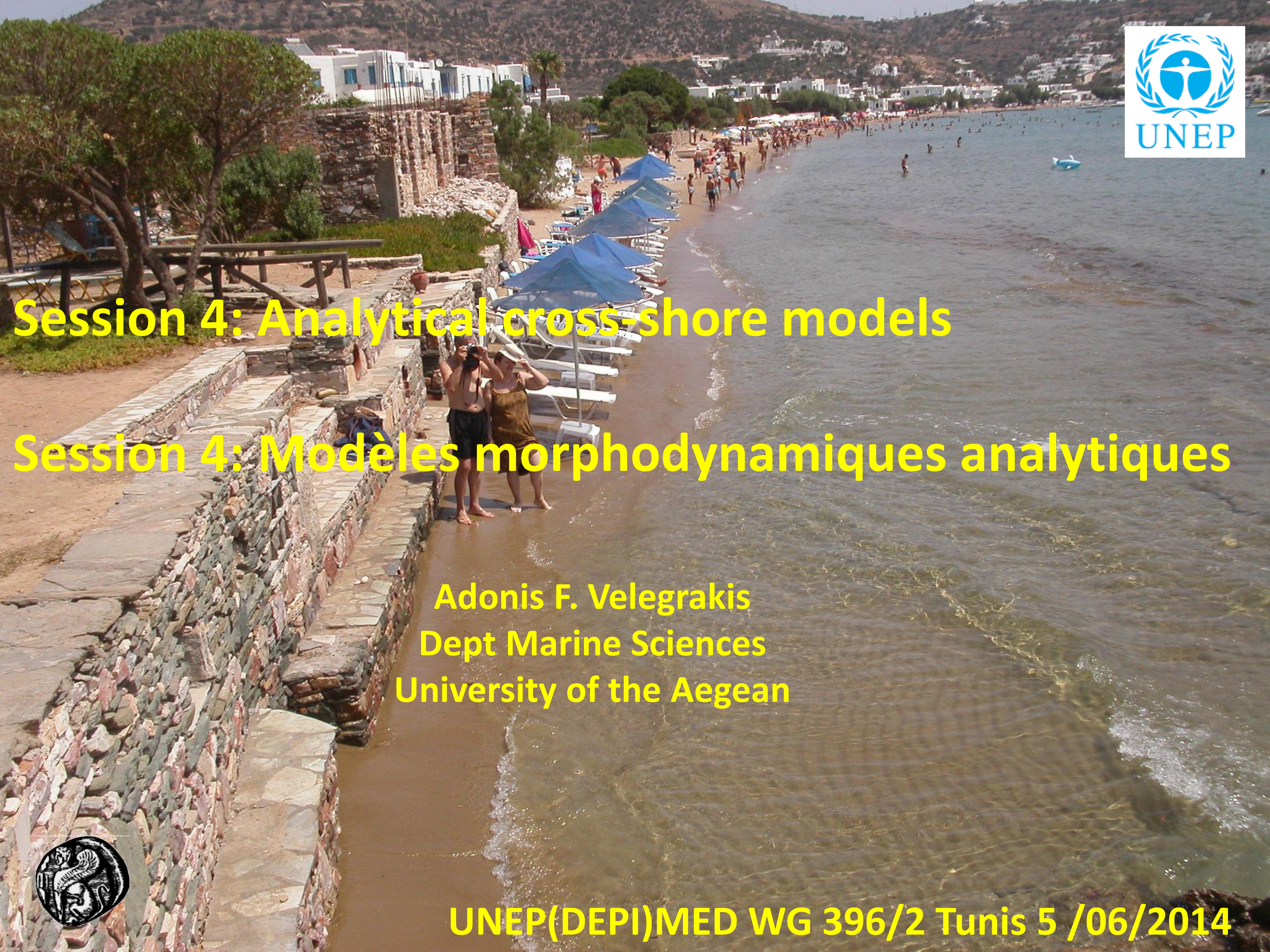

Session 4: Analytical cross-shore models

Session 4: Modèles morphodynamiques analytiques

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UNEP(DEPI)MED WG 396/2 Tunis 5 /06/2014

Synopsis

4.1 Beach retreat due to sea level rise

4.2. Analytical models

4.3 Application with Guide User Interface (GUI)

4.1 Beach retreat due to sea level rise

Coastal erosion. i.e. the retreat of the shoreline relative to a reference shoreline, has recently increased with very significant socio-economic impacts

