DOI	https://doi.org/10.5194/egusphere-2024-3190
Altered Seasonal Sensitivity of Net Ecosystem Exchange to Controls Driven by Nutrient Balances in a Semi-arid Savanna	
Author(s)	Laura D. Nadolski et al.
Handling editor	Marijn Bauters
Manuscript type	Research article
Status	Authors response to reviewer

Response to Report from Reviewer #1

Reviewer comments are printed in black.
Answers are printed in blue below the respective comment.

In a world dealing with a changing climate, there is a need for studies investigating environmental changes following anthropogenic influences, especially in understudied ecosystems with complex dynamics such as semi-arid savannas. This study uses an unique long term dataset collected in a large-scale nutrient addition experiment in a semi-arid savanna in Spain to look into the effect of altered nutrient levels on the relationships between NEE and it's key drivers, using robust methods as Singular Spectrum Analysis and Information Theory. The long term dataset is analyzed both as a whole and divided into phenological seasons, which results in a deeper understanding of the ecosystem as well as interesting insights into the effects of the nutrient addition, underneath the water or energy limitation during different seasons. The methods are well explained and the important results are well discussed, however some points require further clarification or discussion.

Thank you very much for this assessment of our work, for pointing out its relevance and for the very helpful comments. We considered all of them in detail and they have helped us to improve the overall quality and comprehensiveness of this manuscript. Please find below a point-by-point reply to your comments and suggested changes in the revised manuscript.

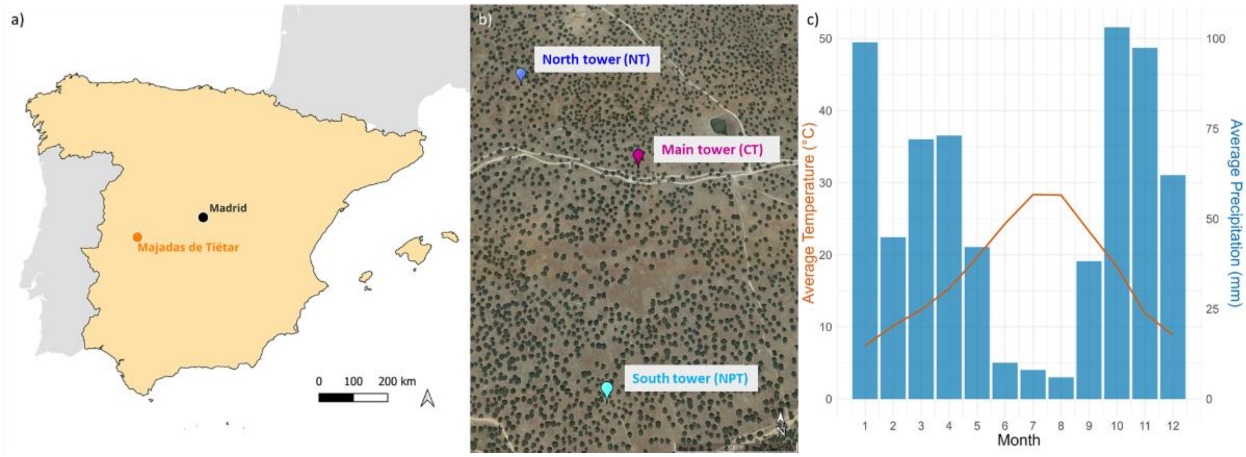
Specific comments:

Materials and Methods

Line 109: Authors could add a map of the region

Thank you for your suggestion, we agree it is great to have this. The Reviewer #2 also suggested adding a site map.

We have added a map with the location of the sites on the Iberian Peninsula and an airborne image showing the location of the three eddy covariance towers. Following suggestions from the Reviewer #2, we additionally compiled a plot showing the monthly mean precipitation sums and temperature across the study period (2016-2023).



"Fig.1: a) site location on the Iberian Peninsula. b) location of the three eddy covariance towers. Nitrogen added tower (NT) is in blue, control tower (CT) is in purple, and nitrogen + phosphorous added tower (NPT) is in light blue. The tower locations were chosen in a way that during dominant wind directions their footprints do not overlap. Footprint climatologies can be found in Fig.1 in El-Madany et al. (2018). c) average monthly precipitation sums and temperature (measured at 15m) across 2016-2023."

