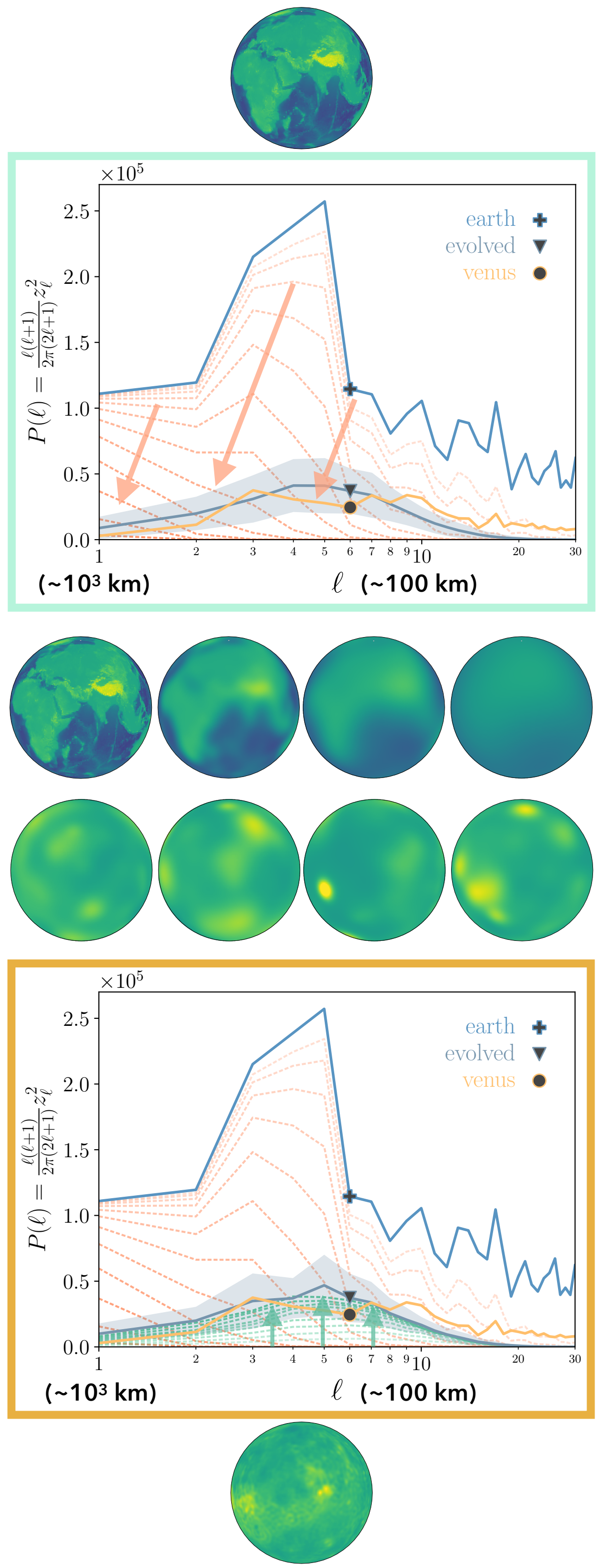
THE STRUCTURE AND EVOLUTION OF TERRESTRIAL TOPOGRAPHY: TURNING EARTH INTO VENUS

A. D. Adams[1] and G. P. Laughlin[2], [1]University of California, Riverside (arthura@ucr.edu), [2]Yale University.

Introduction: Earth's surface structure shows a large contrast between continents and oceans, and maintains active plate tectonics. In contrast, Venus may have had both an Earth-like climate as well as extensive water oceans and active (or incipient) plate tectonics for an extended interval of its history, but now exhibits a nearly unimodal elevation distribution, with roughly 60% of the surface within 500 m of the mean (see e.g. [1]). Under a runaway greenhouse scenario, an Earth-like planet loses its oceans to rapid evaporation [2]. This can potentially lead to rapid continental-scale erosion due to a period of torrential rainfall at very high temperatures.

Model methodology. We develop a simple model to "evolve" Earth's topography by acting on its elevation power spectrum, starting with global diffusion representing ~50 Myr worth of resurfacing from sediment deposition of the scale seen in Earth's rivers. Then we model lava flows as a stochastic process which resurfaces the eroded topography. Our model works directly on the coefficients of the power spectrum with free parameters to set the number, size, and volume of the lava outflows as well as the rate and duration of the global diffusion event.

Applying the model to estimate Venus's topographic history. Venus's surface shows no evidence of recent plate tectonic activity, and is actually quite "young" in geological time (~500 Myr old, see e.g. [3]), suggesting Venus has had a recent global resurfacing. By choosing plausible physical quantities for the parameters in our model, including a volcanic rate similar to that of modern Earth, we estimate it would take ~600 Myr of volcanic activity after wiping out continental features to reproduce a Venusian elevation power spectrum. This scenario is plausible if loss of oceans, the attendant transition to a CO_2-dominated atmosphere, and a subsequent rapid continental-scale erosion were followed by gradual lava resurfacing at an outflow rate r~20 km^3 yr^{-1}.



References: [1] Head, J., Yuter, S., & Solomon, S. (1981), *Am. Sci.*, 69, 614. [2] Kopparapu, R., Ramirez, R., Kasting, J., et al. (2013), *ApJ*, 765, 131, doi: 10.1088/0004-637X/765/2/131. [3] King, S. D. (2018), *J. Geophys. Res. Planets*, 123, 1041, doi: 10.1002/2017JE005475.