EMRAS: Modelling the Transfer of Tritium and C-14 to Biota and Man Notes of the 4th Working Group Meeting Cardiff, UK 13–15 April 2005

EMRAS, Tritium and C-14 Working Group, Meeting Report 4 (draft)

Notes of the IAEA EMRAS Tritium and C-14 Working Group Meeting, Cardiff, UK
13–15 April 2005

The fourth meeting of the IAEA EMRAS Tritium and C-14 Working Group was held in Cardiff, UK. The meeting was hosted by the GE Healthcare, Cardiff.

These Meeting Notes have been prepared by Duncan Jackson (Technical Secretariat), Phil Davis (Working Group Leader) and Mikhail Balonov (Scientific Secretariat). In addition, the following people attended the meeting and contributed to the discussions and decisions documented in these Meeting Notes.

Name	**Organisation**	**Country**
Y Inoue	National Institute of Radiological Sciences (NIRS)	Japan
K Miyamoto	National Institute of Radiological Sciences (NIRS)	Japan
J Koarashi	Japan Nuclear Cycle Development Institute (JNC)	Japan
K Yamamoto	YFirst	Japan
V Soulanen	Technical Research Centre of Finland (VTT)	Finland
W Raskob	Forschungzentrum Karlsruhe (FZK)	Germany
H Lee	Korea Atomic Energy Research Institute (KAERI)	Korea
CW Lee	Korea Atomic Energy Research Institute (KAERI)	Korea
Françoise Siclet	Electricité de France (EDF)	France
F Baumgaertner	Munich Technical University	Germany
D Cutts	Food Standards Agency (FSA)	UK
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Introduction

The fourth meeting of the EMRAS Tritium and C-14 Working Group was held on 13-15 April 2005, hosted by GE Healthcare. A tour of the GE Healthcare Maynard Centre, Cardiff, was held on 12 April 2005 (hosted by Lesley Riddell) and the meeting opened with a presentation by Julie Williams (GE Healthcare, Maynard Centre) to introduce issues of tritium behaviour in the marine and terrestrial environment near Cardiff.

The objectives of the meeting were to:

- present and discuss the results from the second round of calculations for the H-3 hypothetical short term release scenario;
- present and discuss the final results for the H-3 Pickering Scenario;
- present and discuss the final report for the H-3 Soybean Scenario;
- present and discuss the final report for the H-3 Perch Lake Scenario;
- discuss the scenario description and results from the first round of calculations for the H-3 Pine Tree Scenario;
- present the scenario description for the H-3 Mussel Scenario;
- present data on plant OBT/air HTO ratios at Lawrence Livermore National Laboratory;
- discuss the definition of OBT;
- update discussions on identifying and/or obtaining data sets involving tritium concentrations in large animals;
- discuss new scenarios, especially C-14 scenarios;
- plan future work activities.

Participants were welcomed to the meeting by the Working Group Leader, Phil Davis, and the IAEA Scientific Secretary for this Working Group, Mikhail Balonov. Participants introduced themselves and described briefly their background and interest in the working group.

All participants are invited to the next Plenary Meeting of EMRAS (21-25 November 2005 in Vienna, Austria). Further information on EMRAS meetings can be found on the website.[1] Meeting notes and scenario descriptions for this Working Group can also be found on the website.[2]

Discussions of round 2 results for the H-3 hypothetical short term release scenario

Presented by Marguerite Montfort (on behalf of Philippe Guetat)

The objective of the study is to analyse the consequences of an acute atmospheric release of tritium, by considering various pathways in terms of activity in biosphere compartments and products, as well as the contribution of the various forms of tritium (HT, HTO and OBT) to total exposure. The basic assumption is that 10 g of tritium is released over a period of 1 hr and the calculation period is 1 year.

[1] http://www-ns.iaea.org/projects/emras/
[2] http://www-ns.iaea.org/projects/emras/emras-tritium-wg.htm

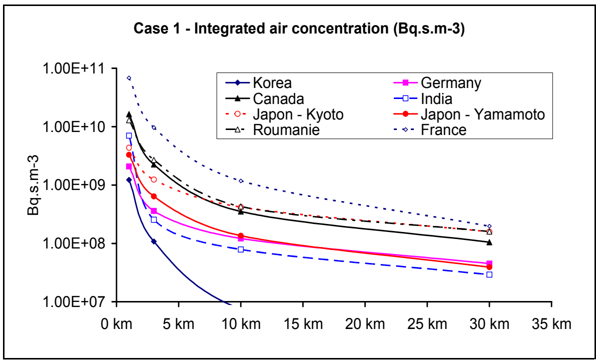
Three cases have been defined, based on meteorological conditions.

