EVALUATION OF SATELLITE SPECTRAL SIGNATURES TO RETRIEVE WATER QUALITY PARAMETERS USING DIFFERENT ATMOSPHERIC CORRECTIONS IN THE RÍO DE LA PLATA TURBID WATERS

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OBJECTIVE

Evaluate the performance of atmospheric correction methods available in the software Acolite for Landsat-8 and Sentinel-2 images across different water quality conditions of turbidity and chlorophyll-a in coastal turbid waters.

STUDY SITE

The Río de la Plata is located in South America, between Argentina and Uruguay. It is approximately 280 km long and 220 km wide at its mouth. It receives an annual mean flow of 22000 m^3/s from the Paraná and Uruguay rivers, and 160 Mt/year of suspended sediments, mostly fines, which results in its high turbidity. This work is focused on the northern coast of the estuary.

Ongoing measurements (02/2018-03/2019), with more frequent field campaigns during the warm season: 10/2018-03/2019.

DATA AND METHODS

In-situ data:

- Remote sensing reflectance (Rrs) obtained with Ramses-Trios hyperspectral radiometers.
- Chlorophyll-a (pigment extraction).
- Total and fixed suspended solids (TSS and FSS)
- Turbidity (with OBS 3+),
- Salinity and temperature (CTD)

Remote data:

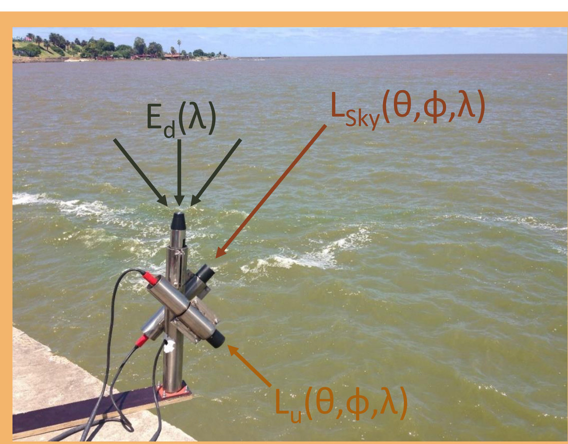
- Landsat-8 (L8)
- Sentinel 2 A/B (S2A/B)

Atmospheric corrections (Acolite version 20181210.0)

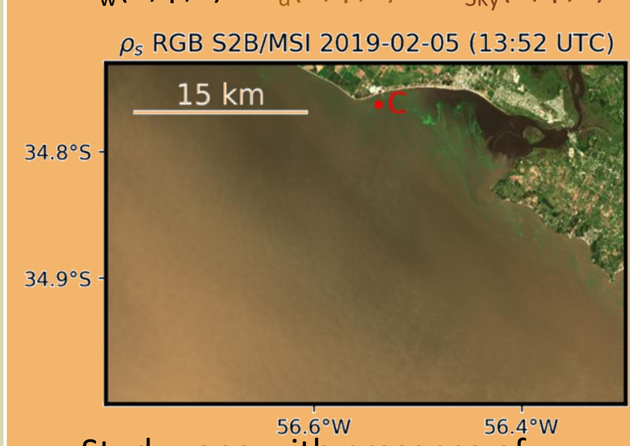
- **DSF**: Dark spectrum fitting (Vanhellemont 2019, Vanhellemont & Ruddick 2018).

Exponential method (Vanhellemont & Ruddick 2015):

- **Exp 5ε**: fixed 5th-percentile ε
- **Exp 50ε**: fixed 50th-percentile ε
- **Exp 50ε ρ_{am}5**: fixed 50th-percentile ε and fixed 5th-percentile aerosol reflectance.

