Particle-based numerical modeling of a thin granular layer subjected to oscillating flow

Communications in Nonlinear Science and Numerical Simulation
Volume 97, June 2021

B. Crespin, M. G. Clerc, G. Jara-Schulz, M. Kowalczyk

Université de Limoges, XLIM/ASALI, UMR CNRS 7252
Center for Mathematical Modeling, UMI (2807), Universidad de Chile

Journée MIRES Axe 2 - Poitiers, 02/06/2022

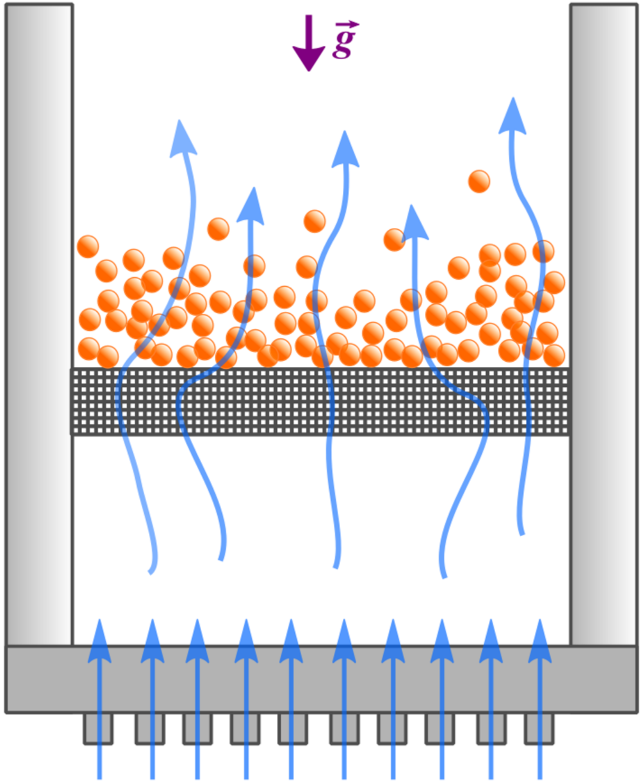
Fluidized granular media

- Granular matter: small, solid components that **behave like a liquid and/or solid**

- To fluidize such a system, **external energy** must be supplied, for example by mechanical agitation or **an up-flow of gas** strong enough to counter gravity

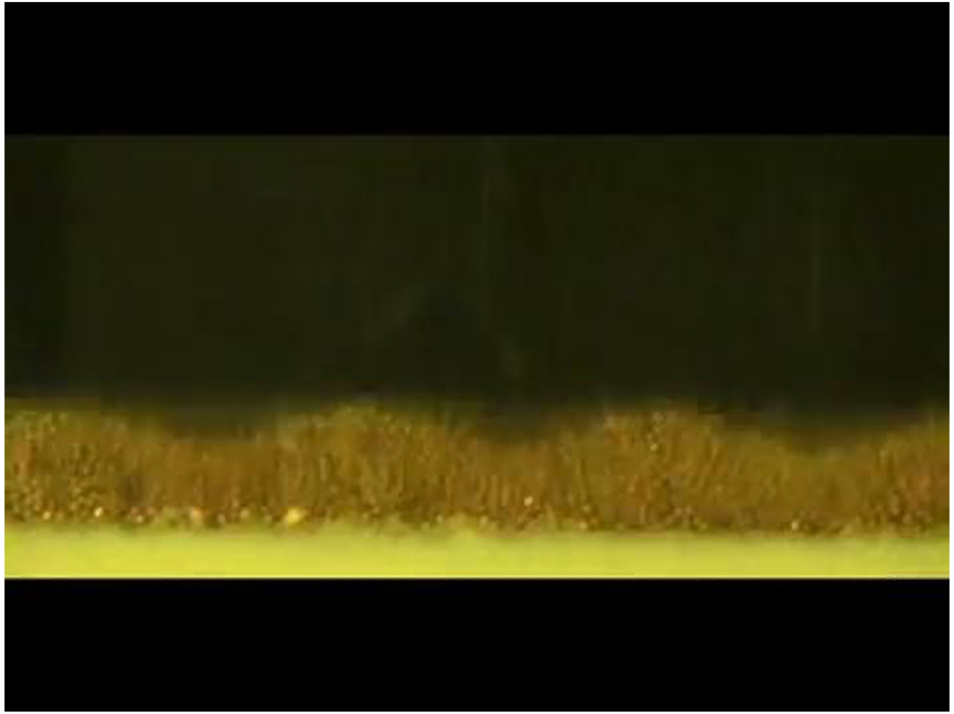
- We propose a **simple numerical model** to characterize **self-organization phenomena**

