Climate and Energy Systems

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CZ.AT Summer School

10.2.2010

The importance of climate (change) in energy systems...

- There is no doubt that climate change is currently the key driver in Energy Research
  - Mitigation
  - Impacts & Adaptation

  - E.g. Programme for this year's International Energy Workshop in Venice:

Overview of Parallel Sessions

WEDNESDAY, 17 JUNE 2009

ROOM	PARALLEL SESSION 1 11.30 - 13.00	PARALLEL SESSION 2 14.30 - 16.30	PARALLEL SESSION 3 17.00 - 18.30
Salone Arazzi	Climate Policy 1	Electricity Systems	Climate Policy 2
Sala Cipressi	R&D and Technology Diffusion	Land Use and Spatial Analysis	Renewable Energy 1
Sala Barbantini	Energy Demand 1	Regional Climate Policies 1	Energy Markets and Prices 1
Sala Consiglio	Uncertainty	International Negotiations	Sustainable Development 1
Sala Soffitto	Policy Instruments 1	Innovation	Sectoral Analysis

THURSDAY, 18 JUNE 2009

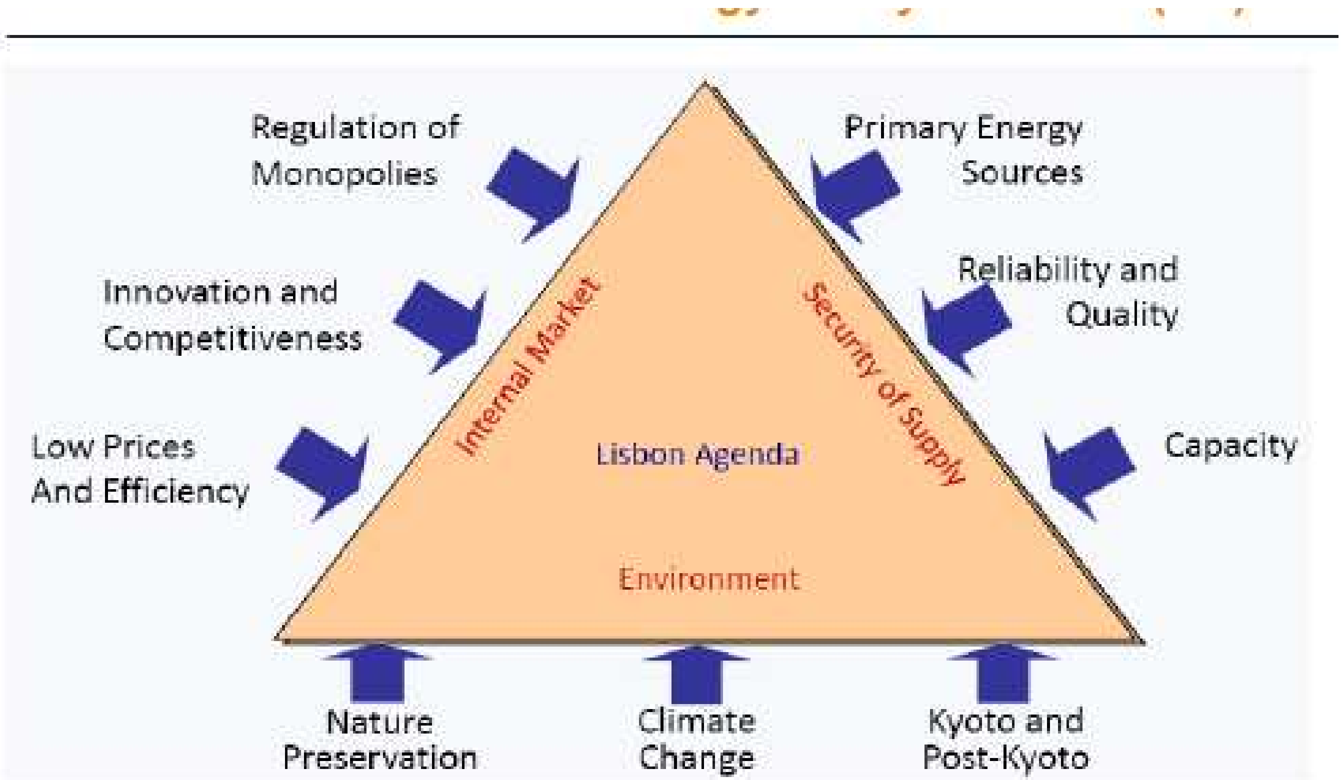
ROOM	PARALLEL SESSION 4 11.30 - 13.00	PARALLEL SESSION 5 14.30 - 16.30	PARALLEL SESSION 6 17.00 - 18.30
Salone Arazzi	Climate Policy 3	PLANETS Project Special Session	Climate Policy 4
Sala Cipressi	Adaptation	Sustainable Energy	Renewable Energy 2
Sala Barbantini	Energy Demand 2	Regional Climate Policies 2	Energy Markets and Prices 2
Sala Consiglio	European Climate Policy 1	Empirical Studies	Sustainable Development 2
Sala Soffitto	Policy Instruments 2	Innovation and Technology Transfer	Energy Scenarios

FRIDAY, 19 JUNE 2009

ROOM	PARALLEL SESSION 7 11.30 - 13.00	PARALLEL SESSION 8 14.30 - 16.30	PARALLEL SESSION 9 17.00 - 18.30
Salone Arazzi	Climate Policy 5	Regional Analysis of the Power Sector	
Sala Cipressi	Transport	Energy Efficiency	Power Generation
Sala Barbantini	Energy Demand 3	Renewable Energy 3	Finance, Climate and Energy
Sala Consiglio	European Climate Policy 2	Carbon Markets	Power Sector: Regional Studies
Sala Soffitto	Policy Instruments 3	Technology Learning and Diffusion	

…but there are other objectives too

➢Energy Policy in the European Union:



Source: Bellmans (2009) in: Bigano et al. (2009)

OUTLINE

- 1: Climate change
- 2: Climate and energy systems
  - Supply side risks
  - Demand side risks
- 3: Climate change mitigation

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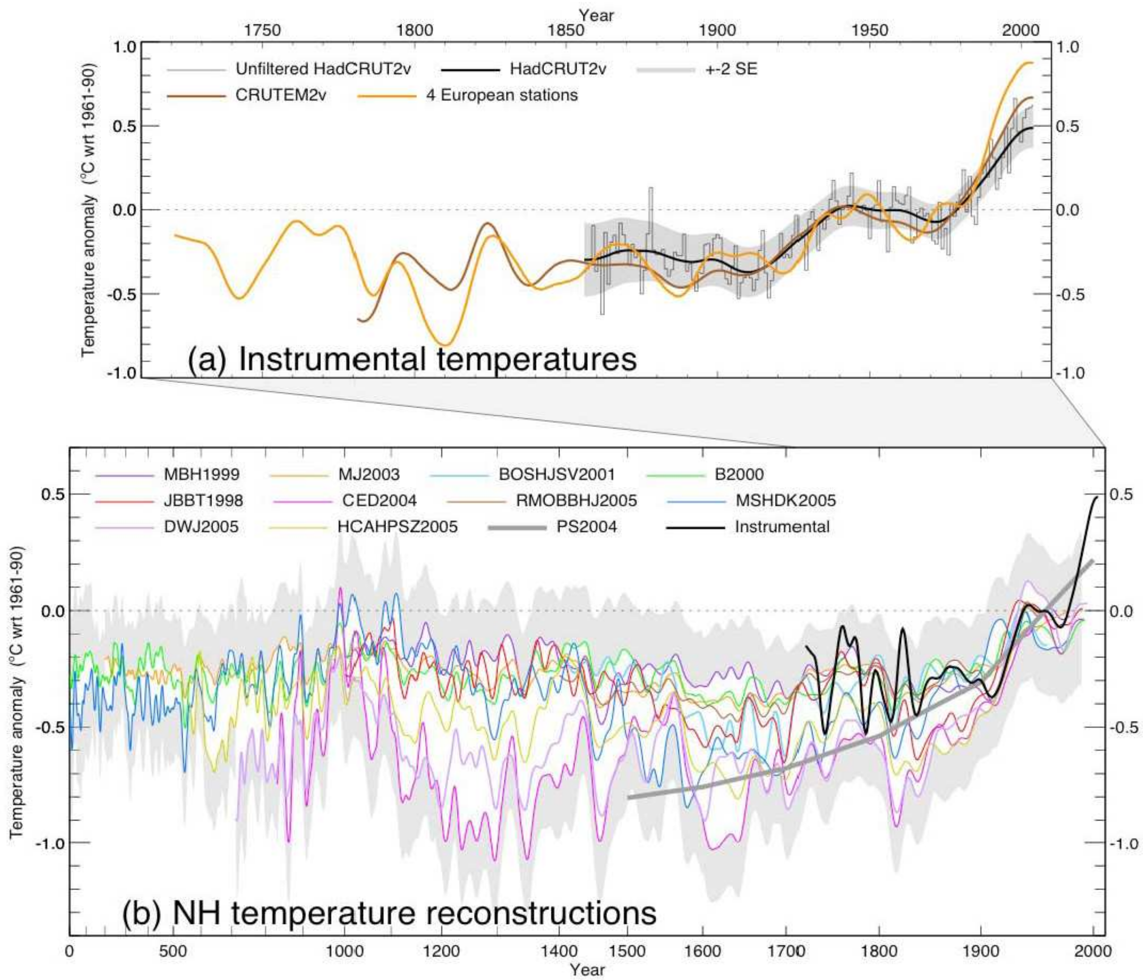
medium climate development

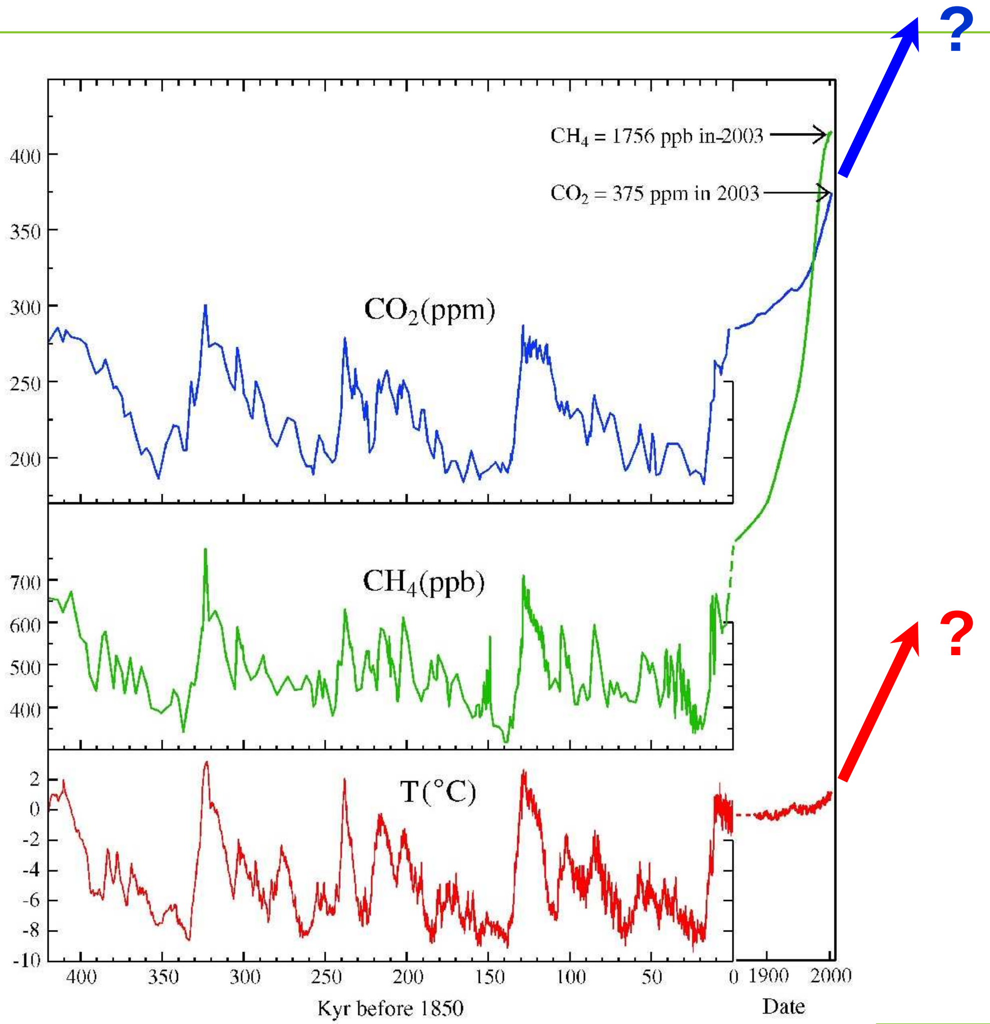


The last millenium:

A lot of „hot air“ in scientific discourse but still the same conclusion: the planet is heating up

