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The State of the Art and Science of Coastal Engineering

The Dynamics of Storm Surge and Mean Sea Level Variability in the Northeastern Caspian Sea

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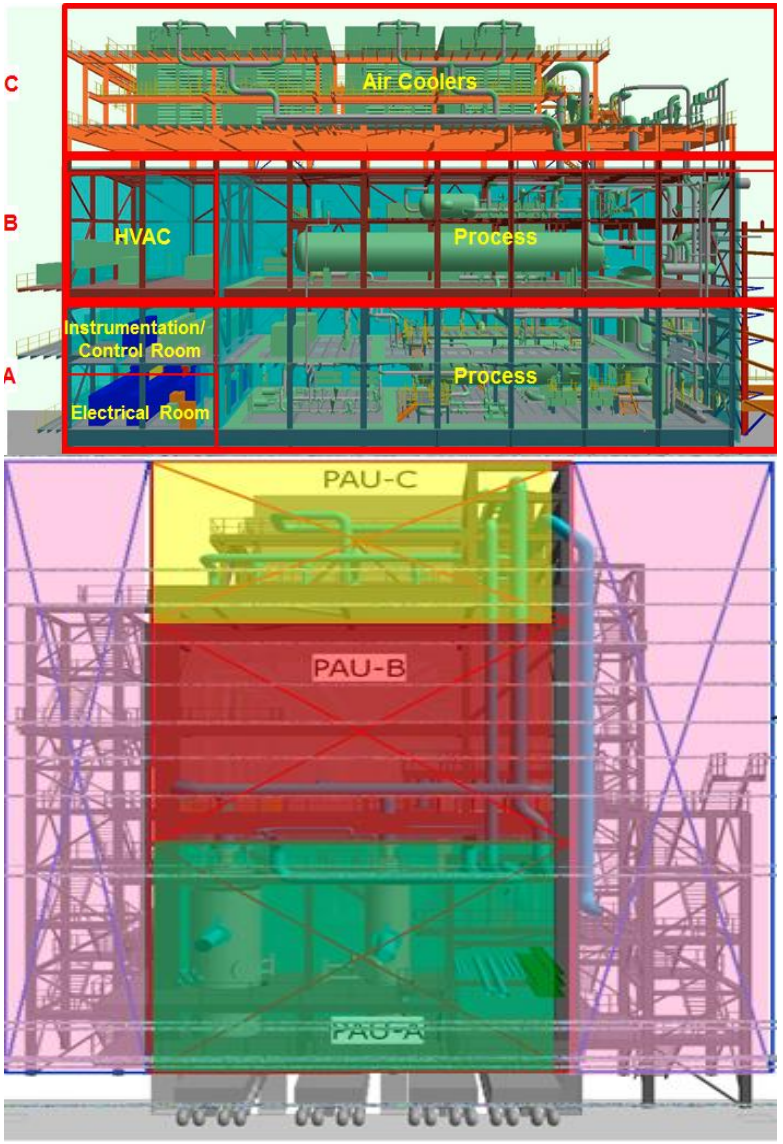
Shipping route

Ocean Shipping

- Modules fabricated in South Korea
- Ocean transport via heavy-lift roll on/off module carriers
- ~ 160 modules on ~ 60 voyages with up to 17 vessels required
- Modules delivered to Transshipment Facilities

