Briefing Note

From Space to Tap — Satellite Technology for Improved Water Management

Space Assisted Water Quality Forecasting Platform for Optimized Decision Making in Water Supply Services

H2020-EO-2016 / Collaborative Project

Partners:

SPACE-O has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 730005

Briefing Note

From Space to Tap — Satellite Technology for Improved Water Management

Table of Contents


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1.Background

This briefing note explores how advanced technology can be used by the water sector to optimize performance (in the case of water utilities) and improve management. The SPACE-O project provides an example of the development and integration of such technologies in practice. This includes vastly improved monitoring capacity from the watershed to the consumer; enhanced ability to understand supply and demand; greater insight for operations optimization and improved asset management; and customer connectivity as the norm. Already, the adoption of digital tools is helping to increase operational stability, resiliency, agility, reduced operating costs and responsiveness to upsets.

The brief takes the learnings from within the SPACE-O project, including feedback received on developed approaches for use by water utilities to provide an overarching view of how advanced technology can be integrated effectively into water management.

1.1. Key messages

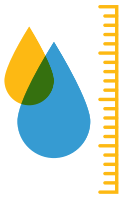
- Technological innovation is instrumental in addressing our increasingly complex and multidisciplinary water challenges.
- Integrating advanced technologies such as satellite data has the potential to expand monitoring capabilities across sectors and provide more dynamic disaggregated information across scales to make better decisions, and plans.
- Earth observation and geospatial information can significantly reduce the costs of monitoring, as well as fill the gaps where information is not available, as well as providing consistent information over time.
- Technologies like SPACE-O close the knowledge gap for informed and sustainable water resources governance and optimized water services provision. But they also need to be built to change and adapt to evolving technologies.
- Innovation should be streamlined into policy instruments, and can be used to bridge silos between Earth Observation technologies and policy implementation requirements.
- In order to be effectively used in decision and policy making, the function of digital technologies and the information they provide needs to be communicated and interpreted to all stakeholders involved.

1.2. About SPACE-O

The SPACE-O project (**https://www.space-o.eu**) funded by the European Union's Horizon 2020 Research and Innovation Programme, provides a decision support platform connecting physical and digital worlds by combining satellite technology with advanced hydrological, hydrodynamic and ecological modelling, in-situ monitoring and citizen science.

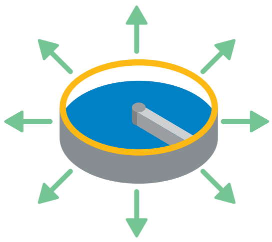
Starting in 2016, an international team of experts from EMVIS Consultant Engineers, Swedish Meteorological and Hydrological Institute (SMHI), EOMAP, European Dynamics, Consiglio Nazionale Delle Ricerche (CNR), and the International Water Association (IWA) joined to harness technology and tackle drinking water challenges. The tools developed were tested in two pilot sites with the support of the local water utilities of Crete and Sardinia (Organization for the Development of Crete S.A., and Ente Acque della Sardegna, respectively).

SPACE-O uses satellite imagery from Copernicus — the European Union's Earth Observation Programme — to develop tools that are useful and usable by water utilities worldwide. These tools include:



A **water information system** that combines in situ measurements, satellite images and modeled hydrological, hydrodynamic and ecological data to fill in the information gaps in space and time about of water quality, and to produce short term forecasts (up to 10 days) with high spatial and temporal resolution;

An **early warning system** that indicates incidences of water quality deterioration with potentially high impact on downstream water utility services;

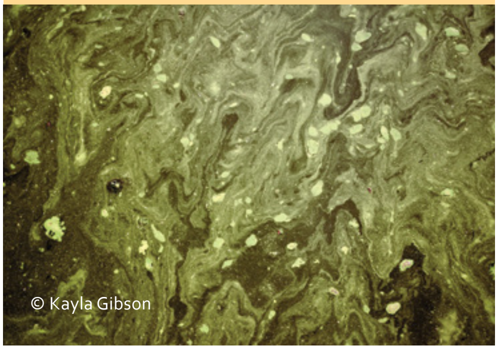


A **tool for water treatment plant optimization**, which provides specific water treatment options based on forecasted raw water quality and advanced machine-learning algorithms that allow for improving efficiency in both drinking water quality treatment and financial performance;

A **tool for catchment risk assessment**, providing a method for water managers to identify hazards within the upstream catchment area and asses the level of risk to their water systems; and

Improve my water, a **citizen science platform** to report, administer and analyze local water issues.

