INTEGRATING GIS-BASED REGIONALIZATION INTO LCA CALCULATIONS: ~~THE EXAMPLE OF WATER~~ *The status quo*

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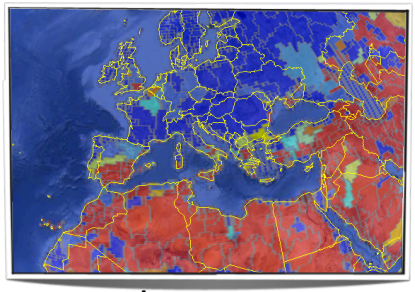
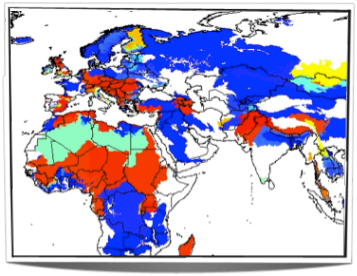
There isn't anything here that is specific to water, but water is the hottest subject for regionalized assessment.

Problem



Freshwater use

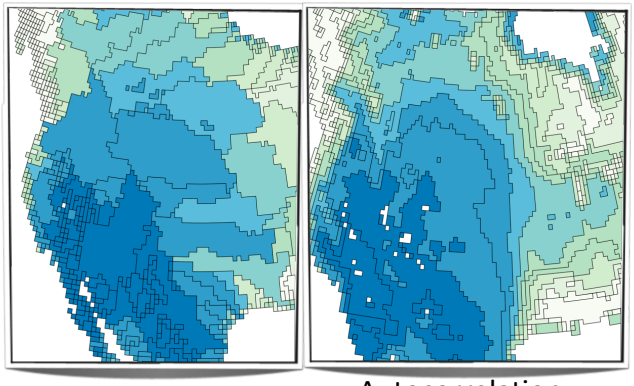


Wetlands

The problem is that we have regionalized impact assessment methods for water, but can't use them to their full potential, because the most popular LCA software doesn't support any GIS functionality. Here are some examples from Pfister et al, 2009, and Verones et al, forthcoming.

Spatial scale of water use

Watersheds?



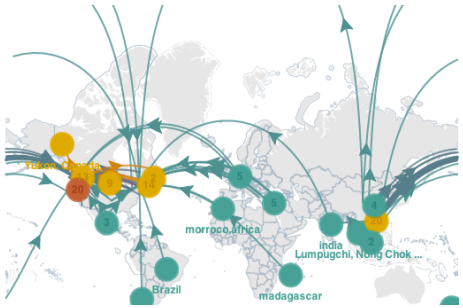
Watersheds

Autocorrelation-optimized

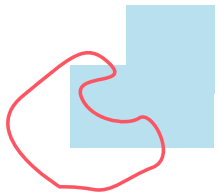
-> Need GIS to work with water CFs

What is the right spatial scale for assessment of water use? If there was one spatial scale for all aspects, then we could pre-calculate the mapping from countries (where most of our data is) to, for example, watersheds. However, watersheds are not the only relevant spatial scale, and may not be the best for any problems. See Mutel et al 2012 for more discussion of systematically choosing the spatial scale for impact assessment.

Challenges



Spatial supply chain data



Matching spatial scales

There are two main challenges in regionalized water assessment - matching the spatial scale of impact assessment and inventory, e.g. watersheds to countries, and generating spatial data for all relevant processes in the supply chain.

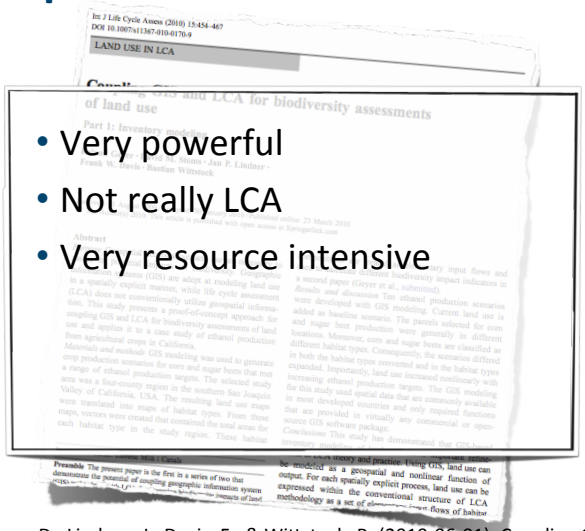
Two complete models

Resources

Computer training

We will look at five different approaches for the first problem, of dealing with two different spatial scales.

