Modelling and validation of OBT formation in tomato and potato plants

V.Y. Korolevych* and S.B. Kim

Chalk River Laboratories, AECL, Chalk River, ON K0J 1J0, Canada

This study is devoted to the collection and robust analysis of 2008-2009 field data pertaining to airborne tritium transfer in potato and tomato plants. The concentration of HTO in the upper soil layer, in the different parts of vegetation and in the air has been assessed in ambient and controlled settings. The sampling was performed on weekly and hourly scales, in the latter case with emphasis on a night-time period. The process of uptake from atmosphere has been clarified using plants grown on the clean tarp-covered soil at Acid Rain Site of Chalk River Laboratories (CRL), which dumped the root uptake pathway. The processes of root uptake and re-emission from plant were clarified at the irrigated Perch Lake site of CRL. Tritium exchange in quasi-equilibrium conditions (weak concentration gradient) was also analyzed in both places, when the direction of exchange changed the sign due to absence or presence of tritium plume.

Existing robust models of tritium bi-directional gaseous transport to and from the vegetated surface performed well after slight modifications and were found appropriate for HTO quantification. It appears however, that robust OBT models are limited in their capability to bridge sparse observations of OBT, when it comes to handling changes of many ambient drivers at a time and prediction of soil thermodynamics and moisture. As OBT resides in photosynthate, the total error is typically amplified by independency of stomatal conductance from photosynthesis. This study is therefore focussed at modelling of detailed dynamics of surface fluxes and on coupling of conductance with photosynthesis. The subsequently modelled OBT became more adequate for bridging scarce experimental measurements of OBT in plants.

Our model of choice is CTEM+CLASS 2.7 (Canadian Terrestrial Ecosystem Model detailing phenomenology for multi-layer Canadian LAnd Surface Scheme from operational models of Environment Canada, Canadian Centre for Climate Modelling, courtesy of Dr. V. Arora). HTO uptake is modelled via exchange velocity and the conversion of HTO to OBT is based upon photosynthesis rate, stoichiometry and isotopic discrimination factor. OBT allocation is modelled within the five prognostic carbon pools of CTEM+CLASS (leaf, stem, root, litter and organic soil) with maintenance and respiration included.

Measurements of OBT (including OBT night-time formation) and OBT/HTO ratios collected at CRL in different years were used for OBT model validation. Additional field experiments were conducted in 2008 and 2009 in attempt to bridge remaining gaps in validation datasets.