On the Evolution of Beach Shoreline According to Equilibrium Profile

Pau Luque, Marta Marcos, Lluís Gómez-Pujol and Alejandro Orfila

(EGU22, 25/05/2022, Wien)

CSIC

INTRODUCTION

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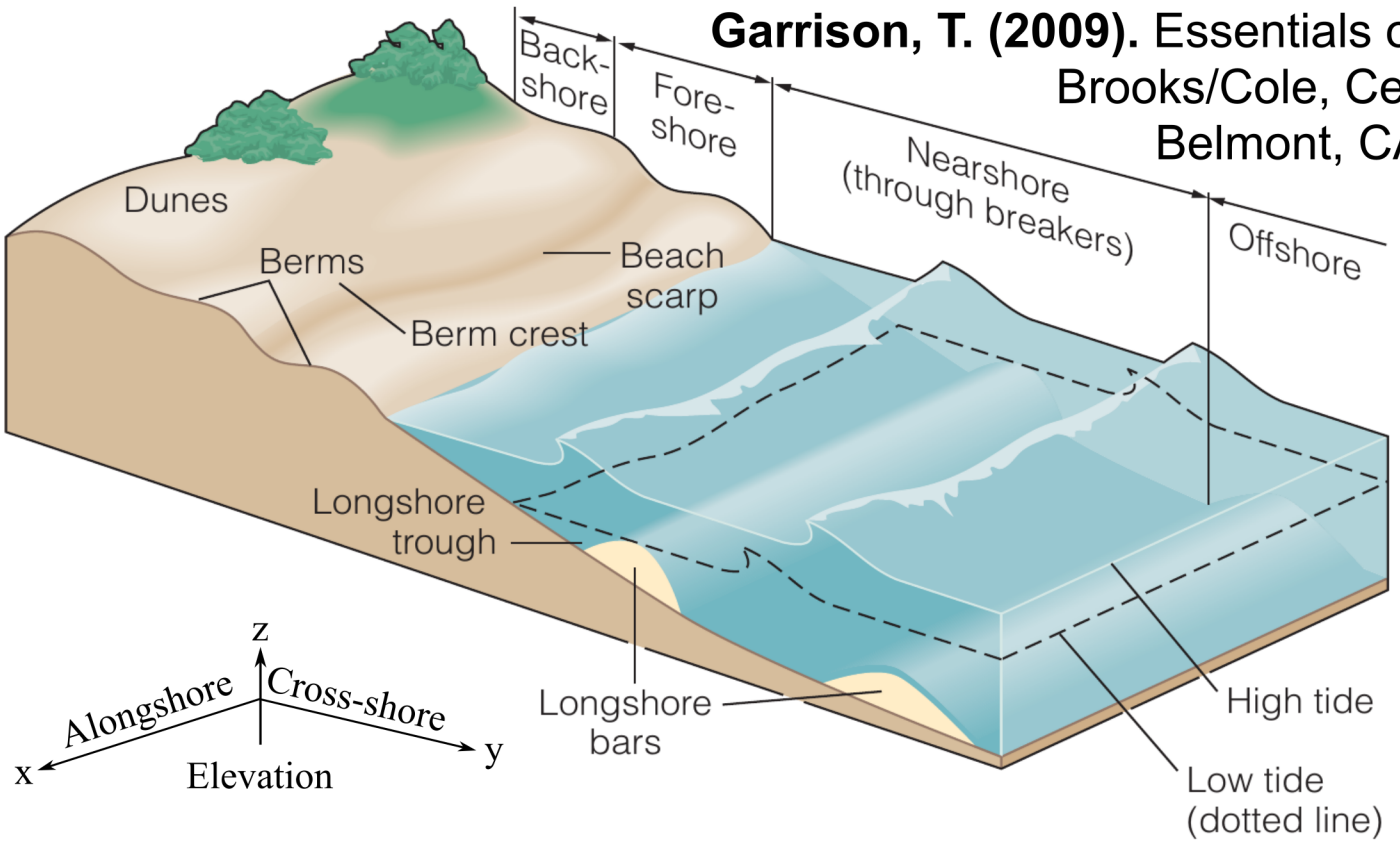

Garrison, T. (2009). Essentials of oceanography. Brooks/Cole, Cengage Learning, Belmont, CA, 5th ed edition.

