The authors would like to thank the Editor and the Reviewers for very careful and detailed review of our manuscript and providing of comments and suggestions to improve the quality of the manuscript.

RC1: The manuscript discusses the light and temperature dependencies of several BVOC emissions from a Mediterranean oak species. This manuscript fits in the scope of the journal presenting a BVOC emission study on a relatively little studied tree species. The authors go through the methods they have used thoroughly, and the results are presented in the text and figures clearly. The discussion on the results and conclusions could, however, be deeper and underline how this study increases the understanding of BVOC emission dynamics. Though the manuscript is carefully written, some English language improvement would not be bad idea. My comments below are rather minor though their number is relatively high.

RC1: Line 13: You discuss many times about BVOC in singular form, though you actually mean plural BVOCs. Please check these throughout the text.
AC: We did the modification in the manuscript.

RC1: Line 23: You claim that the three sampling campaigns cover the entire seasonal cycle. However, note that there are likely sub-seasonal periods, which are not covered by your measurements. For example, the highest natural drought at the site is likely in late summer, when you did not measure. Do you think that your results from these three measurement periods are representative enough to model Q. pubescens BVOC emissions year around? If so, why? Could you describe with a few words the physiological state of the oaks during each of the campaigns, e.g. if the new leaf emergence or leaf size growth occurred during the spring measurement period?
AC: We think that our measurement periods are well representative of Q. pubescens BVOCs emissions because they took place during the principal phenological stages of leaves. There was no leaf emergence during our spring period sampling, it was the end of leaf growth. We also performed an experiment during leaf emergence (in April 2013), not presented in this study, but there were very slight BVOCs emissions. During summer, leaves still matured and autumn was featured by the beginning of leaf senescence. We added a short comment on this part in the manuscript (lines 108-110).

RC1: Line 24: Amplified drought impacted all studied BVOCs, but not necessarily all the minor compounds that the trees produce but you couldn’t quantify.
AC: Indeed, we added “studied” in this line.

RC1: Line 32: Please use throughout the text the unit formatting as advised in the journal instructions.
AC: We did the modification in the manuscript.

RC1: Line 34: Please check the use of subscripts in the entire text.
AC: We did the modification in the manuscript.
RC1: Line 35: You likely mean tropospheric ozone concentration.
AC: Yes, we changed this in the manuscript (line 35).

RC1: Lines 72-74: In my mind, seven commas per a sentence is too much and makes the sentence hard to read. Please edit the sentence e.g.: However, there are still some misunderstandings at the level of emission mechanisms and consequently on model estimations for isoprene and, a fortiori, for highly volatile BVOCs under mild or severe water stress. In addition, you could open which misunderstandings you mean here.
AC: We rewrote this sentence as suggested and we added some details on misunderstandings on isoprene emissions (lines 68-70).

RC1: Line 80-81: Please correct: 2 million ha. Note that the study by Keenan et al. (2009) considers only forests, and there are other remarkable sources as well.
AC: We did the modification in the manuscript (line 84).

RC1: Line 86: The site may be free from direct human disturbance, but indirect disturbance through e.g. air pollution it certainly has experienced.
AC: Indeed, we added “direct” in this sentence (line 90).

RC1: Line 93: The plots were 200-300 m² in size. How many trees were growing in the plots? Can you be sure that the trees at the amplified drought plot did not uptake water by their vast root system from the non-drought area?
AC: In natural drought plot, there is 145 stems and in amplified drought plot, there is 95 stems. We cannot be sure that trees at the amplified drought did not uptake water in natural drought plot. Indeed, we do not know where the trees roots are located. But, on our site, there is a buffer zone for each plot (2 meters). So, we only followed trees located in the heart of both plots. And, also, we observed effect of amplified drought on BVOC emissions and physiology parameters. We think that it a negligible phenomenon.

RC1: Lines 96-97: I do not quite hit the idea of the latter part of the sentence: – corresponding for three years, to 2 months for natural treatment and 5 months for amplified treatment of drought period. Please rephrase.
AC: We rephrased this sentence (lines 101-102).

RC1: Line 100: You had five trees per treatment, but how many enclosures there were per tree and per sampling campaign? Did you move enclosures from tree to tree during one sampling campaign?
AC: During each field campaigns, the five trees of each plot were sampled. We used 2 enclosure systems concomitantly which allowed us to analyze one tree under amplified drought and one tree under natural drought. The analyses was performed during 1 or 2 days, depending on the weather. And, every 1 or 2 days, we moved enclosures from tree to tree. We added a sentence about that in the manuscript (lines 114-115).
To be precise, BVOC exchange between the tree and the atmosphere is a part of tree gas exchange.

We did the modification in the manuscript.

How much biomass the enclosures enclosed? Please give some numbers (branch length, leaf area, leaf mass or equivalent).

We enclosed branches containing between 8 and 12 leaves which corresponded to 1.4g and 3.6g of dry matter. In terms of surface, we enclosed between 110 and 320 cm² of leaves. With these data, we calculated the relation between leaf mass and surface (LMA) and we found no significant difference between leaves from amplified and natural drought at any season. We added a sentence about that (lines 128-130).

A PTFE air generator sounds like it would produce PTFE in the air. Please rephrase.

We rephrased this sentence (line 116).

What do you mean by the excess of air humidity? Was the humidity inside the enclosure controlled (currently not stated in the text) and set to some range? If so, please make an addition in the text, as this is rather critical detail in the case of water-soluble compounds.

The humidity inside the enclosure was not controlled. However, we slightly removed some humidity from entering the chambers (before the air generator), especially in autumn to impede condensation of water vapor which would have disturb mass flow controller.

Rather say: made of PTFE.

We did the modification in the manuscript (line 116).

Is reference to chapter 2.2 correct or should it refer to 2.4 (BVOC analysis)?

Indeed, we did the modification in the manuscript (line 133).

Please edit: gas exchange values.

We did the modification in the manuscript (line 134).

Add s: parameters. Lyophilization is not familiar term to many readers of the journal, so say rather: were lyophilized (freeze-dried) to assess the dry mass.

We did the modification in the manuscript (line 139).

