Impacts of the Drought and Heat in 2003 on Forests

Scientific Conference 17 – 19 November 2004

Freiburg, Germany

Working Group 5: Forest Growth

Impacts of Drought and Heat on Tree and Forest Growth

A Synthesis of Studies on Short-, Medium- and Long-term Effects Observed under Temperate Climatic Conditions

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Questions addressed:

Was Tree Growth Affected by the Heat and Drought in 2003?

- To which **Extent**? (% of “normal”)
- Most affected **Species** (on the same site): Beech vs. Spruce
- Most affected **Sites**: Elevation and Aspect
- Most affected **Stands**: dense vs. open
- Most affected **Crown Class**: dominant vs. intermediate.

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Scaling issues addressed:

Short-term effects on growth?

Effects in 2003? (% of “normal”)

Medium-term consequences?

Effects during the next 5 years?

Long-term consequences?

Effects beyond the next 5 years?

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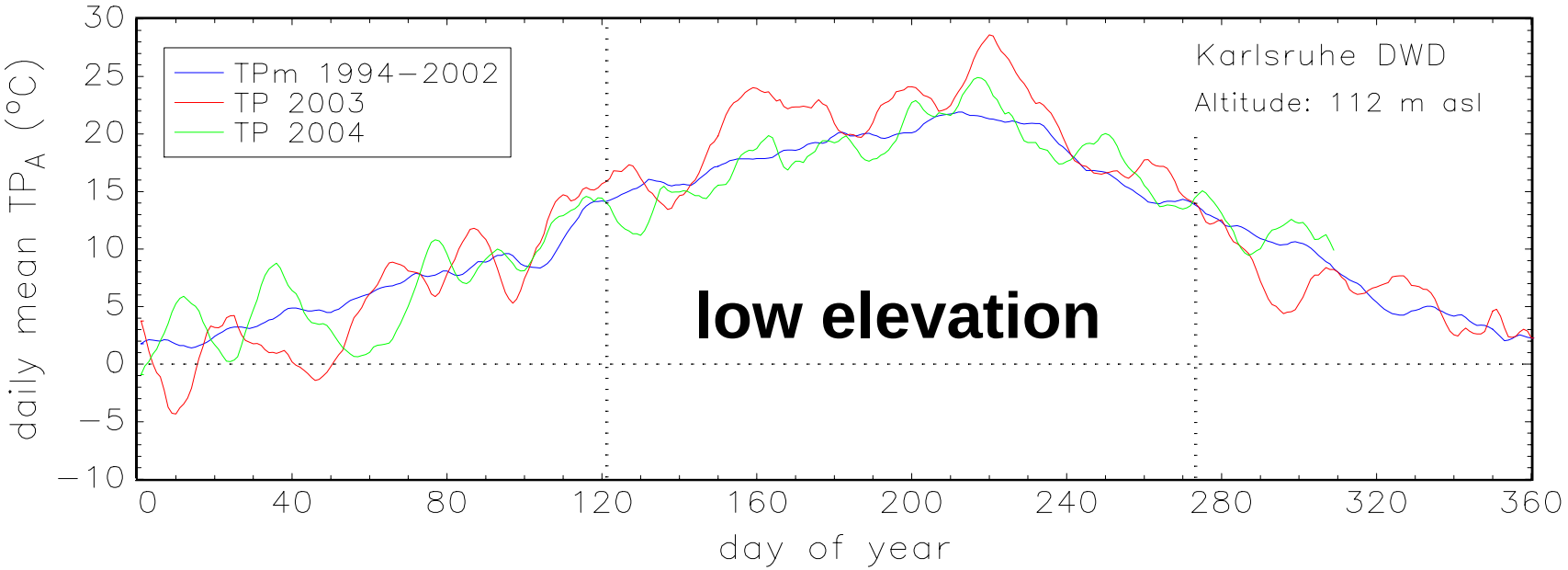
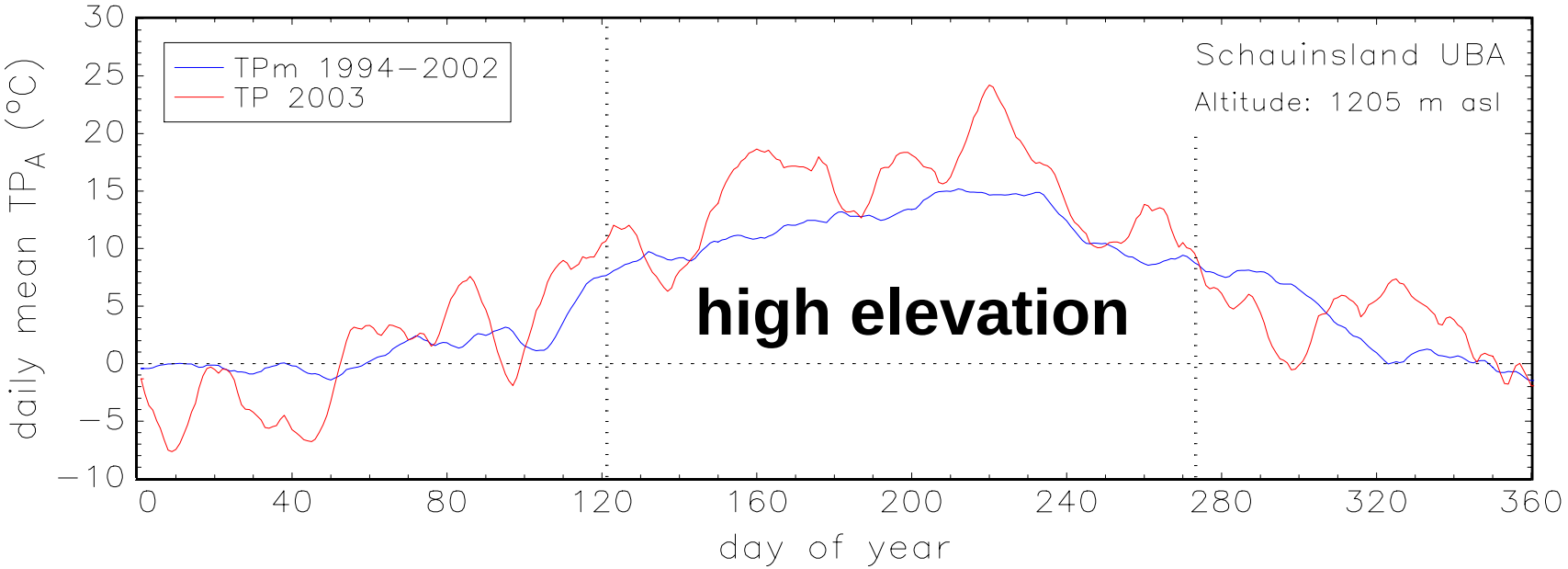
Weather Conditions in 2003

at two meteo stations in Baden-Württemberg:

- **Karlsruhe (DWD): 112 m asl**
- **Schauinsland (UBA): 1205 m asl**

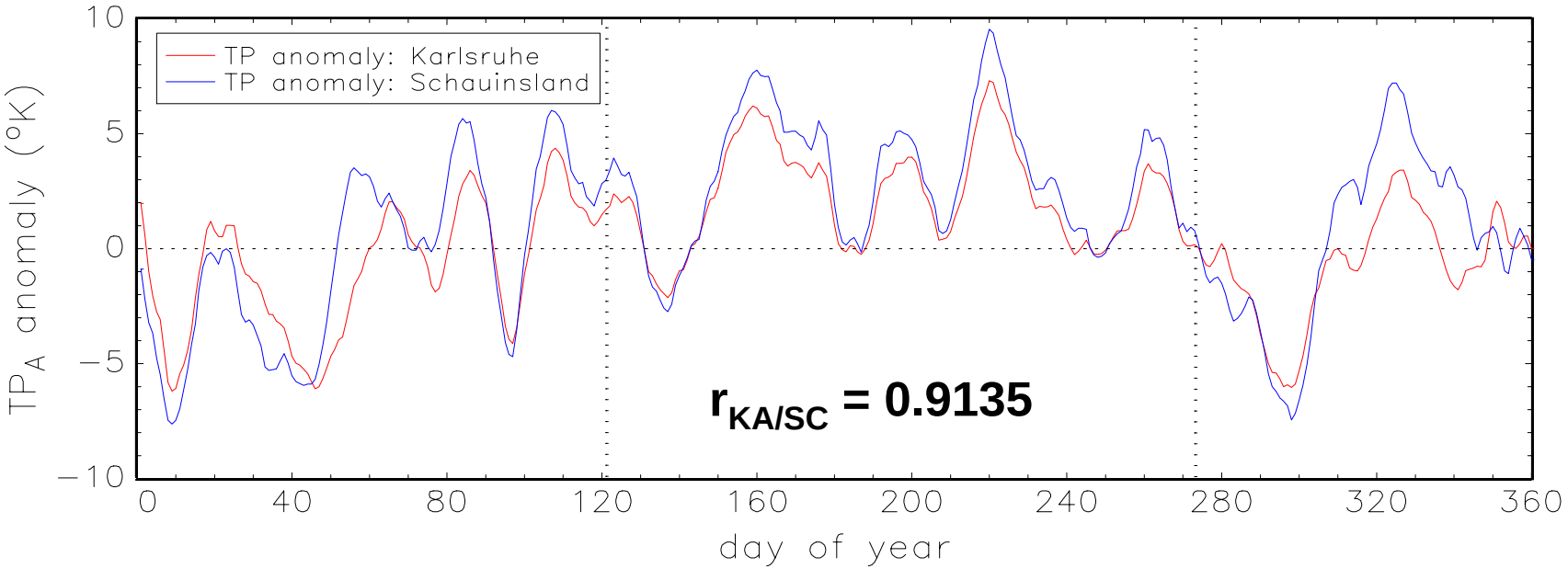
Weather Conditions in 2003: Air Temperature

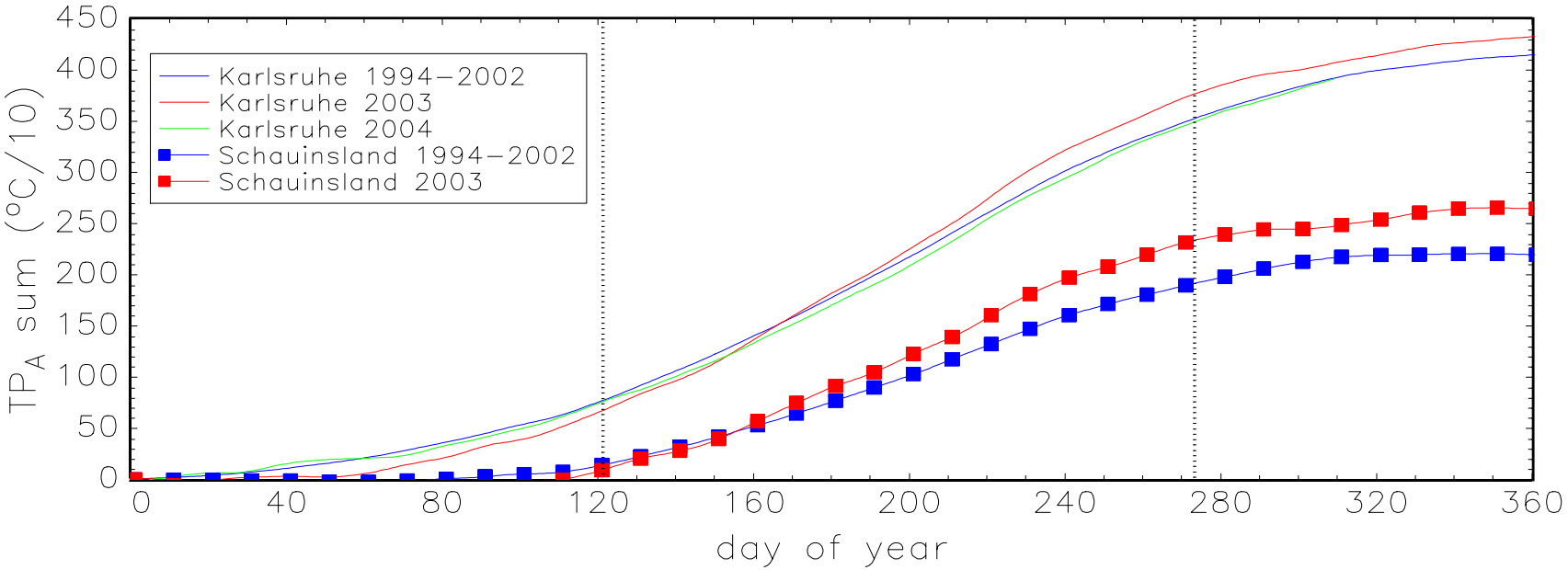




(Data source: DWD 2004, UBA 2004)

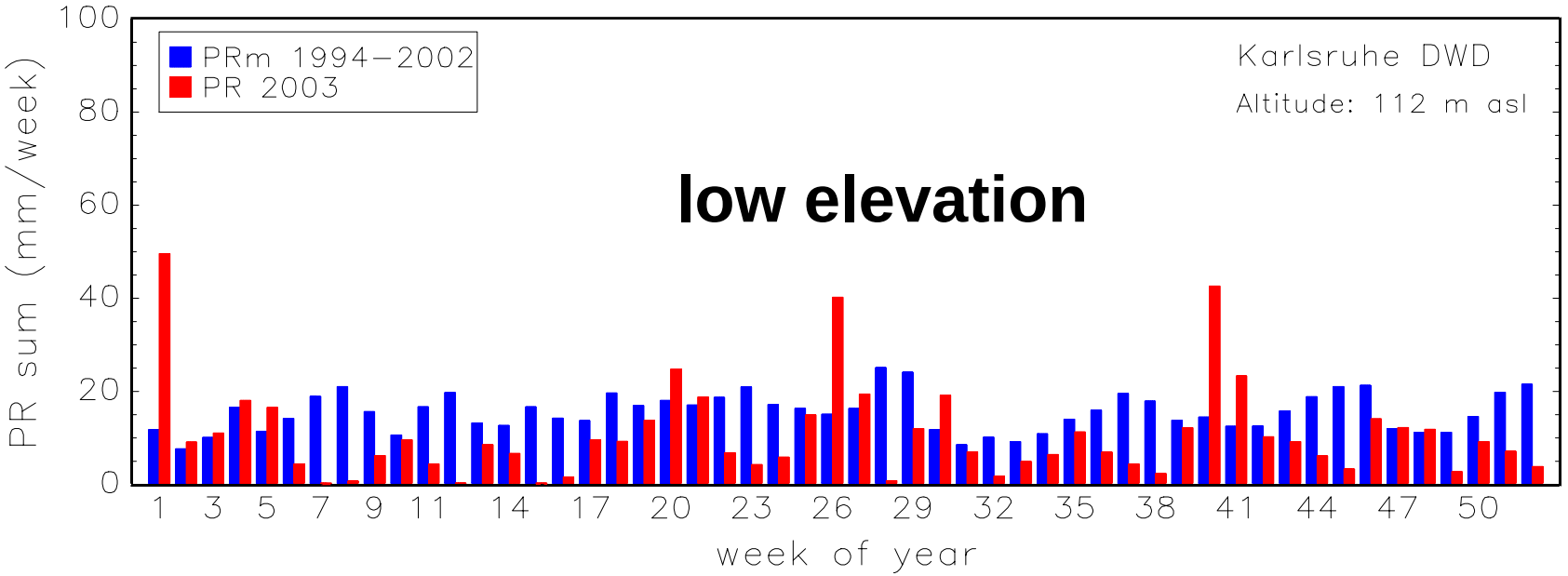
Weather Conditions in 2003: Air Temperature Anomalies

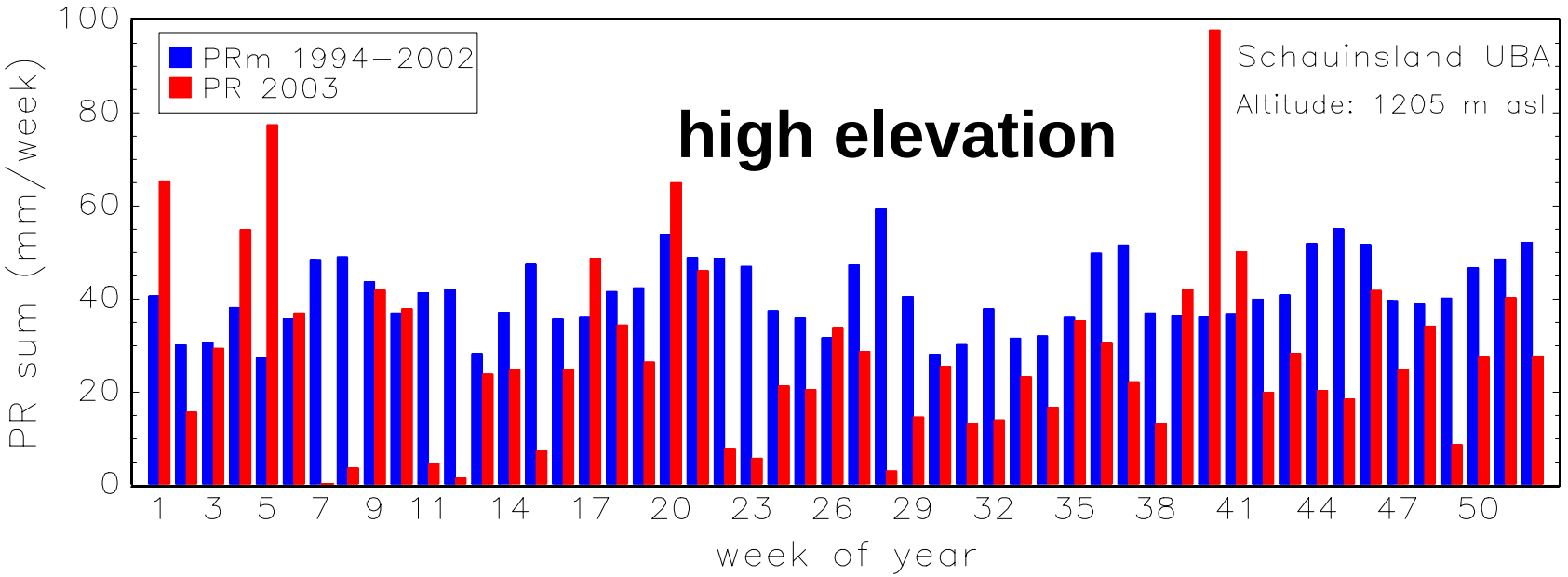




(Data source: DWD 2004, UBA 2004)

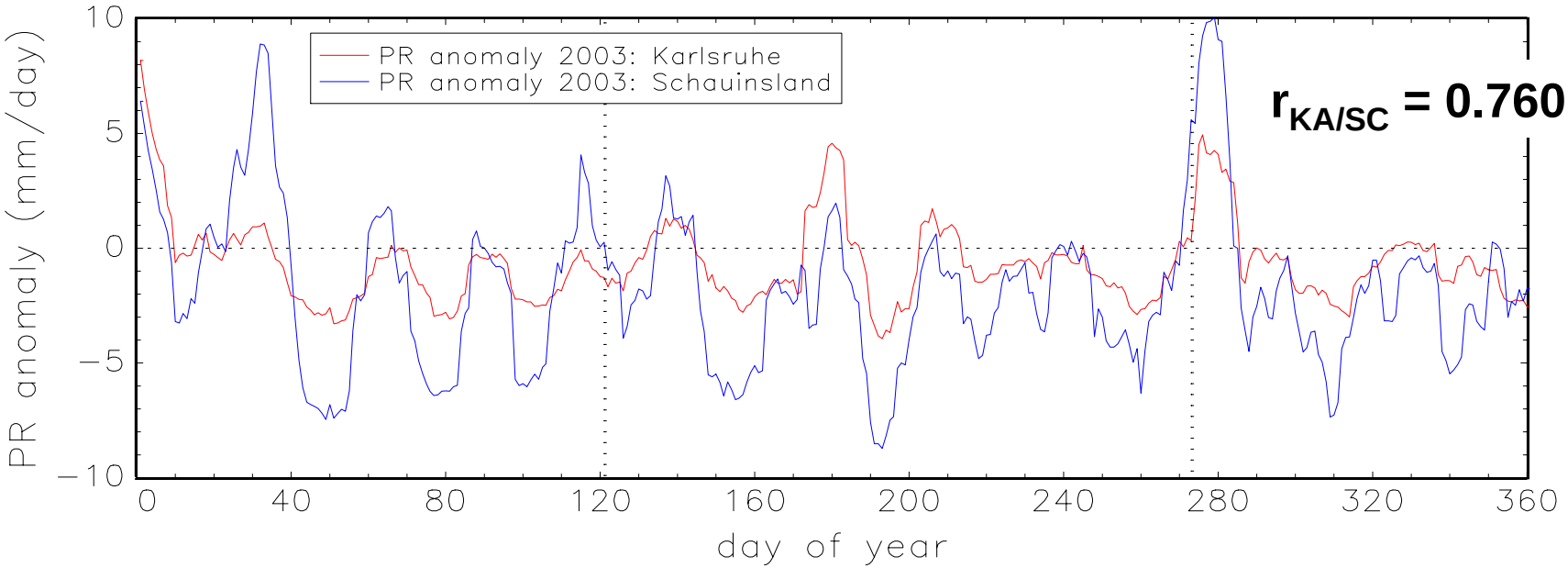
Weather Conditions in 2003: Precipitation

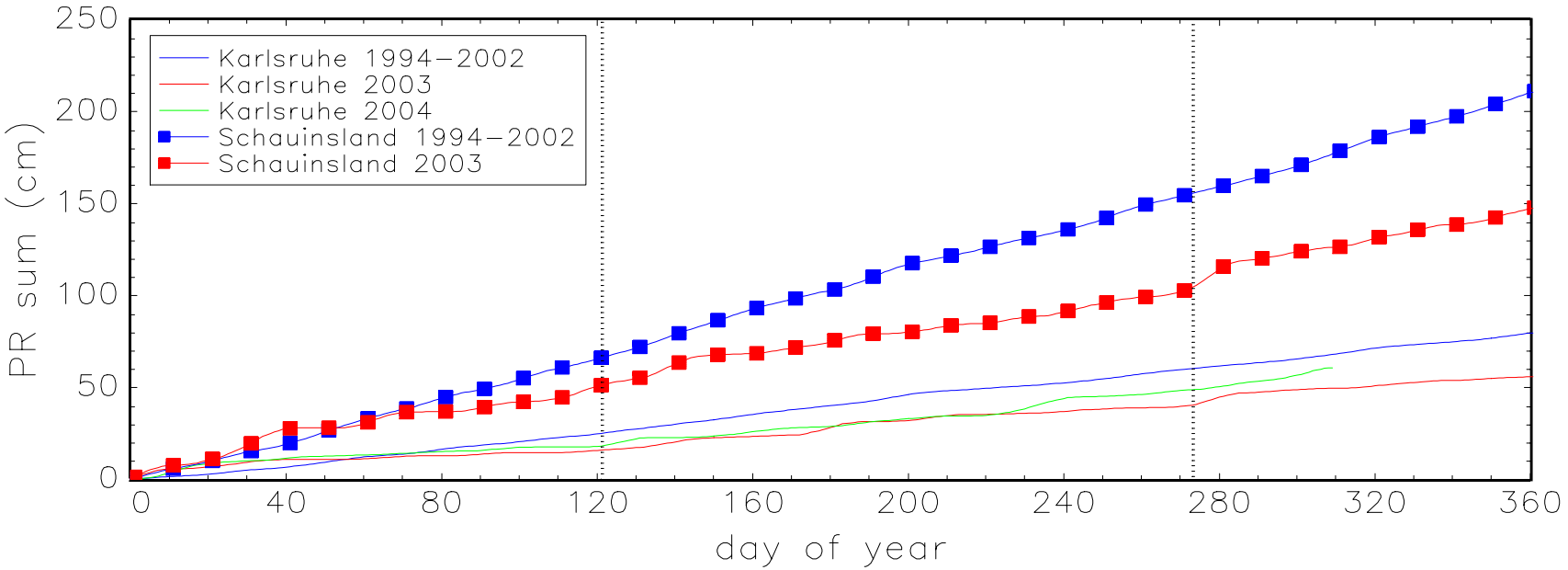




(Data source: DWD 2004, UBA 2004)

Weather Conditions in 2003: Precipitation Anomalies





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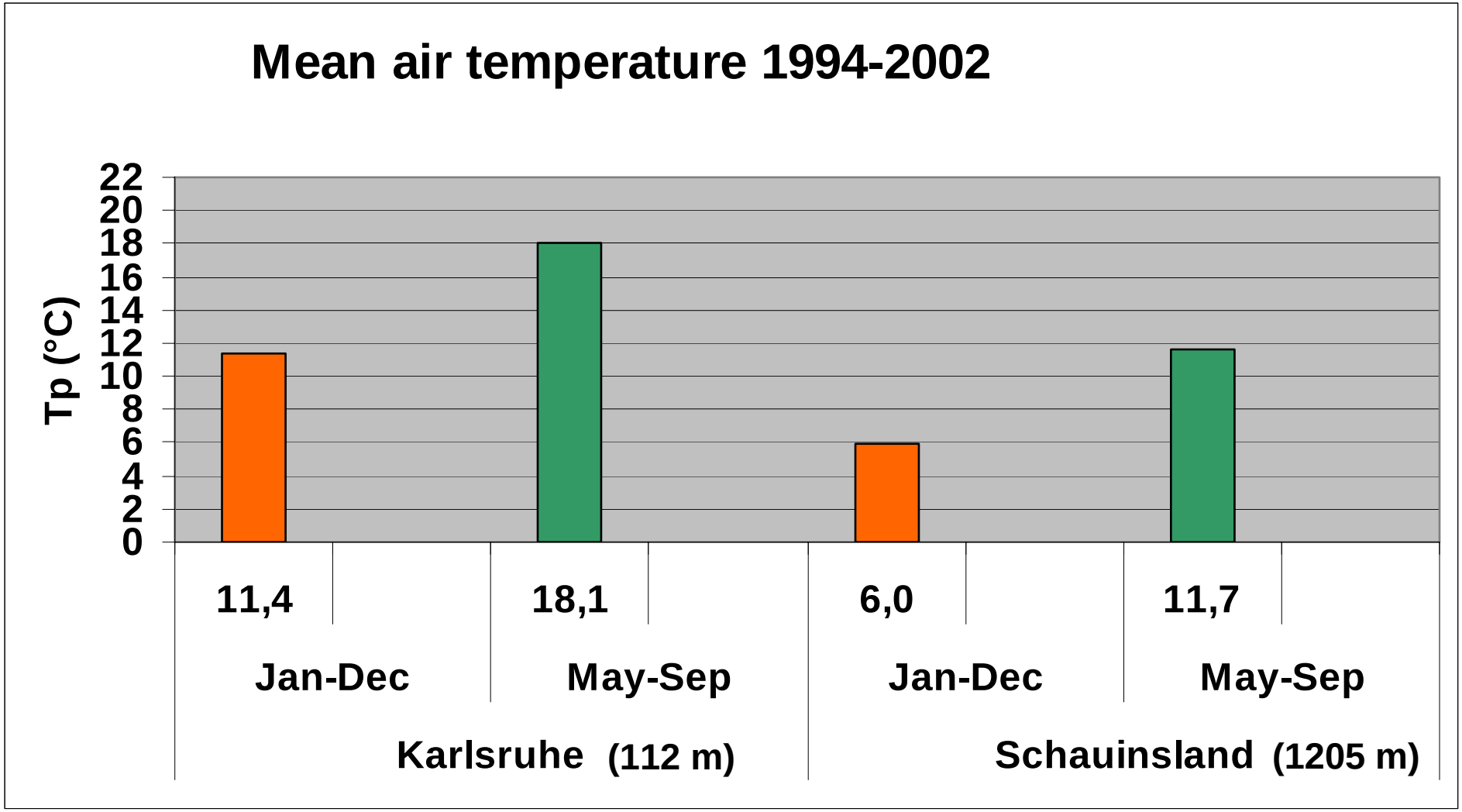

