Where that emission went ?

Assessing the uncertainty of characterisation factors related to underspecified archetypes

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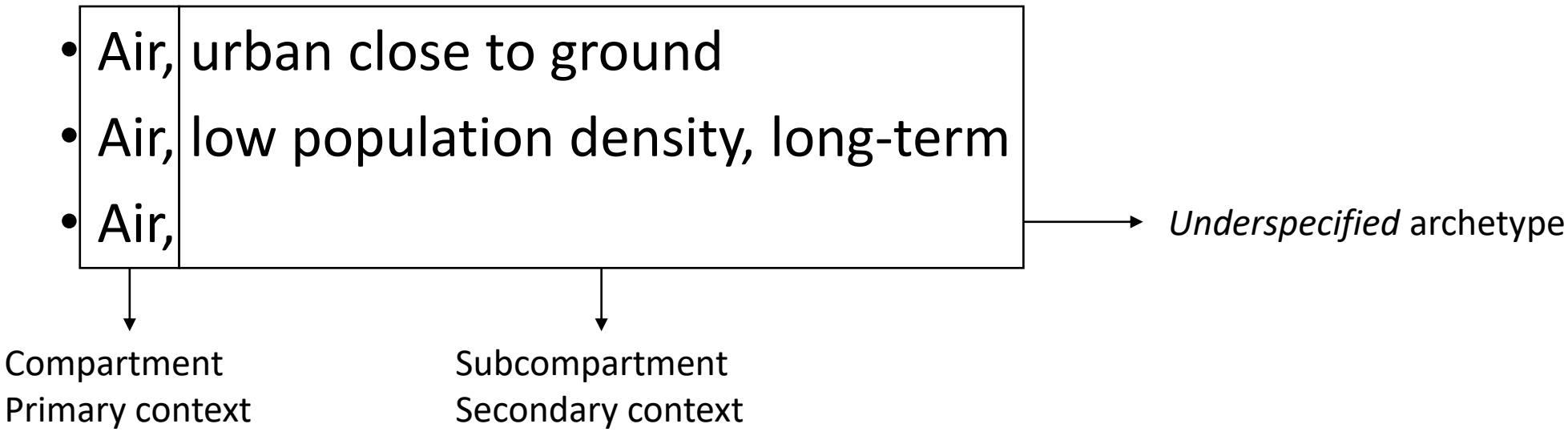
Archetypical scenarios of emissions

In LCIA uses archetypical scenarios to define the “context” on which emissions take place

e.g. X emitted to:



The idea

CFs vary hugely between archetypes and using underspecified archetypes may cause to important errors.

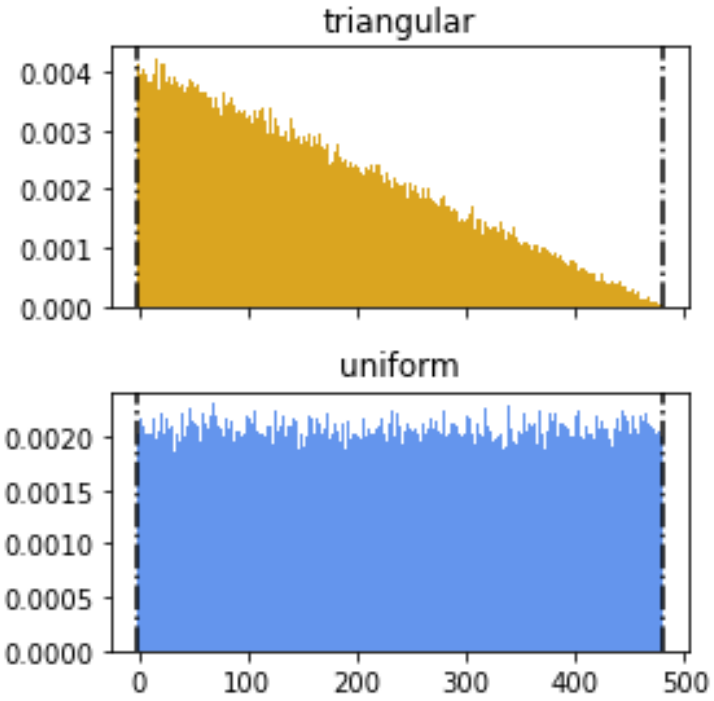
Proposal: define CF to unspecified archetypes as probability distributions

Example:

Usetox, human-toxicity cancer: Cadmium

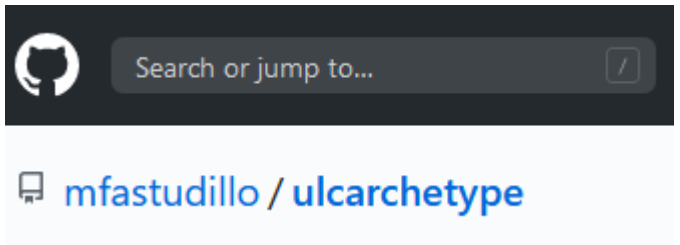
Archetype	CF (CTU / mg)
Soil, agricultural	481
Soil, industrial	0.8
Soil,	0.8

Source: Brightway



Ingredients to account for archetype uncertainty:

Brightway2



Includes:

- Tools to transform an existing method into one with uncertainty
- Examples

How to:

calculate the CF

```
# returns a list of tuples with the CF as defined in brightway
my_new_cf = cf_add_uncertainty(('ReCiPe Midpoint (E) V1.13', 'marine eutrophication', 'MEP'),
                               uncertainty_type=4) # -> uniform
```

store the new Impact Assessment method via the normal procedure

```
my_new_method_name = ('marine eutrophication','with uncertainty')
metadata={'description':'awesome method','unit':'kg N-eq'}

my_new_method = bw.Method(my_new_method_name)
my_new_method.register(**metadata)
my_new_method.write(my_new_cf)
```

ready to use!

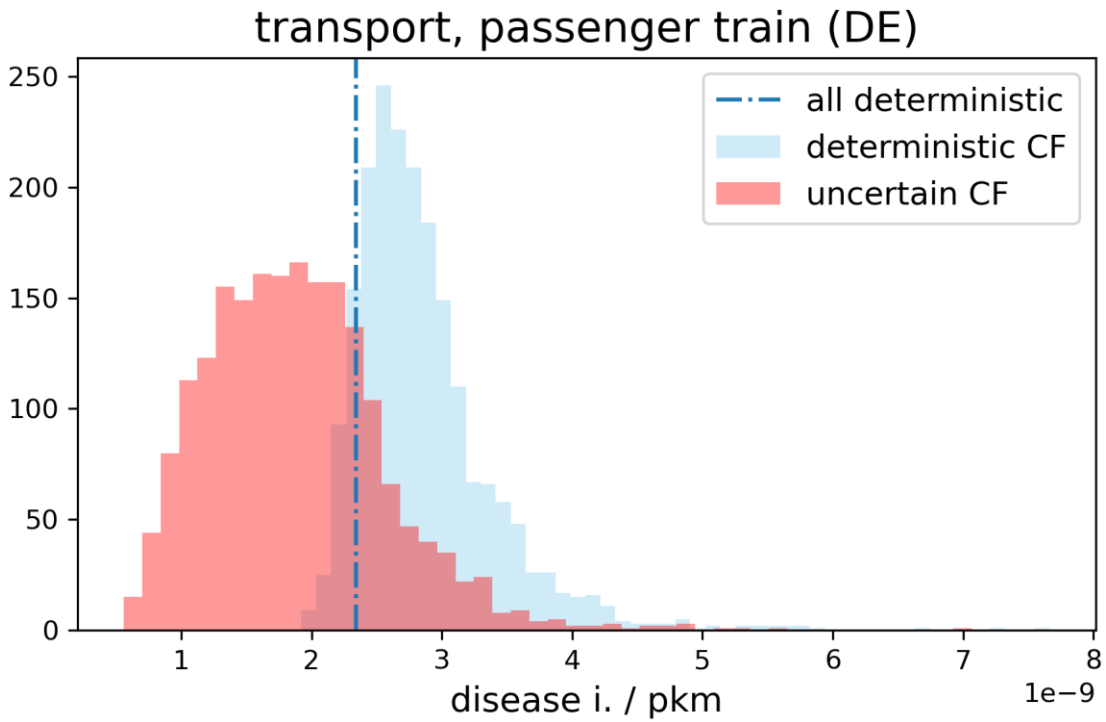
```
# use it!
random_activity = bw.Database('ei_36con').random()
mc = bw.MonteCarloLCA({random_activity:1},
                  method=('marine eutrophication','with uncertainty'))
```

```
next(mc)
```

```
0.04266280375708961
```

