Australian Government

Australian Nuclear Science and Technology Organisation

Little Forest Burial Ground Scenario: Results

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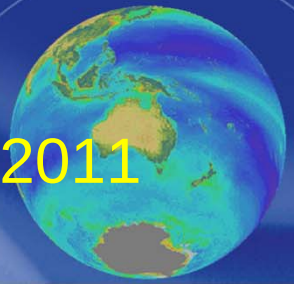
NMES Project, Institute for Environmental Research



EMRAS II, WG 4, IAEA Vienna, Jan 2011

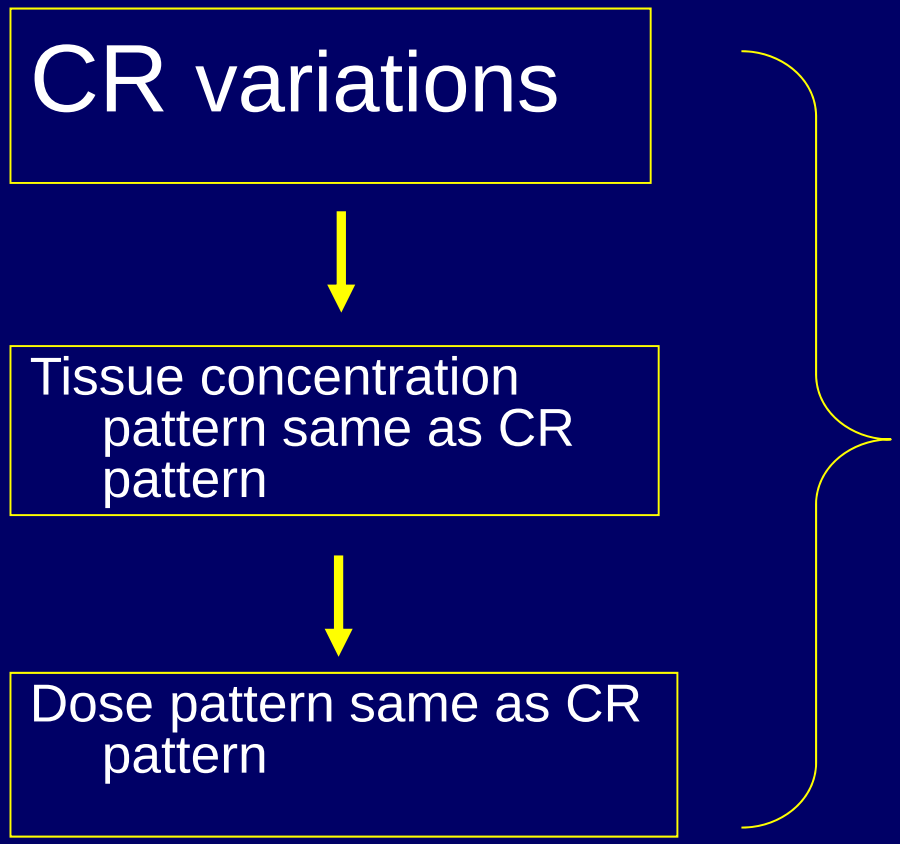
Before looking at results - Refresher on Participant's approaches

Participant	Code	Vers'n	CR sources	CR distributions	Soil distrib'n	alpha, beta, gamma	Notes on run/numeric parameters
CEH Centre for Ecology & Hydrology, Lancaster, UK	ERICA	2009 update v. 1.0	Wildlife Transfer Database (Dec 2010) except: Grass Co-60 (Tecdoc 1616) Yam (tuber, Tecdoc 1616)	Log N (when S. Dev was available in database) Or, Expon. (when S. Dev not available)	Log N	10, 3, 1	200 probability realizations
SCK-CEN Belgian Nuclear Research Centre, Mol, Belgium	ERICA		ERICA defaults except: Grass (Tecdoc 1616), and, Yam (Tecdoc 1616)	Log N (when S. Dev was available in database) Or, Expon. (when S. Dev not available)	Log N	10, 3, 1	Used ERICA Tier 3 default for E'worm and grass (RAPs), Used ERICA "new org" for all else. Progeny included if ½-life < 10d. Th-234 not included.
JSI Jozef Stefan Institute, Ljubljana, Slovenia	ERICA		ERICA defaults	ERICA default distributions Log N and Expon.]	Log N	10, 3, 1	
NRPA Norwegian Radiation Protection Authority, Oesteraas, Norway	FASTer-lite with ERICA, Eikos, and ECOLOGO		CRs from: ERICA Tool database. (soil-to-food only) Eikos and ECOLEGO (soil-to-org) DCCs generated using ERICA Tier 3 "Add Organism"	Log N			Steady- State Probabilistic (Eikos) for Co, Cs, and U where equilib reached quickly. Else, Dynamic (ECOLEGO) for 50% Organism lifespan.
KAERI Korea Atomic Energy Research Institute, Daejeon, Republic of Korea	K-Biota		ERICA defaults for grass, tree, e'worm, insect, bird TRS 364 for yam (potato) K-allometric for goanna, echidna, fox, wallaby	Log N, exponential		10, 3, 1	
ANL Argonne National Laboratory, IL, USA	RESRAD-Biota		RESRAD CR defaults Journal refs	Trunc. Log N, Bounded Log N, Exponential	Log N	20, 1, 1	1500 prob realizations Ext DCF cals, progeny w/<6mo ½ life in equilibrium. Int DCF calcs, progeny w/<100 ½ life in equilib.
Mike Wood/U. of Liverpool/ (Manchester?)	RESRAD-Biota		RESRAD CR recomm. (Grass-insect) K-allometric (Goanna-wallaby)	Not used	Not used	20, 1, 1	Half-life cut-off at 180 days.

Two complimentary approaches to analysing results

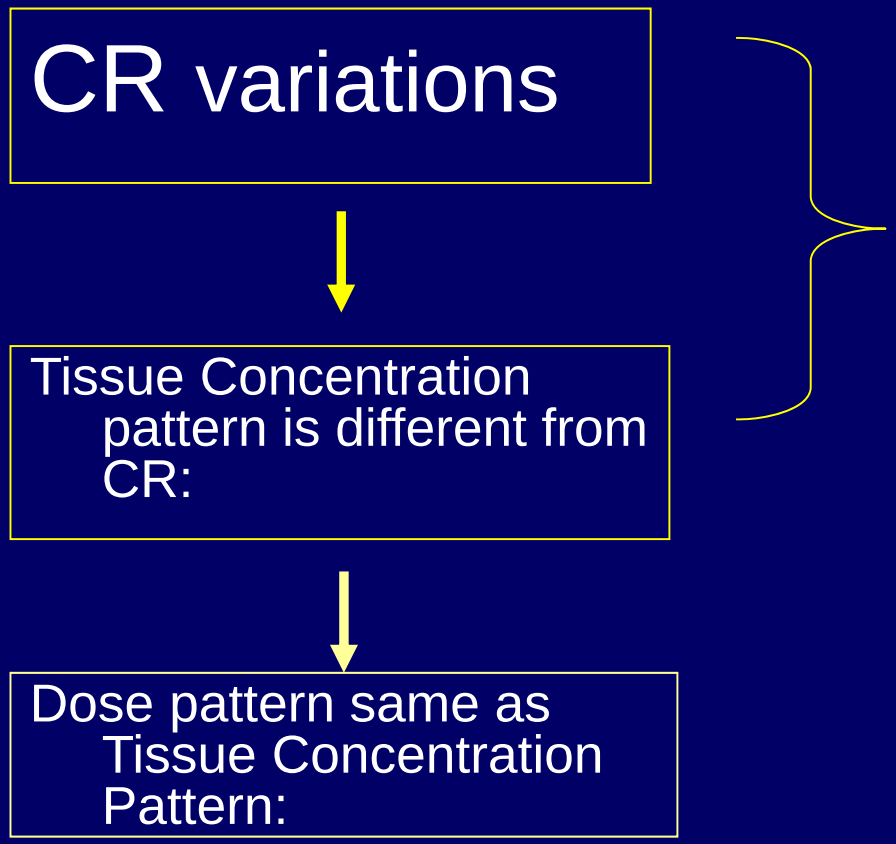
- Statistical approach comparing geometric means of “distances” among participant’s results data. Compares CRs, Int dose, Ext dose, and total dose rates (next presentation by Jordi).
- Identify differences in the progression from CR-Tissue Conc-Dose rate results to identify likely sources of variation. Quantify number & type of sources and the degree of variation (this presentation).

Comparisons of CRs, tissue concentrations and dose estimates



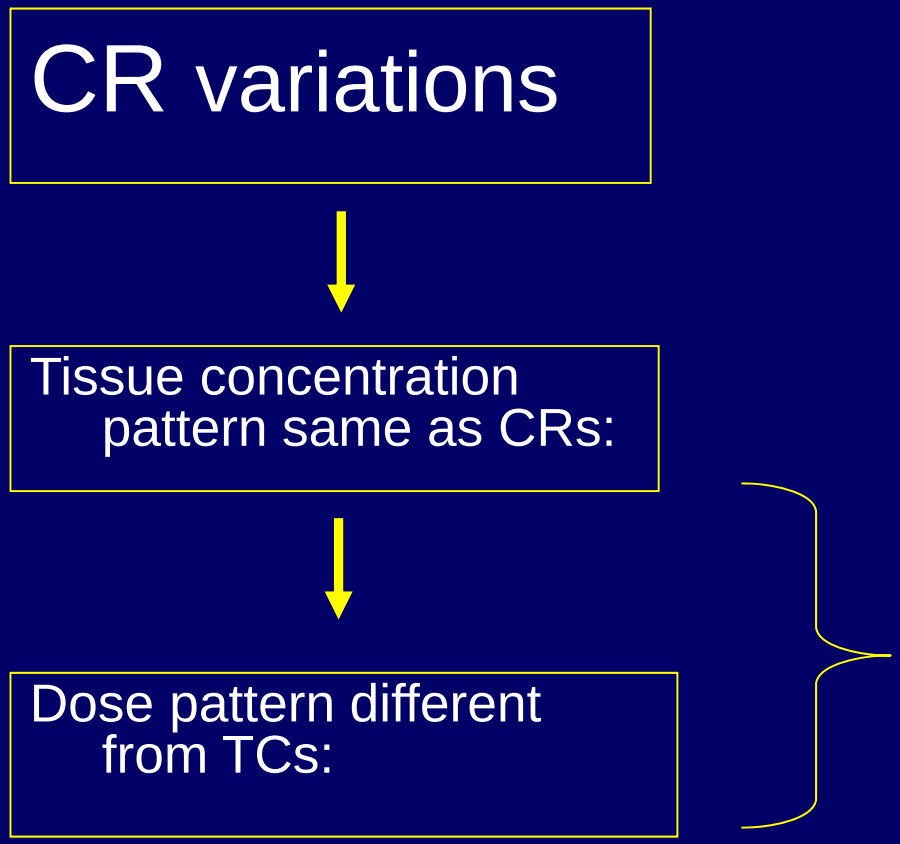
Example 1: If the same pattern of variation carries through from CR-TC-Dose this implies that variation in dose was caused by differences in CR

