The tortoise and the hare: Role of differential process rates in shaping landscapes

Anne Voigtländer

Communities at different paces

Slow rates $<10^{-5}$ m/yr

Uplift, denudation, erosion, creep,...

Constant and continuous

Communities at different paces

Fast rates <10^6 m/yr

Fracturing, faulting, incision, eruption,...

Stochastic and intermittent

How do pacemakers work?

How much? How often?

Internal and external processes/ force balances

Mass, stress, and energy - Magnitude-frequency

Where, when, and how?

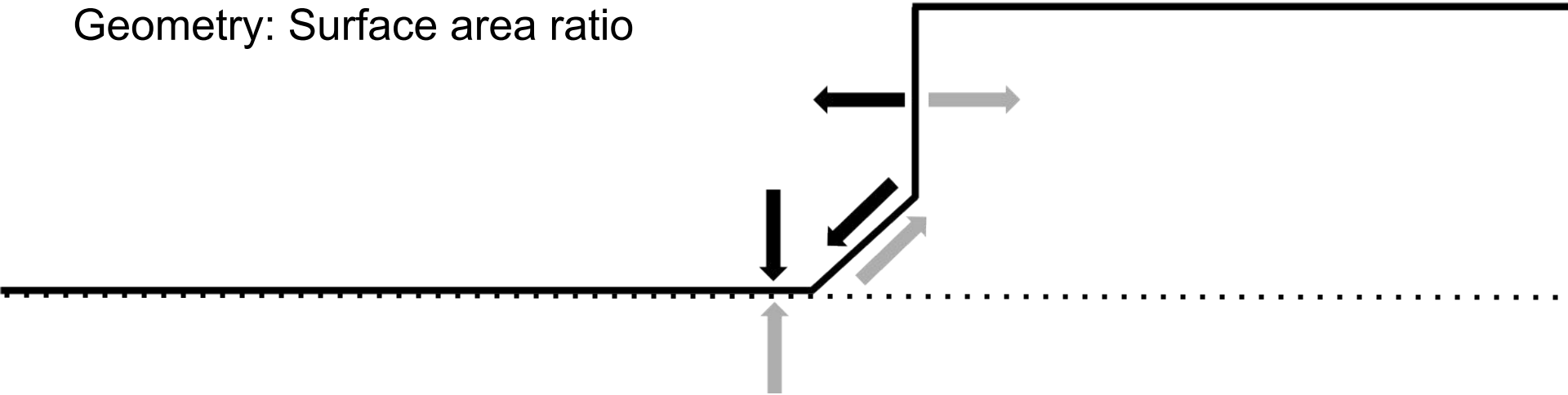
Mechanisms, rheology, and structures/landscapes & seascapes:

Mechanics, materials, and geometry -

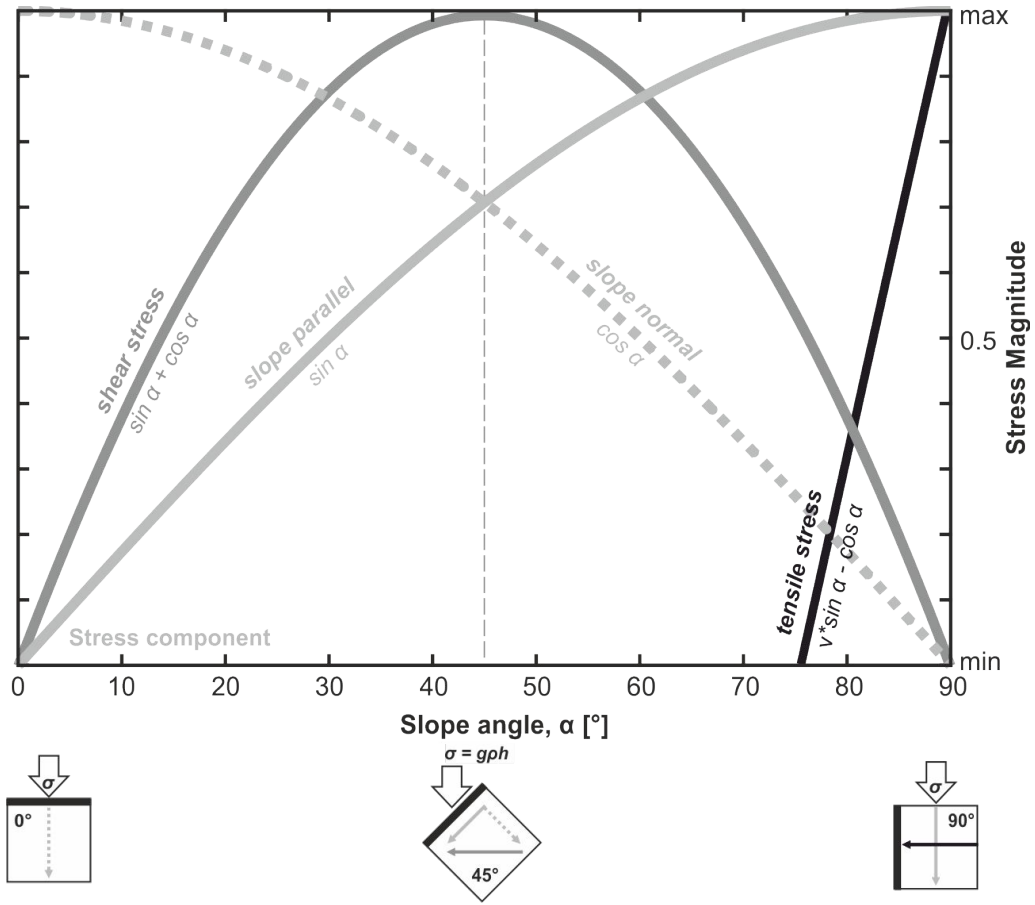
Signatures of differential rates in landscapes

