Active Tectonics in the Tibetan Plateau Region as a Consequence of Plate-Scale Forces on the Eurasian Plate: a Model Study .

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MOTIVATION

The motivation of our work is to predict present-day lithospheric deformation of the Eurasian Plate by integrating plate-scale forces in mechanical equilibrium and estimates of lithospheric rheology.

FORCES

We use mechanically balanced models based on plate interaction (continental collision, plate boundary friction at transform faults and subduction contacts, and slab roll-back forces), lithospheric body forces (from lateral variations in topography, density structure) and convective tractions including dynamic topography.

These forces satisfy the torque balance constraint , drive Eurasia in the observed direction of absolute motion and fit observed horizontal stress directions to first order. Boundary forces and lithospheric body forces have larger imprint on Eurasia forcing than mantle tractions.

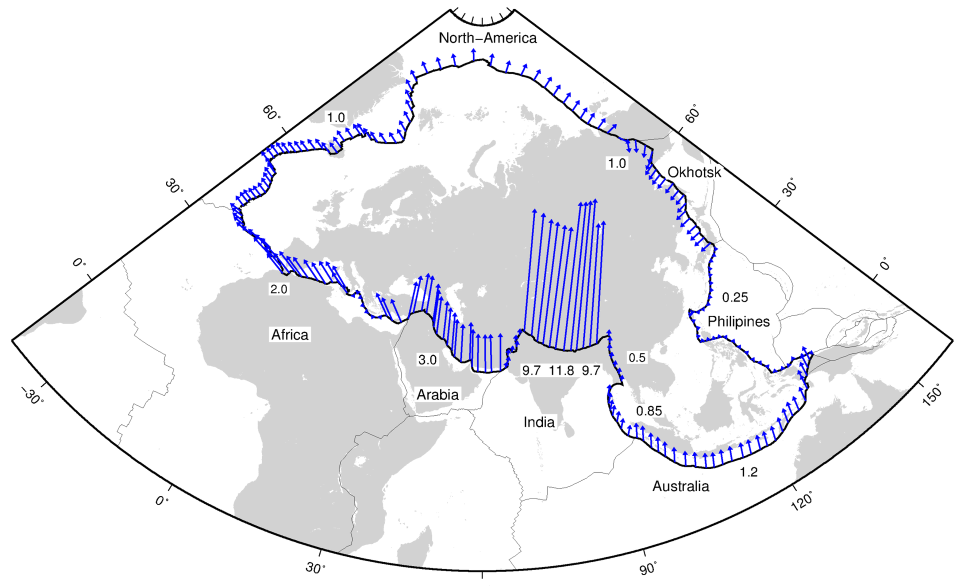


Fig.1. Edge forces of the model , where numbers are average magnitudes in TN/m. Non-uniform distribution of forces along the India boundary (varying from 0 to 11.8 TN/m) in contrast to the uniform plate velocity of India is needed to match the data

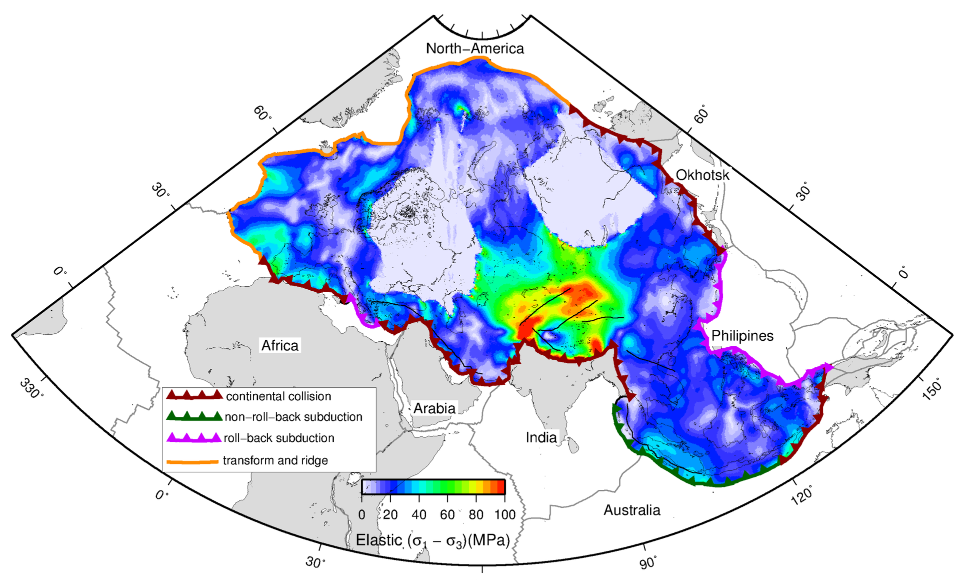


Fig.2. Elastic stress field (contour values) and the four different boundary types of our model.

