BRANCHES OF GEOPHYSICS

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Keywords: aeronomy, atmospheric electricity, bradyseism, conchology, dendrology, eustatic change, geochronology, geotherm, Ice Ages, ionosphere, karsts phenomena, magnetosphere, tephra

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Summary

While geophysics is one of the earth sciences, which are themselves a part of science, it is sometimes perceived as being concerned only with physical phenomena Such a distinction is invalid, however, in that the separation of physics, chemistry, biology, and so on only makes sense when carrying out experiments within the human-made laboratory—it is meaningless in the natural environment. The term “environment” can be applied everywhere—even in interstellar space—while the environment of the biosphere is identified with “climate.” Life-supporting systems are concerned with the regions of space and epochs of time where and when the biosphere develops and survives—hence with climate.

The different disciplines into which present-day geophysics is formally subdivided, including references to their respective international organizations, are mentioned in this article. The prime rationale for subdividing disciplines in the earth sciences is so that the solid earth, the seas and oceans, the atmosphere, and the space environment are considered separately. However, such a distinction is in practice self-limiting in that the biosphere, of which humankind is a part, survives and procreates at the boundary between these different realms. The science of the interaction—or mutual coupling—between such different and individually huge disciplines is, perhaps, the most difficult challenge presently facing the human mind.

Science is first of all made of ideas—instruments, measurements, algorithms, and extremely expensive tools are only means for constructing science. Ideas derive from creativity, which was defined by Karl Popper as a “mystic” process. The study of other planets or planetary systems can be very helpful for checking our present understanding of the earth’s “climate,” which is our real concern and challenge. Prior to Galileo (1564–1642), the environment and climate were studied together—as a unique entity.

After Galileo, when laboratory science began, it became customary to treat separately physical, chemical, and biological effects, which has led to the construction of the present-day branches and disciplines. However, within the natural environment all disciplines and their related effects are closely intermingled, and it often makes no sense to carry out such a separation.

Another closely related problem concerns the heuristic potential of numerical models. Just as clinicians cannot rely on mathematical models of their patients, those studying earth sciences can be misled if they rely—with no critical feeling—on such an approach, which in itself is a most interesting logical tool that should be used, although with suitable care. In any case, it is very important that every separation is overcome in order to avoid partial and misleading monodisciplinary interpretations.

Another crucial problem concerns the transfer of information between the world of science and society. There is an urgent need for substantially improved relations between scientists, legislators, decision makers, and the mass media. The consciousness, within both the scientific community and society, of everybody's role and their potential capabilities, appears to be fundamental in optimizing the management of both territory and the environment, of hazards, risks, emergencies, and catastrophes, and, perhaps, even for the long-term survival of humankind. A correct way of conceiving the science of natural phenomena, and the relation between humankind and territory, is, perhaps, the most fundamental concern of real civilization.

1. Science, the Earth Sciences, and the Environment

Science is the study of nature, and the earth sciences are a subset of it. An important premise here is concerned with the definition of space scales and timescales. Humans inadvertently reckon everything by their own size.

The reference timescale is the average life span of an individual. The age of the sun and the solar system is about 4.6 billion years (see *Solar System*). Earth's history is characterized by events and variations occurring on a scale of several tens of millions of years or longer (see *Continents on the Move* and *Rock Magnetism and Palaeomagnetism*). Some large climatic variations—such as the Ice Ages—are known to occur on scales of about 10 000–100 000 years, although there is evidence of some complex and much older glacial histories. Volcanic activity, average planetary climate temperature phenomena, the magnetic field of the earth, and several related phenomena, display an interannual or secular variation that occurs on a scale of several decades, and are probably associated with some presently not-understood time modulation of solar influence and/or endogenous processes within the earth (see *Geophysical Phenomena and Processes*; *Solar System*; *Volcanology: Volcanic Areas, Chemistry, and Effects on the Environment*; and *Terrestrial Heat Flow*). The best-known cyclic phenomena appear to be the approximately 11- (or 22-) year sunspot cycle, and the quasi-biannual oscillation (QBO) of about 27 months. ENSO and NAO seem to be anomalous variations, occurring every few years. Cycles of time-varying duration, in the time range of several years to several centuries, modulate the activity of different volcanoes. Cycles of a much shorter period are the lunar month and the diurnal variation, and there are some of even shorter duration—such as within a geyser (see *Terrestrial Heat Flow*).

Typical relative space- and energy-scales can be perceived by considering a model earth, or "terrella," with a scale of 1:100 million (i.e., a ball slightly less than 13 cm in diameter, covered by a film of about 0.1 mm—the troposphere—(in the real earth about 10 km in height), while the oceans are a film covering less than two-thirds of the terrella surface and having an average thickness of about 0.04–0.05 mm). Note that the atmosphere's heat capacity is about one-thousandth of the ocean's. The biosphere is some sort of microscopic mustiness, located almost entirely within two such very thin layers, or at most within some lesser region very close to them.

Earth sciences deal with all that is either directly or indirectly concerned with the earth. Environment is a term that applies as such everywhere (e.g., in intergalactic or interstellar space), denoting the ensemble of all quantities or indices that characterize the state of a given domain of space–time. The biosphere can develop and survive only in a limited region of space and interval of time. The "environment of the biosphere" is here simply called "climate." A word of caution here: the commonly accepted definition of climate is identified with the average state of the atmosphere on some suitable space scale and timescale; a discipline that should more properly be considered as long-range statistical meteorology, and in fact, humans have lungs rather than gills. On the other hand, it makes no sense to consider the atmosphere and the oceans separately—oceans play a crucial role in controlling atmospheric temperature As long as life-supporting systems are concerned, climate is the focus, while environment enters into play only as far as it affects it.

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Biographical Sketch

Professor Giovanni P. Gregori ,is currently at the Institute of Acoustics, O.M. Corbino of CNR, located in Rome, Italy. His work there is the study of the application of acoustic emissions to environmental and climatic studies. During the period 1963–2001 he was at the Institute for the Physics of the Atmosphere of CNR, in Rome, his main concern being solar–terrestrial relations and climate. He obtained a "laurea in Physics" in 1961 from the University of Milan, and a "libera docenza" in Terrestrial Physics in 1971. Some relevant information: member of the panel on the earth's electrical environment of the National Research Council of the United States of America (1982); co-chairman of the Interdivisional Commission of the IAGA for External/Internal (E/I) Geomagnetic Relations (1983–1987); chairman of the WG V-3 of the IAGA on the E/I Geomagnetic Relation*s* (1987–1991); in 1991, Associate of the Royal Astronomical Society (1991); member of the executive committee of the IAGA (1991–1995); chairman of the Interdivisional Commission on History of the IAGA (1995–1999); foreign member and later honorary member of the Deutsche Geophysikalische Gesellschaft e.V., Arbeitskreis Geschichte der Geophysik (1999); and in 2000 he was invited to contribute to a volume of autobiographical notes in *Wege zur Wissenshaft*, *Gelehrte erzählen aus ihren Leben* (ed. W. Schröder), *Arbeitskreis Geschichte der Geophysik und Kosmischen Physik*, Bremen, Germany. His main research interests deal with the mechanisms of climate, including the role of humankind since its earliest appearance. The "more traditionally known" factors are, perhaps, highlighted in his recent monograph "Galaxy–Sun–Earth relations" (see Bibliography).