Current and future climate extremes in the Alps

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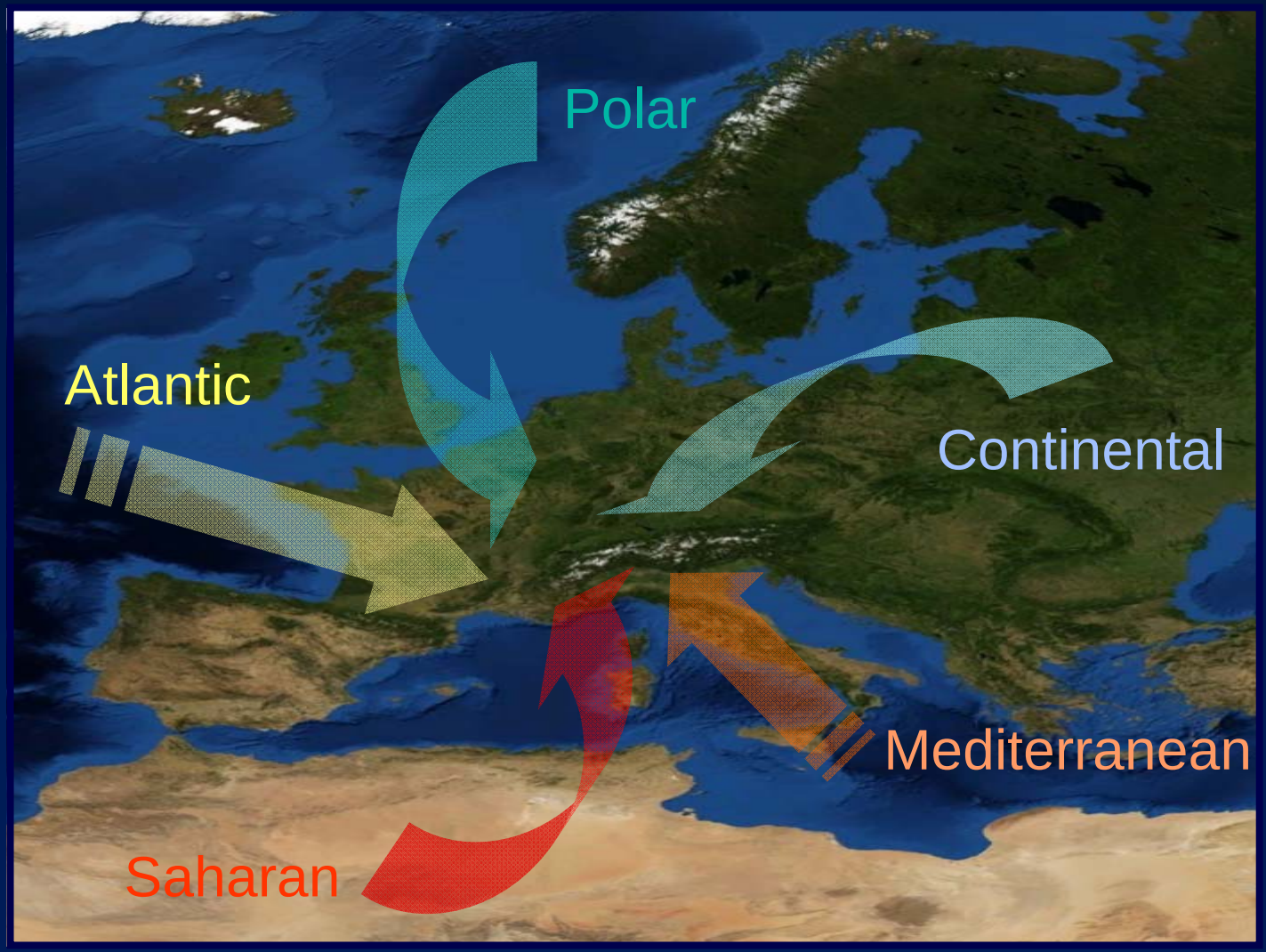
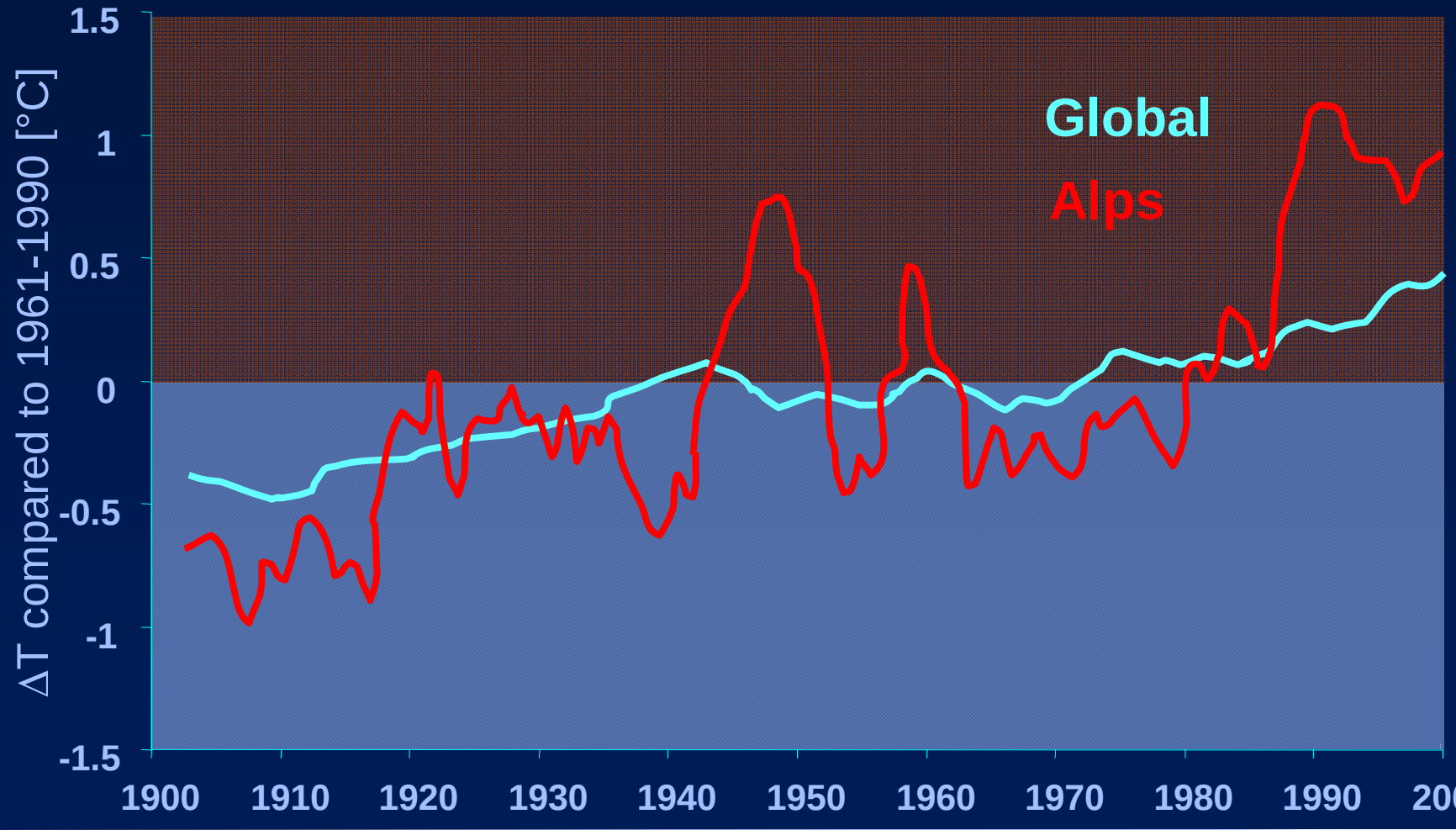
Switzerland

Particularities of Alpine climates

The Alps at the crossroads of different climate regimes



Evolution of global and alpine temperatures, 1901-2000



Beniston, 2000: Environmental Change in Mountains, Arnold, London

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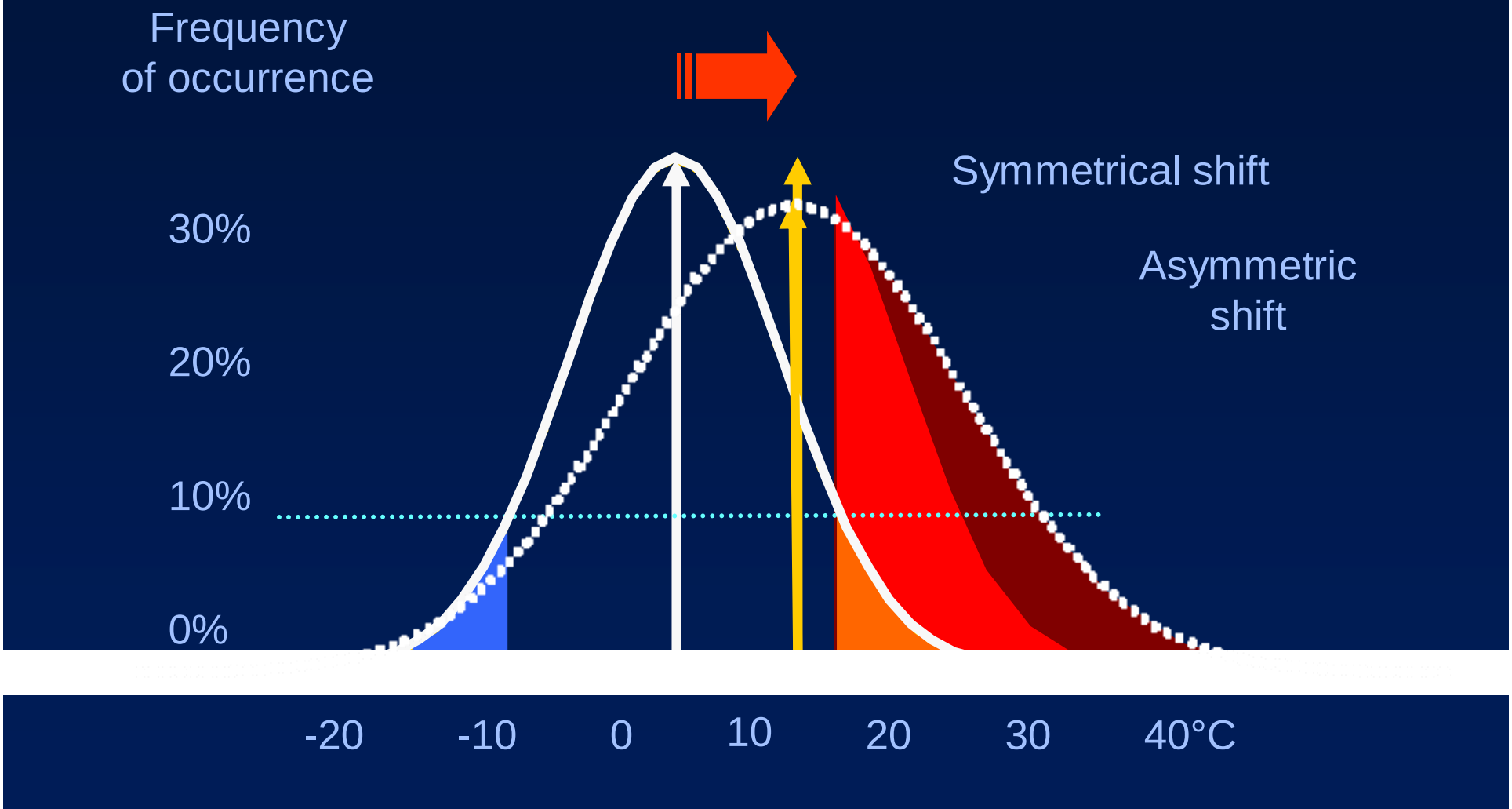
Where do extremes of Alpine weather come from?

