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 –**

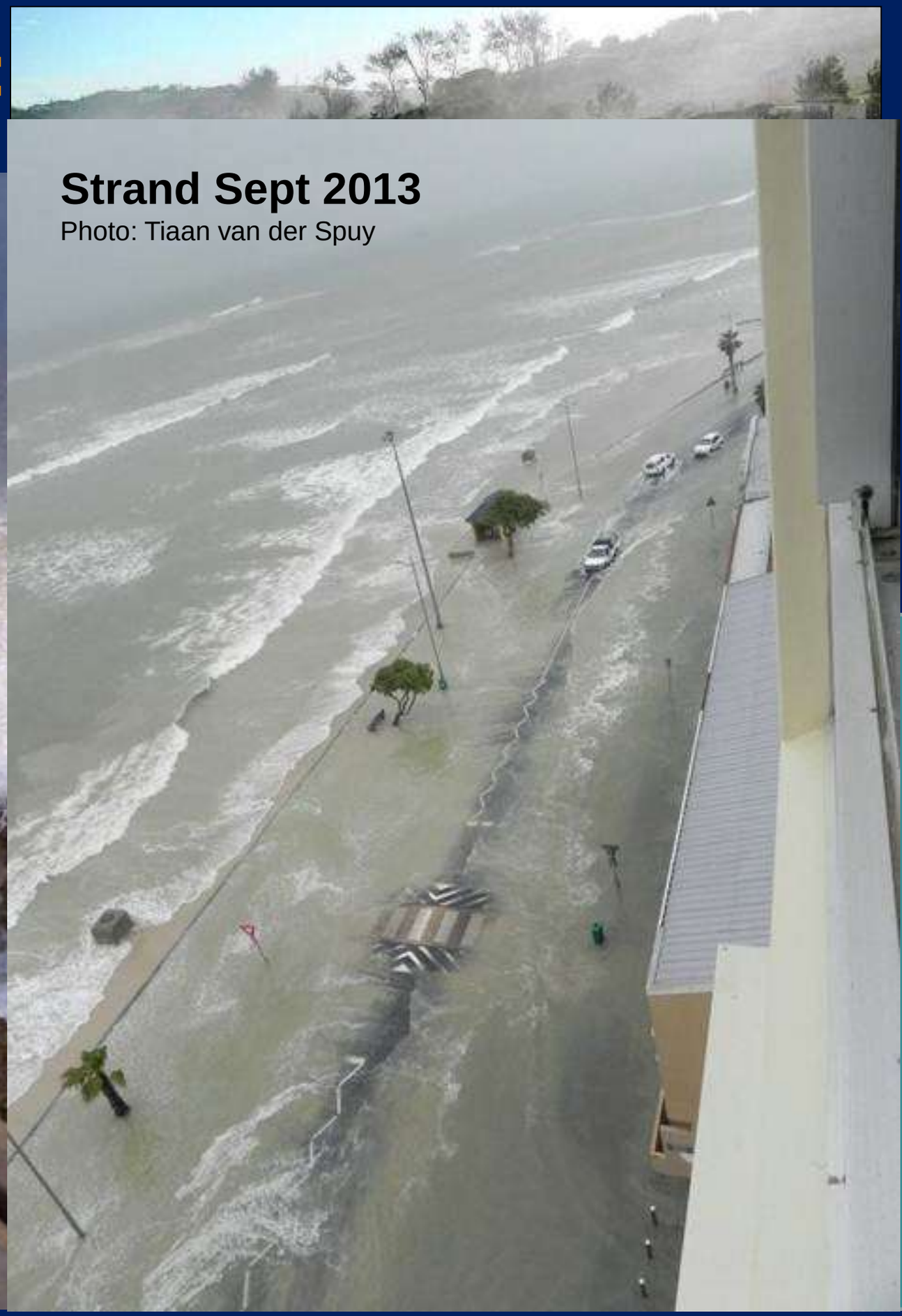
   Medium resolution wave climate & run-up

→ **Coastal flooding levels in SA**

To prevent (more of) this:

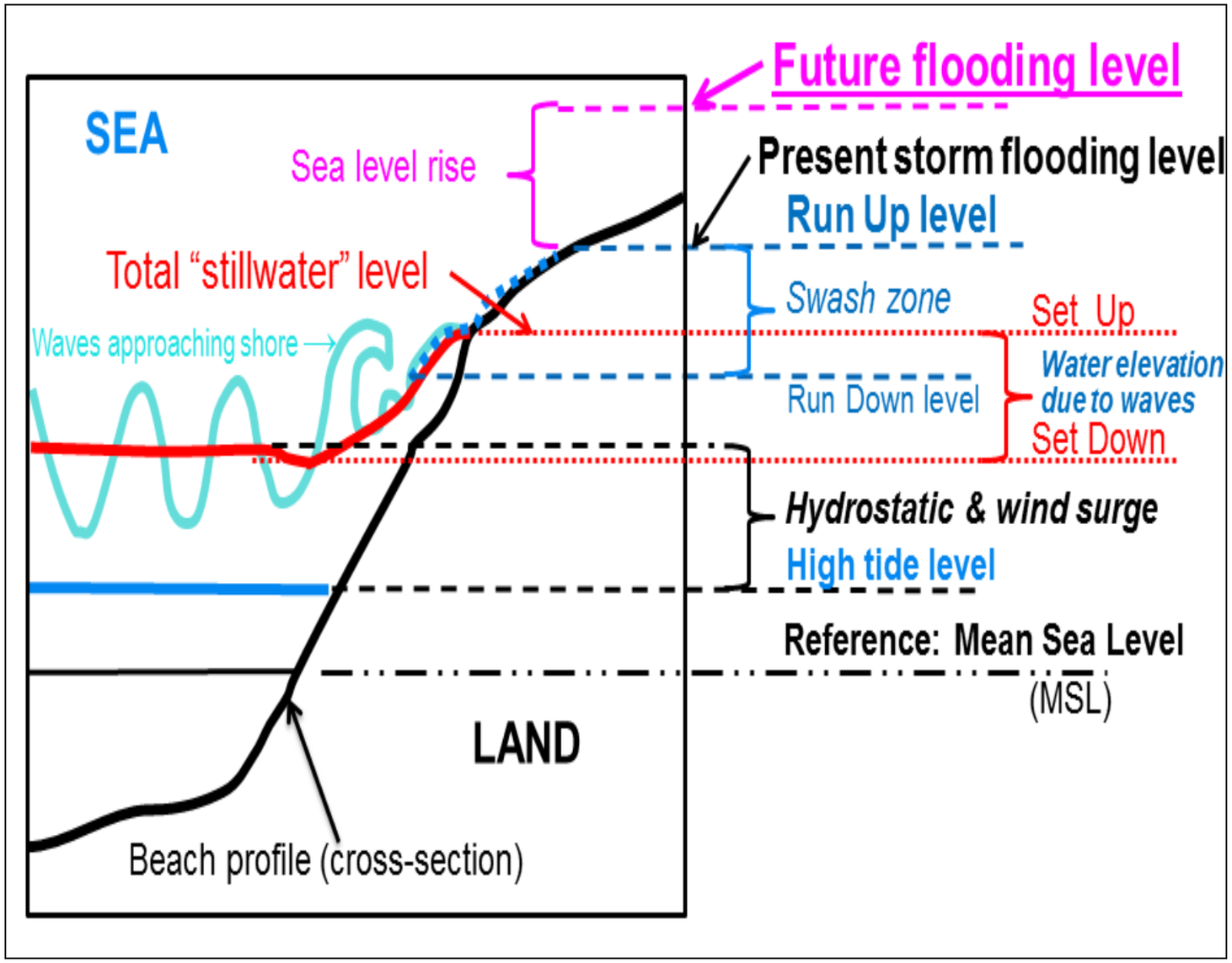
High seawater levels, wave run-up, flooding, erosion