Water managers can use these tools to take proactive action such as blending water from connected reservoirs so as to mitigate or moderate evolving algae bloom events.



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2. Technology Applied to Achieve Sustainable Development

Drinking water accounts for around 18% of total fresh water abstractions in the European Union, and is treated and supplied by almost 70,000 utilities (Eurostat [1]). While freshwater resources are already limited, they face increasing pressures from drought, flooding, pollution, population growth, as well as demands for other uses including agriculture, energy production, recreation and ecosystem protection. For instance, according to the FAO[2], global fertilizer use is likely to rise above 200.5 million tons this year, which will contribute significantly to freshwater pollution and impacts the full water cycle.

The mandate for "universal", "equitable" and "adequate" access and sustainable supply in SDG6 demands long-term planning and collective actions of diverse and interdependent stakeholders. Sound information on demand and use, system yields and hydrology are necessary precondition to any robust planning and reforms, moving from a contingency approach towards a water security one (IWA, 2016) [3].

Addressing such challenges is outlined in the sustainable development goals, specifically SDG 6 (Ensure availability and sustainable management of water and sanitation for all), which is separated into six different overall target topics:

Drinking water: 6.1

By 2030, achieve universal and equitable access to safe and affordable drinking water for all

Sanitation and hygiene: 6.2

By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

Water quality and wastewater: 6.3

By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

Water use and scarcity: 6.4

By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

Water resources management: 6.5

By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

Water related ecosystems: 6.6

By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

These targets are monitored by a set of global indicators [4], which can be supported by application of EO based data sets. This involves indicator 6.6.1 on water related ecosystems with measuring the surface water quality or foremost indicator 6.3.2 on water quality itself, monitoring the percentage of water bodies with a good ambient water quality. Although the selected parameters are not measurable directly with satellite remote sensing, the available satellite-based parameters like turbidity or chlorophyll-a can provide valuable proxies "in areas lacking traditional, ground-based water quality monitoring." [5] Further, the monitoring of indicator 6.5.1 dealing with water resource management can benefit from transboundary satellite-based information.

Additional SDG Targets may also be supported [6] such as SDG 3 – Health with Target 3.3 combat water-borne diseases or Target 3.9. reduce death and illness from hazards chemicals and air, water, soil pollution. In addition, for the monitoring of SDG 12 - production and consumption with Target 12.4 to significantly reduce release of chemicals to air, water and soil in order to minimize their adverse impacts on human health and environment, EO based data sets can provide additional information.

Overall, earth observation can track global change in high resolution and in real time, and has a key role in contributing towards SDG monitoring. This potential combined with demographic and statistical data can enable important developments to analyse and model conditions, create maps and other visualizations, evaluate impacts across sectors and regions, monitor change over time in a consistent and standardized manner and, ultimately, improving accountability and informing decisions [7].

The benefits reported also translate into economic improvements, as the use of EO and geospatial information can significantly reduce costs of monitoring allowing for the different administrations to adopt this technology without ignoring local priorities and ensuring coherence with the state of resources available. The information generated can help fill in gaps or provide a baseline especially where few or no monitoring systems are operational – which has the potential to benefit other decision and policy making processes [8].

In order to be effectively used in decision and policy making, the function of digital technologies and the information they provide needs to be communicated and interpreted to all stakeholders involved – public and private sector, financial institutions, public authorities, academia, civil society and citizens. This is essential to increase the use of such information in making decisions and for innovative investments and sustainable growth to be effective.

2.1. Impact of Advanced Technologies

Current and future technological developments are responding to the challenges or the missions that existing policies pose on utility operators and water managers. New tools like Citizen Science and Blockchain have the potential to fill in the gap between policy and practice because they breakdown complex and sophisticated tools into something practical and user friendly, enabling policy challenges achievable to utility operators and customers.

The SPACE-O platform aims to provide tools which can help interpret water information from a variety of sources including satellite data. The approach is user-centric such that the outputs are accessible and applicable. For example there are tools for water quality forecasting including turbidity and algal blooms in reservoirs. This information can then be used to optimize drinking water treatment operations. Many other water quality dependent activities from recreation to aquaculture to hydropower can benefit as well from the interpretation and provision of water quality information. The infographic on page 10 illustrates the key tools in the SPACE-O platform and how they interact.

