Pan-sharpening to improve spatial resolution of optical remote sensing with examples from Landsat-8 (30m/15m)

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Abstract

Many satellite remote sensing missions designed for land or meteorological applications are designed with a broad “panchromatic” band with higher spatial resolution than the standard multispectral bands. At one extreme the very high spatial resolution Pléiades mission gives 2.8 m multispectral data and 70 cm panchromatic data on demand. At the other extreme the geostationary SEVIRI sensor gives data every 15 minutes (5 minutes in Rapid Scan mode over Europe) with a spatial resolution at nadir (0°, 0°) of 3x3 km for the red (0.6µm) band and 1x1 km for the panchromatic band. The present study investigates the exploitation of these very broad spectral bands for improving the spatial resolution of maps of suspended particulate matter, with a focus on the Landsat-8 30 m multispectral and 15 m panchromatic bands.

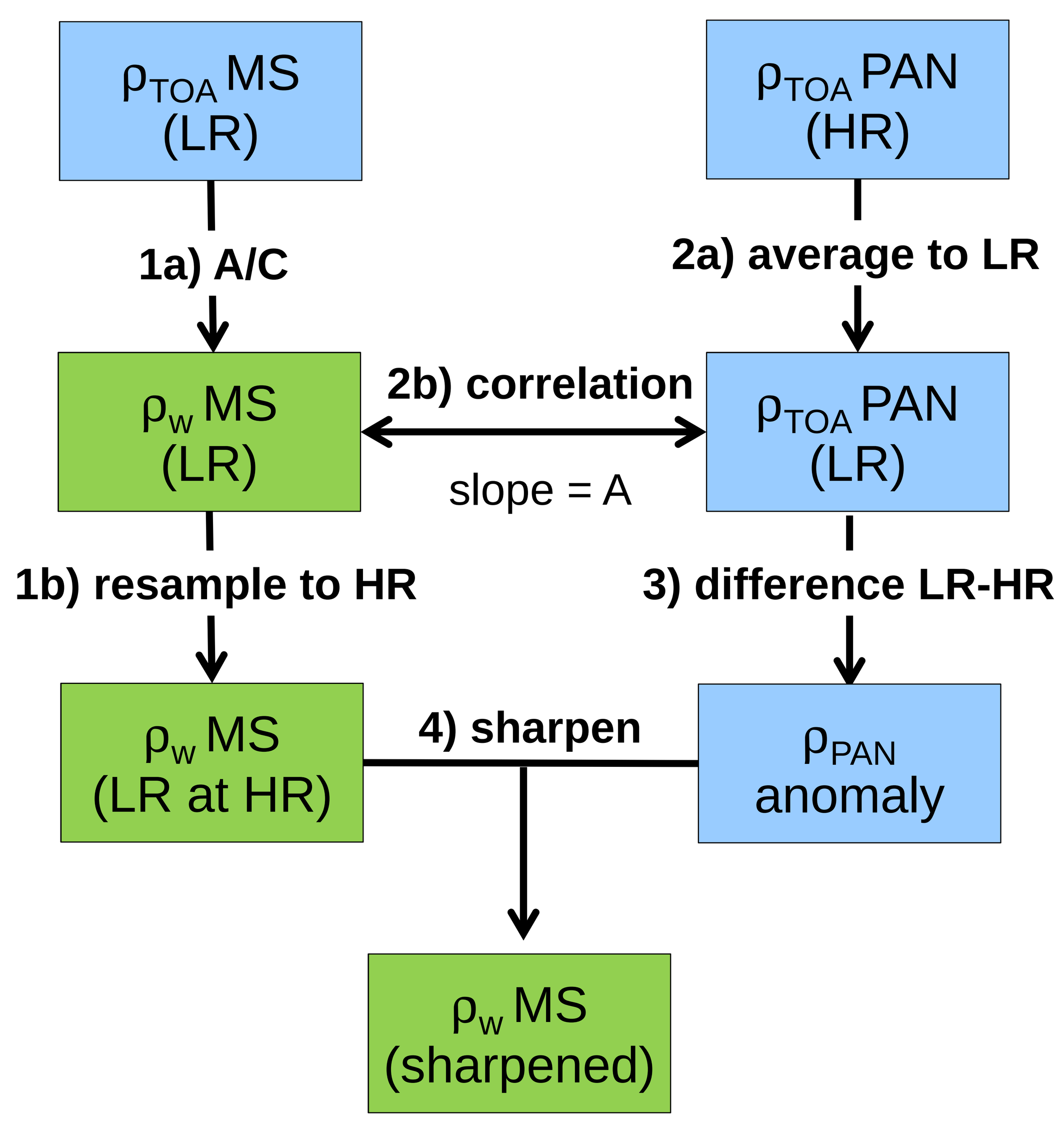

Figure 1 Flow-chart illustrating the method:

1) Multispectral “low” resolution (LR) channels are (a) atmospherically corrected and (b) resampled to panchromatic resolution (HR).
2) The panchromatic band is (a) resampled to LR and (b) scaling factors between the LR PAN at TOA (ρ_{TOA}) and multispectral channels after A/C (ρ_w) are established by correlation. Alternatively, the scaling factor can be based on hyperspectral in situ measurements [N2012].
3) The PAN anomaly is calculated by subtracting the HR PAN from the averaged LR PAN (at HR):

$$\rho_{PAN}^{anomaly} = \rho_{PAN}^{average} - \rho_{PAN}^{TOA}$$

4) Using the scaling factors established in (2b), the pan-sharpened ρ_w VIS (*) is estimated:

$$\rho_w^{*} = \rho_w^{HR} + A \cdot \rho_{PAN}^{anomaly}$$

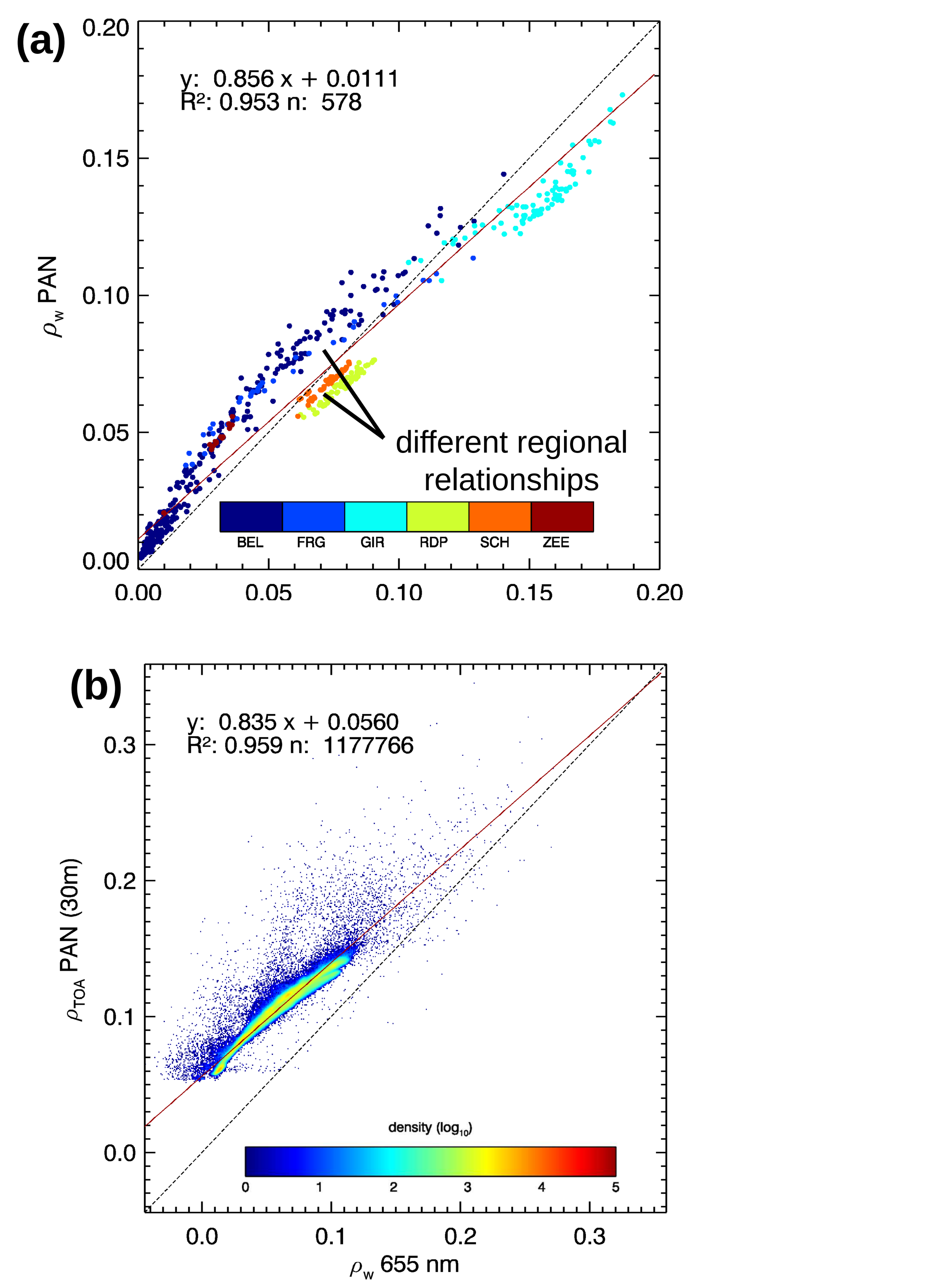

Figure 2 Scatter plots showing the relationships between reflectances in the panchromatic and red channels of OLI, **(a)** derived from in situ TRiOS hyperspectral measurements of ρ_w, **(b)** scatterplot of ρ_{TOA} PAN (resampled to 30 m) and ρ_{TOA} 655 nm. Dashed lines are the 1:1, the solid red lines are the OLS linear regression lines. Colours denote (a) sampling region and (b) pixel density.