Experimental setup

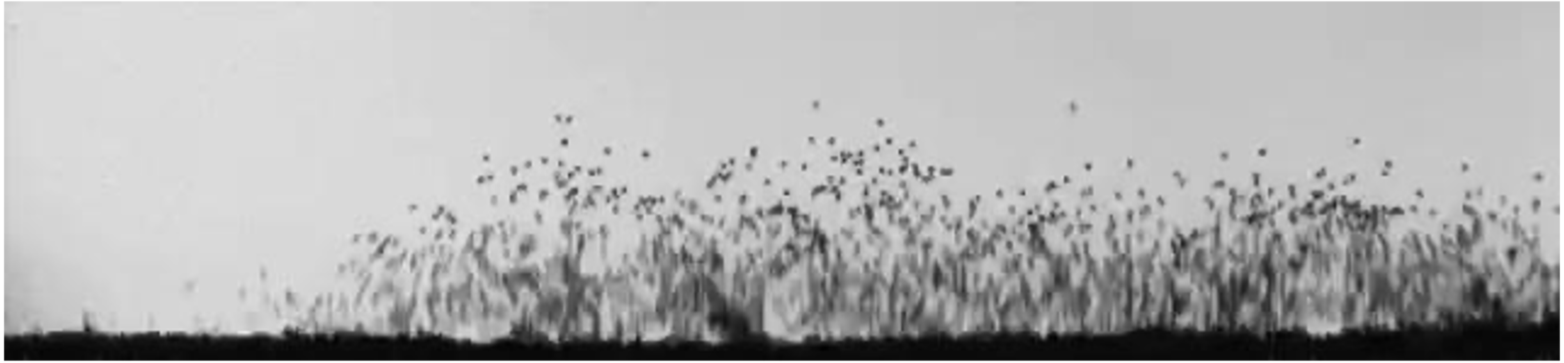


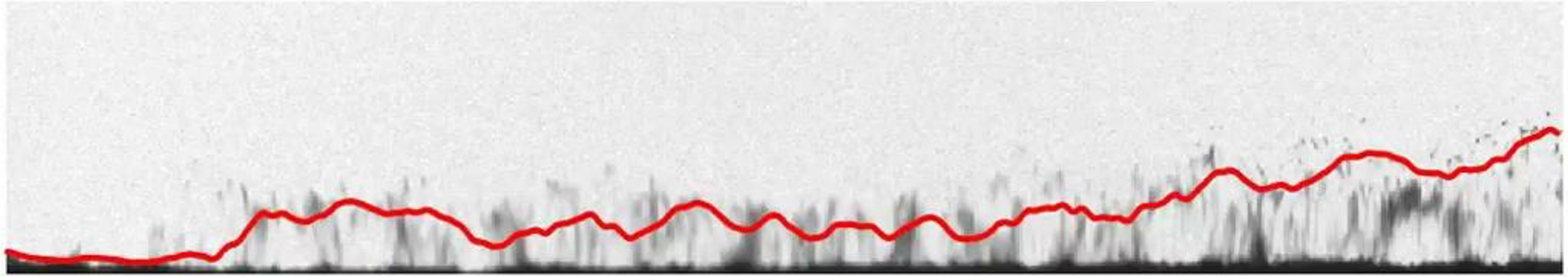
- Monodisperse **bronze particles** of diameter d = ~350 μm
- Thin granular layer (5d high, 400d long, and **10d deep**)
- **Periodic airflow** comes from an air compressor and is regulated by an electromechanical valve
- Control parameters:
    - f_0: **frequency** of the modulated pressure
    - ΔP: **amplitude**