Mechanics: Stress controls

Geometry: Surface area ratio

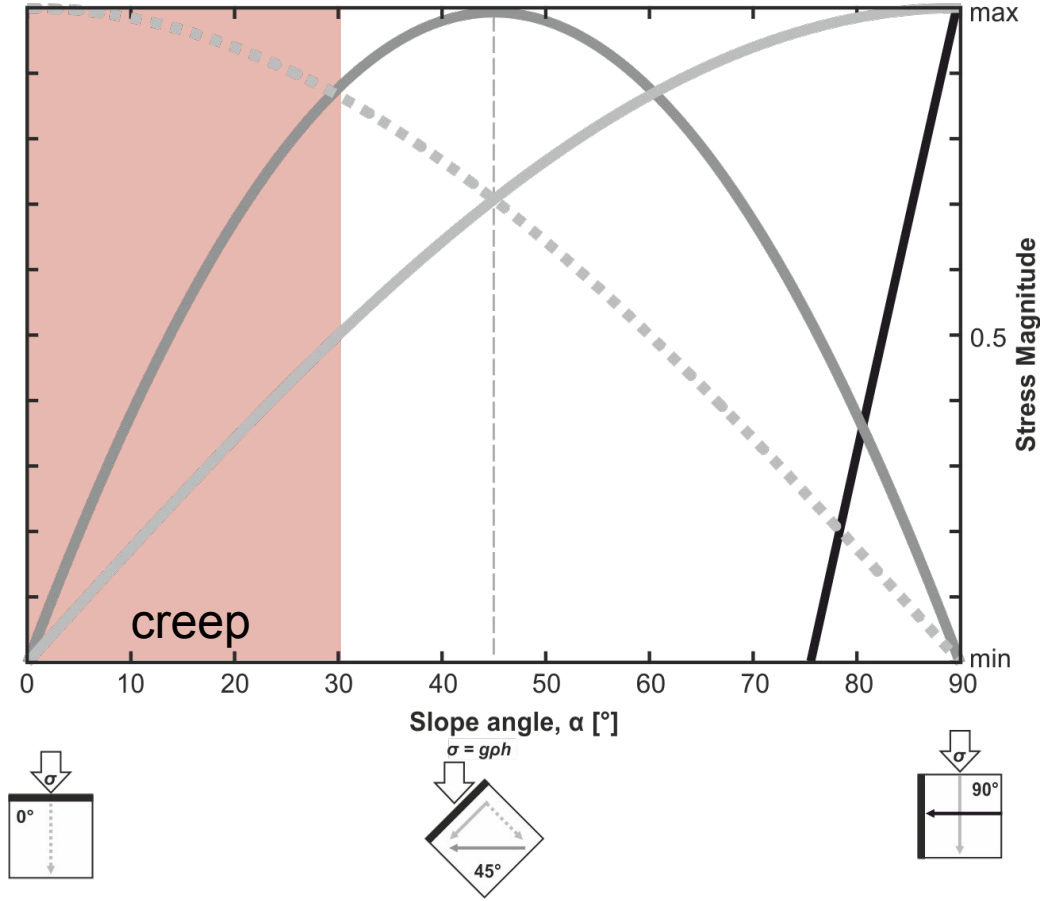


Los Angulos and stresses



Voigtländer & Turowski in review

Slope angle and stress



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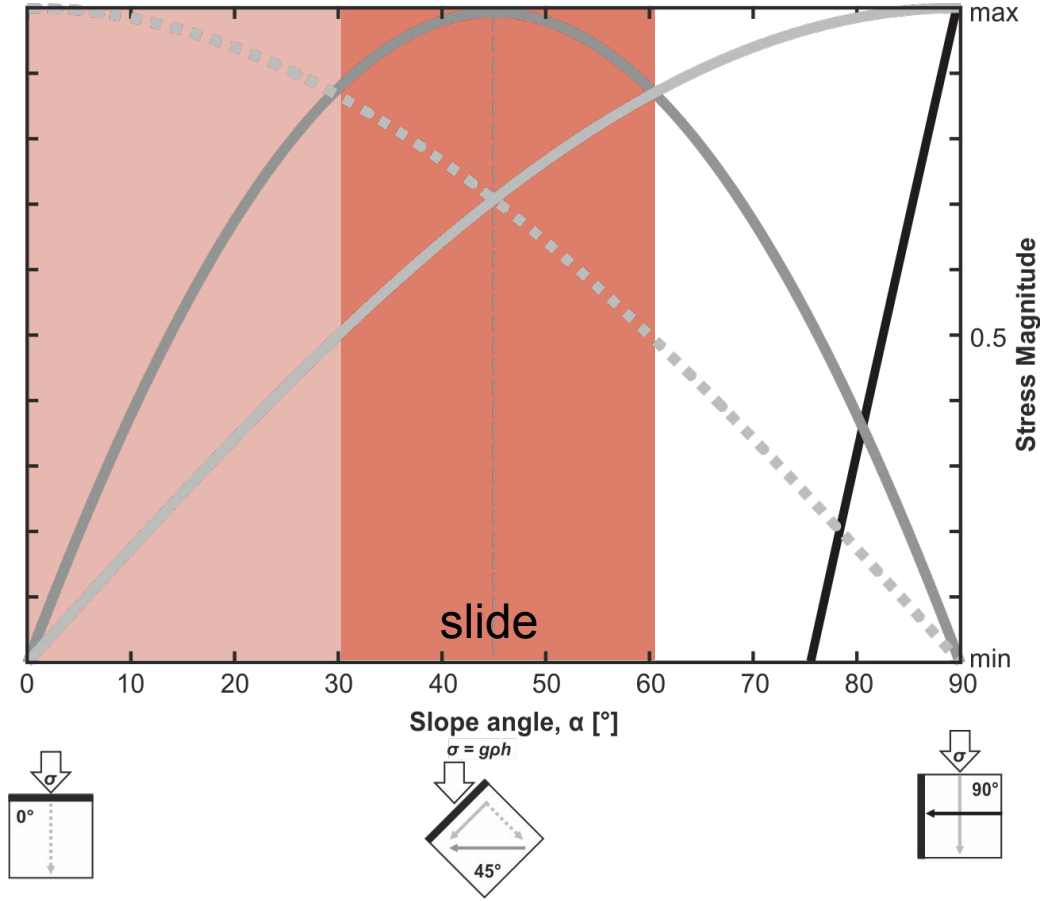