Photo Theron, 2008



Extreme inshore sea water levels

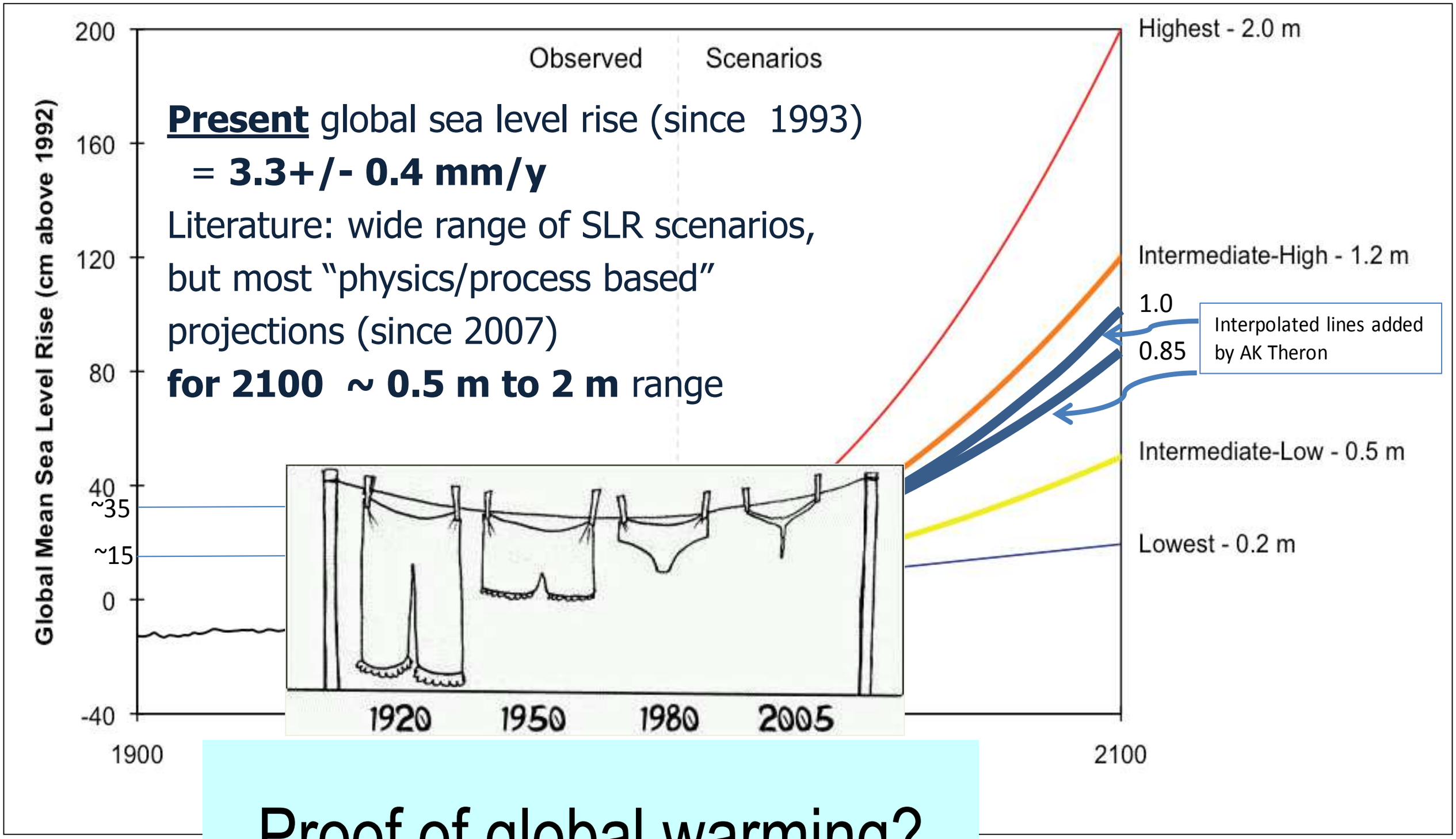
- **Drivers of high levels:**
  1. tides
  2. wind, hydrostatic (/barometric) set-up
  3. wave set-up
  4. future SLR
  5. wave run-up (added effect)



- **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

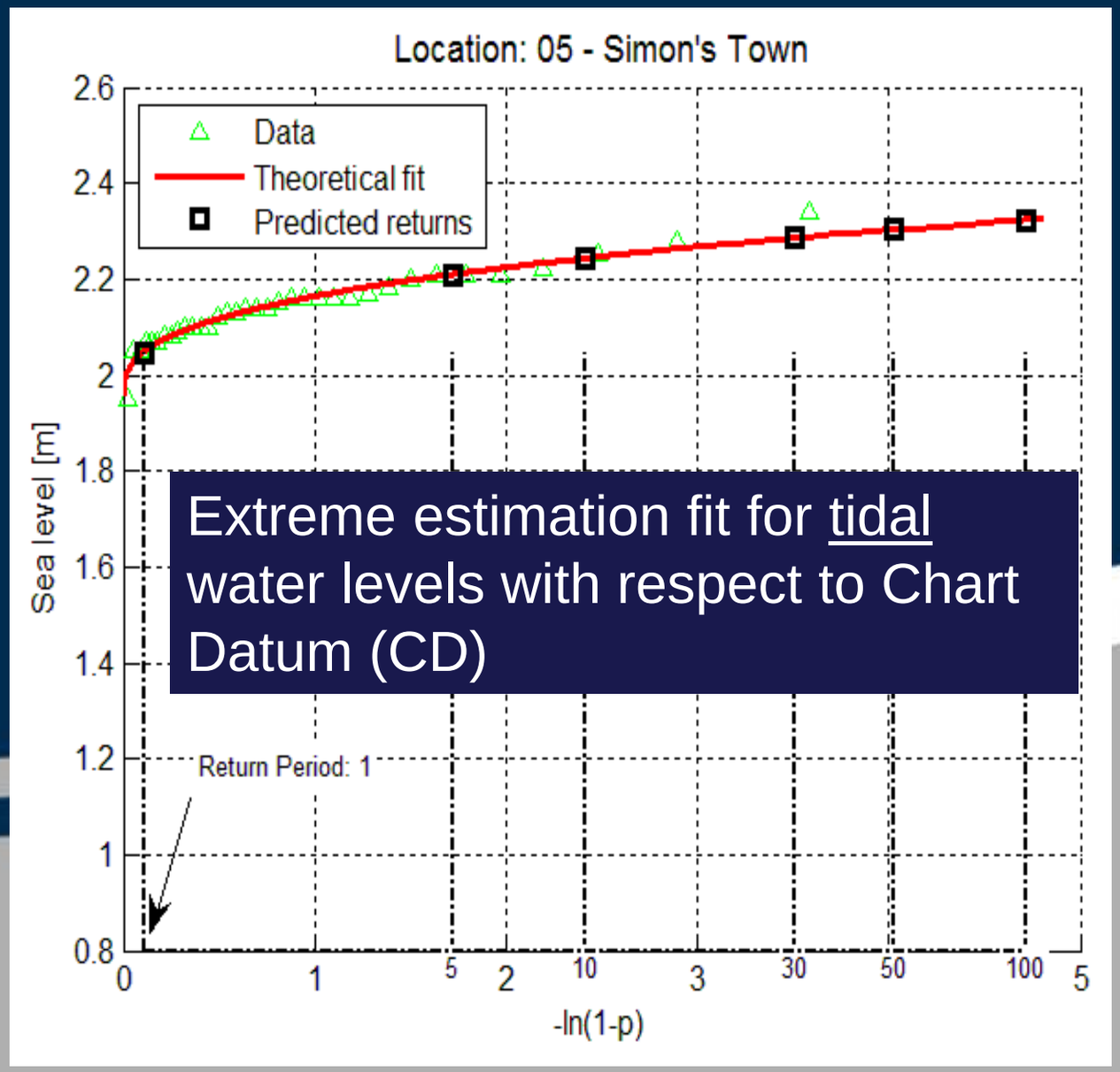


Proof of global warming?

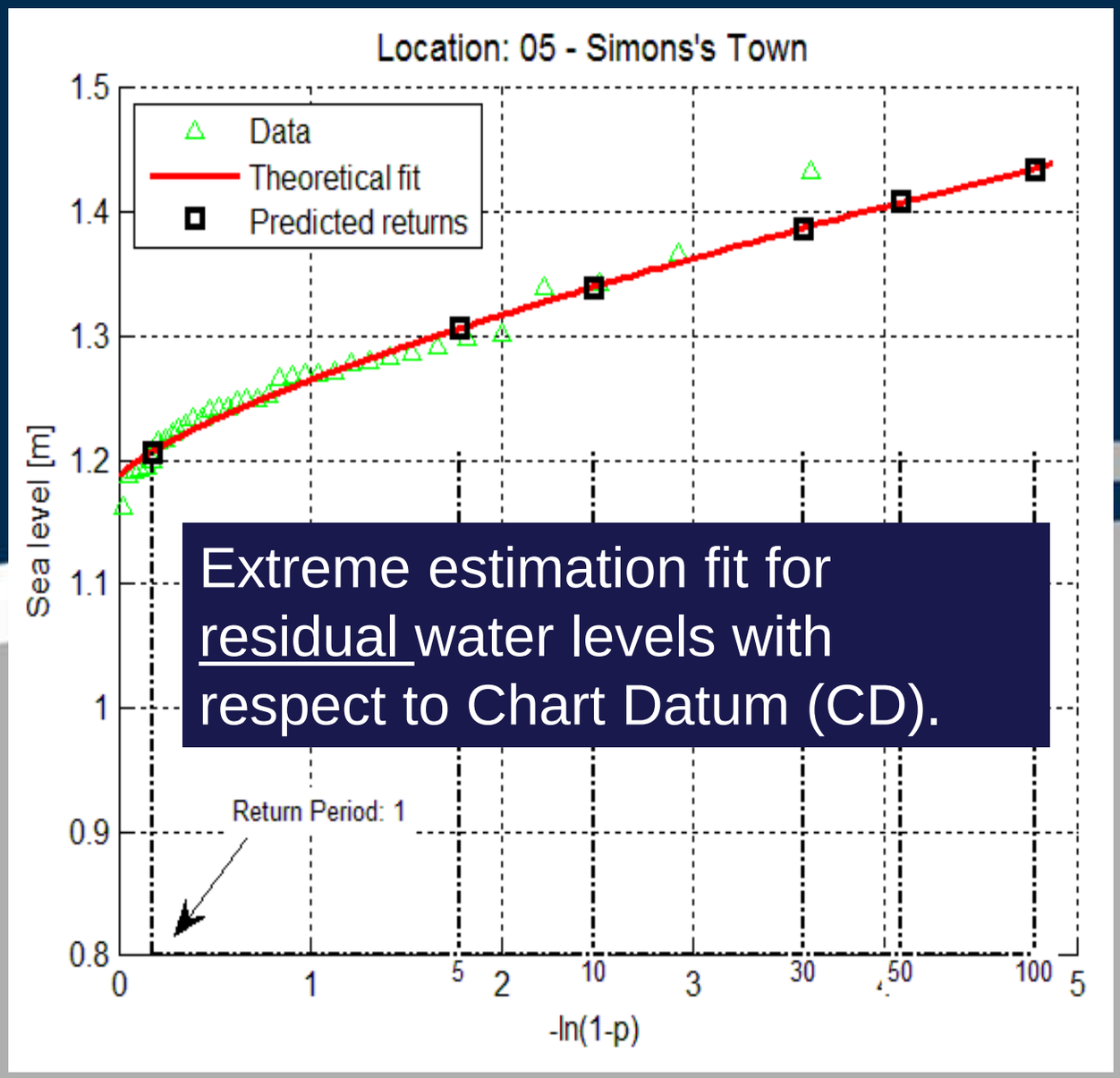
Adapted from Theron, 2015

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)