(Source: Jansen, Overpeck et al., 2005)

medium climate development



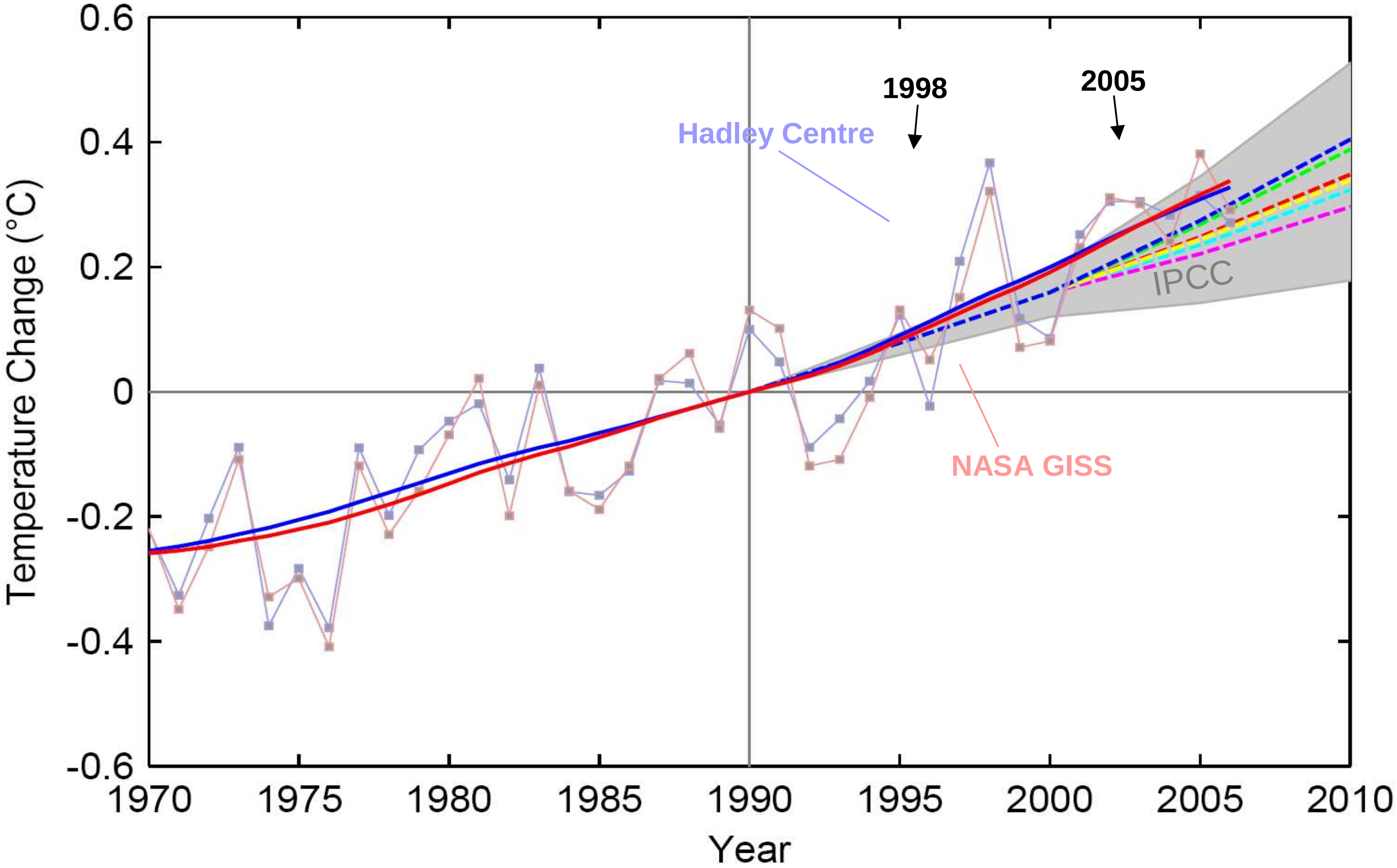
Quo Vadis, earth climate?

After a million years of „well behaved“ oscillations up to the unknown

(Source: Hansen, 2005; on the basis of Petit et al., 1999)

Observed Warming

Climate change projections 1990-2006 from the year 1999 vs. measurements up to 2006



Source: Rahmstorf, Cazenave, Church, Hansen, Keeling, Parker and Somerville (Science 2007)

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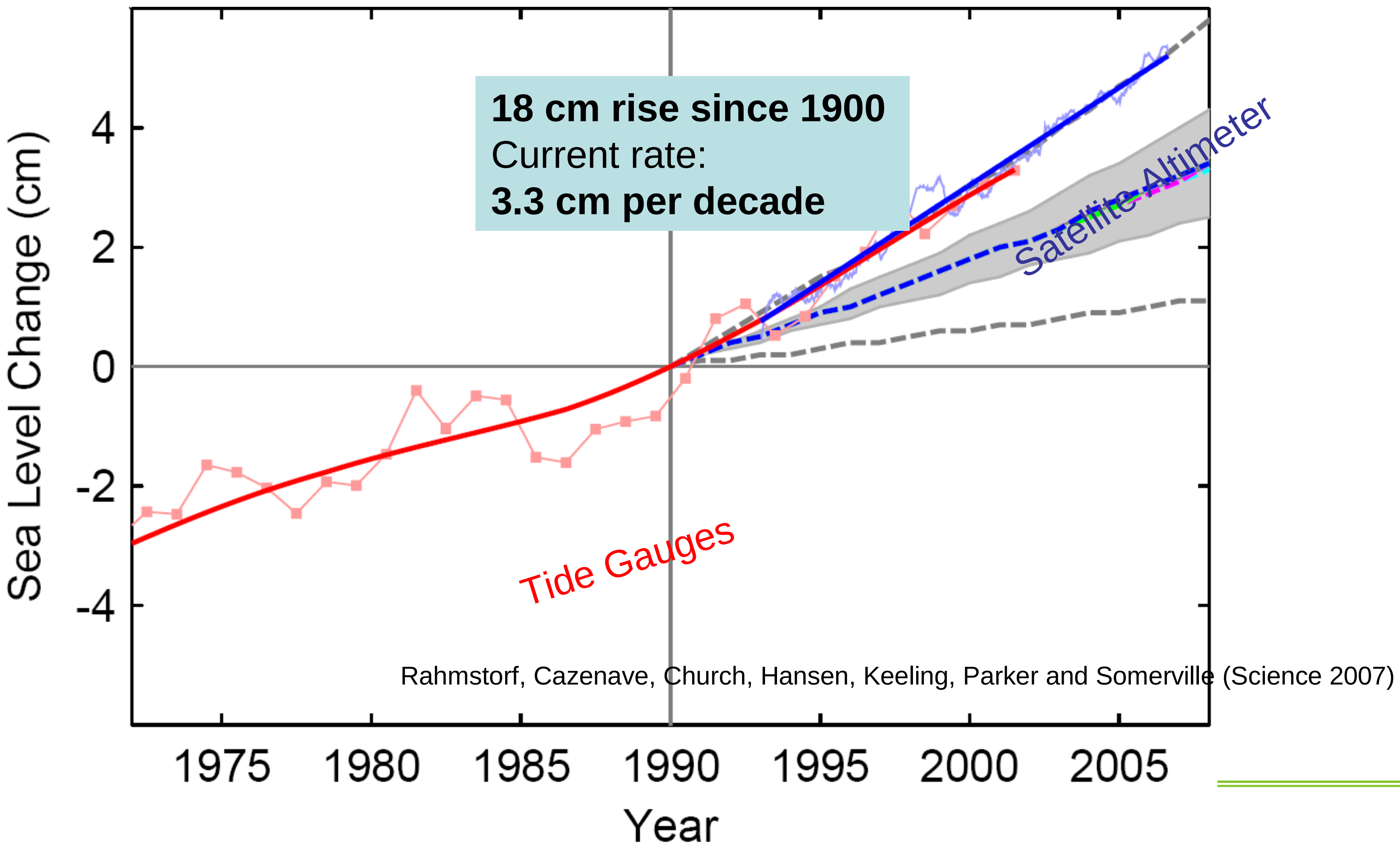
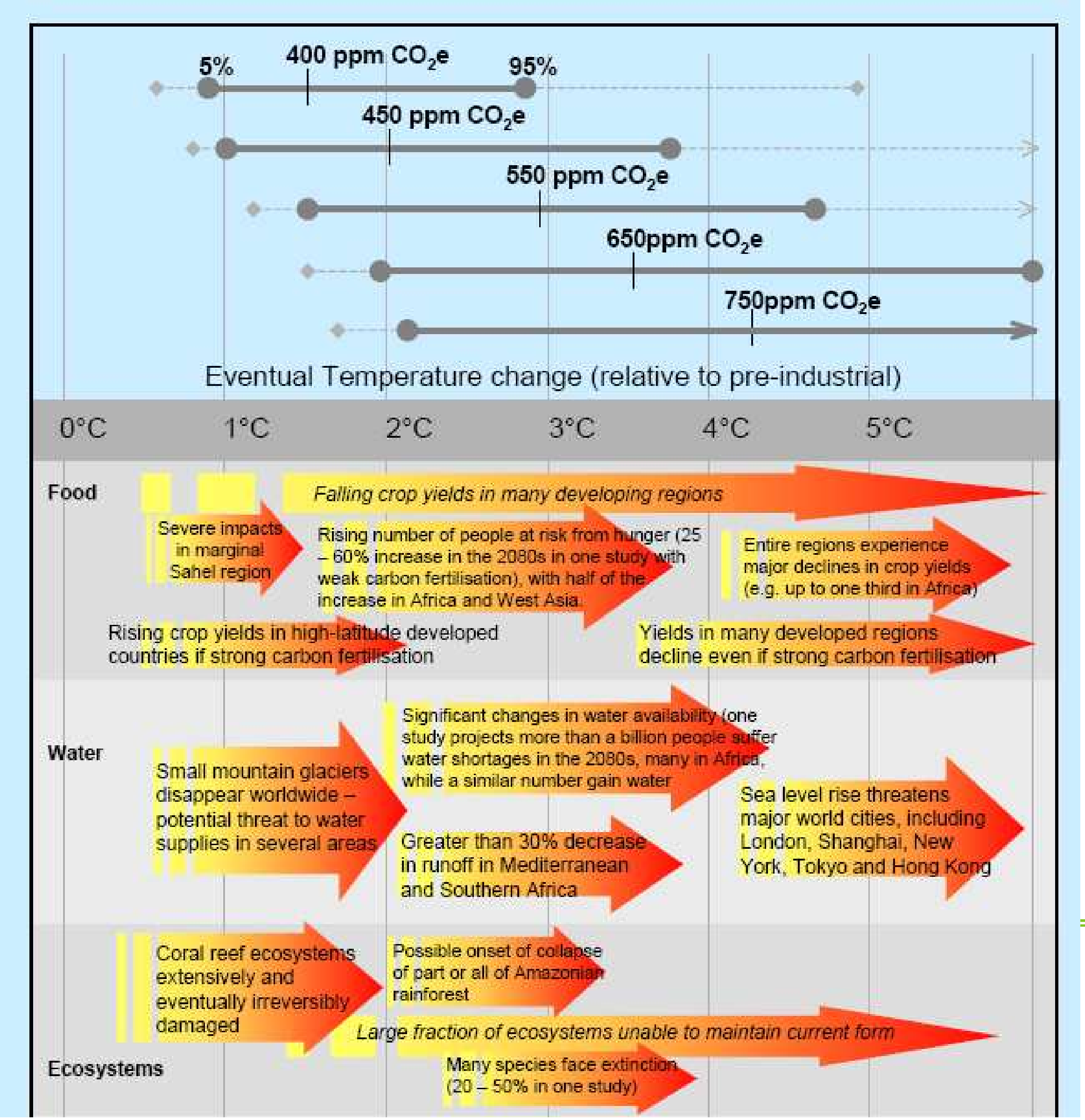
Observed Sea Level Rise



Worldwide Impacts of climate change



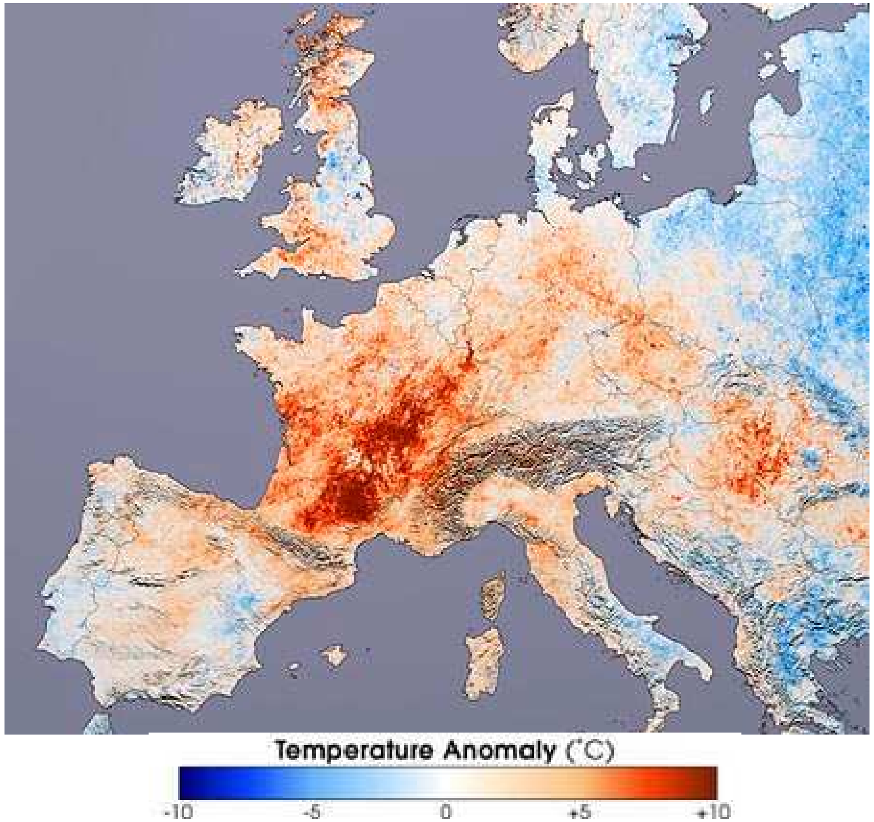
Serious impacts triggered

(Source: Stern Review Report, 2006)

