Origin of spatial variation in United States East Coast sea level trends during 1900-2017

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Summary

Identifying the causes of historical trends in relative sea level—the height of the sea surface relative to Earth's crust—is a prerequisite for predicting future changes. Rates of change along the U.S. East Coast during the last century were spatially variable, and relative sea level rose faster along the Mid-Atlantic Bight than the South Atlantic Bight and Gulf of Maine (**Figure 1a**). Past studies suggest that Earth's ongoing response to the last deglaciation, surface redistribution of ice and water, and changes in ocean circulation contributed importantly to this large-scale spatial pattern. Here we analyze instrumental data records (e.g., **Figures 1a-1b**) and paleo proxy reconstructions using probabilistic methods to show that vertical motions of Earth's crust exerted the dominant control on regional spatial differences in relative sea level trends along the U.S. East Coast during 1900-2017 (**Figures 1c-1d, 2a-c**), explaining a majority of the large-scale spatial variance (**Figure 3**). Rates of coastal subsidence caused by ongoing relaxation of the peripheral forebulge associated with the last deglaciation are strongest near North Carolina, Maryland, and Virginia (e.g., **Figures 1e-1h, 2d-2f**). Such structure indicates that Earth's elastic lithosphere is thicker than has been assumed in other models (**Figures 4a-4b**). We also find a significant coastal gradient in relative sea level trends over this period that is unrelated to deglaciation (**Figures 2g-2i**), and suggests contributions from twentieth-century redistribution of ice and water. Our results indicate that the majority of large-scale spatial variation in longterm rates of relative sea level rise on the U.S. East Coast was due to geological processes that will persist at similar rates for centuries into the future (e.g., **Figures 4c-4d**).

