TSUNAMI SHOALING AND RUN-UP IN THE LARGE WAVE FLUME OF HANNOVER

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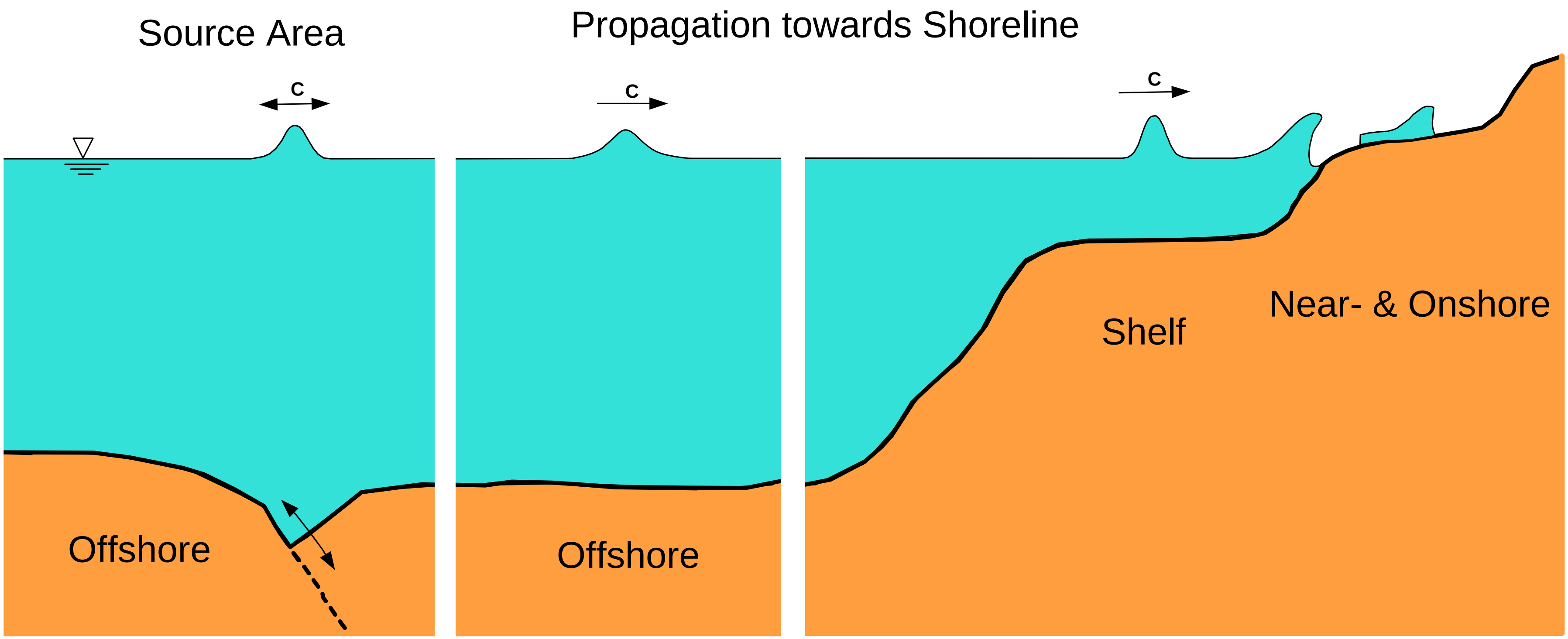
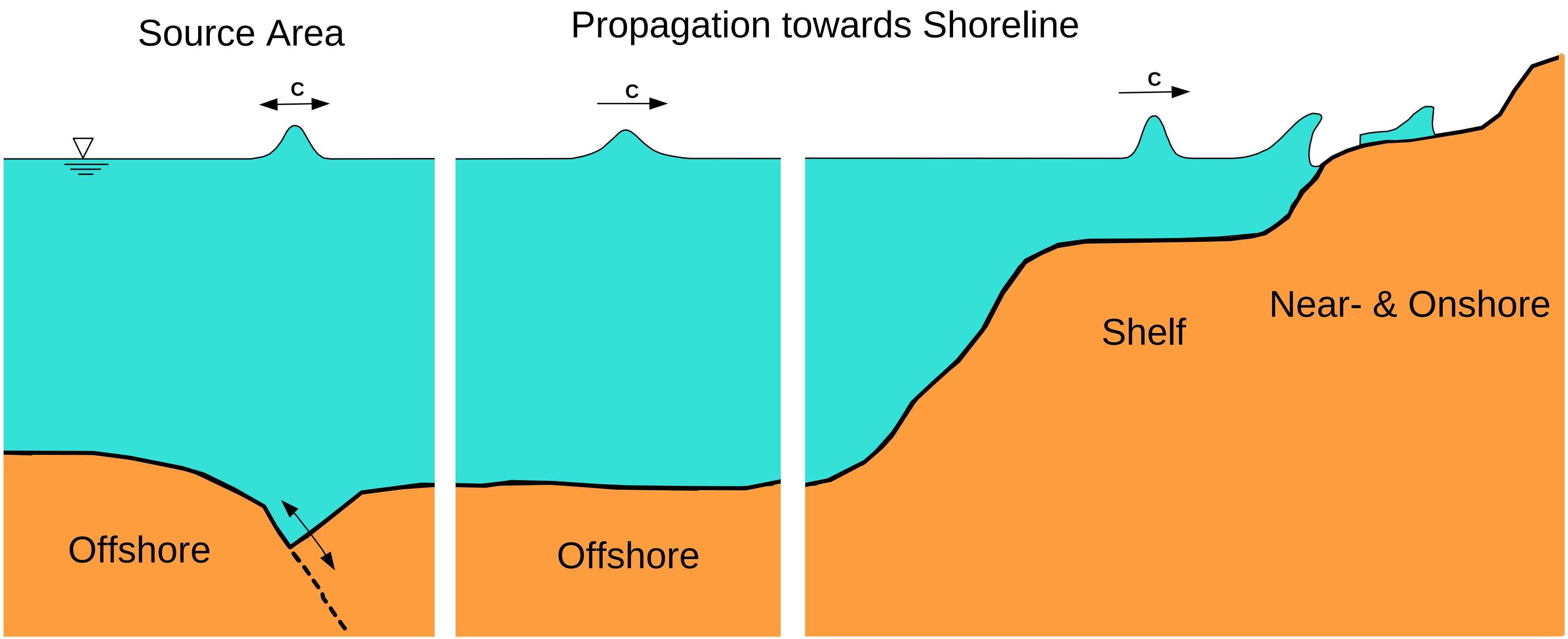
Scheme of Tsunami Wave Propagation



Most important Tsunami effects occur at near- & onshore areas
due to hydraulic performance of Tsunami waves:

- Shoaling, - reflection, - transmission, - breaking, - run-up & overtopping, - backwash, penetration and inundation into settlements

Scheme of Tsunami Wave Propagation



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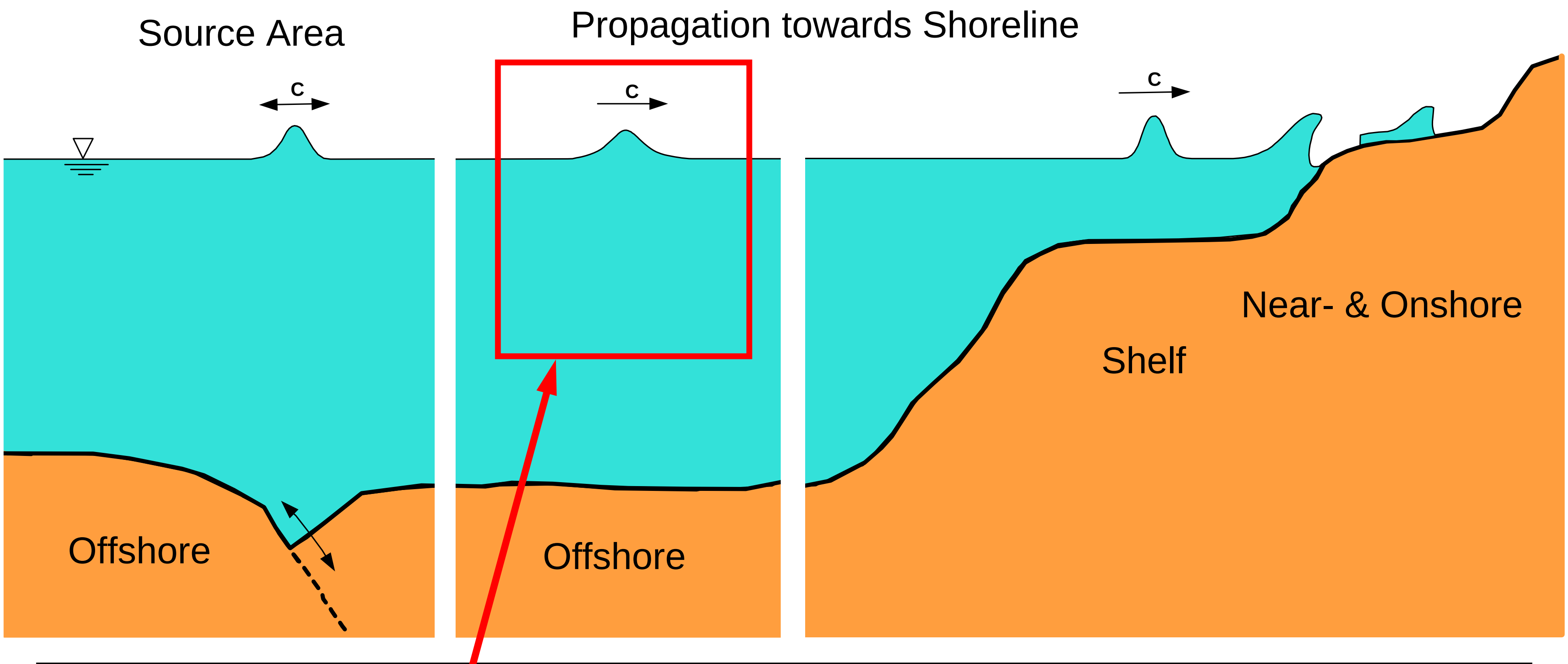
- Shoaling, - reflection, - transmission, - breaking, - run-up & overtopping, - backwash
- penetration and inundation into settlements

Local vulnerability depends strongly on local bathymetric and topographic conditions

Possible Measures to decrease Desaster from Tsunami Wave Impact



Active measures offshore far from shoreline: Early Warning System

(Identifying of tsunami events & numerical modelling of propagation to shoreline)

Passive measures near- & onshore: Coastal protection & land settlement policy

(Integrated Coastal Zone Management)

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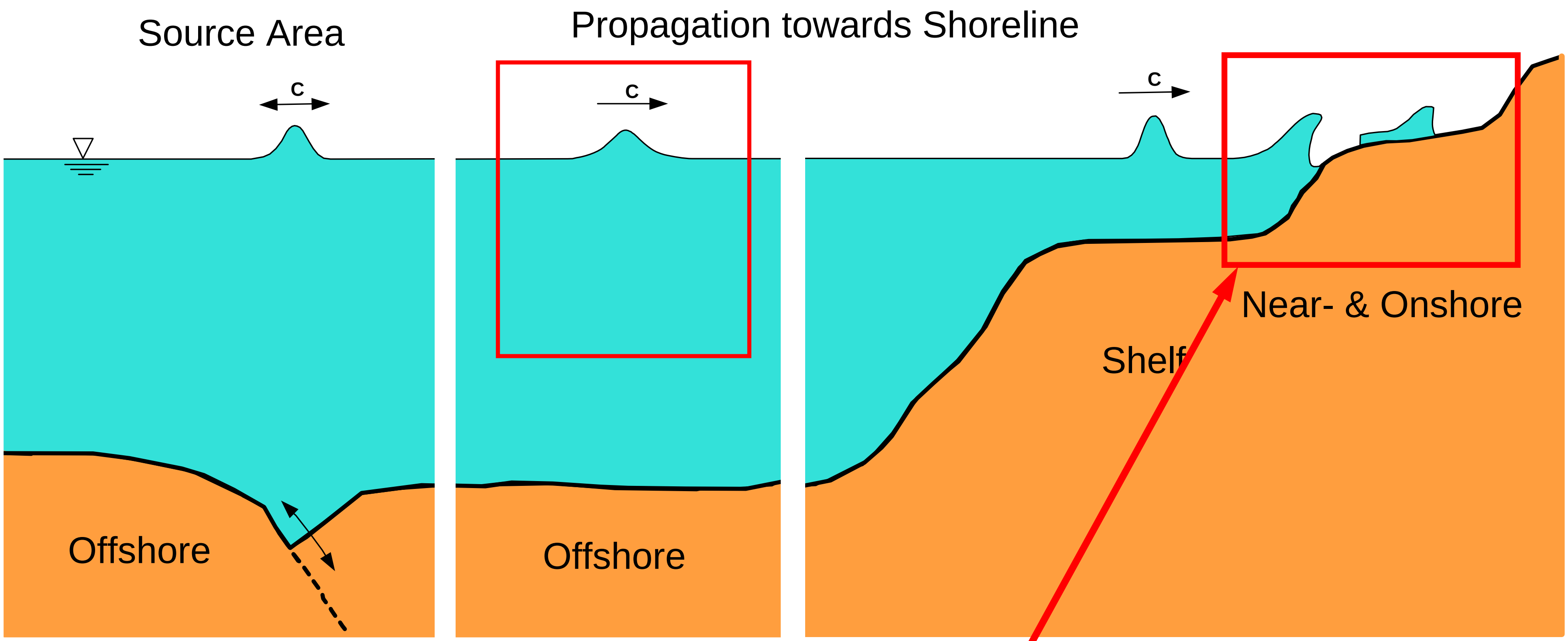

