GLOBOX
A spatially differentiated global fate, intake and effect model for LCA

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What is GLOBOX?

- GLOBOX is a model for the calculation of spatially differentiated LCA toxicity characterization factors on a global scale
  - huge parameter set (GLOBACK)
  - model description (paper in revision)
  - software (downloadable soon)

What is GLOBOX?

GLOBACK parameter set

	A	E	F	G	H	I	J	K	L	M
1	GLOBACK - EN	GEOGRAPHIC PARAMETERS								
2	source	[2]	[2]/derived from [9]	[2]						[2]
3										
4	parameter	total area	area glaciers and icefields *(+ assumptions)*	area inland water *(+ assumptions)*	assumed area fresh water	assumed mixing depth fresh water (d)	assumed total area salt lakes	assumed mixing depth salt lakes (d)	rain water produced on land	land bou (total)
5										
6										
7										
8										
9										
10	symbol in EUSES 1.00	AREA				DEPTH_water (1)		DEPTH_water (2)		
11										
12	symbol in GloboPOP [1			ARW (1+2)	ARW (1)	HTW (1)		HTW (2)		
13										
14	unity	[km2]	[km2]	[km2]	[km2]	[m]	[km2]	[m]	[km3/year]	[km]
15										
16	Afghanistan	647,500	*0*	*2,085*	*65*	*2.0*	2,020	129	211	
17	Albania	28,748	*0*	1,350	1,350	21	0	0	27	
18	Algeria	2,381,740	*0*	*238.17*	*238*	*2.0*	0	0	211	
19	American Samoa	199	*0*	0	0	0	0	0	0.6	
20	Andorra	468	*0*	0	0	0	0	0	0	
21	Angola	1,246,700	*0*	*124.67*	*125*	*2.0*	0	0	1,259	
22	Anguilla	102	*0*	0	0	0	0	0	0	
23	Antarctica	14,000,000	13,720,000	*8*	0	0	8	9	3,200	
24	Antigua and Barbuda	443	*0*	0	0	0	0	0	1.1	
25	Argentina	2,766,890	*0*	30,200	26,865	16	3,335	13	1,616	
26	Armenia	29,800	*0*	1,400	1,400	42	0	0	16	
27	Aruba	193	*0*	0	0	0	0	0	0	
28	Australia	7,686,850	*0*	68,920	2,118	5.5	66,802	7.5	4,071	
29	Austria	838,870	32	1,426	444	30	982	6.5	929	
30	Azerbaijan	86,600	*0*	*603*	603	26	0	0	38	
31	Bahamas	13,940	*0*	3,870	3,870	5.5	0	0	13	
32	Bahrain	665	*0*	0	0	0	0	0	0	
33	Bangladesh	144,000	*0*	10,090	10,090	5.5	0	0	357	
34	Barbados	431	*0*	0	0	0	0	0	0.9	
35	Belarus	207,600	*0*	*192*	192	0	0	0	128	
36	Belgium	30,528	*0*	250	250	5.5	0	0	26	
37	Belize	22,966	*0*	160	160	5.5	0	0	50	

What is GLOBOX?

Model description

Table 4: Overview of chemical-independent equations¶

Number	Equation¤
CLIMATIC PARAMETERS¤	
¤	L: AREA_lake>0: RAINDIRECT_lake = RAINRATE*AREA_lake¤
¤	L: RAINDIRECT_saltlake = RAINRATE*AREA_saltlake¤
¤	L: AREA_lake>0: EVAP_lake = EVAPrate_lake*AREA_lake¤
¤	Ftime_rain = 0.1*RAINDAYS/365¤
¤	Ftime_frost = FROSTMONTHS/12¤
FLOW PARAMETERS¤	
¤	L: AREA_lake > 0: FLOW_river_lake = (AREA_lake*TOTALDEPTH_lake/RES L: AREA_lake = 0: FLOW_river_lake = 0¤
¤	L: AREA_lake > 0: FLOW_lake_river = (AREA_lake*TOTALDEPTH_lake/RES L: AREA_lake = 0: FLOW_lake_river = 0¤
¤	L: FLOW_river_saltlake = EVAP_saltlake-RAINDIRECT_saltlake¤
DIMENSIONAL PARAMETERS¤	
¤	L: AREA_saltlakesed = AREA_saltlake¤
3.5¤	L: AREA_nat = SYSTEMAREA*Farea_nat¤
3.6¤	L: AREA_agr = SYSTEMAREA*Farea_agr¤
3.7¤	L: AREA_urb = SYSTEMAREA*Farea_urb¤
3.9¤	V_air = SYSTEMAREA*HEIGHT_air¤

