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1 Short Communication.

2 **Peatland initiation and carbon accumulation in the Falkland Islands.**

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10 **ABSTRACT**

11 The Falkland Islands in the South Atlantic Ocean contain extensive peatlands at the edge of their
12 global climatic envelope, but the long-term carbon dynamics of these sites is poorly quantified. We
13 present new data for ten sites, compile previously-published data and produce a new synthesis.
14 Many peatlands in the Falkland Islands developed notably early, with a fifth of basal ¹⁴C dates pre-
15 Holocene. Falkland Islands peats have high ash content, high carbon content and high bulk density
16 compared to global norms. In many sites carbon accumulation rates are extremely low, which may
17 partly relate to low average rainfall, or to carbon loss through burning and aeolian processes.
18 However, in coastal Tussac peatlands carbon accumulation can be extremely rapid. Our re-analysis
19 of published data from Beauchene Island, the southernmost of the Falkland Islands, yields an
20 exceptional long-term apparent carbon accumulation rate of 139 g C m⁻² yr⁻¹, to our knowledge the
21 highest recorded for any global peatland. This high accumulation might relate to the combination of
22 a long growing-season and marine nutrient inputs. Given extensive coverage and carbon-dense
23 peats the carbon stock of Falkland Islands peatlands is clearly considerable but robust quantification
24 will require the development of a reliable peat map. Falkland Island peatlands challenge many
25 standard assumptions and deserve more detailed study.

26 **KEYWORDS:** South Atlantic; Carbon accumulation; Bog; Peat; Holocene.

27 **HIGHLIGHTS:**

- 28 • The Falkland Islands contain extensive and poorly-understood peatlands.
29 • Peatlands are notably old with many pre-Holocene in age.
30 • Long-term carbon accumulation rate is very variable between sites.
31 • One site has the highest recorded carbon accumulation rate for any global peatland.
32 • These unusual peatlands deserve further study.

33

34 INTRODUCTION

35 Global peatlands currently store around 400-600 Gt of carbon and the long-term evolution of this
36 carbon pool has been an important focus for palaeoenvironmental research (Gorham, 1991;
37 MacDonald et al., 2006; Yu, 2012). The most extensive peatlands today are in the northern boreal
38 zone, in particular Western Siberia and the Hudson Bay Lowlands (Packalen et al., 2014; Sheng et al.,
39 2004), with other substantial areas in the humid tropics of equatorial Southeast Asia, Africa and
40 South America (Dargie et al., 2017; Page et al., 2011). Peatlands also occur in the high southern
41 latitudes of Australasia, Africa and South America with Yu et al. (2011) estimating the carbon stock of
42 these peatlands as 13-18 GtC. The largest proportion of this southern peatland carbon pool is
43 located in South America where peatlands developed early, have accumulated carbon at a notably
44 rapid rate and exist in a distinct climatic envelope (Loisel and Yu, 2013; Yu et al., 2011). Southern
45 hemisphere peatlands are generally under-researched and there is a clear imperative to improve
46 understanding both in order to fill gaps in global databases and to understand carbon accumulation
47 in distinctive and unusual peat-forming environments.

48 The focus of this study is the Falkland Islands in the South Atlantic Ocean, located 500 km east of
49 mainland South America (~51°41'S, 59°10'W). Peatlands are extensive in the archipelago to the
50 extent that the Falkland Islands have been identified as having the highest proportional peat
51 coverage of any nation or territory (Joosten, 2010; McAdam, 2013). However, there are open
52 questions around whether these peatlands are continuing to accumulate carbon and how their
53 carbon stock has been affected by climate change and land management (Otley et al., 2008). The
54 peatland landscapes of the islands are unusual and varied, including some highly atypical peatland
55 habitats with very tall grasses and extensive influence from marine birds and mammals (McAdam,
56 2013; Smith and Karlsson, 2017). Prior to the first European settlement in the mid-18th century there
57 were no mammalian herbivores on the islands, and the introduction of extensive livestock grazing
58 has therefore led to major ecological change. Despite the presence of highly unusual peatland types,
59 their extensive area, widespread evidence of human-induced modification, and the status of the
60 islands as an Overseas Territory of the United Kingdom – which has considerable peat research
61 capacity – surprisingly little research has been conducted. The carbon stock, current greenhouse gas
62 balance, timing of peat development and rate of carbon accumulation in Falkland Island peatlands
63 are all largely unquantified. Here we present new data and a synthesis of the fragmentary existing
64 data in order to provide an initial assessment of peatland developmental history and long-term
65 carbon accumulation.

66 SITES AND METHODS

67 Our sampling focussed on East Falkland, the largest island containing the greatest peat area, and
68 aimed to sample a range of peatlands spanning much of the island (Table 1; Supplementary Fig. 2).
69 We sampled five sites with vegetation dominated by Whitegrass (*Cortaderia pilosa*); typically in
70 shallow basins, often with shallow peats. We sampled three sites with deeper peats and more varied
71 vegetation, including the shrub *Empetrum rubrum* ('Diddle Dee'), the monocot *Astelia pumila* and a
72 variety of graminoids, forbs and bryophytes. We sampled one coastal site with vegetation a near-
73 monoculture of Tussac grass (*Poa flabellata*). These coastal peatlands are relatively restricted in
74 distribution around the coastal fringe of the islands but have high above-ground carbon stocks and

75 can have deep peats (<11m)(Smith and Clymo, 1984; Smith and Karlsson, 2017). Finally, we sampled
76 one site in a valley system with closely-cropped graminoid vegetation (Table 1).

77 Cores were extracted from a representative location in each site using a Russian-pattern peat corer
78 (Aaby and Digerfeldt, 1986) and were subsampled in the field into 10 cm sections (Fig. 1). Additional
79 samples (c. 4 cm²) were taken from the interface of the lowermost peat and underlying sediment for
80 dating. In the laboratory, sample volumes were determined by water displacement and samples
81 oven dried at 105 °C to calculate dry bulk density (Chambers et al., 2011). Sub-samples were ground
82 and incinerated at 550 °C to calculate loss on ignition (LOI) and a subset of 91 samples (60%) spread
83 evenly across all the cores was analysed for carbon content using an Elementar vario MACRO
84 elemental analyser with glutamic acid and peaty soil standards (Chambers et al., 2011). There was a
85 strong and significant linear relationship between loss on ignition and carbon content ($r=0.98$,
86 $p<0.001$) which was used to calculate carbon content for all samples without direct measurements
87 (Supplementary Fig. 3). Carbon density was calculated as the product of bulk density and measured
88 or modelled carbon content. Core carbon stock was calculated as the product of mean carbon
89 density and depth. Basal peat was disaggregated and inspected under low-powered microscopy
90 before being prepared for AMS ¹⁴C dating using an acid-base-acid protocol (Brock et al., 2016). For
91 four sites (SSX, SWI, ORQ, DPO [Table 1]) it was possible to identify macrofossils suitable for dating,
92 typically above-ground graminoid fragments. For the remaining six sites no suitable macrofossils
93 could be identified so we dated the humate fraction of bulk peat following the removal of roots
94 (Loisel et al., 2017; Shore et al., 1995). The resulting ¹⁴C dates were calibrated using the SHCal13
95 curve (Reimer et al., 2013) in Bchron (Parnell, 2016). The full-core long-term apparent rate of carbon
96 accumulation (here termed LARCA_{FC}) was calculated by dividing carbon stock by the calibrated basal
97 date. To account for the complexity of the calibrated radiocarbon age estimates we re-sampled the
98 individual probability distributions 1000 times and calculated LARCA_{FC} for each; we present results
99 on this basis as the mean and the 5th and 95th percentiles. We also calculated LARCA_{FC} for a
100 previously-published record from Beauchene Island (Smith and Prince, 1985; Smith and Clymo, 1984)
101 by converting wet to dry bulk density on the basis of moisture content, converting loss on ignition to
102 carbon content using the relationship derived in this study and interpolating between the measured
103 depths. To test the representativeness of the core dataset in terms of peat depth we compared the
104 dated core depths to a larger dataset of 805 depth measurements from 371 locations in East
105 Falkland (Supplementary Fig. 2). Depth measurements in this dataset were made using either an
106 avalanche probe or a soil corer, with a maximum recording depth of 2.5 m. Measurements were
107 typically made along transects at a range of upland and lowland locations spanning peat/non-peat
108 transitions. This dataset includes variable numbers of measurements in each peatland so we
109 calculated site mean depths and compared these values to our dated core dataset using kernel
110 density plots. The depth dataset is not considered to be representative of the peatland areas as a
111 whole, but is both considerably larger than the core dataset and includes other areas of the island.