Example of effects: simple case

Respiratory inorganics EF 2.0



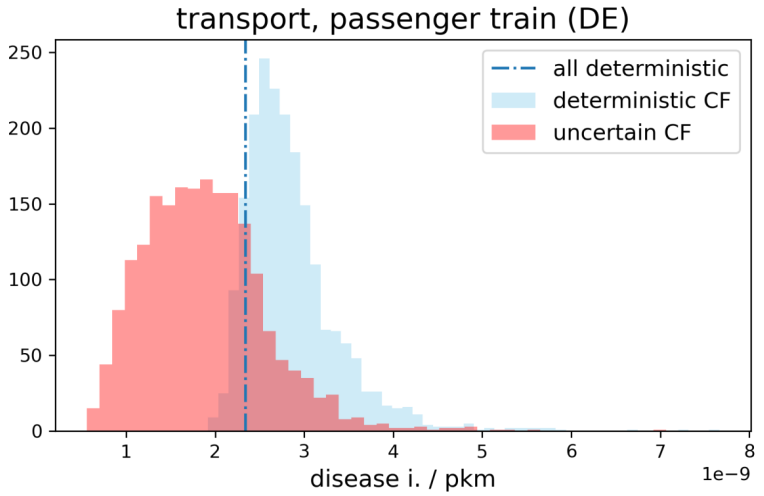
Using uncertain CF:

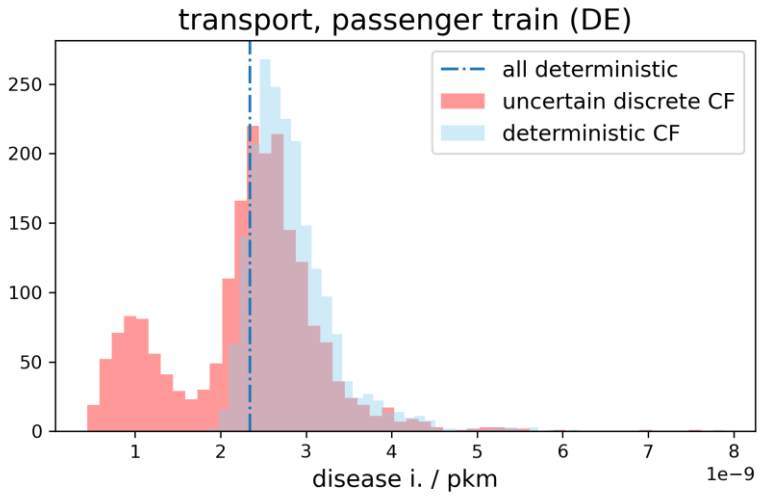
- scores are at least 12% lower for 90% of the iterations
- Introduction of CF uncertainty => larger dispersion

The discrete case

- The archetype uncertainty could be defined as a discrete probability distribution:
  - $PM_{2.5}$, air, urban: 10
  - $PM_{2.5}$, air, rural: 1
  - $PM_{2.5}$, air, ? ϵ {1,10}

- Discrete probability distributions can be handled with *presamples* package
  - In the absence of better info, emission scenarios are considered equiprobable





The discrete case: advantages and disadvantages

Advantage

- Closer to impact assessment implementation

… more accurate ?

- Easy to combine with other sources of uncertainty (e.g. geographical variability)

Disadvantage

- More difficult to operate with

How this uncertainty affects databases?