Some Trends

- **About 60 % of the beaches (globally) i.e. of the low-lying coasts built on unconsolidated sediments are under retreat**
- **High retreat rates (e.g. About 88 % of the Luisiana beaches are under retreat with a rate that may reach 12 m/y.**

Beach erosion due to the sea level rise may be differentiated into

- **Long-term erosion i.e the irreversible shoreline retreat (and/or drowing) due to the long-term sea level rise**
- **Short term retreat (which may or may not be irreversible) due to storm surges and waves**

Sea level rise: Long- and short term

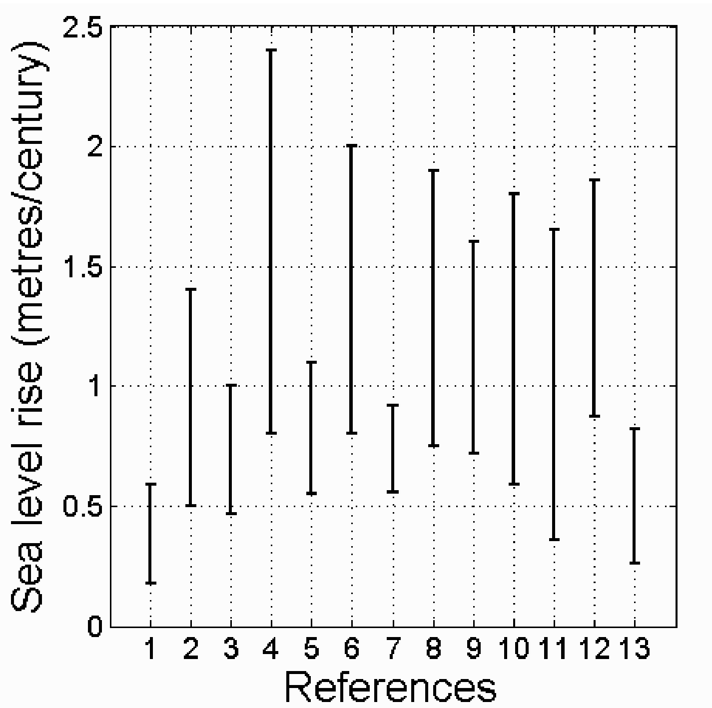
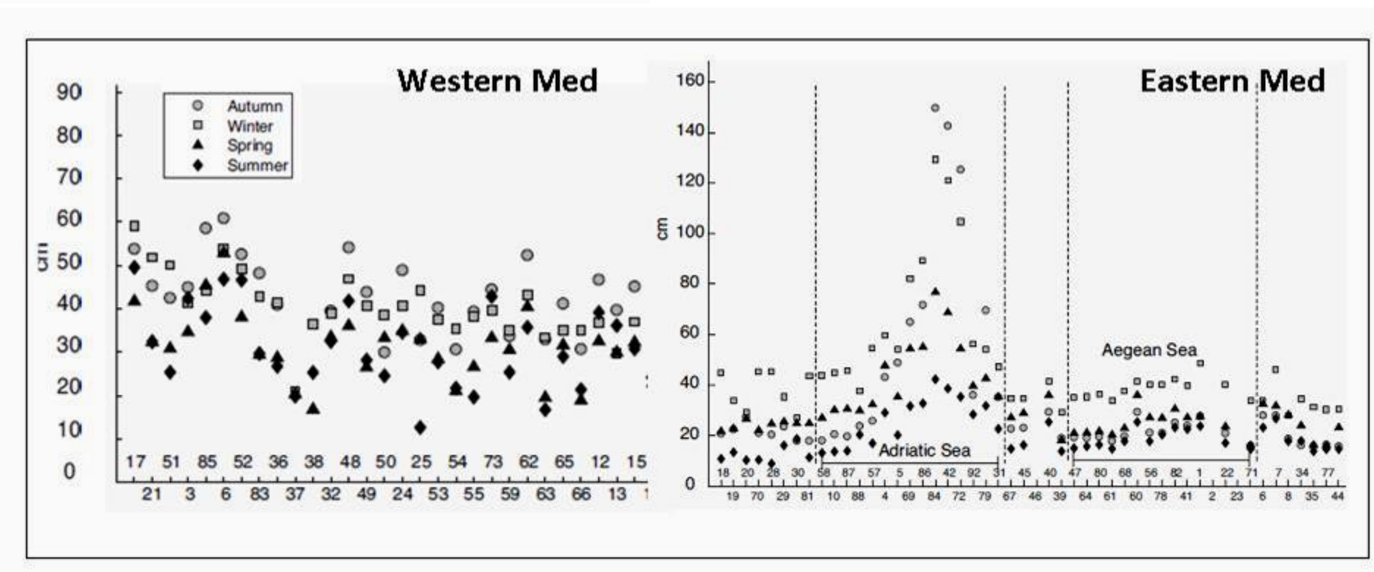


