

Transport & morphodynamics

Needs and prospects for development of French in situ measurement networks in relation to numerical modeling

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INFRASTRUCTURE DE RECHERCHE
LITTORALE & CÔTIÈRE

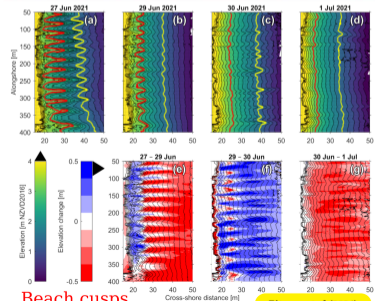


sept. 25-26th, 2024 (Plouzané, France) – 9''

TRANSPORT & BOTTOM MORPHOLOGIES OCCUR EVERYWHERE

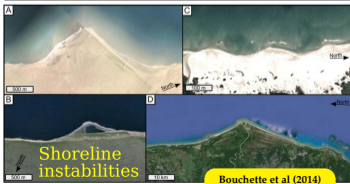
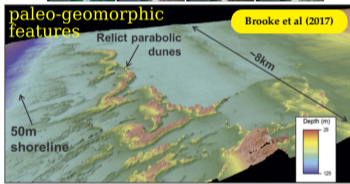
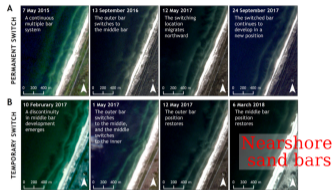


FROM THE DEEP OCEAN TO THE SHORELINE



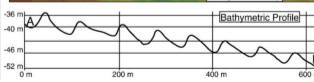
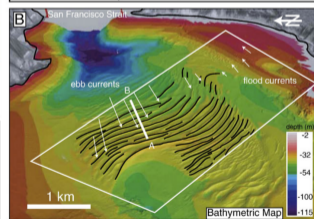
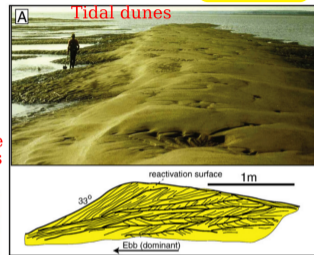
Pitman et al (2024)

Janusaite et al (2021)



Bouchette et al (2014)

Olariu et al (2012)



TRANSPORT & MORPHODYNAMICS IN-SITU CHARACTERIZATION

BRIEF OVERVIEW OF THE CURRENT SITUATION

Théodolites, tacheo & GNSS



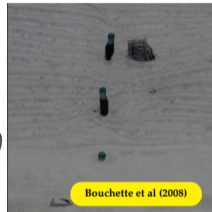
Terrestrial 2DV/3D scanner



Drone HR Scanner

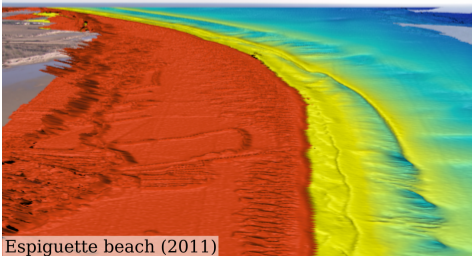


Laser

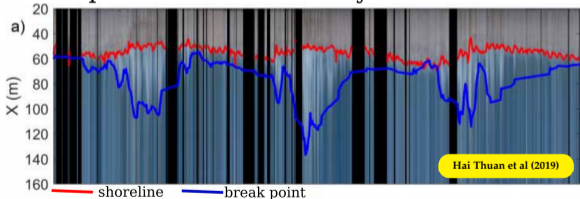


LIDAR surveys

Bouchette et al (2011)



Break point and shoreline by video inversion



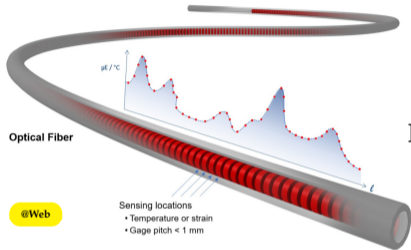
+ topo-bathymetry, sediment traps,
optical back-scattering methods

