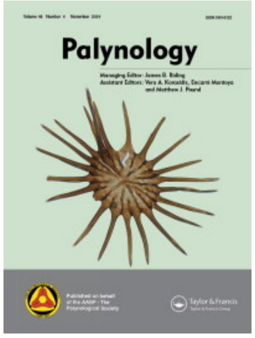

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A global modern pollen and spore dataset

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Abstract

Here we present a new global compilation of modern pollen and spore data for use in testing and evaluating palaeoclimate reconstruction methods. The resulting dataset contains 21,503 pollen assemblages from all continents, excluding Antarctica. All pollen assemblages have geographical coordinates, and the majority have an elevation measurement. Taxonomic nomenclature has been standardised.

Keywords: Contemporary, surface, palynology, world

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1. Introduction

Many Cenozoic plant-based palaeoclimate reconstructions use nearest living relative techniques (Wang et al. 2021; McCoy et al. 2024). These assume that the fossil taxon had similar climatic requirements to its living relative(s). The climatic requirements of the nearest living relative are then used to reconstruct the palaeoclimate of the time interval being investigated (Kershaw 1997; Fauquette et al. 1998; Kühl et al. 2002; Utescher et al. 2014; Chevallier 2022). As part of ongoing research into the global climate of the Middle Miocene geological time interval, it became necessary to evaluate pollen-based palaeoclimate reconstruction techniques with modern data. We present the global modern pollen and spore dataset (here after called GALORE: GlobAL mOdeRn pollEn) developed for this purpose. This dataset compiles data from previously published databases: the African Pollen Database (Ivory et al. 2020), the modern pollen dataset of China (Chen et al. 2021), the Eurasian Pollen Database (Chevalier et al. 2019; Davis et al. 2020), Latin American pollen database (Flantua et al. 2015), LegacyPollen 1.0 (Herzschuh et al. 2022), Neotoma (Williams et al. 2018), and the North American Modern Pollen Database (Whitmore et al. 2005). Additional regional, country, region, and site-specific studies have been added to these, when they are not currently incorporated in these databases, with the aim of increasing geographic coverage. This dataset does not aim to reproduce or replace these existing databases, instead it is a product built from extracting specific data samples from these.

2. Materials and Methods

Modern pollen and spore assemblage data were collated from existing databases, datasets and individual publications. Data collation initially focussed on existing databases. Literature searches, using Web of Science and Google Scholar, were performed for any country that was not present after this initial collation (using both English and official language name for missing countries). Searches concluded at the end of 2023. Geographical data was recorded as a site name that is consistent with that given by the original authors, digital latitude and longitude, and elevation. When publications did not provide any of these details, country, latitude and longitude were determined from published location maps and Google Earth. When elevation was absent, this was listed as n/a. Elevation has also been derived from the WorldClim 2.1 elevation 30 seconds dataset as an additional internally consistent format (Fick & Hijman 2017). Contextual data, including: environmental information of the site, sample type, duration of sampling (for pollen traps only) and how the pollen assemblage was recorded.

Pollen and spore assemblages in GALORE were standardised by removing uncertain identifications, indeterminate records and non-plant taxa. Uncertain identifications were any taxa noted as cf. (confer) or aff. (species affinis), any assigned to more than one family, assigned a morphological name, or any assigned to a rank above family level. Following this filtering of uncertain identifications, all taxa were checked in the Global Biodiversity Information Facility (GBIF) during March 2024 (GBIF 2024) and updated to their current taxonomic name. The GBIF has a taxonomy backbone that draws on 105 different sources to automatically check names and enables this central database to collate from multiple resources (GBIF Secretariat 2023).

Fossil pollen is rarely identified to a modern species level. As such, all species level identifications were aggregated into their generic level. Poaceae genera were collated at the family level, as these pollen are almost never identified to the genus level in Cenozoic

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palynology (e.g. Guimarães et al. 2015; Hui et al. 2018; Mander et al. 2023). Many other pollen grains are commonly identified at the family level, but examples exist in the literature for identification to genus and thus those were left for individual users to determine how to treat them. Sub-families were also collated into their respective families. The resulting dataset contains only genus and family names to mimic the data commonly used for palaeoclimatic reconstructions (Wang et al. 2021; Pilie et al. 2023; McCoy et al. 2024).

