

New insights into aquatic systems with hyperspectral data: The EnMAP satellite and its water-related ground segment processors

Nicole Pinnel
and the entire EnMAP Team

Earth Observation Center (EOC)
Deutsches Zentrum für Luft- und Raumfahrt (DLR)



**WATER
DAYS**

**SDB Day &
EO Technology
Conference**

4 – 6 October, 2022

Overview

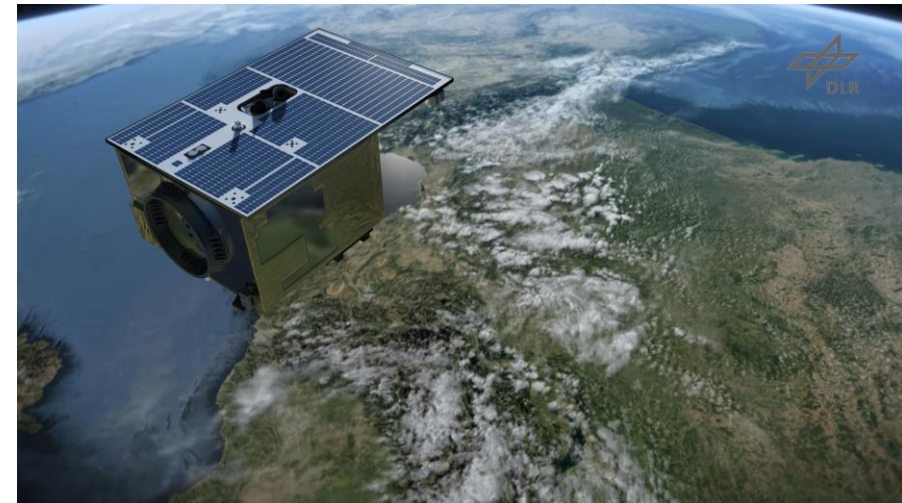
- EnMAP mission and participants, contributions from DLR
- EnMAP Technical Specifications
- Reception, processing and distribution
- EnMAP water-related ground segment processors
- Aquatic application examples



EnMAP Mission

EnMAP \equiv Environmental Mapping and Analysis Program

- Germany's first imaging-spectroscopy satellite-based earth observation mission
- Scientific Pathfinder mission for later operational services (CHIME, SBG)
- Regular provision of high-quality calibrated image products (orthorectification and atmospheric corrections)
- Observation of a wide range of ecosystem parameters,
e.g. Soils, minerals, land degradation
vegetation type and condition water quality



EnMAP Mission Consortium



DLR
Project Management
DLR Space Administration

GFZ
 Helmholtz-Zentrum
POTSDAM
Scientific Principal Investigator
GFZ Potsdam
EnMAP Science Team

OHB
Space Segment
 Sensor | Platform

DLR
Ground Segment
 Operations | Payload | Processing
DLR-GSOC | DLR-DFD | DLR-IMF

Supported by:



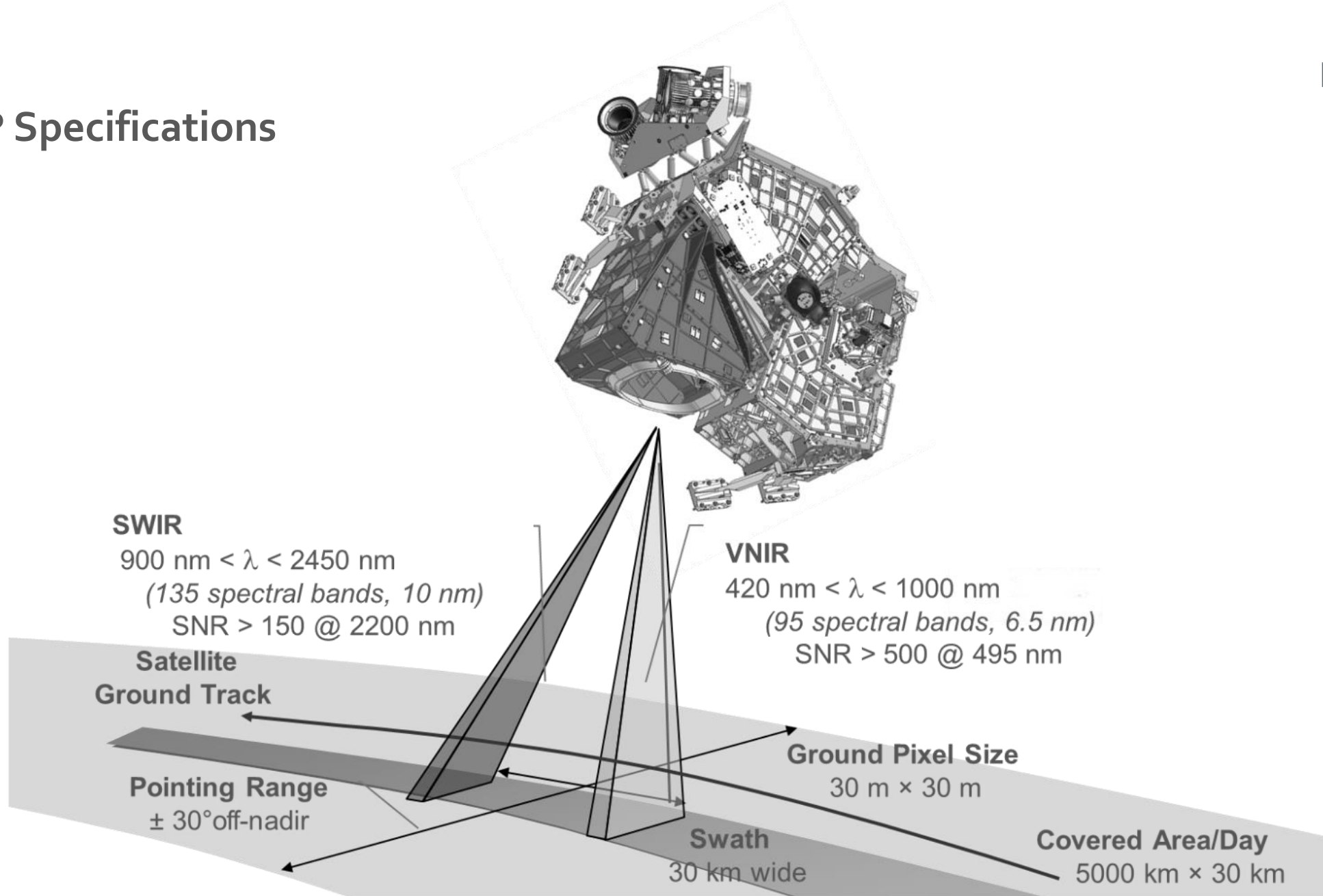
Federal Ministry
 for Economic Affairs
 and Climate Action

on the basis of a decision
 by the German Bundestag

- The DLR Space Administration in Bonn is responsible for the overall project management
- The ground segment is formed by the EOC and the GSOC in Oberpfaffenhofen
- Core funding is provided by the Federal Ministry of Economics and Climate Policy
- In addition: Extensive Scientific Exploitation preparation program

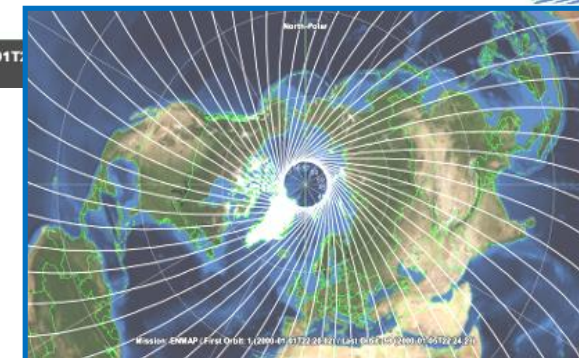
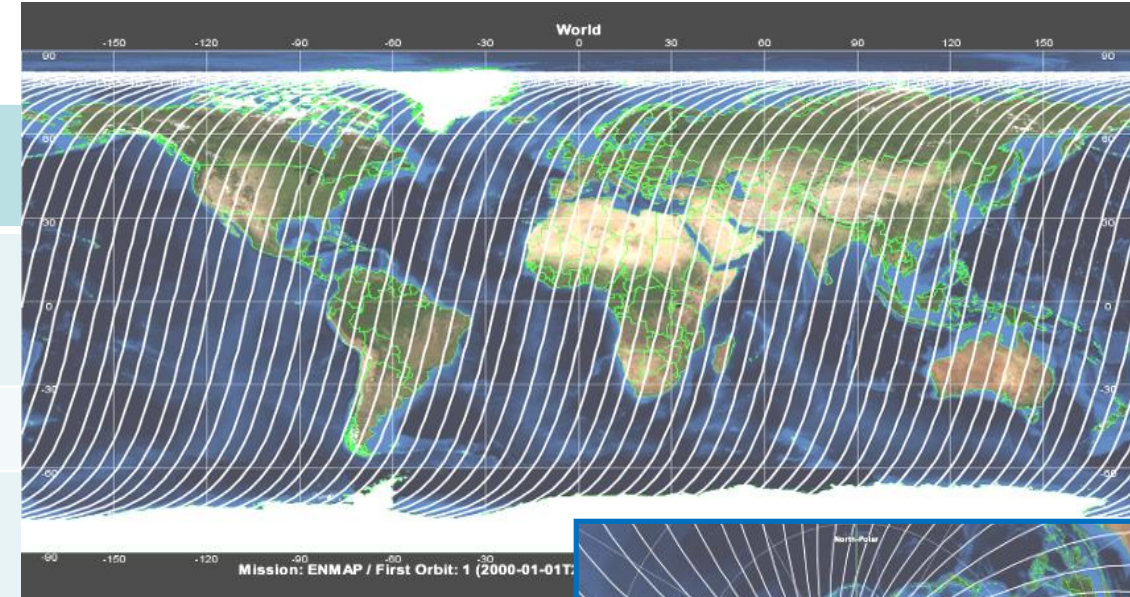


