H_2O HEAT–HEALTH OUTDOORS

A personalized Heat-Health Risk Assessment Tool

PERSON-CENTRIC
Individual vulnerability matters.

REAL-TIME
Live data. Real-time assessments.

RISK AWARENESS
Early warnings to save lives.

ACTIONABLE ADVICE
Personalized guidance for better decisions.

FOR EVERYONE, EVERYWHERE

- Outdoor Workers
- Elderly
- Children
- Pregnant Women
- People with Pre-existing Illnesses
- Travelers & Tourists

CLIMATE CHANGE IS ACCELERATING
Extreme heat events are becoming more frequent and intense.

VULNERABLE POPULATIONS
Need personalized insights, not generic warnings.

REAL-TIME DATA + SMART TECHNOLOGY
Enable timely decisions that protect health and save lives.

H_2O EMPOWERS INDIVIDUALS
With personalized risk information and actionable guidance.

H_2O: Transforming Heat Risk into Health Resilience. Real-Time. Personalized. Actionable.

Heat-**H**ealth **O**utdoors

1. Introduction

Heat is a growing major health risk worldwide due to global warming, temperature extremes, urbanisation, and aging populations. According to the IPCC 6th Assessment Report, climate change is projected to significantly increase population exposure to heatwaves and heat-related morbidity and mortality.

The H_2O project is a mobile phone based human biometeorology framework that implements a **H**eat **E**xposure **A**ssessment for **R**esilience & **T**hermal comfort **(HEART)** System designed to provide element (person) specific assessment of the potential heat impact on human health and well-being in real time and provide warnings and alerts of the potential heat risks of the hot weather. The HEART system is a multifactorial heat health framework. While the minimal implementation that is H_2O Basic ($H_2O\beta$) considers only environmental and meteorological factors alongside fixed, anonymous physiological state, the standard version ($H_2O\sigma$) integrates weather, individual-physiological and demographic factors, activity and exposure data, and behavioral and socioeconomic factors to provide real-time heat-health risk, threshold alerts (warnings) and tailored protective recommendations. The advanced (H_2O+) and futuristic (H_2O++) versions of the H_2O framework will include advanced features and complex enhancements to improve the accuracy of the real-time heat-risk assessment, as well as short-term forecasting of heat stress and heat waves.

Data and methods are briefly described in Section 4. Provision of the physiological, demographic and socioeconomic data to H_2O's heat-health server is completely voluntary and is the sole discretion of the element (person). Without elements' legal consent, such data WILL NOT be used to calculate heat stress in any circumstances whatsoever. However, without these personal data, the user will be able to use only $H_2O\beta$.

This document does not purport to be comprehensive, whether by design or intent. In particular, there is insufficient detail on the data and methods. The main intent of this document is to provide a framework for the implementation of a digital heat-health real (near real) time

assessment. Details about data acquisition, curation, method and implementation would be developed in the different phases.

