Insights into active tectonics of eastern Taiwan from analyses of geodetic and geologic data

by Wen-Jeng Huang[1,2], Kaj M. Johnson[2], Junichi Fukuda[2] and Shui-Beih Yu[1]

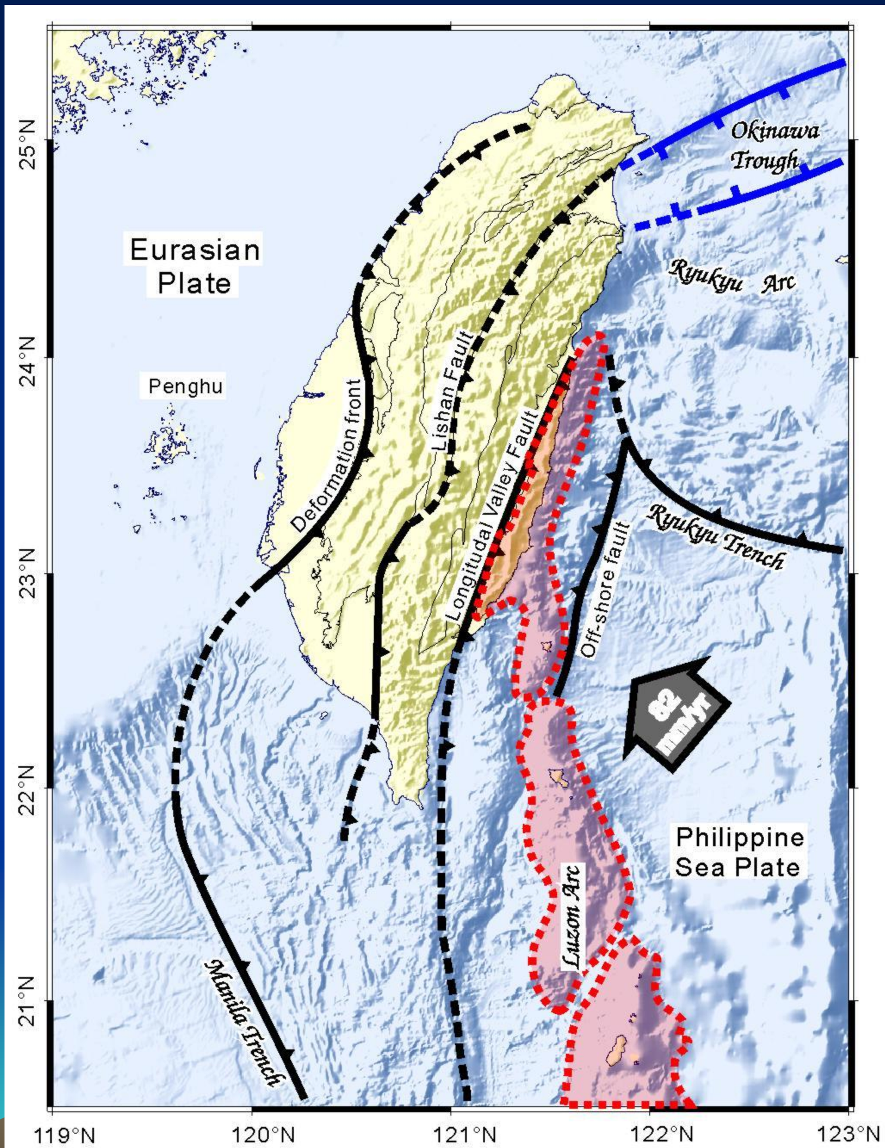
1.Academia Sinica 2.Indiana University

Presenter: Wen-Jeng Huang

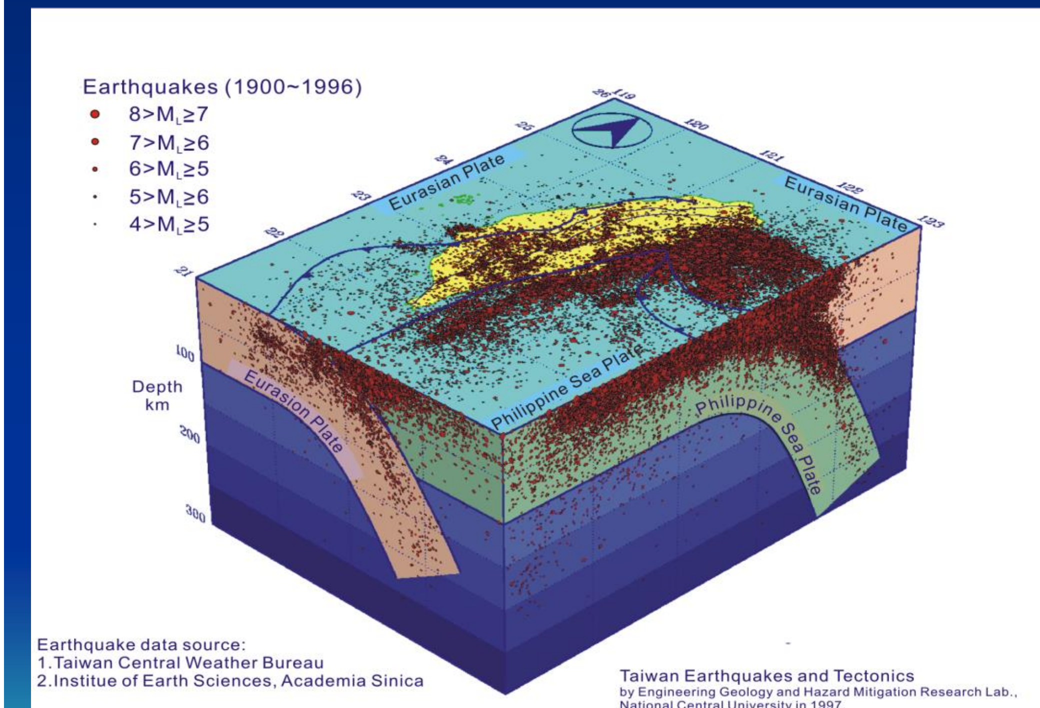
DEC. 2008

AGU

Tectonic Setting

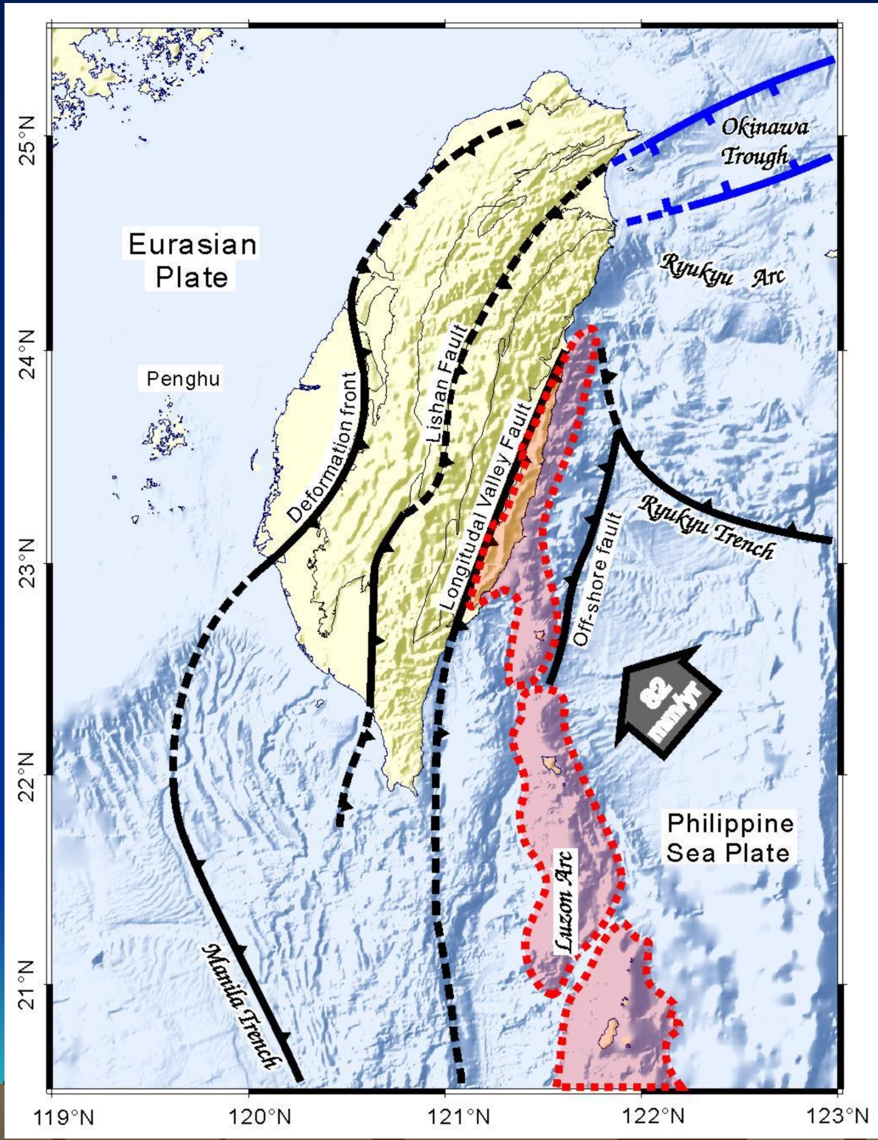


(After Ching et. al., 2007)



(Lee et. al., 1997)

M > 7 Earthquakes



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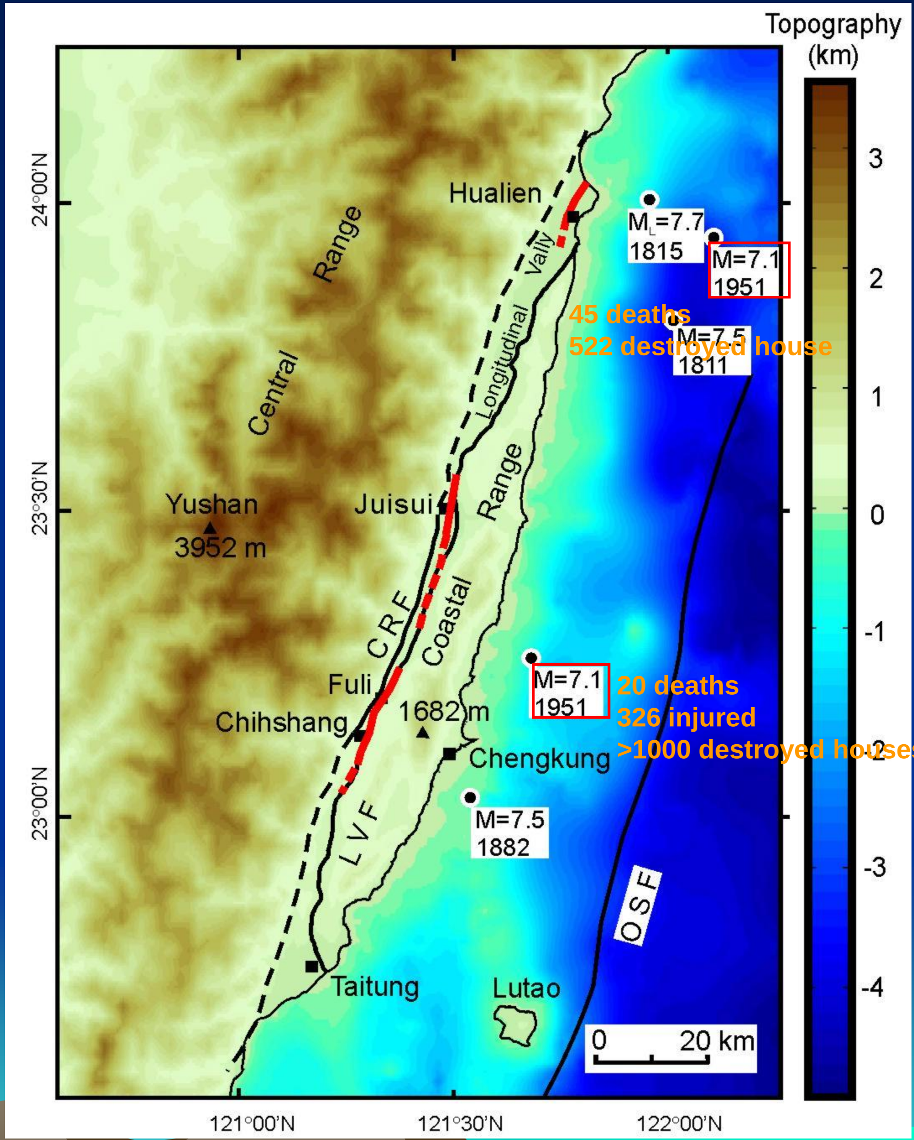
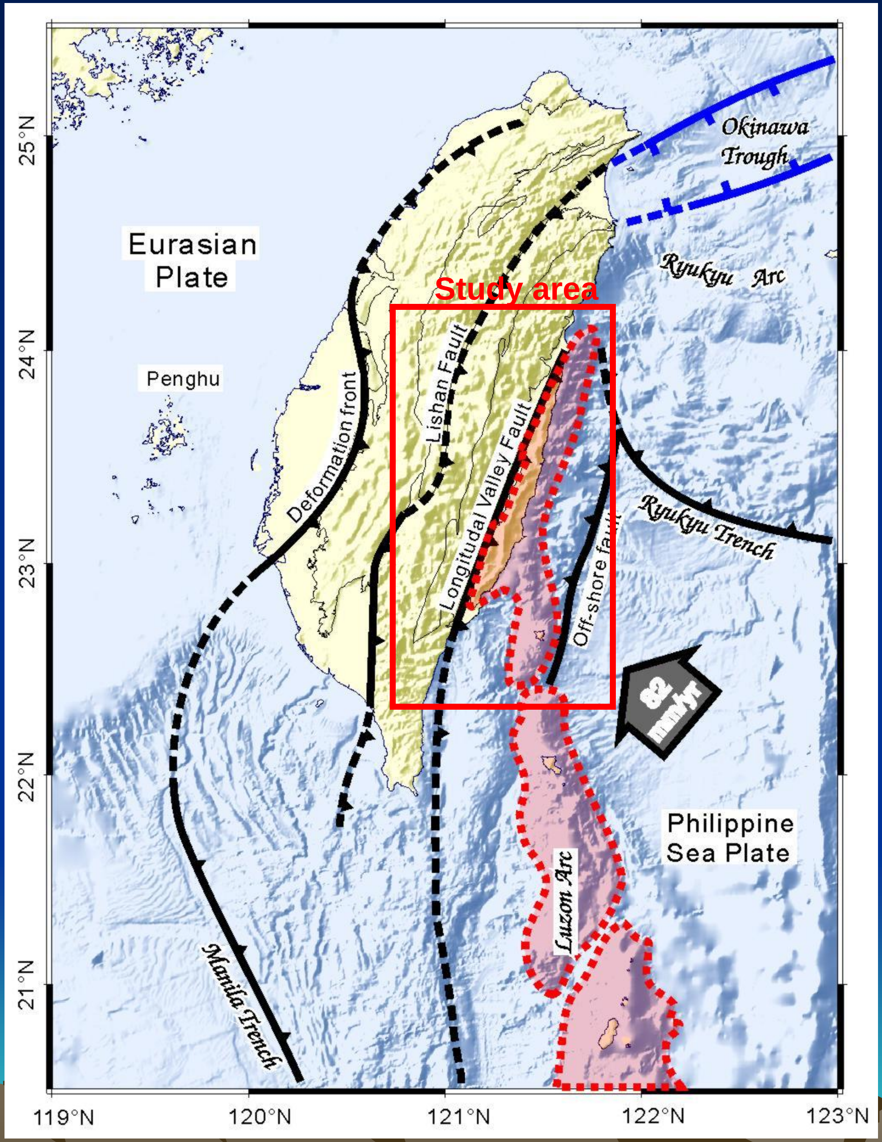
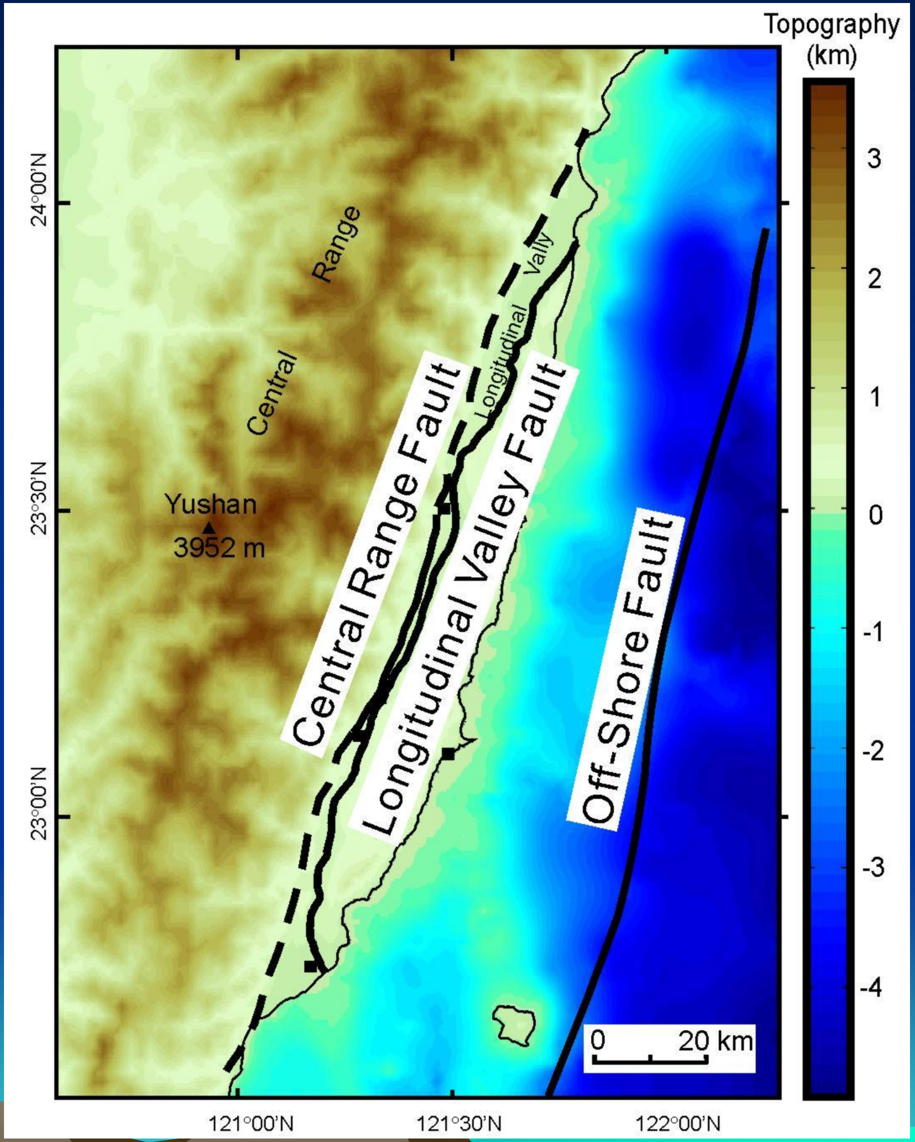


