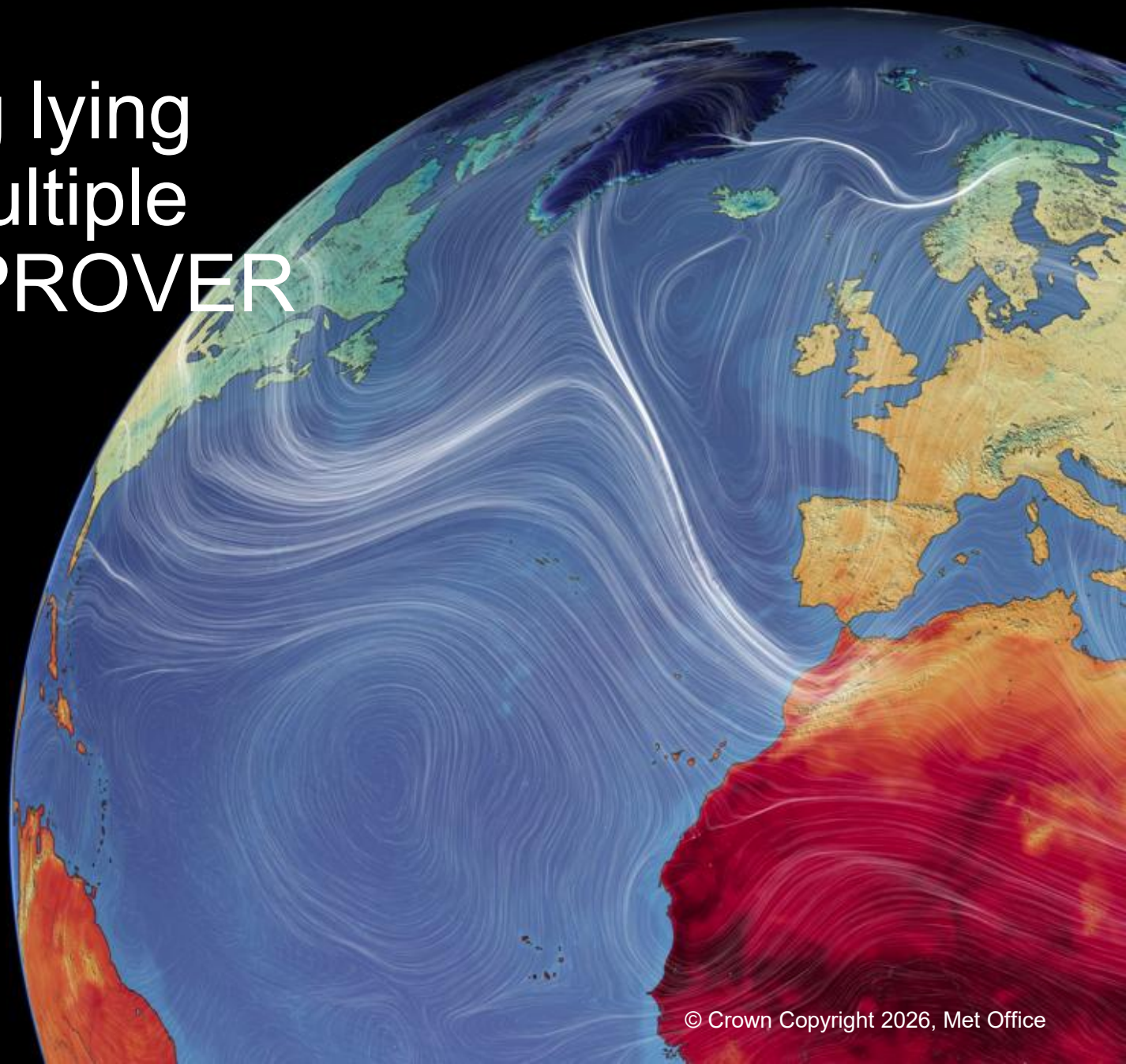
Met Office

A method for regridding lying snow for blending of multiple forecast sources in IMPROVER

