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Enabling Delta Life

Modelling of Annual Sand Transports at the Dutch Lower Shoreface

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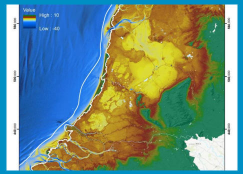
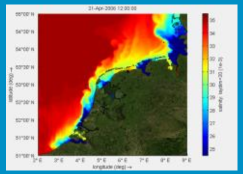
Content



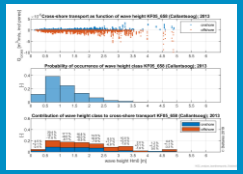
Coastal Foundation



Approach

Peak and residual tidal velocities and waves

Annual transports



Summary

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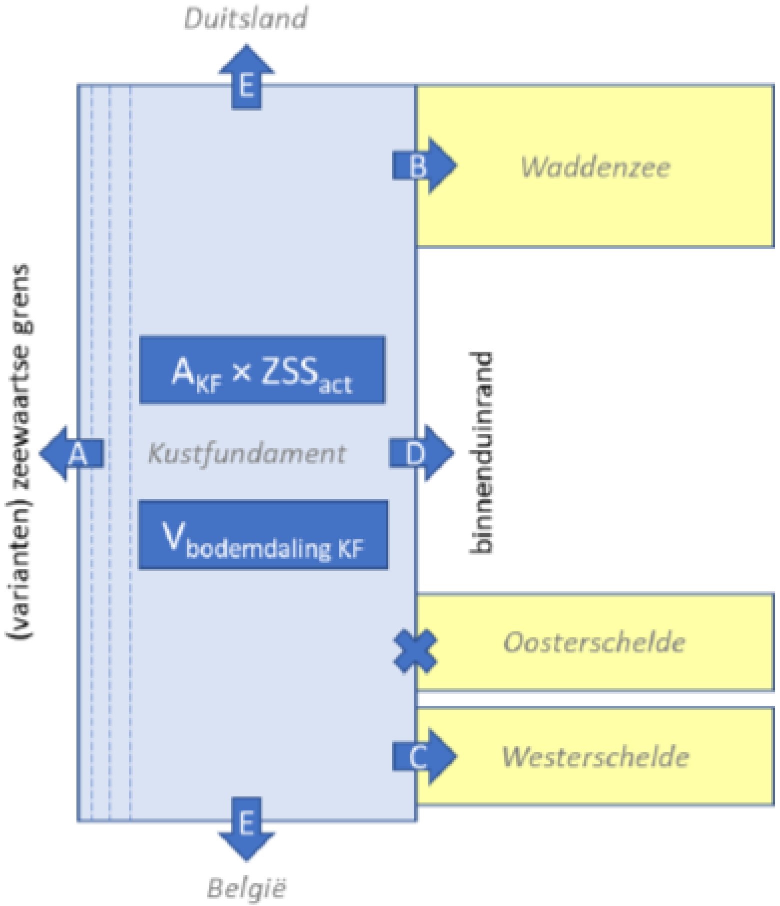
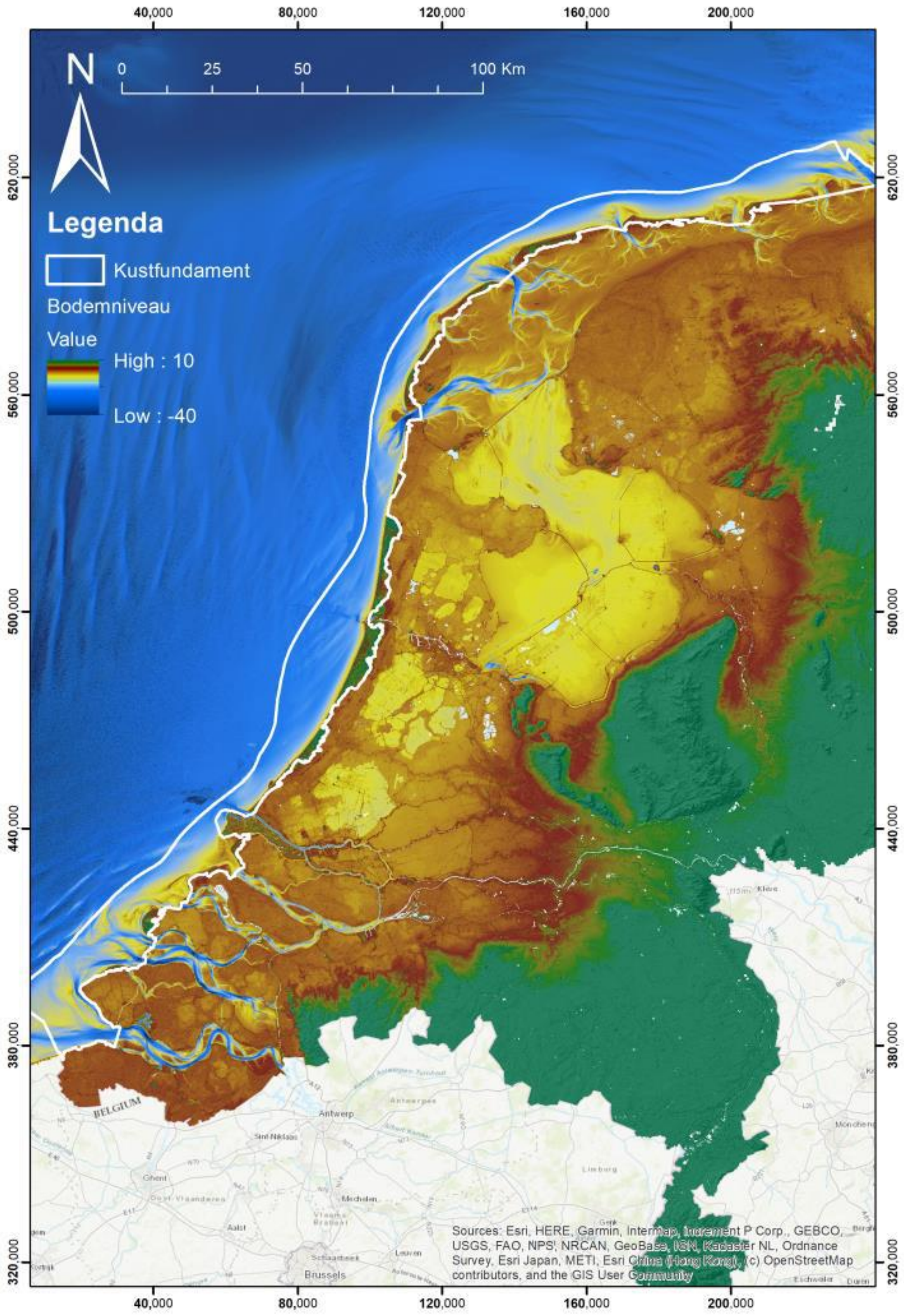
Dutch Coast: Coastal Foundation

What is a good definition of the Coastal foundation?

