IFIN-HH

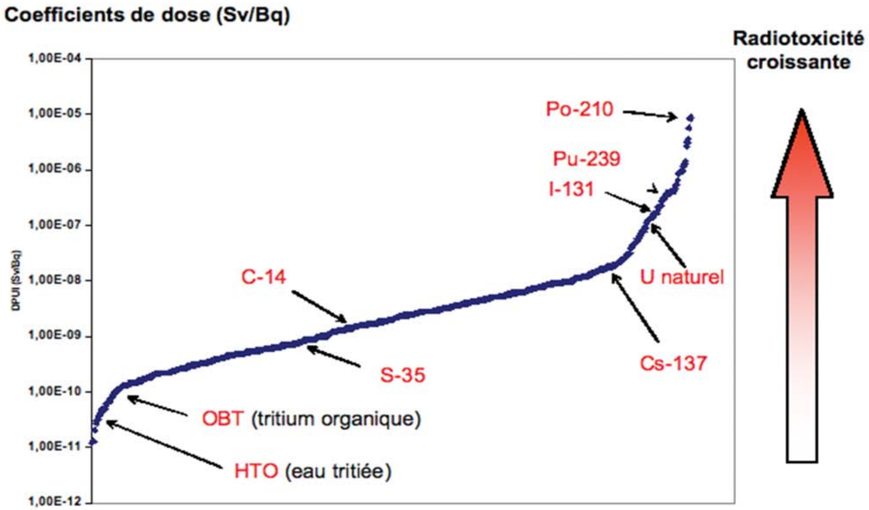
IAEA.org
International Atomic Energy Agency

3rd EMRAS II, Technical Meeting
IAEA Headquarters, Vienna
24–28 January 2011

Working Group 7 “Tritium”

Progress Report

TRITIUM - LOW risk, but how low?



Dose coefficients and
radio toxicity → tritium is good

The AIKEN list (1990) →
Tritium is not well handled

Process	Importance	Status of modelling	Experimental data need
Atmospheric dispersion	H	H	
Atmospheric conversion HT to HTO	L	-	
Wet deposition	M / H	L*	
Condensation / dew	L / M	L	
Dry deposition HTO			
Plants	H	M / H	x
Soil	H	M*	x
Free water surface	L	-	
Dry deposition HT			
Plants	L	-	
Soil	H	M	
Free water surface	L	-	
Re-emission			
Soil surface	M / H	M / H	x
Root / plant uptake	H	M / H	
Synthesis of T into organics			
Plant	H	L / M*	x
Soil	L	-	
Transport through food chain	H	M*	x
Absorption of tritium from			
air in humans HT	L	M	
HTO	H	H	
Translation of exposure to dose	H	M / H*	

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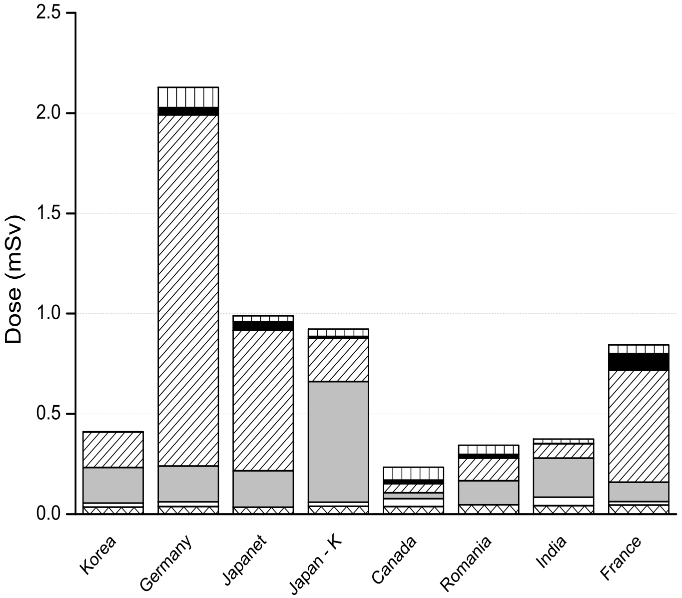
THE CONTEXT ON INCREASED INTEREST FOR TRITIUM

