What drives shoreline changes?

Combining coastal altimetry and optical remote sensing for the barrier island of Terschelling (the Netherlands)

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1. Observations help to separate drivers of shoreline change

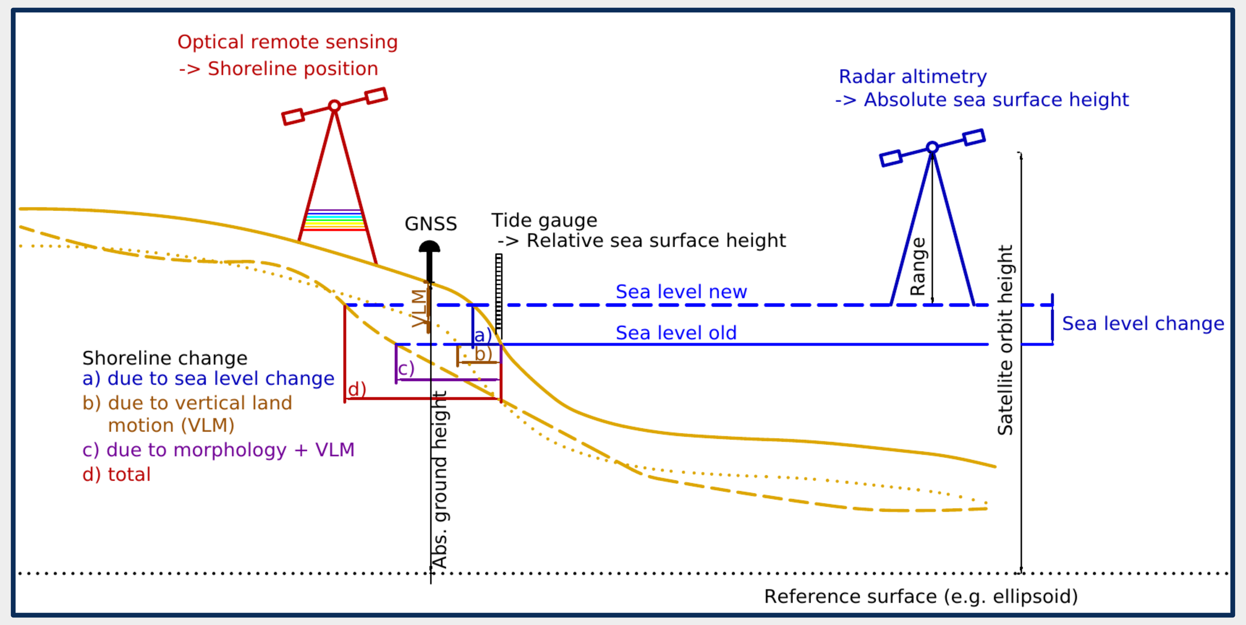

Figure 1: Our goal is to study the relationship between coastline and sea level change by combining observations from sea level, vertical land motion and coastlines extracted from remote sensing images.

