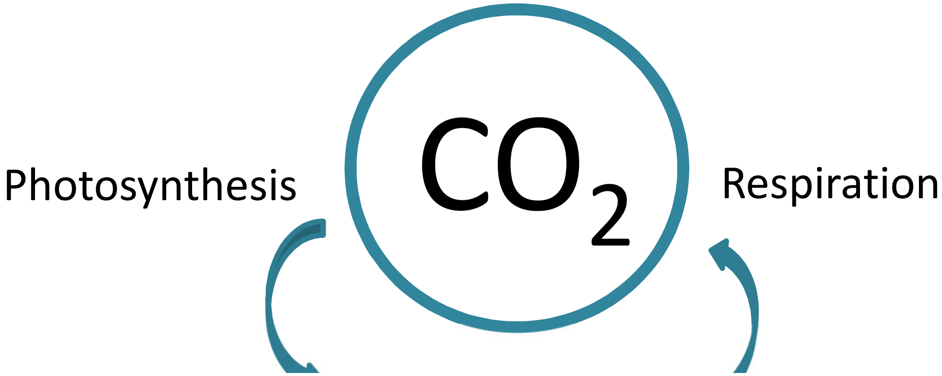
Unraveling the temporal variation in a 16-year net ecosystem exchange time series of a Belgian mixed forest

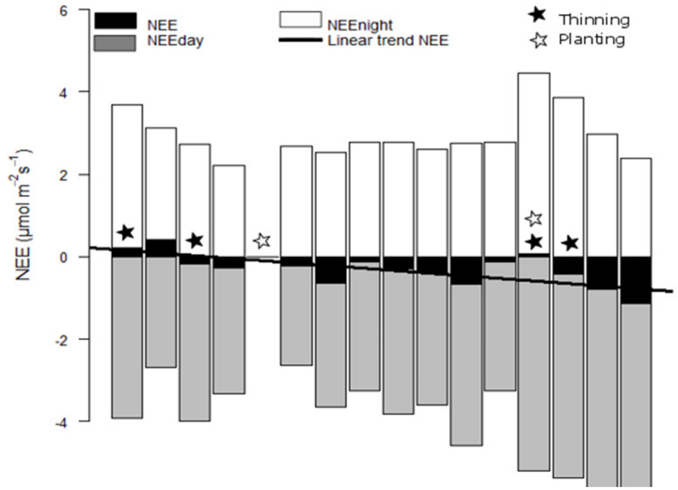
Joanna A. Horemans[1], Ivan A. Janssens[1], Bert Gielen[1], Marilyn Roland[1], Arne Verstraeten[2], Johan Neirynck[2], Reinhart Ceulemans[1]

[1] Centre of Excellence PLECO, Department of Biology, University of Antwerp, Universiteitsplein 1, B-2610 Wilrijk, Belgium
[2]INBO, Research Institute for Nature and Forest, Kliniekstraat 25, 1070 Brussels, Belgium

