Assessing the response of forest productivity to climate extremes in Switzerland using model-data fusion

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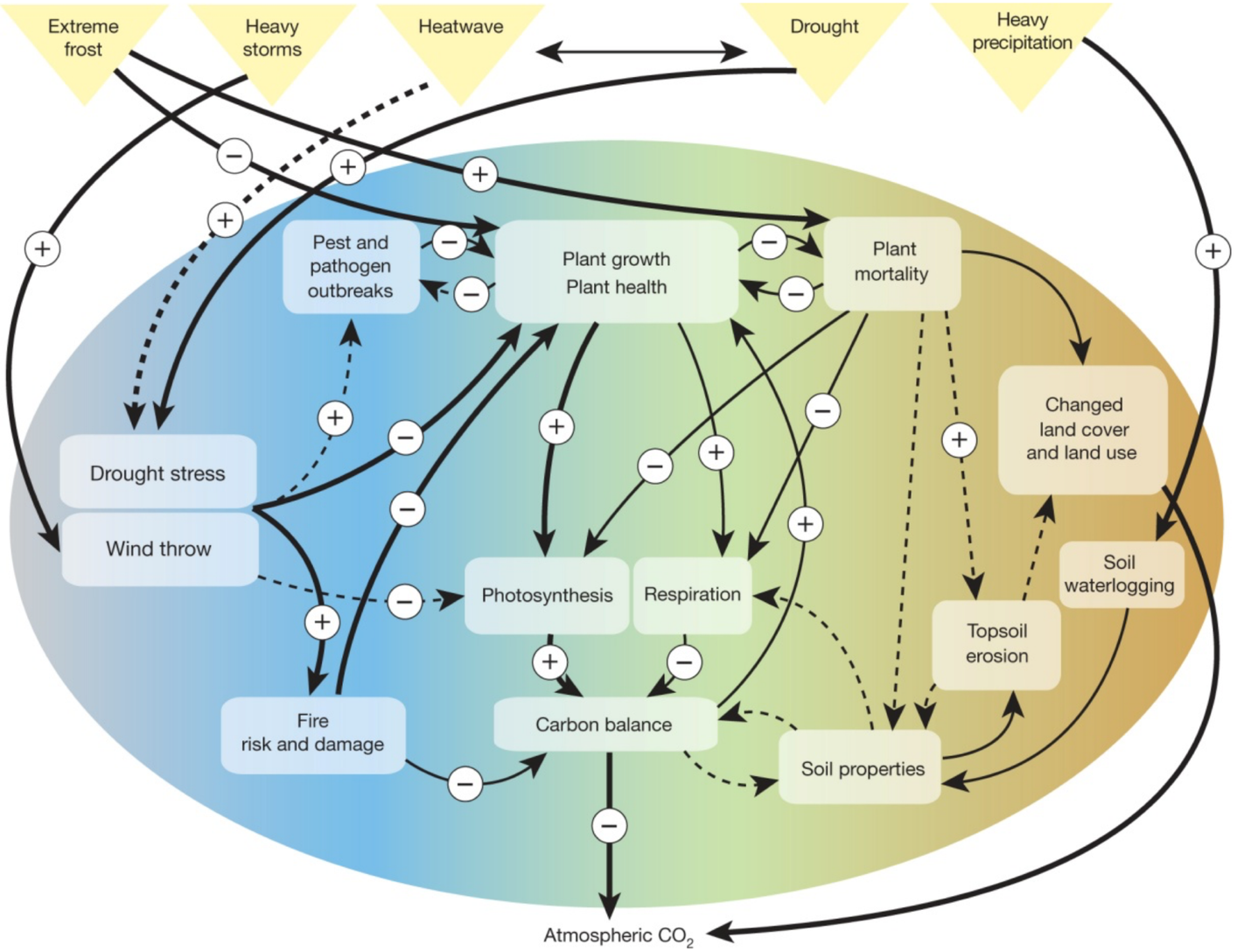
Motivation



- Projected higher frequency of extreme events are predicted to negatively impact forest productivity.
- Existing models of forest dynamics include large uncertainties, which lead to divergence in forecasts.
- It is strongly due to the complexity of the forest and extreme events interaction.

