# Orogenic mass changes detectable in satellite gravity missions

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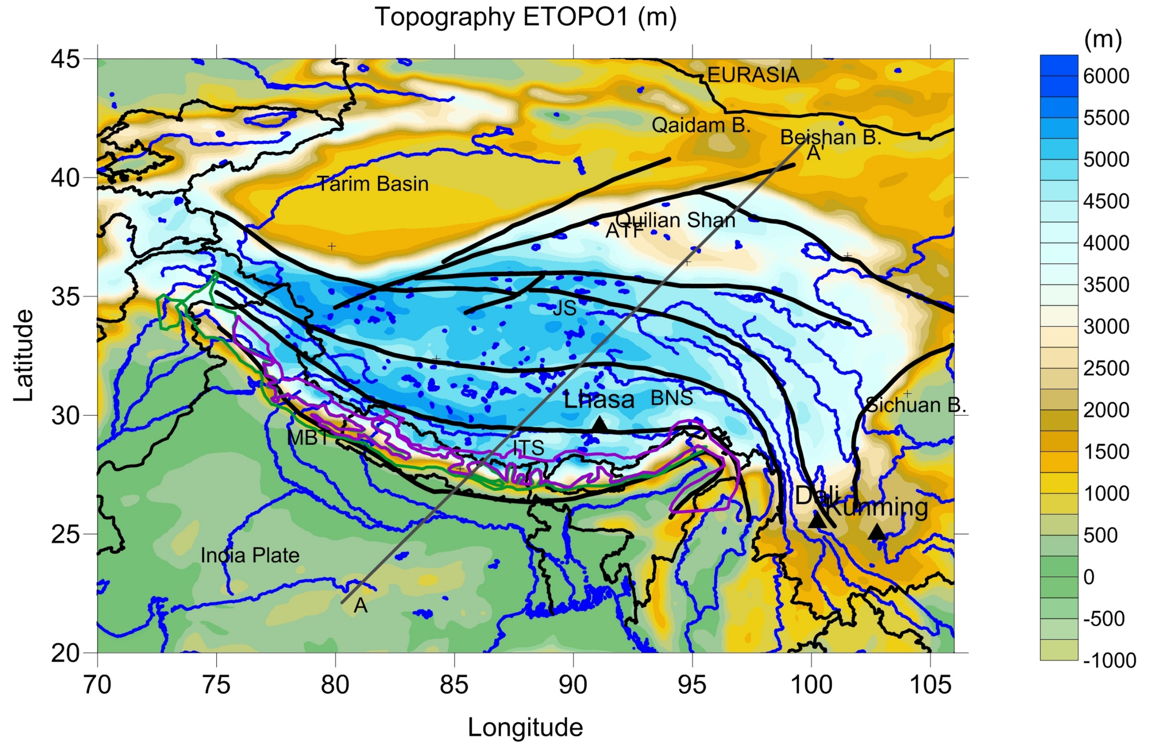
## 1 MASS CHANGES AT A GROWING OROGEN

- Many orogens are uplifting
- Uplift seen by GNSS continuous monitoring
- Mass is added on surface
- Earth Gravity field is sensitive to mass changes
- Terrestrial gravity observations sense mass change and gravity reduction due to uplift
- At satellite: gravity change due to mass variations are sensed
- Proposal: the mass change is big enough to be seen by modern gravity satellites
- Gravity change rate is also sensitive to mass changes at lower crustal level

