

Comparison of model and real dryland ecosystems suggests high adaptiveness of vegetation patterns

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Other people involved:

Mathematicians

- ❖ Olfa Jaïbi
- ❖ Eric Siero
- ❖ Arjen Doelman

Ecologists (theorists)

- ❖ Koen Siteur
- ❖ Maarten Eppinga
- ❖ Max Rietkerk

Ecologists (data scientists)

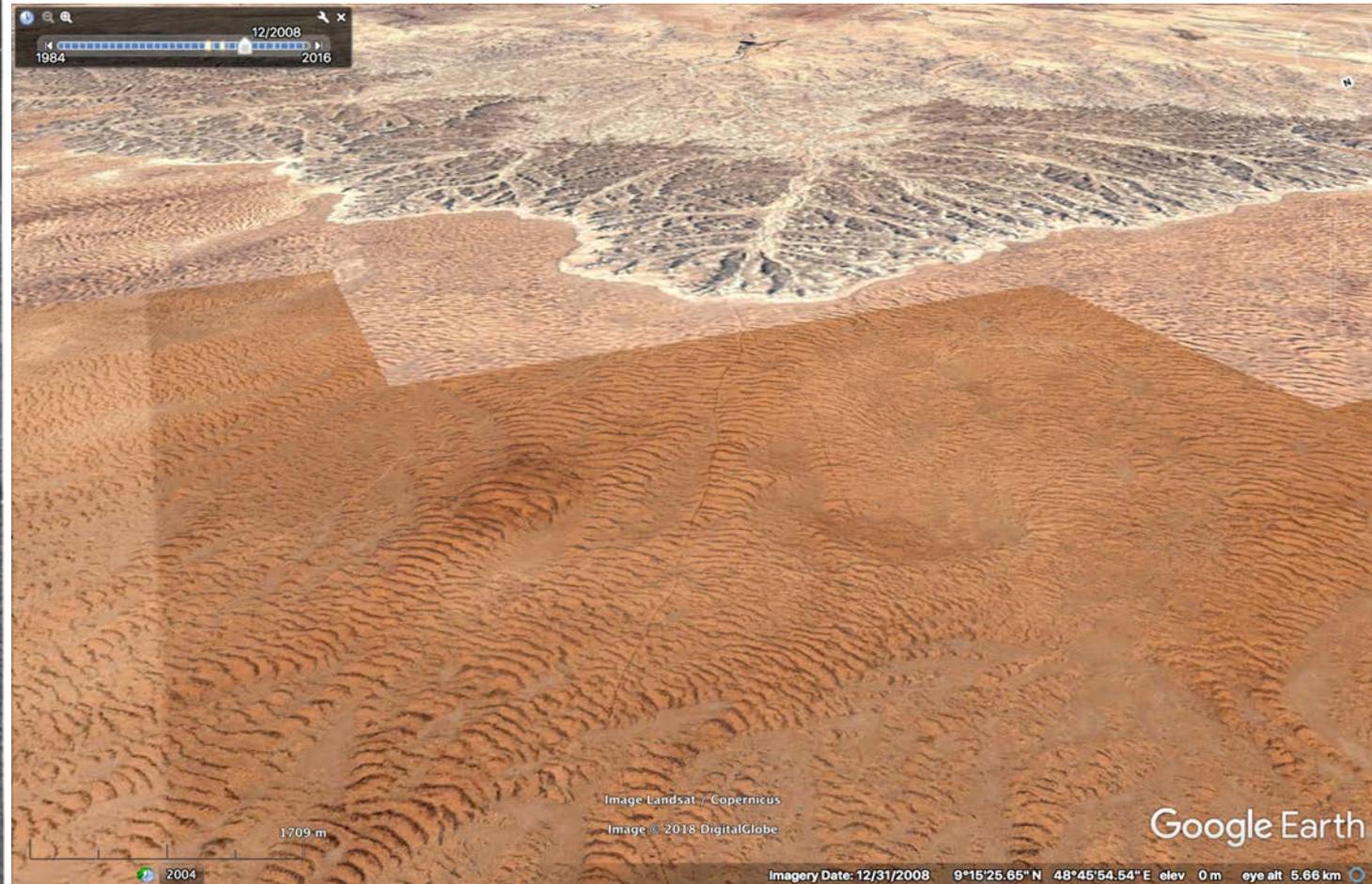
- ❖ Vincent Deblauwe
- ❖ Stephane Mermoz
- ❖ Alexandre Bouvet

