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Applying a water temperature model to a river and calibrating it with downscaled remote sensing data

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Temperature regulates many processes in rivers and lakes, and is essential for water quality modeling. However, river water temperature data are scarse. To overcome this, many models have been proposed to generate river water temperature data series using others data, mainly air temperature. Recently, Toffolon and Piccolroaz (2015) proposed air2stream, a simple, physically-based model to generate these series from air temperature and river discharge. It needs, however, to be calibrated and validated with in situ water temperature data. In cases where there is no data available to calibrate it, remote sensing can be used to estimate surface water temperatures, using data from the thermal infrared bands, and using algorithms to estimate land surface temperature. There is a trade-off between spatial and temporal resolutions in these estimatives: Landsat data has a spatial resolution of 30 m, but temporal resolution of 16 days, whereas MODIS has daily data with spatial resolution of 500 – 1000 m. Since the estimative is being made to river stretches, Landsat's spatial resolution is needed. To overcome this, there are techniques to downscaling MODIS data to Landsat spatial resolution, maintaining its temporal resolution. The objective of this work is to use Landsat data and MODIS data downscaled using the algorithm proposed by Zhu et al (2010), ESTARFM, to estimate river water temperature, to calibrate and validate Toffolon and Piccolroaz's (2015) model applied to river Cebollati, where it discharges in Lagoon Mirim, in Uruguay. We applied the model for 3 years, between 2001 and 2003, using Jiménez-Muñoz and Sobrino's (2003) single-channel model to estimate river temperature from the Landsat 7 data. We applied it to the river stretch between its last tributary and the point where it discharges in the lagoon. For the downscaling of MODIS data, we used its daily LST product from the MOD11A1, MOD09GA reflectance data and ESTARFM algorithm, basing it on Landsat's calculated LST. We then calculated the mean river temperature both for the Landsat and MODIS downscaled data, and along with river discharge estimated by MGB-IPH and air temperature from a nearby meteorological station, we applied the water temperature model for both cases. For the Landsat 7 approach, despite having only 24 water temperature data to calibrate it, the model output showed good relation with the observed data. For the 3 years, the calculated bias was 1.151 K, RMSE was 1.296 K, and the Nash-Sutcliffe efficiency coefficient was 0.900. Considering only the validation period, the calculated bias was 1.105 K, RMSE was 1.245 K, and the Nash-Sutcliffe efficiency coefficient was 0.912, although there were only 8 water temperature data to validate it. For the downscaled data approach, we expect a better association between the generated data and the model output. For future applications, we suggest applying this model to a river where there are in situ data to verify both approaches.