Impact of deglaciation on geodetic uplift and active faulting in the Alps: A rheological control ?

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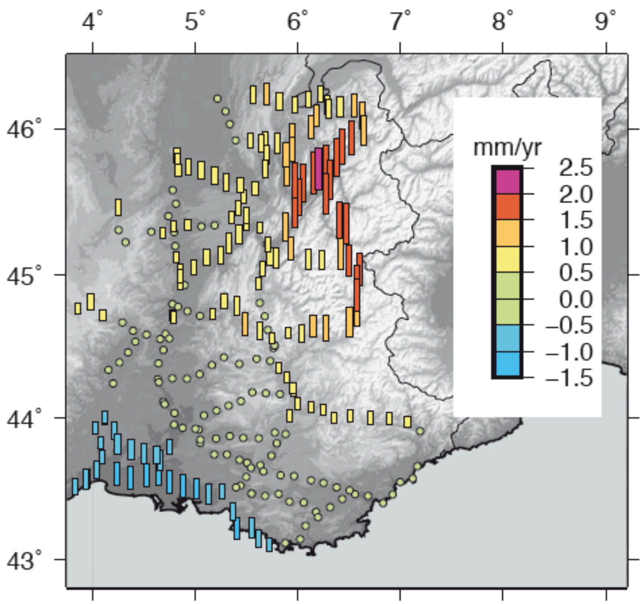
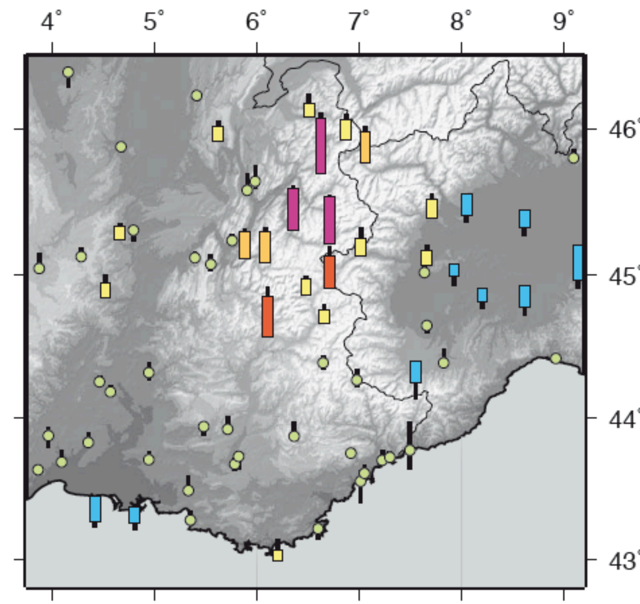
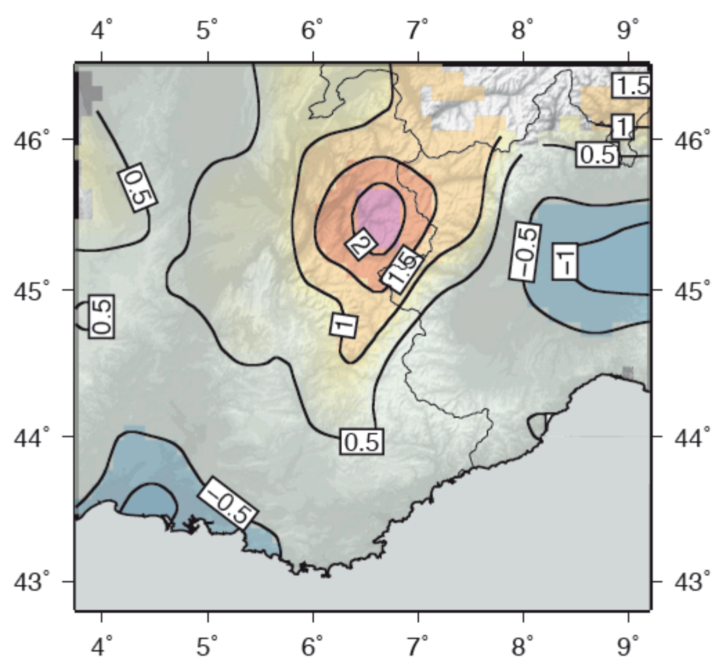
Present-day uplift of western Alps

IGN leveling





GPS RENAG



Surrection 1-2 mm/yr

J.M. Nocquet et al., ongoing work

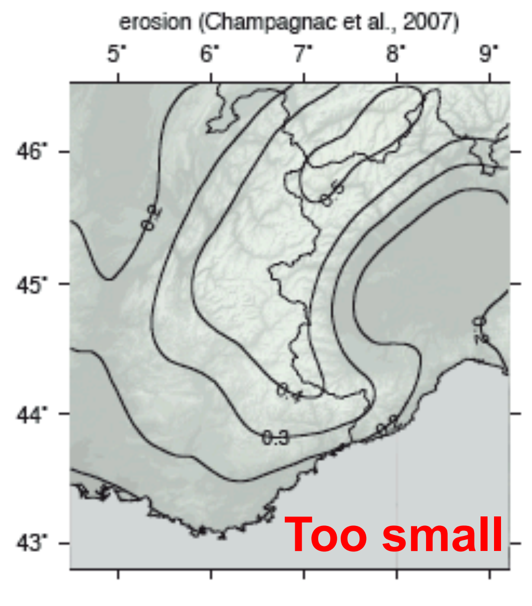
Source of present-day uplift ?