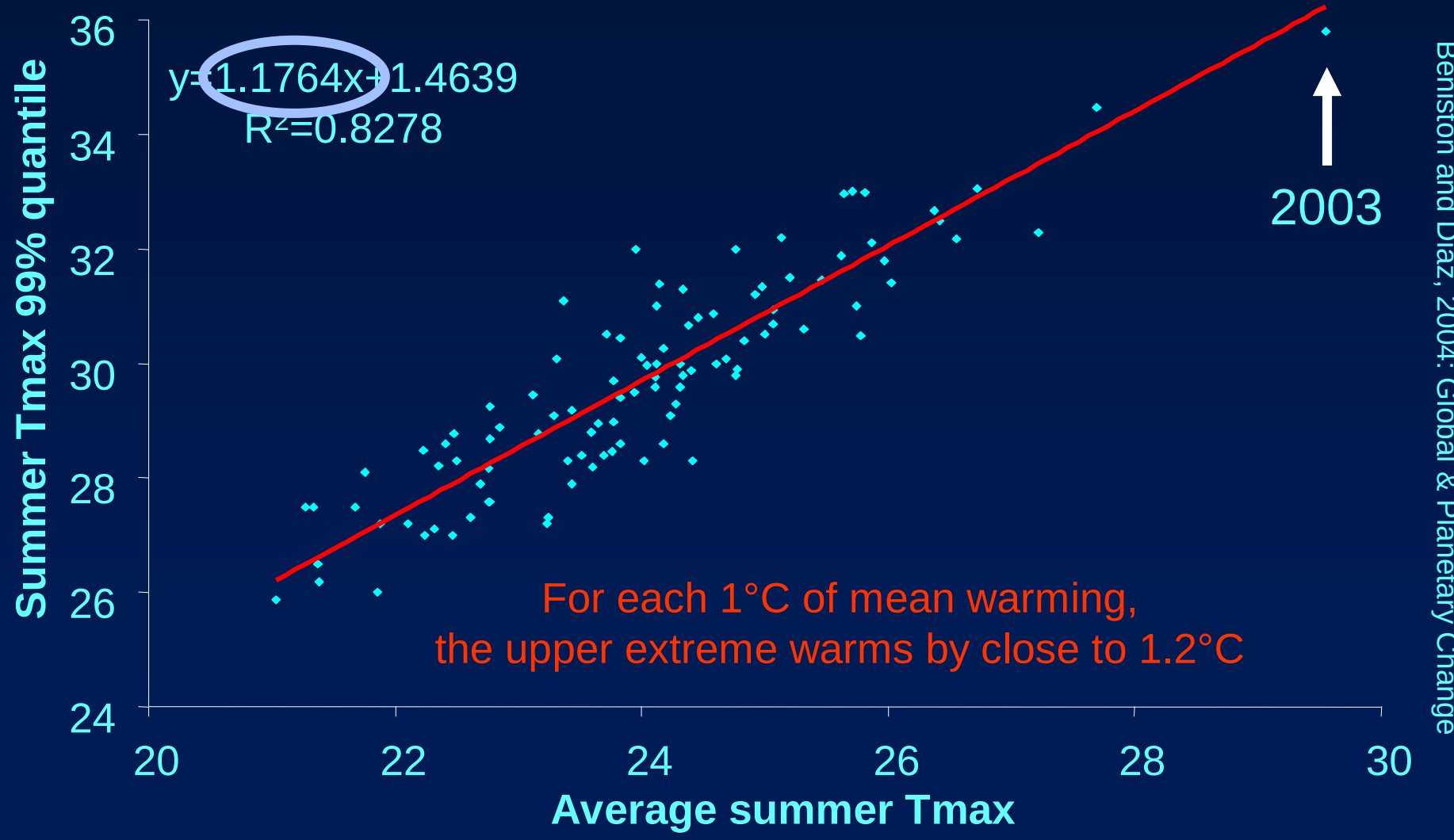
- Close to one of the 2-3 preferential centres of activity of European heat waves
- Orographic amplification of already-heavy precipitation
- Modulation of Alpine weather patterns by the North Atlantic Oscillation (and AO...)
- Unusual Atlantic storm tracks (e.g., 1999 « *Lothar* » storm-of-the-century) + Alpine-scale circulations (Foehn winds) that are frequently very intense

A simple statistical view of extremes

A statistical view of extremes



Average summer Tmax and extreme value of Tmax (20th century) in Basel



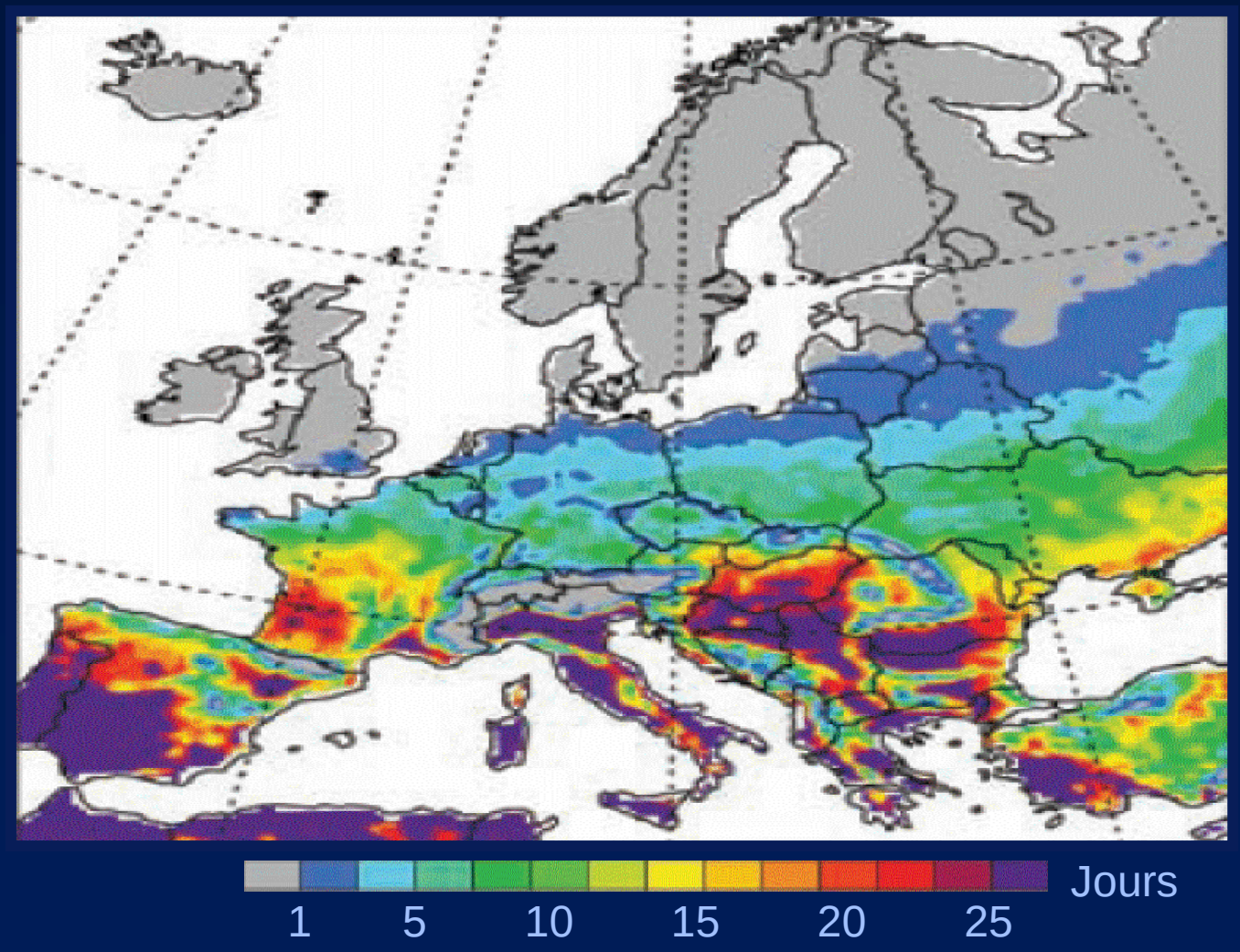
Current and future temperature extremes

Beyond the 40°C threshold in Europe (A2 Scenario)

