Characterizing the Near Shore Wave Energy Resource on the West Coast of Vancouver Island, Canada

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WEST COAST VANCOUVER ISLAND SWAN MODEL

Global wave energy inventories have shown the West Coast of Vancouver Island (WCVI) to possess one of the most energetic wave climates globally, yet efforts to quantify this resource have been limited. UVI’s West Coast Wave Initiative (WCWI) endeavors to investigate, measure, and quantify this resource for wave energy development by running a SWAN version 40.91AB model executed in non-stationary model using 3 hour time steps. The model hindcasts wave conditions over the 2005 to 2012 target period.

In order to maintain computational efficiency, while retaining high resolution in near shore when small scale wave seafloor interaction transformations occur, an unstructured grid of 9449 points was developed. The spatial grid distribution was determined a convergence analysis on the basis of Hm0, and has a larger spacing limit of 75m.

SWAN Model Set-up

Unfortunately, directional wave measurements appropriate for boundary conditions are not available for the WCVI region. The best alternative was to synthesize boundary conditions based on publically available FNMOC and NCEP Wave Watch 3 (WW3) nodes. Assuming a JONSWAP spectrum, and using the parametric Hm0 and T1/3, 30 individual frequency variance density spectrums were synthesized by varying the peakedness factor $\gamma$, from 1 to 7, in 0.2 increments. The final JONSWAP spectrum was determined by minimizing the RMSE between the synthesized spectrums and those directly measured at the Brooks buoy. These were converted into directional spectra by assuming $\frac{\gamma}{2}$ directional spreading - this process was completed for both WW3 models. For wind input conditions for the SWAN model, the FNMOC WW3 results are paired with the COMAPS wind model, while the NCEP WW3 results feature their own wind model.

To determine the optimum SWAN boundary conditions, both combinations of synthesized wave boundary conditions and local winds were run for the entire 2010-2011 test period and the modeled Hm0 and T1/3 were compared against those directly measured at the Brooks and La Pernce buoys. The FNMOC/COMAPS boundary condition combination performed better than the NCEP model and hence was used for all future computations.

CHARACTERISTIC QUANTITIES FOR WAVE ENERGY CONVERTERS

The SWAN model directly outputs many standard parameters for characterizing a sea state and wave response; these include the significant wave height (Hm0), the peak wave period (T1/3), the energy period (TE), the spectral peak direction ($\theta$) and the omnidirectional wave energy transport ($J$).

However, when investigating potential wave energy development sites, a series of additional metrics are used to further describe the sea state for wave energy conversion. These include:

- Directional Resolved Wave Energy Transport: $J_\theta = \rho g \sum_j H_j \cos \theta_j \cos^2 \theta_j$ where $H_j$ = [0 if $\cos \theta_j > 0$] $\geq 0$; $\theta_j$ = [0 if $\cos \theta_j < 0$] $\geq 0$
- Frequency Spectrum Width: $T$ = Direction of Maximum Energy Transport: $D$ = Directional Coefficient: $d = \frac{J_\theta}{J_{TE}}$

The SWAN model target hindcast used measured sea state conditions, for boundary conditions, over the 8 year period between 2005-2012. As a result, it is important to ensure this period is representative of the long term wave climate.

The combined probability density function for the target period and the full dataset for the La Perouse buoy shows excellent correlation. Above 7m, the two curves diverge slightly yet this condition corresponds to < 1% of total energy transport. However, these conditions are important when looking at survivability and extreme loading events.

QUANTIFYING THE WAVE CLIMATE

West Coast Climate Characteristics

The WCVI region is an extremely energetic wave environment and features approximately 45 kWe/m of energy transport along the continental shelf. However, this study reveals the significant spatial variation of wave energy transport in near shore locations.

Ucluelet, British-Columbia is often noted as an area of high wave energy transport, due to interaction with the weather, and is as a result of great interest to many wave energy developers.

Amphitrite Bank Temporal Characteristics

The seasonal variability of the wave climate surrounding Ucluelet, BC is dramatic and has significant consequences on energy production and WEC design. As a result, a detailed understanding of the temporal wave climate is paramount. From the 8 year hindcast, the mean monthly wave characteristics provide some interesting results:

- Directional wave energy transport has a maximum of 49 kW/m in January, while August features only 10 kW/m.
- Wave period values remain relatively constant throughout the year, varying from 10.2 sec (Dec) to 10.8 sec (Aug).
- Direction of maximum directional transport remains constant at ~250° throughout the year, while directional spectrum peak directions vary between 160°-285°.
- The directional co-efficient varies very little and remains constant around 0.84.

Shallow Depth Characteristics

As shallow water locations are of great interest to WEC developers, the WCVI team is “prospecting” for high energy locations very close to shore. One initial shallow water location (see above image) provided some interesting results. Slow water locations are of great interest to WEC developers, the WCVI team is “prospecting” for high energy locations very close to shore. One initial shallow water location (see above image) provided some interesting results.

UCLUELET REGION ENERGY TRANSPORT

SEASONAL ENERGY TRANSPORT PARTIAL AMPHITRITE BANK RESULTS BIVARIATE DISTRIBUTIONS

The mean energy transport values may be smaller in shallow areas, yet the reduced energy transport variability and directional spread may be beneficial and indicate preferred operating locations for certain WEC devices.

ACKNOWLEDGMENTS

The work was funded by Natural Resources Canada, the Pacific Institute of Climate Solutions and the National Sciences and Research Council of Canada.

Additional acknowledgement to the dedicated work of the late Michael Westhuysen, Bryson Robertson*, Clayton Hiles, Bradley Buckham

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