Sandy beaches and dunes and their role in flood protection and nature restoration

Kennis- en Innovatieprogramma Marker Wadden

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Application of sandy beaches

Research topics

- Primary objective: the development of the *shape* of the **profiles**
- Importance of longitudinal transport gradients and lateral loss/retreat
- Development of the crest level of the **wash-overs**
- Development of the **open boundary** on the south side (incl. nourishments)
- Development of the (crest) height of the dunes

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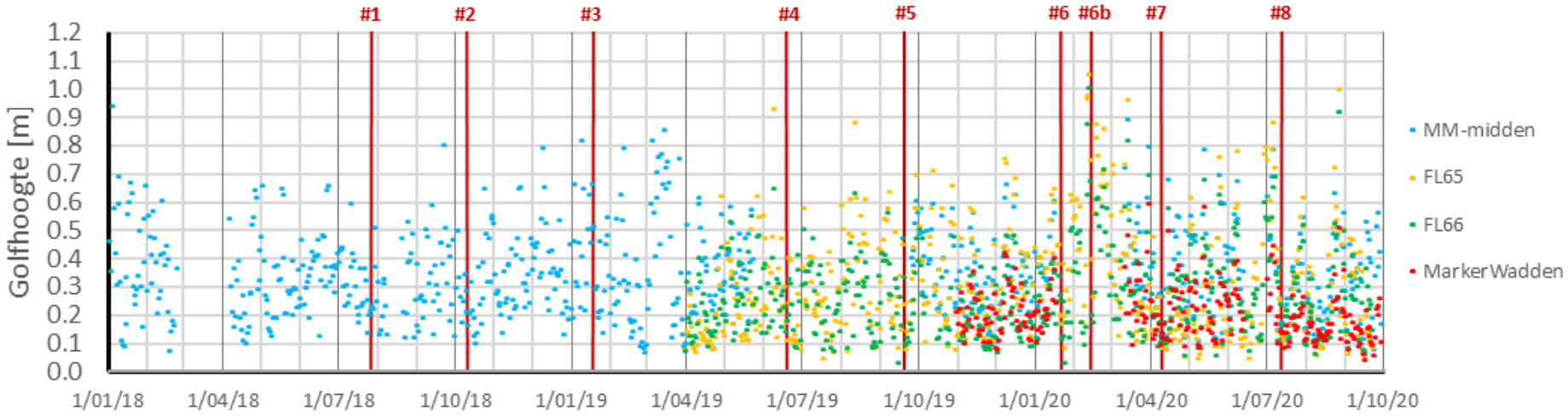
Analyses of the profile shape

- Recordings (underwater, beach, dune) per quarter from #1 on 26/07/18 to #8 on 13/07/20
  (this is period for the large-scale interventions)
- Local water levels/wave attack
  (via LakeSide-project)



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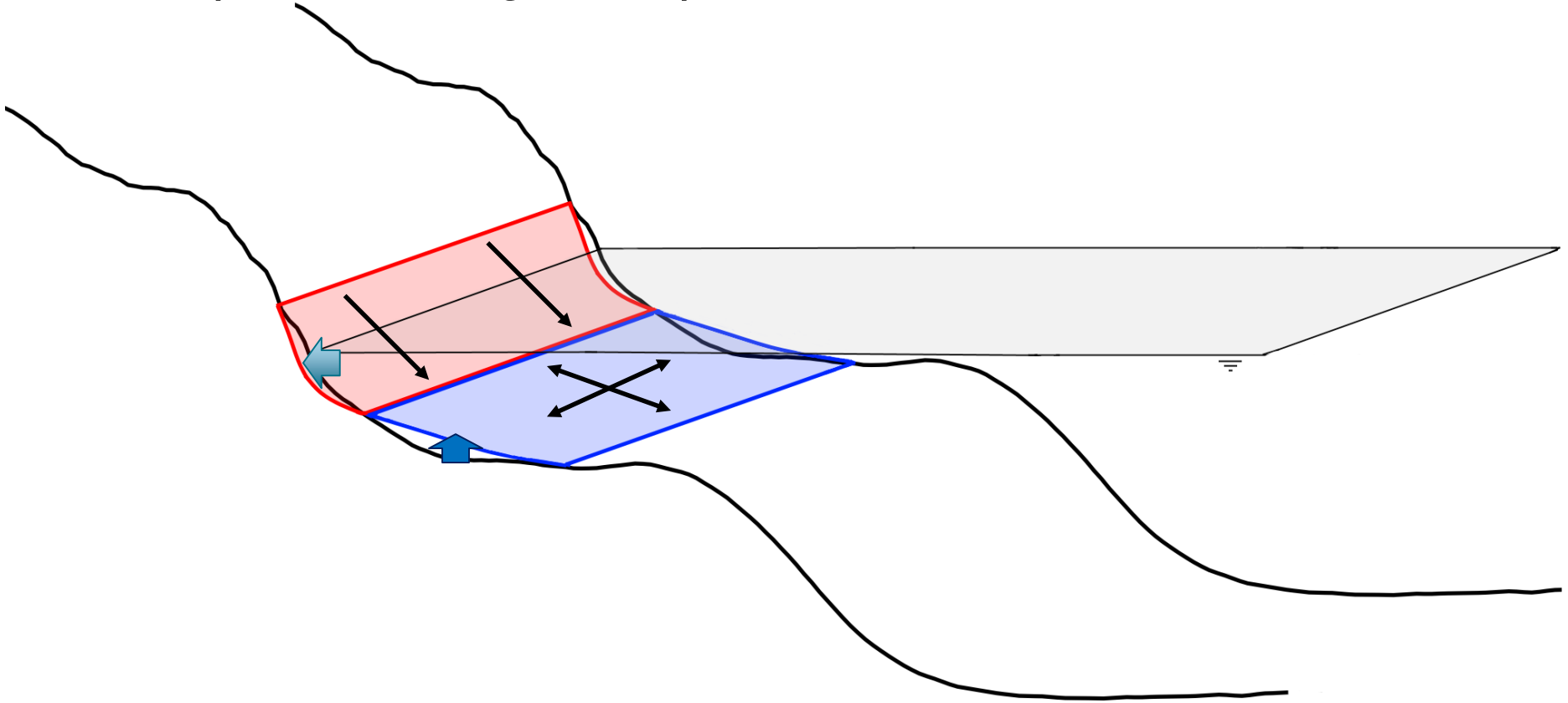
Analyses of the profile shape