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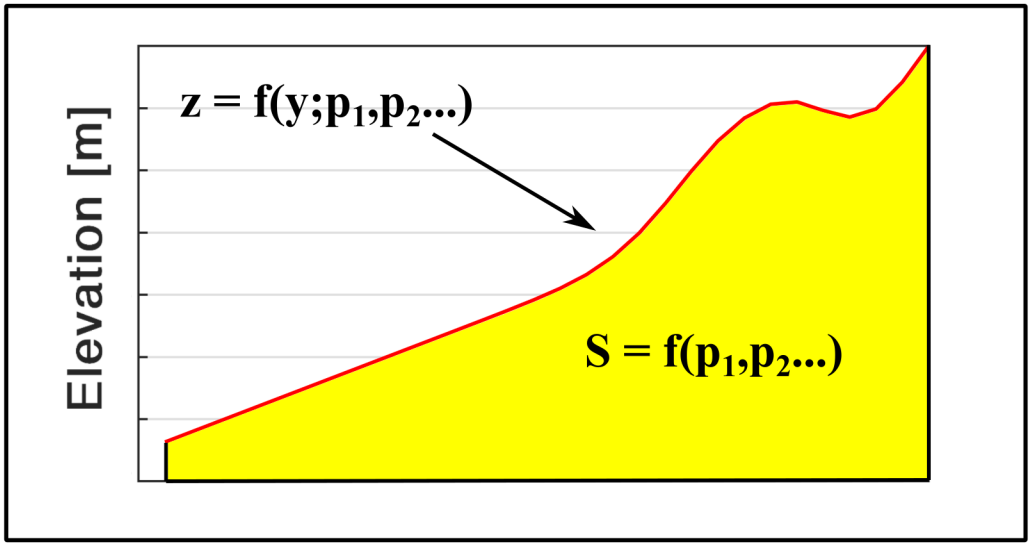
EQUILIBRIUM BEACH PROFILE



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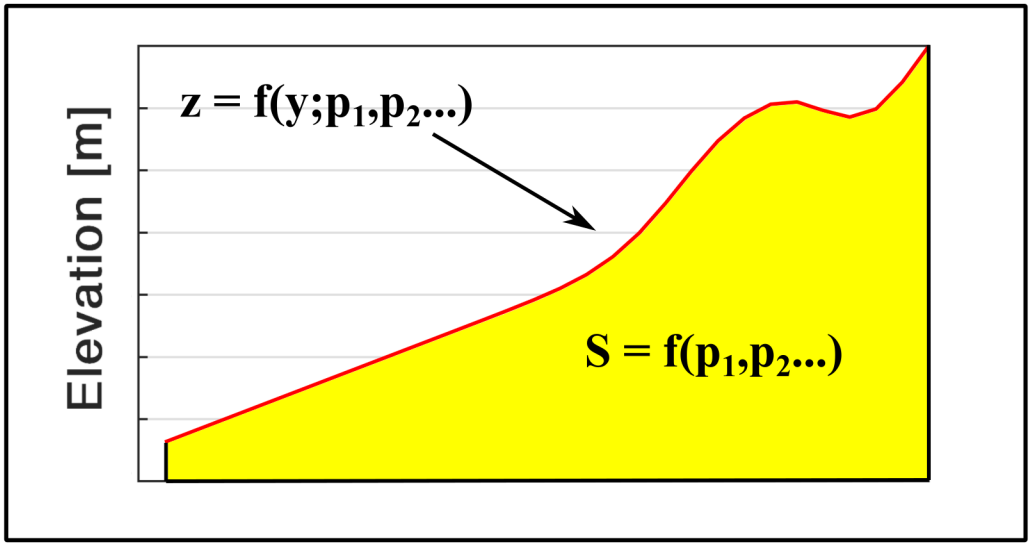

$$dS = 0$$

$$dp_1 = \frac{\partial S/\partial p_2}{\partial S/\partial p_1} dp_2 + \dots$$

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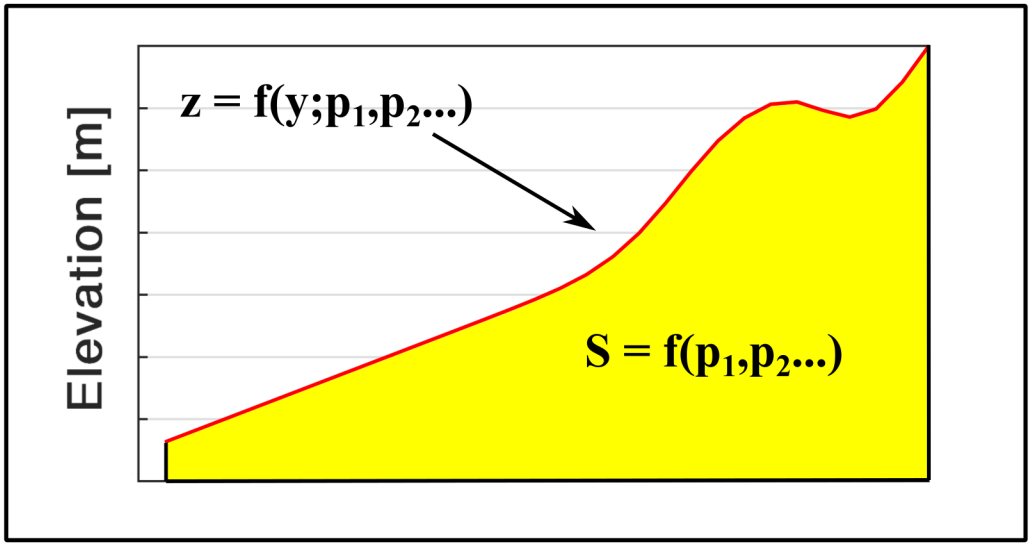