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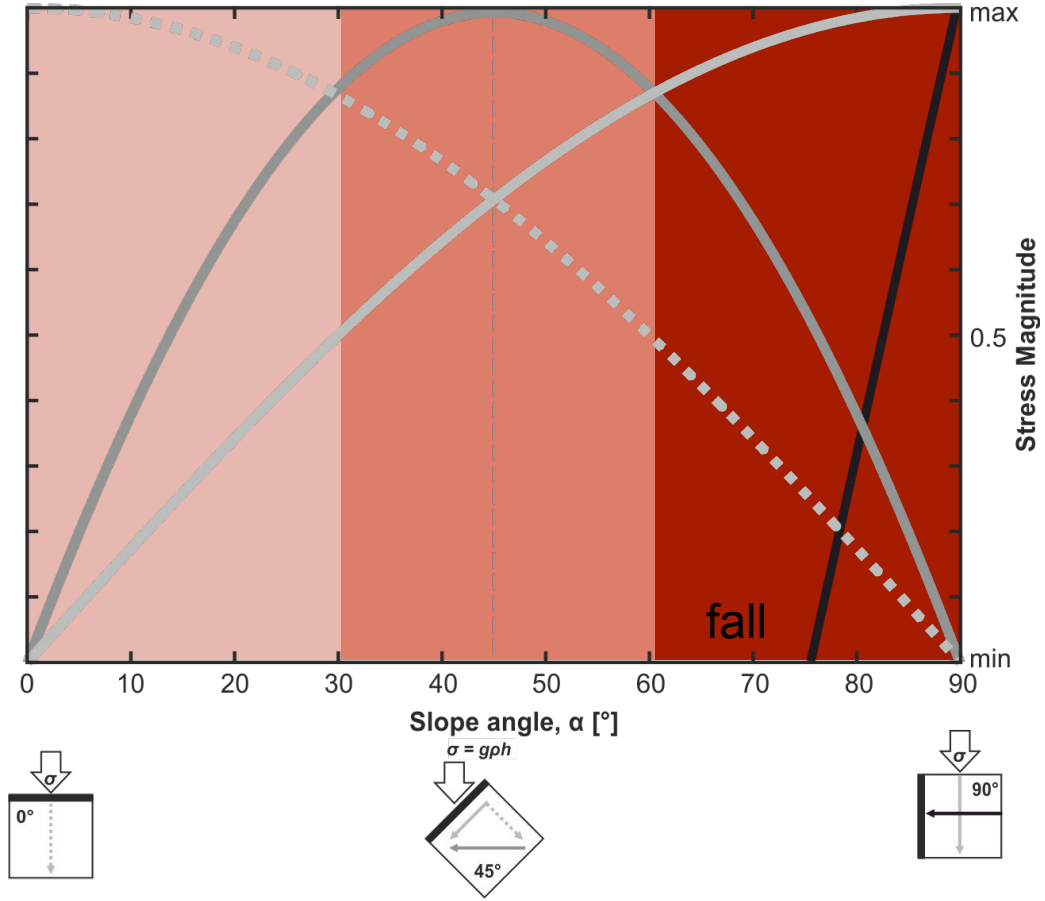
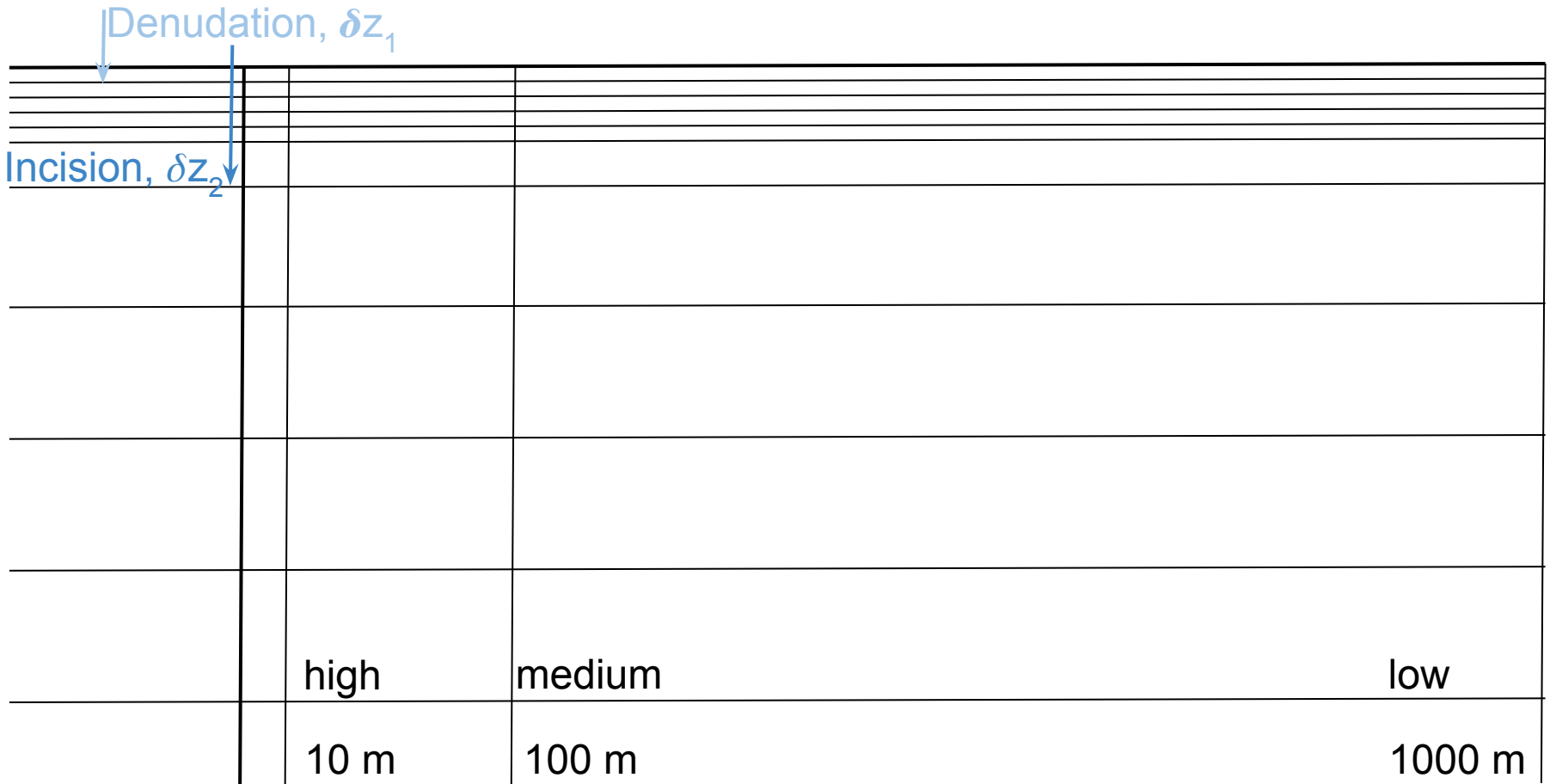


