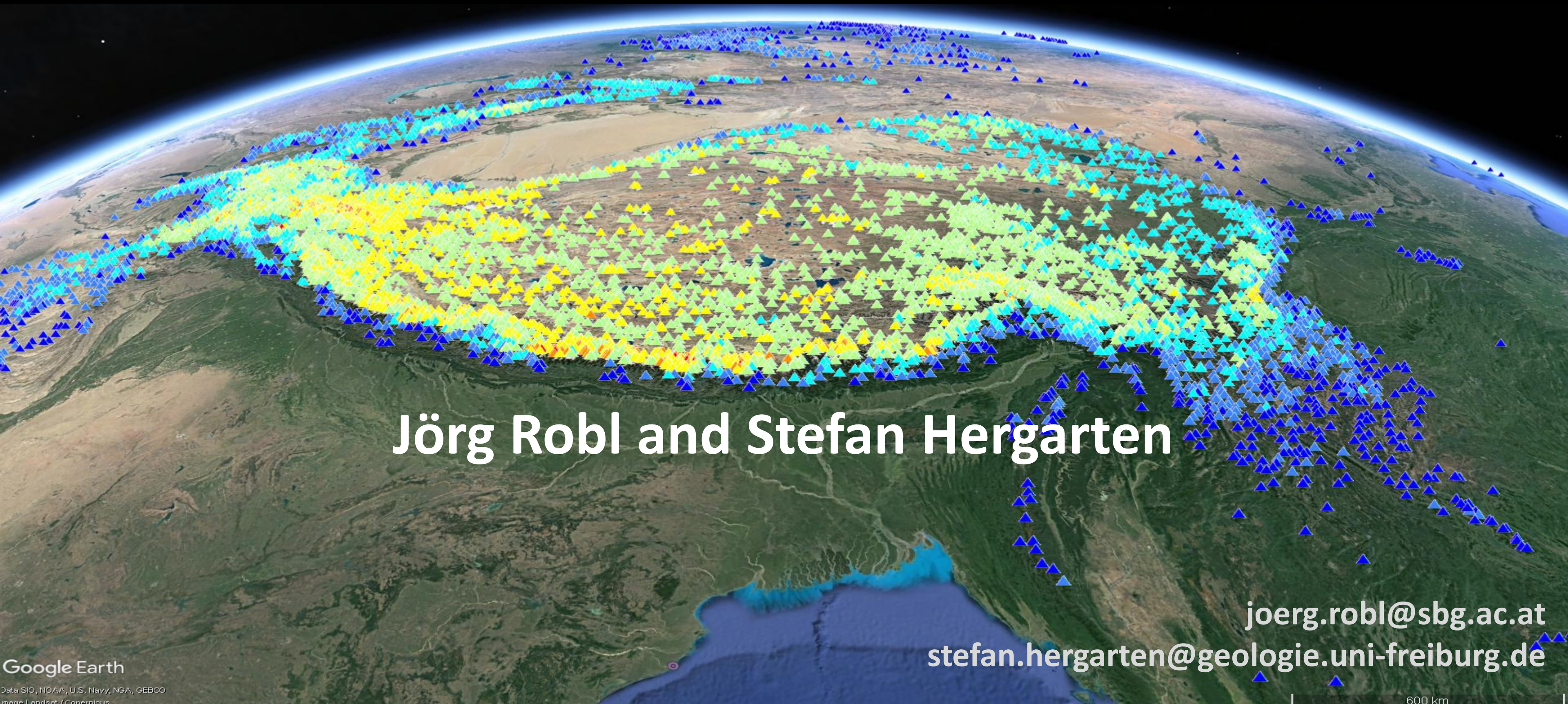
The rise of high mountain peaks: Feedback between orographic precipitation, fluvial erosion and flexural isostasy