What is GLOBOX?

Software

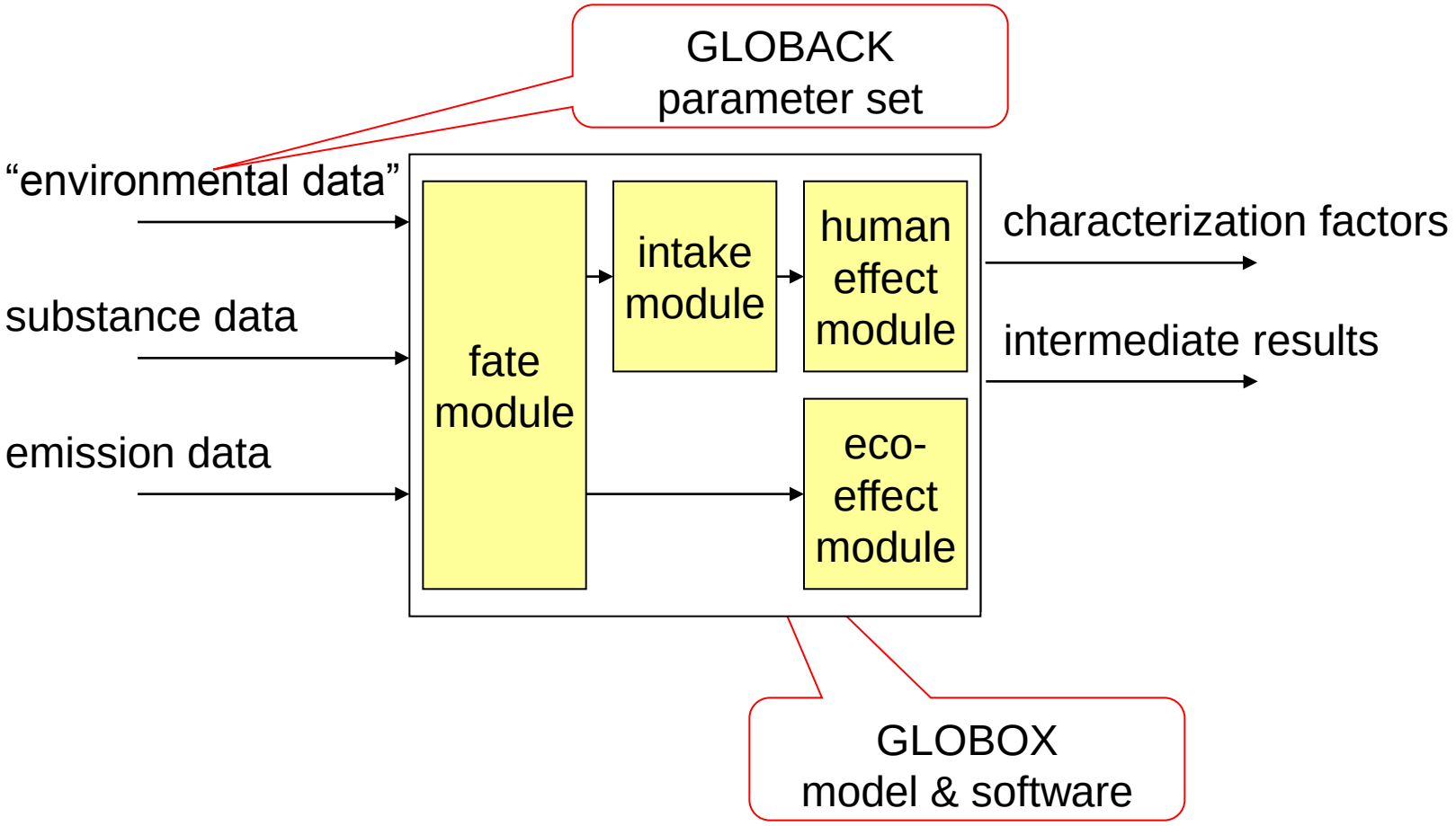
Results - GLOBACK2part1.xls; GLOBACK2part2.xls