Comparisons of CRs, tissue concentrations and dose estimates

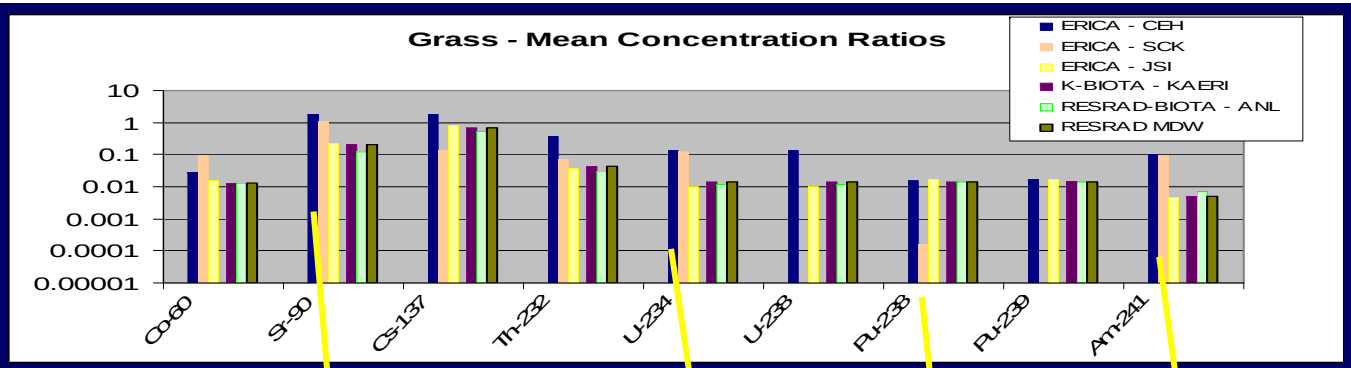


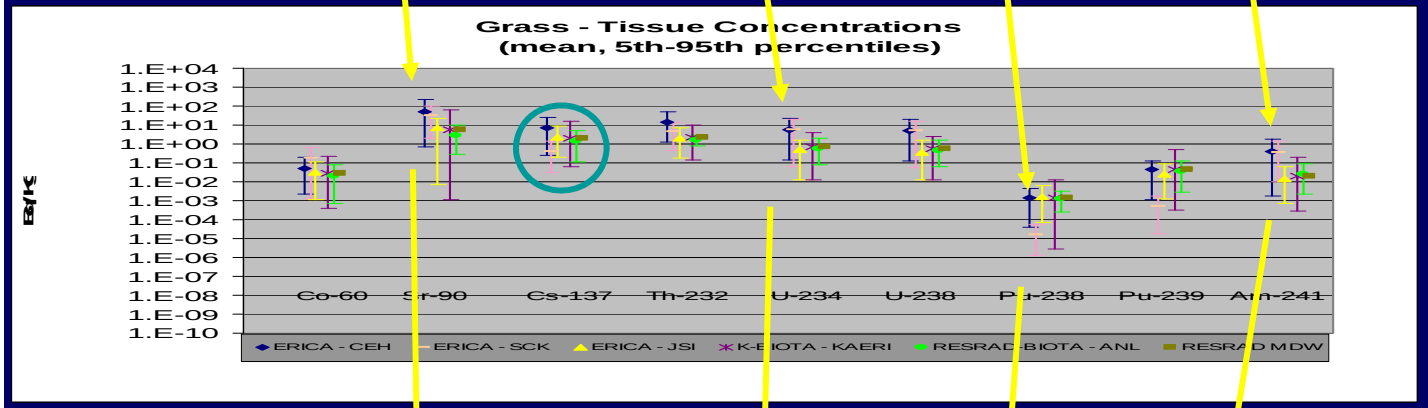
Example 2: When the only change in CR-TC-Dose pattern is between CR and TC, it implies that the variation in dose was caused by differences in food chain model c.f. direct media-biota relationship or assumptions of occupancy factor

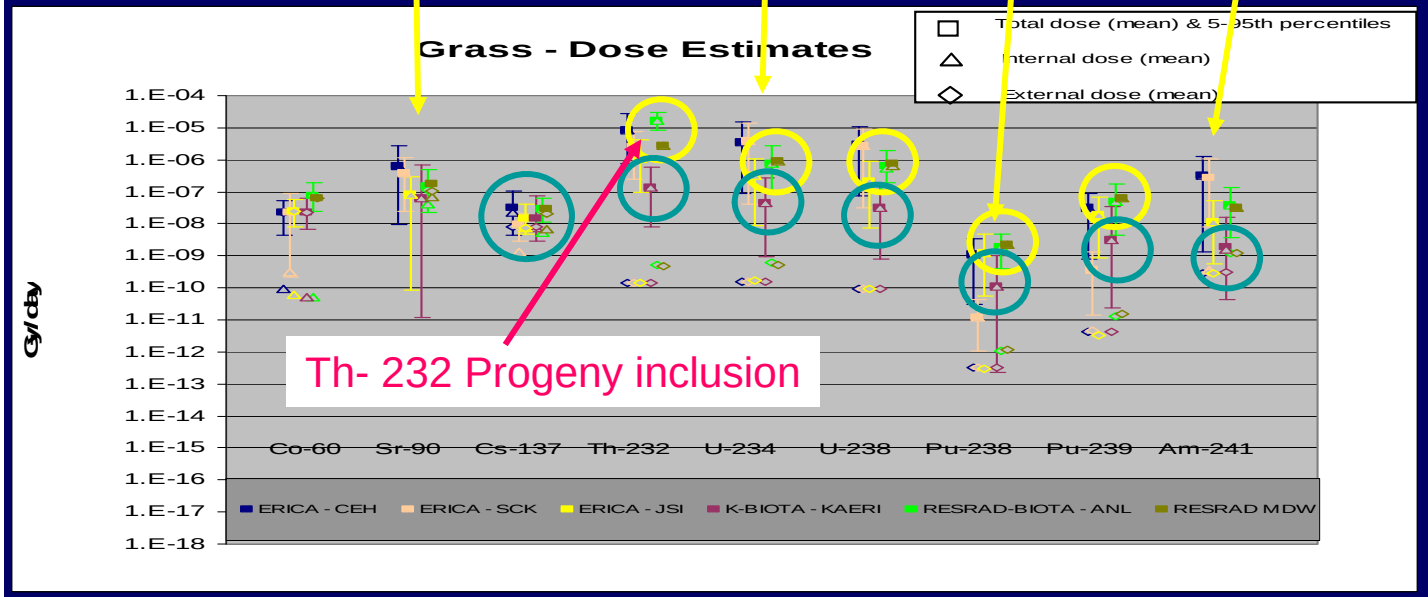
Comparisons of CRs, tissue concentrations and dose estimates



Example 3: Pattern of variation in Tissue Concentrations does not carry through to Dose means that dose variation was caused by differences in DCC, RBE, Progeny assumptions, geometry and/or occupancy factors (external dose)







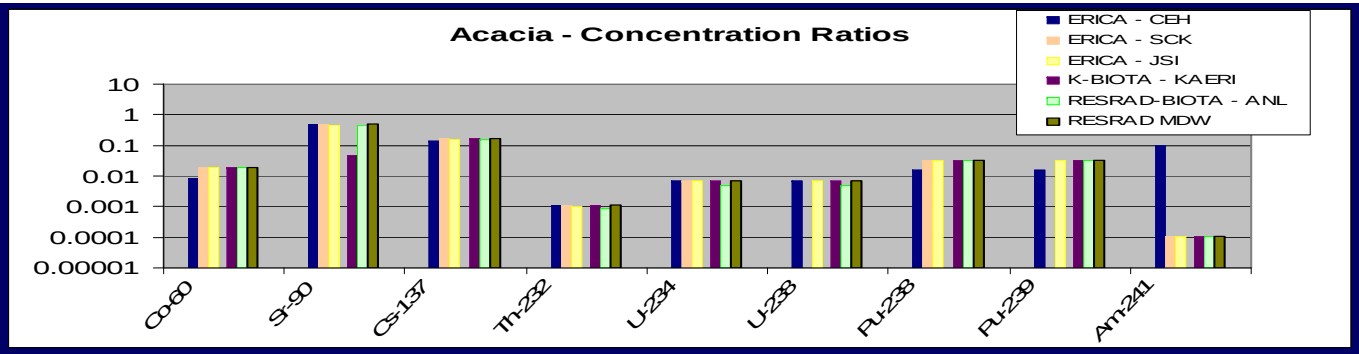
CRs generally carry through to TCs

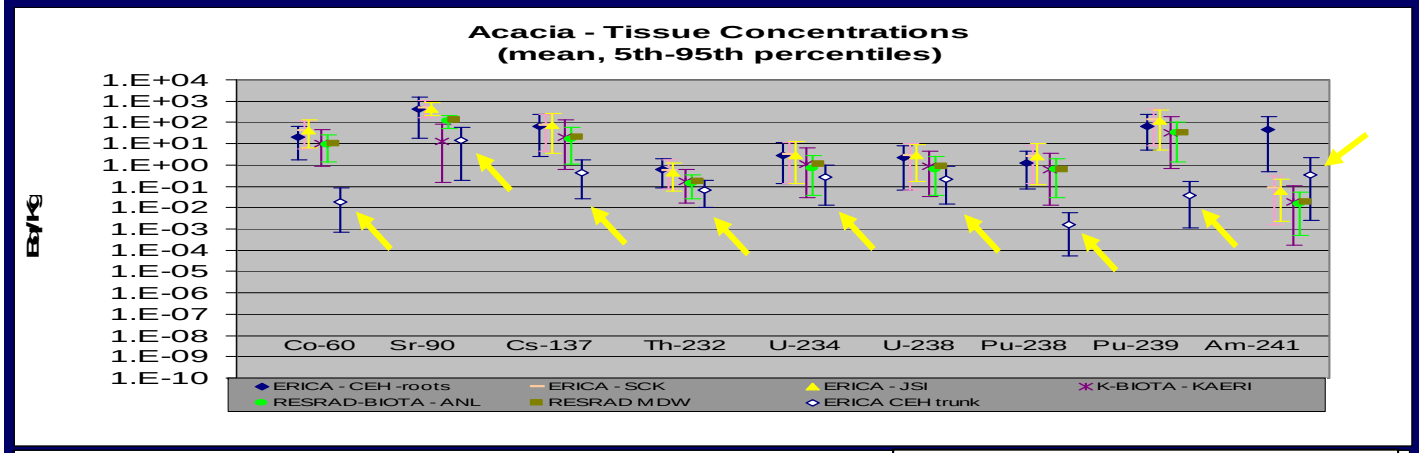
Cs – best studied, small distributions, tightest results

