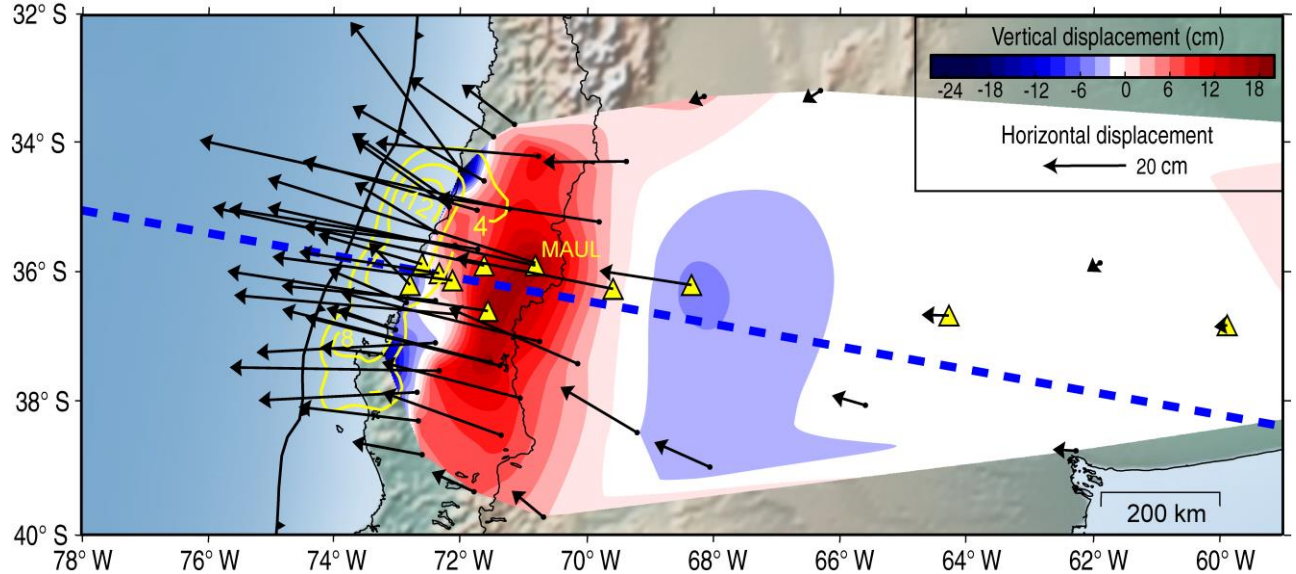
Role of the lower crust in the postseismic deformation of the 2010 Maule earthquake: Insights from a model with non-linear rheology

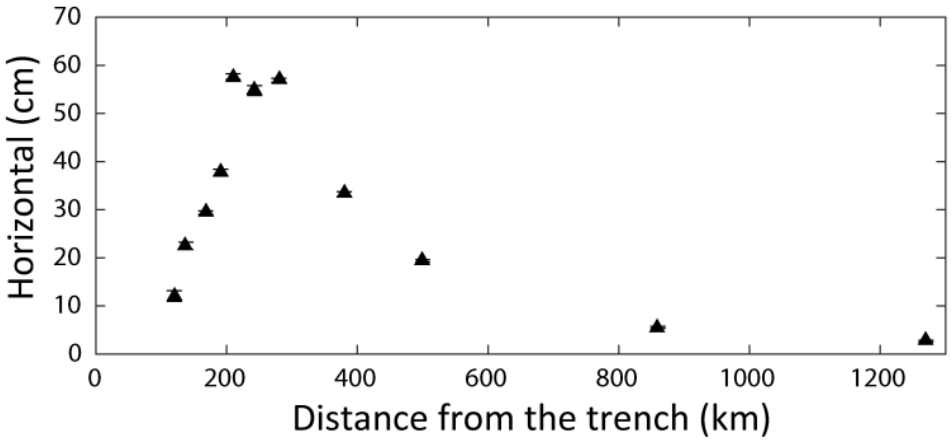
Carlos Peña [1, 2] , Oliver Heidbach[1], Marcos Moreno[1,3], Jonathan Bedford[1], Moritz Ziegler[1, 4], Andrés Tassara[5, 6] and Onno Oncken[1, 2]

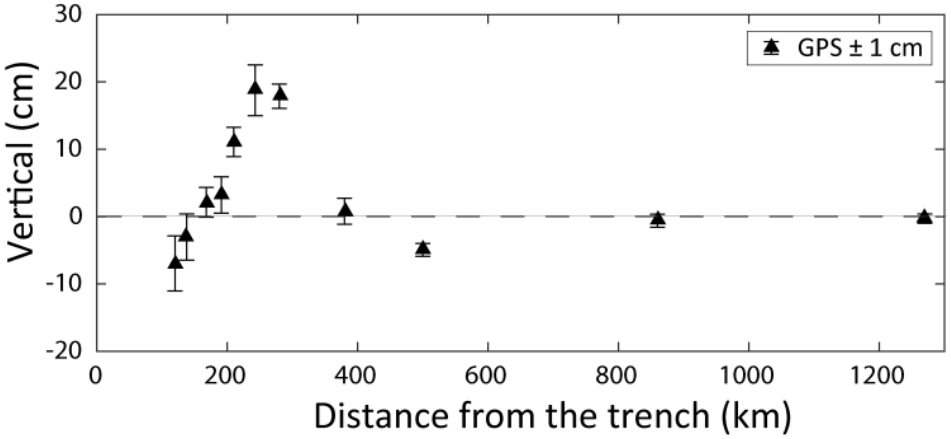
[1] Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany
[2] Freie Universität Berlin, Berlin, Germany
3 Departamento de Geofísica, Universidad de Concepción, Chile
[4] University of Potsdam, Institute of Earth and Environmental Science, Potsdam-Golm, Germany
[5] Departmento de Ciencias de la Tierra, Universidad de Concepción, Chile
[6] Millenium Nucleus CYCLO "The Seismic Cycle along Subduction Zones"

19th general assembly of WEGENER, Grenoble, France , 10.-13. Sept. 2018

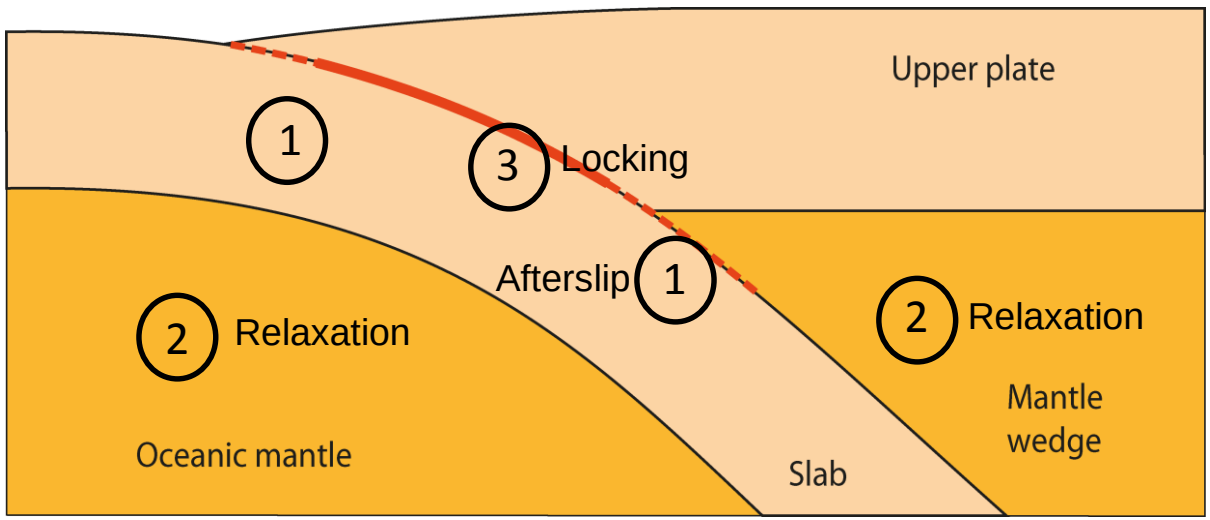
Postseismic GPS of the Maule 2010 earthquake







Primary postseismic processes



Wang et al. (2012)