TRANSPORT & MORPHODYNAMICS IN-SITU CHARACTERIZATION

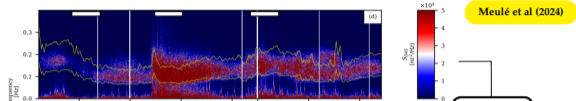


EXAMPLE OF EXPLORATORY METHOD: DAS FOR NEARSHORE WAVE/TRANSPORT RECONSTRUCTION

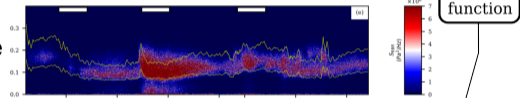
Collect strain along a cable



In-situ strain signal



In-situ pressure signal



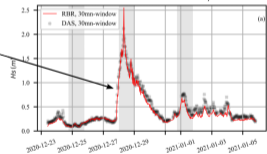
Transfer function

Transform strain (or strain rate) into many meaningful physical processes

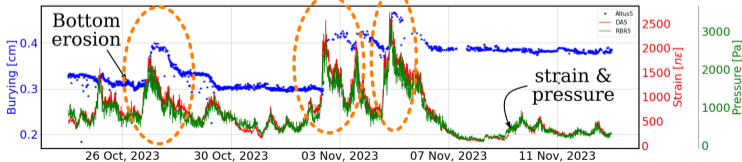


- Temperature
- Waves in the ocean
- Nearshore wave spectrum
- Bottom morphodynamics ?

Reconstruction of nearshore H_S from DAS signal

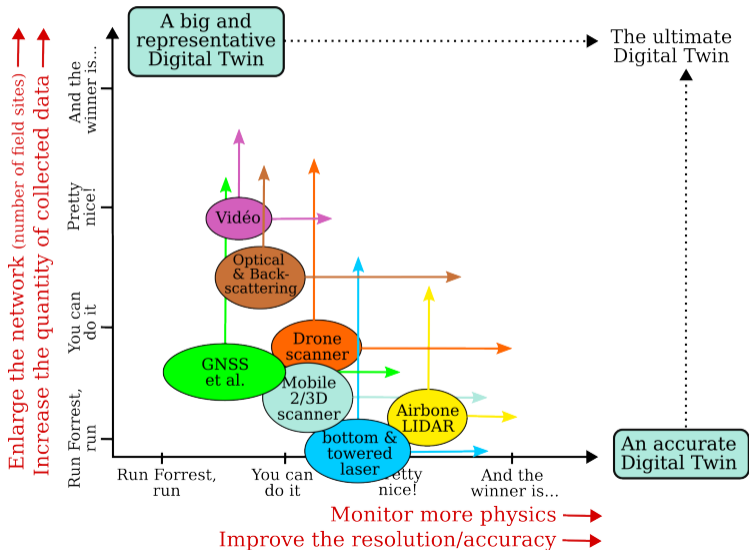


Mohammedi, unpublished PhD



TRANSPORT & MORPHODYNAMICS IN-SITU CHARACTERIZATION

WHERE DO WE STAND ?



What DT ?

- operational forecasting, climate study, french coastal management strategy → **Big DT**
- Understanding Earth, R&D, long-term research → **Accurate DT**