Processes and feedbacks triggered by extreme climate events (Reichstein et al. 2013).

Motivation

- Large variety, velocity and volume of observational data are collected within Swiss forest landscapes.
- Data collected ranges in spatial and temporal resolution, as well as purpose, for which they are collected.
- It would be ideal and beneficial, if the data would be unified, cleans, easy to access, near real-time, etc.

Aim

Aim: Quantify how forest productivity responds to climate variability and what are the limiting factors across elevational gradients on a Swiss scale.

Hypothesis: A combination of available high-quality long-term data sets from WSL and its Swiss partners provides an excellent data basis for a data-model fusion approach within SwissForestLab.

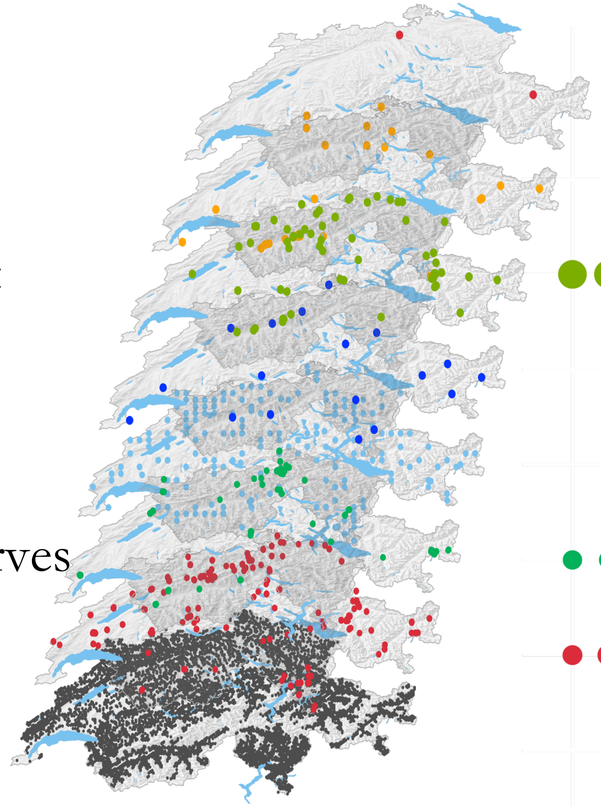
i) We first assimilated extensive and long-term forest ecosystem monitoring data of two dominant European species (*Picea abies* and *Fagus sylvatica*) from 271 sites into the 3-PG forest ecosystem model.

ii) With the parameterised model, we assessed how forest productivity responds to climate extremes across environmental gradients in Switzerland.

