Model descriptions & indicator selection

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Hydrological model WSFS

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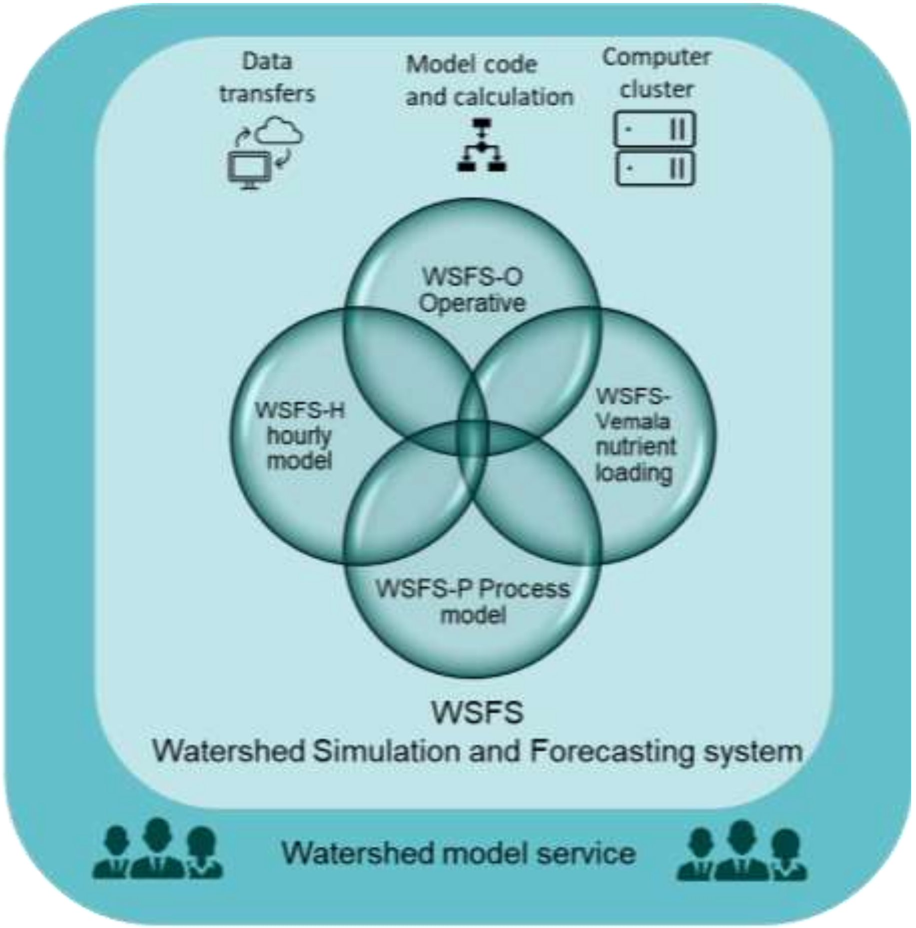
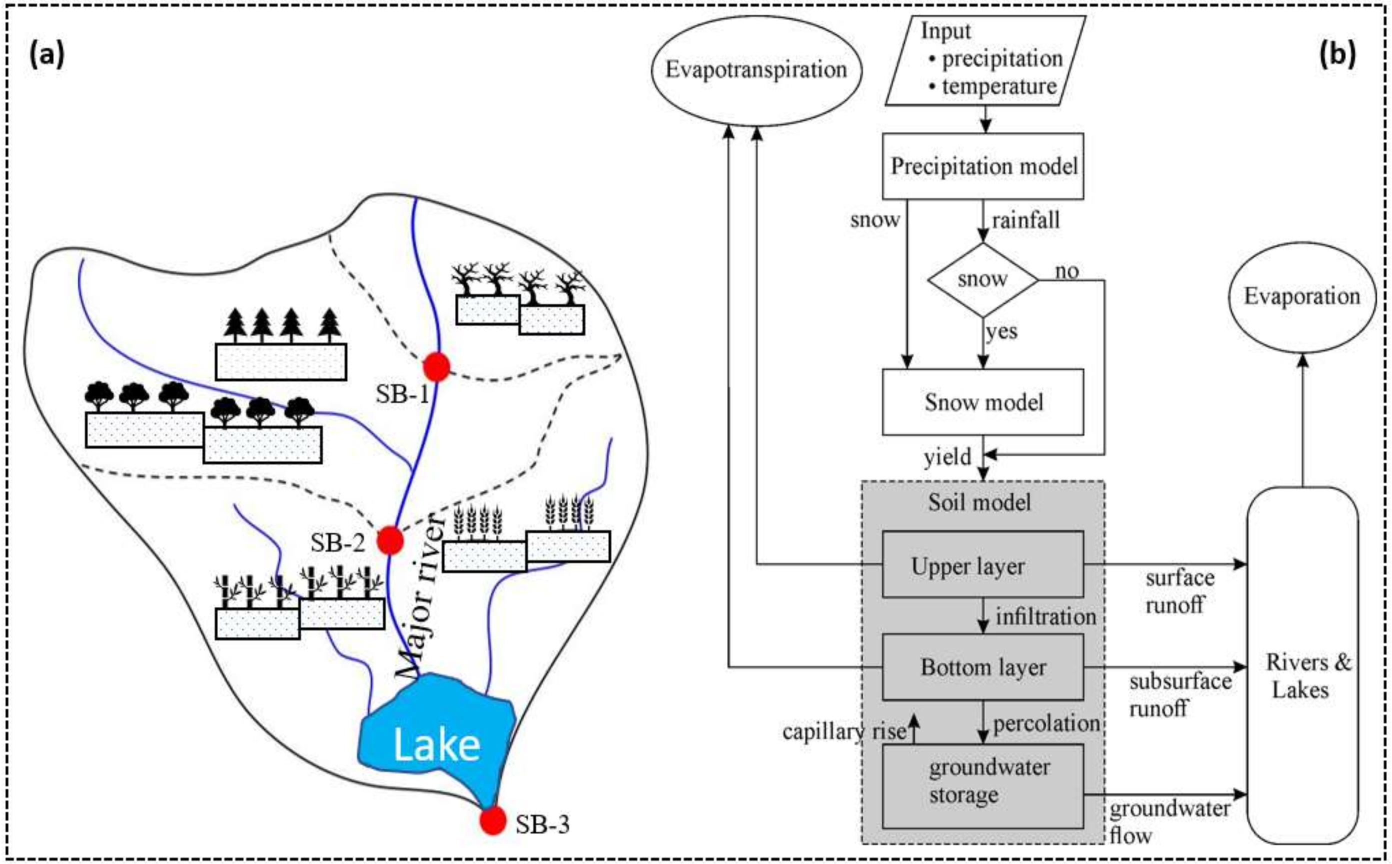
Hydrological modeling

