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Modeling the change in soil organic carbon of grassland in response to climate change: Effects of measured versus modelled carbon pools for initializing the Rothamsted Carbon model

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ABSTRACT

The Rothamsted Carbon (RothC) model with its multi soil carbon pools is widely used to estimate soil organic carbon (SOC) change in response to climate and/or land use change. Many of these pools are conceptual and it is a challenge to correctly parameterize them. Taking Irish temperate grasslands as an example, we study the SOC fractionation procedure of Zimmermann et al. (2007) to partition the measured SOC into the pools required in RothC. This was done with the aim of predicting SOC change in response to climate change. We found good correlation between the measured and modelled values for the pools of BIO (microbial biomass) and HUM (humified organic matter), but poor correlation for the pools of DPM (decomposable plant material) and RPM (resistant plant material). The measured carbon pools more reasonably reflected the real environmental conditions than the modelled. Because of the fast decomposition rate and short term simulation (only 40 years), the RPM pool controlled the trends in the future SOC change. The difference in the trends of the predicted total SOC between using measured and modelled carbon pools (to initialize RothC) rapidly increased in the initial years and slowly decreased thereafter. In order to limit this difference to 1% within the first 3 years (the turnover period for RPM), the difference between the measured and modelled RPM pool should be constrained to be less than 10%. In response to higher temperature and, drier summers and wetter winters, RothC predicted a decrease in the SOC of Irish grasslands.

1. Introduction

The global soil organic carbon (SOC) pool is estimated at 1500 Pg (Batjes, 1996; Eswaran et al., 1995), which is roughly equivalent to the sum of the atmospheric pool estimate of 750 Pg and the biotic pool estimate of 600 Pg (Houghton, 1995; Lal, 2002; Schimel, 1995). Any small change in SOC may greatly impact atmospheric CO_2 concentration. Consequently there is much scientific interest in soil carbon stocks and their potential feedbacks to climate change (Davidson and Janssens, 2007). In order to predict the SOC change in response to climate change, many models (including Century, DNDC (DeNitrification–DeComposition), Daisy and RothC) were developed and most models are based on several conceptual carbon pools (with different turnover rates) within the soil profile (Coleman and Jenkinson, 1999; Jensen et al., 1997; Li et al., 1997; Parton et al., 1995). RothC is among these models, and it has been widely used for arable soils, grassland soils and forest soils (Coleman and Jenkinson, 1996; Coleman et al., 1997; Falloon and Smith, 2002; Ludwig et al., 2007, 2010; Smith et al., 2006). In this model, SOC is partitioned into four active pools and one inert organic matter (IOM). The four active pools are decomposable plant material (DPM), resistant plant material (RPM), microbial biomass (BIO) and humified organic matter (HUM). All of these pools except IOM decompose by first-order decay at rate constants (year^{-1}) of 10 for DPM, 0.3 for RPM, 0.66 for BIO and 0.02 for HUM. These constant rates were originally set by tuning the model to data from some of the long-term field experiments at Rothamsted (Coleman and Jenkinson, 1996). Decomposition rates are modified by temperature, moisture, and by soil cover (Coleman and Jenkinson, 1999). Relating these conceptual pools (note that BIO pool is measurable) to measured pools is not only a great challenge but also a requirement for wider model application. Once measured, these pools can be used to validate the models; on the other hand, these measured pools can also be used to initialize these models at any point in the landscape even without historical data (Zimmermann et al., 2007). Furthermore, it also enables the establishment of the functional relationships between soil organic matter (SOM) functioning and pools and turnover (Bruun et al., 2010). A soil (carbon pool) fractionation procedure to separate the SOC into different carbon

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fractions, which can be directly related to those modelled pools in the RothC model was reported by Zimmermann et al. (2007). However, few studies have been conducted to test the Zimmermann approach (Dondini et al., 2009; Leifeld et al., 2009a,b). Grassland occupies some 62.7 M ha in the EU 25 plus Norway and Switzerland (Janssens et al., 2005). In Ireland, grassland is also the dominant land use accounting for 53% of the total land area in 2000 and 25% of the total SOC stocks to 1 m depth (Eaton et al., 2008). Rising temperature and shifting precipitation patterns towards increasing summer drier periods and wetter winters are expected in Ireland (McGrath et al., 2005). Despite this, the potential response of SOC in Irish grassland to climate change has not yet been assessed.

The objective of this study was: (1) to test whether the measured carbon fractions with the procedure of Zimmermann et al. (2007) are well related with the modelled pools as required by RothC; (2) to determine the effects of different initializations of the RothC model with measured or modelled carbon pools on the outputs of SOC; and (3) to examine the effects of climate change on SOC in the temperate grasslands of Ireland.

2. Materials and methods

2.1. Climate data

The climate inputs were derived from the study by McGrath et al. (2005) (http://www.c4i.ie) who used a regional climate model (RCM) to create a forty-year simulation of the past climate (1961–2000). After verification of the RCM model performance in recreating the recent past climate, McGrath et al. (2005) used the model to simulate the future climate for the period 2021–2060 for a range of IPCC emission scenarios. Average monthly air temperature and total monthly precipitation for 1961–2000 and for the A1B, A2 and B1 emission scenarios (2021–2060) were extracted from McGrath et al. (2005) and used as inputs to the RothC model. The total monthly open-pan evaporation was calculated using the method of Penman (1948).

2.2. Soil data

Eight grassland sites in Southern Ireland (Fig. 1 and Table 1) were examined in 2007 for detailed carbon fractions at three depths (0–10, 10–25 and 25–50 cm) following the procedure proposed by Zimmermann et al. (2007). It is a basic physical and chemical fractionation procedure as shown in Fig. 2a.