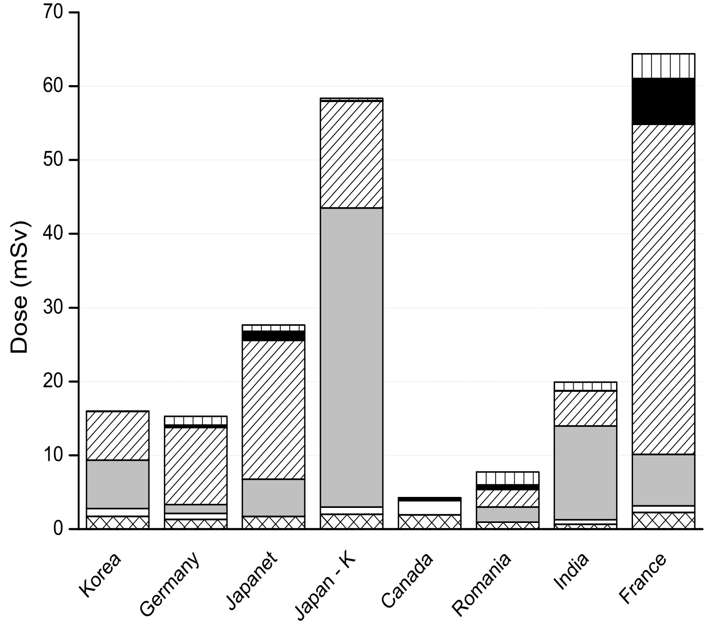
- Greenpeace actions in Canada, UK, Romania, Japan
- Groundwater tritium near nuclear reactors (USA, Canada)
- The need to preserve public trust in nuclear energy
- **EU Scientific Seminar "Emerging Issues on Tritium and Low Energy Beta Emitters"** (Luxemburg, 13 November 2007)
- **Canadian Nuclear Safety Commission: Tritium Studies Project (2007-2010) → *Environmental Fate of Tritium in Soil and Vegetation***
- **Autorite de Surete Nucleaire (France) → Livre Blanc TRITIUM (2008-2010)**
- **International Atomic Energy Agency- EMRAS program , Phase I and II Environmental Modelling for Radiation Safety**
- Working Group 2 - Modelling of Tritium and Carbon-14 transfer to biota and man working group
- Working Group 7 – "Tritium" Accidents (on going)

HYPO scenario EMRAS I

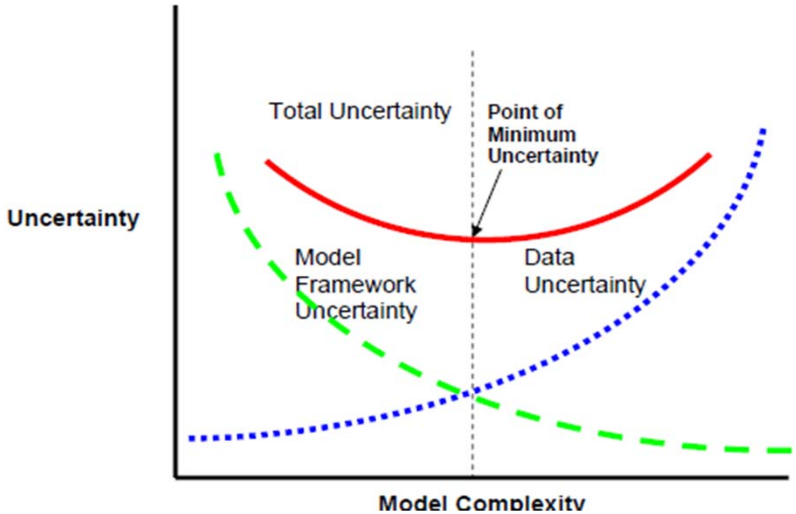
- **Case 1 day** Normalized by 6.10^{9} Bq.s.m^{-3}



- **Case 3 night** Normalized by 3.10^{11} Bq.s.m^{-3}



How to obtain an useful model?

