



# A comparison of two methods for probabilistic modelling of ENM emissions during their life cycle

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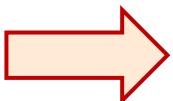
65th LCA Discussion Forum

ETH Zürich - 24 May 2017

# Background



```
File Edit Code View Plots Session Build Debug Tools Help
[...]
153 # notify how long was needed for the whole calculation
154 message("Time needed for the simulation:")
155 print(proc.time() - timer) # second timer
156
157 ##### RETRIEVES VALUES #####
158
159 #####Flows (preparing the data)
160 Mode_Y <- function(x)
161 {
162   [ ... ]
163   dens <- density(x)
164   ind <- which(dens$y==max(dens$y))
165   dens$x[ind]
166 }
167
168 flows <- matrix(NA,23,5)
169
170 for(i in 1:23)
171 {
172   xx <- Mass[i,]
173
174   flows[4,1] <- i
175   flows[1,2] <- quantile(xx,0.15)
176   flows[1,3] <- mode_Y(xx)[1]
177   flows[1,4] <- mean(xx)
178   flows[1,5] <- quantile(xx,0.85)
179 }
180
181 #####
182 #####
183 #####Exporting, provide the desired name and folder
184
185 measures <- rbind(floss)
186 colnames(measures) <- c("Row","Q15","Mode","Mean","Q85")
187 measures_table <- as.table(measures)
188 setwd("C:/users/adv/documents/nanoASE/Modeling/Results/GDP PPP/ZNO")
189 write.table(measures_table,"ZNO_IN_BEL_D.csv")
190
191 ##### Export central measurements (q15,mode...) data to csv file #####
192
193
194 ##### GRAPHS #####
195
196 # saves a pdf file of the histograms of the distributions to the working directory
197 setwd("C:/users/adv/documents/nanoASE/Modeling/Results/GDP PPP/ZNO")
198
199
200
201 pdf(file = "Output_of_ZNO_BEL.pdf",
202      height = 7.5,
203      width = 7.5,
204      pointsize = 10,
205      family="Segoe UI")
206 par(mfrow = c(3,3), mar = c(3,3,3,1), mgp= c(1.5,0.5,0), xpd= F)
207 color=c("gray88", "#14", "cadetblue", "aliceblue", "cornflowerblue", "goldenrod", rep("khaki1", 2), "lightsalmon", "lightgreen", "gray88")
208 for(co in 1:9)
209 {
210   d <- density(Mass[,co])
211   plot(d, main="", xlab="", ylab="")
212   polygon(d, main="", xlab="", ylab="", col= color(co))
213
214   title(main = dimnames(Mass)[1][co])
215   title(xlab = paste("Flow to", dimnames(Mass)[1][co], "(t)", line = 2))
216   title(ylab = "Probability density", line = 2)
217 }
```