Thirty grams of the soil (<2 mm) were added to 150 ml water, and dispersed by ultrasonic vibration with an output-energy of 22 J ml^{-1}. This dispersed suspension was then wet sieved over a 63 μm aperture sieve until the rinsing water was clear. The fraction (>63 μm), containing the sand fraction and stable aggregates (S + A) together with POM (particular organic matter), was dried at 40 °C and weighed. The suspension <63 μm was filtered through a 0.45 μm aperture nylon mesh and the material >0.45 μm was dried at 40 °C and weighed. An aliquot of the filtrate was frozen to measure the amount of the dissolved SOC (DOC). POM was separated by stirring the fraction <63 μm with sodium polytungstate at a density of 1.8 g cm^{-3}. The mixture was centrifuged at 1000 × g for 15 min and the light fraction was decanted. Both fractions (S + A and POM) were washed with deionised water to remove all sodium polytungstate, dried at 40 °C and weighed.

A chemically resistant carbon fraction (rSOC) was extracted from the fraction <63 μm by NaOCl oxidation. Oxidation was done with 6% NaOCl at room temperature after a modified method of Kaiser and Guggenberger (2003). One gram of s + c was oxidized for 18 h at 25 °C with 50 ml of 6% NaOCl adjusted to pH 8 with concentrated HCl. The oxidation was centrifuged at 1000 × g for 15 min, decanted, washed with deionised water and centrifuged again. This oxidation step was repeated twice.

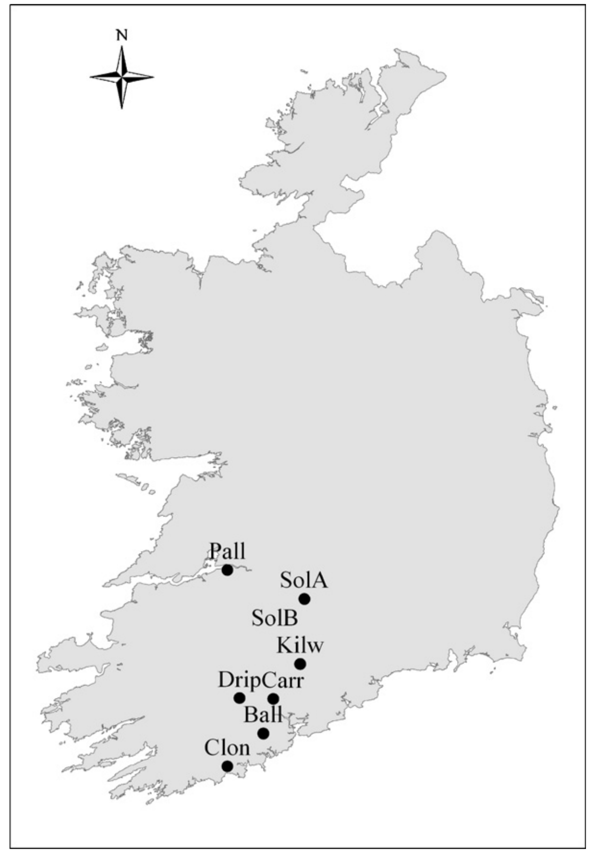

Fig. 1. Location map of the eight sites used in this study (note: SolA and SolB are very close to each other so that their symbols are overlapped).

In this study, the carbon fractions for surface depth (0–10 cm) of the eight sites were used because RothC is suitable for surface soils (Coleman and Jenkinson, 1999). The measured carbon fractions (%) were converted to t C ha^{-1} with known soil bulk densities, which has the same units as the output from RothC.

According to Zimmermann et al. (2007), the measured carbon fractions– sum of POM and DOC correspond to the modelled values– sum of DPM and RPM. The sum of POM and DOC was separated into DPM and RPM using the ratio of DPM: RPM from the modelled DPM and RPM pools for each site. The measured carbon fractions– sum of S + A and s + c − rSOC correspond to the modelled ones– sum of BIO and HUM, and was separated into BIO and HUM by the ratio of BIO: HUM from the modelled BIO and HUM pools for each site. The recalcitrant silt and clay fraction (rSOC) is associated with IOM. The detailed procedure (a flowchart) is shown in Fig. 2b (after Zimmermann et al., 2007). All the pools converted from the measured carbon fractions were called measured pools in this study.

2.3. Application of RothC-26.3

RothC was firstly used to calculate the annual plant inputs (M1) to soils at the mode of known total soil carbon content. Originally, the model approximates IOM using the equation (IOM = 0.049(total SOC)$^{1.139}$) proposed by Falloon et al. (1998), but the calculated IOM is almost three times less than the measured (Fig. 3a) and the relationship between the measured IOM and total SOC (Fig. 3b) is largely different from that of Falloon et al. (1998). In another study on croplands, Leifeld et al. (2009a) indicated that the sizing

Table 1
Eight grassland sites information used in this study.