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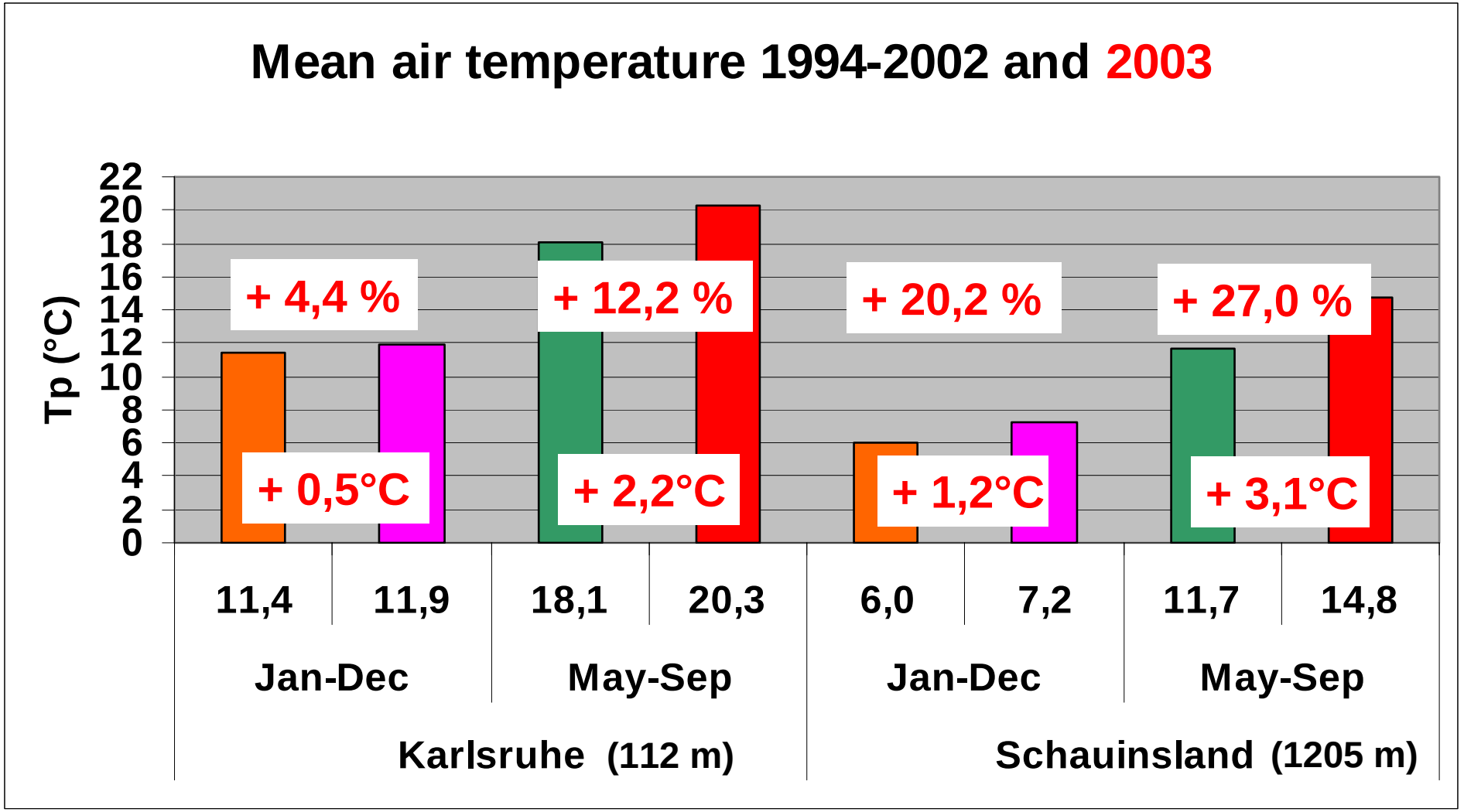

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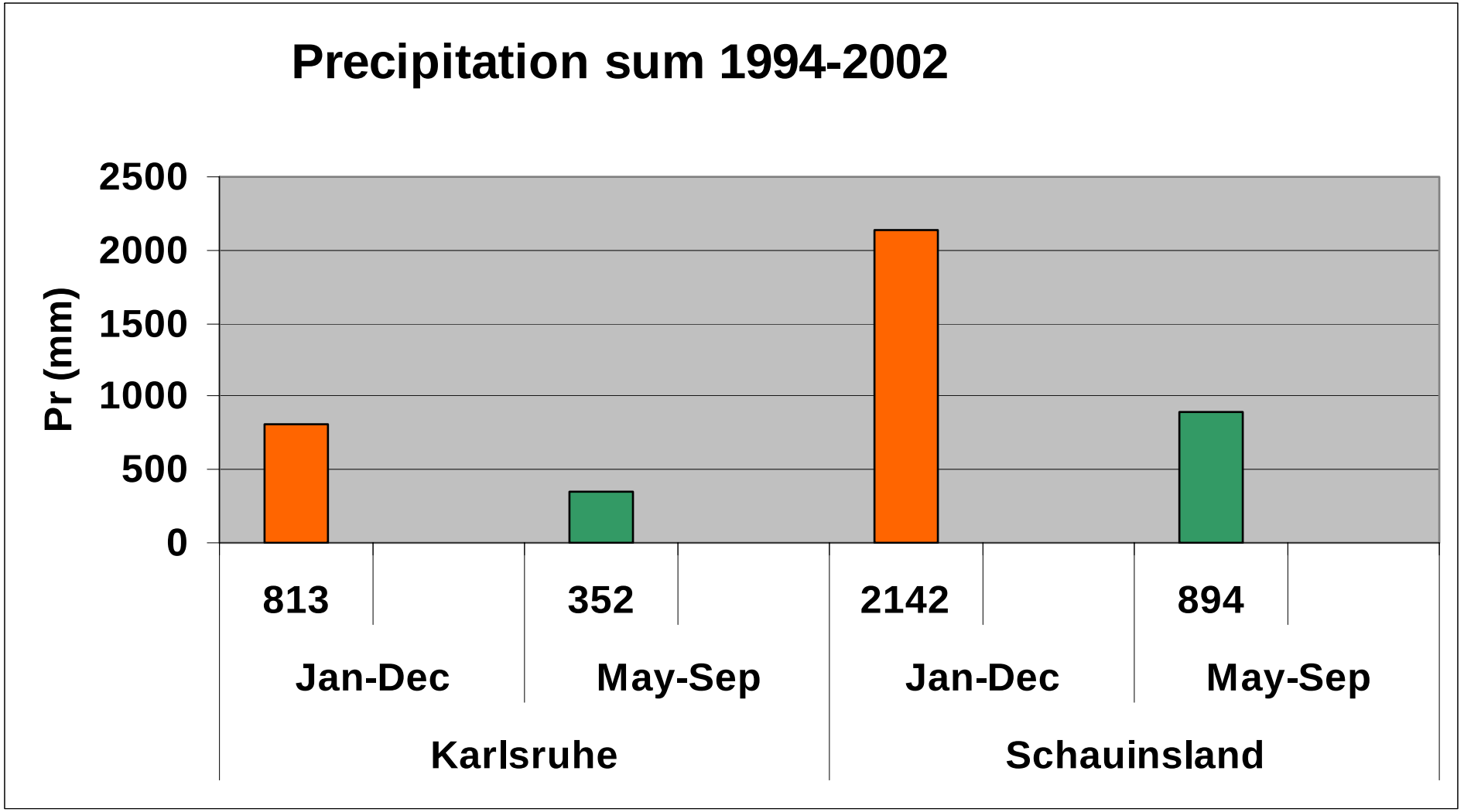
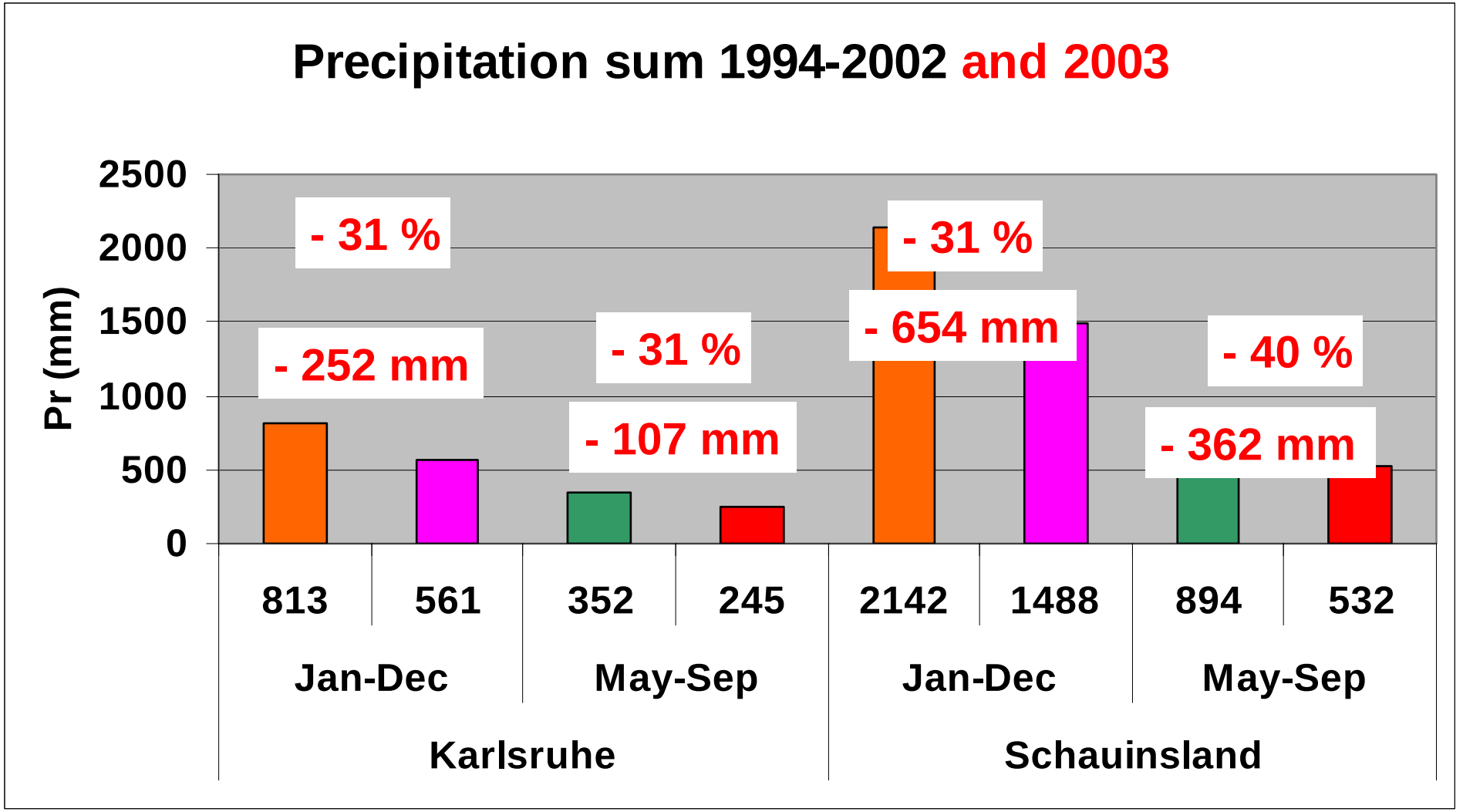
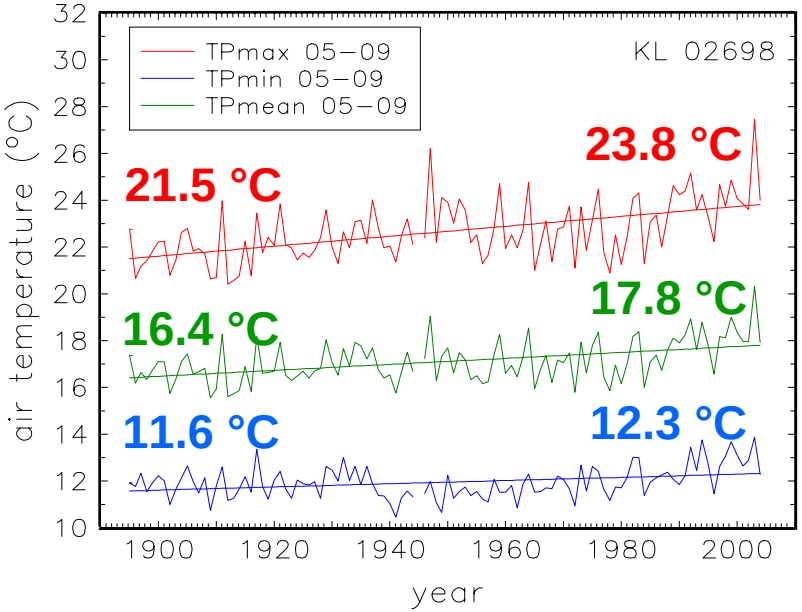


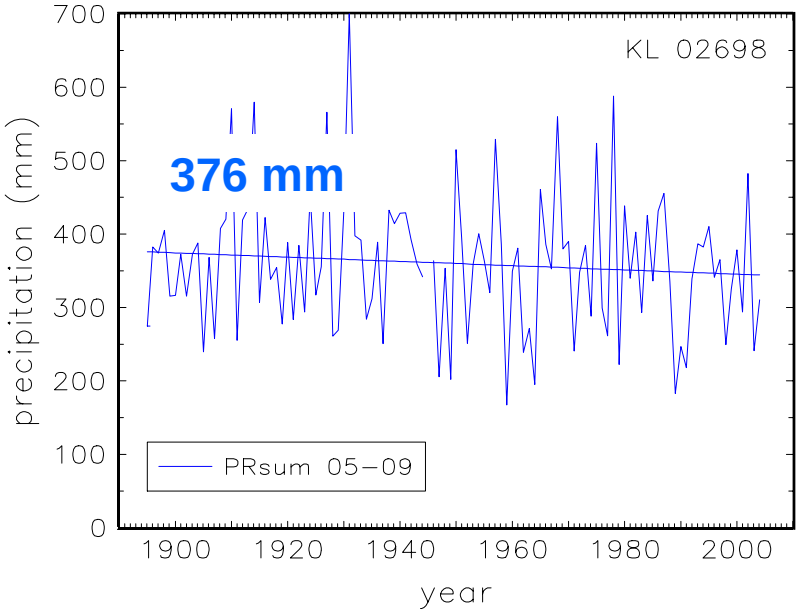
(Data source: DWD 2004, UBA 2004)



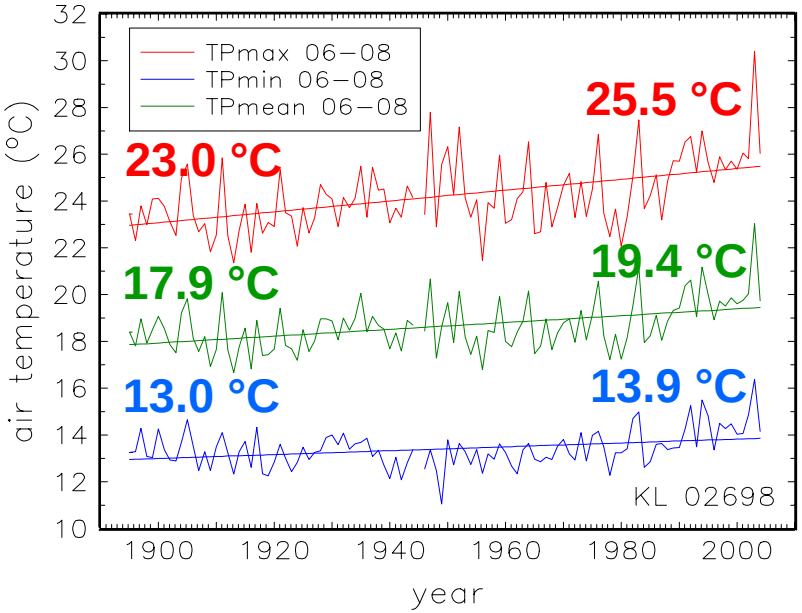
(Data source: DWD 2004, UBA 2004)

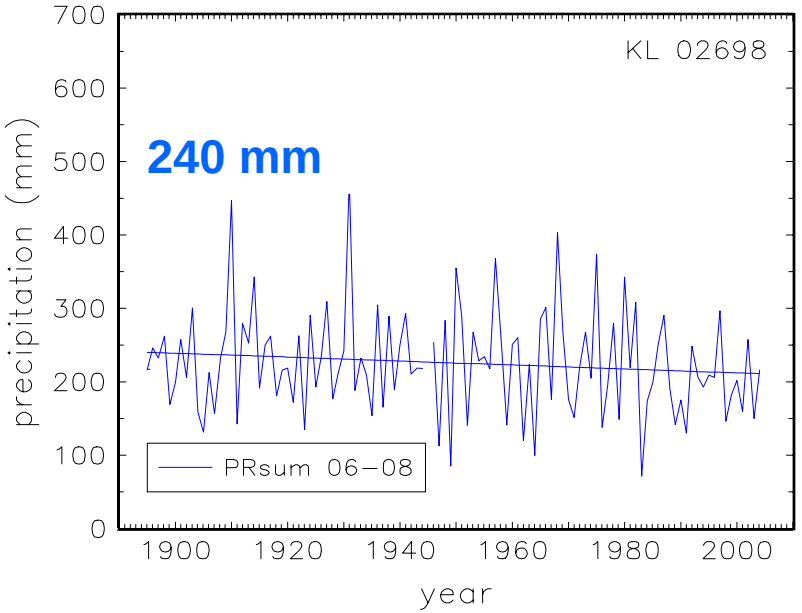
Climate Trends at Karlsruhe: Temperature & Precipitation





344 mm

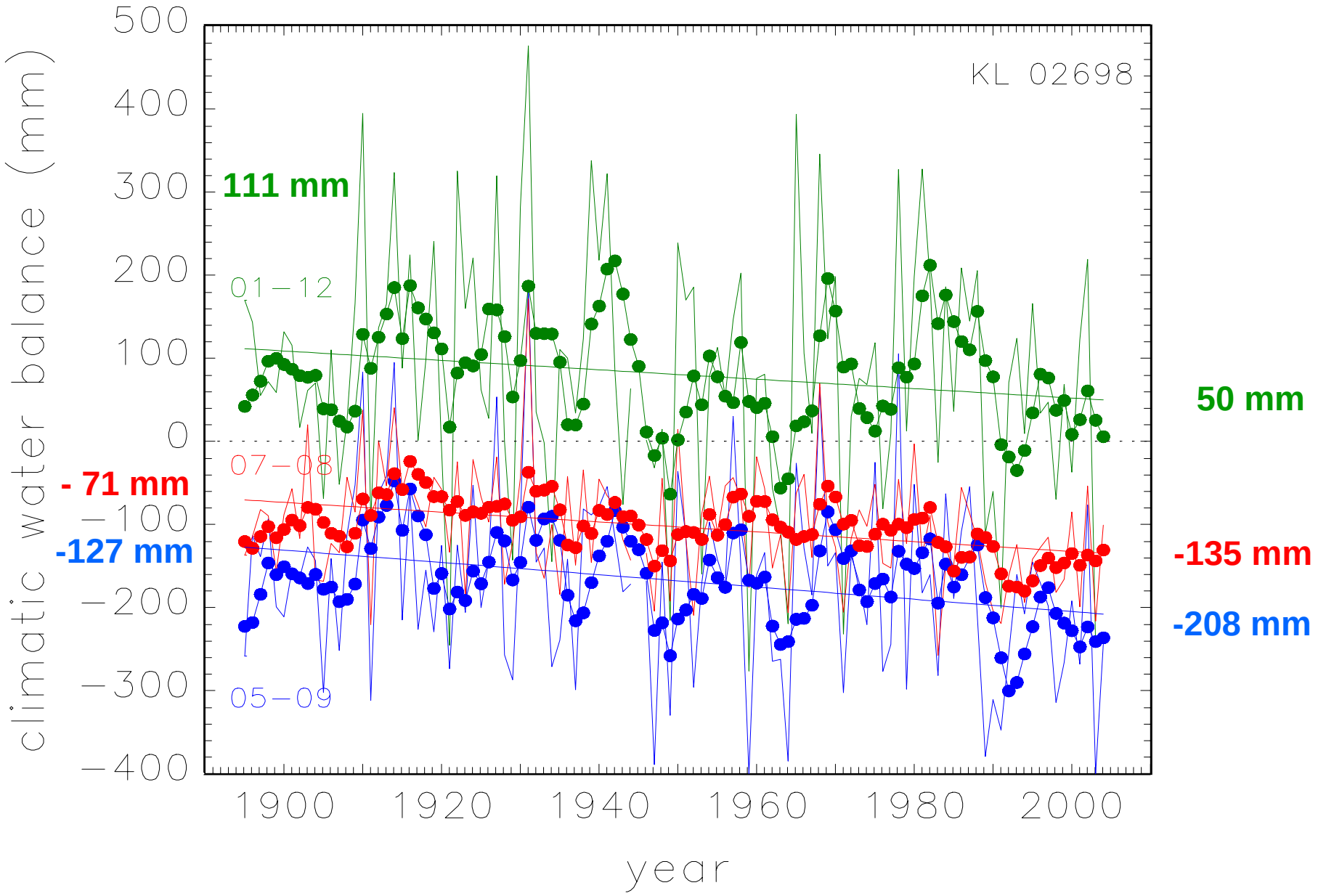




211 mm

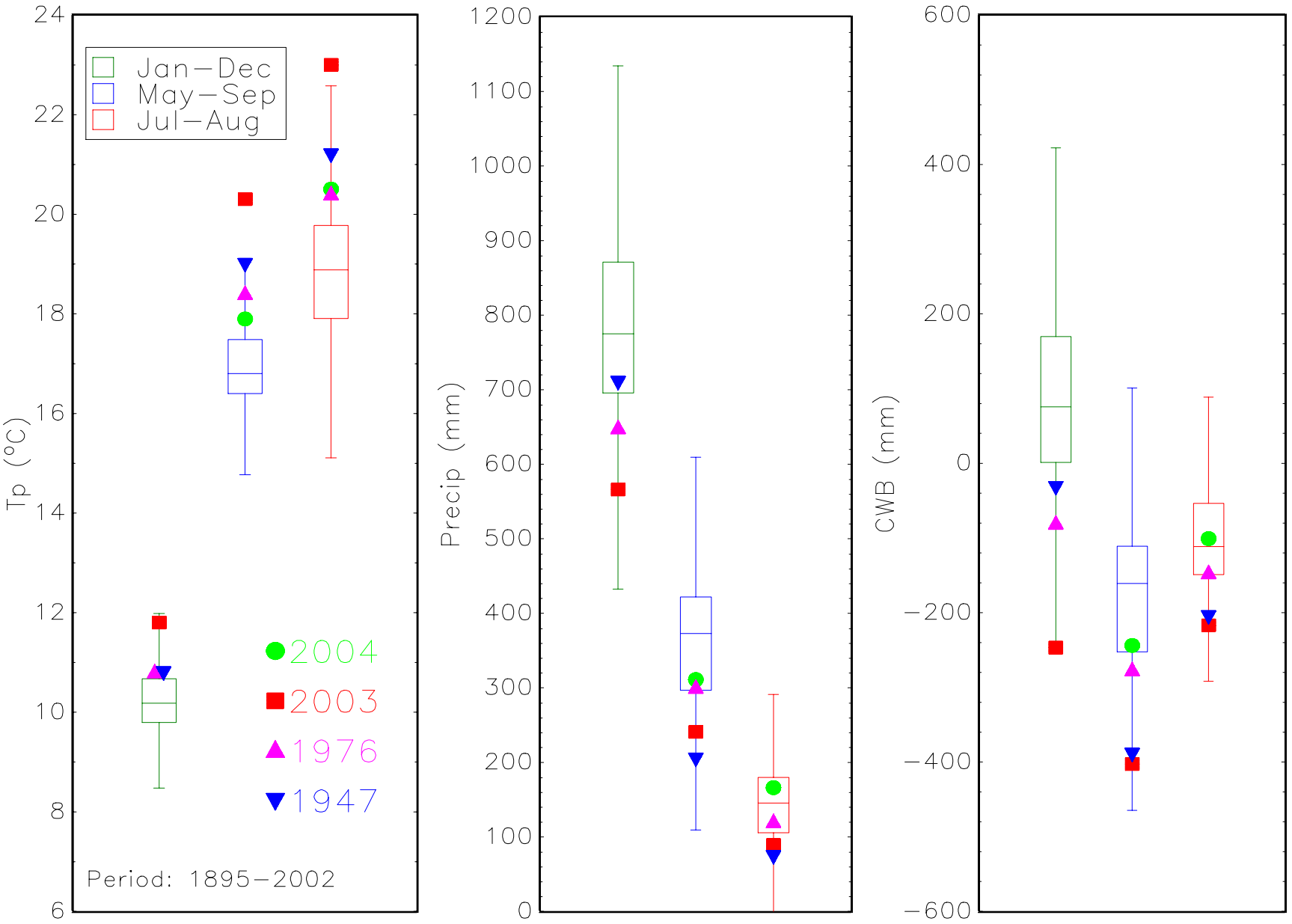
(Data source: DWD 2004)