**WE NEED A PROBABILISTIC APPROACH!**

# Outline

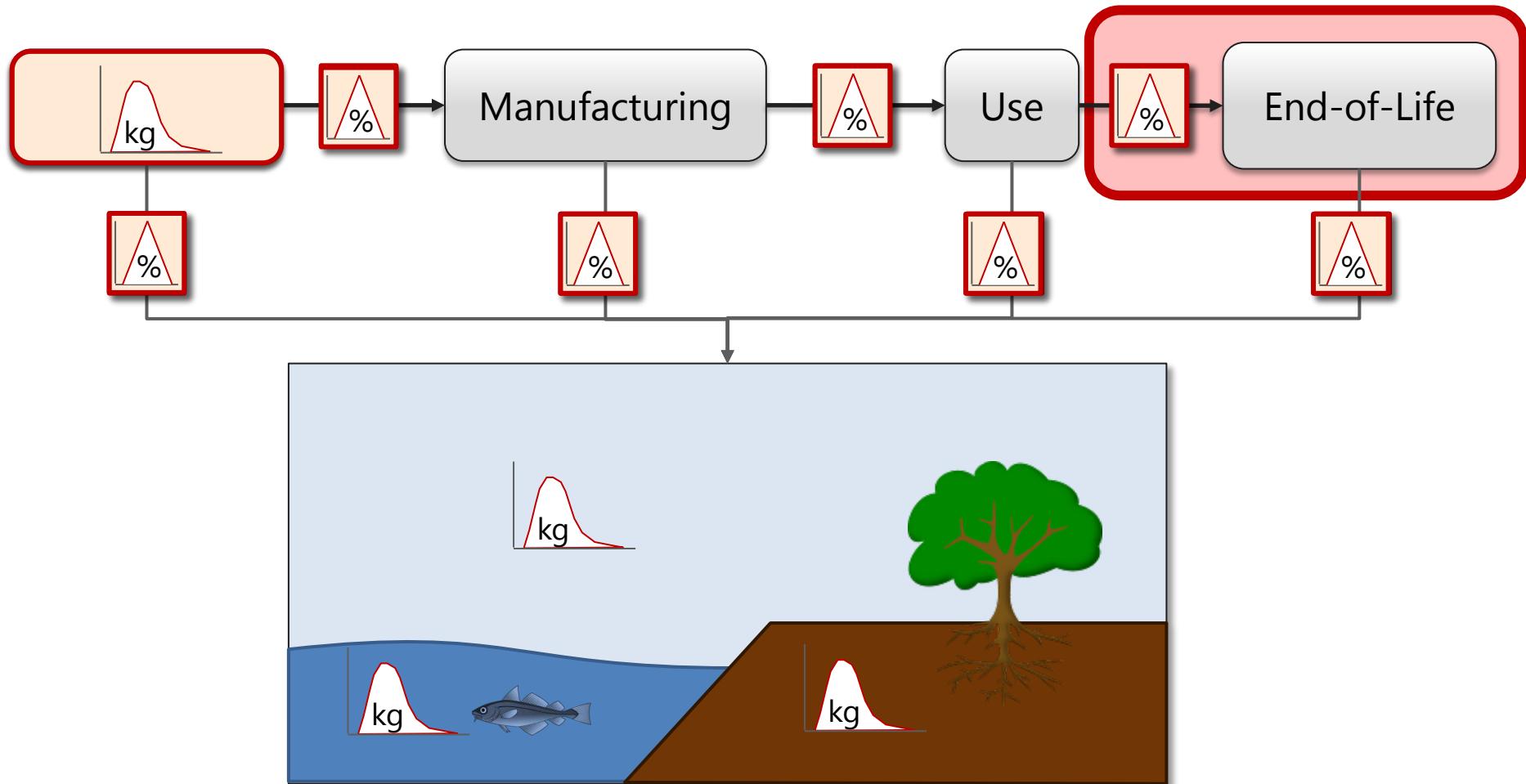
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- Method A: Probabilistic Material Flow Analysis
  - General methodology
  - Example of application
- Method B: Bayesian Networks
  - General methodology
  - Example of application
- Points for comparison

# Probabilistic Material Flow Analysis

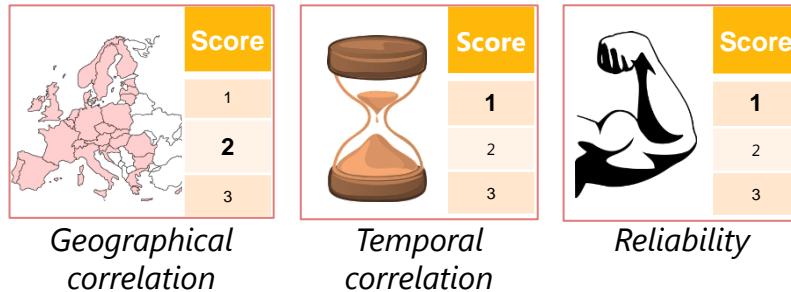
## General methodology



# Probabilistic Material Flow Analysis

## Assessing the probability distributions

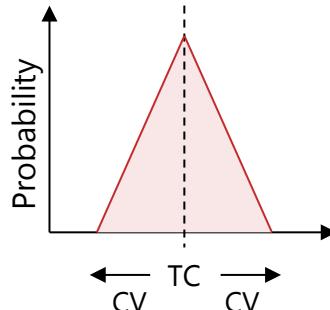
- Various data sources used (Reports, papers, Eurostat)
- Uncertainty assessment for each value (i.e. each reference):



$$DQR = \frac{Geo + Temp + Rel + W_i \times 4}{i + 4}$$

$W_i$  = weakest score  
 $i$  = number of indicators

(EC, 2010)

