Uncertainty to sources of ozone and vegetation data for estimating $POD_{1\text{-}SPEC}$

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Impacts of ozone on tree functions and forest growth

As a strong oxidant, ozone has a negative impact on many cellular and molecular processes

Tree biomass is consequently reduced, with a lower magnitude for evergreen species

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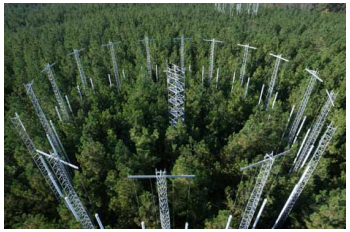

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Ferretti et al. 2018
Wittig et al. 2009

For adult trees, growth is mainly sink-driven

Körner 2015

Other environmental factors may have a stronger impact

Acclimation and compensatory processes

See Cailleret et al. 2018

Context

Considering that the effects of ozone on forest growth are most likely reduced, we need robust ozone metrics

- Concentration-based approach (e.g, mean $[O_3]$, AOT_{40})
- Flux-based approach (e.g, $POD_{y\text{-}SPEC}$)

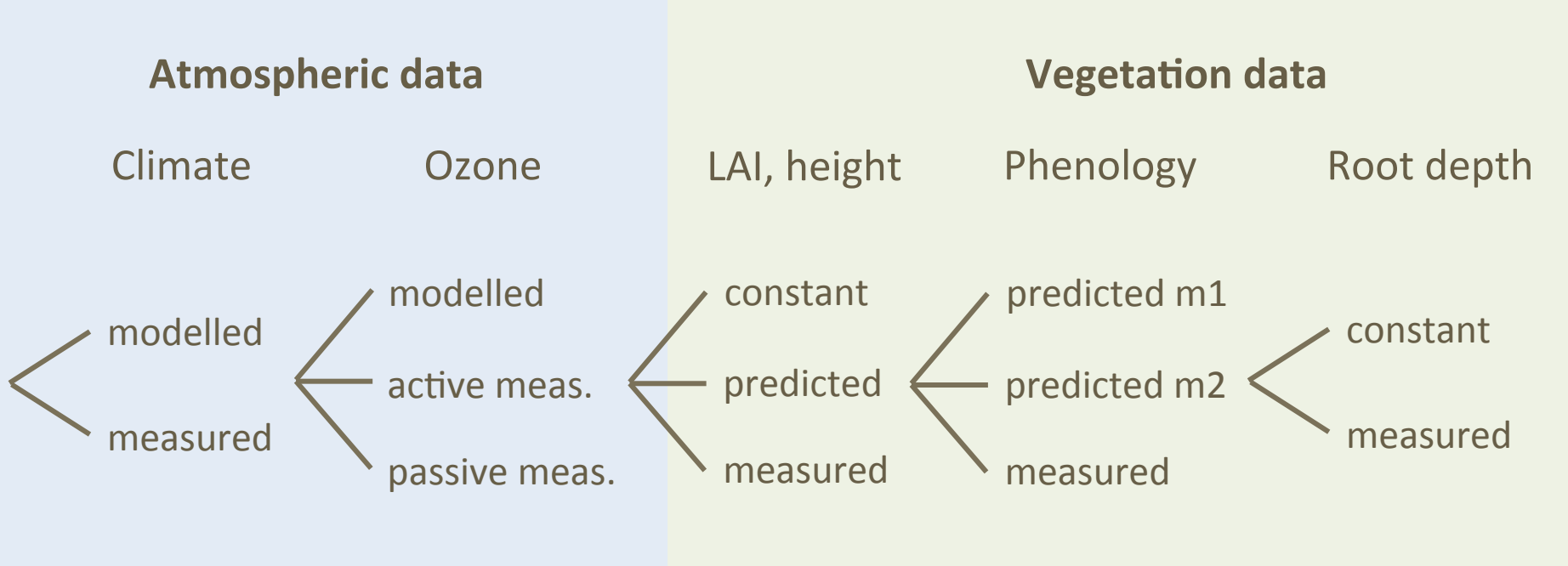
There are various sources of uncertainty that may affect the precision of these metrics :

Input data	Model structure	Parameter estimates

Detecting the most important sources of uncertainty provides us research directions to improve our modeling framework