## 3 TIBET TOPOGRAPHY

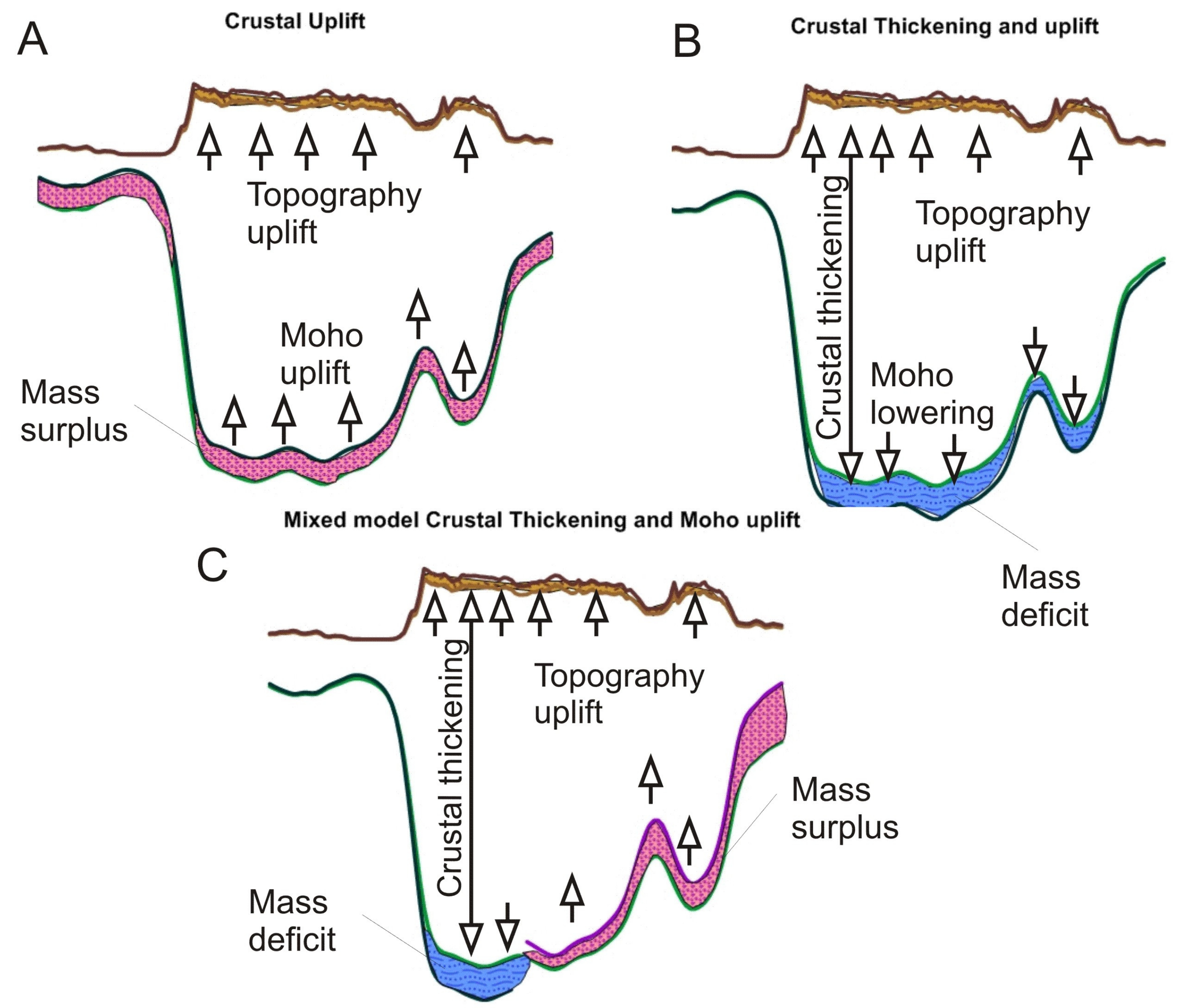



Above Fig., Topography of Tibet Plateau including the Himalayas. AA' is the profile along which gravity is calculated. MBT: Main Boundary Thrust. ITS: Indus Tsangpo Suture. BNS: Bangong Nujian Suture. JS: Jinsha Sutrue, ATF: Altyn Tagh Fault. Triangles: Absolute gravity stations. Pink outline: High Himalayas. Green Outline: Lesser Himalayas.