Approach

Data: Identify extensive and long-term forest ecosystem monitoring data

Data from multiple networks



FluxNet

TreeNet

DendroNet

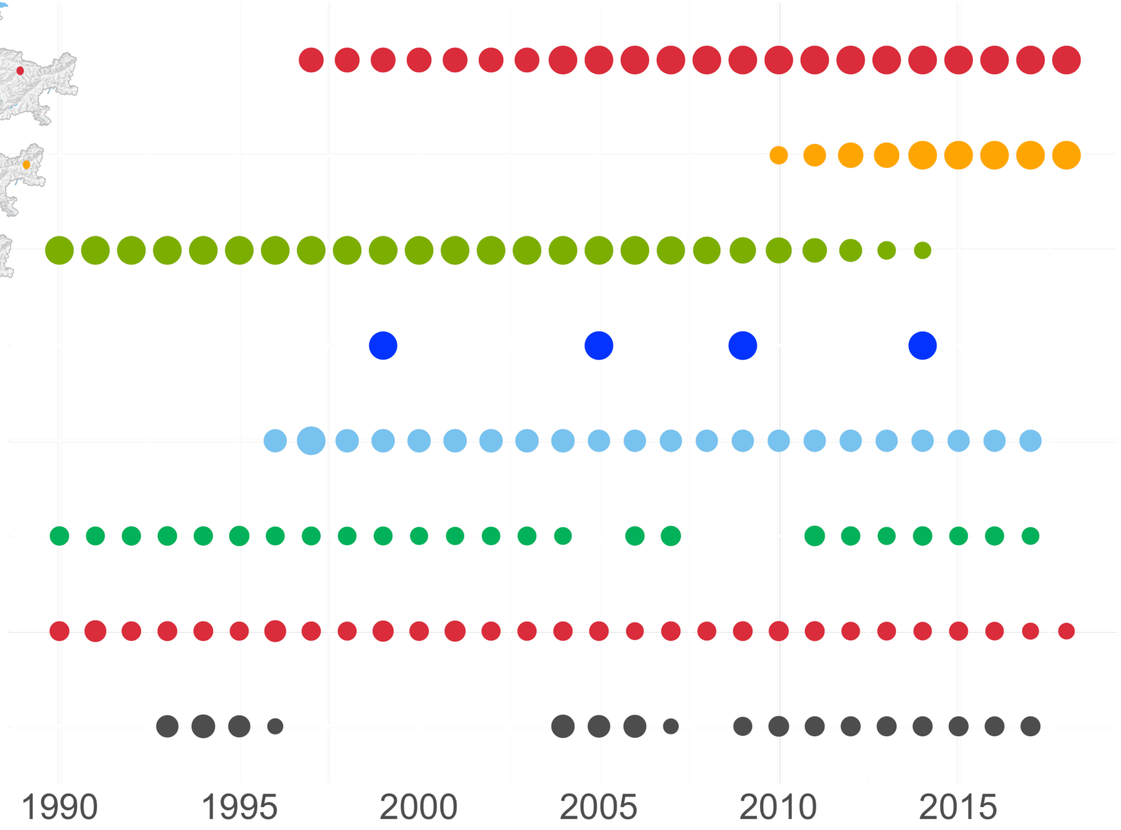