(Ruptures according to Hsu,1962)

Three major faults





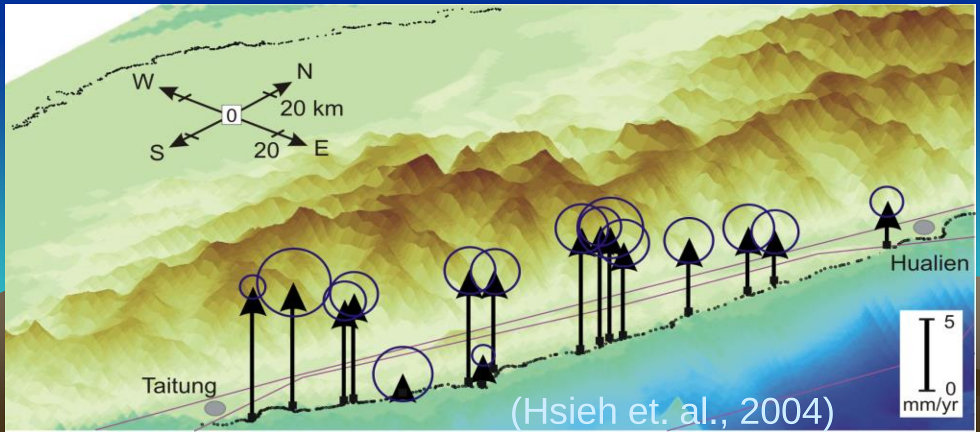
(After Ching et. al., 2007)

Geodetic and Geologic Data

Vertical GPS

Horizontal GPS

Holocene Uplifted marine terraces

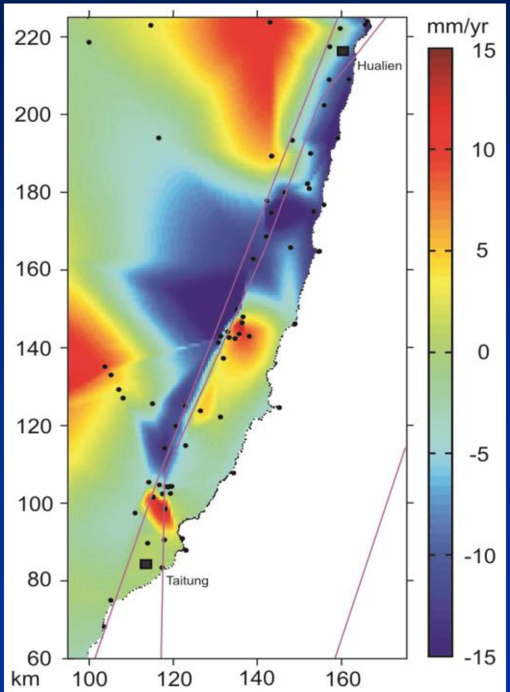


(Hsieh et. al., 2004)

InSAR-inferred differential vertical motion

Geodetic and Geologic Data

Vertical GPS



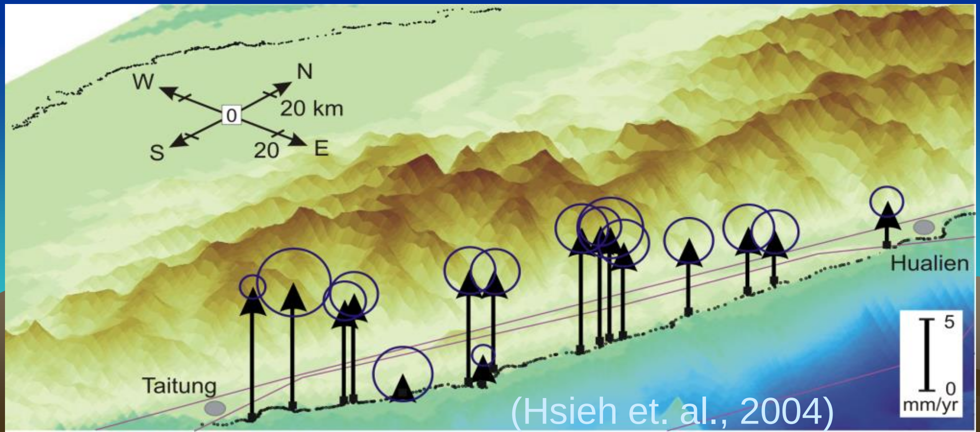
(Yu, unpublished)

Horizontal GPS

(Yu and Kuo, 2001)

InSAR-inferred differential vertical motion

Holocene Uplifted marine terraces

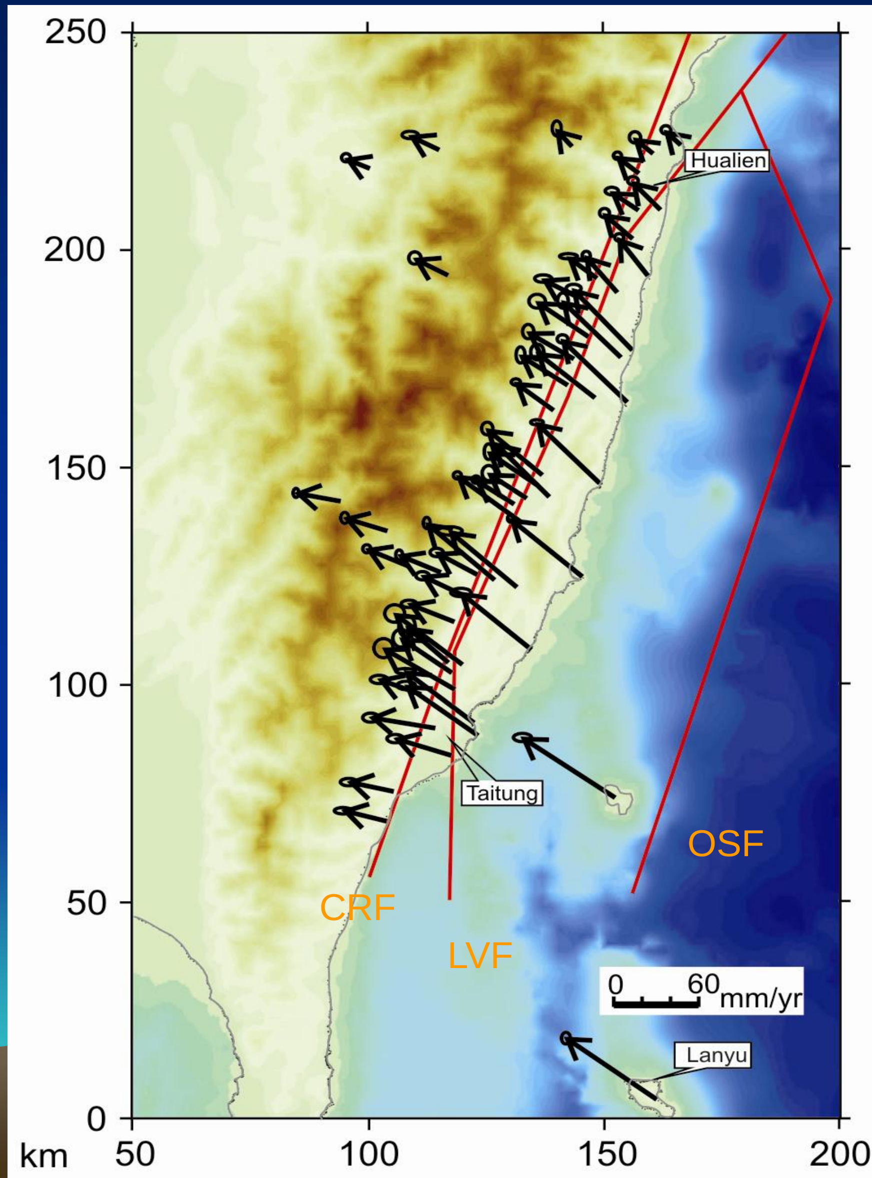


(Hsieh et. al., 2004)

(Hsu and Bürgmann, 2006)

