Empirical modeling of beach evolution: Implementation of coupled cross-shore and longshore approaches

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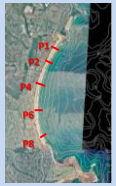
Introduction

- The overall objectif is to improve hindcast and predictive modeling of shoreline evolution with simple modeling approaches using high spatial and temporal resolution observations of coastal morphology and hydrodynamics.
- This study extends an existing cross-shore empirical equilibrium beach change model to incorporate alongshore processes.
- First, a hybrid model that sums the independent contributions of the cross-shore and alongshore models is implemented and tested at Narrabeen-Collaroy Beach.
- Work in progress includes developing and validating a fully coupled approach and then applying it to several study sites worldwide with varying characteristics to examine the generalization of the model parameters.

Field Sites

Vougot Beach:
- Located in Northern Brittany, France
- Macrotidal environment, mean Hs=2.2m
- Low-tide terrace sandy beach
- 6 – 12 years of monthly morphological observations along 6 cross-shore profiles
- Rocky platform outcrop and tombolo generate complex hydrodynamics

Narrabeen-Collaroy Beach:
- Located in Eastern Australia
- Microtidal environment, mean Hs=1.6m
- Dissipative (north) to reflective (south) beach
- 40+ years of monthly morphological observations along 5 cross-shore profiles
- Rocky southern cape and predominantly southern waves generate complex wave refraction in the bay



Methods

Implementation of a hybrid model combining:

- Cross-shore processes simulated with the equilibrium empirical shoreline model of Yates et al. (2009) & Lemos et al. (2018)

$$\frac{dS}{dt} = C^{\pm}\sqrt{E}.\Delta E(S) \quad with \quad \Delta E(S) = E - E_{eq}(S)$$

where: S, cross-shore position of the considered altitude (m),
E, wave energy (normalized, m²)
E_{eq}, equilibrium wave energy as a function of S: $E_{eq} = aS + b$
ΔE, energy disequilibrium
$C^{\pm}$, accretion ($C^{+}$for $\Delta E > 0$) and erosion ($C^{-}$for $\Delta E < 0$) coefficients

Free parameters : a, b , C+ and C- calibrated with observational data

Example of S(t) at Vougot Beach, Profile 5, for Z=1.0m NGF

- Longshore processes simulated using a one-line model approach

$$\frac{\partial S}{\partial t} = -\frac{1}{Dc}\frac{\partial Q}{\partial x}$$

Q = longshore flux (CERC formula, USACE, 1984)
Dc = closure depth, breaking wave conditions calculated following (Larson et al., 2010)
∂x = distance between transect

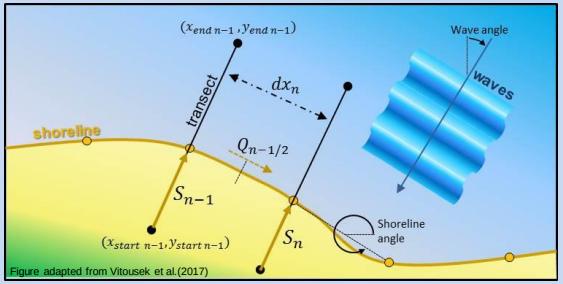
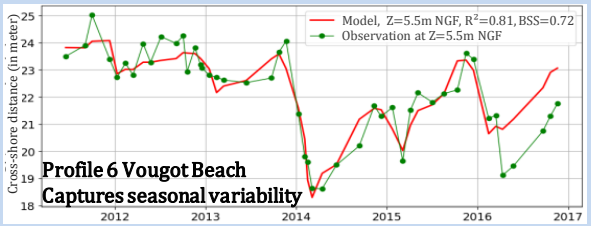
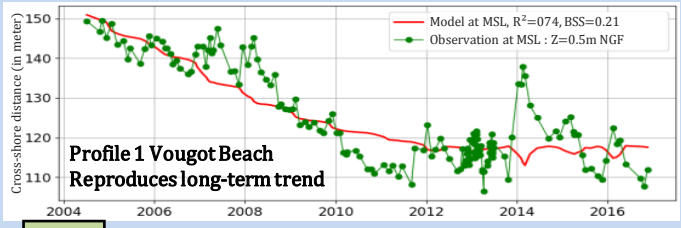


Figure adapted from Vitousek et al.(2017)

Results and Discussion

Cross-shore only model (application at Vougot Beach)





Hybrid (cross-shore + longshore) model (test at Narrabeen Beach)

Observation data from : Turner, I., Harley, M., Short, A. *et al.* A multi-decade dataset of monthly beach profile surveys and inshore wave forcing at Narrabeen, Australia. *Sci Data* **3**, 160024 (2016). https://doi.org/10.1038/sdata.2016.24

Conclusions and perspectives

- Implementation of the fully coupled model:
  1) Longshore shoreline changes impact the energy equilibrium equation following Jaramillo et al. (2019)
  2) Cross-shore changes impact the shoreline angle in the alongshore transport model
- Investigation the cross-shore distribution of the longshore sediment flux
- Application to a variety of study sites with different characteristics to evaluate the generalization of the the model coefficients

Reference

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