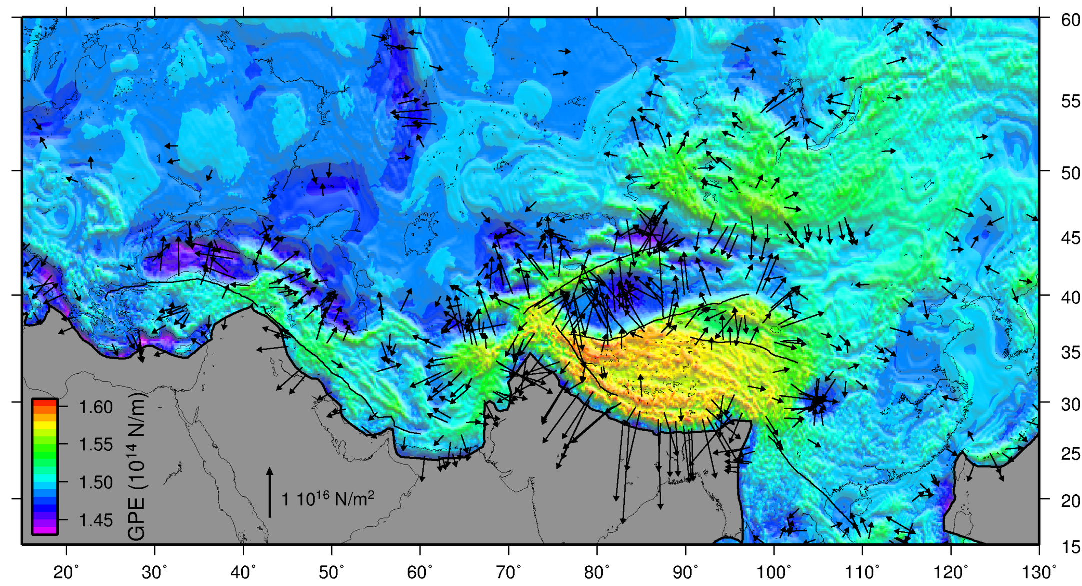


Fig.3. Gravitational Potential Energy (contour values) and corresponding Lithospheric Body Forces (arrows).

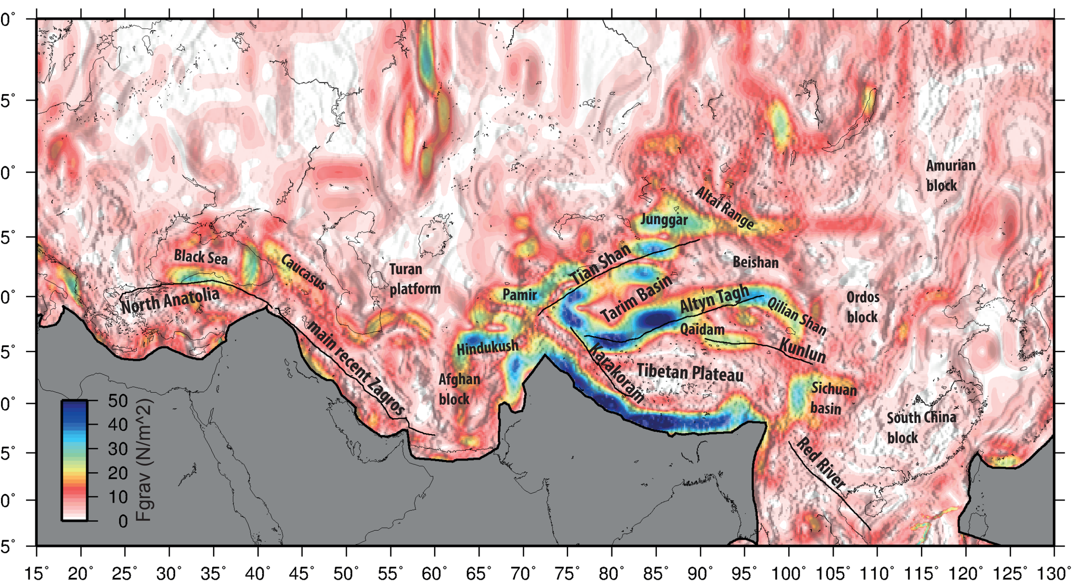
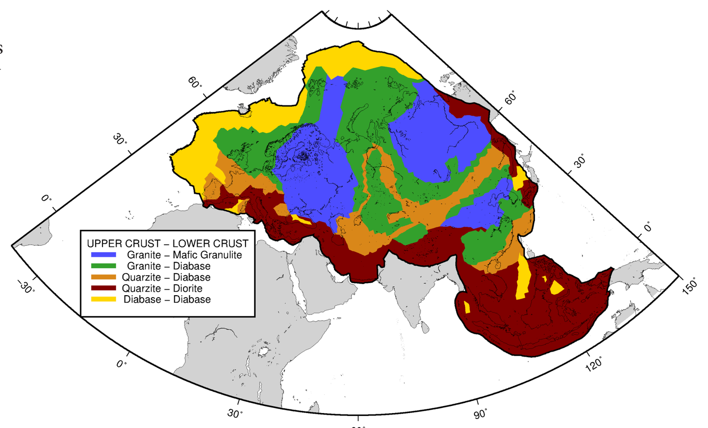