Geodetic and Geologic Data

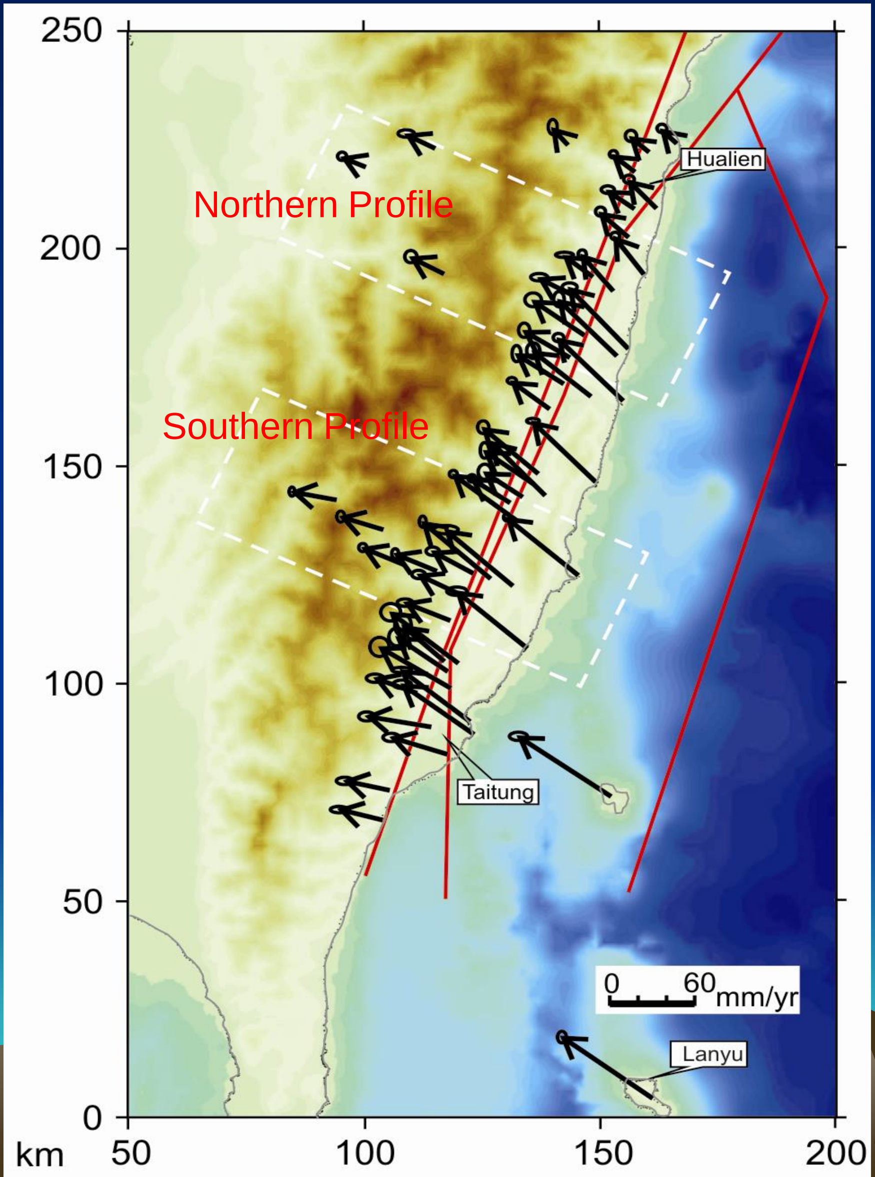
Horizontal GPS



(Yu and Kuo, 2001)

Geodetic and Geologic Data

Horizontal GPS



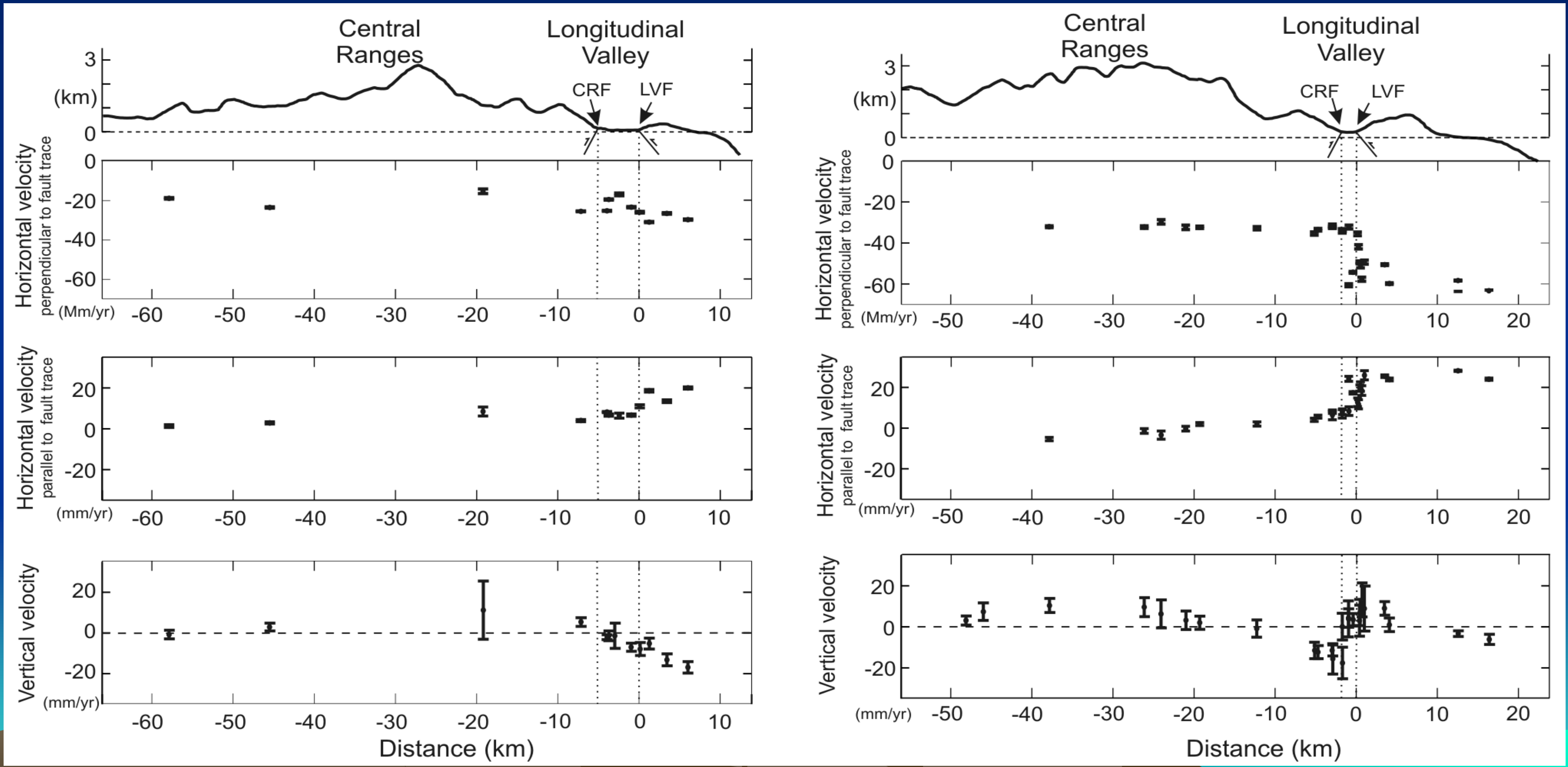
(Yu and Kuo, 2001)

Geodetic and Geologic Data

Horizontal GPS

Northern Profile

Southern Profile



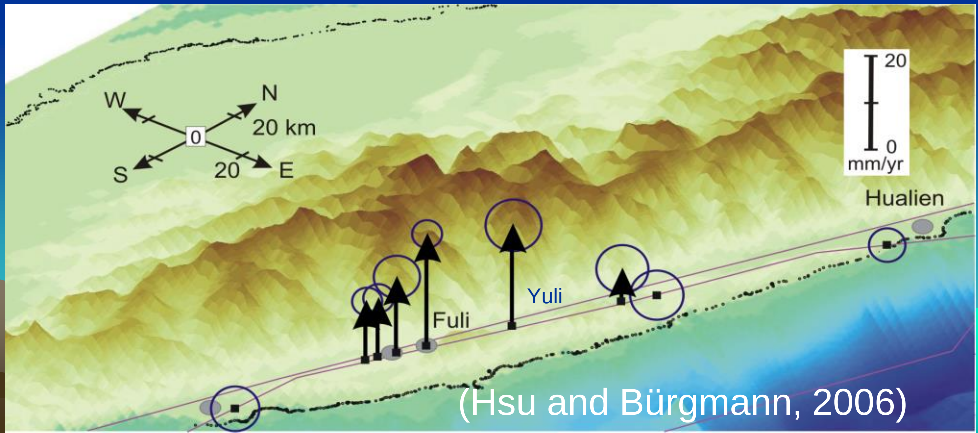
Geodetic and Geologic Data

Vertical GPS

Horizontal GPS

Holocene Uplifted marine terraces

InSAR-inferred differential vertical motion

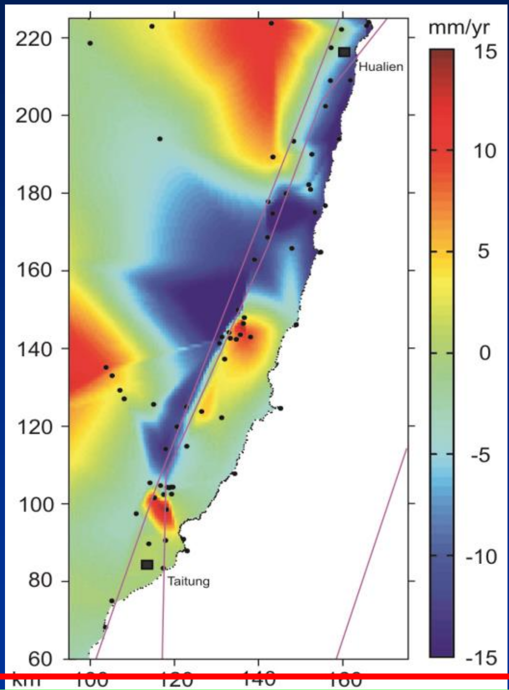


(Hsu and Bürgmann, 2006)

Geodetic and Geologic Data

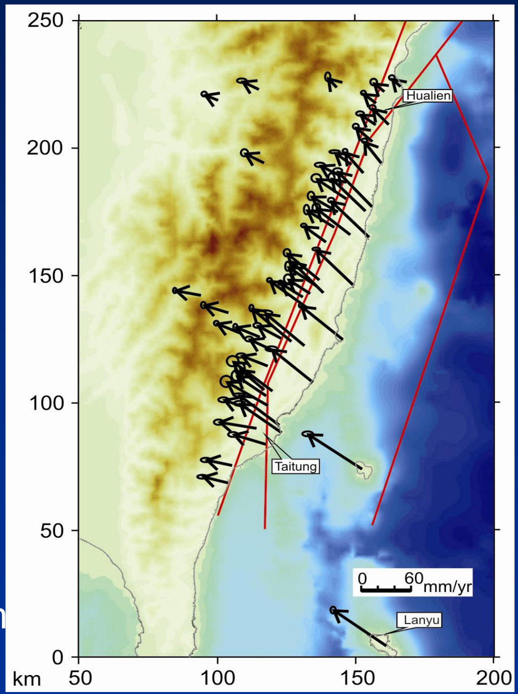
Interseismic deformation

Vertical GPS



(Yu, unpublish

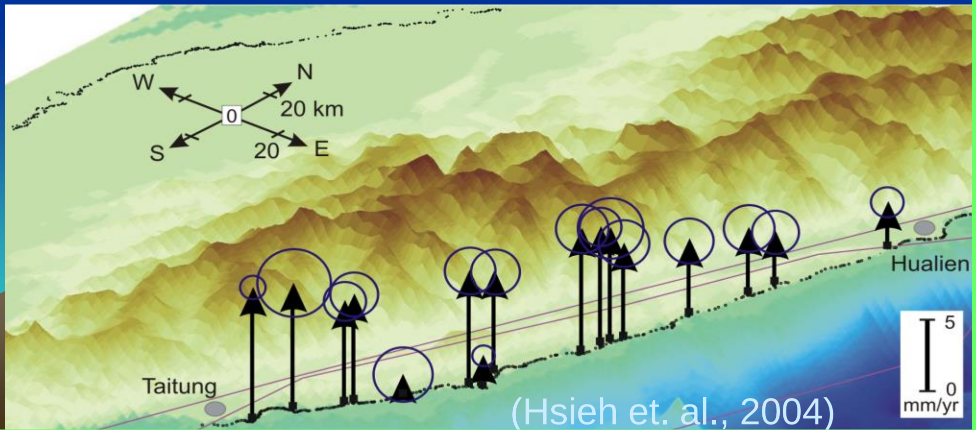
Horizontal GPS



(Yu and Kuo, 2001)

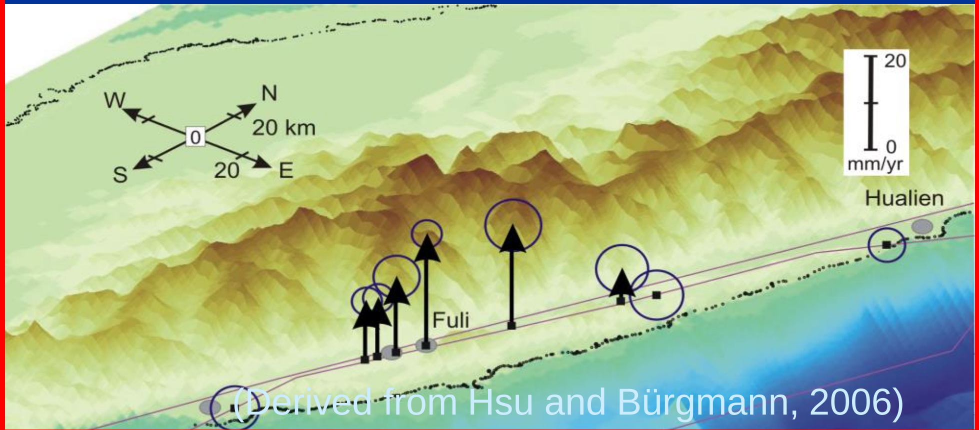
Long-term deformation

Holocene Uplifted marine terraces



(Hsieh et. al., 2004)

InSAR-inferred differential vertical motion



(Derived from Hsu and Bürgmann, 2006)

Buried dislocation model
by Hsu et al. (2003)