Present nourishment volume: 12 million m^3/year

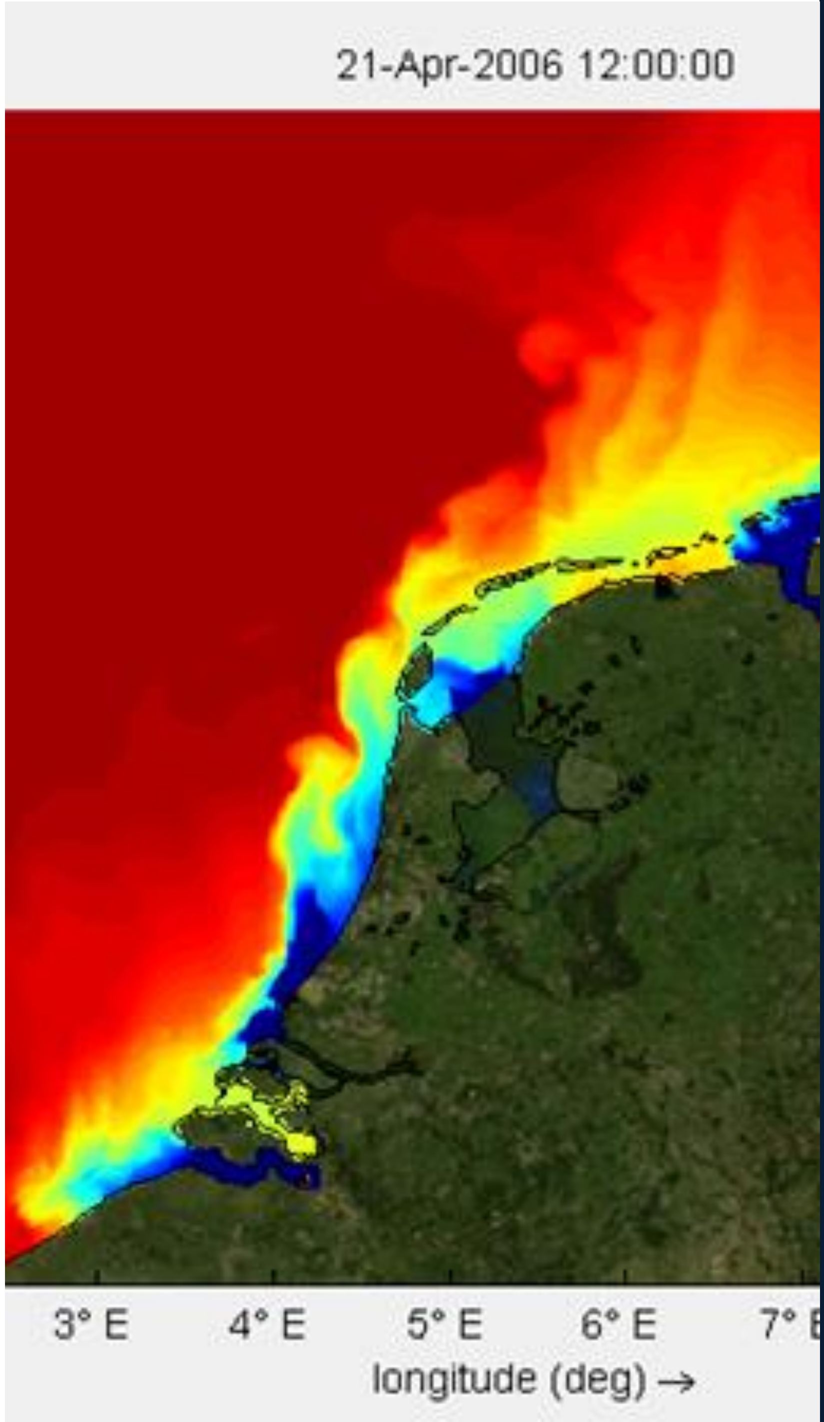




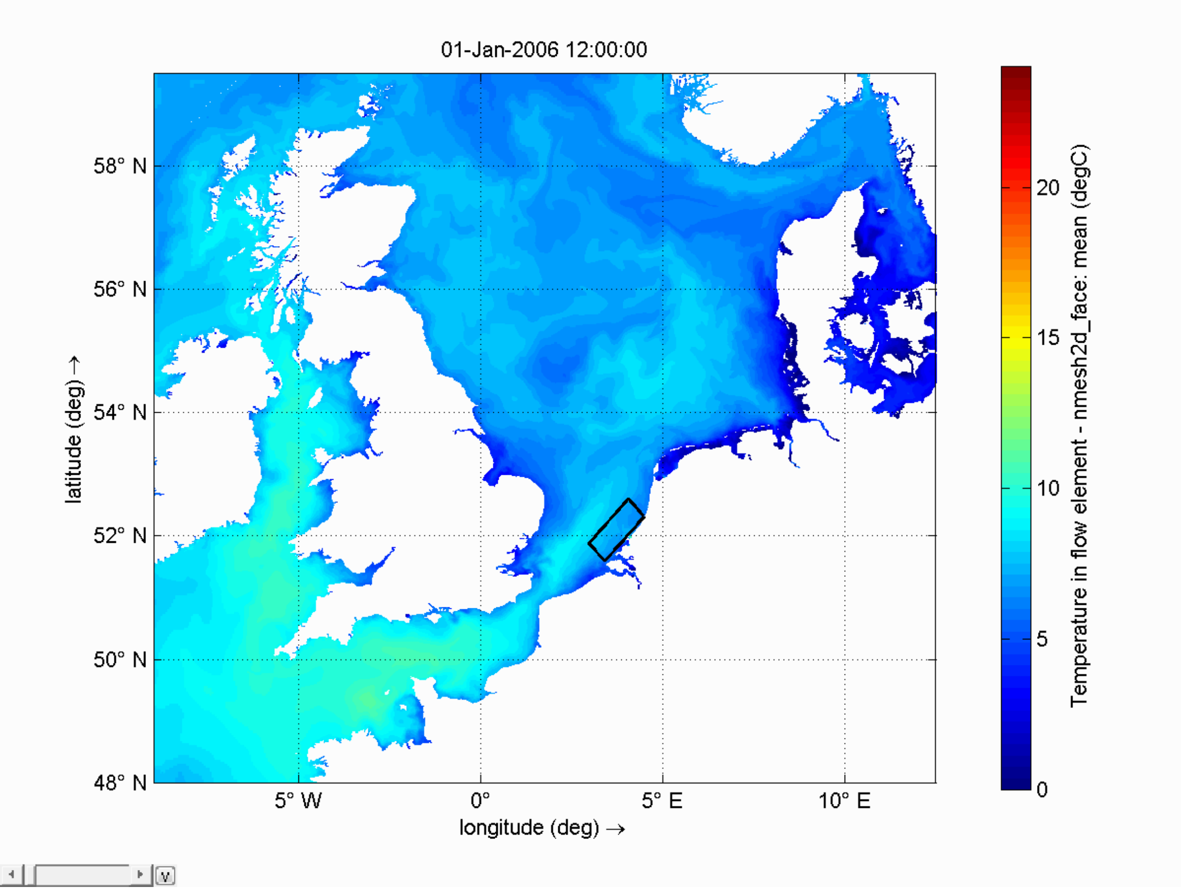
Approach

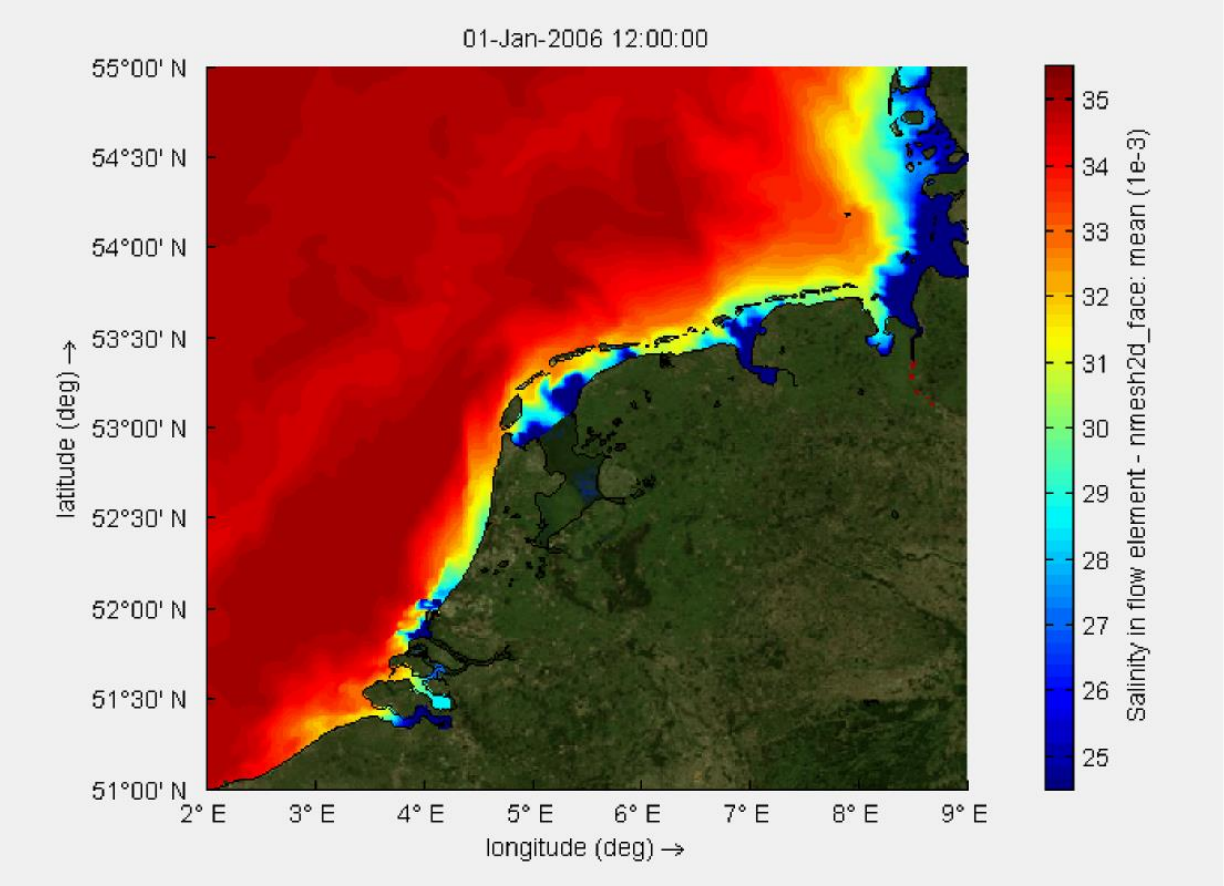
- Flow from 3D DCSM DFlow-FM model (tide+wind+density)
- Waves from wave transformation table (based on wave buoys)
- Sand transport from 1DV transport model

- Calculations for years 2013-2017 (every 30 minutes, brute force)