LWF

Sanasilva

Forest reserves

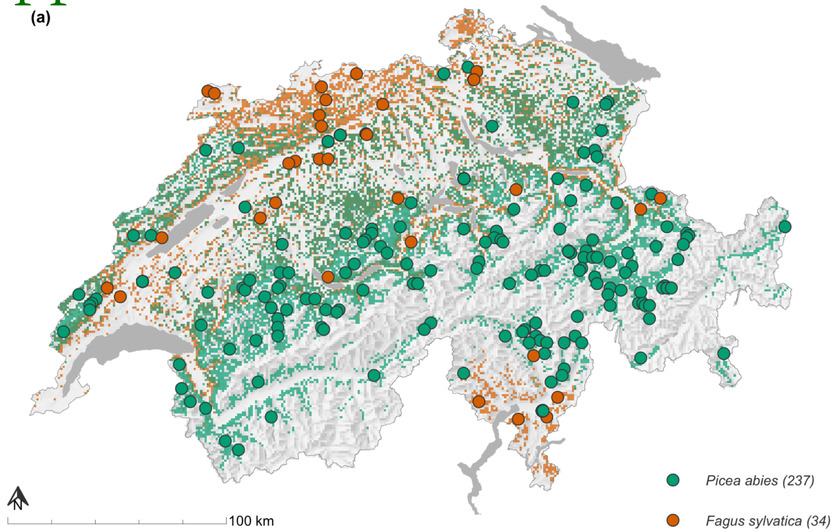
EFM

NFI



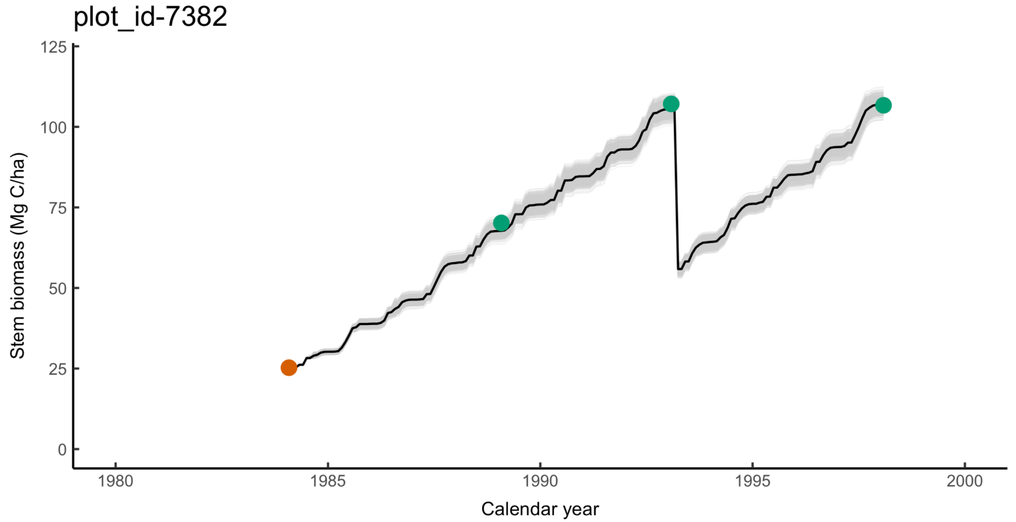
https://www.wsl.ch/en/projects/qupfis-1.html