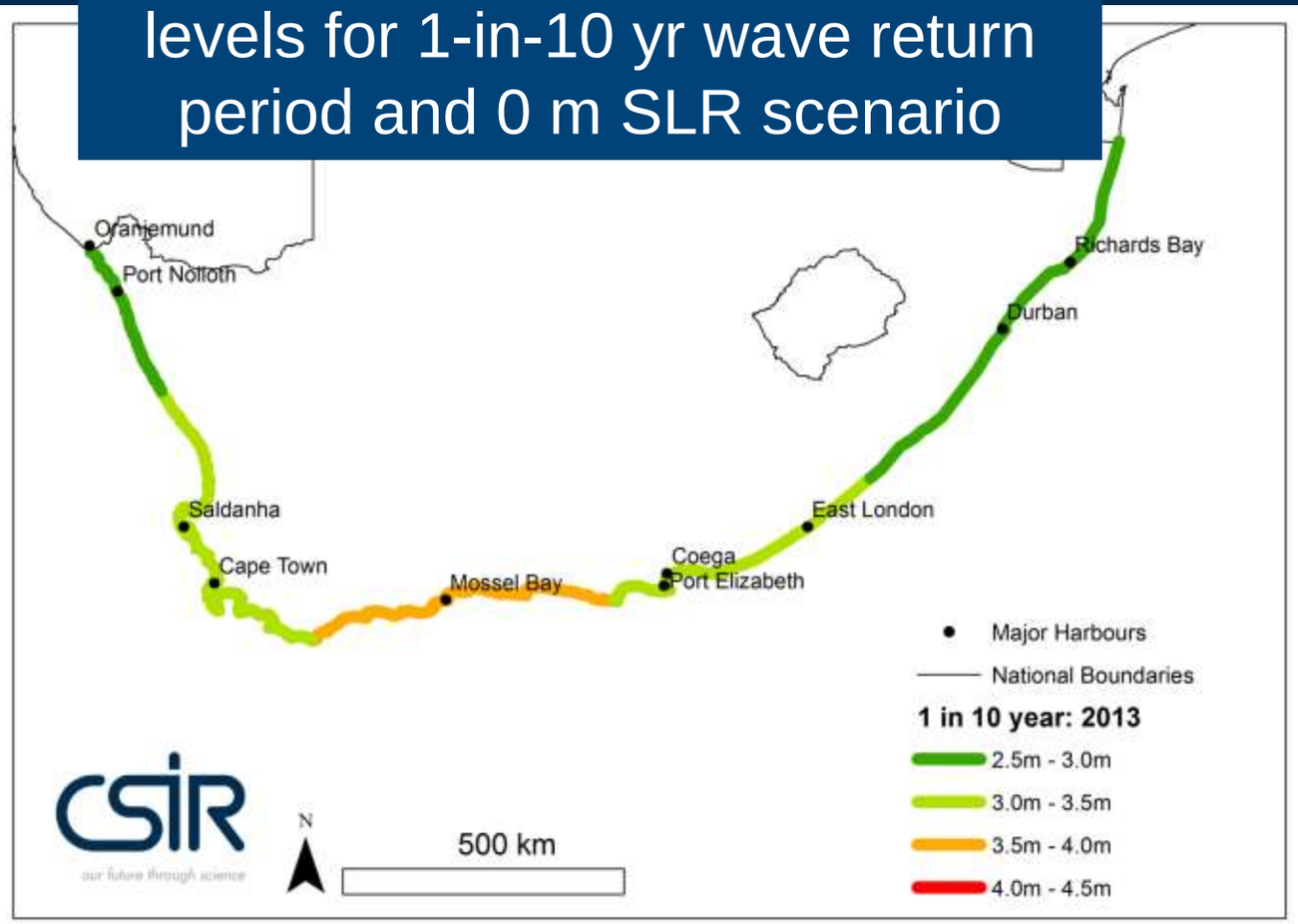
Calculation of SA open coast storm surge elevations (combined mean high-water spring (MHWS) + wind, wave and atmospheric setup for 1-in-10-year wave height and residuals)

→ Extreme open coast SA "storm surge" levels

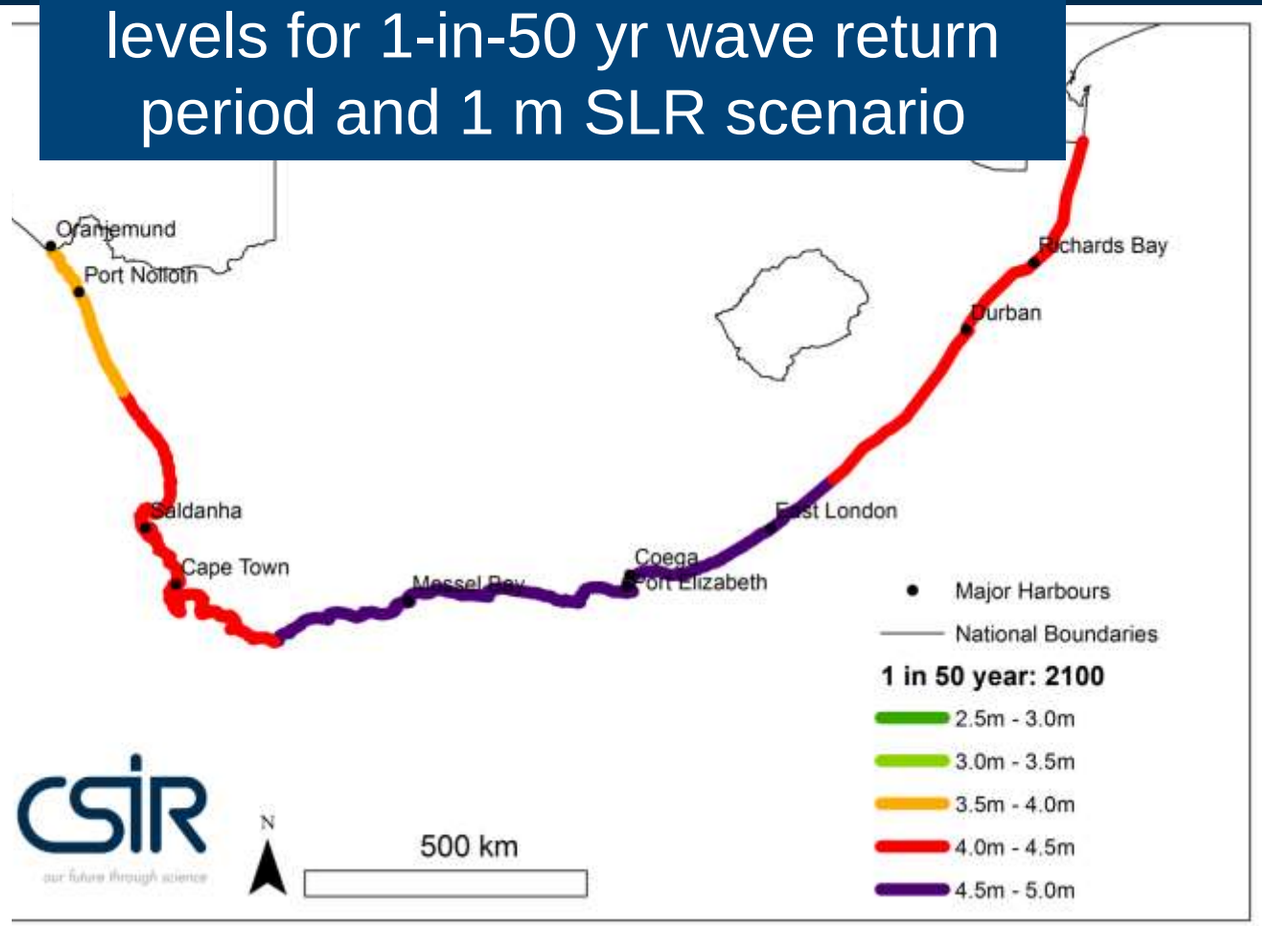
MHWS + residual & setups & SLR,
but <u>excluding wave run-up</u>
(some setups not applicable within bays)

<u>Examples:</u>

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



Determining coastal flooding elevations including wave runup:

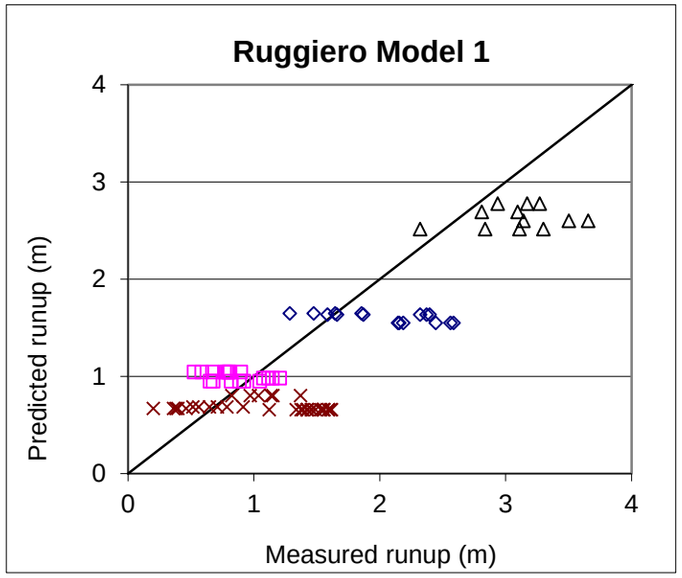
(Setback lines – Step 5)

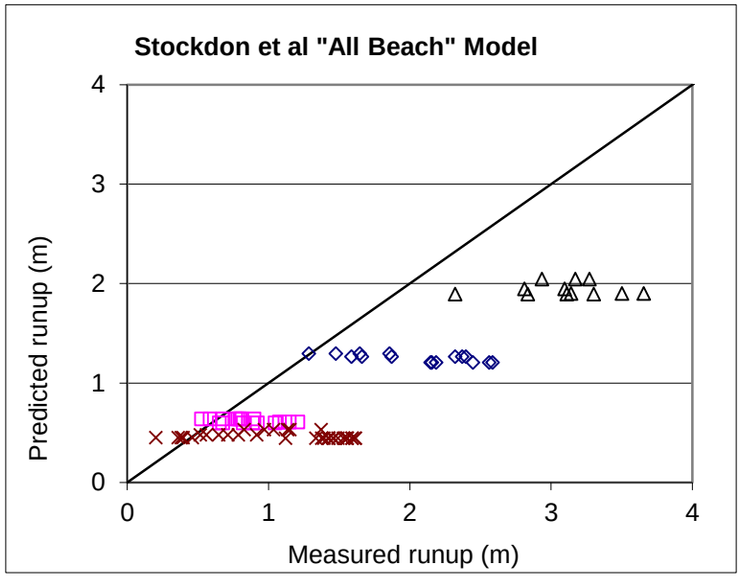
1. Determine extreme seawater levels, including SLR scenarios (» “still” wls / “storm surge” levels).

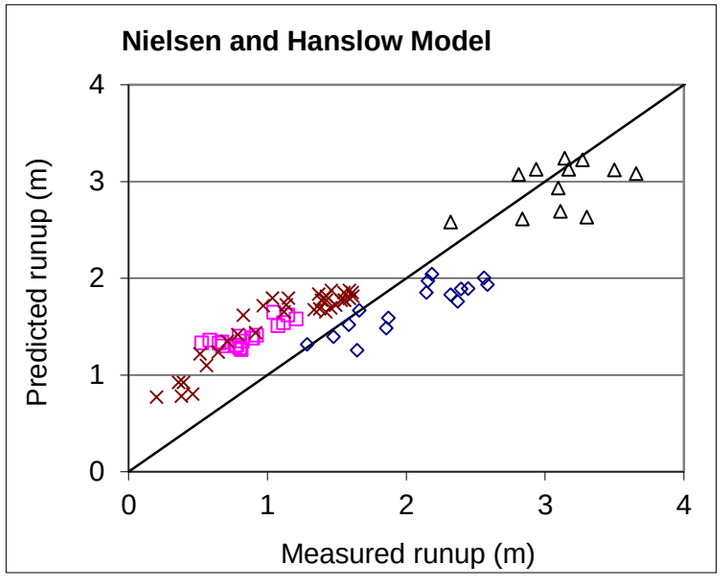
2. **Model wave runup levels.**

3. **Combine to determine coastal flooding elevations.**

Key findings re wave runup models - 1

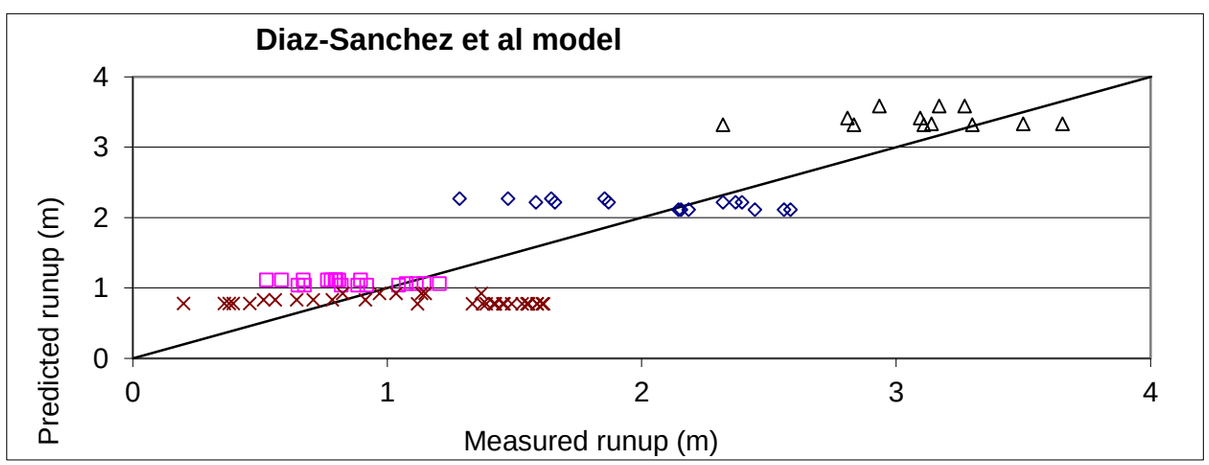


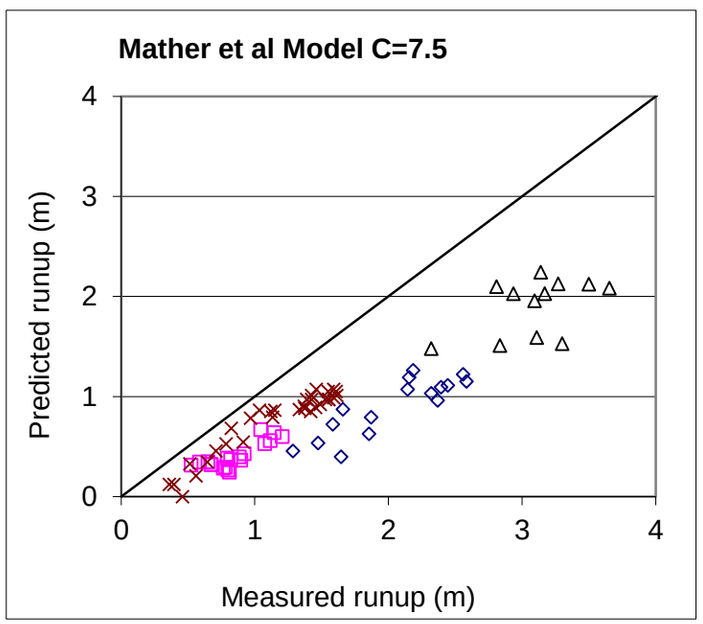




- Tested 13 wave runup models on SA data.
- Best 2 identified for SA application:

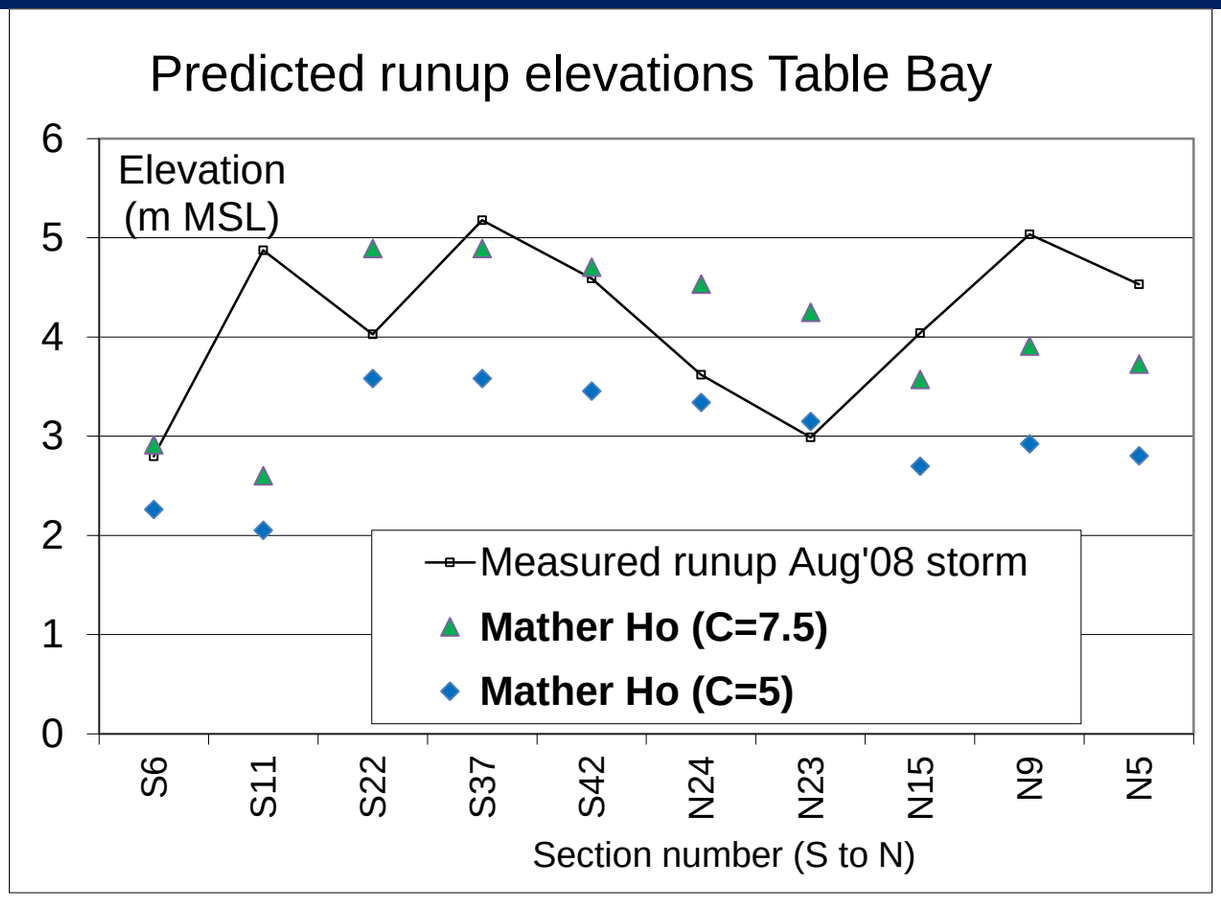
Mather et al (2011); Nielsen & Hanslow (1991).

