We highly appreciate the very helpful and constructive comments of the anonymous referee, which helped us to further improve the manuscript. We tried to consider all of them.

The referee's comments will we shown black. Our response is shown blue, *italic* and tab-indented while changes in the manuscript are in quotation marks and **bold**.

Anonymous Referee #1

The ms describes a study on the influence of changes in plant cover on the decomposition of moss (sphagnum) dominated peat at two peatlands differing in altitude and temperature. The authors investigated a large number of short cores (20 cm) for changes in peat decomposition based on C/N ratios, 13C and changes in organic components derived from pyrolysis GC-MS analyses. The authors found out, that sedges and shrubs litter increases decomposition of moss dominated peat, especially at higher temperature. The effect of vascular plants was more pronounced that that of temperature. Peat decomposition appears to be best reflected by 13C, although its application to distinguish source material from decomposition is seen incomplete. C/N and 15N appear to be not specific enough to indicate the effects of vascular plants on moss peat decomposition. The topic and the conclusions are not entirely new, but this is to my knowledge the most comprehensive study on this topic. Especially the combination of stable isotopes, C/N ratios and pyrolysis GC-MS gives new insights into the role of plant cover for initial organic matter degradation in peatlands on a molecular level. The ms is suitable for Biogeosciences and well written and I suggest publication after addressing some issues.

Specific comments: The use of the term decomposition in peatlands is often a bit unspecific and many different methods (compound specific or only operational defined) are used to determine the degree of peat decomposition. Although the authors describe in the ms what C/N, 13C and py-GC-MS can show, but it remains unclear when I see mass loss (C/N and 13C) or changes in the molecular composition. The problem here, I think is that e.g. C/N and 13C were used in previous studies do distinguish changes in peat decomposition (here it describes mainly mass loss (polysacarides), but what the authors investigated in their study is the initial phase of plant material decay (a lot of qualitative changes/ molecular composition) I suggest that the authors make clear what they mean by "peat" and give a clear statement e.g in their hypotheses what they mean by "decomposition".

> *Thank you for this suggestion. We will include a sentence what we understand as "decomposition". We will integrate this at the end of the sentence in L.55 as follows:*

"**We defined decomposition as any changes in properties of the peat relative to its source material, e.g. plant material from *Calluna vulgaris Eriophorum vaginatum*, *Sphagnum spp.* directly after deposition.**"

> *We will also include a definition of "peat" at the end of the sentence in L.54:*

"**Peat was defined as any organic material that accumulates underneath the peatlands surface, including living stems of *Calluna vulgaris*, *Eriophorum vaginatum* and *Sphagnum spp.***"

The authors address the importance of oxygen availability, redox conditions and water levels at the time of sampling. They also mention that oxygen transport into the peat via aerenchym of E. vaginatium takes place.
However, redox-conditions (here the availability of oxygen for OM mineralisation) are crucial for peat decomposition. For me it remains unclear how much of the observed changes in decomposition/OM quality are related to redox-conditions/water table depth or oxygen transport via the roots of vascular plants and how much to the presence of pant litter from sedges or shrubs. More shrubs and sedges in peatlands are usually a result of drier conditions. Drier conditions mean lower mean water table and aeration/ increased decomposition of peat, a bit a hen and egg problem. The authors remain unclear about this in their conclusions.

We want to thank the referee for this valuable comment. We agree on the referee's comment that redox conditions are a major control on peat decomposition. This was considered in the sampling design, where we restricted the plot installation to hummocks and peat core sampling to the aerobic zone, the acrotelm. Also we specifically chose locations where sedges and shrubs grew in mixed stands, experiencing similar redox conditions. With this strategy we avoided the "hen and egg problem" as much as possible. However, as addressed to the review provided by Tim Moore, sampling depths in the peat cores are periodically water saturated. Water table measurements 2015/08–2016/07 (three gauges at each site) show that the peat within the sampled 20 cm on the High T site stayed aerated for 117, 360 or 366 days of the year as recorded in the three gauges. On the Low T site, the peat of the top 20 cm was aerated for 137, 138 or 284 days of the year. These measurements underline that beside higher temperature and higher vascular plant proportion, the top 20 cm peat at the High T site stays longer aerated over the year than at the Low T site. This information will be replacing the information of water table depths at the end of the sentence in L. 89 as follows:

