Bumpy bads: what to do about them

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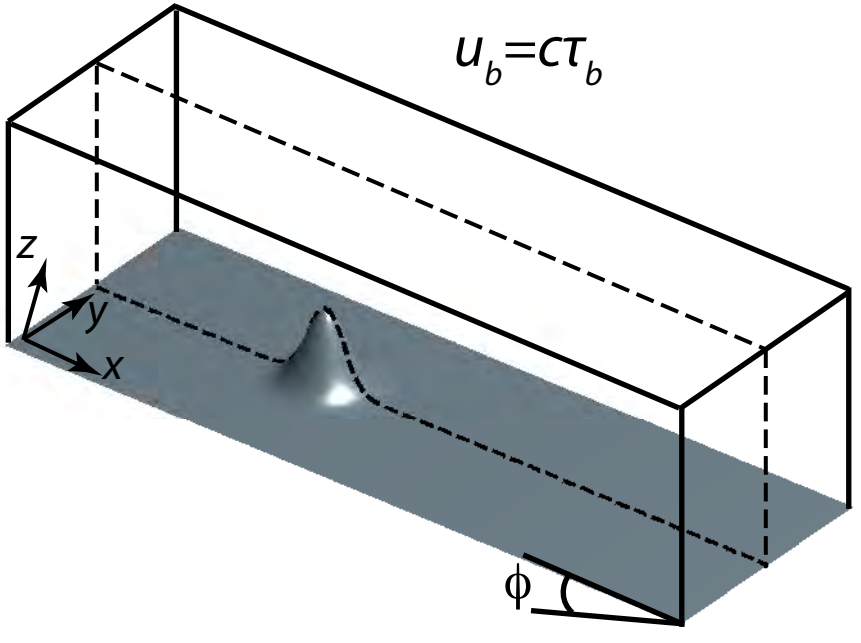
Use plane view models

Have non-uniform grids
for bed topogrpaphy surveys

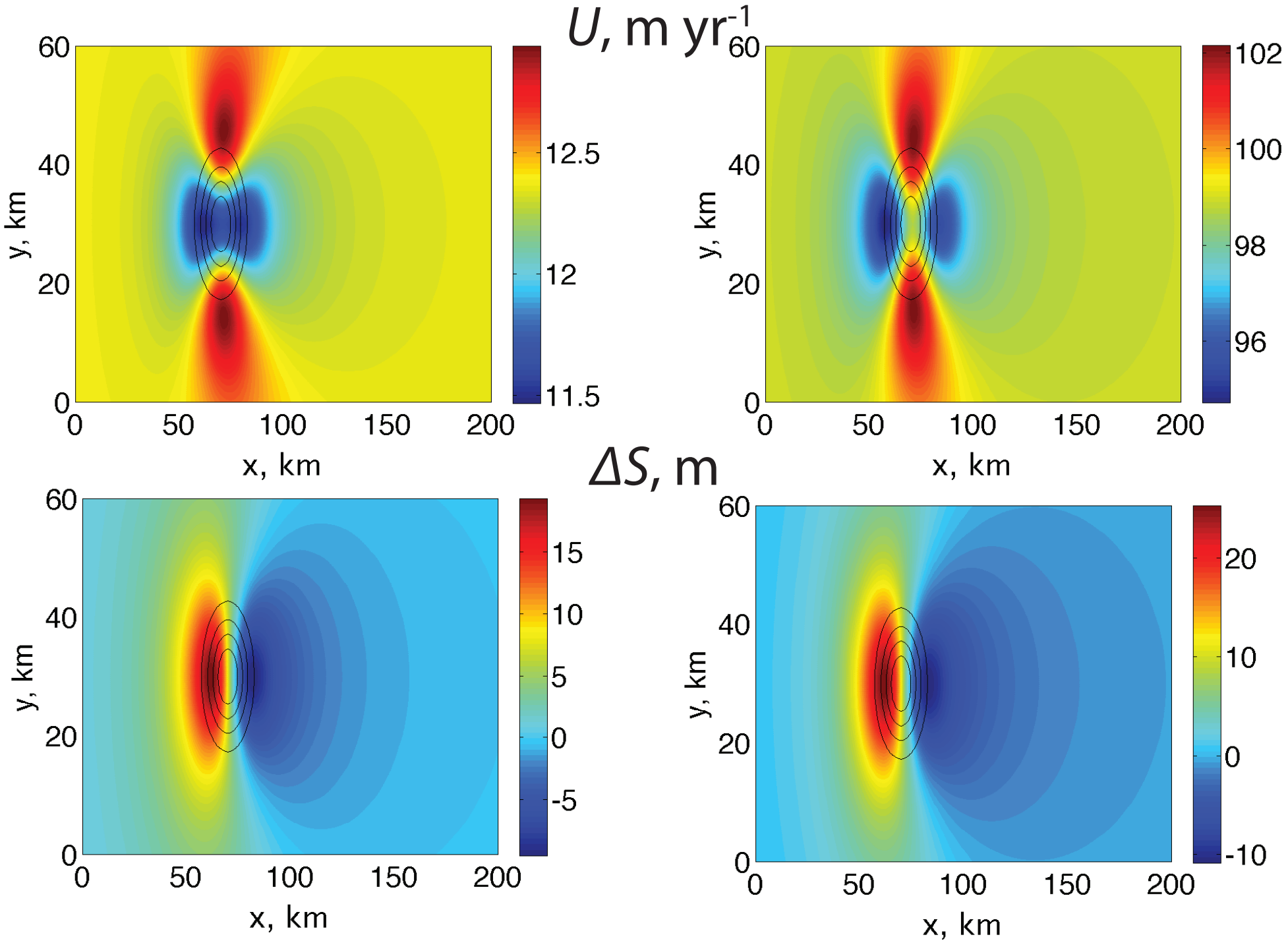
Stokes equations
continuity equation
free surface



