MERIS observations of Lake Balaton phytoplankton dynamics

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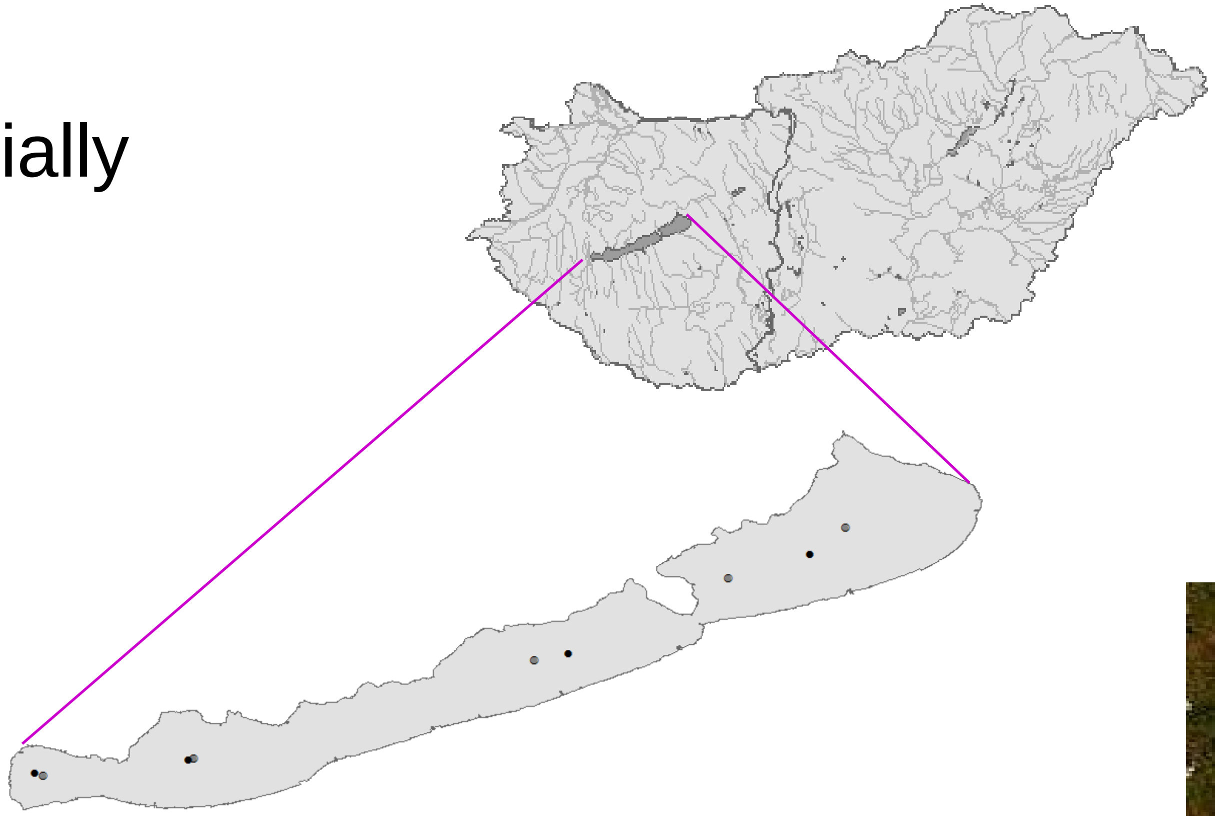
INVESTMENTS IN EDUCATION DEVELOPMENT

Lake Balaton, Hungary

- Large, ~ 600 km^2 surface area
- Severe eutrophication historically, annual blooms
- Trophic gradient, spatially
- Optically complex
- Ongoing monitoring



Chl-*a* retrieval validation

Artificial Neural Network:

- Case 2 Regional
- Eutrophic Lake
- Boreal Lake
- FUB/WeW

Image radiance and geometry input

Reflectances, IOPs and concentrations output

Atmospheric & constituent retrieval components

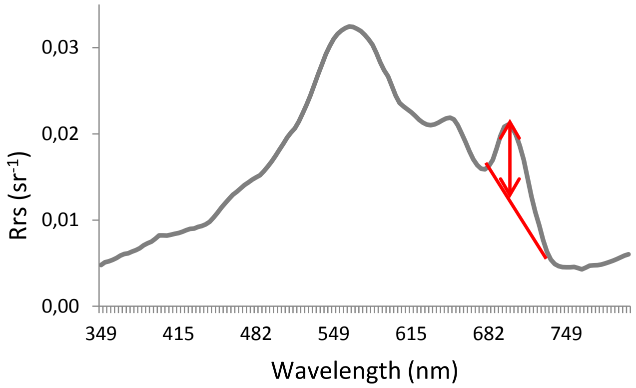
Different in situ calibration conditions

Semi-empirical/band ratio:

- Maximum Chlorophyll Index
- Fluorescence Line Height

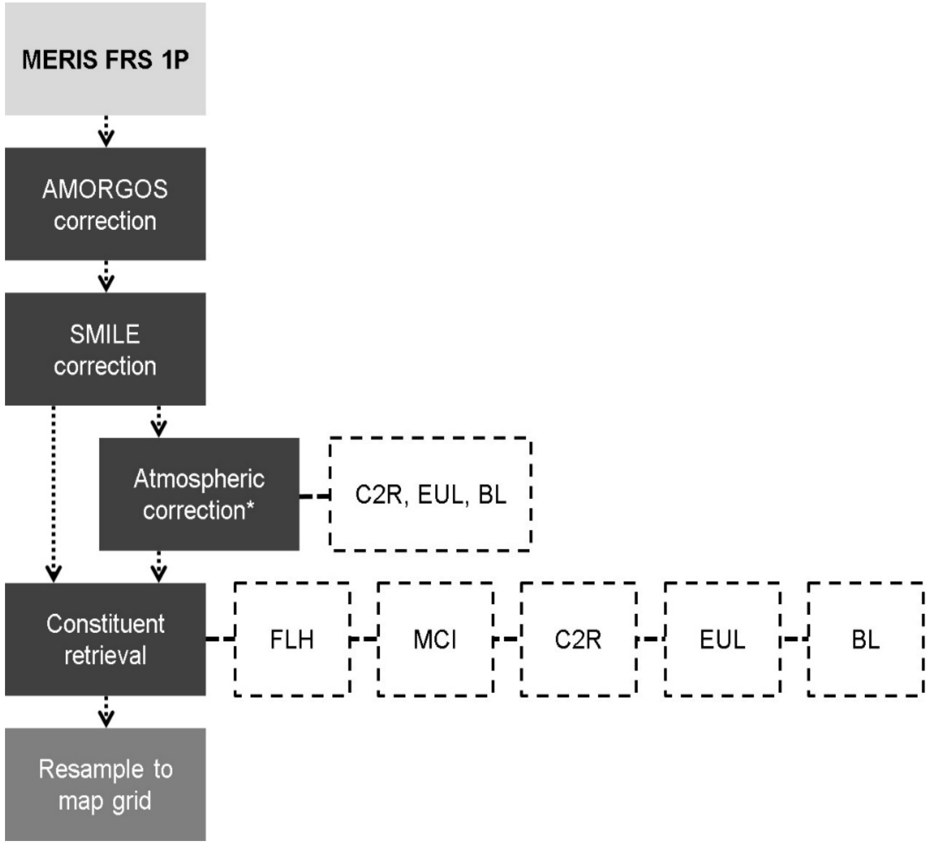
Make use of peak at 685 / 709 nm

Best performance using L1b data



Chl-*a* retrieval validation

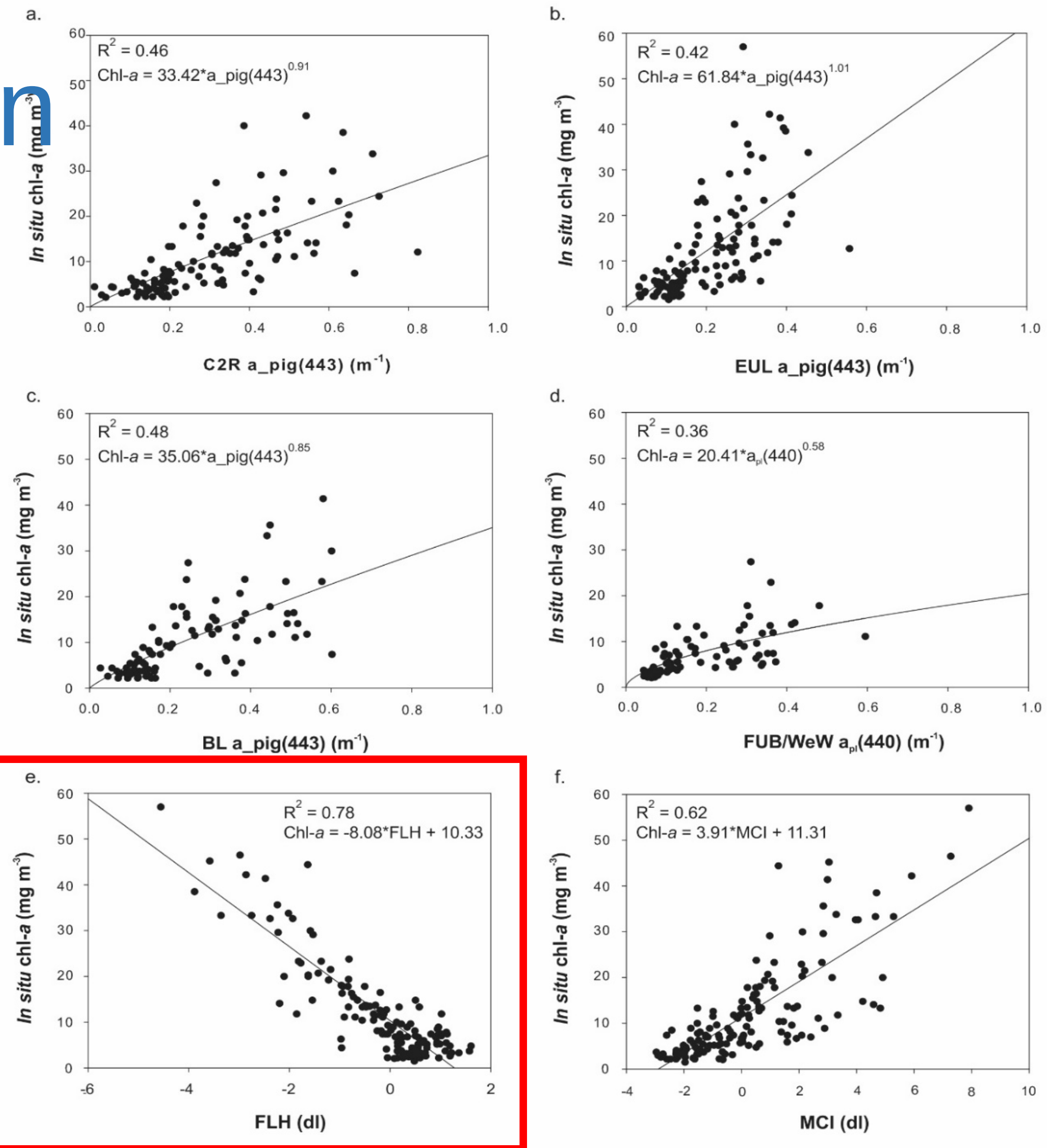
- 1409 full or partial MERIS overpasses (2007-2012)
- 679 *in situ* chl-a measurements (2007-2012)
- **289 in situ chl-*a* / clear MERIS matchup points**
  - **1.5 – 57 mg m^{-3}**



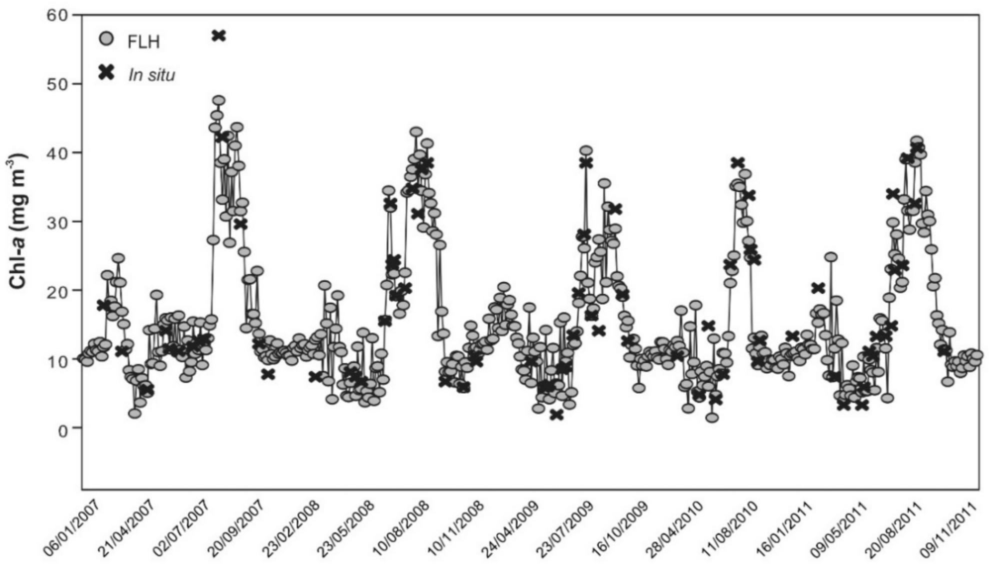
PHAVEOS processing chain.

