

# PALEO-SEAL: an easily deployable tool for the visualization and sharing of Holocene sea-level data.

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## ABSTRACT

We present a simple and easily deployable web interface that allows visualizing, querying and downloading Holocene sea-level datapoints formatted following the HOLSEA data template. The data is hosted on a MySQL database, and the interface uses AngularJS, is scalable to large datasets and can be deployed in few easy steps, that require only basic knowledge of SQL and HTML. The tool is released in the open domain. This is a preprint of a paper appeared in 2021 in Quaternary Science Reviews. The final paper can be retrieved at: 10.1016/j.quascirev.2021.106884

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## 1. Introduction

The standardization of data on Holocene sea-level proxies has been a recurrent theme in coastal Quaternary Science research. While it was theorized and implemented at least since the early 80s (Shennan, 1982; Shennan et al., 1983; Van De Plassche, 1986), only recent work has established a comprehensive framework for the standardization of sea-level data and applied it globally (Khan et al., 2019). The sea-level data standardization efforts were elicited by different IGCP (International Geological Correlation Programme, later renamed as the International Geoscience Programme) projects and the INQUA-PAGES project PALSEA (Palaeo-Constraints on Sea-Level Rise).

A paper stemming from the PALSEA community (Düsterhus et al., 2016) highlights that the key elements to be considered when compiling a sea-level database are: Accessibility, Transparency, Trust, Availability, Continuity, Completeness, and Communication of content. This set of properties was abbreviated into the ATTAC<sup>3</sup> acronym. “Communication of content”, according to Düsterhus et al. (2016), means that interfaces for visualization, and standardized protocols for data extraction need to be implemented to allow users from different disciplines to easily visualize and export data of interest.

In this short note, we present one tool designed to meet such criteria, called PALEO-SEAL. The tool makes use of a MySQL version of the sea-level data template of Khan et al. (2019). Installed on any web server supporting PHP and with few simple steps to set it up, it can be used to create a webpage to explore, plot and download Holocene sea-level data.

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## 2. PALEO-SEAL description

The core of PALEO-SEAL are two main data visualization options. One is a map, where points are clustered and de-clustered at different zoom levels. Within the map, data can be filtered either by a drop-down menu or directly on the map. The drop-down menu allows for the selection of data type (type of sea-level indicator), Region, Subregion, Reference, Publication year, or Dating method. On the map, data can be selected for export with a “draw rectangle” tool. Once a subset of data is selected, it is possible to visualize it in a data explorer interface (Figure 1). The data explorer interface consists of an age/elevation graph (with adjustable X and Y axes) and a simplified table that previews the sea-level data plotted.

The data explorer interface has the same data filtering options as the map, and the two interfaces are linked: what is selected on the map will appear in the data interface and vice-versa. From both map and data explorer, it is possible to create a list of datapoints to be exported. Once filtering is complete, an “Export” button allows the selected data to be downloaded as a \*.csv file, compliant with the Khan et al. (2019) template.

## 3. Installing PALEO-SEAL

PALEO-SEAL is available via Zenodo (Drechsel and Rovere, 2020). The repository can also be forked from GitHub. Pre-requisites for PALEO-SEAL are a server with MySQL (where data is stored) and PHP 7 installed. Then, the following steps allow to deploy PALEO-SEAL.

**Prepare and deploy the MySQL database.** The data that will be shown in PALEO-SEAL need to be hosted on a remote server, where the administrator will have to create a MySQL database. The only privileges needed by the interface are "SELECT" and "SHOW VIEW". As the user name and password to access