Development during **calm** periods



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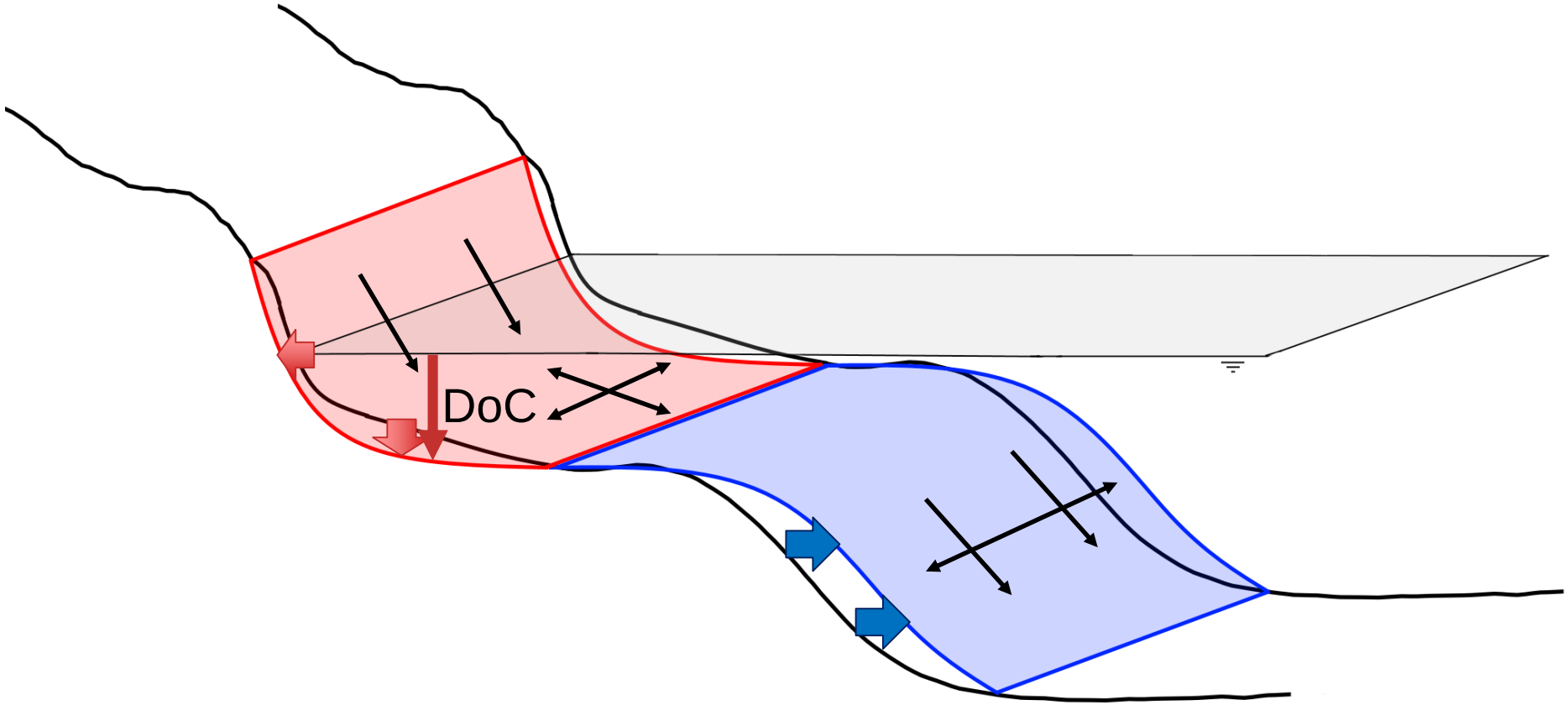
Analyses of the profile shape

Development during **storm periods**



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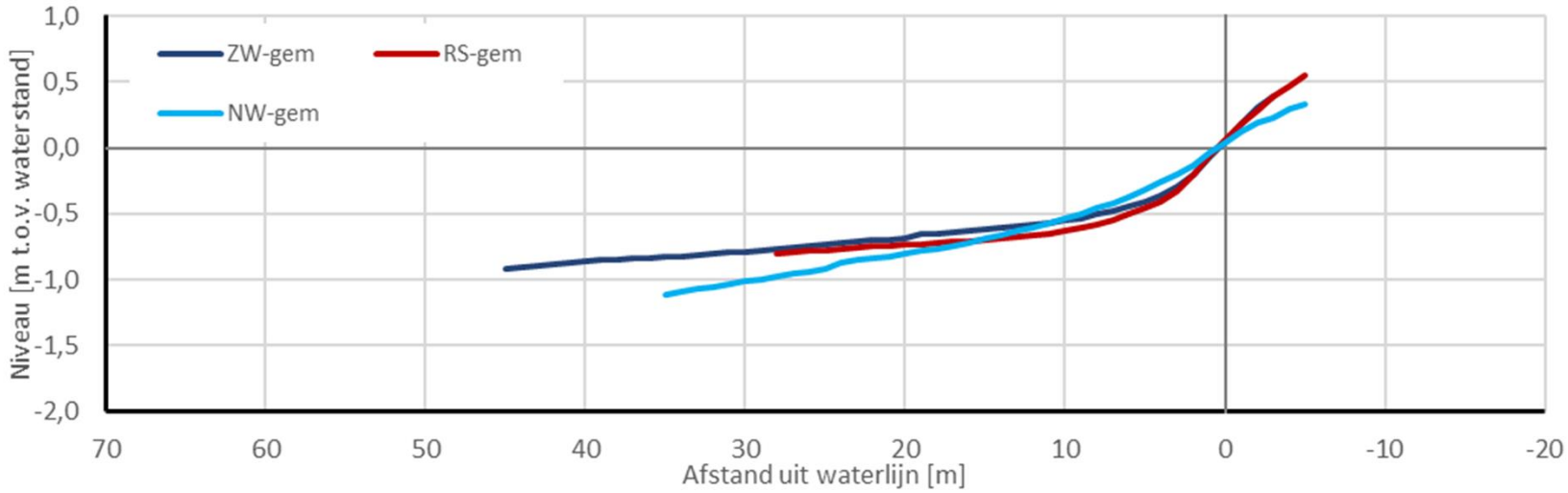
Analyses of the profile shape

Analysis of (equilibrium) profile shape w.r.t. to the waterline for 3 locations



- Profile shape approximately similar
- Profile shape North beach slightly steeper
  (grain diameter, longitudinal processes, ...)
- Relationship profile development vs. forcing not (yet) clear