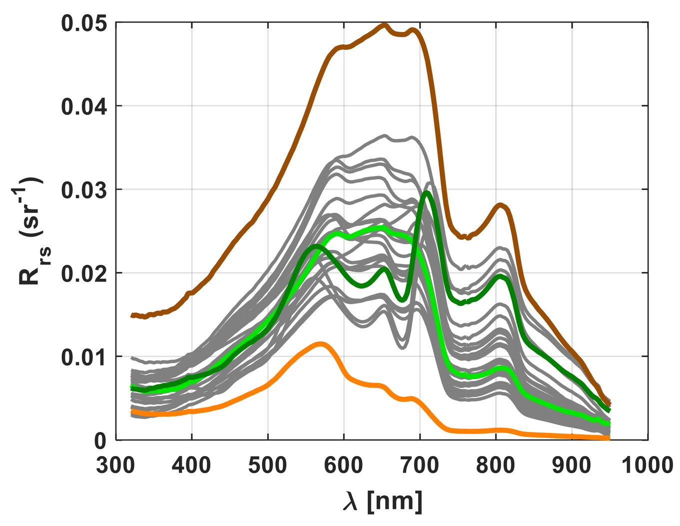


Rrs = $L_w(\theta,\phi,\lambda)/E_d(\lambda)$
$L_w(\theta,\phi,\lambda) = L_u(\theta,\phi,\lambda) - rL_{Sky}(\theta,\phi,\lambda)$



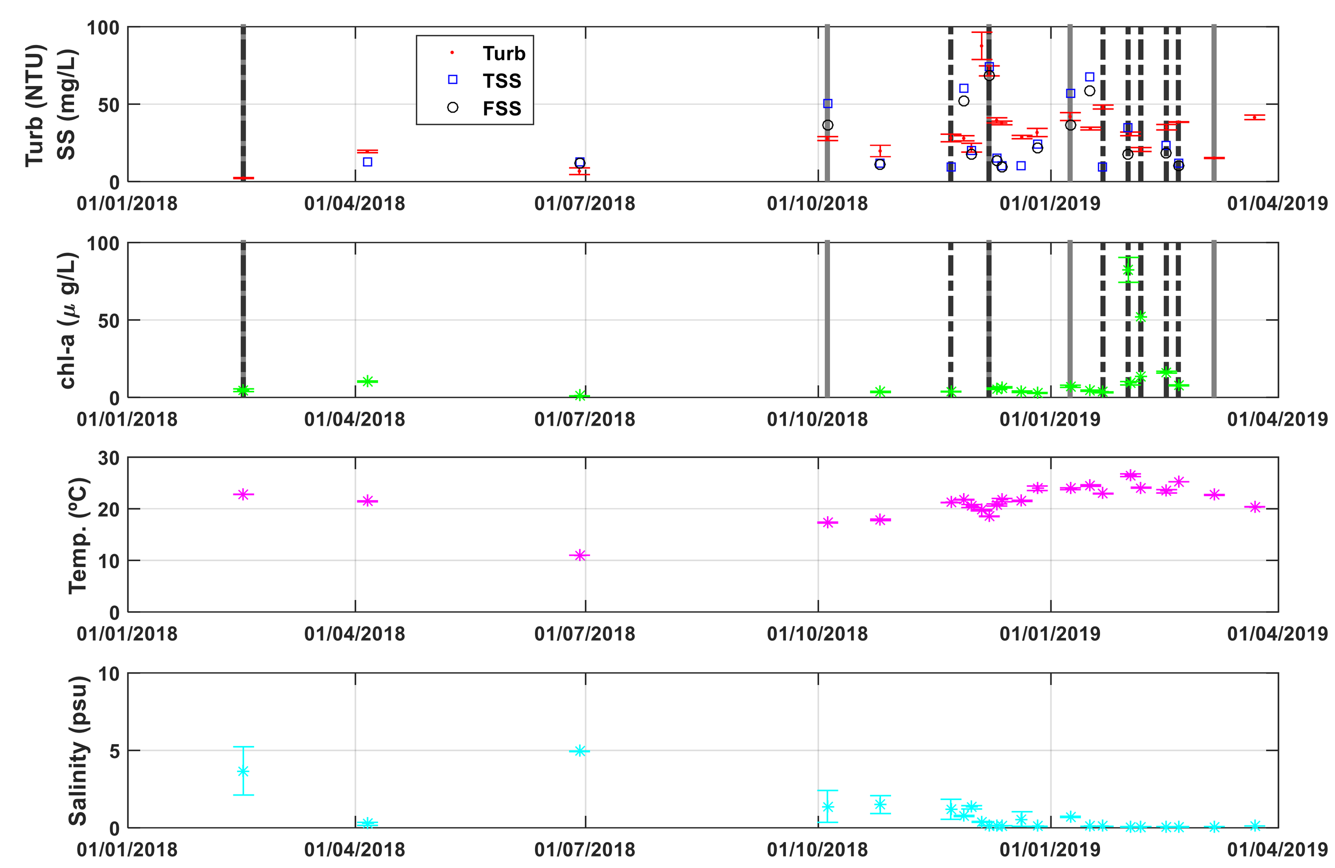
Study zone with presence of cyanobacteria bloom.
Point C: lat -34.763º, lon -56.538º

