Hillslope response to oscillating forcing

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CIRES

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- Hillslopes are key components of landscapes response to climate variations
- Hillslopes occupy most of the continents surface and produce most of the sediments
- Are they just following passively the pace imposed by rivers?

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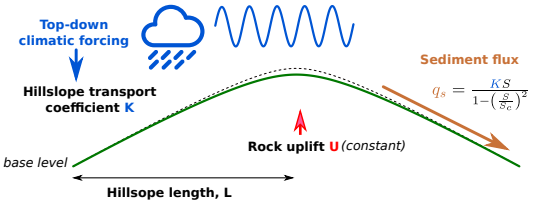
Approach

- 1D hillslope models
- Transport-limited
- Non-linear sediment flux
- Oscillations of transport coefficient K



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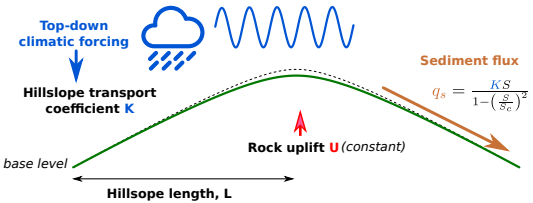

Take home message

- Linear/nonlinear transition induces complex hillslope dynamics
- Impact on filtering potential with respect to climatic signals
- Climatic frequency shift at the Mid-Pleistocene Transition influence erosion response

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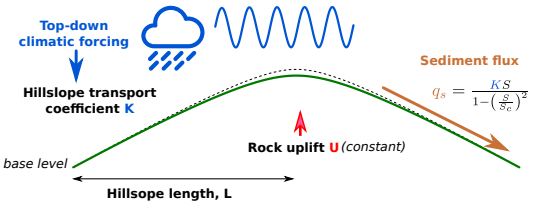

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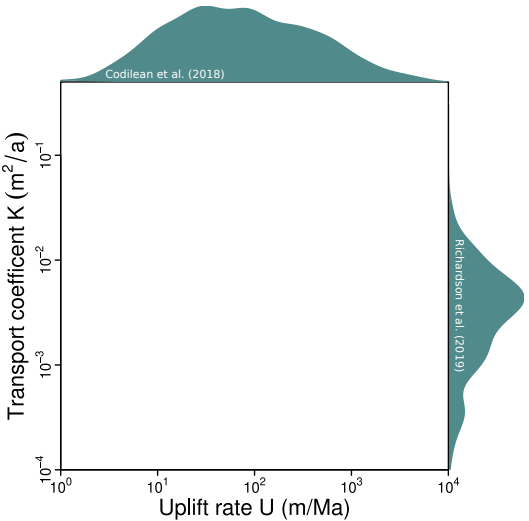
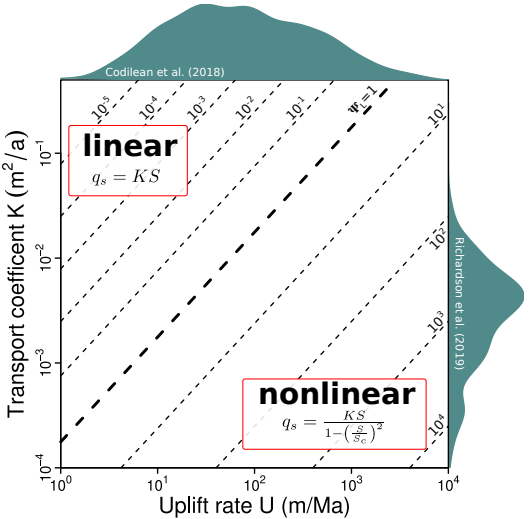
Linear *vs* nonlinear hillslope response



- Hillslope response dependency on :
  - transport coefficient K
  - uplift rate U

Linear *vs* nonlinear hillslope response



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$$\Psi = \frac{q_{nl}}{q_l} = \frac{1}{2}\sqrt{1 + E^{*2}} - \frac{1}{2}$$

