Preparing for Inland Water Quality Monitoring with Sentinel-2 and Sentinel-3

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BACKGROUND

Water is an indispensable resource for the life of humans, plants and animals. Fishing, recreation, water supply, transport, waste disposal, irrigation, amongst others are putting **pressures** on the EU inland waters. To safeguard the EU inland water quality, intensive **monitoring** is required as stipulated by various EU directives like the Water Framework Directive, BUT less resources are available for *in-situ* monitoring. Earth Observation (EO) data can provide harmonized water quality products to complement *in-situ* measurements in the reporting obligations.

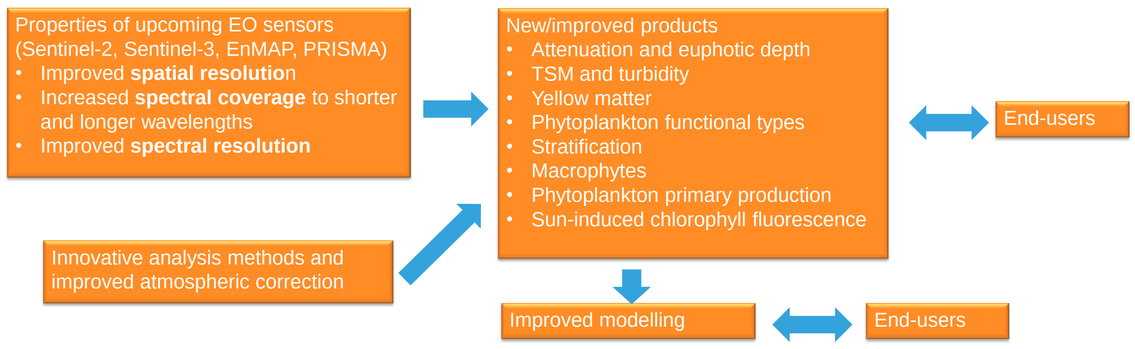
Upcoming satellite missions such as Sentinel-2 and Sentinel-3 will provide much more detailed information, spectrally and spatially, leading to new and improved products for inland waters.

OBJECTIVES

The main objective of the FP7 INFORM project (http://www.copernicus-inform.eu) is to develop and demonstrate **new and improved user-driven products coupled to water quality models** for inland water quality monitoring and forecasting which fully exploit the improved spectral, spatial and temporal capabilities of upcoming EO missions like Sentinel-2, Sentinel-3 and hyperspectral EO missions like EnMAP and PRISMA.

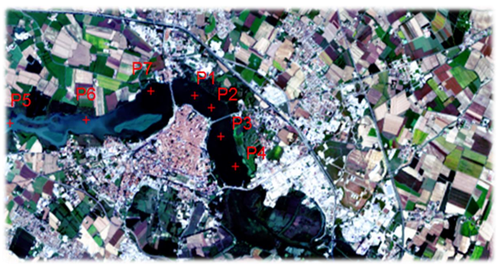
Another objective is to provide **recommendations for future EO missions taking into account requirements for inland water quality monitoring**.

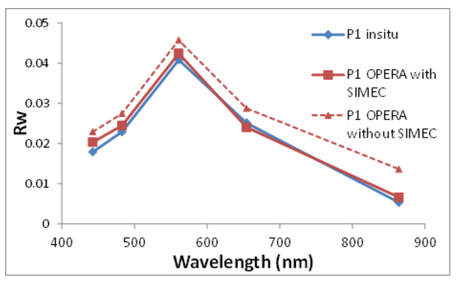
EXPECTED IMPROVEMENTS



IMPROVEMENT 1: OPERA FOR OPERATIONAL LAND AND WATER ATMOSPHERIC CORRECTION INCL. ADJACENCY CORRECTION

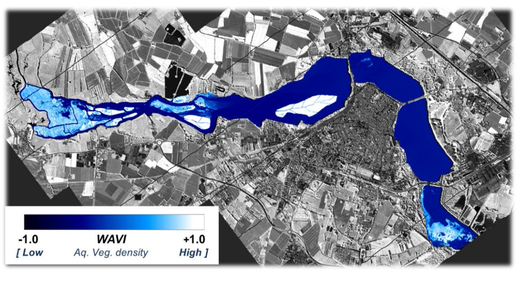
OPERA is a scene and sensor generic atmospheric correction scheme allowing to correct both land and water areas in the remote sensing image. Over water the SIMEC (Sterckx et al., 2015) (SIMilarity Environment Correction) approach is used to correct for adjacency effects. In the figure below OPERA is applied to a Landsat-8 scene over Lake Mantua, Italy.

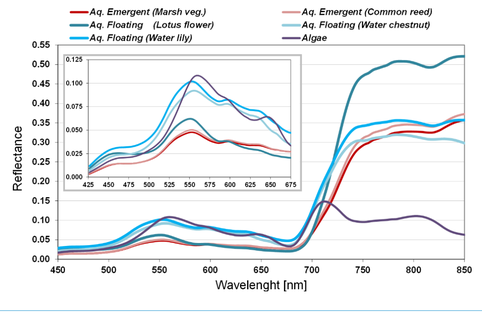




IMPROVEMENT 2: AQUATIC VEGETATION INDICES FOR MACROPHYTES

Hyperspectral data and vegetation indices specifically targeted at aquatic vegetation features can enhance aquatic vegetation detection and characterization (Villa et al., 2014). Mantua lake system, Water Adjusted Vegetation Index (WAVI) map derived from airborne hyperspectral APEX data for September 2011 (left). Spectral response of different aquatic vegetation types and groups derived from APEX (right).





