Fault Dislocation Modeling of Tectonic Landforms in Mare Frigoris

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SSERVI NESF

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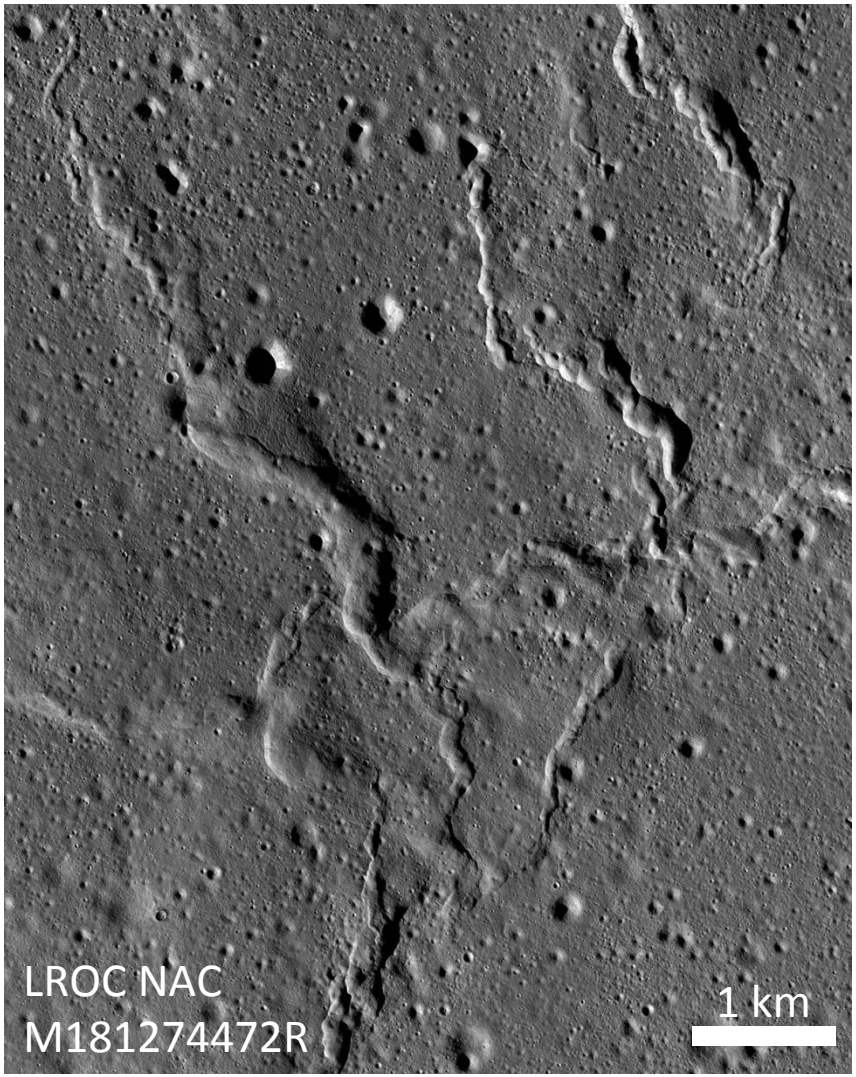
Outline

- Mare Tectonism
- Case Study: Mare Frigoris
- Fault Dislocation Modeling
- Preliminary Results
- Conclusions
- Future Work

