RADIAL GROWTH RESPONSE TO OZONE EXPOSURE AND UPTAKE OF SESSILE OAK (*QUERCUS PETRAEA*) IN MIHAESTI-GORUN IM PLOT, ROMANIA

Diana Silaghi[1], Ovidiu Badea[1], Ionel Popa[1], Elena Paoletti[2]

[1]Forest Research and Management Institute - ICAS, Romania
[2]National Research Council of Italy - CNR, Italy

General considerations

- Sessile oak (*Quercus petraea*) is one of the most important tree species in Romania, both from ecologic and economic point of view.

- In recent years, a decline in the health status of this species was observed in Romania, attributed mainly to climate change and air pollution effects, including ozone.

Objectives

- Analyze the relationship between intra-anual basal area variation and cycardian cycle's phases duration of *Quercus petaea* trees and meteorological parameters, soil water content and ozone exposure and uptake

- Determine if there are negative effects of ozone on sessile oak's growth.

Study location

- Mihaesti Intensive Forest Monitoring Plot (ICP-Forests – level II), placed in the Southern part of Romania, in the Subcarpathians hills.
- The main tree species are *Quercus petraea* (80%) and *Fagus sylvatica* (20%)

Site	Latitude	Longitude	Altitude (m)	Soil type	Soil texture	Precipitation (mm)	Mean temperature (°C)	AOT40 daylight (ppb h)
Mihaesti	45°01’47”	24°59’33”	405	Cambisol eutric	Loamy	537.6	9.2	12280

Data collection

Meteorological station

Soil water content

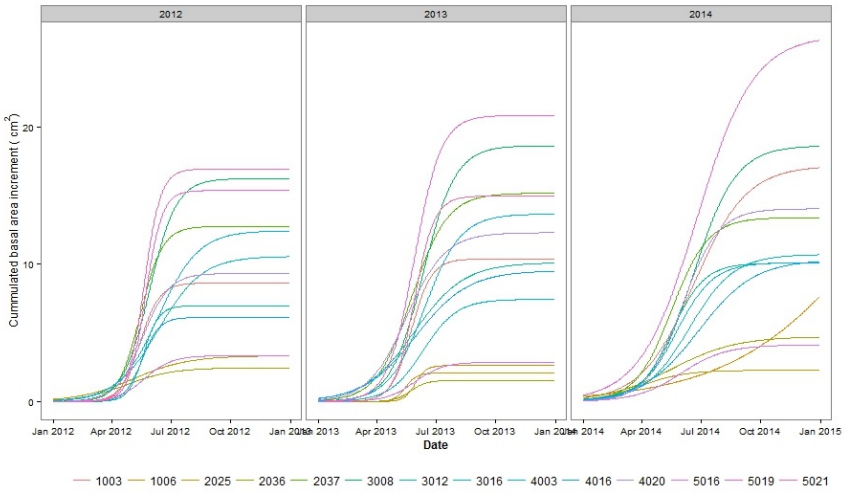
Ozone active monitor

Permanent measurements – 2 weeks resolution

Continuous measurements – 1 hour resolution

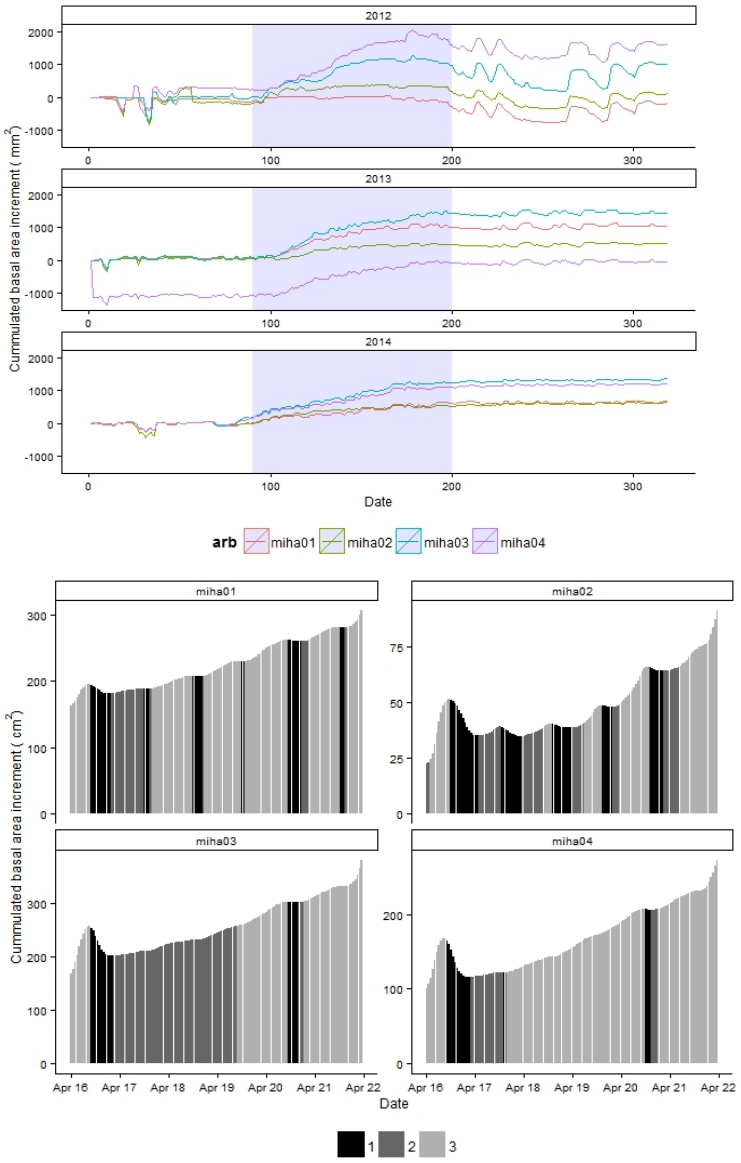
Data processing

- **Permanent growth measurements**
  - Biweekly values were modeled using logistic function in order to derive daily basal area growth



Data processing

- **Continuous growth measurements**
  - **determine daily basal area increment** for day i (±ΔBAI) by by extracting the daily maximum of day i-1 from daily maximum of day i
  - annual stem radial variation was divided into five periods (Vieira et al., 2013): winter dormancy, **spring growth** , pre-summer contraction, summer dormancy and autumn re-hydration
  - **extract the stem radius variation during the growing period** using the stem cycle approach (Deslauriers et al., 2003, Deslauriers et al., 2011): contraction (phase 1), expansion (phase 2) and stem basal area increment (phase 3)
  - environmental variables were processed according to each phase division in order to match them with growth data



Data processing

- Parameterization used for modeling ozone stomatal flux in Mihaesti IM plot

Parameter	Units	Value
g_{max}	mmol H_2O m^{-2} PLA	150
f_{min}	fraction	0.13
SGS	DOY	Calcluated
EGS	DOY	Calculated
light_a	const.	0.006
T_{min}	°C	5
T_{opt}	°C	16
T_{max}	°C	33
VPD_{max}	kPa	1
VPD_{min}	kPa	3.1
SWC_{max}	m^3/m^3	Calculated
SWC_{min}	m^3/m^3	Calculated

- f_{phen} was calculated using the model proposed by Braun et al., 2010, using real observations

Statistical analysis

- Kendall tau correlation
  - Bivariate: daily/phase growth or duration V ozone indicators
  - Partial: daily/phase growth or duration V ozone indicators controlling for temperature, precipitation, SWC, VPD, stomatal conductance; Bonferroni correction was applied to p value
- Multiple regression
  - Dependent variables: daily growth, phase growth
  - Independent variables:
    - Meteorological parameters: mean temperature, sum of precipitation, mean SWC, mean VPD
    - Ozone indicators: AOT40 and ozone flux
- R® packages used: dplyr, ggplot2, ppcor, lmSupport, relaimpo

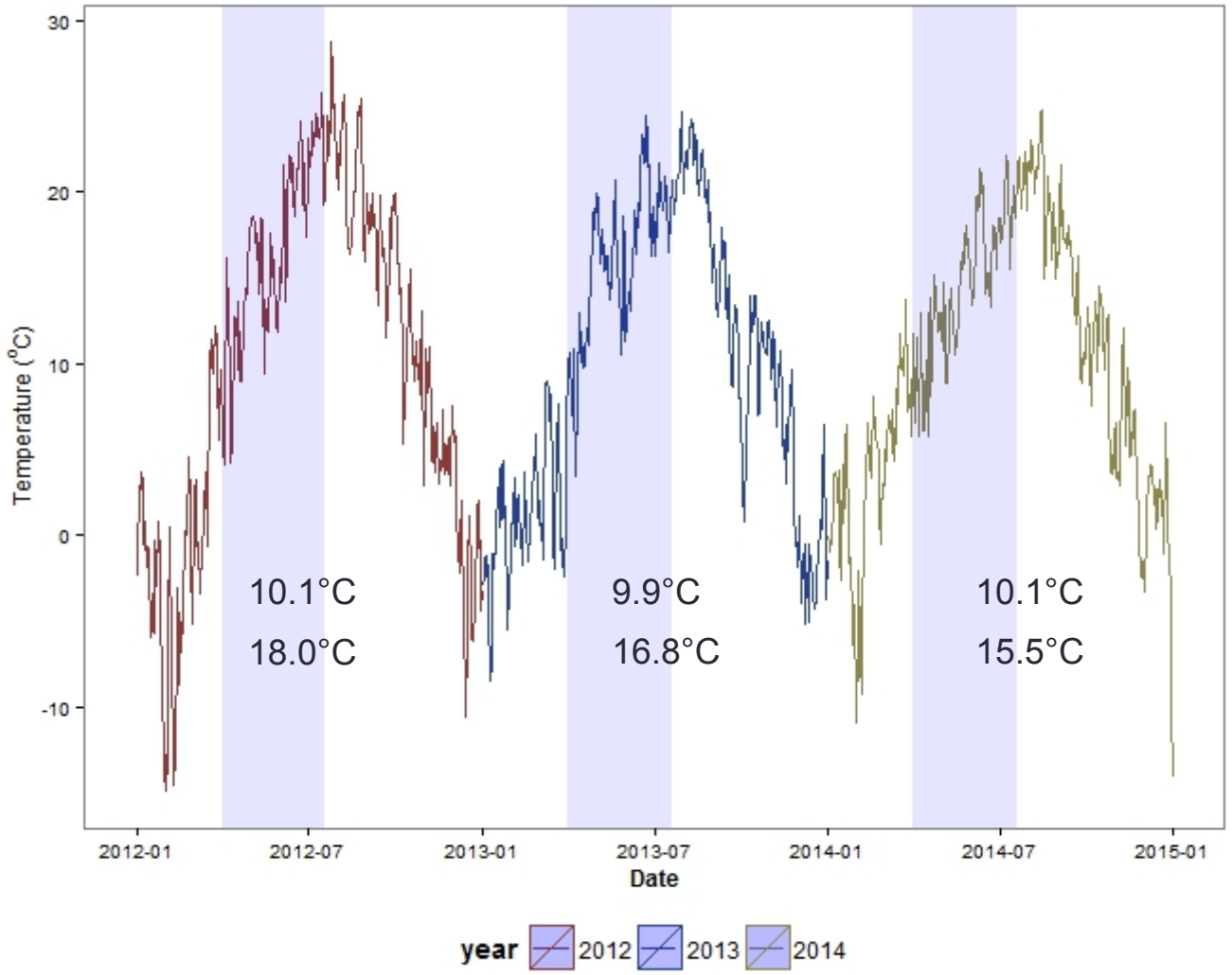
Results

- Growth patterns

Year	Mean BA growth (cm^2)	Standard deviation (cm^2)	Minimum BA growth (cm^2)	Maximum BA growth (cm^2)
Permanent measurements (n=14)				
2012	9.66	6.03	1.95	20.21
2013	8.12	5.10	1.35	15.49
2014	**10.88**	6.90	1.28	24.58
Continuous measurements (n=4)				
2012	9.33	9.03	0.42	20.47
2013	8.20	6.63	0.36	15.48
2014	**9.79**	3.62	6.46	13.57

