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A comparative Study between GoldSim and AMBER Based Biosphere Assessment Models for an HLW Repository

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1. Introduction

To demonstrate the performance of a repository, the dose exposure rate to human being due to long-term nuclide releases from a high-level waste repository (HLW) should be evaluated and the results compared to the dose limit presented by the regulatory bodies. To evaluate such a dose rate to an individual, biosphere assessment models have been developed and implemented for a practical calculation with the aid of such commercial tools as AMBER[1] and GoldSim[2], both of which are capable of probabilistic and deterministic calculationa. AMBER is a general purpose compartment modeling tool and GoldSim is another multipurpose simulation tool for dynamically modeling complex systems, supporting a higher graphical user interface than AMBER and a postprocessing feature. And also unlike AMBER, any kind of compartment scheme can be rather simply constructed with an appropriate transition rate between compartments, GoldSim is designed to facilitate the object-oriented modules to address any specialized programs, similar to solving jig saw puzzles. During the last couple of years a compartment modeling approach for a biosphere has been mainly carried out with AMBER in KAERI in order to conservatively or rather roughly provide dose conversion factors to get the final exposure rate due to a nuclide flux into biosphere over various geosphere-biosphere interfaces (GBIs) calculated through nuclide transport modules[3-6]. This caused a necessity for a newly devised biosphere model that could be coupled to a nuclide transport model with less conservatism in the frame of the development of a total system performance assessment modeling tool, which could be successfully done with the aid of GoldSim. Therefore, through the current study, some comparison results of the AMBER and the GoldSim approaches for the same case of a biosphere modeling without any consideration of geosphere transport are introduced by extending a previous study[7].

2. Methodology and Illustrations

For a modeling and assessment of a biosphere, BIOMASS methodology [8] has been adopted for a HLW repository currently being considered in Korea, which has a similar concept to the Swedish KBS-3 HLW repository[9]. An HLW Repository System has been considered to be located in or at least near a coastal area in view of the general and current sociogeographical situation in Korea. In such a case, fresh water bodies such as water running rivers, wells and/or still lakes and a varying near seawater as well as sediments beneath fresh and marine water bodies are expected to be the principal GBIs, over which a nuclide released from the geosphere could take place and ready for a spread out to the biosphere. Although, through every step of a whole biosphere modeling, the nuclides transport from various geological media to the biosphere might somehow need to be accounted for in detail and in a coupled manner, however to a large extent, a biosphere modeling can be done independently with its linear behavior, without knowing what happens in the geosphere, making an access possible to it in a separate manner, as is currently being done in many other countries. For such cases AMBER and GoldSim look very appropriate to model them independently, exclusive of a consideration of a geological transport before GBIs. However, by supporting a modeling of continuous dynamic systems functionality as well as applying them to such simulations as discrete events and time-delayed effects, GoldSim seems better than AMBER and even could be easily applied for a final assessment of a biosphere since GoldSim efficiently integrates the results of complex nuclide transport models through engineered barriers and geological fractured rock media surrounding an HLW repository site for a consecutive farther transport and a transfer modeling through a biosphere. A linear compartment model to describe the interaction among various biosphere components for the AMBER model is shown in Fig. 1(left) for a nuclide transfer under the assumption of an instant mixing in each compartment volume. And also an equivalent GoldSim model is depicted in Fig. 1 (right). Unlike in AMBER in which the resulting transfers between two compartments due to various processes are described by a simple transfer coefficient expressed as an inverse of a turnover time for the AMBER scheme, in GoldSim the inflows and outflows between two cells are expressed by mass or volumetric flow rates. Both for AMBER and GoldSim, once the concentration in each compartment or cell is calculated, then the nuclide concentration in a foodstuff in food chain pathways is calculated by assuming an instant equilibrium between plants and animals as well as their environment. As always, three exposure groups including farming, freshwater fishing and marine fishing are defined by accounting for the classification of an exclusive intake of local products with relevant assumptions. Nuclide uptake in aquatic biota is calculated using concentration ratios for aquatic organisms or bioaccumulation factors and uptake in a terrestrial vegetation is calculated using soil to plant concentration factors, root-uptake factors and external to internal surface translocation factors. Specific transfer coefficients are also used when a nuclide transfer to animal products is calculated. External doses are calculated with relevant dose conversion factors as well. Uncertainties associated with a model as well as due to other uncertainties involved in parameter values can be estimated by assigning appropriate statistical distributions and ranges whenever necessary.