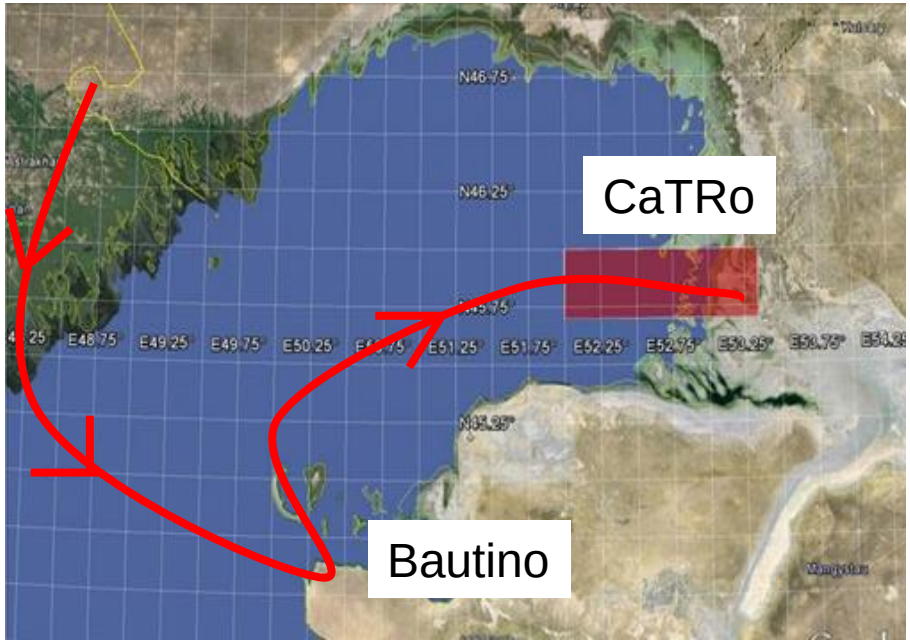


Cargo Transportation Route (CaTRo)

Footprint

- Navigation channel
- Turning basin
- Cargo Offloading Facility (COF)
- Causeway / Heavy Haul Road
- Tengiz

entire CaTRo is in the flood zone!



Mean Sea Level line

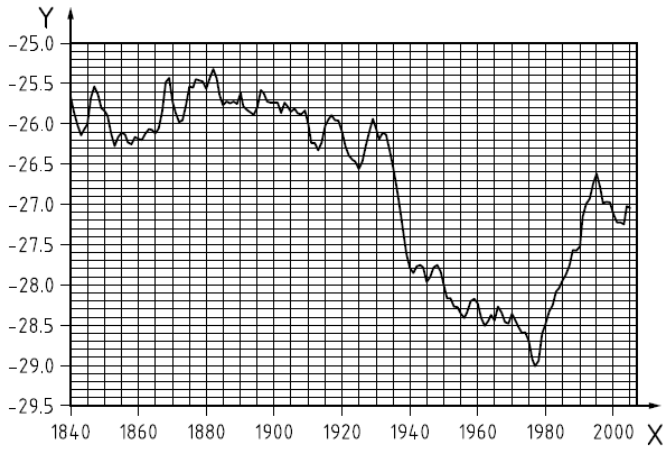
Water Level Variations

Short Term – Storm Surges

- Primarily driven by winds
- Can be positive (up-surge) or negative (down-surge);
- Most hazardous to shallow and gentle sloping coastal areas like NE Caspian

Long Term - Mean Sea Level (MSL) Fluctuation

- Multi-decadal changes in MSL of over 3m occurred
- Affected by both natural oscillations and human interventions



