



Effects of distribution choice on the modeling of LCI uncertainty

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And with...
 **ESD**
ecological systems design

**POLYTECHNIQUE
MONTREAL**

WORLD-CLASS
ENGINEERING

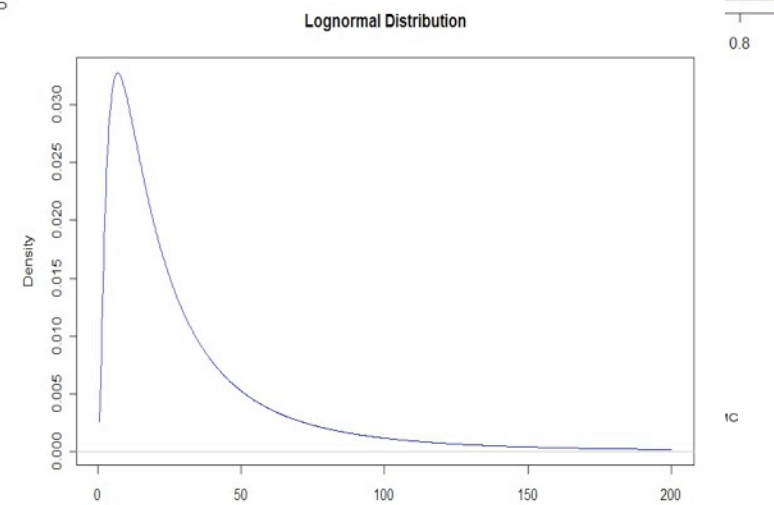
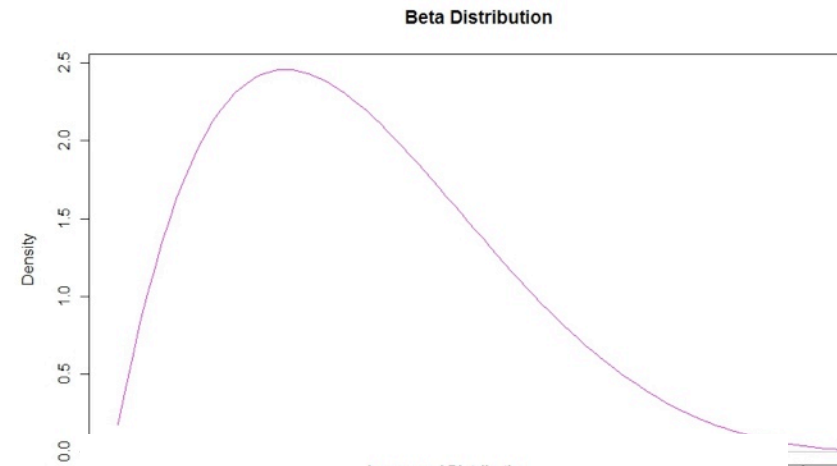
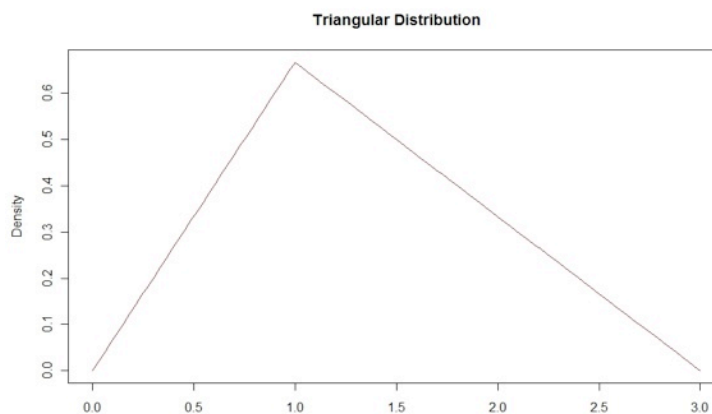
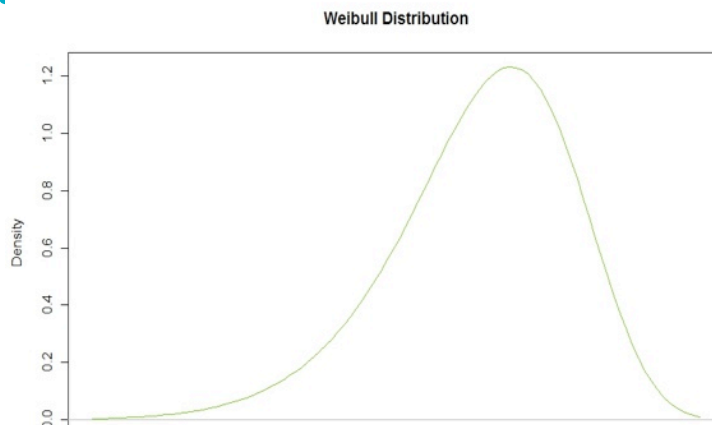