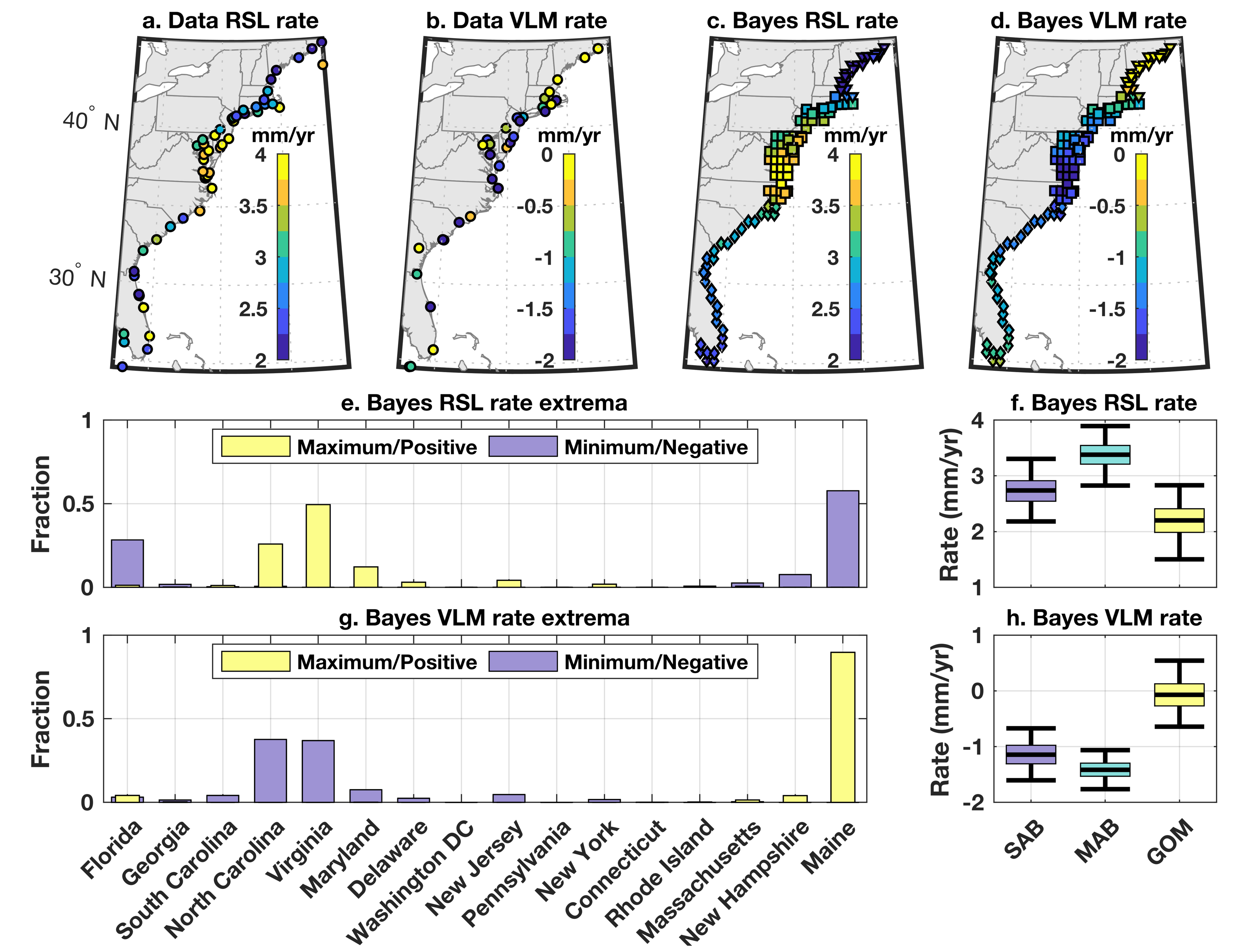

Figure 1 | Rates of change. ***a-b***, *Trends in (**a**) tide gauge relative sea level (**RSL**) and (**b**) GPS station vertical land motion (**VLM**) over the available data record length.* ***c-d***, *Median modeled (**c**) RSL and (**d**) VLM trends. Diamonds indicate South Atlantic Bight (**SAB**), boxes Mid-Atlantic Bight (**MAB**), triangles Gulf of Maine (**GOM**).* ***e & g***, *Modeled probability that maximum/most-positive or minimum/most-negative (**e**) RSL and (**g**) VLM trend occurred in a given state.* ***f & h***, *Model medians (lines), interquartile ranges (shading), and 95% credible intervals (whiskers) on SAB-, MAB-, and GOM-averaged (**f**) RSL and (**h**) VLM trends.*

