Biodiversity Indication for 300 Lakes worldwide using ENVISAT

Daniel Odermatt[a,b], Carsten Brockmann[a], Petra Philipson[c], Marc Paganini[d]

[a] Brockmann Consult GmbH, Germany
[b] Odermatt & Brockmann GmbH, Switzerland
[c] Brockmann Geomatics, Sweden
[d] ESA ESRIN, Italy

ESA Mapping Water Bodies from Space Conference, 18.3.2015

Introduction

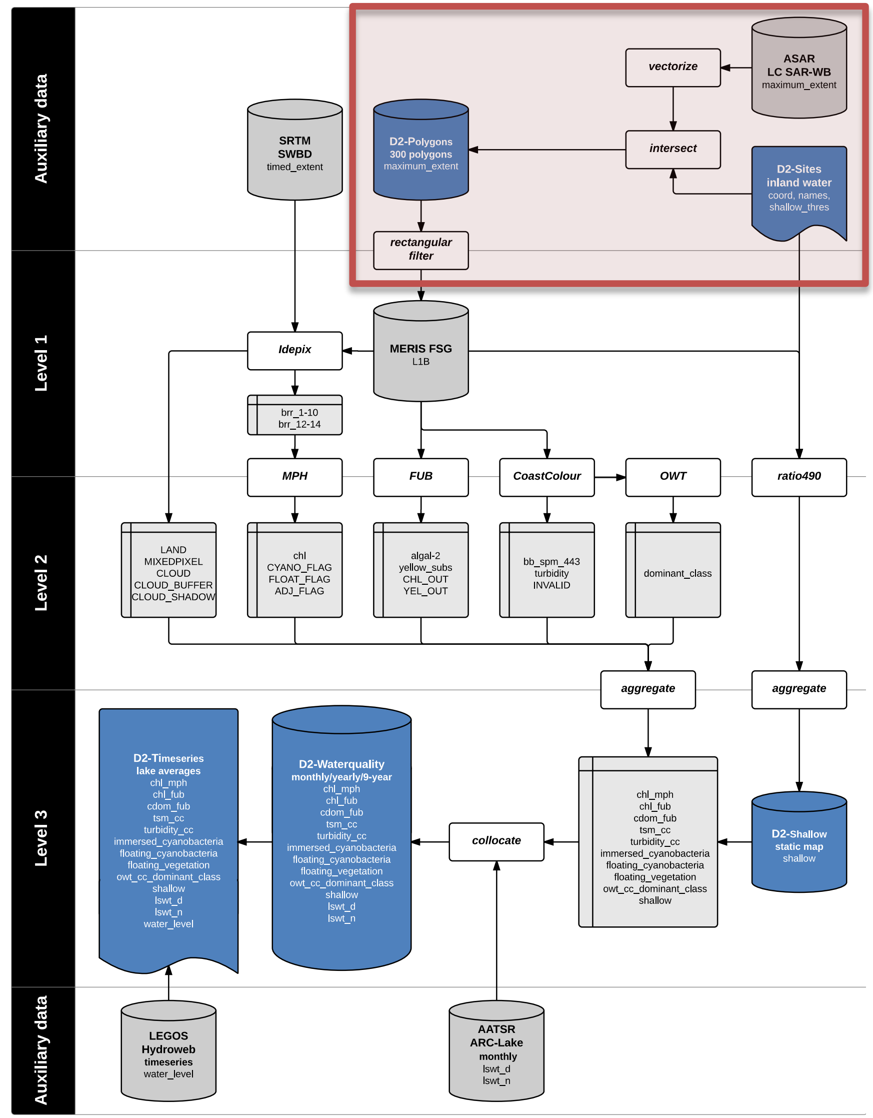
„The ultimate goal of the Diversity II Project is to … contribute to the assessment and monitoring of the Aichi 2020 Biodiversity Targets of the CBD.“ (SoW, 2011)

- Dedicated tasks to achieve this goal:
  - Link biodiversity and EO experts
  - Selection of best algorithms available
  - Production by using and extending existing components
  - Validation
- Diversity II is an ESA DUE project, lasting from September 2012 to May 2015
- The content of this presentation focuses on inland waters, but drylands are addressed equally in the scope of Diversity II
- The CaLimnos lake processing chain developed for Diversity II is further developed in collaboration with the GloboLakes team (Simis et al.@MWBS)

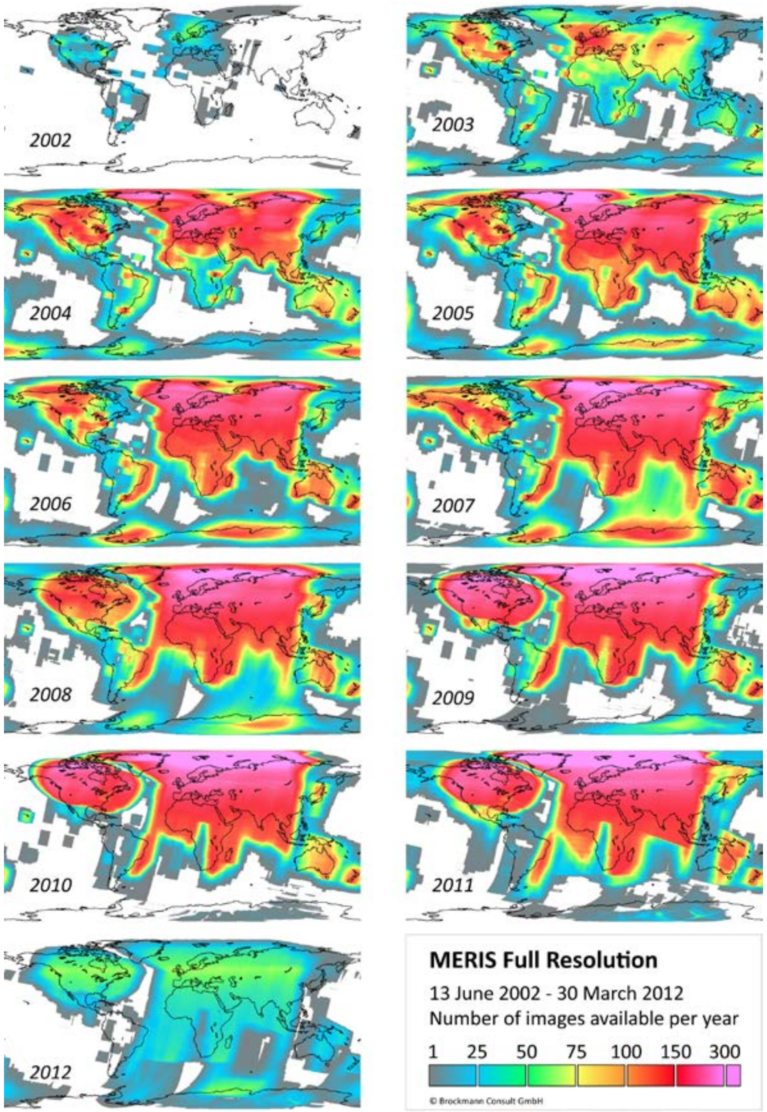
CaLimnos Processing Chain

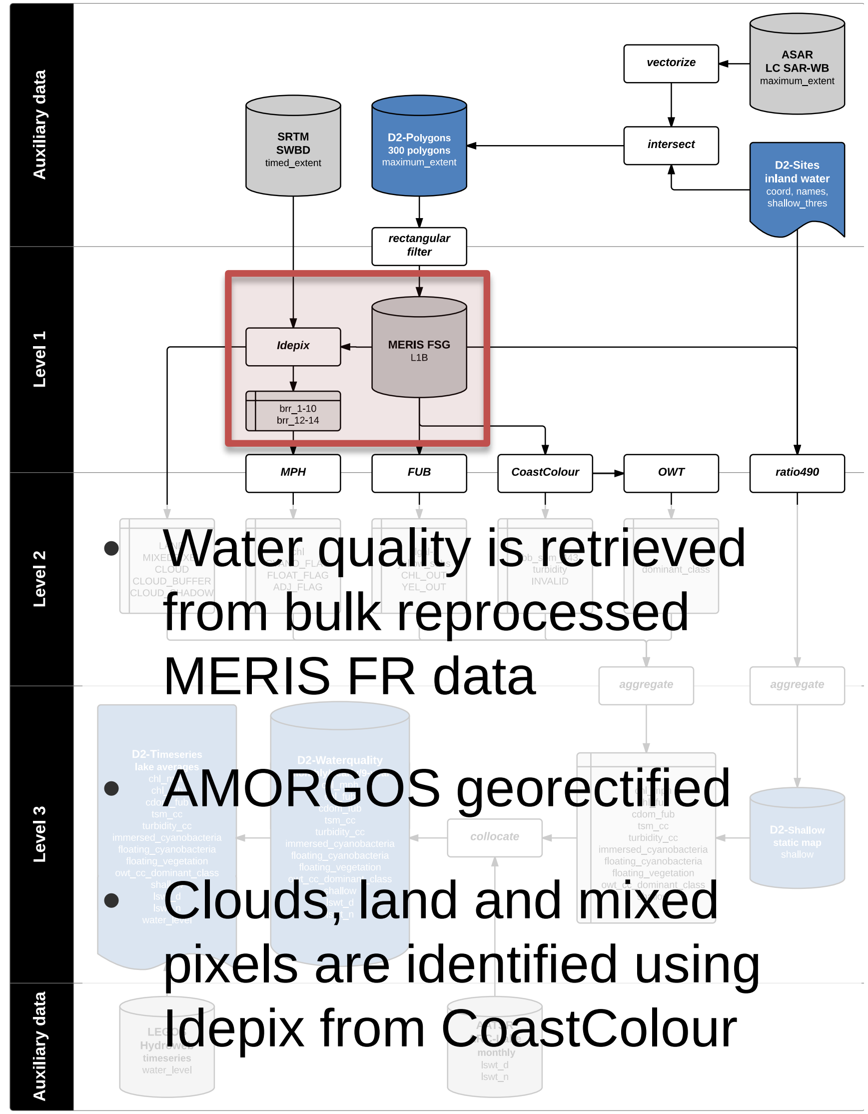
- ROIs are defined as vectorized maximum lake extents from the LC-CCI WB (Santoro et al.@MWBS)
- Each of the 300 lake is represented by one polygon separated at 300 m resolution
- GLWD metadata are provided in a merged attribute table

www.goo.gl/9qES0n



CaLimnos Processing Chain

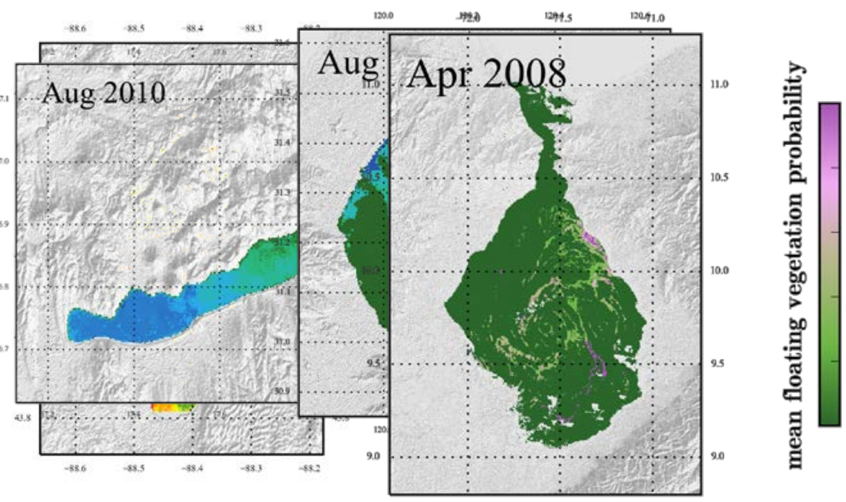


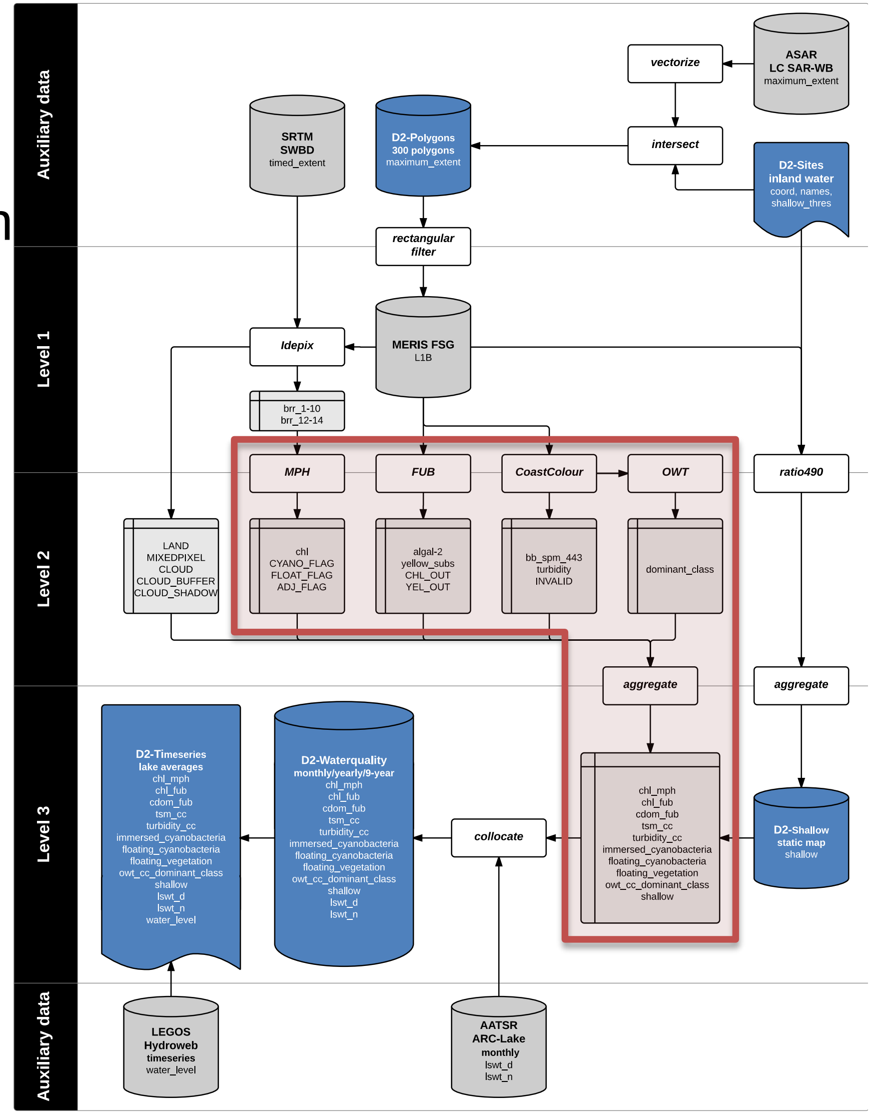


- Water quality is retrieved from bulk reprocessed MERIS FR data
- AMORGOS georectified
- Clouds, land and mixed pixels are identified using Idepix from CoastColour

CaLimnos Processing Chain

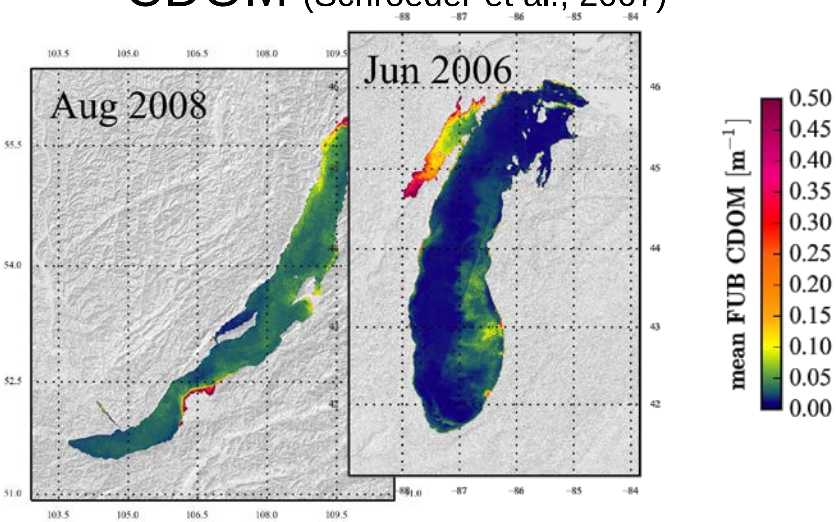
- Water quality retrieval algorithms are applied to derive L2 products
- L2 layers are aggregated as mean monthly L3, using algorithm-specific valid pixel expressions
- MPH for Chlorophyll-*a*, cyano-bacteria and floating matter in eutrophic lakes (Matthews & Odermatt, 2015)