Climate Trends at Karlsruhe: Climatic Water Balance



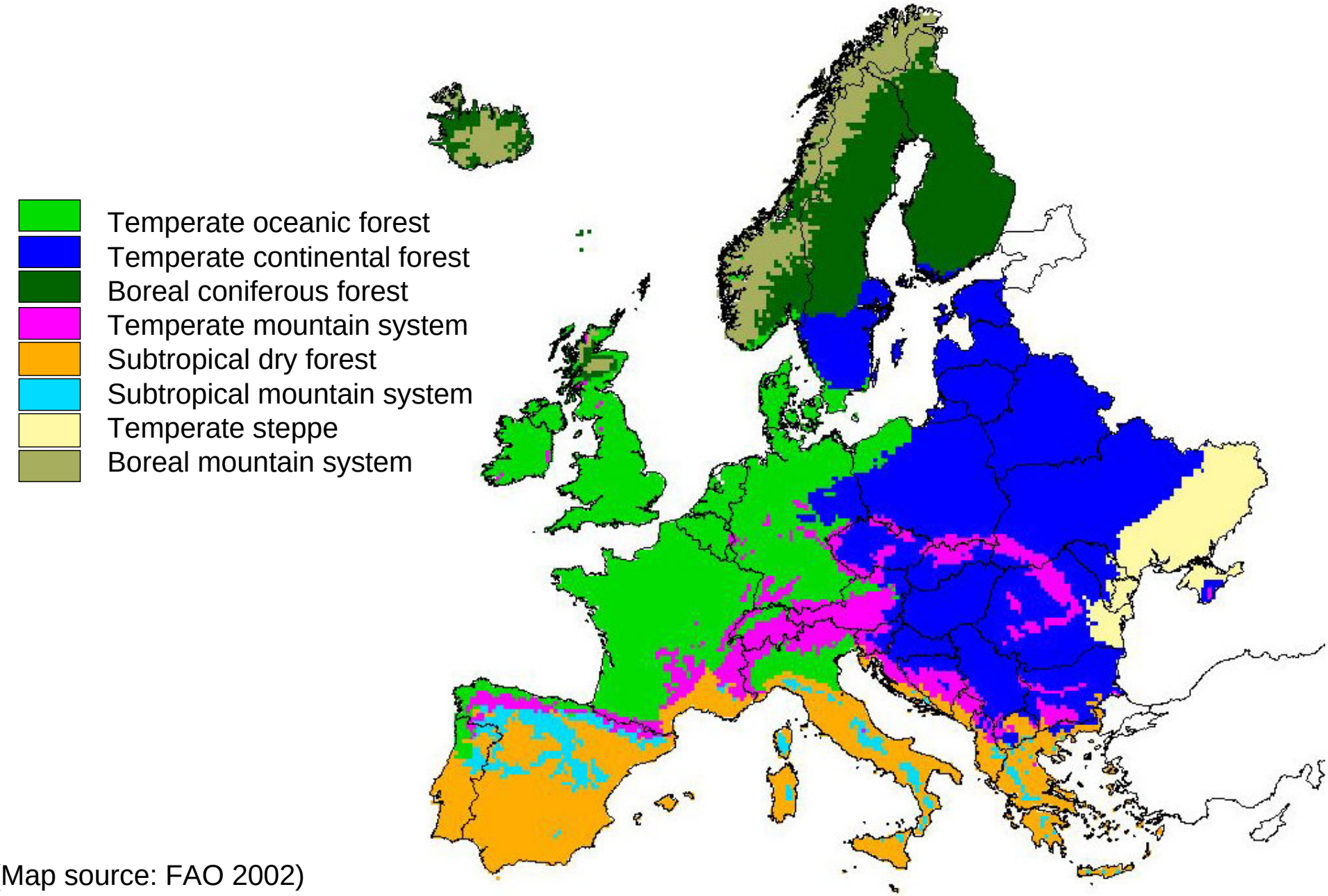
(Data source: DWD 2004)

Weather in Selected Warm and Dry Years in 1895-2004

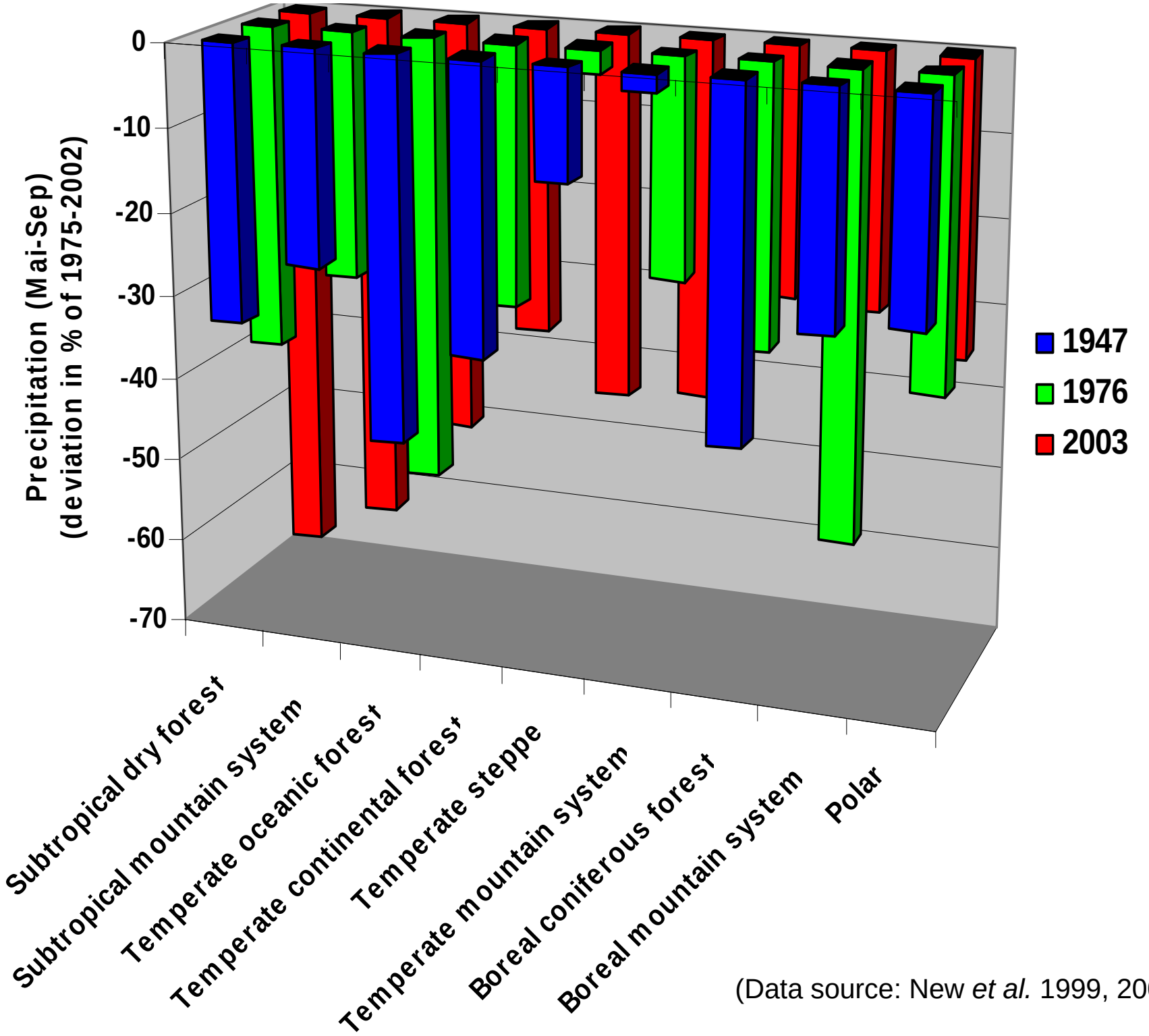


(Station Karlsruhe, Data source: DWD 2004)

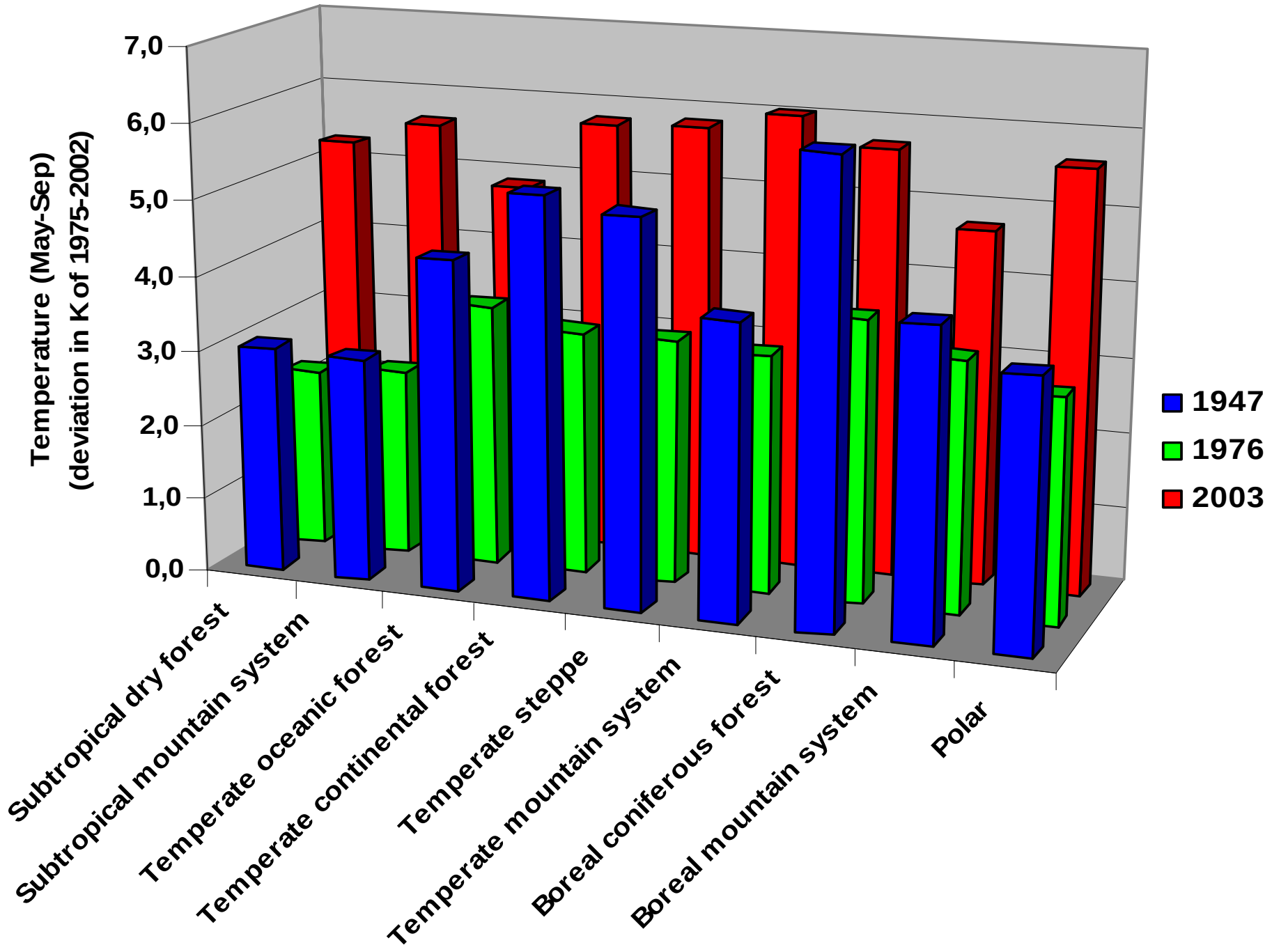
Weather Conditions in Selected Years in Europe
(Ecozones according to FAO classification)



(Map source: FAO 2002)



(Data source: New *et al.* 1999, 2000, 2002)



(Data source: New *et al.* 1999, 2000, 2002)

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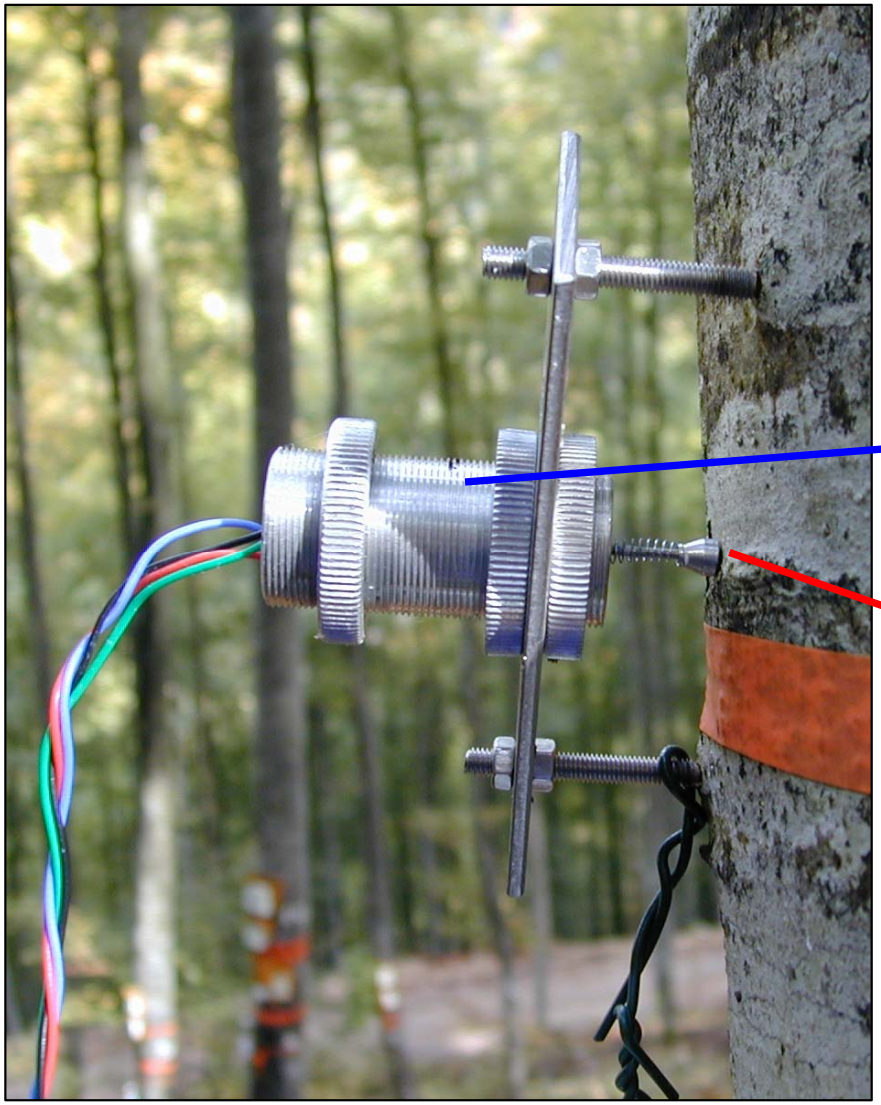
Radial Growth by Species and Elevation

- Dendrometer studies



Point Dendrometer Mounted on a Beech Stem (Hauser 1999)

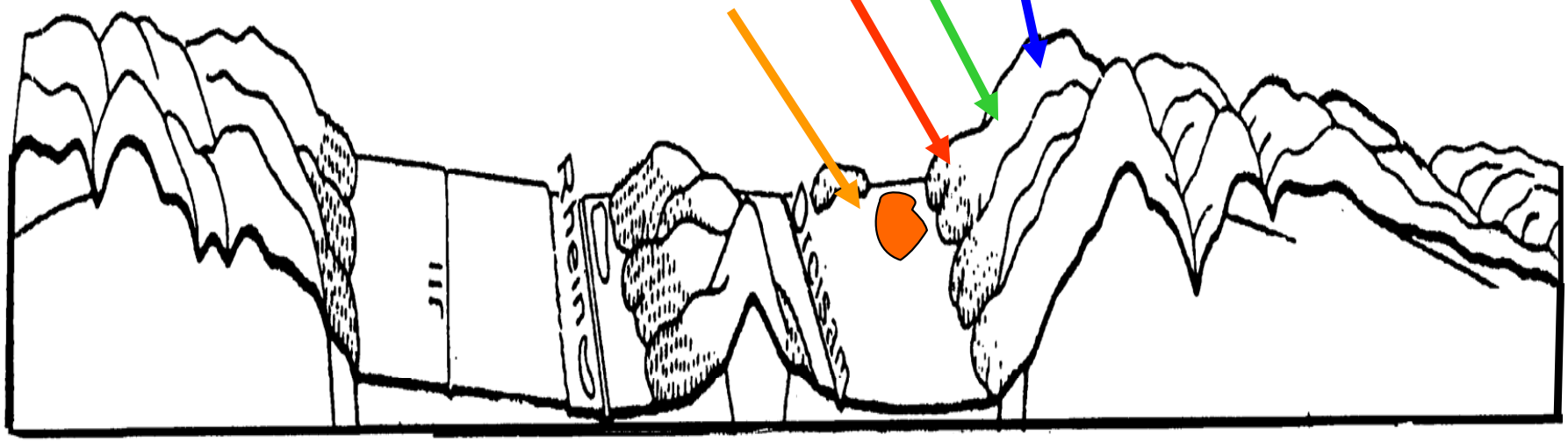
Dendrometer Measurements - Field Sites

Schauinsland: 1250 m asl

Heibrain: 750 m asl

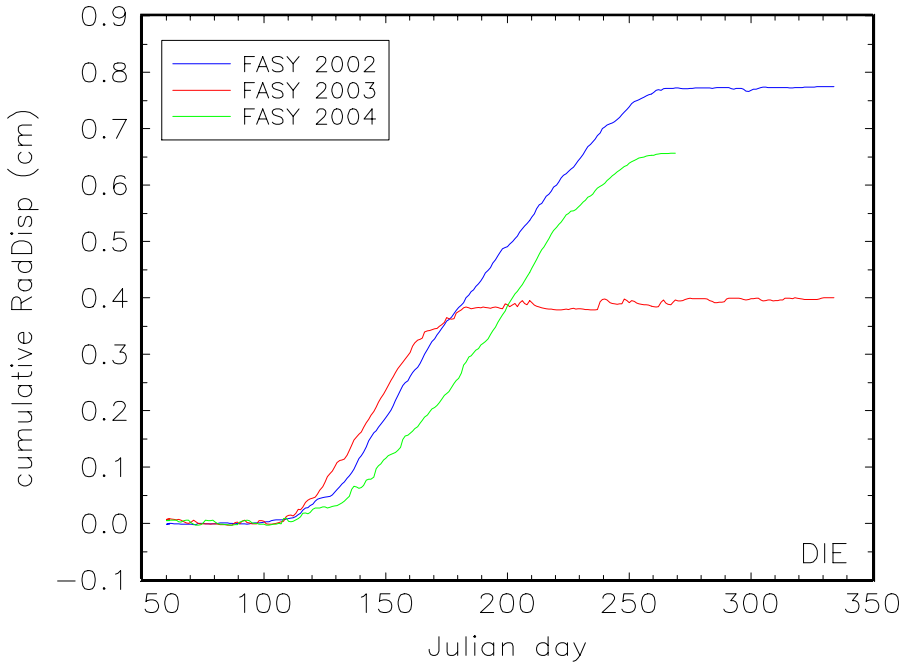
Günterstal: 450 m asl

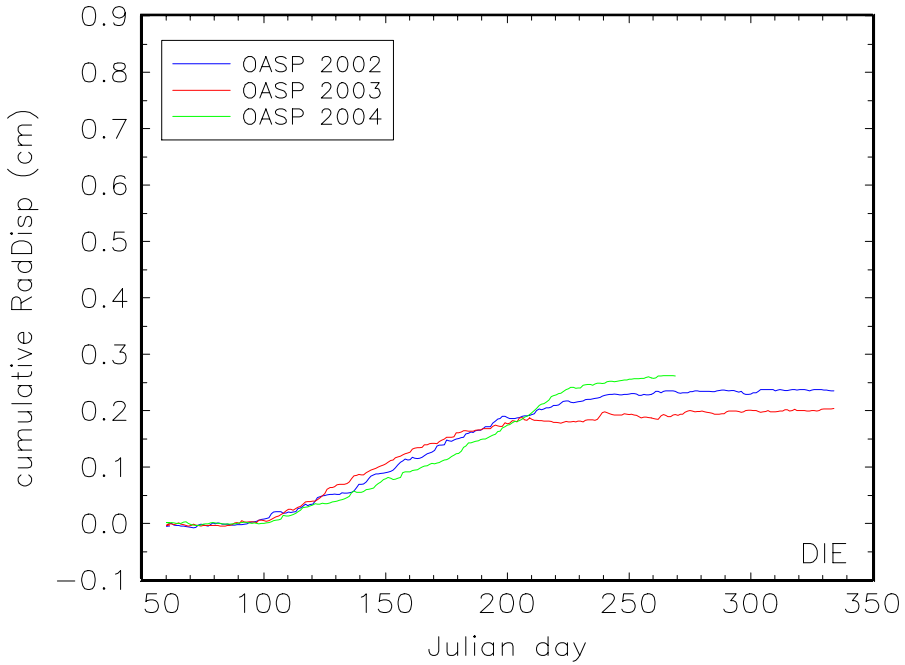
Dietenbach: 220 m asl

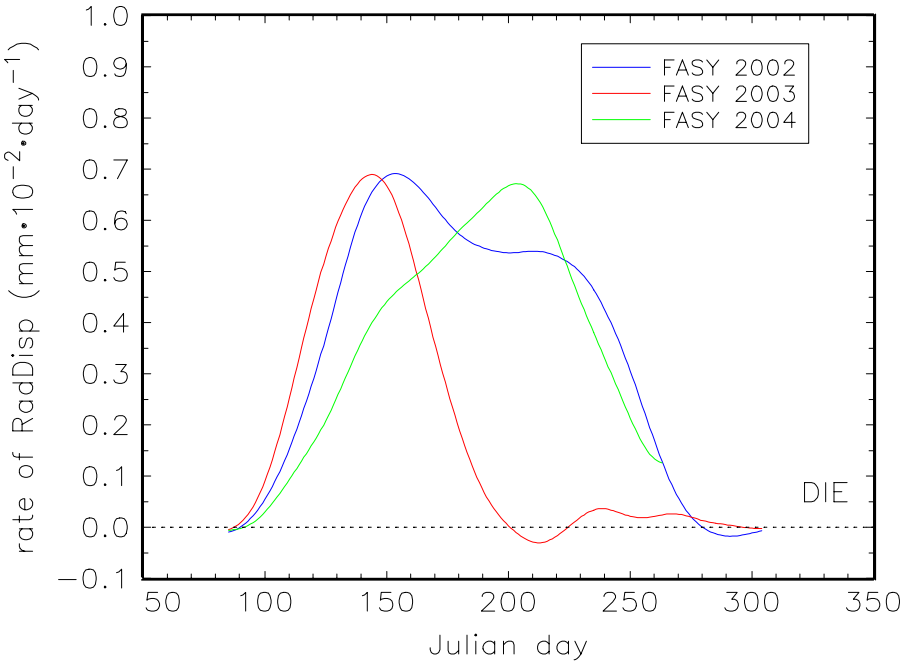


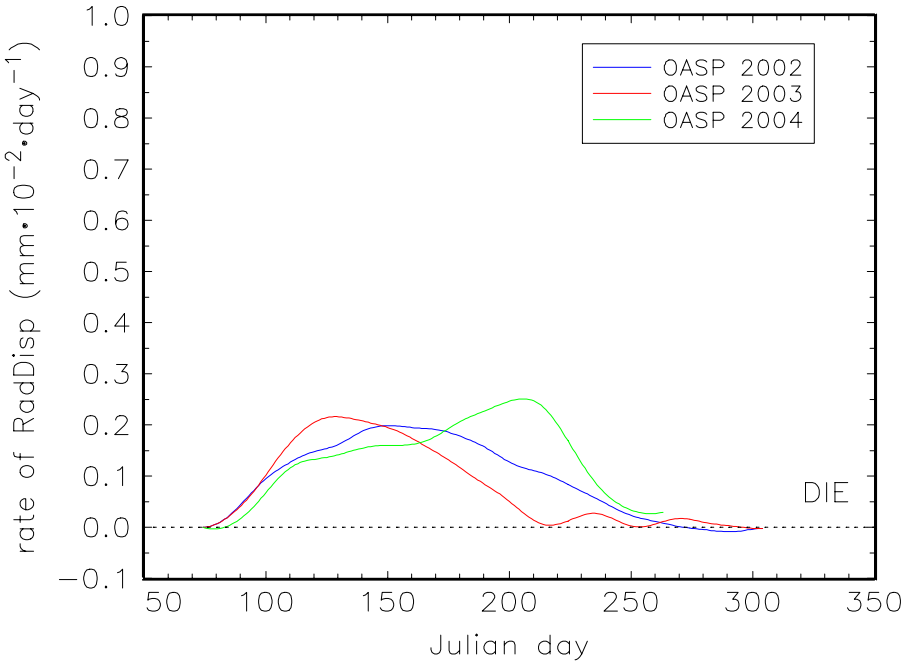
Vosges Mountains Rhine Valley Black Forest