1961-1990

2021-2050

2071-2100



EU-FP6 « ENSEMBLES » Project

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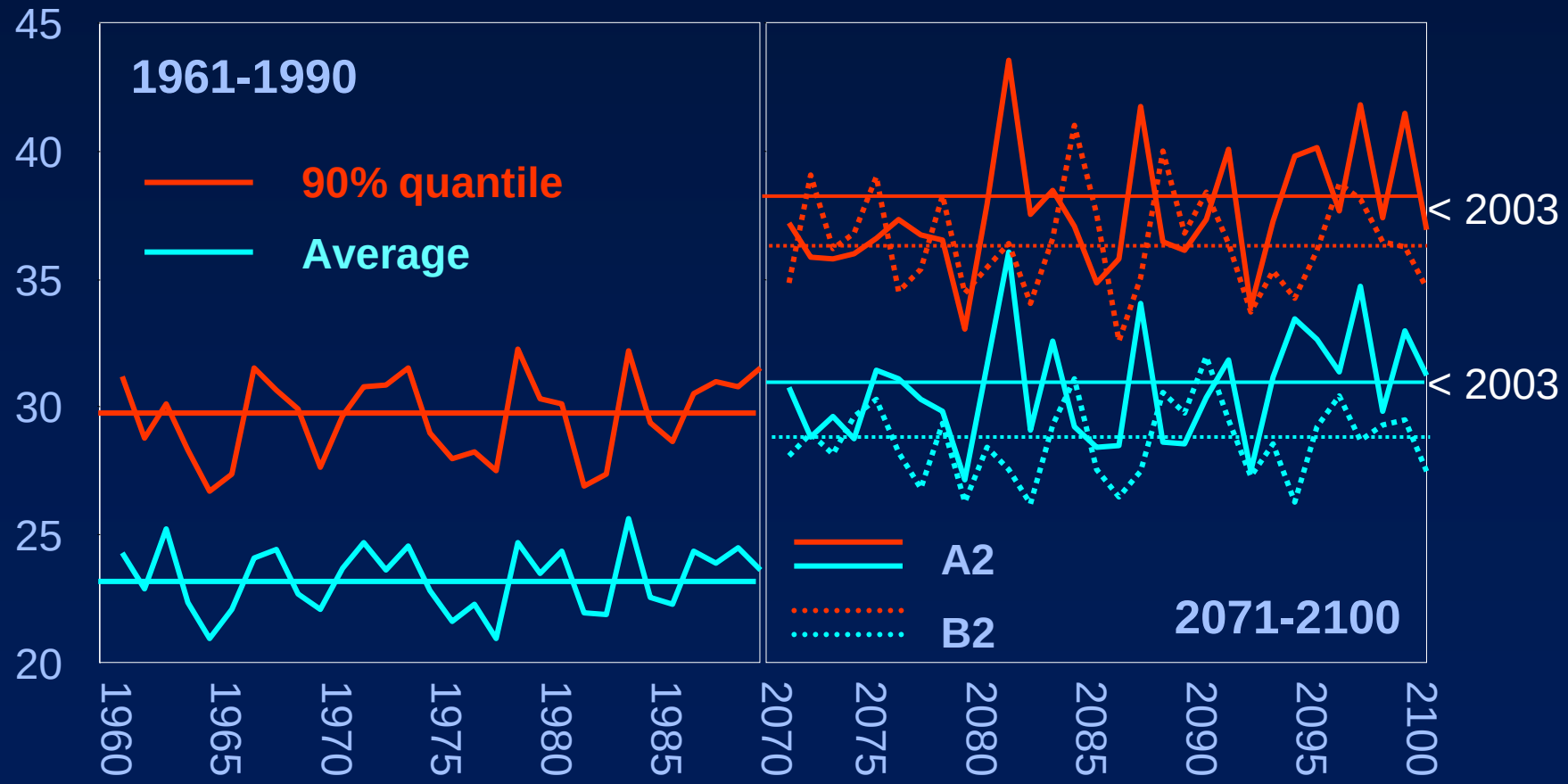
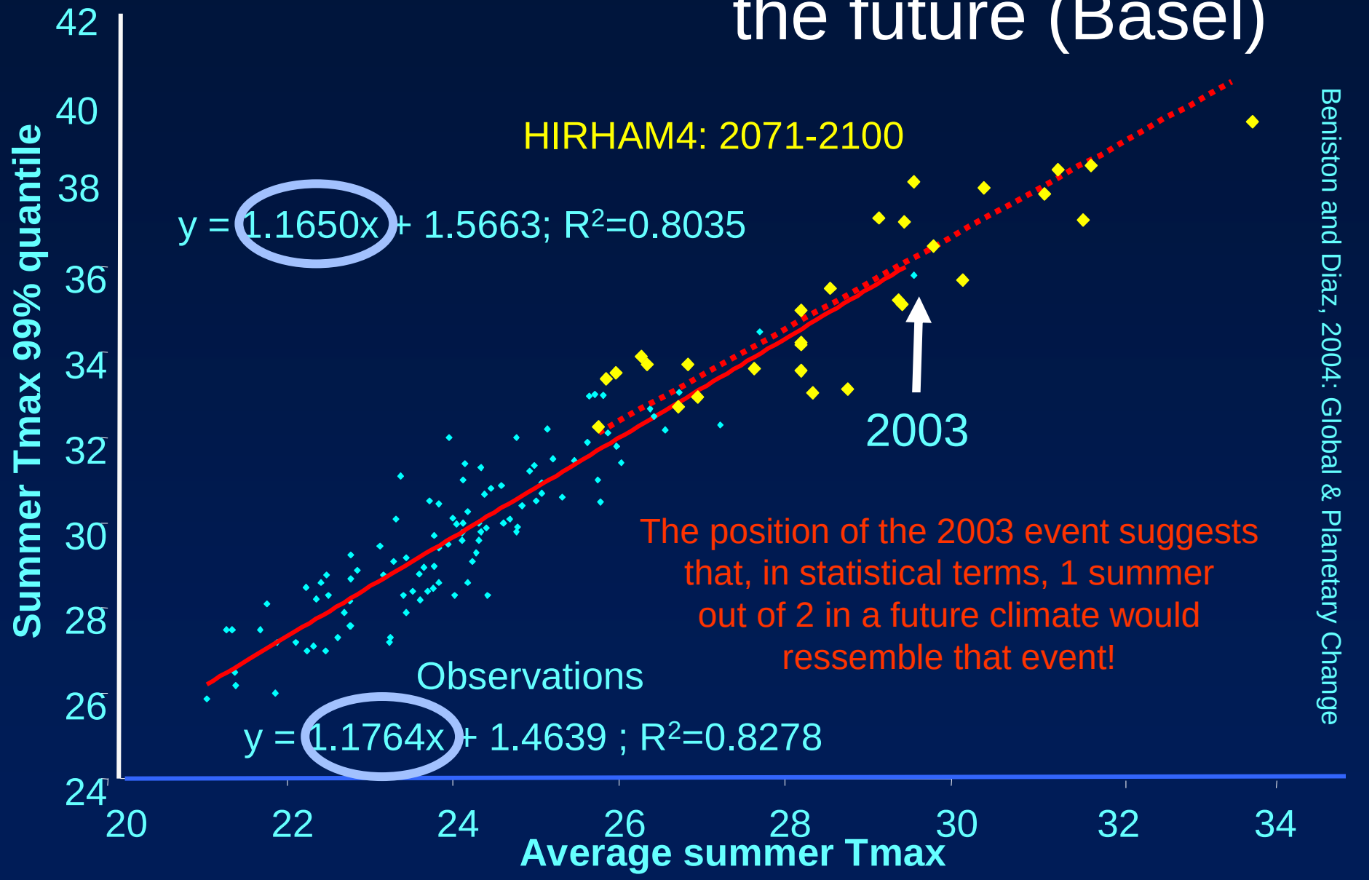
Summer T_{max} mean and 90% quantiles for current and future climates in Basel



Beniston and Diaz, 2004: Global & Planetary Change

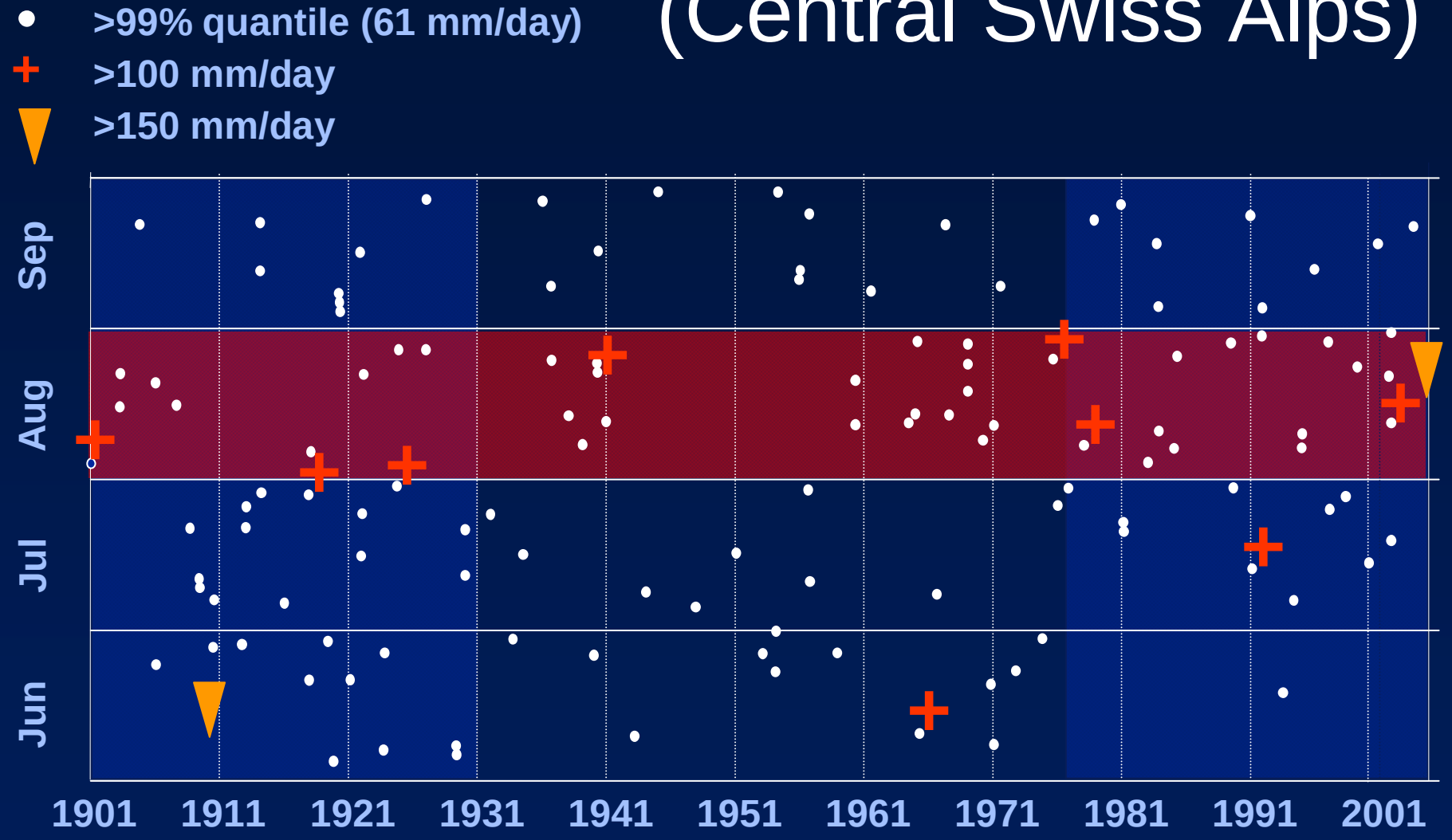
Mean-extreme Tmax relations into the future (Basel)