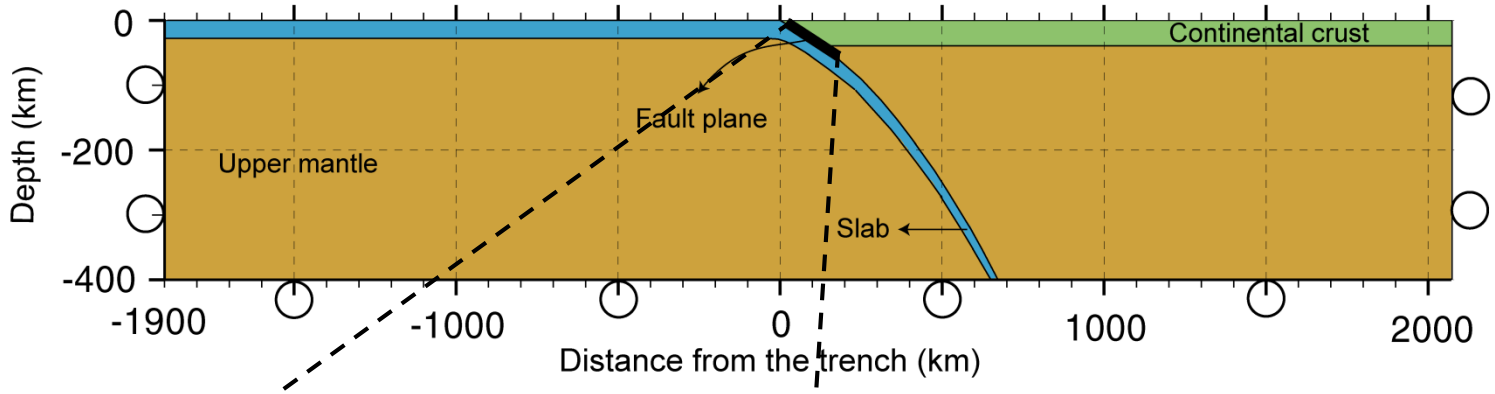
Elastic

Linear viscoelastic

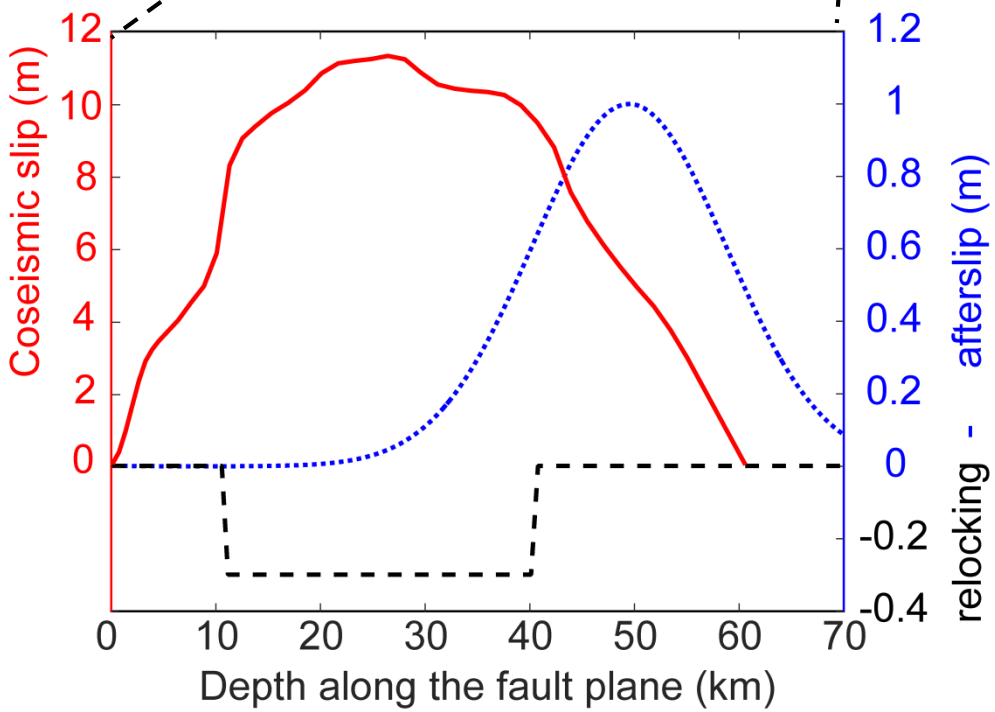
- **Bedford et al. (2016)**
- **Klein et al. (2016)**
- **Li et al. (2017)**

What is the impact of using non-linear rheology?

