SEASONAL EUROPEAN CLIMATE RESPONSE TO MAJOR TROPICAL ERUPTIONS

Erich Fischer,
Jürg Luterbacher,
Heinz Wanner

University of Bern
Switzerland

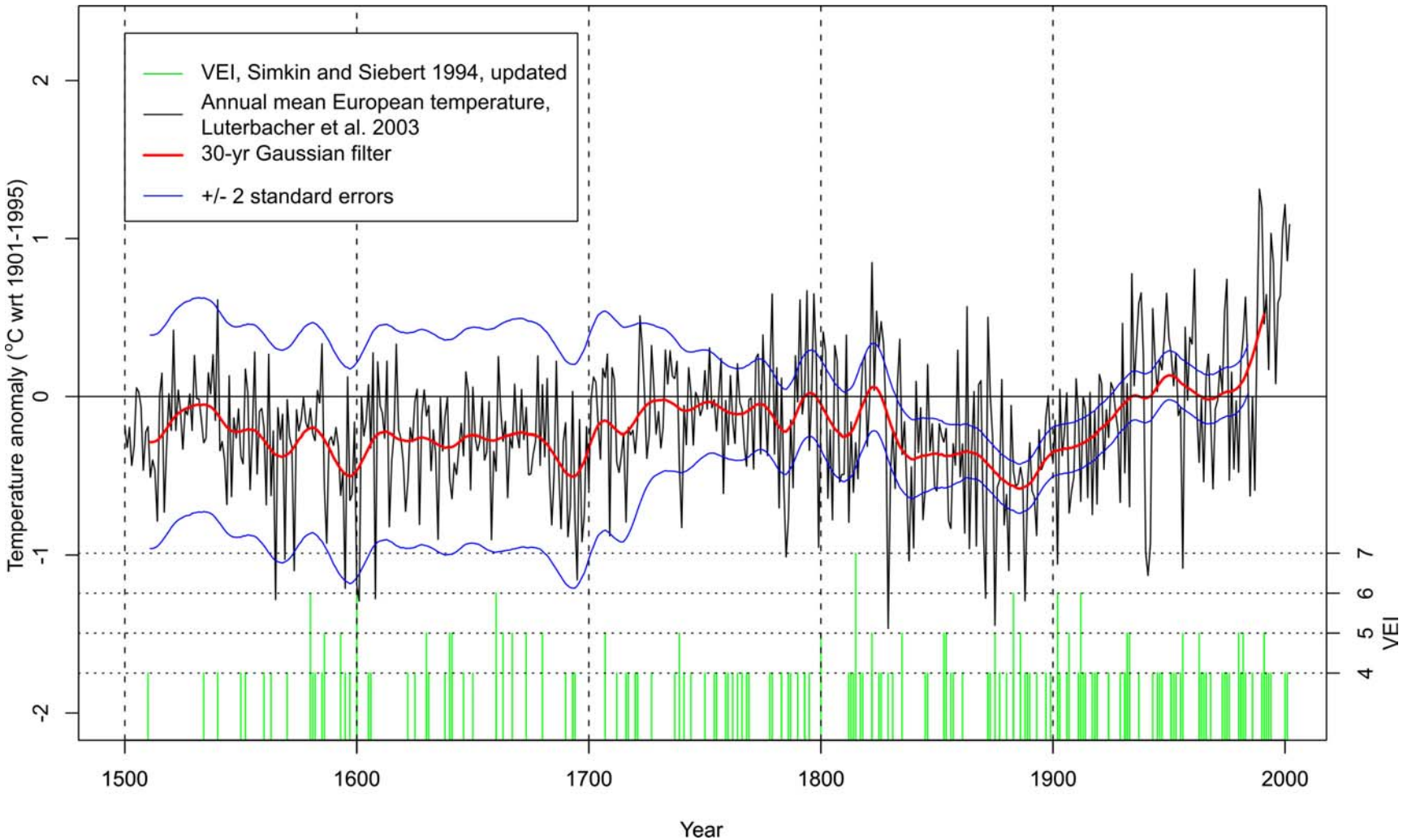
Outline

- Data and Methods
- Temperature response
- Winter atmospheric circulation changes
- Precipitation response
- Conclusions

