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Sharpening the retrieval of stream surface water temperature using Landsat data

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Temperature plays a key role in most physical and biochemical processes taking place in aquatic ecosystems. Thermal infrared (TIR) satellite data are routinely used to monitor surface temperature of oceans and large inland water bodies. However, their use in the observation of medium to small streams and lakes has traditionally been hampered by the course spatial resolution of the space borne thermal sensors. Even in streams wider than the TIR spatial resolution, data retrieved close to the banks is often inadequate for water surface retrieval due to the presence of emerging material or due to mixing with bank radiance.

With native thermal resolutions from 60 to 120 m, Landsat imagery is among the few satellite data sets adequate for temperature mapping of medium-size rivers (i.e. of width down to approximately 100 m). Nevertheless, the use of Landsat thermal data for stream temperature mapping is complicated by the downscaling of the TIR data native resolution for image product distribution. The downscaling is carried out by cubic convolution which causes the mixing of the water and land leaving radiance nearby the river banks. The degree of mixing depends on the geometry of the water boundaries and on the land to water radiance contrast.

Literature is unclear on the spatial extent of this effect. Some authors provide general recommendations such as avoiding the two to three pixels closest to the banks, which greatly limits the use of Landsat TIR data in river reaches approximately less than 200 m wide. In this study we developed a methodology to accurately select pure water river pixels on image basis not affected by bank convolution mixing. The method simulates the downscaling convolution applied to the Landsat native TIR data, considering the water surface geometry and the neighbouring maximum land to water radiance contrast. The method was tested using Landsat-7 and Landsat-8 images of the Ebro River, encompassing the Mequinenza reservoir, in Northeast Spain.

Onsite surface temperature were acquired coinciding with one Landsat overpass and were used to validate the methodology. The sharpening method was applied to a series of Landsat 7 and Landsat 8 images encompassing most of the year 2016. The sharpened retrieval enabled the observation of surface water temperature closely upstream and downstream of the impoundment, enabling the characterisation of its impact on the river thermal regime.