3. Dataset description and limitations

GALORE comprises three items: geographical and contextual data; pollen assemblages; and a reference list. Within the geographical and contextual data is a unique locality-pollen assemblage identifying number that links to the pollen assemblage table. Geographical information includes site name, country, digital co-ordinates and elevation of the site. Where available a description of the environment has been reproduced. Sample type provides the source of the pollen, and, where this is a pollen trap, “time interval” provides the length of collection in months. Data type presents the format the pollen assemblage was recorded as: presence-absence, counts, percentages, or unknown. Finally, source citations are provided to enable traceability of the data. Pollen assemblages are presented in rows, with each pollen taxon listed alphabetically in columns. This table can be related to the first by the ID number and site name. Finally, a full list of references is provided.

GALORE synthesises previously published modern pollen data. The data presented here reflects that published by the authors cited for each locality. There were potential sources of uncertainty in both the geographical and pollen assemblage data. Within the geographical data, determining a precise latitude-longitude from a location map and Google Earth means that some locations have lower geospatial resolution than sites where authors provide this information. The elevation recorded in publications does not always agree with the elevation from the WorldClim 2.1 dataset (the largest difference is 3182m). These differences could stem from either uncertainty in the original publications or topographical features not visible in 30 second WorldClim 2.1 dataset. Despite this, 16176 records have elevation differences <100m between that recorded from the original publications and that derived from the WorldClim 2.1 dataset.

As much of this data can be considered historical (the oldest record was published in 1954), the environmental data may not be accurate to present day conditions at the sampling site. Pollen assemblage data that was recorded as presence-absence was intended to be a less-biasing recording method than attempting to accurately measure from published pollen diagrams (when no other data presentation was published). Whilst this brings in its own biasing - all pollen are present equally in presence-absence data, this is clearly identified in the dataset and therefore a user can filter these out. Presence-absence data is useful, as several palaeoclimate reconstruction methodologies use presence-absence data in their procedures (Utescher et al. 2014; McCoy et al. 2024).

In generating this dataset, it became obvious that a clear geographical bias exists between the northern and southern hemispheres and particular geographical regions (Fig. 1), despite the data having sufficient geographical/elevation spread to incorporate all major vegetated climate zones on Earth (Fig. 1). However, there are clear opportunities to build upon this dataset, either by generating new data, or by making historical and archive data readily available to the wider community. It would also be beneficial to the community for this data to be registered in Neotoma (Williams et al. 2018), or a readily available region-specific database. Although the GALORE dataset was created for a specific purpose, it likely has

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more uses beyond testing palaeoclimate reconstruction techniques, and prospective users are encouraged to reach out to the corresponding author to discuss whether the dataset is appropriate for their needs