$$CBA^{-1}$$

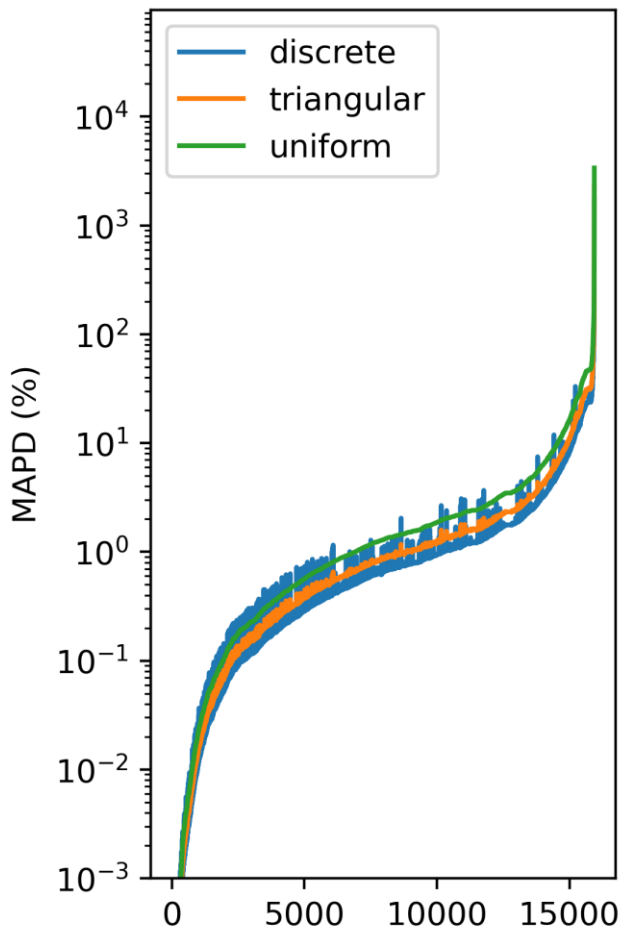
↑
Only source of uncertainty

$$\text{MAPD} = \frac{1}{n}\sum\left|\frac{S_{ref} - S_{alt}}{S_{ref}}\right|$$

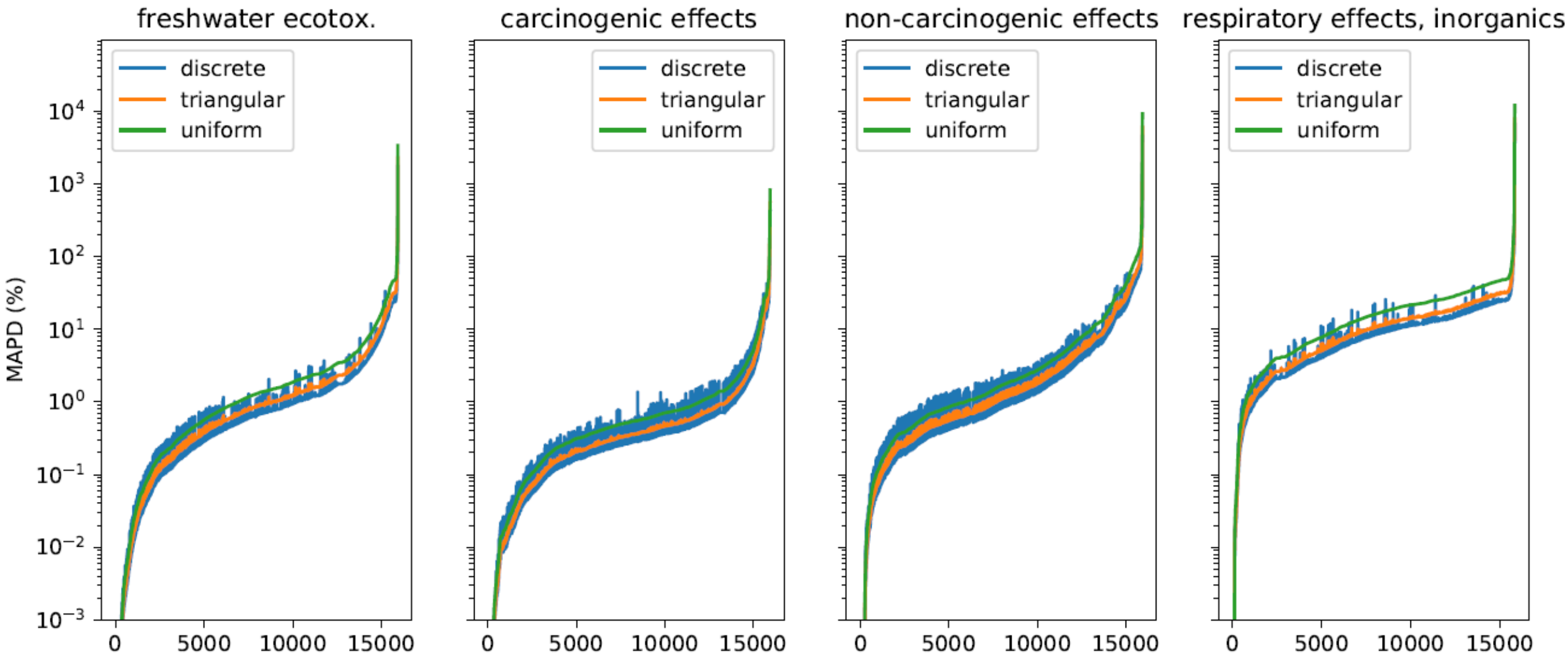
Mean absolute percentage deviation, A measure of the systematic error introduced by not accounting for archetype uncertainty

- Some activities are greatly affected, others not much
- Higher deviations in uniform than triangular (as expected
- Overall, discrete and continuous approaches are similaris
- Similar patterns observed for other impact categories.

Ecoinvent 3.6 consequential freshwater ecotox.



Ecoinvent 3.6 consequential



Conclusions

- Undefined archetypes can bias the results in unforeseen ways.

Brightway users:

- We'd better to account for this uncertainty (easy to do)
- *Ulcarchetype* can be used for this purposes in the Brightway2 framework
- Continuous probability distributions are easier to handle.

Non-Brightway users:

- Specify the archetype if you have the information

Method developers / software providers:

- Explain better how CF to underspecified archetypes are calculated

Next steps

- Add tests to the code and make it more *pythonic*
- Publication under review but preprint available at : https://engrxiv.org/ej7u3/ (suggestions welcomed!)
- Working on a simple procedure to identify the flows with largest contribution to uncertainty
- … open to collaboration :)

Thanks for your attention !

- Questions ?
- Corrections ?
- Suggestions ?
- Opinions?