Transfer functions (Gudmundsson, 2003)
Linear viscosity, small bump amplitude

Numerical simulations
Nonlinear viscosity, arbitrary bump amplitude

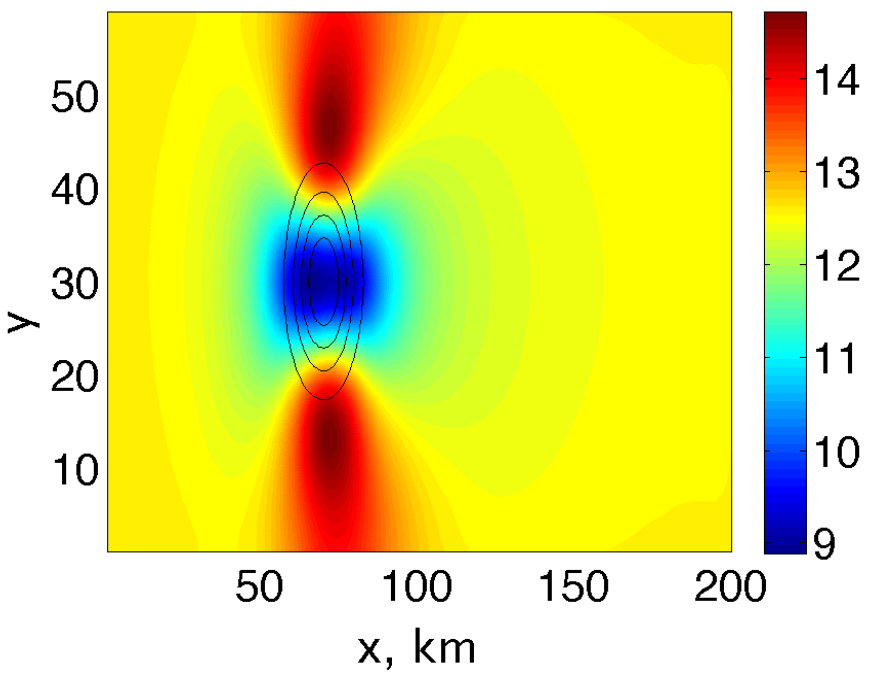
Transfer functions

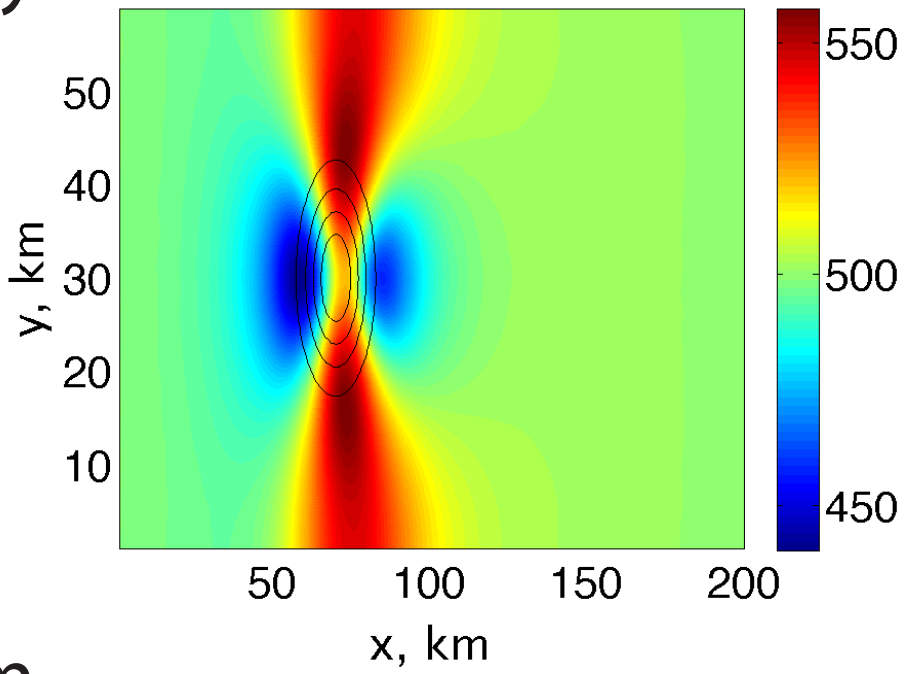


Linear viscosity, small bump amplitude

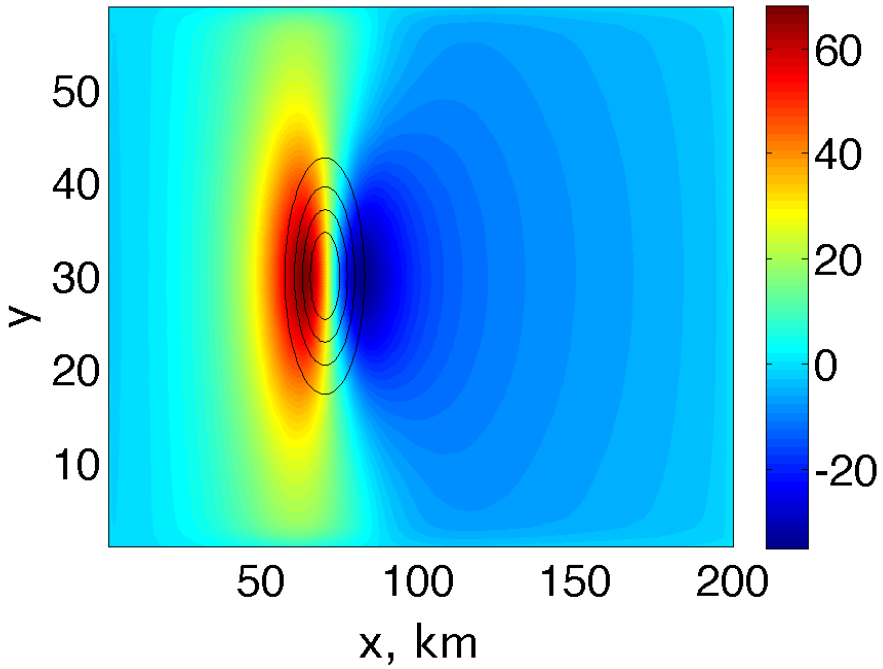
Numerical solutions

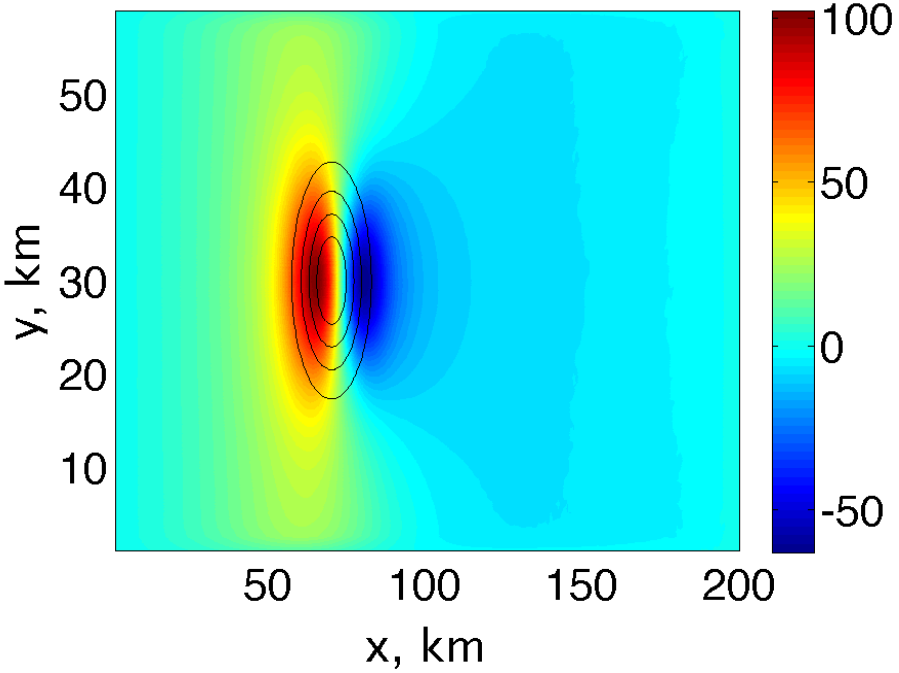
U, m yr^{-1}



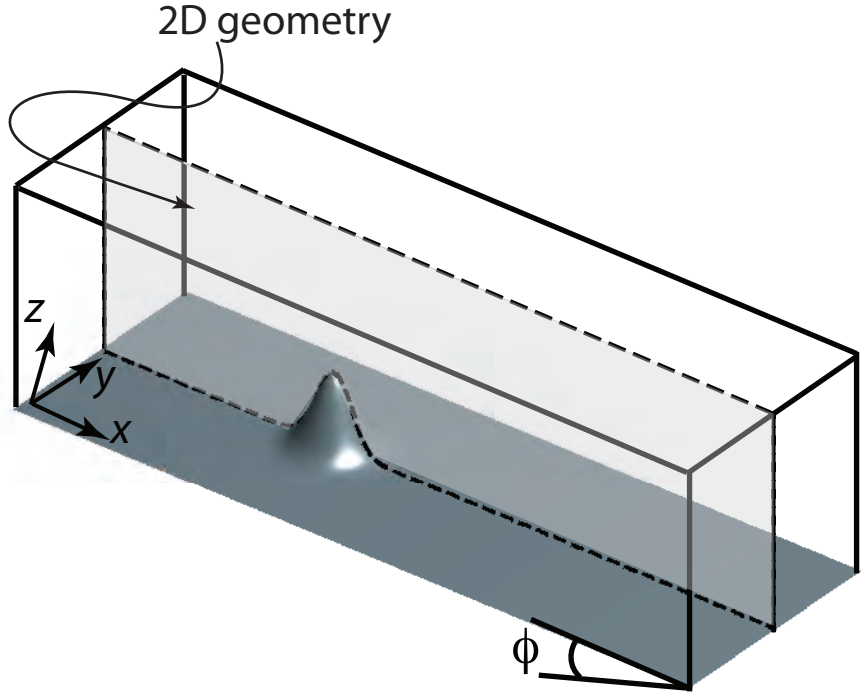


ΔS, m



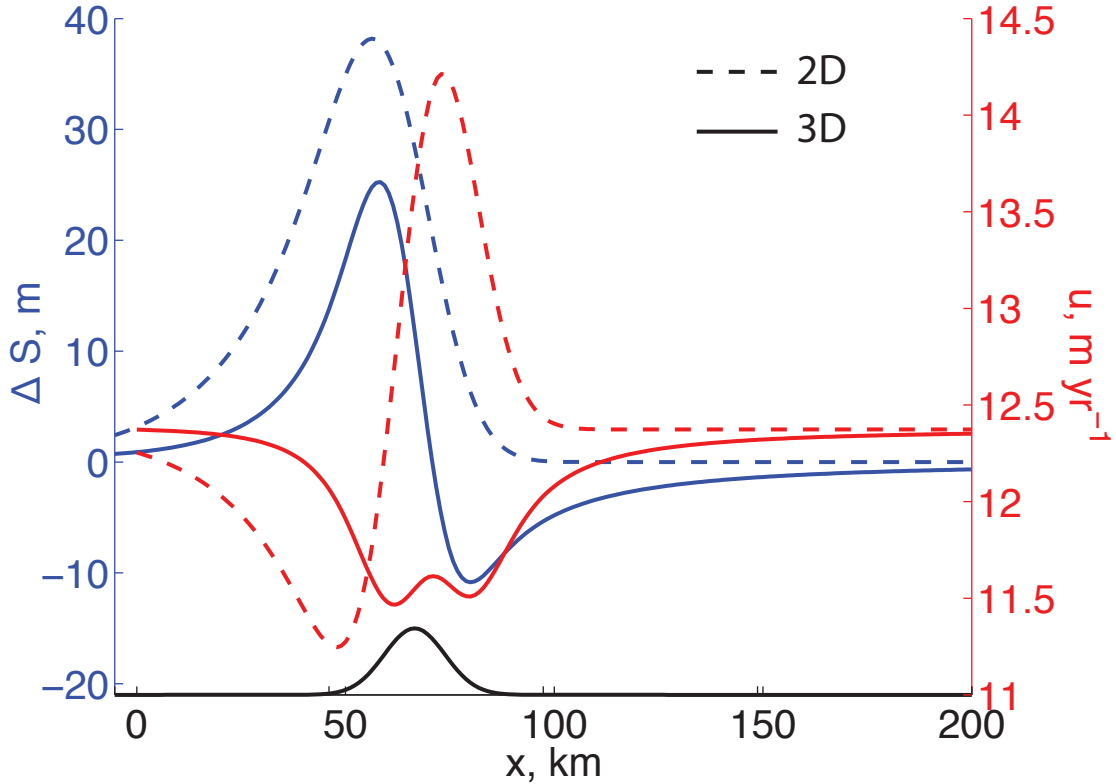


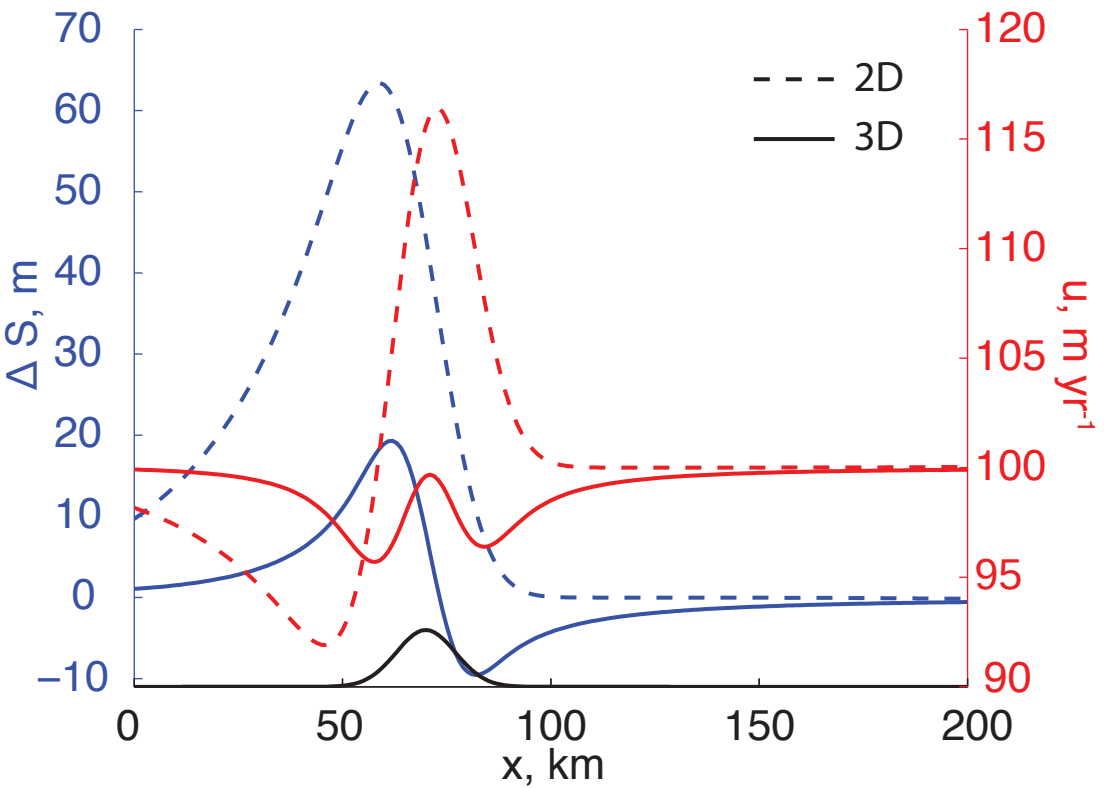
Nonlinear viscosity, arbitrary bump amplitude


2D geometry
z
y
x
ϕ

Transfer functions

Surface elevation and velocity along the centerline

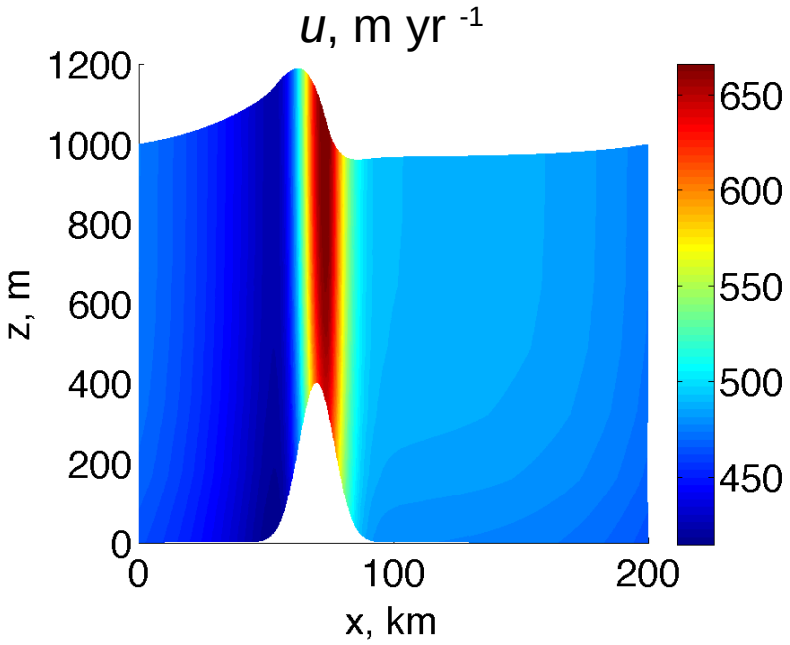


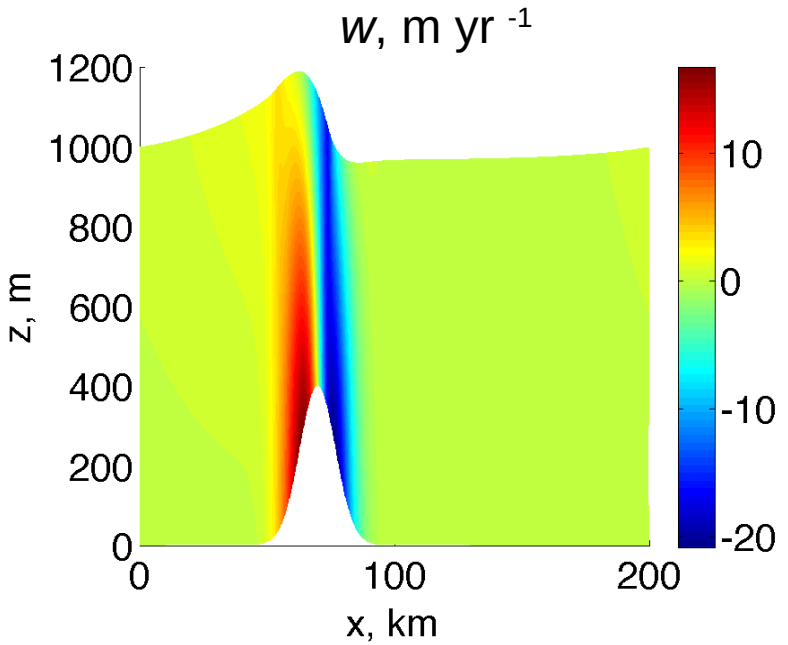


Linear viscosity, small bump amplitude

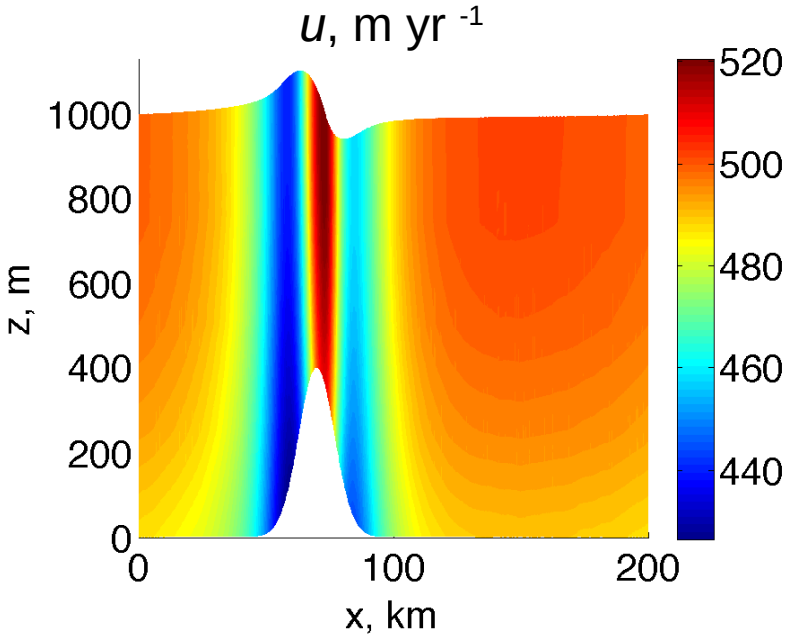
Numerical solutions (velocities)

