

Westerly wind shifts drove Southern Hemisphere mid-latitude peat growth since the last glacial

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Supplementary Information: Westerly wind shifts drove Southern Hemisphere mid-latitude peat growth since the last glacial

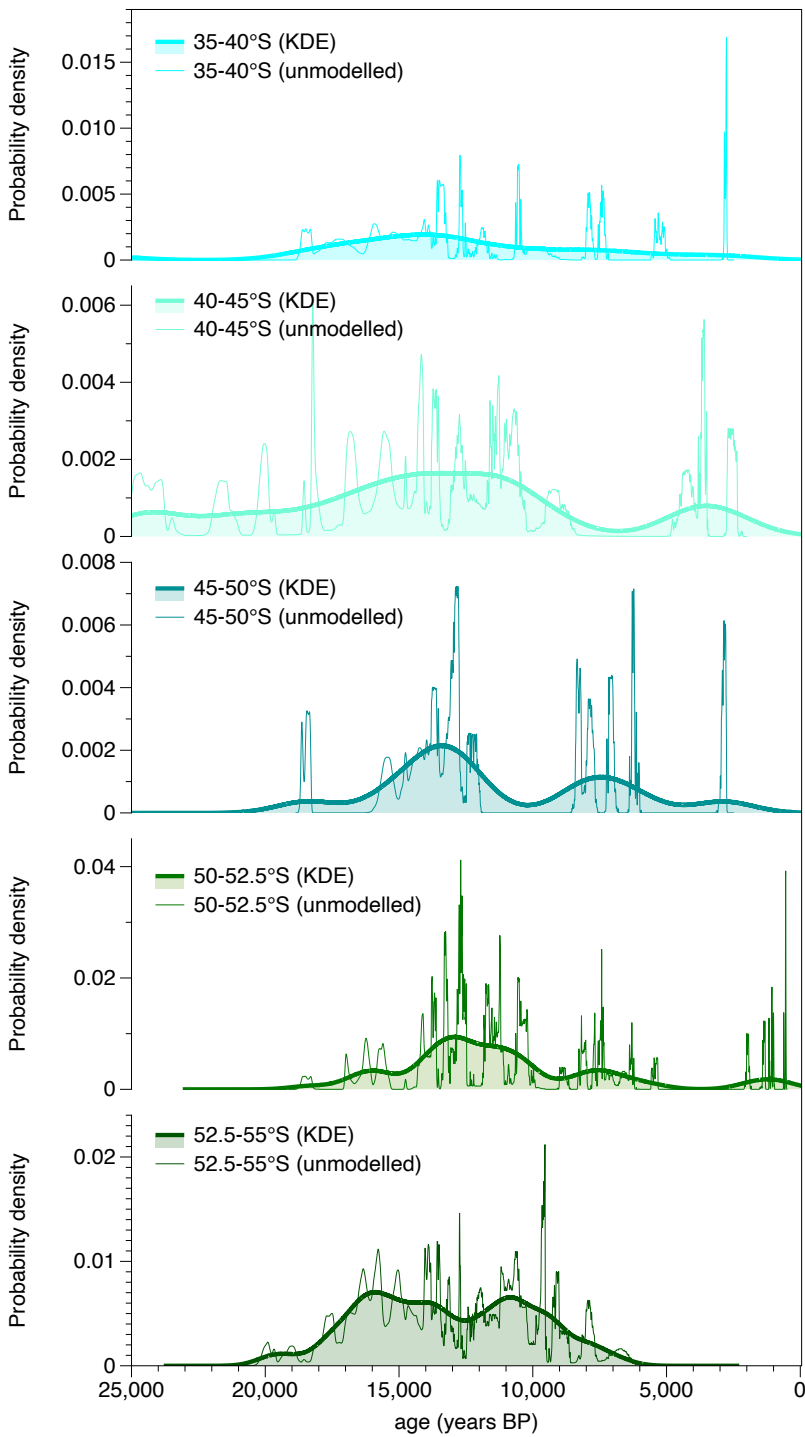


Figure S1. Kernel Density Estimate models with summed probability of basal peat calibrated ages over five different latitude bands. Source data can be found in Supplementary Data Table 5 and 6.

Latitudinal band	Total number of sites	South America	South Atlantic	Southern Indian	South West Pacific
35-40°S	19 (19)	0 (0)	1 (1)	0 (0)	18 (18)
40-45°S	22 (24)	10 (12)	0 (0)	0 (0)	12 (12)
45-50°S	27 (43)	3 (3)	0 (0)	14 (30)	10 (10)
50-52.5°S	64 (81)	6 (6)	39 (56)	0 (0)	19 (19)
52.5-55°S	66 (68)	48 (50)	8 (8)	0 (0)	10 (10)
60-65°S	3 (3)	0 (0)	3 (3)	0 (0)	0 (0)
Total	201 (238)	67 (71)	51 (68)	14 (30)	69 (69)

Table S1. Distribution of basal peat ages across different latitudinal bands and regions of the Southern Hemisphere (number in brackets include duplicate basal ages from the same peatland complex).