4. Data sources

The pollen and spore data in GALORE was collated from: Abreu et al. (2003), Adekanmbi & Ogundipe (2010), Agwu (1986; 2001), Al-Eisawi & Dajani (1988), Amaral et al. (2013), Amaral (2023), Anshari et al. (2004), Barboni & Bonnefille (2001), Barboni et al. (2019), Barrow (1978), Basumatary et al. (2017), Behling et al. (2000), Bell & Fletcher (2016), Bengo (2020; 2023), Bengo et al. (2020), Beuning (1997; 2023), Bishop et al. (2003), Blaus et al. (2020; 2023), Bonnefille & Riollet (1988), Botha et al. (1992), Bourel (2023), Boyd (1994), Buchet (1982; 2023a; 2023b), Burry et al. (2005), Bush (2000), Bush & Rivera (1998), Bush et al. (2001; 2015; 2021), Caratini et al. (1988), Carrion et al. (2000), Chabangborn et al. (2020), Charalampopoulos et al. (2021), Chen et al. (2021), Cheng et al. (2020), Chevalier et al. (2019), Collao-Alvarado et al. (2015), Cooremans (1989), Correa-Metrio et al. (2011; 2013), Davis et al. (2020), Deng et al. (2006), Djamali et al. (2020), Ebenezer & Christopher (2019), Edorh (1986; 2023a; 2023b; 2023c), Edorh & Afidégnon (2008), El Ghazali (2023), El Ghazali & Moore (1998), Elenga (1992; 2023a; 2023b), Elenga et al. (2000), Elliot (1999). El Moslimany (1983), Fiacconi (2017), Fiacconi & Hunt (2017), Flantua et al. (2015), Fontana (2005), Frazer et al. (2020), Fredoux (1978; 2023), Fukumoto et al. (2015), Gaillard et al. (2021), Geng et al. (2022), Ghosh et al. (2017), Gil Romera et al. (2006; 2007), Goldberg et al. (1988), Green et al. (2002), Guarín et al. (2015), Gucel et al. (2013), Hamilton (1972; 2023), Hedberg (1954; 2023), Henga-Botsikabobe (2023), Henga-Botsikabobe et al. (2020), Herzschuh et al. (2022), Hope & Pask (1998), Hope et al. (2019), Horisk et al. (2023), Horrocks & Ogden (1994), Ivory & Russell (2016), Ivory et al. (2020), Jan et al. (2016), Jolly (2023), Jolly et al. (1996), Kiared et al. (2017), Laseski (1983; 2023a; 2023b), Latorre & Perez (1997), Leal & Bilbao (2011), Leal et al. (2013), Lebamba (2009; 2023a; 2023b), Lebamba et al. (2009), Ledru (2002), Lézine (1981; 1987; 2023a; 2023b; 2023c; 2023d; 2023e; 2023f; 2023g; 2023h; 2023i; 2023j; 2023k), Lézine & Edorh (1991), Lézine & Hooghiemstra (1990), Lézine et al. (1998; 2010), Lopez (2023), Lopez et al. (2017), Lu et al. (2010; 2020), Maldonado et al. (2005), Maley (1981; 2023a; 2023b; 2023c) Maley & Livingstone (1983), Mancini (1993), Marais et al. (2015); Masciadri et al. (2013), McGlone & Meurk (2000), McGlone & Moar (1997), Medeanic (2004), Mittre & Sharma (1979), Mohammed (1992; 2023a; 2023b), Mohammed et al. (2004), Nguyen et al. (2022), Niokuocha (2006), Olatoyan et al. (2023), Ortega Rosas et al. (2008; 2020), Ortuño et al. (2011), Palacios (2011), Pandey & Minckley (2019), Pearson (1997), Penny (2001), Penny et al. (2006), Pereira et al. (2018), Perveen et al. (2007; 2014), Pinar et al. (1999), Pocknall (1982), Prasad & Quamar (2023), Punwong et al. (2024), Quamar & Stivrins (2021), Quamar et al. (2018), Randall (1990), Reese & Liu (2005), Reis et al. (2023), Reynaud (2023), Riedel et al. (2015), Ritchie (1986; 2023), Rodriguez-de La Cruz et al. (2010), Rucina (2000; 2023), Saad (2023), Saad & Sami (1967), Saeidi Ghavi Andam et al. (2021), Salzmann (1999), Schüler et al. (2014), Scott (1976; 1982; 1985; 1987; 1988; 1989; 1995; 1996; 1999), Scott & Bonnefille (1986), Scott & Bousman (1990), Scott & Brink (1992), Scott & Cooremans (1990; 1992), Scott & Woodborne (2007), Scott et al. (1992; 2003; 2004), Selkirk et al. (1982; 1988), Semeniuk et al. (2000; 2006), Singh et al. (1974), Stevenson et al. (2007), Straka (1991), Sugden (1989; 2023), Tng et al. (2010), Tossou (2002; 2023), Urrego et al. (2011), Valencia et al. (2010), Van Zinderen Bakker (1984); Van Zinderen Bakker & Müller (1987), Verlhac t al. (2018), Vincens (1982; 1987; 2023a; 2023b; 2023c; 2023d; 2023e), Vincens et al. (2000; 2006a; 2006b), Weng et al. (2004), Whitmore et al. (2005), Williams et

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al. (2018), Ybert (1977; 2023a; 2023b), Young & Schofield (1973a; 1973b), Yulianto et al. (2005).

