Influence of Strike-Slip Fault Activity on the Topographic Evolution of the Eastern Alps: A Modelling Study

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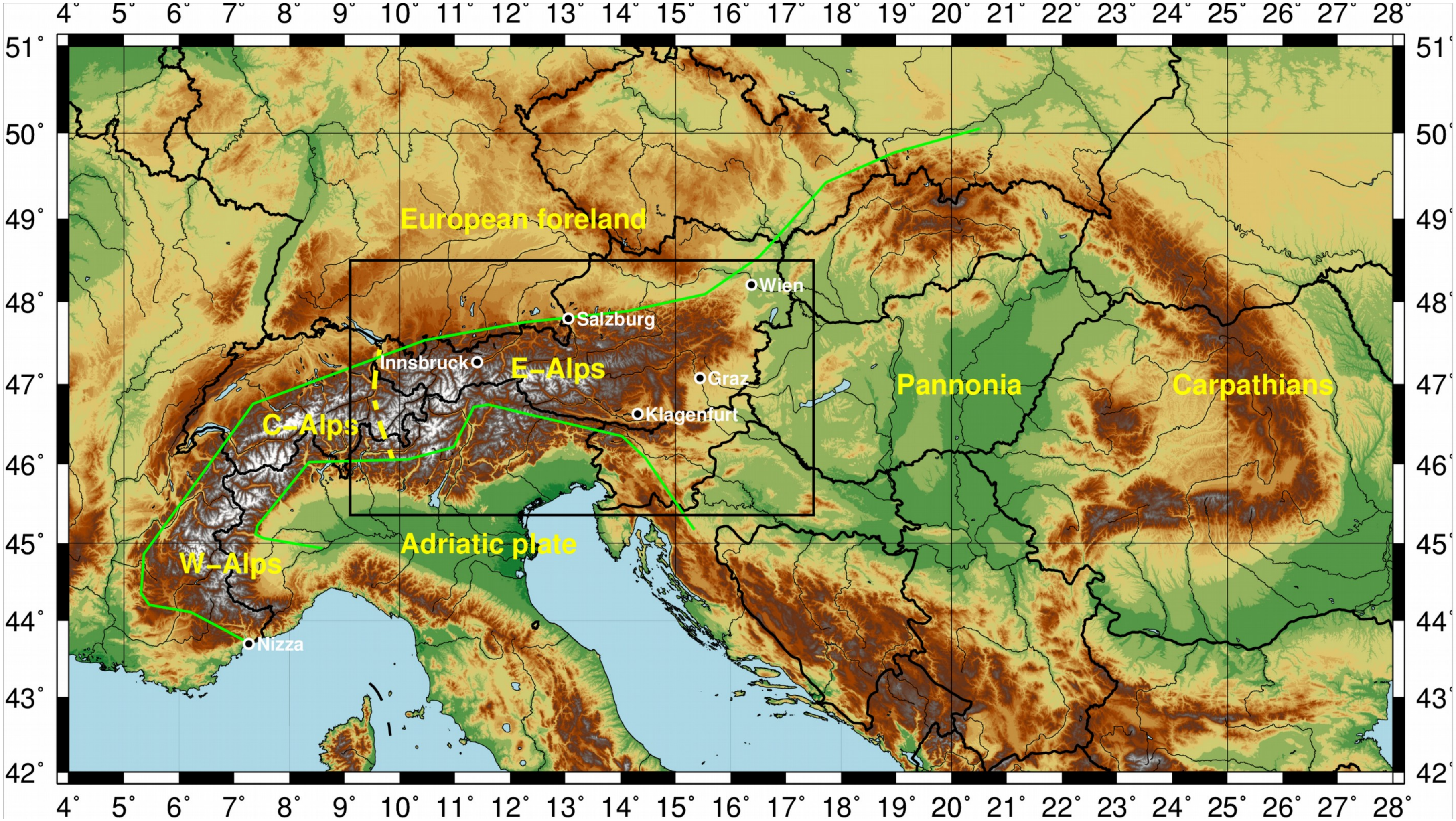
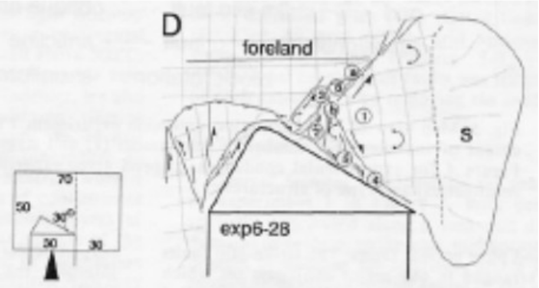
Geological Setting

