Table, Definitions, and Descriptions of Key Hazard Indicators On Which To Focus In Subsequent Tasks

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Contents

1 Summary for Publication

This deliverable is a summary table of climate hazard indices that were proposed by WP4 participants for consideration of the Demonstrator Task Team, the Demonstrator Cities, and their Stakeholders for use in adaptation decision making in the I4C Demonstrators. The table summarises the final set of climate hazard indices that will be produced by the WP4 group and included within the web-based tool which will be delivered in M44 to deliver region specific hazard information for risk assessments to the Demonstrators. This deliverable has defined extreme event and hazard indicators relevant for the European area and specifically for the Demonstrators undertaken in WP6 and for wider networks in WP1 by engaging stakeholders through a series of workshops undertaken in WP6.

2 Contribution to the top-level objectives of Impetus4Change

This deliverable contributes to I4C overall objective SO4 by defining a stakeholder-relevant set of extreme and hazard indicators for Europe which can then be used to develop and apply methods for assessment and quantification of extreme events and hazard indicators for the coming decades, including the assessment of biases and uncertainties, in further deliverables.

2.1.1.1 Objective	2.1.1.2 Contribution from Deliverable
Overall Objective: to improve the quality, accessibility and usability of near-term climate information and services at local to regional scales – where impacts are most keenly felt and on-the ground adaptation is implemented – to strengthen and support end-user adaptation planning and action	Defining a stakeholder-relevant set of extreme and hazard indicators for Europe
1) Improve understanding and flow of climate information through knowledge networks;	
2) Address persistent shortcomings to deliver seasonal to decadal predictions of improved quality;	
3) Develop novel methods to downscale predictions to local scales;	

4) Improve assessments of hazards and translate this into usable information for local risk assessments;	Defining a stakeholder-relevant set of extreme and hazard indicators for Europe
5) Make advances towards the goal of end-to-end seamless climate services;	
6) Through transdisciplinary co-production approaches develop fit-for-purpose "Adaptation support packs" at municipal scales through our so-called urban Demonstrators;	
7) Ensure high impact and visibility through robust and targeted communication and engagement;	
8) Commit to Open Science through development of open access tools and exploitation of data/model outputs via relevant platforms thereby ensuring improved accessibility and usability of climate knowledge.	
Overall Objective: to improve the quality, accessibility and usability of near-term climate information and services at local to regional scales – where impacts are most keenly felt and on-the ground adaptation is implemented – to strengthen and support end-user adaptation planning and action	
1) Improve understanding and flow of climate information through knowledge networks;	
2) Address persistent shortcomings to deliver seasonal to decadal predictions of improved quality;	

3 Detailed Report

3.1 Introduction

This deliverable provides a set of hazard indices for extreme weather relevant to stakeholders in Europe.

3.2 Work Carried Out

This deliverable is a summary table of climate hazard indices proposed by WP4 participants for consideration by the Demonstrator Task Team, the demonstrator cities, and their stakeholders for use in adaptation decision making in the I4C Demonstrators. This set of indices was developed through a series of discussions within the WP4 team and a number of workshops led by the WP6 team.

There are no deviations from the Description of Action.

3.3 Status of Knowledge

Many indicators are available in the literature and often the spatial scale for which they are relevant are not clear or discussed. In this deliverable for the first time a set of hazards indicators has been proposed with the multiple purpose of being relevant for the European wide area as well as the cities scale.

The table has been finalised after several interactions with the Demonstrator Task Team, stakeholders and all the WP4 members. The University of Newcastle (UNEW), The United Nations Educational Scientific and Cultural Organization (UNESCO-ICTP), Stiftelsen nansen senter for miljo og fjernmaling (NERSC), and Norsk regnesentral (NRS) contributed to the finalization of the table.

3.4 Main Results Achieved

The main results achieved are shown in the table below. This table summarises the hazard indices that will be developed within the project.

Hazard indices	Description/Calculation	Critical sector of exposure	References	Demonstrator(s)
TNnTrop Annual	Number of tropical nights. Minimum night-time temperature > 20 °C Annual frequency, and the maximum and average period length for periods of 3 or more days in length	Heatwaves, Human health,		Barcelona, Bergen, Prague
TNnEqua Annual	Number of equatorial nights. Minimum night-time temperature > 25 °C Annual frequency, and the maximum and average period length for periods of 3 or more days in length	Heatwaves, Human health,		Barcelona, Bergen, Prague
Tx25 Annual	Number of Summer Days with maximum daily temperature above 25 degrees Annual frequency, and the maximum and average	Human health, infrastructure, ecosystems, agriculture	Deryng et al. 2014 Petitti et al. 2016	Paris, Prague, Barcelona