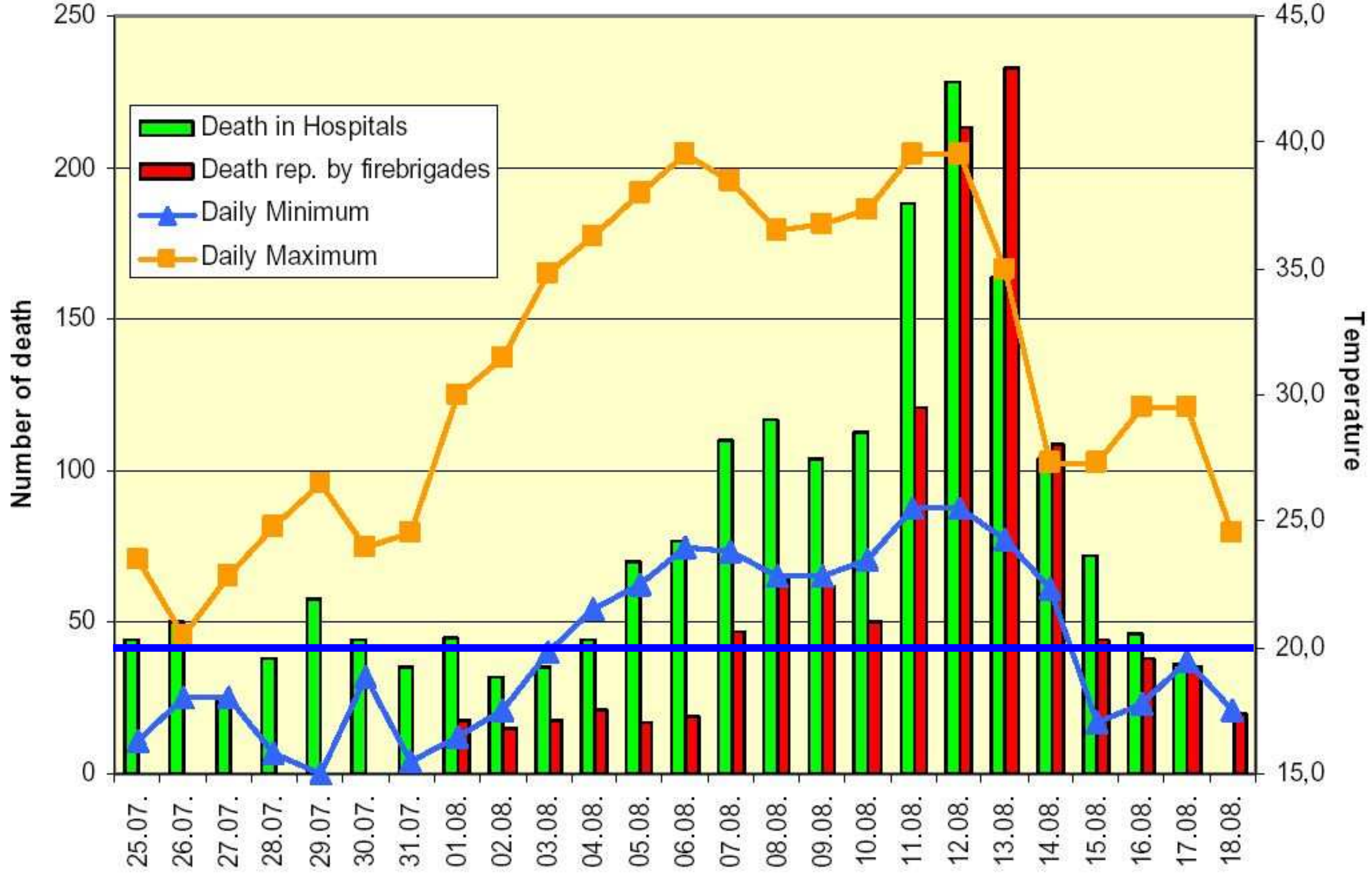
Summer 2003 in Europe

Temperature anomaly July 2003 vs. 2001 (source: Terra Satellit, NASA)

Extremely hot in France, while some parts of Eastern Europe were not affected



Summer 2003 in Paris



source: WHO

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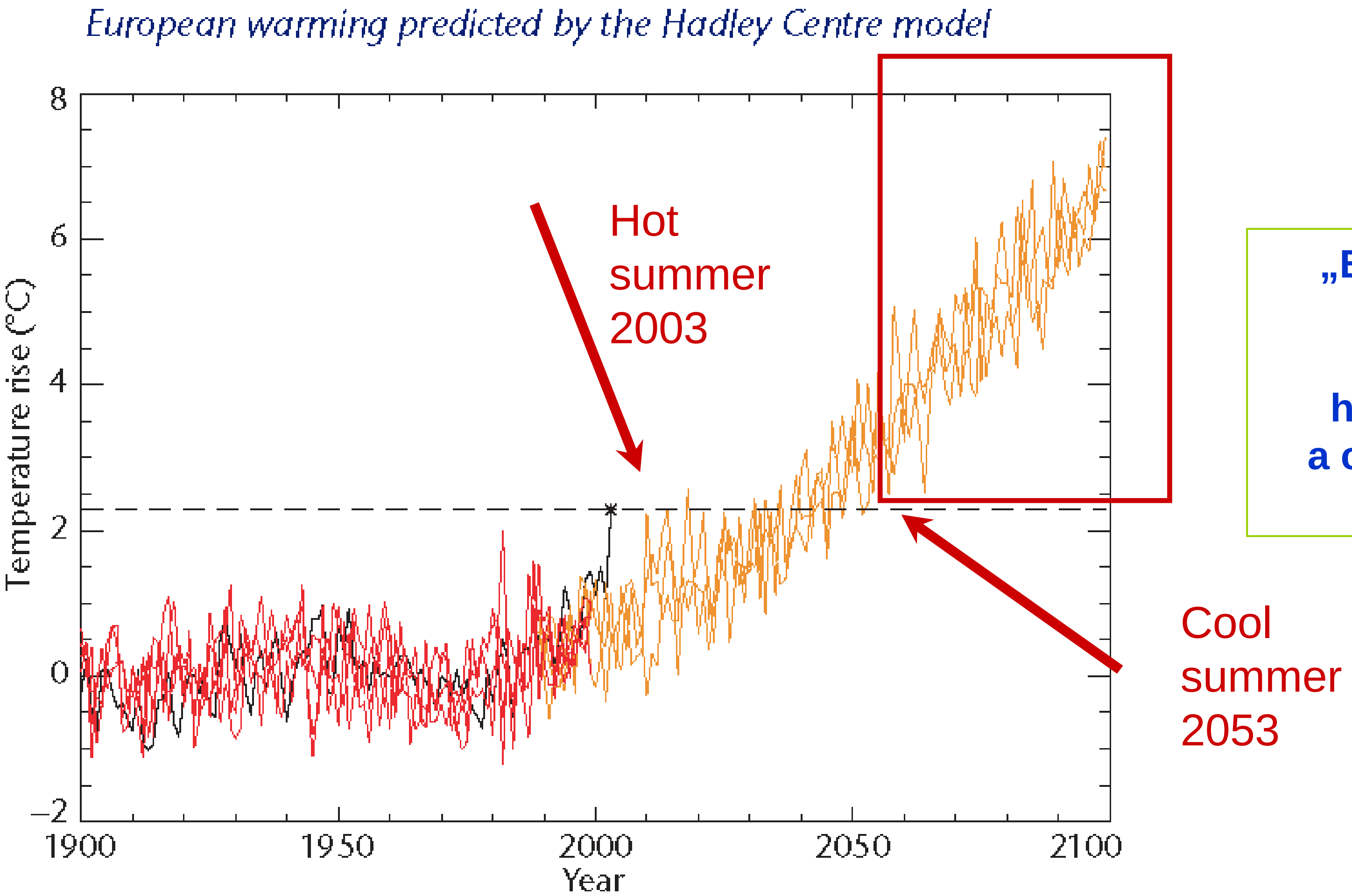
Summer in Europe and extremes



„Business as usual“ … From the hot summer 2003 to a cool summer in the early 2050s

(Quelle: Met Office/Hadley Centre, 2004)

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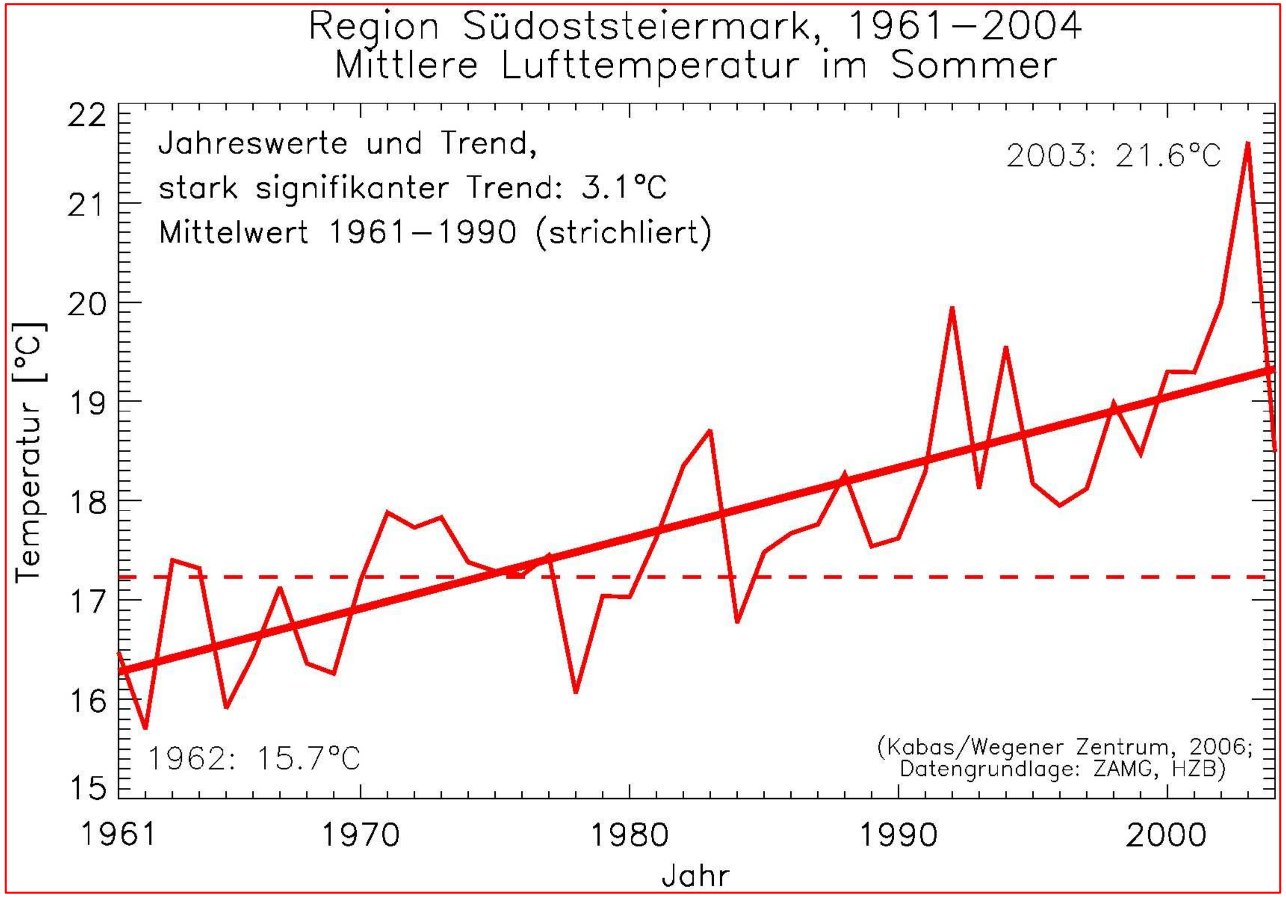
Local impacts



Local impacts will turn out significantly more pronounced

Summer 2003: Precipitation in Graz

• Graz:
long-term average precipitation in August: **112 mm**

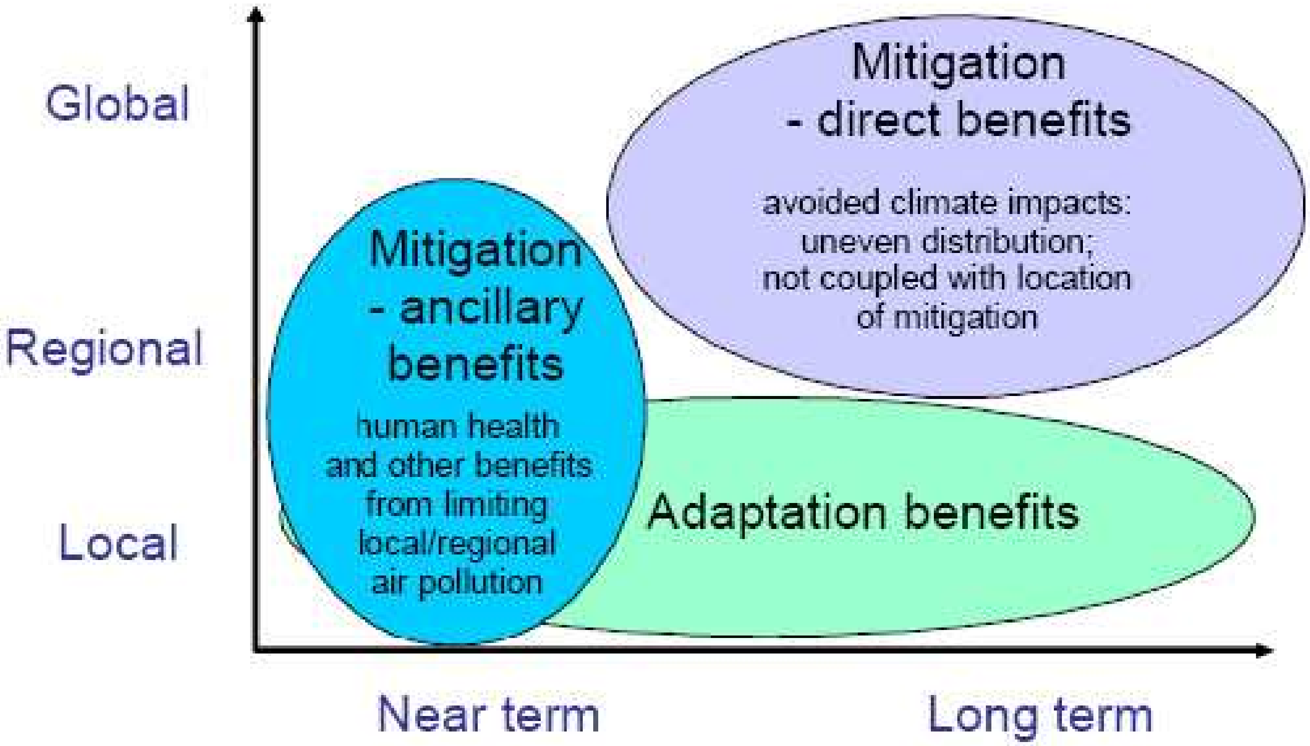
•August 2003: **113 mm**
1st to 28th: **13 mm**: 29th to 31st: **100 mm**

extreme temperatures and drought vs. Heavy precipitation

Mitigation and adaptation: costs and benefits across time and space

In need of both mitigation and adaptation

Incentives differ



(Source: Morlot and Agrawala, 2004)

OUTLINE

- **1: Climate change**
- **2: Climate and energy systems**
  - **Supply side risks**
  - **Demand side risks**

How do climate change affect energy systems?