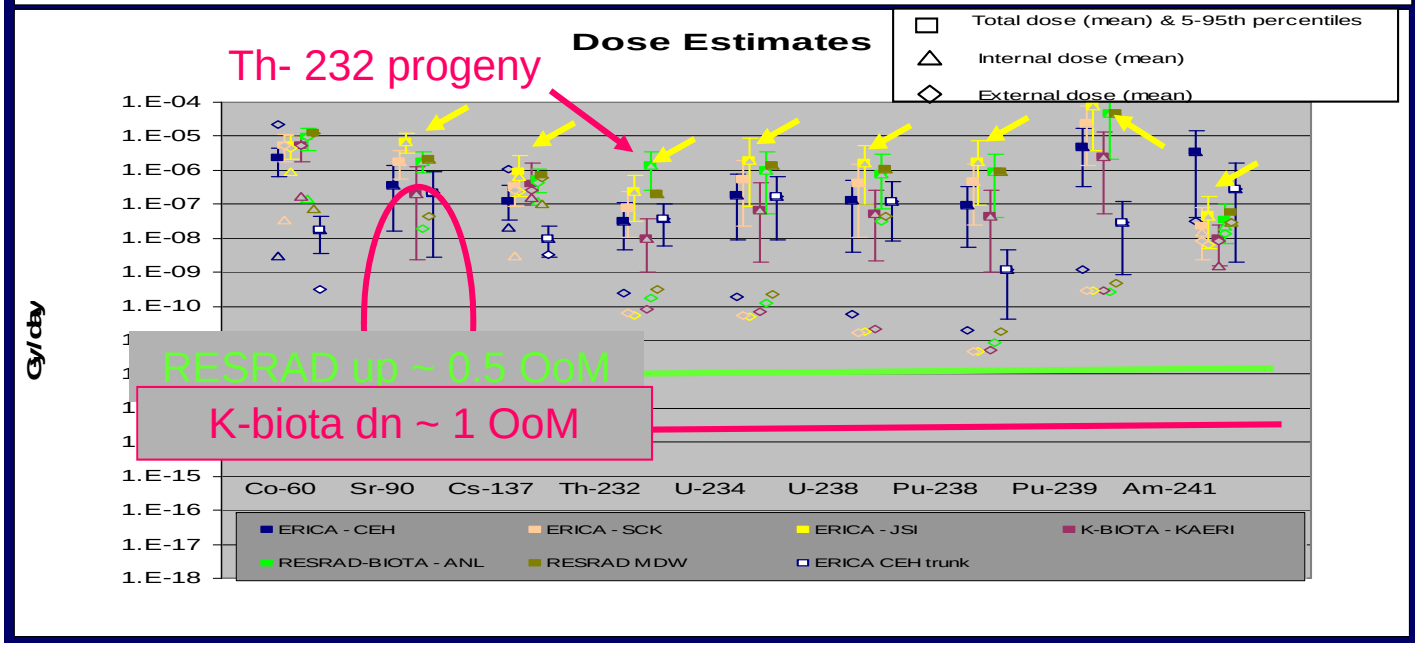
TCs generally carry through to Dose – but not exactly

RESRAD B up ~0.5 OM for Th, U & Pu = RBE?

K-biota lower ~1 OM for Th & above = DCCs +/or progeny?







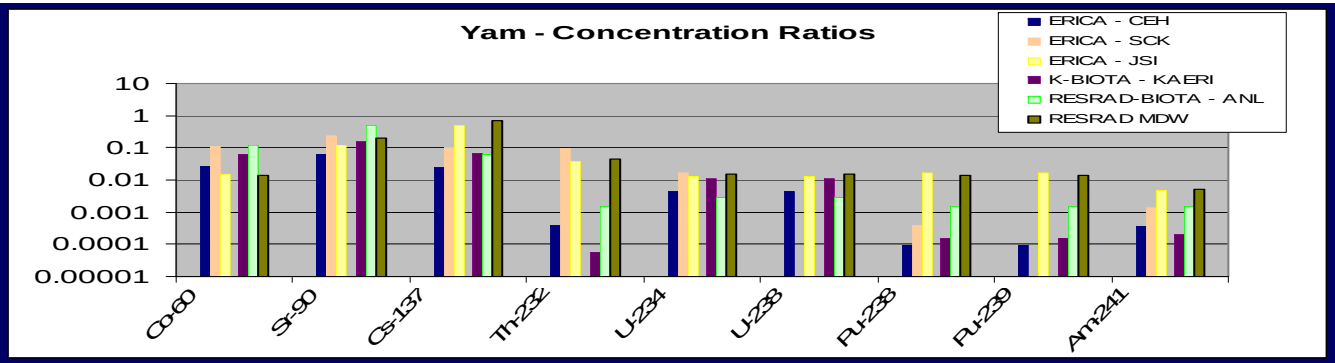
Example of CR not carried through to TCs

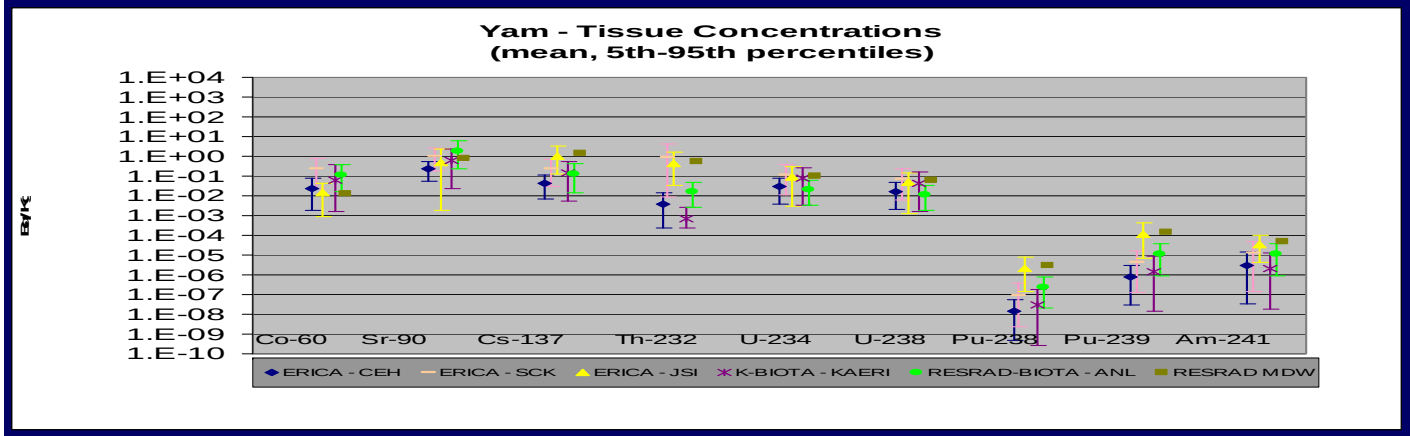
CEH Acacia trunk TC is lower (Co & Pu 3 OM, Cs & Am 2 OM, Sr, U & Th ~1 OM.
TCs ~ carried through to Doses but similar between-model differences
Plus some new effects

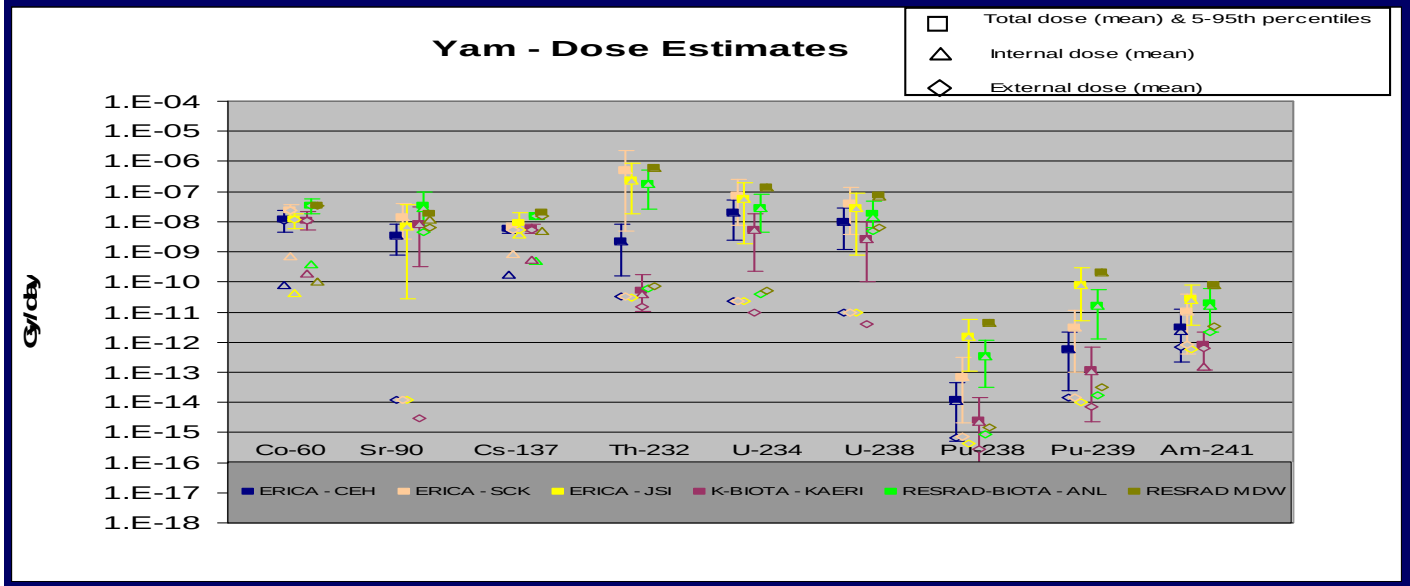
JSI only in Z1, occupancy factor (not Co)

Sr90 Ext D higher in RESRAD = DCC?

Separation of CEH & SCK – biodist?