Homogeneous regime



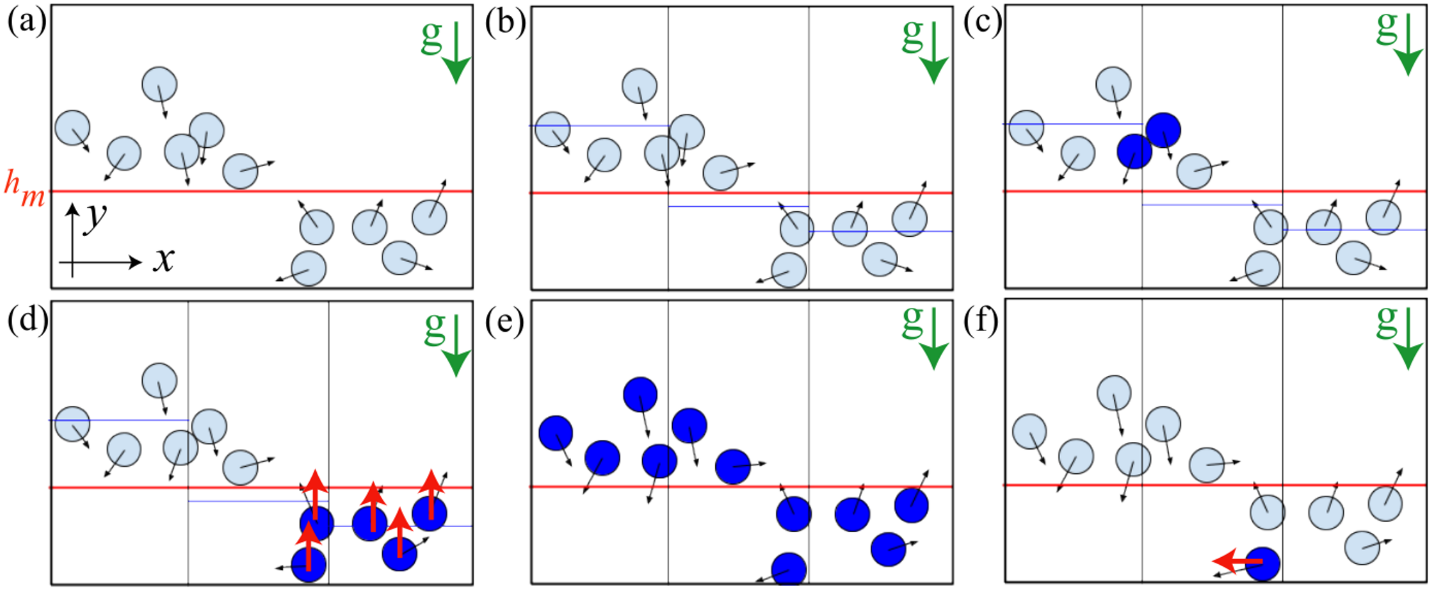
Moving kink regime (stroboscopic view)