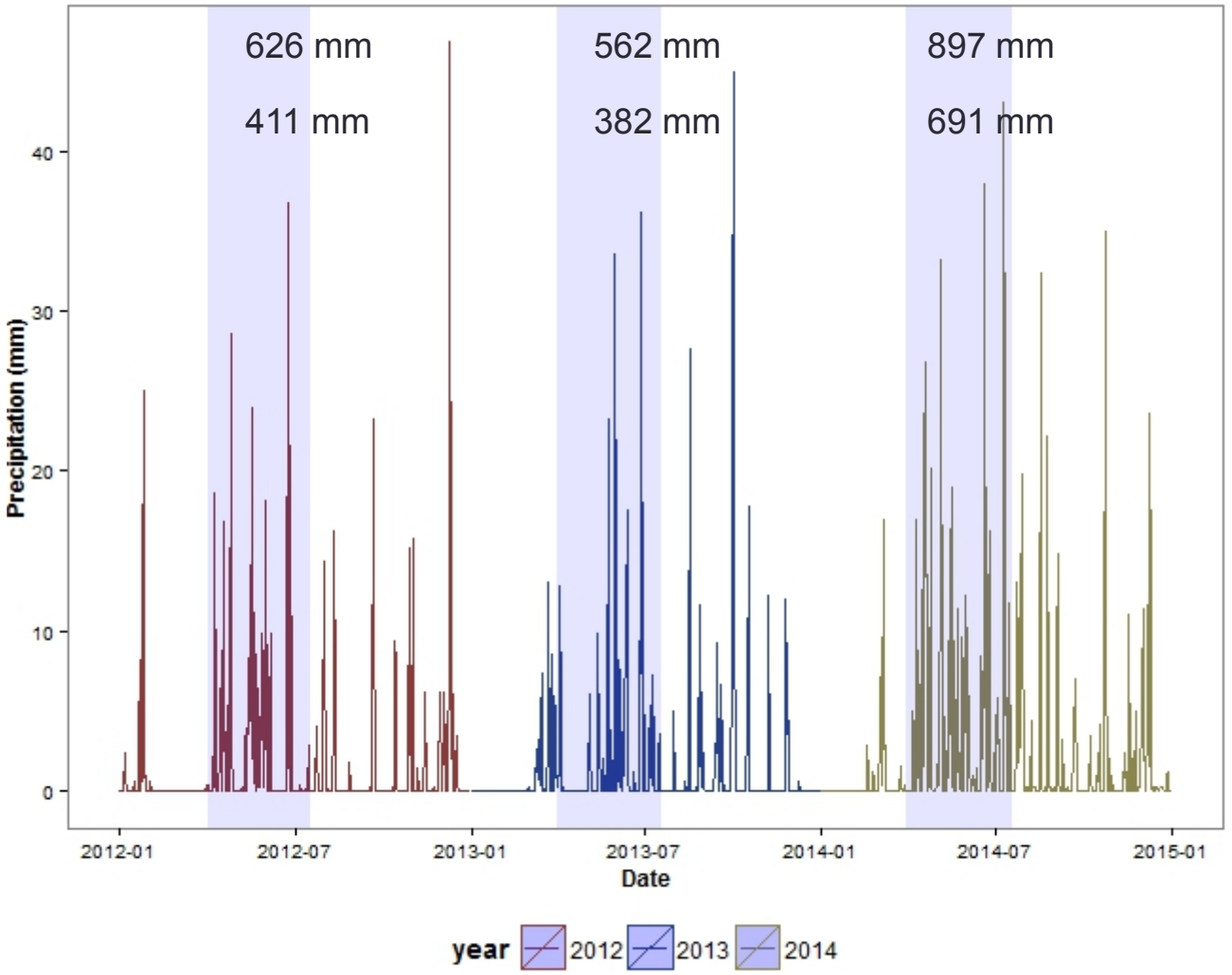
Results

- Temperature



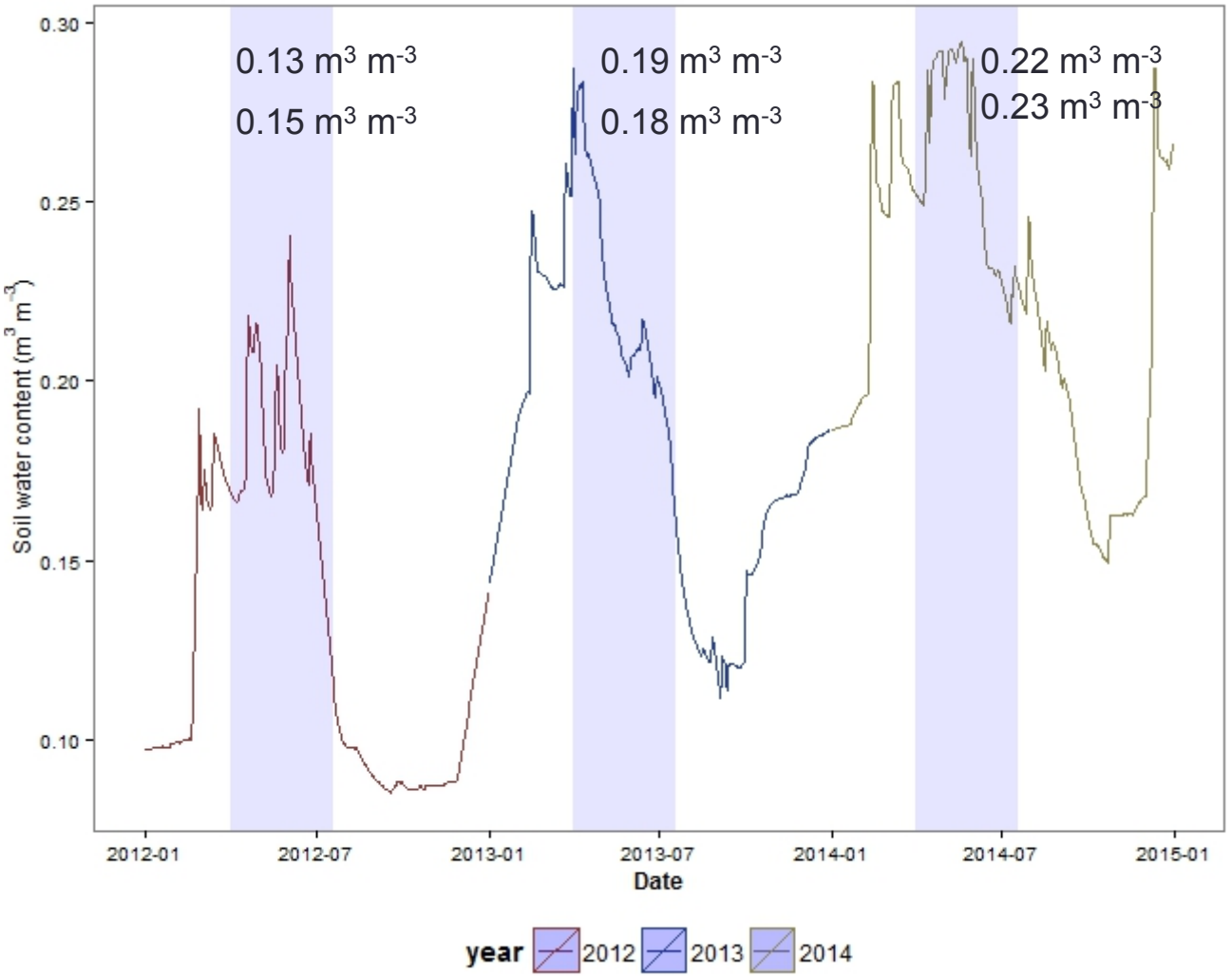
Results

- Precipitation



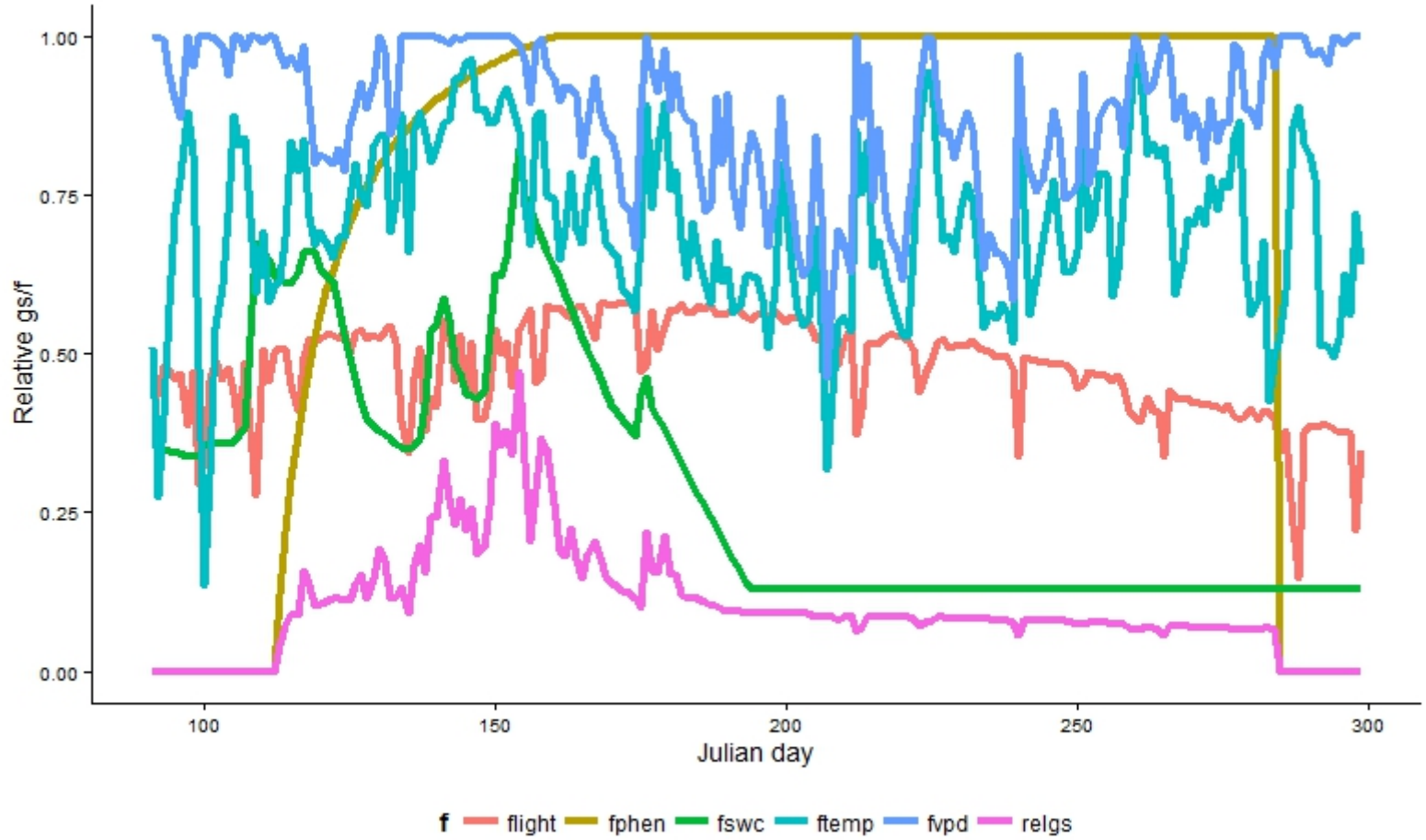
Results

- Soil water content



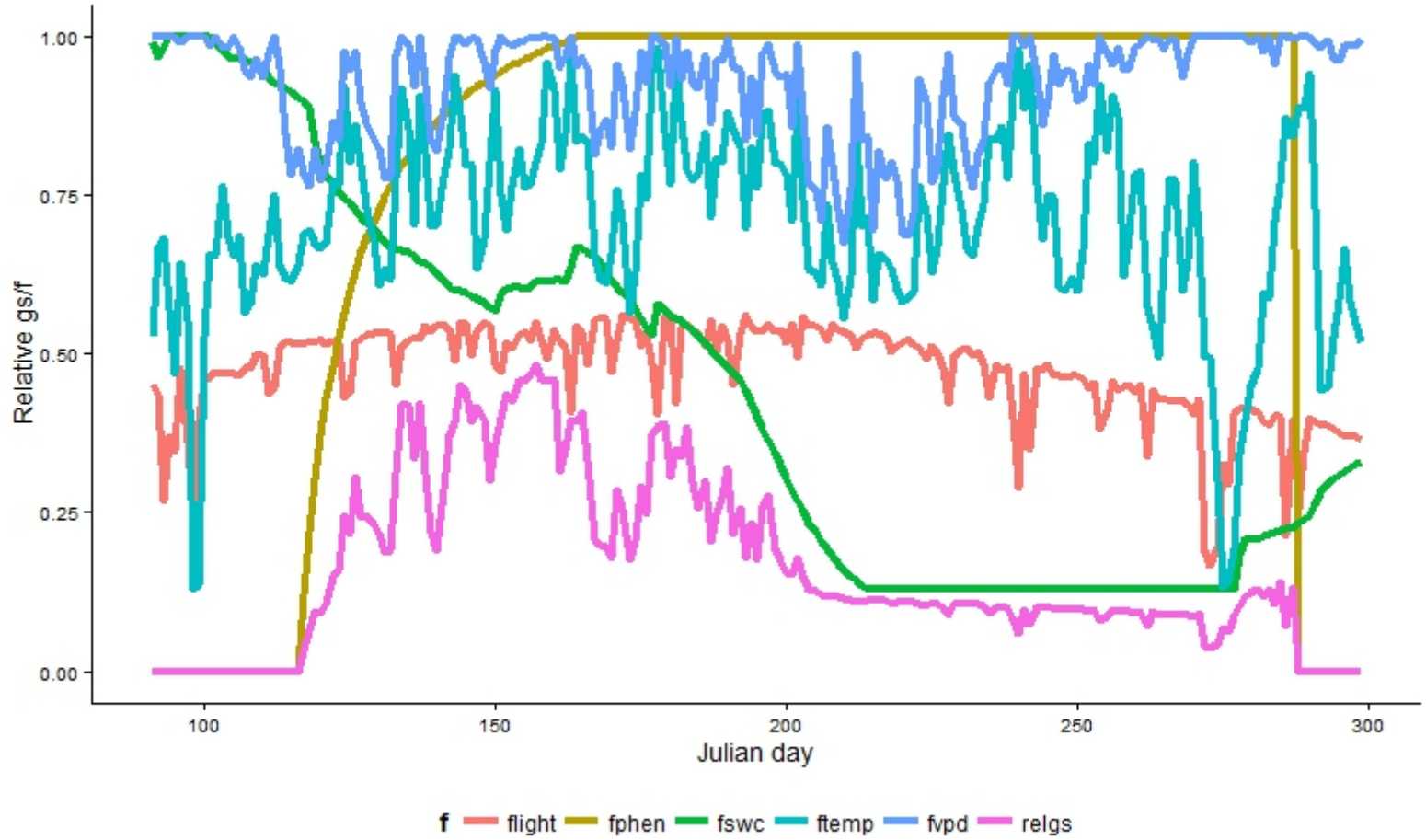
Results

- Variation of g_{sto}, f_{temp}, f_{light}, f_{VPD}, fphen and f_{SWC} in 2012