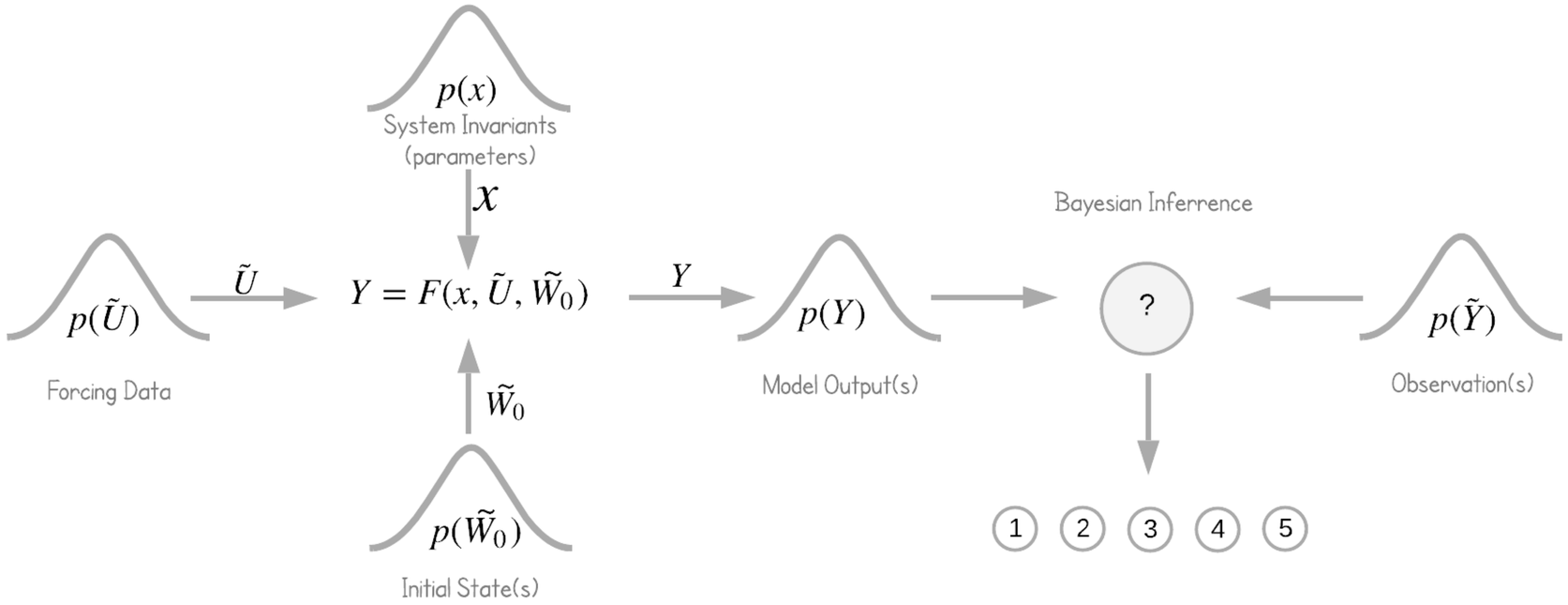
Approach



r3PG

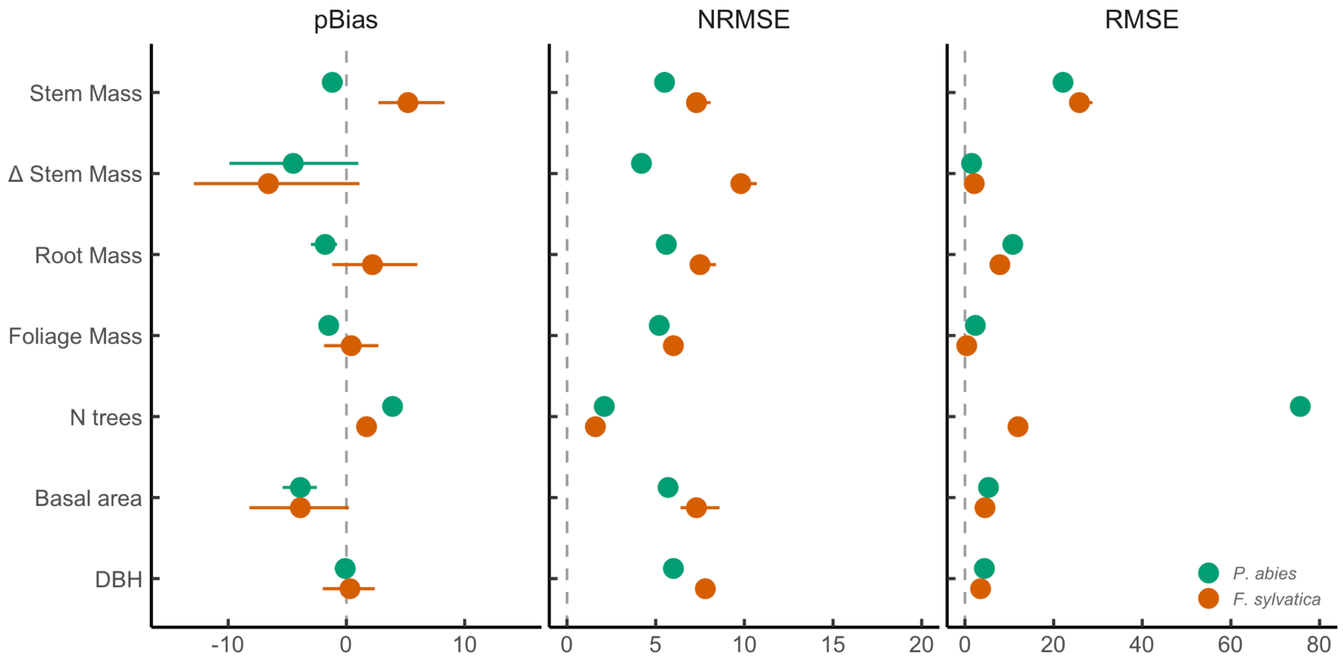
https://github.com/trotsiuk/r3PG





Schematic representation of data assimilation for parameter estimation, using Bayesian inference.

