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Models and Morphology: Achieving Planetary Geomorphological Uberty

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Like much of science, geomorphology is being transformed by rapid advances in computational power, allowing for accelerating growth in the use of quantitative models that predict and simulate the operations of systems, which are presumed to embody the essential components of real-world phenomena. Planetary geomorphology is especially interesting in this context because the pace of scientific study is extremely rapid as new landscapes are discovered or resolved at greatly increased resolution because of the spectacular technological innovations that are being applied in planetary exploration. The most powerful of the new models are essentially deductive systems, which, if properly formulated according to first principles, produce outcomes that are necessarily and justifiably true. However, the resulting truth is only relevant to the validity of the system context in which the models are formulated. Testing "the fit of the model" is not the same as "testing the model," since a physical model is not just its operation in physical terms; the truthfulness of model prediction or simulation also depends on the presumption that the system being modeled is indeed truly representative of the real world. Unbeknownst to many practicing scientists, however, this issue has been compounded by 20th-century developments in logic showing that objective, justifiable, explanatory truth is an elusive expectation in regard to scientific inquiry because of what is termed "the under-determination of theory by data"). A more tractable and reasonable scientific goal is that of uberty, which is a kind of continuing growth of fruitfulness of inquiry and associated development of understanding.

The importance of these philosophical considerations is probably best understood in how they underlie some current controversies in planetary geomorphology. A particularly striking example is provided by what has been termed the "Early Mars Climate Conundrum." Ever since the first global planetary imaging missions of the 1970s the geomorphological features on its surface have revealed Mars is to be a water world, but one having a very different geological evolutionary track than that of Earth. However, physically impressive radiative-convective and global climate models are not able to predict the prolonged periods of precipitation, surface-water flow, deep weathering, and other manifestations of earth-like hydrological cycling that occurred on early Mars. This has led to a "Noachian Icy Highlands" paradigm, holding that exotic, cold-climate phenomena must be envisioned to account for the relevant geomorphological phenomena. Is it the proper role of physical modeling to define the research paradigm, or is that the proper role of nature—to stimulate the alternative working hypotheses that can be subsequently elaborated with the aid of physical modeling tools, keyed in advance to systems that are already highly attuned to what nature presents?