SIMILE, A GEOSPATIAL ENABLER OF THE MONITORING OF SUSTAINABLE DEVELOPMENT GOAL 6 (ENSURE AVAILABILITY AND SUSTAINABILITY OF WATER FOR ALL)

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ABSTRACT:

The paper presents SIMILE (Italian acronym for "Integrated monitoring system for knowledge, protection and valorization of the subalpine lakes and their ecosystems), a cross-border Italian-Swiss project whose general objectives are the strengthening of the coordinated management of the water of the great subalpine lakes in the so-called Insubric region and the intensification of stakeholder participation in the processes of knowledge and monitoring of the water resource. The project fits the purpose of SDG 6 and involves administrations, monitoring agencies, universities and research centers, and citizens.

SIMILE is a system where geospatial data, information, and techniques play a pivotal role. The system strongly benefits the information derived from the analysis of Sentinel 1 and Sentinel 3 imagery, in situ authoritative data, and user-contributed georeferenced data. A Business Intelligence (BI) platform, i.e. a web data-driven decision support system, will allow the integration, analysis, and synthesis of the information derived from the different types of data, heterogeneous in format, coordinate system, information content, and access method. The technologies that will be used are based on open software so as to guarantee the replicability and sustainability of the system.

1. INTRODUCTION

Water resources are central to GOAL 6 of the Sustainable Development goals of the United Nations. Target 6.3 in particular focuses on water quality improvement by reducing pollution and 6.5 strengthens the importance of integrated water resources management, including transboundary cooperation. Moreover, an ecosystem perspective is encouraged: all water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes should be protected and restored. Finally, the participation of local communities in improving water quality is strongly advisable.

Lakes are a fundamental part of the landscape and provide a number of ecosystem services, influencing quality of life quality and contributing to local and regional economy. Lakes represent an invaluable source of freshwater for several uses, including industry, agriculture, energy production and potabilization. Further, they provide prime opportunities for fishing, recreation and tourism.

The lake district south of the Alps is characterized by the presence of a few among the most representative large and deep lakes in Europe (lakes Garda, Maggiore, Como, Iseo and Lugano), representing altogether almost 80% of the total freshwater volume in Italy (Rogora et al., 2018). The long-term data available for these lakes since the 1980s have justified the inclusion of the largest water bodies in the Italian and European Long Term Ecological Research network (LTER).

The Insubric lakes Lugano, Maggiore and Como (Fig. 1) have their catchments shared between Italy and Switzerland, so that management policies should necessarily take into account the transboundary character of water issues. These lakes are the objective of SIMILE, a cross-border Italian-Swiss project aiming at improving the coordinated management of these lakes and strengthening stakeholder participation in the processes of knowledge and monitoring of the water resources.

Figure 1. The Insubric lakes Lugano, Maggiore and Como (North-Western Italy/Southern Switzerland).

The Insubric lakes considered in SIMILE have water surfaces, volumes, and maximum depths ranging between 48.7 and 212.5 km^2, 6.5 and 37.5 km^3, and 288 and 410 m, respectively (Rogora et al., 2018). The great amount of data collected until now on these lakes contributed to monitor their water quality and ecological status and to direct their management, recovery and protection. (Salmaso and Mosello, 2010). Monitoring of these lakes is performed in Italy under the provision of the WFD (Water Framework Directive), Directive 2000/60/EC, and its implementing decrees; lakes are monitored with a varying frequency according to their present condition and collected data define the lake chemical and ecological status. These data are complemented by those collected within research programs, such as the limnological campaigns funded by the International Commission for the Protection of Waters between Italy and Switzerland (CIPAIS) in the case of lakes Maggiore and Lugano (www.cipais.org).

Despite the great amount of physical, chemical and biological data collected over time on the Insubric lakes, these information altogether are still not enough to investigate in detail some important limnological processes which occur over a short time scale. Furthermore, present monitoring is limited in space because just one or a few sampling stations are considered for each lake, normally at the deepest point. SIMILE aims to extend both the spatial and temporal scale of investigations, through an innovative approach integrating satellite data, in situ sensor data, and user-contributed georeferenced data. These different types of data will be integrated and analysed through a Business Intelligence platform, i.e. a web data-driven decision support system (Fig. 2), with these final goals: (1) to improve the evaluation of the status of lake water resource; (2) to strengthen the management capacity of lake water resource by public bodies and administration.

