THE DYNAMICS OF STORM SURGE AND MEAN SEA LEVEL VARIABILITY IN THE NORTHEASTERN CASPIAN SEA

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INTRODUCTION

Storm surge is a major natural hazard to the construction and operation of infrastructure projects in shallow and gently sloping coastal areas such as the northeastern part of the Caspian Sea. Up-surge events cause significant coastal flooding, while down-surge events disrupt marine transportation by constraining safe navigable water depths. Coastal developments therefore have to achieve a judicious balance of these conflicting constraints. Further, the unpredictability of long-term and intra-annual Mean Sea Level (MSL) variability as well as periodic freeze-up and break-up due to ice formation in this part of the Caspian Sea complicate a robust and unequivocal basis for defining storm surge hazards.

STORM SURGE VARIABILITY

An extensive episodic event (storm) and continuous numerical modeling hindcast of atmospheric pressure, winds, storm surge, waves and currents for the entire Caspian Sea was undertaken for the period 1955 - 2016. Storm selection was performed using a multi-parameter screening process whereby waves, up-surge and down-surge events impacting the NE Caspian Sea were simultaneously considered. The screening process utilized data from previous hindcast and was augmented by running a continuous coarse mesh numerical model to fill in gaps. Previous hindcast storm selection was not specifically targeting the NE Caspian Sea, and often screened only on maximum wave heights and not surge events. The modeling incorporated historic ice maps to account for freeze-up and break-up. Calibration and validation were performed against local and regional in-situ measurements of winds, water levels, waves and currents. Local bias of the hindcast versus measured wind speeds was applied as a correction to improve the overall surge and wave model calibration.

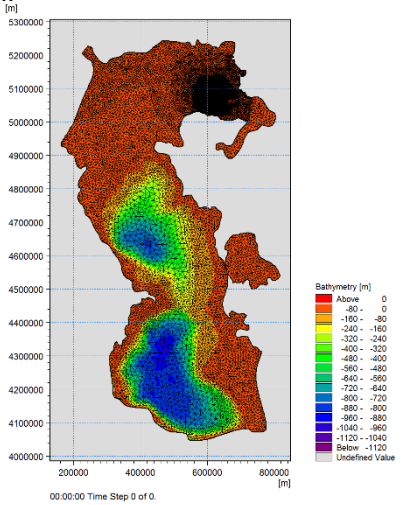

Figure 1 - Model bathymetry in meters (Baltic Datum)

Storm surges in this region, and indeed, whether they are positive or negative, have a direct correlation with the directionality of the winds. As such, they are uniquely influenced by the geographical locations, the available ambient water depth, as well as the configuration of the neighboring built environment. Figure 2 shows a spatial view of the down-surge and up-surge inundation and illustrates that the range of inundation can cover up to about 100km. This study also Investigates the correlation between the return periods of wind magnitudes and surge levels.

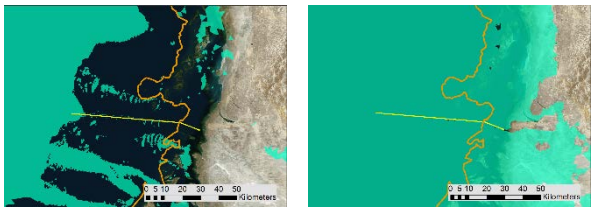

Figure 2 - Inundation in NE Caspian Sea from downsurge (left) and upsurge (right) events. Orange line is the MSL shoreline. Yellow line is the navigation channel location.

MSL VARIABILITY

Multi-decadal secular changes in MSL of over 3 m have occurred in the past century. As MSL variability is affected by both climatic factors and human intervention, and hence impossible to predict, scenario-based modeling was performed to bound the range of expected future variability as determined from historic and recent local and basin-wide measurements. Observations over the past 5 years near the site (Figure 3) show that seasonal variation of the Caspian MSL can be as high as +/- 0.5m around the annualized mean (over 10% of the ambient water depth). Further analysis and results of the hindcast modeling and measurement data will be presented in this study.

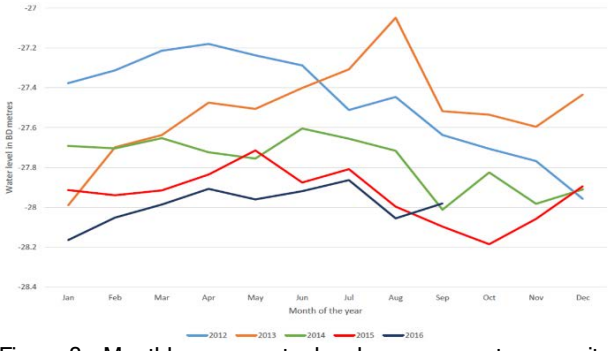

Figure 3 - Monthly mean water level measurements near site from January 2012 - September 2016.