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DATA NOTE

REVISED Thermal Efficiency Dataset for OTEC Applications in Cuban Waters

[version 3; peer review: 3 approved, 1 not approved]

Previous title: Thermal efficiency dataset around Cuban seas (TEDACS)

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Abstract

Currently, the generation of electrical energy in Cuba is supported by oil and natural gas. These sources, as it is known, are directly linked to large emissions of pollutants that are released into the environment. Therefore, it is necessary to search for new energy options aimed at sustainable development, allowing the preservation of natural ecosystems. Owing to the location and geographical characteristics of Cuba, it is necessary to assess the energy possibilities of the seas that surround it and to search for the most feasible areas to obtain energy from the sea temperature. This renewable energy source, in addition to being used to generate electricity, can also be used in derived technologies, such as desalination, refrigeration, and aquaculture. Hence, a dataset is presented with the calculation of the Carnot thermal efficiency for the exploitation of thermal energy from the sea, which is based on the Kelvin thermal gradient between the sea in situ temperatures between the shore and the level of depth being analyzed. Outputs of 27 years of daily data from the Copernicus Marine Environmental Monitoring Service (CMEMS) GLOBAL_MULTIYEAR_PHY_001_030 product with a spatial resolution of 1/12° were used. The calculation was made using a Python script of the daily thermal efficiency at depths of 763, 902, and 1062 m, these

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version 3 (revision) 08 May 2025	✓ view	✓ view		
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version 1 10 Jan 2024	? view	? view	✓ view	? view

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depths belong to the depth levels of the model output data used according to the depth ranges that are traditionally studied for the exploitation of sea thermal energy. In this way, 27 files of each level were generated for a total of 81 files in text format separated by commas. Each file is presented with the date, level, coordinates, and thermal efficiency. The dataset is available from the Science Data Bank repository (https://doi.org/10.57760/sciencedb.10037).

Keywords
Thermal efficiency, OTEC technologies, Sea thermal energy, Sea Surface Temperature

Malaysia, Skudai, Malaysia

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REVISED **Amendments from Version 2**

This new version of the manuscript arose from the need to make several changes:

1. A new title was necessary to avoid omissions in reference search engines, as the titles of the article and the dataset were inconsistent.

2. The dataset was updated with thermal efficiency values in Kelvin.

3. The map in Figure 3 was improved with more geographic detail consistent with the bathymetric description.

4. The maps in Figure 9 were updated based on temperature values in Kelvin.

5. The Figure 10 was improved

6. The comments in Figure 9 were updated.

7. Figure 10 was updated.

8. References that had been omitted in version 2 were added.

Any further responses from the reviewers can be found at the end of the article

Introduction

Ocean thermal energy conversion (OTEC) is a renewable energy technology that harnesses the solar energy absorbed by oceans to generate electricity. Heat from the sun warms surface water more than deep ocean water, creating a naturally available temperature gradient in the ocean. OTEC uses warm sea surface water with a temperature of approximately 25°C to vaporize a working fluid, which has a low boiling point, such as ammonia and propane. The vapor expands and turns a turbine coupled with a generator to produce electricity[1]. The steam was then cooled with seawater that has been pumped up from the deepest layer of the ocean, where the temperature was approximately 5°C.

Thermal efficiency is the amount of heat/power used in a Rankine cycle for converting oceanic thermal energy into electrical energy[2]. Among the different approaches used for the analysis of thermal energy efficiency, an approach based on a theoretical limit is used to maximize the efficiency of an OTEC system by converting the heat stored in the warm surface waters of the oceans into mechanical work[1].

According to previous studies, the temperature of the sea surface around Cuba oscillates throughout the year between 26° and 30°, on average. These characteristics indicate the conveniencеof studying the thermal energy of the seas around Cuba[3].

OTEC is a clean and friendly renewable energy with zero emissions, being capable of generating electricity 24 hours a day all year round, providing a reliable source of electricity. Also, multiple advantages are known, allowing to provide food for aquaculture farms, desalination (purification) of seawater, air conditioning of buildings, etc. This technology has been installed for research and development purposes in several regions of the world[4]. Examples of the aforementioned are Saga and Kumejima (Japan), Reunion Island (France), Gosung (South Korea) and Hawaii (USA). Likewise, studies have been carried out on the energy potential of sea thermal energy in Indonesia, Malaysia, the Philippines[4–6], the Gulf of Mexico the Caribbean[7,8] and the Mexican Pacific[9].

The present work exposes the main features of a dataset that contains the computation of Carnot thermal efficiency in the seas surrounding Cuba between latitudes 18.5° and 24.0° and longitudes -73.5° and -85.5°. The objective is to evaluate the study area according to the requirements for obtaining thermal energy from the sea, which must reach values greater than or equal to 0.7 of thermal efficiency[10]. For the computation, 27 years of global ocean reanalysis data from the GLOBAL_MULTIYEAR_PHY_001_030 product of the Copernicus Marine Environmental Monitoring Service (CMEMS) with a spatial resolution of 1/12° were used[11].

With this dataset presented, it is also possible to develop other investigations in the study area to advance the knowledge of the thermal energy potential of the sea to investigate the selection of sites where OTEC plants can be built for the generation of electrical energy, desalination seawater, and other applications.

In the following sections, the methods are presented, which introduce the study area, equation for calculating thermal efficiency, data validation, vertical temperature assessment; dataset with its structure, generated files, and availability of data.

Methods

This study was performed using the output cmems_mod_glo_phy_my_0.083_P1D-m, available for free download from the Copernicus Marine Environment Monitoring Service (CMEMS) GLOBAL_MULTIYEAR_PHY_001_030 (https://data.marine.copernicus.eu/product/GLOBAL_MULTIYEAR_PHY_001_030/services), that simulates the global ocean at 1/12° (approximately 8 km) resolution[11], using the space-time evolution of the 3D thermodynamic variables temperature and salinity (T, S) at four levels: -0.49, -763.33, -902.34 and -1062.44 m. Were downloaded 27 years of these files with the "motuclient-python" tool[12], which were then manipulated and analyzed with the CDO **adisit** function[13], to calculate the temperature in situ from potential temperature and salinity data.

Using the nodes from the data files to calculate Carnot thermal efficiency, the depth levels from these files were also used. The cold sea temperature at a depth of 1000 m is used as a standard for calculating the ocean temperature gradient. Therefore, according to the depth levels of the reanalysis files used, the level 1062.44 m is the closest to 1000 m. On the other hand, due to the high temperatures of the sea surface around Cuba, it was decided to also do the calculation for the 900 and 800 m depth; coinciding, the closest depth levels are 902.339 m and 763.333 m, respectively.

The calculations of the maximum efficiency and the generation of the efficiency maps for each level were performed using Python version 3.9 (RRID:SCR_008394) of Python

language. Therefore, the presented dataset contains the computation of thermal efficiency in the seas surrounding Cuba between latitudes 18.5° and 24.0° and longitudes -73.5° and -85.5°[10].

Brief characterization of the study area

The study area is influenced by the marine current systems that surround it: The Caribbean current, which extends from the arc of the Lesser Antilles to the vicinity of the Yucatan Peninsula; the Yucatan Current, which connects the Caribbean Sea and the Gulf of Mexico; the Loop Current, a flow that joins the Yucatan current and the La Florida current in the eastern part of the Gulf of Mexico; and the Florida Current, from the Straits of Florida to Cape Hatteras, and is considered the beginning of the Gulf Stream. Trend studies have observed that marine flow in the Caribbean Sea has had a slight decrease in magnitude, while in the Gulf of Mexico and the Near Atlantic, there has been a subtle increase[14].

In this area, the average temperature of the sea surface oscillates between 25 and 30°C, with a minimum in February and a maximum in September. The maxima are found over deep waters in the area of the Casilda - Cazones Gulf and south of Isla de la Juventud, towards the central and northern Caribbean area, as well as another maximum north of the western coasts. Extreme minimum values were recorded in the Gulf of Mexico area, with 24° and maximums values of up to 31°. Calculation of the sea surface temperature trend with the reanalysis data used in this research revealed an increase between 0.5° and 2.5° (Figure 1).

The area is also affected by teleconnection events such as the NAO and ENSO, showing a zonal pattern in the correlation between the sea surface temperature and the NAO index six months before the development of the negative and positive phases of the event[15]. In addition, extreme phenomena such as hurricanes and cold fronts affect the Cuban archipelago every year, highlighting the relationship between the intensity of these phenomena and the different phases of the NAO and ENSO[16]. Figure 2a shows the annual spatial distribution of sea surface temperature (SST) in Cuban waters, while Figure 2b and c show the seasonal spatial distribution.

Bathymetric characterization

Cuba is geographically located in the American Mediterranean, between longitudes 74°7'52" W and 84°54'57" W, and latitudes 19°49'36" N and 23°17'9" N (Figure 3). It is bordered to the north by the Gulf of Mexico, Florida Strait, St. Nicholas Channel, and old Bahama Channel; to the south by the western Caribbean Sea and Strait of Columbus; to the west by the Yucatan Channel; and to the east by the Windward Passage[17]. The westernmost and northernmost island platforms contain the Guanahacabibes Gulf, with depths of 5 - 25 m. Less than one mile from the outer edge, the shelf's insular slope drops steeply from 10 to 100 m. Reefs appear parallel to the coast, cut by numerous ravines, and pass between the 5 and 10 m isobaths, which form a chain that obstructs access to the coast. Continuing along the western north of the Cuban archipelago, the insular slope presents an abrupt, steep, and sinuous drop, very close to the coast, which causes the 200 m isobath to be frequently found less than 1 mile from the slope[18].