You say that formaldehyde calculation took into account the humidity dependence. What about the other humidity-dependent compounds? Could the clearly visible steps methanol and acetone fluxes in the late evenings of natural drought (fig.4 and S3) be humidity-related? Anyhow, there seems to be something else happening simultaneously: net photosynthesis rises to positive values just before midnight (fig. 1, autumn, natural drought). Something wrong with the measurements or calculation?
AC: We only took into account the humidity dependency of formaldehyde because for this compound, this dependency was very problematic compared to the others compounds (Vlasenko et al. 2010).
We do not think that the increase of methanol and acetone in late evening (in autumn) could come from the humidity because we analyzed a pair of trees at a time (one tree under natural drought and one tree under amplified drought). Moreover, the enclosure chambers were feed with the same inlet air (thus, with a similar humidity) and transpiration rate during the night was close to zero. If there was a humidity problem, with our set-up, we would have observed the same phenomenon on amplified drought and it was not the case. Moreover, it seems unlikely that there was a calculation problem because we always used the same calculation. It was probably a phenomenon linked to trees metabolisms but we cannot explain this yet.

RC1: Line 145: Why did you choose to express the emission rates as C (carbon)?
AC: We chose to express the emission rates in carbon because in many studies of dealing with BVOC modelling, they used this unit (Guenther et al. 2012; Guenther 2013). Also, in global scale, it is more convenient to express BVOC emissions in carbon to evaluate their impact on global change.

RC1: Line 164-165: Please rephrase for example as follows: Afterwards, linear regression tests and slope tests (equal to 1) were also performed.
AC: We did the modification in the manuscript (lines 181-182).

RC1: Line 168: Have you any data how dry the soil actually was? Any soil volumetric water content measurements or equivalent throughout the seasons?
AC: We have predawn water potential only for the summer campaign which can give a good idea of water availability in soil. During this season, there is a significant difference between both plots (-0.61MPa for natural drought and -0.85MPa for amplified drought, P < 0.05). Moreover, we observed an effect of our treatments in physiology, especially on stomatal conductance.

RC1: Line 171: Please correct spelling: other season and stomatal closure (the latter one in some following lines as well).
AC: We did the modification in the manuscript.

RC1: Line 177: I wonder if you have any tree growth data from the site ? In ceasing growth (height growth or lateral growth depending on timing) you might see drought effect earlier than in photosynthesis. The results are not discussed and compared to literature too much, so you could here e.g. refer to an earlier drought study (Damesin & Rambal1995) conducted with the same species.
AC: Indeed, we have some data on tree growth (in terms of leaf biomass and lateral growth) but with no change in 2013 and 2014 and significant reduction of growth in 2016 (data showed on other publication) that is the fifth year of amplified drought. Photosynthesis is typically, is the first parameter to be impacted by drought (Chaves et al. 2002). That is exactly what occurred
in our study because we observed reduction of photosynthesis until 2012 (the first year of our experiment) whereas the first effect on growth appeared in 2016.

**RC1: Line 186-187:** Reduced and increased emissions compared to what? And what is the reference for? In the discussion about isoprene emission dynamics during drought, you may also refer to Bruggemann & Schnitzler (2002), who have studied isoprene emissions of Q. pubescens saplings.

**AC:** This experiment was conducted since 2012. In this paper, we only presented the results from the end of the second year to the beginning of the third year. In the first year, an increase of isoprene emissions was observed (data unpublished yet) whereas, we observed a decrease after 2-3 years of amplified drought. We added also a sentence on Bruggermann and Schnitzler’s work (line 205).

**RC1: Line 193:** You write here and in many other cases as well, that a compound responds to something. This reflects very much the modelling point of view. However, the plant responds to the changes in its environment, and that we see as a change in the plant volatile emissions. I would like to see in the discussion more of this plant-point-of-view: what does the plant do so that we see these kind of fluxes.

**AC:** We added some part on plant-point of view throughout the discussion.

**RC1: Line 196-199:** You write: “the daily cycle between natural and amplified drought was very different for each season.” If I look at the fig. 2 about isoprene emissions, I don’t see very different daily cycles. Please clarify what you mean. Moreover, you write: “were not the only parameters driving isoprene emissions.” Please tell which other parameters you think were affecting at that time of the year.

**AC:** Accordingly to the reviewer’s comment, we change this sentence since indeed our description was confused. We should have written the daily cycle between natural and amplified drought was different. What was different but the intensity of isoprene emissions between amplified and natural drought. We suggest that plant likely needed to produce more isoprene with the aim to protect the photosystems apparatus in new leaves. We added this point in the manuscript (lines 220-221).

**RC1: Line 200:** You discuss about MACR+MVK+ISOPOOH basically as a compound. Have you any data if all these three compounds really are present in the fluxes all the time or if one of them dominates the measured flux and thus masks the variations in the others?

**AC:** We did not have data on these compounds separately. We only detected the ion 73 corresponding on the three compounds. Thus, we cannot say if one of these compounds dominated flux.

**RC1: Line 213:** Turn the sign: <.

**AC:** In this line, it is the good sign. It was just for specifying that the slope was not significantly different to 1. Maybe, it is confusing and we can remove this indication.

**RC1: Line 221:** Please check spelling: phenomena.
AC: We did the modification in the manuscript (line 248).

RC1: Line 227: Please change to leaf elongation.
AC: We did the modification in the manuscript (line 256).

RC1: Line 230: You write that methanol emissions respond only to temperature in nighttime. Have you taken into account that in nighttime light intensity is basically zero if no artificial light is available and stays constant over the night? Moreover, in nighttime light intensity range is far smaller than in daytime, and this will be reflected in your modelling results.
AC: We measured light during the night and used these data for modelling. The data on light during nighttime was close to zero and temperature was roughly constant. Thus, we attributed emissions of methanol during the nighttime to a temperature-driven response as already demonstrated by Smiatek and Steinbrecher (2006). We made some figures in the new version of the supplementary files, summarizing light and temperature conditions during our experiment.

RC1: Line 254-255: Would this sentence need a reference?
AC: These results were not published yet. Thus, we added personal communication from A.C. Génard-Zielinski (291).

RC1: Line 261: Please change phenomenon to phenomena.
AC: We did the modification in the manuscript (line 297).

RC1: Line 263: Please check spelling: the calculation of ecophysiological parameters.
AC: We did the modification in the manuscript (line 299).

RC1: Line 278: Please check spelling: vapour.
AC: We did the modification in the manuscript (313).

RC1: Line 327-328: Here and in some other cases as well the italics of scientific names have been replaced with cryptic markings. Please check the reference list.
AC: We did the modification in the manuscript.

RC1: Table 1 caption: Please remove the abbreviation ER and add the explanations for ND and AD.
AC: We did the modification in the manuscript.

RC1: Figure 1: Please remove “ND: natural drought; AD: aggravated drought” as the information is in the figure. The various vertical scales make it hard to compare the seasons, so please consider unifying the scales. And please remove A from the lower right panel.
AC: We did the modification in the manuscript.


