Indecis

Sectorial Climate Services

Integrated approach for the **d**evelopment across **E**urope of user oriented **c**limate **i**ndicators for GFCS high-priority **s**ectors: Agriculture, disaster risk reduction, energy, health, water and tourism

Work Package 7

Deliverable 7.4. ANNEX B

R Code for INDECIS Sun and Beach Index

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1. Overview

This deliverable proposes a fundamental revision of the method to analyse ideal climatic and meteorological conditions at local level presenting and describing a new indice for will use as a climate service. Until recently, the most popular tool used in the tourism literature to pin-point the relationship between climate and tourism competitiveness has been the 'Tourist Climatic Index'. This is intended as a 'measure of comfort' for tourists, and it could be used to analyse 'how far' any destination region, for instance in Europe, finds itself from ideal conditions, hinting at the fact that some regions are 'naturally' more competitive than others on mere climatic concerns.

This approach has some advantages when used at a 'macro' scale: for instance, TCI could be used a measure of the relationship between changing climatic conditions and changing competitiveness in the long run, or to explain some of the origin-destination patterns (slow tourism mobilities where tourists (or new residents) travelling from 'cold' to 'warm' countries and the temporality of such flows). However, it remains a limited tool for other objectives, like the capacity to inform about the product specialisation of different regions. Our paper outlines most important shortcomings of the TCI. Firstly, it does not acknowledge the variety of tourist forms and products and thus the difference in 'ideal' climatic conditions for each. Secondly, it is a uniform, top-down measure which is not informed by 'local knowledge'. Thirdly, it is hardly consistent with the complexity of destinations and the operation of the tourist industry therein.

In short, an altogether new approach and instrument or set of instruments is needed to make sense of how climate affects tourist places, towards the construction of 'climate information services' that could orient policy and business initiatives at local level. We claim that useful climate information services should simultaneously use objective, contrasted information about the relationship between specific meteorological and climate conditions and destination/product performance and 'bottom-up' elicited knowledge from field actors.

In this sense in the framework of the project "INDECIS" , which has the overarching objective of providing an integrated approach to produce a set relevant climate indices targeting the high priority sectors of the World Meteorological Organization's Global Framework for Climate Services (agriculture, disaster risk reduction, energy, health, water) plus tourism; we develope a new methodology to extract information of optimal weather and climate conditions to develop various tourism activities (INDECIS Deliverable 7.2) according to the expertise knowledge of stakeholders, DMO's and destination users, one of the approach to know the best conditions to do tourism (Scott et al 2008). The special focus on tourism, which is developed in this paper, is not trivial. Not only tourism and leisure-oriented mobilities contribute to climate change, but they are fundamentally affected by climate, demanding adaptive actions in order to guarantee resilience.

Local tourists systems (LTS) depend to a large extent on climatic conditions in terms of what can be offered to their customers, how, and when; an increasing variability of meteo conditions, which is a characteristic of climate change, may require introducing important innovations in governance and management, as a 'safety net' to make the destination and the set of products it features less vulnerable to conditions that hinder their performance. On the longer run, LTS need to cope with changing climatic

conditions, which may spur changes in product specialisation, seasonal programming, infrastructure development, market orientation, stakeholder management and destination planning. In all such cases, destination managers and governments who need to provide adequate conditions for such transitions need information, and a good part of such information, especially for what regards the sensitiveness of specific products on climate, can only to some extent be gauged by 'objective' predictive models, but can be obtained through mechanisms eliciting 'collective intelligence' at local level.

In this sense, in this deliverable we present a new tool to calculate, based on the information gathered by local agents, a new index for beach tourism based on daily information and in defined places. This tool, based in R code, This tool allows to download the variables needed to calculate the index.

2. INDECIS Sun and Beach Index (INSBIN)

2.1. Methods

Source datasets

To calculate the Sun and Beach Index R Code employes one information source: the ERA-Interim dataset. ERA-Interim (https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era-interim) is a re-analysis dataset developed by the developed by the European Centre for Medium-Range Weather Forecasts (EWMF) ERA5 is the last generation of the re-analysis dataset developed by the European Centre for Medium-Range Weather Forecasts (EWMF).

2.2. Index calculation

We developed a R code to download and calculate INDECIS Sun and Beach Index. This code can be found here: http://www.indecis.eu/software.php . This index uses five intermediate indices (temperature based, precipitation based, sun based, sea based and wind based to define the optimal conditions for beach tourism). Table 1 shows the variables included in each intermediate index.