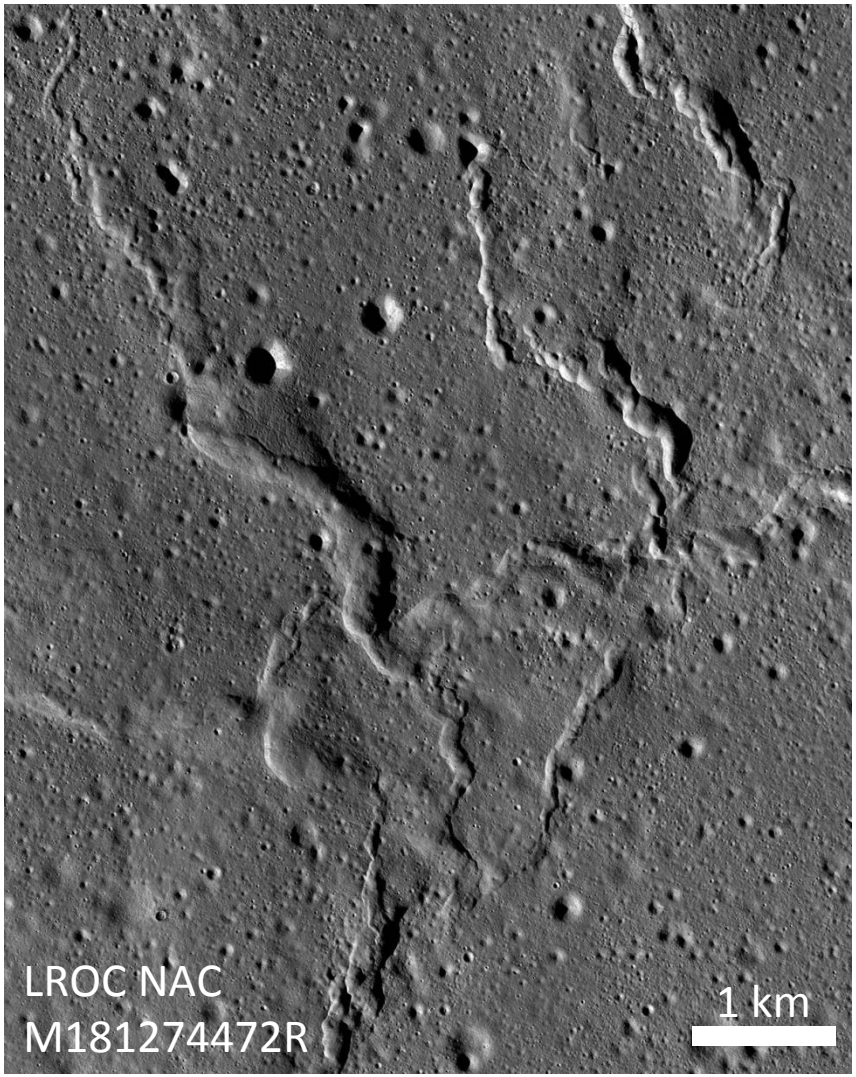
Mare Tectonism Overview (1/2)

- In nearside basins, large-scale extensional tectonism ended ~3.6 Ga and contractional tectonism ended ~1.2 Ga [Lucchitta and Watkins, 1978; Solomon and Head, 1979, 1980; Hiesinger et al., 2003]
- Contraction is primarily accommodated by sinuous wrinkle ridges that are interpreted as folded basalt layers overlying thrust faults [Plescia and Golombek, 1986; Golombek *et al*., 1991; Schultz, 2000; Watters, 2004; Watters and Johnson, 2010]