Fig. 4.1 Fig. 5.1 Recent sea level rise projections for 2100 compared to that of IPCC (2007a). Key: 1, IPCC (2007a), 0.18-0.59 m; 2, Rahmstorf et al. (2007); 3, Horton et al. (2008); 4, Rohling et al. (2008); 5, Vellinga et al. (2008); 6, Pfeffer et al. (2008); 7, Kopp et al. (2009); 8, Vermeer and Rahmstorf (2009); 9, Grinsted et al. (2010); 10, Jevrejeva et al. (2010); 11, Jevrejeva et al. (2012); 12, Mori et al. (2013); and 13, IPCC (2013).. (b) Maximum seasonal extreme sea level values (tidal residuals) in the western and Eastern Mediterranean (Tsimplis and Shaw, 2010).



Beach response to sea level rise

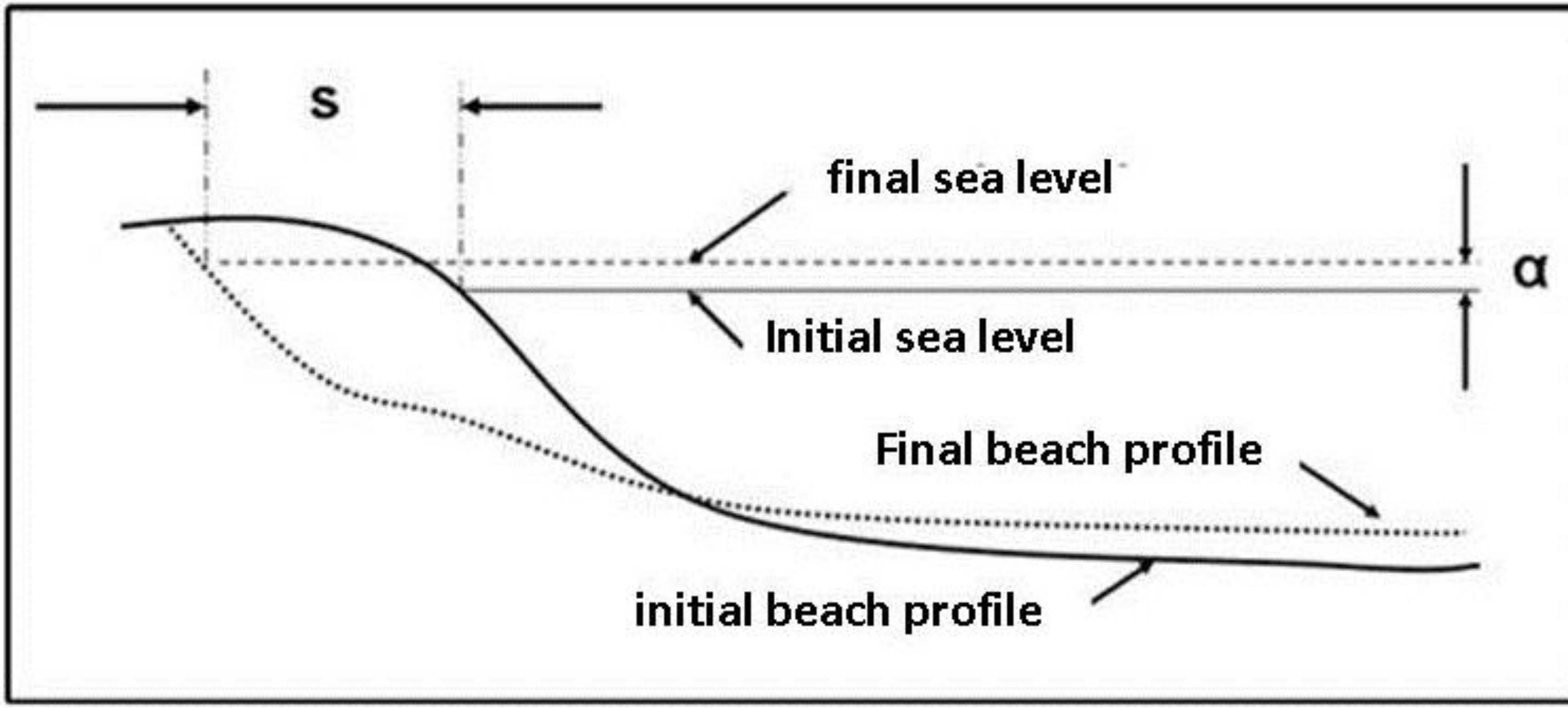


Fig. 4.2.Scetch showing beach response to sea level rise. If the sea level rises by α, beach face sediments are eroded and transported offshore to be deposited at the seabed, resulting to a shoreline retreat of s.