Site name (abbreviations)	Soil type	Elevation (m)	Latitude longitude	Estimated annual plant litter input (t C ha^{-1})	Clay fraction	Land use history
Ballinhassig (Ball)	Grey brown podzolic	79	51°48′07″ −8°32′56″	1.18	0.29	Grassland (unknown date)-Cropland (before 2000)-Grassland (since 2000)
Carraig na Fearr (Carr)	Brown podzolic	104	51°58′57″ −8°28′00″	1.91	0.23	–
Clonakilty (Clon)	Brown podzolic	69	51°37′42″ −8°50′50″	1.46	0.19	–
Dripsey (Drip)	Gley	187	51°59′10″ −8°45′06″	1.74	0.12	Bushes and rushes (before 1989)-Grassland (since 1989)
Kilworth (Kilw)	Acid brown earth	51	52°10′07″ −8°14′25″	1.89	0.18	Grassland (>30–35 years)
Pallas Kenry (Pall)	Grey brown podzolic	15	52°39′18″ −8°51′57″	1.40	0.20	A hilly site; Grassland (at least since 1999)
Solohead A (SolA)	Gley	102	52°30′29″ −8°12′21″	3.52	0.22	Grassland (>30–35 years)
Solohead B (SolB)	Gley	98	52°30′22″ −8°12′13″	2.01	0.39	Grassland (>30–35 years)

'–', No information.

of the IOM pool by means of chemical fractionation (rSOC) is superior to using Falloon's equation (Falloon et al., 1998). Therefore the Falloon's estimate (the originally modelled IOM) was not used for this study. Correspondingly the measured IOM (rSOC) was used to replace the originally modelled IOM. Using the measured IOM (rSOC) we corrected the firstly estimated annual plant inputs as:

$$M2 = M1 \times \left[\left(\frac{\text{Total SOC} - \text{measured IOM}}{\text{Total SOC} - \text{originally modelled IOM}}\right)\right] \qquad (1)$$

where M1 and M2 were firstly calculated plant inputs and corrected plant inputs, respectively. With the corrected plant inputs (M2) required to meet the present SOC content, the model partitions SOC into pools that arise at equilibrium (nominally after 10,000 years). All the pools determined from RothC at an equilibrium state were called modelled pools in this study. Note that because the originally modelled IOM pool from Falloon et al. (1998) was replaced by the measured IOM pool, the so-called modelled IOM pool actually used to initialize RothC model later in this study was the same as the measured IOM pool.

The RothC model was run under the initialization separately with measured and modelled carbon pools to simulate the SOC changes in response to climate change in order to examine the effects of the two initializations on the projected SOC outputs.

2.4. Statistical analysis

Correlations between modelled and measured pools were determined by Spearman's rank order, *R*. The Kolmogorov–Smirnov test was used to test whether differences between modelled and measured pools were significant.

3. Results

3.1. Measured SOC fractions and the modelled pools with RothC at an equilibrium state

As shown in Fig. 4, the measured active SOC were mainly in the pools of S + A (33% of the total SOC) and s + c − rSOC (29% of the total SOC). The pools of POM (14%) + DOC (1%) contributed approximately 15% of the total SOC. For the modelled active pools from RothC at equilibrium, the largest amount of SOC was in the pools of HUM (62% of total SOC) plus BIO (1.6% of total SOC). The pools of DPM (1.2%) + RPM (12%) accounted for 13% of the total SOC.

To directly compare the measured and modelled pools, the SOC content in the measured fractions were converted to the corresponding pools of the RothC model as explained above (Fig. 2b). The measured and modelled values for the BIO pool and the HUM pool were significantly correlated with each other, while the measured and modelled values for the DPM pool and the RPM pool were of similar magnitude but without significant correlation (Table 2 and Fig. 5).

3.2. SOC change in response to climate change

Compared to the 1961–2000 period (for the region of the eight grassland sites in the study, with mean annual precipitation 1829 mm and mean monthly air temperature 9.86 °C), the projected annual precipitation for 2021–2060 is decreased by 0.56, 1.75 and 1.67% for A1B, A2 and B1 scenarios, respectively (Fig. 6a). The annual distribution of precipitation is also changed with higher rainfall from January to March and after August, and lower rainfall in the spring and summer (Fig. 6a). The projected mean monthly air temperature is increased by 11.89, 9.10 and 5.97% for A1B, A2 and B1 scenarios, respectively (Fig. 6b).

As shown in Fig. 7, we found a decreasing trend for the SOC produced with initialization of modelled carbon pools for every future climate scenario (A1B, A2, and B1) at all eight sites. The projected SOC was always highest for scenario B1, and followed by A2 and A1B in a decreasing order. The projected SOC change trends produced with the initialization of the measured carbon pools of the eight sites can be classified into 3 groups. For the sites of Carr, Clon, and Kilw, the projected SOC change trends from the initialization of the measured pools were similar to that when RothC was initialized with the modelled pools. For the