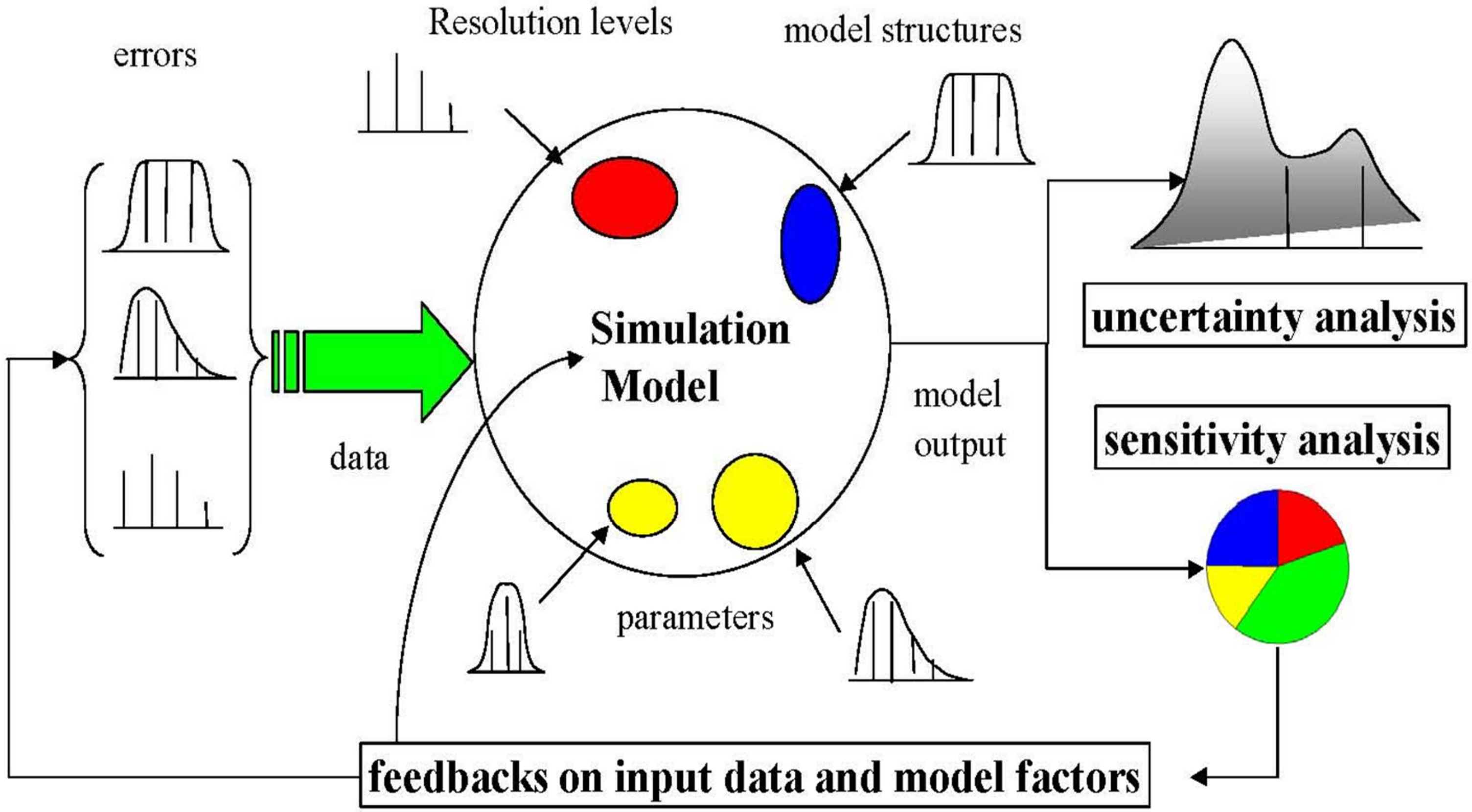


Simple model - Keum et al., Health Physics, January 2006, Volume 90, p.42

Very complex model, M. Ota &H. Nagai, EMRAS WG 7 presentation

SPECIFIC CAUSES OF UNCERTAINTY

- Missing communication;
- Experiments and OBT modelling at AECL - undisclosed;
- Cardiff case - experiments - undisclosed (but reports from Environmental Agency and FSA are available on request);
- Many reports, PhD thesis difficult to access or delayed for accessing;
- Incomplete documentation – ignoring past achievements (BIOMOVS, EMRAS I, selective uptake of DOT);
- No common knowledge data base due to copyright restriction;
- Missing appreciation – S Strack case - lost information for T in wheat;
- Limits in allocation of time and budget
- Missing dedication - only a job
- Missing peer review
- Insufficient parameter uncertainty



errors
Resolution levels
model structures
Simulation
Model
data
model
output
parameters
uncertainty analysis
sensitivity analysis
feedbacks on input data and model factors

Enlarged interest

- INDIA- start large program for experiment and models- need assistance for OBT measurement technique-financing limits
- BRAZIL- prepare for new nuclear plants- tritium in coastal water (tropical)- need cooperation
- UK (Scotland) have problems with tritium at MAGNOX- cooperation, rainy climate
- Kazakhstan, SemiPalatinsk, tritium in the environment- start experiments, will cooperate
- >22 participants, 10 active

Key ideas

- Decrease uncertainty in assessing committed dose for public (deterministic, probabilistic),

We need dose coefficients and time integrated intake (HTO,OBT)

- Needs of indicators (early monitoring) for accident management (countermeasures)
- Needs of sub-model test>>>time dependent prediction of concentration in food and feed
- Processes which should be included in models and their status as defined in the early 90th but no progress in operational models
- Tritium is a very dynamic radionuclide which cannot be modelled with the same approaches as other radionuclides
- In the first days, tritium dynamics depend strongly on the environmental characteristics, therefore a simple compartment model might not be appropriate
- Definition of a worst case different, as physical dependencies should not be ignored – otherwise too conservative

Regulatory requirements for a model

- Relatively simple
- Transparent
- Easy to program
- Results should be conservative (but not too much)
- Deterministic calculations possible (worst case assessments)
- Probabilistic calculations possible (95% percentile as worst case)
- Is this possible for Tritium?
- Problems detected: operational models used for licensing have no provision for robustness and control of uncertainty
- Models for accident management are to complex and user non friendly

Direct interactions with regulatory bodies (France, Canada) and interested utilities

Task groups and few results

Task Group I – Wet deposition

- Sensitivity analysis of rain characteristics on HTO concentration in drops, L Patryl and IFIN.
- Rain scavenging of tritiated water vapour: A numerical Eulerian stationary model, D. Atanassov, D. Galeriu, *J. Environ. Radioact.,*
- Tritium profiles in snowpacks, D. Galeriu, P. Davis, W. Workman, *J. Environ. Radioact.,*