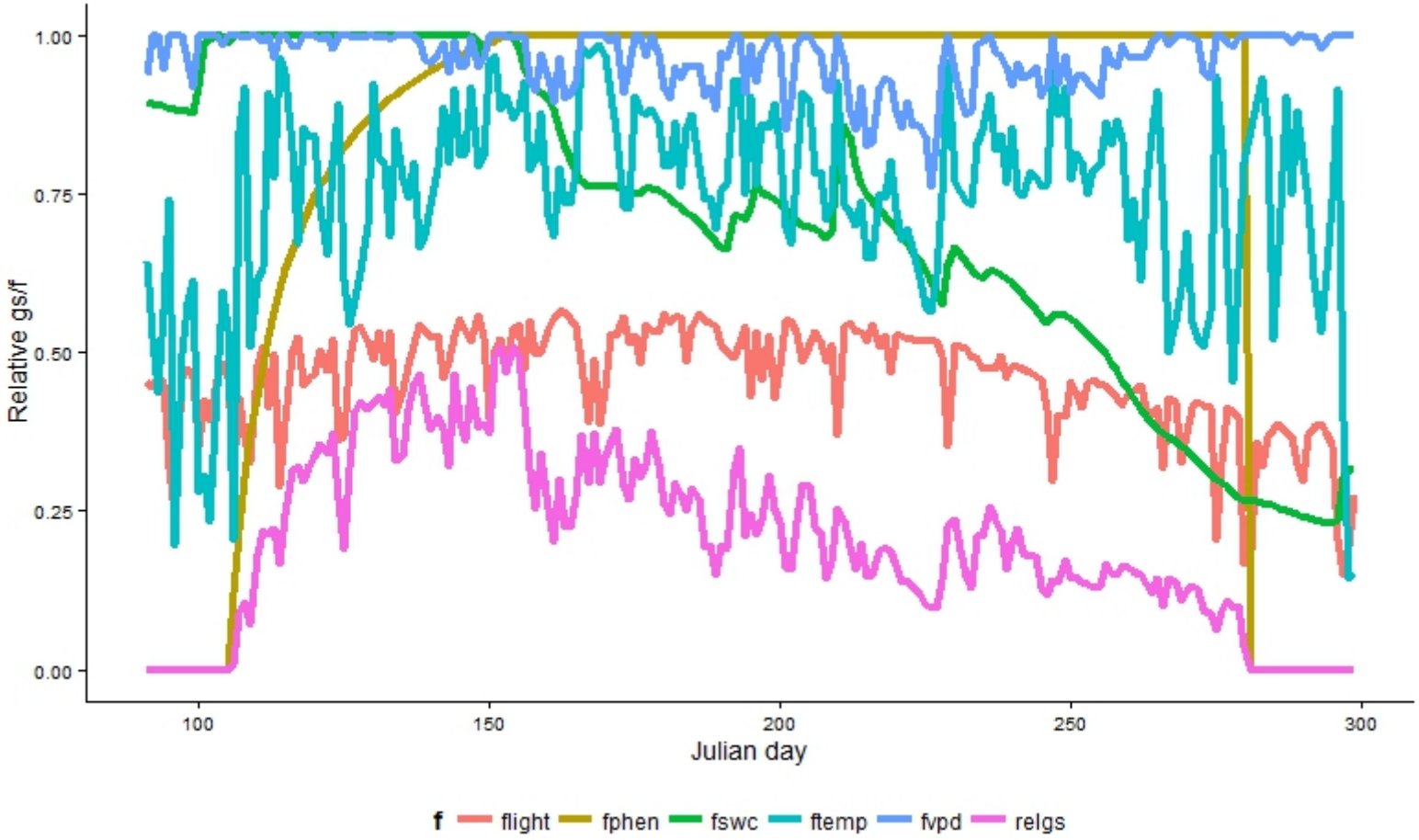
Results

- Variation of g_{sto}, f_{temp}, f_{light}, f_{VPD}, fphen and f_{SWC} in 2013



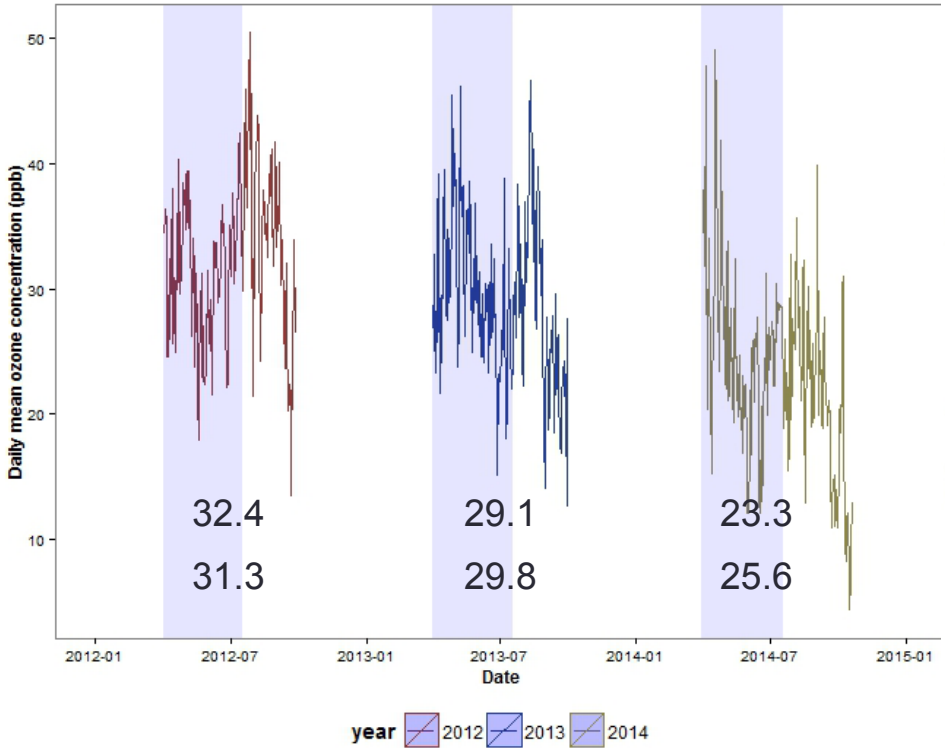
Results

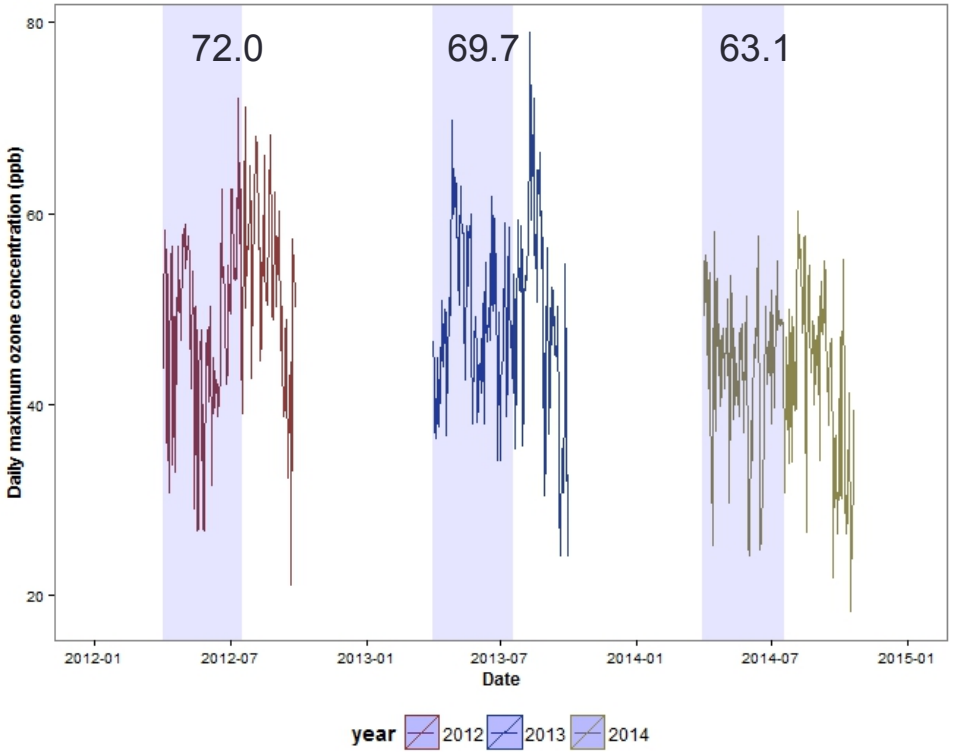
- Variation of g_{sto}, f_{temp}, f_{light}, f_{VPD}, fphen and f_{SWC} in 2014