"The time during which the top 20 cm of the peat was above the water table was determined with water table measurements between August 2015 and July 2016 at three gauges on each site. At the Low T site, the water table remained below 20 cm for 137, 138 and 284 days of the year; at the High T site, this was 117, 360 and 366 days of the year respectively."

Due to this added information, we will adapt the discussion in L. 308 as follows:

"The altitudinal gradient has been used to reveal potential effects of increasing temperature **and associated lower water table** on peat decomposition by comparing the decomposition parameters (Table 1) between the High **T** and Low T site.

Water table and thus aeration did probably not affect peat decomposition under sedges vs. shrubs because our sampling design ensured similar water table between sedges and shrubs at each of our sites. We think that increased peat decomposition as a result of oxygen transportation by the aerenchym of sedges should be more important at the Low T site because of the longer time of water saturation at this site in comparison to the high T site. We will address this in L. 305 as follows:

"This process is particularly relevant at the Low T site, where the uppermost 20 cm of the peat remained water saturated much longer than at the High T site."

In addition, we will refine our conclusions in L. 348:

"The most important and also surprising result of our study was that vascular plants had a more pronounced impact on peat decomposition than temperature **and associated lower water tables together. Potential O_2 transport by the aerenchym of sedges did probably not contribute to enhanced peat decomposition at the High T site, as the top 20 cm peat layer sampled remained above the water table, and thus aerated, for most of the year.**"

- The authors tend to use general terms such as

L 35 alterations in the environment,

We thank the referee for the comment. We will address this in L. 35 as follows:

"Climate change is expected to partly lift these environmental constraints to microbial decomposition **by warmer** (Karhu et al., 2014) **and drier conditions**, threatening to release stored organic C as CO_2 to the atmosphere."

L39 plant-soil feedbacks,

We will change the term in L. 39 as follows:

"A systematic change in composition of plant functional types (PFTs) towards vascular plants has a yet unknown potential to accelerate C losses from the **stored** peat originally dominated by mosses **due to increased C input via roots from vascular plants** (Bragazza et al., 2013; Gavazov et al., 2018; Robroek et al., 2015), **and litter mixing effects (Zhang et al., 2019).**"

L66..hydrological conditions. Please be more specific.

We will change the term in L. 66 as follows:

"However, stable isotope patterns are also affected by **the water table limiting aerobic decomposition and thus isotopic discrimination in the remaining peat (Krüger et al., 2015) and the** plant species forming the litter."

- Can the authors give an estimate about the ages of their plant/peat samples. Is time an issue here?

Unfortunately, we don't have data on the age of peat in 20 cm depth of both sites. A recent study of two other alpine peatlands at an altitudinal contrast higher than our study (1030 m a.s.l. vs. 1880 m a.s.l.) reported peat ages of 40 and 26 years respectively for the peat in 15-20 cm depth (Gavazov et al., 2018). Assuming these peatlands are similar to ours, the age difference between our sites would be less than 15 years.

The differences between the sites may have affected absolute differences between peat decomposition, but not the impact of shrubs relative to sedges on peat decomposition within sites. Furthermore, differences between the sites were quite small, and we are not able to disentangle the effects of the current temperature and water table on the one hand, and differences in environmental condition during peat formation on the other hand.

Accordingly, we will add information on the estimated age of peat at the end of the sentence in L. 90 in the study site descriptions as follows:

"**Furthermore, in peatlands with similar vegetation cover, situated at 1030 m a.s.l. and 1880 m a.s.l. in Switzerland, the age of peat in 15-20 depth was found to be 40 years and 26 year, respectively (Gavazov et al., 2018), meaning that the potential age difference between the peat sampled at our sites is likely less than 15 years.**"

- L185-195 The description of Fig. 1 2 and 4 are a bit difficult to decipher. May be distinguish by site.