Beniston and Diaz, 2004: Global & Planetary Change

Current and future precipitation extremes

Extreme summer precipitation (Central Swiss Alps)



Beniston, 2006: Geophysical Research Letters

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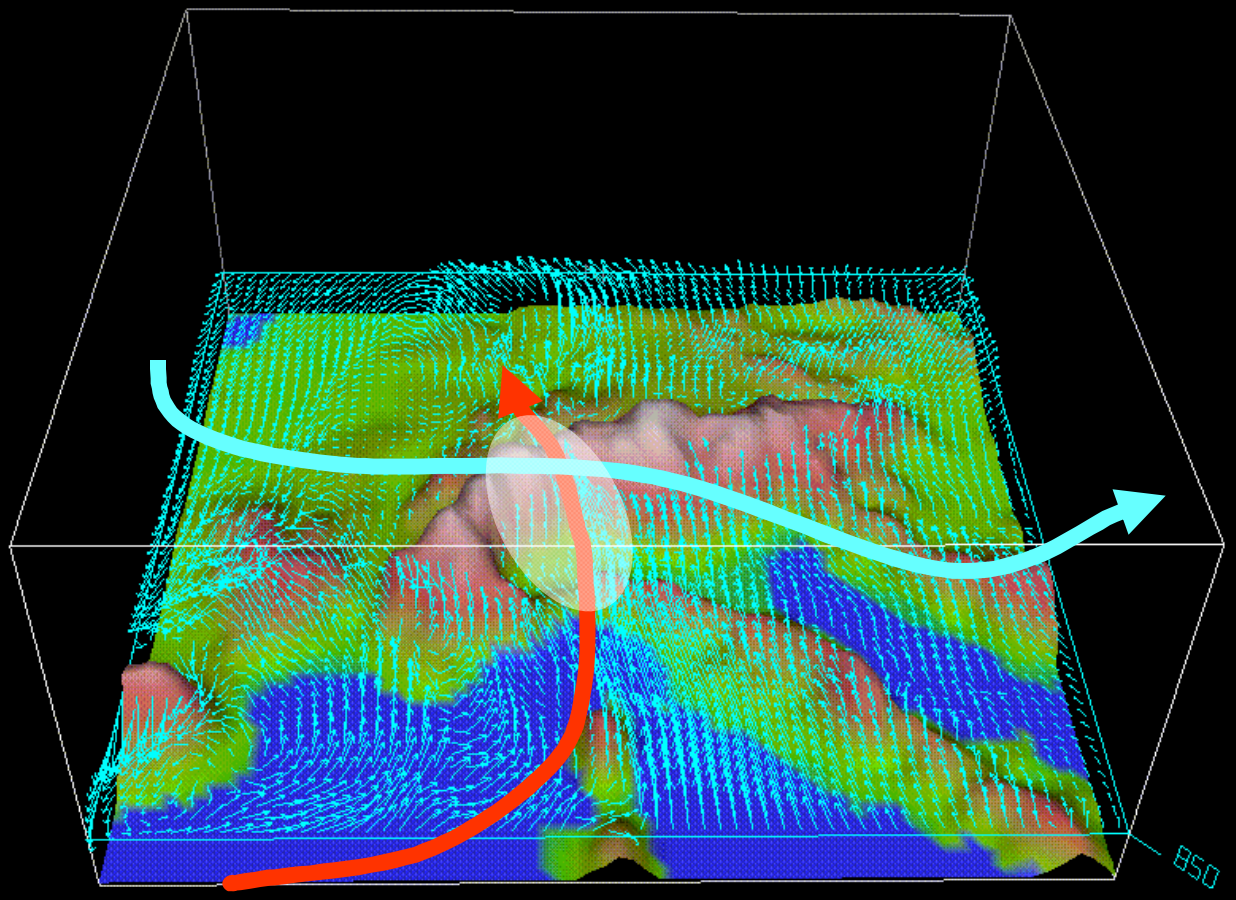
Convergence of moisture-laden air leading to extreme precipitation

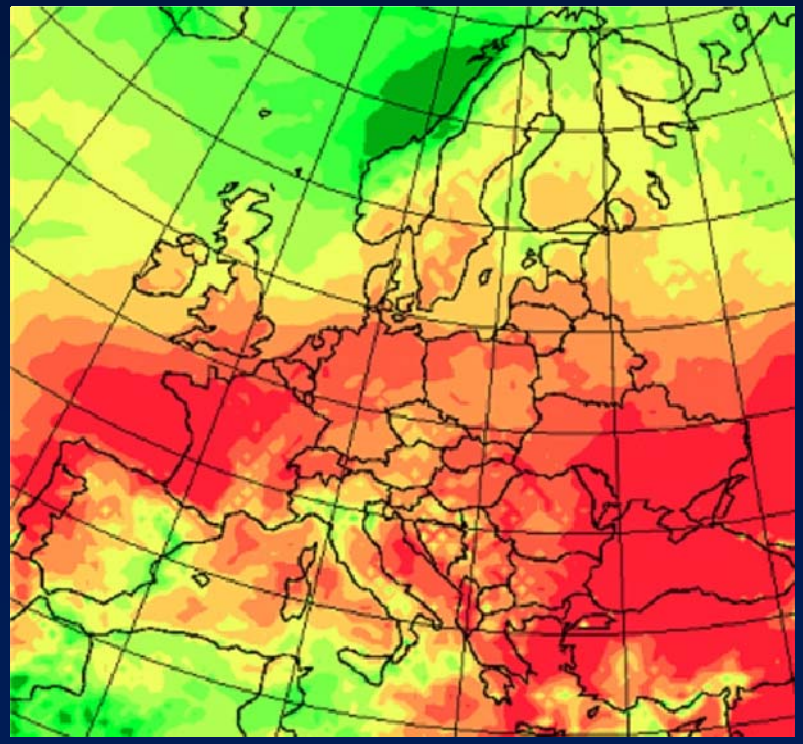


Dual response of precipitation

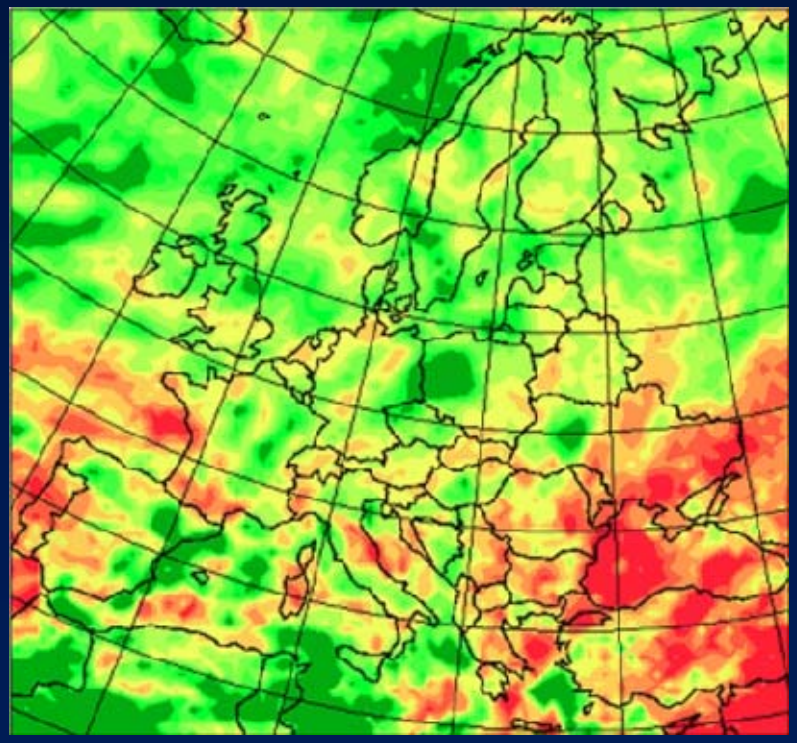
(*Difference between 2071-2100 and 1961-1990*)

(HIRHAM regional climate model)

