Analytical Derivation of Water Clarity Time-Series from Sentinel-2 MSI Imagery

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I. Background

- Water clarity depends on the combined effects of all light-attenuating constituents
- Key parameter in aquatic studies of primary productivity, eutrophication and heat transfer
- Secchi depth is a traditional but spatially limited measurement of water clarity
- The diffuse attenuation coefficient of photosynthetically active radiation (k_d(PAR)) describes how visible light decreases with depth – water clarity proxy
- k_d(PAR) can be derived from satellite imagery
- High spatial resolution k_d(PAR) products are needed for coastal and inland waters studies

II. Methodology

Operational implementation of a two-stream radiative transfer model - 2SeaColor (Salama & Verhoef, 2015):

User Defined:

- Copernicus Credentials
- Area of Interest (GeoJSON)
- Acquisition period
- Cloud cover

Default or retrieved:

- Wind speed and direction
- Water temperature
- Salinity
- IOPs Parametrization

Retrieval from Copernicus Open Access Hub

Sentinel-2 Level 2A Images

- Scene Classification Map
- Illumination Geom.
- Spectral Info.

Land and cloud pixels masking

Surface roughness / glint correction

Calculation of water absorption and scattering

Estimation of IOPs initial values

Forward 2SeaColor model

Inversion by spectral optimization

$k_d(443), k_d(490), k_d(560), k_d(665), k_d(705)$

Spectral Integration

$k_d(PAR)$

CASE STUDY:

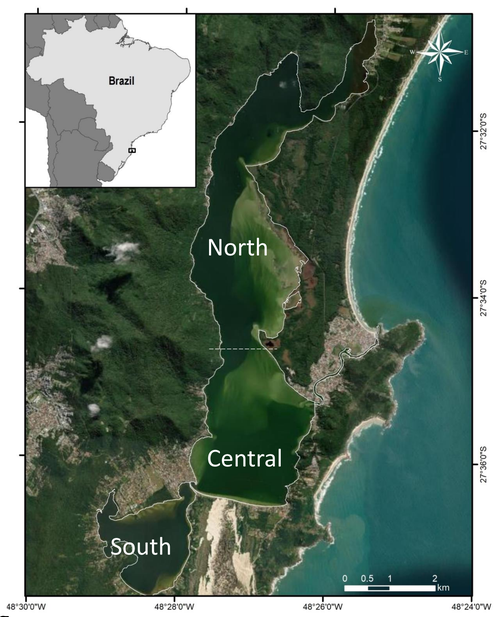
Conceição Lagoon, Southern Brazil

Jan 2019- Dec 2021

Max. 30%

139 scenes (42-49/year)