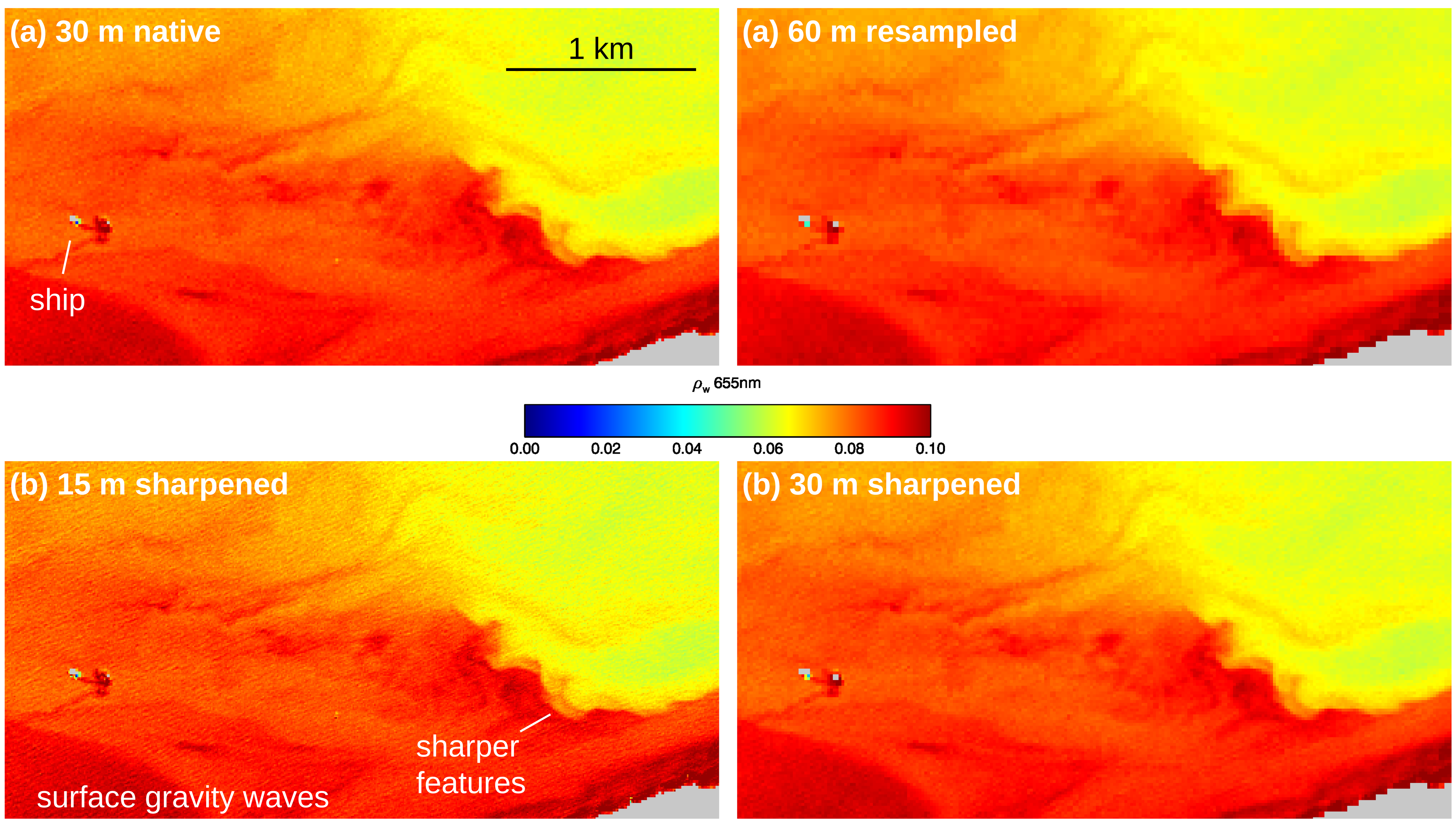

Figure 3 ρ_w 655 nm derived from a subset of Landsat-8/OLI scene LC81990242014075LGN00 using [VR2015] **(a)** at 30 m native resolution **(b)** after sharpening using the 15 m panchromatic band. At 15 m, spatial features are sharper, and surface gravity waves are in many cases spatially resolved.

Figure 4 Validation of the pan-sharpening method. ρ_w 655 nm **(a)** resampled to 60 m resolution **(b)** after sharpening using a simulated 30 m panchromatic band (average of ρ_{TOA} in bands 2-3-4). The 30 m sharpened data resolves spatial features better, and corresponds well to the original 30 m data (Fig. 3a).

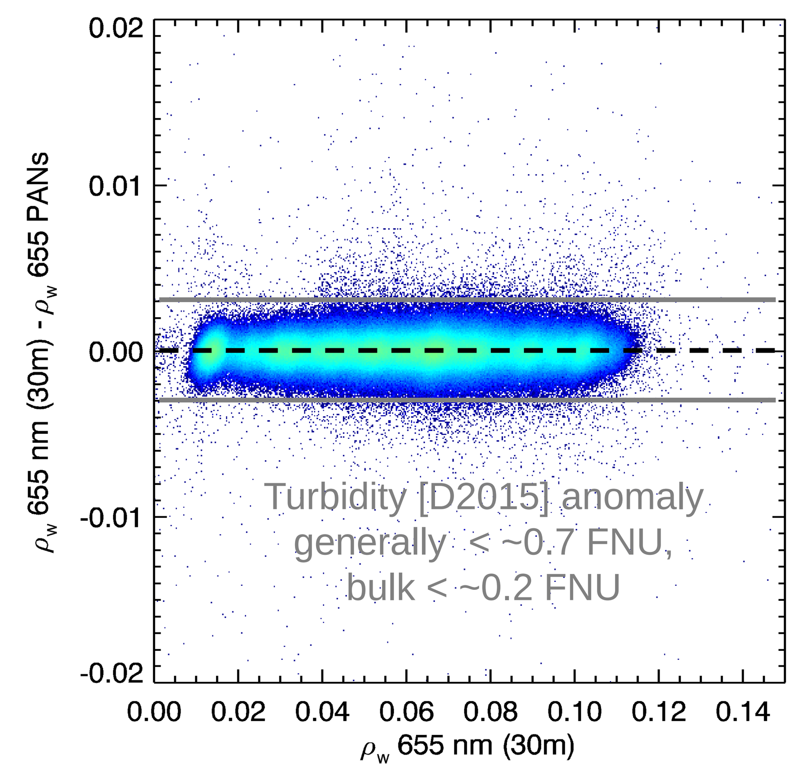

Figure 5 Anomaly between the simulated 30 m pan-sharpened band (Fig. 4b) and the original 30 m data (Fig. 3a), as function of ρ_w.

Conclusions

1) The strong spectral correlation of water reflectances allows for a simple yet robust approach to pan-sharpening for marine applications. The method is here applied to Landsat-8, but can be adapted to Pléiades (high spatial resolution) and SEVIRI (high temporal resolution)
2) The pan-sharpened images reveal fine spatial features derived from a broad spectral band, and performs best for non-mixed pixels. For mixed pixels (e.g. near the coast or floating objects) artefacts are introduced in the determination of the pan anomaly.

References

N2012 Neukermans et al (2012). Diurnal variability of turbidity and light attenuation in the southern North Sea from the SEVIRI geostationary sensor. RSE 124, 564-580.
D2015 Dogliotti et al. (2015). A single algorithm to retrieve turbidity from remotely-sensed data in all coastal and estuarine waters. RSE 156, 157–168.
VR2015 Vanhellemont & Ruddick (2015). Advantages of high quality SWIR bands for ocean colour processing: Examples from Landsat-8. RSE 161, 89–106.

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