- Carried out in Syke using WSFS-P hydrological model
  - Part of the WSFS modeling infrastructure, used for operational hydrological and flood forecasting in Finland
  - Covers entire Finland
  - Has been used in research of climate change impacts and e.g. in the implementation of EU Floods directive
- Scenario neutral approach with Impact Response Surface applied for the first time
  - Comparison with traditional climate scenarios carried out



Hydrological model WFSF-P

- Hydrological indicators are simulated with WSFS-P (Physically based Watershed Simulating and Forecasting System) in SYKE
- A more physically based version of WSFS
  - Energy-balance-based snow model
  - Rainfall-runoff model with a two-layer soil moisture model, and lower groundwater storage
  - Penman- Monteith evapotranspiration method
  - Lake evaporation model



- (a) Schematics demonstrating the watershed delineation for the WSFS model, its subbasins (SB-1, SB-2, SB-3), and the grid-cell discretization by soil type, vegetation, and elevation, (b) a two-layer soil moisture model with the major hydrologic processes for each soil-land-use class.

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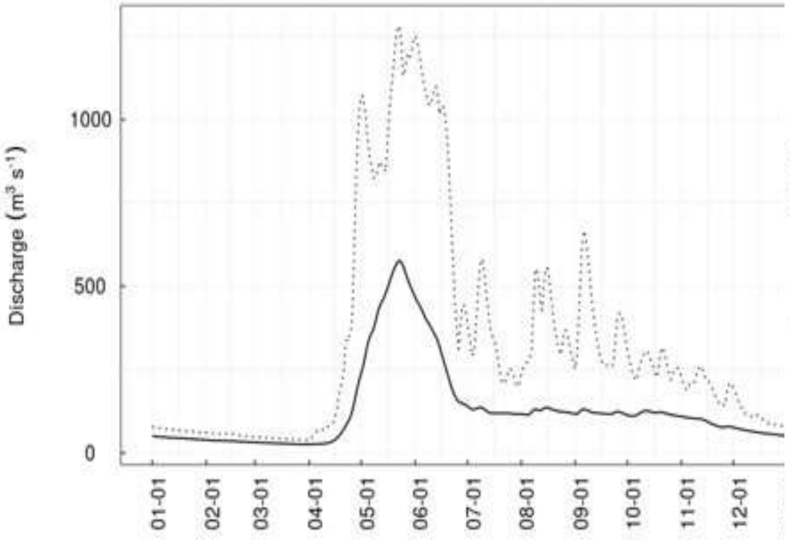
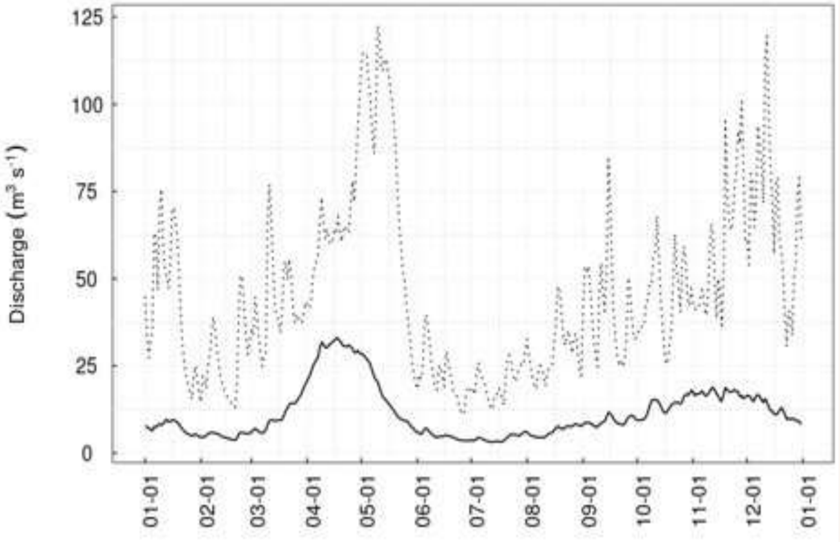
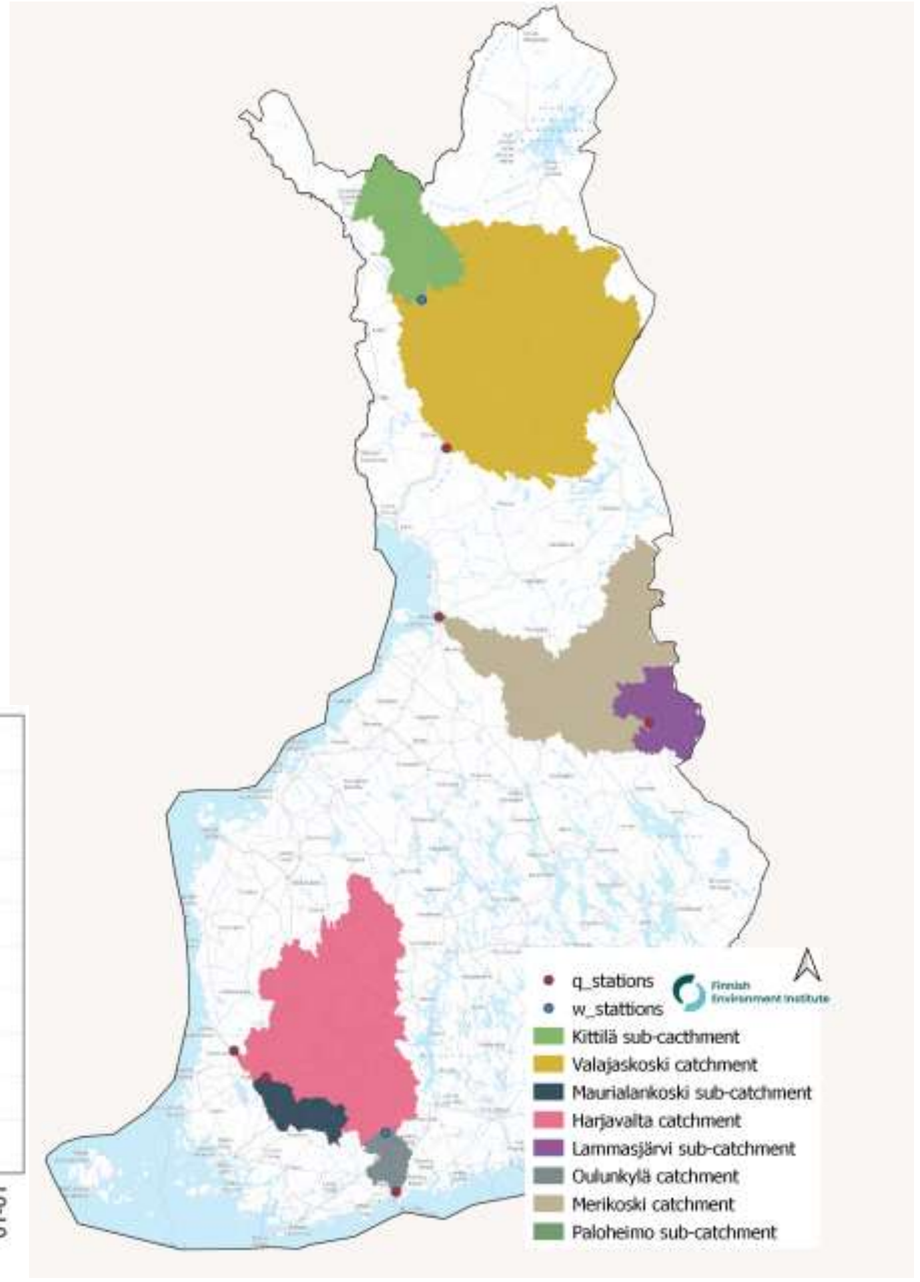
Study catchments

