

Satellite Remote Sensing in Support of African Water Quality Management

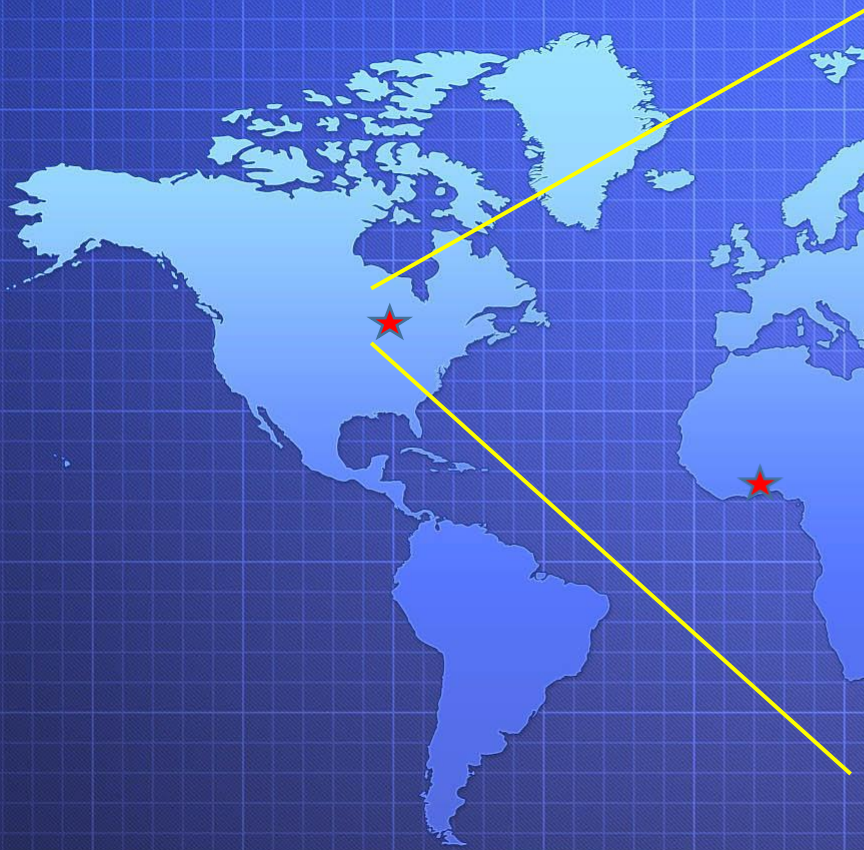
Striving to Ensure Confidence in EO Water Quality Data

Steven Greb

Director, GEO AquaWatch and University of Wisconsin, Madison, WI. USA



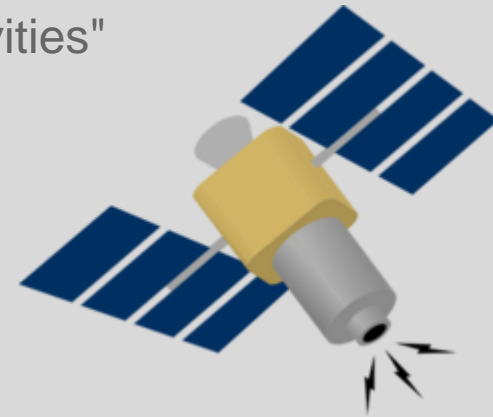




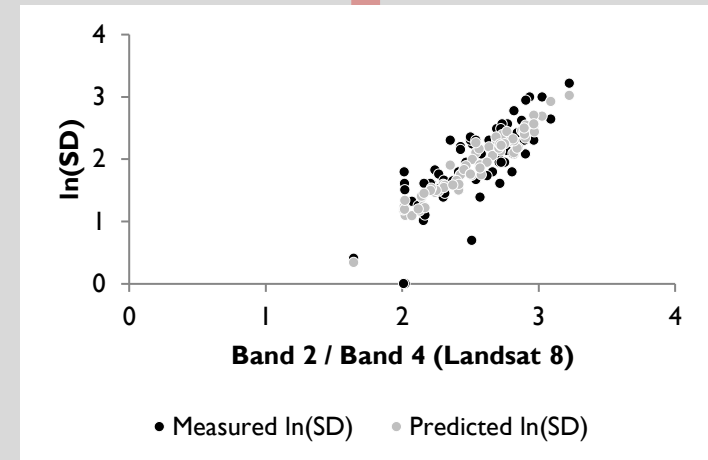
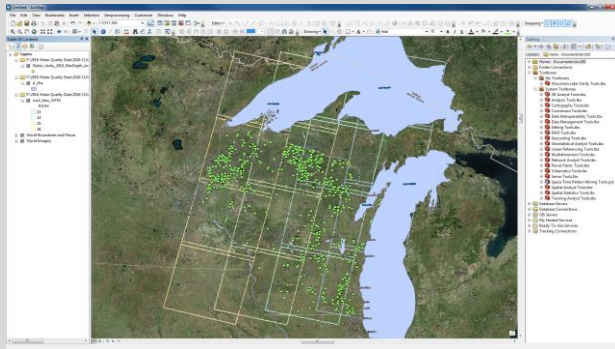
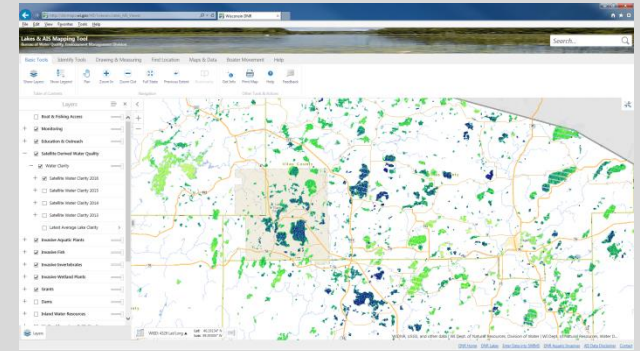