	period length for periods of 3 or more days in length			
HW Annual	Heat wave as 3 consecutive days with TX above the daily threshold (p90 of TXd over ± 15 days) for the reference period 1981-2010. Annual frequency, and the maximum and average period length.	Human health, ecosystems	Russo et al., 2014; 2015	Barcelona, Prague, Paris
HEvent Annual	Heat event as 1-2 consecutive days with TX above the daily threshold (p90 of TXd over ± 15 days) for the reference period 1981-2010.	Human health, ecosystems	Russo et al., 2014; 2015	Barcelona, Prague
EHF (Excess Heat Factor)	Quantifies heat wave severity/intensity based on three-day-averaged daily mean temperature (DMT). $EHI_{sig} = (T_i + T_{i+1} + T_{i+2})/3 -$ $EHI_{accl} = (T_i + T_{i+1} + T_{i+2})/3 - (T_{i-1} + \ \dots \ + T$ $EHF = EHI_{sig} \times \max(1,\ EH$	Heatwaves, Human Health	Nairn & Fawcett (2014)	Barcelona, Prague, Paris
NOAA Heat index (HI)	The 'Heat Index' is a measure of how the hot weather "feels" to the body. The index uses relative humidity and air temperature to produce the "apparent temperature" or the temperature the body feels" $HI = \begin{cases} HI_1 + HI_{A1}, & \text{if } RH < 13\% \text{ and } 80\,°F < T_F < 11 \\ HI_1 + HI_{A2}, & \text{if } RH > 85\% \text{ and } 80\,°F < T_F < 87 \\ HI_1, & \text{otherwise} \end{cases}$ with: $HI_1 = c_0 + c_1 \cdot T_F + c_2 \cdot RH + c_3 \cdot T_F \cdot RH + c_4 \cdot T_F^2 + c_5 \cdot$ $+ c_8 \cdot T_F^2 \cdot RH^2$ $HI_{A1} = (13 - RH)/4 \cdot \sqrt{(17 - \lvert T_F - 95\,°F \rvert)/17}$ $HI_{A2} = (RH - 85)/10 \cdot (87\,°F - T_F)/5$ $c_0 = -42.379\,°F,\ c_1 = 2.04901523,\ c_2 = 10.14333127\,°F,\ c_3$ $c_4 = -0.00683783\,°F^{-1},\ c_5 = -0.05481717\,°F,\ c_6 = 0.0012$ $c_8 = -0.00000199\,°F^{-1}$ If $HI < 80\,°F$, the following equation is used: $HI = 0.5 \cdot (T_F + 61\,°F + 1.2 \cdot (T_F - 68\,°F) + 0.094\,°F \cdot RH$ The calculated HI is converted into °C.	Human health, ecosystems	Annex VI: Climatic Impact-driver and Extreme Indices (IPCC Sixth Assessment Report – WG1) ; Burkart et al. (2011); Lin et al. (2012); Kent et al. (2014), Lu and Romps (2022)	Barcelona, Paris, Prague
CDD Annual	Given a threshold Tb=22°C: $CDD_i = \begin{cases} 0 \\ \frac{T_X - T_b}{4} \\ \frac{T_X - T_b}{2} - \frac{T_b - T_N}{4} \\ T_M - T_b \end{cases} \quad \text{if}$ Then: $CDD = \sum_{i=1}^{365} CDD_i$	Energy consumption for cooling	Spinoni et al. 2015 https://ec.europa.eu/eurostat/cache/metadata/en/nrg_chdd_esms.htm	Barcelona, Paris, Prague, Bergen, Newcastle, Hamburg