THE NUMERICAL MODELING POINT OF VIEW

FUNDAMENTAL QUANTITIES TO BE MEASURED AS PRECISELY AND AS OFTEN AS POSSIBLE

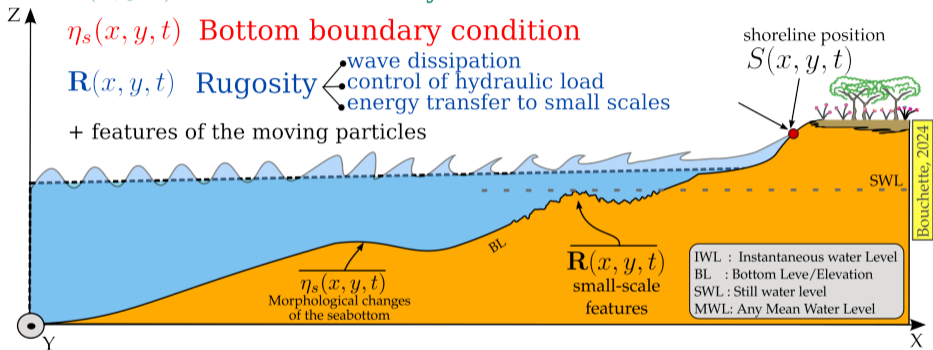
$S(x, y, t)$ Lateral boundary condition

$\eta_s(x, y, t)$ Bottom boundary condition

$R(x, y, t)$ Rugosity

- wave dissipation
- control of hydraulic load
- energy transfer to small scales

+ features of the moving particles



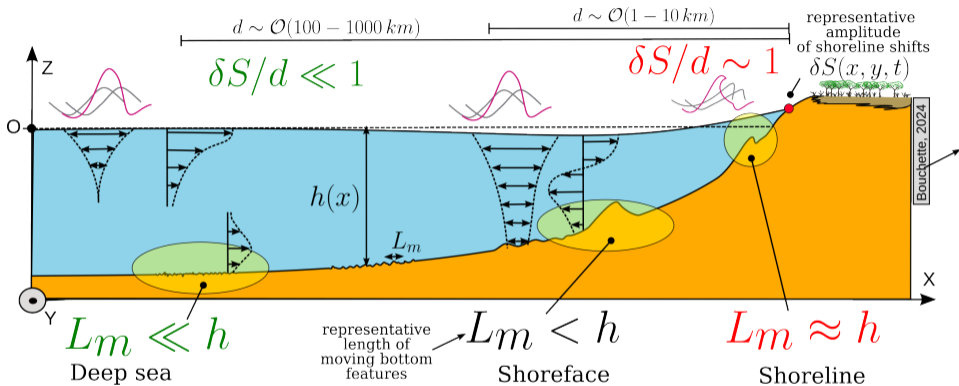
Two bottlenecks strongly depending on time scale considered:

Where do you set the limit between η_s and R ?

How do you define the shoreline numerically w.r.t observations ?

THE NUMERICAL MODELING POINT OF VIEW

DEEP SEA *vs* SHOREFACE: K_m/h AND $\delta S/d$ PARAMETERS



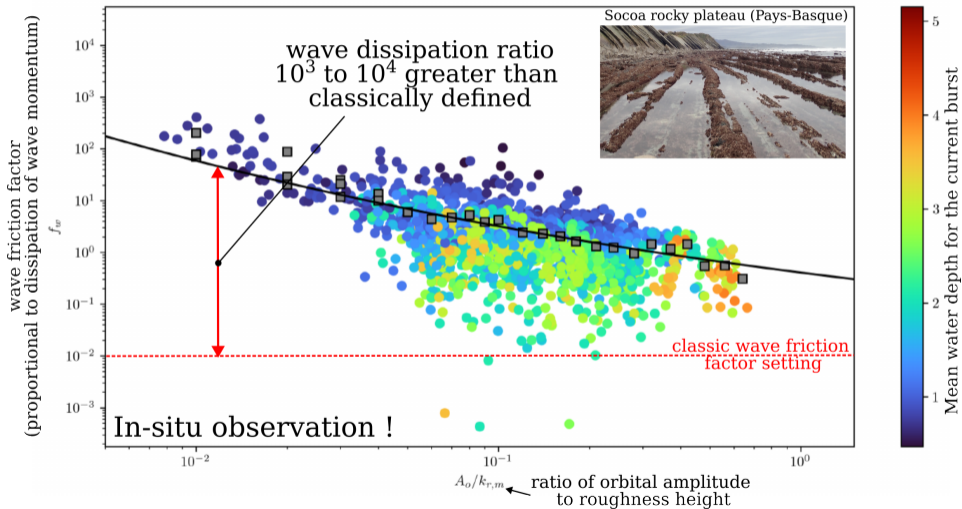
First advice

The morphological feedback loop « dominates » **coastal** wave/current/transport
 \Rightarrow **must measure both hydraulics and morphodynamics with equal diligence**