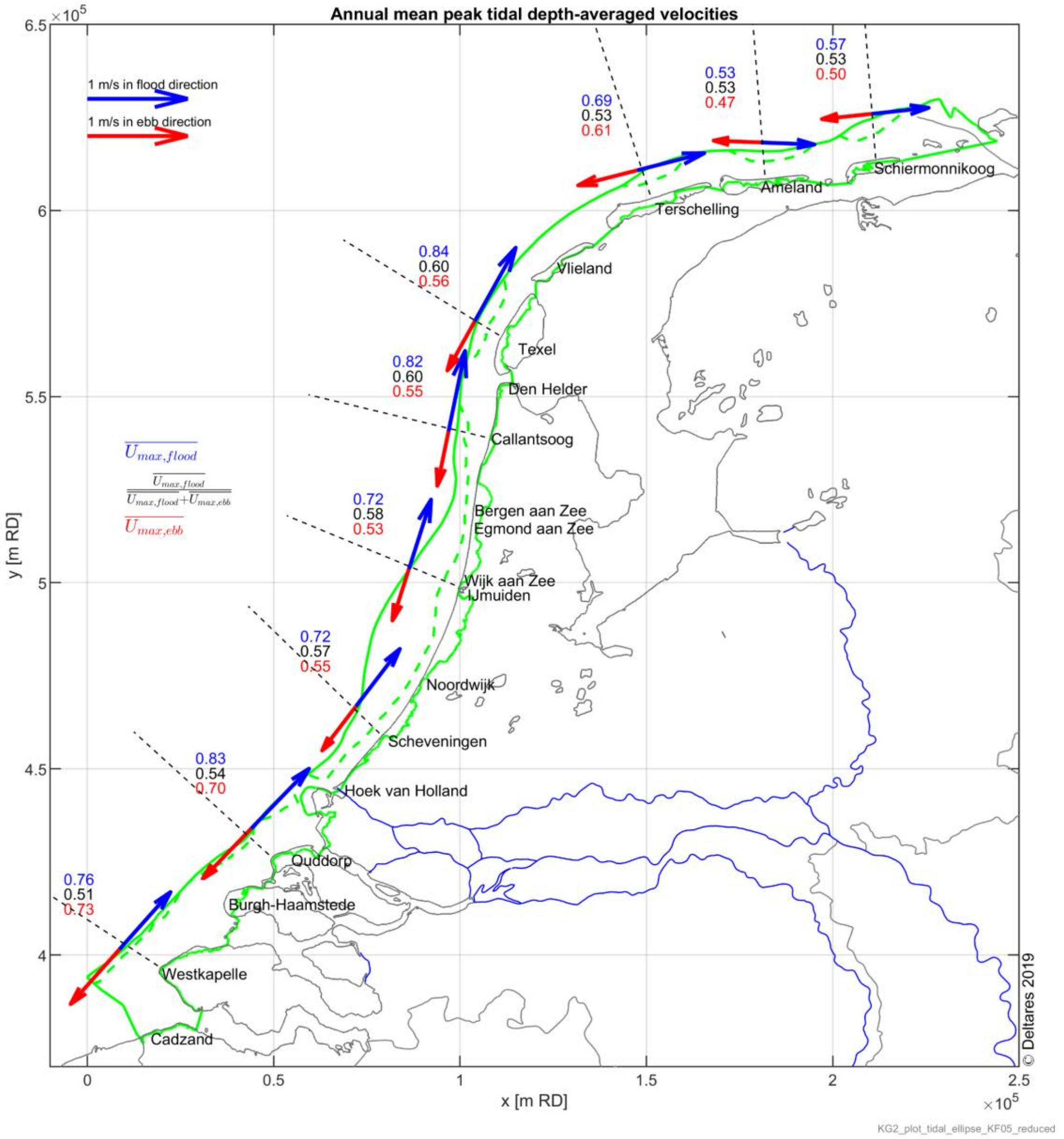


Temperature and salinity





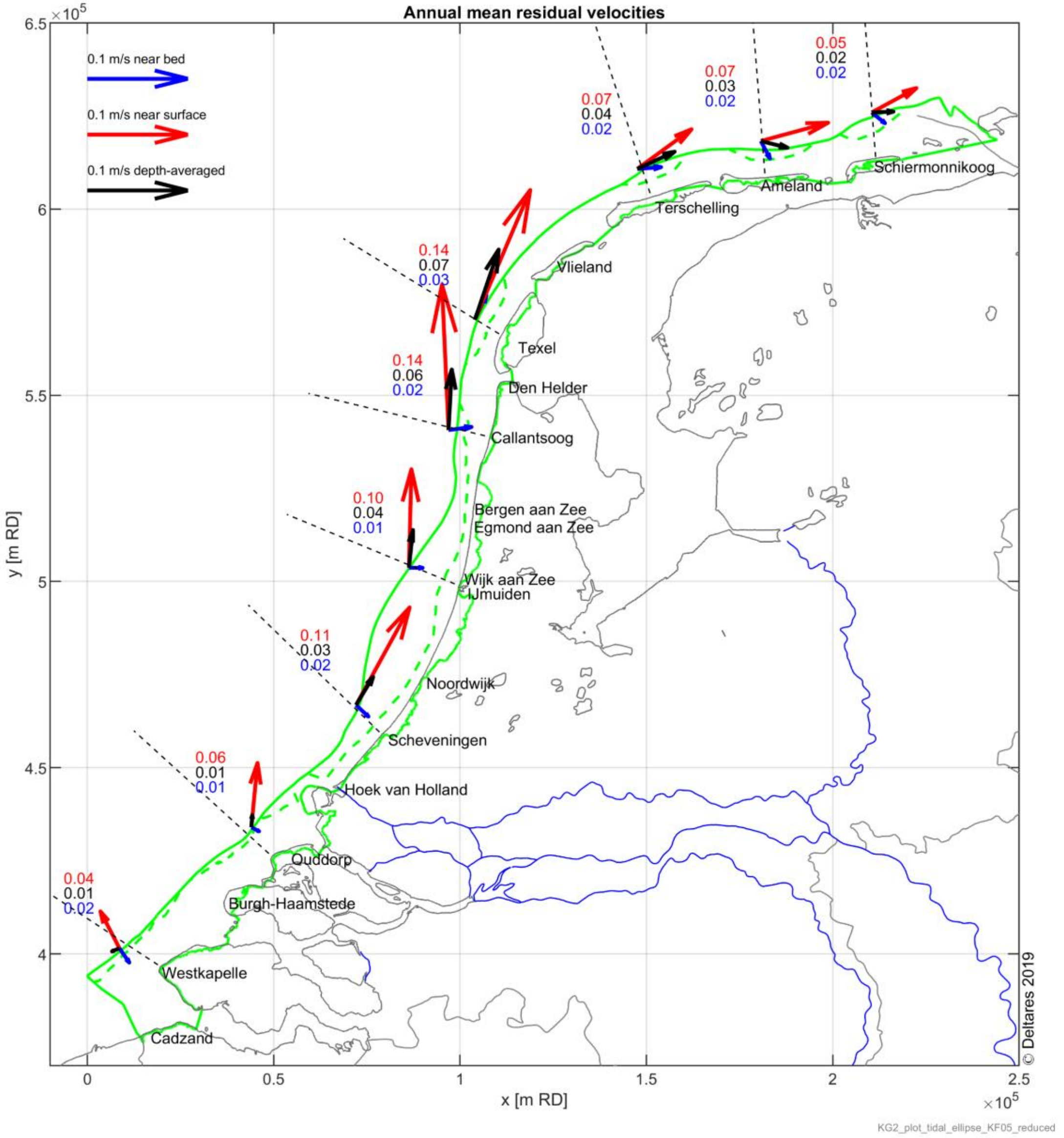
Peak tidal velocities at 20m depth contour



These results are based on simulations with the three-dimensional flexible mesh Dutch Continental Shelf Model over the years 2013-2017. They show the mean of all depth-averaged peak flood and peak ebb velocities.

- ✓ The largest mean peak flood velocity (0.84 m/s; blue vectors) is observed near Texel and decreases towards Schiermonnikoog.
- ✓ The largest mean peak ebb velocity (0.73 m/s; red vectors) is observed near Westkapelle and decreases towards the north-east.
- ✓ As a result: the tidal velocity asymmetry (black numbers) increases towards Texel and decreases towards Schiermonnikoog.

Residual flow velocities at 20m depth contour



These results are based on simulations with the three-dimensional flexible mesh Dutch Continental Shelf Model over the years 2013-2017, with real-time tidal and meteorological forcing and fresh water discharges (including salinity).

- ✓ The depth-averaged residual flow (black vectors) increases from 0.01 m/s near Zeeland to 0.07 m/s near Texel and decreases again to 0.02 m/s near Schiermonnikoog.
- ✓ The near-surface residual flows (red vectors) are more alongshore-directed with sometimes an offshore tendency.
- ✓ The near-bed residual flows (blue vectors) show an onshore-directed tendency.