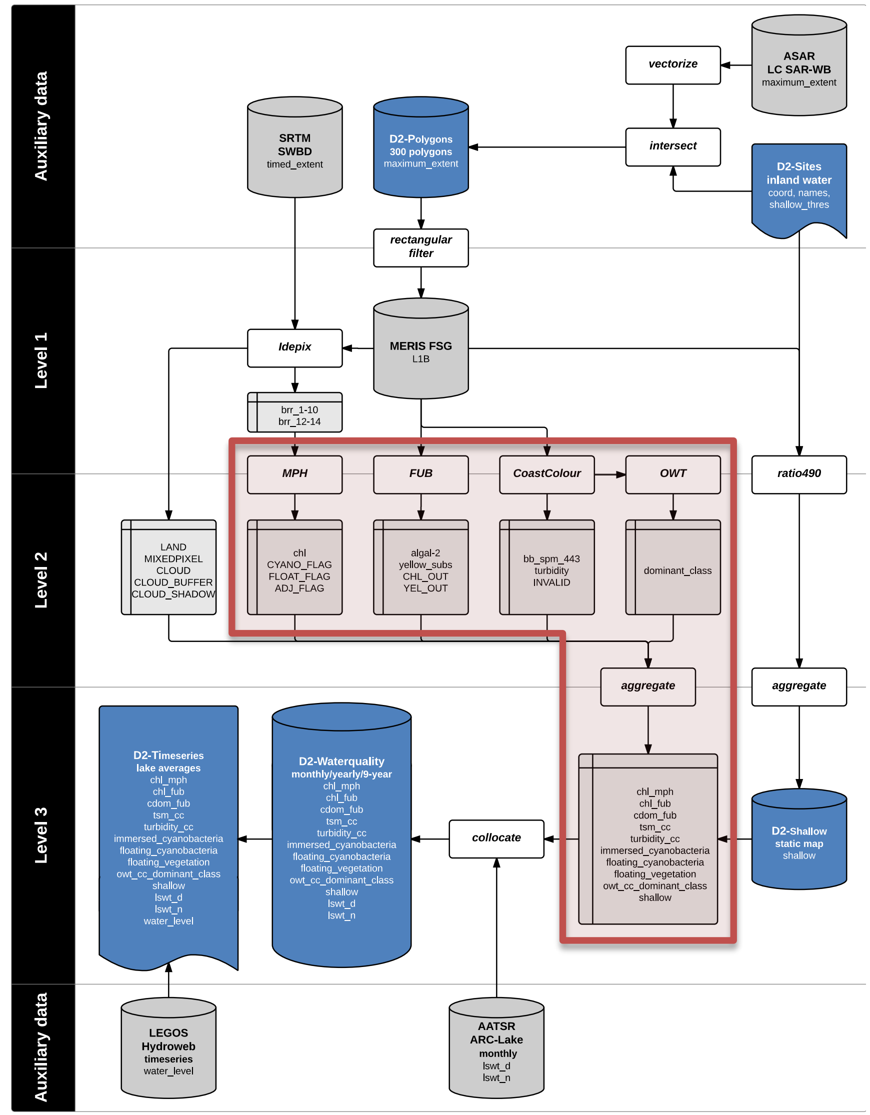




CaLimnos Processing Chain

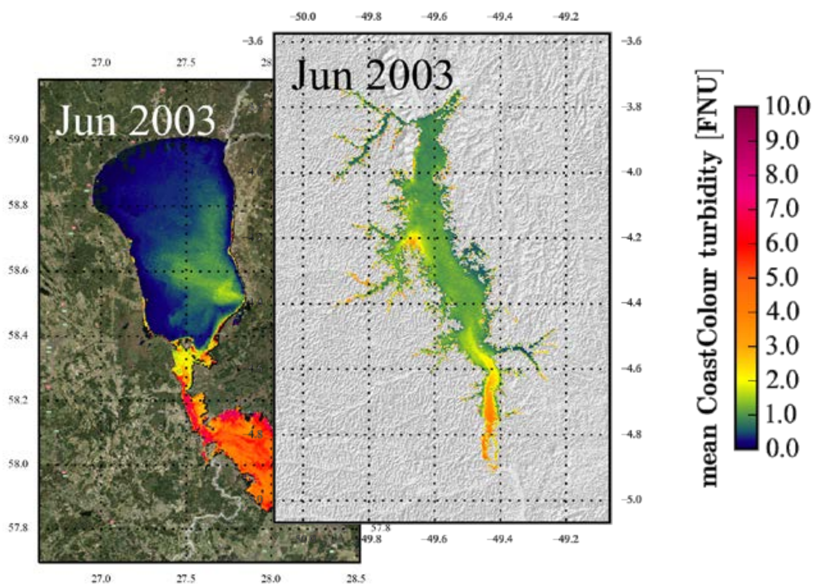
- Water quality retrieval algorithms are applied to derive L2 products
- L2 layers are aggregated as mean monthly L3, using algorithm-specific valid pixel expressions
- FUB algorithm for low to moderate Chlorophyll-*a* and CDOM (Schroeder et al., 2007)

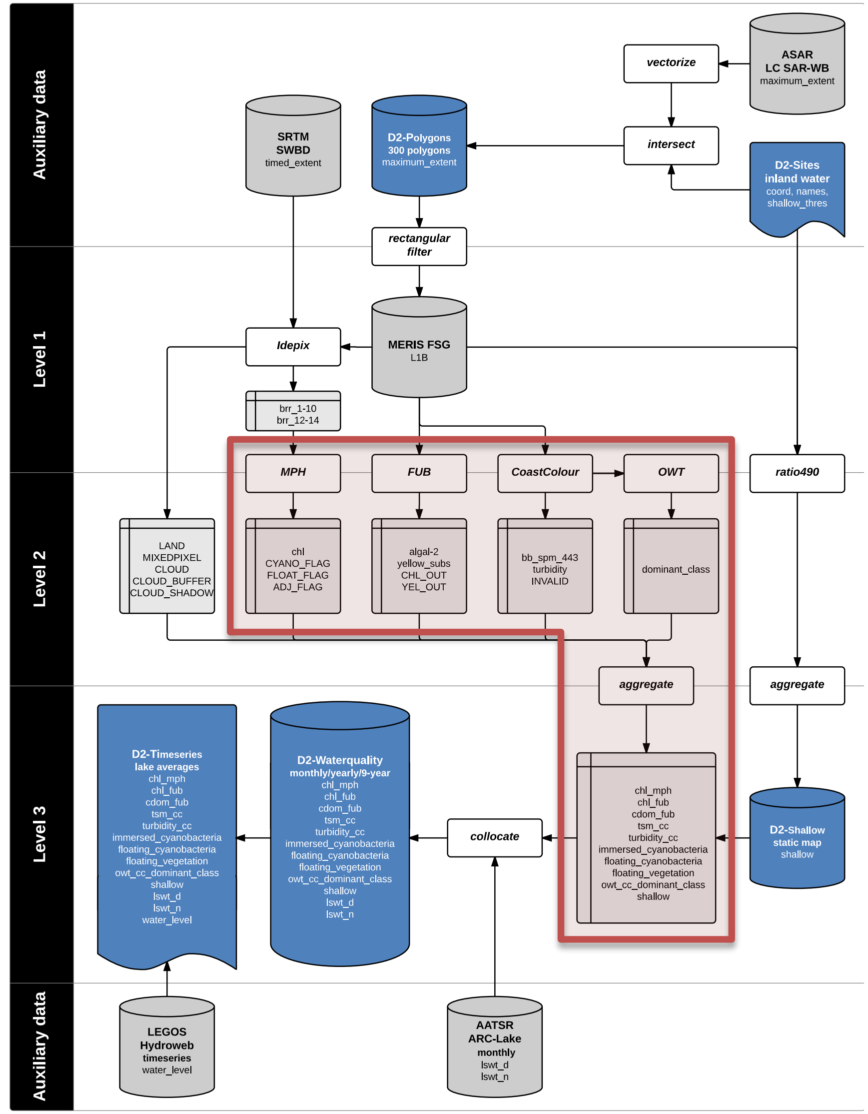




CaLimnos Processing Chain

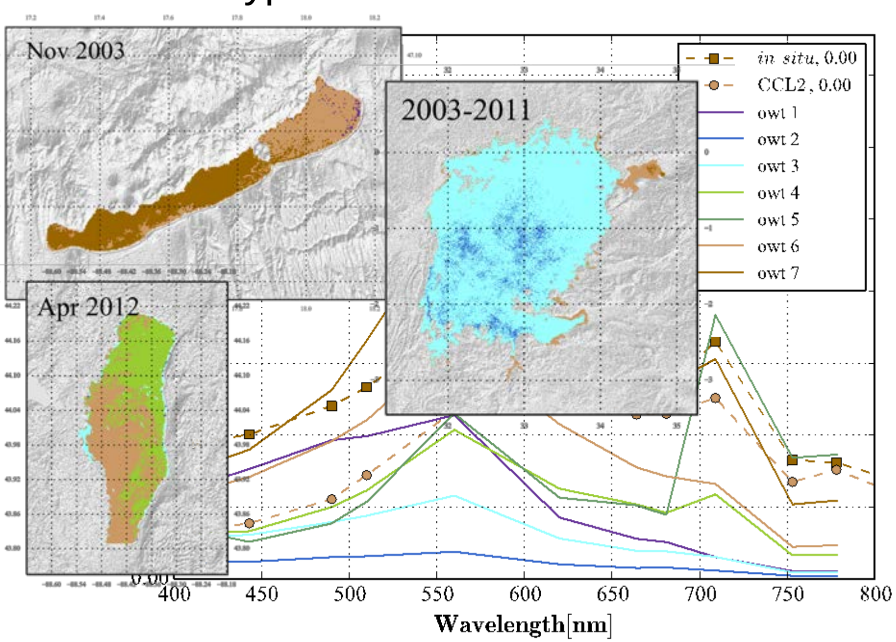
- Water quality retrieval algorithms are applied to derive L2 products
- L2 layers are aggregated as mean monthly L3, using algorithm-specific valid pixel expressions
- CoastColour algorithm for TSM and turbidity (Doerffer et al., 2012)

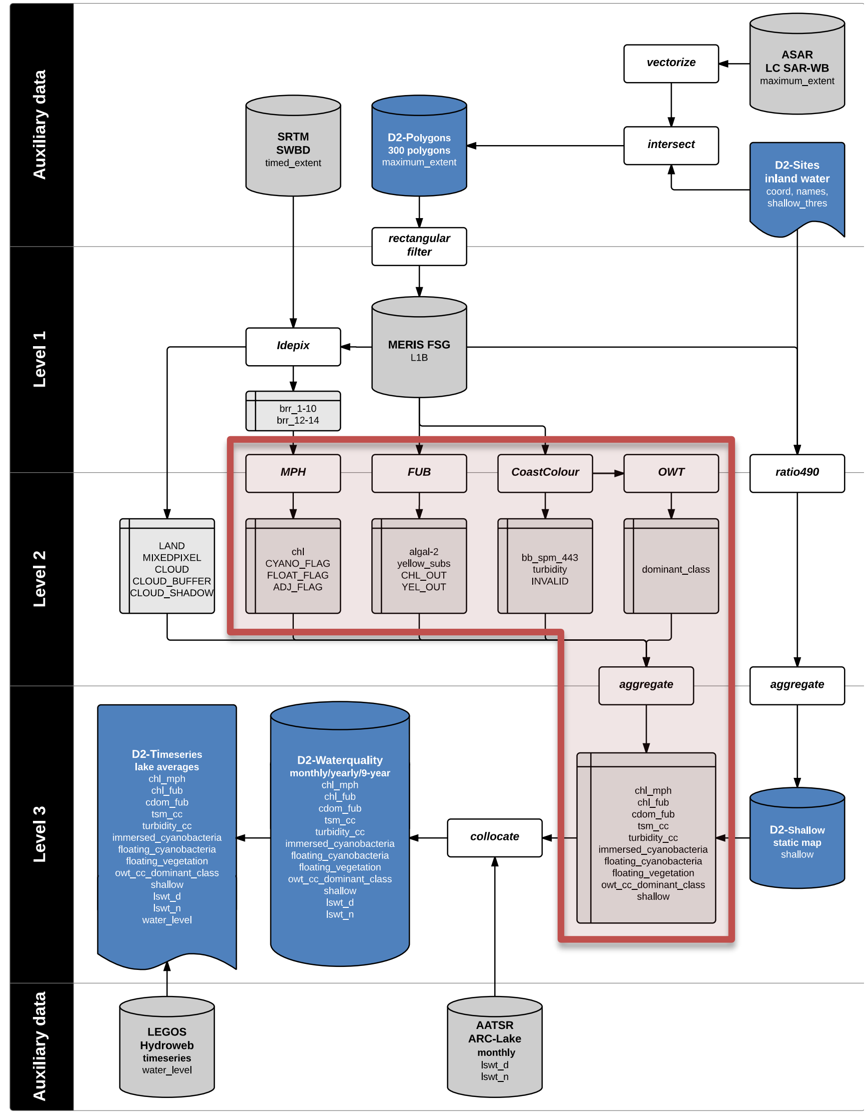




CaLimnos Processing Chain

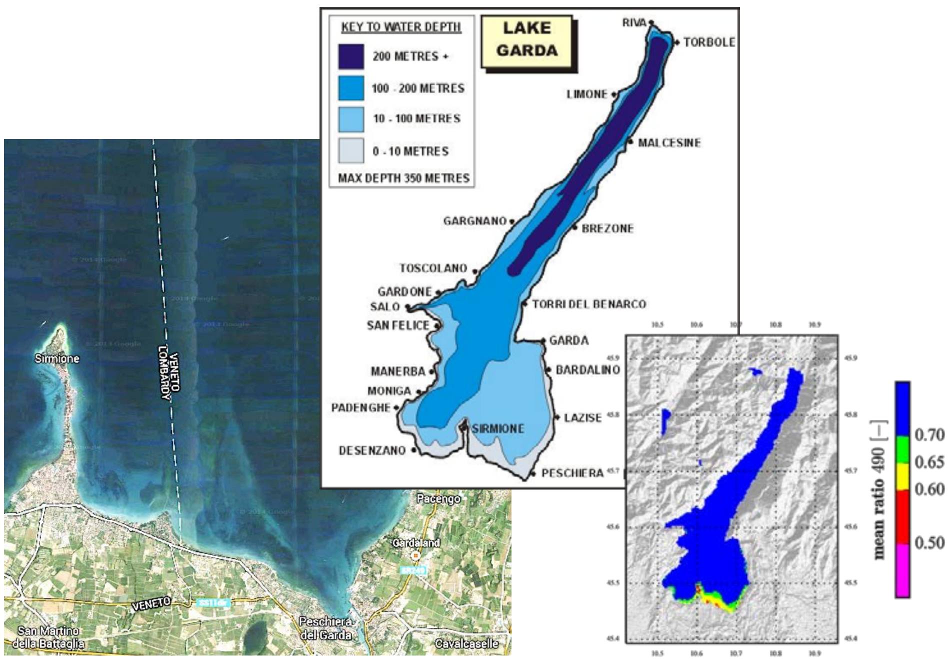
- Mode aggregation is applied to derive dominant optical water types (Moore et al., 2014)
- Allows users to select the appropriate chlorophyll product:
  - Type 1-3: FUB
  - Type 4-7: MPH

