

OFFSHORE-TO-NEARSHORE WAVE TRANSFORMATION

Overview

This program processes wave data from an input CSV file, computes nearshore wave parameters at a specified depth using linear wave theory enhanced with refraction and shoaling effects, and generates:

- **output.csv** – Contains the computed results for each time step.
- **report.txt** – Provides descriptive statistics of both input and computed variables, including annual maxima.

Computed Parameters

Parameter	Description
L0	Deep-water wavelength: $L0 = g * T^2 / (2\pi)$
L	Local wavelength, solved via Newton-Raphson from $L = L0 * \tanh((2\pi * depth_d) / L)$
kh	Product of the wave number ($k = 2\pi / L$) and local depth (<code>depth_d</code>)
alpha_offshore	Signed offshore wave obliquity (crest-to-coast difference in degrees), considering approach relative to the coastline.
alpha_local	Local wave angle (degrees) after refraction, derived using Snell's law.
mwd_local	Local mean wave direction (degrees), adjusted from offshore <code>mwd</code> based on the change in wave angle (<code>alpha_offshore - alpha_local</code>).
Ks	Shoaling coefficient, $Ks = \sqrt{Cg0 / Cg}$.
Kr	Refraction coefficient, $Kr = \sqrt{\cos(alpha_offshore) / \cos(alpha_local)}$.
Hb	Breaking wave height (Miche, 1944): $Hb = 0.142 * L * \tanh(kh)$.
swh_local	Local significant wave height, calculated as the minimum of the transformed height (<code>swh_offshore * Ks * Kr</code>) and the breaking height (<code>Hb</code>).

Note: Waves arriving from directions between `coast_dir` and `coast_dir + 180°` (clockwise, i.e., from the land side relative to the specified coastline orientation), or waves with non-positive offshore height (`swh <= 0`), result in `swh_local` and other derived local parameters (`L`, `kh`, `alpha_local`, `mwd_local`, `Ks`, `Kr`, `Hb`) being set to **zero** for that time step.

Results (Report File)

The `report.txt` file includes:

- The exact command line used to invoke the program.
- **Descriptive Statistics:** For each variable (input and computed), the report provides:
 - Count
 - Mean
 - Standard Deviation

- Minimum & Maximum
- Median (50th percentile)
- Percentiles: 1%, 10%, 25%, 75%, 90%, 99%
- **Annual Maxima:** A table showing the maximum `swh_offshore` and `swh_local` for each year present in the data, plus the overall maximum across all years.

Important Note on Statistics:

- For the variables `alpha_local`, `swh_local`, `mwd_local`, `Ks`, `Kr`, and `Hb`, the descriptive statistics (count, mean, stddev, min, max, percentiles) are calculated **excluding** any time steps where the computed `swh_local` is zero. This effectively removes waves originating from the land side or those with zero initial offshore height from these specific statistical summaries.
- Statistics for all other variables (`swh_offshore`, `mwd_offshore`, `pp1d`, `L0`, `L`, `kh`, `alpha_offshore`) include all valid input time steps.

Directional Statistics (`mwd_offshore`, `mwd_local`): A hybrid approach is used:

- **Circular Mean** and **Circular Standard Deviation** are computed using the unit-vector method.
- Minimum, Maximum, Median, and Quantiles are calculated using ordinary linear statistics on the angles wrapped to the range [0, 360).
- For `mwd_local`, these statistics also exclude time steps where `swh_local` is zero, consistent with the note above.

Usage

```
./transpose input_csv coast_dir depth_d
```

Arguments:

- **input_csv** : CSV input file (with columns: `datetime`, `swh`, `mwd`, `pp1d`)
- **coast_dir** : Coastline orientation in degrees (clockwise from North)
- **depth_d** : Local depth (meters)

CSV Input Format

The input CSV file should be comma-separated with at least the following columns:

```
datetime, swl, mwd, pp1d, [additional columns ignored]
```

CSV Output Format

The generated `output.csv` will contain the following comma-separated columns:

```
datetime,swh_offshore,mwd_offshore,pp1d,L0,L,kh,alpha_offshore,alpha_
```

Compilation

To compile the program, use the following command:

```
g++ -O3 -fopenmp -march=native -std=c++17 -Wall -Wextra -  
pedantic -Wconversion -Wsign-conversion -static -static-  
libgcc -static-libstdc++ -lm -o transpose transpose.cpp
```

This command enables **optimizations** and includes several **compiler warnings** to ensure code quality.
