

Meta-analysis of simulated forest productivity changes under global change

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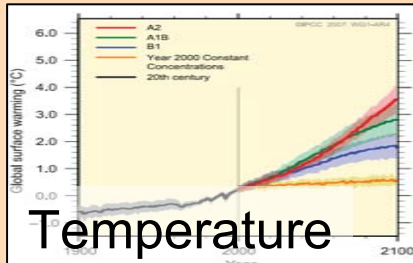
Postdam Institute for Climate Impact Research



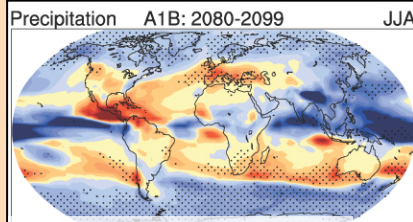
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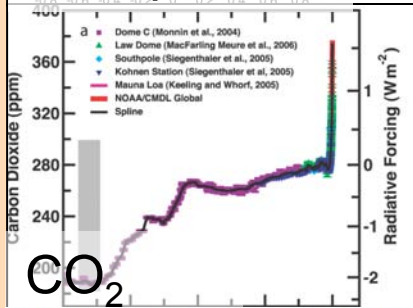
Global Change



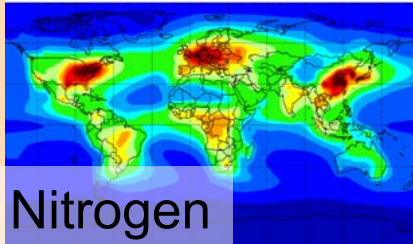
Temperature



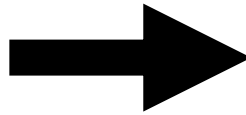
Precipitation (mm day⁻¹)



CO₂



Nitrogen



Process-based Model

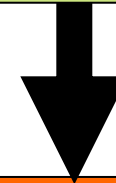
Photosynthesis

Respiration

Evapotranspiration

Allocation

Mortality



Forest Productivity & Biomass

Dentener et al. 2006, IPCC 2007



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Objective

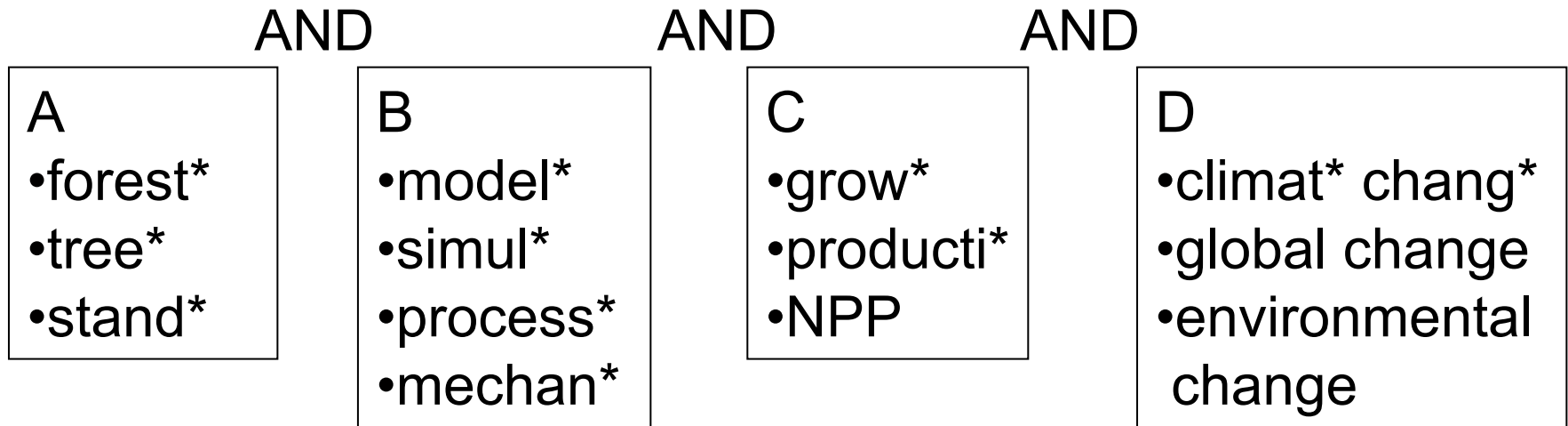
To review forest productivity changes simulated by process-based forest stand models under global change scenarios



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Methods: Data compilation



→ feb 2010: 4,576 paper in WoS

→ title & abstracts: simulate productivity under global change?