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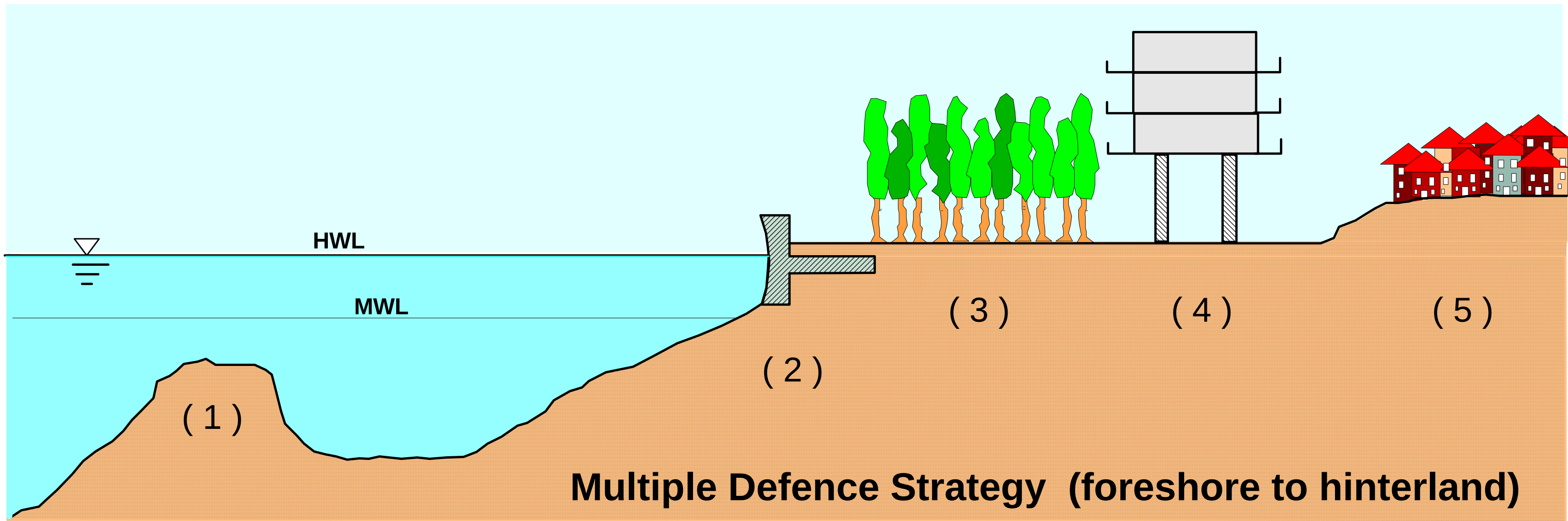
Passive measures near- & onshore: Coastal protection & land settlement policy

(Integrated Coastal Zone Management)

Coastal protection & land settlement policy

Risk-based design, safety assessment & management of defence system, closely linked to land use and coastal development



(1)

Artificial Reefs:

Innovative wave absorbers

Geotextile sand containers

(2)

Man-made protection & defence structures

(3)

Mangrove forest

Dunes

(4)

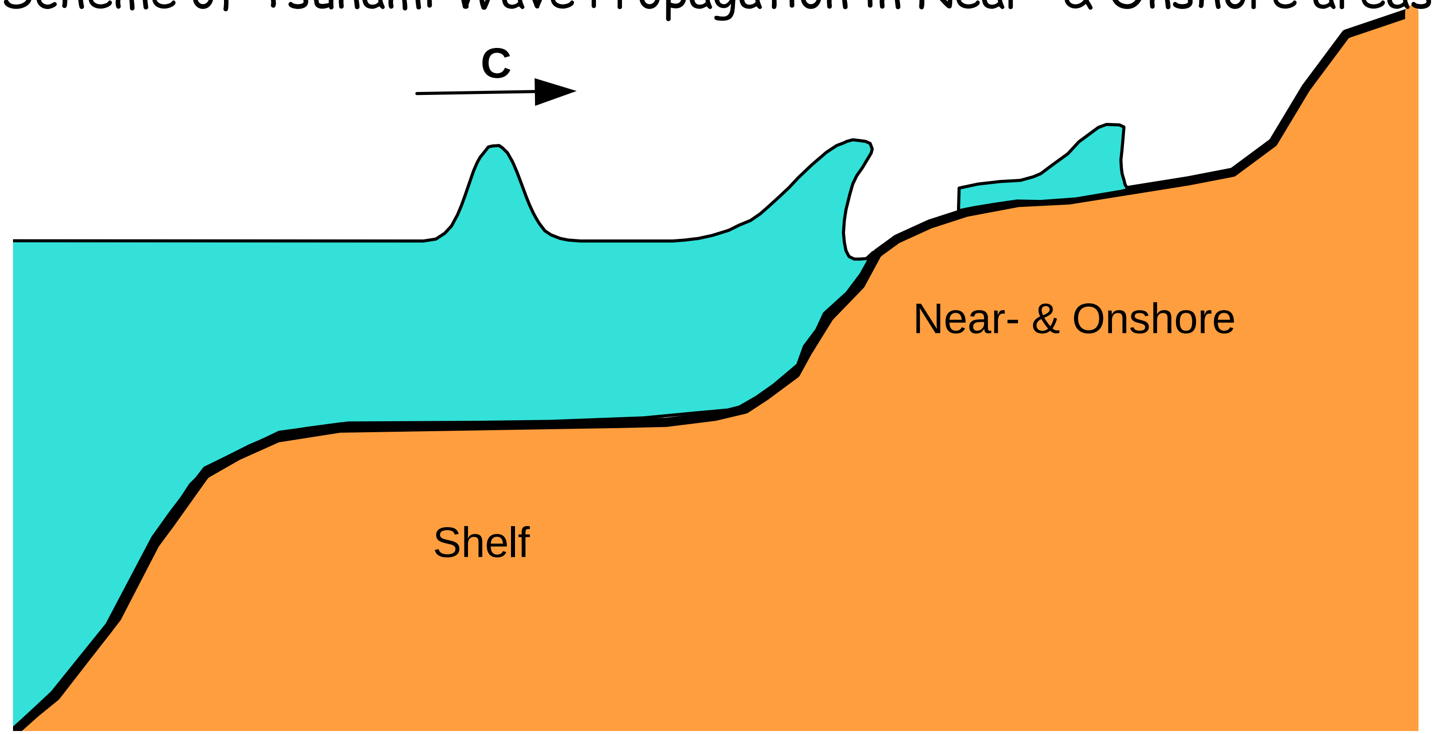
Raising buildings above tsunami inundation levels

(5)

Land settlement measures (distance & height to shoreline)

Multi-purpose high buildings used as safety areas

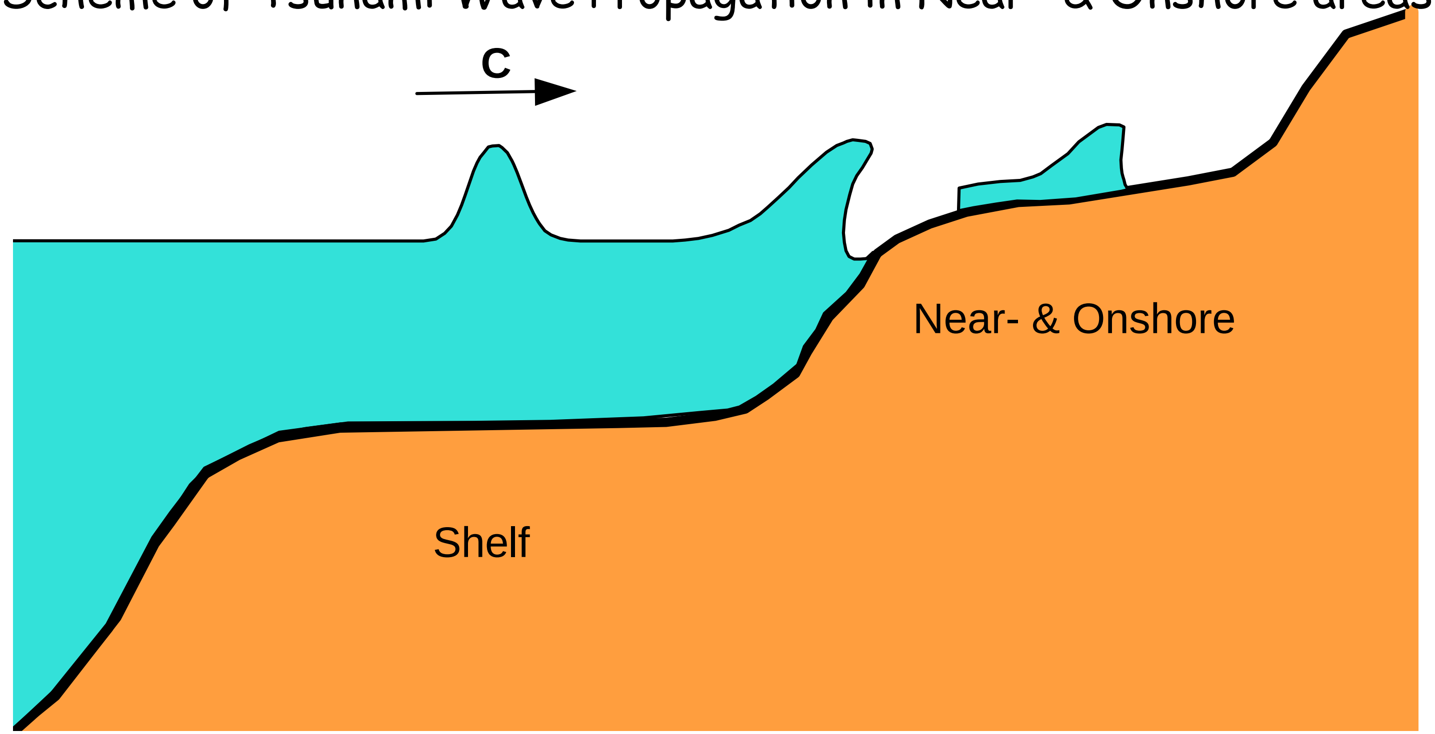
Scheme of Tsunami Wave Propagation in Near- & Onshore areas



Objectives of research: **Improvement of knowledge about hydraulic performance as a tool for Integrated Coastal Zone Management**

Possible methods:
- Numerical modelling (needs calibration)
- Physical modelling (scale & model effects to be minimized)

Scheme of Tsunami Wave Propagation in Near- & Onshore areas



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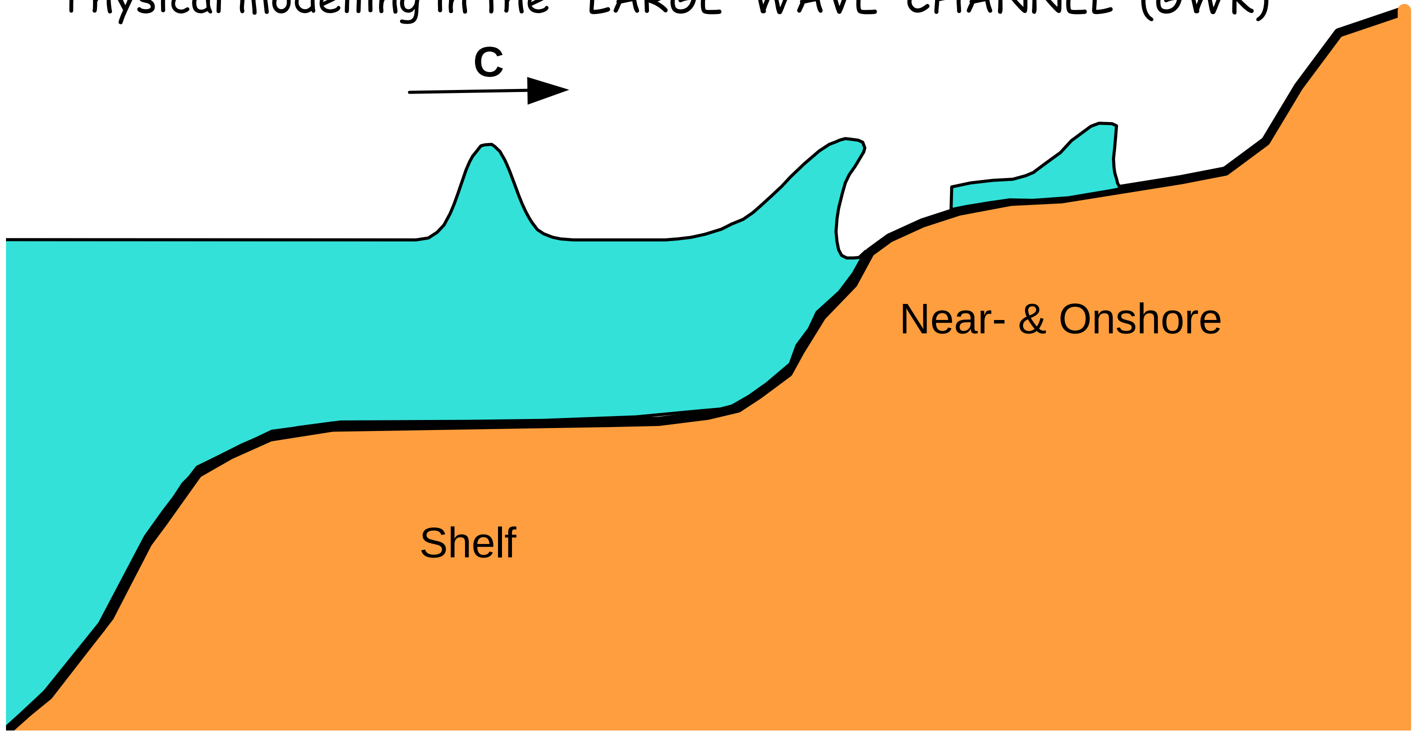
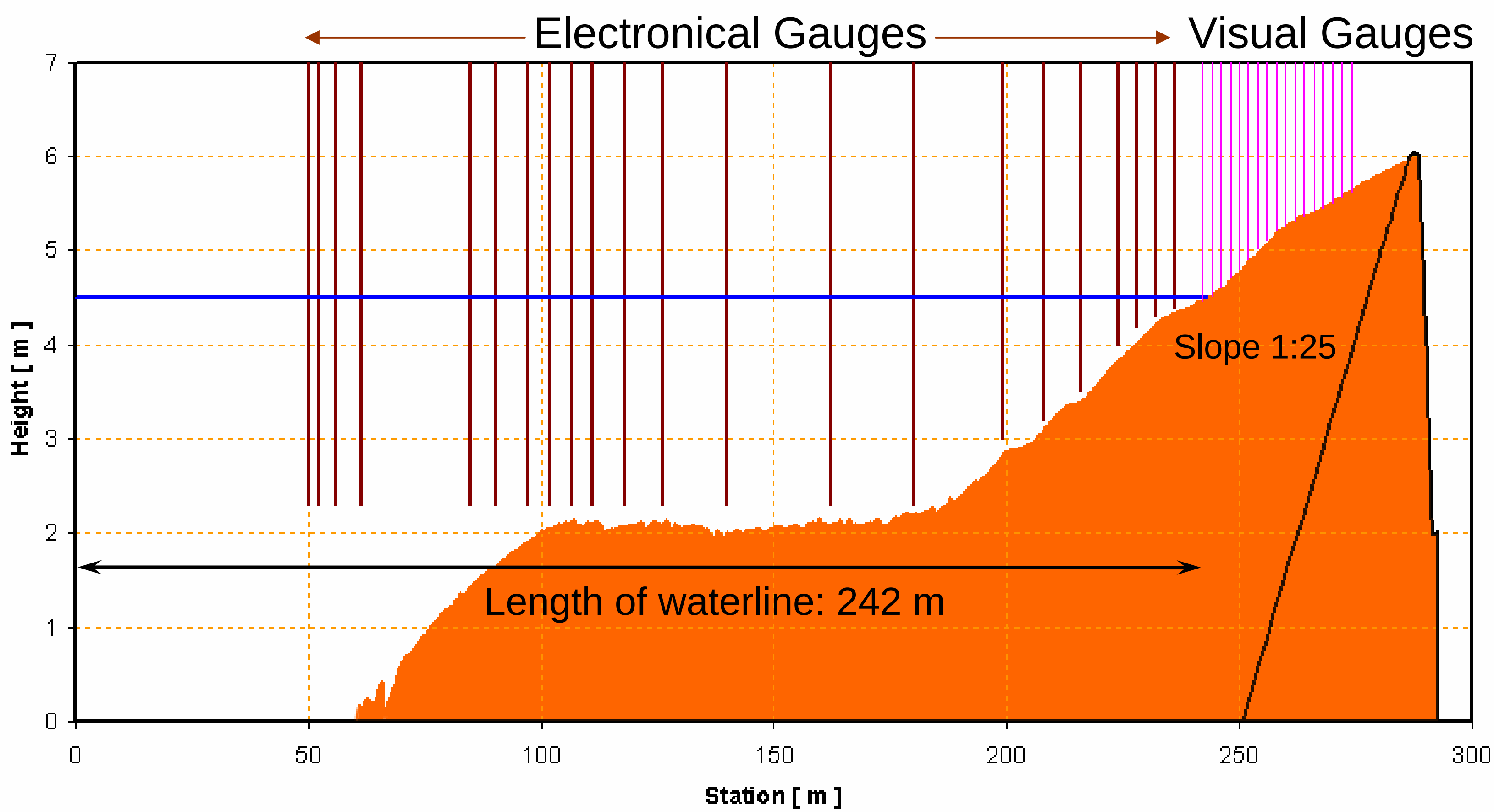
Physical modelling in the LARGE WAVE CHANNEL (GWK)