- Different parts of the country, different types of catchments
  - North vs south
  - Small vs large
  - Regulated vs unregulated







Climate change and extreme flows

- Flood
  - 100-year annual maximum flood (MAF)
  - 10-year seasonal maximum flood
- Drought:
  - 10-year seasonal minimum 7-day average flow
- Snow:
  - Average annual maximum snow water equivalent (SWE)
  - Number of days with SWE > 20 mm
  - Number of days with snow depth > 20 cm
- Soil moisture
  - Average annual minimum soil moisture in the subsurface layer

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Adapt-FIRST project Final Seminar, 27 August 2024, Syke, Helsinki

Forest growth model PREBAS, fire & pest indices

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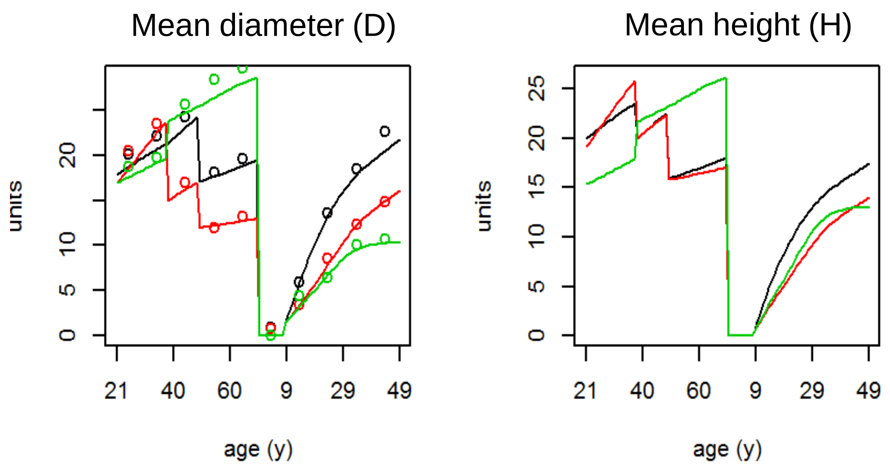
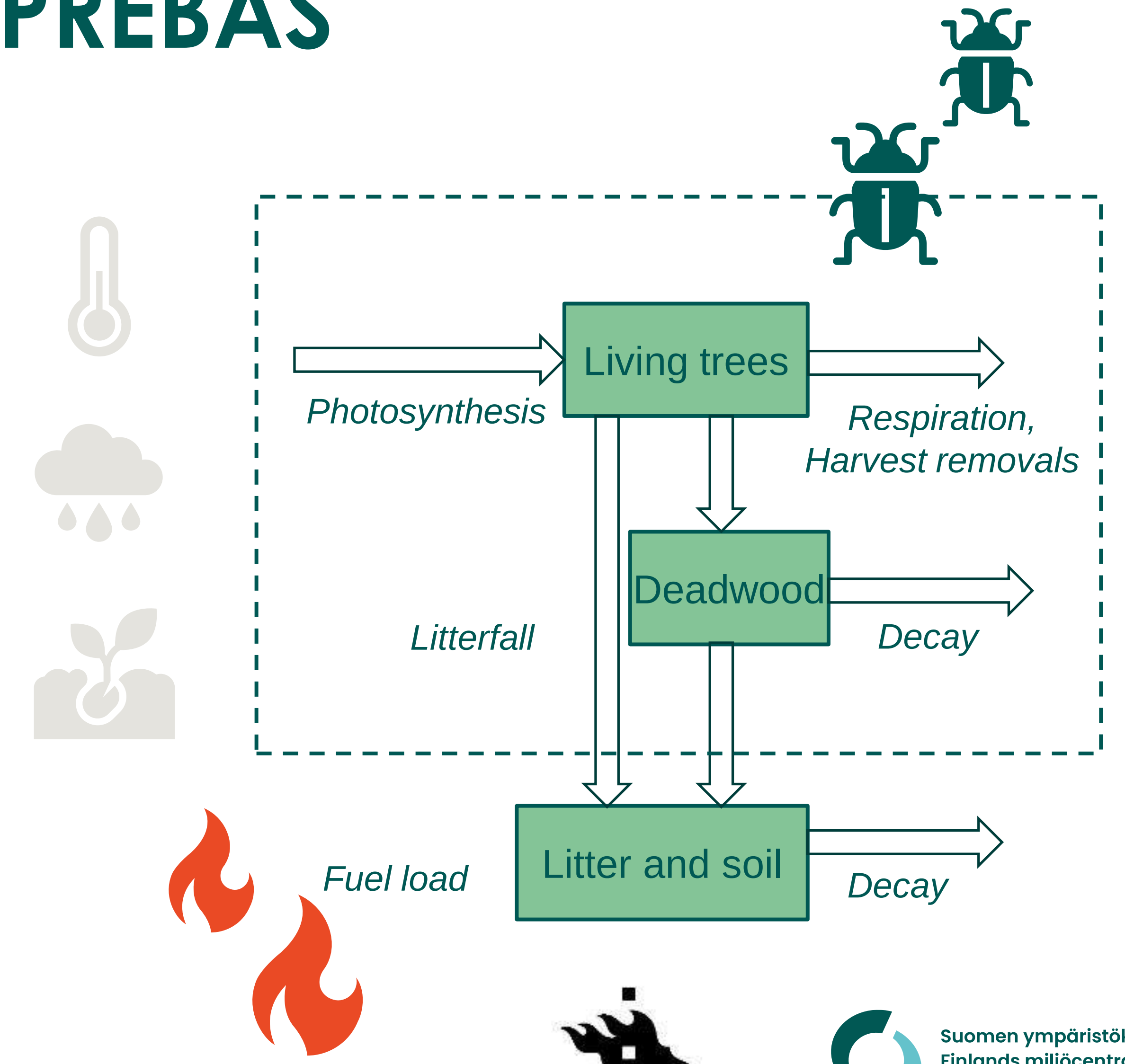
Forest growth model PREBAS

