GreenDelta
sustainability consulting + software

openLCA

Free Webinar: Regionalized LCIA in openLCA 1.5

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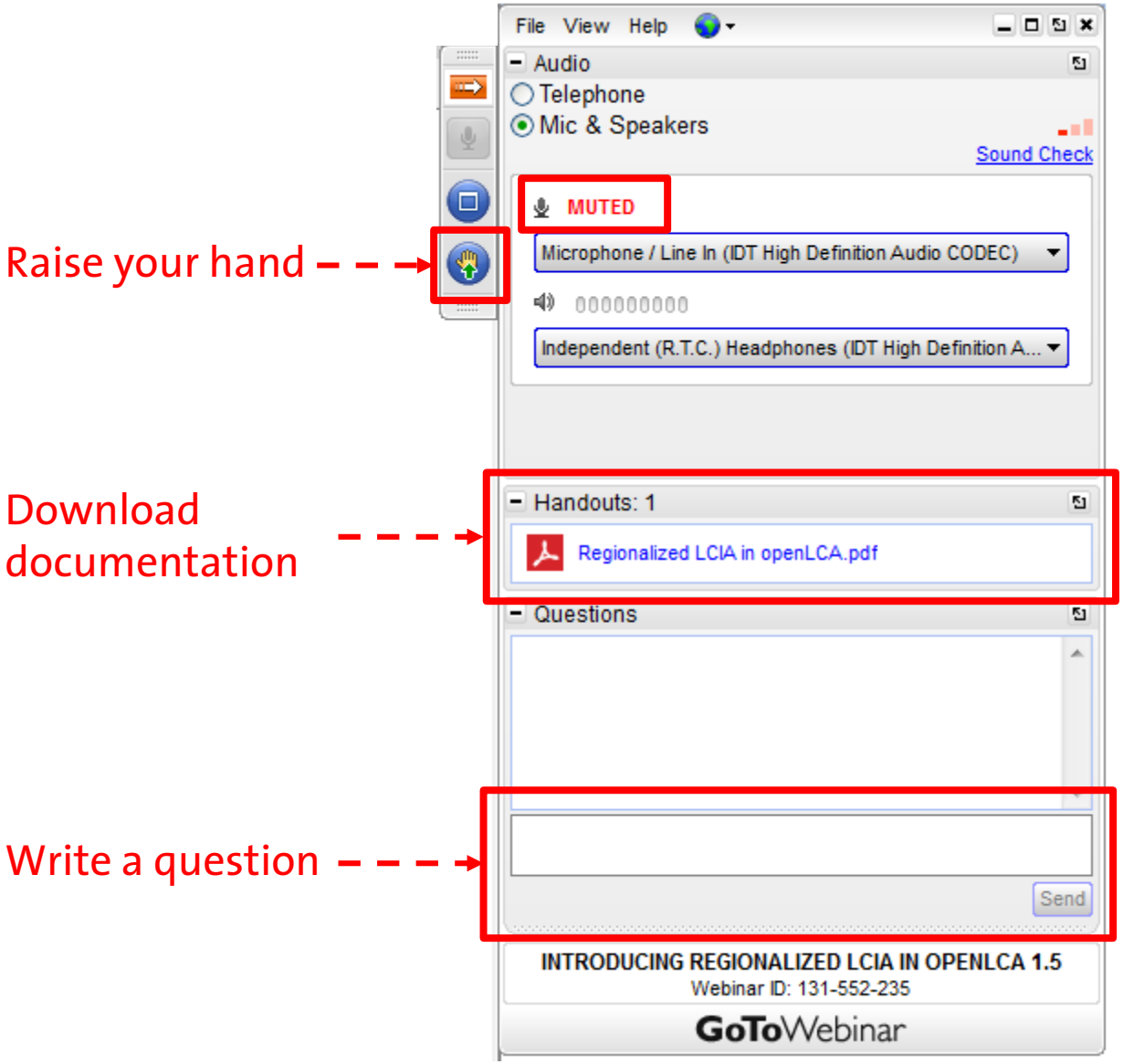
May 2016

Using GoToWebinar: Practical information



Agenda

- Introduction
- Adding GIS data to inventory locations
- Implementation of regionalized LCIA methods
- Regionalized LCIA calculation
- Analysis of regionalized LCIA results
- Outlook
- Q&A

openLCA

Regionalized LCIA is model sophistication

- Commonly, in Life Cycle Assessment (LCA), the impact assessment (LCIA) is performed ignoring any regional differences.

  → But, there are good reasons for considering a regional variation in the impact assessment, although this adds complexity

source: dennis140, aloe vera plantage, Fuerteventura (left); Gario, cows meadow, Texel (right)

Regionalized LCIA is model sophistication

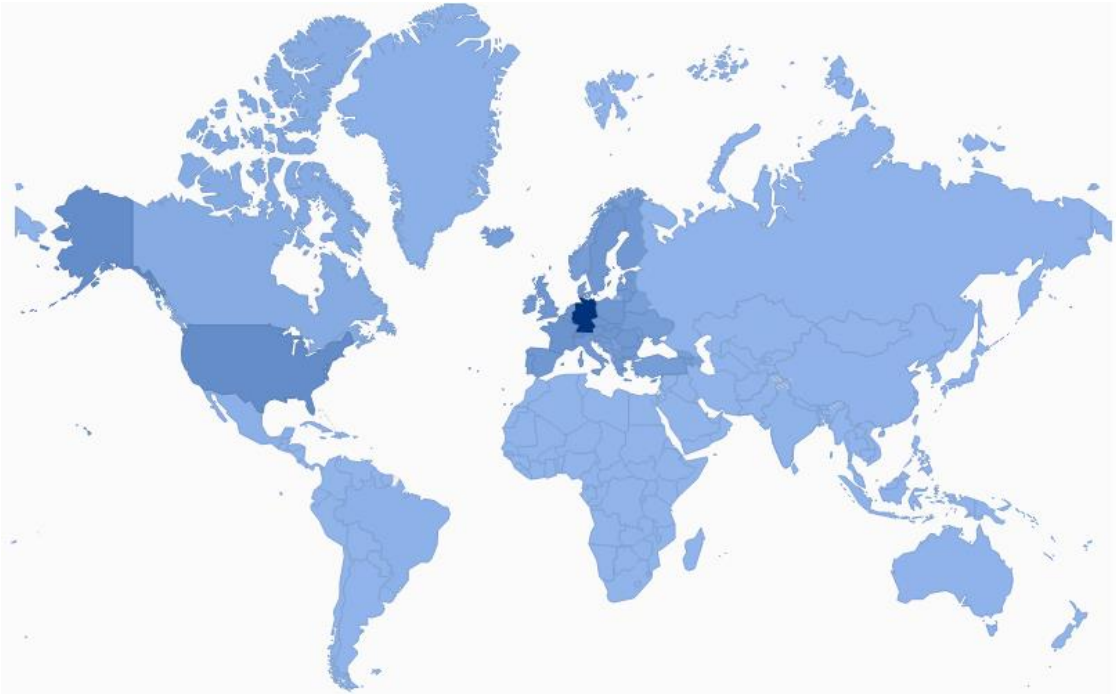
- More and more regionalized LCIA methods available, e.g.:
  - ImpactWorld+

    http://www.impactworldplus.org
  - LC-Impact

    http://www.lc-impact.eu
  - Ecological Scarcity 2013
    http://treeze.ch/projects/methodology-development/life-cycle-impact-assessment/ecological-scarcity-method-2013
  - Enhanced EI99+
    http://archive.baug.ethz.ch/www.ifu.ethz.ch/ESD/downloads/EI99plus.html

Regionalized inventory datasets

- Differences in the inventory are considered as far as possible (e.g., national databases, different processes for electricity generation per country, etc.).



https://nexus.openlca.org/map

Combining regionalized inventory and LCIA methods

- Some databases include elementary flows specific for different regions, to facilitate the regionalized LCIA calculation, e.g.: LC-Inventories.ch

Water, AT
Water, AU
Water, BA
Water, BE
Water, BR
Water, CA
Water, CH
Water, CS
Water, CZ
Water, DE
Water, ES
Water, FR
Water, GB
Water, GR