This manuscript presents BVOC emission data from the drought tolerant Quercus pubescens using PTR-TOF-MS techniques. The authors study a suite of BVOCs (isoprene, methanol, acetone, acetaldehyde, formaldehyde and MACR+MVK+ISOPOOH) at 3 points over a year, under both natural and amplified drought conditions. They compare observations with model algorithms and report 2 types of emission responses: 1) light and temperature dependent and 2) it dependent during the day and only temperature dependent at night.

General Comments
English grammar problems are numerous throughout the manuscript.

Your two types of responses can be more easily summarized throughout the manuscript, “All six BVOCs monitored showed daytime light and temperature dependencies, while three BVOCs (methanol, acetone and formaldehyde) showed nighttime temperature dependencies as well.” Figures 4 and S3 show that the models do accurately simulate the emission burst for methanol as well as the formaldehyde deposition, albeit the models both show a slight lag in the hour of the day in just the autumn natural drought conditions.

AC: The burst of methanol is observed only in spring and summer between 6am and 8am. For example methanol emission reach almost 0.8μgC.gDM⁻¹.h⁻¹ during the burst contrasting with the previous emission (less than 0.01). The graph shows that none of the model (yellow and dotted lines) fit this burst. Concerning formaldehyde deposition (S4), even if the models follow the same emission pattern than the observations, they don’t show any negative emission and so can’t accurately allow to estimate the deposition.

Specific comments
L13 and throughout manuscript: use plural form “BVOCs” when speaking about more than one compound.

L19: “. . .especially in the Mediterranean. . .”

L22: “. . .a drought tolerant. . .”

L51 – 53: You write: “Several models, already existing (Guenther et al. 2006; Guenther et al. 2012; Menut et al. 2014), predict BVOC emissions according to the type of vegetation, biomass density, leaf age, specific emission factor for many vegetal species, as well as the impact of environmental factors.” Please separate references for accuracy. For example, MEAGAN models (Guenther 2006 and 2012 references) do not include vegetation species specific emission factors nor account for leaf age or biomass density.

L70: “. . .IPCC predicts. . .”

L85: “60 km North of Marseille, France. . .”
RC2: L93: You write, “. . .drought (300m²) and an amplified drought (232m²).” Better indicate what the values in parentheses represent.

AC: We have corrected this point as follows: “A rainfall exclusion device (an automated monitored roof deployed during selected rain events) was set up over part of the O3HP canopy (232m² surface) to exclude 30% of raining according to the worst scenario of climate change (Giorgi & Lionello 2008; IPCC 2013). This surface, thus, formed the amplified drought plot which was compared to natural drought plot (300m² surface) where trees grew under natural conditions with no rain exclusion.”

RC2: L93 – 101: This wording was difficult to understand. How did you determine the extent of drought? How do you know this was indeed a drought stress?

AC: To answer to this point, we have added a new graph showing the ombrothermic diagrams for the 2 plots used. The drought periods were presented in this graph showing the recurrence and length of drought periods for every years. Drought stress occurs when the temperature line is above the precipitation bars in ombrothermic diagrams (Emberger et al. 1963).

RC2: L95 – 97: “During the first year of experiments (2012), 35 % of natural rain was excluded and, afterward, 33.5 and 35.5 % were excluded (2013 and 2014, respectively) corresponding for three years, to 2 months for natural treatment and 5 months for amplified treatment of drought period.” This text should be rewritten to clearly describe the differences between the natural and amplified drought treatments in terms of rainfall exclusion and periods of application, i.e. what 2 month period? What 5 month period?

AC: We have rewritten the paragraph to be clearer. Together with the ombrothermic diagram, we hope that the experimental precipitation exclusion is better explained (lines 93-105).

RC2: Was there any sampling conducted prior to the experiment or during the experiment on non-drought stressed trees for comparison?

AC: There was no sampling conducting prior to the experiment on non-drought stress trees. Indeed, we have two treatments: one where trees are submitted to natural rain (and so natural Mediterranean summer drought) and a second one where trees are submitted to amplified drought (more or less 30% according to climatic models) during the tree growth period.

RC2: L229 - 231: Nevertheless, our results suggested that methanol emissions responded strongly to light and temperature during the day whereas, during the night, they responded to temperature. See General Comments for suggested clarification.

AC: We better structured the manuscript by introducing: “All six BVOCs monitored showed daytime light and temperature dependencies while three BVOCs (methanol, acetone and formaldehyde) also showed emissions during the night despite the absence of light under constant temperature. » in the beginning result section (lines 212-215).

RC2: L261 – 262: “Moreover, some phenomenon, such as the burst in early morning (methanol and acetaldehyde) or the deposition/uptake (formaldehyde), were not modelled by L+T or T algorithm.” Figures 4 and S3 show that the models do accurately simulate the emission burst for methanol as well as the formaldehyde deposition, albeit the models both show a slight lag in the hour of the day in just the autumn natural drought conditions.

AC: As we said above: “the burst of methanol is observed only in spring and summer between 6am and 8am. For example, methanol emission reach almost 0.8µgC. gDM⁻¹.h⁻¹ during the burst contrasting with the previous emission (less than 0.01). The graph shows that none of the model (yellow and dotted lines) fit this burst. Concerning formaldehyde deposition (S4), even if the models follow the
same emission pattern than the observations, they don’t show any negative emission and so can’t
accurately allow to estimate the deposition”.

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Effect of mid-term drought on Quercus pubescens BVOCs emissions seasonality and their dependence to light and/or temperature

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Key words: BVOCs, natural and amplified drought, season, light and temperature

Abstract. Biogenic volatile organic compounds (BVOCs) emitted by plants represent a large source of carbon compounds released into the atmosphere where they account for precursors of tropospheric ozone and secondary organic aerosols. Being directly involved in air pollution and indirectly in climate change, understanding what factors drive BVOCs is a prerequisite for modelling their emissions and predict air pollution. The main algorithms currently used to model BVOCs emissions are mainly light and/or temperature dependent. Additional factors such as seasonality and drought also influence isoprene emissions, especially in the Mediterranean region which is characterized by a rather long drought period in summer. These factors are increasingly included in models but only for the principal studied BVOC, namely isoprene but there are still some discrepancies in estimations of emissions. In this study, the main BVOCs emitted by Quercus pubescens: isoprene, methanol, acetone, acetaldehyde, formaldehyde, MACR MVK and ISOPOOH (these 3 last compounds detected under the same ion), were monitored with a PTR-ToF-MS over an entire seasonal cycle, under both in situ natural and amplified drought which is expected with climate change. Amplified drought impacted all studied BVOCs by reducing emissions in spring and summer while increasing emissions in autumn. All six BVOCs monitored showed daytime light and temperature dependencies while three BVOCs (methanol, acetone and formaldehyde) also showed emissions during the night despite the absence of light under constant temperature. Moreover, methanol and acetaldehyde burst in the early morning and formaldehyde deposition/uptake were also punctually observed which were not assessed by the classical temperature and light models.