Beech Low Elevation (220 m asl) Oak

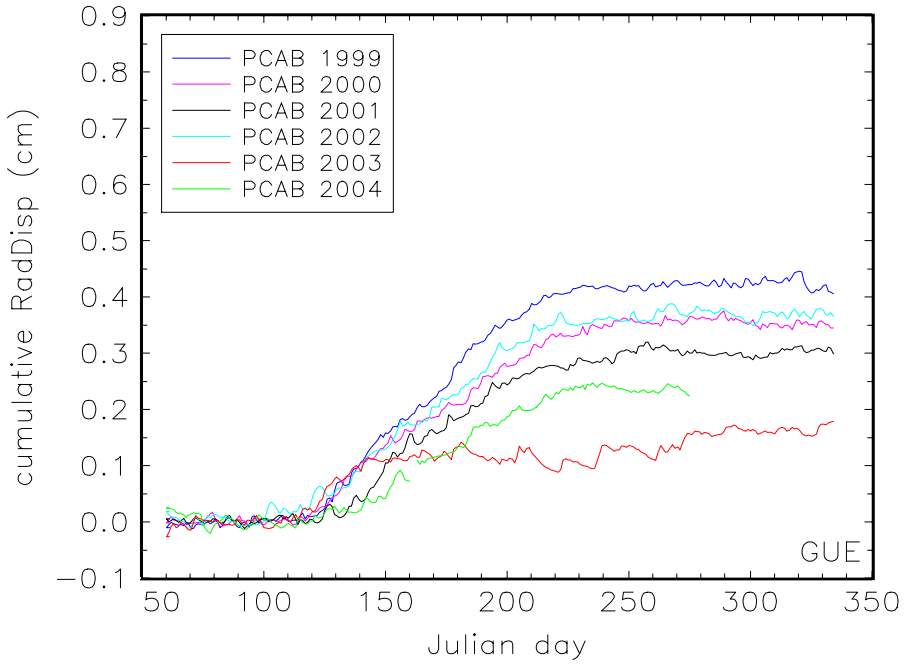


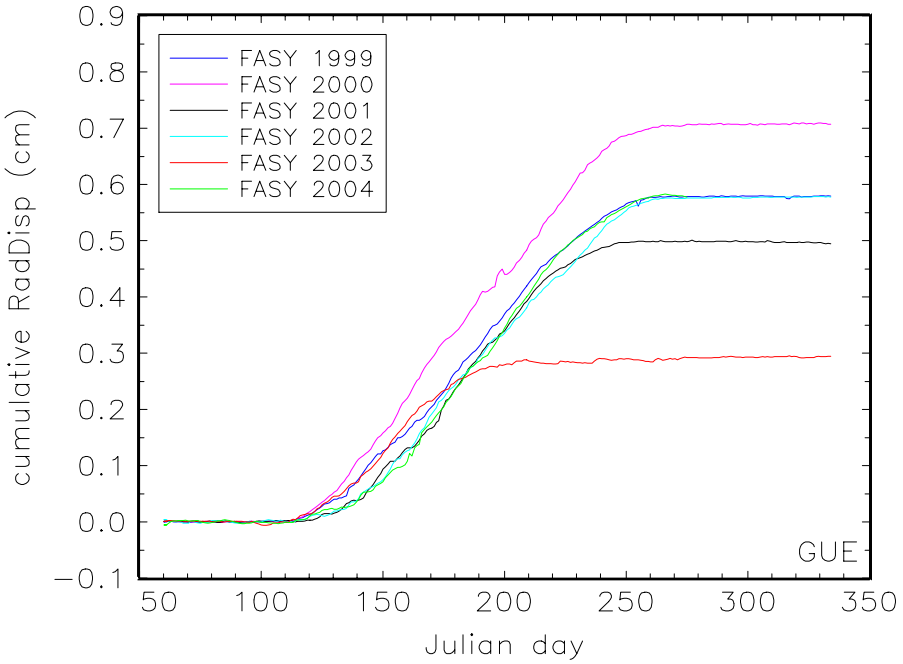


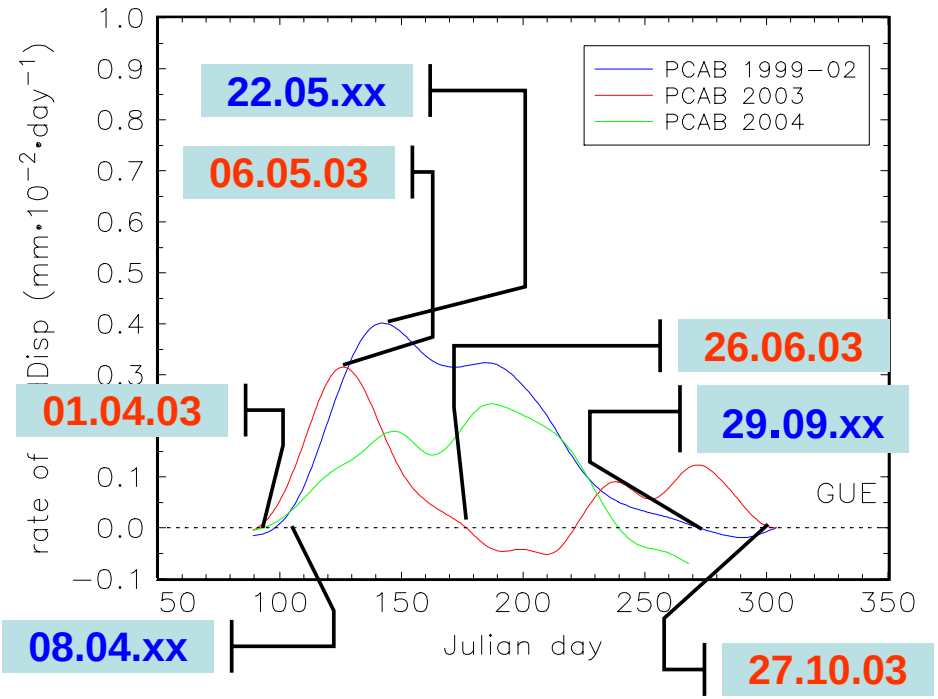


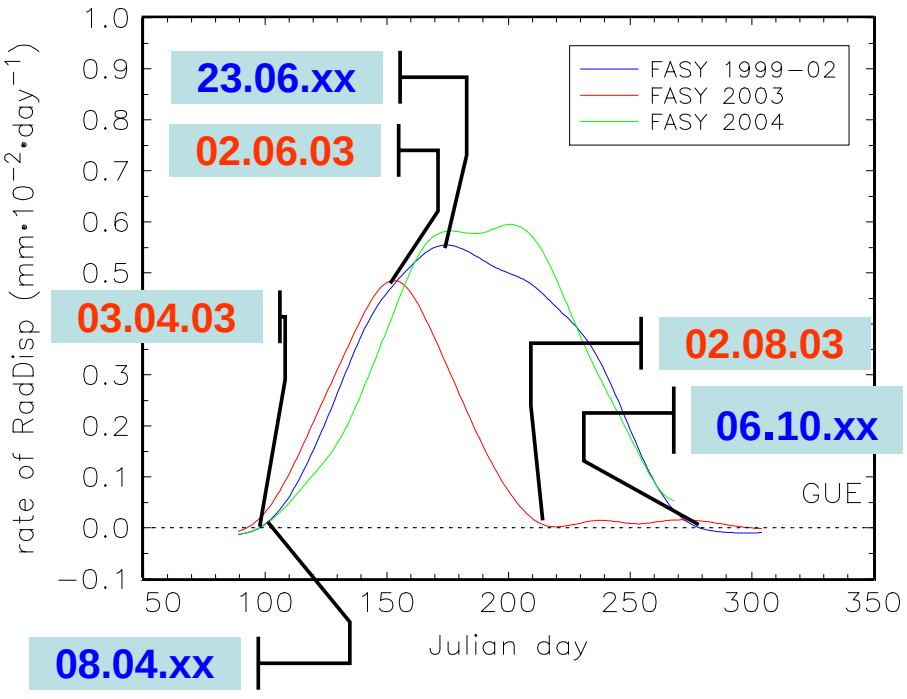


Spruce Low Elevation (450 m asl) Beech

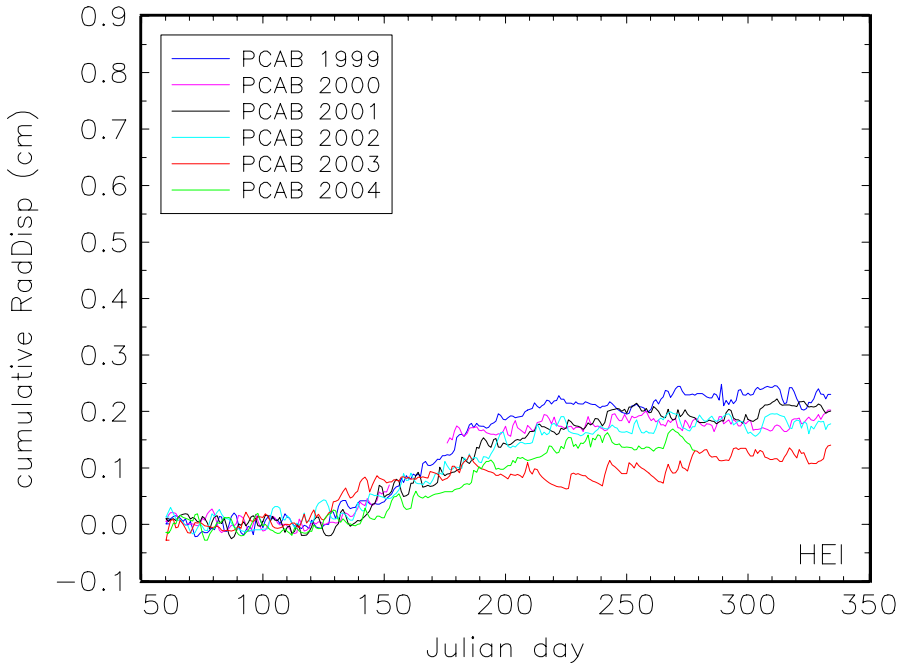


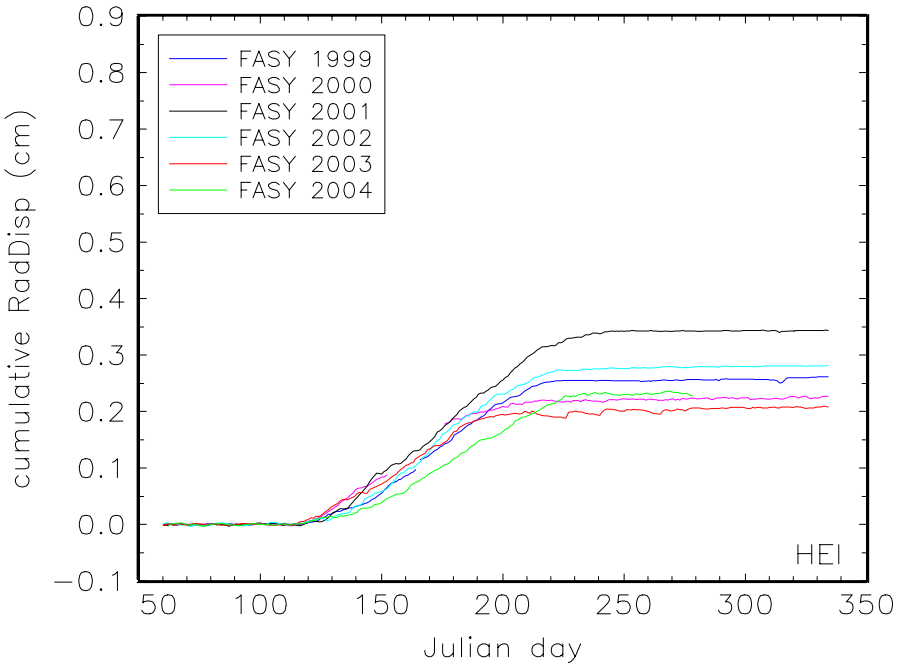


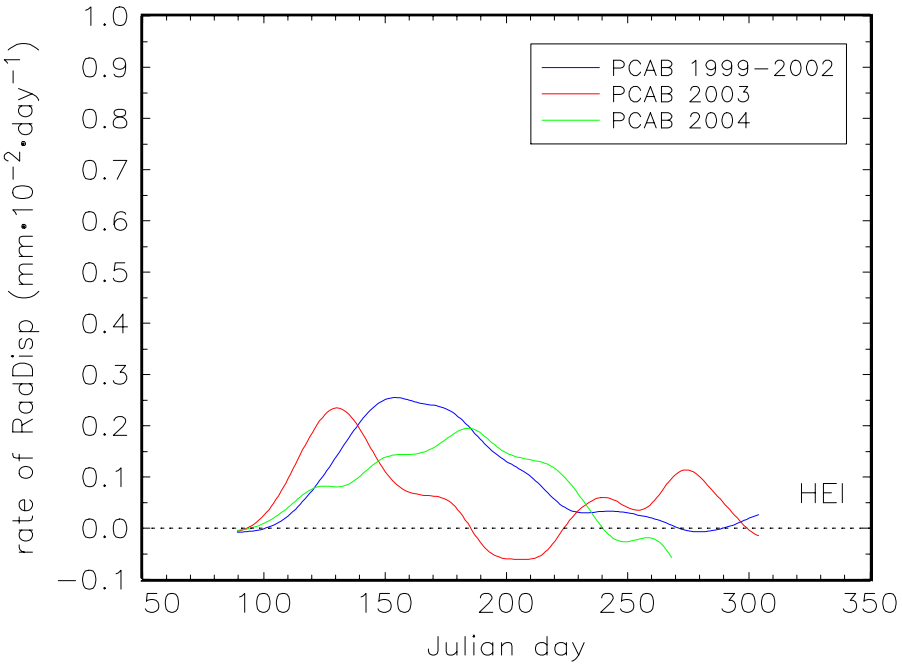


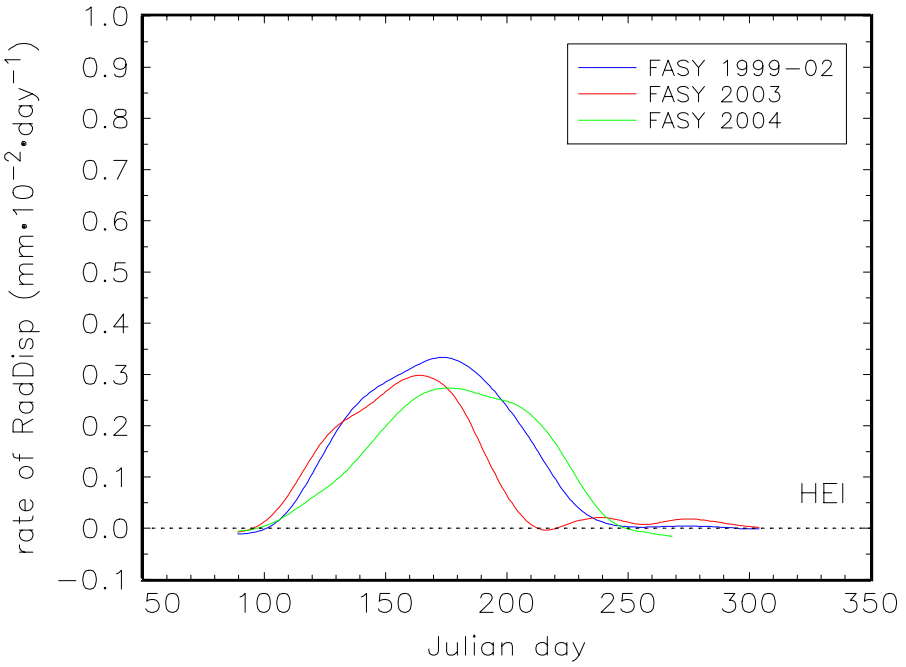


Spruce Medium Elevation (750 m asl) Beech

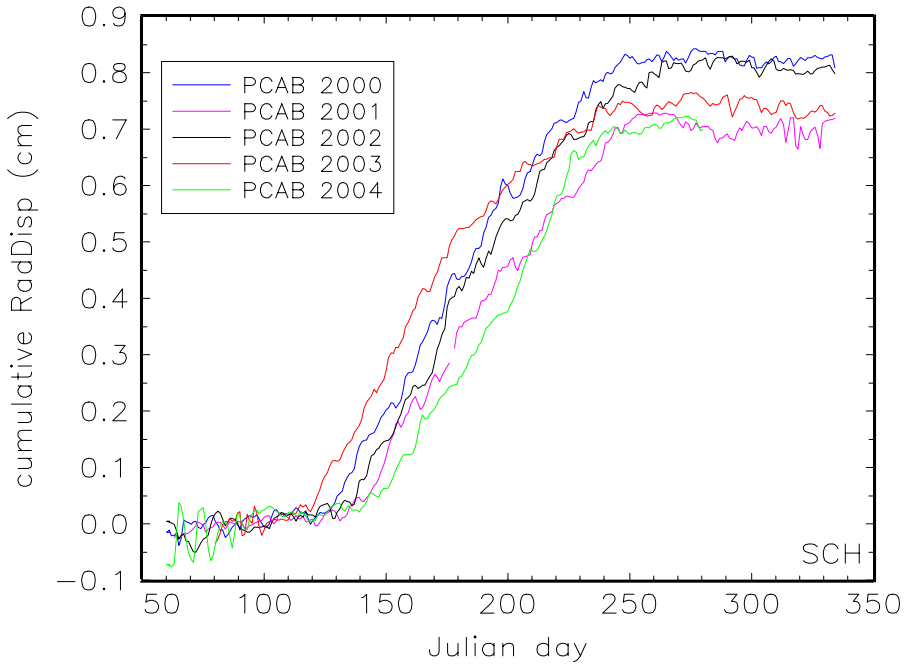


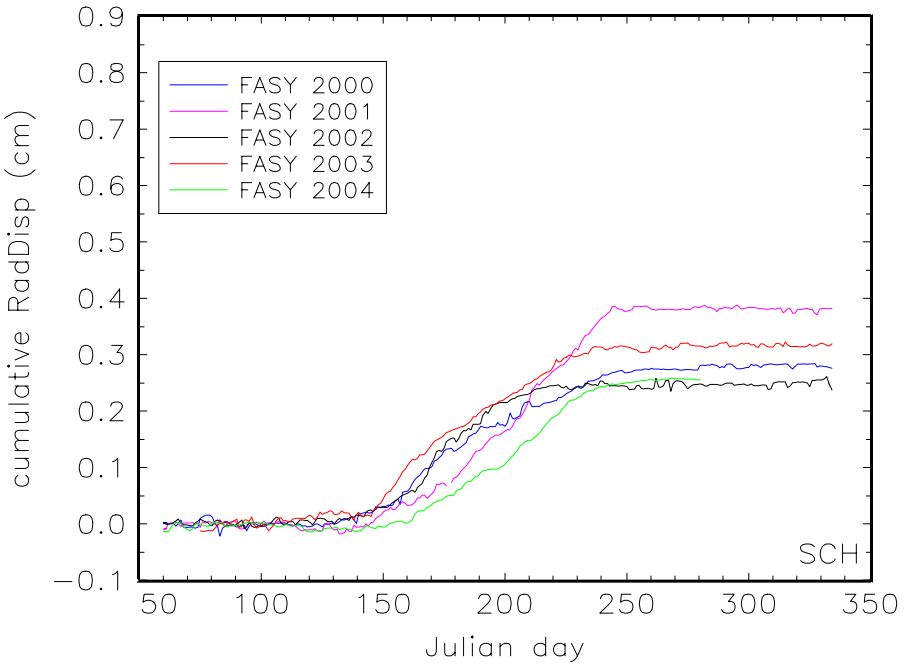


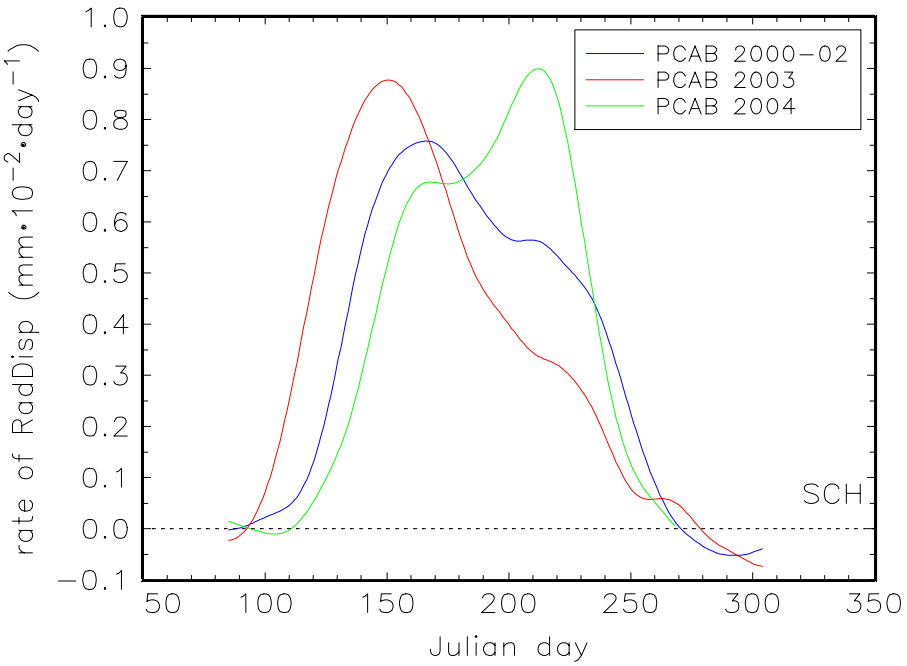


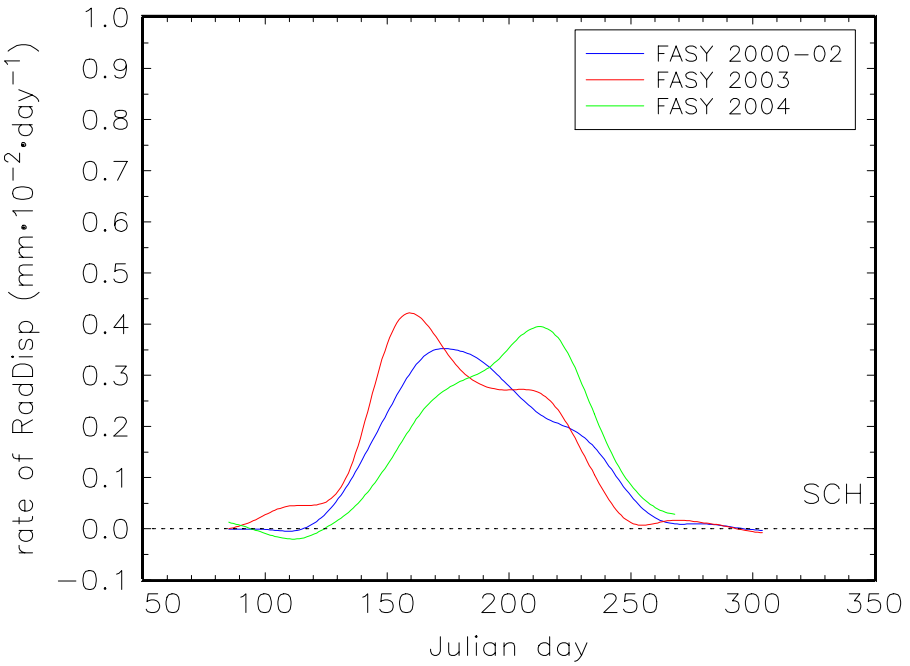


Spruce High Elevation (1250 m asl) Beech





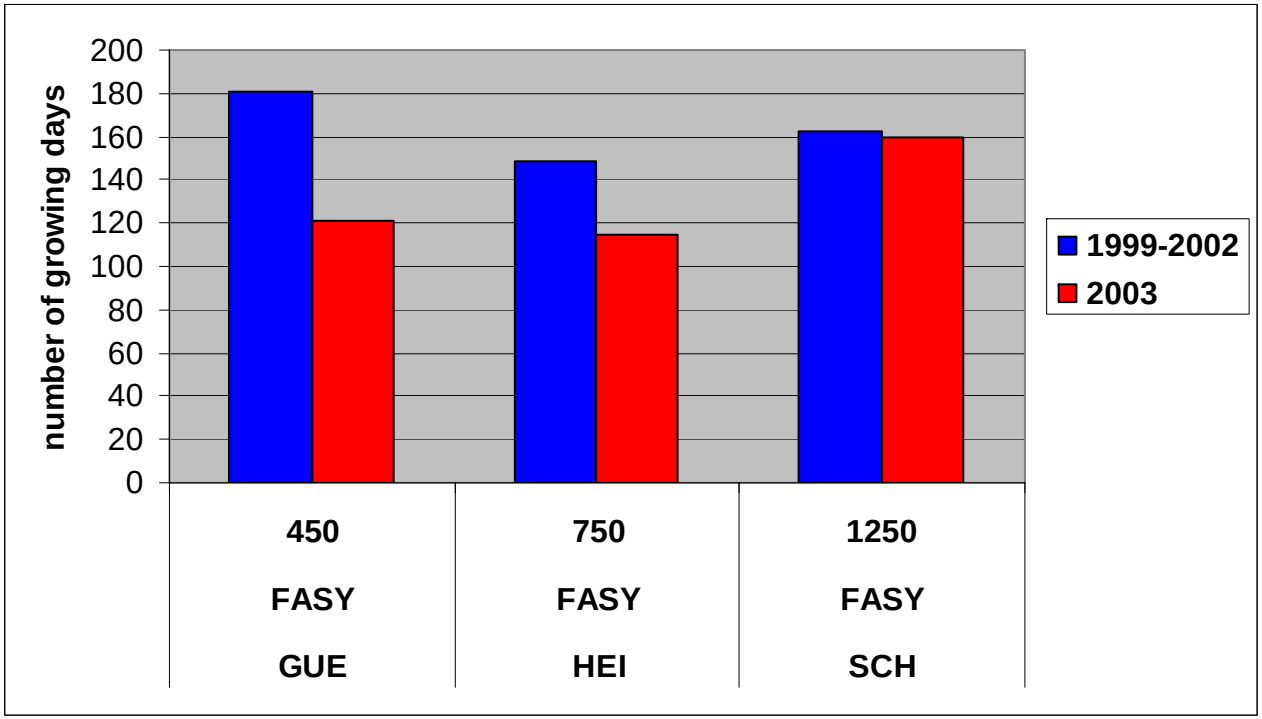


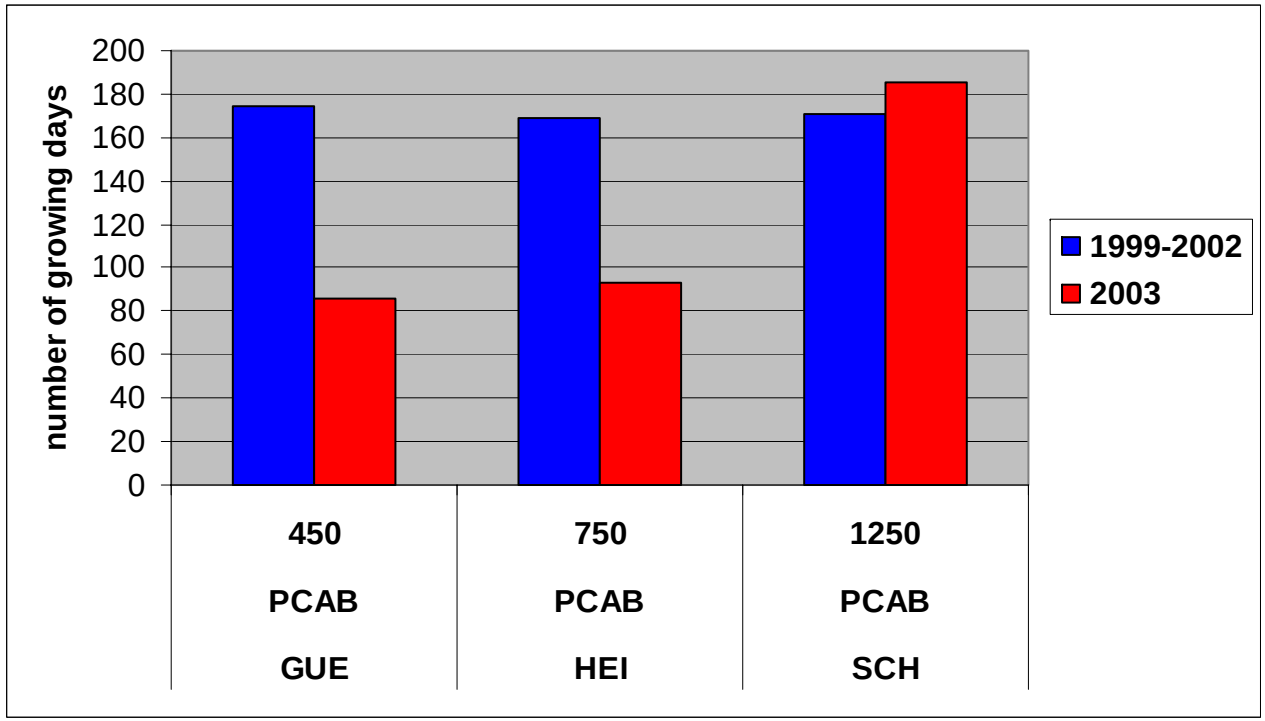


Beech

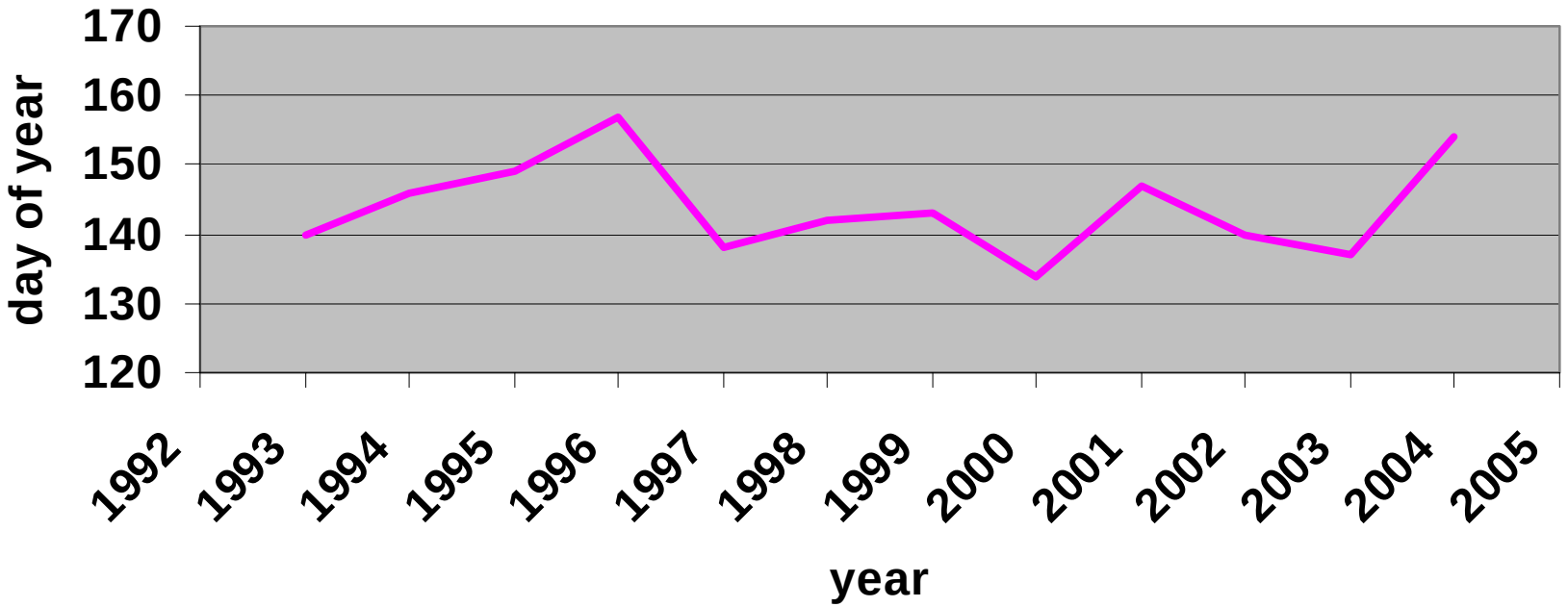
Number of Growing Days derived from Dendrometer Data

