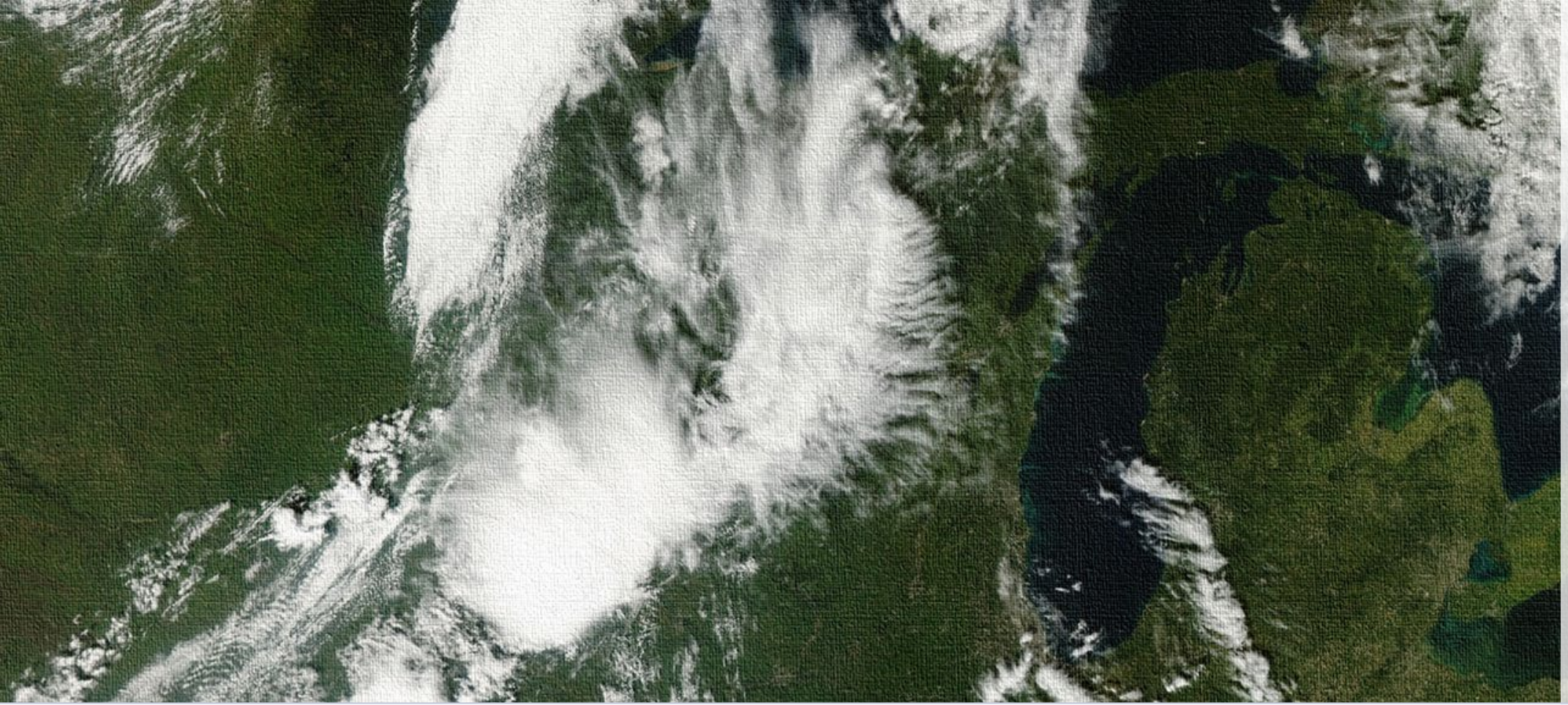

Wednesday, June 08, 2022

Daniela Gurlin[1], Moritz K. Lehmann[2,3], Nima Pahlevan[4,5], Brandon Smith[4,5] **and a community of multinational researchers**