Patterns are omnipresent in dryland ecosystems



Somaliland, 1948

Source: W. A. Macfadyen, 1950



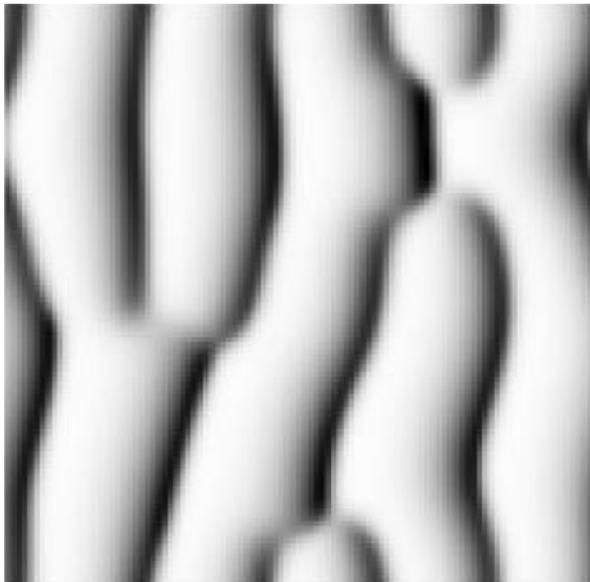
Somaliland, 2017

Source: Google Earth, 2018

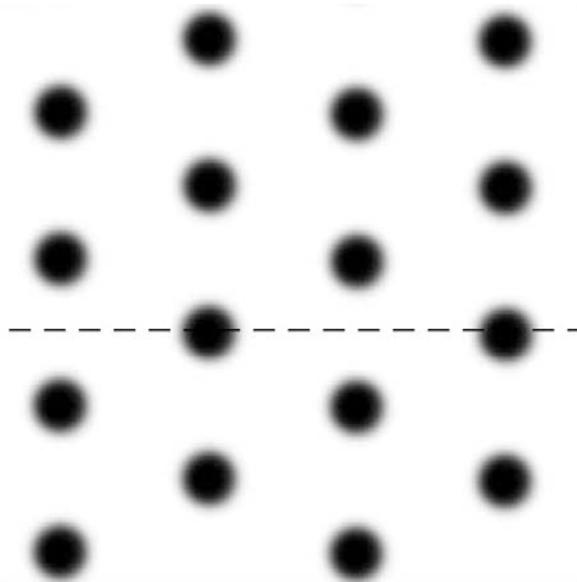
Reaction-diffusion equations model ecosystems

Archetype model: extended-Klausmeier model

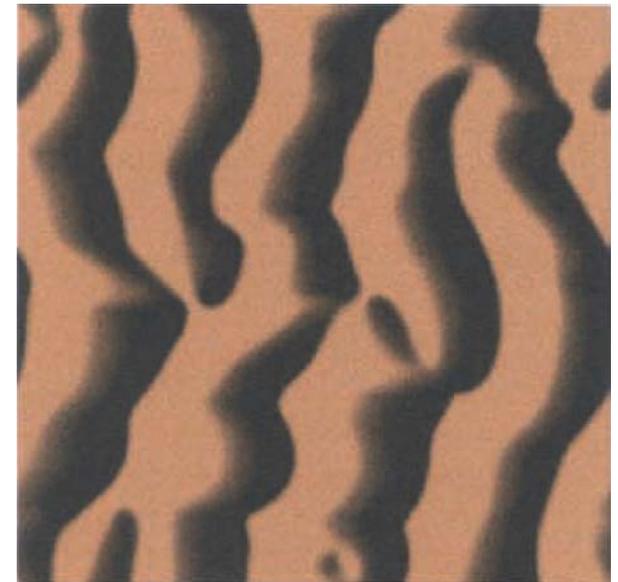
$$\begin{cases} \frac{\partial w}{\partial t} &= e \frac{\partial^2 w}{\partial x^2} + \frac{\partial(vw)}{\partial x} + a - w - wn^2 \\ \frac{\partial n}{\partial t} &= \frac{\partial^2 n}{\partial x^2} - mn + wn^2 \end{cases}$$