112 In parallel with our primary data collection we conducted a systematic search of the literature. We
113 compiled datasets of ¹⁴C dates representing peat initiation and individual site age-profiles and
114 calibrated these dates based on the SHCal13 curve (Reimer et al., 2013) in Bchron (Parnell, 2016).
115 Using both new and published basal peat radiocarbon dates we constructed a cumulative Summed
116 Probability Distribution (cSPD) to quantify the timing of peat initiation in the Falkland Islands (Reyes
117 and Cooke, 2011). To place these results in context we also constructed cSPDs for global and extra-
118 tropical South American peatlands based on the database of Treat et al. (2017). For each site

119 containing at least two dated depths we constructed a Bayesian age-depth model using Bacon with
120 default priors for accumulation rate and memory, accepting alternate suggestions where initial
121 screening suggested these were inappropriate (Blaauw and Christen, 2011; Goring et al., 2012). We
122 assigned the peat surface a calendar date based on the year of first data publication, unless peat was
123 overlain by other sediment.

124 Quantifying temporal change in carbon accumulation requires cores with data on carbon density and
125 adequate chronological control throughout the peat profile which is currently available for very few
126 cores (Turney et al., 2016). However, several cores do have adequately constrained age-depth
127 models and this study presents data on carbon density for a substantial number of samples. In order
128 to use these data to make preliminary inferences about change in apparent carbon accumulation we
129 adopted the empirically-based framework of Ratcliffe et al. (2018) whereby age-depth models are
130 constructed for all available sites, levels are assigned carbon density values of an appropriate age
131 through multiple iterations of random re-selection, results are aggregated across cores and weighted
132 by age-depth model precision to produce an overall reconstruction. These results allow us to make
133 some initial inferences about temporal variability in carbon accumulation across the study region.

134 **RESULTS AND DISCUSSION**

135 *Peatland initiation*

136 Basal peats in our study sites ranged in age from pre-Holocene (SWI) to late Holocene (WCR).
137 Combining our ten new dates with other basal dates from the literature gives a total dataset of thirty
138 peat initiation dates for the Falkland Islands. These suggest that peat formation began very early
139 with six sites showing pre-Holocene peat initiation, and the oldest sample thus-far published dated
140 at 13475 ± 50 BP (calibrated weighted mean: 16163 cal. BP) (Wilson et al., 2002). The oldest dates
141 are from the Lake Sullivan area of West Falkland (Wilson et al., 2002), but this is also the most
142 intensively-studied area and it is probable that similarly old peat is present in other locations. The
143 cSPD plots show that Falkland Island peatlands developed markedly earlier than the global norm, but
144 early peatland development is not unusual for South America (Fig. 3). While considerably older
145 peatlands are present around the world (Treat et al., 2019), many of these are in the tropics and
146 Falkland Islands peatlands are atypically old for the temperate/boreal realm. This may relate to the
147 limited extent of late Quaternary glaciation, which appears to have been restricted to cirques and
148 small mountain glaciers, particularly in West Falkland (Clapperton, 1971; Clapperton and Suggern,
149 1976; Roberts, 1984). The available stratigraphic evidence suggests that peat formation was
150 dominated by primary development and paludification with hydrosereal development rare. Rates of
151 peat initiation appear to have been relatively consistent from the early Holocene to ~ 5 ka cal. BP but
152 then slowed (Fig. 4). However, comparing the cores dated in this study to a larger peat depth dataset
153 from East Falkland suggests a bias towards deeper peats (Supplementary Fig. 4). This may have
154 skewed the sample towards older dates, although it is notable that even some sites with shallow
155 peat have early initiation dates (e.g. HOP) and comparison with the depth dataset is complicated by
156 definitional issues and the fact that some locations in the depth dataset exceeded the maximum
157 measurable depth. However representative they may be, our results demonstrate that the Falkland
158 Islands contain a surprising number of very old peatlands which stresses the importance of including
159 such under-studied regions in global datasets. Considerable work remains to be done to assess the

160 developmental history of South American peatlands and our combined dataset expands the current
161 radiocarbon data resource by almost 50%, albeit with a focus on a single region.

162 *Peat properties*

163 The sedimentary properties of Falkland Islands peats differ from those of most global peatlands (Fig.
164 1; Fig. 2). Ash content in these samples was relatively high with only a small proportion of samples
165 having loss on ignition greater than 95% (15.2%), much less than the global mean (46%)(Fig. 2). Ash
166 content was highest in SWI with sediments barely classifiable as peat (mean loss on ignition: 34%).
167 Inorganic contents were comparatively high even in clearly ombrotrophic sites (e.g. SSX), suggesting
168 that mineral dust transport in the very windy Falkland Islands climate may be the dominant reason
169 for this high ash content. The nature of the inorganic component has not been investigated in detail
170 but is likely to derive from both local aeolian processes and further-travelled mineral dust, with
171 tephra from South America also recorded as highly abundant in Falkland Islands peats (Holmes et al.,
172 1999). Peat bulk density and carbon content were high relative to global norms (Fig. 2). In the case
173 of carbon content this may relate to the comparative rarity of *Sphagnum* in Falkland Island peatlands
174 as *Sphagnum* peats skew carbon content towards lower values in global data (Loisel et al., 2014).
175 The relatively high bulk density may be due to a combination of this relative scarcity of *Sphagnum*,
176 high ash content and the highly humified nature of many peats. The combination of high bulk
177 density and high carbon content means that the carbon density of peat also tends towards the
178 upper end of the global range. Collectively these data demonstrate the importance of region-specific
179 datasets in understanding peatland carbon stocks and dynamics; global values would not be
180 appropriate for Falkland Islands peats.