Results

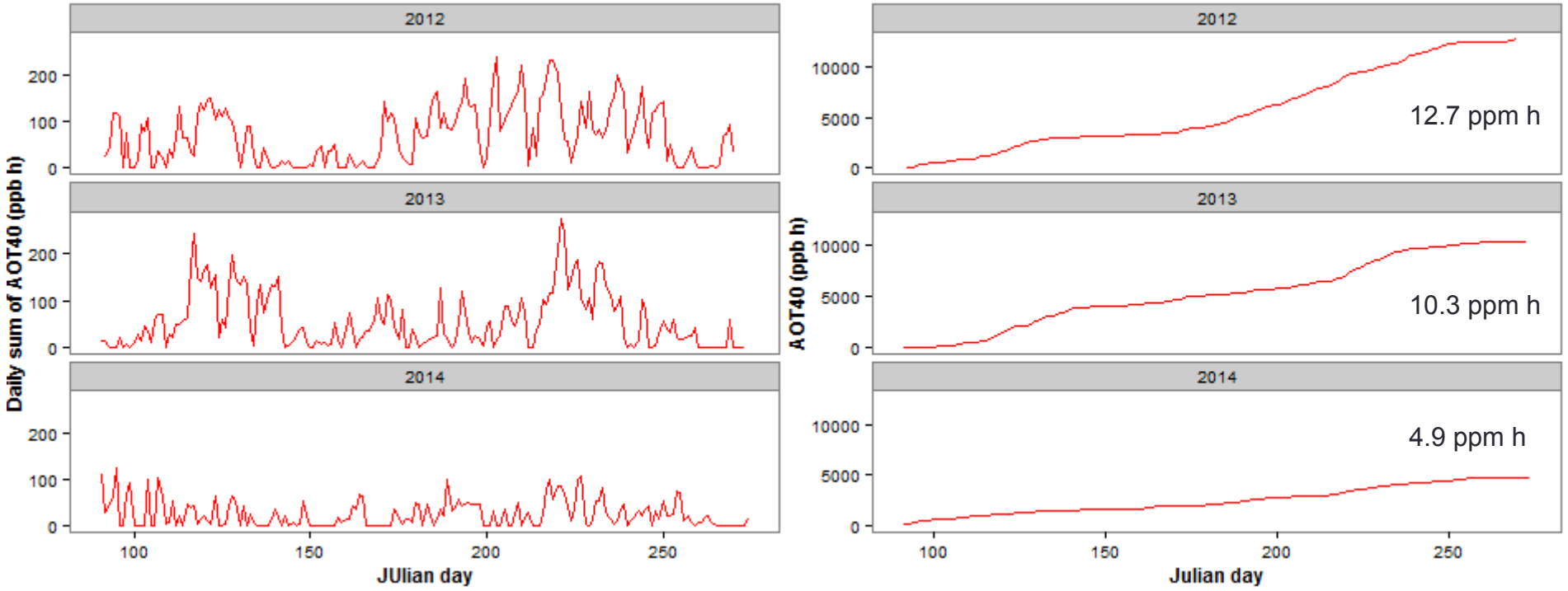
- Ozone concentration





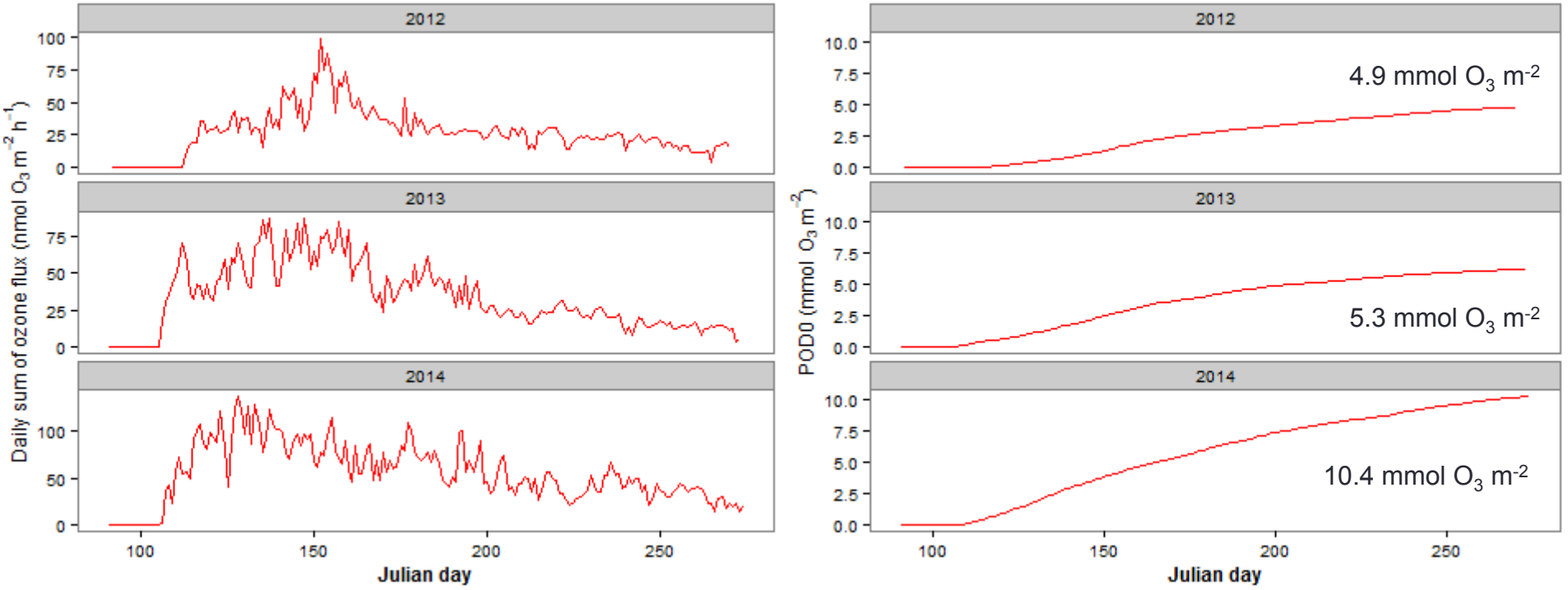
Results

- AOT40



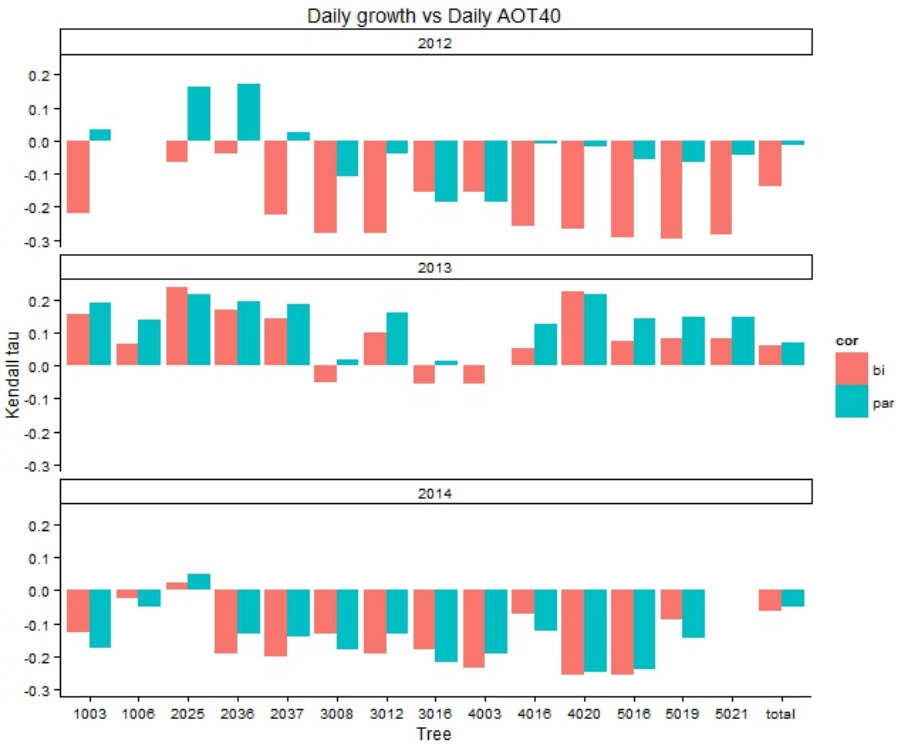
Results

- Ozone fluxes



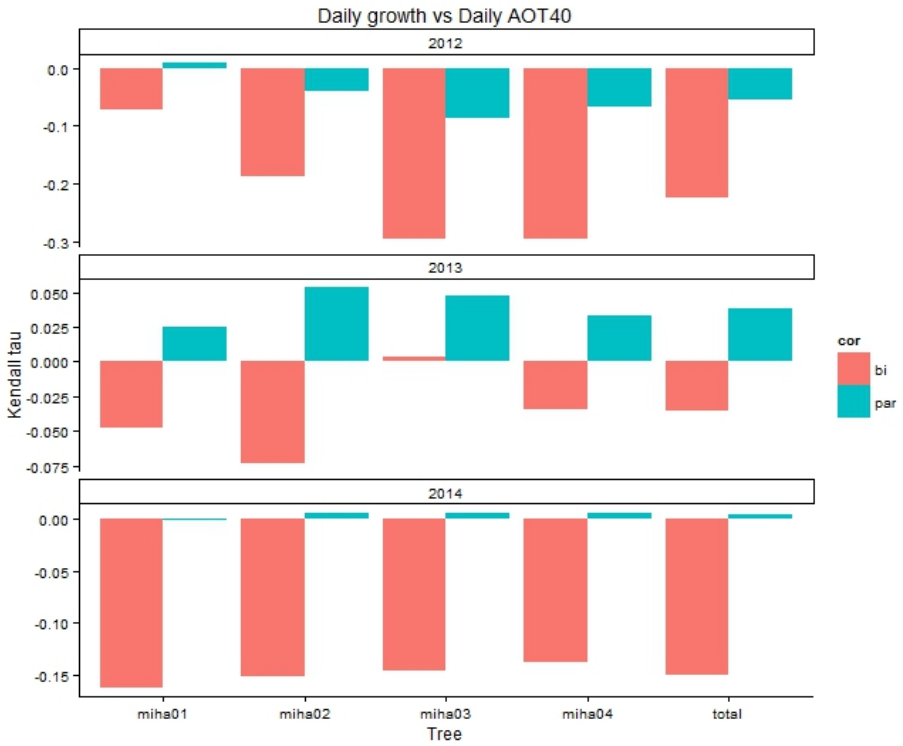
Results

- Kendall correlation: daily growth modeled from permanent measurements v ozone



