Effect of water deficit on tree growth, leaf discoloration and crown transparency in Swiss ICP-Forests level II plots

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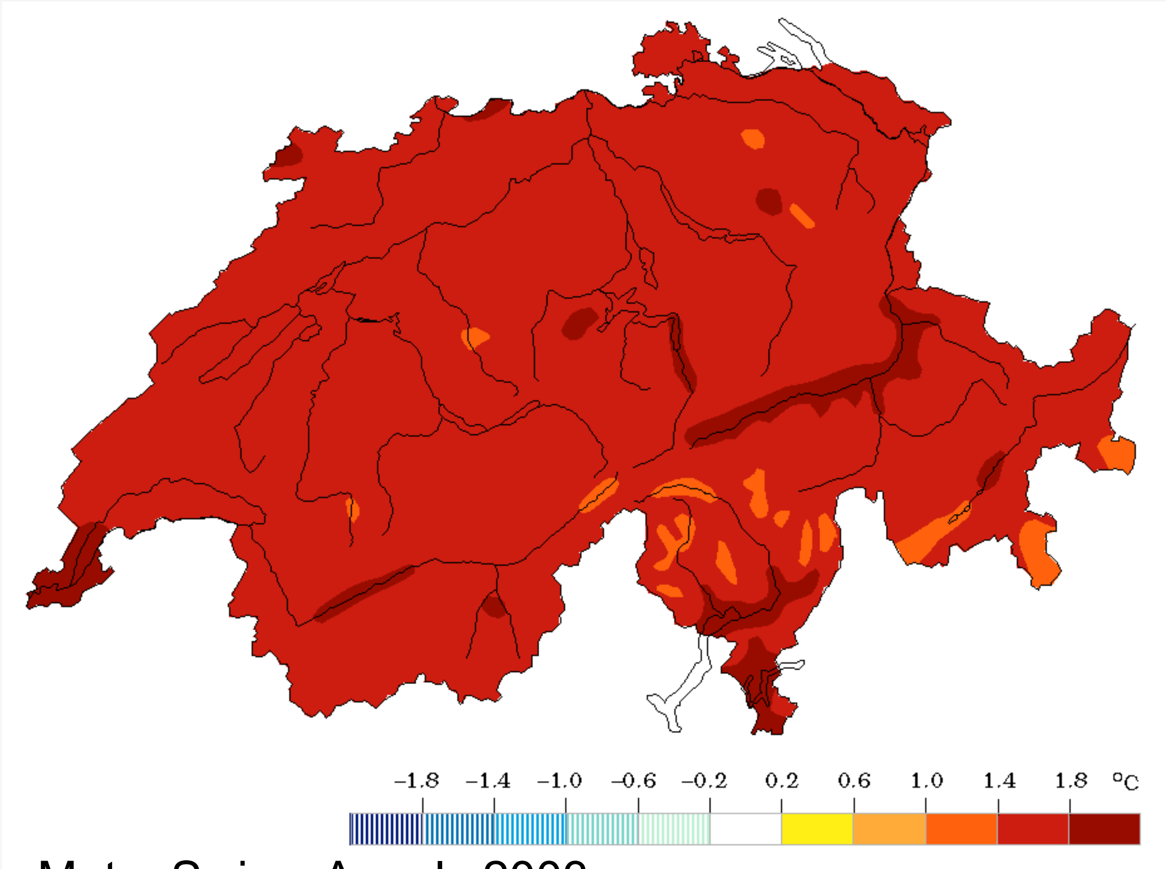
WSL, Swiss Federal Institute for Forest, Snow, and Landscape Research

Weather in Switzerland in 2003: Extremely warm!

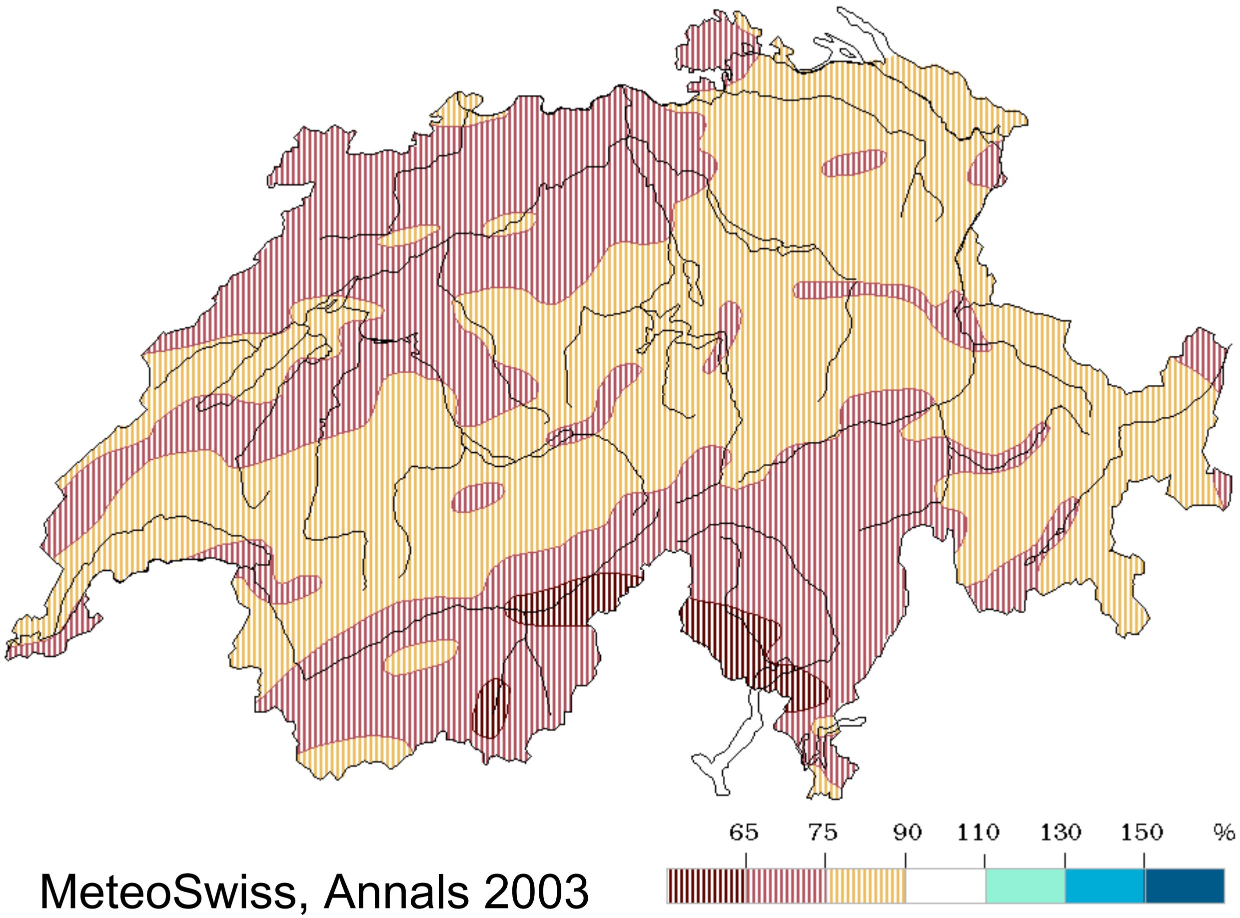
Difference of air temperature with long-term annual mean



MeteoSwiss, Annals 2003

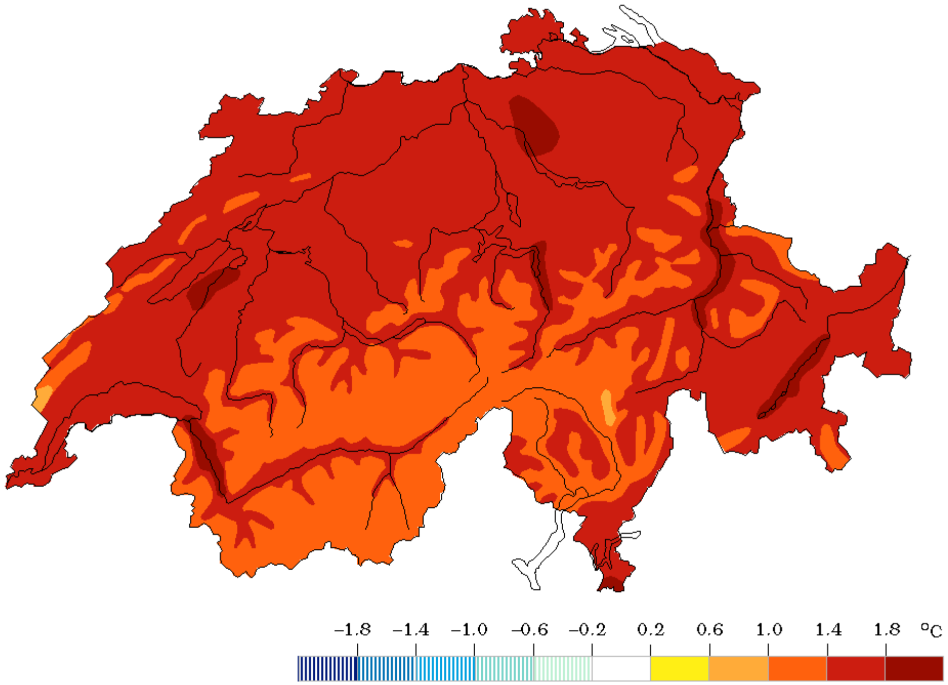
Weather in Switzerland in 2003: Dry!