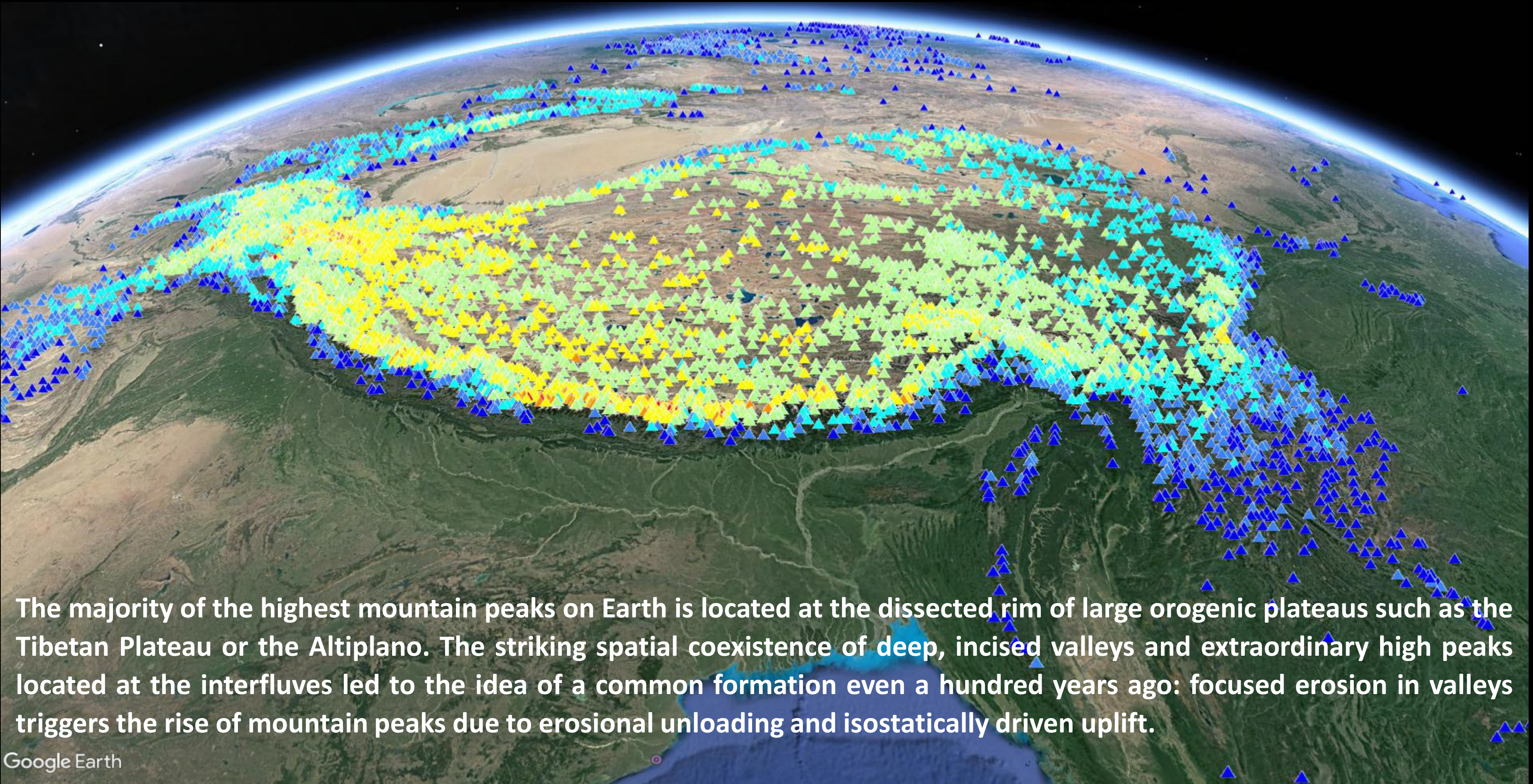


Jörg Robl and Stefan Hergarten

joerg.robl@sbg.ac.at
stefan.hergarten@geologie.uni-freiburg.de

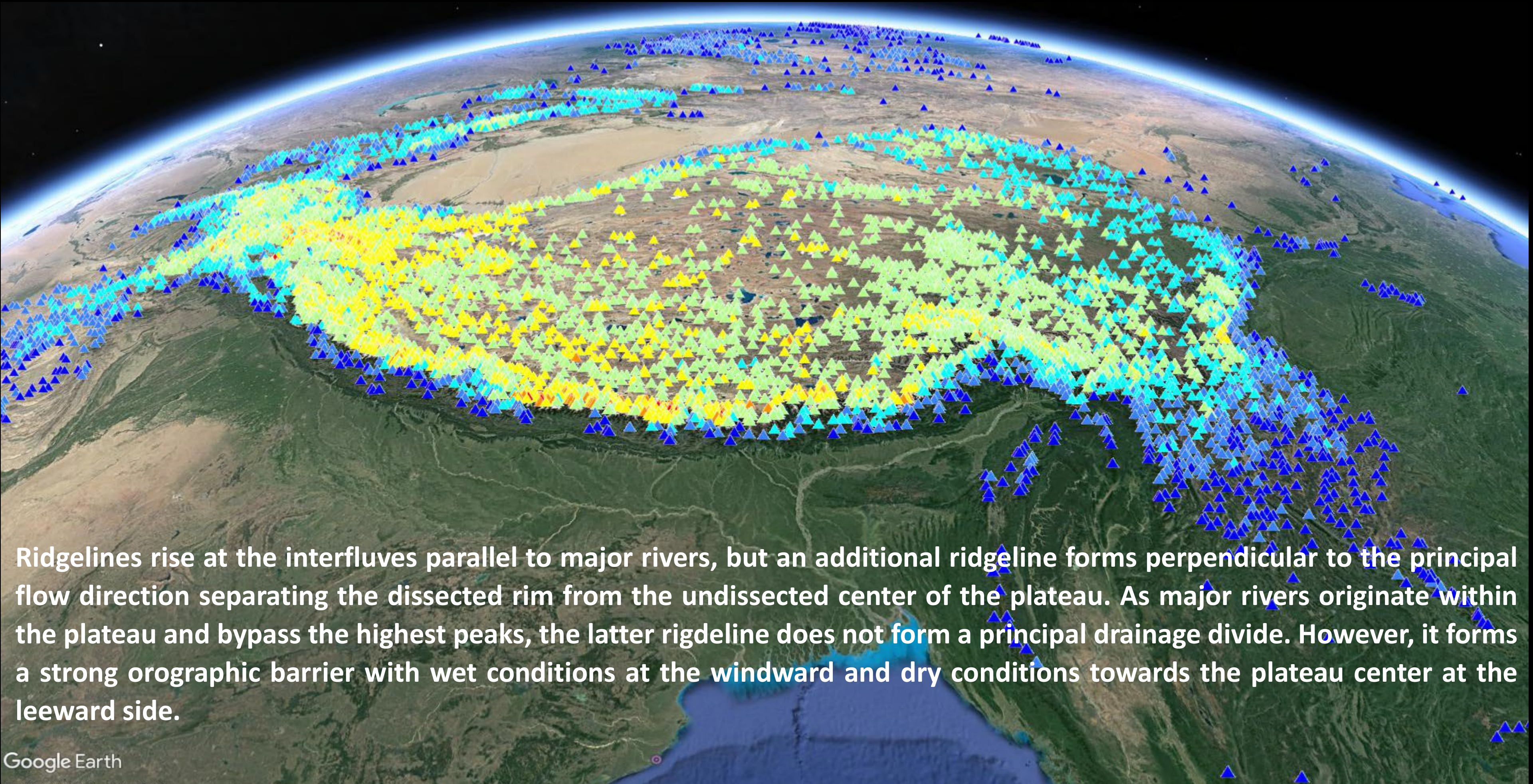
To view the embedded movies please download the presentation and open with Adobe Acrobat Reader

Spatial distribution of high and prominent peaks



The majority of the highest mountain peaks on Earth is located at the dissected rim of large orogenic plateaus such as the Tibetan Plateau or the Altiplano. The striking spatial coexistence of deep, incised valleys and extraordinary high peaks located at the interfluves led to the idea of a common formation even a hundred years ago: focused erosion in valleys triggers the rise of mountain peaks due to erosional unloading and isostatically driven uplift.

Spatial distribution of high and prominent peaks



Ridgelines rise at the interfluves parallel to major rivers, but an additional ridgeline forms perpendicular to the principal flow direction separating the dissected rim from the undissected center of the plateau. As major rivers originate within the plateau and bypass the highest peaks, the latter rigdeline does not form a principal drainage divide. However, it forms a strong orographic barrier with wet conditions at the windward and dry conditions towards the plateau center at the leeward side.

High mountains on thin crust

Please check out our recent paper in EPSL!

The supplement contains our global peak dataset with more than 16,000 prominent peaks.