As suggested, the paragraph in L.185-195 describing the results presented in these figures will be restructured as follows, but Figures 1, 2, and 4 will be maintained as we submitted them:

"Carbon to N ratios and isotopic composition of plant shoots were different between **plant tissues**, PFTs and to a lesser extent between sites (Fig. 1). **Living plant shoots had consistently lower C/N ratios than plant roots irrespective of site or PFT (Fig. 1a). Sedge shoots had significantly lower C/N ratios ($p < 0.001$, Fig. 1a) and were significantly enriched in ^{13}C ($p < 0.001$, Fig. 1b) compared to moss and shrub shoots. Shrub shoots were significantly depleted in $\delta^{15}N$ compared to sedge and moss shoots ($p < 0.001$, Fig. 1c). Sedge shoots and moss from the High T site were both significantly depleted in ^{13}C compared to Low T site (both $p < 0.01$, Fig. 1b).**

Peat C/N ratio and isotopic composition was significantly affected by depth, site and to a lesser extent by PFTs (Fig. 2a, 2b). Carbon to N ratio increased with depth and was higher at the High T site compared to the Low T site (Fig. 2a, Table 2). In the upper 0-2 cm peat layer, C/N ratios and stable isotopes corresponded with values observed for moss (Fig. 1, Fig. 2). Isotopic composition of peat increments was significantly different for depths and PFTs (Table 2). $\delta^{13}C$ and $\delta^{15}N$ of peat increased with depth (Fig. 2b, 2c) and the enrichment in ^{13}C with depth was stronger for sedge-cores than for shrub-cores (i.e. 2.7 ± 0.4 ‰ for sedge-cores and 1.6 ± 0.4 ‰ for shrub cores). The largest enrichment in $\delta^{13}C$ between the uppermost and lowest depth increment appeared in sedge-cores at the High T site (Fig. 2b; i.e., 3.5 ± 0.5 ‰)."

- Table 1: all reference are from one of the authors (Schellekens). Any independent references available here?

The information on peat pyrolysates is frequently fragmented and scattered in the literature and the identification and/or validation of parameters was mainly demonstrated by these studies of Schellekens et al. However, we fully agree with the reviewer that self-citing is not desired and that the original source publication must be cited too. In order to cite correctly and at the same time avoid repeating the whole reasoning behind the pyrolytic parameters *(that was already published in Schellekens et al.), we have checked the literature once more and we will revise the references accordingly as follows (both in Table 1 and in Section 2.5): Also, note that the reference is given for the interpretation in Sphagnum peat (4th column) and not for the source molecule (3rd column); this was not sufficiently clear and perhaps contributed to the reviewers comment. We will clarify this in the revised manuscript by indicating that interpretation refers to Sphagnum peat; see the heading of the fourth column in Table 1.*

Parameter	Unit	Indication	Interpretation in *Sphagnum*-dominated peat
C/N	-	preferential decomposition of C over N	aerobic decomposition
$\delta^{13}C$	[‰]	preferential decomposition of ^{12}C over ^{13}C isotope	aerobic decomposition
$\delta^{15}N$	[‰]	preferential decomposition of ^{14}N over ^{15}N isotope	aerobic decomposition
sum of G and S lignin products	[% TIC[a]]	lignin	vascular plants (van Smeerdijk and Boon, 1987)
sum of *n*-alkenes and *n*-alkanes	[% TIC[a]]	cutan, suberan, leaf waxes	ericoid shrubs (Schellekens and Buurman, 2011; van Smeerdijk and Boon, 1987)
C_3G/G	-	intact lignin	ericoid shrubs (Schellekens et al., 2012)
4-vG/G	-	ferulic acid	sedges (van Smeerdijk and Boon, 1987; Schellekens et al., 2012)
4-isopropenylphenol (Ph6)	[% TIC[a]]	sphagnum acid	aerobic decomposition of *Sphagnum* tissues (preferential loss of polyphenols over polysaccharides; Schellekens et al., 2015b)
levoglucosan/sum of polysaccharides	-	cellulose	aerobic decomposition of *Sphagnum* tissues (preservation of *Sphagnum* polysaccharides; Schellekens et al., 2015b)[b]