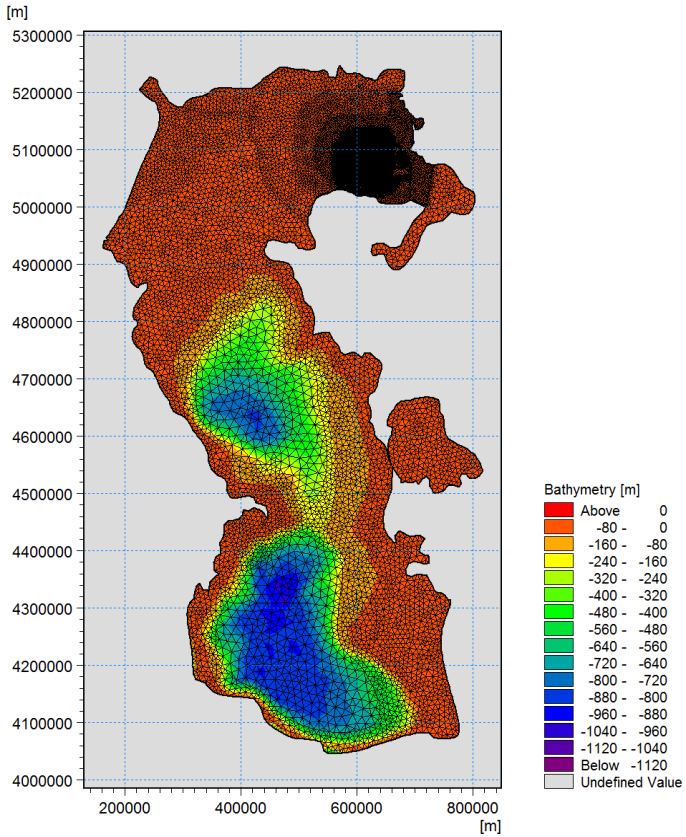
Numerical Metocean Hindcast

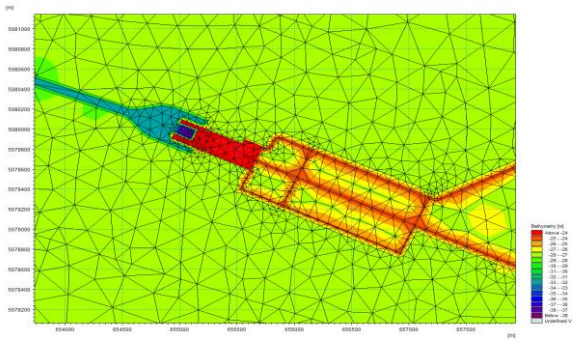
Model Configuration

- Performed by DHI and Chevron ETC
- Winds from StormGEO
- Leveraged past CASMOS JIP results
- Included storm only (1955-2016) and operational (2006-2016) hindcasts
- Included Hydrodynamic Model (surge and current) and Spectral Wave Model (wave)

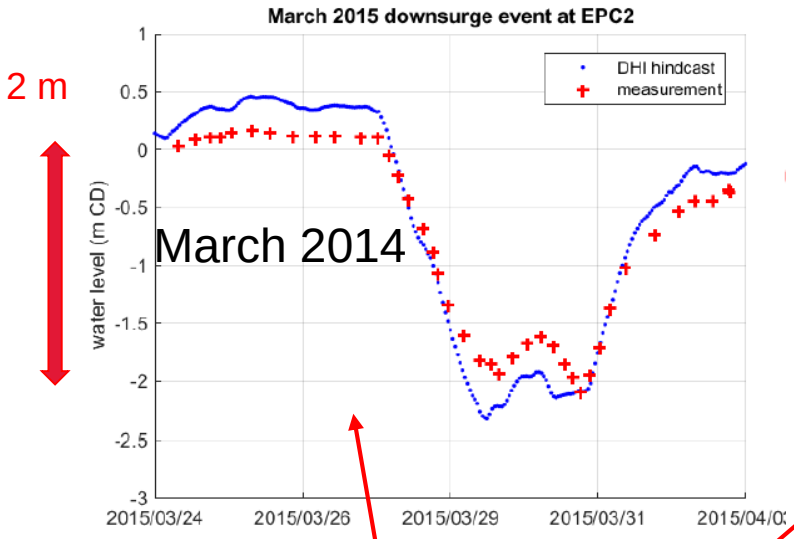
Features

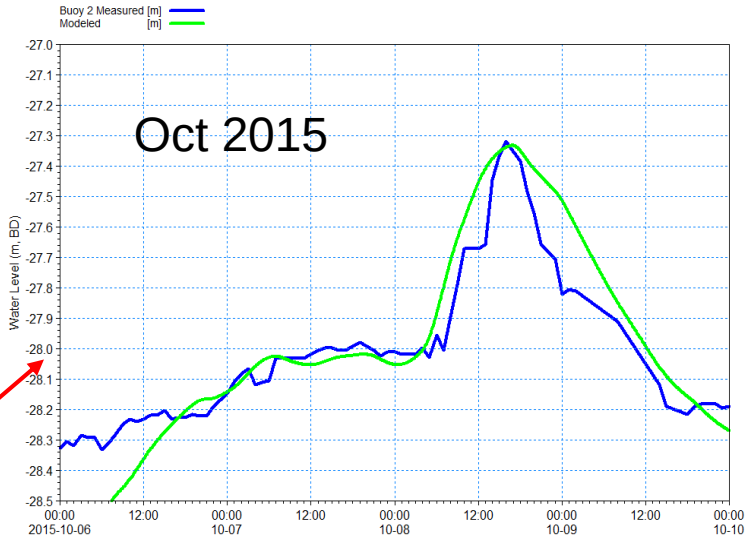
- Storm selection process also focused on selecting storm surge events (unlikely previous hindcast)
- Tailored for NE Caspian (much higher resolution)
- Incorporated historical ice maps to account for freeze-up and break-up
- Comprehensive data analysis and validation

