

# Potential for passive cooling of buildings by night-time ventilation in present and future climates in Europe

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# Introduction

- Decreasing heating and increasing cooling demand in buildings in Europe
  - High internal loads (office buildings)
  - High solar gains (extensively glazed facades)
  - Increased comfort expectations
  - Climate warming
- Night-time ventilation
  - Cooling the building structure overnight
  - Heat sink during occupancy period
- Highly dependent on climatic conditions
- Evaluation of climatic potential for night-time ventilation in present and future climates

# Method

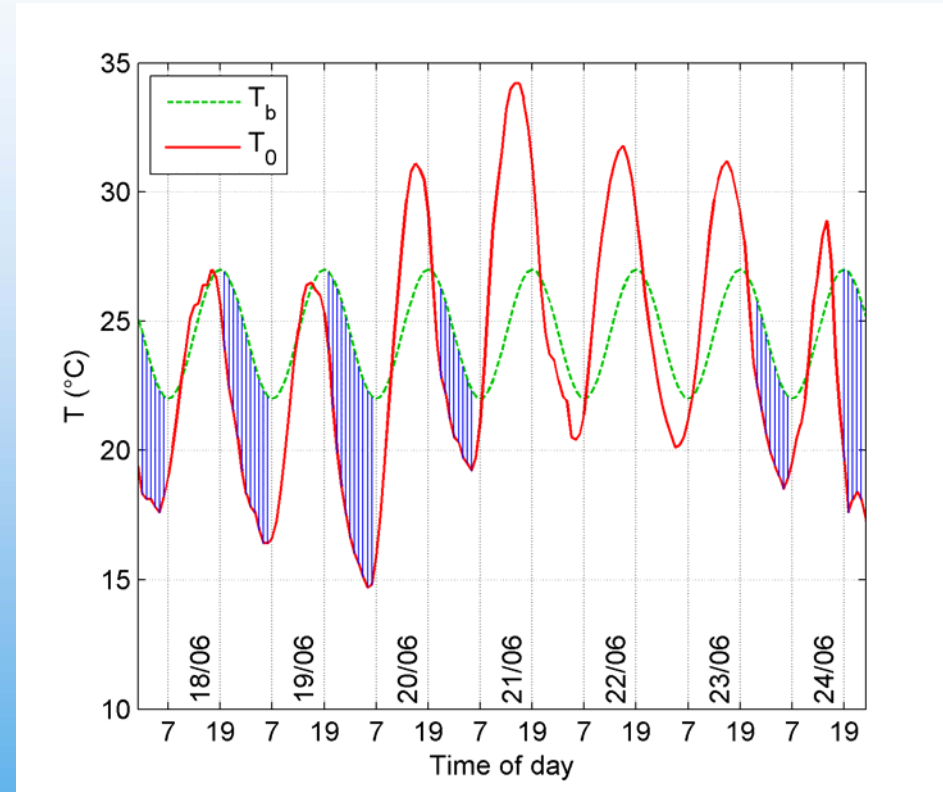
- Degree hours method to quantify the climatic cooling potential
- Harmonically oscillating building temperature within a range of thermal comfort:

$$T_b = 24.5^{\circ}\text{C} \pm 2.5^{\circ}\text{C}$$

- Ventilation period:  
7 pm – 7 am
- Minimum temperature difference:

$$\Delta T_{crit} = 3\text{K}$$

- ➔ Climatic Cooling Potential (K h)



Shaded areas show the climatic cooling potential during one week in summer 2003 for Zurich SMA (ANETZ data)

# Practical significance of CCP

Assumptions:

- Sufficient thermal capacity of building mass
- Closed loop:  $Q_{charge} = Q_{release}$