- A process-based model of the growth and carbon cycle of forest
- Simulates biomass and soil organic carbon cycling at a stand level
- Stand: a forest segment with the same BA, D, H, A, site type and species composition

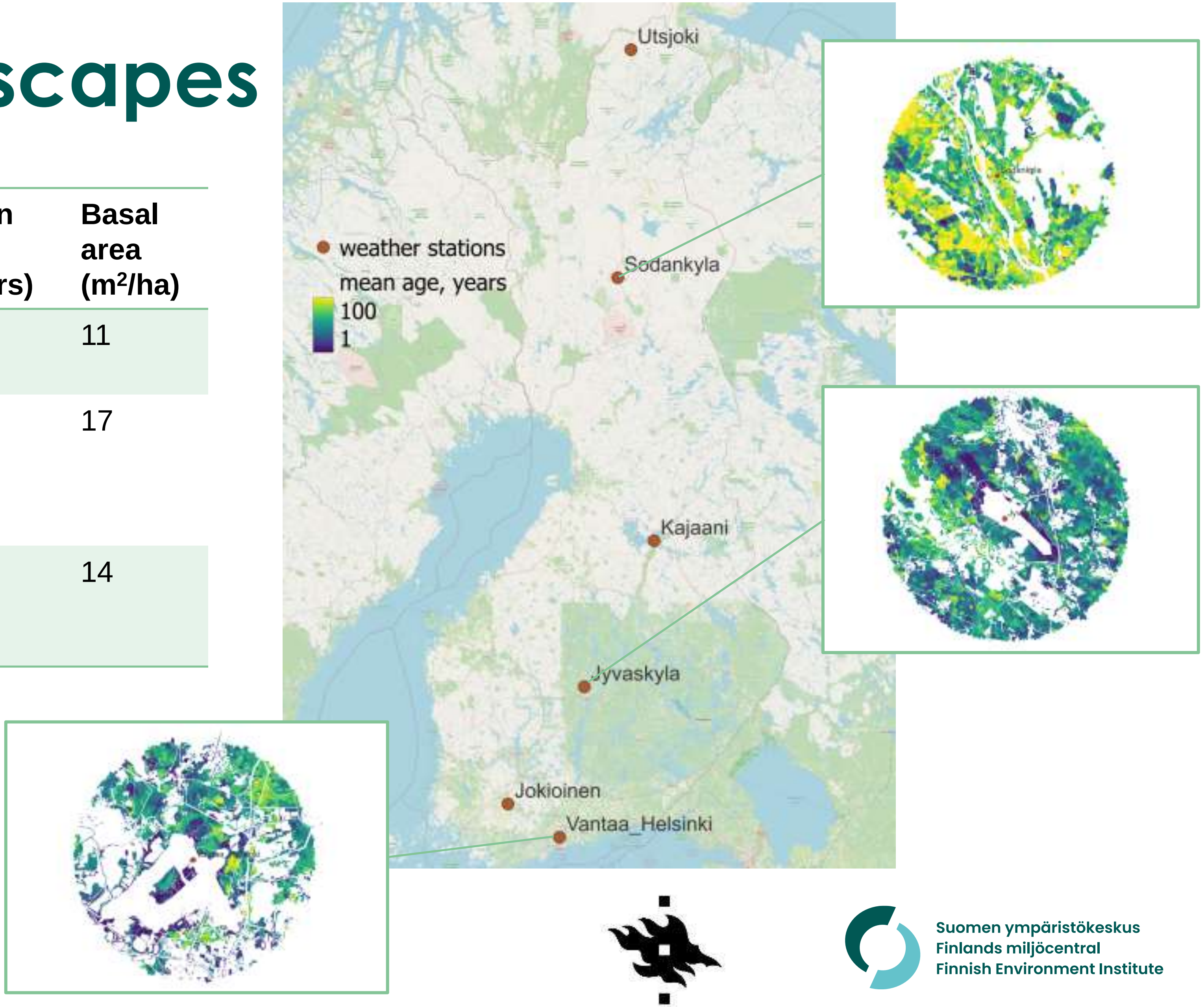




Three forest landscapes

Site	Area (km²)	Site type	Tree species	Mean age (years)	Basal area (m²/ha)
Sodankylä	38.0	Mesic heath	pine	78	11
Jyväskylä	38.0	Mesic heath	pine, spruce	48	17
Vantaa	29.7	Mesic heath	pine, spruce, birch	46	14

Source: Multisource National Forest Inventory Data (MSNFI), sample size 10 000 segments



