

# Multivariate Event Modeller

The Multivariate Event Modeller (MEM) is a tool designed for undertaking joint probability analysis of extremes for up to 10 variables.

The joint probability of two or more variables being “extreme” is relevant in Flood and Coastal Risk Management (FCRM) in various contexts, including:

- Assessing the likelihood of extreme peak flow events on multiple tributaries of a river to help in developing scenarios for a whole-catchment model
- Placing recent or historical floods in context by estimating the combined likelihood of extreme flows, water levels, rainfall, wave or wind observations at one or more locations
- Assessing the likelihood of combinations of extreme river flows, storm surge and possibly other relevant variables
- Modelling the chance of combinations of extreme conditions occurring together in related variables such as soil moisture content, rainfall accumulations and river flows

Previous Defra and Environment Agency guidance describes methods for joint probability calculations for certain pairs of variables, based on statistical models supported by specialist software.

More recently, new statistical methods have been developed that allow for a more general, data-driven analysis of the joint probability of extreme events in combinations of multiple variables. Applications include regional and national scale assessments of the probability of widespread flooding in rivers, and joint probability analysis of extreme surge and waves at the coast.

These methods have been documented and tested through a series of Environment Agency research reports and were applied in the development of the 2017 National Risk Assessment scenarios.

The Multivariate Event Modeller (MEM) implements the new methods with user-supplied data sets to estimate the joint probability of extreme events in combinations of up to 10 variables.

The MEM is designed for joint probability analysis of extremes in time series data for up to 10 variables. Additionally, the MEM handles a special case where data have been sampled for extreme surge events to illustrate the extension of coastal joint probability methods to incorporate spatial dependence.

## Acknowledgements

The Multivariate Event Modeller was initially developed as part of Environment Agency project SC140002 (Spatial Joint Probability for FCRM and National Risk Assessment), within the Defra/Environment Agency/Natural Resources Wales Joint Flood and Coastal Risk Management R&D programme. The tool was updated in 2023, funded by the Environment Agency.

## Documentation

The overview tab within the MEM contains information about how to use the tool. There is also guidance within each tab. Further details can be found in the user guide published in 2018. Changes since 2018 are recorded in the release notes.

## Licences

The code was written by Jeremy Benn Associates Limited.

The code in the ‘Functions.R’ file is released under the GNU General Public License v2.0 and the code in the ‘server.R’ and ‘ui.R’ files is released under the Open Government Licence.

## Support

Please send enquiries to [FloodHydrology@environment-agency.gov.uk](mailto:FloodHydrology@environment-agency.gov.uk)

## Release notes (2023-08-04)

### Changes since previous release

- Compatible with R v4.2.2 and RStudio v2022.12.0.
- Mass update of underlying R packages to recent version (compatible with versions as of January 2023).
- Use of the ‘renv’ package to create a reproducible environment to assist running from RStudio on a desktop.
- Improvements to error catching:
  - Additional validation on inputs to interactive tables.
    - \* Restrictions have been set for the scale and shape parameters for the user marginals table to avoid errors from invalid parameters.
    - \* Restriction set for the table on the ‘Joint probability’ tab of a max AEP of 99.9% to avoid implying a deterministic prediction (i.e. a probability of 1).
  - New warnings and errors to catch if the user has uploaded a file of incorrect format or incorrect type of data, or if the user has tried to use invalid inputs, such as characters in numeric fields, or unrealistic input values.
  - Aesthetic updates to warnings and errors to improve user experience.
- Plot download functionality fixed.
- Reduced point size on plots to improve legibility.
- Stability improvements.
- Added the ability for the user to introduce a time lag.
- Added the ability for the user to edit some plot titles and labels.
- Removed ability to re-simulate without refreshing the MEM as this caused issues.
- Minor edit to the ‘fromUnifToEmp’ function based on recommendation from the functions testing. The impact is very small.
- Corrected the ‘probability’ output in the ‘HT.userMarginals’ function, although this is not used so there is no impact on calculations.

### Known issues

- The axes on the plots on the ‘Joint probability’ tab are not rescaling to include the ‘event’ lines when they are higher than the simulated data.
- Unhelpful errors appear when the statistical models cannot fit the data well due to dodgy values in the data.
- Formatting cannot be applied to user-defined labels on non-interactive plots.