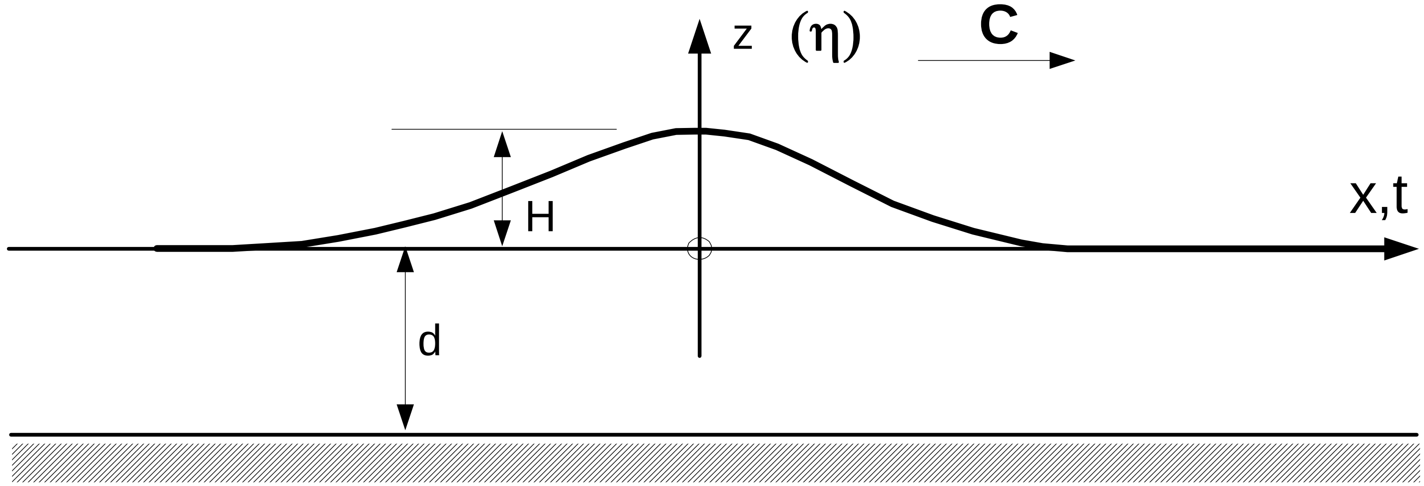
Objectives of performed investigations at the Coastal Research Centre FZK:

- Tsunami wave simulation using solitary wave theory
- Wave run-up on a uniform sloped beach profile
- Influence of composed Tsunami wave train on wave run-up

Longitudinal Section of the Model set - up in the GWK



Definition scheme for solitary wave theory (Quasi - Tsunami wave simulation)



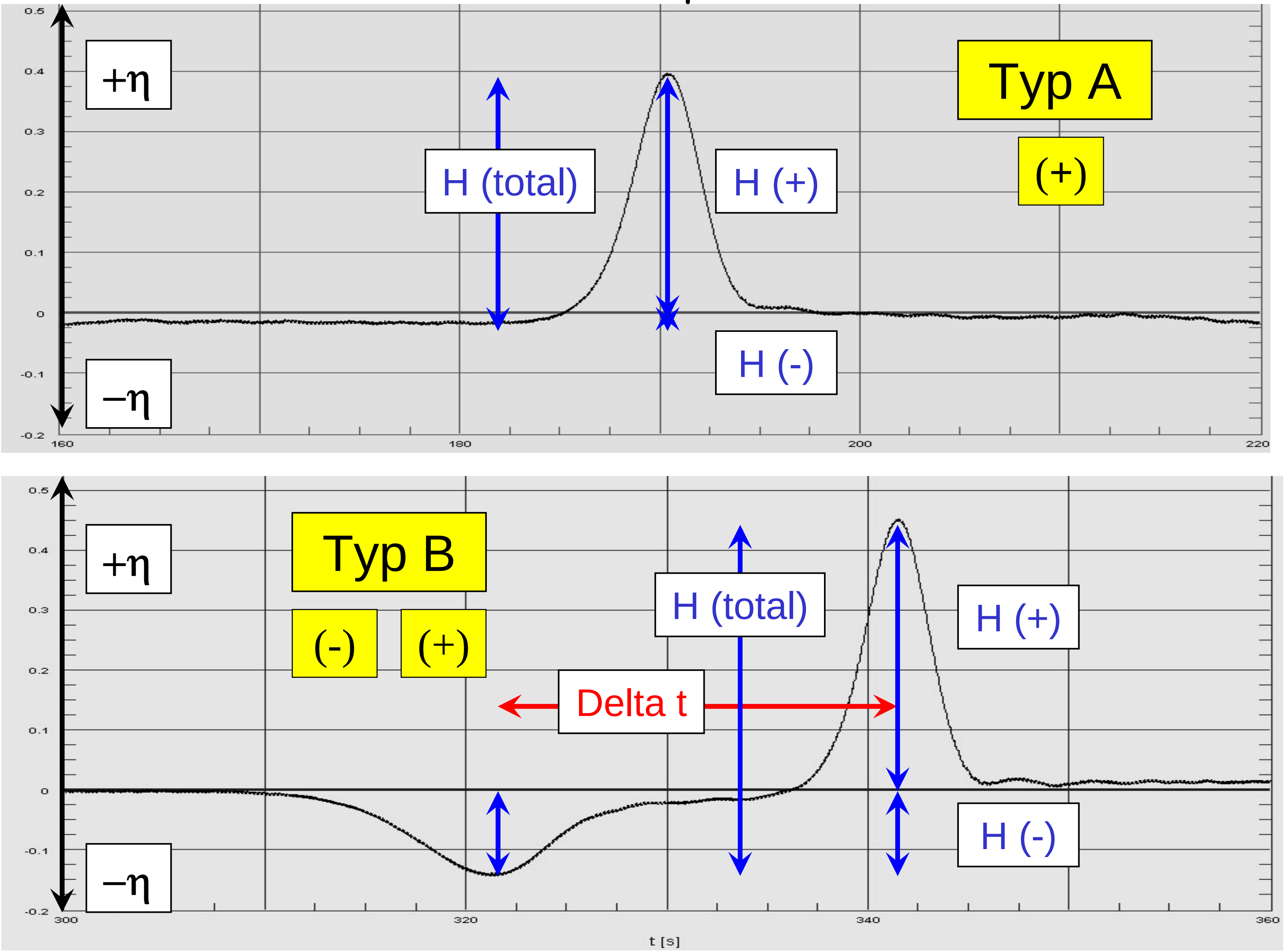
First Order:

$$\eta_{(x)} = H \cdot \sec^2\left(\sqrt{0.75 \cdot H / d} \cdot x / d\right)$$

$$C = \sqrt{g \cdot (H + d)} \qquad L_{98} = 7.6 \cdot d \qquad T_{98} = L_{98} / C$$

According first approximation of the Boussinesq's approach as described by W. H. Munk (1951).

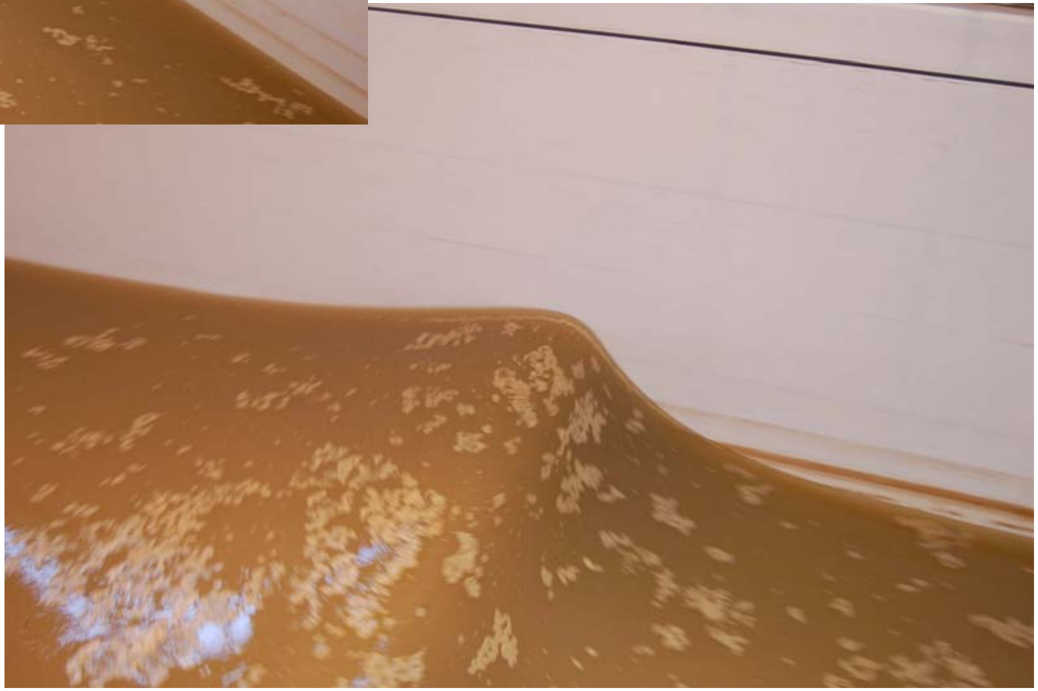
Influence of different shapes of surface elevation



TYP A

Offshore - Shelf

Shoaling
(shortly before breaking)

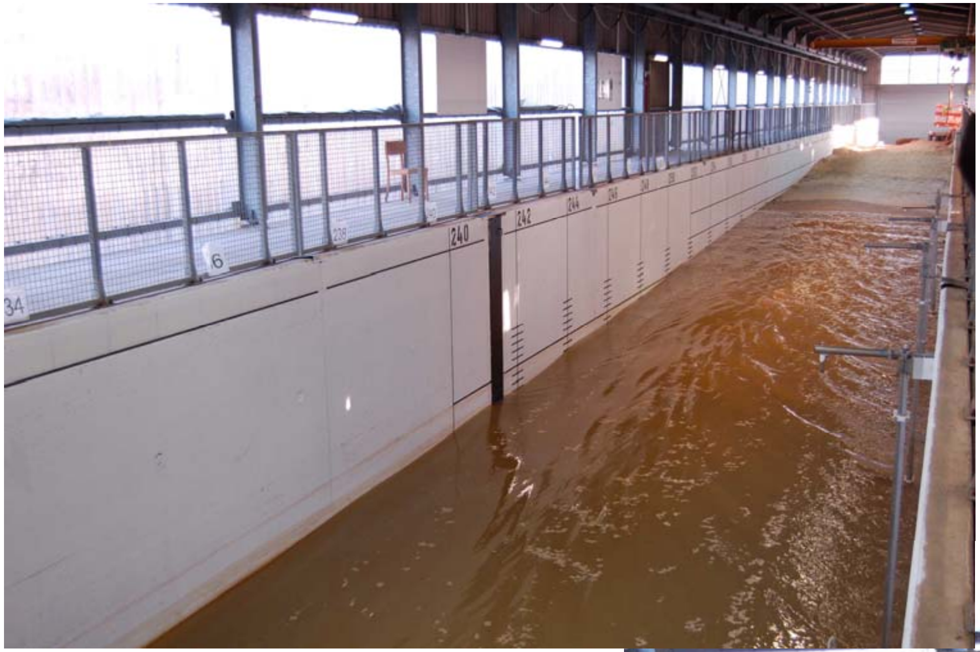


TYP A

Running - up

Breaking
(bore characteristic)