IMPACTS, VULNERABILITY and ADAPTATION

MITIGATION

How do climate change effects companies?

- ➢ Regulatory risk – How can the company compete in a carbon-restricted world?
- ➢ Supply chain risk – How do regulations affect suppliers?
- ➢ Litigation risk – How to avoid the risk of lawsuits (similar to the tobacco industry)?
- ➢ Reputational risk – How to show that a company is a „good citizen"?
- ➢ PHYSICAL RISKS

On the basis of: Lash and Wellington 2007

Please note:

Climate is what you expect,
weather is what you get!

Overview

- Impacts on generation
- Impacts on grid
- Impacts on demand

OUTLINE

➢ 1: Climate change

➢ 2: Climate and energy systems

Supply side risks

Demand side risks

Weather risks for ‚energy supply companies‘

river power plants

pump storage power plants

wind power plants

nuclear power plants

coal, oil, gas power plants

electricity generation depends on:

temperature

precipitation, run-of

wind speed

end user demand

(domestic, industrial etc.)

load depends on:

Temperature

Precipitation

sunshine, cloudiness

spot market

price depends on multiple factors, like the

weather impact on all market participants

On the basis of: Gort 2003

Worldwide capacity and growth rate

	worldwide capacity (GW)	∅ annual growth rate 2000-2004
large hydro power	720	2 %
small hydro power	61	7 %
wind power	48	28 %
photovoltaics (grid connected)	1,8	60 %
photovoltaics (isolated operation)	2,2	17 %

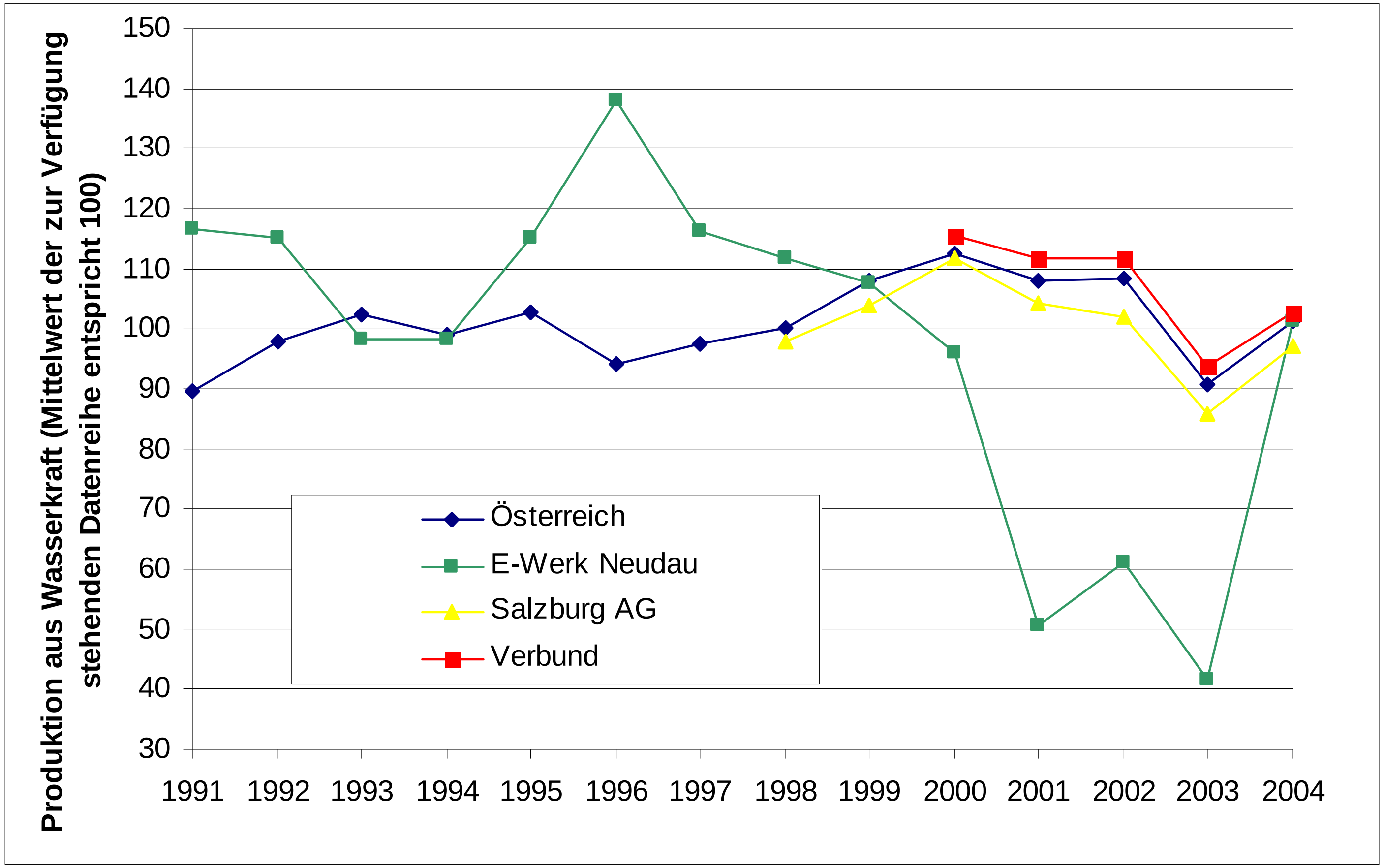
Source: REN 21 2006

EU-25 (GW)	Austria (GW)
128	12
34	0,6
< 1,3	k. A.

Source: Eurostat

Variability of electricity supplied by renewable sources

➢ Impact on companies



Variability of electricity supplied by renewable sources

- Impact on CO_2-emissions - Austria 2003:
  minus 3400 GWh hydro power generation (-9% compared to Ø)
  plus 2,67 million tons CO_2-emissions from heat and power generation – public utilities (+ 38 %! compared to 2002)

- Impact on earnings – Verbund 2003
  „low hydro power production reduced operating result by 47 million Euros“

  Net effect: 2002-2003 operating result: minus 9 million Euros
  group result: + 20% (mainly because of higher spot market prices)

Climate and Hydro power plants

- Flooding: Impacts on Hydro power plants
- Flooding: Hydro power for adaptation
- Increasing risk of land slides
- Changes in siltation
- Changes in seasonal run-off patterns

