THESIS Population Exposure Tool

(1) Role within THESIS

Given an ensemble of gridded urban and rural temperature projections, and given gridded population projections, this tool computes heatwave days at each grid cell and population exposure to heat-related extremes.

(2) General description

This tool computes heatwave days at each grid cell of the global land region over the CESM grid, for a current 20-year period (1986-2005) and a future period (2061-2080). It then computes exposure to heatwave days by matching to those heat wave day counts current and future spatially resolved population counts at the same grid cells.

As an initial configuration, we consider temperature projections under RCP4.5 and RCP8.5, and population projections under SSP3 and SSP5. We also consider the effects of urban heat islands, by defining heat wave days using rural, urban or average temperatures in each grid-cell. The temperature projections come in the form of an ensemble of 15 alternative future trajectories under each RCP. The different projections are generated solely as the effect of internal variability.

We compute aggregated statistics of population exposure and how it changes as a function of climate (RCP) and demographic development (SSP) for large regions and at the global aggregated scale.

See the citation for details on the analysis, like the definition of heatwave day, the nature of the ensemble projections, the grid resolution and how the population projections are allocated to the CESM grid (pre-requirement).

Citation: Jones, B, et al. Avoiding population exposure to heat-related extremes: demographic change vs. climate change. Submitted to Climatic Change (soon).

(3) Specific features

(3.1) Code description

 A driver/master csh script, population_exposure.csh, which in turn calls four R-code sub-scripts: process_temps_general.r, collect_temps_general.r, readPOP_computeEXPO_general.r, and regionalize_general.r.

(3.1.1) population_exposure.csh

   * goal: the master/driver script which runs four underlying R-code scripts in a particular order (see below)

* input: none directly, but see subprograms below
* output: none directly, but see subprograms below

(3.1.2) process_temps_general.r

* runs multiple times, once for each of 14 ensemble members (numbered 2 through 15). This code ingests daily temperature model output derives numbers of heatwave days per year for each gridcell on the global grid.

* input: netCDF file data for 14 ensemble members (numbered 2 through 15) containing daily temperature model output
* output: files containing heatwave days...
  note: a subdirectory is created to store output data: ./Rdatasets
  .../Rdatasets/RData_heatwavedays_TREF_U_R_em<n>
  .../Rdatasets/RData_heatwavedays_TREF_R_R_em<n>
  .../Rdatasets/RData_heatwavedays_TREF_U_U_em<n>
  .../Rdatasets/RData_heatwavedays_TREFHT_em0<n>
  .../Rdatasets/RData_modelcoo
  .../process_temps_general.out.<n>   (stdout from R code)

(3.1.3) collect_temps_general.r

* goal: construct objects containing all members' results.
* input: heatwave days for individual ensemble members (output of previous code)...
  .../Rdatasets/RData_heatwavedays_TREF_U_R_em<n>
  .../Rdatasets/RData_heatwavedays_TREF_R_R_em<n>
  .../Rdatasets/RData_heatwavedays_TREF_U_U_em<n>
  .../Rdatasets/RData_heatwavedays_TREFHT_em0<n>
  .../Rdatasets/RData_modelcoo
* output: combined heat wave day data...
  .../Rdatasets/RData_heatwave_pop_days_TREF_R_R_allems
  .../Rdatasets/RData_heatwave_pop_days_TREF_U_R_allems
  .../Rdatasets/RData_heatwave_pop_days_TREF_U_U_allems
  .../Rdatasets/RData_heatwave_pop_days_TREFHT_allems
  .../collect_temps_general.r.Rout (stdout from R code)

(3.1.4) readPOP_computeEXPO_general.r

* goal: read in population data, data generated in the previous steps, and computes population exposure.
* input: (output of previous code)...
  .../Rdatasets/RData_heatwave_pop_days_TREF_R_R_allems
  .../Rdatasets/RData_heatwave_pop_days_TREF_U_R_allems
  .../Rdatasets/RData_heatwave_pop_days_TREF_U_U_allems
  .../Rdatasets/RData_heatwave_pop_days_TREFHT_allems
* output:
  .../Rdatasets/RData_heatwave_pop_days_TREF_R_R_allems
  .../Rdatasets/RData_heatwave_pop_days_TREF_U_R_allems
  .../Rdatasets/RData_heatwave_pop_days_TREF_U_U_allems
  .../Rdatasets/RData_heatwave_pop_days_TREFHT_allems
  .../readPOP_computeEXPO_general.r.Rout (stdout from R code)

(3.1.5) regionalize_general.r

* goal: aggregates the results of the exposure computed at gridpoints into regional summaries.

* input:
  .../Rdatasets/RData_heatwave_pop_days_TREF_R_R_allems
  .../Rdatasets/RData_heatwave_pop_days_TREF_U_R_allems
  .../Rdatasets/RData_heatwave_pop_days_TREF_U_U_allems
  .../Rdatasets/RData_heatwave_pop_days_TREFHT_allems
* output:
  .../Rdatasets/RData_all_likelihoods
  .../PICS/*.jpg   (result plots for various regions)
  .../regionalize_general.r.Rout (stdout from R code)

(3.2) Running the tool

On the unix command line, one command executes the entire process:
unix> population_exposure.csh >& population_exposure.out &