Incision migration across Eastern Tibet controlled by monsoonal climate, not tectonics

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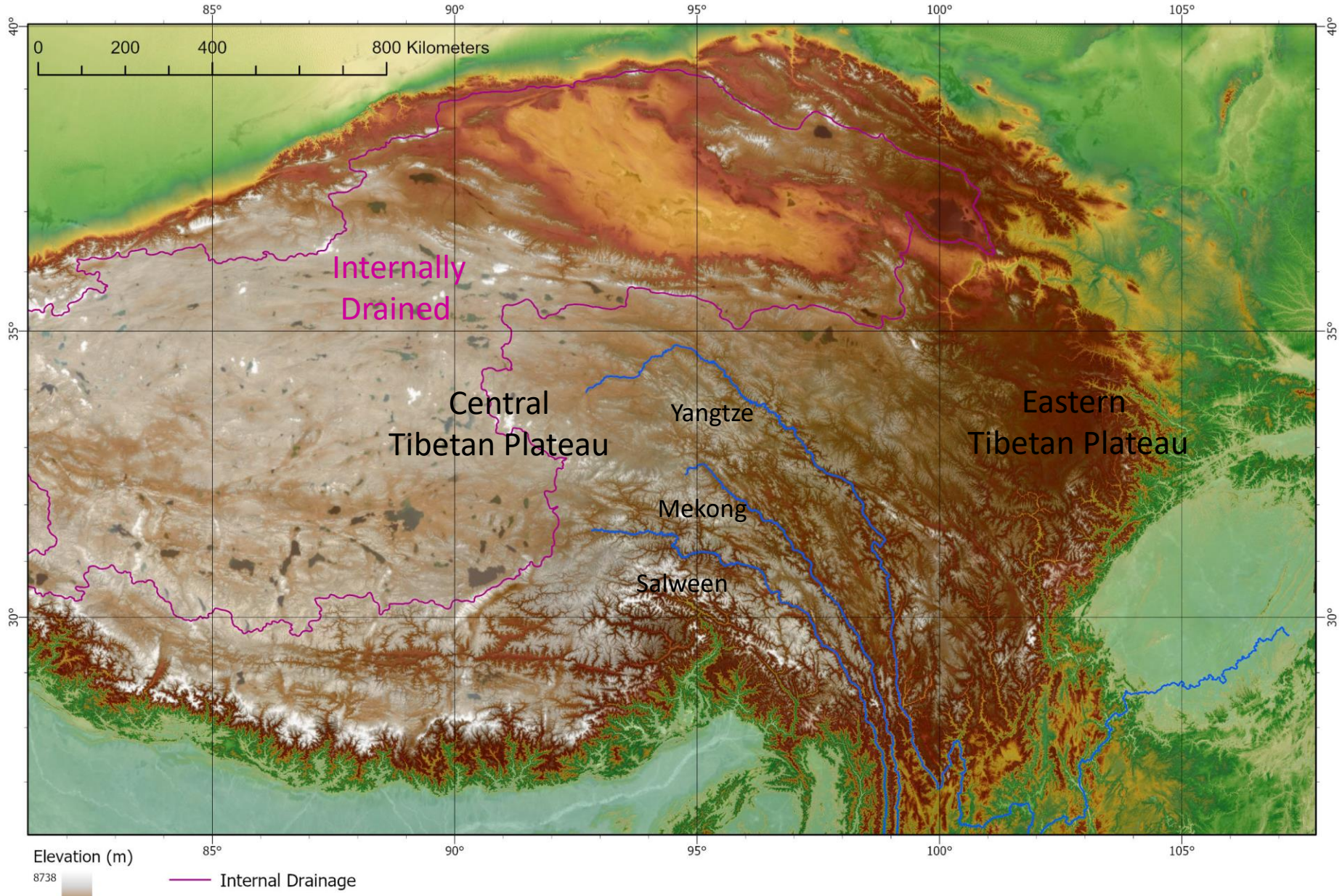
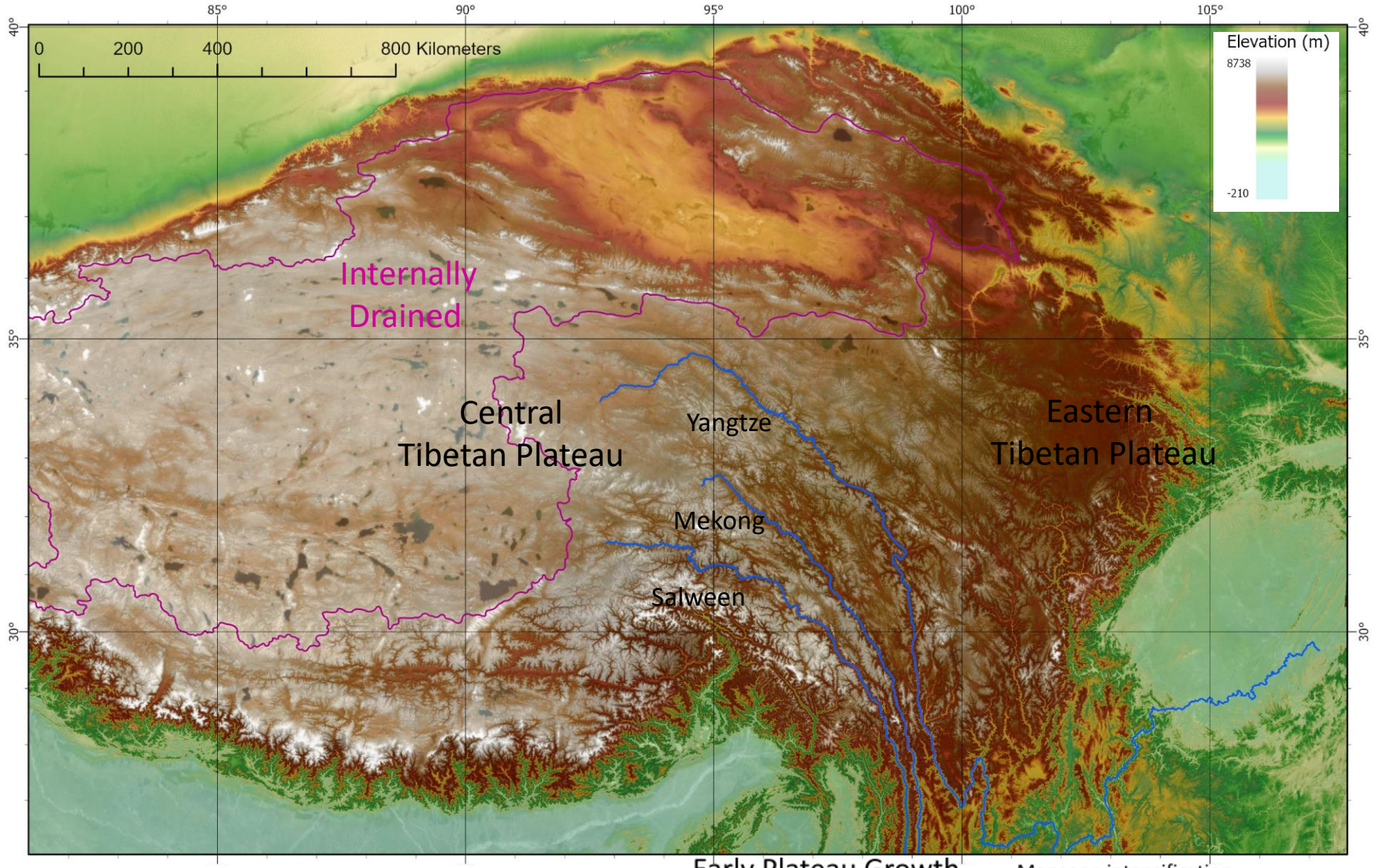


