Influence of oscillating vegetation cover, precipitation, and sediment transport on topography: Insights from a landscape evolution model

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Acknowledgement: This work was supported by the Research Training Group 1829 Integrated Hydrosystem Modelling, funded by the German Research Foundation (DFG).

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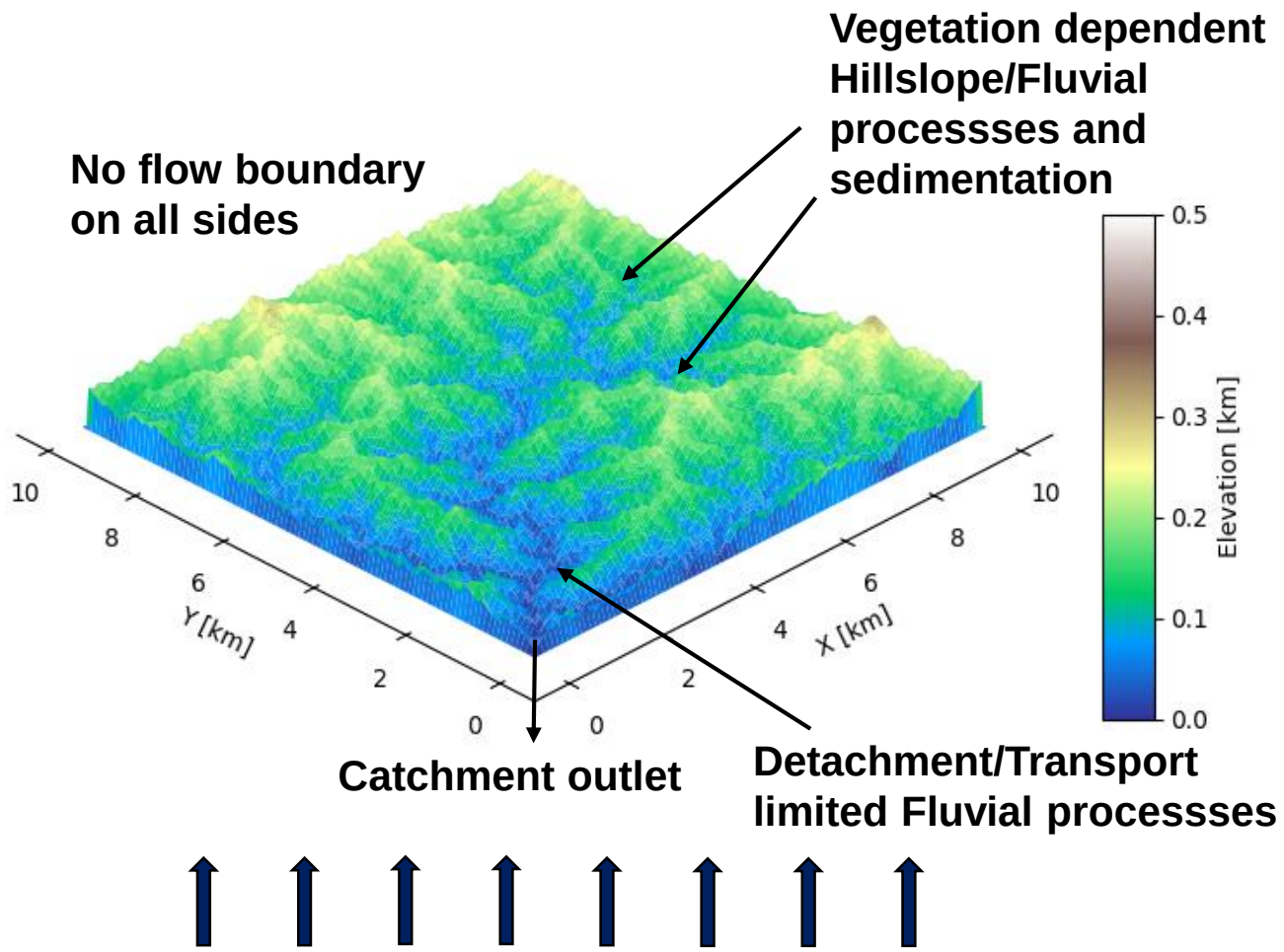
Introduction

- Periodicity in climate and vegetation cover influences catchment geomorphology.
- Rates of rock uplift (tectonics) also play a significant role in altering geomorphological processes.
- Climate and tectonics are variable over millennial to million year time-scales.
- For million year scale landscape evolution studies, it is significant to evaluate the effect of variable tectonics and periodicities of climate/vegetation cover on catchment erosion and sedimentation.