Voigtländer & Turowski in review

Stress controlled processes by differential erosion rates



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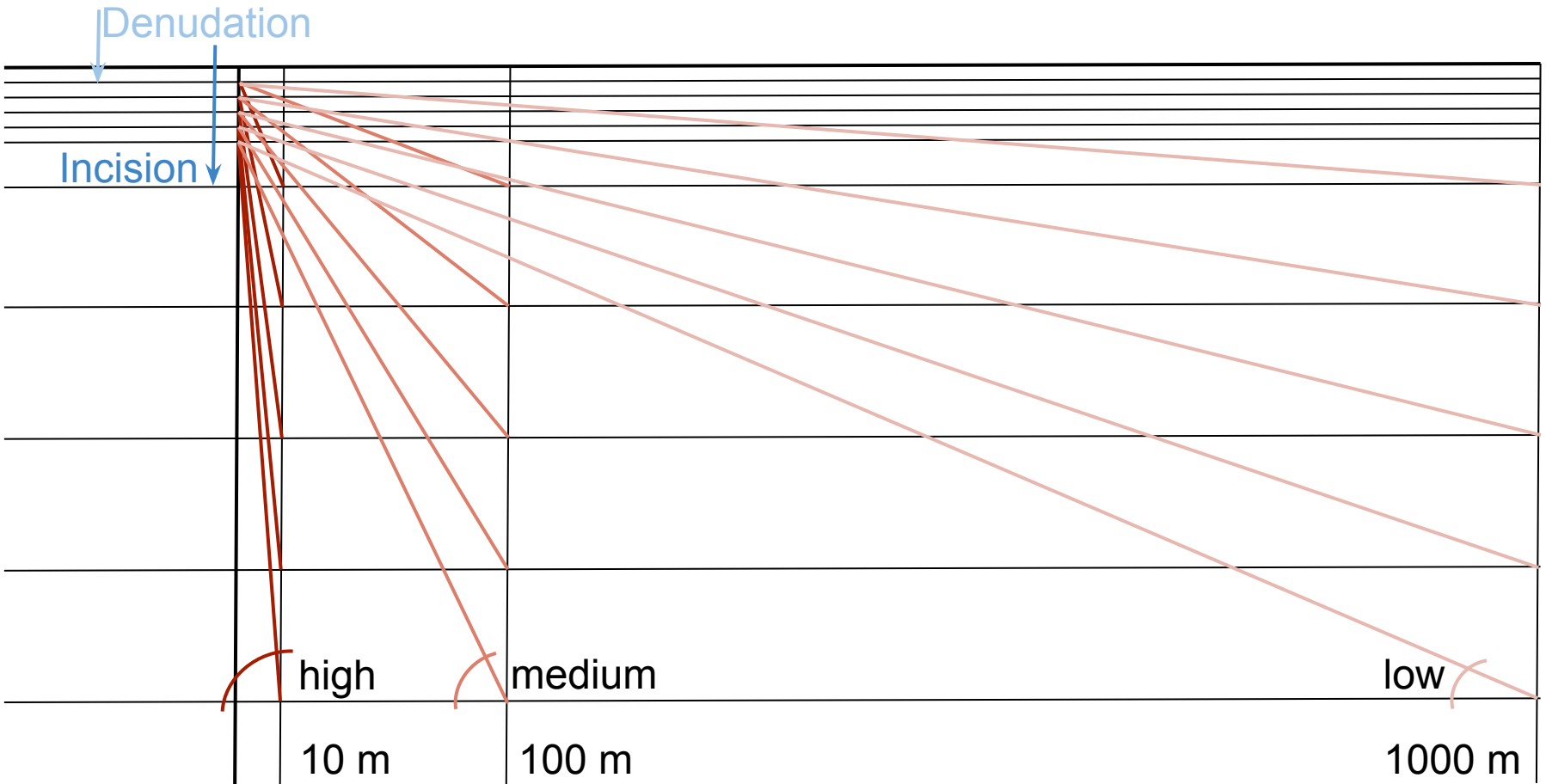
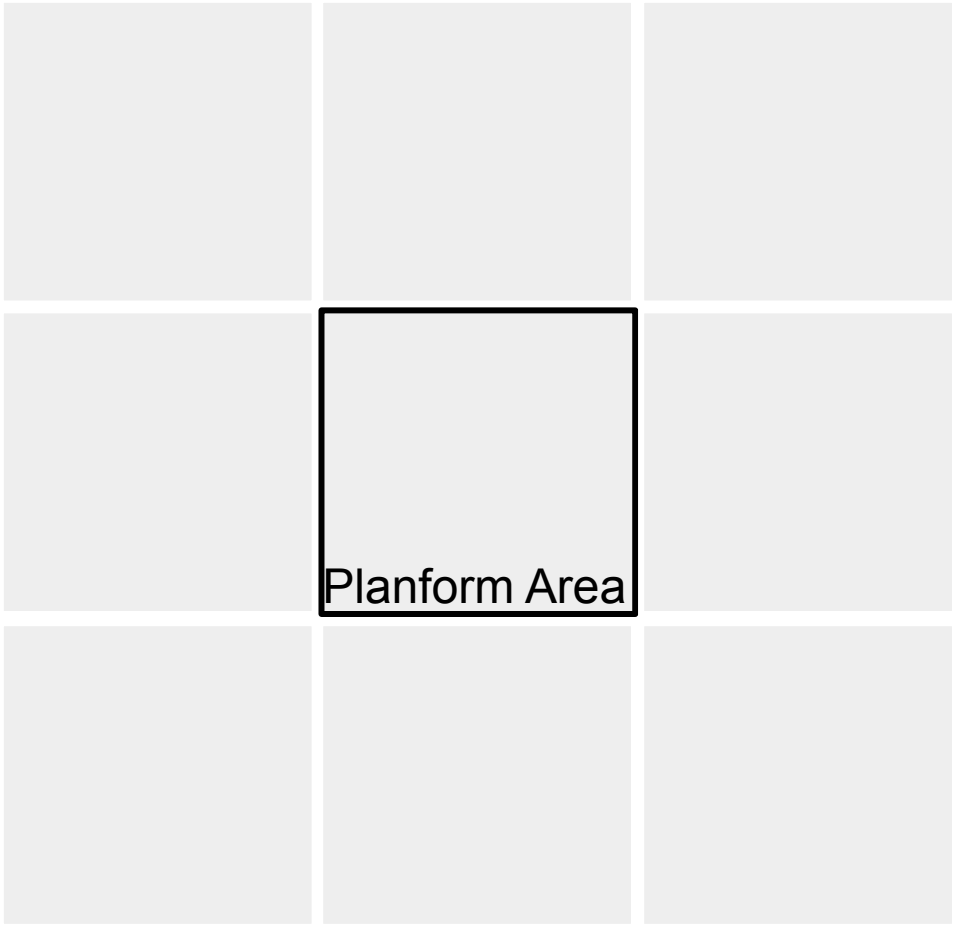