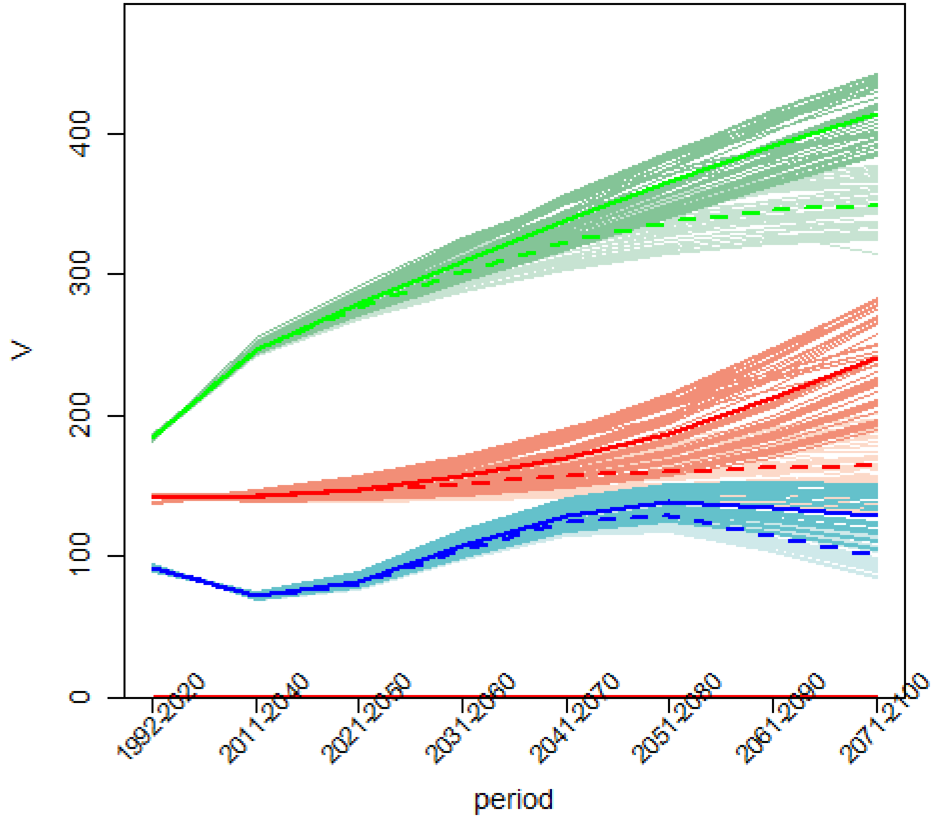
Adaptation through forest management

Scenarios:

- Base: the harvest level stays at a constant level in each region (*Toteutuneet hakkuut*)
- Intensive: the harvest level increases with increasing growth (*Voimakkaat hakkuut*)
- No harvests (*Ei hakkuita*)
- Two CO_2 trajectories: SSP1-2.6 (mild increase) and SSP5-8.5 (severe increase)

Simulated mean volume at a landscape level:

- Volume decreases with increasing harvests
- Volume increases with rising CO_2 concentration



Indicators and their thresholds

Impact indicator **(area weighted means over 2071-2100)**	**Threshold**
Net ecosystem exchange (NEE, kg C ha^{-1} $year^{-1}$) *Hiilensidonta (kasvu – hengitys ja hajotus)*	-
Net biome exchange (NBE, kg C ha^{-1} $year^{-1}$) *Nettohiilitase (hiilensidonta – hakkuupoistuma)*	NBE < 0: sink NBE > 0: source
Spruce bark beetle damage area (%) *Kaarnakuoriaistuhon pinta-alaosuus*	Exceeding the current area share in southern Finland
Forest fire risk (FDI) *Metsäpaloriski*	FDI > 0.2, indicating increase from the current level, medium risk

Crop growth model WOFOST

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WOFOST model description

- WOFOST (WOrld FOod STudies) is a simulation model for the quantitative analysis of the growth and production of annual field crops, developed in Wageningen, Netherlands. Key component of the European yield forecasting system for supporting EU development aid activities (crop shortages…).
- mechanistic, dynamic model, site-based simulation
- explains daily crop growth on the basis underlying processes, such as photosynthesis, respiration and how these processes are influenced by environmental conditions.

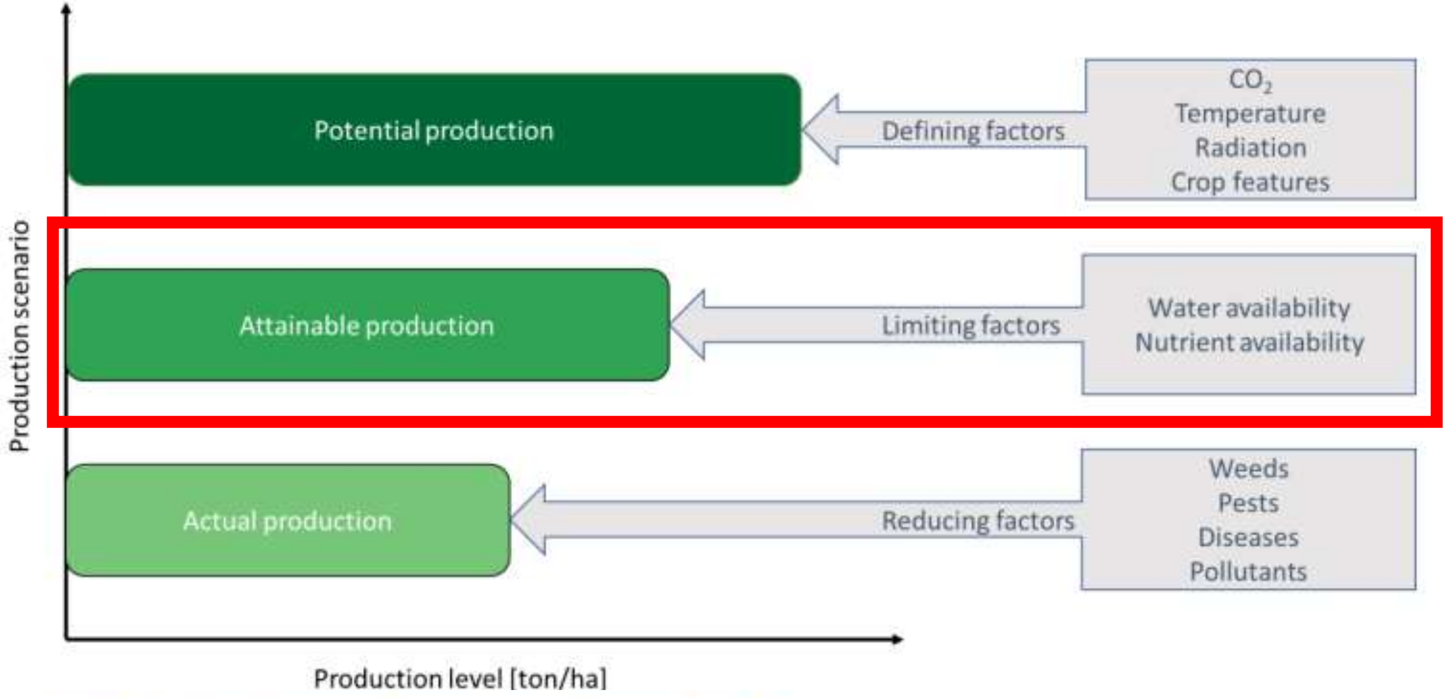

Figure 1. Three hierarchical levels of crop growth

- absolute production ceiling for a given crop when grown in a given area under specific weather conditions; all other factors are assumed to be optimal
- can be increased by breeding

- Water limitation may lead to yield reduction
- depends on soil water availability as determined by amounts of rainfall and evapotranspiration, and their distribution over the growing season, by soil type, soil depth and groundwater influence