Table 1: Climate indices contained in the database of INDECIS

Intermediate Index	Variable	Definition	Source in ECMWF
Temperature	Maximum TX (day)	Maximum temperature in day	Maximum temperature at 2 metres since previous post-processing
	Warm Day	Day with Tx > percentile90	
	Consecutive Warm Day	Consecutive Days with Tx > percentile90	
	Tropical Night	Day with Tn >20 Cº	Minimum temperature at 2 metres since previous post-processing
	Consecutive Tropical Nights	Consecutive Days with Tn > 20 Cº	
Precipitation	Total RR	Total Precipitation	Total Precipitation
	Wet Days	Days with RR >0	

	Consecutive Wet Days	Consecutive Days with RR >0	
	Heavy Rain Days	Day with precipitation >50	
Sun Based	Cloudiness	% of clouds	Total Cloud Cover
	Cloudy Day	Day with % Clouds > percentile 65	
	Consecutive Cloudy Days	Consecutive Days with % clouds > percentile 65	
	UVB	UVB Index	Radiation
	Sunshine Duration	Hours with sun	Sunshine Duration
Sea Based	SST	Sea Surface Temperature	Sea Surface Temperature
	Tropical SST	SST>26.5	
	Consecutive SST	Consecutive days with SST>26.5	
	Wave Heigh	Wave Heigh	Significant Wave Heigh
	Wave Day	Day with wave heigh > percentile 90	
	Calm Day	Day with wave heigh < percentile 10	
	Consecutive Wave Days	Consecutive Days with wave heigh > percentile90	
	Extreme Wave Day	Day with wave heigh > 200cm	
Wind Based	FG	Wind gust	10 metre wind gust since previous post-processing
	Windy Day	Days with FG > percentile 90	
	Consecutive Windy Days	Consecutive Days with FG > percentile 90	

2.3. Technical information.

Requeriments for use INSBIN R Code.

- R o R Studio higher than 4.0 is necessary to run the code because of some packages used need this version.
- A non-commercial license from the European Centre for Medium-Range Weather Forecast (ECMWF) is required to run the code. This licencse allows to download the data of ERA-Interim for non-commercial use.

- The following packages will be automatically installed, if not already installed, on your computer when you run the code: ECMWF, ncdf4, nc, ncdf4.helpers, tidyr, dplyr, lubridate, xlsx

2.4. Usage Notes

For calculate INSBIN for defined place and defined time period you need to follow the next steps:

1.- Sign in in and register in ECMWF (https://www.ecmwf.int/) to acquire the license to use the datasets provided by this organization.

2.- Open the code in your R or Rstudio.

3.- Define Place characteristics in the code. Place Charachteristics are defined as a section on the code. These are: meters above sea in line 12 (by default is 1 because we are calculating a beach index); grid scale of the information requested from 3x3 to 0.125x0.125 (see here for more grid options: https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-interim) in line 17; time-period in format ("dd-mm-yyyy/to/dd-mm-yyyy") in line 14; and, coordinates of the place in format (N, W, S, E) in line 19

4.- Insert your ECMWF credentials in quotation marks of the code (basically, you need to put your registered e-mail and the token provided). (lines 28, 29)

5- Insert your user in the line 34 in quotation marks.

6.- Run the code.

Once the code runs,

7.- The code itself will create the folders in your working directory. By default they are named "/beachindex" and "beachindex/data". If you want to change the names, go to lines 2 and 3. When changing the names, remember also to change the path (line 21) since "beachindex/data" is the destination folder for the files you will download.

8.- It will connect to the ECMWF API service to start downloading data (which can take several minutes).

9.- The following files with meteorological information will be downloaded to the "beachindex/data" folder: tx.nc (Maximun Temperature), tn.nc (Minimum Temperature), hr.nc (Humidity), rr.nc (Precipitation), tcc.nc (Total Cloud Cover), dUV.nc (Radiation), ssd1.nc and ssd2.nc (Sunshine Duration), sst.nc (Sea Surface Temperature), shw.nc (Significant Wave) and fg.nc (Wind Gust).

10.- Once the data is downloaded, different operations are applied to transform it into an understandable scale. For example, the temperature is transformed from Kelvin to Celsius.

11.- The first output will appear in the form of a "csv" file in your working folder. In this first ouptut you will have the Essential Climate Variables (ECV's) for the defined time period of your place.

12.- At this point starts the intermediate indices and INSBIN are calculated.

13..- An Excel file will be created with the intermediate indices (temperature, precipitation, sun, sea and wind), as well as the INDECIS sun and beach index. This file will be created for better data management and visualization.

2.5. Code availability

The code used to calculate the INDECIS Sun and Beach Index is available via: http://www.indecis.eu/software.php