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Changing perspectives: Water quality from space

The World Water Quality Portal developed by EOMAP for UNESCO programme

An article by MARIE-LUISE WILHELM

The rising number of pollutants entering our waterways are challenging our ability to monitor and maintain essential supplies of clean water. Water management teams on the ground often cover large networks of freshwater lakes, rivers or streams stretching over vast landscapes or circumnavigating through remote or inaccessible locations. With these logistical hurdles in mind, there is a pressing demand for new technologies to support water management teams as they undertake one of the biggest challenges for modern society. The UNESCO and many other users believe the answers should also lie within the resources of satellite-based earth observation (EO).

EO – earth observation | water quality | SDB – satellite-derived bathymetry | MarSat

Author
Marie-Luise Wilhelm is head of Marketing & Communications at EOMAP in Seefeld

wilhelm@eomap.de

Space-based monitoring

Today, numerous of vibrant images of the earth are captured daily using satellite-based technology. The exploitation of this potential requires a greater understanding of the colours that show the earth's surface and what they mean for the health of our marine and freshwater systems.

The colour of light that is scattered back out of water can be measured from space and used to derive information about what is in the water column including turbidity, phytoplankton abundance, sediments and harmful algal blooms indicators (Fig. 1). With the knowledge of these light characteristics, experts can obtain concentration levels of different water quality parameters which can then be used to employ effective management and mitigation practices.

Inland water bodies can undergo a range of natural changes over time, often exacerbated by nearby human activities such as agricultural runoff. Yet any efforts to collect data on the ground are limited in both time and space. For this reason, satellite-based observations are important in providing a global view of the earth and monitoring how the patchwork of colours change over time.

Innovating water quality algorithms

The ability to observe water bodies from space has established earth observation (EO) as an important source of information on water quality and ecosystem condition. Earth observation based measurements are of significant value for the evaluation of water bodies, if the measurements can be provided independently to in-situ data and if globally harmonised. However, as for the wide range of optical conditions inland water bodies require very complex and concerted algorithms in global applications.

In 1996, scientists at the German Aerospace Centre (DLR) initiated the development of a unique, physics-based Modular Inversion and Processing System (MIP) to support the robust extraction of water quality parameters from raw satellite and airborne data. As well as being one of the most elite and effective EO processing systems in the world, it requires no expert knowledge about the study area, allowing a more user-friendly approach that can be applied independently from any location worldwide.

In 2006, the leading provider of optical remote sensing for the aquatic environment, EOMAP, took over the MIP development. Today, the MIP has been subject to extensive validations within international research projects such as Space-O and commercial applications including water agencies like the Environmental State Authority Baden-Württemberg (LUBW), and also industry and water environmental consultancy companies for a wide range of lakes, reservoirs and rivers.

Use case: Access to large areas

Over the last decade, the rise of technological innovation and advancements in the accuracy and resolution of satellite data makes EO-based tools more attractive than ever to water quality and environmental managers.

There are around 260 lakes in the south of Germany which are larger than 10 hectares. These lakes must be monitored and maintained making it impossible to only rely on traditional ground methods as the area is too vast. Environmental State Authorities have been working with EOMAP closely validating successfully earth observation as a tool to measure water quality of different sized lakes.

Since 2016, EOMAP has observed a substantial growth in interest and paid services. As such they

are successfully expanding into new applications and industries including aquaculture, river management and dredge monitoring.

Water quality from space: The World Water Quality Portal

As water quality continues to represent a major problem in both developed and developing nations, initiatives are well underway to improve water quality and wastewater management, and to find innovative tools that support global efforts in addressing this issue.

On January 22nd, 2018, the world's first global water quality portal was launched to support the International Initiative on Water Quality (IIWQ) of UNESCO's IHP (Fig. 2).

Developed by EOMAP last year, the comprehensive IIWQ World Water Quality Portal assists with global water quality assessment and capacity building for streams, lakes and rivers. The online interface, based on satellite-derived information, gives for the first time managers, agencies and industry users access to an easy-to-use tool providing detailed global water quality information, campaign planning support and access to remote and inaccessible areas. As a worldwide demonstrator, the World Water Quality Portal will be a key product in improving awareness, capacity building and acceptance of EO products on a global scale.

The web-based service allows users to quickly obtain measurements at freely selectable virtual stations for any location worldwide. The IIWQ Portal also combines a comprehensive range of satellite-based water quality parameters such as turbidity (Fig. 3), chlorophyll and indicators for toxic cyanobacteria blooms using EOMAP's innovative MIP system.

The IIWQ Portal also includes functionalities to select different time periods dating back over the last three decades. Historic measurements are provided at a 30 m resolution for selected regions of each continent throughout 2016, and can be continued with various spatial and temporal resolutions for every country.