Spruce

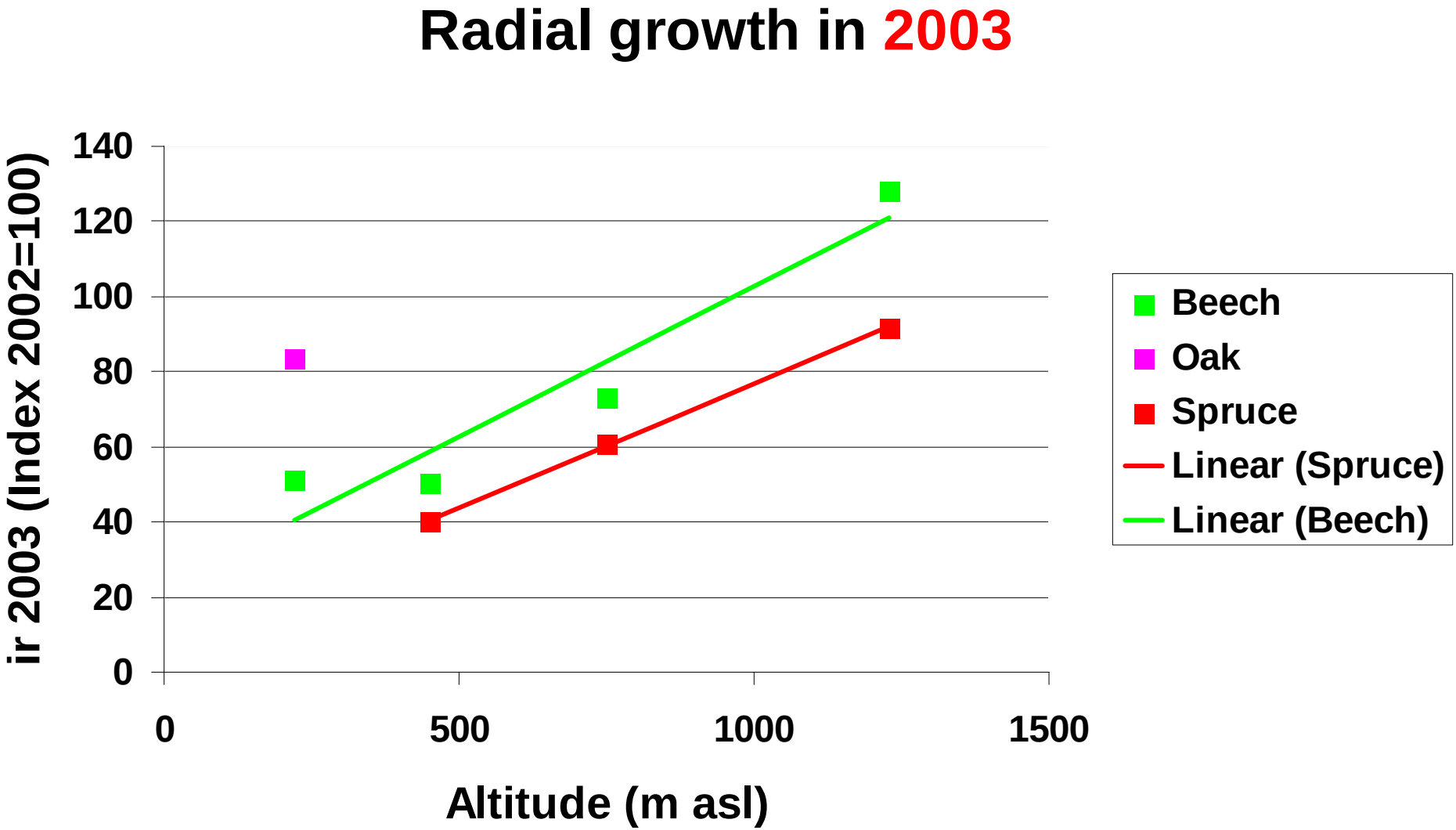


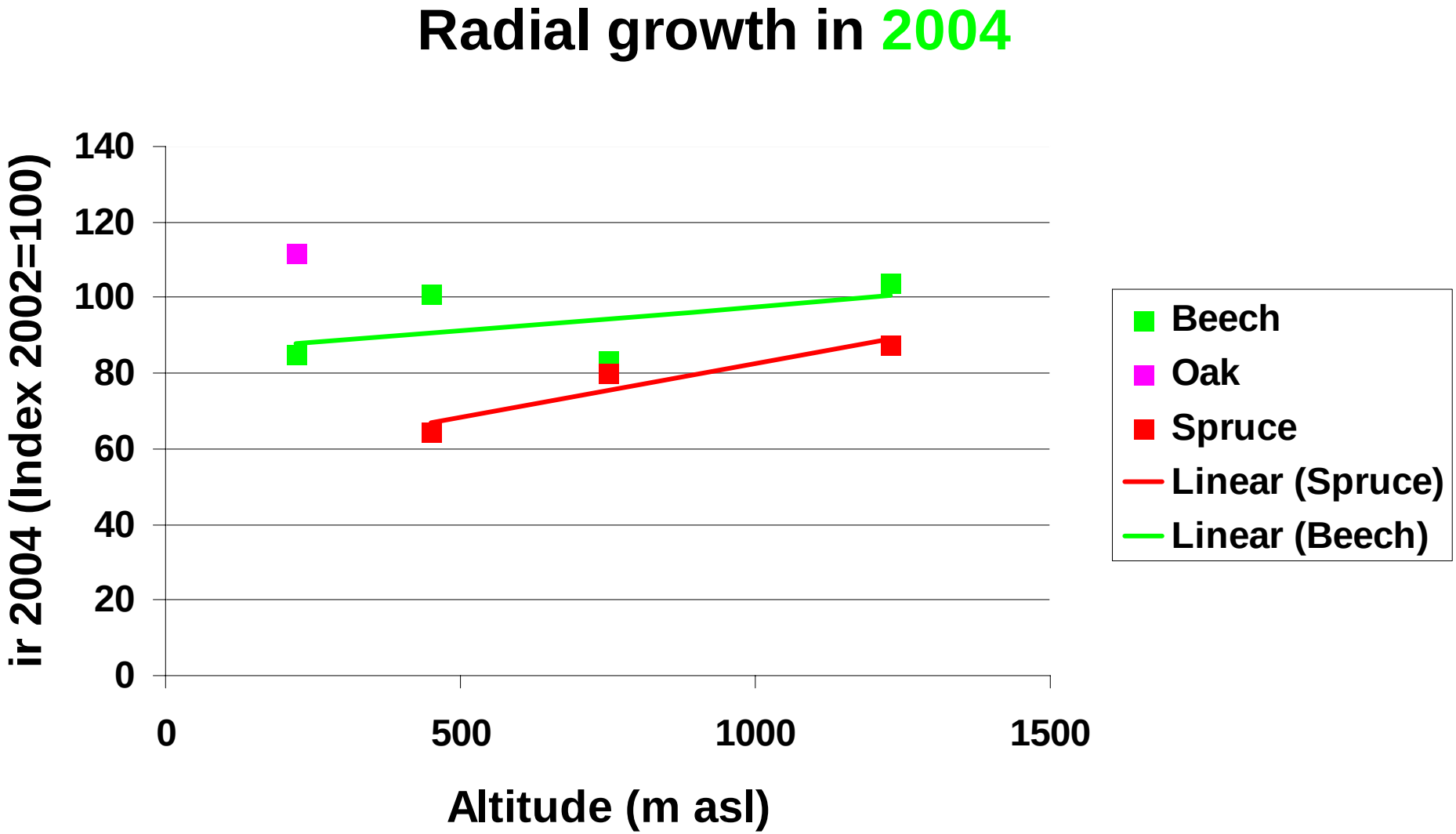


Occurrence of may shoot of Norway spruce at Schauinsland (1250 m asl)



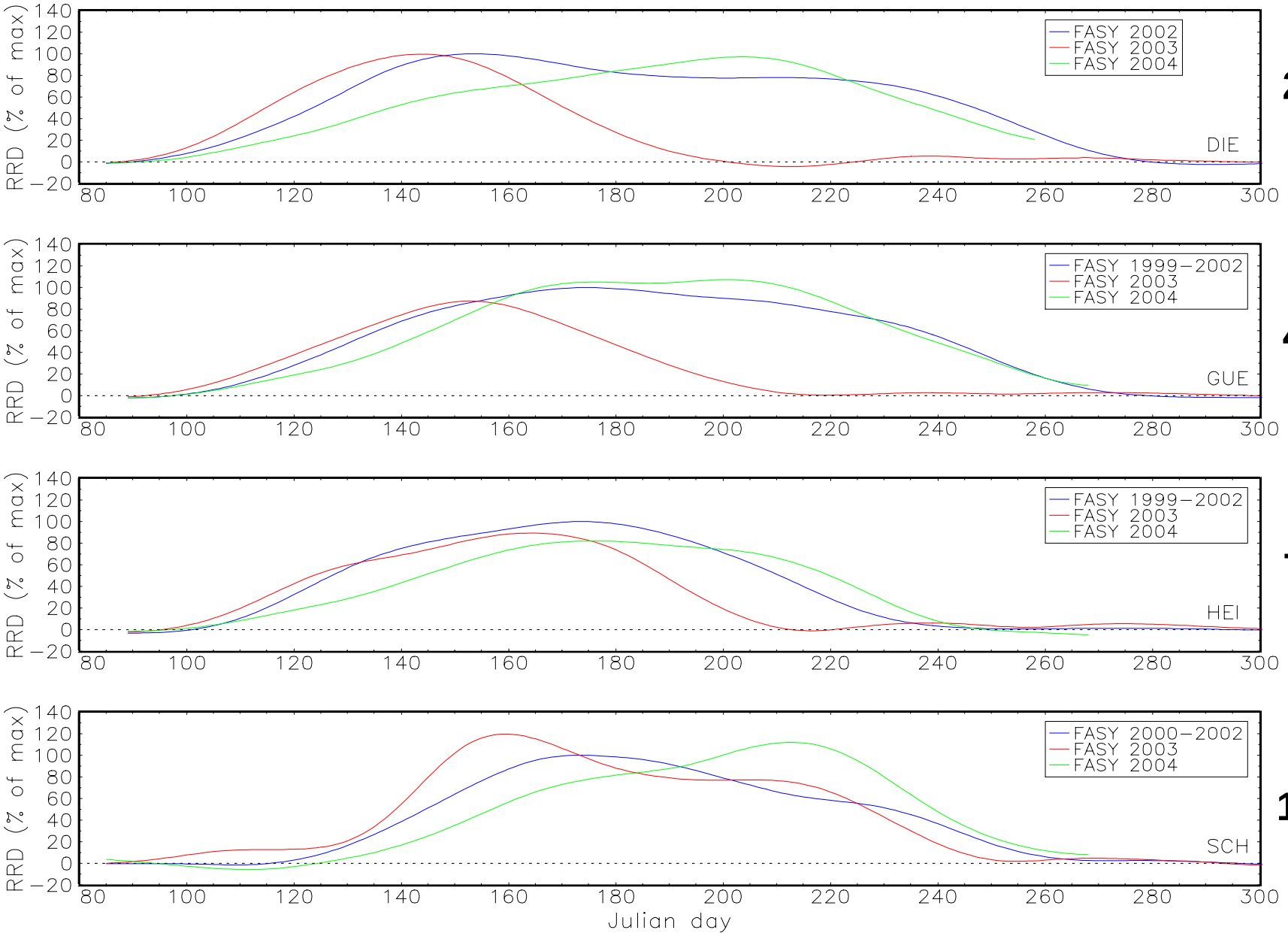
(Data source: Henhappl 2004)


Radial growth in 2003
ir 2003 (Index 2002=100)
140
120
100
80
60
40
20
0
0
500
1000
1500
Altitude (m asl)
Beech
Oak
Spruce
Linear (Spruce)
Linear (Beech)


Radial growth in 2004
ir 2004 (Index 2002=100)
140
120
100
80
60
40
20
0
0
500
1000
1500
Altitude (m asl)
Beech
Oak
Spruce
Linear (Spruce)
Linear (Beech)

Rate of radial displacement of European Beech

(expressed in % of the maximum rate during the period 1999-2002)



220 m asl

450 m asl

750 m asl

1250 m asl

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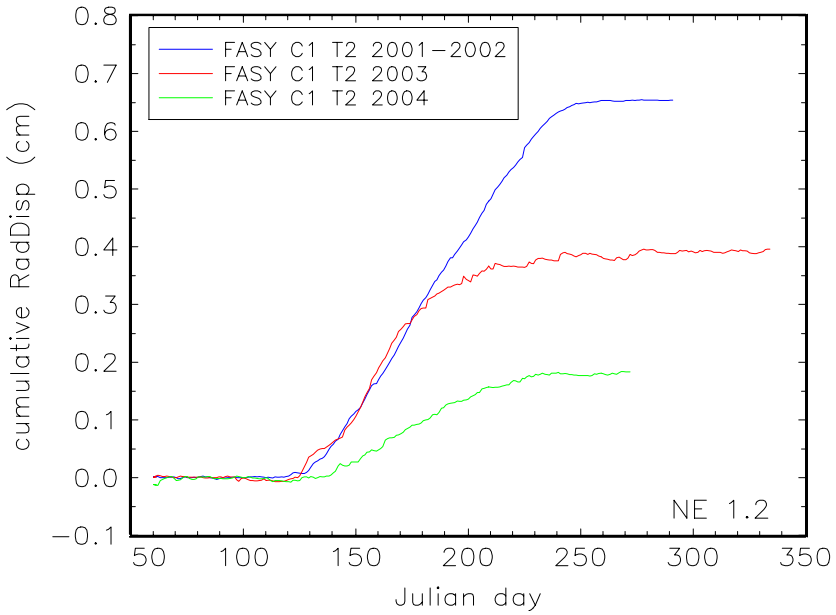
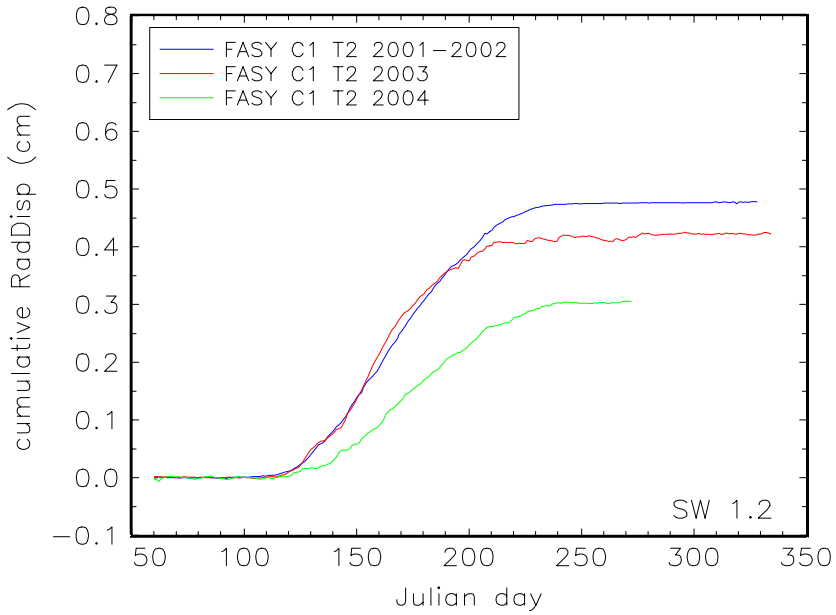
Radial Growth and Aspect of the Site

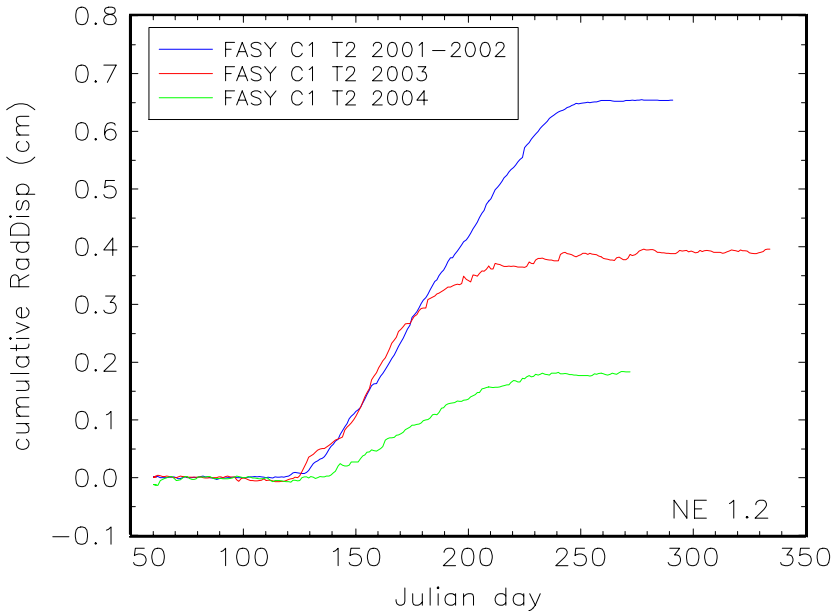
Radial Growth of European Beech at Möhringen (750 m asl)

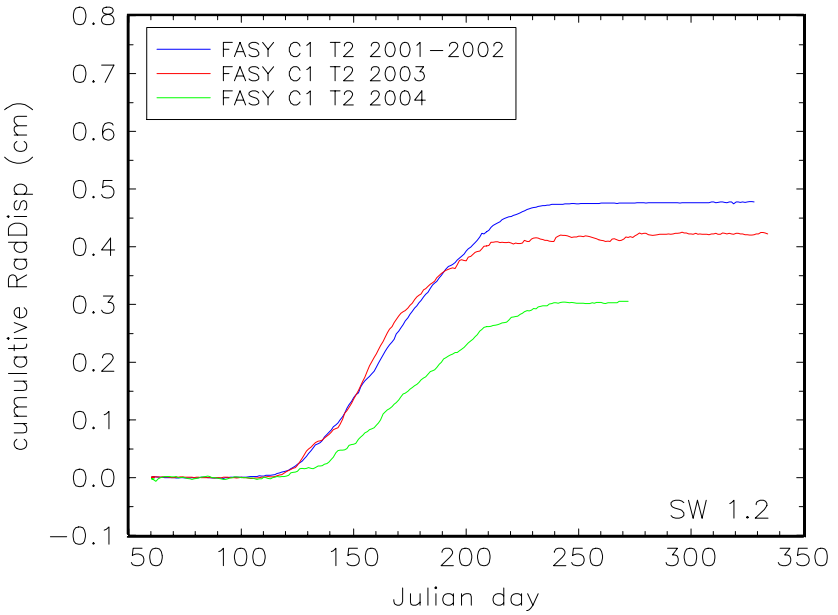


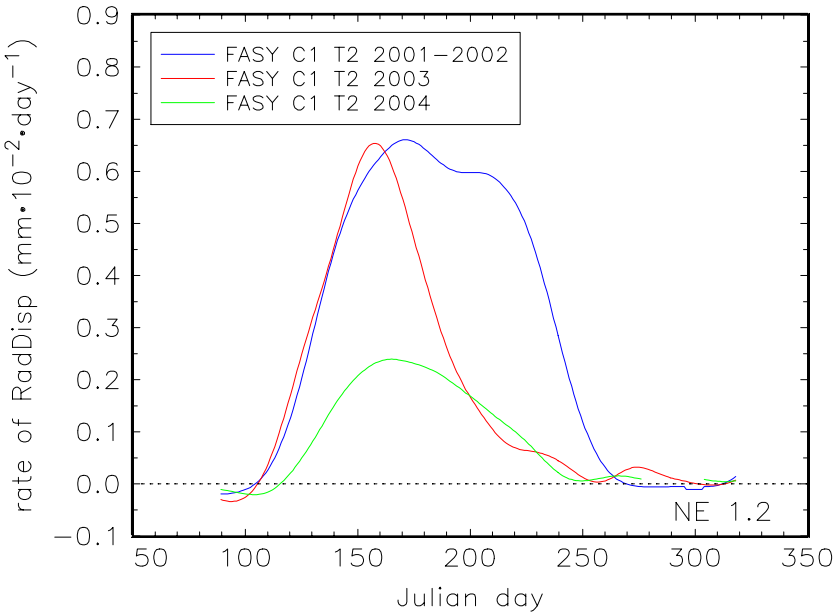


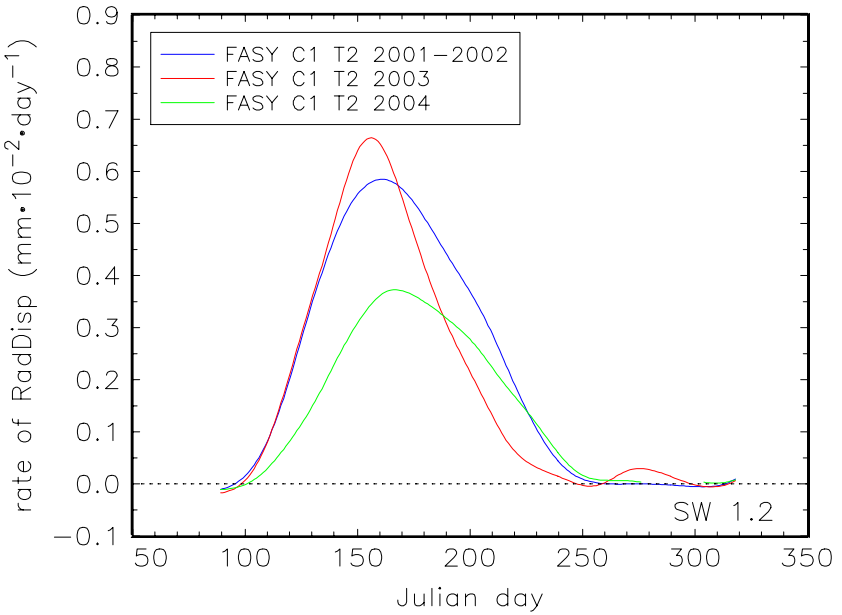
Aspect: **north-east** **south-west**

Radial Growth of European Beech at Möhringen (750 m asl)

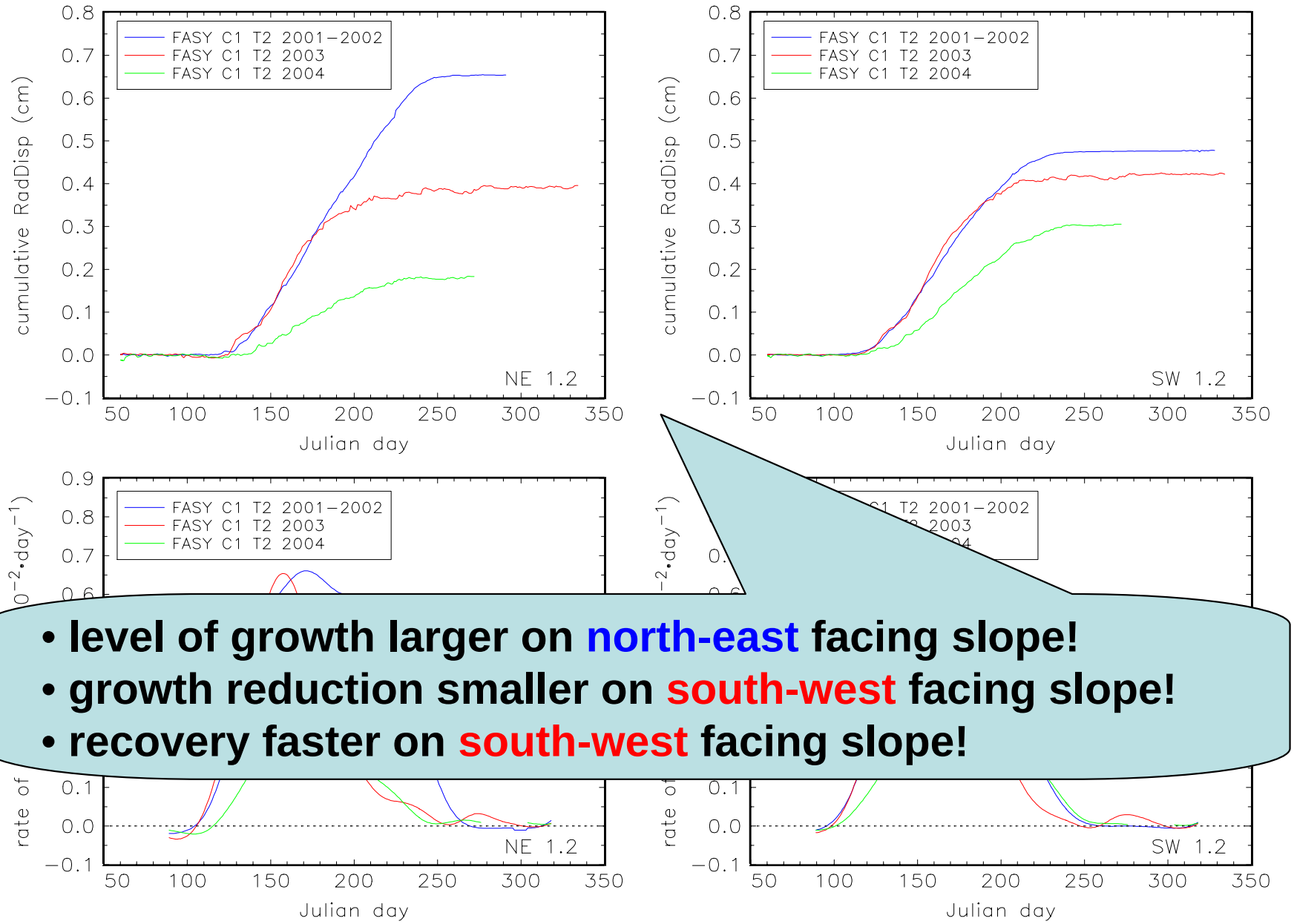








Radial Growth of European Beech at Möhringen (750 m asl)