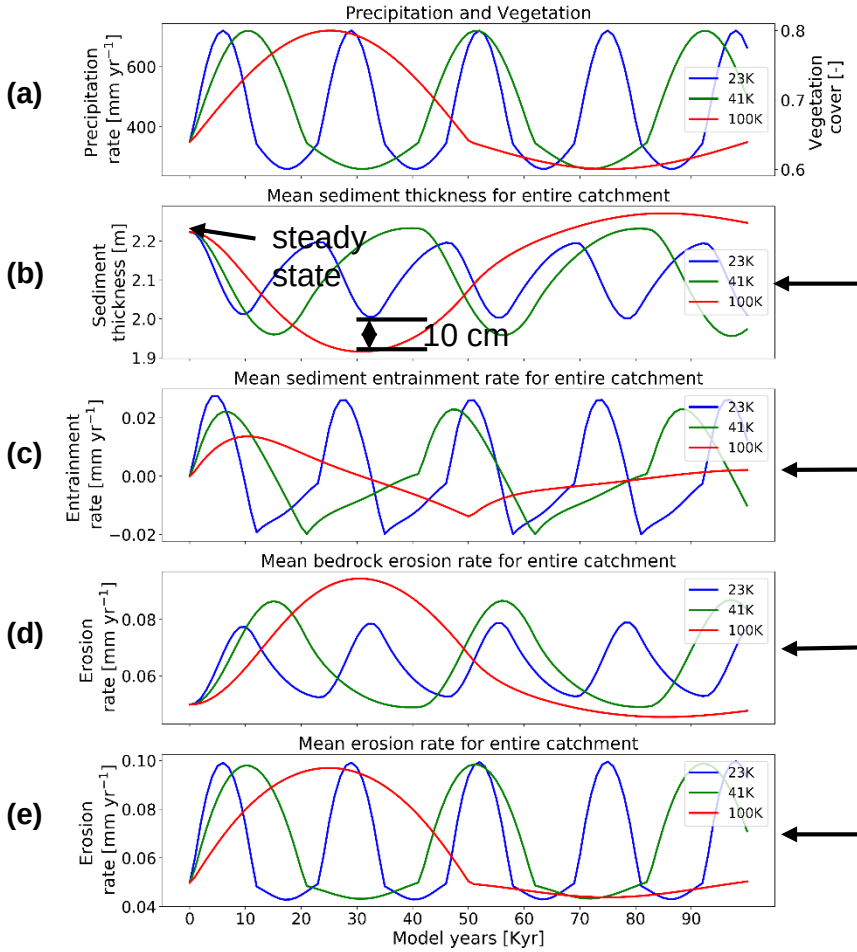
Materials and Methods

- Model inputs reflect desert (~26°S) and Mediterranean (~33°S) climates for sites in Chilean Coastal Cordillera.
- **Landscape evolution model used:** Landlab (Python based toolkit)
- Vegetation dependent hillslope and fluvial processes, weathering and soil production were incorporated in Landlab LEM.
- Sensitivity of catchment erosion and sedimentation was analysed to periodic fluctuations in climate and vegetation for:
    - Different periodicities of climate/vegetation fluctuations (23 kyr, 41 kyr and, 100 kyr)
    - Different rates of rock uplift (0.05 mm a^{-1}, 0.1 mm a^{-1}, 0.2 mm a^{-1})

Model Setup and Boundary conditions



Influence of Climate/vegetation periodicity



Higher influence of longer periodicity (100 kyr) on sediment deposition. Phase lag (~ 5 kyr) with maximum precipitation/vegetation cover and minimum sediment depth

Higher influence of shorter periodicity (23 kyr) on sediment entrainment

Higher influence of longer periodicity (100 kyr) on bedrock erosion

Effect of different periodicities on catchment erosion rates is not significant

Figure 1. *Effect of (a) variable periodicities of vegetation cover [-] and precipitation [mm yr^{-1}] fluctuations on mean catchment (b) sediment thickness [m], (c) sediment entrainment rates [mm yr^{-1}], (d) bedrock erosion rates [mm yr^{-1}], and (e) net erosion rates [mm yr^{-1}]. Rates of rock uplift kept constant at 0.05 mm a^{-1}*