Data

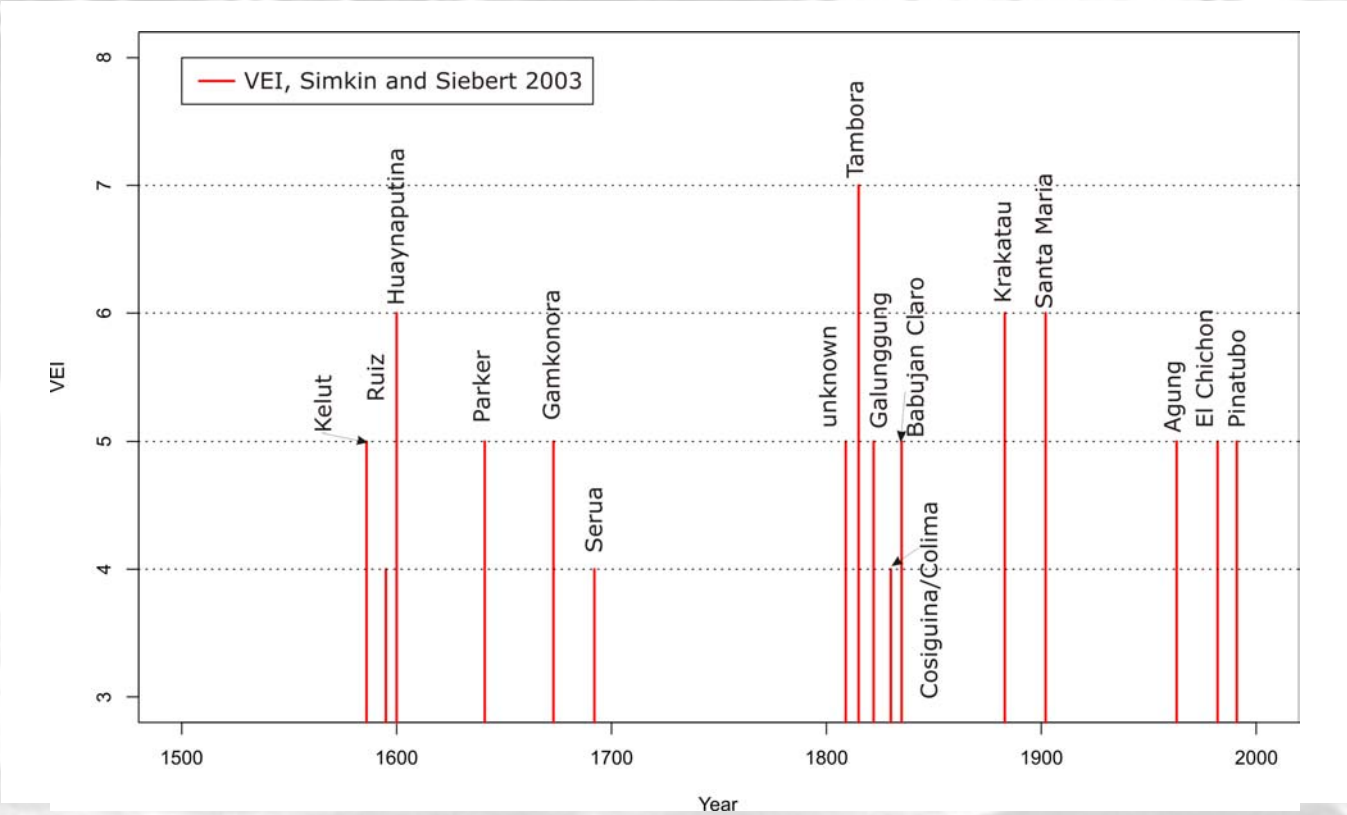
- Temperature and precipitation data
  - Luterbacher et al. (2004): Reconstructed gridded (0.5°x0.5°) data set with monthly (seasonal before 1659) resolution over European land regions.
- Sea Level Pressure (SLP) und GPH_{500} Data
  - Luterbacher et al. (2002): Reconstructed gridded SLP (5°x5°) and GPH_{500} (2.5°x2.5°) over the North Atlantic/European region.