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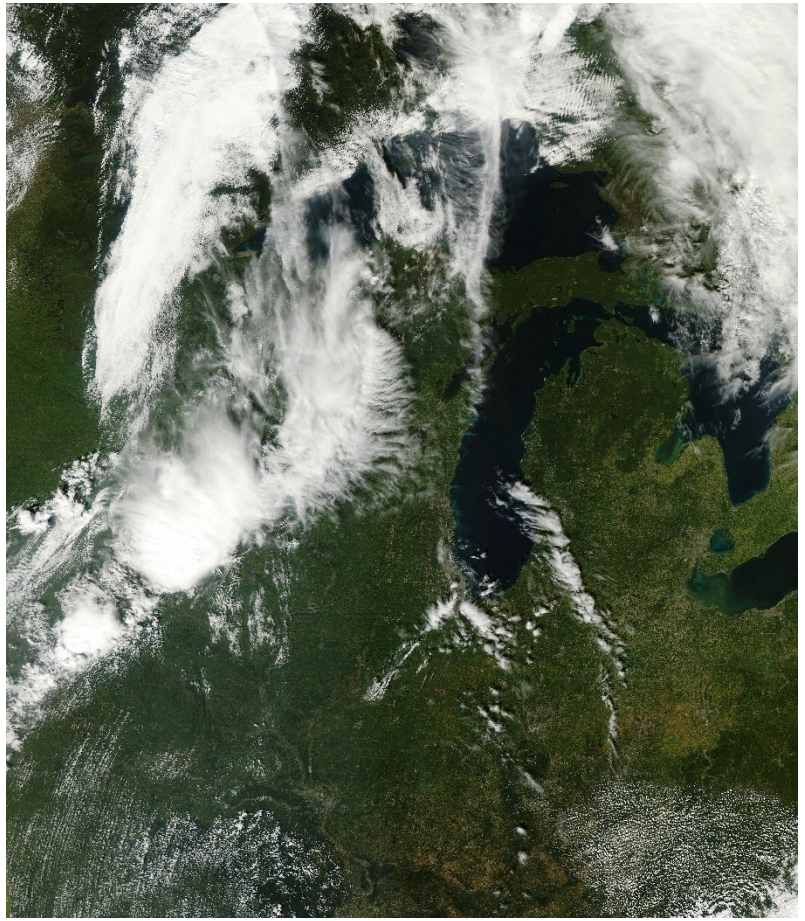
GLORIA

Supporting data-intensive water-quality algorithm development through a globally representative hyperspectral *in situ* dataset from inland and coastal waters: A community-initiative

Terra MODIS images of Wisconsin. Space Science and Engineering Center (SSEC) at the University of Wisconsin-Madison (http://ge.ssec.wisc.edu/modis-today/index.php)