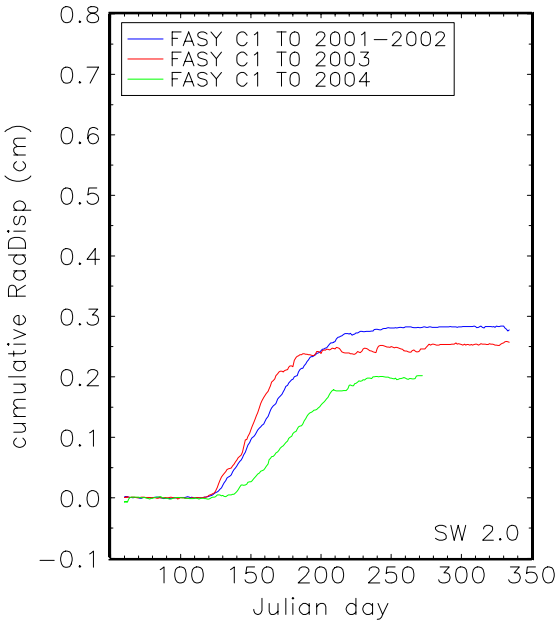
- **level of growth larger on north-east facing slope!**
- **growth reduction smaller on south-west facing slope!**
- **recovery faster on south-west facing slope!**

Drought 2003

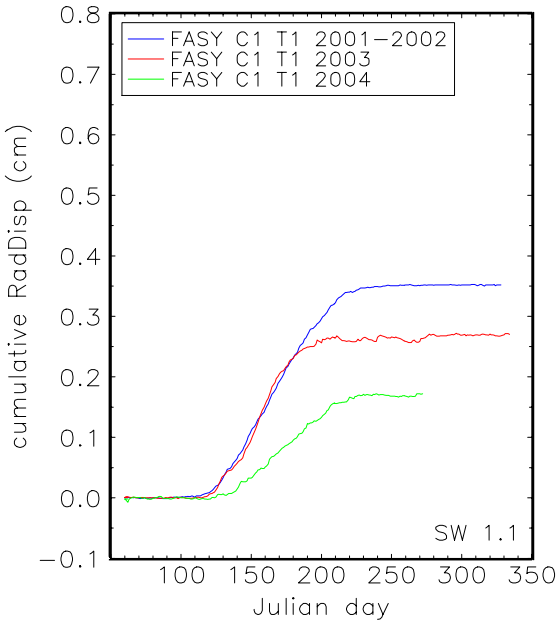
Working Group 5: Forest Growth

Radial Growth and Stand Density

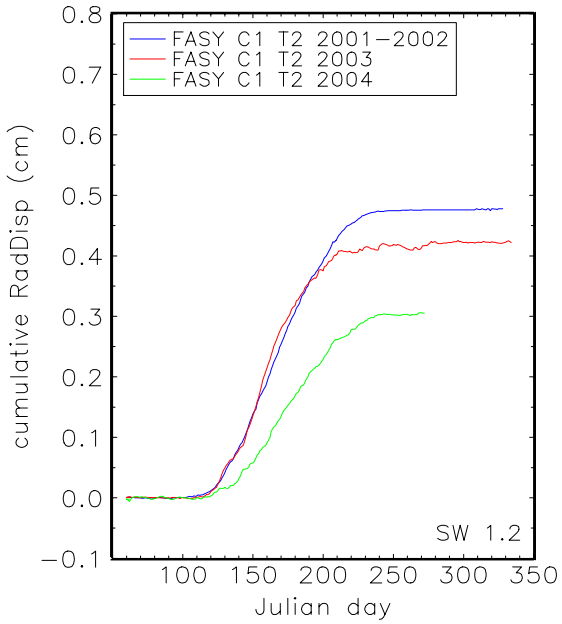
Radial growth of European Beech at Möhringen (760 m asl)



control

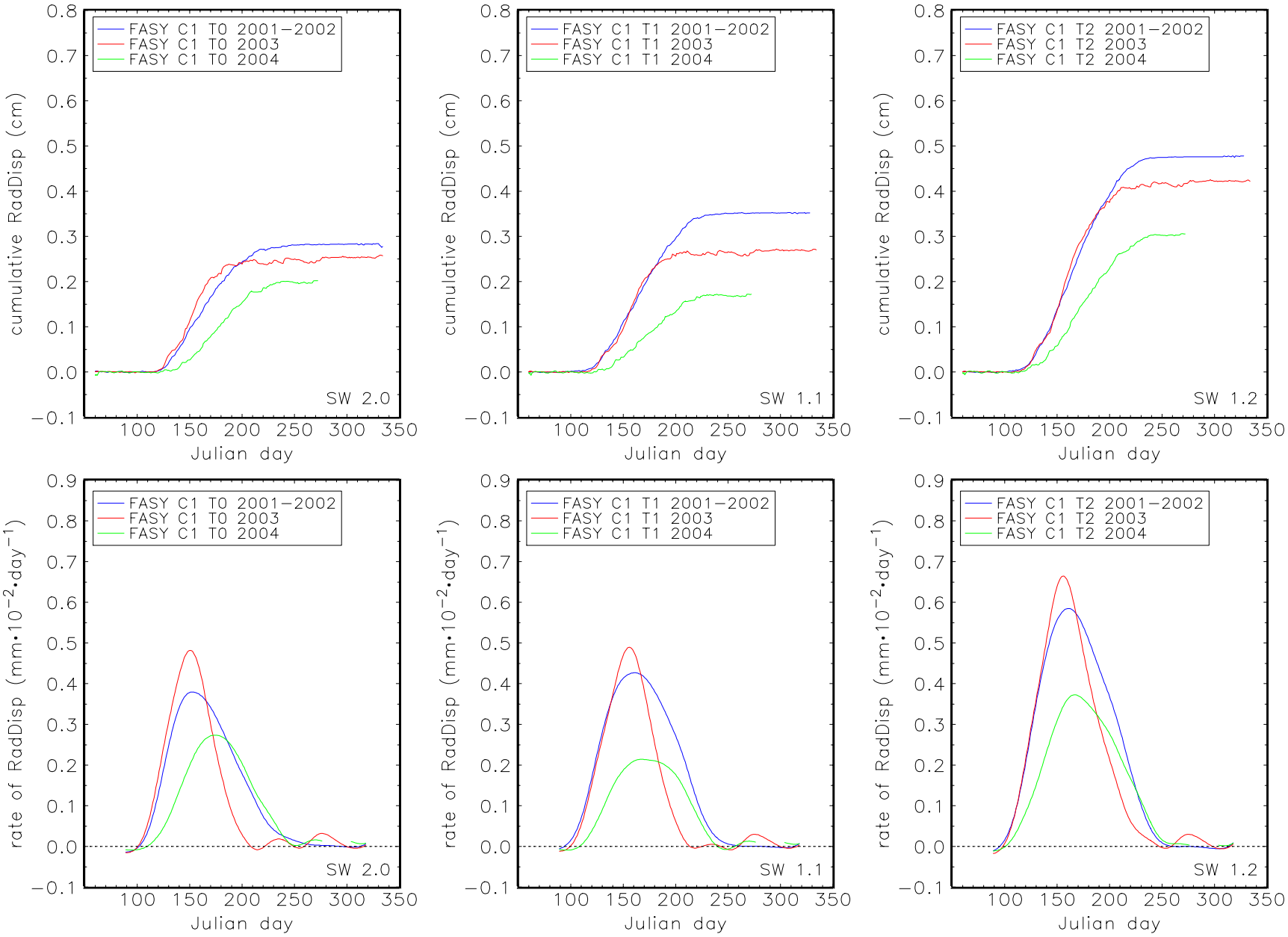


basal area 15 m²



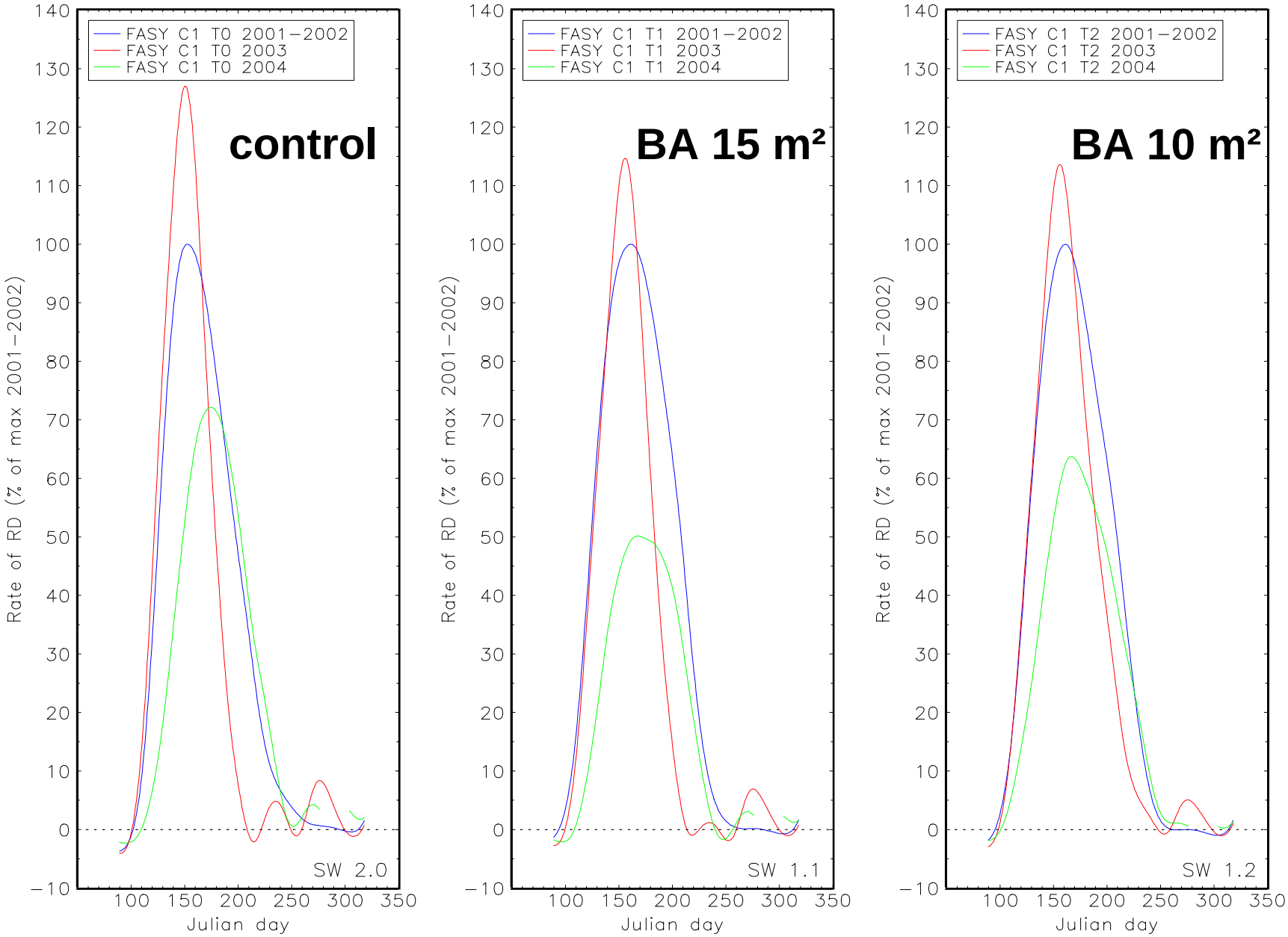
basal area 10 m²

Radial Growth of European Beech at Möhringen (760 m asl)

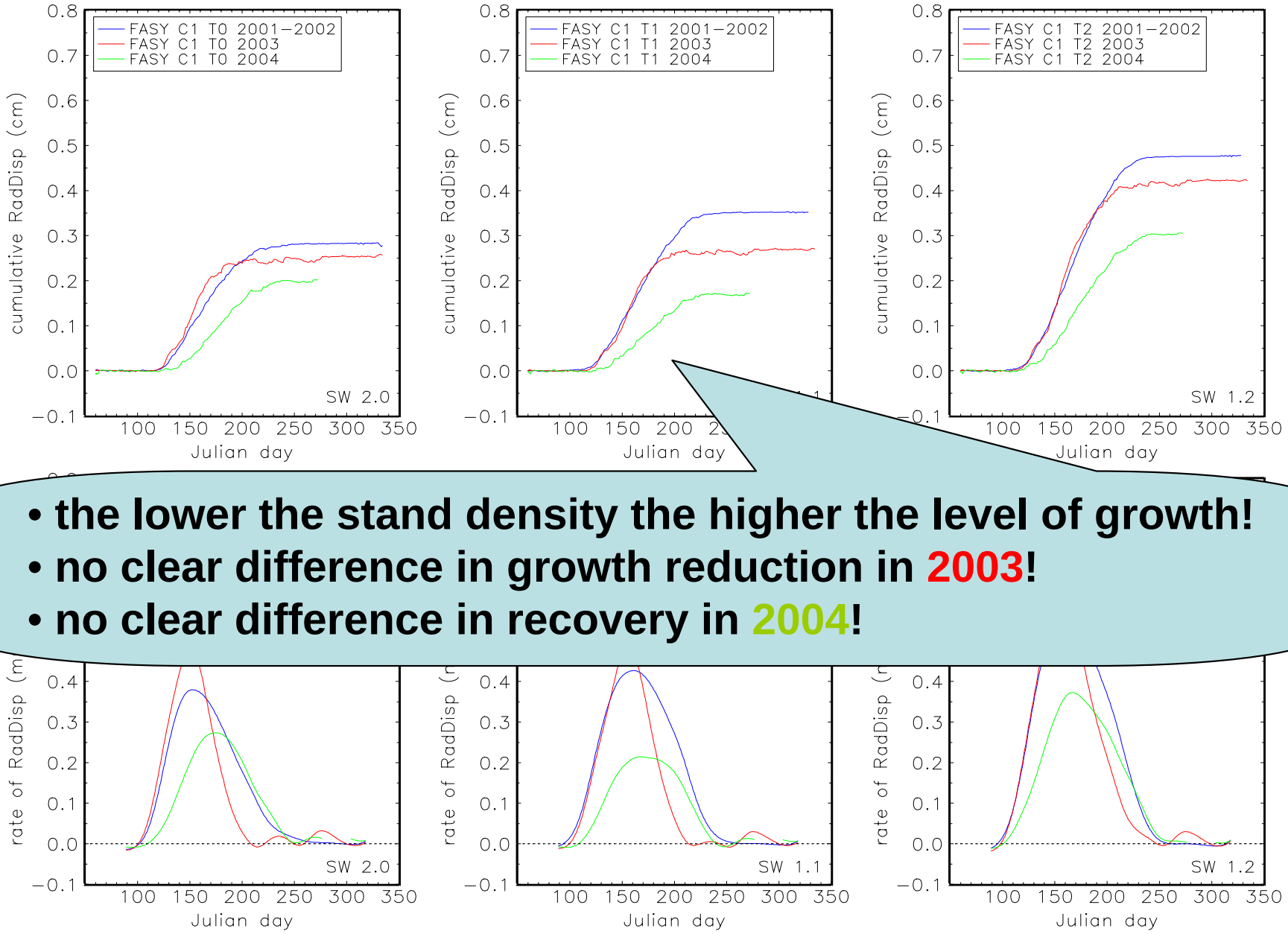


Rate of radial displacement of Beech at Möhringen

(expressed in % of the maximum rate during the period 2001-2002)



Radial Growth of European Beech at Möhringen (760 m asl)



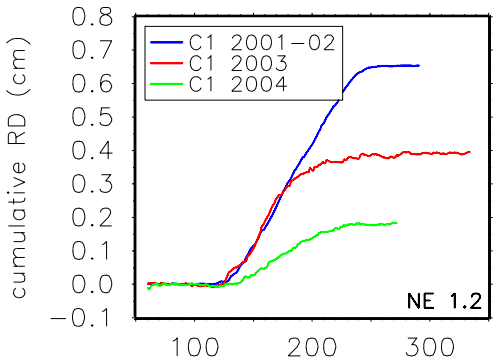
- **the lower the stand density the higher the level of growth!**
- **no clear difference in growth reduction in 2003!**
- **no clear difference in recovery in 2004!**

Drought 2003

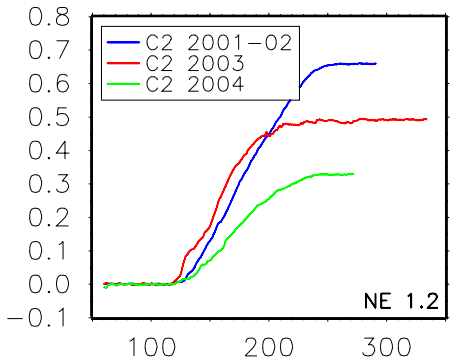
Working Group 5: Forest Growth

Radial Growth and Crown Class

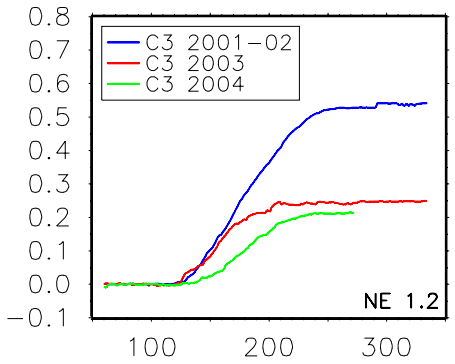
Radial Growth of European Beech at Möhringen (760 m asl)



dominant

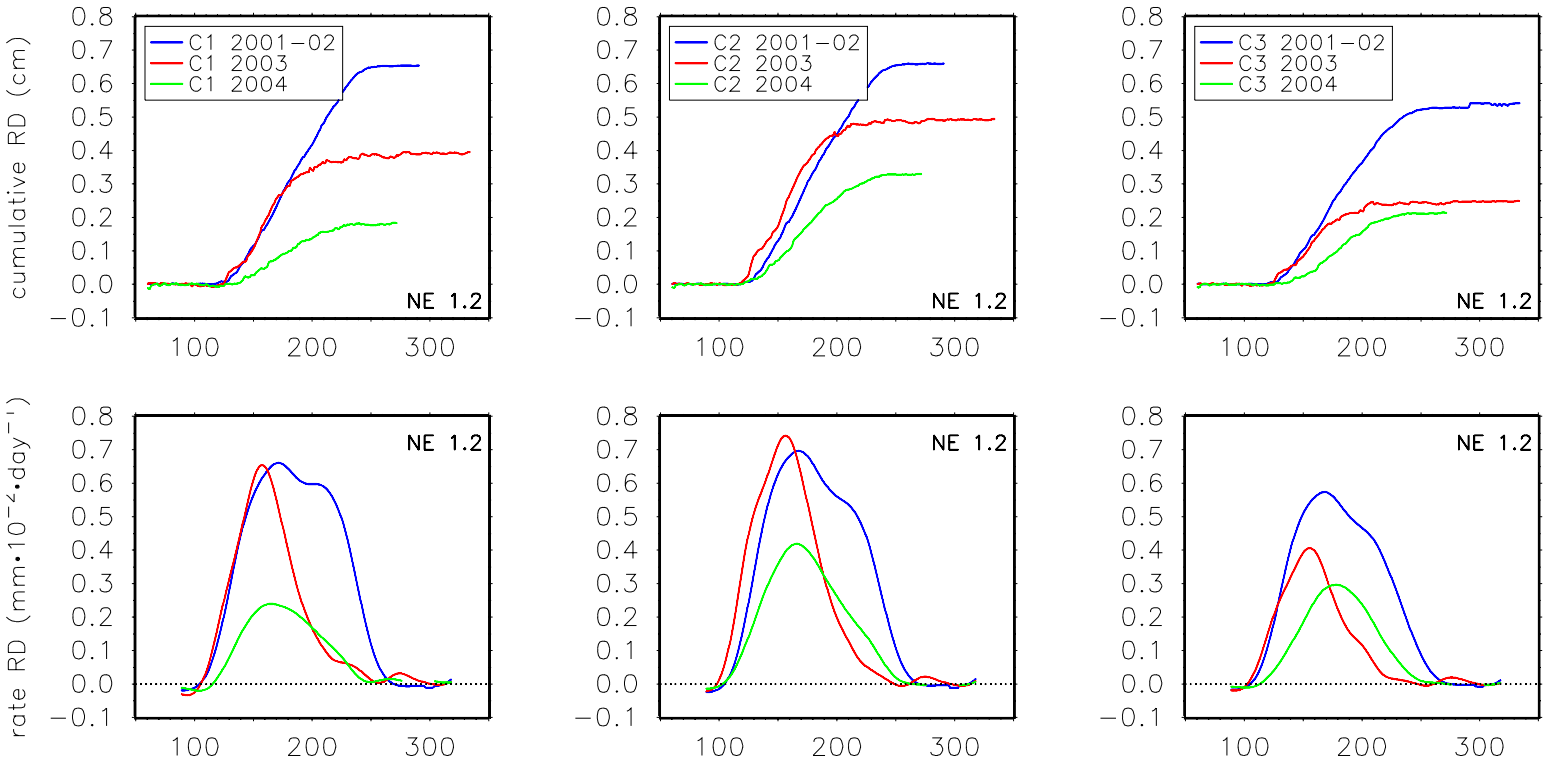


codominant



intermediate

Radial Growth of European Beech at Möhringen (760 m asl)



- **the higher the crown class the higher the level of growth!**
- **intermediate trees show larger growth reduction in 2003!**
- **no clear differences between crown classes in recovery in 2004!**