EnMAP Specifications

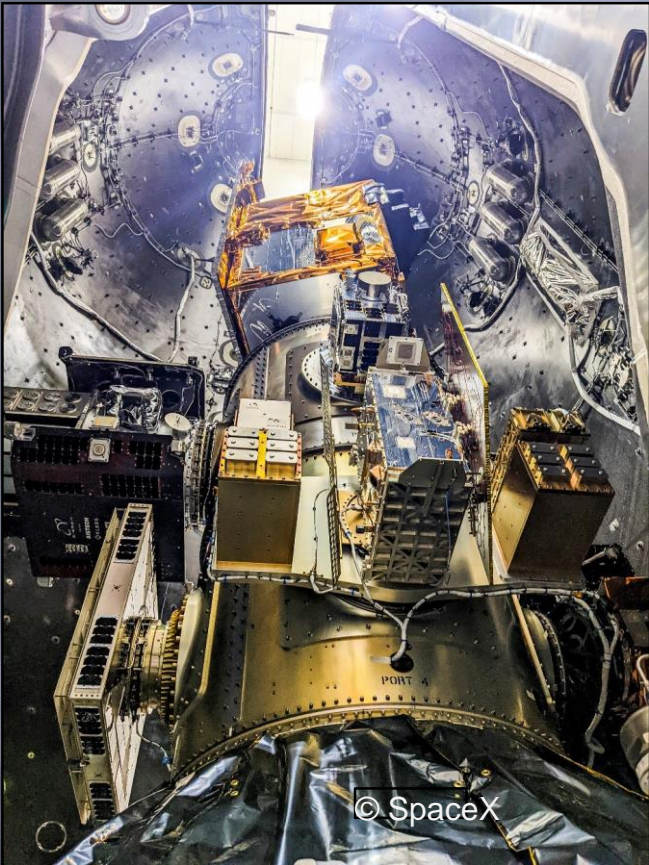
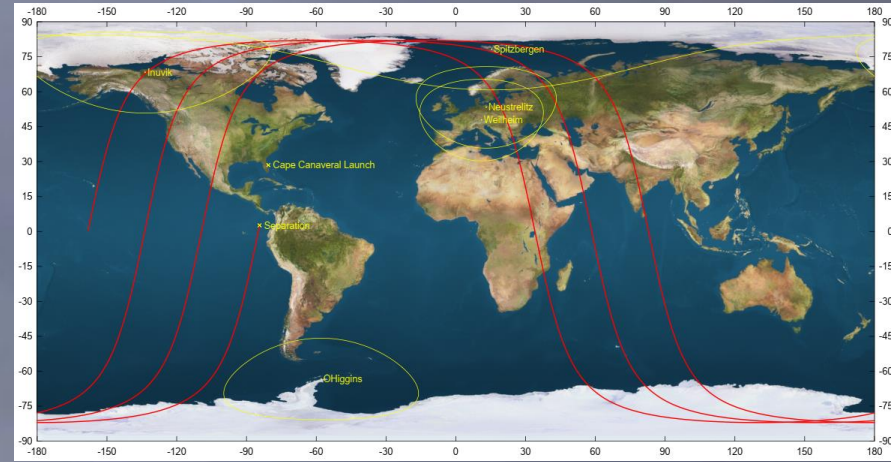


EnMAP Specifications

Parameter	Value
Target Lifetime	04/2022-04/2027 (currently in production phase)
Satellite (Mass, Dimension)	1000 kg, 3.1 m × 2.0 m × 1.7 m
Orbit (Type, Local Time at Equator, Inclination, Altitude, Repeat Cycle)	Sun-synchronous, 11:00, 98.0°, 653 km, 398 orbits in 27 days
Coverage	74° N to 74° S
Revisit	≤ 4 days (-30° to +30° across-track tilt) ≤ 27 days (-5° to +5° across-track tilt)



1st of April 2022



EnMAP Operation Phases

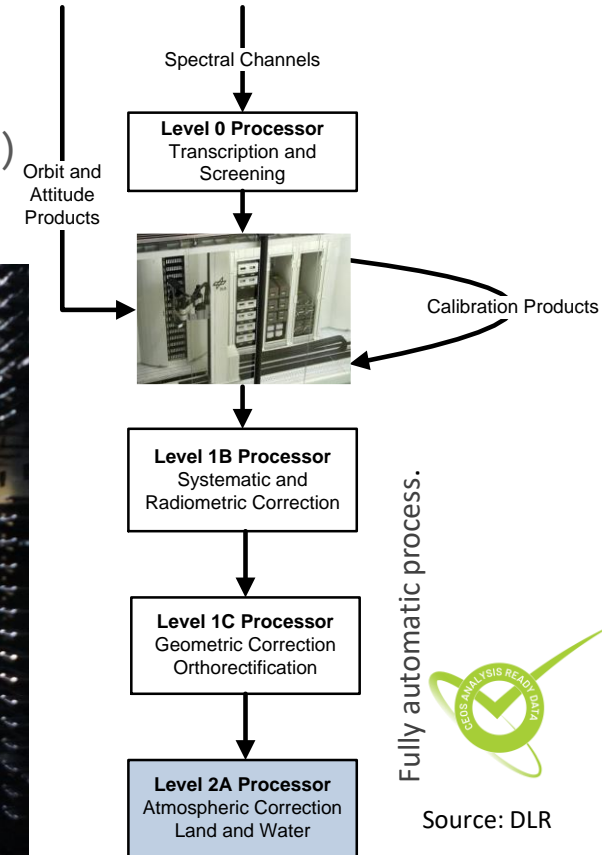
- Launch and Early Orbit Phase (14.04.2022, 2w)
- Commissioning Phase (6 m)
- Routine Phase (5 y)
- De-Commissioning Phase (3 m)



DFD-Station (Data receiving station),
Neustrelitz

GSOC-Station (TMTC),
Weilheim

German Satellite
Data Archive (D-SDA)
und Web-Interfaces

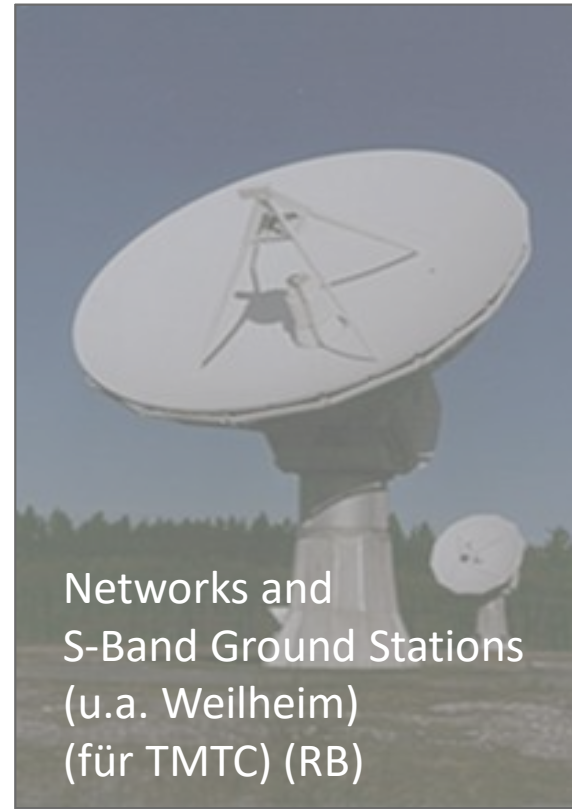


Ground Control Center
(GSOC), Oberpfaffenhofen



EnMAP Operation Phases

- Launch and Early Orbit Phase (14.04.2022, 2w)
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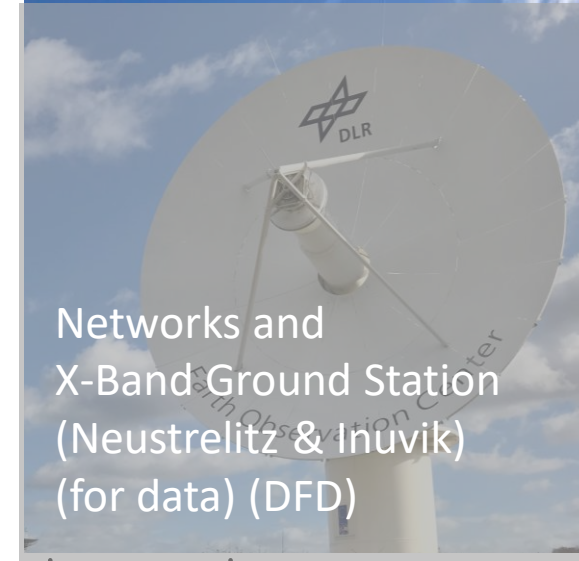


Networks and S-Band Ground Stations (u.a. Weilheim) (für TMTC) (RB)

DFD-Station (Data receiving station), Neustrelitz

GSOC-Station (TMTC), Weilheim

German Satellite Data Archive (D-SDA) und Web-Interfaces



Networks and X-Band Ground Station (Neustrelitz & Inuvik) (for data) (DFD)

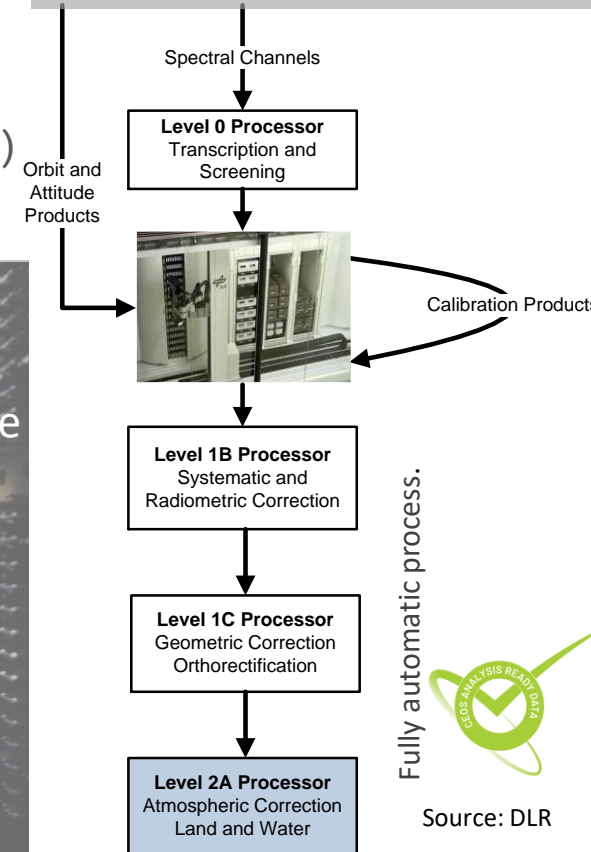
Ground Control Center (GSOC), Oberpfaffenhofen



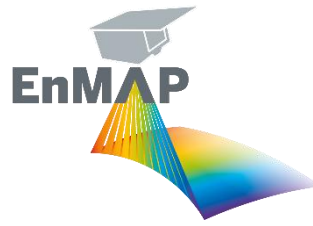
- Flight operations with planning and execution of mission operations as well as control and command (platform and instrument) (RB)
- Provision of position and location products Planning and execution of orbit maneuvers (RB)
- Mission planning using Reactive Planning (RB)