Data


VEI, Simkin and Siebert 1994, updated
Annual mean European temperature, Luterbacher et al. 2003
30-yr Gaussian filter
+/- 2 standard errors
Temperature anomaly (°C wrt 1901-1995)
2
1
0
-1
-2
1500
1600
1700
1800
1900
2000
Year
7
6
5
4
VEI

Data

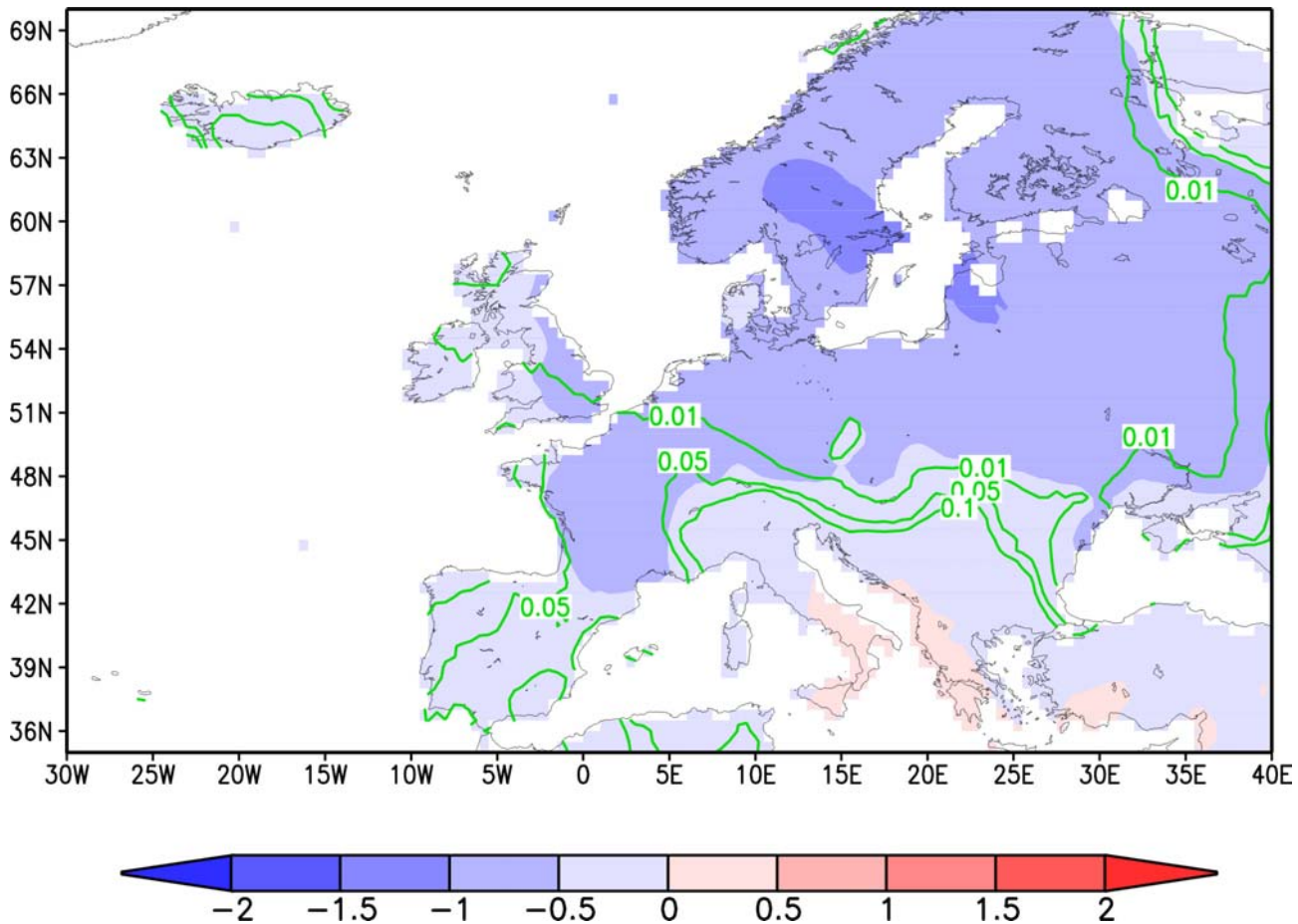
- Dating of volcanic eruptions:
  - Ammann (2003), Robock and Free (1996), Simkin and Siebert (1994, updated)