Line 137: Is there more information on when N and P were applied to the plots in terms of seasons or years? Would you suspect that the results over the years, for example in Fig 6, could be in anyway linked to the timing of the application of N and P?

We agree with the reviewer and have provided more detailed information on the fertilization scheme as follows:

"The N and P fertilization was applied around similar time at the sites each year, with some exceptions due to weather or logistics restrictions (e.g., pandemic). N was added at 100, 20, 50, 24 and 12 kg N ha^{-1} at both sites by end of winter of 2015, 2016, 2017, 2021 and 2023, respectively, and P was added at 50, 10, 25, 6, 6 and 6 kg P ha^{-1} at NPT in fall of 2014, 2015, 2016, 2019, 2020 and 2022, respectively. This timing of the application of N and P was selected to have maximal possibility to be used by vegetation in the next growing season after each addition."

As the timing of the application of N and P was chosen to increase the possibility to be used by vegetation in the next growing season, the increasing trend and altered variability of NEE at NT and NPT might be smaller if fertilization was applied at different timing. We have now added this potential uncertainty in the end of Section 4.4 as follows:

"As the timing of the application of N and P was chosen to increase the possibility to be used by vegetation in the next growing season, the observed changes in NEE and driver importance at NT and NPT might be smaller if fertilization was applied at different timing."

Line 154. How many soil sensors were installed per footprint? And were they installed in open field or under trees or both? There is mention in the discussion part that soil temperatures below oak trees are more important than those in open areas during the regreening in autumn (line 575) and that this also could be related to the variations in soil moisture between open and shaded pastures. Therefore it seems important to know where the sensors were located and if the authors were able to capture some of these variations in soil moisture that could underpin this statement.

Thank you for pointing out that clarifications are needed here.

We used sensors for soil temperatures and soil heat flux from two locations per tower: below the tree canopy and open pasture area. The ones below canopy are named with _Shd in the end (abbreviation for shadow) and the ones in open pasture are suffixed with _Sun (specified in former lines 153-155). As the soil heat flux is influenced by the moisture content of the soil it allows assumptions on the variations in soil moisture between open pasture and shaded areas.

As the terms “shadow” and “sun” might not be the best choice, as below canopy it can be sunny and under open area it can be shadowed, we decided to change the suffx to _bc (“**b**elow **c**anopy”) instead of “_Shd” and “_op” (“**o**pen **p**asture”) instead of “_Sun”.

While we originally had four soil moisture profiles per tower as well, there were many problems with the sensors over the past years, such as communication errors or malfunctions. Therefore, we used integrated soil water content values of the top 20 cm (normalized, in percent), which is weighted on the canopy cover of 20% to obtain soil water content values representative for the ecosystem. We have added this information to the manuscript as follows (former lines 153-156):

“Soil measurements comprised soil temperature in open pasture (Tsoil_op) and below oak tree canopy (Tsoil_bc) as well as soil heat flux in open pasture (SHF_op) and below oak tree canopy (SHF_bc). For soil water content, we used the different measurements integrated over the top 20 cm of the soil, weighted by a canopy cover of 20% to obtain soil water content values (SWCn) representative for the ecosystem.”

The authors use only daytime measurements to calculate the aggregated daily means of NEE. Why is the nighttime data removed?