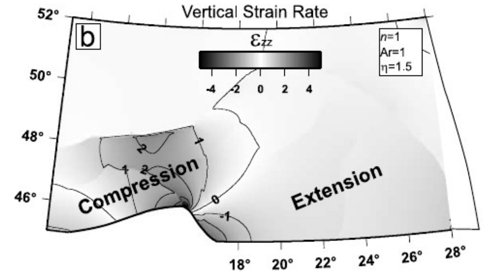


Introduction

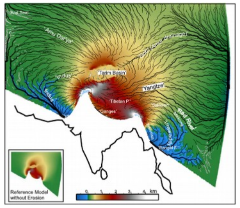
- First analogue indentation experiments **[Ratschbacher et al. 1991]**
  - Introduction of lateral extrusion
  - Importance of strike-slip faulting



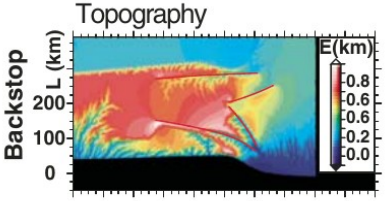
- First deformation modelling of E-Alps **[Robl & Stüwe 2005]**
  thin viscose sheet formulation **[England & McKenzie 1982]**
  2D FE code Basil **[Houseman, England, Barr]**



- BASIL code coupled with an erosion model **[Stüwe et al. 2008]**



- Stationary strike-slip faulting for BASIL **[Robl et al. 2008]**

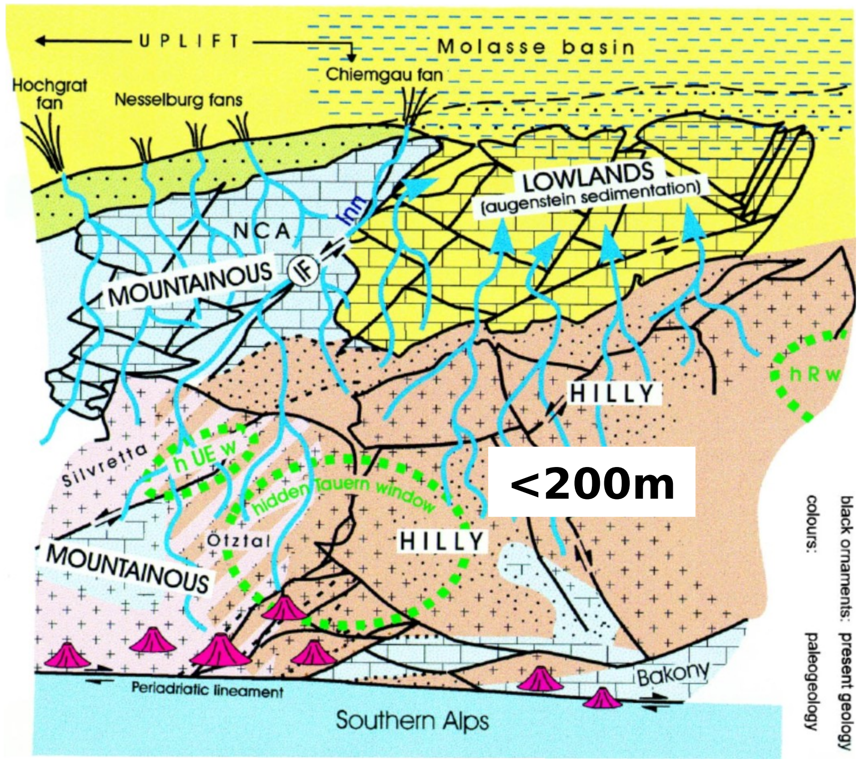


- Non-stationary strike-slip faulting (presented work, [Lynn Evans, pers. com., Monash University])

First record of topographic evolution of E-Alps
[Frisch et al. 1998]