Precipitation in percentage of long-term annual sum



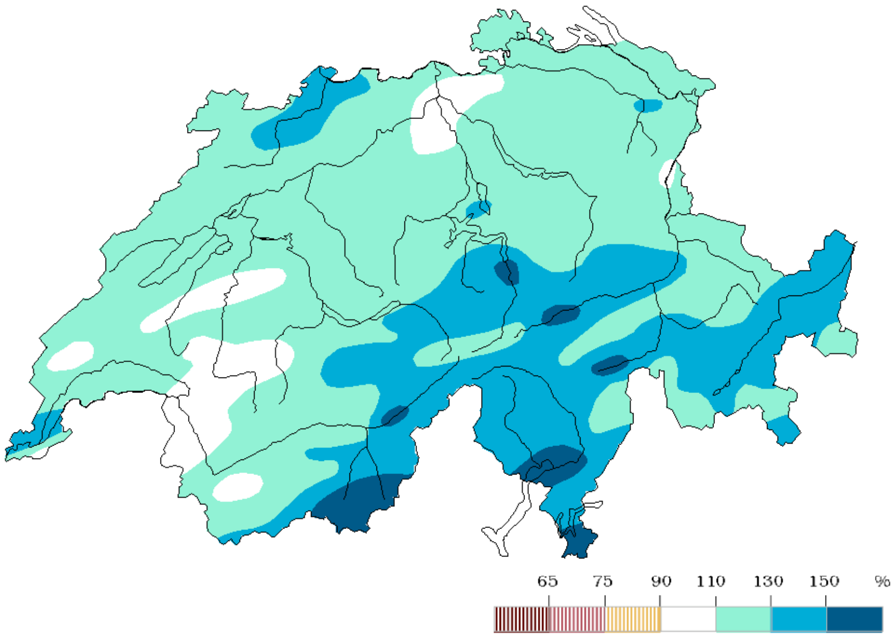
MeteoSwiss, Annals 2003

In 2002: very warm and wet



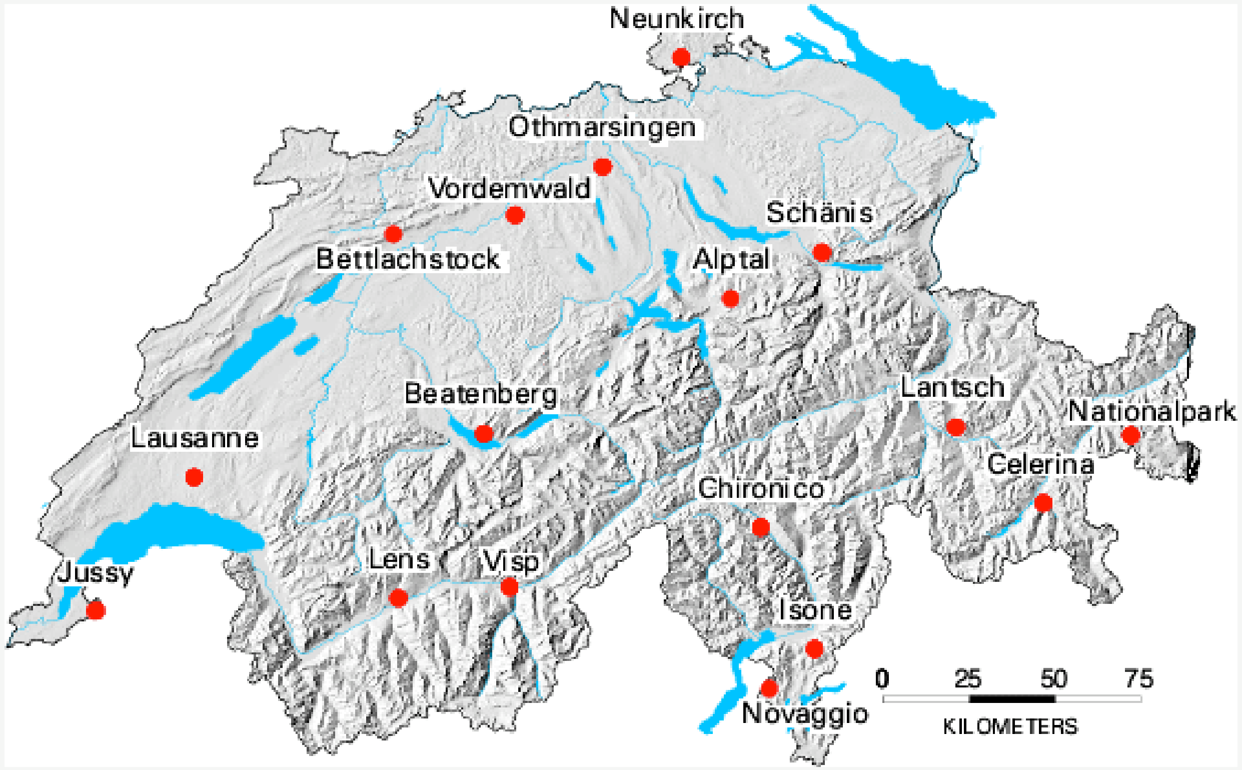
Difference of air temperature
with long-term annual mean

Precipitation in percentage
of long-term annual sum



MeteoSwiss, Annals 2002

Long-term Forest Ecosystem Research in Switzerland (ICP- Forest)



17 intensive monitoring (IM) plots (Level II)

- Jura: 2 plots
- Plateau: 4 plots
- Prealps: 3 plots
- Alps: 5 plots
- Southern CH: 3 plots

Characteristics of Level II plots

Region	Plot	main tree species	soil type (FAO)	altitude m	yearly mean air temperature °C	annual sum precipitation (mm)
Jura	Neunkirch	*Fagus sylvatica*	Rendzic Leptosol	560	8.3	1020
	Bettlachstock	*Fagus sylvatica*	Rendzic Leptosol	1150	6.0	1454
Plateau	Vordemwald	*Abies alba*	Dystric Planosol	480	8.4	1106
	Othmarsingen	*Fagus sylvatica*	Haplic Acrisol	480	8.6	1045
	Jussy	*Quercus robur*	Eutric Gleysol	500	9.5	960
	Lausanne	*Fagus sylvatica*	Dystric Cambisol	800	8.6	1062
Prealps	Alptal	*Picea abies*	Mollic Gleysol	1155	5.3	2129
	Schänis	*Fagus sylvatica*	Eutric Cambisol	700	7.0	1965
	Beatenberg	*Picea abies*	Podzol	1500	4.7	1725
Central Alps	Celerina	*Pinus cembra*	Podzol	1860	0.7	816
	Lens	*Pinus sylvestris*	Haplic calcicsol	1050	8.0	954
	Visp	*Pinus sylvestris*	Calcaric phaeozeme	700	8.8	615
Southern Alps	Novaggio	*Quercus cerris*	Podzol	950	9.1	1887
	Isone	*Fagus sylvatica*	Podzol	1200	7.5	1819
	Chironico	*Picea abies*	Podzol	1350	5.8	1427

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Parameters measured on the IM plots