HDD Annual	Given a threshold Tb=15°C: $HDD_i = \begin{cases} T_b - T_M \\ \frac{T_b - T_N}{2} - \frac{T_X - T_b}{4} \\ \frac{T_b - T_N}{4} \\ 0 \end{cases}$ if Then: $HDD = \sum_{i=1}^{365} HDD_i$	Energy demand for heating	Spinoni et al. 2015	Paris, Prague, Barcelona, Bergen, Newcastle, Hamburg
PrRnn	nn year return value of daily precipitation, e.g., nn= 2, 5, 10, 20, 50, 100, 200 years	Pluvial flooding, ecosystems and crop growth		Bergen, Prague
RX1day Annual	Maximum 1 day precipitation	Pluvial flooding, ecosystems and crop growth		Bergen, Newcastle, Barcelona, Prague
CWD Annual	**CWD**: consecutive wet day /maximum length of wet spell (RR ≥ 1 mm)	Water resources management, Tourists, Flooding, Ecosystems	Climate Indices and Analysis for Sectoral Application, WMO: https://indico.ictp.it/event/a10167/session/16/contribution/12/material/0/0.pdf	Bergen, Prague
Rnnmm Annual	**Rnnmm**: count of days where RR ≥ user-defined threshold in mm. For example, precipitation based on percentile value.	Water resources management, Tourists, Flooding, Ecosystems	Climate Indices and Analysis for Sectoral Application, WMO: https://indico.ictp.it/event/a10167/session/16/contribution/12/material/0/0.pdf	Bergen, Prague
SPI 6 months	Standardised Precipitation Index		WMO (2012)	Barcelona
NDD	Number, average length, and maximum length of dry spells. A dry spell is a period during which the daily precipitation is below a threshold of 1 mm.	Heatwaves, Droughts, Eco systems, Crop growth	Cindric et al. (2010), Manning et al., (2023)	Barcelona, Bergen, Prague, Paris
DF Decadal	Drought frequency based on a 6-month SPI	Ecosystems and agriculture	Spinoni et al. 2014	Barcelona,Prague
Fire Weather Index (FWI)	Fire Weather Index/ a meteorologically based index used worldwide to estimate fire danger. It is calculated using 24-h accumulated precipitation, instantaneous wind speed, relative humidity and daily max temperature.	Human health, ecosystems, infrastructure	Bedia et al., (2013), Bedia et al., (2018) Alternative is Fire Occurrence Probability Index (FOPI) which also considers fuel. Giuseppe et al 2023	Barcelona, Bergen, Prague
RxHhr	Simple monthly maxima of H-hour (1-hour and 3-hour) precipitation series	Flooding	Pritchard, D.M.W., Lewis, E., Blenkinsop, S., Patino Velasquez, L., Whitford,	Newcastle, Bergen

	(using a sliding window to identify maxima when H > 1)		A., Fowler, H.J. GSDR-I: An Observation-Based Dataset of Global Sub-Daily Precipitation Indices. Scientific Data, in press.	
RHhrTmm	Count of hours with greater than 30 or 50 mm thresholds (T)	Flooding	Pritchard, D.M.W., Lewis, E., Blenkinsop, S., Patino Velasquez, L., Whitford, A., Fowler, H.J. GSDR-I: An Observation-Based Dataset of Global Sub-Daily Precipitation Indices. Scientific Data, in press.	Newcastle, Bergen

Indices for specific Demonstrators only:

Hazard indices	**Description/Calculation**	**Critical sector of exposure**	**References**	**Demonstrator(s)**
Q100 Annual	(1) Daily discharge for each climate experiment are produced for a 130 year period (e.g. 1970-2100) (2) Annual maximum river discharge were selected and a Gumbel distribution was fitted on time slices of 30 years From the distribution, the peak corresponding to the 100 year return period is calculated	Flooding, infrastructure	Alfieri et al. 2015a, b Forzieri et al. 2016a, b Already calculated by ICTP – Extract for individual demonstrator cities	Bergen, Prague, Barcelona
Météo France Index	A heat wave occurs when the mean temperature is greater than 25.3 °C and at least > 23,4 °C for 3 consecutive days and always above 22,4 °C	Human health, ecosystems	https://meteofrance.com/	Paris ONLY
H-ASI	Stagnant days defined as days on which three conditions are met simultaneously: Daily precipitation accumulation < 1mm/day, Daily mean (10m) near-surface wind speed < 3.2m/s, Daily mean 500hPa wind speed < 13m/s.	Air quality	Horton, D. E., Skinner, C. B., Singh, D., & Di enbaugh, N. S. (2014). Occurrence and persistence of future atmospheric stagnation events. Nature climate change, 4(8), 698-703.	Prague ONLY
Meteo Cat Number of heat events and	MeteoCat definition of temperature threshold is 98th percentile compared to last decade of June-August average max temperatures (calculated for June-August	Heatwaves, Human health		Barcelona ONLY

heat waves	2012-2021 period). A heatwave is a period of 3 or more consecutive days above this threshold. A heat event is 1 - 2 consecutive days above this level.			

3.5 Progress Beyond State of the Art

The table contains for the first time a set of hazard indices developed specifically with and for city-level decision-makers in Europe.

3.6 Discussion and Next Steps

The next steps in this work will be to develop methods for assessing chosen hazard indicators at local scales on timescales of sub-seasonal to thirty years from multiple lines of evidence, including existing data and regionalised data from WP3, and to develop these eventually into a web-based tool to be delivered as deliverable WP4.4.

4 Impact

The deliverable may have impact beyond the project as it can be used for other stakeholder groups and cities in Europe to define relevant extreme weather hazards.

5 Links Built

Links were built with WP6 to deliver this deliverable.

6 Communication, Dissemination and Exploitation

CDE activities were not carried out at this time.

6.1 Peer Reviewed Articles

No publications will result from this deliverable

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IMPROVING NEAR-TERM CLIMATE PREDICTIONS FOR SOCIETAL TRANSFORMATION

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