1 Introduction
Plants contribute to global emissions of volatile organic compounds (VOCs) with an estimated emission rate of $10^{15}$ gC yr$^{-1}$ (Guenther et al. 1995; Harrison et al. 2013). The large variety of compounds released by plants represents, at the global scale, 2-3% of the total carbon released in the atmosphere (Kesselmeier & Staudt 1999). Under strong photochemical conditions, BVOCs, together with NO$_x$, can significantly contribute to tropospheric ozone concentration (Xie et al. 2008; Papiez et al. 2009). In addition to its greenhouse effect, O$_3$ has strong effects on plant metabolism (Reig-Arriñana et al. 2004; Beauchamp et al. 2005) as well as on human health (Lippmann 1989). BVOCs are also rapidly oxidized by OH radical and NO$_3$ (Hallquist et al. 2009; Liu et al. 2012), which account for an important fraction of the total mass of secondary organic aerosols (SOA, Jimenez et al. 2009). Methanol and acetone are, after isoprene, the principal BVOCs released to the atmosphere. Isoprene emissions represent between 400-600 TgC yr$^{-1}$ at the global scale (Arneth et al. 2008) whereas methanol emissions vary between 75 and 280 TgC yr$^{-1}$ (Singh et al. 2000; Heikes et al. 2002, respectively) and acetone emissions represent only 33 TgC yr$^{-1}$ (Jacob et al. 2002). Other compounds such as acetaldehyde, methacrolein (MACR), methyl vinyl ketone (MVK), isoprene hydroxy hydroperoxides (ISOPOOH) and formaldehyde, whose biogenic origin has been poorly investigated, are better known to be anthropogenic and/or secondary VOCs issued from atmospheric oxidations (Hallquist et al. 2009). However, acetaldehyde is also a by-product of plant metabolism and its emissions represent 23 Tg yr$^{-1}$ at the global scale (Millet et al. 2010). Formaldehyde, MACR, MVK and ISOPOOH are released by plants through oxidations of methanol and isoprene, respectively, within leaves but they can have other leaf precursors (Oikawa & Lerdau 2013). Thus, it is thereby important to model all this panel of BVOCs emissions with the aim of predicting their effect on secondary atmospheric chemistry.

Current models allow to predict BVOCs emissions according to the type of vegetation, biomass density, leaf age, specific emission factor for many vegetal species, as well as the impact of some environmental factors. Models, such as the MEGAN (Guenther et al. 2006; Guenther et al. 2012) or CHIMERE (Menut et al. 2014) model, include at least two main algorithms that allow to model light and temperature emissions dependence (called L+T algorithm afterwards) and a temperature dependent algorithm (called T algorithm afterwards), both described in Guenther et al. (1995). The L+T algorithm is typically used for BVOCs emissions whose synthesis rapidly relies on photosynthesis, and hence include de novo emissions. The T algorithm is used for BVOCs emissions that do not directly rely on BVOCs synthesis when, for example, they originate from permanent large storage pools (Ormeno et al. 2011). The dependence to light and/or temperature is well documented for isoprenoids (Owen et al. 2002; Rinne et al. 2002; Dindorf et al. 2006) but there is still a lack of knowledge about highly volatile BVOCs (e.g. methanol, acetone, acetaldehyde). However, many of these compounds are very reactive in the atmosphere (Hallquist et al. 2009) and, could be emitted in large quantities to the atmosphere at global scale. The characterization of their emissions and sensitivity to light and/or temperature is, thus, necessary in order to obtain reliable predictions of atmospheric processes in order not to miss this important part of the atmospheric reactivity.

Other factors than light and temperature can drive BVOCs emissions such as water stress. Most studies dealing with BVOCs response to water stress have, however, focused on terpene-like compounds and have been carried out after weeks of watering restriction or removal under controlled conditions (for a review, see studies cited in Peñuelas and Staudt 2010). These studies reveal that there are still some misunderstandings at the level of emission mechanisms since some works showed increases (Funk et al. 2004; Monson et al. 2007) or decreases of isoprene emissions (Brüggemann & Schnitzler 2002; Fortunati et al. 2008), and there is a lack of knowledge...
on the impact of water stress on highly BVOCs emissions. Moreover, the sensitivity of isoprene and highly volatile BVOCs emissions to recurrent water stress (few years) under in situ conditions is clearly missing. Likewise, the capacity of current L+T and T algorithms to predict emission shifts under different drought scenarios in the context of climate change needs to be addressed for isoprene and highly volatile compounds. This is of especial interest for the Mediterranean area where the most severe climatic scenario of the IPCC predicts an intensification of summer drought consisting on a rain reduction that can locally reach 30%, an extension of the drought period as well as a temperature rise of 3.4°C, (Giorgi & Lionello 2008; IPCC 2013; Polade et al. 2014) for 2100.

In the present investigation, we aimed (i) to study the standard emission factors of each studied BVOC released by Q. pubescens, including isoprene and highly volatile compounds that originate from plant metabolism under water stress (ii) to test the performance of the L+T and T algorithms to predict isoprene and highly volatile BVOCs emissions over the seasonal cycle and under two recurrent water stress treatments, Q. pubescens was chosen as vegetal model because this species is highly resistant to drought and well widespread in the Northern Mediterranean area occupying 2 million ha (Quézel & Médail 2003). It also represents the major source of isoprene emissions in the Mediterranean area and the second one at the European scale (Keenan et al. 2009).