Seasonal precipitation



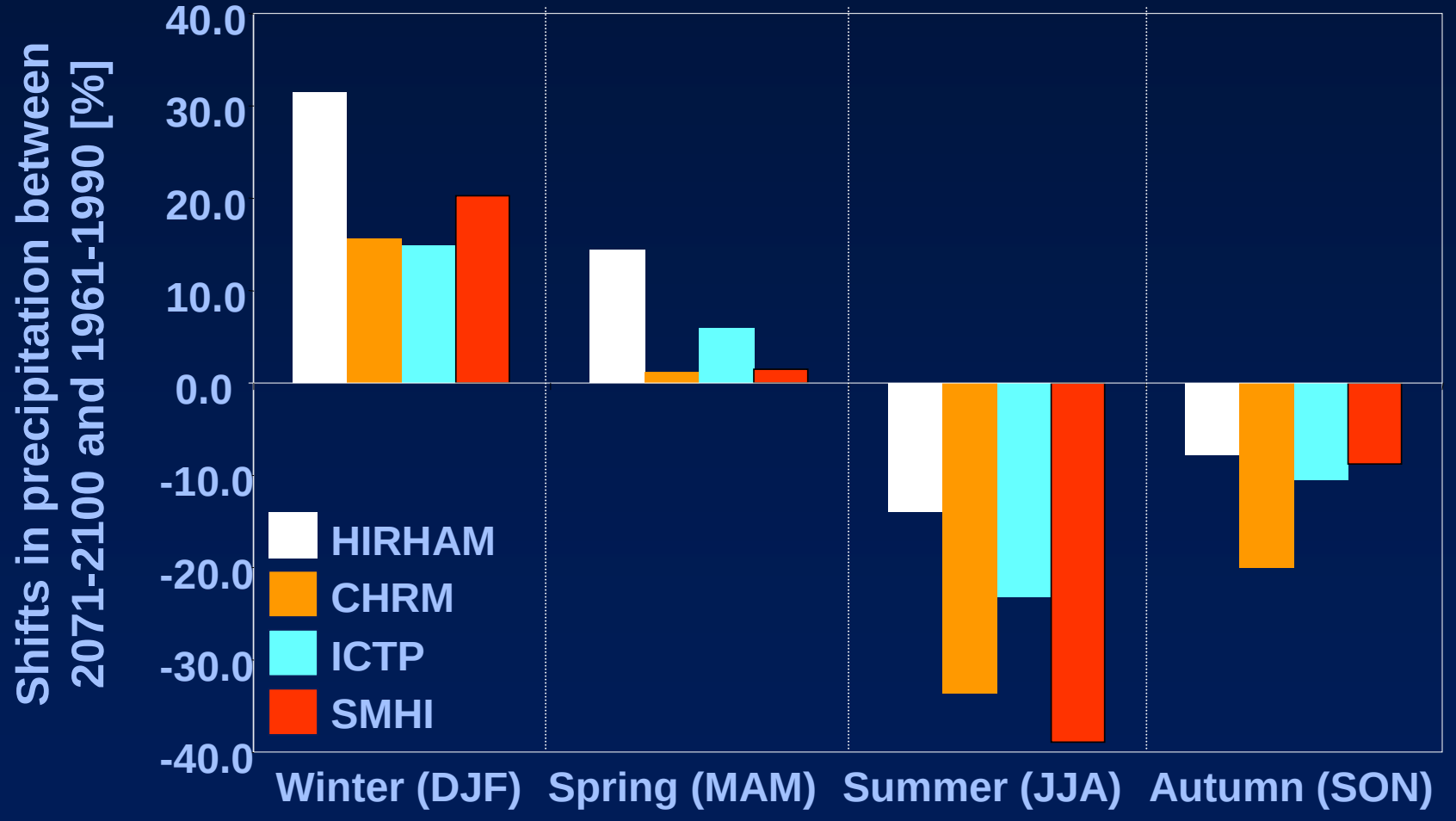
Precipitation > 50 mm / day



Changes in %

Christensen, J. H. and Christensen, O. B., Nature, 2003

Changes in seasonal rainfall in the Alps (A2 Scenario)



Beniston, 2006: Geophysical Research Letters

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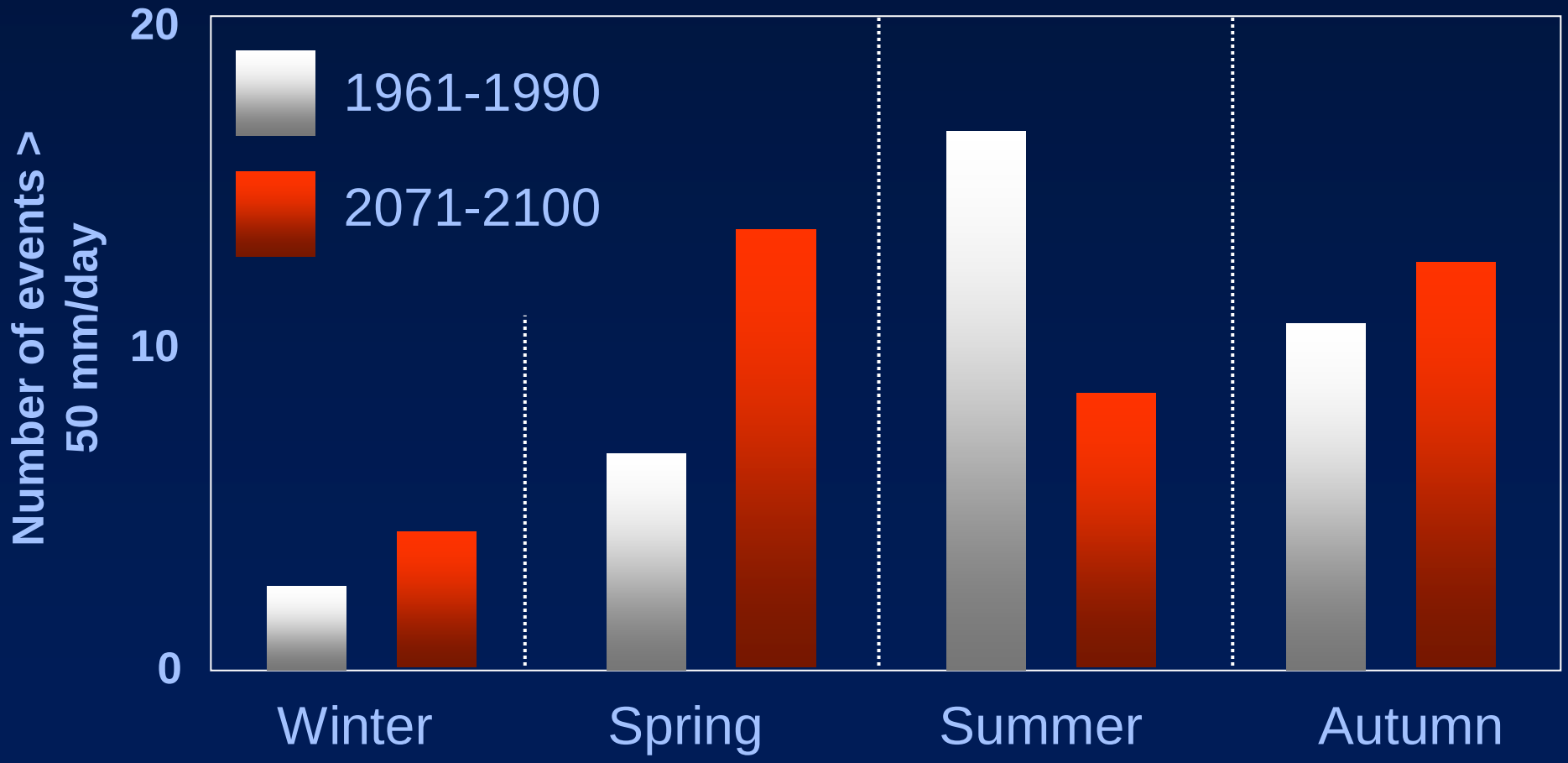
Changes in extreme rainfall in the Alps

(HIRHAM Regional Climate Model)

Beniston, 2006:
Geophysical Research Letters



Implications for floods

Beniston, M., 2006:
Geophysical Research Letters

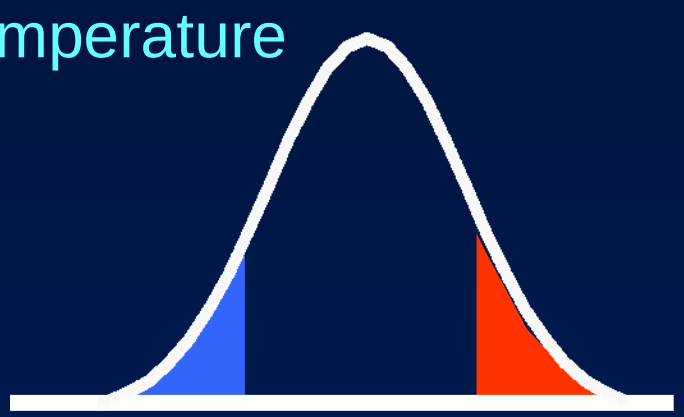
Type of alpine flood events

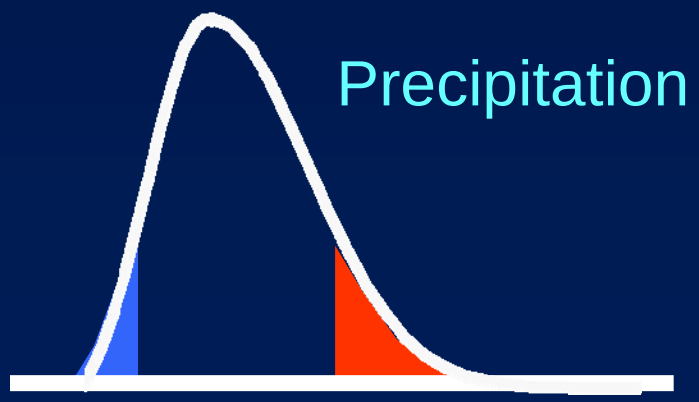
Exploring extremes with joint quantiles

Joint quantile distributions as one objective measure of weather regimes

Characterize weather patterns in a quantitative manner based on combinations of quantiles of temperature and precipitation