3. Results and Concluding Remarks

Nuclide concentrations in compartments and cells shown in Fig. 2 are results from calculations by AMBER and GoldSim, respectively for a comparative purpose for all nuclides considered, whereas results solely due to ^{99}Tc (having *Kd* = 0.1 m^3/kg for all solid media) are shown in Fig. 3 which shows a good coincidence between the models. However some magnitude of discrepancy in the results could be recognized in Fig. 4. which shows the exposure rate to the farming exposure group that might be due to a different modeling scheme for the exposure pathways. Through the study a biosphere assessment model by utilizing GoldSim has been developed and a comparison with a predecessor model by AMBER has been introduced to construct an AMBER template that could used in the new GoldSim biosphere model making enable to be linked to a nuclide transport model with less conservatism in the frame of the development programs of a total system performance assessment modeling tool.

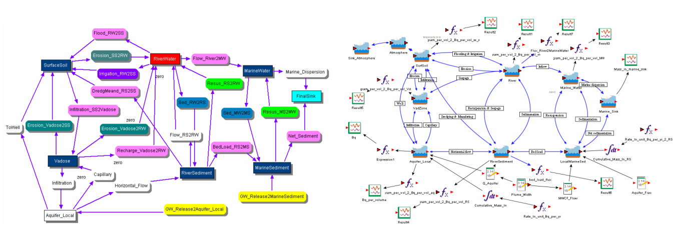

Fig. 1. Biosphere modeling scheme in AMBER (L) and GoldSim (R).

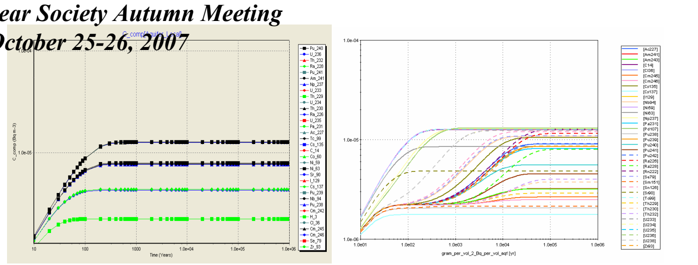

Fig.2. Nuclide concentrations in aquifer by AMBER and by GoldSim.

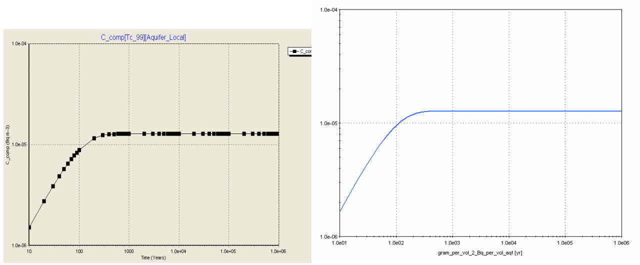

Fig.3. Concentration of 99Tc in aquifer by AMBER and by GoldSim.

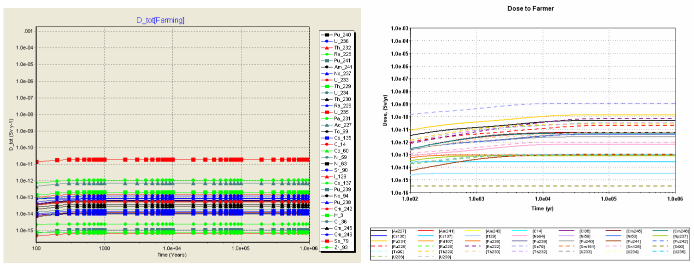

Fig. 4. Exposure rates to farming exposure group due to 1 Bq/y through well GBI by AMBER and by GoldSim.

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