181 *Carbon accumulation rate*

182 Long-term rates of carbon accumulation were highly variable between sites with $LARCA_{FC}$ ranging
183 from 2.6 to 32 g C m⁻² yr⁻¹. Rates were lowest in the valley and Whitegrass dominated sites, higher in
184 the Diddle Dee sites and highest in the Tussac site: Cape Dolphin. However, for the Tussac peatland
185 on Beauchene Island investigated by Smith and Clymo (1984) we calculated an exceptionally high
186 $LARCA_{FC}$ of 139 g C m⁻² yr⁻¹. This is more than six times the global mean accumulation rate (Loisel et
187 al., 2014) and more than 50% higher than the highest published LARCA figure of which we are aware
188 (88.6 g C m⁻² yr⁻¹: Tolonen and Turunen (1996)). Carbon accumulation in this site appears to be the
189 highest documented in any global peatland and was justifiably termed 'extraordinary' by the original
190 authors. While the peat accumulation rate and depth of this site are towards the upper end of the
191 global distribution, the high rate of carbon accumulation is primarily attributable to the extremely
192 high bulk density of the peat. Older data often needs to be treated with caution but in this case the
193 original authors went to considerable efforts to validate their bulk density measurements and the
194 chronology is plausible; there is currently little reason not to accept this as a valid result, although
195 further work would clearly be desirable.

196 Falkland Islands peats appear to encompass a very large range of accumulation rates. In the majority
197 of sites $LARCA_{FC}$ was low to very low. Our data do not allow us to assess whether this is because of
198 low initial carbon accumulation or subsequent carbon loss, but active peat erosion is clearly a
199 feature of the Falklands peatlands landscape. Erosion features are widely visible and in two cores
200 from West Falkland, Wilson et al. (2002) dated the upper surface of eroding peats to 13040 ± 50 BP
201 and 13080 ± 60 BP respectively. It is also clear that fire has had a long-term role in Falkland peatland

202 carbon dynamics with macrofossil charcoal highly abundant in peat cores (Mauquoy, unpublished
203 data). It is likely that factors such as natural and anthropogenic burning, overgrazing and aeolian
204 erosion are at least part of the reason for the low rates observed in many sites.

205 The reasons for the extremely rapid carbon accumulation rates in the Tussac sites are similarly
206 unclear. The Falklands are at the edge of the climatic envelope for global peatlands being relatively
207 dry for their mild temperature, with mean annual precipitation a little over 600mm and mean annual
208 temperature of around 6°C (Supplementary Fig. 5). The climate regime has a high degree of seasonal
209 consistency in precipitation and relatively mild, relatively consistent temperature which may allow
210 for a long growing season (Supplementary Fig. 6). This is similar to Patagonia where high carbon
211 accumulation has been attributed to similar climatic conditions in – otherwise quite different –
212 peatlands (Loisel and Yu, 2013). However, all Falkland Island peatlands experience a broadly similar
213 climate and the distinguishing feature of Tussac sites is their coastal location. In these locations
214 marine birds and mammals are likely to be a significant vector for nutrients as they shelter on or
215 amongst the large grass tussocks. Nutrient inputs through faeces and carcasses may promote high
216 rates of both primary production and decomposition, ultimately leading to the formation of very
217 carbon-dense peat. The biogeochemistry of these highly unusual sites would clearly repay further
218 detailed study.

219 *Variability in apparent carbon accumulation*

220 Two features are apparent in our carbon accumulation simulations (Fig. 4): an increase in peat and
221 carbon accumulation in the late Holocene (last ~2ka) and, less clearly, an increase in carbon
222 accumulation between 7.5 and 9.5ka cal. BP. The latter is based on a relatively limited number of
223 cores and samples but is interesting as it parallels previous reconstructions from cores around the
224 world and often attributed to the Holocene Thermal Maximum (HTM)(Loisel et al., 2014; Ratcliffe et
225 al., 2018). The only previously published peatland carbon accumulation reconstruction does not
226 extend back sufficiently far to address changes in this period (Turney et al., 2016). The Falklands
227 climate is dominated by Westerly winds (Jones et al., 2016) and reduced wind speeds in the
228 Southern Westerly belt have been reconstructed for the HTM (Saunders et al., 2018). Due to the
229 position of the Falkland Islands in the lee of the Andean mountain chain, this may have led to
230 enhanced precipitation on the Falkland Islands during this time interval given the negative
231 correlation between 850-hPa zonal wind speed strength and precipitation in eastern Patagonia
232 (Garreaud et al., 2013). In a previous Falkland Islands study Turney et al. (2016) attributed an
233 increase in carbon accumulation at the top of their cores, similar to that we reconstruct, to recent
234 climate change. However, this conclusion is unsafe because cores will inevitably show an increase in
235 *apparent* carbon accumulation simply due to the transition to acrotelm peat which has not yet had
236 the opportunity to decompose. This ‘near-surface uptick’ is widely reported and can be expected in
237 all peat cores (Loisel et al., 2014). The result here should be considered an artefact pending
238 compelling evidence to the contrary.

239 *Carbon stock*

240 There is currently no established peat map for the Falkland Islands, which makes it impossible to
241 accurately calculate the total carbon stock. A recent assessment by Evans et al. (2019) combined the
242 peat depth survey described in this study with previous superficial deposit mapping by the British
243 Geological Survey (Aldiss and Edwards, 1999) to produce an indicative estimate that 2820 km² ha of

244 the Falkland Islands (around one quarter of the total land area) is peat covered, noting that this
245 estimate is highly uncertain. If we combine this estimate with the measured carbon densities
246 obtained from our cores plus those of Smith and Prince (1985) (mean= 0.073 g C cm⁻³), and take our
247 depth dataset as representative of peat depth (mean= 76cm), the total C stock would be 156 MtC.
248 This approximate figure may be conservative (for example because peat depths > 2.5 m were not
249 captured in the survey) but is, for instance, equivalent to more than 12,000 times the emissions
250 associated with all annual energy consumption on the islands (2009 data: (iMC Worldwide, 2012))
251 and considerably greater than a published assessment of the peatland carbon stock of Wales (~121
252 MtC)(ECOSSE, 2007). Mapping of Falkland Islands peats is now underway which should allow this
253 estimate to be better-constrained in the future.

254

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265 Author contributions: RJP secured funding. RJP, GR and CE conducted fieldwork. FR-H, DM, RJP and
266 TS conducted laboratory work. FR-H and RJP conducted data compilation and RJP conducted data
267 analysis. RJP wrote the first draft of the manuscript, to which all authors contributed with comments
268 and interpretation.

