Geophysical Research Abstracts
Vol. 18, EGU2016-4626, 2016
EGU General Assembly 2016

Input to state stability in reservoir models

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Models in ecology and biogeochemistry, in particular models of the global carbon cycle, can be generalized as systems of non-autonomous ordinary differential equations (ODEs). For many applications, it is important to determine the stability properties for this type of systems, but most methods available for autonomous systems are not necessarily applicable for the non-autonomous case. We discuss here stability notions for non-autonomous nonlinear models represented by systems of ODEs explicitly dependent on time and a time-varying input signal. We propose Input to State Stability (ISS) as candidate for the necessary generalization of the established analysis with respect to equilibria or invariant sets for autonomous systems, and show its usefulness by applying it to reservoir models typical for element cycling in ecosystem, e.g. in soil organic matter decomposition. We also show how ISS generalizes existent concepts formerly only available for Linear Time Invariant (LTI) and Linear Time Variant (LTV) systems to the nonlinear case.