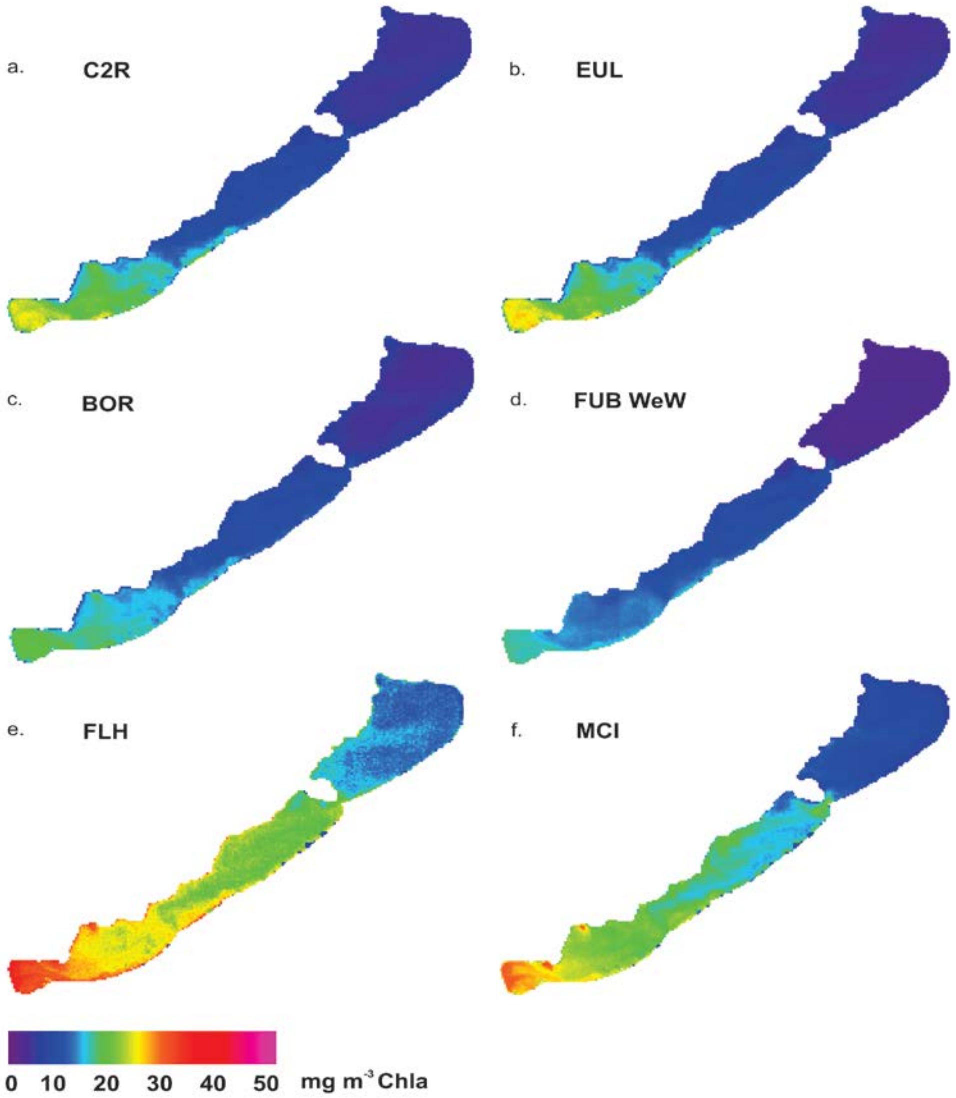
Chl-*a* retrieval validation

- Extremely variable algorithm performance
- Neural networks greatly underestimating high chl-*a*
- Semi-empirical perform well
- FLH performs best



Chl-*a* validation





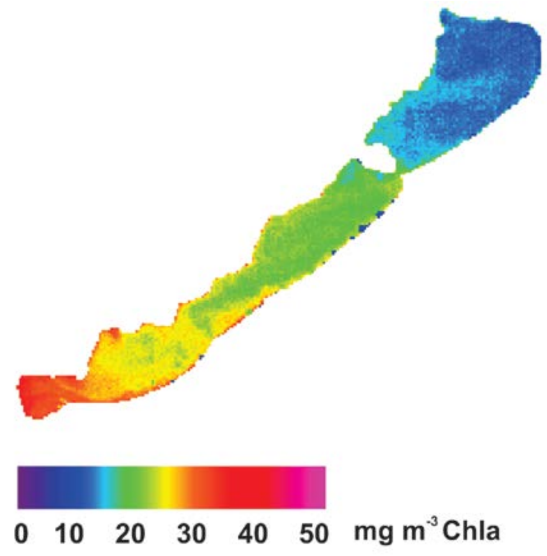
Phytoplankton phenology

- **Seasonal timing and related features of phytoplankton blooms**, such as bloom start & end timing, length, rates of biomass increase & decrease, peak biomass concentrations, number of annual bloom events, etc.
- Has been found to be **sensitive to climate change** and **nutrient loading**
- Important for **trophic level interactions**
- **Phenology** of terrestrial vegetation and increasingly the pelagic ocean is commonly **assessed using RS**; this is **underexploited for inland waters**

Lake phenology from space

- TIMESAT software (Jönsson and Eklundh, 2004)
- Time-series of chlorophyll-*a* concentration maps
- Smoothed time-series for each pixel
- Metrics extracted for each smoothed time series and mapped

1.



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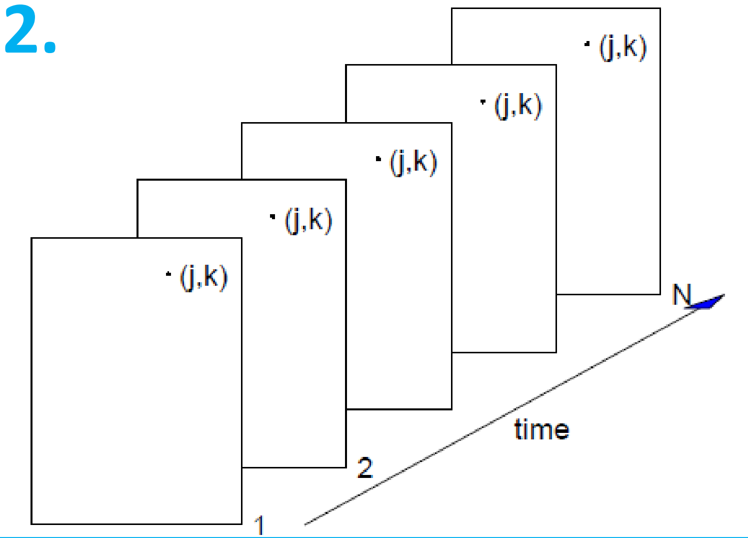

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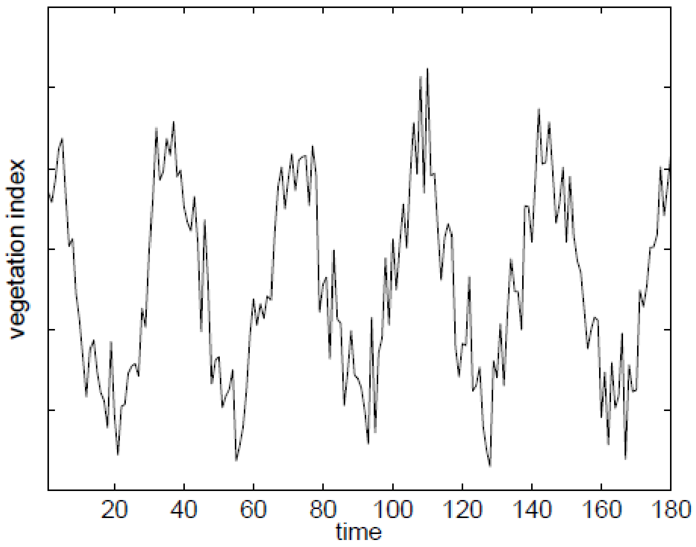

