Conclusions from the BioMoSA project

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Joint Final Seminar on the
EU-BIOCLIM and BioMoSA project

Luxembourg, 27-28 November 2003

Content

- Approach
- Results
  - Deterministic
  - Stochastic
- Conclusions of the study
- Recommendations for performance assessments
- Open questions

Outline of BioMoSA

- Model development
  - 5 European sites
  - Generic assessment tool
- Model comparison
  - Normalized exposures
  - Important processes and parameters
- How site-specific should a biosphere model be?

Normalized exposures

- Transfer of radionuclides from geosphere to man
- Intermediate step in all cases is radioactivity in water
  - Well water
  - Surface water (rivers and lakes)
- Use of water is a key issue in all models
  - Drinking
  - Watering cattle
  - Irrigation

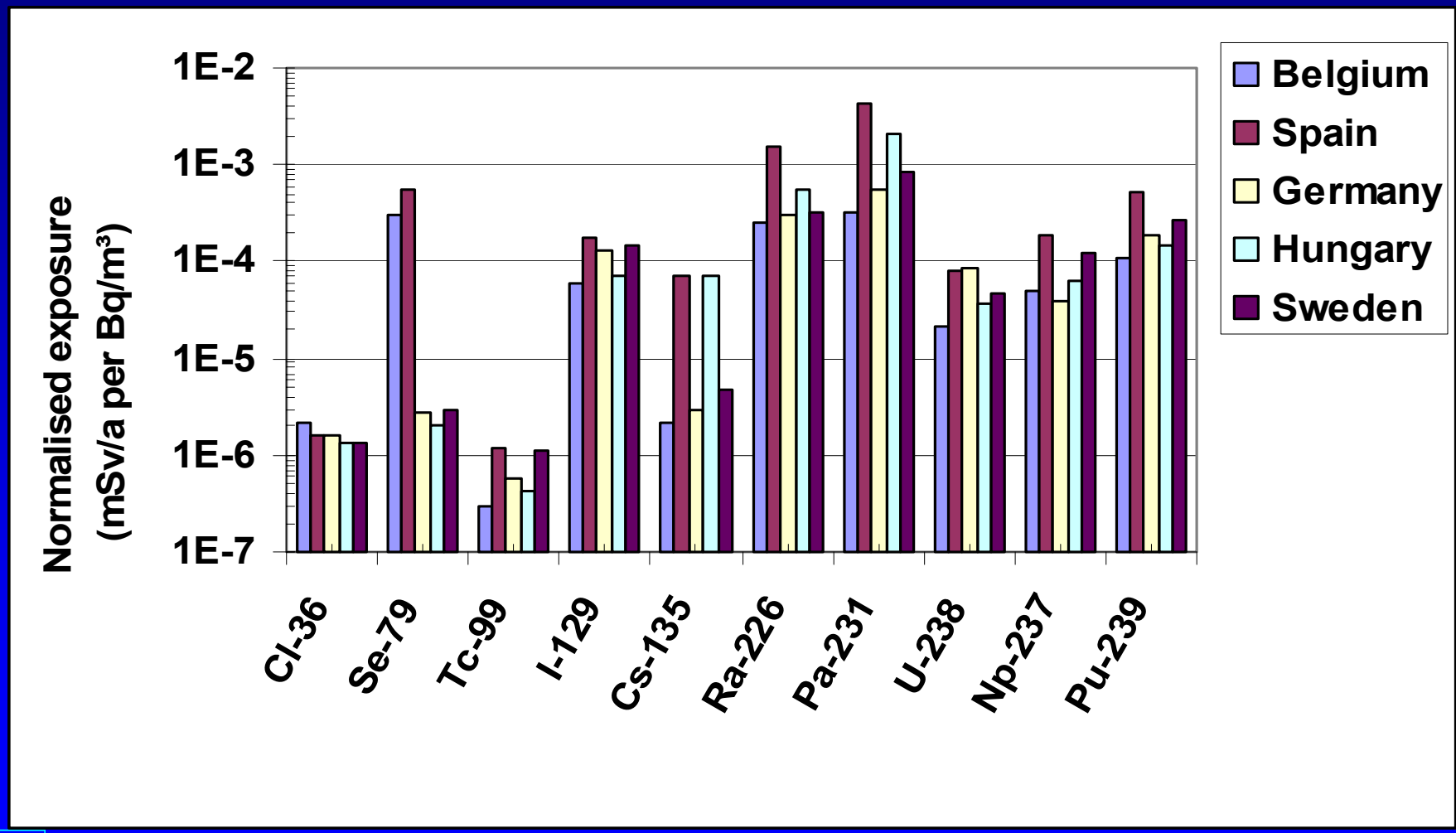
Normalization

- Activity in surface water / Release to surface water
  - [Bq/m³ per Bq/a, Bq/m³ per Bq]
- Exposure / Activity in well/surface water
  - [Sv/a per Bq/m³]
- Enables differentiation
  - Impact of geosphere/biosphere interface
  - Impact of the biosphere system