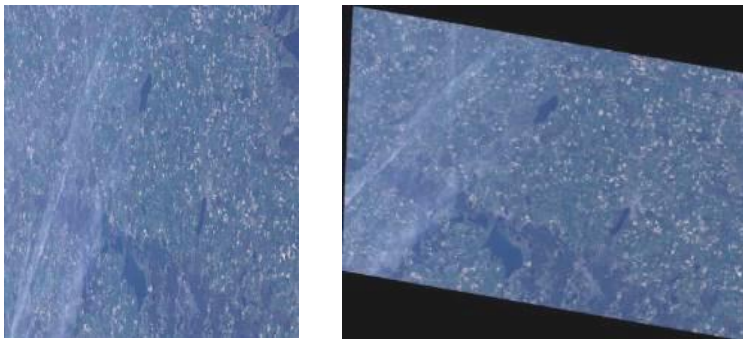
- Data processing for standard products (DFD)
- Instrument Calibration in Service (MF)
- Quality control of standard products (DFD/MF)
- Long-term archiving (DFD)
- User Interfaces (DFD) for record orders and product access



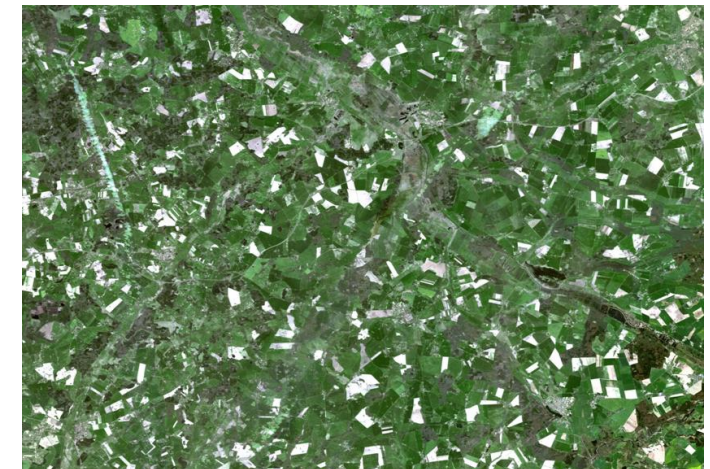
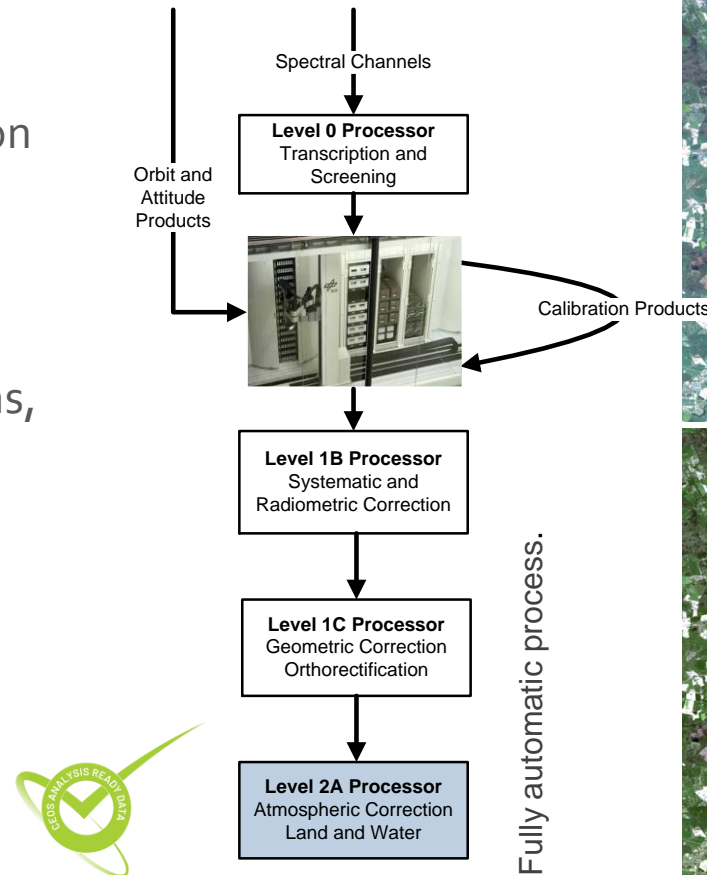
EnMAP Processor, Cal & QC System



- Development of a processing chain for
 - the systematic and radiometric correction (Level 1B)
 - orthorectification (Level 1C)
 - atmospheric correction (Level 2A)
- Calibration of the instrument during operations,
- Quality control of the products.

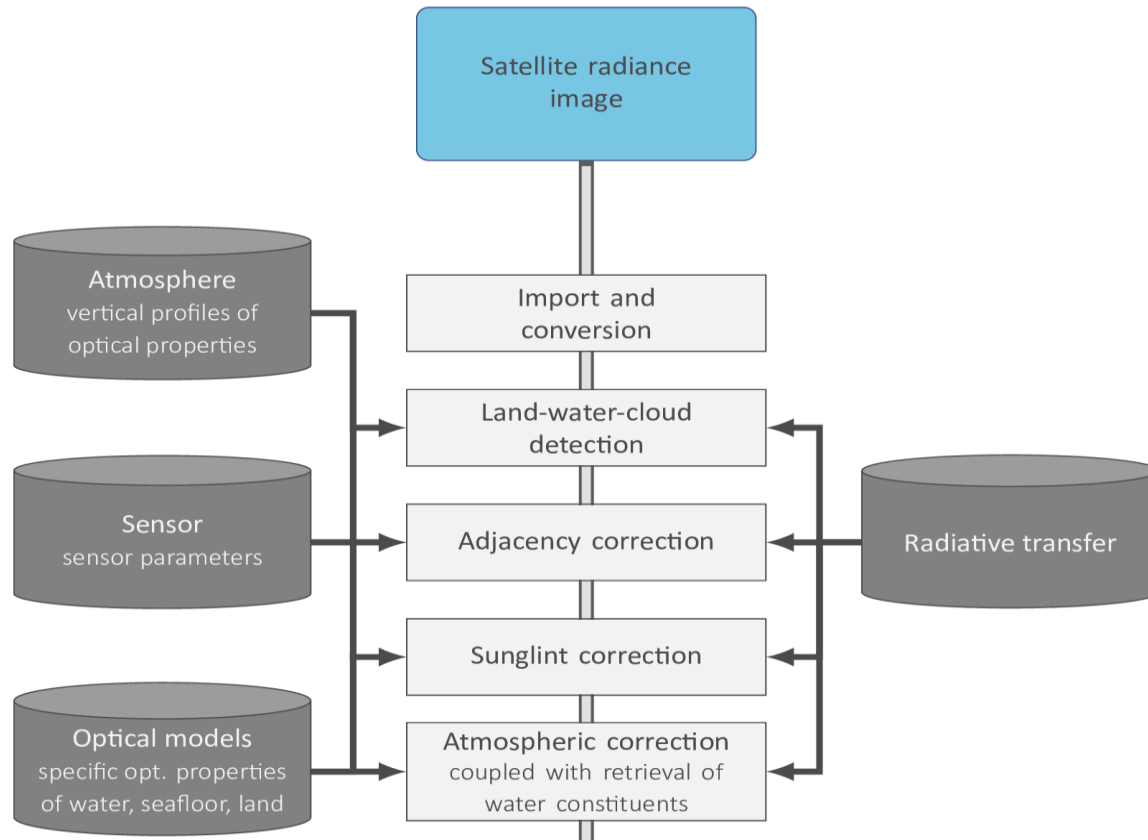


Orthorectification



Atmospheric Correction

EnMAP Water-related Ground Segment Processors

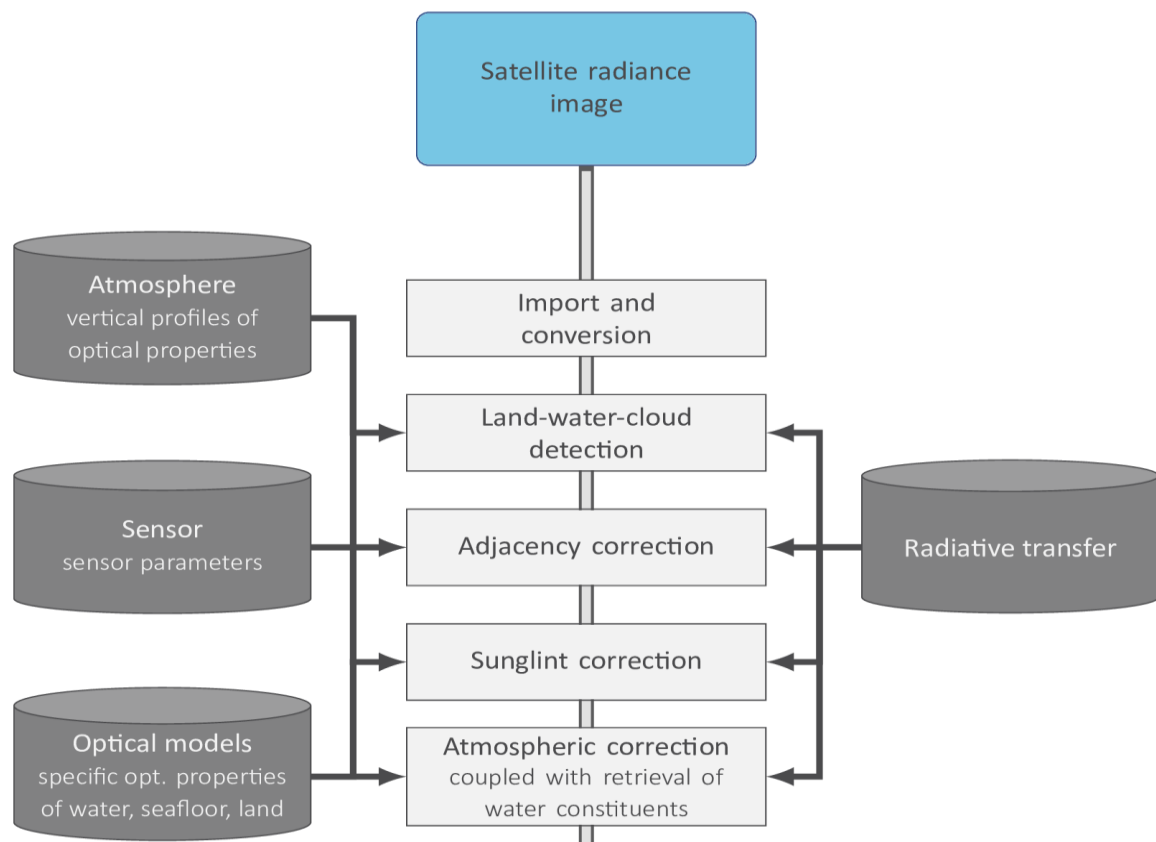


Modular Inversion Processor (MIP)