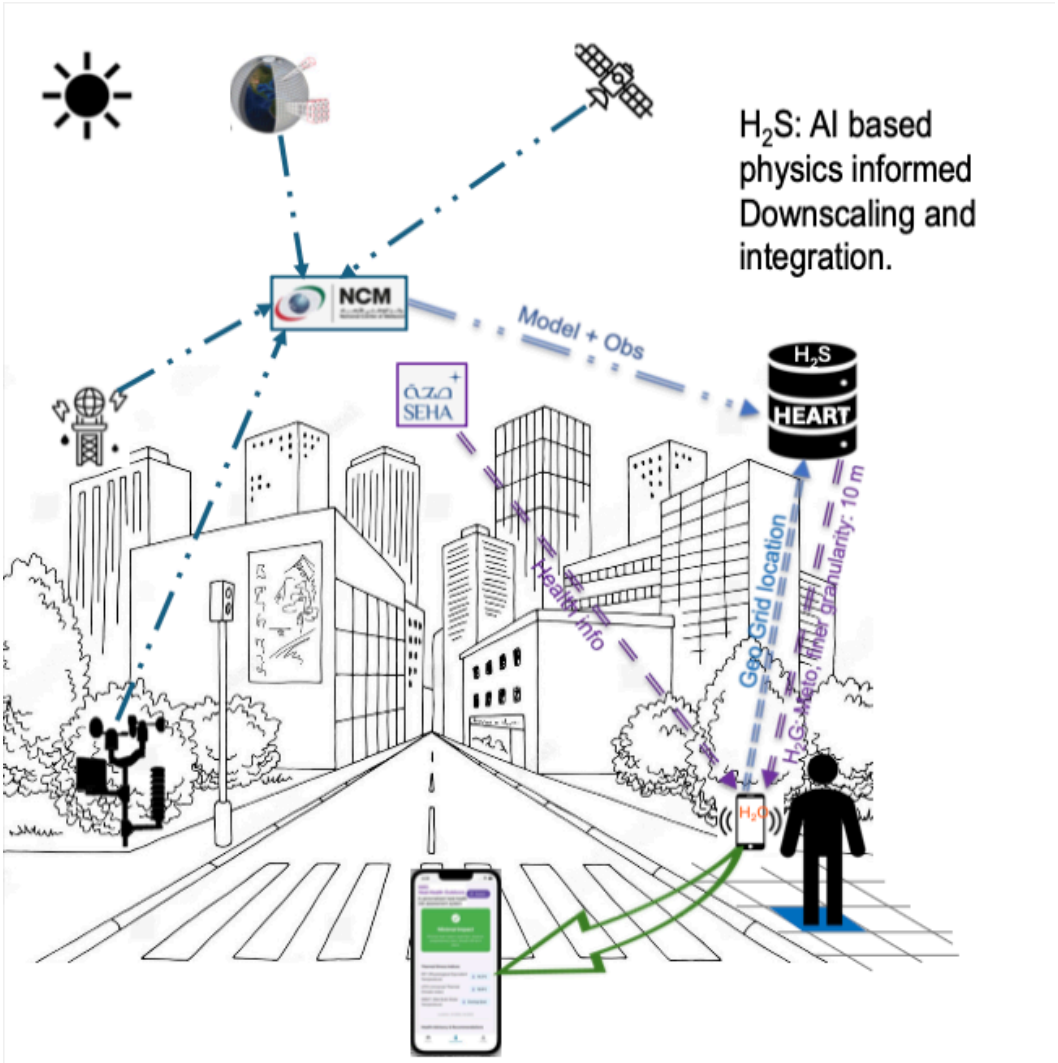

Figure 1. Schematic of the human-centric element(person) specific online real(near real) time digital heat-health risk assessment system, H_2O. The basic version $H_2O\beta$ will leverage data from "OpenMeteo". Subsequent versions of the H_2O will utilize data from NCM and SEHA/DOH. H2O_App

1.1 Objective: *Provision of human-centric element (person) specific online digital heat-health risks assessment, heat-warnings and advisory system in real time.*

1.2 Who should use the H_2O-based digital heat-health risk assessment system:

The system is designed for virtually anyone exposed to extreme temperatures, in particular those vulnerable to extreme outdoor environmental conditions, such as children, the elderly, people with pre-existing diseases, pregnant women, as well as outdoor workers in construction, agriculture, and service sectors who face heightened exposure to extreme temperatures. The H_2O will also be useful for tourists and travelers whose bodies may not be properly acclimatized to local weather conditions.

2. Main components of the HEART System:

A. **Heat Stress Calculation**: Calculate Outdoor thermal index (main candidates: physiological equivalent temperature (PET), Universal Thermal Climate Index (UTCI), and Wetbulb Globe Temperature (WBGT).

B. **Heat Impact Assessment:** The HEART utilizes the OTC category (thermal stress level) of the element from 'A', and other heat vulnerability factors of the element as described in section 1, to generate a brief report to inform potential heat health risks as well as threshold alerts/warnings..

C. A color-coded chart as follows:

- **Green:** Minimal impact expected, but the element preparedness plans should still be in place.
- **Yellow:** Heat conditions may affect particularly vulnerable elements.
- **Amber:** Expected to impact the entire health of the element.
- **Red:** Indicates a significant risk to life for the element, necessitating an emergency response.

D. **Advisory:** Based on 'A' and 'B', the HEART system provides a heat health advisory that contains interventions such as cooling breaks, hydration, clothing adjustments, cooling shelter, medical help, and an emergency preparedness plan to the elements.

