Due: 24 Sept 2025

Energy: Science, Technology, and Society

Problem Set 3

Indicate assistance obtained with each of the tasks defined below, e.g., by naming web source (Wikipedia, Google/Gemini, ChatGPT,…) and a (summary) prompt.

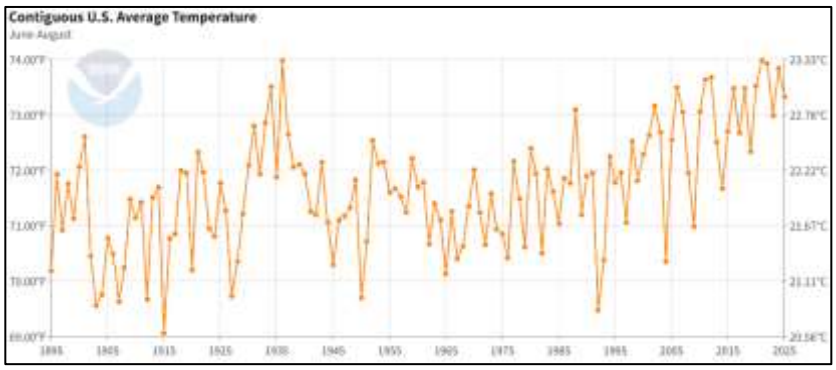
1. World-Hunger Mitigation, Strategic Options & Dilemmas

To reduce present World malnutrition and stem future increases, several strategies were mentioned in class, together with 3-4 corresponding optional actions supporting each strategy.

a) Identify technical hurdles and ethical dilemmas for each strategy. Write down brief explanations.
b) Consider and rate the strategies in terms of global systemic impact and feasibility.
c) Identify strategies that could produce immediate progress in mitigating World Hunger, if implemented.
d) Identify strategies that address potentially existential challenges to civilization.

2. Statistical Analysis of U.S. Surface Temperatures

The United States National Oceanic and Atmospheric Administration (NOAA) tracks and publishes climate data, including the changes in mean surface temperatures for the U.S. The graph shows raw data for the average summer temperature <***T***(t)> in the U.S. vs. time (t). Depicted in the graph is a time period from near the start of the heavy industrialization of the U.S. (**t** = 1895) to today (**t** = 2024). The following numerical tasks can be performed with spreadsheet utility software like MS Excel, or with the tools available on the NOAA sites.



a) Access and download actual numerical data for 3-months (June-August) averaged mean summer temperatures from the NOAA web site at URL

https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/national/time-series

b) Briefly describe the general trends with time seen in the mean U.S. summer temperature data.

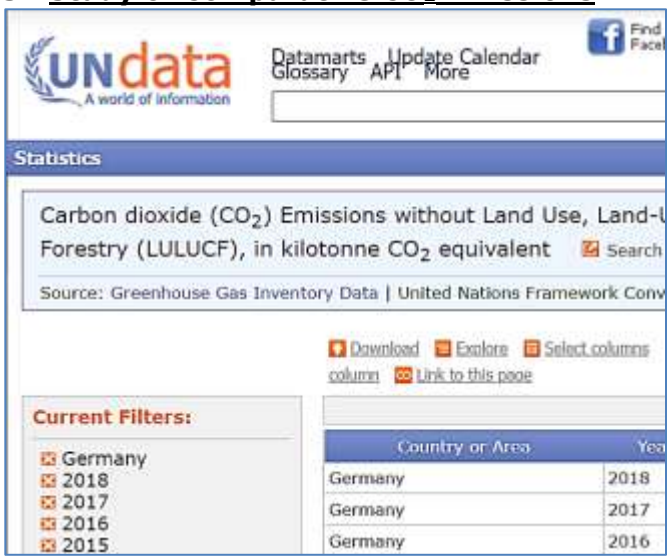
c) Divide the data set into the 30-year periods, an early period $1895 \le \boldsymbol{t} \le 1925$, 2 mid-ranges, $1925 \le \boldsymbol{t} \le 1955$ and $1955 \le \boldsymbol{t} \le 1995$, and a late 30-year period $1995 \le \boldsymbol{t} \le 2025$. Calculate the statistical mean temperatures $<\boldsymbol{T}>$ and the standard deviations σ_T (variance $= \sigma_T^2$) for each of the periods.

d) For each of the time periods, sort the data into a series of sequential $\Delta T = 0.5^0$-wide **bins** centered at $T_i = T_0 + i \cdot \Delta T$ ($i=1,2,\ldots$) with $T_0 = <T(1895\text{-}1925)>$. Normalize the frequency distribution of the temperature data (#events i in a given bin T_i) and plot the resulting probability distribution $\boldsymbol{P}(T_i)$ vs. $T_i - T_0$. (*In MS Excel, an appropriate data sorting function (FREQUENCY) is available for this task.*)

e) Compare the probability distributions for the above four time periods with Gaussian (Normal) functions $G(T_i) = \left(2\pi\sigma_T^2\right)^{-1/2} \exp\{-\left(T_i - <T>\right)^2 / 2\sigma_T^2\}$ with the same mean $<T>$ and variance σ_T^2 as the data. You may use the MS Excel function NORMDIST.

f) Are the mean US summer temperatures observed in the last 30 years consistent with the profile that was normal in the past? Base your arguments on the data.

3. Study of Comparative CO_2 Emissions



Obtain experimental data for the total CO_2 emission rates (in kt CO_2/a) published by the U.N. (data.un.org) for Japan, the U.S., France and Germany, for the years 1990-2020. Populations of the respective countries are 1.33B, 0.33B, 0.06B, and 0.08B. Access data at (UNdata | record view | Carbon dioxide (CO₂) Emissions without Land Use, Land-Use Change and Forestry (LULUCF), in kilotonne CO₂ equivalent)

More extensive database is available at https://data.worldbank.org/indicator/EN.ATM.GHGT.KT.CE.

a) Use the MS Excel (or similar) data analysis utility to calculate and plot the annual emission rates per capita.

b) Compare the patterns observed for the four countries, i.e., discuss values per capita and the trends in time.

c) Propose some likely qualitative reasons for the observed trends.