A secondary zone of uplift measured after megathrust earthquakes: caused by early downdip afterslip?

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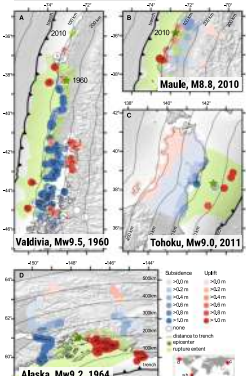
1 A 2nd zone of uplift...

Figure from van Dinther et al. (2019)



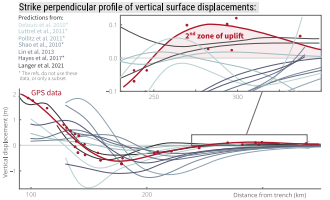
van Dinther et al. (2019) successfully model this 2nd zone of uplift with a generic 2D visco-elasto-plastic seismo-thermo-mechanical simulation of a subduction zone. They suggest that **this 2nd uplift results from a mass conservation-driven return flow** following accelerated slab penetration due to the megathrust earthquake.

2 ... that cannot be explained by slip on the interface...

2010 Mw 8.8 Maule earthquake

No slip model is able to fit this 2nd zone of uplift, the primary zone of uplift, and the horizontal displacements altogether.

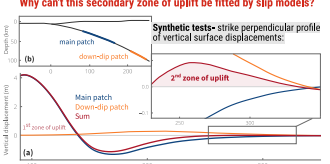
Strike perpendicular profile of vertical surface displacements:



3 ... against Ockham's razor?

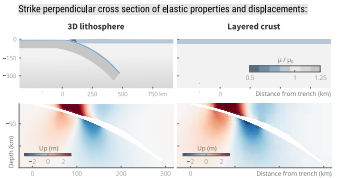
The simplest explanation is a downdip slip patch

The 2nd uplift is reproduced by a down-dip slip patch.
Why can't this secondary zone of uplift be fitted by slip models?



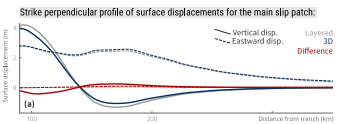
4 Neglecting 3D elastic structure produces an incompatibility in the amount of slip required to explain horizontal and vertical displacements

Strike perpendicular cross section of elastic properties and displacements:



In the region of primary subsidence, the impact of elastic heterogeneity is 5 times larger for vertical displacements than for horizontal ones (25% of peak amplitude versus 5%). If neglecting heterogeneities, the amount of slip required to explain horizontal displacements is incompatible with the smaller amount of slip required to explain the vertical ones.

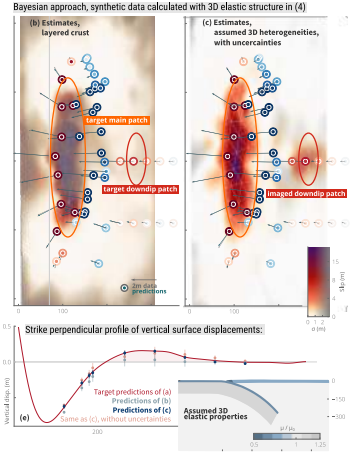
Strike perpendicular profile of surface displacements for the main slip patch:



refs: van Dinther, Y., L. Preuswerk, T. Gerya (2019), A Secondary Zone of Uplift Due to Megathrust Earthquakes." *Pure and Applied Geophysics* 176 (9): 4043–68. doi:10.1007/s00024-019-02230-c.

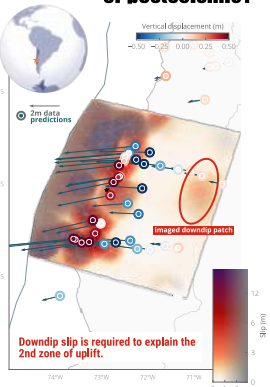
5 Synthetic tests: 2nd zone of uplift can only be fitted if accounting for 3D elastic structure

Bayesian approach, synthetic data calculated with 3D elastic structure in (4)

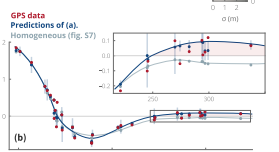


Strike perpendicular profile of vertical surface displacements:

6 2010 Maule earthquake: is the 2nd uplift coseismic or postseismic?



Downdip slip is required to explain the 2nd zone of uplift.



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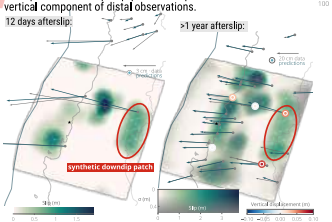
12 days after the mainshock, synthetic down dip slip is consistent with data. >1 year after the mainshock, a 1-m-amplitude down-dip slip patch is required to fit the vertical component of distal observations.



That we image down-dip slip does not mean slip is uniquely the cause of the 2nd zone of uplift. We know the responsible mechanism should occur very early after the mainshock (hours to days). Challenges in modeling highly disparate time-scales prevent van Dinther et al. (2019) to confirm the process they invoke is coseismic, rather than lasting several months after the mainshock.

The down-dip slip we image is consistent with surface displacements measured 12-days and >1 year after the mainshock, further suggesting the 2nd zone of uplift has possibly been caused by very rapid afterslip, which then slipped continuously in the days to months following the coseismic rupture