"to the government in the forms of serving in office, offering advice about public policy, providing information and exercising technical skill, and to the citizens in the forms of doing research directed at solving problems that are important to the state and conducting outreach activities"



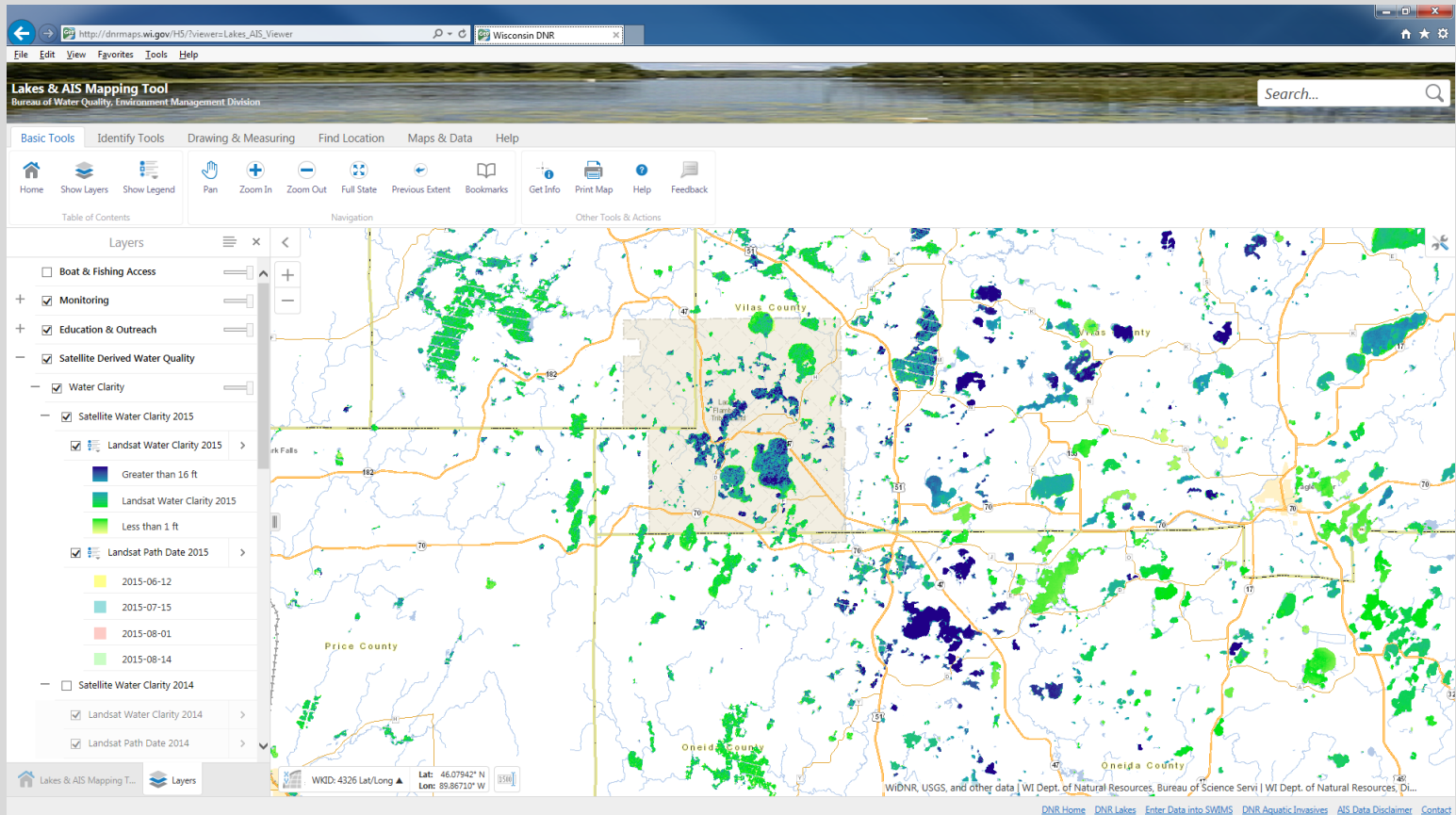
Systematic processing of satellite data



Systematic processing of satellite data

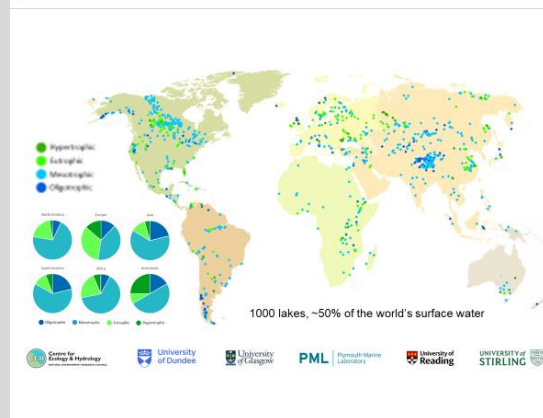
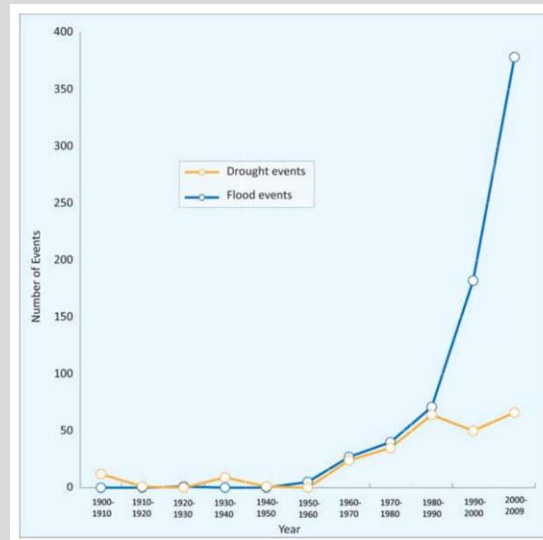
<http://dnr.wi.gov/lakes/viewer/>

