Integration of Time and Space in the Domain of Geography:

A Thorough Analysis of Different Research Studies

Integration of Time and Space in the Domain of Geography:
A Thorough Analysis of Different Research Studies

How Do Contemporary Geographers Integrate both Time and Space in Their Research?

INTRODUCTION

Immanuel Kant (1724-1804) holds a significant position in modern philosophy. Nevertheless, comparatively to his extensive theory of knowledge he is not much well-known for his ideas in physical geography at the University of Konigsberg but still he is considered an influential figure in setting a philosophical base for considering time and space completely separate from each other. Contrary to Kant's opinion, the division of space and time is accepted as a sole definable aspect of reality. It is taken as the domain where without time we cannot have space and vice versa. This perception is among one of the basics of relativity theory and considers time-space in association with the movement of material objects and to events.

In geography, the focus on space-time analysis is increasing in a swift manner. Besides, space and time have always been considered as significant elements of reality by different geographers. Nonetheless, considerable deviations have existed in the meaning linked with these notions. The autonomy of time and space (where each notion gives a discrete context for placing events and objects) is observed in both regional analyses and in attempts to spread geography as an entirely spatial science. In addition to this, for many researchers the combination of time and space into the singular concept of time-space has become an idealistic notion.

In this paper, different aspects of time and space in the domain of geography are presented. A broad view of the integration of both time and space is elucidated in an appropriate manner. In addition, different research studies have been analyzed and presented to determine how the researchers integrate both time and space specifically in the field of geography.

Body (CONTENT)

From an operational and measurement standpoint, research analysts often revert to the Kantian analysis, considering the severance of time and space as a realistic need. Geographers have made an effort to work around this problem in two chief manners. Primarily, descriptive and explanatory models might be used to take into account the human settlement system at diverse instants in time as a way of sensing chronological modifications in the spatial character of the landscape. Next, research analysts may abstract the time aspect of change into phases or levels, occasionally in arbitrary correspondence to the processes being scrutinized. An instance of the later is the employment of census data, where variations might be evaluated over a 10 years phase, for example, population growth surrounded by an area between 2000 and 2010. On the contrary, often researchers also delineate phases of time or stages in accordance with the primacy of particular social conditions (such as, the baby-boom stage) or of current technologies, for instance the automobile period.

In the 1950s and 1960s, efforts made in order to recast geography from a descriptive to an extrapolative/predictive science present a clear edge in the development of thinking about time and space in geography. In the conventional model of regional descriptive geography, time and space were considered as discrete even though concentration was given to documenting landscape circumstances at diverse instants in time. Hypothetical quantitative geography come into sight to deal with the descriptive focus of this convention, however several research analysts kept the severance of time from space in what was expressed as the exceptionalism of the spatial model. This was well-defined by Schaefer (1953) and Bunge (1962), for them geography was an abstract/theoretical science and seeking spatial morphological rules. The combination of geography's theoretical drive with realistic concerns of society, nonetheless, required a predictive point of view. Though invisible and insensible, time and space have engrossed individuals since ancient times (Jammer, 1964).

Due to rapid technical and theoretical advancements and progress, technology has now become extremely complex set of demands and prospective. Though, GIS and geographical databases have been existed for more than 30 years, but has been ignored by the research analysts for a great period of time and it has only been just a few years ago that the concept of the temporal dimension has received a substantial amount of consideration by the researchers of this area (Peuquet, 1999). Directly or indirectly, the representation of time and space has been fundamental for the enhancement of GIS. Highly developed applications need improved integration of time and space and methods to characterize the entities of interest that exceed the objects/fields dichotomy; the prelude of the social viewpoint demands more concentration to the concerns of subjective insights and multiple analysis of spatio-temporal entities and observable facts; and the formation of the information age confronts absolute physical space as the exclusive, undoubted framework for representing geographical actuality.

