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Inter-sensor comparison of lake surface temperatures derived from MODIS, AVHRR and AATSR thermal bands

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Surface temperature of land and water bodies is an ecologically important parameter and can be measured using remote sensing using data acquired in the thermal infrared region. The most commonly used method for deriving water temperature (for both inland and ocean water bodies) is the split window technique. It considers the spectral bands at 10.2 – 11.5 µm (tb1) and 11.5 – 12.5 µm (tb2). The increasing number of sensors which provide these spectral bands at moderate spatial resolution (~1km) at a temporal coverage of 1-3 days globally, attracts many researchers to rely on these data sets in alternative to often scarce field data. The open data policy adopted by different space agencies helped to maximize the usage of remotely sensing data in climate and ecological research. In this study, we compare the usability and sensitivity of three most commonly used sensors – MODIS, AVHRR and AATSR on-board polar orbiting instruments in deriving Lake Surface Water Temperature (LSWT) of big sub-Alpine lakes of Northern Italy. The processing of the thermal bands (tb1 and tb2) differs across these three sensors due to different carrier instruments, multiple level-1B data source formats adopted by the respective agencies, differences in radiometric calibration coefficients, errors originating from instrument decaying, accuracy in geolocation sampling, acquisition times and the various external factors like cloud coverage and the atmospheric profiles at the time of acquisition. This demands different sensor based approaches in processing these datasets. We developed sensor specific workflows using open source geo-spatial tools to read and calibrate level-1B data, apply geo-correction and used Planck's function to derive Brightness Temperature (BT) from the radiances. LSWT was then derived using the Lake/sensor specific coefficients provided by Hulley et.al (2011) using the split window

algorithm. For this study, we are using day images (11 a.m. – 14 p.m.) from these sensors for five overlapping years (2003 – 2008). Specifically, we used MODIS data on-board the Terra satellite and AATSR sensor on-board ENVISAT. For AVHRR, we used data from NOAA 16/18 instruments which have afternoon overpasses. We compared the derived LSWT from these sensors against the field data available for these lakes. We found that MODIS and AVHRR offer higher accuracy in derived lake temperature with observed RMSE between 1.0 to 1.5 K with less variability in case of zenith angles less than 45°. While AATSR derived temperatures are comparable, they show an average RMSE up to 2 K. The increased RMSE with AATSR may occur due to the slightly off acquisition time compared to that of respective field data. Another factors could be undetected sub-pixel size clouds and further outliers due to mixed pixels along shorelines. We continue to develop further techniques to successfully remove outliers from the satellite observations in order to reduce the RMSE to an acceptable range below 1 K. This study is significant in developing unified long term temporal datasets of LSWT by combining multiple sensor data, and analyzing long term trends in warming of sub-alpine lakes due to climate change.

Hulley, G. C., Hook, S. J., and Schneider, P.: Optimized split-window coefficients for deriving surface temperatures from in-land water bodies, Remote Sens. Environ., 115, 3758–3769, 2011