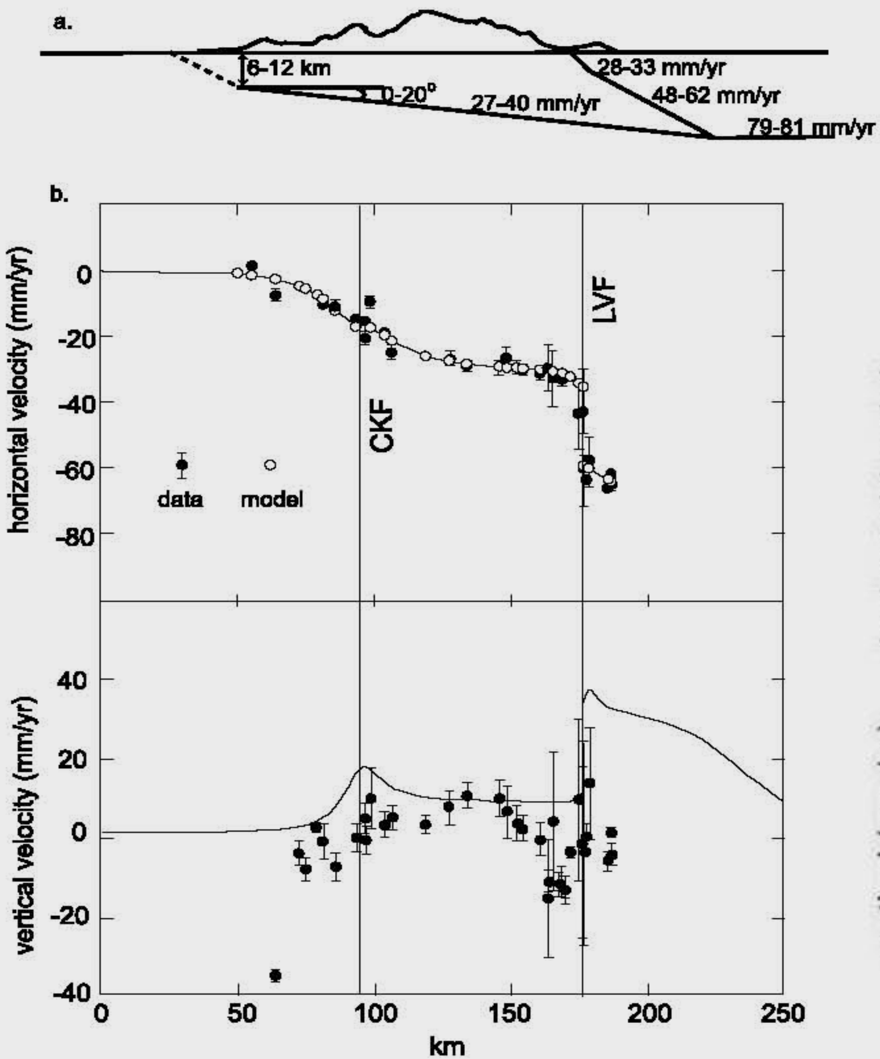


Plate-block model
by Johnson et al. (2005)

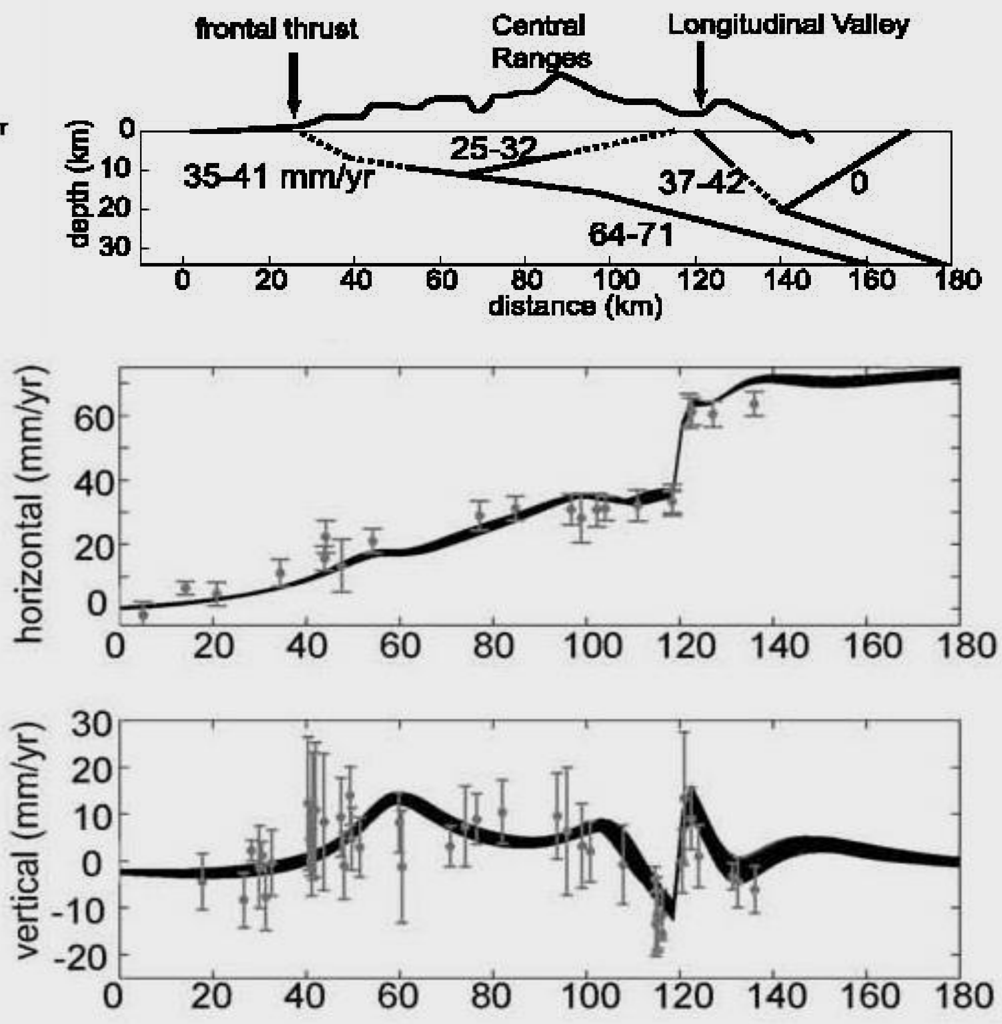
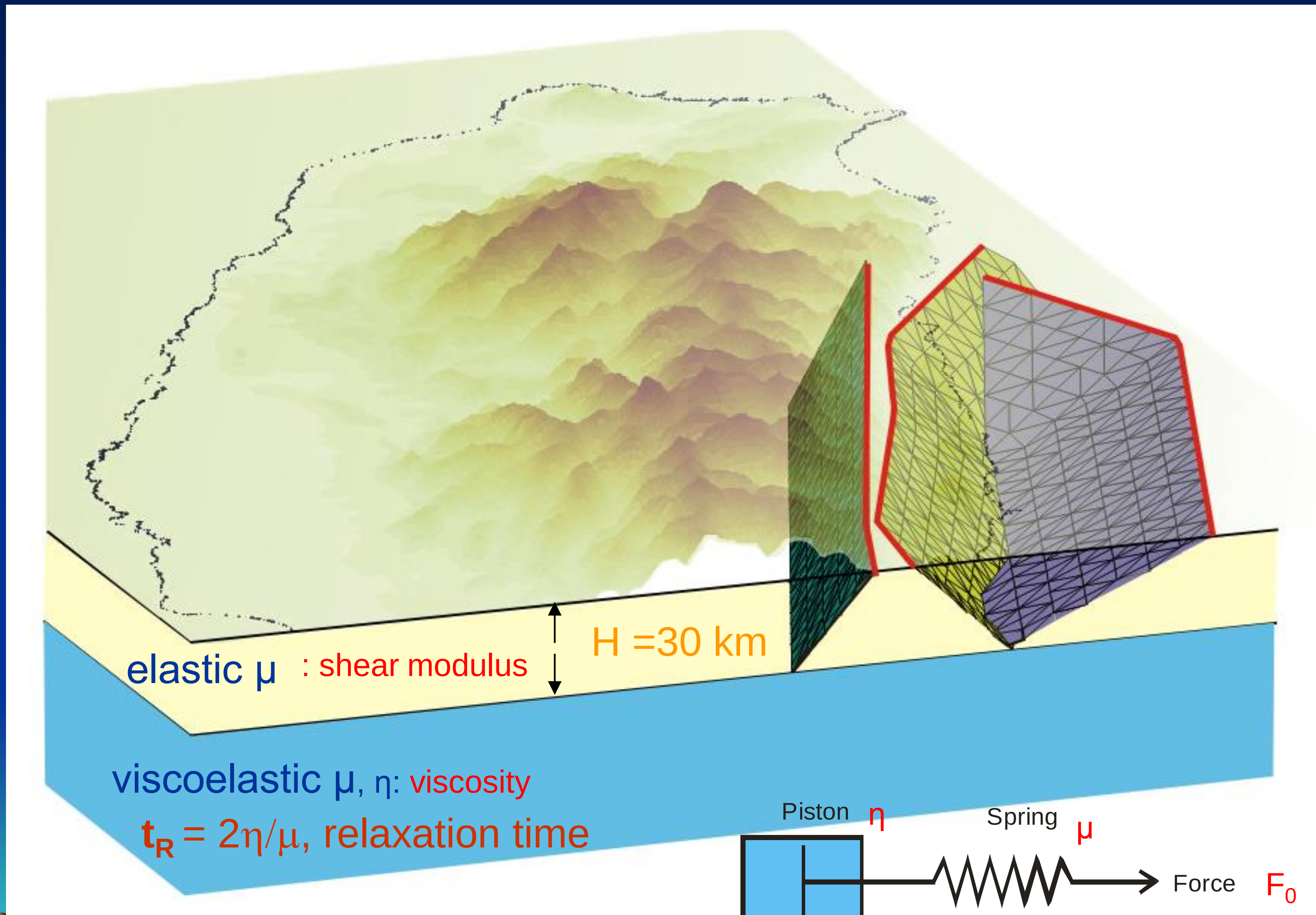


Plate-block Model



$W(t) = (F_0 * S) * \exp(-\alpha t / t_R)$
work

S: displacement
t: time
α: scalar

Plate-block Model

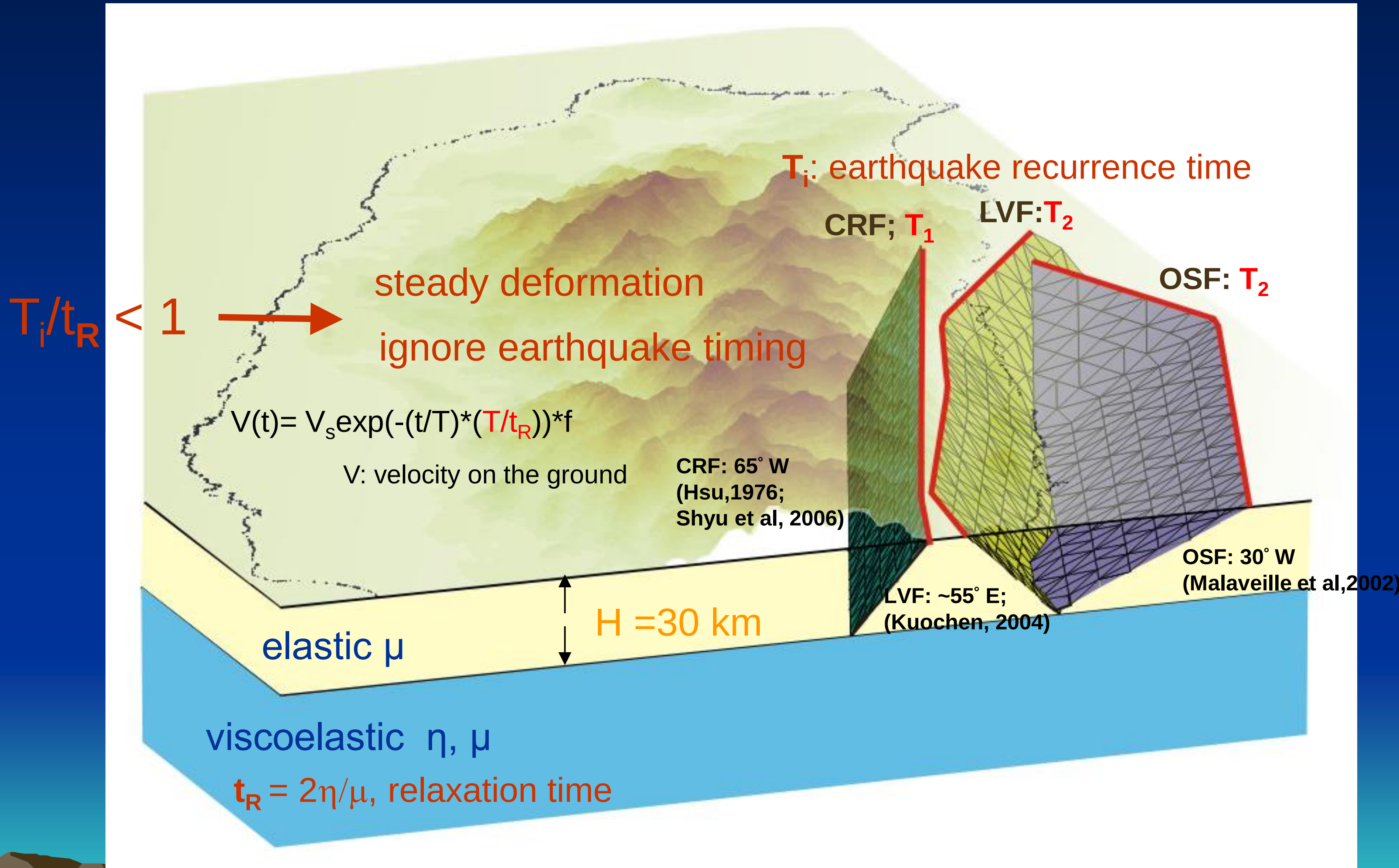
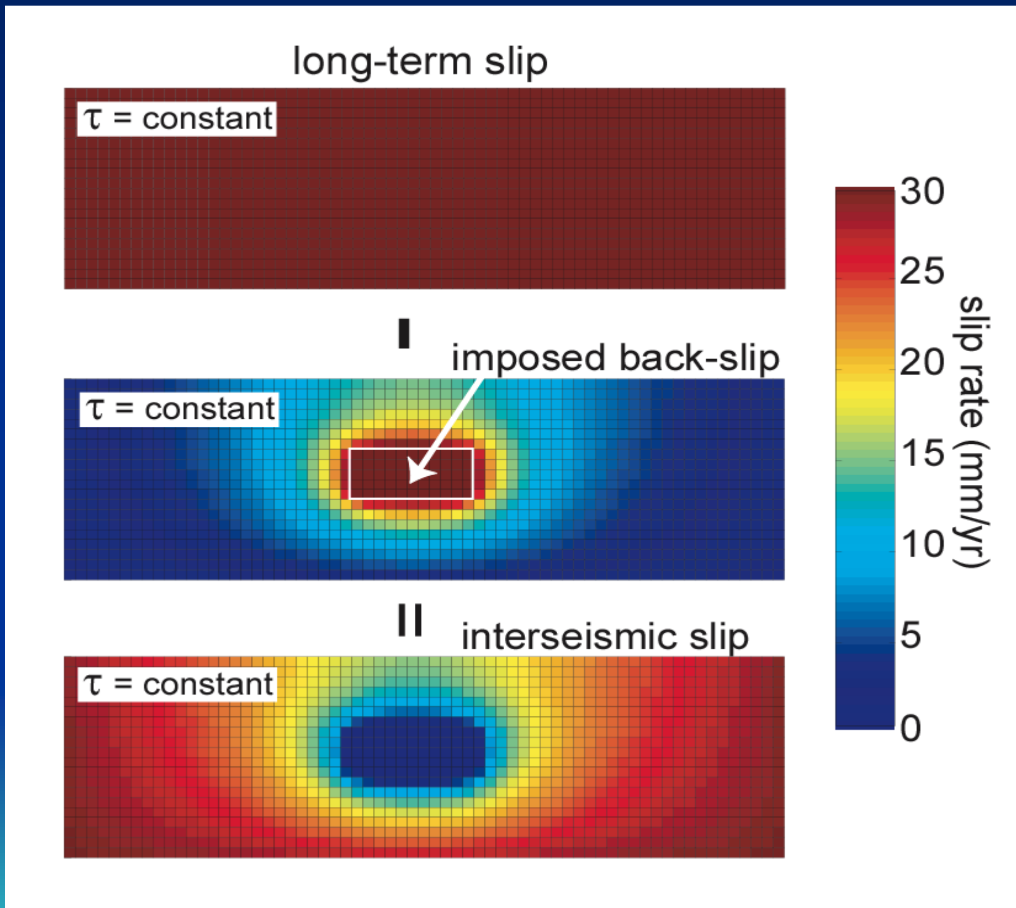
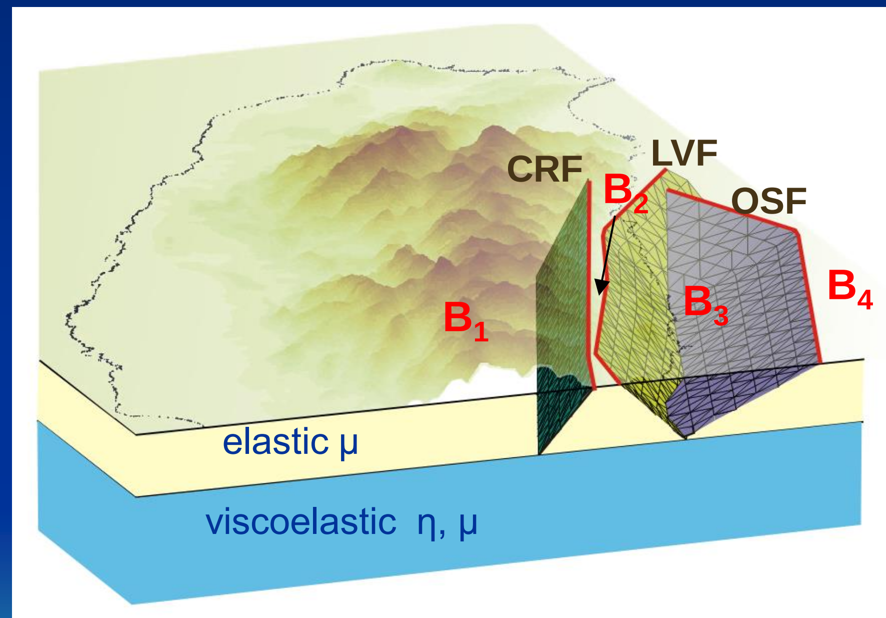