Couclelis (1999) analyzed the theoretical bases of time and space representations in the four conventional fields of geography, philosophy, mathematics, and physics, lately increased by socio-cultural and cognitive viewpoints. Afterward, the researcher evaluated the place of GIS as information technology at the junction of numerous diverse analyses of time and space, and discussed the tension between that plurality and GIS's strong root in a particular analysis (the *map* analysis). In conclusion, the paper summarizes four challenges for GIS research in the area of spatio-temporal representation: the sound integration of time and space, the representation of relative and non-metric spaces, the representation of vague geographical entities and observable facts, and the adaptation of several spatio-temporal viewpoints to encounter various user objectives and requirements.

According to Maidment (1993), the hydrological cycle (a continuous process) is literally defined as the circular flow and storage of water within our planet. Human beings have been influencing this cycle from the local to the planetary level (Committee on Opportunities in the Hydrologic Sciences, 1991). Human activities like increased use of land for agriculture, cattle farming and urbanization have significantly altered the land cover, influencing the hydrological processes from small watersheds to the regional scales (Sahagian, 2000). A defensive approach to this land cover change is watershed management, which provides conceptual and spatial frameworks regarding efficient and effective management of natural resources.

Mendoza, Bocco and Bravo (2002) has apprehended the correlations between distributed hydrological modeling (DHM), remote sensing (RS) and geographical information system (GIS) techniques, employing their geo-morphological knowledge. The research highlights the inference of hydrological variables, whilst presenting characteristics of the models, techniques, and supporting diagnostic gadgets of geographical hydrology.

Integrated assessment modeling is one of the most efficient methods used for studying the hydrological behavior, synchronizing its spatial and temporal aspects, especially for formulating practical approaches. Venneker and Schellekens (1997) recommended that these models should be testable and prove to be functional under different hydrological and environmental conditions. The integrated study of watersheds intended for planning, engineering and management of environmental resources; generally involves temporal and spatial variability (Venneker and Bruijinzeel, 1997). Drawbacks associated with this form of modeling are need for abundance of high resolution data and great computing requirements, plus engagement of a significant number of parameters and variables makes it complex further (Olsson and Pilesjo, 1999).

Spatially distributed hydrological modeling is an alternative model to study hydrological cycle in areas with inadequate gauging facilities. This line of investigation is relatively less discussed in the literature, rather developed to the application of models in gauged catchments. It integrates conventional hydrological models and the scrutiny of remotely sensed data using geographic information systems (GIS) enabling data modeling under a spatial framework that facilitates the understanding of the hydrological conditions of the watersheds under observation. This further paves the way for having an insight of the effects of degradation and land cover changes on the hydrological equilibrium in non-experimental basins. The knowledge derived from spatial modeling also provides solid foundation to devise management and conservation plans of watersheds, as well as the identification of acute regions that are in need of urgent rehabilitation.

The vision of the classical ecologists and bio-geographers was based on the assumption that the ecological systems are in a state of equilibrium and stability; this is encapsulated in the 'balance of nature' paradigm. However, since the last 30 years, this idea is being turned down; instead a non-equilibrium view, emphasizing the role of chance events for instance, disturbance in ecological dynamics, is gaining momentum. Similarly, the perceptions regarding the roles of space and spatial heterogeneity have been greatly modified. Classical ecological theory overlooked the significance of spatial dynamics and heterogeneity and rather emphasized on temporal pattern. Over the last 20 years this view has also transformed and the importance of spatial pattern has been recognized and raised. Perry (2002) comments on the two major changes in the manner our ecological systems are conceptualized; and he further investigates their inter-relation. Detailed exploration of space and spatial pattern has established the idea that spatial heterogeneity may contribute to both stabilizing and destabilizing of ecological systems and processes.