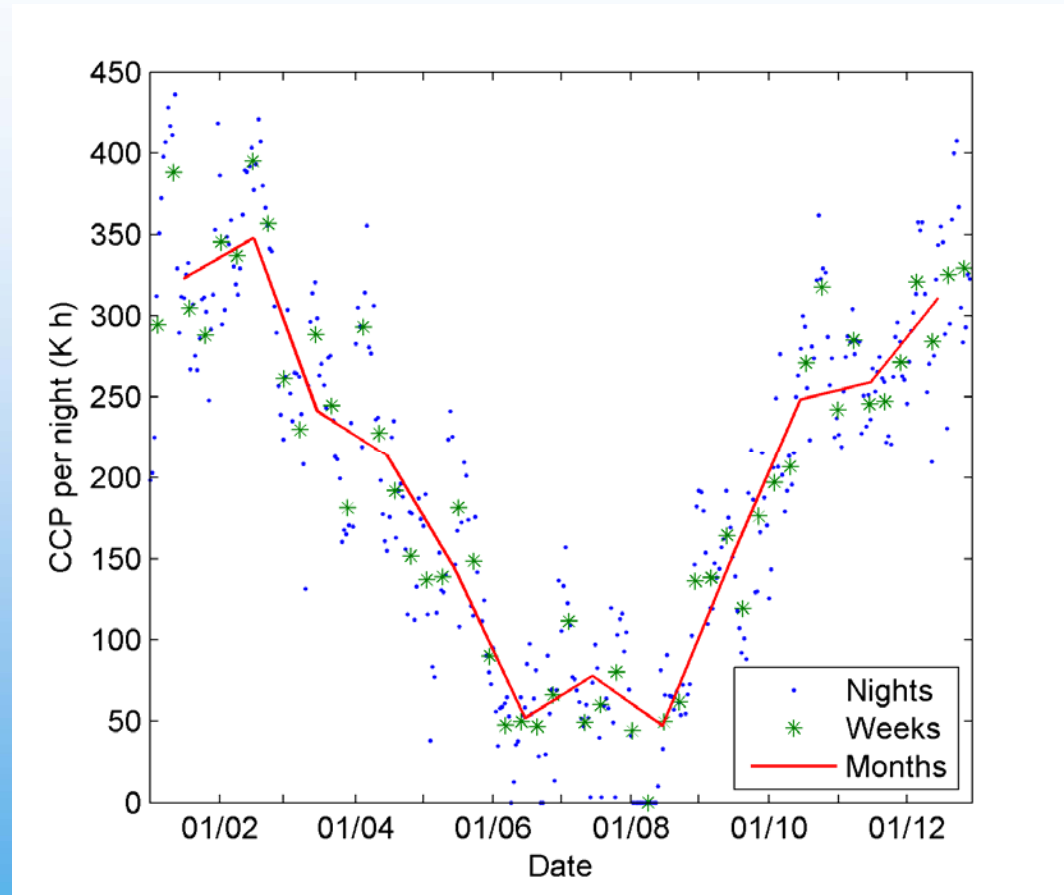
Example:

- Effective air change rate:  $R\eta = 6h^{-1}; \left( \eta = \frac{T_{out} - T_e}{T_b - T_e} \right)$
- Air properties:  $\rho = 1.2 kg/m^3; c_p = 1000 J/(kgK)$
- Occupancy time:  $t_{occ} = 8h$
- Room height:  $H = 2.5m$
- ➔ Heat flux per K h of CCP:  $\frac{\dot{q}}{CCP} = \frac{HR\eta\rho c_p}{t_{occ}} = 0.625 \frac{W/m^2}{Kh}$
- Internal and solar heat gains:  $20 W/m^2 + 30 W/m^2 = 50 W/m^2$
- ➔ Climatic cooling potential:  $CCP = 80Kh$

# CCP in different time intervals

## Stochastic weather patterns

- High variation of CCP within few nights:  $\sim 100 - 200$  K h
- Variation of weekly mean values:  $\sim 50 - 100$  K h
- Heat waves with high daily cooling demand and low cooling potential during nights
- Example:  
First week of August  $\sim 0$  K h  
↔ August mean  $\sim 50$  K h