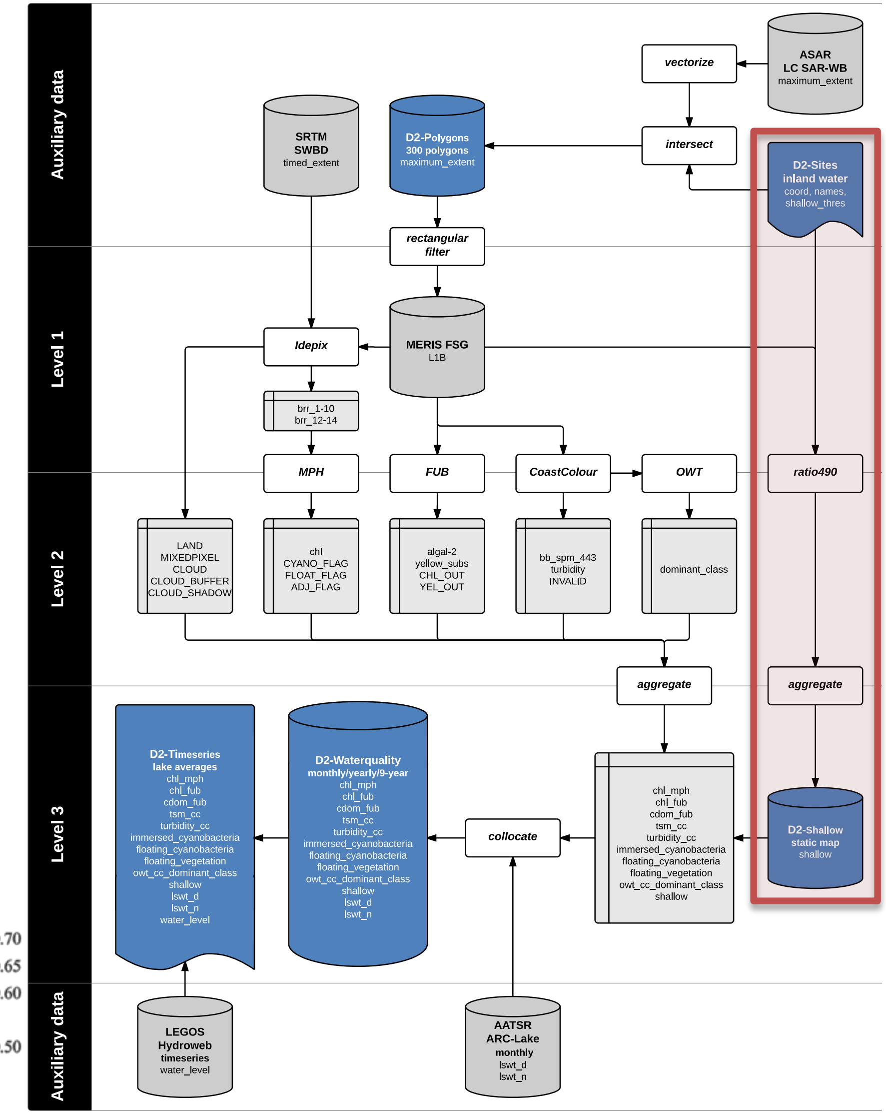




CaLimnos Processing Chain

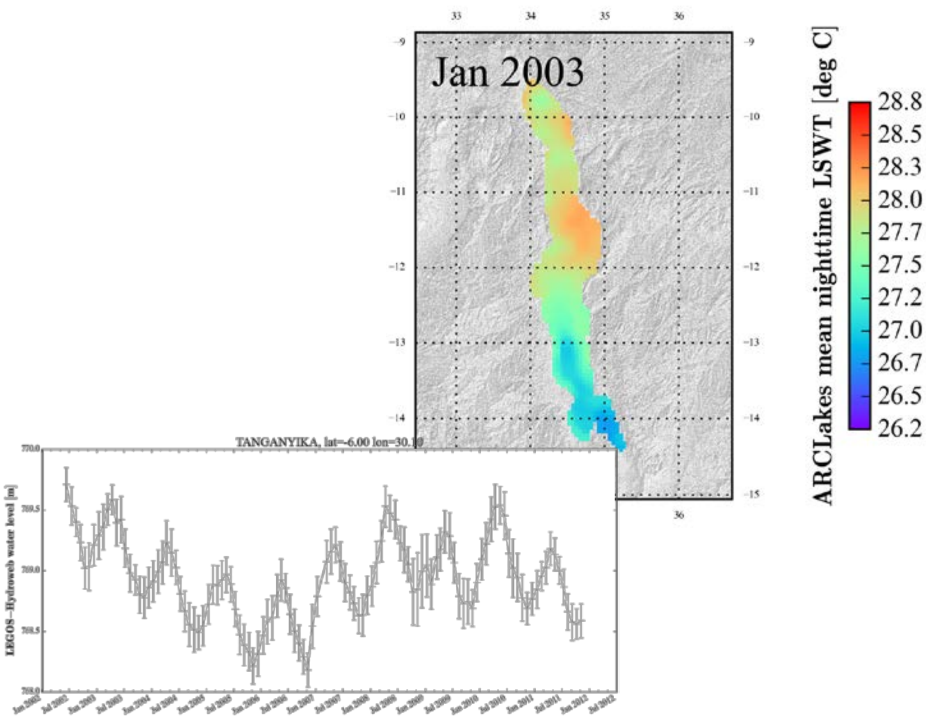
- A new approach was developed to identify shallow water areas (Brockmann et al.@MWBS)
- The shallow water indicator was visually verified for each lake an specific thresholds are set in the attribute table

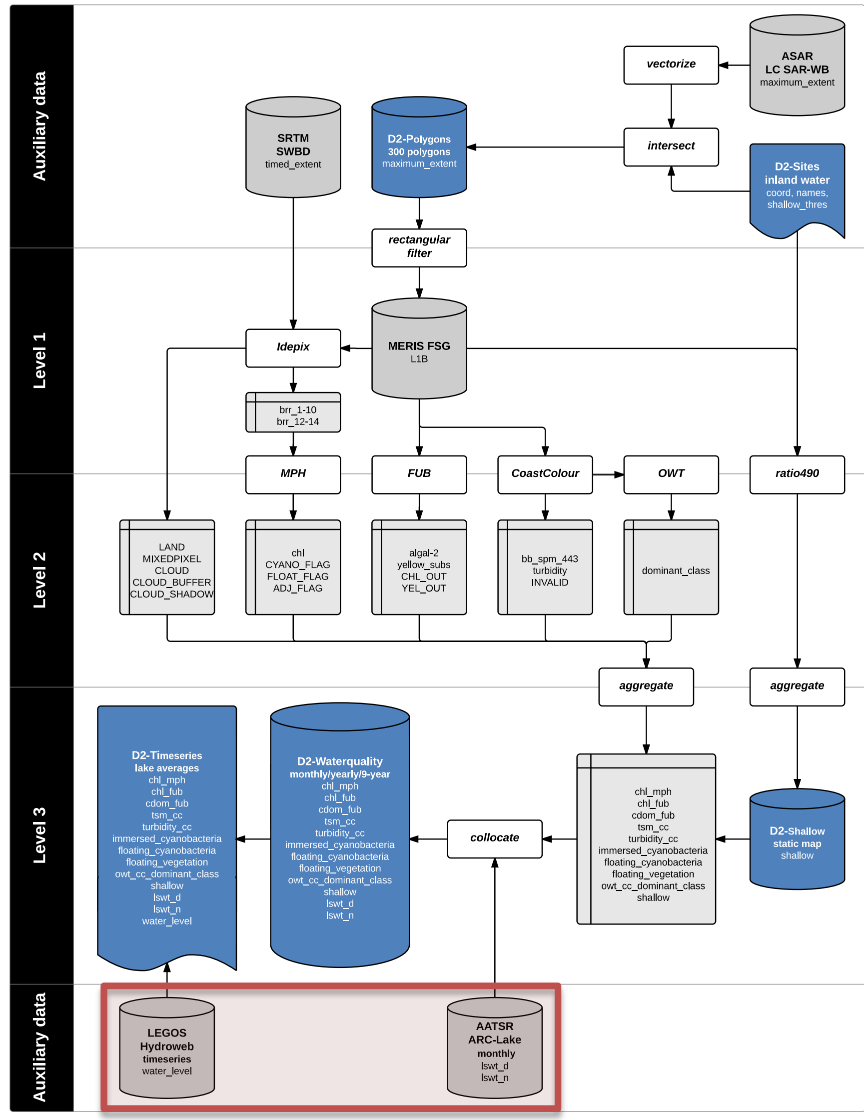




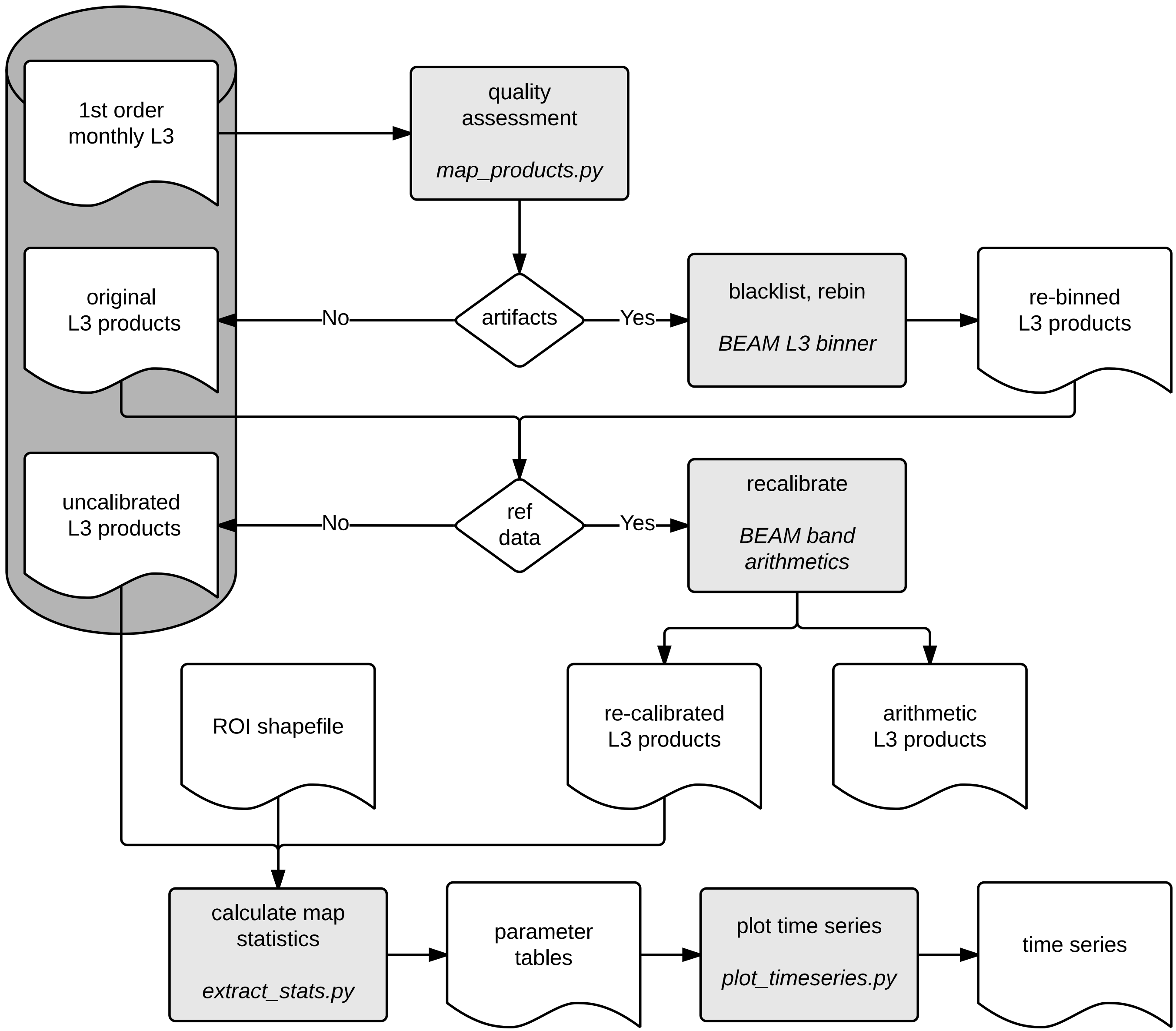
CaLimnos Processing Chain

- Merging of auxiliary datasets
- ARC Lake LSWT products as L3 layer (MacCallum & Merchant, 2012)
- LEGOS/Hydroweb water level estimate timeseries (Crétaux et al., 2011)

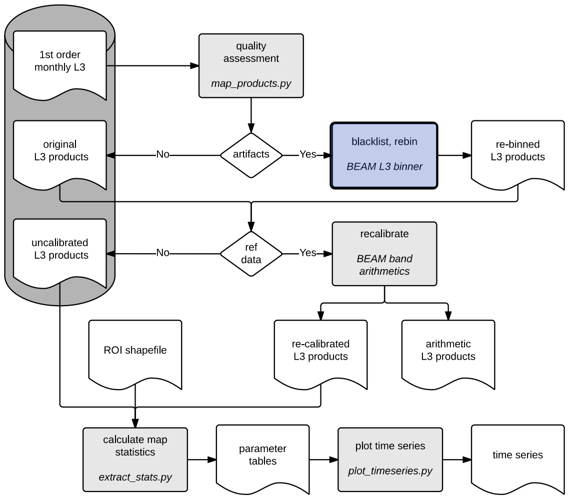




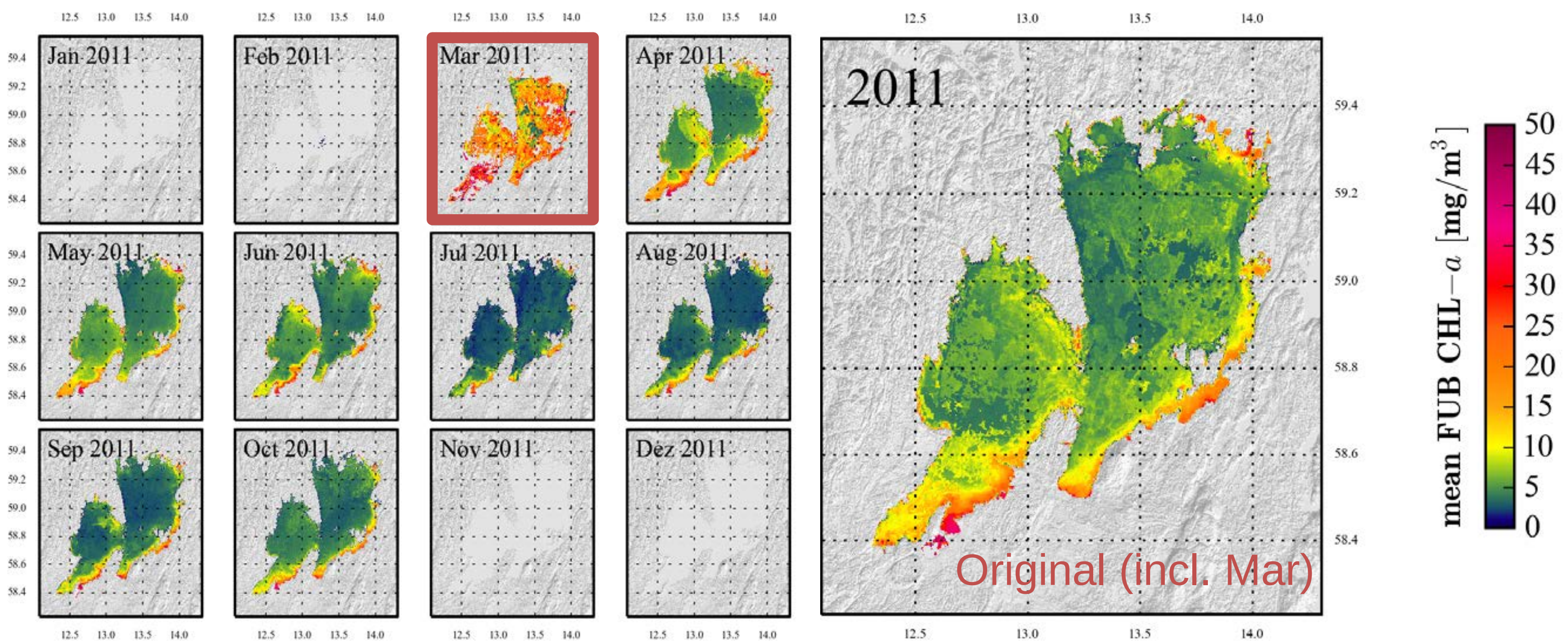
Customization and Analysis Tools



Product Customization



- Re-bin yearly and 9-year products using BEAM level 3 binning
  - Typically needed to remove melting lake ice affected monthly products
  - Available in GUI/VISAT and gpt/batch mode



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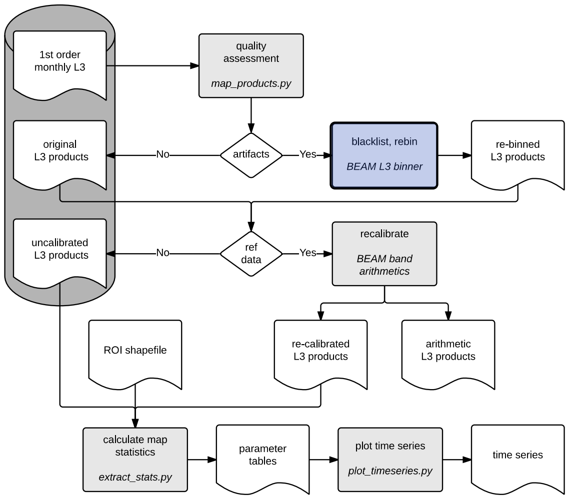