Thanks for your comment, we agree that clarification is necessary here. We used daily aggregated means of daytime NEE to only rely on reliable data.
We only use non-gapfilled, measured flux data, so the driver identification would not be confounded by gap-filling techniques based on meteorological measurements. We selected measured flux data with the highest quality (i.e. quality flag = 0, flagging policy following Mauder and Foken 2004). Therefore the data coverage of the half-hourly timeseries is quite low (around 30% on average), especially during the nighttime, as well-developed turbulence and stationary atmospheric conditions are oftentimes violated during nighttime hours (i.e., quality flag is not 0). Thus, including nighttime-values would introduce a substantial bias in the analysis, as some daily aggregates would have included a significant amount of nighttime data and most others are without nighttime data. We therefore aggregated daytime daily values. We have added the following information into the manuscript (section 2.4.1):

“For our analysis we calculated from the biometeorological and flux data daily mean values aggregated from the half-hourly measured values during daytime. We only use non-gapfilled, measured flux data, so that the driver identification is not confounded by gap-filling techniques based on meteorological measurements. To ensure that there are only high-quality measured values, we selected data with quality flag = 0 (flagging policy according to Mauder and Foken (2004)). Consequently, the data coverage of the measured half-hourly timeseries is quite low (around 30%) and especially heterogeneous during the nighttime. Therefore, we calculated from the biometeorological and flux data daily mean values by aggregating only daytime measurements to avoid the bias.”

Line 228 – 230 “In the second step X is decomposed into its orthogonal components by determining eigenvalues and eigenvectors corresponding to principal components (singular value decomposition). Then the eigenvalues of the covariance matrix $X \cdot X$ are ranked.”
I don’t know the SSA method very well, however this part is slightly confusing for me as I think it is the eigenvalues and eigenvectors of XX_T that are determined and then X is decomposed in matrices with rank 1 which are constructed using these eigenvalues and eigenvectors. For me the term “decomposed in its

orthogonal components" sounds vague. Also maybe avoid the use of "ranked" as I think you mean ordered by decreasing magnitude here. Rank in terms of matrices can be confused with the terminology of rank of a matrix.

Thanks for your suggestions to clarify the description of the SSA method. We decided to not get into more detail regarding the method here, as thorough descriptions can be found in the literature (Golyandina and Korobeynikov, 2014; Golyandina and Zhigljavsky, 2013). The expression "decomposed into orthogonal components" is used in the literature (Baldocchi et al., 2021; Mahecha et al., 2010) and therefore we kept it.
However, we have rephrased the respective sentences for better clarity (former lines 228-230):

"In the second step a singular value decomposition of X is performed and it is decomposed into its orthogonal components by determining eigenvalues and eigenvectors corresponding to principal components. The eigenvalues of the covariance matrix X · X are then ordered in decreasing magnitude."

Line 239: Here is stated that the data is gap-filled using the igapfill – function, however in Line 205 – 206 you state that you only use measured values to avoid confounding with the other meteorological variables in later analyses. Is this gap filling necessary because the method requires a full time series?
Yes, you are completely right, the gap-filling is necessary because the singular spectrum analysis requires a time series without gaps. We indicated that as follows in the respective section:
"First, as required by SSA, we gap-filled the timeseries with the rssa package's internal function, igapfill, which fill gaps using the low-frequency component of the timeseries itself (i.e., not based on meteorological measurements)."

Will you not introduce this confounding again by gap filling here, in the sense that even though you remove the gap filled values again after the SSA (mentioned in Line 299), the gap filling will have an influence on the SSA result? Or is this method of gap filling not based on the meteorological data?
Thanks for expressing your concern on the gap-filling.
The gap-filling with the igapfill()-function does not confound the results, as it is not based on meteorological data or any other ancillary data, but solely on the low-frequency component of the timeseries itself, as stated at Lines 222-224. But, to make it clear, we have edited the sentence as shown in the previous response.

Section 2.4.4: I think that there are some inconsistencies with equations here. Formula (4) has no double sum, iterating over both x and y. This double sum is however seen in equation (6). Equation (6) on the other hand has no logarithm included in the right hand side of the equation both in the numerator as in de denominator (as is present in equation (4)). Also a maximum operator should be present as MI_{max} is the maximum iterated over different values of tau and in the denominator of equation (6) an "i" pops up. Maybe check that these formulas are indeed consistent and correct.

