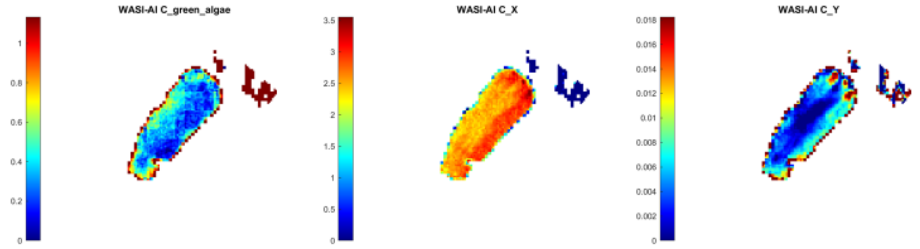
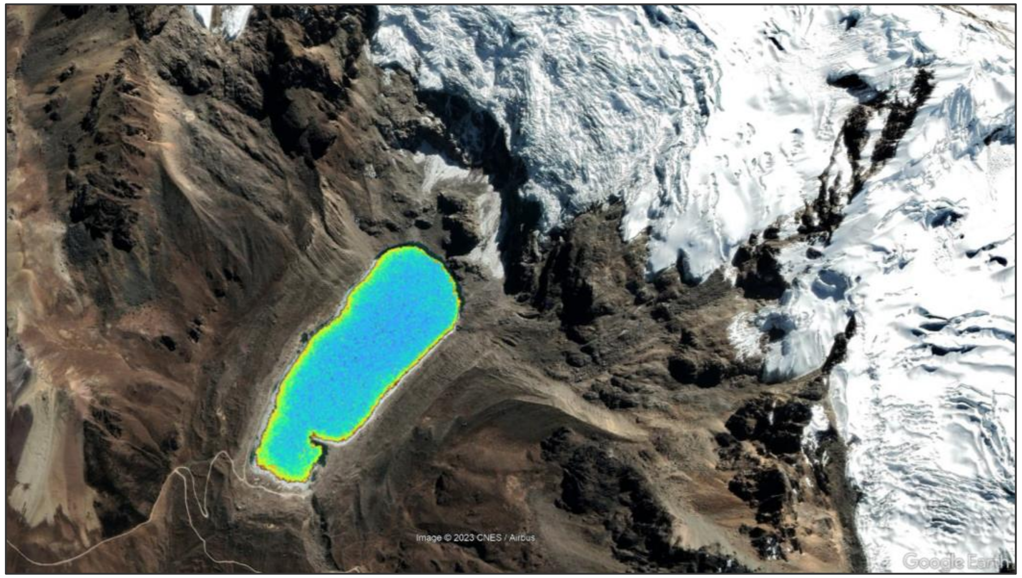
Comparison with WASI-AI results from Sentinel 2B image from 18.08.2022