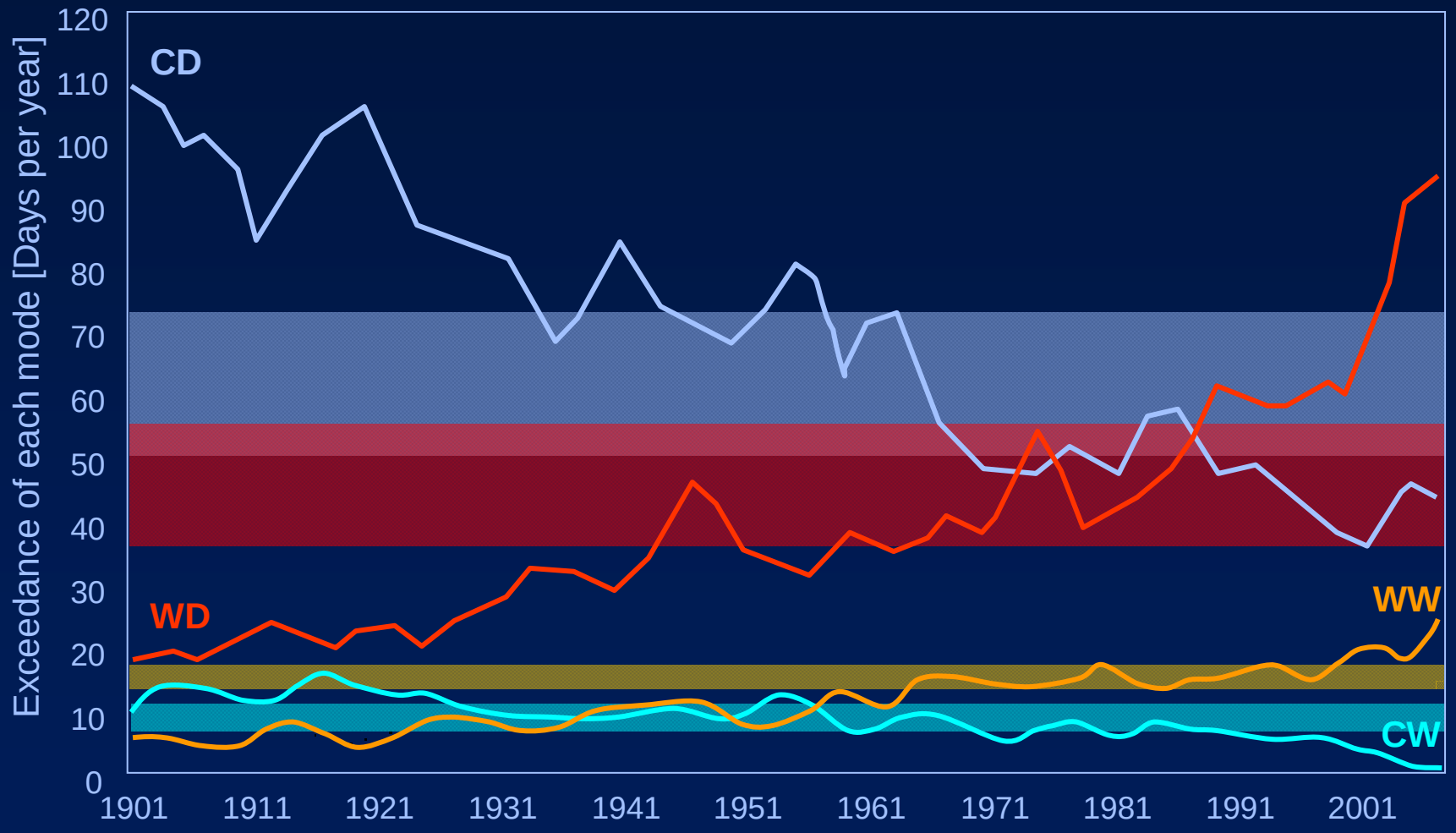
at the 25% and 75% quantile levels





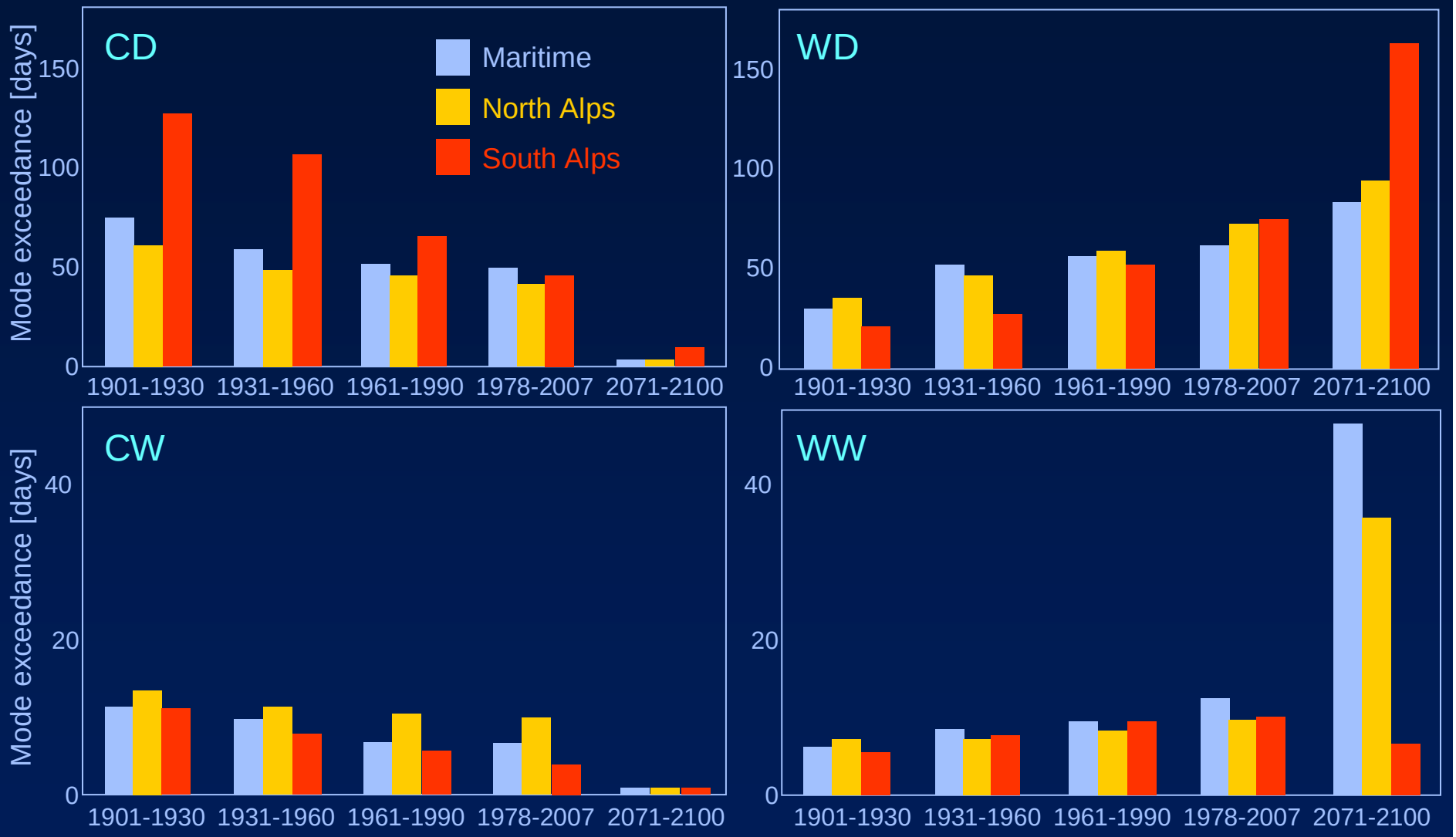
- Cold/dry (CD): T25/p25
  - « Stable winters »
- Cold/wet (CW): T25/p75
  - « Perturbed winters »
- Warm/dry (WD): T75/p25
  - « Stable summers »
- Warm/wet (WW): T75/p75
  - « Perturbed Summers »

