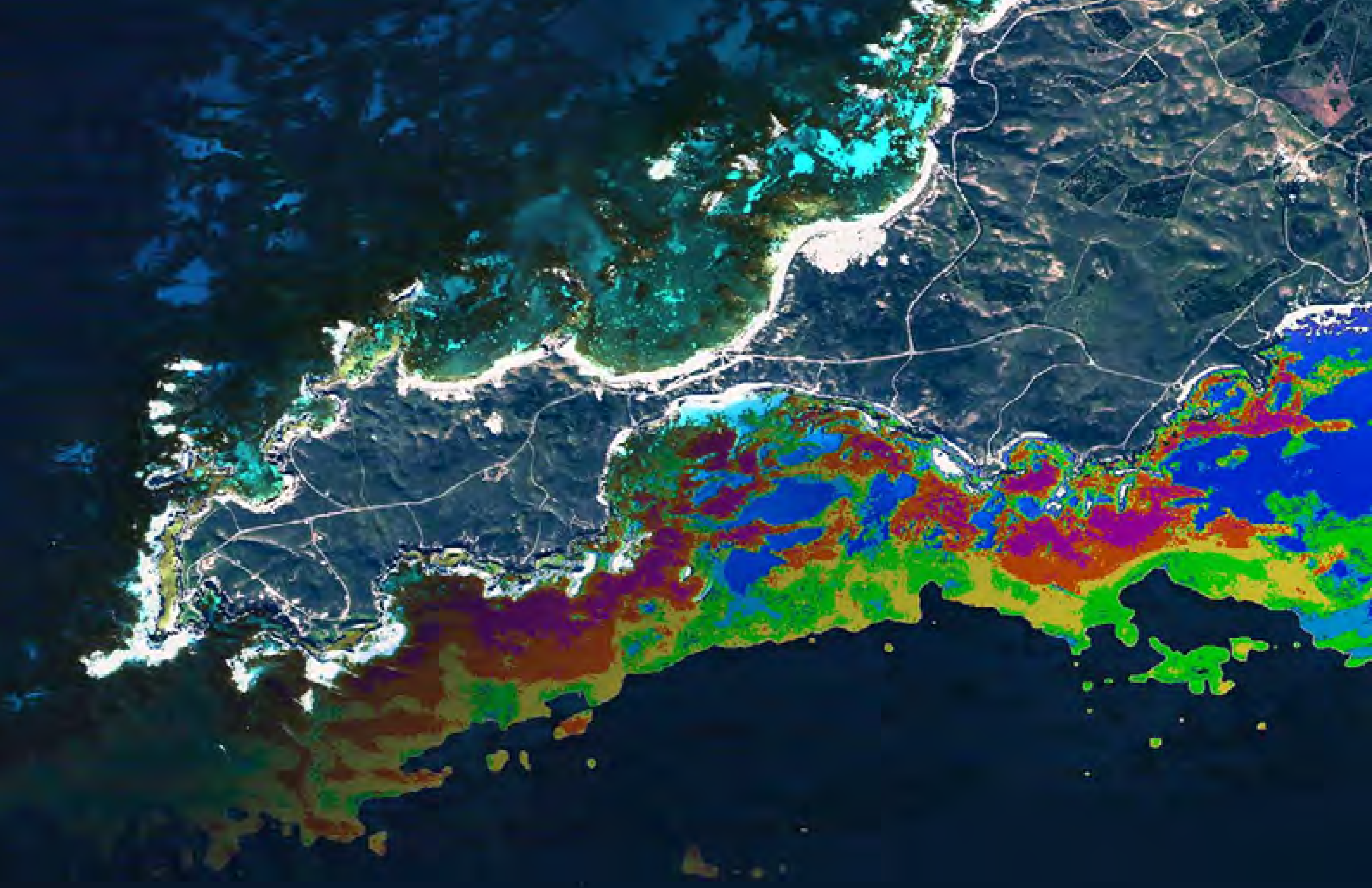

Seafloor Classification

Technical Deep Dive

This paper describes EOMAP's methodology for deriving key insights on benthic habitats from satellite data.
In addition, it includes information on classes we identify, satellite sensors we apply and use cases across the world.

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Content

What is Seafloor Classification?

Seafloor classification (SFC) involves identifying and mapping different types of substrate or coverage on the seafloor such as sand, rock, coral, seagrass, or mud. This information is critical for applications such as marine habitat monitoring, coastal zone management, fisheries and aquaculture planning, environmental impact assessments and marine spatial planning.