TYP A

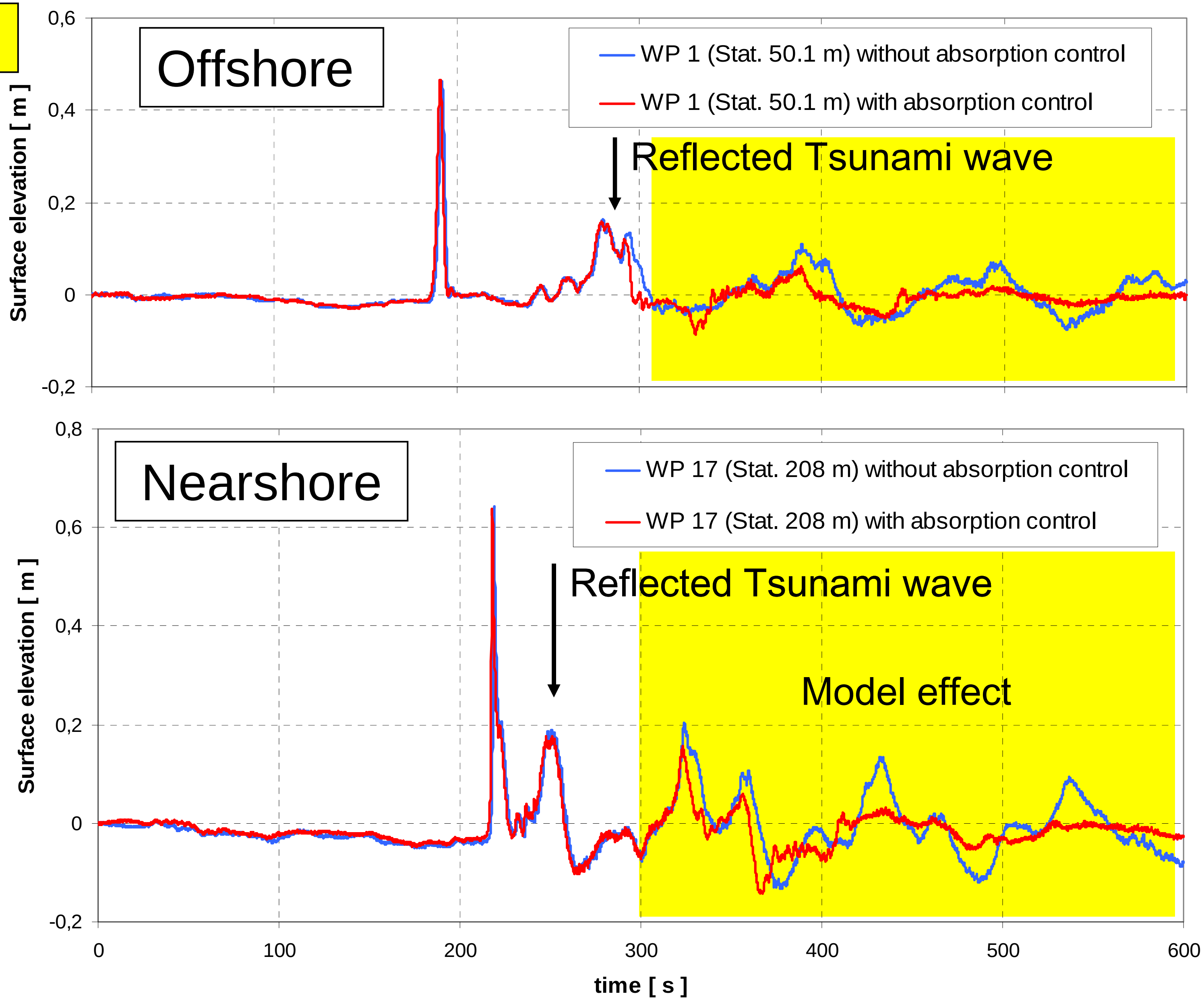


Maximum
Running - up

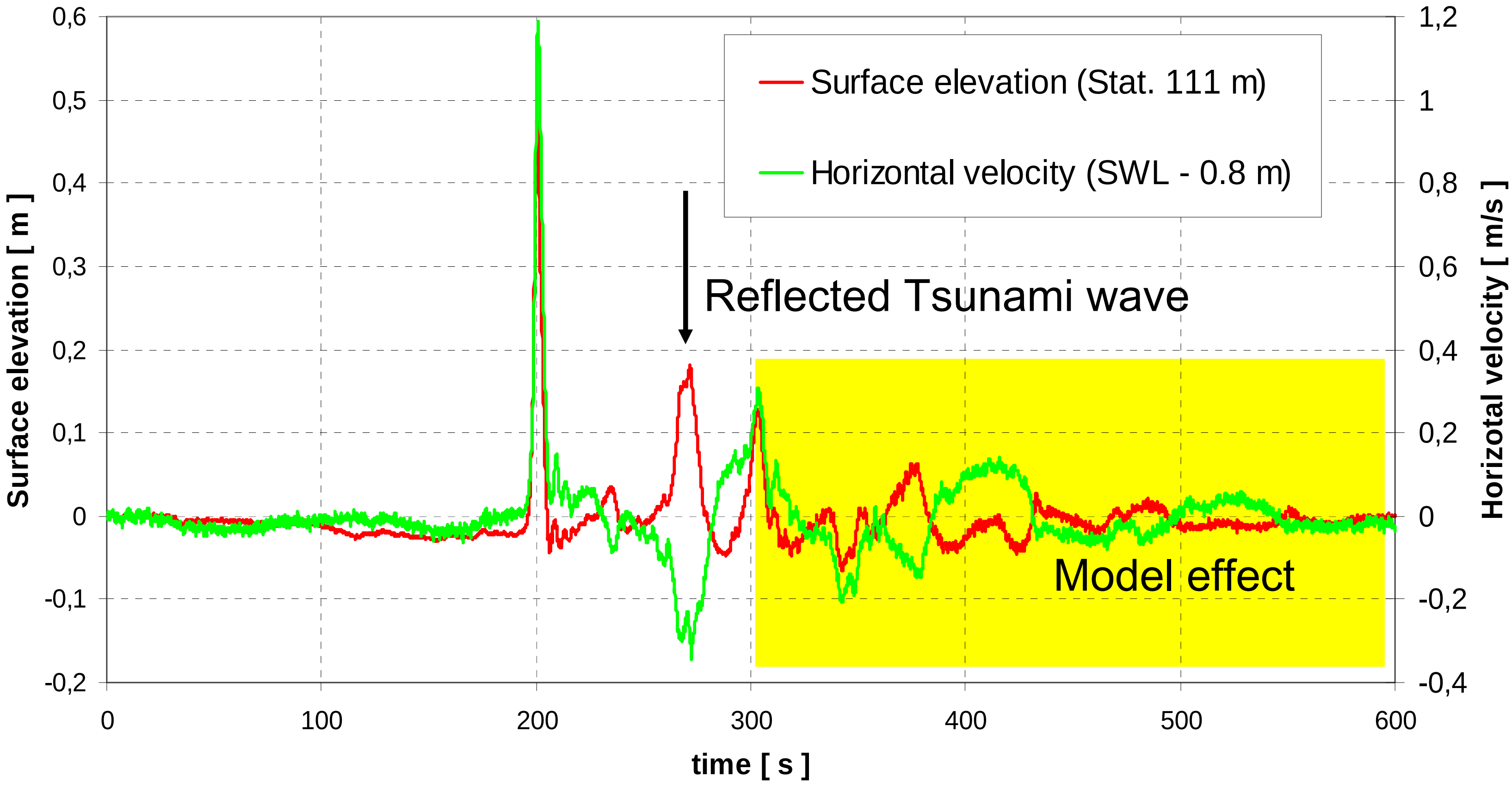
Backwash

Tsunami wave generation in the GWK

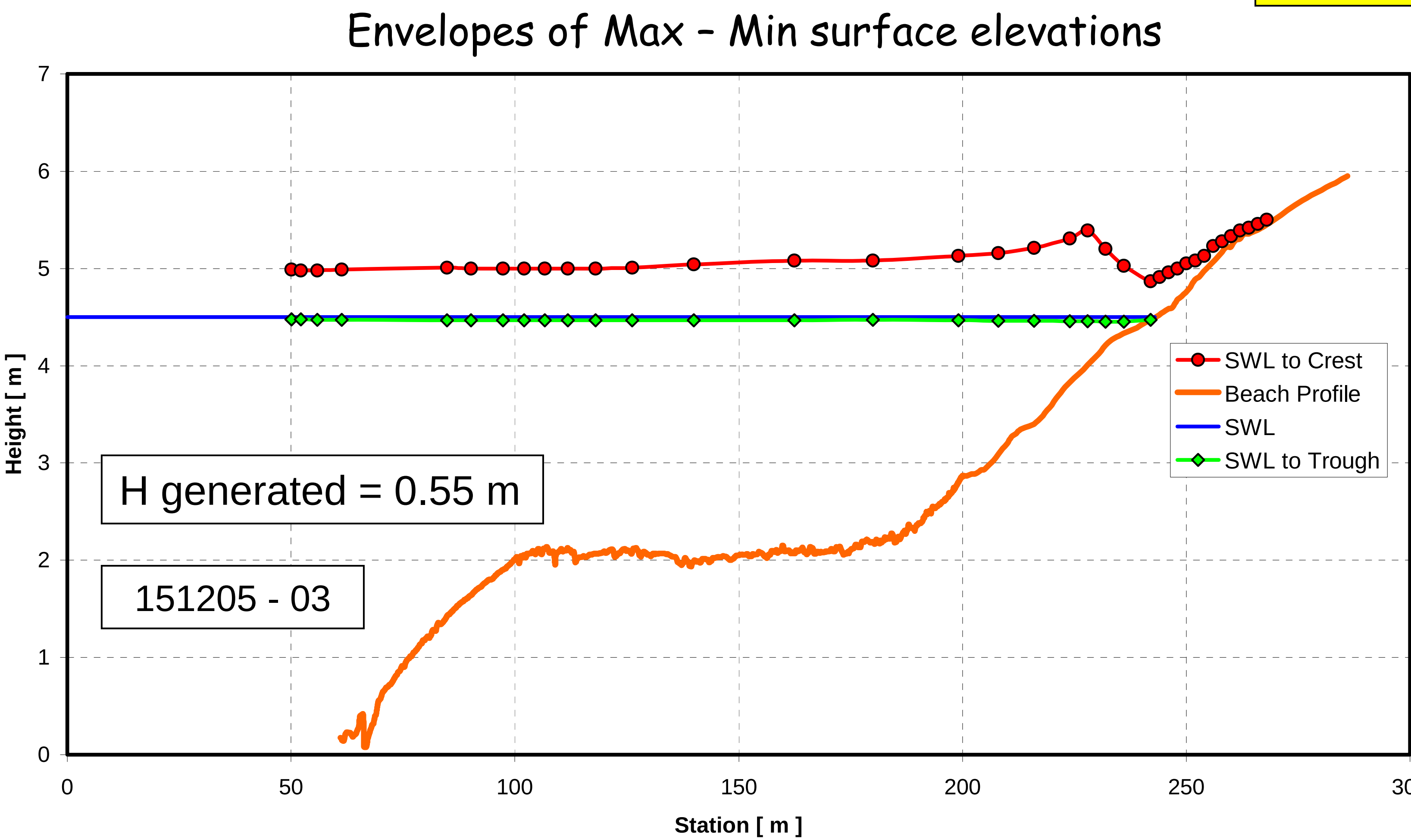
TYP A

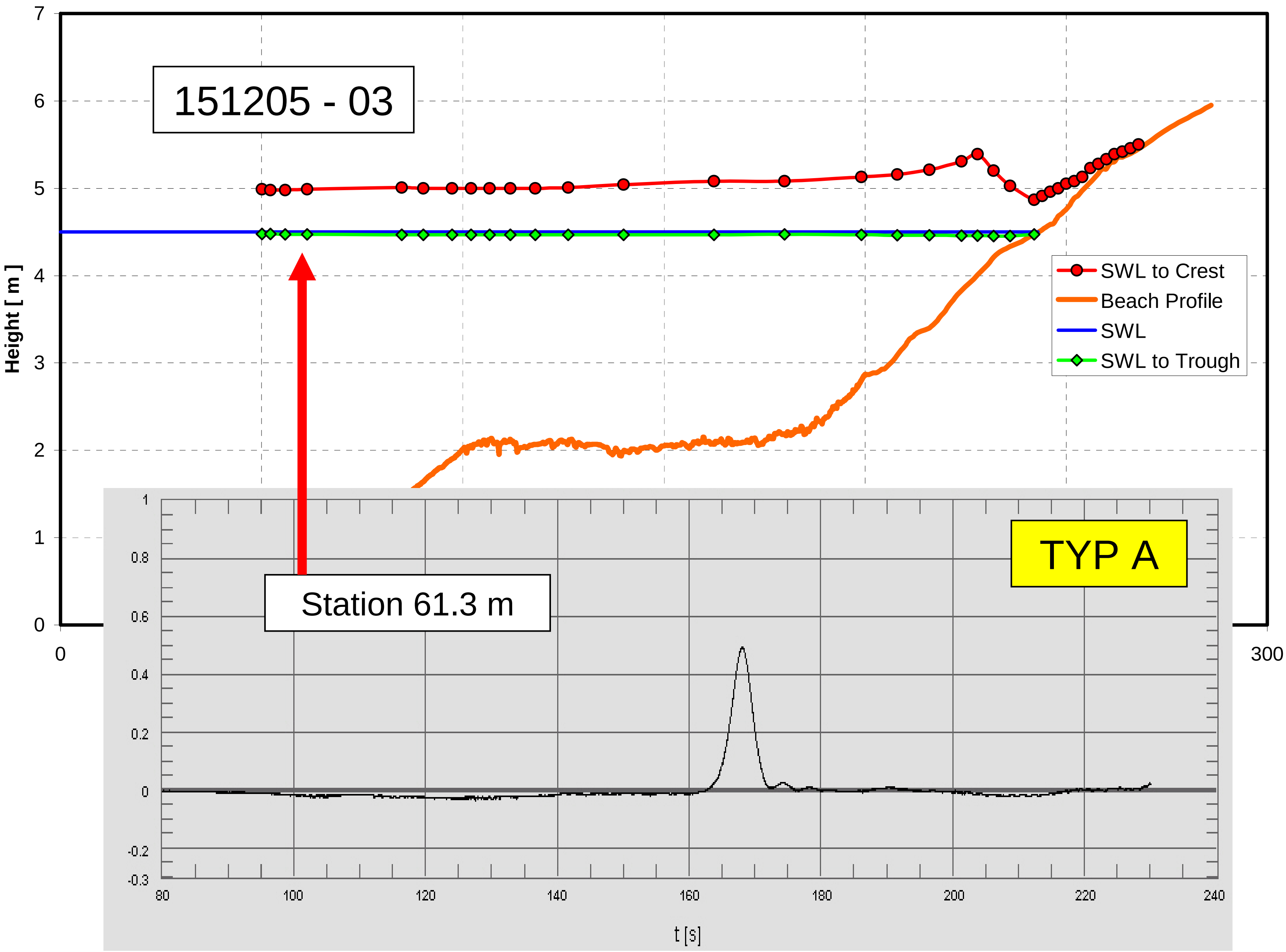

Offshore
WP 1 (Stat. 50.1 m) without absorption control
WP 1 (Stat. 50.1 m) with absorption control
Reflected Tsunami wave
Surface elevation [m]
0,6
0,4
0,2
0
-0,2
Nearshore
WP 17 (Stat. 208 m) without absorption control
WP 17 (Stat. 208 m) with absorption control
Reflected Tsunami wave
Model effect
Surface elevation [m]
0,8
0,6
0,4
0,2
0
-0,2
0
100
200
300
400
500
600
time [s]