Studies that compared non-spatial (or spatially implicit) and spatially explicit models of the same system have drawn interesting conclusions. Tilman *et al*. (1997) and Holmes (1997) are captivating researches that have compared spatially implicit and explicit models (of a patch occupancy system and the Kermack–McKendick epidemic model, respectively). Comparison of these two models displays the effects of including spatial variables upon the potential equilibriums in such systems (equilibriums are analytically solvable in the spatially implicit versions of the model and are estimated using Monte Carlo methods in the stochastic, spatially explicit forms). The spatially explicit model of Tilman *et al*. (1997) also observes the emergence of spatial pattern by employing simple spatial processes such as neighbourhood dispersal, even in the absence of underlying environmental heterogeneity. Processes like equilibrium in disturbed landscapes could also be examined using such tests. For example, simple Markov or differential models of landscape dynamics (Calder *et al*., 1992) could be compared with spatially explicit landscape models representing the same systems. The alternate conceptualizations would no doubt yield very different results; whereas a Markov model will always predict a stable (or steady) state equilibrium, such a state may never be reached in a stochastic, spatially explicit model. Novel approaches such as the 'pair approximations' demonstrated by Hiebeler (2000) are significantly capable of bridging the gap between mean-field or spatially implicit models and spatially explicit simulations. They, and other such refined techniques, may also help provide insight into the conditions when non-spatial approaches and approximations break down. Comparison of spatial and nonspatial (or spatially implicit) models is one way in which the role of space in driving ecological dynamics can be investigated.

Spatial approaches like the ones mentioned prior, undertake the establish relationships between the spatial heterogeneity we see at multiple scales with ideas with equilibrium/non-equilibrium and stability/instability. Nevertheless, another study (Steinberg and Kareiva, 1997) has proved it complex to connect spatial theory and empirical (realistic) observations. A large number of spatial ecological theories have been formulated over the last two decades; yet many of them are still untested or better to say unable to be tested due to their unrealistic nature). Steinberg and Kareiva (1997) entitle two approaches to evaluating spatial theory on factual basis. First, parameters are assigned to a specific model and then the predictions of that model are tested using quantitative methods. However, this approach is not followed very often due to the disinclination to all the confidence in a single complex model (Steinberg and Kareiva, 1997).

Second, a common prediction can be tested without reference to a specific model but this approach has the problems of reproduction, statistical power and scale. In most cases, clear-cut manipulative experiments are less reliable and encounter hurdles such as the definition of terms such as stability or equilibrium. Several spatial landscape issues are accompanied by laborious testing methods, as they are subjected to exceptionally rare and hard to document happenings; for instance, long-distance dispersal is thought to be pivotal in invasion. Another problem is the tests are often vague i.e. in most cases it isn't explicit whether their outcomes embody a 'real-world' effect or are an artifact of the designs/scales used in the experiments. Although, many other areas of ecological theory are difficult to be tested empirically yet it does not render them any less scientific or rational. Contrary to this, carefully designed experiments (and new analytical methods developed) provide interesting results. Yu *et al*. (2001), for example, proposed the idea that species coexistence in a homogenous habitat may be boosted by spatial structure integrating spatial models of coexistence with empirical data. More analytical studies in this regard, are needed for effective promotion of wealth of spatial theory development.

Perry and Enright (2006) inspected few methods and some of the applications of landscape-level models of succession and disturbance dynamics. Their study shows that spatially explicit simulation models have gained great momentum as an imperative tools in environmental and bio-geographical studies conducted because of the spatiotemporal scales involved and the logistical constraints in collecting landscape-level data. Further, it compares the mechanistic as well as stochastic models and observes the development of spatial landscape models of environmental changes that has occurred over the last 15 years. Coarse-grained spatial landscape models and finer-grained individual-based techniques (for example, forest gap models) have been compared; management and examining applications of landscape models are measured alongside a debate over the proper utilization of models related to this framework. An acute area of spatial landscape models that calls for development is their enhanced assimilation with the social sciences – with reference to the factors as well as the procedures that the discussed models incorporate. In conclusion, concerns associated with scale as well as scaling have been pointed out and, the effectiveness of processes for relating ecological models functioning at contrasting scales such as, forest gap models opposed to landscape models, has been scrutinized.

Coarse-grained spatially explicit landscape models and fine-grained individual-based gap models represent two different approaches that investigate landscape changes, and both retain their pros and cons. Reproducing any changes in landscape level processes (such as altered disturbance regimes) using gap models is challenging because such models do not involve the occurrence of environmental processes over a large space. Moreover, these changes may be more responsive to any investigations through spatially explicit landscape models. Despite the fact that such landscape models are helpful tools for investigating the relations of instability and landscape patterns, they do not usually provide the species-level information that ecosystem management often requires (He et al., 1999). As exclaimed by He et al. (1999), it is unjustified to anticipate a single model to be able to encompass the entire labyrinths of landscape dynamics involving the spatial and temporal degrees over which they take place.