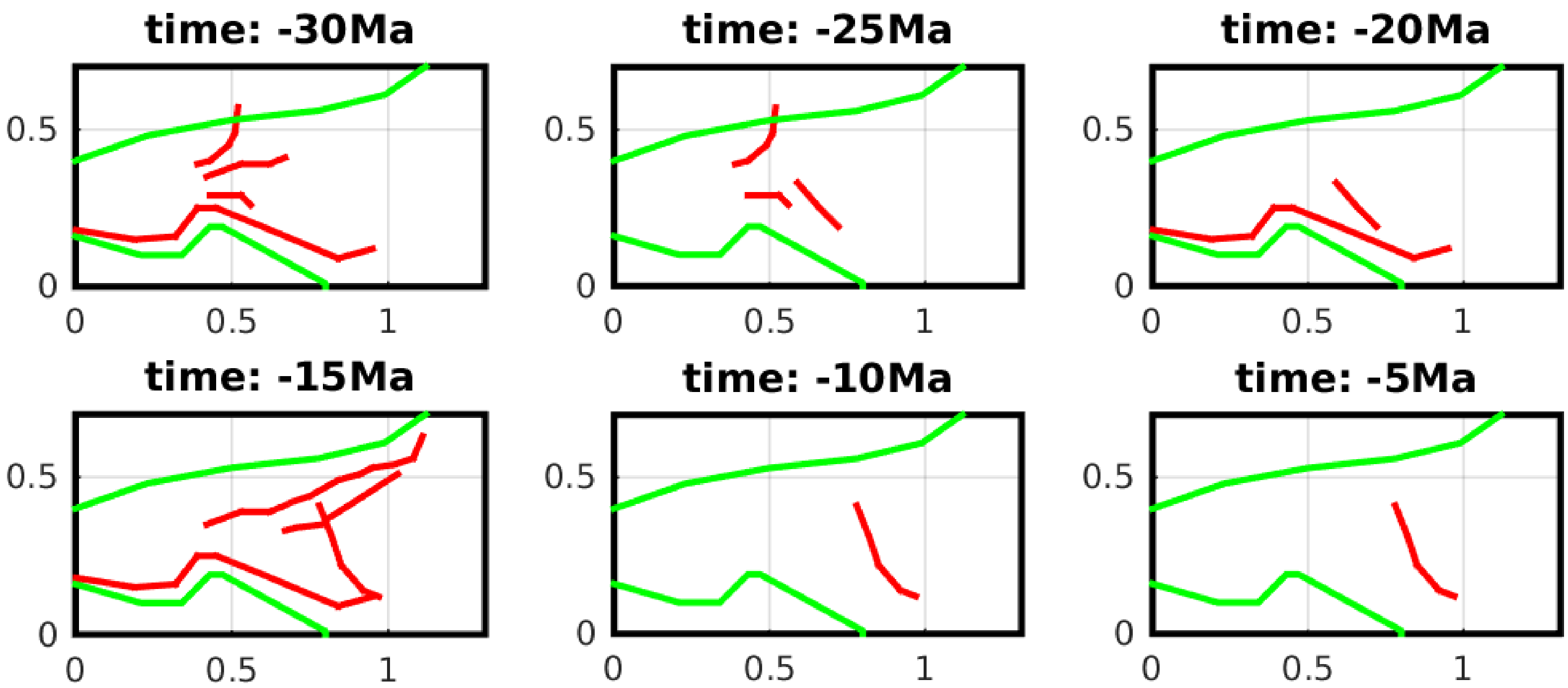
Initial condition for simulation

- Starting time 30Ma ago
- Initial flat topography 200m



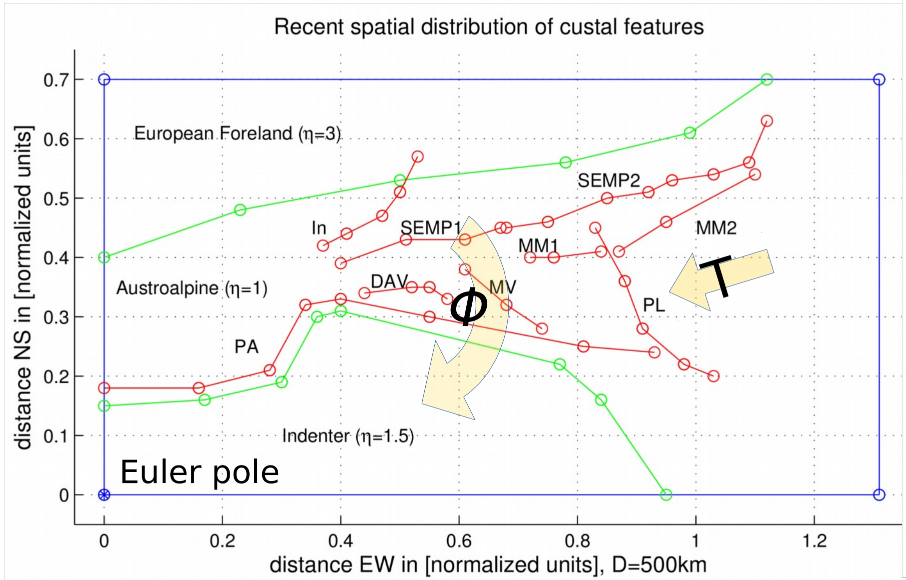
Literature/strike-slip activities

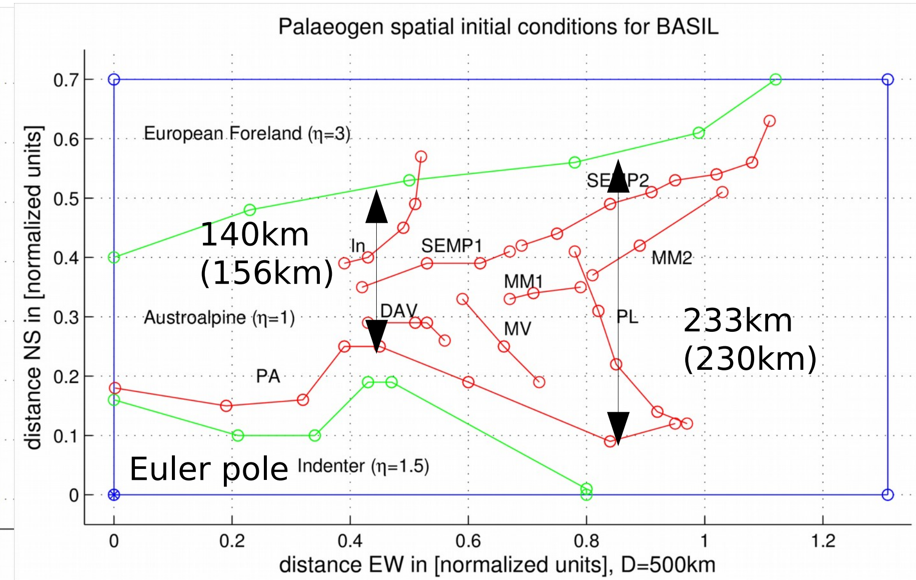
Abr.	fault name	time history of strike-slip activity from literature																																		
	time in [Ma] before recent	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PA	Periadriatic fault																																				
DAV	Defreggen-Anrholz-Völz																																				
SEMP1	Salzach-Ennstal fault																																				
SEMP2	Ennstal-Mariazell-Puchberg fault																																				