## 2 EXPECTED GRAVITY CHANGE RATES

- Gravity change due to topographic growing from terestrial measurements
- Pure growing: -0.18 $10^{-8}$ $m/s^2$/mm (without Moho change)
- Pure uplift: -0.17 $10^{-8}$ $m/s^2$/mm (with Moho uplift)

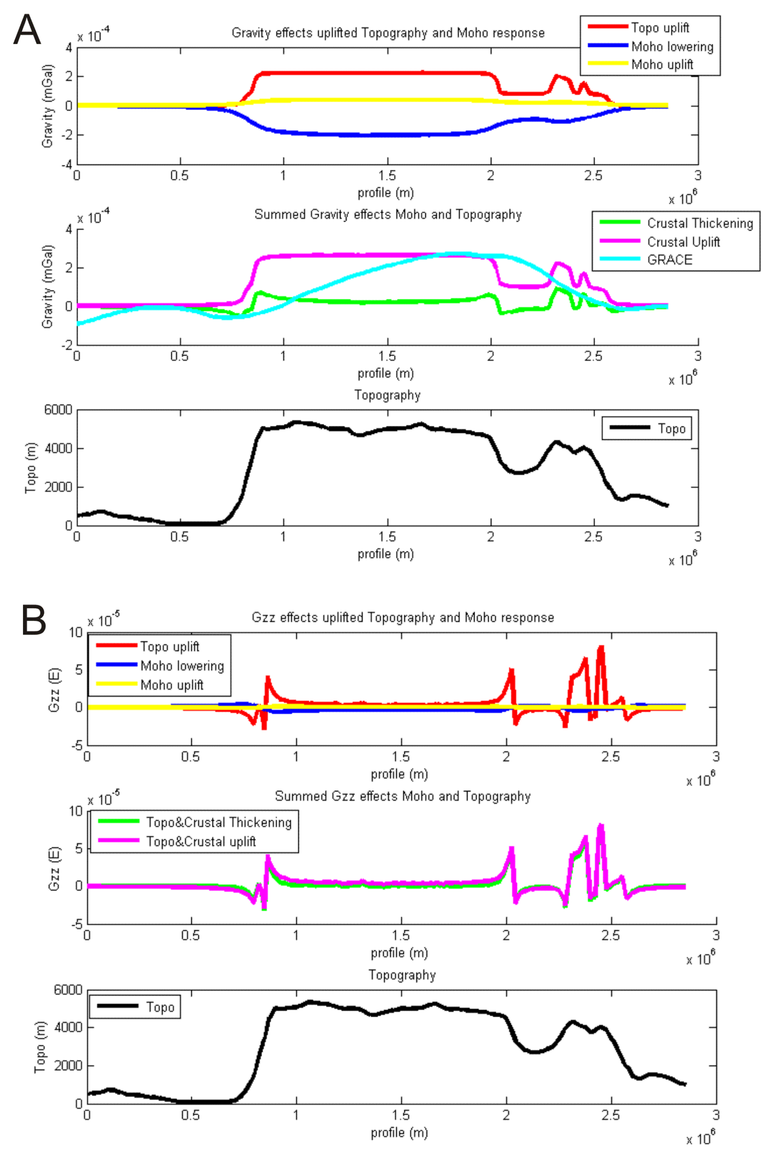
## 4 OROGENIC CRUSTAL MODELS




- Above Fig.: Geodynamic models of crustal thickening and crustal uplift and the corresponding mass changes.
- A Crustal uplift without thickness change.
- B Crustal thickening model.
- C Mixed model, with crustal uplift over the Plateau and crustal thickening for the Himalayas.
- Yellow: positive mass change at topography; red: positive mass change at Moho level; blue: negative mass change at Moho level.