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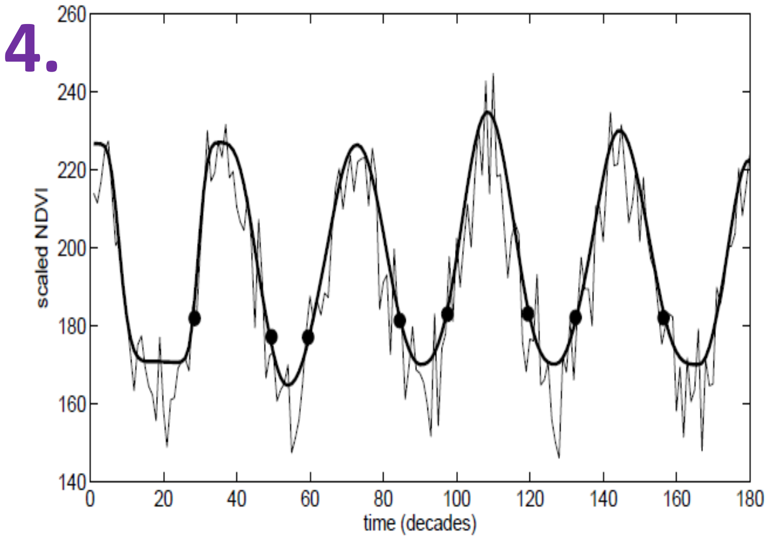
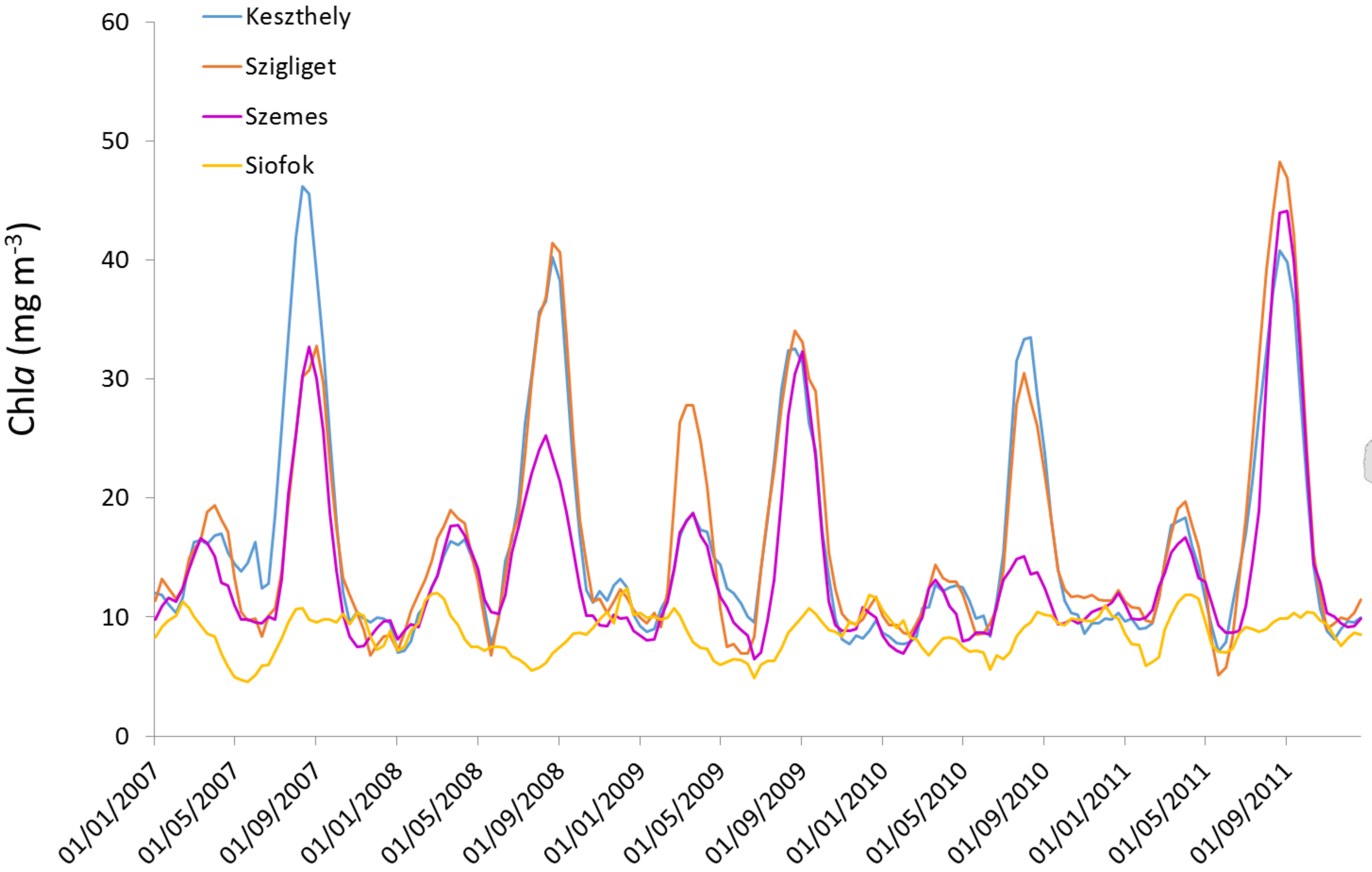
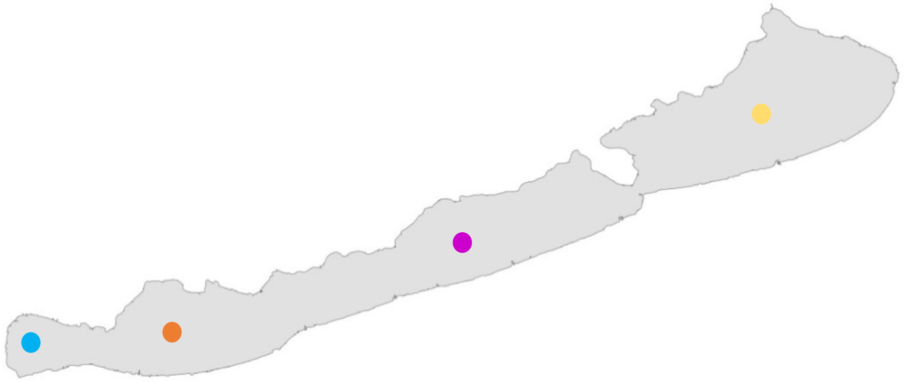
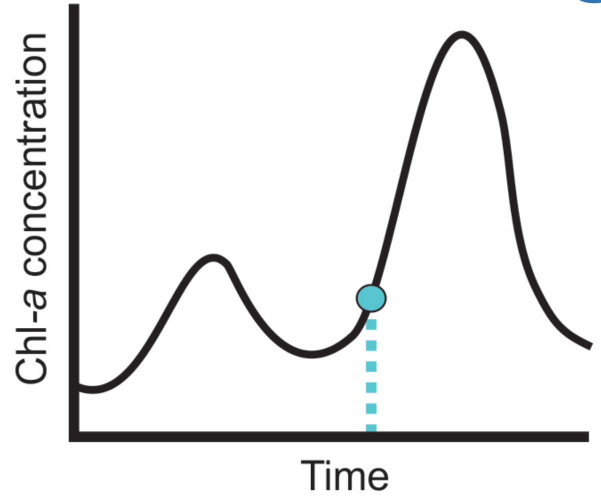