Sources of uncertainty in the calculation of $POD_{1\text{-}SPEC}$

Cascade of uncertainty for a given site and species



+ soil properties, stomatal model, species-specific parameters…

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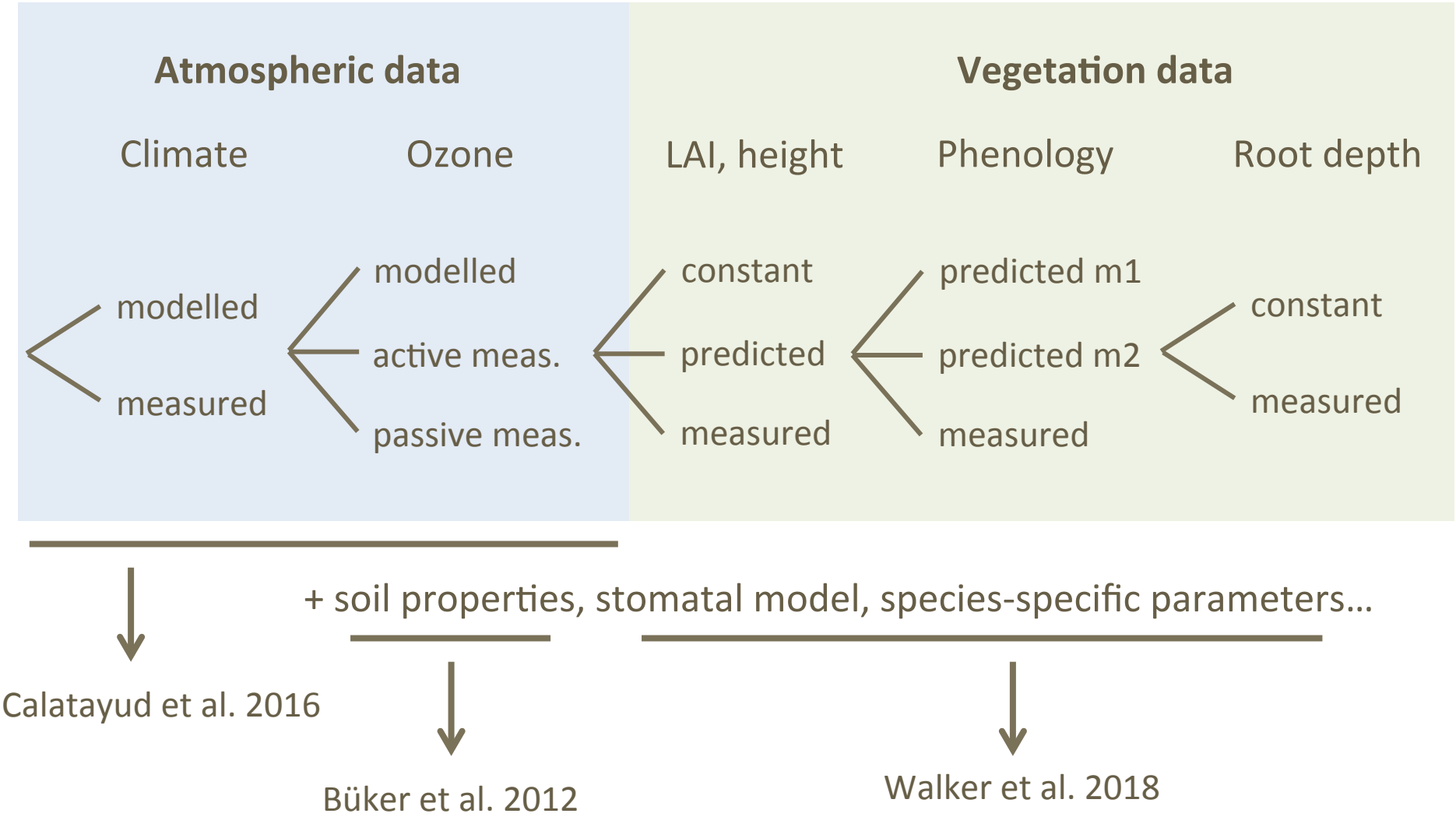
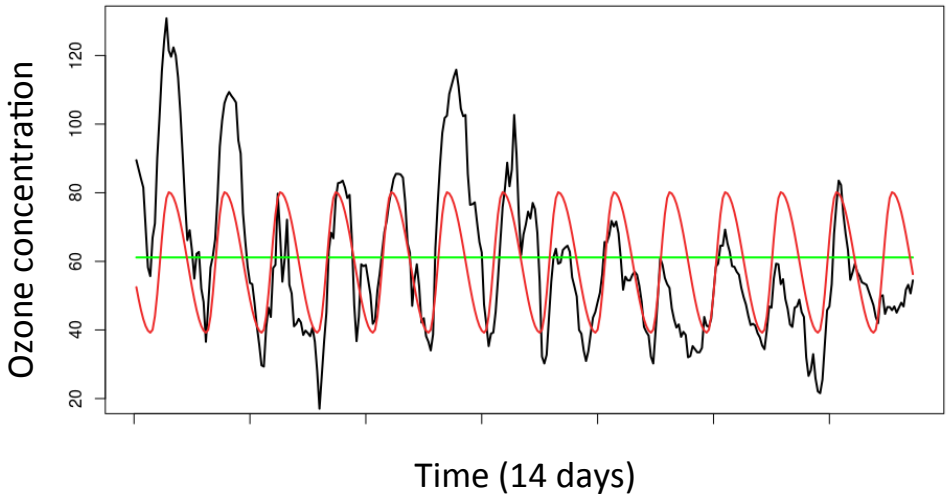


Sources of uncertainty in data input considered here

Atmospheric data

Climate — Ozone

measured
- meas. hourly (active)
- predicted hourly (2 weeks passive)



Measured hourly data (active)

Constant 2-weeks mean (passive)

Reconstructed (passive; 3-parameters cos function)

Sources of uncertainty in data input considered here

Atmospheric data

Climate

measured

Ozone

- meas. hourly (active)
- predicted hourly (2 weeks passive)

Vegetation data

LAI, height

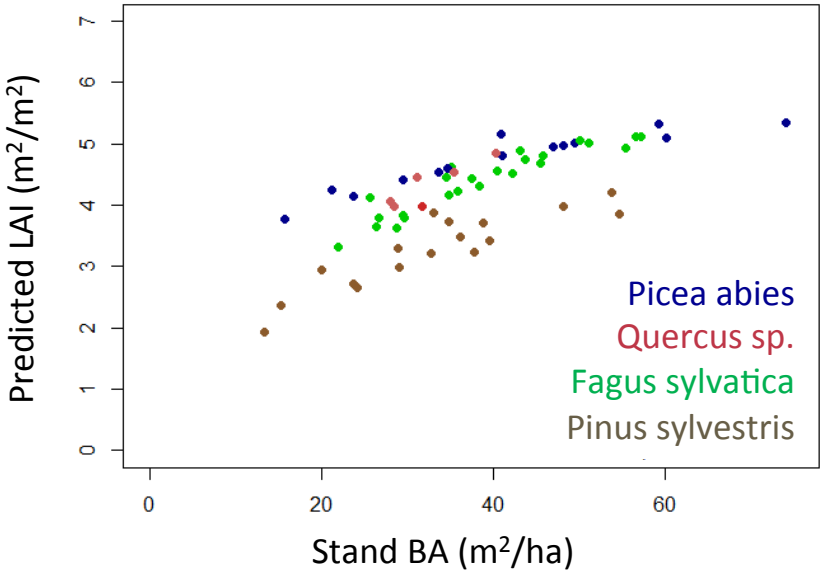
- constant
- predicted (tree DBH)

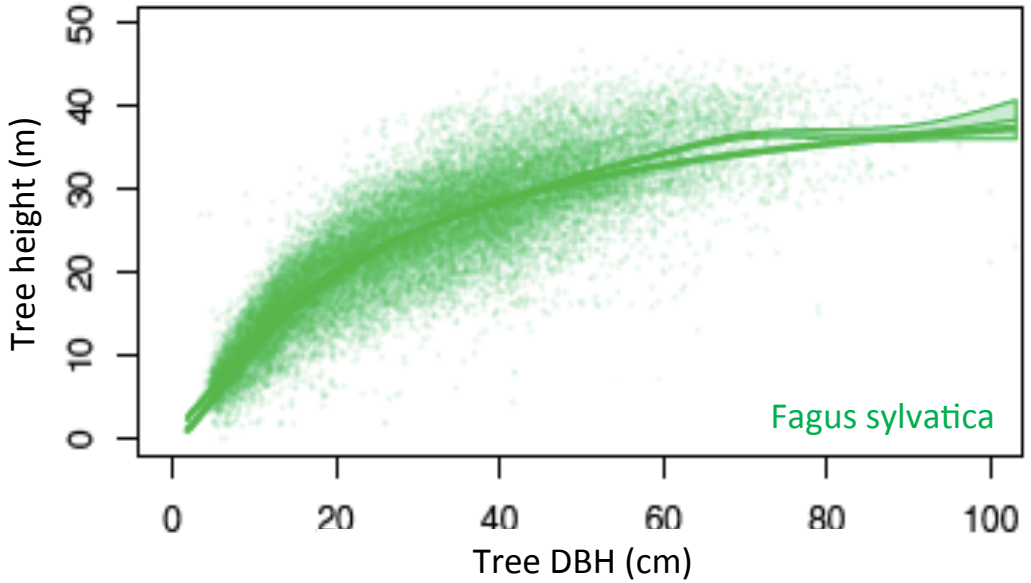
Phenology

- predicted 'forest latitude'
- predicted Delpierre et al. 2009 Vitasse et al. 2011