MM1	Mur-Mürztal fault – west																		?		n	n	n	n													
MM2	Mur-Mürztal fault – east																		?																		
PL	Pöls-Lavanttal fault																																				
MV	Möll-valley fault																																				
In	Inntal fault																																				



- Plate boundary
- Strike-slip fault

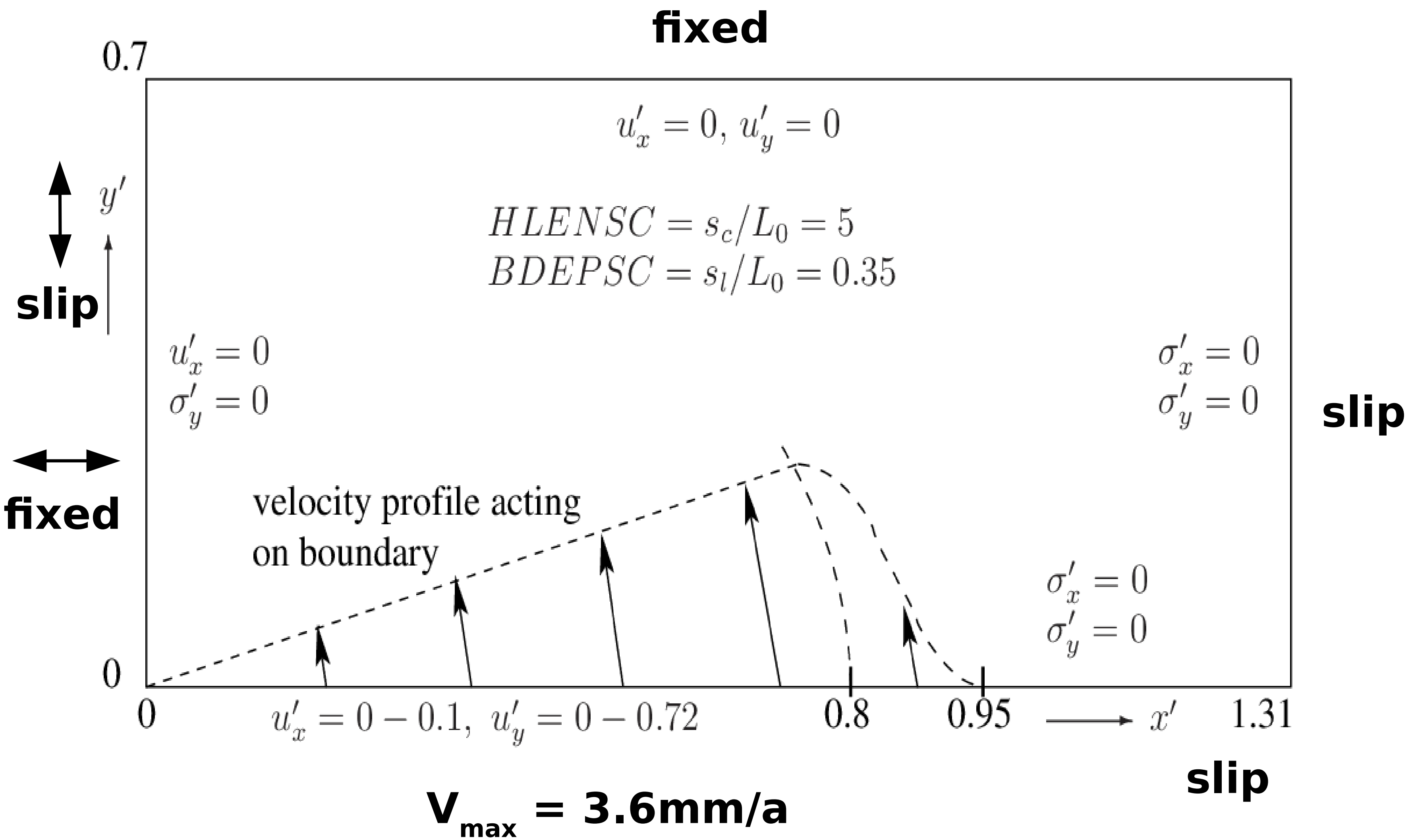
Palaeogen rectification





- Rotation of Adriatic Plate: 0.52°/Ma **[Nocquet & Calais 2003]**
- Heuristic rectification approach:
  - $\Phi \propto$ distance from Adriatic Plate
  - T → compensate lateral extrusion
- Result fits to **[Linzer et al. 2002]**