Intermedia transfer parameters | Borders and flows | Equations | Concentrations | Balance | Distribution | Dos

Region	RCRtox_rive	RCRtox_lake	RCRtox_saltl	RCRtox_sea	RCRtox_soil	RCRtox_hum	R
Afghanistan	2.22E-11	3.76E-11	6.54E-12	-	1.25E-13	8.68E-13	1
Albania	1.78E-10	7.4E-11	0	-	6.4E-13	1.57E-11	2
Algeria	7.1E-11	1.07E-10	0	-	4.08E-13	2.24E-11	3
American Samoa	2.32E-12	0	0	-	1.44E-14	6.79E-12	1
Andorra	4.54E-10	0	0	-	2.8E-12	3.18E-11	4
Angola	7.18E-12	1.41E-11	0	-	4.87E-14	4.46E-12	6
Anguilla	2.27E-11	0	0	-	1.74E-13	2.77E-11	4
Antarctica	1.63E-15	0	5.33E-15	-	1.61E-14	0	0
Antigua and Barbuda	5.79E-11	0	0	-	2.78E-13	2.5E-11	3
Argentina	7.51E-12	6.89E-12	7.83E-12	-	4.9E-14	2E-12	2
Armenia	7.93E-11	2.23E-11	0	-	4.06E-13	7.87E-12	1
Aruba	8.88E-12	0	0	-	5.03E-14	4.18E-11	6
Australia	2.94E-12	1.89E-12	1.9E-12	-	1.34E-14	3.82E-12	5
Austria	6.92E-10	3.15E-10	5.57E-10	-	3E-12	3.96E-11	5
Azerbaijan	3.07E-11	3.63E-11	0	-	2.86E-13	7.6E-12	1

