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EDITORIAL

# The Earth systems and Earth science informatics

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Earth scientists collect, store, manage, process, and organize data about the different components of the Earth system, and about natural and simulated processes. The transition from data to information is achieved through computation, visualization, and other processes that make the data more meaningful to the scientists. All of these activities require information systems, which include people such as IT personnel and scientists who can interpret the data, databases that allow storage and management of data, and software and other information technologies that can process and display the data in meaningful ways. In addition to designing, implementing, and maintaining the information system, informaticists and domain scientists apply existing knowledge to interpret the new information, which may help them to discover new knowledge.

Earth science informatics, as a specialized branch of informatics science, creates and processes information about the Earth system, to allow conceptualization, design, modeling, and implementation methodologies for the management, processing, and representation of the information and knowledge about the Earth. More specifically, Earth science informatics applies informatics science to study the structure, composition, function, production, environment, and interactions of different components of information systems, including people, that develop theoretical and conceptual models (e.g., an ontology, database schema), or store, process, manage, and convey information and knowledge about the Earth system.

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## Ontological view of the Earth system

The Earth is a part of a larger whole, the Solar System, which itself is a part of another larger whole, the Milky Way Galaxy, which is one of many galaxies in the Universe. From this mereological perspective, the Earth is of interest to planetary scientists, astronomers, and cosmologists. At a smaller scale, the Earth itself is a composite system, made of the interconnected and open subsystems of the atmosphere, hydrosphere, geosphere, biosphere, and cryosphere that influence each other by being connected as a result of flow of mass and energy. Each of these parts of the Earth system has its own subsystems and components that are in constant communication and causal relationship. These subsystems and smaller parts are studied by a wide spectrum of Earth scientists with different goals and perspectives (e.g., meteorological, hydrological, geochemical, geophysical).

The constituents of Earth's subsystems are material, concrete things or objects that exist at specific times, independent and outside of our minds, as substantial individuals. Examples of these individuals are: hurricane Katrina, Albert Einstein, Atlantic Ocean, San Andreas Fault, and Grinnell Glacier in the Glacier National Park, Montana. Each object, including the Earth itself, denoted by special signs (e.g., terms in different natural languages), is referenced by a concept that instantiates a type (universal; Dietz 2006). While each individual or object exists in space and time (e.g., Atlantic Ocean), the universal is a construct or concept (e.g., ocean), and exists only in our mind (Bunge 1977). For example, the abstract concept 'Mount St. Helens', which refers to a specific, real volcano in the Cascades, instantiates the abstract 'volcano' type. The real, individual Mount St. Helens volcano is one of many objects in the volcano class, which conform to the volcano type by possessing the set of properties that characterize that type. The types supply global identity conditions to the individuals (Guarino and Welty 2002).

Being a substantial (material) object, every part of the Earth is endowed with a series of properties. For example, the geosphere includes the lithosphere, which is broken into global-scale pieces that are in constant motion and contact with each other. Each of these lithospheric plates has its own properties, and is made of many other objects (e.g., mountains, seas, rocks, fluids, minerals) with their own properties. The lithospheric movements lead to lawful (allowed) physical, chemical, and biological processes that occur in the so-called lawful event space, and transform the state of things (Bunge 1977). At any instant of time, the state of any object that participates in a process, defined by the collection of values for its properties, is in constant flux. The change of state, which is a subject of study by Earth scientists, also occurs in a lawful 'state space', which is restricted by the properties and the physical laws (Bunge 1977).

Through systematic analyses, scientists have discovered that properties in a given type are related to each other through physical (natural) laws that are defined for the type (i.e., universal), and that are themselves complex properties. Their main objective is to generalize their findings (information, knowledge), discovered from the study of the data collected from individuals (e.g., several granitic intrusions or hurricanes), to the type of these individuals (i.e., universals) represented by classes. Science progresses by discovering new properties and laws that restrict the relationship among properties in a given type, and the processes that change the state of objects that conform to the type.

## Need for Earth Science Informatics [ESIN] journal

Earth scientists collect and generate (via models or theories) data about Earth's components and processes either by themselves or by a myriad of instruments located in the atmosphere, oceans, or space, and on continents. Generally, these scientists only know a partial subset of the properties for each type, and assign a set of attributes to each known set of properties in the classes that they design as an extension of the type. The ultimate goal of Earth scientists is to discover the physical laws that map different states of the properties of Earth objects, and learn about the underlying processes that lead to these changes.

Today, advancement of our knowledge about the Earth calls for the application of the white-box model (Dietz 2006) in the integration of the large volumes of data collected by numerous instruments, and generated by models, theories, and people in all fields of Earth science. This approach, which captures the inner structure and dynamics of the complex Earth system, requires an efficient flow of information across fields, and an integrated understanding of the composition, structure, environment, and production in the system. Although the nature of the processes and structure of each subsystem is, to some extent, known to the Earth scientists in each field, the flow of information is restricted to within each field. The white-box approach captures the interrelations and interactions between these subsystems, and hence fields of Earth science, by decomposing and identifying their constituent parts, and understanding the role of these components in the construction and composition of the whole system. Earth science informatics, as defined above, is a promising, emerging field which can undertake the task of knowledge integration by providing the required technology for the integration of knowledge among Earth scientists.

The Earth Science Informatics [ESIN] journal is launched to promote efficient flow of information and knowledge across different fields of Earth science by publishing the latest applications of the theories and methodologies of informatics science in Earth science. It is hoped that the journal will foster interdisciplinary communication among Earth scientists, and help them bring their experiences in applying informatics science in their research. The new journal identifies and promotes the informatics community and provides a forum for the exchange of ideas. Thus, it meets the community's long-standing need for a research publication covering the area between pure physical science and computer science.

## References

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