

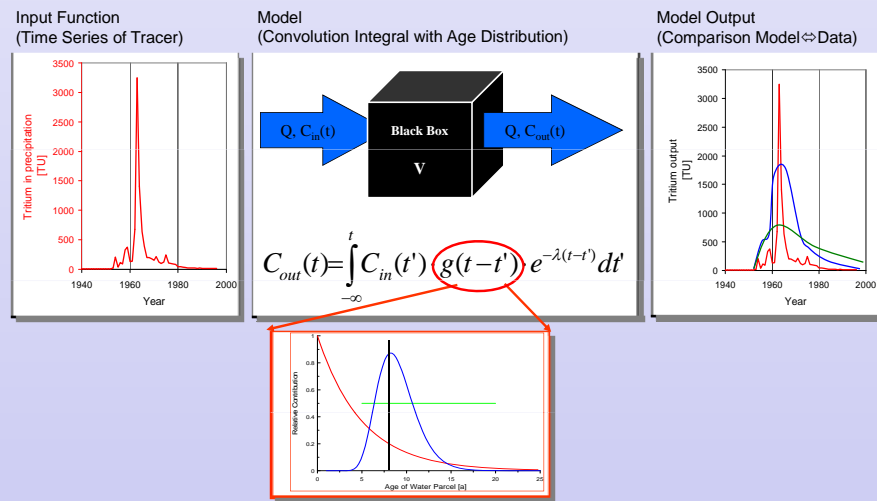
# Lumpy - an Interactive Lumped Parameter Modeling Code based on MS Access and MS Excel

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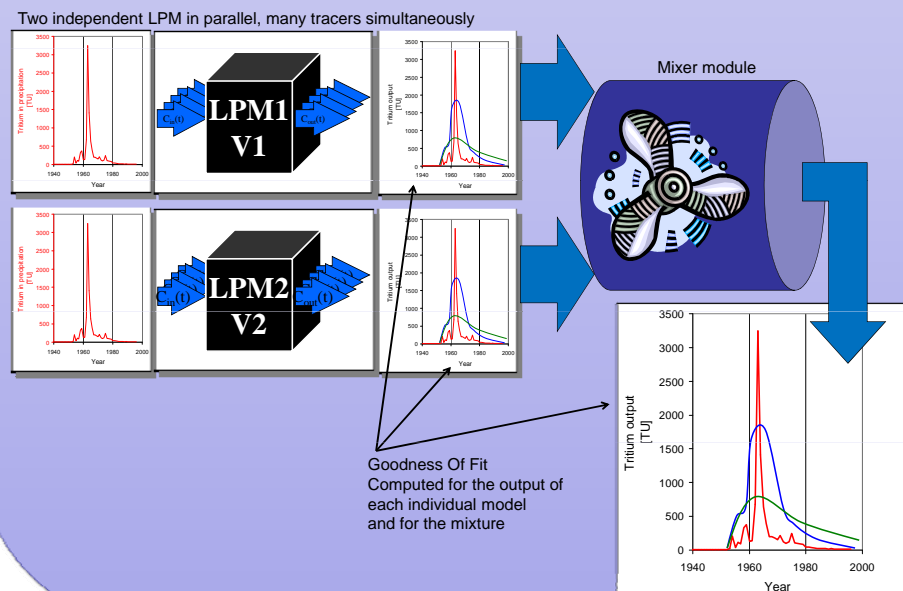
## The General Principle

Lumped Parameter Models (LPM) use a known input function and only few „lumped“ parameters to describe a flow system. Model output is computed as weighted mean of the input function. The weight is a mathematical function of age of the input („age distribution“). Fit parameter is always the mean age and sometimes a second parameter describing the width of the age distribution. Different models (= different shapes of the age distribution) describe different idealized flow systems.



## The Possibilities in Lumpy

Lumpy allows modeling many tracers simultaneously with up to two lumped parameter models in parallel and the output to be mixed at various rates. All common LPM are allowed and the code is probably the most powerful and flexible available at present. Code properties are listed to the right.