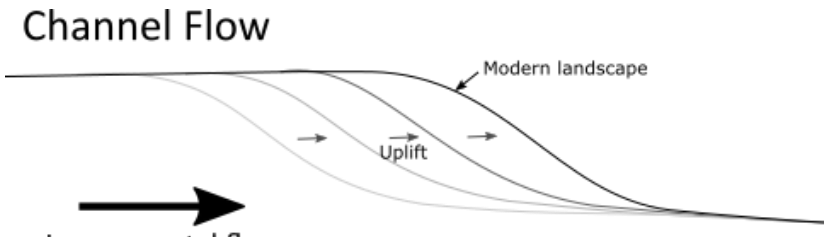
The central Tibetan Plateau has high elevation and low relief and is internally drained.

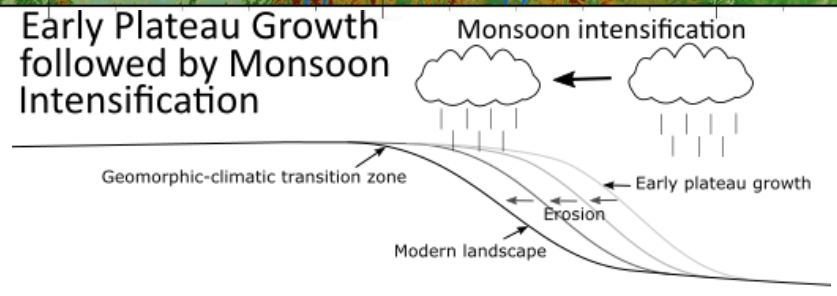
The eastern Tibetan Plateau is drained by major rivers, including the Yangtze, Mekong and Salween.

In this study we analyse the modern geomorphic and precipitation data to highlight a transition zone in the landscape.

We interpret this transition zone in terms of competing models of Tibetan Plateau uplift and growth.







In the eastern Tibetan Plateau there are competing tectonic models of plateau uplift.

These suggest either:

- **early Cenozoic plateau growth**

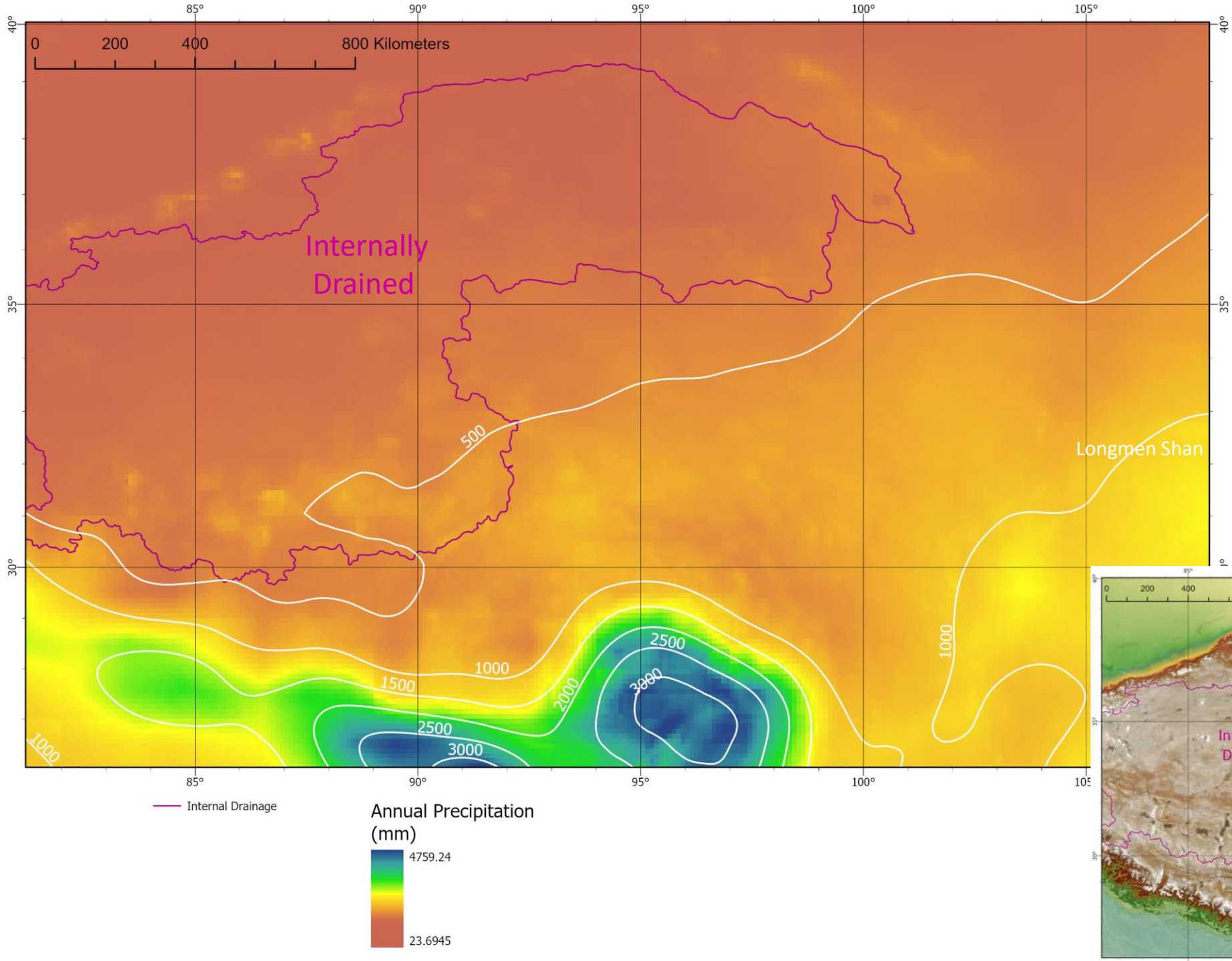
or

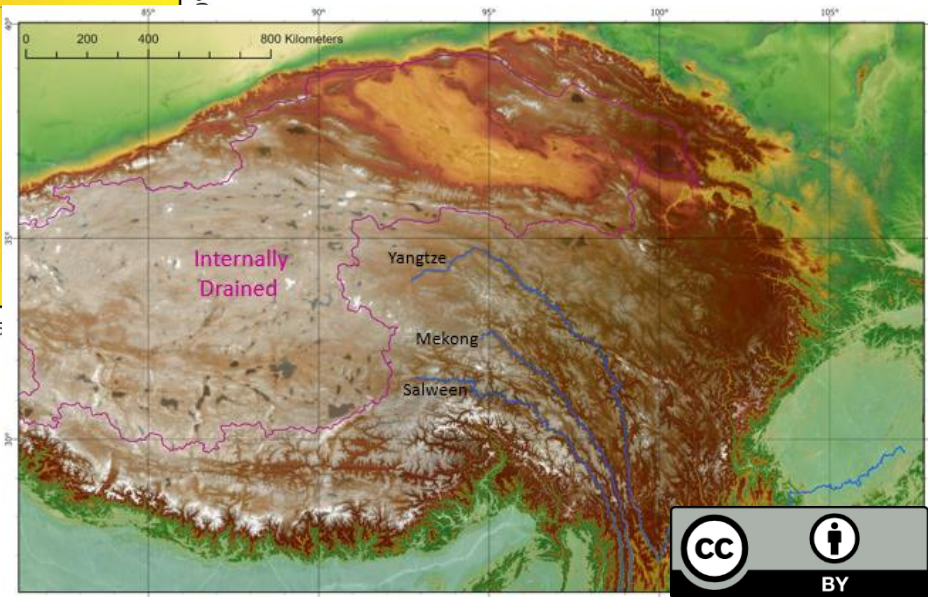
- **a late phase** (Miocene) of crustal thickening, surface uplift and plateau growth driven by lower crustal flow ("**channel flow**") from the central Tibetan Plateau.

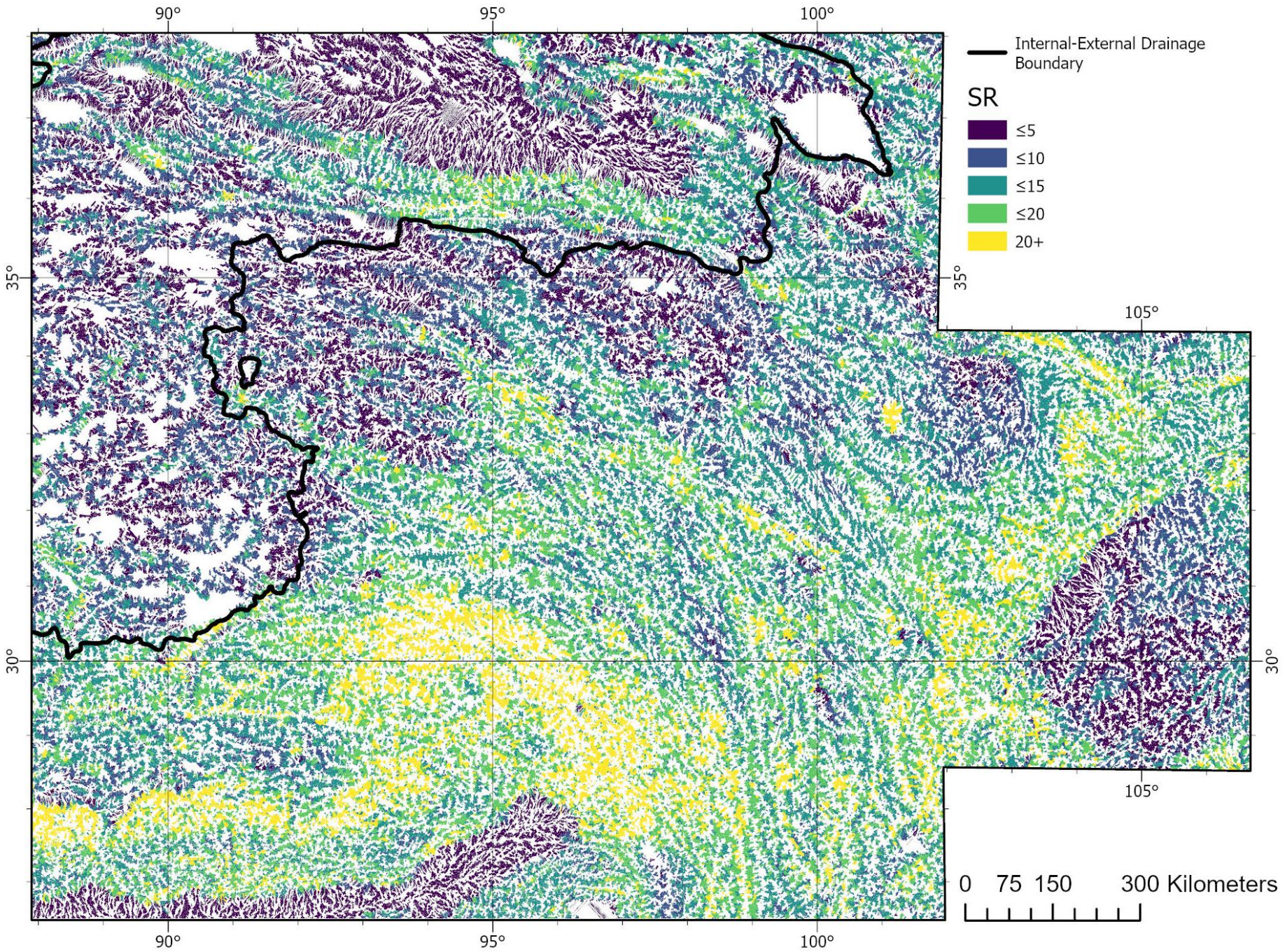
The results of this study suggest that the plateau formed by **early plateau growth followed by monsoon intensification**.