Drought 2003

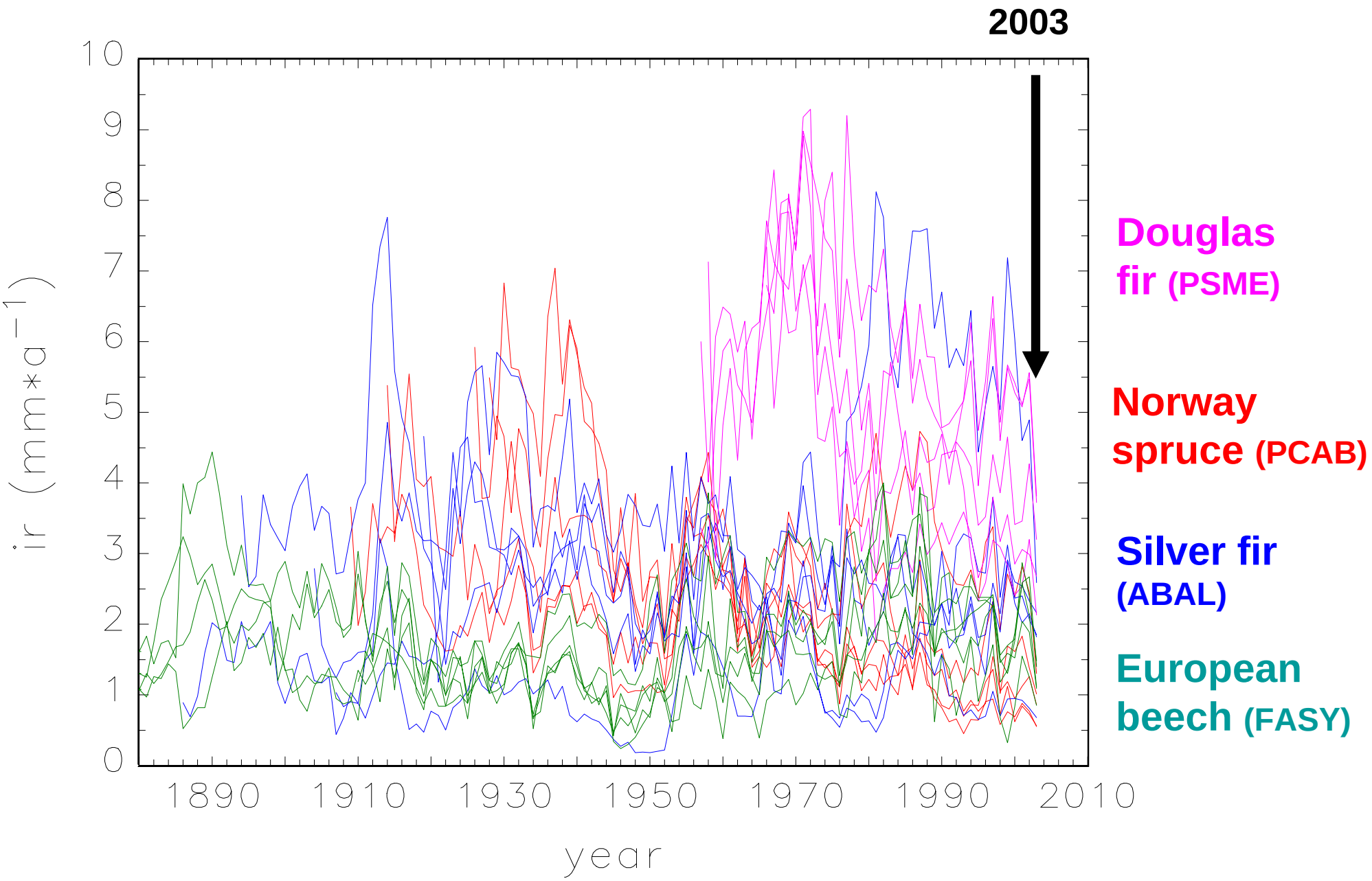
Working Group 5: Forest Growth

Restrospective Growth Analyses

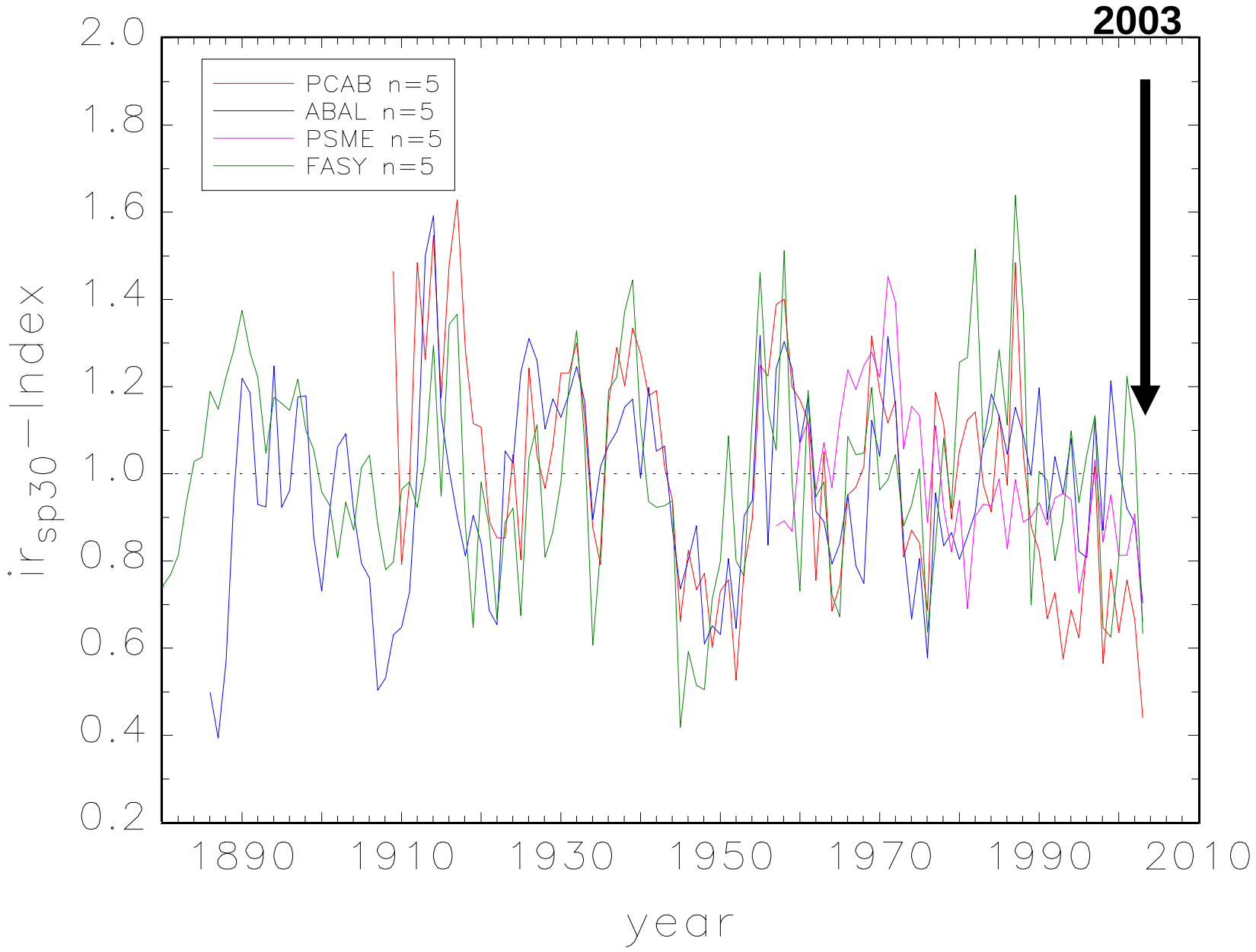
Two sites in the Black Forest:

- **Municipal forest of Freiburg (Dist. I/Abt. 23, 650 m asl)**
- **Community Forest Elzach (Elztal, 400 m asl)**

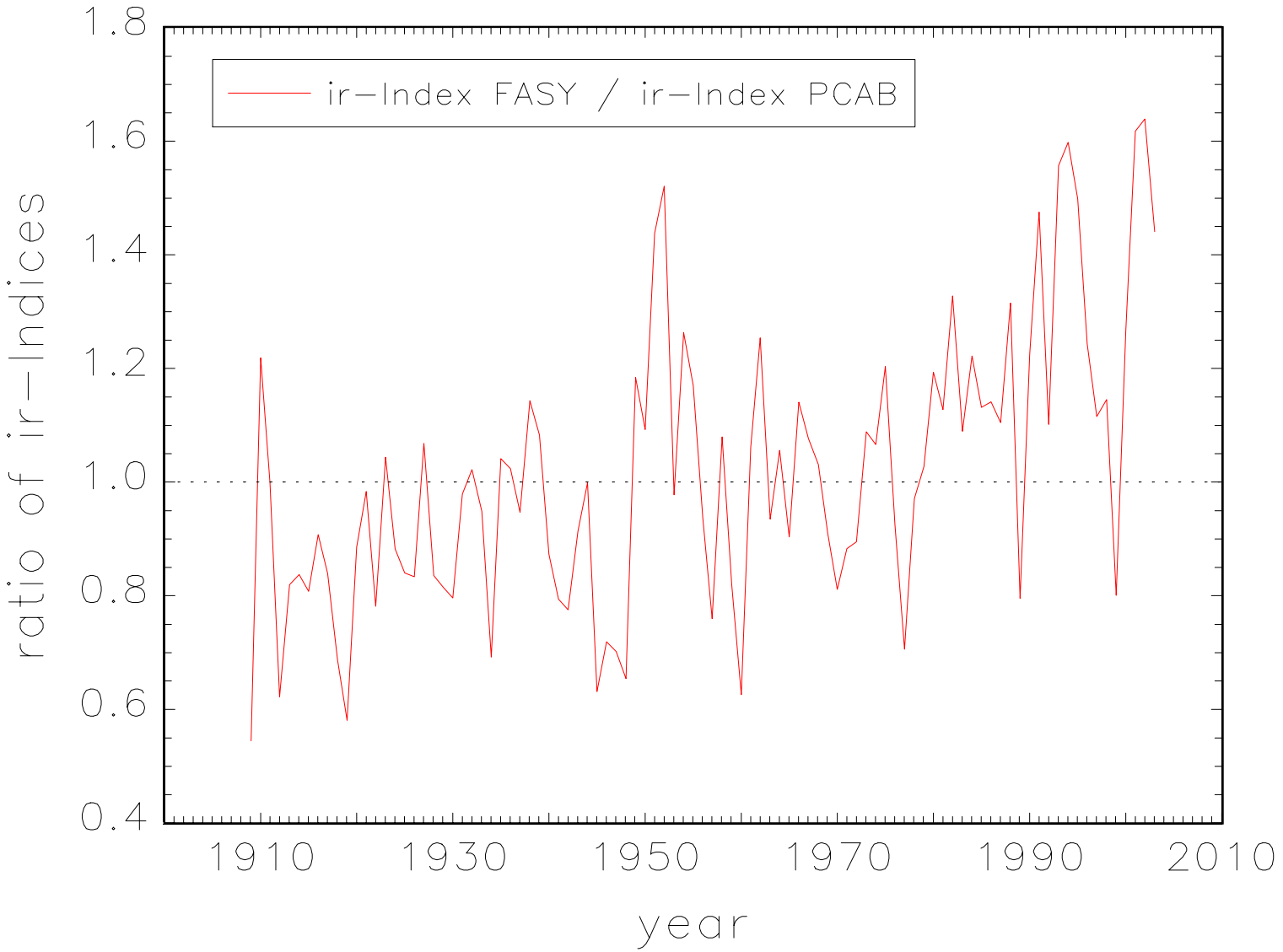
Annual Radial Increment, Black Forest, 650 m asl. (I/23)



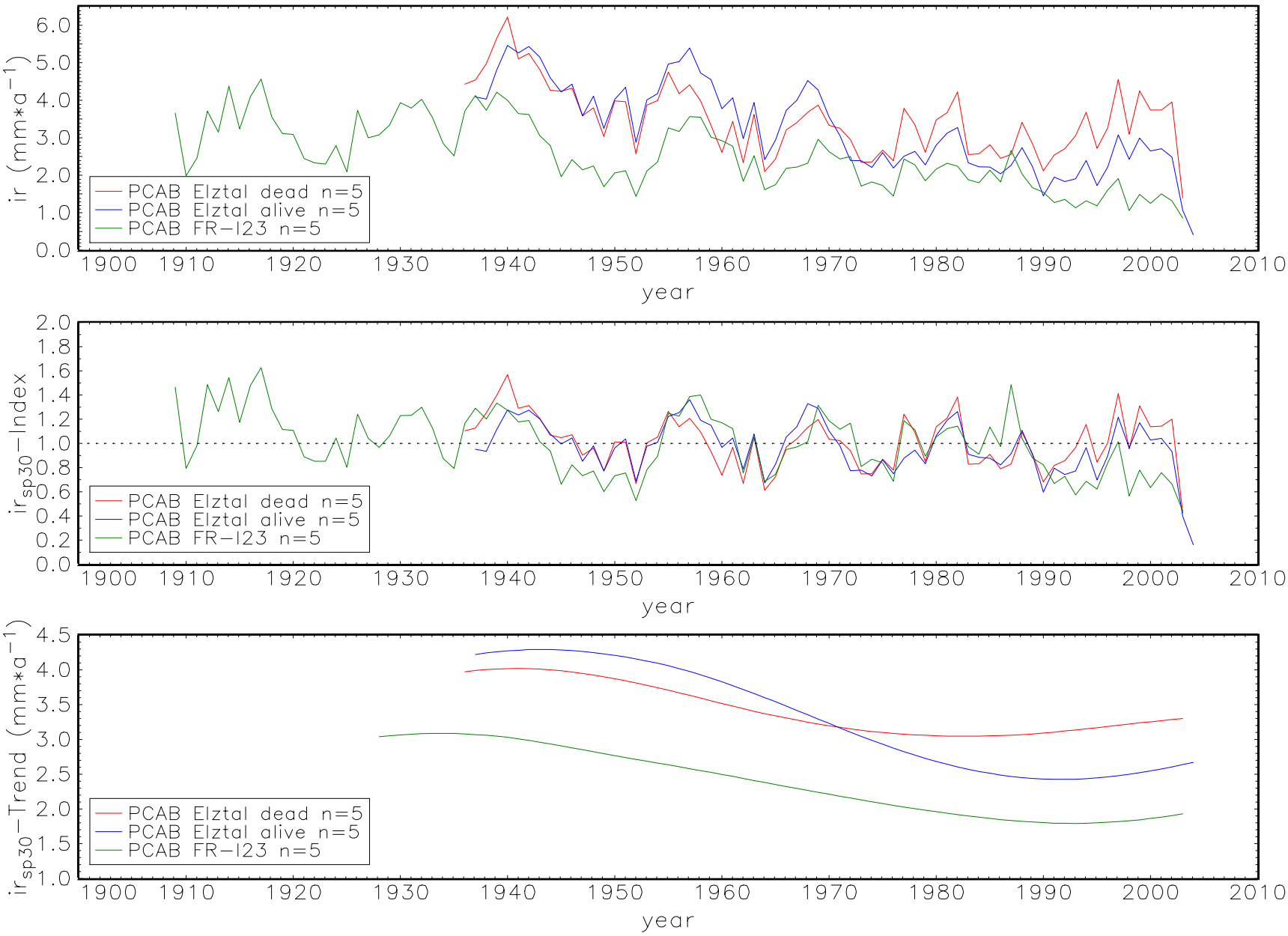
Standardized Annual Radial Increment, Black Forest, 650 m asl. (I/23)



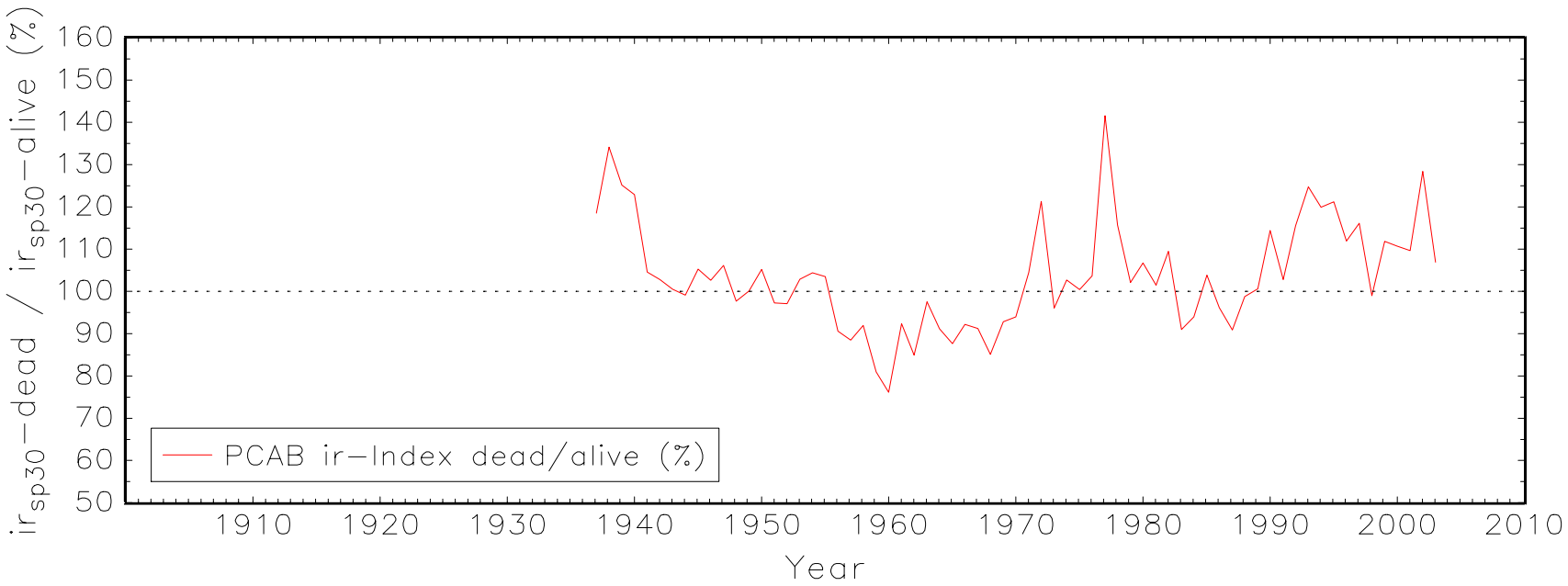
Annual Radial Increment of Beech in Relation to Spruce (Black Forest I/23, 650 m asl.)

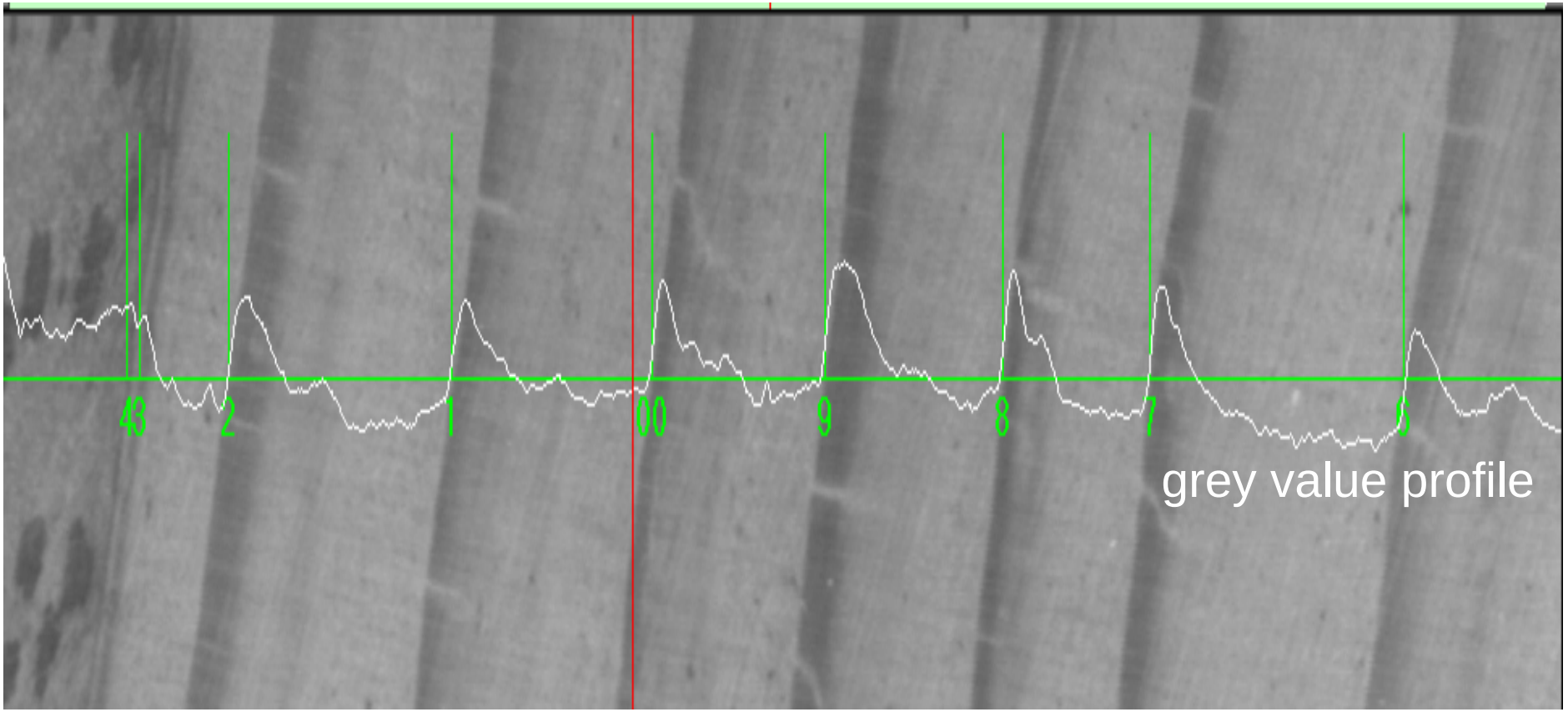


Annual Radial Increment of Dead and Alive Norway Spruce



Annual Radial Increment of Dead vs. Alive Norway Spruce

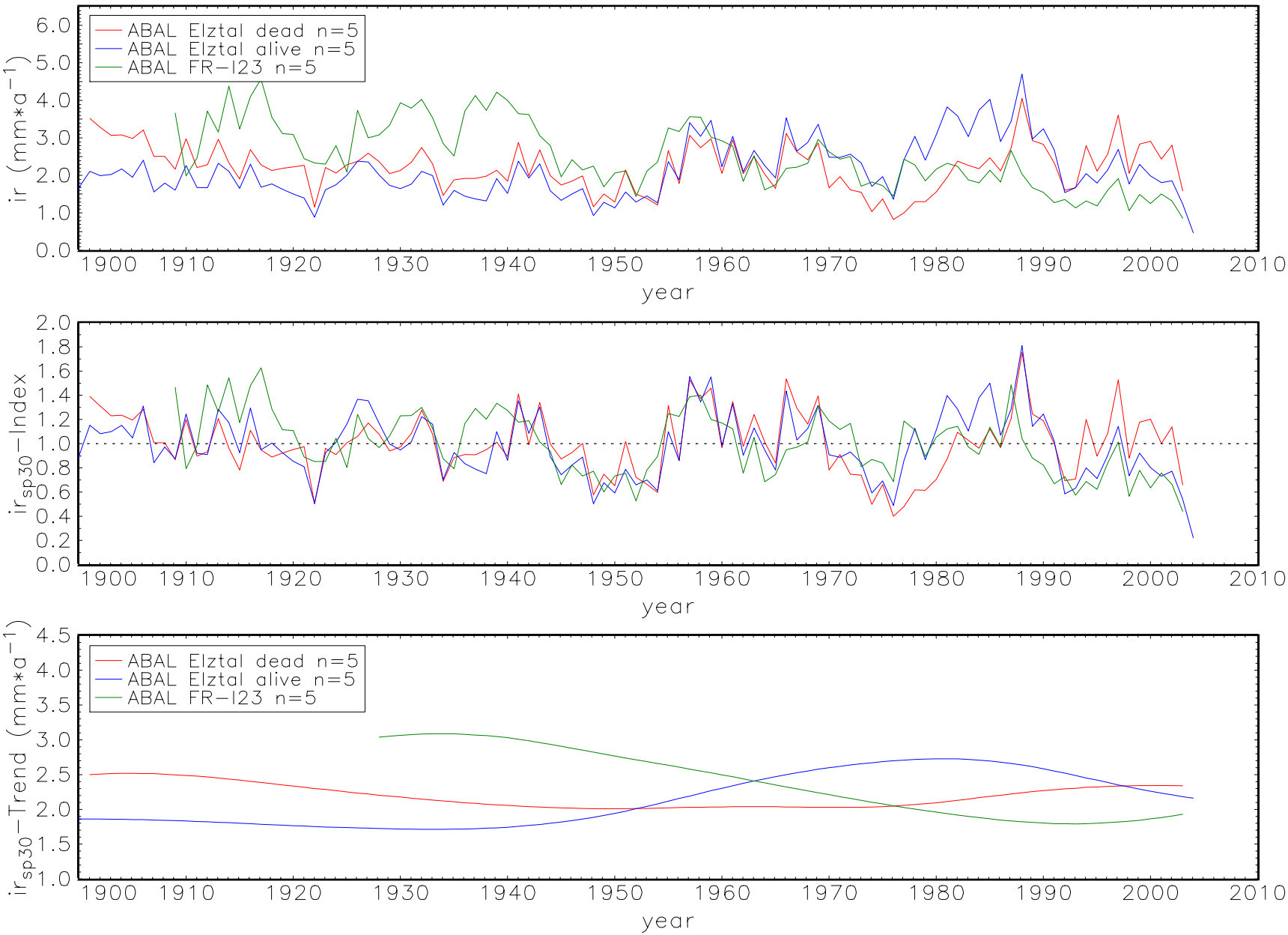




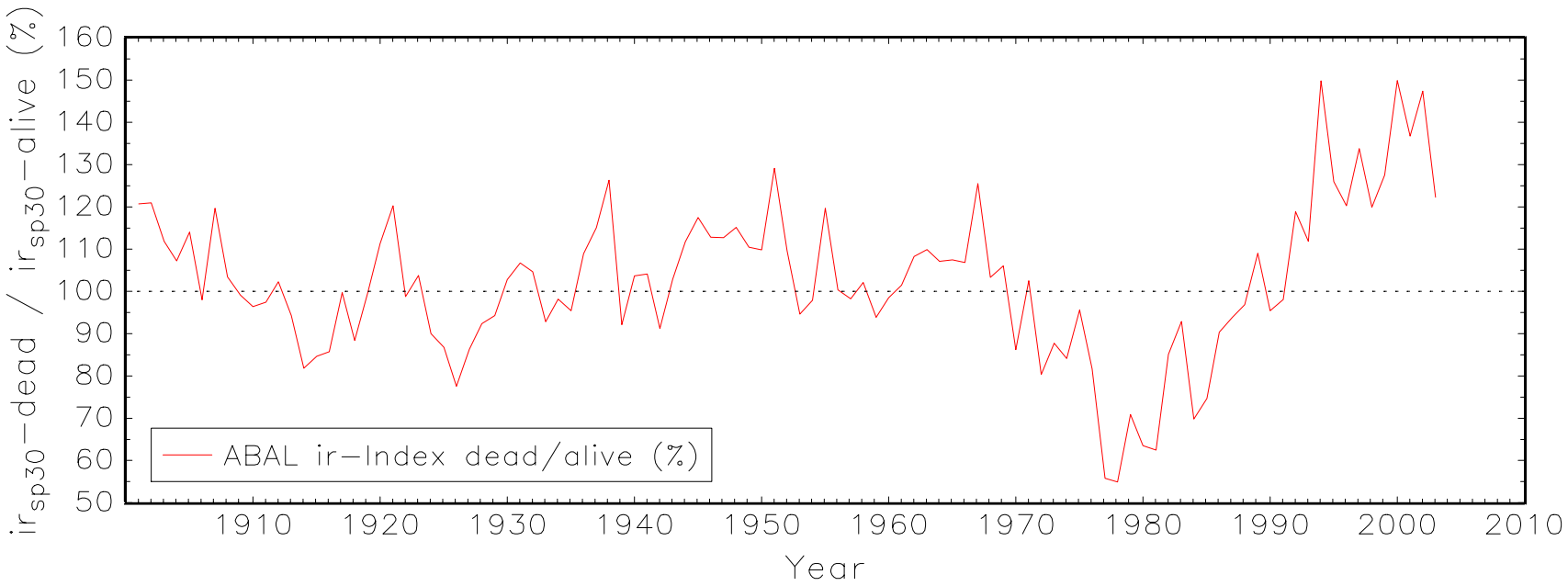
2004 2003 2002 2001 2000 1999 1998 1997 1996

Detail: stem cross section Norway spruce (Elztal, Tree no. 6, Radius 2)