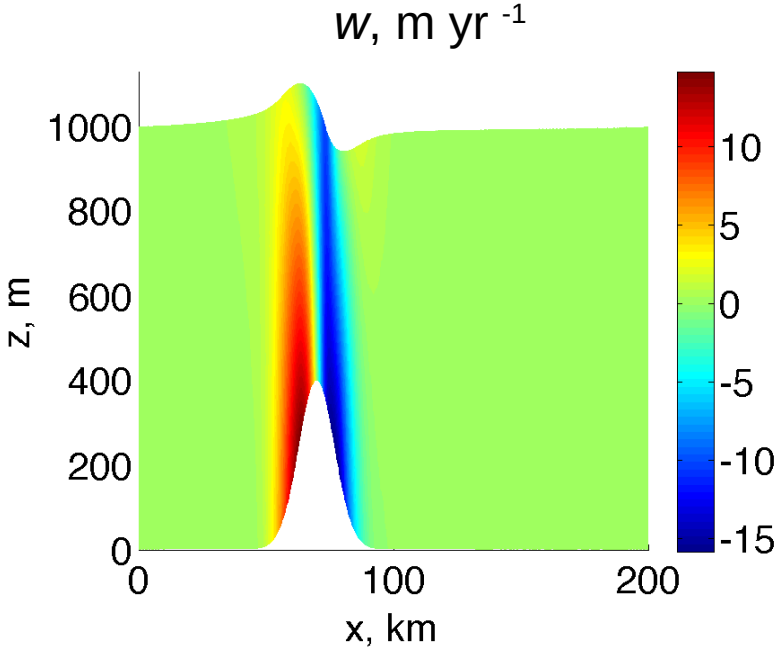
2D





3D

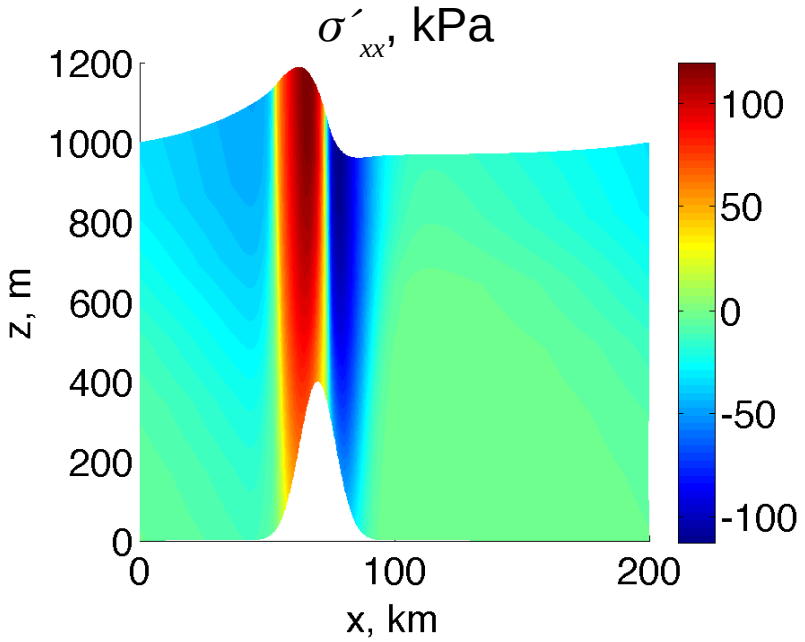


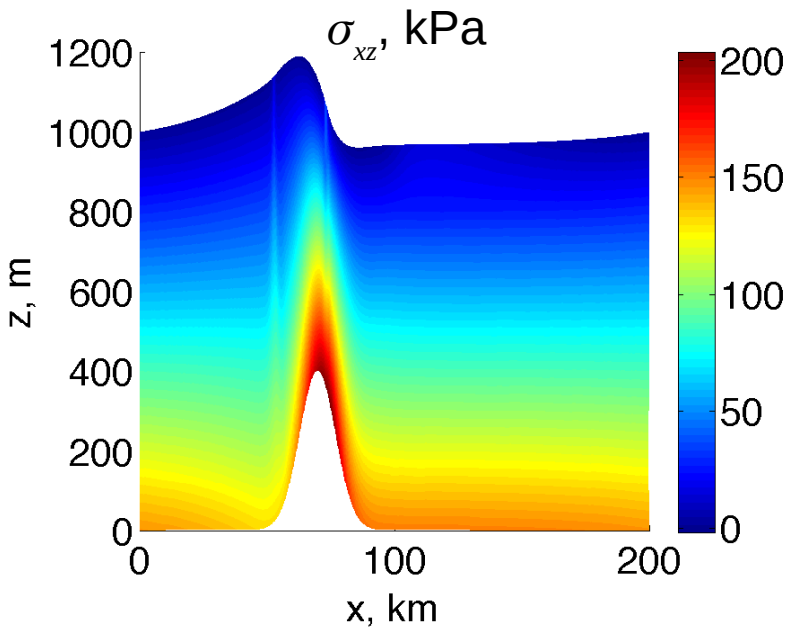


Nonlinear viscosity, arbitrary bump amplitude

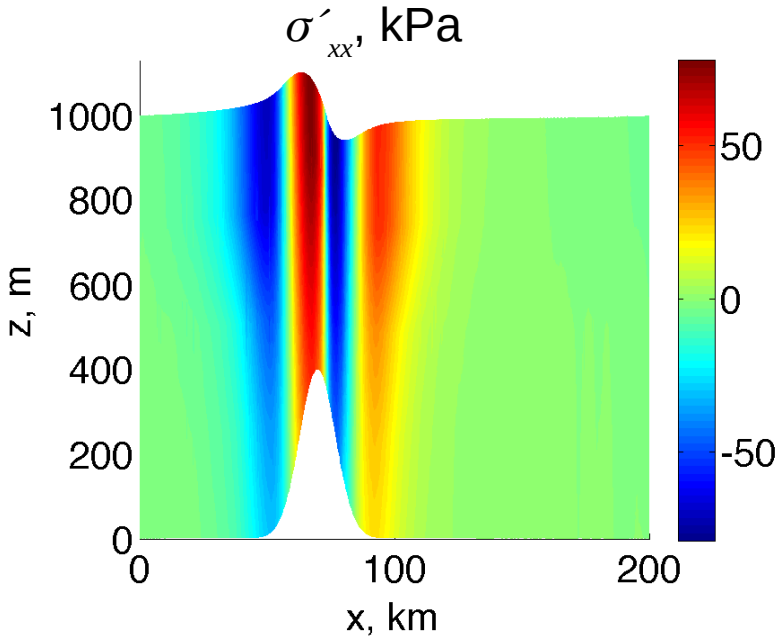
Numerical solutions (stresses)

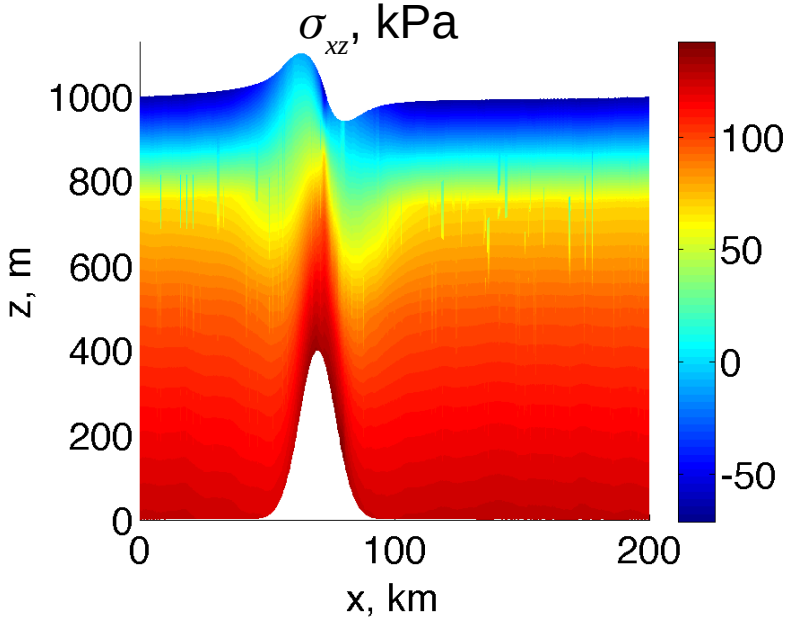
2D





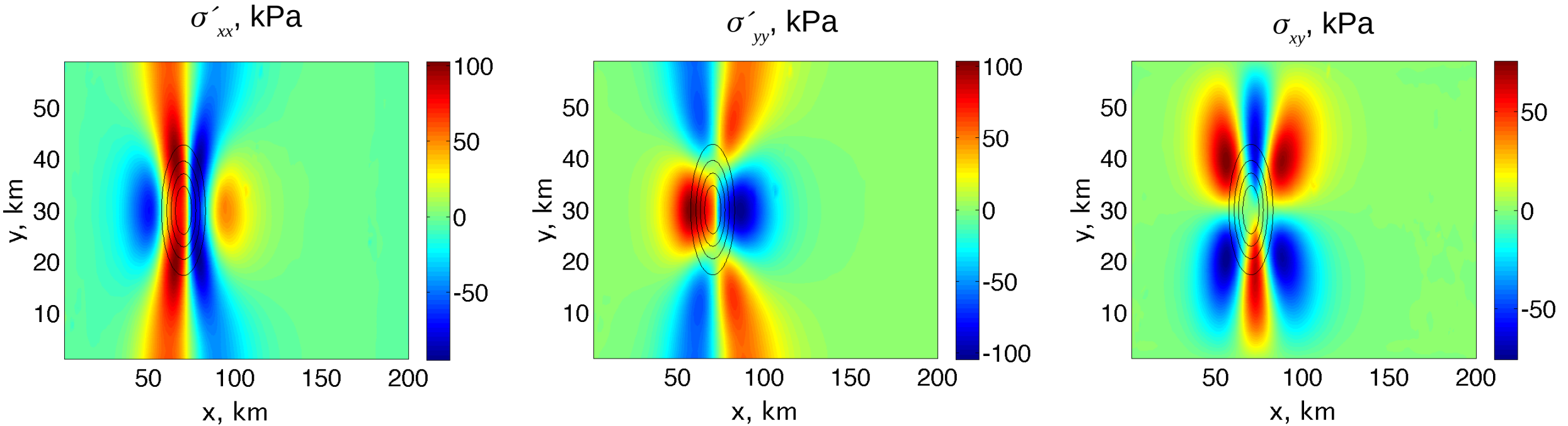
3D





Nonlinear viscosity, arbitrary bump amplitude

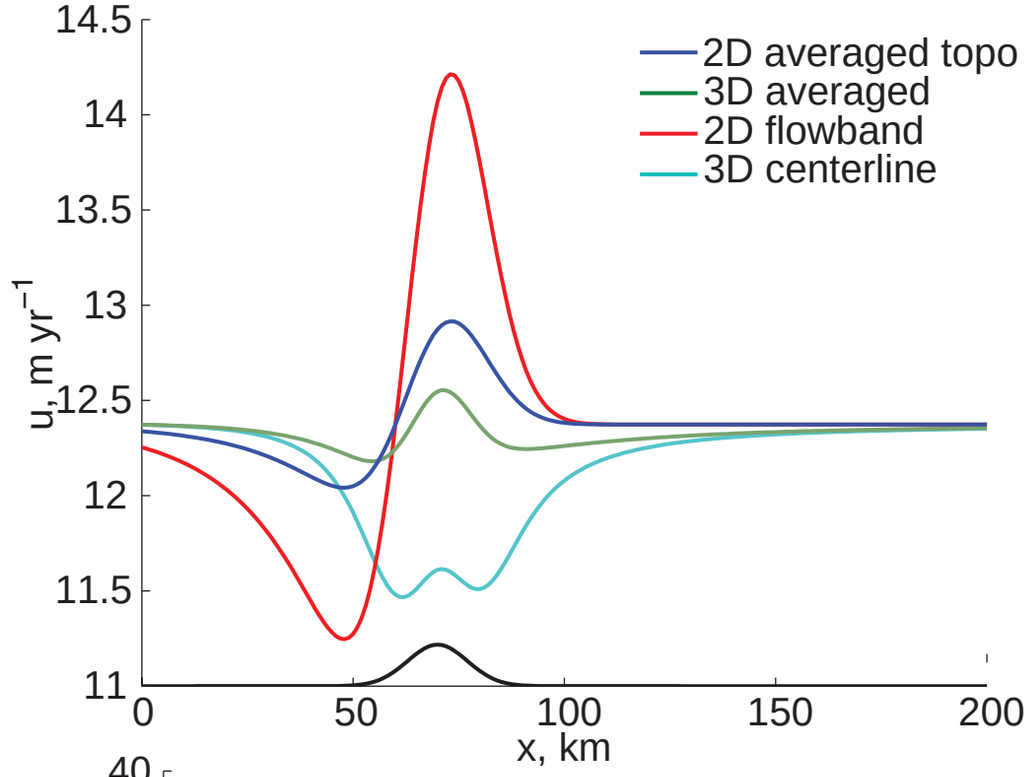
Numerical solutions (surface stresses)