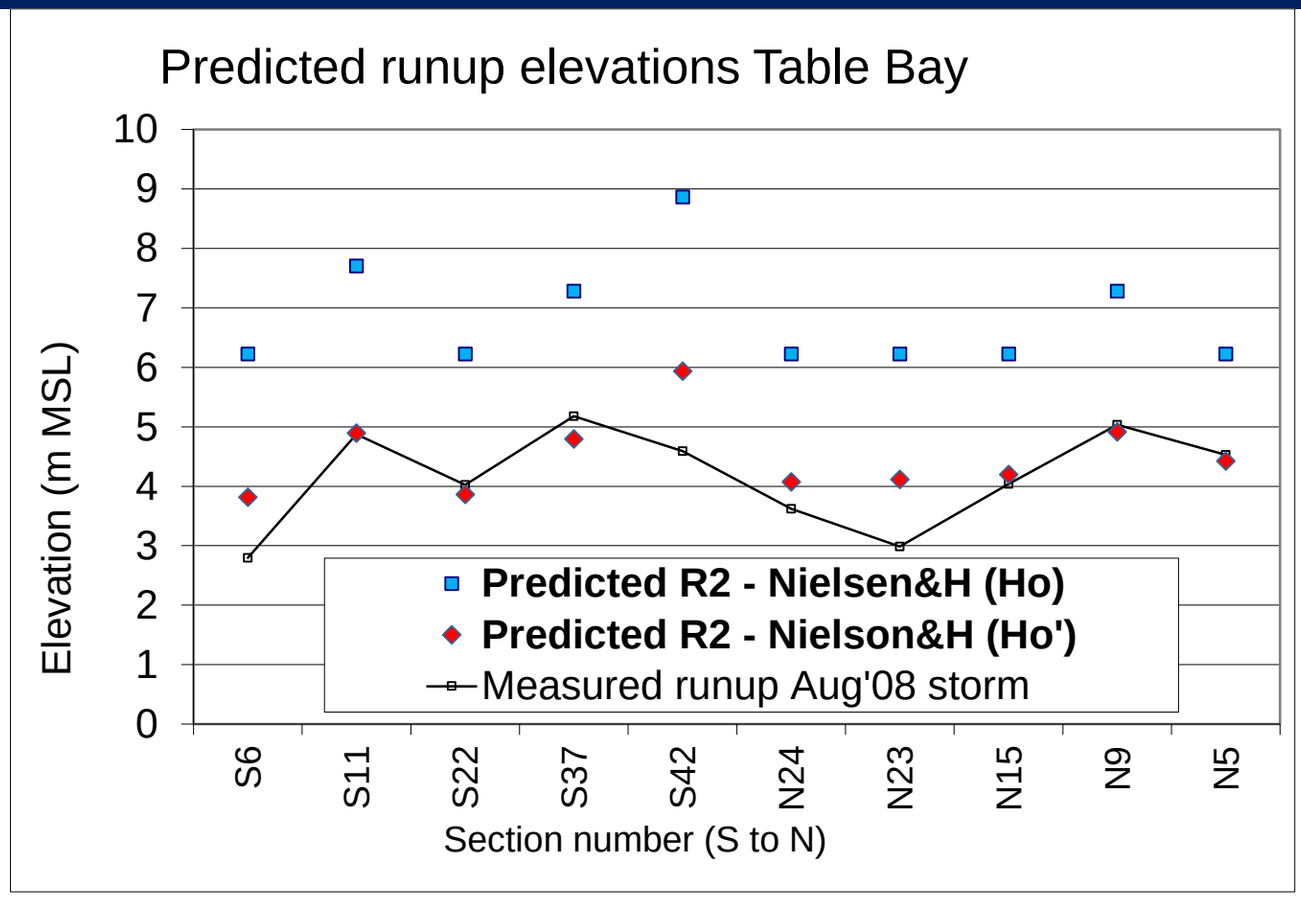




Adapted from Theron, 2015

Key findings re wave runup models - 2





Adaptation of the 2 models for optimum SA performance:

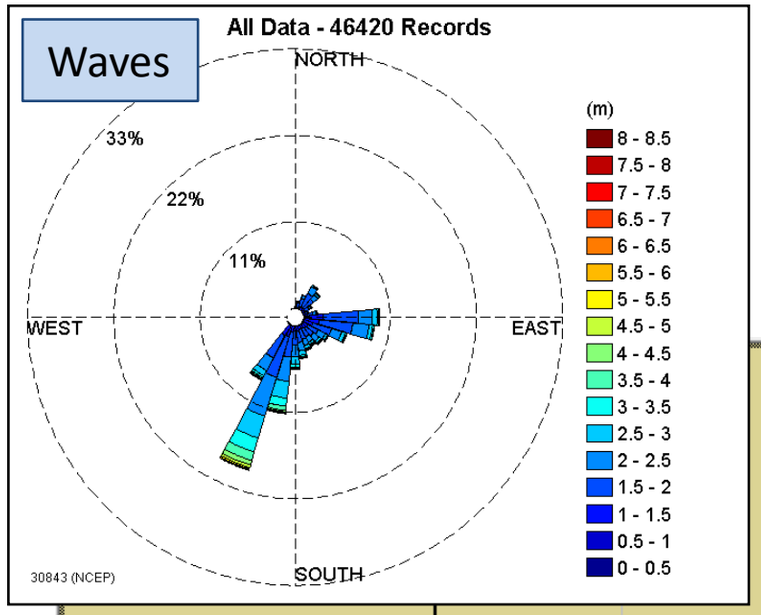
- **Mather model:** Where only deep-water heights are known, or no beach slope data available, the Mather model can be applied.
  Set coeff. C at 7.5 in open coast & semi-exposed locations (K>=0.4). In well sheltered locations (K<0.4), provisionally set C at 5.
- **Nielsen & Hanslow model:** best results with significant wave heights determined at <=20m depth & “reverse shoaled” to give equivalent deep-water wave heights as input.