Outline

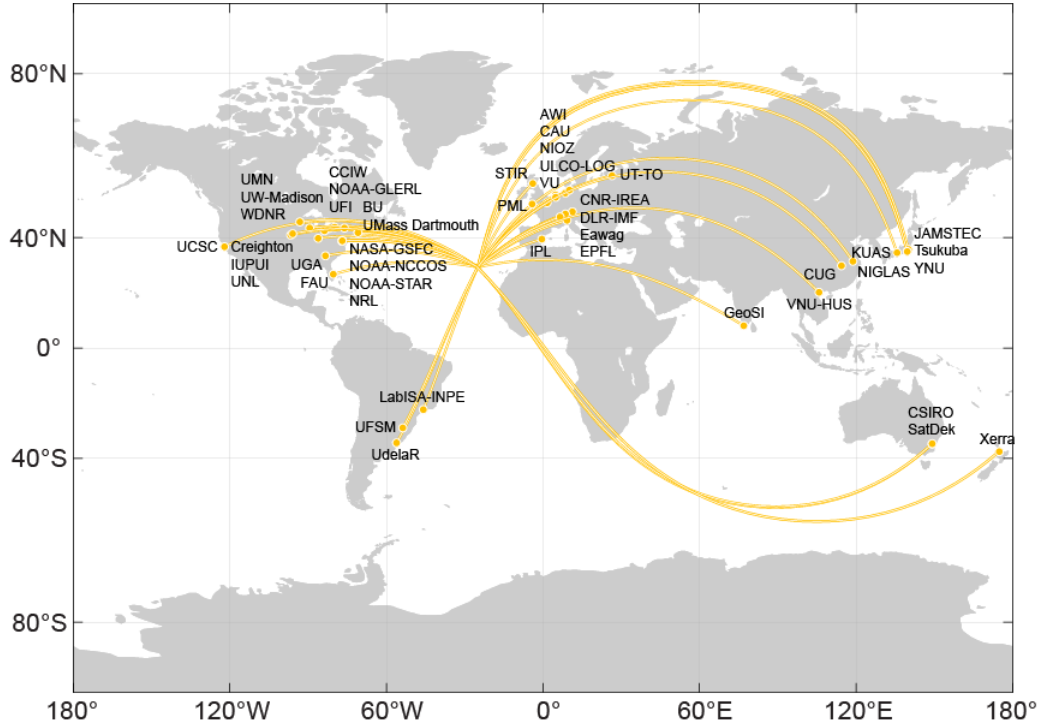
- Introduction to the GLORIA dataset
- Variables and ancillary data
- Data source, geographic extent and timespan covered
- Radiometric and water quality attribute data
- Data access and post-processing
- Data files of the GLORIA dataset
- Metadata
- Method, variable and unit keys
- Quality assurance and quality control
- Possible enhancements of the GLORIA dataset



Terra MODIS image of the Upper Midwest acquired on 09/18/2019 (Source of image: SSEC)

Introduction to the GLORIA dataset

- GLObal Reflectance community dataset for Imaging and optical sensing of Aquatic environments (GLORIA)
- Open-access dataset of over 7000 hyperspectral remote sensing reflectance, Rrs (sr^{-1}), and co-located water quality measurements contributed from researchers affiliated with 45 different institutions
- Expansion of data originally collated for a collaborative NASA-ESA-led exercise to assess the performance of atmospheric correction processors over inland and coastal waters (ACIX-II Aqua)[1]



Worldwide networking map of collaborating institutions

Variables and ancillary data

Variables

(as available)

Chla, mg m^{-3}

Chla_plus_phaeo, mg m^{-3}

TSS, g m^{-3}

a440, m^{-1}

Turbidity, NTU

Secchi_depth, m

AOT

Rrs, sr^{-1}

Radiometric component spectra

Ancillary data

(as available)

Latitude

Longitude

Date_Time_UTC

Elevation_asl, m

Wave_height, m

Wind_speed, m s^{-1}

Cloud_fraction

Depth, m

Data source, geographic extent and timespan covered

Data source

- Data acquired from the
  - SeaWiFS Bio-optical Archive and Storage System (SeaBASS):

    1221 entries

and the

  - data contributors:

    6045 entries

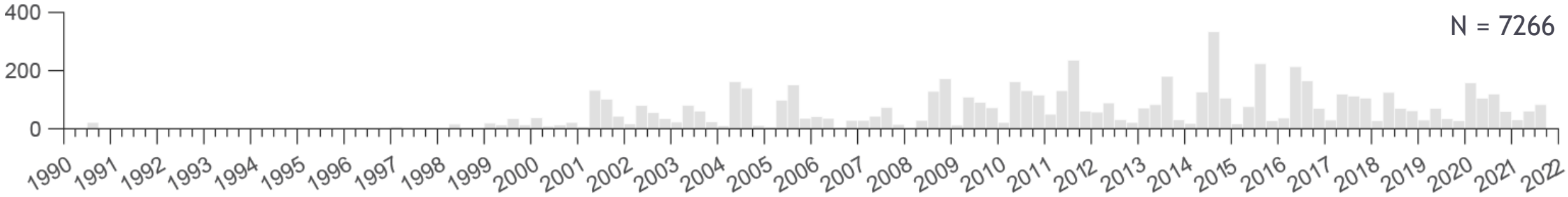
Geographic extent and timespan covered

Rrs measurements represent an

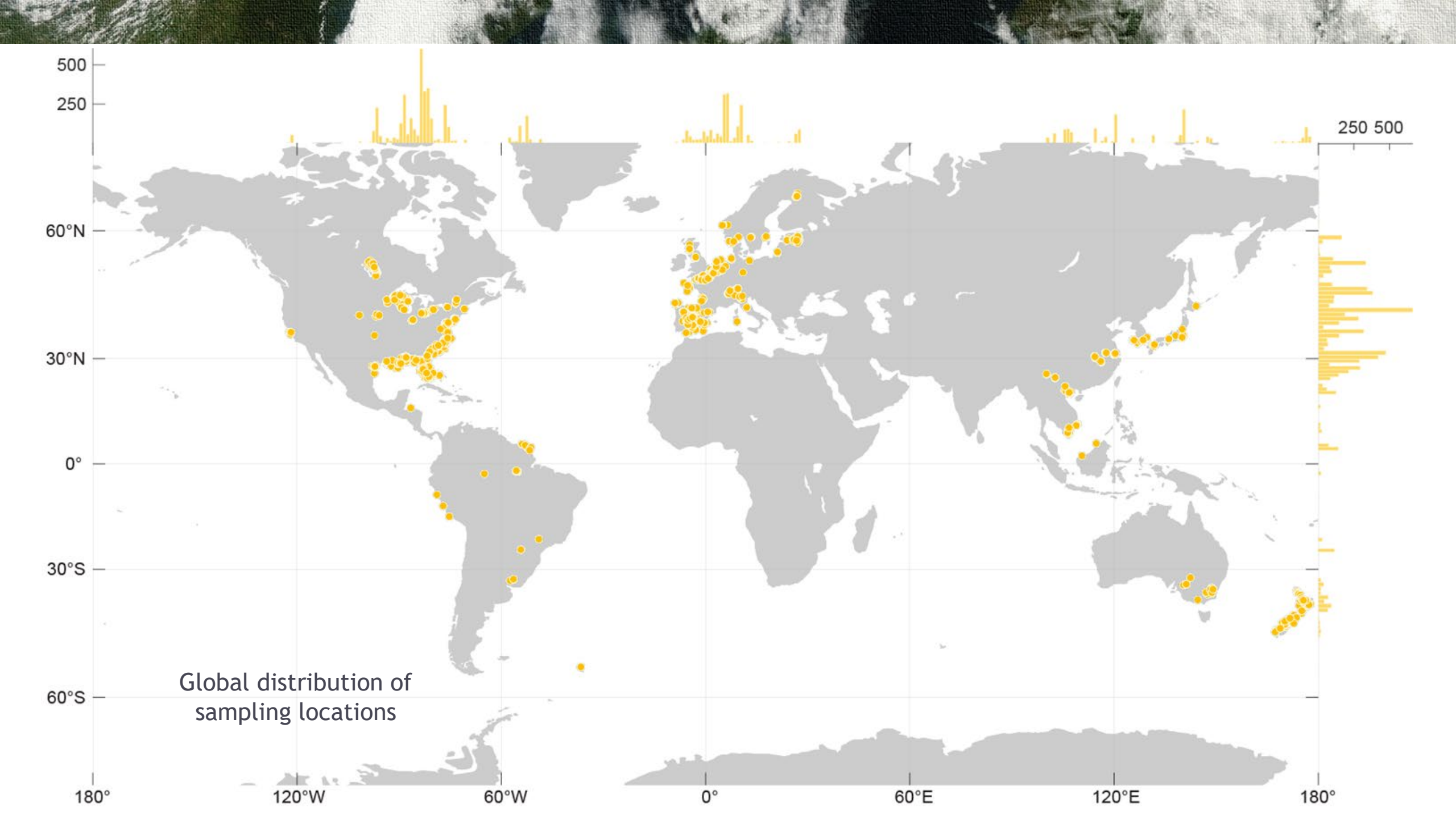
- almost global latitudinal and longitudinal range spanning at least 450 different water bodies in 26 countries over a timeframe of 32 years

from

- lakes (68.1%), followed by coastal waters (21.0%), estuaries (9.3%), rivers (0.8%) and other water body types (0.8%)



