



Regression Models for Non-Gaussian Repeated Measures Data with Application in Ecology and Epidemiology

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Abstract

Regression models for non-Gaussian longitudinal repeated measures data have intractable likelihoods, and inferences require approximation. The Laplace approximation used by the popular lme4 software for fitting these models (Bolker et al. 2009, *Trend. Eco. Evol.*) has recently been shown to produce invalid inferences theoretically and empirically (Bilodeau, Stringer, and Tang 2025, Bernoulli; Stringer 2025, *Stat. Comput.*), requiring methodological innovation. The Fellow will work with Drs. Alex Stringer and Ben Bolker to develop methods for integral approximation in multivariate random effects models for non-Gaussian repeated measures data and implement them within the lme4 universe for widespread use.

Interdisciplinary/Applied Experience

The Fellow will have the opportunity to work on direct applications in statistical ecology in collaboration with Dr. Chantel Markle (Assistant Professor and Tier 2 Canada Research Chair in Wildlife Ecohydrology and Global Change, School of Environment, Resources and Sustainability and the Department of Geography and Environmental Management, University of Waterloo), whose research actively supports development of evidence-based environmental policy. Dr. Markle's lab produces high-quality non-Gaussian repeated measures data which require methods and software that produce numerically accurate and statistically valid estimates in a reasonable amount of time. The Fellow will have the opportunity to

make an immediate impact on the analysis of continuous temperature and biollogger data (e.g., tri-axial accelerometer) from Dr. Markle's lab. These data allow for novel insights into the behaviour of cryptic species and how they respond to environmental stressors.

Teaching/Training/Education

The University of Waterloo is home to Canada's largest academic statistics department with an extensive catalogue of undergraduate and graduate statistics courses. The Fellow will be given the opportunity to teach at least one full-time semester-long course over the 2026 or 2027 academic year in the Department of Statistics and Actuarial Science (SAS) at the University of Waterloo in a subject jointly determined by the Fellow's expertise and interest as well as departmental need. The Fellow will be encouraged to assist with mentorship of junior trainees in Dr. Stringer's research group and interact with Dr. Bolker as well as with many faculty in Biology and other units at McMaster University with whom Dr. Bolker has research connections.

Mentoring

The Fellow will spend their first year at the University of Waterloo under the direct supervision of Dr. Stringer, which will mostly focus on development of methodology and applications in Ecology in collaboration with Dr. Markle. The Fellow will spend their second year at McMaster University under the direct supervision of Dr. Bolker with a focus on implementing the methods they have developed into the lme4 software universe, facilitating immediate uptake by the broader scientific community.

Dr. Stringer has published on the topic of accuracy (Bilodeau et. al. 2025, Bernoulli) and speed/stability (Stringer 2025, *Stat. Comput.*) of inferences in mixed models for non-Gaussian repeated measures data. Dr. Bolker is one of the leading authorities in the world on the development and application of mixed models with a specific focus on statistical ecology. He is a principal developer of the lme4 family of software. The combination of substantial methodological development, access to scientific collaboration, and meaningful implementation in software that is already used by the broader scientific community, all actively supervised by current experts in this field, will prepare the Fellow for a career in academic or industry research.

Both host universities support a variety of research activities in which postdoctoral scholars participate, including seminars, conferences, and reading groups. Both supervisors are able to fund travel expenses for disseminating research.

Schedule

Year 1: University of Waterloo

- Develop methods for accurate integral approximation and fast, stable optimization in multi-level mixed models for longitudinal repeated measures data
- Collaborate with Dr. Markle to apply new method(s) to problem(s) in ecology and wildlife biology
- Teach one full-semester undergraduate statistics course at the University of Waterloo
- Mentor junior trainees including hosting a research group meeting, presentation session, and/or informal seminar
- Present at the SSC conference and one other appropriate Canadian statistics meeting

Year 2: McMaster University

- Develop usable open-source implementation of new methods in the lme4 software universe, providing the first large-scale accurate and stable implementation of mixed models for non-Gaussian longitudinal repeated measures data
- Present at the Statistical Society of Canada (SSC) annual conference and one or two other appropriate Canadian or international statistics meeting(s)
- Develop independent funding proposal(s) and/or research program plan in preparation for job search, with mentorship from both supervisors

List of Desired Qualifications

- PhD in statistical science or similar field (e.g., quantitative epidemiology)
- Demonstrated ability and interest in developing novel statistical methodology and publishing in statistics journals
- Interest in implementing novel methods in usable open-source software
- Interest in collaborating with scientists to address field-specific research questions using novel statistical methods and publishing results in field-specific journals