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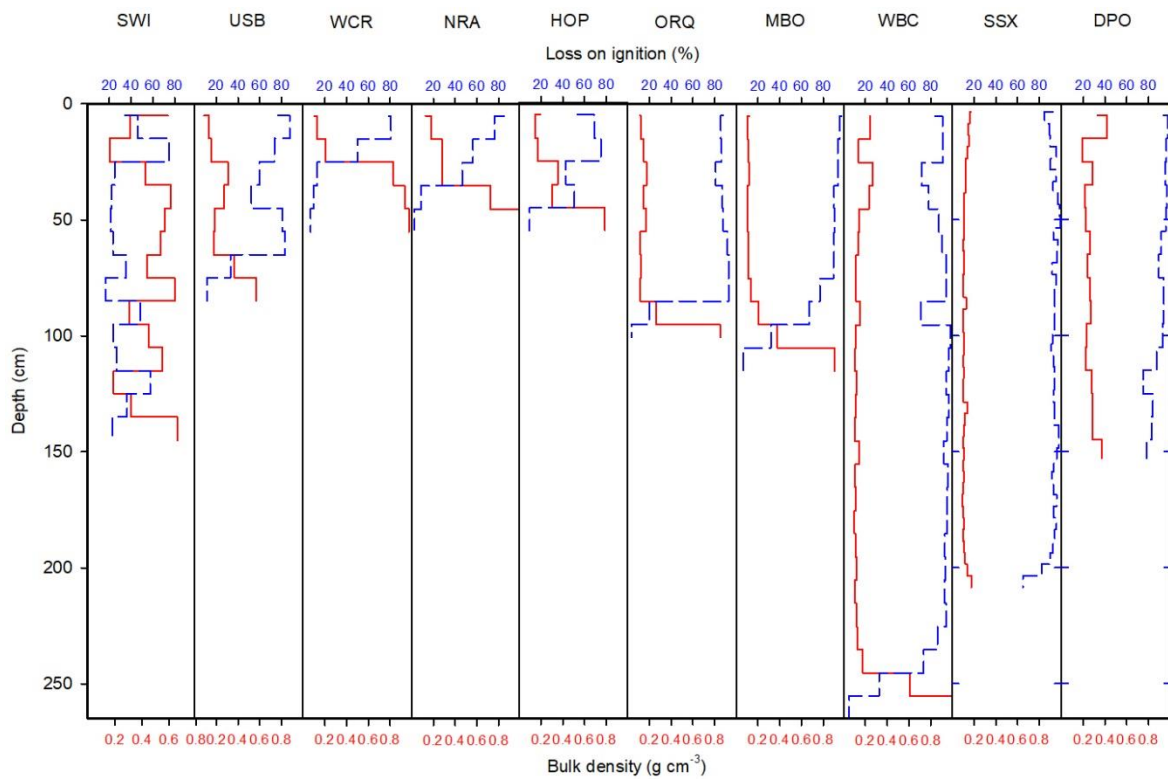
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281 **FIGURES AND TABLES**

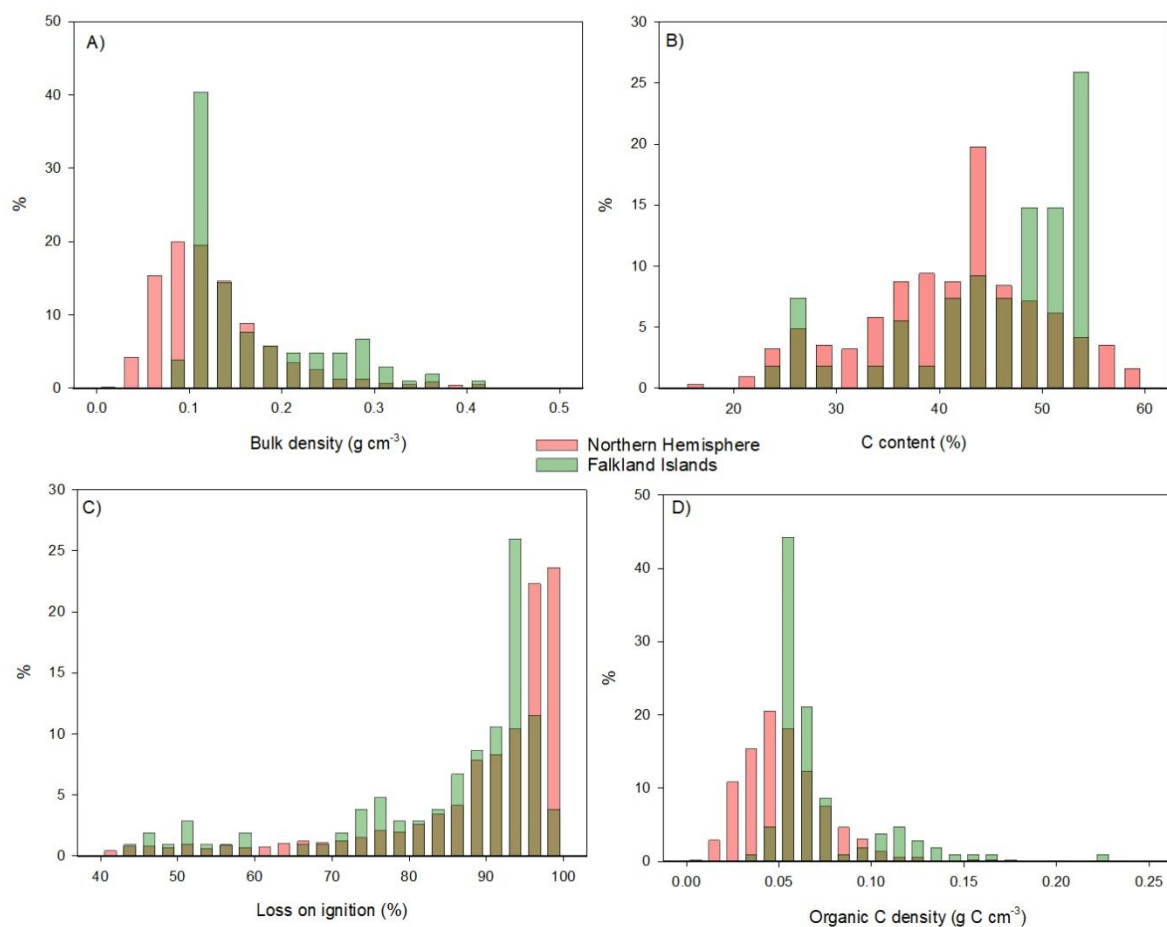
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284 Figure 1. Bulk density (red, solid line) and loss on ignition (blue, dashed line) profiles for the ten peat
285 cores presented in this study.