Root depth

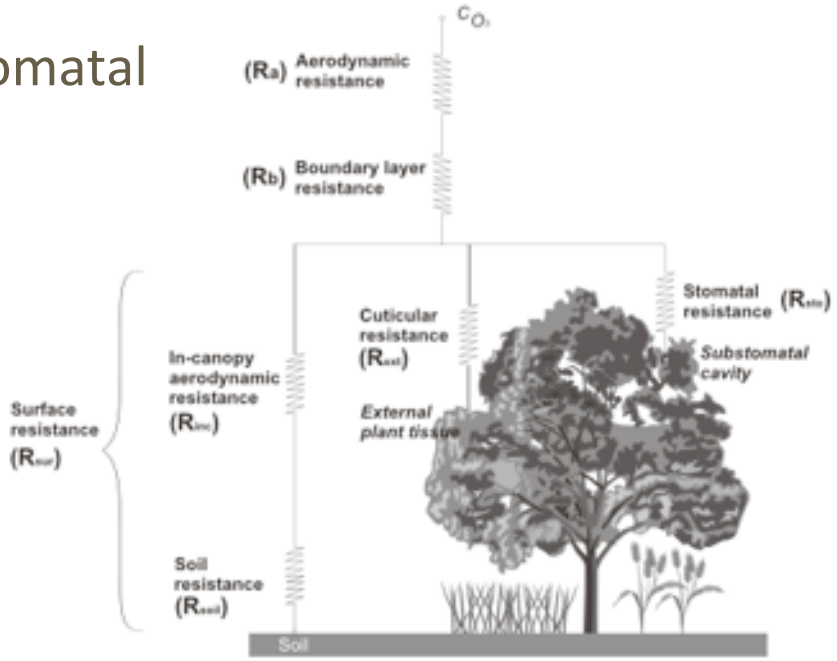
- constant
- measured





Approach: multifactorial simulation design

- DO_3SE model : Deposition for Ozone Stomatal Exchange (Emberson et al. 2001)
- 10 sites, 74 sites*years
- 4 species with varying leaf and stomatal strategies

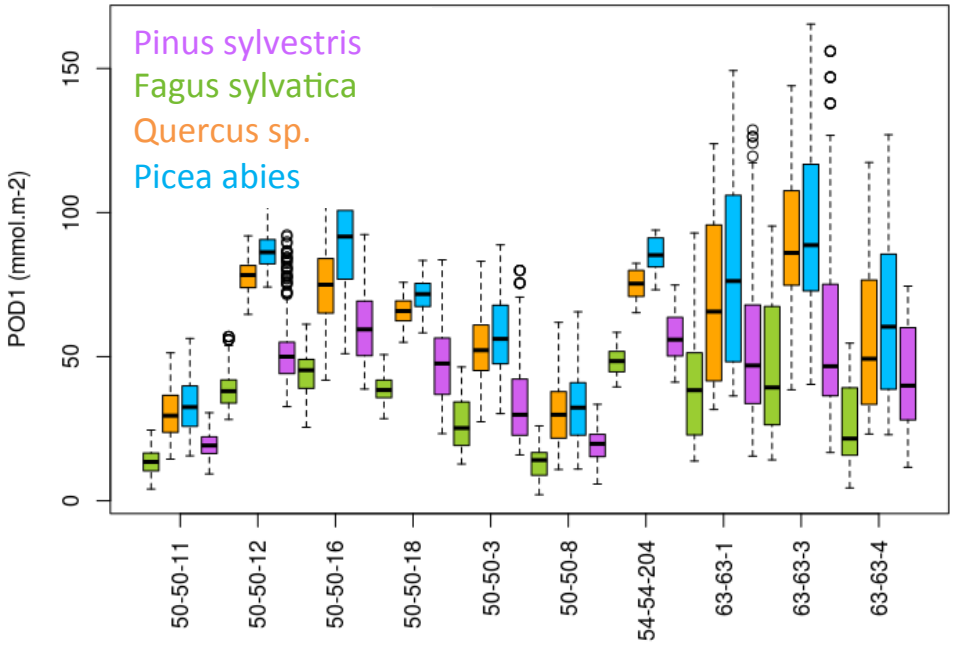


- Multifactorial simulation design -> 14208 runs
- Variance decomposition of $POD_{1\text{-}SPEC}$ values based on the sum of squares of an anova (see Horemans et al. 2016)

Results: variability in $POD_{1\text{-}SPEC}$ accross all simulations

Major sources of variability:

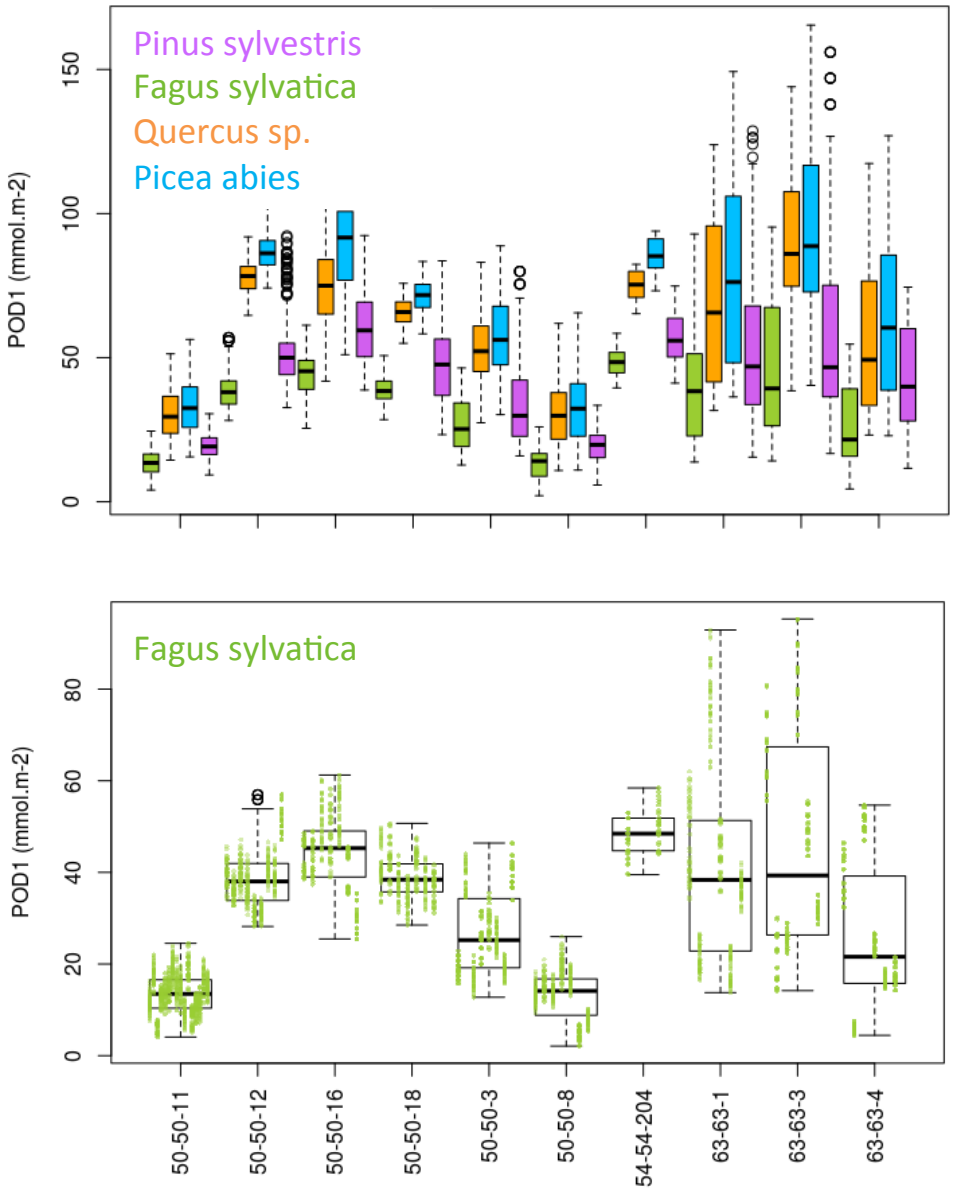
- Site (42%)
- Species (24%)



