ON THE ORIGIN OF SELF-ORGANIZED KM-SCALE SANDY SHORELINE UNDULATIONS

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Sandy shorelines often exhibit undulations in planview with an alongshore wavelength in the range $1-15$ km that are linked to similar undulations in the bathymetry and that are also known as shoreline sand waves. *Ashton et al.* (2001) showed that they can emerge from self-organization through a positive morphodynamic feedback between the morphology and the wave field if the wave incidence angle (between wave fronts and shoreline) is large enough. We here review the physics behind the feedback mechanisms providing new insight into it and we test the self-organization hypothesis against global data analysis.

Waves propagating onshore with an angle experience refraction and shoaling and eventually break. They drive an alongshore current carrying sediments and the sediment flux is an increasing function of wave height and wave angle at breaking relative to the local shoreline. The undulating bathymetry causes alongshore gradients in wave energy and wave angle and thereby in sediment flux. If sediment flux converges near the undulation crest, sediment deposition occurs there so that the undulation grows. We identify four feedback sources: 1) more wave refraction at the downdrift flank of the sand wave (wave-angle mechanism), 2) more refractive wave energy spreading at the downdrift flank (wave-energy mechanism), 3) changes in relative wave angle due to changes in shoreline orientation (undulation shape mechanism) and 4) wave energy focusing by the capes (wave-focusing mechanism). The undulation shape and the wave-focusing mechanisms provide a negative feedback mechanism while the wave-angle wave-energy mechanism mechanisms induces positive feedback. According to a linear stability model (*Falqués and Calvete*, 2005), which mechanism is dominant and whether sand waves form or not depend on wave characteristics, on the cross-shore bathymetric profile and on the closure depth, D_c (maximum offshore reach of the bathymetric undulations). A total length of 8800 km of sandy (also gravel) coastal stretches has been analyzed to find shoreline undulations in the range $1-15$ km wavelength and to test model results. We find a 61% of shoreline stretches exhibiting undulations. Data analysis also reveals that undulations are more frequent for steep surf zone slopes, large incidence angles, large D_c and shallow shorefaces. Although large angles tend to favour sand wave development, both data and modeling show there is not a single critical angle θ_c above which shoreline undulations develop. The parameter having the largest influence on θ_c is the mean surf zone slope. The present work tends to confirm that the four feedback mechanisms described above hold in nature and govern shoreline undulation dynamics at such length scales.

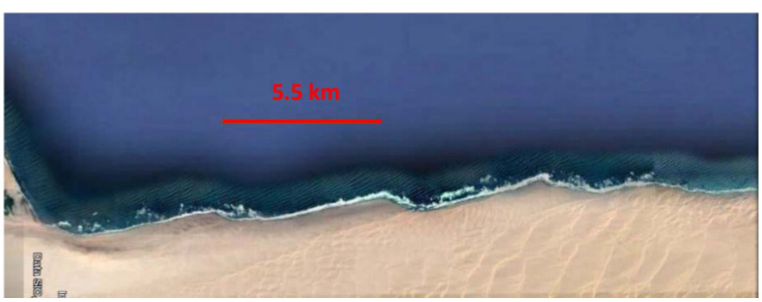

Figure 1. km-scale shoreline sand waves at Namibia coast (from Google Earth).

References

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