How is deformation accommodated and distributed within active fault zones? Insights from satellite geodesy and realistic fault modeling

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1. Introduction

Many fault slip models for strike-slip earthquakes show a deficit of slip in the upper few kilometers of the crust, this is called the Shallow Slip Deficit (SSD). This observation raises several questions :

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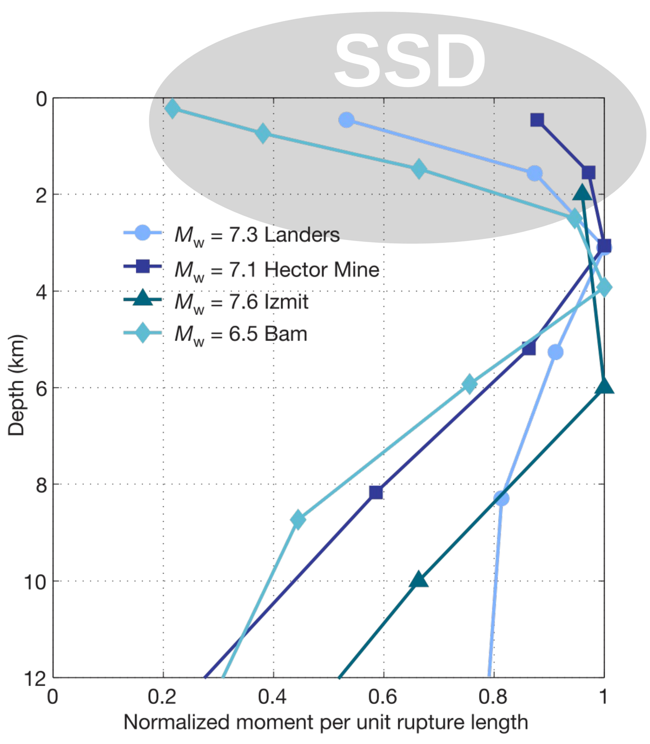
When in the earthquake cycle is this missing slip accommodated?

Is « missing » slip accommodated on or off the main fault?

Is SSD an artefact due to the simplifications made when we model the fault and the medium ?

If real, what are the implications of the existence of the SSD for seismic hazard estimation ?



Fialko et al. (2005)

To properly address these questions, we propose to :

1. accurately measure the coseismic and postseismic surface displacement produced by earthquakes in 3D with optical images

2. model these data, along with other geodetic data available (e.g. GPS, InSAR), using inversion methods that take into account the complexity of the medium, i.e. the topography and the 3D variations in elastic properties of the medium

Target : The 1992 Mw 7.3 Landers earthquake :

- Complex surface rupture
- SSD documented but not fully explained (e.g. XU et al., 2016, Gombert et al., 2017)
- A lot of data available