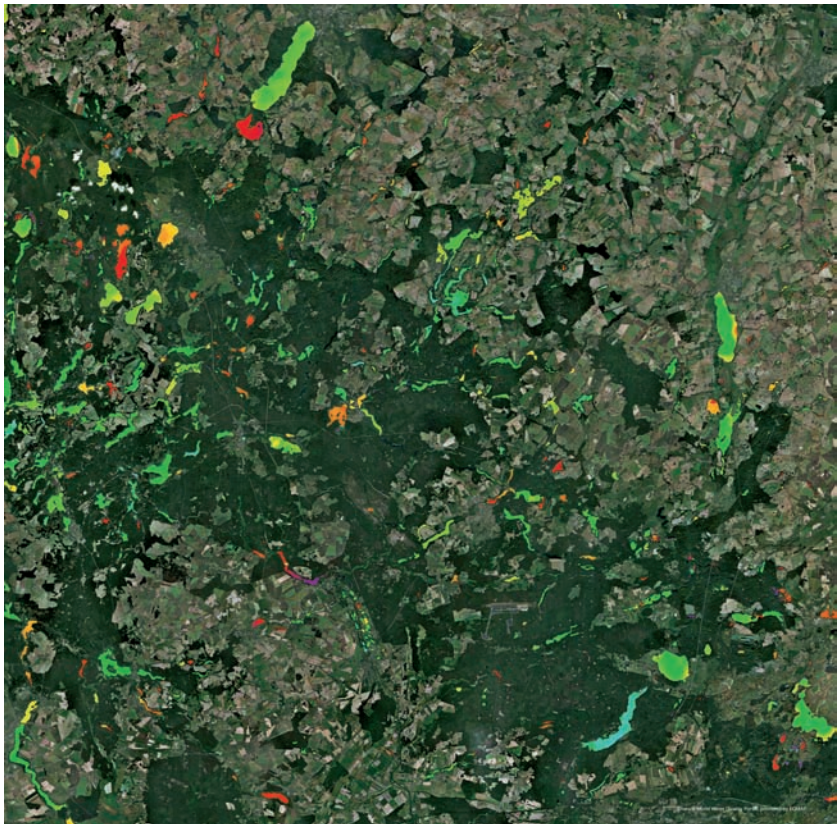

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Fig. 1: Chlorophyll status indicating harmful algal bloom in Mecklenburg Lake Plateau

A further updated web application developed by EOMAP can implement a monitoring system such as the World Water Quality Portal at a range of temporal and spatial resolutions, for any given location, worldwide. This will allow any user to deploy a customised portal for their region, monitoring synoptic water quality on an ongoing basis, with user access customised to their specific constellation of stakeholders.

Future perspectives

Water security is crucial in achieving sustainable development and thriving economies. Remote sensing is an efficient and cost-effective tool to as-

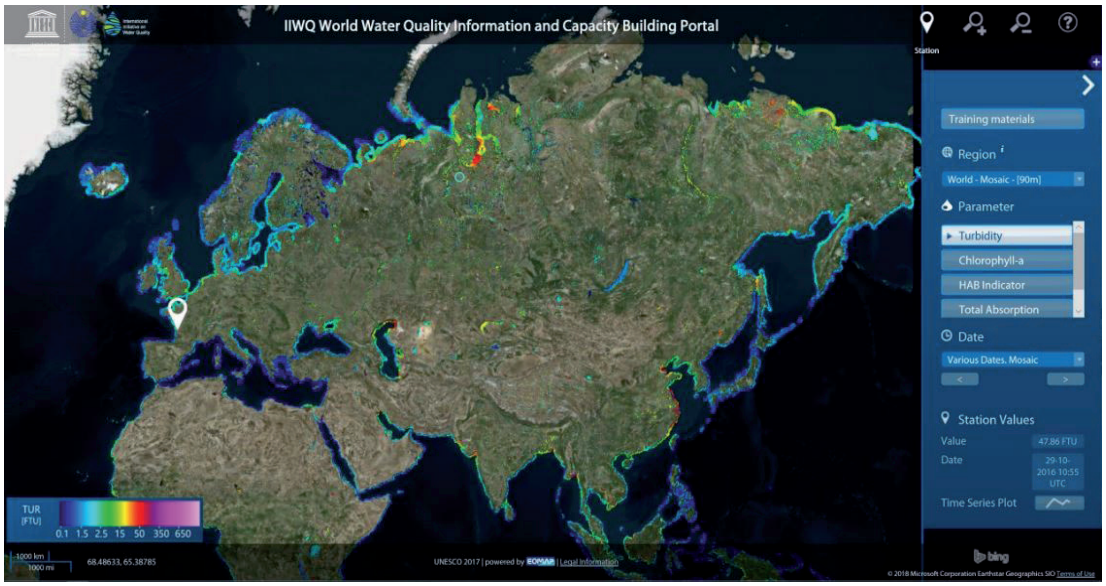

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Fig. 2: The IIWO World Water Quality Portal