The SIMILE project will strongly benefit from the cooperation between scientific partners (universities, research institutes), monitoring agencies and administrations. A relevant component of public engagement is also foreseen, by involving schools, associations and the general public.

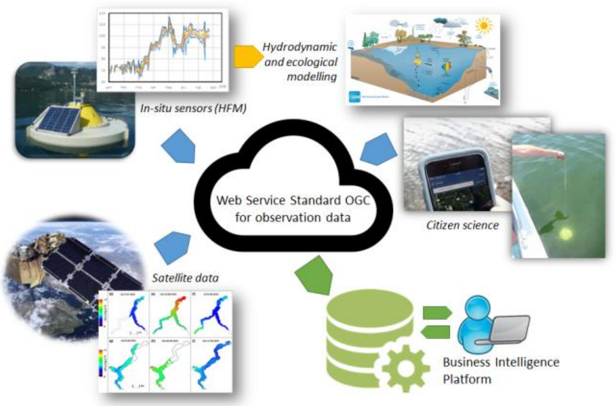

Figure 2. Scheme of the SIMILE project.

2. SENSORS AND SENSOR SERVICES

Since the late 19th century the most developed economies invested in setting-up monitoring systems and incorporating them into governmental policies and actions. While several technologies has been used to measure different variables of the water resource (Zhang, 2016; Toté et al., 2015), the characteristics of in-situ sensors to provides high accuracy, high temporal resolution and consistency in time, make them still today the preferred data source for infrastructure design, policy making and water resources control (Montanari et al., 2013). As a result, in-situ water monitoring is an essential public service that allows allocating and protecting resources, while safeguarding, restoring, and enhancing the natural environments and the society. Today automatic and real time systems are becoming the standard, in fact having the right information at the right time is critical for promptly react, plan and protect. Climate observations are used daily to exploit several tasks, including: effectively guarantee drinking water accessibility, properly support food and economic sectors, protect from flood and drought hazard, administer water permits, comply with laws, set and enforce state regulations, defend the rights to interstate waters, plan for climate-change adaptation measures, and protect endangered species. In the context of water quality monitoring several applications of wireless sensor networks (WSN) have been implemented and presented in literature (Alippi *et al.*, 2011; Kumar *et al.*, 2014; Faustine *et al.*, 2014; Hayes, *et al.*, 2008). Specifically, for lakes water quality, an international community named Global Lake Ecological Observatory Network (GLEON) (Hamilton et al., 2015) is active in the field of high-frequency monitoring. It aims at connecting students, researchers, educators and people in general interested in producing and utilizing observations made on and in lakes and reservoirs all over the world. A recent project from Swiss universities and research centers (https://wp.unil.ch/lexplore) installed a cutting edge monitoring platform in the Lake of Geneva with instrumentation to investigate lake processes as well as interactions between water and atmosphere: this may be taken as a reference for state of the art in lake monitoring.

In the field of data management and distribution, different approaches have been used but the most diffuse practice consists in delegating this task to sensor vendors' solutions, which together with equipment generally provides automatic data collection and access system. As a result, often data are available in a plethora of different formats and accessible with different methods. To increase sensor observation interoperability, the Open Geospatial Consortium (OGC) created the Sensor Web Enablement (Botts *et al.*, 2006) Working Group whose aim is to define standards to communicate information, about sensors (including location) and the observed phenomena. The Sensor Observation Service (SOS) (Bröring *et al.*, 2012) is a SWE standard that defines how to collect and share observations from sensors. As most of the OGC standards it is based on the XML format and HTTP requests. The SOS basically can be described individuating two different types of users: data-consumer and data-producer.

Data-producers are identified as *procedures* and generally consist of a sensor of a WSN that registers to the SOS service and provide data in real-time. The registration is standardized defining the *SensorML* standard format (Robin and Botts, 2014) used to describe the sensor's characteristics and metadata (using the SensorML standard) and the HTTP request in terms of submitted parameters and responses. Once a sensor is registered in a specific SOS service, it will be enabled to continuously send monitored data using the *Observations and Measurements* standard format (Cox, 2006) to represent the data and related metadata (for example the observed temperature, the location and time it was observed and it's quality).