Name	$-\phi^{rot}$ in [°]	$\vec{T}$ in [km]
In	$0.4 - 5.1$	$(-5,0)^T$
SEMP1	$2.7 - 5.7$	$(-8,0)^T$
SEMP2	$0 - 2.6$	$(-5,0)^T$
DAV	$5.9 - 6.2$	$(-25,0)^T$
MV	$4.7 - 6.5$	$(-25,0)^T$
MM1	$2.6 - 3.7$	$(-35,-10)^T$
MM2	$0.3 - 1.2$	$(-35,-15)^T$
PL	$1.6 - 3.4$	$(-35,-10)^T$
PA	15.6	$(0,0)^T$


fixed
0.7
$u'_x = 0,\ u'_y = 0$
y'
$HLENSC = s_c/L_0 = 5$
$BDEPSC = s_l/L_0 = 0.35$
slip
$u'_x = 0$
$\sigma'_y = 0$
$\sigma'_x = 0$
$\sigma'_y = 0$
slip
fixed
velocity profile acting on boundary
$\sigma'_x = 0$
$\sigma'_y = 0$
0
0
$u'_x = 0 - 0.1,\ u'_y = 0 - 0.72$
0.8
0.95
x'
1.31
slip
$V_{max} = 3.6mm/a$

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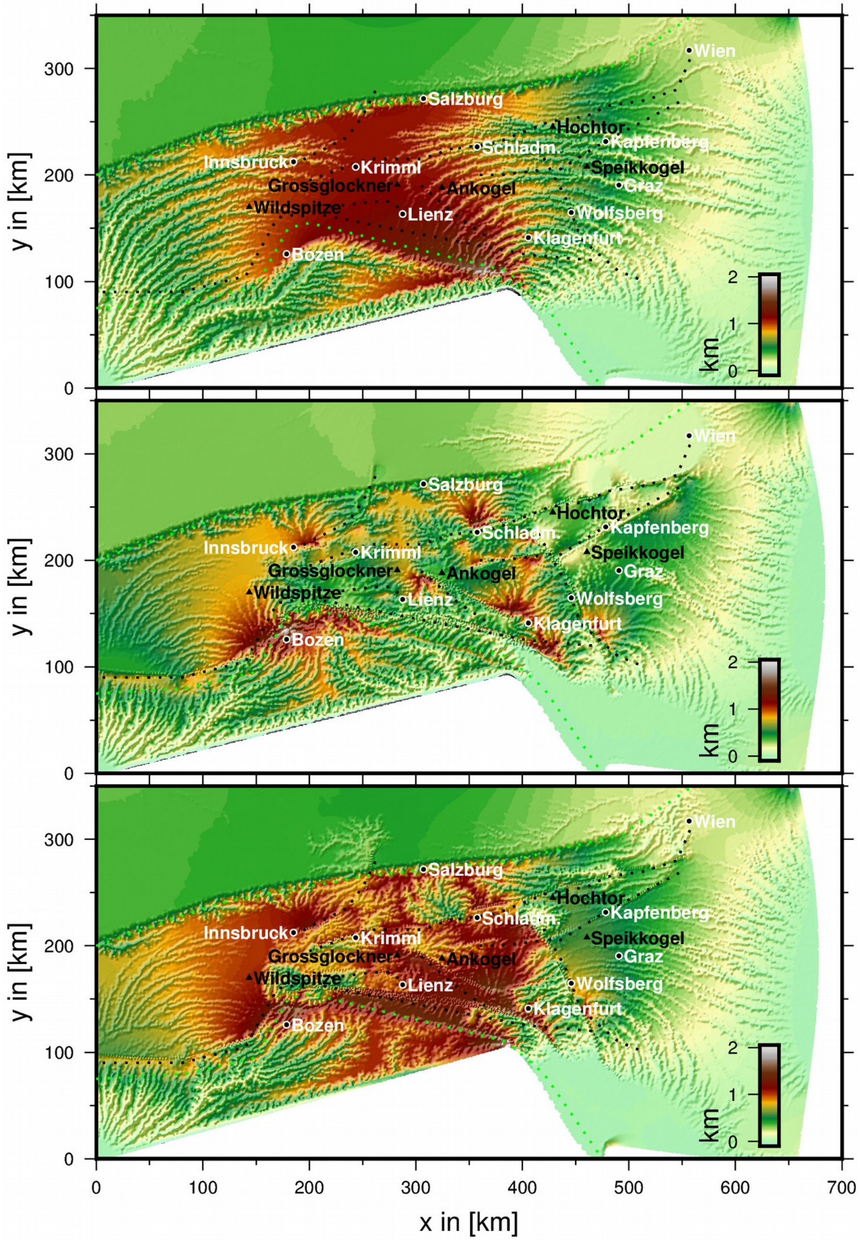
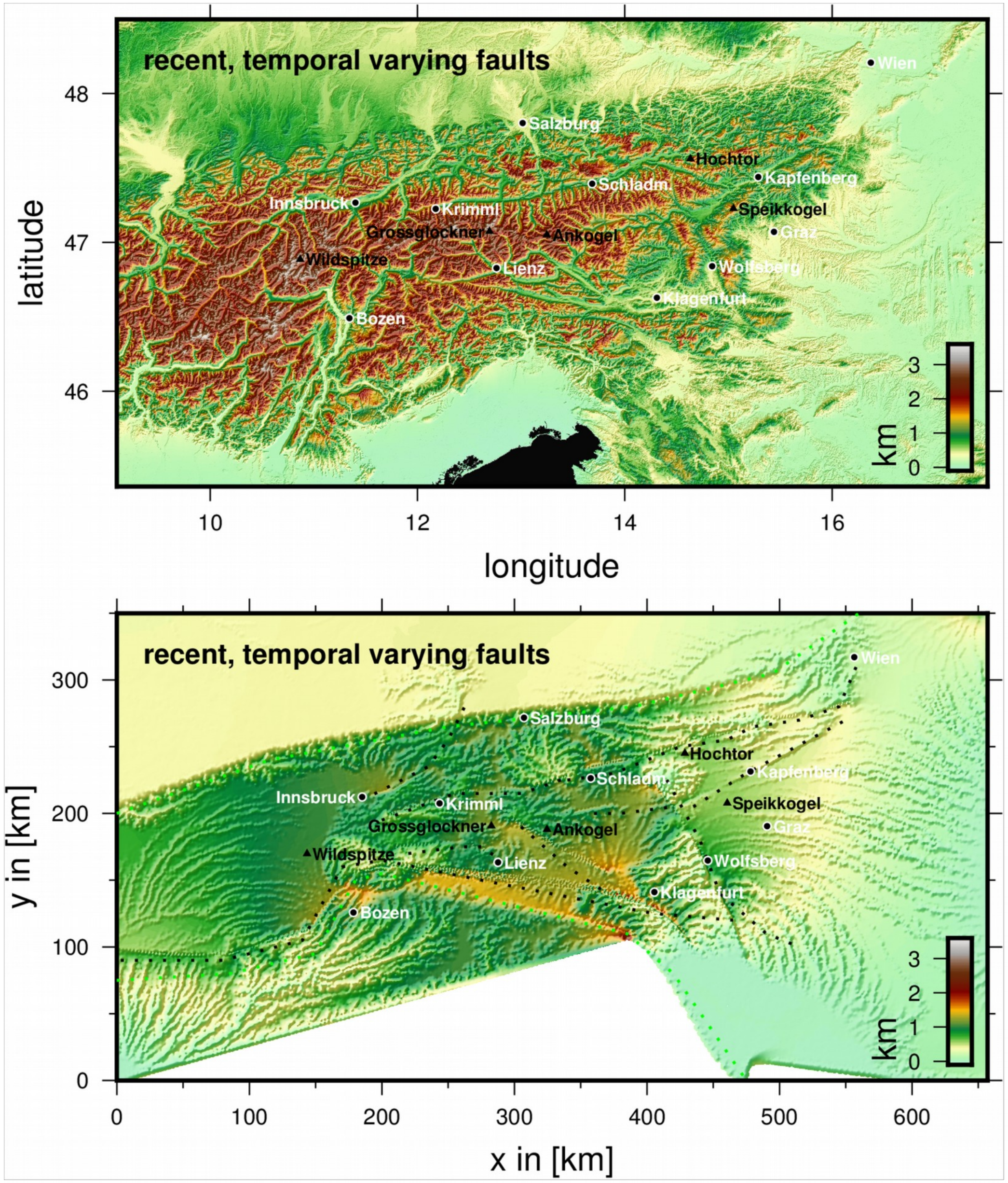
Topographic elevation after 30Ma of deformation

