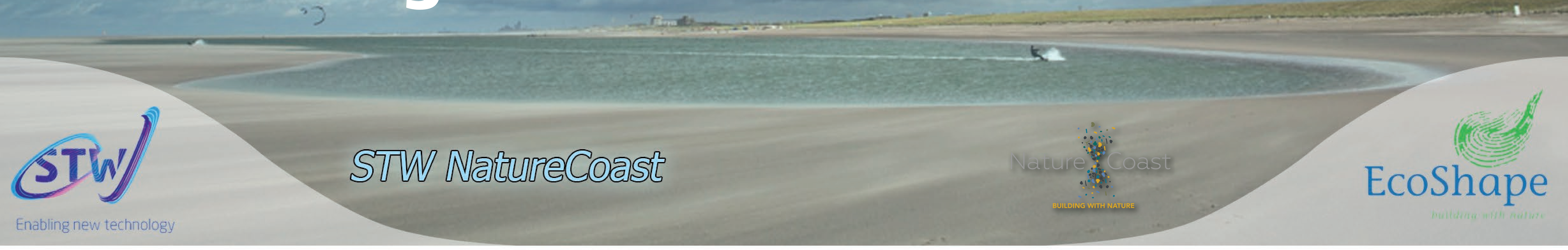
How to measure morphologic evolution near a mega-nourishment?



Inter-comparison of four survey techniques

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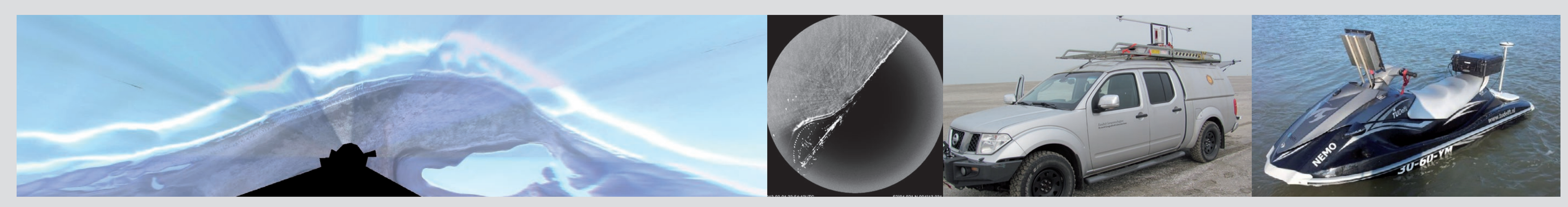
Introduction

The Sand Motor, a large-scale nourishment near Ter Heijde, is evolving rapidly on small and large spatial and temporal scales. This complicates monitoring strongly as there is no single monitoring technique that can do it all. Here the aims are to combine smartly three remote sensing techniques with in situ bathymetric measurements and to evaluate their applicability in a rapidly changing environment. We focus on spatially extensive Digital Elevation Models (DEMs) and aggregated morphologic parameters.

Survey techniques

The four survey techniques are (1) optical imaging with the Argus video system, (2) microwave imaging by X-band radar, (3) Mobile Terrestrial Laser Scanning (MTLS) and (4) echo-sounding considered as *in-situ*.



Morphologic evolution from DEMs

Depth inversion on *I(x,y,t)*
ARGUS: cBathy [1]

- Cross correlations between pixel time series: $Cij(f) = \langle \hat{G}(x_i,y_i,f) * \hat{G}(x_j,y_j,f)\rangle$
- Analysis cube (80x40m x 1024s), Hanning weighted:
  $k \rightarrow$ non-linear fit of observed (EOF on C_{ij}) with modelled slope phase ramp
  $h \rightarrow$ non-linear fit $\sigma^2 = gk \tanh kh$
- Running average (Kalman) filter with process error $Q \sim H_{sig}$, ε_h

X-band: SeaDarQ
$k \rightarrow$ Analysis cube (960x960m x 96s) 3D FFT *on I(x,y,t)*