Regional data

Patagonia

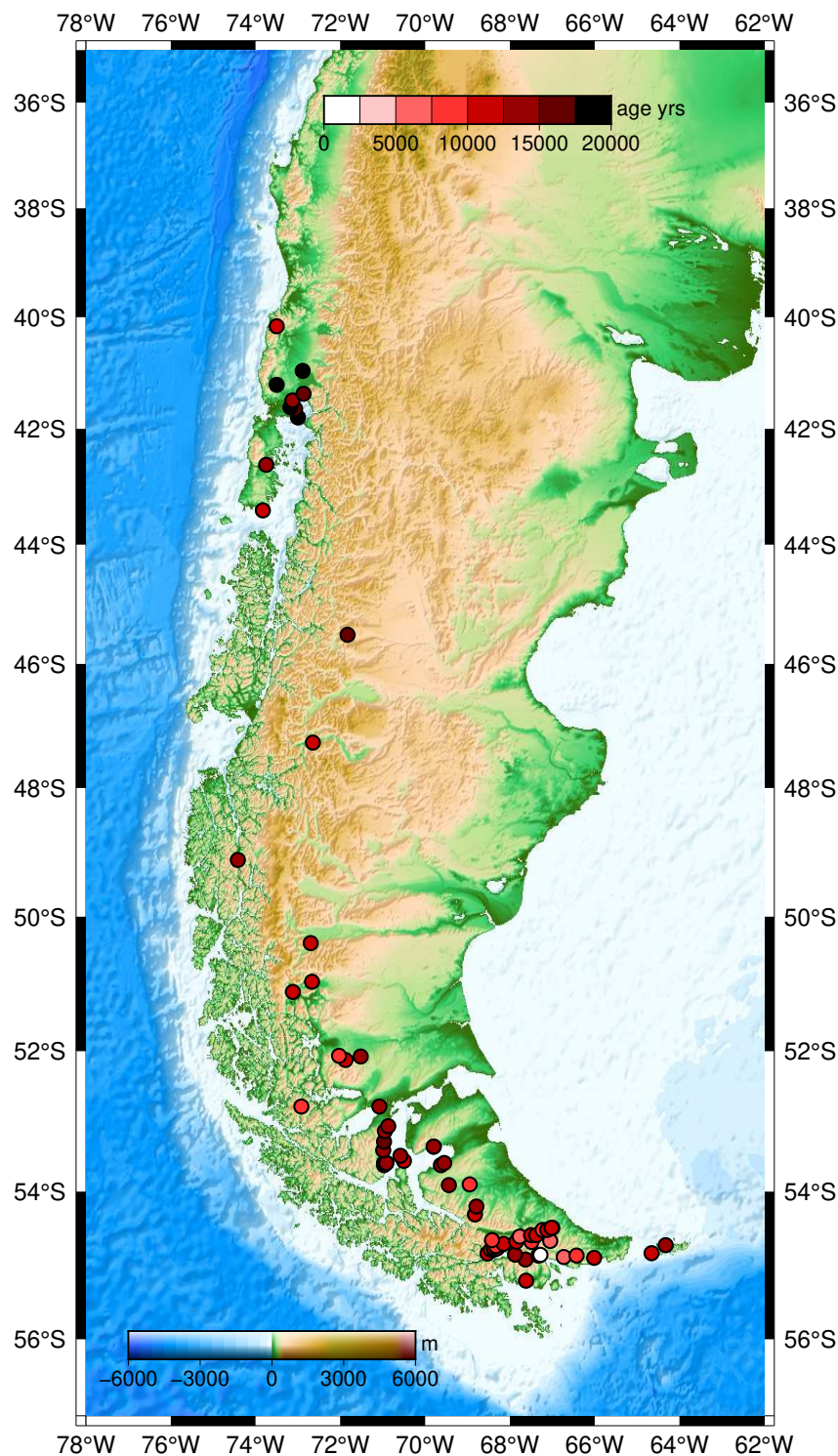


Figure S2. Map showing location and age of peatlands in Patagonia. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the Shuttle Radar Topography Mission (SRTM) 1-arc-second dataset (approx. 30 m resolution)⁴.

Patagonian peatlands occupy a climatic niche with a long, mild growing season promoting greater peat growth despite low precipitation⁵. Patagonian peatlands were mostly formed prior to 10 ka, and are capable of high carbon accumulation rates⁶. An estimated peat carbon pool of 15 GtC for southern peatlands is mostly dominated by Patagonia⁶. A comprehensive review of Patagonian peatlands is found in Leon et al.⁷.

South Atlantic (Falkland Islands, South Georgia, Nightingale Island)

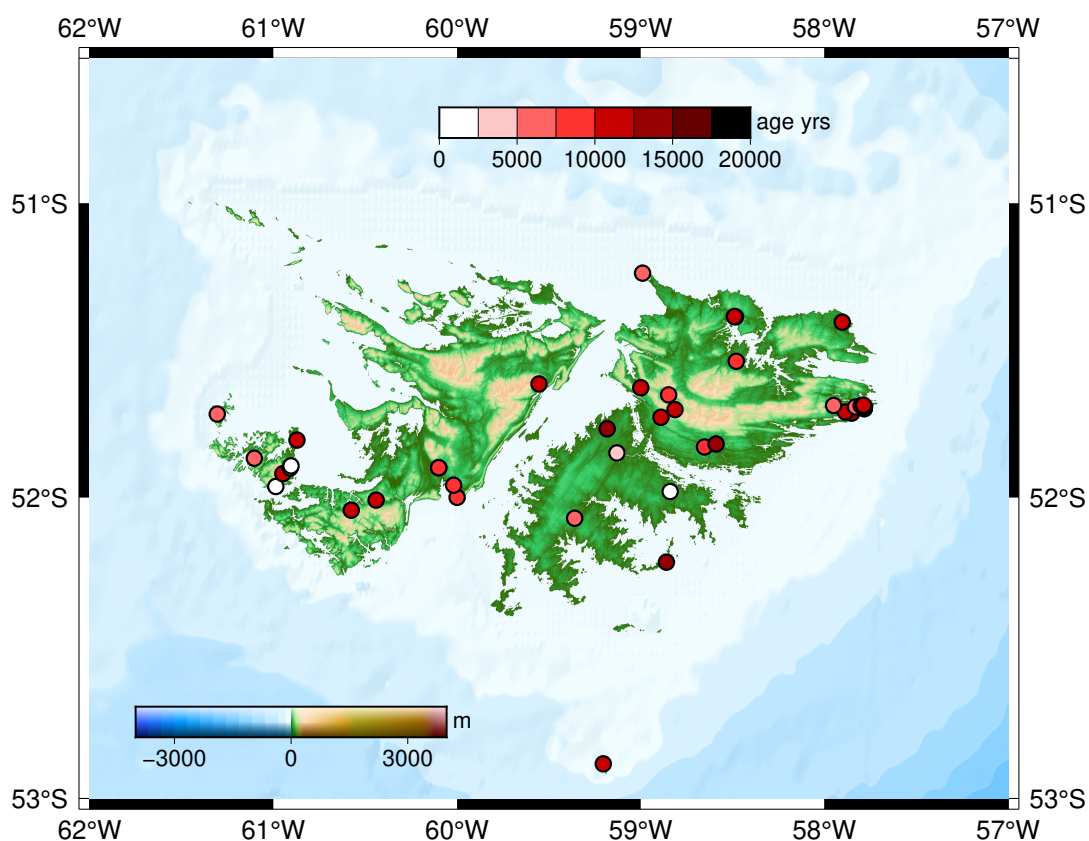


Figure S3a. Map showing location and age of peatlands in the Falkland Islands. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