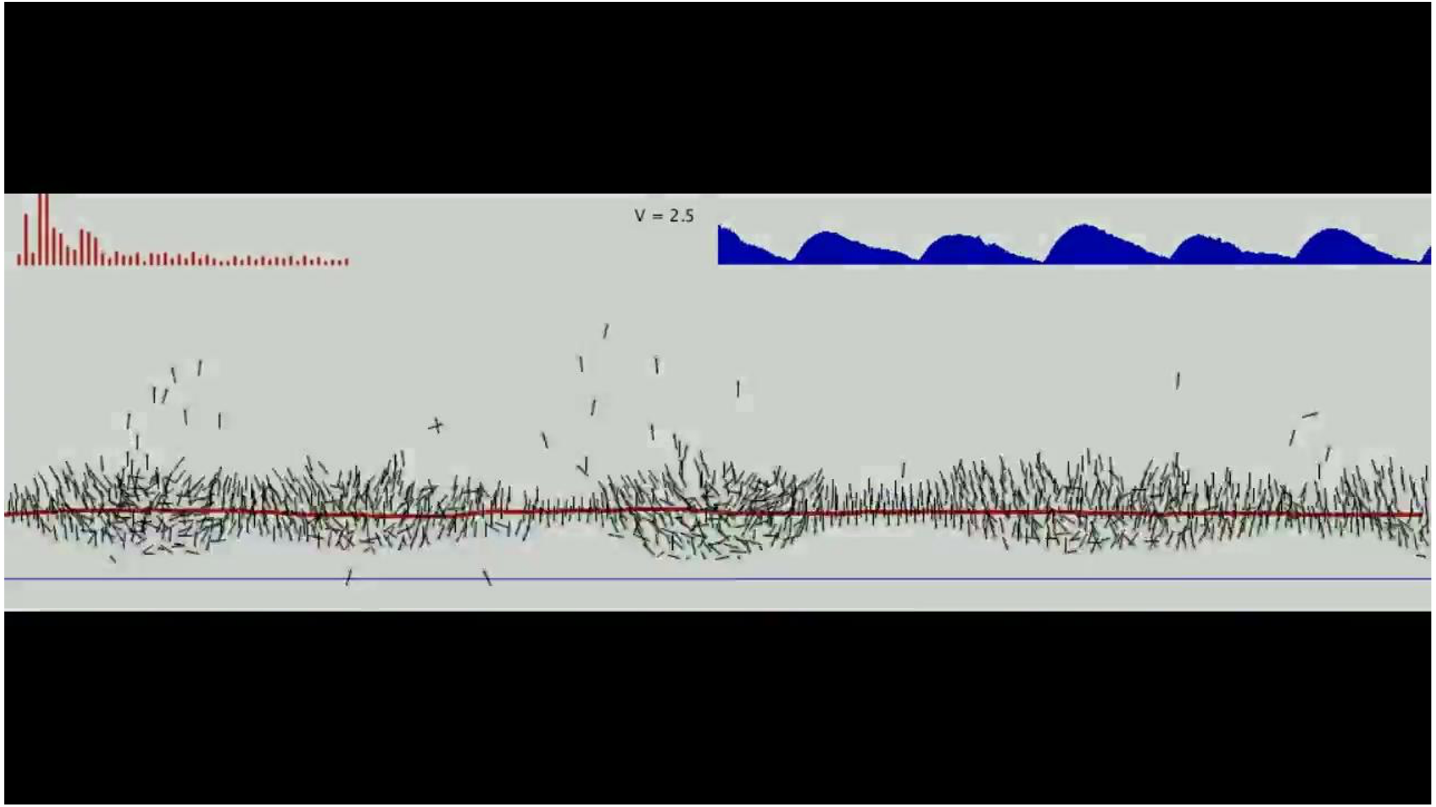


Particle-based numerical modeling

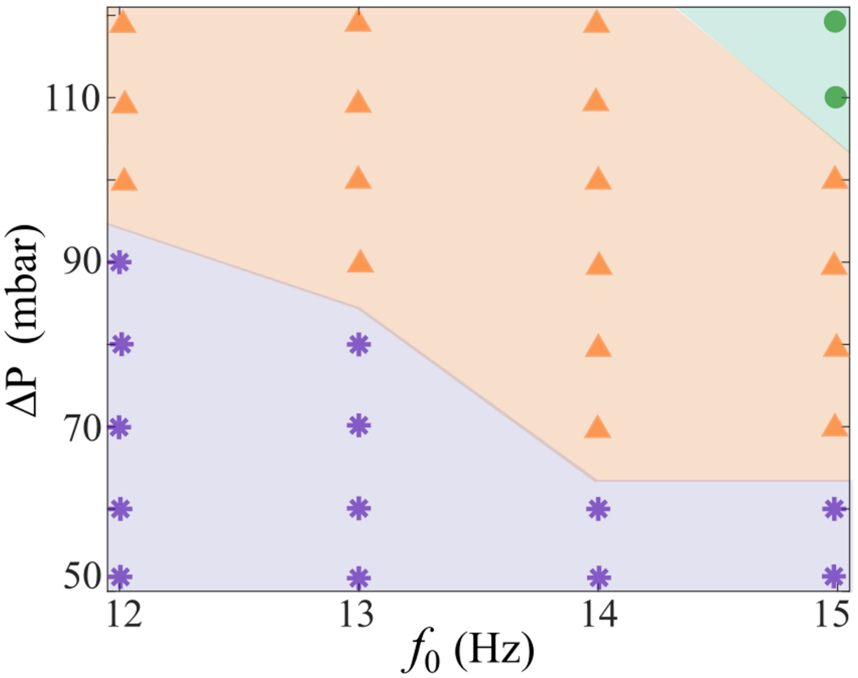
- Simplified 2D particles model :
  - elastic collisions between solid particles
  - the air flow is modelled by a **drag force related to h^3**