Stephen Moseley

EMS, Utrecht, Sept 2026



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Contents

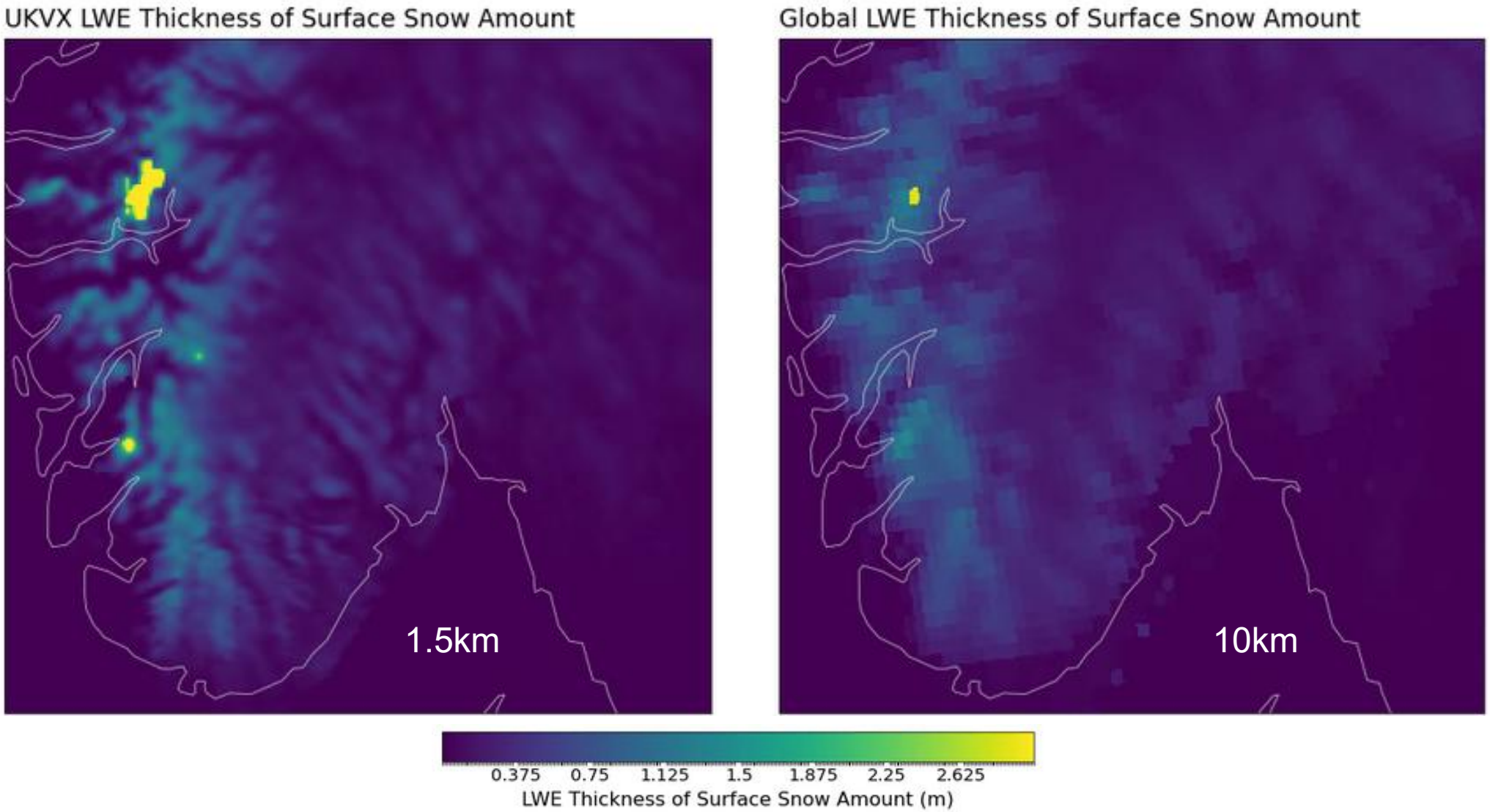
TBC

Creating blended lying snow data

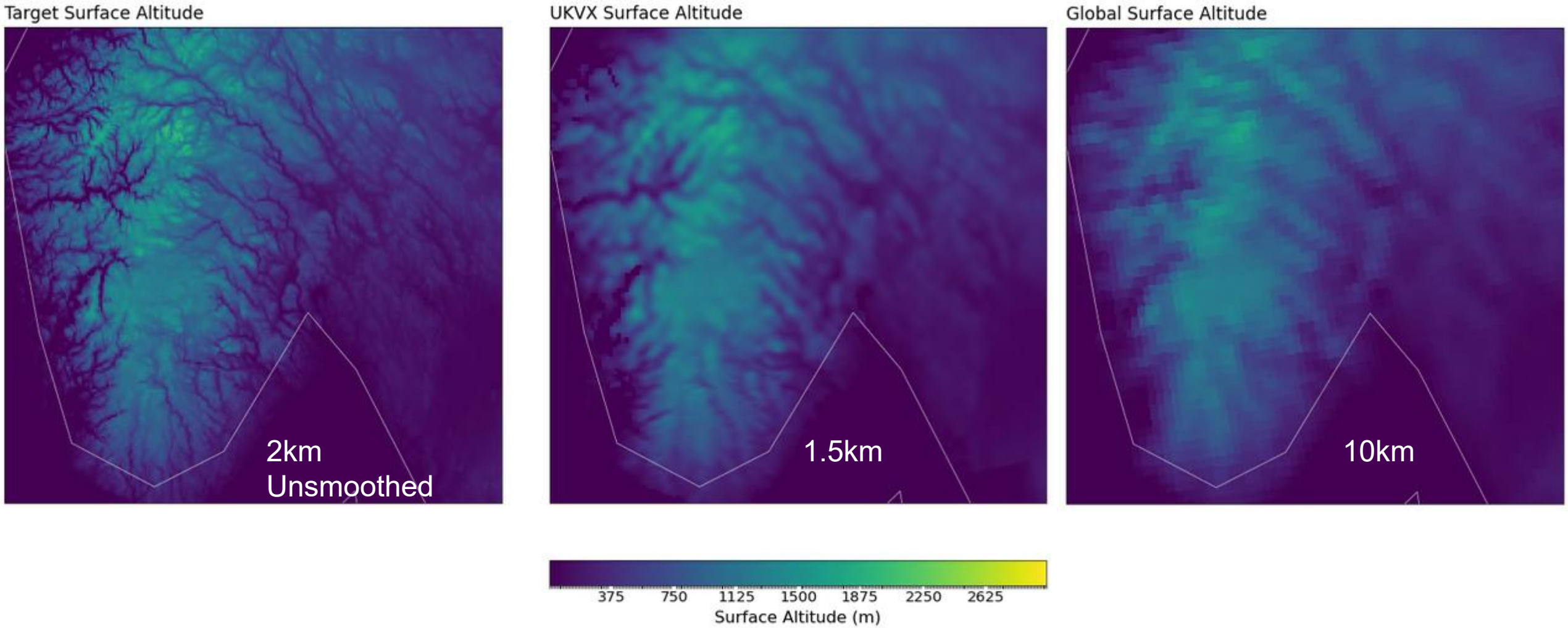
- NWP produces lying snow
- Strongly dependent on orography
- Each NWP model has a different orography
- Lying snow can persist for weeks without changing
- Melting snow is a significant input to hydrology models

- IMPROVER blends probabilistic data from multiple NWP models
- Necessary to adjust NWP data so that it represents
  - The same phenomena
  - The same location
  - Comparable statistical properties

NWP lying snow data



NWP orography



Linear interpolation

- IMPROVER has a linear altitude lapse rate method that is used for temperature
- Literature showed that lying snow can have a near-linear relationship to orography
  - Nishihara, T., Tanise, A., & Watanabe, K. (2017). *Analysis of the Relationship Between Snow Depth and Topography in a Mountainous Region Using Airborne Laser Scanning Data*. International Association for Hydro-Environment Engineering and Research. https://www.iahr.org/library/infor?pid=2970
- We chose to start investigating how useful this method would be

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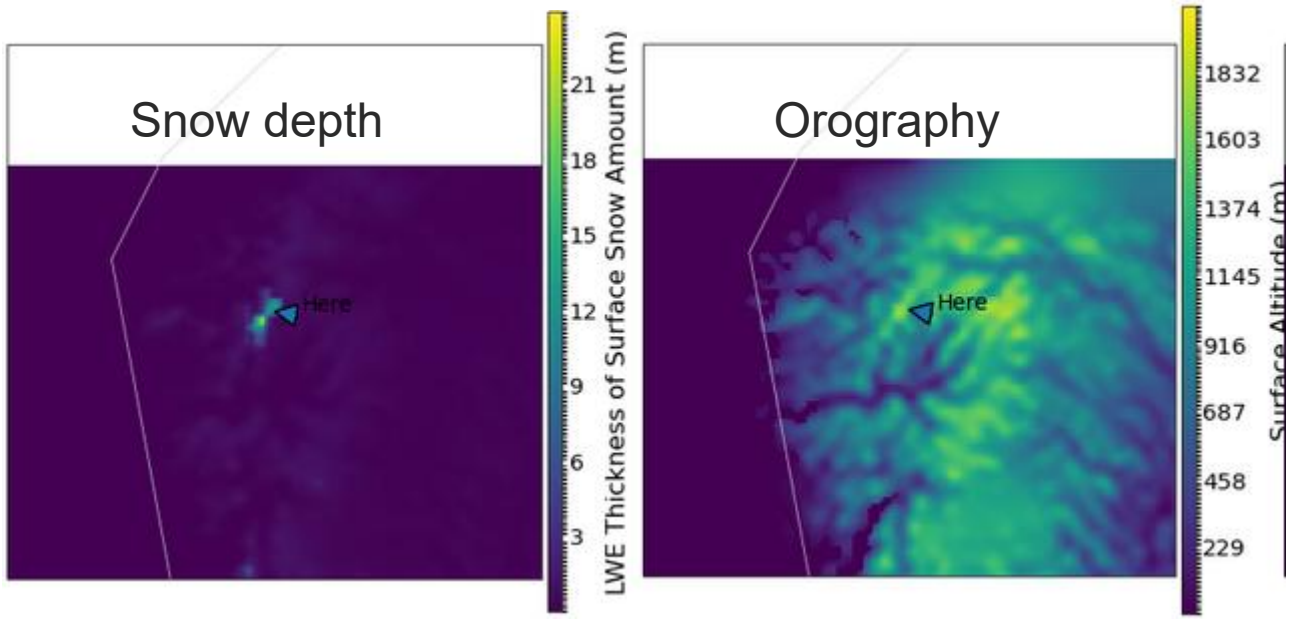
Scenarios

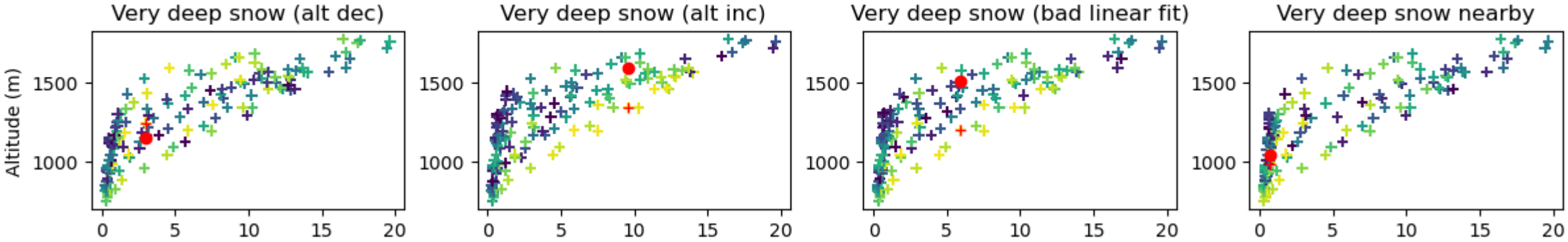
A series of scenarios of different lying snow conditions that we need to handle

Very deep snow (Norway)



- Very high lying snow amount
- NWP never melts or moves this feature
- Looking at four points around this feature

Scenarios of local variation of snow depth with altitude

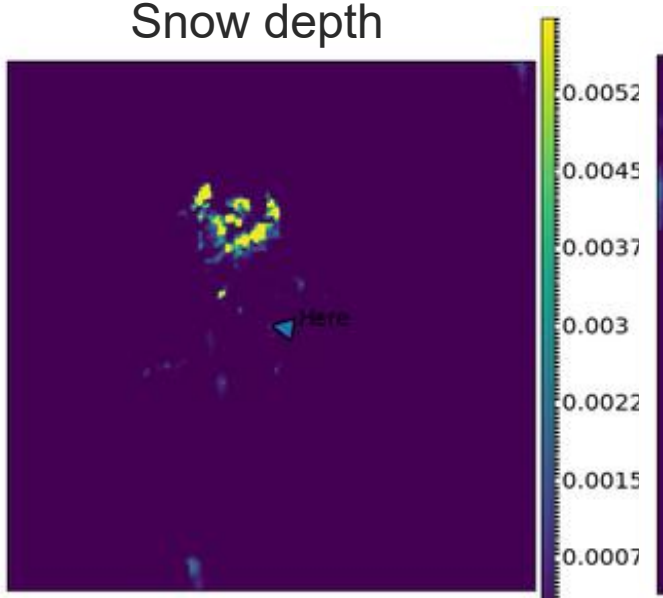


+ Closest NWP point, Proximity of points coloured from yellow (close) to blue (far)