Results: variability in $POD_{1\text{-}SPEC}$ accross all simulations

Major sources of variability:

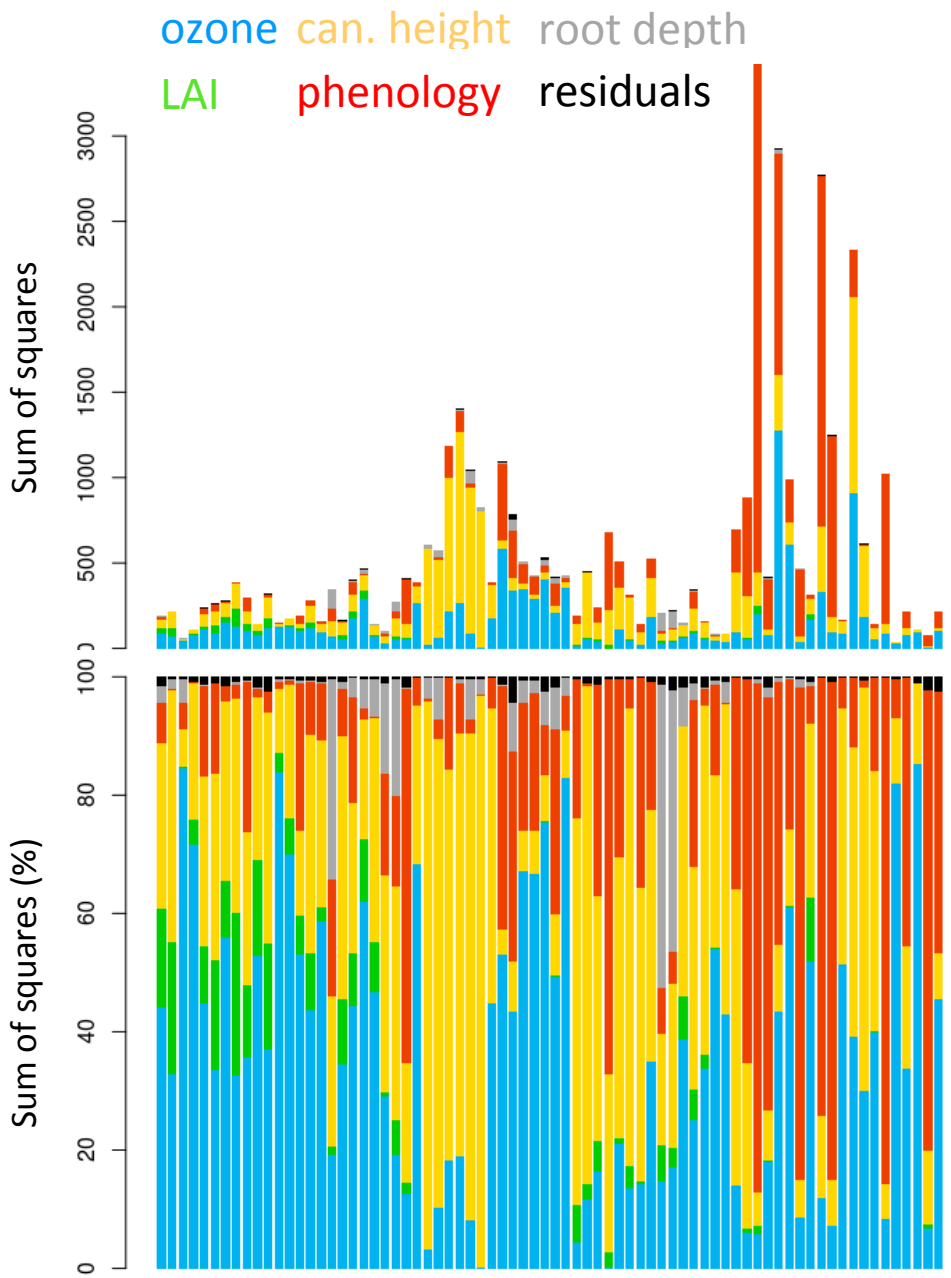
- Site (42%)
- Species (24%)
- Year nested in site (24%)
- Sources of ozone and vegetation input data (5%)



Uncertainty due to data inputs for Fagus sylvatica

High variability in $POD_{1\text{-}SPEC}$ at some sites*years due to the uncertainty in phenological predictions