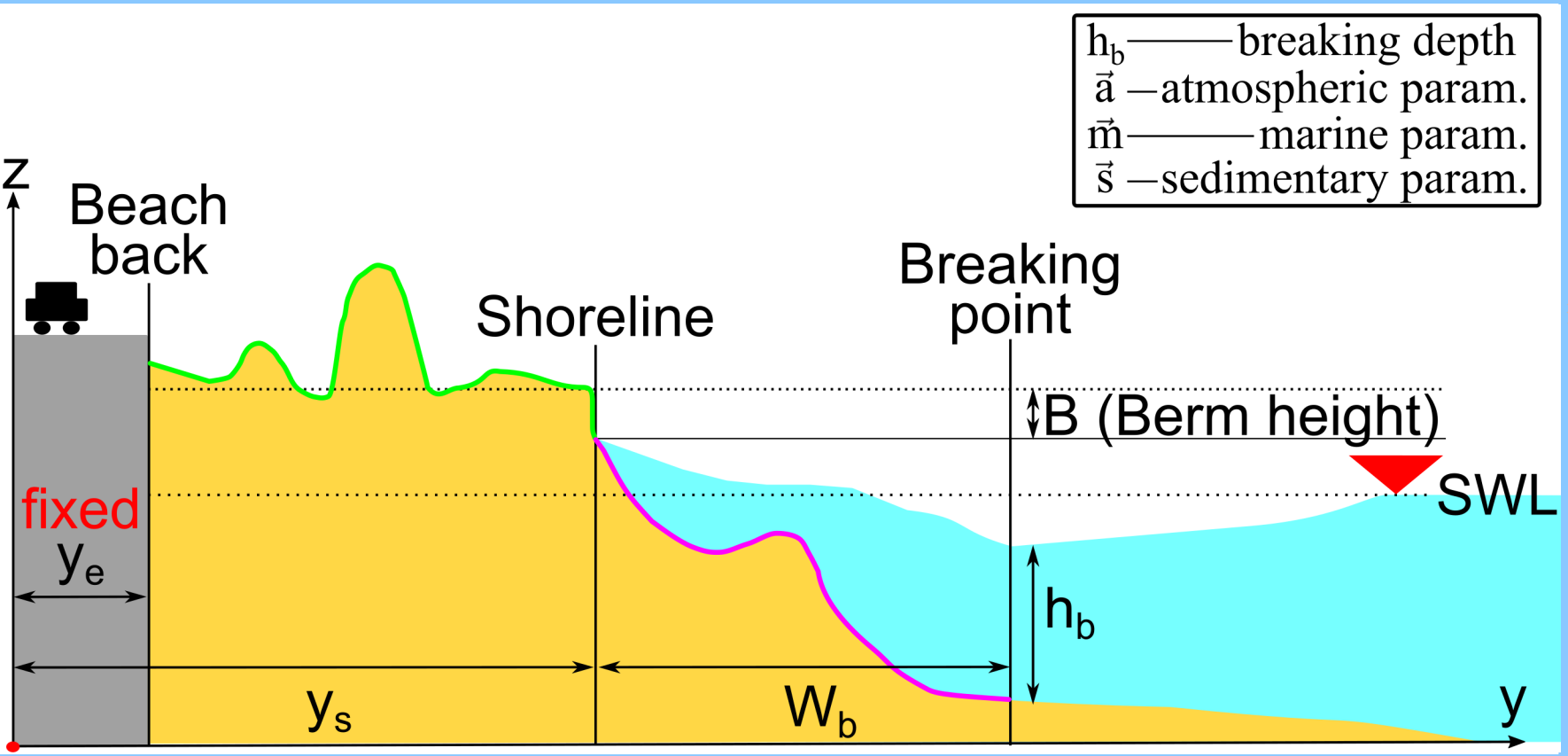
OBJECTIVE:
Sea Level Rise
↓
Shoreline Evolution

$$dS = 0$$

$$dp_1 = \frac{\partial S/\partial p_2}{\partial S/\partial p_1} dp_2 + \dots$$

METHODS

BEACH MODEL


h_b —— breaking depth
$\vec{a}$ — atmospheric param.
$\vec{m}$ —— marine param.
$\vec{s}$ — sedimentary param.
z
Beach back
Shoreline
Breaking point
B (Berm height)
SWL
fixed
y_e
h_b
y_s
W_b
y