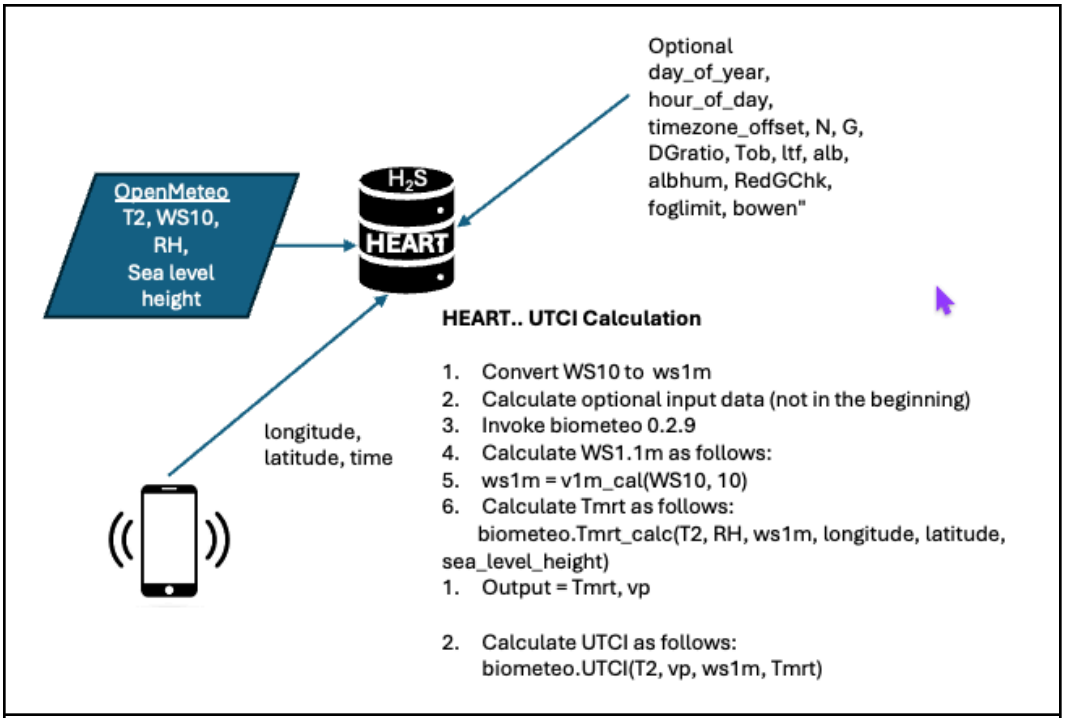

Figure 2: Schematic describes how Heat Exposure Assessment for Resilience & Thermal comfort (HEART) system works to assess thermal stress for the H2O system.

3. Implementation of the HEART System in H_2O:

3.1 $H_2O\beta$ *(Basic)*

The basic version of the H_2O has a more general heat-health assessment without any element-specific physiological and demographic data. The LOD 1 (level of detail 1) version of the digital heat-health risk assessment system. The HEART System in $H_2O\beta$ will perform three tasks 2(A), 2(B), 2(C) and 2(D). The application of the HEART integrated $H_2O\beta$ will be as follows:

a) The element opens the **H_2O** App on his/her mobile.

b) The H_2O App shares the location of the smartphone to the heat-health server that maintains the following updated data of the element:

- AI-enhanced real-time synthetic observations of up to 2 m spatial resolution.
- Python-based OTC and HEART System code

c) The HEART system executes the heat-health risk assessment code and performs tasks from 2(A) to 2(D). The HEART output consists of the following information, which is then passed on to the H_2O of the element's phone ID.

- Outdoor thermal stress level of PET, UTCI, and WBGT at that location in real time.
- Heat-health risks along with heat alert/warning
- Advisory: Leveraging information from (a) and (b) provides advisory/ instruction/guideline to the individual, on whether to:
    - have no heat risks
    - change the work he/she is currently doing
    - change position/location (e.g., going under shade, move to cooling center, or remain inside home or air conditioned environment
    - cooling breaks, hydration, clothing adjustments, cooling shelter, medical help, and an emergency preparedness plan to the elements.

3.2 $H_2O\sigma$ *(Standard)*

The standard $H_2O\sigma$ is the Level of Detail 2 (LOD 2) version of the digital heat-health risk assessment system. It will leverage real(near real) time weather data from the National Center of Meteorology (NCM) UAE, along with element-specific physiological, ~~demographic~~, and socioeconomic data. These inputs will be fed into **HEART** to carry out tasks from 2(A) to 2(D) for an extended and enhanced element-specific heat-health risk assessment.

Data:

a) Meteorological (NCM): model forecast, obs. (in-situ & remote-sensed) *

b) Individual's personal info, socio-economic and health data.*

Salient Features:

- Heat Stress Level (Color Coded); 10 m resolution, actual health and personal data.
- Heat Alert
- Heat Advisory
- Both Cold – Hot Categories.
- H2 Risk assessment for a given location -48-hour forecast.