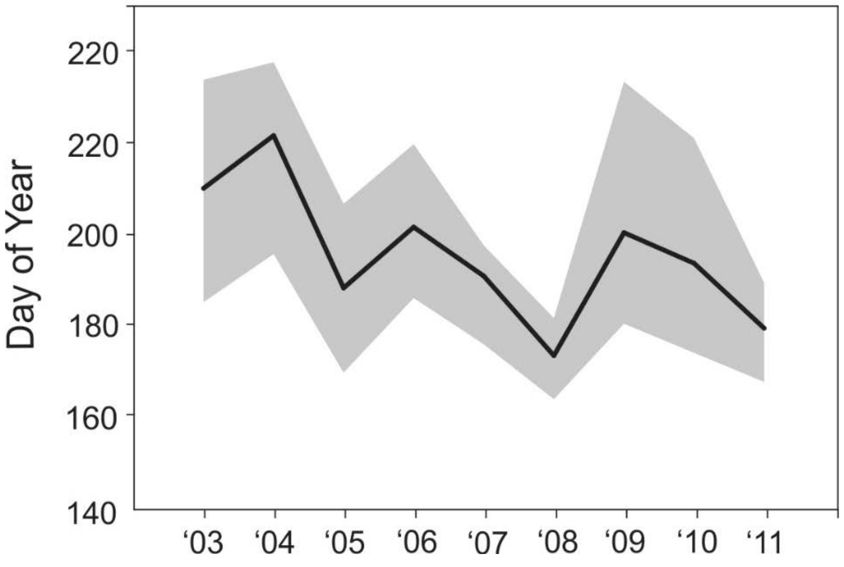
Extracted chl-*a* time-series

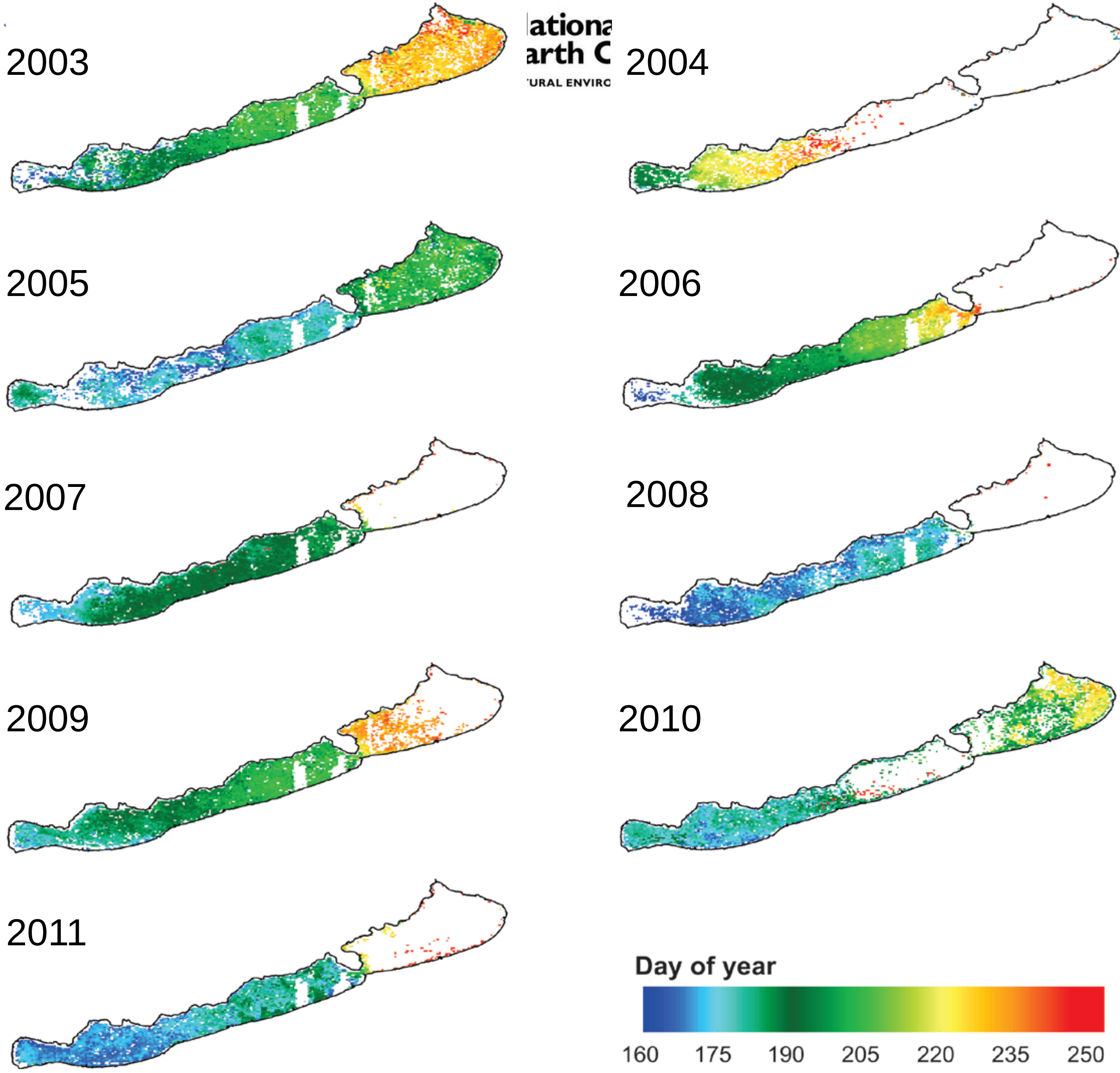




Start timing







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