2.2. Impact of Satellite Technology on Water Management

Improving assessment of risk factors can be enabled through new technologies that address forecasting and modelling or scenario development to map consequences; this in turn can improve planning for risk mitigation. Space technologies such as Earth observation, telecom, navigation, positioning, and timing (some of which were applied in the Space-O project), combined with information and communication technologies can effectively improve the monitoring water issues and the response to day to day threats and in the near-to-medium term future.

As illustrated in the case of Space-O, the coverage of satellites offers a unique, fact-based perspective that can help address water challenges. Moreover, satellite data has a variety of uses across scales –from transboundary to local– that can translate into helping to improve agricultural performance to ecosystem conservation. Information derived from earth observation satellites could improve knowledge of the supply of freshwater and assist in managing its distribution to water users. More specifically, satellite images enable broad and efficient monitoring of reservoir water levels, providing early warning of shortages and uniform data across different countries that share water sources, increasing transparency and consistency in water delivery. The OECD have identified that early risk identification early warning is essential for an effective risk management approach [9]. This is the case of the use of satellite data on climate to plan against the impacts of climate change and mitigate effects of floods and droughts [10].

3. European Policy Challenges to Water Utilities

EU water directives have been –for the last 20 years– the key driver for achieving high quality, safe and sufficient potable water. New concepts have been gradually introduced in the water policy context such as integrated river basin management and cost recovery in the Water Framework Directive (WFD) [11] and risk assessment in the Drinking Water Directive (DWD) [12] that lead towards a more resource-efficient urban water management. Complementary EU policy frameworks, such as the EU Energy Efficiency Directive[13] sets up the basis to allocate energy efficiency targets across economic sectors which include water utilities. Pointing in the same direction, the EU climate and energy package aims at reduction in GHG emissions, raising the share of energy consumption from renewable resources and improvements in energy efficiency to reach "20/20 targets".

As water management evolves into an integrated evaluation of pressures and competing water needs against social and environmental concerns in large hydrologic units (e.g. water catchments) with strong interaction to other policy contexts of energy, climate change, agriculture, etc., there is a growing need for all stakeholders involved – public and private, to adapt.

Through providing better information on water quality and quantity for end users, cases like that of SPACE-O illustrate the concrete reach of EU policies and strategies such as the EU space industrial policy [14] , GEO 2016-2025 strategic plan [15], European innovation plan on water [16], Blueprint to safeguard Europe's water resources [17] and EU climate and energy package [18]. At the technical level, EO-based information services will ultimately provide products that can be used to support effective Integrated Water Resources Management.


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4. Unpacking Digital and Technological Solutions to Water Problems: The SPACE-O Experience

Sophisticated technologies are available just not always accessible, but the costs are not the main limiting factor to achieve a digital transition. The challenge is the change of mentality. Space-O streamlines available but complex technologies to make them accessible and tailored to those that need them.

