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Assessing heat fluxes and water quality trends in subalpine lakes from EO

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Lakes play a fundamental role in providing ecosystem services such as water supplying, hydrological regulation, climate change mitigation, touristic recreation (Schallenberg et al., 2013). Preserving and improving of quality of lakes waters, which is a function of either both natural and human influences, is therefore an important action to be considered.
Remote Sensing techniques are spreading as useful instrument for lakes, by integrating classical in situ limnological measurements to frequent and synoptic monitoring capabilities. Within this study, Earth Observation data are exploited for understanding the temporal changes of water quality parameters over a decade, as well as for measuring the surface energy fluxes in recent years in deep clear lakes in the European subalpine ecoregion. According to Pareth et al. (2016), subalpine lakes are showing a clear response to climate change with an increase of 0.017 °C /year of lake surface temperature, whilst the human activities contribute to produce a large impact (agriculture, recreation, industry, fishing and drinking) on these lakes.
The investigation is focused on Lake Iseo, which has shown a significant deterioration of water quality conditions since the seventies, and on Lake Garda, the largest Italian lake where EO data have been widely used for many purposes and applications (Giardino et al., 2014).
Available ENVISAT-MERIS (2002-2012) and Landsat-8-OLI (2013-on going) imagery has been exploited to produce chlorophyll-a (chl-a) concentration maps, while Landsat-8-TIRS imagery has been used for estimating lake surface temperatures. MERIS images were processed through a neural network (namely the C2R processor, Doerffer et al., 2007), to correct the atmospheric effects and to retrieve water constituents concentration in optically complex deep waters. With regard to L8's images, some atmospheric correctors (e.g. ACOLITE and 6SV) were tested and validated to indentify, for each of the two lakes, the more accurate ones. The atmospherically corrected L8 data were then processed through a site-specific parameterised bio-optical model for water constituents' concentration retrieval.
The EO products thus obtained were then analysed as follows. 1) Statistical analyses of water reflectance, a new Essential Climate Variables within the ESA CCI+ initiative, and chl-a concentration, a proxy of trophic status, were performed. Both water reflectance and chl-a concentration were obtained from the MERIS 10-years time series and were analyzed to identify spatial patterns, temporal trends and the onset of phytoplankton growth. 2) Combination of field shortwave and longwave radiation data with the one estimated from L8 OLI and TIRS atmospherically corrected imagery, was exploited to assess the heat fluxes and evaporation rates. In both cases, the analysis was

supported by field data to highlight the accuracy of measurements obtained from EO technology.
A comparative analysis among the lakes is finally presented. In addition, future work aimed at extending the MERIS time series to the new Sentinel-3-OLCI time series (2016-on going) is discussed, in expectation that EO technology will augment information for lake management and geosciences (lake’s ecology and climate, in particular).