Outputs

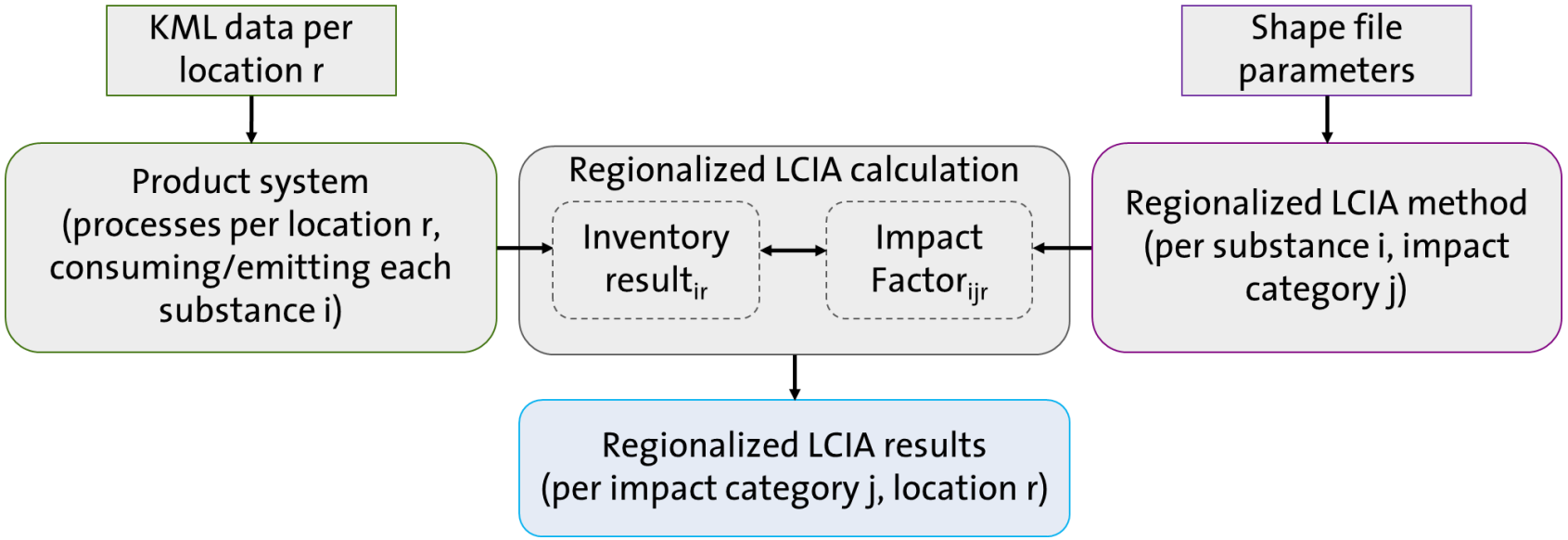
Flow	Category	Amount	Un
electricity, hydropower, at pumped storage power plant - CH	hydro power/...	1.0	
Water, CH	air/unspecified	1.751968153	

→ Not considered a pragmatic approach for openLCA

Regionalization in openLCA

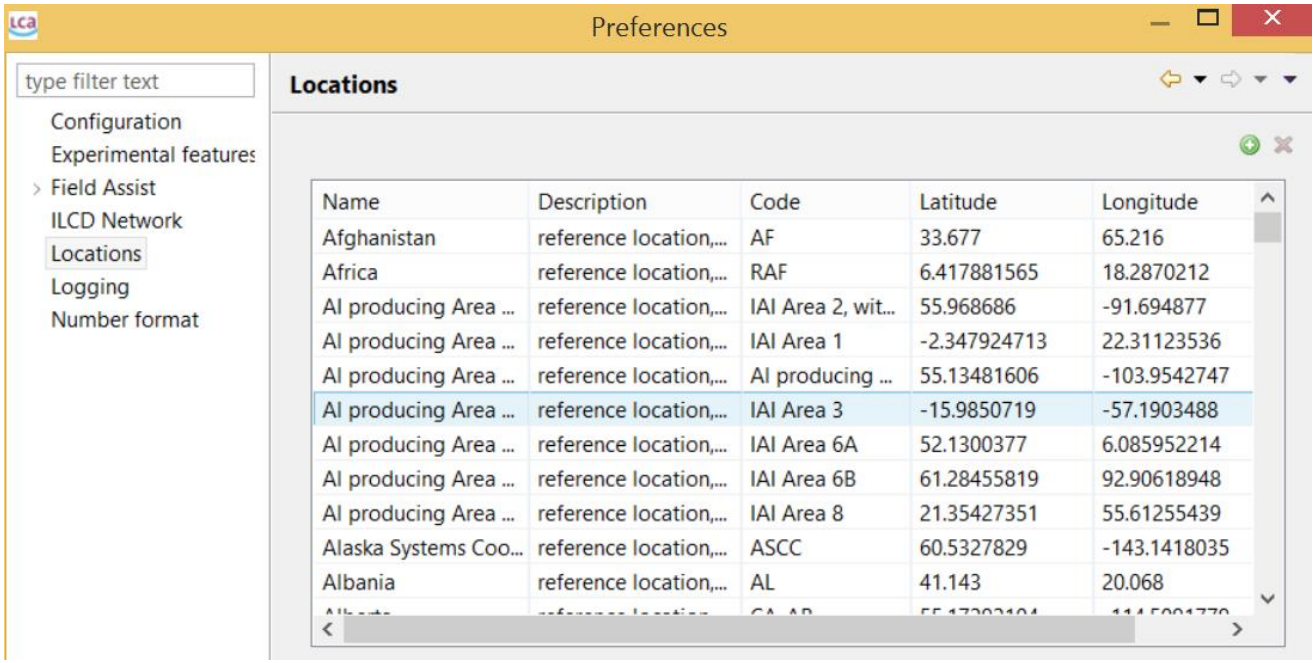
- The location of each elementary flow in the inventory is taken from the process consuming/emitting it.

- Integration of the functionality to handle GIS data:



Locations in openLCA 1.4

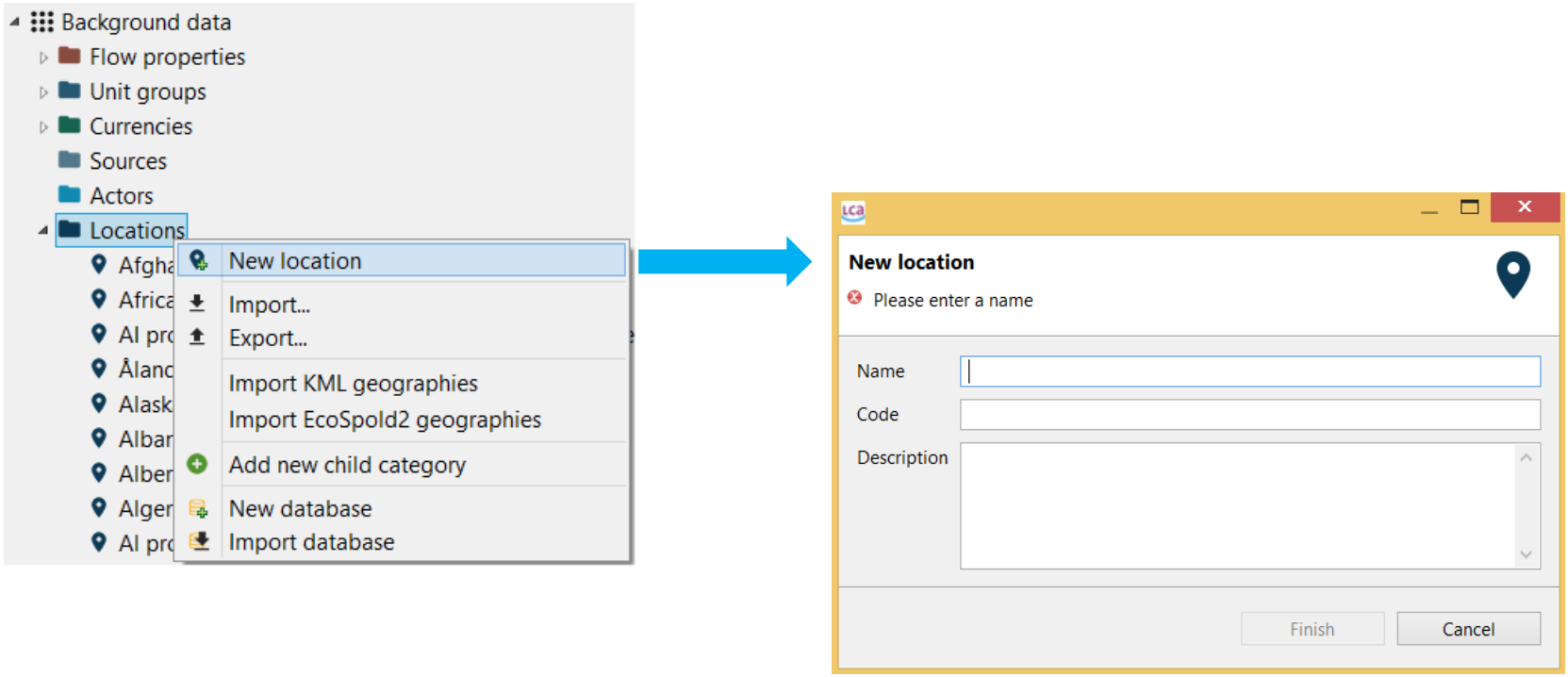
- A list of locations available under: File/Preferences/Locations
- The geographic information of the locations was limited to a pair of latitude, longitude data
- The processes could only use existing locations



Name	Description	Code	Latitude	Longitude
Afghanistan	reference location,...	AF	33.677	65.216
Africa	reference location,...	RAF	6.417881565	18.2870212
Al producing Area ...	reference location,...	IAI Area 2, wit...	55.968686	-91.694877
Al producing Area ...	reference location,...	IAI Area 1	-2.347924713	22.31123536
Al producing Area ...	reference location,...	Al producing ...	55.13481606	-103.9542747
Al producing Area ...	reference location,...	IAI Area 3	-15.9850719	-57.1903488
Al producing Area ...	reference location,...	IAI Area 6A	52.1300377	6.085952214
Al producing Area ...	reference location,...	IAI Area 6B	61.28455819	92.90618948
Al producing Area ...	reference location,...	IAI Area 8	21.35427351	55.61255439
Alaska Systems Coo...	reference location,...	ASCC	60.5327829	-143.1418035
Albania	reference location,...	AL	41.143	20.068

Locations in openLCA 1.5

- Locations as new element in the folder “Background data”

