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Data Article

Global database of salinity gradient energy potential at river mouths

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ABSTRACT

This article presents a global database of salinity gradient energy (SGE) potential at river mouths. The dataset integrates satellite-derived sea surface salinity and temperature with river discharge data to estimate both theoretical and extractable SGE resources worldwide. Two complementary river discharge datasets are used: (i) a global multiannual dataset including 10,848 rivers (N20), and (ii) a curated dataset of 1,078 rivers with monthly discharge variability (ARA24). The database provides spatially distributed estimates of energy density, theoretical potential, and extractable potential, along with key design parameters, including environmental discharge, extraction factor, design flow, and capacity factor. Monthly variability is resolved for systems included in the ARA24 dataset, enabling analysis of seasonal dynamics. All data are provided in structured spreadsheet formats, including global summaries by country, region, and ocean basin. In addition, an interactive visualization tool is included to explore the sensitivity of extractable potential to environmental and operational parameters. This dataset supports global, regional, and site-specific analyses of SGE resources and provides a consistent basis for future techno-economic, environmental, and policy-oriented studies.

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Specifications Table

Subject	Earth & Environmental Sciences
Specific subject area	Global assessment of salinity gradient energy resources at river mouths
Type of data	Tables (Excel spreadsheets) and an Interactive visualization tool (.exe) Processed, analyzed, and derived data
Data collection	Sea surface salinity and temperature were obtained from SMAP (JPL SMAP-SSS V5.0 CAP) and MODIS-Aqua satellite products. River discharge data were compiled from the N20 global dataset (10,848 rivers) and the ARA24 dataset (1,078 rivers with monthly records) from global databases and national hydrological agencies. Data were quality-controlled, harmonized, and combined to estimate energy density, theoretical potential, and extractable potential using consistent physical formulations.
Data source location	Global coverage (river mouths worldwide; coordinates provided in datasets). Data processed and curated at Universidad del Norte, Barranquilla, Colombia.
Data accessibility	Repository name: Global Salinity Gradient Energy Potential Database (ARA24) Data identification number: 10.17632/wn9t2cswgv.2 Direct URL to data: https://data.mendeley.com/datasets/wn9t2cswgv/2
Related research article	Álvarez-Silva, O., Roldán-Carvajal, M., & Arévalo, F. Extended assessment of the globally extractable salinity gradient energy from river mouths, Sustain Energy Technol Assess 91, 105079. [1].

1. Value of the Data

- This dataset provides a globally consistent assessment of salinity gradient energy (SGE) potential at river mouths, integrating satellite-derived salinity and temperature with global-scale river discharge databases. It enables systematic quantification of theoretical energy resources across >10,000 river systems worldwide.
- The inclusion of monthly discharge data for 1,078 rivers allows, for the first time, the analysis of intra-annual variability in SGE potential, supporting studies on seasonality, hydrological extremes, and climate-driven fluctuations in renewable energy resources.
- The dataset includes key derived parameters relevant for engineering applications, such as energy density, extraction factor, design flow, and capacity factor, facilitating preliminary screening and comparison of potential sites for SGE implementation.
- The global coverage and standardized methodology enable comparative analyses across countries, regions, and ocean basins, supporting research in hydrology, oceanography, renewable energy, and land–sea connectivity.
- These data can be reused for techno-economic assessments, environmental impact studies, and energy planning, as well as for coupling with numerical models or other geospatial datasets to refine site-specific feasibility analyses.
- The accompanying interactive visualization tool allows users to explore the sensitivity of extractable potential to environmental and operational parameters, enhancing accessibility and supporting both research and educational applications.

2. Background

Salinity gradient energy (SGE), also known as blue energy or osmotic energy, is generated from the mixing of two water masses with different salt concentration, for example, those available at river mouths, where freshwater from the rivers mixes with the ocean, and represents

a largely untapped renewable energy resource [2,3]. Quantifying its global potential requires integrating hydrological and oceanographic datasets that describe river discharge, salinity, and temperature at river mouths [4]. However, existing global assessments have been limited by data availability, spatial coverage, or temporal resolution, particularly in representing seasonal variability. This dataset was compiled to provide a consistent and comprehensive global framework for estimating both theoretical and extractable SGE potential at river mouths. It integrates satellite-derived sea surface salinity and temperature with two complementary river discharge datasets: a global multiannual dataset and a curated dataset [5] with monthly variability [6]. The dataset supports the research article "Extended assessment of the globally extractable salinity gradient energy from river mouths [1]" by providing the underlying data, derived variables, and intermediate results used in the analysis. It enables reproducibility of the reported results and facilitates further use of the data for independent analyses and applications.

3. Data Description

The dataset is organized into three main components: two spreadsheet-based databases and one executable visualization tool. All files are provided at the repository root without subfolders. File names are self-descriptive and correspond to the datasets described below. The spreadsheet files are provided in Microsoft Excel format (.xlsx), and the visualization tool is provided as a standalone executable (.exe).

File: SGE_Global_Database_N20.xlsx

This file contains a single sheet with data for 10,848 river mouths derived from the N20 database. Each row corresponds to one river mouth. The columns include:

- River identification: river name, country, ocean basin.
- Geographic information: latitude and longitude coordinates.
- Hydrological variables: multiannual mean freshwater discharge.
- Oceanographic variables: mean sea surface salinity and temperature.
- Derived variables: energy density (MJ/m^3) and theoretical SGE potential (MW).

In addition, aggregated summaries of theoretical potential are included by regions.

File: SGE_Global_Database_ARA24.xlsx

This file contains seven sheets with data for 1,078 river mouths with monthly discharge variability.