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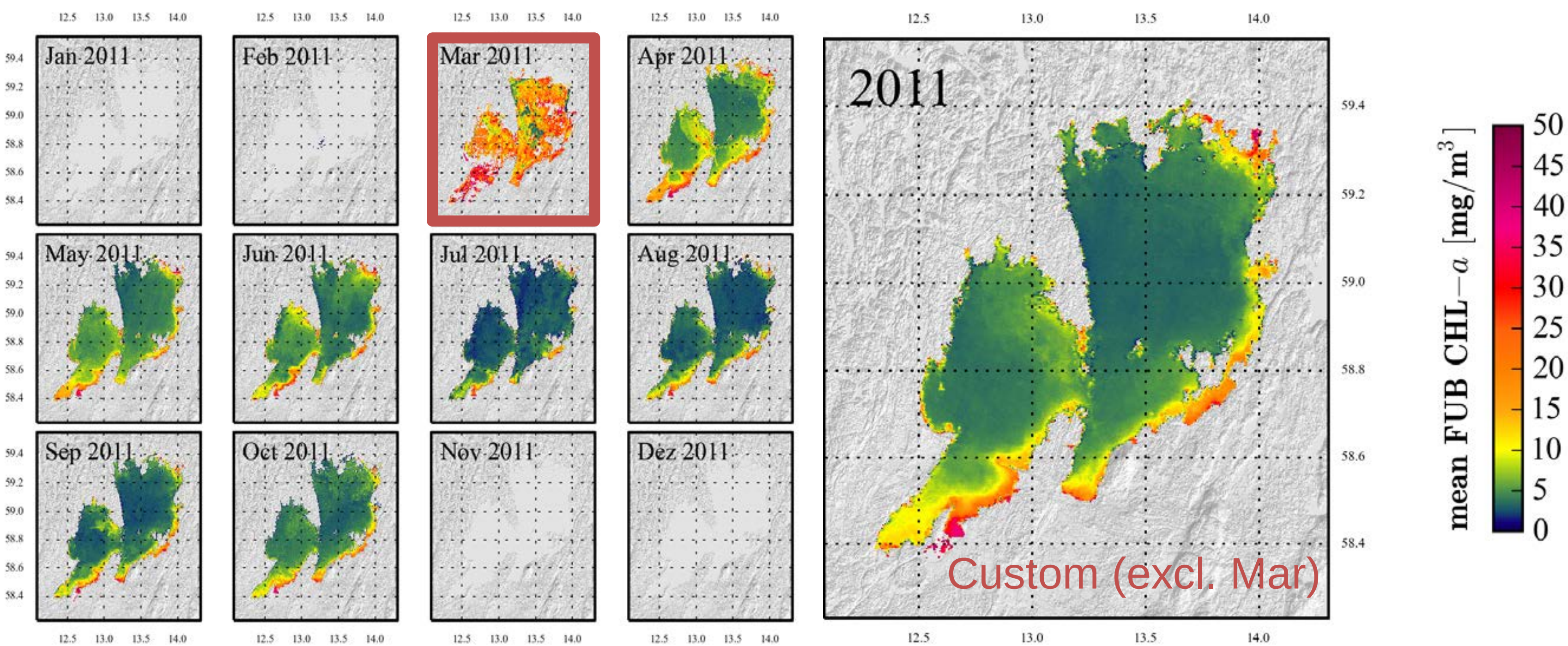
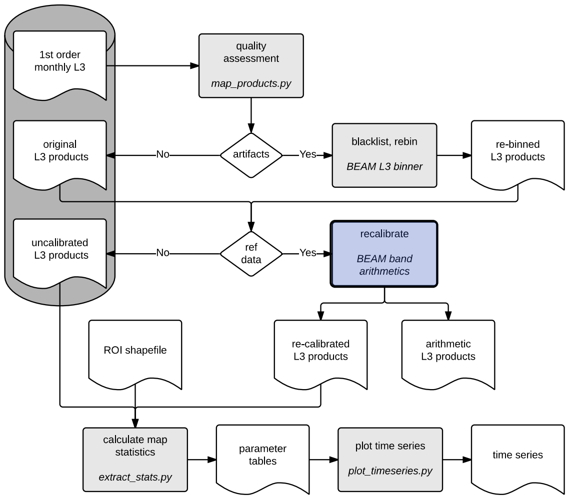
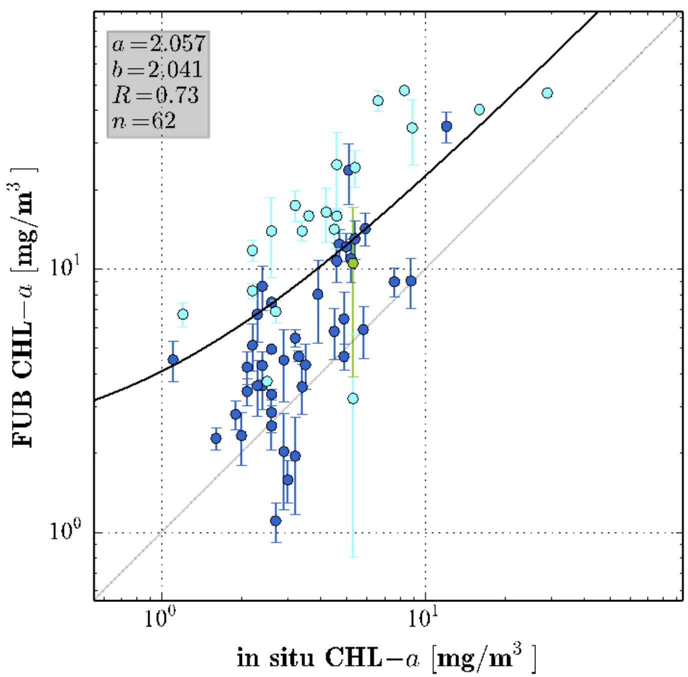
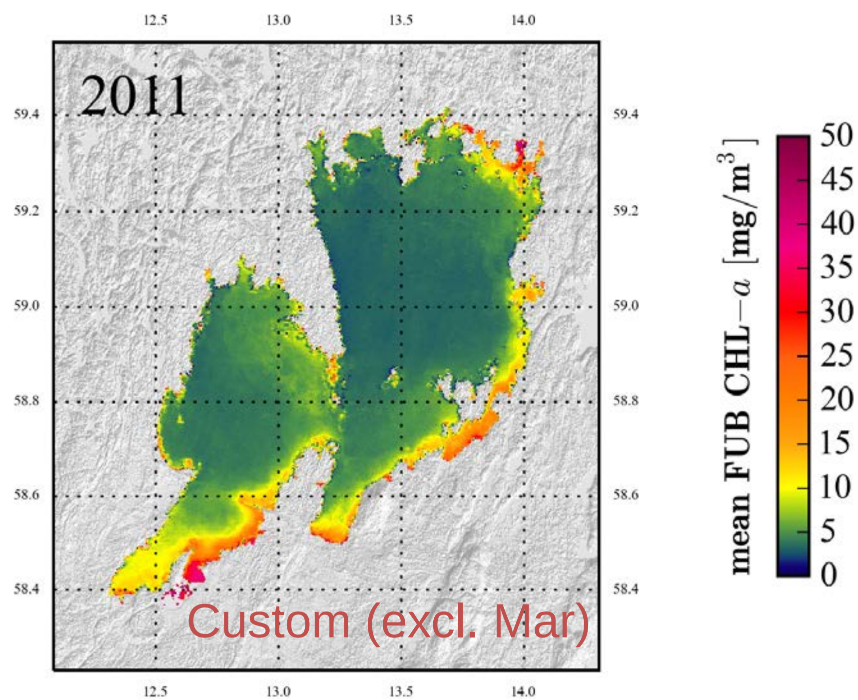


Product Customization



- Calibrate with reference measurements using BEAM band arithmetic
  - Apply slope and intercept from regression with in situ reference data
  - Available in GUI/VISAT and gpt/batch mode





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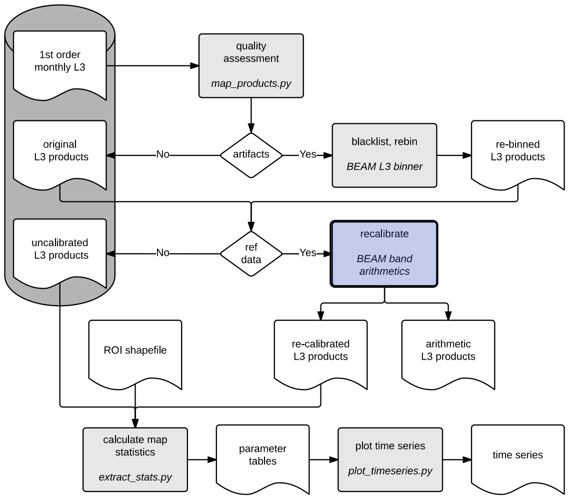

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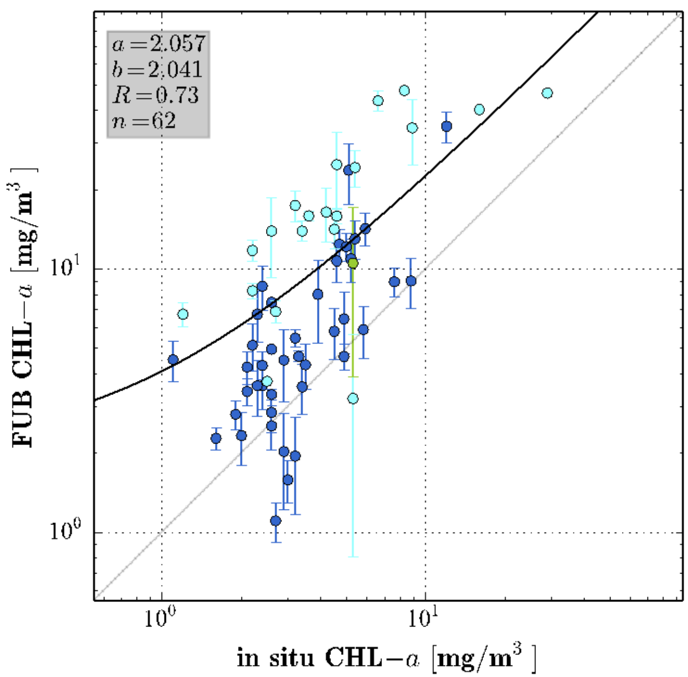
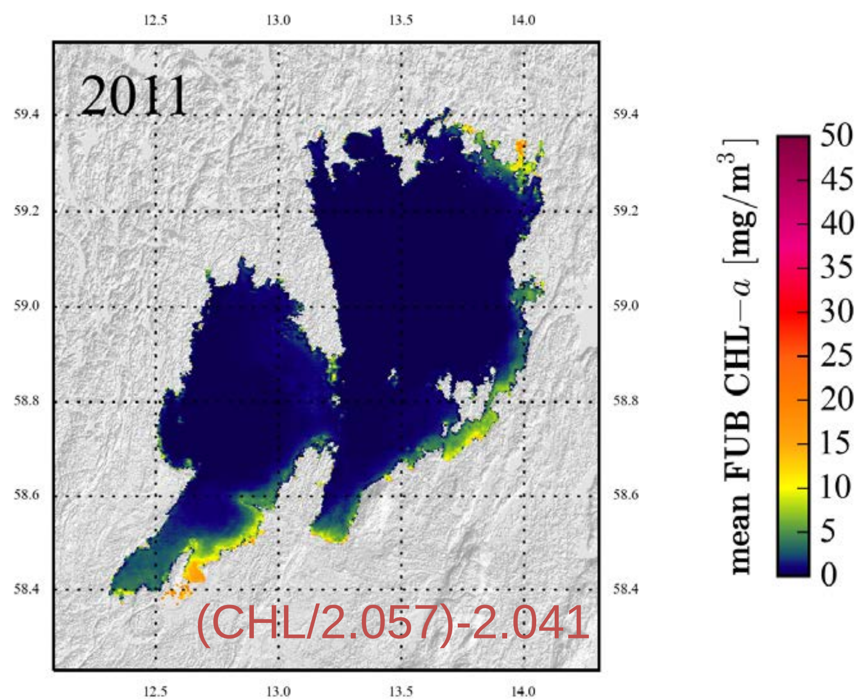
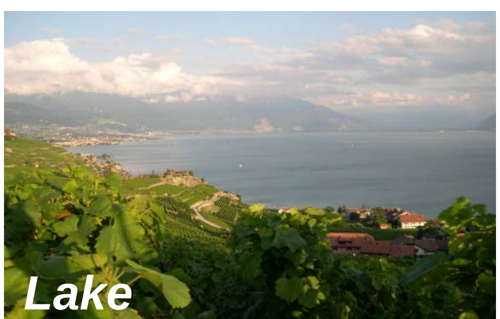




Biodiversity Stories

Diversity II product analyses were provided by: Orlane Anneville, Sean Avery, Damien Bouffard, Steve Greb, Anna-Birgitta Ledang, Mark Matthews, Claire Miller, Todd Miller, Ruth O’Donnell, Frédéric Rimet, Alfred Sandström, Marian Scott, Emma Tebbs.

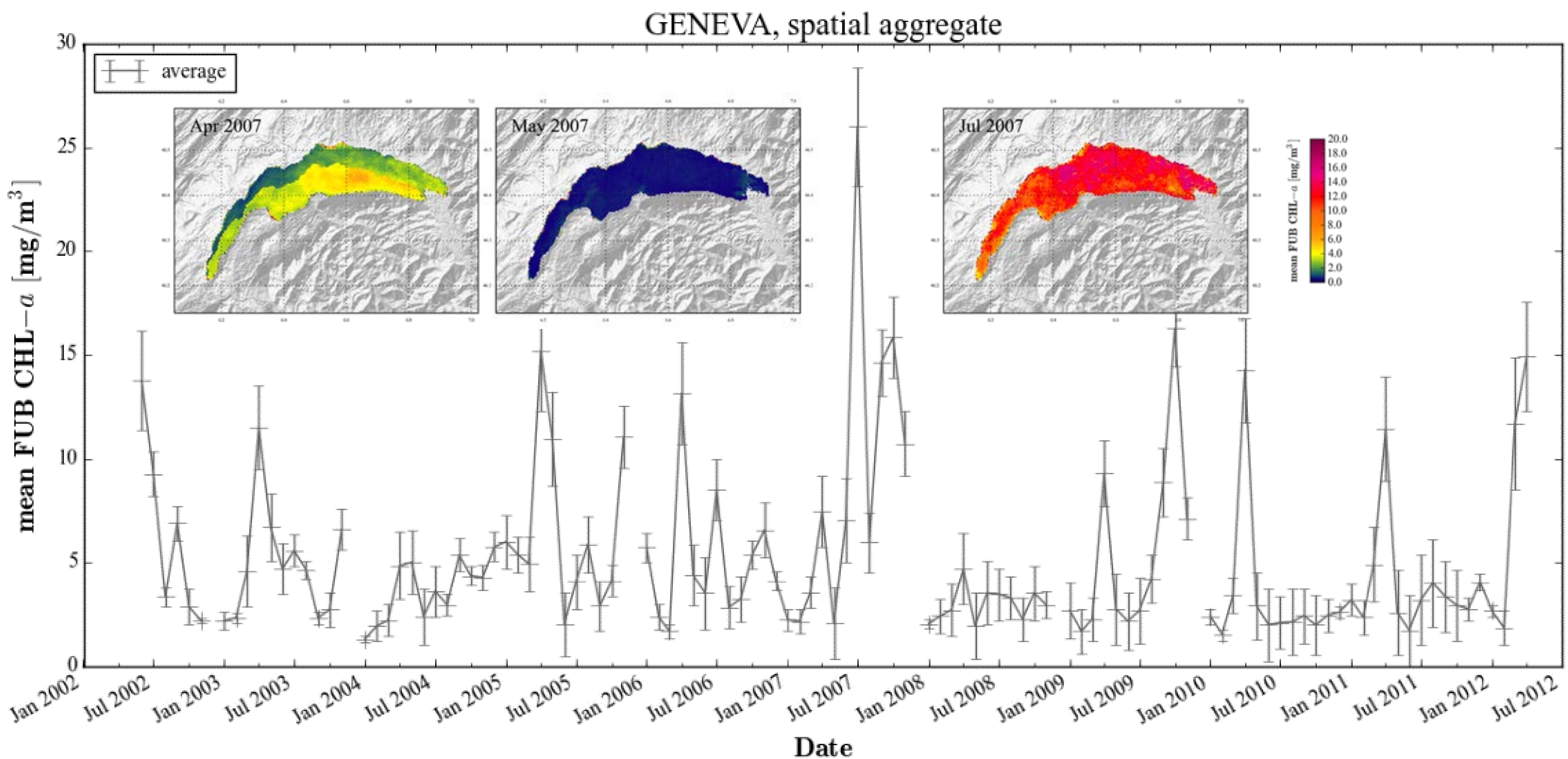


Images courtesy of Conver BV, Wisconsin Dept. of Natural Resources, Damien Bouffard, Wikimedia Commons

