EGU22-50, updated on 04 Oct 2022
https://doi.org/10.5194/egusphere-egu22-50
EGU General Assembly 2022

Towards an improved understanding of vertical land motion and sea-level change in eastern North America

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Many coastal cities are an early casualty in climate-related coastal flooding because of processes resulting in land subsidence and thus enhanced relative sea-level (RSL) rise. Much of the Atlantic coast of North America has been sinking for thousands of years, at a maximum rate of ~20 cm per century as a consequence of solid Earth deformation in response to deglaciation of the Laurentide ice sheet (between ~18,000 and ~7,000 years ago) [e.g. Love et al., Earth's Future, 4(10), 2016]. Karegar et al. [Geophysical Research Letters, 43(7), 2016] have shown that vertical land motion along the Atlantic coast of the USA is an important control on nuisance flooding. A key finding in this study is that while glacial isostatic adjustment (GIA) is the dominant process driving land subsidence in most areas, there can be large deviations from this signal due to the influence of anthropogenic activity impacting hydrological processes. For example, between Maine (45°N) and New Hampshire (43°N), the GPS data show uplift while geological data show long-term subsidence. The cause of this discrepancy is not clear, but one hypothesis is increasing water mass associated with the James Bay Hydroelectric Project in Quebec [Karegar et al., Scientific Reports, 7, 2017].

The primary aim of this study is to better constrain and understand the processes that contribute to contemporary and future vertical land motion in this region to produce improved projections of mean sea-level change and nuisance flooding. The first step towards achieving these aims is to determine a GIA model parameter set that is compatible with observations of past sea-level change for this region. We make use of two regional RSL data compilations: Engelhart and Horton [Quaternary Science Reviews, 54, 2012] for northern USA and Vacchi et al. [Quaternary Science Reviews, 201, 2018] for Eastern Canada, comprising a total of 1013 data points (i.e., sea level index points and limiting data points) over 38 regions distributed throughout our study region. These data are well suited to determine optimal GIA model parameters due to the magnitude of other signals being much smaller, particularly in near-field regions such as Eastern Canada. We consider a suite of 32 ice history models that is comprised mainly of a subset from Tarasov et al. [Earth and Planetary Science Letters, 315–316, 2012] as well as the ICE-6G and ANU models. We have computed RSL for these ice histories using a state-of-the-art sea-level calculator and 440 1-D Earth viscosity models per each ice history model to identify a set of Earth model parameters that is compatible with the observations.