The island platform, in the northern central zone (from Punta Hicacos to Punta Maternillos), is wide, and its edge generally registers depths between 10 - 25 m; outside the edge of the platform, the depths increase sharply, so the island slope varies from to 20 - 200 m depth in less than one meter of distance. Above this island platform, the most continuous and extensive coral barrier in Cuba extends, with depths of less than 10 m and in many places less than 5 m, with cays and heads that

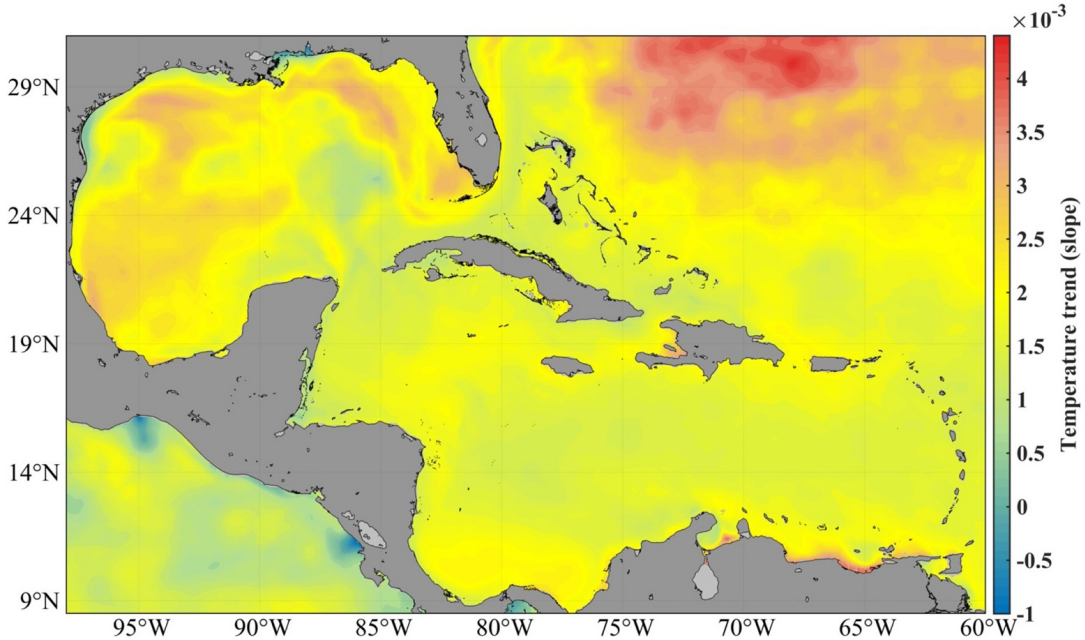


Figure 1. SST trend from GLOBAL_MULTIYEAR_PHY_001_030 product, 1993–2018[11].

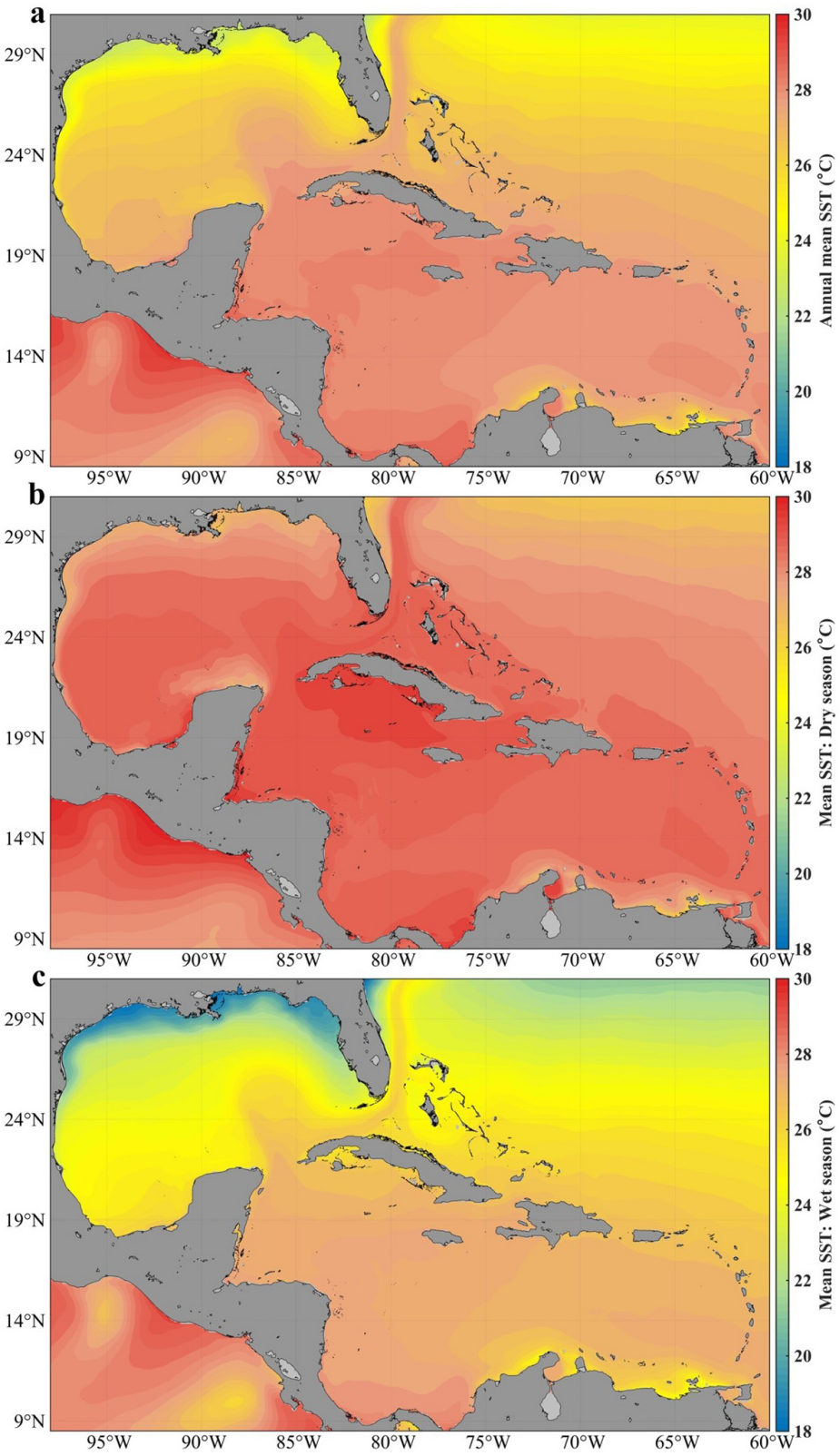


Figure 2. Analysis of the mean sea surface temperature in Cuban waters with the GLOBAL_MULTIYEAR_PHY_001_030 product in the Caribbean Sea and the Gulf of Mexico[11]: a) distribution of the annual mean, **b**) distribution in the dry season, **c**) distribution in the wet season.

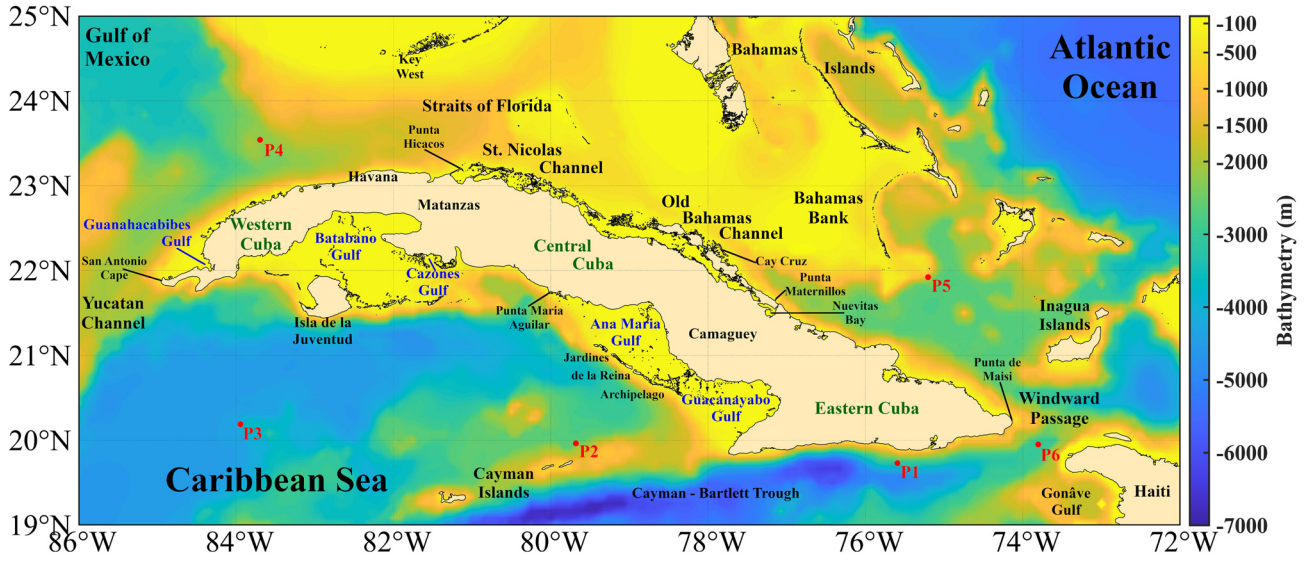


Figure 3. Bathymetry of the seawaters around Cuba taken from the GEBCO Bathymetric Compilation Group[19] under GEBCO 2018 License. P1, P2, P3, P4, P5, and P6 are the points selected for vertical temperature assessment.

emerge. In the northeastern area (from Nuevitas Bay to Punta Maisí), the island platform, less than 10 m in depth, has an edge of 3 miles from the coast. Outside the island shore, there are no shallows, heads, or reefs that are dangerous to navigation, and the depths increase abruptly; the 200 m isobath crosses within one mile of the border throughout the entire region[18].

Continuing along the southeastern area, the entire coast is bordered by a low strait of less than 20 m depth, whose edge corresponds to the vertical slope that the Eastern Trench presents in this part of the coast. The 200 m isobath crosses very close to the coast, over an underwater relief that reaches great depths to the south, so the island platform of the Island of Cuba becomes very narrow, and the slope falls abruptly towards abyssal depths where it is located. The Eastern Trench reaches 7,239 m depth. Further to the west south, in the approaches to the Guacanayabo Gulf from the sea, the depths are great and the 200 m isobath crosses 1.6 miles southwest of Cay Cruz. The isobath is the edge of the island platform, made up of coral reefs submerged at a depth of 20 - 40m. Among these reefs, depths are generally less than 20m, with a gentle slope[18].