3.3 H_2O+ *(Advance)*

This is the advanced version of $H_2O\sigma$, corresponding to Level of Detail 3 (LOD 3) of the digital heat-health risk assessment system, which introduces several enhancements and improvements over the standard $H_2O\sigma$.

a) Everything in $H_2O\sigma$

b) More detailed element-specific, accurate calculation of HTC by including the following parameters in the calculation of PET and UTCI.
   - human geographical tolerance index
   - location of the phone bearer in the shade or under the sun with no shade

c) Enhancement and improvement of the Application console
   - **AI based humanoid Heat-Health Assistant (H_2A):** In addition to displaying the assessment, warning and interventions, an AI-based humanoid Heat-Health Assistant (H_2A) would interact with the element, communicate all the information to the element and answer his/her questions about the assessment/warning/advisory. The H_2A will be able to communicate with the element in at least three languages: Arabic, English, and Hindi/Urdu

d) Heatwave Forecast – 72 hour lead time

e) Advisory (additions)
   - water or other fluid intake and food intake,
   - clothing suggestions
   - Seek medical assistance

* subject to the legal and collaboration agreements with NCM and SEHA

3.4 H_2O++ *(Futuristic)*

The futuristic version of the digital heat-health risk assessment system corresponds to Level of Detail 4 (LOD 4). The H_2O++ has the following enhancements and improvements over H_2O+:

a) Everything in $H_2O\sigma$ & H_2O+
b) Improve human thermoregulation and physiological models by including the following real-time physiological information
   - heart-beat rate
   - pulse
   - blood pressure
   - sugar level
c) Forecast potential heatwave event for a lead time of 72 hours.
d) Forecast OTC and provide heat-health risk assessment for a lead time of 72 hours.
e) Air quality index at the Element location
f) Air quality index with a lead time of 72 hours.

4. Data and Methods

4.1 Data for $H_2O\beta$

a) The meteorological data for $H_2O\beta$ will be obtained from OpenMeteo**,** an online public weather forecast service that provides forecasts from multiple global models. **OpenMeteo** utilizes four global models, ECMWF, ICON Global, and GFS, allowing users to select their preferred model. For LOD 1, $H_2O\beta$, we will use the ECMWF global forecast model, which offers a spatial resolution of 9.0 km.

Data for $H_2O\sigma$ and subsequent LODs

c) The meteorological data for the H_2O Standard, and subsequent versions, will be obtained from the National Center of Meteorology(NCM) from the following sources

- NCM's Observational Network
- NCM's Model forecast with a spatial resolution of 3 km.
- Remote-sensed Satellite observations.
- Remote-sensed Radar observations from NCM

d) The physiological data will be obtained from the health care network of the UAE (SEHA).

4.2 Methods for all LODs of H_2O

a) Utilize attention-based Graph Neural Network (GNN) (Li et al., 2023) to increase the spatiotemporal resolution of the **OpenMeteo** forecast to a few-meter resolution. The GNN will be trained on historical weather data from ERA5 for the period from 1990 to 2022 on seven atmospheric parameters.

b) The thermal indices of PET, UTCI WBGT will be calculated using a Python-based biometeorology package "Biometeo" Chen et al. (2023), and "pythermalcomfort" Tartarini et al. (2020).

5. Benefits of the H_2O driven HEART System

Saves Lives: By providing timely warnings and enabling rapid responses, HEART will significantly reduce heat-related mortality and morbidity.

Builds Resilience: H_2O will enhance an element's ability to cope with and adapt to extreme heat events, which are increasing due to climate change.

Minimizes Economic Loss: Preventing heat-related illnesses can reduce the burden on healthcare systems and protect economic productivity.

Supports Adaptation: The H_2O promotes a broader societal adaptation to heat, fostering more effective heat risk management.

6. Caveats

a) Permissions and Licenses?

b) Element's consent, legal burden and cybersecurity?

c) Funding for the project?

d) Funding for the operational (fixed and variable) cost?

7. References:

Li, P., Yu, Y., Huang, D., Wang, Z. H., & Sharma, A. (2023). Regional Heatwave Prediction Using Graph Neural Network and Weather Station Data. *Geophysical Research Letters*, *50*(7). https://doi.org/10.1029/2023GL103405

Chen, Y. C. (2023). Thermal indices for human biometeorology based on Python. *Scientific Reports*, *13*(1), 20825.

Tartarini, F., & Schiavon, S. (2020). Pythermalcomfort: A Python package for thermal comfort research. *SoftwareX*, *12*, 100578.