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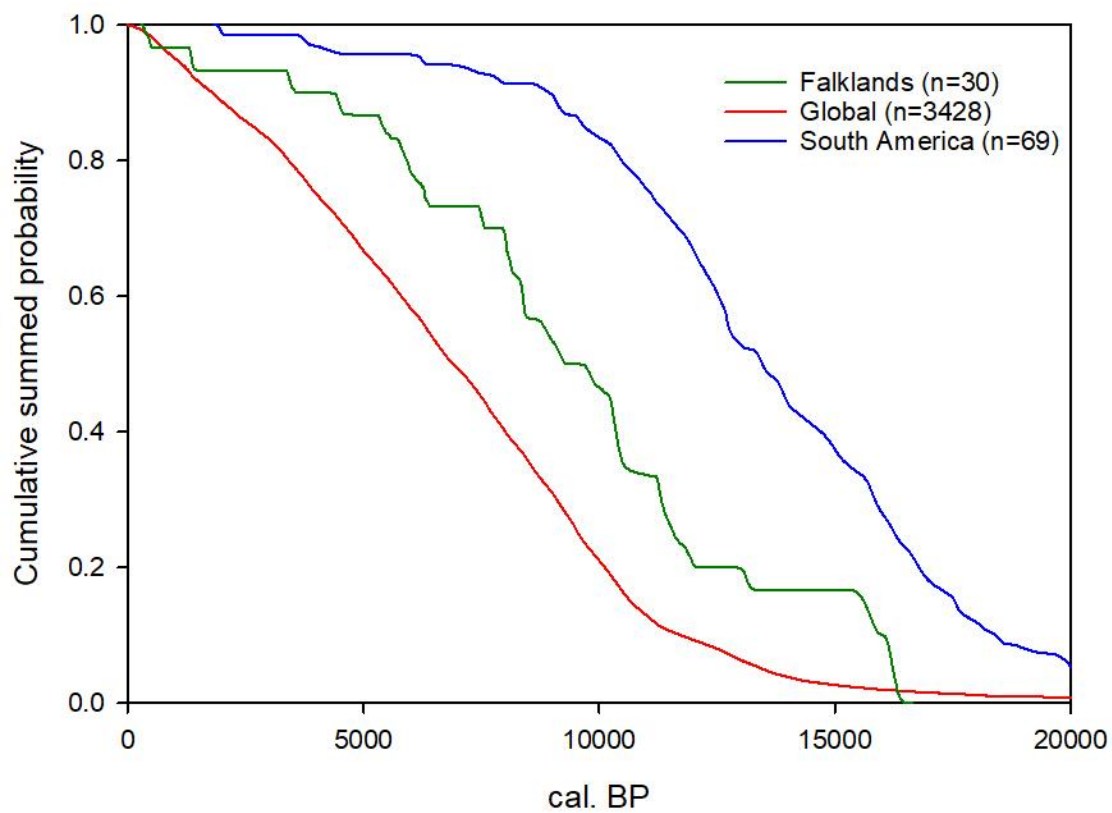


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288 Figure 2. Comparison of peat properties from sites sampled here to the Northern Hemisphere
 289 dataset of Loisel et al. (2014). To avoid over-representing results from cores sampled at high
 290 resolution, all cores were reduced to 10cm increment means. Samples with LOI<40% or BD>0.5g cm⁻³
 291 were excluded.

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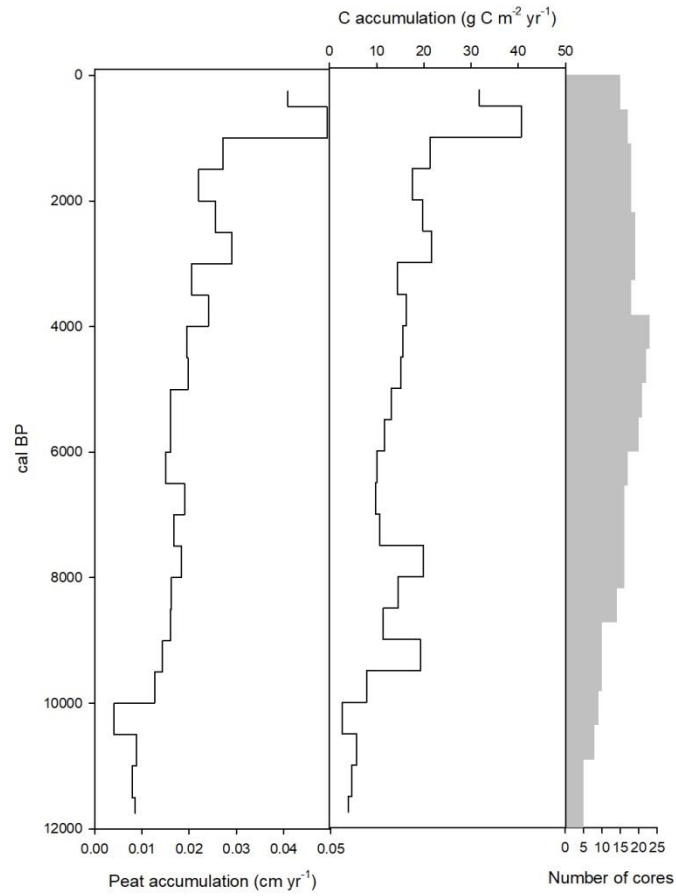


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296 Figure 3. Cumulative summed probability distribution plot of peat initiation ^{14}C dates for Falkland
 297 Island peatlands (this study) compared to previously-presented datasets for global peat and extra-
 298 tropical South America (Treat et al., 2017).

299



300

301

302 Figure 4. Inferred peat and carbon accumulation in Falkland Island peatlands, based on available
 303 data: a) aggregated peat accumulation rate across all sites; b) simulated carbon accumulation; c)
 304 number of dated core records contributing to the results.

305

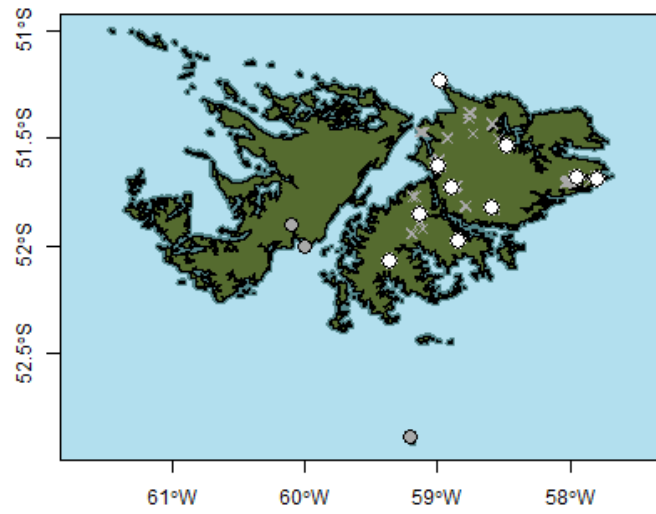
Table 1. Details of sites, basal dates, peat depth and (full-core) long-term apparent rate of carbon accumulation (LARCA_{FC}) for sites in this study.

Site details				Basal ¹⁴ C date			Depth (cm)	LARCA _{FC} (g C m ⁻² yr ⁻¹)		
Name	Code	S	W	Code	BP	Error		Mean	5 th	95 th
<i>Valley fen</i>										
Swan Inlet	SWI	-51.82	-58.59	D-AMS-029687	13516	60	145	5.21	5.18	5.25
<i>Whitegrass</i>										
Mt. Usborne	USB	-51.73	-58.89	D-AMS-030520	10002	47	70	4.07	4	4.11
Walker Creek	WCR	-51.98	-58.84	D-AMS-030519	1520	34	34	12.08	11.62	12.48
North Arm	NRA	-52.07	-59.36	D-AMS-030518	6657	42	47	4.02	3.99	4.06
Hope Cottage	HOP	-51.54	-58.48	D-AMS-030521	9924	47	50	2.65	2.62	2.66
Orqueta	ORQ	-51.85	-59.13	D-AMS-029690	4740	42	97	10.8	10.54	11
<i>Diddle dee</i>										
Moody Brook	MBO	-51.69	-57.95	D-AMS-030516	7277	38	105	7.13	7.05	7.2
Whalebone Cove	WBC	-51.69	-57.80	D-AMS-030517	8041	46	255	19	18.73	19.34
Sussex Mountains	SSX	-51.63	-59.00	D-AMS-029686	10089	42	210	10.67	10.51	10.83
<i>Tussac</i>										
Cape Dolphin	DPO	-51.24	-58.99	D-AMS-029694	5542	45	156	32.18	31.76	32.6