Plate-block Model

creep at constant resistive stress





Solving for parameters:

inverting data through viscoelastic collision model

Forward problem : Interseismic and long-time velocities are solved , given model parameters

$$V_{long}=[G_{block} + G_c B_{cancel} + G_f B_{forward}].\Omega$$

$$V_{int}=[G_{block} + G_c B_{cancel} + G_f B_{forward} + G_b B_{backslip}].\Omega$$

V_{int}: vector of interseismic geodetic data
V_{long}: vector of long-term geologic data
G: Green function
B: corresponding matrix
Ω: vector of Euler poles

$$d = g(m) + \varepsilon$$

m: vector of parameters
ε: vector of errors

Monte Carlo Inversion

- Metropolis method

Bayes' Theroem

P: probability

constant

$$P(m/d) = \frac{P(d/m)P(m)}{P(d)} = \alpha P(d/m)$$

constant

m: vector of parameters
d: vector of data
α: constant scalar

By definition

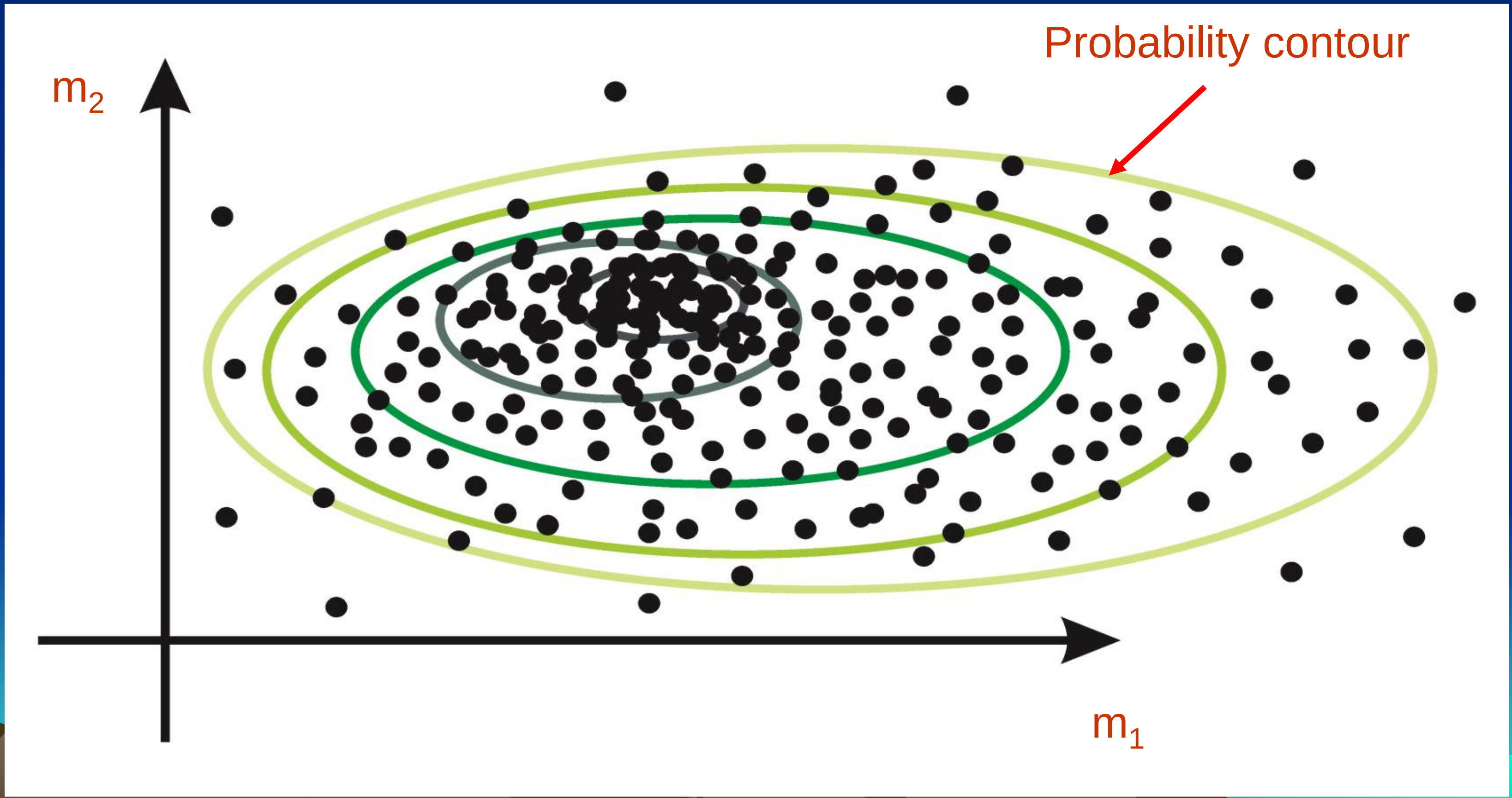
$$P(d/m) = C\exp[-\frac{1}{2}(d-g(m))^T \sum_d^{-1}(d-g(m))]$$

