MODARIA Working Group 7 (WG7): Harmonization and intercomparison of models for accidental tritium releases

Field Testing and Intercomparison of Advanced Tritium Transfer Models

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WG7 Objectives (c.2013)

- Guidance on development and application of environmental tritium transfer models based on the updated Aiken list
- Analysis of the tritium transfer in terrestrial ecosystems
- Identification of knowledge gaps and assessment of their significance
- Inter-comparison of models on specific scenarios
WG7 Progress update

- Contributions to theoretical part of TecDoc are assembled

- Tests against CRL, IRSN and CNSC Scenarios are complete, intercomparison results are drafted, analysis is being finalized

- Analysis and recommendations on future experimental design and model development are in progress
• Finalize provided guidance on tritium land-atmosphere transfer:
  – Foliar uptake and re-emission as an integral part of soil-plant-atmosphere complex
  – Turnover of OBT in litter and soil
  – Parameterization of vegetated and non-vegetated soil
    o Uptake of HTO
    o Re-emission of HTO
• Discuss regulatory prospectives
  - the role of simple “screening” models
  - Possibility of shift of monitoring paradigm from HTO to OBT
  - Formulate the need for quantification of EX-OBT DCF
  - Formulate the need of exclusion of EX-OBT form monitoring program
Discuss and finalize model inter-comparison (3 scenarios)

- **CRL’2008 Scenario (Canada):**
  - HTO in air (intermittent routine release)
  - HTO in soil and vegetation, OBT in vegetation and fruit

- **IRSN’2013 Scenario (France):**
  - HT and HTO in air, CO$_2$ fluxes, soil water dynamics (lysimeters)
  - HTO and OBT in vegetation and soil

- **CNSC’2012 Scenario (Canada):**
  - HT and HTO in air
  - HTO in vegetation and soil and OBT in soil

**Analyzed models:**

- TOKATTA-CHI, IRSN, France
- SOLVEG-II, JAEA, Japan
- CLASS-TT, CNL, Canada
- CERES, CEA, France
Present Status of Tritium Transfer Models

Experimental investigation and subsequent modeling of tritium transfer through atmosphere-vegetation-soil system resulted in harmonized approach to key processes encountered in advanced models:

- foliar atmospheric HT and HTO uptake, including nighttime (Chalk River experiments),
- HT oxidation in soil (International Chalk River experiments),
- removal of soil HTO via evapotranspiration route
- OBT formation in photosynthesis
- parameterization of links to external drivers responsible for stomata opening and uptake rate (solar radiation, meteorology and soil moisture availability)
- parameterization of feedbacks between key processes

Continuous and realistic evaluation of fast post-accident field-scale transfer of airborne tritium finally becomes possible
Specific targets of WG7 experiments

- Chalk River, CNL, Canada (CRL Scenario, 2008)
  Fast processes of airborne tritium transfer and OBT formation in the wake of plume (timeline of TFWT, soil HTO and OBT). **Feature:** Usually infrequently sampled short post-plume-departure episodes are well represented.

- SRBT, Pembroke, Canada 2012 (CNSC Scenario, 2012).
  Measurements in the vicinity of the source where elevated OBT is frequently observed (elevated OBT/HTO ratios). **Feature:** Variable field conditions are well represented, in particular:
  - natural precipitation and various irrigation regimes,
  - natural grass and different crops

- La-Hague processing plant, Cherbourg, France (IRSN Scenario, VATO Programme, 2013 – )
  Testing naturally occurring dynamics of TFWT and OBT in pasture (grass) during the whole year. Variability is addressed in multiannual field campaign. **Feature:** QA checked, first ever observation of whole-year-long variations of soil HTO, TFWT and OBT. First ever test of the whole-year-long predicted dynamics of these values.
Chalk River Scenario
translocation in the wake of plume

OBT in leaves

Concentration (Bq/L)

- L-Potato leaves OBT
- L-Tomato leaves OBT
- R-Potato leaves OBT
- R-Tomato leaves OBT
- L-Tomato OBT
- R-Tomato OBT
- HTOatm
Chalk River Scenario: Model test results

TFWT

Soil HTO
CNSC Scenario: Model test results

TFWT

Soil HTO
Chalk River Scenario: Model test results

**OBT**

**Root OBT**

Obs. Sample No.