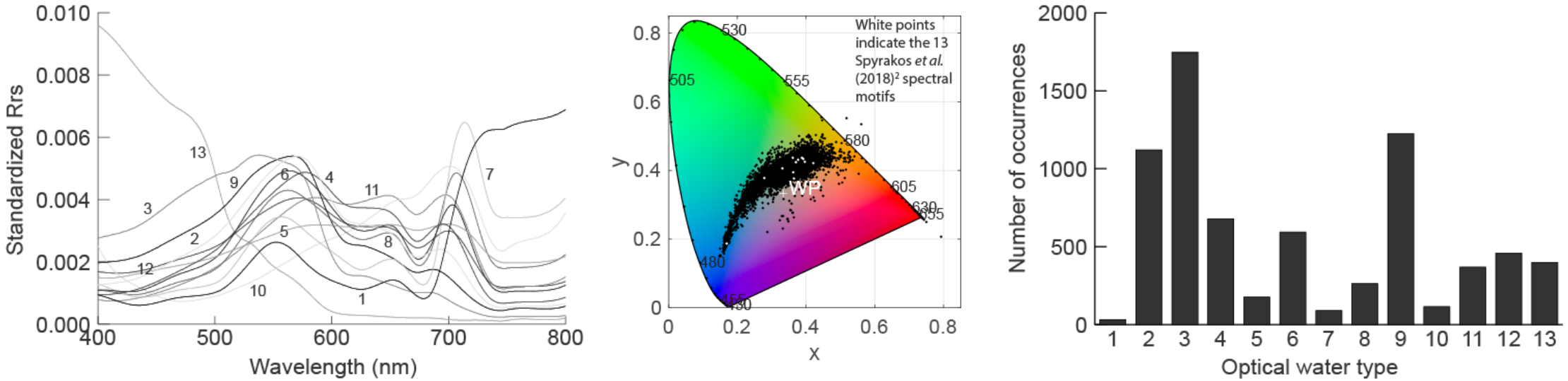
Histogram of samples collected over time



Global distribution of sampling locations

Radiometric and water quality attribute data

Radiometric data currently entail 7266 Rrs measurements ranging from sediment-, chlorophyll-, and/or CDOM-dominated to clear inland and coastal waters

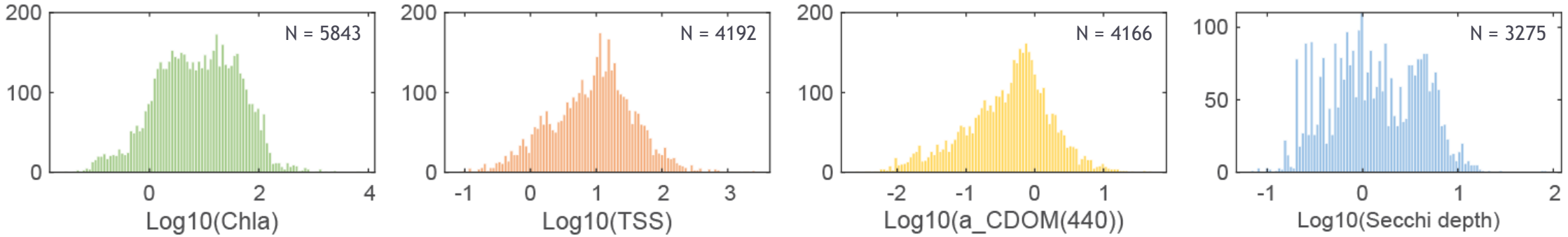


Reference spectral motifs from Spyrakos *et al*. 2018[2], chromaticity, and optical water types of the GLORIA dataset

Radiometric and water quality attribute data

Water quality attribute data currently comprise 5843 Chla, 4192 TSS, 4166 a_cdom(440), 720 turbidity and 3275 Secchi depth measurements from the same water bodies

