Turing pattern formation in vegetation models for arid environments

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Highly organized vegetation patterns are typical of arid and semi-arid environments and manifest themselves as bounded vegetated regions separated by bare ground areas. From the ecological viewpoint, they play a fundamental role as indicators of climate changes and regime shifts. In particular, experimental observations reported abrupt transitions between a patterned state and the desert state that are typically associated to the occurrence of subcritical instabilities. At the same time, other field data noticed inertial effects in the vegetation response (in particular for the woody component) and in patterning dynamics.

Motivated by these observations, we investigate the formation of banded vegetation in arid environments in the framework of a hyperbolic generalization of the Klausmeier model [1]. In particular, we aim at elucidating how the properties exhibited by supercritical and subcritical patterns are affected by the inertial times, in both transient and stationary regimes [2],[3]. To this aim, we carry out, first, linear stability analysis to deduce the threshold condition for Turing pattern formation and, then, weakly nonlinear analysis (based upon the multiple scale method) to describe the time evolution of the pattern amplitude close to the instability threshold. In our analysis, we consider the case in which the emerging patterns do not have any spatial structure, as it is typically assumed in small domains, as well as the scenario in which patterns form sequentially and propagate over a large domain in the form of a traveling wavefront. A comparison with numerical simulations and experimental data is also addressed.

REFERENCES

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