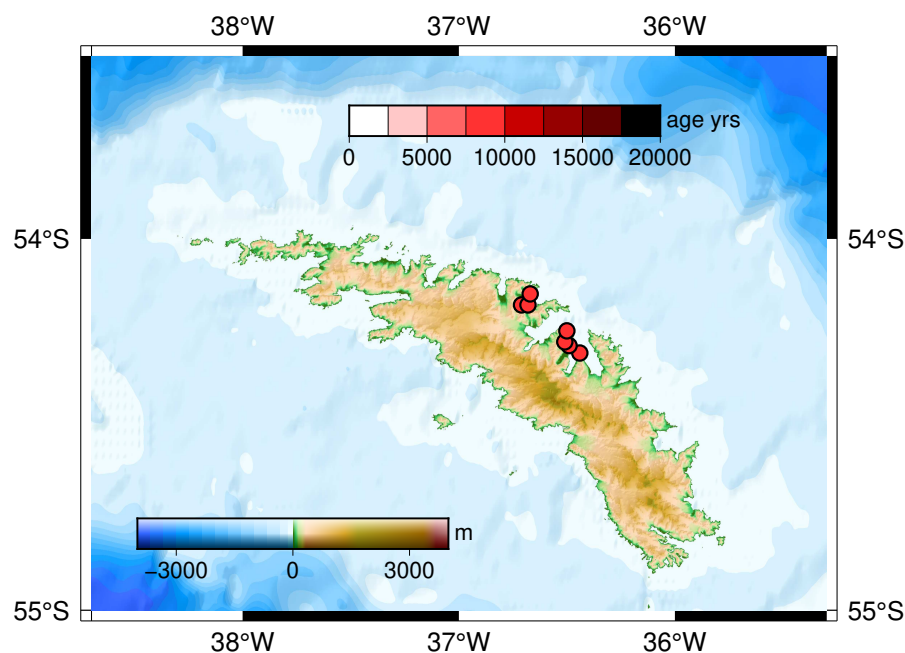


Figure S3b. Map showing location and age of peatlands in South Georgia. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

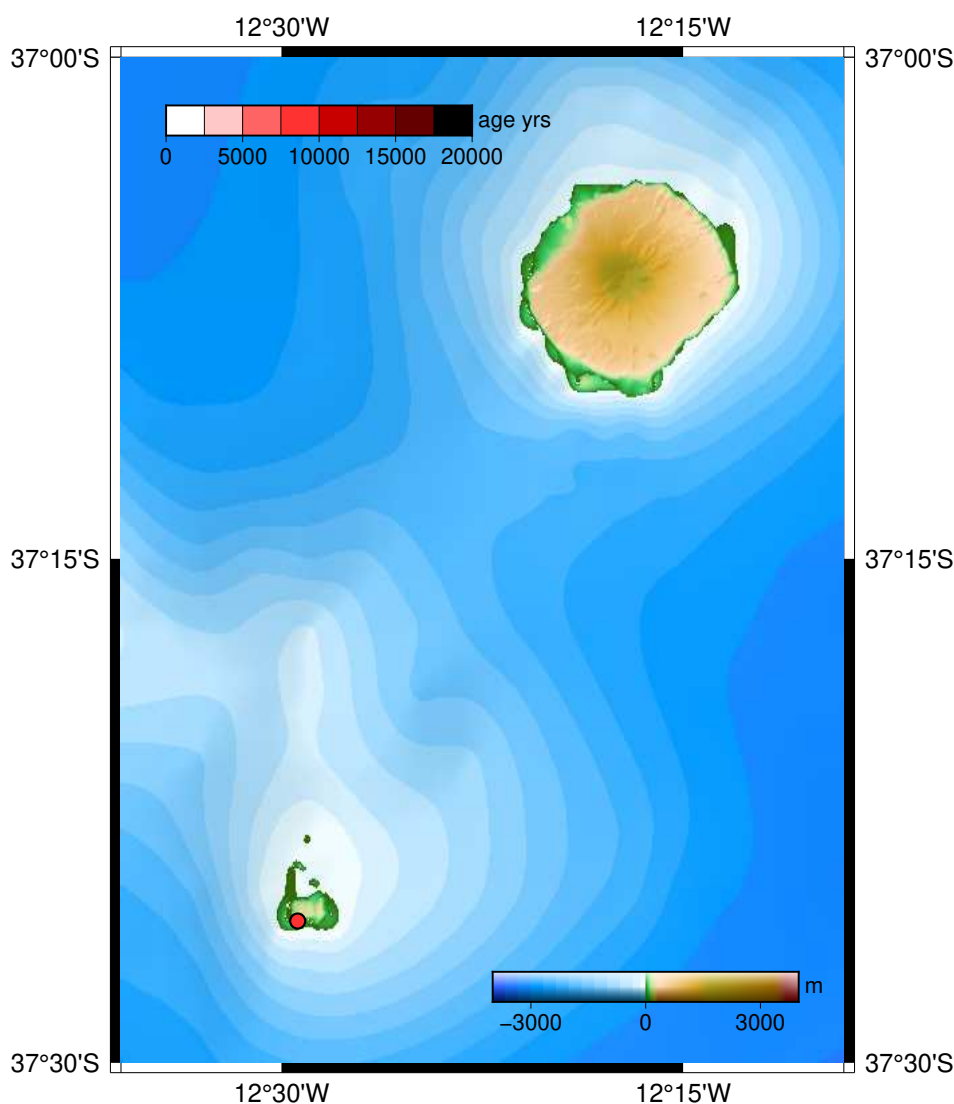


Figure S3c. Map showing location and age of peatlands in Nightingale Island. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

