

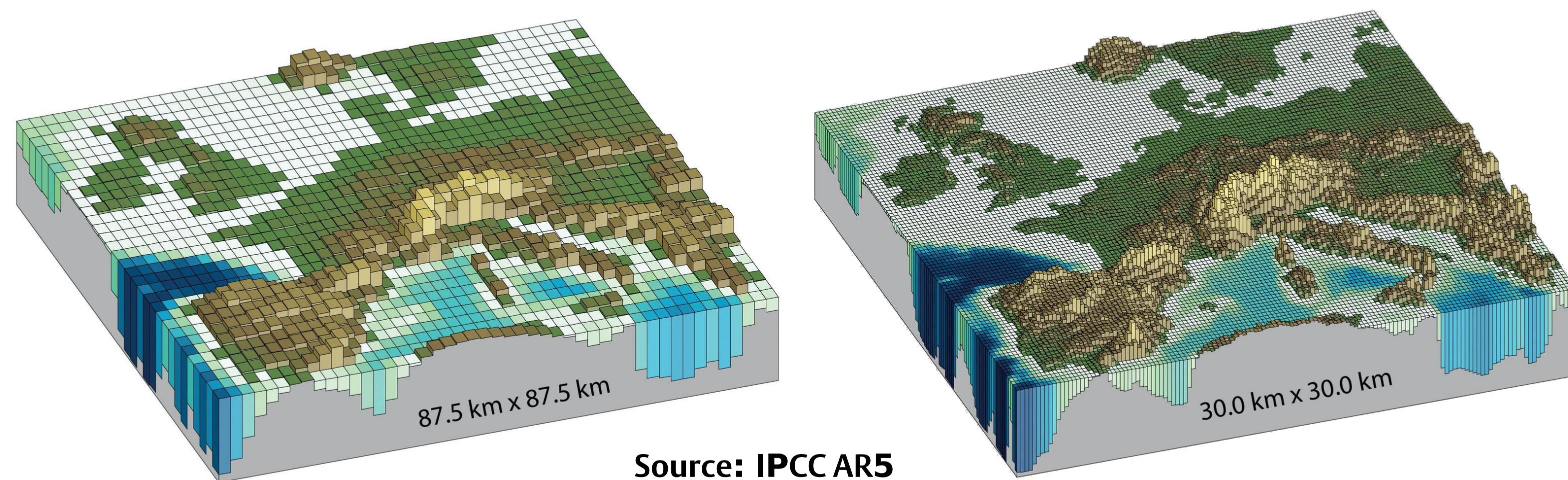


# Improving numerical accuracy over steep slopes

James Shaw | Hilary Weller | John Methven | Terry Davies

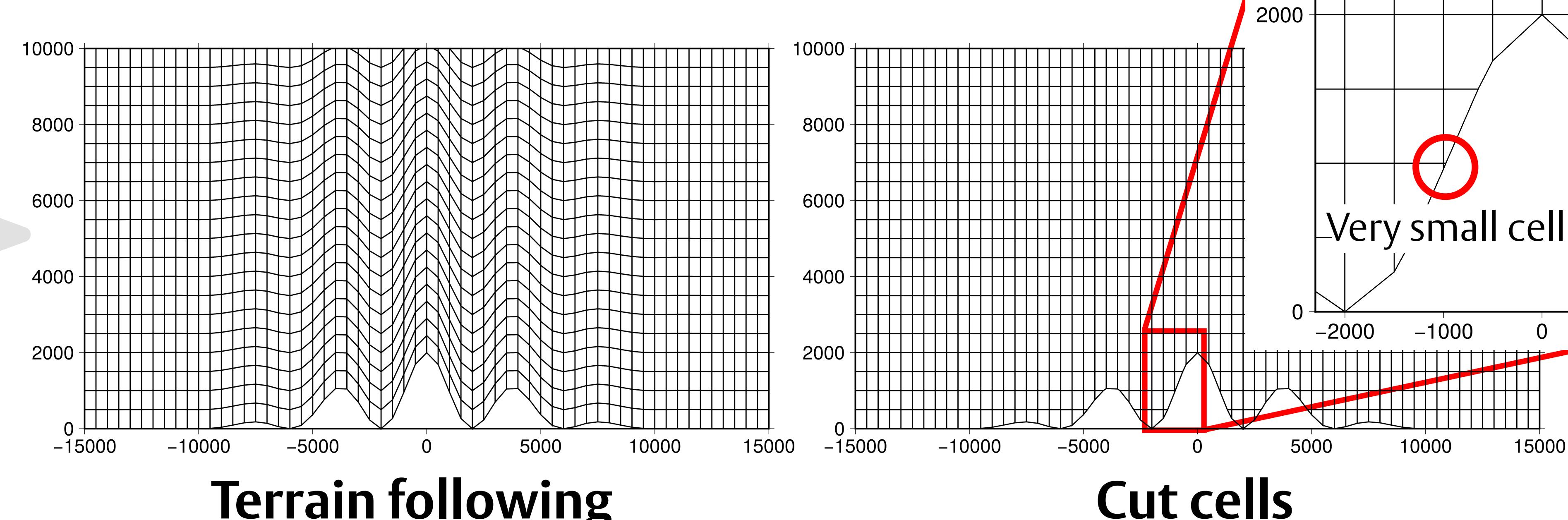
js102@zepler.net | @hertzsprrung | datumedge.co.uk