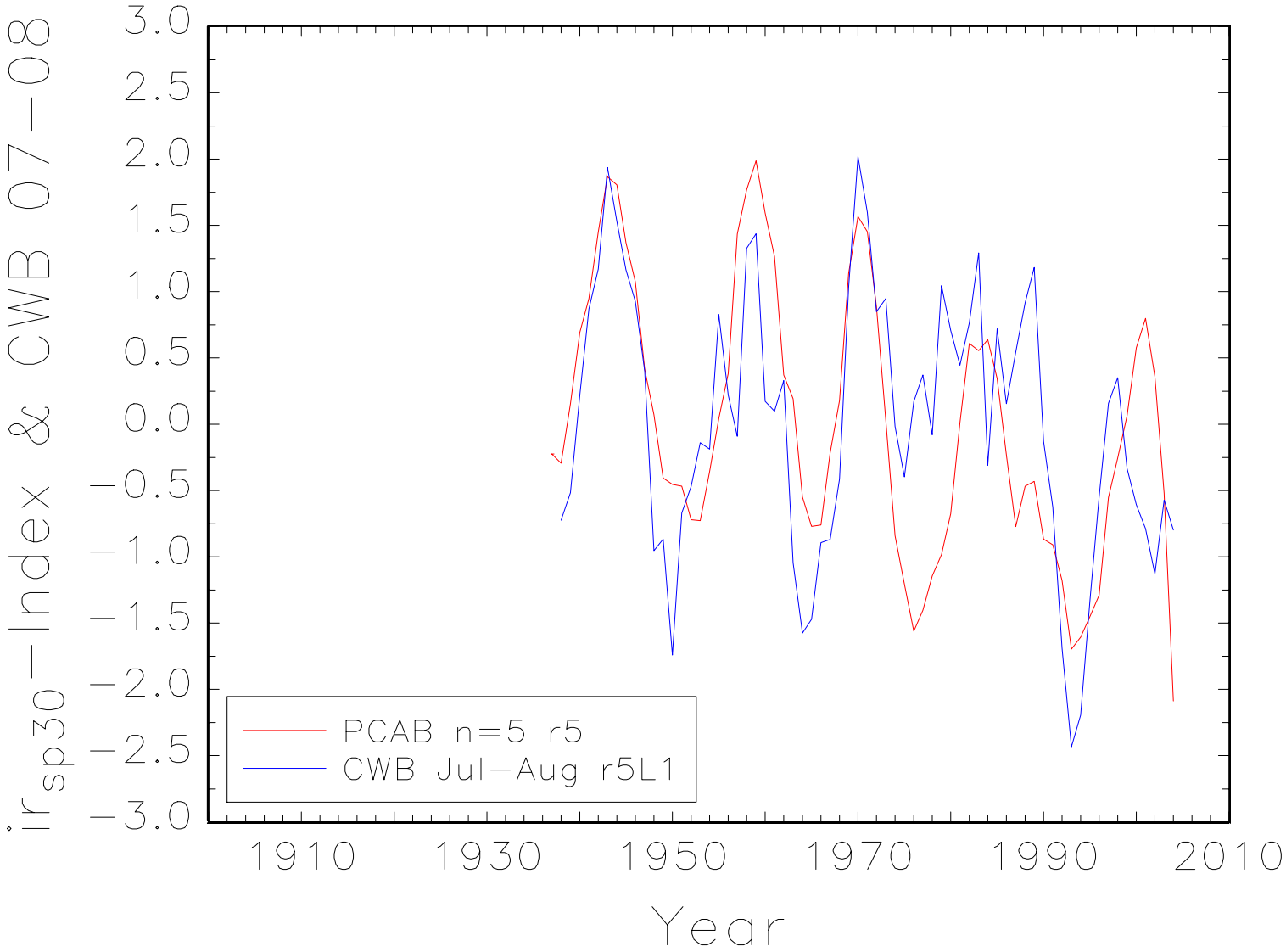
Annual Radial Increment of Dead and Alive Silver Fir



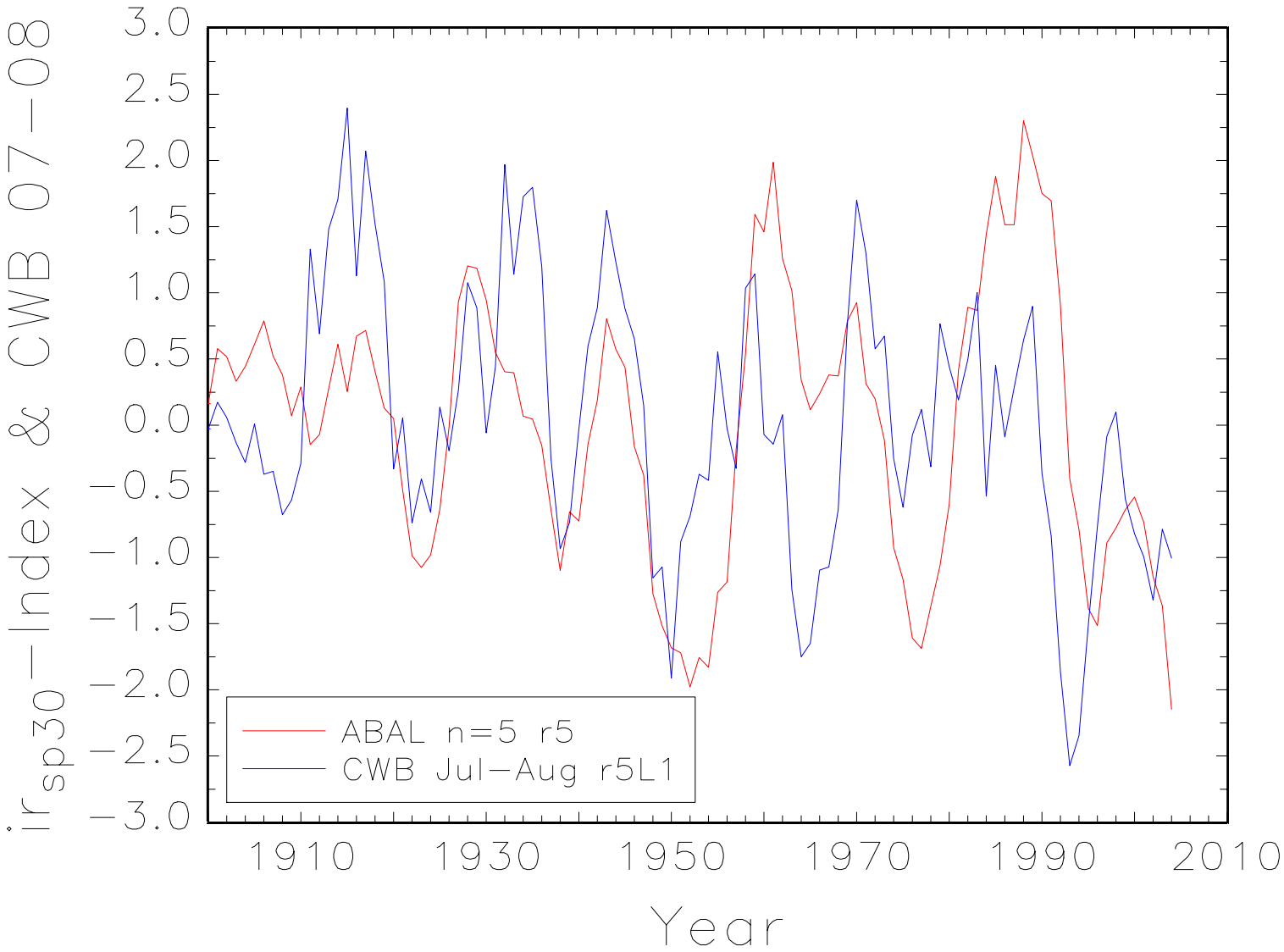
Annual Radial Increment of Dead vs. Alive Silver Fir



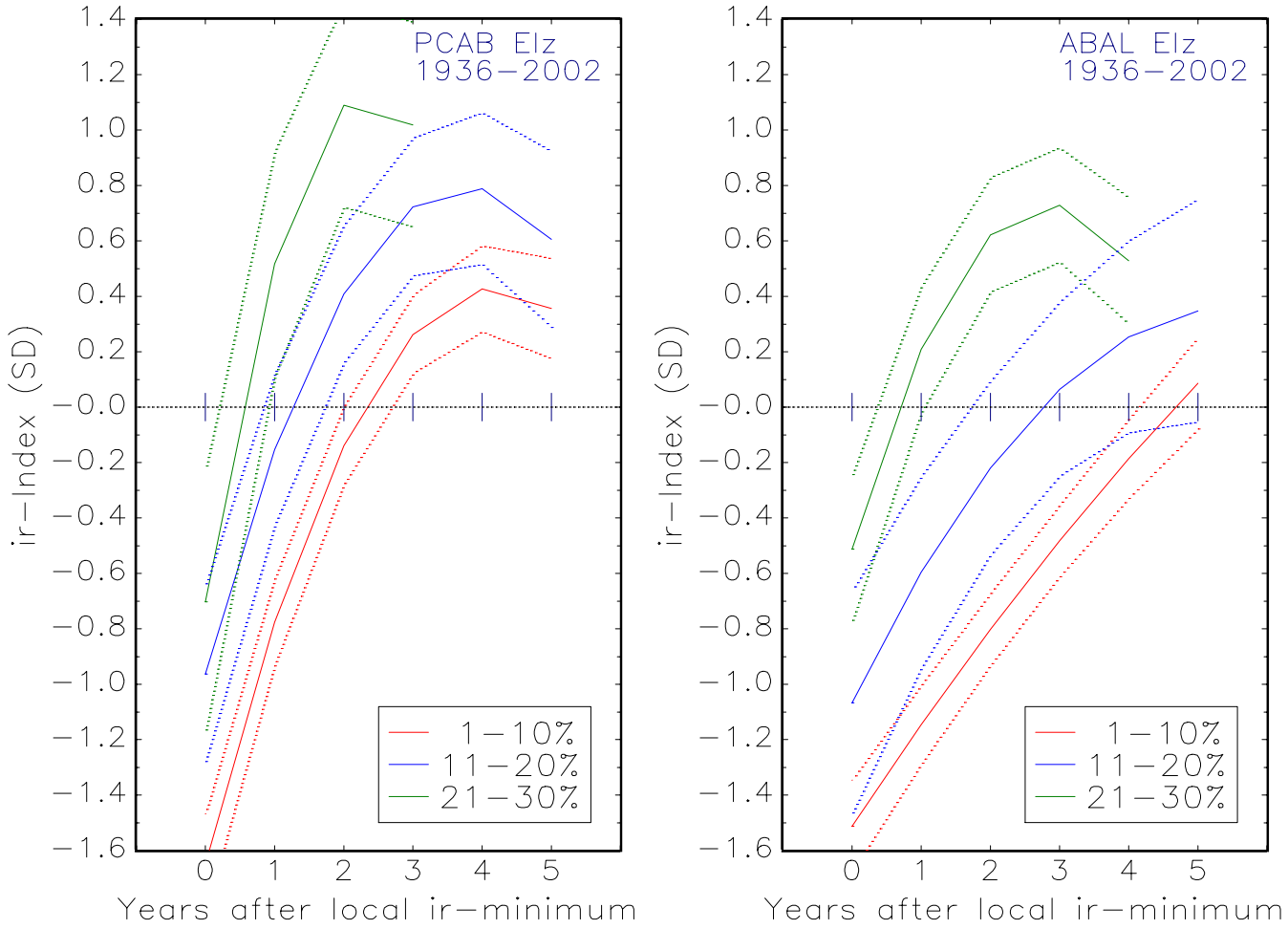
Annual Radial Increment of Norway Spruce and Climatic Water Balance during July-August of the Five Preceeding Years



Annual Radial Increment of Silver Fir and Climatic Water Balance during July-August of the Five Preceeding Years

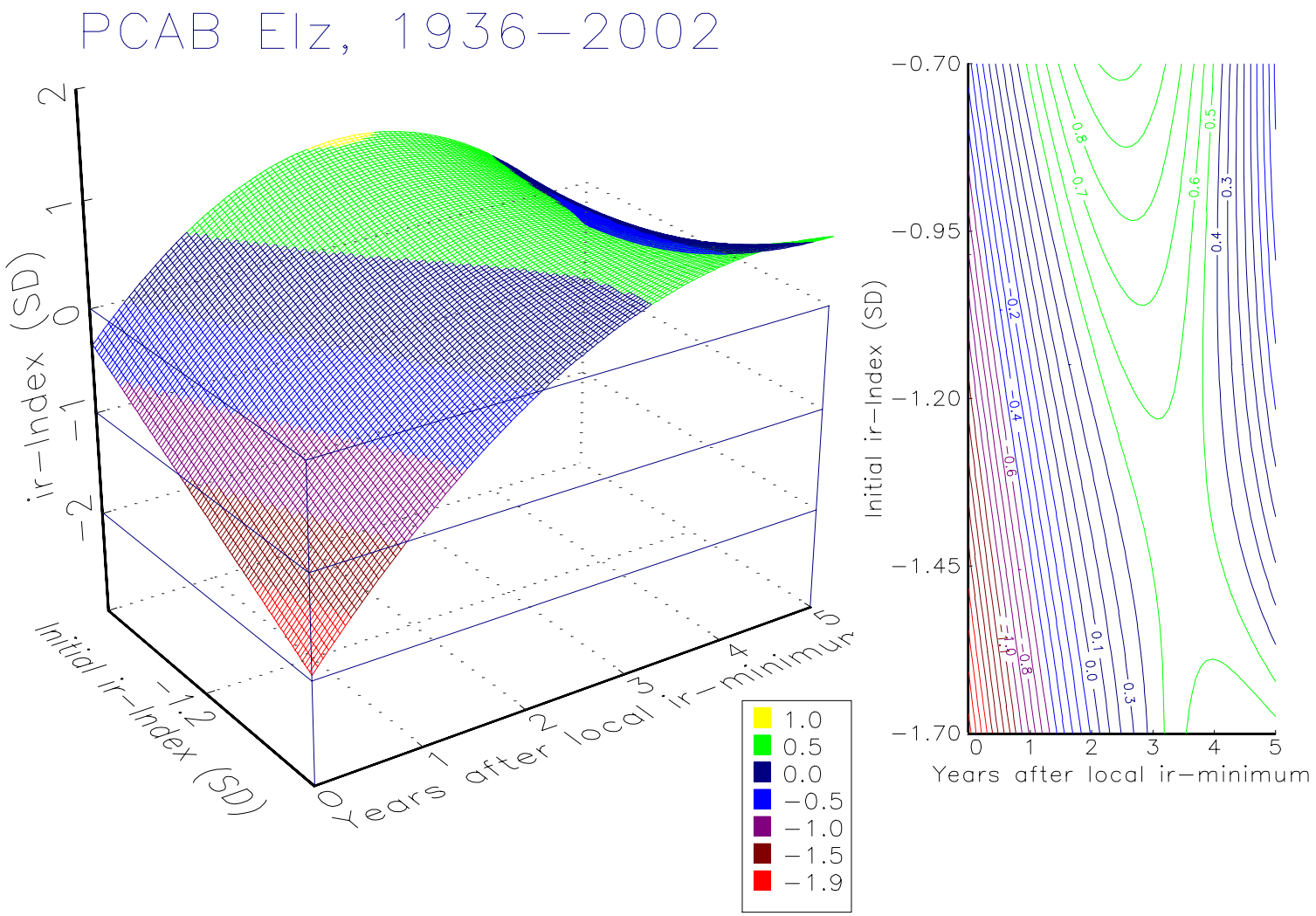


Development of radial increment after extreme growth reduction versus the time in years passed since the reduction occurred



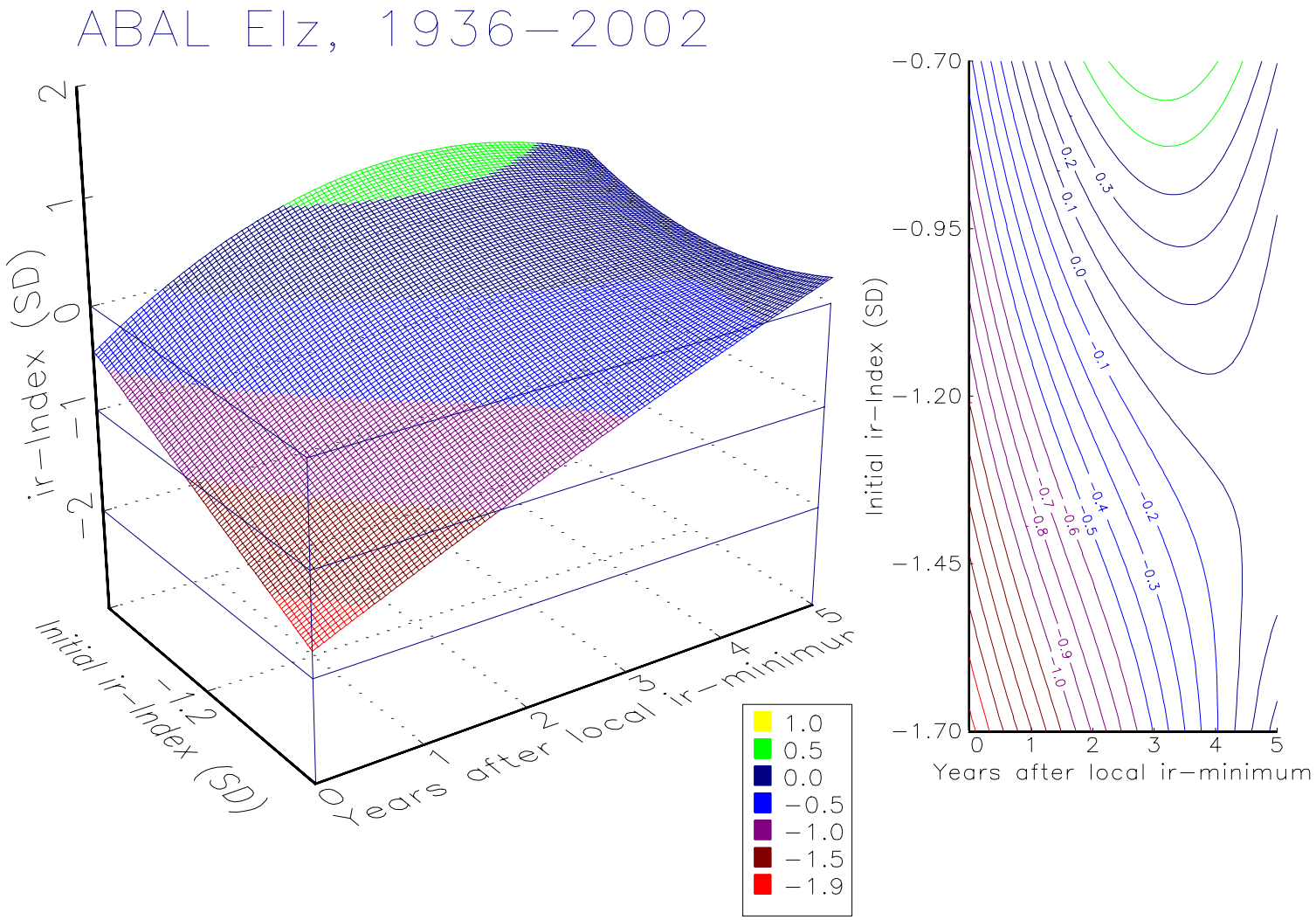
Spruce PCAB: left, Fir ABAL: right. The analysis refers to the time period 1936-2002. Only events where radial increment is within the 1-10- (red line), 11-20- (blue) and 21-30-percentile (green) of the ir-index distribution were selected. The annual radial increment data have been standardised into ir-indices using cubic smoothing splines with 50% frequency cut-off of 30 years and normalised to a mean of zero and a standard deviation of one. The lines are the regression models together with the 95% confidence belts (dotted lines).

Development of radial increment after extreme growth reduction

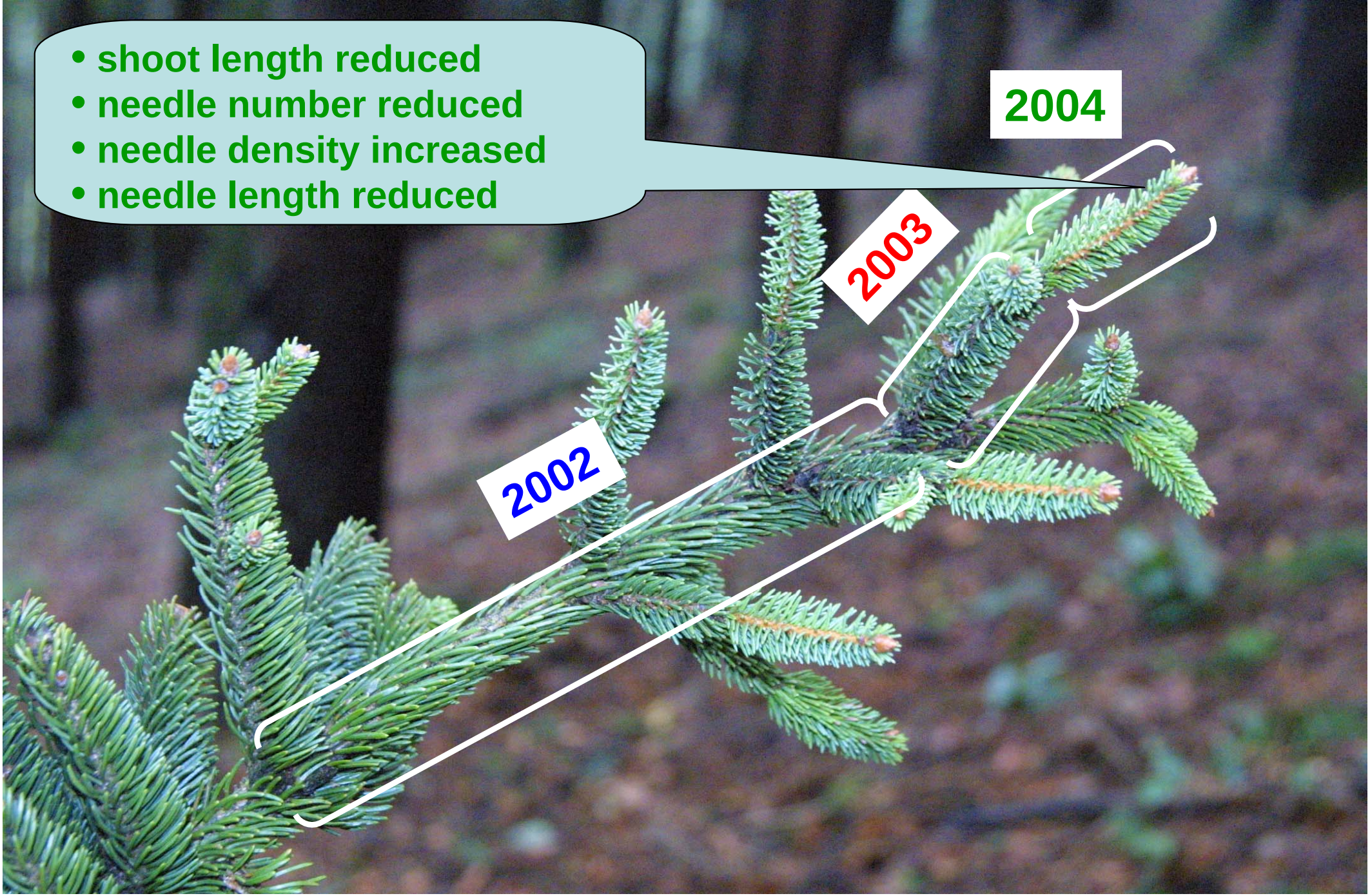


Spruce (PCAB) Elztal. The regression model shows the development of radial increment after extreme growth reduction versus the initial intensity of growth reduction and the time in years passed since the growth reduction occurred. Further explanations see previous figure. Surface plot (left) and corresponding contour plot (right).

Development of radial increment after extreme growth reduction



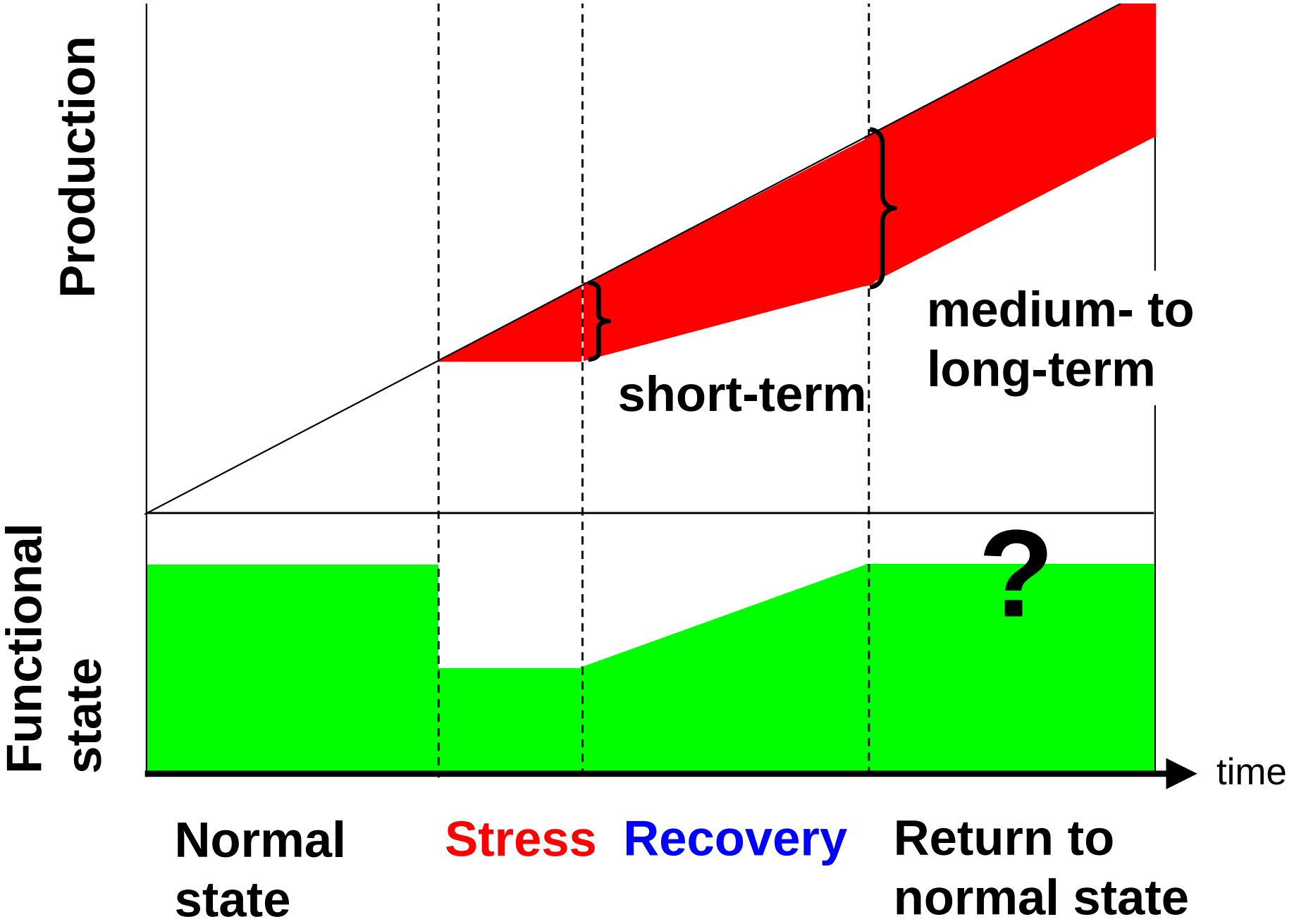
Fir (ABAL) Elztal. The regression model shows the development of radial increment after extreme growth reduction versus the initial intensity of growth reduction and the time in years passed since the growth reduction occurred. Further explanations see previous figure. Surface plot (left) and corresponding contour plot (right).



Norway Spruce: Terminal Shoot of a 32 m tall Tree.

(photo: 28.09.2004, Elzach, Brand)

Stress concept: temporary stress, elastic response



(acc. to Larcher 2003)

Drought 2003

Working Group 5: Forest Growth

Conclusions: Radial Growth Reduction in 2003

Elevation: low elevation > high elevation

Aspect: north-east > south-west

Drought 2003

Working Group 5: Forest Growth

Conclusions: Radial Growth Reduction in 2003

Species:	**Spruce > Beech**
Recovery:	**Beech > Spruce**
	Spruce > Fir
Crown Class:	**intermediate > dominant**
Density:	**no (clear) difference**

Drought 2003

Working Group 5: Forest Growth

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Thank you
for your attention!