Abstract for poster presentation to EUMETSAT 2018 (Topic: Monitoring climate and the oceans)

Integrated lake ice monitoring in Swiss lakes

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Various lake observables are related to climate and climate change and provide a good opportunity for long-term monitoring, among them the duration and extent of lake ice, as part of the Essential Climate Variable (ECV) "lakes". This is recognized in the Status of the Global Observing System for Climate (task T10). Lake ice observations in Switzerland are not systematic and come from different, uncoordinated and not secured sources. Thus, MeteoSwiss (GCOS Switzerland) initiated in 2016 a two-year project for an integrated monitoring of lake ice, using various data and processing methods. The project aims at detecting the extent and duration of lake ice (including the so-called ice on/off dates) and developing models for freezing based on meteorological data and lake characteristics, with focus on the integration of various input data and monitoring methods. This last point characterizes the main novelty of the approach.

The input data include: Terra MODIS and Suomi-NPP VIIRS satellite images, publicly available WEBCAMs (for validation but also observation of small lakes hardly visible in the satellite images) and in-situ T and pressure measurements. Though not part of the project, we will also present some results from drones (to show their possible potential and for validation). For validation, we also use Landsat and Sentinel-2 data and media reports. In some cases (MODIS), the lower-resolution satellite channels were super-resolved to the highest spatial resolution ones. The data processed include the full winter 2016/2017 and other selected periods. The target lakes have variable area (1-11 km^2), altitude (medium to high) and surrounding topography (flat/hilly to mountainous) and freeze often, covering thus difficult to medium difficulty cases, regarding area, altitude and topography. The lake outlines are digitized from OpenStreetMap, generalised and projected onto the images to guide the search and estimation of lake ice, while their projection is corrected for absolute geolocation errors found by matching outlines of well-distributed large lakes to the images. Only cloud-free pixels lying totally within each lake are processed. Cloud masks are used as provided for MODIS and VIIRS (using a conservative approach; better classify a pixel as cloud than not) but were checked, showing sometimes errors (especially cloud pixels marked as cloud-free are critical), which cause classification errors between frozen (ice/snow) and water pixels, as clouds often spectrally overlap with snow/ice. Regarding the methods, we use: a) a classification method using xgboost and Support Vector Machines for MODIS and VIIRS, b) reflectances and thermal infrared-derived Lake Surface Water Temperature (from a single channel Physical Mono Window approach developed in the framework of the EUMETSAT's Satellite Application Facility on Climate Monitoring (CM SAF)) for VIIRS, c) a Convolutional Neural Network for WEBCAMs, and d) models for temporal evolution of T and forcing of internal waves mainly due to wind for in-situ measurements.

Here, we present the project aims, the processing methods and the results/validation for each method. A very important issue and focus of the paper is the comparison and integration of these methods, based on detailed predefined criteria, leading to a recommendation for an optimal lake ice monitoring. The project end approximately coincides with EUMETSAT 2018, so we will be able to present the final project results.

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