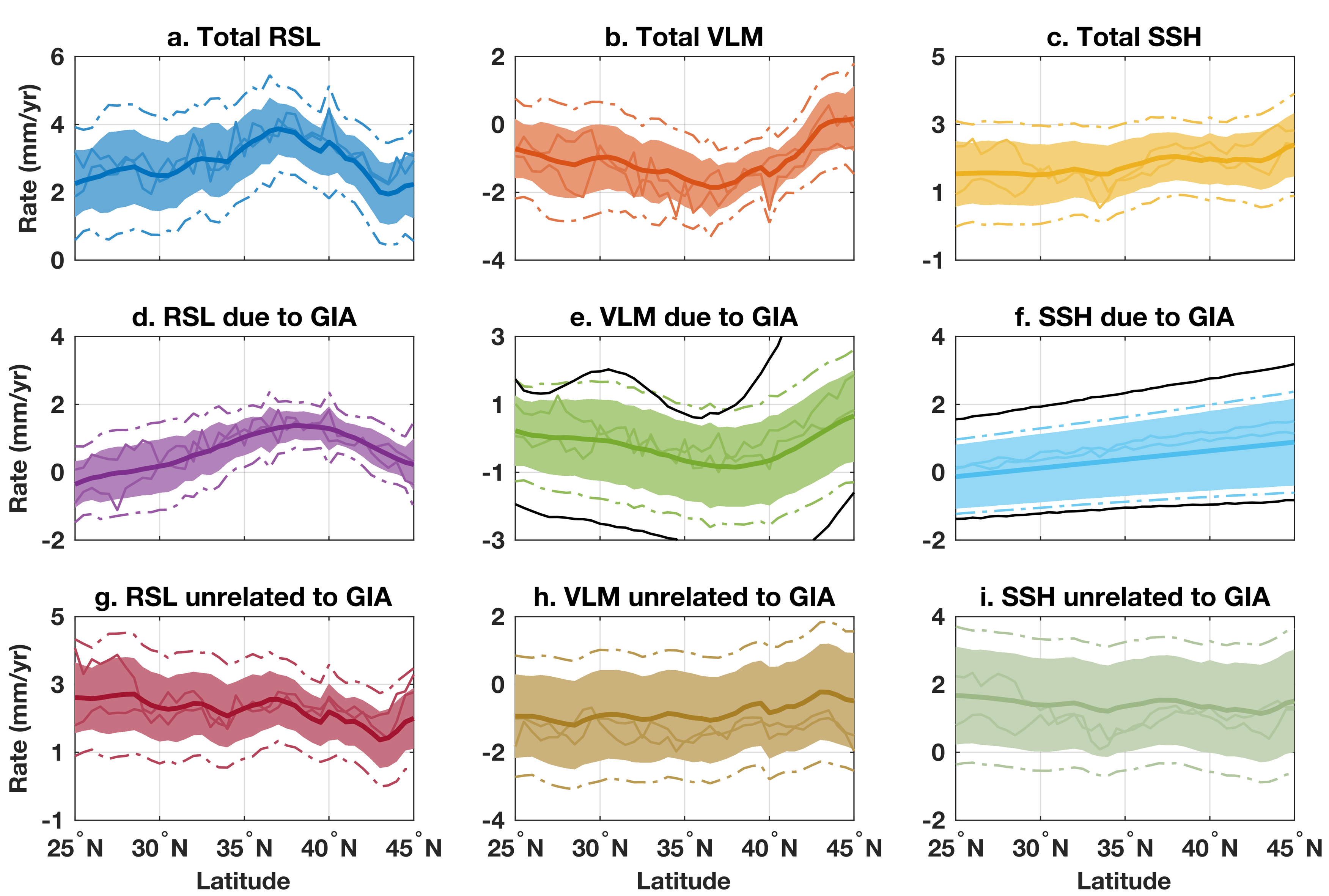

Figure 2 | Latitudinal trend structure. ***a-i***, *Model median (thick line), 95% pointwise (light shade) and pathwise (thin dash) credible intervals, and two sample draws from the posterior solution (thin lines) for regional trends versus latitude on the U.S. East Coast for (**a**), relative sea level (**RSL**), (**b**), vertical land motion (**VLM**), (**c**), sea surface height (**SSH**), (**d**), RSL driven by glacial isostatic adjustment (**GIA**), (**e**), GIA-driven VLM, (**f**), GIA-driven SSH, (**g**), non-GIA RSL, (**h**), non-GIA VLM, and (**i**), and non-GIA SSH. Black lines are prior 95% pointwise credible intervals. The 95% pathwise credible interval is determined by broadening the 95% pointwise credible interval until 95% of the posterior regional trend vector solutions are entirely encompassed.*