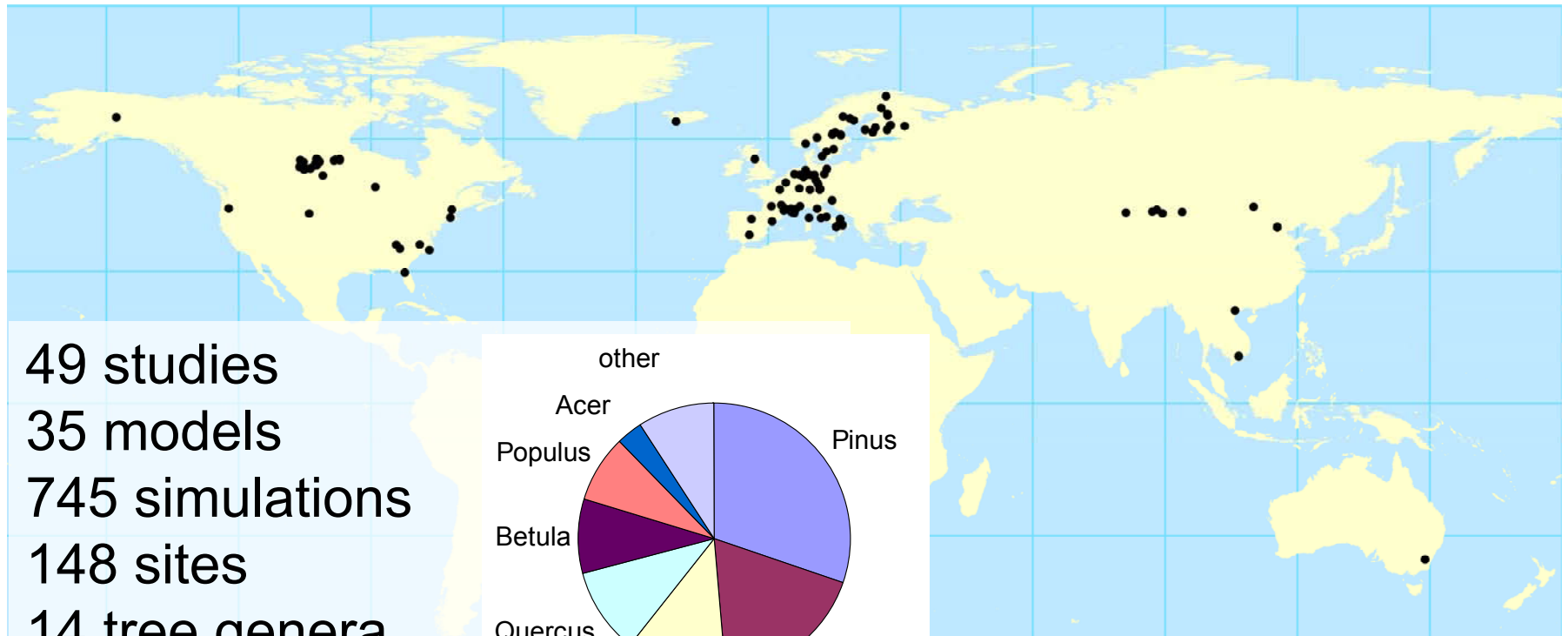
→ ~400 papers: process-based (tree, stand, grid), gap, hybrid or statistical models

→ focus: stand-level PBMs

Methods: Data preparation

- forest productivity: carbon (NPP...) & forest growth (biomass, volume, stem wood) (Keeling & Phillipps 2007)
- productivity change [%] & relative productivity change [%*yr⁻¹]
- change: end of, mean over simulation period & others

“Study Sites”