Algal Communities in Lake Geneva

Damien Bouffard, Frédéric Rimet

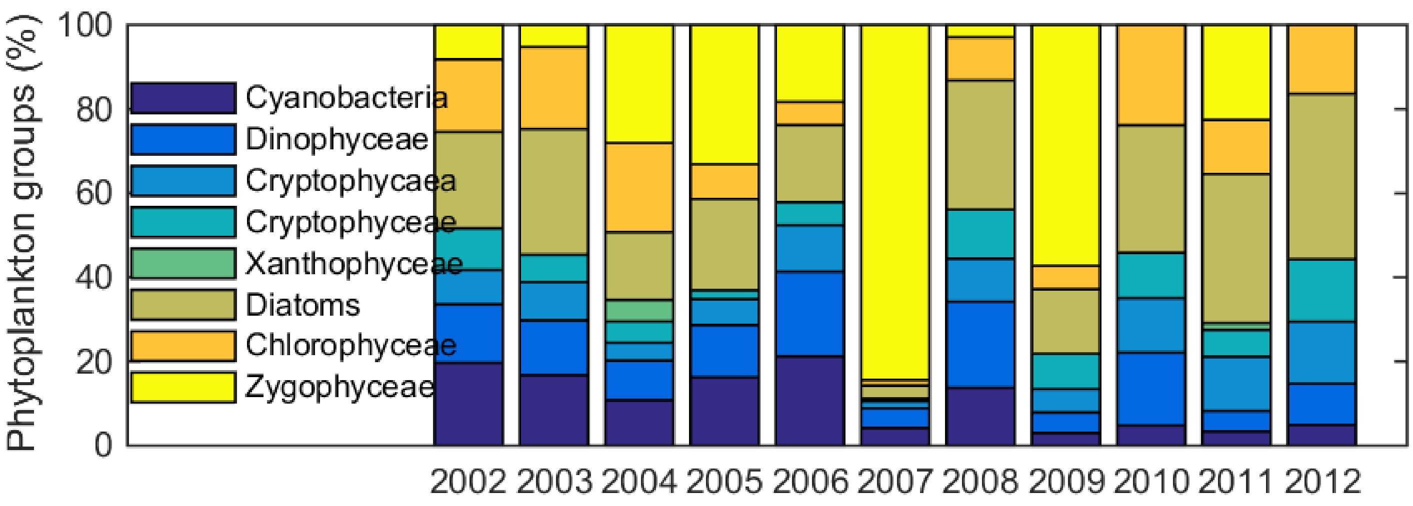
- An extraordinary algal bloom occurred in summer 2007, following a moderate spring bloom and a pronounced depletion phase



Algal Communities in Lake Geneva

Damien Bouffard, Frédéric Rimet

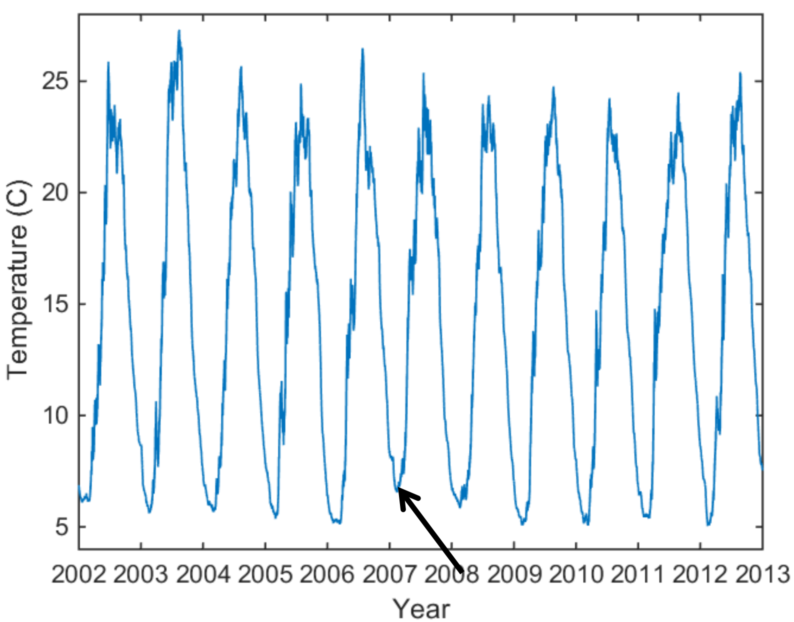
- Reference data by Rimet (2014) indicate that the algae are *Mougeotia sp.* (Zygophyceae)
- According to Tapolczai et al. (2014), they benefit from:
  - an early annual development following a mild winter
  - strong wind mixing in early summer
  - a deep photic zone

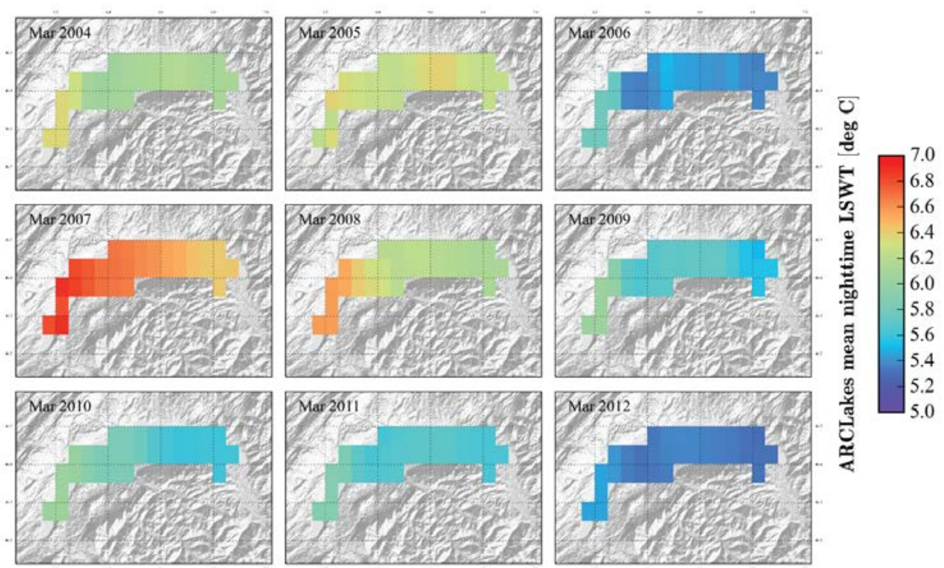


Algal Communities in Lake Geneva

Damien Bouffard, Frédéric Rimet

- K-ε turbulence modelling and Diversity II LSWT for the annual cooling peak in March agree in warm 2007 temperatures
- Together with the deep photic layer following the spring bloom depletion, ideal conditions for *Mougeotia sp* are observed

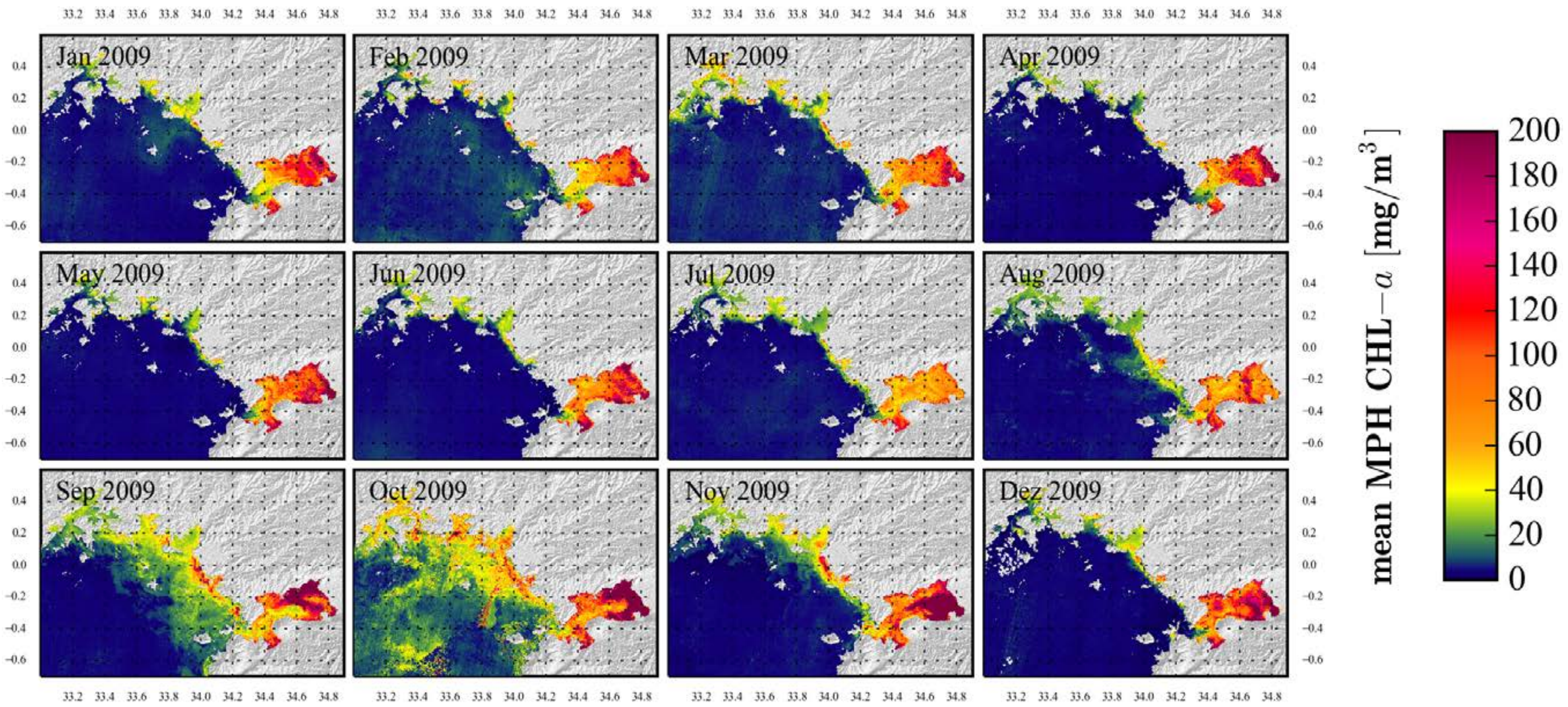




Eutrophication in Lake Victoria

Anna-Birgitta Ledang, Daniel Odermatt

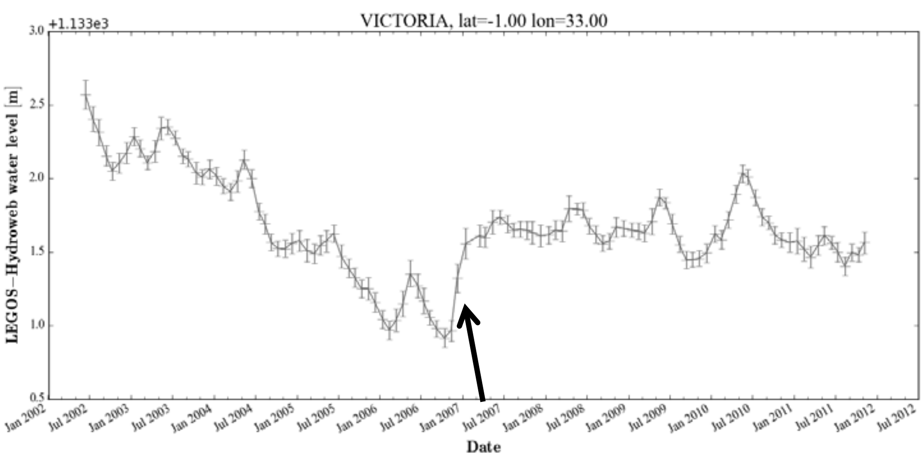
- Cyanobacteria blooms originating from the highly eutrophic bays occasionally extend to pelagic waters