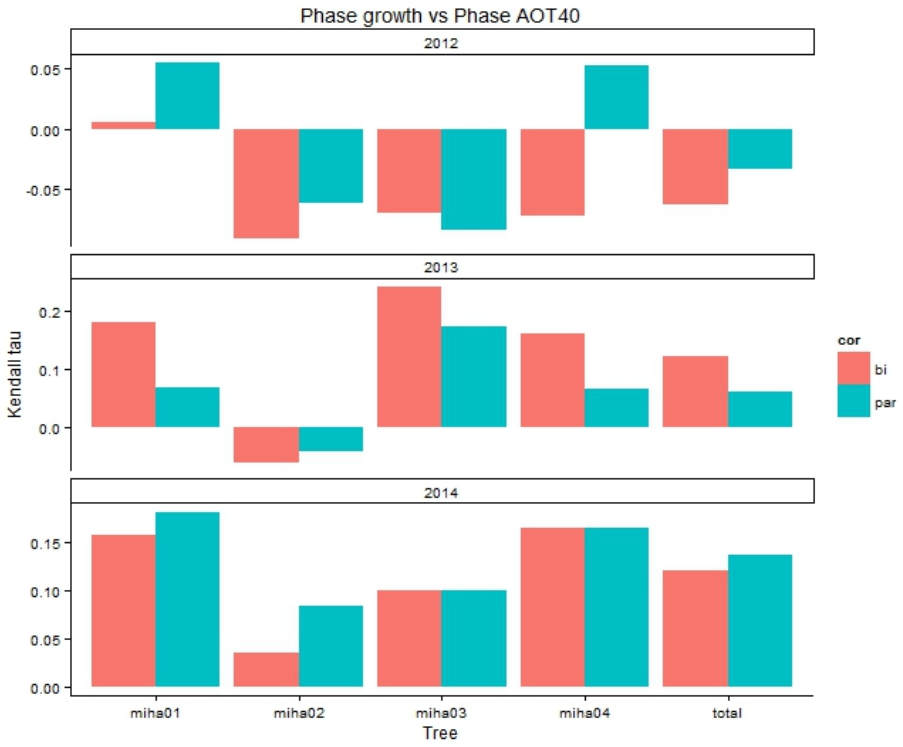
Results

- Kendall correlation: daily growth from continuous measurements v ozone



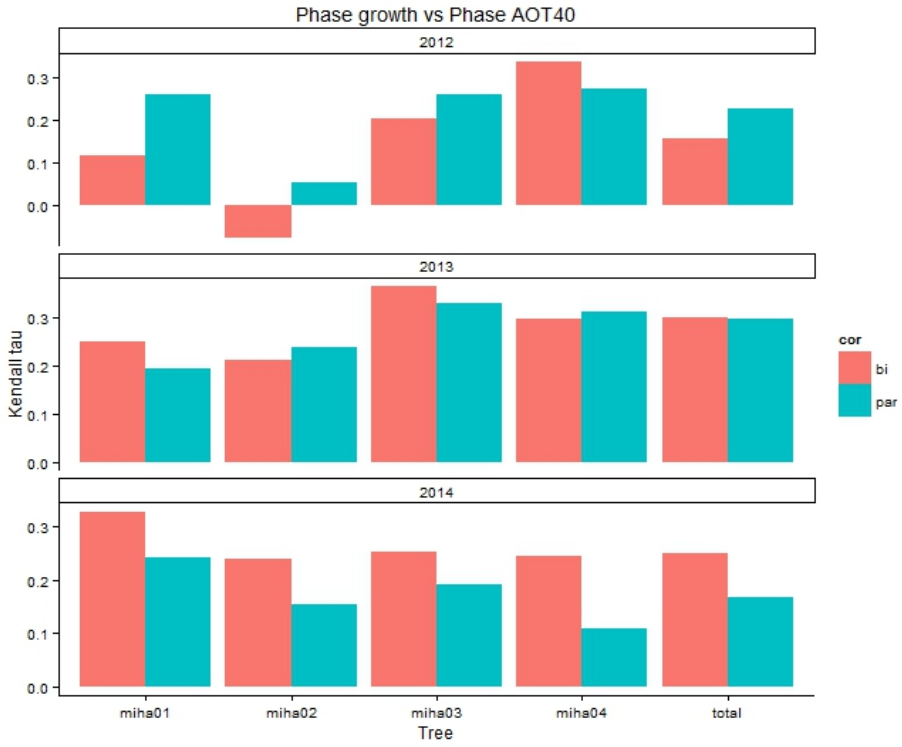
Results

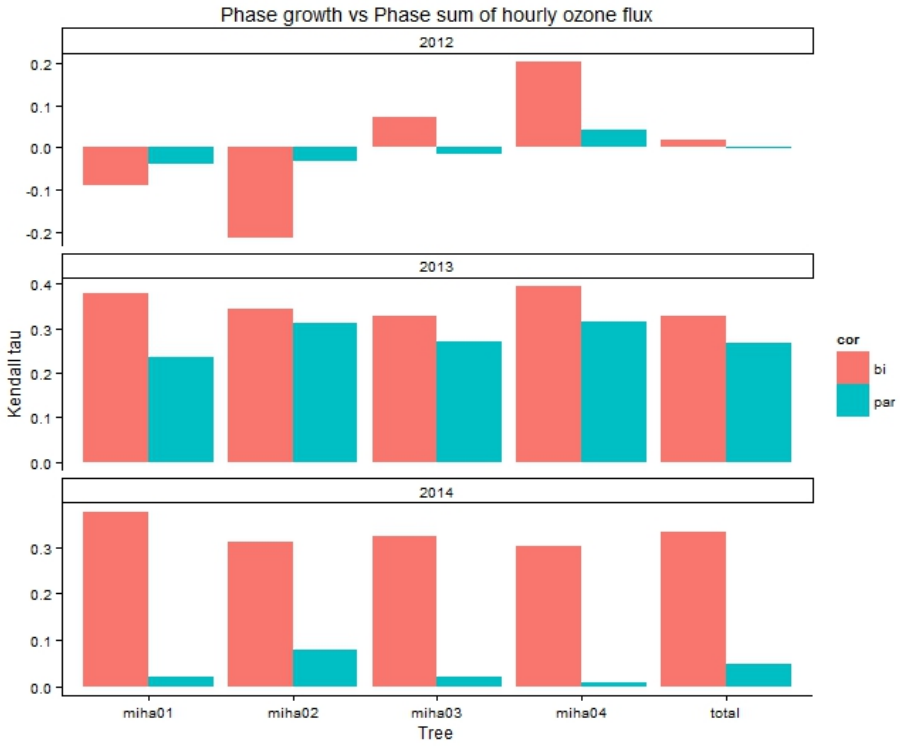
- Kendall correlation: phase II growth from continuous measurements v ozone