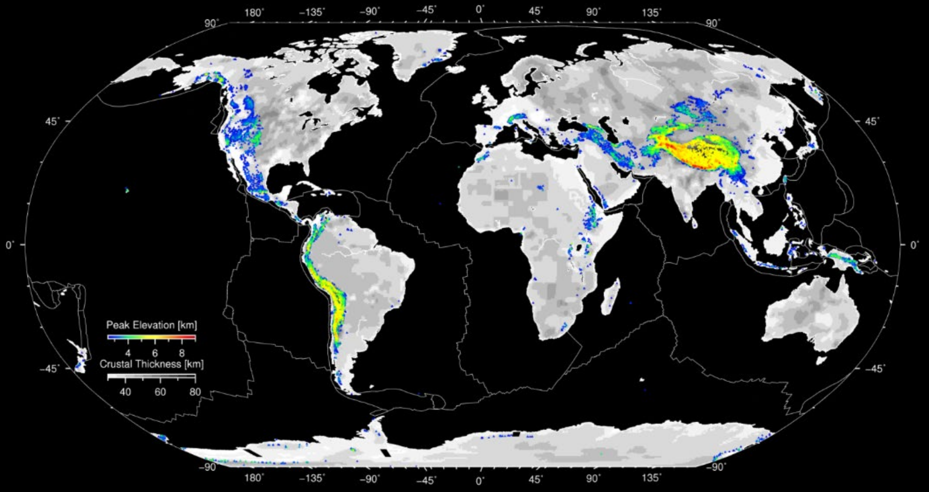

Contents lists available at ScienceDirect

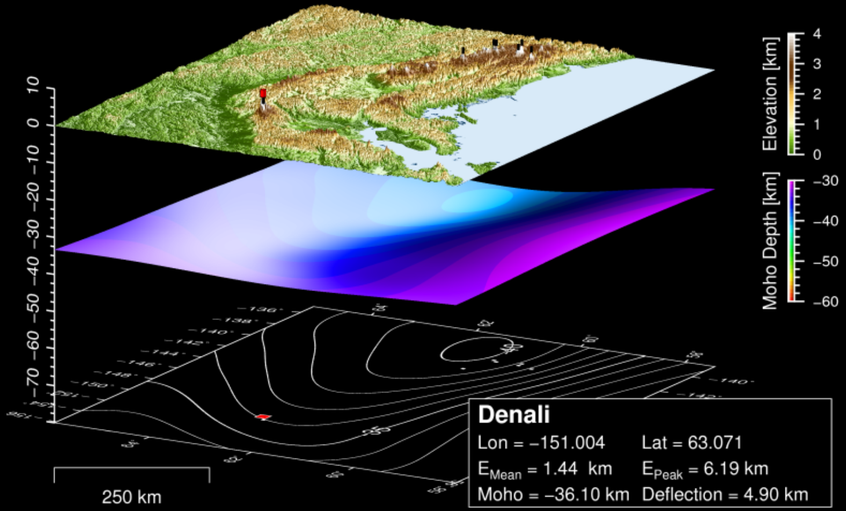
Earth and Planetary Science Letters

www.elsevier.com/locate/epsl

Glacial erosion promotes high mountains on thin crust

J. Robl [a,*], S. Hergarten [b], G. Prasicek [c]

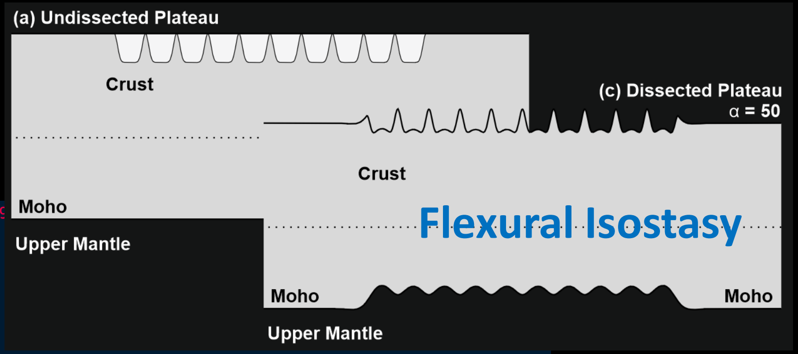


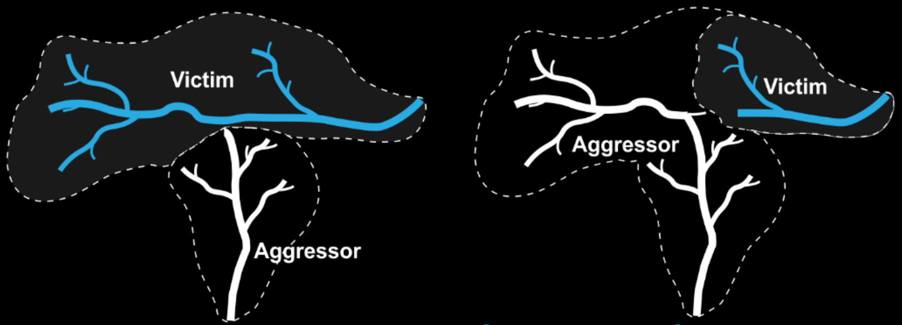


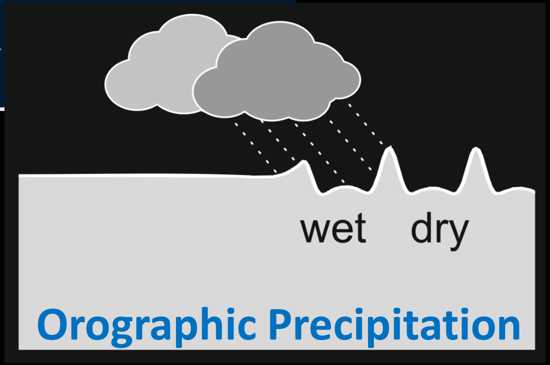
OpenLEM

Stefan's **OpenLEM** code efficiently couples Earth surface processes such as fluvial erosion and mass wasting at hillslopes with flexural isostasy and orographic precipitation.

This allows for the exploration of complex feedbacks between topography, climate and the Earth's crust.







Network Reorganization | Erosion | Deposition

Work in Progress Examples

The Impact of Flexural Isostasy

Mountain Range Evolution | Topography and Peaks | Drainage Networks

- Block uplift: central model domain
- Uniform Precipitation
- No Isostasy

Topography forms a central ridge – highest peaks are located at the central ridge

Mountain Range Evolution | Topography and Peaks | Drainage Networks

- Uniform Precipitation
- Flexural Isostasy
  Flexural Parameter
  α = 25 km

- Central part of the mountain range subsides under it own weight
- Main ridges and highest peaks evolve at the transition from the range to the foreland
- Main ridges and highest peaks migrate towards the uplift center

Mountain Range Evolution | Topography and Peaks | Channels

- Uniform Precipitation
- No Isostasy

- Uniform Precipitation
- Flexural Isostasy (α = 25 km)

Work in Progress Examples

The Impact of Orographic Precipitation

Mountain Range Evolution | Topography and Peaks | Drainage Networks

Orographic Precipitation

- Q controls advection of moisture in wind direction.
- D controls diffusion normal to wind direction
- S controls the rate of saturation
- P controls precipitation rate at boundary cells
- A is a scaling parameter

No Flexural Isostasy

Orographic precipitation causes a strong topographic asymmetry