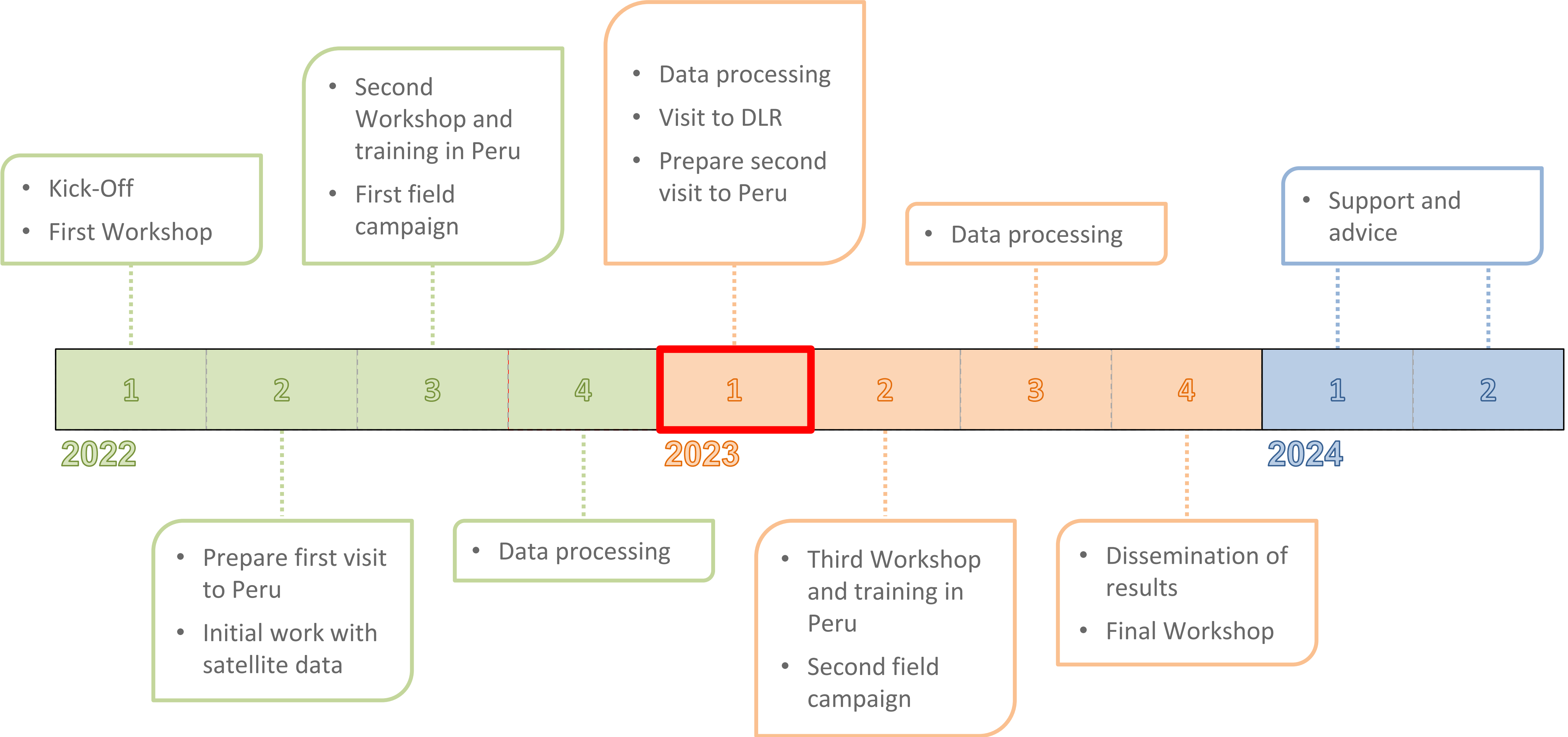


→ Results are comparable! (different satellites, 2 days apart)

→ Need to validate with in-situ radiometry and laboratory results



Project Timeline & Status



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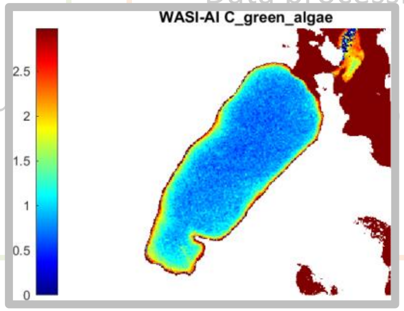

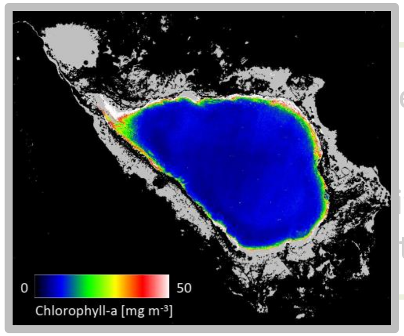

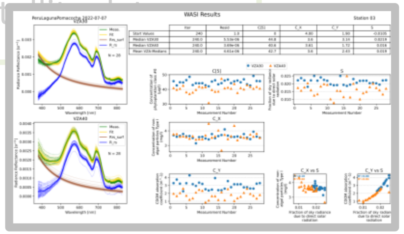

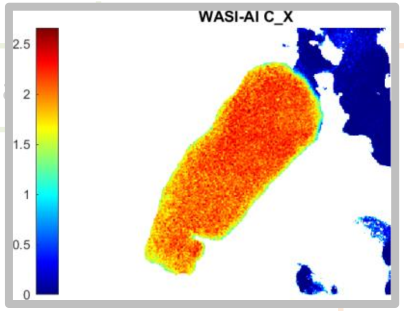

- Data processing
- …nd

- Data processing

- Support and advice

1			4	1	2	3	4	1	2

2022 2023 2024

- Third Workshop and training in Peru
- Second field campaign

- Dissemination of results
- Final Workshop

Thank you! - ¡Muchas gracias! - Vielen Dank!

DLR-Team “Validation”: Peter Gege, Stefan Plattner, Thomas Schwarzmaier, Ian Somlai