INTRODUCTION

When performing LCA uncertainty assessments:

Major LCA software offer the possibility to run Monte Carlo analysis

→ **The practitioner needs to define PDF to model a datum with its uncertainty**



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Lack of time and lack of data, for modelling both background and foreground:

Experts' judgments to derive PDFs

Use of default distributions

- **Beta** (Kennedy et al., 1996; Canter et al. 2002; Wang et al. 2012)
- **Beta PERT** (Koffler and Kalish, 2012)
- **Ecoinvent database – Lognormal** (Frischknecht et al., 2005)

DOES THE CHOICE OF THE DISTRIBUTION
MATTER WHEN PERFORMING A MONTE
CARLO LCA UNCERTAINTY ASSESSMENT ?

HOW DOES THE CHOICE OF THE DEFAULT
DISTRIBUTION DRIVE RESULTS'
CHARACTERISTICS ?

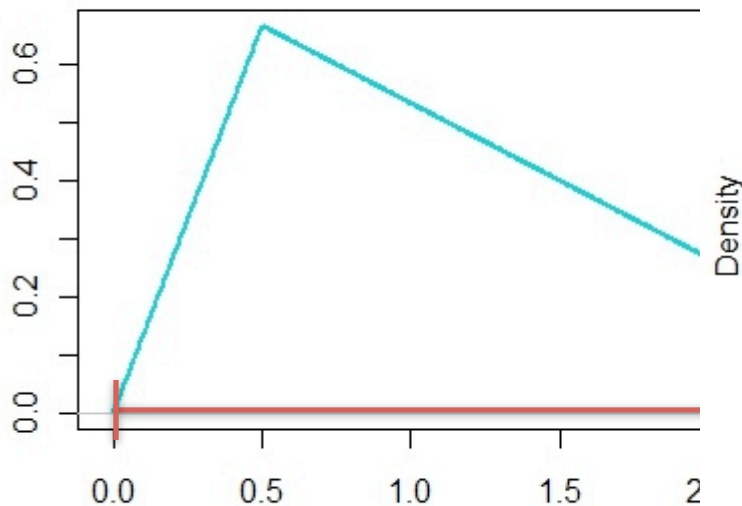
1. PDFs CHARACTERISTICS

Generally distributions are defined through:

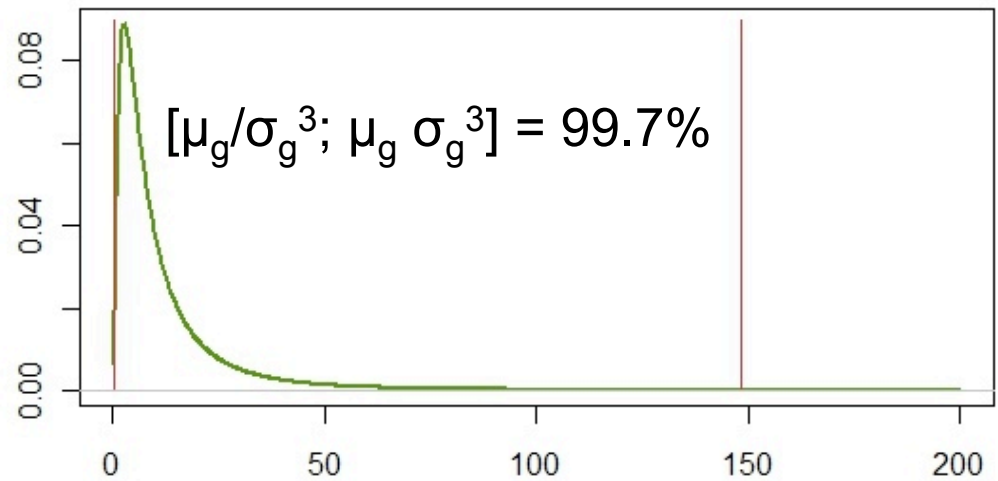
- a. Their location parameter(s) (i.e. range)
- b. Their shape

