wiseman_metadata_optics

Project Name	Start Date	End Date	Lat range	Lon range
WISE-Man	2019-08-17	2019-08-25	48.94568 49.25000	-68.61499 -68.01103

Role	Name	Affiliation	Email
PI	Simon Bélanger	UQAR	Simon_Belanger@uqar.ca
Database contact	Véronique Thériault	UQAR	Veronique_Theriault2@uqar.ca

Citation:
Université du Québec à Rimouski. Aquatel Laboratory. (2019). WISE-Man Project (WaterSat Imaging Spectrometer Experiment), characterization of shallow inland and coastal waters. [Version 1.0] Data published on St. Lawrence Global Observatory-SLGO. [https://slgo.ca]. Access date: [YYYY-MM-DD].

Project Description:
The WaterSat Imaging Spectrometer Experiment (WISE) for optically shallow inland and coastal waters assessment (the WISE-Man project)'s objective was to demonstrate the potential of hyperspectral imagery for mapping bathymetry, water column quality (or inherent optical properties) and retrieve bottom properties in order to respond to the pressing needs of science (e.g. ecology, geomorphology, coastal risk), resource management and defense operation. Within this framework ,an intensive fieldwork campaign was conducted in the Manicouagan / Baie-Comeau region (Québec, Canada) in July-August 2019. The database includes several datasets (csv files) related to water optical properties, water biogeochemistry and bio-optical properties of intertidal vegetation. This particular database refers to the optical parameters sampled within the water column.

Funders:
Canadian Space Agency (FAST program 2017), Department of Fisheries and Oceans (DFO) (Ocean protection plan), Réseau Québec Maritime (RQM), Québec-Océan network, UQAR, NSERC discovery grant to Simon Bélanger.

Datasets Table of Content

data_dictionary_optics_wiseman.csv

Description:
The “data_dictionary_optics_wiseman.csv” file contains the description and units of all parameters included in each dataset (each csv file). Parameter’s names are based on SeaBass standardized field names when possible (https://seabass.gsfc.nasa.gov/wiki/stdfields).

Dataset Contact:

Name	Affiliation	Email
Veronique Theriault	UQAR	veronique_theriault2@uqar.ca

Instruments:
NA

Sampling and Analysis:
NA

References:
NA

watercolumn_station_wiseman.csv

Description:
This dataset is used as a reference table and contains basic information on stations sampled from boats. Date, time, latitude, longitude, boat used, water depth, secchi disk and forel-Ule scale are the parameters given for each station. The “station_id” column is the primary key to which other datasets can refer to perform joins.

Dataset Contact:

Name	Affiliation	Email
Veronique Theriault	UQAR	veronique_theriault2@uqar.ca

Instruments:
NA

Sampling and Analysis:
NA

References:
NA

Ed_cops_long_wiseman.csv

Kd_10p_cops_long_wiseman.csv

Kd_1p_cops_long_wiseman.csv

Rb_cops_long_wiseman.csv

Rrs_cops_long_wiseman.csv

Description:
Optical parameters measured in situ from a boat, including remote sensing reflectance at sea surface (Rrs), diffuse attenuation coefficient (Kd, at 1 and 10 percent of Ed), downwelling irradiance (Ed) and bottom reflectance (Rb) using the C-OPS. Refer to the "watercolumn_station_wiseman.csv" dataset for additional information on the station sampled, based on the "station_id" column.

Start Date: 2019-08-17
End Date: 2019-08-24

Dataset Contact:

Name	Affiliation	Email
Simon Bélanger	UQAR	Simon_Belanger@uqar.ca
Soham Mukherjee	UQAR	saion523@gmail.com
Raphael Mabit	UQAR	raphael.mabit@uqar.ca

Instruments:

Instrument Type	Manufacturer	Model	Instrument Features / Calibration
Compact Optical Profiler System (C-OPS)	Biospherical Instruments	SN 13	UQAR Calibrated in March 2019

Compact Optical Profiler System (C-OPS)	Biospherical Instruments		Boston University

Sampling and Analysis:

Sampling: Three to five C-OPS profiles were performed on each station from a boat. Most of the time, the boats were drifting during the measurements and the instrument was kept outside any disturbance or boat shadow. In very shallow waters (less than 2 m) where tidal currents were strong, the boats were anchored to stay on station and the instruments were transported away from the boat shadows.

