AN INTEGRATION FRAMEWORK OF ECOLOGICAL MODELS

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1. INTRODUCTION

Each existing model, developed to direct against a certain specific issue, is may achieve satisfactory results by used separately. But while many models are selected for simulating one complex issues (e.g. one ecological issue), not only the accuracy and practical scope of each selected model must be considered (Z.M. Fan and T.X. Yue 2004, 2006), but also the complex relationships including internal and external mutual influence between simulation objects of selected models must be taken into account (Z.M. Fan, 2005). Model integration is becoming ever more important for studying various complex issues (R.M., Argent, 2004). The researches of how to integrate many ecological models (G. Guariso and H. Werthner, 1989; A.B. David, 1997; A.E. Rizzoli and R.J. Davis, 1999; T. Maxwell, 1999; A.M., Geoffrion, 1999), particularly those from different study fields. Especially recent years, the technique of model integration has been well developed and the practice of it has been increased. But existing integration methods mainly focused on considering the realized technology and integration environment, however, the relations between these sub-models being used in the integrating progress and the accuracy assessment of integrated pattern are not enough to discuss. So How to evaluate the accuracy of integrated pattern included many sub-models is the key issue to deal with the complex ecological issue. For dealing with theses problems, an integration framework and its accuracy assessment method developed in this paper.

2. BASIC IDEAS OF THE INTEGRATION FRAMEWORK

The Meta-Synthesis defined at firstly by X.S. Qian in 20th century, as the methodology of researching complex system, promotes the development of basic idea during utilizing its achievement. The representative instruction function of Meta-Synthesis mainly include the research route of top-down and bottom-top, the technical route of man-machine and human network union, and realizing the integration of information, knowledge and wisdom (X.S. Qian, et al, 1990; J.Y. Yu, and Y.J. Tu, 2002). On the basis of Meta-Synthesis idea, we discovered that each integrated model contains a series of sub-models, and each sub-model respectively play different role in those integrated model (e.g. the Integrated Model to Assess the Global Environment (IMAGE), the Asian and Pacific Integrated Model (AIM), etc), and there has an analogy phenomenon in these integrated models as followed: In every integrated model, there may be no relation between some sub-models, but some others are linked with head and tail, and some sub-model's outputs is as other sub-model's inputs. If the information transmission were

regarded as the information flow between sub-models, certain general rule or the transmission pattern would be found. The rule is that the information flow between sub-models in the integrated model is similar to the electric current in the circuitry, and the sub-model is similar to the resistor. Just as every resistor consumes partial electrical energy, each sub-model will cause the information losses during the simulation process of integrated model because that has a certain extent simulation error. In view of the fact of the above thought idea, an integration framework, including three integration patterns, respectively series-wound pattern, shunt-wound pattern, and mix pattern, are developed to evaluate the accuracy of ecological integration model by introducing the transmitted pattern of electric current in the circuitry.

3. THREE PATTERNS IN THE INTEGRATION FRAMEWORK

3.1 The series-wound integration pattern

The series-wound integration pattern of ecological model means among these sub-models there is one kind of relation called series-wound, in other words it means that the output result of previous sub-model is the input parameters of the next sub-model. These sub-models seem like a series of resistor in the circuitry, when electric current passes through each resistor, the electrical energy would be loss partially. Each sub-model operation process will cause such input parameter's information loss as data precision, parameter amount and other parameters in the integration process of series-wound pattern of ecological models. The series-wound integration pattern can be present with Figure 1.

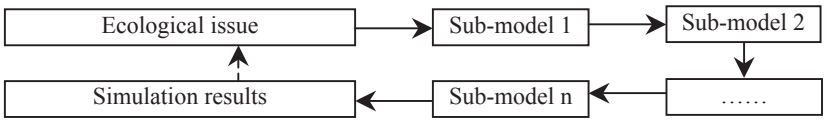

Figure 1. The series-wound integration pattern of ecological models

The accuracy of information flow in the series-wound integration pattern can be calculated by the formula as follows:

$$IX_{\text{accuracy}} = Mw_1 \times Mw_2 \times \cdots \times Mw_{n-1} \times Mw_n \qquad (1)$$

Where IX_{accuracy} is the accuracy of series-wound pattern; $Mw_1, Mw_2 \ldots Mw_n$ are, respectively, the precision of each sub-model from 1 to n. According to the equation, we can see that the sub-models 's error transmission presents multiplication relation.

3.2 The shunt-wound integration pattern

The shunt-wound integration pattern of ecological model means that among the selected sub-modes exists one kind of shunt-wound relation, when using these models to simulate the ecological issue. The simulation and analysis of the ecological issue adopts each sub-model's output information being used in the integration pattern, which can be presented with Figure 2. Every sub-model looks like a series of resistor in the shunt-wound circuitry,

and undertakes some tasks respectively for solving the ecological issue. These sub-model's input or output parameter may not have any relation, but they contribute to the solution jointly.