The South Atlantic region experiences a similar climatic niche to Patagonia and hosts extensive peatlands, covering some 45% of the land surface of the Falkland Islands⁸, and found throughout the lowlands of South Georgia and the South Sandwich Islands. A distinctive feature of many peatlands in these South Atlantic island archipelagos is that their formation and growth is limited by moisture availability rather than temperature⁹. For example, the Falklands have an unusually high mean annual temperature (7°C) and low mean annual precipitation (~700mm) for temperate/high-latitude peat forming regions¹⁰. A range of peatland initiation dates are reported here, with the New Haven site the oldest reported for the South Atlantic to date (peat initiation at $16,930 \pm 20$ cal yrs BP). Quaternary glaciation on the Falkland Islands is thought to have been limited to small mountain glaciers, potentially explaining the relatively old ages of these basal peats. This is supported by cosmogenic isotope surface exposure dates on valley-axis and hillslope stone runs which shows absence of widespread LGM glaciation¹¹. The Falkland Islands do have a weak longitudinal precipitation gradient, with higher rainfall on the east relative to the west, but there does not appear to be any clear spatial relationship of where the oldest peats are found. The estimated carbon stock from peatlands on the Falkland Islands is ~156 MtC¹⁰.

In South Georgia, the only dated peat deposits are from the west side of the island. These deposits are several metres thick and appear to be relatively consistent in age, with the oldest deposit reported at $11,000 \pm 220$ cal years BP¹². The single basal peat age from Nightingale Island, approximately 38km southwest of Tristan de Cunha is the result of terrestrialisation of a series of ponds¹³.

Southern Indian Islands (Kerguelen, Marion, Isles Crozet)

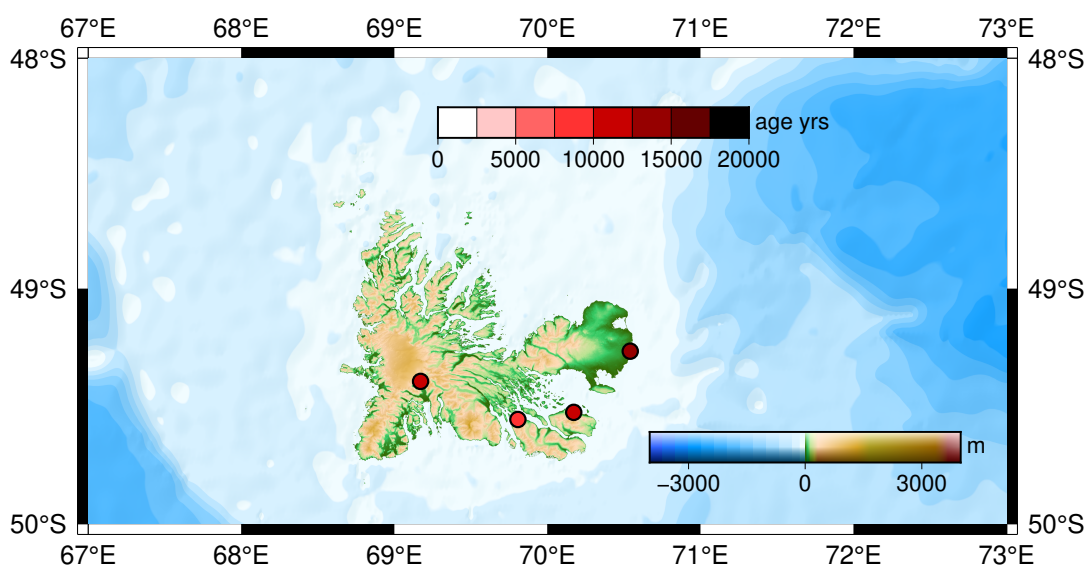


Figure S4a. Map showing location and age of peatlands in Kerguelen Island. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