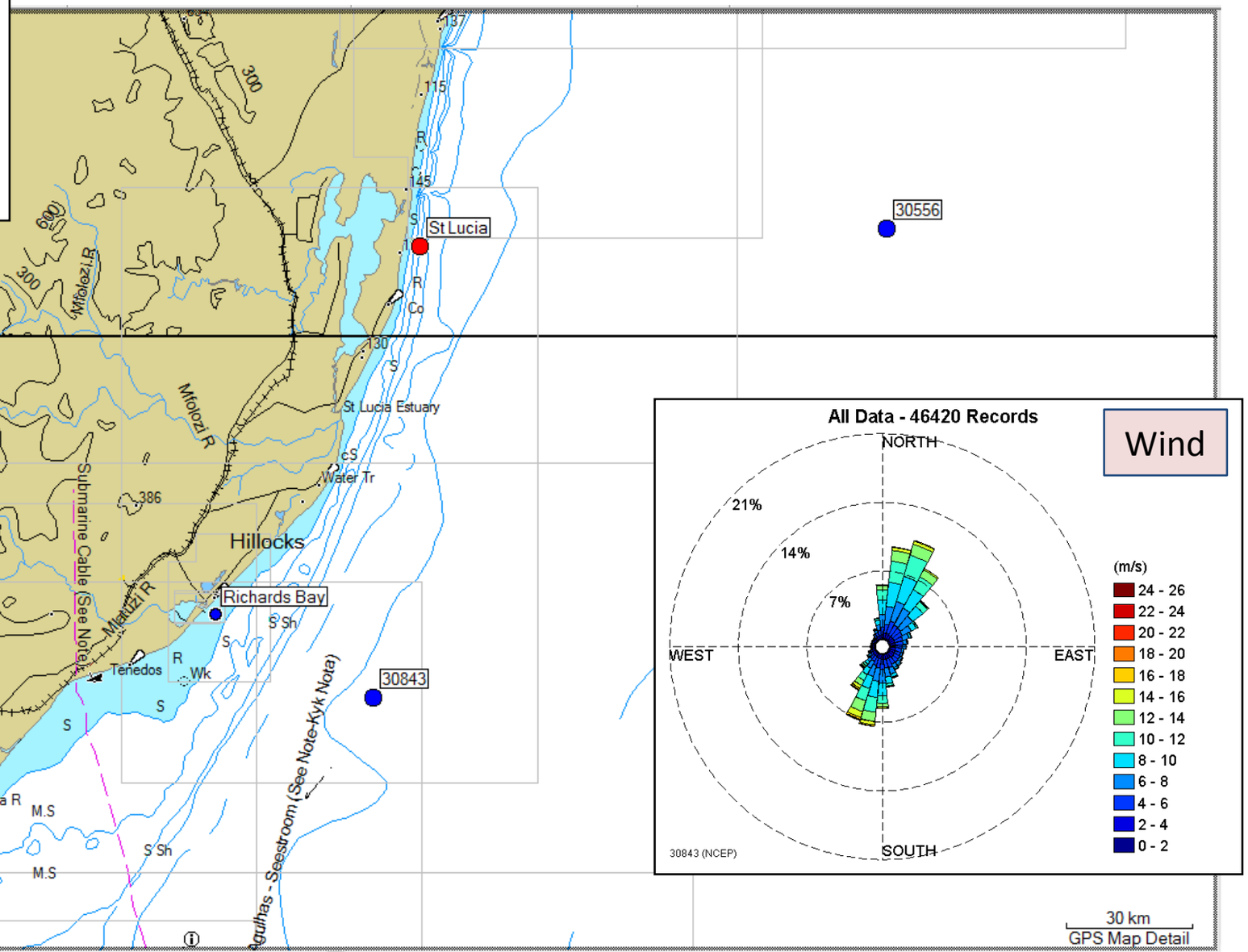
Adapted from Theron, 2015

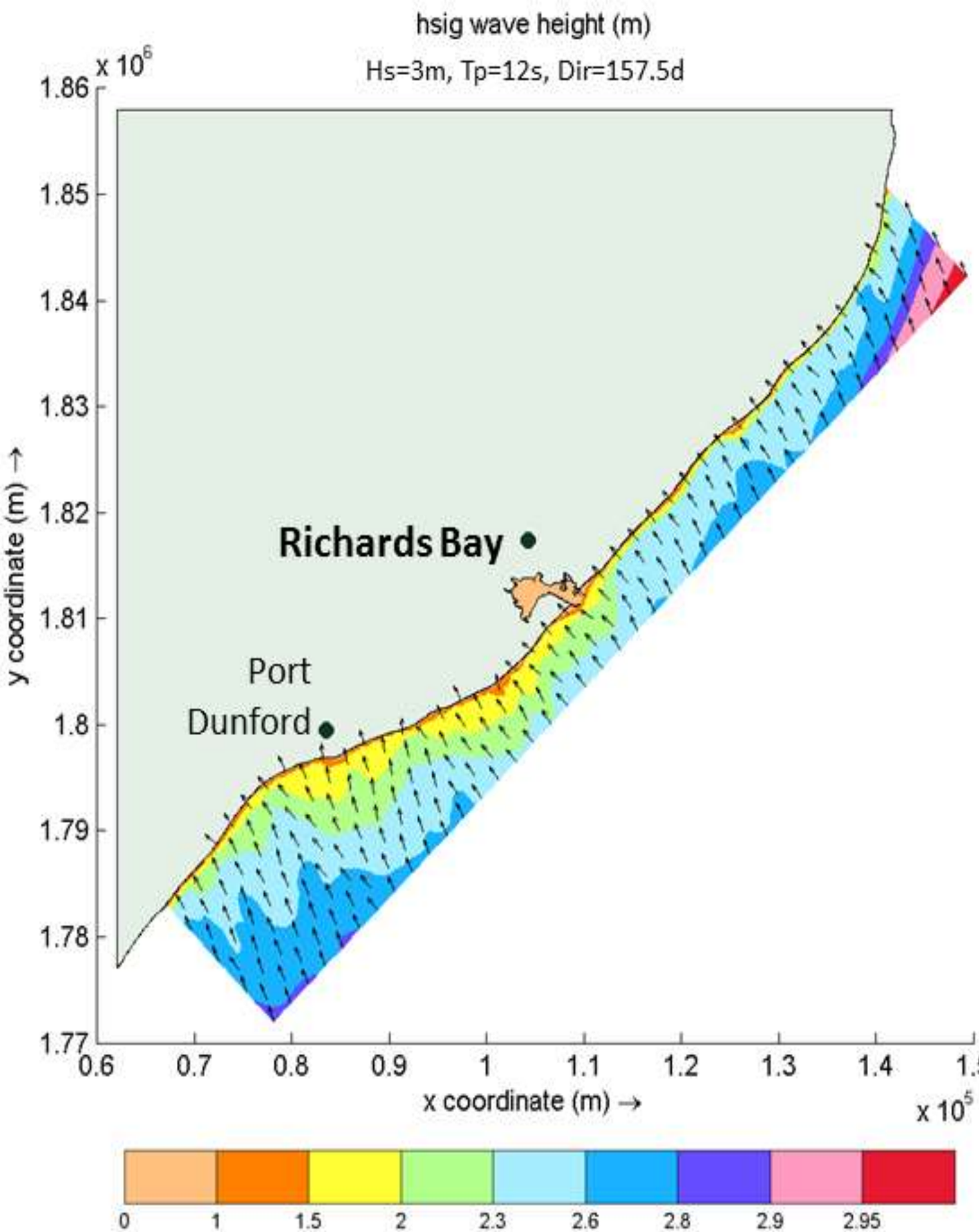
Modelling of wave runup levels - offshore wind & wave climate input example:

Location area: Richards Bay and St Lucia

NCEP grid-point: 30843
Approx. 45 km offshore







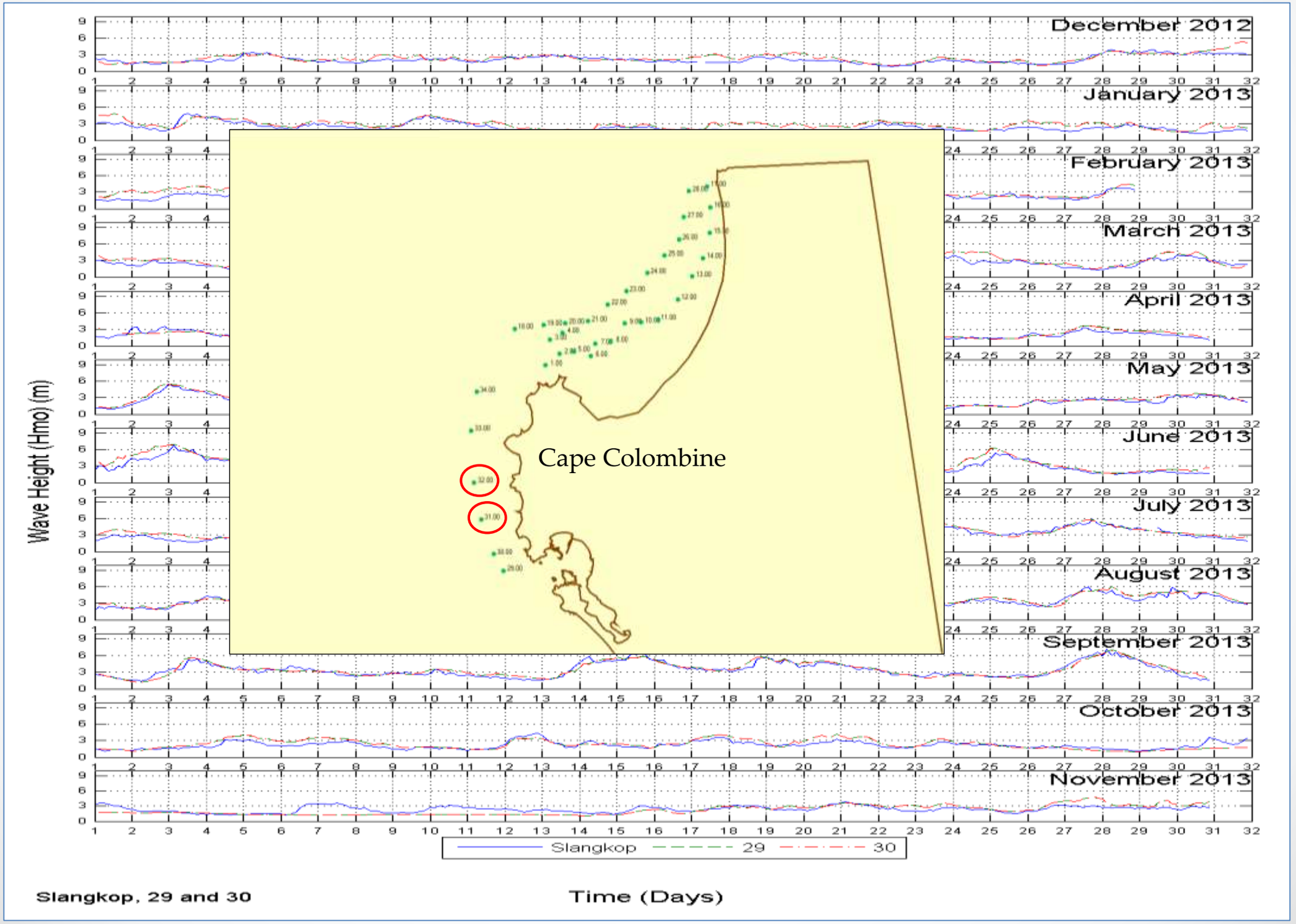
Process of **transforming off-shore wave climate into near-shore** wave climate via numerical wave modelling.