Seafloor Classification with Remote Sensing

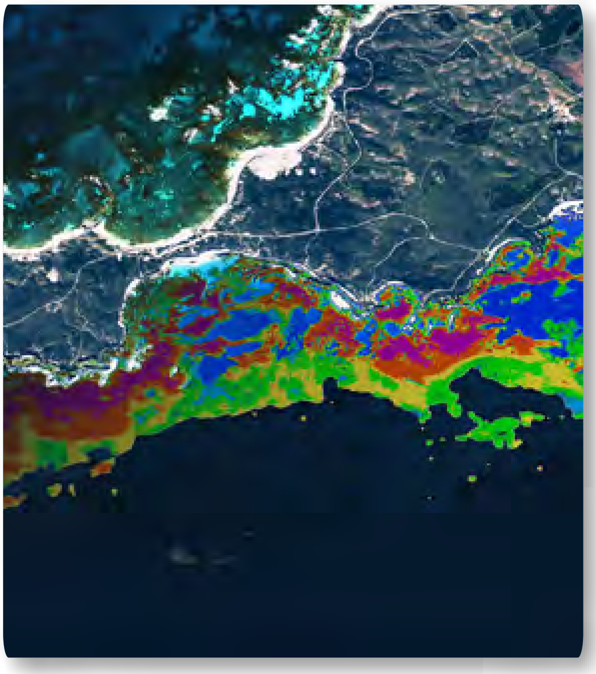
When it comes to optically shallow waters (generally <30 meters deep, depending on water clarity), remote sensing proves to be an efficient and cost-effective tool in categorisation of the seafloor. The thematic classification of the seabed in this case is based on multispectral satellite images.

The satellite imagery is pre-processed by applying a set of image correction procedures which aim to reduce environmental noise and result in a standardised subsurface and seafloor reflectance. This process involves correction for atmospheric effects and sea surface impacts, minimisation of water surface effects such as sun glint, pixel-wise retrieval of inherent optical properties, pixel-wise retrieval on water depth, seafloor and subsurface reflectance. This methodology employs the Modular Inversion Processing system (MIP), a physics-based approach that reduces differences between satellite measurements and modelled spectral responses.

The data is segmented and thematically classified using prior knowledge of spectral properties of the seafloor cover classes, bathymetric data, client in-situ data or analytical skills of one of our aquatic EO experts. Remaining clouds and cloud shadows are addressed through manual quality control routines, with additional validation performed against in-situ data if available.

Depending on the sensor resolution (Table 1) and the auxiliary in-situ information the following classes can be identified using remote sensing techniques:

- Sediment Dominated
- Seagrass Dominated, dense
- Seagrass Dominated, sparse
- Coral Dominated
- Macroalgae Dominated
- Rock Dominated
- Rock partly covered with Coral and/or Macroalgae
- Mangrove Dominated
- Artificial



Satellite Data Sources

The main data sources are either non-commercial data from Copernicus mission Sentinel-2A/B or very high resolution satellite data from commercial service providers, which does come with additional data costs.

Please contact us to discuss the most appropriate set of satellite sensors for your needs.

Satellite / Sensor	Spatial Resolution	Temporal Resolution	Start and End Date	Data Source
Sentinel-2 A/B	10m	5 days	2015/2018 – now	Open Source
Planet SuperDove	3m	daily	2019 – now	Commercial
Maxar WorldView	2m	upon request	2009 / 2014	Commercial
Pleiades Neo 3, 4	1.2m	upon request	2021- now	Commercial
Planet SkySAT	1m	up to daily / upon request		Commercial
SPOT 6	6m	upon request	2012 - now	Commercial
RapidEye 1 - 5	5m	upon request	2009 - 2020	Commercial

Table 1: Overview of commonly used satellite sensors with temporal and spatial specifications

Use Cases for Seafloor Classification

Several case studies demonstrate the effectiveness of using satellite data for mapping underwater topography and geomorphology.

The classification of benthic habitats of the Puerto Morelos Reef National Park on the Mexican Caribbean coast using EOMAP technology on World View-2 data was one successful study. It emphasised the potential of this approach for generating detailed habitat maps that are repeatable through a standardized physics-based approach and hence can contribute to valuable time-series data.

The full published paper can be found here:

Puerto Morelos Reef National Park

The ISPRA Seagrass Mapping Initiative by the Italian Institute for Environmental Protection and Research where EOMAP's seafloor classification products are being used to map two different seagrass types, namely Posidonia oceanica as well as Cymodocea nodosa, along the Italian coastline. It thereby supports the Marine Ecosystem Restoration (MER) Project which aims at restoring and conserving marine habitats in Italy.

More information on the project can be found here:

ISPRA Seagrass Mapping Initiative

The 2019 mapping of several Atolls in the Maldives demonstrated the use of EOMAP's Seafloor classification products, derived from satellite data technology, in reducing environmental impacts and improving financial and time resources for multiple stakeholders particularly for large-scale projects in sensitive biological habitats.

The detailed brochure can be found here:

Maldives Atoll Mapping

The mapping of Great Barrier Reef World Heritage Area and the Torres Strait covering approximately 350,000 km2 of area at a 30m spatial resolution. The 3D map products comprising of water depth and coral reef classification exhibited an exemplary alternative approach to conventional surveying vessels or aircrafts which had limited capabilities over sensitive or "unmappable" areas of the reef.