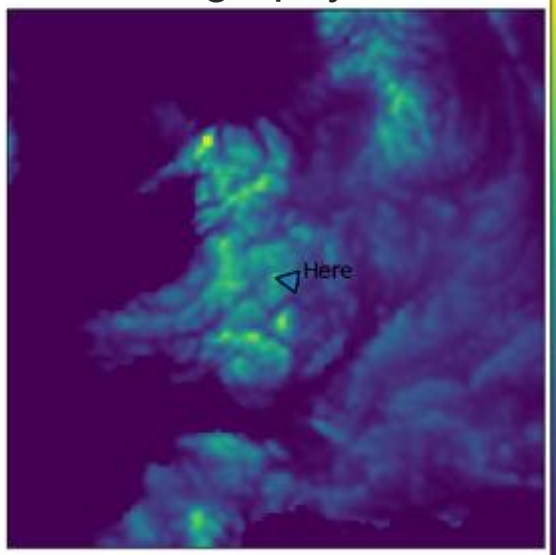
● Target orography

Fresh snow (Wales)

Snow depth

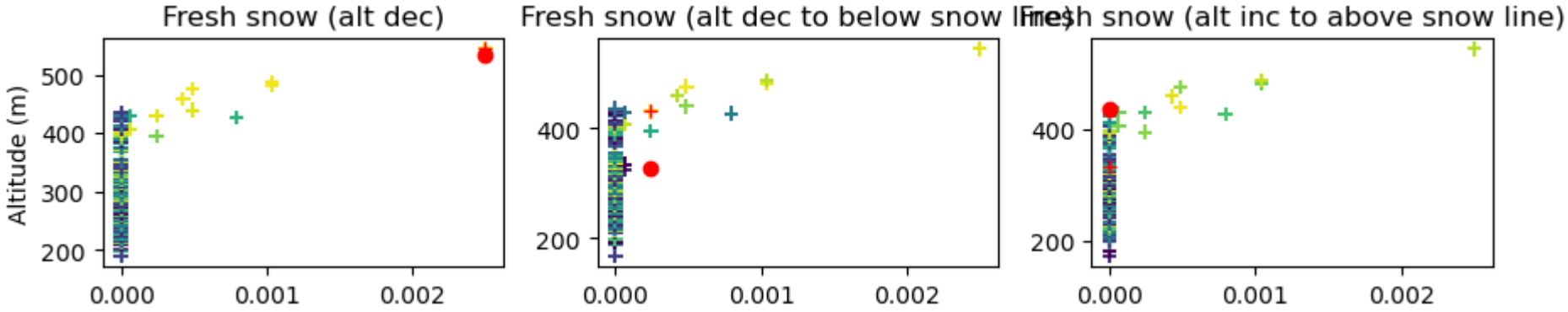


Orography



- Fresh snow
- Just a few mm
- Many zero points
- Looking at three points around this feature

Scenarios of local variation of snow depth with altitude

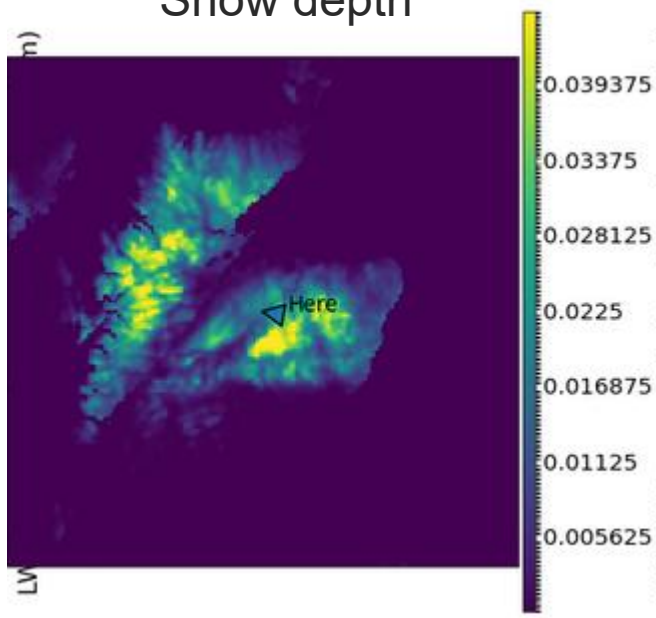


+ Closest NWP point, Proximity of points coloured from yellow (close) to blue (far)

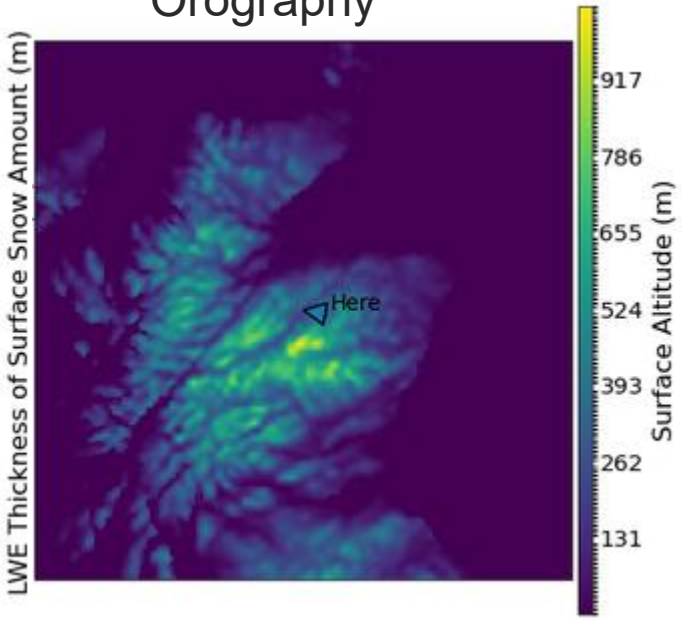
● Target orography

New on old snow (Scotland)

Snow depth

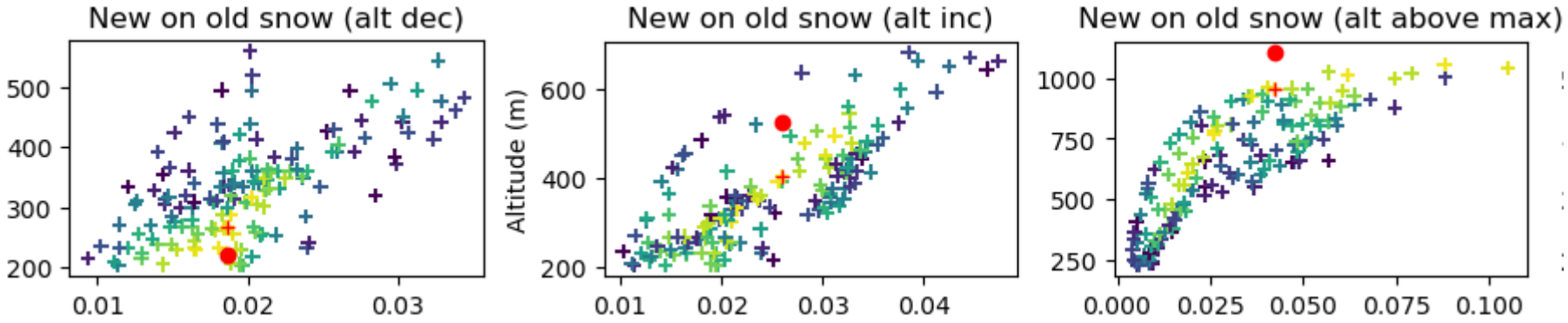


Orography



- New snow falling on existing snow
- Confusing to linear extraction
- Looking at three points around this feature

Scenarios of local variation of snow depth with altitude

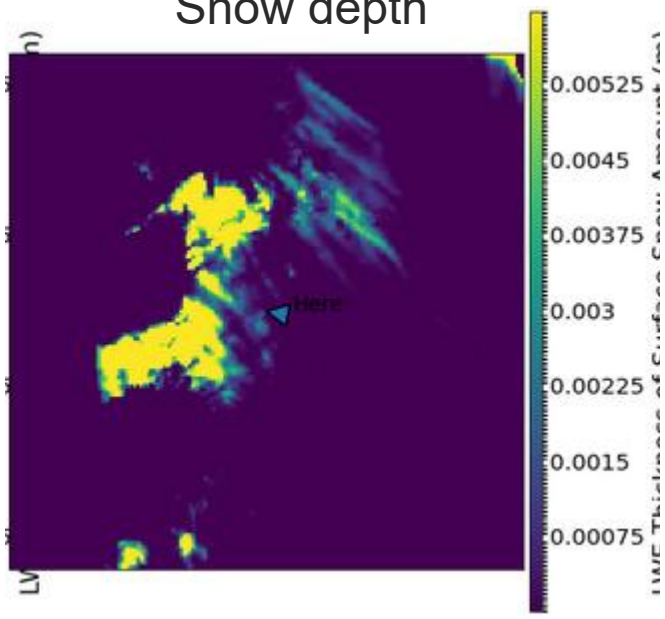


\+ Closest NWP point, Proximity of points coloured from yellow (close) to blue (far)