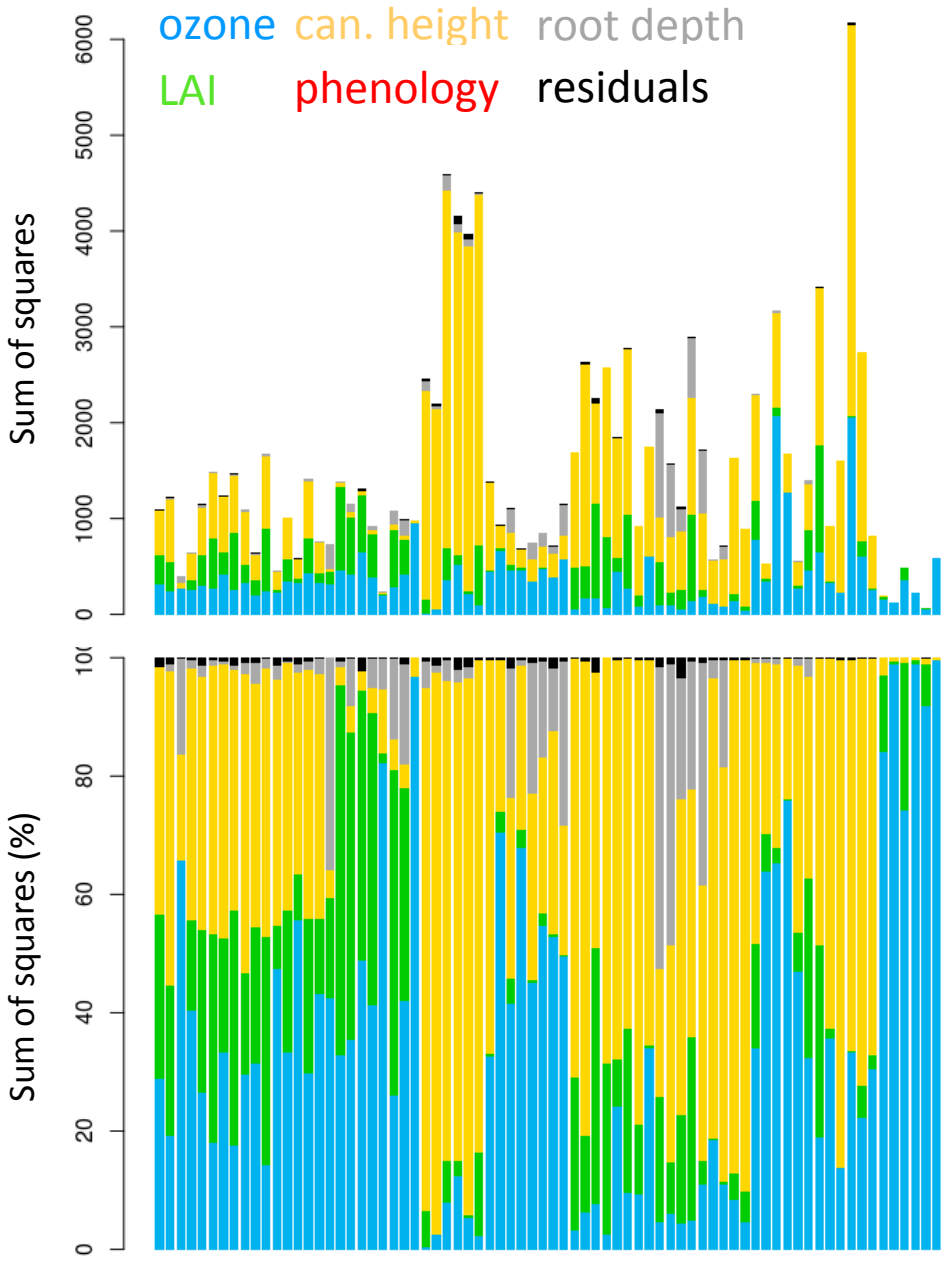
The relative impact of each uncertainty source strongly differs among sites and years



Uncertainty due to data inputs for Picea abies

No impact of phenology

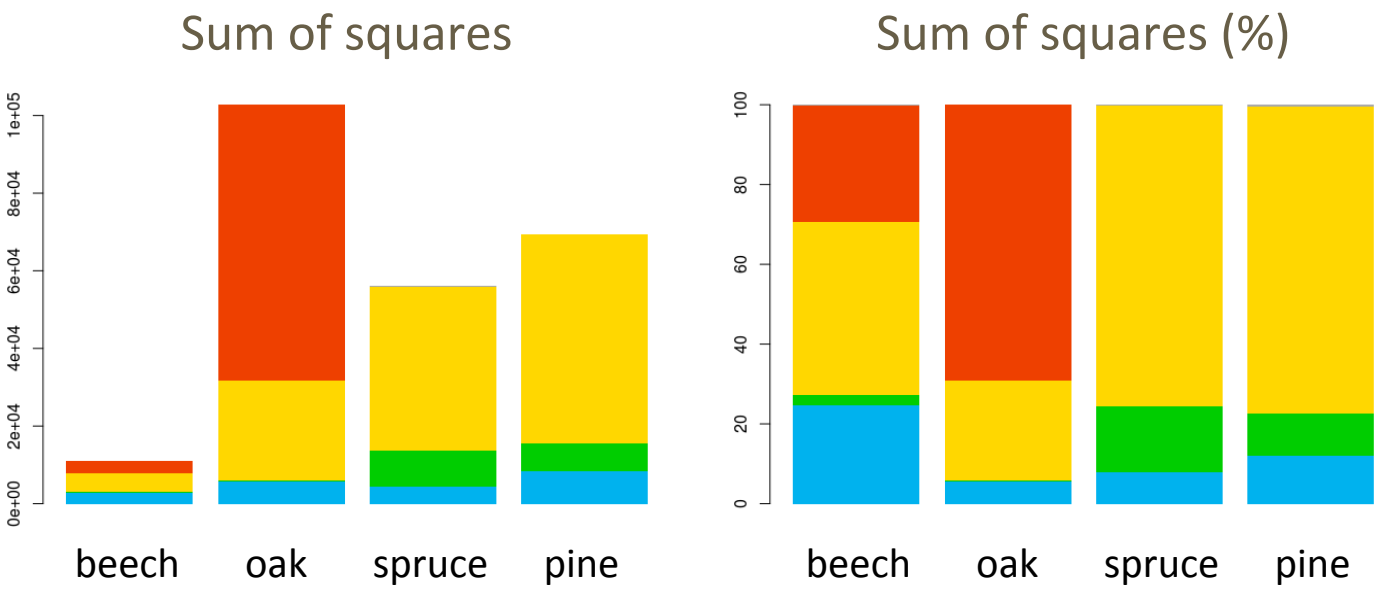
The relative impact of each uncertainty source strongly differs among sites