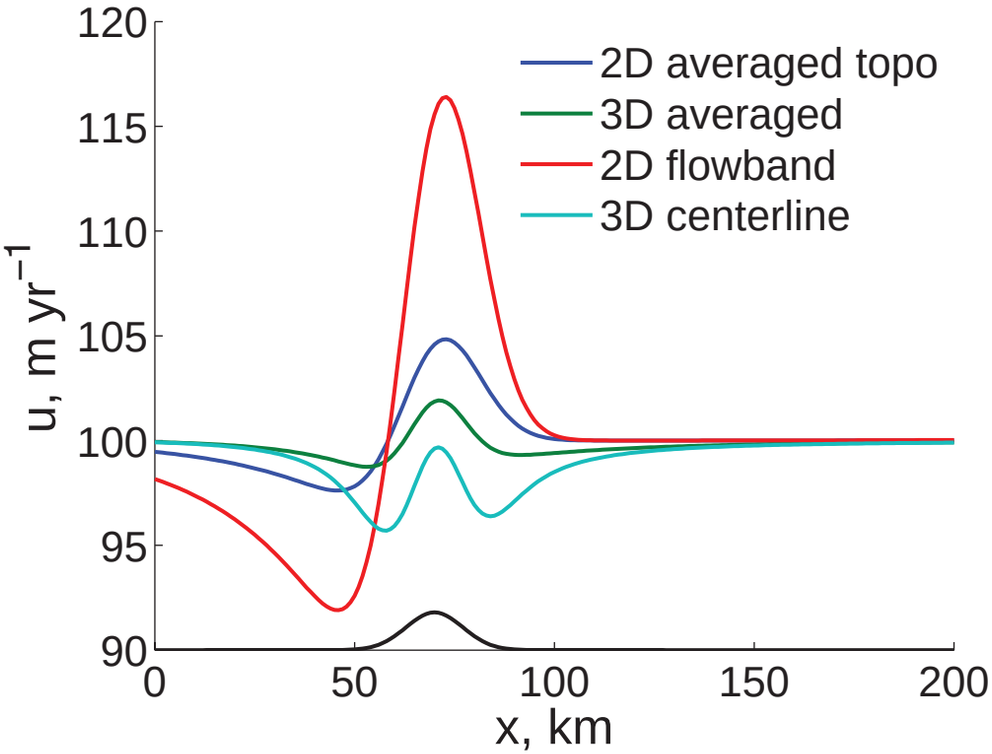


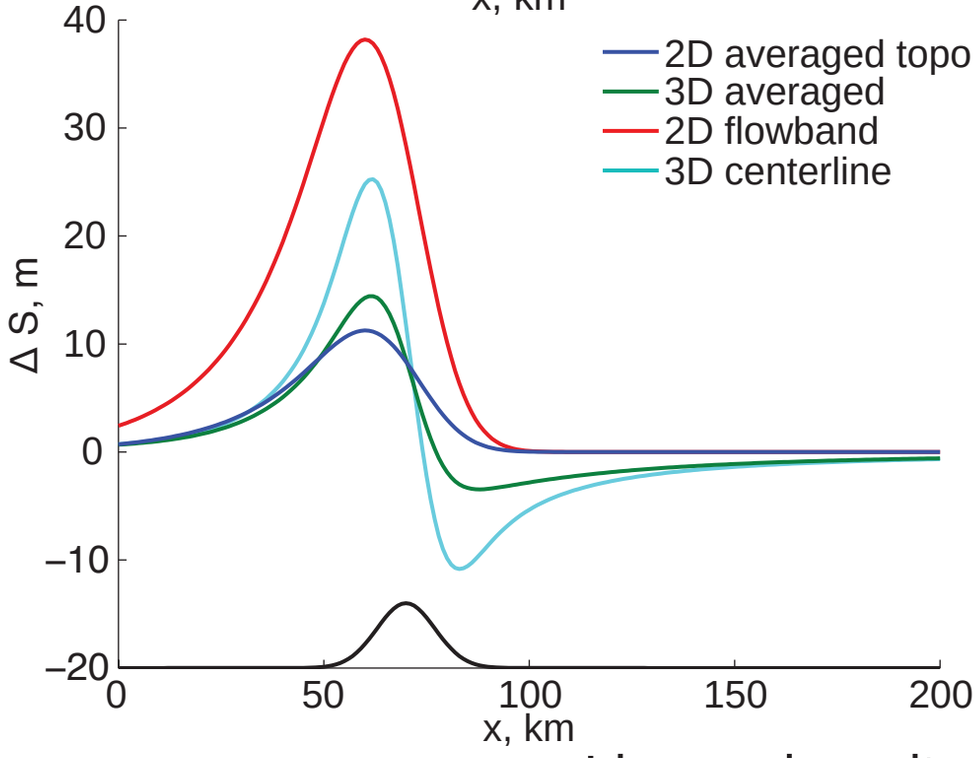
Nonlinear viscosity, arbitrary bump amplitude