2 Material and methods

2.1 Experimental site

Our study was performed at the O3HP site (Oak Observatory at OHP, Observatoire de Haute Provence), located 60 km North of Marseille, France (5°42'44'' E, 43°55'54'' N), at an elevation of 650m above the sea level. The O3HP (955m²), free from direct human disturbance for 70 years, consists of a homogeneous forest mainly composed of Q. pubescens (≈ 90 % of the biomass and ≈ 75 % of the trees) with a mean diameter of 1.3 m. The remaining 10 % of the biomass is mainly represented by Acer monspessulanum trees, a very low isoprene-emitter species (Genard-Zielinski et al. 2015). The O3HP site was created in 2009 in order to study the impact of climate change on a Q. pubescens forest. Using a rainfall exclusion device (an automated monitored roof deployed during rain events) set up over part of the O3HP canopy, it was possible to reduce natural rain by 30% and to extend the drought period in an attempt to mimic the current climatic model projections for 2100 (Giorgi & Lionello 2008; IPCC 2013; Polade et al. 2014). Two plots were considered in the site: a plot receiving natural precipitation where trees grew under natural drought (300m² surface, used as control plot) and a second plot submitted to amplified drought (232m² surface, used as amplified drought plot). Rain exclusion on this latter plot started on April 2012 and was continuously applied every year, principally, during the growth period. Ombrothermic diagrams indicated that the drought period was extended for 2 months in 2012, 4 months in 2013 and 3 months in 2014 for amplified drought relative to natural drought (Fig 1). Data on cumulative precipitation showed that 35% of rain was excluded in 2012 (from 29 April from to 27 October), 33.5 % in 2013 (from 7 July from to 29 December), 35.5% in 2014 (from 8 April to 8 December). This experimental set up involved a recurrent drought in the amplified drought plot. Sampling was performed at the branch-scale at the top of the canopy during three campaigns from October 2013 to July 2014, covering an entire seasonal cycle: in autumn (14 to 28 October 2013, 2nd year of amplified drought), in spring (12 to 19 May 2014, 3rd year of amplified drought) and in summer (13 to 25 July 2014, 3rd year of amplified drought). Spring, summer and autumn
campaigns corresponded to the end of leaf growth, leaf maturation and the beginning of the leaf senescence, respectively. The same five trees per plot were selected and investigated throughout the study.

2.2 Branch scale-sampling methods

Two identical dynamic branch enclosures were used for sampling gas exchange (in terms of CO₂, H₂O and BVOCs) as fully described in Genard-Zielinski et al. (2015) with some modifications. Branches were enclosed in a ≈ 30L PTFE (polytetrafluoroethylene) frame closed by a 50µm thick PTFE film. One tree from natural and one tree from amplified drought plot were analysed concomitantly during 1 or 2 days. Inlet air was introduced at 9L.min⁻¹ controlled by mass flow controllers (MFC, Bronkhorst), using an air generator made, inside, by PTFE (KNF N840.1.2FT.18®, Germany) allowing for air renewal inside the chamber every ~3min. Ozone was removed from inlet air by placing PTFE filters impregnated with sodium thiosulfate (Na₂S₂O₃) as described by Pollmann et al. (2005), so that oxidation of BVOCs due to ozone within the enclosed atmosphere is negligible. The excess of air humidity was removed using drierite. A PTFE fan ensured a rapid mixing of the chamber air and a slight positive pressure within the enclosure enabled the PTFE film to be held away from leaves to minimise biomass damage. Microclimate (temperature, relative humidity and photosynthetically active radiation or PAR) was continuously (every minute) monitored by a data logger (LI-COR 1400®; Lincoln, NE, USA) with a relative humidity and temperature probe placed inside the chamber (RHT probe, HMP60, Vaisala, Finland) and a quantum sensor (PAR, LI-COR, PAR-SA 190®, Lincoln, NE, USA) placed outside the chamber. The climatic conditions in terms of PAR and temperatures are summarized in Fig. S1 (in supplementary files) for each field campaigns. All air flow rates were controlled by mass flow controllers (MFC, Bronkhorst) and all tubing lines were made of PTFE. Chambers were installed the day before measurements and flushed overnight. Enclosed branches contained 8 to 12 leaves corresponding to a range of 1.4 to 3.6g of dry matter and 110 to 320cm² of leaf surface, respectively.

2.3 Ecophysiological parameters

Exchanges of CO₂ and H₂O from the enclosed branches were continuously (every min) measured using infrared gas analysers (IRGA 840A®, LI-COR) concomitantly with BVOCs emission measurements (cf. 2.4). Gas exchange values were averaged by taking into account all the data measured between 12h and 15h (local time). Net photosynthesis (Pn, µmolCO₂ m⁻² s⁻¹) and stomatal conductance to water (Gw, mmolH₂O m⁻² s⁻¹) were calculated using equations described by Von Caemmerer and Farquhar (1981) as used in Genard-Zielinski et al. (2015) (for more details, see Appendix A, equations A1 to A4). Leaves from enclosed branches were directly collected after gas exchange sampling to accurately measure leaf surface with a leaf area meter. Gas exchange were hence expressed in a leaf surface basis. After that, leaves were freeze-dried to assess their dry mass.

2.4 BVOCs analysis

A PTR-ToF-MS 8000 instrument (Ionicon Analytik GmbH, Innsbruck, Austria) was used for online measurements of BVOCs emitted by the enclosed branches. A multi-position common outlet flow path selector valve system (Vici) and a vacuum pump were used to sequentially select air samples from: amplified drought, inlet air, natural drought, ambient air and catalyser. Each sample was analysed every hour, with 15min of
analysis. Mass spectra in the range 0-500amu were recorded at 1min integration time. The reaction chamber pressure was fixed at 2.1mbar, the drift tube voltage at 550V and the drift tube temperature at 313 K corresponding to an electric field strength applied to the drift tube (E) to a buffer gas density (N) ratio of 125Td (1Td = 10^{17} V cm^2). A calibration gas standard (TO-14A Aromatic Mix, Restek Corporation, Bellefonte, USA, 100 ± 10ppb in Nitrogen) was used to experimentally determine the ion relative transmission efficiency. BVOCs targeted in this study and their corresponding ions include formaldehyde (m/z 31.018), methanol (m/z 33.033), acetaldehyde (m/z 45.03), acetone (m/z 59.05), isoprene (m/z 41.038, 69.069) and MACR+MVK+ISOPOOH (m/z 71.049, these three compounds were detected with the same ion with PTR-MS). The signal corresponding to protonated VOCs was converted into mixing ratios by using the proton transfer rate constants k given by Cappellin et al. (2012). Formaldehyde concentrations were calculated according to the method described by Vlasenko et al. (2010) to account for its humidity dependent sensitivity.

BVOCs emissions rates (ER) were calculated by considering the BVOCs concentrations in the inlet and outlet air as follows (equation 1):

\[ ER = \frac{Q_0(s(C_{\text{out}}-C_{\text{in}}))}{B} \]  

where ER was expressed in µgC g_{DM}^{-1} h^{-1}, Q_0 was the flow rate of the air introduced into the chamber (L h^{-1}), C_{\text{out}} and C_{\text{in}} were the concentrations in the inflowing and outflowing air (µgC L^{-1}), respectively, and B was the total dry biomass matter (g_{DM}). Daily cycles were made by averaging measured emissions of all trees every hour.