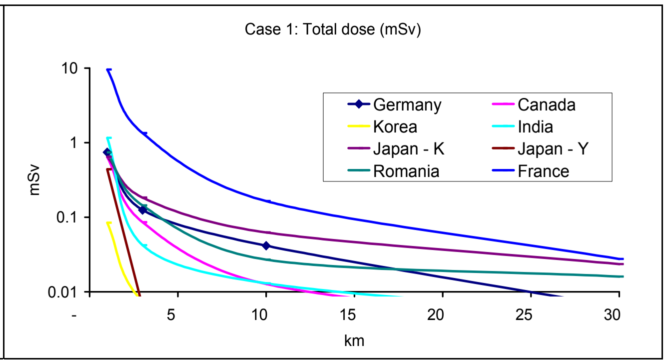
	Case 1	Case 2	Case 3
Timing of release	day	day	midnight
Wind speed (m s^{-1})	2	5	2
Direction (°N)	45±25	45±10	45±3
Diffusion conditions	unstable	neutral	stable
Weather	fine	cloudy	clear
Pasquill category	A	D	F
Solar radiation (W m^{-2})	700	300	0
Temperature (°C)	20	20	10
Rain	-	15mm	-
Relative humidity (%)	70	90	95

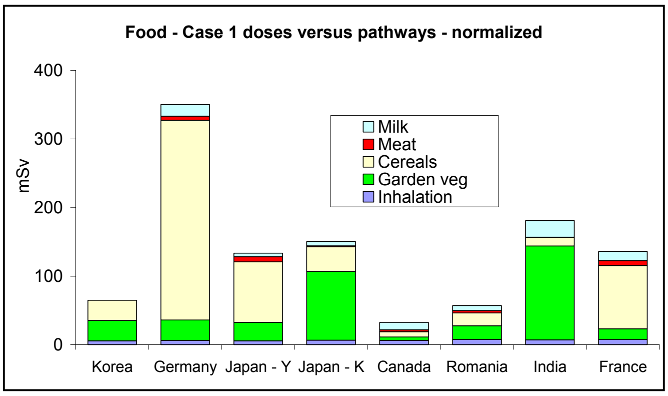
Results have been submitted by 8 participants: Germany, Korea, Canada, Japan Y, Japan K, India, Romania and France.

Modellers were asked to estimate integrated air concentrations (Bq s m^{-3}), dose to consumers/residents (mSv) broken down by pathway and form of tritium, and concentration in local foodstuffs (Bq kg^{-1} fw).

Air concentrations and dose estimates presented differed by several orders of magnitude, especially for Case 1, although if the projections supplied by Korea are considered separately, other modellers achieved relatively close agreement on air concentrations.







Dose estimations differed both in absolute magnitude and in relative contribution from the different pathways. Dose estimates against a normalised air concentration of 1E12 Bq s m^{-3} at 1 km from the discharge point indicated a range in predicted doses from <50 to >300 mSv, with dominant pathways identified as cereals (e.g. Germany and France) or garden produce (e.g. Japan-K and India). The contribution from milk and meat is smaller but equally variable and the latter appears significant only in the model proposed by France.

For Case 3 predictions are closer but, for instance, the projected dose at 10 km still varies from around 0.1 to 10 mSv. Concentrations in some food items were checked but the differences in the predicted values seemed too small to explain the differences in the doses.

Next steps

The next steps for this scenario are to understand the key causes for the differences in results. For air concentrations, factors to consider include the different ways to calculate the dispersion parameters for a given Pasquill stability category. Hansoo Lee (Korea) explained the basis for his atmospheric dispersion modelling and the reasons underlying the low predicted air concentrations, especially for Case 1.

For dose predictions, it is apparent that the relative contributions from milk, cereals, garden vegetables and meat differ significantly. Assumptions underlying these pathways need to be checked and tabulated. For case 3 (the night time release) the discrimination within the models for stomatal opening requires further consideration.

In order to further understand the basis of results presented, modellers were asked to supply specific model outputs, normalised to unit air concentrations, for Case 1:

- HTO concentration in soil water (Bq/l) at cessation of release, +1 hr, +4 hr, +24 hr, +48 hr and at harvest.
- OBT concentration in salad vegetables and cereal (Bq/l) at cessation of release.
- The exchange rate between plant (initially salad vegetables and cereals) and air at cessation of release, +1 hr, +4 hr, +24 hr, +48 hr and at harvest.

In order not to confuse the process, revisions to model structures, parameters and outputs should not be submitted unless there is a clear mistake to be rectified.

The timetable for requested actions is:

- end May, Marguerite Montfort/Philippe Guetat, Phil Davis, Mikhail Balonov to indicate the final report layout, general headings and a standard way of presenting model descriptions
- end-June, modellers check distributed material to ensure their results have been properly tabulated and graphed
- end-July, modellers submit requested information
- end-September, modellers provide model descriptions, key assumptions and conceptual format (if not submitted previously), summarise processes within the food pathways in the model and offer thoughts on reasons for differences between model outputs

Discussion of final results for the H-3 Pickering scenario

Presented by Phil Davis

Small amounts of tritium are released continuously from the CANDU reactors that make up Pickering Nuclear Generating Station (PNGS) on the north shore of Lake Ontario. The releases have been going on for many years and concentrations in various parts of the environment are likely to be in equilibrium. A large number of environmental and biological samples were collected in July and September 2002 from four sites in the vicinity of the station. HTO concentrations were measured in air, precipitation, soil, drinking water, plants (including the crops that make up the diet of the local farm animals) and animal products. OBT concentrations were measured in the plant and animal samples.