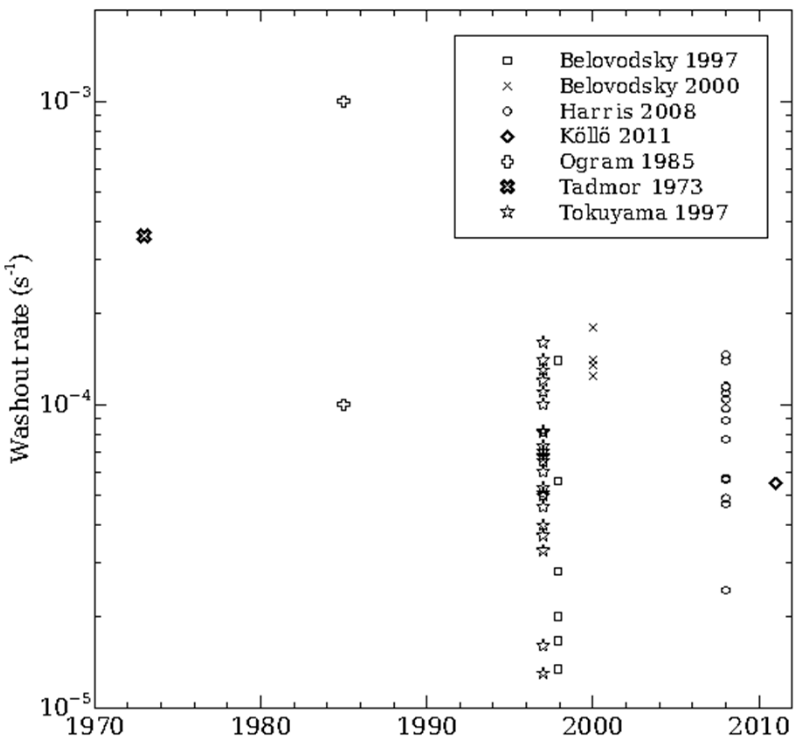
Task Group II Aquatic pathways (EDF,IFIN, Brazil)

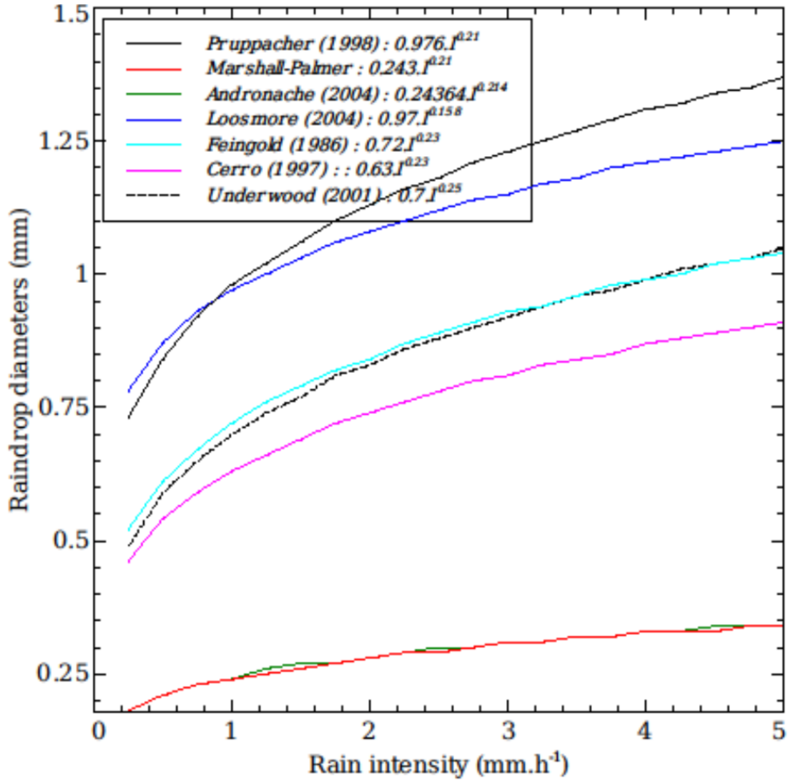
- Simple model (EDF)
- bioenergetics (IFIN)
- New experiments (AECL)
- Coastal waters (Brazil)

Task Group III - Terrestrial pathway (atmospheric source)

- Transfer to farm animal (published, IFIN et co) robust, can be simplified
- New experiments and modeling trials (AECL)
- Interaction matrix (IRSN)
- Complex model (JAEA)
- Overview on uptake by crops and OBT formation in daylight
- Overview on night processes