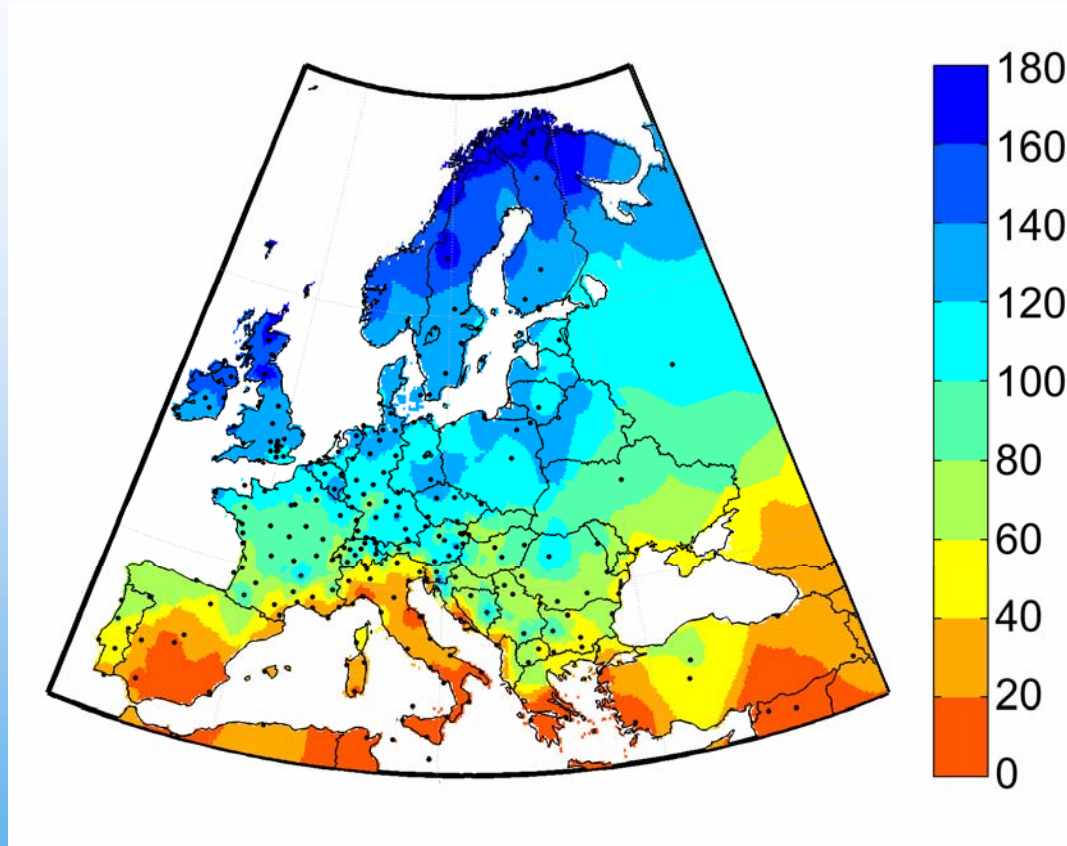


Climatic cooling potential per nights, weeks and months for Zurich SMA in 2003 (ANETZ data)

# Results – Mean CCP in July

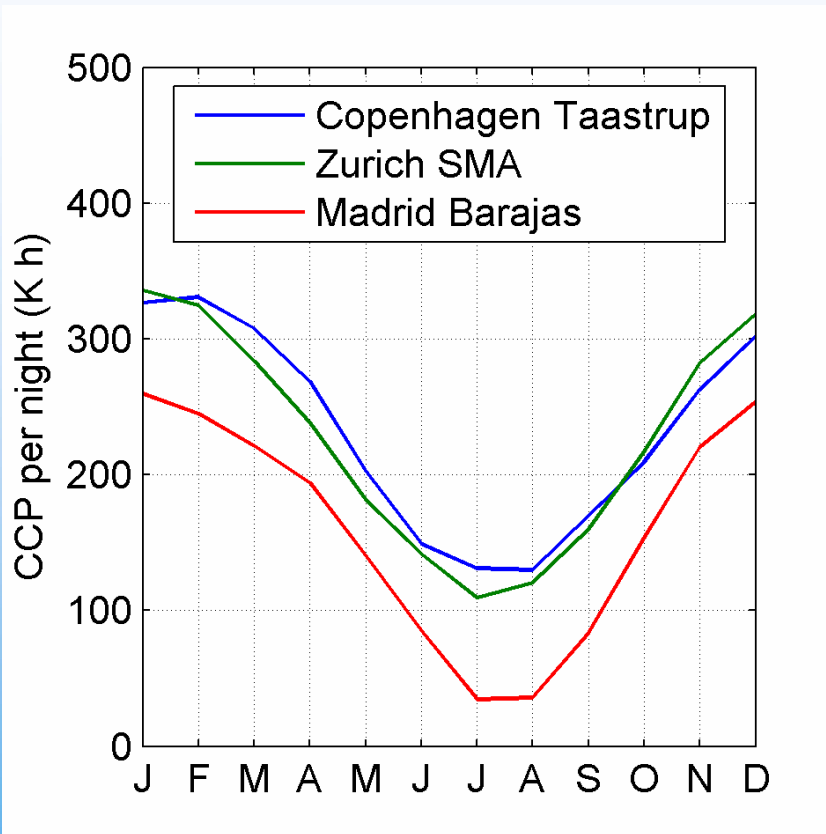
## Gradient from North to South

- Very high potential of 120 – 180 K h in Northern Europe (incl. British Isles)
- High cooling potential (60 – 140 K h) in Central, Eastern and parts of Southern Europe
- Low cooling potential in Southern Europe: 0 – 80 K h