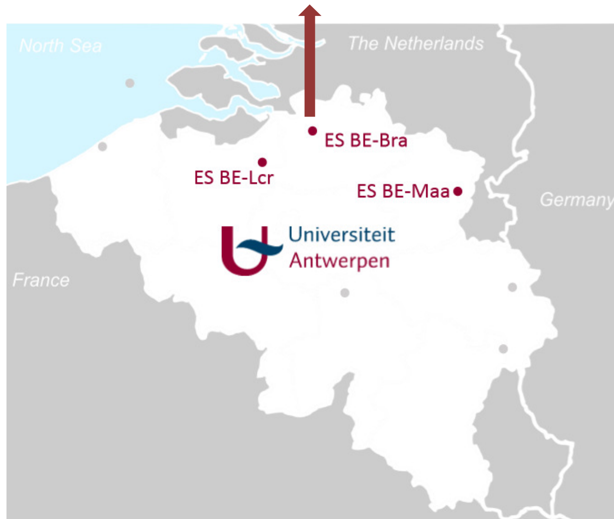
Context and research question

CO_2 net flux = Net Ecosystem Exchange NEE
Negative value = carbon uptake



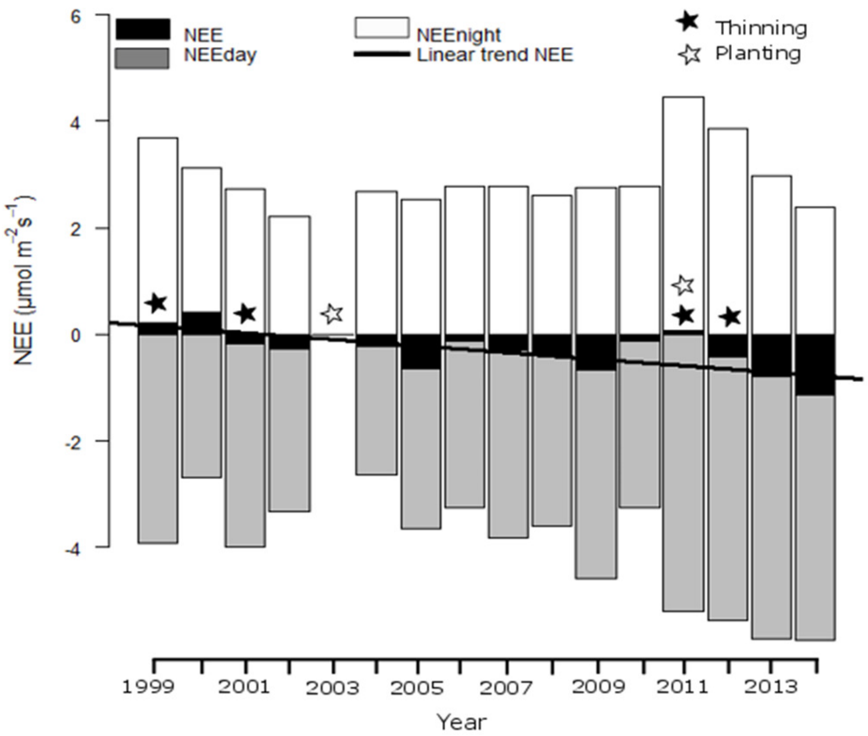


How do we explain the variation in NEE on different temporal scales?

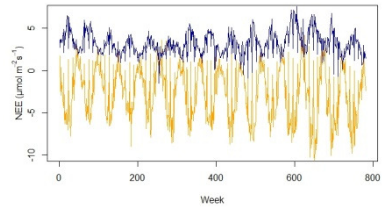


Course of the study

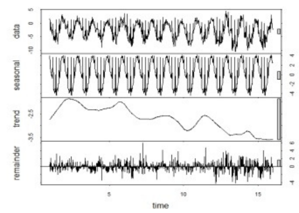
How can we explain the variation in NEE on different temporal scales?



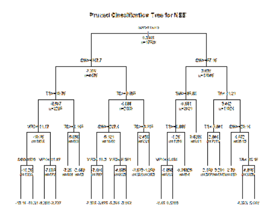
1: data assimilation



2: time series decomposition



3: random forest analysis



Data assimilation

Water availability
Precipitation **PR**
Ground water table depth **GWT**

Atmosphere and soil
Ozone **O3**
Nitric oxide **NO**
Nitrogen dioxide **NO2**
Sulpher dioxide **SO2**
Carbon dioxide **CO2**
pH soil
ANC soil

Photosynthesis and respiration
Enhanced Vegetation index **EVI**
respiration **INTlc** at 0 wm^{-2}
Quantum yield **QY**
optimum **GPPopt** at an *Rg* value of 1000 Wm−2.

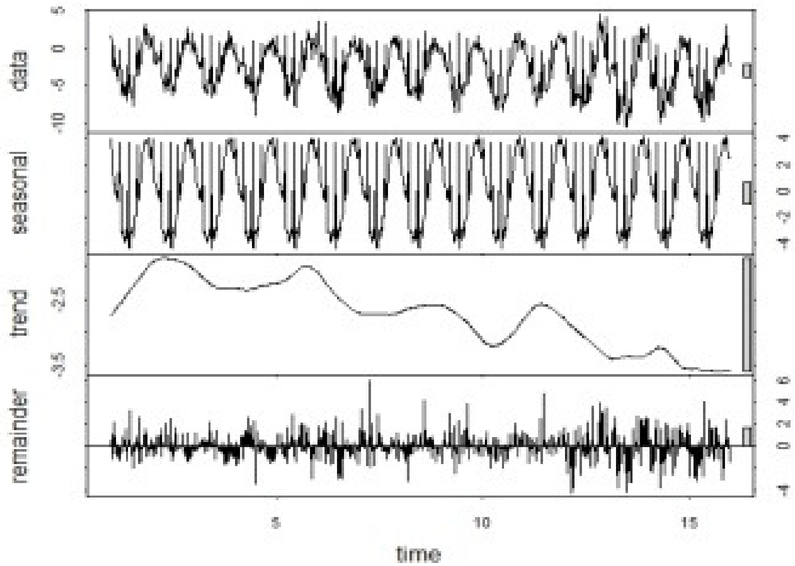
$$NEE = \frac{-QY * R_g}{1 - (R_g/1000) + (QY * R_g/GPP_{opt})} + INT_{lc}$$