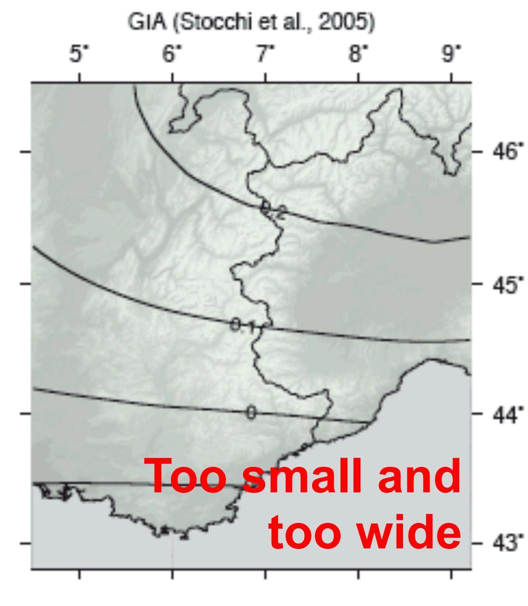
Flexural isostasic adjustement to :

1/ Present-day denudation
(Champagnac et al. 2006)
Elastic plate 10km

2/ Post Wurm (LGM) deglaciation
(Stocchi et al. 2005)
Visco-élastique mantle 10^{20} Pas

Current models do not explain geodetic observations





Idea : test the effect of alpine rheology on post-deglaciation uplift

4 rheological models of the Alps

Relation between deglaciation, rheology and geodetic uplift ?

Ice thickness at 18 000 BP (Late Glacial Maximum - LGM)

