



**Integrated approach for the development across Europe of user oriented climate indicators for GFCS high-priority sectors: Agriculture, disaster risk reduction, energy, health, water and tourism**

**Work Package 4**

**Deliverable 4.1**

## **Report on the Inventory and Catalog of Indices Datasets**



This report arises from the Project INDECIS which is part of ERA4CS, an ERA-NET initiated by JPI Climate, and funded by FORMAS (SE), DLR (DE), BMFWF (AT), IFD (DK), MINECO (ES), ANR (FR), with co-funding by the European Union's Horizon 2020 research and innovation programme

In the pursuit of WP4 of INDECIS, we have prepared a comprehensive catalogue of a broad range of standard climate indices. These indices were selected, based on their direct and significant impacts on the INDECIS target sectors, after a thorough review of the literature in the field of extreme weather events and natural hazards. In the literature, these indices have been specified by the Expert Team of the World Meteorological Organization and Climate Variability and Predictability (ETCCDMI), and substantially applied in many hydrometeorological studies. These indices have been widely recognized by many scientists as “reliable” indicators of the possible impacts of climate change and variability on both physical and human environments (e.g. hydrology, water resources, biodiversity, agriculture, crop yield, health, tourism, energy, etc). Overall, the selected indices characterize different aspects of the frequency, intensity and duration of extreme events, and are derived from a broad set of climatic variables, including surface air temperature, precipitation, relative humidity, wind speed, cloudiness, solar radiation, and snow cover. The catalogue extends further beyond these key climatic variables to account for other indices associated with important hydroclimatic risks (e.g. drought, aridity, continentality). The indices can also be categorized into two broad groups: uni-based and multi-based variables indices. The uni-based indices are calculated using data from an individual climatic variable, such as majority of air temperature, precipitation and snow cover indices. Other indices account for characteristics of a combination of different climatic variables (e.g. fire-based indices), which consider data from air temperature, relative humidity, wind speed, etc. This also incorporates drought indices (e.g. SPEI), which account for the role of precipitation and evapotranspiration. Importantly, recalling that the selected indices can be linked directly to various sectors in Europe, including agriculture and crop yield, forest fire, tourism and human health, some indices were categorized – in the early stages of INDECIS - into discipline-based categories. This includes – for example– the fire-based indices (e.g. Fire Weather Index [FWI], Finnish Forest Fire Index [FFFI]) and tourism-based indices (e.g. Holliday Climate Index [HCI] and Tourism Climatic Index [TCI]).

From a statistical point of view, the selected indices were computed using different state-of-the-art approaches. In specific, some indices were calculated simply using arbitrarily-based thresholds that adopt pre-fixed thresholds, which fit well with the European context. These fixed thresholds have physical, hydrological or biological meaning, making them appropriate for climate impact assessments, particularly at fine spatial scales. Other indices were computed using more sophisticated statistical approaches, such as the percentile-based approaches and data distribution fits, allowing for direct comparison between the European regions with different climatic conditions (e.g. semi-arid, Mediterranean, temperate, and cool climates). In their calculations, some indices were calculated using climatic data at daily resolution, while other indices employed data at coarser temporal resolution (i.e. monthly, annual).

Within the scope of INDECIS, the inclusion of different definitions of extreme events, using a wide range of climatic variables, allows for a comprehensive assessment of climate indices at different spatial and temporal scales and also explore whether changes in these indices are consistent over space and time, providing important information for climate change impact studies at local, national and regional scales.

Here, we list the full catalogue of climate indices included in INDECIS.

### Temperature based indices

1. Mean TX (GTX)
2. Maximum TX (XTX)
3. Minimum TX (NTX)
4. Mean TN (GTN)
5. Maximum TN (XTN)
6. Minimum TN (NTN)
7. Mean TG (GTG)
8. Maximum TG (XTG)
9. Minimum TG (NTG)
10. Cold days (CD)
11. Cold nights (CN)
12. Cold spell duration (CDD)
13. Diurnal temperature range (DTR)
14. Mean daily difference DTR (vDTR)
15. Frost days (FD)
16. Growing season length (GSL)
17. Ice days (ID)
18. Maximum consecutive frost days (CFD)
19. Extreme temperature range (ETR)
20. Summer days (SUD)
21. Maximum consecutive summer days (CSD)
22. Difference days above/below Tx17 (D17)
23. Tropical nights (TN)

24. Heating degree days (HD17)
25. Very cold days (VCD)
26. Very warm days (VWD)
27. Warm days (WD)
28. Warm nights (WN)
29. Warm spell duration (WSD)
30. zero crossing days (ZCD)
31. Onset of growing season 6 days (OGS6)
32. Onset of growing season 10 days (OGS10)
33. Growing season (Apr-Oct)
34. Growing season(May-Sep)
35. Growing degree days (GD4)
36. Winkler index (WKI)
37. Winter Severity (WS)
38. Sums TX32 (STX32)
39. Days TX32 (D32)
40. Sums TN-15 (STN15)
41. Sums TN-10 (STN10)
42. Sums positive (PTG)