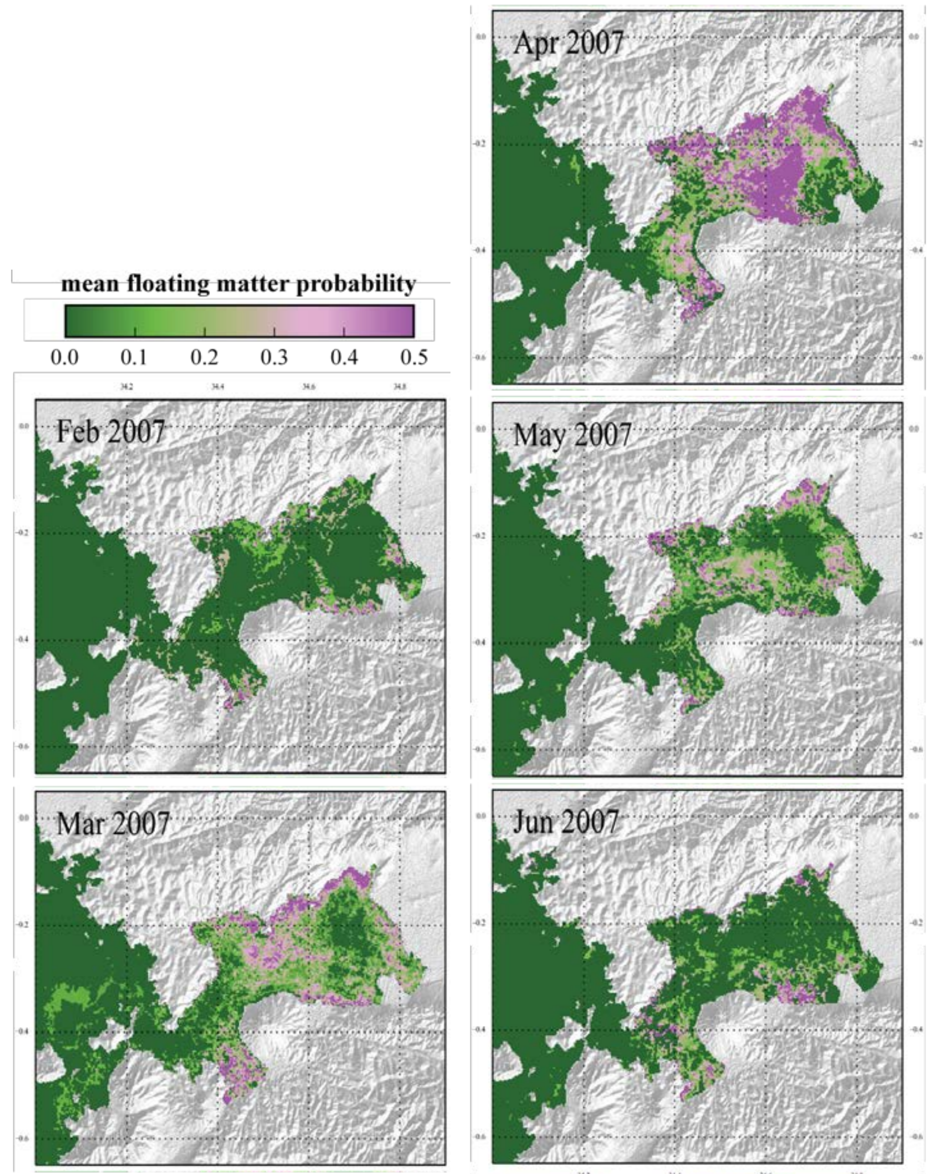


Eutrophication in Winam Gulf

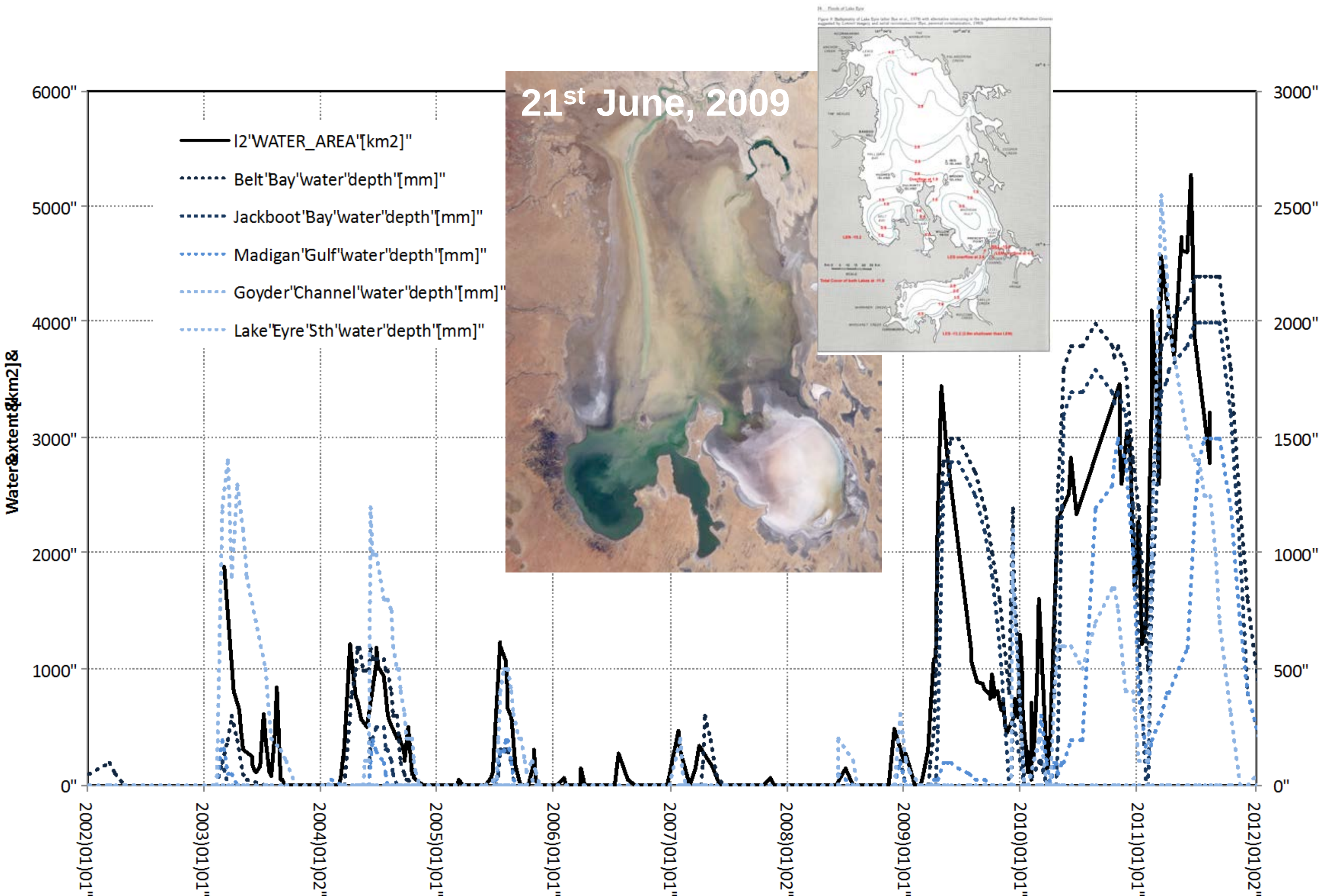
Anna-Birgitta Ledang, Daniel Odermatt

- Water hyacinth (*Eichhorna crassipes*) proliferation observed following El Nino rainfalls in 1998 and 2007
- Relative dynamics in good agreement with SAR and Landsat observations (Fusilli et al., 2013)



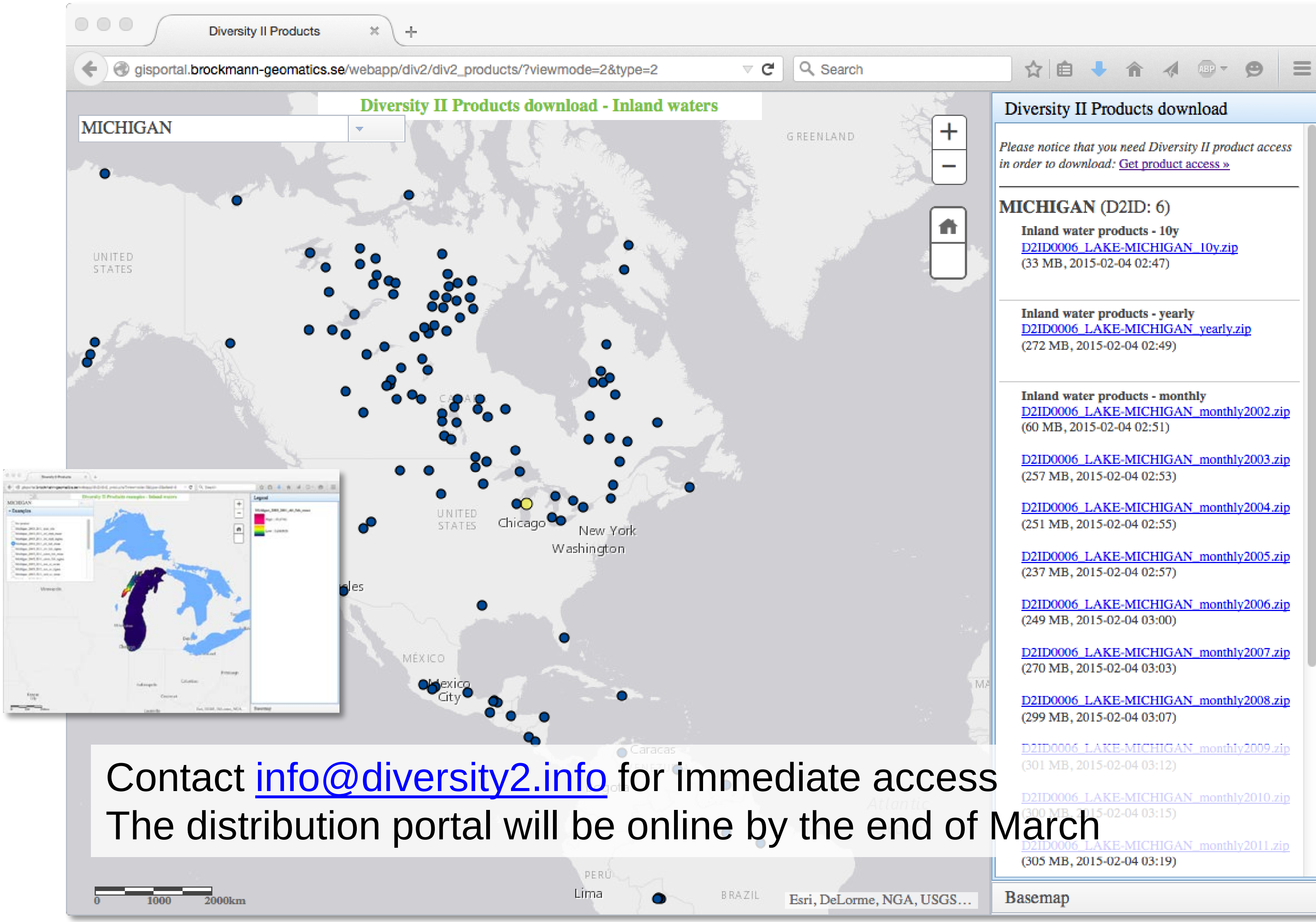


Water Extent Variations in Lake Eyre



Reference data courtesy of the Lake Eyre Yacht Club

WebGIS Product Distribution Portal



Contact info@diversity2.info for immediate access
The distribution portal will be online by the end of March

Conclusions

- A database of the most common water quality and quantity parameters feasible from remote sensing is provided for 340 lakes worldwide
- Several *existing global lake datasets* and archives are used and re-distributed (LC-CCI WB, ARC Lake, LEGOS Hydroweb)
- A *post-processing framework* for analysis and display tasks is provided to allow for lake and interest specific customization
- *Biodiversity studies* highlight successful applications of the provided data and post-processing framework
- The project ends in May with the completion of all documentation
- Further development of the *CaLimnos processing chain* is planned in collaboration with the GloboLakes team (Simis et al.@MWBS)

Acknowledgements

We thank the inland water experts listed in the following non-exhaustive enumeration for supporting Diversity II:

Consultancy: Steve Greb, Sampsa Koponen, Kai Sorensen.

User requirements: Stewart Bernard, Bill Brierley, Mark Dowell, Jörg Freyhof, Steve Greb, Steve Groom, Paul Hanson, Ian Harrison, Erin Hestir, Peter Hunter, Isabel Kiefer, Engin Koncagul, Sampsa Koponen, Mark Matthews, Kai Sorensen, Evangelos Spyrakos, Emma Tebbs, Andrew Tyler.

Implementation: Jean-François Crétaux, Marieke Eleveld, Luis Guanter, Annelies Hommersom, Stuart MacCallum, Mark Matthews, Tim Moore, Eirini Politi, Richard Smith.

Reference data: Bob Backway, Selima Ben Mustapha, Caren Binding, Michael Feld, Justin Funk, Steve Greb, Peter Hunter, Peter Keller, Allyn Knox, Oliver Koester, Sampsa Koponen, Vincent Kotwicki, Susanne Kratzer, Tiit Kutser, Paul Mann, Bunkei Matsushita, Mark Matthews, Kirk McIntosh, Ghislaine Monet, Jun Nagasato, Stephanie Palmer, Matyas Présing, Laiho Risto, Antonio Ruiz Verdu, Jennifer Slate, Kai Sorensen, Evangelos Spyrakos, Rémy Tadonléké, Kumiko Totsu, Juha Tiihonen, Andrew Tyler.

Biodiversity Stories: Orlane Anneville, Sean Avery, Damien Bouffard, Steven Greb, Anna-Birgitta Ledang, Mark Matthews, Claire Miller, Todd Miller, Ruth O'Donnell, Frédéric Rimet, Alfred Sandström, Marian Scott, Emma Tebbs.

Dissemination: Arnold Dekker, Stephanie Palmer, Natacha Pasche.

For a more detailed version of this presentation, please refer to http://www.earthobservations.org/webinar_wq.shtml

Product basemaps are created from SRTM and Microsoft QuadTree image tiles.

diversity
inland waters

Biodiversity Indication for 300 Lakes worldwide using ENVISAT

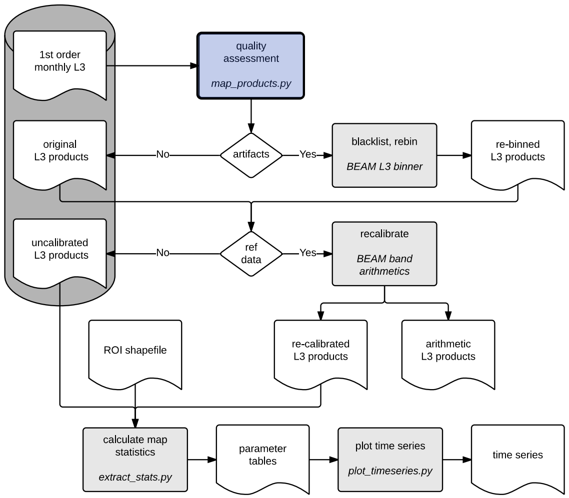
Appendix

ESA Mapping Water Bodies from Space Conference, 18.3.2015

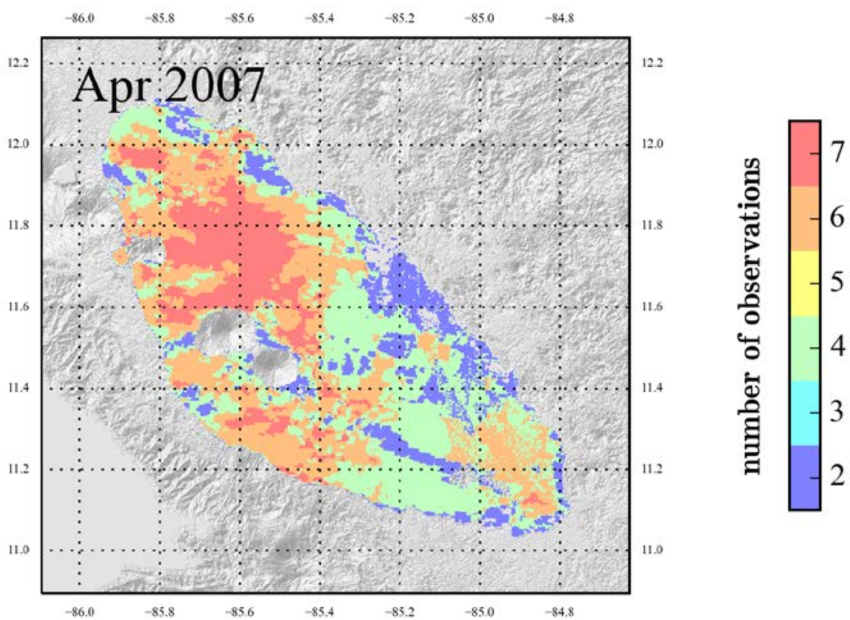
Overview of Database Contents

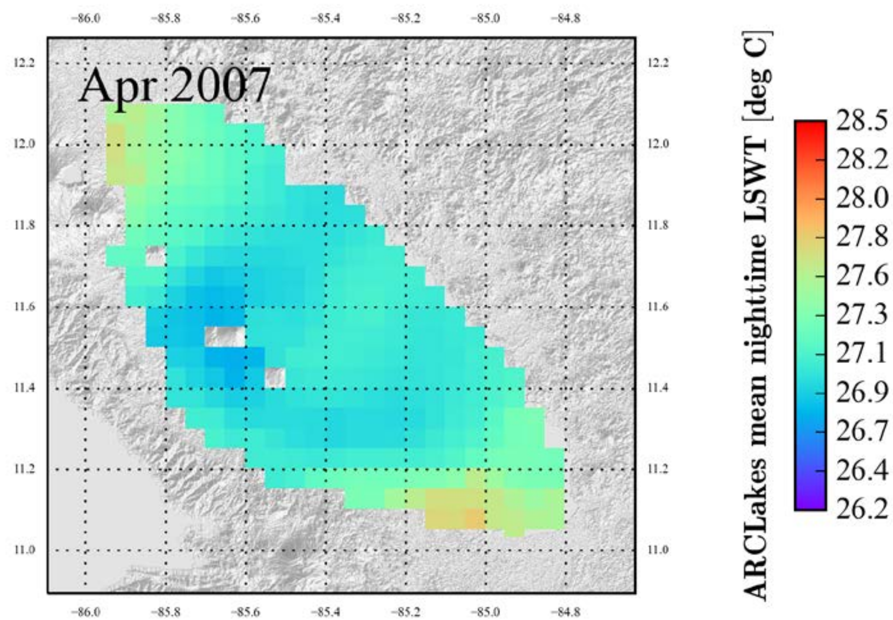
Parameter	Format	Temporal resolution	Time series	n_lakes
num_obs	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	341
chl_mph_mean, sigma	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	341
chl_fub_mean, sigma	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	341
cdom_fub_mean, sigma	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	341
tsm_cc_mean, sigma	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	341
turbidity_cc_mean, sigma	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	341
immersed_cyanobacteria_mean	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	341
floating_cyanobacteria_mean	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	341
floating_vegetation_mean	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	341
owt_cc_dominant_class_mode	geotiff	monthly, yearly, 9-y	-	341
lswt_d_mean	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	298
lswt_n_mean	geotiff	monthly, yearly, 9-y	*plot_timeseries.py*	298
shallow	geotiff	-	-	341
water surface level	csv, png	ca. monthly	png	103
lake shapefiles	shp	9-y	-	341
lake list	xlsx, shp	-	-	341
merged GLWD attribute table	xlsx	-	-	315