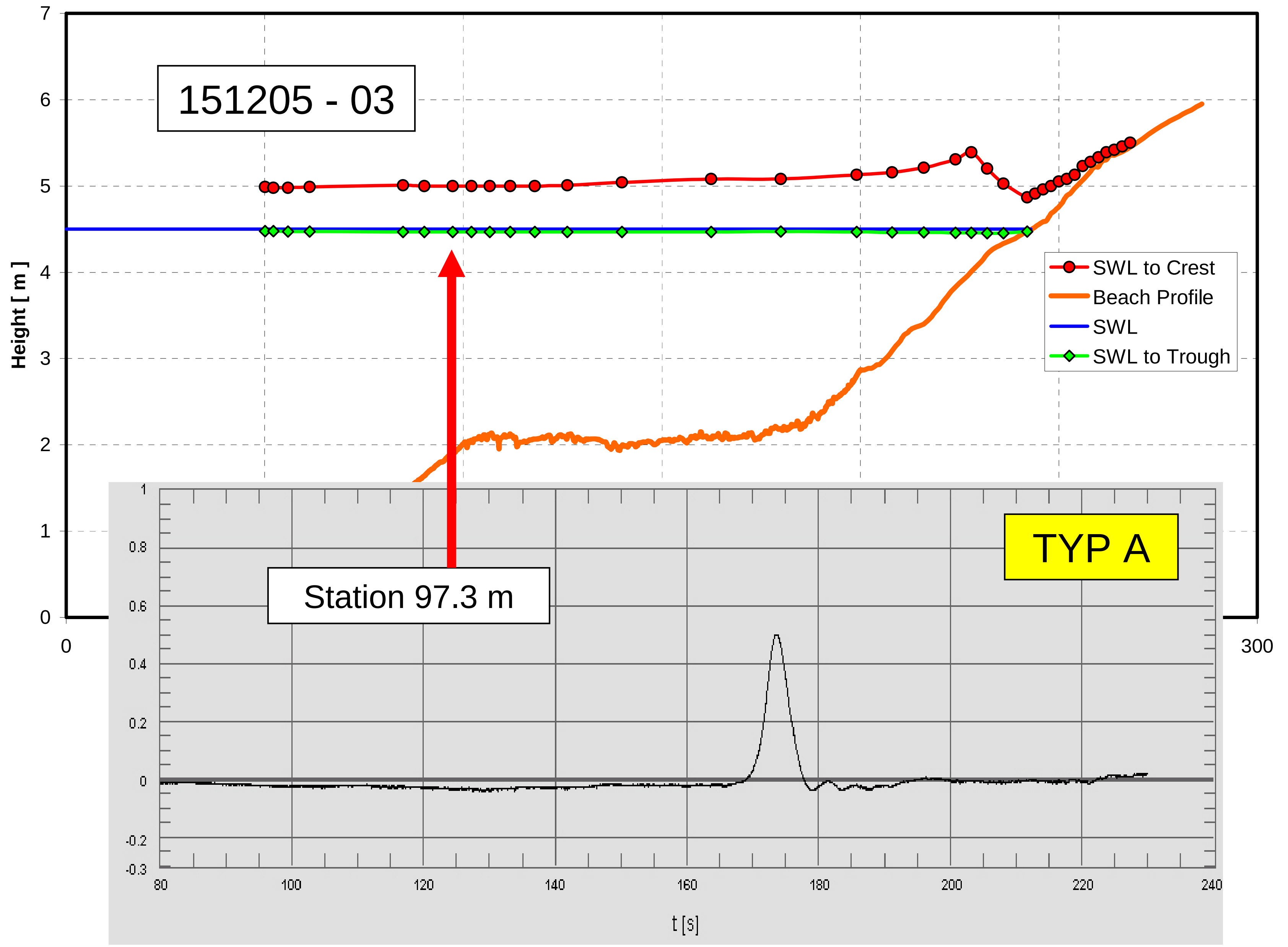
TYP A

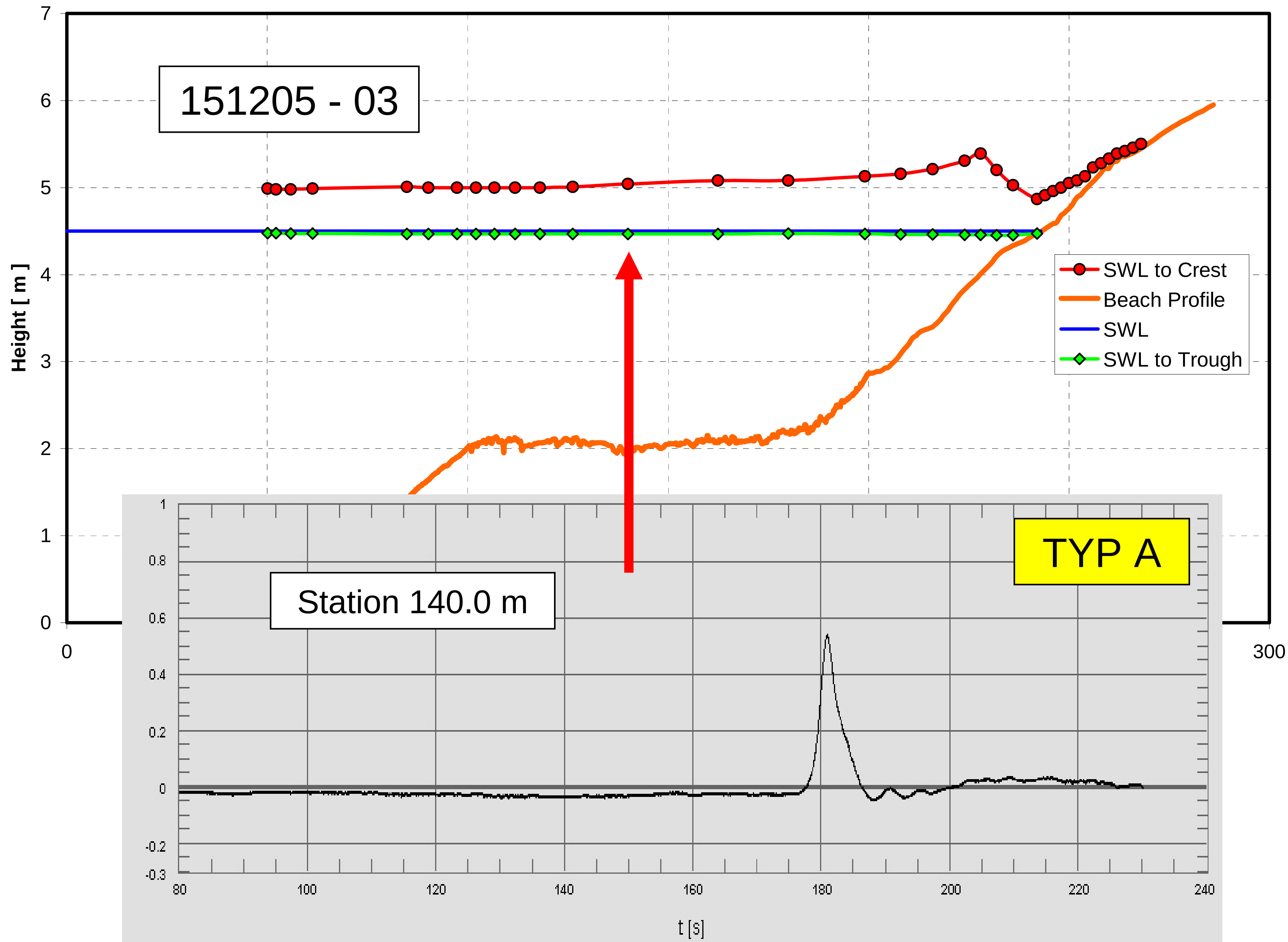

Surface elevation (Stat. 111 m)
Horizontal velocity (SWL - 0.8 m)
Reflected Tsunami wave
Model effect
Surface elevation [m]
Horizotal velocity [m/s]
time [s]
0,6
0,5
0,4
0,3
0,2
0,1
0
-0,1
-0,2
1,2
1
0,8
0,6
0,4
0,2
0
-0,2
-0,4
0
100
200
300
400
500
600