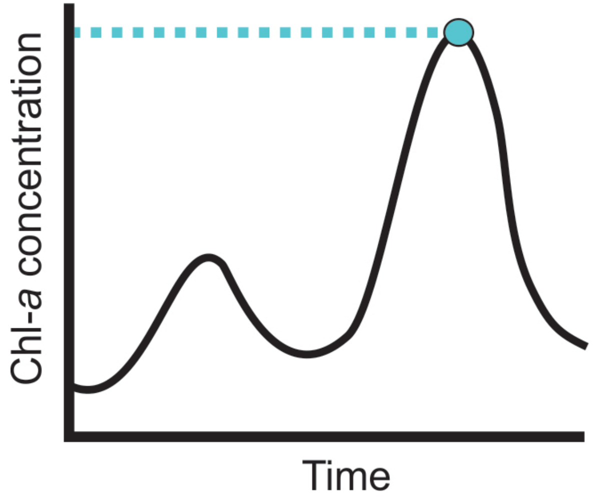
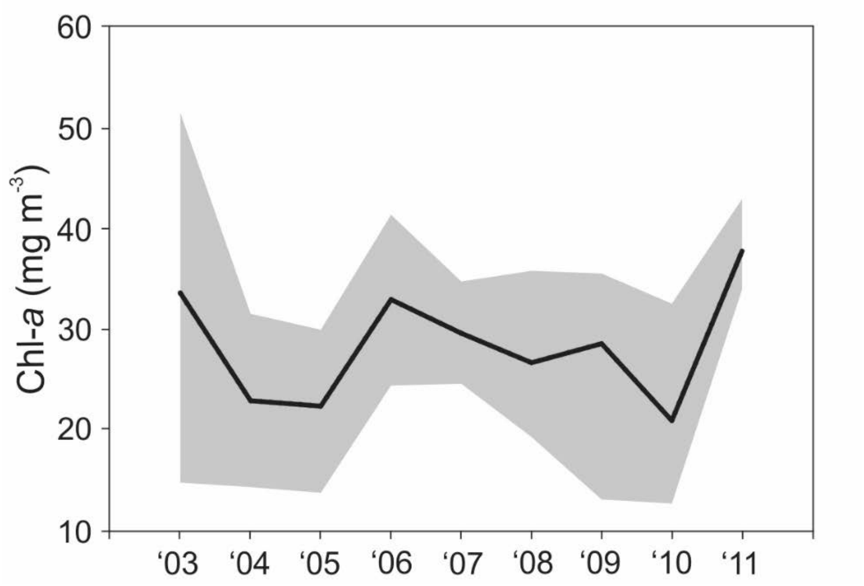
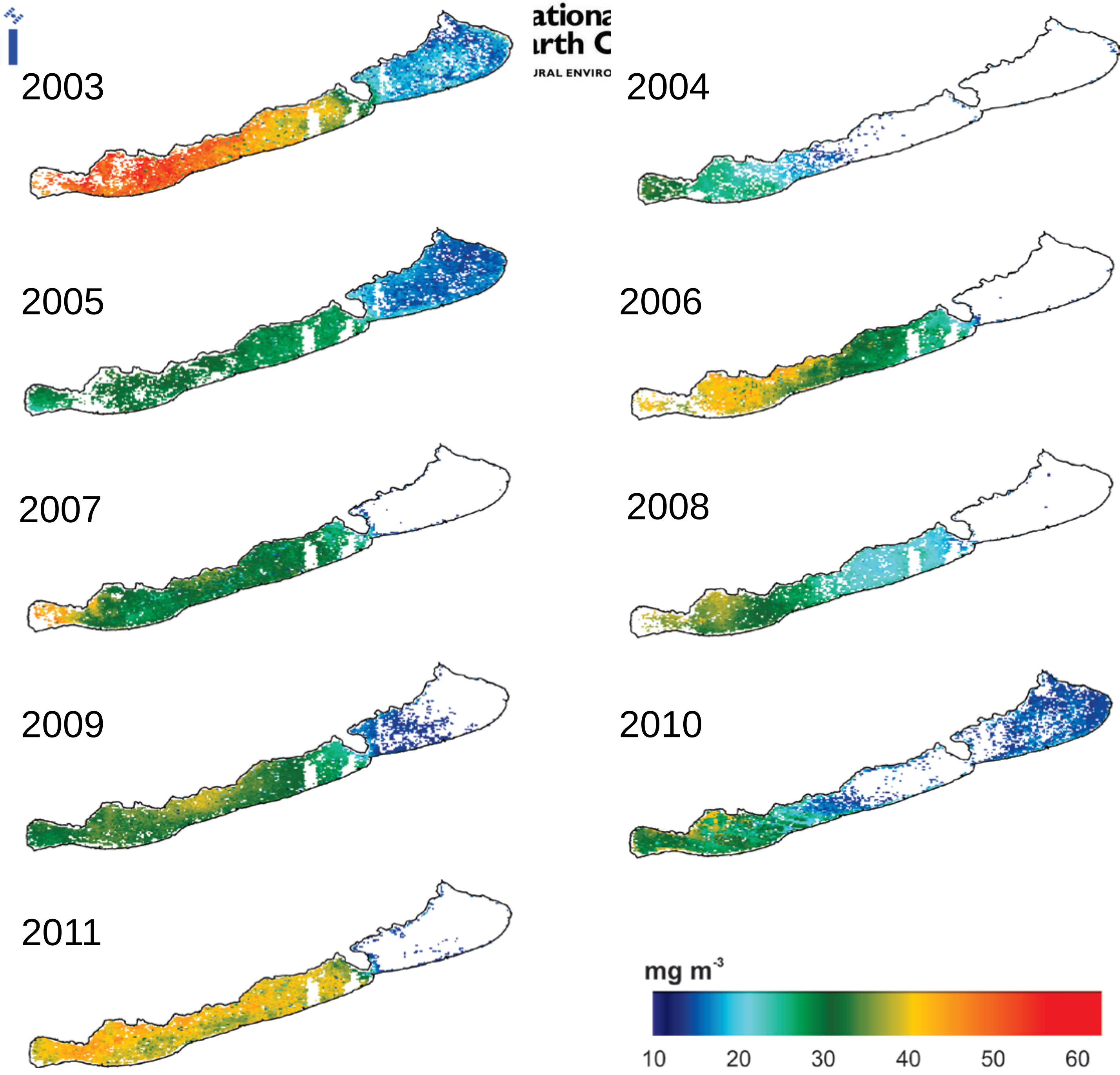
Maximum chl-*a* concentration