Overview on tritium washout



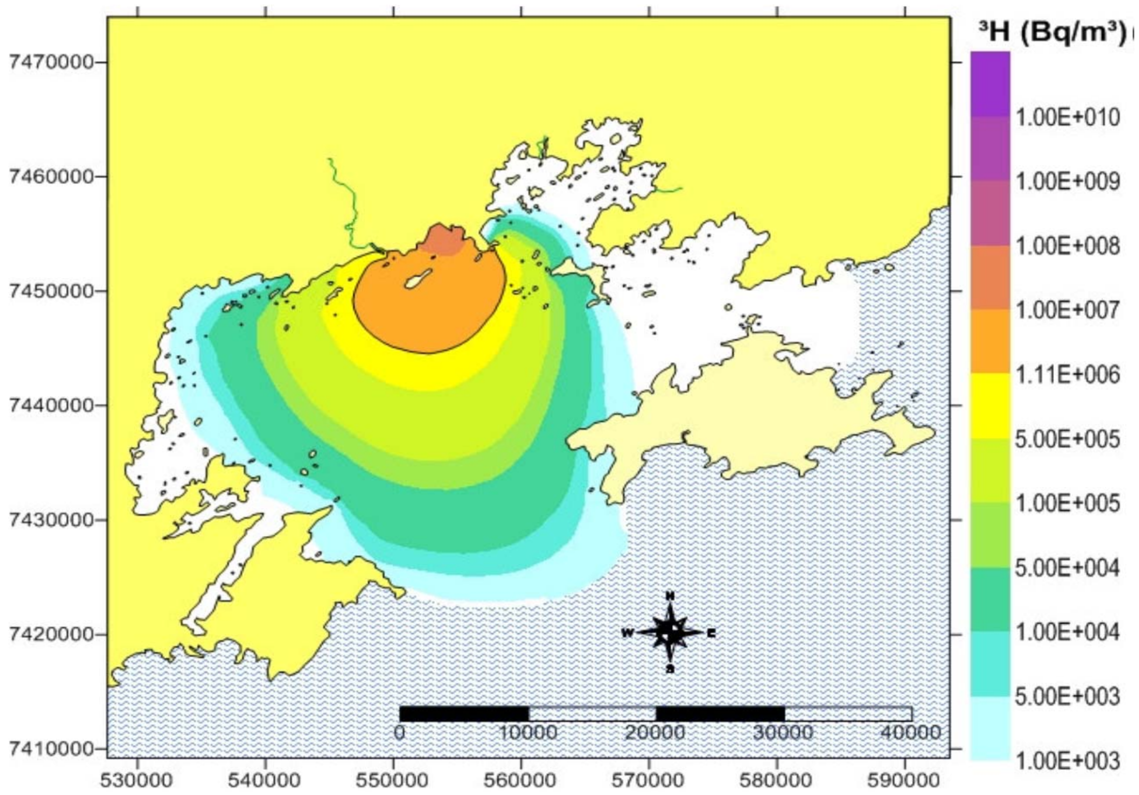


Based on experimental data

various correlations on raindrop diameter and rain intensity

Key parameter raindrop diameter distribution for typical rain
Non Gaussian tritium in air profile

Hydrological model for tritium dispersion after a release of 37 PBq



Dispersion of HTO plume after 3 days following the accident in the scenario 1

F. Lamego, Institute of Nuclear Engineering, Rio de Janeiro, Brazil

DOT- The Cardiff case (submitted IFIN)

For the Cardiff case it should be noted that the tritated waste from GE Healthcare (former Amersham) includes not only the HTO and the by-product, but also the high bio available tritiated organic molecules (*i.e.* hydrocarbons, amino acids, proteins, nucleotides, fatty acids, lipids, and purine / pyrimidines).

For the model application, the input data as: the annual average of total tritium and organic tritium releases from GE Healthcare, tritium concentration in sea water and the monitoring data for mussel and flounder have been taken from literature

Using the available input data, the model successfully predicts the trend for tritium concentration in mussels and flounders

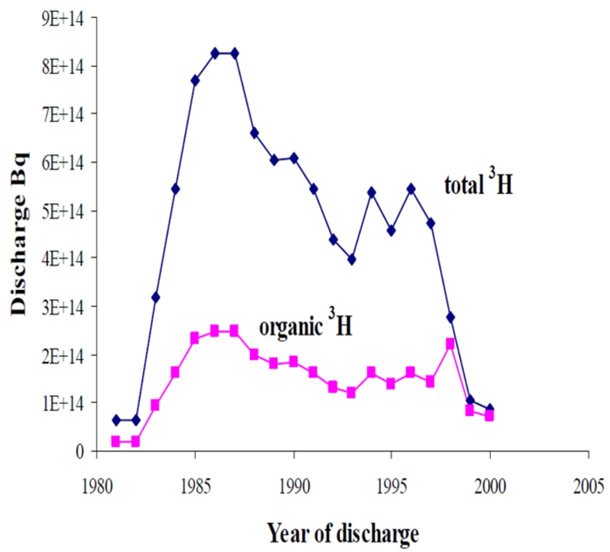
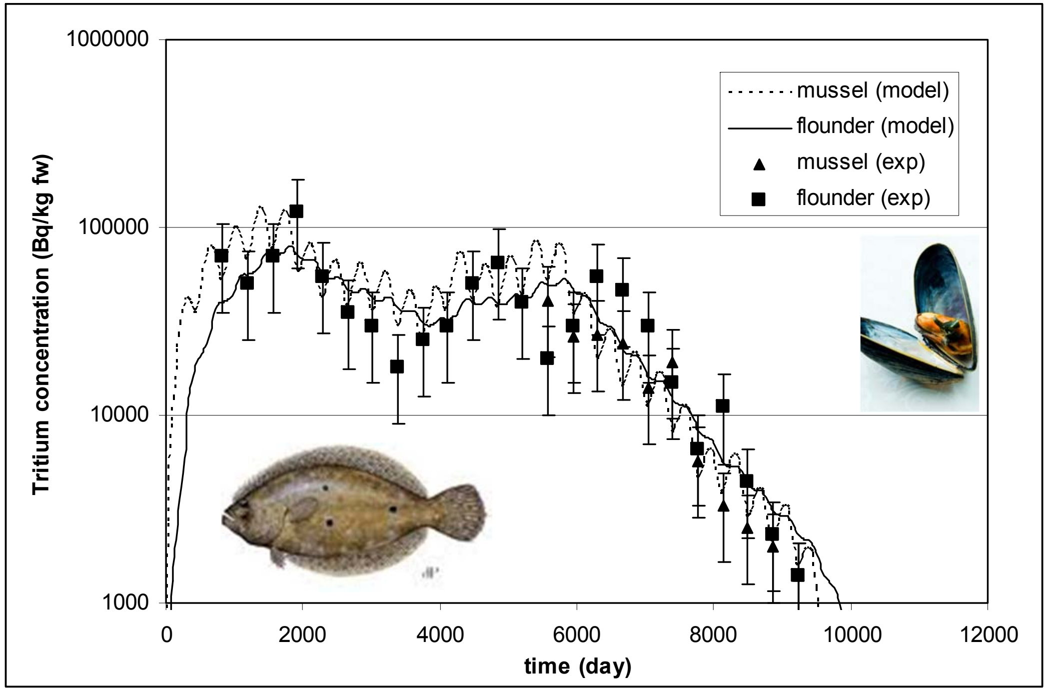