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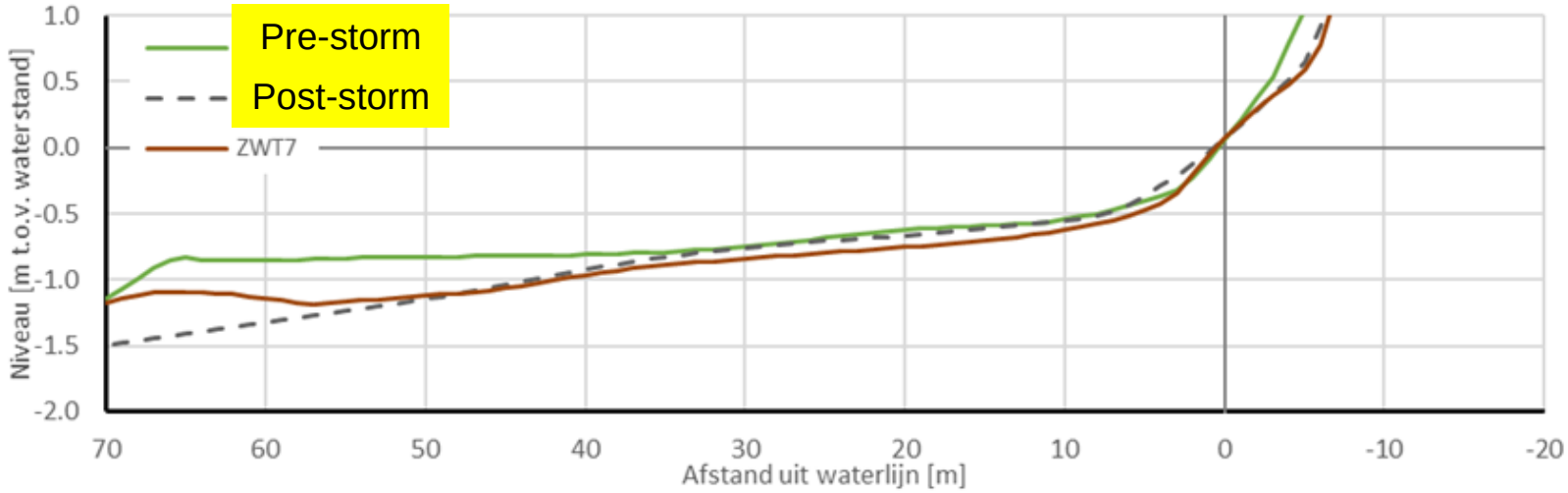
Analyses of the profile shape

Conclusions:

- Initially developed cross-section shape is fairly stable
- Not even major changes around water line during extreme storm conditions *(Storm Ciara in February 2020 with waves up to 1.3 m high)*



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Analyses of the profile shape

Conclusions:

- Sandy beaches are applicable as boundary
  (and also have added value)

- Results will be used for the calibration/validation of morphological models to be used for safety assessment

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Analyses of the profile shape

Conclusions (continued):

- Gradual retreat of the waterline is primarily due to lateral losses
- Not only by waves, but also by currents
  (North beach)

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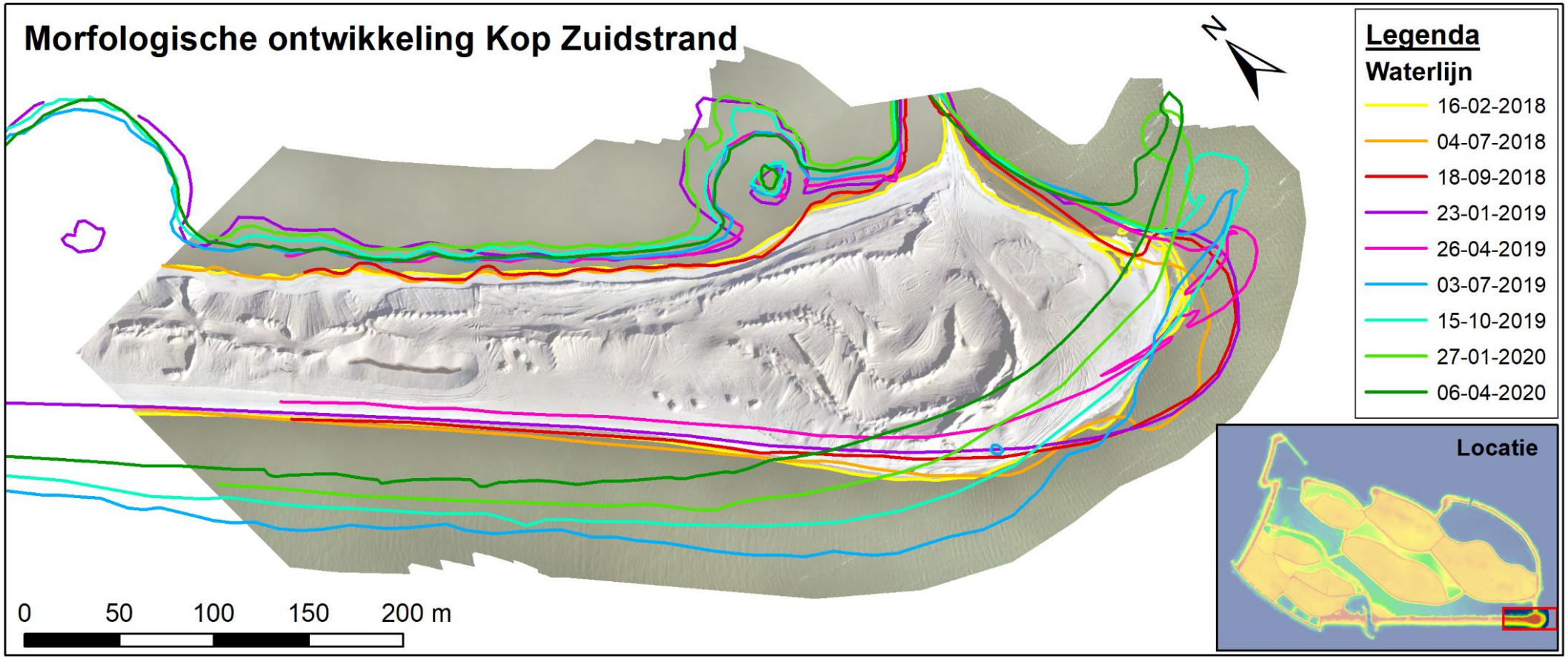
Development of an open edge



