EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

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SATELLITE BASED PRODUCTS AND SERVICES FOR WATER RESOURCES MANAGEMENT

water resources management
eo4sd

esa

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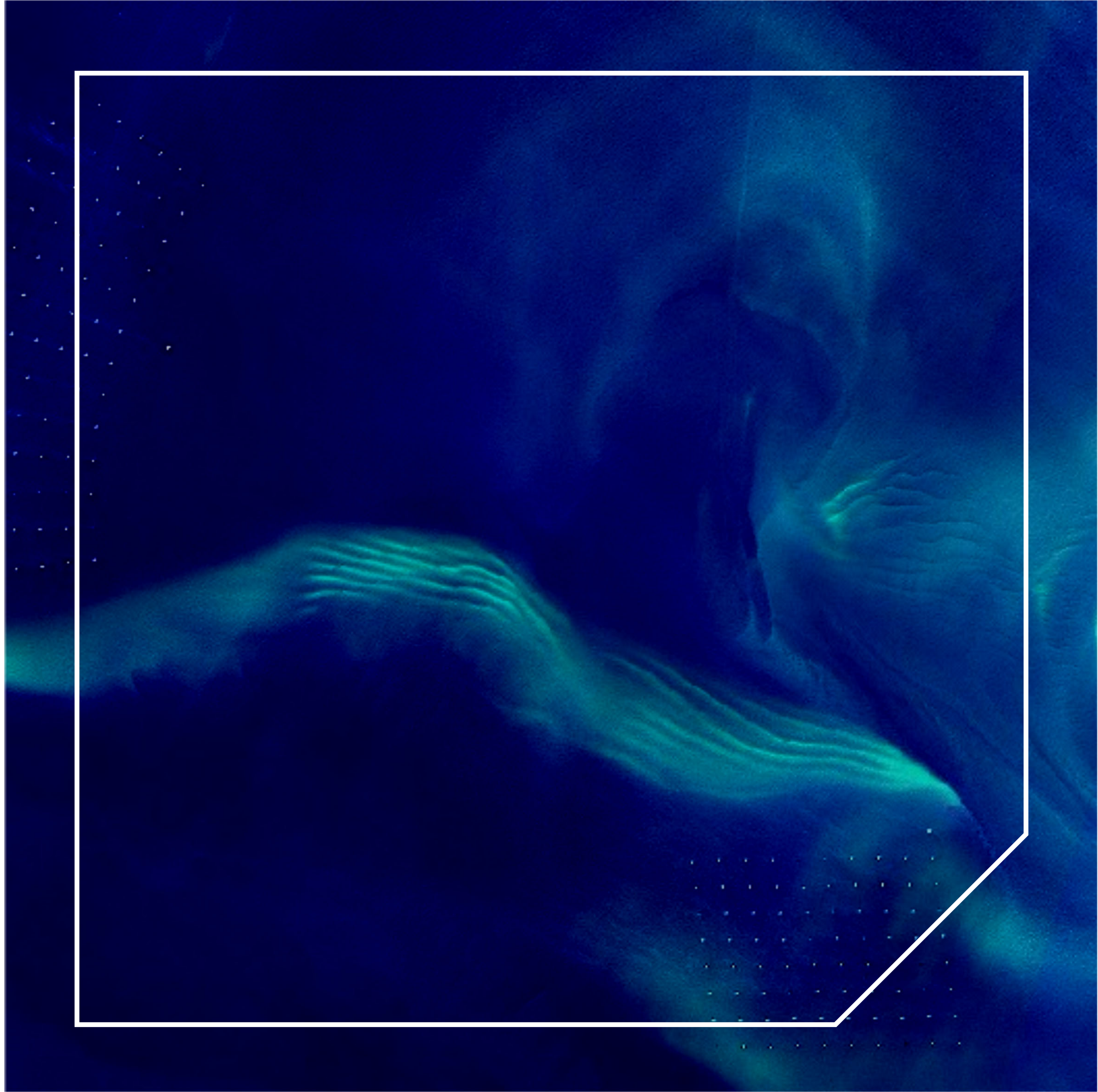


INTRODUCTION

Water is essential for life on Earth. Water is the critical natural resource which underpins all social and economic activity. During last century water use grew twice as fast as the world's population, and today's water scarcity affects more than 40 percent of the global population – a disturbing figure which is expected to rise if we do not change our habits.

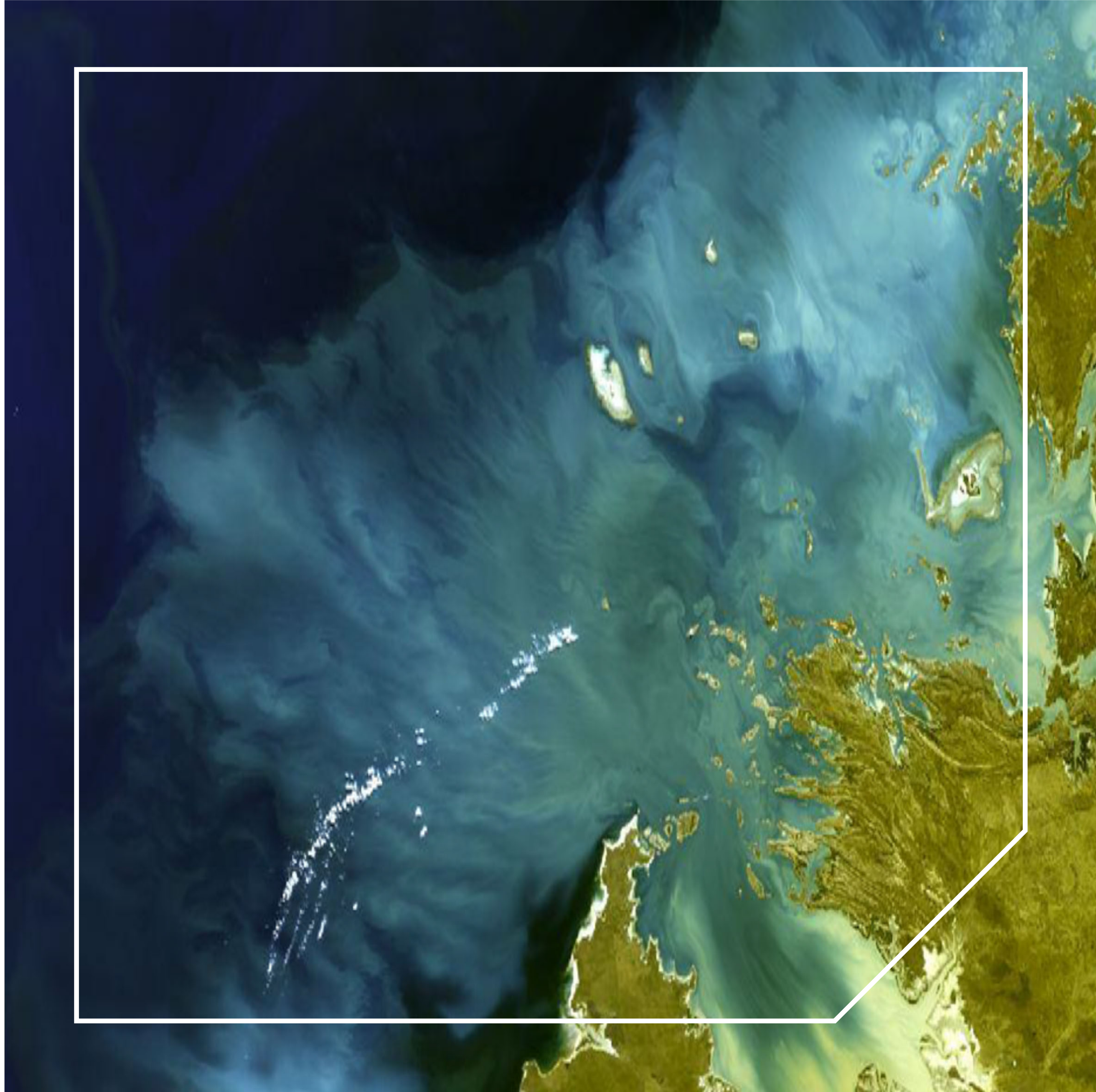
The dedicated goal on water in the 2030 agenda for sustainable development has brought a spotlight to water policy at global level and in national planning to avoid an accelerating 'water crisis' towards 2030.