Continuing westwards to the south, the Ana María Gulf is separated from the Guacanayabo Gulf by the cays Mate and Laberinto de las Doce Leguas (Figure 3); and to the southwest it is limited by the barrier reef of the Jardines de la Reina Archipelago, which extends 118 miles to the northwest with depths mostly less than 5 m. The greatest distance between the edge of the platform and the coral reef barrier does not exceed two miles. Beyond this, the depths are abyssal, located at distances between 16 and 20 miles, with depths of 22 - 58 m. From the Punta María Aguilar to the Cazones Gulf, the shallow area at less than 10 m depth that borders the coast is very narrow, and there are places where the cliffed coast falls directly to greater depths. Depths of 100 m were recorded 2 miles from the coast and 2,000 m in the central part of the Gulf of Cazones[18].

Next, from south to west, the underwater relief of the Batabanó Gulf has some irregularities due to the existence of cays and shoals with depths between 2 - 5 m (Figure 3). In the central part, the underwater relief of the gulf is gentle, with maximum depths between 6 - 7 m, and a shallow slope. In the westernmost area of the southern portion, from Guano del Este Cay to San Antonio Cape, the slope of the island platform of Cuba falls abruptly towards great depths, finding in many places an isobath of 1,000 m very close to the edge of the platform. Finally, the southern and southeastern coasts of Isla de la Juventud, with steep cliffs, drop abruptly to abyssal depths of 3,000 m[18].

Computation of thermal efficiency

The real thermal efficiency (η_{real}) is obtained by multiplying the Carnot efficiency by the efficiencies of the individual components and subtracting the losses, therefore, an equation of a fairly complete general form can be written to determine the real thermal efficiency as follows: this equation can be written as a general way to compute the real thermal efficiency (Equation 1).

$$\eta_{real} = \eta_{Carnot} \times \eta_{Exchanger} \times \eta_{Turbine} \times \eta_{Generator} - \frac{P_{Pumps} + P_{Anxiliaries}}{Q_{Input}} \quad (1)$$

Where η_{Carnot} is the theoretical maximum efficiency of a Carnot cycle (Equation 2)[20].

$$\eta_{Carnot} = 1 - \frac{T_{Cold}}{T_{Warm}} \quad (2)$$

T_{Warm} is the absolute temperature of the hot source (surface water), T_{Cold} is the absolute temperature of the cold source (deep water), $\eta_{Exchanger}$ measures the ability of a heat

exchanger to transfer heat between two fluids at different temperatures. It is the ratio of the actual heat transferred to the maximum theoretically possible heat transfer[21], $\eta_{Turbine}$ indicates how effectively the turbine converts the thermal or pressure energy of the working fluid into rotational mechanical energy[22,23], $\eta_{Generator}$ measures how effectively the generator converts mechanical rotational energy into electrical energy, Q_{Input} represents the heat absorbed by the system from the hot source, in this case, the surface ocean water, P_{Pumps} is the electrical power consumed by the pumps used to move water from and to different depths in the ocean, and $P_{Auxiliaries}$ represents the power consumed by all auxiliary systems that support the main operation but do not directly contribute to energy production[24,25].

The equation for η_{real}, expressed as the product of several individual efficiencies, is derived by analyzing the contributions of each system component to the overall efficiency[26,27]. Mathematically, this is based on how the available energy is distributed throughout the different stages of the process. The theoretical and practical underpinnings provided for each component of Equation 1 were taken from El-Wakil[28], Incropera *et al.*[21], Karassik *et al.*[24], Moran and Moran *et al.*[20], Chapman[29], Dixon and Hall[22], Yuan *et al.*[23], Çengel and Boles[25], Zhang *et al.*[26], Fontaine *et al.*[30], and Abbas *et al.*[27].

In the most feasible marine areas for the operation of OTEC plants, the average surface temperature of each year is approximately 26.7 to 29.4°C, with cold water available at 4.4°C or less at a depth of 900 - 1000 m[20]. Therefore, even without the inevitable reduction caused by friction and heat loss, the maximum efficiency achieved by heat conversion in an OTEC plant can be reached with a very small rate of energy production. The objective of this research is to study the thermal efficiency of a Carnot cycle. To apply the calculation of thermal efficiency, the approach proposed in the research carried out in was considered, which is based on a theoretical limit, up to a maximum efficiency of an OTEC system through the conversion of heat into mechanical work stored in the warm surface waters of the tropical oceans (Equation 2).

The computation of the Carnot thermal efficiency around Cuba[31] was made without taking into account the characteristics of the coastal relief at the selected points. The calculation process with the data used is described with the following steps:

a. Using the CDO adisit function, the potential temperature from the reanalysis file was converted to in situ temperature.

b. The study area was divided into two zones: northern zone and southern zone.

c. The points on land that had the geographic longitude values of the nodes in the reanalysis file for each zone were located, assigning each one the surface temperature value of the closest node and with the same geographic longitude value to the selected coastal point.

d. The calculation of thermal efficiency with the Equation (1) was applied to each node with temperature Kelvin values at each depth selected for the study, moving in a north (south) direction for the north zone (southern zone).

Vertical temperature assessment

The evaluation of the vertical temperature will be performed by comparing the vertical temperature profiles at 6 points obtained from the GLOBAL_MULTIYEAR_PHY_001_030 product (re-analysis)[11], whose geographical location is shown in Figure 3 and Table 1. The reference vertical profiles were obtained from the MULTIOBS_GLO_PHY_TSUV_3D_MYNRT_015_012 product[12,32] at the same coordinates. The monthly bias is calculated by Equation 3[33] using the compVert software[34].

$$Bias = \frac{\Sigma_{i=1}^{n}(D_i - R_i)}{n} \quad (3)$$

Where D_i are the values of the reference dataset, R_i are the values of the re-analysis dataset, and n is the total of months for which the comparison was made. The MULTIOBS_GLO_PHY_TSUV_3D_MYNRT_015_012 product, developed by the CLS Production Unit (MULTIOBS-CLS-TOULOUSE-FR), offers global Level-4 (L4) analyses of oceanic 3D temperature, salinity, geopotential height, and geostrophic currents from the surface to a depth of 5,500 meters, along with 2D Mixed Layer Depth (MLD) on a 1/4° regular grid. The temperature biases are minimal, particularly during the 2004–2018 Argo period. The root mean square differences range from 0.8°C to 1.4°C at 100 meters depth and from 0.18°C to 0.5°C at 1000 m depth. The expansion of the Argo network does not cause inhomogeneity in ARMOR3D, and the trends and climatic modes remain consistent despite the changes. The thermosteric trend in dynamic height for the [0 – 1,500 m] layer between 1993 and 2018 is approximately 1 mm/year. This trend has not yet been recalculated for the entire period (as of the publication date) but will be updated in the next complete reprocessing revision before the end of 2024.

Analysis of uncertainty in the spatial and temporal distribution of temperature

The Median Absolute Deviation (MAD) is a measure of statistical dispersion that indicates the average distance between each data point and the median of the dataset. It is a robust measure of spread[35], meaning it is less sensitive to outliers compared to the standard deviation. The MAD provides a measure of dispersion or spread of ocean temperatures around the median value. A lower MAD indicates that the

Table 1. Geographical location of the points used for temperature assessment of GLOBAL_MULTIYEAR_PHY_001_030 product.

Name	Longitude	Latitude
P1	75.67 °W	19.75 °N
P2	79.67 °W	19.92 °N
P3	83.92 °W	20.33 °N
P4	83.83 °W	23.50 °N
P5	75.33 °W	21.67 °N
P6	73.75 °W	20.08 °N

temperatures are clustered closer to the median, suggesting a more uniform distribution. Conversely, a higher MAD suggests that the temperatures (T) are more dispersed, indicating greater variability. Analyzing MAD across different ocean regions can reveal patterns in temperature variability. For instance, regions with lower MADs might experience more stable temperature conditions, while regions with higher MADs might exhibit greater fluctuations. The MAD is computed using the mathematical Equation 4.

$$MAD(T) = Median\left|T - Median(T)\right| \quad (4)$$

The MAD is useful for analysing data uncertainty because it is a robust measure of variability[36–38], less affected by outliers compared to standard deviation. By relying on the median rather than the mean, MAD provides a more accurate representation of standard deviation in data sets with outliers. This robustness makes it ideal for assessing uncertainty in situations where data may not follow a normal distribution, ensuring a more reliable estimate of variability. MAD can also be used to identify outliers[39], as data points with large absolute differences from the median are potential outliers[40]; to compare the dispersion of two or more datasets; and to analyze ordinal data, which is data that can be ranked but doesn't have meaningful numerical differences.

The temperature of the GLOBAL_MULTIYEAR_PHY_001_030 product are stored in 4D variable as T(lon, lat, depth, time), to compute the MAD we have set the depth at the surface, 763, 902, and 1062 m. Remaining in 3D as T(lon, lat, time) in four vertical levels, this simplifies the MAD computation. Thus, MAD at the surface can be calculated according to Equation (5).

$$MAD^{z}_{\lambda,\varphi} = Median\left|T(\lambda,\varphi,z,t) - Median(T(\lambda,\varphi,z,t))\right| \quad (5)$$

Where λ and φ are the longitudes and latitudes respectively and t is in time (monthly mean). T is the temperature and SST is the sea surface temperature, both in °C. In Equation 4, Equation 5, and Equation 6, the depth is denoted by z and only values of Z = 0.5, 763, 902, and 1062 m are taken into account. It is also analyzed how MAD varies with respect to longitude over time ($MAD^{z}_{\lambda,t}$; Equation (6) and with respect to latitude over time ($MAD^{z}_{\varphi,t}$; Equation (7). All these parameters will be computed through the gStat software[39].

$$MAD^{z}_{\lambda,t} = Median\left|T(\varphi_j,z,t_k) - \text{Median}(T(\varphi_j,z,t_k))\right| \quad (6)$$

$$MAD^{z}_{\varphi,t} = Median\left|T(\lambda_i,z,t_k) - Median(T(\lambda_i,z,t_k))\right| \quad (7)$$

Data validation

The MODIS Aqua Level 3 dataset encompasses sea surface temperature (SST) information derived from the NASA MODIS sensor situated on the Aqua satellite. SST data were extracted from the thermal infrared spectrum with wavelengths of 11 and 12 µm. After processing, the data is projected onto a cylindrical equidistant map with spatial bins measuring either 4.63 or 9.26 km. This mapping method offers a comprehensive perspective of SST variations across diverse geographical areas[41].