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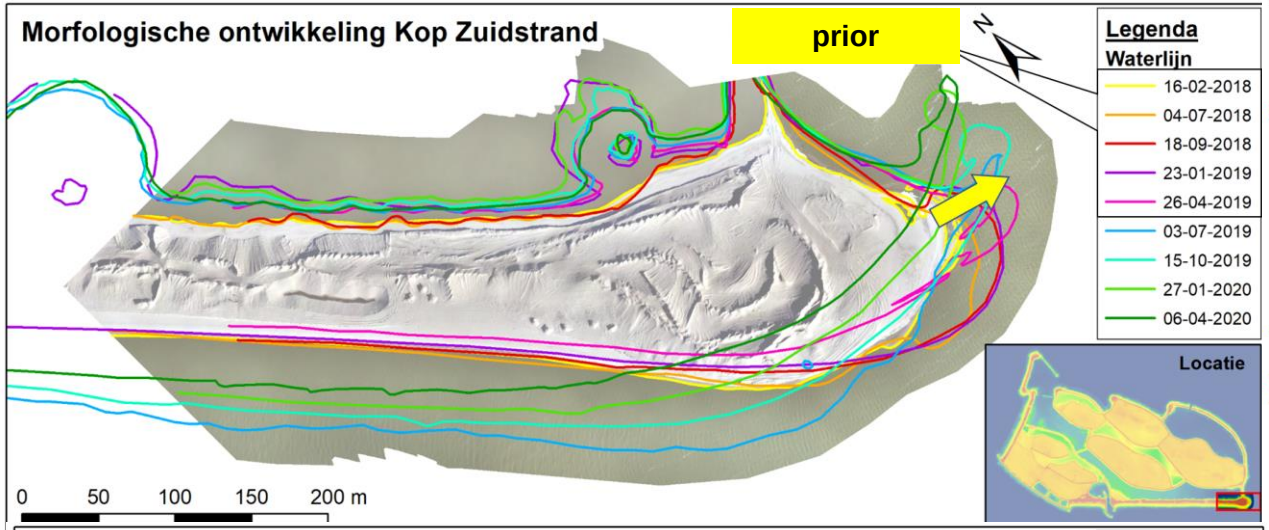
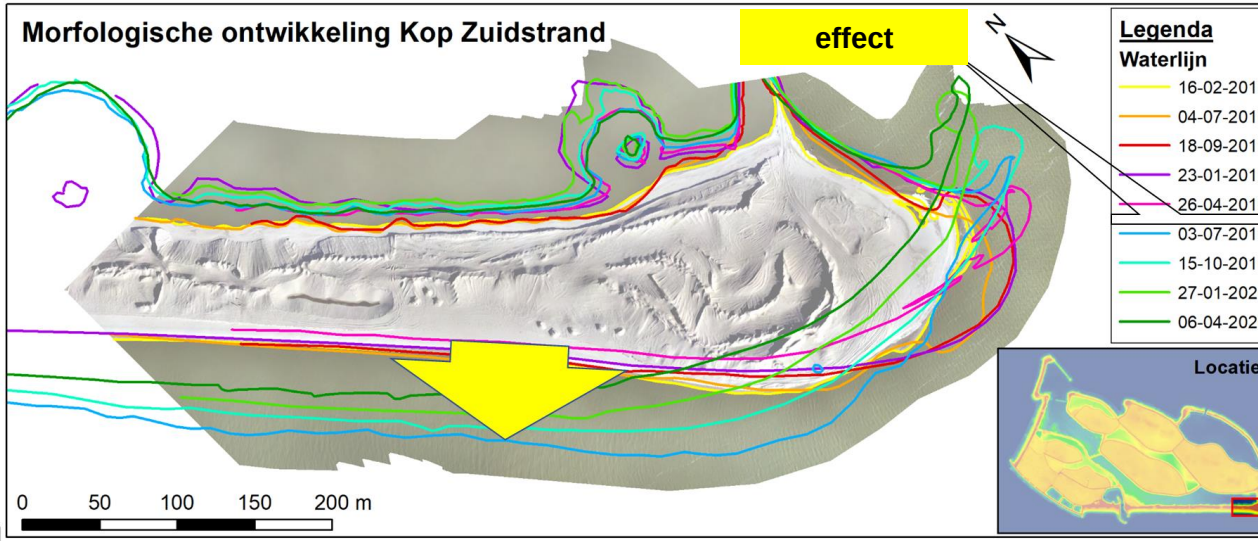
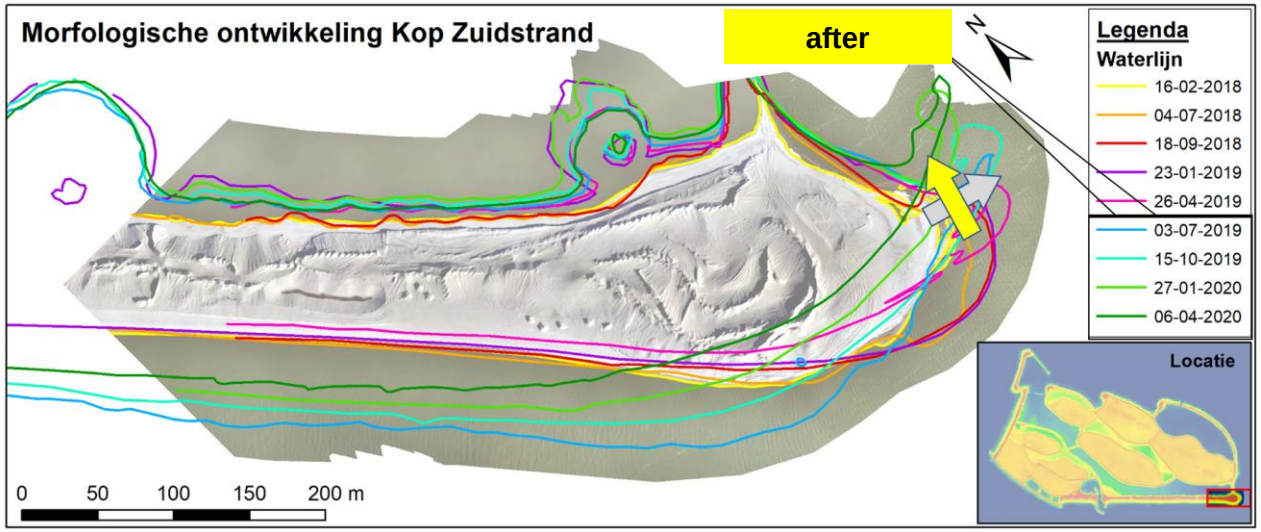
Development of an open edge







- Large-scale nourishment disturbs initial autonomous development
- Nourishment is subject to losses
- Only temporary solution ...