Fully physics-based processor for EnMAP AC correction over water, includes coupled AC-water retrieval

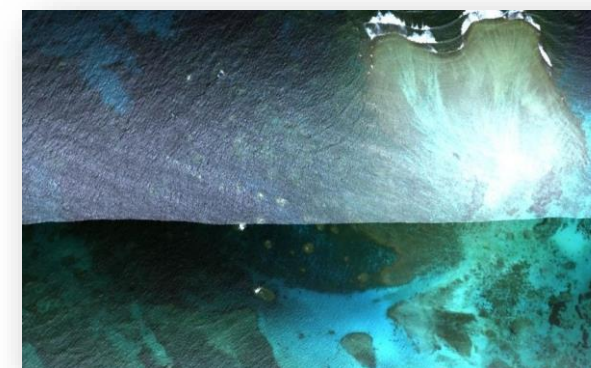
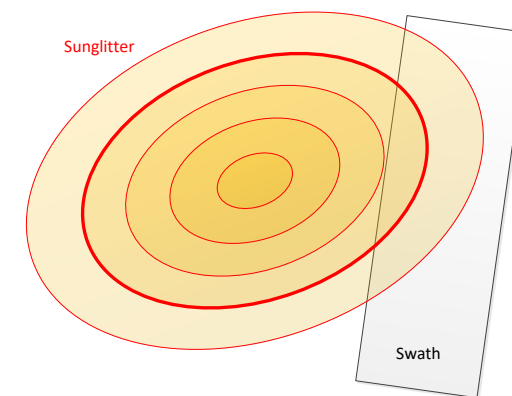


EnMAP Water-related Ground Segment Processors



Modular Inversion Processor (MIP)

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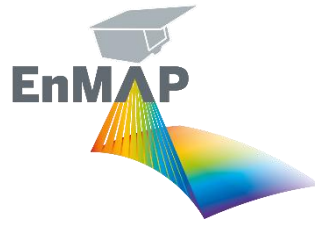


Sunglint avoidance algorithm

Maximum coverage of areas affected by sunglint will be considered during acquisition planning



EnMAP Users



- Internal User
 - Mission
 - Charter
- *Category I*
 - *Based on science AO*
 - *With proposal*
- *Category II*
 - Based on Space Administration
 - Without proposal
- Background Mission

Proposal Portal
EnMAP Proposals, Announcement of Opportunity Processes, Reviews, Up and Download of proposal-related Files.

Observation Request Portal
EnMAP Observation Requests, Planning Support for Observation Request Single Pass Coverage Acquisitions.

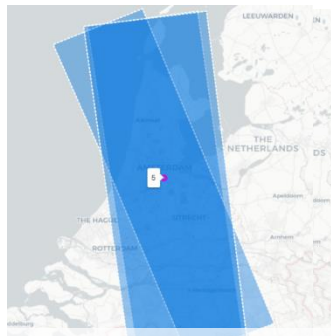
Calibration Request Portal
EnMAP Calibration Requests.

User Portal
Handling of IPS User Roles.

Data access via EOWEB@Geoportal

Product Type	Start Date	End Date	Mission/Orbit	Sensor/Mode	Satellite Number	Pass Direction	Cloud Coverage	Orbit	Datatac Nr	Tile Nr	File Preview
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	135721	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	16	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	16	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	20	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	1	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	4	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	2	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	8	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	1	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	6	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	7	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	8	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	9	3
EnMAP-H-L3	2017-06-28T10:29:29.961Z	2017-06-28T10:29:34.512Z	EnMAP	HSI	1	EnMAP	DESCENDING	0	15K42	10	3

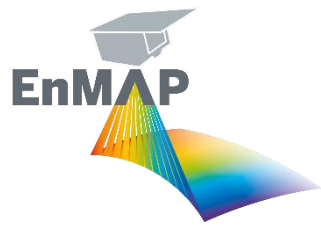
free and open



Data acquisition via EnMAP Instrument Planning Portal

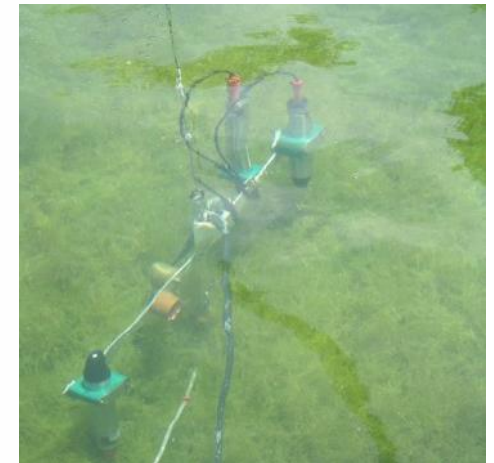
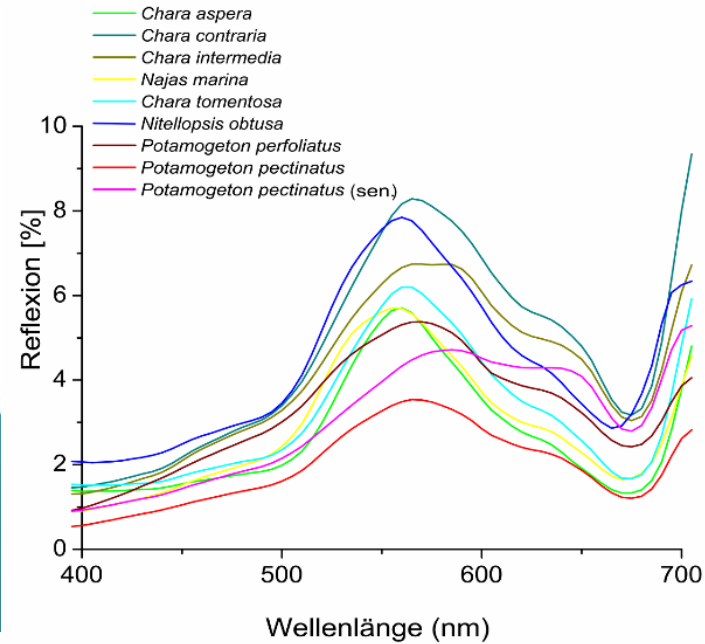
Year ops	Quota for Category I	Quota for Category II
1	80%	20%
2	70%	30%
3	70%	30%
4	60%	40%
5	60%	40%

Water Quality Application



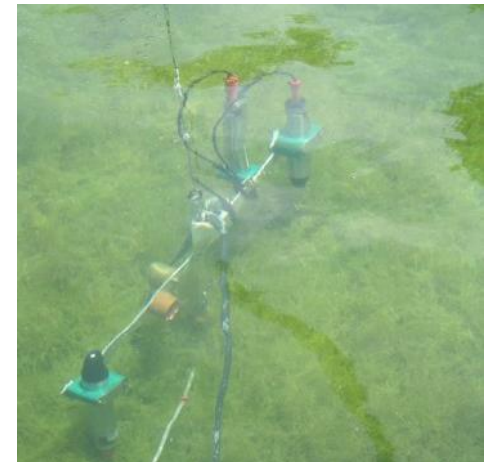
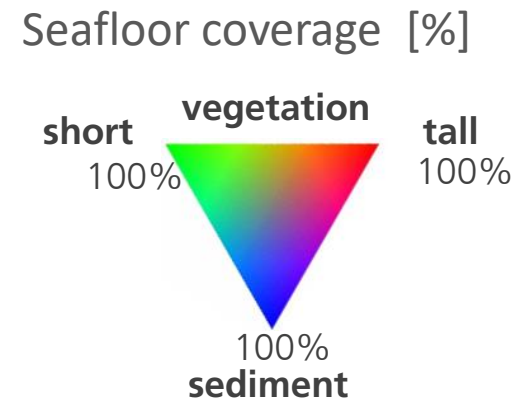
Water Quality Application - Submerged Aquatic Vegetation Mapping

Lake Starnberg (Airborne HyMAP Sensor)



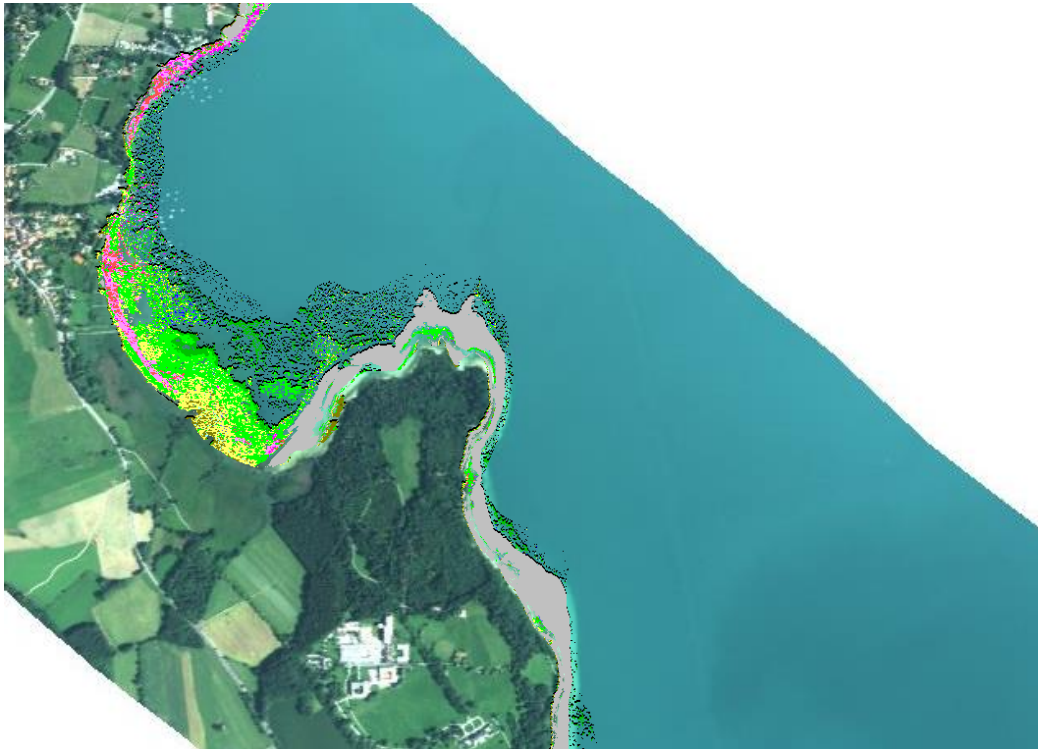
Water Quality Application - Submerged Aquatic Vegetation Mapping