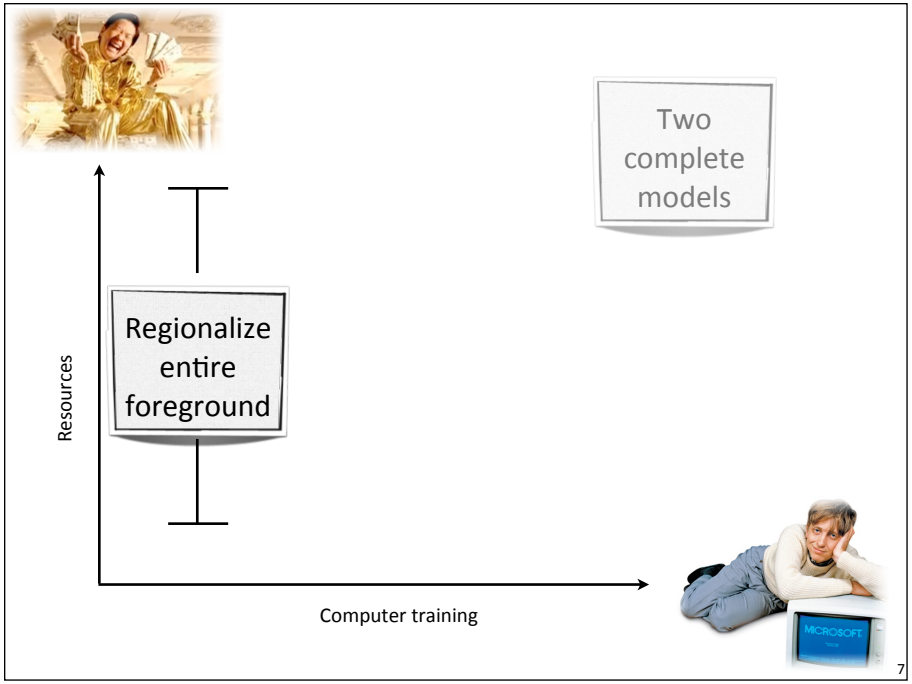
Two complete models



- Very powerful
- Not really LCA
- Very resource intensive

Geyer, R., Stoms, D., Lindner, J., Davis, F., & Wittstock, B. (2010-06-01). Coupling GIS and LCA for biodiversity assessments of land use. The International Journal of Life Cycle Assessment, 15(5), 454--467.

The first approach is two completely different models (LCA and spatial), with data passed manually back and forth.



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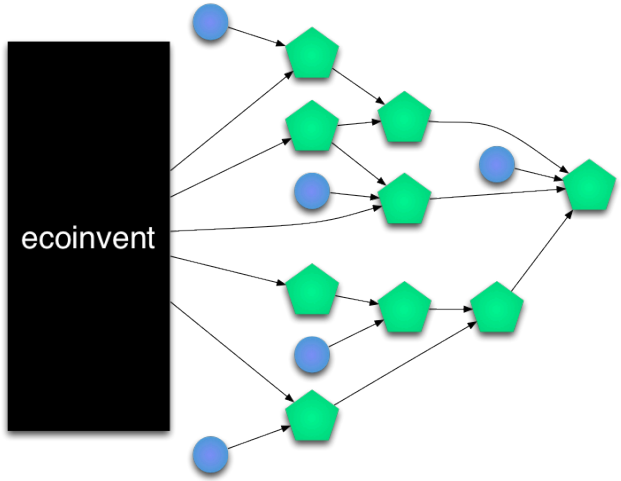
Regionalize entire foreground