STUDY SITES AND END-USER REQUIREMENTS

Site	Country	Characteristic	Parameters of interest
Lake Balaton Kis Balaton	Hungary	Largest shallow lake in Central Europe, meso-oligotrophic Water Protection System, hypereutrophic	Phytoplankton functional types Chl-a, CDOM, TSM concentrations and Algal biomass Lake Primary Production TIC, P, N Macrophyte biomass and cover
Curonian lagoon	Lithuania	Hypereutrophic coastal lagoon	Phytoplankton bloom occurrence Euphotic depth Turbidity Phytoplankton functional types Chl-a concentration
Lakes Mantua	Italy	Small and shallow artificial eutrophic basins	Phytoplankton functional types Chl-a, CDOM, TSM concentrations and Algal biomass TIC, P, N Macrophyte biomass and cover
Lagoon of Venice	Italy	Turbid coastal lagoon	Acquatic Vegetation Light extinction/attenuation
Lake Constance	Germany, Switzerland, Austria	Meso-oligotrophic lake	Sun-induced chlorophyll fluorescence Euphotic depth Stratification of the water body Light extinction/attenuation
Lake Geneva	Switzerland	Meso-oligotrophic lake	Sun-induced chlorophyll fluorescence Euphotic depth Stratification of the water body Light extinction/attenuation
Gironde river	France	Highly turbid river	TSM concentrations Turbidity
Scheldt river	Belgium	Highly turbid river	TSM concentrations Turbidity
Lake Windermere	UK	Mesotrophic lake	Sun-induced chlorophyll fluorescence Chl-a, CDOM, TSM concentrations and Algal biomass
Loch Lomond	UK	Warm, monomictic basin. Oligotrophic northern basin, mesotrophic southern basin	Chl-a, CDOM, TSM concentrations and Algal biomass Phytoplankton bloom occurrence
Loch Leven	UK	Polymictic, nonstratifying and eutrophic shallow lake	Chl-a, CDOM, TSM concentrations and Algal biomass Euphotic depth
Ijsselmeer	The Netherlands	Eutrophic lake, largest freshwater lake area in Northwestern Europe Markermeer is a turbid lake	Chl-a, CDOM, TSM concentrations and Algal biomass TIC, P, N

The benefits that **harmonized MULTI-TEMPORAL AND SPATIAL information derived from satellite images** can give with respect to traditional *in-situ* monitoring techniques based on point measurements was pointed out as the **most important improvement compared to their current practices** at the INFORM End-User Advisory Board (EUAB) Meeting 01, CNR, Venice, 20-21 March 2014.

In addition, the following requirements were formulated by the EUAB members:

TEMPORAL AND SPATIAL RESOLUTION: Monthly temporal frequency of EO data, with a spatial resolution of **100 m**. **Exceptions are TSM, Turbidity and Chl-a maps which are required daily**.

ACCURACY: Associated information about the quality of pixel values; robust algorithms with reference to literature or algorithm theoretical basis document (ATBD).

CONSISTENCY: Consistency between products derived from different sensors; a robust atmospheric correction with reference to literature or ATBD.

TAXONOMY: A standardized taxonomy (e.g. parameters names, measurement units, legend, color code) is received as a prerequisite for a harmonized EU-wide inland water quality monitoring.

ACCESSIBILITY: Easily accessible data and downloadable preferably by Web Map Service (WMS); training is requested.

DATA GATHERING

Data sets of *in-situ* data and/or airborne hyperspectral images of EU inland waters are already available for the study sites listed above. An extensive *in-situ* and airborne APEX (http://www.apex-esa.org) campaign was executed from 14-28 July 2014 at Lake Balaton and Kis Balaton, Hungary. Teams from U STIRLING, CNR, VITO, MTA OK, and Central-Transdanubian Water Directorate performed *in-situ* measurements simultaneously with APEX and Landsat-8 and HICO overpasses. APEX data is used to simulate Sentinel-2 MSI data and Sentinel-3 OLCI data.

In addition, *in-situ* and/or airborne campaigns were executed in 2014 at UK lakes, Curonian lagoon and Mantua lakes. In 2015, another *in-situ* and EUFAR-funded APEX campaign is planned at Lake Geneva. In 2016, several *in-situ* campaigns and an APEX campaign are planned simultaneously with Sentinel-2 and Sentinel-3 overpasses for validation of Sentinel-2 and Sentinel-3 based inland water quality products.

REFERENCES

Sterckx S. & Knaeps E. & Kratzer S. & Ruddick K. (2015). Remote Sensing of Environment, 157, 96–110.

Villa, P., Mousivand, A., & Bresciani, M. (2014). Journal of Applied Earth Observation and Geoinformation, 30, 113-127.

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