Analytical procedure: The C-OPS data were processed in R software with the “Cops” package first developed by Dr. B. Gentili at the Laboratoire d'Océanographie de Villefranche (LOV) and now maintained by Dr S Bélanger (the source code is available at https://github.com/belasi01/Cops). The data processing respects the NASA protocols (Mueller et al. 2003) but additional features have been developed to optimize the data processing.

Wavebands available on the two C-OPS systems used in 2019.

UQAR SN 13	Boston University
NA	305
320	320
330	NA
340	340
380	380
NA	395
412	412
443	443
465	465
490	490
510	510
532	532
555	NA
NA	560
589	589
625	625
665	665
683	683
694	694
710	710

780	780
875	NA

References:

- Mueller, James L et al. 2003. Ocean Optics Protocols For Satellite Ocean Color Sensor Validation , Revision 4 , Volume I: Introduction, Background and Conventions

Rrs_asd_long_wiseman.csv

Description:
Above water reflectance measured with the ASD. Refer to the "watercolumn_station_wiseman.csv" dataset for additional information on the station sampled, based on the "station_id" column.

Start Date: 2019-08-18
End Date: 2019-08-25

Dataset Contact:

Name	Affiliation	Email
Soham Mukherjee	UQAR	saion523@gmail.com

Instruments:

Instrument Type	Manufacturer	Model	Instrument Features / Calibration
Spectroradiometer	Analytical Spectral Device (ASD)	FieldSpec Handheld 2	Calibrated spectralon panel used as reference

Sampling and Analysis:
Sampling: The instrument was used from a boat at each station. The instrument had a spectral resolution of ~3 nm covering a spectral range from 325 to 1075 and was fitted with a bare fiber optic with a 25° field of view (FOV).

Analytical procedure: The remote sensing reflectance (Rrs) was computed following Mobley 1999, based on the total upwelling radiance from the water as measured by the instrument; the skylight reflectance that depends upon the sun-viewing geometry, sea state (i.e., wind speed) and instrument FOV; the sky radiance coming from the direction of specularly reflected sky light; the up-welling radiance and reflectance of the spectralon panel. The instrument integration time and dark current subtraction were systematically applied for each radiance measurement. The solar zenith angle of ~40° and an azimuth difference between the solar and sensor planes between 90 and 135° was chosen to minimize the sun glint contamination (Mobley 1999). The wind speed and sun-view geometry was recorded systematically to perform the sky glint correction. Several methods were tested to correct the sky glint. A total of 9 methods (See https://srscm03.uqar.ca/belasi01/asdsvc for details on methods, Kutser et al, 2013; Jiang et al., 2020; Ruddick et al., 2005, 2006) were compared. The selected method assumes null reflectance in both UV (350-380nm) and in NIR (890-900nm) ranges. These assumptions allow a direct estimation of the fresnel reflectance (r_{sky}) in the UV and NIR. A linear interpolation of r_{sky} was calculated between the UV and NIR to obtain a spectrally varying r_{sky}.

References:

- Mobley 1999,Estimation of the remote-sensing reflectance from above-surface measurements, Applied Optics, 36:38,7442, Optical Society of America,10.1364/AO.38.007442
- Jiang, Dalin, Bunkei Matsushita, and Wei Yang. 2020. “A Simple and Effective Method for Removing Residual Reflected Skylight in Above-Water Remote Sensing Reflectance Measurements.” *ISPRS Journal of Photogrammetry and Remote Sensing* 165 (March): 16–27. https://doi.org/10.1016/j.isprsjprs.2020.05.003.
- Kutser, Tiit, Ele Vahtmäe, Birgot Paavel, and Tuuli Kauer. 2013. “Removing Glint Effects from Field Radiometry Data Measured in Optically Complex Coastal and Inland Waters.” *Remote Sensing of Environment* 133: 85–89. https://doi.org/10.1016/j.rse.2013.02.011.
- Ruddick, Kevin, Vera De Cauwer, and Barbara Van Mol. 2005. “Use of the near Infrared Similarity Reflectance Spectrum for the Quality Control of Remote Sensing Data.” *Proceedings of the SPIE International Symposium on Optics and Photonics: Remote Sensing of the Coastal Oceanic Environment* 2005 (August).
- Ruddick, Kevin G, Vera De Cauwer, Young-Je Park, and Gerald Moore. 2006. “Seaborne Measurements of near Infrared Water-Leaving Reflectance: The Similarity Spectrum for Turbid Waters.” *Limnol. Oceanogr.* 51 (2): 1167–79.