Geometry of Digital Terrain Models



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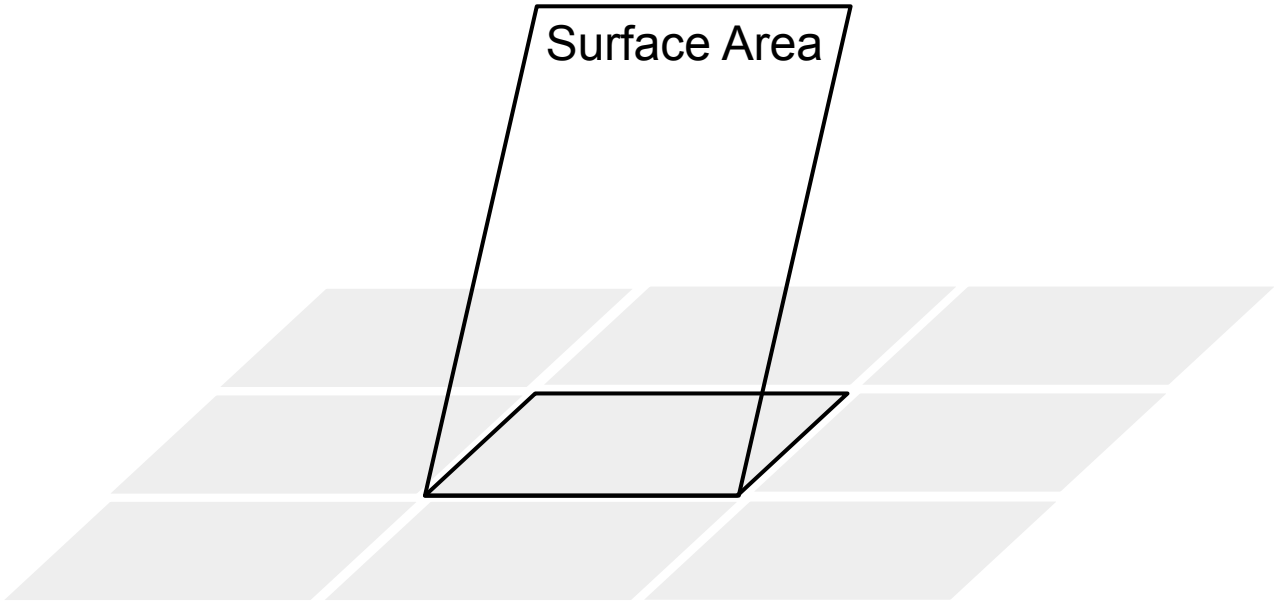