The World Ocean Circulation Experiment (WOCE) program was an ambitious international oceanographic research initiative conducted in the 1990s. With the participation of multiple countries and scientific organizations, the WOCE has focused on mapping and understanding global ocean circulation in detail. Fundamental technical data were collected through an extensive network of buoys, floats, and research vessel expeditions, including measurements of temperature, salinity, ocean currents, and sea level across the oceans. These data provide crucial information for understanding weather patterns, heat distribution on Earth, and ocean current variability, contributing significantly to the improvement of global climate models[42,43].

The *GLOBAL_MULTIYEAR_PHY_001_030 product* is a reanalysis dataset; therefore, it must be validated against observed datasets, and the quality information document for this product must be reviewed[44]. For surface validation, DSCompare v2.1 software was used[35], and the SST was validated using the Mann-Whitney statistical test comparing the global-reanalysis-phy-001-030 product with the observed MODIS Aqua level 3 and WOCE datasets. In both comparisons, no significant differences were found throughout the Caribbean Sea and Gulf of Mexico (Figure 4); the significance level used was 0.05.

Drévillon[44] performed several validations of the GLOBAL_MULTIYEAR_PHY_001_030 reanalysis product, it has regional biases of less than 0.4 °C in temperature with respect to the World Ocean Atlas 2013 climatology (comparisons were made near surface, 100 m, 300 m, 500 m, 800 m, and 2000 m depth) and to in situ observed data; the computed bias was less than 0.1°C global mean with respect to in situ temperatures. The largest biases occurred in the 50 - 100 m layer north of the Atlantic Ocean. The thermal structure improved significantly after 2002 with the deployment of Argo buoys, mainly at depths shallower than 300 m, with an RMSE versus all in situ observations of less than 1°C and a bias close to 0°C and. The RMSE also decreases with time as a function of the density of the network of observations[44]. The differences between the GLOBAL_MULTIYEAR_PHY_001_030 product and observations show that the reanalysis is very stable over the period 2000–2016. There is a small bias of 0 - 0.1°C located between 100 and 200 m. This reanalysis product outperforms climatology in terms of bias and RMS, with lower RMS differences in the 0–500 m layer[44]. In addition, comparisons of this product with observed data from the CORA5 dataset[45,46] and other sources in the years 1993, 1998, 2003, 2008, 2013,

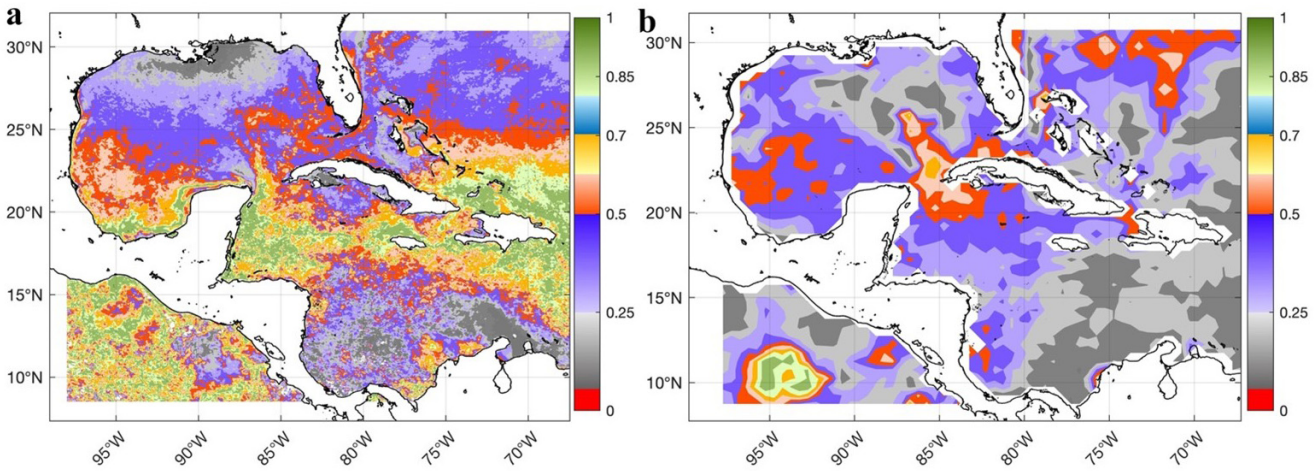


Figure 4. Validation of the SST of the GLOBAL_MULTIYEAR_PHY_001_030 product in the Caribbean Sea and the Gulf of Mexico through the spatial distribution of the p-values of the Mann-Whitney test for a significance level of 0.05: a) Comparison of the SST of the GLOBAL_MULTIYEAR_PHY_001_030 product with the SST of MODIS Aqua level 3 (Probability) and **b**) Comparison of the SST of the GLOBAL_MULTIYEAR_PHY_001_030 product with the SST of the WOCE dataset (Probability)[32].

and 2016 showed that the mean differences tended to 0°C in the Caribbean region.

The thermal efficiency of the ocean is closely linked to the heat exchange between the atmosphere and ocean. Large SST anomalies indicate significant deviations from their mean values, which can lead to a more substantial heat exchange; thus, the accuracy of the Carnot thermal efficiency computation can be affected. Large SST anomalies can also trigger feedback mechanisms in the climate system, further complicating the computation of ocean thermal efficiency. For example, a positive SST anomaly can lead to increased evaporation, which in turn affects heat fluxes and vertical temperature variation in the oceans. These anomalies can also affect ocean circulation patterns. These changes affect heat transport within the ocean, which in turn influences the computation of thermal efficiency.

Figure 5 shows the minimum and maximum SST anomalies. The variability of the SST is greater in shallow waters, mainly in the gulfs (Guacanayabo, Batabano, and Ana Maria; see Figure 3), and in the archipelagos of southern and northern Cuba. In these areas, the depth is less than 763 m, so this dataset does not provide thermal efficiency data. In the Bahama Bank and in some areas of the Gulf of Mexico the same thing happens, the SST variability is large, but depths shallower than 763 m predominate. The SST anomaly varies less (the temperature is more stable) in the Caribbean Sea, in northern areas of Cuba (eastern and western part), in the Yucatan Channel, and in the Windward Passage (Figure 3), where the depth is greater than 763 m; therefore, the value of the thermal efficiency is quite accurate. The north of the central part of Cuba, north of the archipelagos (St. Nicolas Channel and Old Bahama Channel; see Figure 3), the temperature is more stable, but the depth does not reach 763 m.

Figure 6 shows the vertical comparison between the GLOBAL_MULTIYEAR_PHY_001_030 and MULTIOBS_GLO_PHY_TSUV_3D_MYNRT_015_012 products at the points located according to Table 1. In all profiles, good agreement is observed in the first 30 m depth, with bias less than 0.5°C. In P1, P2, P3, P5 and P6, in the layer from 30 to 250 m, the maximum biases are obtained, reaching to exceed 2°C in all months in P2, P3, and P6, while in P1 and P5, the bias varies between 1. 5 and 2°C. For depths greater than 250 m, a good agreement is obtained throughout the year in all profiles with a bias less than 0.75°C, existing in P4 an excellent agreement throughout the period in all depths. All this makes the GLOBAL_MULTIYEAR_PHY_001_030 product good for this study.

The MAD distribution over longitudes and latitudes with respect to time is shown in Figure 7. Analyzing the variation of SST in Figure 7ab, it was observed that SST values clustered around the median by 54.55% and 82.27% with respect to longitude and latitude over an interval of $0.2 > MAD \geq 0.6°C$. At 763 m depth, temperature values clustered around the median by 60.05% and 72.46% with respect to longitude and latitude in an $0.2 > MAD \geq 0.8°C$ interval (Figure 7cd). In these two layers, the latitudinal variations of temperature with respect to the median are smaller than the longitudinal variations, on the contrary, in layers 902 m

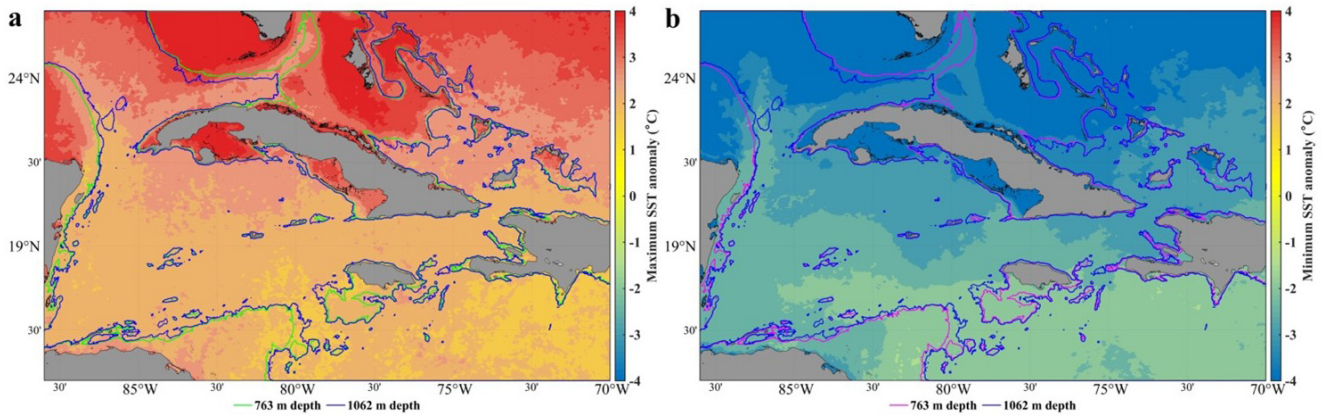


Figure 5. SST anomaly in the seawaters around Cuba[47], extracted from the DACS-PHY dataset[48], and computed with the CalcPlotAnomaly algorithm[49]. a) Minimum SST anomalies. **b**) Maximum SST anomalies. 763 m and 1062 m isobaths taken from the GEBCO Bathymetric Compilation Group[19] **under** GEBCO 2018 License.

