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Environmental complexity across scales: mechanism, scaling and the phenomenological fallacy

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Ever since Van Leeuwenhoek used a microscope to discover "new worlds in a drop of water" we have become used to the idea that "zooming in" - whether in space or in time - will reveal new processes, new phenomena. Yet in the natural environment – geosystems - this is often wrong. For example, in the temporal domain, a recent publication has shown that from hours to hundreds of millions of years the conventional scale bound view of atmospheric variability was wrong by a factor of over a quadrillion (10**15).
Mandelbrot challenged the "scale bound" ideology and proposed that many natural systems - including many geosystems – were instead better treated as fractal systems in which the same basic mechanism acts over potentially huge ranges of scale. However, in its original form Mandelbrot's isotropic scaling (self-similar) idea turned out to be too naïve: geosystems are typically anisotropic so that shapes and morphologies (e.g. of clouds landmasses) are not the same at different resolutions. However it turns out that the scaling idea often still applies on condition that the notion of scale is generalized appropriately (using the framework of Generalized Scale Invariance). The overall result is that unique processes, unique dynamical mechanisms may act over huge ranges of scale even though the morphologies systematically change with scale. Therefore the common practice of inferring mechanism from shapes, forms, morphologies is unjustified, the "phenomenological fallacy". We give examples of the phenomenological fallacy drawn from diverse areas of geoscience.