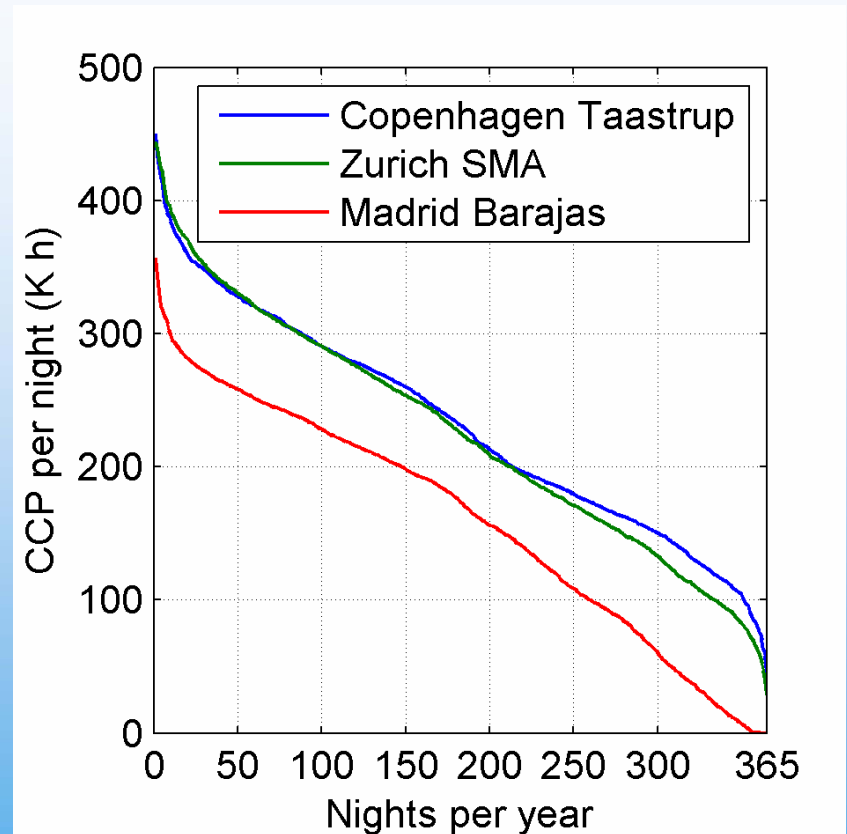


Map of mean climatic cooling potential (K h / night) in July (Meteonorm data)

# Results – monthly mean and CDF



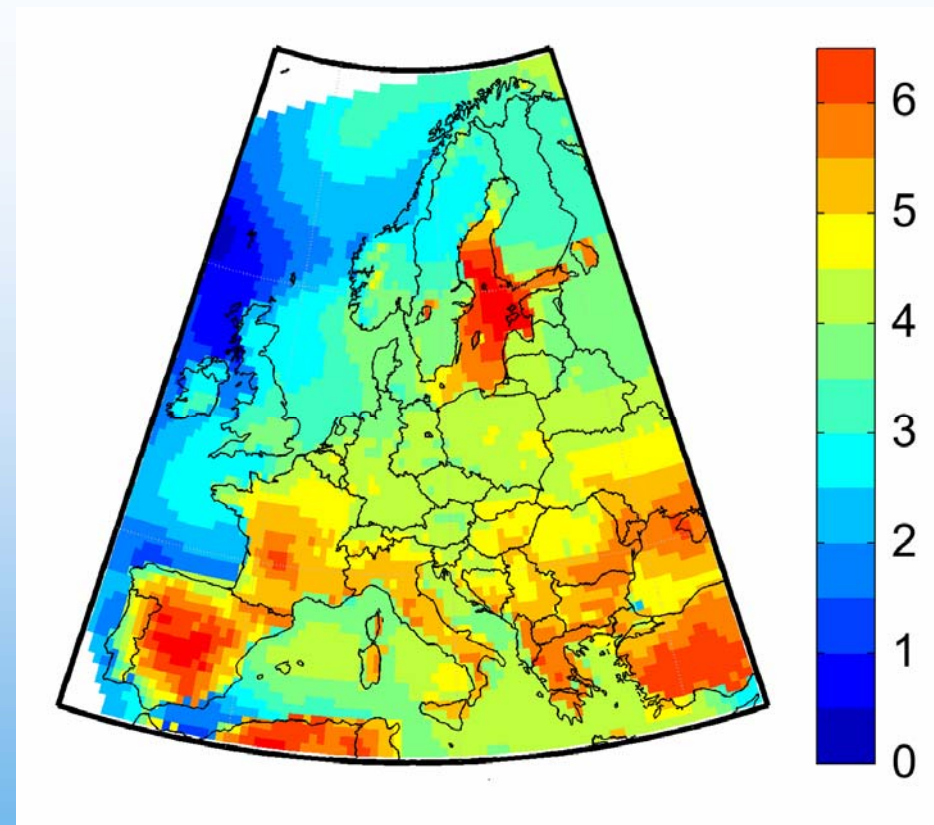
Monthly mean values of the climatic cooling potential per night for three different locations (Meteonorm data)