A 'water crisis' is ultimately a management crisis that can be solved through the application of sound water management policies and integrated water resource management (IWRM) initiatives. The successful implementation of water polices and IWRM requires access to reliable data and information on key water related challenges. There is now a growing awareness that Earth Observation (EO) data has the potential to serve these data needs. This is especially relevant in the context of Official Developing Assistance (ODA), which normally target regions where policies and management decisions are more often based on sparse and unreliable information.

Since 2010 the **European Space Agency (ESA)** has worked closely with International Financing Institutions (IFIs) and Client States to harness the benefits of EO for global sustainable development. The ESA initiative **Earth Observation for Sustainable Development (EO4SD)** aims at increasing the uptake of EO-based information in the planning and implementation of the development projects, programmes and activities of the IFIs, together with their respective Client States.

With this catalogue we wish to shed light on how the latest generation of satellites can support international development assistance by helping countries to better measure and manage their water resources.

For more information, visit us on our website: **www.eo4sd-water.net**



NEW SENSORS—NEW OPPORTUNIIES

Since 2014 and following the commissioning of the Sentinel satellites from the European Copernicus program, the earths land surface can be captured more accurately than before. Copernicus data streams are free and open to the public and covered by an operational service guarantee for many years to come and hence provides long-term access to enhanced high and medium spatial resolution radar, and optical observations, opening a new era for the systematic mapping and monitoring of surface water resources:

→ The C-band radar of the **Sentinel-1** mission provides all-weather and day-and-night imagery which is powerful when monitoring surface water dynamics and cropping patterns in cloud prone regions;

→ The large footprint size of the **Sentinel-2** data along with its short revisit time and its systematic acquisition policy allows land surface features to be precisely monitored;

→ The Sentinel-2 mission ideally complement the longest continuously acquired collection of optical observations at high resolution made by the family of Landsat imagers (operational since 1972) which are freely accessible and offer a unique opportunity to assess the historical conditions of surface water resources worldwide;

→ In addition to high accuracy optical and thermal sensors the **Sentinel-3** mission also carries a radar altimeter which can be used to estimate the changes in water levels in rivers and lakes

The Sentinels has opened a new era for the systematic mapping and monitoring of the Earths land surface. The high revisit time of Sentinel-1 and Sentinel-2 allows to produce complete, high quality weekly/monthly image composites which are essential for dynamic monitoring. On the spatial level, the high spatial resolution of Sentinel-1 and Sentinel-2 (10-20 meters) increases the classification accuracy especially for smaller features.

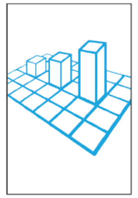
A key objective of this brochure is to illustrate, through practical examples, how the enhanced monitoring capacities of the Sentinels can support the planning, implementation and evaluation of international development projects.

Earth Observation for international development assistance

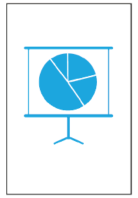
Through the EO4SD partnership with ESA, IFIs such as **World Bank**, **Asian Development Bank** and **Inter-American Development Bank** have shown considerable interest in expanding the use of EO to augment the transparency and to increase the effectiveness of project management and execution.

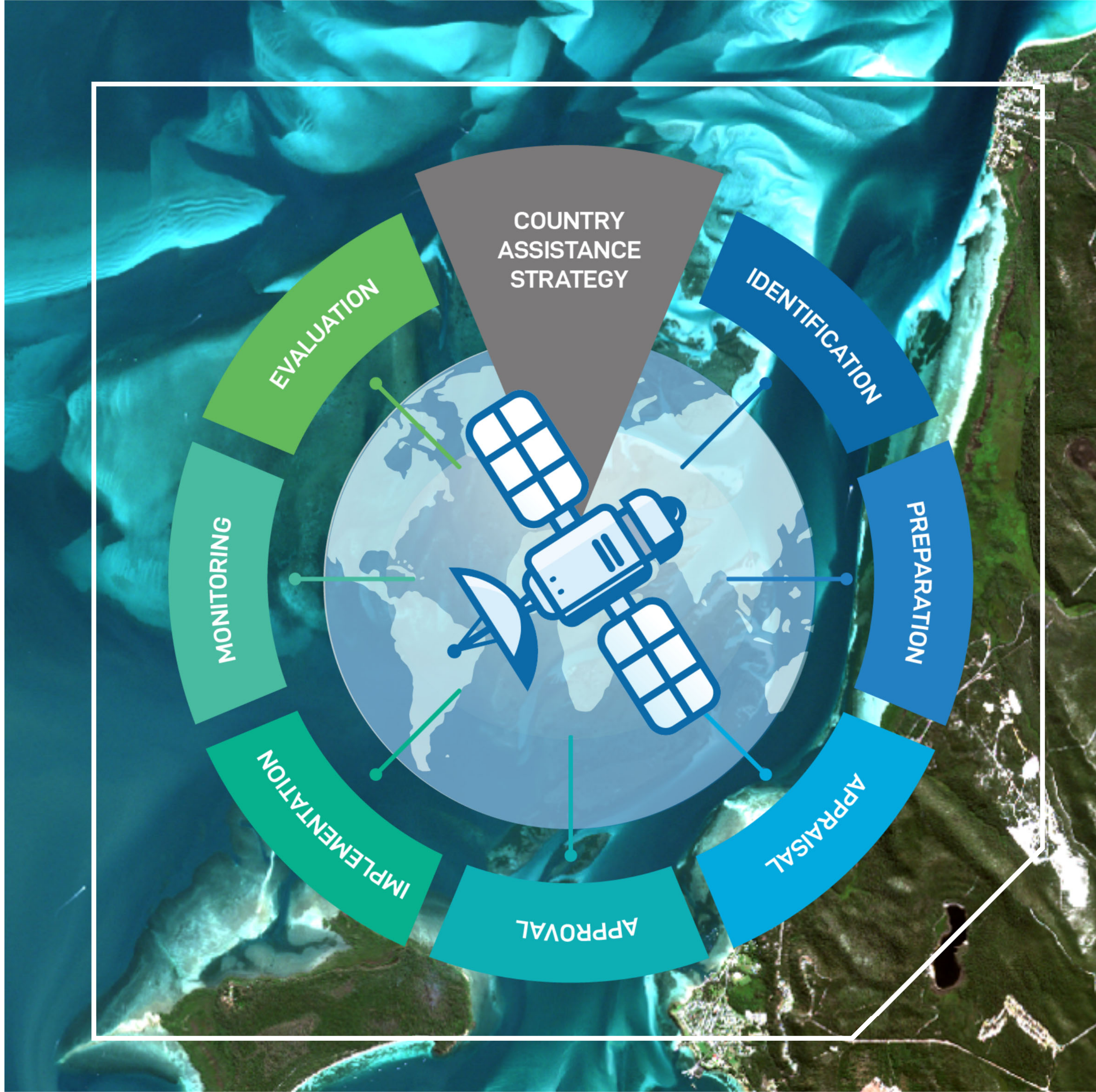
EO can play a key role in many stages of the project cycle of international development assistance. In the early stage of project identification and preparation EO can provide rapid, cost-effective and reliable information on the water cycle, related land surface processes, climatic facts and socio-demographic developments. In doing so EO can be used to identify areas with water management issues, and as indicators on where to intervene. In later stages, EO can be used to assist and monitor implementation and evaluate project outcomes. In addition, the transboundary information provided by EO helps to ensure transparency. The generated maps are an efficient way to communicate results and visualize water and environmental disparities in both space and time.