Main features

Model structure



Main features

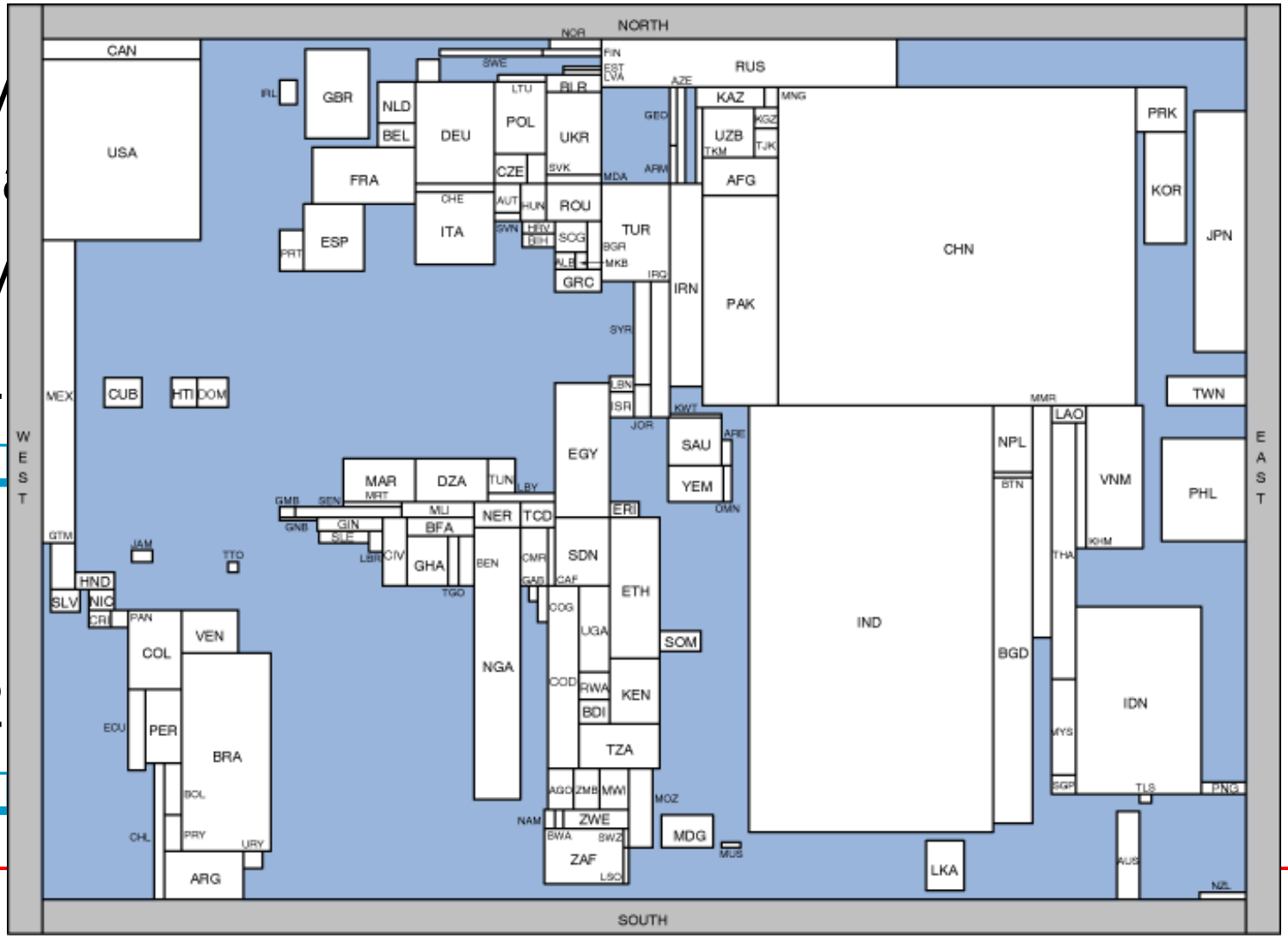
Model structure

- Modular approach
  - fate, intake and effect modules
- Input
  - “environmental” data
    - dimensions, climate, diet, population, ...
  - substance data
    - physical, chemical, persistence, bioaccumulation, ...
  - emission data
    - 1 kg/s, emission profile, ...
- Output
  - characterization factors
  - fate, intake and effect factors, intake fractions

Main features

Fate module

- M
  - ca
- M
- 1
  -
- 2
  -



Main features

Fate module

- Distribution parameters differentiated per country/territory or sea w.r.t geographic features, hydrology, and climate
- Regions interconnected by atmospheric and aquatic flows
- Specific equations for air and water transport between countries and/or seas
- Distribution equations solved by matrix inversion
  - matrix dimension 3000×3000

Main features

Intake module

Human intake based on intake of chemicals through several routes

- food (dairy, meat, root crops, leaf crops, fresh water fish, seafish)
- drinking water
- inhalation

- Intake parameters differentiated per country w.r.t. population density, body weight and food/drinking water consumption