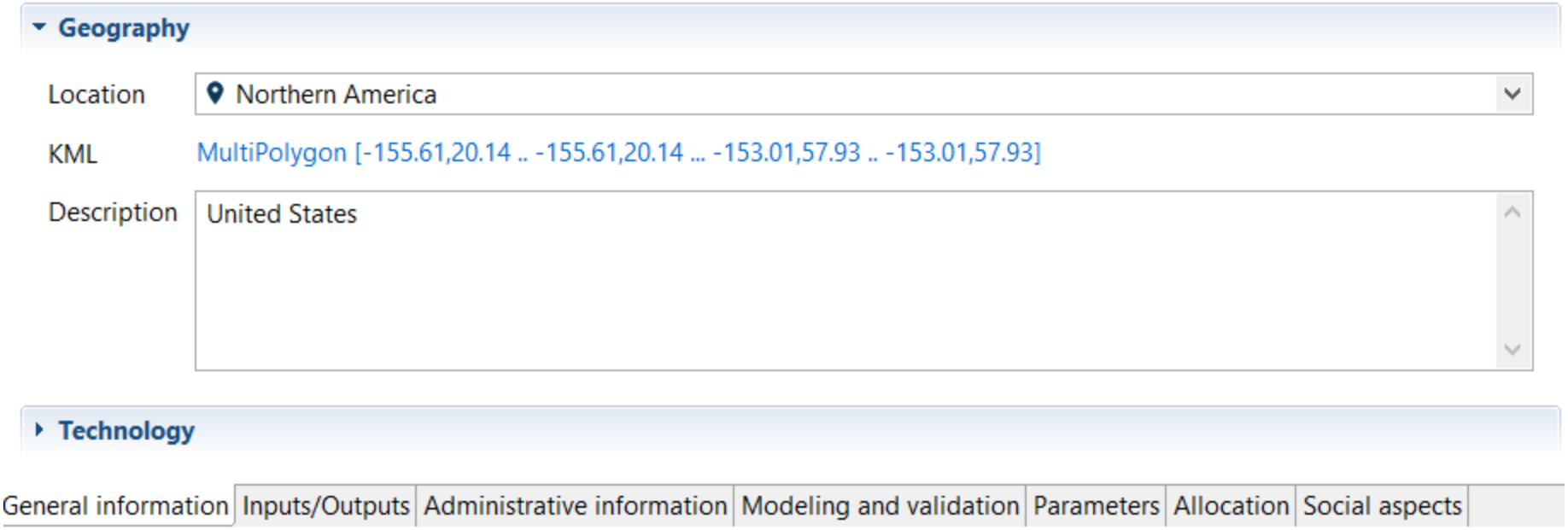


Location editor in openLCA 1.5

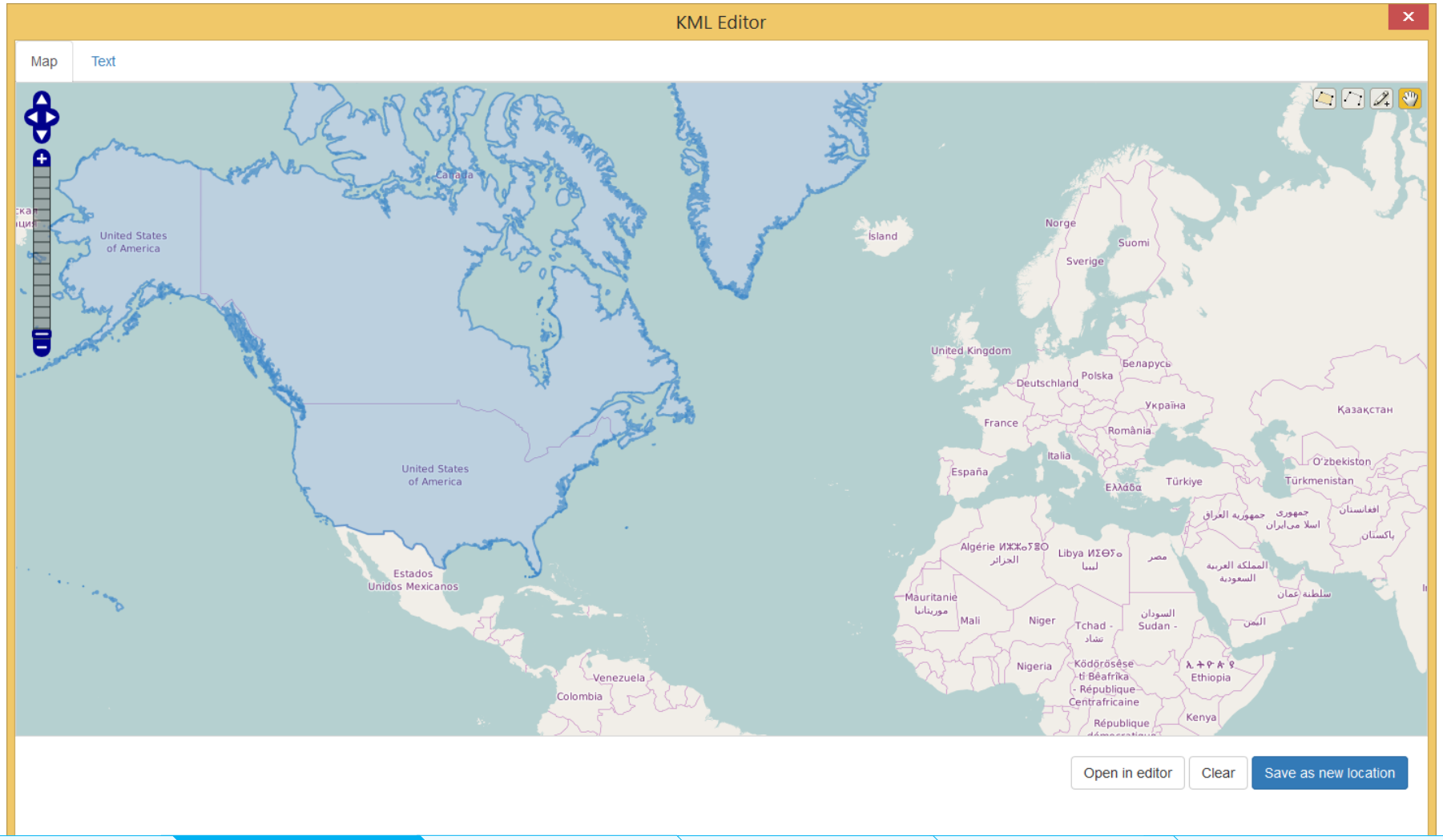
- KML data can be added to each location:
  - Draw polygons, lines or points in the KML editor
    →Multi-geometries of the same type are allowed
  - Write the coordinates in the "Text editor"
  - Import KML or EcoSpold2 files with geographic data, e.g.:
    http://geography.ecoinvent.org/report
    http://www.census.gov/geo/maps-data/data/tiger-kml.html
- If no KML data is added, a point will be created with the average latitude/longitude when saving the location

Locations in the Process Editor

- Locations can be created, viewed and opened in an editor within the “Geography” section of the process
  - Click on the KML information to open the KML editor



KML editor (map) in the Process Editor



KML editor (text) in the Process Editor

KML Editor

Map | Text

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://earth.google.com/kml/2.1">
  <Folder>
    <name>OpenLayers export</name>
    <description>Exported on Fri Mar 11 2016 12:57:01 GMT+0100 (Romance Standard Time)</description>
    <Placemark>
      <name>OpenLayers_Feature_Vector_128047</name>
      <description>No description available</description>
      <MultiGeometry>
        <Polygon>
          <outerBoundaryIs>
            <LinearRing>
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-155.5271939969999,20.126268986000138 -155.49107825399994,20.11302317900012 -155.42071461799995,20.09018548900012 -155.3323127789999,20.046721443000123
-155.21510593099987,19.975645397000065 -155.1680427339999,19.94682721500012 -155.1158533549999,19.896732304000025 -155.08714118899994,19.86037983400002
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-154.9669701269999,19.63625192300003 -154.94990596099996,19.61144557400014 -154.8996216029999,19.567016293000126 -154.84662324899992,19.544937986
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-155.02666307099992,19.31617095300006 -155.06261297099994,19.307820063000097 -155.0930314219999,19.28620959700012 -155.15304103099987,19.269204240000146
-155.2029575719999,19.255579602000033 -155.2450593649999,19.265539102000126 -155.2692813719999,19.26618159300008 -155.29112743399992,19.25952350200012
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```

Open in editor | Clear | Save as new location

Parameterization of LCIA methods

- The attributes contained in a shape file can be used as parameters in the LCIA method.
- Shape file specifications:
  - Coordinate reference system: WGS84, EPSG:4326.
  - Only numerical attributes can be used as parameters in openLCA.
  - There must be a single layer in each file.
  - Unique names for the attributes to be used as parameters.
  - The features should not overlap (e.g. the same shape file cannot contain features for Europe and Germany).
- Shape files are stored in the database, and can be exported as zolca or JSON format.