[Link to web site](http://dnr.wi.gov/lakes/viewer/)



Sobering Water Facts of Africa

- 663 million people rely on unimproved sources, including 159 million dependent on surface water
- Contaminated water can transmit diseases such as diarrhea, cholera, dysentery, typhoid and polio.
- Poor sanitation and water quality practices result in 115 deaths every hour in the African Region (WHO Regional Office for Africa).
- Africa is home to 677 lakes, 25% of the planet's unfrozen surface fresh water.
- Many of the rivers and lakes in Africa are shared by more than 1-2 or more countries leading to political stress, where the parties interested keep conflicting over the ownership/usage of the resources.
- Unequal distribution of water (e.g. 30% of the continent's water is found in the Congo Basin)
- Dearth of Water Quality Information





New Sensor Technology



Big Data and Cloud Processing

Rapid
Advancement in
Satellite Remote
Sensing



Algorithm Advancement and
Machine Learning

$$r_{rs}(\lambda) \approx \sum_{i=1}^2 g_i \left(\frac{b_b(\lambda)}{b_b(\lambda) + a(\lambda)} \right)^i \quad (\text{sr}^{-1}),$$



Education and Capacity
Development

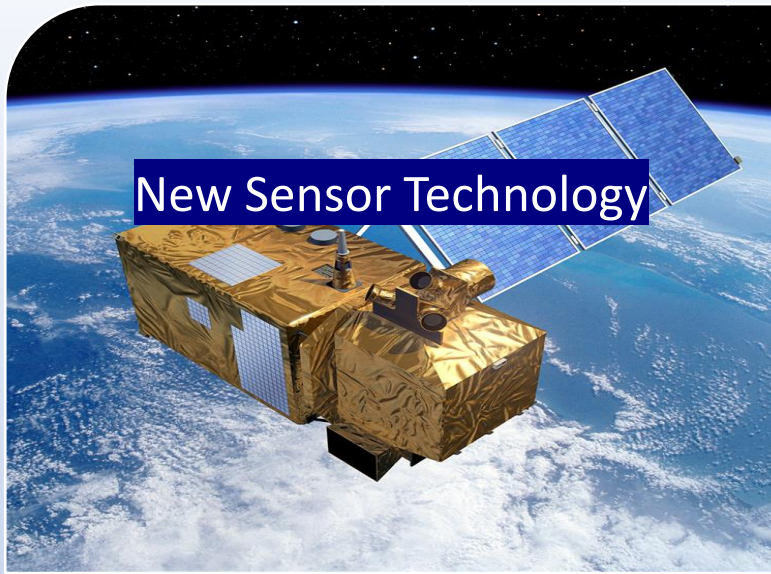
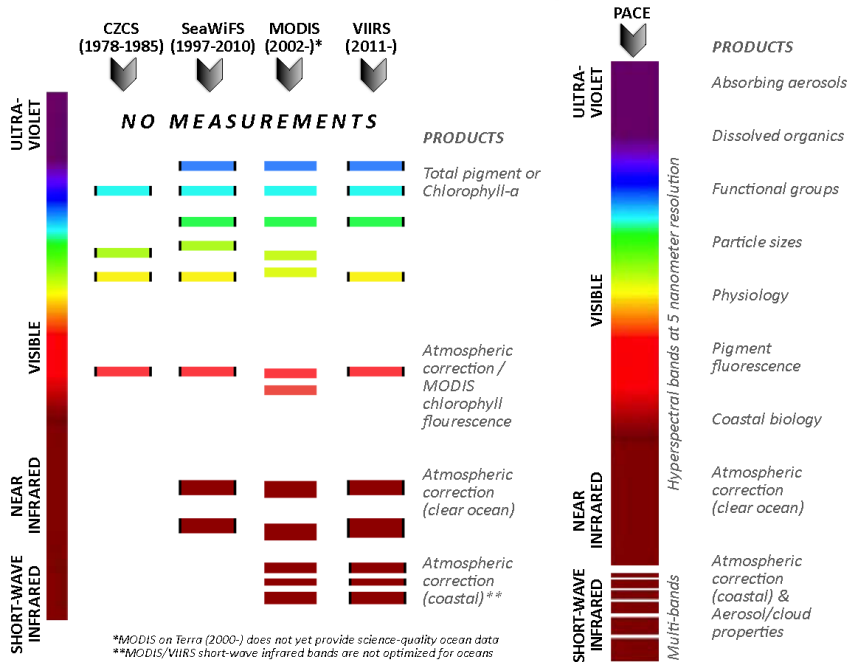


Table 6.4 - Continued from previous page

Sensor Type	Sensor	Resolution (Pixel size)	Spec. Bands	Revisit Frequency	Data Cost	Launch Date	Water Quality Variables						Macrophytes		
							CHL	CYP	TSM	CDOM	Kd	Turb	Emerg.	Float	Subm.
high spatial resolution	QuickBird, SPOT6, GeoEYE	2 - 4 m	3 - 4	programmable 60 d to 2-3 d	5-15	1999 onwards	●	●	●	●	●	●	●	●	●
	RapidEye	6.5 m	5	daily	1.5	Aug-08	●	●	●	●	●	●	●	●	●
	WorldView-2	2 m spectral, 0.5 m B&W	8	programmable 60 d to 1 d	30	Oct-09	●	●	●	●	●	●	●	●	●
	WorldView-3	1.2 m spectral, 0.5 m B&W	8	programmable 60 d to 1 d	30	2014	●	●	●	●	●	●	●	●	●
ocean-coastal	OLCI	300 m	21	daily (2 sats.)	free	2016	●	●	●	●	●	●	●	●	●
ocean-coastal	SGI-2	250 m	9	2 - 4 d	free	2017	●	●	●	●	●	●	●	●	●
	JPSS-1, JPSS-2, etc.	750 m	10	daily	free	2017, 2022	●	●	●	●	●	●	●	●	●
	JPSS-1, JPSS-2, etc.	375 m	3	daily	free	2017, 2022	●	●	●	●	●	●	●	●	●
hyperspectral	OCM-3	300 m	15	2-3 d	free	2017	●	●	●	●	●	●	●	●	●
	EnMap	30 m	90	programmable (once/4 d)	free (?)	2019	●	●	●	●	●	●	●	●	●
	DESIS	30 m	235	orbit 51°N, 51°S, 3 to 5 d cadence	free (?)	2018	●	●	●	●	●	●	●	●	●
	HISUI-hyper	30 m	60	orbit 51°N, 51°S, 3 to 5 d cadence	free (?)	2018	●	●	●	●	●	●	●	●	●
	PRISMA	20 m spectral, 2.5 m B&W	60	25 d / pointing 7d	free (?)	2018	●	●	●	●	●	●	●	●	●
	HySpIRI*	30	60	16	free	2022	●	●	●	●	●	●	●	●	●