[a] total ion current

[b] interpretation refers to relatively low values

We will update the paragraph in L. 141ff. as follows:

"Based on the results of previous pyrolysis studies from peatlands a number of pyrolytic parameters reflecting plant species and the degree of **peat** decomposition were extracted (Table 1). A pyrolysis product specific for sphagnum acid (4-isopropenylphenol; Van Der Heijden et al., 1997) has been found to very sensitively reflect aerobic decomposition of *Sphagnum* tissue in *Sphagnum*-dominated peat **(Schellekens et al., 2015b**). Methoxyphenols are unique to lignin, thereby providing a measure for the contribution from vascular plants in peat dominated by *Sphagnum*, because *Sphagnum* contains no lignin (Abbott et al., 2013; Kracht and Gleixner, 2000**; Schellekens et al., 2015c; van Smeerdijk and Boon, 1987).** Since both shrubs and sedges contain lignin, additional parameters were included to distinguish between them. Sedges have large contributions from p-coumaric and ferulic acid (Lu and Ralph, **1999**) with typical pyrolysis products 4-vinylphenol (Lg1) and 4-vinylguaiacol (Lg4), respectively (**van der Hage et al., 1993**). Because 4-vinylphenol is also abundant in *Sphagnum* tissue **(van Smeerdijk and Boon, 1987)**, the ratio of 4-vinylguaiacol to the summed guaiacyl products (G) **can** be used to reflect sedges (Schellekens et al., 2012). The ratio of C_3-guaiacol to G **usually reflects intact lignin in soils but has been found** indicative for shrubs **in peat** (Schellekens et al., 2012, 2015a). *n*-Alkenes and *n*-alkanes (Al) originate from cutan and suberan present in roots and bark (**Nierop, 1998; Tegelaar et al., 1995**) and leaf waxes (Eglinton and Hamilton, 1967), depending on their chain length, all of which are associated with shrubs in *Sphagnum*-dominated peat (Schellekens and Buurman, 2011**; van Smeerdijk and Boon, 1987**)."

Furthermore, we have checked the whole text for possible reduction of self-citing. In L.73 we will exclude Schellekens et al., 2009 and 2015c.

Further, we will change typography and make other corrections:

Sentence in L. 77 will be changed to:
"In this multi-proxy study, we combined the analytical approaches outlined above to explore the influence of vascular plants on chemical properties and degree of **peat** decomposition in **two** moss-dominated peatlands contrasting in temperature."

We will correct the following references in our manuscript:
- L. 147f where (Lu and Ralph, 2010) will be changed to **Lu and Ralph, 1999**
- L.278 where Schellekens et al., 2015a will be changed to **Schellekens et al., 2015b**
- L.317 where Schellekens et al., 2015c will be changed to **Schellekens et al., 2015b**

Commas will be included in:
- L. 324: "Given the above**,** …"
- 4.2.2 too**,**

Changes to italic will be done in:
- L. 336 *E. vaginatum*
- L. 327 *Sphagnum*-dominated

Grammar in L. 243 will be corrected to:
"Furthermore, the similarity of C/N ratios, $\delta^{13}C$ and $\delta^{15}N$ of the uppermost peat increment to those of moss are indicative for moss-dominated peat (Schaub and Alewell, 2009) and **has** been measured likewise in *Sphagnum* peatlands by Kracht and Gleixner (2000)."

