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The essential climate variables for lakes: exploring satellite products from global to local scale

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Lakes are integrators of environmental and climatic changes occurring within their contributing basins. Understanding the complex behavior of lakes in a changing environment is essential to effective water resource management and mitigation of climate change effects. The ESA CCI Lakes is a multi-disciplinary project (https://climate.esa.int/en/projects/lakes) combining expertise to exploit data to create the largest and longest possible consistent, global record of five lake climate variables: lake water level, extent, temperature, surface-leaving reflectance, and ice cover. The phase 1 version of the database covers 250 globally distributed lakes with temporal coverage, depending on parameter, ranging from 1992 up to 2019. The dataset is planned to expand to 2000 lakes in the second phase. The distribution of the dataset will be introduced over space and time. The potential of the dataset and in particular of data records on chlorophyll-a concentrations, is explored for Lake Trasimeno, a shallow eutrophic lake of central Italy which is a specific case study of the lakes CCI project included in the Long-Term Ecosystem Research (LTER) network. In situ measurements from LTER were used to evaluate satellite products as well as to complete the CCI data record. Meteo-climatic data were extracted to analyze the interrelationships between the trend in water parameters and climate factors. An in situ WISPstation sensor was also used to provide high frequency (every 15 minutes) information on chlorophyll-a and phycocyanin concentration for last two years.

We used Artificial Intelligence (AI) and Non-Parametric Multiplicative Regression (NPMR) techniques to analyze the data. Chlorophyll-a in Lake Trasimeno was dominated by a summer bloom consistently initiating in July and typically peaking in early September and was largely predicted by the time variable - accounting for 87% of feature importance. The North Atlantic Oscillation (NAO) was the next most important variable (4% feature importance) corroborated by NPMR and shown to be largely important during early to mid-September when a positive NAO, associated with high pressure and warm sunny weather, led to an increase in chlorophyll-a concentrations. Regional climatic indices as well as the more obvious nutrient drivers of algal blooms should therefore be considered in lake management. Comparing the high frequency WISPstation data (2018-2020) with the CCI dataset allows for detailed cross validation. Interestingly some of the rapid fluctuations visible from the satellite record that may have been interpreted as

noise are supported by the in situ data. In addition, utilizing the phycocyanin results from the WISPstation showed, in near real time, how cyanophytes played a key role in the sudden increases and declines in chlorophyll-a in mid to late summer. Coupling climatic indices, nutrient concentrations and near real time phycocyanin concentrations could be indispensable to the management of blooms in high value recreational lakes such as Trasimeno.