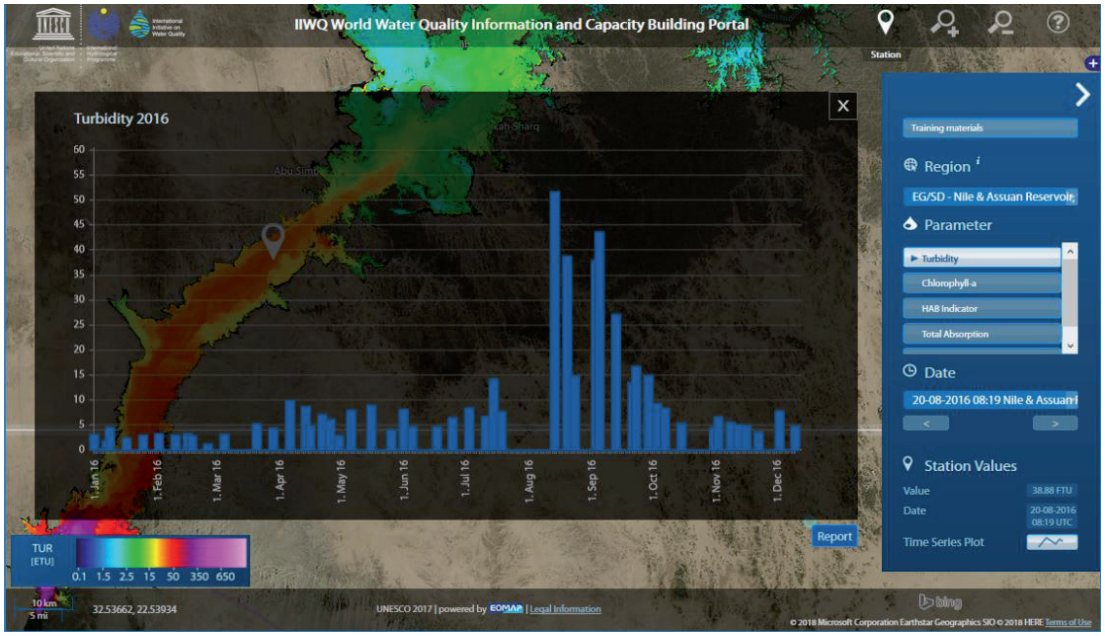

Fig. 3: Lake Nubia, Aswan reservoir: The IIWQ Portal shows the seasonal turbidity trend for year 2016

sess a variety of physical and biological parameters in aquatic ecosystems over small-scaled and large areas. Until now, the industry lacked a method that can support users, from managers to utilities, by removing some of the issues they have around interpretation and data access.

The satellite-based monitoring service can respond to the challenges that industry and governmental institutions have to address for effectively assessing water quality threats such as algal blooms and turbidity. The UNESCO portal, the first portal of its kind, can be used as the basis for the ongoing improvement of combining high-resolution global coverage with the range of measurements needed for effective global water quality monitoring. It provides user-friendly features encouraging the industry's adoption of EO products and helps to protect a resource that is increasingly under threat. Due to yearly improvements in spatial and temporal resolution of EO satellites the future of these tools for water quality monitoring is becoming clear.

The approach and technology will decide the achievable reliability of the data. There is no other way to provide holistic, area wide data that EO information products can offer nowadays. This will change the view on how our inland water environments are interconnected and therefore more effective water management can take place. In the near future the use of EO products and services will be a mandatory element for all environmental analyses.

Other EO-based tools: satellite-derived bathymetry

Similar growth mechanisms have been observed for other EO services and sectors. The acceptance of satellite-derived bathymetry (SDB) services and market-take-up is expanding significantly.

Initially established as a reconnaissance tool for shallow water bathymetry only, cutting-edge satellite-derived bathymetry techniques are increasingly used when environmental conditions allow as a cost-efficient and rapid survey method for acquiring high-resolution bathymetric data down to water depths of 30 metres.

The use of the satellite-derived bathymetry technology in applications such as safety of navigation, reconnaissance surveys, coastal zone management and hydrodynamic modelling is increasing significantly and so is the demand to discuss key issues on capabilities, data integration and quality standards.

With this pressing need EOMAP organised the first international conference on satellite-derived bathymetry: The Satellite-Derived Bathymetry Technology and User Forum (SDB Day 2018, Fig. 4) which took place beginning of June 2018 attracted international speakers, panellists and participants from North America, Europe, Middle East and Asia. Topics included quality assurance and uncertainties, integration and use concepts, standards and capacity building. The next SDB Day is planned for 2019.

Further EO-based innovations for the marine industry: MarSat

MarSat, a network of six private companies and a research institute, aims to provide innovative integrated satellite-based services for the maritime and coastal industry to improve safety and efficiency in shipping, offshore industries, emergency response and rescue operations.

There are many users who require current high-quality bathymetric information for the shallow-water zone, highlighting the need to fill this data gap.

MarSat plans to initiate a service chain that provides a simple and fast way to obtain current shallow-water bathymetric data, from the acquisition of satellite data to its interpretation to conversion and integration into bathymetric Electronic Nautical Charts (bENCs).

Fig. 4: SDB Day 2018 – Satellite-Derived Bathymetry Technology and User Forum