- 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.

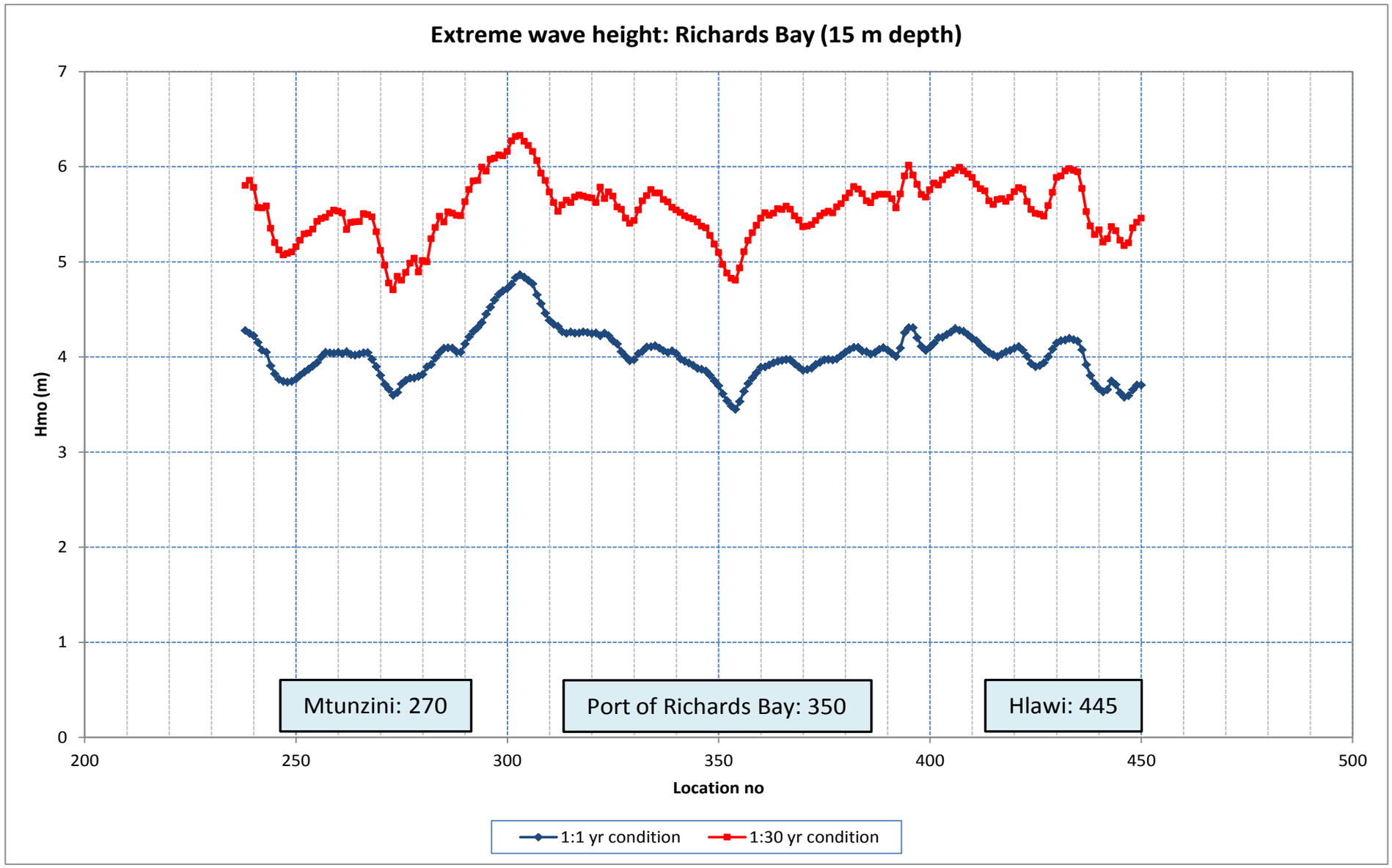
- 21 numerical wave models were completed each 100km+ alongshore.
- Provides medium resolution inshore wave climate data at 0.5km resolution (~2/3 SA coast).

Wave modelling verification example:

Wave height comparison off Cape South-west coast – Measured versus SWAN.

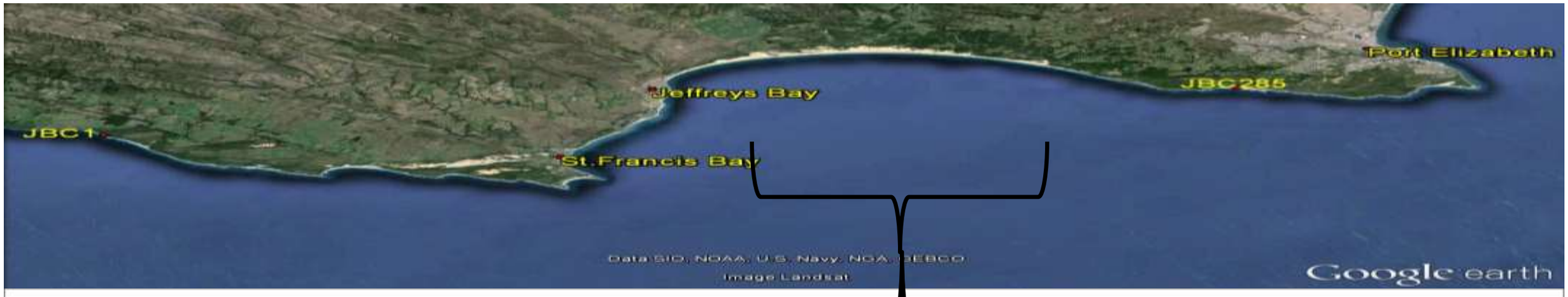


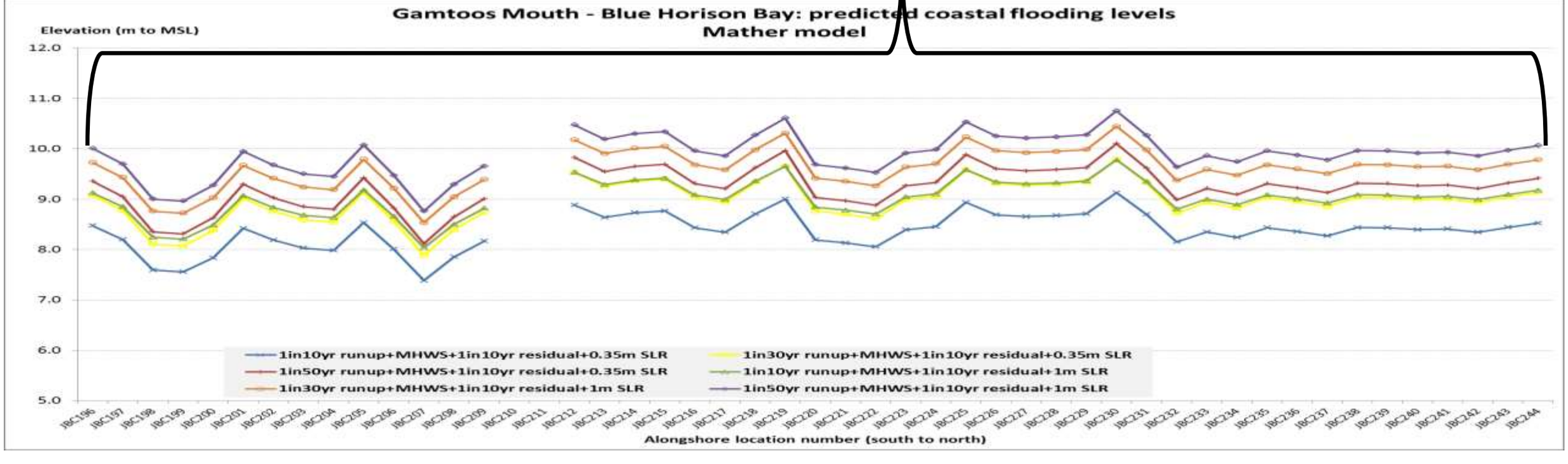
- For each 15yr time series of wave conditions, the extreme wave heights were estimated using an **Extreme statistical Values Analysis** (**EVA**).
- This procedure was applied to each of the shallow water output locations for each of the 21 modelled areas.