Model setup



Boundary conditions on the fault plane

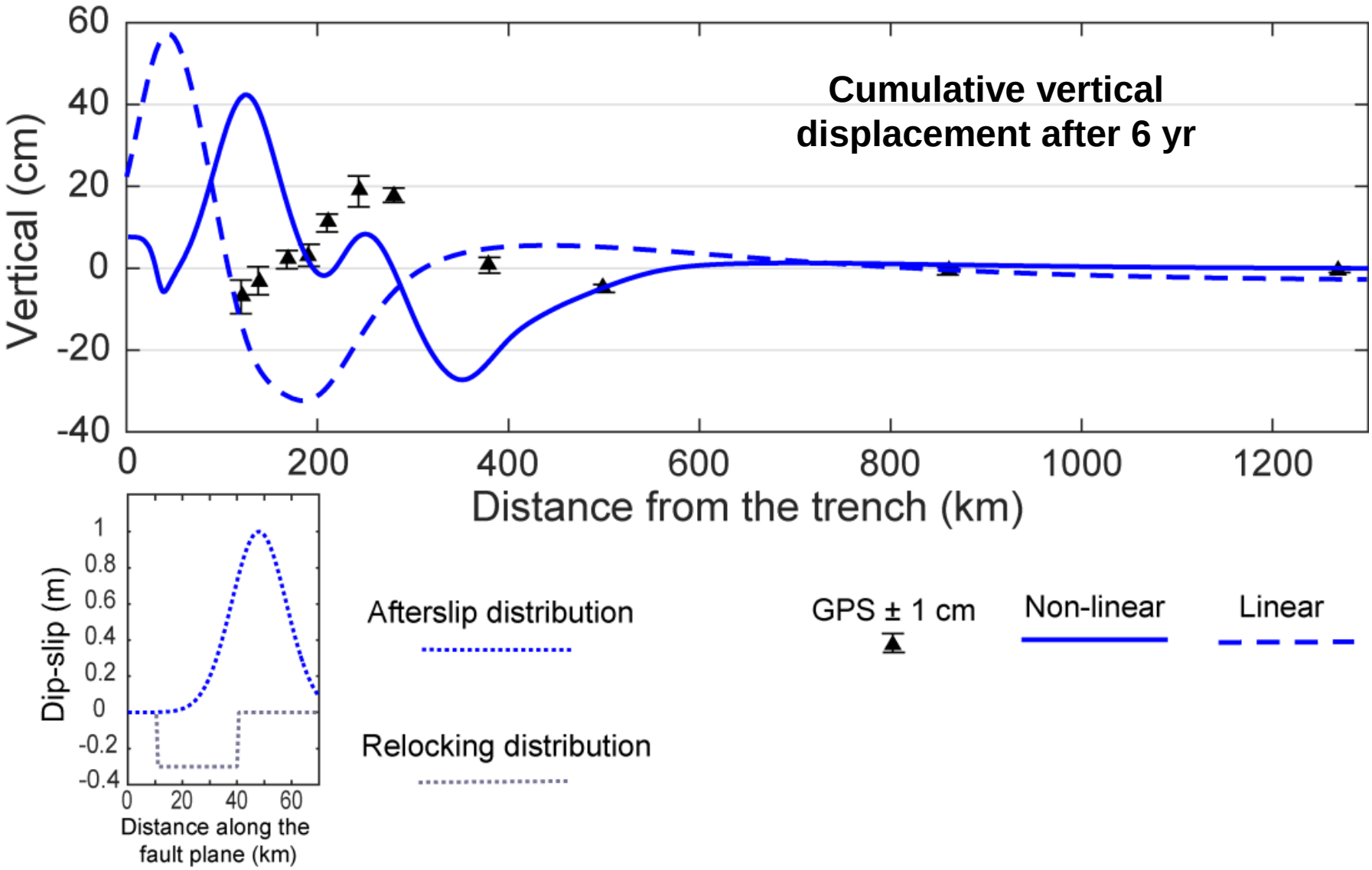


Dislocation creep

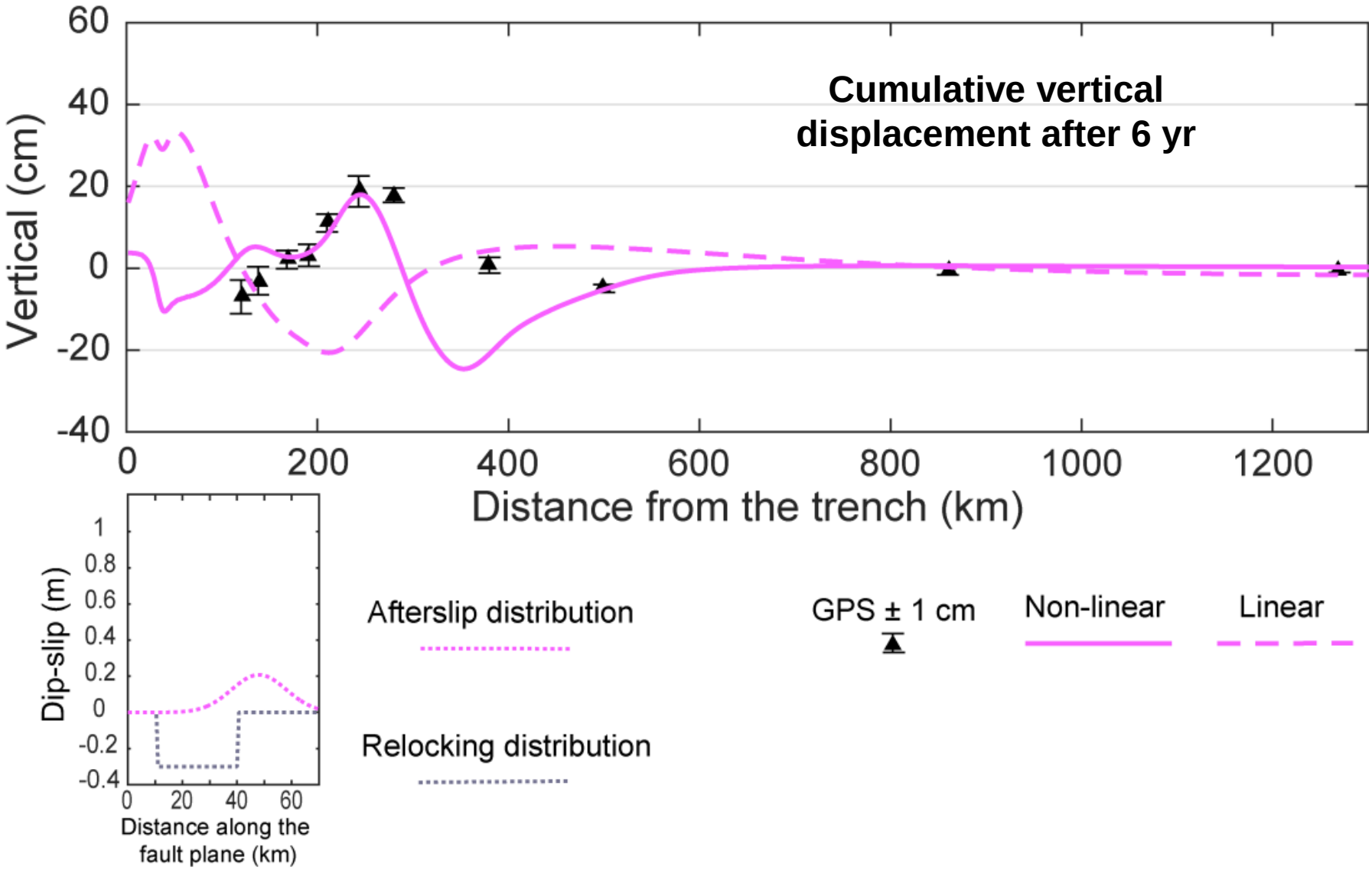
$$\dot{\varepsilon} = A\sigma^n exp\left(\frac{-Q}{RT}\right)$$

- $\dot{\varepsilon}$ strain rate
- A material constant
- σ differential stress
- Q activation enthalpy
- R gas constant
- T absolute temperature

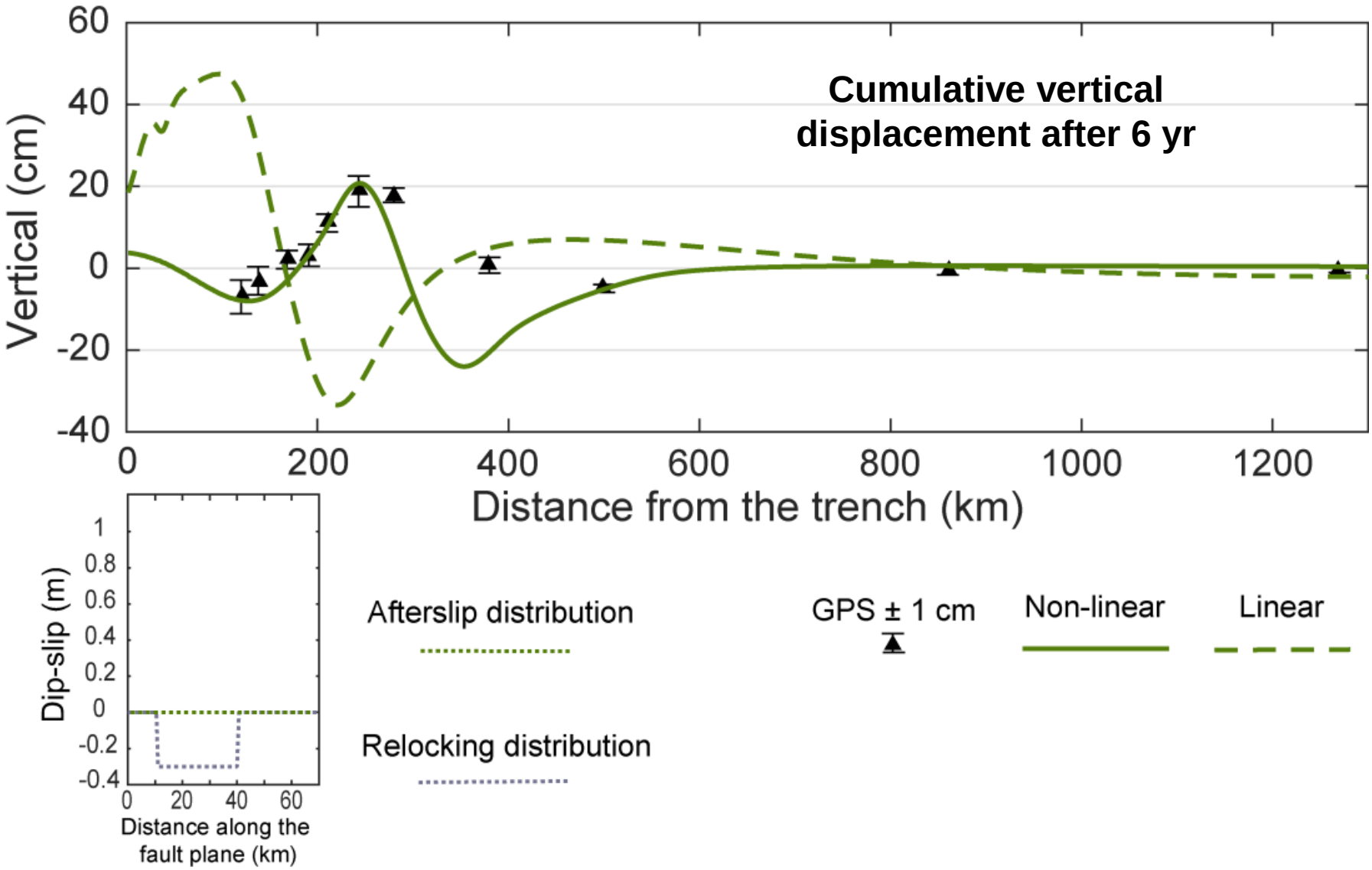
Sensitivity regarding afterslip magnitude