Modellers were provided with site locations, meteorological data (including air temperatures and rainfall), animal diets, and HTO concentrations in air and drinking water. From this information, modellers were asked to estimate:

(i) HTO (as Bq l^{-1}) and non-exchangeable OBT (as Bq l^{-1} in combustion water) concentrations in plants and animal products.
(ii) HTO (Bq l^{-1}) concentrations in the top 5-cm soil layer for each site.
(iii) 95% confidence intervals on all predictions.

Results to date have been received from 7 participants, although some data from GE Healthcare, UK, may be revised.

Discussion of results

Soil: Four sets of data were submitted for HTO concentration in soil. Of these, three sets were in good agreement with the measured data (LLNL, IFIN, SRA) and one set was 'not bad' (LIET).

Forage crops: All seven modellers provided results. All models over-predicted by a factor around 2-3, except for the FSA predictions, which were higher than measured by a factor of 4-5.

Other crops: All modellers over-predicted concentrations in fruit and vegetables (generally by a factor of 2-3) with root crops over-predicted to a greater extent. Predictions for leafy vegetables were best.

Animal products: Measured data for milk are available for OBT concentrations only. Model predictions for OBT generally scattered around the measured data (except for FSA who over-predicted by a factor of 5). Model predictions for HTO were tightly clustered (although comparison to measured data could not be provided), again except for FSA who were approximately 5-8 times higher. For calf meat, HTO predictions were generally good (although FSA predicted concentrations 5 times higher than observed) but OBT predictions were more variable. Most models over-predicted the HTO and OBT concentrations in eggs and chicken meat by factors of 2 to 7.

Estimates of uncertainty were not reported in all cases. Generally these were variable (from ±20% to a factor of 3) and were derived both statistically and as 'expert judgement'.

Next steps

Phil Davis will circulate a full draft report prior to the November meeting. To achieve this, model descriptions (ca. 2 pages) are required from each contributor, giving key assumptions, parameter values and particular reasons for differences in model predictions (e.g. the adoption of deliberate conservatism) by the end of July.

Discussion of final report for the H-3 Soybean Scenario

Presented by Hansoo Lee

The soybean scenario is based on experimental data collected at the Korean Atomic Energy Research Institute. Commercially available soybean was sown in May 2001 in 6 plastic pots (41cm x 33cm x 23cm high). Tritium exposure was carried out six times at different growth stages: July 2, July 13, July 30, August 9, August 24, and September 17. The pots were introduced into a glove box for the tritium exposure and the experiments were conducted under natural solar conditions, which resulted in high temperatures within the glove box. The surface of the soil was covered with vinyl paper so that uptake was only through the foliage. After exposure, the pots were placed in an open field among other soybean plants.

Modellers were asked to predict:

(i) HTO concentrations in the free water of the plant body and pods in the SB1 and SB4 experiments at the times the plants were sampled;
(ii) the non-exchangeable OBT concentrations in the plant body and pods at harvest for each of the six experiments SB1 to SB6; and
(iii) the 95% confidence intervals on all predictions.

Data were submitted by twelve modellers last spring and Hansoo Lee presented a report on the findings. In general, models tend to overestimate early concentrations of HTO (i.e. over the first few hours) but at later times there is considerable scatter about the true value. This is true for both SB1 (illustrated) and SB4. Observations have been normalized to the air moisture concentrations in the exposure chamber, so that a more meaningful comparison of the results could be made across experiments.

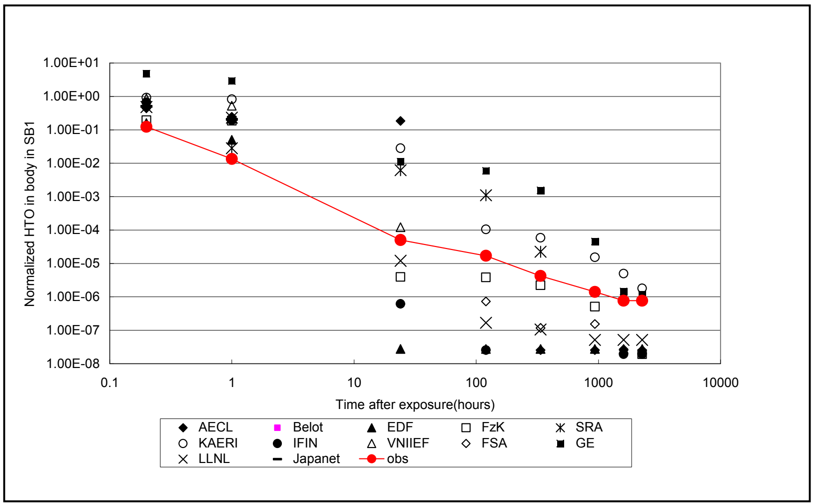


Figure 1. Predicted and observed normalized HTO concentration in plant body in SB1

Possible shortcomings in the experimental set-up were discussed as a potential cause for these results (for instance, the soil covering may have been incomplete). But some of the cause must rest with the models themselves, since their results span up to 6 orders of magnitude.

The models for tritium transfer from air to leaves were generally based on an activity balance, yielding the HTO concentrations in the plant body or pods.