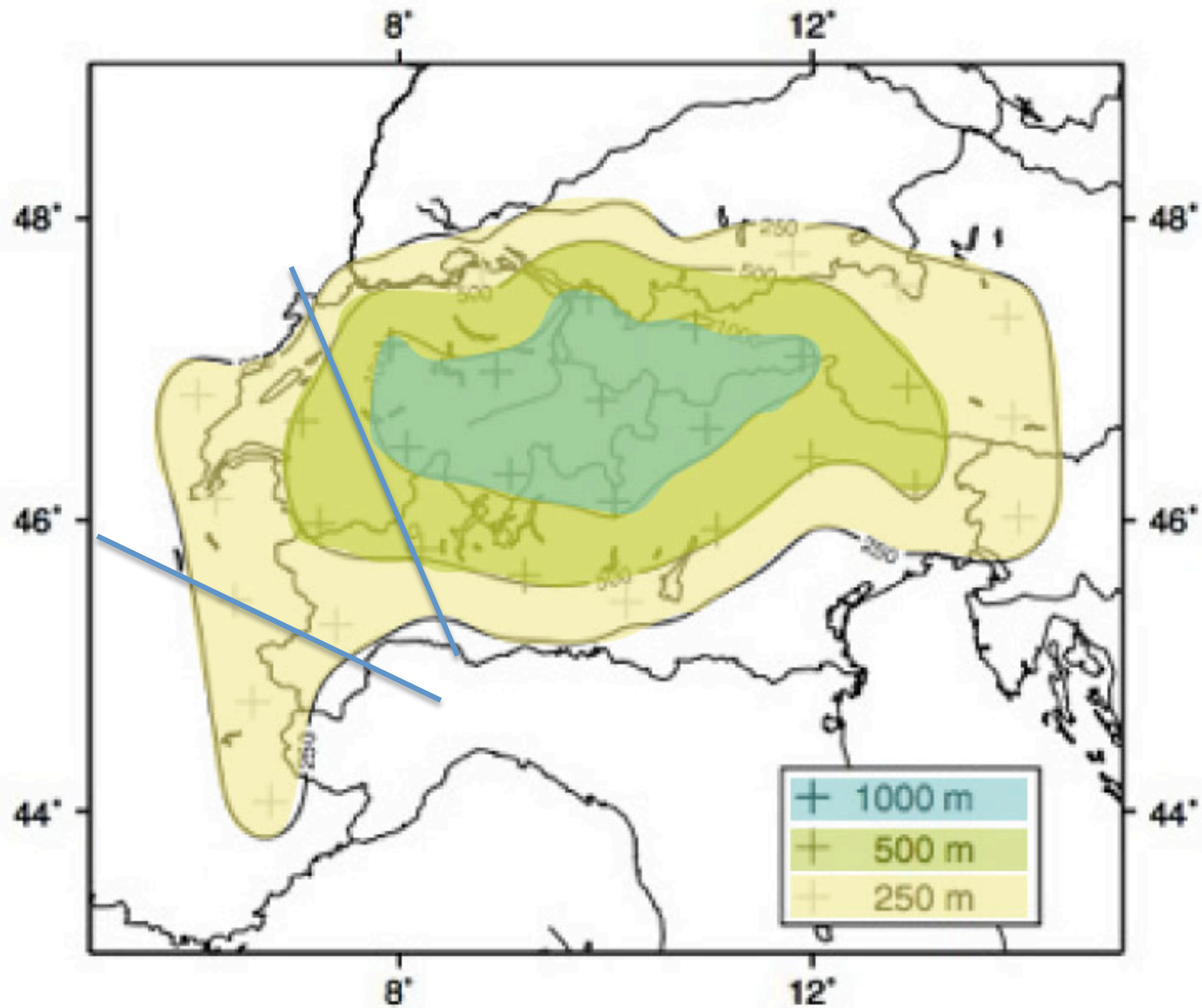


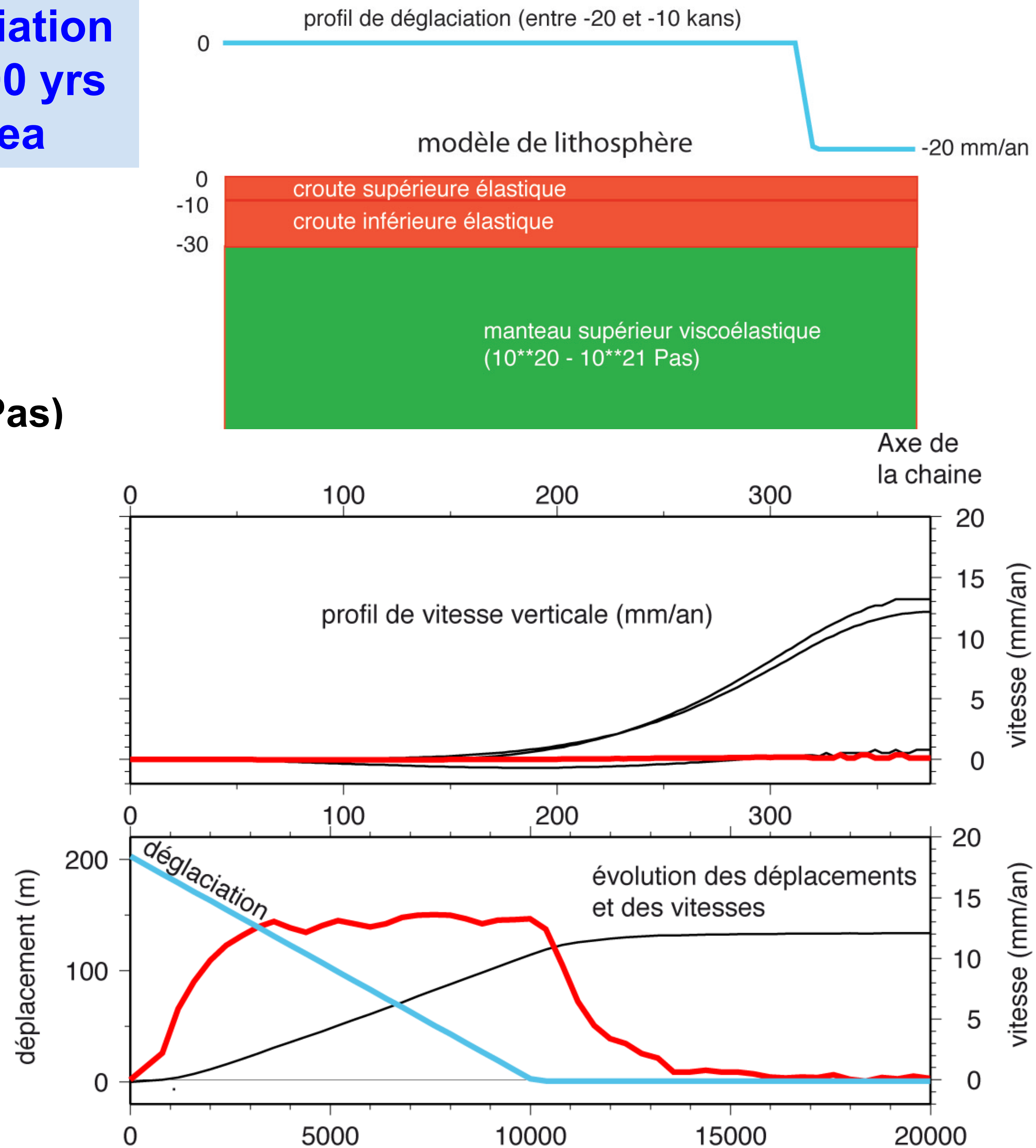
Figure 1. Contour lines showing the thickness of the ALPS1 model for the Alpine deglaciation at the LGM (e.g. 18 000 BP). The crosses show

Input load : 500 m deglaciation between -20 000 et -10 000 yrs over a 150km width area