Influence of variable uplift rates

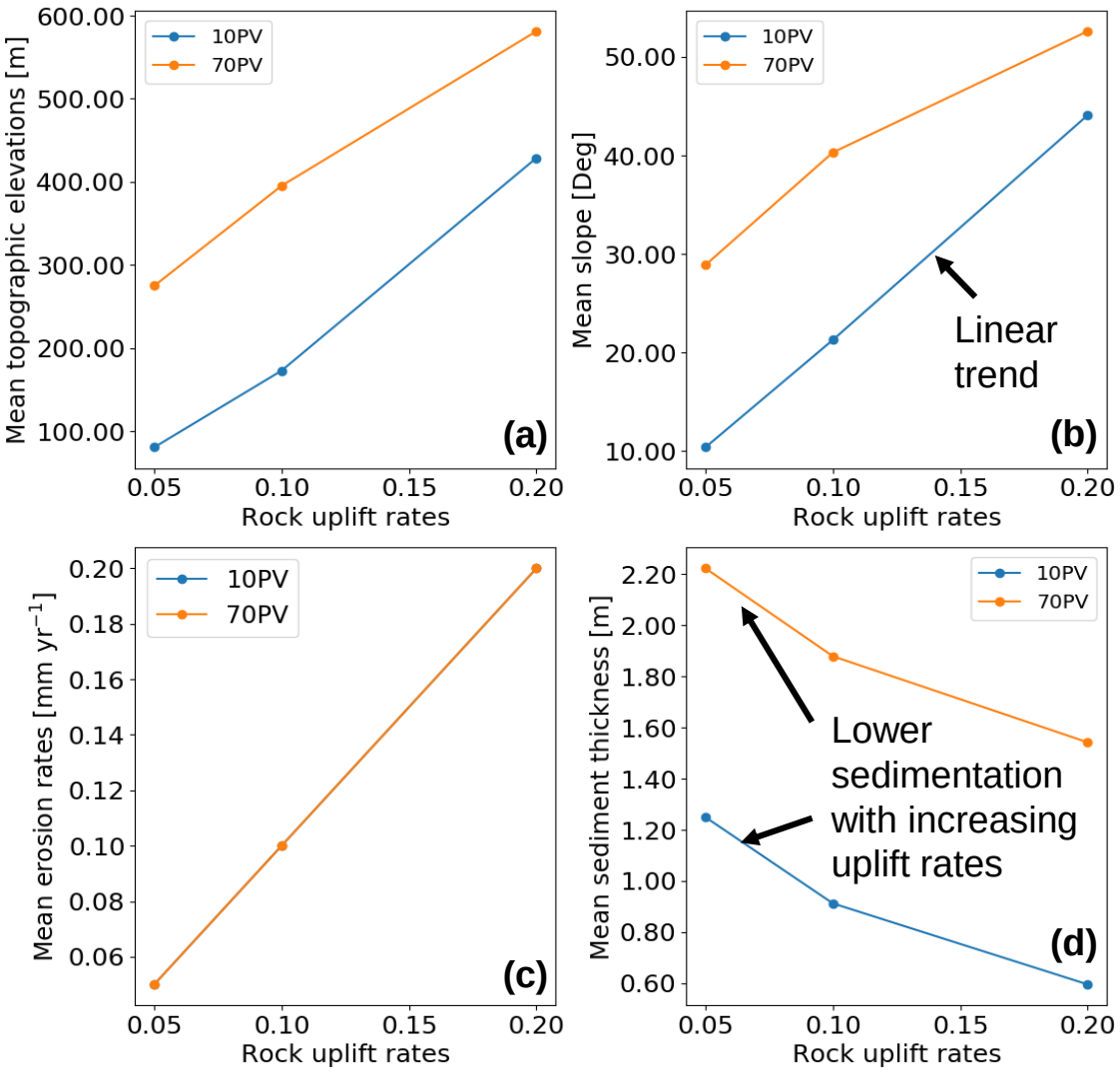


Figure 2. *Effect of variable rock uplift rates (0.05 mm a^{-1}, 0.1 mm a^{-1} and, 0.2 mm a^{-1}) on mean catchment (a) topographic elevations [m], (b) slope [Deg], (c) erosion rates [mm yr^{-1}] and, (d) sediment thickness [m]. Periodicity of climate/vegetation cover fluctuations kept constant at 23 kyr*

Conclusions

- Variable rates of rock uplift influences catchment topography, erosion and sedimentation linearly.
- The effect of variable periodicities of climate/vegetation fluctuations is significantly pronounced in longer periods (100 kyr) for sedimentation and bedrock erosion.
- The effect of variable climate/vegetation on catchment erosion and sedimentation vary significantly with variable rock uplift rates.
- However, periodicity of climate/vegetation change influences erosion (~0.01 mm yr^{-1}) and sedimentation (~10 cm) to lesser extent than variable rock uplift rates.