Parameterization of LCIA methods

- Different options for the content of the shape file parameters:
  1. The parameter represents the impact factor of a specific substance and impact category

Parameters - LC-Impact_land_annual_crops

Name	Minimum	Maximum
f_x annualcrop	0.0	1.7E-

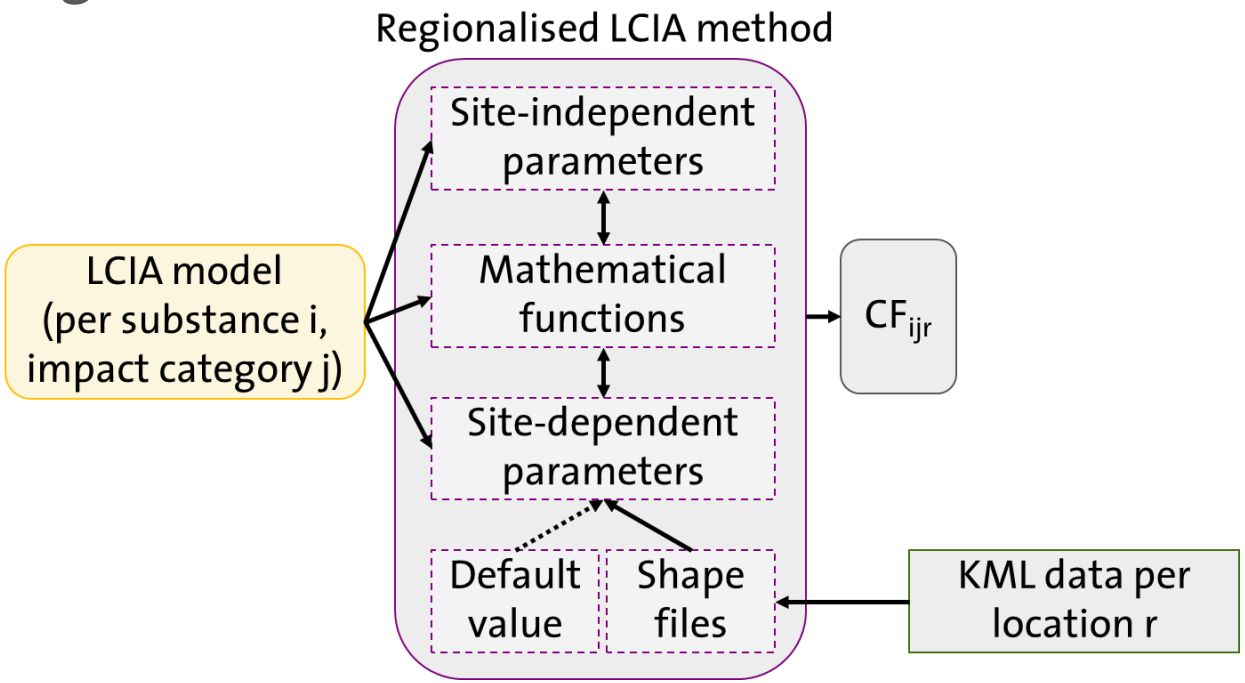
Impact factors

Impact category: Land use (Occupation)

Flow	Category	Unit	Factor
Occupation, annual crop	resource/land	PDF/m2*a	annualcrop
Occupation, forest, extensive	resource/land	PDF/m2*a	ext_forest
Occupation, forest, intensive	resource/land	PDF/m2*a	int_forest
Occupation, pasture, man made	resource/land	PDF/m2*a	pasture
Occupation, permanent crop	resource/land	PDF/m2*a	perm_crops
Occupation, urban, continuously built	resource/land	PDF/m2*a	land_urban

Parameterization of LCIA methods

2. The parameter represents a regional characteristic used for the calculation of the impact factors of different substances within one or multiple impact categories:



Parameterization of LCIA methods

Example: Land use model from de Baan et al. (2012), as implemented in Ecological Scarcity 2013 (Frischknecht and Büsser Knöpfel 2013)

$$Eco-factor_{Flow\_j}^{Region\_i} = K_{Flow\_j}^{Region\_i} \cdot \frac{c}{F_n^{CH}} \cdot \left(\frac{F}{F_k}\right)^2$$

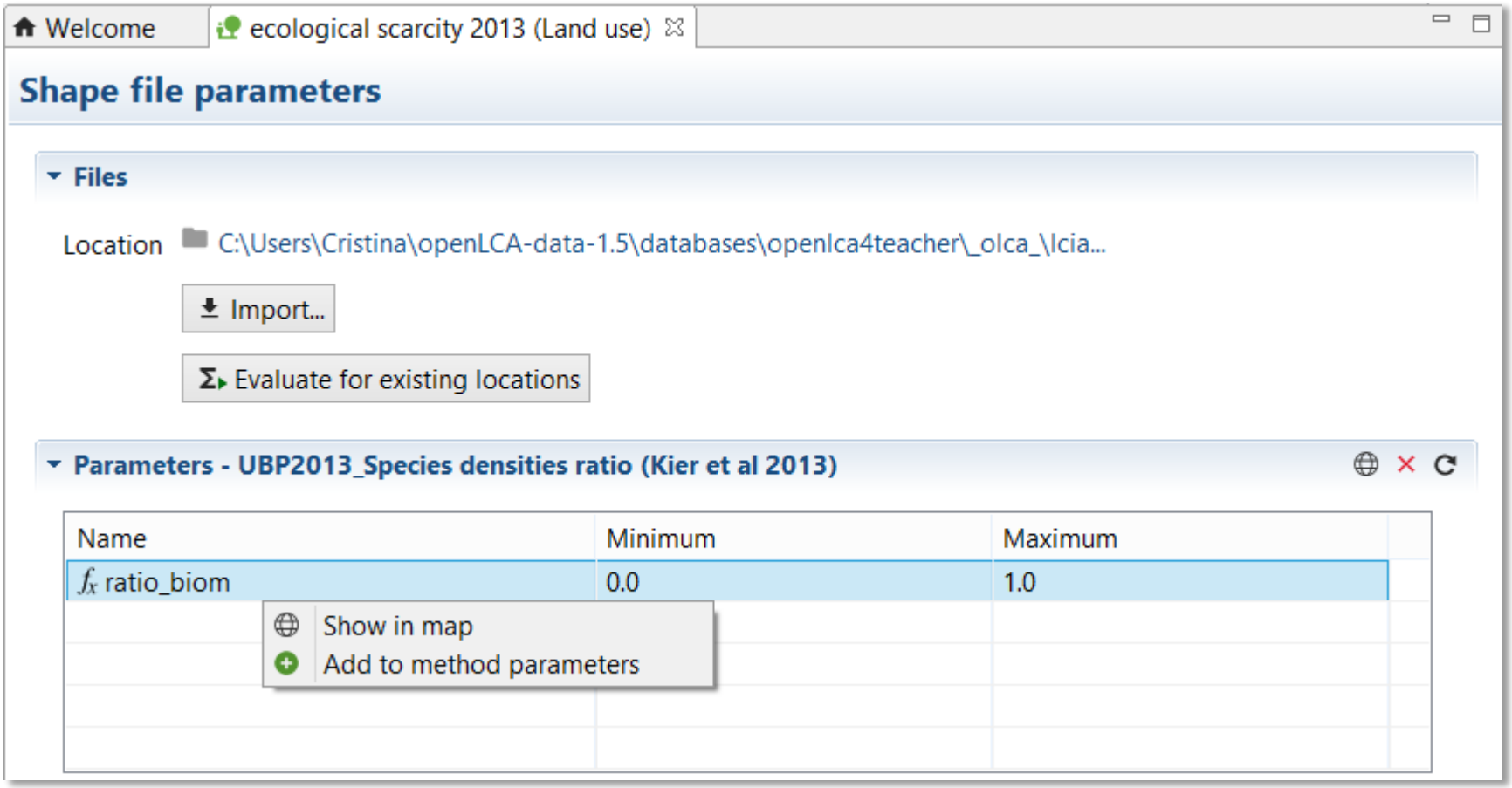
$$K_{flow\_j}^{biome\_i} = \frac{BDP^{biome\_i}}{BDP\_settlement\_area\_biome5} = \frac{BDP_{flow\_j}^{biome5} \cdot ratio^{biome\_i}\_to\_biome5}{BDP\_settlement\_area\_biome5}$$

$$Eco-factor_{Flow\_j}^{Region\_i} = \frac{BDP_{flow\_j}^{biome5}}{BDP\_SA\_biome5} \cdot \frac{c}{F_n^{CH}} \cdot \left(\frac{F}{F_k}\right)^2 \cdot ratio^{biome\_i}\_to\_biome5 \left[\frac{UBP}{m^2a}\right]$$