Results

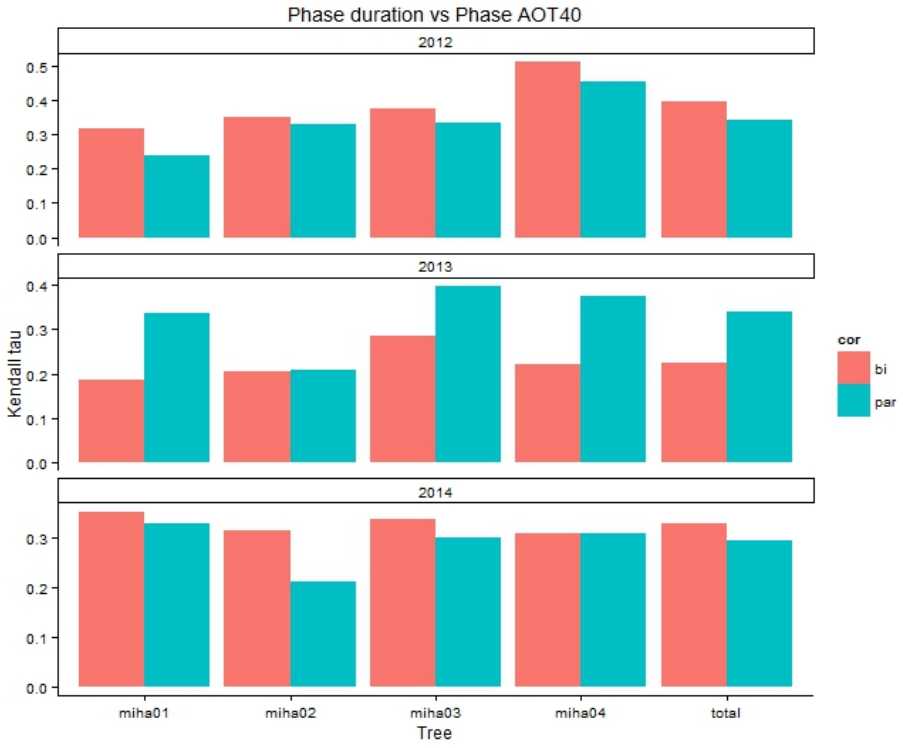
- Kendall correlation: phase III growth from continuous measurements v ozone

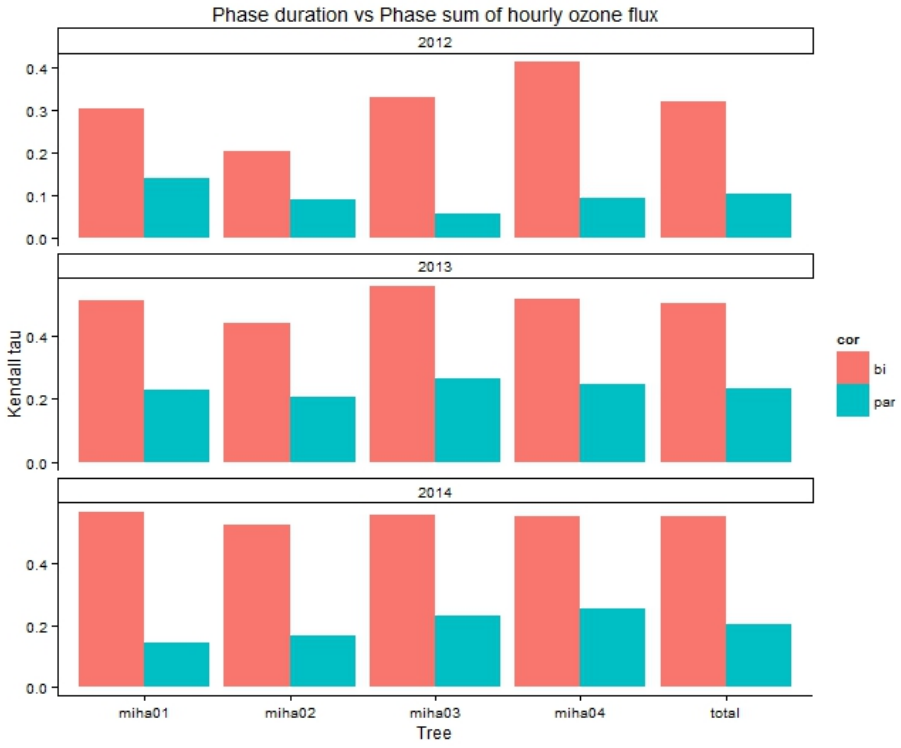




Results

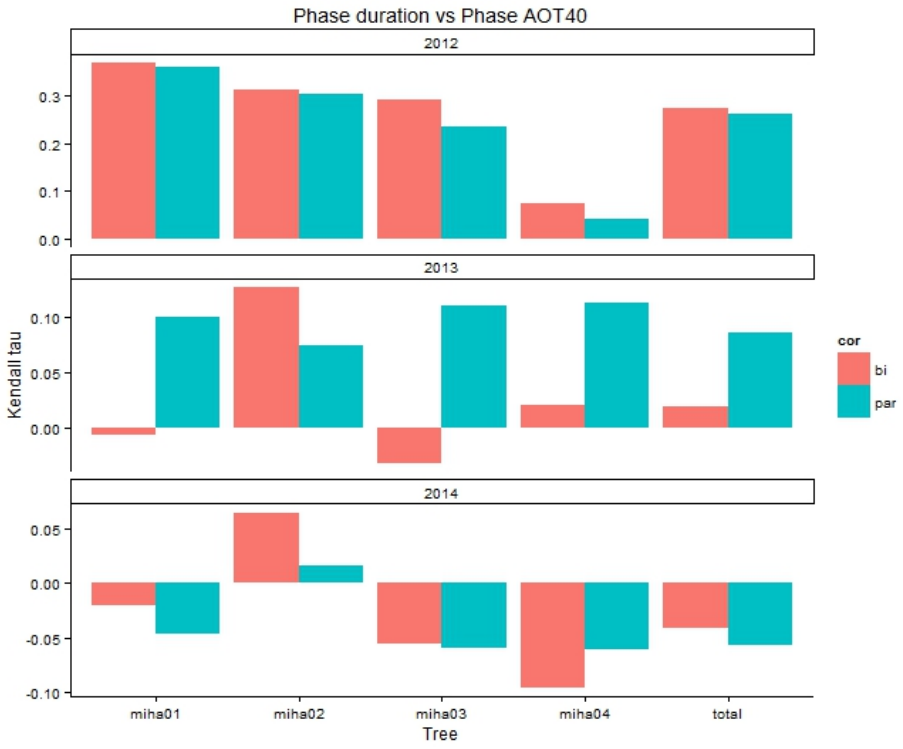
- Kendall correlation: phase I duration from continuous measurements v ozone

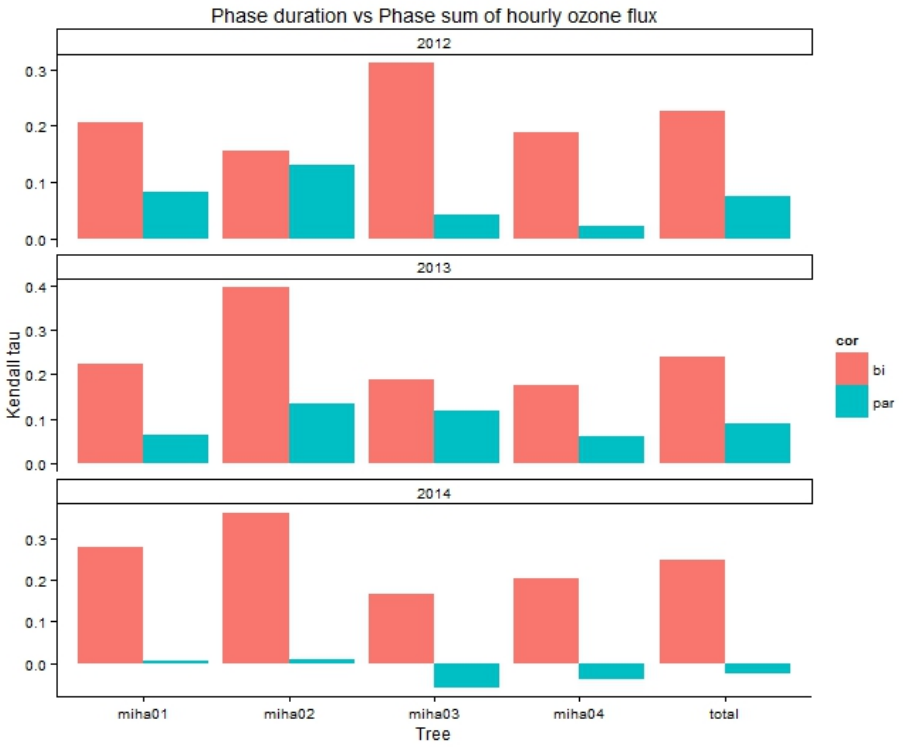




Results

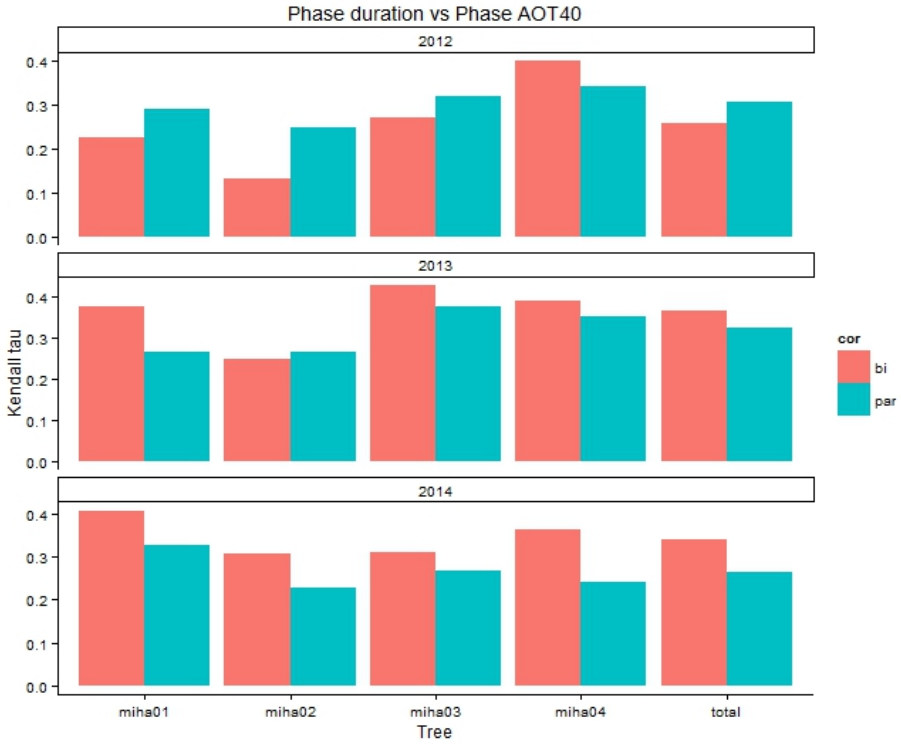
- Kendall correlation: phase II duration from continuous measurements v ozone