49 studies
35 models
745 simulations
148 sites
14 tree genera
27 species

Directions of Change

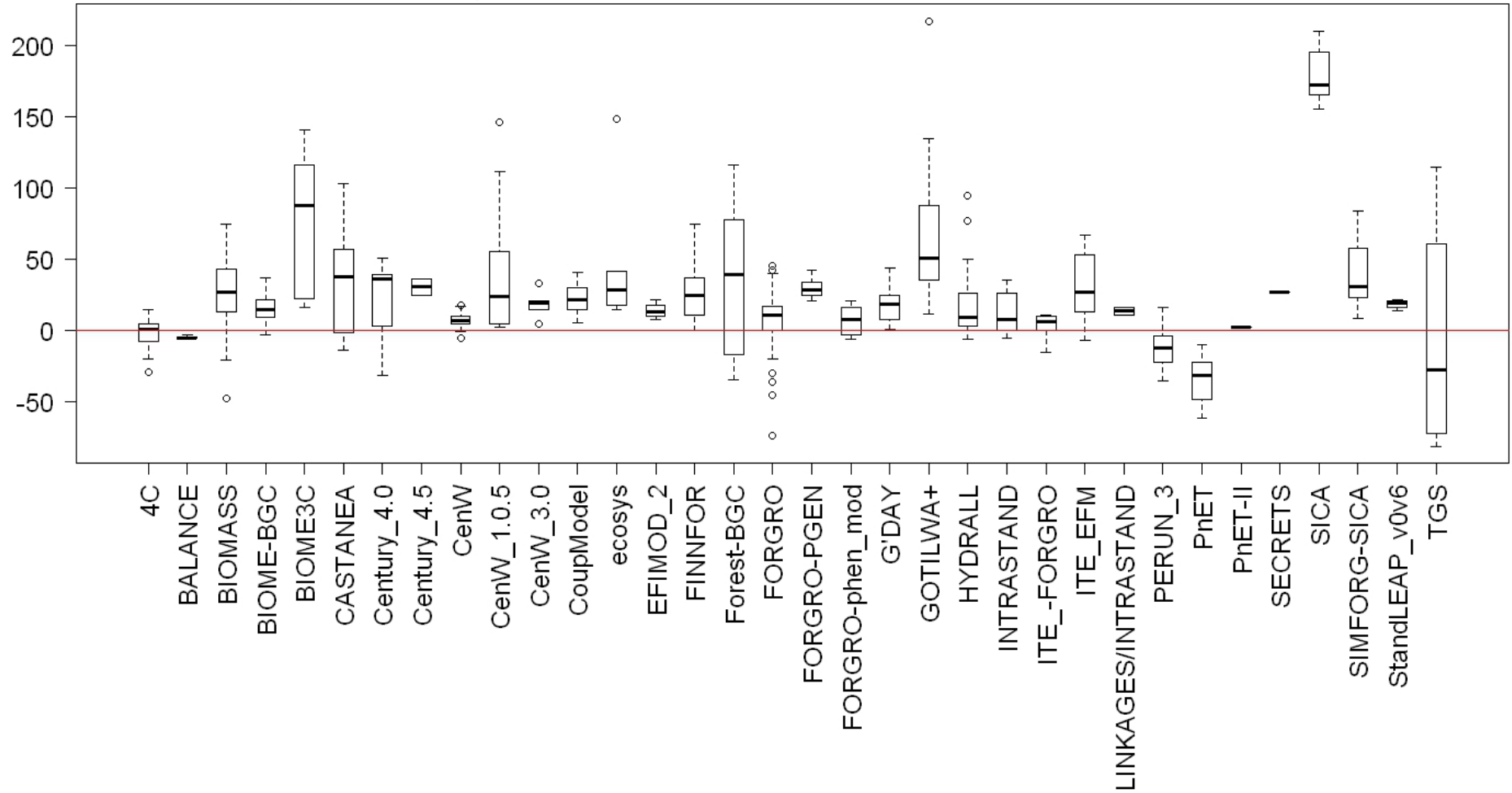
745 simulations: 85% positive, 14% negative, 1% null



Past changes: satellite & ground-based (Kauppi et al. 1992; Nemani et al. 2003; Spiecker et al. 1996; Boisvenue & Running 2006; Mc Mahon et al. 2009; Zhao & Running 2009)