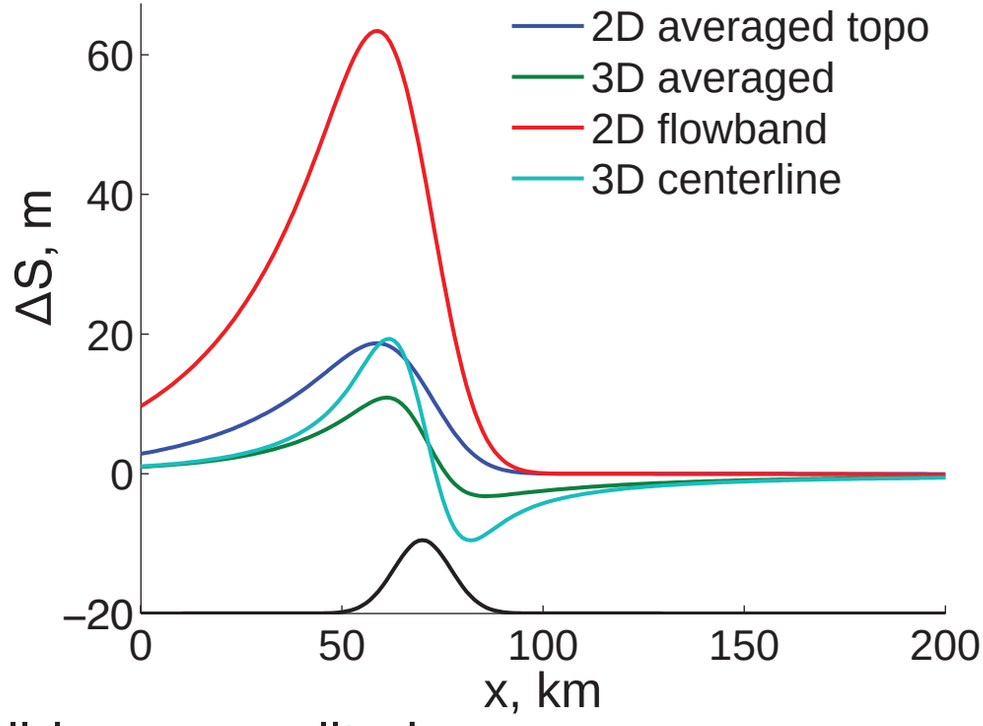
Transfer functions

Surface elevation and velocity





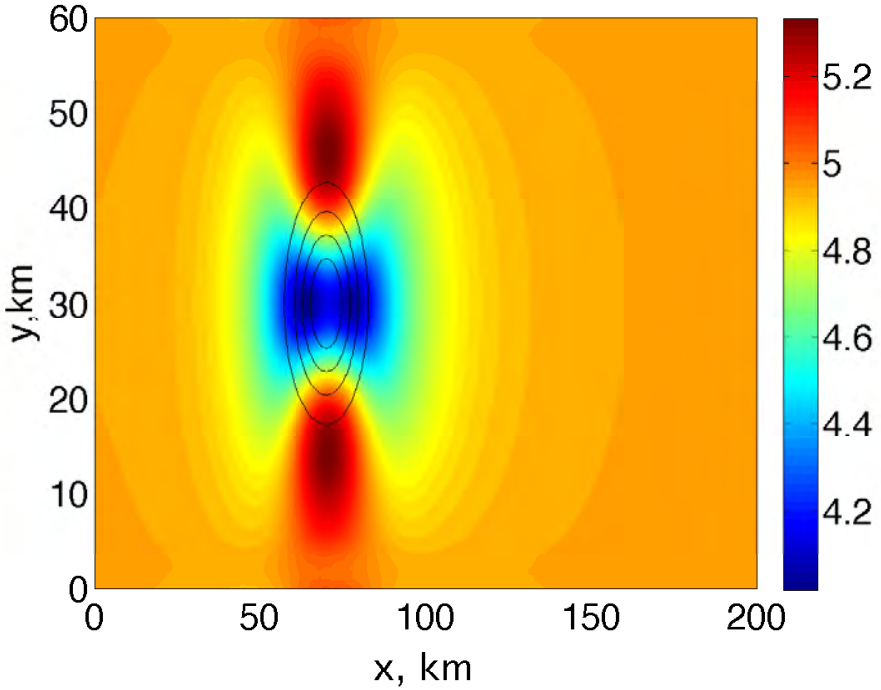


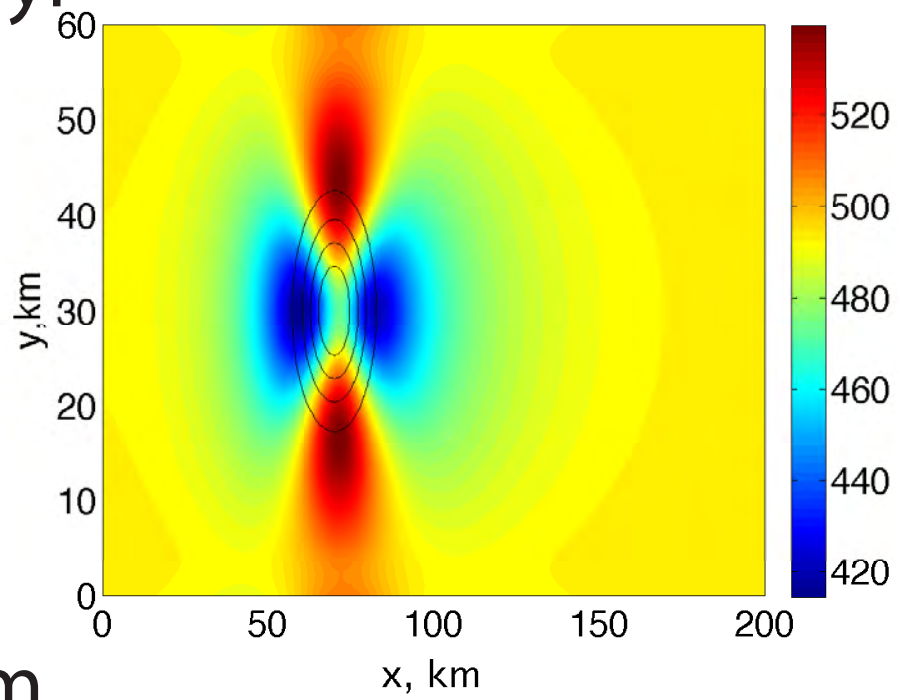


Linear viscosity, small bump amplitude

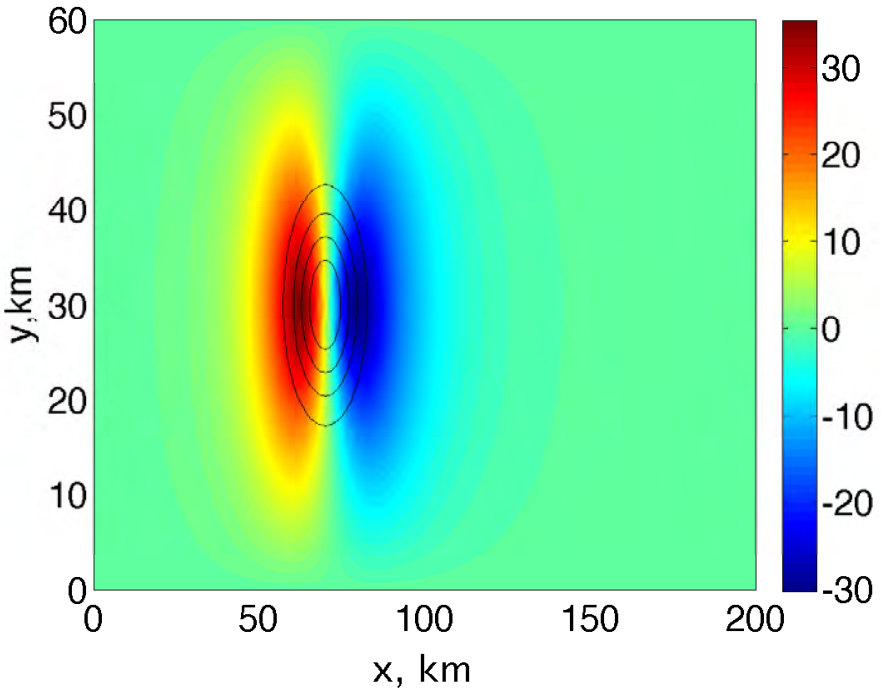
Hybrid model

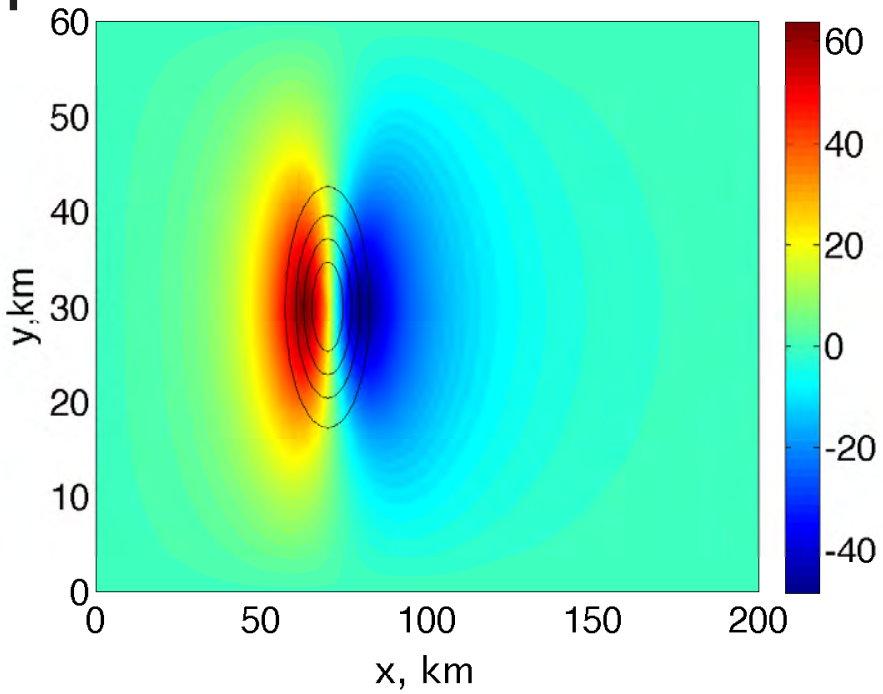
U, m yr^{-1}



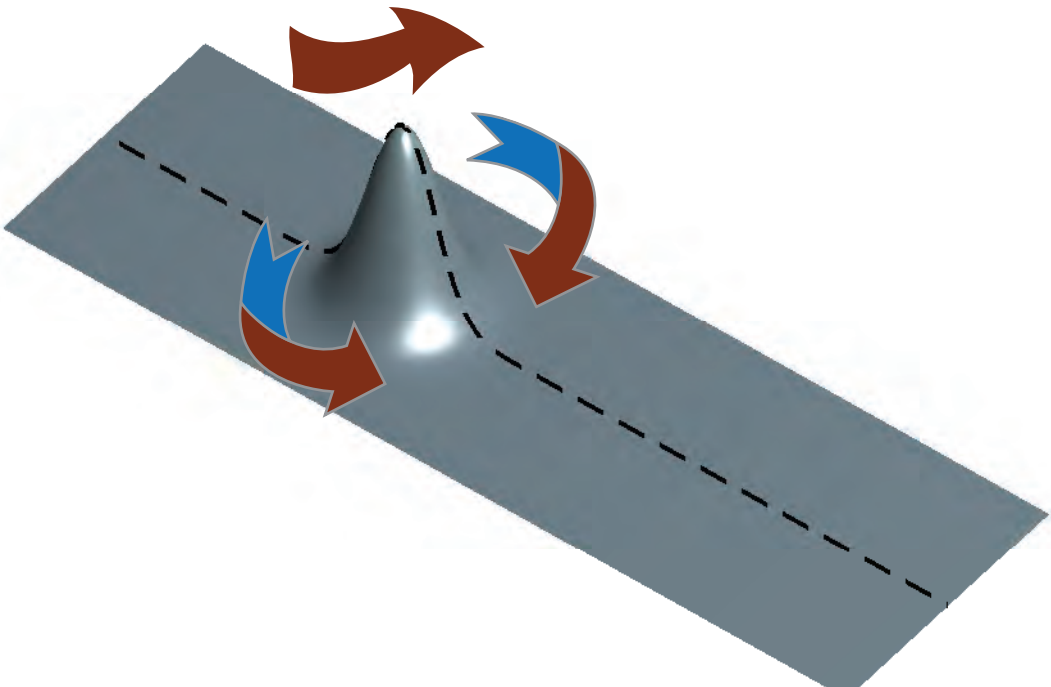


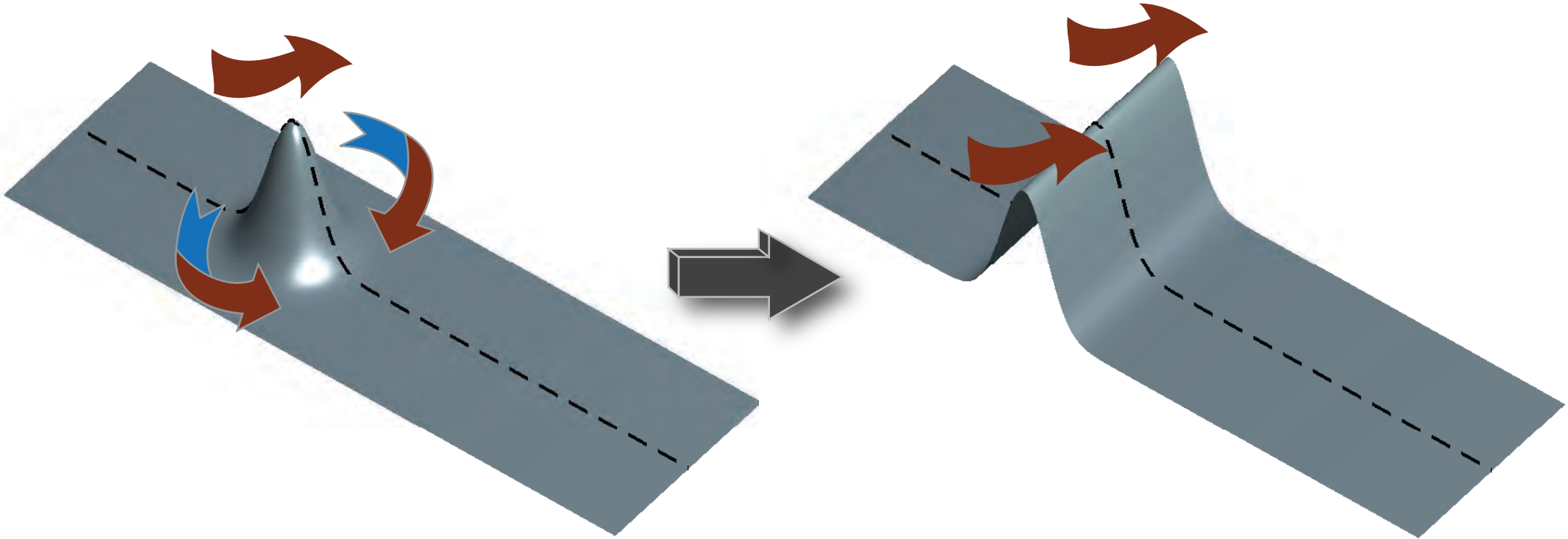
ΔS, m



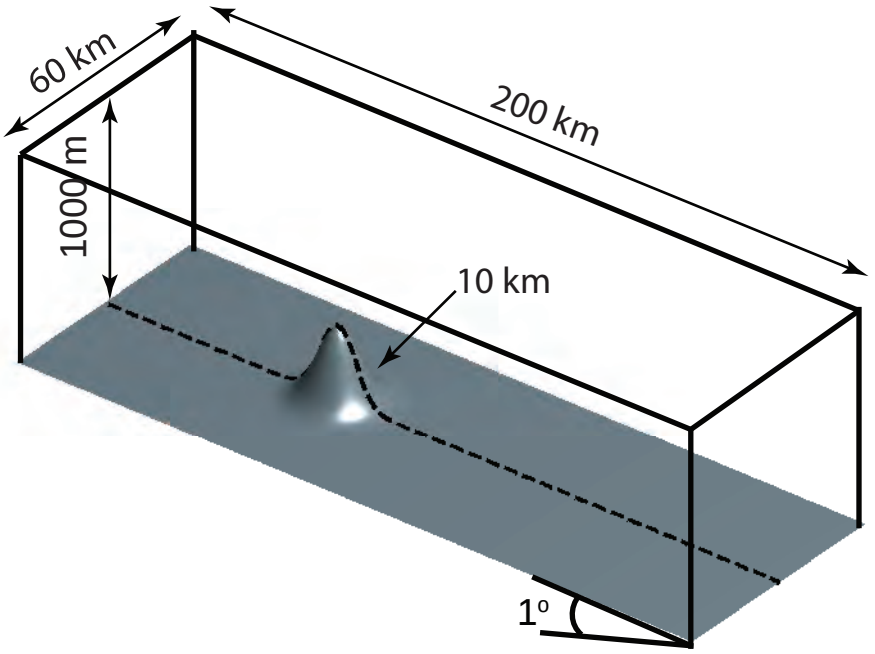


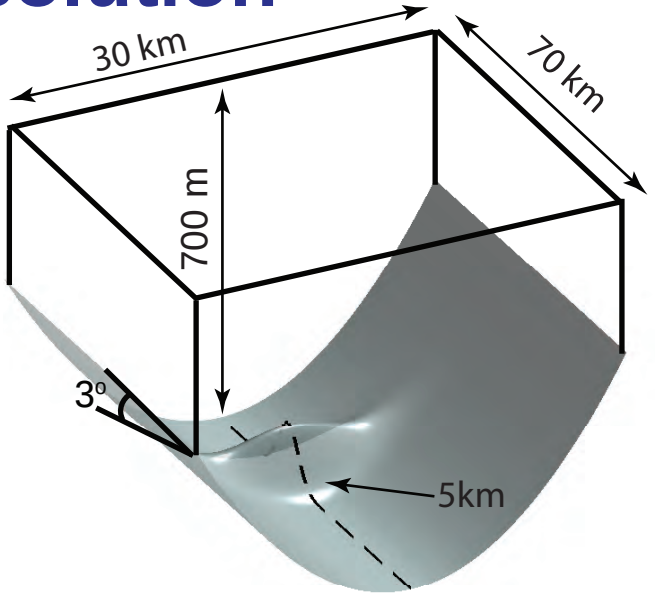
Nonlinear viscosity, arbitrary bump amplitude, Goldberg (2011) hybridization