Results

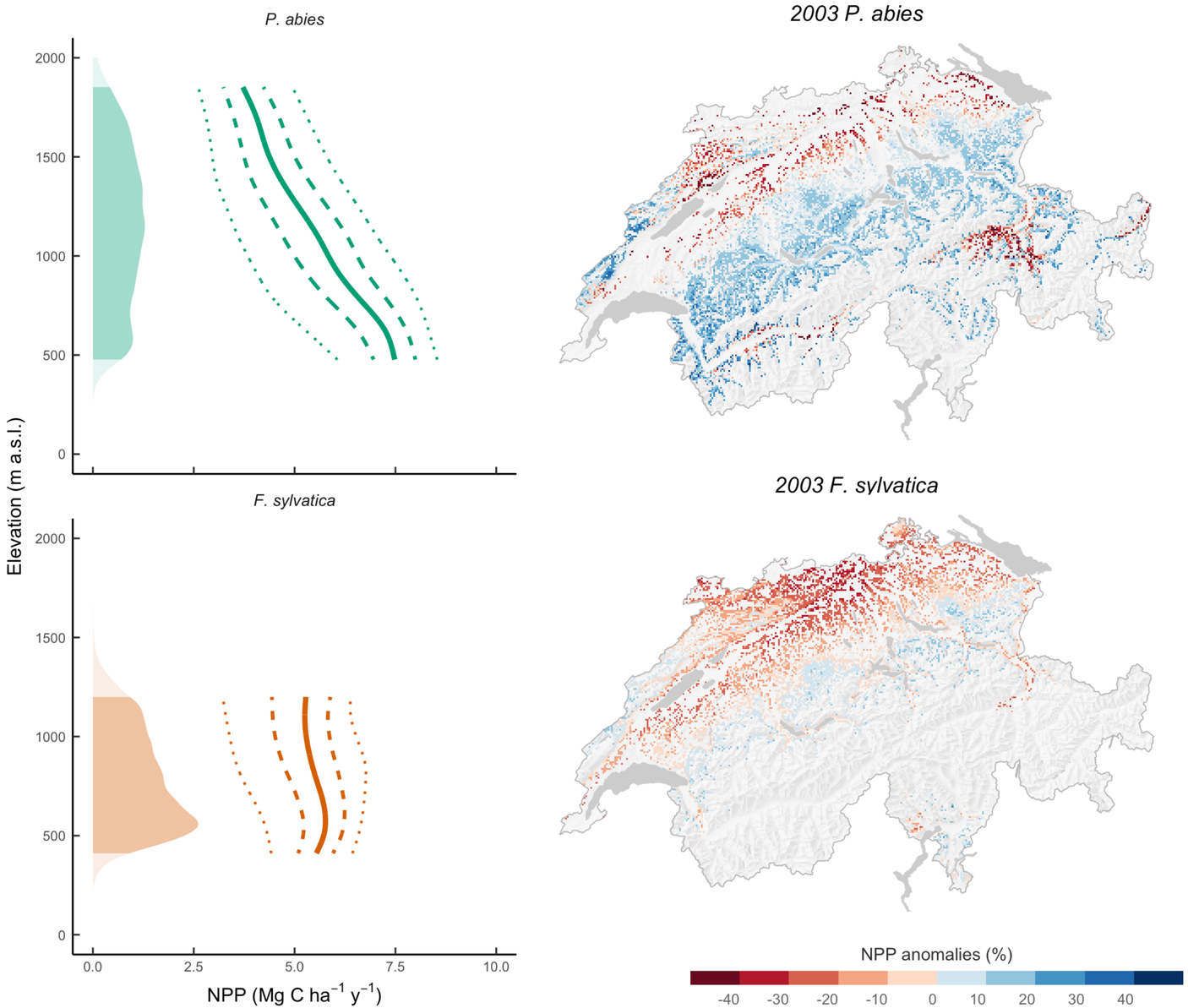


- Predictions based on the posterior distributions significantly improved compare to predictions based on the prior distribution

- The pBias is below 10% (mostly below 5%).