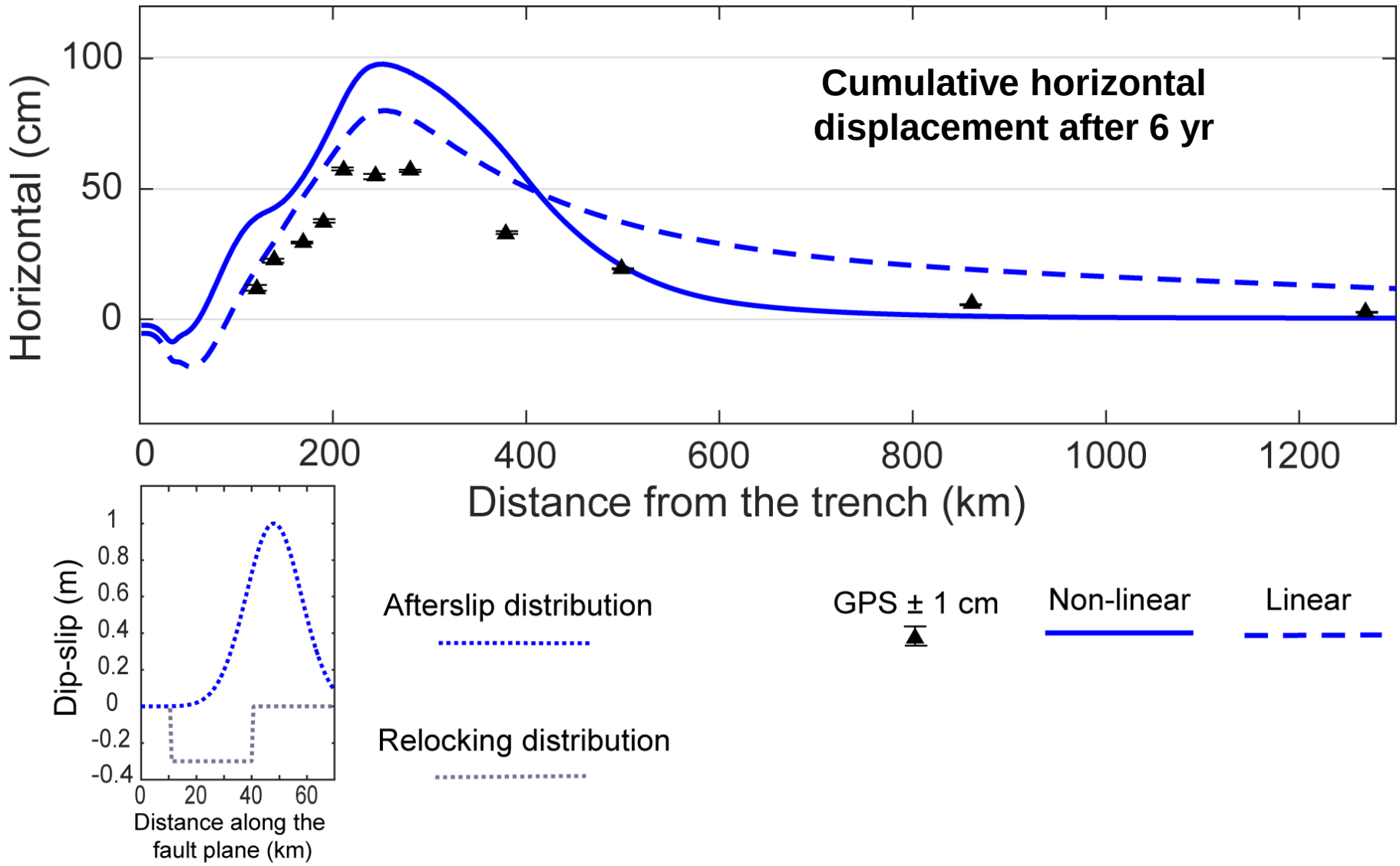
Sensitivity regarding afterslip magnitude



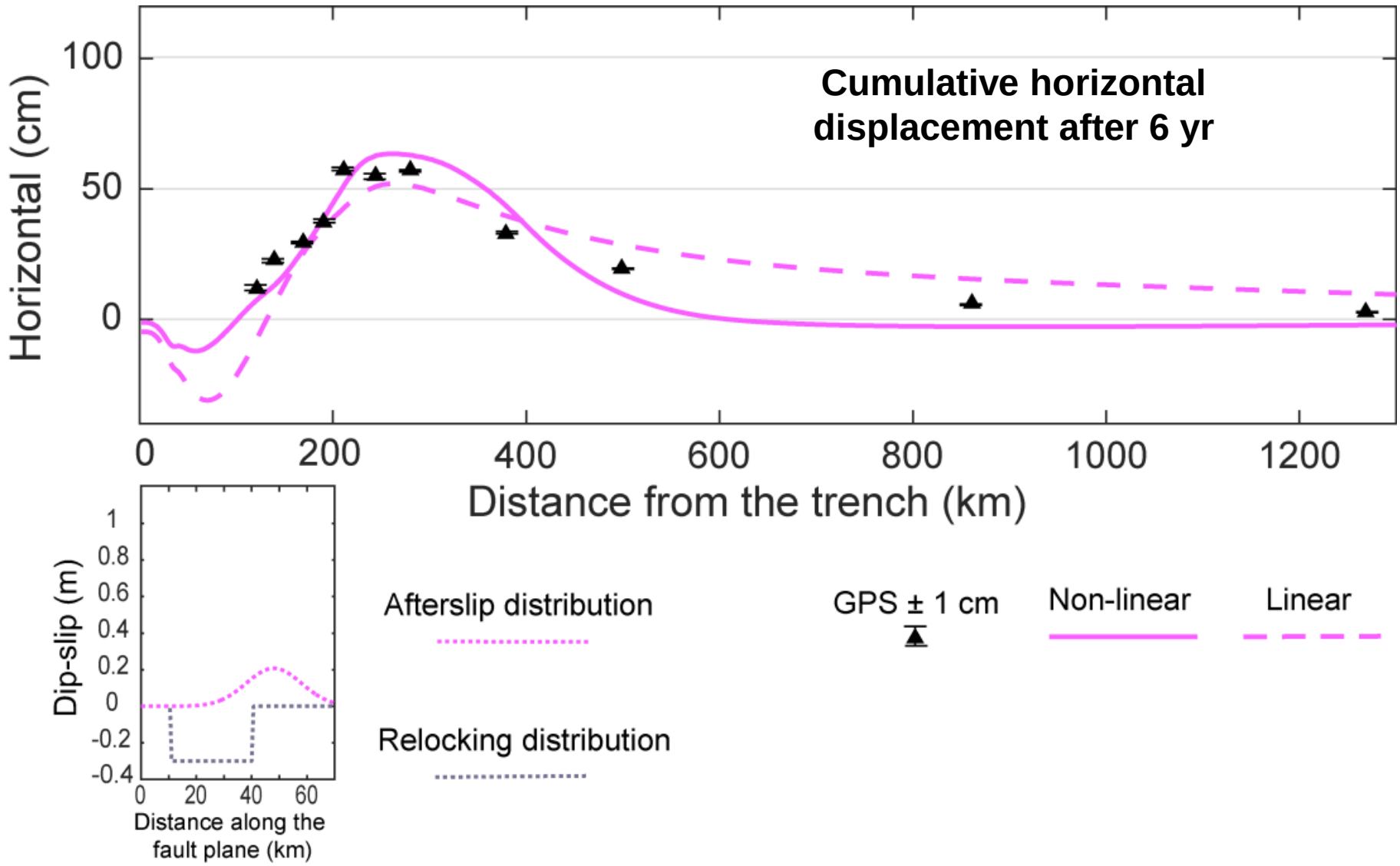
Sensitivity regarding afterslip magnitude