5. Data Availability Statement

Data is available from Zenodo (https://zenodo.org/doi/10.5281/zenodo.11125269) and the National Geoscience Data Centre (submission id 21D8A562BB2C1740E0630B37940A6E9E).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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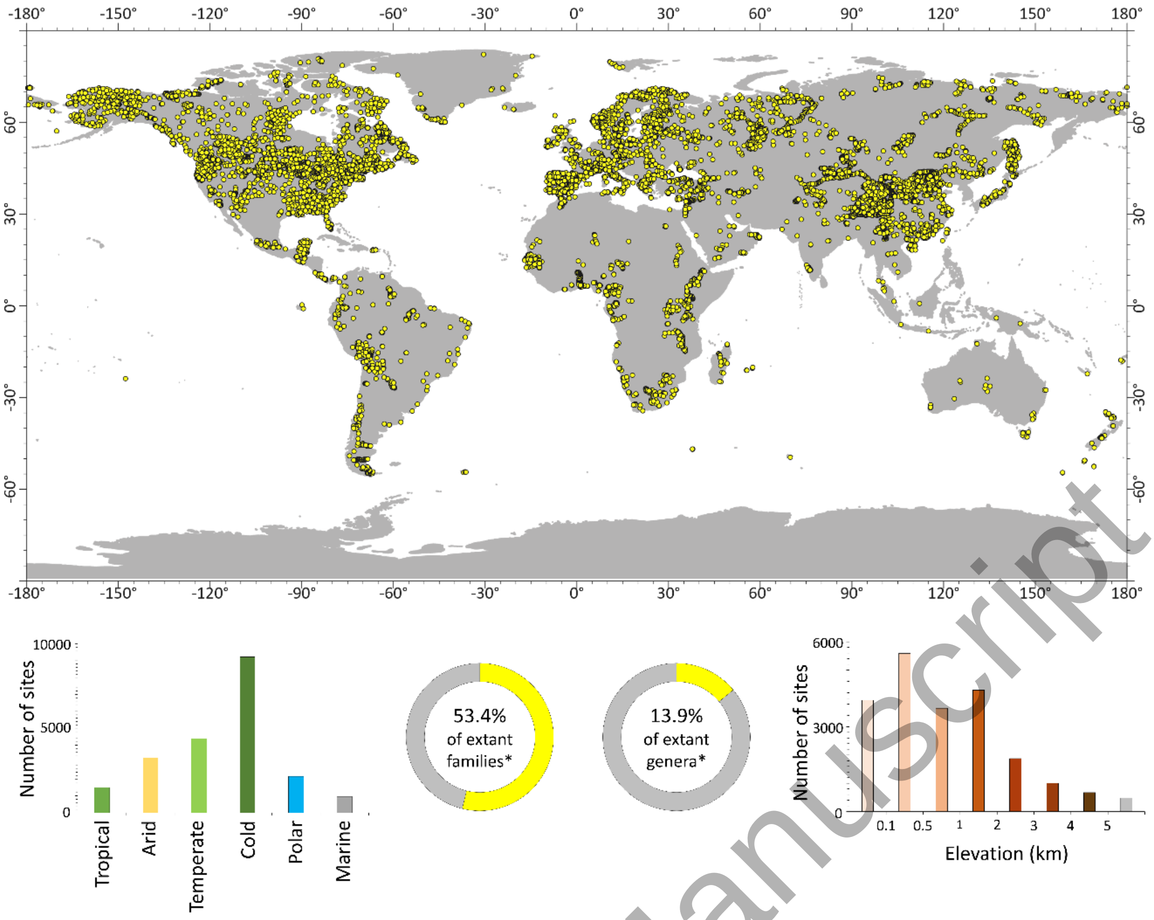

Figure 1. The GALORE dataset showing geographical distribution, and below, numbers of sites in climate zones (Beck et al. 2018), number of extant family and genera (Christenhusz & Byng 2016; Brinda & Atwood 2024) recorded in GALORE and numbers of sites binned by elevation (excluding the 482 sites without elevation data).

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