Precipitation is controlled by the East Asian Monsoon

Precipitation decreases from east to west from over 1000 mm/yr at the Longmen Shan to less than 200 mm/yr in the central, internally drained region.







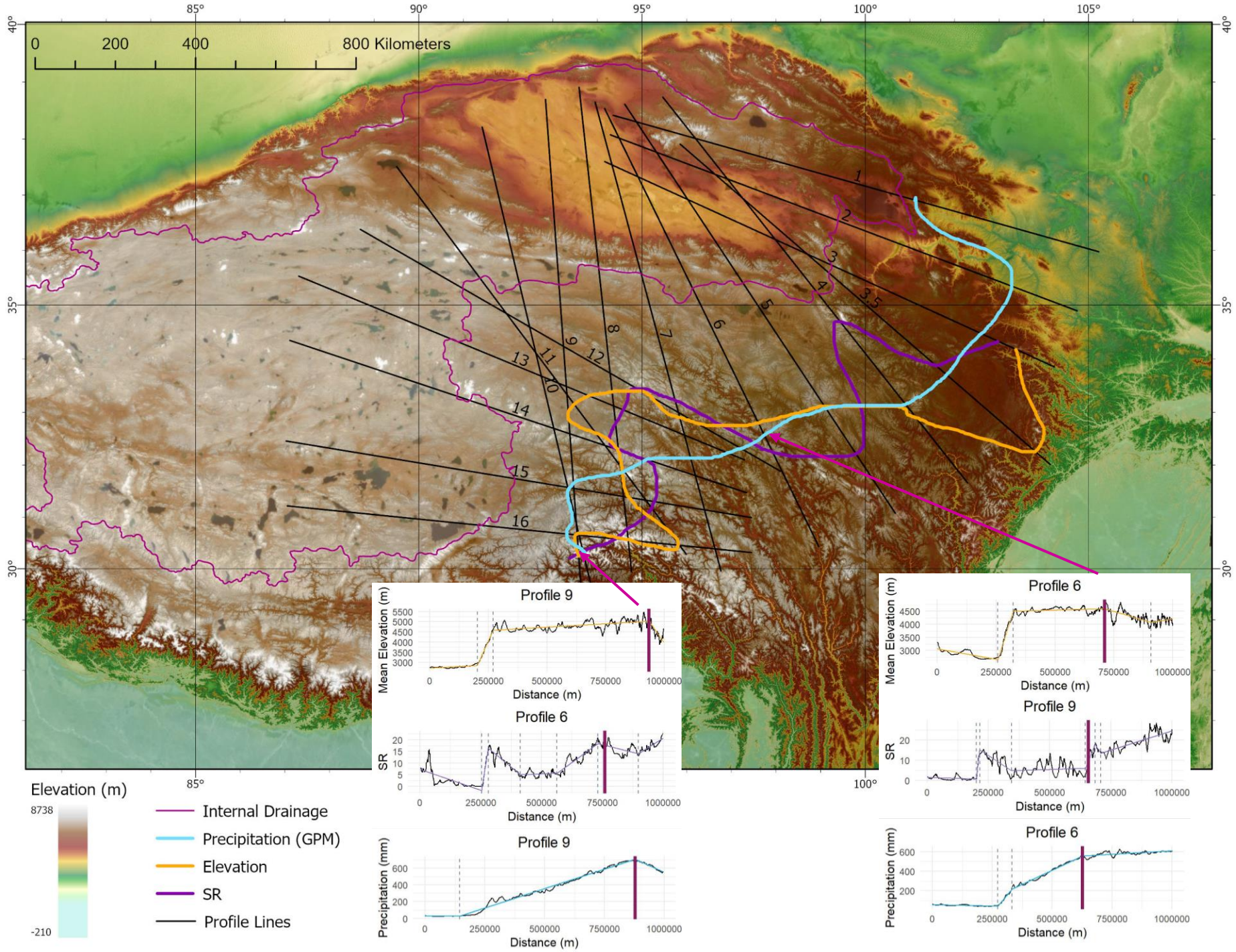
Geomorphic analysis show the high elevation, low relief areas, within the internally drained Tibetan Plateau:

Surface Roughness (**SR**):

High SR (yellow) indicates **variable topography** within each drainage basin and is usually associated with **steeper slopes** occurring in areas with **high incision**.

Low SR (purple) indicates less variable topography, showing **flatter landscapes** and indicating low uplift and incision.

The standard deviation of slope within each second order drainage basin, calculated from 90m SRTM data.