Fig.4. Contour Lithospheric Body Force magnitudes.

RHEOLOGY

Following Tesauro et al (2012) we assume five different lithospheric compositions, using their geotherms and crustal thicknesses to estimate depth-dependent rheological profiles, making use of the stress field to compute vertically averaged viscosity of each element of the model.

Fig.5. Eurasia compositional types of upper and lower crust over dry olivine lithospheric mantle.



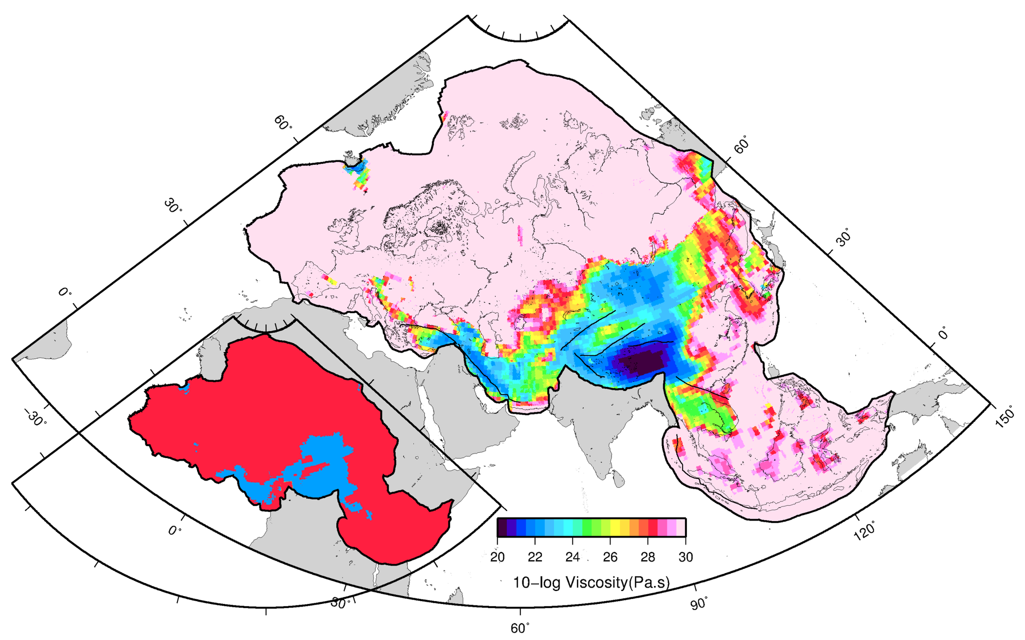


Fig.6. 10-log of the vertically averaged lithospheric viscosity (Pa s-). Simplified viscosity model displayed in the inset.

The viscosity map in Figure 6 gives a large mismatch with observations in some areas of the model (specially in Western Tibetan Plateau). Given the integration times of 100 - 500yr, large part of the plate presents elastic behaviour (high viscosity) meanwhile a small fraction has viscous flow.