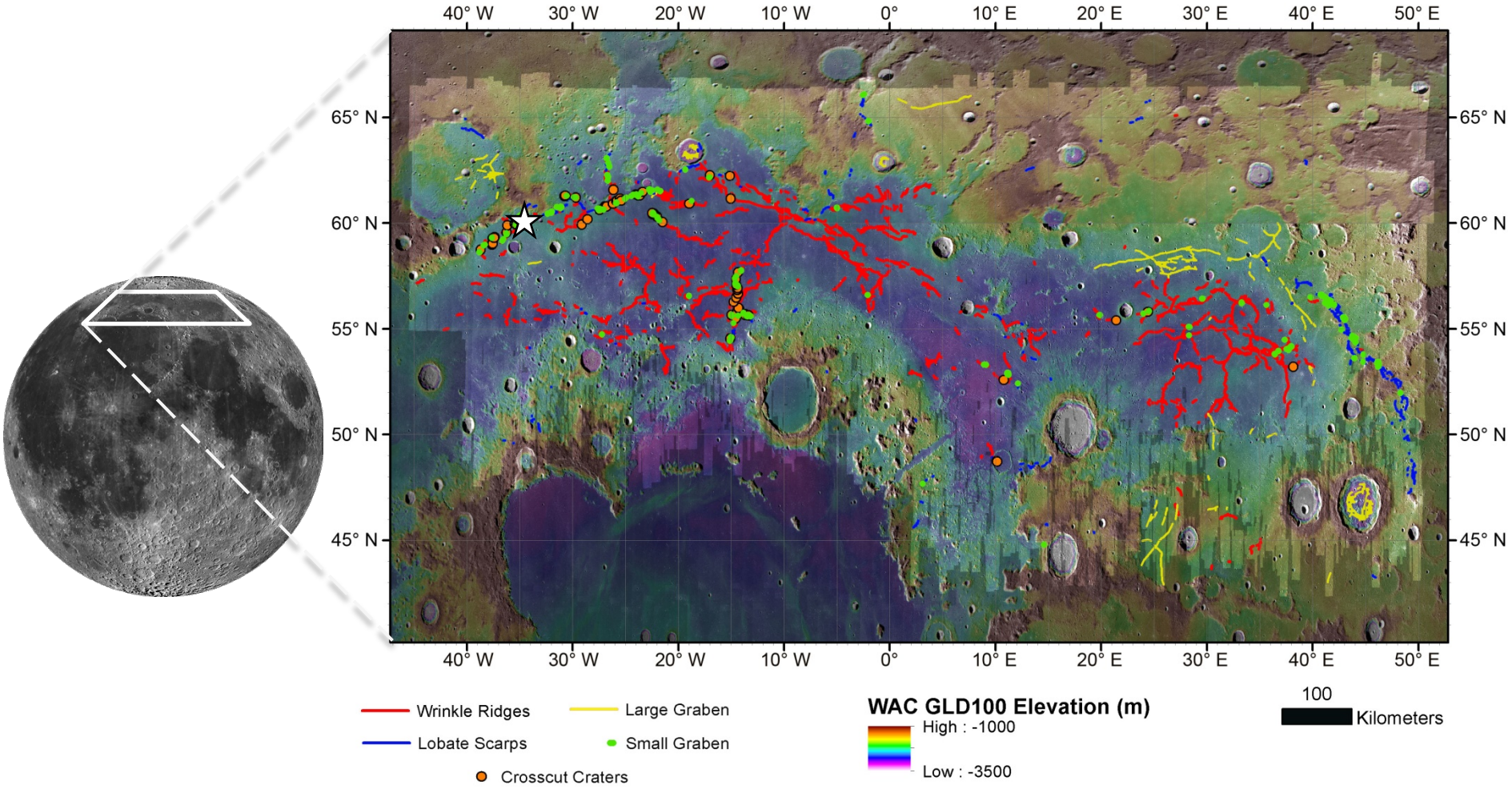


Mare Tectonism Overview (2/2)

- In some mare, wrinkle ridges occur radial to or concentric with the basin centers and are associated with mascons where subsidence causes flexural bending and compression [Solomon and Head, 1979, 1980]
- Not all mare are associated with mascons, but still contain wrinkle ridges
- Origin of compressional stresses in non-mascon environments remains an outstanding question