- No faults
- With faults
- With temporal varying faults

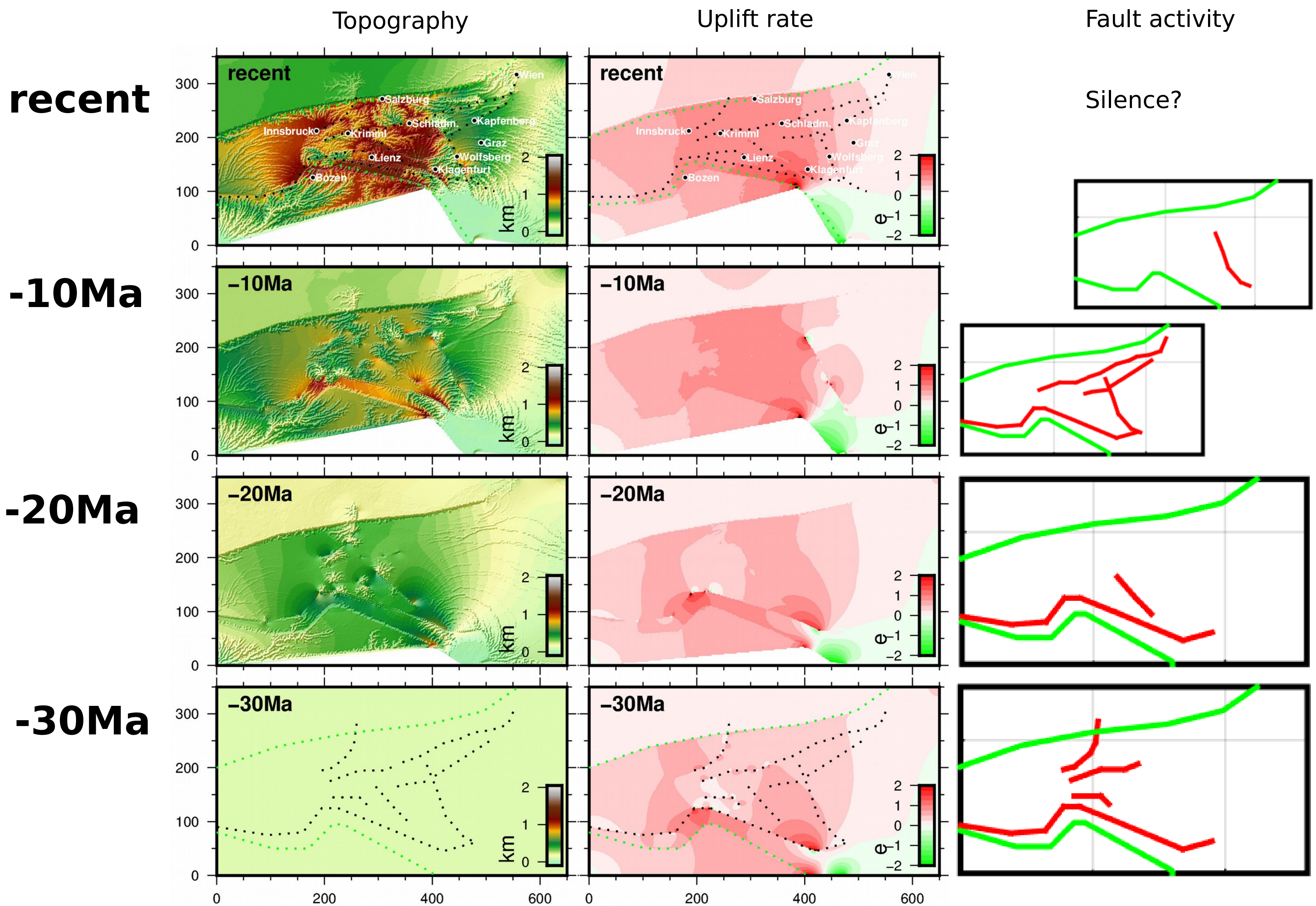


Topography about 400-1200m peak height below real world

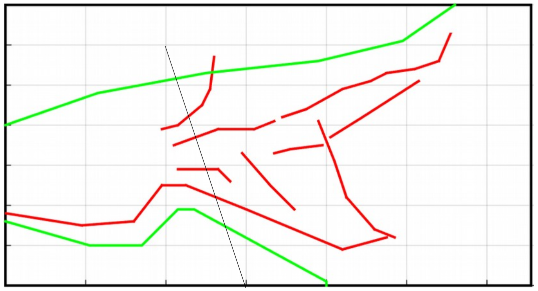
- glacial erosion **[Sternai et al. 2015]**
- Plate rebound **[Willet, 2010]**
- Asthenosphere upwelling **[Lippitsch et al. 2003]**