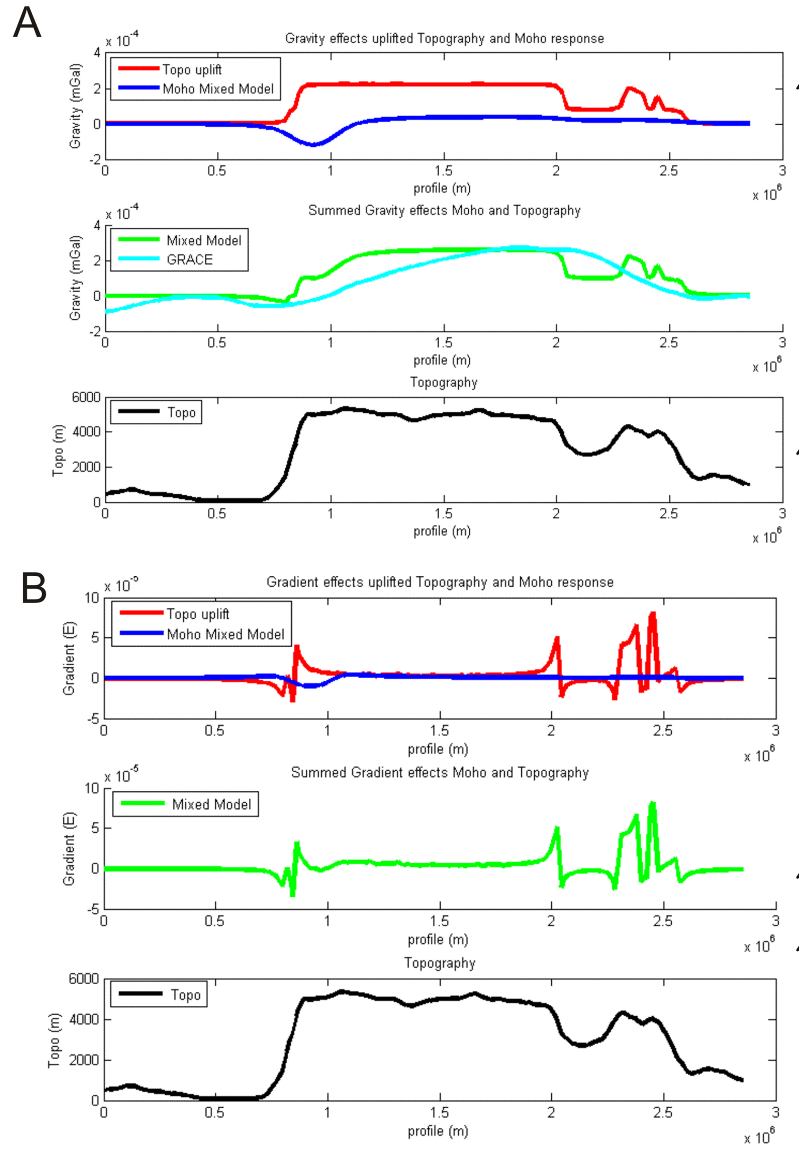
## 5 FORWARD MODELING

**Testing the gravity effect for the three geodynamic models.**



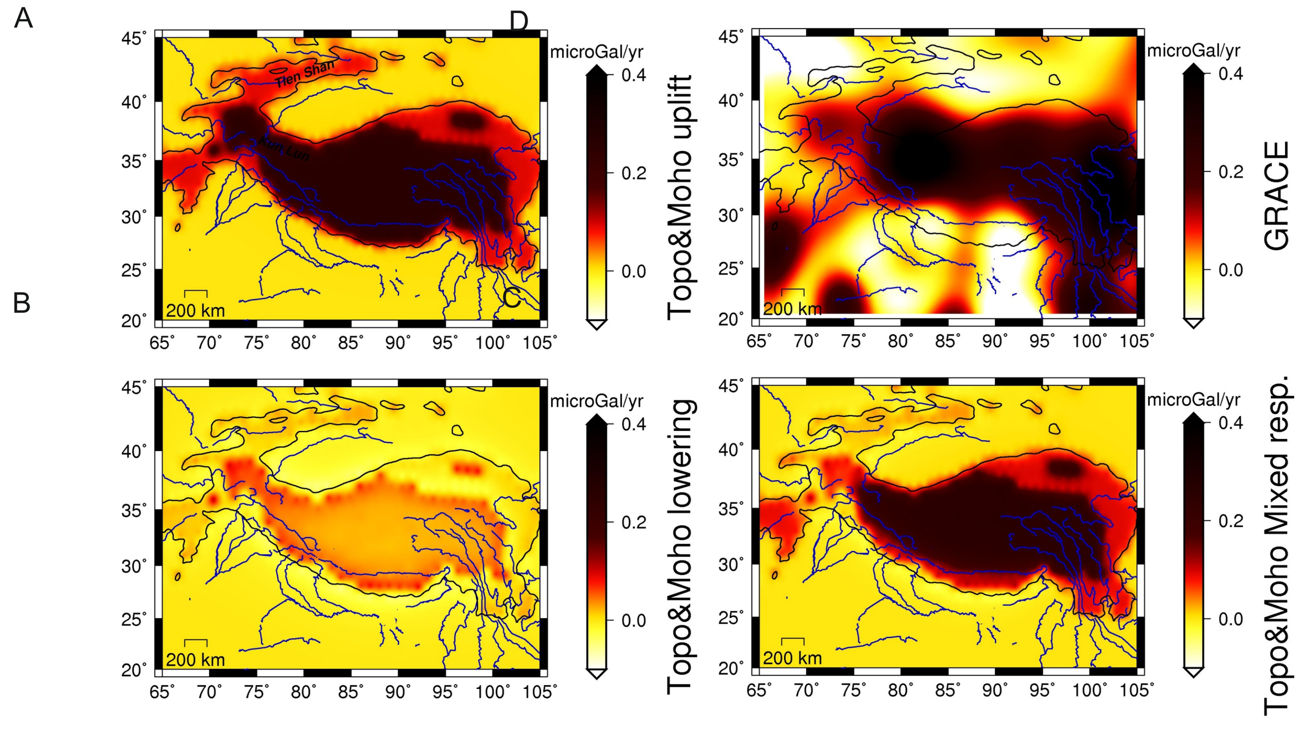

- Left: Gravity changes over the Tibetan Plateau including the Himalayas for two different geodynamic models.
- Elevation increases at the rate of 2 mm/yr, accompanied with crustal thickening or with constant crustal thickness, which is uplifting.
- A) Gravity field,
- B) Vertical Gravity Gradient. Location of profile shown in Map as AA'; the origin of the profile is in point A, the end in point A'.

## 6 MIXED MODEL




- Left:Gravity changes over the Tibetan Plateau and the Himalayas for a mixed geodynamic model in the Tibetan Plateau and the Himalayas.
- Elevation increases at the rate of 2 mm/yr, accompanied with crustal thickening in the Himalayas and with constant crustal thickness, which is uplifting in the Tibetan Plateau.
- A) Gravity field,
- B) Gradient field.

## 7 RESULTS




Gravity response of different geodynamic models for a given topographic uplift over Tibet and Himalaya and observed gravity rate. Elevation increases at the rate of 2 mm/yr, accompanied with A) crustal uplift everywhere, B) crustal thickening everywhere, C) mixed model, with crustal thickening from Himalaya to Tien Shan and with constant crustal thickness which is uplifting in Tibet. White outline gives the area in which crustal thickening is assigned. D) Residual gravity rate from satellite GRACE according to Yi & Sun (2014)

## 8 CONCLUSIONS

- Gravity can distinguish pure uplift from crustal thickening
- Isostatically balanced uplift has a signal smaller than expected for a given uplift measured by GNSS
- In Tibet GRACE positive residual remains after correction for hydrology
- It is compatible with Tibet uplifting without a Moho lowering
- Could be due to partial melting of lower crust as hypothesized from seismology

### REFERENCES

- Braitenberg & Shum, 2017. Italian J. Of Geosciences
- Yi & Sun, 2014. JGR

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