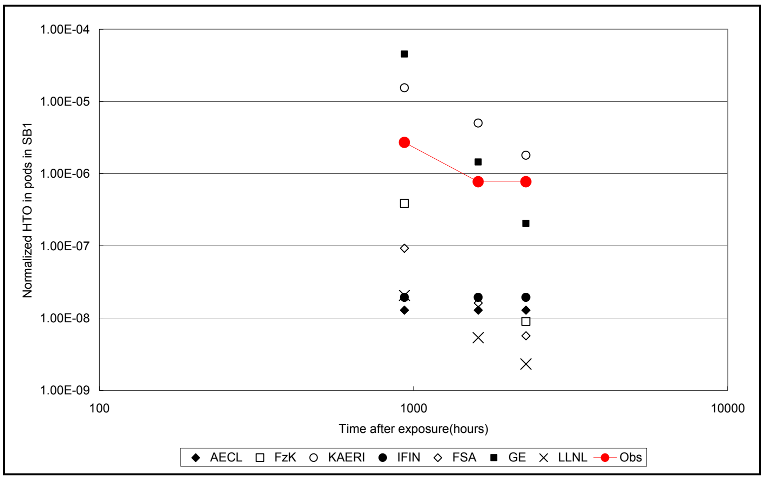


Figure 2. Predicted and observed normalized HTO concentration in pods in SB1

Some participants used equilibrium assumptions to calculate OBT concentrations based on the HTO levels whereas others used compartment models to simulate HTO and OBT concentrations simultaneously and time-dependently. Predictions for OBT show less scatter, but data are presented only for later growth stages.

Discussion of results

A number of questions were raised for discussion:

1. Why do some models over-predict HTO at later times, and others under-predict concentrations?
2. Why do model outputs differ over orders of magnitude?
3. Are discrepancies in OBT predictions the result of errors in predicted HTO concentrations or errors in the conceptual models of OBT formation?
4. Why is OBT in SB6 so high, when the plant is no longer gaining biomass?
5. Averaging the model outputs gives good predictions. Are the models essentially correct in structure but with different basic assumptions and/or parameter values driving the results?
6. Is one model better than the others?
7. How should model uncertainties be presented? (They have been omitted here as the introduction of further information confuses the graphs).

A lively discussion ensued.

As a general observation, the temperature of the glove box during the tritium uptake experiments was quite high (rising to more than 40^{o}C) as the glove box included the heating coil for the HTO evaporation and was subject to greenhouse heating by solar radiation. Under these conditions plant stomata may close, reducing the HTO uptake. Most models are set to reflect ‘natural’ conditions. Even introducing factors to reduce stomatal uptake, it is likely that these would be somewhat arbitrary and likely to be conservative (i.e. assume greater uptake than occurred). This may explain the initial over-prediction of HTO concentrations in the leaves.

There also appeared to be differences in the assumed initial air concentrations in the growth chamber.

Table 1. Assumed air concentrations in the chamber and plant water contents

	AECL		GE Healthcare	
Experiment	Air concentration (Bq l^{-1})	Plant water content (%)	Air concentration (Bq l^{-1})	Plant water content (%)
SB1	8.42×10^{7}	82.0	1.04×10^{9}	71.2
SB2	1.59×10^{8}	78.7	1.97×10^{9}	63.9
SB3	1.24×10^{8}	73.3	1.52×10^{9}	69.7
SB4	5.71×10^{7}	68.7	7.02×10^{8}	68.0
SB5	9.96×10^{7}	68.3	1.23×10^{9}	67.2
SB6	1.49×10^{8}	67.5	1.83×10^{9}	59.0

With respect to Question 3, (the basis of OBT modelling) most models derive OBT from HTO concentrations and do not incorporate dynamic reflux terms. The latter might improve some models as it would maintain higher HTO concentrations at later times (e.g. EDF). It might be useful to compare integrated HTO and OBT concentrations over 24 hours and possibly up to 7 days.

With respect to Question 4 (uptake of OBT in the absence of plant growth) it was observed that cell turnover and metabolism continue even when no specific growth is observed. Hence, OBT uptake continues, but at a reduced rate and is probably not driven by photosynthesis.
It was generally accepted that it would be useful to understand why the models differ (Question 5) but it is probably coincidental that the mean model predictions give good results. Given that all models over-predict initial HTO uptake but many of the models then under-predict OBT in seed at harvest, there may be a common fault in some core assumption and no single model can currently be identified as the 'best' (Q6).

With respect to uncertainty (Question 7) it was agreed that the final report would include separate graphs for the three contributors providing estimates of 95% confidence intervals.

Next steps

The draft final report is to be circulated. Currently appendices give details of model approaches. It was requested that these be amended where necessary to include basic model descriptions as well as parameter values. The template developed for the hypothetical scenario is to be used.

In addition:

- check that data are reported correctly in the draft final report (end May);
- consider further the queries raised above, and especially comment on possible causes for differences between model outputs (end June);
- compare leaf HTO concentrations integrated over the first 24 hours with the OBT concentrations predicted at 24 hours (end June);
- try to find an explanation for the under-prediction of OBT at harvest when the HTO concentration in the leaves is over-predicted in the first 24 hours (end June);
- comment on uncertainty within and between models (end June);
- incorporate new material into a revised draft and circulate for comment (end August)
- publish the final report (end October)

Discussion of final report for the H-3 Perch Lake Scenario

Presented by Phil Davis

This report is now posted on the EMRAS website[3] and has been circulated for comment. The scenario is based on data collected in Perch Lake, a shallow freshwater lake located within the borders of AECL's Chalk River Laboratories in northeastern Ontario, with elevated levels of tritium due to long-term discharge from nearby waste management areas. Tritium concentrations were measured in samples of air, lake water, sediments, aquatic plants (algae, bladderworts, hornworts and cattails) and animals (clams, bullheads and pike) collected in summer and autumn 2003.