Advection (Q) and diffusion (D) of moisture controls the pace of incision and divide migration

Mountain Range Evolution | Topography and Peaks | Drainage Networks

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Orographic precipitation causes a strong topographic asymmetry

Advection (Q) and diffusion (D) of moisture controls the pace of incision and divide migration

Mountain Range Evolution | Topography and Peaks | Channels

Low spreading rate of moisture

- Orographic Precipitation
- Q=10: Slow advection of moisture in wind direction
- D=10: Low diffusion moisture normal to wind direction

High spreading rate of moisture

- Orographic Precipitation
- Q=100: Fast advection of moisture in wind direction
- D=100: Strong diffusion moisture normal to wind direction

Work in Progress Examples

The Impact of Orographic Precipitation and Flexural Isostay

Unfortunately we messed up a new scaling routine for precipitation so that precipitation rates are not comparable between different model runs. It seems that we produced 800 GB of "garbage" … .

Orographic Precipitation

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Flexural Isostasy

- α (50 km) controls the length scale of flexure

- Orographic precipitation causes a strong topographic asymmetry
- Isostatic uplift due to erosional unloading causes a complex topographic pattern

Mountain Range Evolution | Topography and Peaks | Drainage Networks

Orographic Precipitation

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Weak Lithosphere

Flexural Isostasy

- α = 50 km (still realistic)

Precipitation

- Low Q and low D (not to scale)

Very weak Lithosphere

Flexural Isostasy

- α = 10 km (not on Earth)

Precipitation

- Low Q and low D (not to scale)

What next?

Repair scaling method for orographic precipitation

Explore the entire parameter space

Apply to natural examples

Please stay tuned and visit us at:

http://www.geodynamics.at (joerg.robl@sbg.ac.at)

http://hergarten.at/ (stefan.hergarten@geologie.uni-freiburg.de)