# Exploitation of SENTINEL-2 time series for monitoring ecological quality parameters of french lakes and reservoirs (TELQUEL project)

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# TELQUEL project (2015 – 2017) : SENTINEL-2 time series for monitoring ecological quality parameters of French lakes and reservoirs

## *Presentation of objectives and first results*

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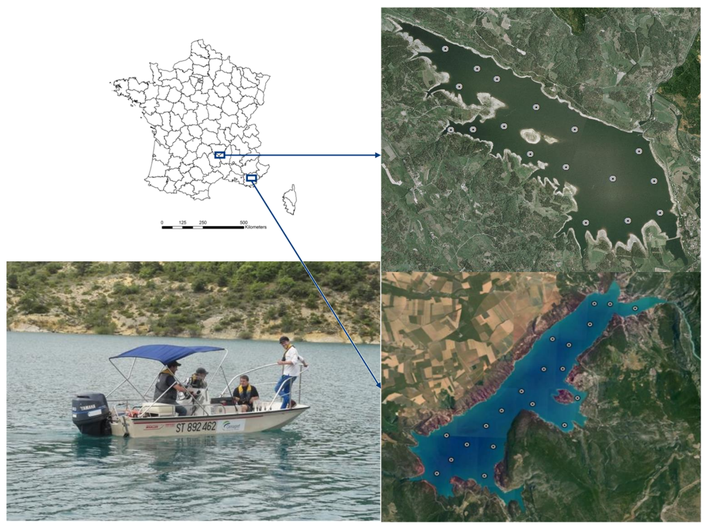
## OBJECTIVES

**The main objective of the TELQUEL project is to provide quantitative observations to monitor the ecological state of the French lakes.**
**In this direction, MSI/Sentinel-2 and OLI/Landsat 8 data are exploited to**

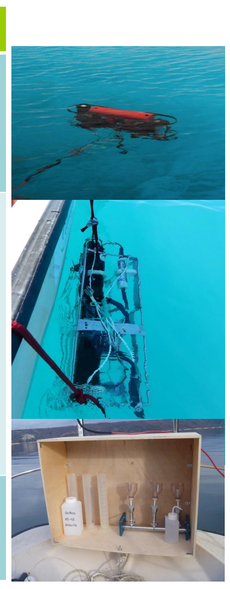
**(i) identify/develop a specific atmospheric correction algorithm over lake areas;**
**(ii) establish bio-optical relationships between the water-leaving radiance and the concentration of the biogeochemical parameters;**
**(iii) provide bio-optical algorithms to retrieve water transparency and water constituent concentrations (Chl-a, CDOM and TSM).**
**(iv) use the retrieved bio-optical properties and matter concentrations for enhancing the lake water quality evaluation and biogeochemical models.**

## STUDY SITES & FIELD DATA




**- 8 field campaigns** have been planned for collecting **apparent and inherent optical properties** (AOP, IOP), **transparency and biogeochemical concentrations** (see table below for details).
- 1 campaign per season over 2 years.
- 4 campaigns have already been done.
- a comprehensive database has been generated for an easy access to the collected data.

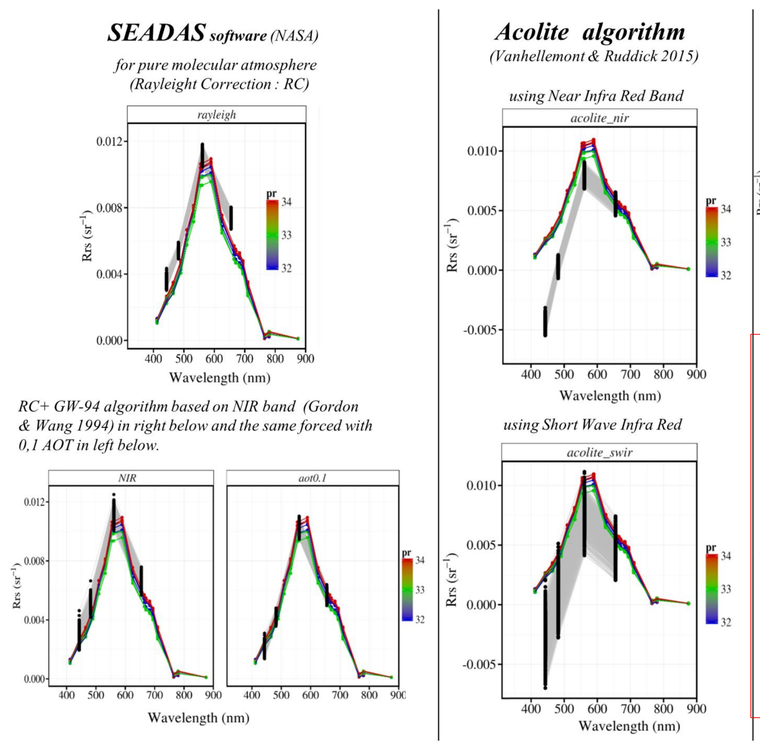
| Data Type | Measures | Materials |
|---|---|---|
| **AOPs** | $L_u$ : upwelling radiance<br>$E_d$ : downwelling irradiance<br>$E_0$ : solar irradiance | C-OPS<br>(Wetlabs Ins.) |
| IOPs | **c** : attenuation coefficient<br>**a** : absorption coefficient<br>**acdom** : cdom absorption coefficient<br>**bbp** : back-scattering coefficient | AC-S<br>& ECO BB3<br>(Wetlabs Ins.) |
| | **aphyto** : phytoplancton aborption coefficient | Sprectrometer with integrating sphere<br>(in the laboratory) |
| Biochemical concentrations | TSS : Total Suspended Solids<br>SOM : Suspended Organic Matter<br>Chl-A : Chlorophylle-a concentrations | Filtration rampers<br>Concentrations measurements in the laboratory. |

