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Project summary

GEISHA

Global Evaluation of the Impacts of Storms on freshwater Habitat and structure of phytoplankton Assemblages

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GEISHA is part of a series of GLEON projects related to the effects of physical disturbances and water column stability on freshwater plankton communities. Framed within the GLEON Stormblitz project, GEISHA's goal is to assess the impacts of storms on phytoplankton and provide new frameworks to answer questions on rules of phytoplankton community assembly and succession.

Context and objectives

Phytoplankton abundance and composition have critical implications for ecological processes and ecosystem services. They are sensitive to water column conditions which are strongly influenced by weather (e.g., wind and rain). Interest in the impact of more frequent extreme weather conditions on biological

communities due to climate change is growing in the scientific and management communities. However, the impacts of storms on lake phytoplankton have been poorly addressed, in part because field logistics and statistical issues complicate sampling, replication, and mechanistic attributions to drivers. Such methodological challenges can be circumvented by using long-term data sets. GEISHA was framed in support to the GLEON Stormblitz project to gather and analyse time-series through collaborative efforts. The project includes more than 80 researchers from governmental Institutes and Universities. GEISHA's goals were to :

1. gather and standardize existing long-term datasets,
2. assess the impact of storms on nutrients, light, water column stability and subsequent impacts on the structure of phytoplankton communities,
3. perform meta-analyses to evaluate the sensitivity of aquatic ecosystems to extreme weather events,
4. provide new frameworks to explore theoretical questions related to phytoplankton diversity, succession and ecosystem resilience to extreme weather events.

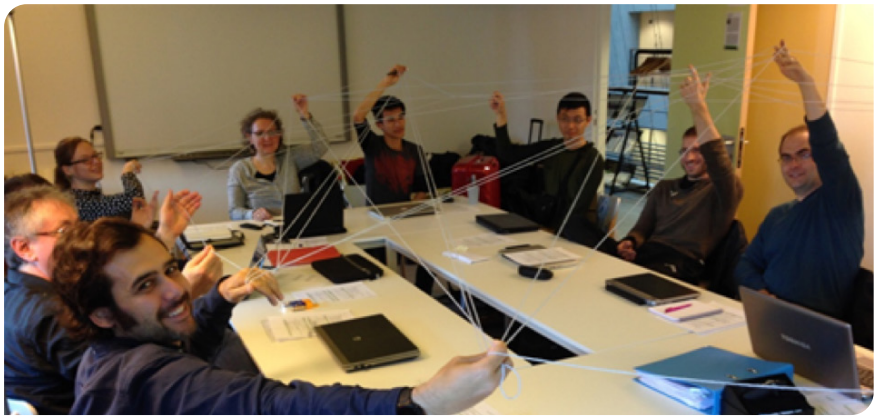
Methods and approaches used for the project

The execution of GEISHA has involved challenges related to the acquisition of high-quality temporal data, and the standardization of phytoplankton datasets based on diverse and ever-changing taxonomic nomenclature in time and among sites. We produced protocols that clearly define the format for datasets and developed a controlled vocabulary. To overcome the challenges associated with heterogeneous datasets and achieve inter-site comparisons of systems, the group adopted trait-based approaches and used appropriate statistical tools to describe communities and deviations from typical seasonal trajectories. As an example, we used multivariate statistics and over-sampling techniques designed to deal with imbalanced data, which are well-suited to assess the impact of rare events. Furthermore, the GEISHA group also applied team-science practices and produced clear policy rules regarding data-sharing and co-authorships, which have been extremely useful to set transparent and agreed-upon boundaries and promote confidence and trust among collaborators.

Principal conclusions

From our systematic review of the literature, we found a lack of consistency in the definitions of storms within the field of limnology, and we conclude that our understanding of storm impacts is fragmented and incomplete. GEISHA provided a conceptual model that identifies how storms interact with lake and watershed attributes to alter light and nutrient conditions, which then sets the stage for how phytoplankton communities are impacted and respond to abrupt environmental change, based on functional traits of those communities. The datasets compiled during this project have allowed testing of our conceptual model. Results obtained with high-frequency data indicate that storms generally resulted in an ecologically minimal decrease in lake temperature for phytoplankton, suggesting that other changes from storms such as nutrients concentrations or light availability may have a more significant effect on phytoplankton than temperature changes.

Time series from long-term monitoring provide interesting to assess the impact of storms on phytoplankton. Data analysis indicated that storms impact the rate of community turnover at the scale of the year. When a storm induces deepening of the thermocline and decrease in lake stability, the disturbance may induce a reversion in the pattern of phytoplankton annual succession. That is, most often, storms are likely to favor fast growing species and low-light adapted strategies that are characteristic of well-mixed conditions, depending on the time of the year and lake-specific characteristics.



1st GEISHA Workshop (Aix-en-Provence, CESAB, December 2016)

Anticipated (or actual) impact of these results for science, society, and public and private decision making

A team-science approach enabled us to develop solid, transparent and agreed-upon boundaries and confidence among GEISHA collaborators. These efforts turned this project into an impressive mould for new networking and future international collaborations. Furthermore, GEISHA was invited by a leading scientific journal (Global Change Biology) to write a review article on the highly relevant and emerging issue of extreme event impacts on lakes. Our work has stimulated efforts on the use of long-term data sets and underlined the value of long-term monitoring. The project has increased the visibility of existing long-term monitoring programs and provides computed derived data which can be used openly for further meta-analyses and are of great interest for inter-lake comparisons. As an example, GEISHA received several queries to use the compiled data in existing or planned large international programs including ISIMIP and H2020.

Interest in using morpho-functional approaches to link biodiversity to ecosystem functioning is growing. GEISHA has produced a unique and solid functional classification to facilitate the use of robust, repeatable functional classification systems. The "algaeClassify" R package, available on the CRAN repository, contains R-code designed to facilitate the application of common morpho-functional and life-history classifications to phytoplankton species lists and/or trait datasets. GEISHA members are continuing to add functionality to this package, and an open-source development version can be downloaded from github (https://github.com/vppatil/GEISHA_phytoplankton/tree/master/package%20builds/algaeClassify). This package, will facilitate widespread application of functional diversity classifications to phytoplankton data and provide tools to combine and homogenize datasets that may have been collected at different times and that incorporate different combinations of species names, higher taxonomy and functional traits. Finally, the GEISHA website (https://www.geisha-stormblitz.fr/) provides a place to know more about and follow the project.

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