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Short communication

Crowdsourcing in the Quaternary sea level community: insights from the Pliocene

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ABSTRACT

In order to establish the 'fingerprint' of past sea level changes, many field measurements of paleo sea level from globally distributed locations are needed. It is because this problem requires a geographically expansive database that it becomes an ideal candidate for crowdsourcing techniques. In order to crowdsource sea level data from the Mid-Pliocene Warm Period, we developed three tools: PlioWiki, RSL_{calc} and RSL_{map}. PlioWiki is a web portal, open to contributions, where investigators can share knowledge on Pliocene to Quaternary relative sea levels. RSL_{calc} is a standardized, ready-to-use tool for field geologists to log their own sea level field observations and, if they desire, submit new data to an open access database of relative sea level markers. RSL_{map} allows one to visualize and query the database built with RSL_{calc} on a Google Map interface. Here we describe these tools and discuss the advantages of crowdsourcing, relative to traditional approaches, for the creation of sea level databases for any time period.

1. Introduction

J. Howe first introduced the term "crowdsourcing", an analogy of outsourcing, in his 2006 *Wired* magazine article, "The Rise of Crowdsourcing". Wiktionary defines crowdsourcing as delegating a task to a large diffuse group, usually without substantial monetary compensation. In the scientific arena, this term is often linked with the concept of wikinomics which comes straight from 'Wikipedia' and is a system designed to crowdsource the editing of documents that are then immediately presented as publicly visible web pages (Tapscott and Williams, 2006; Rinaldi, 2009).

In Earth sciences, crowdsourcing has been used to build collaborative networks aimed at collecting and geo-locating field observations at global scales (Heipke, 2010). An early example of this comes from Wisser et al. (2009), whose paper describes a web-based platform (http://wikipeatia.org/) that assembles peat land data through crowdsourcing. Similarly, Fritz et al. (2009) describe a wiki portal (www.geo-wiki.org) that allows users to submit ground-verified data used to validate global land cover estimates obtained by satellites. The USGS website "Did you Feel It?" (http://earthquake.usgs.gov/earthquakes/dyfi/), allows users to contribute their experience of an earthquake, providing a more complete description of the effects and the extent of earthquake damage. These types of community-based collaborative methods have also been widely used in disaster-response actions where obtaining ground data in relatively short time is essential (e.g., Zook et al., 2010).

While crowdsourcing in the Quaternary Sciences is not widespread (probably due to the more specialized way in which field data are collected), the compilation of large comprehensive databases of RSL markers is an objective shared by a number of recent projects focusing specifically on Quaternary RSL markers. Such groups include PALSEA (http://eis.bris.ac.uk/~glyms/working_group.html, Siddall and Milne, 2012), MEDFLOOD (www.medflood.org, Rovere et al., 2012), IGLASS (http://www.highstand.org/iglass/) and SLIVISU (http://www.vismaster.eu/news/slivisu/, Klemann et al., 2011). These databases are necessary because past sea level observations need to be evaluated within the context of glacioisostatic models of crustal loading. Such models make predictions as to where diagnostic responses of sea level to a given ice volume change are likely to be observed. As no site can perfectly record global eustatic sea level, numerous field measurements of paleo sea level estimates from globally distributed locations are required to create a 'fingerprint' of global sea level change.

The PLIOMAX project (Raymo et al., 2009) aims to reconstruct the 'fingerprint' of sea level change for the Mid-Pliocene Warm Period (MPWP), between 3.3 and 2.9 million years ago. As uplift corrections are typically dependent on the knowledge of late

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Pleistocene sea level history, PLIOMAX addresses not only Pliocene, but also Pleistocene field observations. Here we describe three web applications (named PlioWiki, RSL_{calc} and RSL_{map}) that can be used to "crowdsource" information and data on MPWP and Pleistocene sea levels.

2. PlioWiki

PlioWiki (www.pliomax.org) is a wiki site whose aim is to summarize both existing evidence on Pliocene sea level as well as review the field and dating methods that are used to generate such data. The main page of PlioWiki describes the goals of PLIOMAX and the current state of knowledge on Pliocene ice sheets and climate. Additional pages are dedicated to the description of field and dating techniques and the use of glacioisostatic models. Scientists or students willing to contribute to PlioWiki can request editing access, and after registering they can add to or modify the content of existing pages, start a discussion on a particular topic, or add a new page. From the wiki, two tools that facilitate the logging, submission, and visualization of data on RSL markers can be accessed: RSL_{calc} and RSL_{map}.

3. RSL_{calc}

RSL_{calc} (http://pliomax.org/pliowiki/index.php/RSLcalc) stands for Relative Sea Level calculator – a web based calculator, built using MsExcel® and converted into HTML with SpreadsheetConverter© software. RSL_{calc} can be used for calculating relative sea levels from geological field data and contains fields for entering essential observations and metadata. The spreadsheet also contains equations that can calculate the position of a former sea level corrected for post-depositional uplift or subsidence using the observational values inserted. On the home screen, a link is provided to download the spreadsheet on which RSL_{calc} is based. While the online version of RSL_{calc} allows for the entry of data on a single site per session, the downloadable spreadsheet contains the same functions but allows the insertion of data for up to 100 sites. When all the mandatory fields are filled a 'Submit' button becomes available allowing the user to enter their published or unpublished field results into the database. Although a similar button is not inserted in the downloadable spreadsheet, authors are encouraged to consider sending their Excel data file by email. Data received via RSL_{calc} are checked for completeness before being inserted into the opensource database that can be publically accessed using RSL_{map}.