Meteo

Circumference band

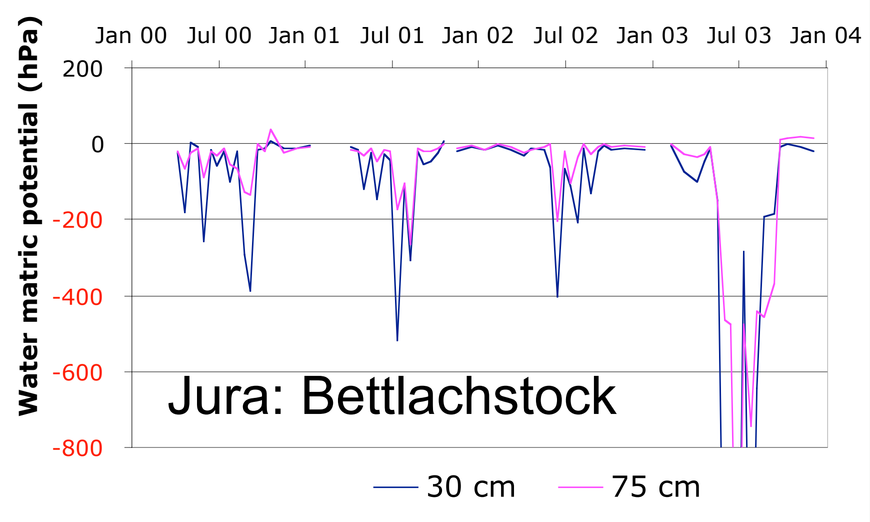
Crown transparency

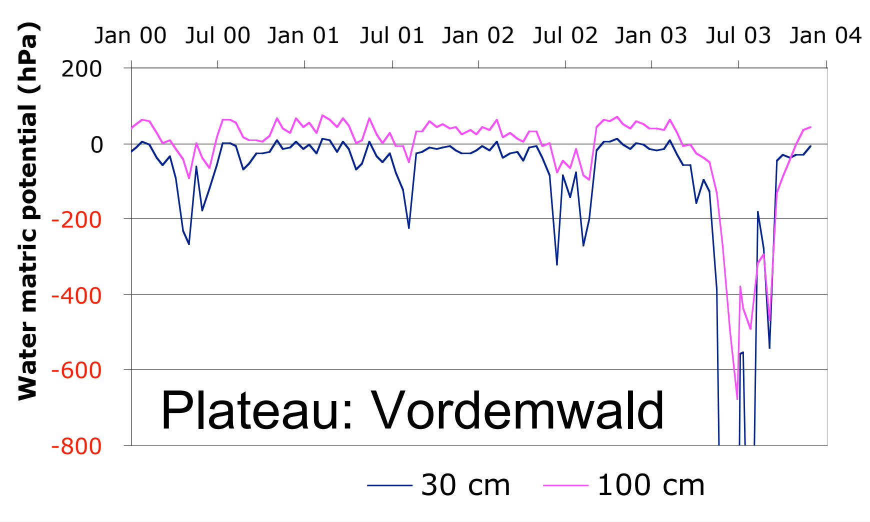
Soil water potential

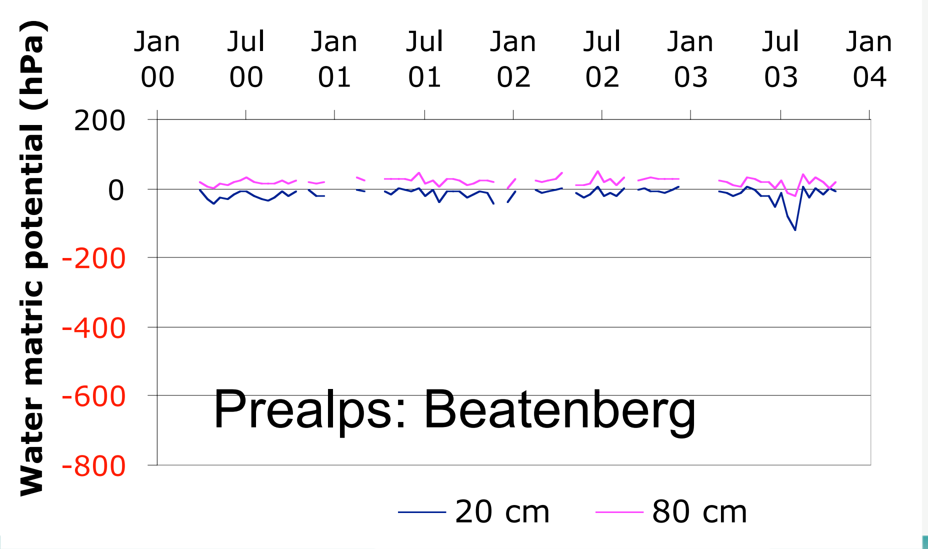
Throughfall

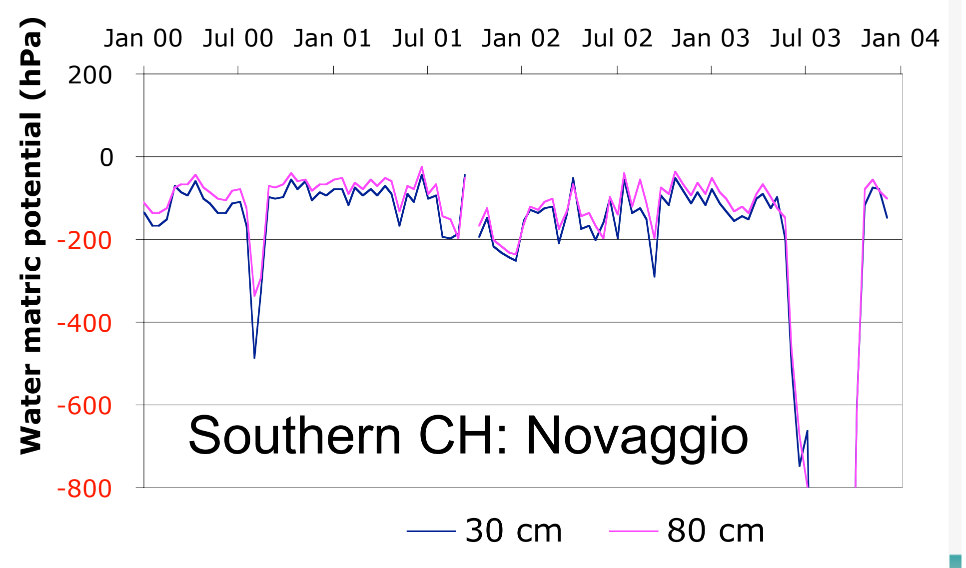
Soil

Soil water potential 2000-2003









Water balance model (WATBAL)

- Monthly water balance model developed by Michael Starr (Finnish Forest Research Center)

- Simple model

- Storage model
  Precipitation = AET + RUNOFF + Drainage + Δ Soil moisture + Δ SNOW + Matrix_losses

- Evapotranspiration calculated from insolation, applied to sloping surfaces of any orientation

WATBAL: Input data and parameters

Input data:

- Precipitation
- Air temperature
- Cloudiness
- slope factors

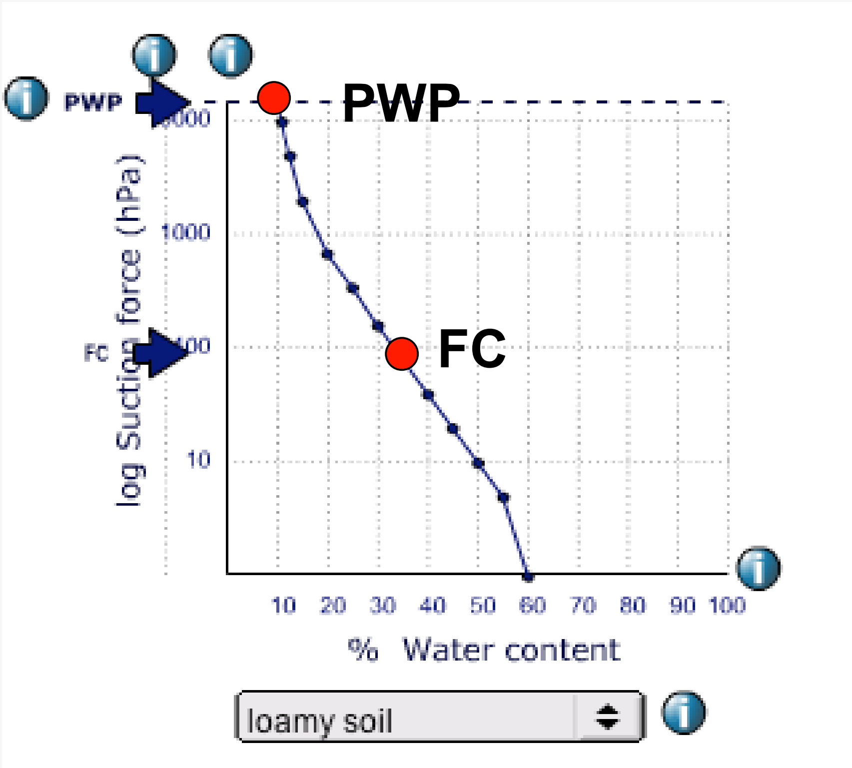
Initial values:

- Soil moisture
- Amount of snow

Parameters:

- Long-term min and max. air temperature of warmest month
- SM at field capacity
- SM at wilting point
- Altitude, latitude