Data-consumers are identified as persons, machines or processes that requires access to the produced information. To permit a complete understanding and self-explanatory access, the consumer, similarly to most of the OGC standards, has the ability to request an overview of the SOS service capabilities and get informed on offered sensors, observed properties, monitored area, service provider, and more. Once informed on the overall network picture, the consumer can request information on specific sensors, so that he can get insight of the sensor specifications, responsible party, data types, observed phenomena and period. Responses are provided with the SensorML format. The consumer, identified the sensors of his interest, has all the information to request the data he's interested in by applying filters on time period, spatial relations, observed properties. Returned observations are provided in Observations and Measurements format. All the previously defined processes occurs according to well defined and standardized requests, formats and methods.

In SIMILE, in order to achieve interoperability, the envisioned approach consists in using the istSOS software (Cannata *et al.*, 2015) (www.istsos.org) which is a Free and Open Source Software for Geospatial (FOSS4G) compliant with the SOS standard (Fig. 3). This will permit to easily access and integrate or compare data collected by the different monitoring systems that are going to be deployed on the subalpine lakes Lugano, Maggiore and Como. With respect to the sensors types, SIMILE will not pose any constraint so that each lake will select the most useful parameters to be monitored and appropriate sensors to comply with available budget and specific challenges. Nevertheless a common platform for discussion of experiences and sharing of insights will be activated.

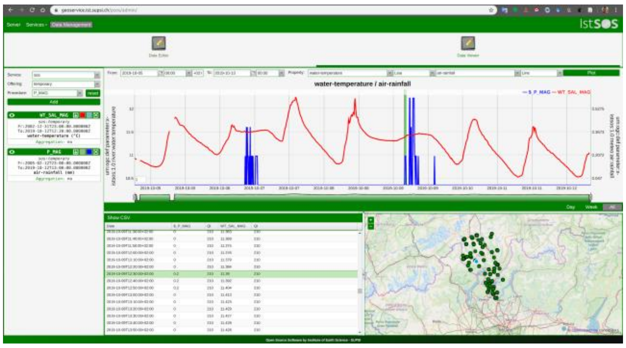

Figure 3. istSOS administration Web interface adopted to enable sensor data interoperability in the SIMILE Project.

3. LAKE MODELLING

Models of wide range of complexity have been commonly applied to water bodies with the aim of a better comprehension of physical, chemical and biological processes but also for management purposes. In the case of lakes, models have been extensively used since the 1970s in the field of eutrophication (Vinçon-Leite and Casenave, 2019). More recently, lake models have tried to merge different domains, for instance coupling hydrodynamic, chemical and ecological processes (Jorgensen, 2010). Model complexity and the number of details and processes incorporated have increased in time, allowing a better representation and understanding of ecological processes and an improved evaluation of how water quality and quantity could be affected by external forcing e.g. nutrients, pollutants. In particular, in recent years there has been an increasing concern for modelling the impact of climate changes on lakes and water resources in general (MacKay et al., 2009). Climate change has indeed proved to be one of the main drivers affecting water quality and ecosystem services provided by water bodies (Adrian et al. 2009). In this context, model outputs combining climate change effects with other important stressors such as nutrient loads are highly advisable, especially in environmental management.

The deep lakes South of the Alps considered in the SIMILE project have been subject of modelling studies, mainly aimed to assess nutrient load reduction needed to achieve specific target in terms of trophic status (e.g. Bryhn and Håkanson, 2007). More recently, hydrodynamic models have been applied to these lakes, to better investigate the role of physical processes (e.g. inflow relevance), with potential applications for management purposes (Laborde et al., 2010; Fenocchi et al., 2017). In deep lakes, indeed, stratification and circulation patterns are extremely important in shaping water chemistry, mainly oxygen and nutrient distribution, and biological communities. In particular, the occurrence of complete or deep circulation at the end of the winter season is a fundamental process (Ambrosetti & Barbanti, 1999).

Climate change has proved to strongly impact on lake hydrodynamics, increasing water column stability and decreasing the occurrence and extent of circulation episodes, with overall effects on water chemistry, especially of bottom layers (Rogora et al., 2018). To assess the effects of these processes in the long-term, the open-source numerical model GLM (General Lake Model: Hipsey et al., 2013; 2014) has been applied to Lake Maggiore (Fenocchi et al., 2018; 2019), to predict the future evolution of the lake under different climate change scenarios. GLM was specifically designed to simulate the hydrodynamics of lakes, reservoirs, and wetlands in support of the scientific and management questions relevant the Global Lake Ecological Observatory Network (GLEON) (Hanson et al., 2016).