2.5 Emission algorithms

The light and/or temperature dependence of *Quercus pubescens* BVOCs (isoprene and highly volatile compounds) under natural and amplified drought was tested using both the L+T and T algorithms. Emission rates calculated according to these algorithms (called afterward ER_{L+T} and ER_{T}, respectively) were calculated using the equation described in Guenther et al. (1995) (for more details, see Appendix B, equations B1 to B5). The empirical coefficient β (used in the T algorithm) was determined for each compound according to the season and the treatment through the slope of correlation between the natural logarithm of emissions rates (measured emissions, µgC g_{DM}^{-1} h^{-1} ) and experimental temperature (K). Standardised emissions rates (EF, emissions rates at standard conditions of light and temperature, 1000µmol m^{-2} s^{-1} and 30°C), were used to calculate modelled emissions. EF were determined for each compound according to the season and the treatment and corresponded to the slope of the correlation between experimental emission rates and values of C_{\text{L+T}} and C_{\text{T}} when using the L+T algorithm or C_{\text{T}} when using the T algorithm (see Appendix B for a full description of C_{\text{L+T}}, C_{\text{T}}, C_{\text{L}}, and C_{\text{T}}). All parameters used for the calculation of modelled emissions are presented in supplementary files (Table S1).

2.6 Data treatment

Data treatment was performed with the software STATGRAPHICS® centurion XV (Statpoint, Inc). After having checked the normality of the data set, two-way repeated measures ANOVA were performed to evaluate the variability of *Pn*, *Gw* and BVOCs emission rates according to the drought treatment and the season. Pearson's correlations between measured and modelled emissions were performed to evaluate the algorithm (L+T or T) that better predicted *Quercus pubescens* emissions under the different drought conditions and over the
seasonal cycle. Afterwards, linear regressions tests and slope comparison tests (equal to 1, referred to “sl” afterwards) were also performed to evaluate the good fit of tested algorithms with BVOCs emissions rates.

3. Results and discussion

3.1 Ecophysiological parameters

The physiology of *Q. pubescens* was slightly impacted by amplified drought (Fig. 2), over the whole study, with a decrease of *Gw* under amplified drought compared to natural drought, by 44 % in spring (*P* < 0.1) and 55 % in summer (*P* < 0.01, Table 1). In autumn, there was no significant difference between both treatments. *Pn* was only reduced in summer by 36 % (*P* < 0.1) and there was no difference for the others season. Thus, the stomatal closure observed had a slight impact on carbon assimilation. Indeed, *Q. pubescens* has a high stem hydraulic efficiency (Nardini & Pitt 1999) which compensates the stomatal closure since it allows to use water more efficiently, thus, maintaining *Pn*. Moreover, it must be noted that an increase of *Pn* was observed in autumn and could likely be attributed to the autumnal rains. These results showed that the amplified drought artificially applied to *Q. pubescens* at O3HP led to a moderate drought for this species, based on a moderate reduction of the physiological performances (Niinemets 2010).

3.2 Effect of drought on BVOCs emissions

The emissions of all BVOCs followed during this experimentation were reduced under amplified drought compared to natural drought, especially in spring and summer (Table 1) except for acetaldehyde emissions. Indeed, for this compound, there was no significant difference between both treatments probably due to a large variability of the data set. In autumn, for all BVOCs, there was no difference between both plots. The decrease of oxygenated BVOCs in spring and summer under amplified drought (e.g. methanol, MACR+MVK+ISOPOOH, formaldehyde, acetone) could be explained by the concomitant stomatal closure in spring and summer under amplified drought. Indeed, the emissions of these compounds are strongly bound to *Gw* (Niinemets et al. 2004). Isoprene emissions were also reduced in spring and summer during the third year of this experiment whereas an increase was observed in the first year (personal communication from A.C Génard-Zielinski) as well as what had been shown by Brüggemann and Schnitzler (2002) but this work was conducted with potted plants. The isoprene decrease observed in our experiment cannot be explained by the stomatal closure because this compound could also be emitted through the cuticle (Sharkey & Yeh 2001). It could rather be due to the decrease of *Pn* which reduced the carbon availability to produce isoprene. Moreover, carbon assimilated through *Pn* can be also invested into the synthesis of other defense compounds leading to a decrease of isoprene production and emission.

3.3 Effect of drought on light and/or temperature dependence through a seasonal cycle

All six BVOCs monitored showed daytime light and temperature dependencies (isoprene, degradation products of isoprene and acetaldehyde), while three BVOCs (methanol, acetone and formaldehyde) also showed emissions during the night despite the absence of light under constant temperature.
Regarding the light and temperature dependencies, the daily cycle of isoprene emissions (Fig. 3) showed that this compound responds strongly to light and temperature as already known (Guenther et al. 1993), and that this response was not impacted by amplified drought. Isoprene can protect thylakoids from oxidative damage (Velikova et al. 2011) occurring mainly during the day which can explain this kind of dependence. Yet, our results showed the importance to take into account the effect of amplified drought on emission factors because the intensity of isoprene emissions between natural and amplified drought was very different independently of the season. The modelled emissions were very representative of measured emissions except in spring for natural drought when we obtained a slight underestimation of emissions (sl = 0.84, P < 0.05) maybe, because light and temperature, in spring, were not the only parameters driving isoprene emissions. At this season, plants likely needed to produce more isoprene to protect the establishment of photosystems in the new leaves.

MACR+MVK+ISOPOOH emissions, as isoprene, seemed to respond better to light and temperature than to only temperature (Fig. S2 in supplementary files) since correlations between measured emissions and ER_{L+T} were always better than with ER_{T}. Since MACR+MVK+ISOPOOH are oxidation products of isoprene (Oikawa & Lerdau 2013), it is not surprising that these compounds followed the same pattern than isoprene in terms of dependence to light and temperature. The estimations of ER_{L+T} were quite good except in spring under natural drought where a slight underestimation was observed (sl = 0.87, P < 0.05).

The dependence of acetaldehyde emissions to light and/or temperature is very contrasted; studies have shown that they are bound to both light and temperature (Jardine 2008; Fares et al. 2011) or to temperature only (Hayward et al. 2004). Our results suggested that acetaldehyde emissions were mainly bound to light and temperature (Fig. 4). Indeed, correlations between measured and ER_{L+T} were always better than with ER_{T}. However, some discrepancies were observed. Under natural drought, underestimations were observed in spring and summer (sl = 0.72, and sl = 0.57, P < 0.05, respectively) whereas in autumn, there was a good estimation (sl = 0.86, P > 0.05). Under amplified drought, underestimation was only observed in summer (sl = 0.80, P < 0.05).