Topography resolution

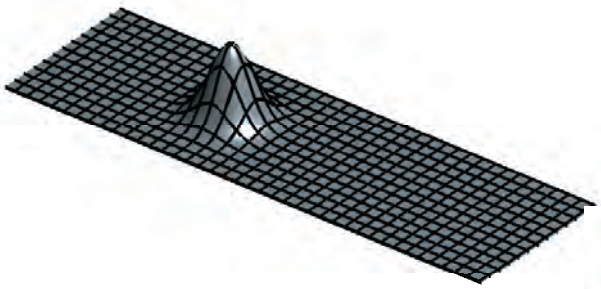


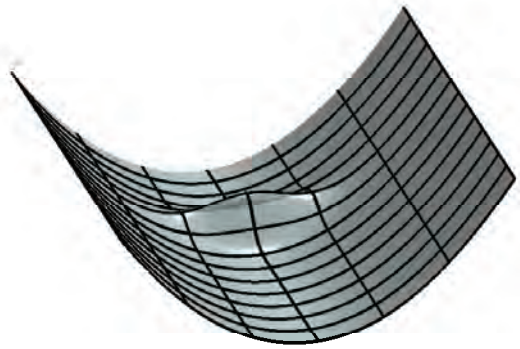


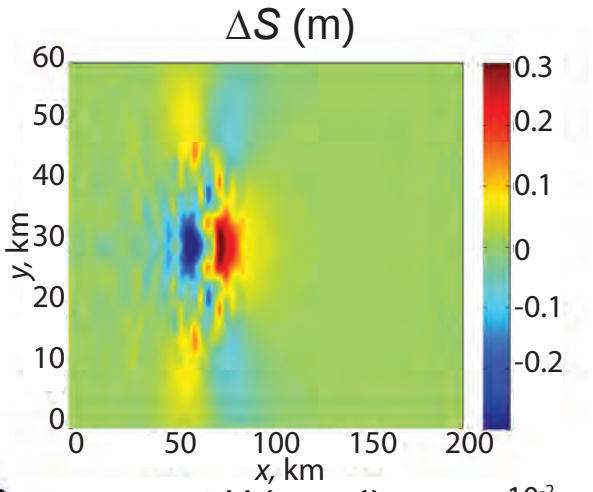
Numerical simulations

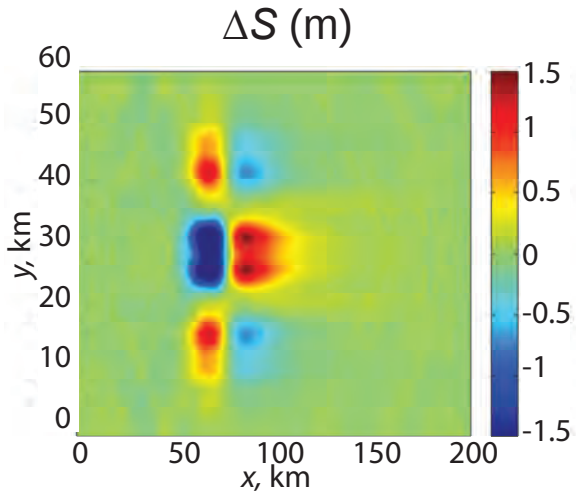
Nonlinear viscosity, arbitrary bump amplitude