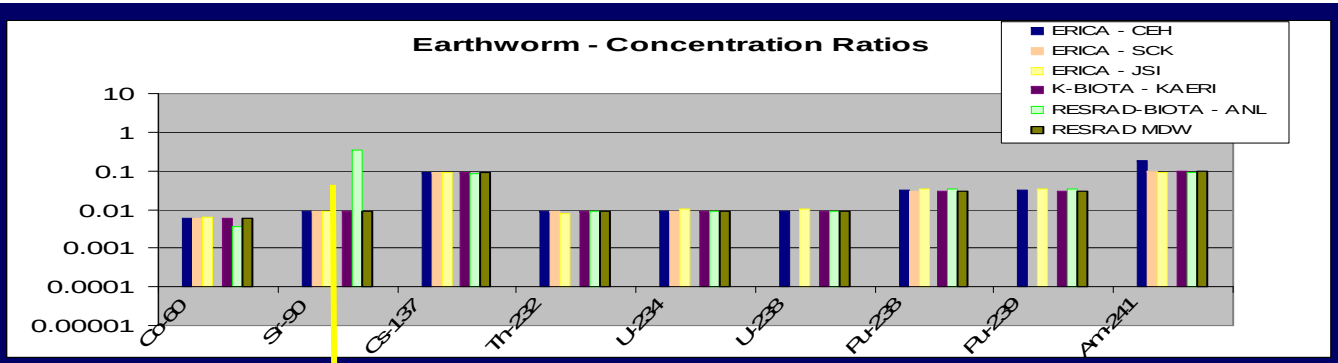


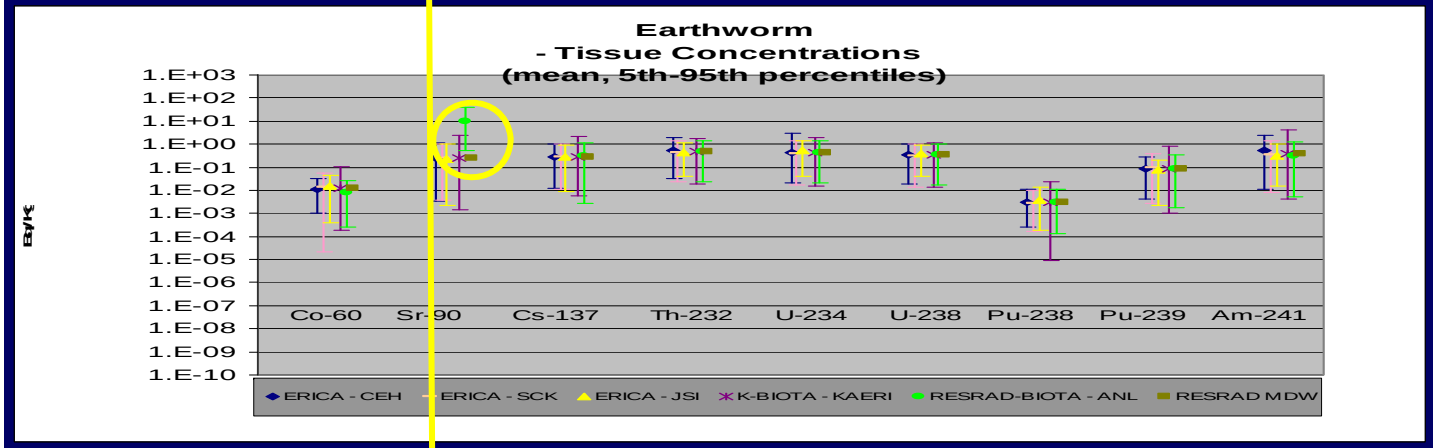


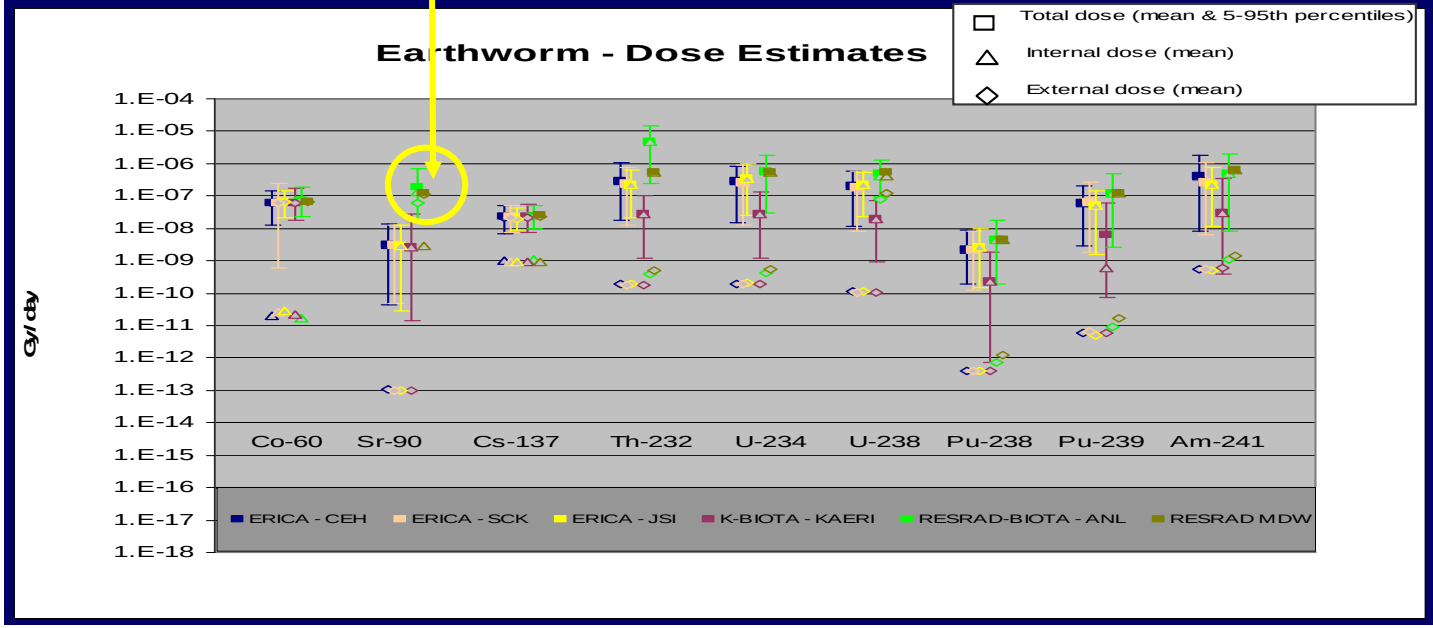
More variable CRs than for trees & grasses. Hardly any replication for any isotope