We will adjust the sentence in L. 247 as follows:
"**Peat composition under shrubs and sedges is influenced by these species in the studied peat (0-20 cm) as indicated by the molecular parameters for sedge and shrub in the corresponding peat cores (Fig 4b, 4c, 4d).**"

We will make changes in L. 274:
"In addition to changes in $\delta^{13}C$ and $\delta^{15}N$ reflecting the decomposition of the bulk peat (i.e. cumulative effects on all peat components), we examined changes in compounds being indicative for the decomposition of specific plant tissues, i.e. *Sphagnum*-derived peat (**4-isopropenylphenol**)."

We will make changes in L. 295:
"**Because this is not evident from the 4-isopropenylphenol record, it probably reflects a** higher contribution of sedge-derived polysaccharides **at these depths**."

The sentence in L. 296f. ("Such a shift….") will be deleted.

We will make changes in L. 298:
"The observed **decomposition** patterns were detected by a parameter describing the whole peat ($\delta^{13}C$), and were also reflected by compounds indicative for *Sphagnum* material (4-isopropenylphenol)."

The Figure reference in the sentence in L. 302 will be specified:
"Sedge litter is likely to be more readily decomposable compared to shrub litter, caused by its lower C/N ratios (Fig. 1**a**; Huang et al., 1998; Kaštovská et al., 2018; Laiho et al., 2003; Limpens and Berendse, 2003).

We will make changes in L. 336:
"On the other hand, Zeh et al. (2019) could show that shrubs translocated more C into the peat at

higher temperatures than sedges, which **could** result in reinforcing effect on peat decomposition with increasing temperature."

We will add these references to our literature:

Aerts, R., Callaghan, T. V., Dorrepaal, E., Van Logtestijn, R. S. P. and Cornelissen, J. H. C.: Seasonal climate manipulations result in species-specific changes in leaf nutrient levels and isotopic composition in a sub-arctic bog, Funct. Ecol., 23(4), 680–688, doi:10.1111/j.1365-2435.2009.01566.x, 2009.

Asada, T., Warner, B. G. and Aravena, R.: Nitrogen isotope signature variability in plant species from open peatland, Aquat. Bot., 82(4), 297–307, doi:10.1016/j.aquabot.2005.05.005, 2005.

Bragazza, L., Gerdol, R. and Rydin, H.: Effects of mineral and nutrient input on mire bio-geochemistry in two geographical regions, J. Ecol., 91(3), 417–426, doi:10.1046/j.1365-2745.2003.00773.x, 2003.

Bragazza, L., Limpens, J., Gerdol, R., Grosvernier, P., Hájek, M., Hájek, T., Hajkova, P., Hansen, I., Iacumin, P., Kutnar, L., Rydin, H. and Tahvanainen, T.: Nitrogen concentration and δ15N signature of ombrotrophic Sphagnum mosses at different N deposition levels in Europe, Glob. Chang. Biol., 11(1), 106–114, doi:10.1111/j.1365-2486.2004.00886.x, 2005.

Emmerton, K. S., Callaghan, T. V, Jones, H. E., Leake, J. R., Michelsen, A. and Read, D. J.: Assimilation and isotopic fractionation of nitrogen by mycorrhizal and nonmycorrhizal subarctic plants, New Phytol., 151(2), 513–524, doi:10.1046/j.1469-8137.2001.00179.x, 2001.

Galloway, J. N., Townsend, A. R., Erisman, J. W., Bekunda, M., Cai, Z., Freney, J. R., Martinelli, L. A., Seitzinger, S. P. and Sutton, M. A.: Transformation of the Nitrogen Cycle: Recent Trends, Questions, and Potential Solutions, Science (80-.)., 320(5878), 889–892, doi:10.1126/science.1136674, 2008.

Gebauer, G. and Dietrich, P.: Nitrogen Isotope Ratios in Different Compartments of a Mixed Stand of Spruce, Larch and Beech Trees and of Understorey Vegetation Including Fungi, Isot. Isot. Environ. Heal. Stud., 29(1–2), 35–44, doi:10.1080/10256019308046133, 1993.

Gerdol, R., Siffi, C. and Bombonato, L.: Aboveground production and nutrient status of the vegetation of different mire types in the South-eastern Alps (Italy), Bot. Helv., 120(2), 85–93, doi:10.1007/s00035-010-0077-x, 2010.