* The 2017 US Decadal Survey recommended several designated target observables, including surface biology and geology (SBG). SBG has candidate measurement approaches that are similar to the HySpIRI mission concept that NASA was developing over the past decade, including inland and near-coastal aquatic ecosystems.

SPECTRAL COVERAGE OCEAN COLOR HERITAGE SENSORS compared with PACE

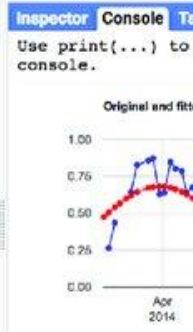




Big Data and Cloud Processing

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ine Search places and datasets...

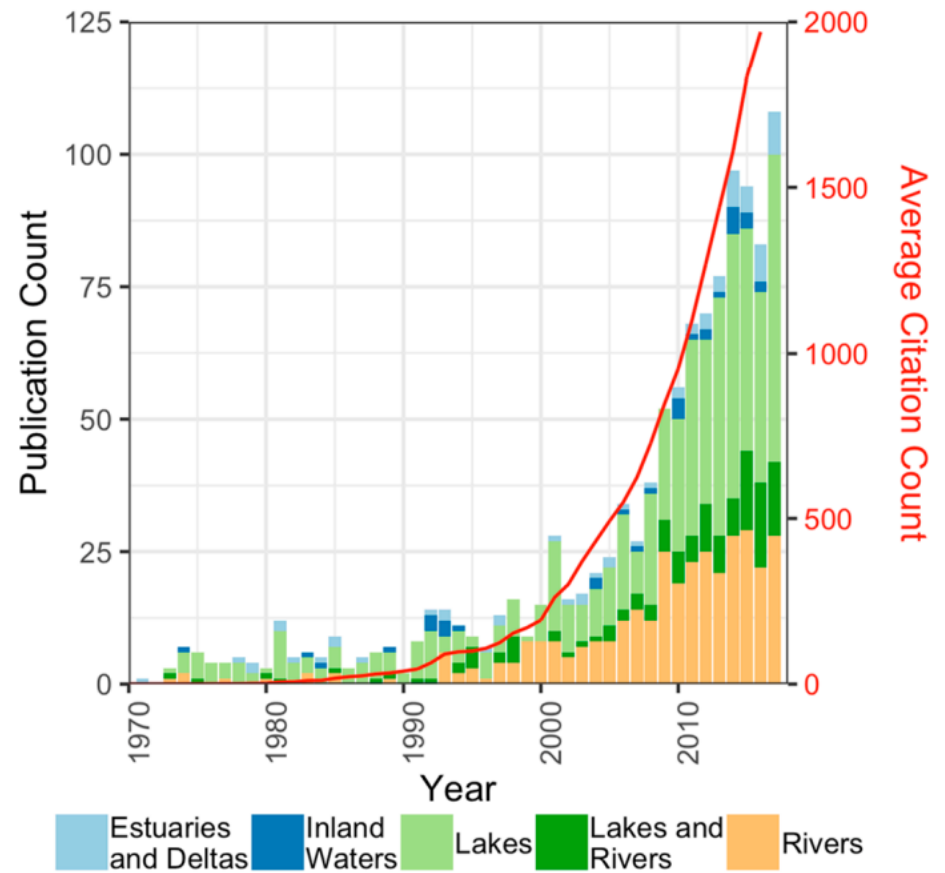
Landsat - Phenology Model.js Get Link Save Run Reset Inspector Console Ta
37 // Set up the "design matrix" to input to the regression.
38 function createLinearModelInputs(img) {
39   var tstamp = ee.Date(img.get('system:time_start'));
40   var tdelta = tstamp.difference(start, 'year');