2. Satellite radar altimetry can replace tide gauges

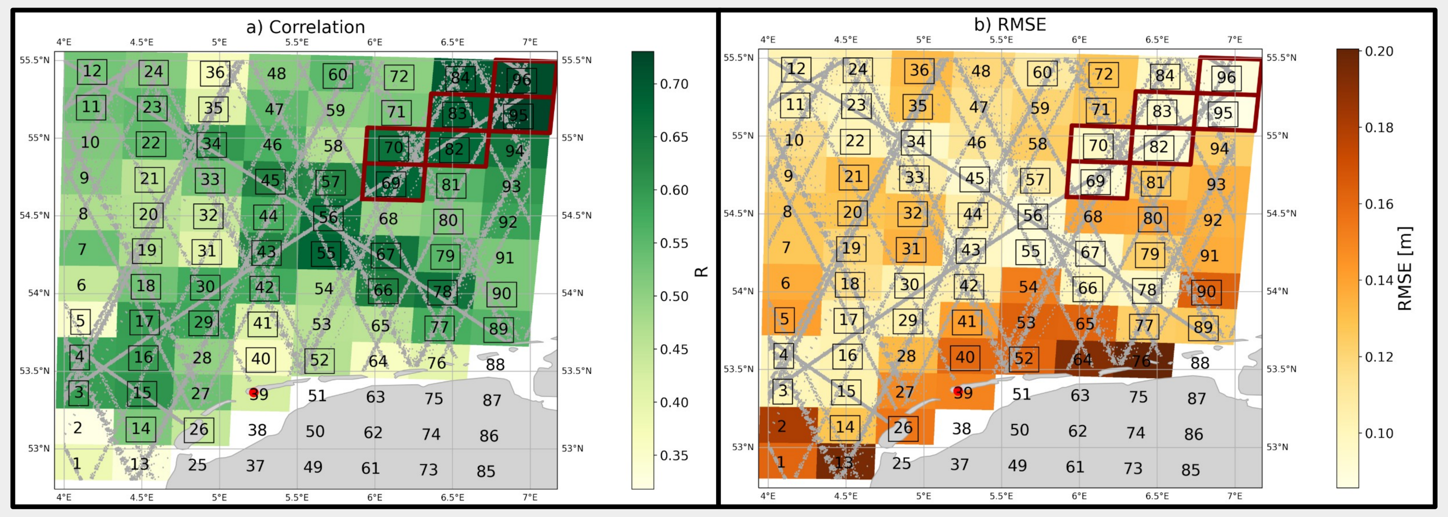

Figure 2: Correlation and RMSE between ALES-retracked altimetry and a tide gauge at Terschelling for the period 2002-2020. We created altimetry timeseries by binning observations in cells of 25 x 25 km. Similarity with the tide gauge is highest along the Jason tracks (best temporal coverage) and about 250 km away from the coast. The extracted altimetry timeseries has a trend of 3.6 mm/year (tide gauge: 4.7 mm/year).