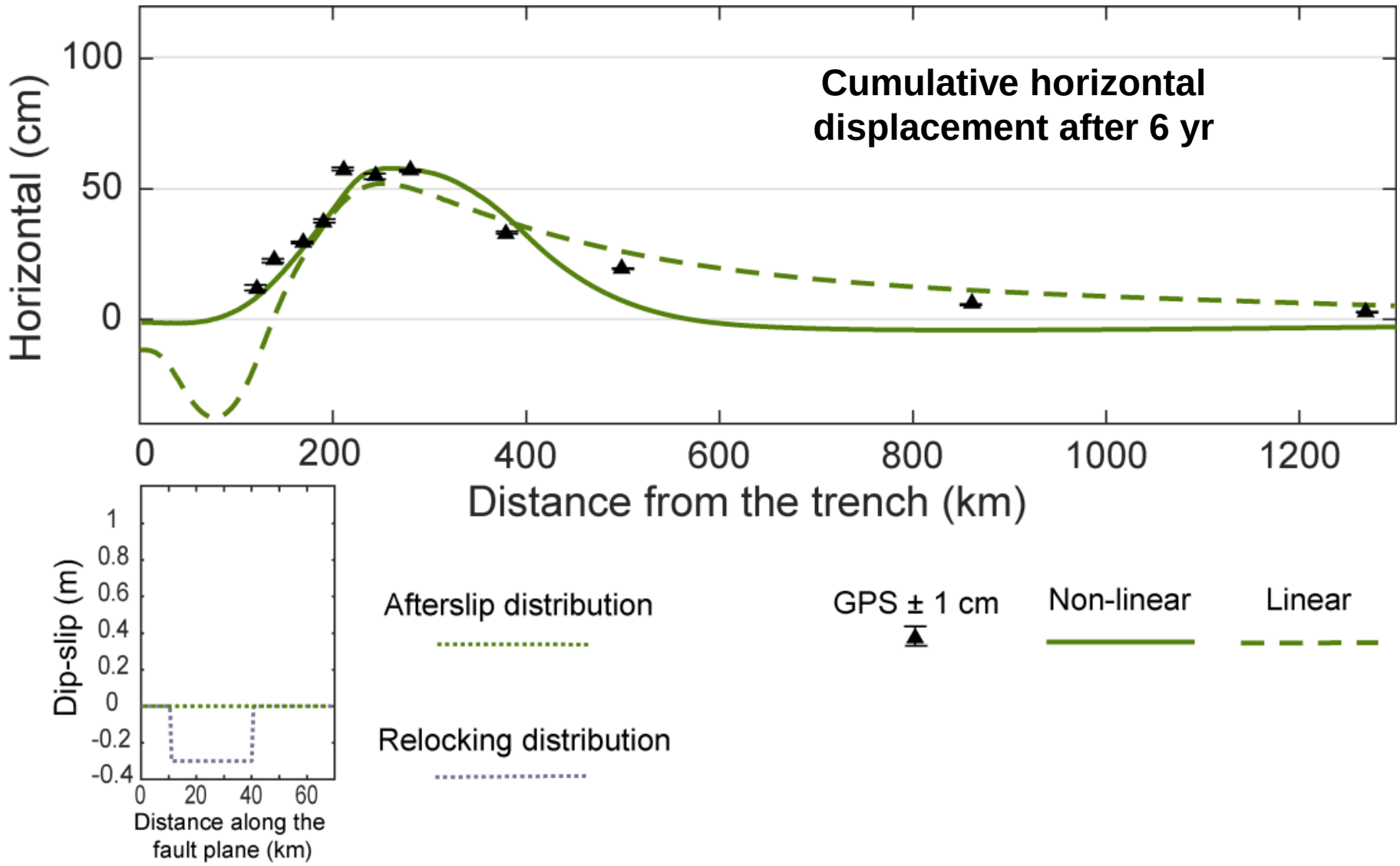
Sensitivity regarding afterslip magnitude



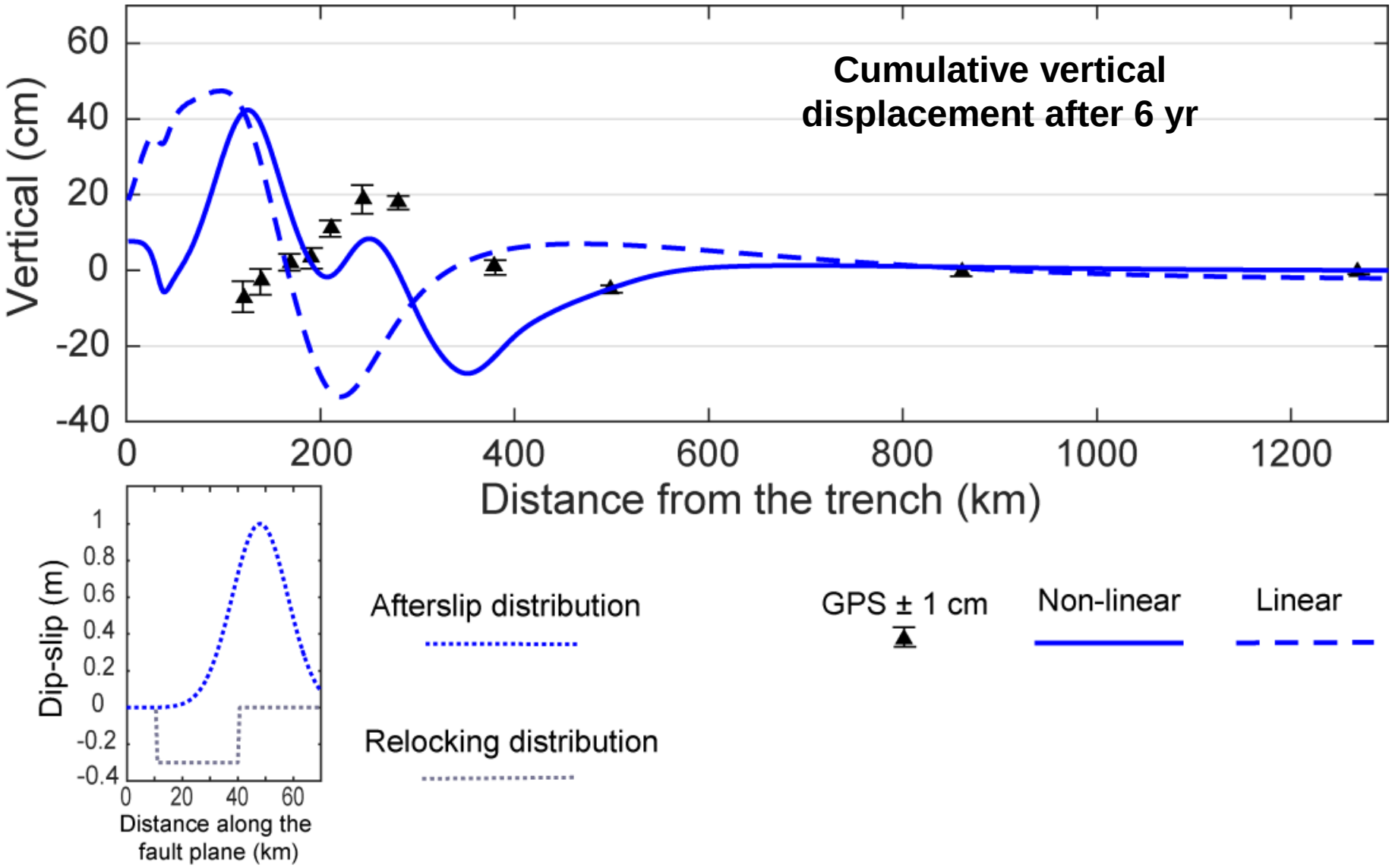
Sensitivity regarding afterslip magnitude



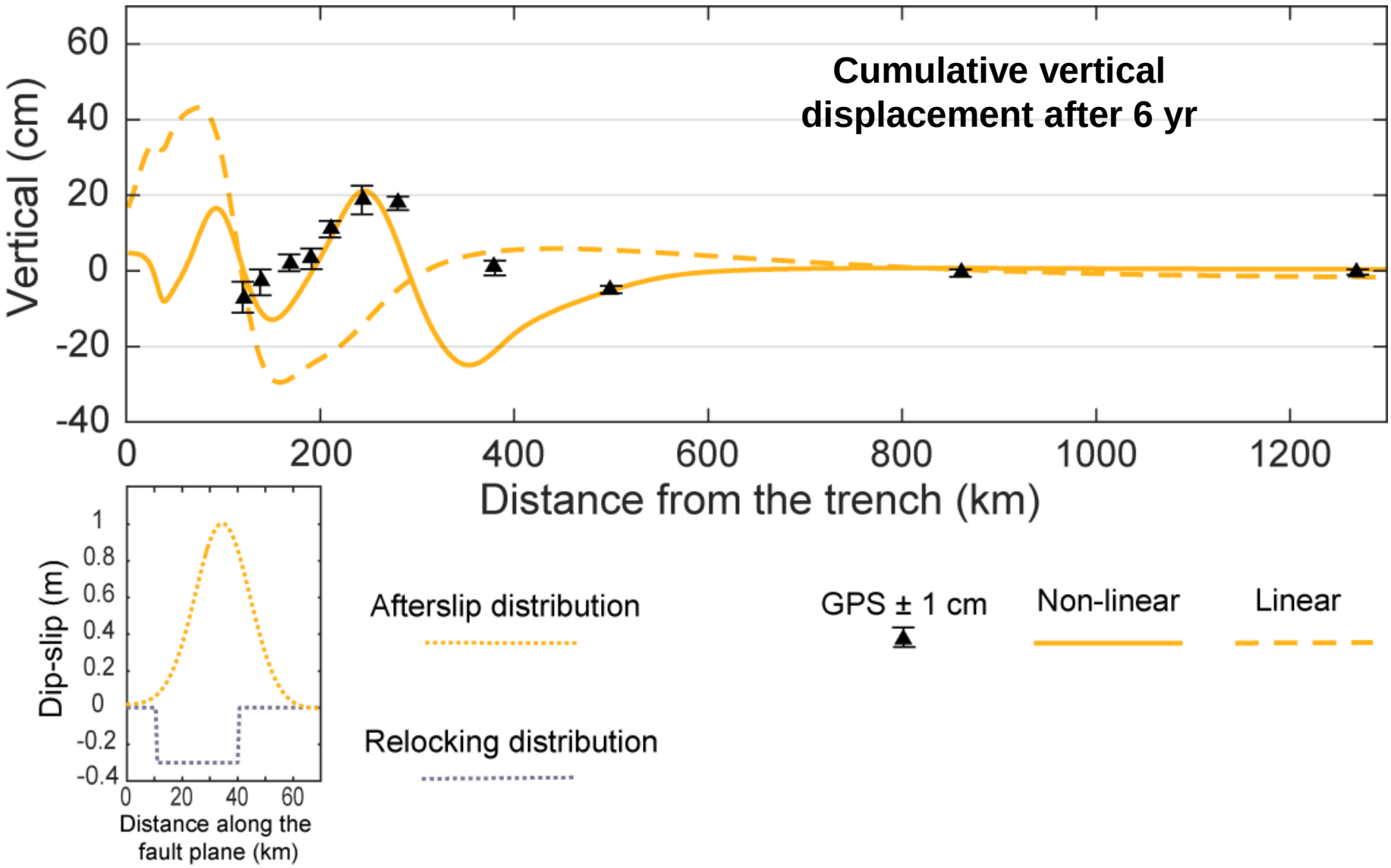
Sensitivity regarding afterslip magnitude