2. 3D co- & post-seismic displacement field

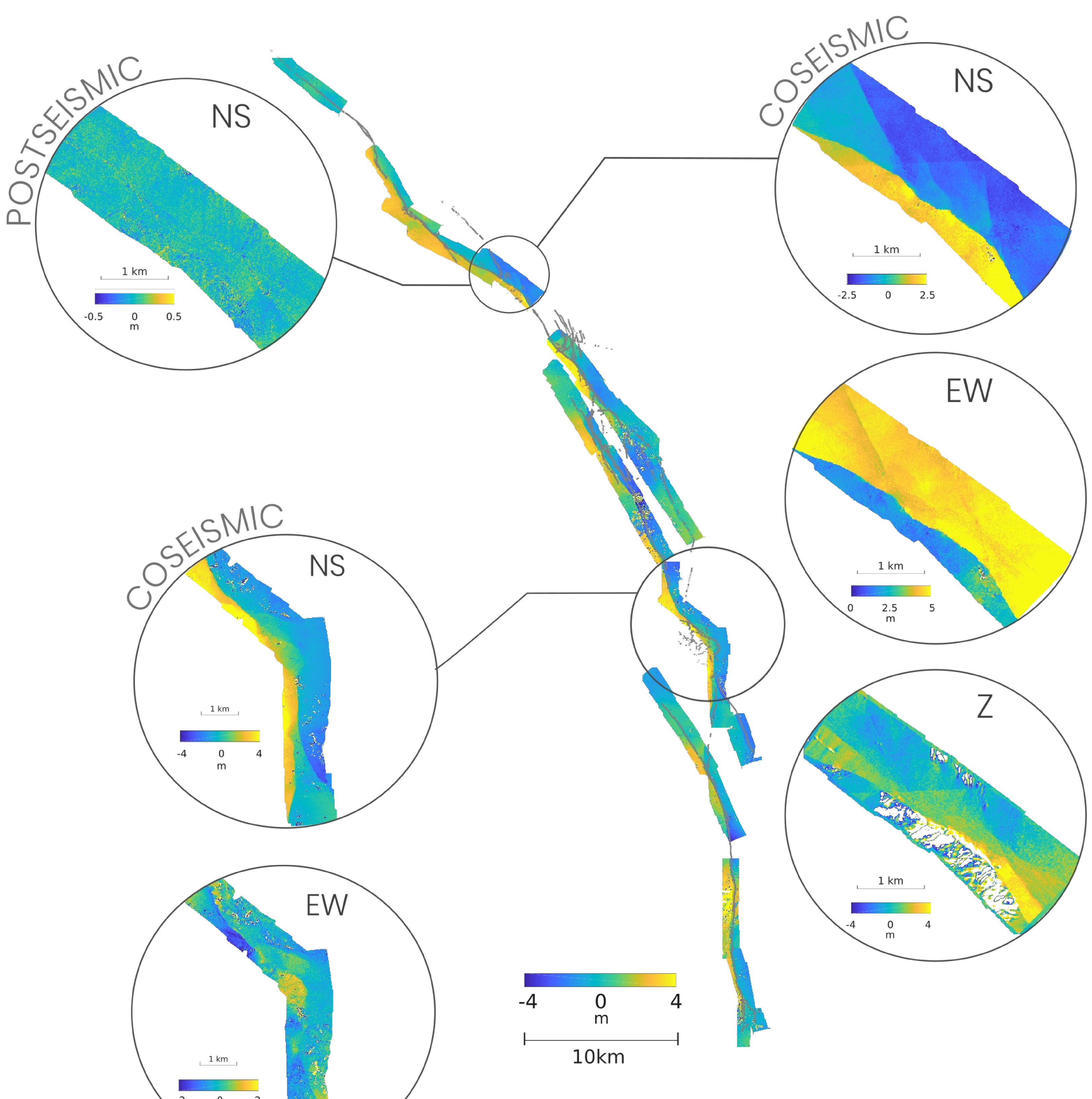
Data

- 400 aerial optical images taken 2 days after the earthquake ⇒ processing challenging!

+ aerial optical images from 1989 and Worldwiew images from 2008

Method

- DEM generation from pre/post stereo-pairs and orthorectification using ASP (Beyer et al., 2018)
- 2D correlation of ortho-images using COSI-Corr (Leprince et al, 2007) ⇒ horizontal displacements
- DEM differencing (accounting for horiz. disp.) ⇒ vertical displacements