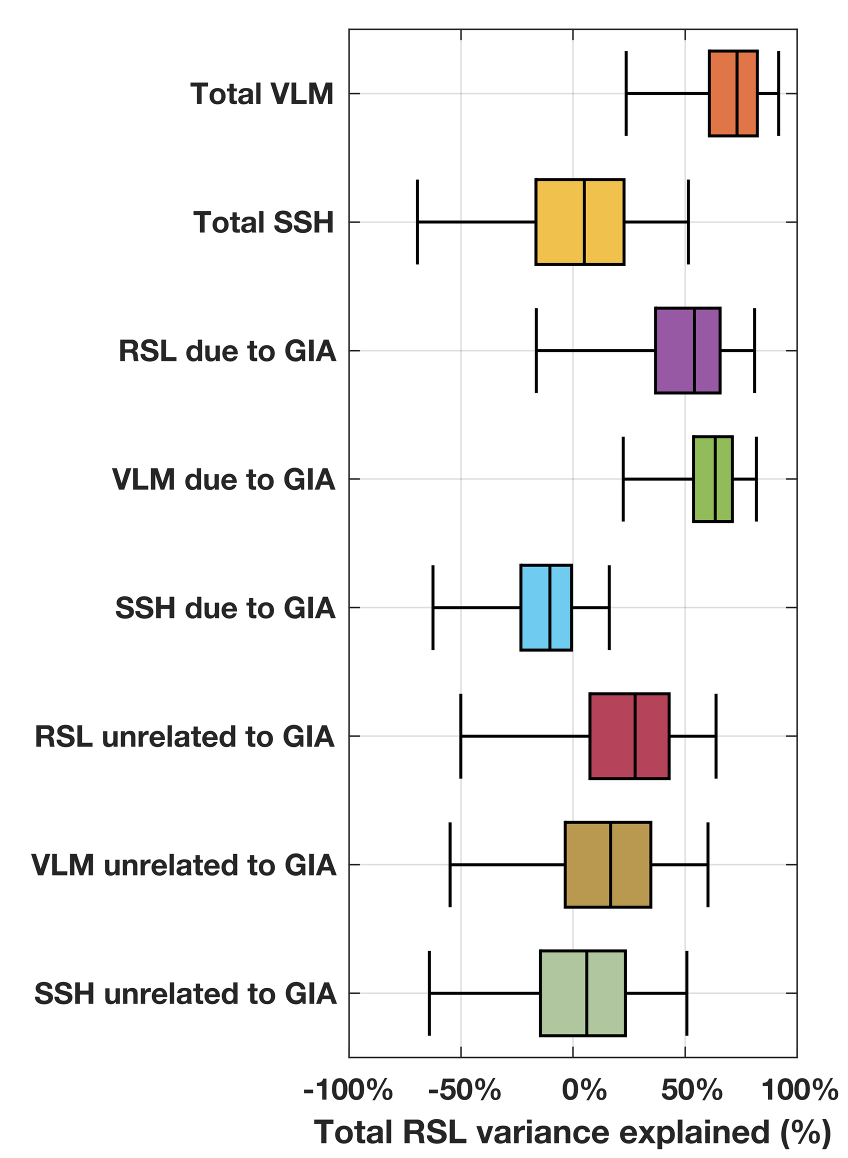

Figure 3 | Contributions to spatial differences. *Model median (black vertical lines), interquartile range (color shading), and 95% credible interval (black whiskers) for the alongshore spatial variance in regional relative sea level (**RSL**) linear trends during 1900-2017 explained by vertical land motion (**VLM**) or sea surface height (**SSH**) related to glacial isostatic adjustment (**GIA**) or other processes. Percentage variance V in x explained by y is defined as 100%×[1-var(x-y)/var(x)], where var is variance. Given the differences in sign convention (e.g., negative VLM rate relates to positive RSL trend), variances explained in RSL by VLM terms are computed by adding, rather than subtracting, the respective VLM component.*