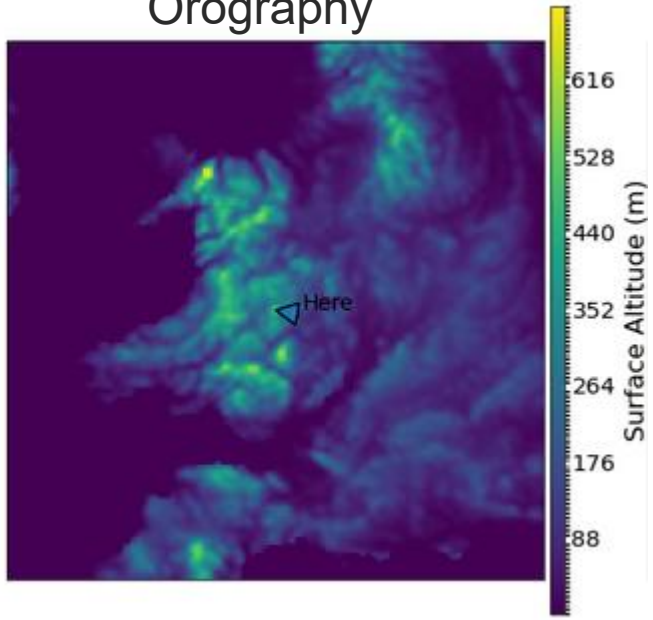
● Target orography

Melting snow (Wales)

Snow depth

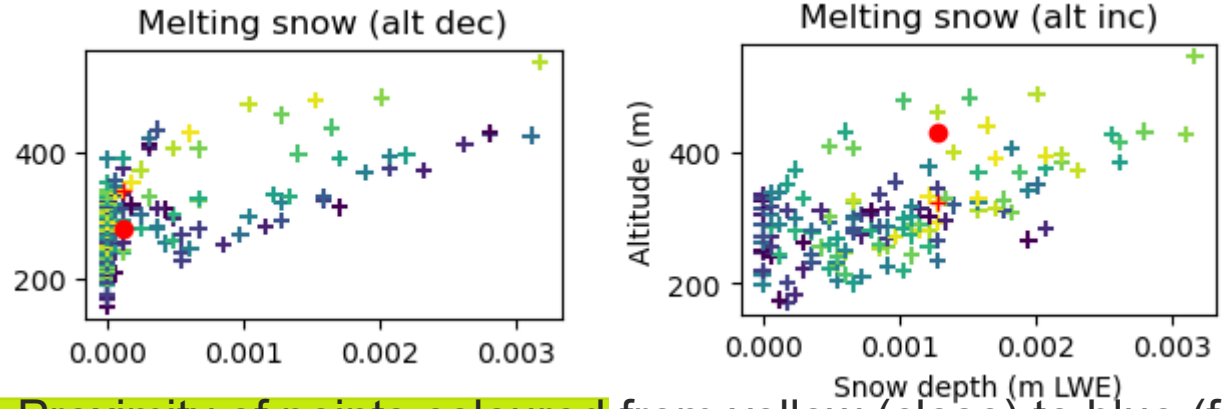


Orography



- Melting snow
- Faster melting at lower altitude
- Looking at two points around this feature

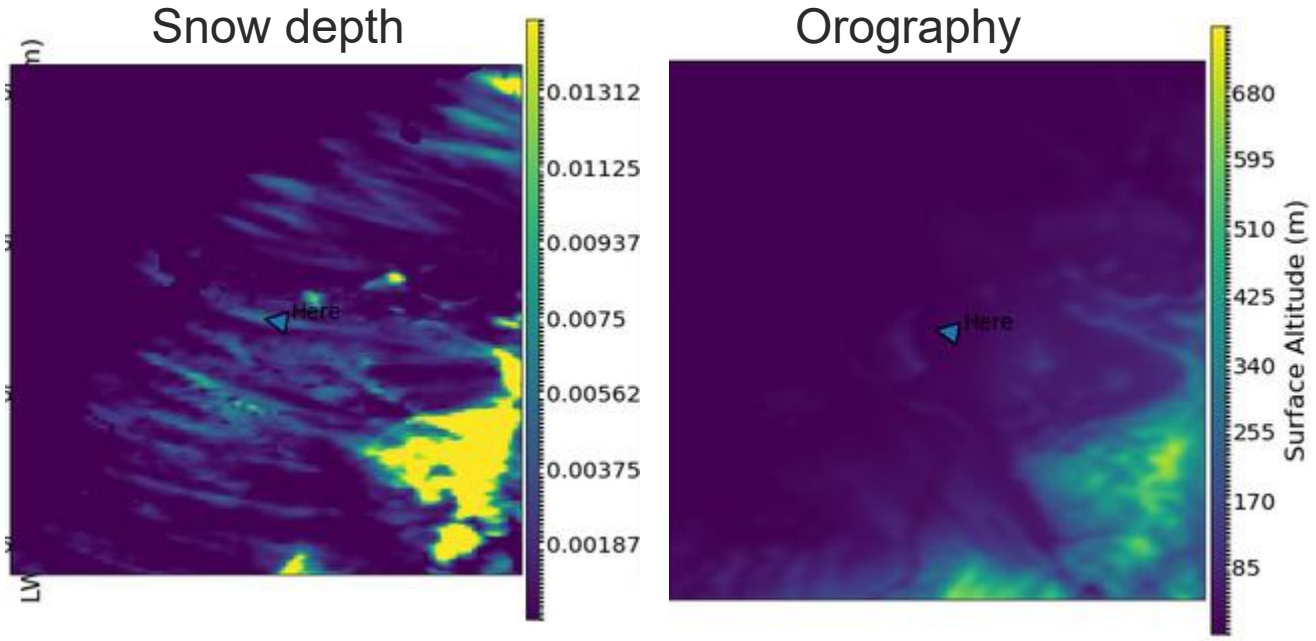
Scenarios of local variation of snow depth with altitude



+ Closest NWP point, Proximity of points coloured from yellow (close) to blue (far)

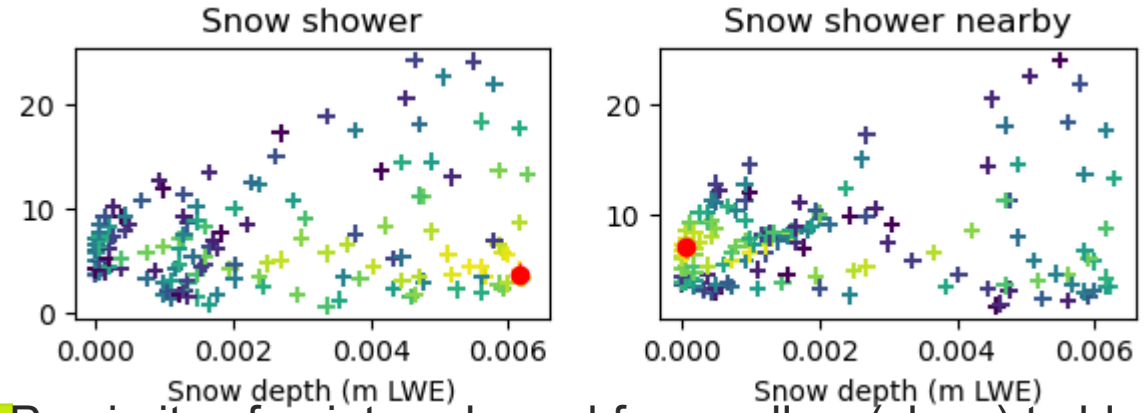
● Target orography

Snow shower (Netherlands)



- Snow shower
- No orographic link
- Looking at two points
  - Centre of shower swath
  - Just to south of swath