BEACH MODEL

$$z = f_{dry}(y; \vec{a}, \vec{m}, \vec{s}, y_s, y_e, SWL)$$

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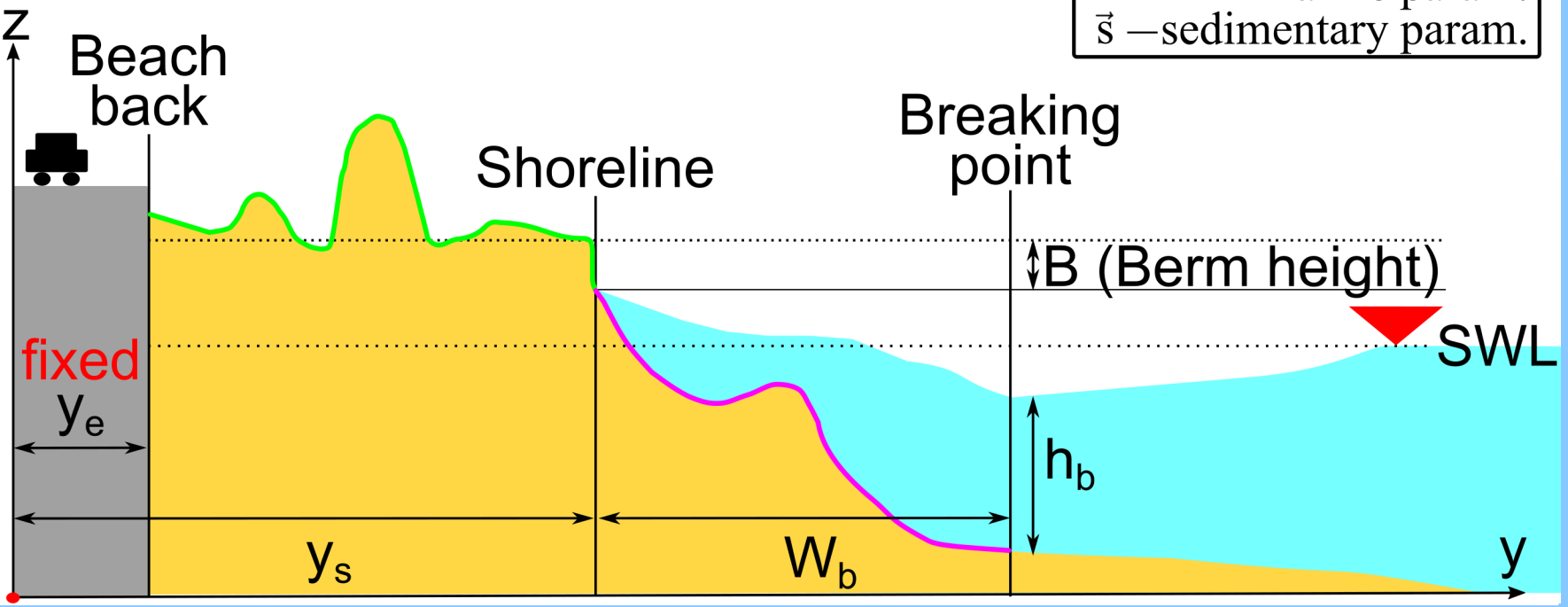