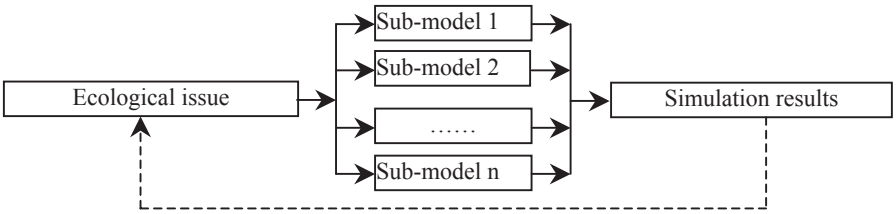

Figure 2. The shunt-wound integration pattern of ecological models

The accuracy of information flow in the shunt-wound integration pattern can be calculated by the formula as follows:

$$IY_{\text{accuracy}} = Mw_1 \cdot a_1 + Mw_2 \cdot a_2 + \cdots + Mw_n \cdot a_n \quad (2)$$

Where IY_{accuracy} is the accuracy of shunt-wound pattern; Mw_1, Mw_2 … Mw_n are, respectively, the precision of each sub-model from 1 to n; a_1, a_2 … a_n are, respectively, the weight coefficient of each sub-model, and $a_1 + a_2 + \ldots + a_n = 1$. While the weight coefficient of one sub-model is larger, it is much important than other sub-model.

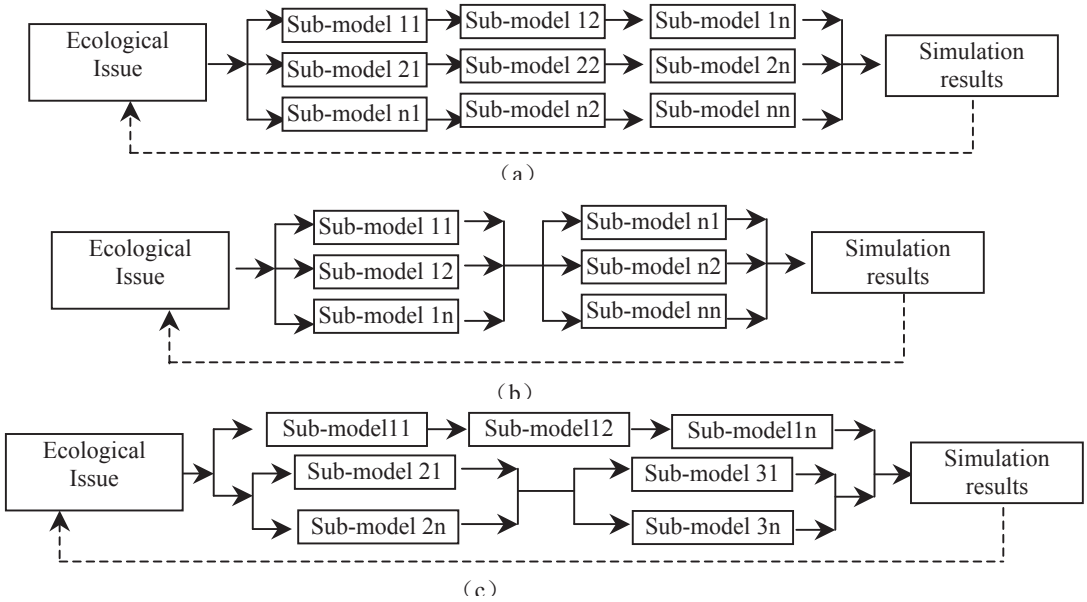

Figure 3. The three basic mix integration pattern of ecological models

3.3 The mix pattern

As certain complex ecological issue is investigated, which will involve many ecological sub-models. When series-wound pattern or shunt-wound pattern is used singly, it can't offer enough simulation information to solve the issue successfully. How to integrate these sub-models and evaluated the accuracy and availability of integrated model is the key difficult problem to simulate and analyze the complex ecological issue successfully (A.B. David,

1997; Z.M. Fan and T.X. Yue, 2006.) On the basis of series-wound pattern and shunt-wound patterns discussed in above section, mix integration pattern, as a complex integration pattern, is put forward, which can be presented by figure 3(a), (b) and (c), respectively. The accuracy of these three basic mix integration patterns of ecological models can be calculated by the evaluated methods of shunt-wound integration pattern and series-wound integration pattern.

4. DISCUSSION

The integration framework being developed in this paper, includes three integration patterns, will have two significances as follows: 1) it provides an effective quantitative method for evaluating the accuracy of the integrated model; 2) and helps the researchers select efficiently the integration pattern with lots of sub-models that must be used in the study of complex ecological issue.

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