Thank you for pointing out inconsistencies in the equations. Indeed, the double sum in equation (4) was missing, we have corrected it as follows:

$$MI = \sum_{x_t, y_t} p(x_t, y_t) log_2 \frac{p(x_t, y_t)}{p(x_t)p(y_t)}$$

And the logarithms were missing in the notation of Equation (6), we have added them now, and switched the accidental "i" for a "t". In addition, a maximum operator was introduced. The revised Equation (6) is now as follows:

$$MI_{max} = MI_{sync_{(\tau)}} = \max\left(\frac{\sum_{x_{t-\tau}} \sum_{y_t} p(x_{t-\tau}, y_t) \log 2 \frac{p(x_{t-\tau}, y_t)}{p(x_{t-\tau}), p(y_{t)}}}{-\sum_{y_t} p(y_t) \log 2 \ p(y_t)} \right)$$

Results

Section 3.2.

Line 351 – 354 states the common, most important predictors which are nicely highlighted and explained in the discussion, section 4.2

Line 385 – 388 highlights that r and MI nicely agreed in the detection of the most important drivers, which explains why you continue only with the MI measurements.

Line 355 – 384 describes the key controls for each plot, however I would suggest to make this shorter and more to the point. It reads difficult due to the many variable names and these separate results for each plot are nowhere discussed in the discussion section. The comparison between the towers in section 3.3 contributes more to the story of the paper than these separate observations, in my opinion. The section and graph are needed to support discussion section 4.2 but I feel like the separate observations could be either shortened or restructured.

We appreciate this comment. We have addressed this comment in the results section 3.2 by revising the respective paragraphs and shorten them to make it more concise.

"At CT, T_{soil}_bc and Ta15 further exhibited strong interactions with NEE using both *r* and MI_{sync} (Fig.3 (a), (b)). Variables describing water availability, such as VPD, SWCn and Rh were ranked in the middle ranges by MI_{sync}. The MI analysis provided deeper insights into the interactions between the environment and NEE by considering leading and lagging effects, as shown by MI_{max} (Fig. 3(c)). NDVI showed the highest interaction with NEE at a time lag of 16 days, and gcc_gr had a lag of 7 days. When considering leading and lagging effects, EF became relatively less important. Soil temperatures were identified amongst the five most important controls. SWCn was also important with a 20-day lag. Other variables such as air temperature and VPD showed the highest interaction with a lag of around a month. Radiation-related variables like PAR and SWDR exhibited long lag times in their highest interaction with NEE (60 days and 53 days, respectively). All MI values can be found in the Supplementary Material (S3).

At NT, soil temperatures, VPD, SWCn and air temperatures were among the most significant controls identified by both synchronous methods, following vegetation greenness and EF. NDVI showed the highest interaction with NEE with a lag of 12 days, followed by gcc_gr with a lag of 6 days. Soil temperatures exhibited the highest interactions with a lag of around a month, while air temperatures showed the highest interaction at a lag of 26 days. Moisture-related variables all showed similar time lags (16-20 days). EF had the highest interaction with NEE at a lag of two weeks. Shortwave radiation-related variables showed a strongly lagged effect (i.e., PAR 59 days, SWDR 57 days) (Fig.3 (f)).

At NPT, both *r* and MI_{sync} detected soil temperatures, air temperatures and VPD as the most important NEE controls behind gcc_gr and NDVI (Fig.3 (g), (h)). NDVI and gcc_gr led NEE with the strongest interaction at lags of 2 weeks and 10 days, respectively, followed by soil temperatures and air temperatures with the highest interaction at a lag of around a month (Fig.3 (i)). EF showed the highest interaction at a lag of 12 days. Other moisture-related variables like VPD, SWCn, and Rh were also detected to be in the middle ranks by MI_{max}, with time lags of 20-26 days. PAR and SWDR showed the highest interaction with NEE at time lags of around 50 days (Fig.3 (i)). "

Table 2: the authors might add the MI values in the table or in supplementary material of the five most important drivers for each phenological season. Would be interesting to see if for example the three first ones have a way higher MI value than the two last ones, or if the values are all close to each other.

Thank you, we agree that it is interesting for the reader to see if the MI values are close to each other or not. Therefore, we have added the respective MI_{sync} values with two decimal places in brackets in Table 2.