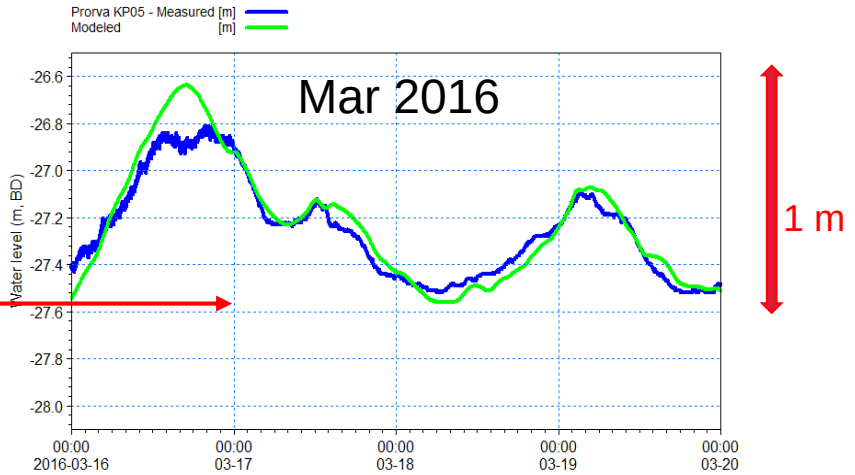




Model Validation

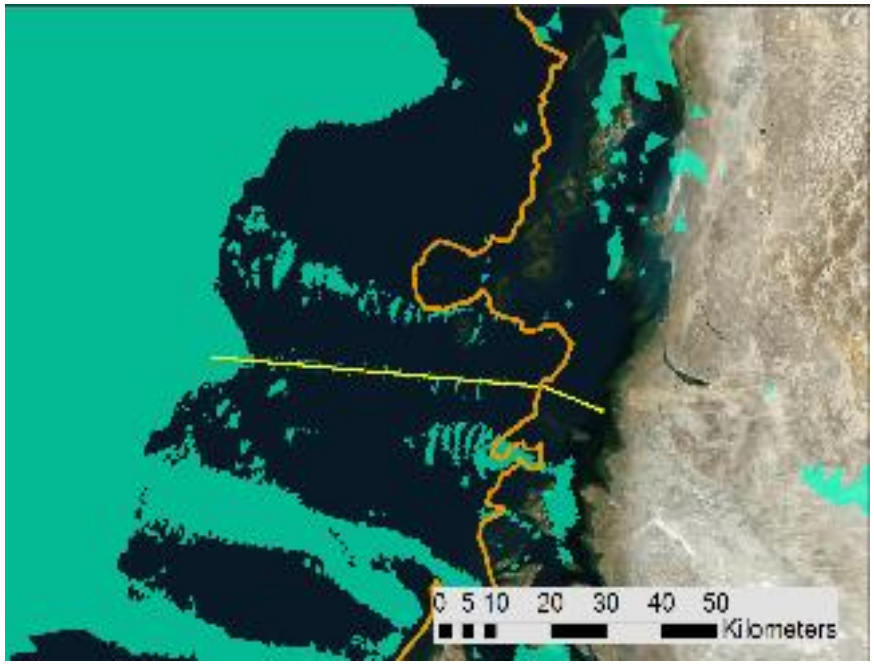






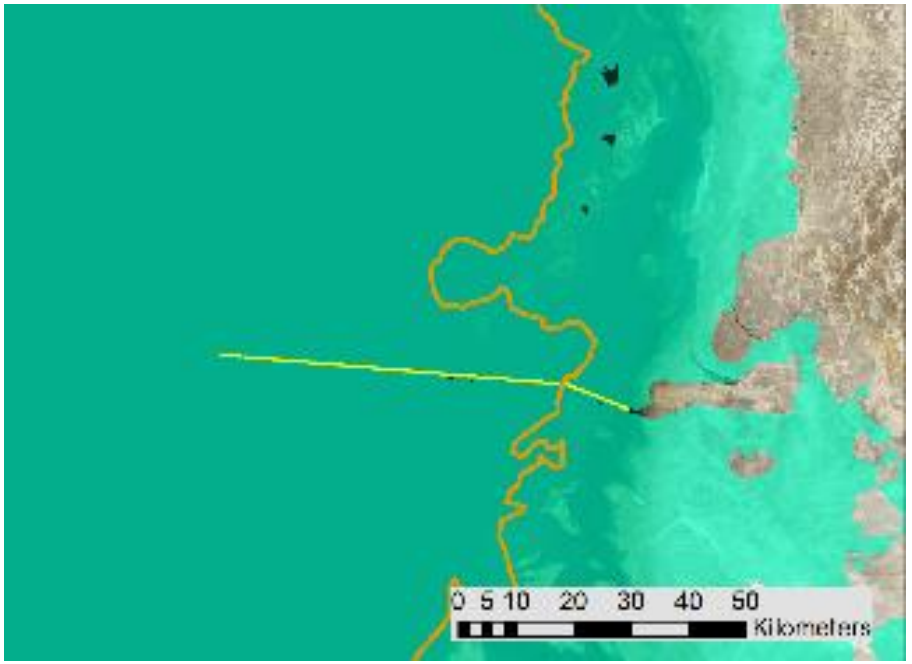
Surge Inundation