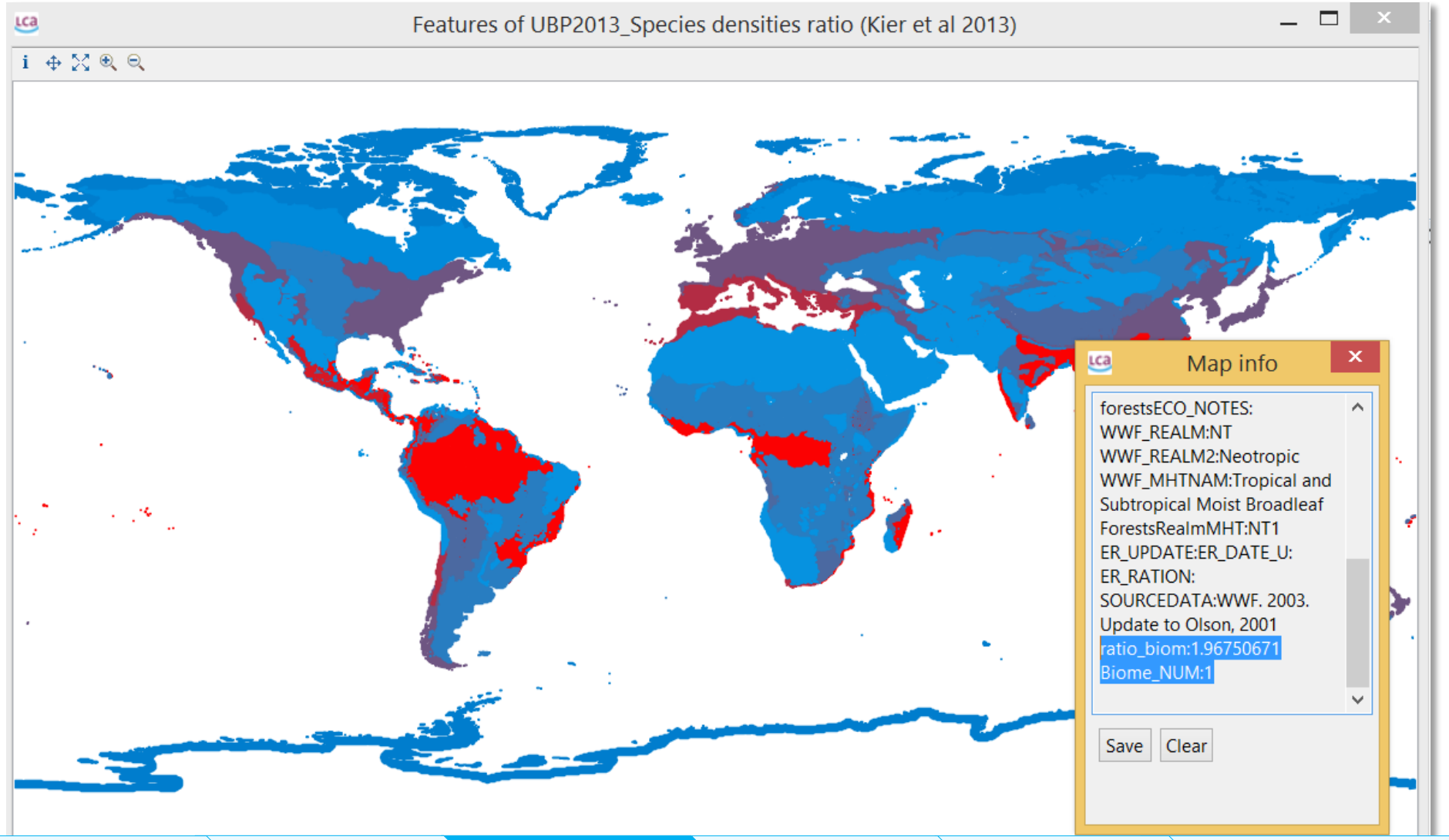
Site-independent parameters

Shapefile parameter

Shape files containing regional characteristics



Shape files parameters: “Show in map”



Use shape file parameters in the LCIA method

- "Add to method parameters" if the parameter doesn't exist yet in the "Parameters" tab
- Select "External source" if the parameter already exists

Global parameters

Input parameters

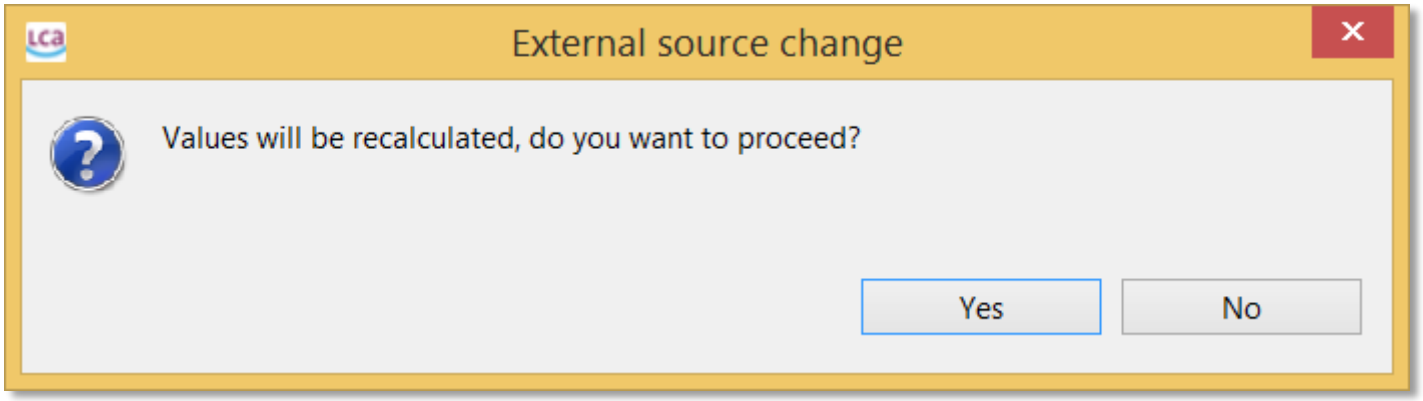
Name	Value	Uncertainty	Description	External source
BDP_SA	0.44	none	Biodiversity Damage Potential "S...	
c	1.0E12	none	Constant	
conv_factor	1.0E-6	none	Conversion from m2 to km2	
F	3027.0	none	Current annual flow (km2)	
Fk	3535.0	none	Critical annual flow (km2)	
Fn	2437.0	none	Annual flow in Switzerland (km2*...	
ratio_biom	1.0	uniform: min=0.00 ...	from shapefile: UBP2013_Species ...	UBP2013_Species d...

Dependent parameters

Name	Formula	Value	Description
normalization	conv_factor/Fn	4.10340582683627...	1/m2*a SA eq.

Use shape file parameters in the LCIA method

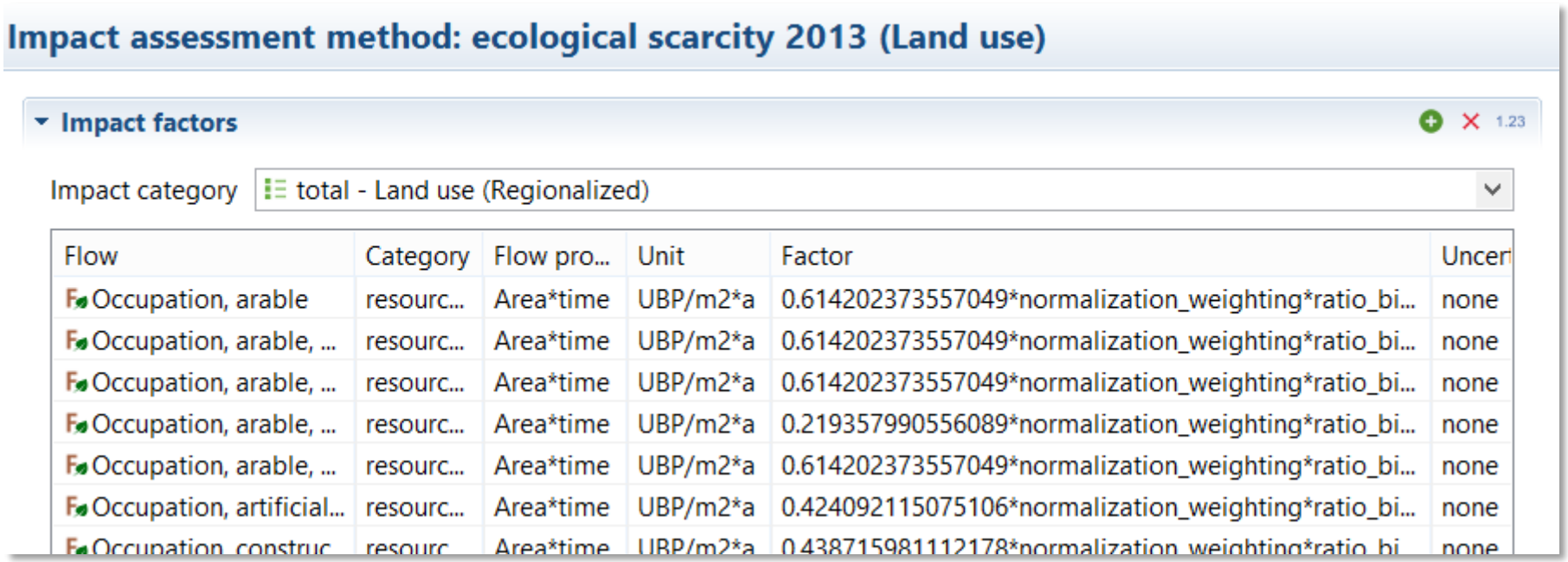
- The default value and uncertainty will be calculated depending on the “External source (i.e. shape file)” selected



- The default value can be modified and will be used in:
  - “Quick results” and “Analysis” calculations
  - In “Regionalized LCIA” calculations, when a process has a location without KML data or has no location
  - Formula evaluation in the LCIA method

Impact factors defined with formulas

- Once the parameters are created, they can be used in the formulas for the impact factors per flow and impact category



Impact assessment method: ecological scarcity 2013 (Land use)