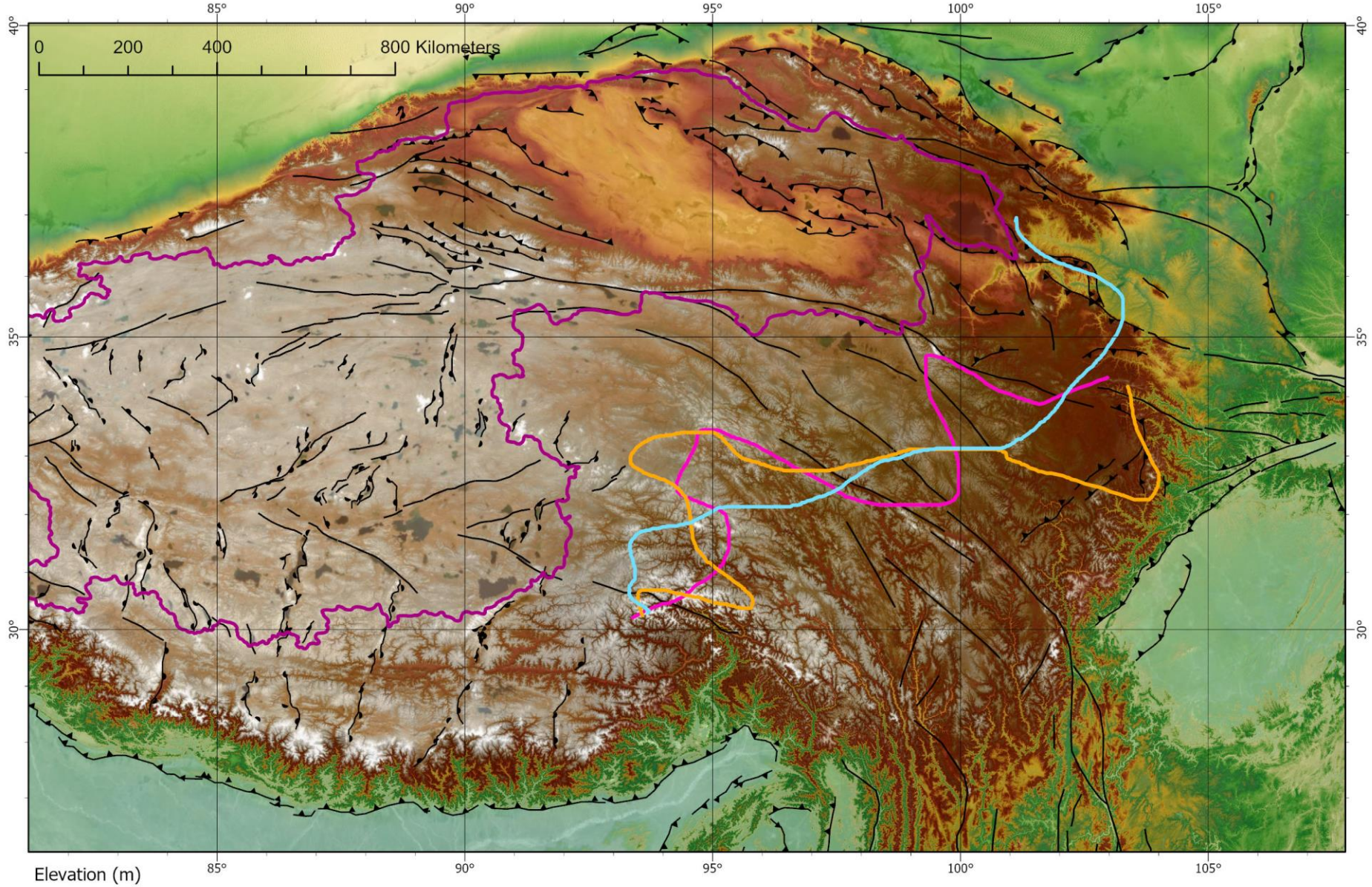


17 swath profiles were drawn orthogonal to and centred on the internal-external drainage boundary. Swath profiles were of 30 km width. Profiles were taken of elevation and mean annual precipitation (GPM, 2002-2018) and SR.

Along each profile the **maximum change in trend** (shown by the purple vertical lines) from south-east to north-west to find:

- A change to constant high elevations
- Decline in SR
- Sharp decline in rainfall (interpreted as the western extent of the East Asian monsoon)

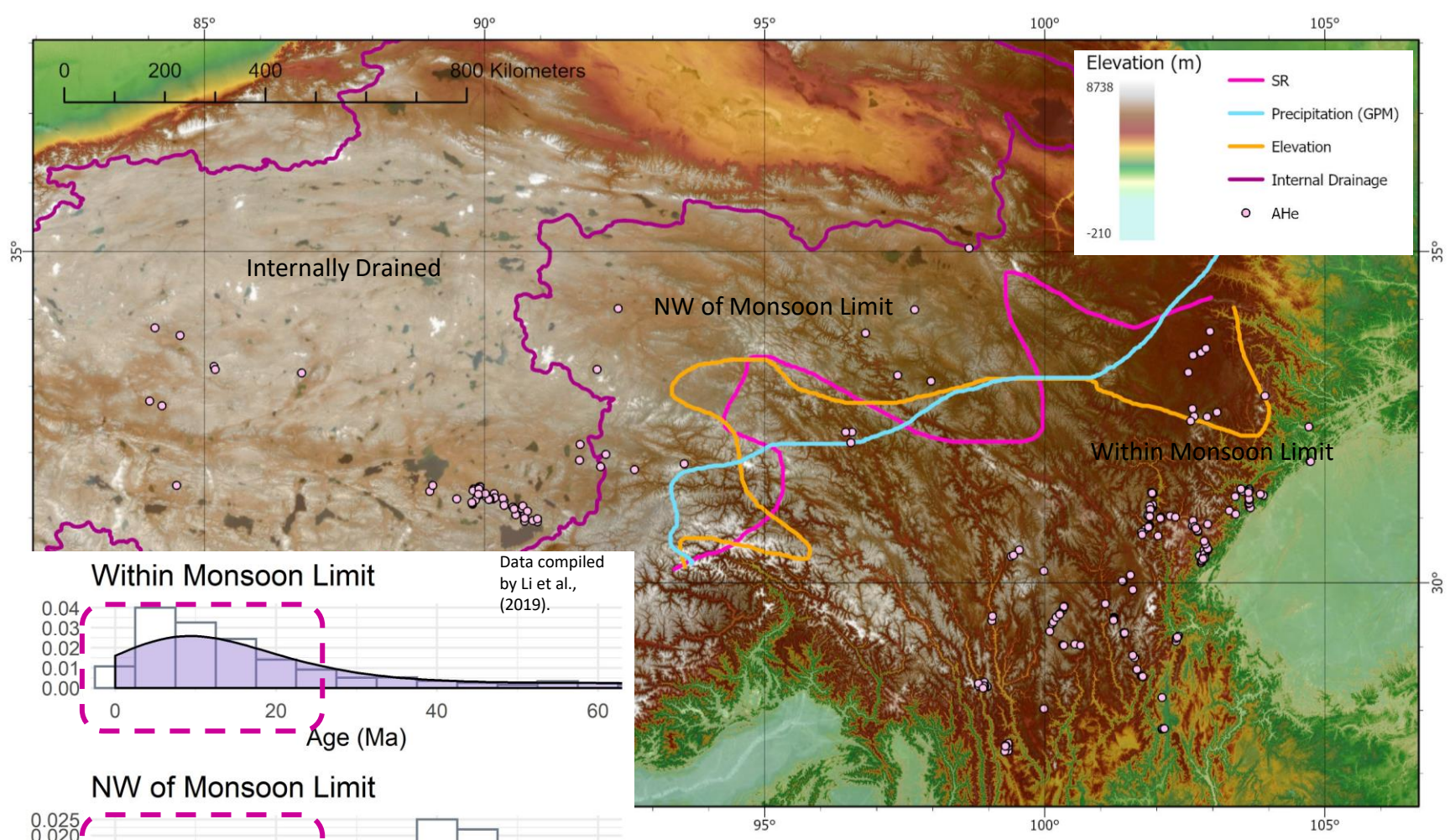
The location of these changes was mapped