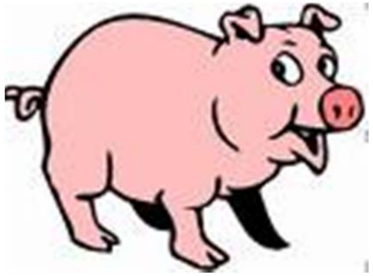
Figure 1: Record of discharges of tritiated waste from Amersham plc into the Severn Estuary



Gas and water source interaction matrix

SOURCE (Gas)			Dry deposition (if HT release)	1)Wet deposition 2) Sprinkler irrigation 3) Interception by soil		Advection/diffusion							1)Wet deposition 2) Sprinkler irrigation 3)Interception by plant		
	SOURCE (Water)			Irrigation (Infiltration) 2)Upwelling 3)Capillary rise									Interception of irrigation water		
		SOIL WATER													
			HT	Soil microbial oxidation											1)Surface run-off 2)Percolation to groundwater
	Percolation			HTO Transport by bulk flow (see hydrological IM)	OBT formation	Diffusive exchange	Evaporation	Evaporation		Root uptake					1)Surface run-off 2)Percolation to groundwater
					OBT										
				1)Diffusive exchange 2)Gas sorption		SOIL ATMOSPHERE	Degassing	1)Diffusion 2)Pressure pumping		Root uptake			Aerenchyma	Aerenchyma	
						1)Diffusion 2)Pressure pumping	CANOPY ATMOSPHERE - slow air flow (below Zd)	Diffusion/advective transport					FoliarUptake	Gross photosynthesis	
							Diffusion/advective transport	CANOPY ATMOSPHERE - fast air flow (above Zd)					FoliarUptake	Gross photosynthesis	Free air
									BELOWGROUND PLANT MATERIAL			Translocation (assuming root uptake)			Cropping loss
										HTO	OBT formation				
			Root exudation	Root exudation	Death & decomposition (UL & LL)& ploughing	Root respiration					OBT Biological growth of roots				
									Translocation			ABOVEGROUND PLANT MATERIAL			1)Cropping loss 2) Weathering
							Transpiration	Transpiration					HTO		
							Aboveground plant respiration	Aboveground plant respiration						OBT Biological growth of aboveground parts	
															SINK

Farm animal model -Tests with growing pigs and veal



Few experiments

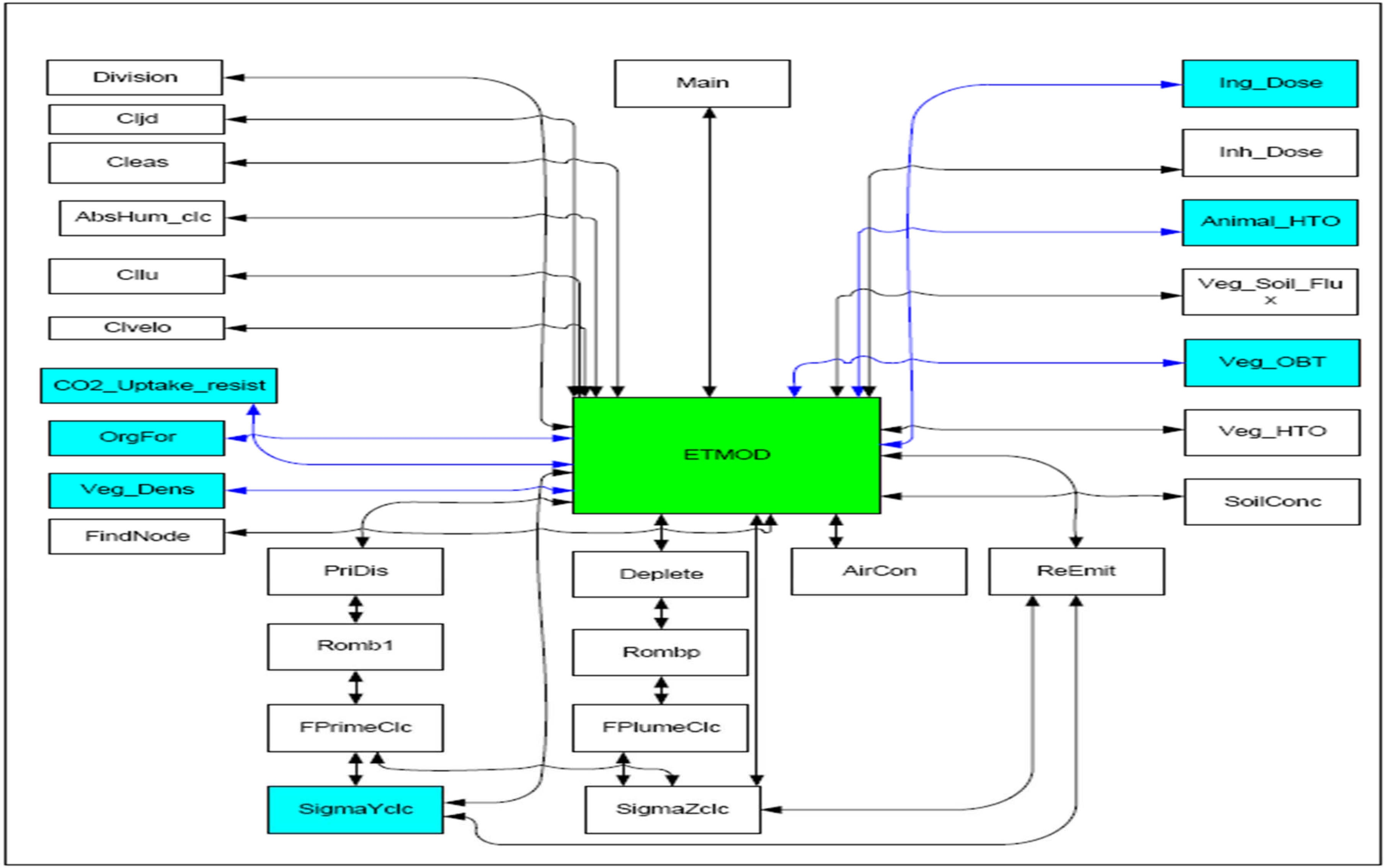
1. Pigs of 8 weeks old fed for 28 days with HTO:
   Muscle P/O ~ 1
   Viscera P/O ~1

