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Turbulence and intermittency in lakes, a multifractal correlation analysis

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Cyanobacteria proliferation in lakes, such as those occuring frequently in Lake Bourget, is an environmental issue, as well as a matter of public health. In the frame of the PROLIPHYC project, an alarm system to warn about sudden proliferations of cyanobacteria was developed. The system is based on high-frequency measurements of water temperature and of the fluorescence of different phytoplankton classes, a proxy of their concentrations. In an attempt to simplify the warning system, we investigate the predictability of the proliferation of cyanobacteria from measurements of precursor variables, which are easy to measure (e.g. water temperature). The classical approach would be to find the correlations at a given scale of cyanobacteria fluorescence with the precursor fields. However, this is rather in contradiction with the multiscale variability of lake dynamics, which results from nonlinear interactions between different scales and processes.

To find an alternative, we first performed a spectral analysis of the velocity, temperature and cyanobacteria fluorescence measurements to have a first estimate of their scaling ranges. For instance, the temperature spectrum over small scales is rather similar to that of a passive scalar. To go beyond the limitations of a second order statistical analysis, we performed multifractal analyses (Trace Moment, Double Trace Moment) to estimate the scaling behaviour of statistical moments of different orders $q's$. The nonlinear behaviour of their scaling moment function $K(q)$ shows that the fields are indeed multifractal and therefore intermittent. As a consequence we proceed to a multifractal correlation analysis between these fields, i.e. a correlation analysis across scales, in particular between temperature and cyanobacteria fluorescence.

In conclusion, we discuss the predictability of the proliferation of cyanobacteria from temperature measurements, which results from their multifractal correlation.