Therefore, a weak zone of viscous flow in steady state surrounded by elastic material is a consistent representation of the viscosity structure of Eurasia.

DEFORMATION RESULTS

We employ plane stress spherical finite elements (GTecton) and a linear visco-elastic rheology to compute the lithosphere-averaged mechanical response.

We consider the influence of including the major active faults, the definition of Eurasia reference frame and the distribution of the edge forces in these models.

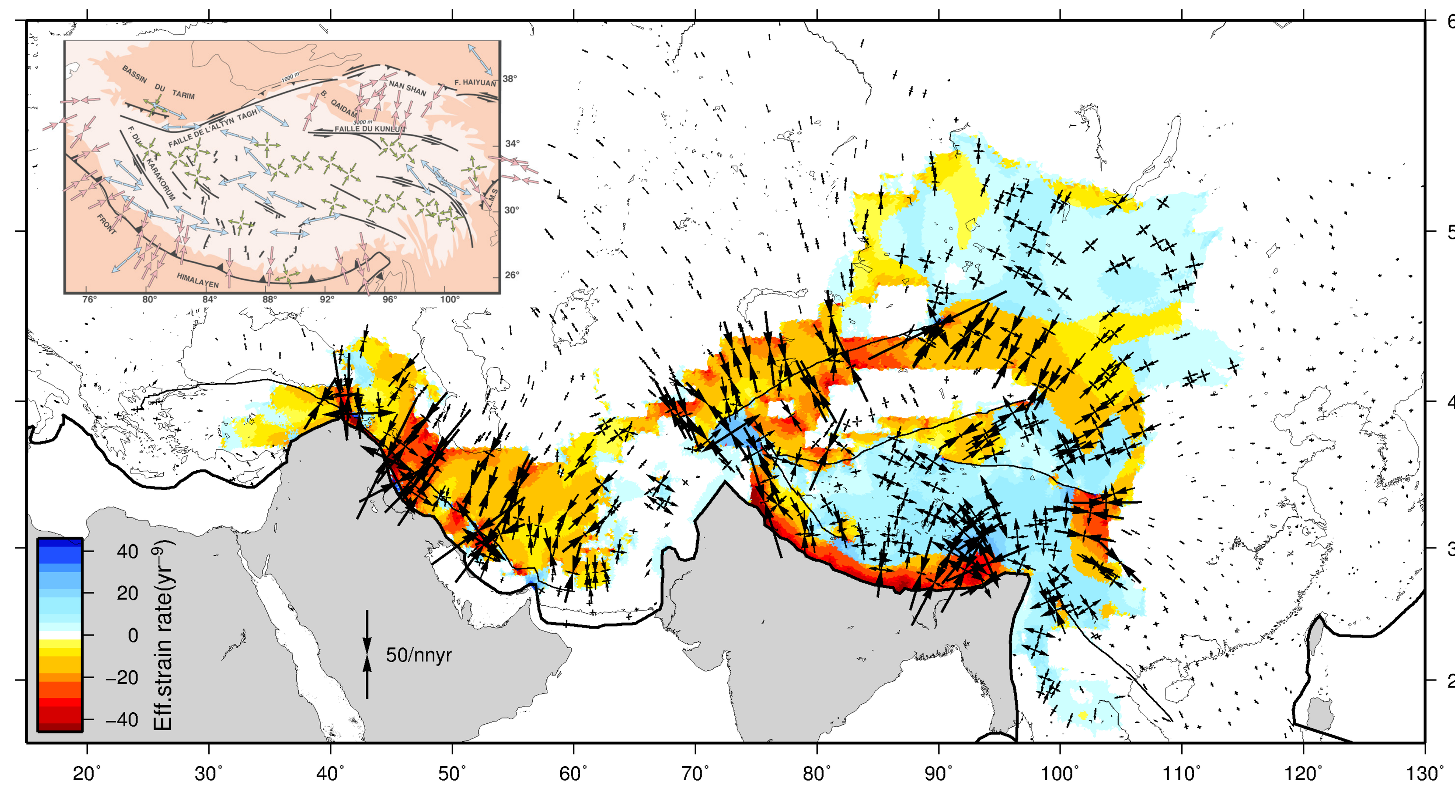


Fig.7. Effective shear strain rate field of the Eurasian plate (yr^{-9}). Arrow represent strain field and yellow/red (blue) colours represent shortening (extension).