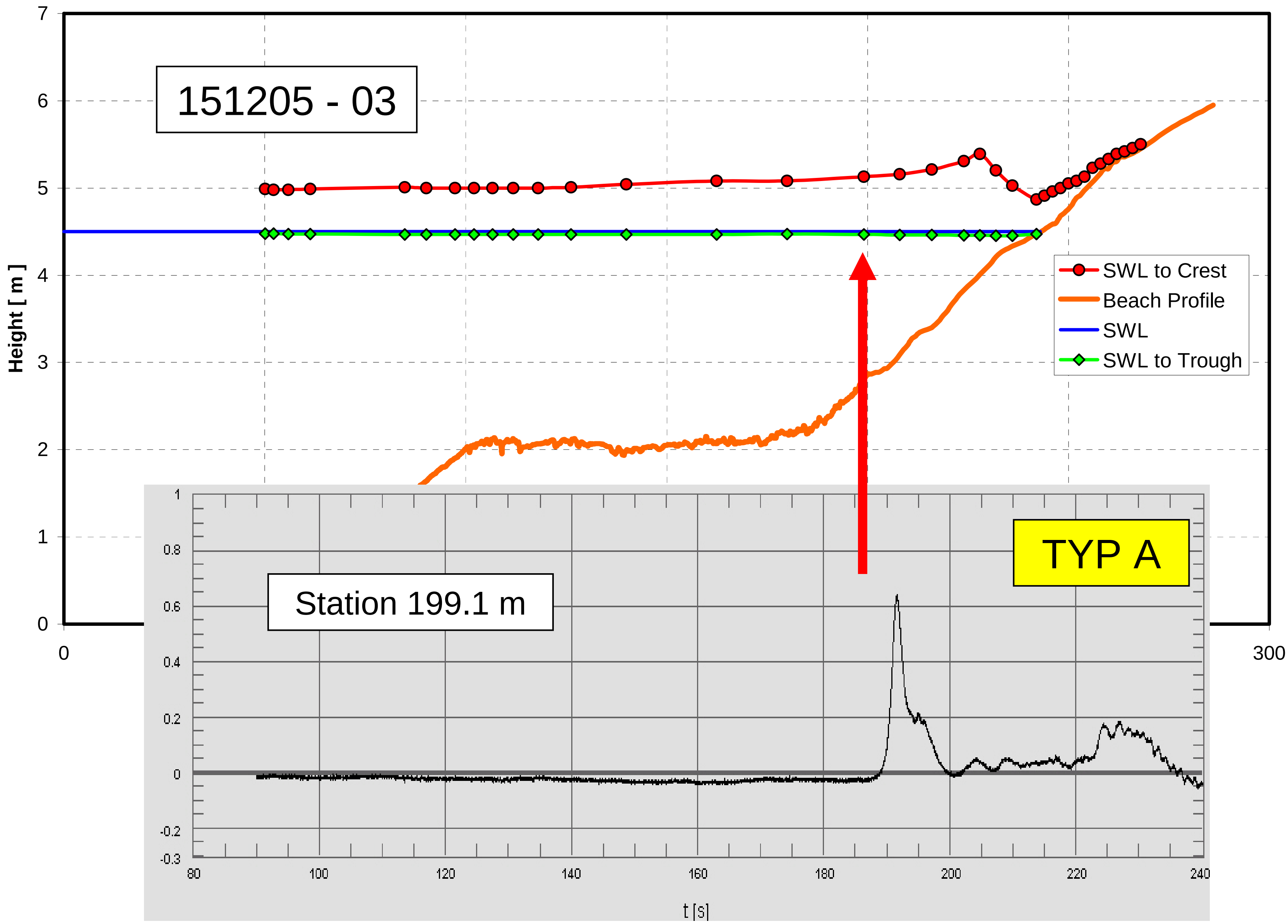
TYP A

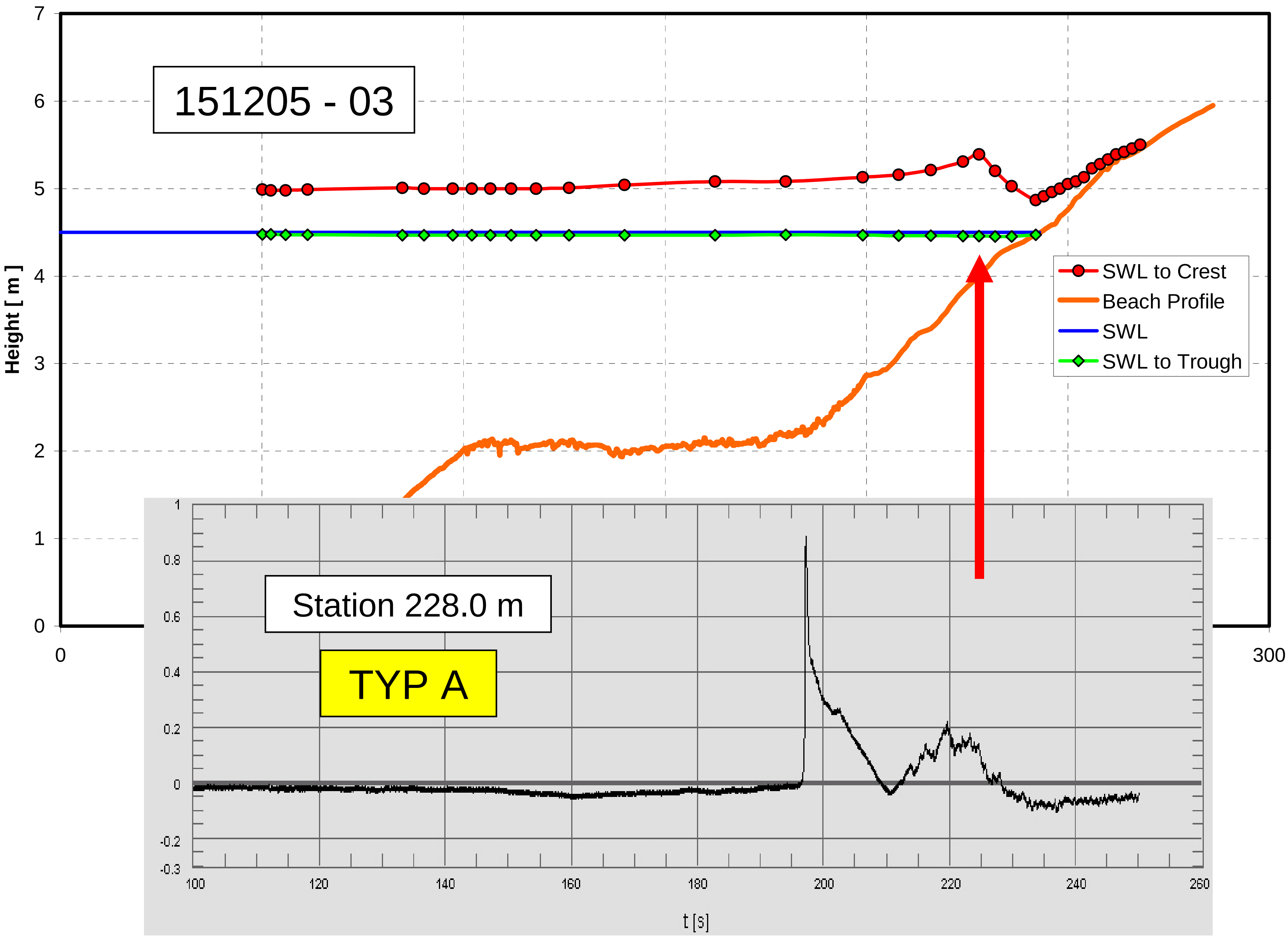

Envelopes of Max - Min surface elevations
H generated = 0.55 m
151205 - 03
SWL to Crest
Beach Profile
SWL
SWL to Trough
Height [m]
Station [m]
0
1
2
3
4
5
6
7
0
50
100
150
200
250
300

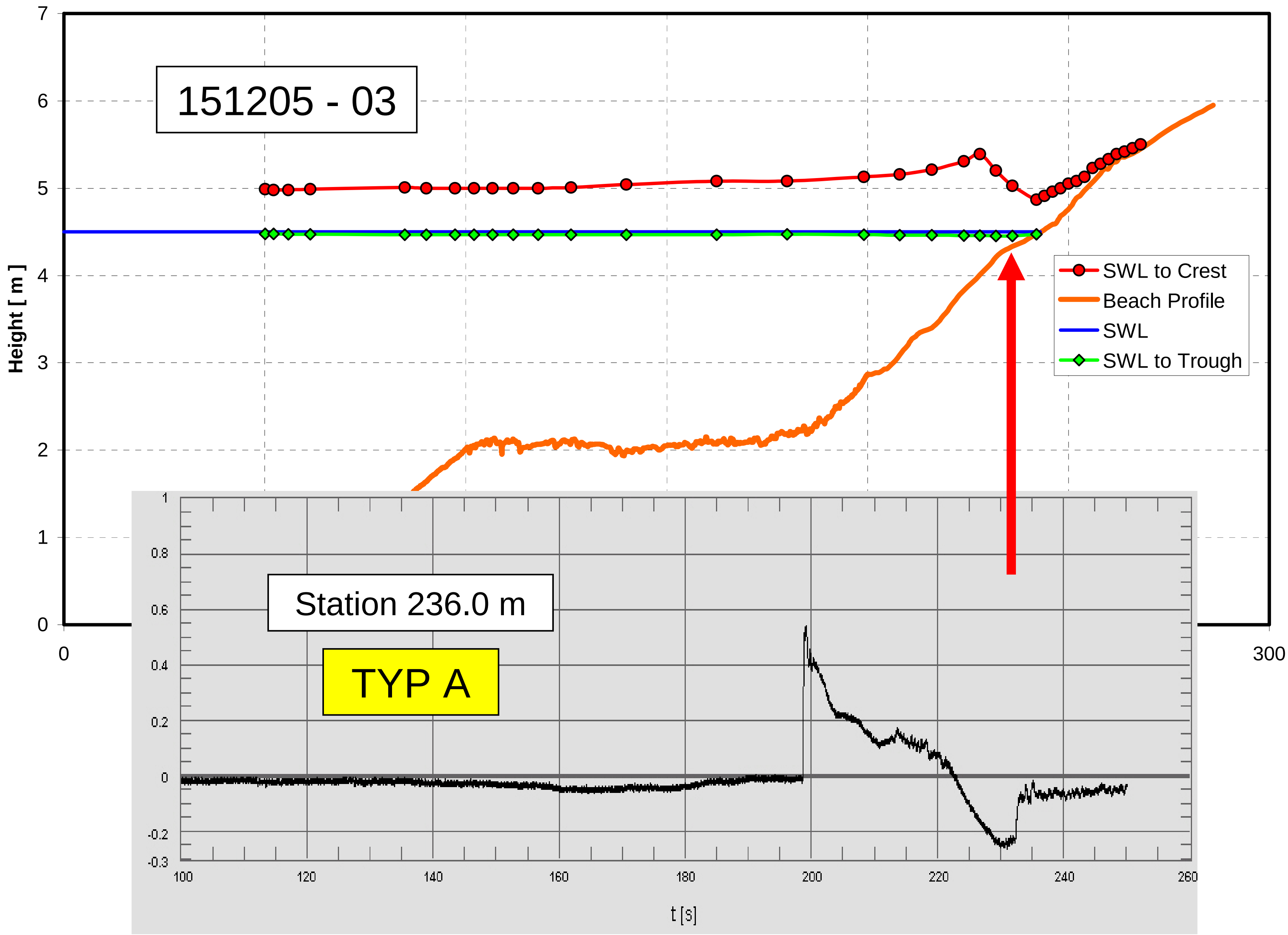

151205 - 03
Height [m]
7
6
5
4
3
2
1
0
0
300
SWL to Crest
Beach Profile
SWL
SWL to Trough
Station 61.3 m
TYP A
1
0.8
0.6
0.4
0.2
0
-0.2
-0.3
80
100
120
140
160
180
200
220
240
t [s]


151205 - 03
Height [m]
SWL to Crest
Beach Profile
SWL
SWL to Trough
Station 97.3 m
TYP A
t [s]


151205 - 03
Height [m]
SWL to Crest
Beach Profile
SWL
SWL to Trough
Station 140.0 m
TYP A
t [s]

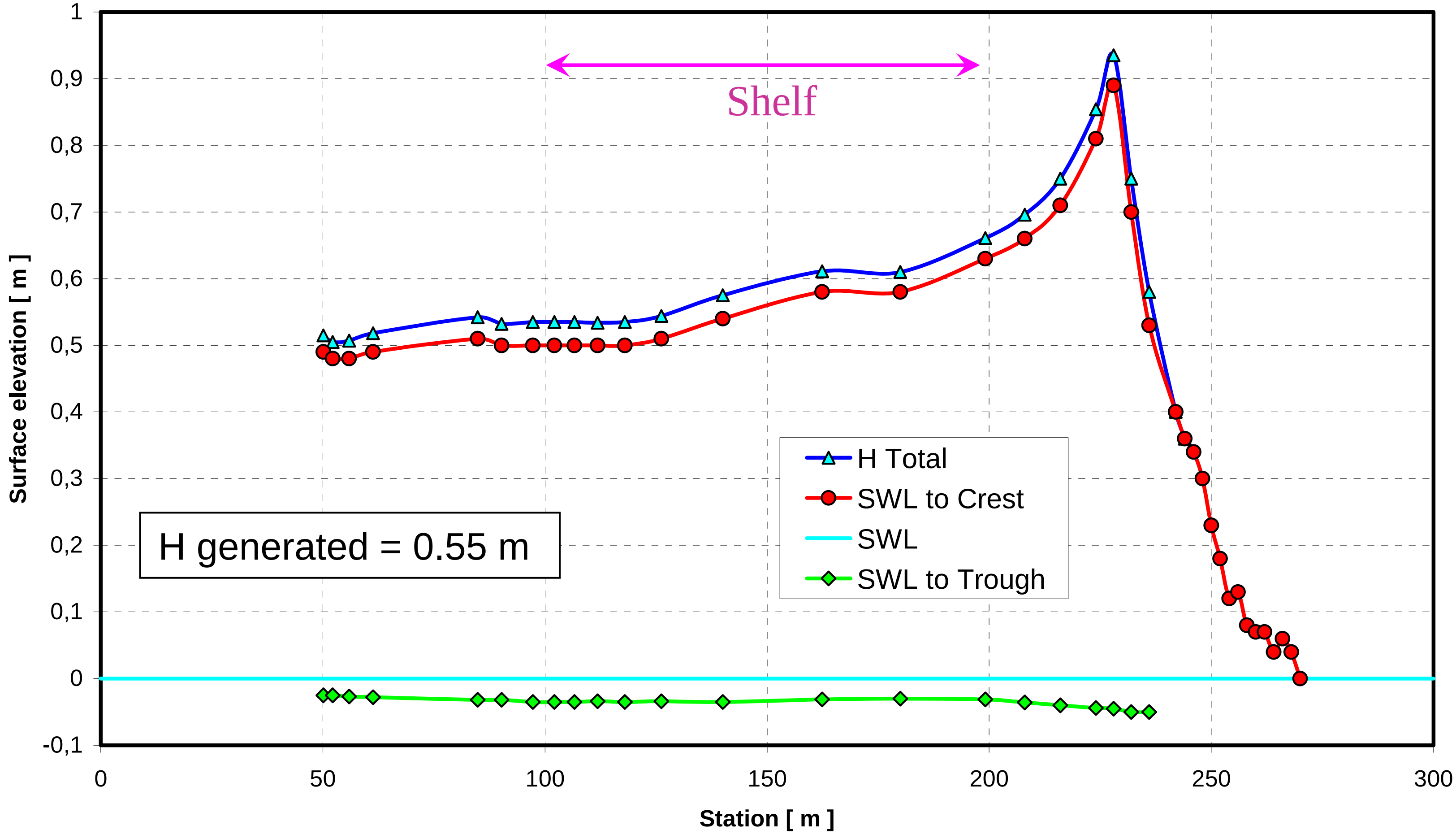

151205 - 03
Height [m]
SWL to Crest
Beach Profile
SWL
SWL to Trough
Station 199.1 m
TYP A
t [s]
0
300
7
6
5
4
3
2
1
0


151205 - 03
Height [m]
7
6
5
4
3
2
1
0
0
300
SWL to Crest
Beach Profile
SWL
SWL to Trough
Station 228.0 m
TYP A
1
0.8
0.6
0.4
0.2
0
-0.2
-0.3
100
120
140
160
180
200
220
240
260
t [s]


151205 - 03
Height [m]
7
6
5
4
3
2
1
0
0
300
SWL to Crest
Beach Profile
SWL
SWL to Trough
Station 236.0 m
TYP A
1
0.8
0.6
0.4
0.2
0
-0.2
-0.3
100
120
140
160
180
200
220
240
260
t [s]