REFERENCES

- Bunge, W. (1962) *Theoretical Geography*. Gleerup, Lund, Sweden

- Calder, J.A., Bastow-Wilson, J.B., Mark, A.F. and Ward, G. (1992) Fire, succession and reserve management in a New Zealand snow tussock grassland. *Biological Conservation* 62, 35–45.

- Committee on Opportunities in the Hydrologic Sciences 1991: *Opportunities in the hydrologic sciences*. New York: National Academy Press.

- Couclelis, H. (1999) *Space, time, geography. Geographical Information Systems: principles, techniques, management, and applications*. 2d ed., eds. Paul Longley, Michael Goodchild, David Maguire, and David Rhind Vol. 1. New York: Wiley, 29-38.

- Perry, G. L. (2002) Landscapes, space and equilibrium: shifting viewpoints. *Progress in Physical Geography* 26,3 pp. 339–359

- Perry, G.L and Enright, N. J. (2006) Spatial modelling of vegetation change in dynamic landscapes: a review of methods and applications. *Progress in Physical Geography* 30, 1, pp. 47–72

- He, H.S. and Mladenoff, D.J. (1999) Spatially explicit and stochastic simulation of forest-landscape fire disturbance and succession. *Ecology* 80, 81–99.

- Hiebler, D. (2000) Populations on fragmented landscapes with spatially structured heterogeneities: landscape generation and local dispersal. *Ecology* 81, 1629–41.

- Holmes, E.E. (1997) Basic epidemiological concepts in a spatial context. In Tilman, D.A. and Kareiva, P.M., editors, *Spatial ecology: the role of space in population dynamics and interspecific interactions*. Princeton, NJ: Princeton University Press, 111–37.

- Jammer, M. (1964) The concept of space in antiquity. In Smart J J (ed.) *Problems of space and time*. New York, Macmillan

- Maidment, D.R. (1993) *Handbook of hydrology*. New York: McGraw Hill.

- Mendoza, M., Bocco, G., and Bravo, M. (2002) Spatial prediction in hydrology: status and implications in the estimation of hydrological processes for applied research. *Progress in Physical Geography* 26,3, pp. 319–338

- Olsson, L. and Pilesjo, P. (1999) Development and applications of spatially distributed hydrological models in a GIS environment. In *Short course of environmental modelling*. Enshede: ITC. http//www.natgeo.lu.se/lennartweb

- Peuquet, D. J. (1999) "*Time in GIS and geographical databases" in Geographical Information Systems: Principles and Applications* (Maguire, Goodchild, Rhind, and Longley, Eds.), 2nd edition (London: Longman), pp. 91-103.

- Sahagian, D. (2000) Global physical effects of anthropogenic hydrological alterations, sea level and water redistribution. *Global and Planetary Change* 25, 39–48.

- Schaefer, F. K. (1953) Exceptionalism in geography: A methodological examination. *Annals of the Association of American Geographers.* 43: 226-49

- Steinberg, E.K. and Kareiva, P.M. (1997) Challenges and opportunities for empirical evalution of 'spatial theory'. In Tilman, D.A. and Kareiva, P.M., editors, *Spatial ecology: the role of space in population dynamics and interspecific interactions*. Princeton, NJ: Princeton University Press, 318–33.

- Tilman, D.A., Lehman, C.L. and Kareiva, P.M. (1997) Population dynamics in spatial habitats. In Tilman, D.A. and Kareiva, P.M., editors, *Spatial ecology: the role of space in population dynamics and interspecific interactions*. Princeton, NJ: Princeton University Press, 3–21.

- Venneker, R.G.W. and Schellekens, J. (1997) A framework for development of hydrological models. In *The IHE-VUA catchment research and modelling initiative*.

- Venneker, R.G.W. and Bruijinzeel, L.A. (1997) The IHE-VUA Catchment research and modelling initiative CRMI. In *The IHE-VUA catchment research and modelling initiative*.

- Yu, D.W., Wilson, H.B. and Pierce, N.E. (2001) An empirical model of species coexistence in a spatially structured environment. *Ecology* 82, 1761–71.