Given the measured HTO concentrations in water, sediments and air, participants in the scenario were asked to calculate:

(i) HTO and non-exchangeable OBT concentrations in nearshore cattails and worts and offshore algae for the summer period. For cattails, concentrations were requested for both the above water and below water parts of the plant.

[3] http://www-ns.iaea.org/downloads/rw/projects/emras/2nd-combined-meeting/scenario-twg-perch-lake-report-1.pdf

(ii) HTO and non-exchangeable OBT concentrations in clams, bullheads and pike for each of the sampling periods. For bullheads and pike, concentrations were requested in head, flesh and internal organs (liver, gonads, stomach and intestines).
(iii) Non-exchangeable OBT concentrations in near shore sediments for the summer period.
(iv) 95% confidence intervals on all predictions

Observed concentrations of HTO in sampled organisms generally reflect the HTO concentration in the surrounding medium:

Sample	Ratio			Comments
Algae and worts	Plant/water	0.94 ± 0.27	n = 12	1 outlier ignored
Cattails (submerged part)	Plant/sediment	1.06 ± 0.29	n = 9	
Clams	Clam/water	1.05 ± 0.14	n = 2	
Bullheads	Fish/water	0.96 ± 0.06	n = 3	HTO concentrations in flesh, head and internal organs show no significant differences
Pike	Fish/water	0.96 ± 0.04	n = 3	

- OBT concentrations in the combustion water of algae and worts are proportional to the HTO concentrations in the aqueous part of the respective plants, with a proportionality constant of 0.48.
- OBT concentrations in all parts of cattails are proportional to the HTO concentrations in the emergent part of the plant, with a proportionality constant of 0.70.
- OBT concentrations in clams, bullheads and pike are proportional to the HTO concentrations in water, with a proportionality constant of 0.79.
- OBT concentrations in sediments are about 60% of the OBT concentration in plants.

The average of all model predictions agrees well with the observations for both HTO and OBT concentrations, although there is considerable spread between individual model results.

Endpoint	Ratio of mean prediction to observation		Ratio of highest to lowest prediction	
	HTO	OBT	HTO	OBT
Algae	0.92	1.2	1.8	2.6
Worts	0.83	1.3	1.7	4.1
Submerged cattails	1.2	1.7	93	103
Emergent cattails	1.3	1.4	6.5	103
Bullhead flesh	1.1	0.87	3.3	6.1
Pike flesh	1.0	0.71	2.6	7.8
Clams	0.95	0.91	2.8	5.2
Sediments	*	2.3	*	97

* HTO concentrations in sediments were given as part of the scenario description

Modelling approaches

Most models for uptake of HTO to plants are based on steady state assumptions while for animals some modellers use a dynamic approach. There seems to be no improvement in model performance adopting the more complex approach. Likewise, modelling OBT as a simple ratio of HTO seems to be adequate.

Comments on report

- Figure 11 is missing the lower confidence interval on measured concentrations.
- In general (especially for HTO in plants) it might be useful to include relevant water HTO concentrations as a point of reference in the figure captions (e.g. lake nearshore, lake offshore, sediment pore water).

- Above table 5 it is stated that "OBT breaks down as organic matter decomposes". This requires further explanation. The relatively low sediment concentrations may be due simply to decay rather than the breakdown of OBT.
- For tables 7 and 8 inclusion of observed OBT/HTO ratios would be helpful.
- Table 7. EDF determined OBT/HTO ratio as 1. Suggests a wrong value has been picked up in this summary.

Next steps

All participants to check the final report, especially Tables 7 and 8 (mid May)
Supply model descriptions where these are still outstanding (end June)
Circulate final draft report for comment (end July)
Amend as required and publish final report (end August)

Discussion of round 1 results for the Pine tree Scenario

Presented by Yoshikazu Inoue

Since 1981, NIRS has conducted a monthly monitoring programme in the vicinity of nuclear sites in Tokaimura, Japan, where a few sources have released HTO vapour into the atmosphere continuously for many years. Discharge data and meteorological data are available for modellers who wish to participate in the calculations. The NIRS observations include HTO concentrations in air, rain, groundwater, pine needles and tree rings. The data are incomplete at two sampling sites (P3 and MS2) but are supplemented by similar observations published by JAERI for MP7, which is close to the other two sites.

Modellers were supplied with a description of the area, meteorological data and discharge rates. To date, three sets of model predictions have been received (IFIN, Kyoto University and LLNL). In general terms, data from Kyoto University over-predict HTO concentrations whereas both IFIN and LLNL under-predict concentrations.

It was noted that in the scenario description the soil infiltration rate had been wrongly defined as the vertical velocity of water penetration in the unsaturated soil layer (5.5 m a^{-1}) whereas it is nearer to half the rate of precipitation (700 mm a^{-1}).

Geological sections of the area can be provided. On average, the depth of soil from the surface to the top of the groundwater aquifer is 10 m (range from a few m to 15 m).