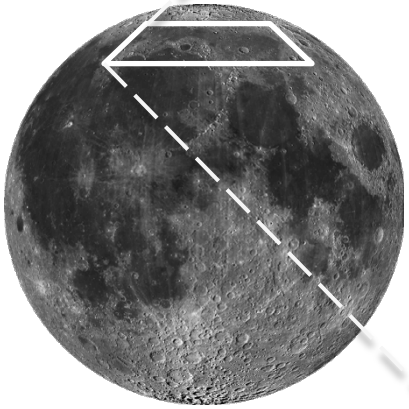


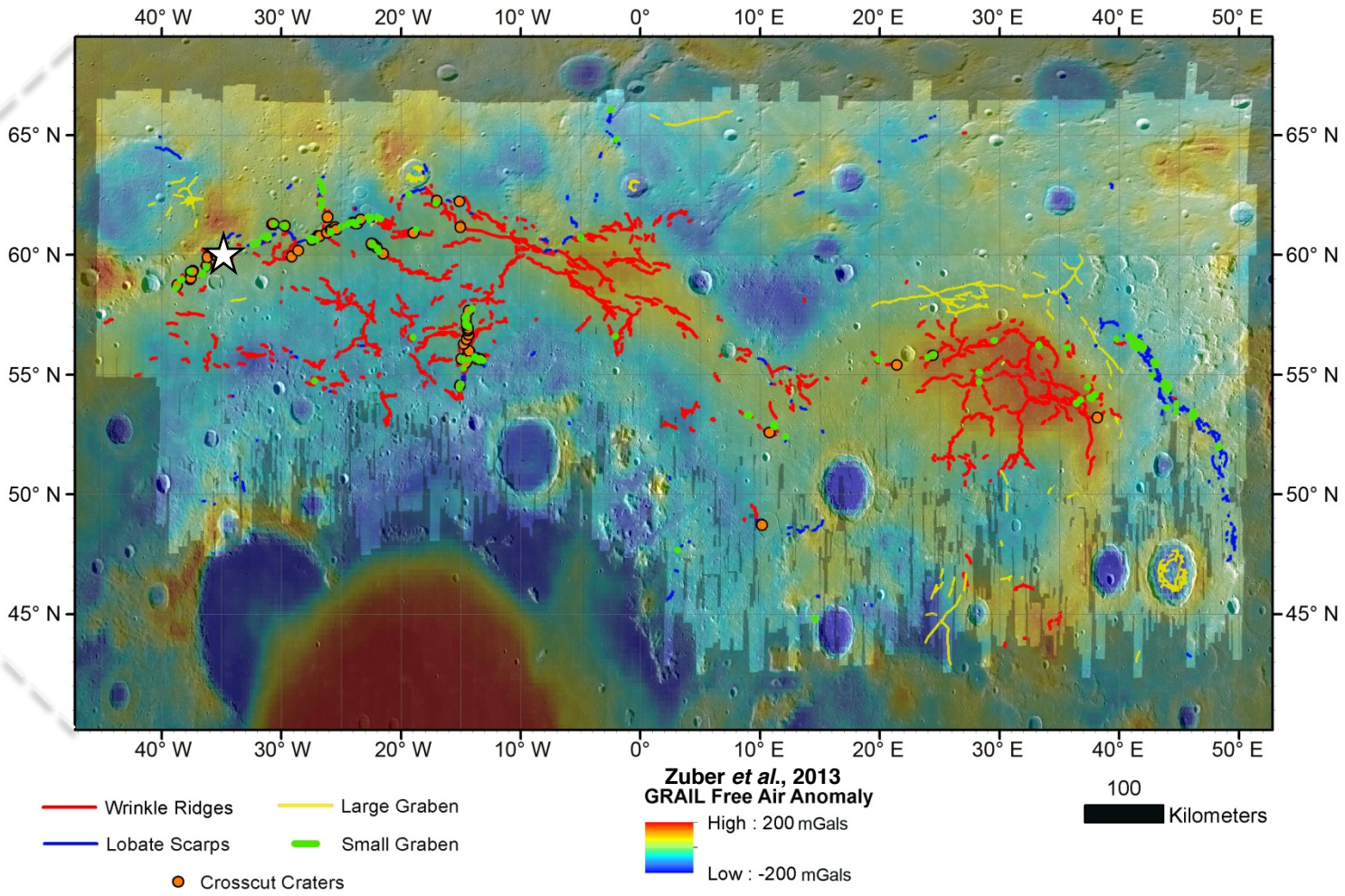
Non-Mascon Case Study: Mare Frigoris



Western Mare Frigoris on the northern nearside is a prime example of a non-mascon basin with numerous wrinkle ridges and other tectonic landforms [Whitford-Stark, 1990; Williams *et al.*, 2014]

Non-Mascon Case Study: Mare Frigoris





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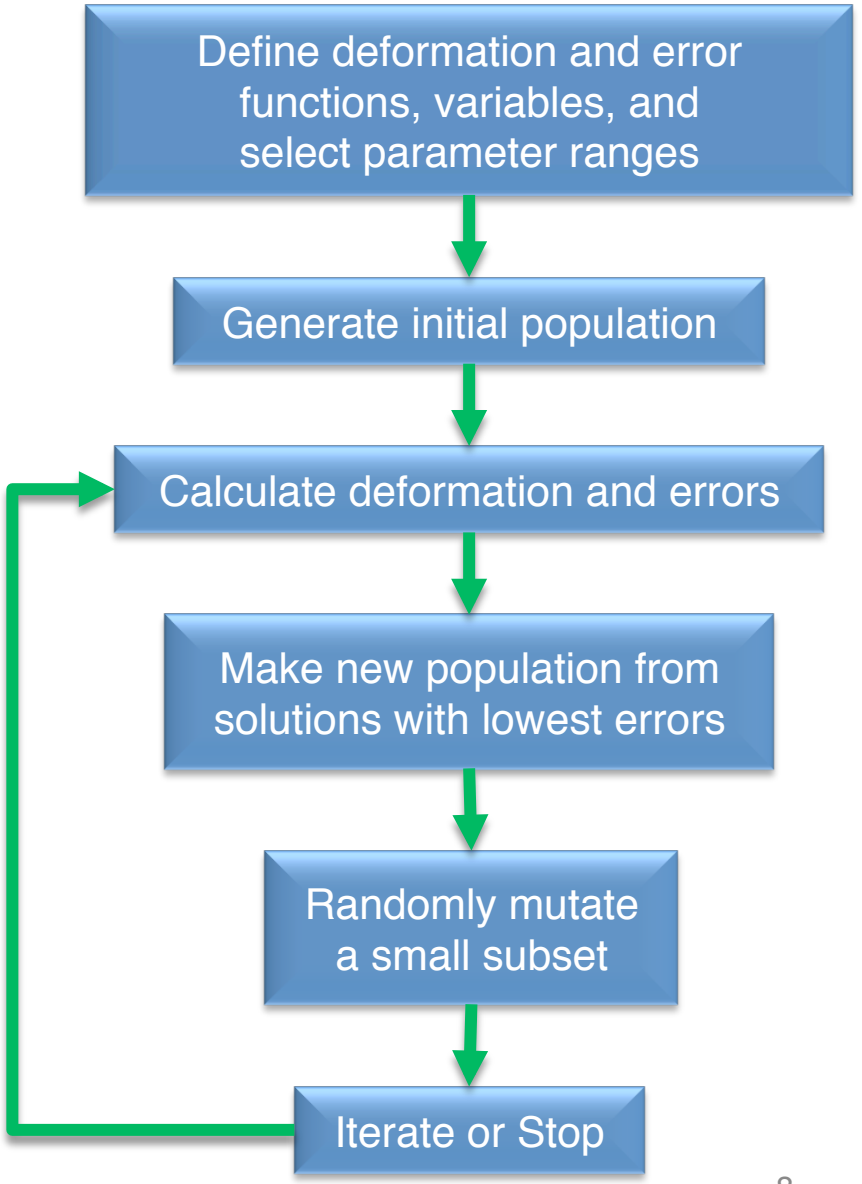
Fault Dislocation Modeling