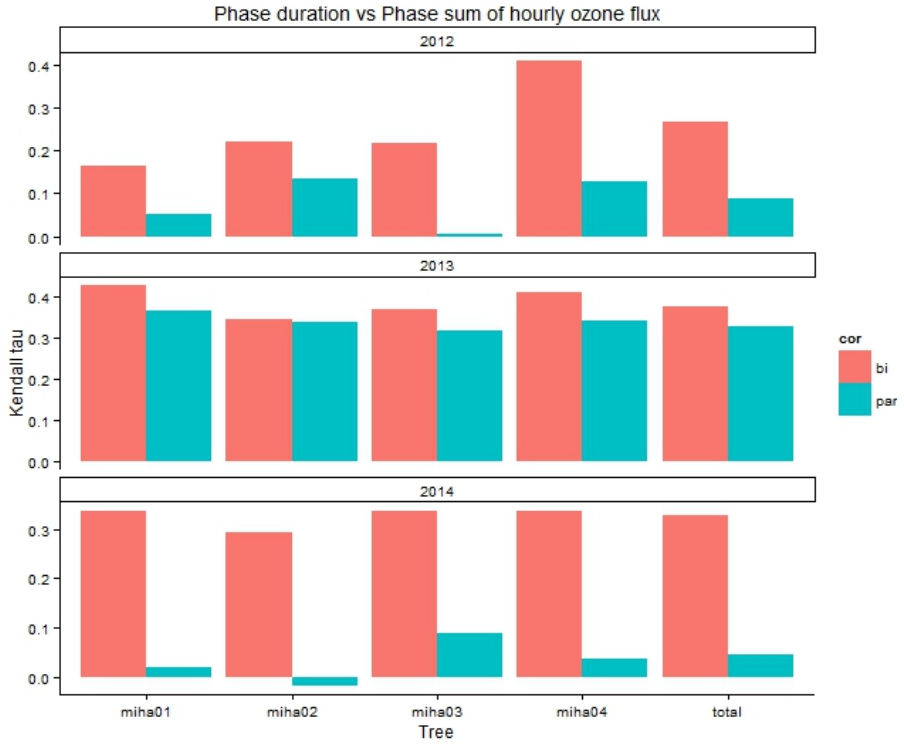




Results

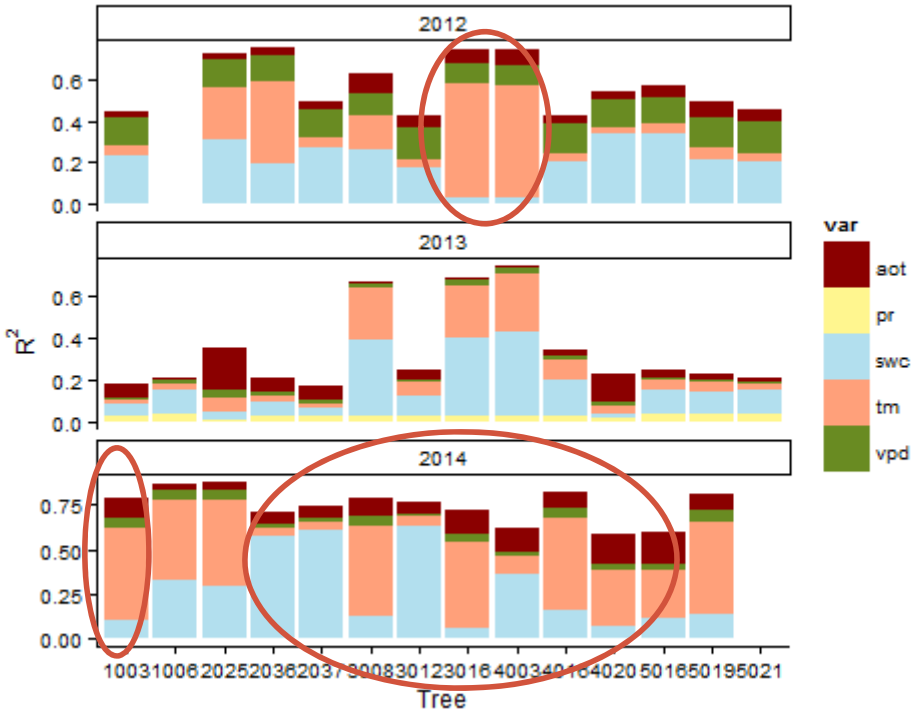
- Kendall correlation: phase III duration from continuous measurements v ozone

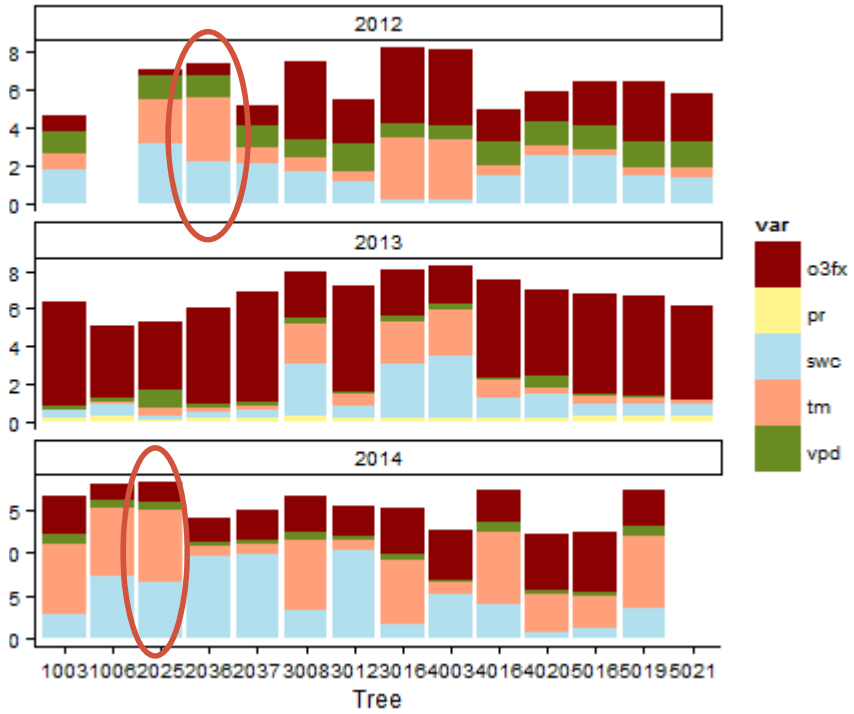




Results

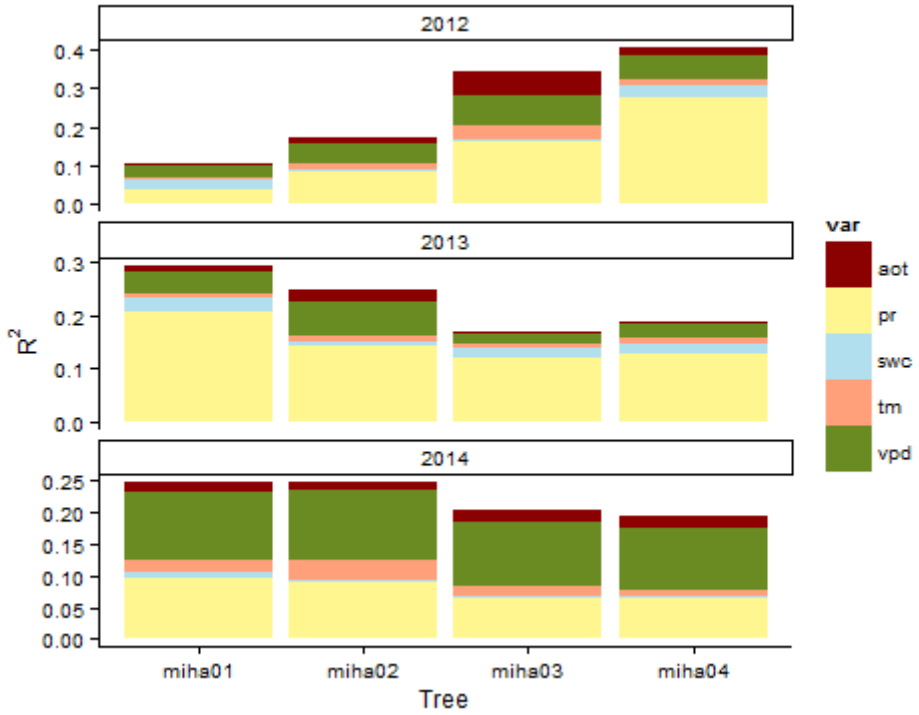
- Daily growth derived from permanent measurements

