

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

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

---