Quality Assessment

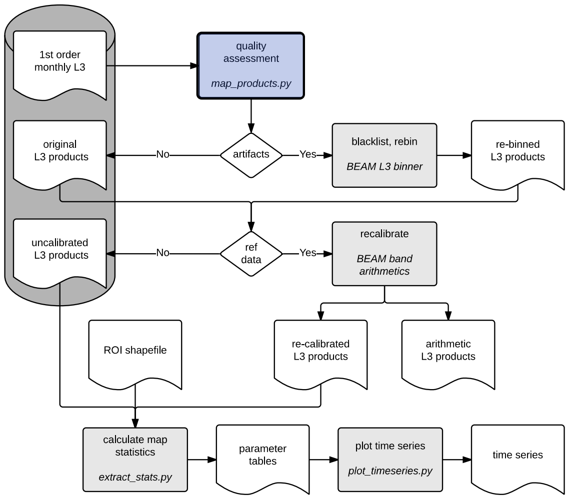


- *map_products.py*
  - Predefined colour scales for each parameter

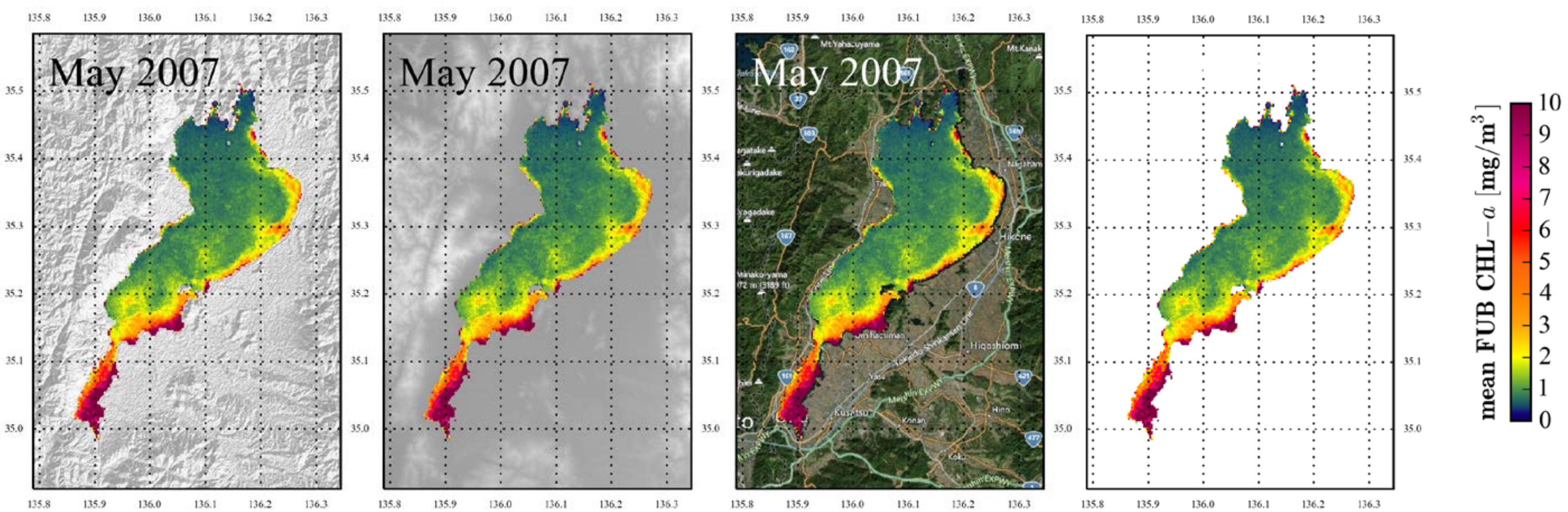




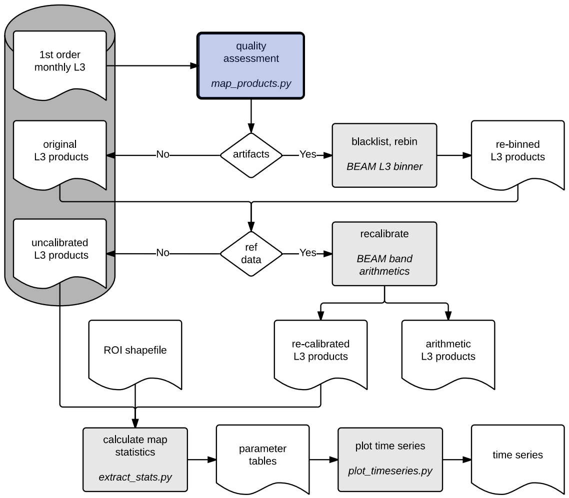
Quality Assessment



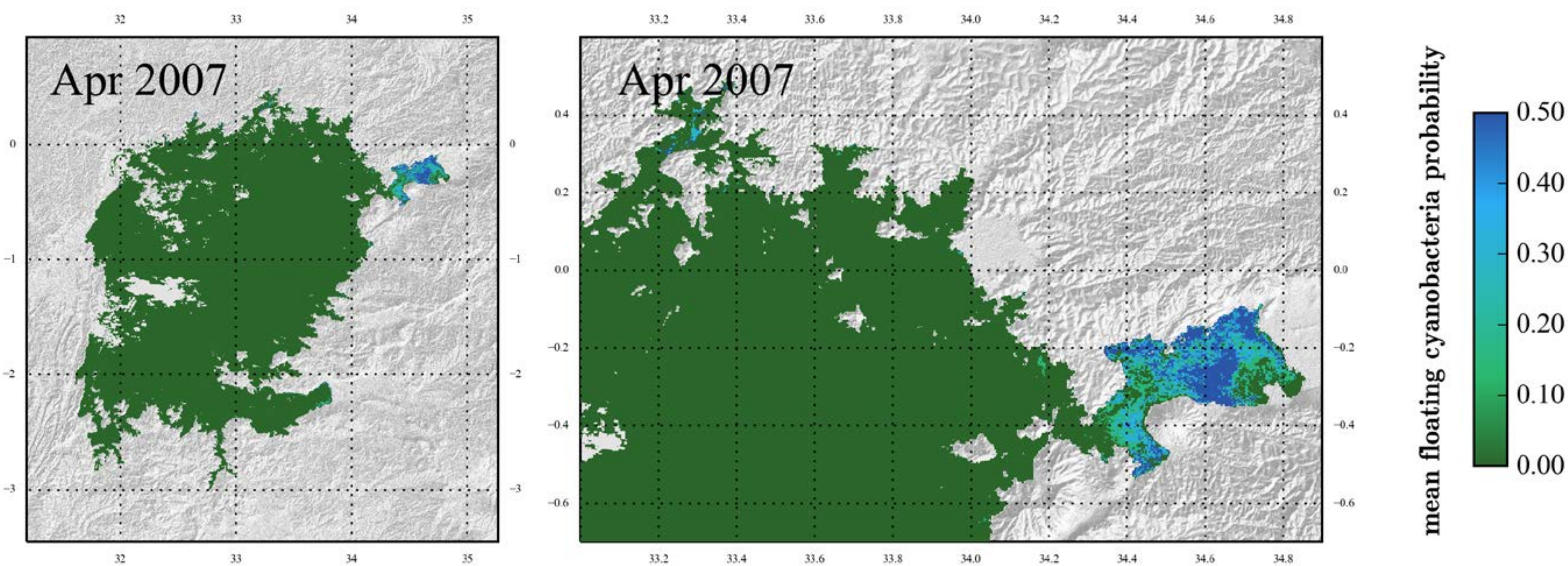
- *map_products.py*
  - Predefined colour scales for each parameter
  - SRTM and quadtree RGB basemaps



Quality Assessment



- *map_products.py*
  - Predefined colour scales for each parameter
  - SRTM and quadtree RGB basemaps
  - User-defined geographic areas



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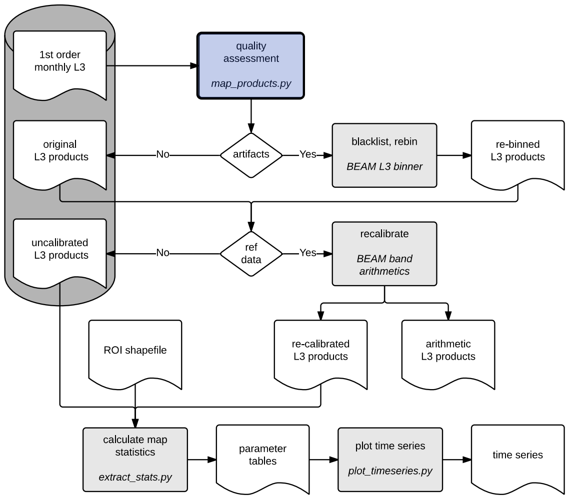
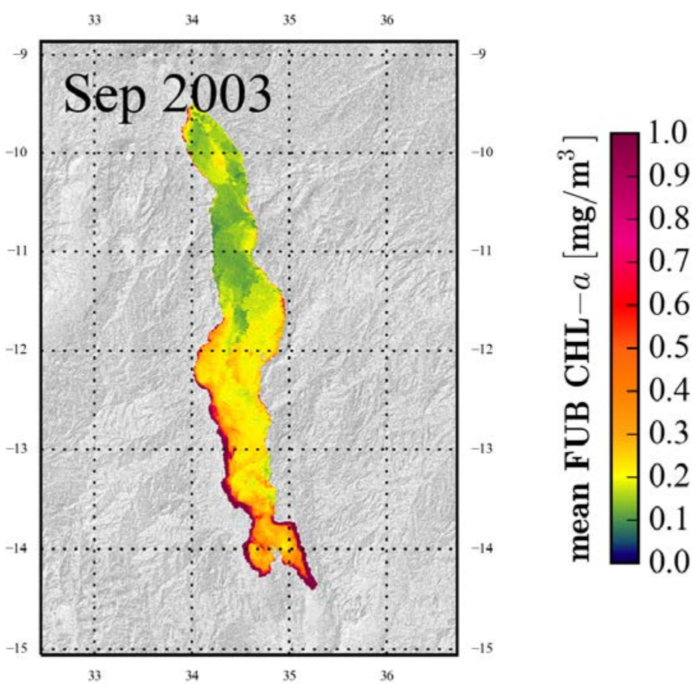
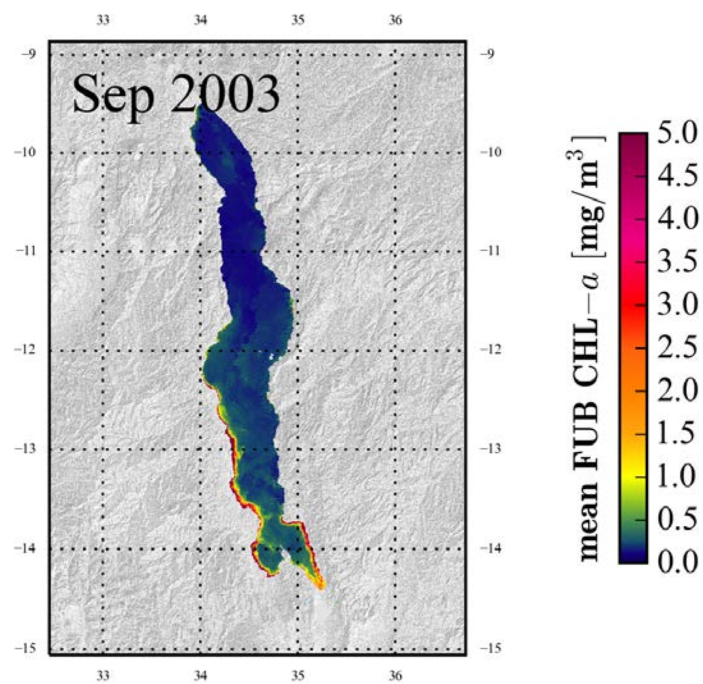
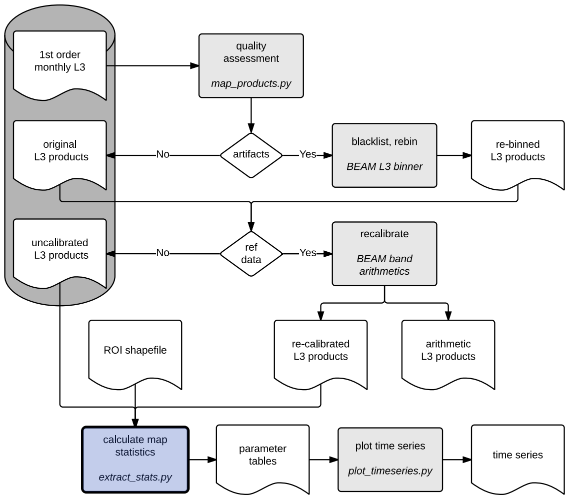


- *map_products.py*
  - Predefined colour scales for each parameter
  - SRTM and quadtree RGB basemaps
  - User-defined geographic areas
  - User-defined parameter ranges





Extract Product Statistics

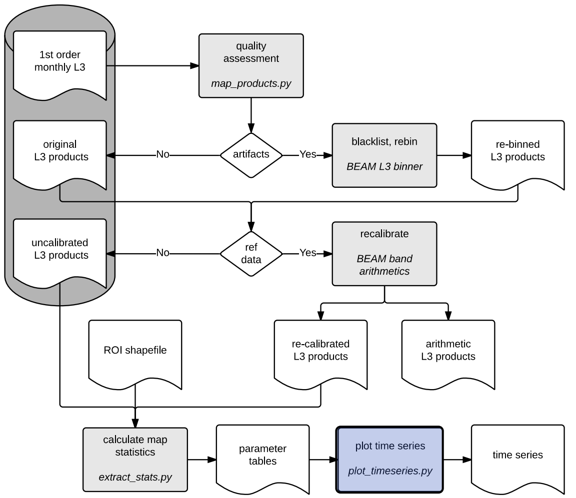


- *extract_stats.py*
  - User-defined ROI shapefile
  - Select relevant percentile thresholds
  - Table 1: List of parameters for one product
  - Table 2: List of products for one parameter

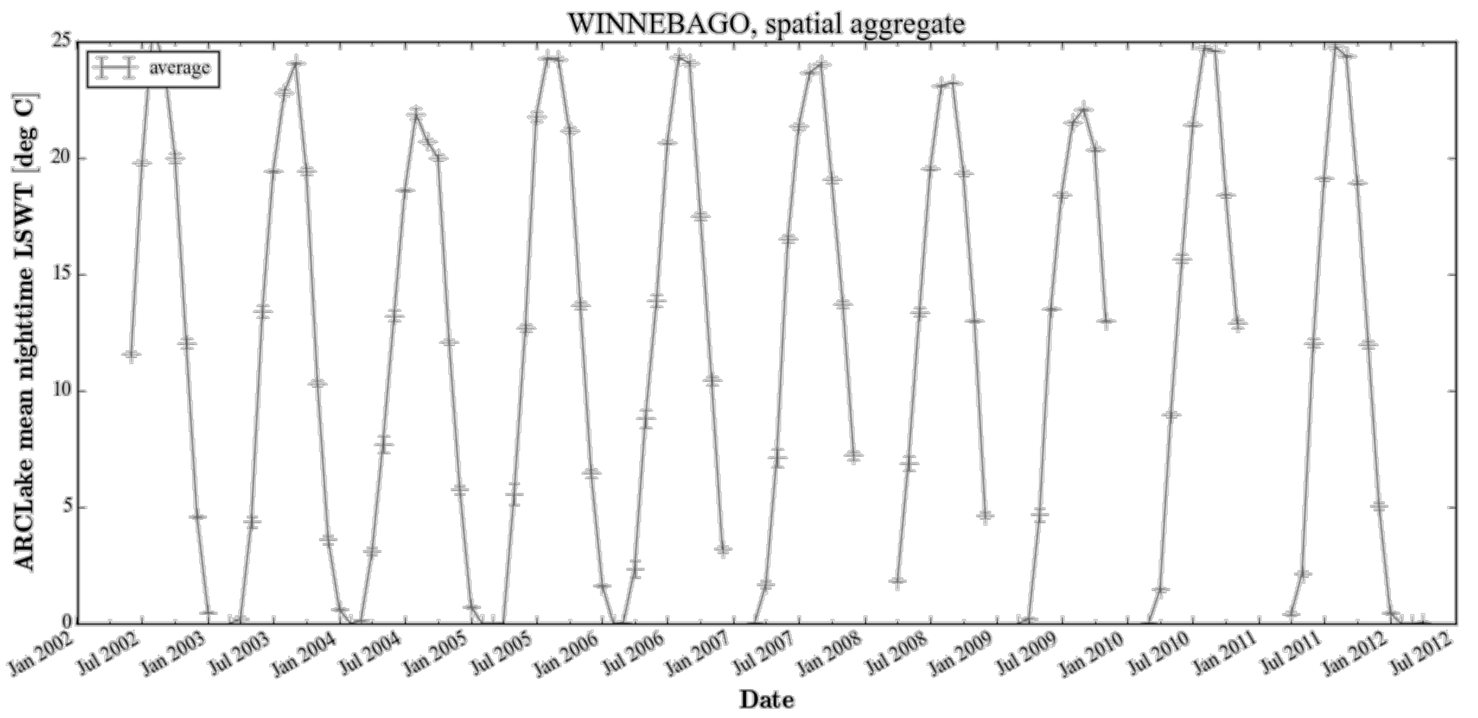
Table 2: Statistics for all annual chl-mph products of Lake Winnebago

stats_start_date	stats_end_date	average	max_error	maximum	median	minimum	p10_threshold	p90_threshold	sigma	total
01.01.03	31.12.03	58.3817	0.0227	229.4457	55.9768	2.1542	34.8614	86.1384	19.5814	7582
01.01.04	31.12.04	44.8263	0.0146	153.4678	44.2148	7.1533	33.6948	55.4371	9.4054	7583
01.01.05	31.12.05	39.6636	0.0163	170.9711	38.9712	7.524	28.1346	50.2164	10.2415	7584
01.01.06	31.12.06	58.4701	0.0228	230.8199	57.4622	3.1071	38.9719	76.8177	16.7209	7576
01.01.07	31.12.07	58.6078	0.0195	199.1671	57.5363	4.4588	39.2727	78.6427	16.0813	7587
01.01.08	31.12.08	55.727	0.0138	149.5578	53.9714	11.0669	45.8004	68.4991	10.4695	7586
01.01.09	31.12.09	118.8993	0.0262	269.7176	114.5339	7.2283	81.329	157.4247	30.9506	7586
01.01.10	31.12.10	52.9466	0.0196	212.8041	50.367	17.1439	40.858	67.2721	13.1837	7586
01.01.11	31.12.11	225.9449	0.0404	457.5571	224.5013	53.7175	189.448	264.5218	32.2115	7585