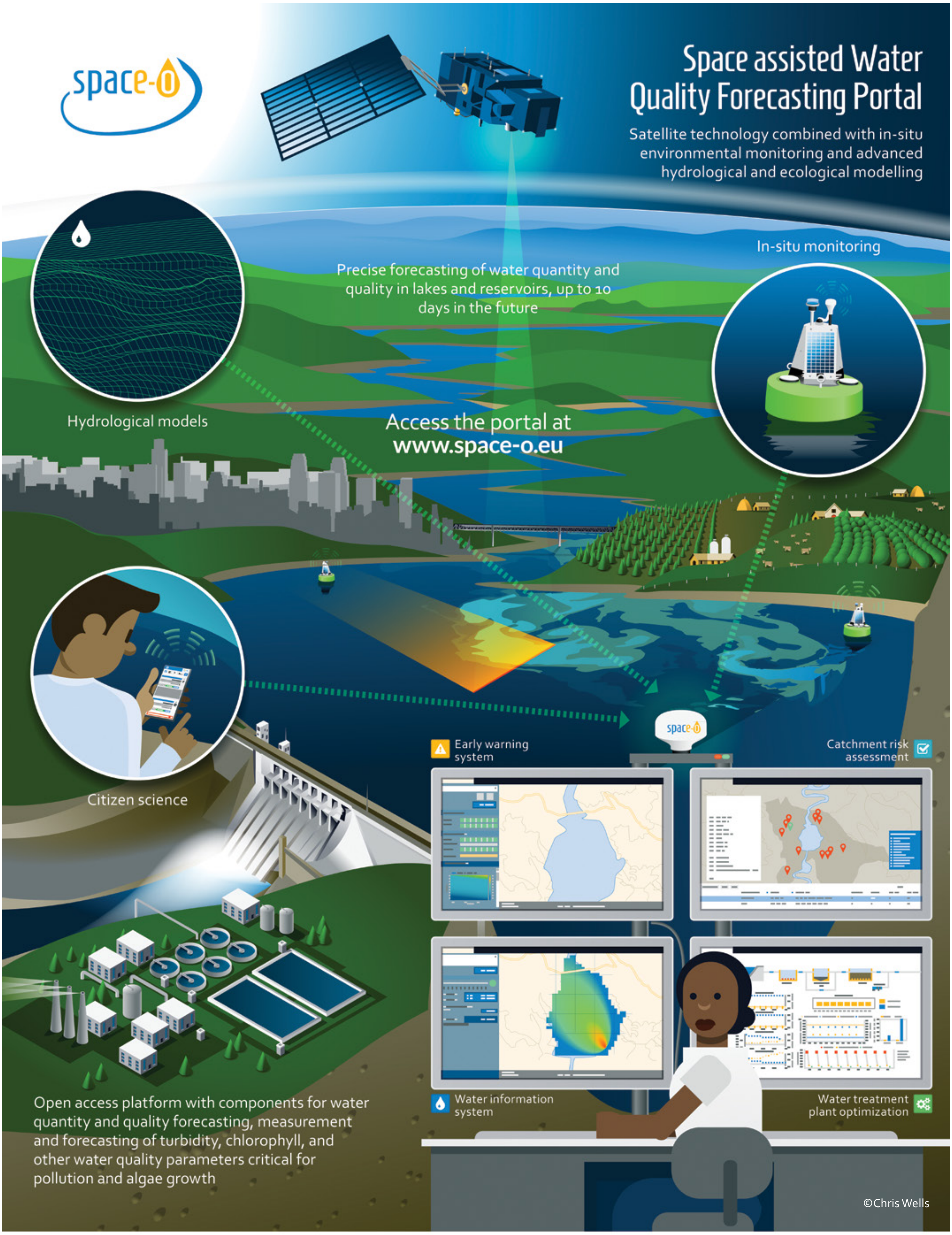
Technological innovation is instrumental in addressing our increasingly complex and multidisciplinary water challenges, but feasibility to make use of advanced technology often depends on the specific local context and associated capacity of institutions to integrate such tools in their daily work. SPACE-O allows water quality forecasting for reservoirs and use of this information to optimize water treatment operations linking science with practice.

The decision support system (DSS) connects physical and digital worlds by combining satellite technology with advanced hydrological modelling, in-situ monitoring and citizen science. The DSS integrates Earth Observation data to provide information such as water quality forecasting, in-situ monitoring data and data collected through SCADA (Supervisory control and data acquisition) systems in WTP for operation control.

The applications of this tool were made possible (and effective) using a consultation process that targeted drinking water treatment plants and reservoir managers. Their inputs have been crucial to ensure the development of functional and user friendly tools, tested, shaped and customized against real operational conditions.

The way that the SPACE-O platform has been designed is such that various stakeholders across a catchment area have the potential to act collectively and collaborate to solve water issues. While local water resources authority will use these tools to better plan for events of low water quantity or poor quality, reservoir managers can be proactive by blending water from other connected reservoirs so as to mitigate or moderate evolving algae bloom events. Furthermore the provided forecasts enable adjustments to critical downstream water cleaning operations achieving a more economical and sustainable performance. The use of satellite information is also being used by the public water resources authority to improve local and regional emergency management. Finally, the achieved platform represents a user-friendly interface for citizens who, through this system, can signal problems on the network and in the water supply and contribute to an improvement in management.