THE NUMERICAL MODELING POINT OF VIEW

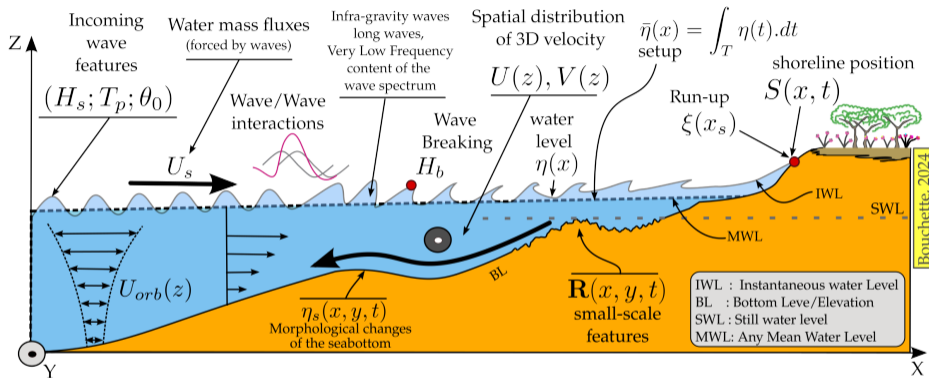
AN ILLUSTRATIVE EXAMPLE

Dealbera (Phd 2023, @UPPA)



THE NUMERICAL MODELING POINT OF VIEW

DETERMINING DOMINANT AND SUBORDINATE CONTROL PARAMETERS



Second advice:

quantifying **uncertainty** (from measurement and from modeling) \rightarrow sorting

EXPLORATORY PROBLEMS IN NUMERICAL MORPHODYNAMICS



ONE EXAMPLE: NON-LOCAL FOWLER TRANSPORT EQUATION

A very old statement:

Local sediment transport law are based on very heavy/restrictive parameterisations



Lack of field data drives poor control of sediment fluxes

May we explore alternative **theoretical** point of view ?

The non-local FOWLER equation :
quantifying the creation and motion of hydraulic dunes

$$\begin{cases} \partial_t u(t, x) + \partial_x \left(\frac{u^2}{2} \right) (t, x) + \mathcal{I}[u(t, \cdot)](x) - \partial_x^2 u(t, x) = 0, & x \in \mathbf{R}, t > 0, \\ u(0, x) = u_0(x), & x \in \mathbf{R}, \end{cases}$$

where $u = u(t, x)$ represents the dune height and \mathcal{I} is a nonlocal operator defined as follows: for any Schwartz function $\varphi \in \mathcal{S}(\mathbf{R})$ and any $x \in \mathbf{R}$,

$$\mathcal{I}[\varphi](x) := \int_0^{+\infty} |\xi|^{-\frac{1}{3}} \varphi''(x - \xi) d\xi.$$

The nonlocal term \mathcal{I} is anti-diffusive.

$$\mathcal{F}(\mathcal{I}[\varphi])(\xi) = -4\pi^2 \Gamma\left(\frac{2}{3}\right) \left(\frac{1}{2} - i \operatorname{sgn}(\xi) \frac{\sqrt{3}}{2}\right) |\xi|^{4/3}$$

To explore the validity of such an exploratory formalism, robust field data are necessary

Theoretical developments
ALSO need field data

HIGHLIGHTS



- The monitoring of coastal morphologies currently focuses on the mid- to long term changes. **The shortest time scales must be considered also simply because it is now understood that the processes that remain to be described on the wave-IG-tide scales strongly control longer term trends;**
- Big Digital Twins (IA,...) are ONE future of the research. But for transport and morphodynamics in the shoreface, we still need **theoretical works on hydro-morphodynamics** ⇒ **PEPR MathVivES, Hydraumath, Complexflow, Climath**
- We need to provide in-situ observations with **uncertainty**;
- In the shoreface, hydraulics and morphodynamics must be monitored with the same effort and in the same time.
- we need sites where collective efforts are shared over the long term to obtain high-frequency, multi physics data that includes the effects of global changes.
⇒ **We need the concept of IN-SITU EXPERIMENTAL CENTER**

Thank you.

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