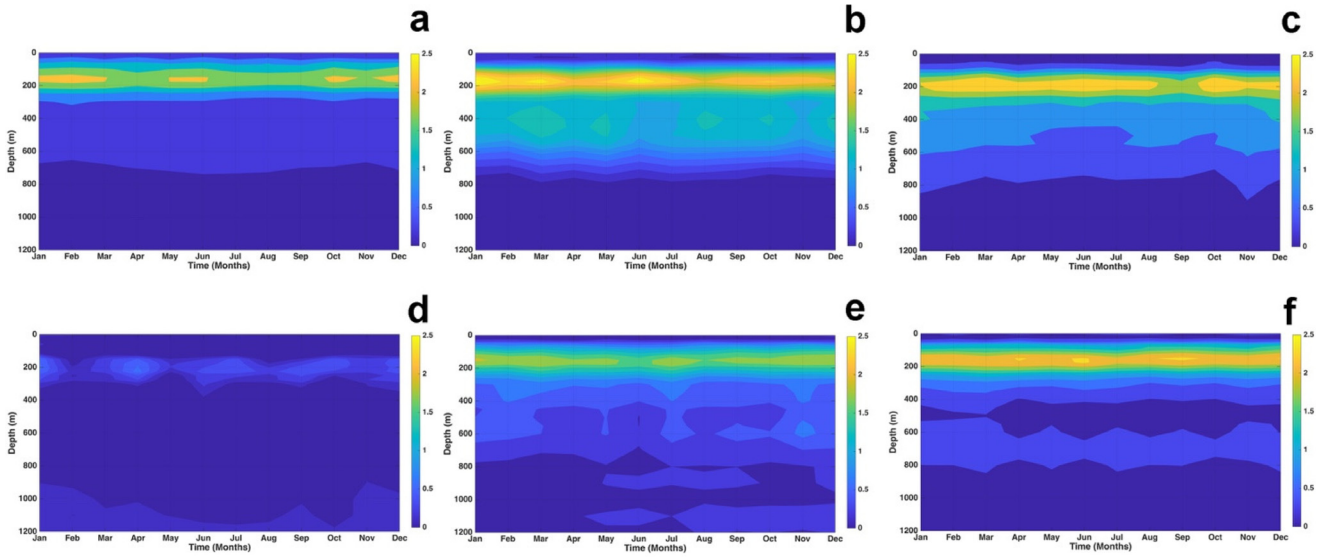


Figure 6. Evaluation of the vertical temperature of the product MULTIOBS_GLO_PHY_TSUV_3D_MYNRT_015_012 at points: a) P1, **b**) P2, **c**) P3, **d**) P4, **e**) P5, and **f**) P6.

(Figure 7ef) and 1062 m (Figure 7gh) the longitudinal variations of temperature around the median are smaller than the latitudinal variations. At 902 m the temperature values are clustered around the median by 76.15% and by 68.29% with respect to longitudes and latitudes in the intervals of $0 > MAD \geq 0.6^{\circ}C$ and $0.2 > MAD \geq 0.6°C$ respectly, this behavior is similar to that occurring at 1062 m, where the clustering of temperature values around the median is 89.5% with respect to longitudes in interval $0 > MAD \geq 0.4°C$ and 79.07% with respect to latitudes in interval $0.2 > MAD \geq 0.6°C$. All this indicates that in the two deeper layers, the temperature is more stable in the spatio - temporal variations.

Figure 8 shows the spatial distribution of the MAD in the study region, in the four layers there is a clustering of the temperature values around the median. This clustering is smaller in the SST values, being in an interval of $0 > MAD \geq 1.5°C$, reaching values in the range of $1.5 > MAD \geq 1.75°C$ in the Ana Maria and Guacanayabo Gulfs and MA = 2.4°C in the Batabano Gulf. In the rest of the layers the temperature

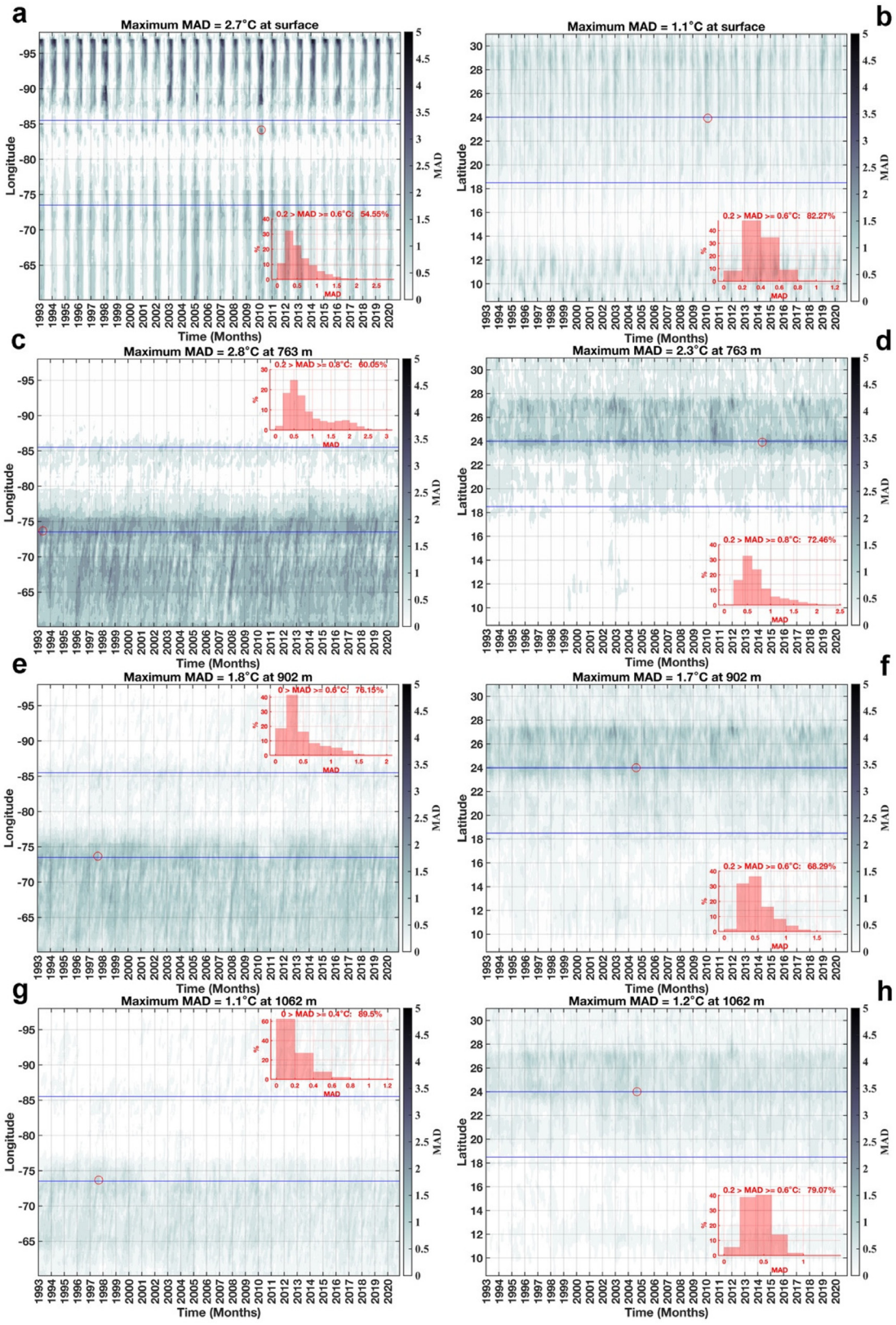


Figure 7. MAD distribution in longitude and latitude with respect to time: a) longitude vs time at surface, **b**) latitude vs time at surface, **c**) longitude vs time at 763 m, **d**) latitude vs time at 763 m, **e**) longitude vs time at 902 m, **f**) latitude vs time at 902 m, **g**) longitude vs time at 1062 m, and **h**) latitude vs time at 1062 m. The blue lines delimit the longitudes and latitudes of our study region. The red circle represents the maximum MAD within the study region. The histograms represent the percentage of MAD according to their values.

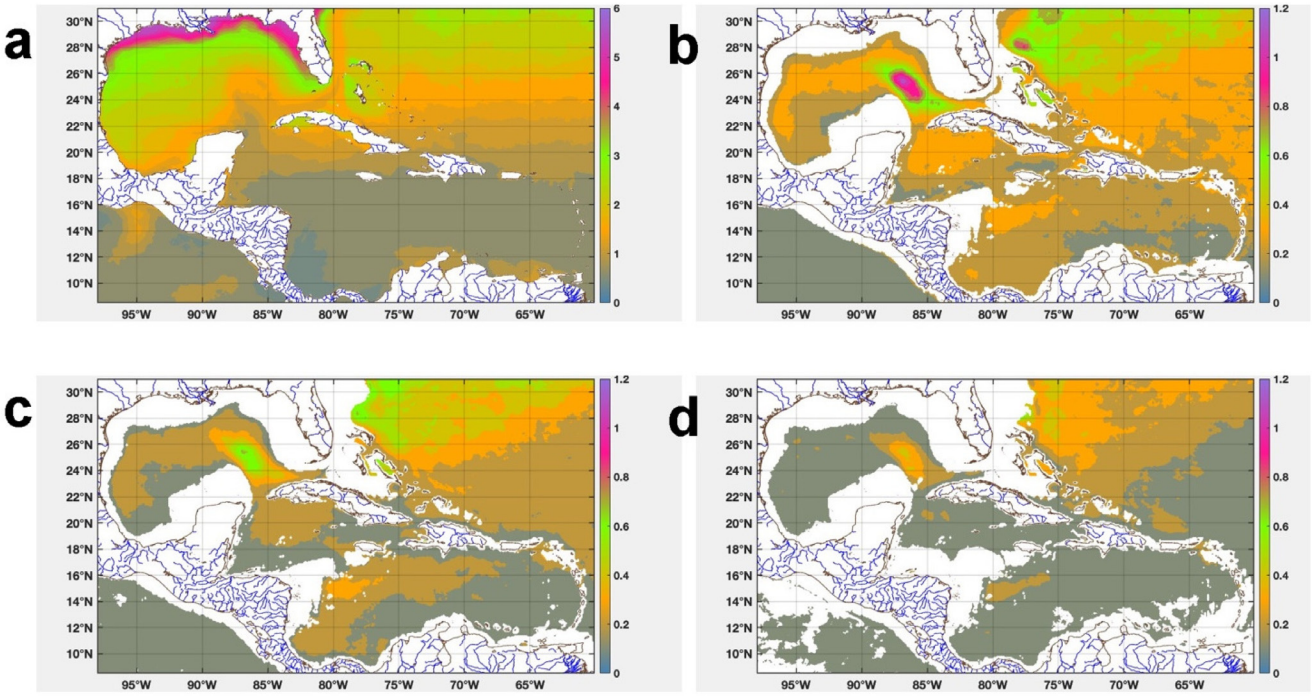


Figure 8. MAD spatial distribution of temperature: a) Surface, **b**) 763 m, **c**) 902 m, and **d**) 1062 m.

values are clustered around the median in the interval of $0 > MAD \geq 0.3°C$. This figure also shows that the deeper the layer, the more stable the temperature is.