The following pages will provide examples on how the EO4SD initiative has supported development projects in Africa (Sahel, Africa Horn, Zambezi), Asia (Myanmar and Lao PDR) and Latin America (Peru and Bolivia) by delivering EO information and services in response to stakeholder requirements for water resources monitoring and management at local, national and basin levels.


Statistics


Analyse


Communicate



Country and basin planning support

Having established Integrated Water Resources Management Plans, many countries and river basins around the world are now planning to formulate water infrastructure development plans. These plans will help countries and regions to realize the potential of their water resources – including agriculture, energy generation and tourism – while preserving the environment and considering the uncertainties related to future climate.

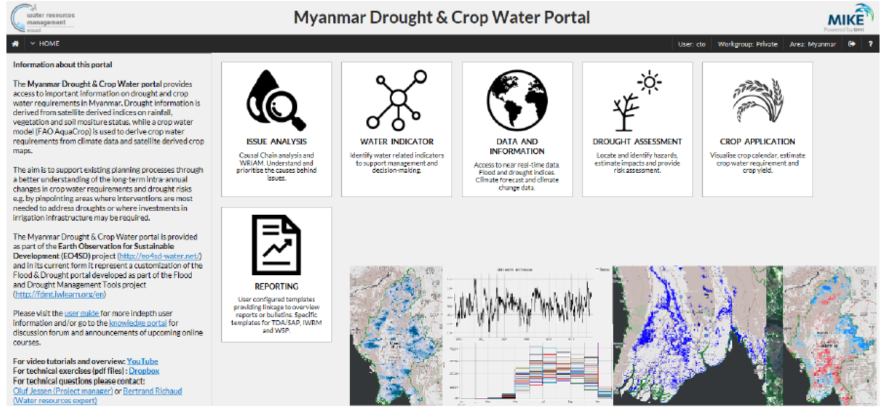
The need for proper and timely information on water (non-) availability is probably the most important requirement for water management activities. In large, remote and inaccessible regions, in-situ monitoring of inland waters is sparse and hydrologic monitoring and modelling can benefit from information extracted from satellite EO.

"The established web based portal addresses a critical knowledge gap and provides an essential platform for ongoing and future projects in Myanmar, where lack of baseline data and reliable climate data are often a serious impediment for the ability to execute meaningful water resource assessments and climate adaptation projects"

Indira J Ekanayake -Senior Agriculture Economist, World Bank

Online portal with historic and real time satellite information

The Myanmar Drought & Crop Water portal provides access to important information on drought and crop water requirements in Myanmar. Drought information is obtained from satellite derived indices on rainfall, vegetation and soil moisture status, while a crop water model is used to obtain crop water requirements from climate data and satellite derived crop maps. The web based technical tools support decision-makers in Myanmar with effective water resource management and planning. The tools can be used for issue identification and prioritization, indicator mapping, drought and flood assessment, planning and decision making as well as automated reporting.

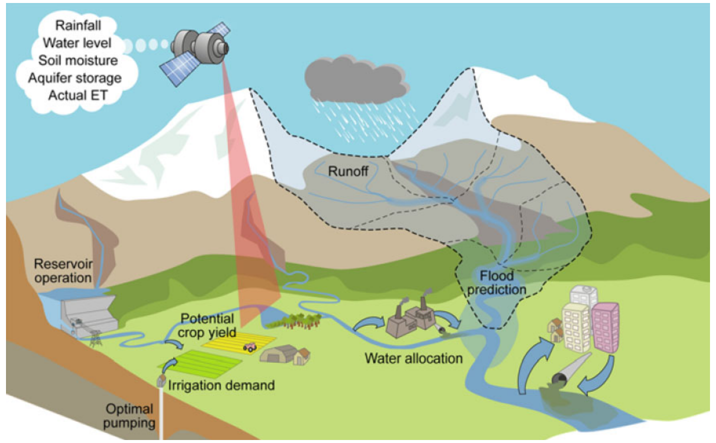


Myanmar Drought & Crop Water portal is freely available for national stakeholders (Credits: DHI for World Bank/Asian Development Bank 2019)

Steward water resources with hydrological modelling

Hydrological modelling is as a key decision support tool used to systematically evaluate the interactions between water availability, water use sectors and future climate and socio-economic change.

However, hydrological models critically depend on reliable and accurate input data on water availability and water demands. EO has a key role in providing such datasets for large and remote river basins that often have weak in-situ monitoring infrastructure.



EO4SD-Water implemented a hydro-economic model for northern Lao to investigate trade-offs between hydropower and irrigation (Credits: DTU for Asian Development Bank 2019)

Surface Water Dynamics

Throughout the world, inland water resources are used for multiple purposes incl. irrigation, livestock watering and as a source for hydropower and recreation. Still, in most countries, government's measurement of water resources is limited to major dams and river flow stations, yet this only represent a small share of the overall water resources. The unmonitored proportion of water resources represents a major known unknown, which can produce inaccuracies that may lead to ineffective or erroneous decision-making.

Earth Observation (EO) is a reliable and cost-effective method for large scale monitoring and analyzing of water bodies both temporary and permanent in nature. The wealth of information derived from dense, complete and highly resolved time series provides unprecedented level of detail on every individual water body and thus allows water authorities to better target their investments and activities to develop sustainable water management solutions.

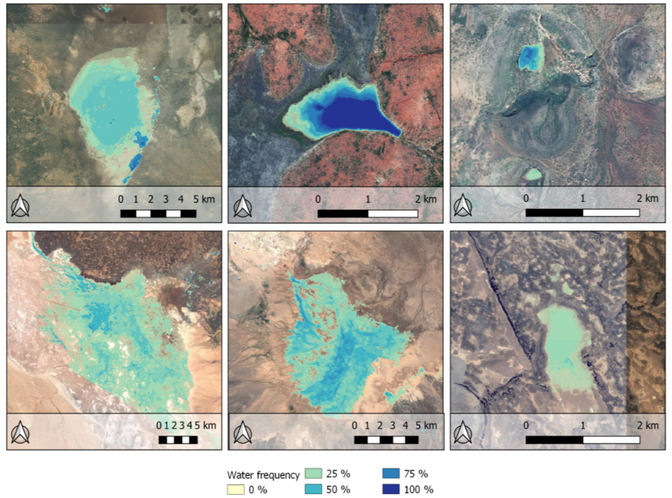
""In Zimbabwe, we have over 8000 dams, but we are currently only monitoring 250 of the larger dams, as monitoring is very time consuming and costly. But the small dams also contribute a lot in terms of water availability … as the monitoring system in all SADC countries is dilapidated; Earth Observation comes as a rescue to this problem."