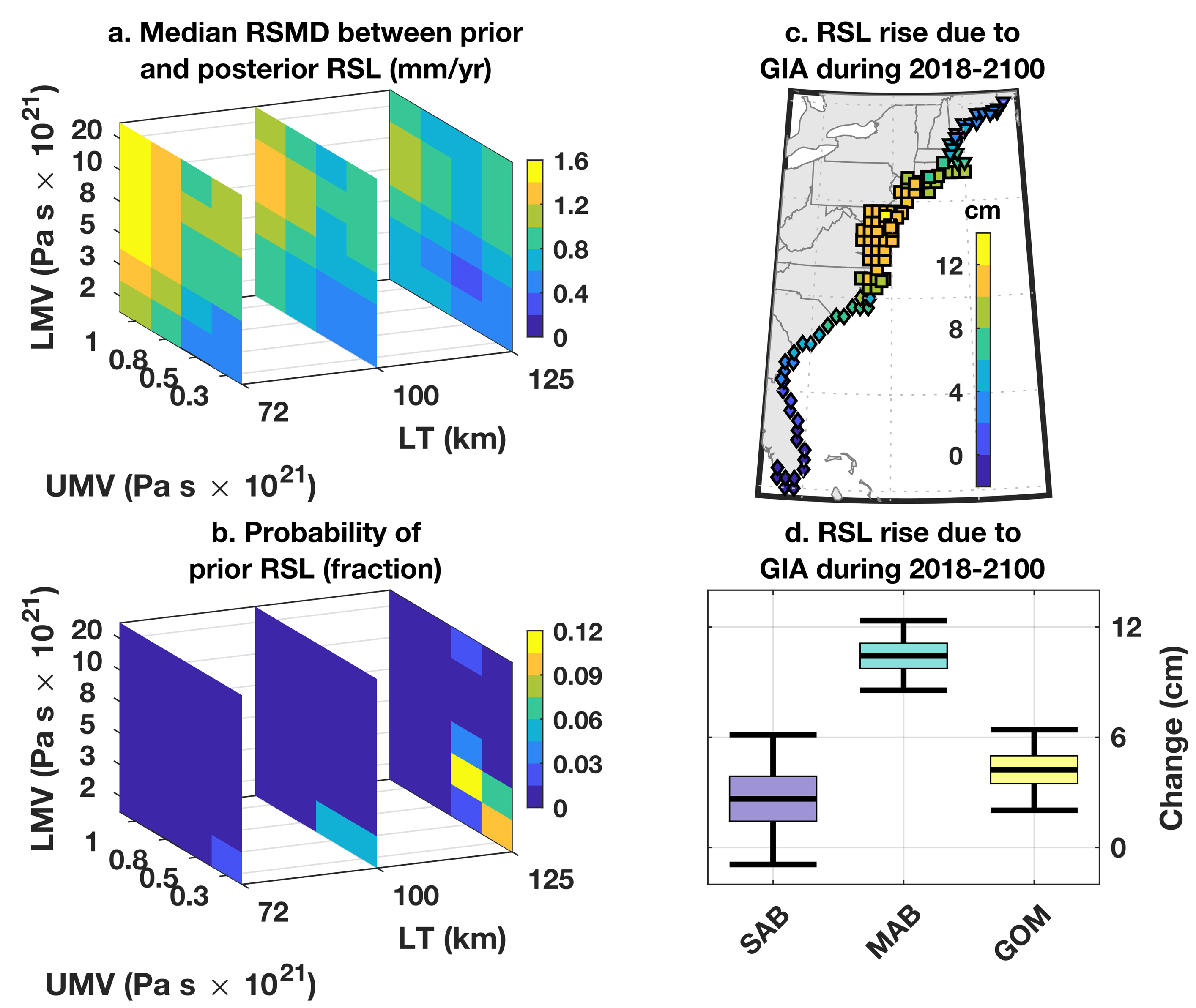

Figure 4 | Relative sea level (RSL) trends driven by glacial isostatic adjustment (GIA). ***a***, *Median root-mean-square deviation between prior and posterior GIA-driven RSL trends as a function of Earth-structure parameters used for the priors: lithospheric thickness (**LT**), upper-mantle viscosity (**UMV**), and lower-mantle viscosity (**LMV**).* ***b***, *Marginal posterior probability distribution that best correspondence between prior and posterior solutions occurs for a given combination of rheological parameters.* ***c***, *Posterior medians of large-scale GIA-driven RSL change along the coast during 2018-2100.* ***d***, *Posterior medians (lines), interquartile ranges (shading), and 95% credible intervals (whiskers) on the GIA-driven RSL rise during 2018-2100 averaged over the South Atlantic Bight (**SAB**), Mid-Atlantic Bight (**MAB**), and Gulf of Maine (**GOM**).*

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