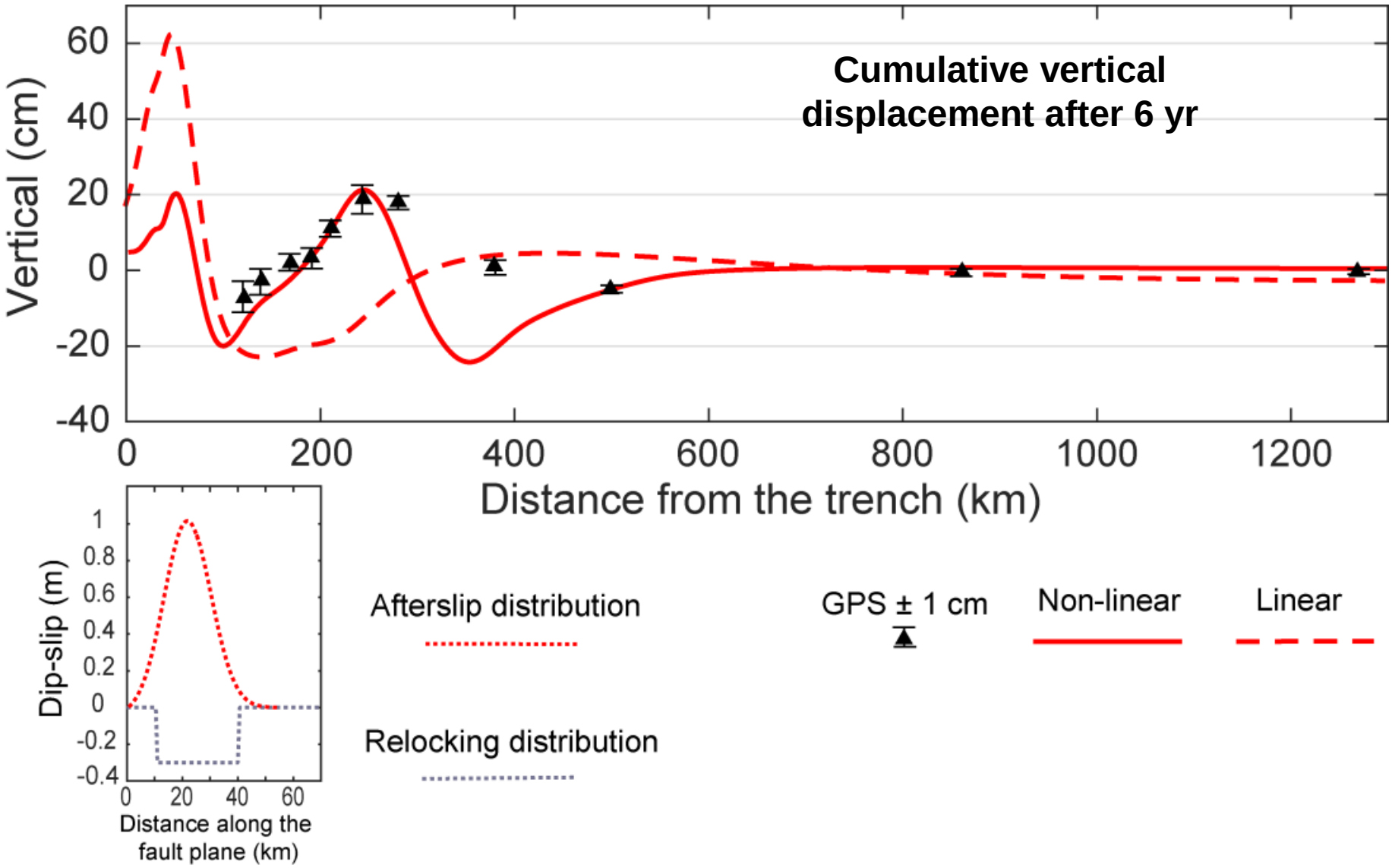
Sensitivity regarding afterslip location



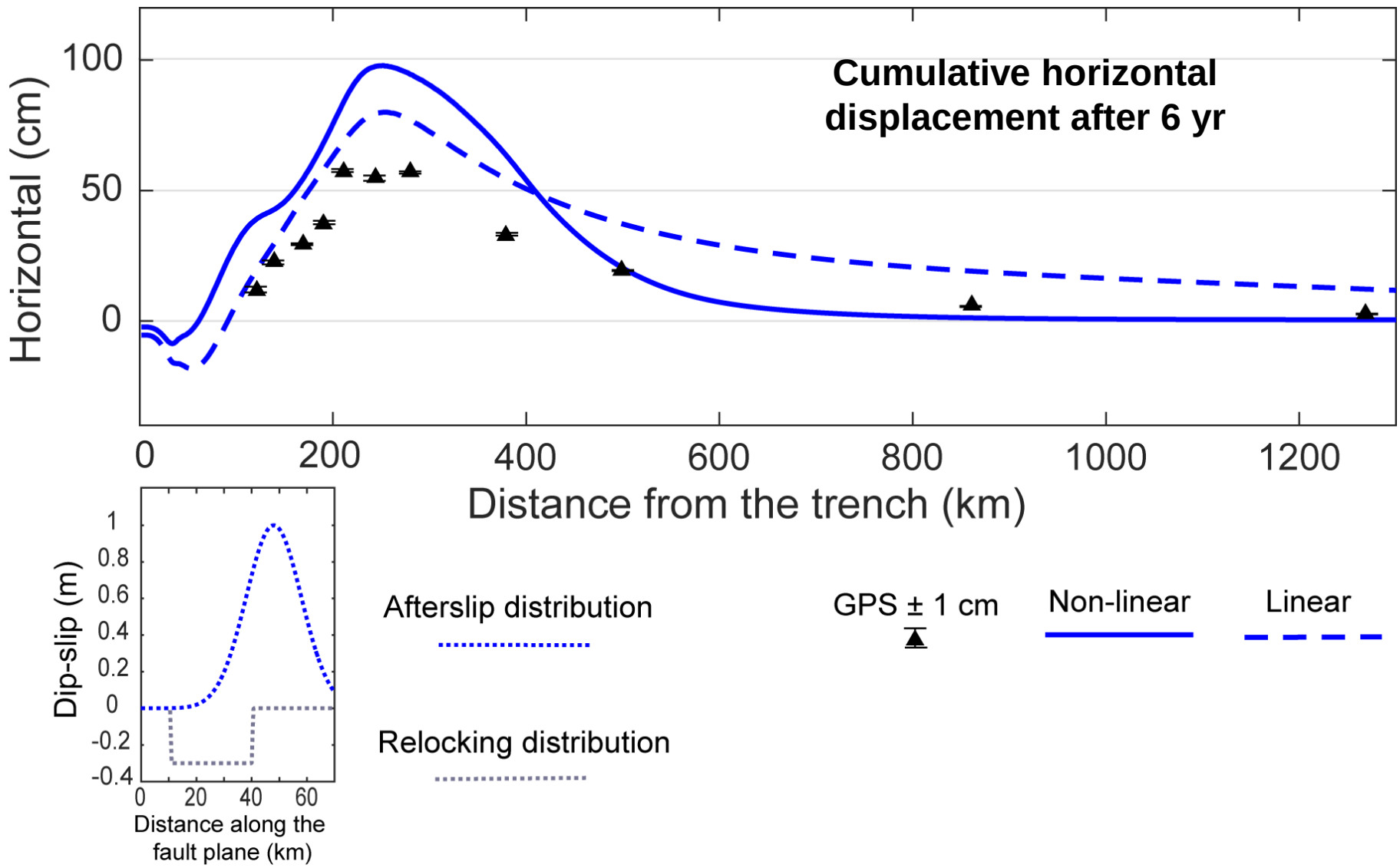
Sensitivity regarding afterslip location