Long term beach erosion

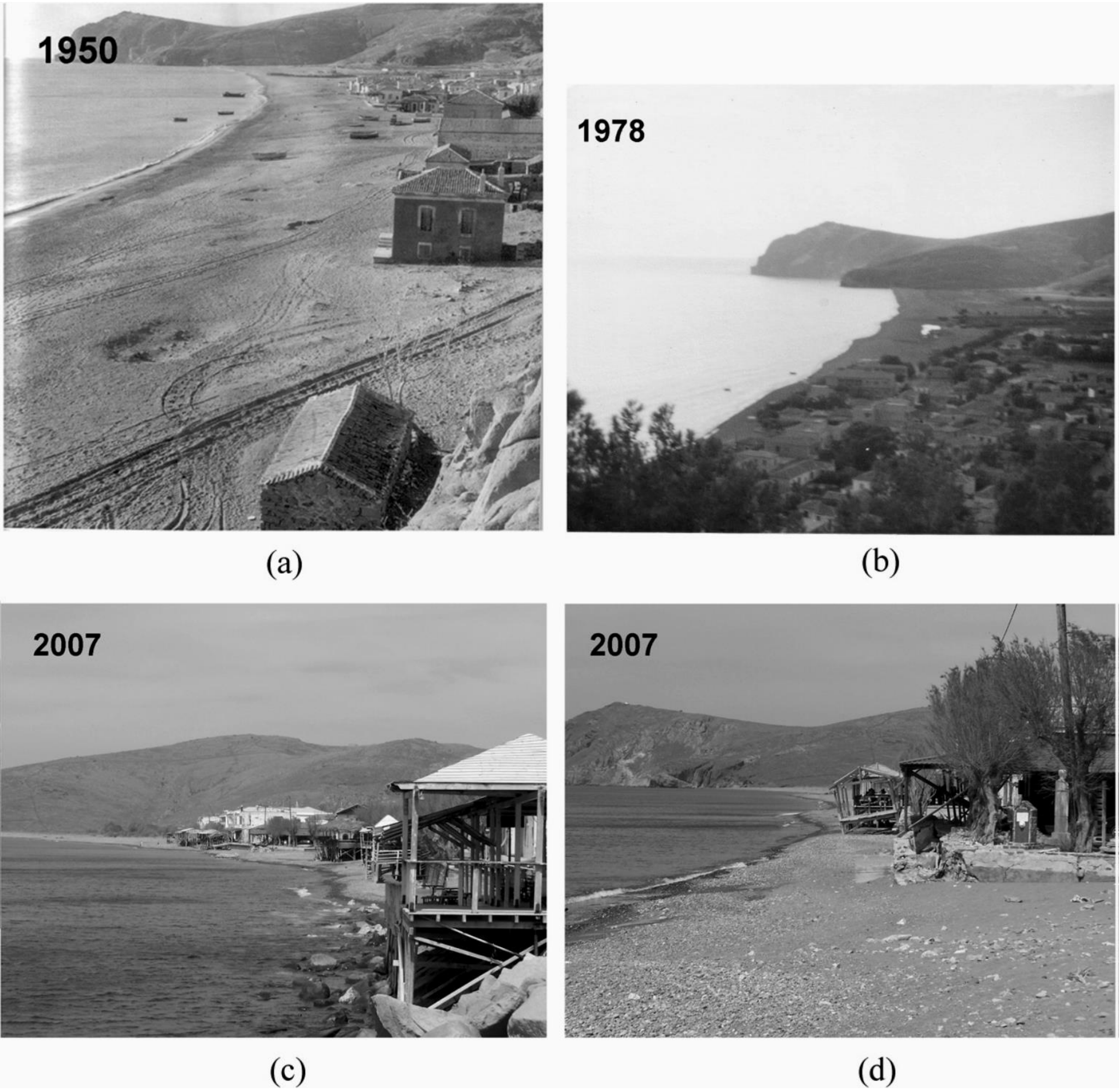


Figure 4.3 (a) Eresos beach in 1950, (b) Eresos beach and village in 1978, (c) and (d) Eresos beach in summer 2007 showing severe beach erosion and destruction of the seawall and the promenade (Velegrakis et al., 2008)

Short term beach erosion: Forcing

Fig. 4.4 Storm at the Eresos beach (06/01/2012)

Short term beach erosion: Impacts

Fig. 4.5 Storm impacts at the Eresos beach (Lesbos, E. Med 07/01/2012

4.2 Analytical (Static) models

The Bruun (1988) model

A widely-used model, based on the concept of the beach equilibrium profile

Its analytical expression is

$$s = \frac{l \cdot a}{h_c + B_h}$$

where *s* is the beach retreat, *l* the cross-shore distance to the closure depth h_c , *α* the sea level rise and B_h the (first) berm height above the mean sea level

4.2 Analytical (Static) models

The Edelman (1972) model

It can deal with natural cross-shore profiles and with larger/temporally variable changes.

The the cross-shore profile maintains its basic morphology under a rising sea level and its basic expression for the beach retreat *s* is:

$$s(t) = w_b \ln\left[\frac{h_b + B_o}{h_b + B_o - \alpha(t)}\right]$$