Rrs_psr_long_wiseman.csv

Description:
Above water reflectance measured with the PSR. Refer to the "watercolumn_station_wiseman.csv" dataset for additional information on the station sampled, based on the "station_id" column.

Start Date: 2019-08-17
End Date: 2019-08-25

Dataset Contact:

Name	Affiliation	Email
Joshua Harrington	Boston University	joshuaph@bu.edu

Instruments:

Instrument Type	Manufacturer	Model	Instrument Features / Calibration
spectroradiometer	Spectral Evolution	PSR-1100f	Calibrated spectralon panel used as reference

Sampling and Analysis:
Sampling: The instrument was used from a boat at each station. The instrument had a spectral resolution of ~3 nm covering a spectral range from 320 to 1100 and was fitted with a bare fiber optic with a 25° field of view (FOV).

Analytical procedure: The remote sensing reflectance (Rrs) was computed following Mobley 1999, based on the total upwelling radiance from the water as measured by the instrument; the skylight reflectance that depends upon the sun-viewing geometry, sea state (i.e., wind speed) and instrument FOV; the sky radiance coming from the direction of specularly reflected sky light; the up-welling radiance and reflectance of the spectralon panel. The instrument integration time and dark current subtraction were systematically applied for each radiance measurement. The solar zenith angle of ~40° and an azimuth difference between the solar and sensor planes between 90 and 135° was chosen to minimize the sun glint contamination (Mobley 1999). The wind speed and sun-view geometry was recorded systematically to perform the sky glint correction. Several methods were tested to correct the sky glint. A total of 9 methods (See https://srscm03.uqar.ca/belasi01/asdsvc for details on methods, Kutser et al, 2013; Jiang et al., 2020; Ruddick et al., 2005, 2006) were compared. The selected method assumes null reflectance in both UV (350-380nm) and in NIR (890-900nm) ranges. These assumptions allow a direct estimation of the fresnel reflectance (r_{sky}) in the UV and NIR. A linear interpolation of r_{sky} was calculated between the UV and NIR to obtain a spectrally varying r_{sky}.

References:

- Mobley 1999,Estimation of the remote-sensing reflectance from above-surface measurements, Applied Optics, 36:38,7442, Optical Society of America,10.1364/AO.38.007442
- Jiang, Dalin, Bunkei Matsushita, and Wei Yang. 2020. “A Simple and Effective Method for Removing Residual Reflected Skylight in Above-Water Remote Sensing Reflectance Measurements.” *ISPRS Journal of Photogrammetry and Remote Sensing* 165 (March): 16–27. https://doi.org/10.1016/j.isprsjprs.2020.05.003.
- Kutser, Tiit, Ele Vahtmäe, Birgot Paavel, and Tuuli Kauer. 2013. “Removing Glint Effects from Field Radiometry Data Measured in Optically Complex Coastal and Inland Waters.” *Remote Sensing of Environment* 133: 85–89. https://doi.org/10.1016/j.rse.2013.02.011.
- Ruddick, Kevin, Vera De Cauwer, and Barbara Van Mol. 2005. “Use of the near Infrared Similarity Reflectance Spectrum for the Quality Control of Remote Sensing Data.” *Proceedings of the SPIE International Symposium on Optics and Photonics: Remote Sensing of the Coastal Oceanic Environment* 2005 (August).
- Ruddick, Kevin G, Vera De Cauwer, Young-Je Park, and Gerald Moore. 2006. “Seaborne Measurements of near Infrared Water-Leaving Reflectance: The Similarity Spectrum for Turbid Waters.” *Limnol. Oceanogr.* 51 (2): 1167–79.

a_long_wiseman.csv

c_long_wiseman.csv

Description:
Spectral non-water absorption coefficient (a) measured in situ with the a-sphere and the AC-s and beam attenuation coefficient (c) measured in situ with the AC-s. Refer to the "watercolumn_station_wiseman.csv" dataset for additional information on the station sampled, based on the "station_id" column.