Attribute	Unit	Min	Max	Median	Mean	Std. dev
Chla	mg m^{-3}	0.000	6988	7.88	29.9	128
TSS	g m^{-3}	0.000	2627	10.1	26.6	95.9
a_cdom(440)	m^{-1}	0.000	49.1	0.511	1.00	2.05
Turbidity	NTU	0.255	787	7.86	16.8	39.6
Secchi depth	m	0.0	28.5	1.2	2.3	2.5



Histograms of log transformed water quality attributes

Data access and post-processing

- Preliminary access for data contributors in summer 2022
- Completed detailed information recovery with them to expand and standardize the metadata
- Started to identify outliers and unrealistic spectral shapes in the radiometric data
- Open access with the acceptance of a data publication targeted for spring 2023
- Submission to the publicly shared data archives LIMNADES, PANGAEA and SeaBASS pending outstanding quality control
- Data access through the respective web portals
- Convolution to the relative spectral responses of satellite sensors in post-processing required as radiometric data is spectrally sampled to 1 nm
- Re-processing of radiometric components to Rrs for parts of the dataset optional

Data files of the GLORIA dataset

- meta_and_lab.csv
- rrs.csv
- ed.csv
- lw.csv
- lt.csv
- lu.csv
- ls.csv
- qc_codes.csv

- Metadata and water quality measurements associated with each Rrs spectrum
- Radiometric quantities at 1 nm intervals from 350 - 900 nm, or less as available
- Quality control (QC) flags (binary) for each QC procedure
- Metadata includes numerical codes from multiple choice lists, dates and text entries
- Data files linked through GLORIA unique sample ID (GID_#)

Metadata

Referencing and identification

(e.g., GLORIA_ID, Organization_ID, Dataset_ID, Sample_ID, LIMNADES_ID, LIMNADES_UID)

Site and conditions

(e.g., Site_name, Country, Country_code, Latitude, Longitude, Date_Time_UTC)

Environment

(e.g., Landcover, Topography, Distance_to_river_dis-charge, Optical_stability_of_water, Rain_event_hour)

Radiometry

(e.g. Instrument_manufacturer, Instrument_model, Last_calibration, Measurement_method)

Sample collection and analysis

(e.g. Sample_depth, Water_collection_equipment, Chl_method, Phaeophytin_correction, TSS_method, a440_method)

Radiometry

- Instrument_manufacturer
  Instrument manufacturer (multiple choice list)
- Instrument_model
  Instrument model (model number optional)
- Last_calibration
  Date last calibrated prior to data collection (yyyy-mm-dd)
- Measurement_method
  Measurement method used for radiometric measurements (multiple choice list)
- Lt_nadir_deg, Lt_azimuth_deg and Lt_relative_azimuth_deg
- Ls_zenith_deg, Ls_azimuth_deg and Ls_relative_azimuth_deg
- Spectral_resolution_nm
  Spectral resolution (FWHM) of the measurement (nm)
- Number_of_radiometers
  Number of radiometers used for radiometric measurements
- Field_of_view_Lt_radiometer_deg and Field_of_view_Lu_radiometer_deg
- Skyglint_removal
  Skyglint removal approach (multiple choice list)
- Bias_removal_in_NIR, Self-shading_correction and Viewing_angle_correction
- Additional_data_corrections
  Specification of any additional data corrections
- Availability_of_IOPs
  Absorption and scattering data availability (Not available/Available)