CRs generally carry through to TCs

Same general observations and conditions on carry through to Dose







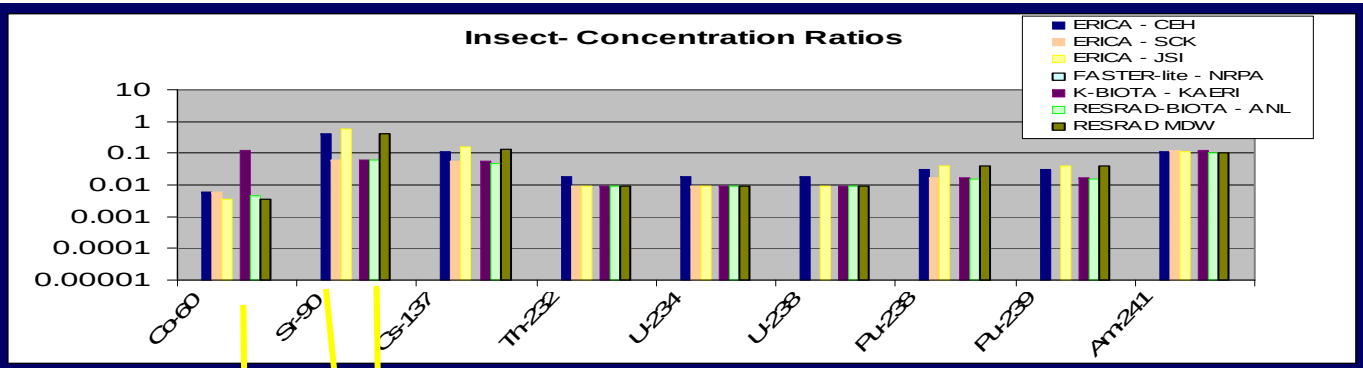
Most consistency w.r.t. CRs

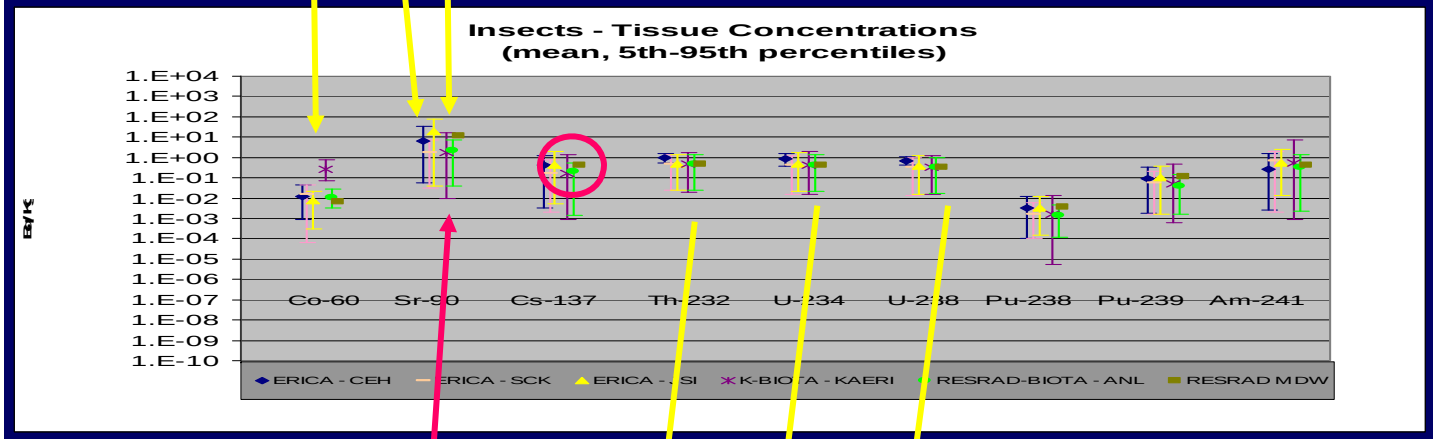
Consistency carries through to TCs

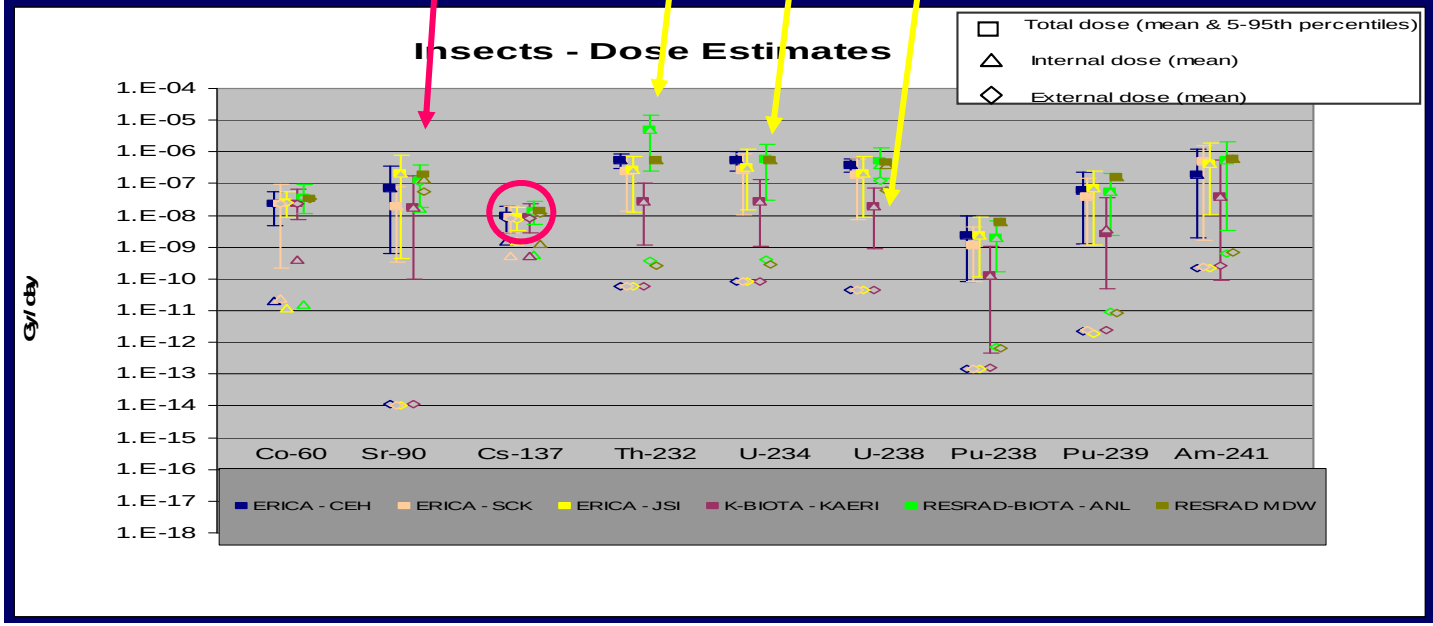
Same general variations converting to Dose as before.

But:

Note RESRAD biota models for Sr-90 (in addition to Th-232)



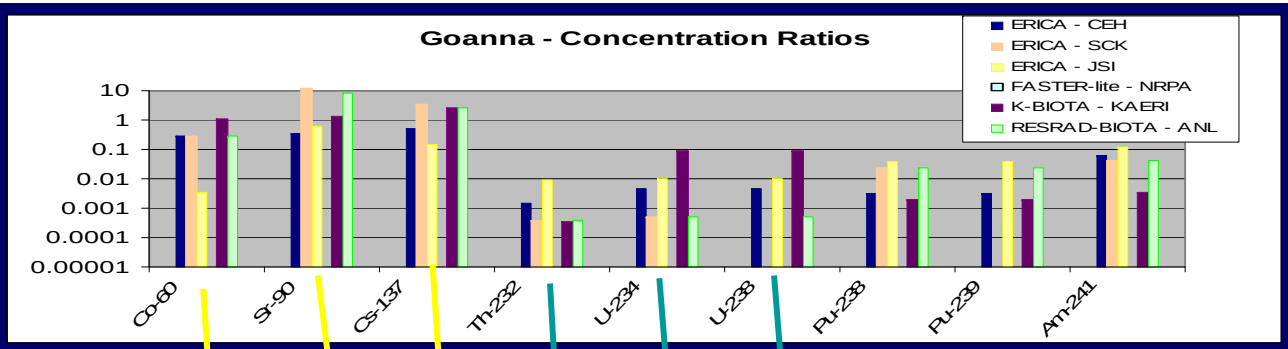


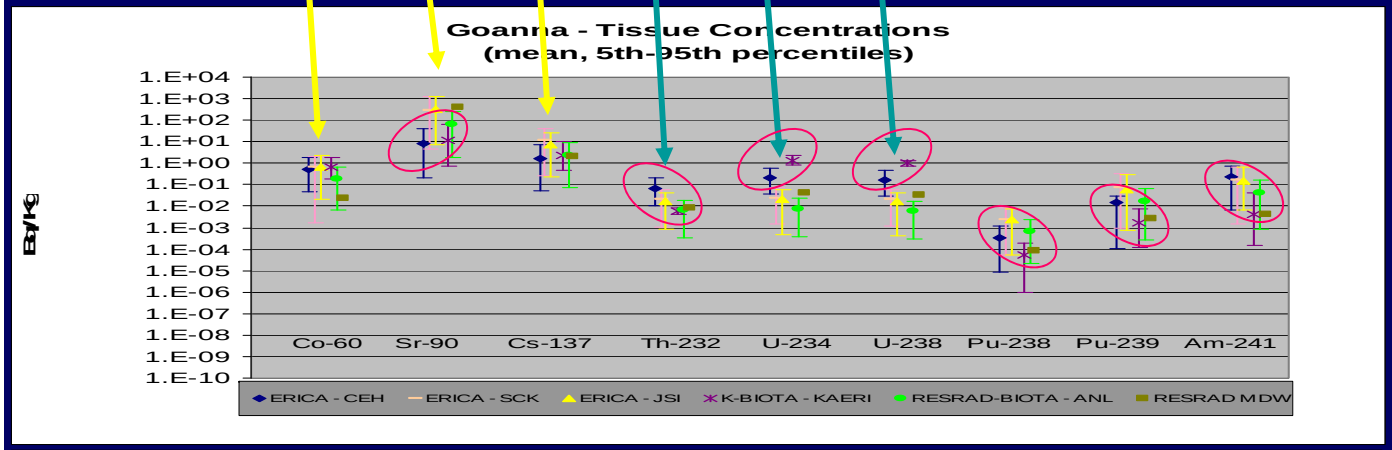


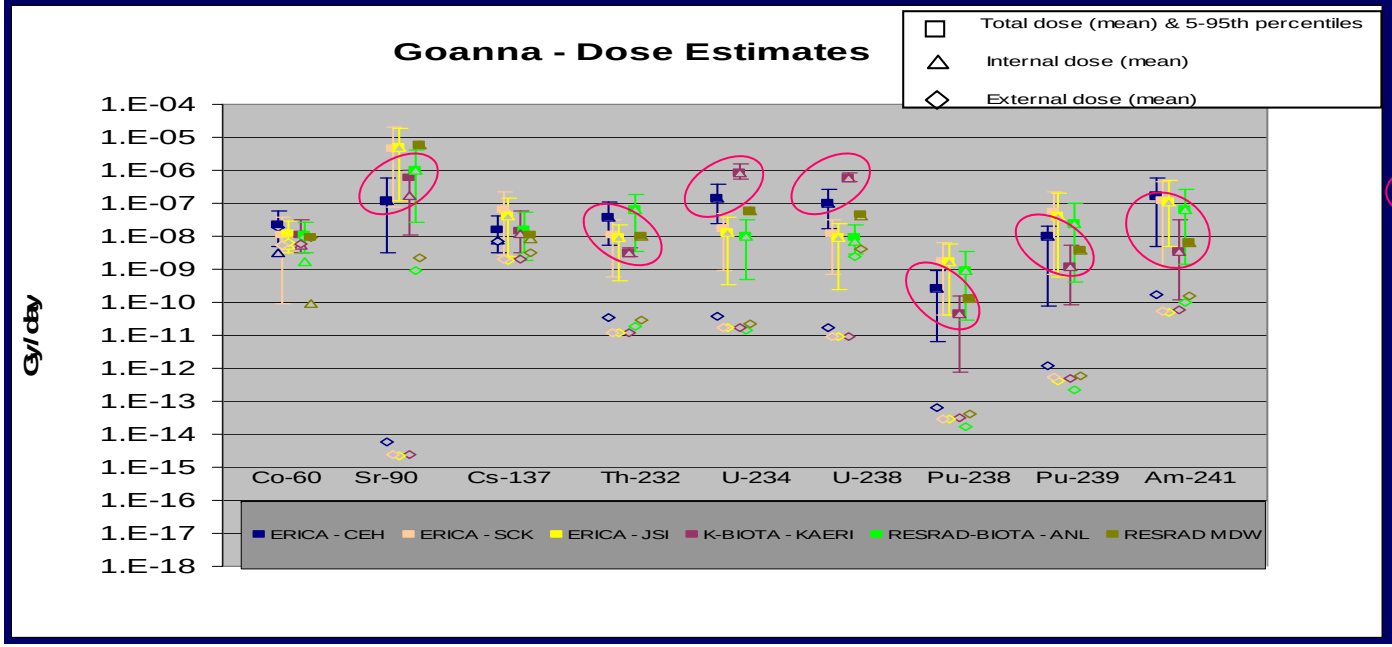
CRs generally carry through to TCs

Similar observations as before for carry through to Doses

But note relative increase in ANL Cs-137 dose ~0.5 OoM – flying insect chosen so dose should be lower due to distance from source







CRs don't carry through to TCs as well

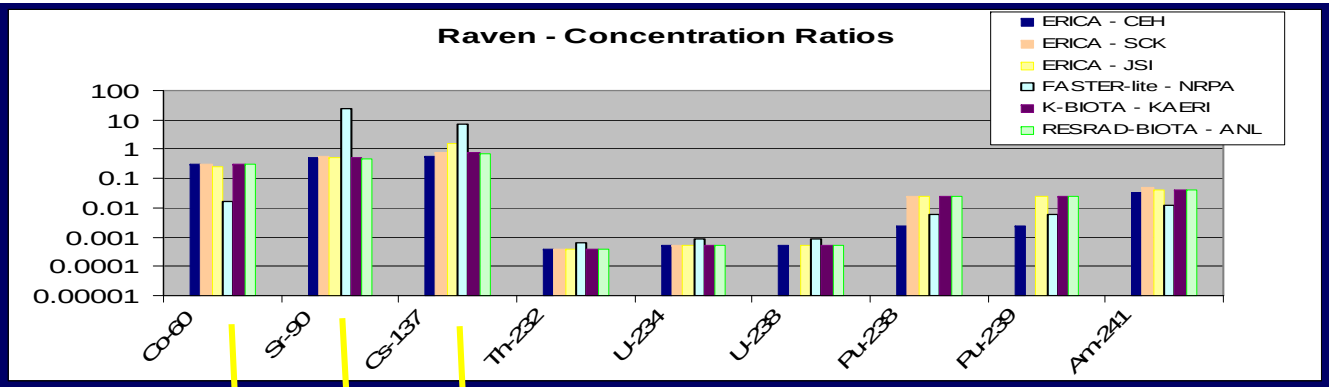
MW using allometics (no CRs)

