Towards an Interannual to Decadal Local Sea Level Forecasting System

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Societal and environmental effects of sea level rise are among the major impacts of climate change. The USA is one of the countries most exposed to high economic costs of sea level rise and the resulting coastal flooding, and the U.S. East Coast is a “hotspot of accelerated sea level rise.” Recent assessments of future local sea level (LSL) rise mostly addressed the next 50 to 200 years, and they revealed a very large range of plausible LSL trajectories, which provides little actionable decision support. However, rapid LSL changes far exceeding those experienced over the last 6,000 years or those considered plausible in most recent assessments of future changes can not be excluded, not even for the next few decades. Such changes pose an unparalleled threat to humanity. A reliable interannual LSL forecasting service would provide "early warning" in case of an onset of rapid LSL rise with necessary lead time for actions to mitigate the impact of such a low-probability, high-impact event.

We are implementing a semi-operational system model for decadal coastal LSL forecasts. As far as possible, the LSL system model makes use of existing model components. LSL is the combined output of many Earth system processes acting on spatial scales from global to local, and including mass relocation and exchange between ice sheets, glaciers, land water storage, and oceans; deformation of the solid Earth and gravity-field changes caused by the mass relocation; changes in ocean heat storage and ocean currents; changes in atmospheric circulation; tectonic processes; and natural and anthropogenic local coastal subsidence. Our system model for LSL forecasting is designed to interface with existing modular Earth system models. The scalable framework can easily be adapted to any coastal location. Modules of the system model include global models (climate, ocean, ice sheets, glaciers, continental hydrosphere); regional models for steric effects; local models for vertical land motion; and physical models to convert global processes into local effects. Initially, some of the modules are weakly coupled and based on input from complex models (both internal and external), while other modules are networked locally. The modular nature of the system allows improvements of individual modules, thus enabling rapid integration of advances within modules. Assimilation of observations on global to regional scales (e.g., gravity field, Earth rotation, sea surface heights) and on local scale data (e.g., InSAR, GNSS) provide additional constrains. The system model ensures global consistency for key Earth system parameters, such as mass and momentum conservation. The model will be validated with observations covering ca. 1970 or earlier to the present. Focus will be on the assessment of the predictive capabilities of individual modules, where some of the modules will have strong capabilities on global scales, while others will add regional and local scales or facilitate the down-scaling of the global processes. Performance is being assessed using NCEP's metrics. Depending on performance, the validated system model could be a key element of a pilot decadal forecasting service for LSL changes for integration in the portfolio of NOAA's climate services. Although many scientific issues need to be addressed before reliable forecasting is achieved, it is important to start forecasting as soon as possible to further assess the forecasting capabilities.