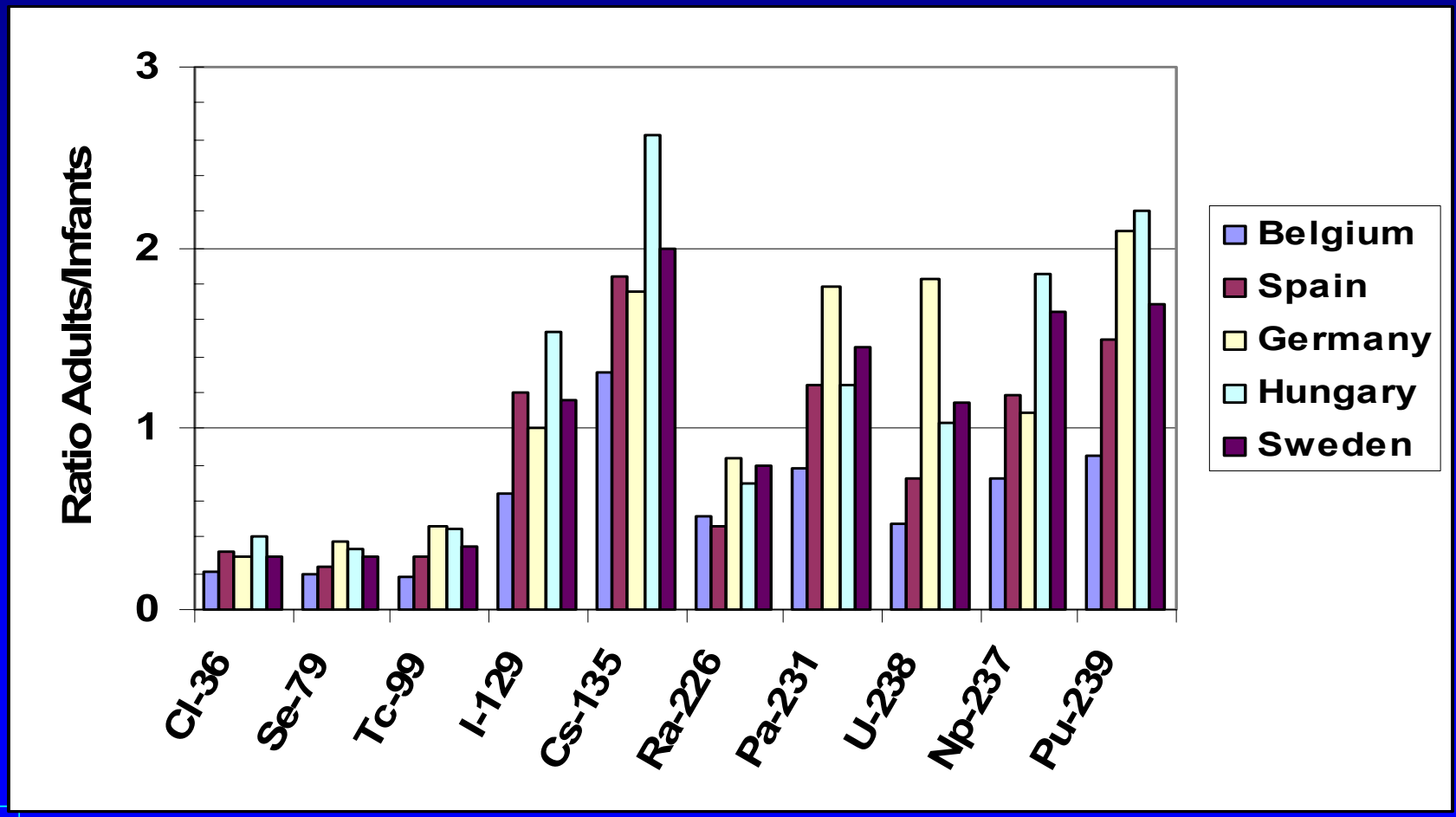
Pathways

Pathway	Model				
	Germany	Belgium	Spain	Sweden	Hungary
Ingestion					
Drinking water	x	x	x	x	x
Cereals	x	x	x	x	x
Potatoes & roots	x	x	x	x	x
Leafy vegetables	x	x	x	x	x
Fruit vegetables	x	x	x		x
Milk	x	x	x	x	x
Beef	x	x	x	x	x
Pork	x	x	x		x
Lamb	x	x	x		x
Freshwater Fish	x	x	x	x	x