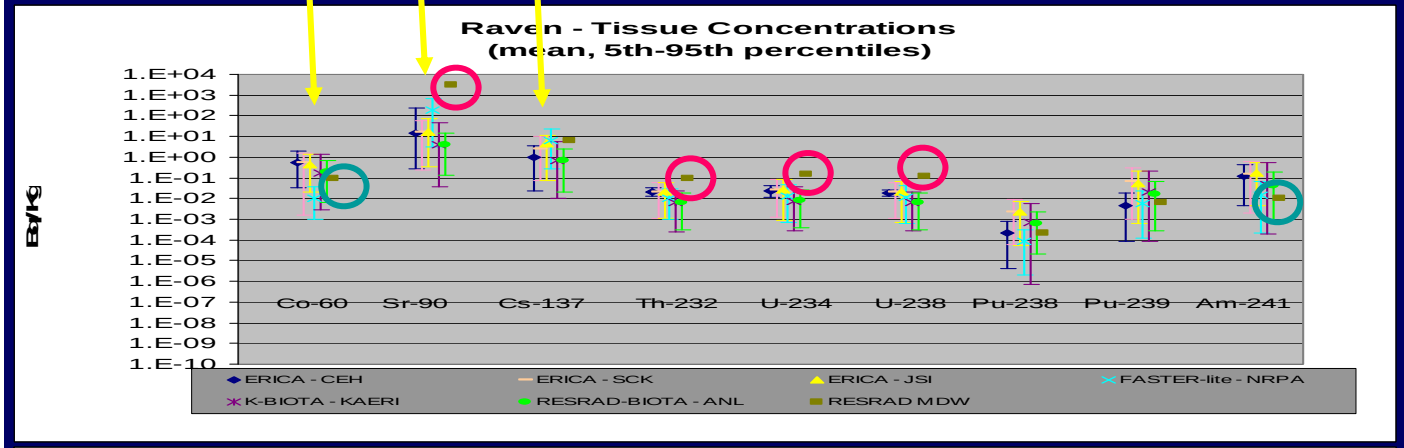
JSI relatively high TC based on CR up to Cs. Occupancy factor?

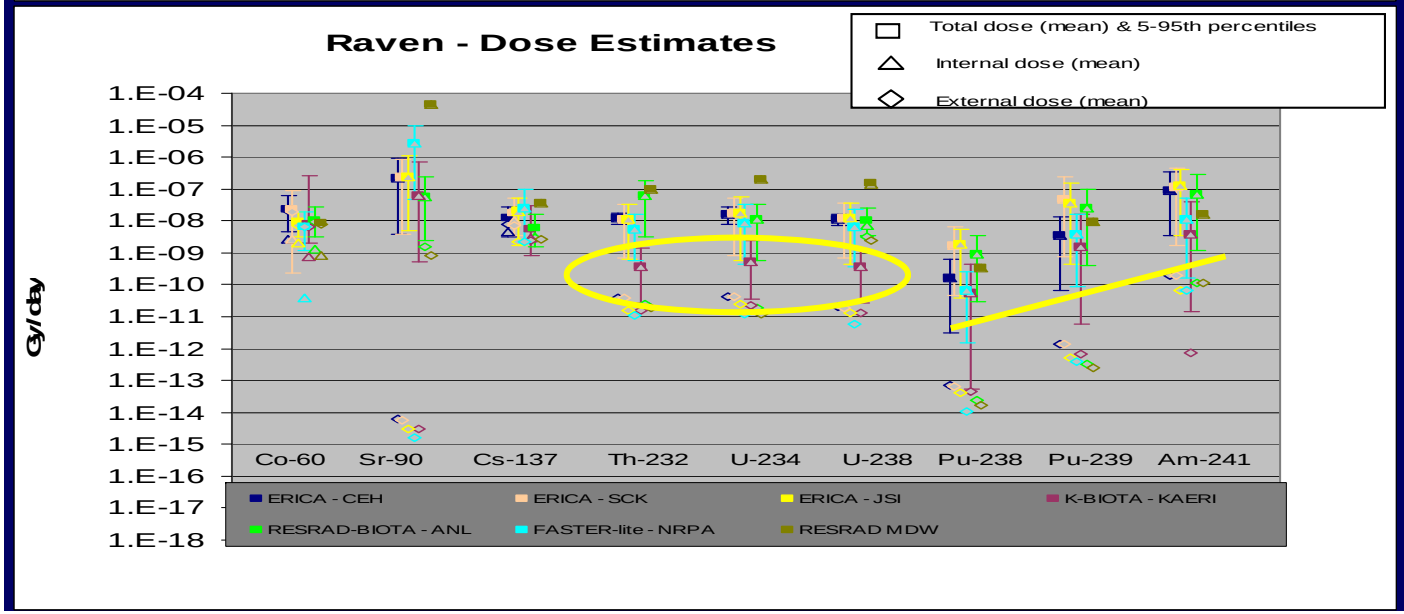
K-biota using CRs in food pathway approach (100% grass/crops)