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BEACH MODEL

SWL = Mean Sea Level + Astronomical Tides + Storm Surge

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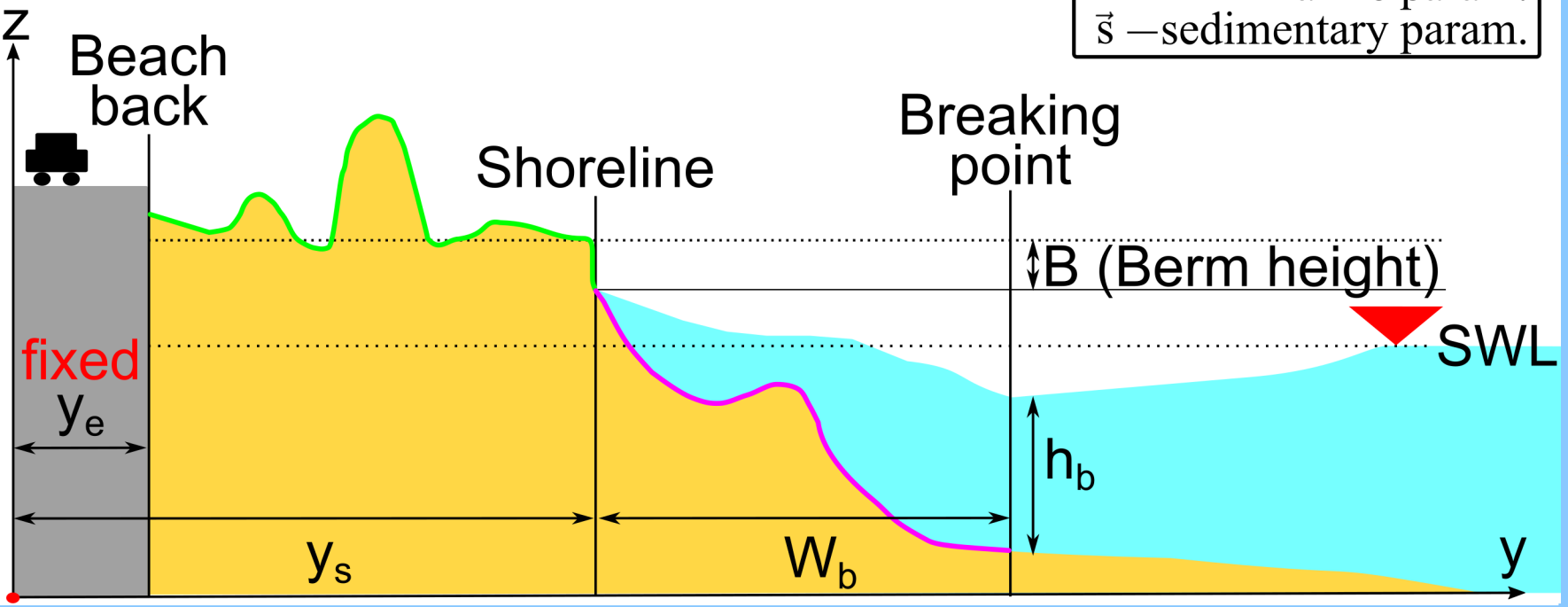

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$$z = f_{dry}(y; \vec{a}, \vec{m}, \vec{s}, y_s, y_e, SWL)$$

$$z = SWL + \bar{\zeta}(y - y_s; h_b, \vec{m}, \vec{s}) - h(y - y_s; \vec{m}, \vec{s})$$

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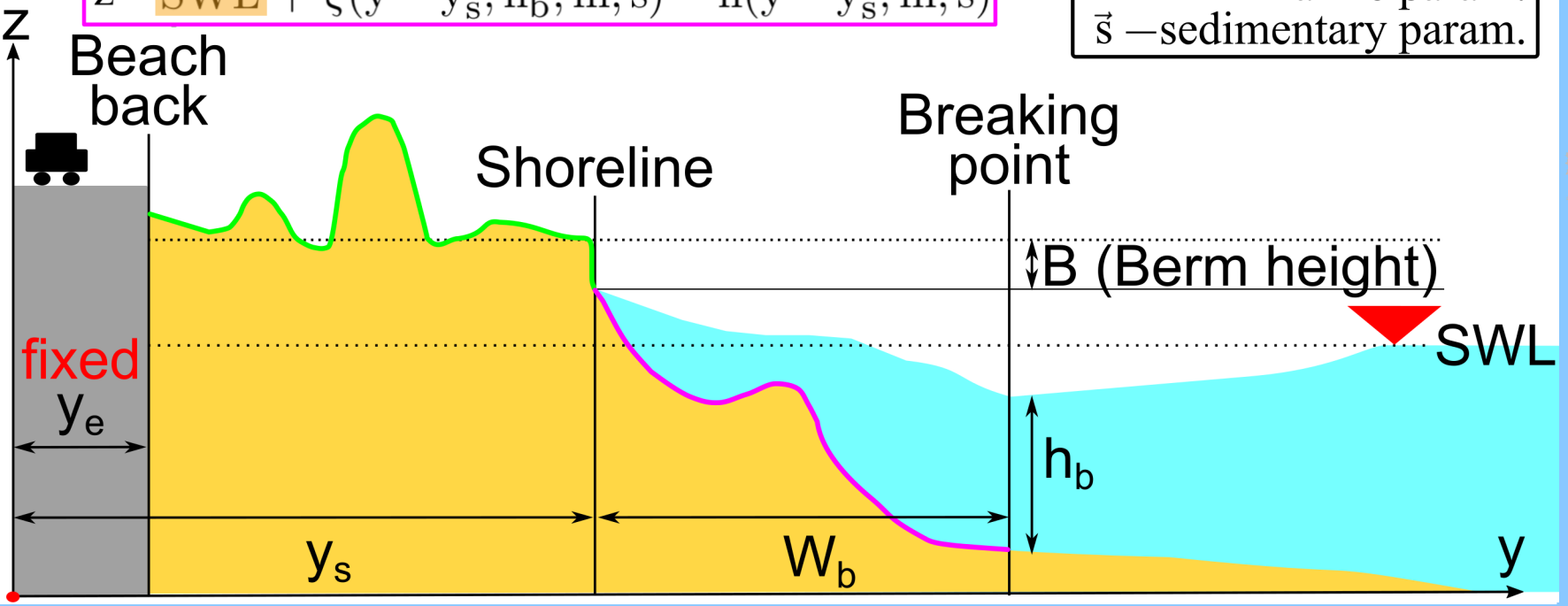

