SNAC-CHILD Coupling: Preliminary Results Towards Interoperable Modeling Frameworks

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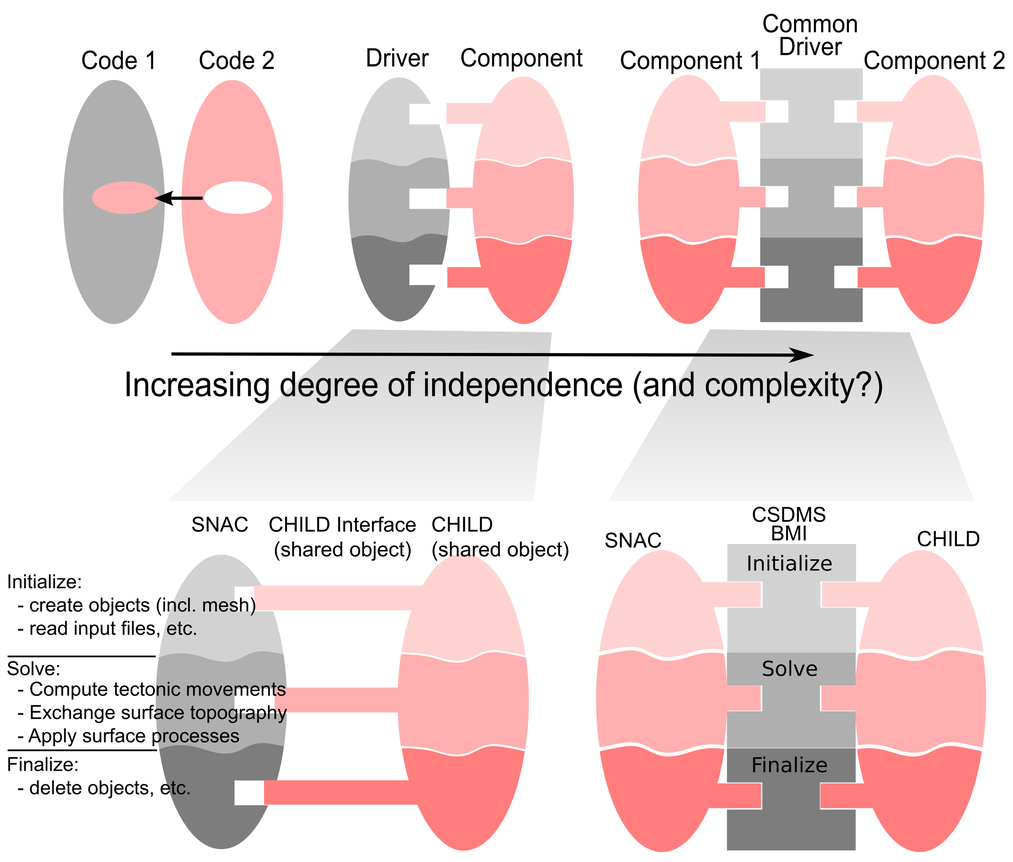
Abstract

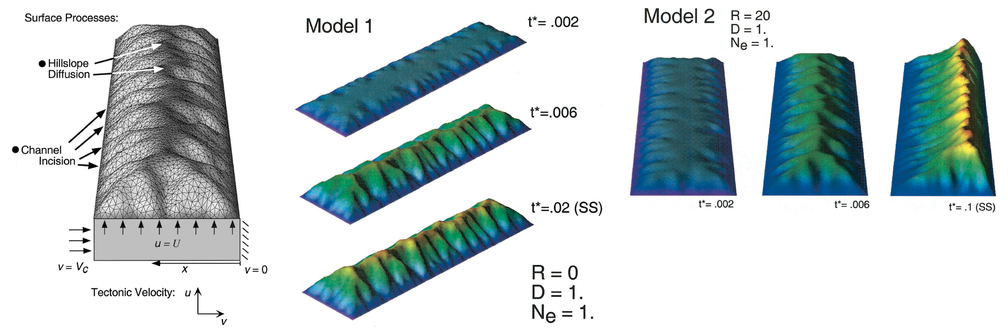
Geodynamic modeling of the Earth's subsurface provides critical boundary conditions for surface dynamics and deformation modeling, at various time scales. This in turn may be used to investigate the formation of specific landscape and geology configurations. Linking these two scientific tool chains, and the corresponding communities, through setting up an interoperability protocol between a framework for tectonic modeling applications, Pyre, and the CSDMS model coupling approach is one of the direct aims of the on-going EarthCube Building Blocks project, *Earth System Bridge: Spanning Scientific Communities with Interoperable Modeling Frameworks*. I present preliminary works towards coupling SNAC, a Pyre-compatible application for tectonic modeling, with CHILD, a landscape evolution modeling code available as a component of the CSDMS Modeling Toolkit. As a proof of concept, a coupling scheme has been implemented without making explicit use of any framework. This simplistic coupling scheme is described, validated through non-trivial models, and discussed in terms of the interoperability of frameworks.