Metadata

*MP – Moving Platform

No.	Measurement method used for radiometric measurements (multiple choice list)
1	Sequential Lt(0+), Ls, and Ed(0+) via a plaque on MP*
2	Simultaneous Lt(0+), Ls, and Ed(0+) on MP*
3	Simultaneous Lt(0+), Ls, and Ed(0+) from a fixed platform
4	Lu(0-) and Ed(0+) on pole connected to a spectrometer via fiber optics from MP* or water edge
5	Lw(0+) and Ed(0+) afloat away from MP*
6	Lu(0-) afloat away from MP*, Ed(0+) on MP*
7	Lt(0+), Ls, and Ed(0+) on MP*
8	Lt(0+), Ls, and Ed(0+) on a frame deployed on MP*
9	Lu(0-) and Ed(0-) in-water profiling from MP*, Ed (0+) on MP*
10	Lu(0-) and Ed(z) units on a depth adjustable bar (measurements at -0.21 and -0.67m) on a frame afloat …
11	Lu(0-) and Ed(0-) from winch on MP*, Ed(0+) on MP*
12	Lt(0+) and Ed(0+) on pole from water edge
13	Lu(0-) and Ed(0-) autonomous in-water profiling from a fixed platform
14	Sequential Lt(0+) and Ed(0+) via a plaque, mounted on gimbal stabilized pole from MP*
15	Lu(0-) (and Ed(0-) only for depth information) from in-water profiling from MP*, Edf(0+) recorded simul-…
16	Lt(0+), Ls, Ed(0+), combined with one Lu unit (aperture at -0.05 to -0.10m) placed on a pole
17	Sequential Lu(0-) and Ed(0+) via a plaque, both measurements using an optical fiber to a black masked …

Method, variable and unit keys

Method details for Chla measurements

Dataset, methodology short name, filter type, pigment extraction technique, pigment quantification technique, phaeophytin correction, instrument manufacturers and models and references to the approach and applications

Method details for TSS measurements

Dataset, methodology short name, filter type, measurement technique and references to the approach and applications

Method details for a440 measurements

Dataset, methodology short name, filter type, measurement technique, instrument manufacturers and models and references to the approach and applications

Key to variables and units in the ancillary and metadata table

Data and metadata headers, decriptions and units

Quality assurance and quality control

- Some quality assurance and quality control of the submitted data, metadata, and method details has been done
- Continuous feedback loop with data contributors throughout the data standardization process ensured accurate representation of their datasets
- Use of automated quality assurance and quality control steps helped to identify outliers and unrealistic spectral shapes in the radiometry data
- Flags for Steep_UV, Noisy_rededge, Noisy_UV, Negative_Rrs_UV and Negative_Rrs_rededge in a separate qc_codes.csv file provide information on data quality issues
- Preliminary data access for data contributors will serve as additional opportunity to review the dataset

Possible enhancements of the GLORIA dataset

- Classification of the methodology, viewing angle, azimuth angle, time window, and sensor tilt would provide useful data quality filters
  - Information on sensor tilt needed
- Information about uncertainty in radiometric and water quality attribute measurements would increase user confidence
  - Information about uncertainty and/or replicates as standard deviation and bincount needed
  - Reprocessing of the radiometric data using the most recent algorithms
  - Information about differences in the original and reprocessed data to help with an assessment of the uncertainties

Acknowledgments

We would like to express our gratitude to the contributors of the GLORIA dataset and co-authors of the associated data publication

Krista Alikas, Mariana Altenburg Soppa, Janet Anstee, Sundarabalan V. Balasubramanian, Cláudio C.F. Barbosa, Caren Binding, Astrid Bracher, Mariano Bresciani, Ashley Burtner, Zhigang Cao, Arnold G. Dekker, Nathan Drayson, Reagan M. Errera, Virginia Fernandez, Cédric G. Fichot, Peter Gege, Claudia Giardino, Anatoly A. Gitelson, Steven R. Greb, Hayden Henderson, Hiroto Higa, Abolfazl Irani Rahaghi, Cédric Jamet, Dalin Jiang, Kersti Kangro, Raphael Kudela, Lin Li, Martin Ligi, Hubert Loisel, Steven Lohrenz, Ronghua Ma, Daniel A. Maciel, Tim J. Malthus, Bunkei Matsushita, Camille Minaudo, Deepak R. Mishra, Sachidananda Mishra, Tim Moore, Wesley J. Moses, Hà Nguyễn, Evlyn M.L.M. Novo, Stéfani Novoa Gautier, Daniel Odermatt, David M. O'Donnell, Leif G. Olmanson, Michael Ondrusek, Natascha Oppelt, Waterloo Pereira Filho, Stefan Plattner, Antonio Ruiz Verdú, Salem I. Salem, John F. Schalles, Stefan G.H. Simis, Eko Siswanto, Ian Somlai-Schweiger, Evangelos Spyrakos, Hans J. van der Woerd, Andrea Vander Woude, Vincent Vantrepotte, Marcel R. Wernand, Mortimer Werther and Linwei Yue

for recognizing the value of open-access datasets and contributing their data to this dataset.