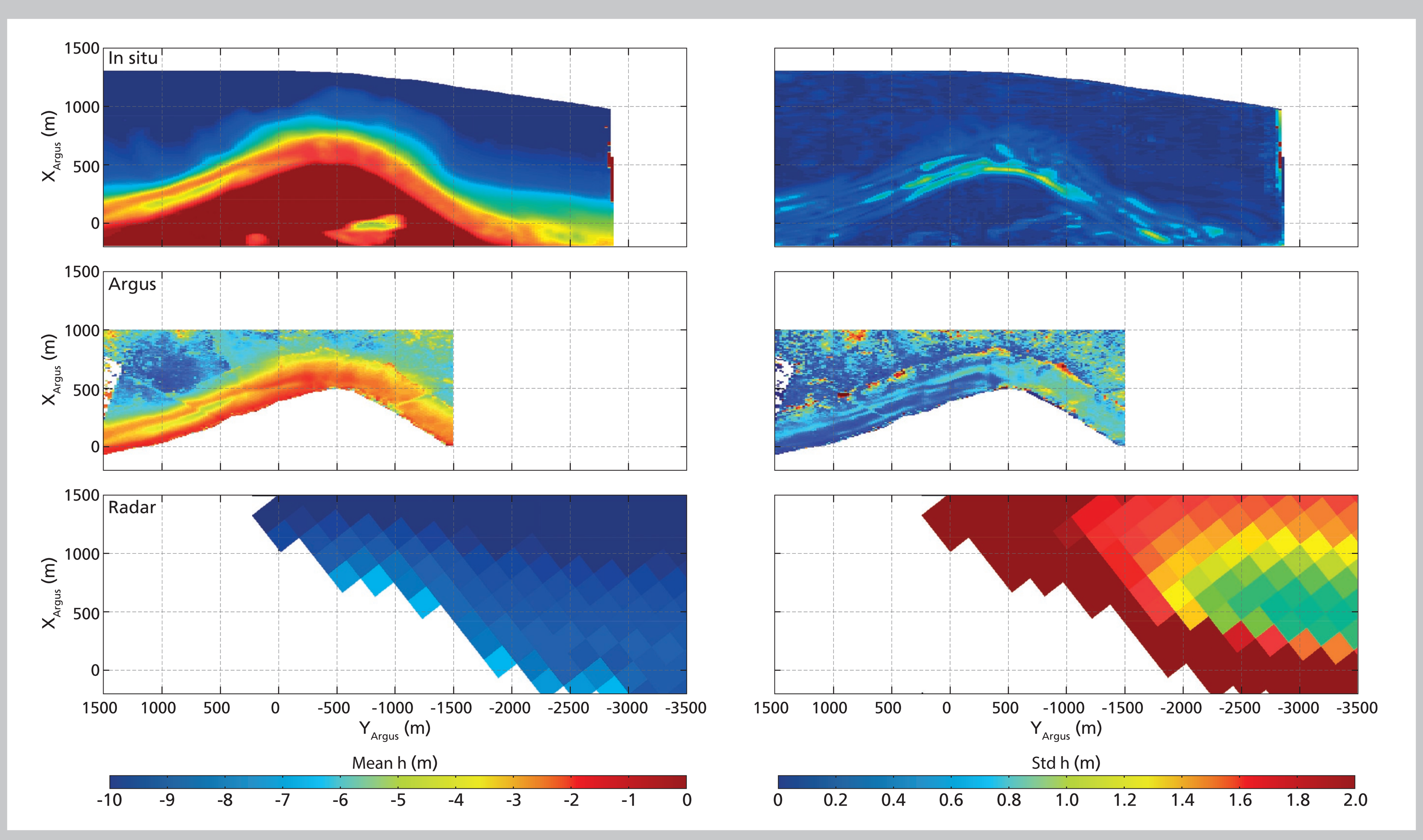


Figure 1. A time average (left) and standard deviations (right) of DEMs show cBathy (Argus) can be used to monitor evolution of morphologic features on the scale of sand bars. SeaDarQ (X-band) returns poor estimates in the inner nearshore due to large analysis tiles.

Morphologic evolution from aggregated parameters

Cross-shore sandbar position:

- Argus: location white banded outer breaker line from 10min time-averaged images
- *In situ*: location bar crest

Cross-shore shoreline and -1m position:

- Argus: location inner breaker line converted to -1m contour, required shoreline elevation from wave setup and tide [2].
- *In situ*: location -1m contour

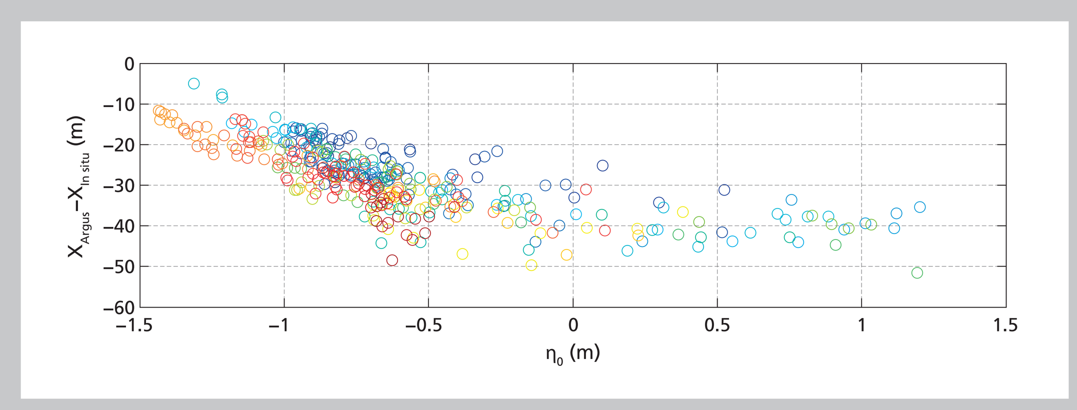


Figure 2. Argus derived sandbar position depends strongly on the tide, shown for March 2013.