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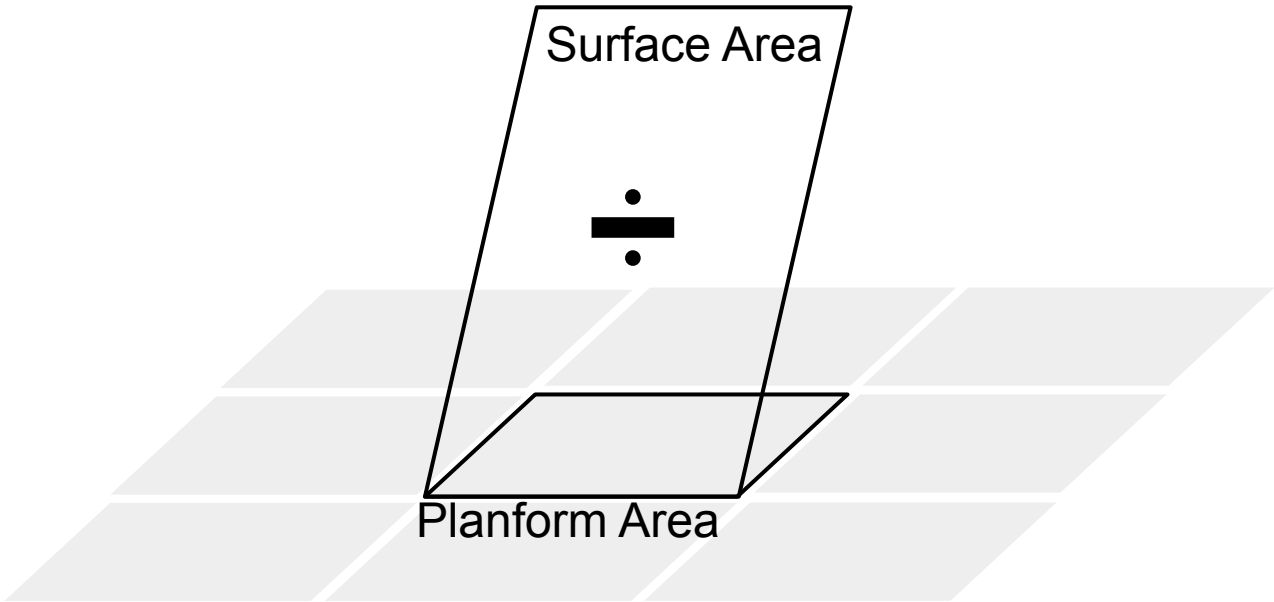
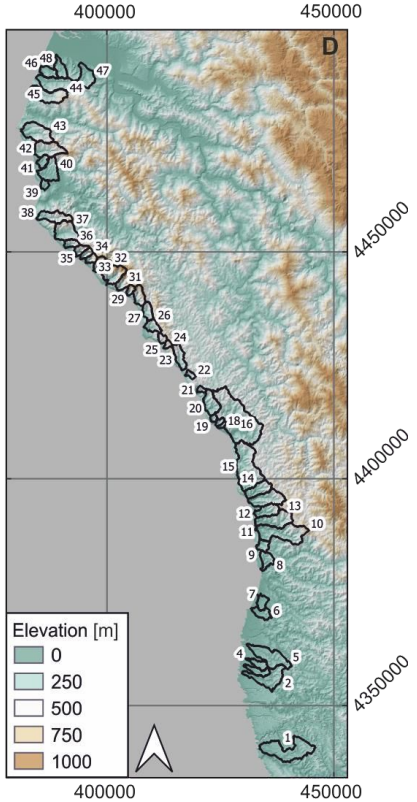


= Surface area ratio

Landscape response signatures in DTMs

Mendocino Triple Junction
Northward migrating uplift pulse
High resolution DTMs (~1m)
48 catchments



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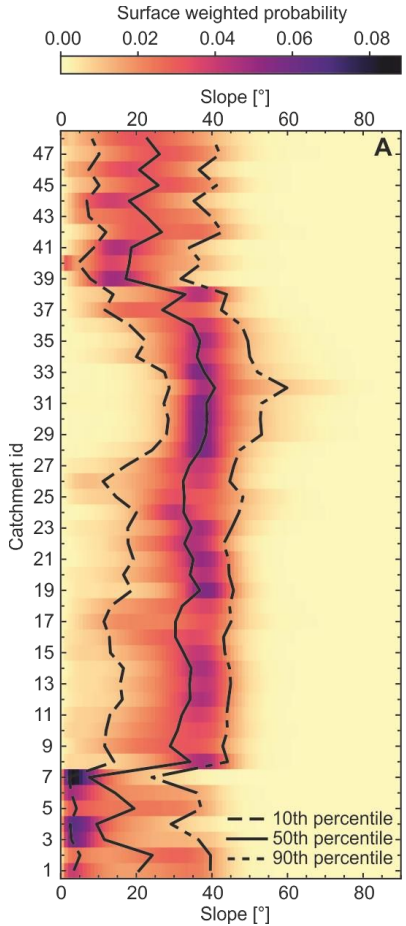
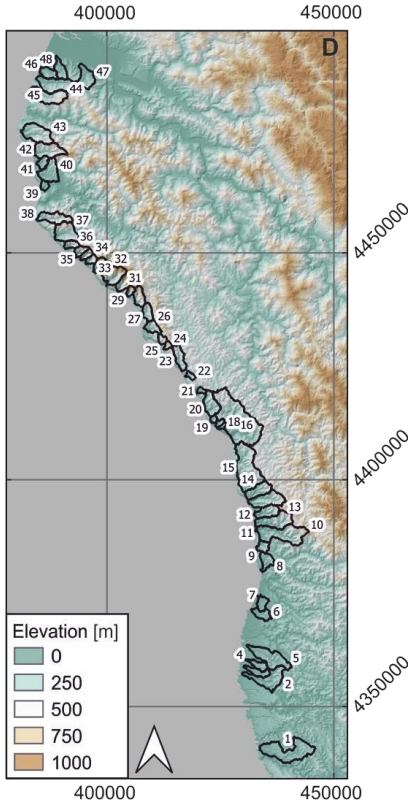
Landscape response signatures in DTMs