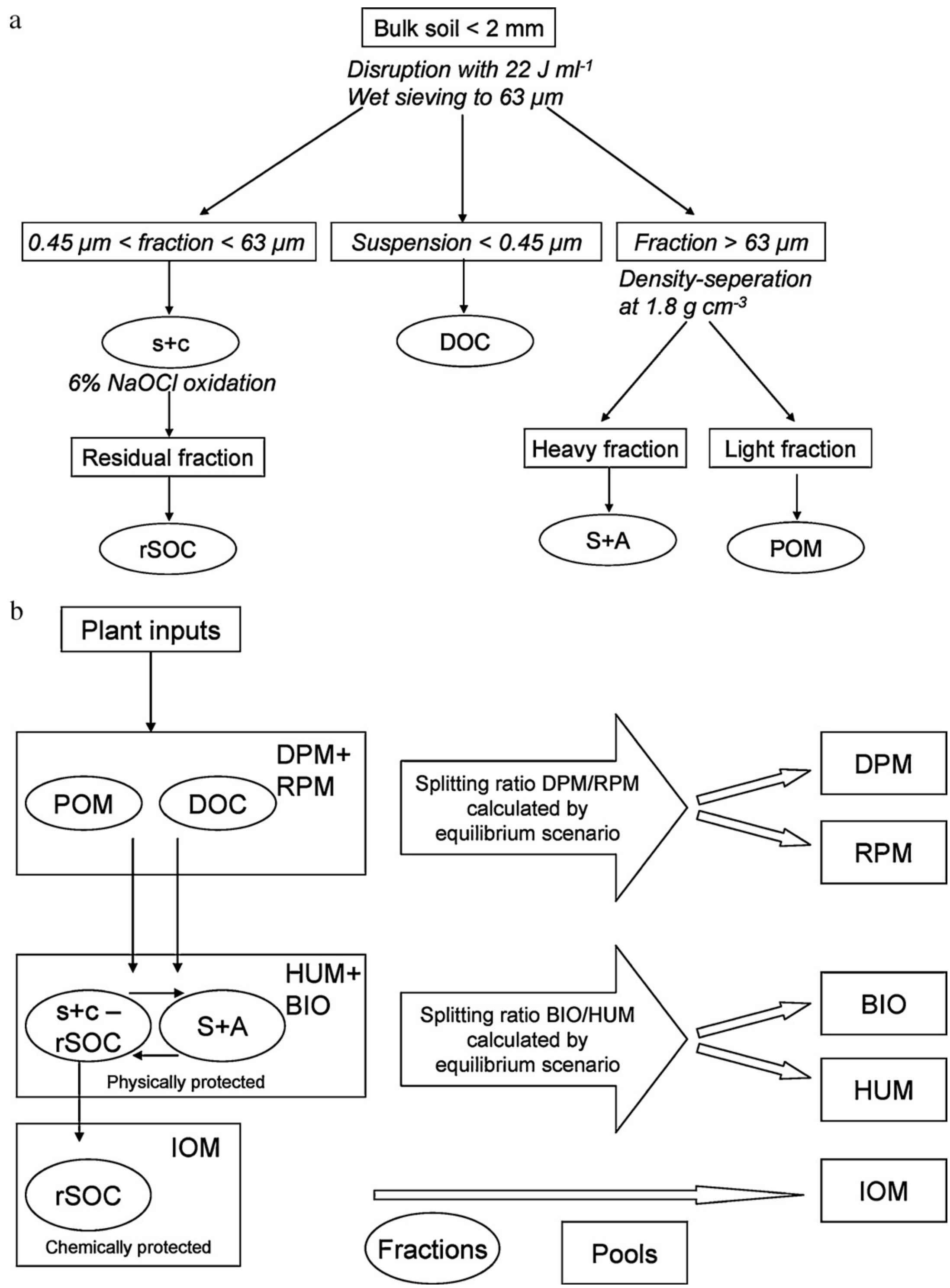

Fig. 2. (a) Diagram of the fractionation procedure: s + c, silt and clay; rSOC, resistant soil organic carbon; DOC, dissolved organic carbon, S + A, sand and stable aggregates; and POM, particulate organic matter (after Zimmermann et al., 2007), and (b) the concept of summarizing and splitting SOC fractions and pools (after Zimmermann et al., 2007).

sites of Ball and Drip, the projected SOC change trends with initialization of the measured pools, rapidly decreased in the early years of the simulation and then slightly increased. For the sites of Pall, SolA and SolB, the projected SOC change trends with the initialization of the measured pools rapidly increased at the beginning of the modelled period and then decreased relatively slowly.

4. Discussion

4.1. Comparison of measured and modelled carbon pools

RothC is a process based model, which can be used to estimate the SOC change in response to climate change or land use management alterations (Falloon et al., 2006; Ludwig et al., 2007,

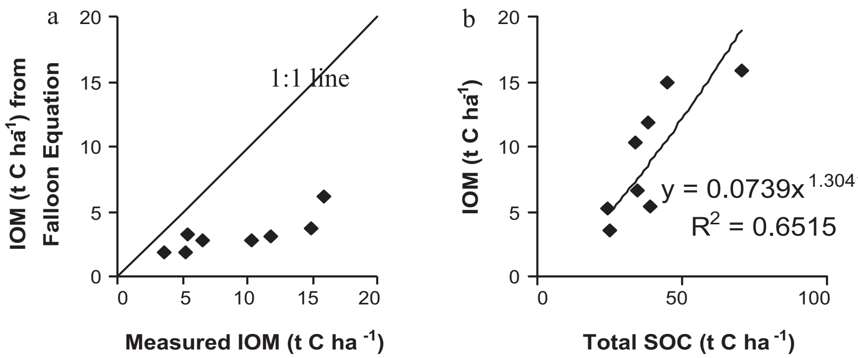

Fig. 3. The relationship between (a) the measured IOM and the estimated from Falloon's equation (Falloon et al., 1998) used in RothC model, and (b) the measured IOM and the total SOC.

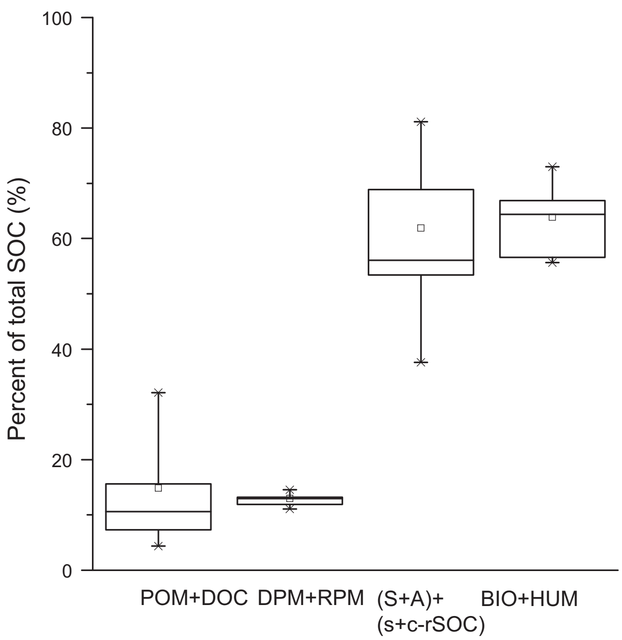

Fig. 4. Box plots for the measured fractions (POM + DOC and S + A + s + c-rSOC) and RothC modelled pools (DPM + RPM and BIO + HUM) at equilibrium state. *Note*: The measured values were determined from soil samples which were analyzed in accordance with Zimmermann et al. (2007).