Technologies like SPACE-O close the knowledge gap for informed and sustainable water resources governance and optimized water services provision. But they also need to be built to change. In this regard, the SPACE-O platform is both scalable and flexible to include new services and technologies (e.g. Blockchain [19]) into the future.



www.space-o.eu

SPACE-O has received funding from the European Union's Horizon 2020. Research and Innovation Programme under Grant Agreement No 730005

infographic: www.chris-wells.com

Footnotes

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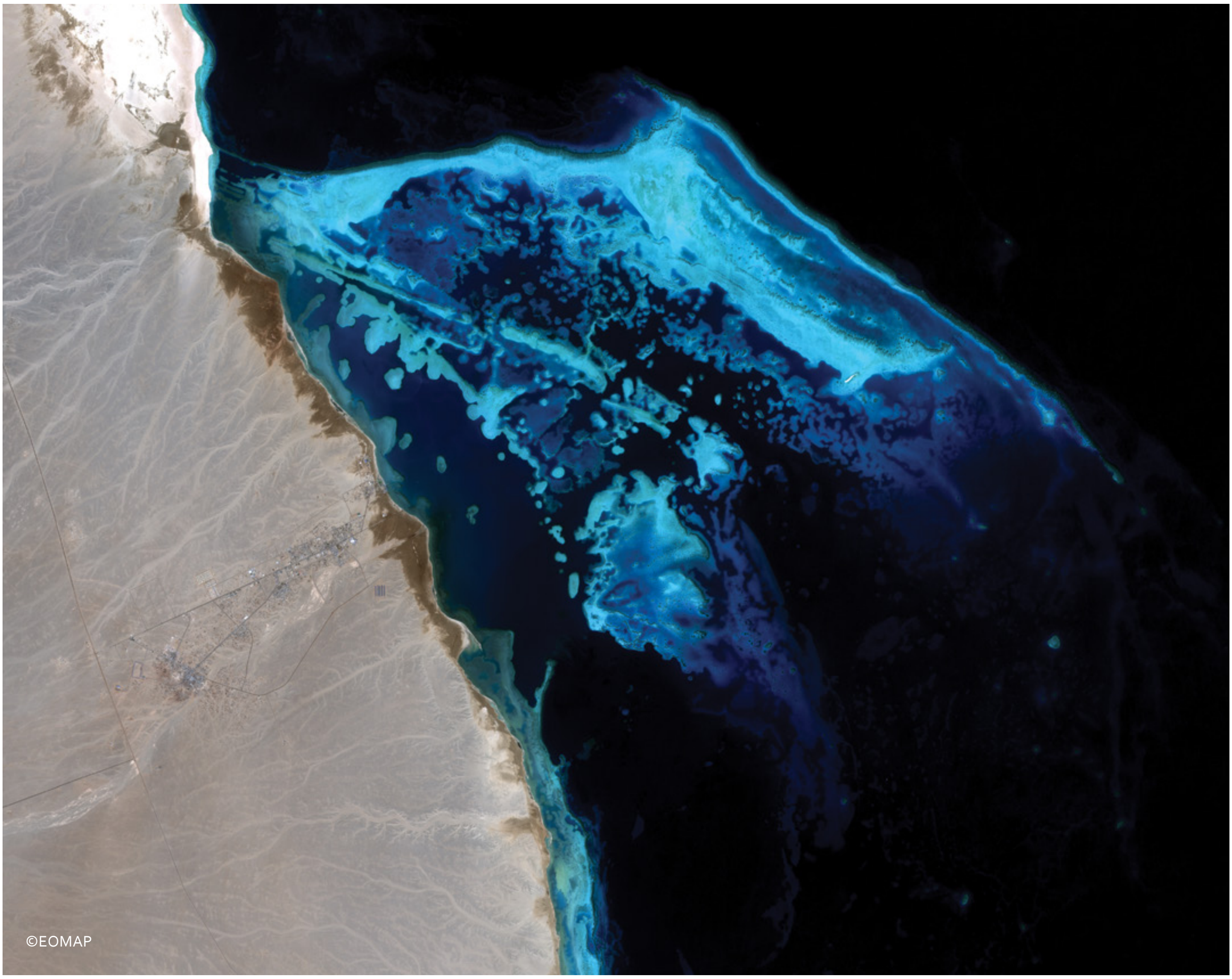

Contact

Apostolos Tzimas
EMVIS, Athens (Greece)

E: atzimas@emvis.gr
W: www.space-o.eu/contact/

SpaceOProject
@SpaceO_Project
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