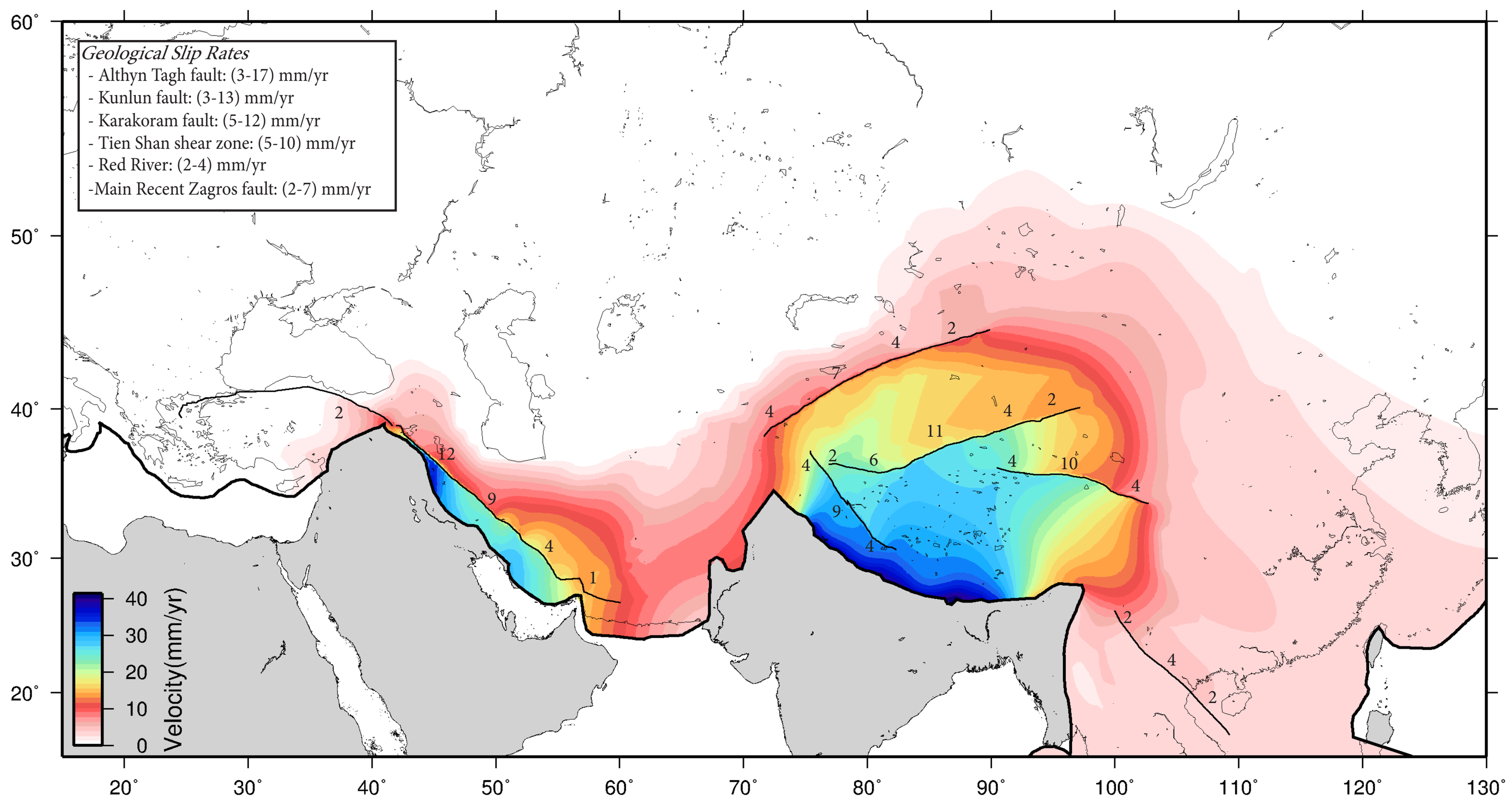


Fig.10. Model horizontal velocity field as contour plot of the Eurasian plate (mm/yr). Numbers indicate model slip rates in mm/yr and arrows indicate slip direction. Geological slip rates are shown in the legend.