More on the study can be found here:

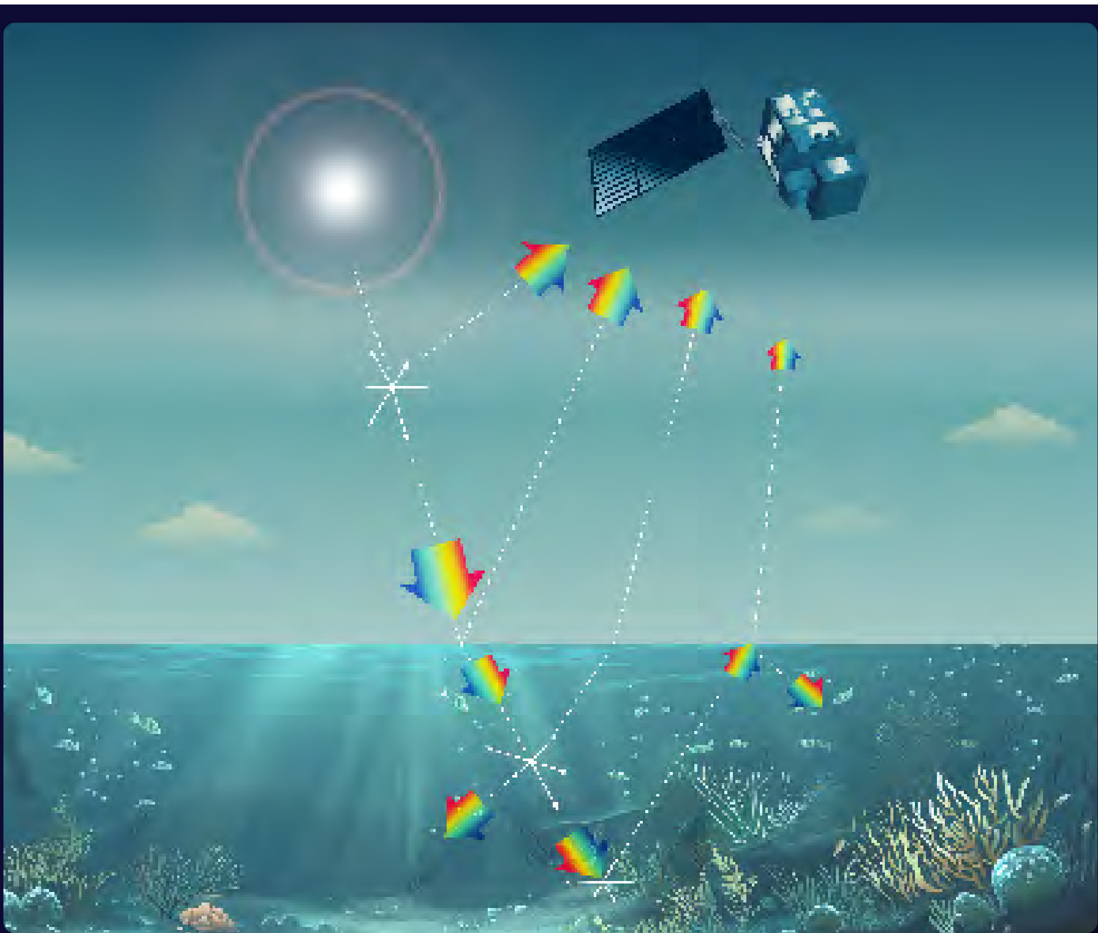
Great Barrier Reef World Heritage Area

Deep Dive - Methodology

Multispectral satellite sensors are capable of measuring water constituents using sunlight, as it penetrates the atmosphere and waterbody. This light is absorbed and scattered as a function of the particles and dissolved materials in the waterbody. The **reflected light spectrum** detected by the satellite sensors can be used to analyse the optically active water constituents, directly related to relevant water quality parameters such as turbidity and suspended matter, phytoplankton and its main pigment Chlorophyll, detritus and dissolved colored organic matter. With the knowledge of their optical characteristics it is possible to retrieve quantitative values of the concentrations for these water constituents, solely based on the reflectance of light measured by satellite sensors.

In other words:
The water colour is used to derive water quality information.
However, the satellite signal is strongly modified by a number of further very variable impacts. These originate from varying atmospheric aerosols, water surface reflections, scattered light from adjacent land areas, and the observation geometry. The most accurate correction of all these impacts is thus a fundamental requirement of the satellite data analysis.

The final water quality products of EOMAP are generated within a **fully physics-based retrieval** approach, using the Modular Inversion and Processing System MIP. Such approaches are capable to provide harmonized, globally comparable products due to their relation to the absorption and scattering properties of water constituents. This concept ensures the long-term continuity of EOMAP's water quality data: Products related to physical units are in principle not restricted, neither to specific algorithms nor to dedicated production software.



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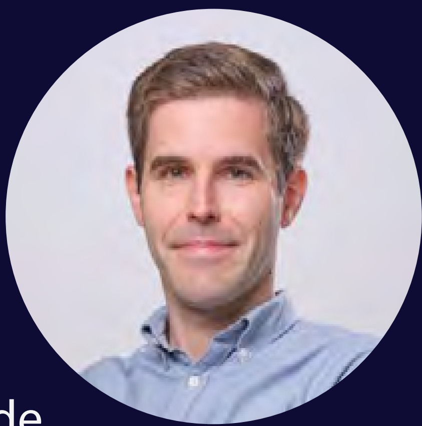

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