Start Date: 2019-08-18
End Date: 2019-08-24

Dataset Contact:

Name	Affiliation	Email
Soham Mukherjee	UQAR	saion523@gmail.com

Instruments:

Instrument Type	Manufacturer	Model	Instrument Features / Calibration
a-sphere	HOBILabs		Factory calibrated before field campaign
AC-s	WetLabs		

Sampling and Analysis:

Sampling: Vertical profiles of the spectral non-water absorption coefficient (*a*) were done from a boat using an a-sphere or an AC-s. The HOBILabs a-sphere is a submersible teflon integrating sphere. The instrument was factory calibrated before the field campaign with pure water. The a-sphere measures the absorption at 1500 wavelengths between 360 and 764 nm, that are binned at 1 nm resolution. The WET Labs ACS instrument measures *in situ* absorption (*a*) and attenuation (*c*) at frequency intervals of 5Hz. The instrument uses a pump to pull water through two flow tubes having a path length of 25cm, each with an integrated light source, detector and filter wheel. a and c are binned at 81 varying wavelengths between 400 and 756 nm.

Analytical procedure: For the a-sphere, raw data were converted into absorption coefficients using the manufacturer software and calibration files. The parameter was corrected for

temperature and salinity as measured with the CTD at the same depth using the coefficients published by Röttgers et al. 2014.
We observed spectral anomalies in the absorption coefficient spectra at wavelengths > 680 nm after September 16 due to low battery voltage, which wavelengths were discarded from further analysis.

For the AC-S, in order to retrieve *in situ* non-water *a* and *c*, first field acquired binary data is converted to raw text data using the manufacturer's software (WET Labs, WAP). Next, the raw data is converted into engineering units by applying a device file containing the manufacturer given pure-water offset calibration values along with the corresponding temperature. Next, both *a* and *c* were corrected for temperature and salinity effects as measured with the CTD at the same depth using the coefficients published by Röttgers et al. 2014. Finally, laboratory pure water calibration is performed to obtain the non-water *a* and *c*.

One issue with the *a* sensor is though the a-tube is reflective in design that attempts to accumulate photons scattered using total internal reflection at the exterior wall the flow tube, it cannot accumulate photons scattered more than 41 degrees of critical angle. It creates an overestimation of acquired absorption. For the *c* tube lens, aperture arrangement is engineered to only collect directly transmitted light through the volume of the sample. This configuration overestimates the acquired photons by accidental collection of photons that have been forward scattered in directions with smaller angle than the collection angle of the lens-aperture system in AC-s. It results in underestimation of *c*.

These scattering errors are corrected by the method given by McKee et al. (2008) for both the absorption and attenuation tubes by using Monte Carlo simulations given a weighting function that describes the collection of angular scattering with ancillary use of relevant backscatter data. In case of absence of backscatter data, the *a* data is corrected using empirical proportional method after Zaneveld et al. (1994) assuming negligible NIR absorption and a wavelength independent scattering phase function inside the reflective tubes. All the processing is implemented using the Riops R package (https://github.com/belasi01/Riops).

References:

- Röttgers, D. McKee, and C. Utschig, 2014. Temperature and salinity correction coefficients for light absorption by water in the visible to infrared spectral region. Opt. Express, 22, 25 093–25 108, doi:10.1364/OE.22.025093.
- McKee, D., Piskozub, J., & Brown, I. (2008). Scattering error corrections for in situ absorption and attenuation measurements. *Optics Express*, *16*(24), 19480. https://doi.org/10.1364/OE.16.019480
- Zaneveld, J. R. V., Kitchen, J. C., & Moore, C. C. (1994). Scattering error correction of reflection-tube absorption meters. In Ocean Optics XII (Vol. 2258, pp. 44-55). International Society for Optics and Photonics.

bbp_long_wiseman.csv

Description:
Backscattering coefficient of particles (bbp) measured in situ with the Hydroscat-6 and BB9. Refer to the “watercolumn_station_wiseman.csv” dataset for additional information on the station sample, based on the “station_id” column.

