SUPPLEMENTARY INFORMATION

Mediterranean UNESCO World Heritage at risk from coastal flooding and erosion due to sea-level rise

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PLEASE NOTE:

This document includes all supplementary information provided in figures and tables. For the supplementary data please see the following files:

| Document name               | Description                                           |
|-----------------------------|-------------------------------------------------------|
| Supplementary_Data_1        | Results of the flood risk calculations                |
| Supplementary_Data_2        | Results of the erosion risk calculations              |
| Supplementary_Data_readme   | Description of the variables included in Supplementary Data 1 and 2 |
Supplementary Figure 1 Spatial patterns of the extreme sea level components storm surge and sea-level rise. 

a) 100-year storm surge (in m) taken from the Mediterranean Coastal Database, b) regional sea-level rise (in m) in 2100 under the high-end scenario based on Kopp et al. (2017)
Supplementary Figure 2 Characteristics of the flood risk indicators flood area and flood depth at each World Heritage site under current and future conditions. a) and b) area flooded (in %) in the base year 2000 (a) and in 2100 under the high-end sea-level rise scenario (b), c) and d) maximum flood depth (in m) in 2000 (c) and in 2100 under the high-end sea-level rise scenario (d)
Supplementary Figure 3 Characteristics of the erosion risk indicator distance from the coastline (in m) at each World Heritage sites under current and future conditions. a) in 2000, b) in 2100 under the high-end sea-level rise scenario.
Supplementary Figure 4 Characteristics of the static erosion risk indicators at each World Heritage site. a) coastal material, b) mean wave height (in m), c) sediment supply (in mg l$^{-1}$) given for coastal materials other than rocky.
### Supplementary Table 1 Attributes of the corrected Mediterranean UNESCO World Heritage site data

| Attribute name | Description | original dataset<sup>a</sup> | added<sup>b</sup> |
|----------------|-------------|-----------------------------|-----------------|
| unique_id      | unique ID of each serial site | x                           |                 |
| id_no          | ID of main site                     | x                           |                 |
| site_id        | ID of serial nomination                | x                           |                 |
| name_seria     | Name of serial nomination            | x                           |                 |
| name_en        | Name of main site in English         | x                           |                 |
| name_fr        | Name of main site in French          | x                           |                 |
| date_inscr     | Date when it was inscribed in the list | x                           |                 |
| sec_date       | Date when changes have been made (e.g. adjusting boundary) | x                           |                 |
| danger_lis     | Date when it was put on the danger list (if applicable) | x                           |                 |
| longitude      | X coordinate of center point in decimal degrees | xérox*              |                 |
| latitude       | Y coordinate of center point in decimal degrees | xérox*              |                 |
| area_ha        | Area of site in hectares (excl. buffer zone) (-9999 = not given) | xérox*              |                 |
| area_ha1       | Area of site in hectares (excl. buffer zone) as calculated based on the WHS polygons produced | x                           |                 |
| C1 – C6        | Criteria of Outstanding Universal Value (OUV) (1/0) | x                           |                 |
| criteria_t     | OUV criteria in text                  | x                           |                 |
| category       | Cultural (or natural)                 | x                           |                 |
| category_s     | C for cultural                        | x                           |                 |
| states_en      | Name of the country (countries) in English | x                           |                 |
| states_fr      | Name of the country (countries) in French | x                           |                 |
| region_en      | Name of the region in English         | x                           |                 |
| region_fr      | Name of the region in French          | x                           |                 |
| iso_code       | 2-digit country code                  | x                           |                 |
| undp_code      | 3-digit country code of the UNDP (United Nations Development Programme) | x                           |                 |
| transbound     | Cross-border site (1/0)               | x                           |                 |
| no_serial      | Number of serial sites                | x                           |                 |
| her_type1      | Heritage type based on ICOMOS (2011)<sup>1</sup> and Daly (2014)<sup>3</sup> | x                           |                 |
| her_type2      |                                       | x                           |                 |
| her_type3 | 1 = cultural landscape  
2 = built heritage/architecture/historic urban center  
3 = archaeological remains  
4 = single monument |
|-----------|----------------------------------------------------------|
| buffer_ha | Buffer area in hectares (-9999 = not given)               |
| srtm_min  | Lowest site elevation in the SRTM90 DEM                   |
| srtm_max  | Highest site elevation in the SRTM90 DEM                  |
| srtm_mean | Mean site elevation in the SRTM90 DEM                     |
| p_lecz    | Percent of site located in the LECZ                       |
| ur_grump  | Location of WHS in urban areas based on the GRUMP urban extents grid$^7$ (1/0) |
| ur_mod_buf| Location of WHS in urban areas based on the MODIS urban extents grid$^8$ with a 500 m buffer (1/0) |
| urJoined  | Combination of ur_grump and ur_mod_buf based on Google Earth™ satellite imagery |
| dist_MCD  | Distance from the coast [m] based on the Mediterranean coastal database (MCD)$^2$ |
| dist_gshhs| Distance from the coast [m] based on the global self-consistent, hierarchical, shoreline database (GSHHS) version 2.3.7 by Wessel et al. 1996$^9$ |
| dist_join | Combination of dist_MCD and dist_gshhs based on Google Earth™ satellite imagery |