#### **Precipitation based indices**

43. Total precipitation (RT)
44. Maximum precipitation (Rx)
45. Days precipitation  $\geq$ R10mm (R10mm)
46. Days precipitation  $\geq$ R20mm (R20mm)
47. Maximum daily R (Rx1d)

48. Maximum 5 days R (Rx5d)
49. Simple daily intensity index (SDII)
50. Dry days (DD)
51. Effective precipitation (EP)
52. Longest dry period (LDP)
53. Longest wet period (LWP)
54. Precipitation fraction very wet days (R95%tot)
55. Precipitation fraction extremely wet days (R99%tot)
56. Heavy precipitation days (D50mm)
57. Very wet days (D95p)
58. Precipitation Concentration Index (PCI)
59. Modified Fournier Index (MFI)
60. Growing season precipitation (GSR)
61. Non-growing season precipitation (NGSR)
62. Total precipitation wet days (RTWD)
63. Wet days 1mm (DR1mm)
64. Wt days 3mm (DR3mm)

#### **Bioclimatic indices**

65. TG warmest quarter (BIO10)
66. TG coldest quarter (BIO11)
67. Precipitation wettest month (BIO13)
68. Precipitation driest month (BIO14)
69. Coefficient of variation precipitation (BIO15)
70. Precipitation wettest quarter (BIO16)
71. Precipitation driest quarter (BIO17)

72. Precipitation warmest quarter (BIO18)
73. Precipitation coldest quarter (BIO19)
74. Temperature seasonality (BIO4)
75. TX warmest month (BIO5)
76. TN coldest month (BIO6)
77. Difference warmest/coldest month (BIO7)
78. TG wettest quarter (BIO8)
79. TG of driest quarter (BIO9)
80. Mean radiation (BIO20)
81. Universal thermal climate index (UTCI)
82. Mould index (MI)
83. Heat index (HI)
84. Wind chill index (WCI)
85. Apparent temperature (AT)

#### **Wind-based indices**

86. Days wind gusts above 21 m/s (DFx21)
87. Daily maximum wind gust (FXx)
88. Mean of daily mean wind strength (FG)
89. Calm days (FG $\leq$ 2)
90. Days daily averaged wind above 10.8m/s (FG6Bft)

#### **3.5 Aridity/continentality indices**

91. Reference evapotranspiration (ETo)
92. UNEP aridity index (UAI)
93. Climatic moisture deficit (CMD)
94. De Martonne aridity index (MAI)

95. Emberger aridity index (EAI)
96. Johansson Continentality Index (JCI)
97. Kerner Oceanity Index (KOI)
98. Pinna Combinative index (PiCI)
99. Budyko Index (BI)
100. Marsz Oceanity Index (MOI)

#### **Snow-based indices**

101. Snowfall sum (SS)
102. Snow days depth 0-10 (SD0\_10)
103. Snow days depth 10-20 (SD10\_20)
104. Snow depth (SD)
105. Frequency of snow days (FSD)
106. Mild snowy days (MSD)
107. Heavy snowy days (HSD)
108. Date of first snow cover (FSC)
109. Date of first permanent snow cover (FPSC)
110. Date of last permanent snow cover (LPSC)
111. Average snow depth (ASD)
112. Amount of snow covered days (SCD)
113. Maximum snow depth (MS)

#### **Cloud/radiation based indices**

114. Sum of sunshine duration (SSD)
115. Sunny days (SND)
116. Cloudy days (CID)
117. Mean daily cloud cover (CC)

118. Sunshine duration fraction (SSp)

119. Atmospheric Clarity Index (ACI)

#### **Drought indices**

120. Standardized precipitation index 1 (SPI1)

121. Standardized precipitation index 3 (SPI3)

122. Standardized precipitation index 6 (SPI6)

123. Standardized precipitation index 12 (SPI12)

124. Standardized Precipitation-Evapotranspiration Index 1 (SPEI1)

125. Standardized Precipitation-Evapotranspiration Index 3 (SPEI3)

126. Standardized Precipitation-Evapotranspiration Index 6 (SPEI6)

127. Standardized Precipitation-Evapotranspiration Index 12 (SPEI12)

#### **Fire indices**

128. Canadian Fire Weather Index (FWI)

129. Kneetch-Byram Drought Index (KBDI)

130. McArthur Forest Fire Danger Index (FFDI)

131. Modified Nesterov Index (MNI)

132. Finnish Forest Fire Index (FFFI)

#### **Tourism indices**

133. Holliday Climate Index Urban (HCI:U)

134. Tourism Climatic Index (TCI)

135. Good tourism days TCI>60 (TCI60)

136. Excellent tourism days TCI>80 (TCI80)