Uncertainty due to data inputs for all species

ozone can. height root depth
LAI phenology residuals

$POD_{1\text{-}SPEC}$



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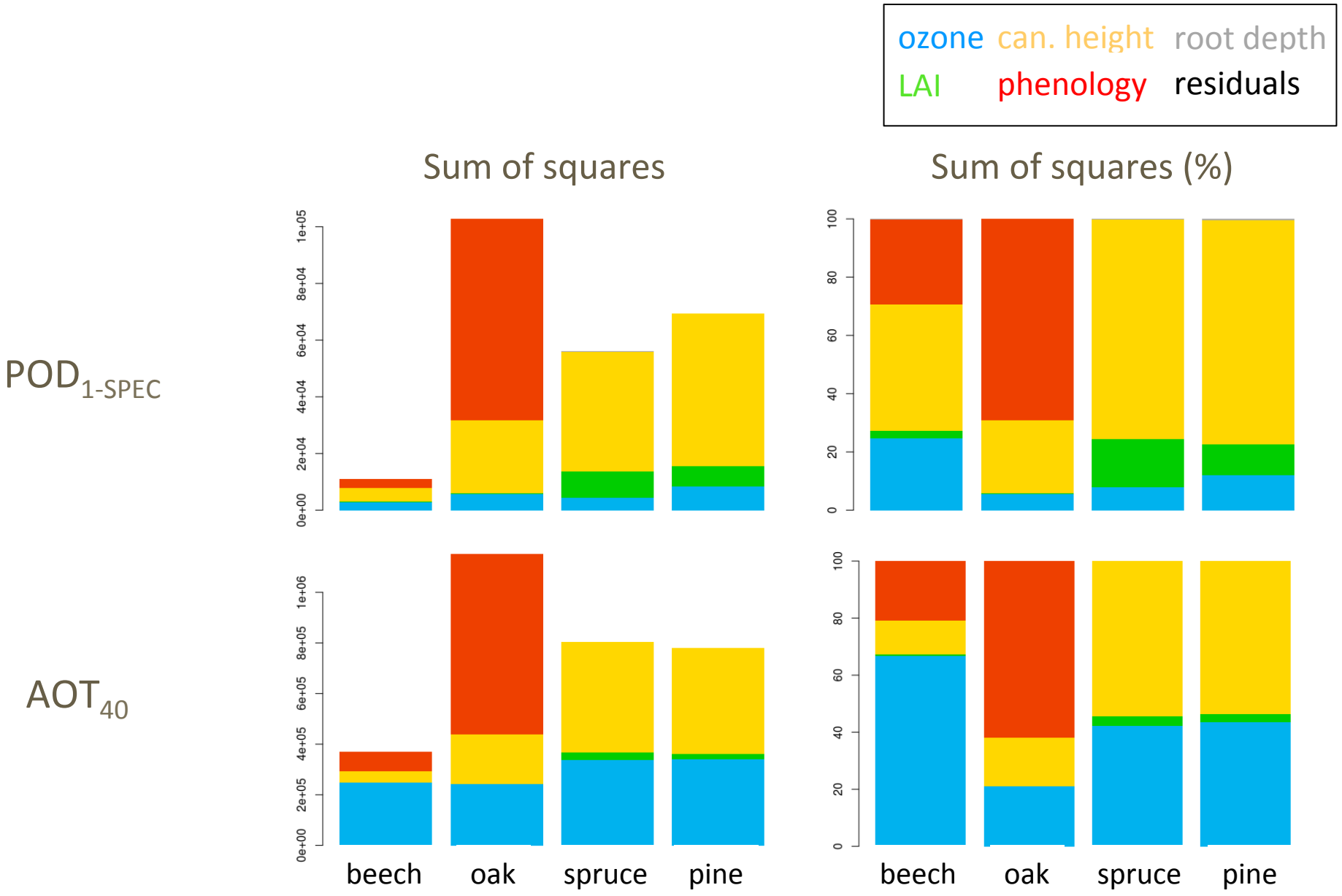

Take home messages - perspectives

Each source of uncertainty matters! This depends on the species, site, and ozone metric of interest.

Ozone data is not the main source of uncertainty for $POD_{1\text{-}SPEC}$. Passive data are highly valuable to increase the spatial and temporal data coverage

Highlights the need for 'ensemble modeling' approaches to derive robust O3 metrics and to assess their uncertainties.

Preliminary results !

- more uncertainty sources (e.g., modeled climate and ozone data from EMEP)
- Include more sites -> currently in progress (PRO_3FILE project), but we need more (clean) hourly climate, and ozone data !

Uncertainty to ozone and vegetation data sources for estimating $POD_{1\text{-}SPEC}$

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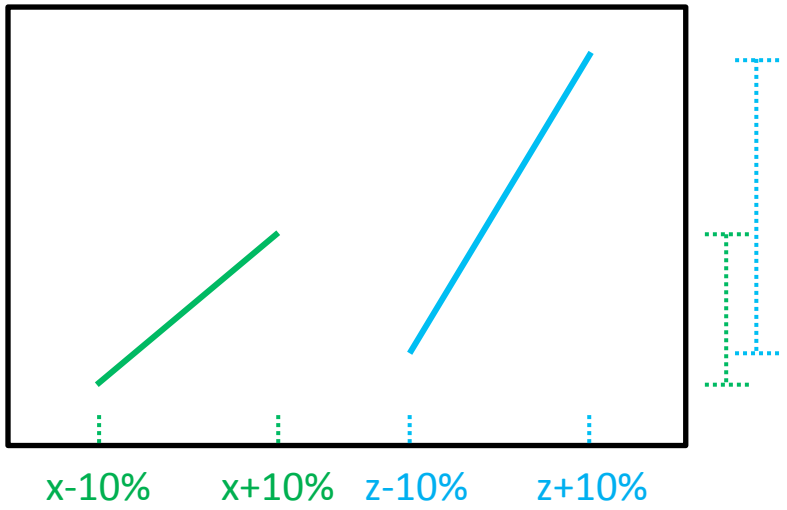
Uncertainty analysis rather than sensitivity analysis