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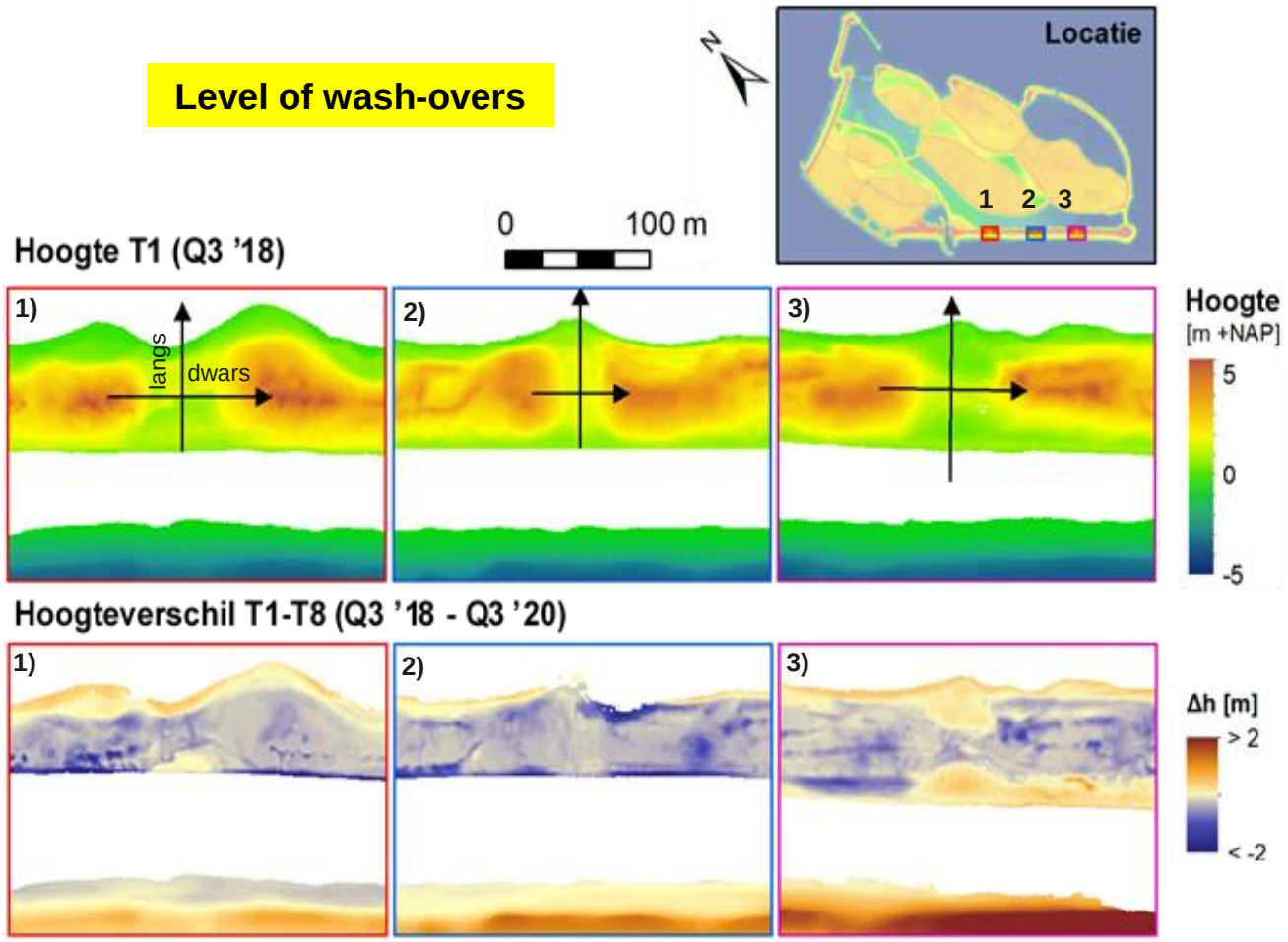
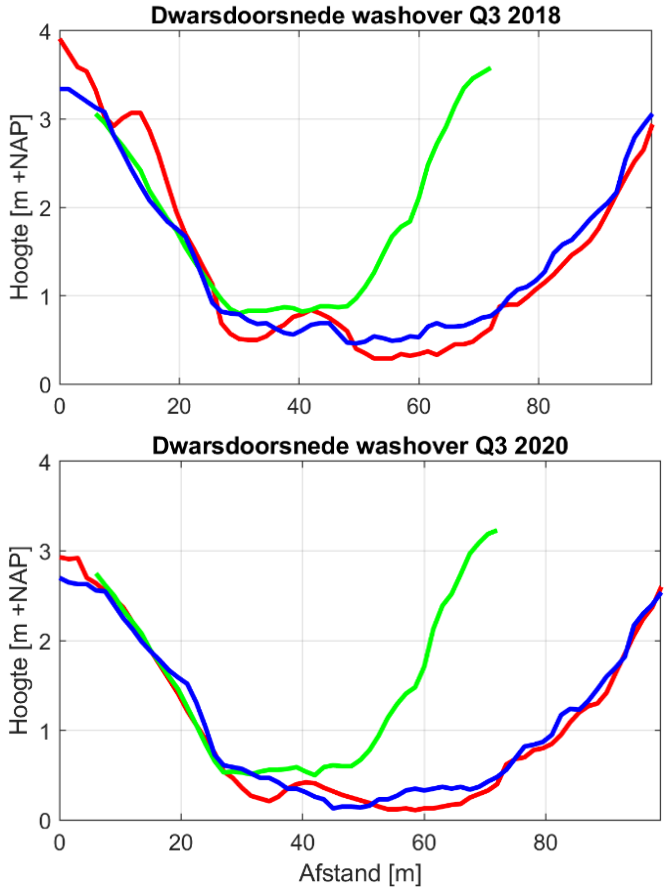
Development of wash-overs