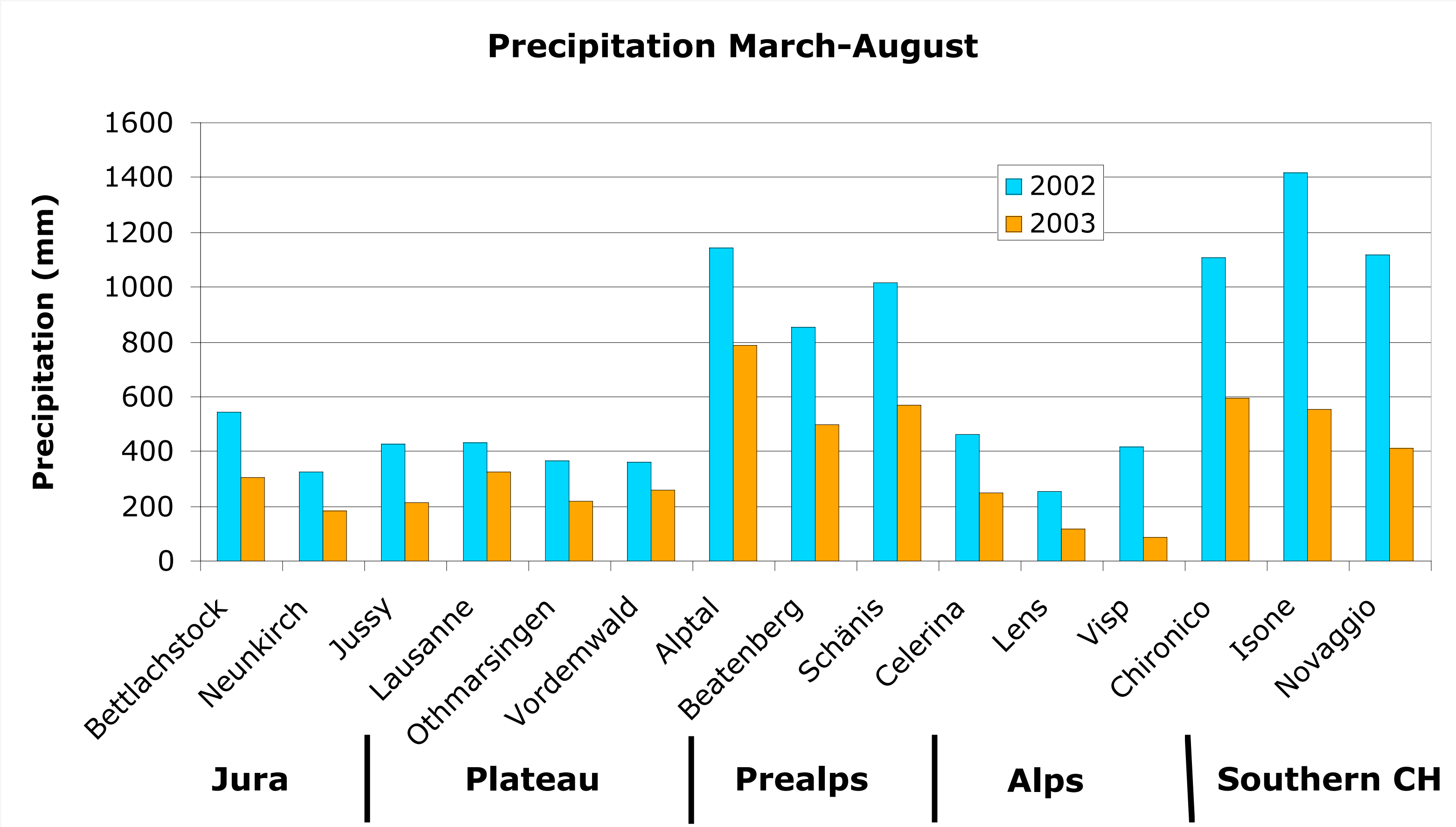
Physical soil properties



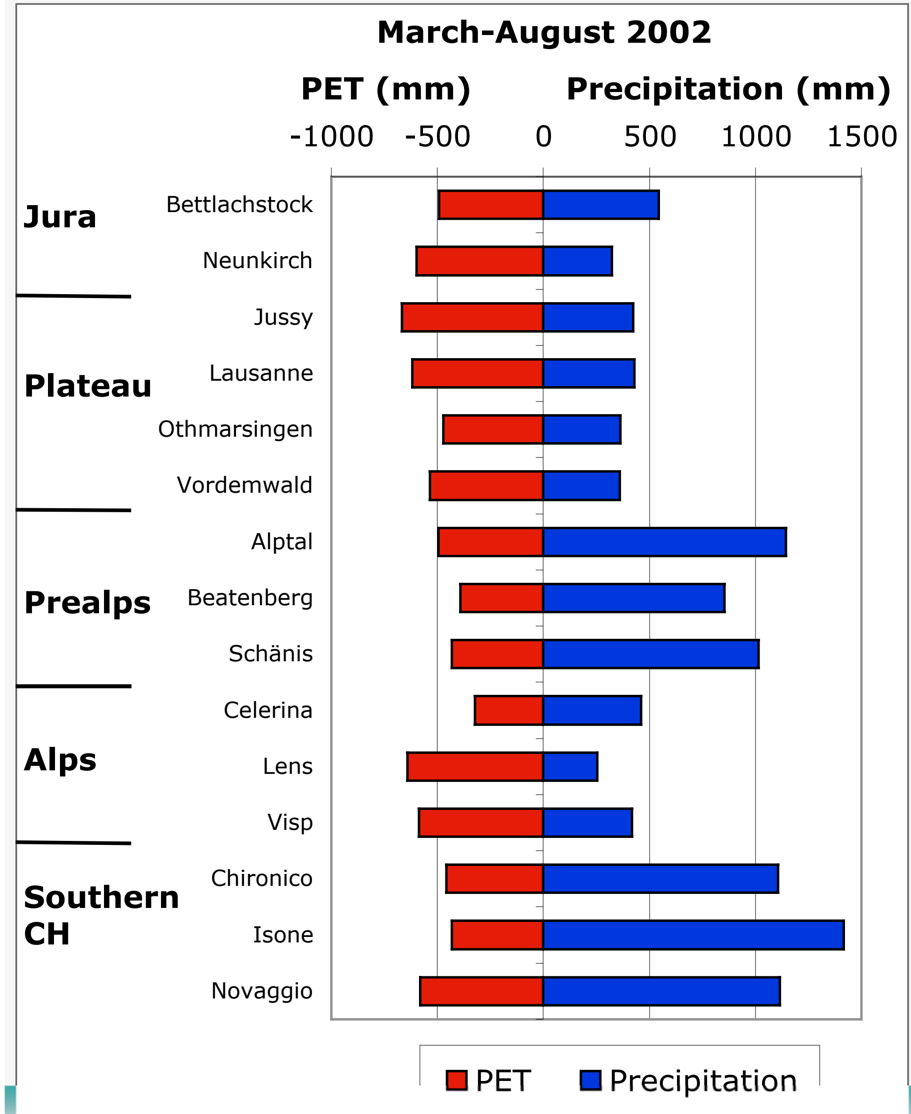
Soil moisture at field capacity and permanent wilting point:

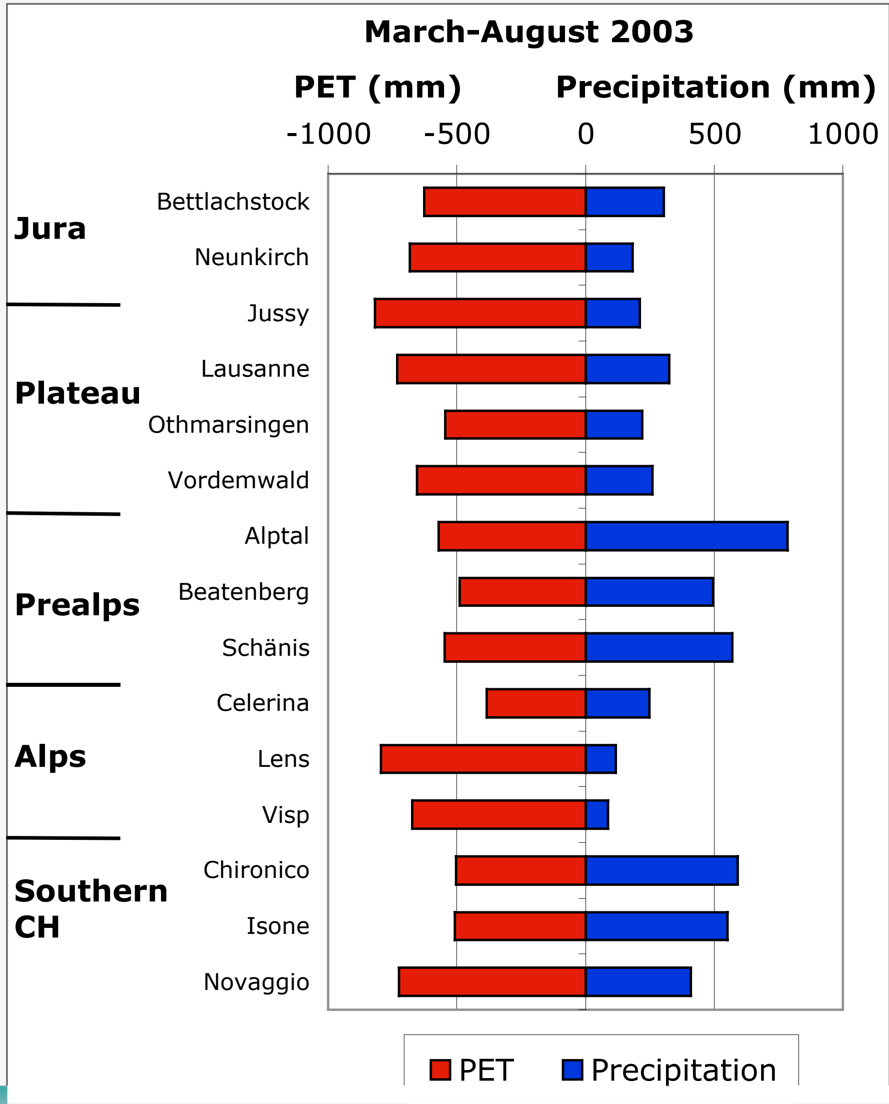
- derived from pedotransfer functions in german forest soils:
  - (Forstliche Standortaufnahme, Arbeitskreis Standortskartierung,2003)
- Soil texture, bulk density, organic matter content (Walthert et al. 2003)