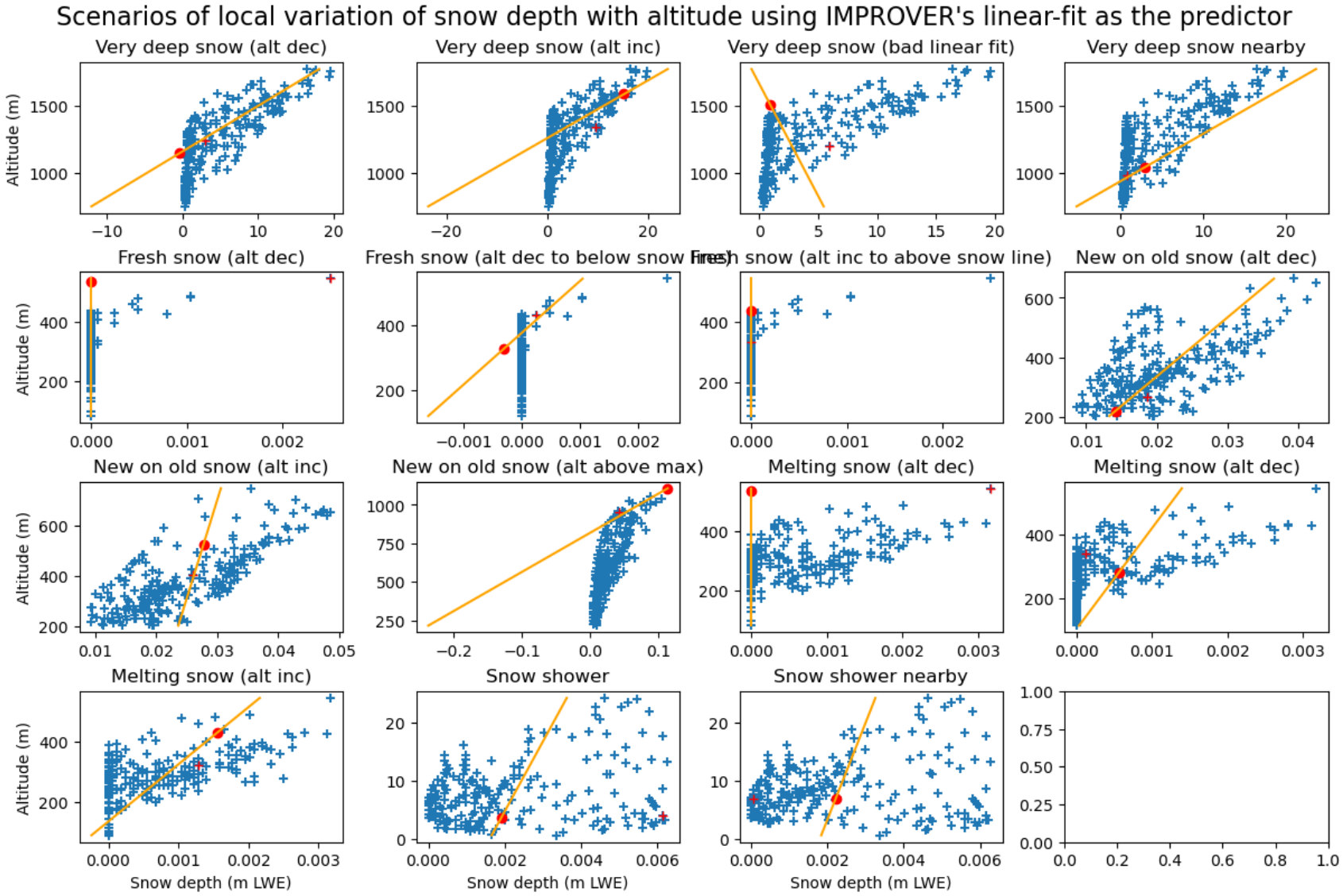
Scenarios of local variation of snow depth with altitude



+ Closest NWP point, Proximity of points coloured from yellow (close) to blue (far)