Level of wash-overs





First recording

Last recording

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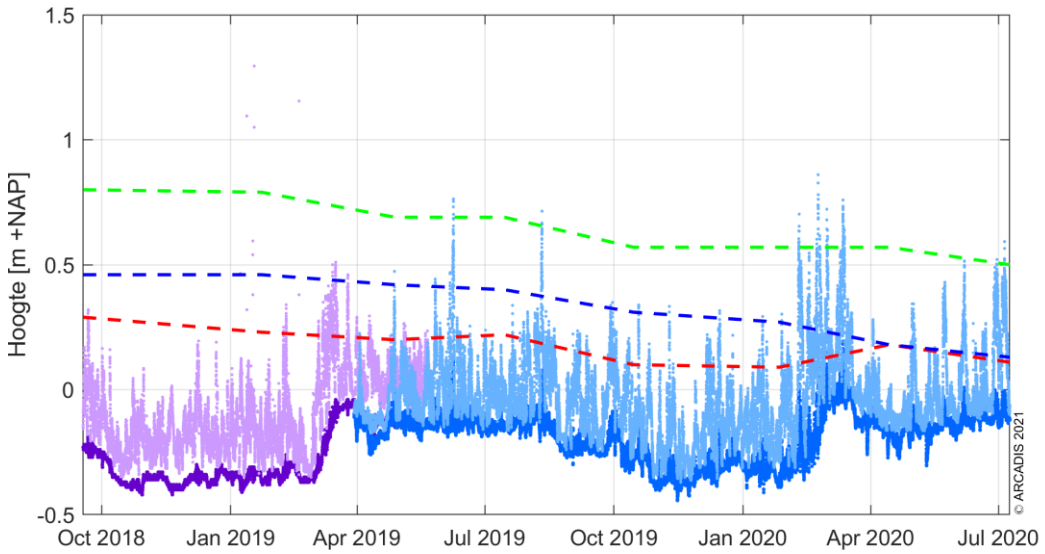
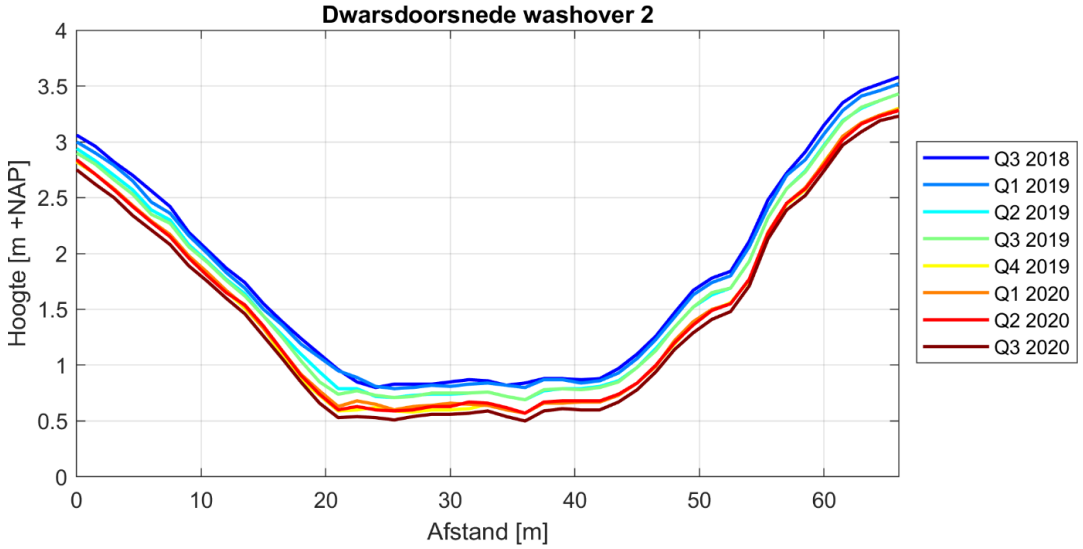
Development of wash-overs





- Initial level often too high for a real washover
- Level shows gradual decrease so the probability of overwashes increases
- Decrease in level related to settlement of subsoil

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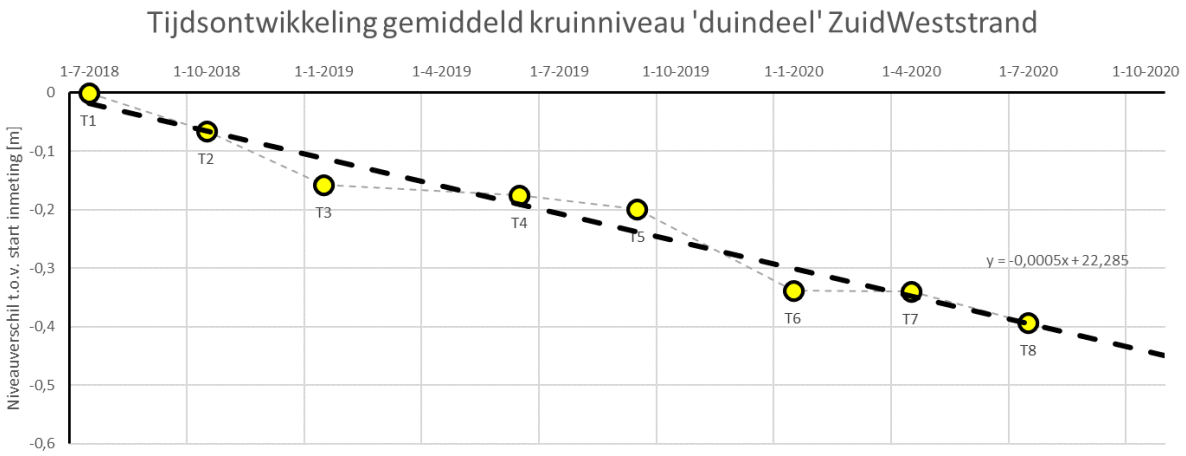
Gradual reduction of the crest levels

- Development of the average crest level of cross profiles
- Average decrease is 0.2 m/year
- Still a straight line …

- Losses have been accounted for in the design



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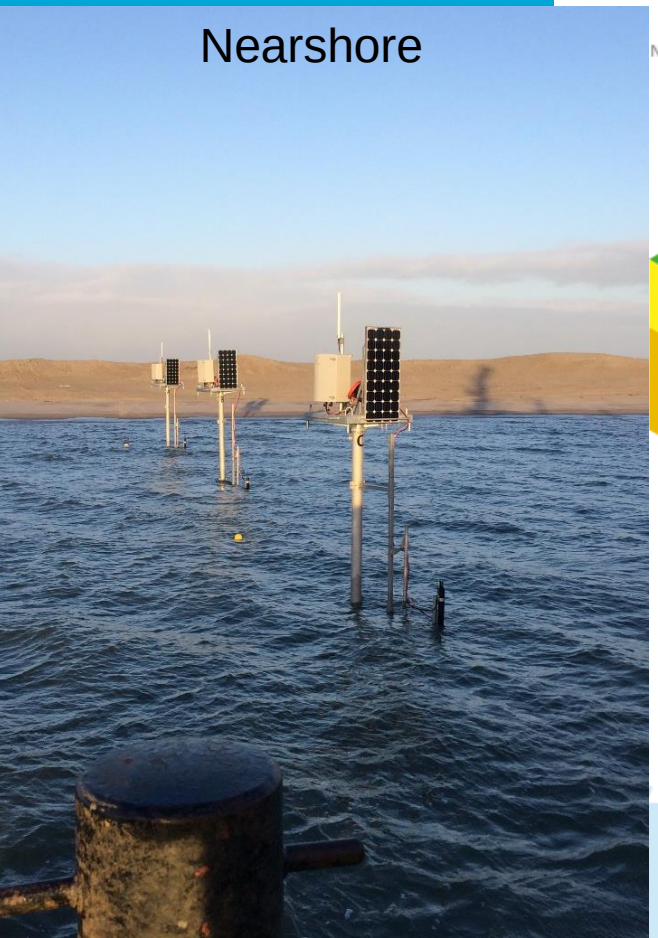
2 - Large-scale lake processes