Discussion.
Section 4.1

Line 475: there is an increasing trend in the difference between annual NEE maximum and annual NEE minimum in the NPT plot. Is both the minimum value going down and the maximum value going up? Or is this increase in difference guided by mainly one of the two?
Thanks for your comment. The increases in maximum values are a bit stronger than the decreases in minimum values. The rising difference is therefore slightly more driven by the maximum value. However, the interannual variability of the maximum and minimum values is high. We think this information is a nice addition and have added it to section 4.1 in the revised manuscript as follows:

"This trend is driven slightly more by increasing maximum values."

Only NPT has a significant increase, however the explanation as why this could be the case, does not specifically mention only N+ P addition, so you would also expect this increase in the N plot. Is there an explanation why this is not the case? Or would you nuance the p-value and suggest that this increase might also be the case for N addition?
Yes, increase is also the case for the N addition site. We have edited the sentence to be clearer as follows (former lines 473-477):
"Our results indicate that both nutrient addition cases enhance seasonal NEE variability compared to the control. Additionally, the seasonal variability increases over time at both fertilized plots. Looking at the difference between annual NEE maximum and annual NEE minimum, we notice substantial increasing trends at both site, with the trend at NPT plot being significant (Fig.6)."

Line 530: here is stated that EF, which is a proxy for rain pulses, is an important driver but that SWC, VPD and RH are not important drivers following the MI analyses. This seems to be contradictory results as you mention both of them as proxies for rainfall. Points this towards the fact that in this study soil water related variables and rain pulses are not as important as previously found in other studies and that the link with EF as important driver is more based on its relation with LAI or radiation than with moisture related variables? However in line 544 is also stated that Radiation does not seems to have a major influence. How can this opposite results be interpreted?

Thank you for pointing this out. We agree that the results here seem a bit contradictory and we were also debating about this.

We argue that indeed the rain pulse effect plays an important role in this ecosystem; however, its importance is limited to the dry summer months, whereas in the regreening season, winter and spring, water availability is abundant. Therefore, in the respective plots (Fig. 3 & Fig. 4), which depict the data of all years across the whole year (including the seasons with high water abundance), the importance of the rain pulse effect in explaining NEE diminishes. Therefore, in this context the relation of EF with LAI might be the dominant one. We clarified it in the manuscript (former line 532) to avoid confusion:

"This might point to the relationship of EF with LAI being the dominant one in this context, as the vegetation indices are higher in their importance than other water related variables."

Section 4.3: the authors could restructure the sections to follow the order of Table 2 and section 3.4. or restructure the table and the accompanying result section to follow the order from the discussion section.

Thank you for your suggestion, we agree that changing the order of the section according to the structure of Table 2 and section 3.4 facilitates reading and understanding this part of the discussion.
We have made the respective adjustments in section 4.3 as follows:

"In winter, the ecosystem is energy-limited (Luo et al., 2018), therefore radiation components (i.e., PAR and SWDR) are important predictors for NEE. Tree Albedo shows strong interactions with NEE at CT and NT, and NDVI shows strong interactions with NEE at both fertilized plots. Plant growth is enhanced by added nutrients (Luo et al., 2020) and made available by abundant water availability (Lee et al., 2010) in this season. Also, N+P addition can lead to an increased species diversity due to alleviated nutrient limitation facilitating the co-existence of multiple species (Köbel et al., 2024). Additionally, EF shares high mutual information with NEE variations. This is likely because respiration does not change significantly during this period, and VPD is relatively low, leading to a strong coupling between NEE and LE. Additionally, in winter, the stomatal control of the tree transpiration is not too strong, as soil water is abundant (Klein et al., 2013).
In the primary growing season, spring, NEE is typically dominated by GPP. The key drivers during this season across sites are NDVI and GCC of both the herbaceous and tree layers (Table 2). Water is typically abundant promoting plant photosynthesis during moderate temperatures in this time (Baldocchi and Arias Ortiz, 2024). These conditions are further supported by increased day length and higher radiation levels (Luo et al., 2018). The rise in incoming radiation, extended daylight hours, and elevated temperatures, coupled with the increased atmospheric evaporative demand (i.e., higher VPD), lead to a strong correlation between precipitation and both GCC and GPP, as observed in various Mediterranean ecosystems (Diodato and Bellocchi, 2008; Luo et al., 2018; Ma et al., 2007).
In the water-limited seasons, the nutrient effect is minimal as the grass layer is dormant and nutrients are not available due to a lack of water. During the drydown period, soil moisture (i.e., SWCn) decreases drastically due to increasing air temperatures and scarce rainfall (Battista et al., 2018; Luo et al., 2018). This induces annual grasses to become senescent, leading to a loss of chlorophyll content (Luo et al., 2018). The rate of this senescence can determine whether NEE becomes positive or negative during this time. NDVI and grass layer GCC, the most important predictors of NEE in this season across sites, can provide insights into the dry down rate. At NT grass layer GCC is less important, which we attribute to a more rapid drydown, causing the grass layer to enter dormancy earlier than at other sites (Luo et al., 2020). This is because N addition promotes faster water usage (Luo et al., 2020), accelerating the decrease in SWCn and thereby hampering photosynthesis. It leads to a higher transpiration at NT compared to the other sites, potentially due to rhizosphere priming to increase P mobilization through microbes, as adding only N to the system leads to a P deficiency (El-Madany et al., 2021). In addition, N fertilization can alter species

diversity and composition, likely selecting for species that senesce early (Wang and Tang, 2019). The higher interaction of soil temperatures with NEE in this season compared to the wetter seasons, show that R_{eco} starts dominating NEE, as R_{eco} is strongly connected to soil temperatures (Metz et al., 2023). VPD is a stronger control of NEE at NT compared to the other two plots. Transpiration is highest at NT, as plants transpire more to obtain limited P from the soil (El-Madany et al., 2021; Pang et al., 2018; Rose et al., 2018). It is therefore more sensitive to changes in VPD.

In summer, the driest period at the ecosystem, R_{eco} dominates NEE and thus we find a strong interaction between NEE and soil temperature and soil heat flux (i.e., SHF_Sun and SHF_Shd). Besides, PAR is important for predicting seasonal NEE, showing the strongest interaction at CT. The importance of PAR is lower at NT and lowest at NPT. N+P addition increases the light use efficiency most because P has a positive effect on photochemical quenching in leaves and on active fluorescence measurements (Martini et al., 2019; Singh and Reddy, 2014), leading to less dependency of NEE to radiation parameters at that site. At CT and NT, tree layer GCC is important as the grass layer becomes senescent in the summer and is dormant in terms of ecosystem carbon flux. Since the greenness of the oak trees is constant throughout the year, GPP is mainly determined by the tree layer in the summer months (Luo et al., 2018). However, gcc_gr shows a higher interaction with NEE than gcc_tr at NPT. Even though most of the grass layer is mostly dead in this season, there are some perennial species (e.g. *cynodon dactylon*) remaining green for longer in summer and can regreen after any rain events (personal communication with local collaborators). Therefore, N+P addition very likely leads to a consequential change in species composition (Köbel et al., 2024) with an increase in these perennial species or results in an increase in their productivity. So far it has been found that N+P addition can lead to an increasing number of forbs (Köbel et al., 2024), which tend to senesce later than other herbaceous species at the site (Luo et al., 2020). Nevertheless, the occurrence of summer-green species following nutrient addition will have to be investigated further.