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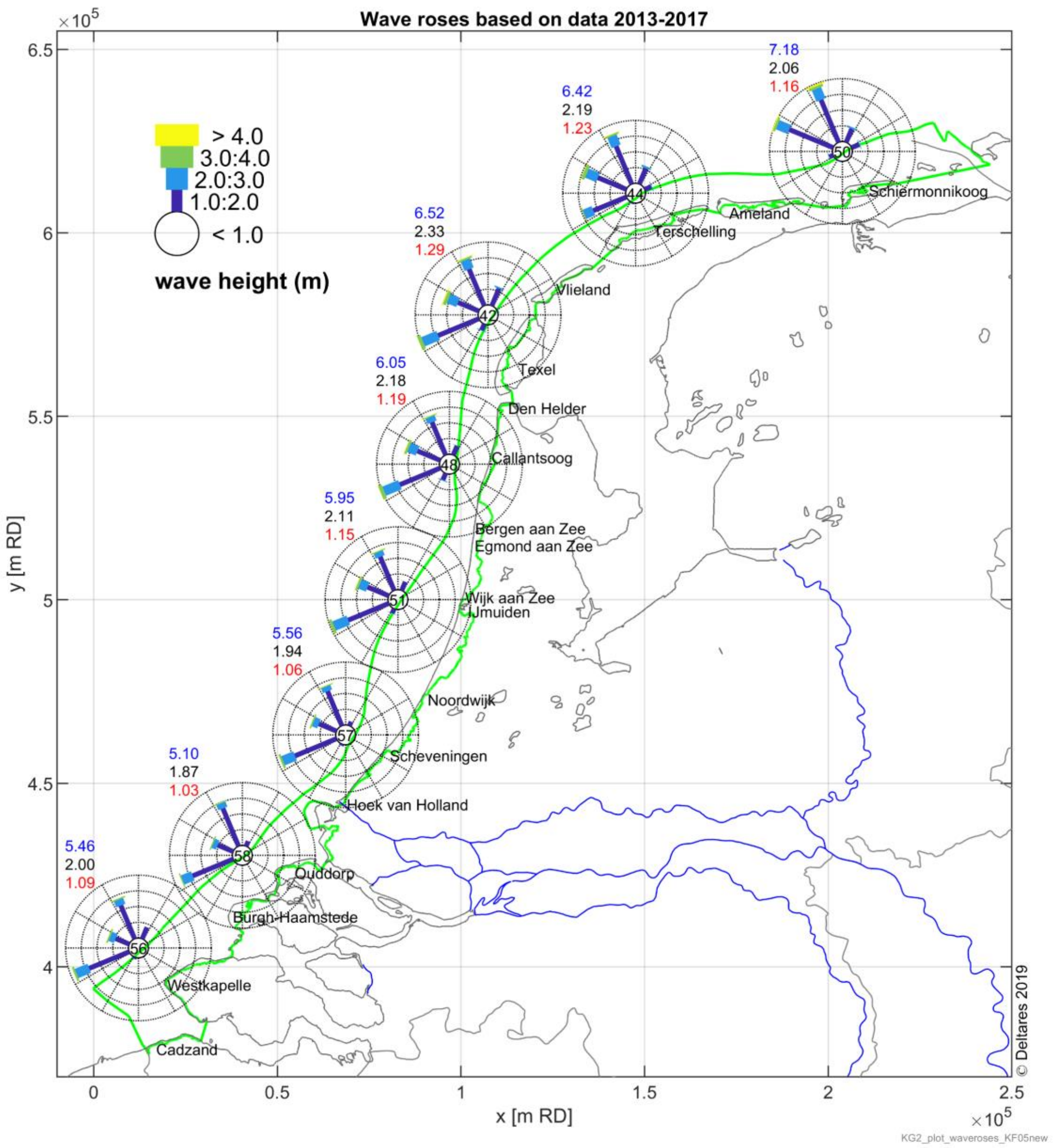
Wave climate at 20m depth contour



The wave climate information is based on wave buoy measurements over the years 2013-2017. These observations have been translated to the -20m contour for the entire Dutch coast using a wave transformation matrix.

- ✓ The mean significant wave height H_{m0} (red numbers) increases from about 1.1 m near Zeeland to about 1.3 m near Texel.
- ✓ In Zeeland, the significant wave height H_{m0} was larger than 2.0 m during 10% of the observation interval (black numbers). Near Texel, this value is about 2.3 m.
- ✓ The maximum wave height (blue numbers) increases from about 5.5 m near Zeeland to about 7 m near Schiermonnikoog.

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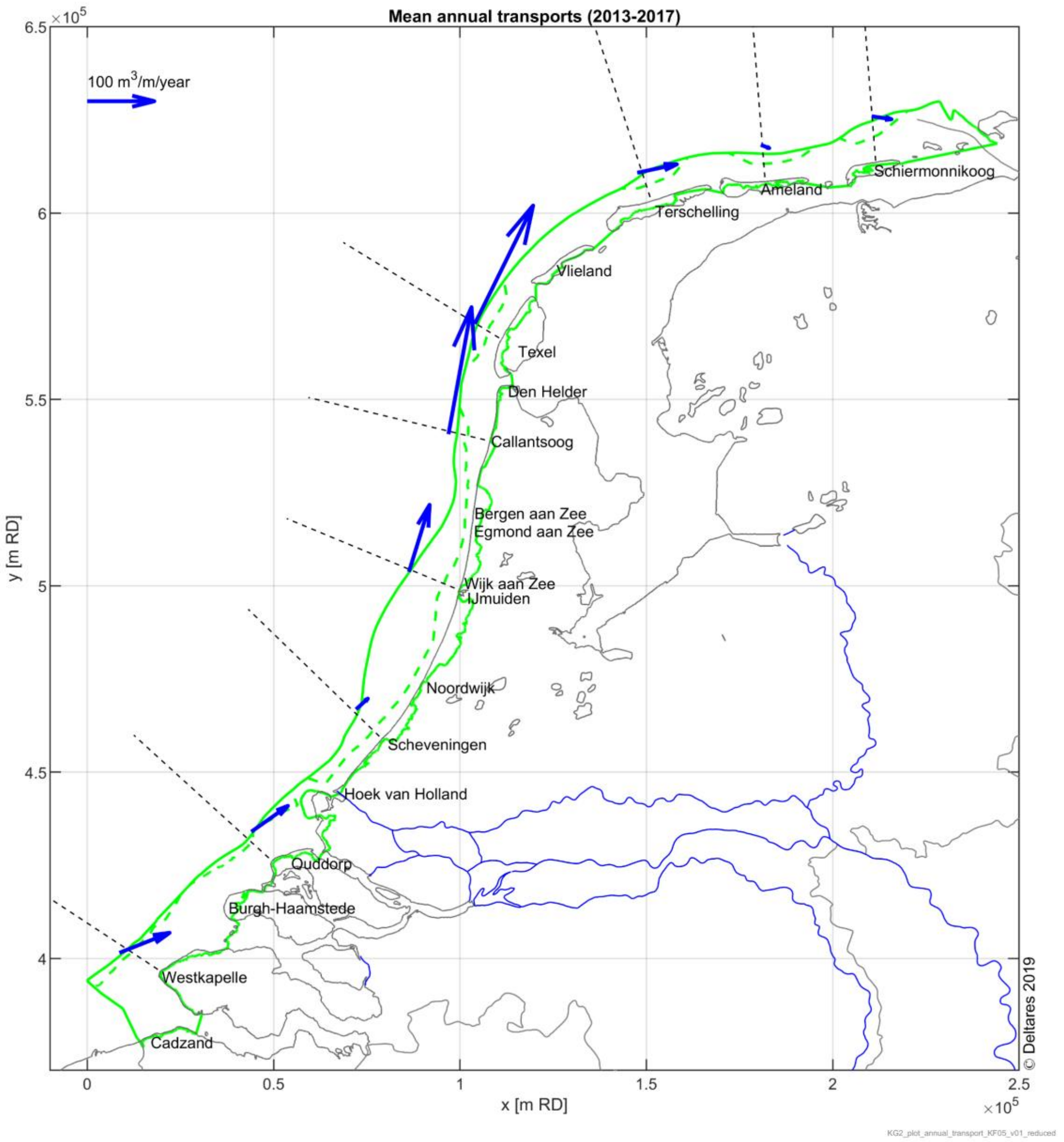
Mean annual sand transport at 20m depth contour



These calculated transports are based on simulations with the three-dimensional flexible mesh Dutch Continental Shelf Model over the years 2013-2017, using a wave transformation matrix and the 1DV Van Rijn transport model (D_{50} = 250 µm; incl. pores).