- TOKATTA_Grass total OBT
- CERES_OBT_tomato
- SOLVEG_OBTlf
- CLASS_OBTlf
- OBS_total_OBT

Obs. Sample No.

- TOKATTA_Grass_nexchOBT
- CERES_OBT_potato
- SOLVEG_OBTrt
- CLASS_OBTlf
- OBS_OBT-potato
Chalk River Scenario: Model test results

TFWT

Bq/L vs. Bq/L for different scenarios:
- TOKATTA_Grass_TFWT
- CERES_TFWT_tomato
- SOLVEG_HTOlf
- CLASS_

Linear (1:1 perfect fit)
Chalk River and CNSC Scenarios: Model test results

TFWT

Bq/L vs. Bq/L

Linear (1:1 perfect fit)

TFWT

- TOKATTA_Grass_TFWT
- CERES_TFWT_tomato
- SOLVEG_HTOlf
- CLASS_HTOlf

- Chalk River and CNSC Scenarios: Model test results
Chalk River and CNSC Scenarios: Model test results

TFWT

Bq/L vs. Bq/L scatter plot with data points for different models:
- TOKATTA_Grass_TFWT
- CERES_TFWT_tomato
- SOLVEG_HTOlf
- CLASS_HTOlf

Linear (1:1 perfect fit) line is also shown.
Chalk River Scenario: Model test results

The graph shows the comparison of different model results for soil HTO concentrations. Symbols represent different models:
- **TOKATTA_Clay_Conc**
- **CERES_soil_HTO**
- **SOLVEG_HTOsol1**
- **CLASS_HTOsol1**

The data points are plotted against the expected linear (1:1 perfect fit) relationship, indicating how well the models match the actual soil HTO concentrations.
Chalk River and CNSC Scenarios: Model test results

soil HTO

- TOKATTA_Clay_Conc
- CERES_soil_HTO
- SOLVEG_HTOsol1
- CLASS_HTOsol1

Linear (1:1 perfect fit)
Chalk River Scenario: Model test results

Shown: TOKATTA – Total OBT, SOLVEG – n/e root OBT, CERES and CLASS – n/e OBT
Model Test Conclusions

CRL Scenario

Immediate post-plume phase is characterized by fast tritium exchange processes. TFWT and Soil HTO in this phase are modelled quite well. Advanced multilayer tritium transfer models can be used in lieu of expensive experiments (CRL Scenario)

Exchangeable OBT also exchanges fast in the post-plume phase of tritium transfer and assimilation. Not exchangeable OBT in the post-plume phase plays minor role. Models based solely on n/e OBT underpredict. Trial model of total OBT (ex_OBT + n/e_OBT) tested with a ponderation (25%/75%) of a fast kinetic (as TFWT) and a slow kinetic (as NE-OBT) improves slightly OBT P/O but might not be sufficient to explain differences (CRL Scenario)
Model Test Conclusions

CNSC Scenario

Models predict TFWT and soil HTO well in variable field conditions.

SRBT site in CNSC Scenario is characterized by OBT which is systematically elevated due to reasons different from fast dynamical exchange (i.e. from CRL Scenario). These processes are currently under investigation and will be included in models in the future. Current models underpredict OBT at SRBT site.
Model Test Conclusions

IRSN Scenario

First ever test of the whole-year-long predictions of soil HTO, TFWT and OBT, including their fast dynamics and variability is completely successful.
➢ TM-IV: WG7 Scope of work (key targets)

➢ Model inter-comparison, agree on interpretation

➢ Future development, agree on priorities
Thank you