Statistics on predictive error of the 3-PG model (Trotsiuk et al. 2020).

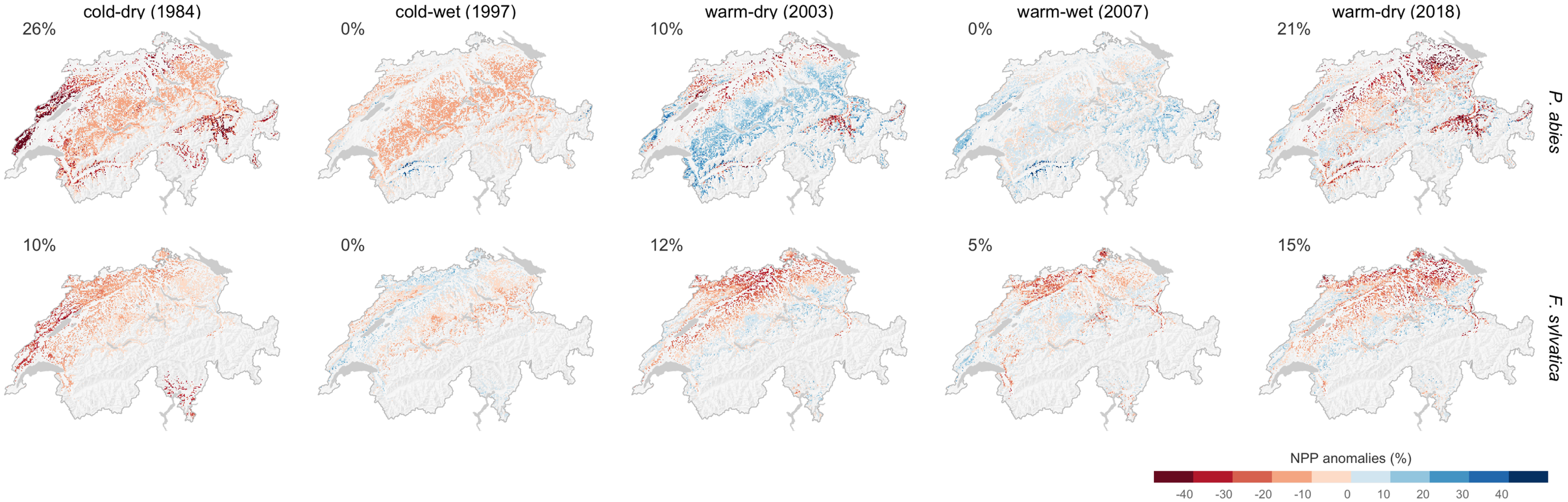
Results



- NPP decrease with elevation, with stronger effect for *P. Abies*
- There are was a strong agreement in terms of the trend and magnitude of NPP simulated by the 3-PG and NPP derived from MODIS
- The 2003 year have a different pattern in the lower vs upper elevations, specially for *P. abies*.