2010; Smith et al., 2005). This model partitions SOC into pools with different turnover rates. But some of the pools are conceptual in nature and therefore it would be useful to relate these conceptual pools to some measured fractions. Zimmermann et al. (2007) proposed physical and chemical methods to separate the measured SOC into different carbon fractions, which can be directly related to the modelled pools of RothC. However, to our knowledge, only a few studies (Dondini et al., 2009; Leifeld et al., 2009a,b) have been conducted to test this method. Our study shows that the measured values were well correlated with the modelled values for the pools of BIO and HUM and not well correlated but of similar magnitude for the pools of DPM and RPM (Fig. 5 and Table 2). This is a similar observation to previous studies: Zimmermann et al. (2007) showed significant difference only in the magnitudes of the DPM and RPM pools between the modelled and measured values for a temperate grassland; Leifeld et al. (2009b) indicated the measured particulate organic matter (POM) was higher than the corresponding modelled pool- (DPM + RPM) in alpine grasslands. In a study on croplands (including both conventional and organic farming), Leifeld et al. (2009a) presented systematic difference in the measured and modelled pools of DPM, RPM and BIO, and the biggest difference was for the DPM pool. In a study for Irish bioenergy croplands (*Miscanthus*), Dondini et al. (2009) found good correlation between the measured and modelled pools, and the best correlation was for the HUM pool.

Compared with the previous studies, our study further evaluated the effects of different model initializations with measured or modelled carbon pools on projected SOC change trends in response to climate change. For five of the eight sites (the sites of Ball, Drip, Pall, SolA and SolB, see Fig. 7), there were large differences in the projected SOC change trends between using measured and modelled carbon pools to initialize RothC. But the big difference mostly occurred in the earlier years and gradually decreased some years later. In the study on croplands, Leifeld et al. (2009a) also found some difference in their simulation results (SOC dynamics over time) from either initialization with modelled carbon pools or with measured carbon pools. They attributed this difference in total SOC to the difference in the HUM pools. However, we found the projected total SOC change trends from RothC initialized with measured pools were controlled by the RPM pools' change trends (an example in Fig. 8a). As shown in Table 2, both HUM (~80%) and RPM pools (~16%) accounted for relatively high proportion of the active carbon pools, and therefore the change in each of them can dominate the total SOC change trends, but why RPM rather than HUM? In the RothC model, the RPM pool decomposes (0.3 year^{-1}) an order of magnitude faster than the HUM (0.02 year^{-1}) pool. For the same amount, it takes 1/0.02 = 50 years to completely decompose for HUM, but only 1/0.3 = 3.33 years for RPM. Our study did the simulation only for a period of 40 years, and therefore the dynamic of RPM

Table 2
Relationships between the measured and modelled pools (t C ha^{-1}).

Pools	Spearman's *R*	Measured pools		Modelled pools		*n*	Kolmogorov–Smirnov test (*P*)
		Mean	Std. deviation	Mean	Std. deviation		
DPM	−0.214	0.49	0.26	0.45	0.16	8	>0.1
RPM	−0.214	4.87	2.60	4.52	1.65	8	>0.1
BIO	0.958**	0.62	0.29	0.63	0.24	8	>0.1
HUM	0.929**	23.56	11.15	23.94	9.03	8	>0.1

** Means that correlation is significant at the 0.01 level.

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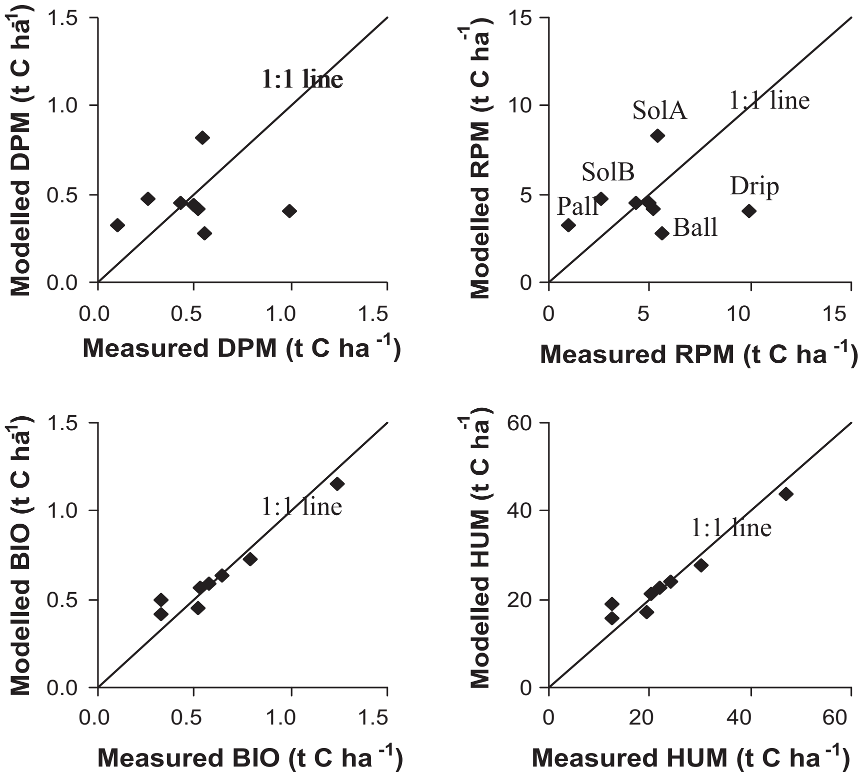