SPECTRAL SIGNATURES AND WATER QUALITY CONDITIONS



Left: In situ reflectance spectra. Colors indicate the extreme measured values of turbidity and chlorophyll-a :
Turb = 2 - 88 NTU
Chl-a = 1 - 80 µg/L

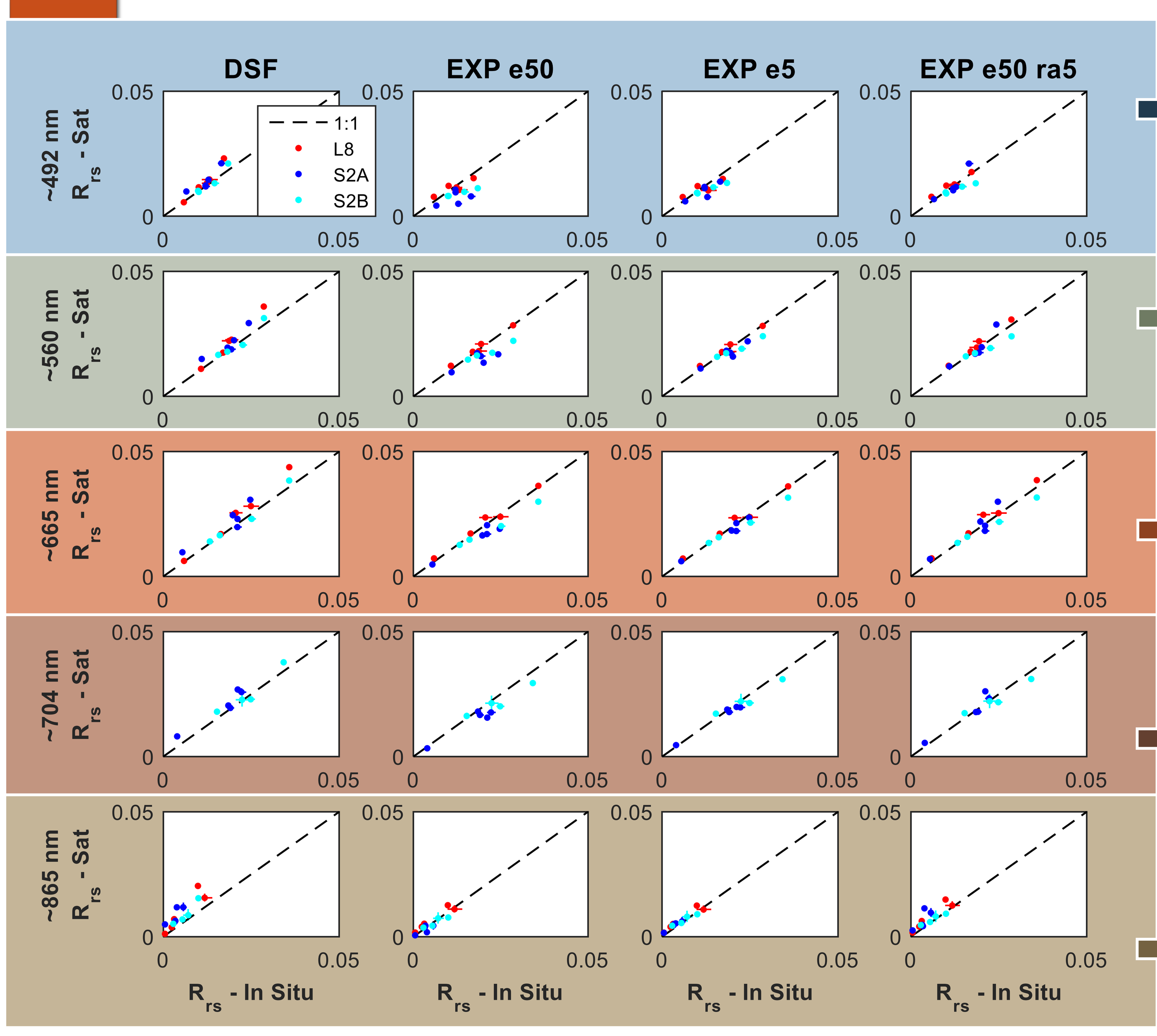
Below: water quality parameters during the study period. Solid gray vertical lines indicate available Landsat-8 images, while dotted vertical lines indicate available Sentinel 2 A/B images.