Model 1: y=b+1x

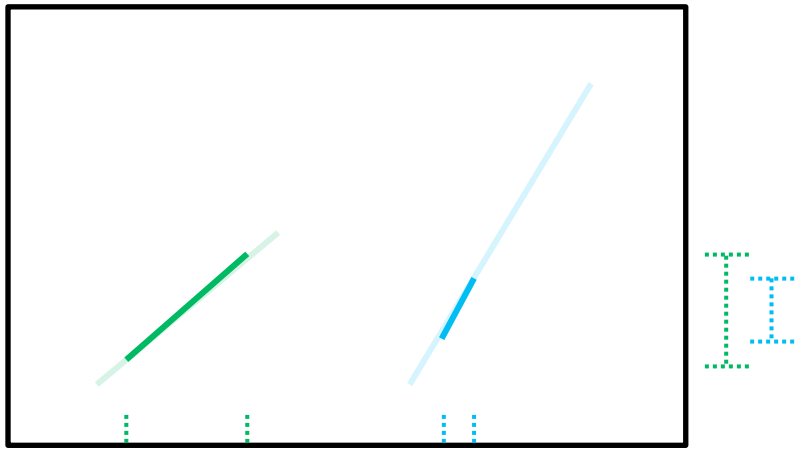
Model 2: y=a+2z



Higher sensitivity to z than to x

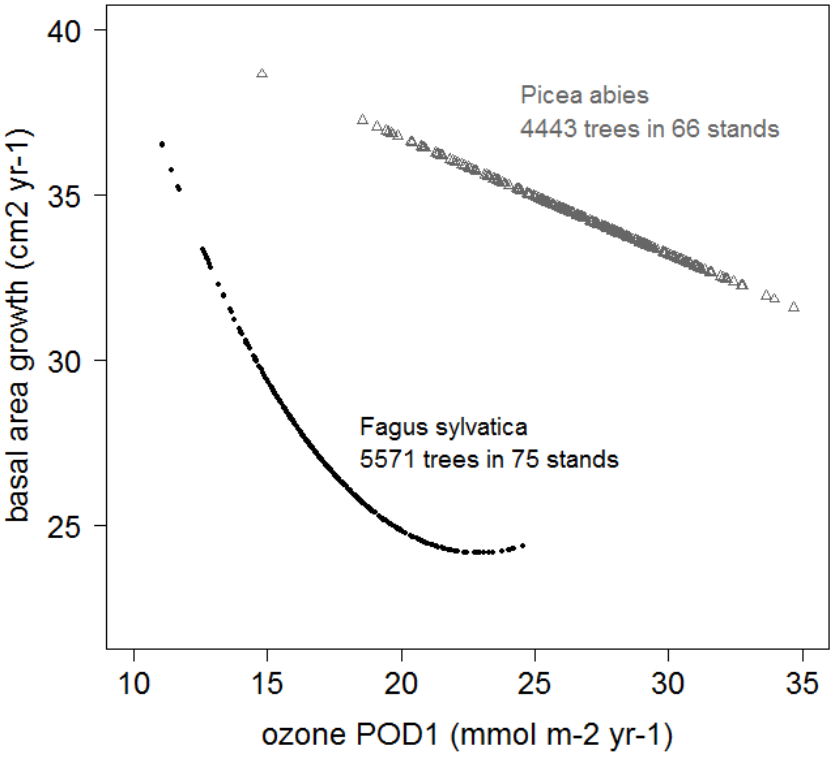
Model 1: y=b+1x

Model 2: y=a+2z

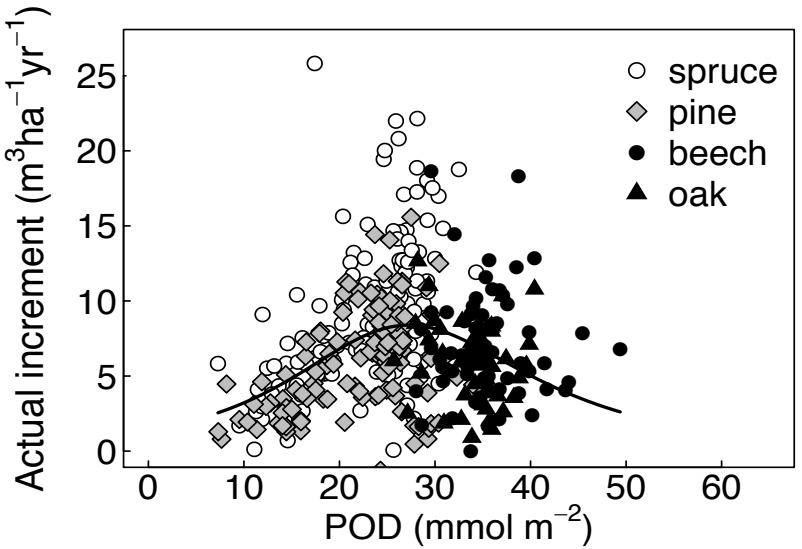


Lower uncertainty in y related to the uncertainty in z than in x

Contradicting ozone-growth relationships

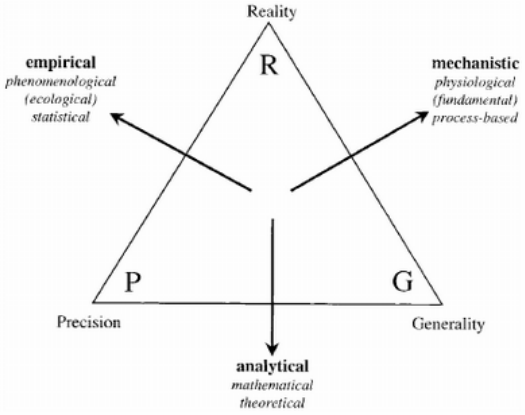


Braun et al. 2017

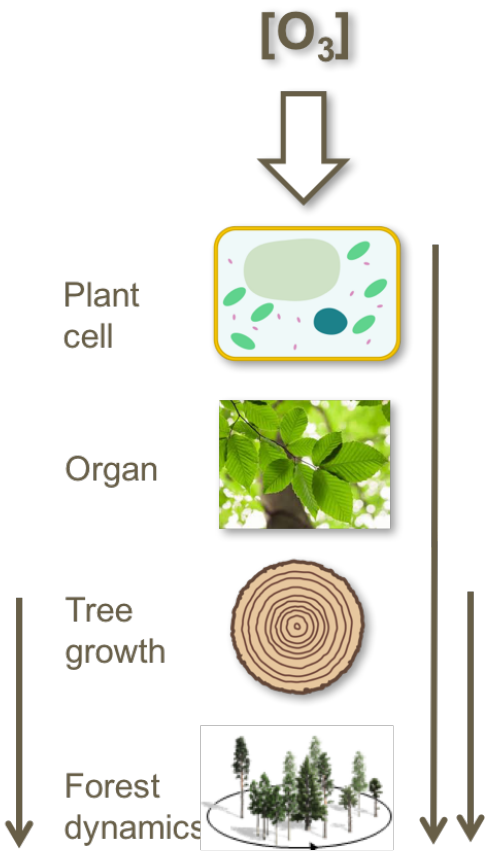


Etzold et al. in rev.

Project framework



Levins' model classification (1966)



O_3 deposition and uptake model: **DO_3SE**

Physiological model **CASTANEA** (2)

Forest gap model **ForClim** (3)

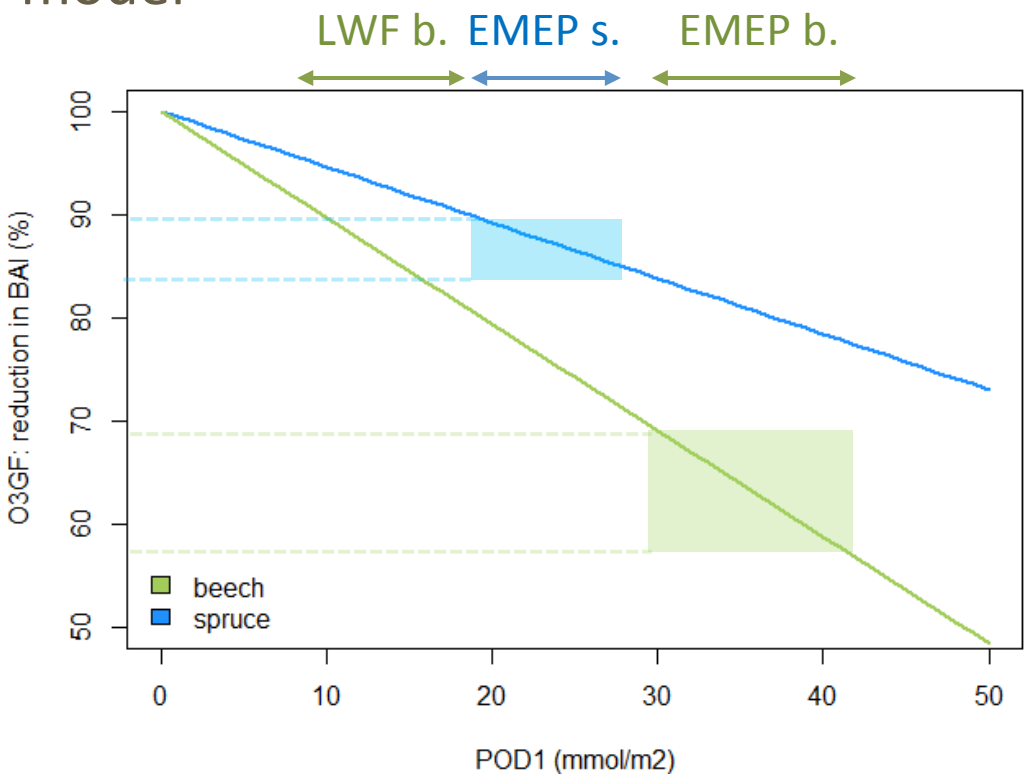
ICP Forests Swiss NFI (1)