- = included in the serial site dataset only  
- = included in the main site dataset only  
$^a$ taken over from the original World Heritage List data of 2018$^{10}$  
$^b$ added to the original World Heritage List data with the help of the data sources stated in the description  
$^*$ modified from original World Heritage List data
### Supplementary Table 2 Data used

| Variable                          | Indicator(s)                                                                 | Reference                                      |
|----------------------------------|-----------------------------------------------------------------------------|------------------------------------------------|
| Coastal World Heritage           | World Heritage sites 2018                                                  | UNESCO (2018)<sup>10</sup>                    |
| Elevation                        | Shuttle Radar Topography Mission (SRTM) DEM                                  | Farr et al. (2007)<sup>6</sup>, Jarvis et al. (2008)<sup>5</sup> |
| **Flood risk**                   |                                                                             |                                                |
| Sea-level rise scenarios         | RCP2.6, RCP4.5, RCP8.5 (50<sup>th</sup> percentile)                        | Kopp et al. (2017)<sup>4</sup>                 |
|                                  | High-end (RCP8.5, 95<sup>th</sup> percentile)*                              |                                                |
| Storm surge                      | 100-year surge height                                                       | Wolff et al. (2018)<sup>2</sup>, based on Muis et al. (2016)<sup>11</sup> |
| Mean dynamic ocean topography (MDT) | Used to reference the surge heights to the EGM96 geoid                    | Wolff et al. (2018)<sup>2</sup>, based on Rio et al. (2014)<sup>12</sup> |
| **Erosion risk**                 |                                                                             |                                                |
| World Heritage distance from the coastline | Mediterranean Coastal Database (MCD); Global self-consistent, hierarchical, shoreline database (GSHHS) version 2.3.7 | Wolff et al. (2018)<sup>2</sup>, Wessel et al. (1996)<sup>9</sup> |
| Erodibility                      | Coastal material                                                            | Wolff et al. (2018)<sup>2</sup>                 |
| Waves                            | Mean wave height                                                            | Wolff et al. (2018)<sup>2</sup>                 |
| Sediment supply                  | Total suspended matter                                                      | Schuerch et al. (in press)<sup>13</sup>, based on data of the GlobColour project<sup>14</sup> |

* We found the sea-level rise projections of the high-end scenario in 2100 to be lower than those of 2090 at a number of grid points, which we considered to be implausible due to the fact that the projections post-2100 continue to increase in an accelerating manner. Therefore we have calculated the mean of the sea-level rise growth rates between the years 2080-2090 and 2110-2120 and added it to the projection of 2090 to adjust the projection of 2100.
Supplementary References

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