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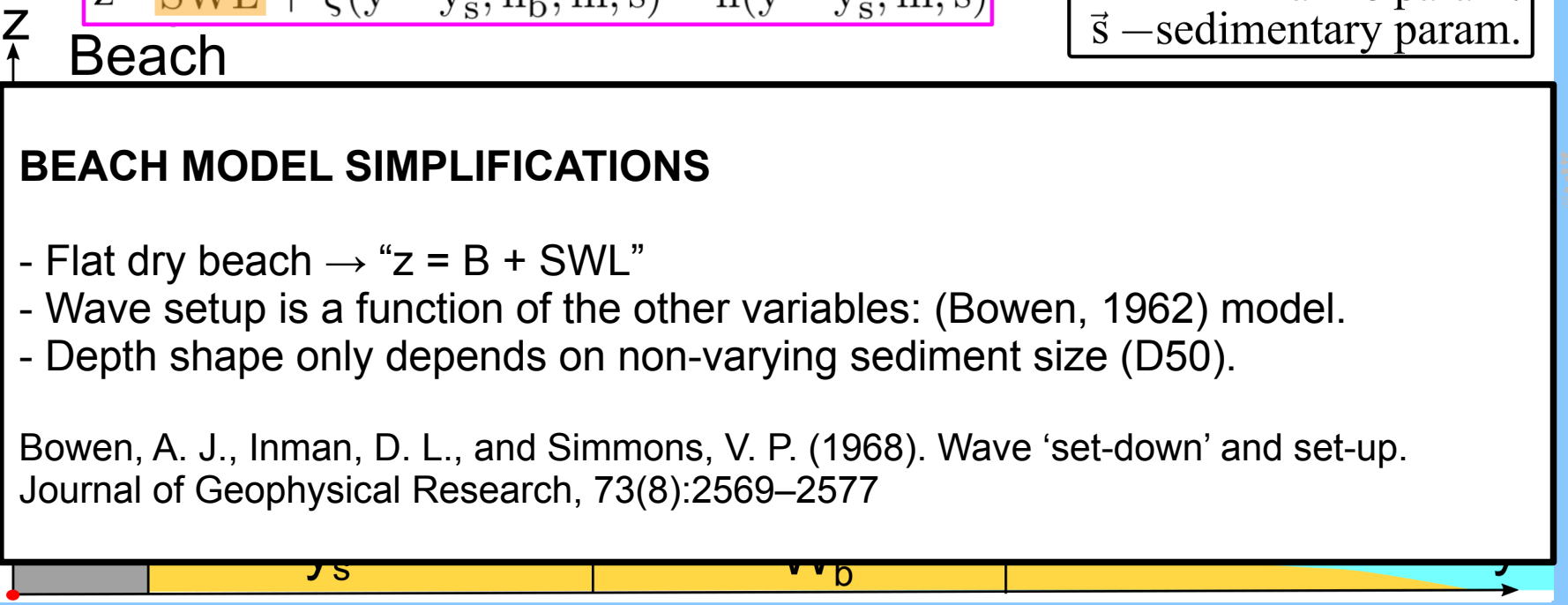

BEACH MODEL SIMPLIFICATIONS

- Flat dry beach → "z = B + SWL"
- Wave setup is a function of the other variables: (Bowen, 1962) model.
- Depth shape only depends on non-varying sediment size (D50).

Bowen, A. J., Inman, D. L., and Simmons, V. P. (1968). Wave 'set-down' and set-up. Journal of Geophysical Research, 73(8):2569–2577

EQUATIONS

Present Approach

$$-\frac{W_b + (y_s - y_e)}{B + \left(1 + \frac{\gamma^2}{16}\right) \cdot h_b} \cdot dSWL - \frac{\left(\frac{J}{1-J} - \frac{\gamma^2}{16}\right) \cdot W_b}{B + \left(1 + \frac{\gamma^2}{16}\right) \cdot h_b} \cdot dh_b$$

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Dean, R. G. (1991). Equilibrium beach profiles: Characteristics and applications. Journal of Coastal Research, 7(1):53–84.