Bridging Modeling Frameworks: Work Plan



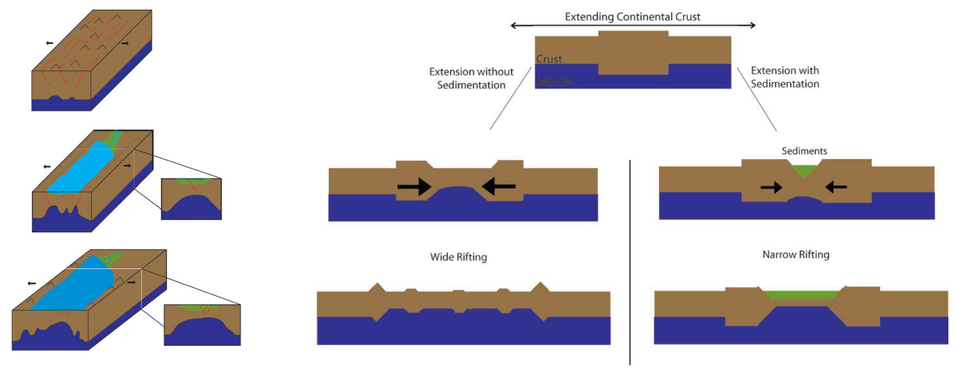
Tectonically-Driven Landscape Evolution

◇ Erosion in a convergent orogen



(*Willett et al.*, 2001)

◇ Sedimentation and the rifting style

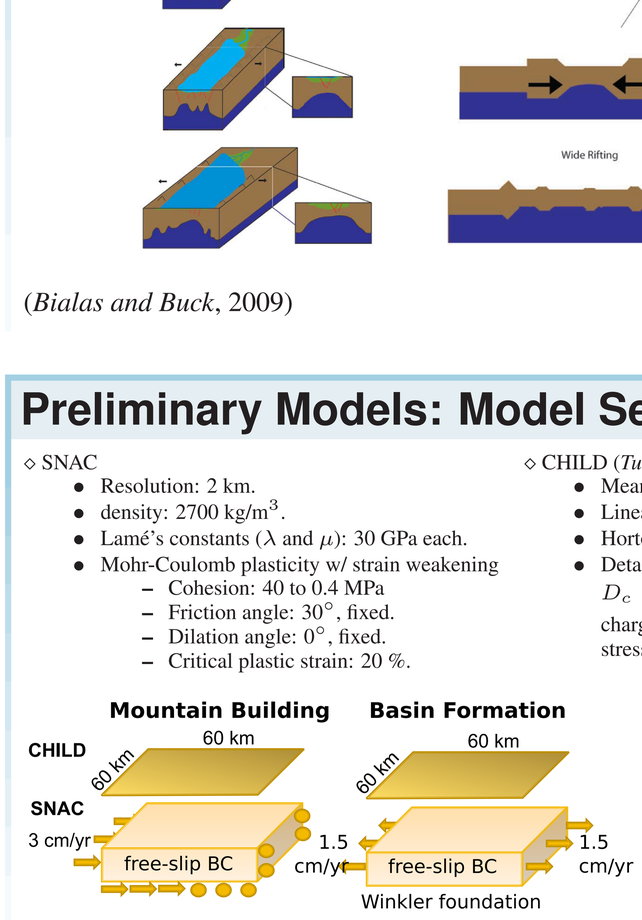


(*Bialas and Buck*, 2009)

Preliminary Models: Model Setup

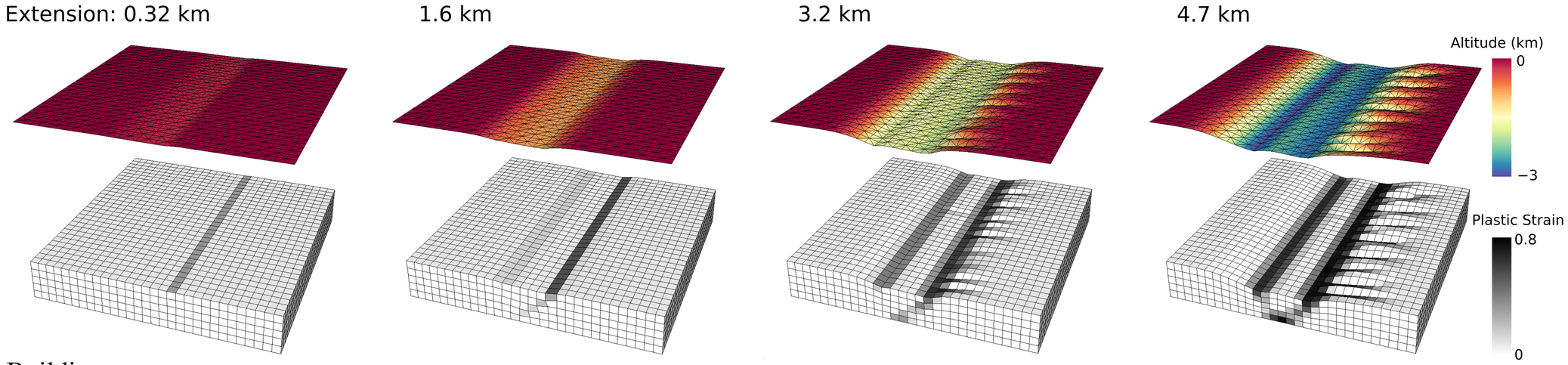
◇ SNAC
- Resolution: 2 km.
- density: 2700 kg/m^3.
- Lamé's constants (λ and μ): 30 GPa each.
- Mohr-Coulomb plasticity w/ strain weakening
  - Cohesion: 40 to 0.4 MPa
  - Friction angle: 30°, fixed.
  - Dilation angle: 0°, fixed.
  - Critical plastic strain: 20 %.