41   // Build an image that will be used to fit the equation
42   // c0 + c1*sin(2*pi*t) + c2*cos(2*pi*t) = NDVI
43   var img_fitting = img.select()
44     .addBands(1)
45     .addBands(tdelta.multiply(2*Math.PI).sin())
46     .addBands(tdelta.multiply(2*Math.PI).cos())
47     .addBands(img.select('NDVI'))
48     .toDouble();
49   return img_fitting;
50 }
51
52 // Estimate NDVI according to the fitted model.
53 function predictNDVI(img) {
54   var tstamp = ee.Date(img.get('system:time_start'));
55   var tdelta = tstamp.difference(start, 'year');
56   // predicted NDVI = c0 + c1*sin(2*pi*t) + c2*cos(2*pi*t)
57   var predicted = ee.Image(meanCoeff)
58     .add(c0Coeff.multiply(tdelta.multiply(2*Math.PI).sin())
59     .add(c1Coeff.multiply(tdelta.multiply(2*Math.PI).cos())
60     .add(c2Coeff.multiply(tdelta.multiply(2*Math.PI).cos()));
61 }
62 }
63 }
64 }
```



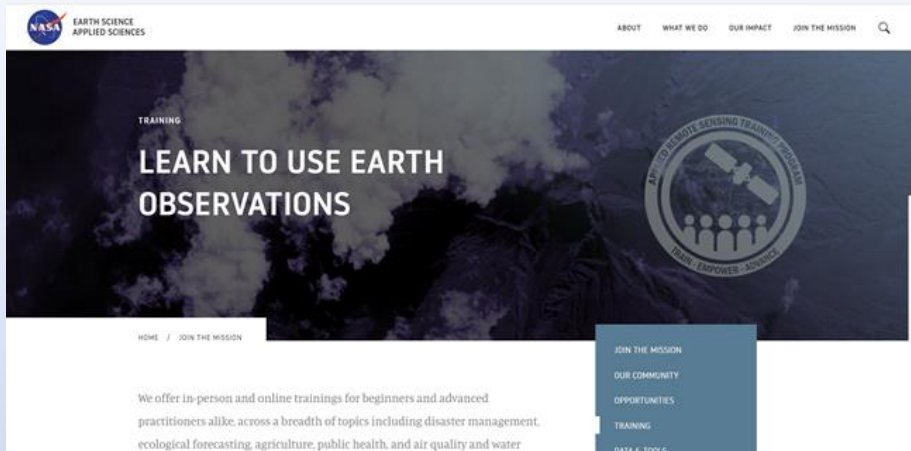


Algorithm Advancement and Machine Learning

$$r_{rs}(\lambda) \approx \sum_{i=1}^2 g_i \left(\frac{b_b(\lambda)}{b_b(\lambda) + a(\lambda)} \right)^i \quad (\text{sr}^{-1}),$$



Topp et. al.,2020



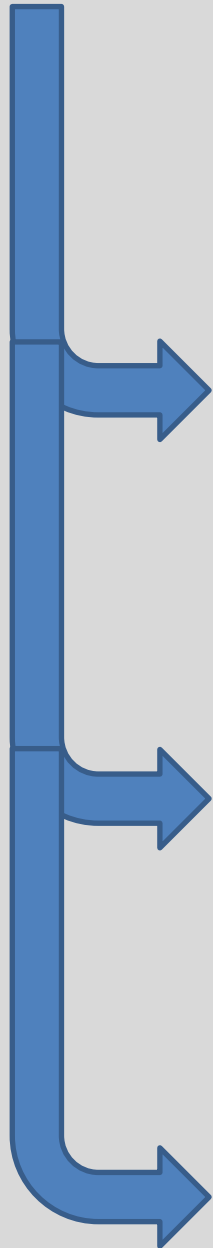
<https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset>



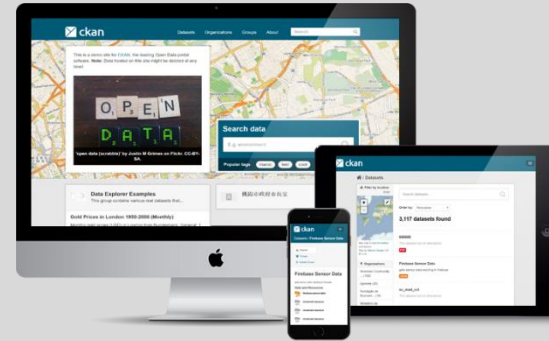
<https://www.copernicus.eu/en/opportunities/education/copernicus-academy>



Entrance ramps to data products



Web applications/
portals



PC Softwares



Cloud Resources



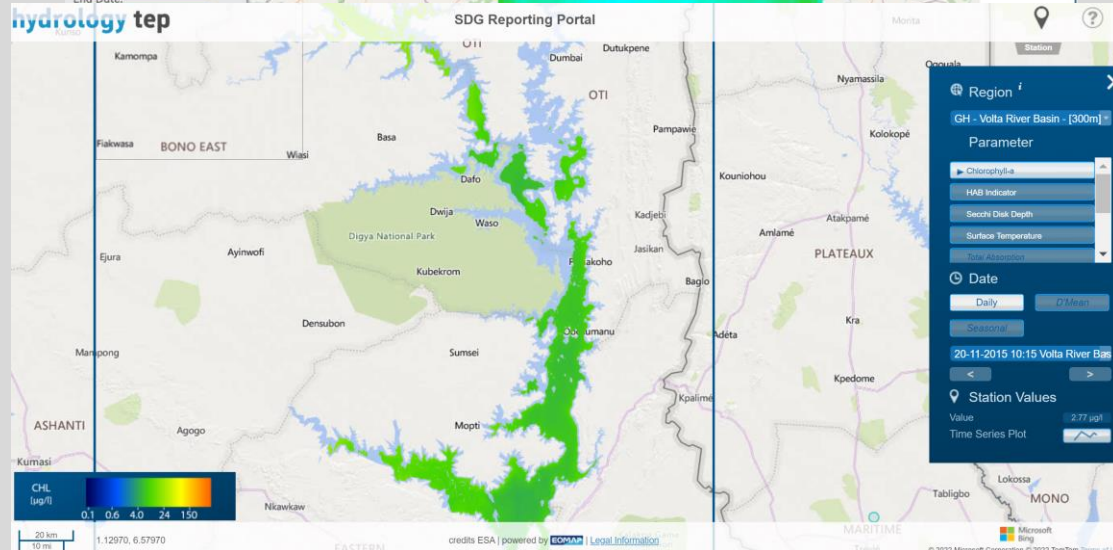
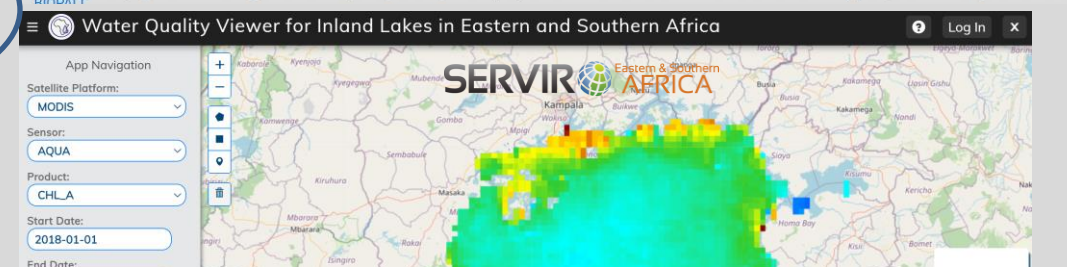
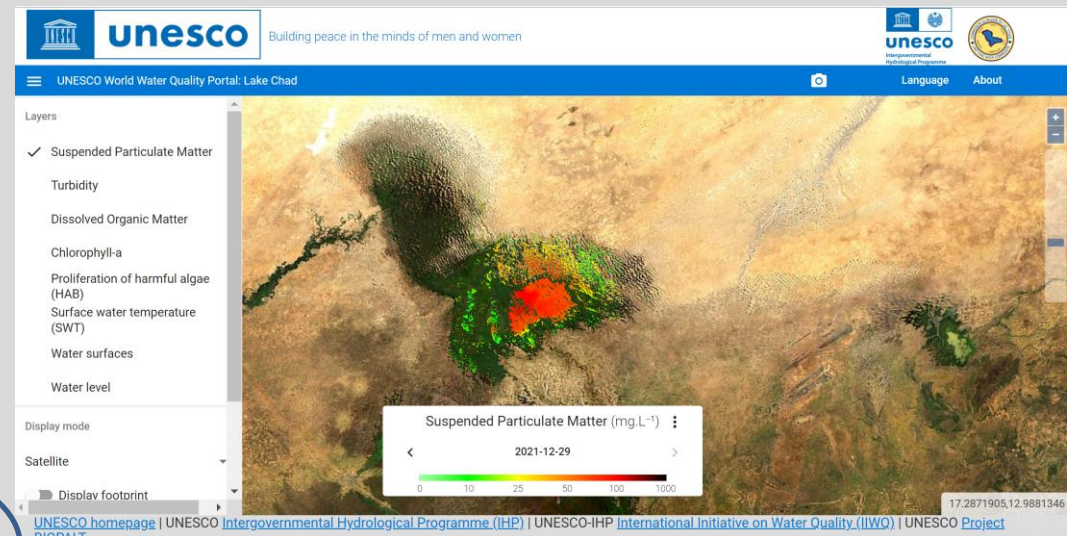
Entrance ramps to data products

Examples of African Web portals

Web applications/
portals

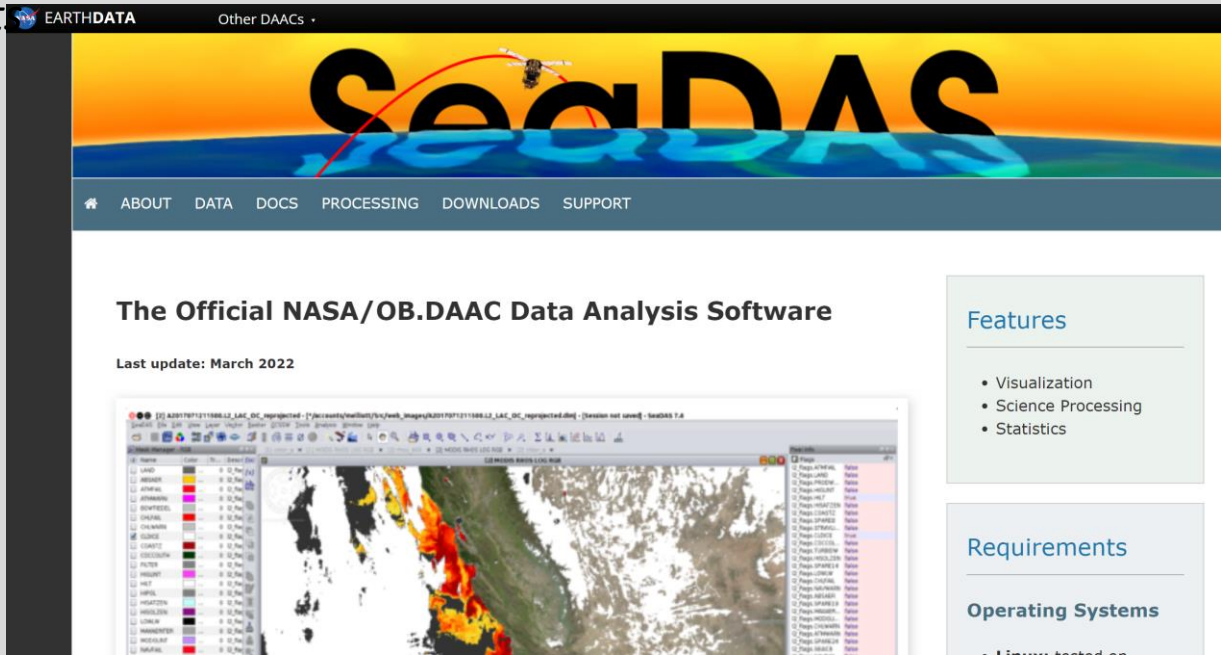
PC Softwares

Cloud Resources



Thematic Exploitation Platform