3. Morphodynamics had more effect on shoreline evolution than sea level rise

- over the past 30 years at Terschelling -

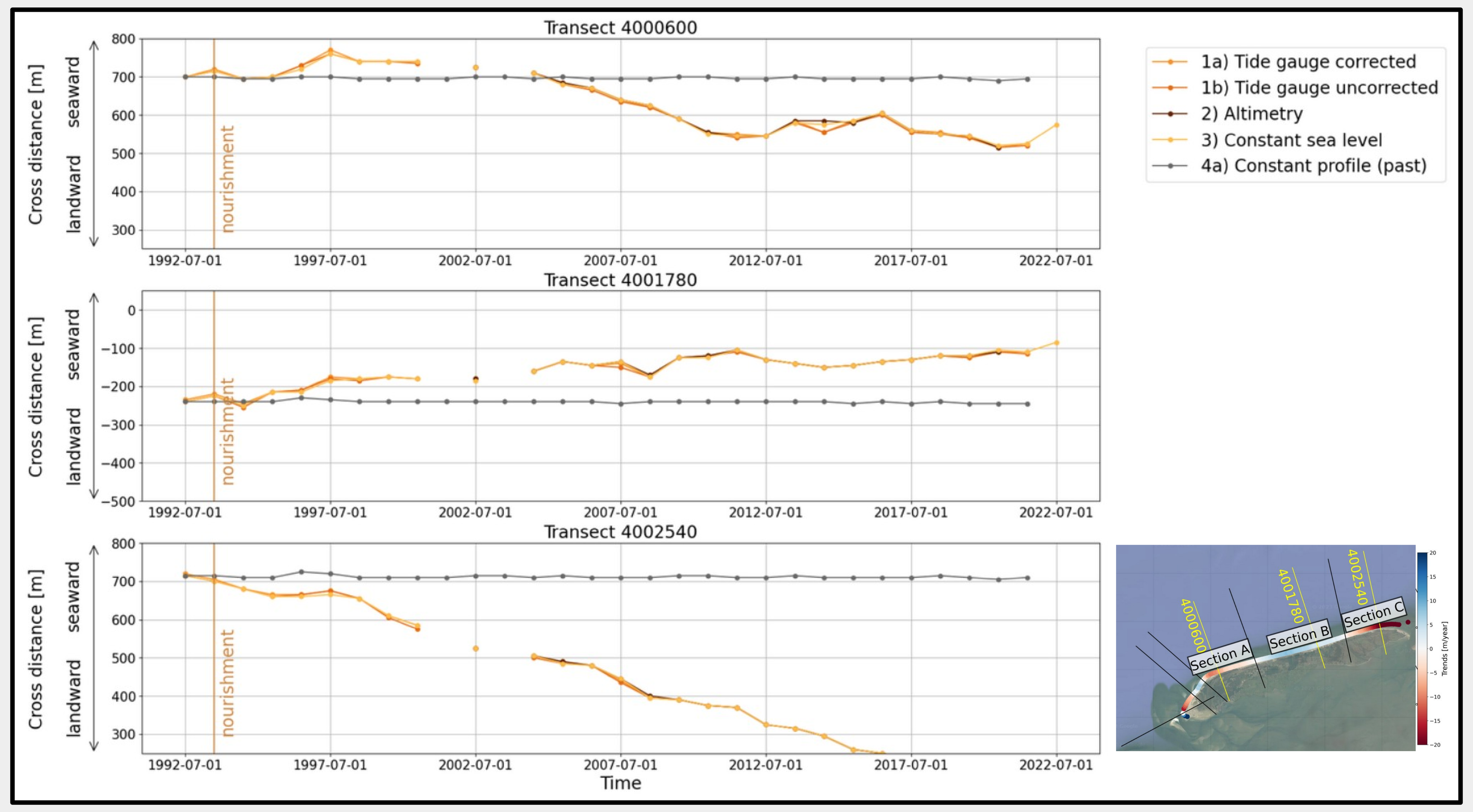

Figure 3: Timeseries of shoreline change derived as the intersection of land elevation data (from LiDAR and bathymetry) with a horizontal plane at sea level at three example transects. Over all 152 transects, intersections with a yearly updated elevation profile (solutions 1) to 3), orange lines) result in shoreline trends of -3.3 to -3.7 m/year. On contrast, the solution with the profiles fixed in 1992 (solution 4a), grey line), with sea level being the only varying factor, on average only lead to -0.3 m/year shoreline change. The majority of shoreline changes were therefore driven by morphodynamics.

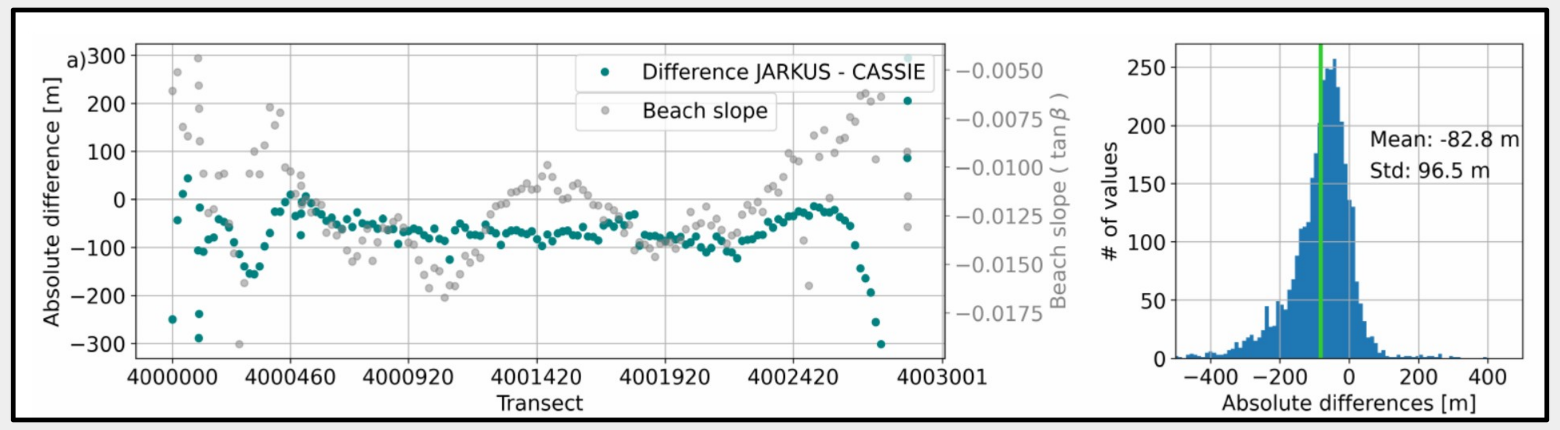

Figure 4: Differences in timeseries of cross-shore changes derived from land elevation data (as in figure 3) and derived from Landsat images with the CASSIE software show an average bias over all transects by -82.8 m, meaning that the satellite-derived shorelines (SDS) were on average further seaward. However, timeseries of SDS showed large variability up to 226 m in response to different settings used for timeseries processing, for example during tidal correction.

4. Summary

- In this case study we found that by combining different remote sensing observations we can assess the impact of **sea level changes, vertical land motion and morphodynamics** on shoreline changes.
- **Morphodynamics** (changes in topobathymetry) had the biggest effect on shoreline evolution.
- **Satellite radar altimetry** can represent sea level changes with suitable accuracy for coastline studies, opening up the **possibility to upscale** this research to places without tide gauges.
- The key limitation is the **availability of high-quality and high-resolution land elevation data**.

5. Upscaling: Collaboration wanted!

- Mid-term goal: **Upscale** these methods to study the effect of relative sea level rise and morphodynamics on **shoreline evolution worldwide**.
- Short-term goal: **Create a Digital Elevation Model** that covers the coastal and intertidal topography **based on remote sensing data**. The idea is to combine a global coastal DEM with an intertidal point cloud from the “waterline method”.
- **Get in touch!** Are you also working on coastal DEMs? Or do you have a cool solution to extract shorelines from optical or SAR images? Let me know more about your research and maybe we can join forces!

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