Daily cycles of acetaldehyde emissions presented also an emissions burst in the morning (at 7h, local time) in spring (under both treatments) and in summer (only under natural drought). Acetaldehyde can be produced due to an overflow of pyruvic acid during light-dark transitions. Cytosolic pyruvic acid levels rise rapidly and it can be converted into acetaldehyde by pyruvate decarboxylase (Fall 2003). This mechanism could explain the morning burst for this compound and the fact that no emissions during the night was observed.

We observed emissions of methanol, acetone and formaldehyde during the night under no light and constant temperature (around 20°C, see supplementary files S1). Correlations between ER_{L+T} or ER_{T} and measured methanol emissions were very similar especially in spring and summer (Fig. 5). However, some observed phenomena suggested that methanol emissions was sustained by temperature alone at certain moment of the day. Indeed, the burst in the early morning (at 7h, local time), similar to acetaldehyde, was observed when stomata opened in spring and summer, independently of the drought treatment although it was clearer under natural than amplified drought. This burst can be explained by a strong release of this compound that has been accumulated in the intercellular air space and leaf liquid pools (due to the relative high polarity of methanol) at night when stomata are closed (Hüve et al. 2007). Moreover, for both drought treatments, methanol emissions during the night were observed at any seasons (especially autumn) which could be explained by nocturnal temperatures (roughly constant) that sufficed to maintain the biochemical processes involved in methanol formation. Methanol
emissions, which result from the demethylation of pectin during the leaf elongation, has already been described to be temperature dependent alone (Hayward et al. 2004; Folkers et al. 2008). However, our results suggest that methanol emissions respond strongly to light and temperature during the day. This kind of diurnal emissions cycle has already been described by Smiatek and Steinbrecher (2006).

Our results about daily cycles of acetone emissions (Fig. S3 in supplementary files) showed that this compound responded better to light and temperature than only temperature since correlations were better with ER<sub>L+T</sub>. Under natural drought, the modelled emissions were well representative of measured emissions in summer. By contrast, in spring and in autumn, slight underestimations were observed (sl = 0.88, P < 0.05 and sl = 0.69, P < 0.05, respectively). Under amplified drought, good estimations were observed in summer and autumn but in spring, there was an overestimation of modelled emissions (sl = 1.27, P < 0.05). Previous studies have shown that acetone rather depends on temperature alone (Fares et al. 2011) or to light and temperature (Jacob et al. 2002), indicating that its dependence to light and/or temperature remains unclear. During the day, acetone emissions were dependent to light and temperature and emissions still occurred during the night, especially in autumn. Alike methanol, nocturnal temperatures could allow to maintain acetone formation (Smiatek & Steinbrecher 2006). Acetone is a by-product of plant metabolism (Jacob et al. 2002) and its production can be enzymatic and non-enzymatic (Fall 2003) which can explain these observed differences through the day. We can suppose that acetone emissions observed during the day could come from the enzymatic activity and, on the contrary, during the night, they could come from the non-enzymatic production.

Formaldehyde emissions followed the same pattern than methanol and acetone emissions (Fig. S4 in supplementary files), especially in autumn. By considering only the daytime (correlation with L+T modelled emissions), there were good estimations in summer and autumn and a slight underestimation was observed in spring (sl = 0.89, P < 0.05) for natural drought. Under amplified drought, correlations indicated that L+T modelled emissions were well representative of measured emissions, but some negative emissions were observed in summer which suggested a deposition or an uptake of this compound by leaves as already highlighted by Seco et al. (2008). This phenomenon could have a role in stress tolerance, since formaldehyde can be catabolised (mainly through oxidations) within leaves leading to CO₂ formation (Oikawa & Lerdau 2013). Emissions during the night suggest that formaldehyde came from another source than oxidation within leaves since oxidations occur mainly during the day due to an excess of light in chloroplasts, principal place of reactive oxygen species production (Asada 2006). Thus, formaldehyde emissions observed during the night could result from, for example, the glyoxylate decarboxylation or the dissociation of 5,10-methylene-THF (Oikawa & Lerdau 2013).

### 4 Conclusion

After 3 years of amplified drought, all BVOCs emissions were reduced in spring and summer compared to natural drought whereas, in autumn, an increase was observed for some compounds. These results are in opposition with the results obtained after only one year of amplified drought (2012), especially for isoprene, where an increase was observed for this compound (personal communication from A.C. Génard-Zielinski).
Amplified drought did not seem to shift the dependence to light and/or temperature which remained unchanged between treatments. Moreover, two different dependence behaviours were found: (i) all six BVOCs monitored showed daytime light and temperature dependencies while (ii) only three BVOCs (methanol, acetone and formaldehyde) also showed that their emissions were maintained during the night with no light at rather constant nocturnal temperatures. Moreover, some phenomena, such as methanol and acetaldehyde emissions bursts in early morning or the formaldehyde deposition/uptake (formaldehyde), were not assessed by either L+T or T algorithm.

Appendix A: calculation of ecophysiological parameters

Net photosynthesis (Pn, µmolCO₂ m⁻² s⁻¹) was calculated using equations described by Von Caemmerer and Farquhar (1981) as follows:

\[ Pn = \frac{F \cdot (Cr - Cs)}{S} - CS \cdot E \]  (A1)

Where \( F \) is the inlet air flow (mol s⁻¹), \( Cs \) and \( Cr \) are the sample and reference CO₂ molar fraction respectively (ppm), \( S \) is the leaf surface (m²), \( Cs \cdot E \) is the fraction of CO₂ diluted in water evapotranspiration and \( E \) (molH₂O m⁻² s⁻¹ then transformed in mmolH₂O m⁻² s⁻¹, afterward) is the transpiration rate calculated as follow:

\[ E = \frac{F \cdot (Ws - Wr)}{S \cdot (1 - Ws)} \]  (A2)

where \( Ws \) and \( Wr \) are the sample and the reference H₂O molar fraction respectively (molH₂O mol⁻¹).