Meteorology
Air temperature **TA**
Soil temperature **TS**
Maximal wind speed **WS**
Vapor pressure deficit **VPD**
Day
Shortwave incoming radiation
SW
Cloudiness **CLO**

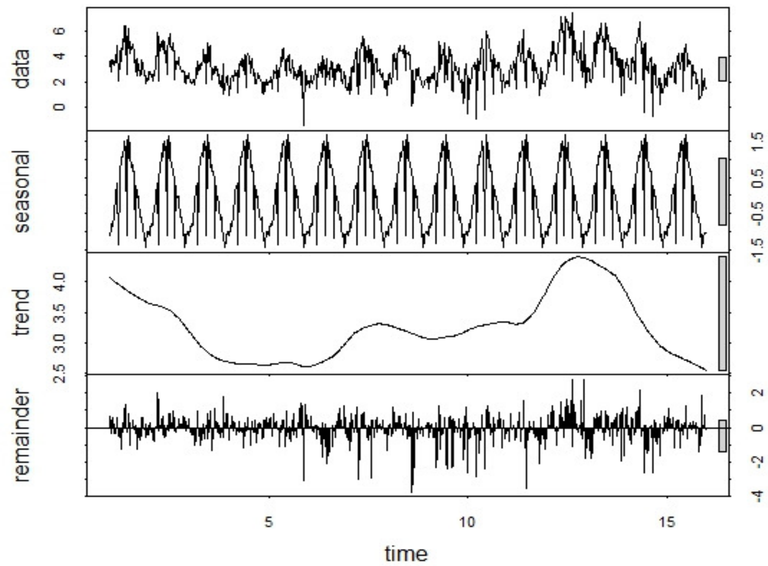
Time series decomposition

Weekly time series of NEE_{day} + 19 drivers

Weekly time series of NEE_{night} + 17 drivers



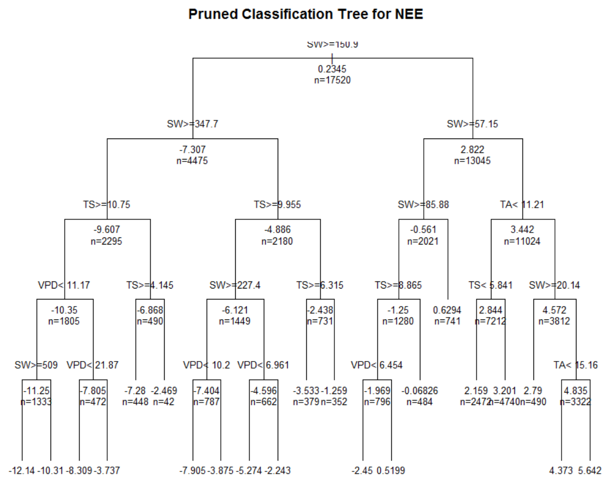
60 weekly time series



54 weekly time series

Random forest analysis