Mapping thermal efficiency

Figure 9 shows the monthly mean distribution of the theoretical maximum efficiency of a Carnot cycle in the waters around Cuba between 763 and 1062 m, in the months of February/1993 and February/2019. At 736 m depth the thermal efficiency ranged between 0.050 and 0.076, while at depths of 902 and 1062 m, it ranged between 0.050 - 0.080 for 902 m and for 1062 reaches 0.062 - 0.079, reaching up to 0.081 in small regions north of Havana, south of the "Isla de la Juventud" and the Eastern Cuba region, mainly in Feb/2019 (Figure 9F). In general, the highest values of oceanic thermal efficiency were obtained at 1062 m depth, not only for having a lower potential temperature than the rest of the levels, but also for having a more stable temperature than the rest of the levels, with MAD <= 0.4°C (Figure 8d).

Dataset

This dataset can be a reference in the future for the implementation of OTEC technology in Cuba. Furthermore, research can be carried out aimed at selecting the best places for the installation of OTEC plants, based on the shortest distances from the coast to the isobaths of 1000, 900 and 800 m; applying internationally established methodologies that are based on the economic, social and cultural context of the selected places, the frequency of extreme meteorological and geological events, etc.

This research has a high level of relevance to national policies as it corresponds to the strategic tasks defined in the State Plan of Cuba to confront climate change (Tarea Vida) and by the Country Program (2020–2024) prepared by the UNDP and reconciled with the Government of Cuba, in particular with the priority of cooperation related to the promotion of sustainable environmental bases, incorporating effects of climate change in the processes of economic and social development by 2030 with the strengthening of national capacities. It is also relevant to the development policies towards 2030 of the nations of Central America and the Caribbean. In this way, there may be a high interest from the Cuban government and through Cuba's collaboration with the Caribbean, joint collaborations can be designed in this sense.

The database for the calculation of thermal efficiency in the seas around Cuba is the result of an investigation conducted

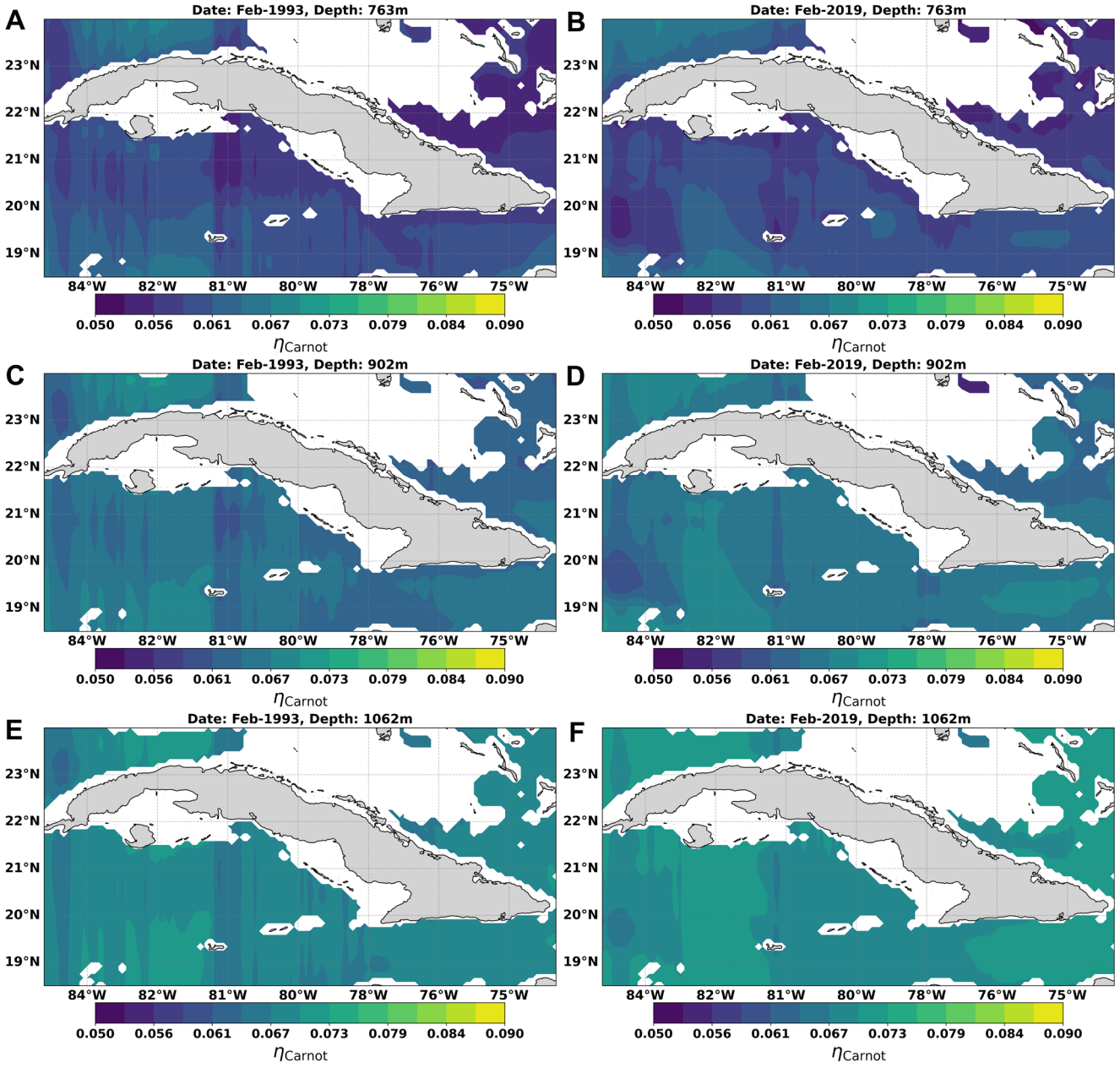


Figure 9. Spatial distribution of the theoretical maximum efficiency of a Carnot cycle in the waters adjacent to Cuba: **A**) Feb/1993 at 763 m, **B**) Feb/2019 at 763 m, **C**) Feb/1993 at 902 m, **D**) Feb/2019 at 902 m, **E**) Feb/1993 at 1062 m, and **F**) Feb/2019 at 1062 m. White areas represent missing data due to depths less than 763 m.

by 1. As shown in Figure 10, the dataset includes three folders that contain annual information on thermal efficiency from 1993 to 2019:

(i) 27 files calculated for the 1062 m depth level.

(ii) 27 files, calculated for a depth level of 763 m, and

(iii) 27 files calculated for the 902 m depth level.

Each of the 81 files is stored in comma-separated txt format and 162.68 MB in size.

The same nodes of the regular data mesh of the temperature files **global-reanalysis-phy-001-030-daily**[1] for the study area were downloaded from the Copernicus site, and the number of nodes was 145 × 67. A description of the fields of each file separated by commas that do not have a header is presented in Table 2.

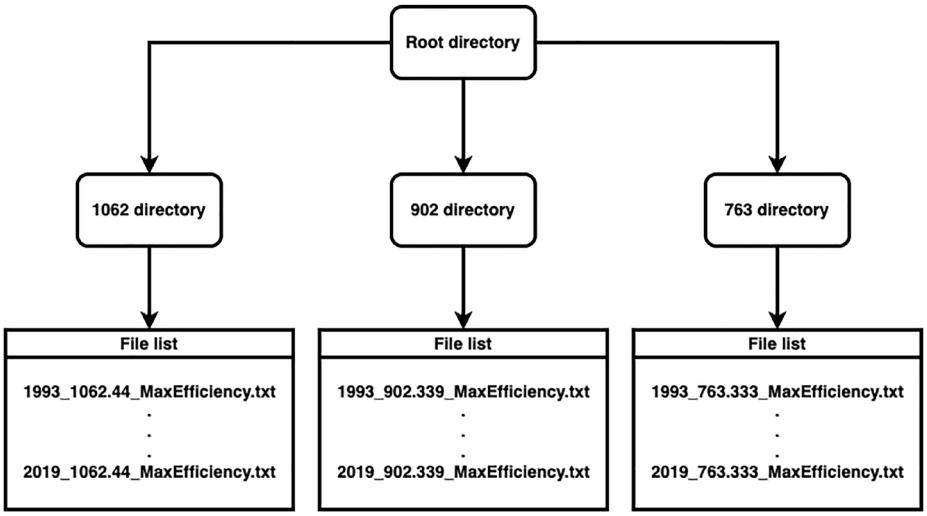


Figure 10. File distribution by directory.

Table 2. Description of the fields of the output files of the calculation of thermal efficiency.
*When it is not possible to calculate the thermal efficiency, either because the point is on land or because the depth level does not exist, the value is -32767.

Description of field	Data type
Date	Date
Level	float
Longitude	float
Latitude	float
Thermal efficiency	float*

Ethics and consent

No ethics approval or consent was required for this study

Data availability

The data is available on the Science Data Bank site. The site is free to download and use data sets respecting the corresponding data license.

Repository name: Science Data Bank.

Dataset name: Thermal Efficiency Dataset Around Cuban Seas (TEDACS).

