Coast GIS 2015

Coastal flooding levels in South Africa

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CSIR & DEA – Phases 1 & 2 Research Study:
South African Coastal Vulnerability Assessment

PHASE 2 - main components:
1. Setback Lines (SBLs) and the ICM Act
2. National Estuarine Vulnerability Assessment
3. Coastal LiDAR Workshop and National Inventory
4. MetOcean Conditions & Vulnerability –
   Medium resolution wave climate & run-up

→ Coastal flooding levels in SA
To prevent (more of) this:

High seawater levels, wave run-up, flooding, erosion

Strand Sept 2013
Photo: Tiaan van der Spuy
Extreme inshore sea water levels

- **Drivers of high levels:**
  1. tides
  2. wind, hydrostatic (barometric) set-up
  3. wave set-up
  4. future SLR
  5. wave run-up (added effect)

- **Most significant in SA:**
  1. tides (e.g. spring tide in SA > +1 m MSL, Moz > +3.5 m MSL)
  2. potential SLR
  3. wave run-up → dominant factor in SA

Adapted from Theron, 2015
**Sea level rise**

**Present** global sea level rise (since 1993) = \(3.3 +/- 0.4\) mm/y

Literature: wide range of SLR scenarios, but most “physics/process based” projections (since 2007) for 2100 \(\sim 0.5\) m to 2 m range

**Proof of global warming?**

Adapted from Theron, 2015
Analyses of extreme SA sea-level recordings

Example: Simon’s town

Extreme estimation fit for tidal water levels with respect to Chart Datum (CD).

Extreme estimation fit for residual water levels with respect to Chart Datum (CD).
Parameters & estimated extreme effects on “still-water” levels for SA coast (i.e. excluding runup)

Calculation of SA open coast storm surge elevations (combined mean high-water spring (MHWS) + wind, wave and atmospheric setup for 1-in-10-year wave height and residuals)
Extreme open coast SA “storm surge” levels

MHWS + residual & setups & SLR,
but excluding wave run-up
(some setups not applicable within bays)

Examples:

SA regional coastal storm surge levels for 1-in-10 yr wave return period and 0 m SLR scenario

SA regional coastal storm surge levels for 1-in-50 yr wave return period and 1 m SLR scenario
1. Determine extreme seawater levels, including SLR scenarios (» “still” wls / “storm surge” levels).

2. Model wave runup levels.

3. Combine to determine coastal flooding elevations.
Key findings re wave runup models - 1

- Tested 13 wave runup models on SA data.

Adapted from Theron, 2015
Adaptation of the 2 models for optimum SA performance:

- **Mather model**: Where only deep-water heights are known, or no beach slope data available, the Mather model can be applied. Set coeff. C at 7.5 in open coast & semi-exposed locations \((K>=0.4)\). In well sheltered locations \((K<0.4)\), provisionally set C at 5.

- **Nielsen & Hanslow model**: best results with significant wave heights determined at \(\leq20m\) depth & “reverse shoaled” to give equivalent deep-water wave heights as input.

Adapted from Theron, 2015
Modelling of wave runup levels - offshore wind & wave climate input example:

Location area: Richards Bay and St Lucia

NCEP grid-point: 30843
Approx. 45 km offshore
Process of transforming off-shore wave climate into near-shore wave climate via numerical wave modelling.

- Example of the medium resolution, nested, numerical wave model for the Richards Bay area.
- Output was given at the 7m and 15m depth contour.
- Bathymetry data based on charts by Hydrographic Office of SA Navy.
• 21 numerical wave models were completed each 100km+ alongshore.
• Provides medium resolution inshore wave climate data at 0.5km resolution (~2/3 SA coast).
Wave modelling verification example:
Wave height comparison off Cape South-west coast – Measured versus SWAN.
• For each 15yr time series of wave conditions, the extreme wave heights were estimated using an **Extreme statistical Values Analysis (EVA)**.

• This procedure was applied to each of the shallow water output locations for each of the 21 modelled areas.
Coastal flooding levels - results:

- Graphs generated from the predicted flooding levels along sandy coasts produced by the Mather model.
- Show flooding levels for 10, 30 & 50yr wave heights, with low (0.35m) & high (1m) sea level rise (i.e. runup + spring tide + 1in10yr residual + SLR combined) = 6 scenarios.
Coastal flooding elevations – example: Richards Bay
Quantification of risks to coastal areas and development: potential coastal flood lines

**Red line — Scenario 1:**
1-in-10yr runup + MHWS + 1-in-10yr residual + 0.35m SLR

**Blue line — Scenario 2:** (on-land)
1-in-30yr runup + MHWS + 1-in-10yr residual + 0.35m SLR

**Yellow line — Scenario 6:**
1-in-50yr runup + MHWS + 1-in-10yr residual + 1.0m SLR

(all Mather wave runup model)
Table Bay predicted coastal flooding levels - Mather vs. N&H model

- Blue lines — Nielsen & Hanslow model (beach slope)
- Red lines — Mather model (inshore bottom slope)

Adapted from Theron, 2015
Thank you

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