C: constant scalar

P(*m* / *d*): posterior probability

Markov Chain random walk

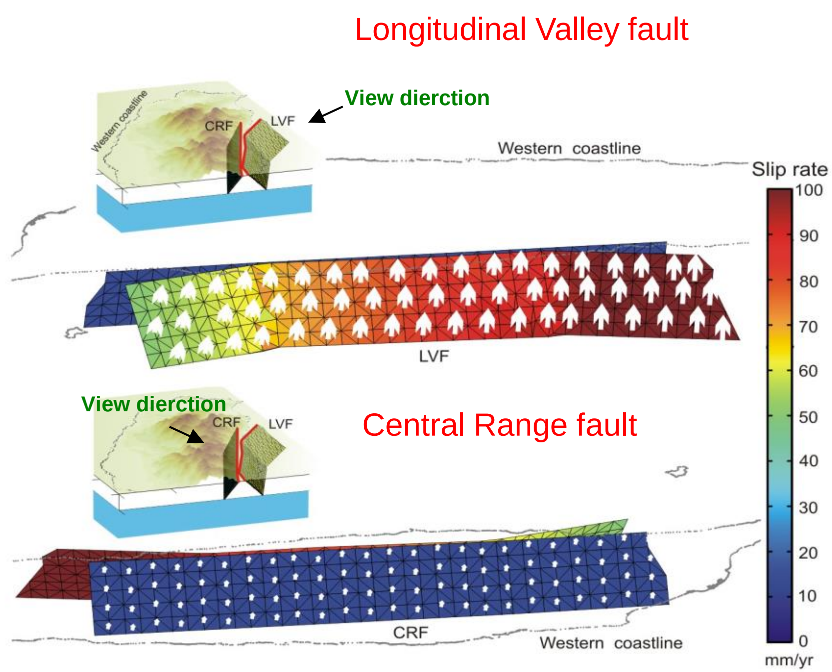
Sample distribution

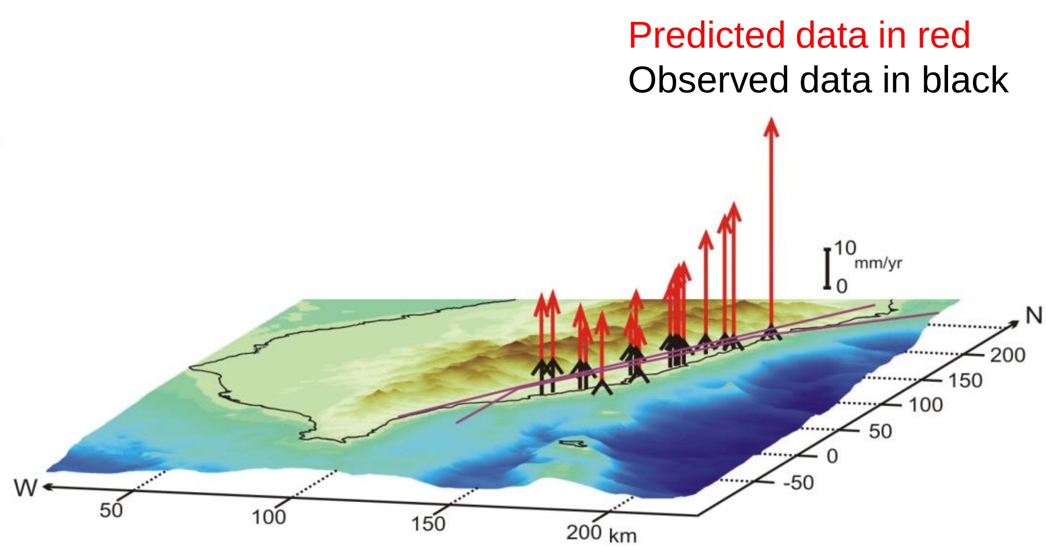


Two-fault Model

Long-term slip rate

Long-term coastal uplift rates

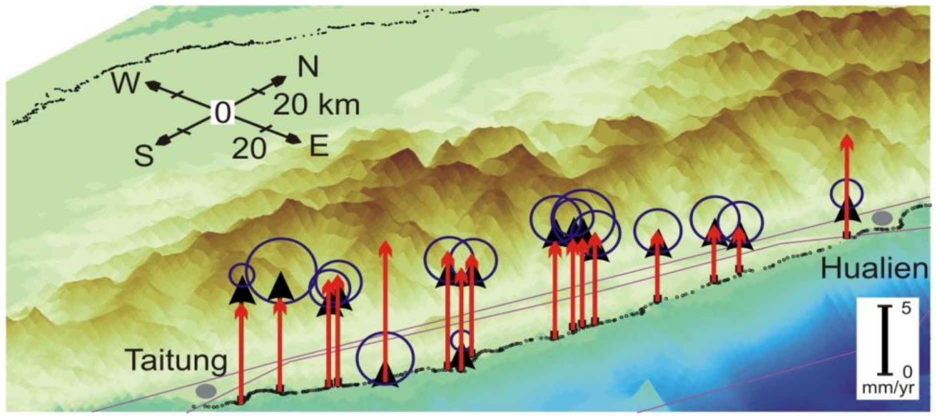




LVF slip rate high – badly over-predicted coastal uplift

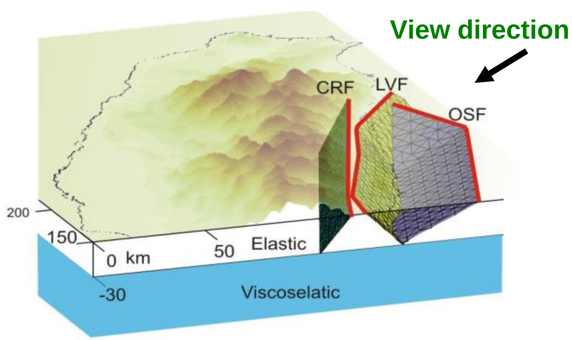
Three-fault Model

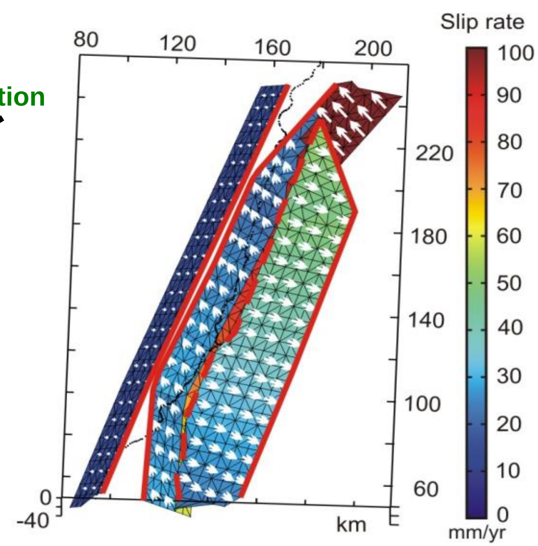
long-term coastal uplift rates

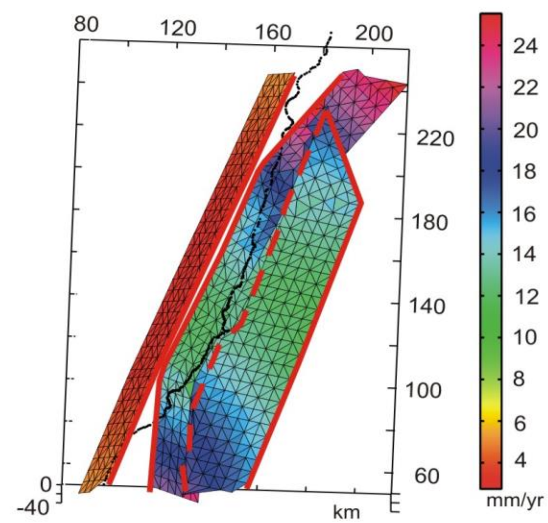


long-term fault slip rate

uncertainty

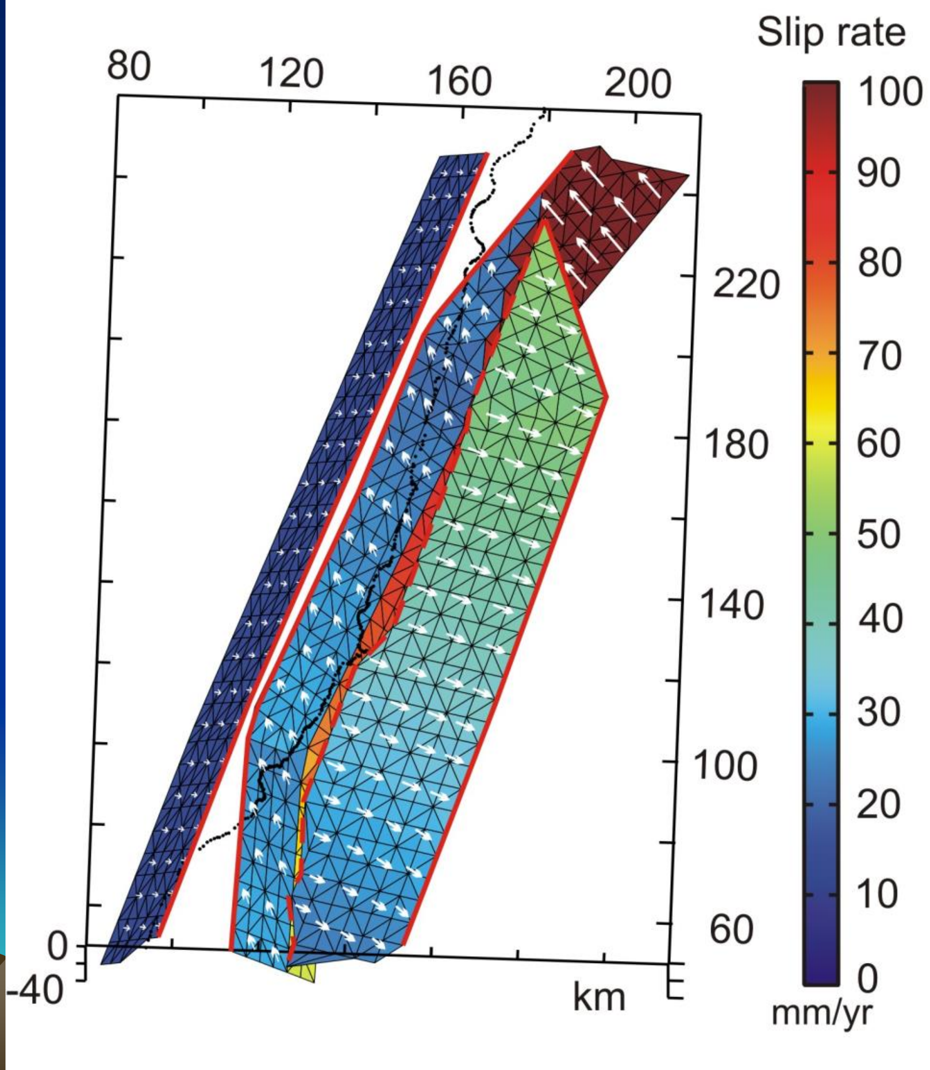


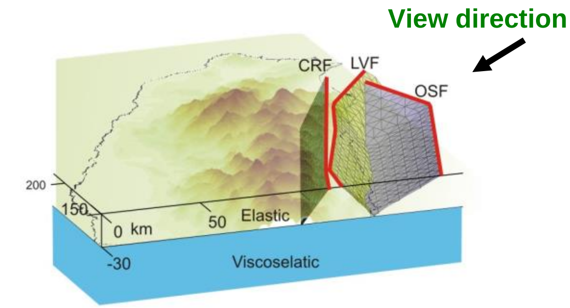




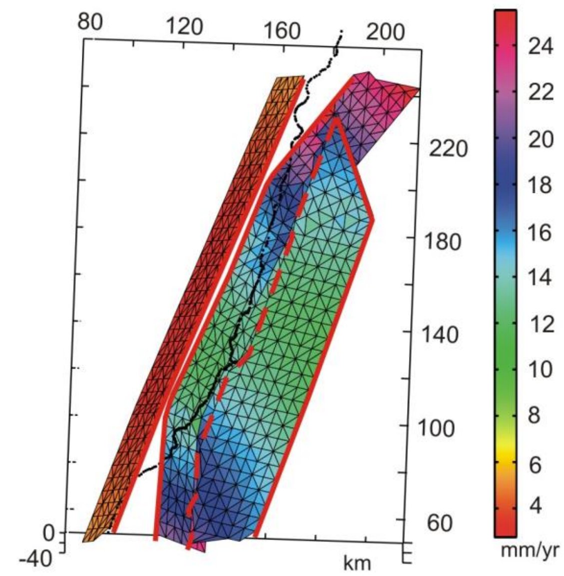
Three-fault Model

long-term fault slip rate



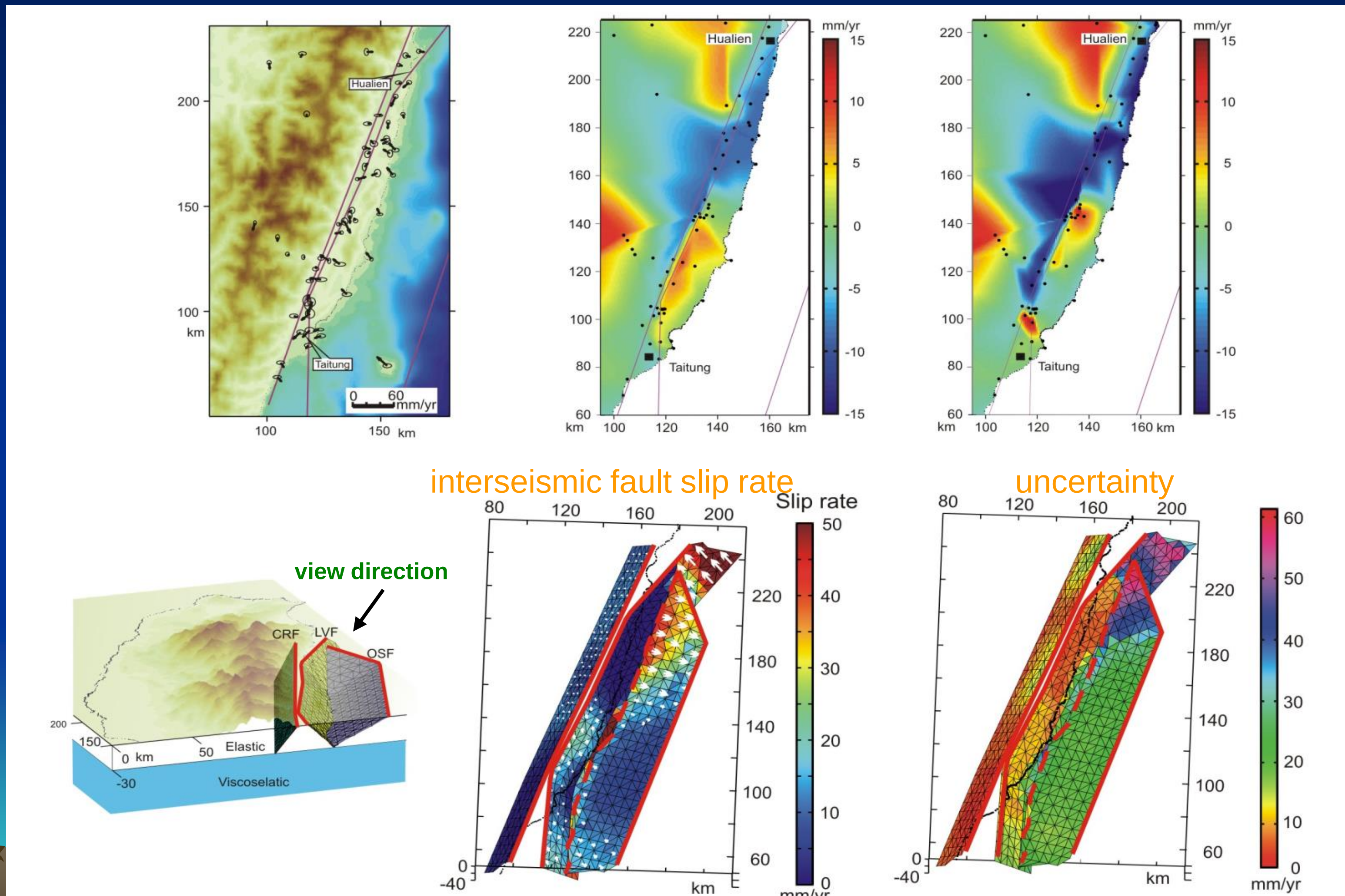


uncertainty



Three-fault Model

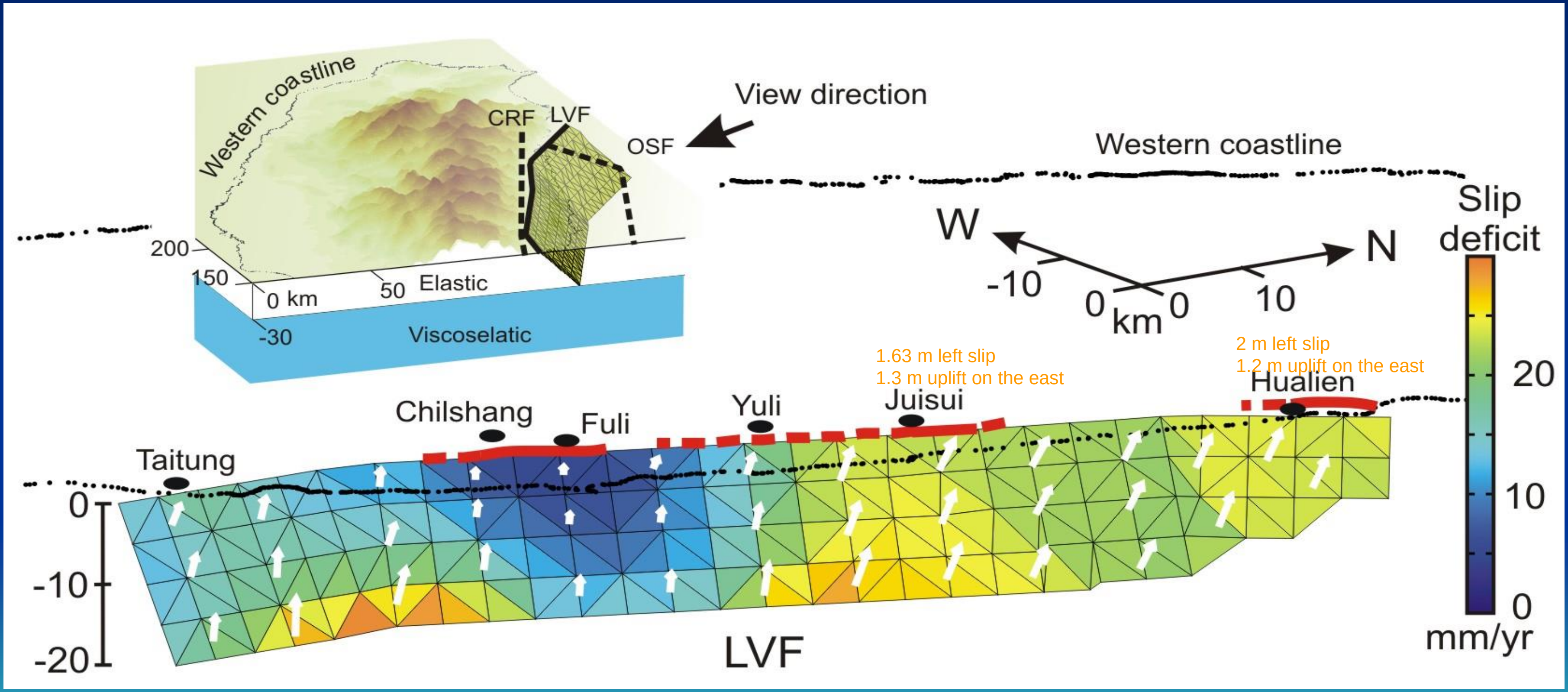
horizontal residual model vertical vertical GPS