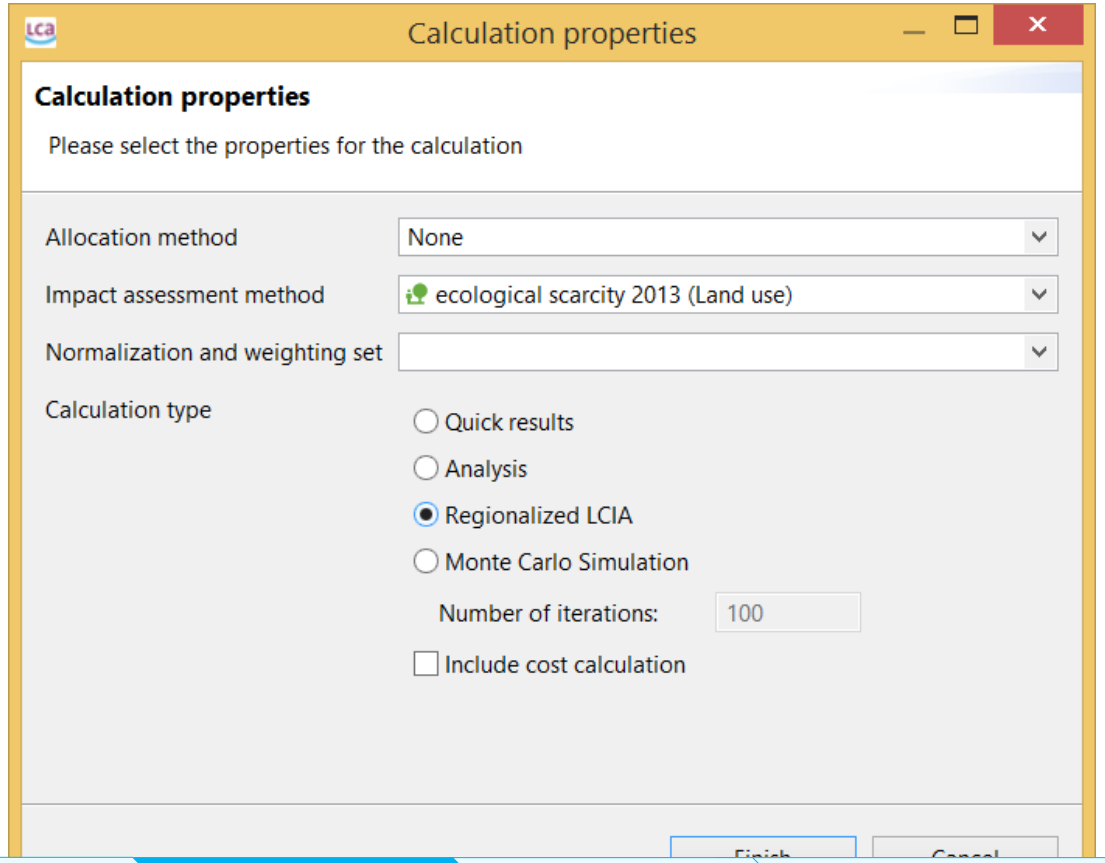
Impact factors

Impact category: total - Land use (Regionalized)

Flow	Category	Flow pro...	Unit	Factor	Uncer
Occupation, arable	resourc...	Area*time	UBP/m2*a	0.614202373557049*normalization_weighting*ratio_bi...	none
Occupation, arable, ...	resourc...	Area*time	UBP/m2*a	0.614202373557049*normalization_weighting*ratio_bi...	none
Occupation, arable, ...	resourc...	Area*time	UBP/m2*a	0.614202373557049*normalization_weighting*ratio_bi...	none
Occupation, arable, ...	resourc...	Area*time	UBP/m2*a	0.219357990556089*normalization_weighting*ratio_bi...	none
Occupation, arable, ...	resourc...	Area*time	UBP/m2*a	0.614202373557049*normalization_weighting*ratio_bi...	none
Occupation, artificial...	resourc...	Area*time	UBP/m2*a	0.424092115075106*normalization_weighting*ratio_bi...	none
Occupation, construc	resourc	Area*time	UBP/m2*a	0.438715981112178*normalization_weighting*ratio_bi	none

Calculation procedure for Regionalized LCIA

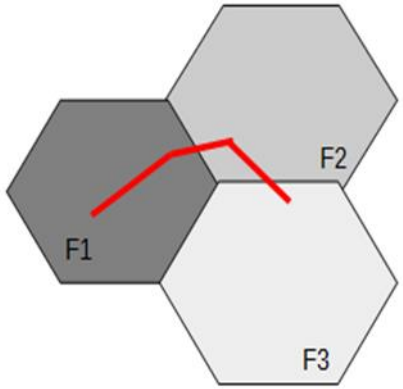
- Select the “Regionalized LCIA” option in the calculation properties window:
  - → The impact method select must contain regionalized impact factors
  - → At least 1 location of the product system must contain KML data



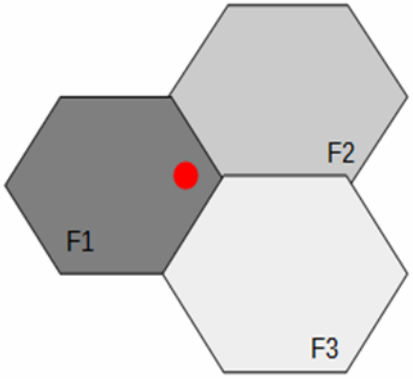
Calculation procedure for Regionalized LCIA

- The intersection between shape files features and process geometries is calculated by openLCA

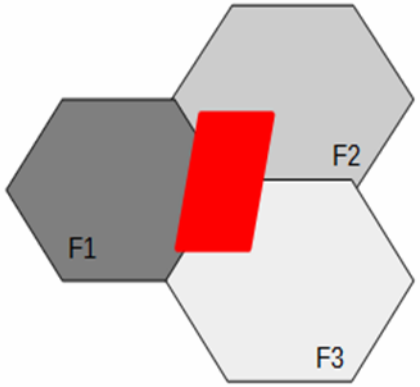
  →A weighted mean calculated for each regional parameter