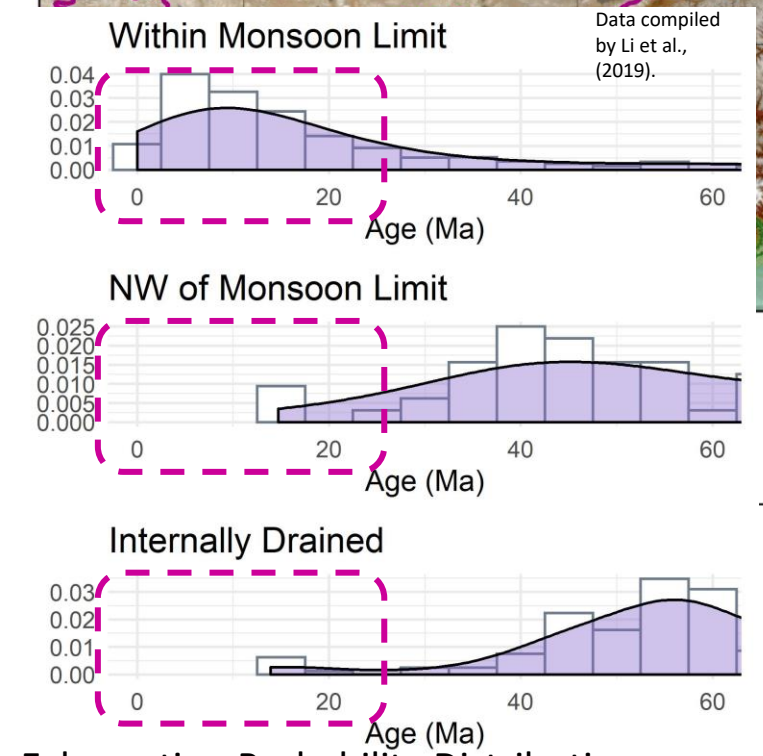


A broad transition zone is present in the landscape, where **changes in landscape and precipitation are grouped and in alignment**.

It represents, from East to West, a **sharp decline in precipitation** below ~650 mm/yr (interpreted as the **western extent of the East Asian monsoon**), a change from a high relief landscape to **smoother elevations at 4500-5000** and a **decrease in SR .**

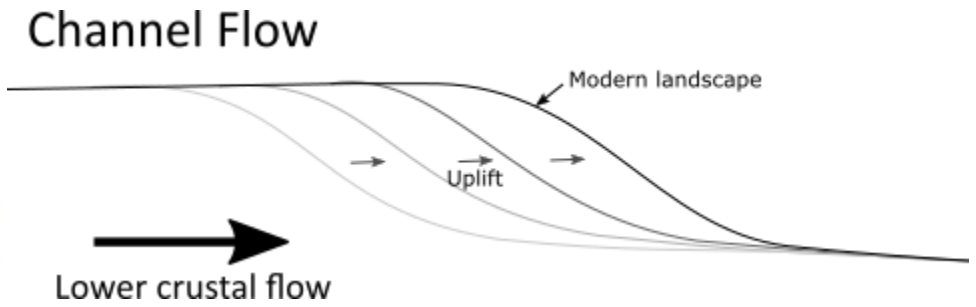
This zone is not a drainage divide: the main rivers have their headwaters further West, in the interior of the plateau. The zone cuts across structural boundaries.





Data compiled by Li et al., (2019).