Next steps

Yoshikazu Inoue to send a revised scenario description for mid May. Revised model predictions to be submitted for discussion at the next Working Group meeting.

Ring Peterson (LLNL) requested a full set of the observed data as her dispersion model appears to give low concentrations in air and she would like to normalise data in order to compare pine needle predictions independently of the dispersion model.

Scenario description for the Perch Lake H-3 Mussel Scenario

Presented by Phil Davis

Mussels have been collected from a clean river and transplanted to Perch Lake in 4 cages on the east side of the lake, 64 mussels to a cage. All mussels are 9-11 cm in diameter but their ages are unknown. Individual mussel weights, dimensions and water contents are available if required. Cages were suspended in water, 2 with bare bottoms, 2 covered with 10 cm of sediment. All mussels survived and appeared to be feeding. Mussels were sampled at 1 hr, 2 hr and at increasing intervals to 88 days. HTO concentrations in water were determined for samples taken beside each cage at the same time the mussels were sampled. HTO and OBT concentrations were measured in sediments periodically throughout the study.

- Data available for modellers: HTO and OBT concentrations in clean mussels
- Weight, size and water content of mussels
- Water temperature (at 5 min intervals but data for the first 14 days or so may be suspect)
- HTO and OBT concentrations in one plankton sample
- HTO concentrations in lake water and sediment pore water as a function of time throughout the experiment
- OBT concentrations in sediments as a function of time throughout the study

Predicted concentrations in mussels are requested as:

	Bare cages				Sediment cages			
Time	HTO	95% CI	OBT	95% CI	HTO	95% CI	OBT	95% CI
1 hr								
2 hr								
↓								
88 d								

Interest in participating in this study was expressed by a number of groups. Some interest was also expressed in a follow-up study on depuration rates following transplantation of Perch Lake mussels to a clean water body. This experiment is being conducted this summer.

Next steps

A revised scenario is to be circulated (end June)
Comments and clarification of the scenario to follow (end July)
Modellers submit round 1 results (end September)
Presentation of round 1 results at the next Working Group meeting

Presentation of data on plant OBT/air HTO ratios at LLNL

Presented by Ring Peterson

Plant samples were obtained from two locations (VIS and CRED) in December 2004 and analysed for HTO and OBT. Air sample data have been collected for the last 6 years, with samples collected bi-weekly during 2004.. Typically air contains 100-200 pCi HTO l^{-1} at VIS and 100-300 pCi HTO l^{-1} at CRED. During 2003 HTO in air was somewhat higher at 200-1000 pCi l^{-1} in general and up to 3000-7000 pCi l^{-1} in June and July.

Concentrations of OBT in the plants varied with type (shrubs and herbs) but typically were around 200-400 pCi l^{-1} in leaves in 2004. These values are around 4 times higher than would be expected by backfitting predicted air moisture OBT concentrations for 2004.

Comment was invited.

Discussion

It is possible that some retention of OBT between years is occurring (so that results would be influenced by the high HTO in air concentrations during 2003). However this seems unlikely as the plants die back above ground almost completely each year during the summer dry months.

Yoshikazu Inoue presented some data indicating higher than expected concentrations of OBT in pine needles following short-term releases of HTO and postulated that recycling of OBT from the tree body to the leaves occurs.

Alternatively, if releases occur predominantly during daylight hours, the HTO concentrations experienced by the plants during periods of photosynthesis and OBT formation might be higher than the average air concentration obtained from continuous air samplers.

Further thoughts are welcome.

Update on discussions on identifying/obtaining datasets for H-3 in large animals

Discussion led by Phil Davis

Discussions have continued with R Alexakhin (Russia) regarding experiments on the uptake of H-3 in large animals. The format for these experiments was discussed previously by the Working Group and is recorded in the meeting notes for September 2004 (Baden Baden). The experimental protocols appear to be of a high standard and the data obtained would add to a very sparse existing pool of information. The latest experimental design proposed by Dr. Alexakhin was circulated and comments were solicited.

In order for the experiments to proceed, funding will be required. Funding via the ISTC is possible, but takes a long time for approval and is considered uncertain. The preferred route is for funding from one (or a collective) western partner.

The level of funding required is not clear but previous experience suggests that it is likely to be in the region $200,000 to $300,000 over 2 to 3 years.

Even if the experiments go ahead it is unlikely that they will yield information in time for use by this Working Group. Consequently, efforts to identify existing data sets will continue. Phil Davis will speak to Dan Galeriu, who has the most expertise in this area.

In the meantime, participants at this working group meeting are being offered the opportunity to express an interest in funding (or joint funding) the studies. The invitation will be extended to all members of the Working Group at the end of May if insufficient interest has been expressed by then.

Definition of OBT

The following definition was tabled, together with explanatory notes.

"OBT is carbon-bound tritium that is originally formed in living systems through natural environmental or biological processes from HTO (or HT via HTO). OBT concentrations are determined experimentally as the activity of non-exchangeable tritium in the combustion water of the dried sample in question. Other types of organic tritium (e.g. tritiated methane,

tritiated pump oil or radiochemicals) should be called tritiated organics, which can be in any chemical or physical form."