- Under actual field conditions all kinds of additional yield reducing factors occur leading to reduced yield
- yields which are typically obtained on farmers' fields in practice

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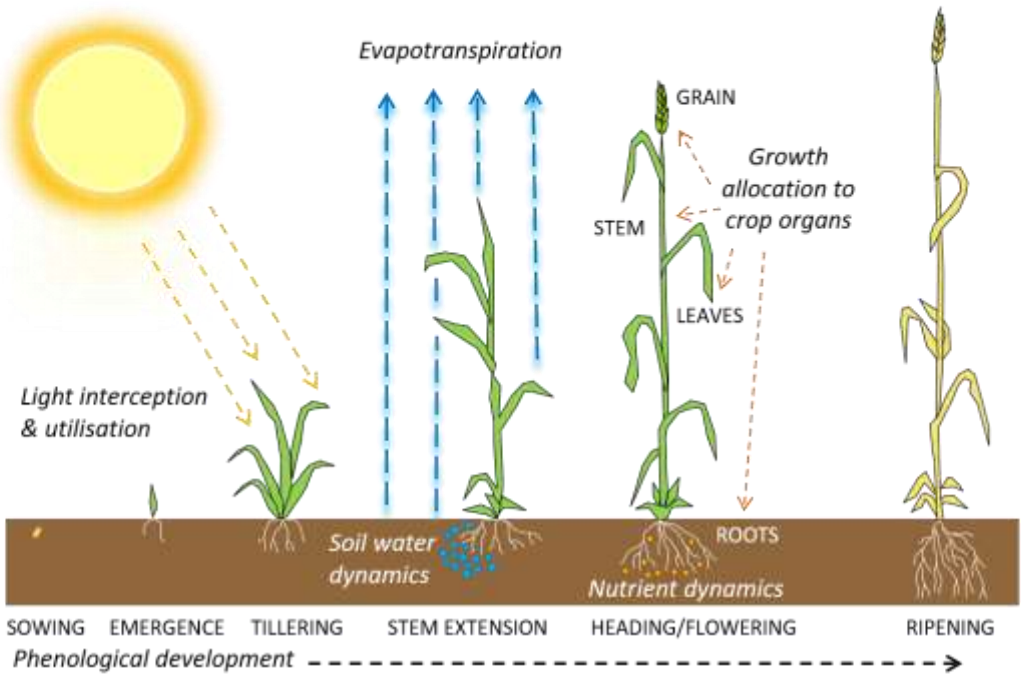
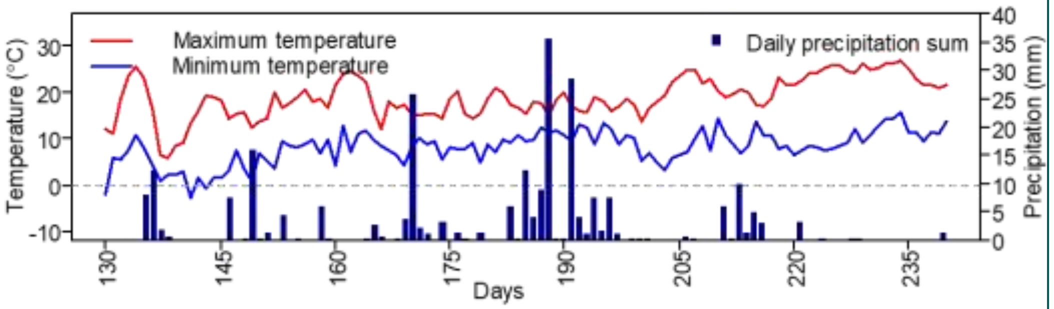
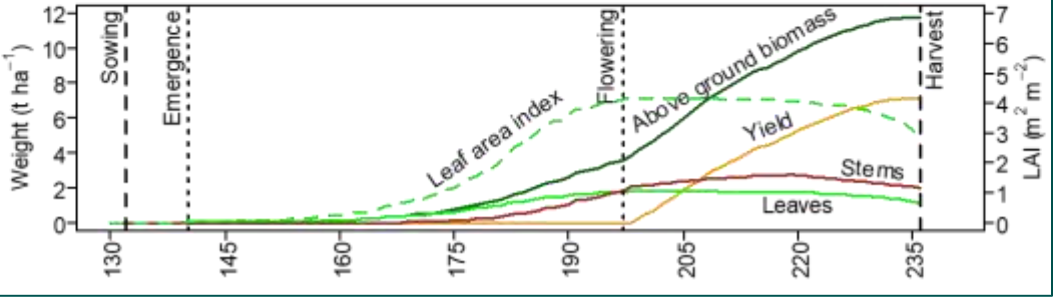
Key processes required for modelling crop growth



Weather input data



Crop model output

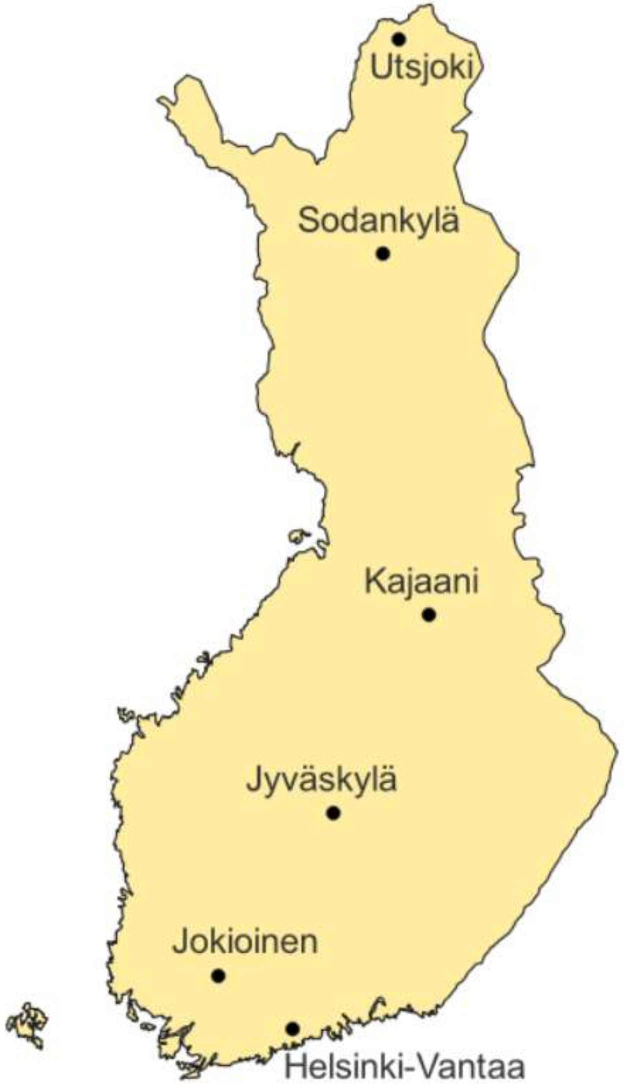


10 May

23 August

- In WOFOST each year is simulated individually
- The development and growth of the crop is different during each simulation depending on the unique conditions of each site and year.
- In unfavourable conditions the crop may not even reach harvest in time

