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A conceptual data model and modelling language for fields and agents

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Modelling is essential in order to understand environmental systems. Environmental systems are heterogeneous because they consist of fields and agents. Fields have a value defined everywhere at all times, for example surface elevation and temperature. Agents are bounded in space and time and have a value only within their bounds, for example biomass of a tree crown or the speed of a car. Many phenomena have properties of both fields and agents.

Although many systems contain both fields and agents and integration of these concepts would be required for modelling, existing modelling frameworks concentrate on either agent-based or field-based modelling and are often low-level programming frameworks. A concept is lacking that integrates fields and agents in a way that is easy to use for modelers who are not software engineers. To address this issue, we develop a conceptual data model that represents fields and agents uniformly. We then show how the data model can be used in a high-level modelling language.

The data model represents fields and agents in space-time. Also relations and networks can be represented using the same concepts. Using the conceptual data model we can represent static and mobile agents that may have spatial and temporal variation within their extent. The concepts we use are phenomenon, property set, item, property, domain and value. The phenomenon is the thing that is modelled, which can be any real world thing, for example trees. A phenomenon usually consists of several items, e.g. single trees. The domain is the spatiotemporal location and/or extent for which the items in the phenomenon are defined. Multiple different domains can coexist for a given phenomenon. For example a domain describing the extent of the trees and a domain describing the stem locations. The same goes for the property, which is an attribute of the thing that is being modeled. A property has a value, which is possibly discretized, for example the biomass over the tree crown extent. Properties sharing the same domain are grouped into a property set. The conceptual data model is translated into a physical data model in de Jong et al. (2016, presented in the same session).

We have designed a modelling language that allows domain specialists to build models without the programming efforts required by many programming environments. The language is based on the ideas of map algebra. We have defined data types that are associated with a phenomenon. These data types determine the behavior of the language when used as arguments in operations. The result is a concise language in which fields and agents can be combined in operations. We test the language in a case study modelling exposure to air pollution of commuting children.

References

De Jong, K, M. de Bakker, D. Karssenberg. 2016. A physical data model for fields and agents. European Geosciences Union, EGU General Assembly, 2016, Vienna.