TCs carry through fairly well to Dose

K-biota relatively consistent with ERICA



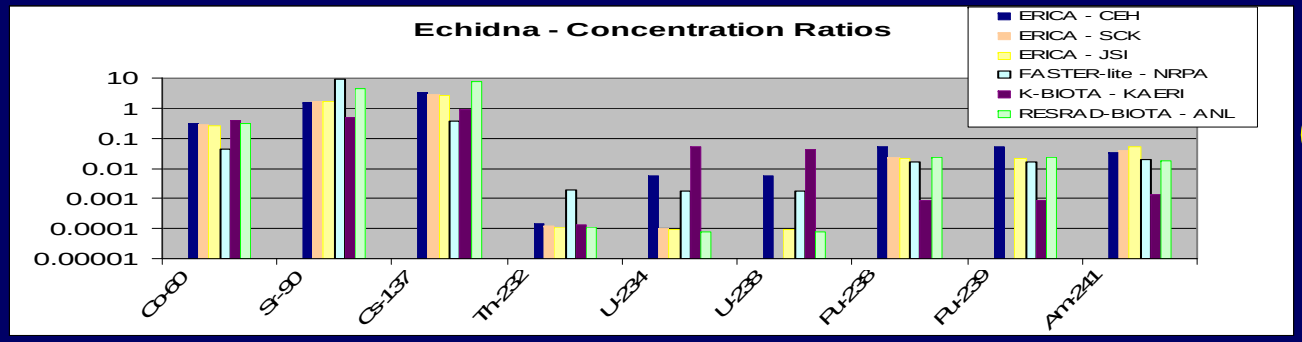


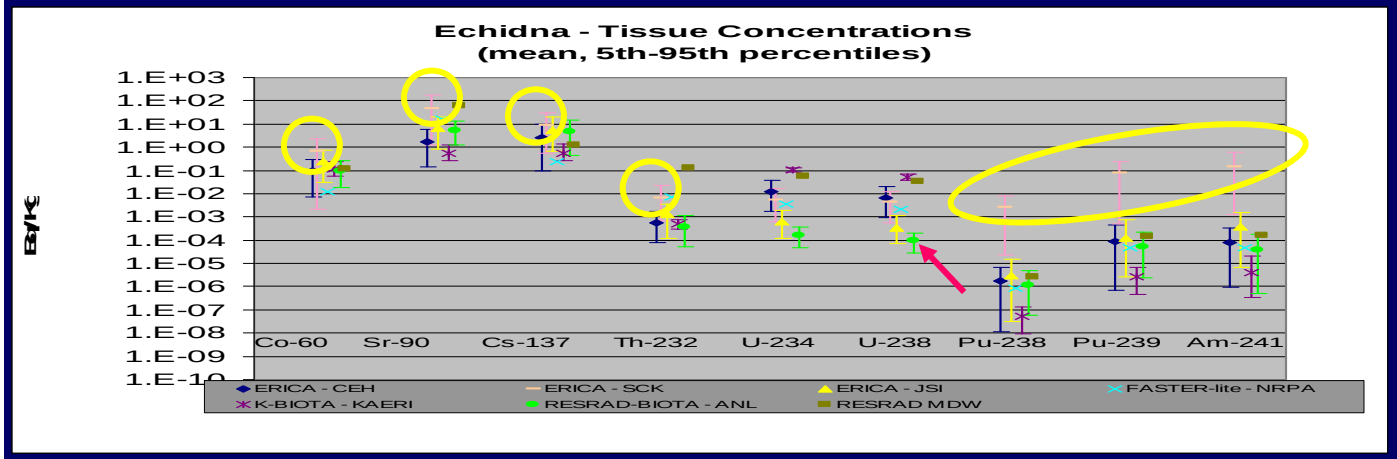


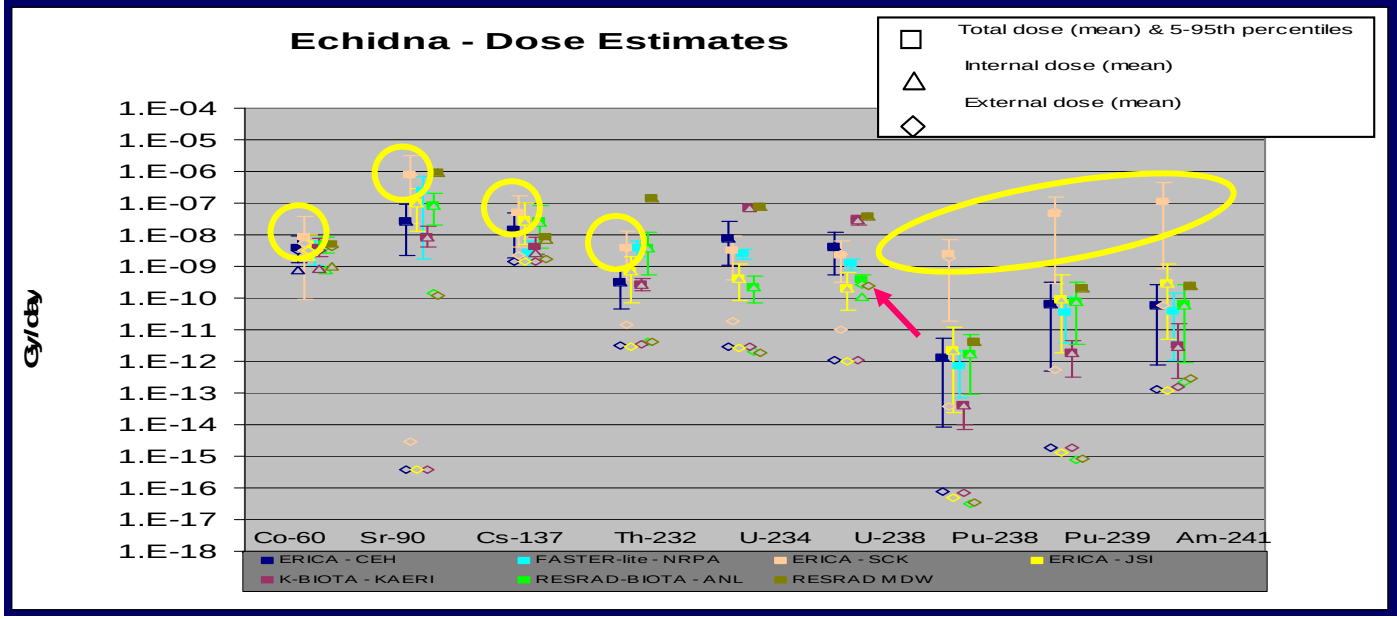
CRs generally carry through to TCs

Allometry gives higher TCs (& dose) for Sr, Th & U and lower for Co & Am

K-biota gives lower dose, particularly for U & Th



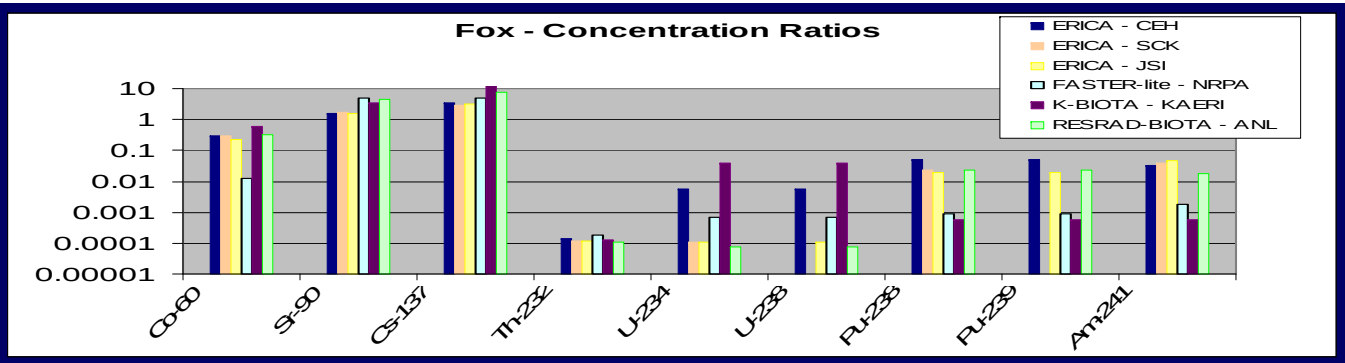




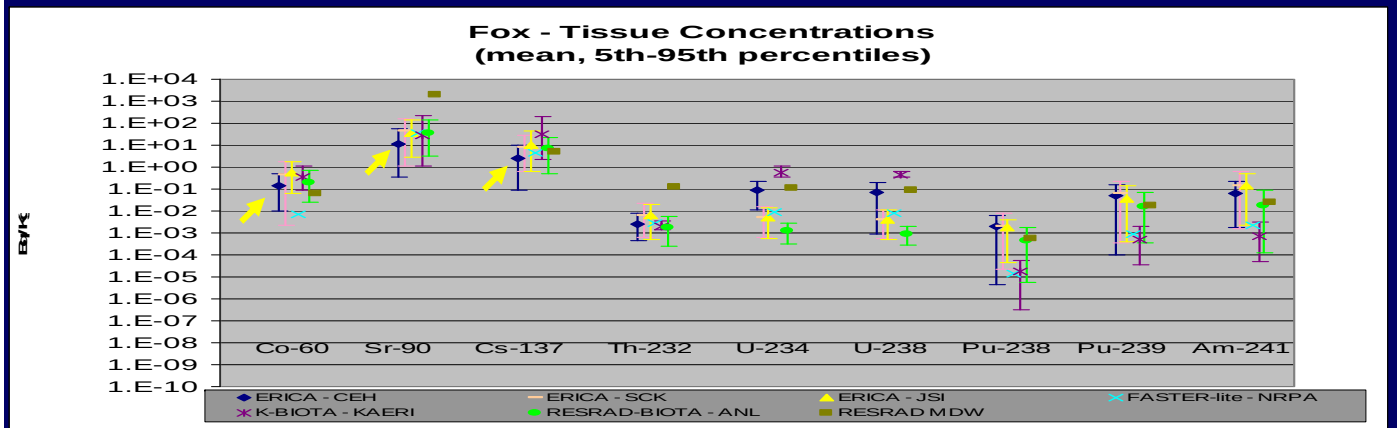
CRs did not carry through to TCs and Dose – particularly for Pu & Am

? Effect of inhalation on TC or dose in K-biota or FASTer(lite)

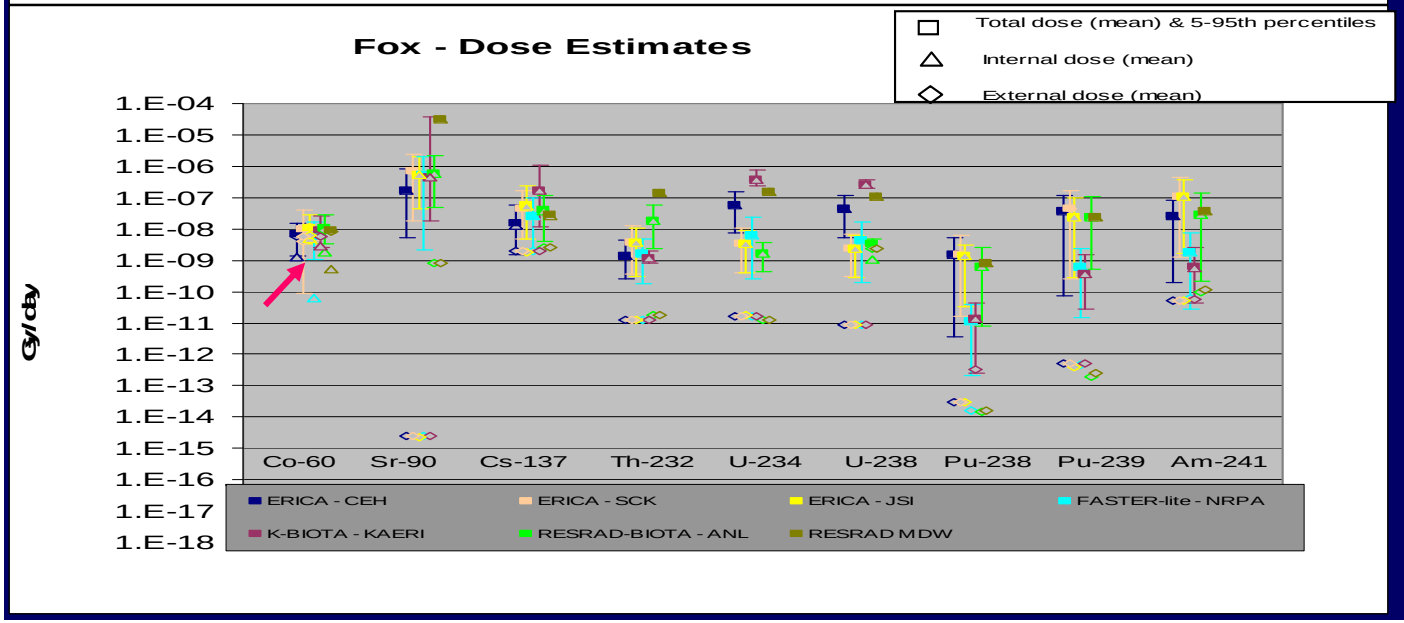
RESRAD up by ~0.5 OoM for U-238 (but not 234?)