Source: Klausmeier, 1999

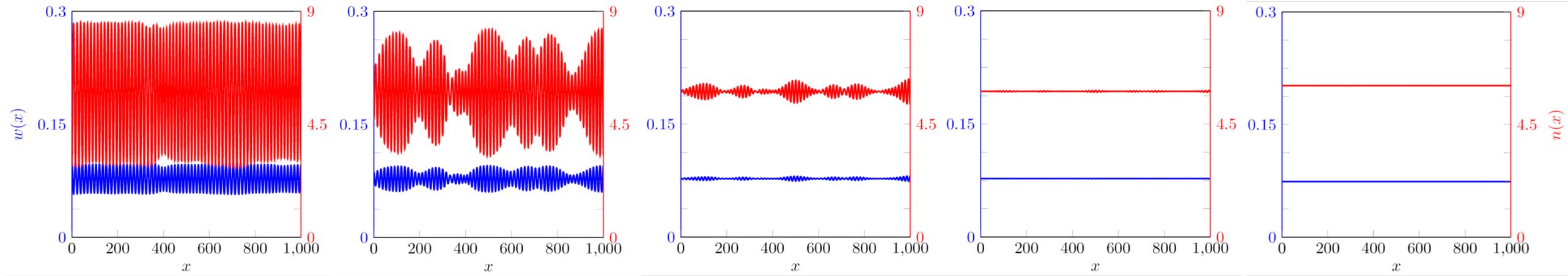


Source: Gilad et al, 2004



Source: Rietkerk et al, 2002

The origin of patterns in reaction-diffusion models



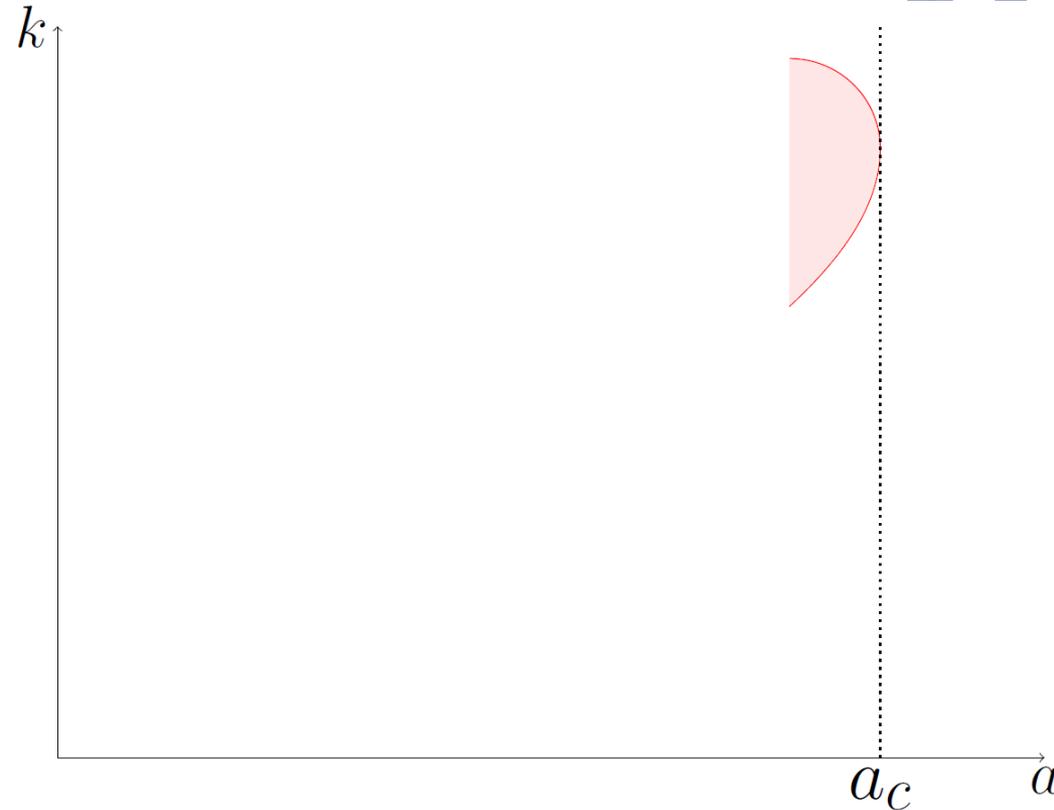
← Low rainfall

Critical rainfall
Onset of patterns