Three-fault Model

slip deficit per year on Longitudinal Valley fault

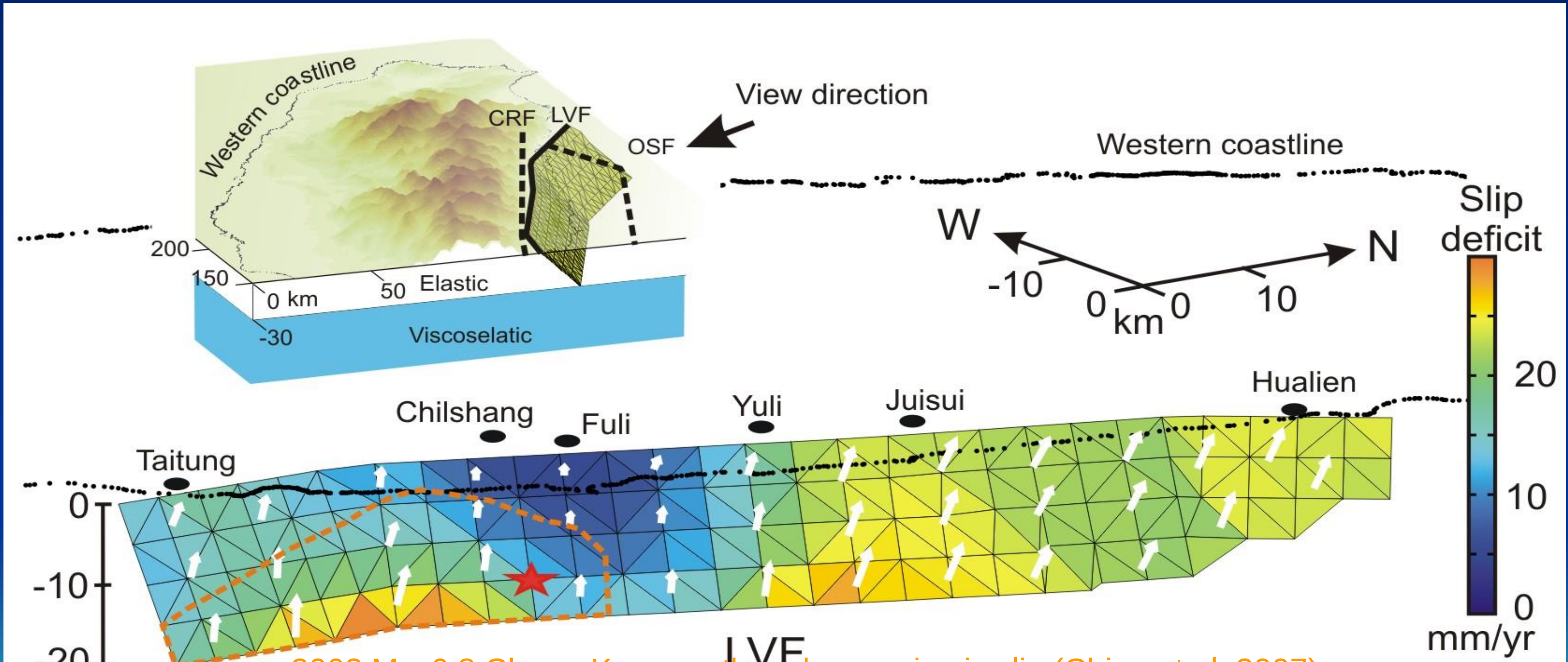
(long-term slip rate minus interseismic slip rate)



1951 earthquakes surface ruptures (Hsu, 1962)

Three-fault Model

slip deficit on Longitudinal Valley fault



2003 Mw 6.8 Cheng-Kung earthquake coseismic slip (Ching et al, 2007)

Conclusion

1. Holocene uplift rates (long-tem uplift rates) along eastern coast can only be reproduced if a significant amount of convergence is accommodated offshore on the OSF.
2. Including the OSF in the model reduces the estimate of long-term slip rate on the LVF by a factor of about two and changes the LVF from a nearly pure dip-slip reverse fault to an oblique reverse, left-lateral fault, consistent with independent observations.
3. The LVF is largely locked north of Yuli and is creeping to the south.
4. The transition from creeping to locked on the southern segment of LVF corresponds with the hypocenter of the 2003 Chengkung earthquake.

Thank you for your attention!

Talk Outline

- Tectonic setting and research interests
- Method
  - Forward model
    - Plate collision model
  - Inverse model
    - Inverse scheme
    - Resolution test
- Results
  - Two-fault model
  - Three-fault model
- Conclusion

M～6 Earthquakes

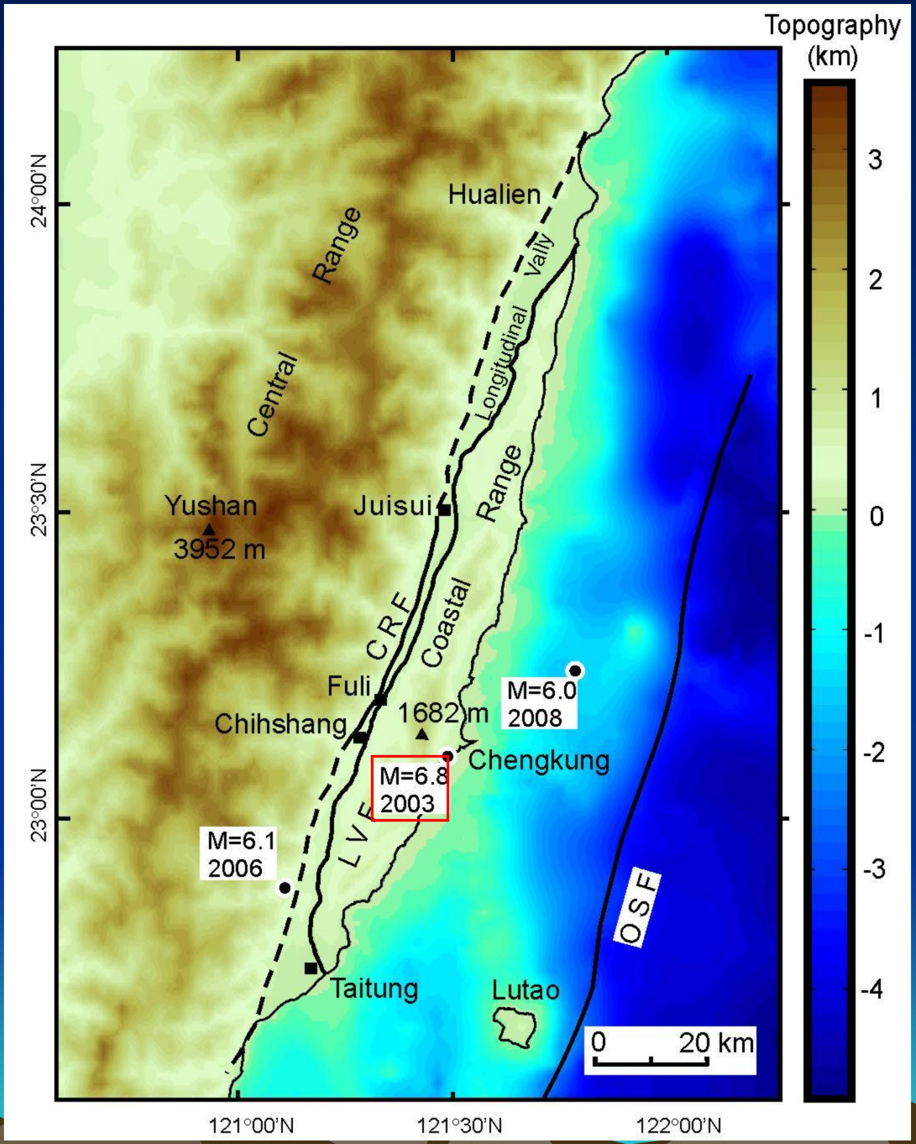
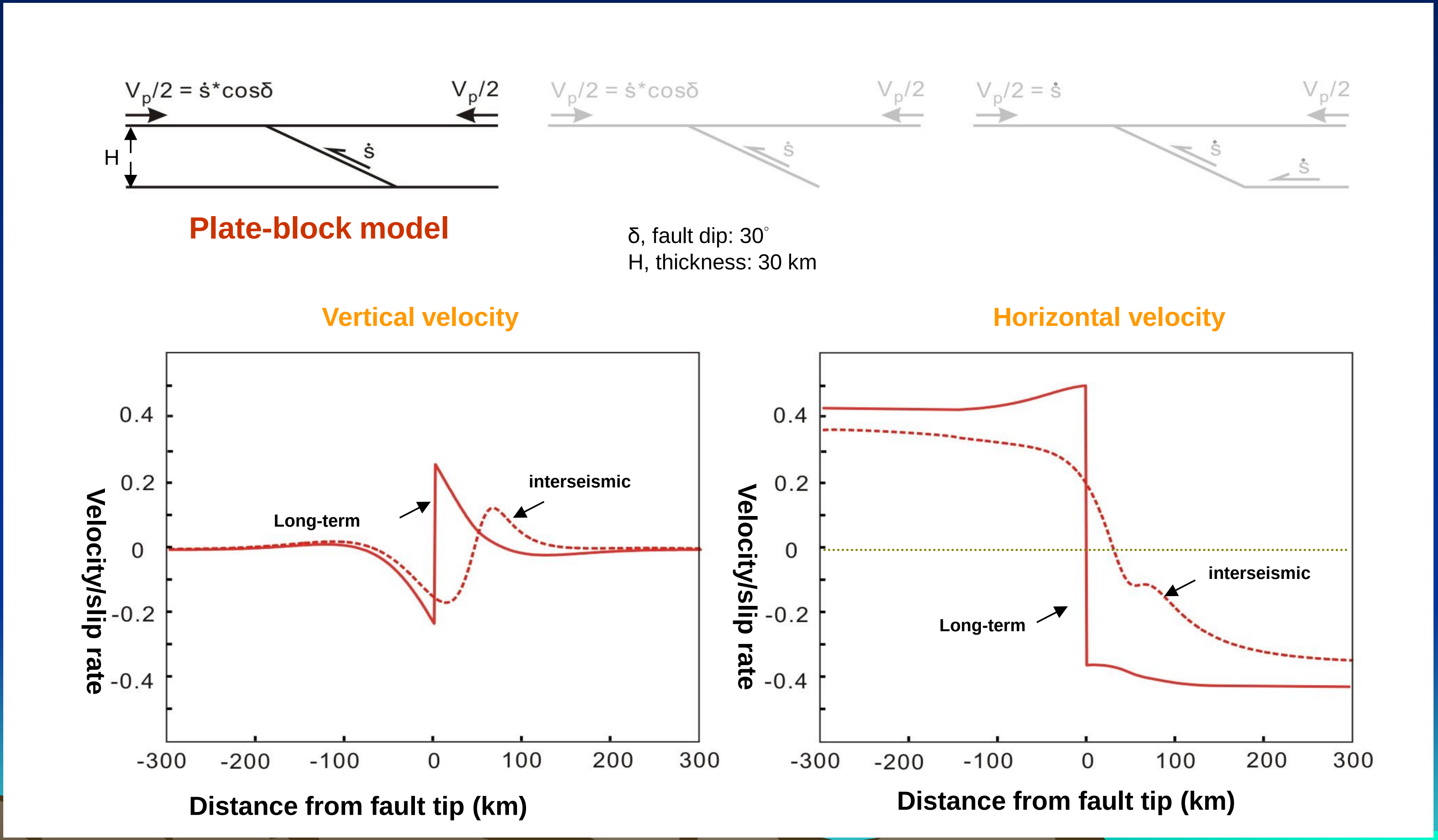
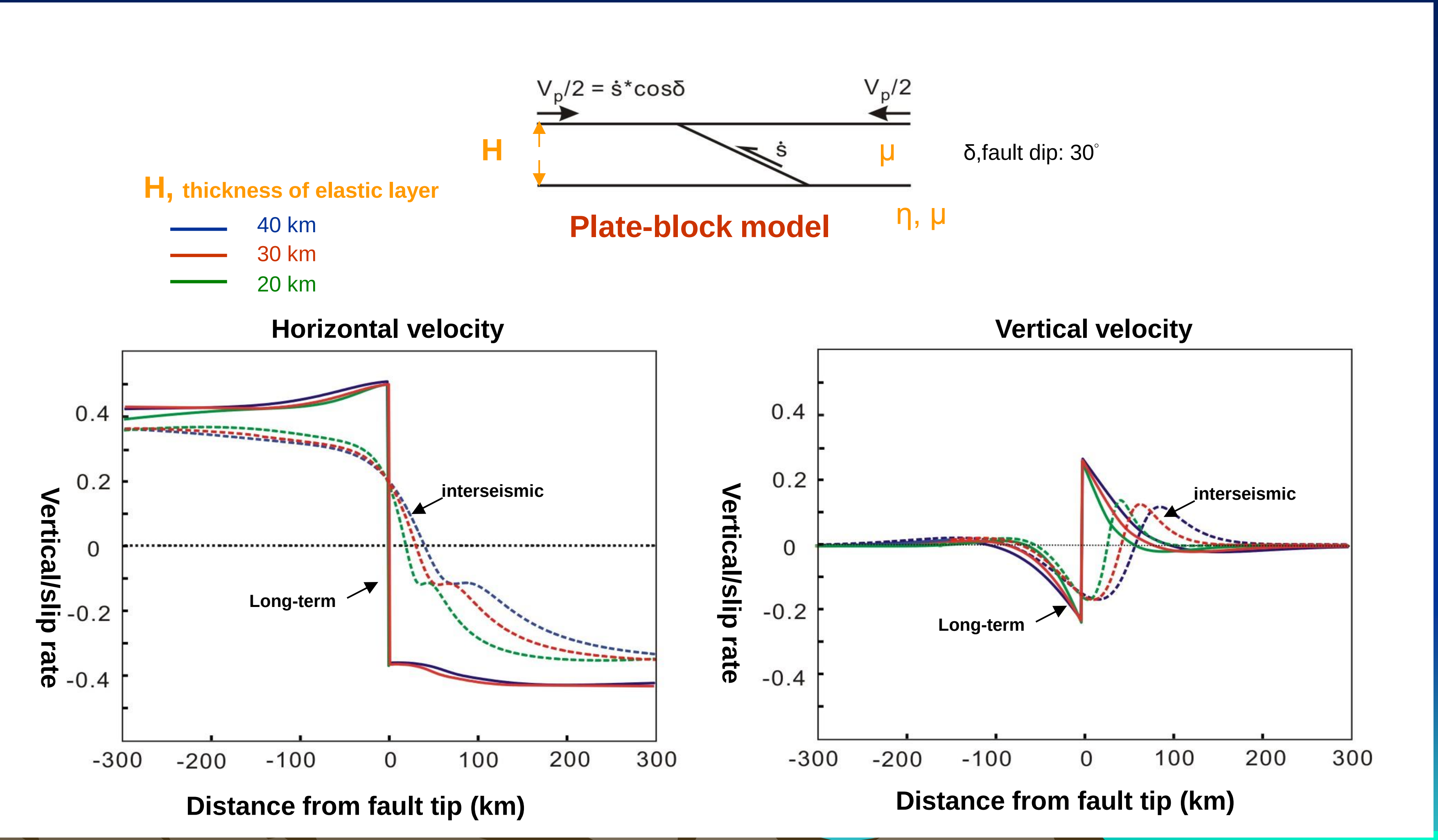