Down-surge event in
March 2015



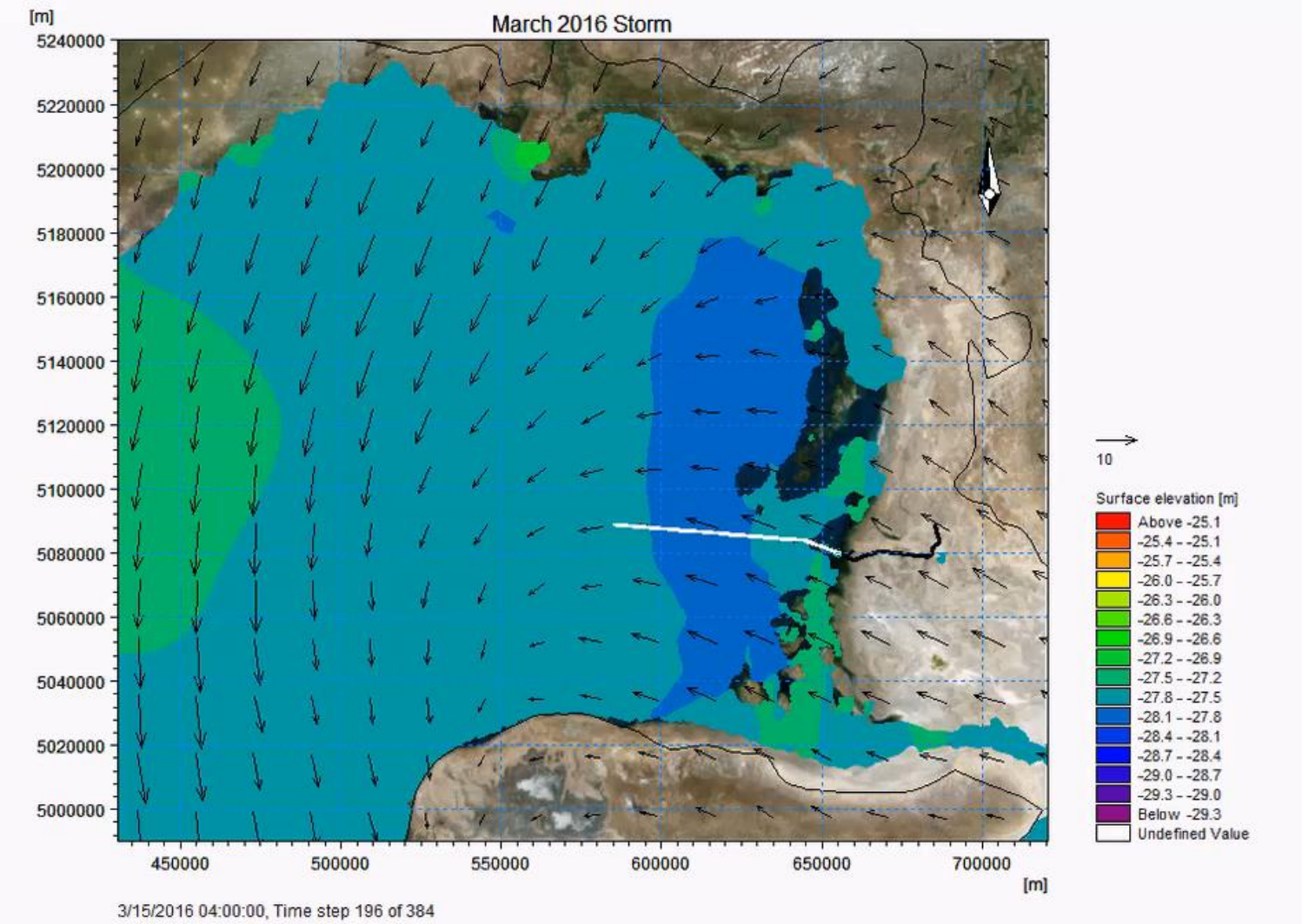
Mean Sea Level line

Up-surge event in
March 2016



Mean Sea Level line

Surge Inundation