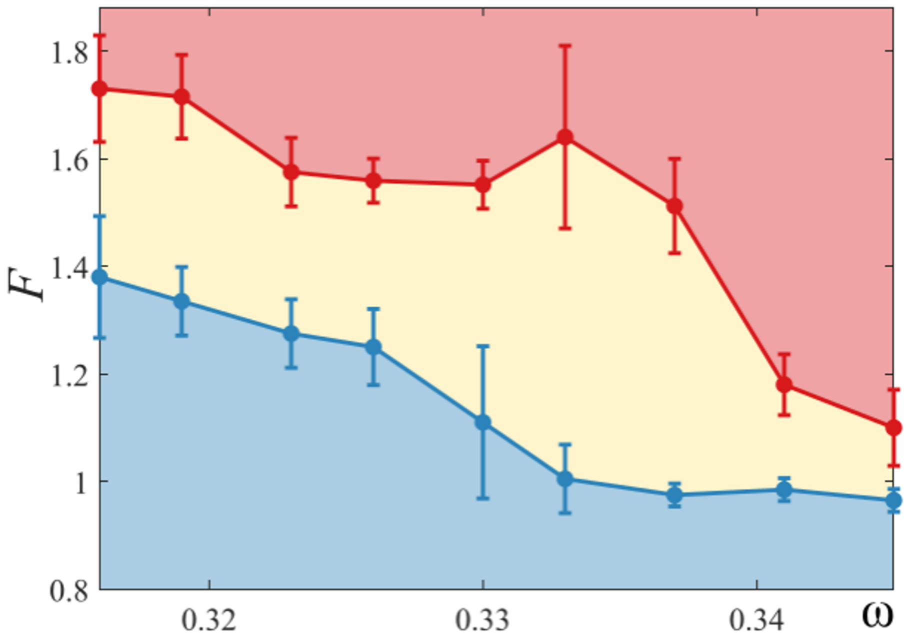


Numerical results

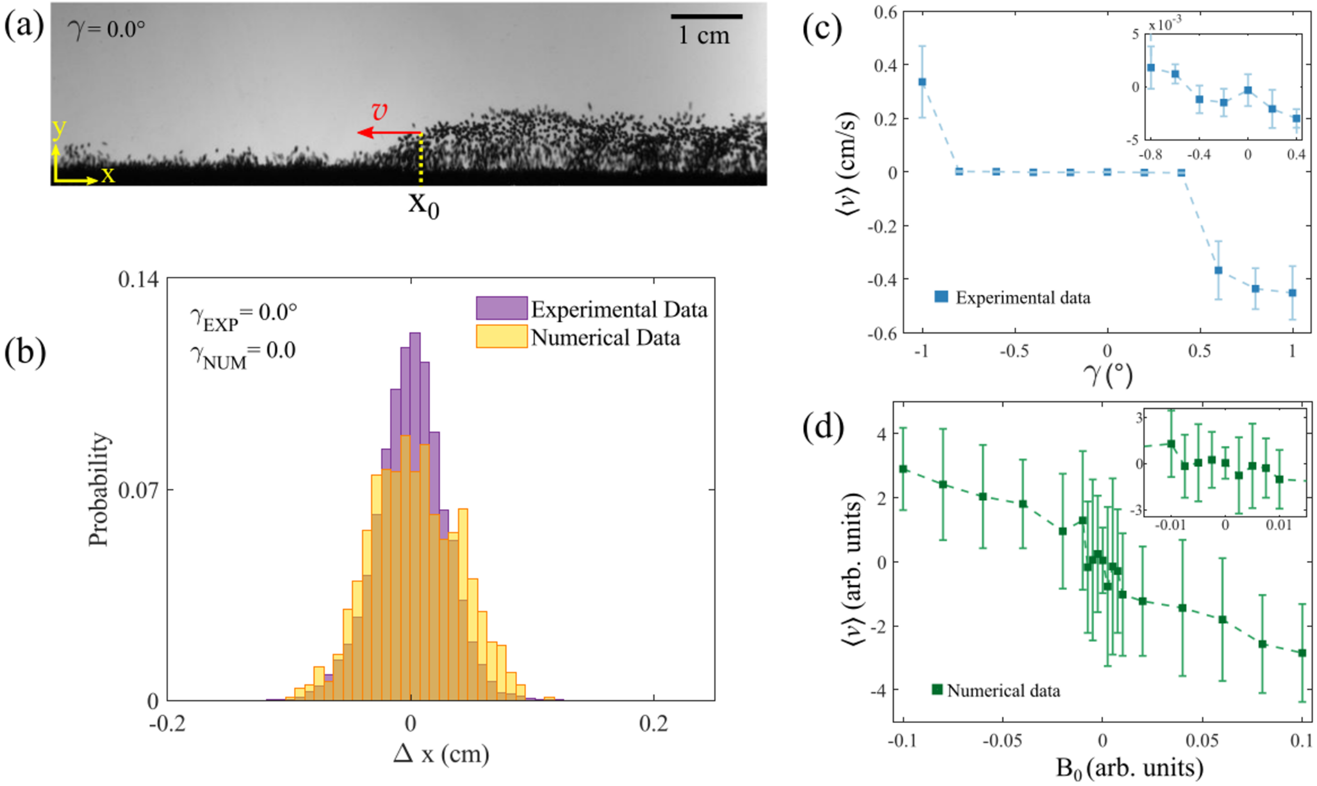


Experimental vs numerical results (regimes)



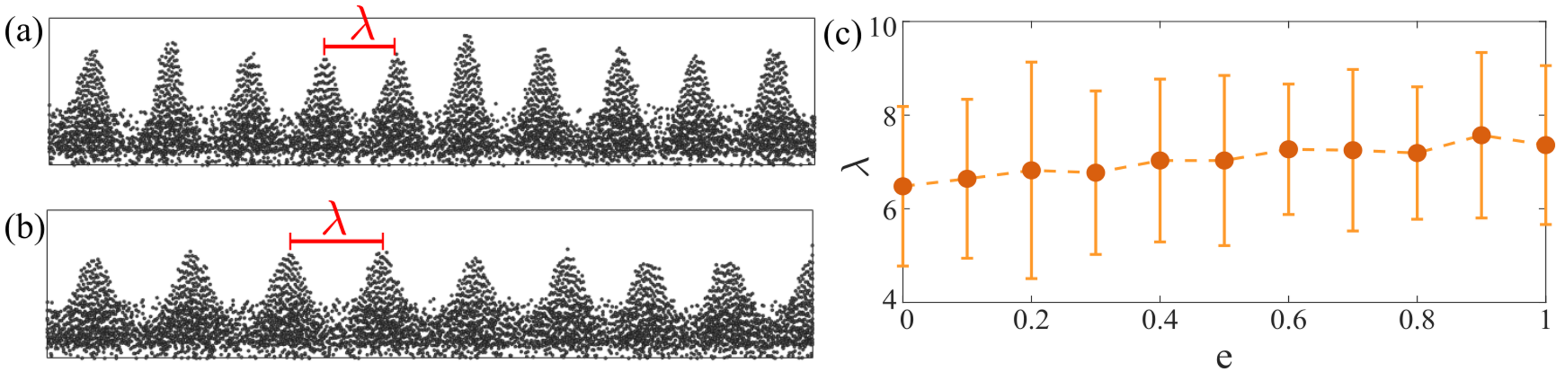


Experimental vs numerical results (kink displacement)



Numerical results (pattern wavelength vs friction)

… difficult to reproduce with real experiments



Discussion

- A **minimal model** in good agreement with experiments:
  - first step to describe the dynamics of complex phenomena through coarse-graining processes, and derive **mathematical models**
  - makes it possible to study **new behaviours**
  - … but not able to reproduce all phenomena (eg *convection rolls*)

- Next steps:
  - Towards more realism ?
    - GPU implementation in 3D ?
    - represent airflow ?
  - Towards less realism ?
    - heightfield-based discrete model ?