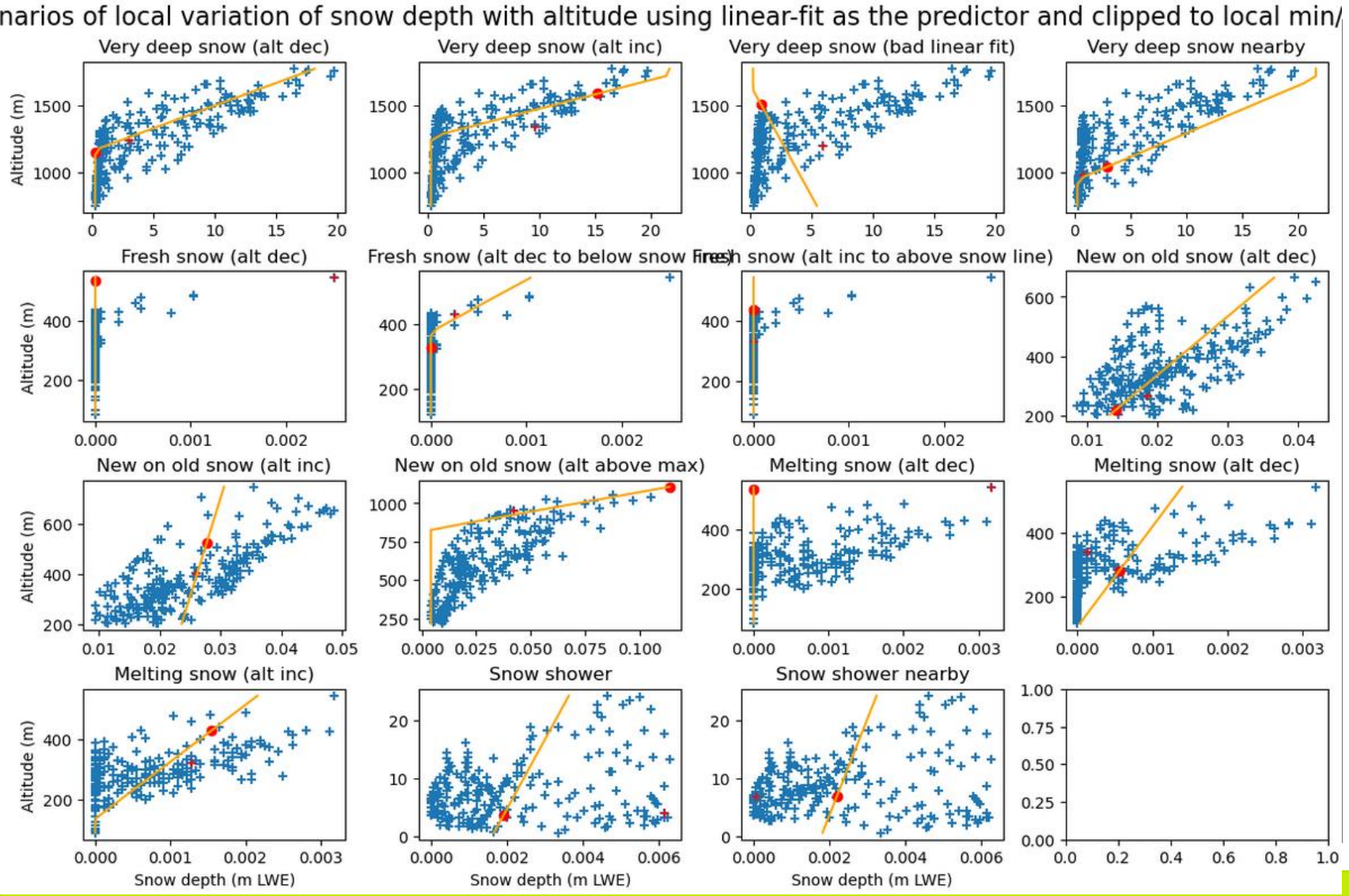
● Target orography

Linear fit



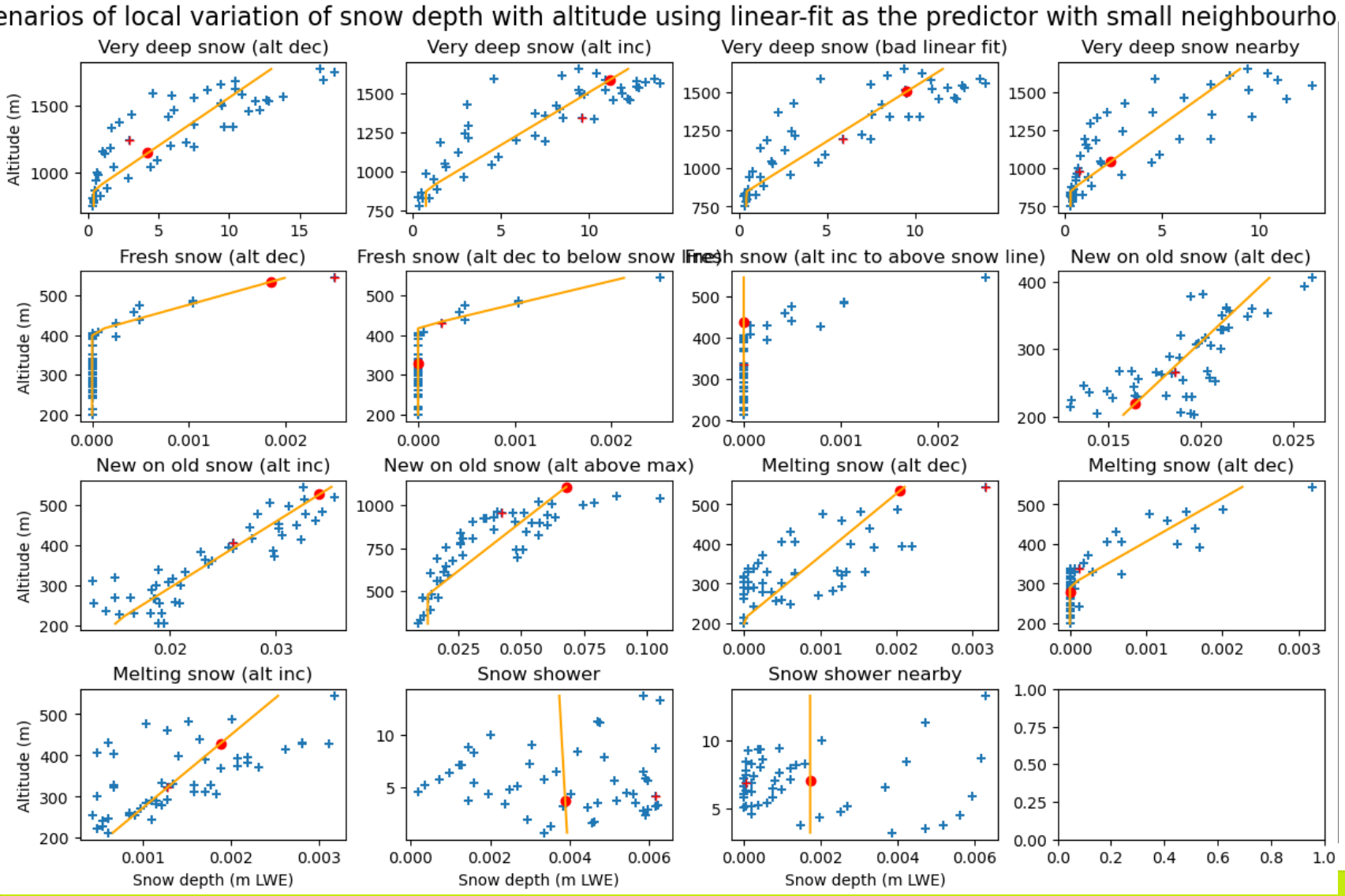
- Naïve linear fit
- Results in unphysical values below and above max
- Inverted lapse rate is possible
- Many zeroes dominate lapse rate

Linear fit with capping



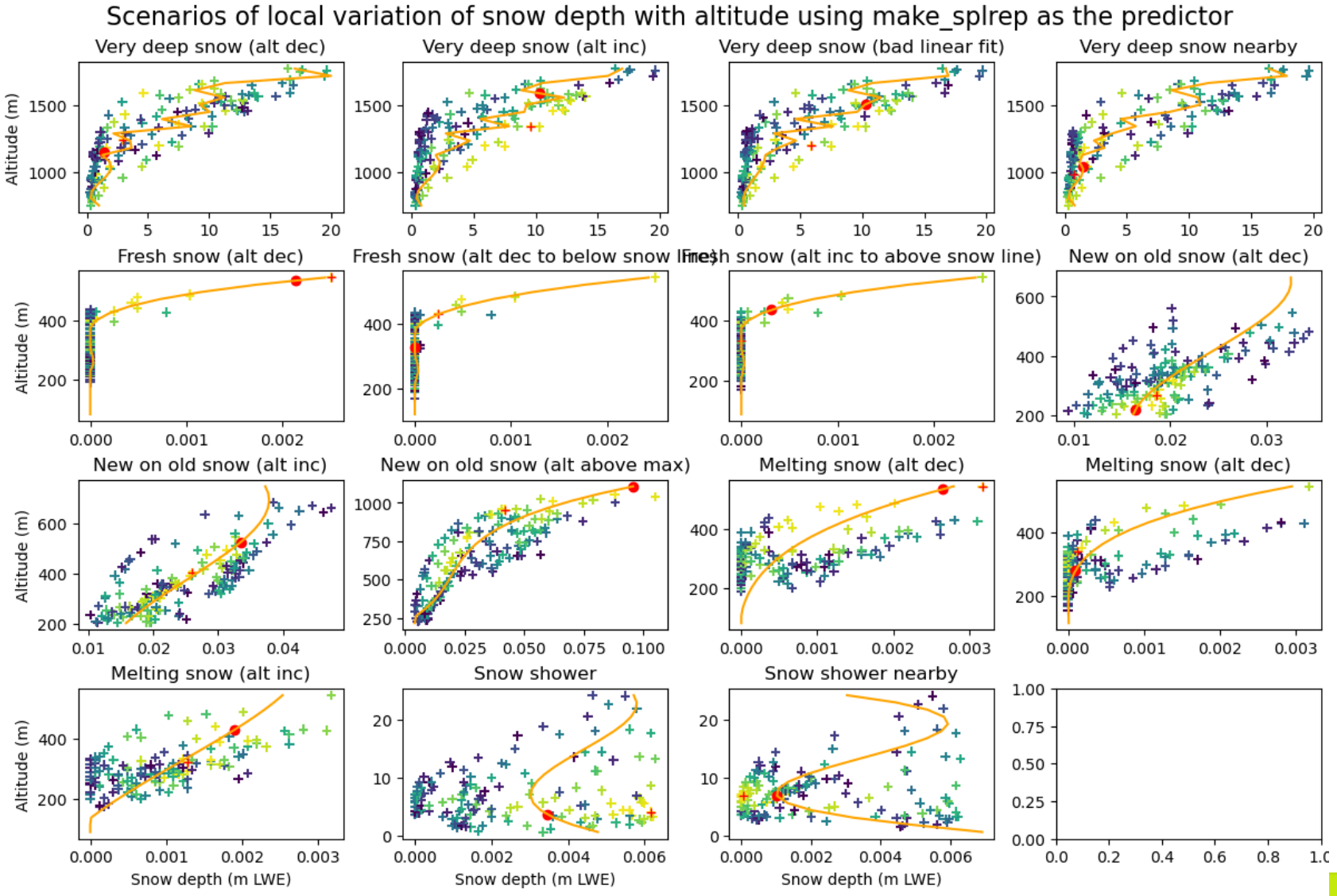
- Naïve linear fit
- Predicted value limited to min: max+10% of inputs
- Doesn't address inverted lapse rate

Linear fit with small neighbourhood



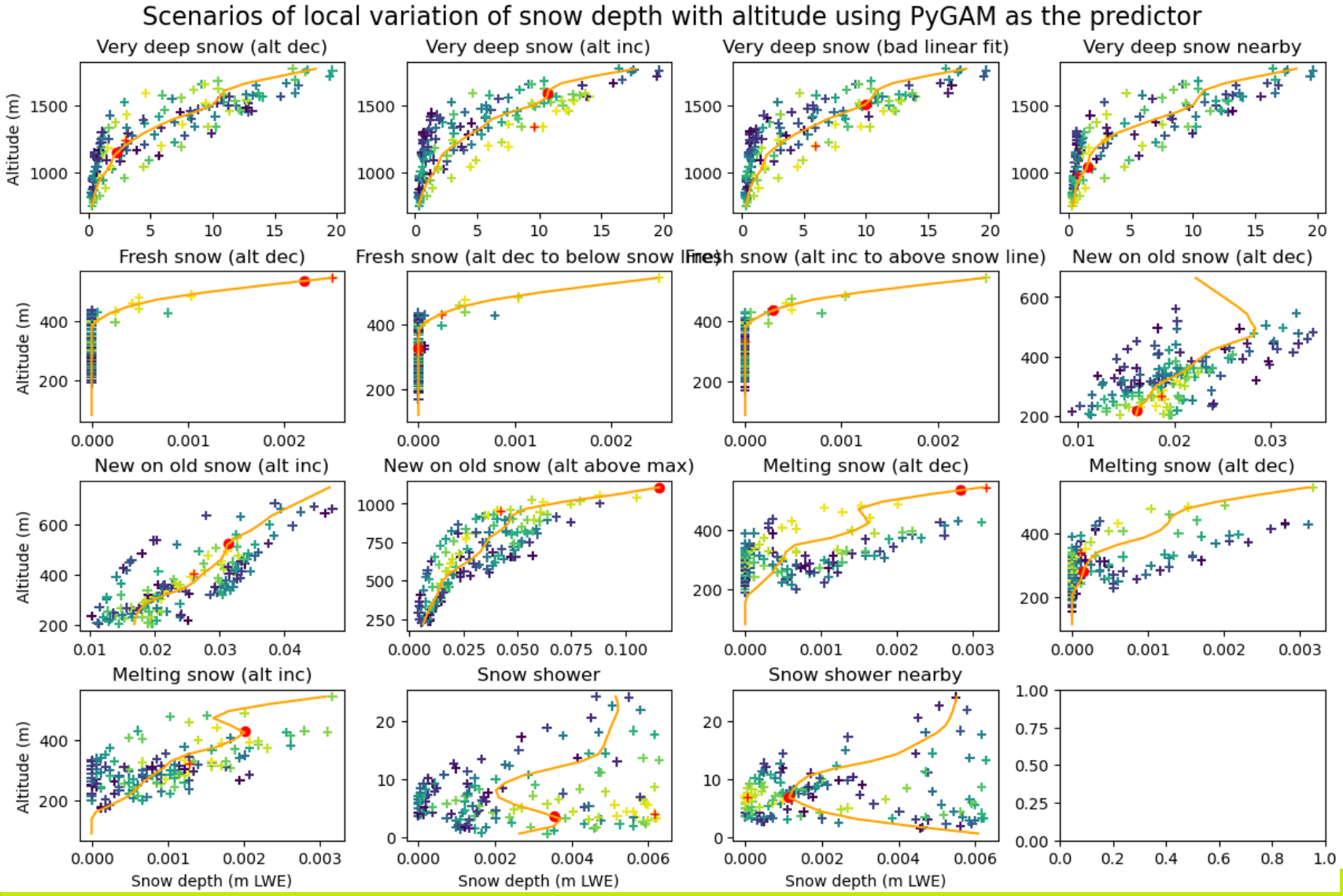
- Naïve linear fit
- Only closest points considered
- Capping included
- Different scenario has inverted lapse rate