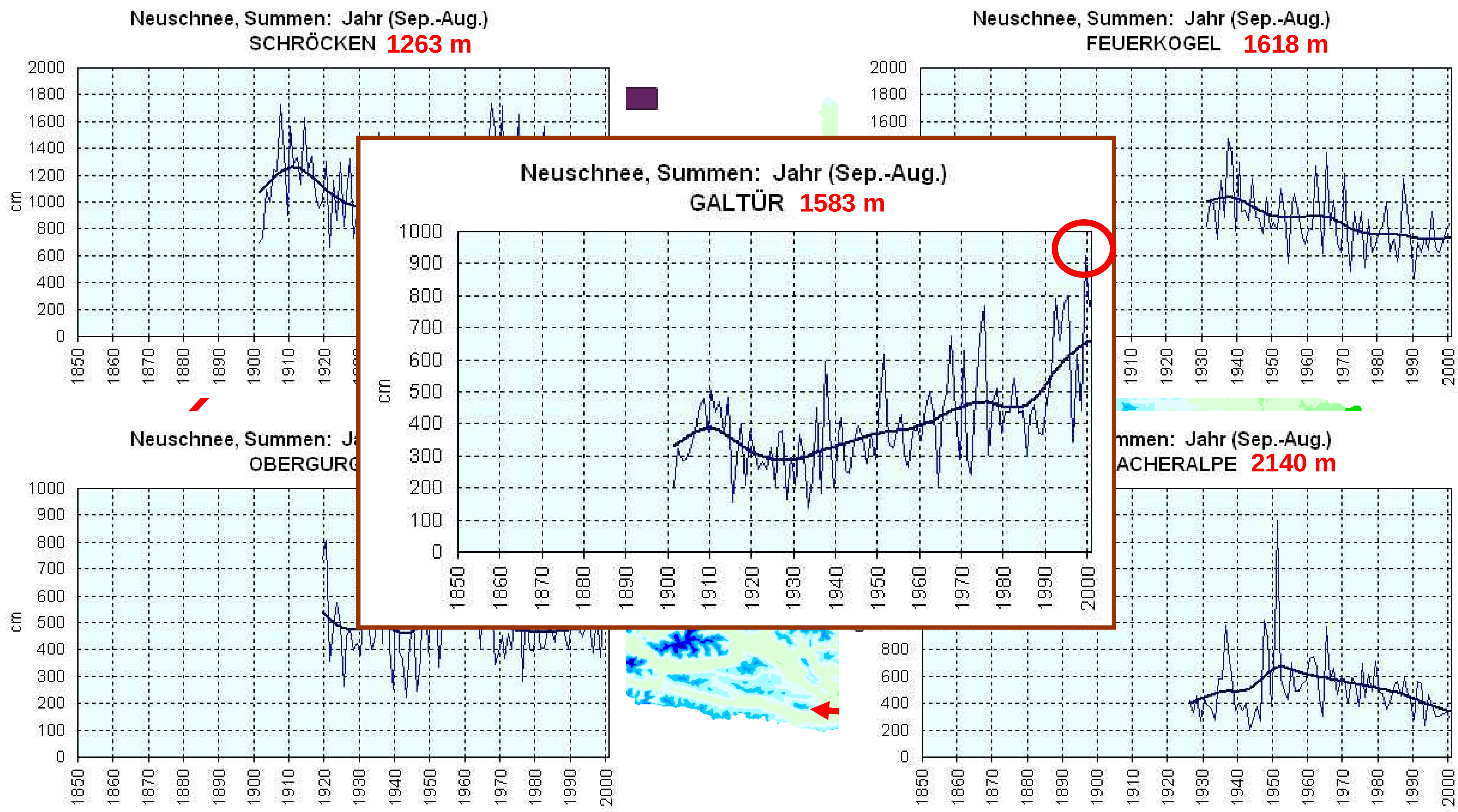
Source: ProClim 2003

Melting Glaciers in Austria

1938 **Pasterze**, longest glacier in the Eastern Alps **2003**

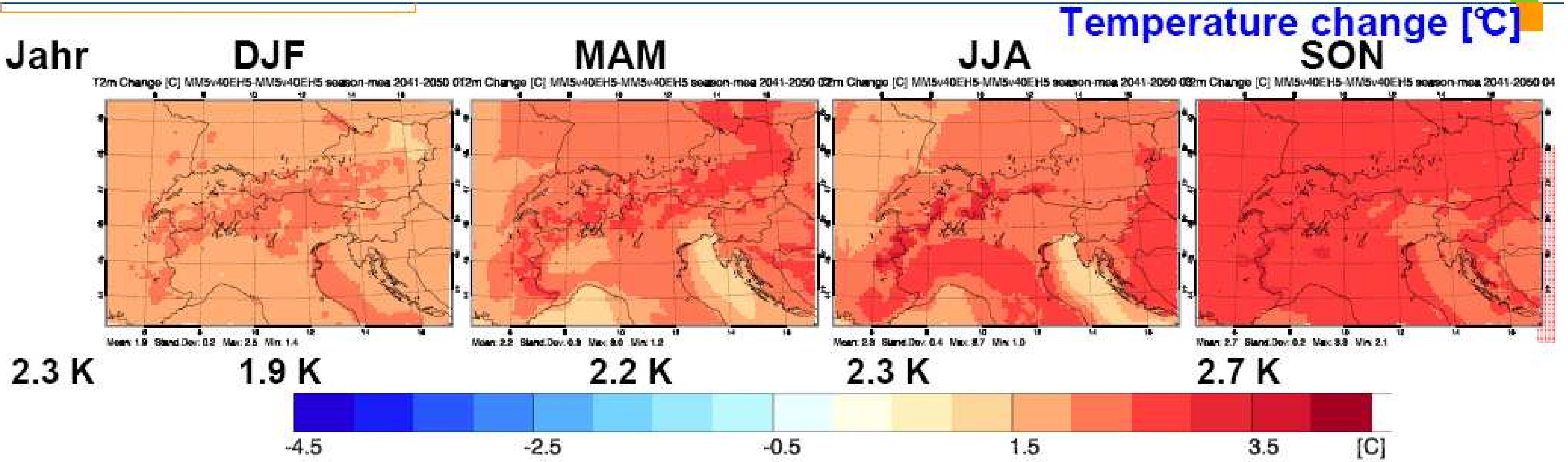
Source: www.gletscherarchiv.de

Changes in snow fall patterns

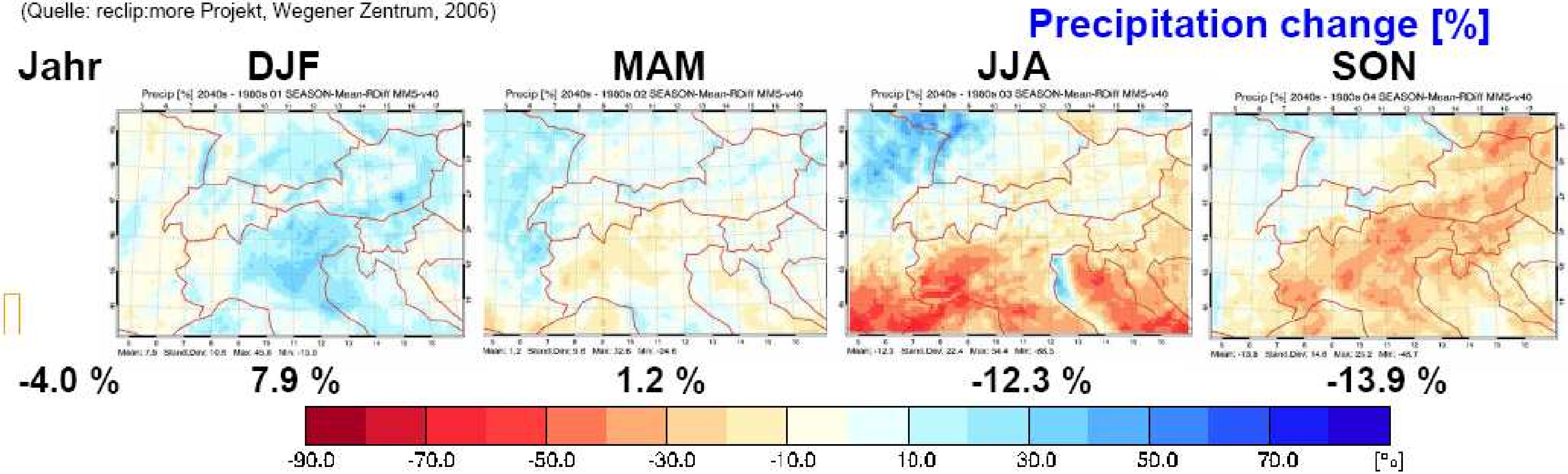


Stations above 1000 m, source: ZAMG

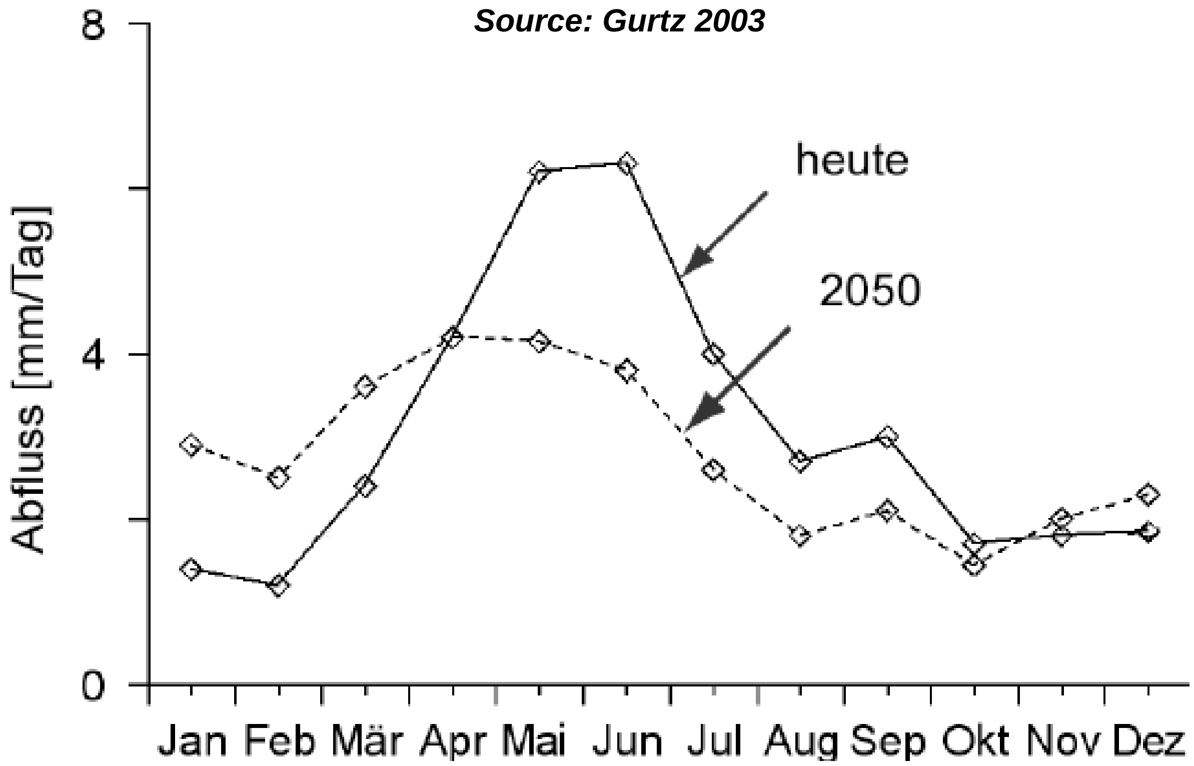
Temperature and precipitation change 1980s to 2040s: (10 km x 10 km resolution)



(Quelle: reclip:more Projekt, Wegener Zentrum, 2006)



Expected Changes for Stein/Thur (CH)



Mean monthly run off – NEED TO CONSIDER ALSO EXTREME EVENTS!

Weather risks for ‚energy supply companies‘

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load depends on:

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spot market

price depends on multiple factors, like the

weather impact on all market participants

On the basis of: Gort 2003

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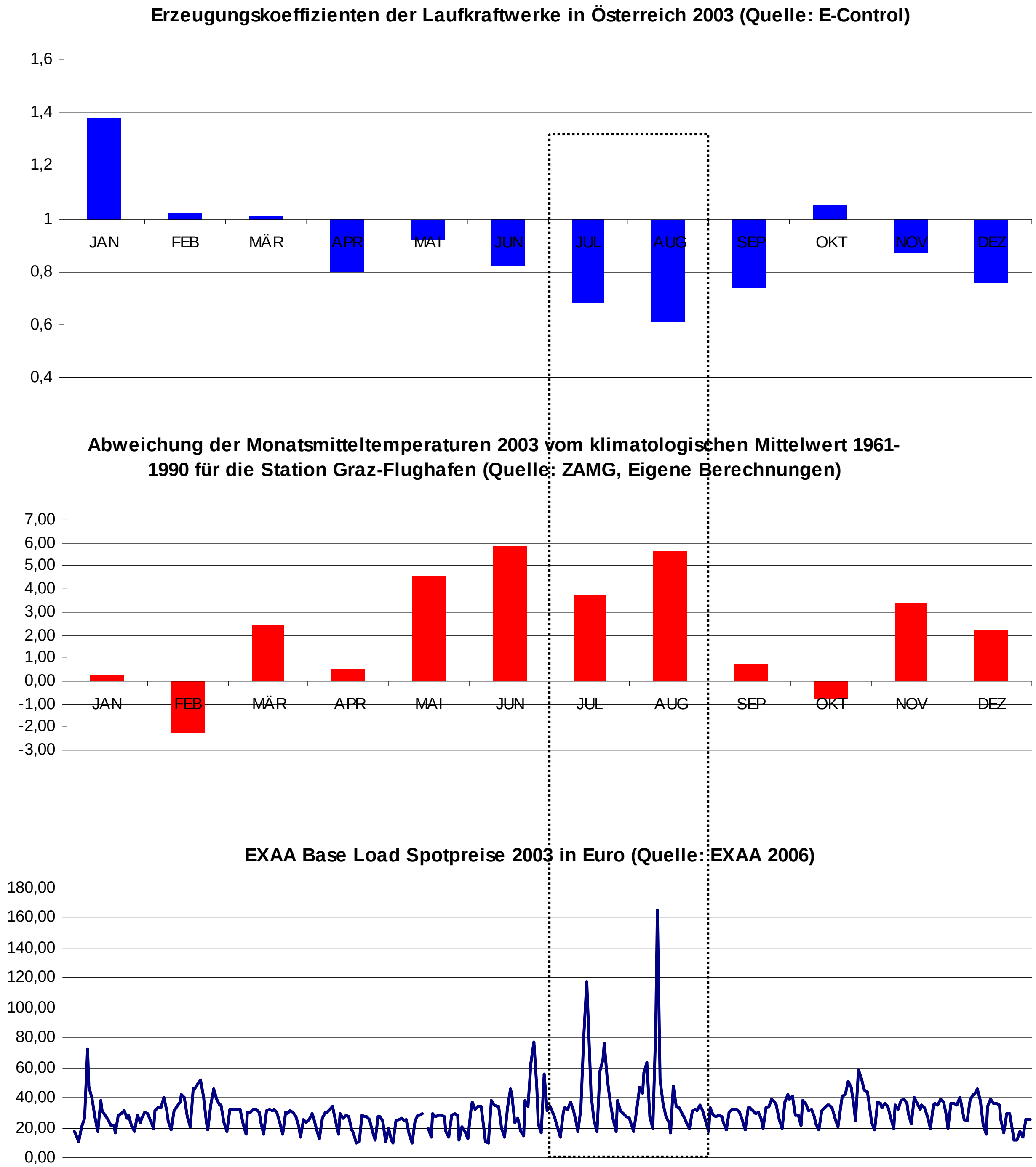
- The Austrian – Mid-european example



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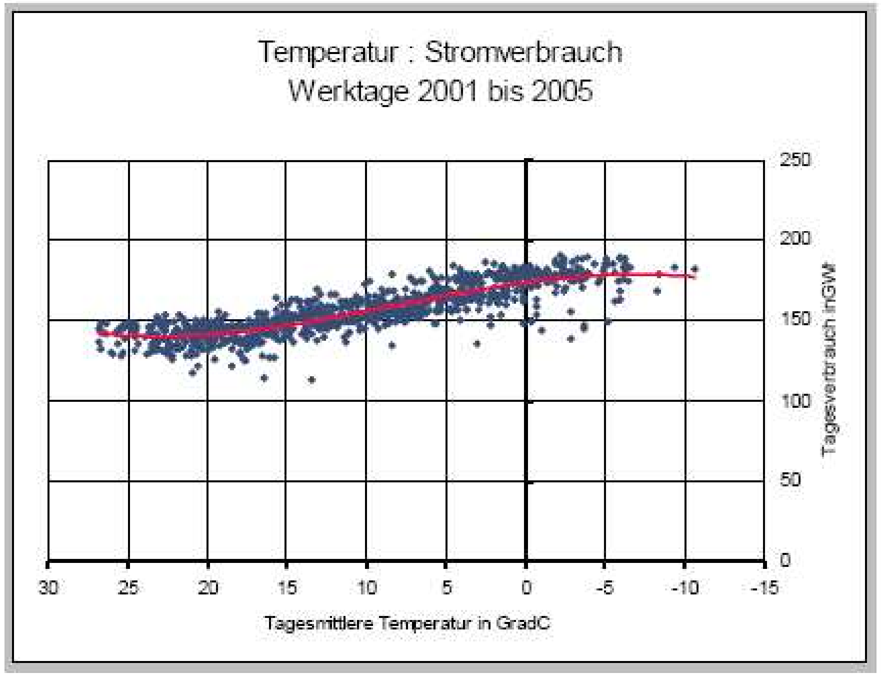
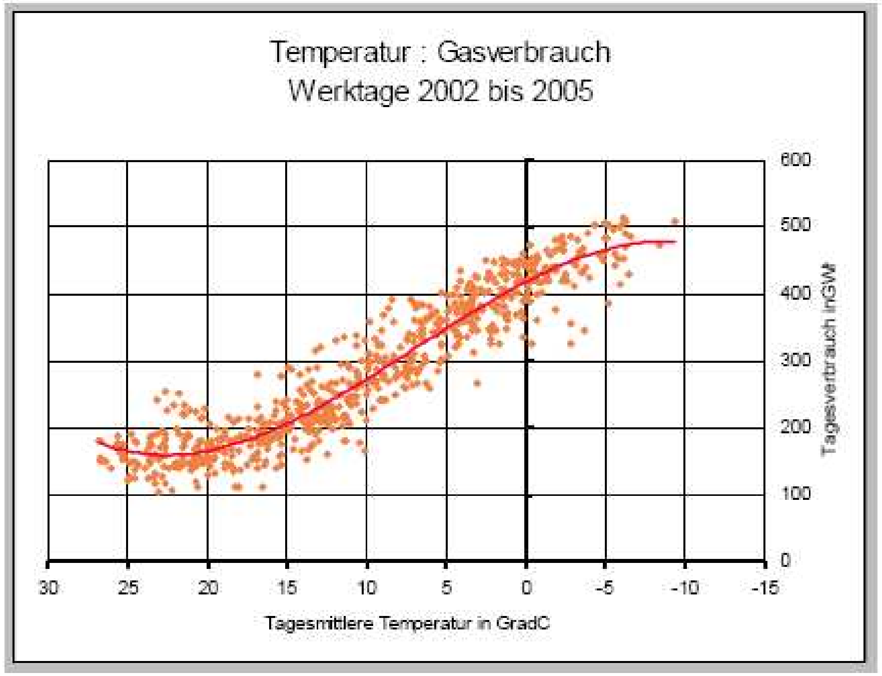
Temperature impact on electricity load and natural gas demand (in Austria)





Function seems to be similar for heating oil demand

Source: E-Control 2005

Temperature impact on electricity load (in Spain)

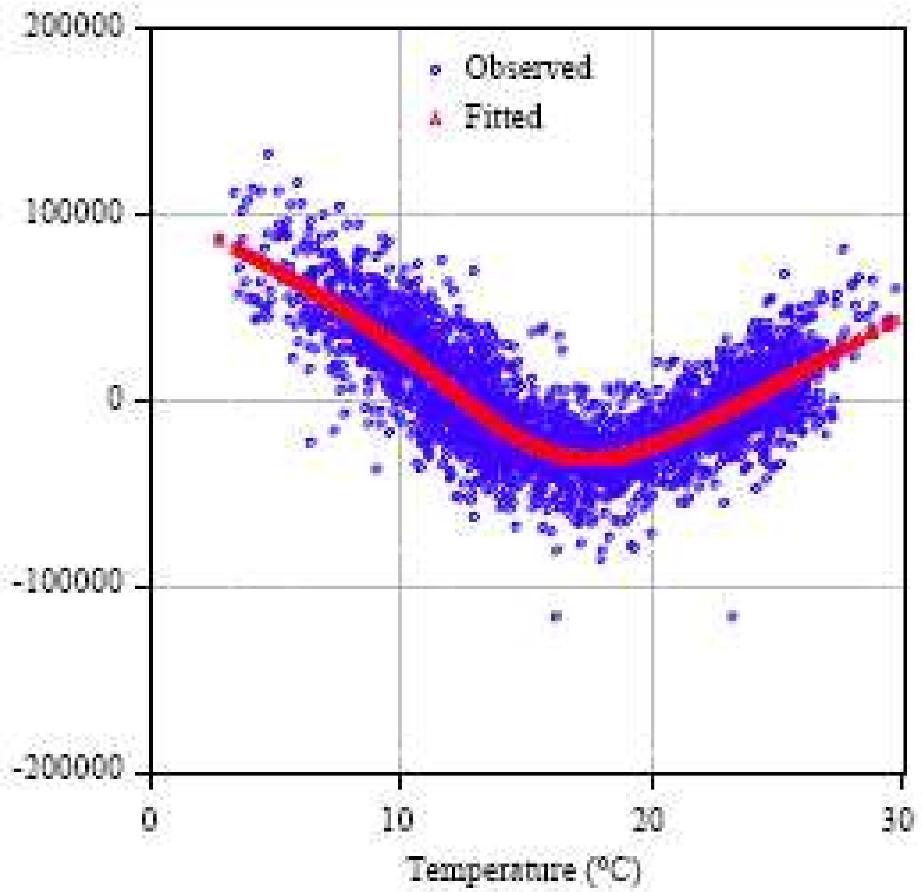


Fig. 6. Electricity response observed and fitted.