Methods

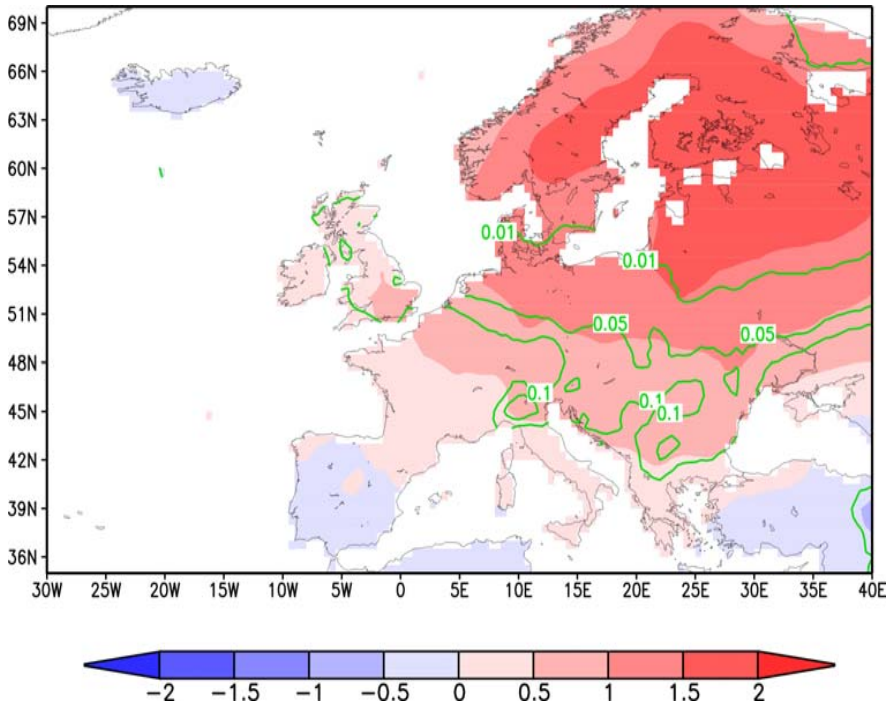
- Calculating seasonal anomalies following major tropical eruptions with respect to the five pre-eruption years.
- Superposed epoch analysis by compositing seasonal anomalies following 16 major tropical eruptions.
- Significance testing using Mann-Whitney test and Monte Carlo resampling procedure.

Summer temperature

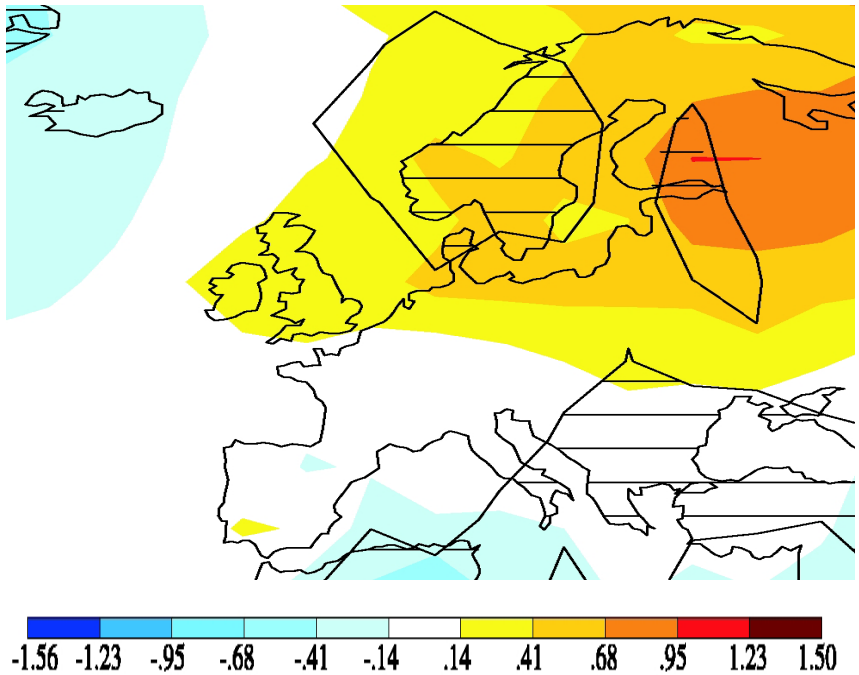


Temperature anomaly composite of second summer (JJA).