Plot Time Series for Extracted Statistics



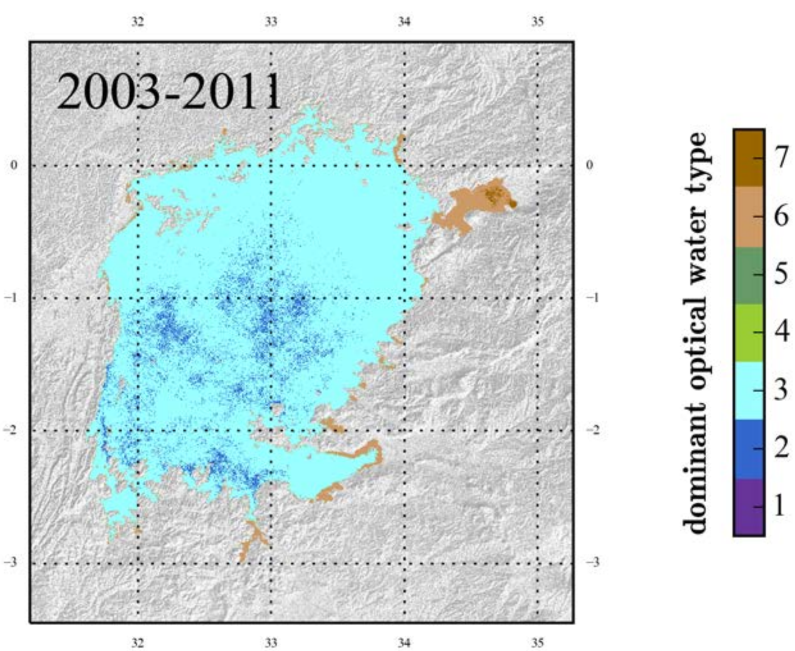
- *plot_timeseries.py*
  - Select parameter and statistical measure
  - Plot decade by months
  - Plot decade by years or years by month
  - User-defined blacklist for outliers

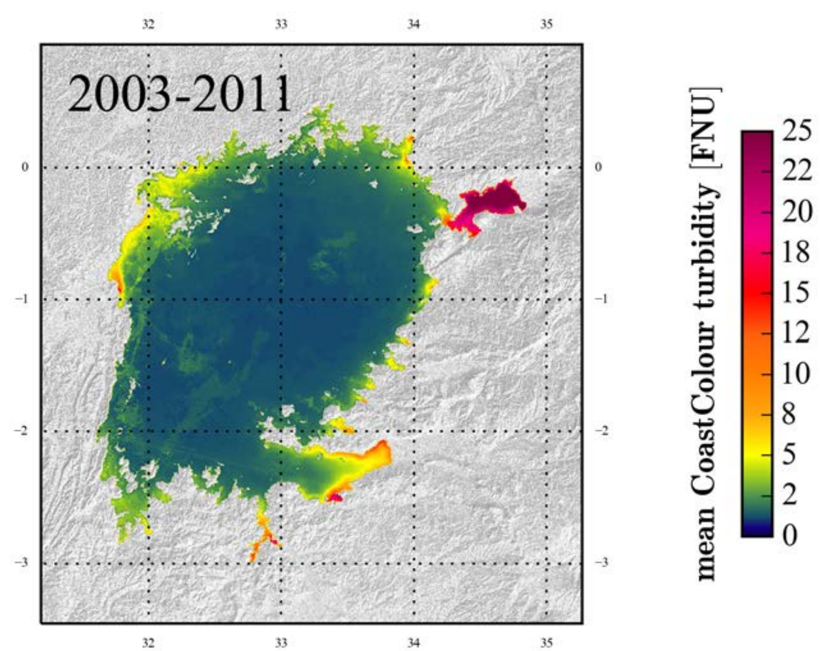


Eutrophication in Winam Gulf

Anna-Birgitta Ledang, Daniel Odermatt

- Lake Victoria receives about 85% of all water from precipitation, and 85% of water loss is through evaporation
- Winam Gulf however receives about 40% of all terrestrial inflow to Lake Victoria, including large loads of nutrients
- Circulation is restricted to the 3 km wide Rusinga Channel





Deep Water Hypoxia in Lake Biwa

Daniel Odermatt

- Lake Biwa is oligo- to mesotrophic, with increasing nutrient input by small, untreated tributaries especially in the South
- The northern and southern basin are only 40 m and 4 m deep, respectively, and accommodate a high diversity of benthic grazing and detritus-feeding organisms

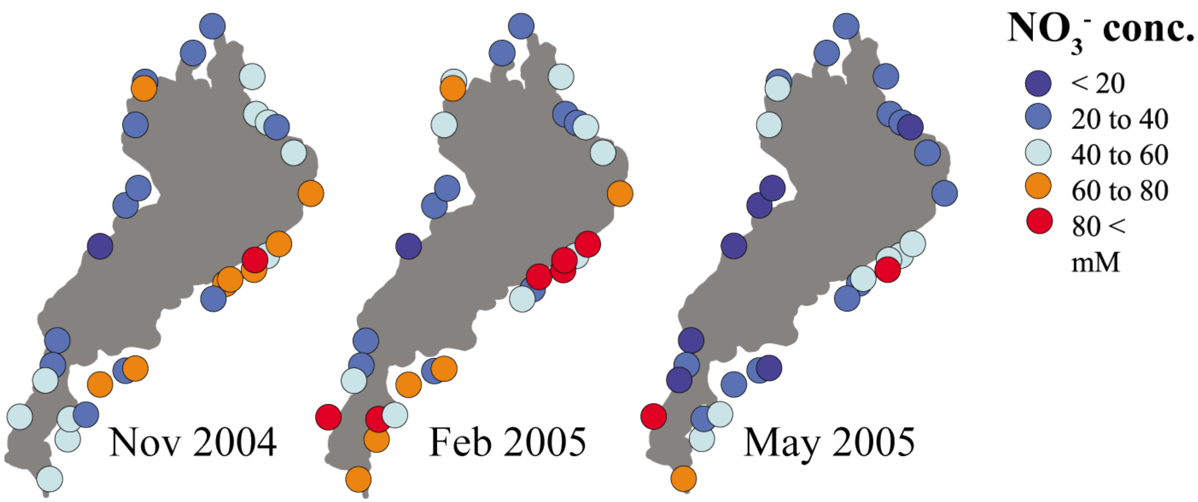
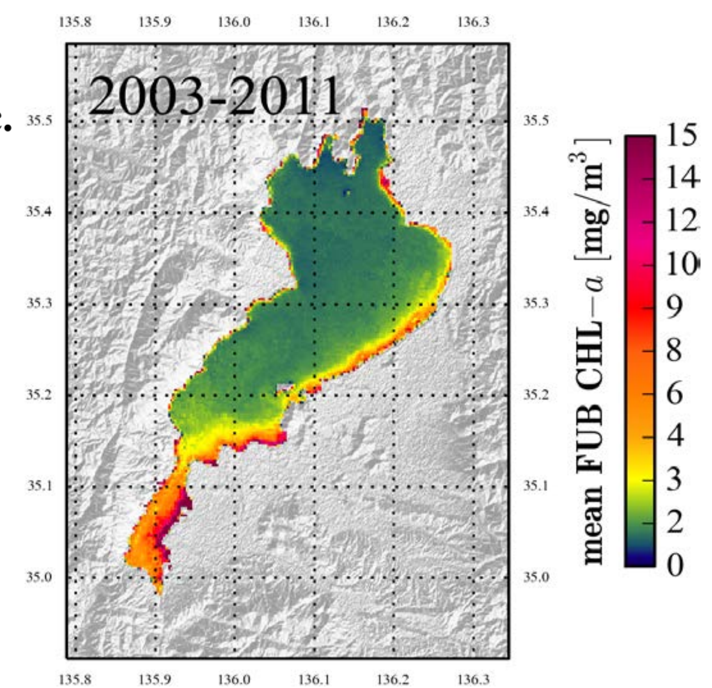


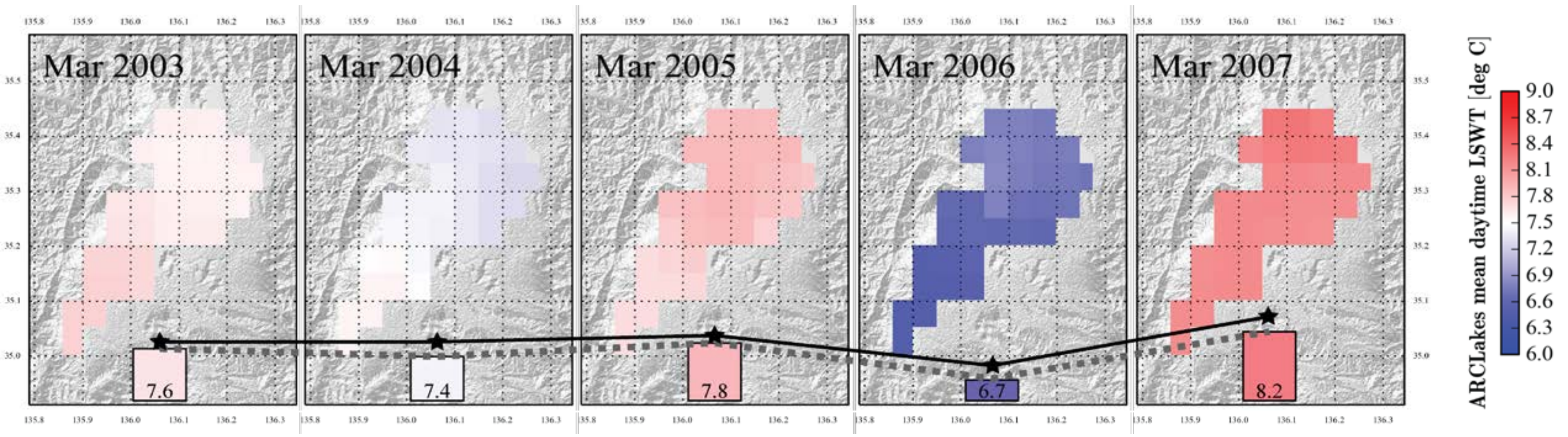
Figure from Ohte et al. (2010)



Deep Water Hypoxia in Lake Biwa

Daniel Odermatt

- Vertical circulation is vital to sustain deep water oxygen levels
- In autumn 2007, investigations with an AUV revealed more than 2000 dead Gobi fish and lake prawns on the benthos
- Low oxygen concentrations and heavy metals mobilized under anaerobic conditions were identified as the cause of the die-off
- Insufficient surface cooling in early 2007 and persistent stratification is assumed to be the driver of this hypoxia

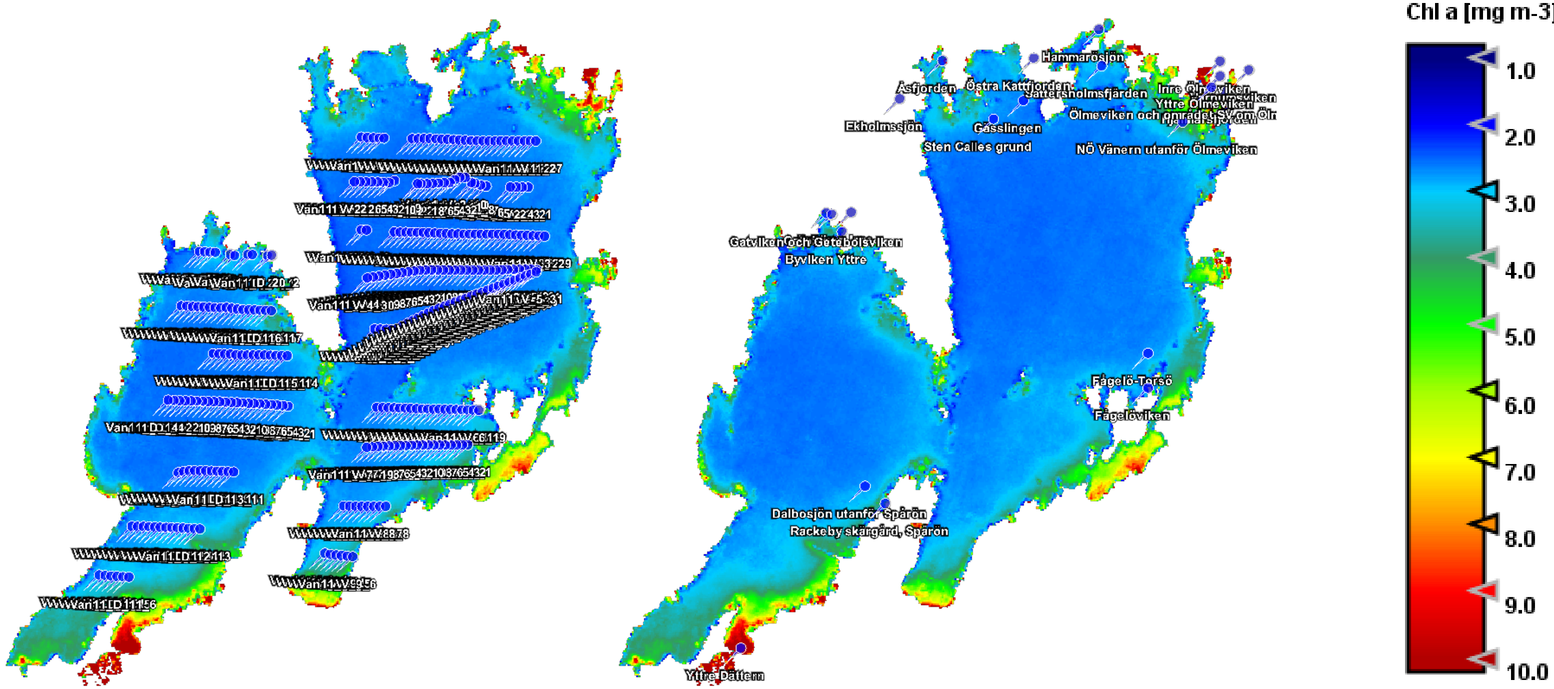


In situ data (solid lines) from monitoring survey database, Kyoto University Center for Ecological Research

Fish Ecology in Lake Vanern

Petra Philipson, Alfred Sandström

- Multivariate regression trees were used to link acoustic survey and and fish count data from Hjalmaren, Malaren, Vanern and Vattern to EO products, water depth and distance from shore
- Data is repeatedly split into a pair of clusters using the driver variable that allows for minimal variability within clusters



Fish Ecology in Lake Vanern

Petra Philipson, Alfred Sandström

- In littoral areas water depth, CHL-*a* and CDOM explain a significant part of fish assemblage variations
- The most determining habitat property is water depth shallower or deeper than the median thermocline at 12.2 m
- Habitat-specific CDOM levels are the second main driver