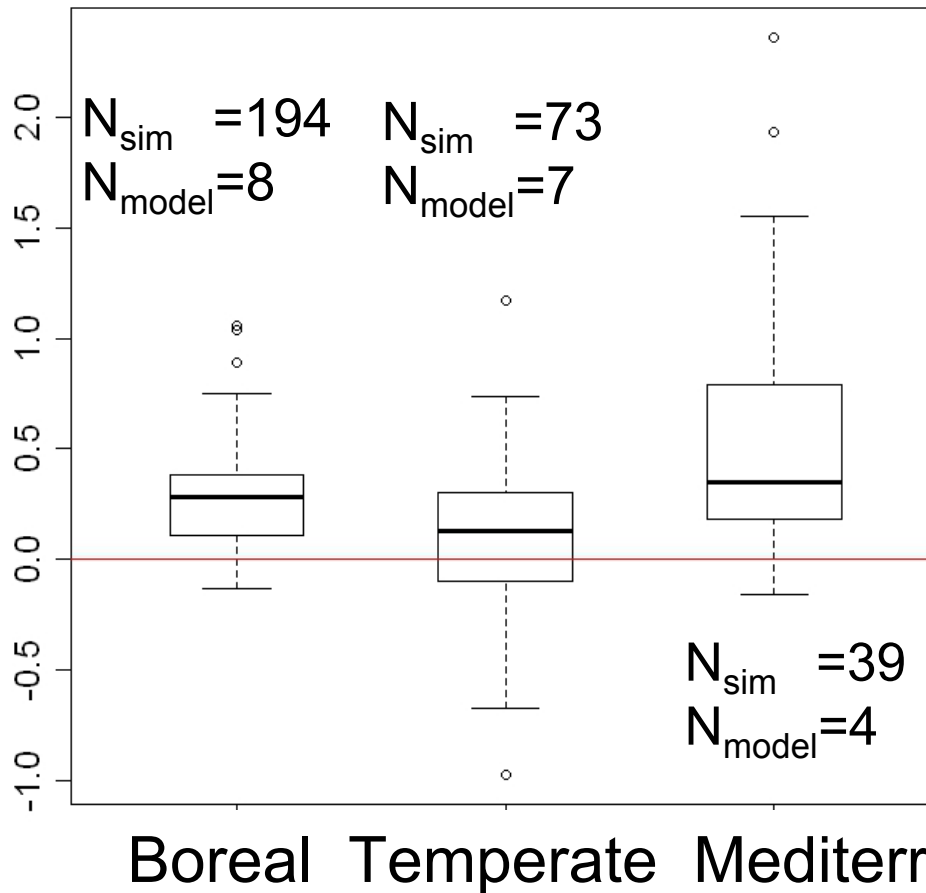
Models

productivity change [%]



Transient simulations: Biom

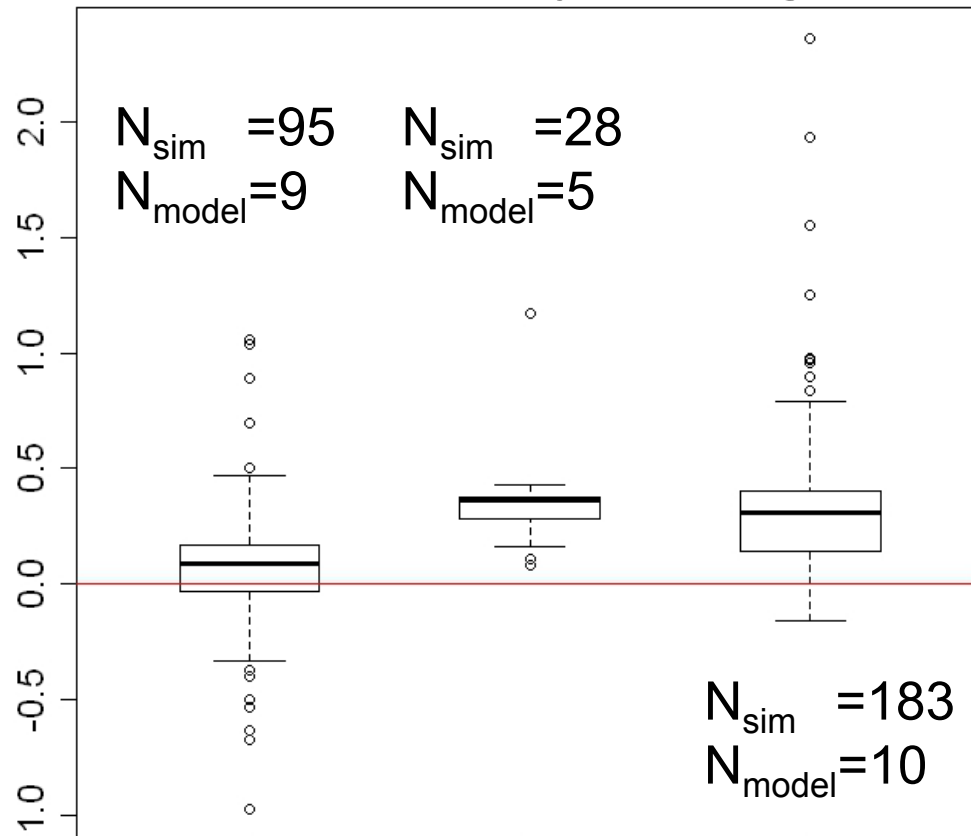
relative productivity change [%*yr⁻¹]



...strong CO₂-effect
(Kirschbaum 2000; Keenan et al. 2011)

Transient simulations: Global Change Driver

relative productivity change [%*yr⁻¹]