Winter temperature

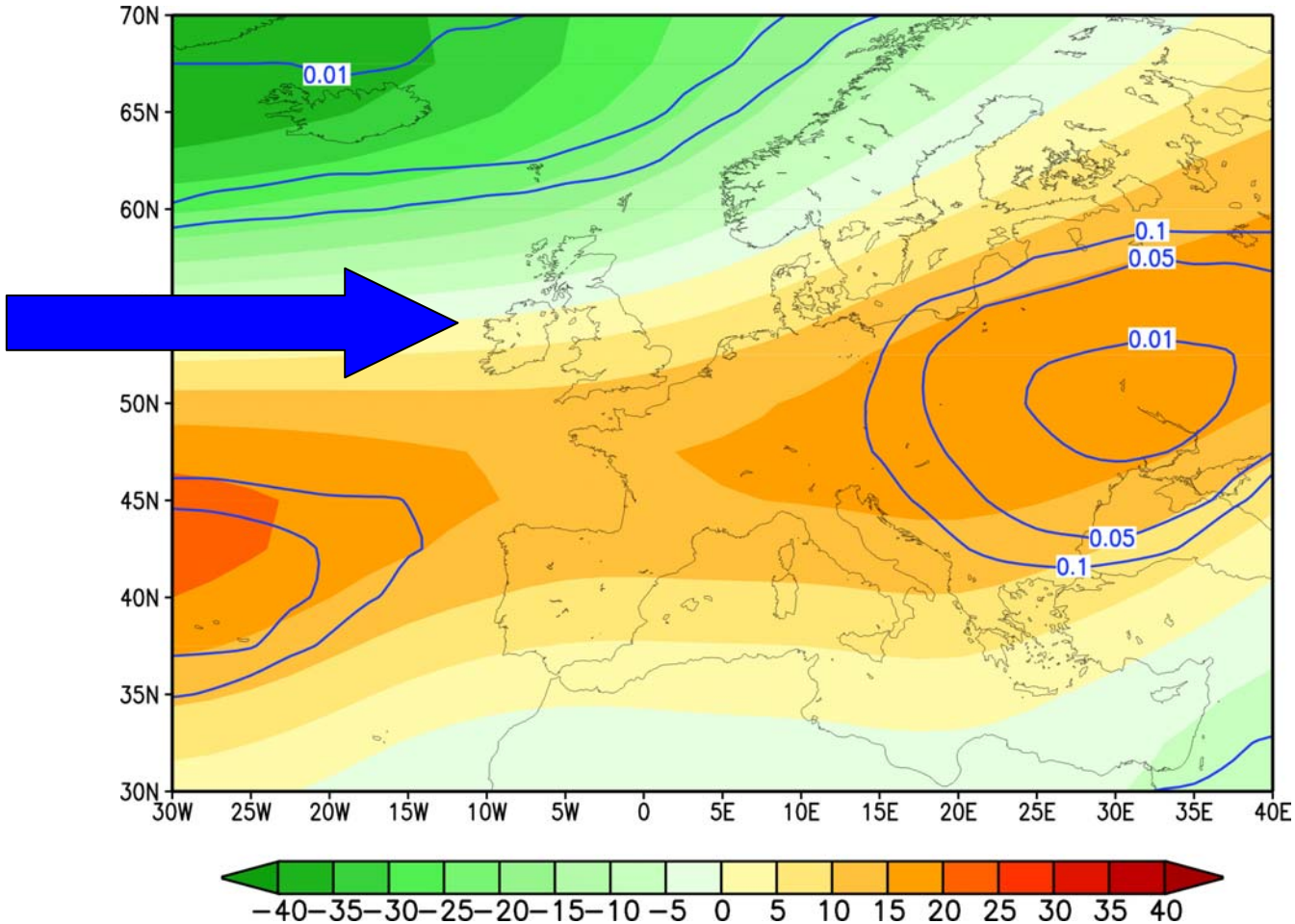


Temperature anomaly composite of second winter (DJF) (this study).



