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Mapping Mean Lake Surface from satellite altimetry and GPS kinematic surveys

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Lake water height is a key variable in water cycle and climate change studies, which is achievable using satellite altimetry constellation. A method based on data processing of altimetry from several satellites has been developed to interpolate mean lake surface (MLS) over a set of 22 big lakes distributed on the Earth. It has been applied on nadir radar altimeters in Low Resolution Mode (LRM: Jason-3, Saral/AltiKa, CryoSat-2) in Synthetic Aperture Radar (SAR) mode (Sentinel-3A), and in SAR interferometric (SARin) mode (CryoSat-2), and on laser altimetry (ICESat). Validation of the method has been performed using a set of kinematic GPS height profiles from 18 field campaigns over the lake Issykkul, by comparison of altimetry's height at crossover points for the other lakes and using the laser altimetry on ICESat-2 mission. The precision reached ranges from 3 to 7 cm RMS (Root Mean Square) depending on the lakes. Currently, lake water level inferred from satellite altimetry is provided with respect to an ellipsoid. Ellipsoidal heights are converted into orthométric heights using geoid models interpolated along the satellite tracks. These global geoid models were inferred from geodetic satellite missions coupled with absolute and regional anomaly gravity data sets spread over the Earth. However, the spatial resolution of the current geoid models does not allow capturing short wavelength undulations that may reach decimeters in mountaineering regions or for rift lakes (Baikal, Issykkul, Malawi, Tanganika). We interpolate in this work the geoid height anomalies with three recent geoid models, the EGM2008, XGM2016 and EIGEN-6C4d, and compare them with the Mean Surface of 22 lakes calculated using satellite altimetry. Assuming that MLS mimics the local undulations of the geoid, our study shows that over a large set of lakes (in East Africa, Andean mountain and Central Asia), short wavelength undulations of the geoid in poorly sampled areas can be derived using satellite altimetry. The models used in this study present very similar geographical patterns when compared to MLS. The precision of the models largely depends on the location of the lakes and is about 18 cm, in average over the Earth. MLS can serve as a validation dataset for any future geoid model. It will also be useful for validation of the future mission SWOT (Surface Water and Ocean Topography) which will measure and map water heights over the lakes with a high horizontal resolution of 250 by 250

meters.