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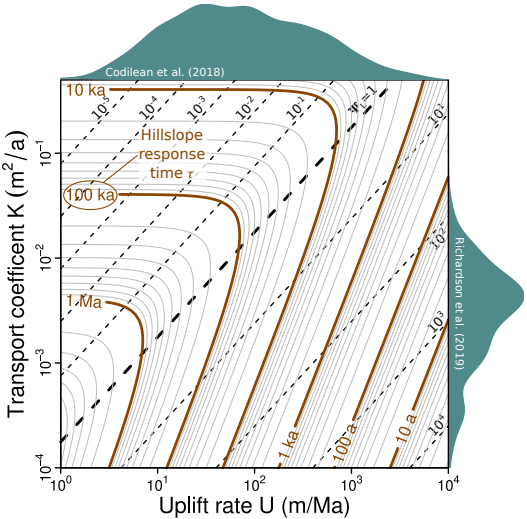

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- Hillslope response time

$$\tau = \frac{AL^2}{K(1+\Psi)^B}$$

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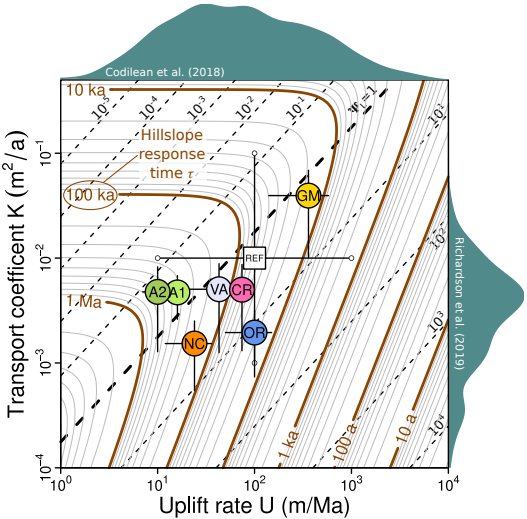

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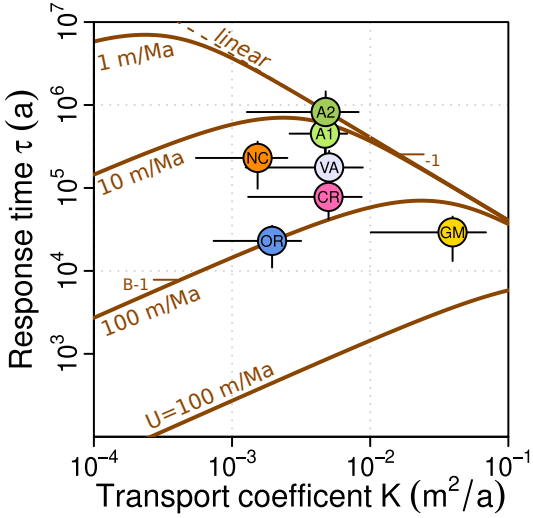
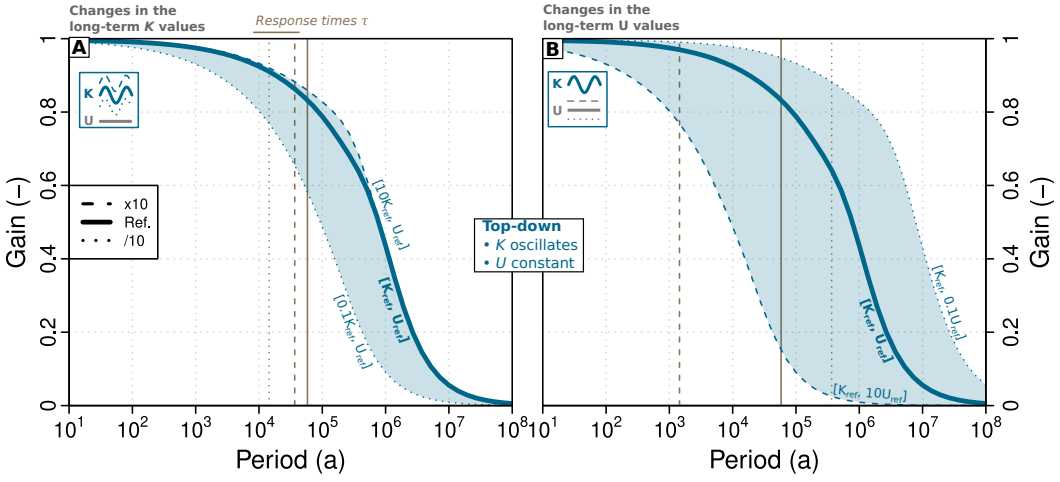
- Well constrained settings
  - **GM** Gabilan Mesa, CA (Roering et al., 2007)
  - **A** SE Australian Escarpment (Godard et al., 2019)
  - **CR** Sierra Nevada, CA (Hurst et al., 2012)
  - **NC** Coweeta, NC (Grieve et al., 2006)
  - **OR** Oregon Coast Range (Reoring et al., 2007)
  - **VA** Provence, France (Godard et al., 2020)