Fig. 5. Scatter plots of the modelled versus the measured pools.

rather than HUM controlled the total SOC change trends. Another question to be addressed was: why did the projected total SOC (from the RothC initialized with measured carbon pools) rapidly decrease and diverge from the projected total SOC (from the RothC initialized with modelled carbon pools) in the earlier years for the sites of Ball and Drip, but rapidly increase at the earlier years for the sites of Pall, SolA, and SolB? According to Fig. 5, the measured RPM pool was 2 times higher for Ball and 2.4 times higher for Drip than the modelled, but it was 0.3 times lower for Pall, 0.66 times lower for SolA and 0.55 times lower for SolB than the modelled RPM pool. As we know, the modelled pool is at a theoretical equilibrium. If the measured RPM pool is higher than the equilibrium state and the future conditions (climate) facilitate its decomposition, the change amount of the measured RPM pool would be higher than the modelled (due to the measured RPM being larger), and this trend will continue until a new equilibrium occurs (Fig. 8b). In the opposite direction, if the measured RPM pool is lower than the modelled pool (equilibrium state), only a small amount of RPM can decompose, but the continuous inputs from plants would be higher than the decomposition, resulting in an increase in the net amount of RPM, up and until a new equilibrium occurs (Fig. 8c). We consider that different soil (subsurface) and surface drainage characteristics led to the differences between the sites of Ball and Drip and, the sites of Pall, SolA and SolB. For the sites of Pall, SolA and SolB, there was good surface drainage due to the sloping lands and man-made drainage channels which likely accelerated the decomposition of the RPM pool. This was likely even though the gley soils (at SolA and SolB sites) in themselves have poor soil drainage characteristics. This resulted in the measured pools (real values) being lower than the modelled ones (theoretical value). For the sites of Ball and Drip, there was poor soil drainage due to underlying iron pan at Drip site and samples being taken in the flat areas at Ball site. This is likely to have slowed the decomposition of the RPM pool, resulting in the measured RPM pools being higher than the modelled values. Particularly at Drip site, the low soil clay content for the surface layer (See Table 1) was the only soil parameter control-

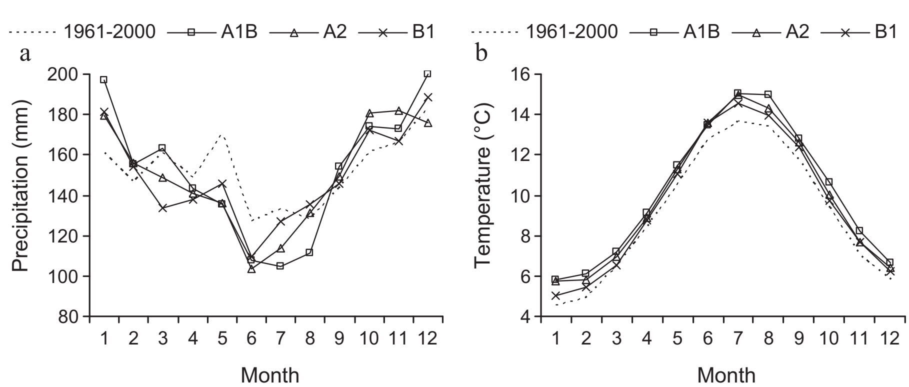

Fig. 6. (a) Monthly precipitation, and (b) monthly air temperature.