Precipitation in the growing season

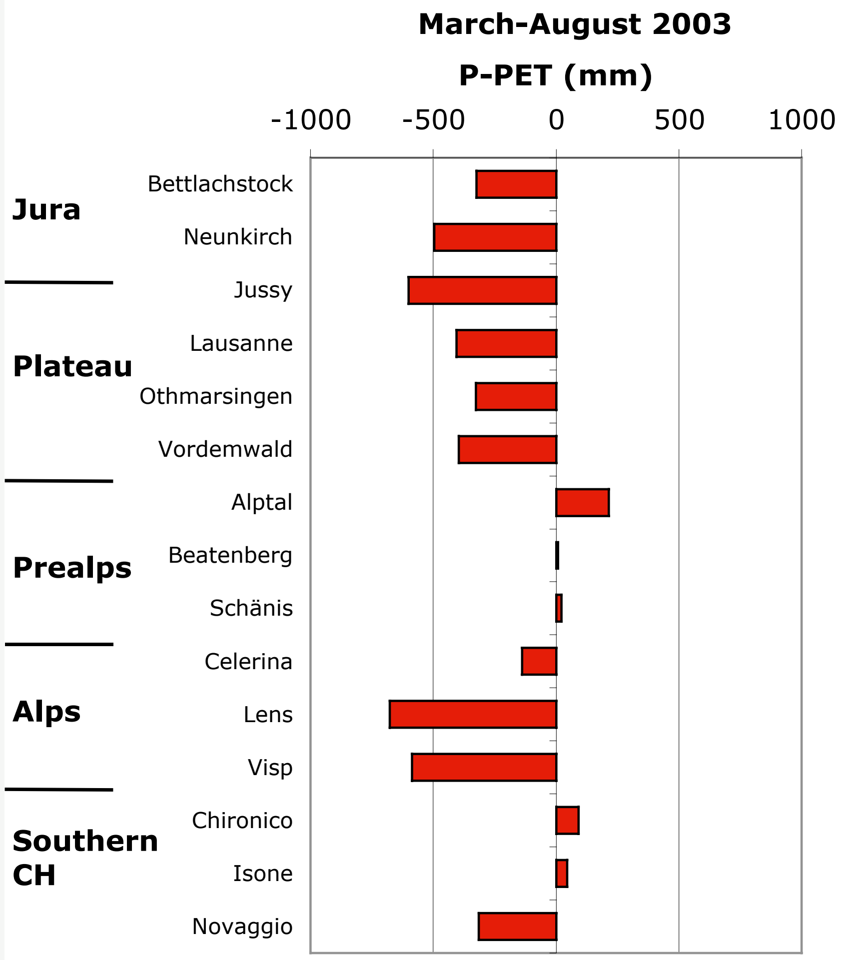


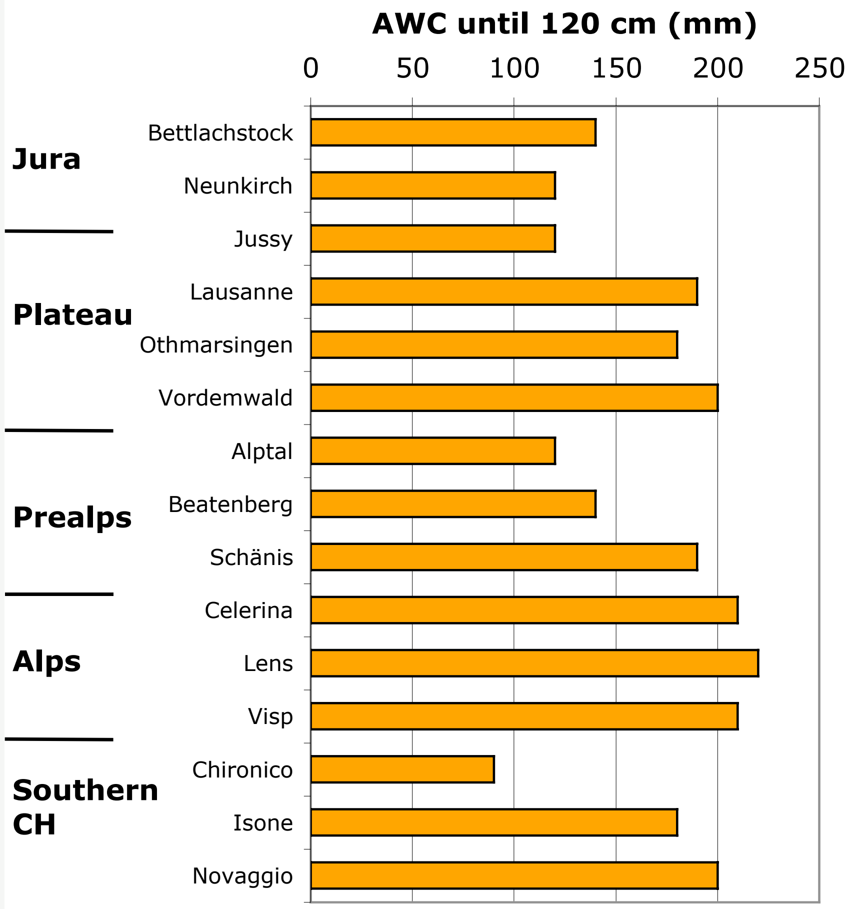
Precipitation and PET in 2002 and 2003



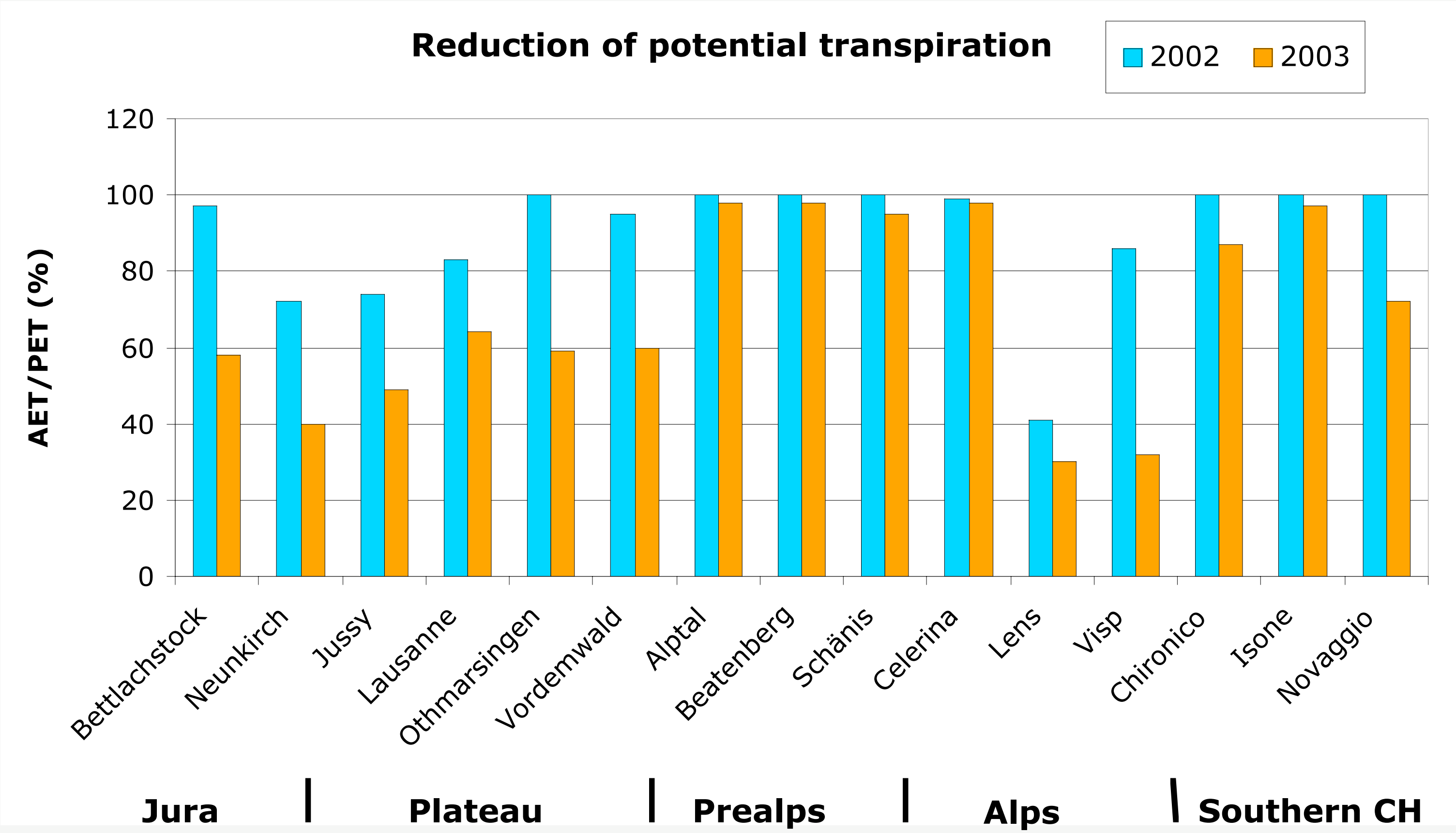


Evaporative demand compared to available soil water capacity

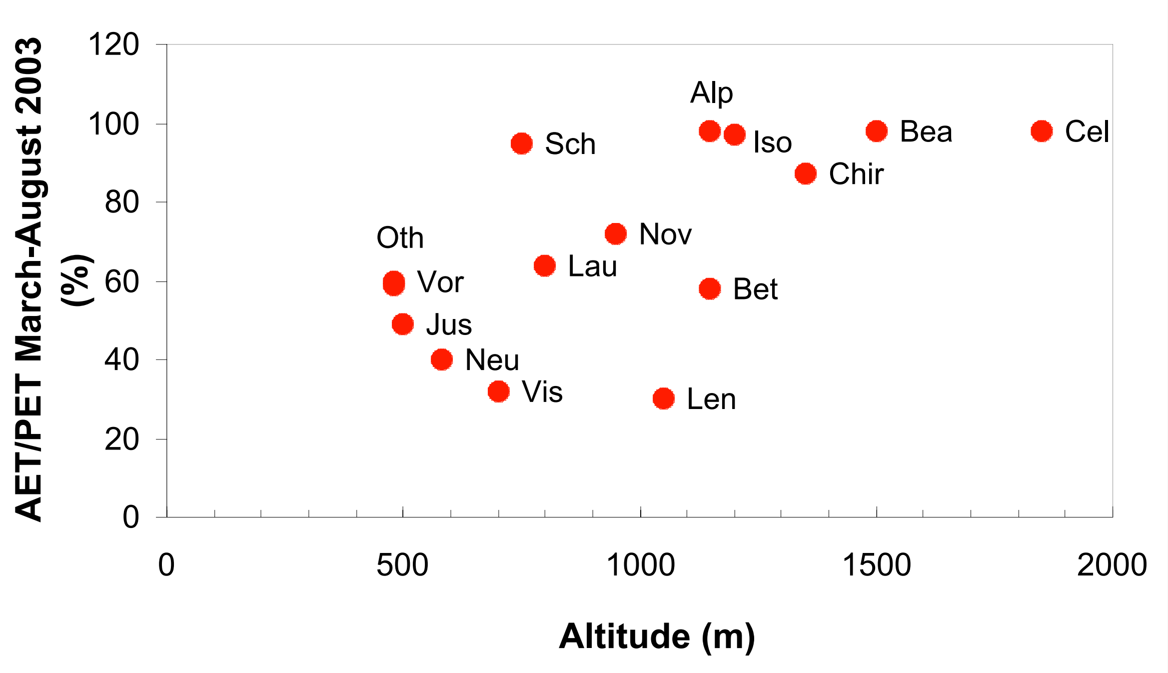




Reduction of evapotranspiration



Water stress and altitude



Measurement of tree growth

- Permanent stem circumference bands on 10 trees of the main species in 2001 at 15 sites

- Stratified random selection approach:
  - fives classes of stem diameters