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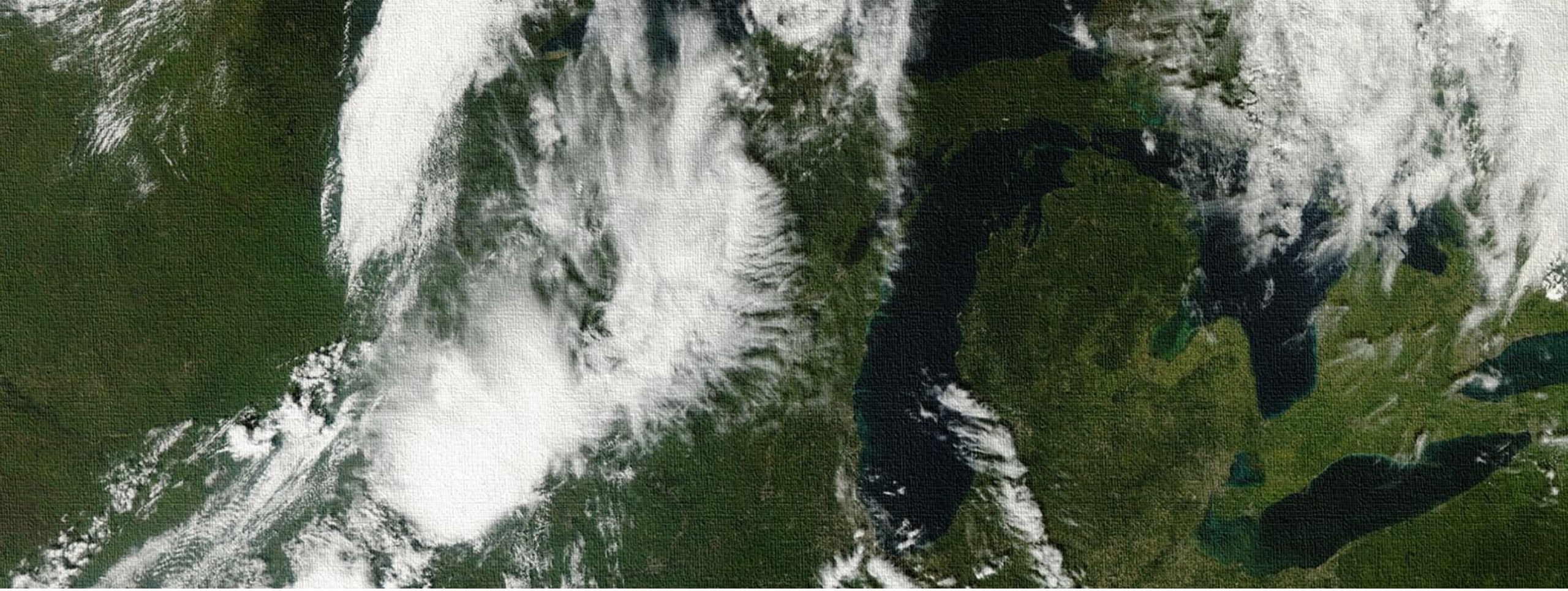
1. Pahlevan, N. *et al*. ACIX-Aqua: A global assessment of atmospheric correction methods for Landsat-8 and Sentinel-2 over lakes, rivers, and coastal waters. *Remote Sens. Environ*. 258, 112366 (2021).
2. Spyrakos, E. *et al*. Optical types of inland and coastal waters. *Limnol. Oceanogr*. 63, 846-870 (2018).



Thank you!