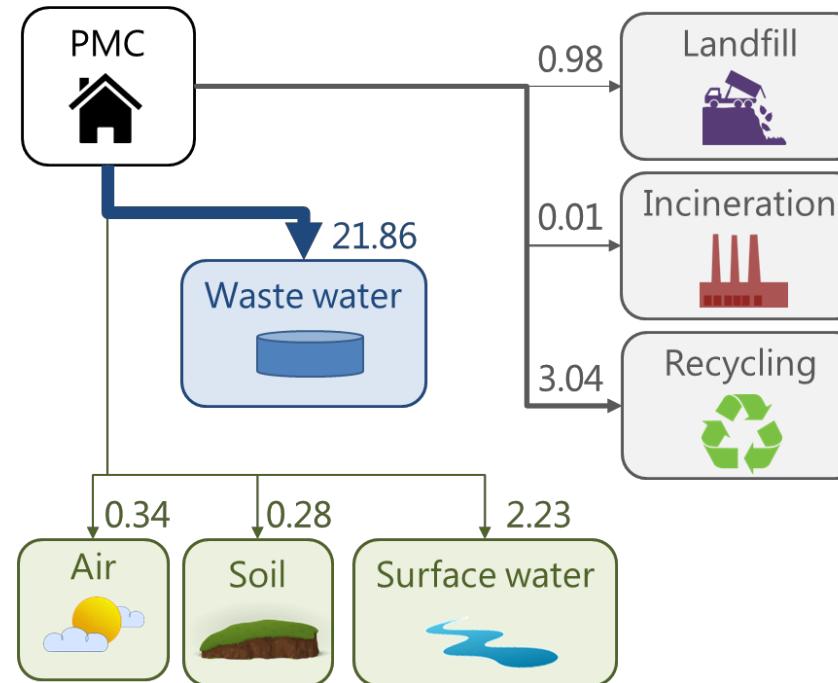


Data Quality Rating	Coefficient of Variation
$1 \leq DQR < 1.5$	4.5%
$1.5 \leq DQR < 2.5$	13.75%
$2.5 \leq DQR \leq 3$	41.5%

(adapted from Laner et al., 2015)

# Probabilistic Material Flow Analysis

## Results visualisation



Nano-ZnO (tonnes) in Romania

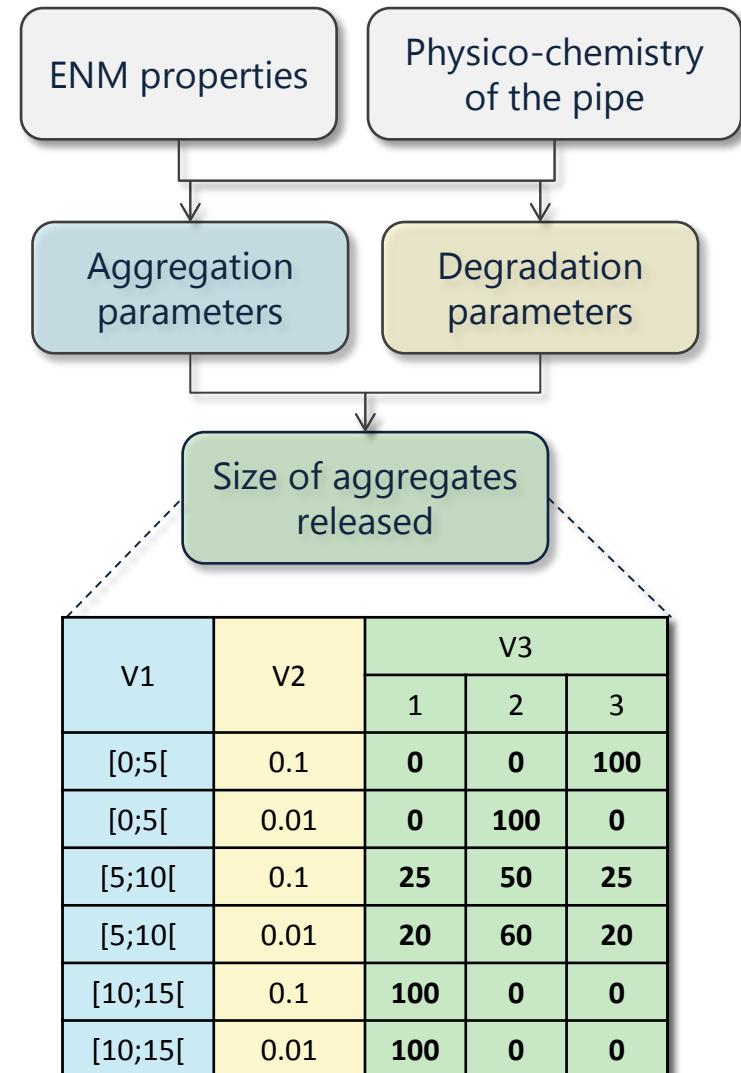
Difficult to represent the whole distributions...