During the regreening of the herbaceous layer starting in autumn, NDVI shows the strongest interaction with NEE at the fertilized plots - but not at the control plot. This aligns with previous studies showing that the green-up in this season happens faster and the maximum GPP is higher at the fertilized plots, resulting from larger resource utilization at NT or improved resource use efficiency at NPT (Luo et al., 2020). With the increase in soil moisture in early autumn, a greater quantity of organic and inorganic nutrients becomes available to plants (Agehara and Warncke, 2005; Luo et al., 2020). N availability in the soil is expected to be highest in this time (Morris et al., 2019), leading to higher net carbon uptake rates (El-Madany et al., 2021). Leaves quickly expand and pigments rapidly increase during this green-up period (Croft et al., 2015). At CT, the green-up happens later compared to the fertilized plots and NEE is dominated for a longer time by R_{eco} instead of photosynthetic activity (Luo et al., 2020). Our results indicate that soil temperatures below oak trees are more important than those in open areas during this season (Table 2). The carbon pools under oak trees are the largest, providing substantial material for heterotrophic decomposition (Casals et al., 2009). During autumn, after a prolonged dry season where a significant amount of litter and organic material has already been decomposed by microbes, litter remains available for further heterotrophic decomposition mainly below the trees. This ongoing decomposition under oak trees contributes to R_{eco}, especially as the onset of rains enhances microbial activity due to increased water availability (Borken and Matzner, 2009). Additionally, the topsoil layer remains wet for longer after rain pulses under oak trees compared to open areas, as soil moisture is primarily influenced by soil evaporation in this season as the soil is rather bare. Therefore, differences in soil respiration between open and shaded pastures can also be attributed to variations soil moisture."

Technical corrections:

Abstract

Line 15: Semi-arid ecosystems dominate the variability and trend of the terrestrial carbon sink.

Thank you, we have corrected that.

Line 29 -30: The increasing NEE variability might become even more pronounced with increasing N deposition and a changing climate in the future.
Thanks, we have corrected it.

Introduction
Line 62: human shaped man-made savanna-like agroecosystem, …
Thanks for your suggestion, we have corrected it.
Line 72-73: Few studies so far have dealt so far with …
Thank you, we have corrected that.

Materials and Methods
Table 1: add in the caption that the soil heat flux and soil temperature in the shadow were calculated based on the shadow fraction … Also the height of the air pressure device is not present
Thank you for your comment. The soil heat flux and soil temperatures were not calculated based on shadow fractions, but were measured indeed in the shadow (_Shd, under tree canopy) and in the sun (_Sun, in open field). However, we have added this calculation information for SWCn as follows: "normalized soil moisture content for top 20cm using the shadow fraction of 20% to represent ecosystem values"

Also, we have added the heights of the air pressure devices to table 1 (15m, 15.5m (CT).

Line 113: heterogeneous with values between 0.5 and 2.5 ….
Thank you, we have corrected that.
Line 151: here CO2- flux is also in the list of additional atmospheric variables, maybe remove
Thank you, we have removed it.
Line 173: and collected red, blue, ….
Thanks, we have corrected that.
Line 291: Positive and negative values of τ show an asynchronous interaction between X and Y, with a lag …
This phrasing may sounds like it insinuates that it is the value of tau that is the interaction, however tau is merely the time lag. Maybe rephrase.
Thank you for pointing this out, we have rephrased the sentence for more clarity as follows: "When τ is positive or negative (= 0), the interaction between X and Y is characterized as asynchronous, with τ showing the lead or lag in Y relative to X, respectively."

Results
Line 347-350: this sentence is difficult to understand and has a point which seems wrongly placed. "accounts for collinear relationships. and MIsync and …"
Thank you for your comment. We have rephrased the sentences and changed their structure, to provide more clarity and correct grammar as follows:

"Pearson correlation coefficient r considers only linear relationships between variables; Mutual Information (MI), accounts for collinear relationships. MI_{sync} and r values show synchronous relationships, MImax values can account for leading and lagging interactions by identifying the day of the highest interaction between the potential driver and NEE within a 60-day window."

Line 411: remove the sentence about soil temperature here, soil temperature is again mentioned in a better way in Line 416
Thanks, we have removed that sentence.

Line 455: “We observed that with N addition, NEE became less sensitive to certain variables during autumn (i.e., the regreening phase), the drydown phase, and winter over time (Fig.5).”
In winter this is “more sensitive” and not “less sensitive” as there is increase as mentioned in line 459.
Thank you for pointing this out, we have corrected that and removed “and winter”.

Figure 5: the caption states that NT vs CT is in the bottom figure and NPT vs CT in the top figure but it is the way around.
Thank you very much for spotting this, we have corrected it.