The ensuing discussion considered first this specific definition and secondly a radically different approach presented by Franz Baumgaertner equating OBT with 'buried water' and 'shell bound tritium' as well as carbon bound tritium.

Specific comments on the tabled notes included the deletion of note (vi) in its entirety and a simplification of note (ii) to state 'non-exchangeable OBT can then be determined as the H-3 in the residue.' Note (iii) to read 'exchangeable tritium atoms are removed by washing and replaced by hydrogen.' Note (iv) to omit 'readily'.

For comparison with current ICRP thinking, Mikhail Balonov noted that for worker doses the ICRP is considering categories of H-3 as:

- water (HTO)
- Gas (HT, CH_3T etc)
- Metallic tritides
- Luminous compounds (mainly polymer chemicals)
- Organic compounds of tritium

No specific category for 'OBT' is included (although for members of the public ICRP56 remains the current recommended dose coefficients and this does provide for 'OBT').

The information presented by Franz Baumgartner essentially suggested, based on extraction experiments with water, urea and LiCl, that measured values of OBT reflect not simply carbon bound tritium but include buried tritium (OBT_{exc}) and shell bound tritium (SBT), such that:

$$OBT = CBT + [OBT_{exc} + SBT]_{buried}$$

For clarity, the full presentation is circulated with the notes. A number of points were raised in discussion. In particular, if this definition of OBT is accepted, then the use of OBT as an indicator of C-14 behaviour may be inappropriate as only a fraction of the OBT is carbon bound. Moreover the SBT fraction of OBT may account for the very rapid formation of OBT in plants often observed (although this finding does not appear to be true for animals). However, it is not clear why SBT would not exchange equally as rapidly when washed with tritium-free water, in which case it should not appear in the measured values of OBT.

Since current analytical methods are unlikely to distinguish the SBT component separately, at a pragmatic level it is unlikely that a change in the definition of OBT will affect model dynamics or calculated doses, since biological half-times are based generally on empirical observations.

It was accepted that the current definition of OBT be taken as a working definition, whilst encouraging new experimental work to identify bound fractions more realistically. Phil Davis agreed to make available reference material from Chalk River for comparative analysis by interested parties.

Description of C-14 in rice scenario

A full description of the C-14 in rice scenario was circulated and is attached with these notes.

C-14 has been released from three discharge points at Tokamurai over several decades. Weekly monitoring data are available from October 1991. Discharges have decreased considerably over that period, from about 800 GBq in 1991 to near zero in 2000. Corresponding samples of C-14 in rice are available. Data obtained in 1991 indicate that any effect from earlier discharges was negligible in the plants. Analysis of wines undertaken through the 1990's can be used to establish general background C-14 levels.

Meteorological information at 10-m height is available at 10 minute intervals if required.

Modellers are requested to:

(i) Calculate monthly mean C-14 concentrations in air at two locations
(ii) Calculate C-14 concentrations in rice grain at harvest
(iii) Express 95% confidence intervals on all estimates

Further information was requested, including grid co-ordinates for the stacks and sample locations, stack emission temperatures, and meteorological data averaged over at least hourly periods. The source of paddy field water is to be identified (particularly if this may be a source of C-14 input, which is thought unlikely). It was also suggested that model predictions be restricted to May to October (i.e. the rice growing season) for 1991/1992 to 1997, which reduces the amount of analysis required and provides the period for fullest comparative data.

It was noted that the sample locations are very close to the stacks, so some uncertainty (especially from plume rise effects) is likely as the sites may be within the skip distance for deposition.

Several members expressed a willingness to be involved in this scenario.

Next steps

- A revised scenario description with additional information to be supplied (end May)
- Comments and requests for clarification to be received (end June)
- Modellers to submit round 1 results (end September)
- Presentation of round 1 results (end November)

Discussion on potential new C-14 scenarios

Seven scenarios are currently underway and it is important not to overload Working Group members. With this in mind, following on from previous discussions, three potential datasets involving C-14 were thought to be potentially worth pursuing:

- EDF data: Continuous release, endpoints would be C-14 concentration in ivy leaves and grass, availability of meteorological data unknown.
- C-14 dataset from Imperial College. Similar to soybean scenario, endpoints would be time-dependent C-14 concentrations in cabbage, potatoes and beans.
- The Centre for Ecology and Hydrology (UK) has carried experiments with C-14 on sheep. The data have been published.

Most interest was expressed in the Imperial College dataset. Duncan Jackson was tasked with discussing the data with Imperial College, FSA and other parties to determine whether funding to analyse the data and provide a Working Group leader could be made available.

Status of Work Programme

Item	Status for next Working Group meeting	Person
Soy bean H-3 scenario	Final report to be complete and published on website	Hansoo Lee
Perch Lake H-3 scenario	Final report to be complete and published on website	P Davis
Pickering H-3 scenario	Draft report to be complete	P Davis
Hypothetical H-3 short term release scenario	Information supplied to be checked. All model descriptions to be complete. Report layout to be proposed. Additional predictions to be supplied by the modellers.	P Guetat, M Montfort & modellers
Pine tree scenario	Revised scenario to be distributed and second round model predictions to be submitted	Y Inoue & modellers
Rice C-14 scenarios JNC Rice	Revised task description to be circulated, round 1 results to be submitted ready for analysis and presentation	J Koarashi & modellers
Mussel scenario	Revised task description to be circulated, round 1 results to be submitted ready for analysis and presentation	P Davis & modellers
Plant chamber C-14 scenario	Availability of data and funding to be explored. Draft scenario to be prepared if funding available	D Jackson
Definition of OBT	Current definition adopted as a pragmatic approach. New experimental work and/or datasets to be identified	F Baumgaertner
Animal experiments	Funding to be clarified. Recommendations to be made regarding possible scenario development based on existing datasets.	All Working Group members; Dan Galeriu

It was suggested that an important output from the working group would be an overall set of recommendations for processes to be included in H-3 models.