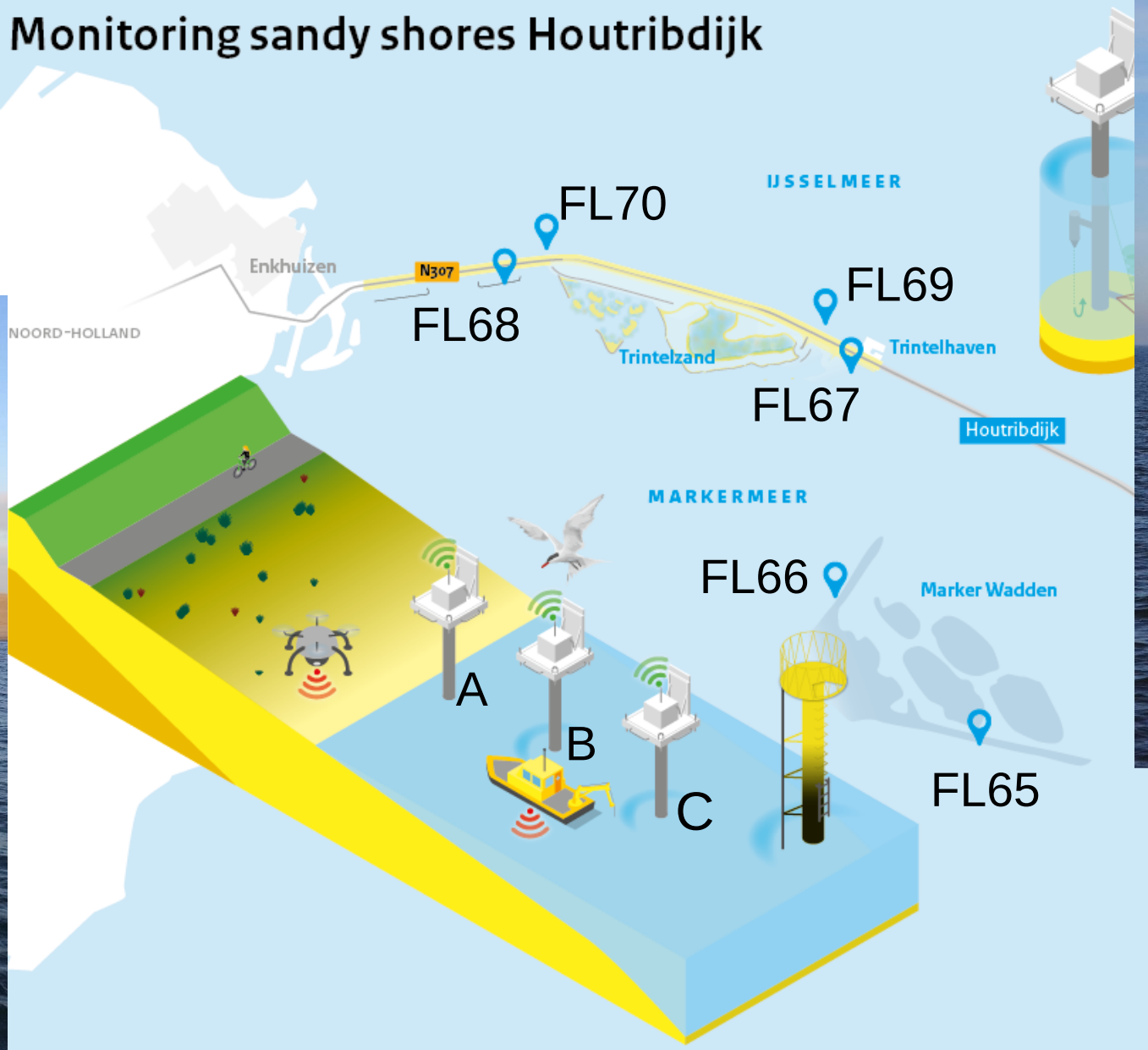
Rijkswaterstaat
Ministry of Infrastructure and Water Management

Monitoring sandy shores Houtribdijk

Offshore

Nearshore





Noordstrand 2-2-2022

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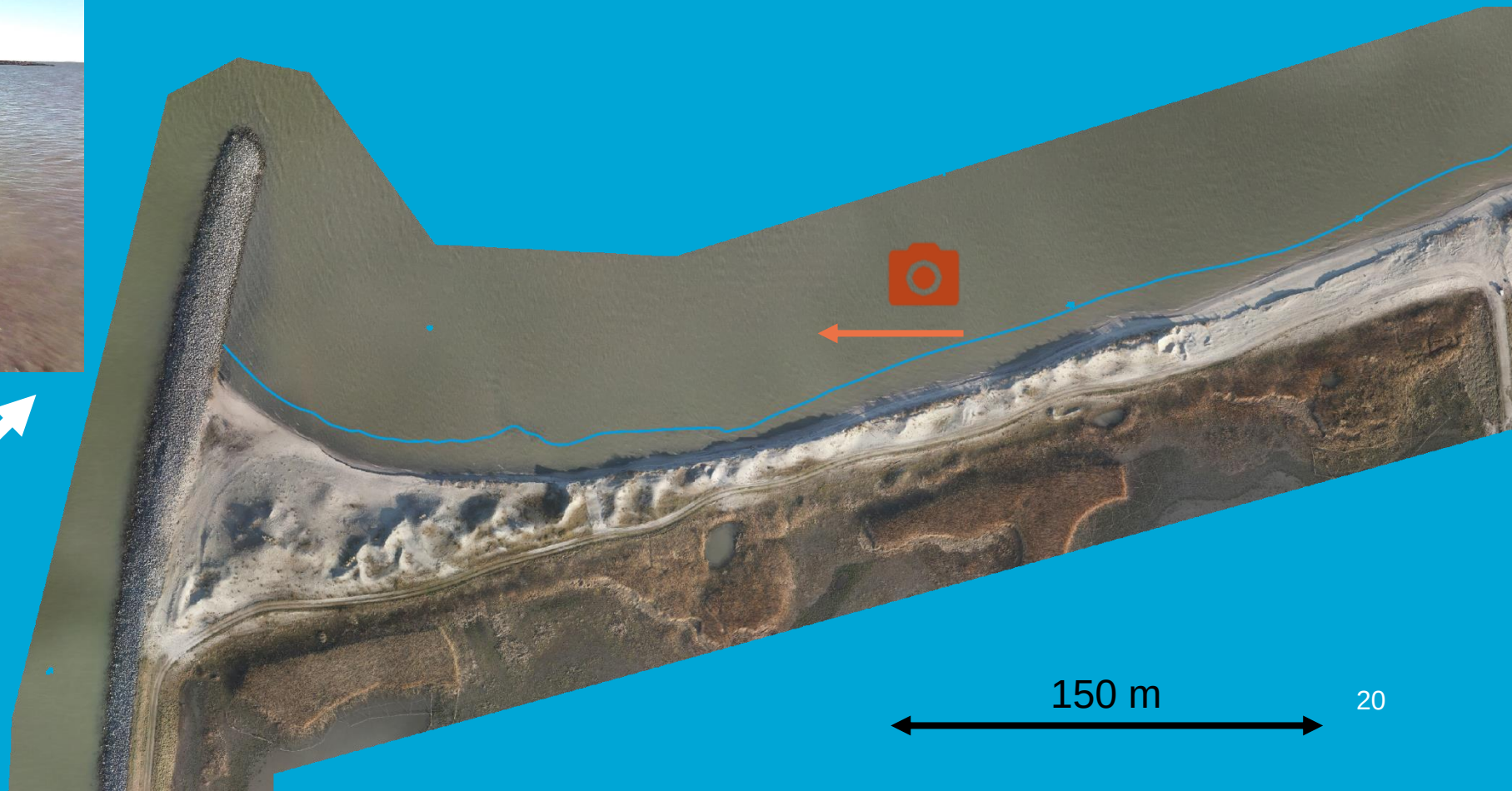
Noordstrand 3-3-2022