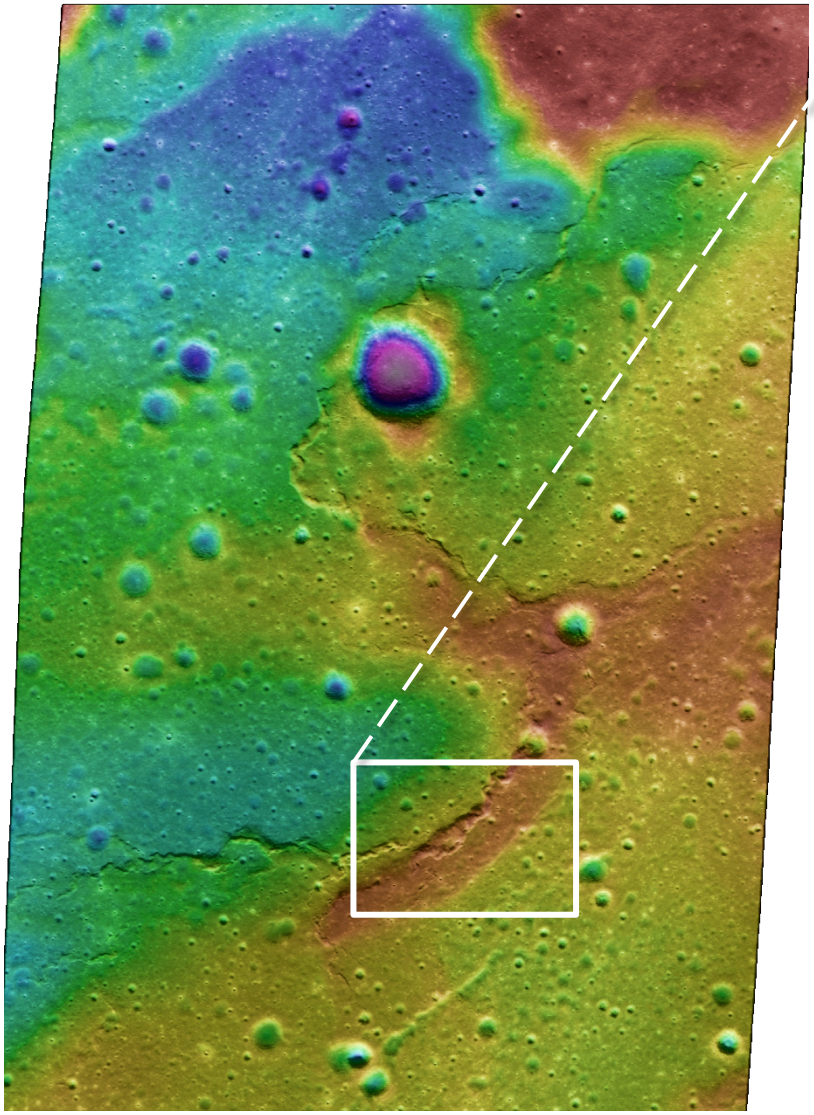
- A key step to better understanding the occurrence of wrinkle ridges in non-mascon basins is characterizing the behavior of the underlying faults
- Surface deformation of faults in a half-space follows a set of analytical nonlinear equations [Okada, 1985,1992]
- We apply fault dislocation modeling to estimate geometries and displacements for selected wrinkle ridge faults in Mare Frigoris [Schultz, 2000; Watters and Schultz, 2004; Williams *et al*., 2013]
- Fault models are constrained by Digital Terrain Models (DTMs) derived from Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) stereo pairs [Schultz, 2000; Watters and Schultz 2004; Tran *et al*., 2010; Williams *et al*., 2013]