Charles Sakuhuni, Senior hydrologist, Zimbabwe National Water Authority (ZINWA)

Supporting pastoralist in Horn of Africa

Surface water is a scarce resource in many areas on the Horn of Africa and a changing precipitation regime has put additional stress on the water resource availability. Given its vital importance to human health and economic stability and growth, water availability is a key factor in reducing poverty, increasing food security and building climate resilience in dry areas at the African Horn.

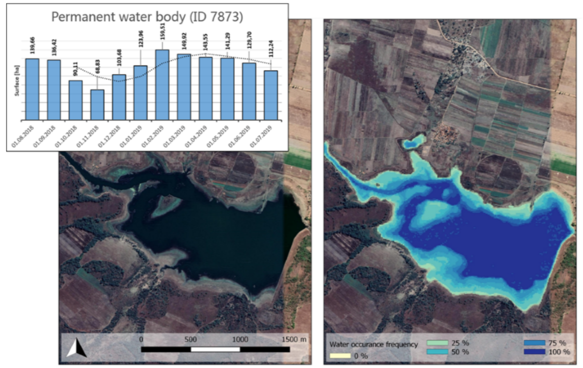
Especially, pastoralists face daunting challenges from the multiplied effects of climate variability, access to water and grazing resources and the lack of early warning systems for drought. Earth observation satellites can deliver essential information on seasonal water availability and hence provides a fundamental input for a livestock management system enabling pastoralist to better plan herding according to seasons and the changing availability of water.



Water occurrence maps for permanent and ephemeral water bodies in Horn of Africa (Credits: GeoVille for World Bank 2019)

Monitoring small dams and reservoirs in Zimbabwe

Although, Zimbabwe is generally endowed with abundant water resources then the dry season lasts seven months a year and why local and temporary water shortages is common. To deal with this water crisis the creation of small water bodies has become an essential part of the development activities in the country, and today these water bodies play a vital role in the country's food and energy security.



Both the government of Zimbabwe and the FAO have compiled inventories on small water bodies. Still, these databases do not include all relevant information. For instance, the capacity of close to 8.000 dams is known, but the surface area is available for only a few hundred. With Earth Observation data the authorities can get a complete picture of the surface water area and the water storage changes for the unknown cases can be estimated based on empirical derived relations between area and capacity. Satellite-based monitoring therefore provide crucial information on which to base various planning and operational actions related to water supply (food, energy, domestic) as well as for drought and disaster management.

Water body near the town of Concession (Zimbabwe) along with the 12-month water occurrence frequency in map and statistics (Credits: GeoVille for World Bank 2019).

Change in the extent of water-related ecosystems over time

When the SDG goals were adopted in 2015, countries committed to measure and monitor the 17 SDG's and their associated targets and indicators.

Effective reporting of progress toward these indicators will require the use of multiple types of data, including traditional national accounts, household surveys and routine administrative data as well as new, nationwide sources of data outside the national statistical system, such as can be provided through satellite Earth observation and geospatial information.

One of the indicators which is very suitable to be monitored by EO is SDG 6.6.1 "Change in the extent of water-related ecosystems over time", which is basically a reporting on the change in open water and vegetated wetlands.

"Myanmar is vulnerable to seasonal floods and water related extreme weather events, which has led to establish a National Integrated Flood Management Platform under the National Water Resources Committee (NWRC). Our finding is that seasonal information on flood dynamics and patterns are of high importance for planning- and management purposes in Myanmar. Such information is currently not available on a large geographical- and time scale, and that is where EO really adds value"

Prof. Dr. Khin-Ni-Ni Thein - Director of Hydro-Informatics Centre (HIC)

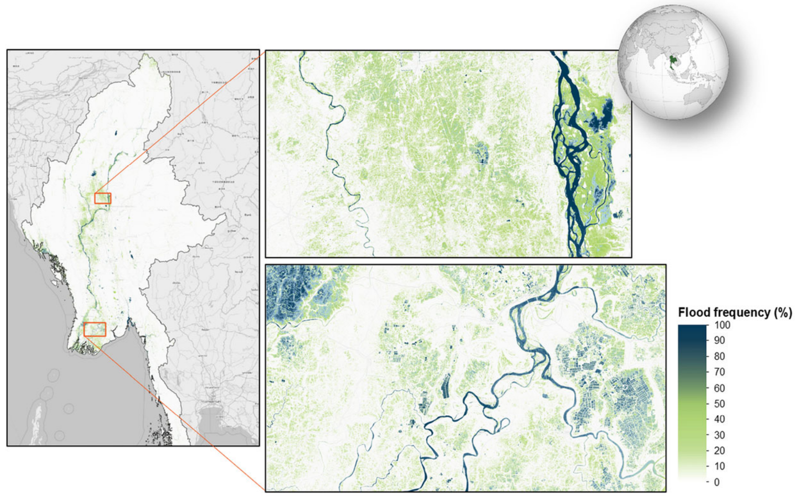
"Wetlands are important water systems in Uganda and continue to be highlighted by the UN Sustainable Development Goals. A good starting point for wetland protection and restoration is a good mapping inventory of the wetlands."

Paul Mafabi, Head of Ramsar Administrative Authority for Uganda

Inundation patterns, Myanmar

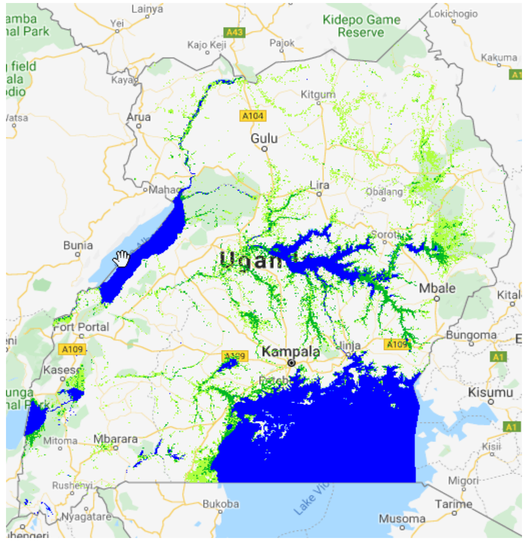
For Myanmar the full archives of Sentinel and Landsat imagery was processsed to detect inundation frequency. Frequently dealing with damaging floods, the inundation maps can help identify flood prone areas. Moreover, the maps clearly identifies location and size of irrigated rice areas, and offers opportunities to understand why areas are more or less productive in terms of e.g. cropping intensities.

The generated time series maps is also consistent with the official SDG reporting guidelines i.e. the maps can be used to derive national statistics on changes in "Open water" (i.e. rivers and estuaries, lakes, and artificial waterbodies) as required by SDG indicator 6.6.1.