Model I

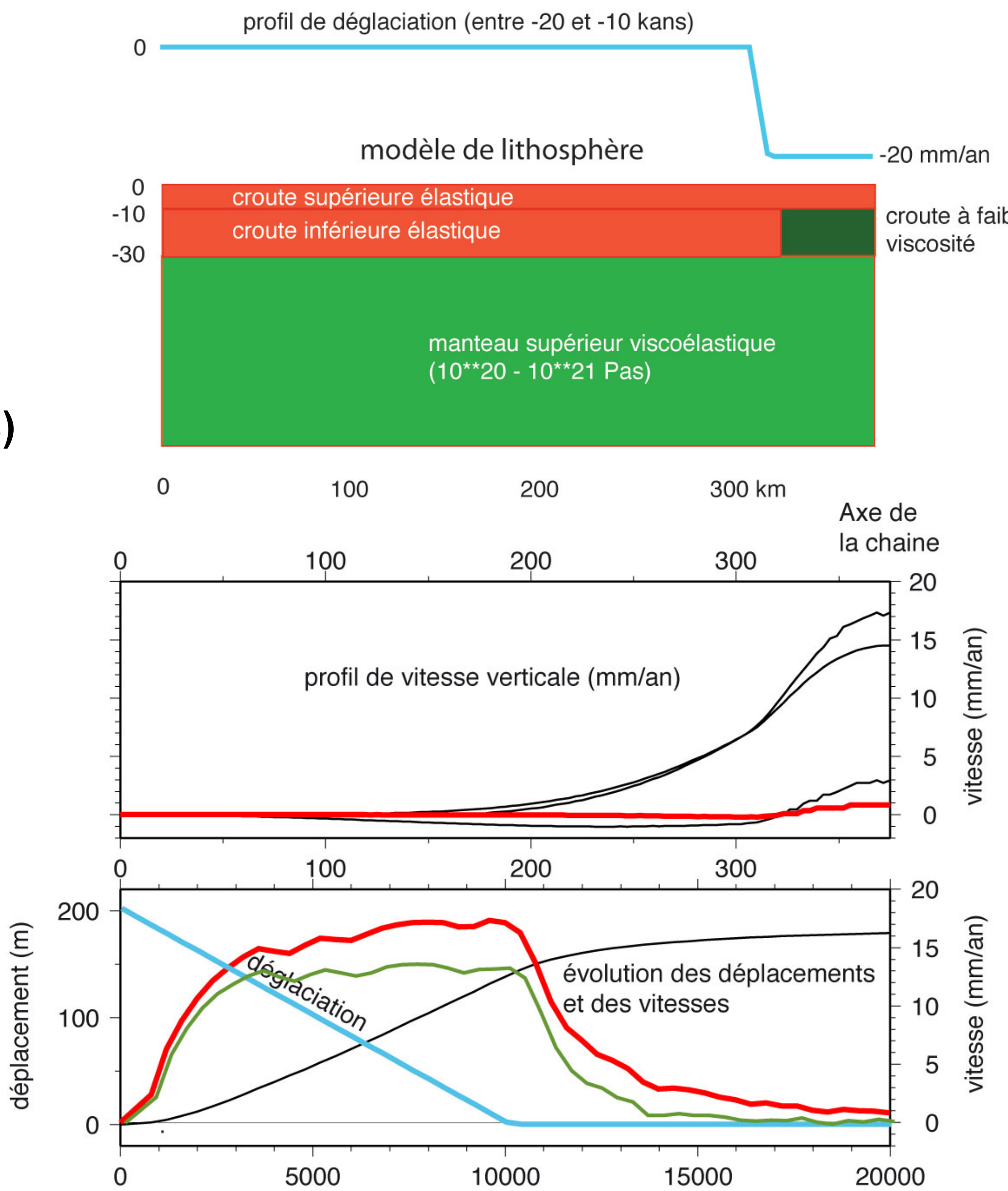
Elastic crust (Te=30km)
Visco-elastic mantle (10^{20} Pas)

Distributed post-glacial uplift, completed at present-day



Model II :

Elastic crust (Te=30km)
Low viscosity crustal root (10^{20} Pas)
Visco-elastic mantle (10^{20} Pas)



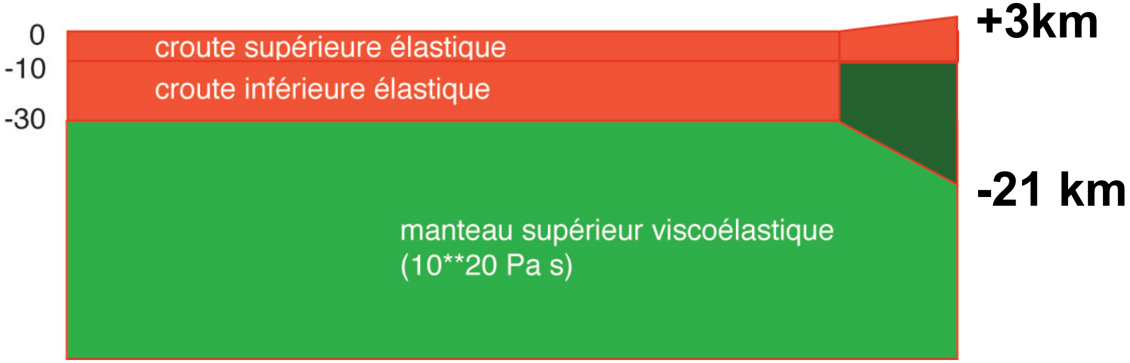
Localized post-glacial uplift, 1mm/an at present-day

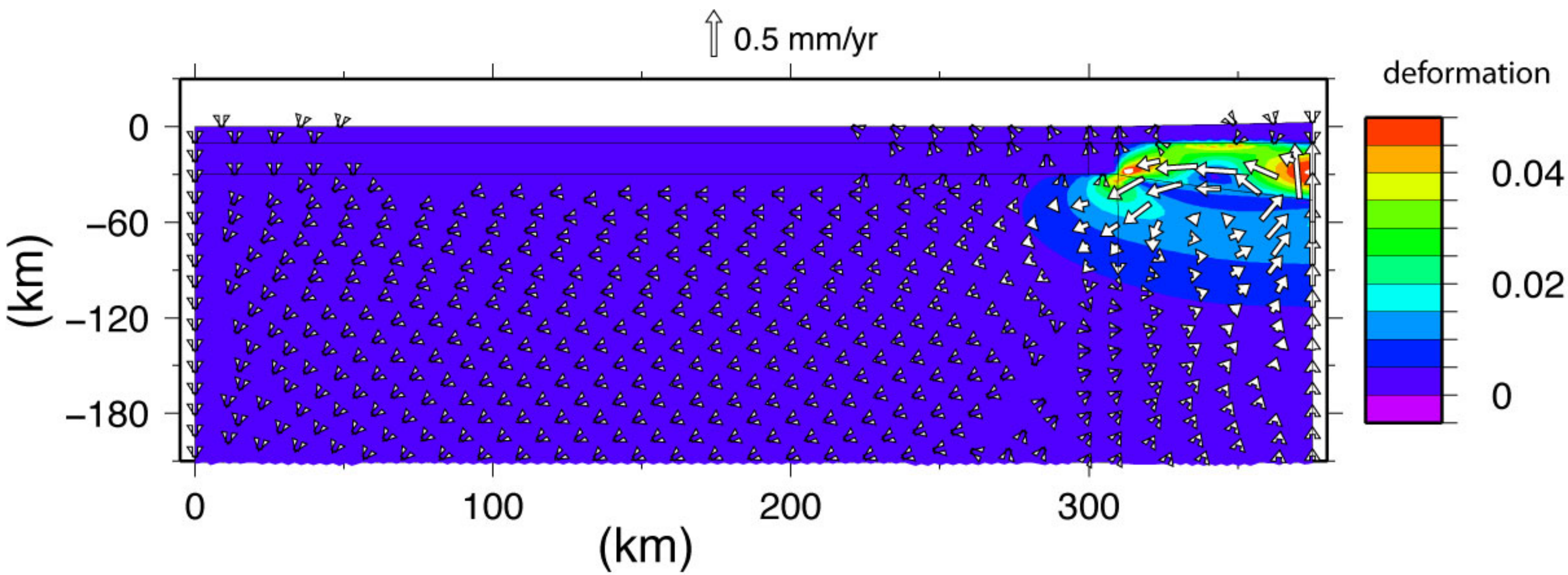
A viscosity of 10^{20} Pas … how this behaves on the long term ?