11 Secchi measurements* w/ Sentinel-2 overpass

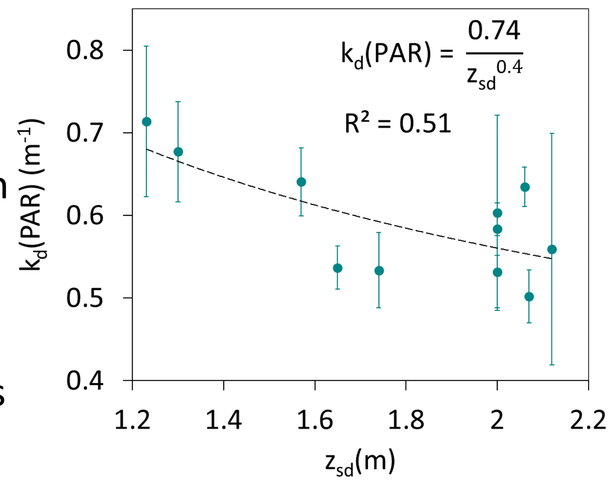


*Credits to Guimarães (2017) for data collection and sharing

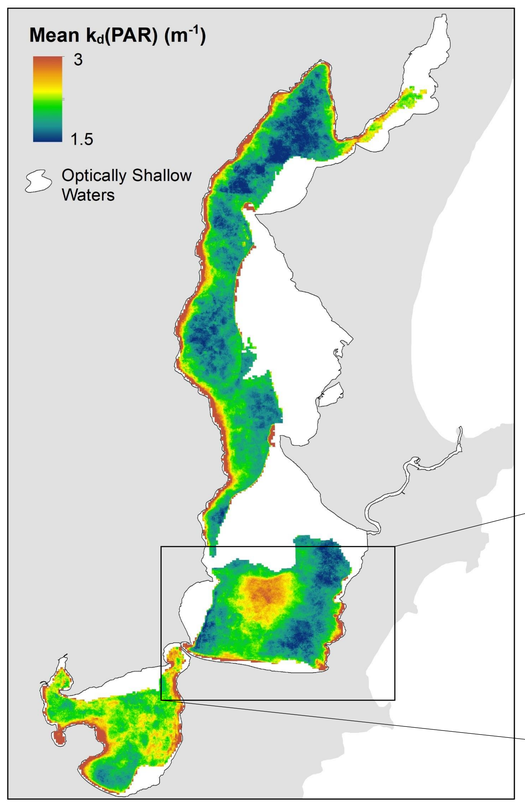
III. Preliminary Results

DERIVED kd(PAR) VS. IN-SITU SECCHI DEPTH:

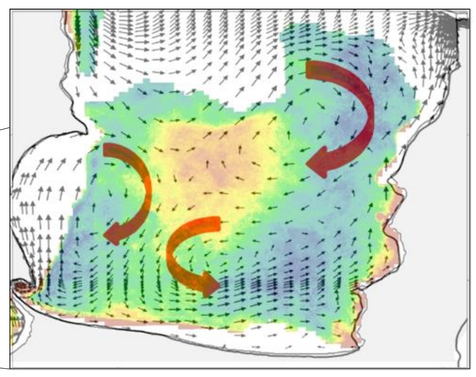
- One match-up with 11 in-situ data points
- General inverse relationship in line with other studies
- Limitations due to:
  - No. of matchups
  - Small range of values



MAIN SPATIAL PATTERNS:



- Overall **lower water clarity in South Lagoon**
  - organic matter + poor circulation
- High k_d(PAR) values at the margins
  - adjacency effects suspected

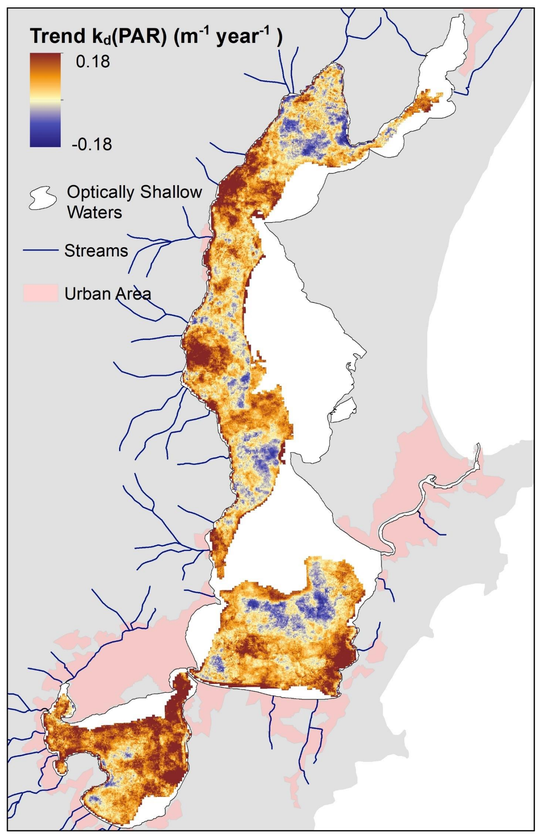


Modeled mean circulation pattern in Central Lagoon (from from Silva (2013))

- **Low water clarity hotspot in Central Lagoon** consistent with edge of 2 cyclonic gyres
  - nutrient resuspension + increase in primary productivity

TREND ANALYSIS:

- Significant ($p < 0.05$) **decreasing water clarity trend** in most of the Lagoon, especially in the South
  - increasing anthropic pressure + poor circulation



IV. Summary

Operational implementation of a physically-based model to derive water clarity (k_d(PAR)) from Sentinel-2 MSI imagery. Highlights of the method include:

- Automatic image retrieval from Copernicus Hub
- Masking of land, clouds, and glint correction
- Application for multiple water management purposes

For more information

Scan to access contact details and references

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