Coseismic NS displacement field

3. First step towards a realistic fault modeling of the Landers earthquake

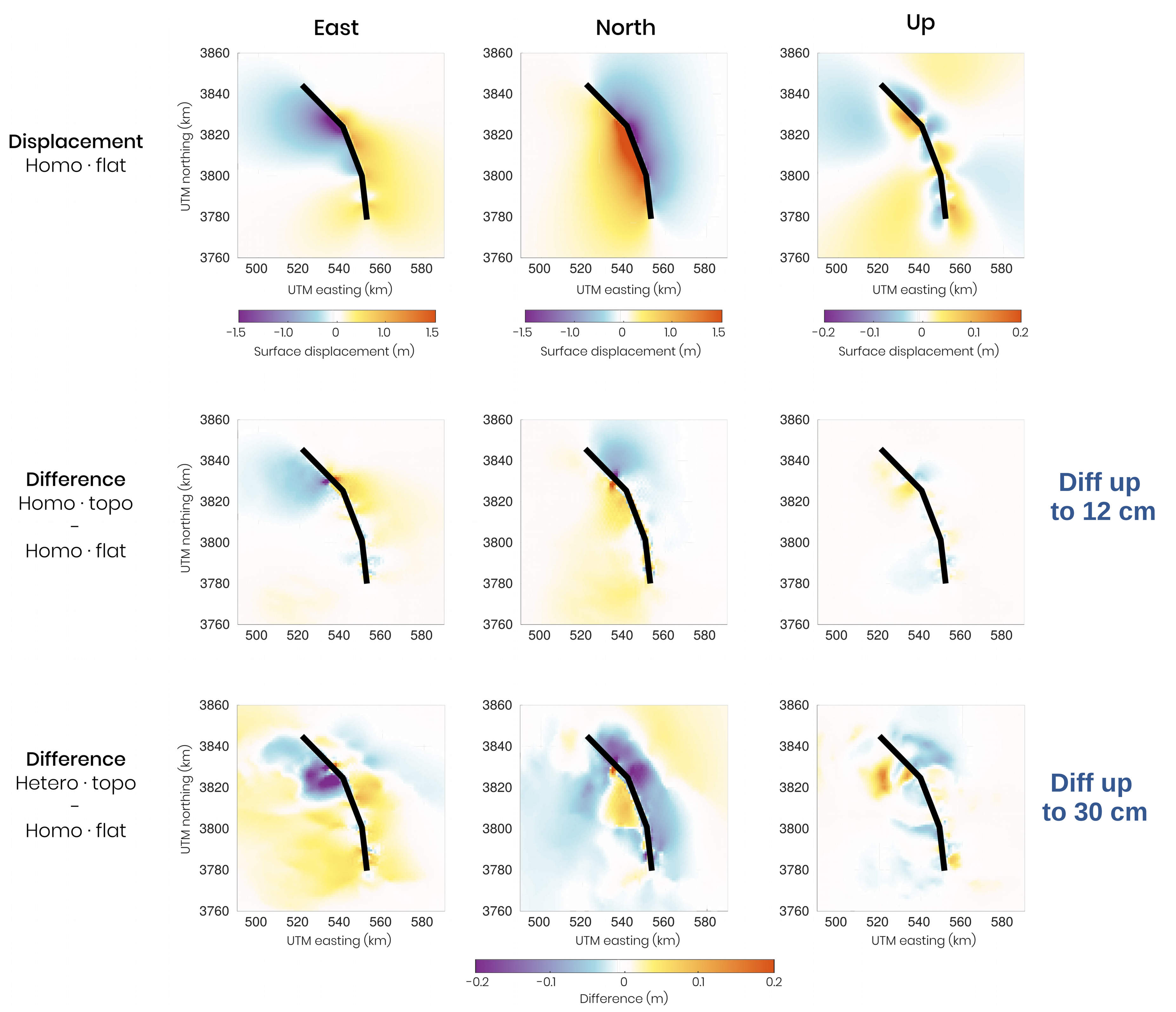
On-going work

Impact of the medium complexities on the surface displacements

Comparison of the surface displacement fields computed in :

- A Homogeneous and flat medium (**Homo · flat**)
- A Homogeneous medium with topography (**Homo · topo**)
- A medium with 3D variations in elastic properties and topography (**Hetero · topo**)