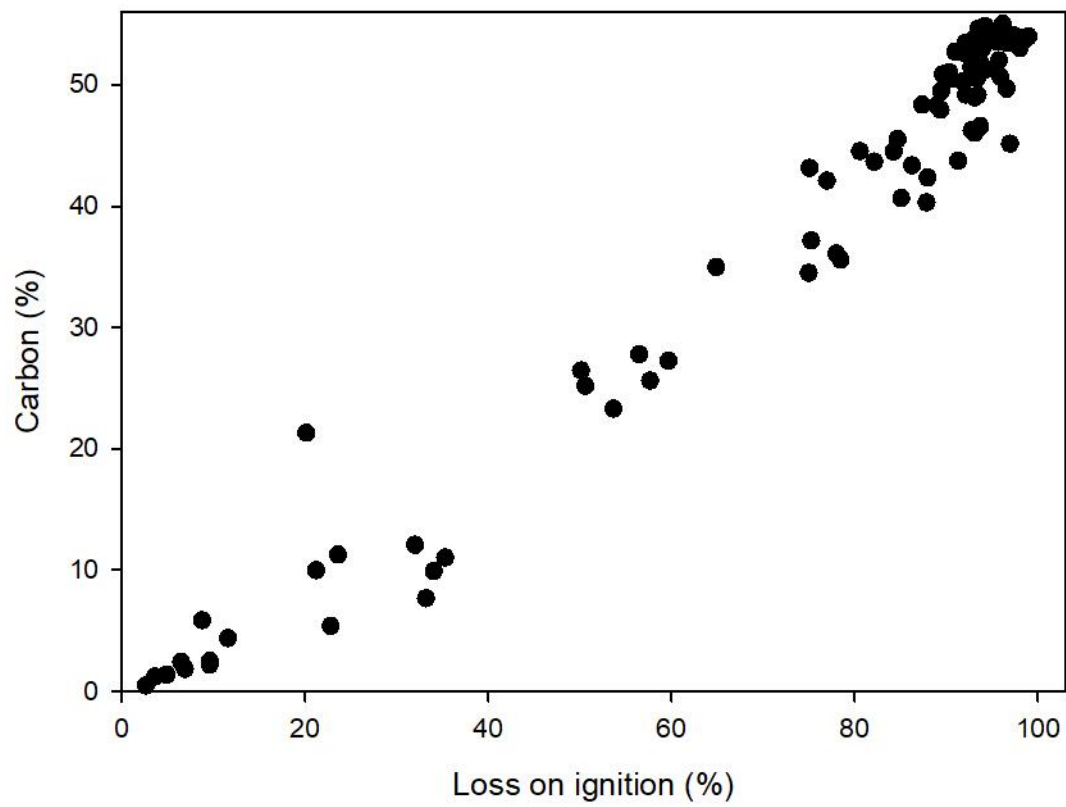
SUPPLEMENTARY FIGURES AND TABLES



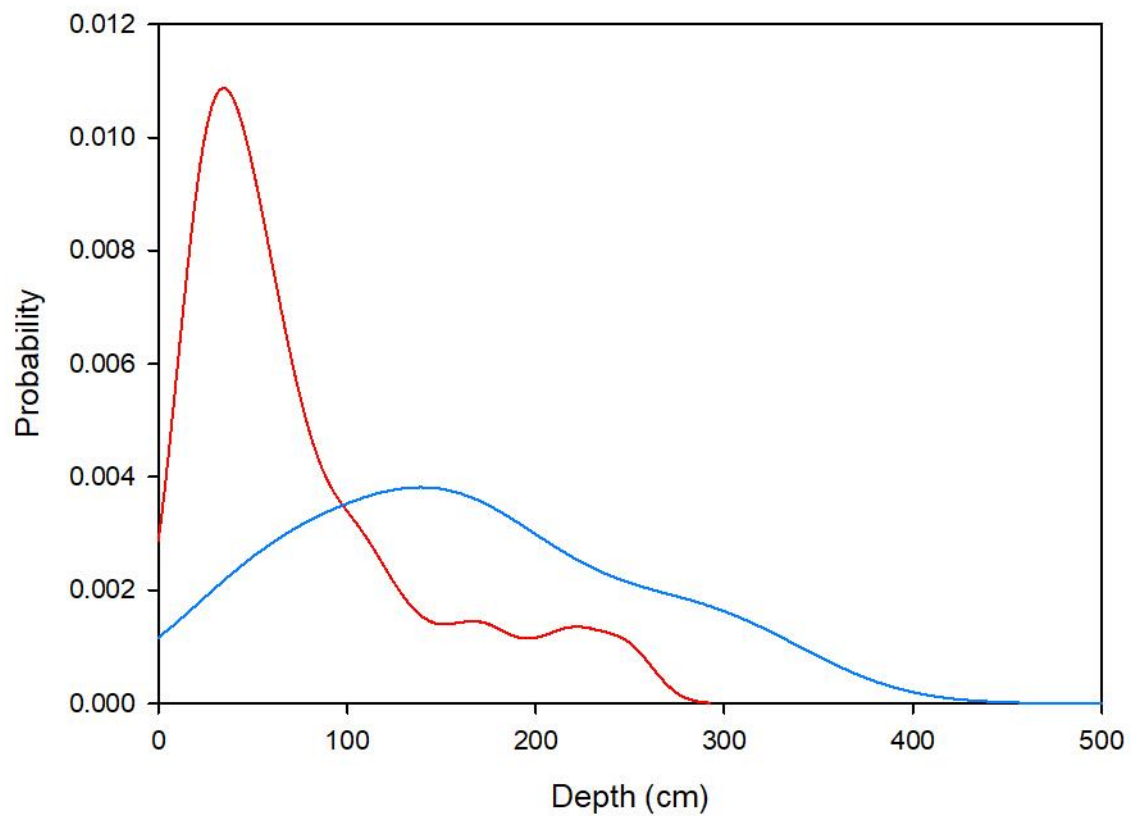
Supplementary Figure 1. Selected images of study sites, demonstrating different types of Falkland Island peatlands: A) Cape Dolphin (Tussac); B) Hope Cottage (Whitegrass); C) Whalebone Cove (Diddle Dee); D) Swan Inlet (Valley).