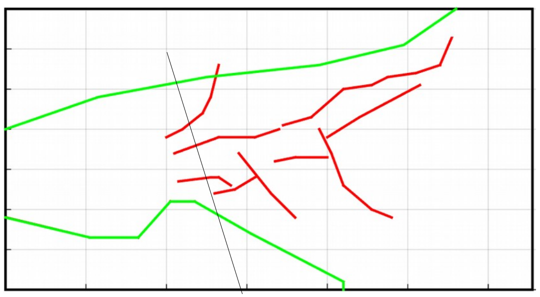


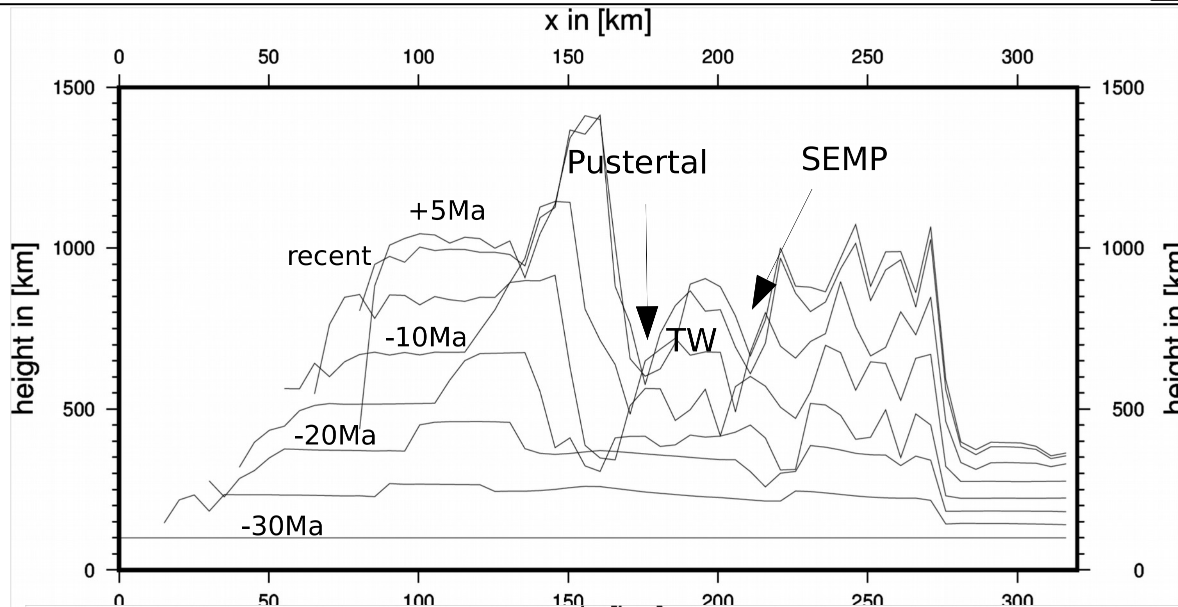
Topographic evolution

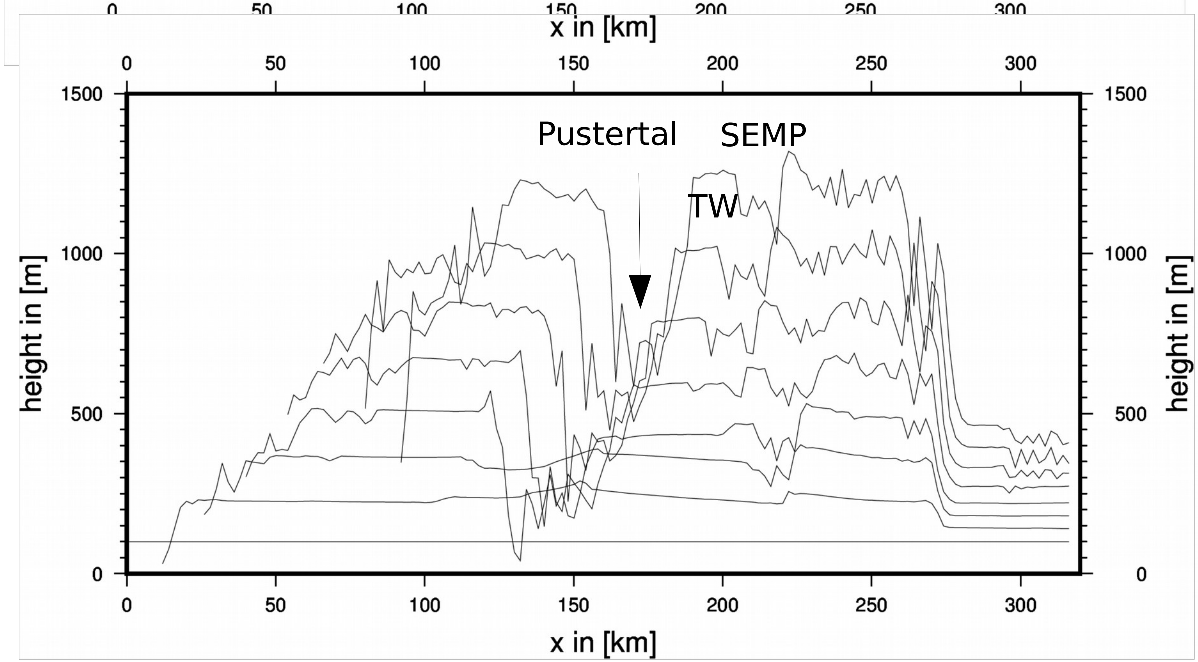


Tauern Window exhumation









PA = Adriatic plate boundary

Conclusion

- Final topography depends strongly on strike-slip activity patterns → backs up earlier findings
- Tauern Window exhumation strongly depends on activity patterns of faulting
- Maximum indenter velocity with v_{max}=3.6mm/a over 30Ma
  - Rectification fits to Linzer et al. (2002)
  - Lower convergence rates than claimed in literature
- Stiffness control modelling of the Austroalpine instead of boundary condition modelling
  (e.g. Miocene roll-back at Carpathian arc)