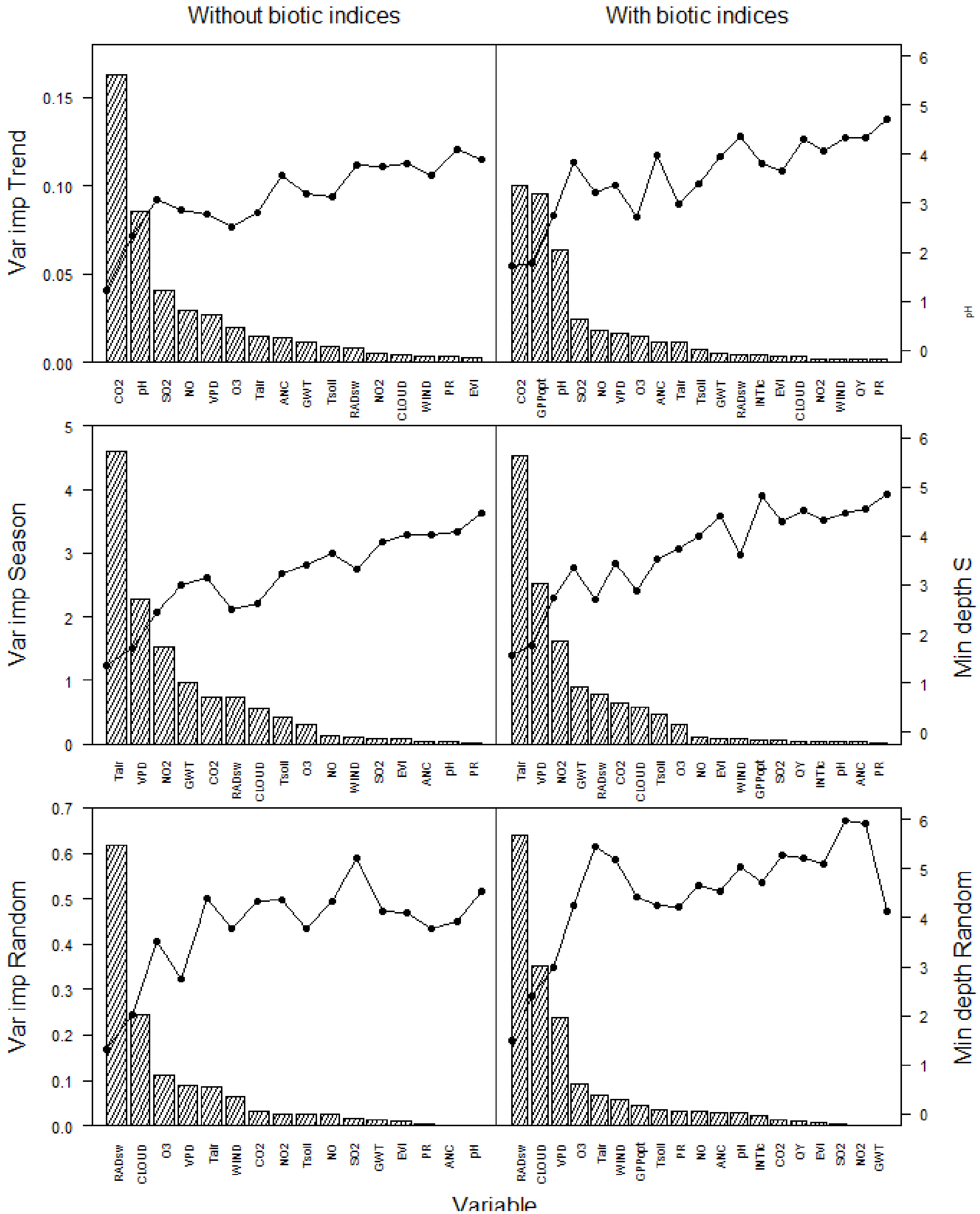
Non-parametric statistical technique aiming to optimize a model to explain the variance in the response variable by fitting an ensemble of regression trees (1000 trees)



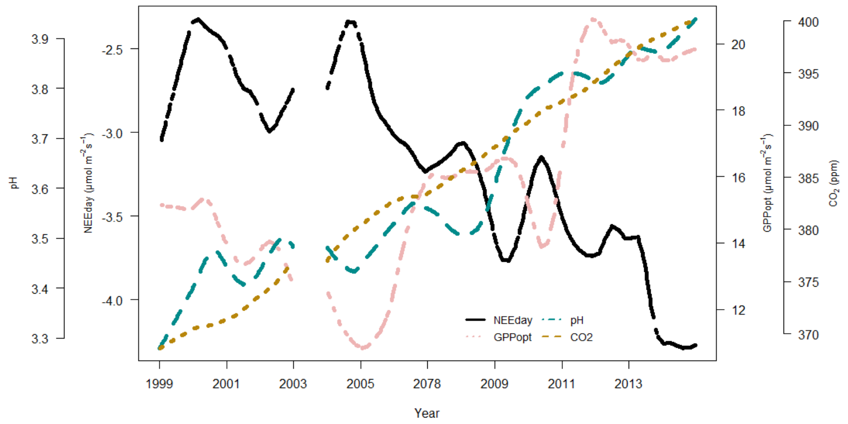
Variance importance (Vimp):
difference between prediction error when var x_i is noised up by randomly permuting its values, compared to prediction error under the observed values