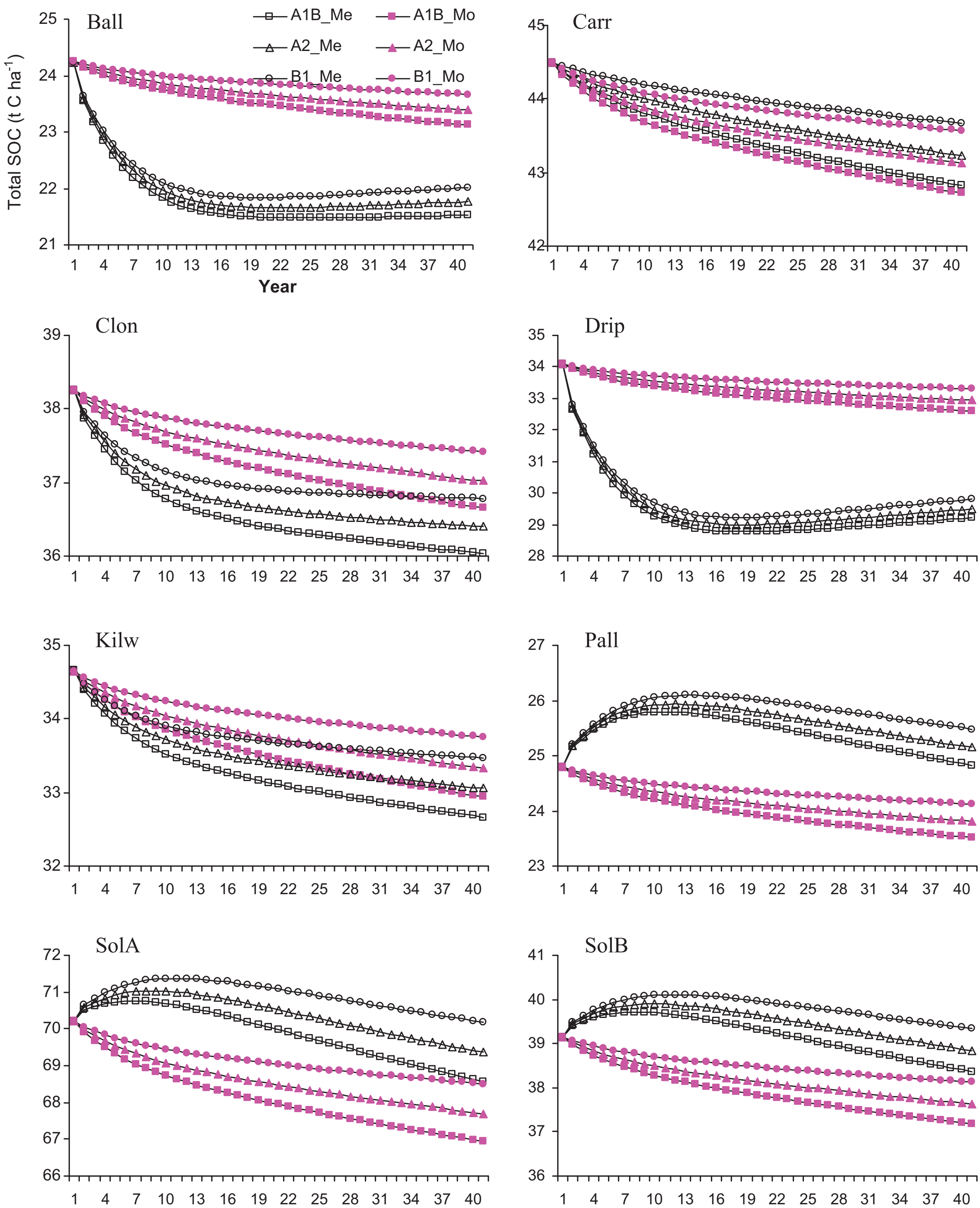

Fig. 7. Projected SOC change trends of 8 grassland sites in response to climate change (A1B, A2 and B1 scenarios) under the initializations of RothC model with measured or modelled carbon pools. Me, measured pools; Mo, modelled pools.

ling the soil moisture condition in RothC model. This resulted in an overestimate of the decomposition of the modelled RPM pool, and thereby increased the difference between the modelled and measured RPM pools (Fig. 5). In another study of agricultural regions in Belgium, Van Wesemael et al. (2010) found that improved drainage conditions caused a decrease in SOC stock, but the RothC model was unable to capture this aspect (drainage condition change). Based on the above, we can also suggest that the measured carbon pools more reasonably reflect the real conditions than the modelled pools.

Another question may also arise: how much difference between the measured and the modelled RPM is enough to cause this difference in the projected total SOC change trends (for the sites of Ball, Drip, Pall, SolA and SolB, See Fig. 7)? In other words, is there some threshold for the difference between the measured and modelled RPM pool to produce an appreciable difference in the projected total SOC change trends when used to initialize the RothC model? This question is actually same as “the difference between one measured fraction and one modelled pool should be within acceptable limits”