  - within each class, two trees were randomly selected

- Circumference was measured annually at the end of the growing season (October) at the 1/10 of a mm

- Tree growth in 2002 and 2003:
  - Mean diameter growth in 2003 in percent of the growth in 2002
  - Basal area growth in % of the basal area at the beginning of the growing period (BAI-%)

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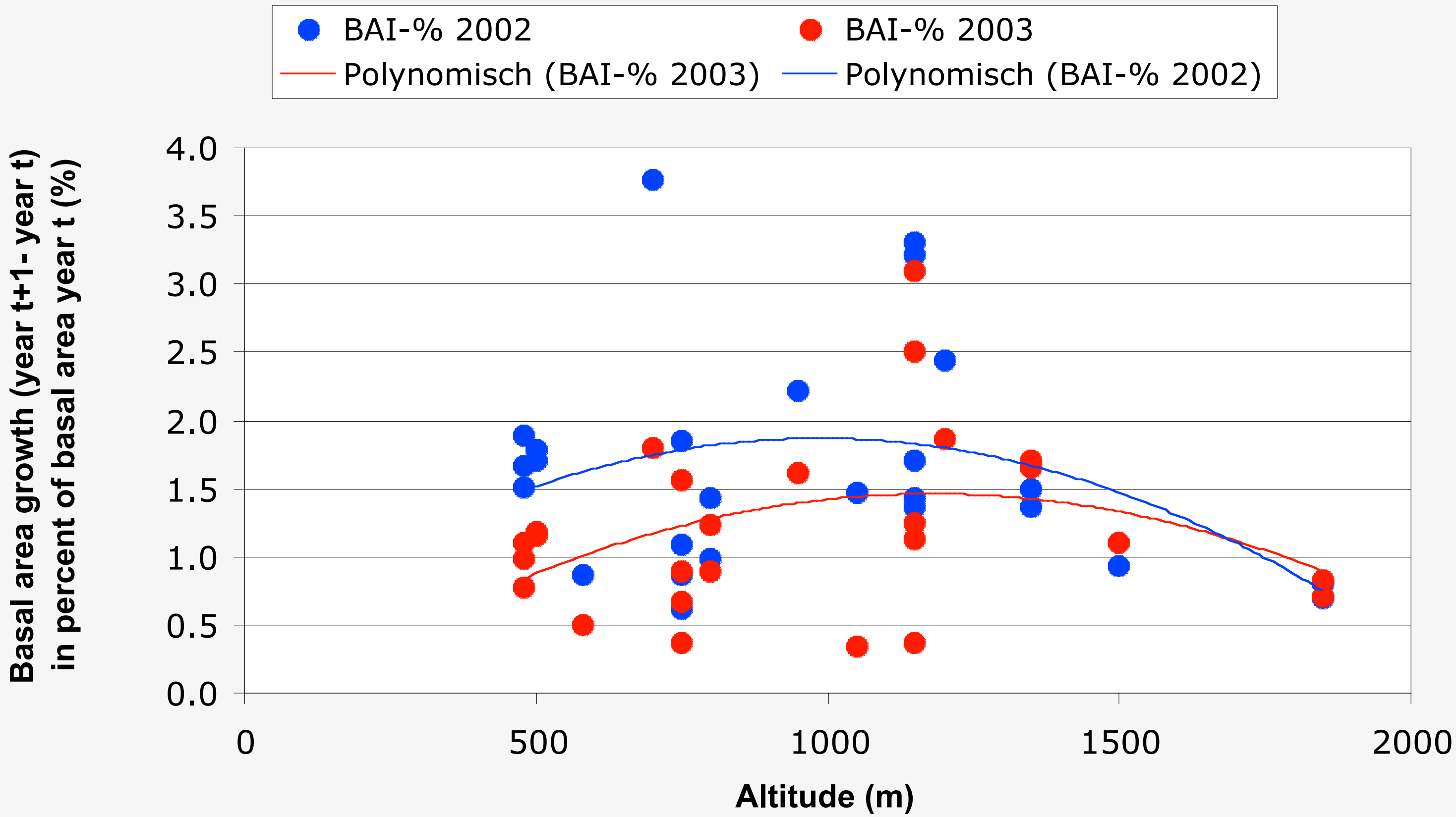
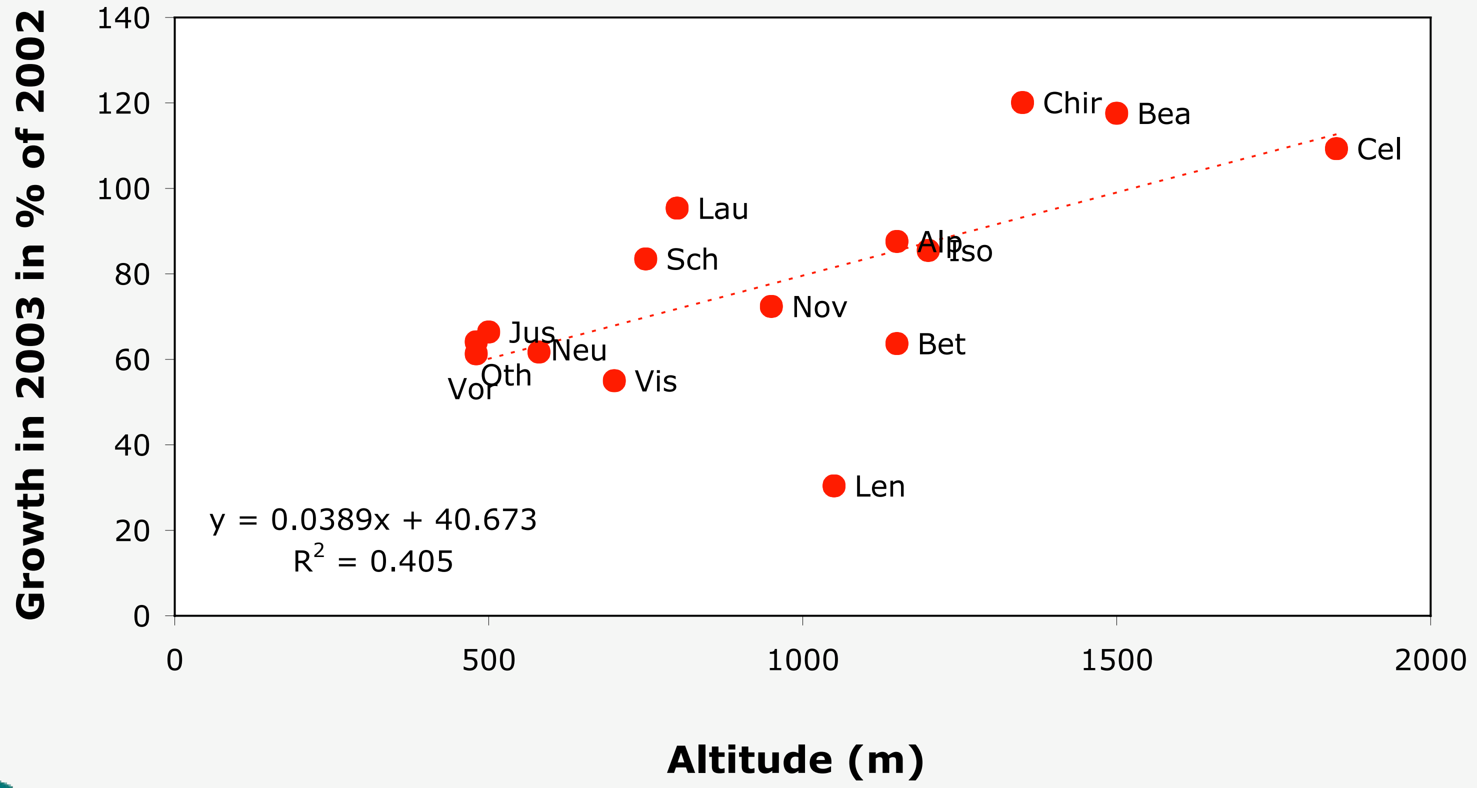
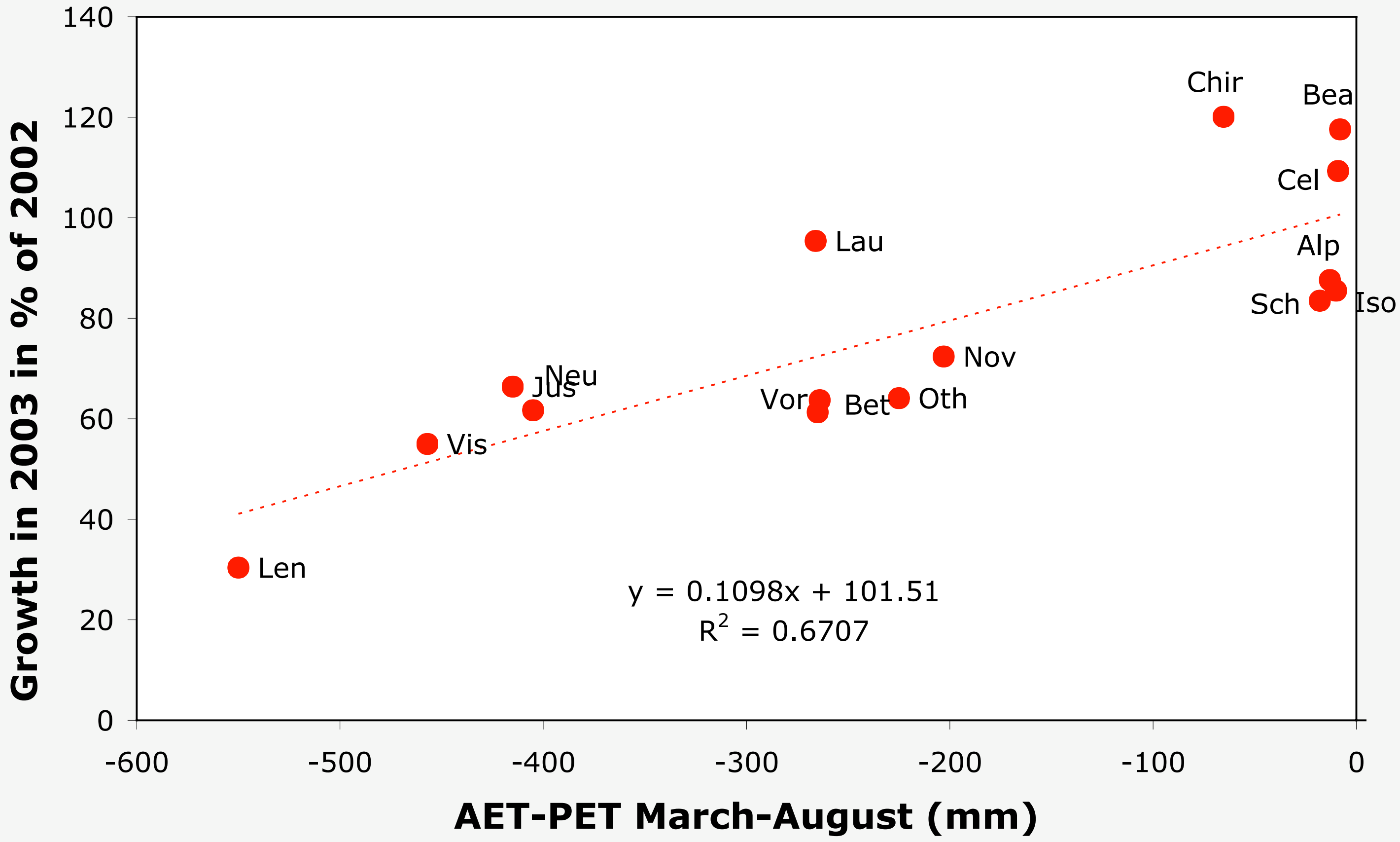
Tree growth in 2002 and 2003