Linear *vs* nonlinear hillslope response



- Non-linear response time depends on both U and K
- Transition from linear to non-linear regime
- Most settings are close to the transition point
- Change in dependency on K related to the steepening of nonlinear hillslope at low K values

Response curves for transport coefficient oscillations



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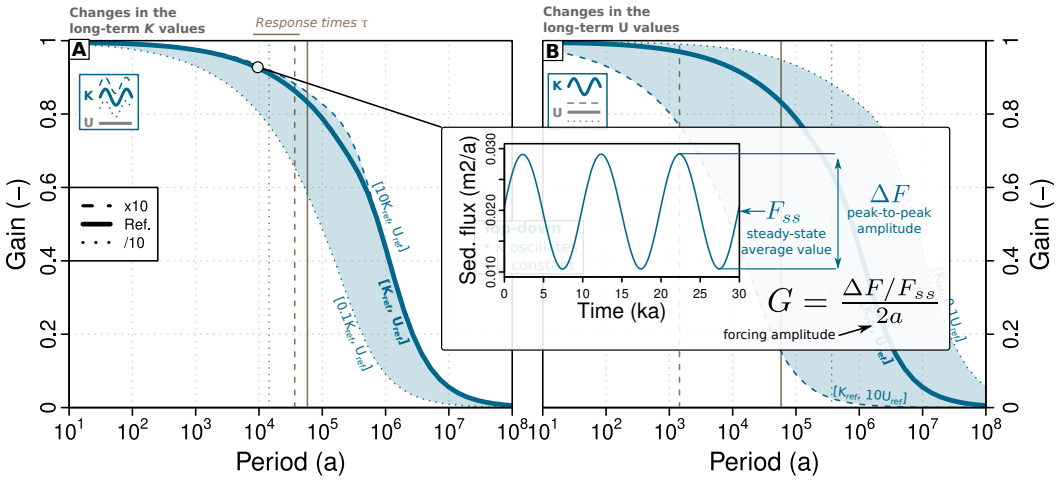

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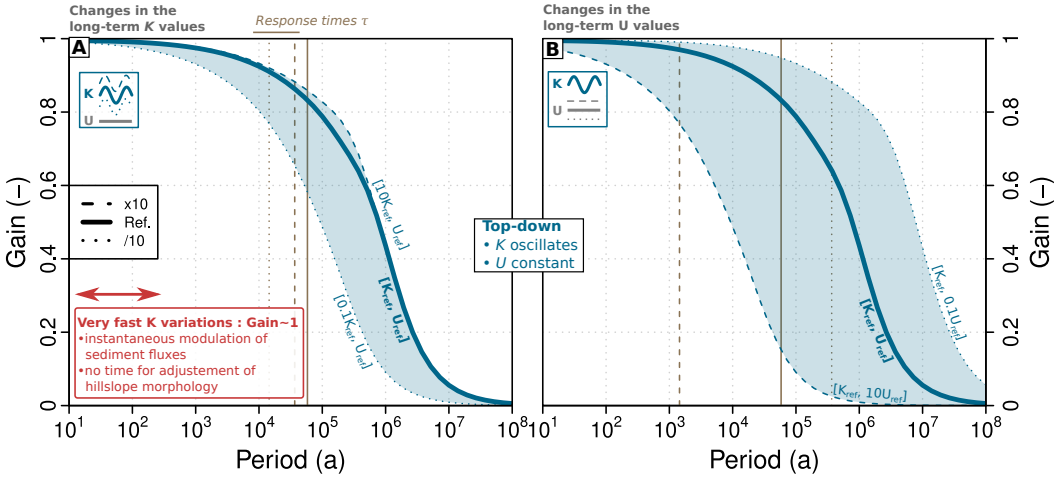