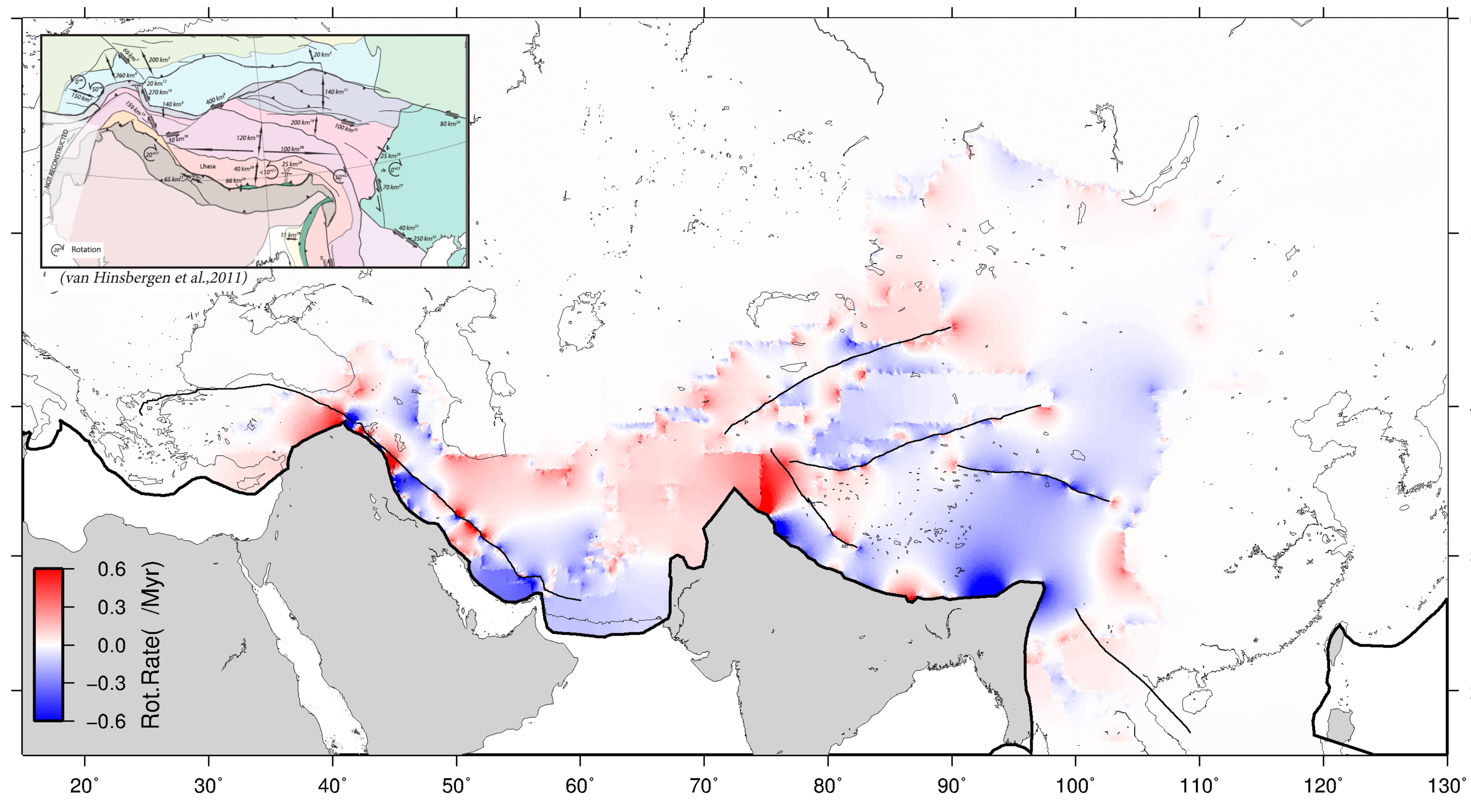


Fig.8. Vertical axis rotation rate of the Eurasian plate (degree/Myr). Negative values (blue) represent clockwise rotation and positive values (red) represent counter-clockwise rotation.