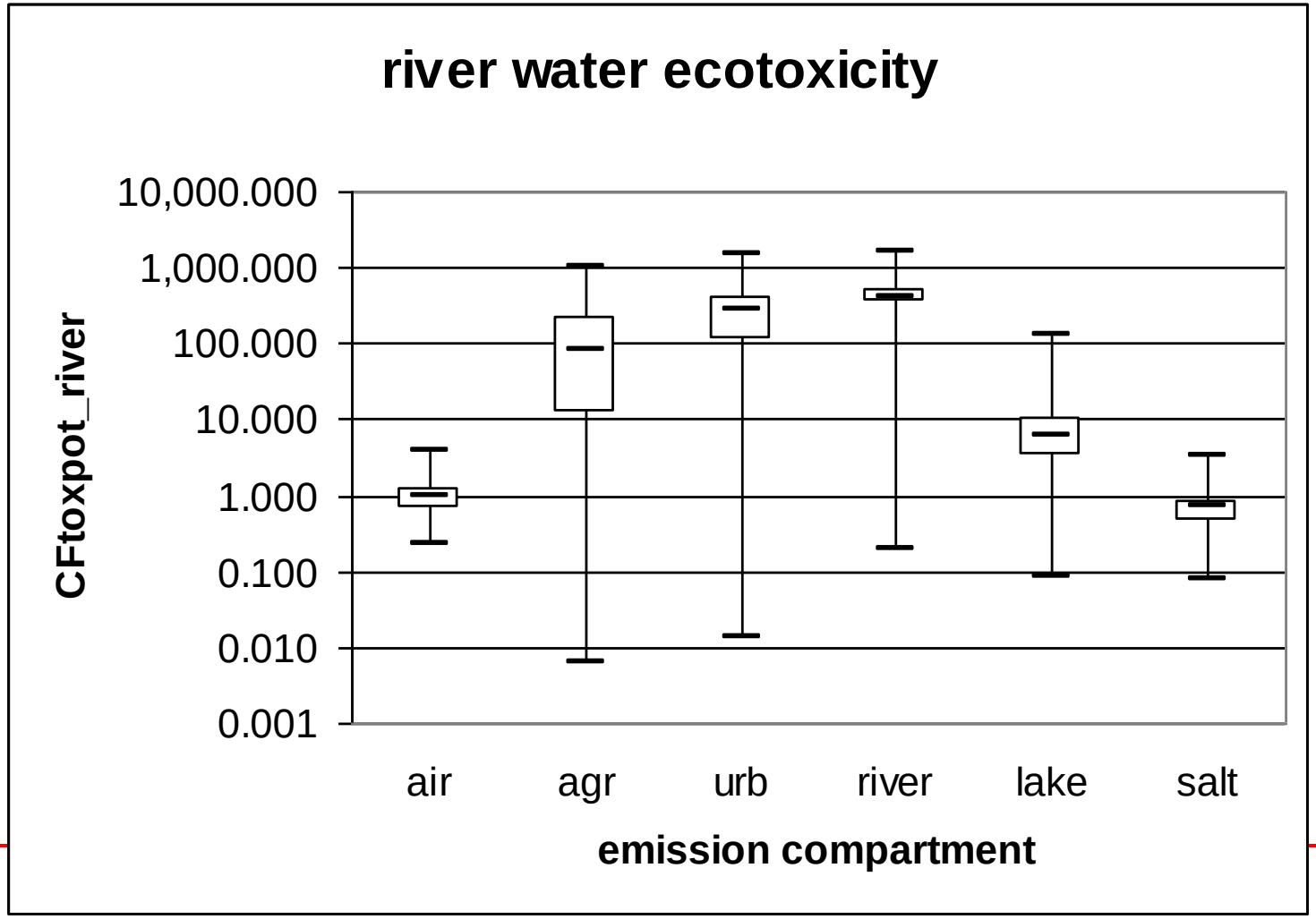
Main features

Effect module

- Metal-specific equations for speciation in fresh and marine water
- Effect modelling differentiated w.r.t. regional sensitivity and relationship between toxic threshold values and regional background concentrations
- Several impact categories
  - rivertox, laketox, saltlaketox, seawatertox, soiltox, humantox (carc/non-carc)