Bruun, P. (1962). Sea-level rise as a cause of shore erosion. 88:117–130.

$$-\frac{W_*}{B + h_*} \cdot \Delta MSL$$

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$$\int_{t_0}^{t} k \cdot e^{-k \cdot (t - t_0)} \cdot -\frac{W_b}{B + h_b} \left[\Delta SWL + \left(\frac{2/5 \cdot J}{1 - J} - \frac{\gamma^2}{16} \right) \cdot h_b \right] dt$$

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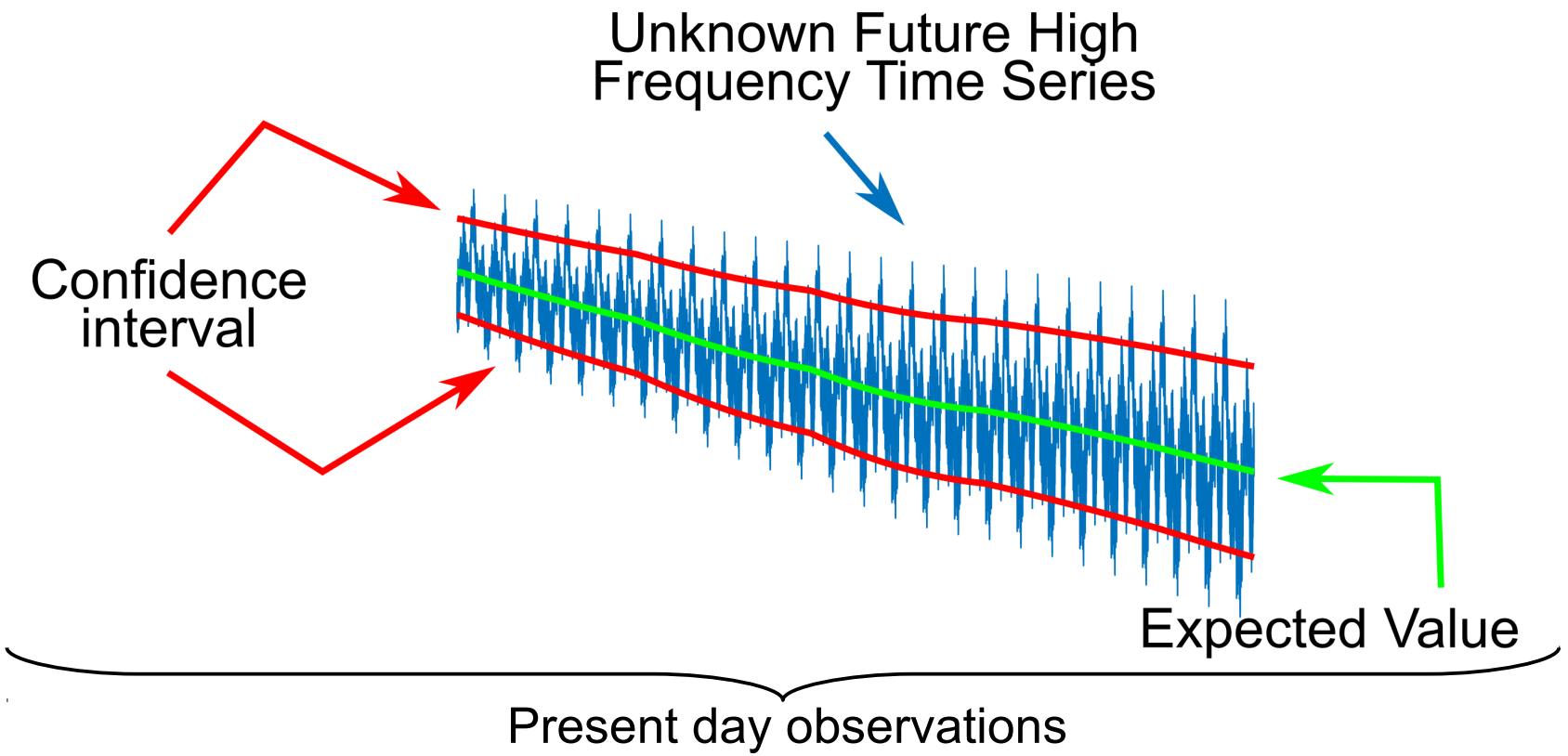
INTEGRATION APPROACH



RESULTS

SOLUTIONS

Present Approach

$$-(\text{correction} \pm \text{spread}) \cdot \rho \cdot \left[\frac{\frac{dMSL}{dt}(t)}{\theta(t)} - \frac{\frac{dMSL}{dt}(t_0)}{\theta(t_0)} - \frac{\frac{d^2MSL}{dt^2}(t)}{\theta^2(t)} + \frac{\frac{d^2MSL}{dt^2}(t_0)}{\theta^2(t_0)} \right]$$

$$-\alpha \cdot [MSL(t) - MSL(t_0)] + \frac{\alpha}{k} \cdot \left[\frac{dMSL}{dt}(t) - \frac{dMSL}{dt}(t_0) \right] - \frac{\alpha}{k^2} \cdot \left[\frac{d^2MSL}{dt^2}(t) - \frac{d^2MSL}{dt^2}(t_0) \right]$$