Dataset location: https://www.scidb.cn/en/detail?dataSetId=c36d48ae4d5444e69458e9c80fea84dc&version=V2

DOI: https://doi.org/10.57760/sciencedb.10037

Scientific Data Confirmation Certificate: https://cert.scichain.cn/scidb/2025/01/26/1078085787.en.v2.pdf

Publication date: 2023-10-08

Updated on 2025-01-26

This project contains the following data:

- *_1062.44_MaxEfficiency.txt
- *_763.333_MaxEfficiency.txt
- *_902.339_MaxEfficiency.txt

*Years: 1993, 1994, 1995 … 2019

Data are made available under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0).

Acknowledgements

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Current Peer Review Status: ✔ ✔ ✔ ✘

Version 3

Reviewer Report 27 May 2025

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✔ **Erfan Amini**
Department of Civil, Environmental, and Ocean Engineering, Stevens Institute of Technology (Ringgold ID: 33694), Hoboken, New Jersey, USA

The authors have addressed all the previous comments, and I am in favor of accepting the manuscript for indexing.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Coastal Engineering, Ocean Energy

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 31 May 2025

Alejandro Rodriguez

Dear Mr. Erfan Amini,
The authors of this manuscript thanked you for all your feedback and suggestions throughout the review process of our article.
Thank you very much.
Alejandro Rodriguez.

Competing Interests: No competing interests were disclosed.

Reviewer Report 16 May 2025

https://doi.org/10.21956/openreseurope.21975.r53999

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Dodi Sofyan Arief
Universitas Riau, Pekanbaru,, Indonesia
Abdul Khair Junaidi
Mechanical Engineering, Technology College of Pekanbaru, Pekanbaru, Riau, Indonesia

This revised article makes a valuable contribution to the exploration of renewable energy potential in Cuba, specifically focusing on ocean thermal energy. The use of long-term data from the Copernicus Marine Environmental Monitoring Service to calculate Carnot thermal efficiency at various depths demonstrates a strong analytical approach. The revisions—such as the improved title, updated dataset in Kelvin, enhanced geographic detail in the figures, and the inclusion of previously omitted references—significantly strengthen the clarity, accuracy, and overall quality of the manuscript.

Competing Interests: No competing interests were disclosed.

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 31 May 2025

Alejandro Rodriguez

Dear Mr. Dodi Sofyan Arief,
The authors of this manuscript thank you for all your feedback and suggestions throughout the review process of our article.
Thank you very much.
Alejandro Rodriguez.

Competing Interests: No

Version 2

Reviewer Report 28 December 2024

https://doi.org/10.21956/openreseurope.20765.r48872

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Ji Zhang
Ocean University of China, Qingdao, China

In my first review, I pointed out that the author's calculation of the thermal efficiency for OTEC was incorrect. However, it is regrettable that the author has still not corrected this in the revised manuscript. They continue to use Celsius temperatures for the calculation of thermal efficiency, which is unacceptable in thermodynamics, and this mistake is also rudimentary. Although the authors noted that they did not consider the degradation of thermal efficiency in engineering, that is not the issue here. The theoretical thermal efficiency, or the limit thermal efficiency, should be calculated using Kelvin temperatures. Therefore, I suggest that the authors seek out several more authoritative papers on OTEC to truly understand the calculation of OTEC's thermal efficiency. The Carnot cycle efficiency (the perfect thermodynamic cycle in theory) is approximately 6.7% when the temperature difference is 20 °C. （Review of enhancement for ocean thermal energy conversion system. In: Journal of Ocean Engineering and Science. Elsevier BV, 2023 [Ref-1]; 8(5): 533–545）

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1. Abbas S, Alhassany H, Vera D, Jurado F: Review of enhancement for ocean thermal energy conversion system. *Journal of Ocean Engineering and Science*. 2023; **8** (5): 533-545 Publisher Full Text

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Ocean thermal energy conversion; energy system

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 28 Dec 2024

Humberto L. Varona

The difference between the Kelvin and Celsius scales lies in the initial reference point. The Kelvin scale is defined from absolute zero, making it an essential absolute scale for scientific computations. In contrast, the Celsius scale, based on the freezing and boiling points of water under normal pressure, is more convenient for everyday applications and practical situations where a relative reference is sufficient. This shift between the two scales, of a constant 273.15 °C, does not affect the temperature differences between specific points, since both scales share the same magnitude of increase per unit. Both scales, therefore, measure the same physical property, but the Kelvin scale provides an indispensable absolute framework in thermodynamics. The mathematical relationship between the scales ensures that, if converted correctly, temperature differences remain invariant, guaranteeing consistency in calculations such as those related to thermal efficiency. In the context of calculating thermal efficiency, such as in a Carnot cycle, there is no difference in the results when using Celsius or Kelvin, provided that the temperatures are correctly transformed to an absolute scale prior to their application in the equations. This is because thermal efficiency depends on the ratios between absolute temperatures, not on their individual values on a relative scale. The unique scenario in which it would be erroneous to use

degrees Celsius directly is if the cold source temperature approaches -273.15 °C, which does not occur under natural conditions because absolute zero is unattainable in practice. In environments such as the ocean, where the lowest observed temperatures are well above absolute zero, such an error would not have any relevance.

Competing Interests: No competing interests were disclosed.

Author Response 29 Dec 2024

Humberto L. Varona

On the Celsius temperature scale there is also an under-therm in equation 2 when the cold source temperature is 0°C; this temperature is possible in the ocean due to the presence of salt. The freezing point of seawater ranges from -2.010 to -1.796°C for salinities of 33 to 36.52 psu (Doherty et al., 1974; Fujino et al., 1974; and Kester 1974). This phenomenon is due to cryoscopic lowering, which reduces the freezing point of a solution compared to pure solvent. In our case this did not affect the computation of the thermal efficiency because the minimum temperature in the 3 depth levels used are higher than 0°C. Doherty, Brendan T., and Dana R. Kester. 1974. "Freezing point of seawater." *Journal of Marine Research* 32, (2). https://elischolar.library.yale.edu/journal_of_marine_research/1290 Fujino, K., Lewis, E. L., & Perkin, R. G. (1974). The freezing point of seawater at pressures up to 100 bars. In Journal of Geophysical Research (Vol. 79, Issue 12, pp. 1792–1797). American Geophysical Union (AGU). https://doi.org/10.1029/jc079i012p01792 Kester, D. R. (1974). Comparison of recent seawater freezing point data. In Journal of Geophysical Research (Vol. 79, Issue 30, pp. 4555–4556). American Geophysical Union (AGU). https://doi.org/10.1029/jc079i030p04555 On the other hand, the difference in results when using Celsius versus Kelvin temperatures arises because the ratio between temperatures changes when using a scale with a constant offset such as the Celsius scale. In thermodynamics, temperature ratios must be calculated in terms of their absolute value (Kelvin) because they determine relative energy ratios. The Celsius scale does not reflect the actual ratios because of its 273.15°C offset. Using degrees Celsius ignores that the temperature 0°C is not a minimum energy point; on the contrary 0 K is the correct thermodynamic reference point. **Conclusion:** ***Let's create a new thermal efficiency dataset from the Kelvin temperatures at the hot and cold sources.***

Competing Interests: No competing interests were disclosed.

Author Response 29 Dec 2024

Alejandro Rodriguez

Dear Ji Zhang.
We appreciate your review of our work. You are certainly right in your view that the thermal efficiency should be calculated in Kelvin.
In your first review, we focused on the equations for calculating the thermal efficiency and did not realize that we had to update our dataset by doing the calculations with the temperature values in Kelvin. Please excuse us for such a serious omission.

We will immediately update our dataset and submit version 3 of our datanote with the mapping of the thermal efficiency around Cuba in Kelvin, as it should be done.
We strongly request the editors and all reviewers to allow us to submit version 3 of our manuscript with the correct calculation of the thermal efficiency.
Thank you very much.

Competing Interests: No competing interests were disclosed.

Author Response 30 Dec 2024

Alejandro Rodriguez

Dear Mr. Ji Zhang.
We appreciate your review of our manuscript and agree with your rating. It is truly essential to calculate the thermal efficiency in Kelvin because of all the physical implications regarding energy taking the temperature in degrees Celsius, and the indeterminacy of the equation for the value of 0 degrees Celsius.
We apologize for having overlooked this criterion that you pointed out to us from the first review, we are only focused on improving the equations.
We will immediately update the dataset and submit version 3 of our datanote.
Thank you very much.

Competing Interests: No competing interests were disclosed.

Version 1

Reviewer Report 14 August 2024

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Ji Zhang
Ocean University of China, Qingdao, China

This article provides a detailed analysis of the potential for thermal energy from sea temperature gradients around Cuba, utilizing 27 years of daily data to calculate thermal efficiency at different depths. This long-term data analysis is significant for understanding the availability and variability of thermal energy resources. The study generates 81 files, meticulously recording dates, depths, coordinates, and thermal efficiencies, providing a valuable foundation for future energy planning and environmental impact assessments. Additionally, the research explores applications beyond electricity generation, such as desalination, refrigeration, and aquaculture, highlighting the

versatility of thermal energy resources.

However, it must be noted that the calculation of thermal efficiency presented in the article is wrong. In reality, the maximum thermal efficiency of using sea temperature gradients, even under ideal conditions, is limited by the Carnot cycle efficiency and could not possibly reach around 80%. The author needs to reinforce their understanding of thermodynamics, particularly when dealing with temperature units. Kelvin and Celsius are two different temperature scales, differing in their reference points (zero points) and temperature intervals. The thermal efficiency values reported in the article require further validation and explanation to ensure the accuracy and reliability of the findings.

Is the rationale for creating the dataset(s) clearly described?
Partly

Are the protocols appropriate and is the work technically sound?
Partly

Are sufficient details of methods and materials provided to allow replication by others?
Partly

Are the datasets clearly presented in a useable and accessible format?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Ocean thermal energy conversion; energy system

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 14 Aug 2024

Alejandro Rodriguez

Dear Ji Zhang
On behalf of the authors of this paper, I thank you for taking part of your valuable time to review our article.
Regarding your remarks, I must say that the authors did not consider developing in its entirety the theory of energy transformations in the OTEC generation process. We based ourselves fundamentally on a work published by Adrian Rizki Sinuhaji (https://doi.org/10.18502/ken.v1i1.330), which makes an excellent exposition of the subject; and which arrives, after transformations of the different equations, to an equation that is the one we use for this exercise. This excellent work has been cited by us.
Obviously, we know that the values of maximum thermal efficiency decrease in practice when the different components of an OTEC plant are installed; but this is a matter for the engineers who are dedicated to building the generating plant. Our work is the calculation of

the energy potential that exists in the sea around Cuba, knowing that with a minimum maximum thermal efficiency of 0.7 (this is the conclusion that Sinuhaji reached in his research) it may be feasible to build an OTEC plant in the place, that is, to have a performance of 0.25 to 0.3 as it is known.
Thank you very much.
Alejandro Rodríguez

Competing Interests: No competing interests were disclosed.