- Sheet 1 (Rivers): Includes river identification (name, country, region, continent, ocean basin), geographic coordinates, mean monthly discharge, environmental discharge, extraction factor, design flow, monthly extractable discharge, and capacity factor.
- Sheet 2 (SGE density): Monthly values of energy density (MJ/m^3) for each river mouth.
- Sheet 3 (Theoretical SGE potential): Monthly theoretical SGE potential (MW) for each river and corresponding long-term averages.
- Sheet 4 (Extractable SGE potential): Monthly extractable SGE potential (MW) and long-term averages for each river.
- Sheet 5 (Summary_Basin): Monthly extractable potential aggregated by ocean basin.
- Sheet 6 (Summary_Country): Monthly extractable potential aggregated by country.
- Sheet 7 (Summary_Region): Monthly extractable potential aggregated by geographic region.

File: SGE_Global_Viewer.exe

This executable file is an interactive visualization tool developed in Matlab®. It allows users to explore the ARA24 dataset by adjusting key parameters, including the extraction factor and environmental discharge. The tool outputs updated values of design flow, capacity factor, and extractable potential for selected river systems. No Matlab® installation or license is required to run the application.

4. Experimental Design, Materials and Methods

The dataset was generated by integrating satellite-derived oceanographic variables with river discharge datasets to estimate salinity gradient energy (SGE) potential at river mouths. Sea surface salinity (SSS) data were obtained from the Soil Moisture Active Passive (SMAP) mission, specifically the JPL SMAP-SSS V5.0 CAP product [7]. Sea surface temperature (SST) data were obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the Aqua satellite (NASA EOS program) [8]. River discharge data were obtained from two sources (i) the N20 dataset, providing multiannual mean discharge (1980–2010) for 10,848 river mouths derived from global-scale hydrological modeling [5], and (ii) the ARA24 dataset, compiled from global databases and national hydrological agencies, containing monthly discharge records for 1,078 rivers with at least two years of observations [6].

All datasets were converted to consistent units and formats. Geographic coordinates of river mouths were used to extract corresponding SSS and SST values from satellite grids. When necessary, spatial matching was performed using nearest-neighbor interpolation. Quality control procedures included removal of inconsistent or incomplete records, verification of coordinate consistency, and standardization of variable names and units. River discharge data from different sources were harmonized to ensure comparability across datasets. All input datasets are publicly available from their respective sources. The processed datasets provided in this research include all intermediate and final variables required to reproduce the results presented in the associated research article [1].

Theoretical SGE potential was estimated from the Gibbs free energy of mixing between freshwater and seawater, assuming seawater as a sodium chloride solution [9]. Energy density (MJ/m^3) was calculated as a function of the salinity difference between river water and seawater, and local temperature [10]. For the N20 dataset, the theoretical potential (MW) was computed using the multiannual mean discharge and corresponding oceanographic conditions. For the ARA24 dataset, monthly discharge values were used to calculate time-varying energy density, theoretical potential, and extractable potential.

Extractable potential was estimated by applying (i) an environmental discharge constraint defined as a fixed fraction of the mean discharge; (ii) an extraction factor defining the fraction of available flow used for energy generation, and (iii) a design flow derived from the combination of these parameters. The capacity factor was computed as the ratio of the mean extractable power to the installed capacity, derived from design flow conditions. All methodological details for this procedure are described in the accompanying paper [1].

Monthly values of energy density, theoretical potential, and extractable potential were computed for each river in the ARA24 dataset. Long-term averages were calculated from the monthly time series. Aggregated values were derived at different spatial scales, including country, region, and ocean basin, by summing the extractable potential across all river systems within each category.

Limitations

- The ARA24 database includes 1,078 rivers with monthly discharge records, representing a subset of global river systems. Small rivers are underrepresented due to limited monitoring and data accessibility. River discharge data were compiled from multiple sources with varying temporal coverage and measurement methodologies, potentially introducing inconsistencies despite harmonization procedures.
- Satellite-derived sea surface salinity and temperature data are limited to surface conditions and may not capture subsurface variability at river mouths.
- The dataset relies on simplified assumptions in derivating variables, including uniform parameter definitions and standardized environmental discharge fractions, which may not reflect local variability across all systems.

- The dataset inherits uncertainties from the primary data sources used in its construction. Sea surface salinity retrievals from SMAP may exhibit greater uncertainty in coastal regions due to land contamination. MODIS sea surface temperature products are also subject to retrieval uncertainties associated with atmospheric conditions and cloud cover. River discharge records were compiled from multiple agencies and databases with heterogeneous measurement techniques and quality-control procedures. Consequently, uncertainties in the original datasets propagate into the derived SGE estimates. Despite these limitations, the selected products represent the most comprehensive and consistent global datasets currently available for large-scale SGE assessment.

Ethics Statement

The authors confirm that they have read and comply with the ethical requirements for publication in Data in Brief. The work presented in this article does not involve human subjects, animal experiments, or data collected from social media platforms. The dataset is based exclusively on environmental and geophysical data obtained from publicly available sources and institutional databases.

CRediT Author Statement

Óscar Álvarez-Silva: Conceptualization, Supervision, Methodology, Validation, Writing - original draft, Writing - review & editing. **Mateo Roldan-Carvajal**: Investigation, Visualization, Software, Writing - original draft. **Franklin Arévalo**: Data curation, Visualization, Investigation, Software, Writing - original draft.

Data Availability

Global Salinity Gradient Energy Potential Database (ARA24) (Original data) (Mendeley Data).

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Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Some of the findings in this paper result from a consultancy for SWEETCH ENERGY. The authors declare that the methods and results presented here were not influenced by company representatives.

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