This modelling approach will be adopted in SIMILE and applied to the Insubric lakes (Fig. 4), possibly coupling climate change scenarios with scenarios of change in nutrient loads. These forecasts will serve as a basis for decision making: management of water bodies to preserve their quality in the near future will be necessarily based on a reliable assessment of climate change effects and their interaction with other stressors such as catchment loads. The modelling activities will aim to provide an improved scientific basis for sustainable freshwater resource management.

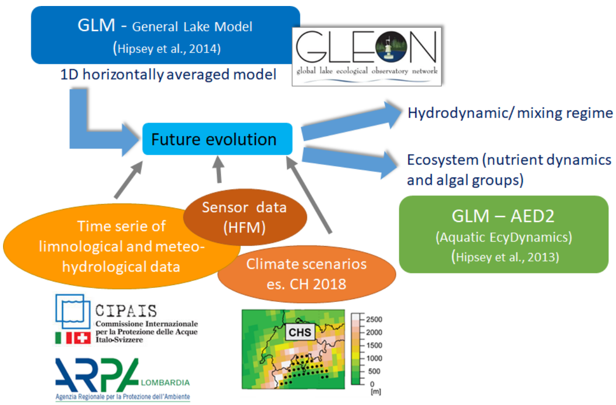

Figure 4. Modelling approach adopted in the SIMILE Project.

A fundamental input for the Insubric lake modelling will be provided by the long-term series of limnological data, which have been made available by the research campaigns funded by the CIPAIS and, more recently, by the institutional monitoring of lakes according to the EU WFD. These input data will be complemented by those deriving from in-situ high frequency monitoring, allowing a more affordable modelization of in-lake processes (Fig. 3). Modelling forecasts will be made available to decision makers through the Business Intelligence platform developed in the project.

4. SATELLITE MONITORING

In situ sensors provide series of data, continuous in time but spread (and with small density) in space. Satellite imagery can be used for complementing this information, as these data have different characteristics from the in situ ones.

The last few years have seen an impressive evolution in the field of Earth Observation, with important initiatives carried out by Space Agencies. One of the most relevant is that included in the Copernicus Programme, which is a programme jointly coordinated and managed by the European Commission, the European Space Agency (ESA), the EU Member States and the EU Agencies.
Copernicus consists in three components:

- the space component
- in-situ measurements
- services offered to Copernicus users and public in general.

The space component is composed by ESA's families of satellites, called the Sentinels, and missions from other space agencies, called Contributing Missions.
The ESA constellation currently active are:

- Sentinel 1 (1A, launched in April 2014 and 1B, launched in April 2016) providing radar imaging;
- Sentinel 2 (2A and 2B, launched respectively in June 2015 and March 2017), providing multispectral images;
- Sentinel 3 (3A and 3B, launched February 2016 and April 2018), Temperature Radiometer medium-resolution imaging spectrometer.

The parameters that the SIMILE project is monitoring thanks to satellite observations are:

- the superficial concentration of Chlorophyll-a (Chl-a);
- the surface concentration of Total Suspended Solids (TSM);
- the presence of cyanobacteria on the surface;
- the surface water temperature.