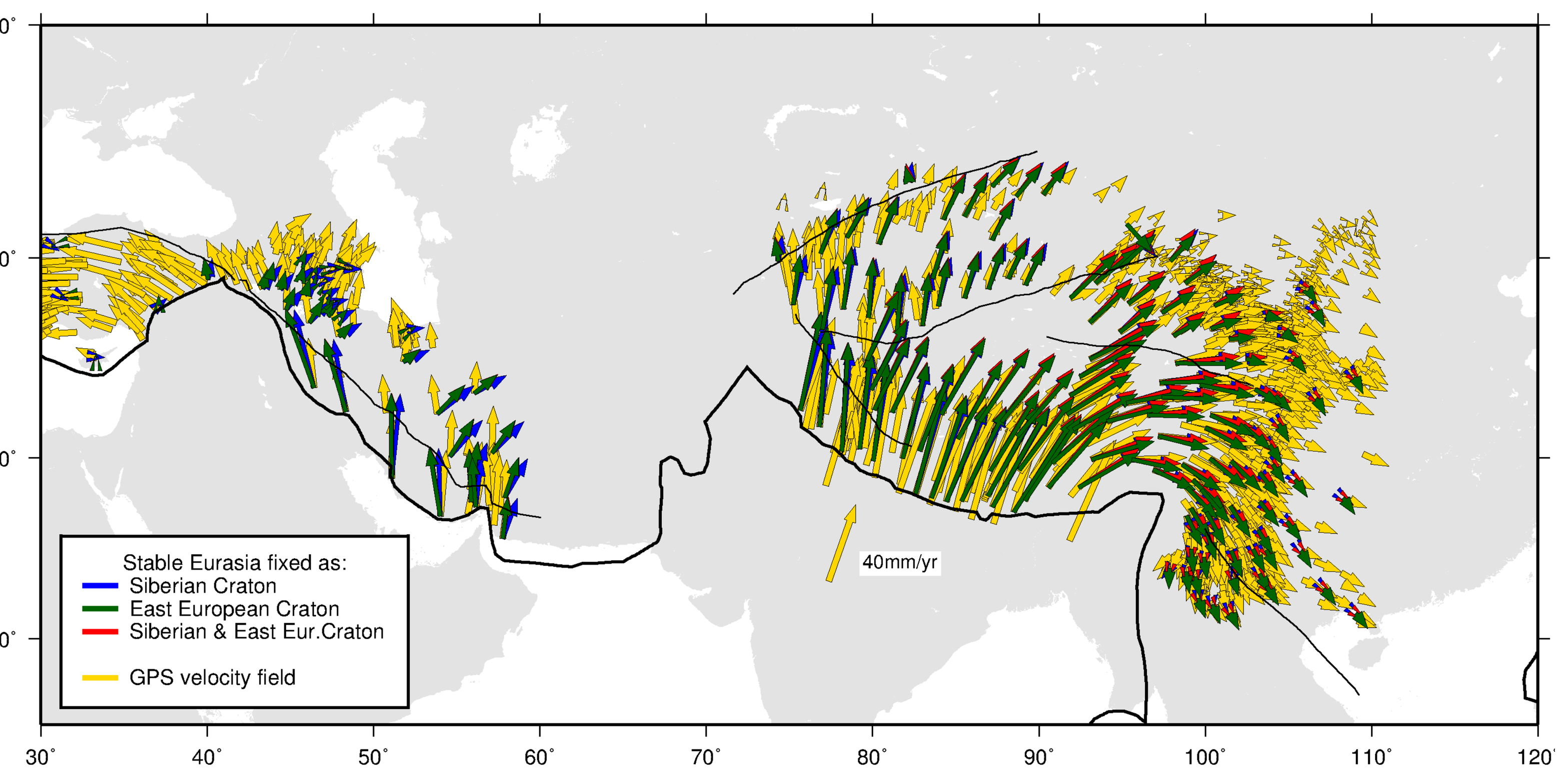


Fig.11. GPS horizontal velocity field (yellow arrows) of the Eurasian plate (mm/yr) from Gan et al.(2007). Model horizontal velocity fields for different reference frames: Siberian Craton (blue) is fixed, East European Craton (green) is fixed and both Siberian and East European Cratons are fixed (red).