High rainfall

Turing Patterns [Turing, 1952]
Found in most reaction-diffusion equations

Wavenumbers of Turing patterns

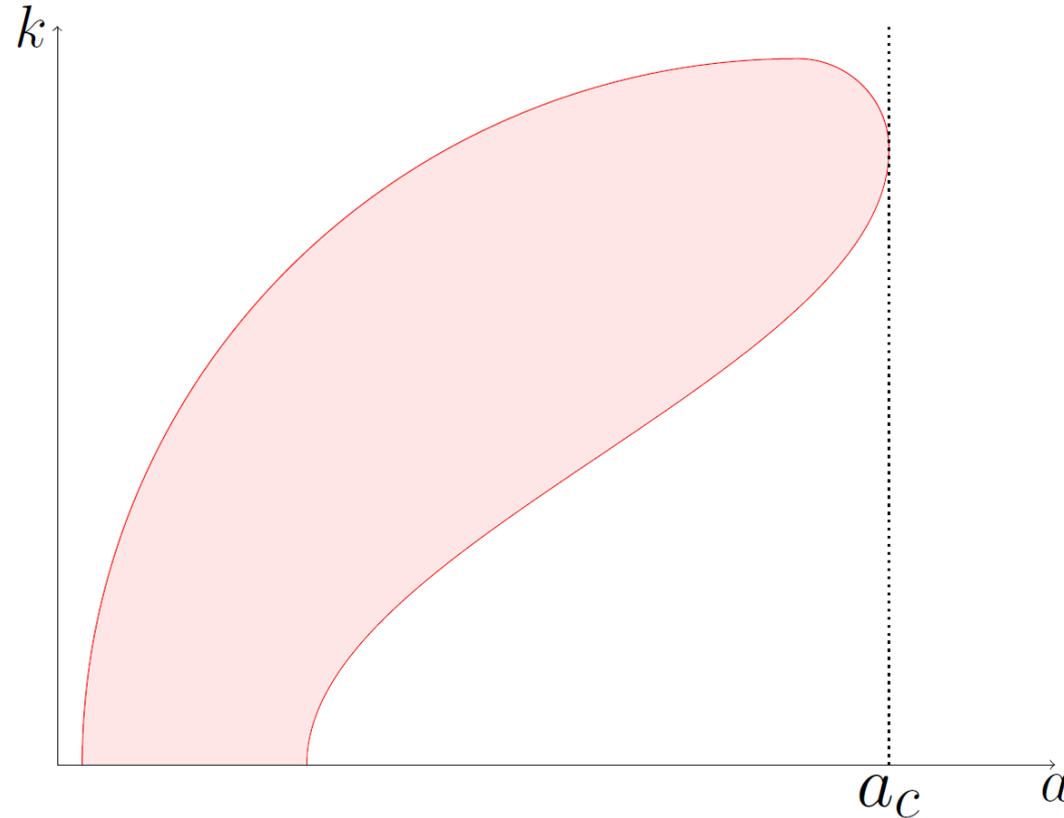


Eckhaus/Benjamin-Feir-Newell instability criterion

[Eckhaus, 1965; Benjamin & Feir, 1967; Newell, 1974]