Spline fit – make_splrep



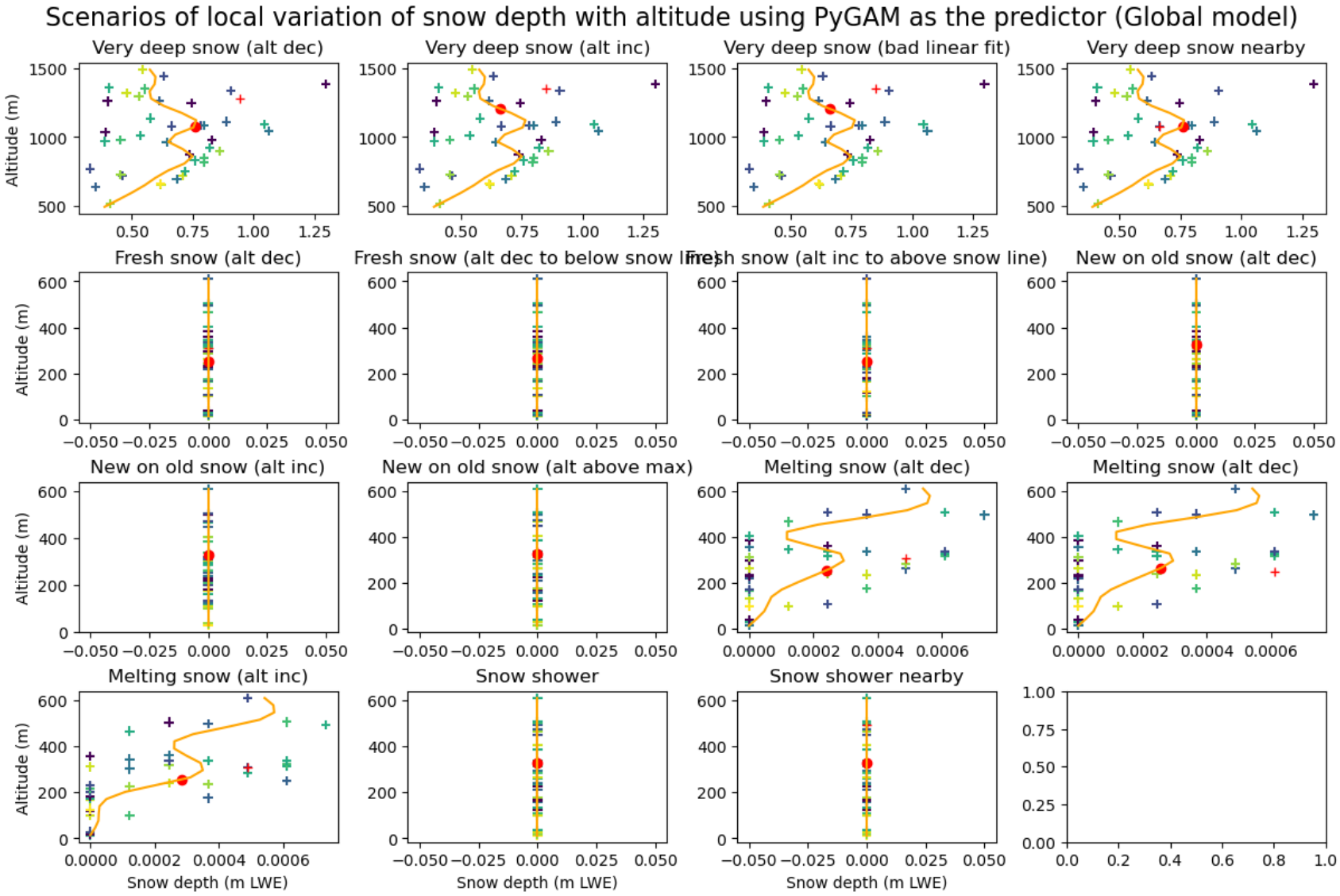
- From Scipy.interpolate
  - Degree of fit: k=3 (default)
  - Smoothing condition: s=N
  - Weighted by proximity
- Capping included
- Some noise
- Odd bumps in zeroes
- Better in showers?

Spline fit – PyGAM



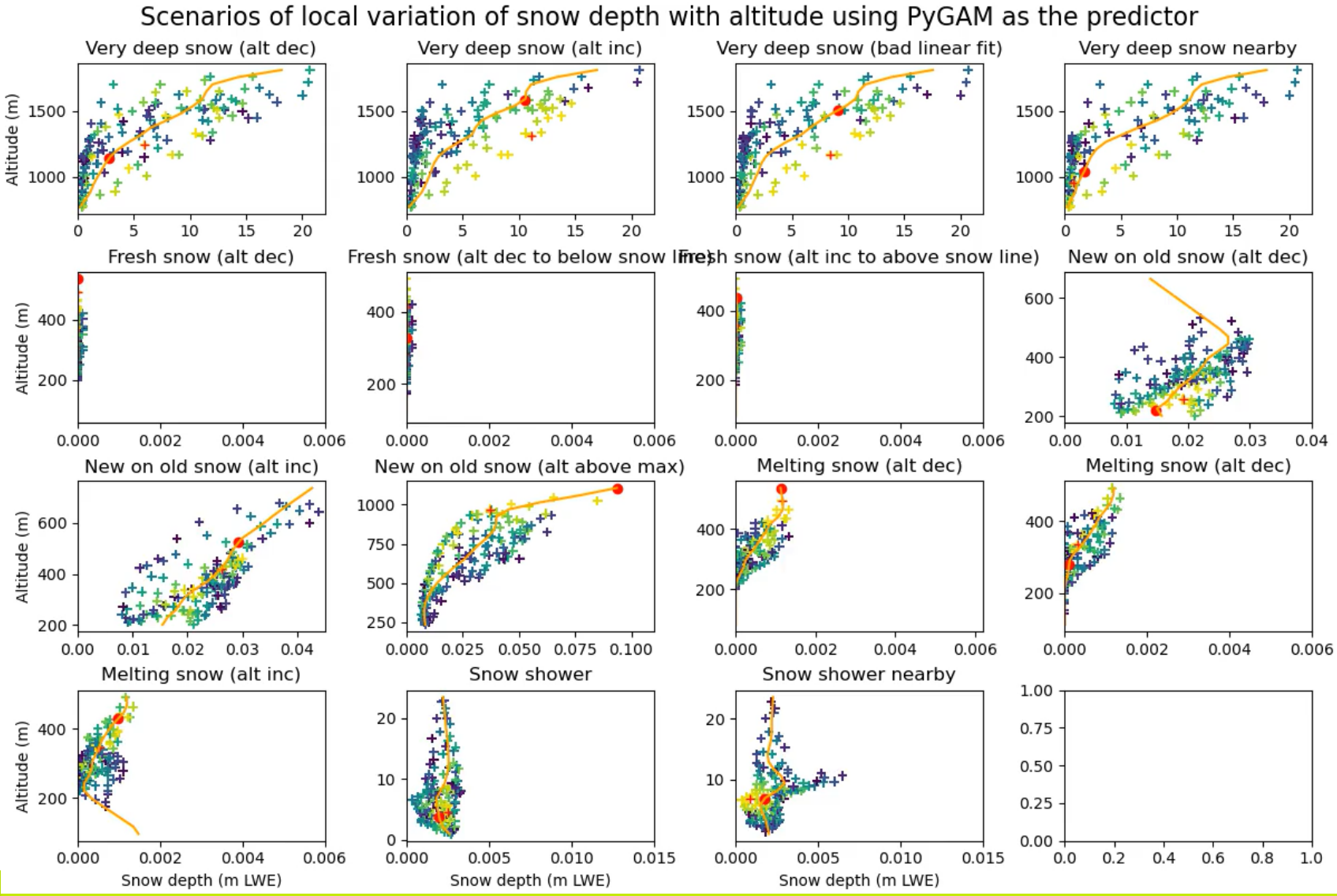
- LinearGAM
  - n_splines: 20,
  - Lambda: 0.6
- Capping included
- Better smoothing