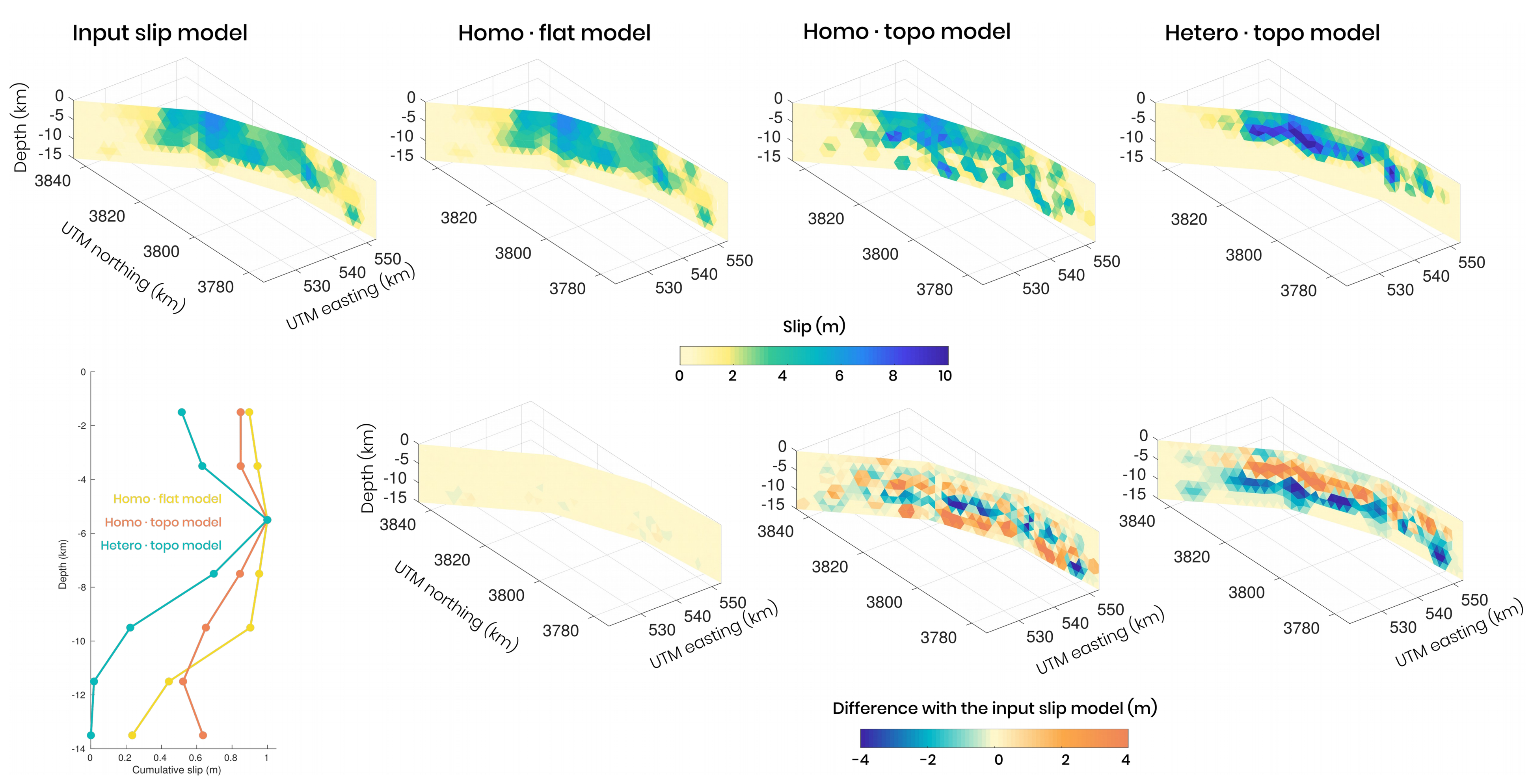
Input slip model : Hernandez et al. (1999) (SRCMOD data base) | Elastic structure from the velocity model of Share et al. (2019) | Topograghy : ASTER GDEM | Mesh generation : Trelis | Displacements computed with Pylith (Agaard et al., 2013)



In the case of Landers, the 3D variations in elastic structure have a bigger impact on the surface displacement field than the topography

Impact of neglecting the medium complexities on the retrieved slip model

--→ Inversion of synthetic data computed in a complex medium using Green's functions computed in flat and homogeneous medium



- Neglecting the topography, even in relatively flat area as the Landers area, can lead to important bias in the slip distribution.
- The shallow slip deficit is 5 times higher when the variations in elastic properties are neglected

Next step : Reassess the slip model of the Landers earthquake inverting optical correlation, InSAR, and GPS data and taking into account the topography and the 3D variations in elastic properties of the medium.

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