Soil	-	-	x	x	-
Chicken	-	-	x		x
Eggs	-	-	x	-	x
Citrics			x		
Fruit			x		
Leguminosae			x		
Inhalation					
Resuspended soil	x	x	x	x	x
External exposure					
Contaminated land	x	x	x	x	x

Normalized exposure (mSv/a per Bq/m³)



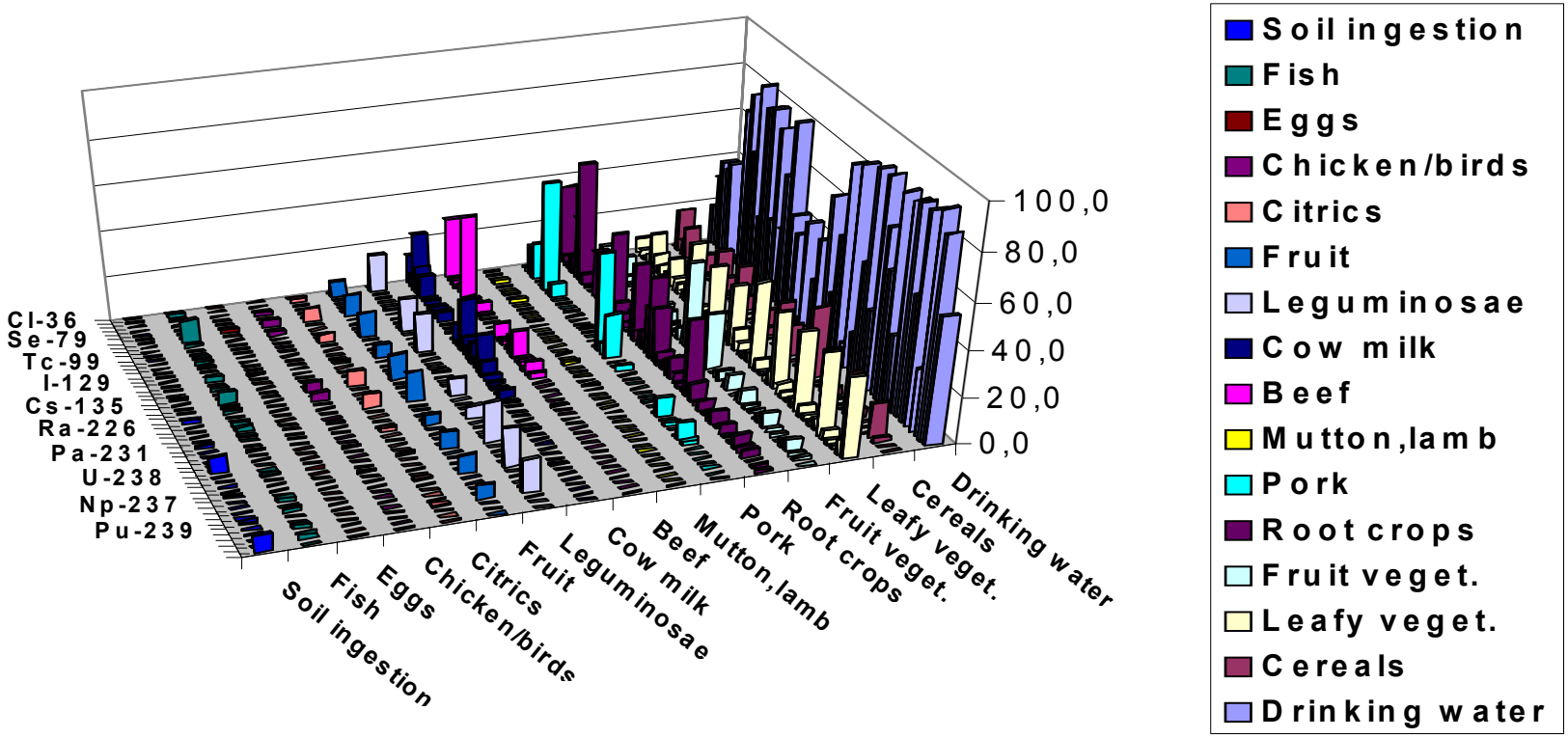
Ratio normalized exposure: adults/infants