Cumulative distribution function (CDF) of CCP per night for three different locations (Meteonorm data)

# Outlook – impact of climate change

- Expectation of a significant increase in temperatures within service life of presently constructed buildings
- Need for a detailed analysis of the potential for night cooling in future climate
- PRUDENCE project provides climate projections for 2071-2100
  - Forcing scenarios
  - AOGCM (Atmosphere-Ocean General Circulation Models)
  - RCM (Regional Climate Model)
- High uncertainties of future climate models



Map of the shift in mean daily minimum temperature in summer (JJA) modelled by the Danish Meteorological Institute (DMI) based on a HadAM3H A2 simulation run. (PRUDENCE project: <http://prudence.dmi.dk>)

# Conclusions

- Quantification of the potential for cooling by night-time ventilation in different climatic zones of Europe
  - Very significant potential in Northern Europe (sufficient for most applications)
  - High potential in Central, Eastern and parts of Southern Europe (risk of thermal discomfort on a few days per year)
  - Insufficient potential in Southern Europe (still useful for hybrid systems)
- Degree hours method useful for quantification of cooling potential in first design phase of a building
- Need for detailed analysis of transient thermal behaviour (building energy simulation) and air flow patterns (CFD)
- Improvement of simulation models for air exchange and cooling effect in building energy simulation codes

# Potential for passive cooling of buildings by night-time ventilation in present and future climates in Europe

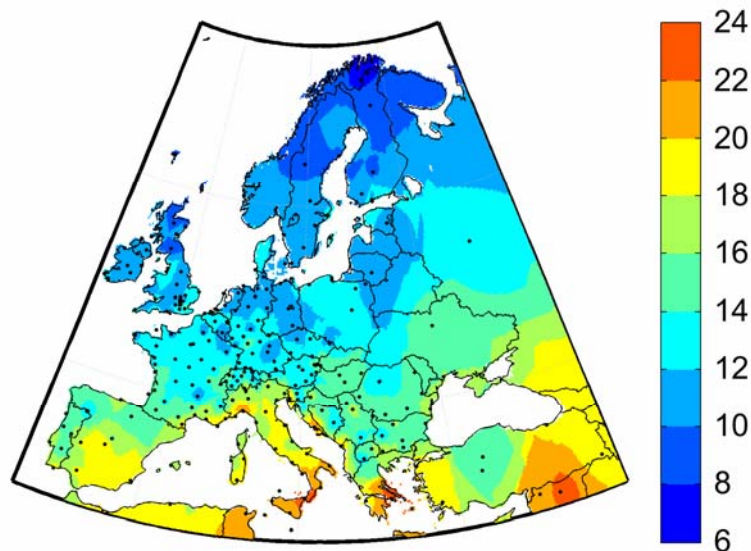
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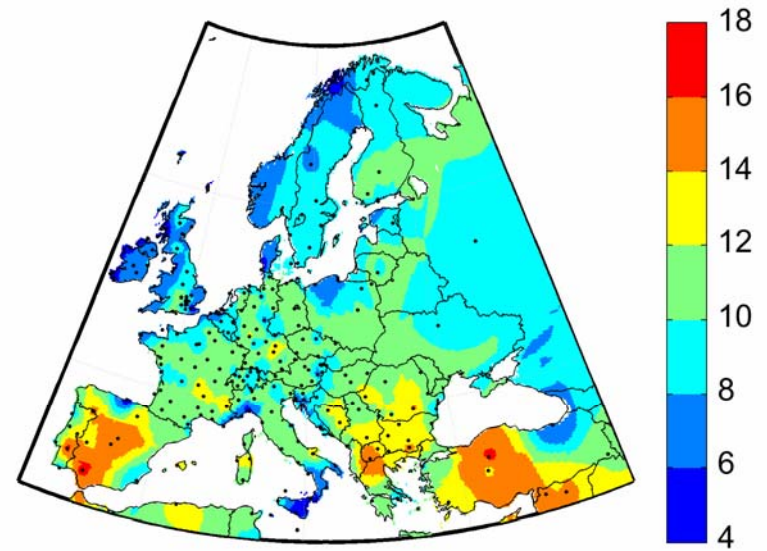
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# Climatic data