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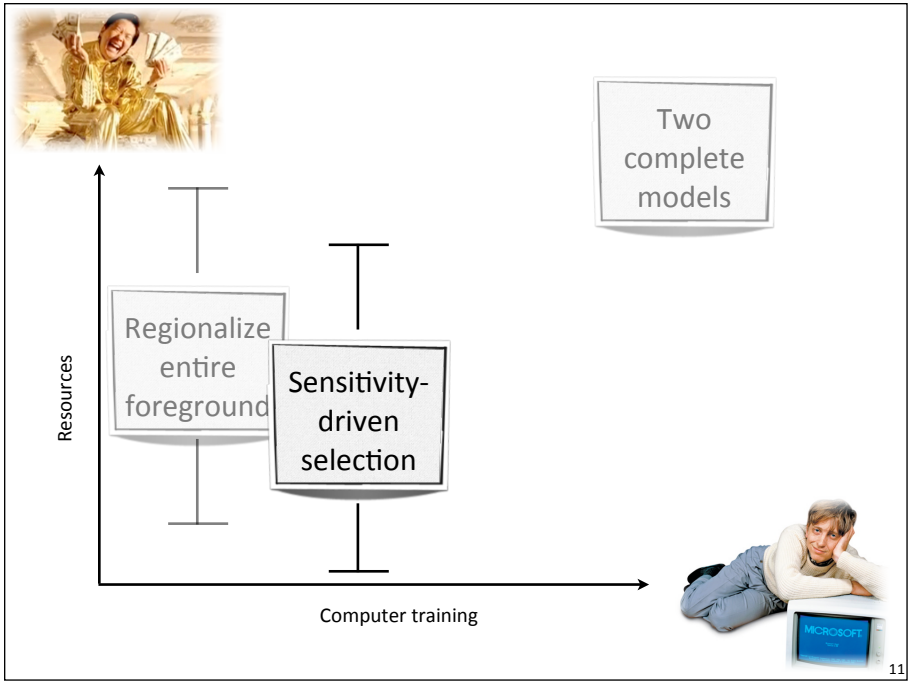
The second approach is to regionalize the entire foreground, creating new site-specific substance flows and associated characterization factors for each process in the foreground system.

Looking up lots of data

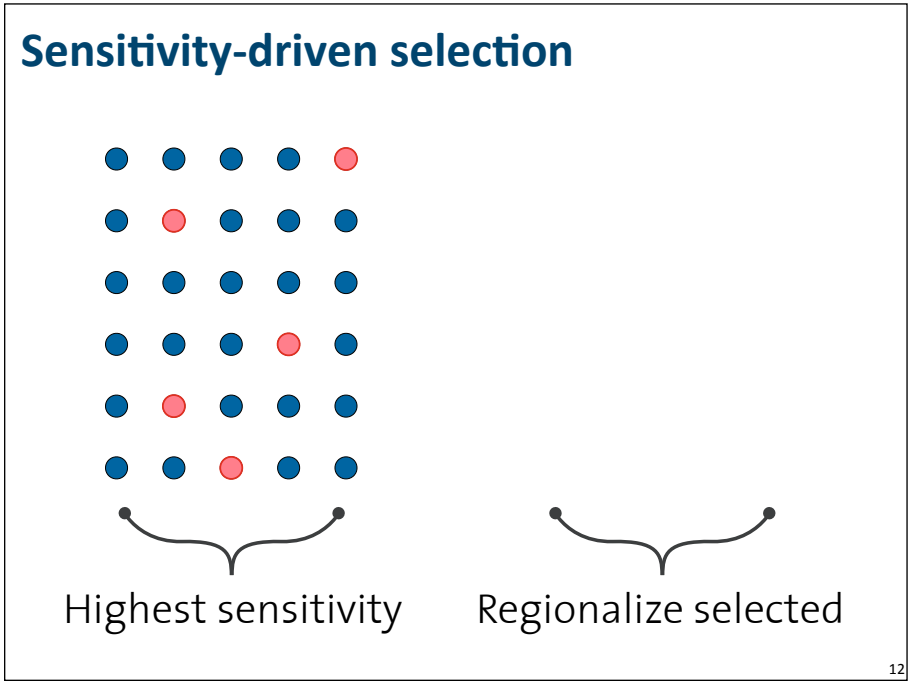
- Create foreground as set of separate data
  - Geocode and match in an easy GIS
  - Quantum GIS is open source, free, and easy
  - Also consider Google Fusion Tables
- Consider doing LCIA calculations in separate data
  - Import directly as EcoIndicator points
  - Easier than creating region-specific CFs in e.g. SimaPro