Entrance ramps to data product



The screenshot shows the SeaDAS website header with the NASA EarthData logo and navigation links: ABOUT, DATA, DOCS, PROCESSING, DOWNLOADS, SUPPORT. The main heading is "The Official NASA/OB.DAAC Data Analysis Software" with a "Last update: March 2022" note. A central image displays the SeaDAS software interface, which includes a satellite data visualization of a coastal region and a list of data products on the left. To the right of the interface, there are sections for "Features" (Visualization, Science Processing, Statistics), "Requirements", and "Operating Systems".

Web applications/
portals

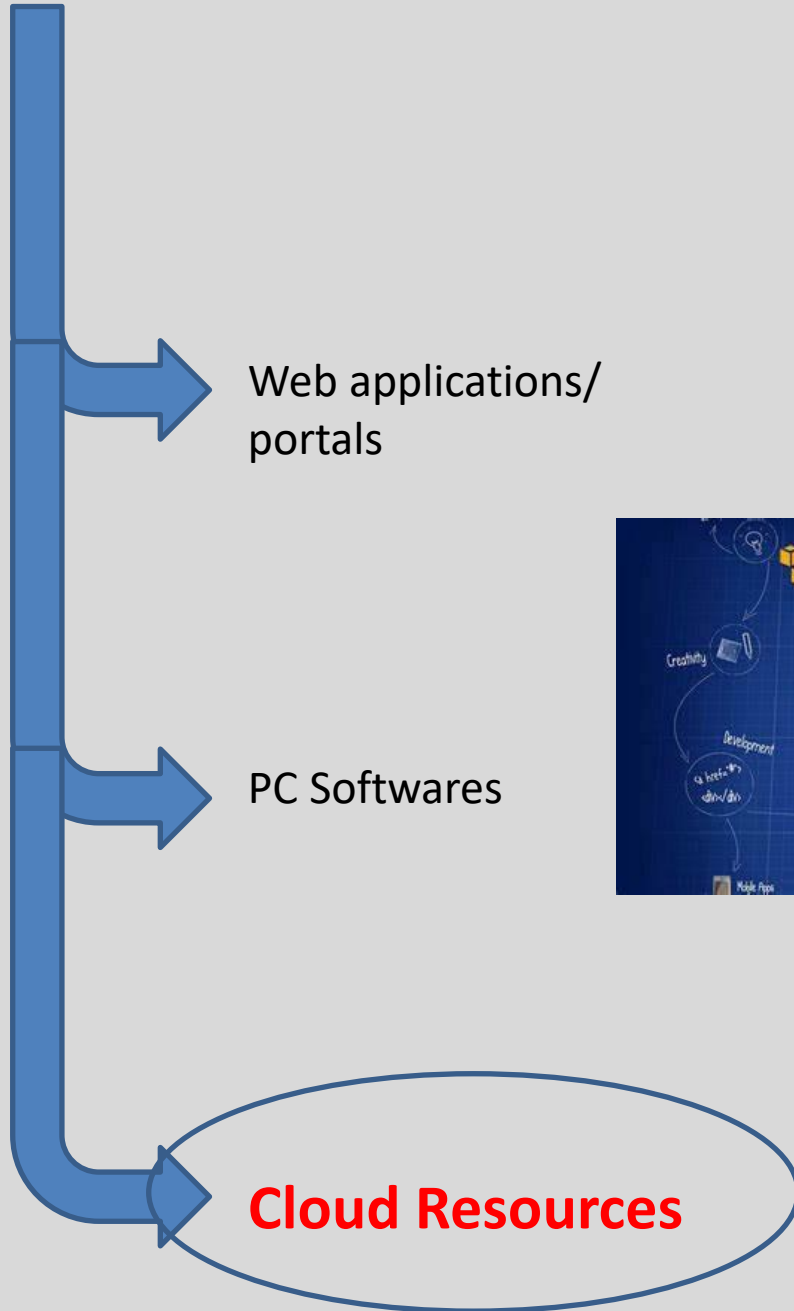
PC Softwares

Cloud Resources



The screenshot shows the SNAP (Software for Near-Realtime Analysis of Precipitation) interface. The header includes the ESA logo and the text "Science Toolbox