$(p(F_1)*L(F_1) + p(F_2)*L(F_2) \ldots) / L$



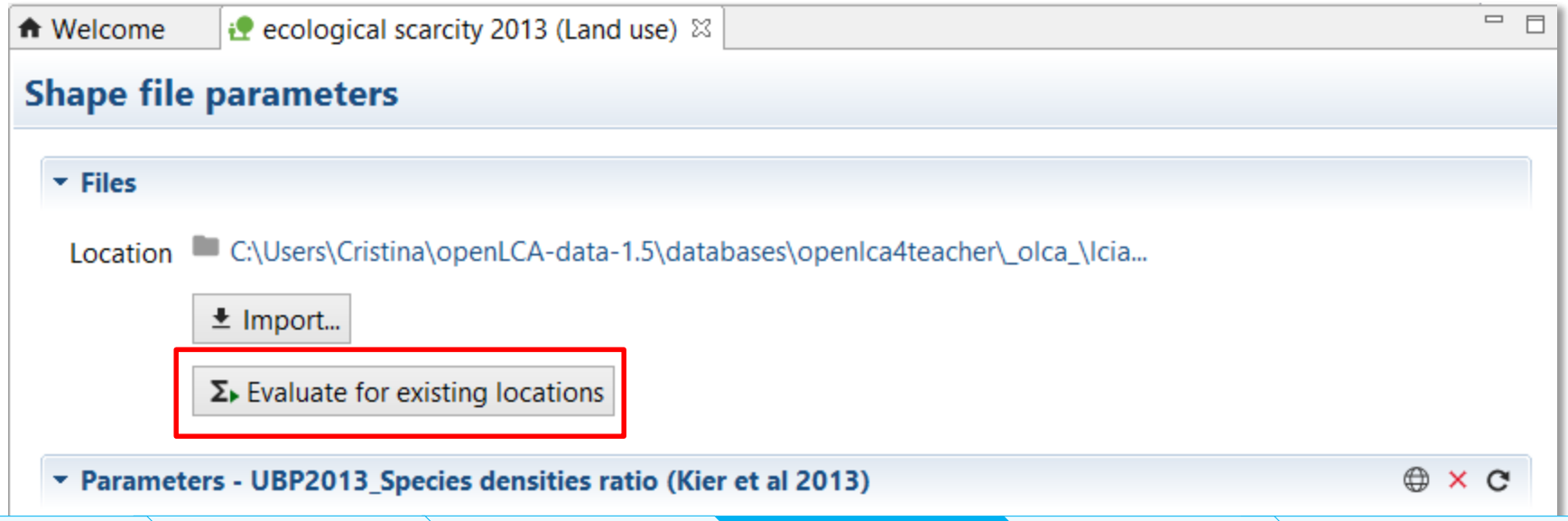
$p(F_1)$



$(p(F_1)*A(F_1) + p(F_2)*A(F_2) \ldots) / A$

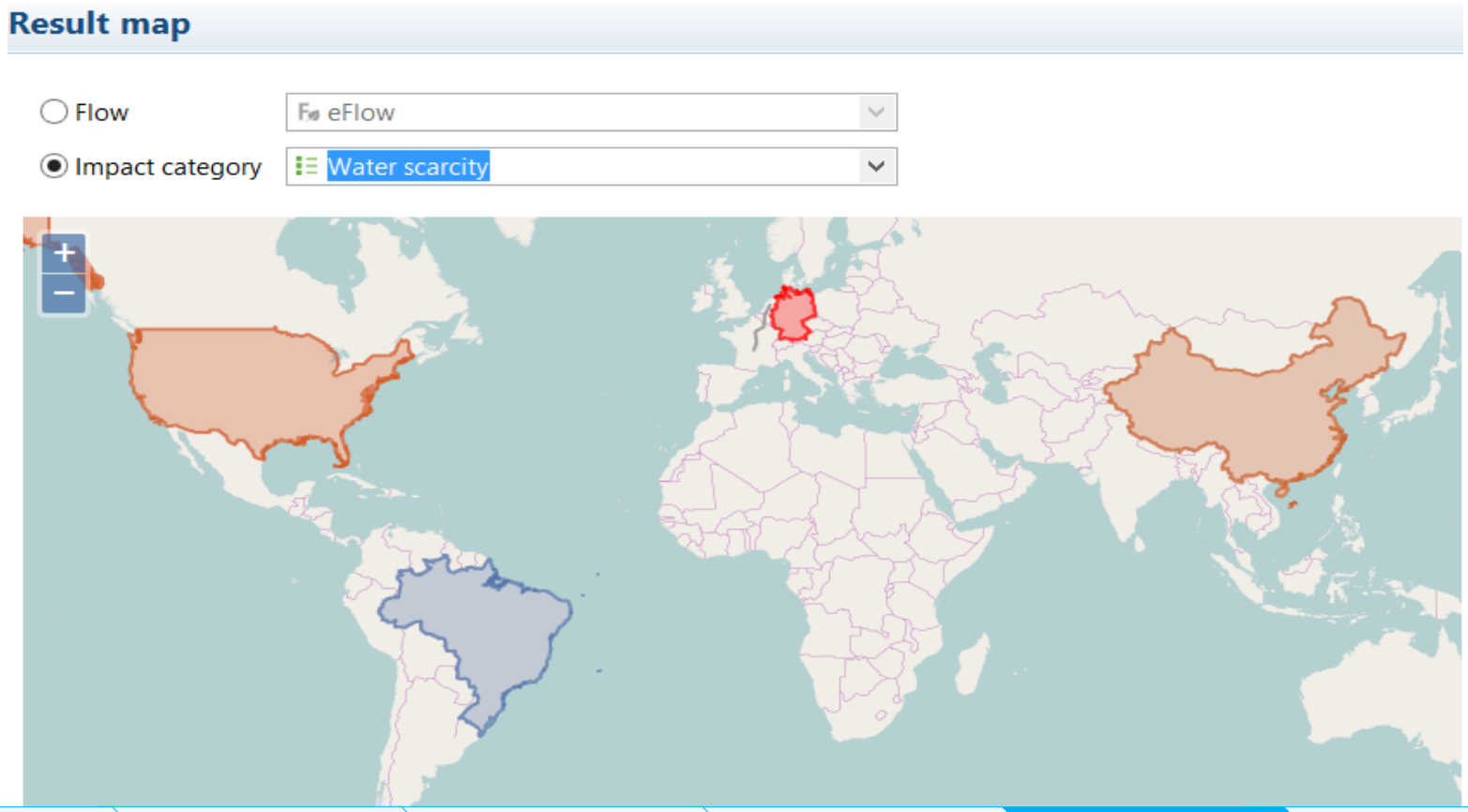
Calculation procedure for Regionalized LCIA

- Use “Evaluate for existing locations” to pre-calculate the intersections with the existing database locations
  - In systems with many locations the calculation can take long, so it is recommended to pre-calculate the intersections before the assessment needs to be done



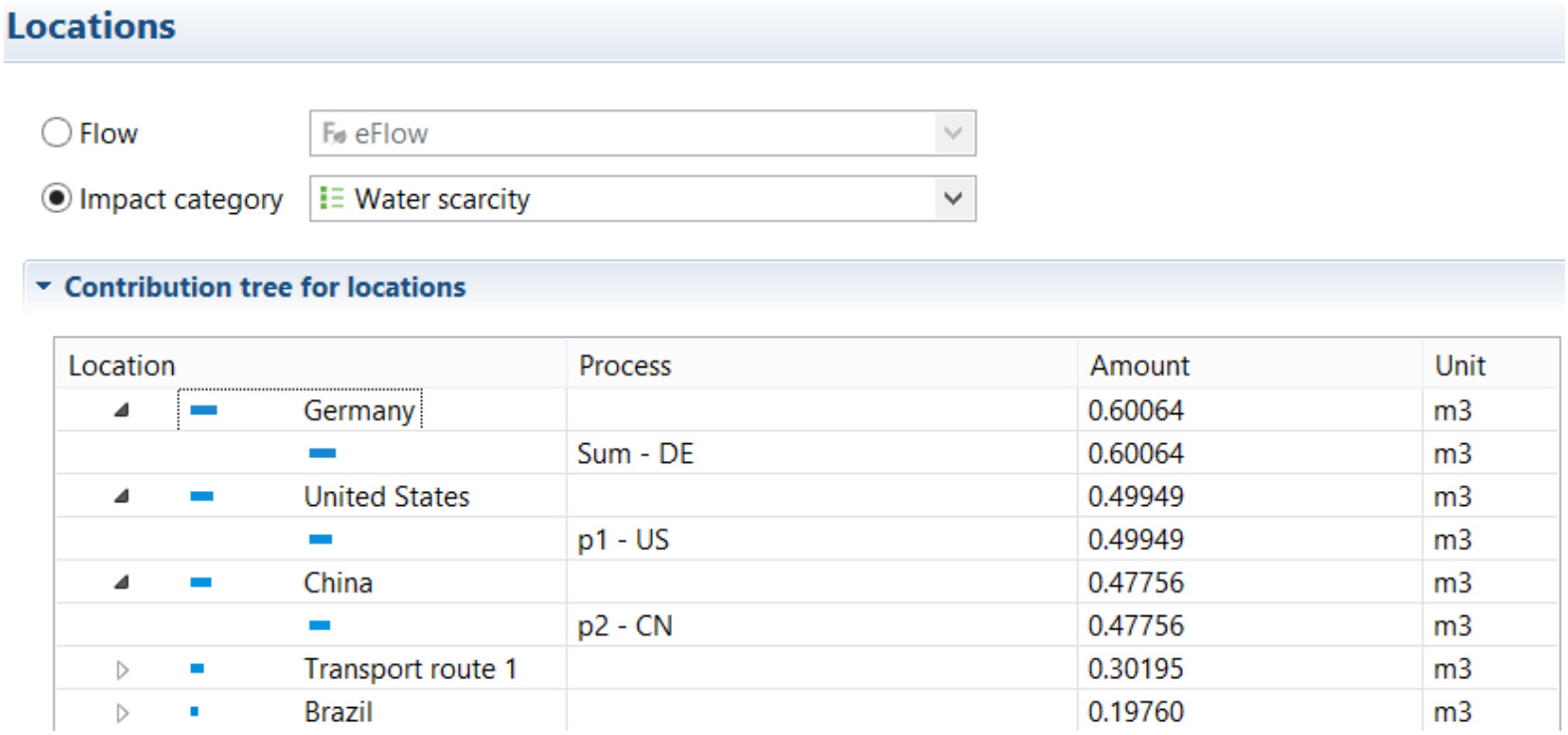
Regionalized LCIA results: Result map

- Map coloured depending on the direct contributions of each location



Regionalized LCIA results: Locations

- Contribution of each location to the inventory and LCIA results, broke down into the direct contributions of the processes within that specific location



Location	Process	Amount	Unit
Germany		0.60064	m3
	Sum - DE	0.60064	m3
United States		0.49949	m3
	p1 - US	0.49949	m3
China		0.47756	m3
	p2 - CN	0.47756	m3
Transport route 1		0.30195	m3
Brazil		0.19760	m3

Regionalized LCIA results: Impact analysis

- Direct LCIA results of each process, including information about process location, inventory, LCIA results and impact factor value per flow in the process

Impact analysis

Impact analysis

Impact category: Water scarcity | Cut-off: 2 % | Exclude zero entries

Process/Flow name	Location	Flow category	Inventor...	Unit	Impact f...	Unit	Impact r...	Unit
P p2	China						0.47756	m3
eFlow			1.00000	kg	0.47756	m3/kg	0.47756	m3
P Sum	Germany						0.60064	m3
eFlow			5.00000	kg	0.12013	m3/kg	0.60064	m3
P p3	Transport route 1						0.30195	m3
eFlow			1.00000	kg	0.30195	m3/kg	0.30195	m3
P p1	United States						0.49949	m3

Outlook

Already in progress:

- Implementation of regionalized LCIA methods in openLCA:
  - ImpactWorld+
  - LC-Impact

Ideas for future projects:

- Regionalized LCIA in the Project level
- Regionalized LCIA in the Monte Carlo simulation:
  - Uncertainty of regionalized impact factors
  - Uncertainty of the locations in the inventory
- ...

→Support welcome!

Acknowldegments

- 2013-2014: US Department of Agriculture (USDA), National Agricultural Library
  - Cooperative agreement number 58-8220-2-112F

- 2014-2015: SCS Global Services
  - Enhancement of the existing regionalized LCIA calculation
  - Integration of LEO-SCS-002 standard LCIA methodology in openLCA

Thank you!