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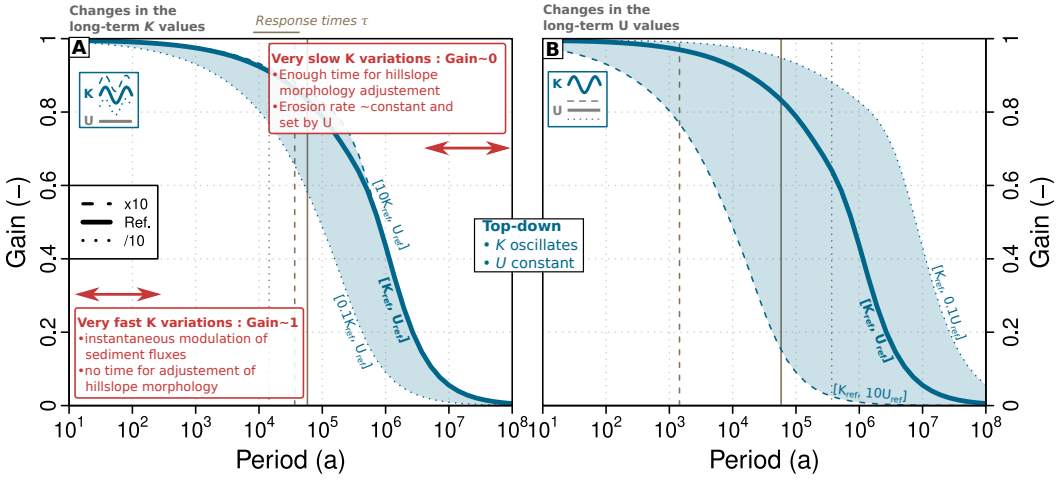
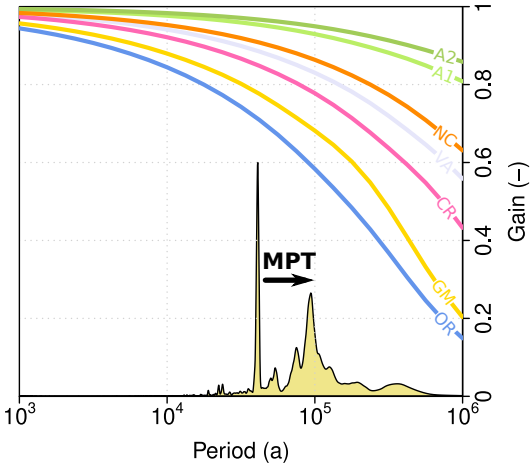


Impact of Mid-Pleistocene Transition



- Changing K oscillations from 40 ka to 100 ka periods
- Overall decrease in response gain

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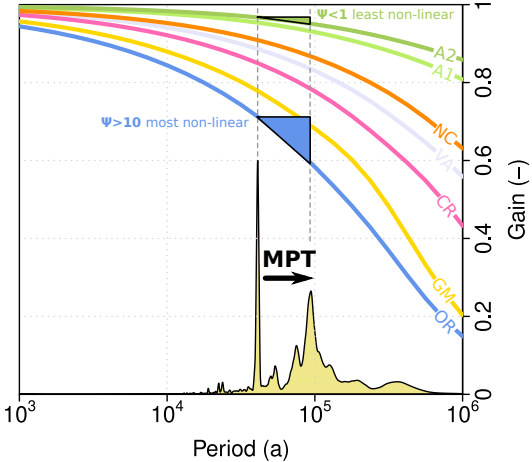

- Changing K oscillations from 40 ka to 100 ka periods
- Overall decrease in response gain
- SE Australian Escarpment (A)
  - $\Psi < 1$
  - High τ (several 100 ka)
  - Limited change in response gain
- Oregon Coast Range (OR)
  - $\Psi > 10$
  - low τ ($\sim$10 ka)
  - Nearly 0.15 change in response gain

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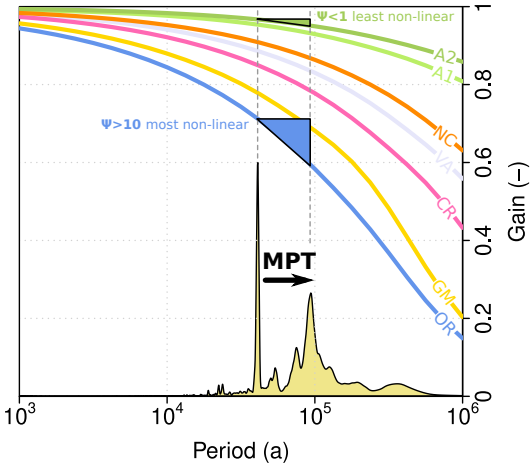

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Conclusion

A pure frequency change in the climatic forcing can impact hillslope dynamics in high relief / fast erosion landscapes