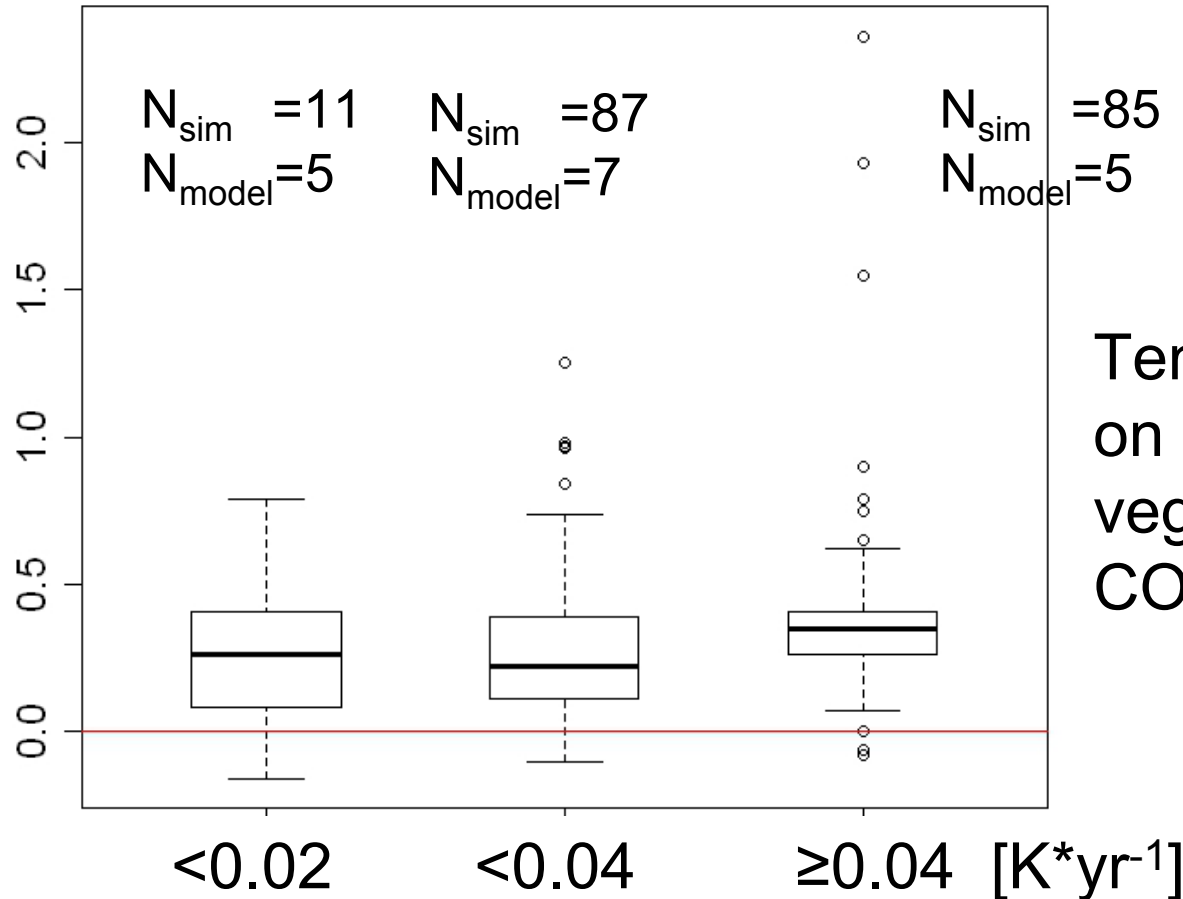


Climate Change CO₂ Climate Change+CO₂

...in reality: drought, N-limitation, acclimation override CO₂-effect (Penuelas et al. 2010; Norby et al. 2010), temperature response differs between biomes (Way & Oren 2011)

Combined simulations: Temperature Increase

relative productivity change [%*yr⁻¹]



Temperature effect on photosynthesis & vegetation period, CO₂-effect

Discussion

- assumptions
 - models equally good & independent (Tebaldi & Knutti 2007; Medlyn et al. 2011)
 - similar measures of productivity
 - but higher NPP → higher turnover → less carbon (Körner et al 2005; Boisvenue & Running 2006)
 - relationship biomass & NPP (Keeling & Phillips 2007)
- mean climate not best predictor of biomass (Stegen et al. 2011)
 - e.g. drought (Zhao & Running 2010)
- model comparisons are useful but synchronized (IPCC, COST FP 0603) better to quantify uncertainties
- publication bias

Conclusions

- strong model effects
- not possible for tropics (Laurance et al. 2004; Lewis et al. 2004 but Feeley et al. 2007)
- many studies but more needed
- boreal & temperate productivity increase
- ➔ interactions, feedbacks & disturbances
- ➔ full carbon cycle