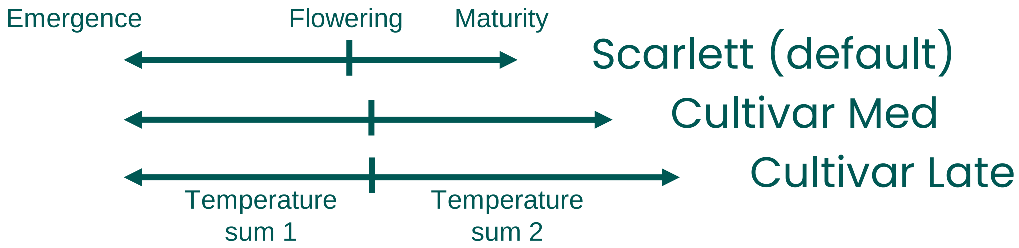
Simulation setup



Crop: Spring barley **Soil:** Clay loam / *Coarse sand*

Adaptation options:

- Cultivar



- Sowing date – "optimal" sowing

Selected indicator :
- dry matter grain yield (kg/ha)

Likelihood threshold for assessing yield shortfall:
- 30-year baseline mean yield (~**6000 kg/ha**) simulated by WOFOST for Scarlett at Jokioinen, where conditions for barley are currently among the best in Finland

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Human mortality model

Lisa Haga, Reija Ruuhela (Finnish Meteorological Institute)

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How does extreme temperatures affect mortality and morbidity?

- Non-optimal temperature is estimated to cause 7,7% of all deaths and **cold is responsible for the majority of deaths (Gasparrini, 2015)**.
- 30% of the world's population is already exposed to severe heat waves, and by the end of the century this proportion is projected to rise to 48-74% (Mora et al., 2017). **Due to climate change, heat-related impacts are expected to increase**.
- In Finland, also heat-related mortality is significant (Ruuhela et al., 2017)
- In particular, the elderly and chronically ill die prematurely due to heat

Our research and methods

Our ongoing research focuses on the impact of extreme temperatures on mortality in Finland:

1. IRS model (Adapt-FIRST)

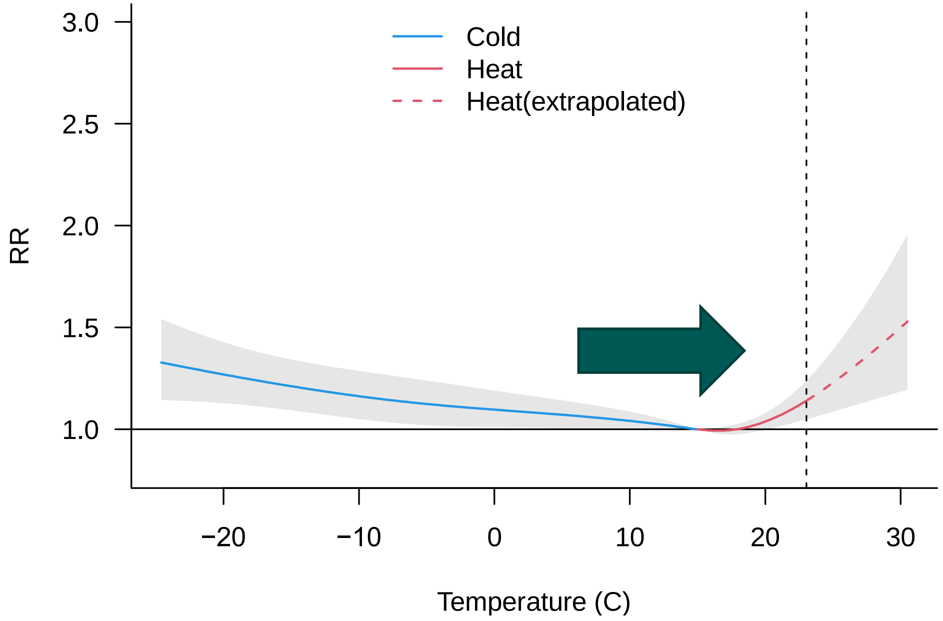
2. Projections of future excess temperature-related mortality with adaptation (CHAMPS project)

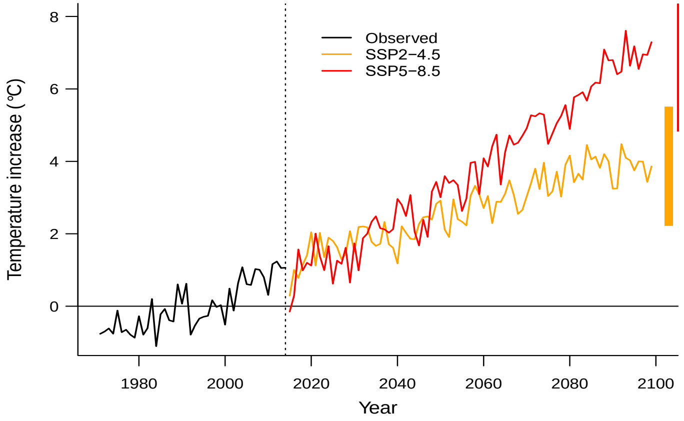
->We apply the statistical regression model **DLNM (Distributed lag nonlinear model) and model future mortality projections utilizing a step-wise modelling approach.**

Vicedo-Cabrera et al., 2019: DOI: 10.1097/EDE.0000000000000982

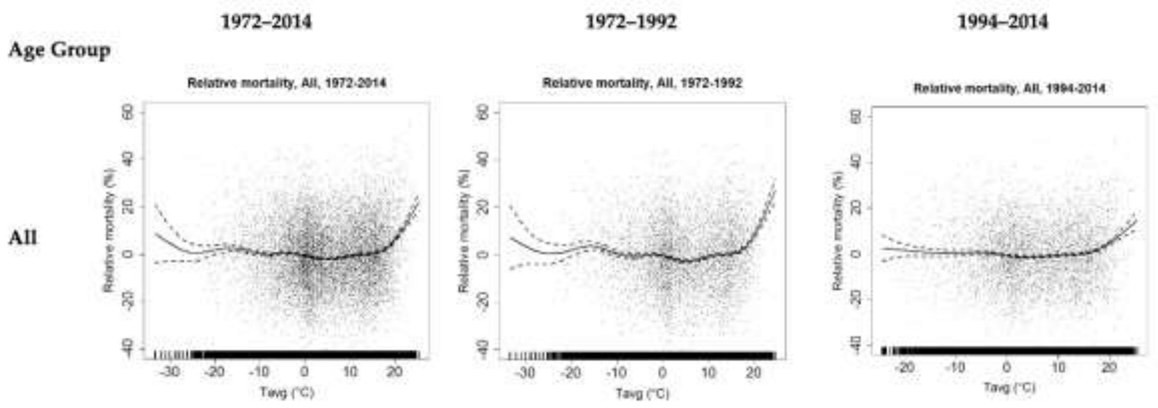
What is the relationship between temperature and mortality?