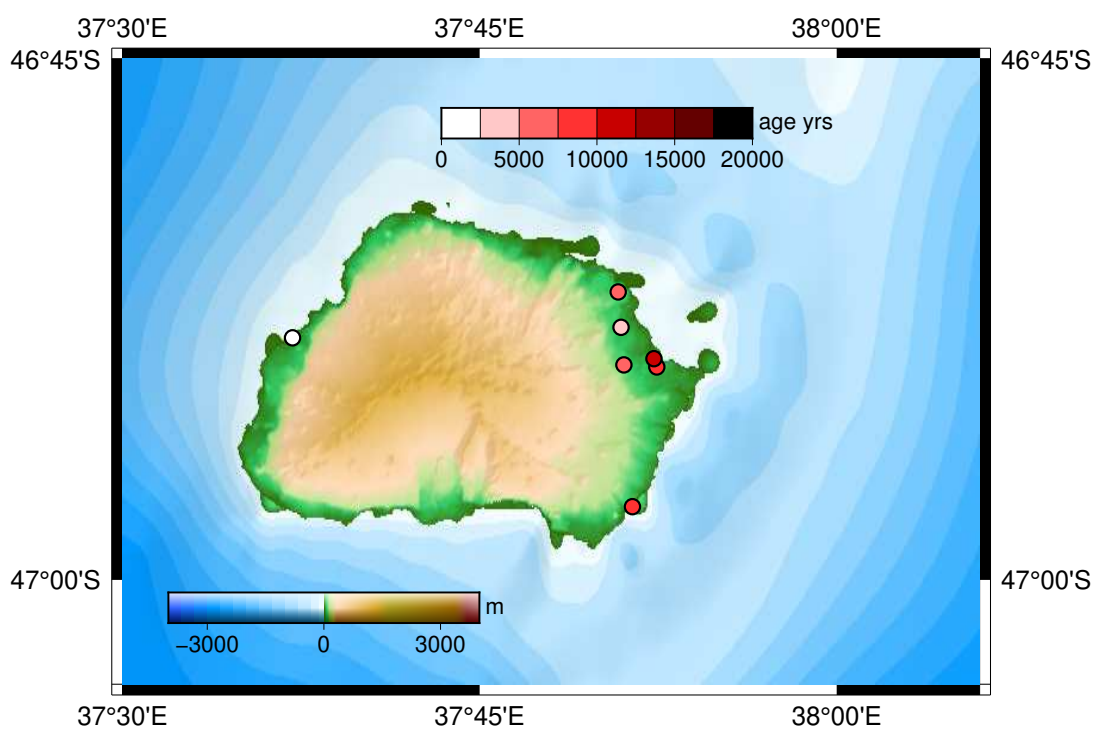


Figure S4b. Map showing location and age of peatlands in Marion Island. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

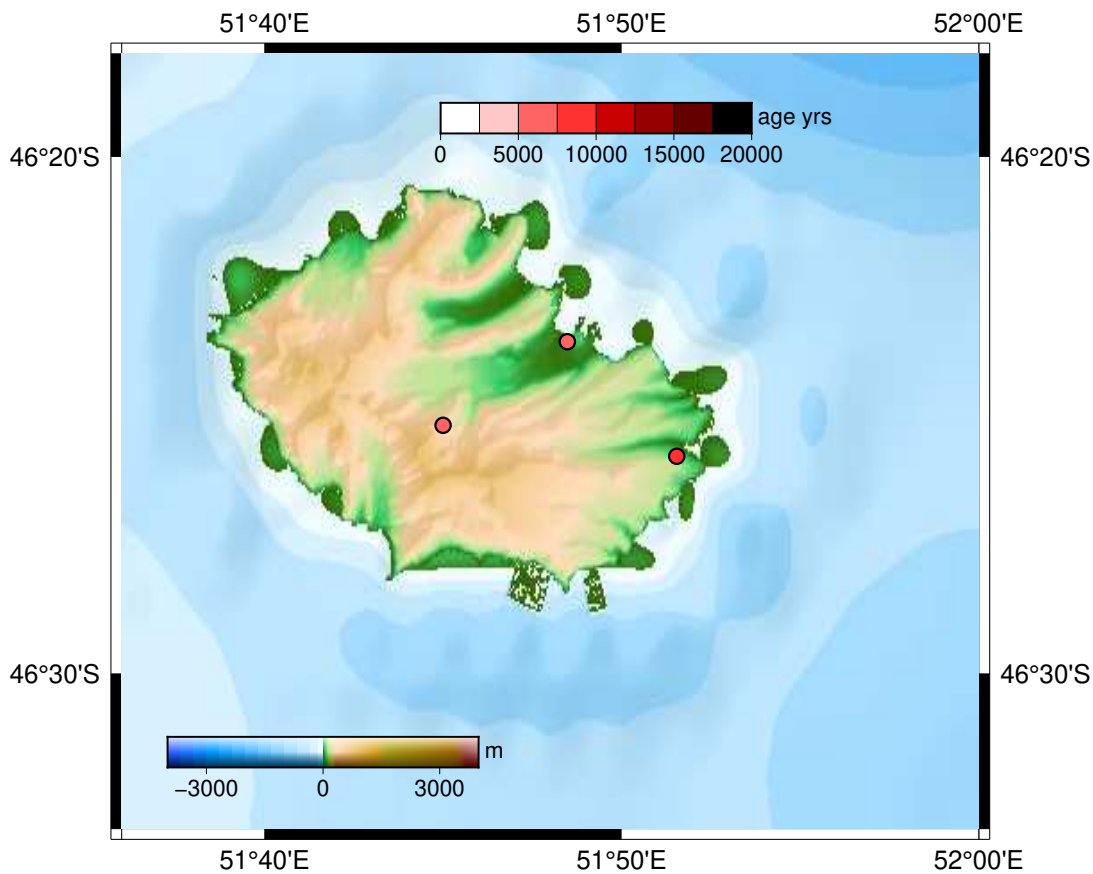


Figure S4c. Map showing location and age of peatlands in Isles Crozet. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

The sub-Antarctic islands of the Southern Indian Ocean are volcanic islands of varying ages (with Marion, Prince Edward, and Kerguelen Island still considered 'active'), and have more limited peat deposits mostly in coastal areas^{14,15}. Peat bogs are dominant on the lowlands of Marion Island, Kerguelen and Isles Crozet. Basal peat ages range from mid to late Holocene¹⁵. Across these islands, effective precipitation (precipitation minus evapotranspiration) plays a critical role in peat formation, with peat accumulation often constrained by the interplay of wind exposure, temperature fluctuations, and volcanic substrate conditions.

