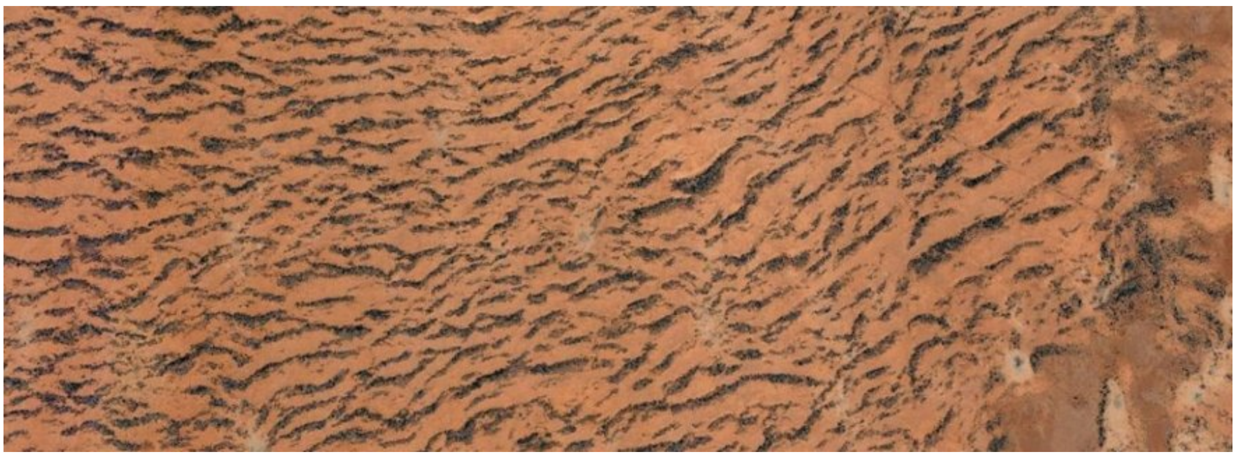
Mathematics as weapon against desertification

October 22 2018



Google Earth image from the research area (8°5'N; 47°27'E), with clear vegetation patterns.

Ph.D. student Robbin Bastiaansen applies mathematics to get insight in practical problems. By comparing mathematical models with developments in existing ecosystems, he hopes to demystify the process of desertification. His research has been published in *Proceedings of the National Academy of Sciences* (*PNAS*), a rare achievement for a mathematician.

During desertification, a desert area is extending or a new desert is created. Intermediates of this process are 'almost deserts," with vegetation patterns where vegetation and bare spots alternate (see banner picture). For his research Bastiaansen studied the properties of these patterns. By joining forces with mathematicians and ecologists, he looked at the typical behavior of models and the implications of this on real ecosystems. New available data sets from satellites provide valuable information, for example about the biomass of these patterns. This enabled Bastiaansen and co-authors to make a thorough comparison between model predictions and reality.

Irrevresible

One of the most important findings is the 'multi-stability' that the areas show. "In the near-desert areas, not one specific pattern is predominant, but a whole range of patterns is possible," Bastiaansen explains. "This means that these areas are much more robust and resilient than previously known and will therefore less quickly than expected collapse into a bare, barren desert." This is particularly important because such a collapse is virtually irreversible: a completely withered area will be very difficult to get overgrown again—even if it is not disturbed further and / or climatic conditions improve again.

Bastiaansen finds it a challenge to use mathematics to tackle social problems. Desertification is one of these: "There are many areas on earth that are threatened by desertification. In these areas there are also many people who depend on cattle and crops for their food supply, and this requires fertile soil. The prevention of such irreversible 'desertification' is therefore very important for the population."

The unique collaboration between mathematicians and ecologists has been essential for the research. "It was only through this collaboration that it was possible to include the general behavior of models on the one hand and translate the behaviour into measurable ecology on the other," says Bastiaansen. However, this cooperation also involved challenges:

concepts from one discipline were not always known in the other, or sometimes have a slightly different meaning. "That requires a lot of consultation, coordination and patience," Bastiaansen now knows.

Although the researchers have done their best to make measurable comparisons possible, many things were not yet feasible due to lack of data. "The desertification process, for example, is relatively slow. We would have liked to have looked at the course of this process, but there is still too little data available for this: detailed satellite photos only go back forty years in time." The standard models also have some shortcomings. The challenge is therefore to improve these, to make them correspond better to reality. "Moreover, more knowledge about the exact steps of the desertification process is needed, in order to ultimately prevent the spread of deserts worldwide."

More information: Robbin Bastiaansen et al. Multistability of model and real dryland ecosystems through spatial self-organization, *Proceedings of the National Academy of Sciences* (2018). DOI: 10.1073/pnas.1804771115

Provided by Leiden University