◇ CHILD (*Tucker et al.*, 2001)
- Mean rainfall intensity: 10 m/yr
- Linear diffusion: $k_D = 0.03$ m^2/yr.
- Hortonian flow generation with infiltration capacity of 0 m/yr.
- Detachment-limited water erosion: $D_c = k_b \left(k_t \left(\frac{Q}{W} \right)^{m_b} S^{n_b} - \tau_{cb} \right)^{p_b}$, where Q is total discharge, W is channel width, S is local slope and τ_{cb} is critical shear stress for detachment.
  - k_b=1e-8, k_t=987.3, m_b=2/3, n_b=2/3, p_b=1.5, and $\tau_{cb} = 30$ Pa.
  - $W = W_b (Q/Q_b)^{\omega_s}$ and W_b is bankfull width given as $k_w Q_b^{\omega_b}$ where Q_b is bankfull discharge.
  - k_w=10, Q_b=?, and ω_b=ω_s=0.5.

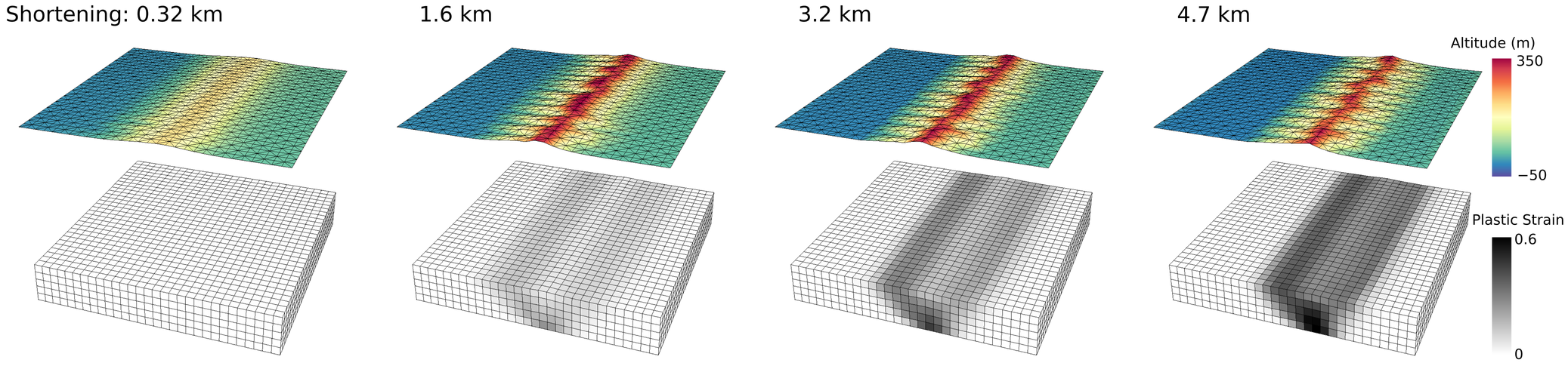


Preliminary Models: Results

◇ Basin Formation



◇ Mountain Building



Future Work

- Parallelization for higher resolution models. SNAC: MPI-parallel. CHILD: Not parallel yet. Which parallelization strategy: MPI, OpenMP, or accelerator?
- Synchronizing the two codes in case *dt*'s are significantly different.
- ***Short-term goal*: Porting SNAC to BMI**. Can this automatically and efficiently address the above two issues?
- Maybe time to move on to coupling DynEarthSol3D (*Tan et al.*, 2013), a successor of SNAC, and CHILD (or Landlab)?

References

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Tan, E., E. Choi, L. Lavier, and V. Calo (2013), DynEarthSol3D: An Efficient and Flexible Unstructured Finite Element Method to Study Long-Term Tectonic Deformation,, *Abstract DI31A-2197 presented at 2013 Fall Meeting, AGU, San Francisco, Calif., 9-13 Dec.*

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