New Zealand

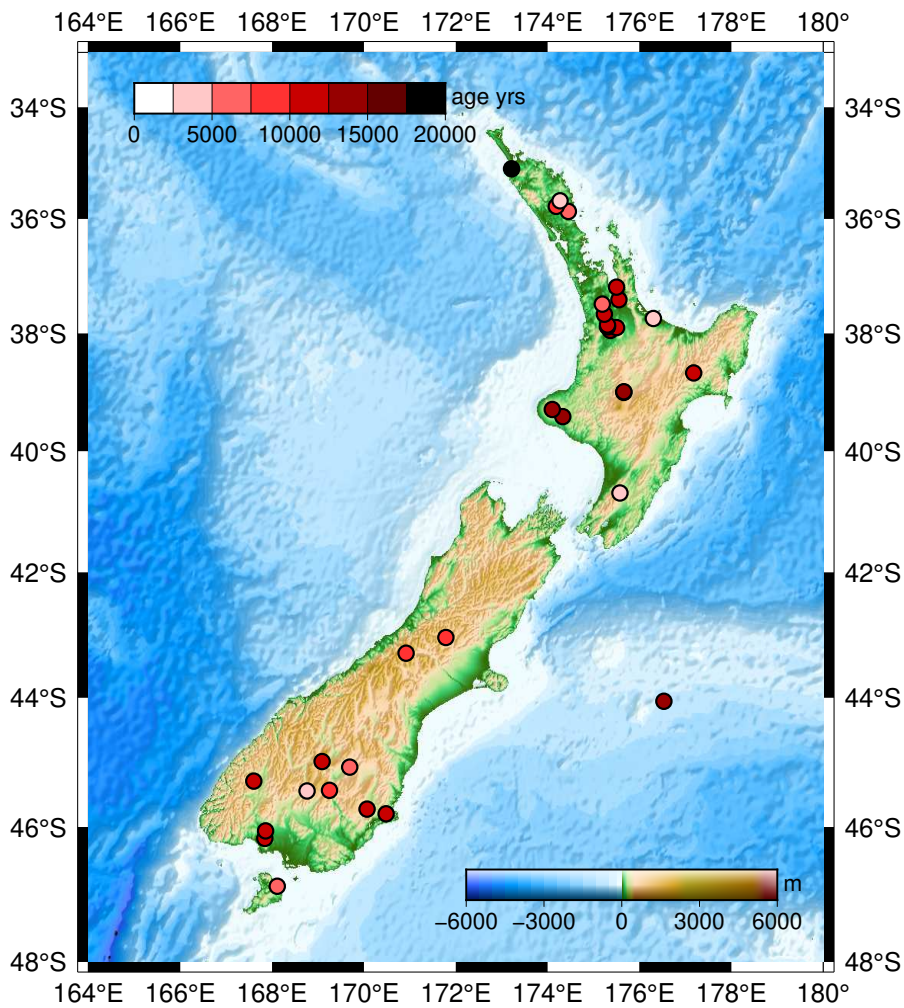


Figure S5. Map showing location and age of peatlands in mainland New Zealand. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

Most of New Zealand's wetlands formed at or after the end of the last glaciation¹⁶, particularly post 14ka, and are sensitive to changes in climate as well as geomorphic processes that alter moisture availability¹⁷. Many of these wetlands are several metres deep and are ubiquitous in high rainfall mountainous regions – few pre-Holocene mires form in the dry eastern districts, suggesting that moisture availability is a major limiting factor in some of these regions. However, it has been suggested that peatland initiations are largely due to landscape change rather than climatic change over the last 14ka¹⁶.

Tasmania

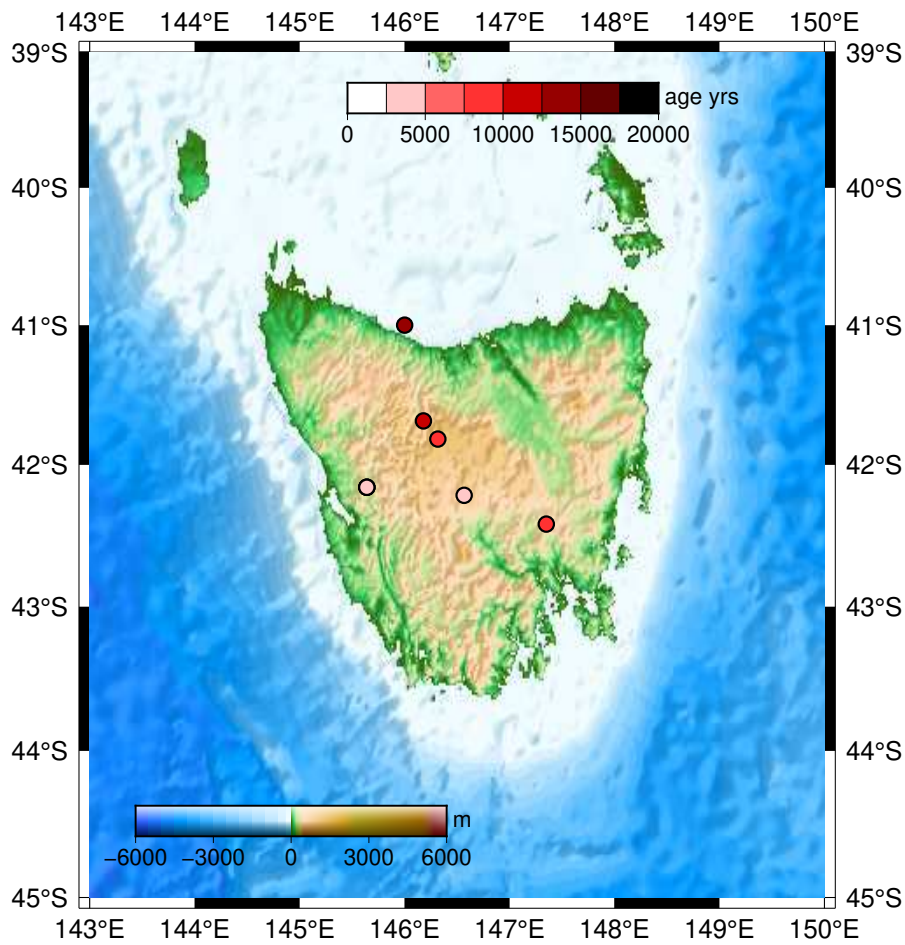


Figure S6. Maps showing location and age of peatlands in Tasmania. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

Tasmania's soils are largely shallow, acidic and infertile, and peat is not extensive, except in poorly drained areas^{18,19}. While Tasmania's climate is suitable for peat formation, some peats are thought to have formed during periods of groundwater level fluctuations²⁰.