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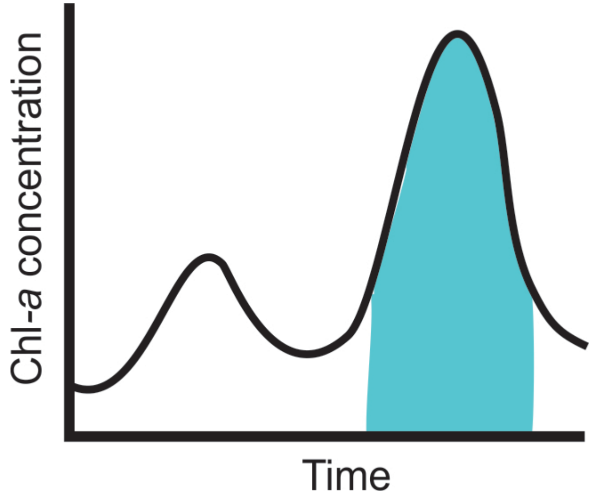
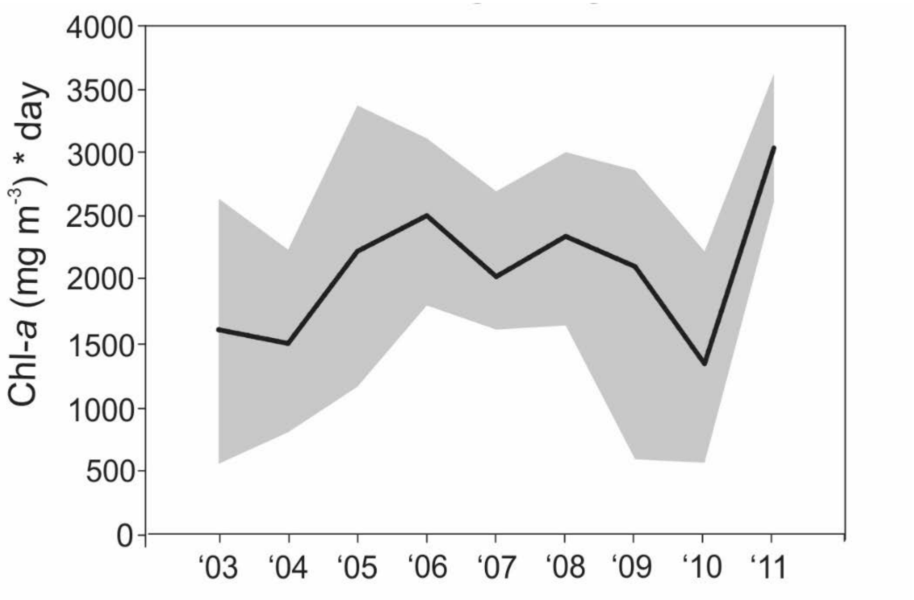
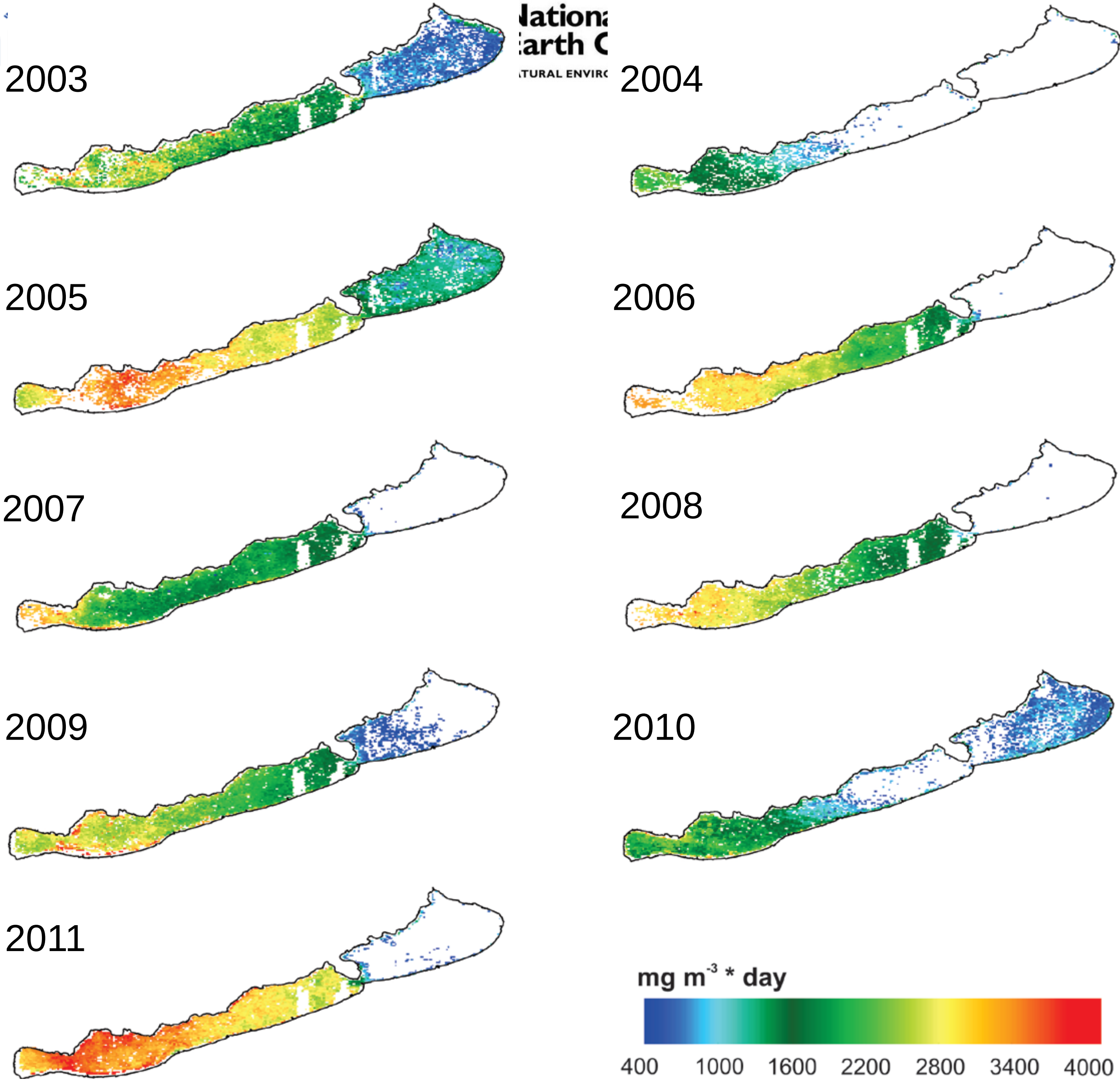
Large integral