Source: Moral Carcedo 2005

Heating and cooling degree days

Heating degree days (HDD)

- ‚American Definition‘:

$$HDD(T_1,T_2)=\sum_{t=T_1}^{T_2}(18{,}3-\theta_t)$$

for days where: $\theta_t \leq 18{,}3$

- ÖNORM 8135-Definition:

$$HGT(T_1,T_2)=\sum_{t=T_1}^{T_2}(20-\theta_t)$$

for days where: $\theta_t \leq 12$

Cooling Degree Days (CDD)

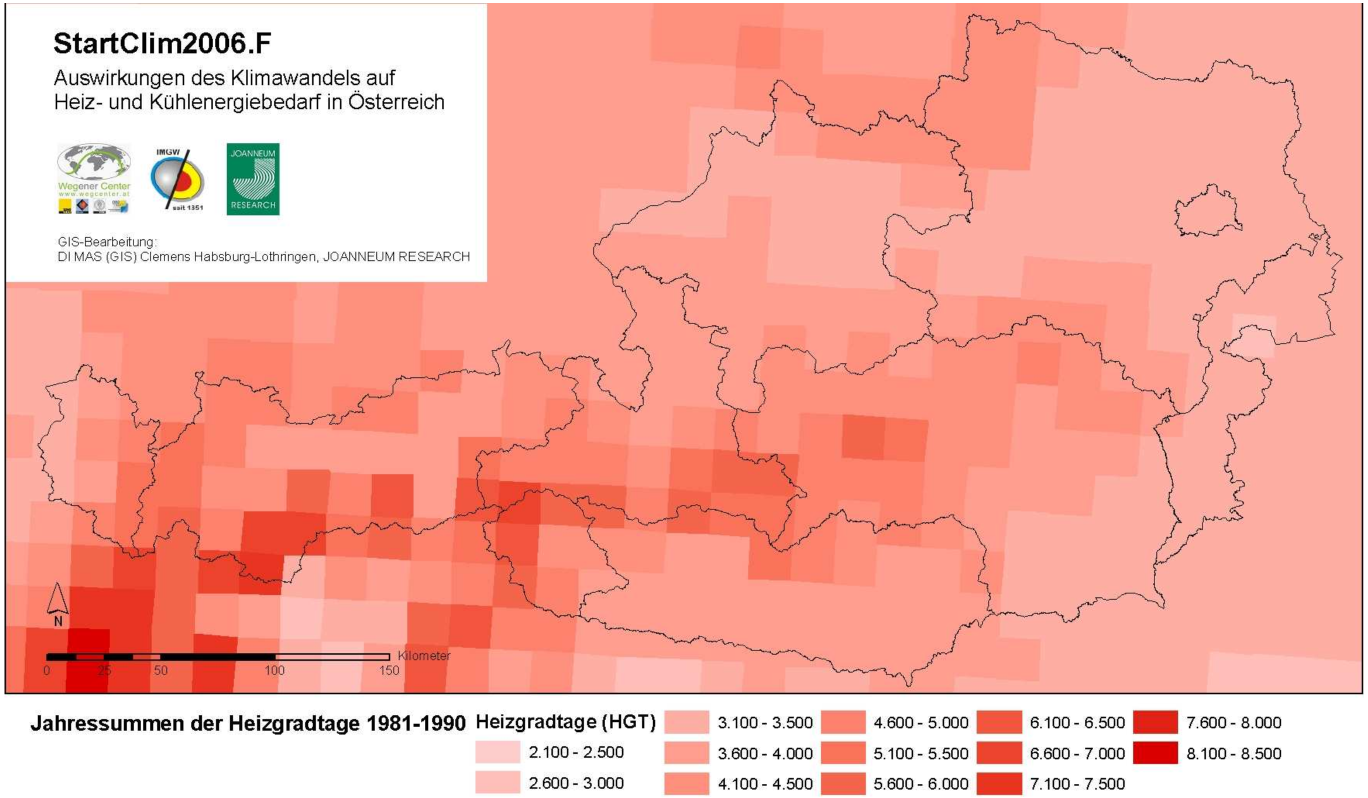
- ‚American Definition‘:

$$CDD(T_1,T_2)=\sum_{t=T_1}^{T_2}(\theta_t-18{,}3)$$

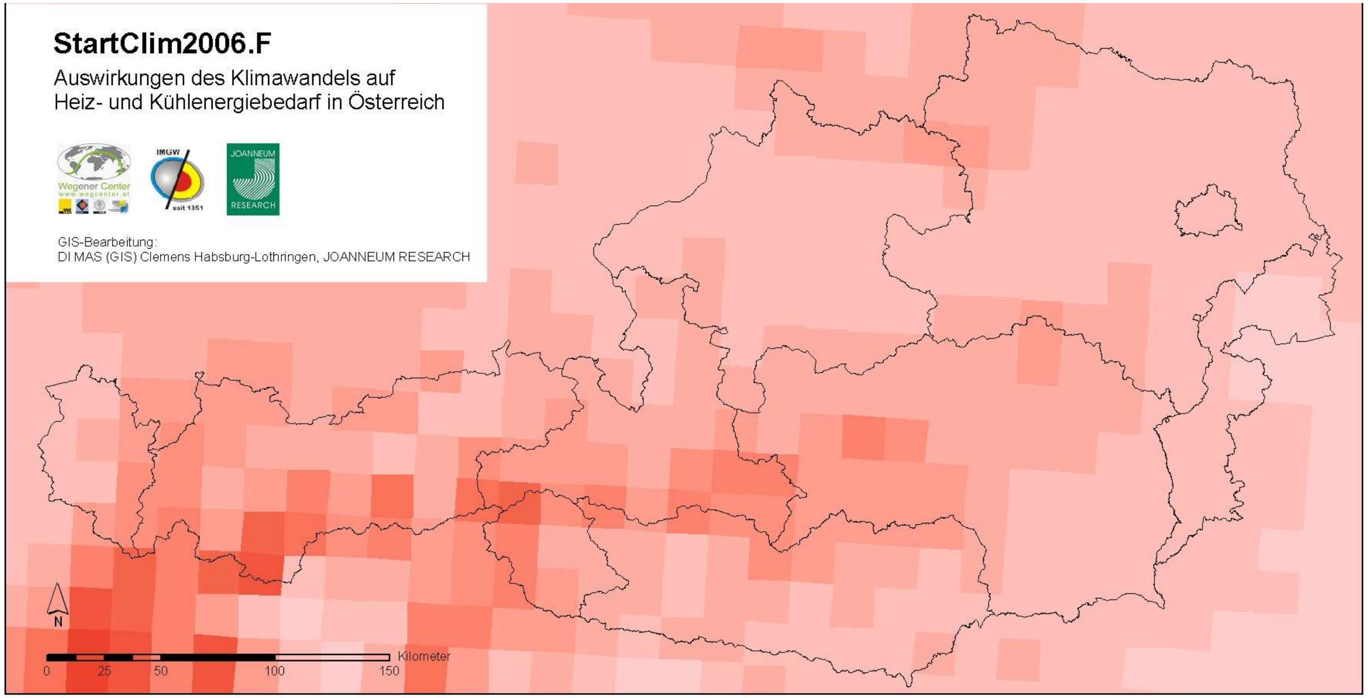
for days where: $\theta_t \geq 18{,}3$

- The higher the threshold value, the higher the interannual variations

Heating degree days 1981-1990



Heating degree days 2041-2050



Jahressummen der Heizgradtage 2041-2050

Heizgradtage (HGT)

- 2.100 - 2.500
- 2.600 - 3.000
- 3.100 - 3.500
- 3.600 - 4.000
- 4.100 - 4.500
- 4.600 - 5.000
- 5.100 - 5.500
- 5.600 - 6.000
- 6.100 - 6.500
- 6.600 - 7.000
- 7.100 - 7.500
- 7.600 - 8.000
- 8.100 - 8.500

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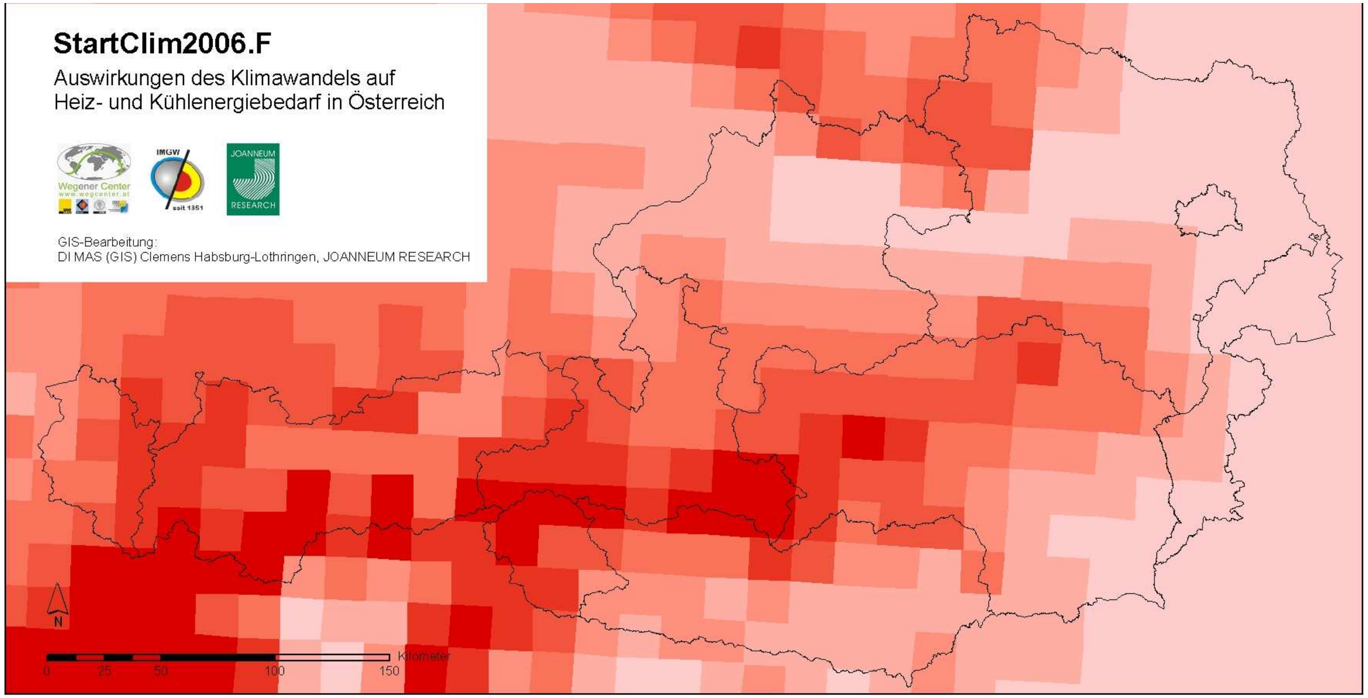
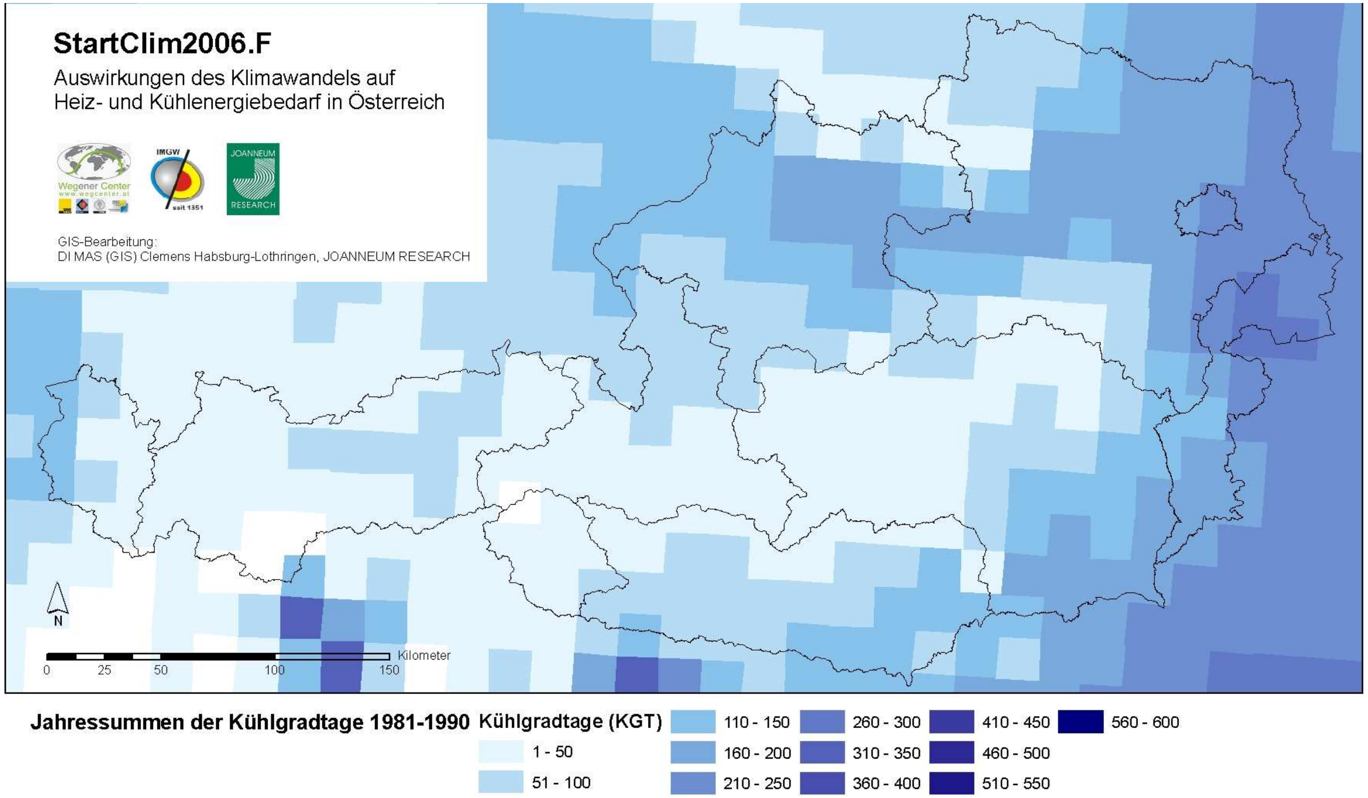
Δ HDD 2041-2050 vs. 1981-1990