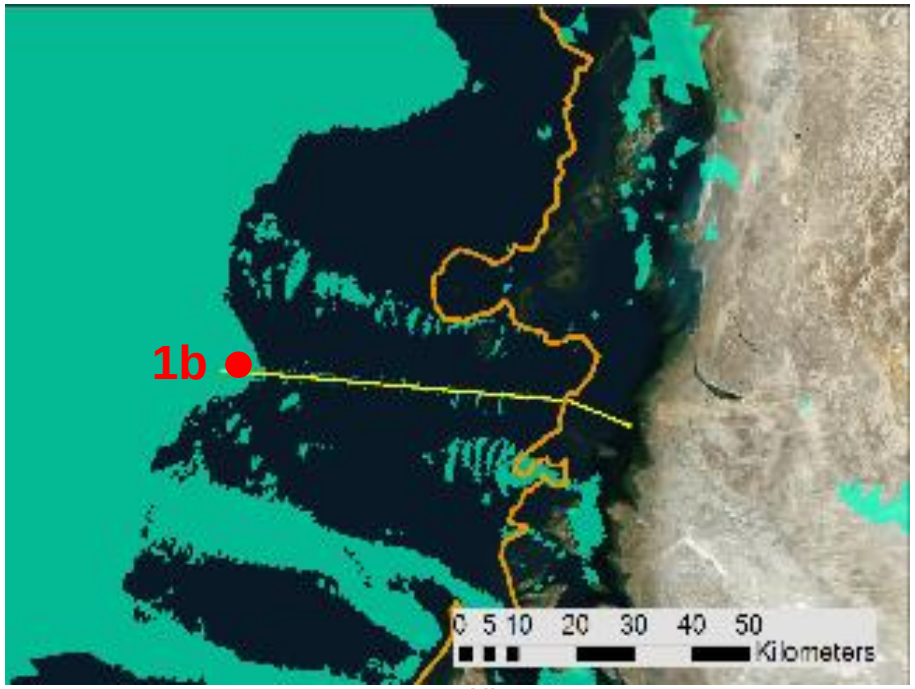


Wind Speeds vs. Surge Levels

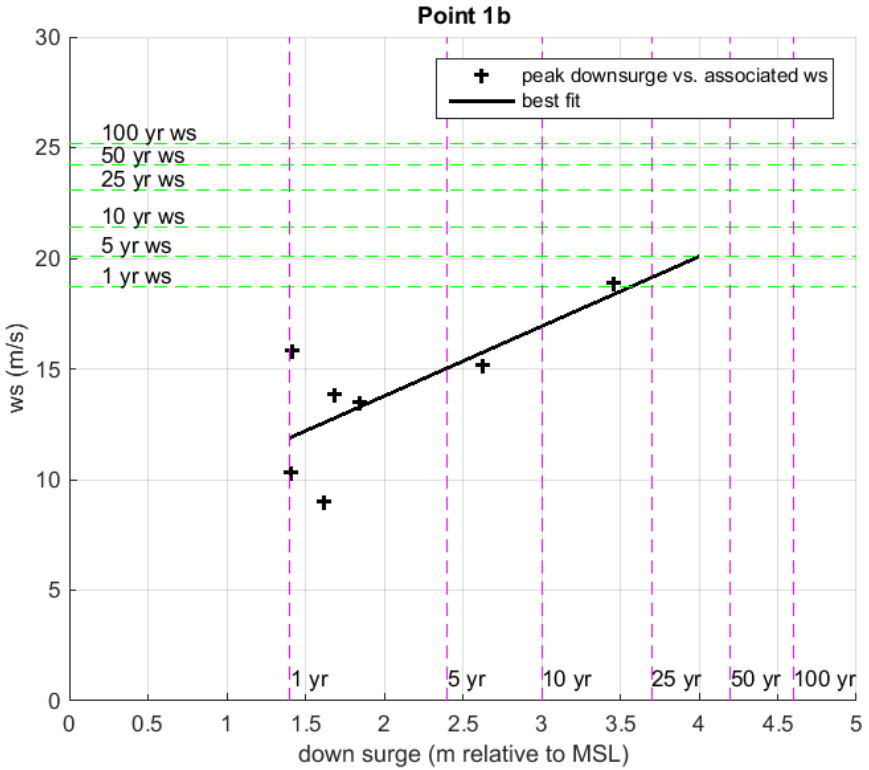
Relationship between winds and surge levels are complex