Author Response 13 Dec 2024

Humberto L. Varona

Dear Dr. Ji Zhang Thank you very much for your review and pointing out to improve this research. Our thermal efficiency computations are correct. As thermal efficiency depends only on the accuracy of hot and cold temperatures, we have added to our research an evaluation of the vertical temperature by comparing the dataset used for the computation with a dataset created from observed data, 6 random points were chosen around the island of Cuba, the bias in all points has been small, mainly at depths 763, 902, and 1062 m. In addition, studies of the spatial and temporal behavior of the Median Absolute Deviation in all the levels used were added, indicating that the spatial and temporal distribution of the temperature in the deep levels is very stable, being this favorable to obtain values of good thermal efficiency. In the first version we already had an evaluation of the surface temperature, comparing this with two sources of observed data, in addition to a study of the temperature anomalies, which are quite variable in the Caribbean Sea, existing regions with remarkable maximum anomalies, this produces a greater temperature gradient between the surface and the deep levels used in the computation of the thermal efficiency, this also contributes to an increase of the efficiency in the Carnot cycle.

Competing Interests: No competing interests were disclosed.

Reviewer Report 14 August 2024

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Hooi Siang Kang
Universiti Teknologi Malaysia, Skudai, Johor, Malaysia

The research presents an exploration of Ocean Thermal Energy Conversion (OTEC) feasibility in Cuba's maritime surroundings, underpinned by bathymetric characterization and thermal efficiency computations. The dataset, compiled over 27 years utilizing Copernicus Marine

Environmental Monitoring Service (CMEMS) data, offers insights into thermal efficiency across specific latitudinal and longitudinal bounds.

The dataset's creation is evidently meticulous based on reliable data sources. The inclusion of CMEMS global ocean reanalysis data ensures a reliable foundation for thermal efficiency calculations. Furthermore, the utilization of MODIS Aqua and WOCE datasets for validation enhances the reliability of the dataset. Protocols employed in the research exhibit its alignment with established practices in OTEC feasibility studies. The computation of thermal efficiency reflects sound scientific methodology. Moreover, the detailed description of methods enhances transparency and facilitates replication by other researchers. The dataset's usability and accessibility are comprehensively documented. Overall, the research provides a potentially valuable contribution to sustainable energy development.

The suggested improvements could include conducting sensitivity analyses to assess the impact of various parameters on thermal efficiency calculations. Additionally, detailing quality control measures and the potential impact of SST anomalies on thermal efficiency calculations, would further facilitate research endeavors in utilizing the dataset.

Is the rationale for creating the dataset(s) clearly described?

Yes

Are the protocols appropriate and is the work technically sound?

Yes

Are sufficient details of methods and materials provided to allow replication by others?

Yes

Are the datasets clearly presented in a useable and accessible format?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Ocean Engineering

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 14 Aug 2024

Alejandro Rodriguez

Dear Hooi Siang Kang
The authors of this paper thank you for taking part of your valuable time to review our article.
We are very pleased to receive the satisfactory review from an expert who belongs to a nation that exhibits great strength in the OTEC issue. We are working on version 2 of the paper that we will soon submit for reviewers and the public's consideration.
Thank you very much.

Alejandro Rodríguez

Competing Interests: No competing interests were disclosed.

Reviewer Report 17 May 2024

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Erfan Amini
Department of Civil, Environmental, and Ocean Engineering, Stevens Institute of Technology (Ringgold ID: 33694), Hoboken, New Jersey, USA

The authors present a valuable dataset for assessing the thermal efficiency potential in the seas surrounding Cuba, which can contribute to research on Ocean Thermal Energy Conversion (OTEC) technologies and renewable energy exploration in the region. However, there are some limitations and areas that require further clarification or improvement.
The introduction effectively establishes the context and significance of the research, highlighting the potential of OTEC as a renewable energy source. However, the authors could provide more background information on previous studies or datasets related to thermal efficiency in the region to better situate their work within the existing literature.
The methods section provides details on the study area, data sources, and the equation used for calculating thermal efficiency. However, there are some limitations and uncertainties associated with the methodology that should be discussed. For example, the authors used reanalysis data with a spatial resolution of 1/12°, which may not capture local variations in thermal efficiency.
The authors performed data validation using statistical tests to compare the reanalysis data with observed datasets. While this is a useful step, the validation could be more comprehensive. For instance, the authors could compare their thermal efficiency results with any available in-situ measurements or other published datasets in the region to further validate their findings.
The dataset is well-organized and made publicly available, which is commendable. The figures and tables are informative and support the text. However, some figures, such as the SST trend map (Figure 1) and the spatial distribution of SST (Figure 2), could benefit from a more detailed interpretation and discussion of their implications for thermal efficiency calculations.
Overall Evaluation: The paper presents a valuable dataset for assessing the thermal efficiency potential in the seas around Cuba. The methodology is generally sound, and the data validation steps enhance the credibility of the results. However, the authors should address the limitations and uncertainties associated with their methodology and dataset more thoroughly. This would help users better understand the potential drawbacks and make informed decisions when using the dataset for their specific applications.
Suggestions for Improvement:

- Discuss the limitations and uncertainties associated with the spatial and temporal resolution of the reanalysis data and how they may impact the accuracy of the thermal

efficiency calculations.
- Provide more background information on previous studies or datasets related to thermal efficiency in the region to better contextualize the current work.
- Expand the data validation by comparing the thermal efficiency results with any available in-situ measurements or other published datasets in the region.
- Provide a more detailed interpretation and discussion of the implications of the SST trend map and spatial distribution of SST for thermal efficiency calculations.
- Discuss the potential limitations and uncertainties associated with the dataset and how they may affect its usability for different applications.

Is the rationale for creating the dataset(s) clearly described?
Yes

Are the protocols appropriate and is the work technically sound?
Yes

Are sufficient details of methods and materials provided to allow replication by others?
Partly

Are the datasets clearly presented in a useable and accessible format?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Ocean Renewable Energy, Desing Optimization, Coastal Infrastructures

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 18 May 2024

Alejandro Rodriguez

Dear Reviewer Erfan Amini, Thank you very much for your time for reviewing and suggestioning. Comments regarding the limitations of the spatial and temporal resolution of the data used in the research will be added in the next version of the article and mention will be made of previous studies in the area (there are really few). We will also expand the discussion of the implications of the sea surface temperature trend, and work to show the limitations associated with the data set. Thanks a lot.

Competing Interests: No competing interests were disclosed.

Reviewer Report 16 May 2024

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Dodi Sofyan Arief
Universitas Riau, Pekanbaru,, Indonesia
Abdul Khair Junaidi
Mechanical Engineering, Technology College of Pekanbaru, Pekanbaru, Riau, Indonesia

1. How was the process of calculating thermal efficiency conducted in this study?
2. Why were depths of 763, 902, and 1062 meters chosen as the focus of research for exploiting sea thermal energy?
3. What insights can be gained from the presented dataset regarding the potential development of renewable energy in the vicinity of Cuba?
4. What is the data quality of the Copernicus Marine Environmental Monitoring Service (CMEMS) GLOBAL_MULTIYEAR_PHY_001_030 product used in this research?
5. What are the potential implications of the thermal efficiency findings from this research on the energy industry and environment in Cuba or surrounding regions?
6. What potential future research directions or areas can be developed based on the findings of this research data in the context of OTEC system development?

The literature review is not sufficient for the given title. Try to expand the reviewed references by prioritizing publications. The following papers are just suggestions and can help improve the given discussion:

(Koto, 2012) (Ref-1)
(Koto et al.,2017)(Ref-2)
(Koto et al.,2016)(Ref-3)
(Koto et al.,2012)(Ref-4)

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2. J. Koto A, Tasri K, Insannual D, Arief Efiafrizal, et al.: Sea Temperatures Profiles for Ocean Thermal Energy Conversion in Siberut-Mentawai, Sumatera Barat, Indonesia. *https://isomase.org/JSOse/Vol.11%20Sep%202017/11-2.pdf*.
3. J, Koto N, Ridho: Preliminary Study on Ocean Thermal Energy Conversion in Siberut Island, West Sumatera, Indonesia. *https://isomase.org/JAse/Vol.6%20May%202016/6-1.pdf*.
4. J, Koto D, arief A, Tasri I, et al.: Ocean Thermal Energy Conversion in Indonesia, Malaysia and Philippines. *https://isomase.org/Journals/index.php/ijerce/article/view/94/70*.

Is the rationale for creating the dataset(s) clearly described?

Yes

Are the protocols appropriate and is the work technically sound?

Yes

Are sufficient details of methods and materials provided to allow replication by others?
Yes

Are the datasets clearly presented in a useable and accessible format?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Ocean thermal energy conversion (OTEC) is a renewable energy technology (Mechanical Engineering)

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.

Author Response 18 May 2024

Alejandro Rodriguez

Dear Dodi Sofyan Arief
We thank you for taking your time to review our article.
All your comments, suggestions and bibliographic references suggested by the reviewer will be taken into account in the next version of the article.
We will take all the questions you have asked into account for version 2 of the manuscript.
We truly believe that it will raise its scientific level. We will study and use, in the new version, the suggested bibliography.
Thank you so much.

Competing Interests: No competing interests were disclosed.

Reviewer Response 09 May 2025

Dodi Sofyan Arief

Dear Alejandro Rodriguez, Thank you for considering the feedback and suggestions I provided on your article. I am pleased to know that the comments and bibliographic references I suggested were found to be helpful. It is encouraging that you plan to incorporate them into the next version of your manuscript. Addressing these points will certainly enhance the scientific quality of your work. Best regards,
Dodi Sofyan Arief

Competing Interests: No competing interests were disclosed.