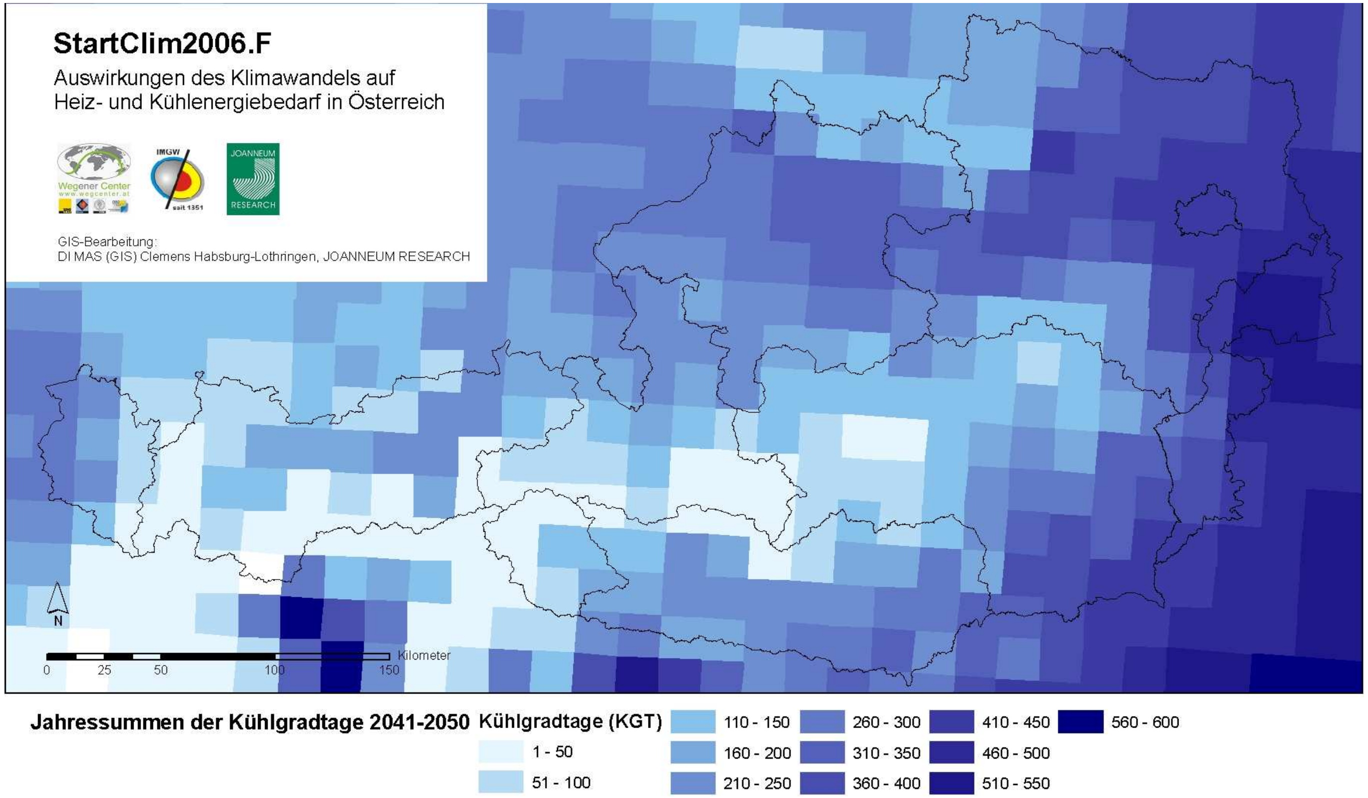
Abnahme der Heizgradtage 1981-1990 vs. 2041-2050 Heizgradtage (HGT)

- -1.200 - -1.000
- -900 - -930
- -920 - -840
- -830 - -770
- -760 - -700
- -690 - -640
- -630 - -570

Cooling degree days 1981-1990



Cooling degree days 2041-2050



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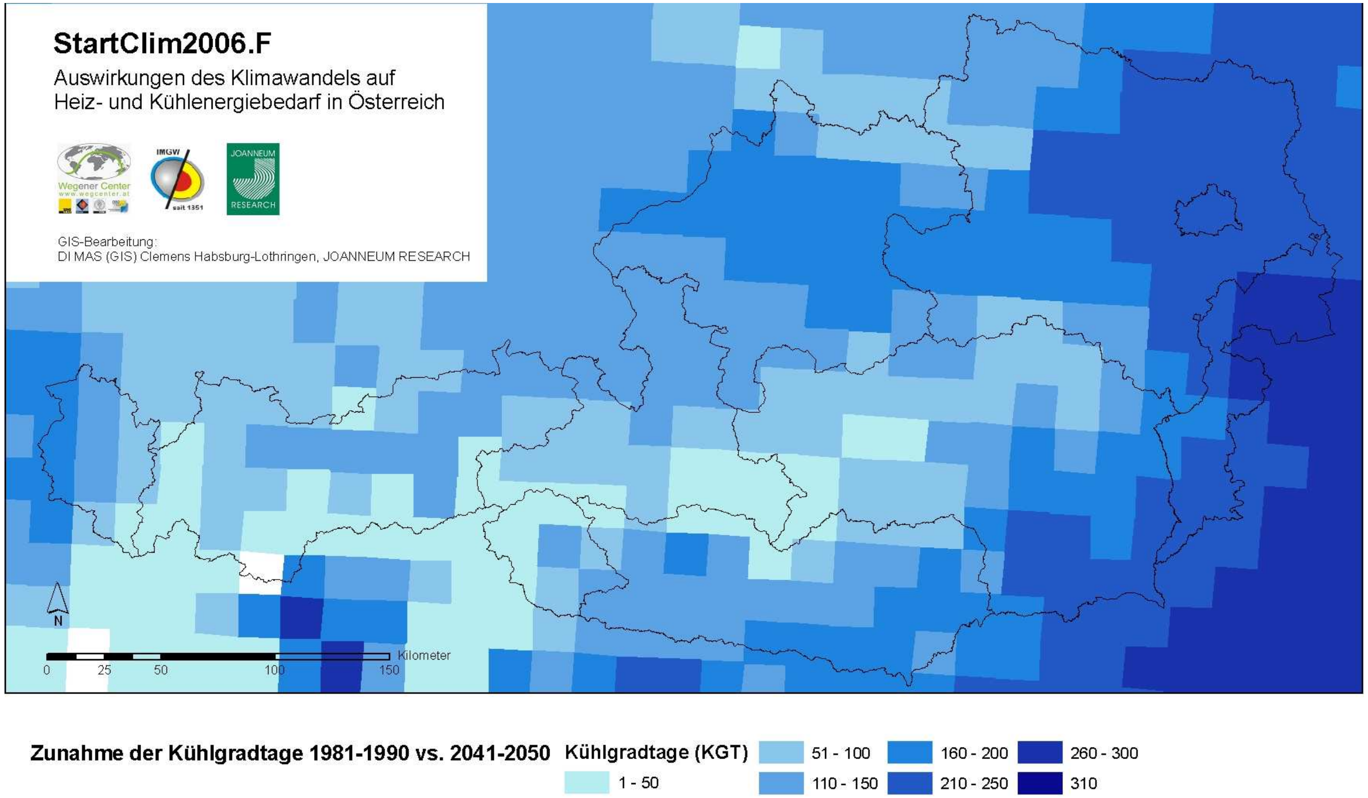
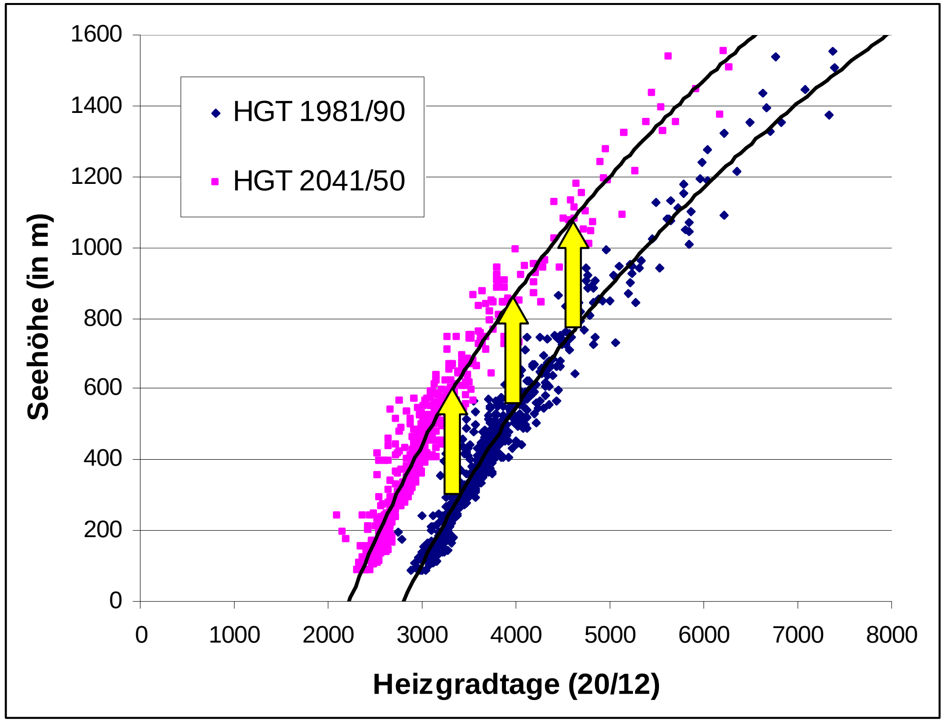
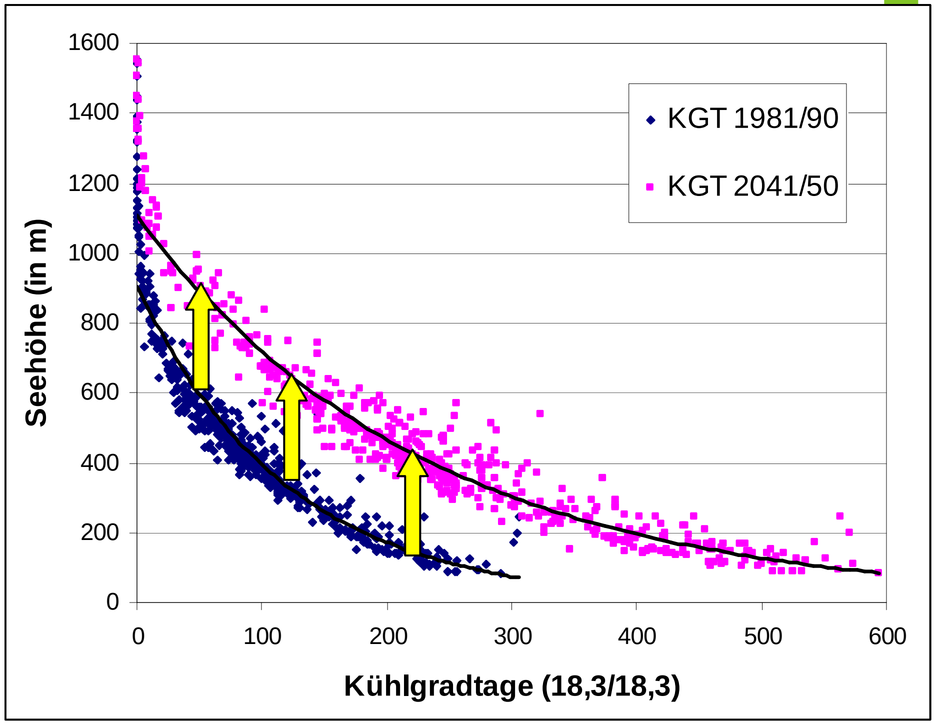
∆ CDD 2041-2050 vs. 1981-1990



Sea level





- HDD and CDD will rise approximately 300 meter
- More than half of the Austrians live below 400 m