SW Pacific Islands (Auckland Islands, Campbell Island, Macquarie Island)

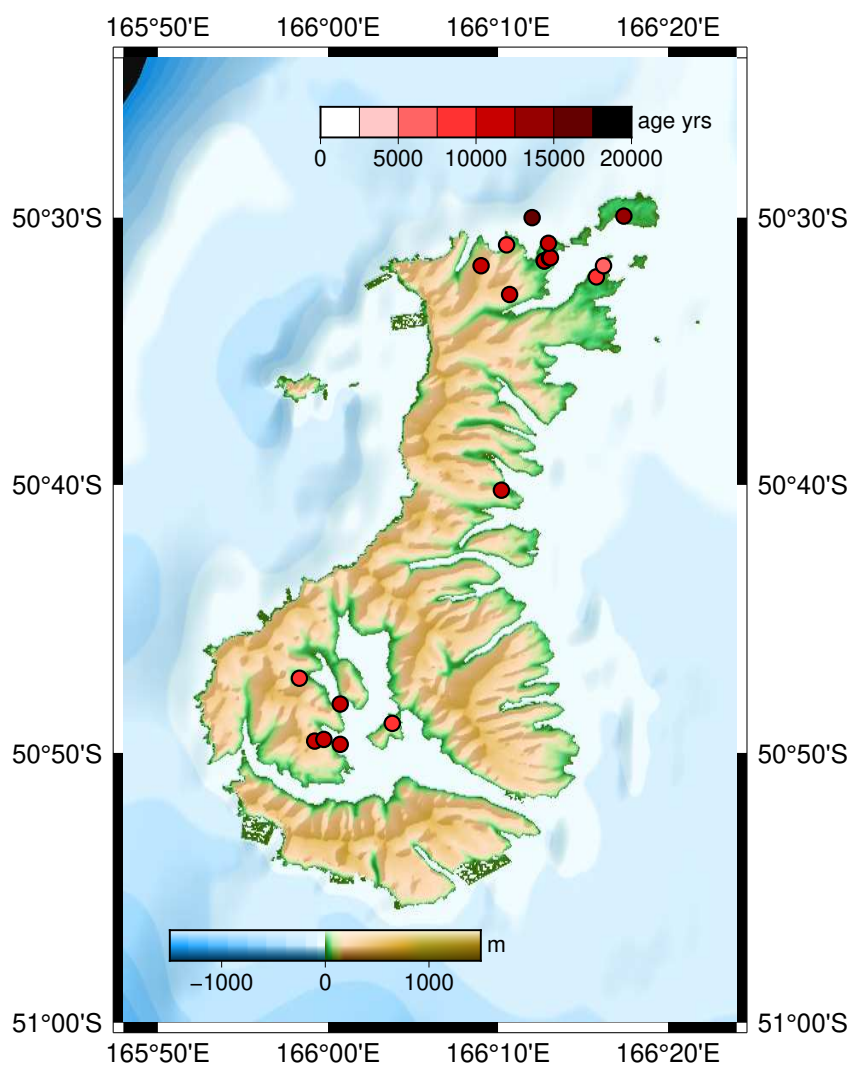


Figure S7a. Maps showing location and age of peatlands in the Auckland Islands. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

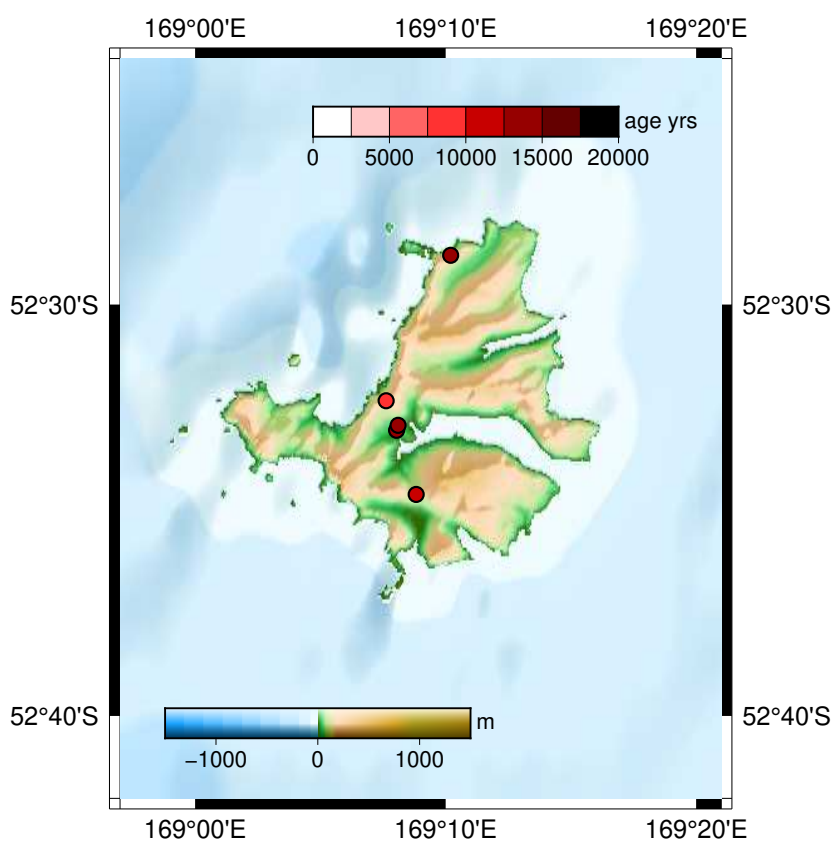


Figure S7b. Maps showing location and age of peatlands in Campbell Island. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