Regionalize entire foreground

- Can use existing workflows and LCA software
- Don't have to include water in LCA inventories
- Resource use depends on breadth of foreground
- Difficult to iterate or include variations
- Can miss significant impacts



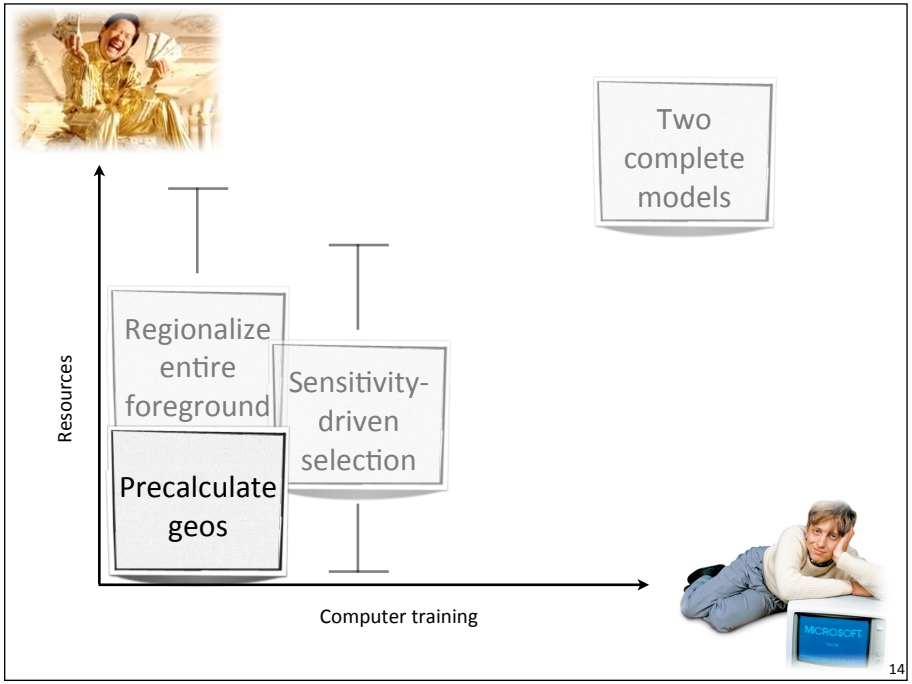
Sensitivity-driven selection



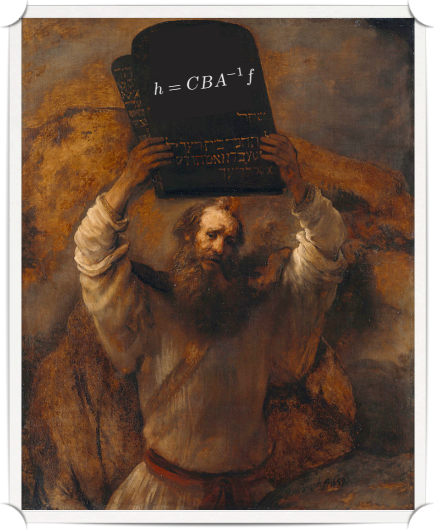
The third approach, borrowed from Pascal Lesage at CIRAIG, is to apply characterization factors at the spatial scale of the inventory (e.g. countries), with their associated uncertainty intervals, and to then use sensitivity analysis to identify the activities and flows that contribute the most to model result uncertainty. Site-specific characterization factors would then be applied to those selected flows.