- ANETZ: Measured hourly temperature data for Switzerland since 1981
- Meteonorm: Semi synthetic climatic data based on worldwide 7400 stations (hourly data generated from monthly mean values)
- Selection of 259 stations at densely populated locations in Europe



Mean daily minimum temperature (°C)  
in July (Meteonorm data)



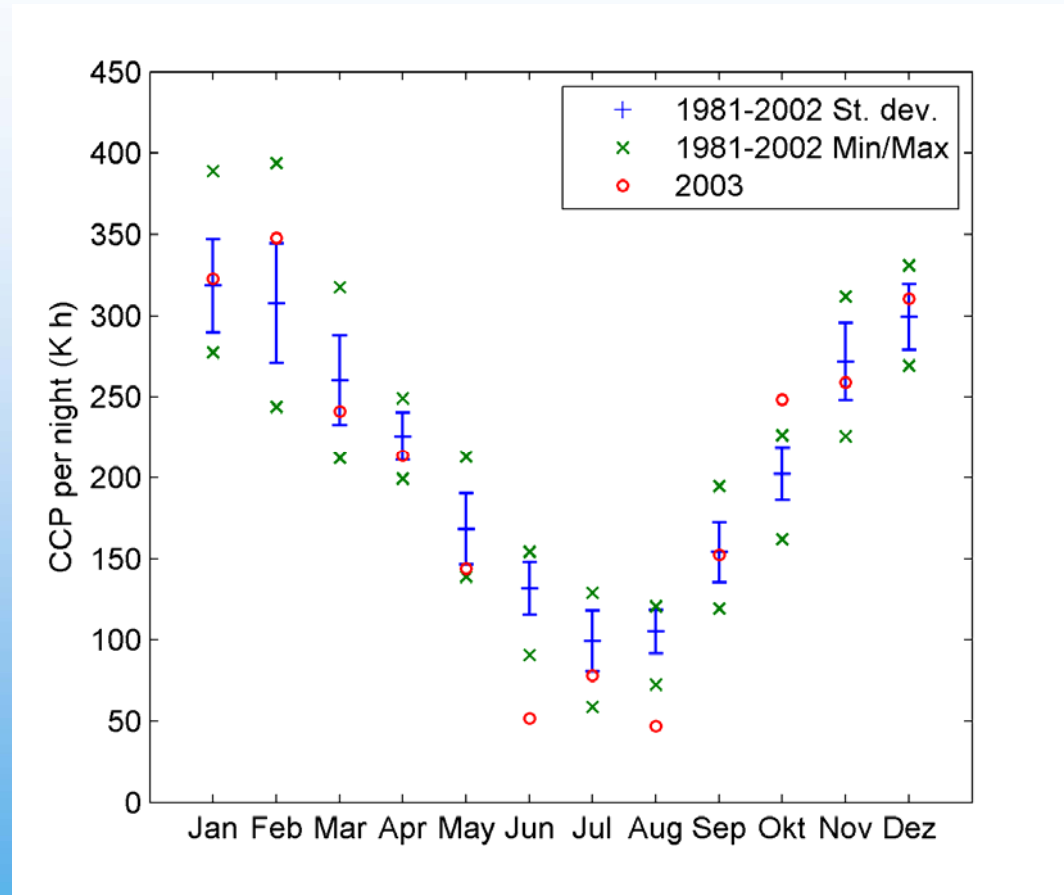
Mean daily temperature fluctuation  
(°C) in July (Meteonorm data)

# CCP in different time intervals II

High variation of monthly mean values over the years: ~ 100 - 150 K h

## Outlook:

- Exceptionally hot summer in 2003
- Very low cooling potential in June and August
- Is this, what a typical summer will be like at the end of this century?



Mean value, standard deviation, minimum and maximum of monthly mean CCP for Zurich SMA 1981 to 2002 and monthly mean for 2003 (ANETZ data)