- Mortality data for the Finnish wellbeing service counties, all age groups and average daily temperature for 2000-2017.
- We model the relationship between temperature and mortality based on MMT (minimum mortality temperature) using statistical DLNM (Distributed lag nonlinear model).
- Extreme cold and heat increase Relative Risk (RR)
- We combine these results with climate models under SSP2-4.5 and SSP5-8.5 and calculate the future projections as excess attributable number or fraction of deaths.

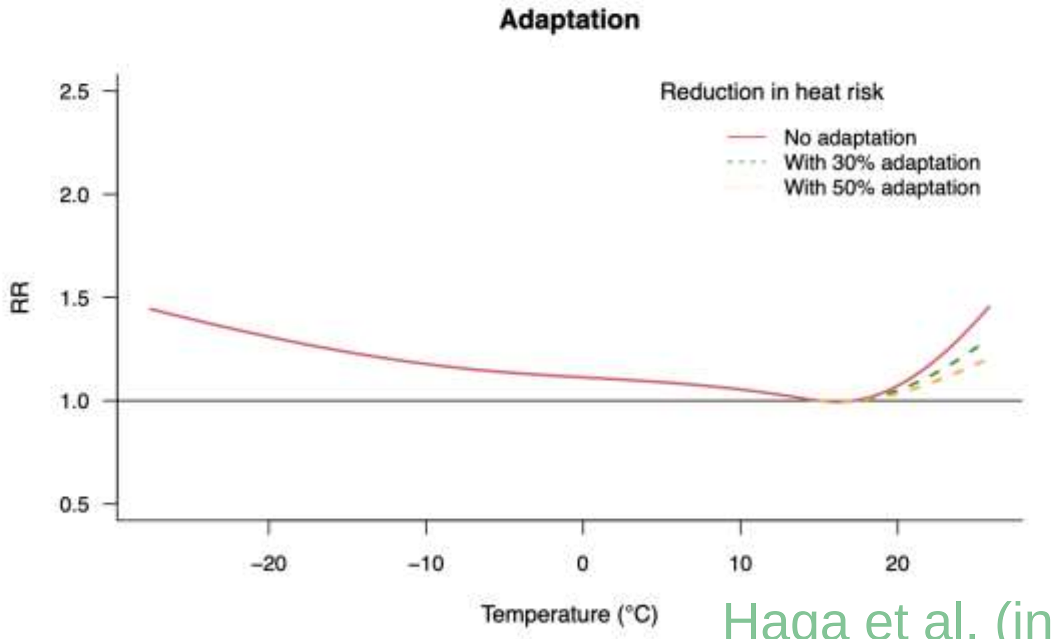




How to include adaptation in the modelling?



Ruuhela et al. 2017



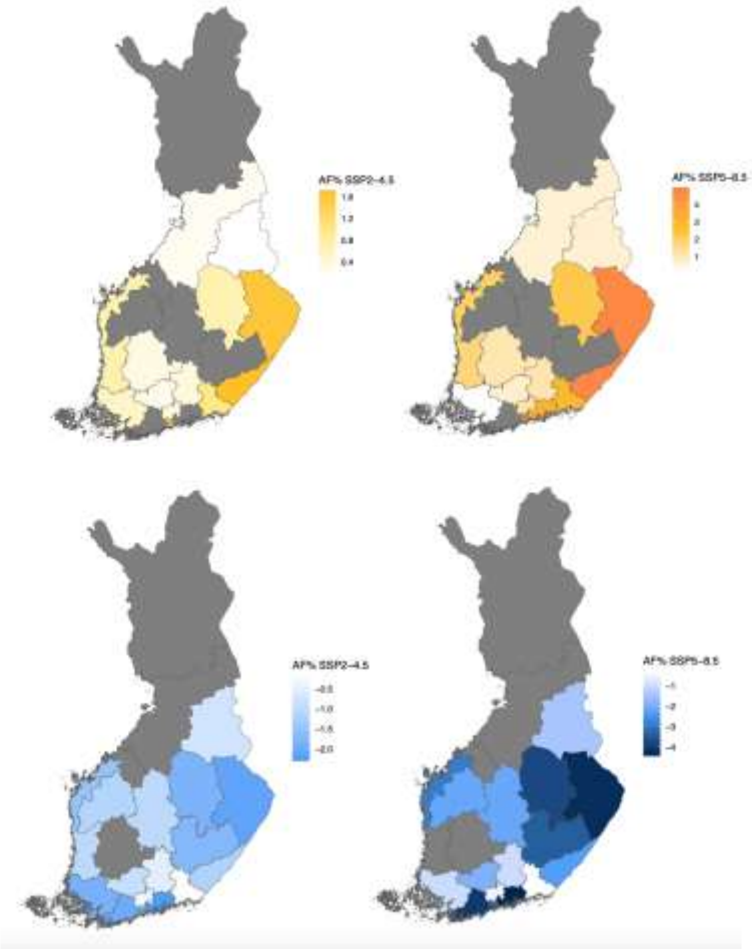
Haga et al. (in preparation)

*Ruuhela et al. 2017: 50% **decrease in heat sensitivity** between 1972-1992 and 1994-2014 in Finland for all aged and >75 years old
* 20, 50, 80% slope reduction by 2071-2100: used by Lee et al. 2019 => 2.5%, 6.25%, 10%/decade.
* No adjustment or shift in the RR curve: use population projections.

Conclusion

- Heat related risks will increase in the future
- For future projections different modelling alternatives available:
  - IRS adaptation model
  - DLNM model with future projections: Attributable numbers (how many excess heat or cold related deaths.)

Projections of excess heat and cold related deaths in Finland 2090-2099 (compared to 2010-2019)



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