Surface area PDFs heatplots



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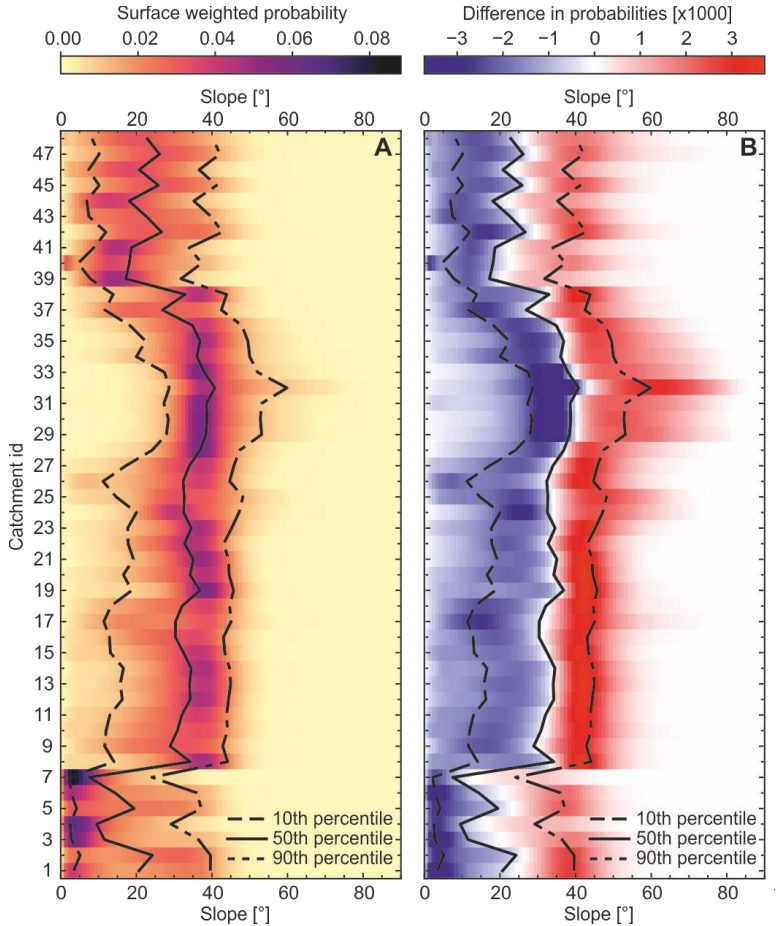
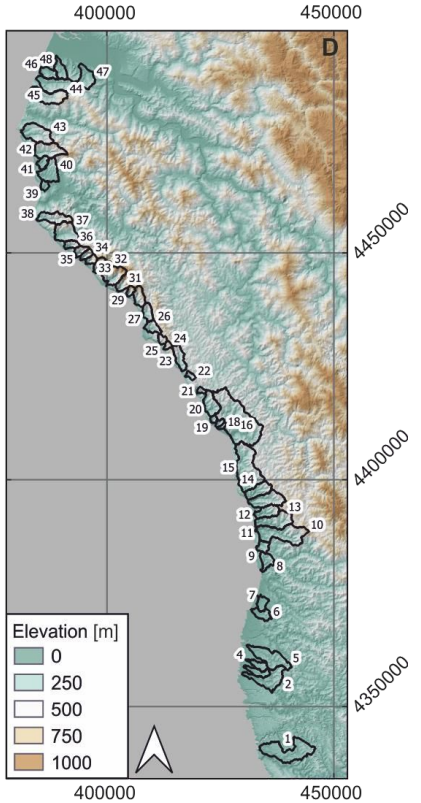


Differences in planform area and surface area PDFs



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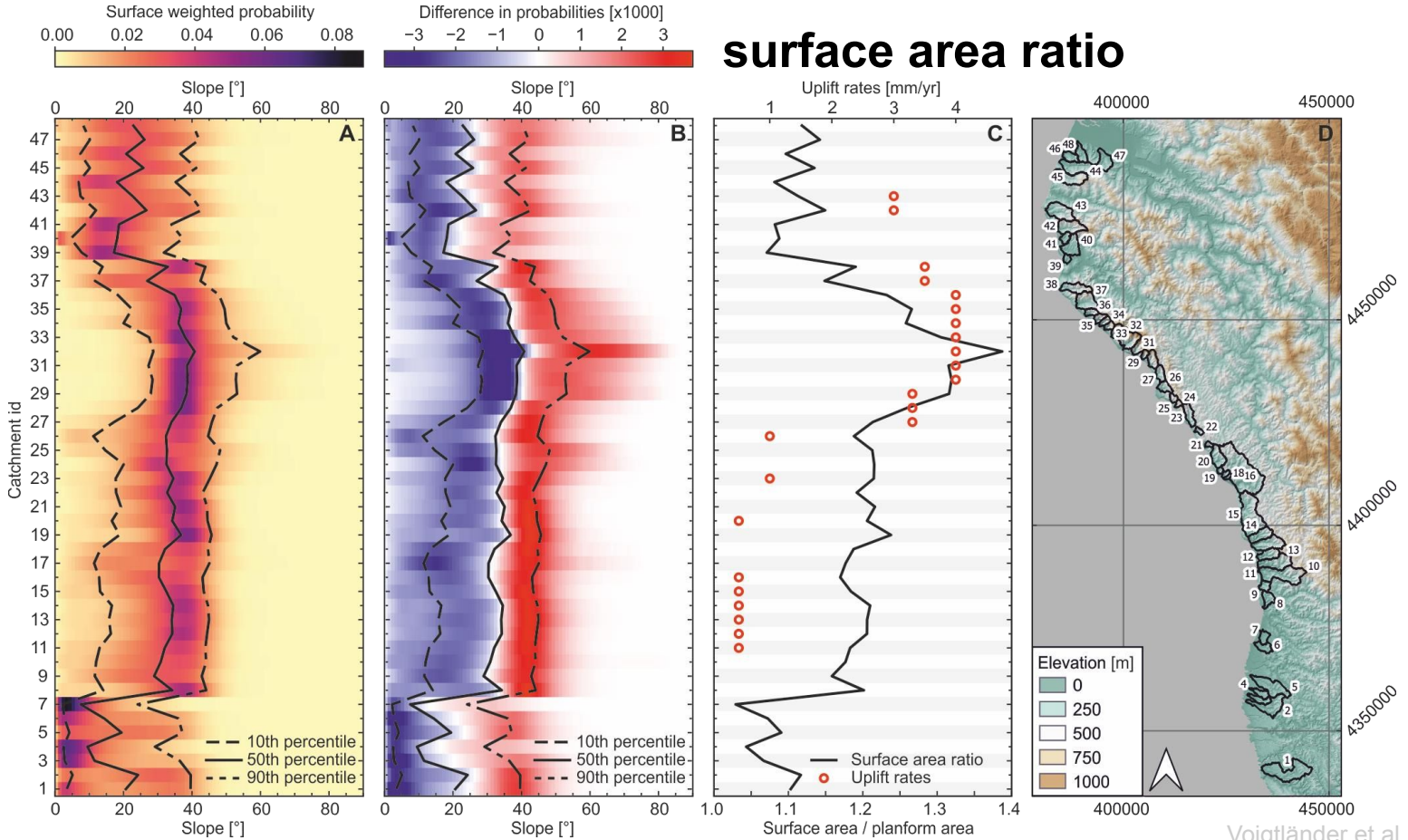

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A tale, where tortoises and hares intentionally work together.