Sensitivity-driven selection

- Sensitivity-testing not built into most LCA software
- IA uncertainty not built into most LCA software
- Foreground and background
- Small regionalized data-entry
  - (assumes uncertain, aggregated CFs available)



Precalculate geometry intersections

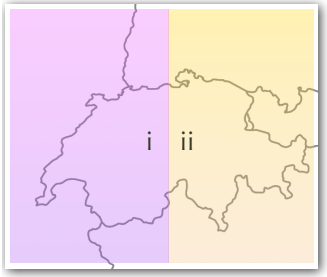


The formula for LCA is not written in stone - we can modify it to include GIS-based results in our LCA calculations.

Precalculate geometry intersections

$$h_r = [\mathbf{MGR}]^T \circ [\mathbf{BA}^{-1} diag(f)]$$

G is the geographic transform matrix, from inventory spatial support to impact assessment spatial support

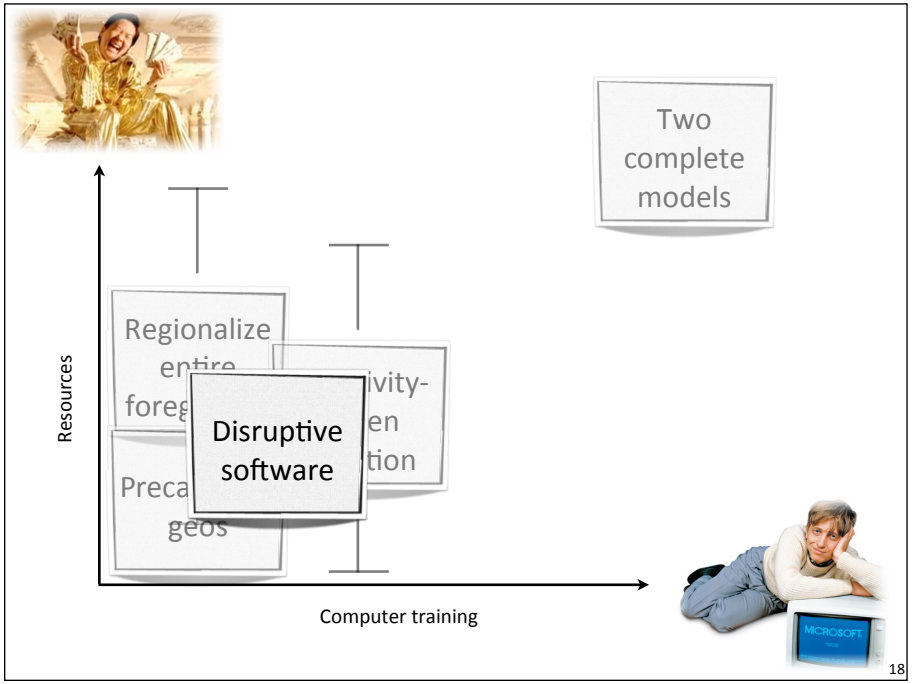


$$\begin{array}{c} \\ \text{CH} \\ \text{FR} \end{array} \begin{array}{c} \begin{array}{cc} \text{i} & \text{ii} \end{array} \\ \begin{bmatrix} 0.5 & 0.5 \\ 1 & 0 \end{bmatrix} \end{array}$$

Mutel, C. L., Pfister, S., & Hellweg, S. (2011). GIS-Based Regionalized Life Cycle Assessment: How Big Is Small Enough? Methodology and Case Study of Electricity Generation. Environmental Science & Technology, 46(2), 1096--1103.

Precalculate geometry intersections

- Little to no effort from practitioners
  - More effort from software developers
  - Precalculation by web service or method developers
- Difficult to add new locations
  - Stuck with pre-defined locations



Disruptive software

- Inclusion of GIS functionality directly in LCA
  - or other way around
- Brightway2 is one such attempt
  - But regionalization is not scheduled for 2-3 months
- Inclusion of GIS **increases** data requirements
  - Shouldn't just know countries

The limited GIS functionality needed for regionalized water assessment can be built into LCA software. As it doesn't seem like this is a priority for the popular LCA software makers, it is probably up to the disruptors to add this new functionality.

Spatial supply chain data

- Water database in ecoinvent 3
- Global data on agriculture is available
- Country-level data on power production as well
- Eternal burden of LCA...

Thank you for your attention.

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