The data considered for the analysis of the water quality are those of the Sentinel 2 and Sentinel 3 satellites.
The MSI (MultiSpectral Instrument) sensor of Sentinel 2A and 2B has not been specifically configured for aquatic environments, but recent studies (Bresciani et al., 2018) have shown that it can also be used in such an environment if properly corrected. The advantage is that MSI spatial resolution is very high, varying between 10 and 60 meters. The MSI measures the Earth's reflected radiance in 13 spectral bands from VNIR (Very Near InfraRed) to SWIR (Short-Wave InfraRed). The two satellites guarantee a revisiting time of five days under the same viewing conditions. Moreover, the overlap between swaths from adjacent orbits increases the revisit frequency even if with different viewing conditions.
On the opposite, the images of the OLCI sensor (Ocean and Land Color Instrument) were selected, on board the ESA Sentinel-3A and Sentinel-3B satellites, as suitable for the evaluation of the optically active parameters of the waters. This sensor acquires in 21 spectral bands in the VIS-NIR (Visible- Near InfraRed) range, with a signal-to-noise ratio suitable for the study of aquatic environments. It acquires daily with a spatial resolution of 300 meters. All images acquired on the study area will be downloaded and processed by radiometric, atmospheric correction and application of specific algorithms for subalpine aquatic environments within the free software SNAP (Zuhlke et al., 2015) with C2RCC (Case-2 Regional CoastColour) neural network (Brockmann et al., 2016) parameterized for the optical properties of subalpine lakes.
When, from the daily analysis of the OLCI images, superficial phytoplankton flowering phenomena and / or river plumes are identified, in order to increase the spatial resolution of the information, the MSI images will be used. Also these images have to be processed to correct atmospheric disturbances and the presence of glints. The codes present in SNAP and the 6Sv codes will be used (Vermote et al., 2006).
The applied algorithms will be different depending on the parameter to be monitored: ACOLITE (Vanhellemont, Ruddick, 2016) will be used for the mapping of water turbidity; the bio-optical model BOMBER of the CNR-IREA - Italy (Giardino et al., 2012) will be used for phytoplankton chlorophyll-a. In addition, in order to have products related to the surface water temperature (LSWT), the LANDSAT-8 images will be downloaded and processed and the TIRS sensor (Thermal Infrared Sensor) with a spatial resolution of 100 meters, acquisition interval of 16 days will be employed. Finally, the EUMETSAT products of the SLSTR sensor (Sea and Land Surface Temperature Radiometer) will be downloaded on board the Sentinel-3A and Sentinel-3B satellites (daily acquisition, spatial resolution of 500 meters).
The processing and analysis of satellite data will allow a synoptic view of the quality status of the surface water in the Insubric lakes. The maps generated during the project will allow the evaluation of the temporal and spatial variability of the surface water quality status. The results produced will be important inputs for ecological models and will allow us to identify the presence of any anomalies due to algal blooms and / or river plumes.
The output of the project will be a WMS (Web Map Service) serving maps of the water quality of the lakes Como, Maggiore and Lugano for the monitored parameters.
In addition to the individual maps, the results obtained from satellite image processing during the project will be extracted to obtain spatially distributed time series. Furthermore, the maps of the single parameters will be aggregated at a temporal level to create synthetic maps of the average seasonal / annual concentrations, which will be based on the WFD.
In Figure 5, as an example, the maps of 2 June 2019 of the concentration of Chlorophyll-a obtained with Sentinel-3B imagery for the three lakes are shown.

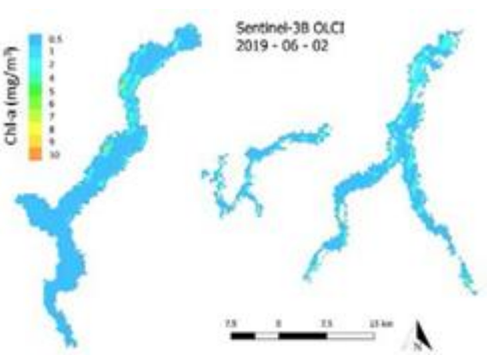

Figure 5. Maps of concentration of Chlorophyll-a obtained with Sentinel-3B imagery (2 June 2019).

5. CITIZEN SCIENCE

Citizen science concerns the involvement of citizens during different phases of a scientific project (for example for the collection of field data, the evaluation of previously collected data, etc.) and has proved to be an efficient tool over the last few years (Garbarino & Mason, 2016).
Different classifications of citizen science projects exist based on the degrees of influence and contributions of citizens. Haklay, Mazumdar, and Wardlaw (2018) distinguish the citizen science projects in three different classes:

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1. Long-running citizen science, which are the traditional ones, the projects similar to those run in the past (Kobori et al., 2016; Bonney et al., 2009)
2. Citizen cyberscience, strictly connected with the use of technologies (Grey, 2009) and which can be subclassified in:
   a. volunteer computing, where citizens offer the unused computing resources of their computers;
   b. volunteer thinking, where citizens offer their cognitive abilities for performing tasks difficult for machines;
   c. passive sensing, where citizens use the sensors integrated into mobile computing devices to carry out automatic sensing tasks.
3. Community science, involving a more significant commitment of citizens also in designing and planning the project activities in a more egalitarian (if not bottom-up) approach between scientists and citizen scientists (Jepson & Ladle, 2015; Nascimento, Guimarães Pereira, & Ghezzi, 2014; Breen, Dosemagen, Warren, & Lippincott, 2015), which can be divided into:
   a. participatory sensing, where citizens use the sensors integrated into mobile computing devices to carry out sensing tasks;
   b. Do It Yourself (DIY) science, which implies participants create their scientific tools and methodology to carry out their research;
   c. civic science, "which is explicitly linked to community goals and questions the state of things" (Haklay et al., 2018).

For the purposes of the SIMILE project, which falls within the Community science projects, citizens will collect data and provide reports on the quality of the water in the lakes under study, focusing in particular on transparency and water temperature and on the presence of physical pollutants and algal blooms. The collection will be carried out using smartphone technology (Lane et al., 2010; Brovelli et al. 2016) and, where possible, with the help of additional devices such as Secchi disks and thermometers. The data will be viewable by the public through the same data collection app and will eventually be downloadable from the project website.
Before starting the design of the new mobile application for monitoring the water quality, the already developed applications at international level were tested and analyzed. It was possible to identify several projects aimed at water monitoring using smartphone applications (Leeuw T. & Boss E., 2018; Seafarers et al., 2017).
Some of these applications are free, but none of them is open source. The solution that will be implemented for the SIMILE project will try to take into account the strengths of the applications examined, focusing in particular on the simplicity of use. Moreover we intend to use free and open source software to guarantee sharing and interoperability of the products developed within the project.
Many parties interested in the lake water quality will be involved in the SIMILE project. In particular, associations and organizations in the area of interest which have been contacted as potential stakeholders are: fishermen's associations, rowing teams, swimming and diving clubs, shipping companies, local civil protection groups, local and regional authorities, schools and universities.
Effective involvement of the citizens is essential for the success of Citizen Science activities and this has to be done identifying appropriate strategies to raise awareness and motivate the potential users. By using the application, citizens will have the opportunity to contribute according to their abilities and means. For this reason, the application will be divided into four types of activities, which can also correspond to different levels of complexity. The citizens scientists can choose whether to carry out one or more activities in relation to their availability and their skills. The first activity concerns the collection of photos related to water quality, for instance the presence of algal blooms. The second activity concerns the collection of some textual information, useful for describing the detected situation. The third and fourth type of activity concern the measurement of water transparency using the Secchi disk and the measurement of water temperature with the aid of a thermometer.
The application will be developed using free and open source technologies. The system will consist of the smartphone application (client side) that will be used to collect and display data and a Web platform for viewing and downloading data. The Web platform will be accessible from the official website of the project. The access will be open, possibly after registration, to all citizens and not only to those who will contribute to data collection. The collection of any personal data will comply with the provisions of the General Data Protection Regulation (GDPR).
The objectives of the citizens involvement in the SIMILE project are different (Fritz et a., 2017). Citizens will allow researchers and technicians dealing with the quality of the water of the lakes to have an additional source of information, compared to other technologies explored by SIMILE. The data acquired in real time by the citizens will help in gathering information, which, integrated and appropriately compared with the data coming from the sensors positioned on the buoys and from satellite images, will help to calibrate the models and make the right decisions regarding the water management of the three lakes.
Furthermore, the citizens themselves can benefit from the data collected, since they will be freely accessible on the project's Web platform. In this way, everyone can be informed about the state of the water quality of the Insubric lakes under study.
The output of the SIMILE Citizen Science activities will first of all be the application for mobile devices and the corresponding Web platform for data collection and visualization.
The application will be available for everyone as an open source one. Everyone will be able to use it as it is or change it following her/his requirements. The data collection will be individual and autonomous or may be organized in measurement campaigns, coordinated by the project proponents. These measurement campaigns will be combined with moments of information and training and these events will also be important to increase scientific literacy and education of the citizens scientists.