Topographic impact of 10^{20} Pas root on strain ?

Model III

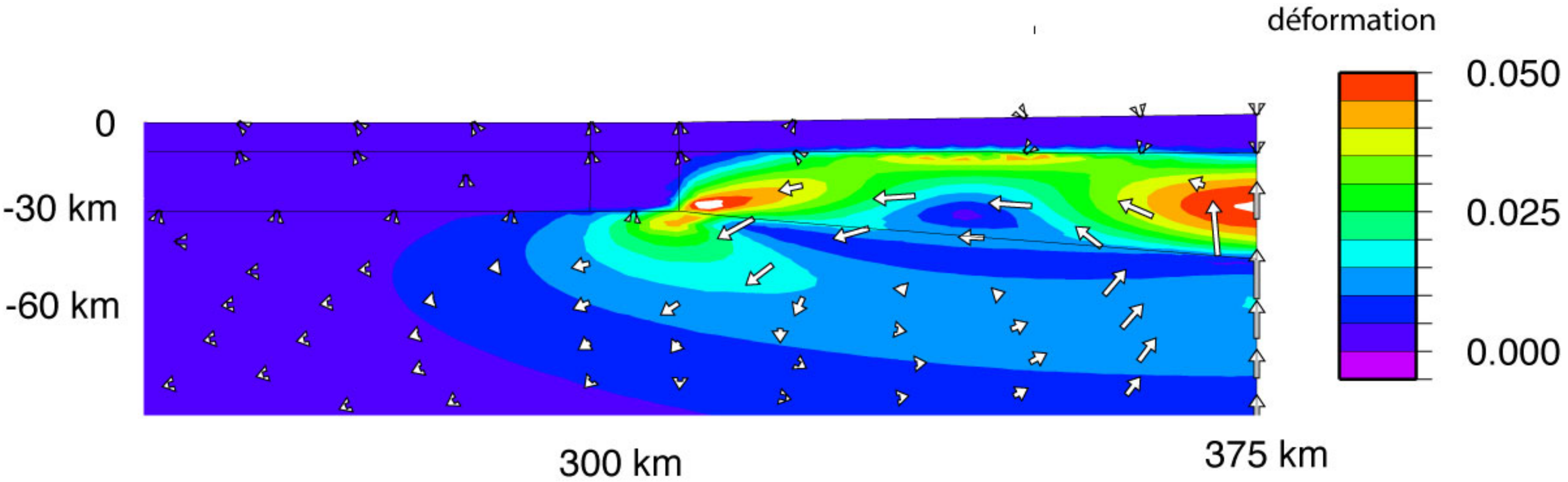
= model II + topography
without glacial unloading





… gravitational collapse of the lower crust

Model III



Fast collapse :
several cm/yr, 5% strain après 0.04 Ma
→ flat Moho after 1Myr

How to reconcile

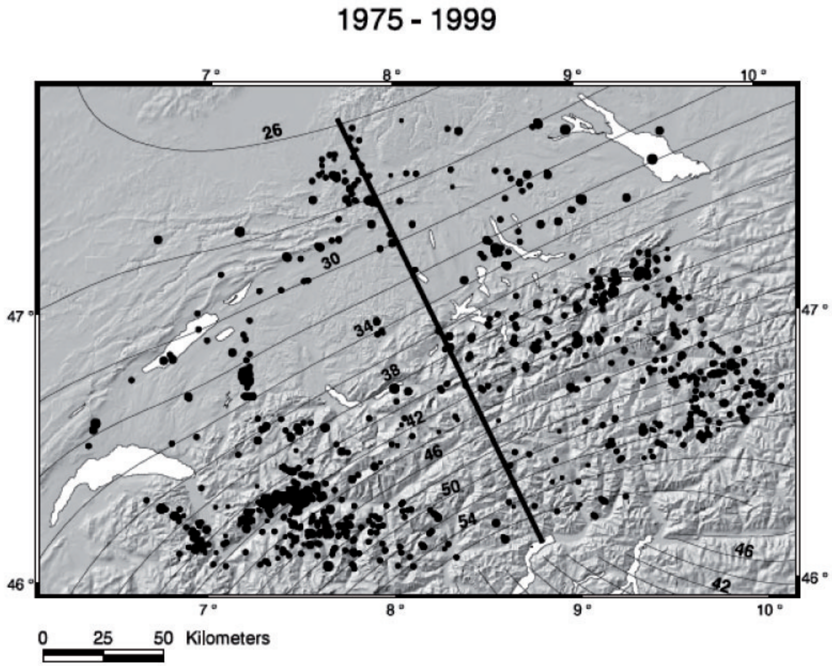
1/ post-glacial rebound
(0.01 ka - 10^{20} Pas)

2/ stable 3km topography over 10 Ma
(needs large stress → viscosity > 10^{23} Pas)

?