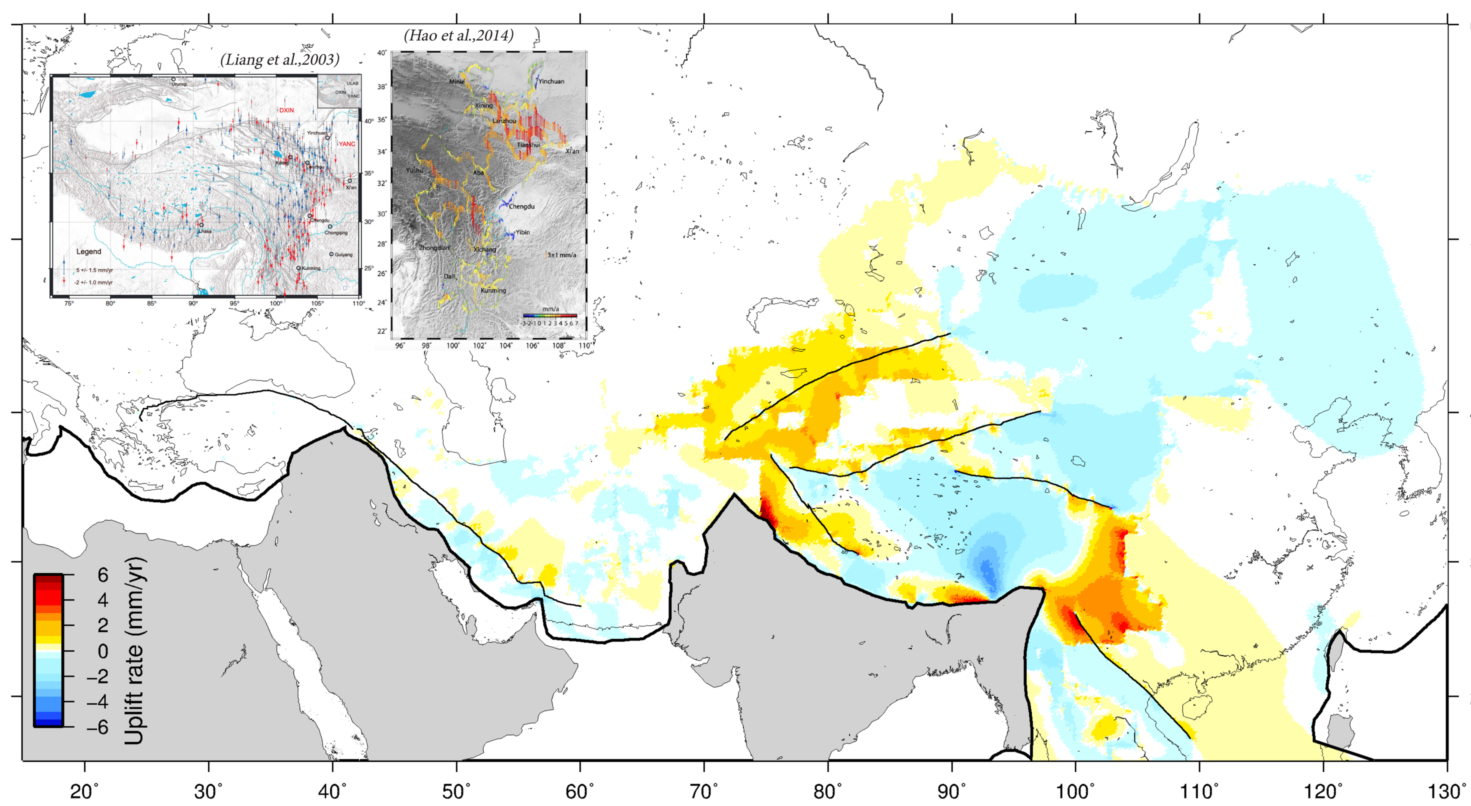


Fig.9. Uplift rate of the Eurasian plate (mm/yr). Yellow/red colours represent uplift (up to 6 mm/yr) and blue colours represent subsidence.

CONCLUSIONS

-Deformation in Tibetan Plateau turns out to be extremely sensitive to the edge force distribution on India and Birma segments.

-Model horizontal velocity field is highly dependent on the horizontal viscosity distribution contrast and geometry of the low viscosity area.

-Predicted velocities show sensitivity to the reference frame: Eurasia consists of cratonic regions that are surrounded by more recently active “mobile belts”.

-Predicted velocities are not significantly affected by faults. Frictionless faults slip rates and directions agree with geological observations to first order.

-Clockwise vertical axis rotation rates, extensional regime and uplift rates in agreement with observations in Eastern Himalayas Syntaxis .

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