Exploitation Platform". The main area features a background image of Earth from space with satellite icons and the text "TOOLBOXES" and "SNAP".

Entrance ramps to data products



Web applications/
portals

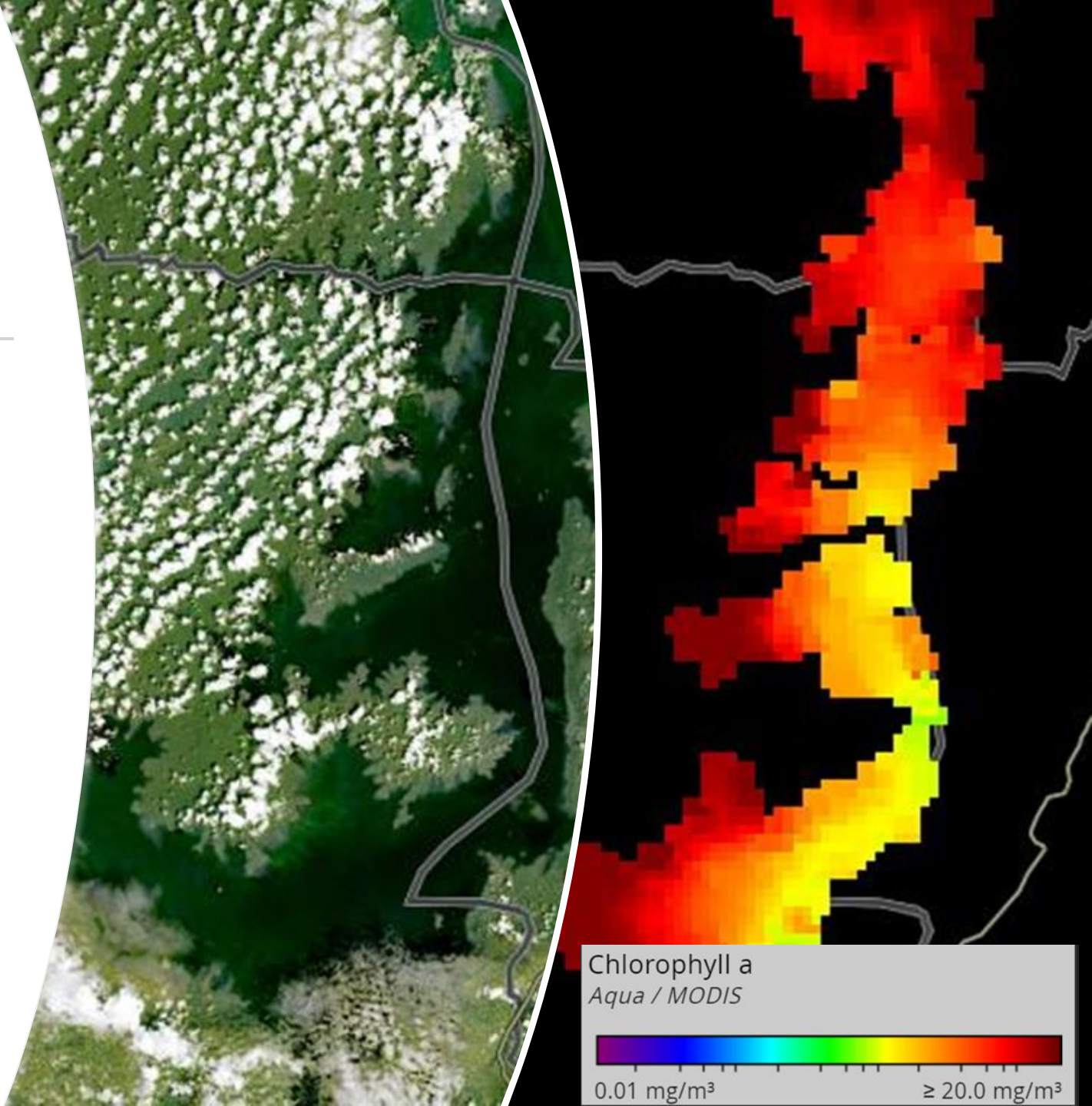
PC Softwares

Cloud Resources



A call for *in situ* observations

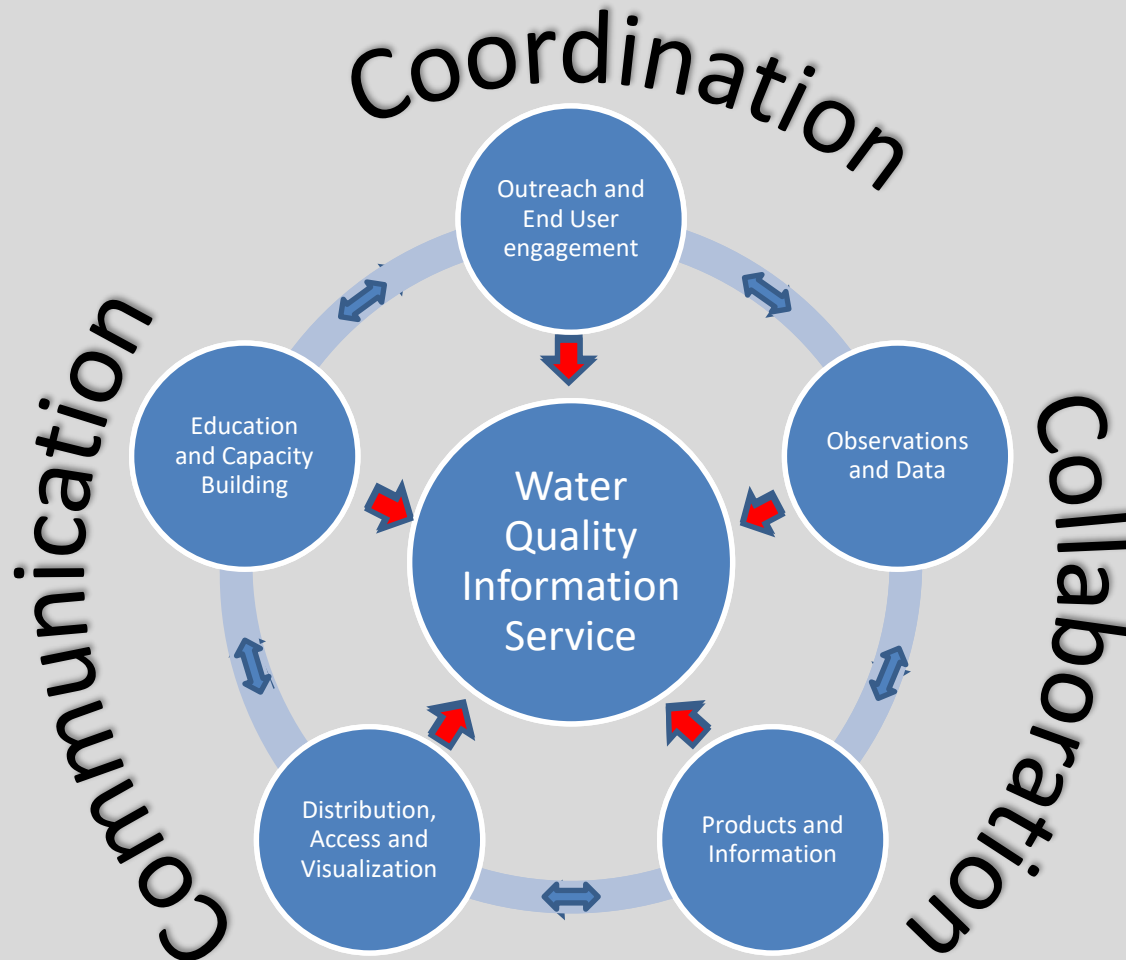
- Optimize algorithm parameterizations **for full range of OWTs** or regions
- Validate algorithms and data products **over the lifetime** of satellite missions
- Fill spatial and temporal gaps in satellite data coverage



Chlorophyll a
Aqua / MODIS



AquaWatch aims to develop and build the global capacity and utility of Earth Observation-derived water quality data, products and information to support water resources management and decision making.



Website

www.geoaquawatch.org



DNR photo by Diane Glodoski