Where, when and how changes happen over long or short times depend on the differential pace that create structures and topography.

Community tasks:

Define rate (e.g. forcing vs. response rates)

Quantify rates (e.g. independently, resolution)

Select which rates define topography, structures, failure, flow,... (e.g. strain, deformation, diffusion,event rate)

Thank you for your attention!
Questions?

If you want to discuss, collaborate, or co-create more ideas let me know. I am also looking for a position.

Later:
eina2neinmale@gmail.com
avoigtlaender@lbl.gov
anne.voigtlaender@gfz.de

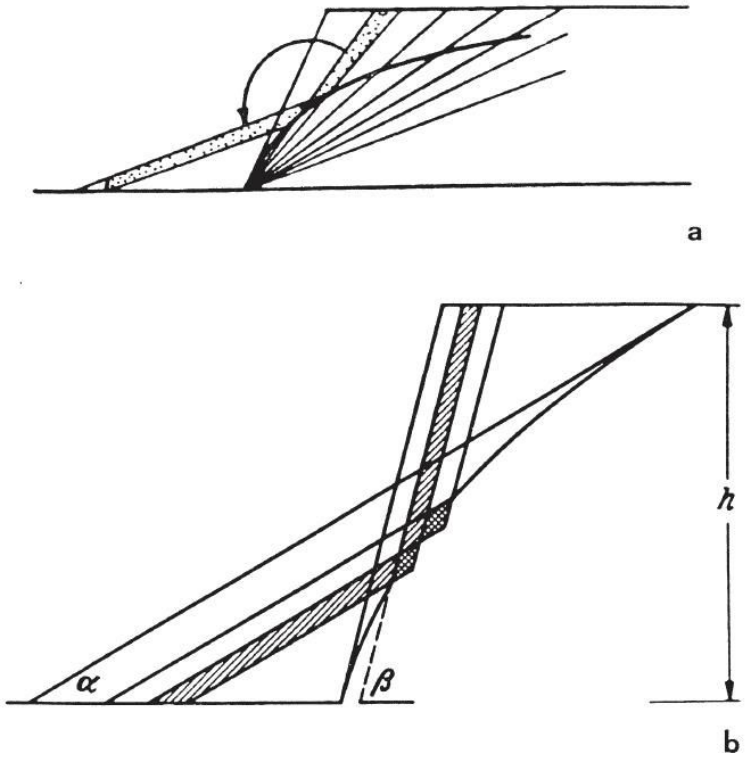
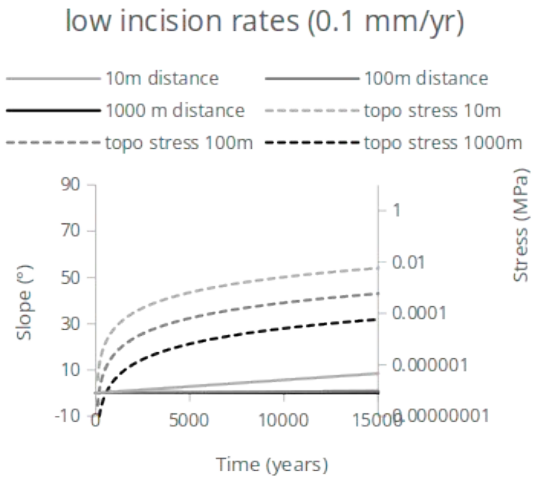
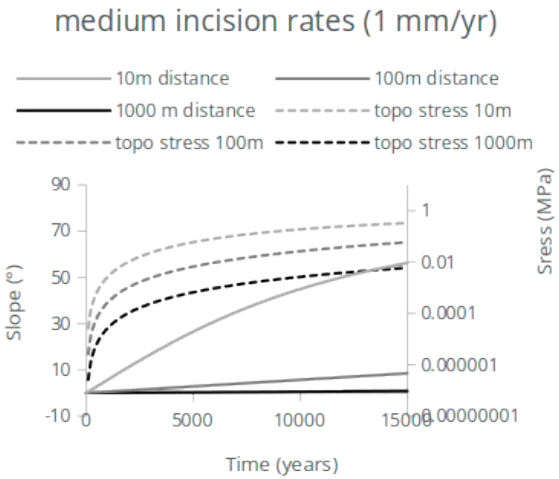
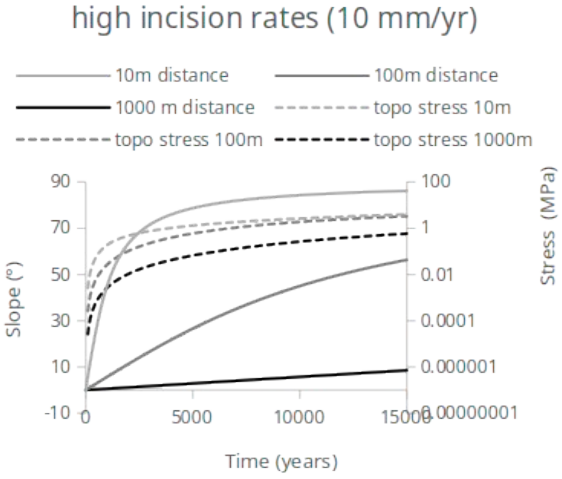


Fig. 5. Cliff recession (a) by progressive decrease of the declivity (wrong!), (b) parallel cliff recession and rock-core formation beneath the scree slope

Differential rates examples







$$\frac{\delta z}{\delta t} = U - K A^m S^n$$