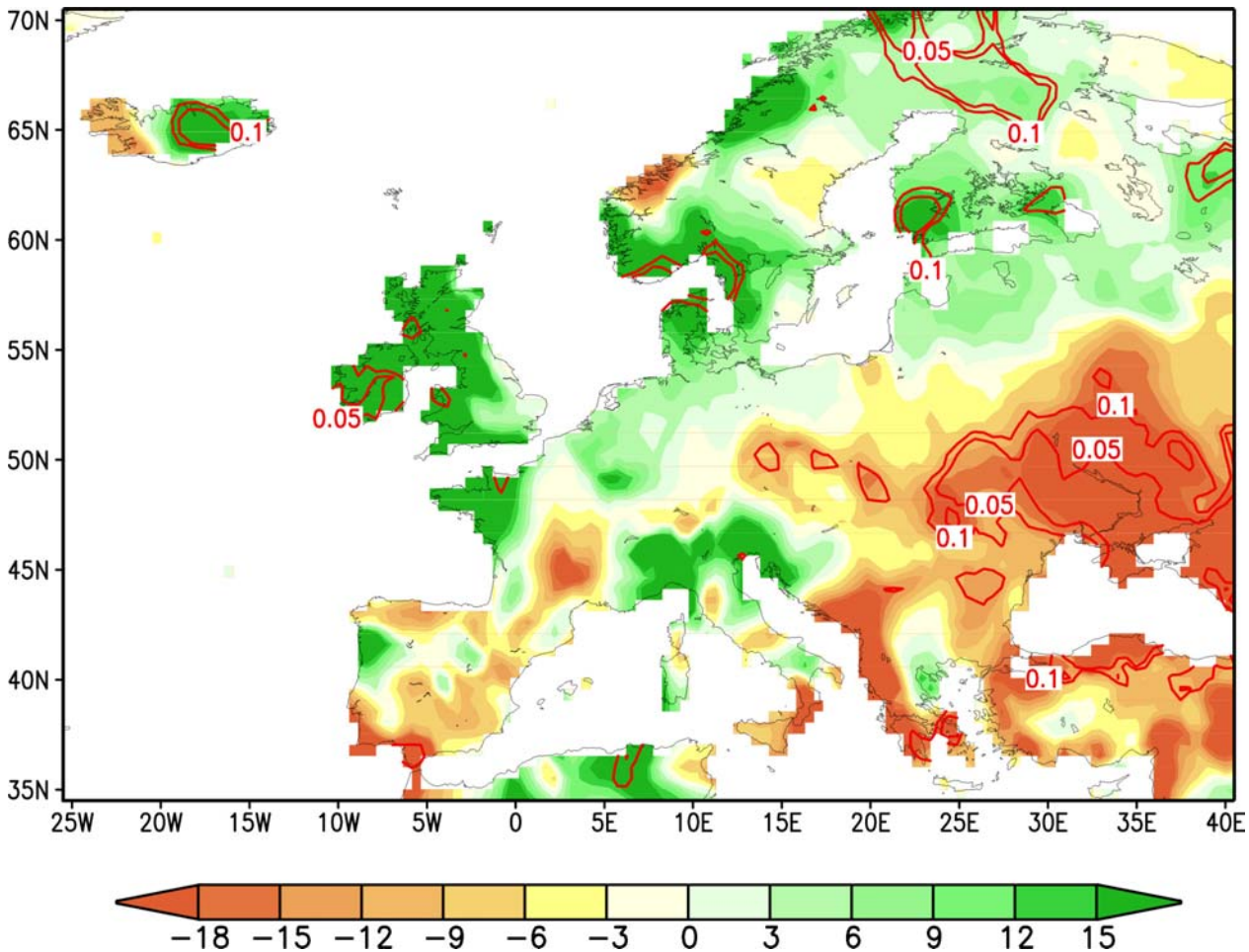
Mean winter response following the eruptions of Pinatubo, Santa Maria, and Krakatau (mean forcing -3.68 W/m^2) in modelE GCM (Shindell et al. 2004).

GPH_{500} Winter



Geopotential height anomaly on the 500hPa level of second post-eruption winter.

Winter precipitation



Precipitation anomaly composite of second post-eruption winter.