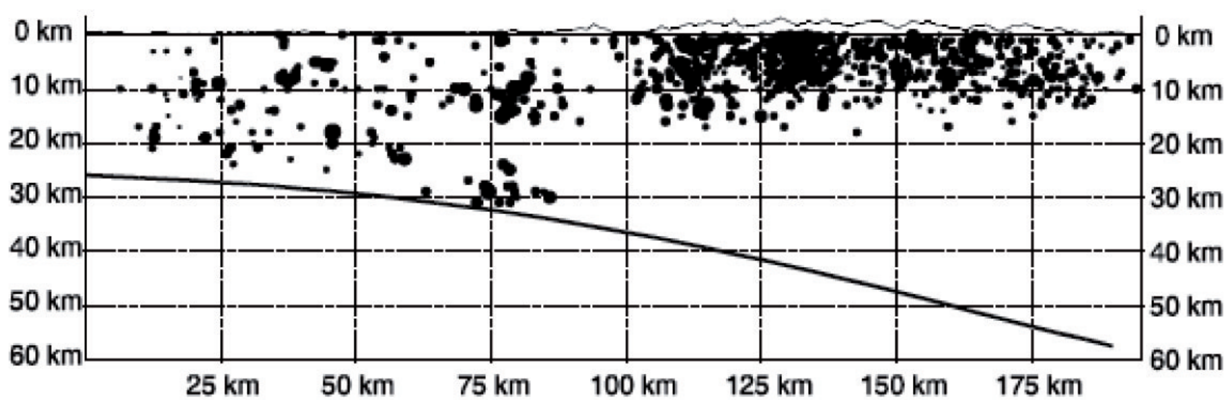
… back to Alpine geophysics

Swiss Alps seismicity



Foreland :
20-30 km elastic thickness

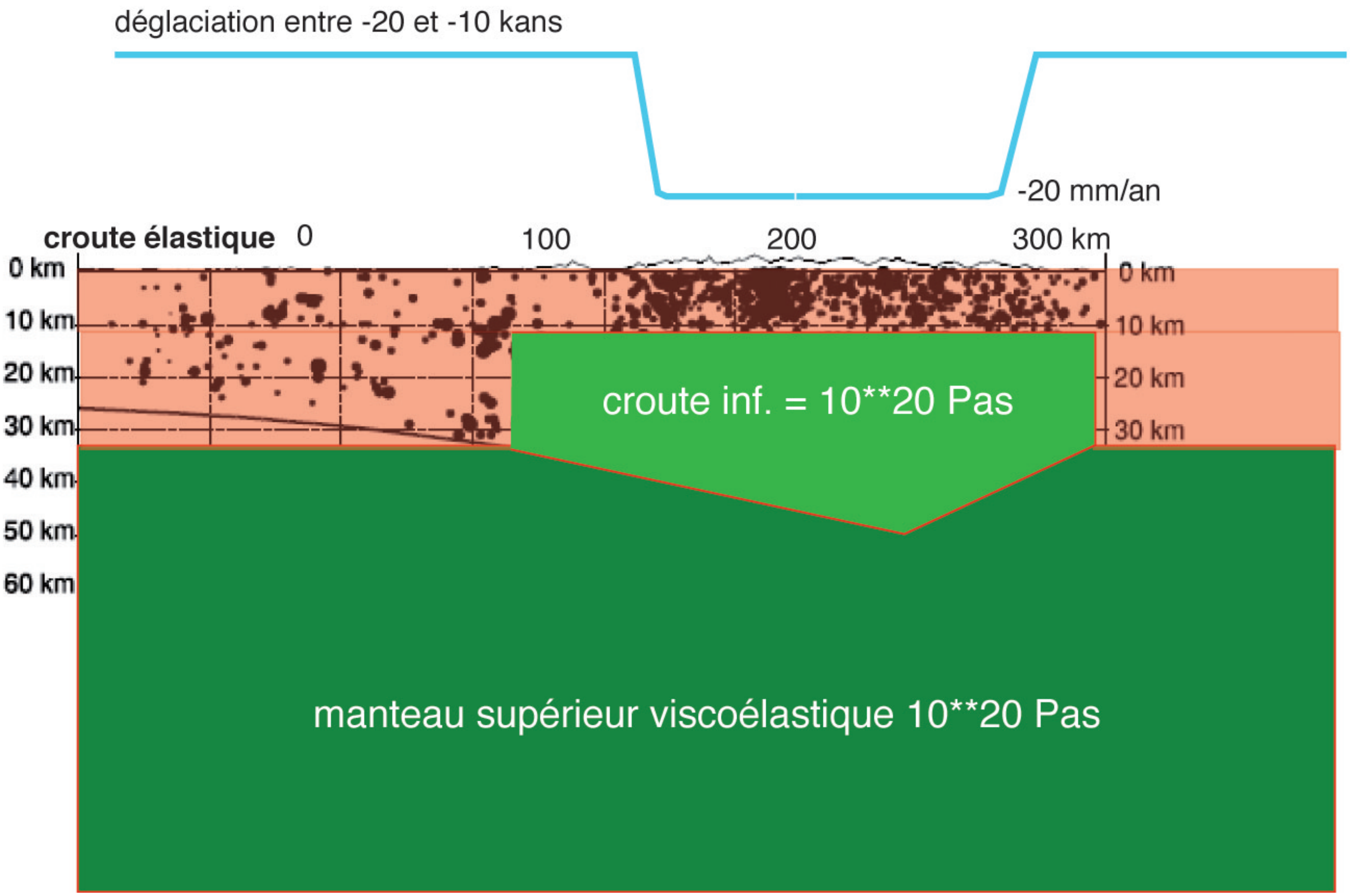
High topography :
5-12 km elastic thickness