Findings

- In general, little differences between the sites
- Considerable differences for Se-79, Cl-36, Cs-135
  - Parameter selection to be reviewed
- Variation between adults and infants
  - Factor of 3-5 for Cl-36, Se-79 and Tc-99
  - Less than a factor of 3 for other radionuclides

Importance of pathways



Adults: Drinking water (%) (adults)

Nuclide	B	E	G	H	S
Cl-36	17,6	32,5	40,6	39,2	43,1
Se-79	**0,4**	**0,3**	71,4	80,0	56,7
Tc-99	86,7	30,0	80,4	81,4	34,5
I-129	75,9	33,9	59,2	83,3	44,7
Cs-135	38,1	**1,5**	46,7	**1,5**	25,0
Ra-226	44,0	14,7	66,7	26,3	53,1
Pa-231	84,8	9,3	87,7	18,1	50,6
U-238	90,9	33,8	91,7	72,2	56,3
Np-237	89,8	32,1	89,5	90,8	55,0
Pu-239	90,9	27,5	94,7	86,7	55,6

Adults: Cereals (%)

Nuclide	B	E	G	H	S
Cl-36	0,0	18,8	6,9	13,8	0,0
Se-79	0,0	6,1	7,9	0,4	0,0
Tc-99	0,0	16,7	6,4	1,3	0,0
I-129	0,0	18,9	6,6	0,1	0,0
Cs-135	0,0	2,8	9,7	3,9	0,0
Ra-226	0,0	20,7	13,0	13,9	0,0
Pa-231	0,0	7,1	4,2	31,4	0,0
U-238	0,0	18,8	3,0	0,2	0,0
Np-237	0,0	17,9	3,9	0,1	0,0
Pu-239	0,0	15,3	1,9	0,1	0,0

Adults: potatoes & roots (%)