Inundation frequency, Myanmar
(Credits: Satelligence for World Bank/Asian Development Bank 2019)

Earth Observation — the best way to take stock of national wetland resources



Wetlands are one of our most precious resources providing people and societies with many important benefits such as improved water quality, flood control, biodiversity and recreational opportunities. Despite their value wetlands are disappearing and needs protection to maintain ecosystem services on the long-term.

Better information on wetland status and trends are paramount to preserve and reverse the ongoing loss of wetlands. The Sentinel satellites now provide global imagery at the required temporal and spatial resolutions to derive information on wetland extent in high resolution. In an activity supported by the Global Partnership for Sustainable Development Data (GPSDD) Sentinel data was used to accurately map the extent of wetlands at national scale in Uganda. Thereby, generating information which is crucial to measure the effectiveness of policy, legal and regulatory mechanisms and essential for tracking progress against the SDG indicator 6.6.1. on change in water related ecosystems.

Satellite-based wetland inventory for Uganda (Credits: GeoVille for GPSDD 2018)

Water Quality and Levels Monitoring

Satellite derived water quality information is essential to assess the ecological state of inland and coastal waters and to identify changes or trends in water quality over time. Such information is needed in order to be able to respond to emerging water quality problems, such as point source pollution, sedimentation, harmful algae blooms and aquatic weed proliferation. In addition, satellite altimetry has become increasingly important for measuring water levels of rivers, lakes and reservoirs in order to address key hydrological questions on water storage and discharge.

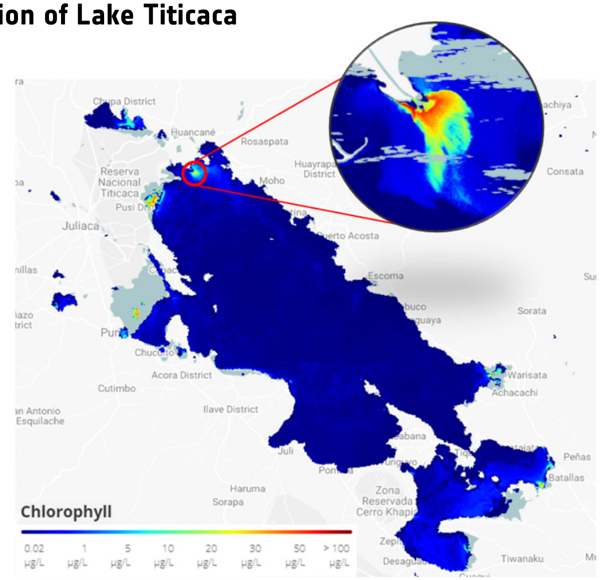
This is especially the case in developing countries where existing water quality and quantity information is sparse, difficult to obtain/maintain, and vary in content and validity. EO-based information should not replace in-situ networks (availability of in-situ data is essential to calibrate and validate the retrieval algorithm), but may complement them, offering cost-effective solutions for up-scaling in space and time.

"We started 2017, before the project we only used EO to receive meteorological information, now we use more geographic information, … In the case of water quality I see more opportunities, in Lake Titicaca where there are sanitation plans and also cooperation with Bolivia is important" – Carlos Verano, Water Resources Specialist in Agualimpia and former Director of Atoridad Nacional de Agua—ANA, Peru

Improved monitoring: the first step to deal with pollution of Lake Titicaca

Lake Titicaca, is the largest lake in South America. It is an extremely complex, unique and yet fragile ecosystem, which is being negatively impacted by environmental degradation, caused by natural and anthropogenic causes, including sediment runoff and soil salinization, untreated urban and mining effluents and unsustainable agriculture, fishing and aquaculture practices.

EO is recognized as a reliable and cost-effective technique for describing and quantifying various aspects of inland water quality. EO-based monitoring of water quality is essential in order to characterize waters and identify changes or trends in water quality over time. It further allows to respond to emerging water quality problems, such as identification of sediment plumes, harmful algae blooms and red tides.

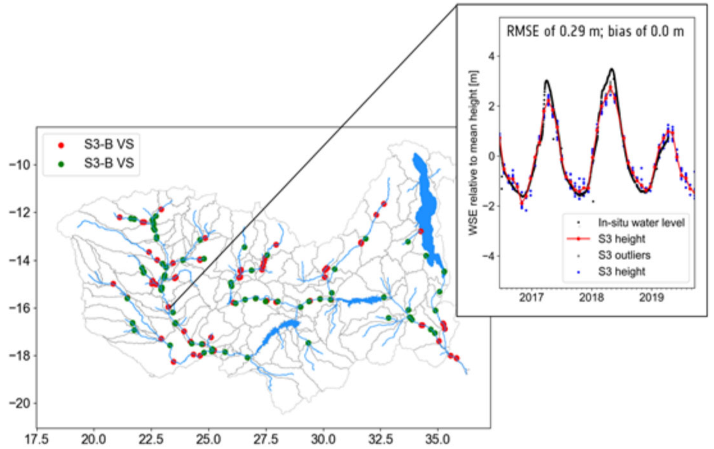


Chlorophyll concentrations in Lake Titicaca showing elevated concentrations near major inlets and urban centers (Credits: DHI GRAS for World Bank 2019)

River levels tracked from space

EO can be used to track not only changes in surface water extent and quality but also the water level of water bodies. This is done using satellite altimetry which is a technique that determines the distance from the satellite to a target surface by measuring the travel time of a radar pulse.

In the Zambezi River Basin the collection of consistent water level data remains a challenge and the in-situ networks have gradually declined over time. Satellite altimetry therefore bears some important perspectives for complementing the existing ground monitoring system with space based measurement of water levels.



Sentinel 3 Virtual Stations (VSs) in the Zambezi River Basin. The river water level as observed by Sentinel-3 are closely related to the in-situ measurements (Credits: DTU for World Bank 2019)

Natural Risk Management

High population densities and poor infrastructure, coupled with unstable landforms and exposure to severe weather events, makes developing countries particularly vulnerable to natural disasters.

Official development assistance therefore often aims at improving disaster preparedness and reducing disaster impact from floods, droughts, landslides and other water-related disasters. Several phases in risk management (prevention, forecasting, alert and crisis) require reliable geodata.

This is where EO data can help with essential monitoring information. EO can provide information over large and inaccessible areas, and it is an ideal source of information for historical mapping and for near real time monitoring of (potential) disaster areas.

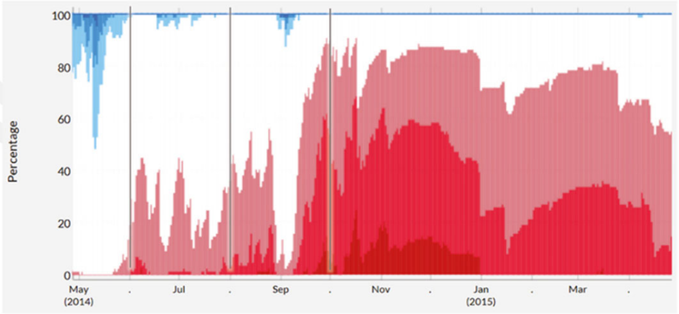
"Disaster risk reduction and management is a cornerstone of the ZAMCOM agreement and Earth Observation makes an important contribution to the the Zambezi Water Information System (ZAMWIS) and towards the implementation of a fully operational Decision Support System for flood forecasting and early warning in the Zambezi river basin".