# Bayesian networks

## General methodology



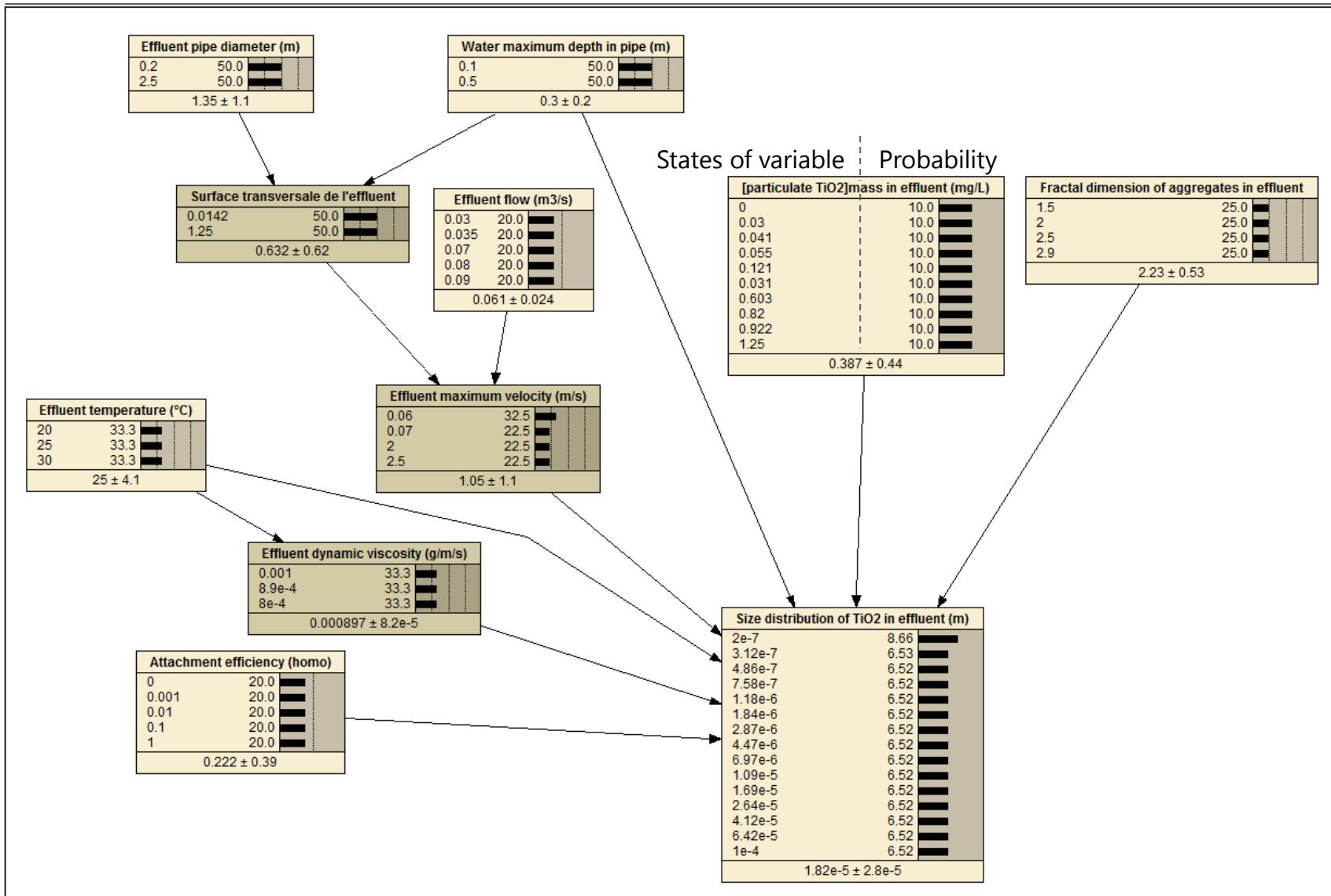
1. Define the **parameters** needed and their **relationships** (models, lab,...)