6. THE SIMILE BUSINESS INTELLIGENCE PLATFORM

Water resource managers should be able to access accurate and up-to-date data for effectively conduct the activities and plan the intervention following an adaptive approach, guided by the real situation and detected risks. Unfortunately, the required information is very often collected with different methodologies, is represented with highly heterogeneous data formats and is often stored and disseminated on a myriad of dissimilar applications and solutions which often are available on the desktop application only. These dishomogeneity complicates, and often prevents, the correct and optimal use of scientific data in decision-making processes. SIMILE plans to overcome this issue by integrating all the data described in the previous sections (sensors, models, citizen science and satellite) in a single platform, which provides decision makers (administrators or stakeholders) with timely accessible, updated and targeted information.

To this scope the project will set up a *Business Intelligence* (BI) platform which is defined as "a data-driven decision support system that combines data gathering, data storage, and knowledge management with analysis to provide input to the decision process" (Negash and Gray, 2008; Chen et al., 2012). Private sector like hospitals, banks or manufacturing companies have long used BI tools that include analysis, reporting, evaluation and data extraction functionality as a means to improve the understanding of the situations in progress thanks to the processing of different forms and sources of data. Differently, in the environmental sphere decision support systems are often limited to GIS systems and applications that spatially combine different layers of information. Although GISs have the ability to spatially represent phenomena, they usually have no advanced features to perform evaluations of environmental data for trends detection, scenarios identification and phenomena understanding by means of graphics, tables and indicators.

As represented in figure 6, the approach of SIMILE consists in implementing a number of Open Geospatial Consortium (OGC) services (i.e.: SOS, WMS, WCS, etc.) that offer standard access to data. Thanks to the interoperability of the implemented services it will be possible to implement extensible functionalities for data Extraction, Transformation, and Load (ETL). These functionalities has the scope of: select and extract from the source systems only the portion of data that are relevant; cleanse and transform the selected data applying appropriate pre-processing and elaborations; and finally load the transformed data in a specific data warehouse designed to be agile and efficient. A Web API will be implemented to support Online Analytical Processing (OLAP) and Web user interface generation. Authentication and authorisation system will be adopted to secure data and protect information by limiting access to functionalities. The BI Web interface should be designed to be user-type centric, meaning that depending on the role of the user the visual aspect and the information content should change to fit, quickly and effectively, its specific needs. Intense interaction with the different types of envisioned users is therefore a key factor, in fact, the design process requires active inputs from various stakeholders including developers, analysts, testers, managers.

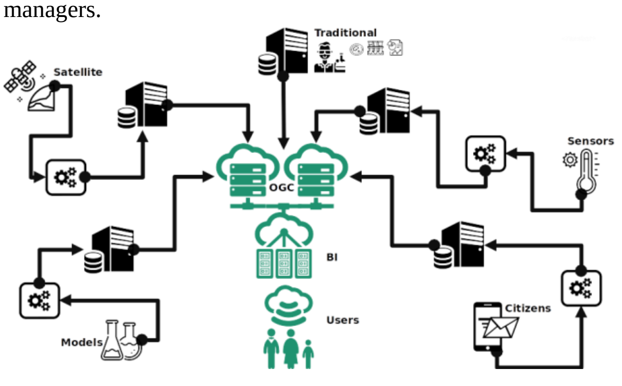

Figure 6. General architecture of the Business Intelligence platform envisioned in the SIMILE Project.

7. CONCLUSION

Insubric lakes represent a cross-border resource and the quality of their waters and their ecosystems is a key element in terms of recreational/touristic use and, meanwhile, for energy production, agricultural and domestic use. Water consumption has being increased over the years and, in general, the use of high quality water is subject to strong pressure. To this, we must add the possible negative effects related to climate change.

The SIMILE project was born as a cross-border Italy-Switzerland proposal, with a strong connotation of synergy between technical/scientific and institutional/management actors in the two states involved.

The project aims at implementing the integration of data from in situ sensors, open and free satellite data and data provided by citizens. A decision support system will allow the knowledge of the state of the resource also to the decision-making component in a simple way (through the consultation of an intelligent geoportal). In all these components, geomatics and earth observation expertise play a crucial role. Experimentation will lead to guidelines and best practices that can be the basis for defining a shared cross-border approach to the management of lake water resource. These guidelines will be available also for other regions of the world as basis for the implementation of the indicators of SDG 6. Finally, the involvement of citizens in monitoring will have a value not only of education but also of shared approaching the problems of the resource management faced by the institutional component.

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