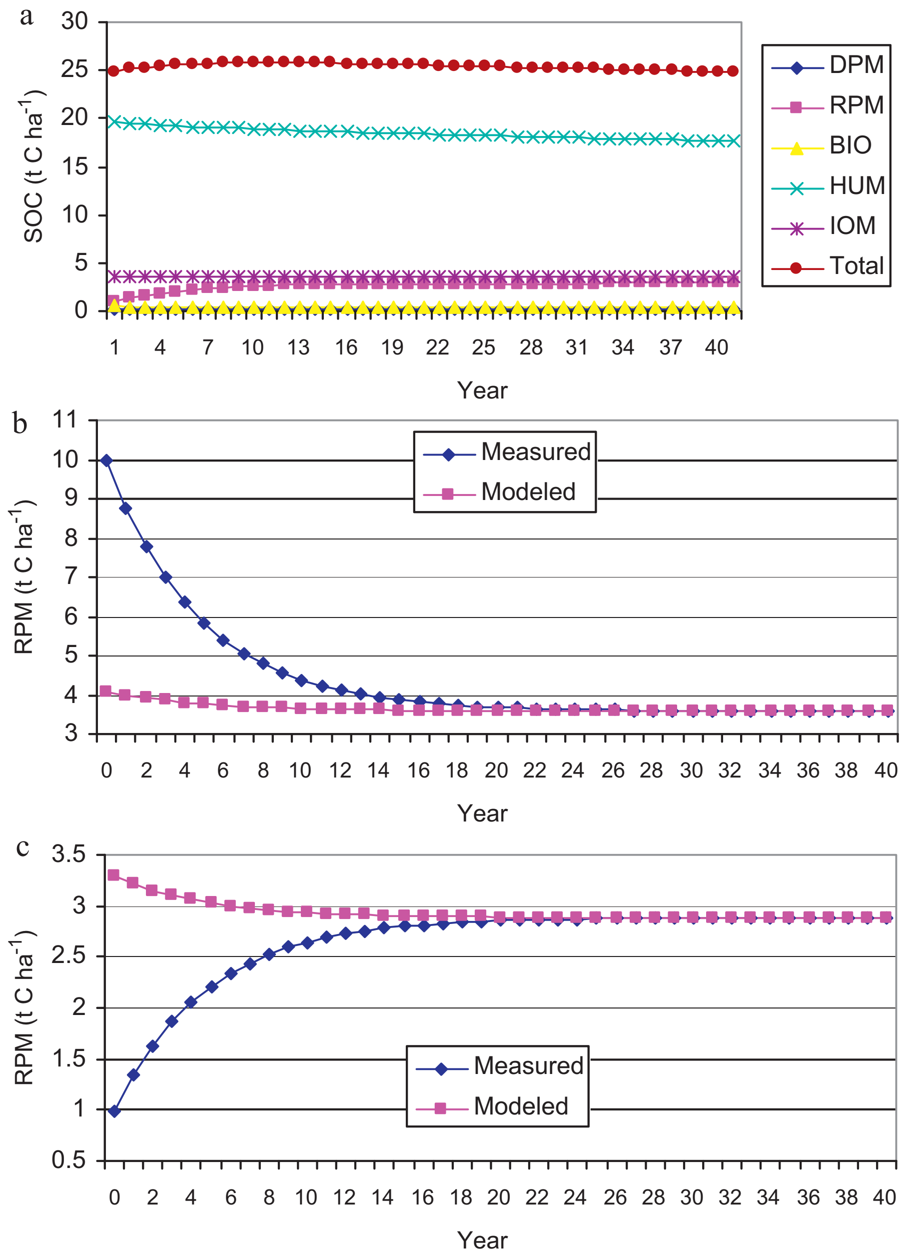

Fig. 8. (a) An example of the projected RPM controlling the projected total SOC trends in response to climate change produced with the measured pools to initialize RothC model, and the examples of the projected RPM change trends in response to climate change for the cases of (b) the measured RPM pool is higher than the modelled one, and (c) the measured RPM is lower than the modelled one.

pointed out by Smith et al. (2002), who proposed some constraints to ensure that one measured carbon fraction is equivalent to one modelled pool. According to Fig. 7 (for the sites of Ball, Drip, Pall, SolA and SolB), the difference in SOC changes trends increase only in the earlier years, and decrease in later years. As the turnover period for the RPM pool is 1/0.3 = 3.3 years, the magnitude of the difference between the measured and modelled RPM pool that can decrease the difference of the projected SOC change to 1% within the first 3 years can be set as the threshold. Based on this assumption and by continuously adjusting the original modelled RPM (and DPM) pool at a step of ±1% change, the thresholds for different sites and different climate scenarios can be calculated, and range from 11% to 15%. Strictly 10% can be set as the final threshold. We therefore provide one reference (threshold) based on which we can identify whether or not the measured pools (DPM and RPM) are accurate enough to replace the modelled pools to initialize the RothC model. Although the result (threshold) of this study is case-specific, the method used to determine the reference (threshold) has wider application. We quantified the thresholds in the difference between the measured fractions and the modelled pools based on the difference in the model's outputs caused by using these two types (measured and modelled) of pools to initialize RothC model.

Overall, this study indicates that the Zimmermann method has good potential, and the measured carbon fractions can reflect the real environmental conditions more reasonably than the modelled pools (reference to Leifeld et al., 2009a and this study). The existing studies implicitly assume the modelled pool distribution of equilibrium is a gold standard (Dondini et al., 2009; Smith et al., 2002; Zimmermann et al., 2007; this study), and aim to determine the measured carbon fractions as close to the modelled pools (at equilibrium state) as possible. However, the so-called modelled equilibrium was produced by considering only limited environmental

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factors (parameters for models), all of which can reflect only some of the real conditions as stated for the Drip site above. Moreover, whether the concept of the 'equilibrium' for models is correct or not, a long period of time is required to reach a so-called equilibrium. This would limit the model's wider application particularly for the managed land systems which have undergone disturbance (e.g. land use conversion, management change, drainage).

4.2. SOC change in response to climate change

Increasing temperatures will accelerate decomposition and will increase the loss of soil carbon in the future, where soil moisture is not limiting (Smith et al., 2005). Our study shows that the RothC predicted SOC using the modelled carbon pools for initialization decreased by 2–6% over the forty years timeframe (from 2021 to 2060) for different climate change scenarios and different sites. In this study, the future increase in temperature would increase SOC decomposition, and thereby SOC loss. Summer drought (in the future) may increase losses of SOC, but decomposition may remain relatively unchanged during the winter months as a result of increased precipitation. In a study of European grassland soils, Smith et al. (2005) found that climate impacts would reduce the mean grassland soil carbon stock by 6–10% of the 1990 level by 2080, but changes (increases) in net primary productivity can compensate for losses of soil carbon in three out of four scenarios examined. According to the studies by Ludwig et al. (2007, 2010), the plant carbon inputs to soil are positively correlated to crop yields. In our simulation, plant inputs were set the same for the current and future periods. However, the study by Holden and Brereton (2002) indicated that future summer drought would reduce grass yield, which suggests that no increased productivity and associated litter inputs will compensate for the projected topsoil carbon loss in Irish grasslands.

5. Conclusions

This study showed that there was no significant difference in the magnitude (or relative contribution to the total SOC) between the measured and modelled active pools (including DPM, RPM, BIO and HUM). The projected total SOC change trends in response to climate change between using measured and modelled carbon pools to initialize RothC were largely (even in opposite direction) different from each other for 5 of the 8 sites. Although the HUM pool accounted for most of the active carbon pools (∼80%), it was the RPM (∼16%) rather than HUM pool that controlled the projected total SOC change trends due to its (RPM) faster decomposition rate and the short term simulation (40 years) in this study. The big difference in the projected total SOC change trends only increased in early years of the simulation, and it decreased with time some years later. In order to decrease the difference to 1% within the first 3 years (about one turnover period for RPM), about a 10% difference between the measured and the modelled pools of RPM and DPM should be set as a constraint. The SOC partitioning procedure by Zimmermann et al. (2007) has potential, and the measured carbon pools more reasonably reflected the real environmental conditions than the modelled pools. In response to increasing temperature and summer drought in the future (2021–2060), the SOC will tend to decrease for temperate grassland in Ireland by between 2 and 6%, and suitable grassland land management practices therefore should be examined to limit this loss.

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