Joint extreme temperature/precipitation quantiles: Geneva



Beniston, 2009: Geophysical Research Letters

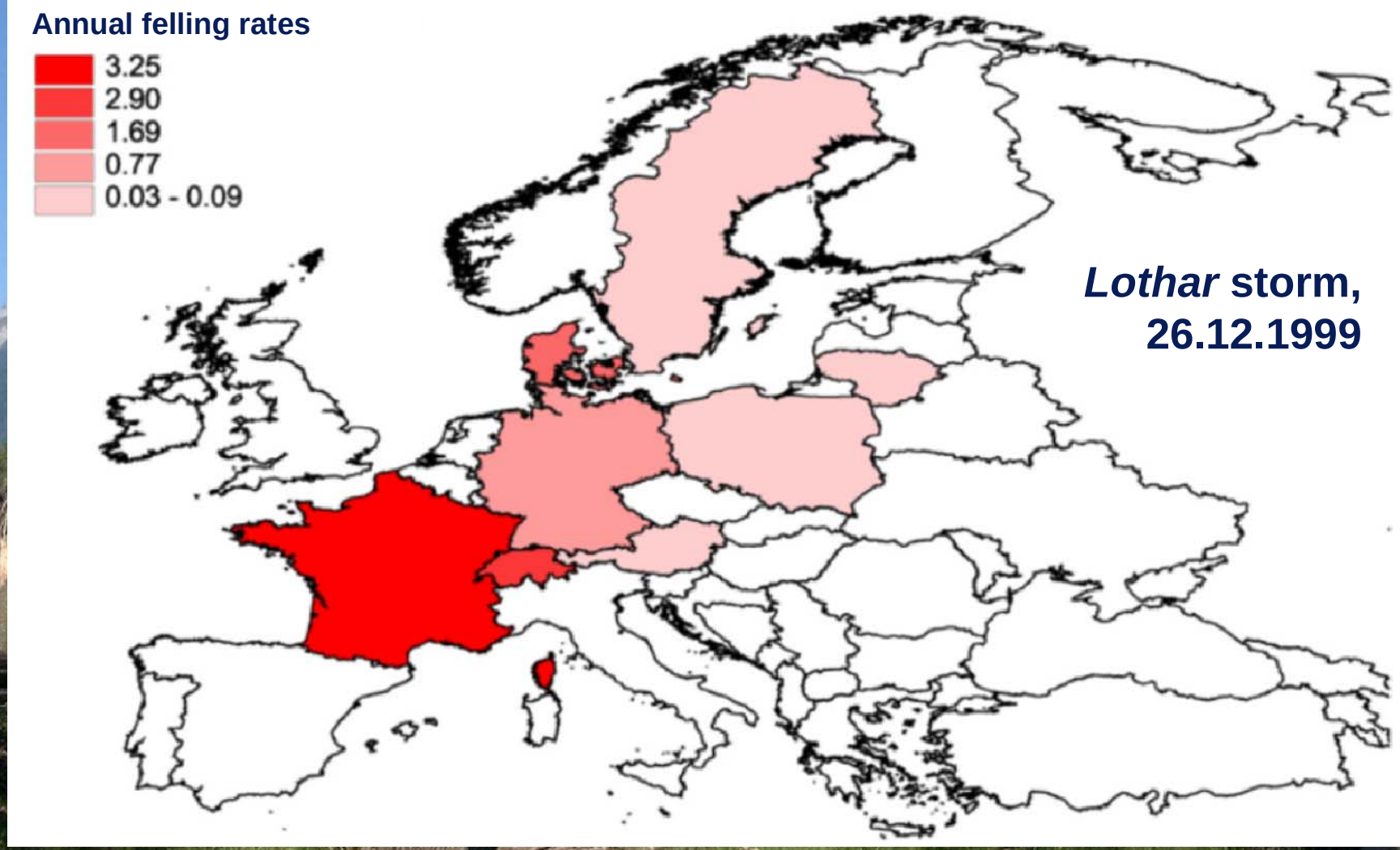
Changes by 2100



Beniston, 2009: Geophysical Research Letters

Winter wind storms

Wind storms

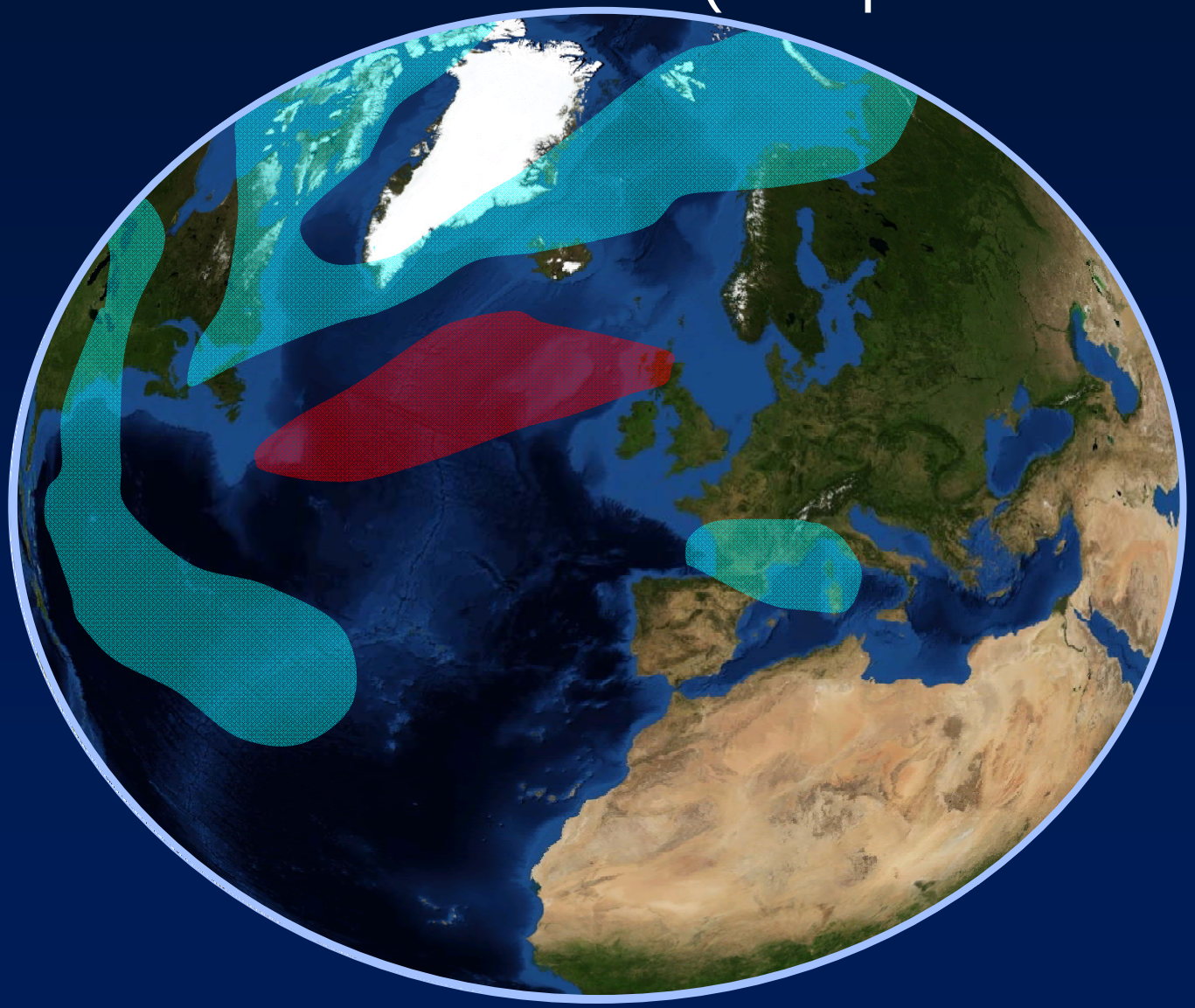


Changes in storminess by 2100
(Europe-Atlantic Sector)

Extreme

-

+



« EU-ENSEMBLES » project www.ensembles-eu.org

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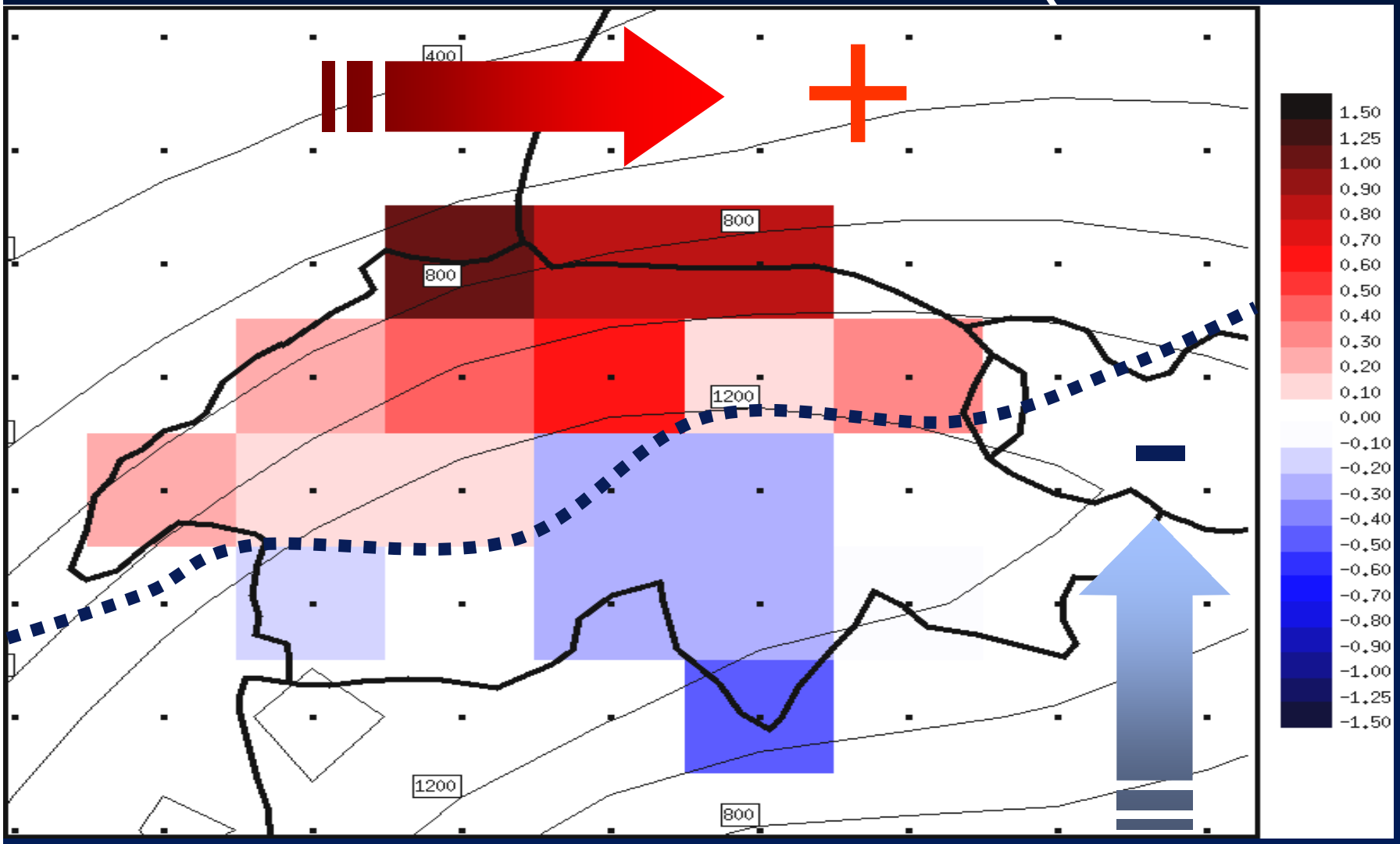
Changes in the distribution of strong winds in Switzerland (2071-2100)



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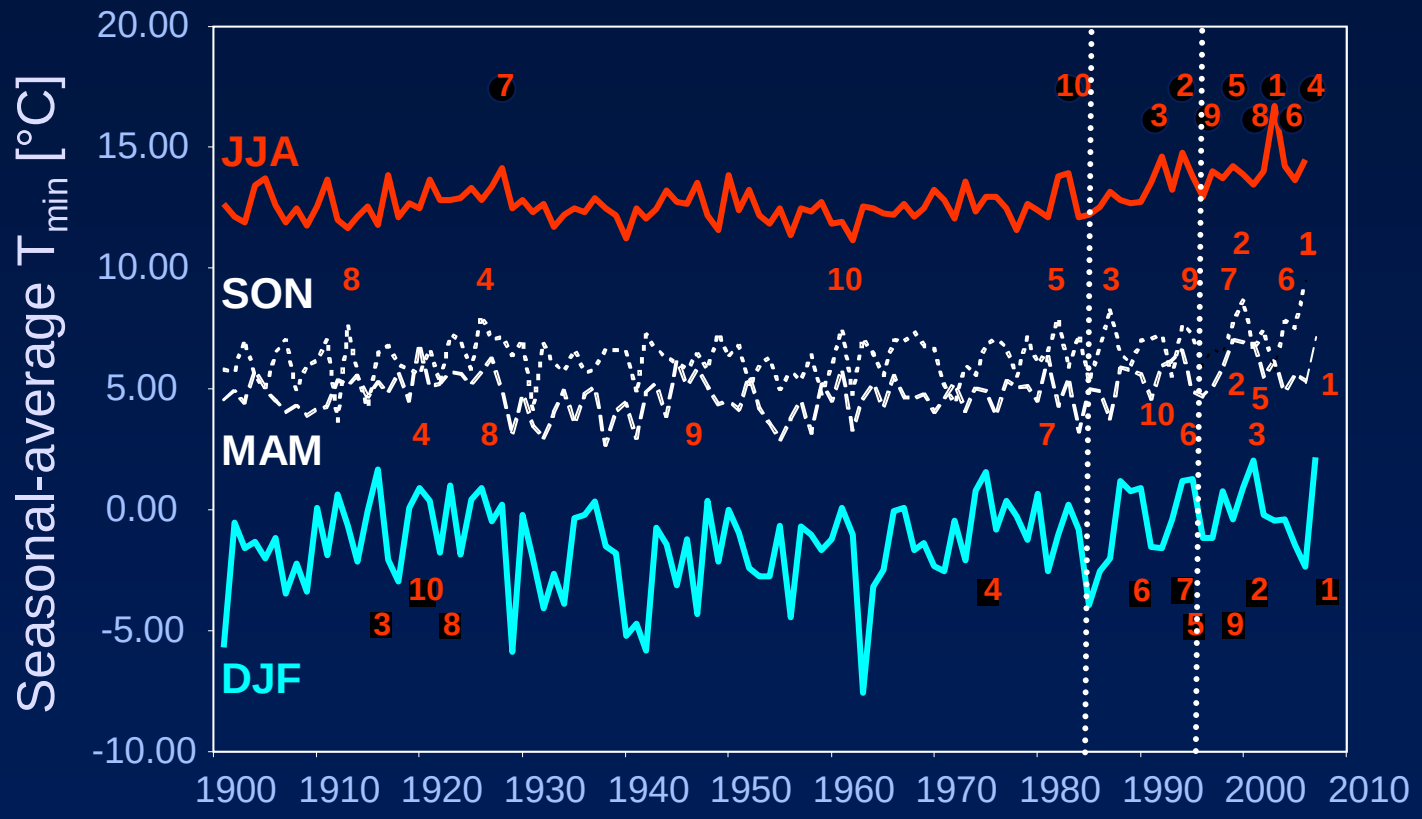
Recent extreme seasons in the Alps:
a shape of things to come?