Empirical analysis ⟷ Process-based modeling tools

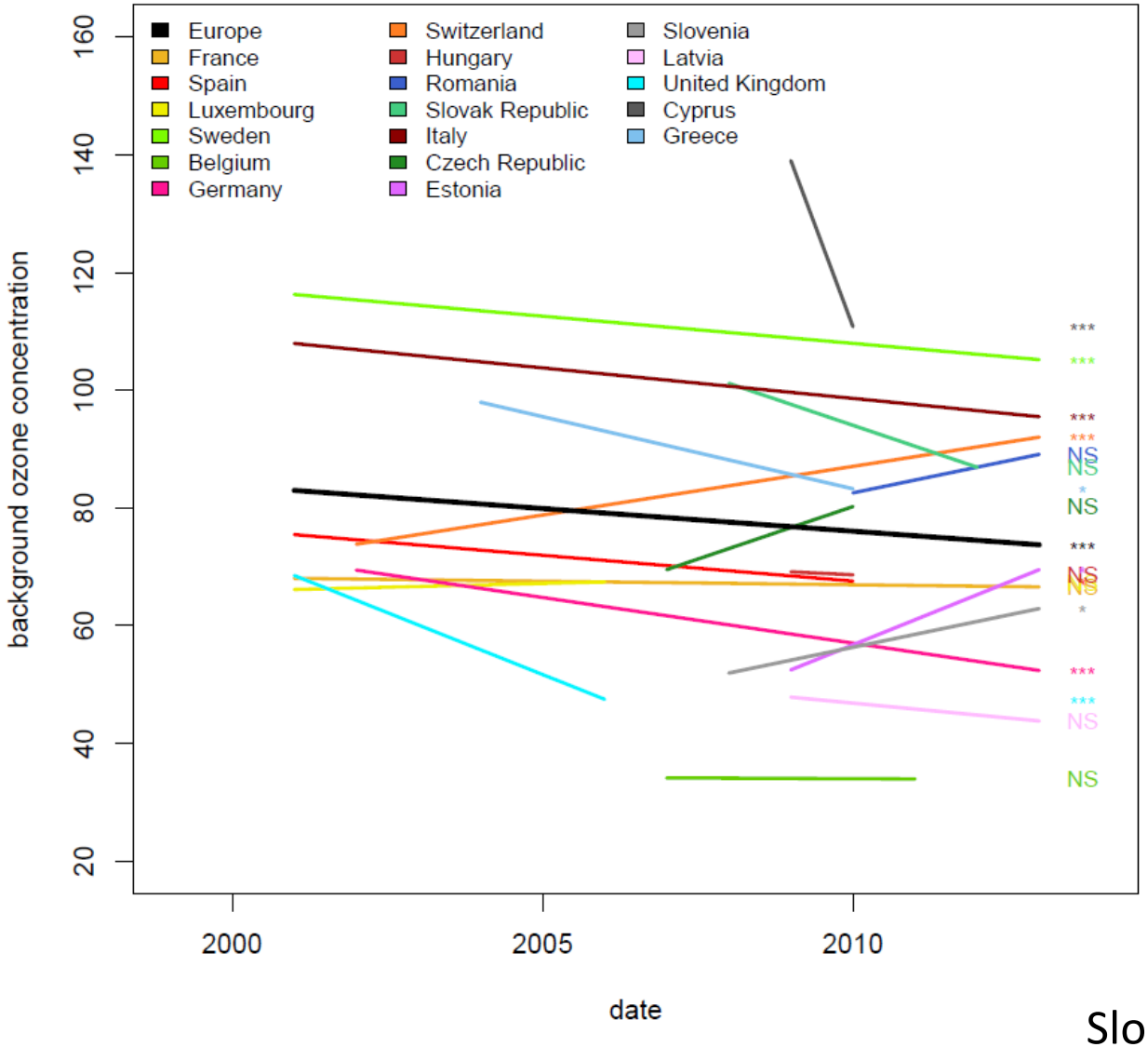
Implementation of a growth reduction due to ozone

- GRF = (DDGF * SMGF * SNGF * ALGF * CLGF)$^{1/3}$ * O_3GF
- O_3GF calculated using species-specific DRRs derived during the ECLAIRE project (for spruce and beech)
- POD_1 values from the EMEP model

« WORST-CASE SCENARIO »



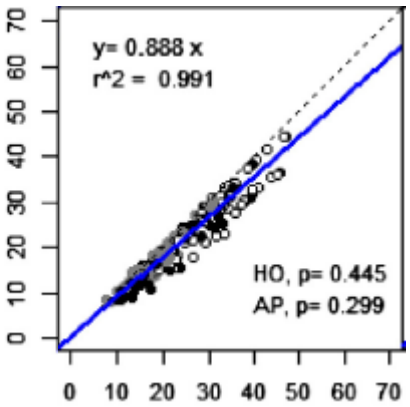
European-wide decrease in O3 concentration



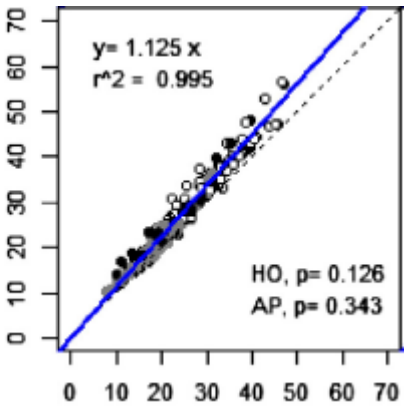
Slope = -0.77 *u*g/m3; p < 0.001

POD_1 aggregated
(weekly resolution)

Constant ozone



Loibl's hourly profile



Calatayud et al. 2016