Determination of the stable Turing patterns

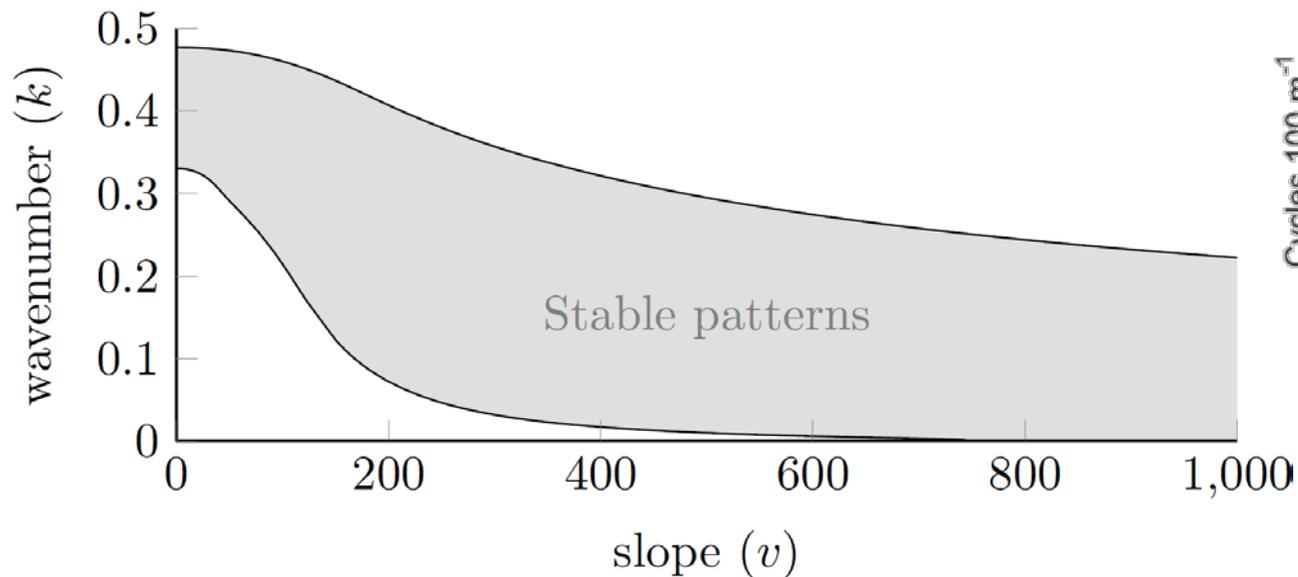
Busse balloon



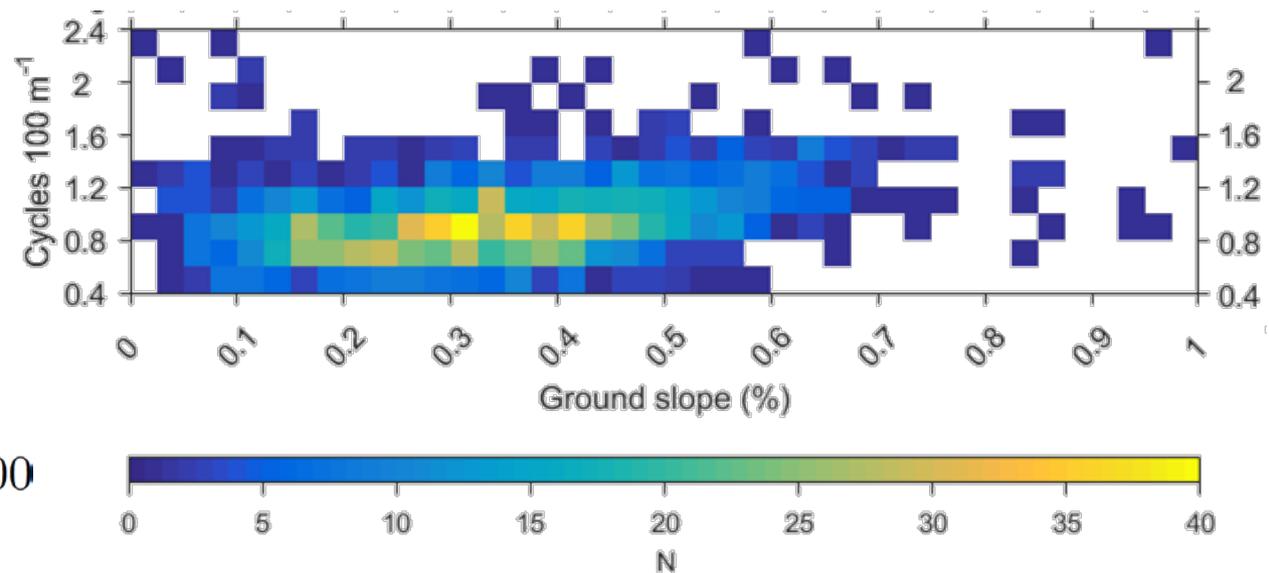
Busse balloon [Busse, 1978]

A *Busse balloon* is a model-dependent shape in (*parameter, wavenumber*)-space that indicates all combinations of parameter and wavenumber that represent stable solutions of the model