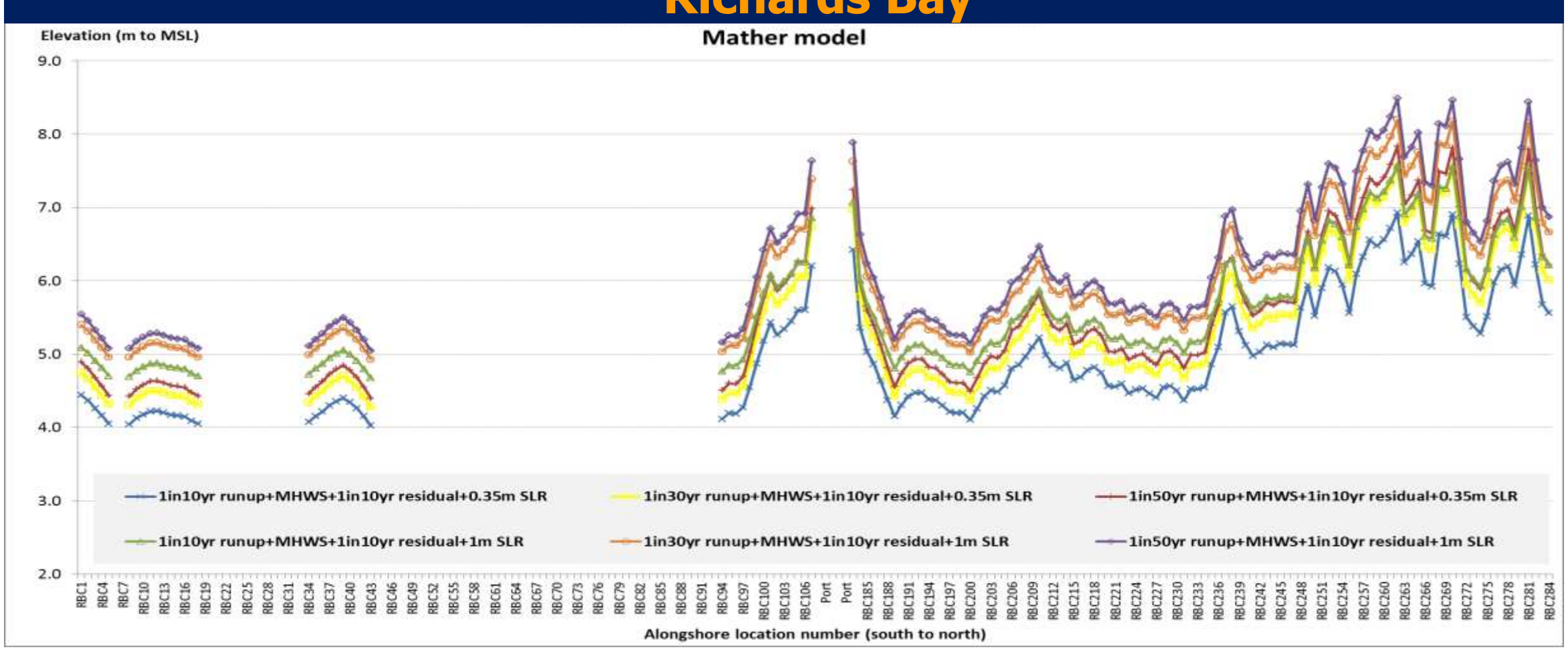
Coastal flooding levels - results:

- 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

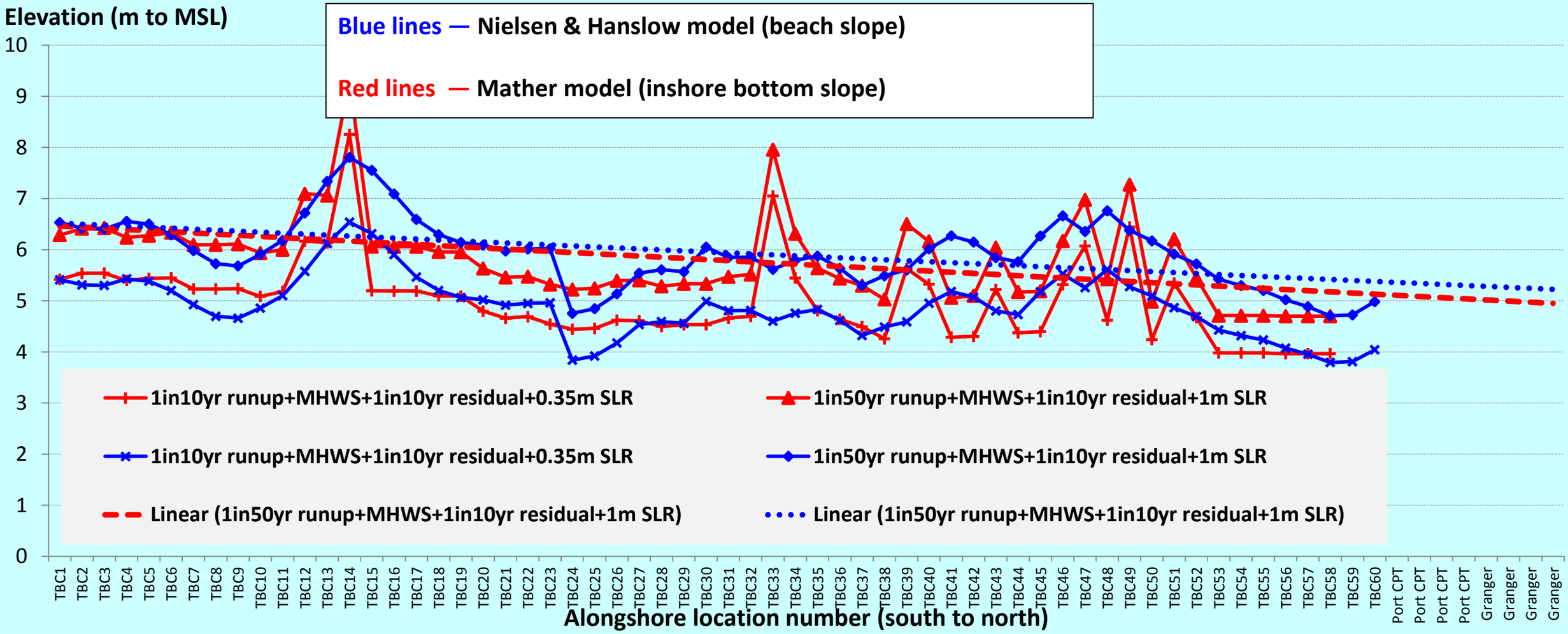
Red line — Scenario 1:
1-in-10yr runup + MHWS + 1-in-10yr residual + 0.35m SLR

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

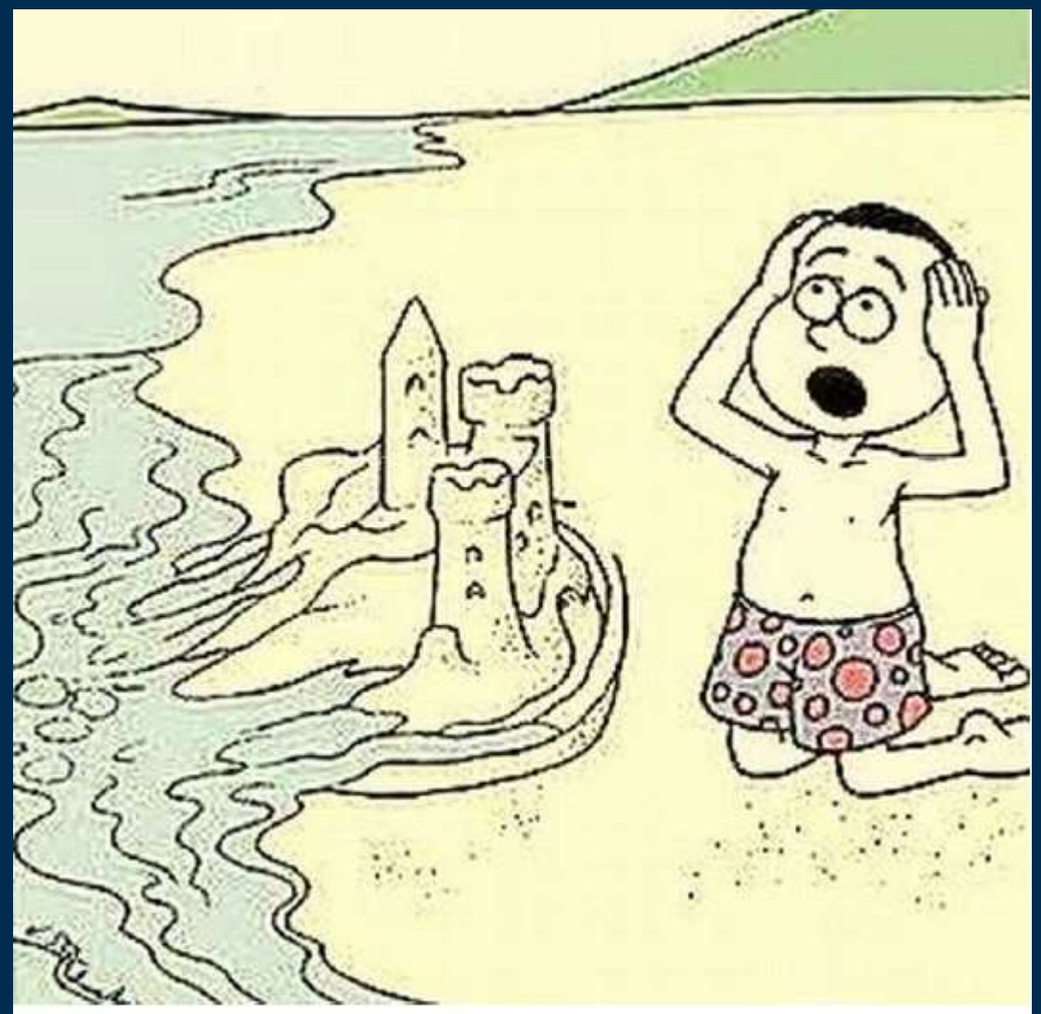
(all Mather wave runup model)

Table Bay predicted coastal flooding levels -Mather vs. N&H model



Adapted from Theron, 2015

Thank you



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