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










Water Quality Application - Submerged Aquatic Vegetation Mapping

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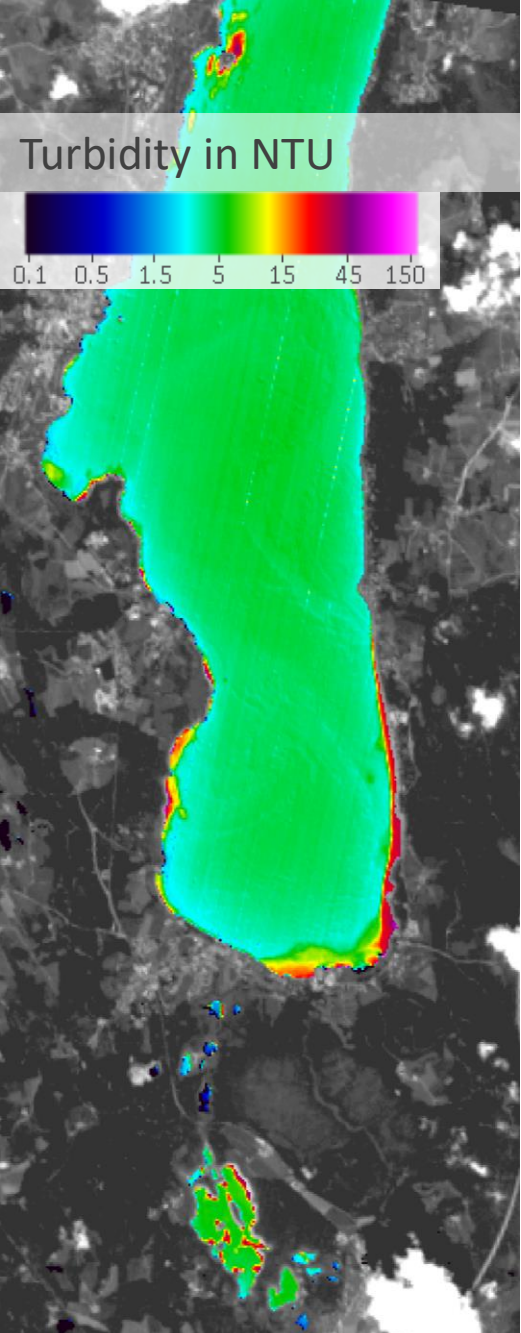
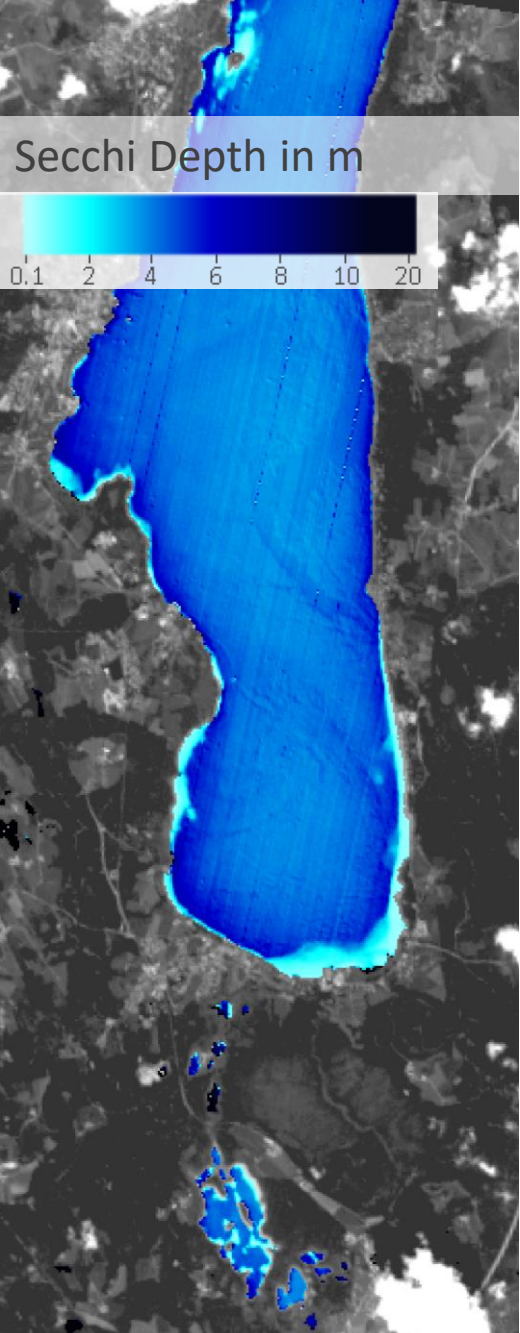
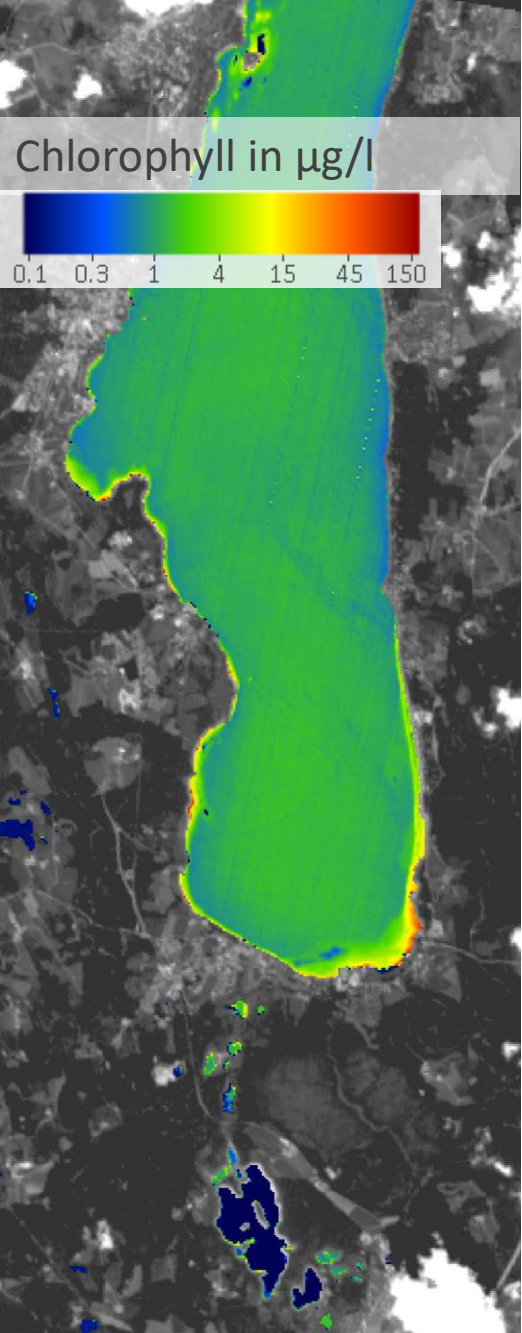
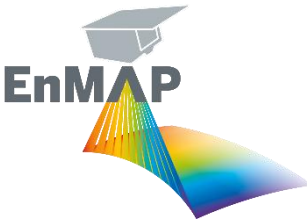


Macrophyte species

-  *P.perfoliatus*
-  *P.pectinatus*
-  *P.pectinatus sen.*
-  *Najas marina*
-  *Chara aspera*
-  *Chara aspera sen.*
-  *Chara contraria*
-  *Chara contraria sen.*
-  uncovered sediment



Water Quality Application – Lake Starnberg, Germany, 24.07.2022



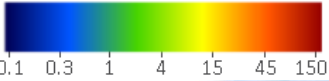
EnMAP Commissioning phase data ©DLR 2022. All rights reserved



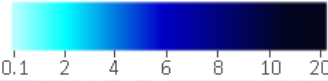
Water Quality Application – Lago di Garda, Italy, 28.07.2022