where s the beach retreat, α the sea level rise, B_o the initial berm height, $B_{h(t)}$ the instantaneous overall berm height above the sea level, and h_b και w_b το wave breaking depth and the surf zone width, respectively.

4.2 Analytical (Static) models

The Dean (1991) model

It assigns a greater significance than the previous models on the wave energy. Beach retreat s due to sea level rise *α* is given by:

$$s = \left(a + 0.068 H_b\right) \frac{w_b}{B_h + h_b}$$

where h_b the wave breaking depth, H_b the wave height at breaking, w_b the surf zone width (the horizontal distance between the shoreline and the wave breaking) from and B_h the (first) berm height (above the mean sea level).

4.2 Analytical (Static) models: Parameters

Wave height H_b at breaking (CEM, 2008)

$$\frac{H_b}{H_0} = 0.56\left(2\pi \frac{H_0}{g T_0^{\,2}}\right)^{-0.2}$$

where H_0 , T_0 are the open sea wave height and period, respectively

h_b the wave breaking depth

$$h_b = H_b / \gamma \qquad \gamma = \xi^{0.17} + 0.08 \qquad \xi = \frac{\tan\beta}{\left(H_o / L_o\right)^{1/2}} \qquad L_0 = \frac{g T_0^2}{2\pi}$$

4.2 Analytical (Static) models: Procedure

Estimation of beach (shoreline) retreat under sea level rise

Data → **Parameters** → **Results**

Analytical models

Data:

Offshore wave height H_0 and period T_0

Initial bathymetry or seabed slope

Parameters:

B_h, berm height above the sea level

h_c, closure depth

l, the cross-shore distance to closure depth

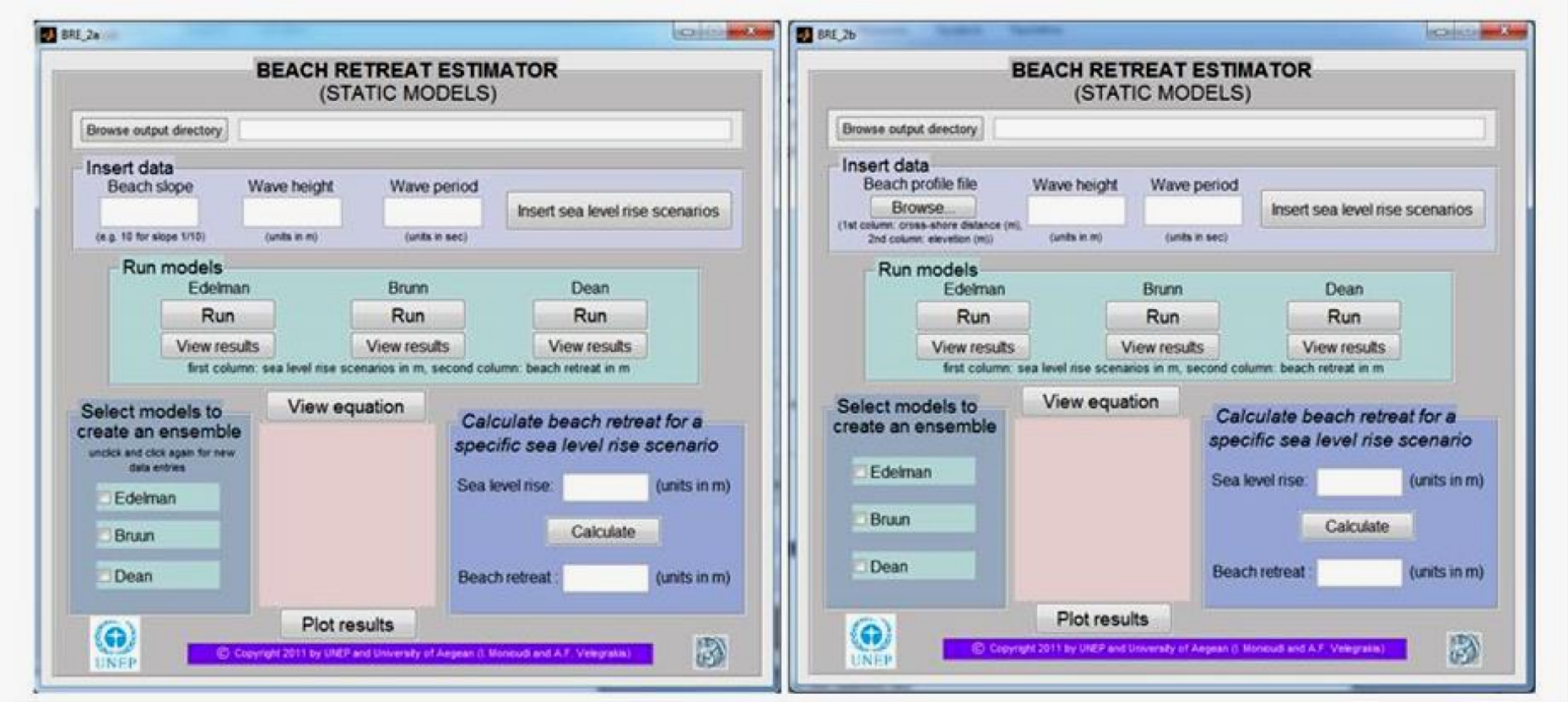
h_b, wave breaking depth

W_b , surf zone width (distance from wave breaking to shoreline)

Results:

Estimation of beach retreat s under sea level rise α

4.3. Application with Guide User Interface (GUI)



Output files

Output files are saved in the same folder with the platform's exe file, replacing pre-existing files)

extpr.txt (only for natural profiles): is the extended profile of the initial profile given by the user. First column is cross-shore distance (in m) and second column is elevation (in m).

sEdel.txt: an one column matrix with beach retreat projections by the Edelman model.

sBruun.txt: an one column matrix with beach retreat projections by the Bruun model.

sDean.txt: an one column matrix with beach retreat projections by the Dean model.

slrs.txt: an one column matrix containing the sea level scenarios entered by the user.

total_table.txt: a table with 5 rows and columns equal with the number of the sea level rise scenarios entered by the user. Contains the beach retreat projections made by the Edelman (1st row), Bruun (2nd row) and Dean (3rd row) models. Each column corresponds to a different sea level rise scenario.

path.txt (only for natural profiles): contains the path and the filename of the imported profile.

***Beach retreat estimations.tiff*: is the plotting figure of the polynomial equations of all selected models together with the polynomial equation that fits in the mean values of beach retreat projections of the models selected by the user.**