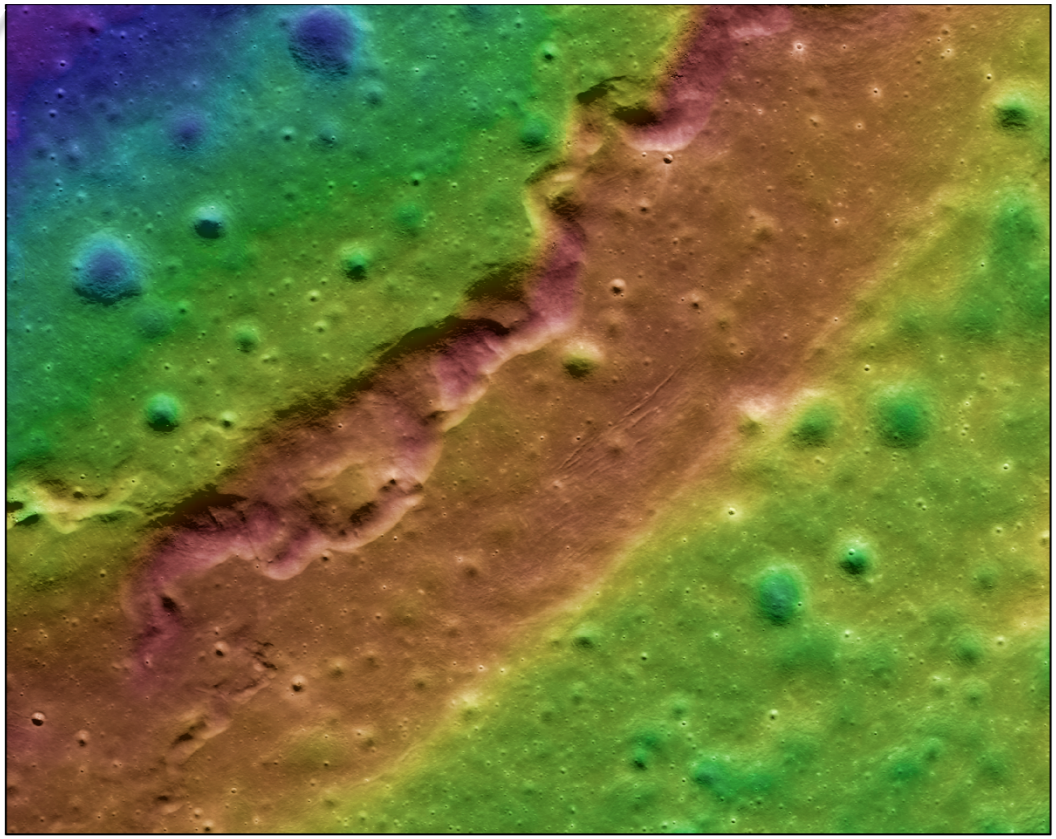
Inverting Topography with a Genetic Algorithm

- Genetic algorithms allow for simultaneous estimation of multiple variables in nonlinear systems
- For our fault model, we find solutions for fault location, size, depth, slip, strike, and dip of each fault patch
- We solve for fault planes deepening at constant or decreasing dip angles
- Iterate for 1,000+ generations, and repeat 100+ times to empirically determine error