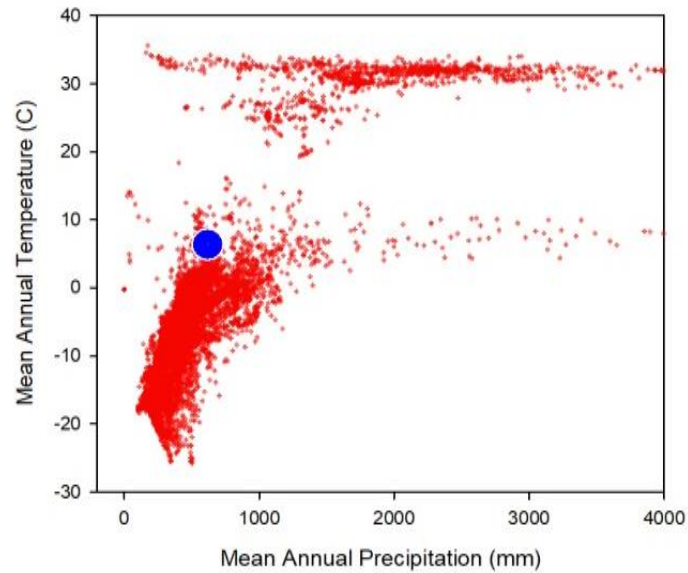
Supplementary Figure 2. Locations of sites considered in this study. Sites of new coring shown by white circles, previously studied coring sites shown by grey circles and sites of depth measurements shown by crosses.



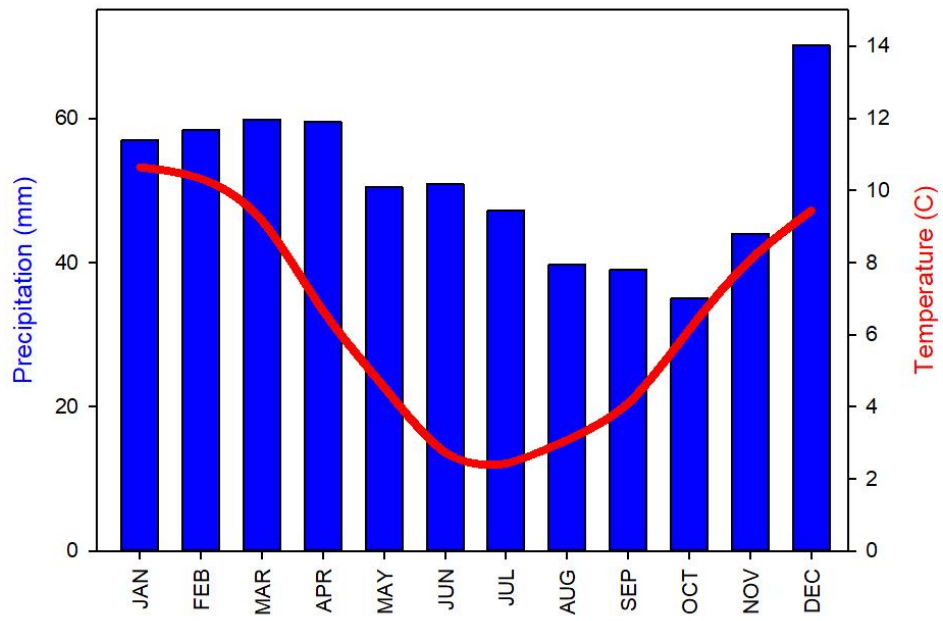
Supplementary Figure 3. Loss on ignition versus carbon content for Falkland Islands peat samples analysed in this study.



Supplementary Figure 4. Kernel density plot comparing total depths of dated cores (blue) to depths derived from a larger dataset of depth measurements from across East Falkland (red). See text for caveats on data quality and comparability.



Supplementary Figure 5. Climate space of global peatlands and the Falkland Islands. Red dots show 10,000 randomly positioned points on the global peat map of Yu et al. (2010) with mean annual temperature and precipitation data extracted from the database of Hijmans et al. (2005). Blue dot shows meteorological data for RAF Mountain Pleasant in central East Falkland (close to the SWI site) for the period 1985-2018. The bimodal temperature distribution of global peatlands represents the distinct climate spaces of tropical and temperate/high-latitude peatlands.



Supplementary Figure 6. Annual variability in precipitation and temperature (Station: RAF Mount Pleasant, 1985-2018).

DATA AVAILABILITY

Data underlying this study are available at: [URL to be added on acceptance]

REFERENCES

- Aaby, B., Digerfeldt, G., 1986. Sampling techniques for lakes and bogs. *Handbook of holocene palaeoecology and palaeohydrology*, 181-194.
- Aldiss, D., Edwards, E., 1999. *The geology of the Falkland Islands*. British Geological Survey, Keyworth.
- Blaauw, M., Christen, J.A., 2011. Flexible paleoclimate age-depth models using an autoregressive gamma process. *Bayesian Analysis* 6, 457-474.
- Brock, F., Higham, T., Ditchfield, P., Ramsey, C.B., 2016. Current Pretreatment Methods for AMS Radiocarbon Dating at the Oxford Radiocarbon Accelerator Unit (Orau). *Radiocarbon* 52, 103-112.
- Chambers, F.M., Beilman, D., Yu, Z., 2011. Methods for determining peat humification and for quantifying peat bulk density, organic matter and carbon content for palaeostudies of climate and peatland carbon dynamics. *Mires and Peat* 7, 1-10.
- Clapperton, C.M., 1971. Evidence of Cirque Glaciation in the Falkland Islands. *Journal of Glaciology* 10, 121-125.
- Clapperton, C.M., Suggern, D.E., 1976. The Maximum Extent of Glaciers in Part of West Falkland. *Journal of Glaciology* 17, 73-77.
- Dargie, G.C., Lewis, S.L., Lawson, I.T., Mitchard, E.T., Page, S.E., Bocko, Y.E., Ifo, S.A., 2017. Age, extent and carbon storage of the central Congo Basin peatland complex. *Nature* 542, 86.
- ECOSSE, 2007. *ECOSSE: Estimating Carbon in Organic Soils - Sequestration and Emissions: Final Report*. Scottish Executive, Edinburgh.
- Evans, C., Artz, R., Moxley, J., Smyth, M.-A., Taylor, E., Archer, N., Burden, A., Williamson, J., Donnelly, D., Thomson, A., Buys, G., Malcolm, H., Wilson, D., Renou-Wilson, F., 2019. Implementation of an emission inventory for UK peatlands. Report to the Department for Business, Energy and Industrial Strategy. Centre for Ecology and Hydrology, Bangor.
- Garreaud, R., Lopez, P., Minvielle, M., Rojas, M., 2013. Large-scale control on the Patagonian climate. *Journal of Climate* 26, 215-230.
- Gorham, E., 1991. Northern peatlands: role in the carbon cycle and probable responses to climatic warming. *Ecological applications* 1, 182-195.
- Goring, S., Williams, J.W., Blois, J.L., Jackson, S.T., Paciorek, C.J., Booth, R.K., Marlon, J.R., Blaauw, M., Christen, J.A., 2012. Deposition times in the northeastern United States during the Holocene: establishing valid priors for Bayesian age models. *Quaternary Science Reviews* 48, 54-60.
- Hijmans, R.J., Cameron, S.E., Parra, J.L., Jones, P.G., Jarvis, A., 2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25, 1965-1978.
- Holmes, J., Hall, V., Wilson, P., 1999. Volcanoes and peat bogs. *Geology Today* 15, 60-63.
- iMC Worldwide, 2012. *Needs assessment: The Falkland Islands*. Department for International Development, London.
- Jones, J.M., Gille, S.T., Goosse, H., Abram, N.J., Canziani, P.O., Charman, D.J., Clem, K.R., Crosta, X., de Lavergne, C., Eisenman, I., England, M.H., Fogt, R.L., Frankcombe, L.M., Marshall, G.J., Masson-Delmotte, V., Morrison, A.K., Orsi, A.J., Raphael, M.N., Renwick, J.A., Schneider, D.P., Simpkins, G.R., Steig, E.J., Stenni, B., Swingedouw, D., Vance, T.R., 2016. Assessing recent trends in high-latitude Southern Hemisphere surface climate. *Nature Climate Change* 6, 917.
- Joosten, H., 2010. *The global peatland CO2 picture: Peatland status and drainage related emissions all countries of the world*. Wetlands International, Ede.
- Loisel, J., van Bellen, S., Pelletier, L., Talbot, J., Hugelius, G., Karran, D., Yu, Z., Nichols, J., Holmquist, J., 2017. Insights and issues with estimating northern peatland carbon stocks and fluxes since the last glacial maximum. *Earth-Science Reviews* 165, 59-80.
- Loisel, J., Yu, Z., 2013. Holocene peatland carbon dynamics in Patagonia. *Quaternary Science Reviews* 69, 125-141.
- Loisel, J., Yu, Z., Beilman, D.W., Camill, P., Alm, J., Amesbury, M.J., Anderson, D., Andersson, S., Bochicchio, C., Barber, K., 2014. A database and synthesis of northern peatland soil properties and Holocene carbon and nitrogen accumulation. the Holocene, 0959683614538073.