Surges are affected by: - wind speed

- wind direction
- wind duration
- consistency of wind action



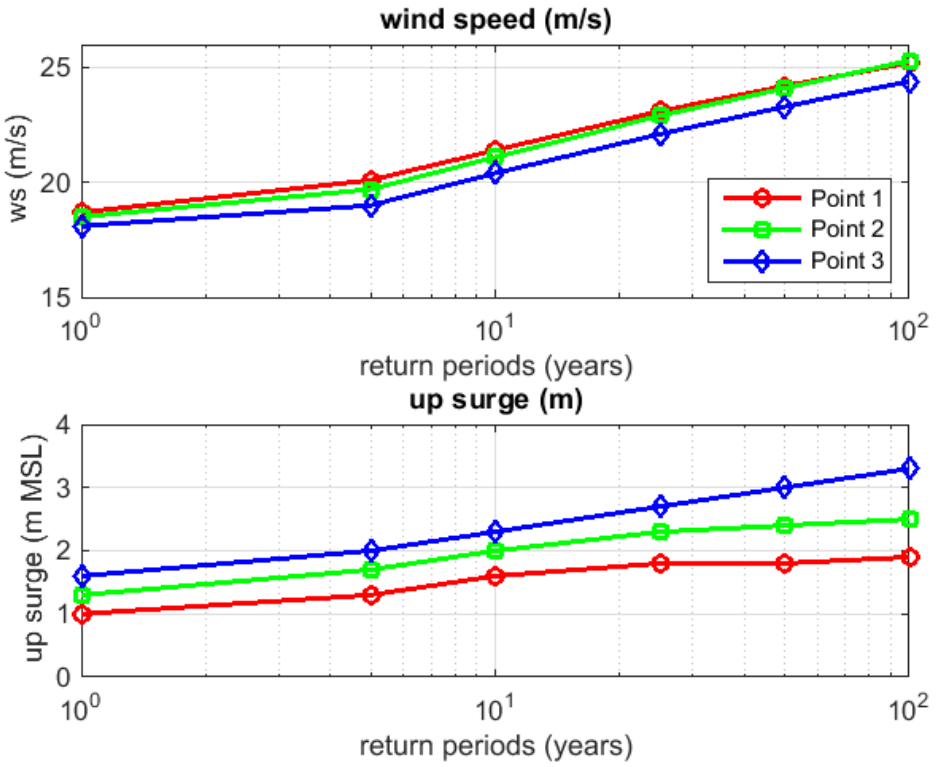
Mean Sea Level line



Take-away: peak surge levels do not simply correlate with peak wind speeds

Spatial Variation of Surges

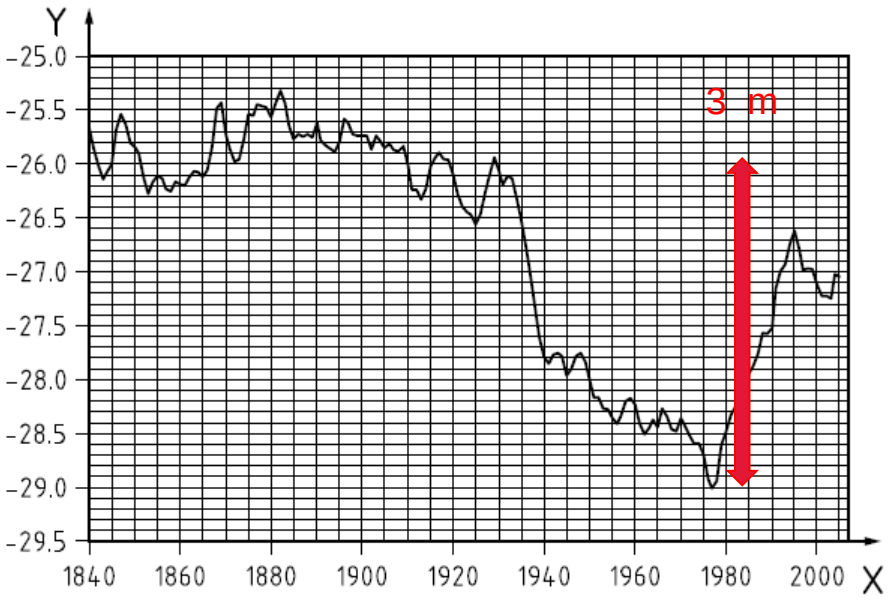
Surges are also affected by: - geographical locations
- ambient water depths
- natural and built environment

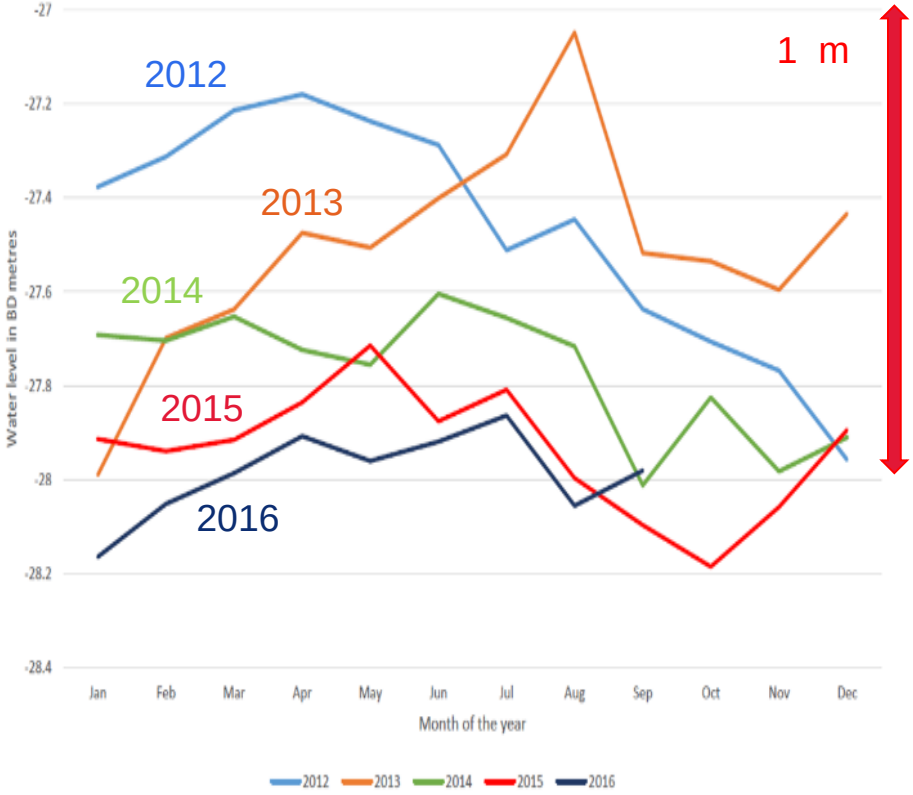


Take-away: do not simply predict surge level at one location using data from another location

Long Term MSL Variability

- Multi-decadal changes in MSL of over 3 m have occurred
- Affected by both climatic factors and human interventions





Summary

- **Water level variations are a major design consideration for projects in shallow coastal areas like NE Caspian Sea**

- **Short term water level variations**
  - **– primarily driven by winds; but the relation between winds and surges are complex**
  - **– also affected by geographical locations, ambient water depth, environment.**

- **Long term water level variations**
  - **– driven by both climatic and human factors**
  - **– extremely difficult to predict; therefore, uncertainty needs to be factored in the design of coastal projects**


Thank you!
Questions?