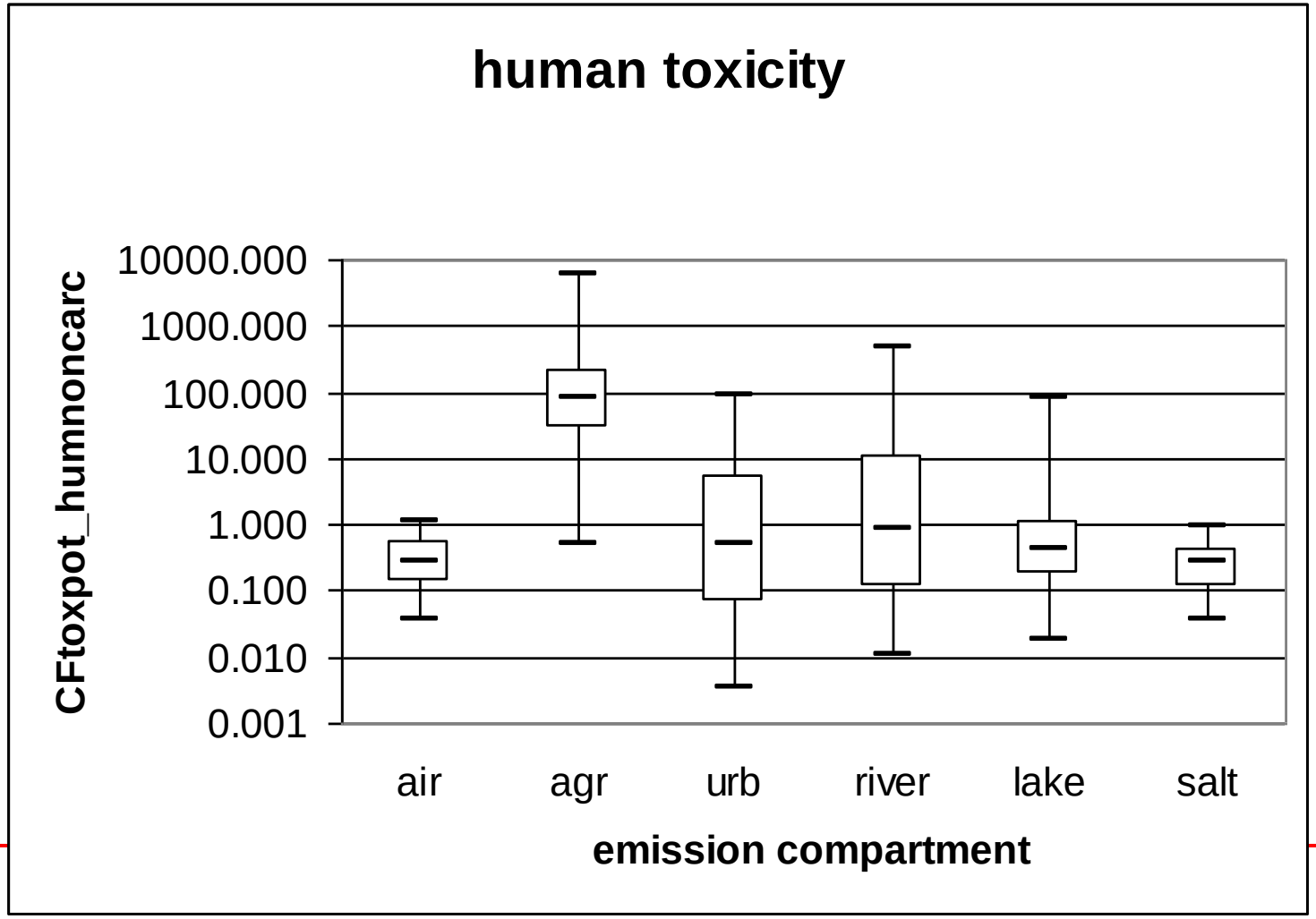
Results for nitrobenzene

Range of results



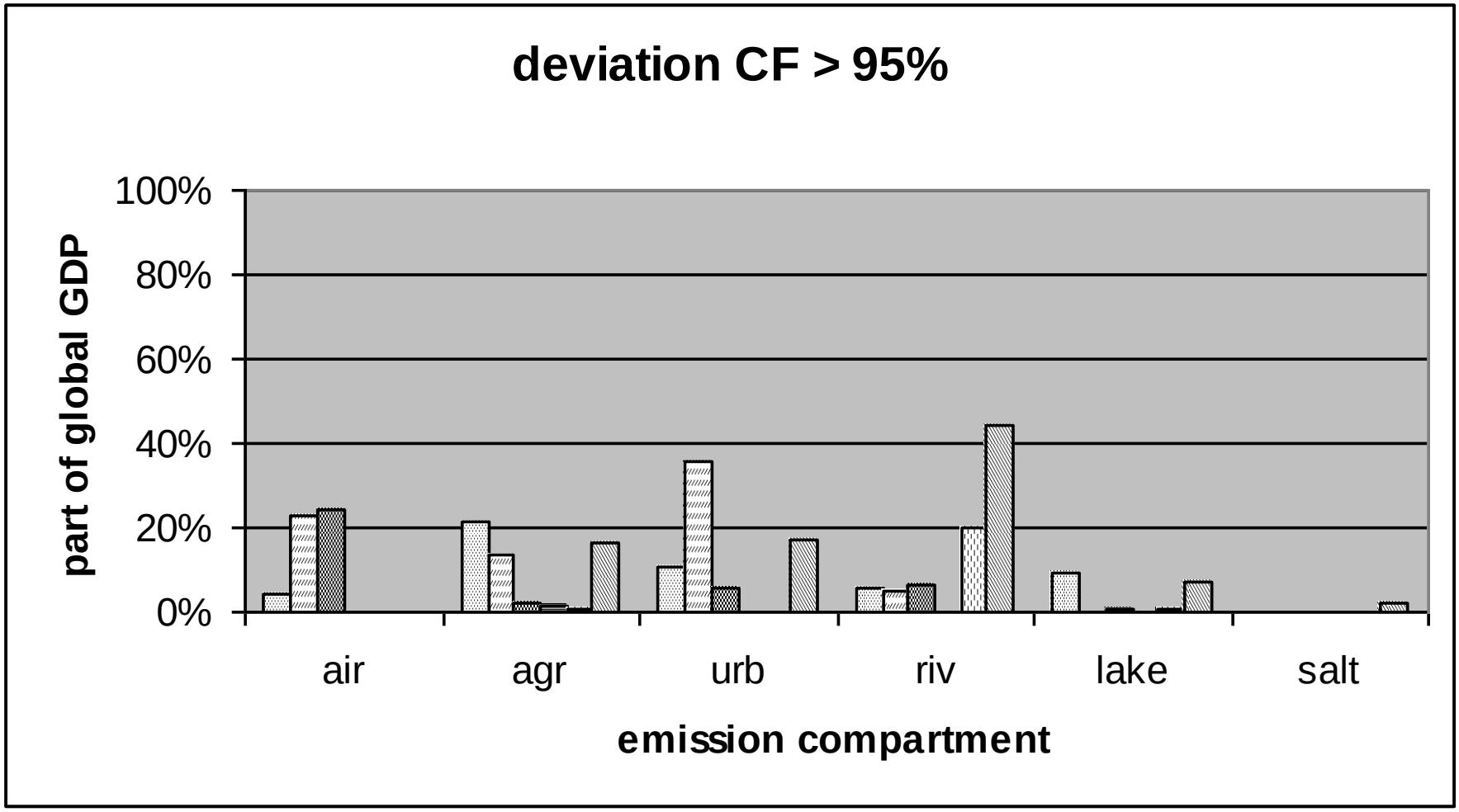
Results for nitrobenzene

Range of results



Results for nitrobenzene

Relevance of range of results



Does regional differentiation matter?

- Spatial differentiated CFs differ by many orders of magnitude
  - especially for releases to soil and fresh water
- CFs may be more than 95% wrong
  - for up to 40% of the world's emissions

Thank you!

- Publication in Science of the Total Environment, forthcoming
- Model, data and description available soon at http://cml.leiden.edu/