a. Bounded vs. unbounded distributions

Triangular Distribu



Lognormal Distribution



Unbounded distributions can be bounded with 95% or 99% confidence intervals

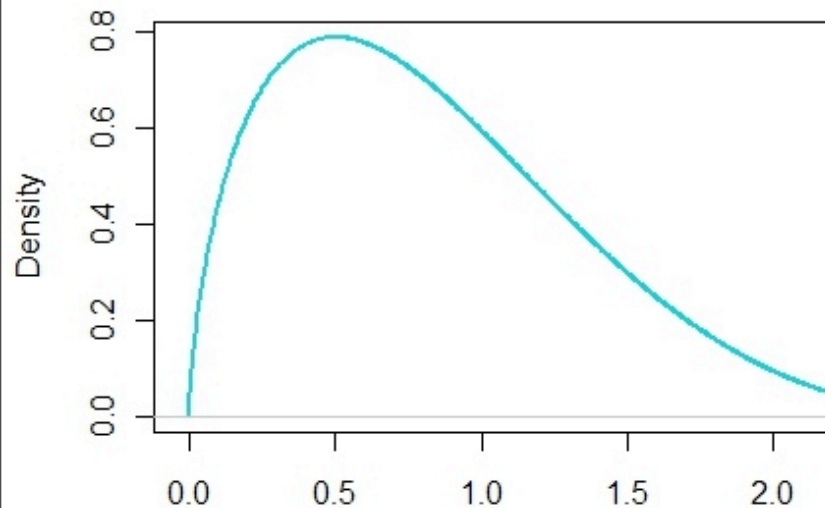
1. PDFs CHARACTERISTICS

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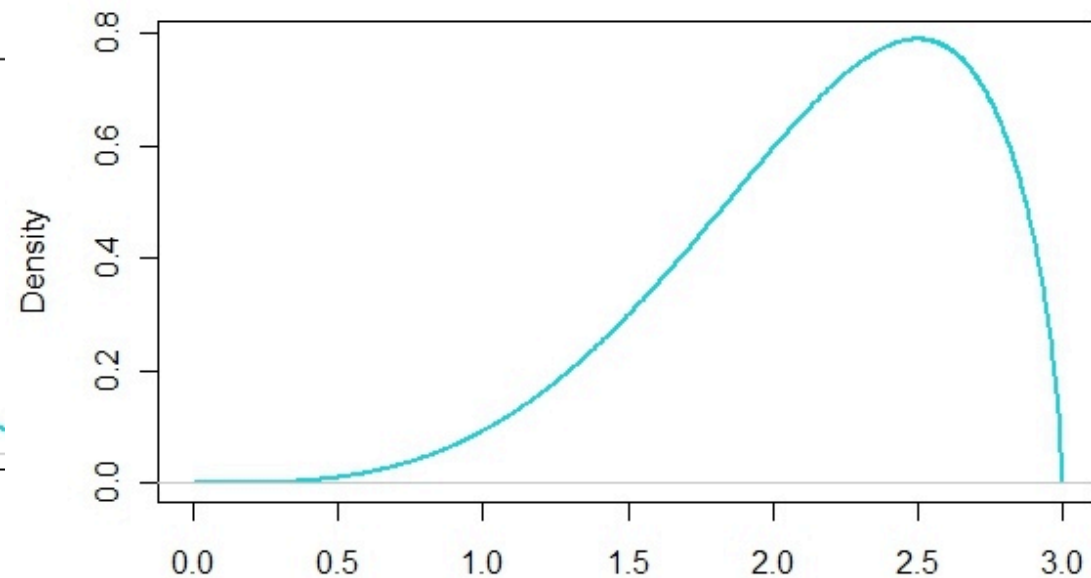
- a. Their location parameter(s) (i.e. range)
- b. Their shape

- a. Bounded vs. unbounded distributions
- b. Symmetric vs. skewed distributions

Positively skewed



Negatively skewed



2. THE LOGNORMAL DISTRIBUTION

The distribution by default to model uncertainty on parameters in the Ecoinvent database:

Is the result of the multiplication of independent processes

→ **as many variables in natural science**

Its resemblance to the normal distribution

→ **definition parameters that can more easily be determined**

Is a positive and a positively skewed distribution

→ **convenient to model physical parameters with large uncertainties or based on experts' judgments**

Permits to apply analytical uncertainty propagation methods

WHAT IF THE LOGNORMAL DISTRIBUTION IS
NOT THE ONE USED BY DEFAULT?