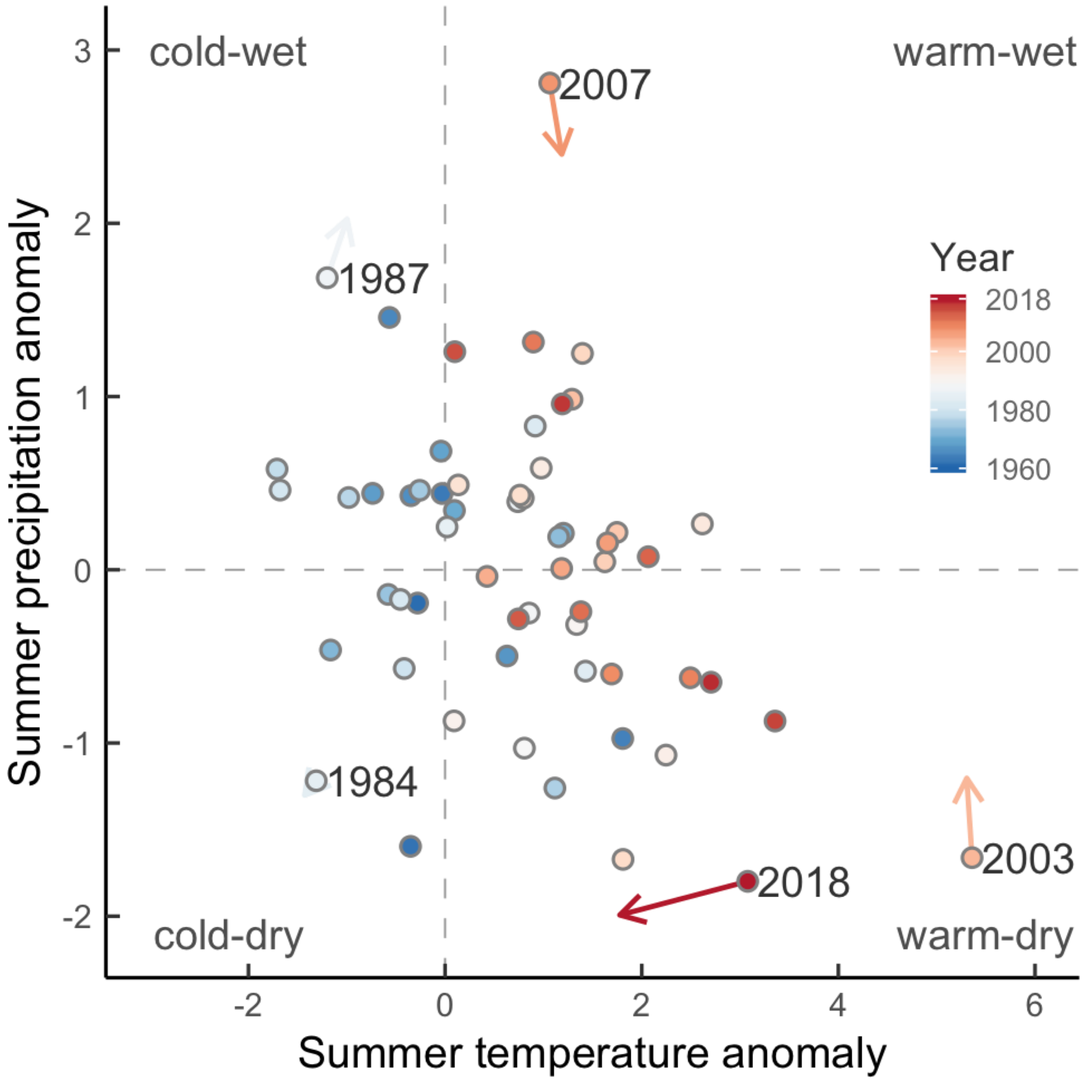
Trajectory of net primary productivity (NPP) along the elevational gradient simulated by the 3-PG model for *P. abies* and *F. sylvatica* potential distribution ranges.

Results



Spatial variation of simulated NPP anomalies (percent deviation) in selected extreme years relative to the 1961-1990 reference period for *P. abies* and *F. sylvatica* (Trotsiuk et al. 2020).

Results



Growing season (May-August) mean temperature anomaly *vs.* growing season precipitation anomaly expressed by standard deviation compared to the reference period (1961-1990). The error indicate how much and in which direction the anomalies change by 1,000 m elevation change.

Summary

- Data assimilation significantly improved model simulation performance

- During extremely warm-dry years, forests at lower elevations will suffer from soil water deficit and increased evaporative water demand, whereas forests at higher elevations where trees are growing still below their temperature optimum will benefit from warmer conditions.

- During the extremely cold and wet years both species experienced strong reductions in NPP.

- Both species showed a higher NPP during the more recent period (1991-2018) compared to the baseline period (1961-1990).

Thank You

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Trotsiuk Volodymyr & QUPFiS team