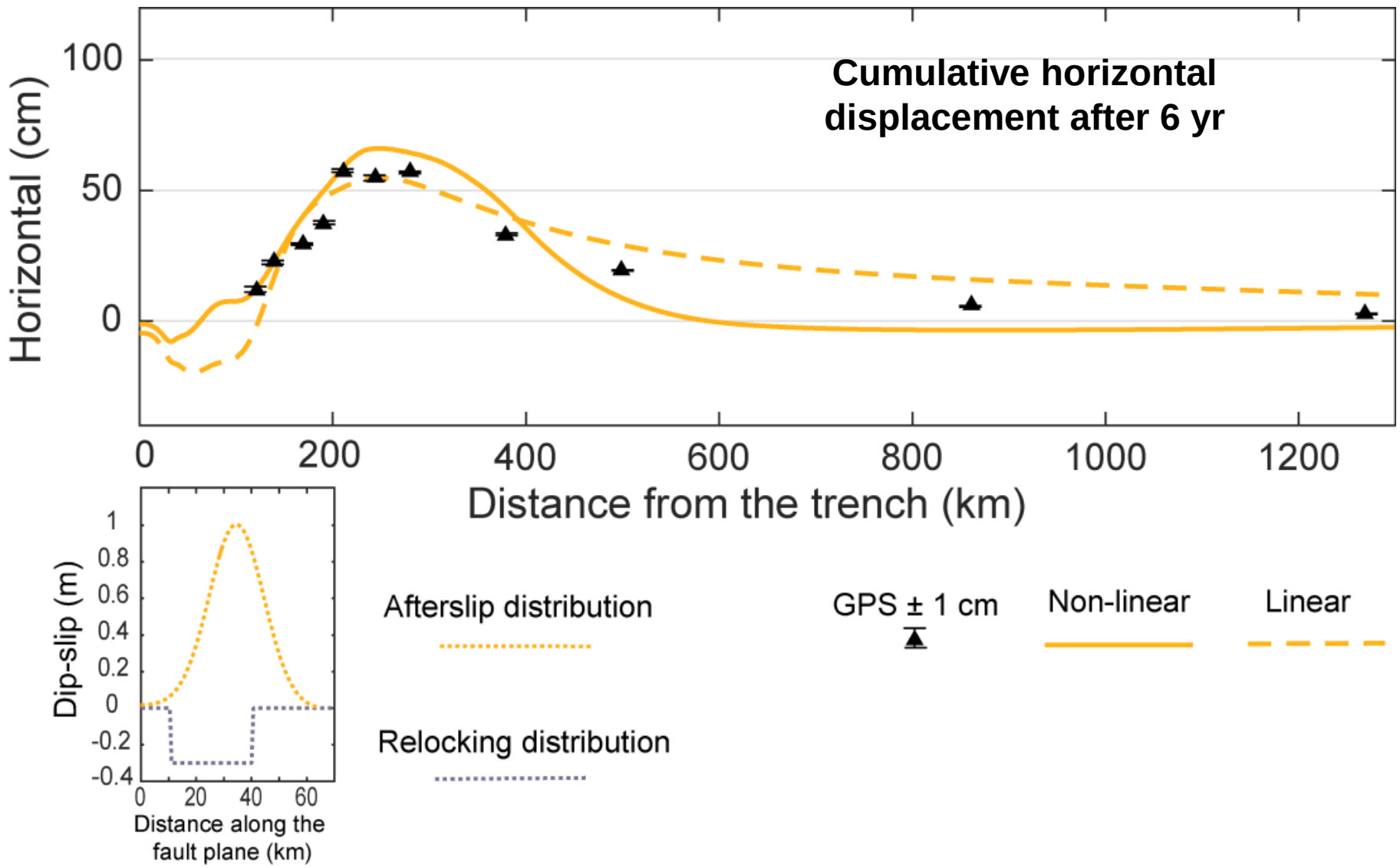
Sensitivity regarding afterslip location



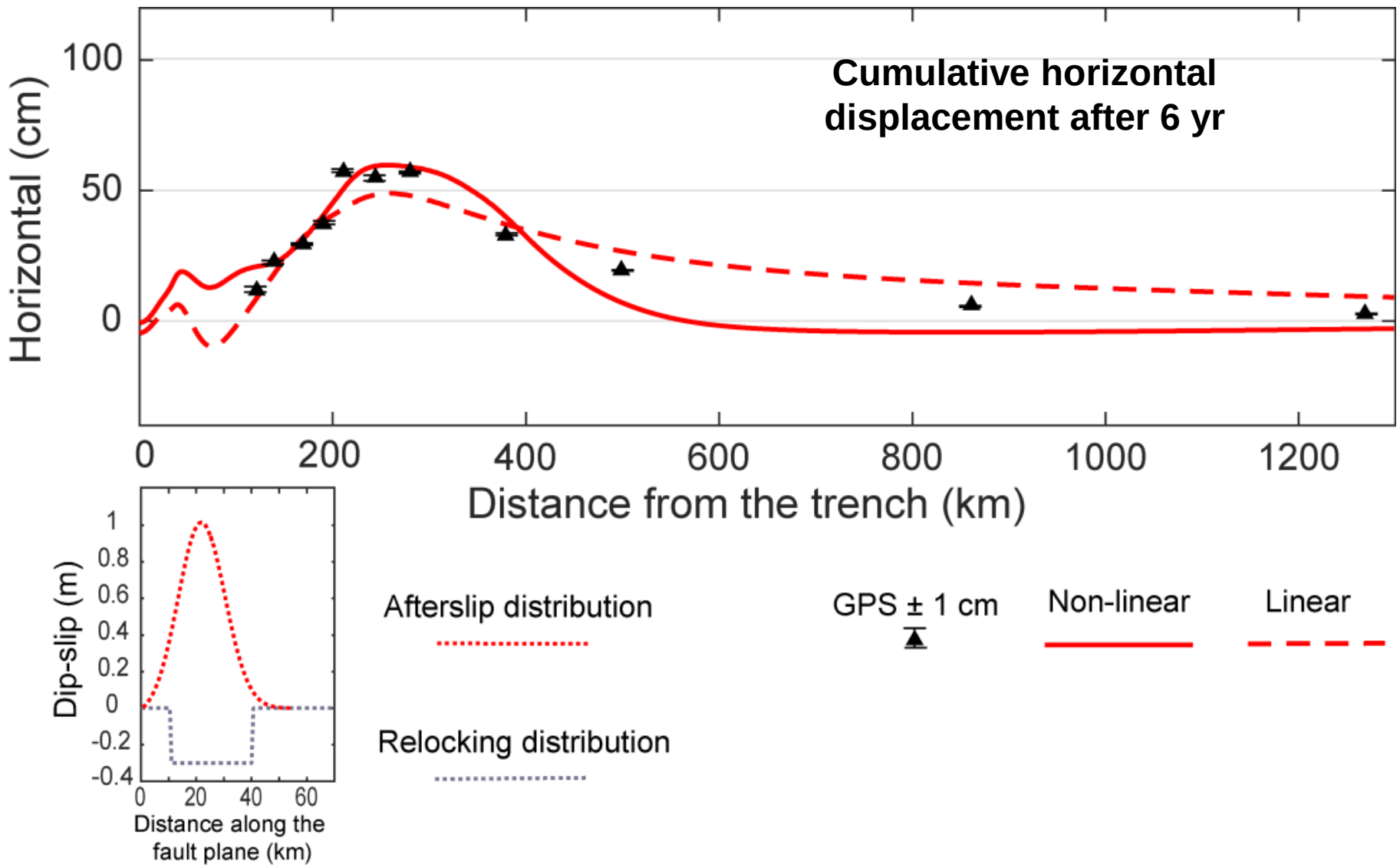
Sensitivity regarding afterslip location