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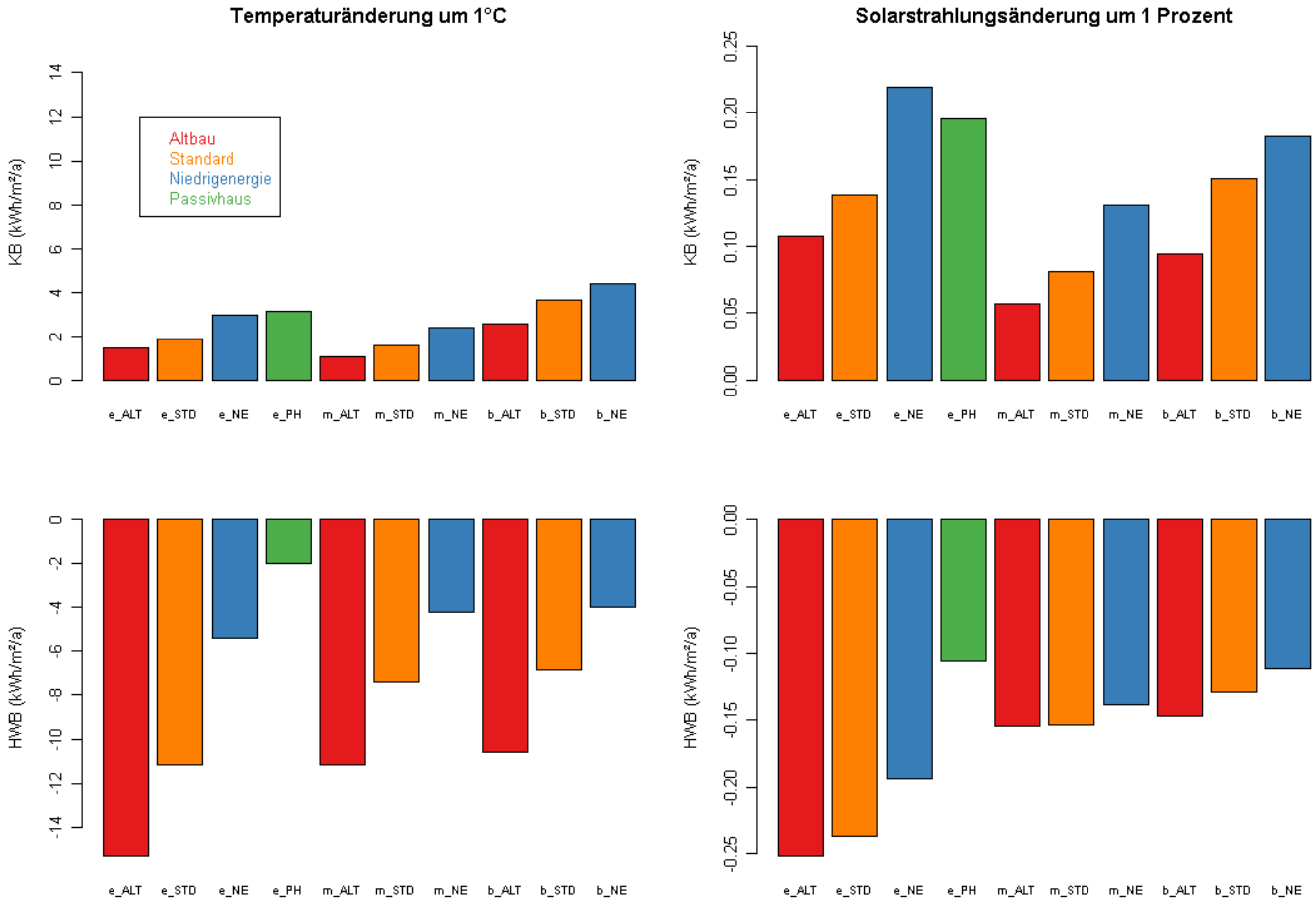
How sensitive are buildings?



Source: Gobiet et al. (2009- forthcoming)

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Residential and commercial AC markets

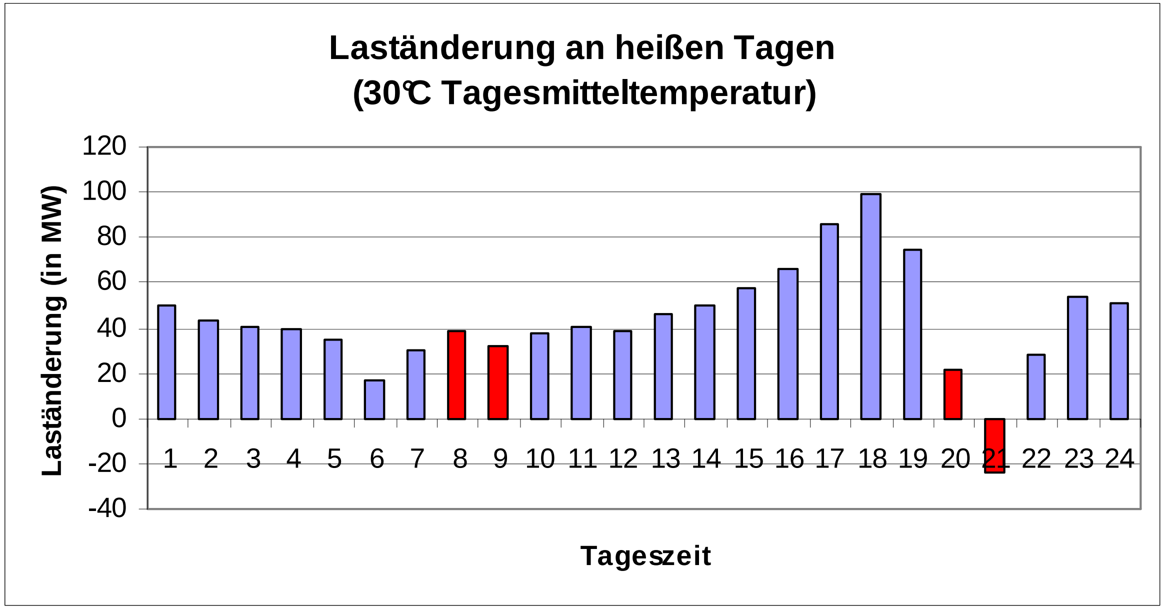
- *Percentage of Households with Air Conditioning*
- USA 65%
- Japan 85%
- Europe 5%

- *Percentage of Commercial Buildings with Air Conditioning*
- USA 80%
- Japan 100%
- Europe 27%

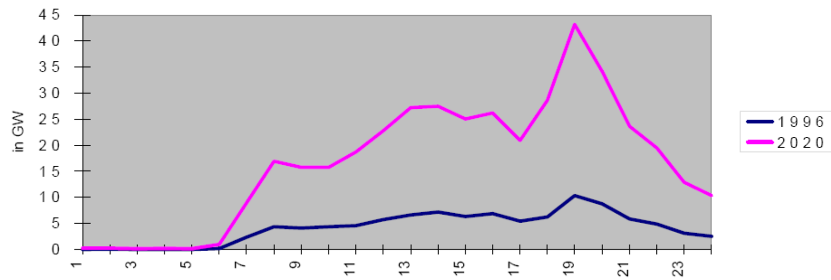
Source: Centre for Energy Studies 2003 (in: *Paul Waide, IEA 2004)*

Cooling: Is it already an issue in Austria?

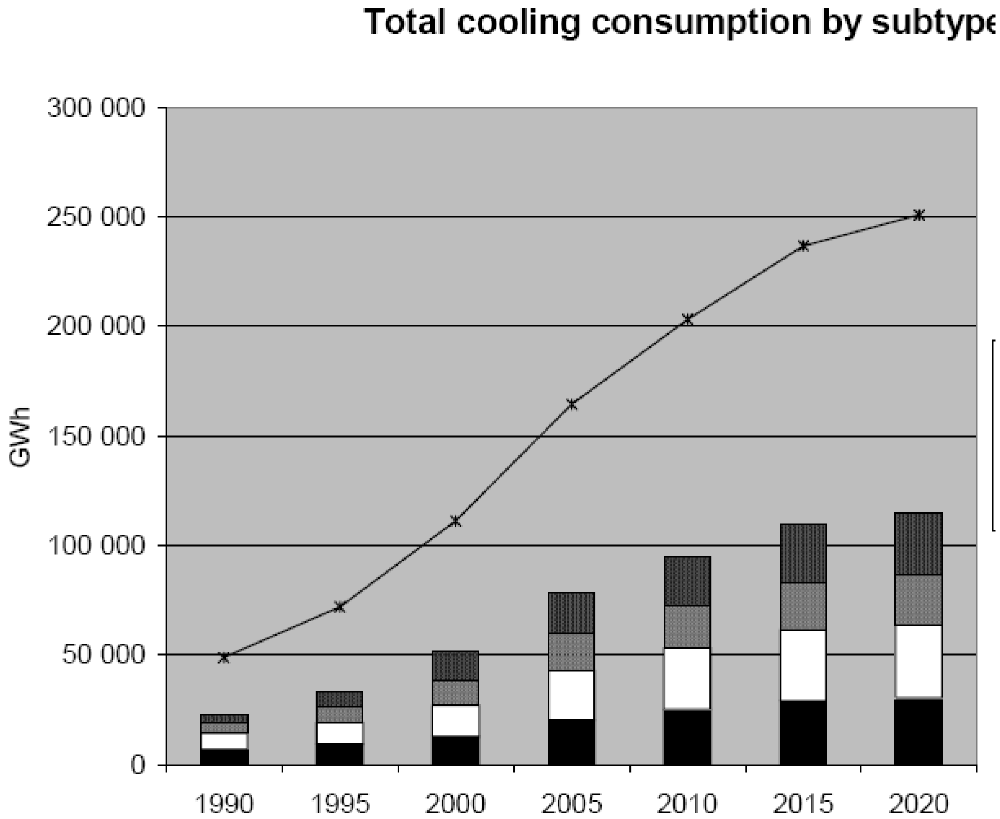
Source: Klimastudien Land Niederösterreich – Toeglhofer et al. (2008)



Source: Adnot et al. (2003)



Cooling energy consumption in the EU-15: BAU projection



COMPARE:

Total Austrian electricity demand 2005: 65,747

Austrian emissions 2005: 93 000
Kyoto target: 68 700

CO_2 emissions (in thousand tons)

Total	18 073	27 336	33 154	38 371	40 103

Source: Adnot et al. 2003

Increase in Cooling Degree days, what else matters?

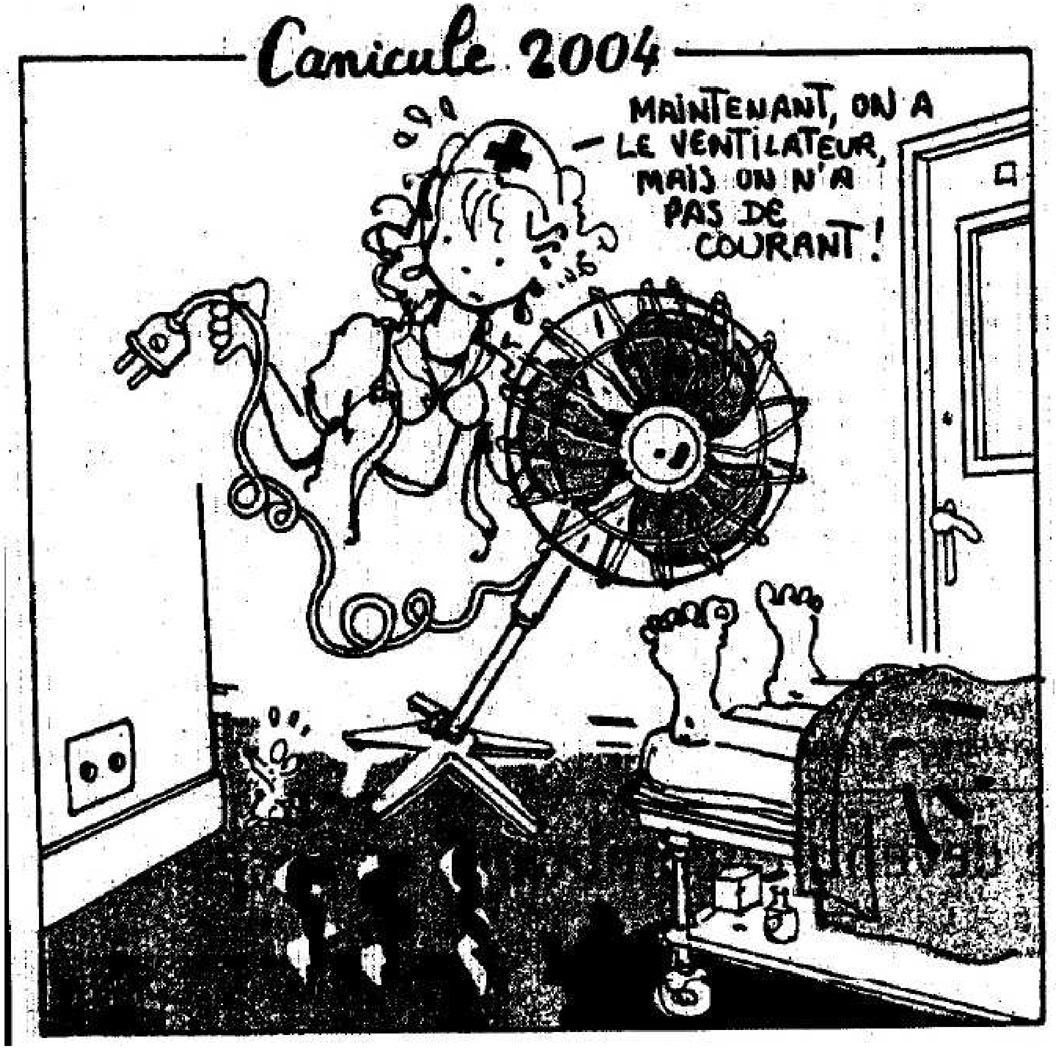
- Increasing affordability of cooling devices
- □ Shifts in comfort culture, behavioural patterns and consumer expectation
- □ Increasing internal loads
- □ Increase in urban heat island phenomenon
- □ Movement toward universal building designs which are poorly adapted to the local climatic conditions

Source: Paul Waide, IEA 2004

Conclusion: Heating and Cooling Energy Demand in Austria

- The **climate induced** decrease in heating energy demand will be clearly stronger than the **climate induced** increase in cooling energy demand
- For the energy carrier electricity the additional demand in summer for cooling could outhweigh reductions in heating energy demand in winter.
- The future heating and cooling energy demand will be determined less by climate change impacts than by future technical and socio-economic developments

Where are we going?



Source: Le Monde 2003

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Special thanks to

Ulrich Foelsche and Karl Steininger

for providing some of the slides

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  - Demand side risks
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Questions? Comments?

THANK YOU!

Some useful links:

… to get into the topic

http://www.ipcc.ch/ Intergovernmental Panel on Climate Change (IPCC)

http://www.hm-treasury.gov.uk/sternreview_index.htm Stern Report

http://www.iccgov.org/iew2009/ International Energy Workshop 2009

… to our work

www.wegcenter.at Wegener Center for Climate and Global Change

www.klimarisiko.at The Economics of Weather and Climate Risks in Austria (under construction)

… to survive in a fact based world

www.wolframalpha.com Wolfram Alpha – My current favourite

www.gapminder.org Gapminder – for visualizing developments

www.economist.com The Economist – not only for (wannabe) Economists