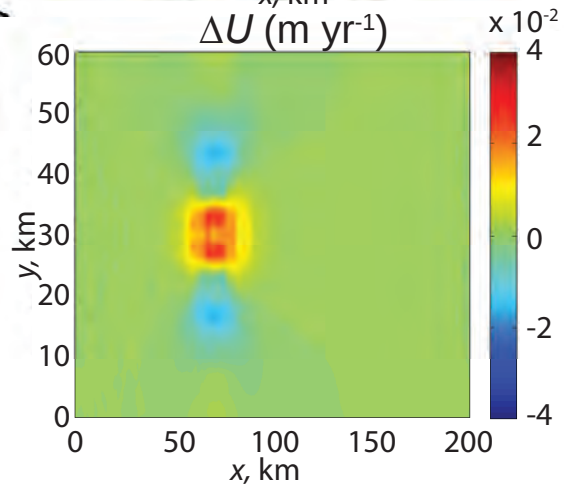
Uniform grid

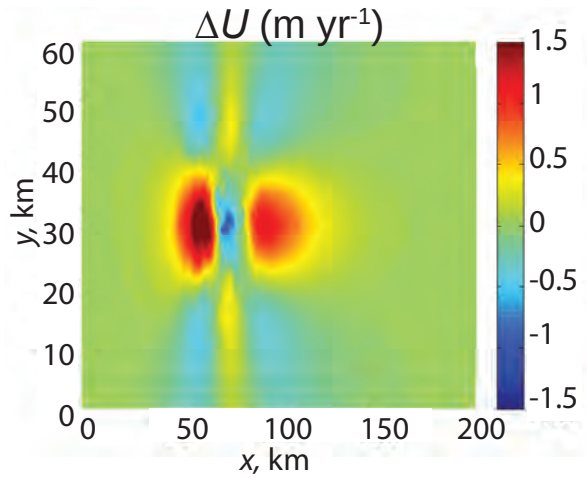




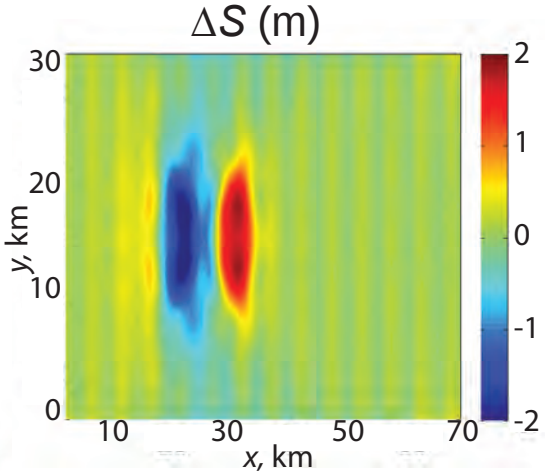




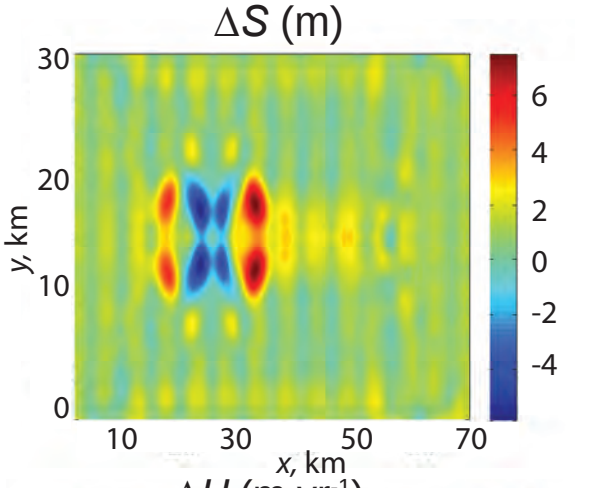


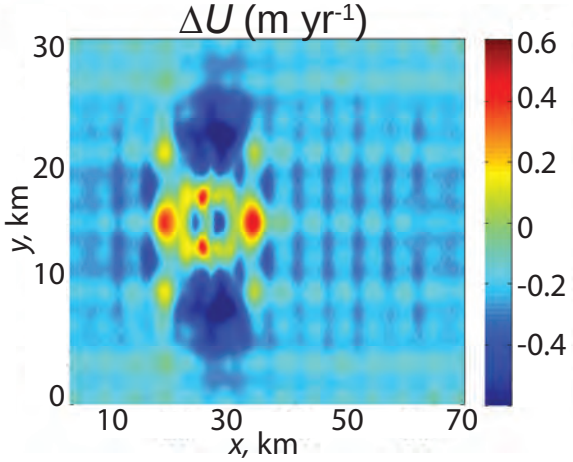


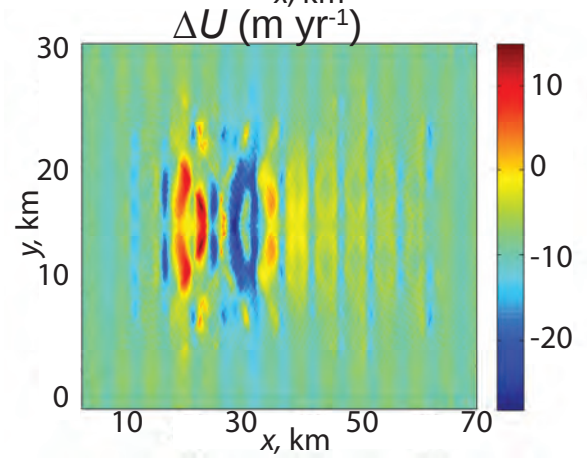
frozen



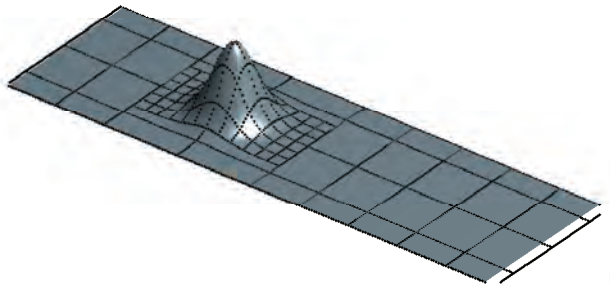
$c = 10^{-9}$ m s^{-1} Pa^{-1}

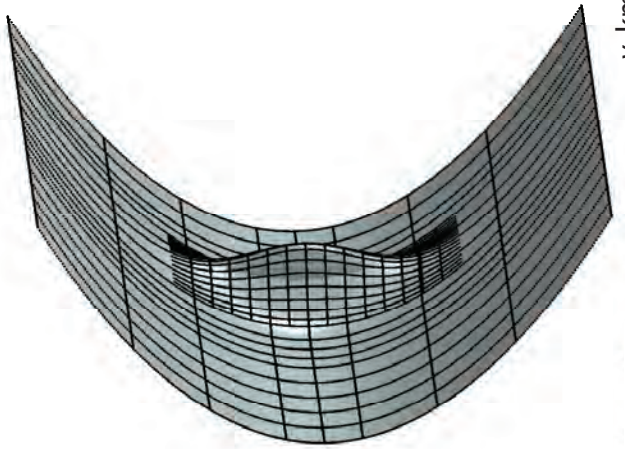


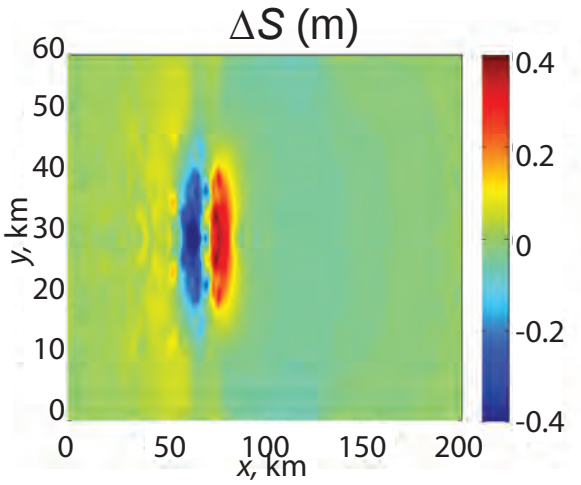


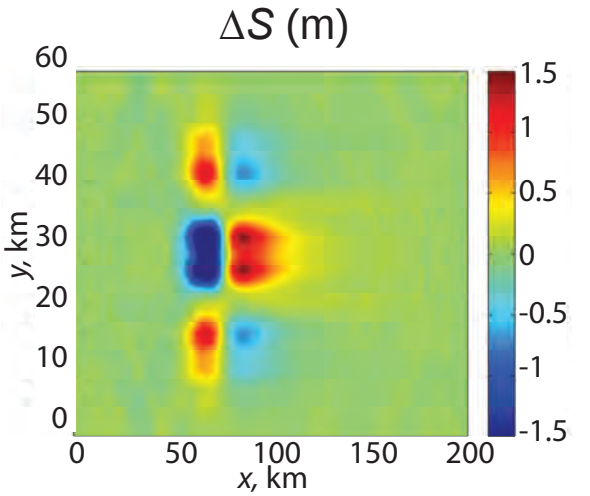


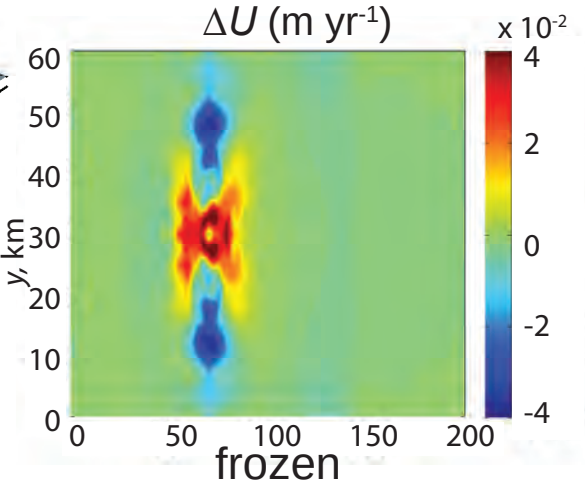
Non-uniform grid

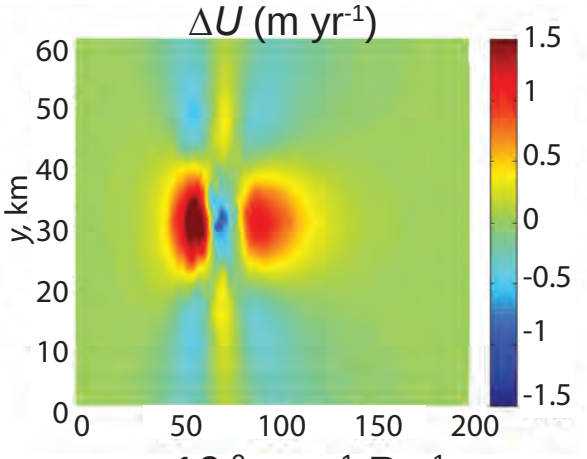












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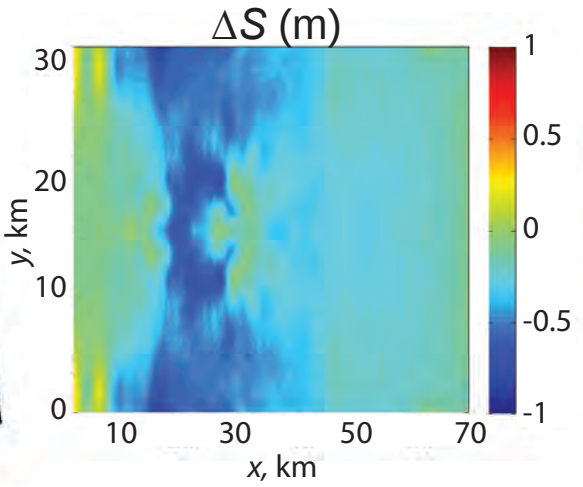
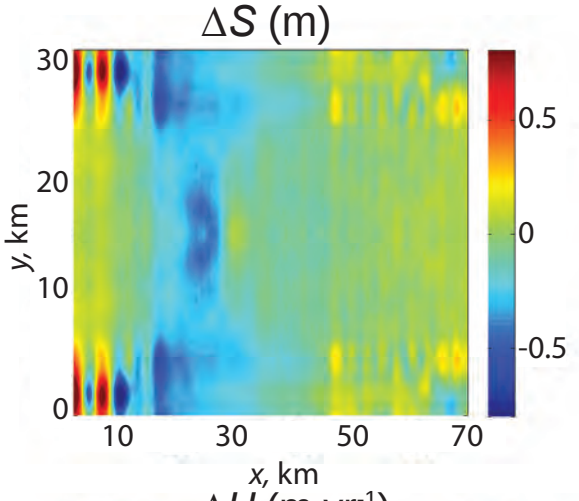
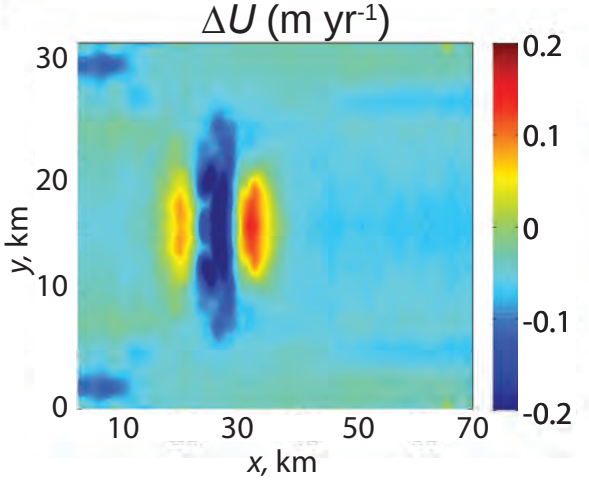
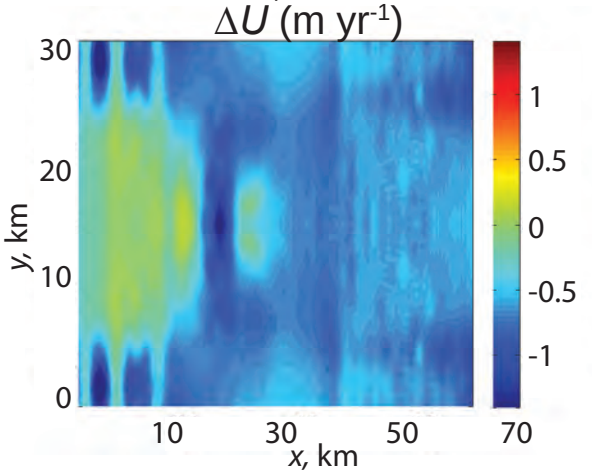


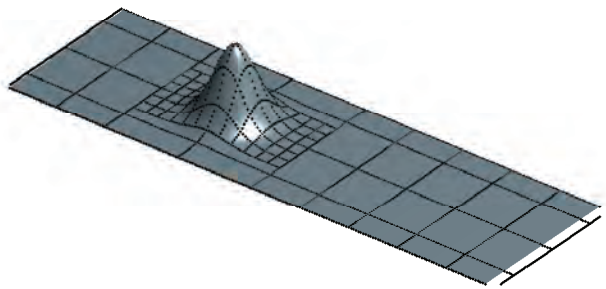
c = 10-9 m s-1 Pa-1

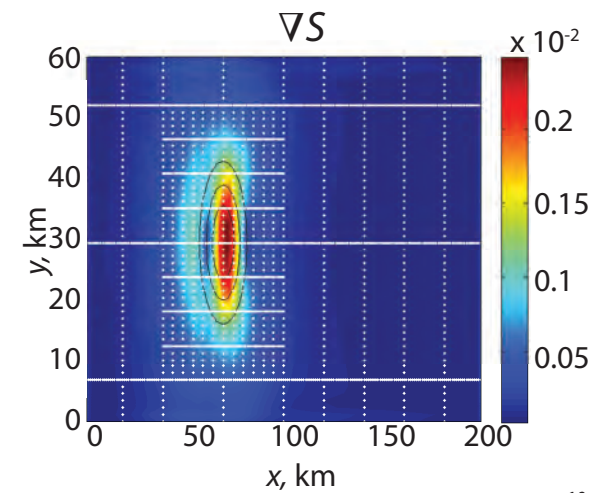


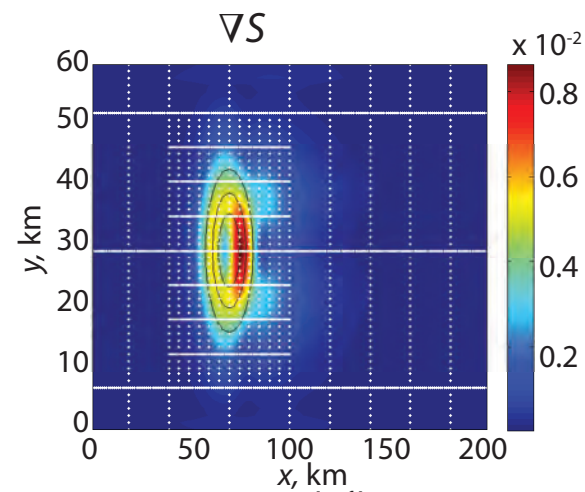


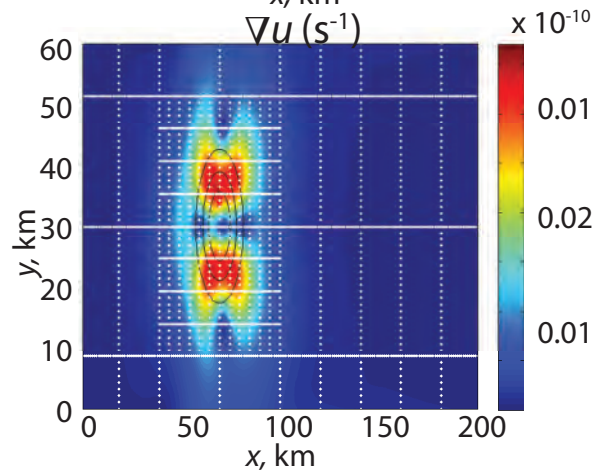


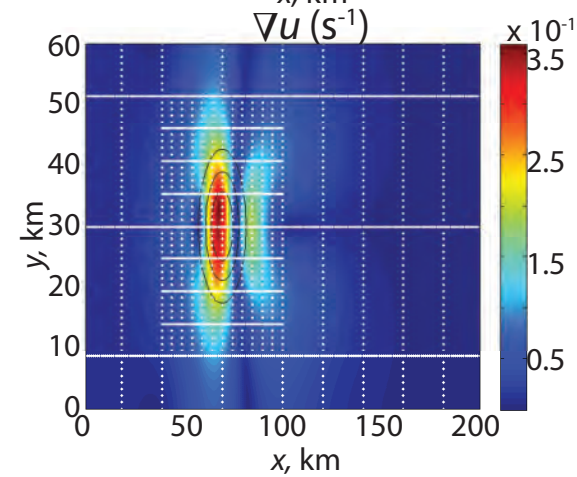
Surface gradients

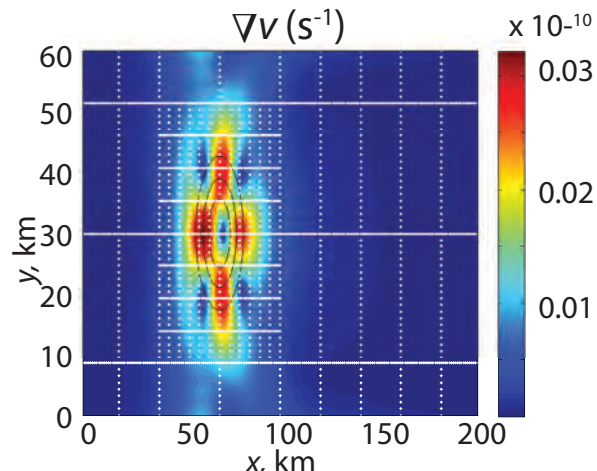












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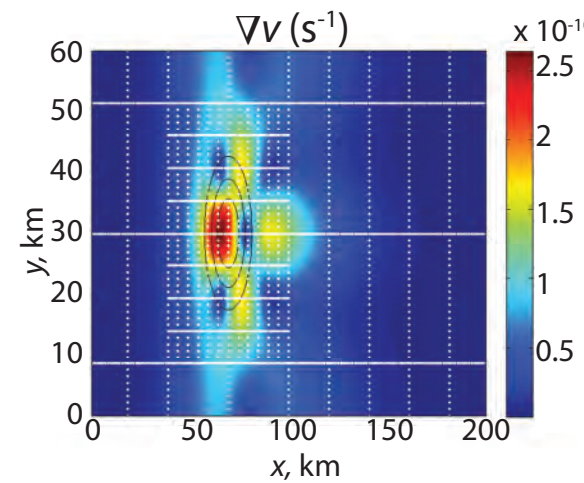
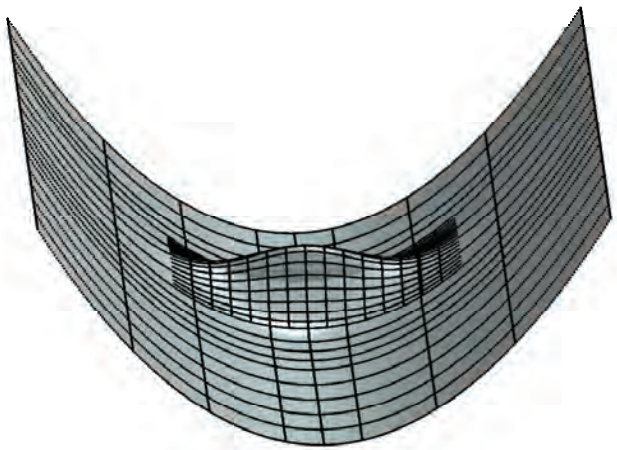
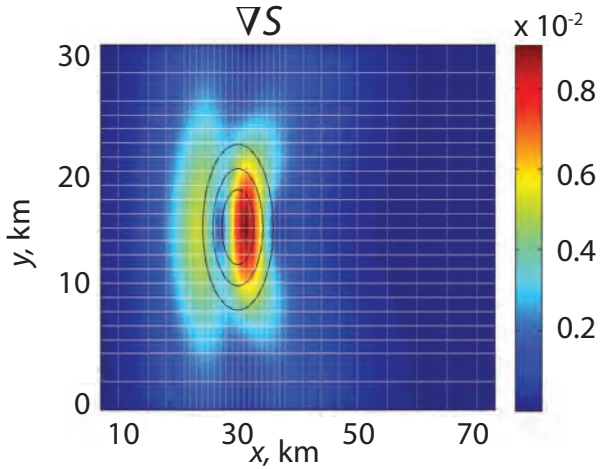
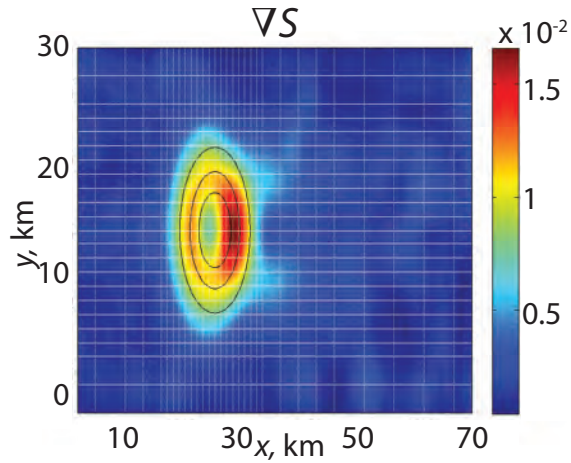