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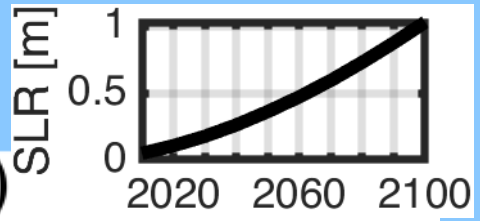
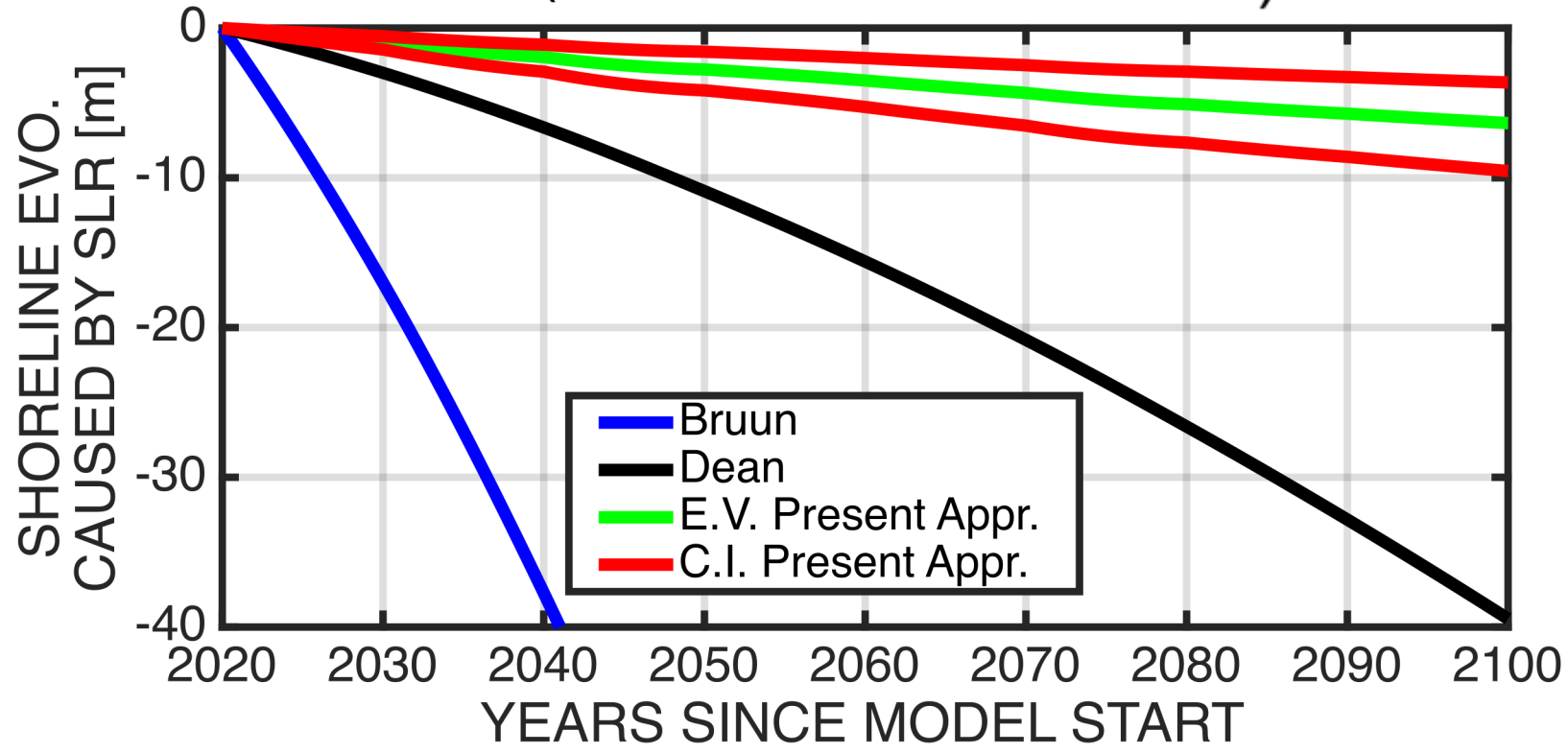
$$-\alpha_* \cdot [MSL(t) - MSL(t_0)]$$

COMPARISON



SON BOU BEACH (MENORCA, WEST. MED.)



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CONCLUSIONS

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- Generalistic equation for sea-level rise induced shoreline recession based on equilibium beach profiles.
- Englobing relevant previous models in our generalistic equation.
- Theoretical justification of the exponential rate.
- **Shoreline recession (almost) proportional to the rate of mean sea-level rise.**

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Sharing is encouraged

ABSTRACT

This presentation participates in OSPP

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Outstanding Student & PhD candidate Presentation contest