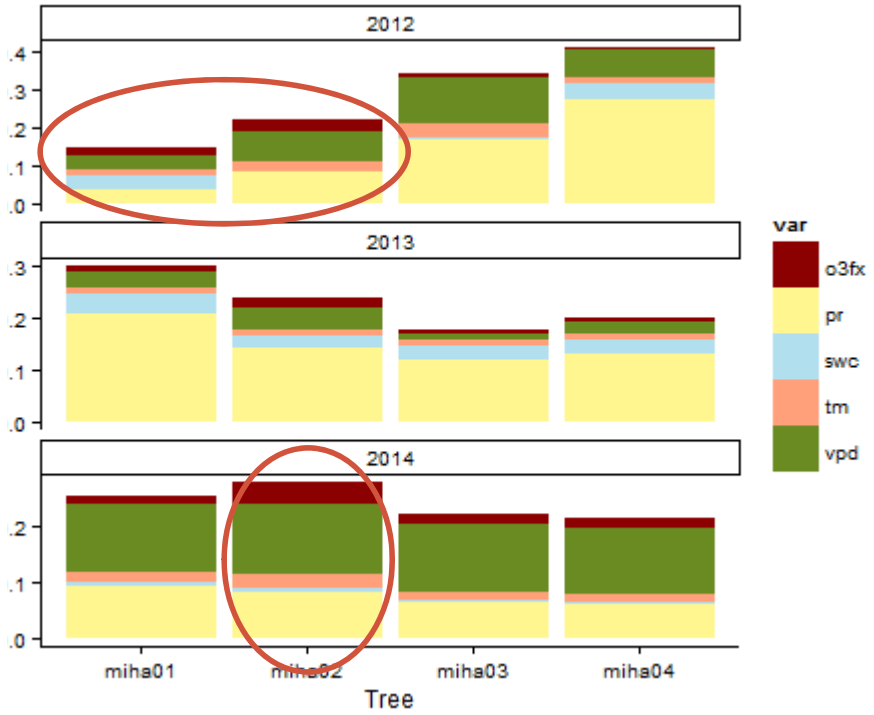




Results

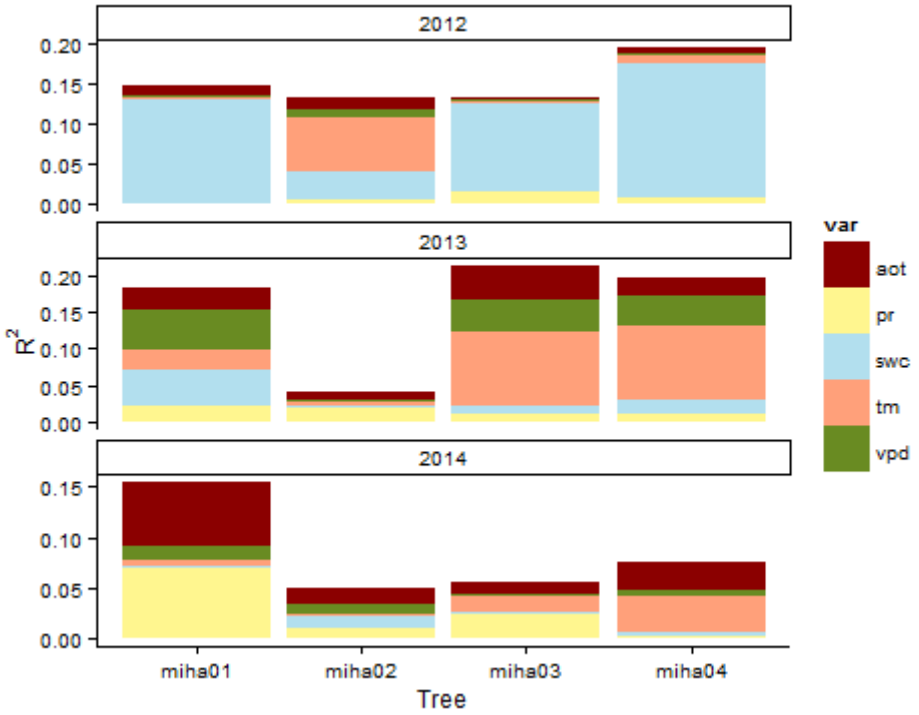
- Daily growth derived from continuous measurements

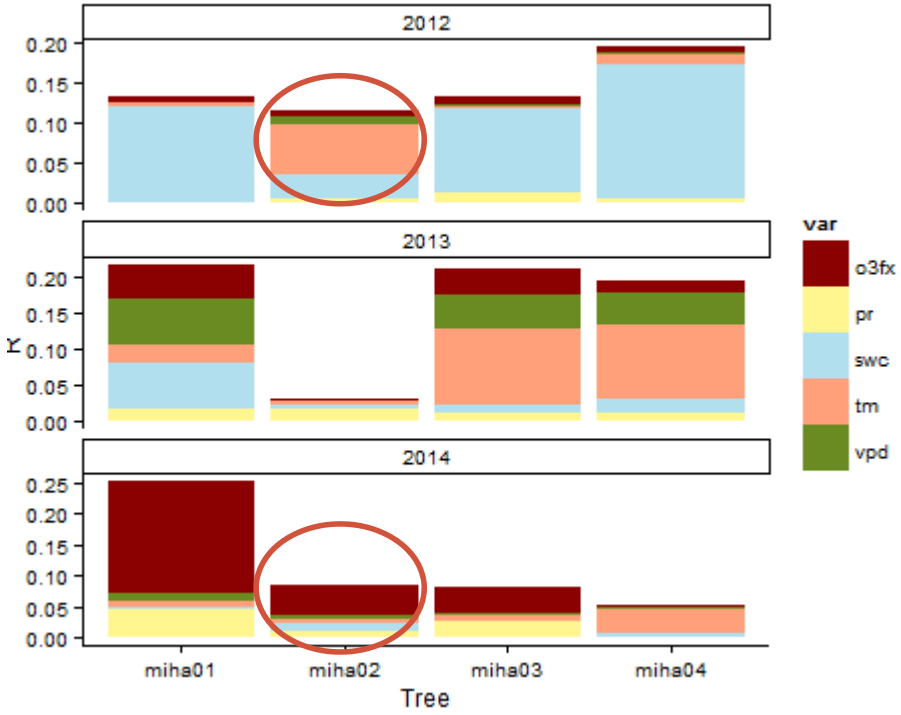




Results

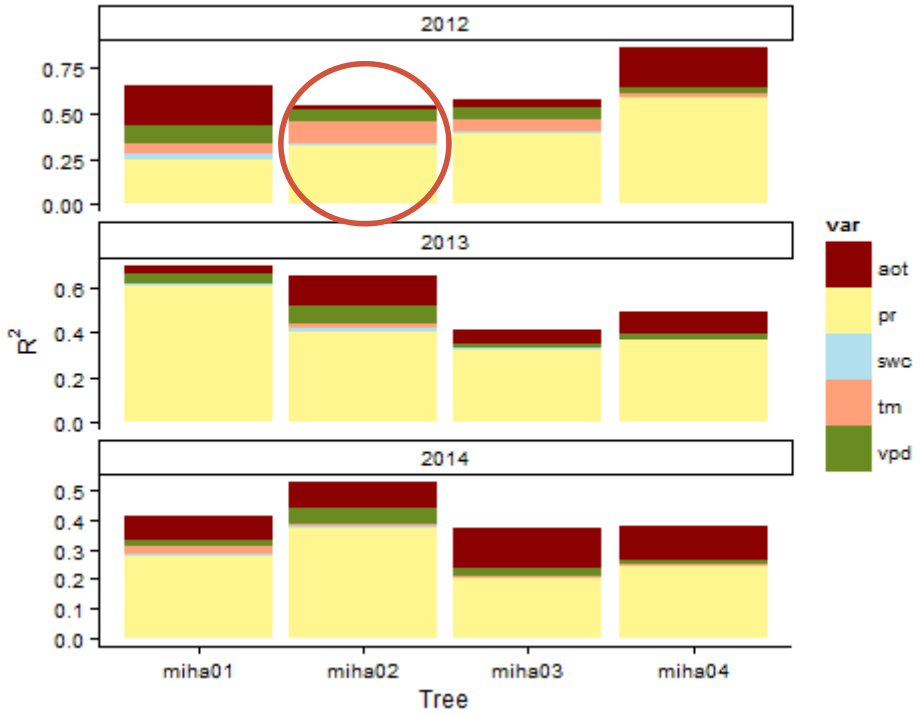
- Phase II growth derived from continuous measurements

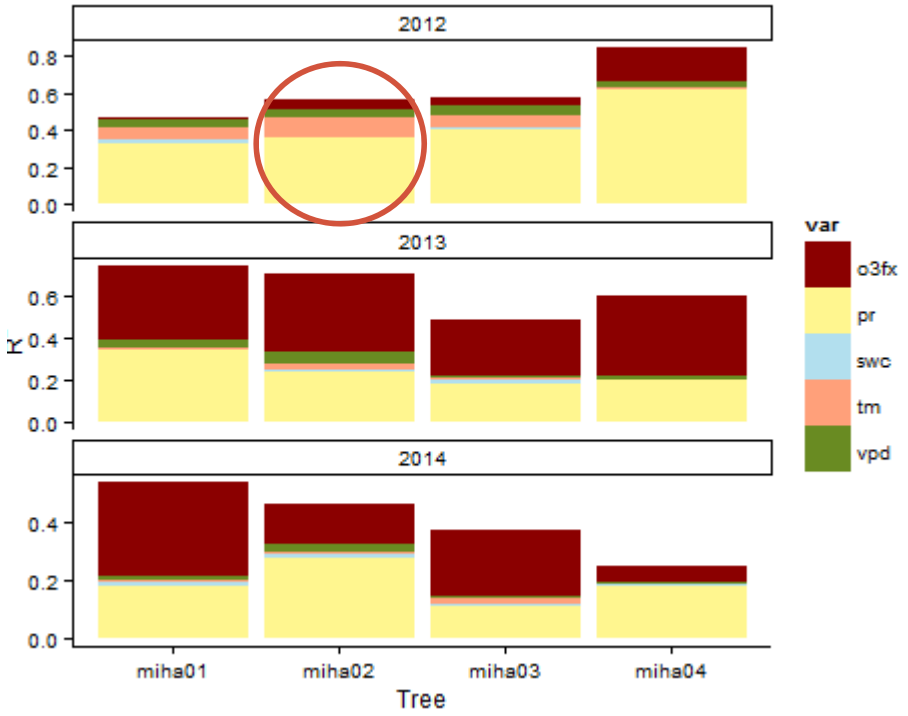




Results

- Phase III growth derived from continuous measurements





Summary

- SWC is the most important limiting factor for stomatal conductance in Mihaesti IM plot, being a critical factor in calculating stomatal ozone fluxes, even in a temperate continental climate

- Although AOT40 calculated for the growing season had decreasing values, from 12.7 ppm h in 2012 to 10.3 ppm h in 2013 and 4.9 ppm h in 2014, POD_0 registered values of 4.9 mmol O_3 m^{-2} in 2012, 5.3 mmol O_3 m^{-2} in 2013 and 10.4 mmol O_3 m^{-2} in 2014.

- There is no consistent response of tree growth to ozone expressed as exposure and uptake, in few cases the correlation having the same direction, although 2012 and 2014 growth proved to be more sensitive to ozone than the one in 2013.

- The relationship between cycardian cycle phase duration and sum of AOT40/sum of hourly ozone fluxes is not conclusive, further analysis must be performed using different expressions of ozone

Summary

- A significant reduction in daily growth due to daily sum of AOT40 was noticed in 13 cases, and due to sum of hourly ozone fluxes in 5 cases.

- The positive influence of ozone flux on tree growth may be explained by the ozone fluxes high correlation and dependency to stomatal conductance.

- The results must be seen as “warning messages”. To correctly assess the influence of ozone uptake on tree growth, local parametrization of DO3SE model is required.

Acknowledgements

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Thank you for your attention!