Start Date: 2019-08-18
End Date: 2019-08-24

Dataset Contact:

Name	Affiliation	Email
Soham Mukherjee	UQAR	saion523@gmail.com

Instruments:

Instrument Type	Manufacturer	Model	Instrument Features / Calibration
HydroScat-6P	HOBILabs		2019
BB9	WetLabs		

Sampling and Analysis:
Sampling: Vertical profiles were done from a boat using an hydroscat-6 and a BB9. The Hydroscat-6 measured the volume scattering function at 140°, β(140) with bands centered at 394, 420, 470, 532, 620 and 700 nm. The instrument was factory calibrated in 2019 following the method of Maffione and Dana 1997. For the BB9, it measured the volume scattering function at an effective scattering angle of 117°, β(117) with bands centered at 412, 440, 488, 510, 532, 595, 650, 676 and 715 nm.

Analytical procedure: The bbp for HS6 is derived from integrating the β(140) whereas for BB9, bbp is computed by integrating the volume scattering function with respect to the polar coordinates of the observation and multiplying with a *chi* factor of 1.1. Next the attenuation of scattered photons along the detector's viewing pathlength is corrected for both sensors using the total absorption coefficient measurements from the a-Sphere and AC-S instruments respectively (see a_long_wiseman.csv.) following Doxaran et al. (2016). For the effects of salinity on the pure seawater scattering, correction after Zhang et al (2009) has been performed. The processing has been implemented in the Riops R package (https://github.com/belasi01/Riops) (Araújo and Bélanger, 2022).

References:

- Carlos A.S. Araújo, Simon Bélanger, 2022. Variability of bio-optical properties in nearshore waters of the estuary and Gulf of St. Lawrence: Absorption and backscattering coefficients, Estuarine, Coastal and Shelf Science, Volume 264,2022,107688,ISSN 0272-7714,https://doi.org/10.1016/j.ecss.2021.107688.
- Doxaran et al., 2016. D. Doxaran, E. Leymarie, B. Nechad, A. Dogliotti, P. Gernez, E. Knaeps, Improved correction methods for field measurements of particulate light backscattering in turbid waters, Opt Express, 24 (2016), pp. 5415-5436, 10.1364/OE.24.003615.
- Maffione, Robert and Dana, David, 1997. Instruments and methods for measuring the backward-scattering coefficient of ocean waters, Applied optics, 24 (36),6057-6067.
- Zhang, X., L. Hu, and M.-X. He, 2009: Scattering by pure seawater: Effect of salinity. Opt. Express, 17, 5698–5710, doi:10.1364/OE.17.005698.

AOT_wiseman.csv

Description:
Sun photometry related parameters, i.e, aerosol optical thickness (AOT), water vapor and angstrom coefficients.

Start Date: 2019-08-18
End Date: 2019-08-25

Dataset Contact:

Name	Affiliation	Email
Julien Lalibteré	DFO-MPO	julien.laliberte@dfo-mpo.gc.ca

Instruments:

Instrument Type	Manufacturer	Model	Instrument Features / Calibration
Microtops	Solar Light Company	Handheld microtops II	Calibrated by NASA prior to field work

Sampling and Analysis:
Sampling: Measurements taken from a boat. One measurement refers to a series of scan replicates, five on average, to lower the uncertainties associated with operating the instrument from small vessels. The measurements are not associated with a specific station.

Analytical procedure: The inversion of the signal was performed by AERONET using their Version 2 algorithm, with AOT uncertainties evaluated to be smaller than 0.02 at all wavelengths (Smirnov et al. 2009). Visual inspection of the AOT distributions per wavelength as well as spectral shape led to the removal of five suspect sequences for which only two or less scans were recorded and led to questionable values.

References:

- Smirnov, Alexander & Holben, Brent & Slutsker, I. & Giles, David & Mcclain, Charles & Eck, Thomas & Sakerin, S. & Macke, Andreas & Croot, Peter & Zibordi, G. & Quinn, P. & Sciare, J. & Kinne, S. & Harvey, Mike & Smyth, Timothy & Piketh, Stuart & Petelski, Tomasz & Proshutinsky, Andrey & Goes, Joaquim & Jourdin, Frédéric. (2009). Maritime Aerosol Network as a component of Aerosol Robotic Network. Journal of Geophysical Research: Atmospheres. 114. 10.1029/2008JD011257.