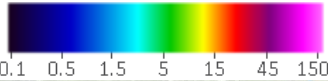
Chlorophyll in $\mu\text{g/l}$



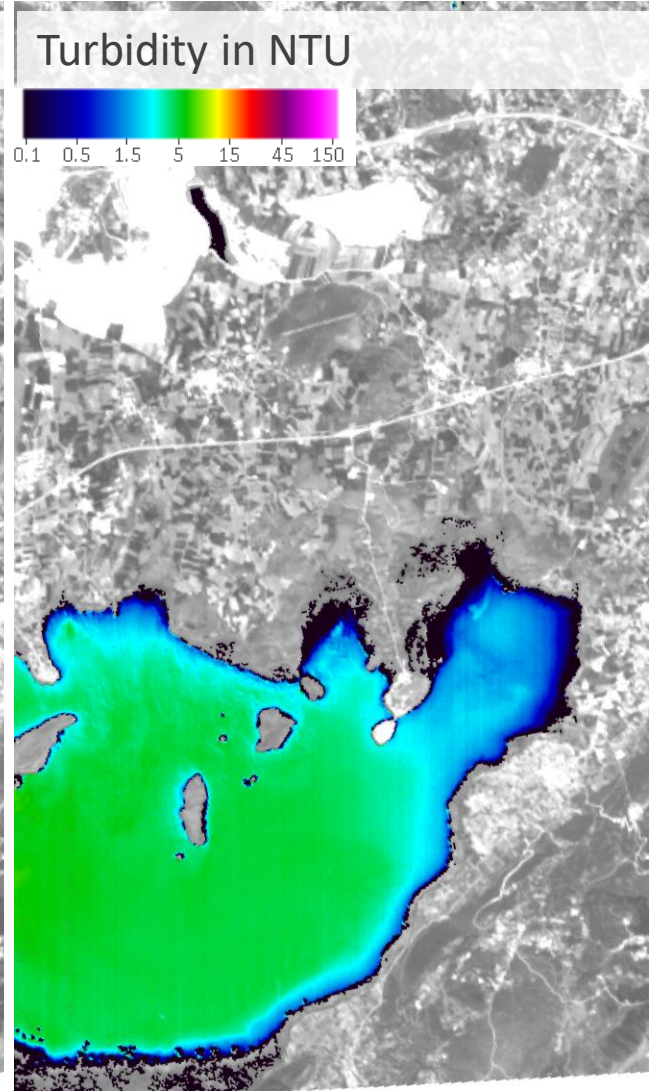
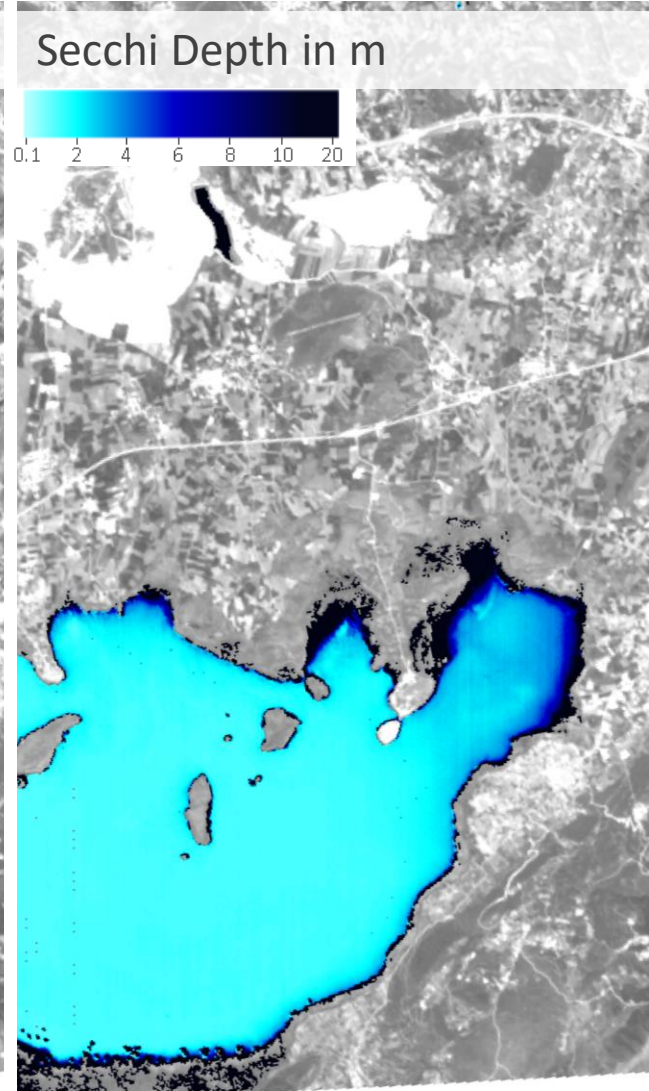
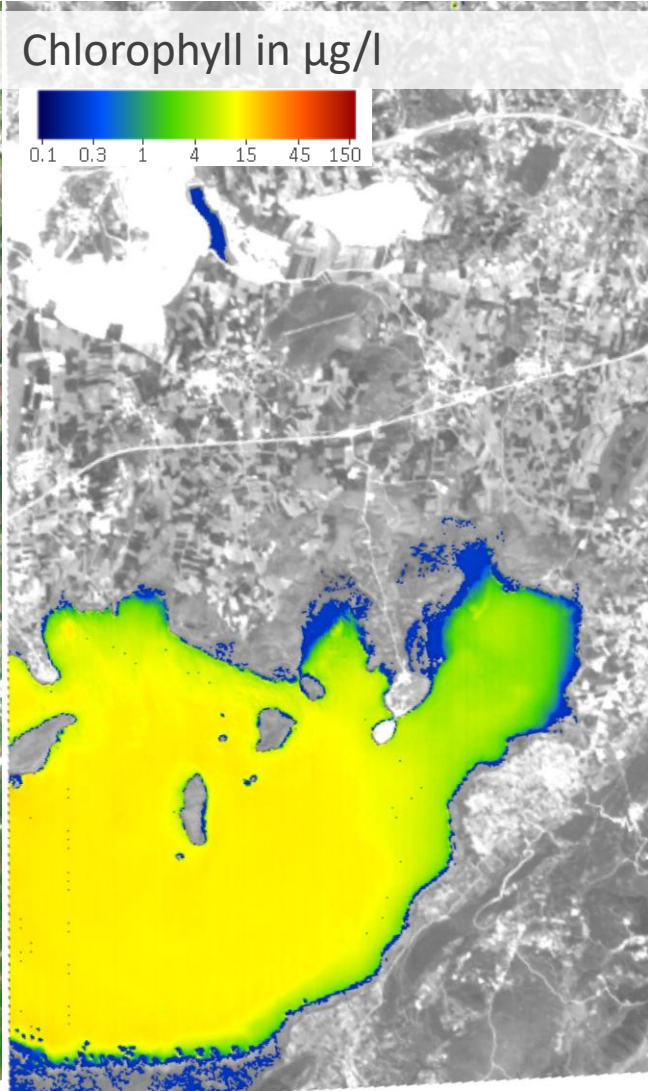
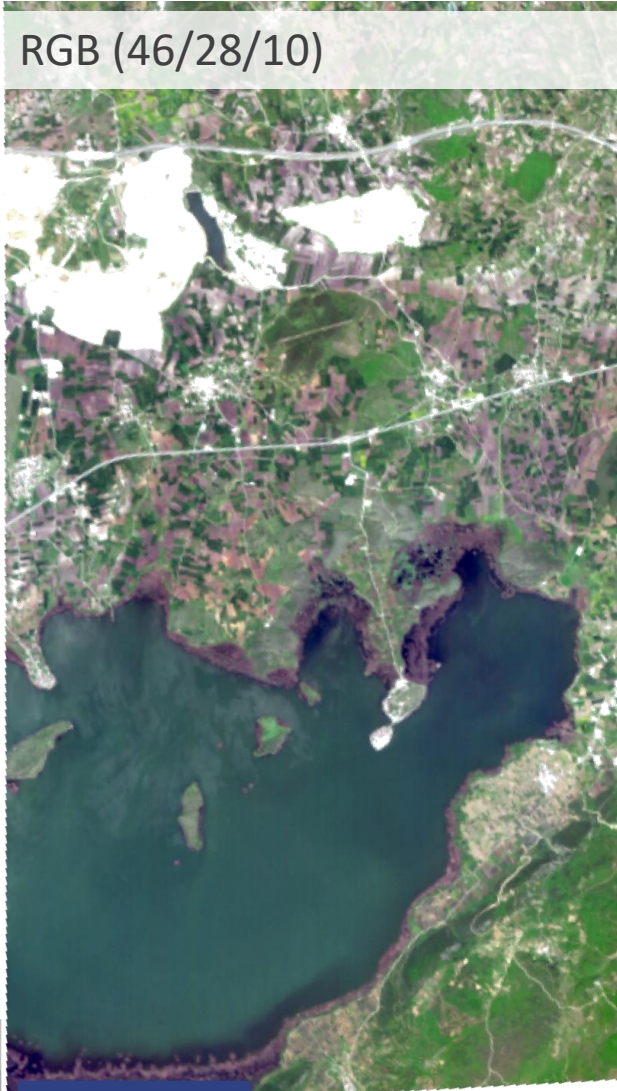
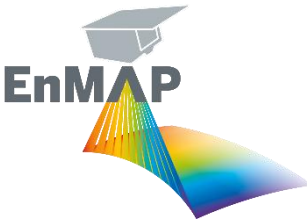
Secchi Depth in m



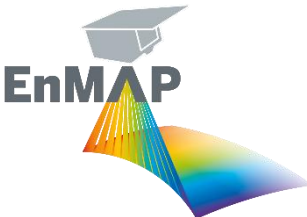
Turbidity in NTU



Water Quality Application – Turkey, 04.05.2022



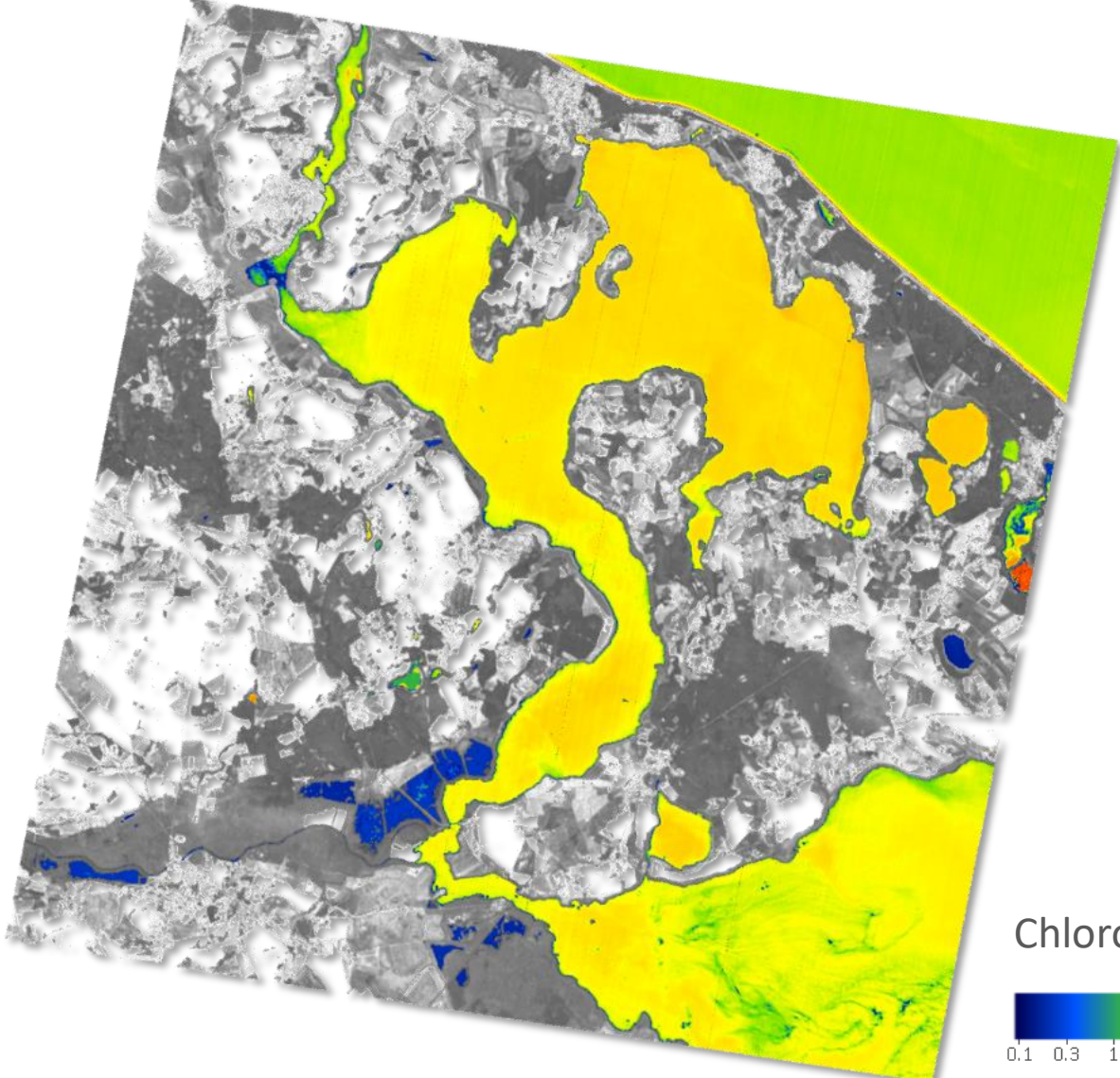
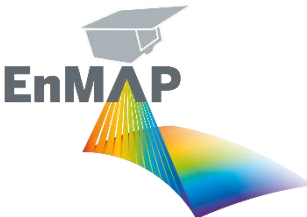
Water Quality Application – Stettiner Haff (Oder), Germany, 24.07.2022