- ✓ The largest transport occurs between Callantsoog and Texel.
- ✓ The alongshore-directed sand transport is much larger than the cross-shore sand transport; ~100 m^3/m/year and ~10 m^3/m/year, respectively.
- ✓ The annual net sand transport is directed to the north-east due to tidal asymmetry and residual flow.
- ✓ Near-bed density-driven currents typically cause onshore-directed sand transport.

Modelling results from Grasmeijer et al., 2019

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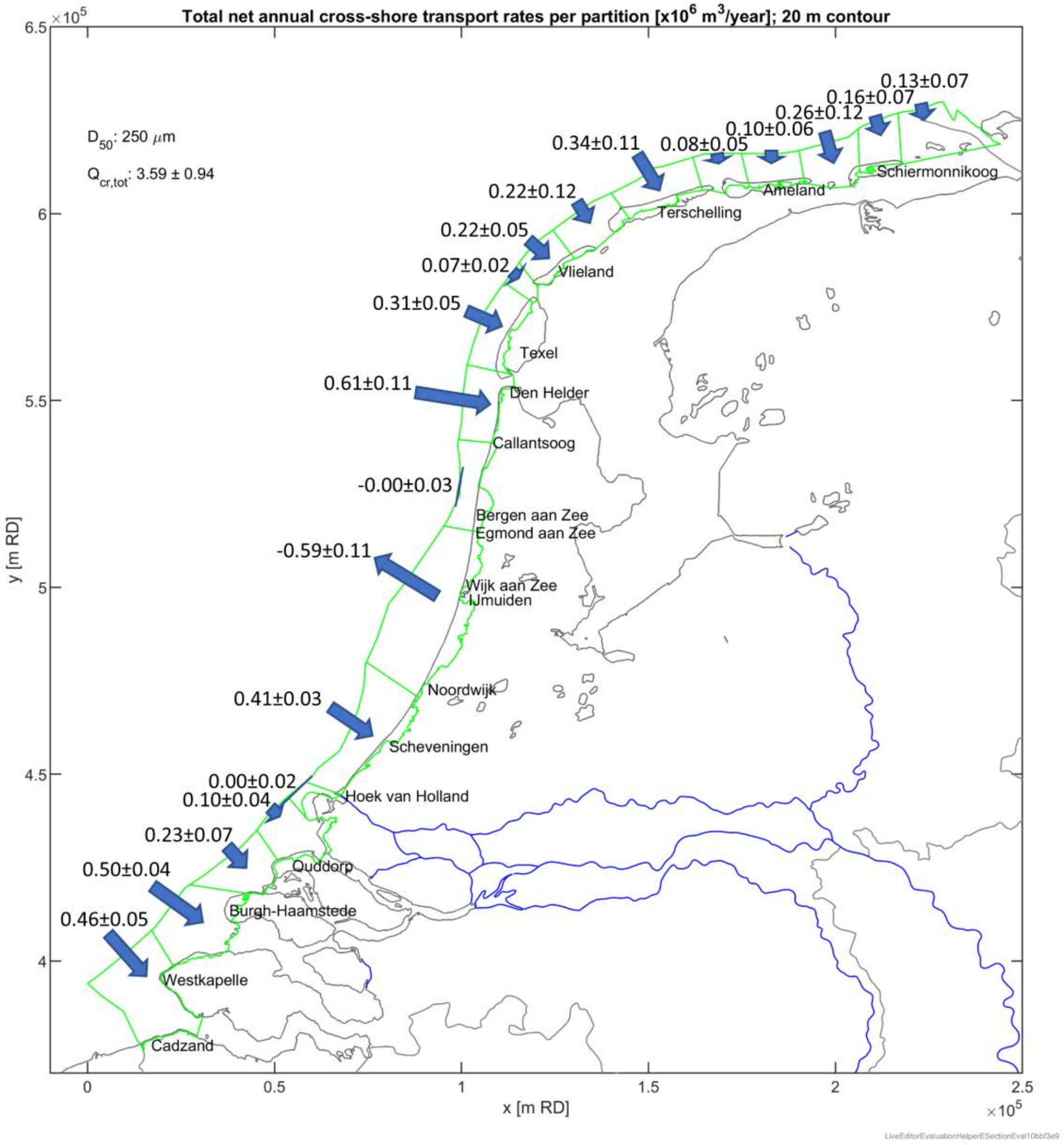
Mean annual sand transport at 20m depth contour



Modelberekening	Netto landwaarts zandtransport (miljoen m³/jaar)		
	NAP-20 m	NAP-18 m	NAP-16 m
1. Referentie (D_{50} = 250 μm, zonder retourstroming)	+3,6 ± 0,9	+5,0 ± 1,4	+7,1 ± 2,0
2. Met retourstroming	+3,0 ± 0,8	+4,3 ± 1,2	+6,4 ± 1,9
3. Met D_{50} = 275 μm	+3,5 ± 1,0	+4,9 ± 1,4	+7,1 ± 2,1
Gemiddelde (1., 2., en 3.)*	+3,4 ± 0,9	+4,7 ± 1,3	+6,9 ± 2,0
4. Zonder dichtheidseffecten	+1,3 ± 0,9	+3,1 ± 1,3	+6,2 ± 2,1
5. Met Sinterklaas-storm tot 1/100 verhoogd**	+5,5 ± 1,7	+7,6 ± 2,2	+11,4 ± 3,0