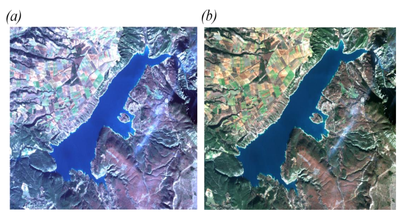


## FIRST RESULTS

### Atmospheric correction algorithm

Remote sensing reflectance (Rrs) of Landsat-8 image recorded on October, 30 2015 over lake Ste-Croix retrieved from different atmospheric correction algorithms (black points) versus Rrs derived from C-OPS in situ data (in color) at different stations.




Landsat-8 image acquired on Oct., 30 2015 . (a) : TOA reflectance, (b) : Rrs using Rayleigh correction.

Satisfactory results for Rrs from the products routinely provided for land surfaces

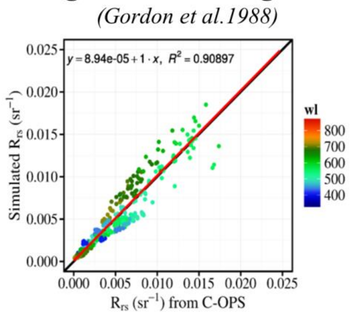
(https://peps.cnes.fr/rocket/#/home)

Aerosol optical thickness (AOT) provided by MACCS

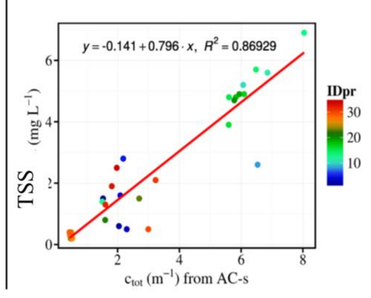
### Bio-optical relationships

Several bio-optical relationships were explored using traditional ocean optics algorithms. **Promising correlations are observed** between (i) Rrs derived from C-OPS and simulated from IOPs (see A); (ii) IOPs and total suspended matter (TSS) concentrations (see B); (iii) measured IOPs and IOPs retrieved from C-OPS and Landsat-8 data (see C).

**A- Rrs from C-OPS vs. simulated Rrs from IOPs** *using Gordon-88 algorithm (Gordon et al.1988)*

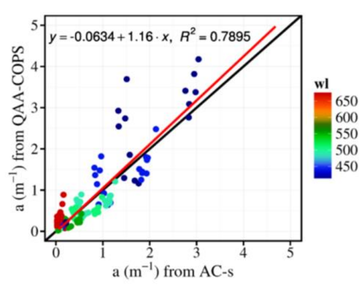



**B- IOPs (c) vs. TSS**

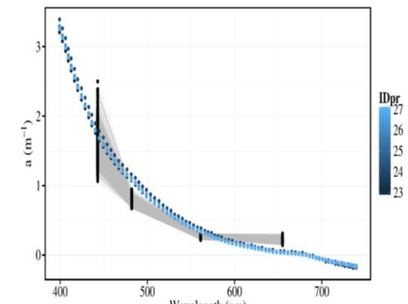



**C- IOPs vs. simulated IOPs** *using QAA algorithm (Lee et al.2002)*

**from C-OPS**




**from Landsat 8** (30th October 2015)




## IN THE FUTURE

**1- Exploitation of MACCS algorithm coupled with corrections for both sky (already developed) and sun (ongoing) reflections on water surface.**

**2- Building specific bio-optical algorithms for OLI and MSI sensors based on Lee et al. 2002 algorithm calibrated from our field data.**

**3- Testing the biogeochemical products retrieved from Landsat 8 and Sentinel-2 for evaluation and modeling of lake ecological state.**

### References:

Gordon, H. R., Brown, J. W., Evans, R. H., Brown, O. B., Smith, Baker et Clark, D. K. (1988) A semianalytic radiance model of ocean color. Journal of Geophysical Research, vol. 93, n°D9, p. 10909-10924
Gordon, H. R. et Wang, M. (1994) Retrieval of water leaving radiance and aerosol optical thickness over the oceans with seawifs: a preliminary algorithm. Applied Optics, vol. 33, n°3, p. 443-458.
Hagolle, O., Huc, M., Pascual, D. et Dedieu, G. (2015) A Multi-Temporal and Multi-Spectral Method to Estimate Aerosol Optical Thickness over Land, for the Atmospheric Correction of FormoSat-2, LandSat, VENS and Sentinel-2 Images. Remote Sensing, vol. 7, n°3, p. 2668-2691.
Harmel, T., Gilerson, A., Tonizzo, A., Chowdhary, J., Weidemann, A., Arnone, R. et Ahmed, S. (2012) Polarization impacts on the water-leaving radiance retrieval from above-water radiometric measurements. Applied Optics, vol. 51, n°35, p. 8324-8340
Lee, Z. P., Carder, K. L. et Arnone, R. A. (2002) Deriving inherent optical properties from water color: a multiband quasi-analytical algorithm for optically deep waters. Applied Optics, vol. 41, n°27, p. 5755-5772
Vanhellemont, Q. et Ruddick, K. (2015) Advantages of high quality SWIR bands for ocean colour processing: Examples from Landsat-8. Remote sensing of environment, vol. 161, p. 89-106.

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