T_{min}: 10 warmest seasons (Geneva, 1901-2008)



Beniston, 2007: Geophysical Research Letters

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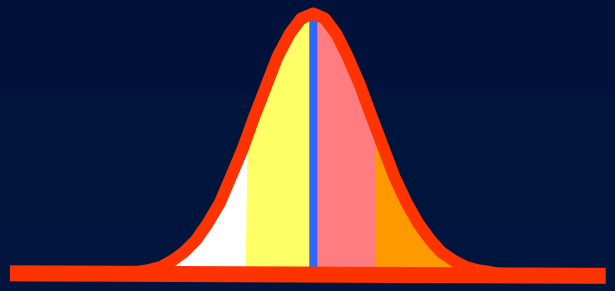
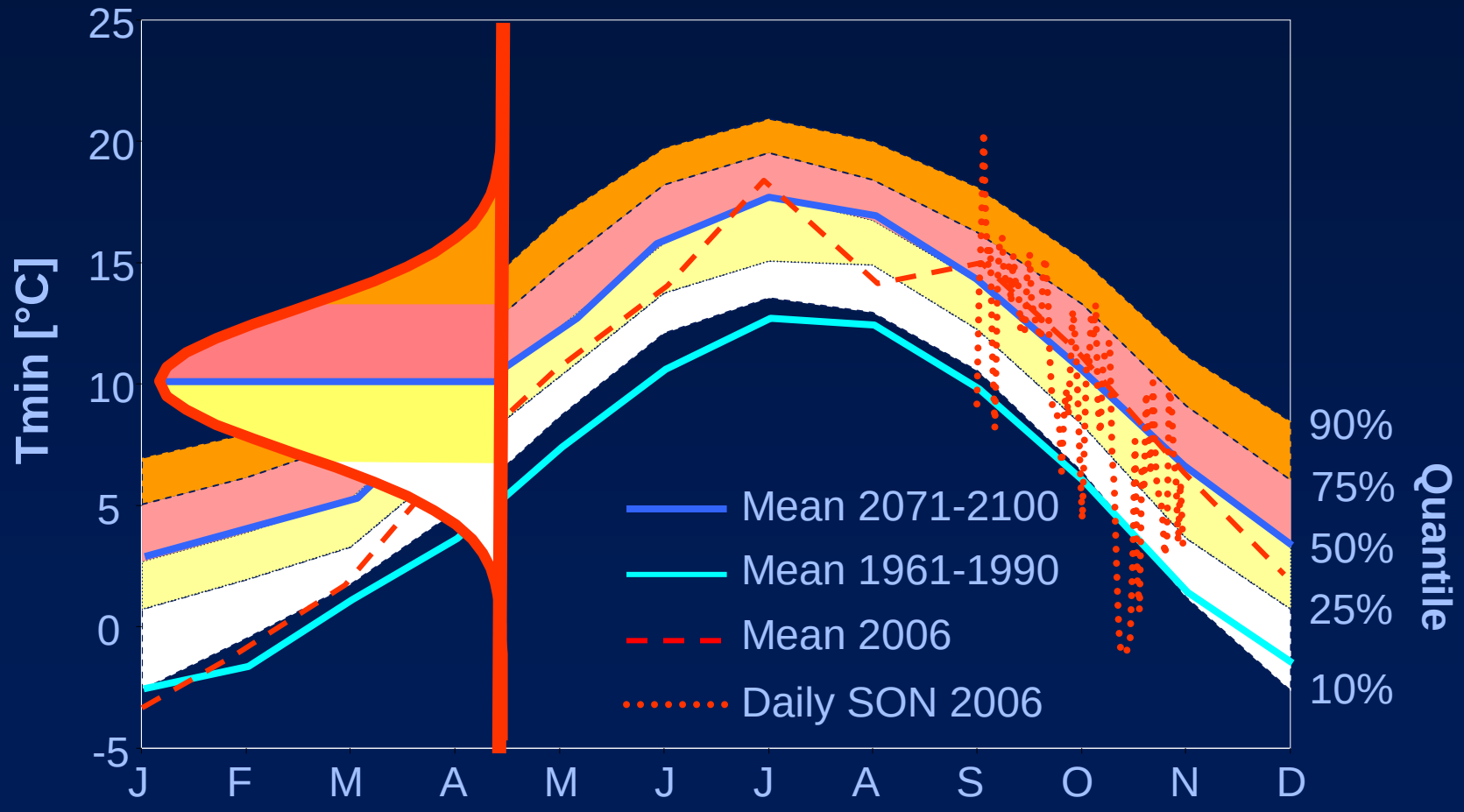
Tmin in Geneva:

1961-1990
2071-2100
Autumn 2006 statistics





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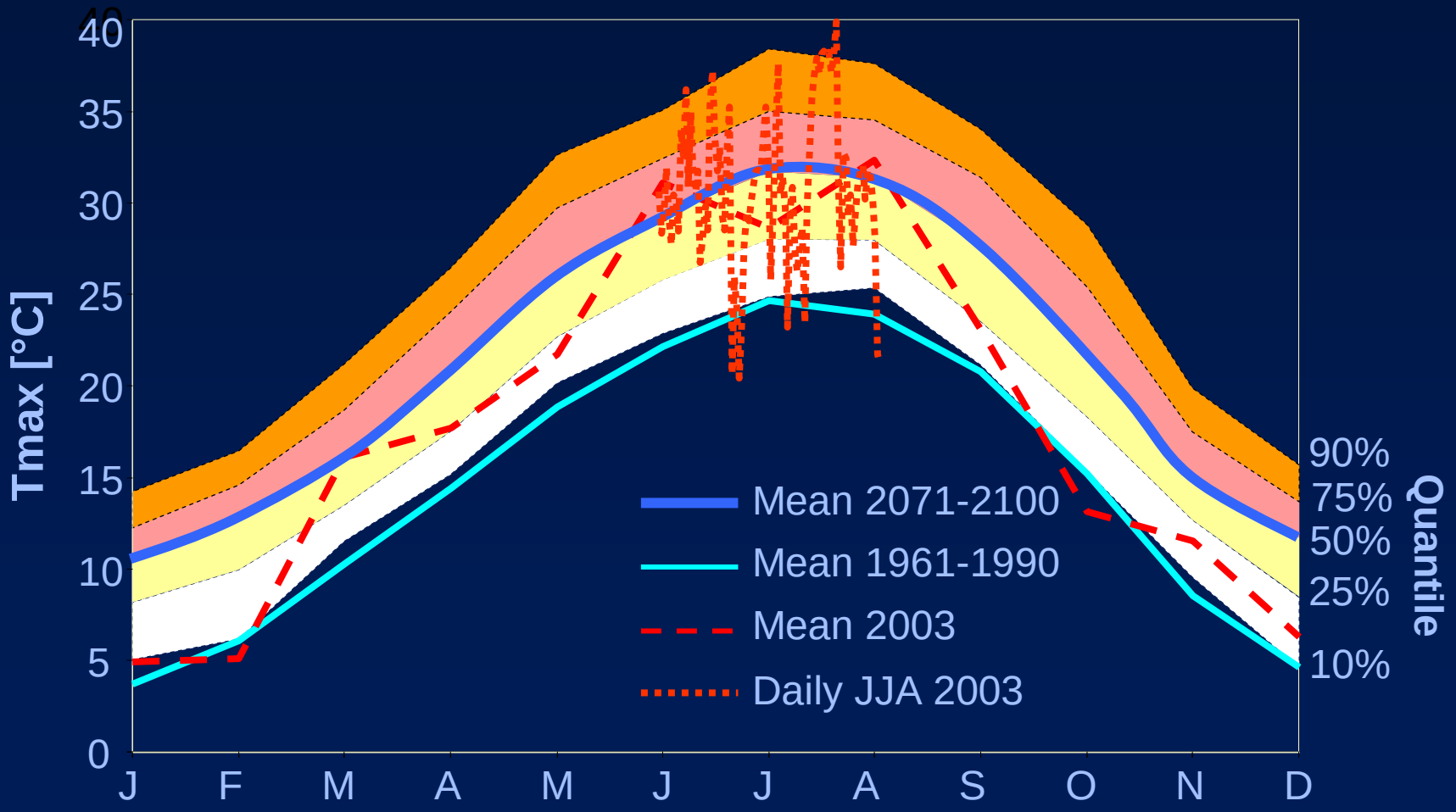
Tmax in Geneva:

1961-1990

2071-2100

Summer 2003 statistics



Beniston, 2007: Geophysical Research Letters

How close do these recent seasons come to those projected by 2100?

6 out of 10 winters (DJF) will be like the 2006/2007 season

7 out of 10 springs (MAM) will be like the 2007 season

5 out of 10 summers (JJA) will be like the 2003 season

6 out of 10 autumns (SON) will be like the 2006 season

For both T_{min} and T_{max} statistics

Such statistics can help in advance planning for risk reduction

- The recent record seasons can be used as «proxies» to conditions that will likely become the norm by 2100
- The impacts of extreme climatic conditions on environmental and socio-economic systems can be assessed on the basis of these recent seasons
- Advance planning based on likely future impacts similar to those experienced in a recent past can help minimize the impacts associated with future extreme seasons

Current and future climate extremes in the Alps

Thank you for your attention

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