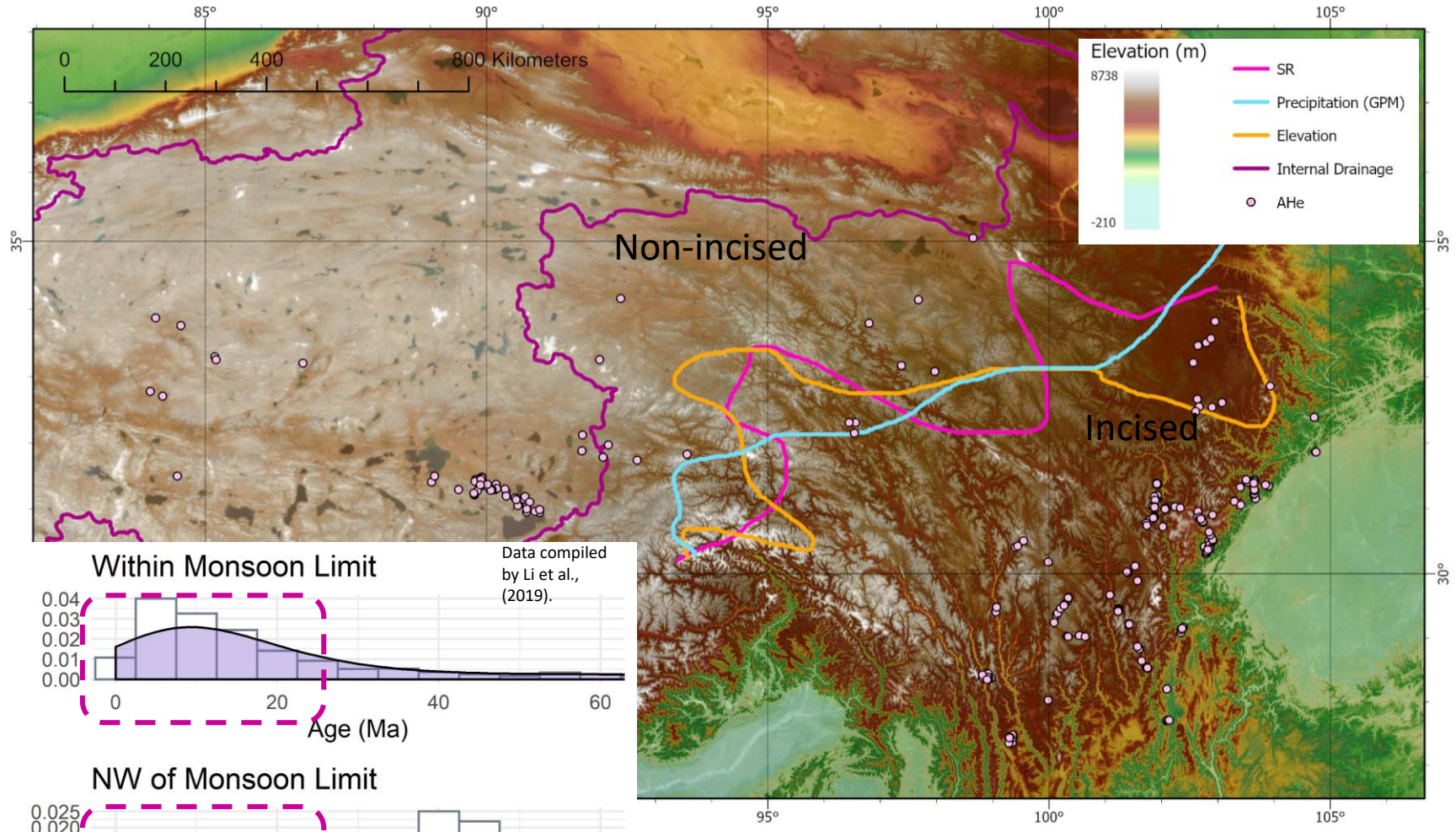
Exhumation Probability Distributions

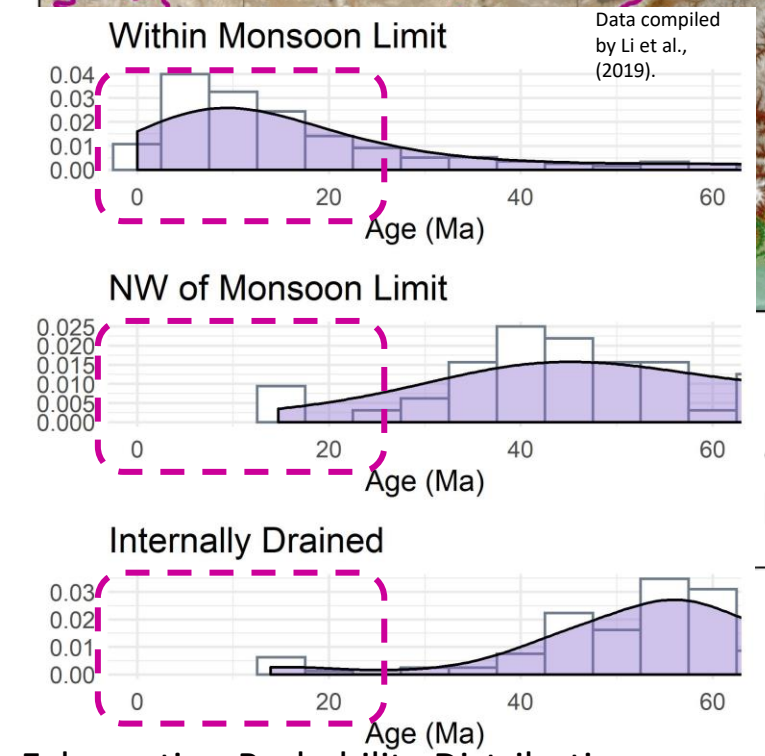


Compiled thermochronology data shows an **increase in exhumation from ~25 Ma in the area to the south east of the monsoon limit** (blue line). There is **no evidence of this increased exhumation to the north west of the monsoon limit**.

The channel flow model predicts a west to east wave of uplift and exhumation across the plateau as the landscape is uplifted during the Miocene (< 23 Ma).

This is not shown by the thermochronology data and therefore **does not support the channel flow model**.





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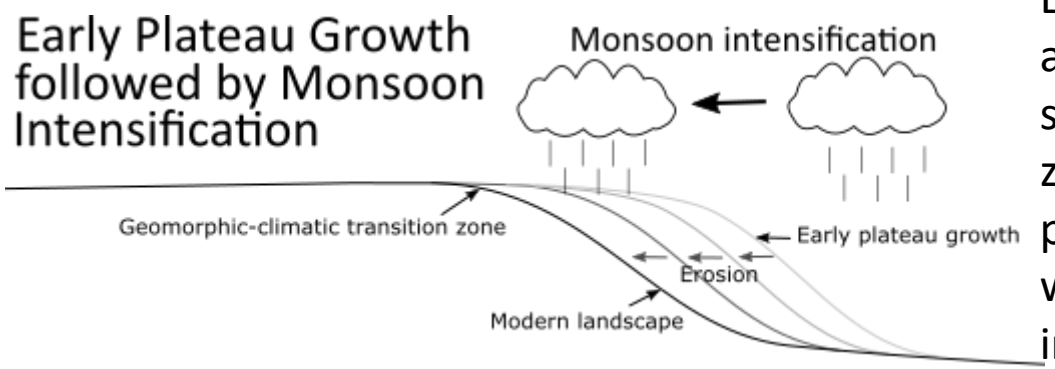
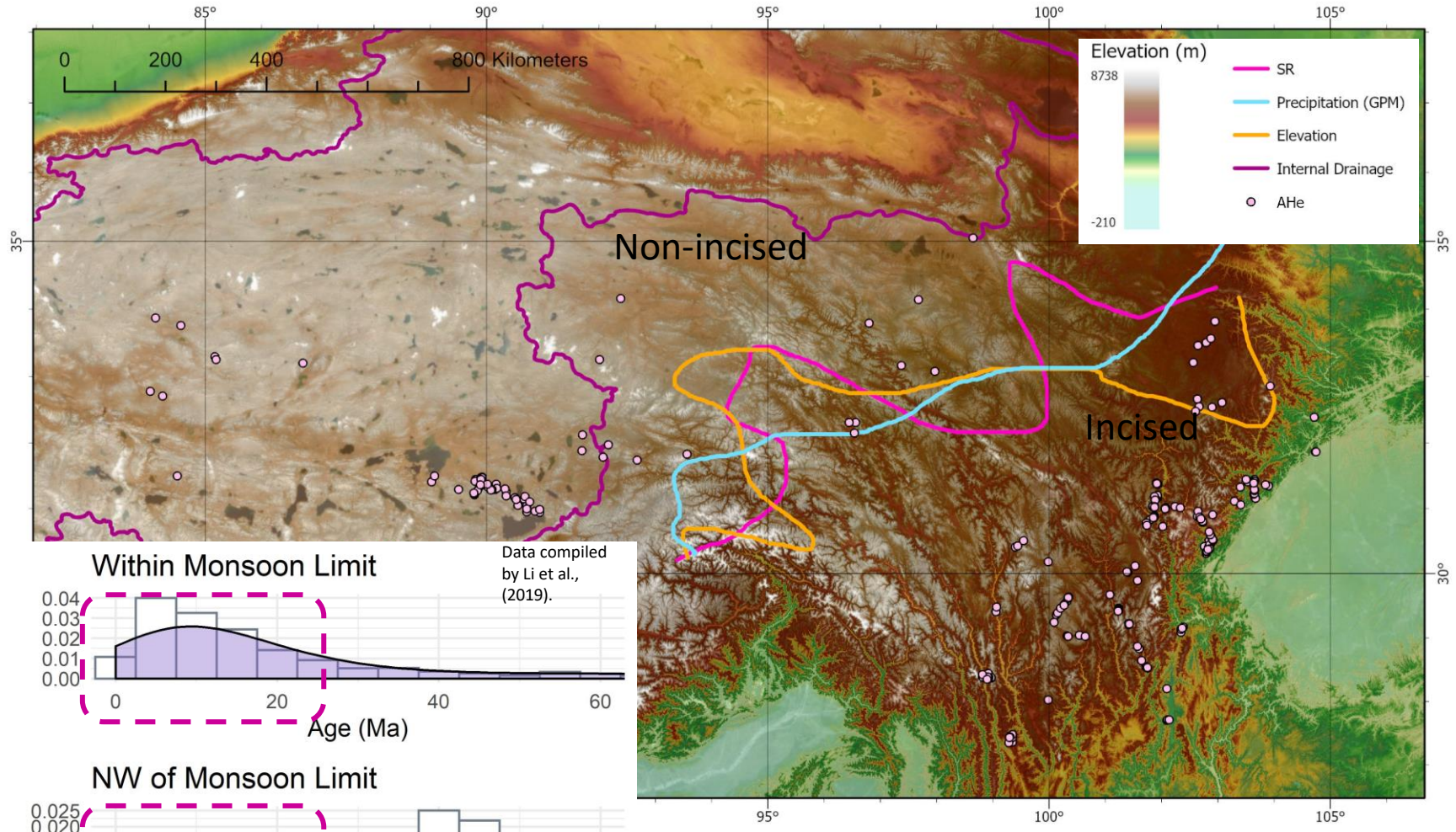