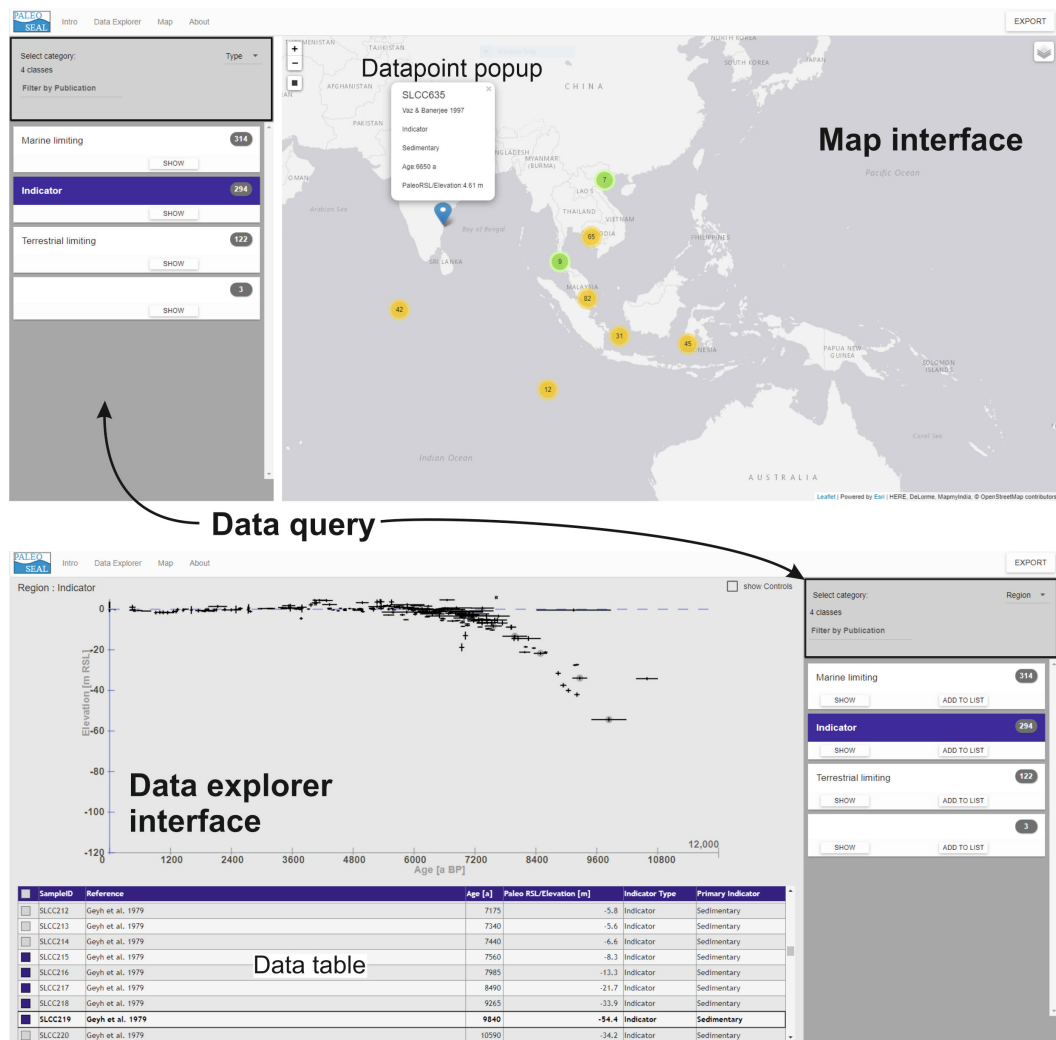


Figure 1: Screenshots of the maps and data explorer interfaces in PALEO-SEAL.

the database will be visible to anyone with access to the code, it is strongly suggested to create a user with only these minimal privileges dedicated to the PALEO-SEAL interface. This will protect the data from unwanted changes by non-admin users. Once the database is created, run the SQL command "create table", included in the mysql folder. This will create 79 fields, reproducing the HOLSEA data table in the mySQL database. Fields headers in the database are coded with alphanumeric codes, corresponding to the fields in the HOLSEA database. To obtain descriptions of each field, you can refer to the `data_headers_lookup.json` file in the `\data\lookups` folder. Then, data can be imported into the mySQL database using common import functions from csv or excel.

**Modify the connection string.** Navigate to the folder `scripts\data\connect.php` and open the file with a text editor. Edit line 3 to connect to your database as follows inserting the server name, username, password, database and port to connect to your database.

```
$con=mysqli_connect("SERVER NAME", "USERNAME", "PASSWORD", "DATABASE", "PORT");
```

**Deploy your application.** Deploy the application by copying the entire PALEO-SEAL folder on a web server that supports PHP 7.0. The directory where PALEO-SEAL is copied needs to be publicly accessible.

**Change style (optional).** It is possible to change the appearance of PALEO-SEAL using HTML and CSS. For example, the logo can be changed by overwriting the `logo.svg` file in the `\common\img` folder. The web-pages of the application are contained in the `\pages` folder. Text and content can be edited from here. To change the page style, it is possible to modify the `\common\css\app` file and, if necessary, the `index.php` file.

## 4. Technical details

PALEO-SEAL uses different libraries to interrogate the database and display data.

The map was built with following leaflet.js and ESRI directives for AngularJS:

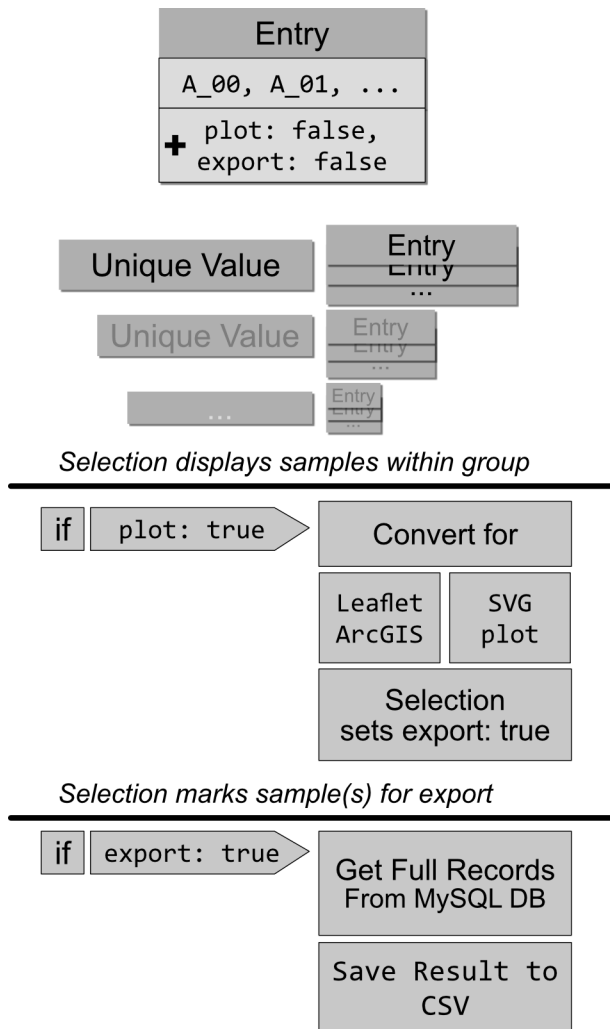


Figure 2: Data handling and processing within PALEO-SEAL.

- leaflet.js - *basic web map*
- esri-leaflet.js - *base maps*
- ui-leaflet.min.js - *user interface elements*
- angular-leaflet-directive.js - *connect AngularJS & Leaflet*
- leaflet.draw.js - *marker selection by area*
- leaflet.markercluster.js - *cluster markers based on scale*

The data explorer was built using a custom Scalable Vector Graphic (SVG) HTML element, extended with AngularJS directives to dynamically manage displayed data. The map and data explorer graph are interconnected with the AngularJS framework, which allows asynchronous storage and rendering the interface elements base on this dynamic data. The entire interface is a one-page website, rendering different outputs based on data and user choices.

## 5. PALEO-SEAL applications

In general, PALEO-SEAL can be used to visualize, query and download Holocene sea-level data related to a research project or a scientific paper. For example, we deployed PALEO-SEAL to showcase the data reviewed in the context of a research project on South-East Asia sea-level proxies by Mann et al. (2019). The deployed interface is available at this link. In general, the interface can be easily scaled up to thousands of points. Testing it with ca. 1000 records did not affect the query speed significantly. Papers similar to the available example are available from the areas listed in Table 1 of Khan et al. (2019).

## 6. Author contributions

Jan Drechsel developed PALEO-SEAL, Nicole Khan worked on the database template, Alessio Rovere wrote the paper and supervised the tool development.

## 7. Data and code availability

The code is available from GitHub at this link: <https://github.com/jDrechsel/PALEO-SEAL.git> or from Zenodo: <https://doi.org/10.5281/zenodo.4394223>. PALEO-SEAL is released under the terms of the Apache License 2.0 (<http://www.apache.org/licenses/LICENSE-2.0>). An example of deployment is hosted at <https://warmcoasts.eu/paleo-seal/>. In case this deployment will become unavailable in the future, we included the hosted files in the GitHub folder `Working_example`.

## 8. Acknowledgments

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## References

- Drechsel, J., Rovere, A., 2020. Paleo-seal: visualization and sharing of holocene sea-level data doi:10.5281/zenodo.4394223.
- Düsterhus, A., Rovere, A., Carlson, A.E., Horton, B.P., Kleemann, V., Tarasov, L., Barlow, N.L., Bradwell, T., Clark, J., Dutton, A., et al., 2016. Palaeo-sea-level and palaeo-ice-sheet databases: problems, strategies, and perspectives. *Climate of the Past* 12, 911–921.
- Khan, N.S., Horton, B.P., Engelhart, S., Rovere, A., Vacchi, M., Ashe, E.L., Törnqvist, T.E., Dutton, A., Hijma, M.P., Shenan, I., 2019. Inception of a global atlas of sea levels since the last glacial maximum. *Quaternary Science Reviews* 220, 359–371.

- Mann, T., Bender, M., Lorscheid, T., Stocchi, P., Vacchi, M., Switzer, A.D., Rovere, A., 2019. Holocene sea levels in south-east asia, maldives, india and sri lanka: the seamis database. *Quaternary Science Reviews* 219, 112–125.
- Shennan, I., 1982. Interpretation of flandrian sea-level data from the fenland, england. *Proceedings of the Geologists' Association* 93, 53–63.
- Shennan, I., Tooley, M.J., Davis, M.J., Haggart, B.A., 1983. Analysis and interpretation of holocene sea-level data. *Nature* 302, 404–406.
- Van De Plassche, O., 1986. Introduction. Springer Netherlands, Dordrecht. pp. 1–26. URL: [https://doi.org/10.1007/978-94-009-4215-8\\_1](https://doi.org/10.1007/978-94-009-4215-8_1), doi:10.1007/978-94-009-4215-8\_1.