RGB (46/28/10)



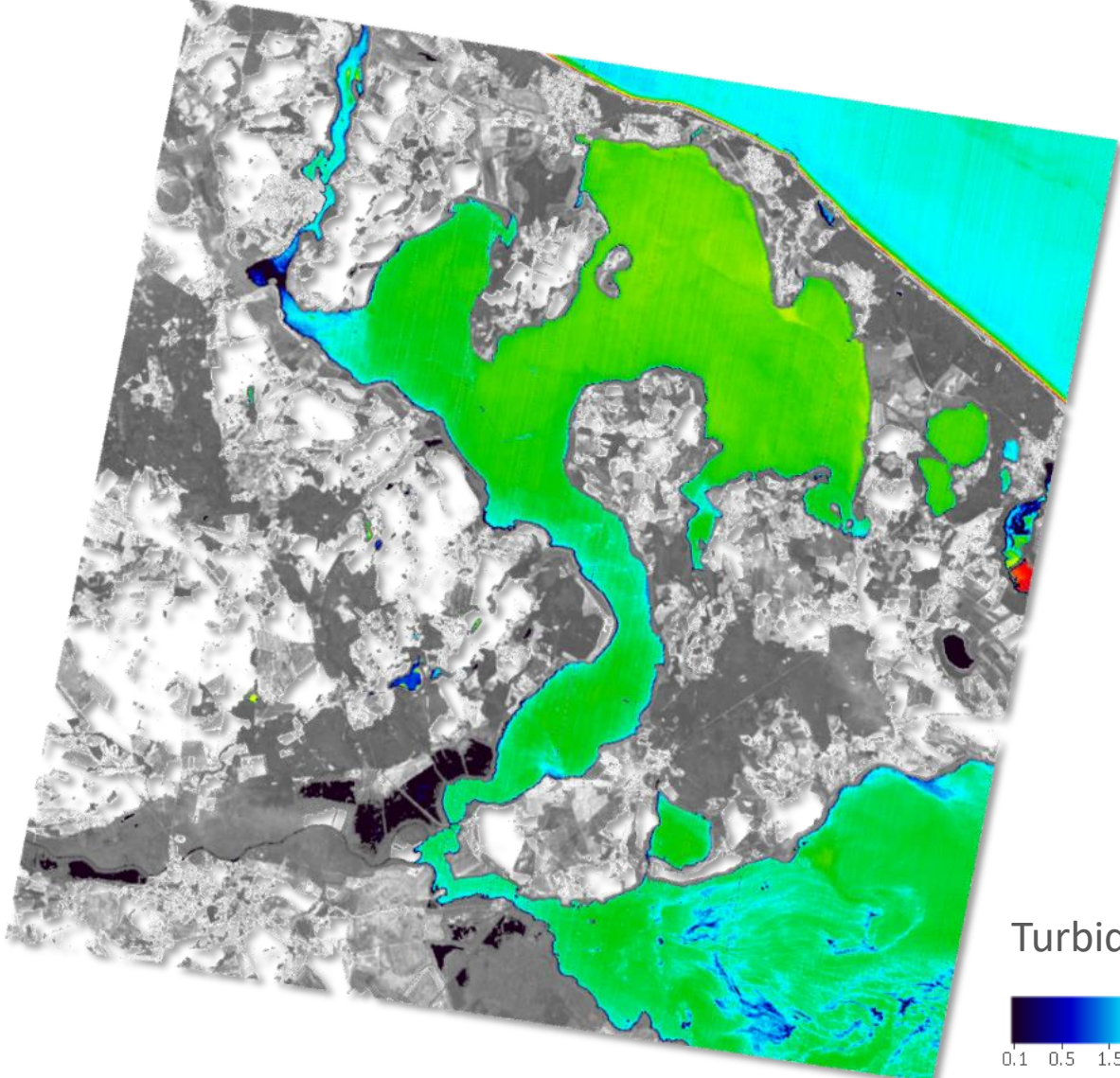
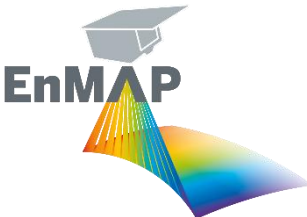
Water Quality Application – Stettiner Haff (Oder), Germany, 24.07.2022



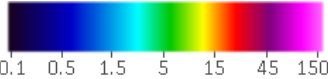
Chlorophyll in $\mu\text{g/l}$



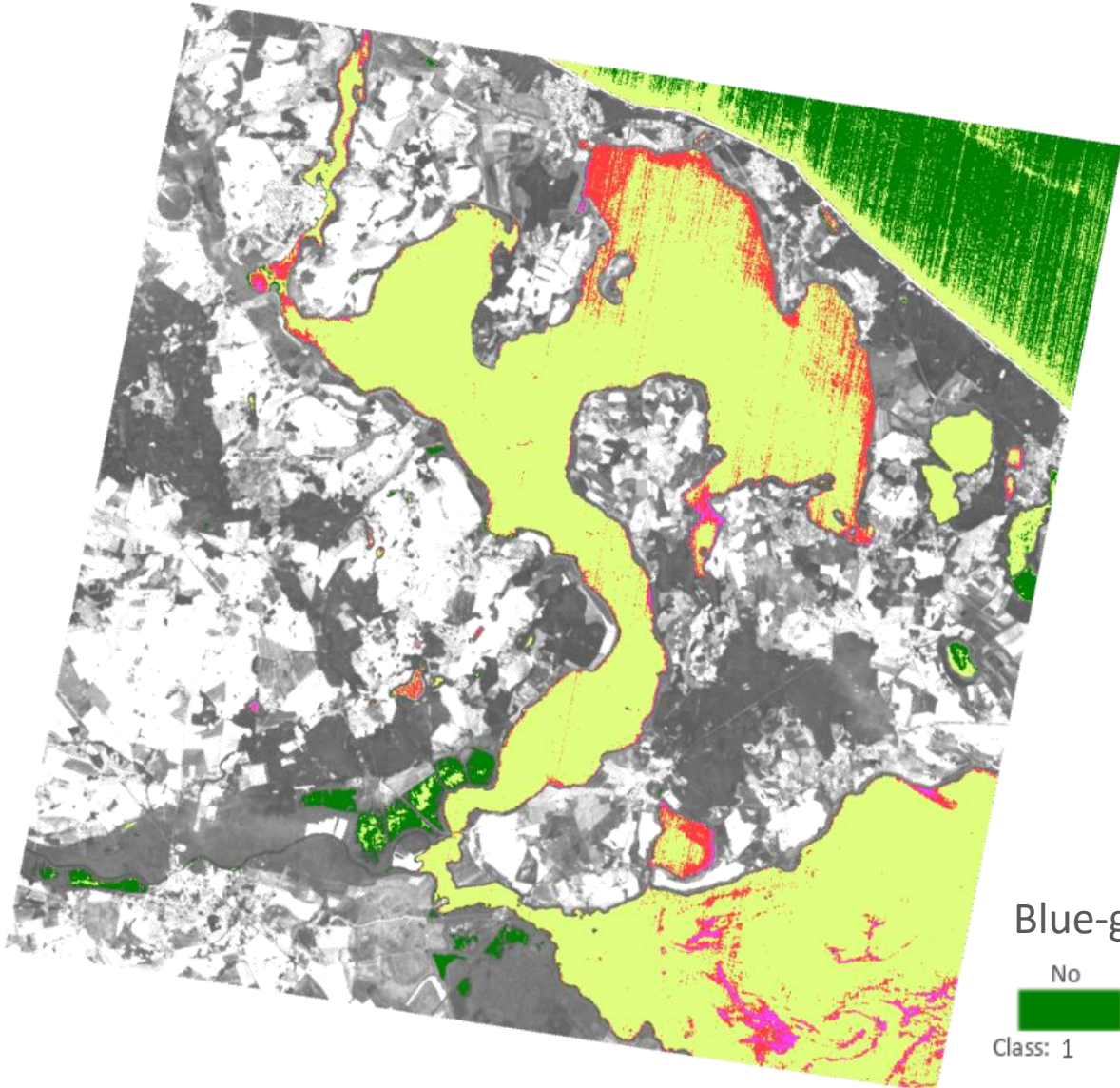
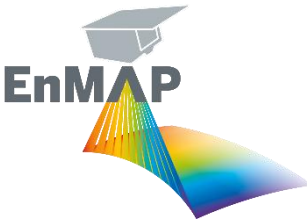
Water Quality Application – Stettiner Haff (Oder), Germany, 24.07.2022



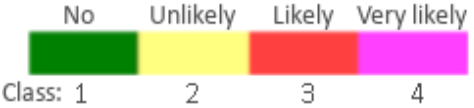
Turbidity in NTU



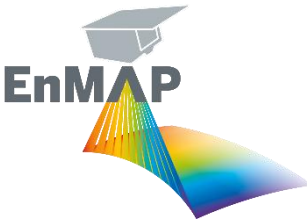
Water Quality Application – Stettiner Haff (Oder), Germany, 24.07.2022