GreenDelta
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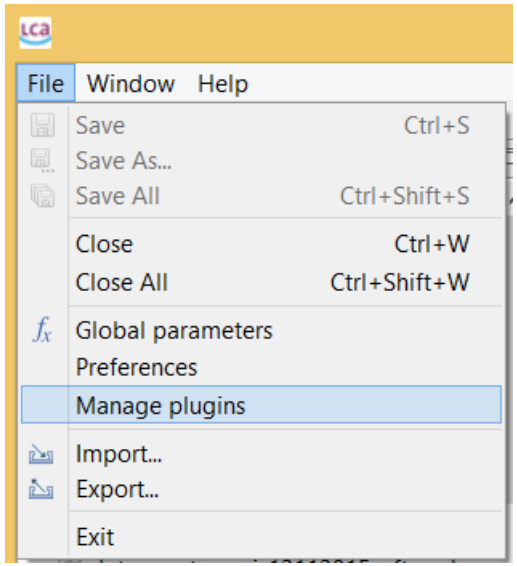
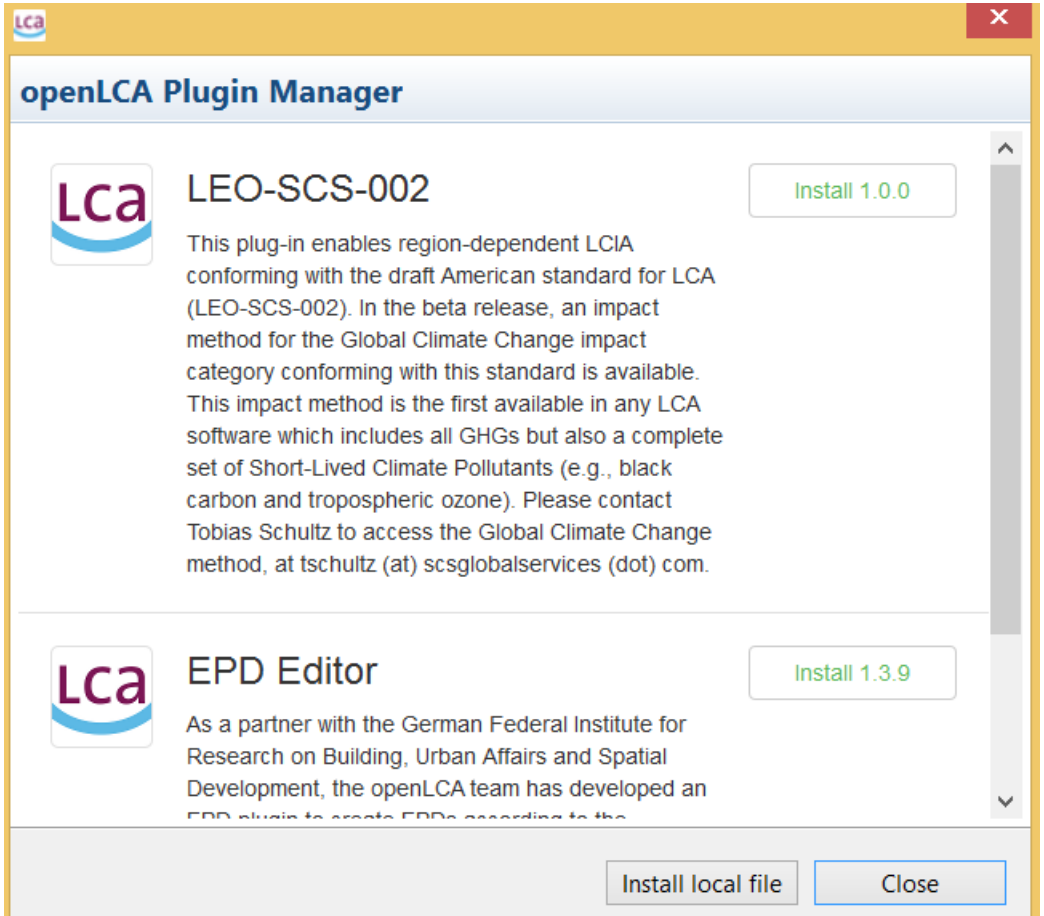
LEO-SCS-002 Plugin (I)

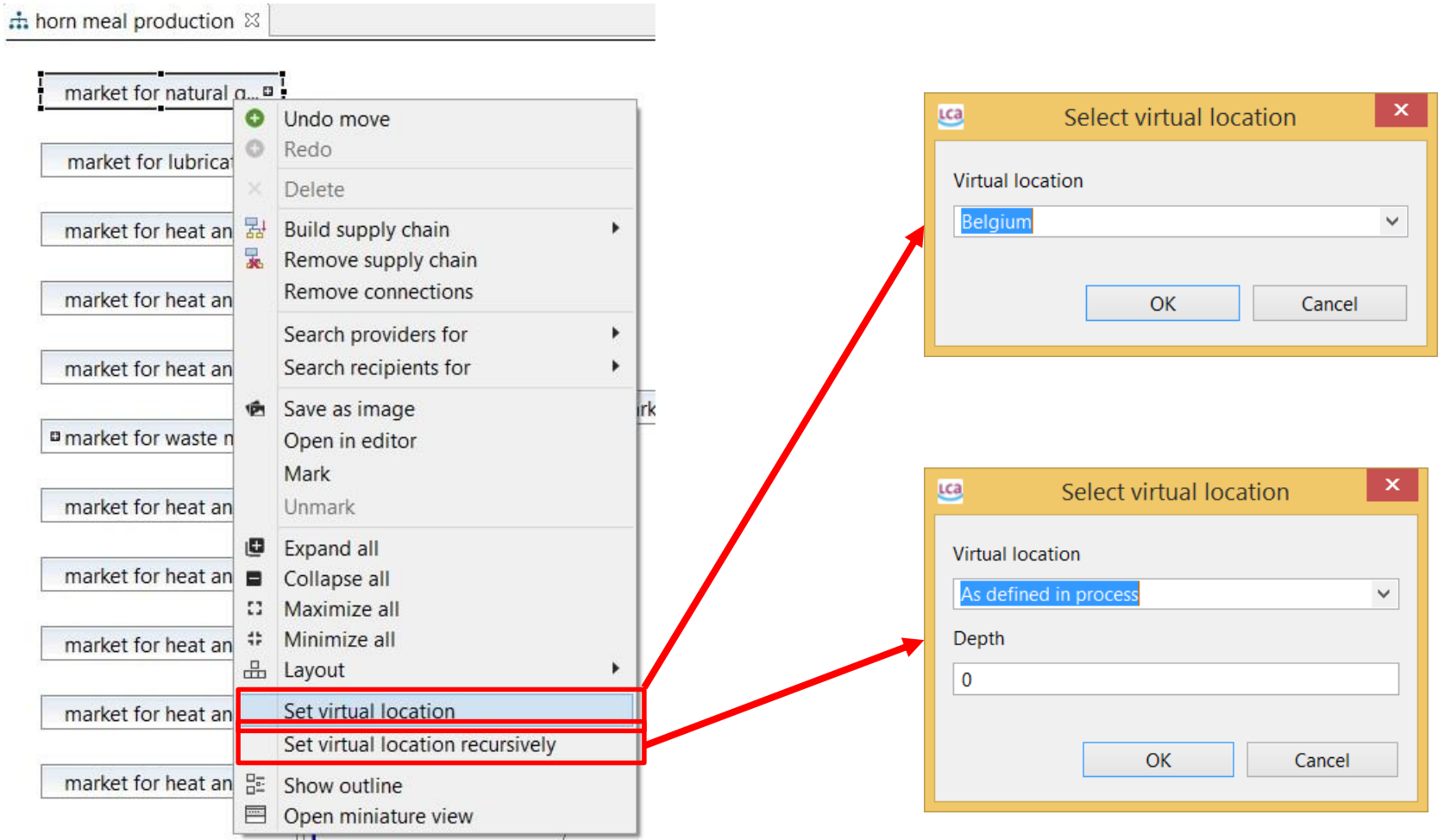
- It allows to override the locations specified in the existing process data sets for a specific product system by using the so-called “virtual locations”





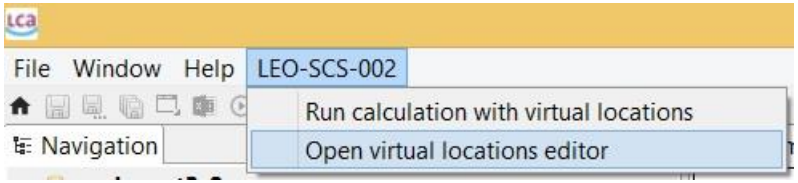
LEO-SCS-002 Plugin (II)

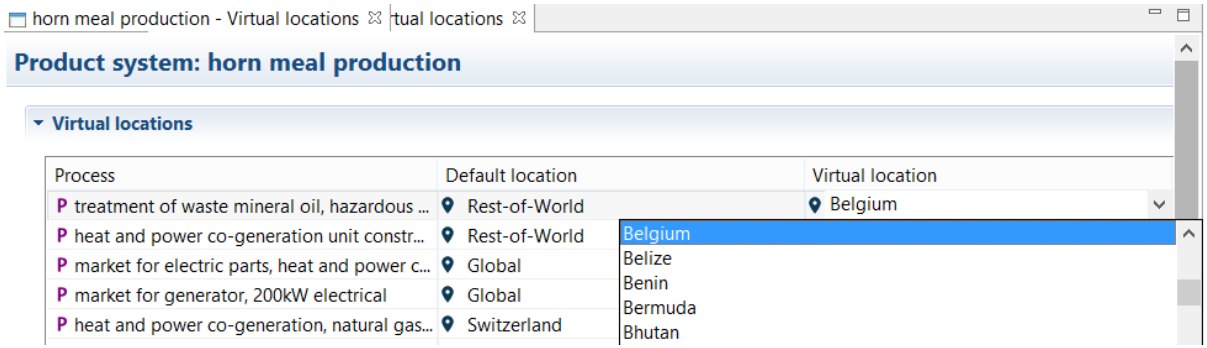
- Two options for setting “virtual locations”:
  1. In the model graph



LEO-SCS-002 Plugin (III)

- Two options for setting “virtual locations”:
  2. In the “Virtual locations” editor





Regionalized LCIA with System processes

- Crop, at plant – US (Ecoinvent v.2.2 database)