MacDonald, G.M., Beilman, D.W., Kremenetski, K.V., Sheng, Y., Smith, L.C., Velichko, A.A., 2006. Rapid early development of circumarctic peatlands and atmospheric CH₄ and CO₂ variations. *Science* 314, 285-288.

McAdam, J., 2013. The impact of the Falklands War (1982) on the peatland ecosystem of the islands, in: Rotherham, I. (Ed.), *War and Peat*. Sheffield Hallam University, Sheffield.

Otley, H., Munro, G., Clausen, A., Ingham, B., 2008. *Falkland Islands State of the Environment Report 2008*. Falkland Islands Government and Falklands Conservation, Stanley.

Packalen, M.S., Finkelstein, S.A., McLaughlin, J.W., 2014. Carbon storage and potential methane production in the Hudson Bay Lowlands since mid-Holocene peat initiation. *Nature Communications* 5, 4078.

Page, S.E., Rieley, J.O., Banks, C.J., 2011. Global and regional importance of the tropical peatland carbon pool. *Global Change Biology* 17, 798-818.

Parnell, A., 2016. *Bchron: Radiocarbon dating, age-depth modelling, relative sea level rate estimation, and non-parametric phase modelling*. R package version 4.1. 1; 2015.

Ratcliffe, J., Payne, R.J., Sloan, T., Smith, B., Waldron, S., Mauquoy, D., Newton, A., Anderson, A., Henderson, A., Andersen, R., 2018. Holocene carbon accumulation in the peatlands of northern Scotland. *Mires and Peat* 23, 1-30.

Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Ramsey, C.B., Buck, C.E., Cheng, H., Edwards, R.L., Friedrich, M., 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. *Radiocarbon* 55, 1869-1887.

Reyes, A.V., Cooke, C.A., 2011. Northern peatland initiation lagged abrupt increases in deglacial atmospheric CH₄. *Proceedings of the National Academy of Sciences* 108, 4748-4753.

Roberts, D.E., 1984. *Quaternary history of the Falkland Islands*. University of Aberdeen, Aberdeen.

Saunders, K.M., Roberts, S.J., Perren, B., Butz, C., Sime, L., Davies, S., Van Nieuwenhuyze, W., Grosjean, M., Hodgson, D.A., 2018. Holocene dynamics of the Southern Hemisphere westerly winds and possible links to CO₂ outgassing. *Nature geoscience* 11, 650-655.

Sheng, Y., Smith, L.C., MacDonald, G.M., Kremenetski, K.V., Frey, K.E., Velichko, A.A., Lee, M., Beilman, D.W., Dubinin, P., 2004. A high-resolution GIS-based inventory of the west Siberian peat carbon pool. *Global Biogeochemical Cycles* 18, n/a-n/a.

Shore, J., Bartley, D., Harkness, D., 1995. Problems encountered with the ¹⁴C dating of peat. *Quaternary Science Reviews* 14, 373-383.

Smith, R., Prince, P., 1985. The natural history of Beauchêne Island. *Biological Journal of the Linnean Society* 24, 233-283.

Smith, R.L., Clymo, R., 1984. An extraordinary peat-forming community on the Falkland Islands. *Nature* 309, 617.

Smith, S.W., Karlsson, S., 2017. High stocks, but slow recovery, of ecosystem carbon in southern oceanic tussock grasslands. *Polar Biology* 40, 1617-1628.

Tolonen, K., Turunen, J., 1996. Accumulation rates of carbon in mires in Finland and implications for climate change. *The Holocene* 6, 171-178.

Treat, C., Kleinen, T., Broothaerts, N., Dalton, A., Dommain, R., Douglas, T., Drexler, J., Finkelstein, G., Grosse, G., Hope, G., 2019. Widespread global peatland establishment and persistence over the last 130,000 years. *Proceedings of the National Academy of Sciences of the United States of America*.

Treat, C.C., Broothaerts, N., Dalton, A.S., Dommain, R., Douglas, T., Drexler, J., Finkelstein, S.A., Grosse, G., Hope, G., Hutchings, J.A., Jones, M.C., Kleinen, T., Kuhry, P., Lacourse, T., Lähteenoja, O., Loisel, J., Notebaert, B., Payne, R.J., Peteet, D.M., Sannel, A.B.K., Stelling, J., Strauss, J., Swindles, G., Talbot, J., Tarnocai, C., Verstraeten, G., Williams, C.J., Xia, Z., Yu, Z., Brovkin, V., 2017. Widespread global peatland establishment and persistence for the last 130,000 years, Supplement to: Treat, CC et al. (in prep.): Widespread global peatland establishment and persistence for the last 130,000 years. *Nature Geoscience*. PANGAEA.

Turney, C.S., Jones, R.T., Lister, D., Jones, P., Williams, A.N., Hogg, A., Thomas, Z.A., Compo, G.P., Yin, X., Fogwill, C.J., 2016. Anomalous mid-twentieth century atmospheric circulation change over the South Atlantic compared to the last 6000 years. *Environmental Research Letters* 11, 064009.

Wilson, P., Clark, R., Birnie, J., Moore, D.M., 2002. Late Pleistocene and Holocene landscape evolution and environmental change in the Lake Sullivan area, Falkland Islands, South Atlantic. *Quaternary Science Reviews* 21, 1821-1840.

Yu, Z., 2012. Northern peatland carbon stocks and dynamics: a review. *Biogeosciences* 9, 4071-4085.

Yu, Z., Beilman, D., Frohking, S., MacDonald, G.M., Roulet, N.T., Camill, P., Charman, D., 2011. Peatlands and their role in the global carbon cycle. *Eos, Transactions American Geophysical Union* 92, 97-98.

Yu, Z., Loisel, J., Brosseau, D.P., Beilman, D.W., Hunt, S.J., 2010. Global peatland dynamics since the Last Glacial Maximum. *Geophysical Research Letters* 37.