Hastings Chibuye, Programme Manager , Zambezi Water Resources Information System, Zambezi Watercourse Commission

Early warning for disaster preparedness

Drought is a recurrent phenomenon, which is likely to be enforced by climate change. Droughts imply significant water shortages, economic losses and adverse social consequences. The need for proper monitoring and reporting of drought development and quantification of drought impacts is hence of critical importance. In many parts of the world the meteorological ground network for drought monitoring is not dense enough to accurately monitor drought occurrence over extended areas.

Applied EO techniques combined with spatial analysis is an effective set of tools for mapping, monitoring and analyzing temporal drought intensity variations and impacts. By having access to satellite based monitoring capabilities, authorities will benefit from region-wide and up-to-date data that enable informed decision making, saving both economic costs and human lives.

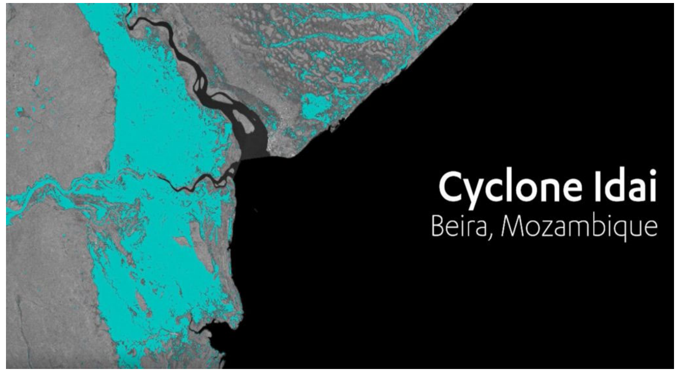


	Extreme dry		Very dry		Moderate dry		Normal	
	%	km²	%	km²	%	km²	%	km²
June 2014	0	0	2	900	26	11 700	72	32 400
Aug 2014	0	0	3	1 350	32	14 400	64	28 800
Octo 2014	6	2 700	48	21 600	36	16 200	10	4 500

Trends in drought impacted area in Magway region, Myanmar (Credit: DHI for World Bank/Asian Development Bank 2019).

Timely information when disaster strikes

Flood maps, extracted from satellite data, provides valuable information to the institutions involved in flood preparedness and response. While optical sensors are limited to daylight observations and cloud free conditions, radars offer their own source of illumination and a weather independent observation capability.



On March 14, the cyclone Idai made landfall on the coast of Mozambique, causing severe rainfall and widespread flooding throughout Mozambique, Malawi and Zimbabwe. Synthetic Aperture Radar (SAR) images, captured by the Sentinel-1 satellite, was used to accurately map the extent of flooding around Beira – Mozambique's fourth largest city and one of the most severely affected areas. These maps are essential for informing authorities and development organizations about the geographical extent and impact from flooding events, in order to target emergency response and post-disaster development efforts.

The extent of flooding caused by Cyclone Idea along the coast of Mozambique (Credit: DHI GRAS for World Bank 2019).

Agriculture and Food Security

Maps of crop area, types and stages of development are used by many institutes, such as national agricultural agencies, regional agricultural bodies, statistical offices, NGO's, etc., to estimate crop inventories of what, where, and when certain crops are grown. Such information can feed into models of supply and yield prediction, soil productivity, land use intensity, indicators of crop stress and damage from natural disasters, as well as monitoring general agricultural practices.

EO based crop area, type and status mapping can provide national and regional authorities with improved agricultural statistics and crop production assessments; it can help aid agencies to decide when and where to intervene in food insecure countries and it can help farmers to better manage their stocks through better knowledge on existing growing conditions.

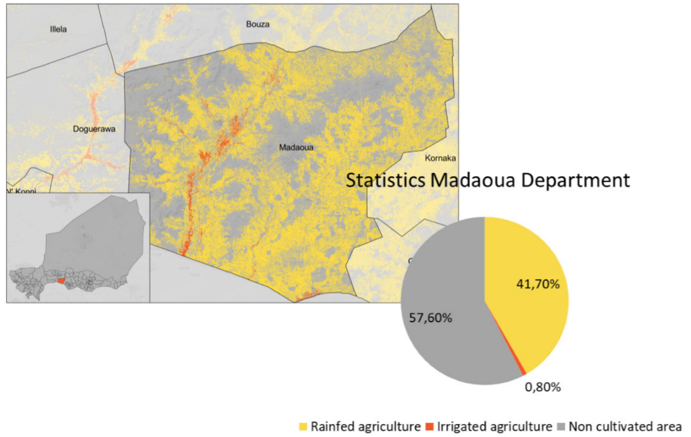
"La cartographie satellitaire des cultures et la surveillance des eaux de surface sont des outils indispensables pour le système d'information sur l'eau et l'irrigation qui sera mis en place dans le cadre du projet PARIIS. Il permettra ainsi de produire et mettre à la disposition des utilisateurs des informations utiles pouvant leur permettre d'améliorer quantitativement et qualitativement leur production. Il permettra aussi aux décideurs et gestionnaires de projet, de disposer de données leur permettant une meilleure planification , un meilleur suivi des activités menées et aussi faciliter les activités de suivi évaluations"

Issoufou Maigary, hydrologist at AGRHYMET

Dynamic crop mapping, Niger

The Sahel Irrigation Initiative Support Project (SIIP) aims to improve investment and management capacity for irrigation services and increase irrigated areas across the region, as part of a holistic landscape approach. The EO4SD dynamic crop mapping product can be used to gain insight into recent and current irrigated areas, representing an important baseline and trend indicator for the SIIP project.

The methodology is based on time-series analysis of the spectral profiles of high resolution (10-20m) and dense optical and SAR time-series. The product meets the objective of being scalable across all six countries to tackle key constraints for irrigation monitoring and evaluation.

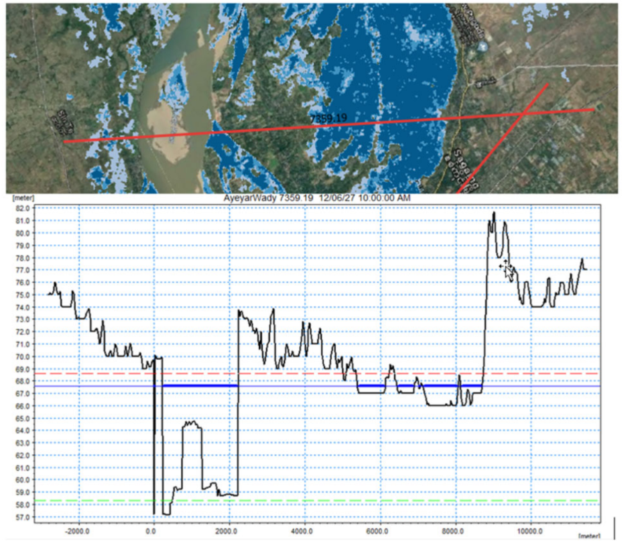


Irrigated vs. non-irrigated crop land in Madaoua Departmemt, Niger (Credits: Satelligence for World Bank 2019).

The floodplains of Ayeyarwady, Myanmar

Like other developing countries Myanmar wants to develop its hydropower resources, yet large hydropower schemes may alter the hydrological regime, which again may impact the flood plains along the Ayeyarwady. This is a concern for local communities as the fertile flood plains are important spaces for flood recession agriculture, also referred to as river gardening.