Modeled Wrinkle Ridge in Mare Frigoris





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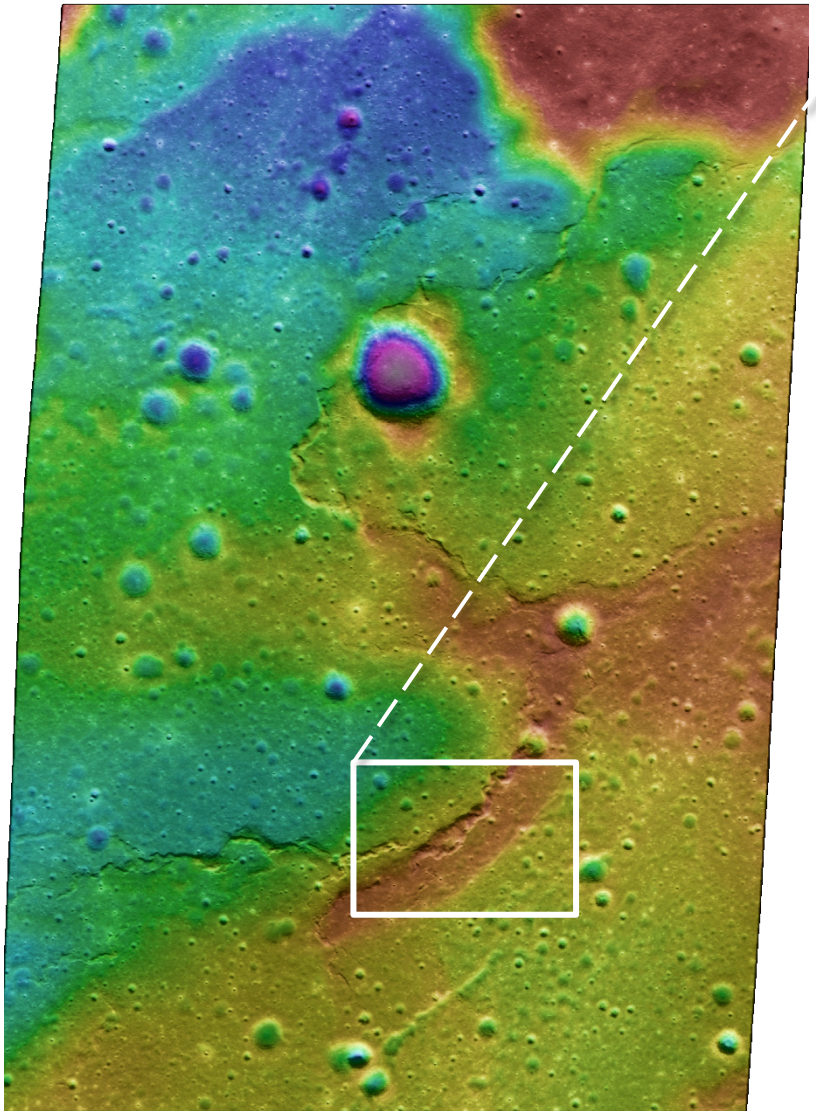
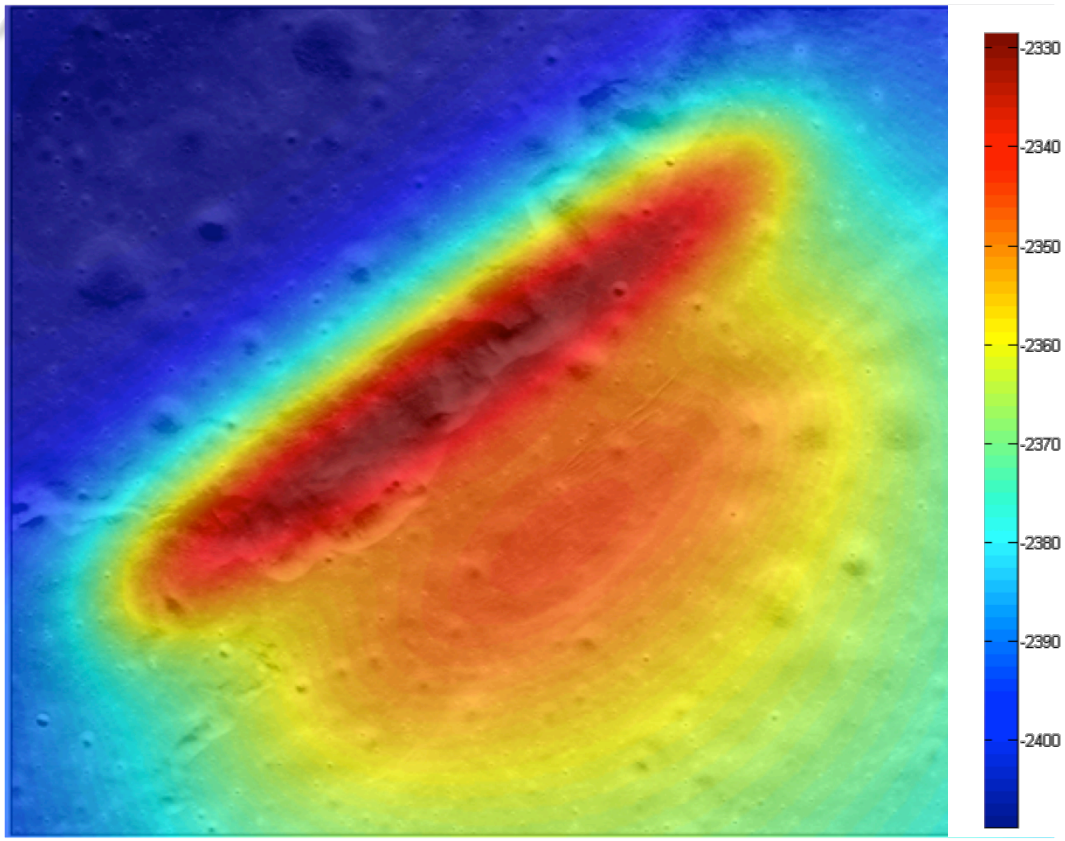
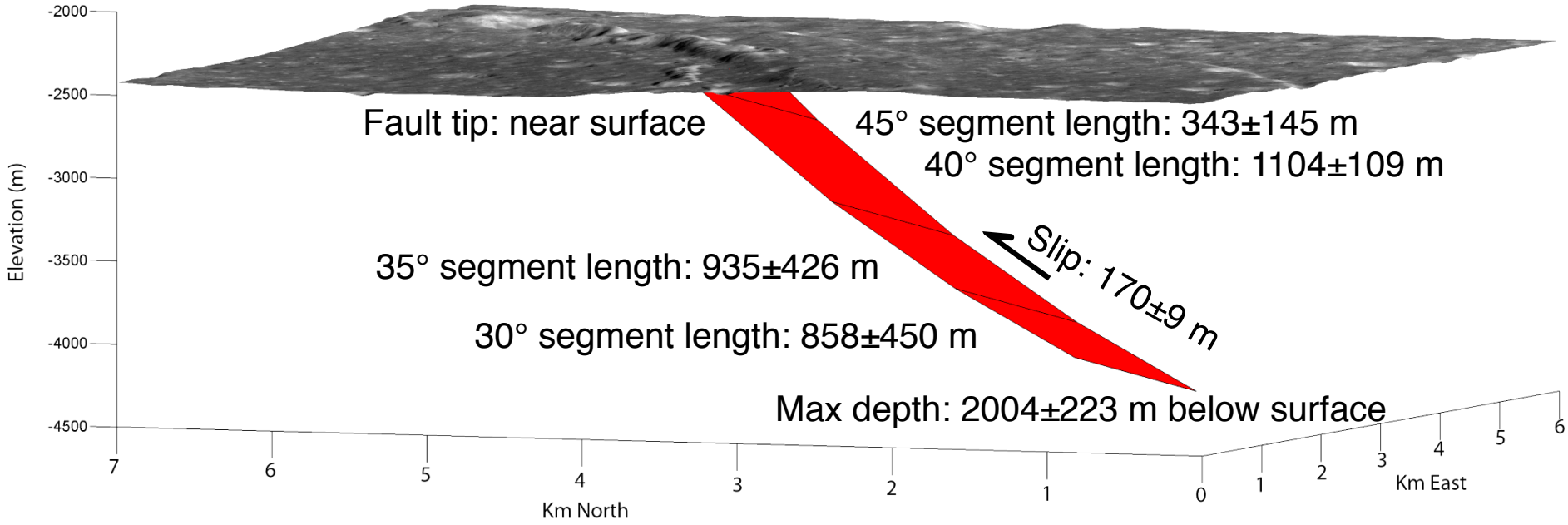




Genetic Algorithm Median Solution

Preliminary Model Results



*Lesser and greater dipping segments had near-zero lengths

<u>The shallow depths suggest that faulting is likely confined to within the mare fill and not rooted deeply in anorthositic crust</u>

Conclusions

- Inverse methods enable simultaneous computation of multiple fault parameters to find optimal solutions
- Preliminary results for a wrinkle ridge suggest faulting occurs shallowly within 2.0 km of the surface
- Wrinkle ridges in non-mascon mare basins may not be rooted in the deeper crust

Future Work

- Non-rectangular (triangular) fault patches will enable continuous modeling of a fault with variable strikes and dips
- Expand models to include spatially variable slip
- Use modeled geometries to constrain near-surface stresses
- Apply to additional wrinkle ridges in Mare Frigoris and globally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Thank you!
Questions?