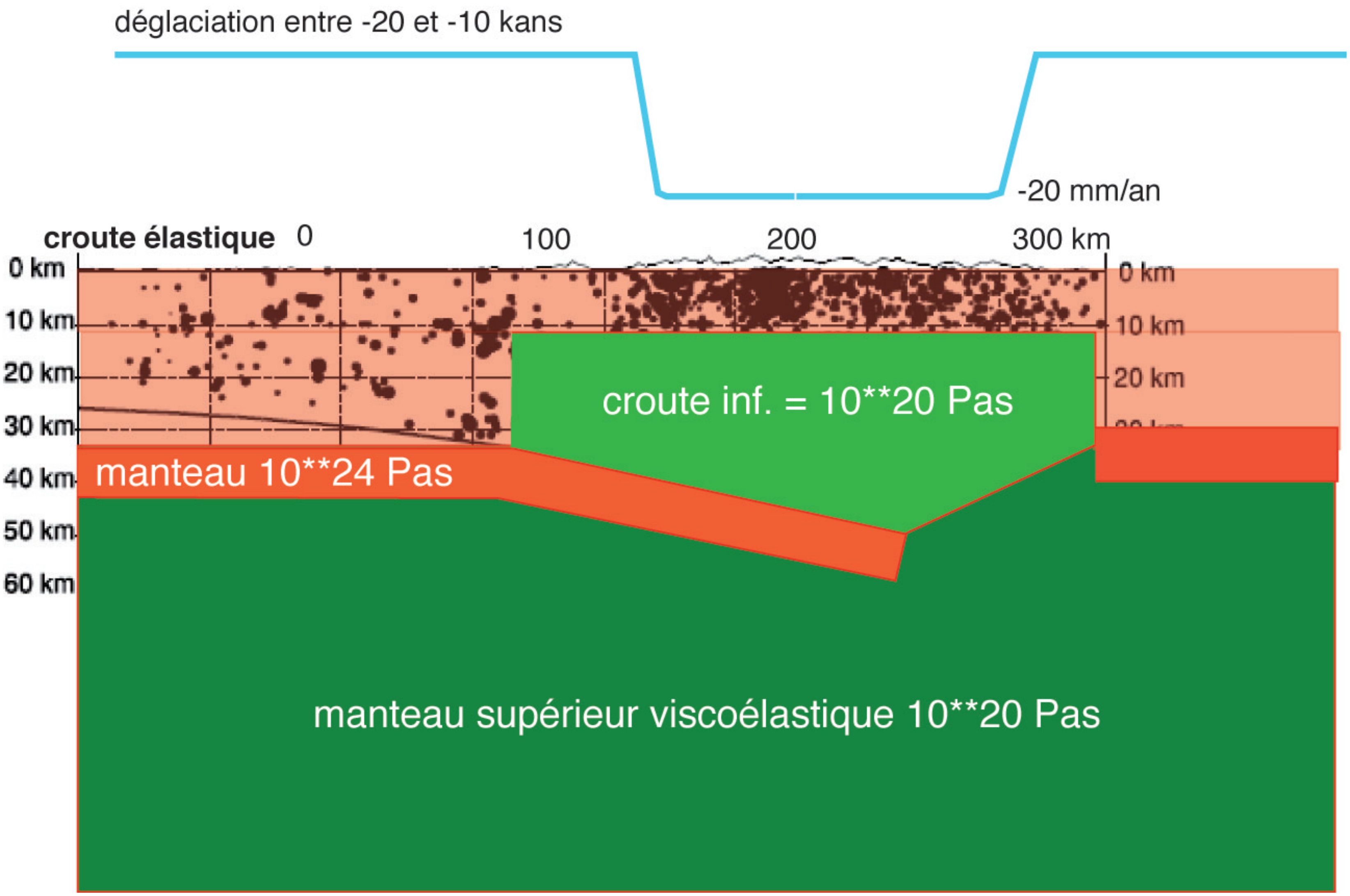
Deichmann, 2003

Subcrustal mantle = weak elastic plate

Model II adapted to the Alps ($\rho_c=\rho_m$)