## Motivation



- Increasingly fine meshes allow atmospheric models to resolve small-scale, steep slopes
- Steep slopes reduce accuracy when traditional numerical schemes are used
- I am exploring new meshes and numerical schemes to improve accuracy over steep slopes

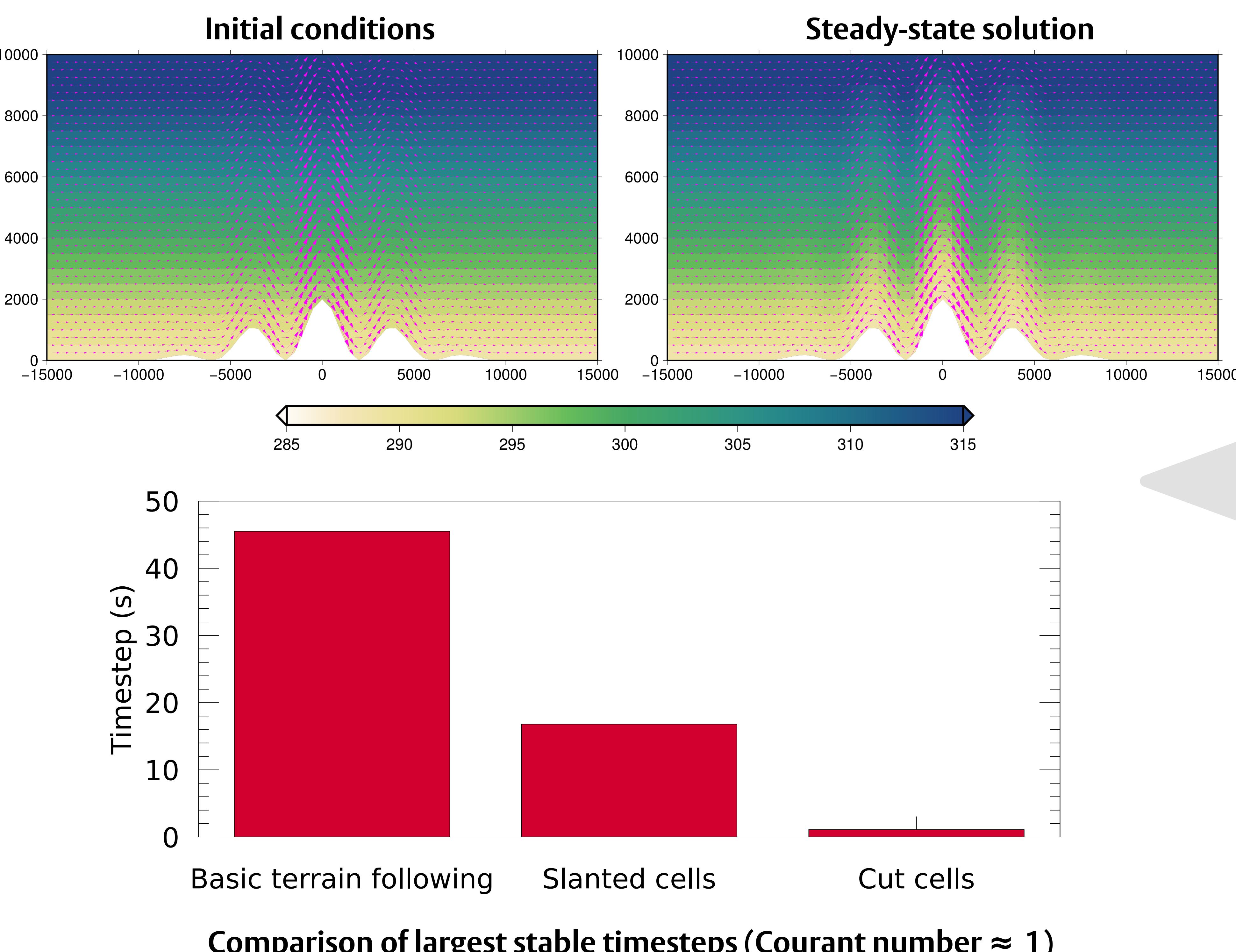
## Existing types of mesh



- + Widespread operational use
- + Modelled with simple data structures
- Mesh can be highly distorted
- + More orthogonal
- + Can improve numerical accuracy
- Small cells constrain the timestep

## Slanted cells avoid severe timestep constraints

- A new advection test is used to examine timestep constraints on the slanted cell mesh
- The test has a stratified thermal profile advected in a prescribed wind field
- Mimics real atmospheric flow over orography
- Steady-state thermal field has an analytic solution



- Slanted cells alleviate the timestep constraint associated with cut cells



- Work is ongoing to improve stability and accuracy for arbitrary meshes

## A new type of mesh: the slanted cell mesh

- The slanted cell mesh is designed to improve accuracy without severely constraining the timestep