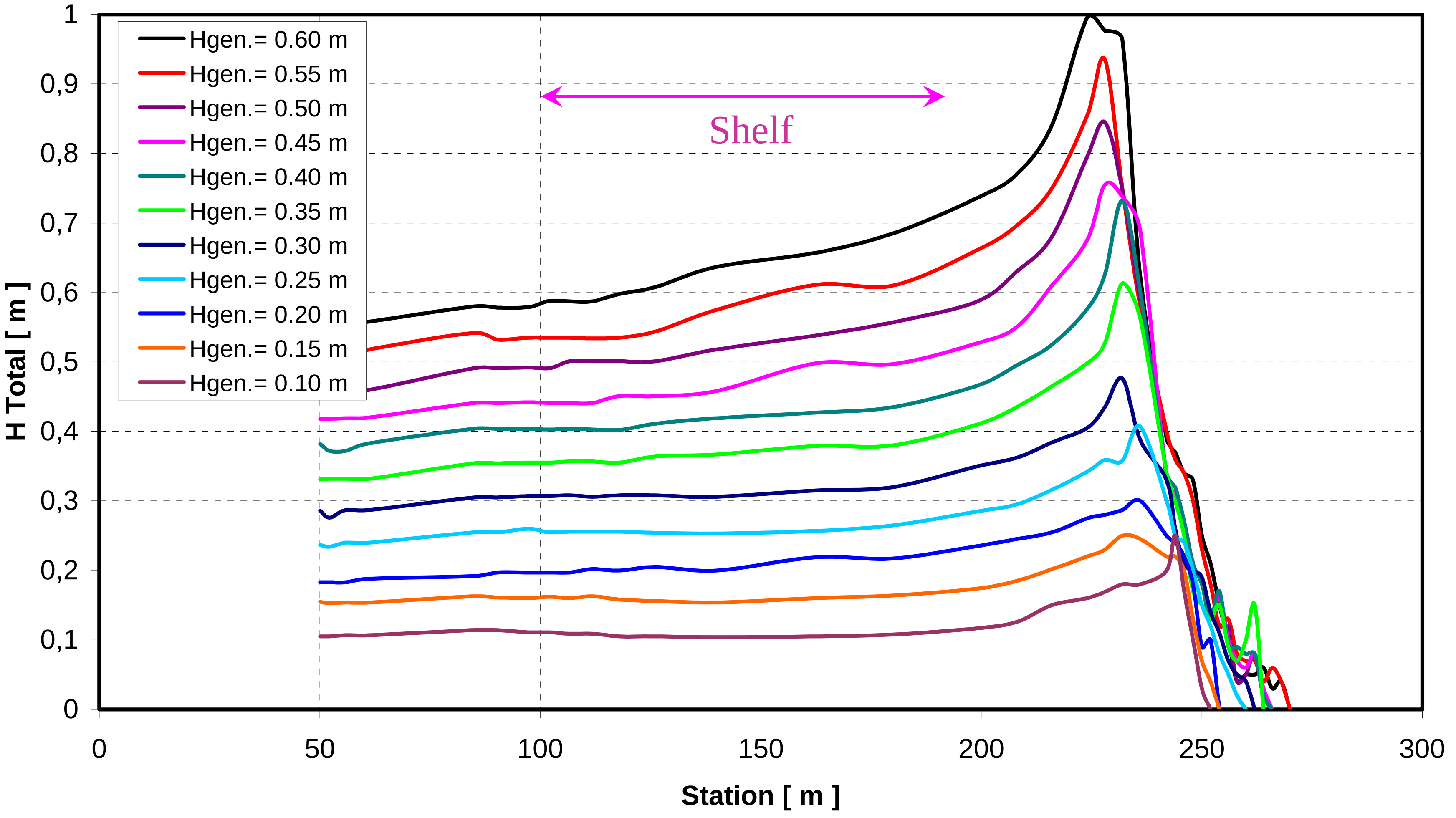
TYP A

Envelopes of Max – Min surface elevations & of Total Height



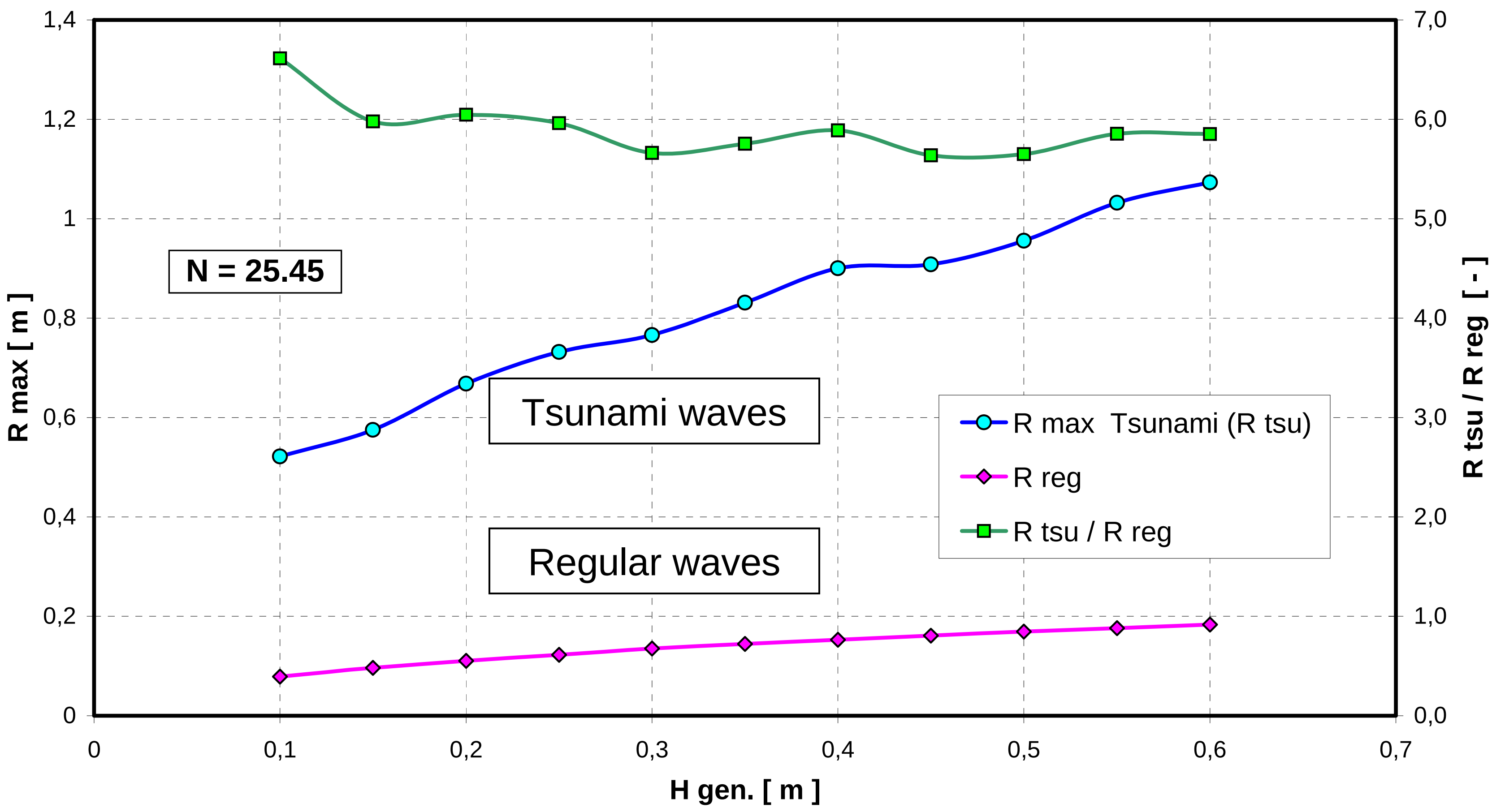
TYP A

Envelopes of Total Heights

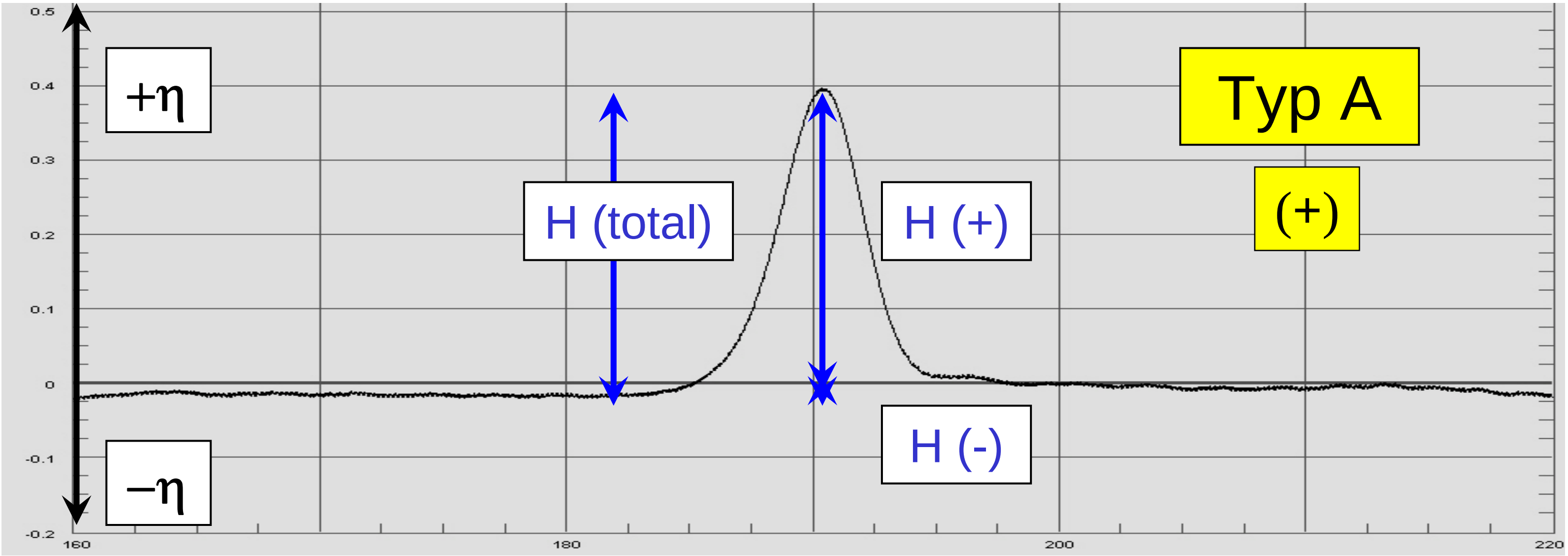


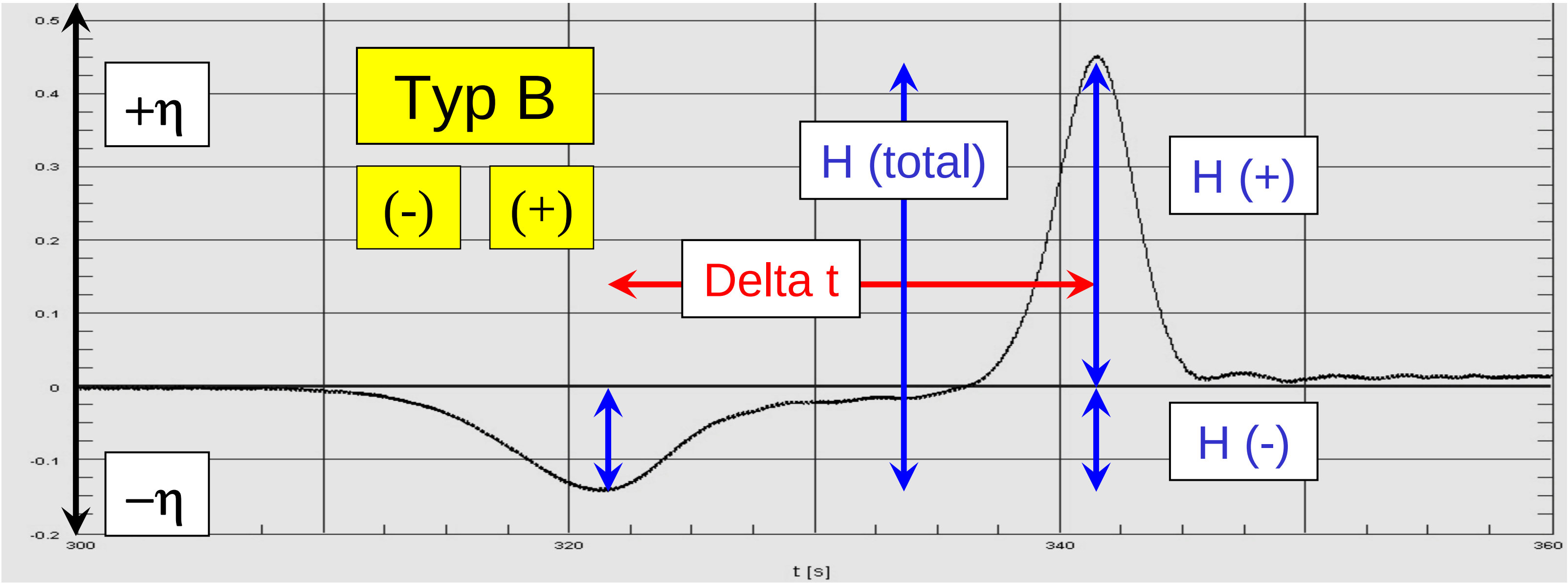
TYP A

Comparison of Wave Run - Up of Tsunami & Regular Waves

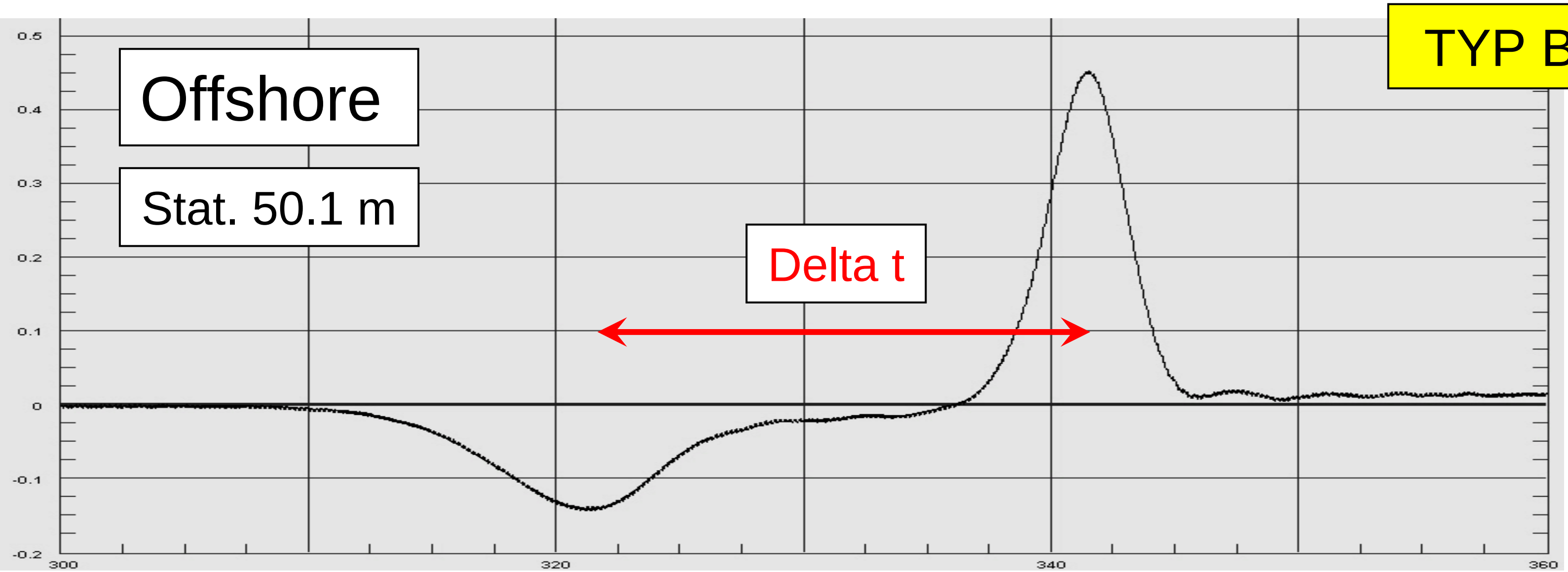


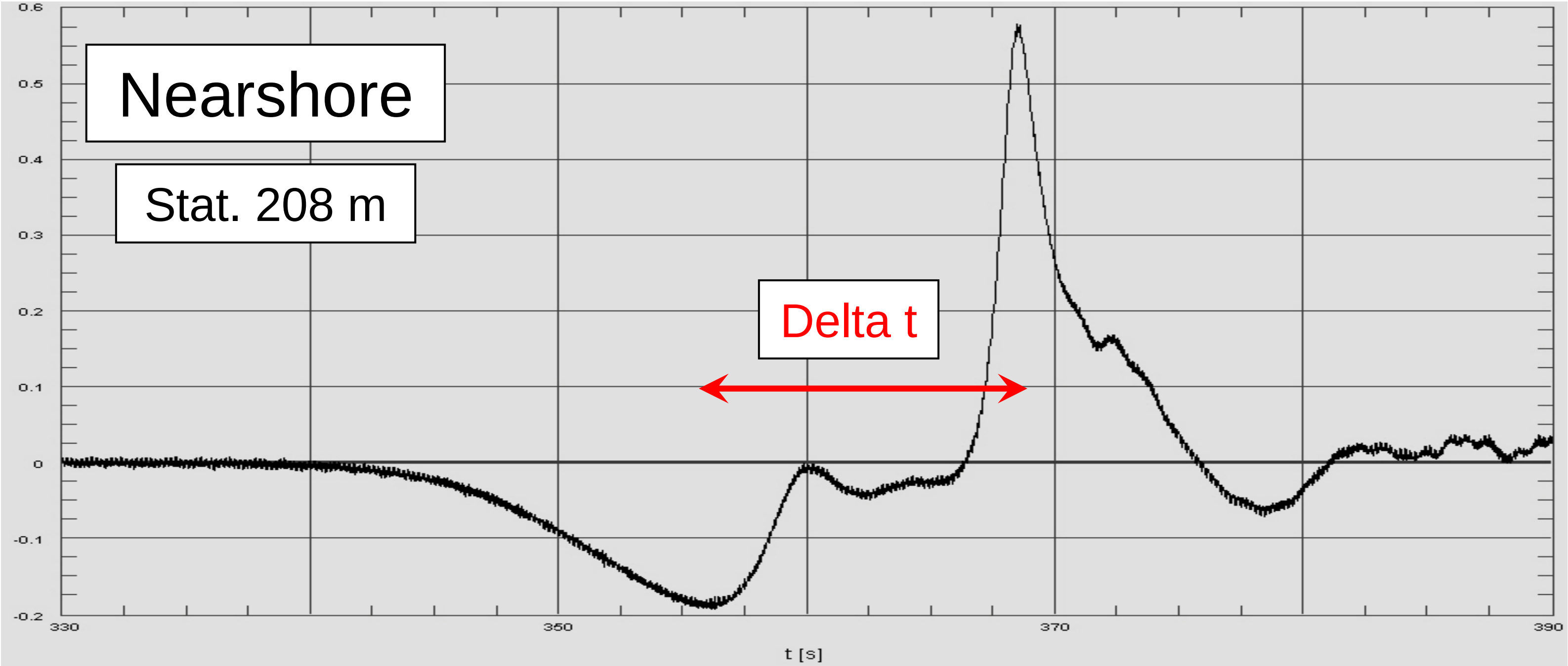
Influence of different shapes of surface elevation



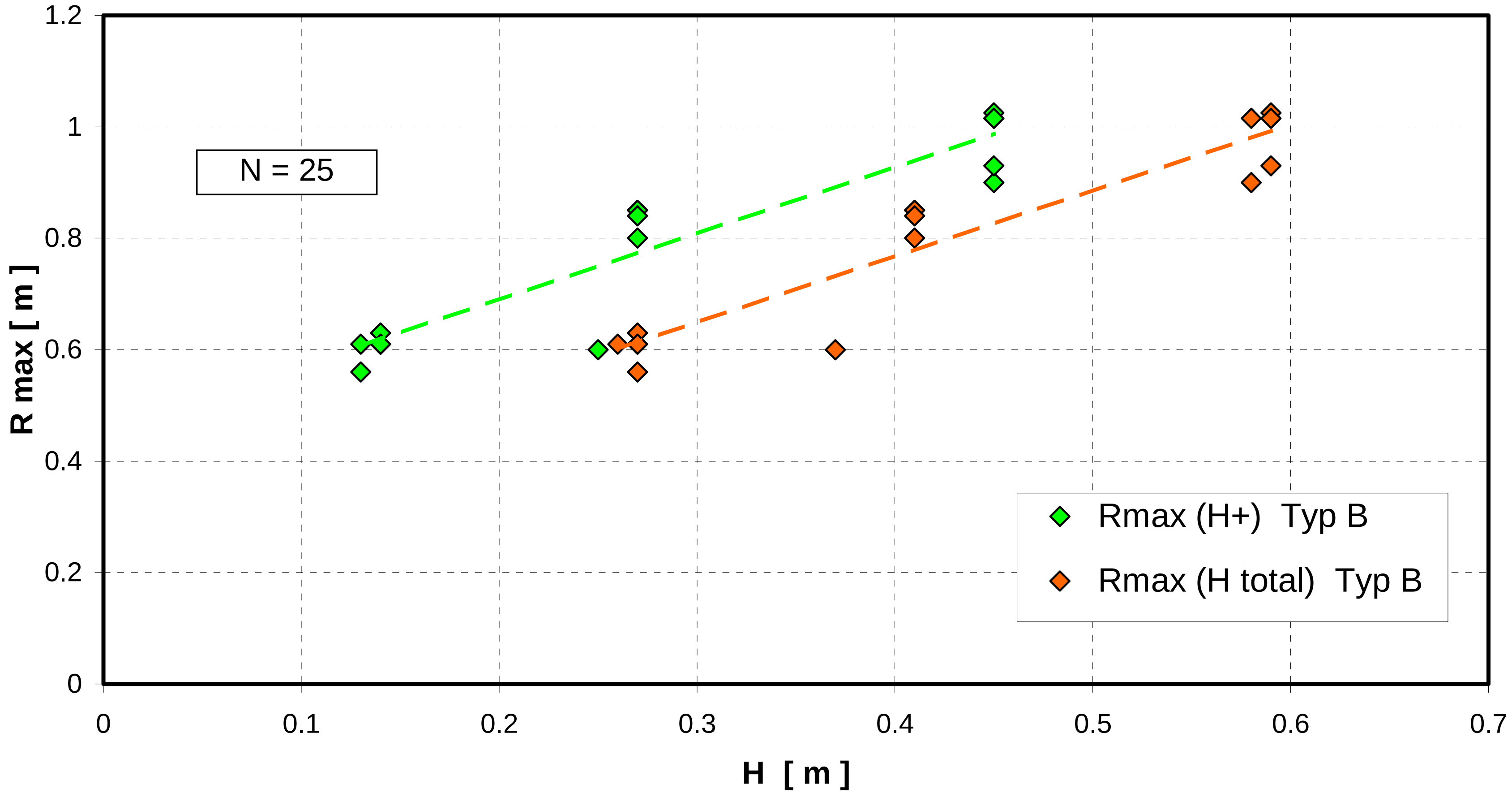


TYP B

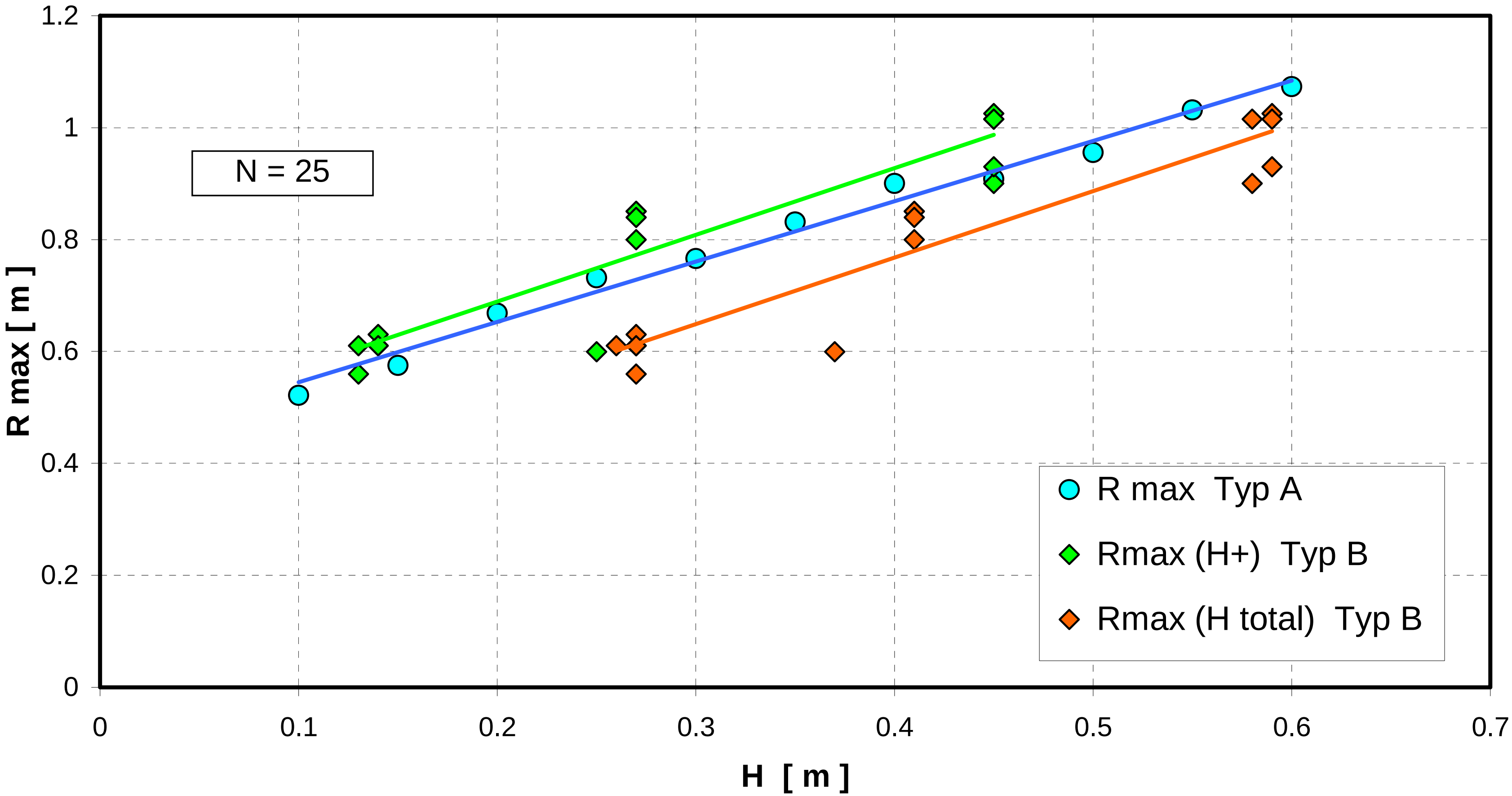

Offshore
Stat. 50.1 m
Delta t
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
300
320
340
360


Nearshore
Stat. 208 m
Delta t
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
330
350