Spline fit – PyGAM – Global data



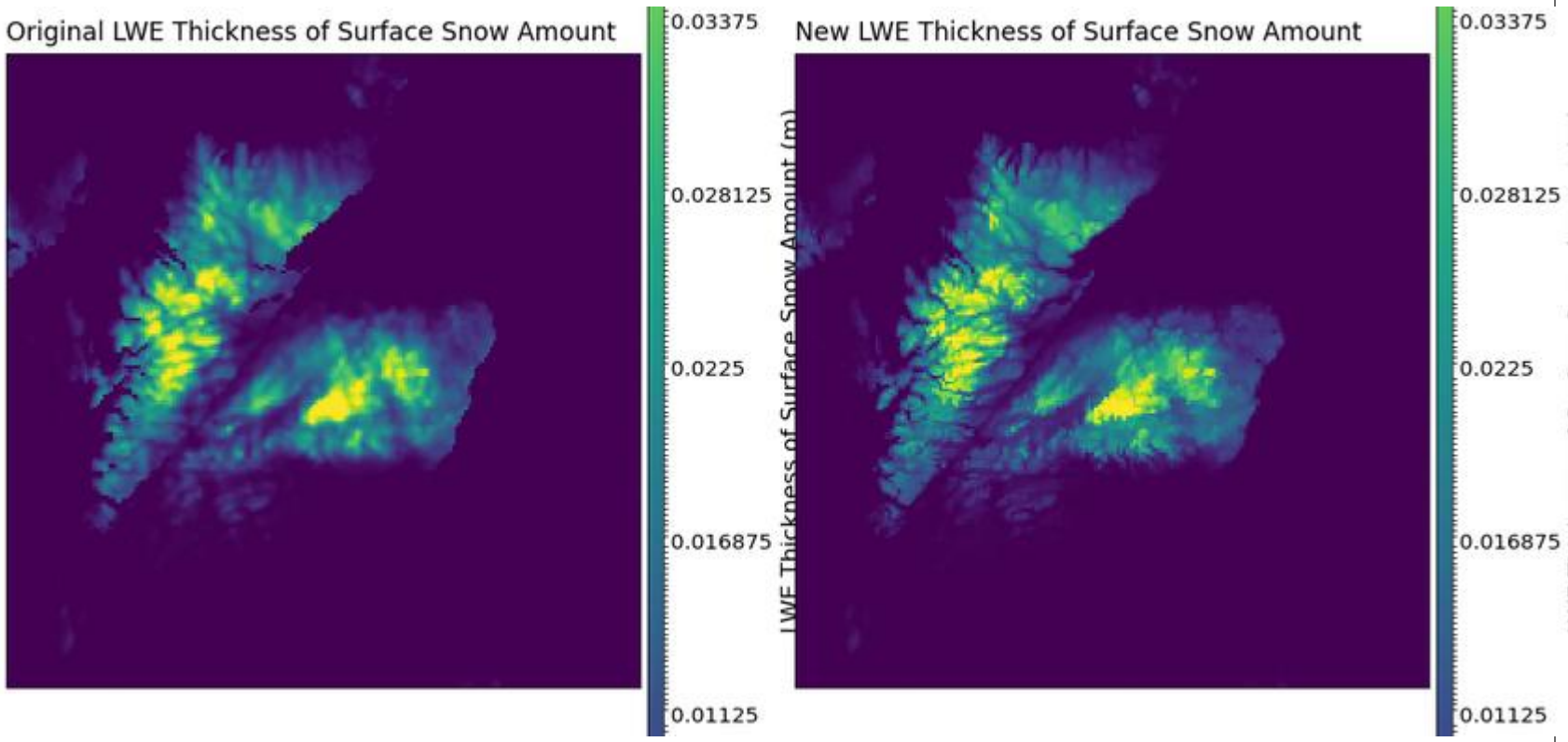
- As before, but smaller neighbourhood to account for coarser resolution
- No snow in several cases
- Not that great

Spline fit – PyGAM – UK ensemble



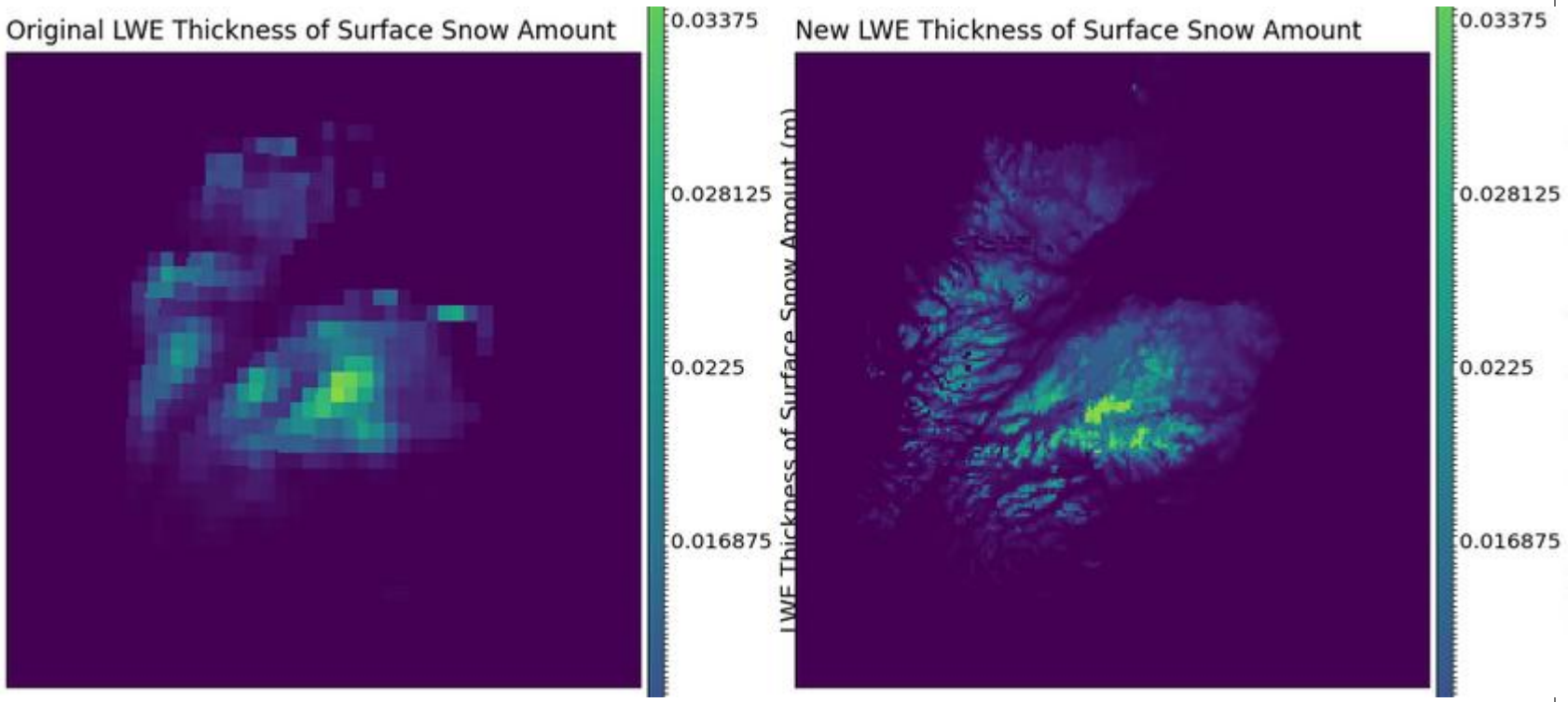
- As before
- For each of 18 members

Spline fit – make_splrep – UK



- Adds orographic detail that looks realistic
- Preserves large-scale pattern
- Slow to execute

Spline fit – make_splrep – Global



- Adds orographic detail that looks realistic
- Adds snow to south
- Slow to execute

Conclusions

- Lying snow does not have a linear relationship with orography, except when freshly fallen.
- Splines offer an opportunity to downscale lying snow from different models onto a common orography ready for blending.

- Splines are slow to calculate and we need a lot of them so optimisation needs exploring.
- No comparison with observations, so we don’t know how good this is.
- Tends to add snow nearby.