3. DISTRIBUTIONS SWITCH - TOOLBOX

Distributions switch



Datasets selection



LCA and Monte Carlo



Results comparison

Test the lognormal distribution against positively skewed distributions:

A bounded distribution : **triangular**

Similar distributions but less skewed: **gamma and weibull**

How to switch:

Gamma and weibull:

→ Solve the equations that link the parameters to the **median and variance** of the lognormal distributions

Triangular distribution defined by **location parameters**:

→ The min and max are derived from the lognormal **95th confidence interval**

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Results comparison

Among all the processes available in Ecoinvent v2.2.

→ 100 were kept

3. DISTRIBUTIONS SWITCH - TOOLBOX

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Results comparison

LCA calculations based on the Global Warming category for each process

Uncertainty assessment based on a Monte Carlo simulation

- 5000 steps calculations
- For the **initial distributions** and for **the switch** from the lognormal to the other “by default” distribution

Software used

- **Brightway2**: open source tool to perform LCA calculations
For more info <http://brightwaylca.org/>

3. DISTRIBUTIONS SWITCH - TOOLBOX

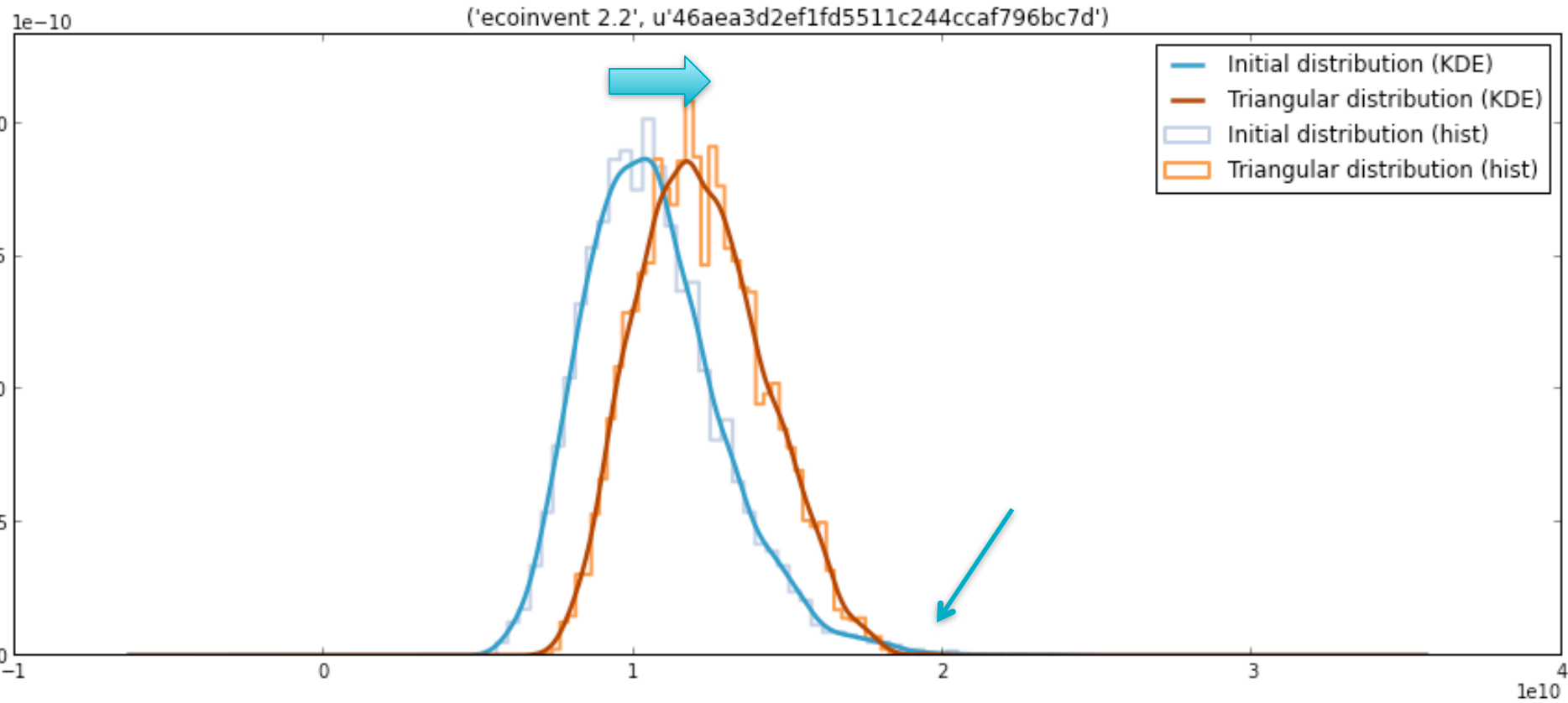


Assessment of differences in the resulting distributions:

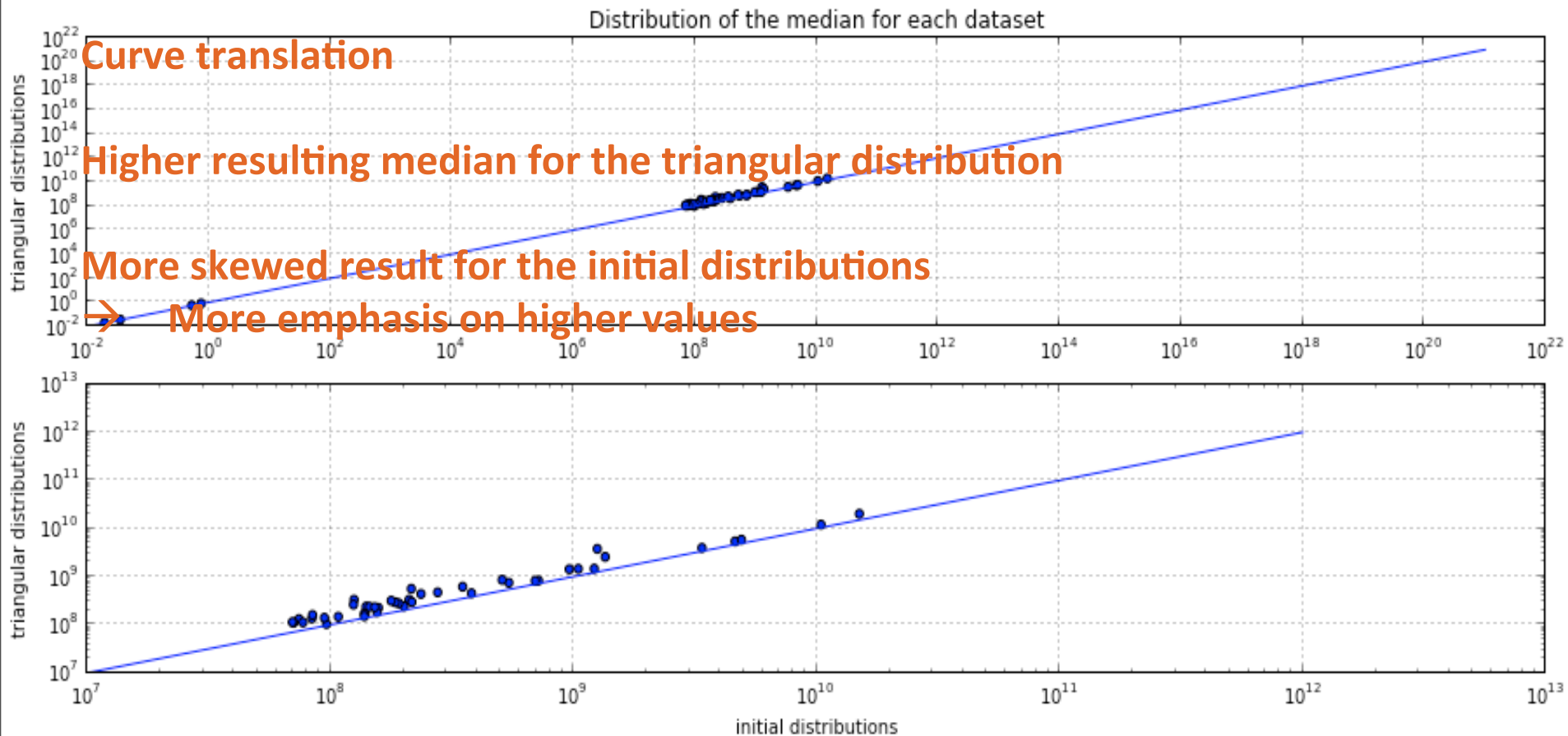
- the **shape**
- the **range**
- the **deterministic value**, the median