370
390
t [s]

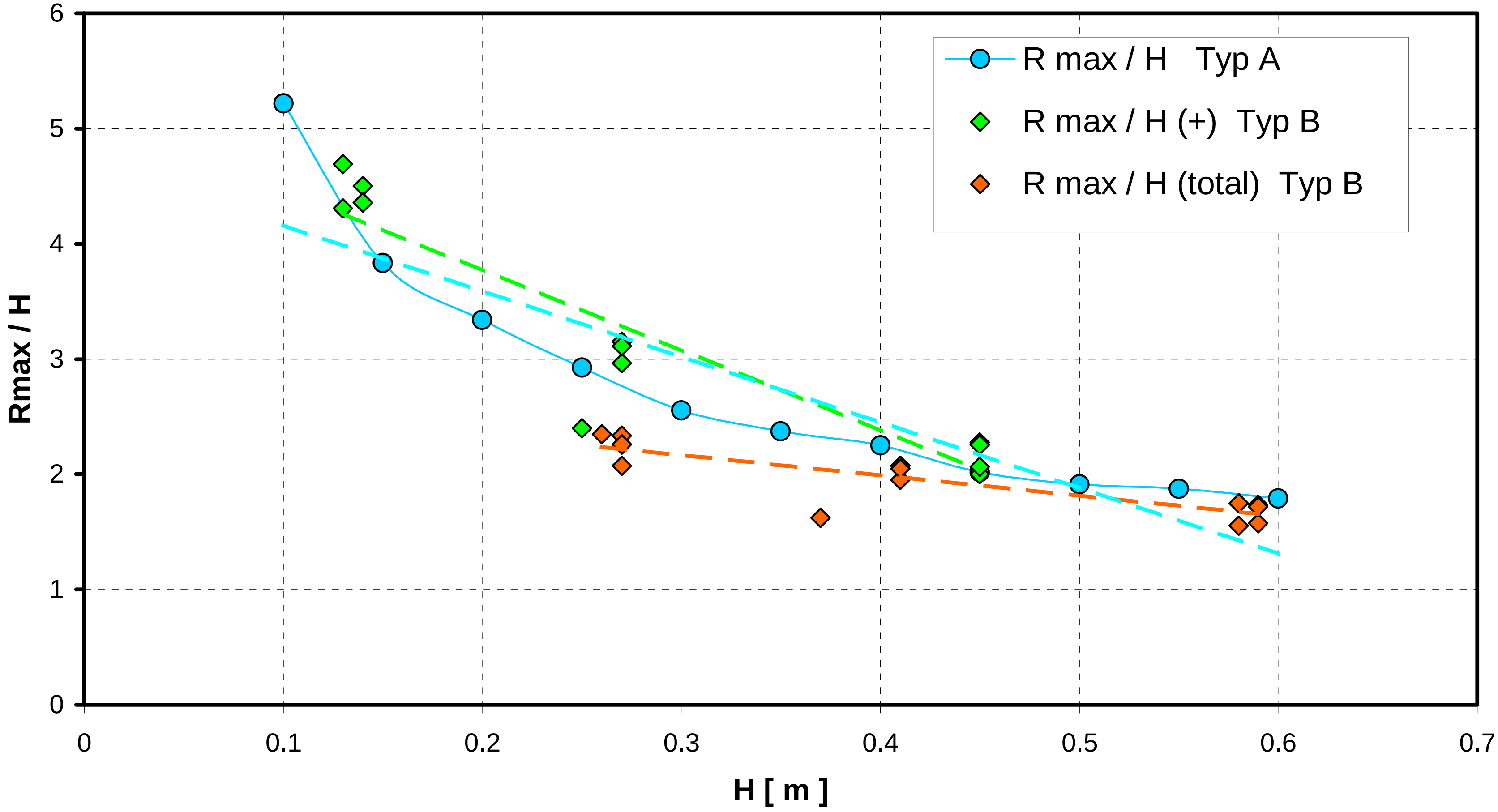
Run-up versus wave height



Run-up versus wave height



Wave height related Run-up versus wave height



Conclusion

- A large scale and a long waterline in a physical model was used for simulation of the tsunami wave propagation process in the near - and onshore area
- Tsunami waves may be simulated sufficiently in a physical model using solitary wave theory. <u>But lately this has to be proved by field records and numerical simulations.</u>
- It was demonstrated that the impact from Tsunami waves are quite different compared to consecutive wave trains
- For composed waves with negative and positive wave elements it was found that the positive elements are dominant creating the wave run-up