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Reduced Complexity Modeling (RCM): toward more use of less

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Although not exact, there is a general correspondence between reductionism and detailed, high-fidelity models, while 'synthesism' is often associated with reduced-complexity modeling. There is no question that high-fidelity reduction- based computational models are extremely useful in simulating the behaviour of complex natural systems. In skilled hands they are also a source of insight and understanding. We focus here on the case for the other side (reduced-complexity models), not because we think they are 'better' but because their value is more subtle, and their natural constituency less clear.

What kinds of problems and systems lend themselves to the reduced-complexity approach? RCM is predicated on the idea that the mechanism of the system or phenomenon in question is, for whatever reason, insensitive to the full details of the underlying physics. There are multiple ways in which this can happen. B.T. Werner argued for the importance of process hierarchies in which processes at larger scales depend on only a small subset of everything going on at smaller scales. Clear scale breaks would seem like a way to test systems for this property but to our knowledge has not been used in this way. We argue that scale-independent physics, as for example exhibited by natural fractals, is another. We also note that the same basic criterion – independence of the process in question from details of the underlying physics – underpins 'unreasonably effective' laboratory experiments. There is thus a link between suitability for experimentation at reduced scale and suitability for RCM. Examples from RCM approaches to erosional landscapes, braided rivers, and deltas illustrate these ideas, and suggest that they are insufficient.

There is something of a 'wild west' nature to RCM that puts some researchers off by suggesting a departure from traditional methods that have served science well for centuries. We offer two thoughts: first, that in the end the measure of a model is its performance against observations , not its provenance; and second, that a rule-based approach is a way in which traditional descriptive approaches can be made concrete, specific, and predictive. As such RCM represents an avenue for formalising description that has not been exploited as far as it could be. Improved metrics for comparing models with observations might be one way to enhance acceptance of RCM approaches as a useful complement to high-fidelity modeling for complex natural systems.