Busse balloon in dryland ecosystems



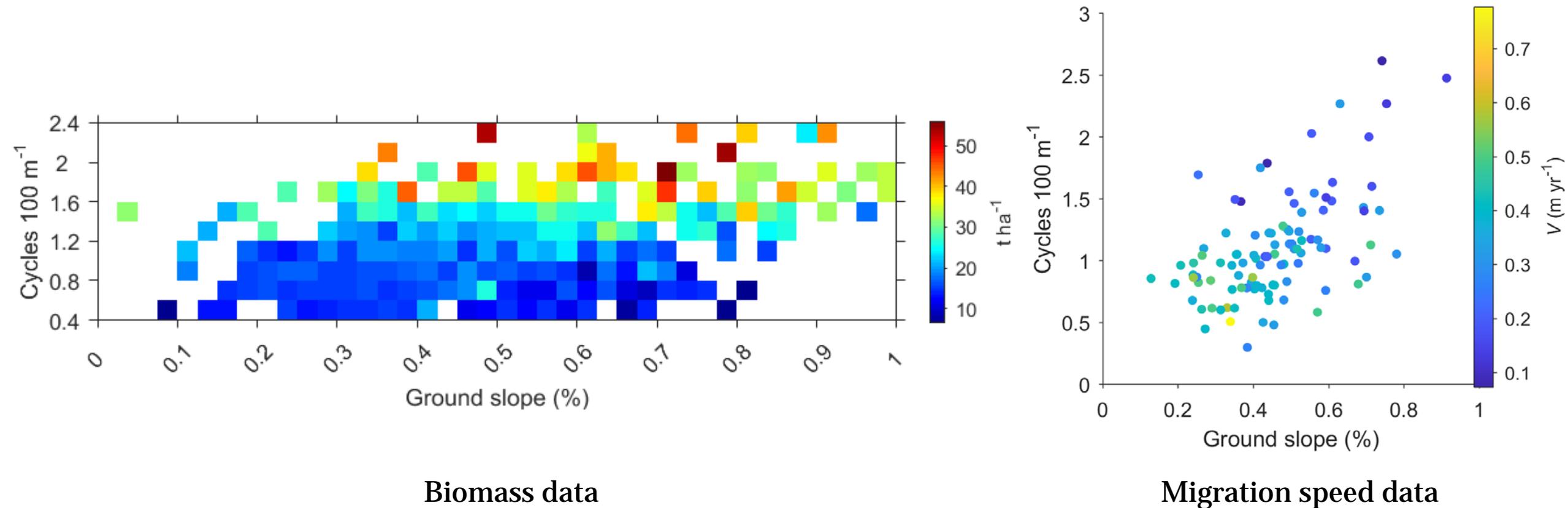
extended-Klausmeier model



Somaliland data

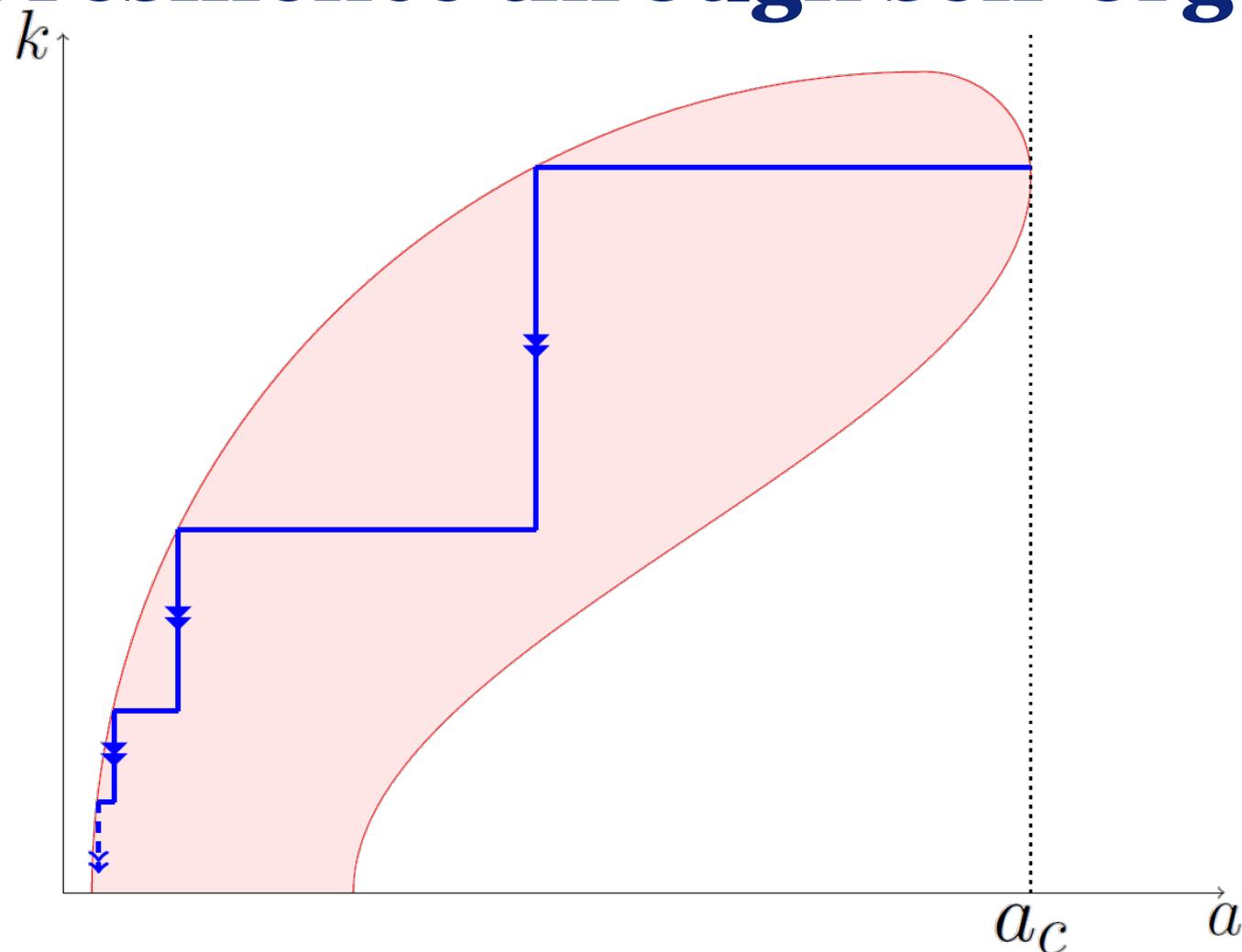
Wide wavenumber spread in both!

Wavenumber influences state variables



Biomass and migration speed change with wavenumber!