By combining the areal extent of the river garden as derived from EO data with the shape of the river cross sections and the simulated max/min water level it can be shown that the floodplains will not be significantly impacted even if all potential dams are constructed.



Relation between flood plains and simulated min/max water levels following new hydropower developments along the Ayeyarwady river, Myanmar (Credits: DHI GRAS/DHI for World Bank 2019).

Irrigation Mapping and Management

The growing population and associated increase in food production, together with shifting weather patterns due to climate change, are putting increased pressure on fresh water resources.

As a large majority of worldwide fresh water withdrawals are for agricultural use and specifically for crop irrigation, there has been an increased interest in using modern technology to improve crop water use efficiency at field and irrigation scheme levels.

Satellite-based EO is an example of such technology, which could have significant impact on agricultural water use. EO can provide information on the distribution of crops and vegetation and water extraction of these and make an important contribution to water management, enabling modelling of crop water needs and plant deficiencies to support irrigation planning and implementation activities.

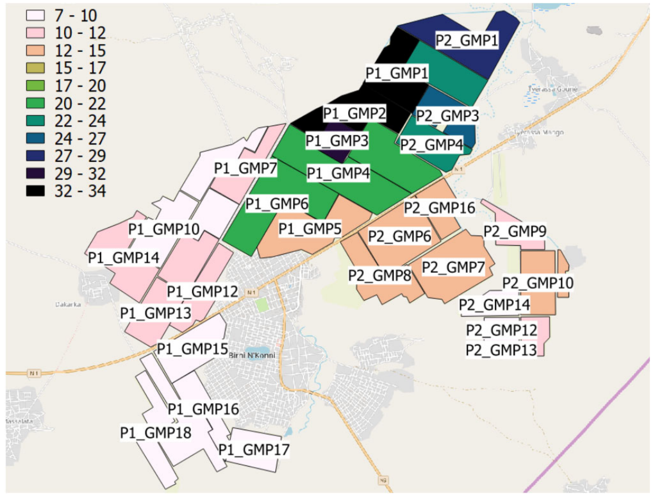
"The National Map of irrigation will help us with difficult management decisions and prioritization of resources to better effectuate water licensing. With this facility, we will now have a better overview of where water abstraction takes place and this information coupled with our water abstraction permits will enable to determine where to focus our efforts on the ground"

Peter Banda—National Water Ressource Authority, Malawi

Climate Smart Irrigation Services, Niger

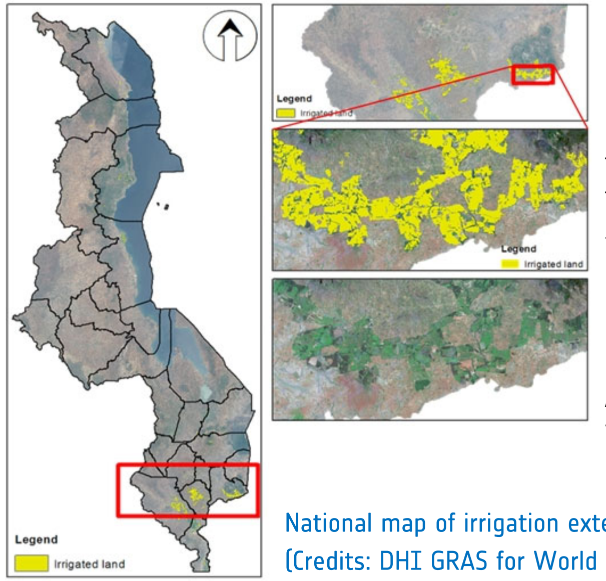
EO based Climate Smart Irrigation services provide actionable insights from field- to system-level that lead to optimized irrigation practices. Central to the service is satellite based estimates of evapotranspiration (ET), which is a physical parameter, closely linked to plant development and health.

By mapping and utilizing the knowledge of ET at the appropriate spatial and temporal scales, it is possible to better allocate water within irrigation perimeters and to execute a more efficient irrigation within a farm, thus increasing crop water productivity (crop per drop) and even improving crop yield.



Actual Evapotranspiration (water consumed by plants in mm) averaged per aggregation unit of the Birni N'Konni irrigation scheme for the dry season of December 2017 to March 2018. (Credits: eLeaf for World Bank 2019

Water licensing, Malawi



Like many developing countries, Malawi's water resources are under increasing strain, why the national water resource authority has developed and implemented a water license system. Yet, not having a clear overview of the large water users, especially irrigators, is a challenge that the authorities face to properly effectuate the water licensing.

This is where EO can help, as new free and open satellite data can be used to map and monitor the extent of irrigation at national scale in order to compare with active water licenses and for potential identification of non-licensed water usage.

A preliminary assessment suggest license fees could be increased by 75% if all known license holders were charged and approximating up tp 200K USD per year.

National map of irrigation extent in Malawi for the 2017/18 growing season (Credits: DHI GRAS for World Bank 2019)

EO4SD IN A NUTSHELL

From 2016 to 2019 the EO4SD – The Earth Observation for Sustainable Development - initiative of the European Space Agency has worked with international development projects to demonstrate the benefits of satellite-based environmental information for sustainable development and within different thematic areas.

For the thematic area **water resource management** the project highlights include:

→ **Geographic footprint**: 9 development projects spanning 24 countries in 3 continents

→ **Donor agencies engaged**: World Bank; Asian Development Bank; Inter-American Development Bank

→ **Other stakeholder engagements**: UNEP, IWMI, GEF, GPSDD, GMES&Africa, AMCOW, ECOWAS, GIZ, PPCR, GWP, WWF

→ **Private stakeholder involvement**: ZIEM, TROPIS, ImpactTerra, INCLAM Group and DHI Peru

→ 11 **Capacity Building** events (~200 participants from 17 countries); online learning material at: World Bank Open Learning Campus and via http://eo4sd-water.net/content/capacity-building