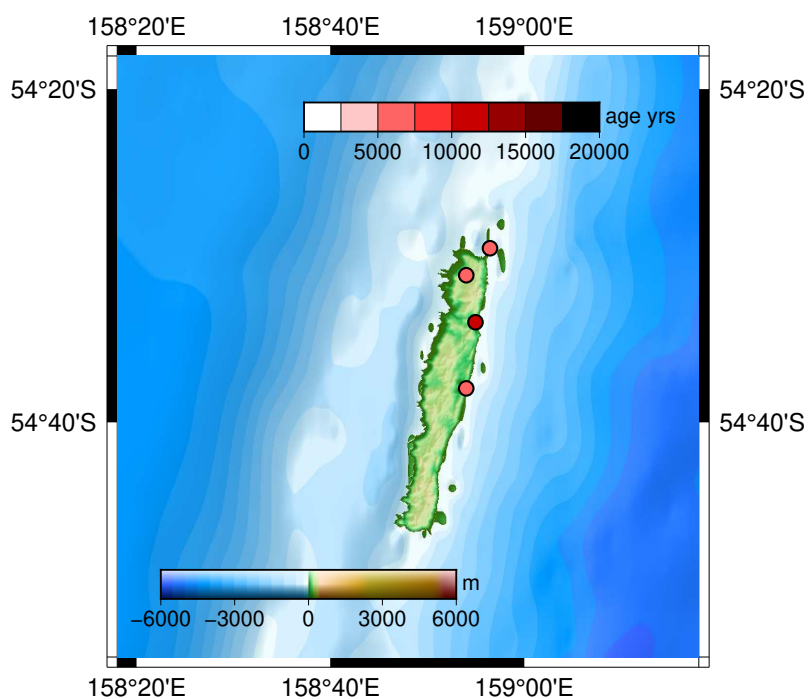


Figure S7c. Maps showing location and age of peatlands in Macquarie Island. Map generated using the Generic Mapping Tools v6² using coastlines from the GSHHG database³ and topography from the SRTM 1-arc-second dataset (approx. 30 m resolution)⁴.

Deep peat soils cover most of the SW Pacific islands, except for steep slopes and exposed high altitude sites²¹. Most are blanket peats several metres in depth but there are some smaller areas of oligotrophic bogs and fens²¹. The rapid peat accumulation rate in inland blanket peats appears to be driven by the inhibition of decay, rather than enhanced productivity. McGlone²¹ suggested that this was linked to the length of time that the soil surface remains moist throughout the year – requiring constant rain fall, high humidity, low daily temperatures, and low surface evaporation. No significant glaciation is thought to have occurred on Auckland or Campbell Islands during the Last Glacial Maximum or the Antarctic Cold Reversal, despite pronounced atmospheric and oceanic temperature reversals²².

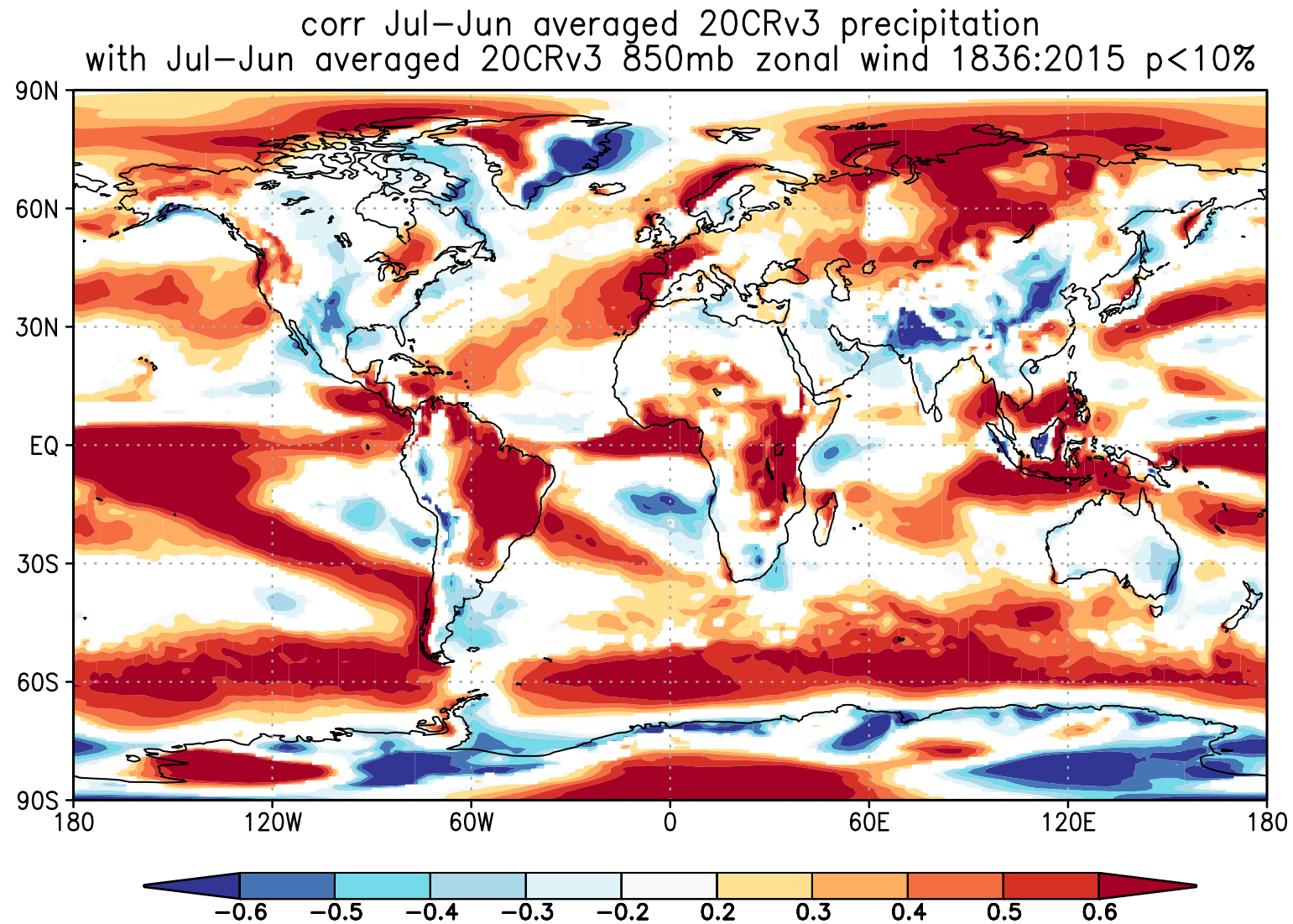


Figure S8. Correlations between the mean annual precipitation and 850mb zonal wind averaged over July to June, using 20CRv3. Significance $p_{\text{field}} = 0.1$. Analyses were made with KNMI Climate Explorer²³.

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