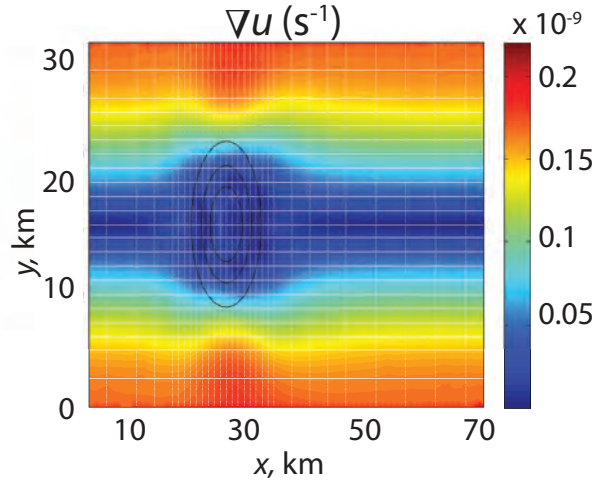
$c = 10^{-9}$ m s^{-1} Pa^{-1}

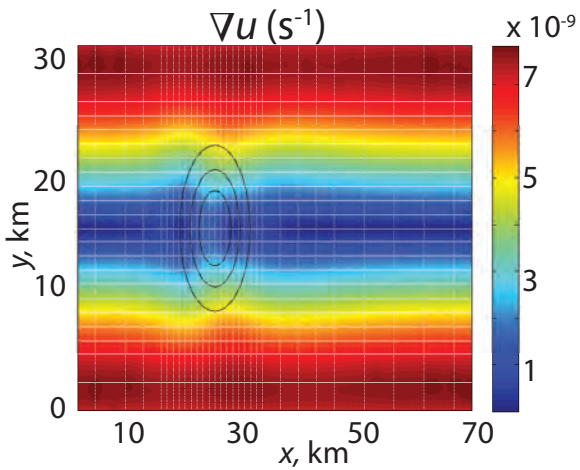
Surface gradients

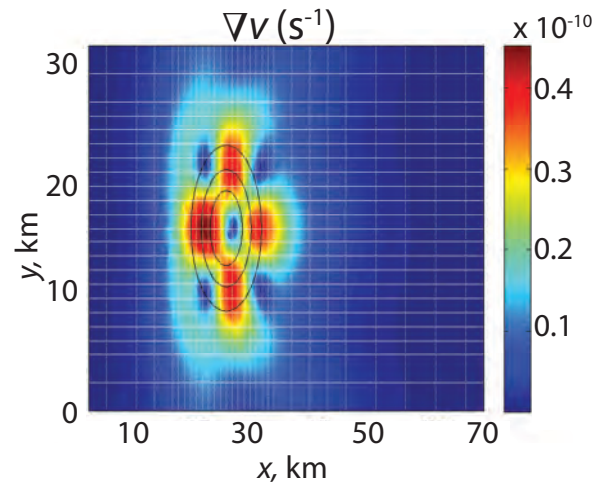


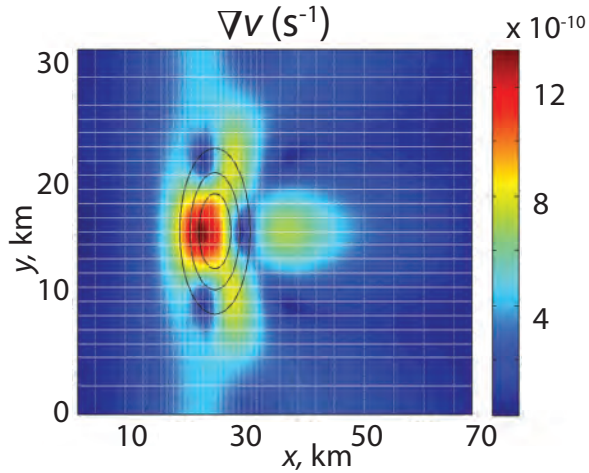








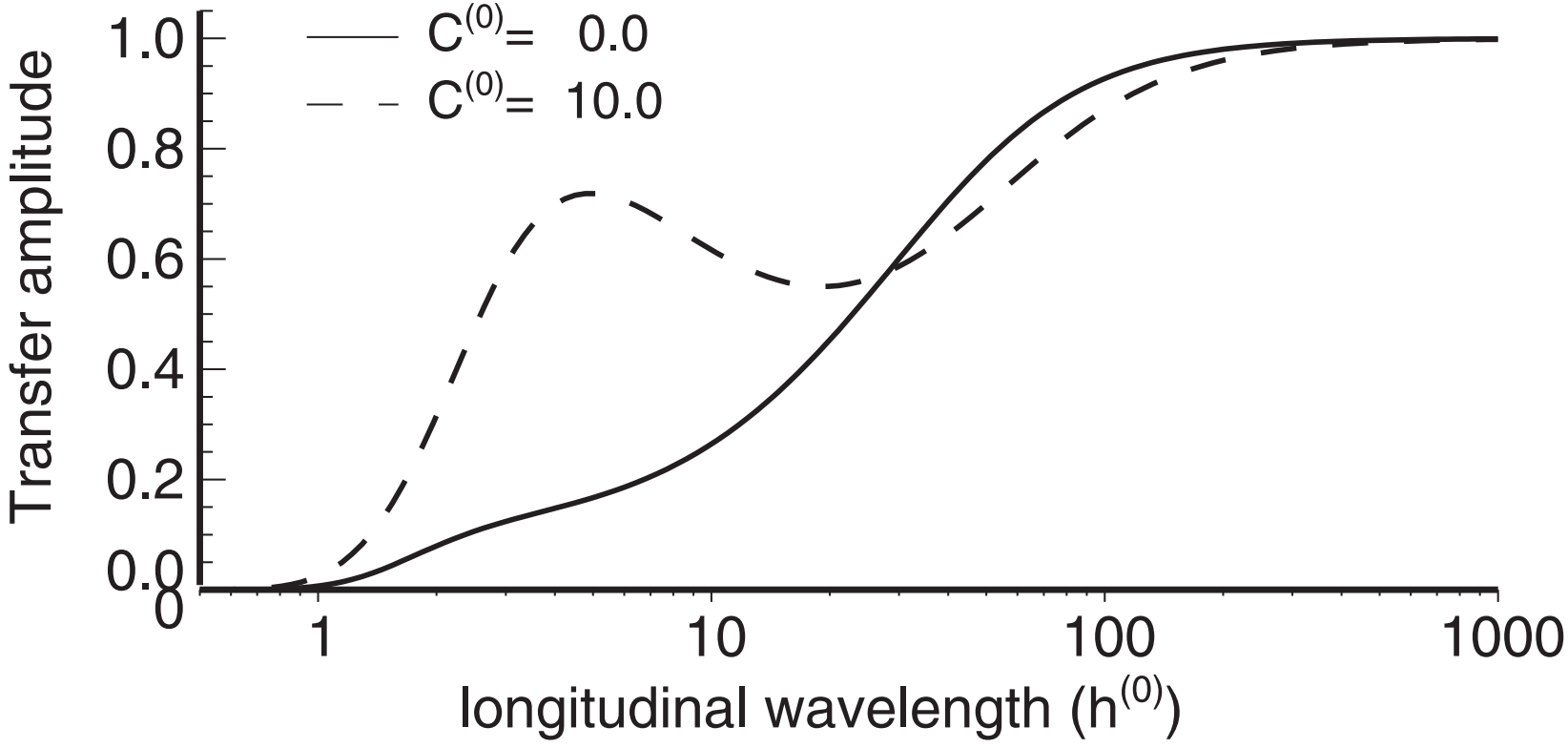




frozen

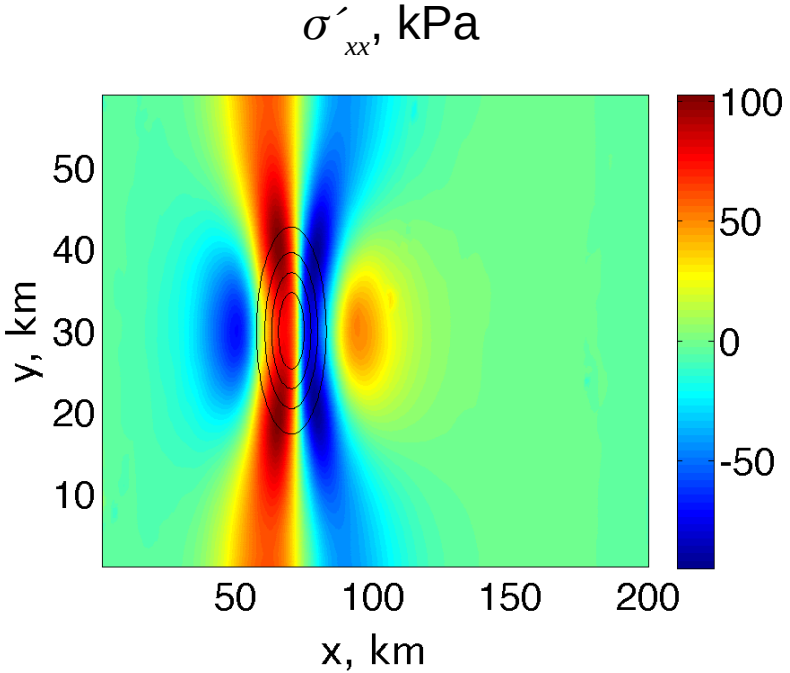
$c = 10^{-9}$ m s^{-1} Pa^{-1}

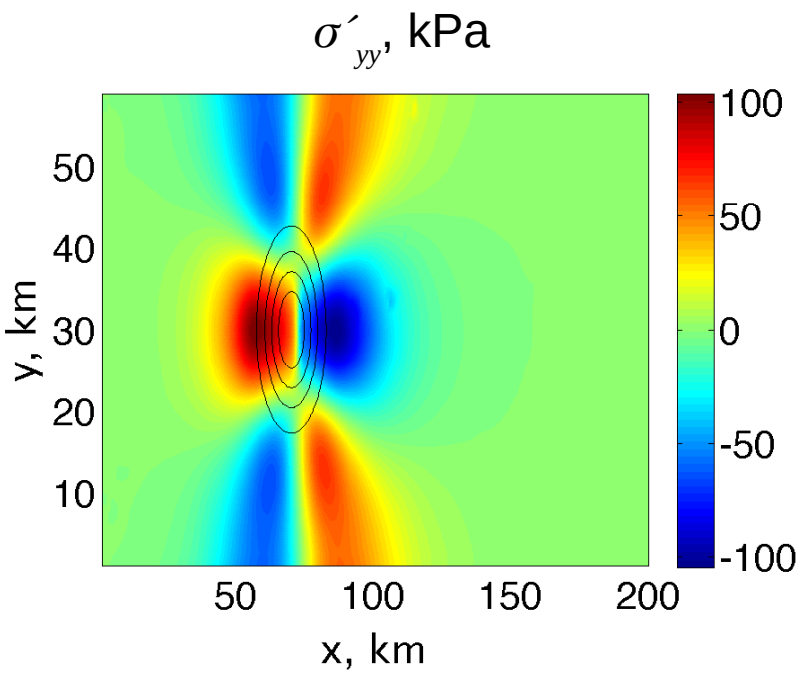
Transfer of bump amplitude to ice surface

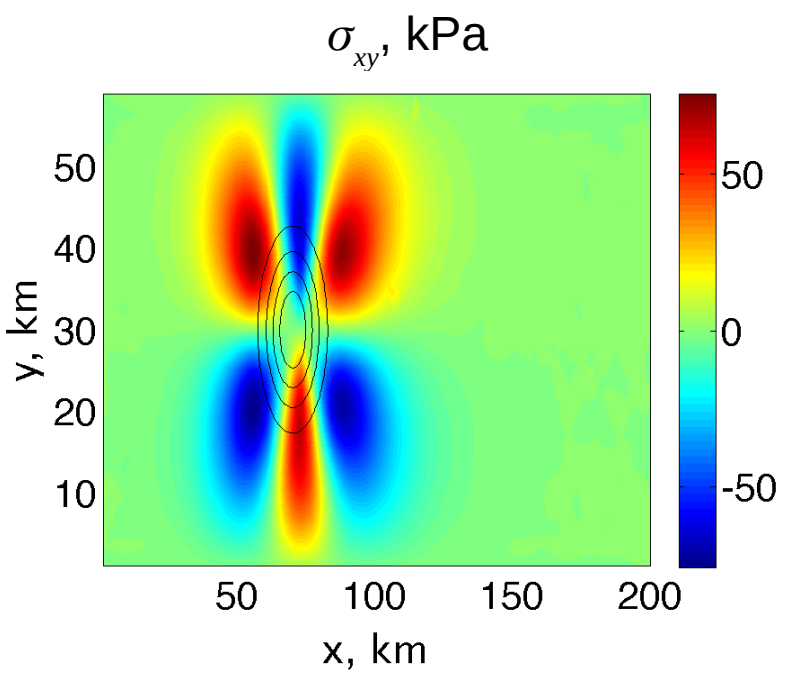


Gudmundsson (2003)

Surface stresses







Nonlinear viscosity, arbitrary bump amplitude

What to do about bumpy beds

If Model:

better to use a hybrid/plane view model
or use width averaged topography for flowband models
and compare with width averaged surface observations

If Measure:

one size of the bed resolution does NOT fit all beds
higher resolution for slippery, high slopes, thinner ice areas
transfer functions and surface gradients help

In the field:

bumps affect areas much larger than they are
measurements along the centerline are NOT representative
so plan field measurements accordingly