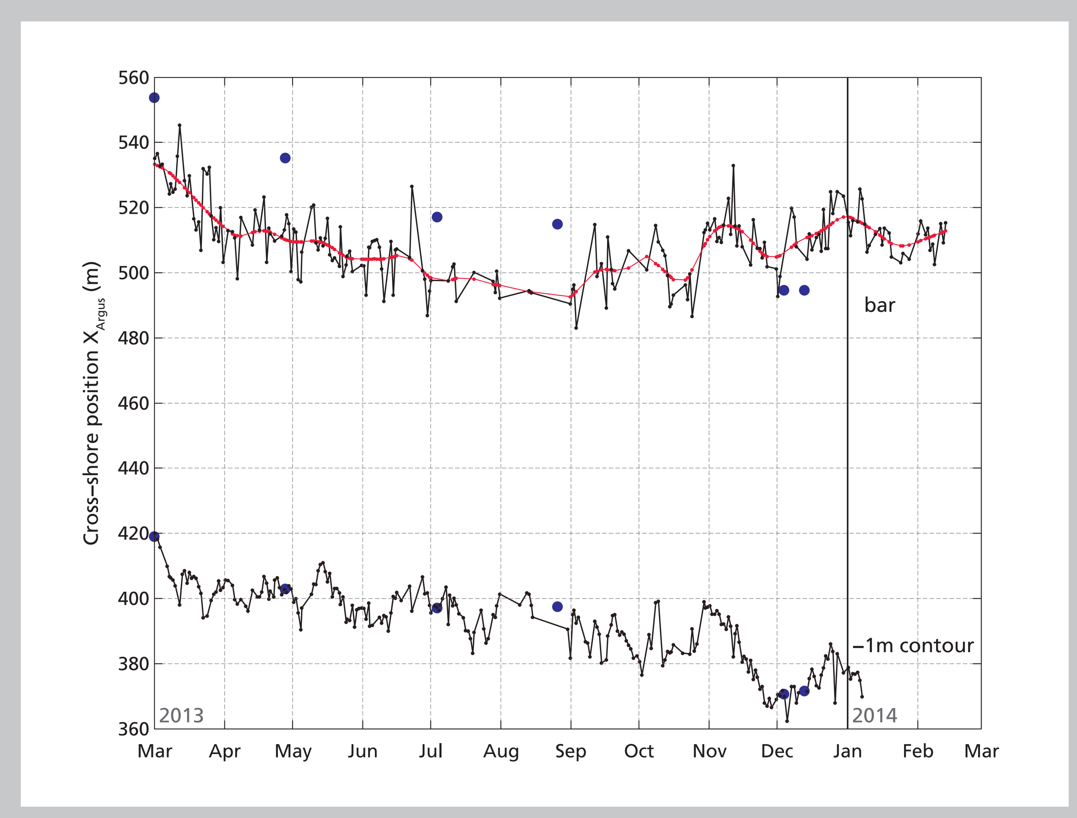


Figure 3. A pre-selection of low tide images removed the tide induced bi-diurnal variability in sandbar position. A Hanning filter with a width of 14.77 days removed variability due to the spring and neap cycle.

Conclusions

- Morphodynamics of spatially extensive study sites, on small to large spatial and temporal scales, can be monitored by combining less accurate frequent remote sensing derived DEMs with a traditional monitoring technique.
- Video derived DEMs improve temporal resolution over *in situ* surveys and morphologic change in the surf zone of O(50m) can be followed on timescales of days to weeks.
- Cross-shore sandbar and shoreline position is an indicator for morphologic evolution on seasonal timescales and can be obtained from Argus imagery.

Perspective

- Densely spaced topography:
  Intertidal-upper shoreface, northward side Sand Motor (cBathy on X-band data)
  Intertidal-dunes (MTLS)
- Volumetric change as additional aggregated parameter
- Non-linear celerity predictor in cBathy to improve *h* estimates in shallow water

References

1 Holman, R., Plant., N., Holland, T. (2013). cBathy: A robust algorithm for estimating nearshore bathymetry. Journal of Geophysical Research: Oceans 118:1-15.

2 Aarninkhof, S.G.J., Turner, I.L., Dronkers., T.D.T., Caljouw, M., Nipius, L. (2003). A video-based technique for mapping intertidal beach bathymetry. Coastal Engineering 49: 275-289.

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