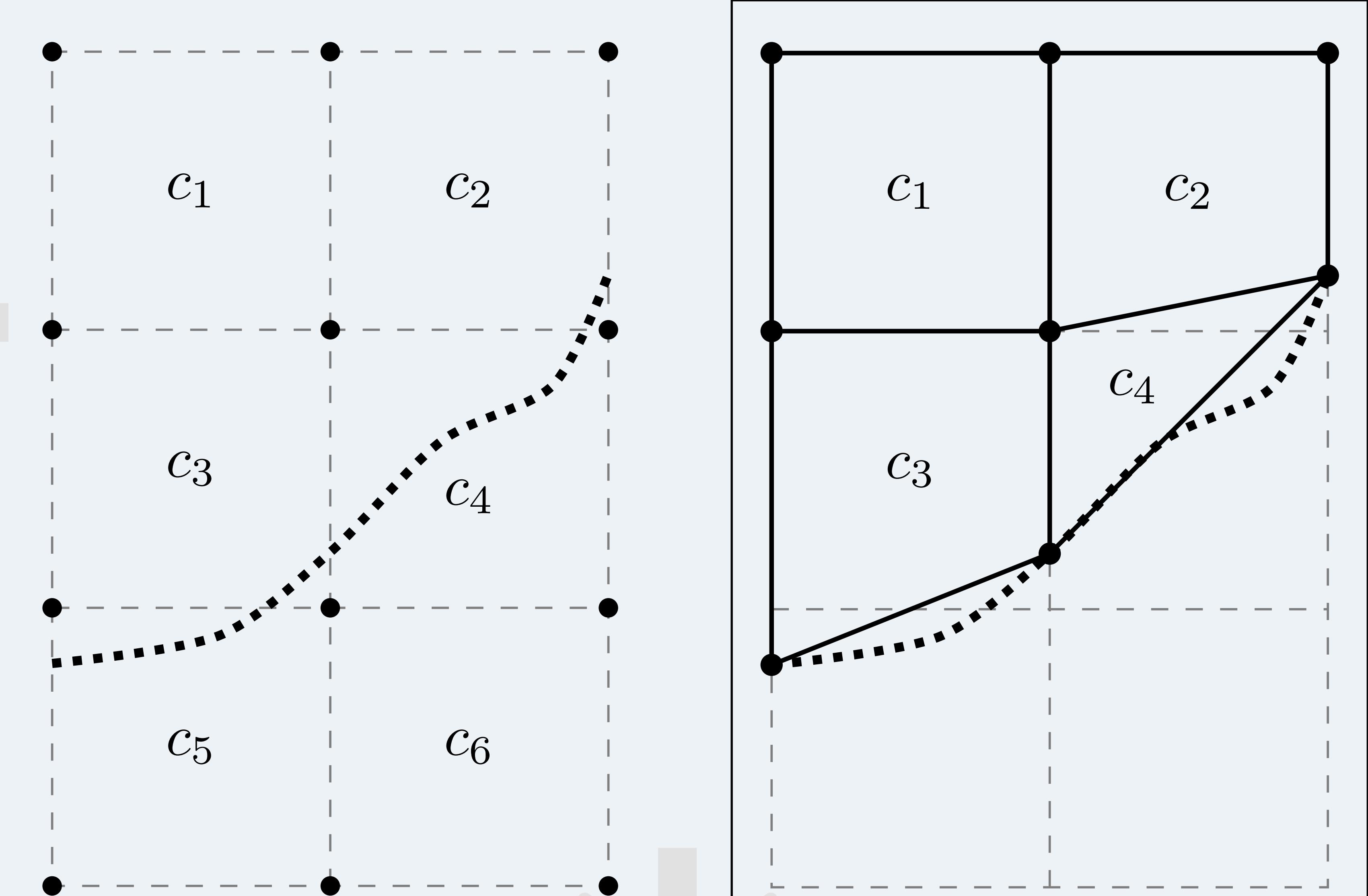
### Make your own slanted cell mesh

The push pins are the cell vertices and the elastic bands form the cell edges

To create a slanted cell mesh, start from a uniform mesh of quadrilaterals:

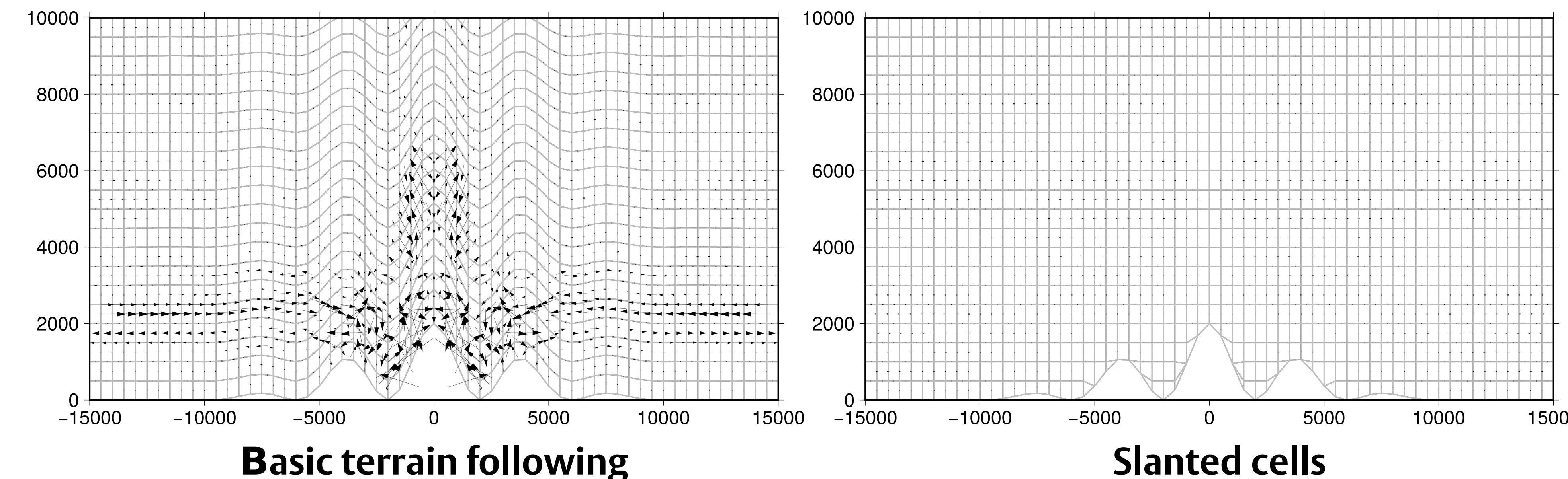
- Move any push pins that are just above the ground to the surface
- Move any push pins that are underground upwards so that they are at the surface
- Wrap elastic bands around the push pins to create triangles and quadrilaterals

Lift the flap to check that your mesh matches ours



## Slanted cells reduce pressure gradient errors

- Numerical errors in calculating pressure gradients generate spurious circulations
- Calculations are tested using a stratified atmosphere initially at rest
- An inversion layer that intersects the orography challenges the numerical scheme



- Spurious circulations are much smaller on the slanted cell mesh