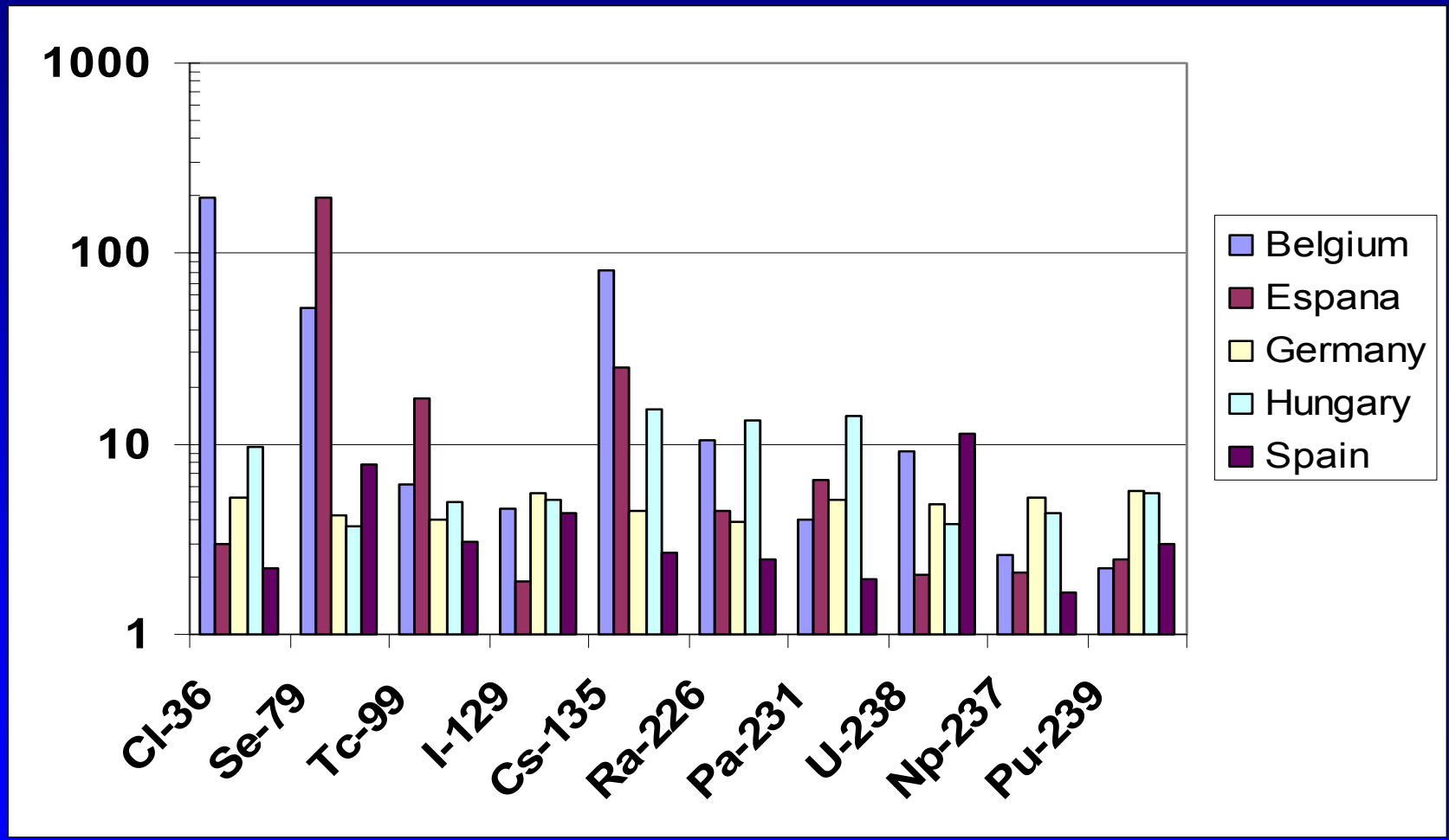
Nuclide	B	E	G	H	S
Cl-36	34,8	4,5	2,8	7,6	27,7
Se-79	53,3	4,9	1,0	0,5	20,7
Tc-99	1,4	3,7	2,0	0,6	37,3
I-129	7,9	4,3	2,4	0,4	12,0
Cs-135	34,3	5,8	7,7	21,1	35,4
Ra-226	23,6	5,8	3,7	7,0	9,1
Pa-231	4,2	2,4	1,5	33,8	8,0
U-238	1,9	4,1	0,8	1,2	6,0
Np-237	1,4	4,1	1,0	0,6	5,8
Pu-239	2,7	3,3	0,5	1,0	1,0

Important pathways

- Drinking water dominating
  - Exception Se-79, Cl-36, Cs-135

    Parameter selection!!!
- Cereals
  - More important in warm climates
- No clear trend for other pathways