Kohzu, A., Matsui, K., Yamada, T., Sugimoto, A. and Fujita, N.: Significance of rooting depth in mire plants: Evidence from natural 15N abundance, Ecol. Res., 18(3), 257–266, doi:10.1046/j.1440-1703.2003.00552.x, 2003.

Ménot, G. and Burns, S. J.: Carbon isotopes in ombrogenic peat bog plants as climatic indicators: Calibration from an altitudinal transect in Switzerland, Org. Geochem., 32(2), 233–245, doi:10.1016/S0146-6380(00)00170-4, 2001.

Nordbakken, J. F., Ohlson, M. and Högberg, P.: Boreal bog plants: nitrogen sources and uptake of recently deposited nitrogen, Environ. Pollut., 126(2), 191–200, doi:10.1016/S0269-7491(03)00194-5, 2003.

Van Smeerdijk, D. G. and Boon, J. J.: Characterisation of subfossil Sphagnum leaves, rootlets of ericaceae and their peat by pyrolysis-high-resolution gas chromatography-mass spectrometry, J. Anal. Appl. Pyrolysis, 11(C), 377–402, doi:10.1016/0165-2370(87)85043-X, 1987.

We will delete these references from our literature:

Boon, J. J., Wetzel, R. G. and Godshalk, G. L.: Pyrolysis mass spectrometry of some Scirpus species and their decomposition products, Limnol. Oceanogr., 27(5), 839–848, doi:10.4319/lo.1982.27.5.0839, 1982.

Elmendorf, S. C., Henry, G. H. R., Hollister, R. D., Björk, R. G., Boulanger-Lapointe, N., Cooper, E. J., Cornelissen, J. H. C., Day, T. A., Dorrepaal, E., Elumeeva, T. G., Gill, M., Gould, W. A., Harte, J., Hik, D. S., Hofgaard, A., Johnson, D. R., Johnstone, J. F., Jónsdóttir, I. S., Jorgenson, J. C., Klanderud, K., Klein, J. A., Koh, S., Kudo, G., Lara, M., Lévesque, E., Magnússon, B., May, J. L., Mercado-Dı´az, J. A., Michelsen, A., Molau, U., Myers-Smith, I. H., Oberbauer, S. F.,

Onipchenko, V. G., Rixen, C., Martin Schmidt, N., Shaver, G. R., Spasojevic, M. J., Þórhallsdóttir, Þ. E., Tolvanen, A., Troxler, T., Tweedie, C. E., Villareal, S., Wahren, C.-H., Walker, X., Webber, P. J., Welker, J. M. and Wipf, S.: Plot-scale evidence of tundra vegetation change and links to recent summer warming, Nat. Clim. Chang., 2(6), 453–457, doi:10.1038/nclimate1465, 2012.

Hatfield, R. D. and Chaptman, A. K.: Comparing corn types for differences in cell wall characteristics and p-coumaroylation of lignin, J. Agric. Food Chem., 57(10), 4243–4249, doi:10.1021/jf900360z, 2009.

Hobbie, S. E. and Chapin, F. S.: Response of tundra plant biomass, aboveground production, nitrogen, and CO2 flux to experimental warming, Ecology, 79(5), 1526–1544, doi:10.1890/0012-9658(1998)079[1526:TROTPB]2.0.CO;2, 1998.

As already addressed to Tim Moore, in L. 375 the Biester et al. reference occurs twice in the literature of which one will be deleted. Accordingly, Biester et al., 2014a will be changed to Biester et al., 2014.

As already addressed to Tim Moore, in L. 559 the Ward et al. reference will be corrected to:

"**Ward, S. E., Ostle, N. J., Oakley, S., Quirk, H., Henrys, P. A. and Bardgett, R. D.: Warming effects on greenhouse gas fluxes in peatlands are modulated by vegetation composition, Ecol. Lett., 16(10), 1285–1293, doi:10.1111/ele.12167, 2013.**"