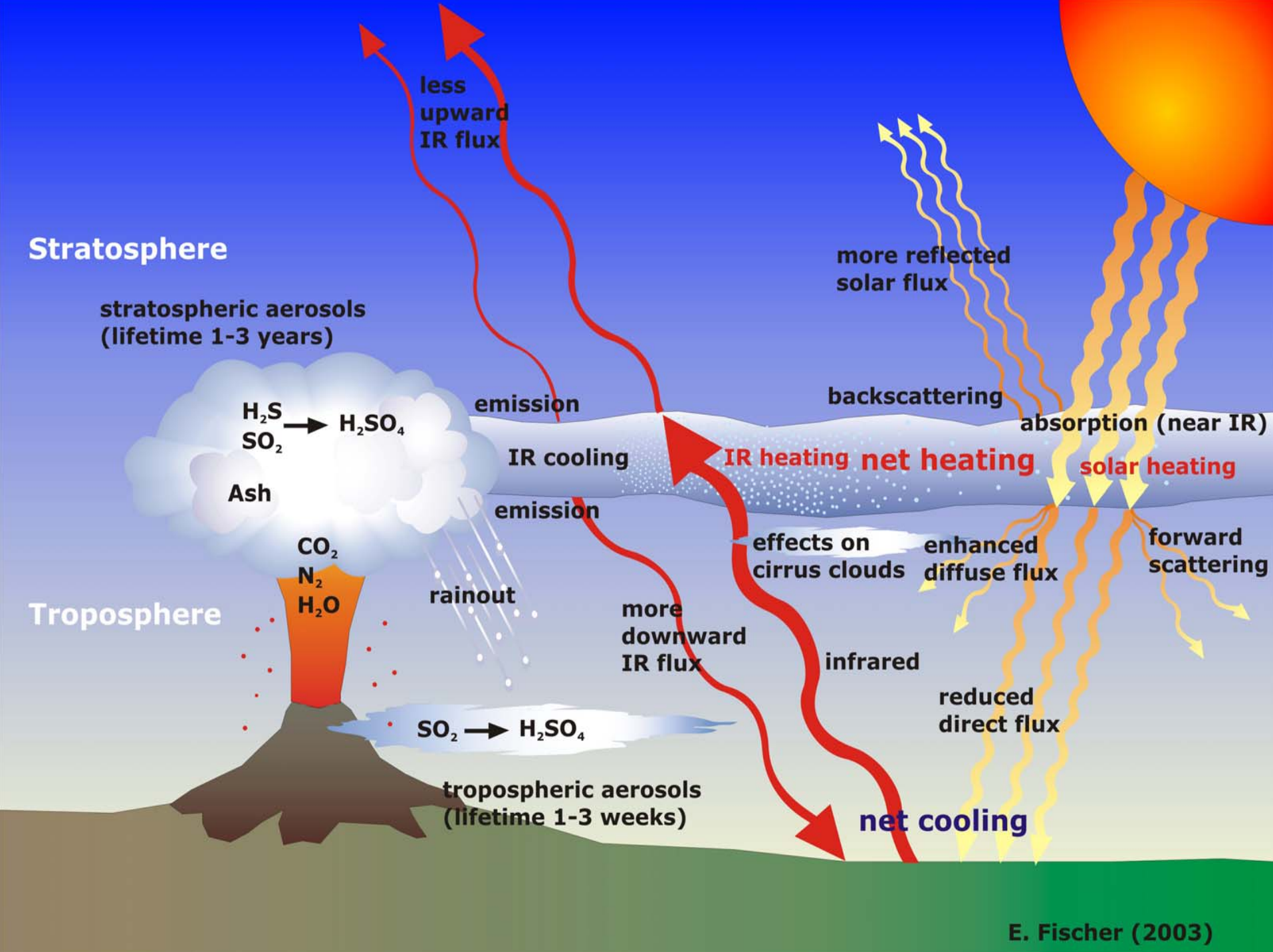
Conclusions

- Apart from direct radiative effects there is a substantial indirect dynamic response to eruptions causing atmospheric circulation changes.
- The changes are associated by significant winter warming over Northern European land regions.
- Winter precipitation tends to be enhanced over Northern Europe and reduced over the Southeastern Europe.
- The analysis of climate reconstructions offers a large potential to identify the climate response to volcanic eruptions and provides a key test for a climate model's response to forcing at continental scale.

Contact:
fischer@giub.unibe.ch
www.giub.unibe.ch/~fischer

Thank you

Erich Fischer,
Jürg Luterbacher,
Heinz Wanner


less
upward
IR flux
Stratosphere
more reflected
solar flux
stratospheric aerosols
(lifetime 1-3 years)
H_2S
SO_2
H_2SO_4
emission
backscattering
absorption (near IR)
IR cooling
IR heating
net heating
solar heating
Ash
emission
CO_2
N_2
H_2O
effects on
cirrus clouds
enhanced
diffuse flux
forward
scattering
rainout
Troposphere
more
downward
IR flux
infrared
reduced
direct flux
SO_2
H_2SO_4
tropospheric aerosols
(lifetime 1-3 weeks)
net cooling
E. Fischer (2003)

Winter NAO Index