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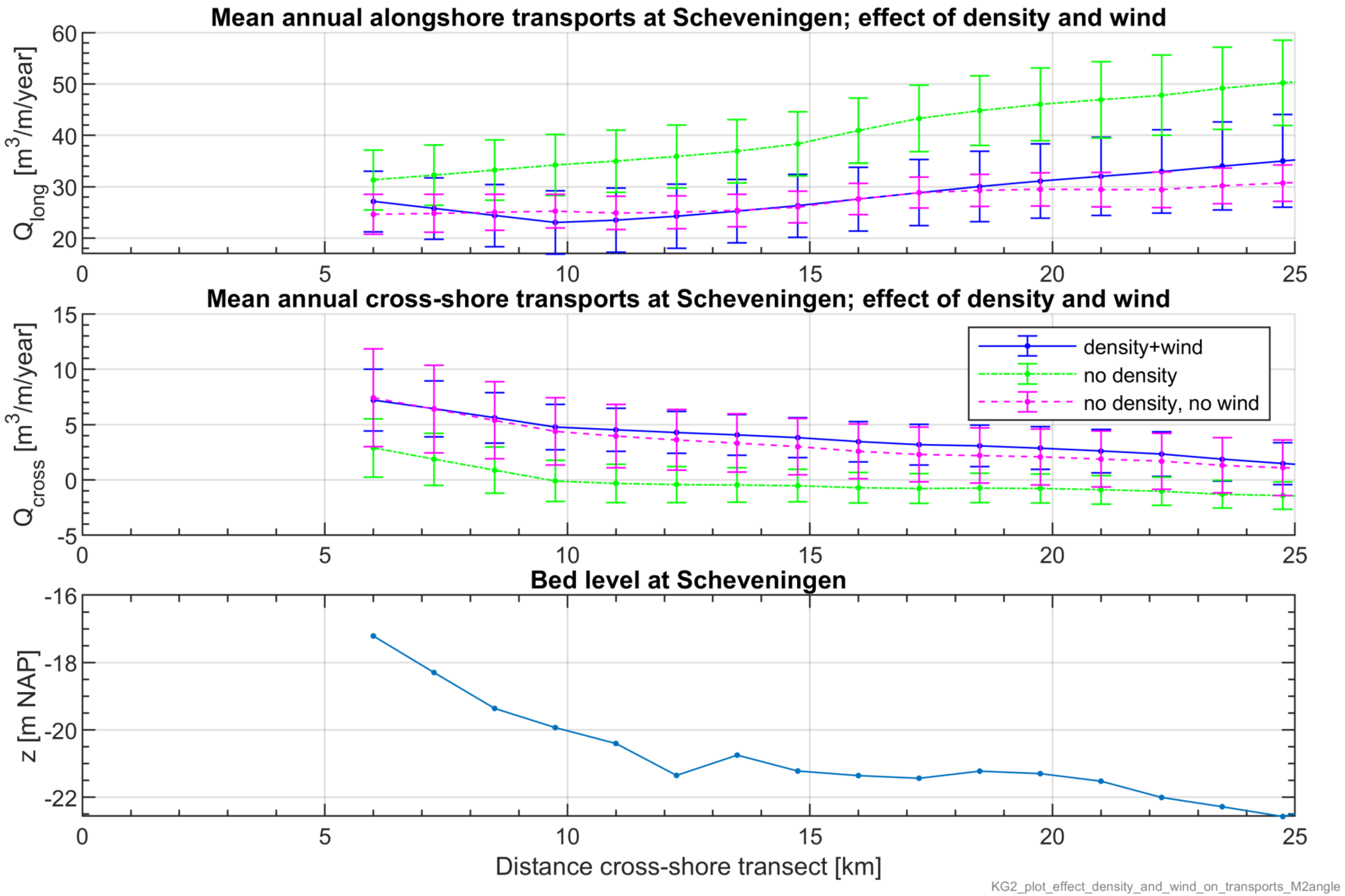
Effect density and wind in a cross-shore transect



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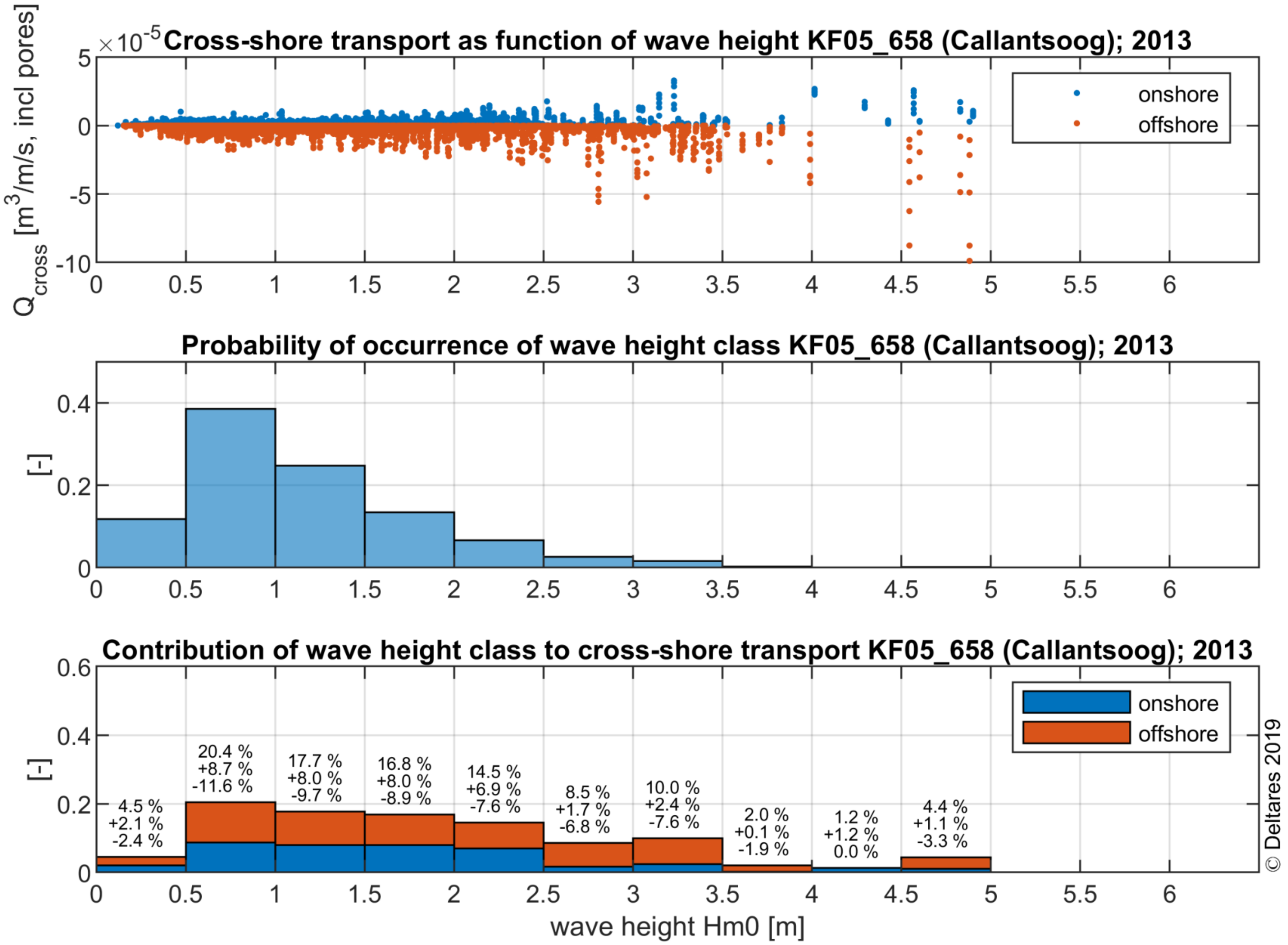
Contribution of wave height classes to cross-shore transport



