

R in support of Environmental Risk Assessment

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Abstract

Package `morse` is devoted to the analysis of experimental data collected from standard toxicity tests (Baudrot and Charles 2021). It provides ready-to-use functions to visualize raw data and to estimate several toxicity indices to be subsequently used in support of environmental risk assessment in full compliance with regulatory requirements. Such toxicity indices are indeed classically requested by standardized regulatory guidelines on which national agencies base their evaluation of applications for marketing authorisation of active chemical substances.

Package `morse` can be used to get estimates of LC_x ($x\%$ Lethal Concentrations) or EC_x ($x\%$ Effective Concentrations) by fitting standard dose-response models on toxicity test data. Risk indicator estimates as well as model parameters are provided along with the quantification of their uncertainty. Package `morse` can also be used to get estimates of NEC (No Effect Concentrations) by fitting a Toxicokinetic-Toxicodynamic (TKTD) model (namely GUTS models, that is *General Unified Threshold models of Survival*). Using GUTS models also allows to get estimates of $LC_{(x,t)}$ (whatever x and t) and $LP_{(x,t)}$ ($x\%$ Lethal Profile), this later being defined by the European Food Safety Authority as the $x\%$ multiplication factor leading to an additional reduction of $x\%$ in survival at the end of an exposure profile. Above all, GUTS models can be used under environmentally realistic time-variable exposure profiles, package `morse` providing all features to easily perform prediction of the survival over time associated with the uncertainty, propagated from a previous calibration process.

This talk will illustrate a typical use of package with survival data collected over time and at different increasing exposure concentrations, analysed with the reduced version of GUTS models based on the stochastic death hypothesis (namely, the GUTS-RED-SD model). This case studies can then be followed step-by-step to analyse any new data set, as long as the data set is correctly formatted.

Keywords

Toxicity indices – Modelling – Bayesian inference – R-package `morse`

Statement of Need

Package `morse` (Baudrot et al. 2021) has been tested using R (version 3.5 and later) on macOS, Linux and Windows machines. Regarding the particular case of toxicokinetic-toxicodynamic (TKTD) models for survival, namely GUTS models, package `morse` was ring-tested together with nine other GUTS implementations under different software platforms (Jager and Ashauer 2018). All participants to the ring-test received the same data sets and tasks, carried out their simulations independently from each other and sent the results back to the coordinator for the comparative analysis. Giving very similar results than all the other implementations, package `morse` was thus confirmed as fit-for-purpose in fitting GUTS models on survival toxicity test data.

All functions in package `morse` can be used without a deep knowledge of their underlying probabilistic model or inference methods. Rather, they were designed to behave as well as possible, without requiring the user to provide values for some obscure parameters. Nevertheless, for advanced R users, models implemented in `morse` can be used as a first step to tailor new models for more specific situations.

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Note that package `morse` benefits from a web interface, MOSAIC, from which the same analyses can be reproduced directly on-line. MOSAIC is freely available at <https://mosaic.univ-lyon1.fr/> (Charles et al. 2018).

Availability

Package `morse` is available as an R package; it can be directly downloaded from CRAN <https://CRAN.R-project.org/package=morse>, where package dependencies and system requirements are also documented. The development version can be found on GitHub <https://github.com/pveber/morse>, where code contributions, bug reports, fixes and feature requests are more than welcome by opening issues and pull requests.

A **Tutorial** is available at <https://cran.r-project.org/web/packages/morse/vignettes/tutorial.html>, with all necessary details to plenty use all `morse` features. A more formal description of the models and the estimation procedures are provided in a document called “Models in morse package” available at <https://cran.r-project.org/web/packages/morse/vignettes/modelling.pdf>.

Références

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