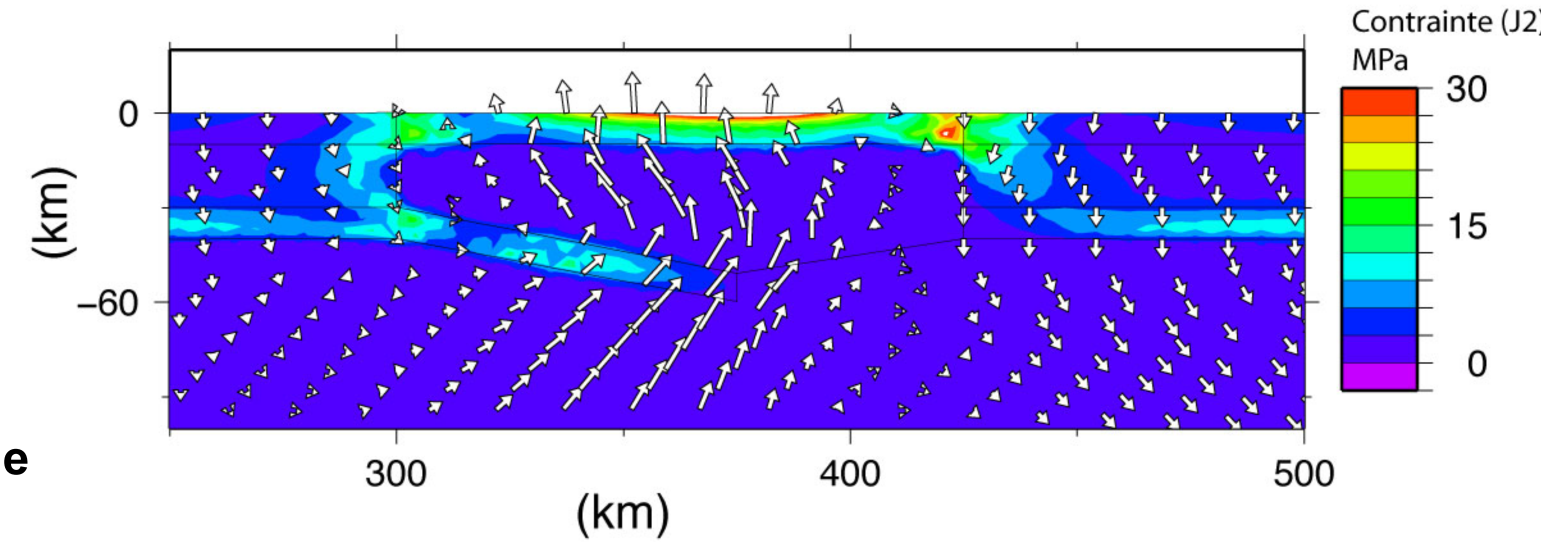
Model II adapted to the Alps ($\rho_c=\rho_m$)



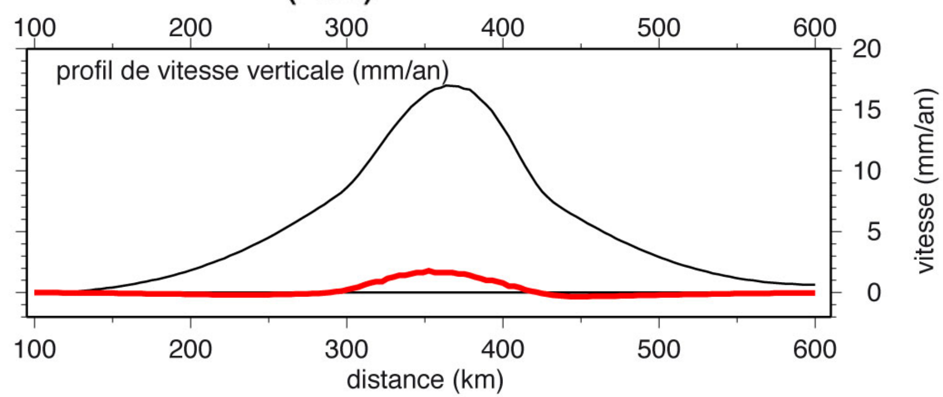
Model IV = CRUSTAL ASTHENOSPHERE + THIN ELASTIC PLATE

Model IV : The 3 effects of the (half) thin plate

1/ Deflect the crustal flow

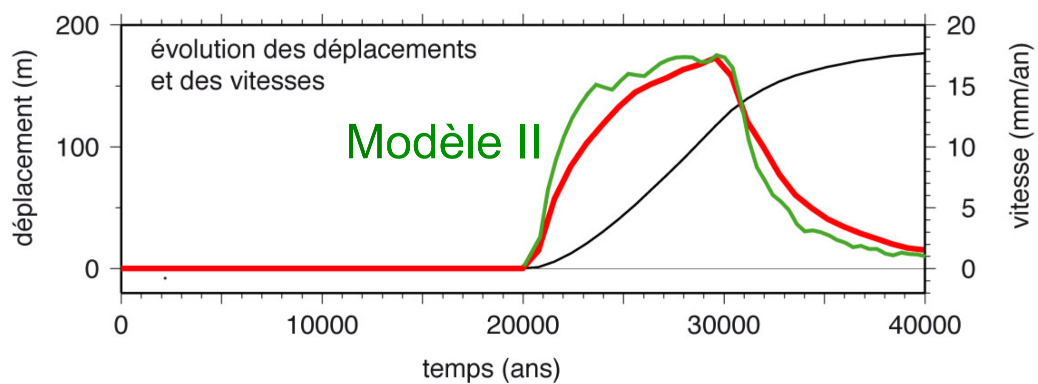


2/ Maintain the crustal root



3/ Allow for post-glacial rebound

Max : +17 mm/an
Today : +1.5 mm/an



Conclusions

- **Present-day geodetic uplift of the Alps may correspond to the coda of a post-glacial rebound controlled by a low viscosity crustal body**

- **A thin subcrustal elastic plate is then needed for preventing mountain root collapse**

Perspectives

- **Document Holocene tectonic activity** (e.g. Hyppolite et al. 2009)
- **Correlate geodetic uplift and LGM ice thickness**
- **Build a 3D rheological model integrating geological and geophysical data** (e.g. Lardeaux et al. 2006, Diehl et al. 2009)