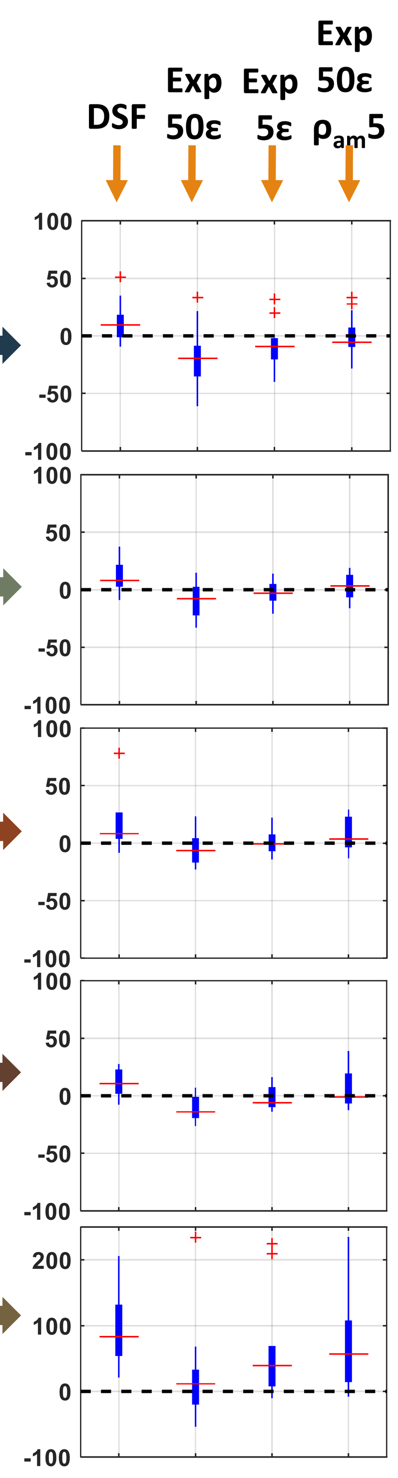


Water temperature follows the annual cycle, oscilating between 10ºC in winter (June-August) and 5ºC in summer (Dec-Feb). Starting towards the end of January 2019 cyanobacteria blooms occurred along the Uruguayan coast, affecting recreational beaches. Cyanobacteria were visualized in all field campaigns since Feb 2019 at the study site. Salinity, which is usually low in this area (although it can reach 25 psu), has remain null since mid January.

