In fluid dynamics the *Reynolds Number* is the ratio of inertial to viscous forces, and is used to distinguish laminar from turbulent flow:

$Re = \rho V D/\mu$,

where ρ is density and μ the molecular viscosity of the fluid, V is velocity, and D is depth (or pipe diameter). One way to think of it is that Re is the ratio of the effects of factors external to the fluid driving flow (e.g., gravity for water in a stream channel) vs. the internal resistance of the fluid.

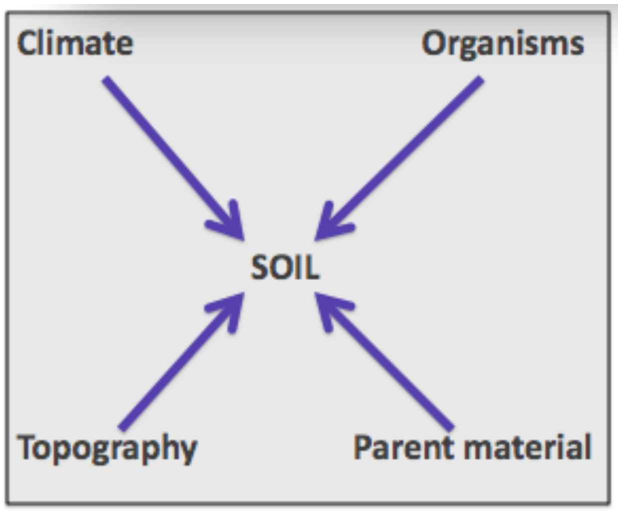
Peter Haff (2007) applied this logic to develop a landscape Reynolds number, and also suggested how other generalized "Reynolds numbers" can be constructed as ratios of large-scale to small-scale diffusivities to measure the efficiencies of complex processes that affect the surface. As far as I know, there has been little follow-up of this suggestion, but the premise seems to me quite promising at an even more general level, to produce dimensionless indices reflecting the ratio of larger to smaller scale sets of processes or relationships.

Take, for example, the famous "clorpt" equation, articulated in this form by Hans Jenny from the seminal pedology ideas of V.V. Dokuchaev:

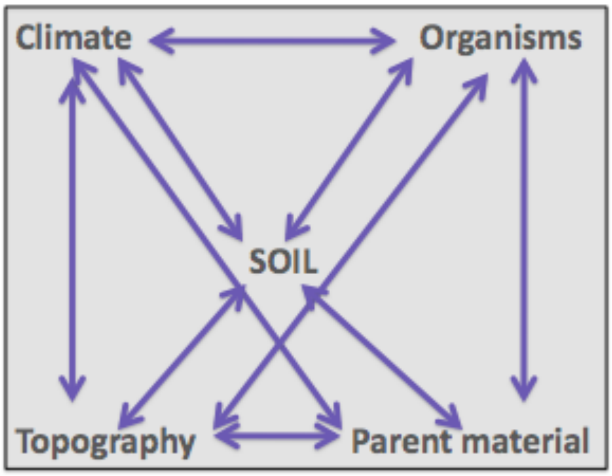
S = f (cl, o, r, p, t) . . . .

where S is soil type or a soil property, cl = climate, o = organisms or biota, r = relief (topography), p = parent material, t = time, and the trailing dots indicate the possibility of other soil forming factors not included in the others that may be locally important (e.g., sea-level or salinity in coastal locations).

Time is the only independent state factor, and soil, climate, organisms, topography, and parent material are in fact interdependent, at least globally. The "clorpt" equation, represented as a network-graph, looks like this:



The overall set of relationships looks like this:



If we just used the numbers of links or edges in the graph (recalling that the double arrows each represent two edges) to represent the relative importance of the "global" set of interrelationships with respect to the "local" set of state factor influences on soils:

Scale ratio = 20/4 = 5.

Alternatively, using the spectral radius[1] of the associated graphs,

Scale ratio = 4/1.732 = 2.31

Of course, having a clever measure of something is a long way from knowing what it means, or putting it to good use. However, I think by applying this sort of analysis to a number of Earth surface systems, some meaningful patterns could emerge.

For another example, consider the ratio of cross-sectional stream power in a river channel (rate of work or energy expenditure for the entire cross section) to the stream power per unit weight of water as a measure of macro/micro scale:

Scale ratio = $\gamma A V S/VS = \gamma A$

where γ is specific gravity of water, A is cross-sectional area, V is mean velocity, and S is the energy grade slope. This tells us that the macro/micro ratio scales as a function of channel cross-sectional area (since specific gravity is more or less constant), which is not very surprising to any geomorphologist, hydrologist, or engineer. On the other hand, maybe this reveals something about the importance of cross-sectional area we haven't thought about before.

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[1]Spectral radius is equal to the largest eigenvalue of the adjacency matrix of a graph, and is generally considered the best index of graph complexity.

Haff, P.K., 2007. The landscape Reynolds number and other dimensionless measures of Earth surface processes. Geomorphology 91, 178-185.