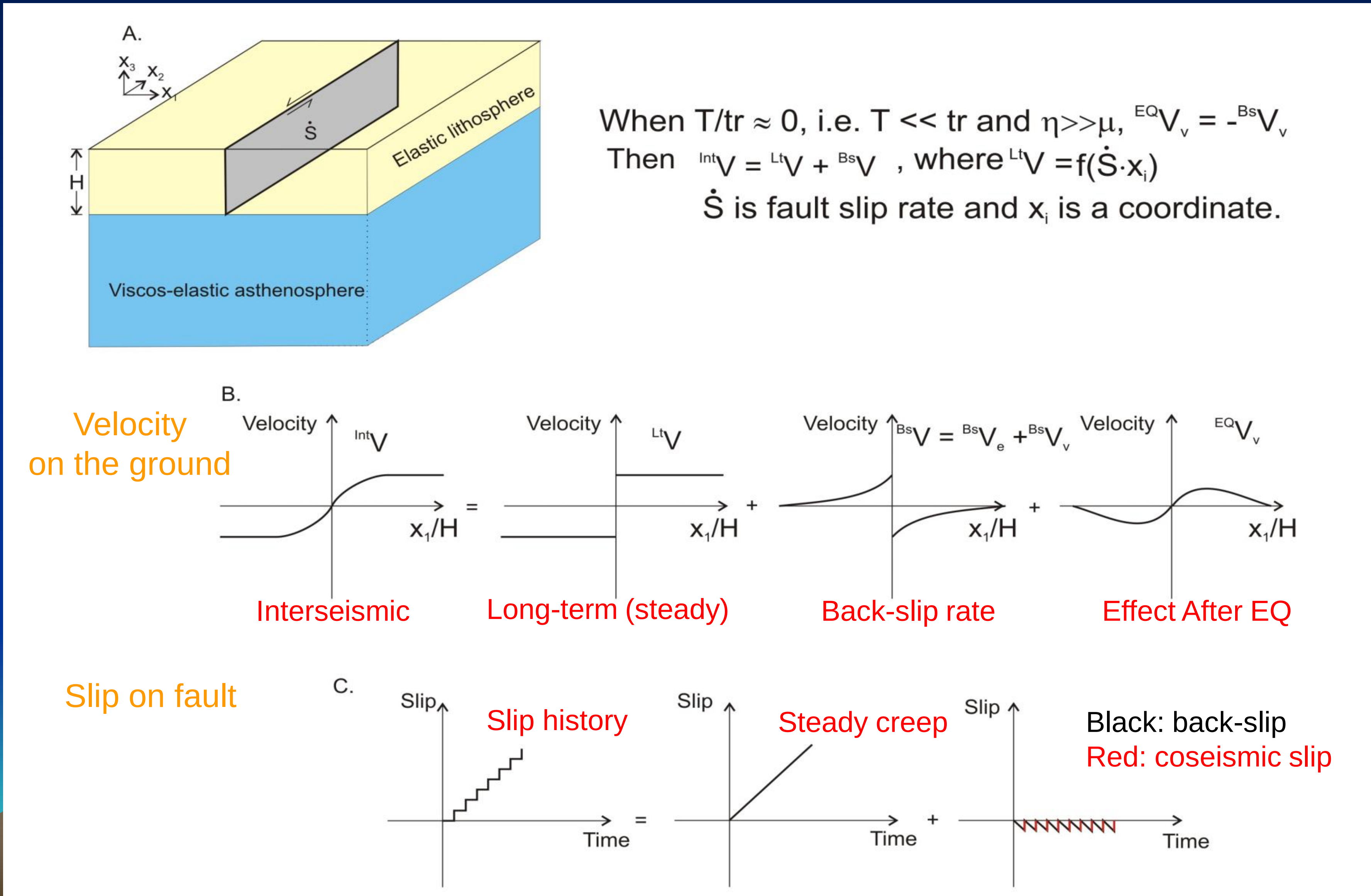
Plate-block model



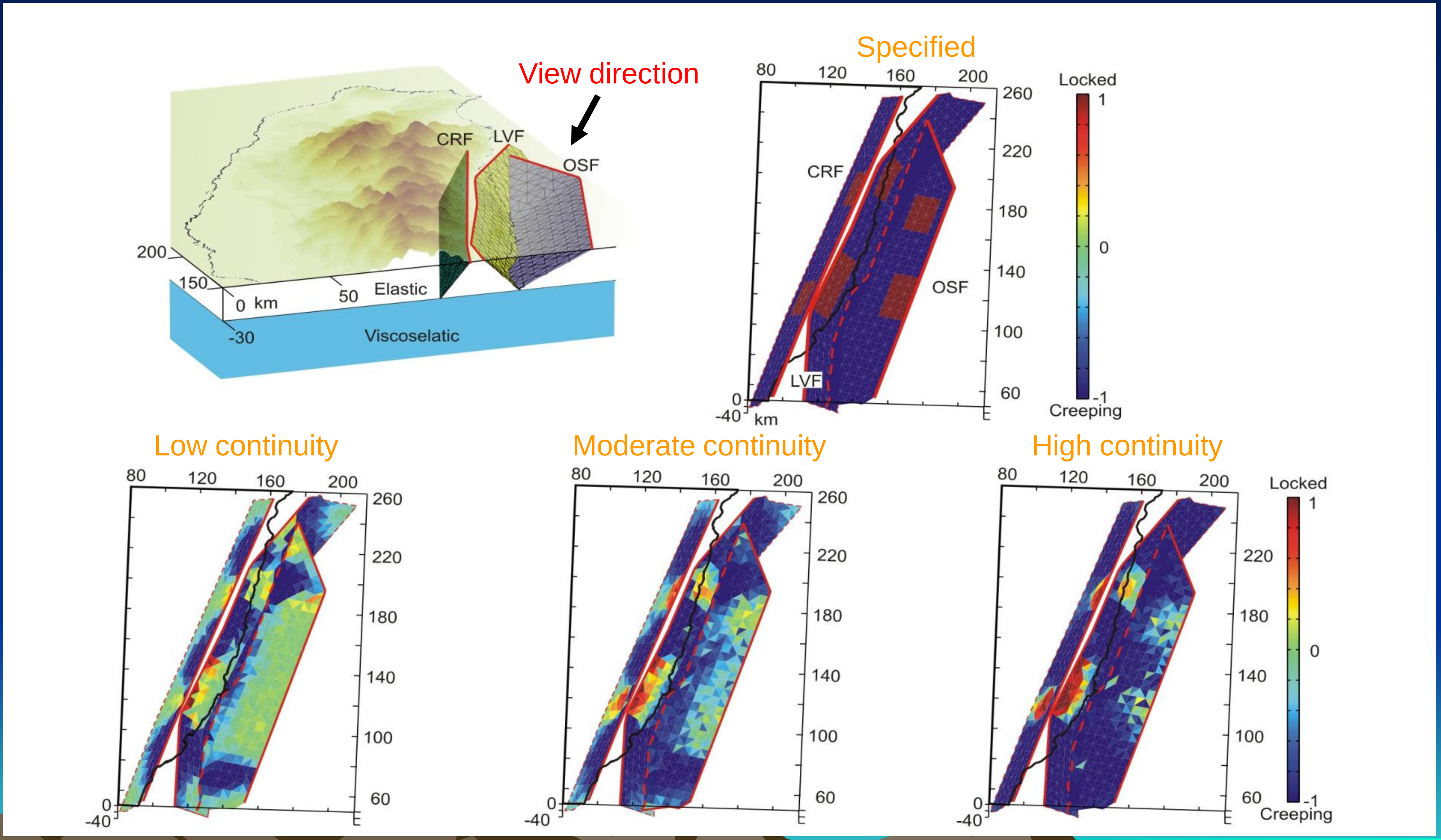
Effect of elastic layer thickness



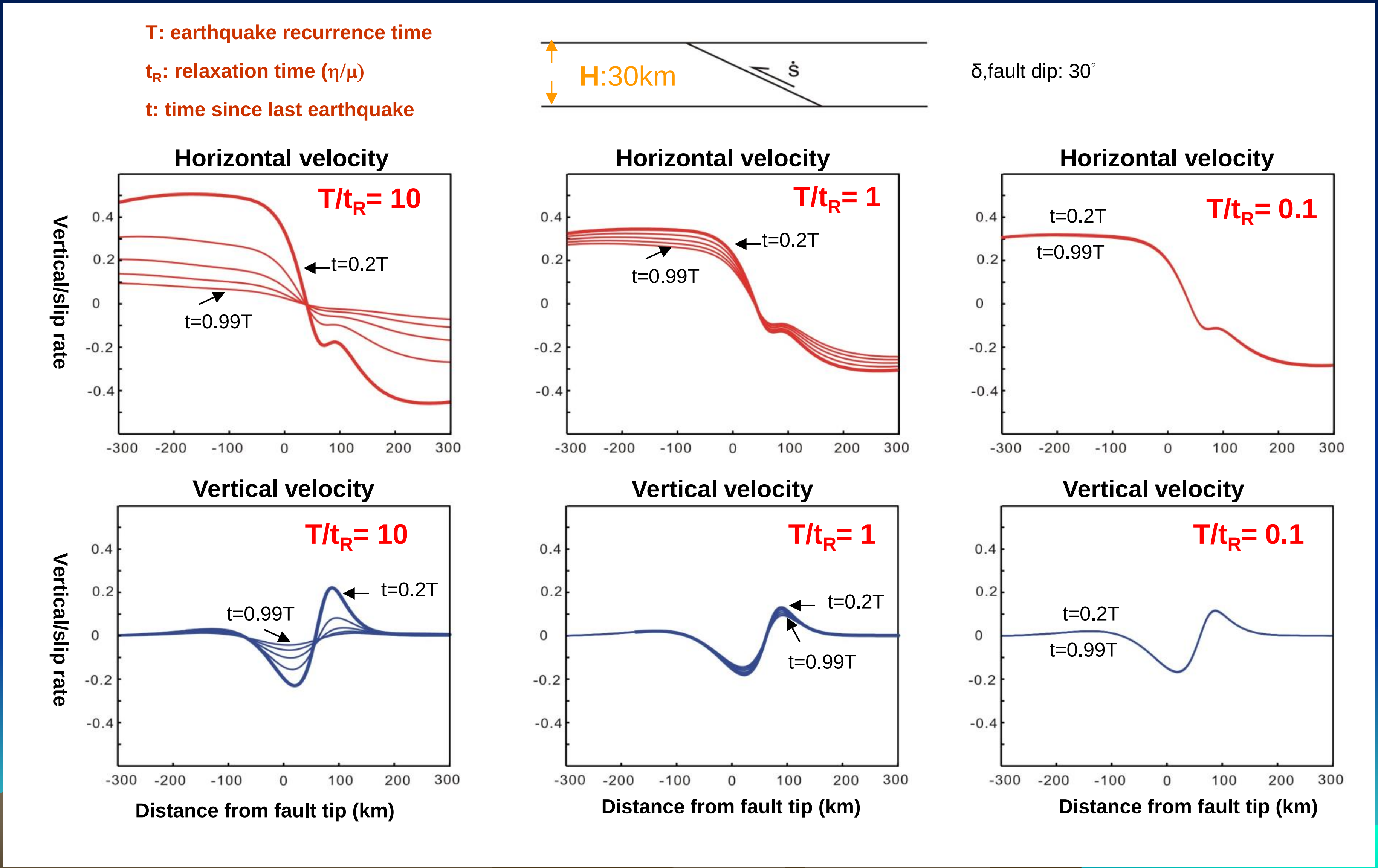
Viscoelastic Earthquake cyclic model



Resolution Test

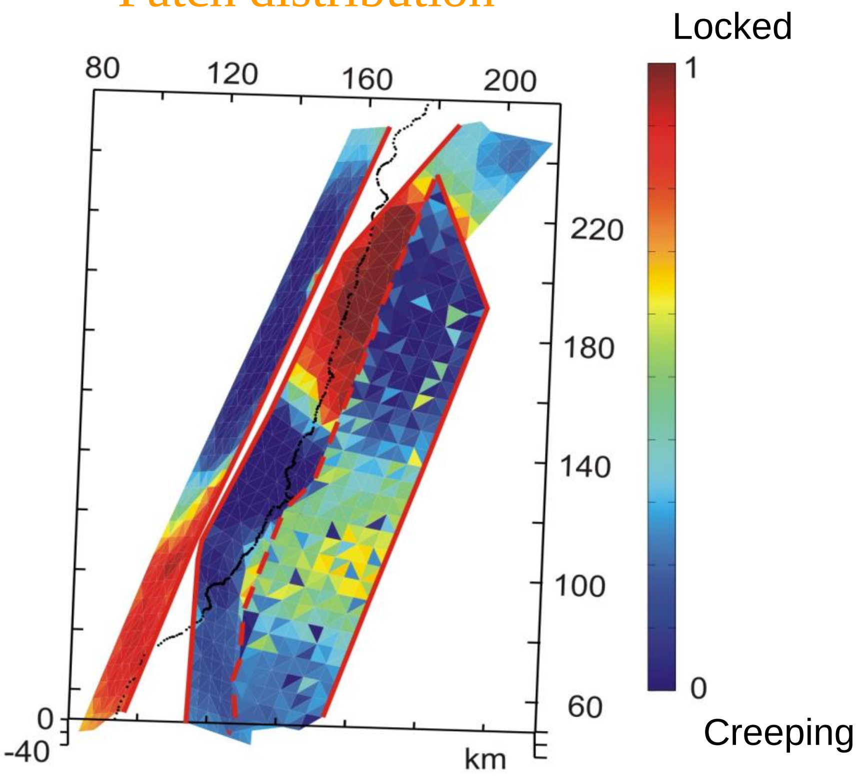


Earthquake cycle



Three-fault Model

Patch distribution



Fit of InSAR-inferred differential vertical motion