EVALUATION OF REFLECTANCES

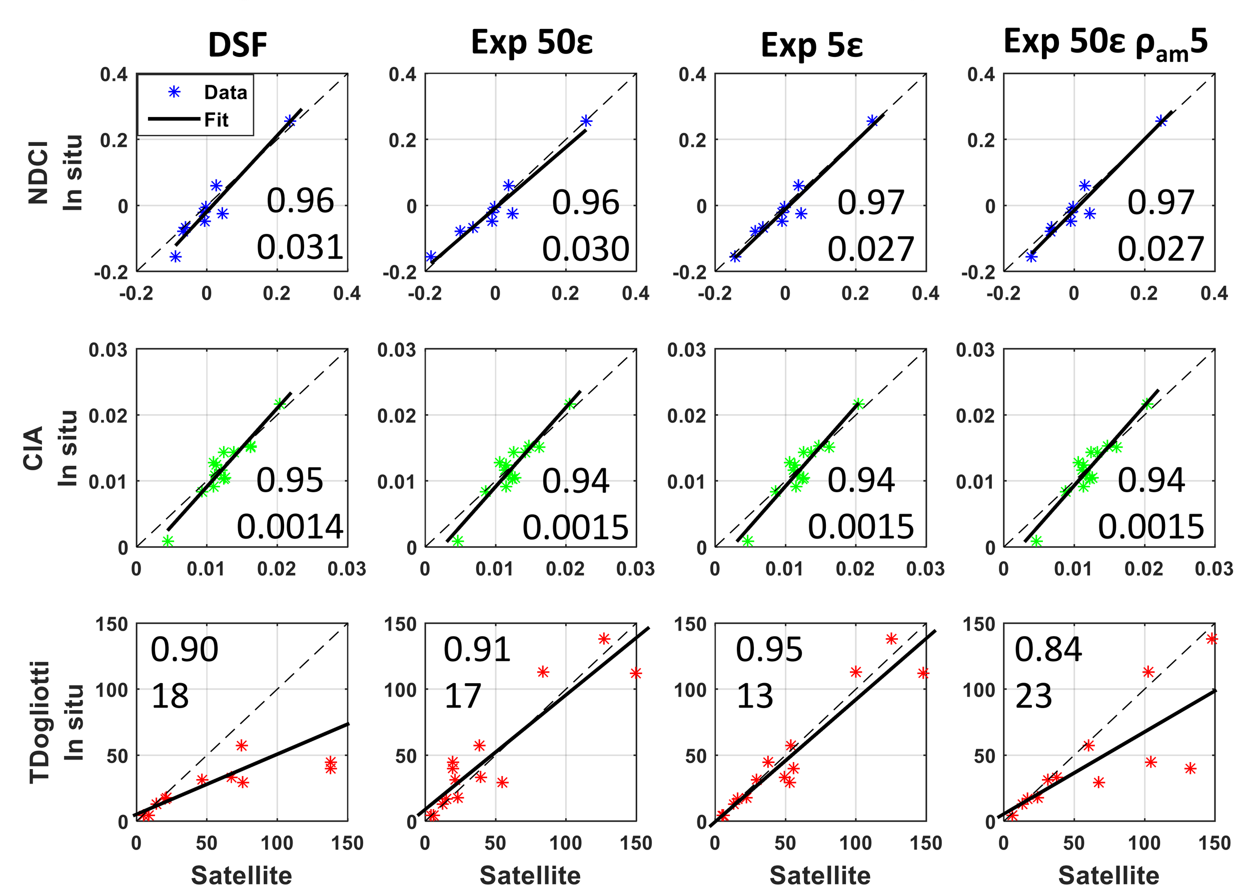
In situ- and satellite-derived Rrs are compared for different satellite bands, as shown in the left figure below (similar satellite bands are grouped in the plots (eg. 483 nm of L8 and 492 nm of S2A/B). Relative errors (considering in situ Rrs as the "true" value) are presented in the right plots.





EVALUATION OF WATER QUALITY INDICES

A few water quality indices are selected for this comparison. For chlorophyll-a: NDCI (Mishra & Mishra 2012), and CIA (Hu et al 2012). For turbidity: TDogliotti (Dogliotti et al 2015). As indices can be calibrated against chlorophyll-a and turbidity data, the linear fit between satellite and in situ indices is computed (solid line in the figure below; the 1:1 line is also included as a reference). Pearson correlations and the RMSE (of fitted against in situ indices) are indicated in each plot.



CONCLUSIONS AND FUTURE WORK

Regarding reflectances, overall the exponential method Exp 5ε presents better results. DSF presents better results in the blue part of the spectrum. For larger wavelengths it tends to present a positive bias. On the other hand, the Exp 50ε method always has a negative bias, but it presents the best results for the NIR band.

The AC methods do not show significant performance differences for chlorophyll-a indices CIA and NDCI, while for turbidity index the best results are achieved by Exp 5ε.

As future work DSF+glint correction (as suggested by Vanhellemont 2019) will be evaluated.

REFERENCES

Dogliotti, A. I., K. G. Ruddick, B. Nechad, D. Doxaran, E. Knaeps (2015). A single algorithm to retrieve turbidity from remotely-sensed data in all coastal and estuarine waters. Remote Sensing of Environment, 156, 157-168

Hu, C., Z. Lee, and B. Franz (2012). Chlorophyll a algorithms for oligotrophic oceans: A novel approach based on three-band reflectance difference. Journal of Geophysical Research, 117, C01011

Vanhellemont, Q. (2019). Adaptation of the dark spectrum fitting atmospheric correction for aquatic applications of the Landsat and Sentinel-2 archives. Remote Sensing of Environment, 225, 175-192

Vanhellemont, Q., Ruddick, K. (2015). Advantages of high quality SWIR bands for ocean colour processing: Examples from Landsat-8. Remote Sensing of Environment, 161, 89-106.

Vanhellemont, Q., Ruddick, K. (2018). Atmospheric correction of metre-scale optical satellite data for inland and coastal water applications. Remote Sensing of Environment, 216, 586-597.

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