Use of descriptive statistics

4. RESULTS – LOGNORMAL AGAINST TRIANGULAR

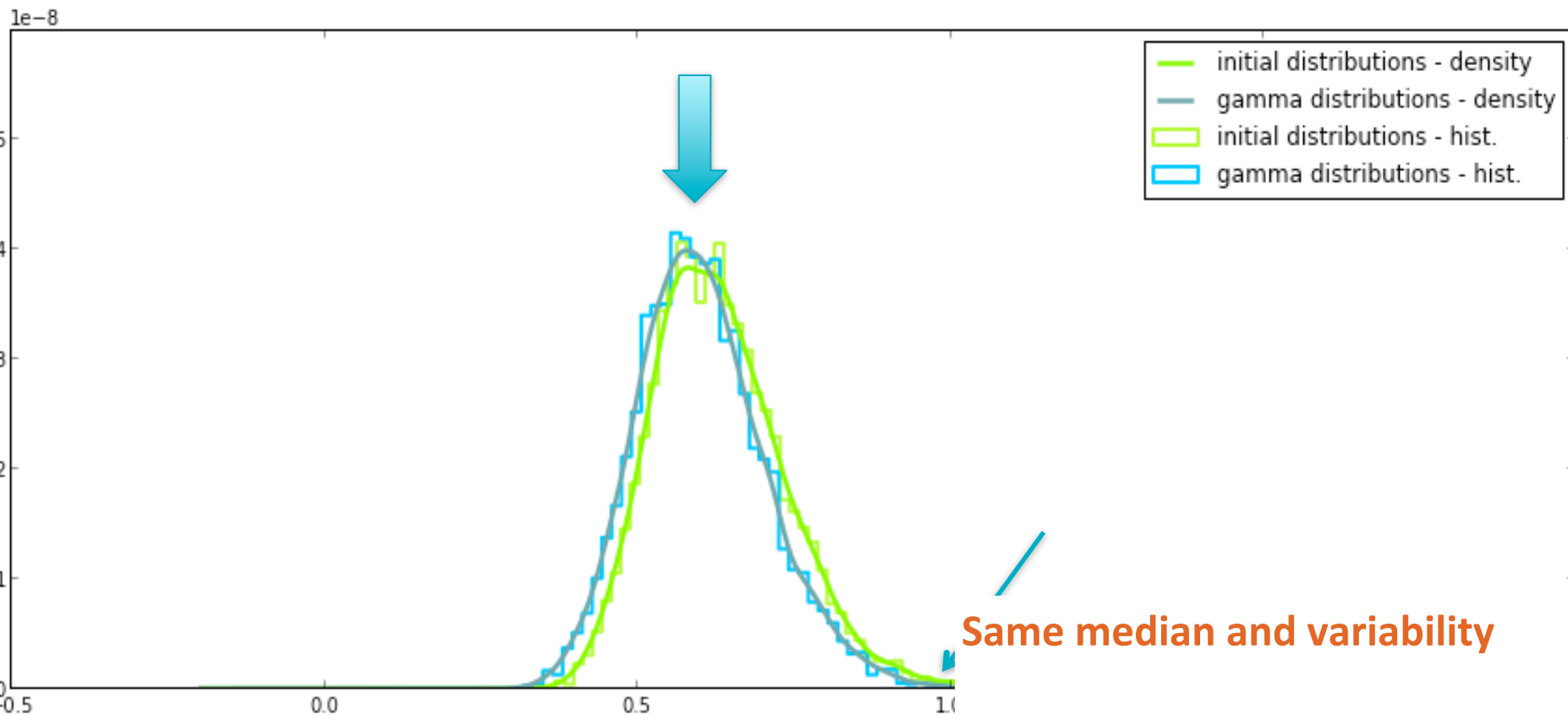


4. RESULTS – LOGNORMAL AGAINST TRIANGULAR



Lower graph is a zoom in of the upper graph

4. RESULTS – LOGNORMAL AGAINST GAMMA

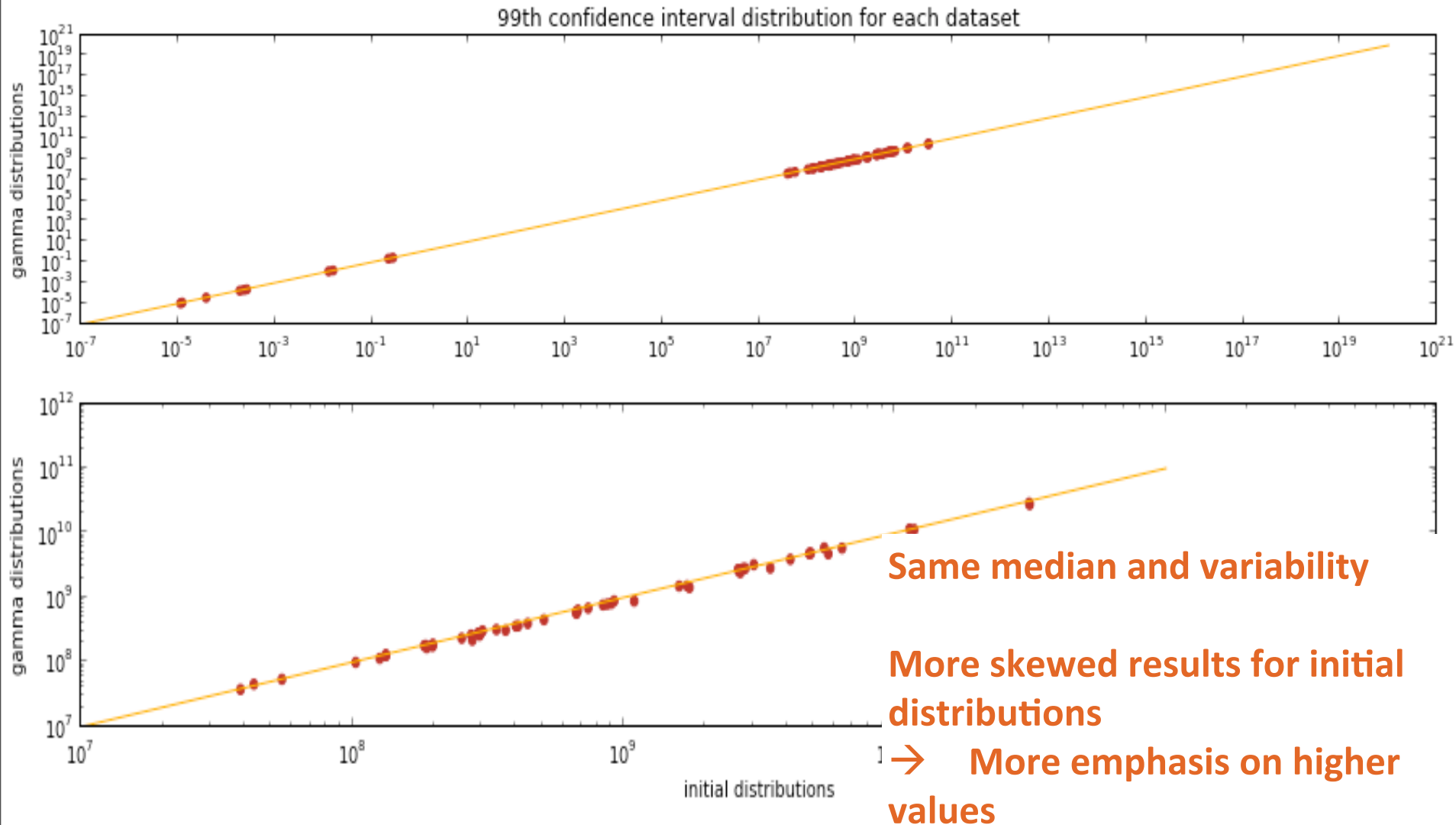


Same median and variability

More skewed results for initial distributions

→ More emphasis on higher values

4. RESULTS – LOGNORMAL AGAINST GAMMA



Lower graph is a zoom in of the upper graph

5. SOME THOUGHTS

A sensitivity assessment around the use of “by default distributions”

Showing the global behaviour

→ Globally, same conclusions for all datasets

Resulting distributions are not the same

→ Depend on the characteristics of the initial used distributions

Distributions can easily be switched

More flexibility for the analyst

→ Choosing the distribution based on the data characteristics

→ Parameters derivation based on some assumptions

→ Being consistent in the way to model uncertainties

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