2. Pigs of 8 weeks old fed for 28 days with milk powder contaminated with OBT:
   Muscle P/O ~ 3
   Viscera P/O ~ 2

3. Pigs of 8 weeks old fed for 21 days with boiled potatoes contaminated with OBT:
   Muscle P/O ~ 0.2
   Viscera P/O ~ 0.3
   } Not quite sure about these values → Potential explanation: old and insufficiently reported experimental data

4. Two calves of 18 and 40 days old, respectively fed for 28 days with milk powder contaminated with OBT:
   Muscle P/O ~ 1
   Viscera P/O ~ 2.5

ETMOD-2 overview



EXCHANGE VELOCITY APPROACH AND OBT FORMATION IN PLANTS DURING THE DAYTIME

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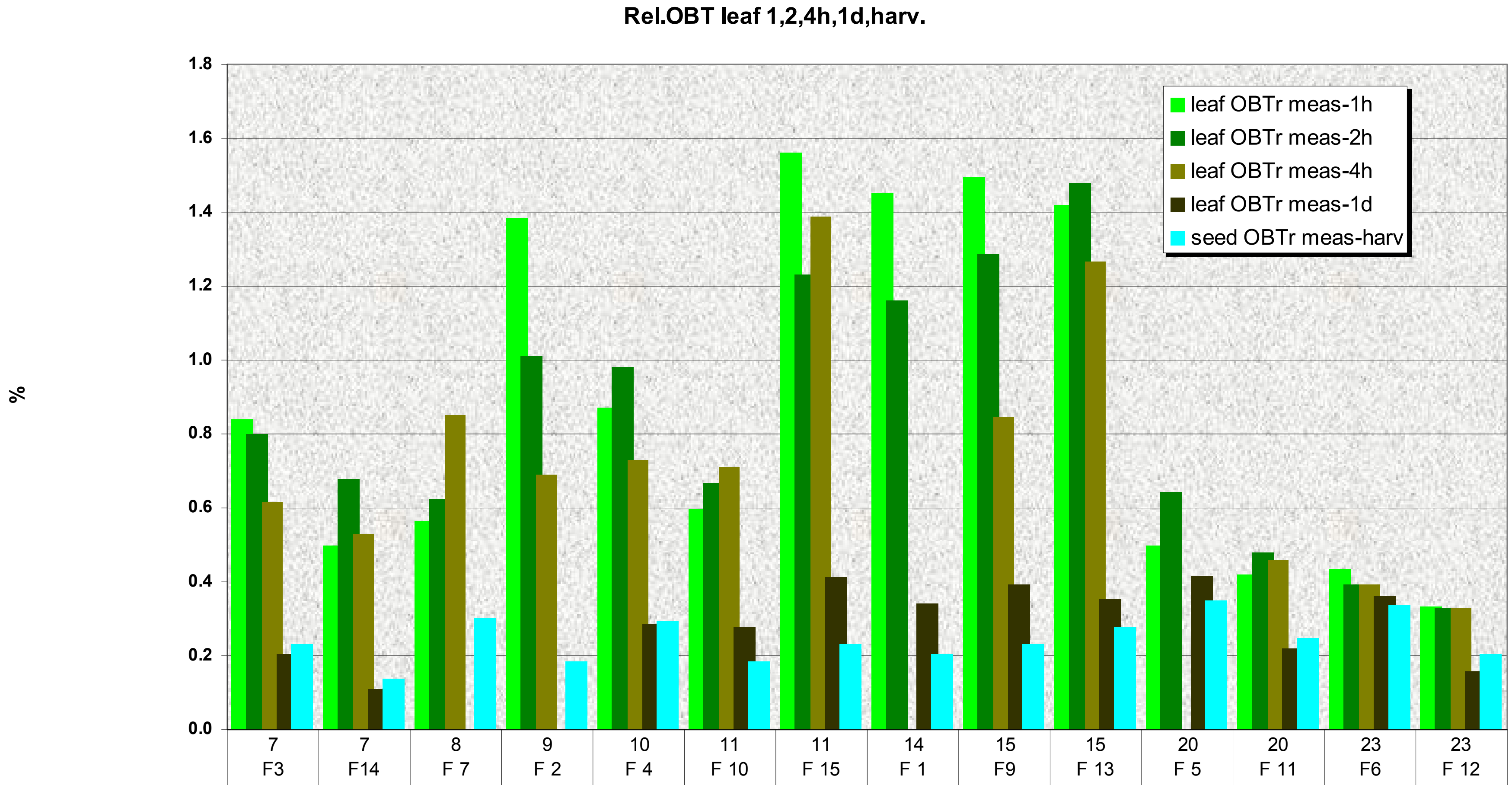
Importance of Night OBT