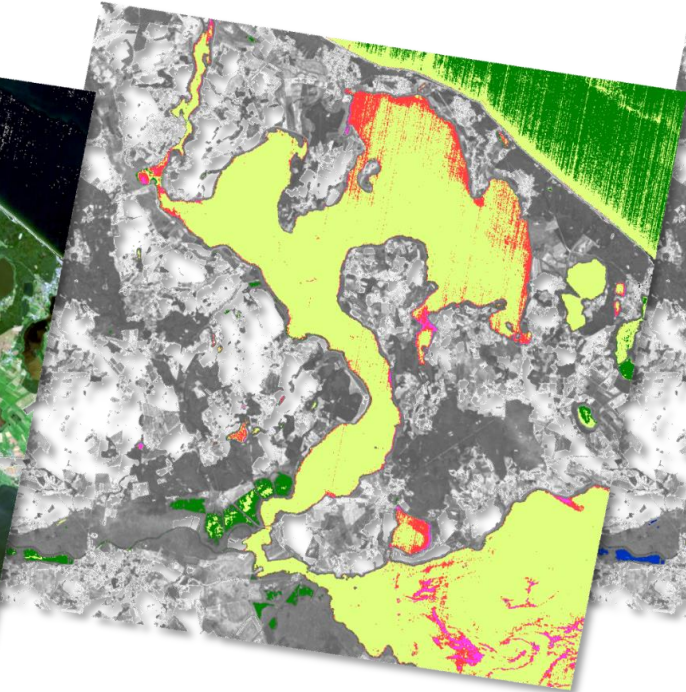
Blue-green Algae Probability



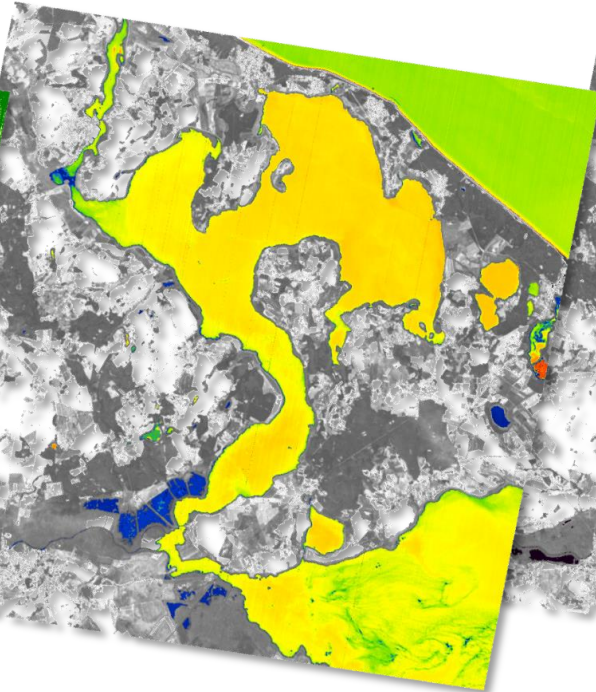
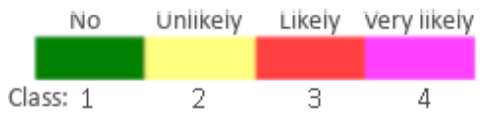
Water Quality Application – Stettiner Haff (Oder), Germany, 24.07.2022



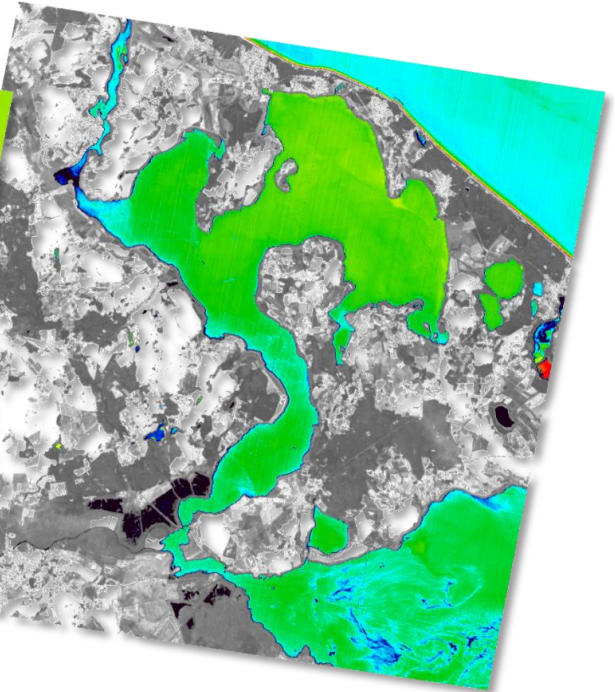
RGB (46/28/10)



Blue-green Algae Probability



Chlorophyll in $\mu\text{g/l}$



Turbidity in NTU



Outlook

Future operational hyperspectral sensors will in future support space-based services with:

- more detectable species and environmental habitats
- quantitative mapping of major phytoplankton species
- improve legislative mapping (e.g. water frame directive (WRRL))
- improve required assessments in times of climate and environmental changes





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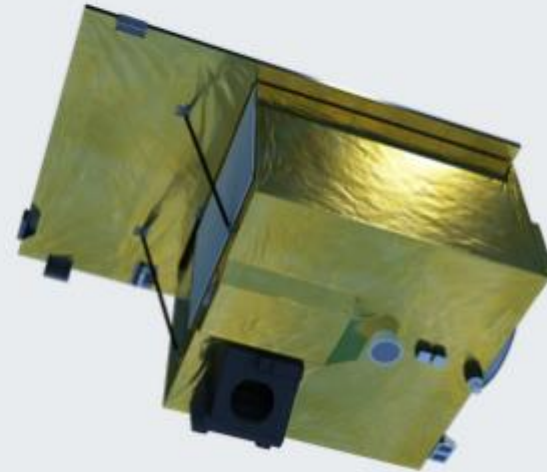
IMAGE GALLERY



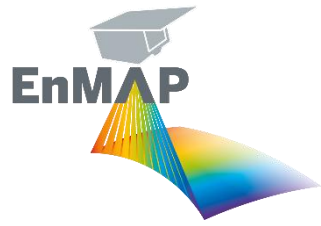
Welcome to EnMAP

The German Spaceborne Imaging Spectrometer Mission

The Environmental Mapping and Analysis Program (EnMAP) is a German hyperspectral satellite mission that aims at monitoring and characterising Earth's environment on a global scale. EnMAP measures and models key dynamic processes of Earth's ecosystems by extracting geochemical, biochemical and biophysical parameters that provide information on the status and evolution of various terrestrial and aquatic ecosystems. For more information about the main objectives and the status have a look at the [mission page](#).



Thank you for your attention!



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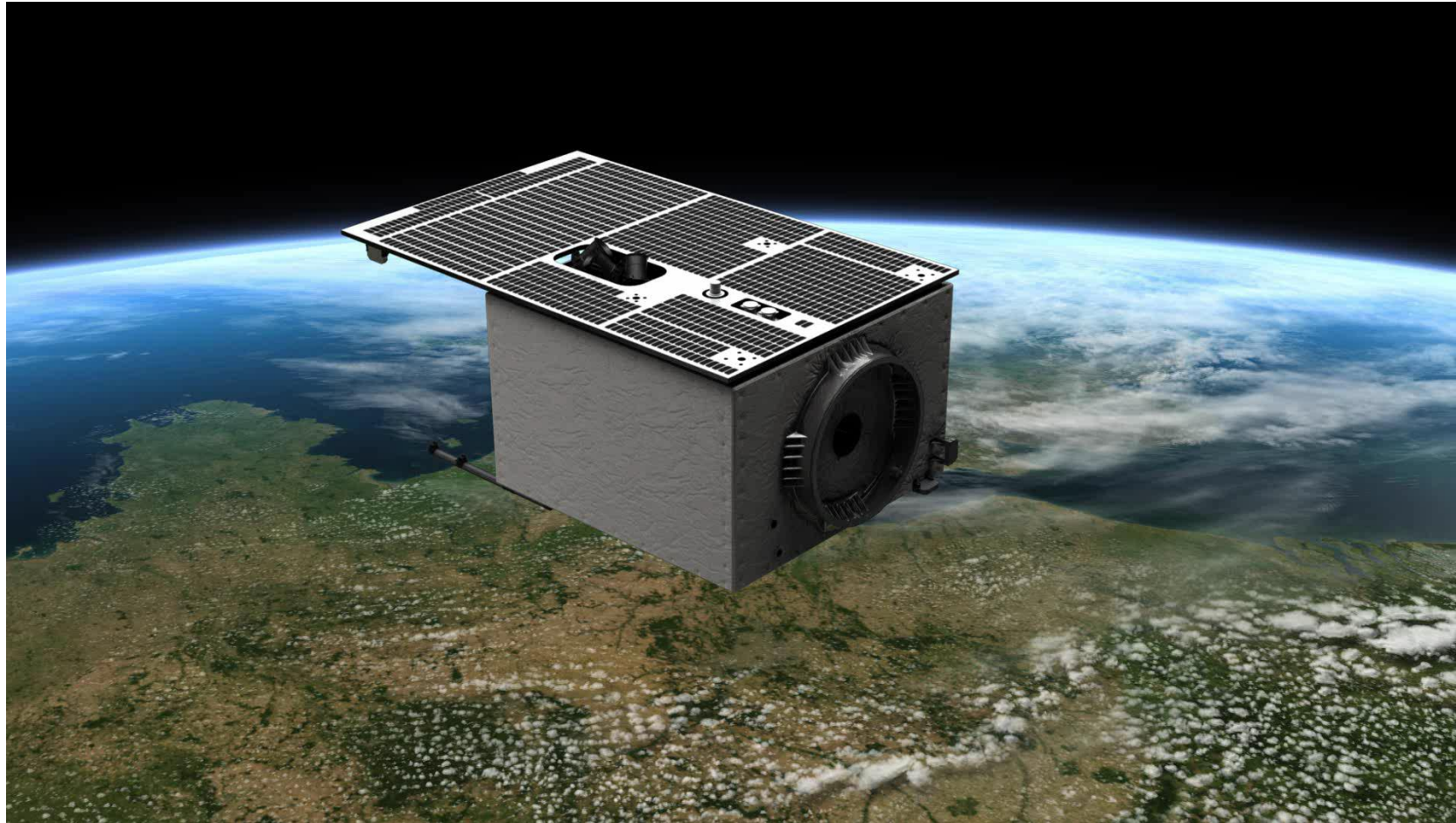
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