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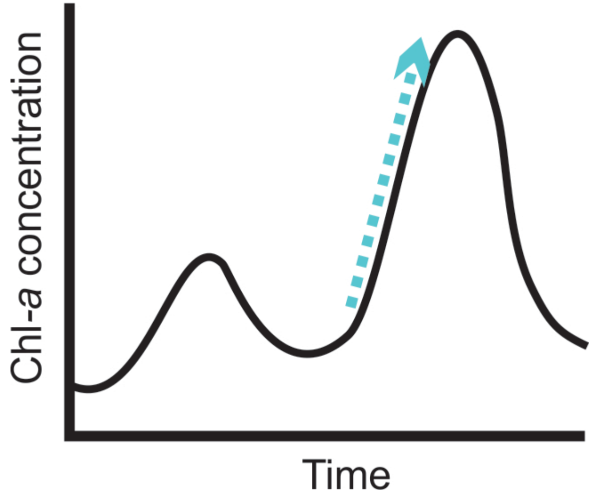
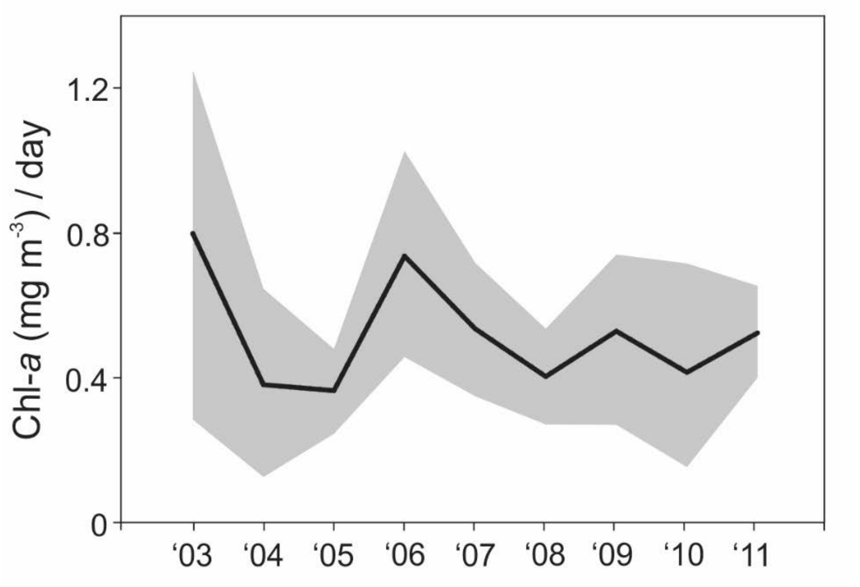
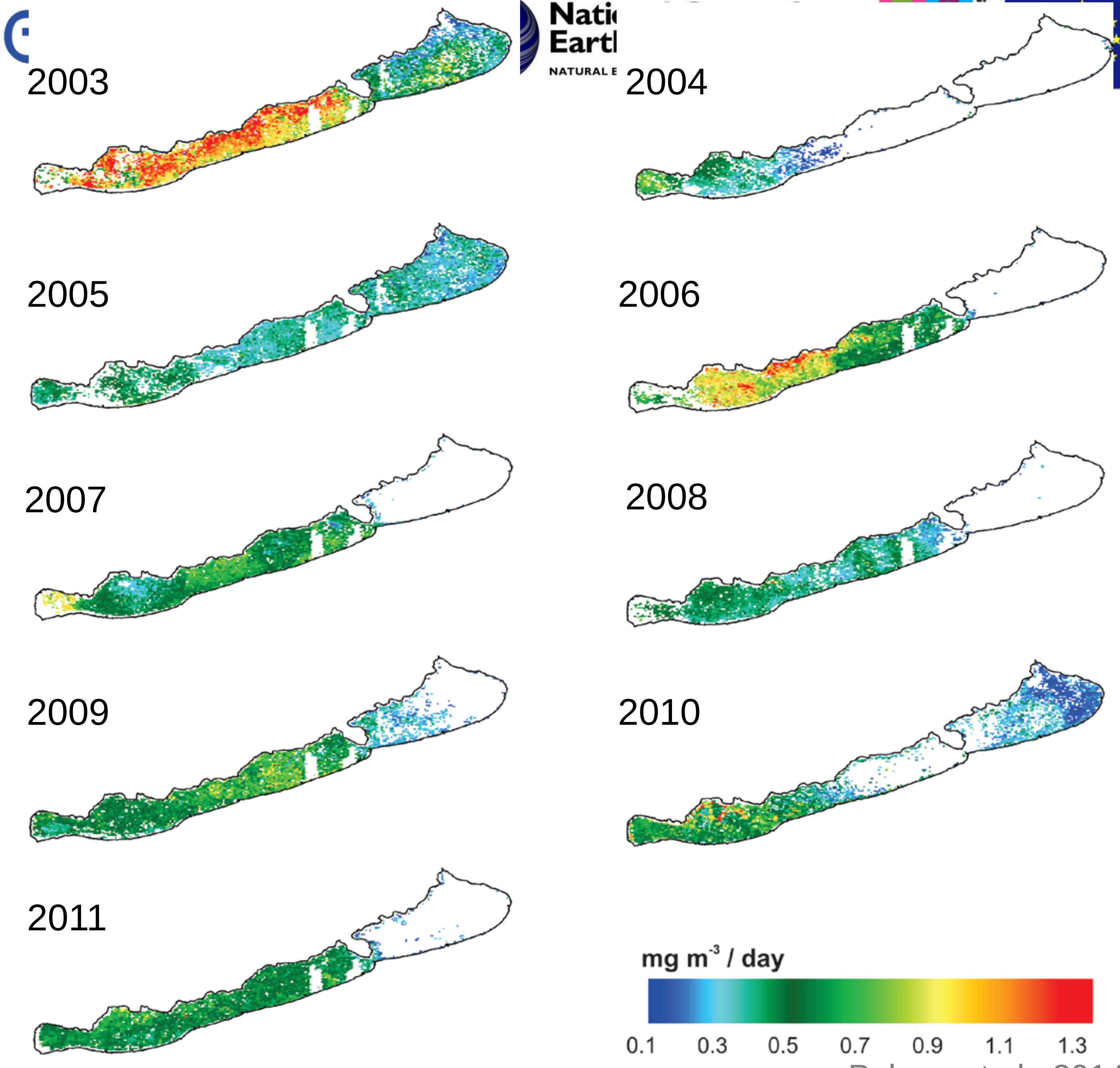
Rate of increase







Palmer et al., 2014b

Conclusions

- Phenology metrics are important ecological indicators; their mapping using EO has been demonstrated for Lake Balaton, Hungary
- A cohesive spatial component is added to phenology analysis & temporal dimension of satellite imagery is taken advantage of in a quantitative manner
- Both spatial and temporal variability of all phenology metrics considered, and of bloom extent, has been revealed

Outlook

- Application to other lakes!
- **Robust chl-*a* product as input is crucial; error will propagate into phenology analysis**
- Optimal definition of bloom events (“start” & “end”) may vary from lake to lake, and at sub-lake scales, and is to be considered
- Work on climate (temperature) and nutrient drivers of spatial and temporal variability of EO-mapped phenology metrics is underway for Balaton
- Cyanobacteria phenology mapping may be possible. Again, robust retrieval algorithms for input maps are the bottom line

Publications

- Palmer, S.C.J., Hunter, P.D., Lankester, T., Hubbard, S., Spyrakos, E., Tyler, A., Présing, M., Horváth, H., Lamb, A., Balzter, H. and Tóth, V.R. (2014, in press): Validation of Envisat MERIS- and Sentinel-3 OLCI-compatible algorithms for chlorophyll retrieval in a large, turbid and optically complex shallow lake. *Remote Sensing of Environment,* http://www.sciencedirect.com/science/article/pii/S0034425714002739

- Palmer, S.C.J., Pelevin, V.V., Goncharenko, I., Kovács, A.W., Zlinszky, A., Présing, M., Horváth, H., Nicolás-Perea, V., Balzter, H. and Tóth, V.R. (2013): Ultraviolet Fluorescence LiDAR (UFL) as a robust measurement tool for water quality parameters in turbid lake conditions, *Remote Sensing* 5, 4405-4422 http://hdl.handle.net/2381/28884

Thank you!

Questions?

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