Well scenario, stochastic calculations: Ratio 95/5-percentile



Findings

- Uncertainty is relatively low
  - Ratio 95/5percentile in general around a factor of 10
- Cl-36, Se-79, Cs-135
  - Combination of very pessimistic assumptions

Parameter selection

- Interpretation of data is a major source of uncertainty
- Cl-36, I-129 and Se-79
  - Data vary over orders of magnitudes
  - Correlations
- Careful consideration
  - Speciation
  - Interaction with soil constituents

Parameters

- Pronounced differences in
  - Interception
  - Translocation
  - Migration in soil
  - TF soil-plant
  - CF water-fish
  - K_d water-sediment

Parameters: Serious differences with massive impact on exposures

- Chlorine, selenium (B, E)
  - Root uptake: > Factor of 10 higher than other models
  - Migration: > Factor of 10 lower than other models
  - conflicting with speciation
  - Transfer to milk and beef close to the physiological limits
- Cesium (E, H)
  - Migration: > Factor of 10 lower than other models
- Reconsideration required

K_d-values and migration in soil

- The kd-concept is used in 4 of the site-specific models.
- Determination of K_d-values is essential for its application
- Results from batch experiments are difficult to apply
- Further migration processes
  - Erosion
  - Bioturbation
  - Migration of radionuclides attached to soil particles

Recommendations for performance assessments

- Reference Biosphere Methodology is a good starting point
  - Provides useful guidance
  - Ensures completeness of the model
- FEP-List is very useful
- Nevertheless, modeling is subject to individual interpretation

Modeling

- Model complexity should be consistent with available data
- Complex models are more difficult to communicate
  - Inherent lack of knowledge on future
  - Long time frames
- Simpler models facilitate uncertainty analysis

Results

- Variations for well and river scenarios are relatively low
- Drinking water is an important or even dominating pathway
- Due to physiological reasons, the variation of drinking water is relatively low
- Drinking water represents a kind of a “baseline” with relatively little variations among the sites
- Ingestion of foods are „on top“

Results II

- Larger uncertainties for releases to
  - Lakes
  - Marine
  - Deep soil
- Transfer is more complex
- More site-specific
- More difficult to generalize

Soil as geosphere-biosphere interface

- Contamination of soil surface due to rising contaminated groundwater associated with pronounced uncertainties
- Poor data base
- Site-specific
- Experiments needed

Impact of climate

- BioMoSA sites covers wide range of climatic conditions
- Climate-sensitive parameters
  - Intake of drinking water
  - Irrigation rates
  - Dust load in air
- Impact on exposure relatively low

Factors limiting uncertainty and variability

- Intake of drinking water is the most important pathway
  - Little contribution to uncertainty due to low variation (< factor 2)
- Food intake
  - Limited by physiological requirements (energy, proteins)
  - 15-20 plant and 5 animal species are relevant for food supply
  - Limit for potential contribution of food to exposure ???

Limiting factors

- Irrigation
  - Assessment context defines sustainable agriculture
  - Possible salinisation in arid climates:

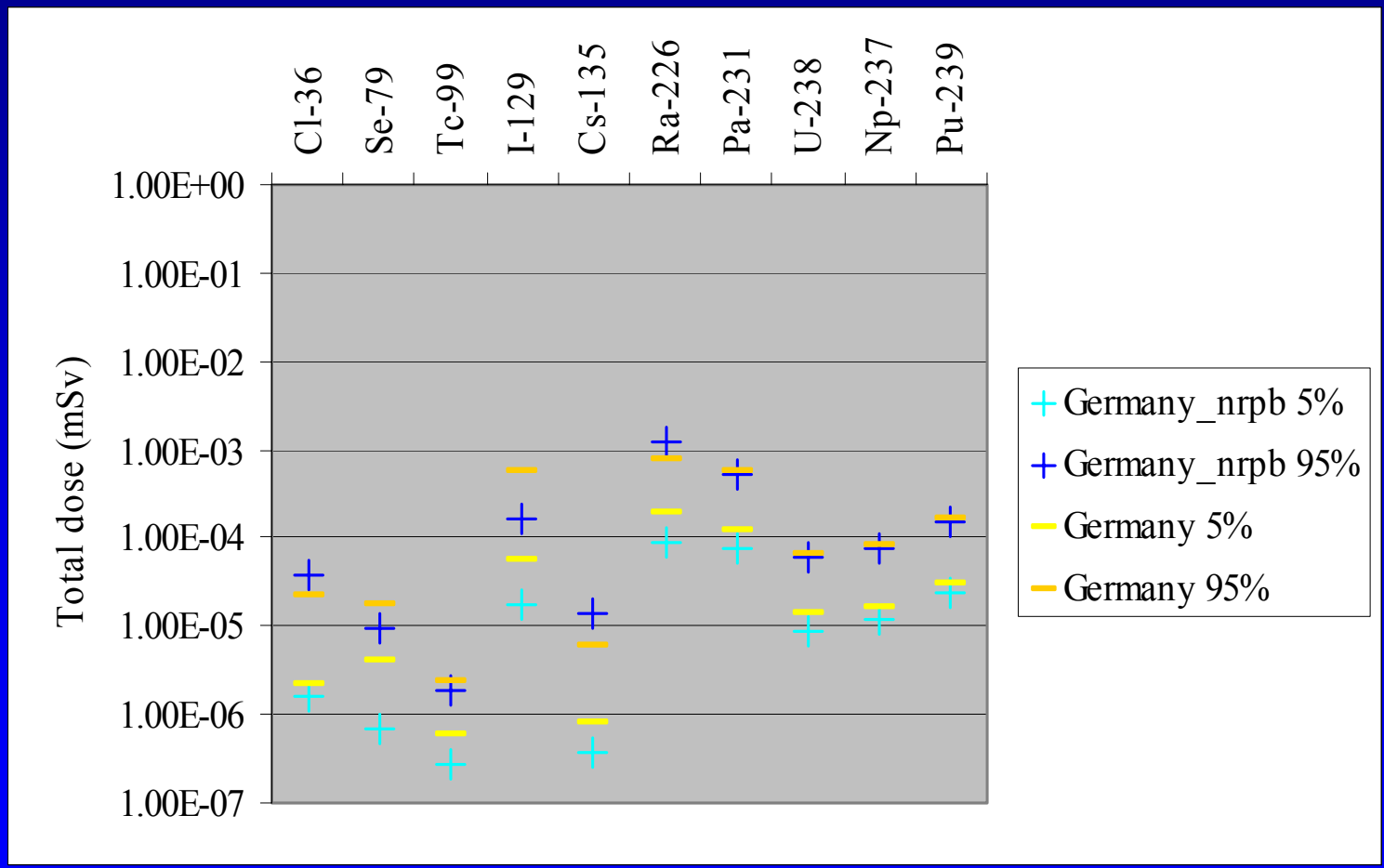
    Limitation of application of irrigation water
- Sustainable irrigation regimes are not to implement in any climate

Generic model

- Development of a generic model
  - Contains all FEPs
  - Contains all Geosphere-Biosphere-Interfaces
- Comparison against site-specific models
- Identification of important pathways
- Suggestions for model simplification

German site, well scenario

5th and 95th percentile infant total dose



Model simplification

- Remove pathways not included in the majority of the assessments
- All runs (sites and BioGeM),pathways to contribute less than 10% to the total dose for all radionuclides
  - Chicken
  - Eggs
  - Liver
- Parameters
- Modelling approaches
- Nearly any pathway/nuclide combination may be potentially relevant

Model simplification II

- Important pathways in all assessments
  - Drinking water
  - Cereals
  - Potatoes & roots
  - Leafy vegetables
  - Fish
- Generic model
  - Good agreement for well scenario
  - Re-iteration necessary for other GBIs

Open questions

- Find consensus on appropriate parameters
  - Speciation
  - Typical ranges for parameter values
  - Ensure consistency among parameters
  - Avoid conflicting data sets
- Data base for rise of contaminated ground water
  - Experimental data base needs considerable improvement
- Communication of results
  - Comparison with analogues
  - Consideration of historical data