Minimal depth (MinD):
average of the depth of the first split for var x_i over all trees in the forest

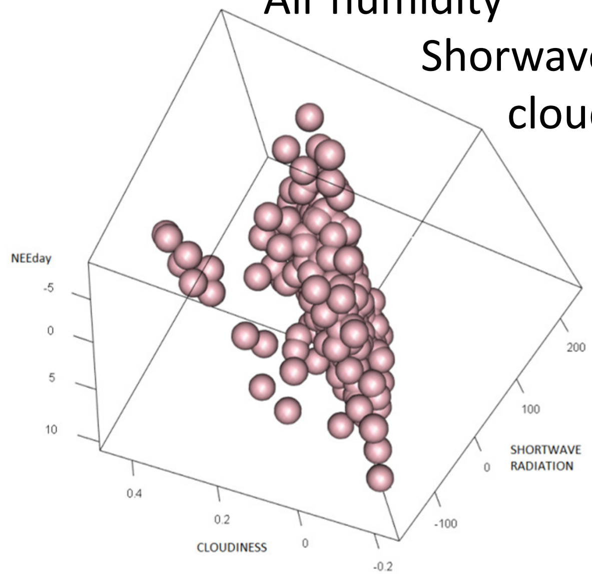
Results daytime NEE



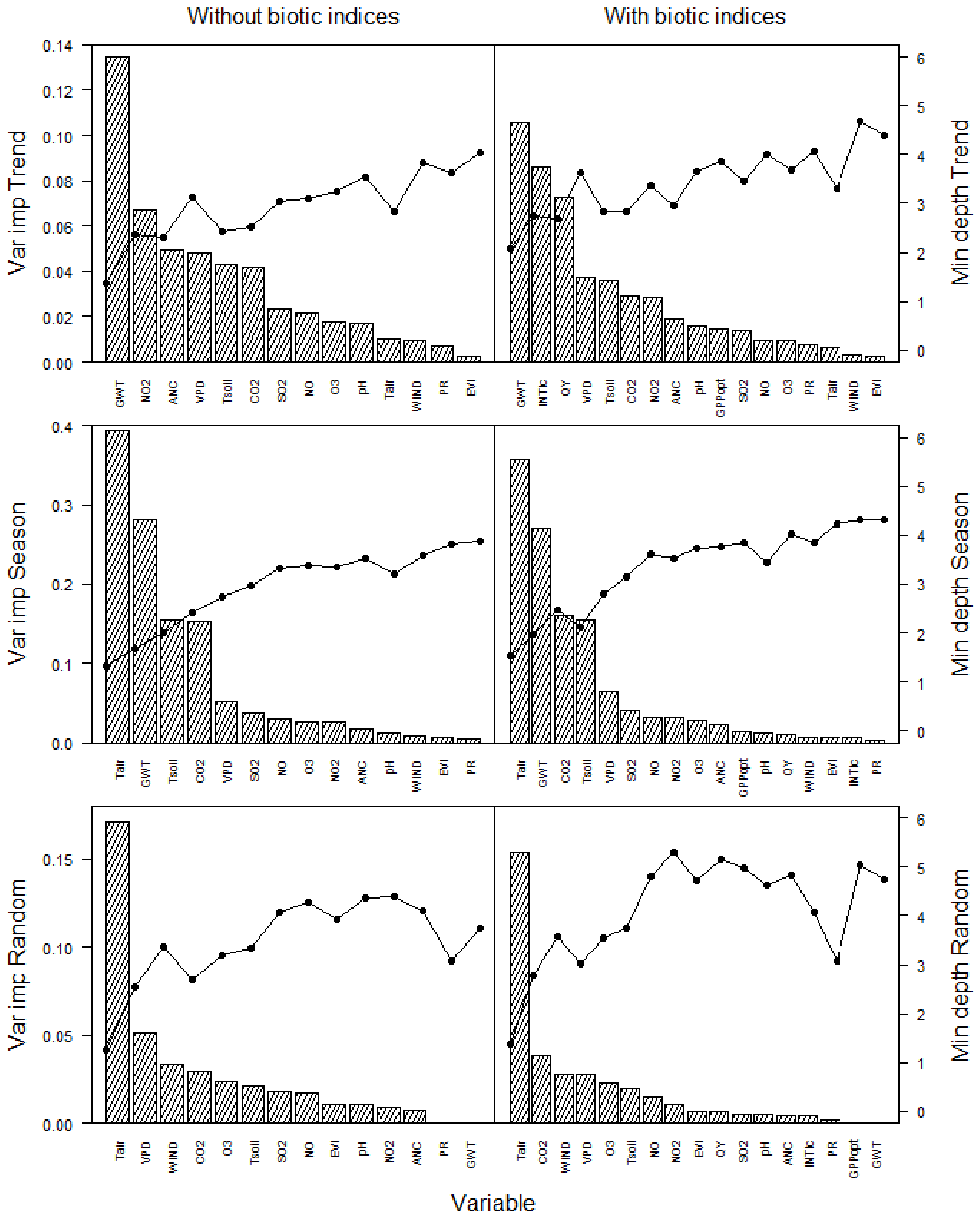
C02 concentration,Soil solution acidity,