4. RSL_{map}

RSL_{map} (http://pliomax.org/pliowiki/index.php/RSLmap) is a visualization tool for RSL markers, and is based on a Google Maps API® connecting to a Google Fusion Tables layer®, inserted into a HTML5 webpage. This tool allows the display and querying of the public database built with RSL_{calc} through an interactive map that contains a series of points, each representing a RSL indicator published in literature (or submitted with relevant metadata by an online user). When one clicks on a point on the map, a pop-up window appears showing information about that site, including marker type and elevation, age of the marker, tectonics, sea level corrected for tectonics by RSL_{calc} and bibliographic reference(s). At the top of the page, a user can filter the data to be displayed by selecting a time period, a location (nation, region or site name) or a specific author (Fig. 1).

5. Discussions and conclusions

The Pliocene epoch is an ideal testing ground for the potential of such approaches, as the number of scientists engaged in Pliocene sea level research are relatively fewer than, for example, those

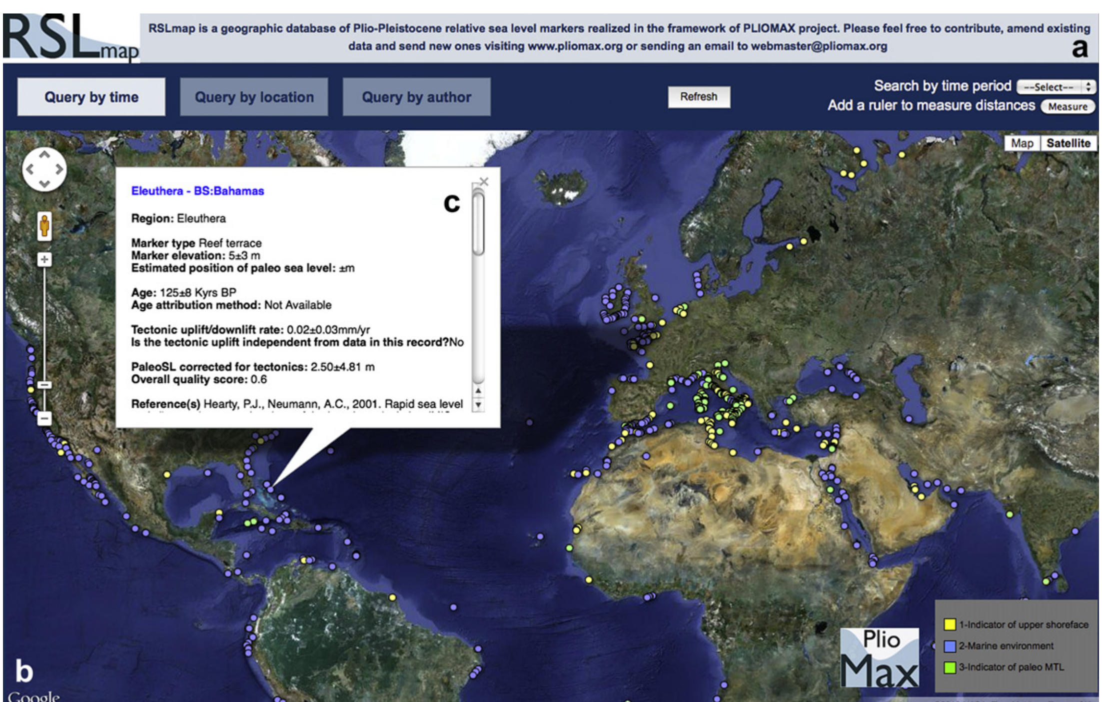

Fig. 1. Screenshot of RSL_{map}. a) Toolbar with which a user can query data and measure distances between locations; b) Google maps API, with common google visualization functions; c) Pop-up window that appears when the user clicks on one of the points on the map. This pop-up window displays data from Hearty (1998) on MIS 5.5 at Eleuthera Island, Bahamas.

concerned with Holocene or late Pleistocene sea level studies. Within the framework of PLIOMAX, we offer three tools that employ crowdsourcing to collect, and make accessible, knowledge and data on MPWP paleo-sea levels. PlioWiki represents a way of providing basic information, including links, tools, and references, to students or scientists seeking to deepen their knowledge of the methods used to study Pliocene sea level history. RSL_{calc} and RSL_{map} are more specialized tools, built for scientists looking for a standardized way to build their own database or for a specific dataset of published paleo relative sea levels.

Using these tools to contribute data and content, scientists can make their published data easily updatable and accessible to a broad audience. The use of tools such as RSL_{calc} and RSL_{map} will allow the sea level community to resolve two common issues faced when working with RSL markers. The first issue concerns standardization of metadata. Papers reviewing evidence of past sea level typically adopt the database structure chosen by the author pool, with the result that the same data are often reported with different table structures in different papers. RSL_{calc} and RSL_{map} provide a standardized framework within which to organize and retrieve field data. Reviews or research papers published using datasets built using RSL_{calc} or downloaded from RSL_{map} would be ‘snapshots’ linked to a dynamic, up-to-date and crowdsourced database. A second advantage of RSL_{calc} is that authors have the ability to modify the database, revisiting earlier interpretations of their field data, and/or adding updates as they are successively published.

QSR’s byline states that “all the Quaternary sciences are changing rapidly and subject to re-evaluation as the pace of discovery quickens”. This is especially true for RSL markers field databases that are constantly expanding as well as getting revised, updated, re-evaluated or re-measured by scientists around the world. Such databases provide an ideal subject for the application of crowdsourcing approaches as introduced here.

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