Next Meeting

The next meeting is scheduled for Vienna, to be held as part of the EMRAS plenary meeting, 21–25 November 2005.

Documents circulated with these notes:

Hypothetical H-3 scenario comparison of model outputs (Excel document)
Soybean H-3 draft final report v3.1 (Word document)
Perch Lake H-3 final report v1 (Word document)
OBT new definition (PowerPoint)

Further Information

Information on the activities within EMRAS generally and on the Tritium and C-14 WG in particular (including the scenarios being used for model testing), can be obtained from the following people, respectively:

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ANNEX A: Summary of Actions

Date due	Activity	Persons Responsible
May 2005	Indicate generic final scenario report layout (e.g. main headings) and a standard way of presenting model descriptions	Marguerite Montfort, Philippe Guetat, Phil Davis, Mikhail Balonov
	Soybean H-3 scenario: i) distribute draft final report (v3.1), ii) all modellers to check that data are reported correctly and amend appendices (if necessary) to include basic model descriptions as well as parameter values.	i) Duncan Jackson ii) Relevant modellers
	Perch lake H-3 scenario: check final report, especially Tables 7 and 8	Relevant modellers
	Pine Trees H-3 scenario: circulate a revised scenario description	Yoshikazu Inoue
	Pine Trees H-3 scenario: full set of observed data to be sent to Ring Peterson only	Yoshikazu Inoue
	H-3 large animal data: identify existing data sets	Phil Davis to speak to Dan Galeriu
	H-3 large animal experimental studies: interest in funding to be expressed	Initially participants at this meeting, to be extended to the full Working Group depending on the initial responses
	C-14 in rice scenario: revise task description with additional information	Jun Koarashi
June 2005	Hypothetical short term H-3 release scenario: check tabulated data for correctness	Relevant modellers
	Soybean H-3 scenario: i) consider the queries raised, and especially comment on possible causes for differences between model outputs, ii) comment on uncertainty within and between models, iii) explain the under-prediction of OBT at harvest when HTO concentrations are over-predicted in the first 24 hours, iv) compare integrated HTO:OBT concentrations	i), ii) & iii) Relevant modellers iv) Duncan Jackson
	Perch lake H-3 scenario: submit model descriptions where still outstanding	Relevant modellers
	With respect to encouraging new experimental work to identify bound fractions of H-3 more realistically, reference material from Chalk River to be made available for comparative analysis by interested parties	Phil Davis
	Discuss C-14 data set with Imperial college, FSA and other parties to determine whether funding to analyse the data and provide a Working Group leader could be made available	Duncan Jackson
	C-14 in rice scenario: submit comments on revised scenario description	Relevant modellers
	Mussel scenario: revise scenario description and distribute for comment	Tamara Yankovich
July 2005	Hypothetical short term H-3 release scenario: modellers submit information on • HTO concentration in soil water at cessation of release, +1 hr, +4 hr, +24 hr, +48 hr and at harvest. • OBT concentration in salad vegetables and cereal at cessation of release • Exchange rate between plant and air at cessation of release, +1 hr, +4 hr, +24 hr, +48 hr and at harvest.	Relevant modellers
	Pickering H-3 scenario: model descriptions (ca. 2 pages) are required from each contributor, giving key assumptions, parameter values and reasons for differences in model predictions (e.g. the adoption of deliberate conservatism).	Relevant modellers
	Perch lake H-3 scenario: circulate final draft report	Phil Davis
	Mussel scenario: finalize scenario description and distribute for calculation	Tamara Yankovich
August 2005	Perch lake H-3 scenario: i) submit final comments on report, ii) amend as required and publish	i) Relevant modellers ii) Phil Davis
September 2005	Hypothetical short term H-3 release scenario: provide model descriptions and conceptual format (if not submitted previously), summarise processes within the food pathways in the model and offer thoughts on reasons for differences between model outputs	Relevant modellers
	Pine Tree H-3 scenario: submit revised predictions	Relevant modellers

Date due	Activity	Persons Responsible
	C-14 in rice scenario: submit round 1 results	Relevant modellers
	Mussel scenario: submit round 1 results	Relevant modellers
October 2005	Pickering H-3 scenario: circulate full draft report	Phil Davis
November 2005	Next Working Group meeting Hypothetical scenario: present most recent results Pickering scenario: present draft final report Pine tree scenario: discuss round 2 results C14 in rice scenario: discuss round 1 results Mussel scenario: discuss round 1 results	All Working Group members Marguerite Montfort / Philippe Guetat Phil Davis Yoshikazu Inoue Jun Koarashi Phil Davis

ANNEX B: List of Participants

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