Conclusions

- Large-scale lake circulations, in combination with waves, have a big influence on longshore flow and transport
- With measurement and modelling results, potential longshore transport can be predicted
- These large-scale processes are important for maintenance of the beaches

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3 - Maintenance of beaches

Discussion on beach maintenance

Sandy beaches

- Are indeed applicable in a lake-environment
- Protect area behind the beaches
- Have also an added natural value

Discussion on beach maintenance

Lateral and cross-shore losses

- Can lead to a retreat of the position of the water line
- Due tot incoming waves (at an angle)
- Also longshore currents plays an important role

- Nourishments can be used to mitigate this retreat
- This asks for recurring maintenance efforts

Discussion on beach maintenance

Settlement of the subsoil

- Leads to a steady/continuous decrease in the crest level
- For the dunes/beaches, this may require measures in the long term
- For other parts of the island effects are even more relevant

Discussion on beach maintenance

Discussion

- Sandy boundaries suitable in lake environments?
- Maintenance scheme required or not?
- Vertical losses a problem?

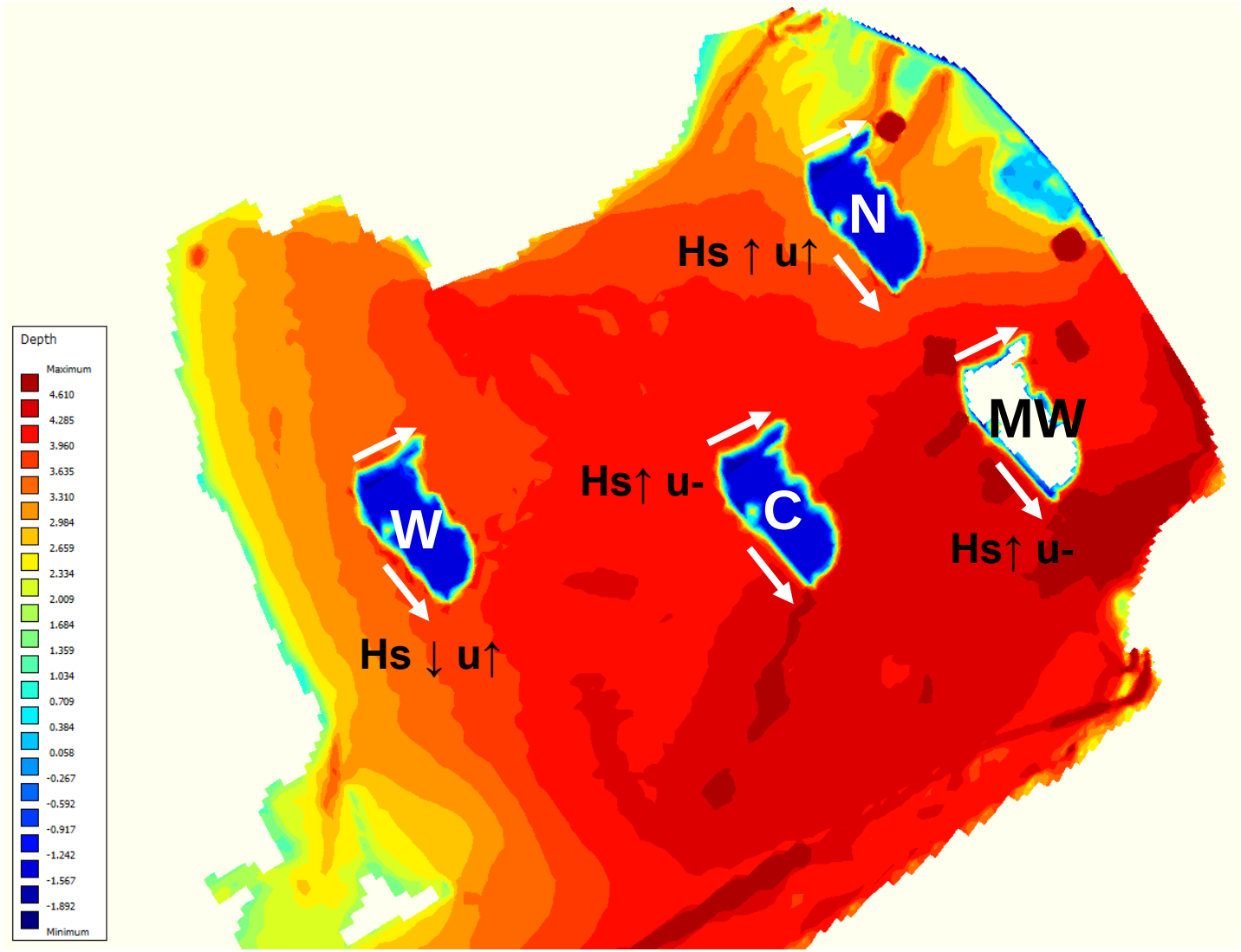
4 - Large-scale lake processes & Expansion of islands

What if… Marker Wadden was in a different location?

- Least longshore transport for location W:
  - Very little waves
- Currents most in balance for location C:
  - Central location
- Highest velocities on Noordstrand N:
  - Funnel effect

Conclusion:

Currents important for direction longshore transport, but waves are needed to stir up sediment



Conclusions

- Location of the island relative to the large-scale circulations is crucial for the design and maintenance.
- **Location** of the island relative to the **circulation cell** is important for flow velocities and directions
- The **shape** of the islands and whether they are streamlined relative to large-scale circulations determines whether nearshore eddies arise.
- **Sand mining pits** affect both flow velocity and direction.

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Discussion expansion islands

What if… Marker Wadden will expand?

- Increase of funnel effect
- Do we need to change lay-out of islands?
- Can we benefit from longshore current in maintenance?
- What does this mean for water quality?

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