Stomatal conductance to water (\( Gw \), molH₂O m⁻² s⁻¹ then transformed in mmolH₂O m⁻² s⁻¹) was calculated using the following equation:

\[ Gw = \frac{E \cdot (1 - Wl - Ws)}{Wl - Ws} \]  (A3)

where \( Wl \) is the molar concentration of water vapour within the leaf (molH₂O mol⁻¹) calculated as follows:

\[ Wl = \frac{Vpsat}{P} \]  (A4)

where \( Vpsat \) is the saturated vapour pressure (kPa) and \( P \) was the atmospheric pressure (kPa).

Appendix B: Modelled emissions calculation

The modelled emissions rates according to light and temperature (\( ER_{L+T} \)) or the temperature algorithm (\( ER_T \)) were calculated according to algorithms described in Guenther et al. (1995) as follows:

\[ ER_{L+T} = EF_{L+T} \cdot Cl \cdot Ct \]  (B1)

where \( EF_{L+T} \) is the emission factor at 1000 µmol m⁻² s⁻¹ of photosynthetically active radiation (PAR) and 30°C of temperature (obtained with the slope of the correlation between experimental emissions and \( Cl \cdot Ct \)). \( Cl \) and \( Ct \) correspond to light and temperature dependence factors respectively and were calculated with the following formulae:

\[ Cl = \frac{aL \cdot L}{\sqrt{1 + aL}} \]  (B2)
\[ \begin{align*}
C_t &= \exp \left( \frac{C_{T_1}(T-T_S)}{RTST} \right) \left[ 1 + \exp \left( \frac{C_{T_2}(T-T_M)}{RTST} \right) \right]^{-1} \tag{B3} 
\end{align*} \]

where \( \alpha = 0.0027 \), \( CL_1 = 1.066 \), \( C_{T_1} = 95000 \text{ J mol}^{-1} \), \( C_{T_2} = 230000 \text{ J mol}^{-1} \), \( T_M = 314 \text{ K} \) are empirically derived constants, \( L \) is the photosynthetically active radiation (PAR) flux (\( \mu \text{mol m}^{-2} \text{s}^{-1} \)), \( T \) is the leaf experimental temperature (K) and \( T_S \) is the leaf temperature at standard condition (303K).

Modelled emissions according to temperature alone that is \( ERT \), was calculated as follows:

\[ \begin{align*}
ERT &= EF_T \times CT \tag{B4} 
\end{align*} \]

where \( EF_T \) is the emission factor at 30°C of temperature (obtained with the slope of the correlation between experimental emissions and \( CT \)) and \( CF \) is a temperature dependence factor calculated as follows:

\[ \begin{align*}
CT &= \exp \left[ \beta (T - T_S) \right] \tag{B5} 
\end{align*} \]

where \( \beta \) is an empirical coefficient (with a standard variation value of 0.09K\(^{-1}\) used in literature when not measured) determined, in this study, for each compound according to the season and the treatment through the slope of the correlation between the natural logarithm of measured emissions rates (\( ER, \mu \text{g C gDM}^{-1} \text{ h}^{-1} \)) and experimental temperature (expressed in K). \( T \) is the leaf experimental temperature (K) and \( T_S \) is the standard temperature (303K).

**Author contribution**

AS, EO and CF designed the research and the experimental design. AS, BTR, EO and CF conducted the research. AS, CB, BTR, and CL collected and analyzed the data. AS, EO, CB, HW, BTR, AA and CF wrote the manuscript.

**Competing interests**

The authors declare that they have no conflict of interest.

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Table 1: Net photosynthesis (Pn, μmolCO₂ m⁻² s⁻¹), stomatal conductance to water (Gw, mmolH₂O m⁻² s⁻¹) and emission rates (µgC gDM⁻¹ h⁻¹) according to treatment and season. Values represent an average of all data measured between 12h and 15h (local time). Letters denote the difference between drought treatments with a > b (P < 0.05) and values showed represent the mean ± SE, n=5. ND: natural drought and AD: amplified drought.

<table>
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<th>Season</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
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</thead>
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<td>AD</td>
<td>ND</td>
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<td>MACR+MVK</td>
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Figure legends

**Figure 1**: Ombrothermic diagram for natural and amplified drought in 2012, 2013 and 2014. Bars represent mean monthly precipitation (mm) and curves represent mean monthly temperature (°C). On each amplified drought graph, the percentage represents the proportion of excluded rain compared to natural drought plot.

**Figure 2**: Diurnal pattern of stomatal conductance ($G_w$) and net photosynthesis ($P_n$) according to drought treatment and season. Values showed represent means ± SE, n=5.

**Figure 3**: Diurnal pattern of isoprene emissions rates, where points represent measured emissions, and the yellow line correspond to modelled emissions rates according to the $L+T$ algorithm ($ER_{L+T}$). Values are mean ± SE, n=5. R² and slope (sl) of correlations between measured and modelled emissions are presented in the yellow frame. Correlations were obtained without forcing data through the origin.

**Figure 4**: Diurnal pattern of acetaldehyde emissions rates, where points represent measured emissions, the yellow line correspond to modelled emissions rates according to the $L+T$ algorithm ($ER_{L+T}$) and dotted line is modelled emissions rates according to $T$ algorithm ($ER_T$). Values are mean ± SE, n=5. R² and slope (sl) of correlations between measured and modelled emissions are presented in the yellow frame for $L+T$ and in the white frame for $T$. Correlations were obtained without forcing data through the origin.

**Figure 5**: Diurnal pattern of measured methanol emissions rates. Points (means ± SE, n=5) represent measured emissions, yellow line correspond to modelled emissions rates according to the $L+T$ algorithm ($ER_{L+T}$) and dotted line is modelled emissions rates according to $T$ algorithm ($ER_T$). Values are mean ± SE, n=5. R² and slope (sl) of correlations between measured and modelled emissions are presented in the yellow frame for $L+T$ and in the white frame for $T$. Correlations were obtained without forcing data through the origin.
Figure 1:
Figure 2:
Figure 3:
Figure 4:
Figure 5: Graphs showing the comparison of \( R^2 \) values for different seasons and drought conditions. The graphs depict the modeled and measured methane emissions with error bars indicating variability. The key points are:

- **Spring**
  - Natural Drought: \( R^2 = 0.78 \), sl = 0.73
  - Amplified Drought: \( R^2 = 0.62 \), sl = 0.56

- **Summer**
  - Natural Drought: \( R^2 = 0.80 \), sl = 0.79
  - Amplified Drought: \( R^2 = 0.69 \), sl = 0.70

- **Autumn**
  - Natural Drought: \( R^2 = 0.53 \), sl = 0.70
  - Amplified Drought: \( R^2 = 0.29 \), sl = 0.47

The graphs are color-coded with symbols indicating measured data and modeled results for the different scenarios.