2. Define the **conditional probability tables**

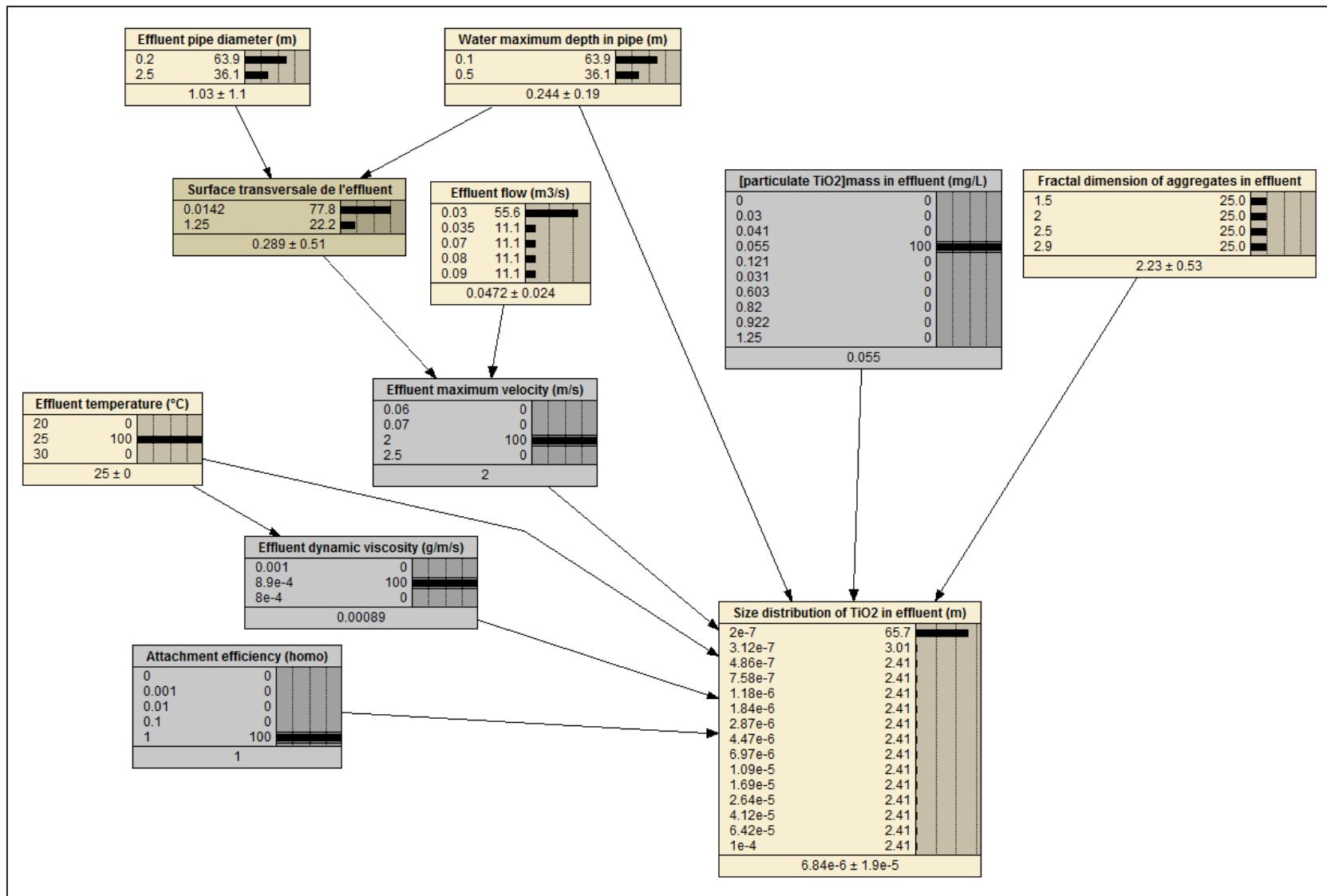
# Bayesian networks

## Example of application



# Bayesian networks

## Example of application



# Conclusion



- Two powerful and flexible tools
  - Mechanistic or «black box» models
  - Local to global scales
  - Can include temporal dynamics

## So which should we use?

- Current probabilistic MFA for ENM
  - National to continental scales
  - (Over)simplified probabilistic modelling(?)
- Bayesian networks
  - Easier track of the uncertainty propagation
  - Can become very complex



**It depends on the purpose!**

# Thank you!

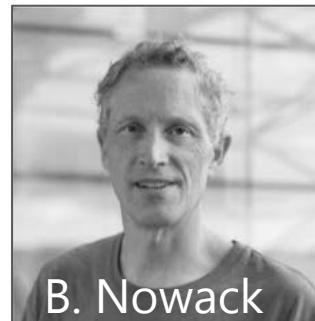
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Région  
Alsace



EOST  
Ecole et Observatoire  
des Sciences de la Terre



UNIVERSITÉ DE STRASBOURG



Laboratoire d'Hydrologie et  
de Géochimie de Strasbourg



CEINT



CRISTAL  
Global



Empa

Materials Science and Technology



Nanofase

Fate and Exposure models for you - [www.nanofase.eu](http://www.nanofase.eu)

# Appendix: Uncertainty in waste management

Score			
1	Country considered	$\geq 2014$	Reports, communications, papers
2	Local data	$2010 \leq x < 2014$	Eurostat
3	Different country	$< 2010$	Expert estimation