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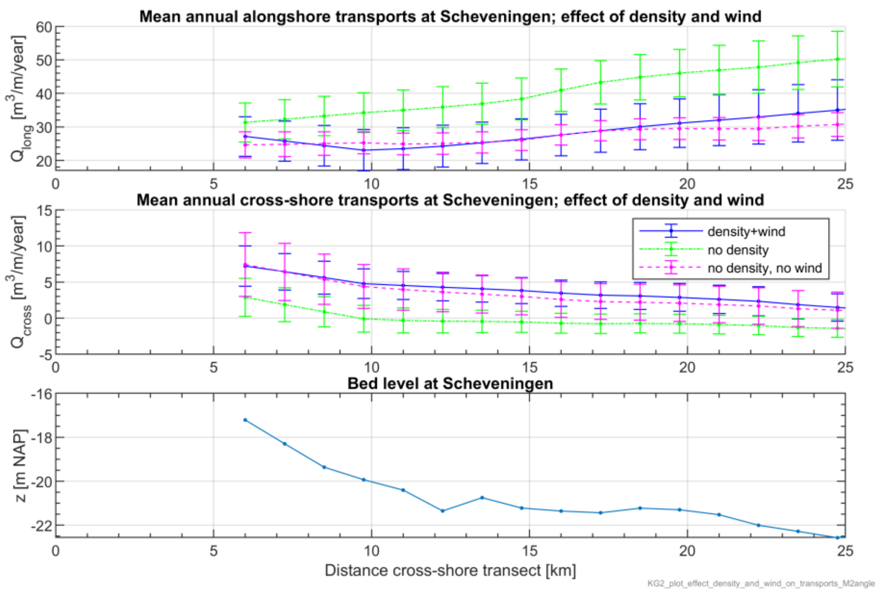
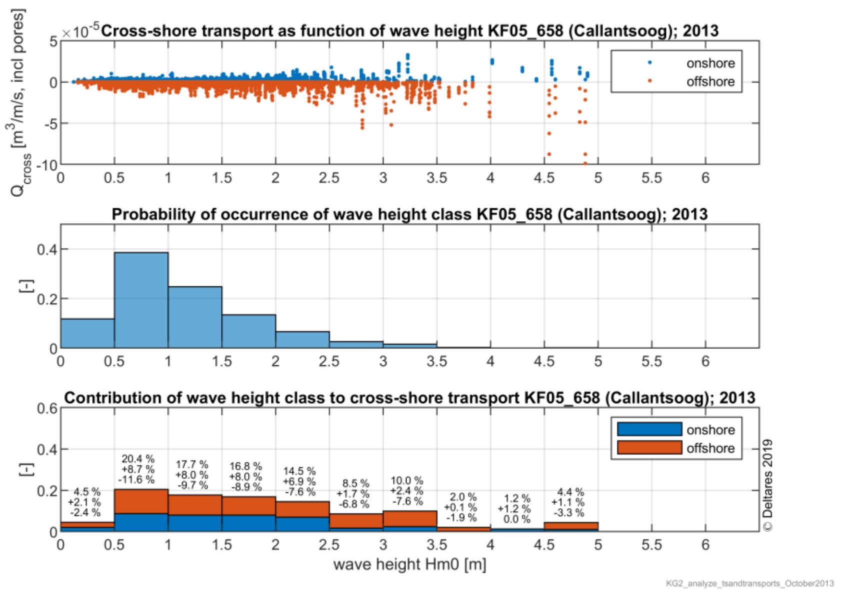
Summary

- Efficient Process-based 3D modelling approach.
- Annual sand transports entire Dutch coast.
- Cross-shore transports 20 m, 18 m and 16 m depth contours onshore directed.
- Onshore transport increases with decreasing water depth.
- Density and wind (storms) play important role for net transport rates at lower shoreface.





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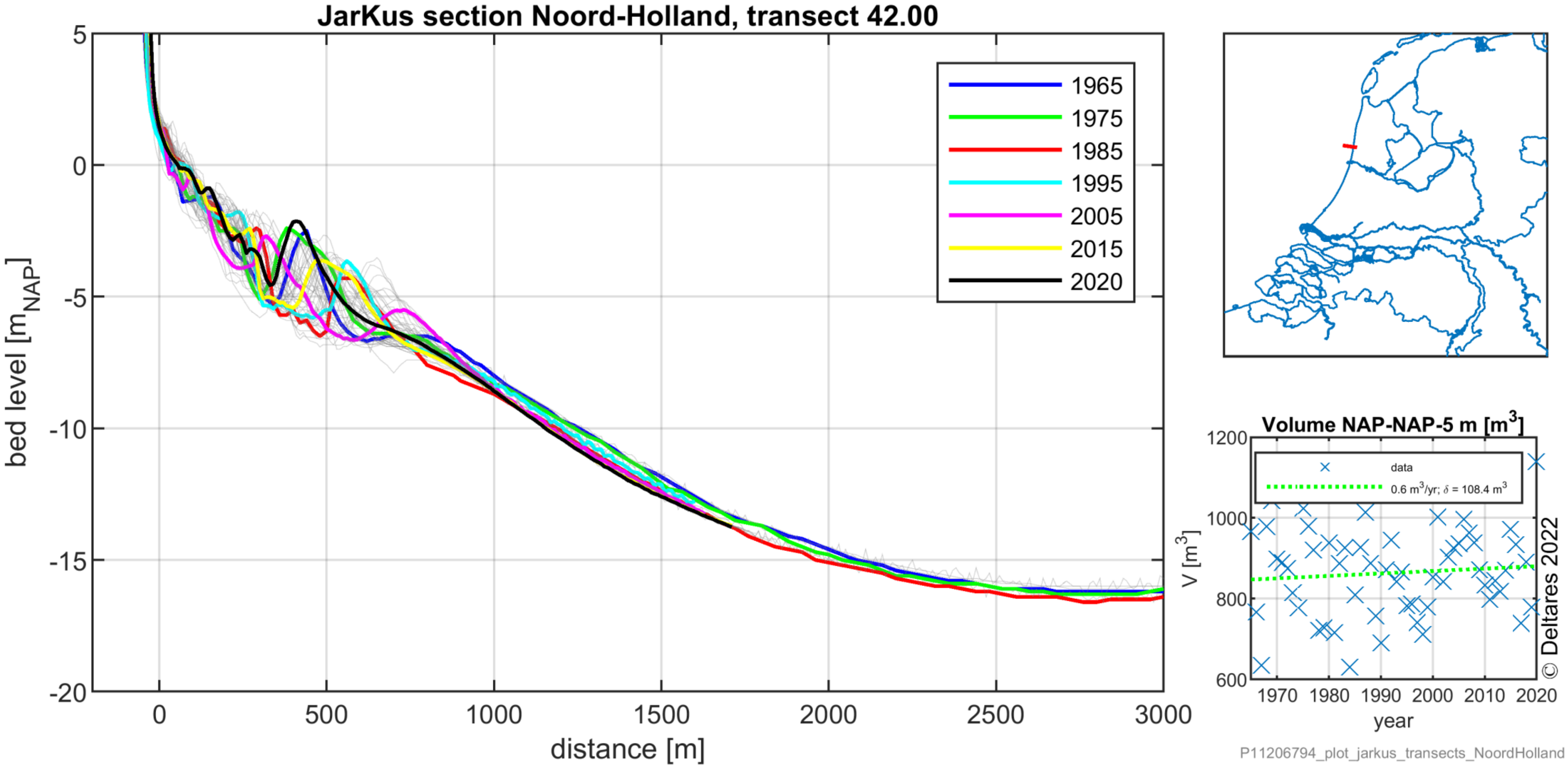
Thank you!

Example JarKus transect 42.00 from 1965 to 2020



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