- Night air concentration > day (average factor 10, but can be > 40)
- Night HTO uptake by crops < day (average factor 4; range 2-10)
- For same HTO in leaves, night OBT production is 1/10-2 from day one (exp. data)

Germany (S. Diabate, **S. Strack**, W. Raskob)
Canada (S. B. Kim, P. Davis, N.W. Scheier)
Japan (**M. Atarashi-Andoh**, N. Momoshima, I. Ichimasa)
Korea ? to find night experiments
Romania (D Galeriu, A Melintescu, N Paunescu)
France (Boyer, Guetat)

Dynamics of OBT in leaves and the harvest value for grain, in relative units (HTO concentration in leaves at end exposure)



	7 F3	7 F14	8 F 7	9 F 2	10 F 4	11 F 10	11 F 15	14 F 1	15 F9	15 F 13	20 F 5	20 F 11	23 F6	23 F 12
leaf OBTr meas-1h	0.8398742	0.4974324	0.5642564	1.3862011	0.8713017	0.597344	1.56	1.4502809	1.4935269	1.4188636	0.4996208	0.4180299	0.4357019	0.332595
leaf OBTr meas-2h	0.8014334	0.6785377	0.621814	1.0103351	0.9812237	0.6648128	1.23	1.160563	1.2869737	1.48	0.6446733	0.476718	0.391995	0.3312465
leaf OBTr meas-4h	0.6152852	0.5313257	0.8526928	0.6895166	0.73	0.71	1.39		0.8462179	1.2686161		0.4586435	0.391995	0.3312465
leaf OBTr meas-1d	0.2022103	0.1115011			0.2847011	0.278103	0.4105411	0.3408383	0.3936255	0.354457	0.4162202	0.2180439	0.3588892	0.1587702
seed OBTr meas-harv	0.2329832	0.1376657	0.3038118	0.1860488	0.2931243	0.1860569	0.2318863	0.2034843	0.2296406	0.2800298	0.35	0.245797	0.3387211	0.2045089

Working Document (IAEA)- draft September meeting (Romania?)

- Introduction, general tritium and aim in EMRAS (briefing recent lit)\
- INTERACTION MATRIX
- Wet deposition (rain and snow)-status, models, experimental and modeling comparison and improvements needed (CEA draft practical, IFIN help) final draft in september 2011
- Aquatic pathway- briefing of experimental data,, main processes, recommended models, associate hydrological model (only ref)- EMRAS mussel and AECL experiments ;Aquatrit update; AECL fish experiments

  Decision of Cardiff case TO INCLUDE
- Terrestrial pathway (final draft September 2011)
- Update of processes :

  _Dry dep (after recent results)   reemission HT&HTO JAEA

  Uptake of HTO and OBT formation Day IFIN+all

  Uptake of HTO and OBT formation Night IFIN+all
- Recommended models for farm animals (simple and process level), experimental database OKI FIN

*Soil-Plant model review DRAFT AECL

*BRIEFING OF A COMPLEX MODEL (JAEA)

- Sources of uncertainties OK Slovakia

+++

  Discuss models for crops (simple and process level), classes of crops, OPEN

  Foggy deposition ? OPEN

HOW TO DERIVE SIMPLE< TRANSPARENT AND ROBUST MODELS (low conservatism) OPEN

- Recommendation to users-site adaptation OPEN

Main tasks this year

- Publishing all new results to can incorporate in the final document
- Find a plant physiologist/ biochemist to help understanding OBT in night
- Make pressure for better OBT measurements
- Start training of new generation (Kazakhstan, for example)
- Prepare for the next step-operational model incorporated in a lagrangian atmospheric transport model with better deposition-reemission
- ECOARD 2011 (Mc Master) with tritium section
- Organize September meeting and final document

Find resources and enlarge interdisciplinary approach