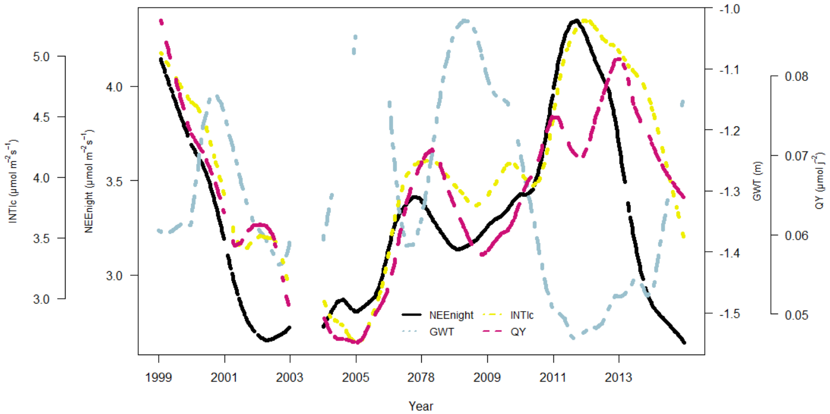
Air temperature
Air humidity
Shorwave radiation
cloudiness



Results nighttime NEE

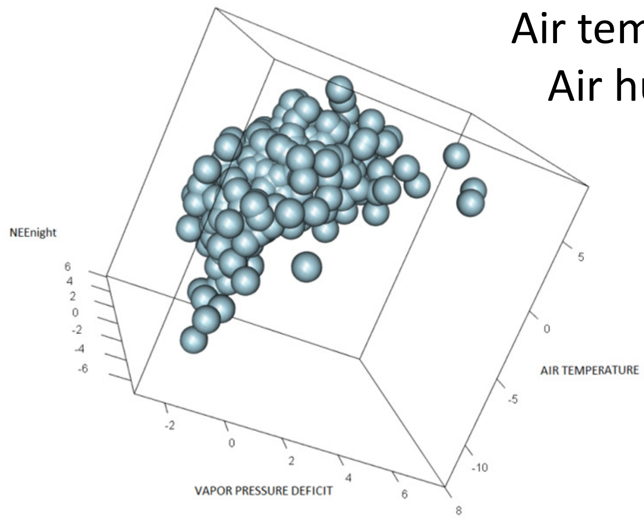


Groundwater table depth
Physiological state



Air temperature
Groundwater table depth

Air temperature
Air humidity



Conclusion and limitations

The new methodology, i.e. combining time series decomposition and random forest analysis is an excellent tool for studying NEE drivers of a forest.

Drivers of NEE change with temporal scales

Uncertainty NEE not taken into account

Causality drivers -> NEE not proved

Only true for this forest?

Perspectives

We expect the drivers to be spatially heterogeneous. The same work on many different locations would lead to more insight in the global carbon balance

This study gives valuable information for model development, needed to make projections of forest responses to climate change.

The results show that forest models should take into account the change in NEE drivers over different temporal scales and the changes in the forests physiological state over longer time scales.

THANK YOU