## Features

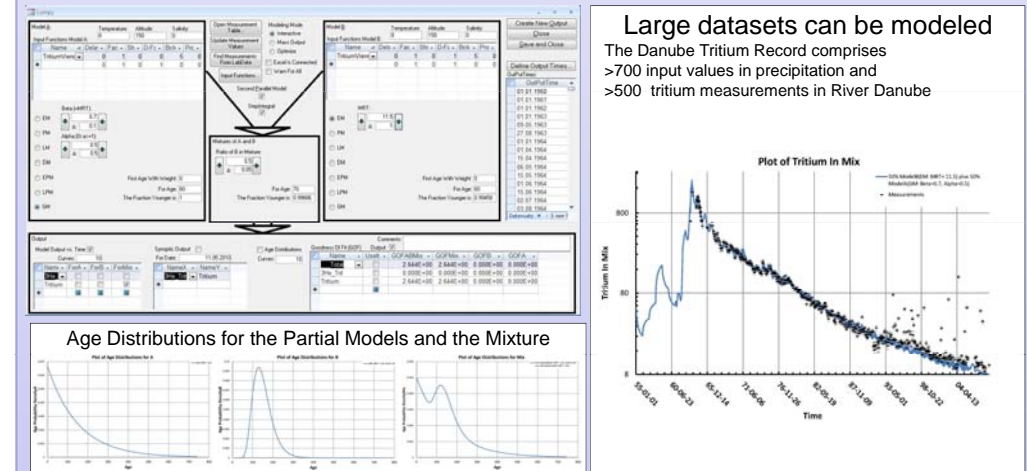
- **Hardware requirements**
  - Any modern PC, two screens strongly recommended
- **Software requirements**
  - Windows XP or higher, MS Access, MS Excel 2000 or higher
- **Wetware requirements**
  - Understanding of the concepts of age distribution and mixing
- **Up to two LPM in parallel**
  - Exponential Piston Flow Model (EM & EPM)
  - Piston Flow Model (PM)
  - Linear Piston Flow Model (LM & LPM)
  - Dispersion Model (DM)
  - Gamma Model (GM)
- **„All“ Tracers**
  - $^{18}\text{O}$ , D, Tritium,  $^3\text{He}_{\text{Tri}}$ , CFCs,  $\text{SF}_6$ ,  $^{85}\text{Kr}$ ,  $^4\text{He}_{\text{Rad}}$ ,  $^{39}\text{Ar}$ ,  $^{14}\text{C}$ ,  $^{81}\text{Kr}$ ,  $^{36}\text{Cl}$ ...
- **Goodness Of Fit for each LPM and the mixture**
  - Any number of input and output data (Database)
  - Several modes of Goodness Of Fit (GOF)
  - All GOF computed for all tracers simultaneously
  - Finds best fit of a series of combinations (MRT, Dispersion, Mixing)
- **Individual input function per model**
  - Not necessarily equidistant in time (missing GNIP data no problem)
  - Can be delayed (e.g. Tritium passing the unsaturated zone)
  - Can be shifted (e.g. for stable isotope input of different altitude)
  - Can be changed by constant factor (e.g. geochemical initial  $^{14}\text{C}$ )
  - Constant value prior to time series (e.g. pre-bomb Tritium)
- **Excel as data display**
  - Interactive change of parameters directly displayed
  - Time Series
  - Synoptic Tracer versus Tracer plots
  - Age Distributions

**Just get a copy and try it:  
It's Freeware!**

Lumpy was successfully used:  
 Aggarwal, P.K., Araguas-Araguas, L., Gröning, M., Newman, B., Kurtas, T., Papesch, W., Rank, D., Suckow, A., Vitvar, T. (2010): Long-term tritium monitoring to study river basin dynamics: case of the Danube River basin. EGU General Assembly 12 EGU2010-11775.  
 Babinka, S. (2007): Multi-Tracer Study of Karst Waters and Lake Sediments in Croatia and Bosnia-Herzegovina: Plitvice Lakes National Park and Bihać Area. PhD thesis, Bonn University.  
 Stolp, B. J., Solomon, D. K., Suckow, A., Vitvar, T., Rank, D., Aggarwal, P. K., Han, L.-F. (2010): Age dating base flow at springs and gaining streams using helium-3 and tritium: Fischs-Dagnitz system, southern Vienna Basin, Austria. Water Resources Research 46, DOI: 10.1029/2009WR008006.

## User Interface and Output Interactive Mode

In interactive mode Lumpy computes GOF and displays data in a connected Excel workbook whenever a parameter is changed. This allows a very direct user control of how well the selected model fits the data. All parameters displayed in the user interface for the two models and the mixing can be changed in this interactive manner. As additional user information Lumpy also displays the fraction of water younger than a certain value and the first non-zero age in the age distribution.



## Mass Output / Optimize

In Mass Output mode, Lumpy simultaneously computes and displays several output curves. This is useful for multi-parameter modeling to plot different tracers against each other, to visualize the data space describable by the selected model combination. Optimize mode reduces this parameter space (maybe 2000) to those with best fit for each individual tracer and for all tracers together (a handful).