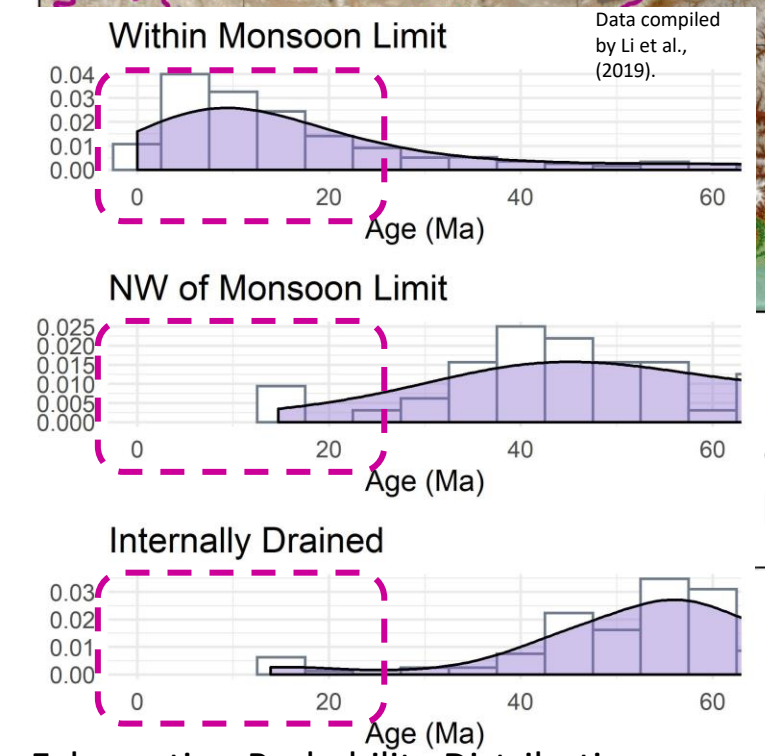
Early plateau growth predicts little exhumation in the plateau interior during the past ~25 Ma, as is seen to the NW of the monsoon limit.

We suggest that increased exhumation since ~25 Ma to the south of the identified geomorphic-climatic transition zone is due to **intensification of the monsoon** at this time.

The transition zone therefore represents a change from an incised to non-incised landscape, **controlled by the western extent of the monsoon** (blue line).

Erosion of the plateau would lead to a east to west regression of the steepest part of the landscape. The zone may represent the current position of an east to west migrating wave of incision driven by monsoon intensification.





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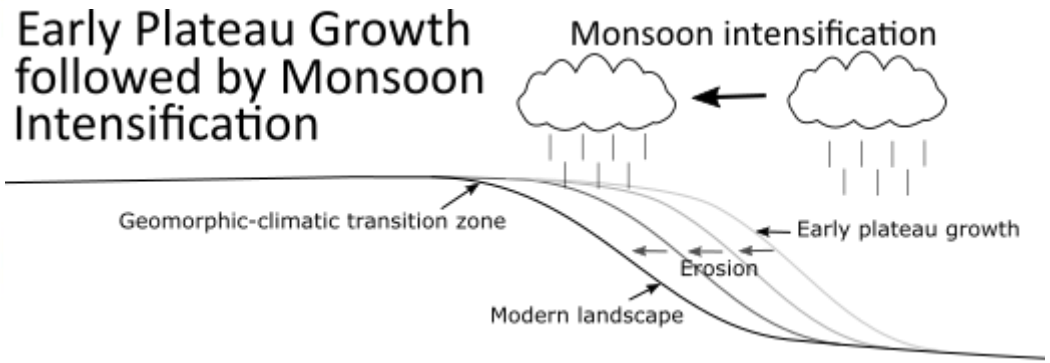

In conclusion:

- We find a **geomorphic and climatic transition** in the eastern-central Tibetan Plateau. We suggest that the precipitation transition represents the **western limit of the East Asian monsoon**.
- Thermochronology data is consistent with **early uplift** of the eastern Tibetan Plateau with **increased exhumation from ~25 Ma, consistent with late Cenozoic intensification of the monsoon climate**.
- **This work supports a model of early Cenozoic growth of the eastern Tibetan Plateau, superimposed by incision driven by climate change; it does not support the channel flow model.**

References:

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