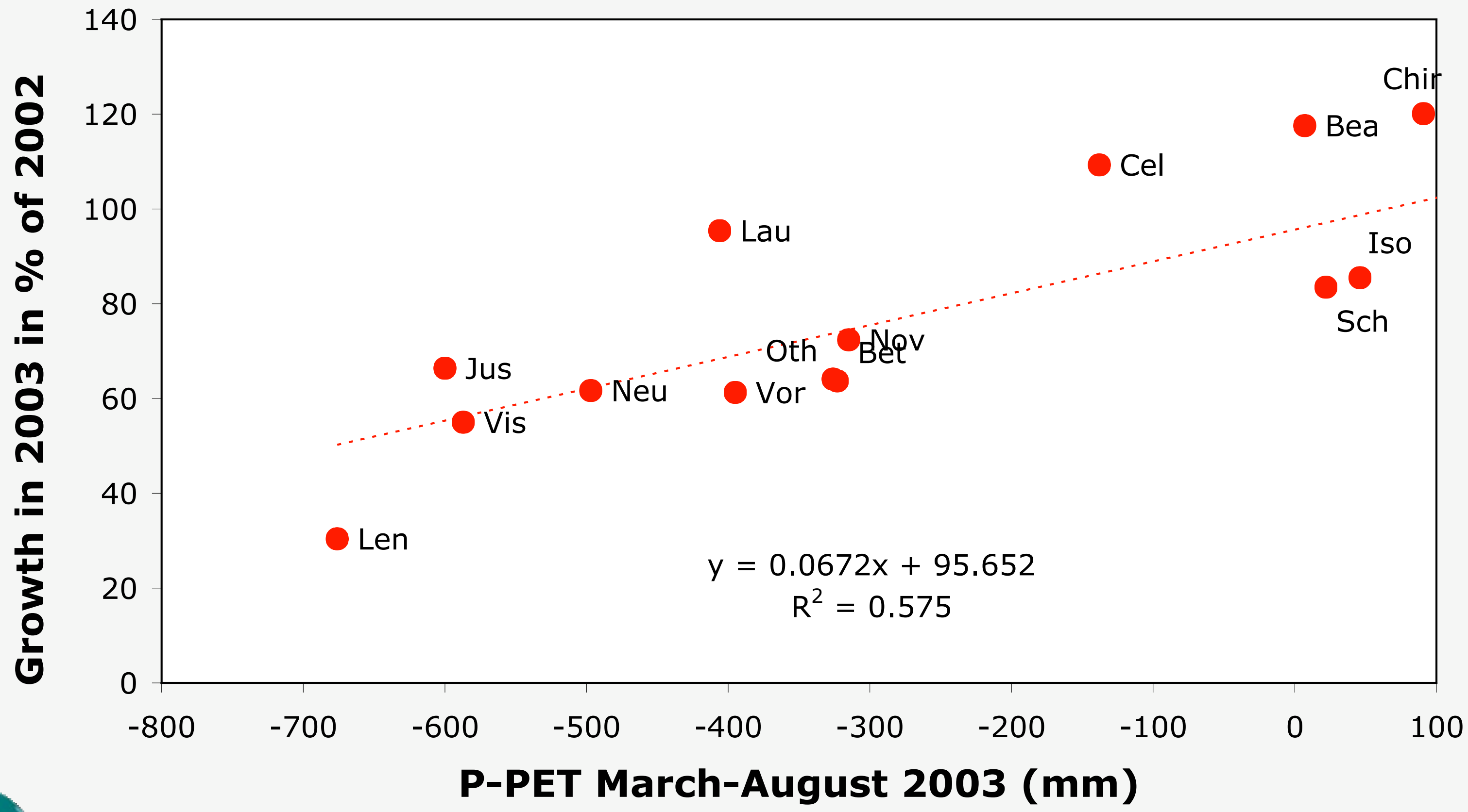
Growth and altitude



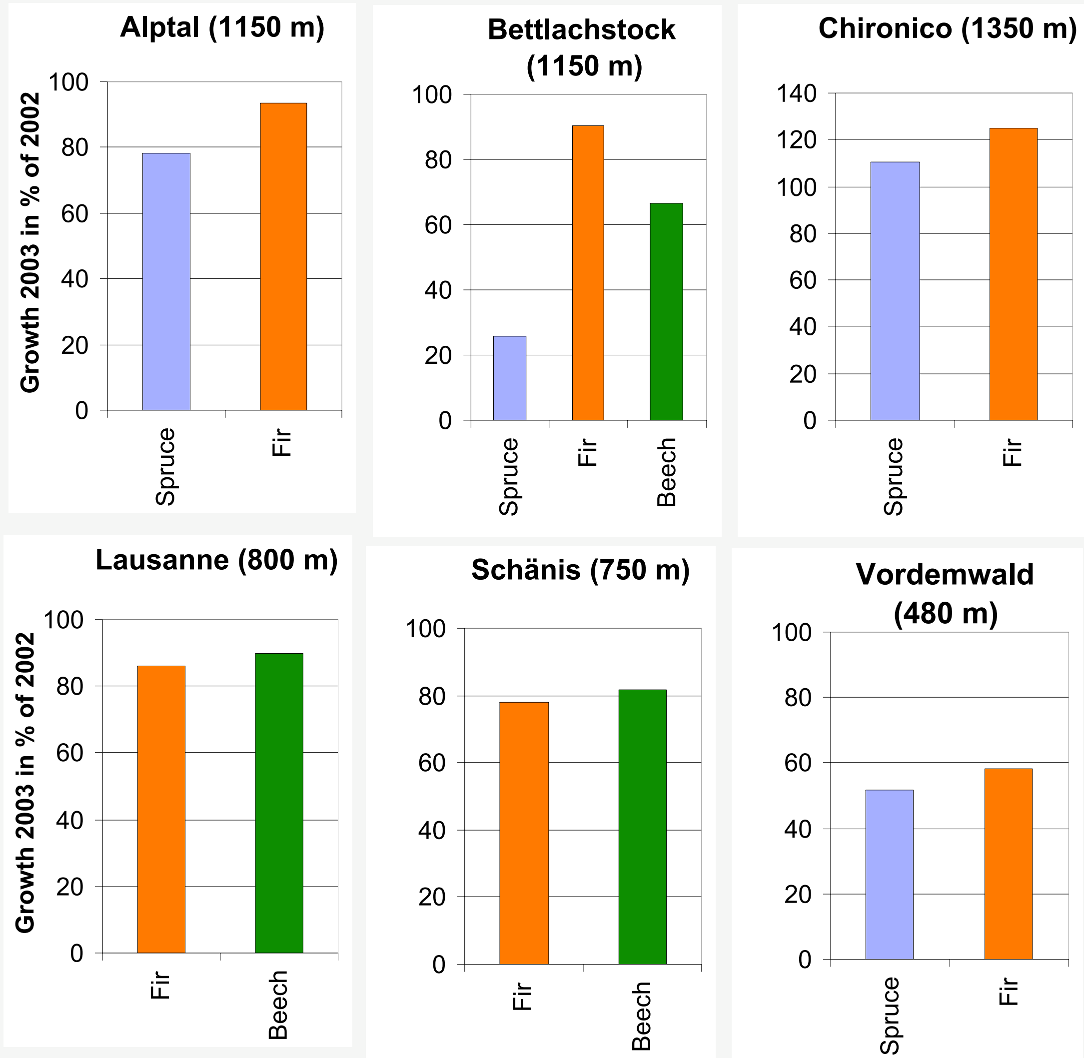
Growth and AET-PET (March-August) in 2003



Growth and P-PET (March-August) in 2003



Growth and tree species



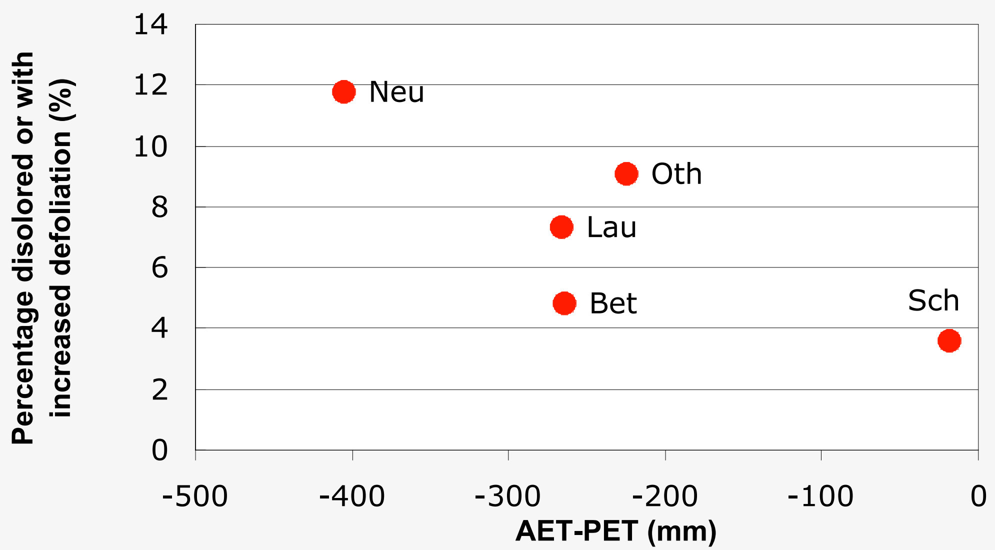
Leaf discoloration and crown transparency

- Records of discoloration in 5 plots:
  - between July and middle August 2003
  - by mid September 2003
- Records of transparency:
  - between July and middle August 2003 (13 plots)
  - by mid September 2003 (5 plots)
  - by July and mid August 2004 (13 plots)

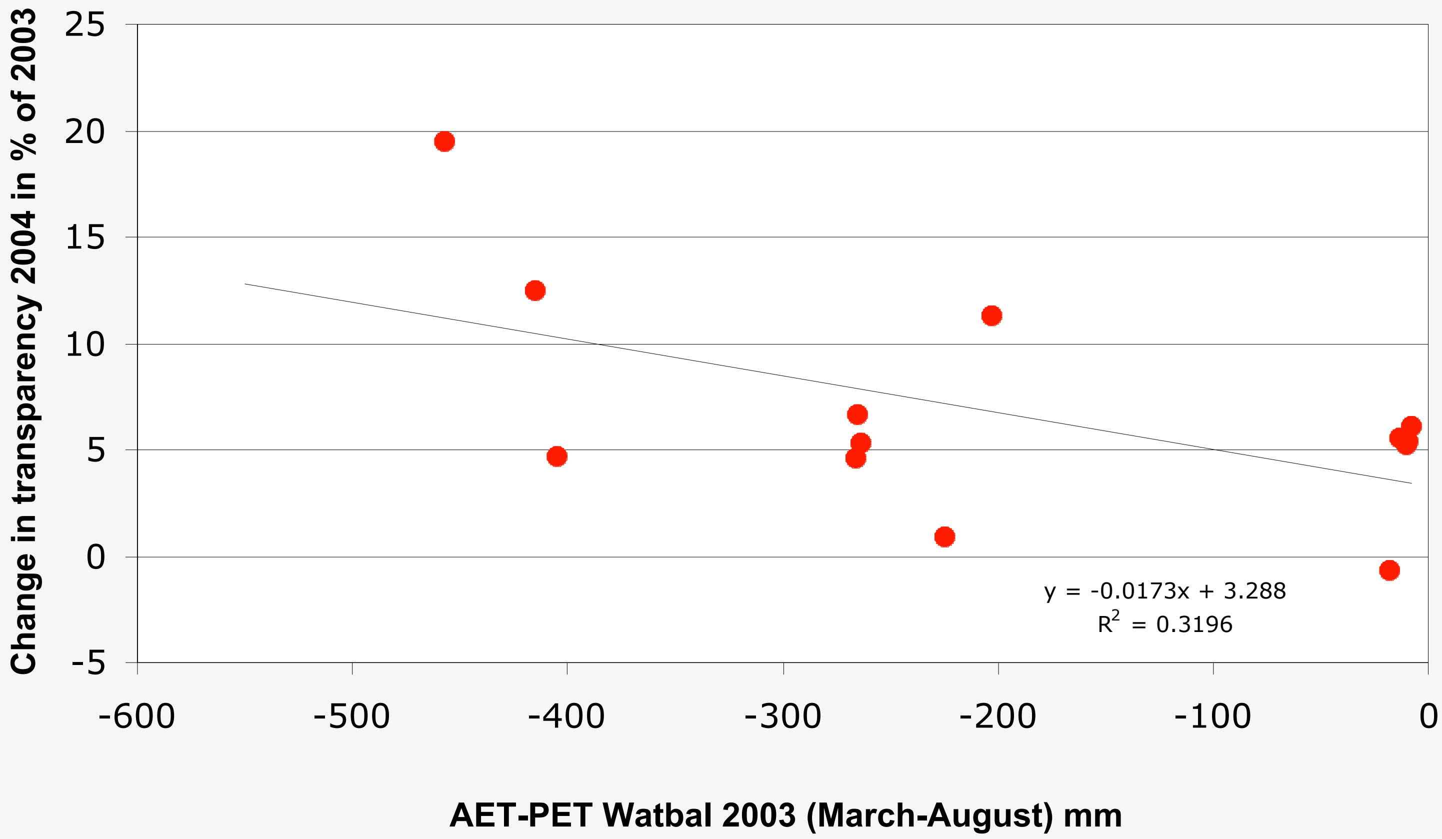
Discoloration and defoliation of beech

- July-mid August 2003 :
  - almost no discoloration
  - defoliation lower than in 2002

- Mid September 2003 at 5 plots:
  - 7% of trees (26 out of 374) showed either an increase in transparency of ≥15% or discoloration of 10% of the leaves



Change in defoliation between 2003 and 2004 at 13 plots



Conclusions

- Modeled water stress (AET/PET<<1) at low elevations sites. No water stress at sites located higher than 1200 m

- At low altitude, water stress likely contributed to a significant decrease in tree growth in 2003 relative to growth of the previous year

- Above 1200 m, trees grew more in 2003 as compared to growth in 2002

- P-PET can be used as water stress indicator (P-PET>>AWC)

- Defoliation and discoloration were not observed in summer 2003. First signs in autumn 2003 at sites with water deficit. One year later, increase in transparency relative to 2003 with increasing water stress.

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Thank you!

- To the LWF team
- To the Sanasilva team
- To the local foresters
- To Michael Starr
- To the Swiss Federal Institute for Forest, Snow and Landscape
- To the Federal Office of Environment, Forest, and Landscape