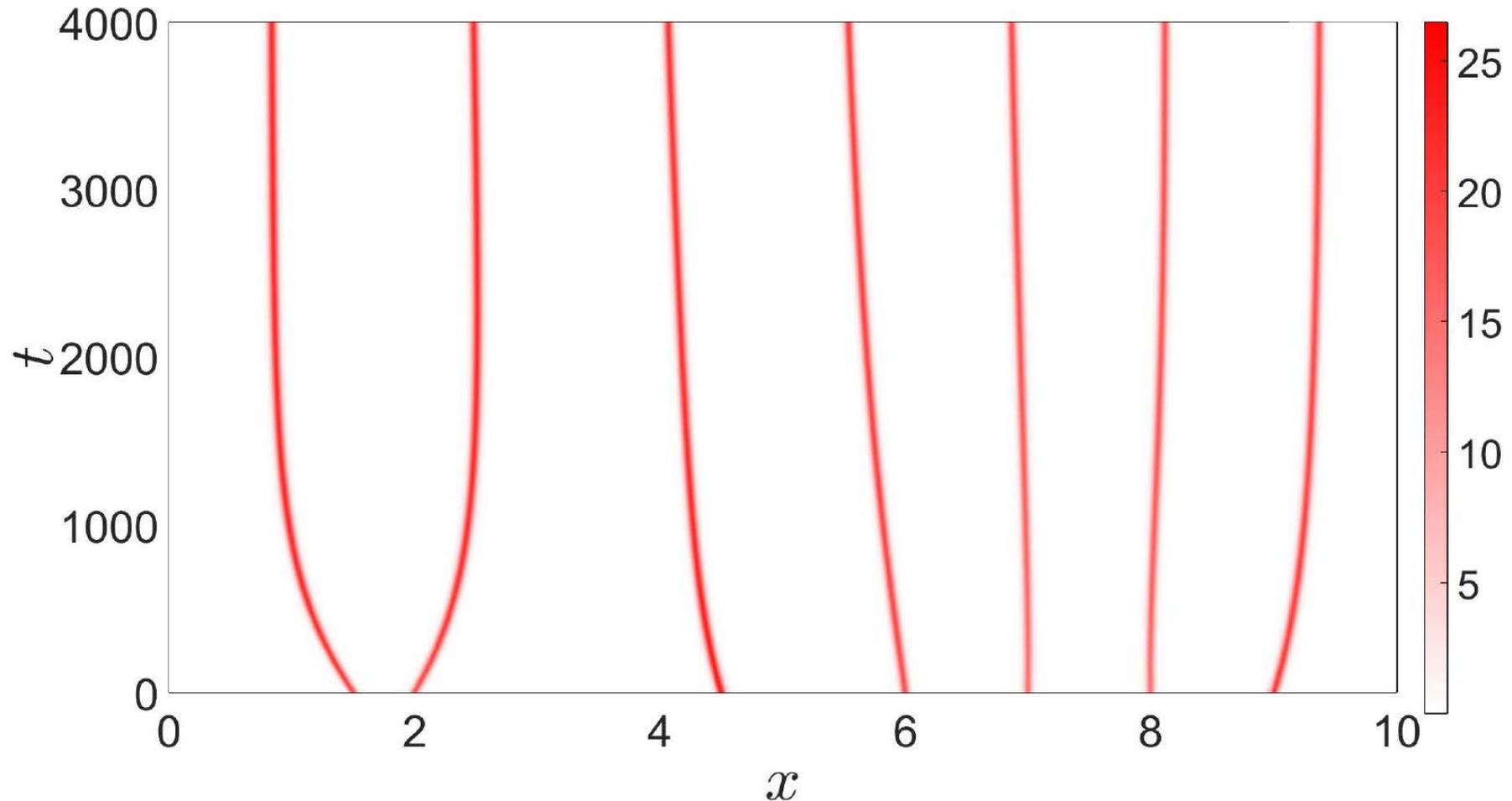
Enhanced resilience through self-organisation?



Wavelength adaption

Siteur et al, 2014

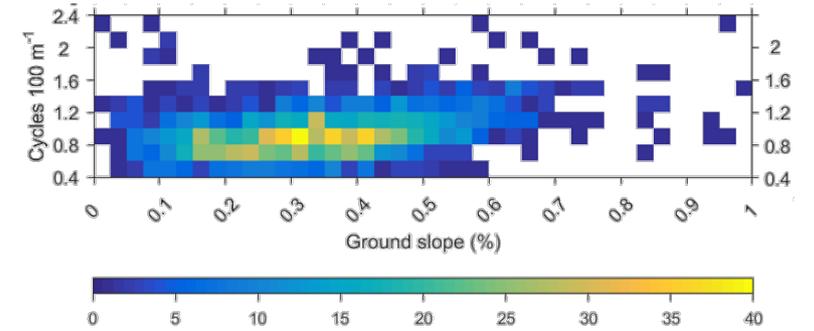
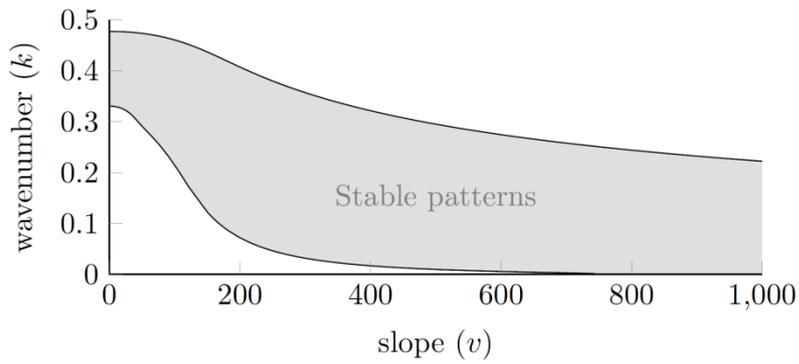
Enhanced resilience through self-organisation?



Pulse rearrangement

Bastiaansen & Doelman, *submitted*

Conclusions



Wide wavenumber spread in model and real dryland ecosystems

implies

Biomass and migration speed change with wavenumber

and suggests

Enhanced resilience through self-organisation via ...

Wavelength adaption

&

Pulse rearrangement