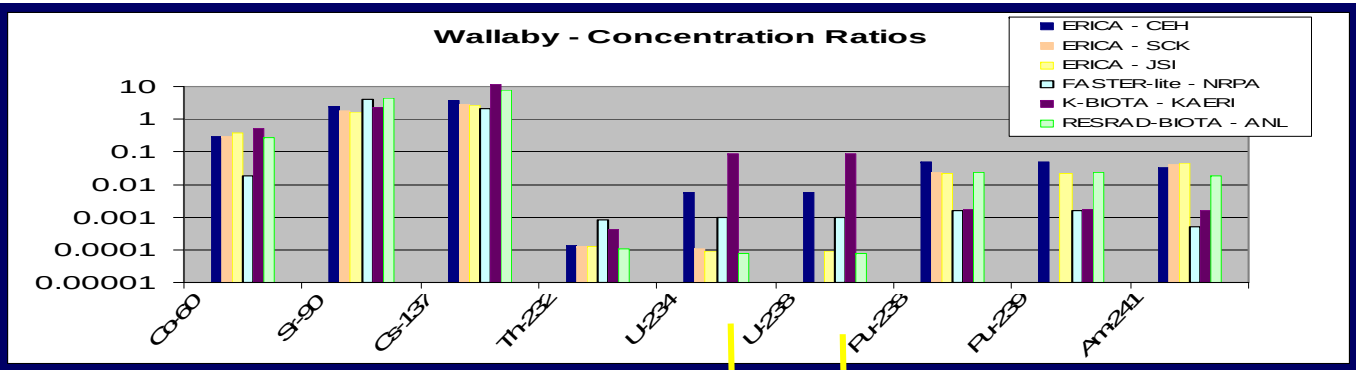


CEH lower than other ERICAs for gamma TCs despite similar CRs

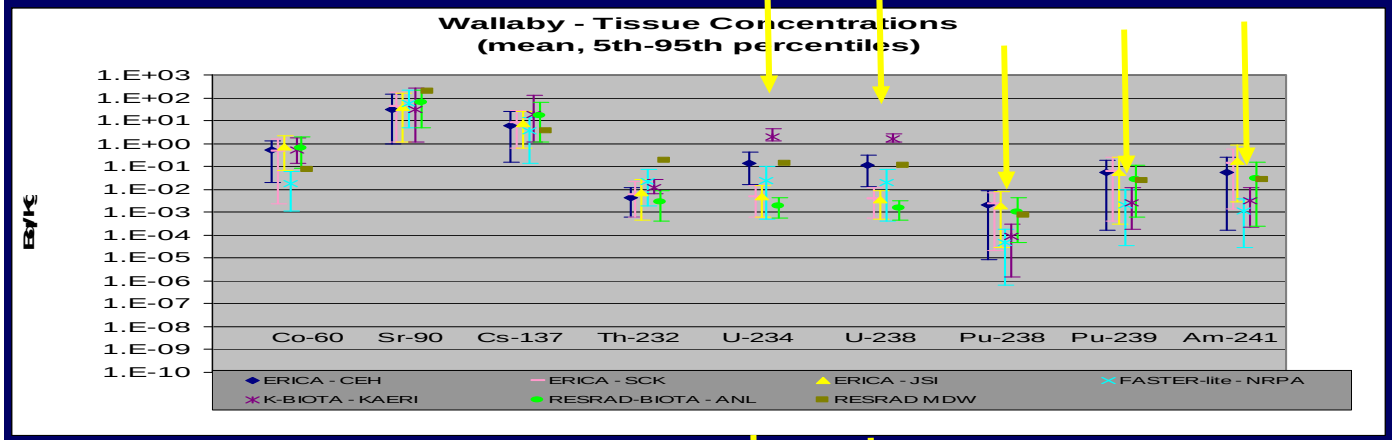


FASTer(lite) and K-biota track CRs right through except to Co-60 dose

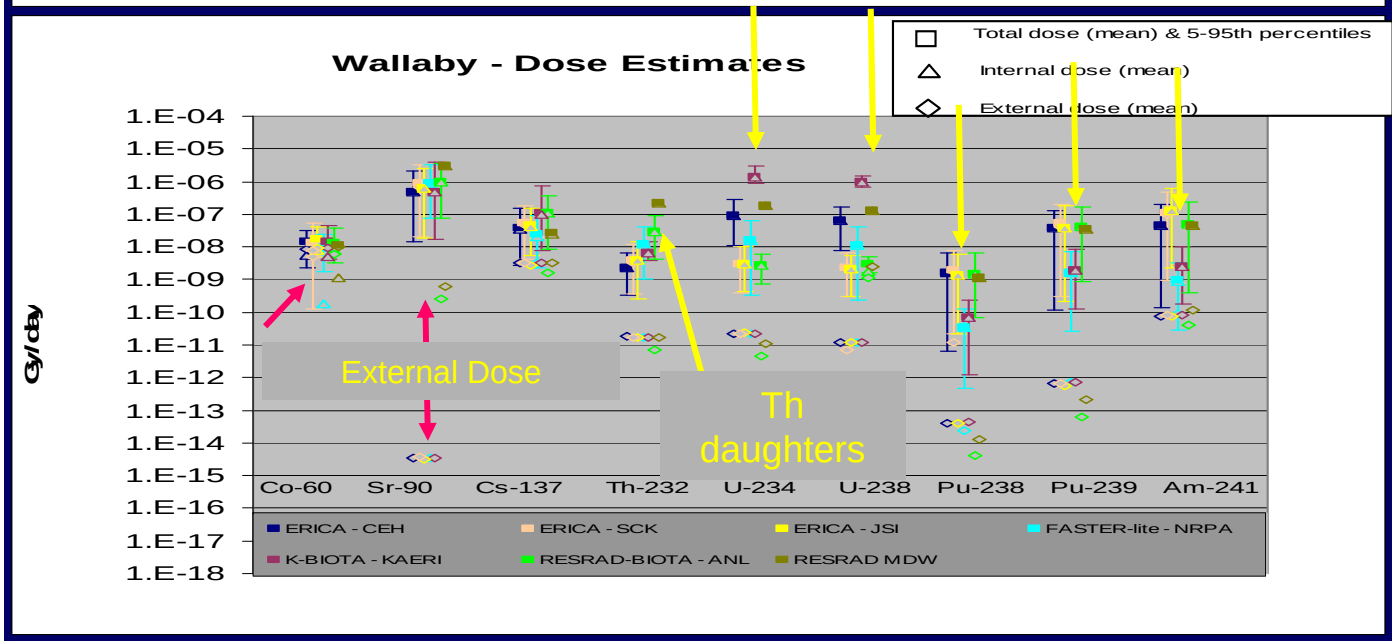




CRs generally track through to Dose.



Effect of FASTer(lite) on Co dose is consistent



Now we will…

- Approximately rank factors introducing variability in outputs
- Evaluate the degree of variability each factor introduces

Intercomparison of approaches – some key differences

- Concentration Ratio (direct) differences
  - Grass - For most rads, Wildlife Trans Database (WTDB) (CEH) was up to 1.5 OoM higher
  - Acacia - For Am, the WTDB Grass/herb CR for Pu was used for Am (CEH), ~3 OoM higher
  - Yam - For Th, Pu and Am, the Grass/herb CR was used in ERICA (JSI) and RESRAD-B (MDW), ~2 or more OoM higher
  - Earthworm - For Sr-90, RESRAD default (ANL) ~1.5 OoM higher
  - Insect - For Co, CR for ERICA flying insect used in K-Biota (KAERI) +1 OoM higher; 3 participants used 1 OoM higher/lower CR for Sr.
  - Goanna - For Co, Cs (low), and alpha (higher) ERICA CR (JSI) varied + 1 OoM
  - Fox - For U, WTDB (CEH) CR for mammal was ~2 OoM higher.
- At least 7 clear examples where differences in CRs resulted in variation in total dose of ~1-3 OoM

Intercomparison of approaches – some key differences

- Kinetic (food chain)/allometric approach differences in transfer from soil to tissue
  - Goanna - for U, Pu, Am, K-allometric CR (KAERI) was +/- ~1-2 OoM; RESRAD participants vary by ~ 1 OoM for Sr
  - Raven - For Co, Sr, FASTer(lite) (NRPA) CR up to ~2 OoM higher
  - Echidna - for U, Pu, Am, K-allometric CR (KAERI) was +/- ~1-2 OoM; For Sr, Th, U, K-allometric transfer (MDW) was up to 2 OoM higher; For Th, U, FASTer(lite) (NRPA) CR +1 OoM higher
  - Fox - for U, Pu, Am, K-allometric CR (KAERI) was +/- ~1-2 OoM; For Sr, Th, U, K - allometric transfer (MDW) was up to 2 OoM higher
  - Wallaby - for U, Pu, Am, K-allometric CR (KAERI) was +/- ~1-2 OoM.
- At least 8 clear examples where differences in Kinetic (food chain)/allometric approach for Soil-TC resulted in variation in total dose of up to 2 OoM from average (~up to 4 OoM O/A)

Intercomparison of approaches – some key differences

- Differences in <u>how organisms occupied/accessed contaminated soil zones</u>
  - For Grass-insect, for gamma emitters, RESRAD (MDW) used a “geometry alignment technique” (e.g., grass had 0.8 in soil and 0.2 on soil) that appeared to raise ext (and tot) dose rates by ~0.5-1 OoM.
  - Goanna - for Co, Sr, Cs, ERICA (SCK and JSI) started with ~2 OoM differences in CR, but have similar TC’s and doses with JSI rising relative to SCK. Dose difference all from zone exposure assumption of 100% Z2 (JSI) vs. 30% Z2 (SCK)?
  - Acacia - ERICA (CEH) considered two exposure configurations - roots (below ground) and trunk (above ground): both were exposed to same soils. Doses to the trunk were ~2-3 OoMs lower than doses to roots despite same CR.
  - Acacia - ERICA (JSI) assumed entire exposure from Z1 (<1% from Z2), ~ 0.5 OoM higher
  - Fox - for Co, Sr, Cs, and Th ERICAs (CEH, SCK, JSI) have similar CRs but vary somewhat in TCs and dose rates, <1 OoM
- Differences in doses due to assumptions of occupancy/access to soil zones were fewer (4) with variation of up to 3 OoM

Intercomparison of approaches – some key differences

- Differences in progeny assumptions
  - All organisms - For Th-232 the RESRAD (ANL) the internal dose (and total dose) increased relative the other RESRAD, and all others due to Th progeny equilibrium assumption, ~1+ OoM
  - Most organisms (but not all) - For alpha emitters, K-biota (KAERI) had slight relative reduction in int/total dose rates (? Progeny ?)
  - Fox - For U-238 (but not 234), the RESRAD (ANL) increased relative to others (? Progeny?), of ~ 0.5 OoM
- One clear example of progeny assumption leading to variation in dose of ~1+ OoM. Need to follow-up on others.

Intercomparison of approaches – some key differences

- Differences in RBE, DCC assumptions

  - Earthworm and other organisms - for alpha emitters, the RBEs in RESRAD (ANL and MDW) were 20 compared to 10 used by other participants. RESRAD internal dose (and total dose) outcomes appear slightly higher as a result.

  - Grass, yam, earthworm, raven and insects - the internal doses (and total doses) of K-Biota (KAERI) decrease relative to other approaches. This implies a difference in use of RBE or DCC (but why not for goanna, fox, echidna and wallaby?)

  - All organisms - the Sr-90 external dose of RESRAD (ANL and MDW) was many OoMs higher than other approaches. This slightly increased total dose in some cases (e.g., grass, yam), but <1 OoM. (?DCC?)

  - Raven, echidna, fox, wallaby - For Co, FASTer(lite) (NRPA) dose rises relative to TC. (?DCC?), ~ 1+ OoM

- Differences in RBE, DCC assumptions/calculations appear to lead to ~ 0-2 OoM differences in total doses.

Intercomparison of approaches – some key differences

- Differences of indeterminate cause
  - Acacia - dose separation of ERICA (SCK) and ERICA (JSI) for most rads
  - Earthworm, others - Sr dose difference RESRAD (ANL) and RESRAD (MDW)
  - Insects - RESRAD participants vary in Cs Dose by ~0.5 OoM
  - Echidna - ~3 OoM increase from CRs to Tissue Concentrations for ERICA (SCK) for discussion/follow up
  - Raven, echidna, fox, wallaby - ~1+ OoM increase from TCs to external (and total dose) for FASTer (lite) (NRPA).

Intercomparison of approaches –

- Some approach differences that did not lead to apparent (> than half OoM) dose rate differences
  - Echidna - NRPA and KAERI included dust inhalation. Lung to whole-body issue?
  - Differences in probabilistic and numeric approaches. (Cs distributions of dose tend to be tighter ? Better knowledge base).

Jordi next