Sensitivity regarding afterslip location



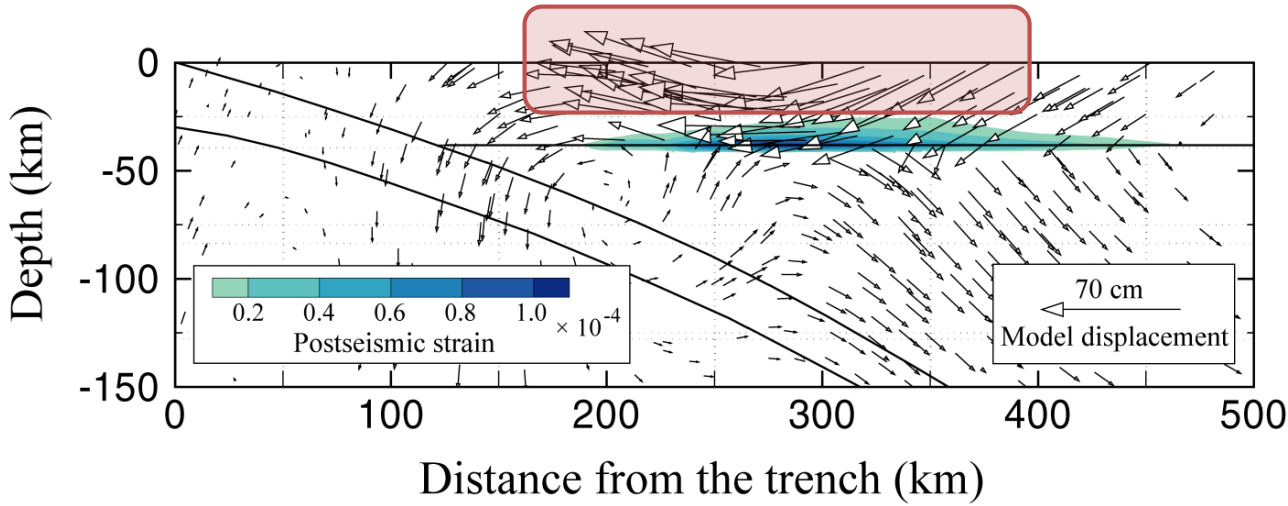
Sensitivity regarding afterslip location



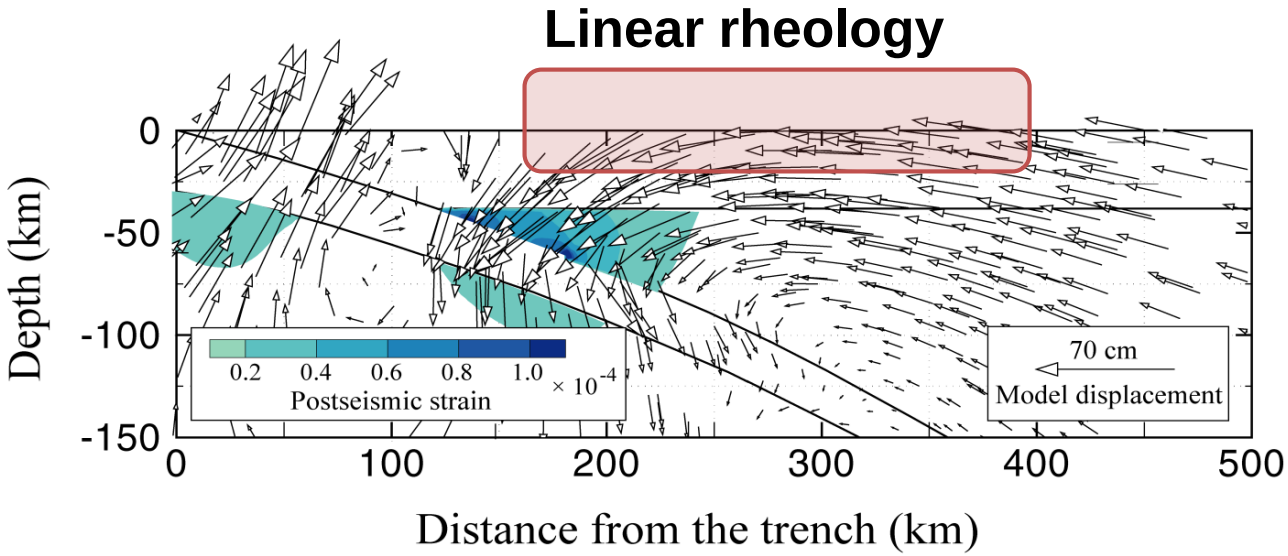
Summary

- **Cumulative horizontal surface displacement is similar, but vertical shows large differences.**
- **Afterslip in models with non-linear rheology is shifted to shallower region to reproduce vertical displacement pattern.**
- **Tensional stresses are mainly relaxed in the lower crust in a non-linear model.**

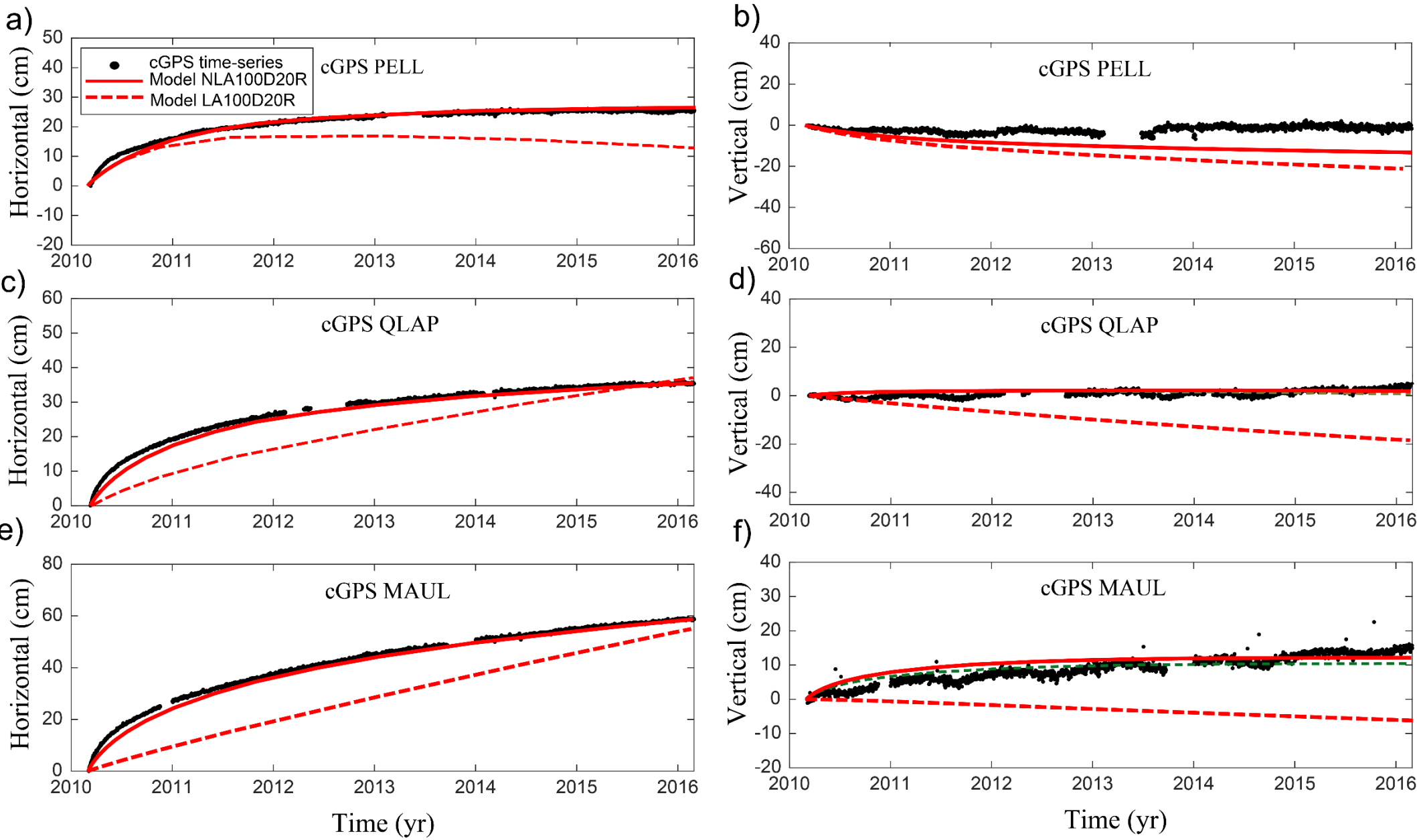
Non-linear rheology



Linear rheology



Time-series


a)
b)
c)
d)
e)
f)
cGPS time-series
Model NLA100D20R
Model LA100D20R
cGPS PELL
cGPS QLAP
cGPS MAUL
Horizontal (cm)
Vertical (cm)
Time (yr)
2010
2011
2012
2013
2014
2015
2016