The impact of sea-level rise on coastal flooding due to extreme storm tides under climate change projections in the 21st century: Application to the Kalamaria littoral zone (N. Aegean Sea, Greece)

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Abstract:
This study assesses the evolving impacts of climate-induced sea-level-rise (SLR) and compound storm tide events on the vulnerable coastal zone of Kalamaria, a densely urbanized littoral area in the northeastern Thermaikos Gulf (Northern Aegean Sea, Greece). Integrating high-resolution hydraulic simulations (CoastFLOOD model), extreme value statistics, and regional climate model projections (Med-CORDEX), we quantify the frequency, magnitude, and spatial extent of coastal inundation under Representative Concentration Pathways RCP4.5 and RCP8.5 for two future horizons (2021–2055 and 2066–2100), compared against a historical baseline (1971–2005).

The coastal Total Water-Level (TWL) projections were derived as the sum of Sea Surface Height (SSH) anomalies (storm surges), astronomical tides, and mean SLR. These were used as boundary inputs in dynamic coastal inundation modeling. Storm surge return levels were obtained through Generalized Extreme Value (GEV) analysis, and the contribution of astronomical tides was calibrated using observational data from Thessaloniki port and TPXO tidal models. Mean SLR projections were sourced from satellite altimetry and NASA's IPCC-AR6 tool, with annual trends exceeding 9 mm/year under high-emission scenarios post-2050.

Impact quantification employed a suite of composite indices and flood flow parameters to evaluate the exposure of critical infrastructure (harbor, marina, and airport), residential and touristic assets, public spaces, natural settings, businesses, and population clusters. The results show substantial increases in flood-prone coastal areas, particularly in the Aretsou, Nea Krini, Mikra, and Foinikas neighborhoods, with high exposure for local businesses, port waterfronts, seaside buildings, and recreational spaces.

This integrated methodology highlights the need for robust, locally tailored adaptation strategies. It also provides a reproducible framework for assessing future coastal flood risk under climate uncertainty in Mediterranean urban zones.

Keywords: coastal flooding; sea level rise; numerical model; exposure; littoral inundation; impact assessment; Kalamaria; urban environment; coastal hazard; storm tide; climate change; exrteme value analysis