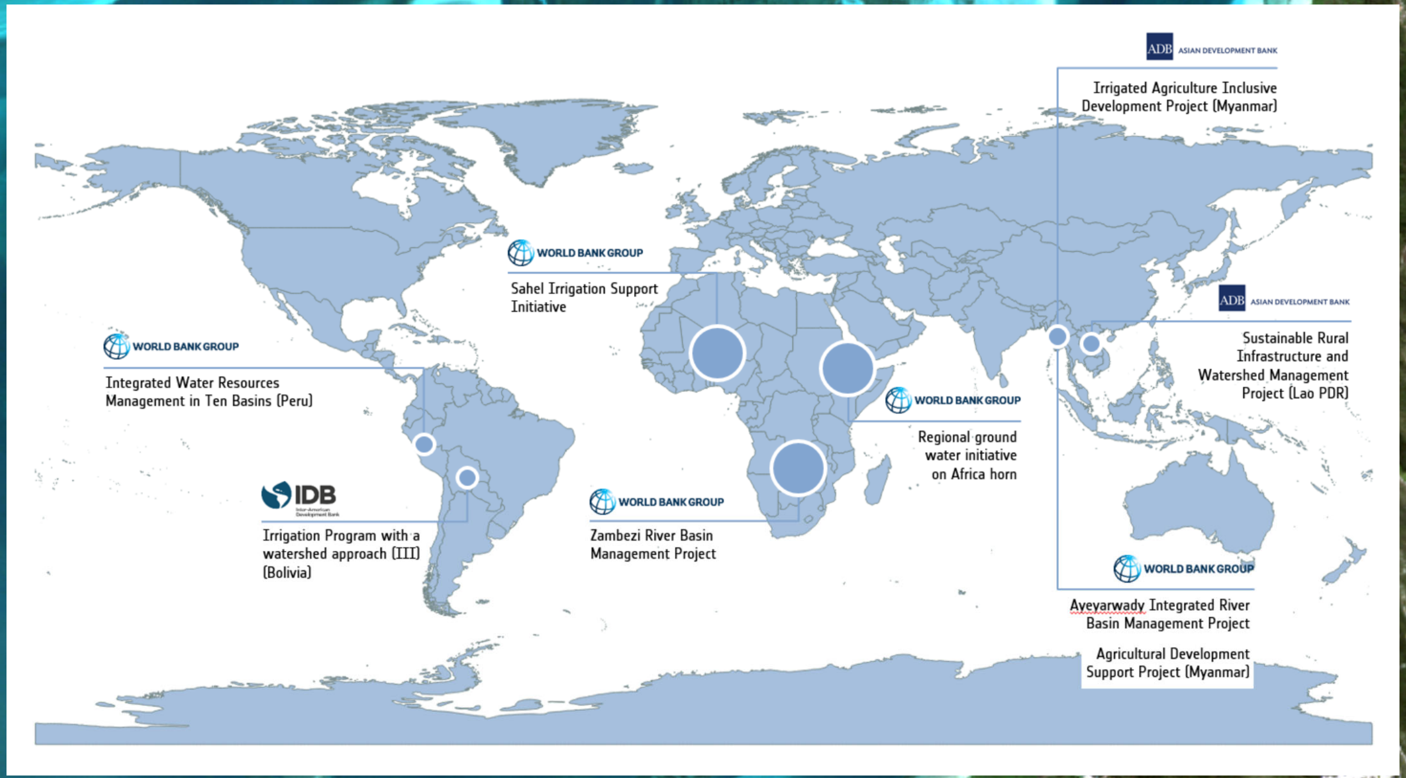
→ 4 national EO **Awareness workshops**: Senegal, Zambia, Peru and Myanmar (+100 participants)

→ **Info-sessions** at World Bank and Asian Development Bank

→ **International events**: World Water Week, Land & Poverty conference, Asian Water Forum, AARSE conference, Living Planet Symposium, Myanmar World Water Day, Africa Water & Sanitation Sector SDG Monitoring Workshop, Water-Energy-Food Nexus workshops, ECOWAS regional water observatory meeting and the Zambezi Basin-wide Stakeholder Forum

→ **Dissemination**: eo4sd-water.net/maps, ZAMWIS, Flood & Drought portal, WB DDH

→ **Publication**: Earth Observation for Water Resource Management and Sustainable Development. In S. Wade (ed.), Earth Observations and Geospatial Science in Service of Sustainable Development Goals: https://doi.org/10.1007/978-3-030-16016-6_1



Consortium

DHI GRAS (Denmark, Project prime and EO service provider)

GeoVille (Austria, EO service provider)

Satelligence (the Netherlands, EO service provider)

eLEAF (the Netherlands, EO service provider)

Starlab (Spain, EO service provider)

DTU (Denmark, Hydrological modeling and radar altimetry)

DHI (Denmark, Water domain experts and lead on the strategic assessment)

ITC (the Netherlands, lead on capacity building)

adelphi (Germany, lead on the stakeholder engagement review)

For more information, please contact:

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water resources management

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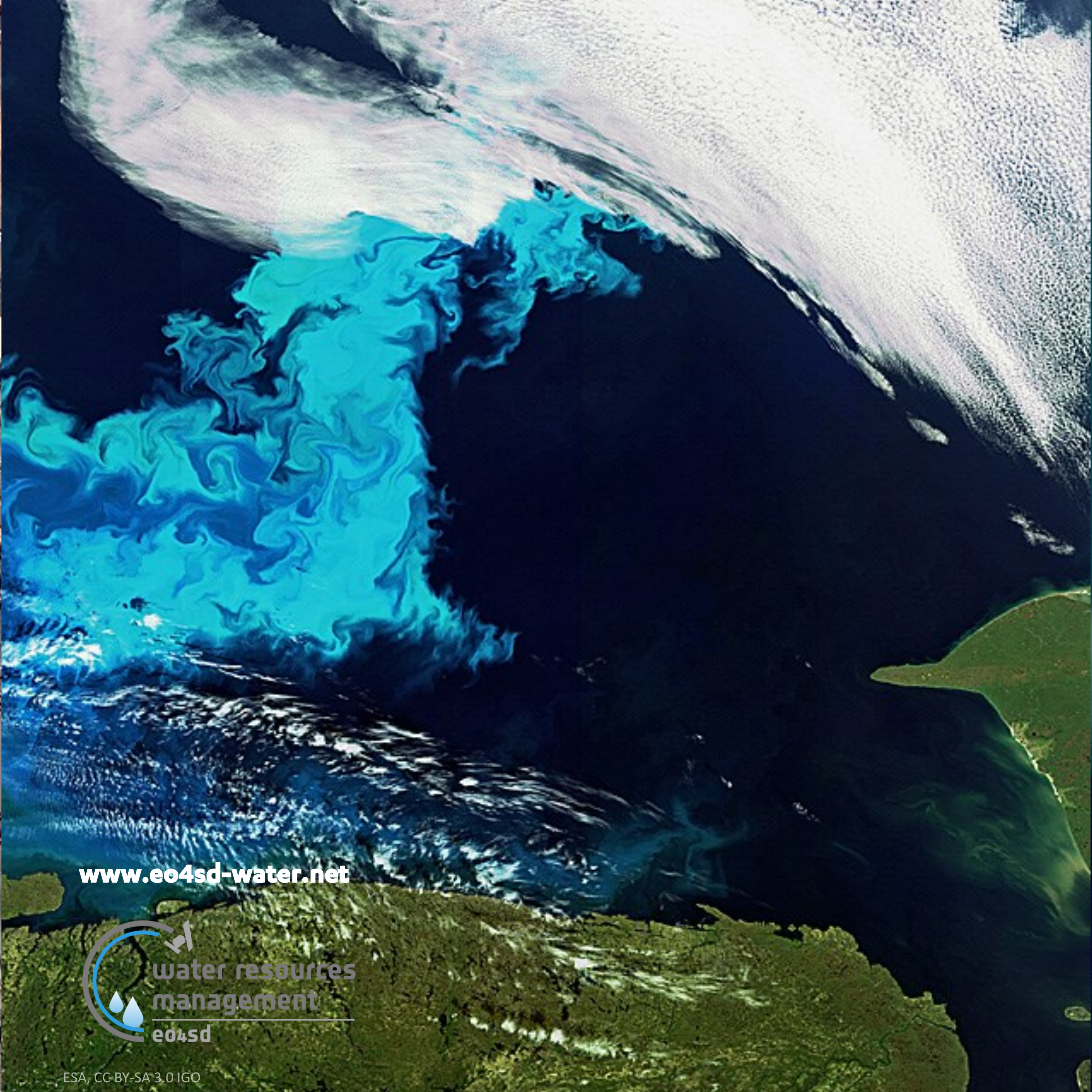
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