Future vulnerability assessment of energy demand to climate change impacts in Cyprus

V. Psiloglou, G. Lemesios, D. Xevgenos, M. Zachariou-Dodou, K. Moustakas, K. Ioannou, C. Giannakopoulos*, M. Petrakis, M. Loizidou

*National Observatory of Athens

Structure of the talk

- Electricity demand and temperature
- Temporal variability of electricity demand
- Future electricity demand levels

Factors that Influence Electricity demand

- Human Activities - Habits
- Prevailing Meteorological Conditions
  (Air Temperature & Rel. Humidity, Wind,
  Solar radiation Intensity)

Data Availability (case study: Cyprus)

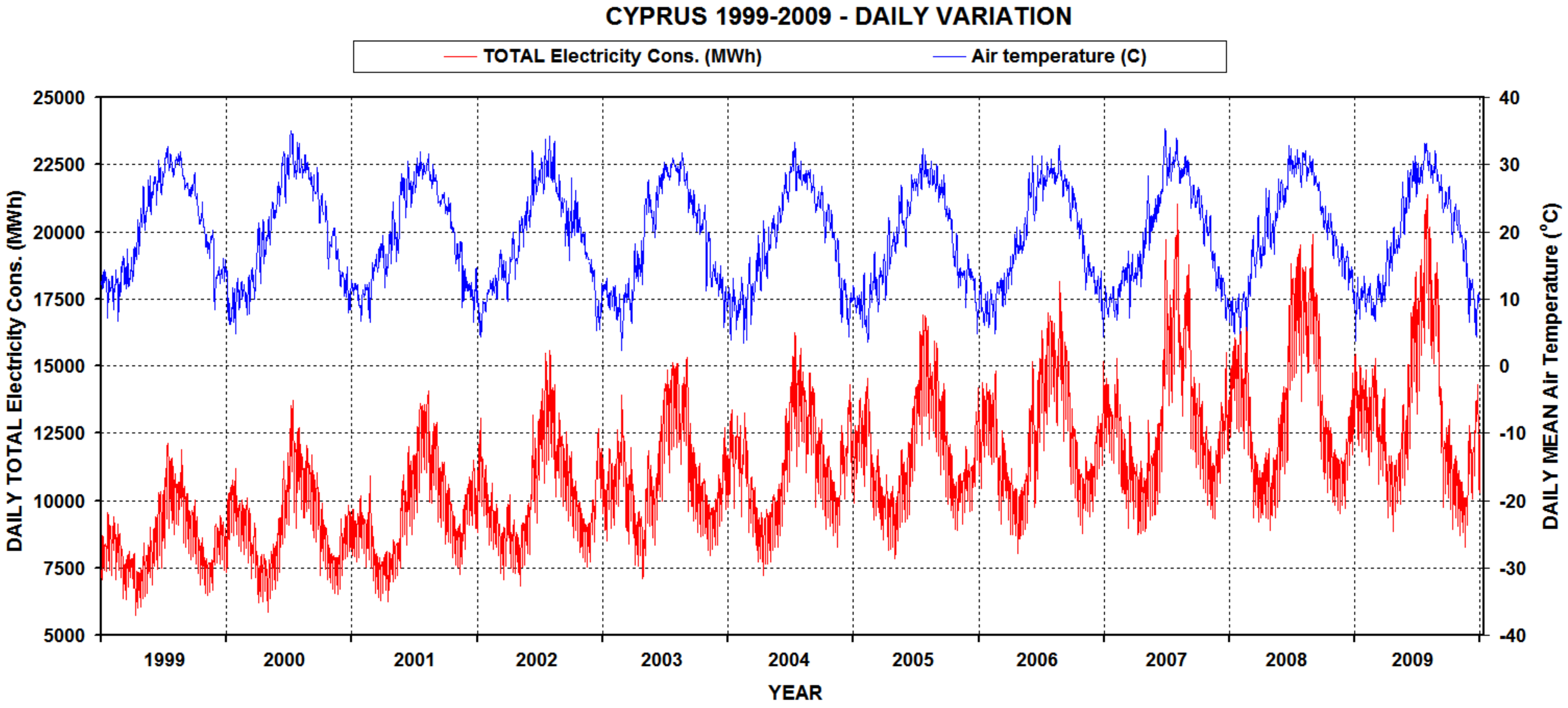
Total Hourly Residential & Commercial electricity Consumption (MWh), spanning the period from January 1999 to December 2009

Source: → Cyprus Transmission System Operator

Daily Mean Hourly air temperature Meteorological Parameters (Air Temperature & Rel. Humidity, Wind, Solar rad. Intensity), for the same period 1999-2009

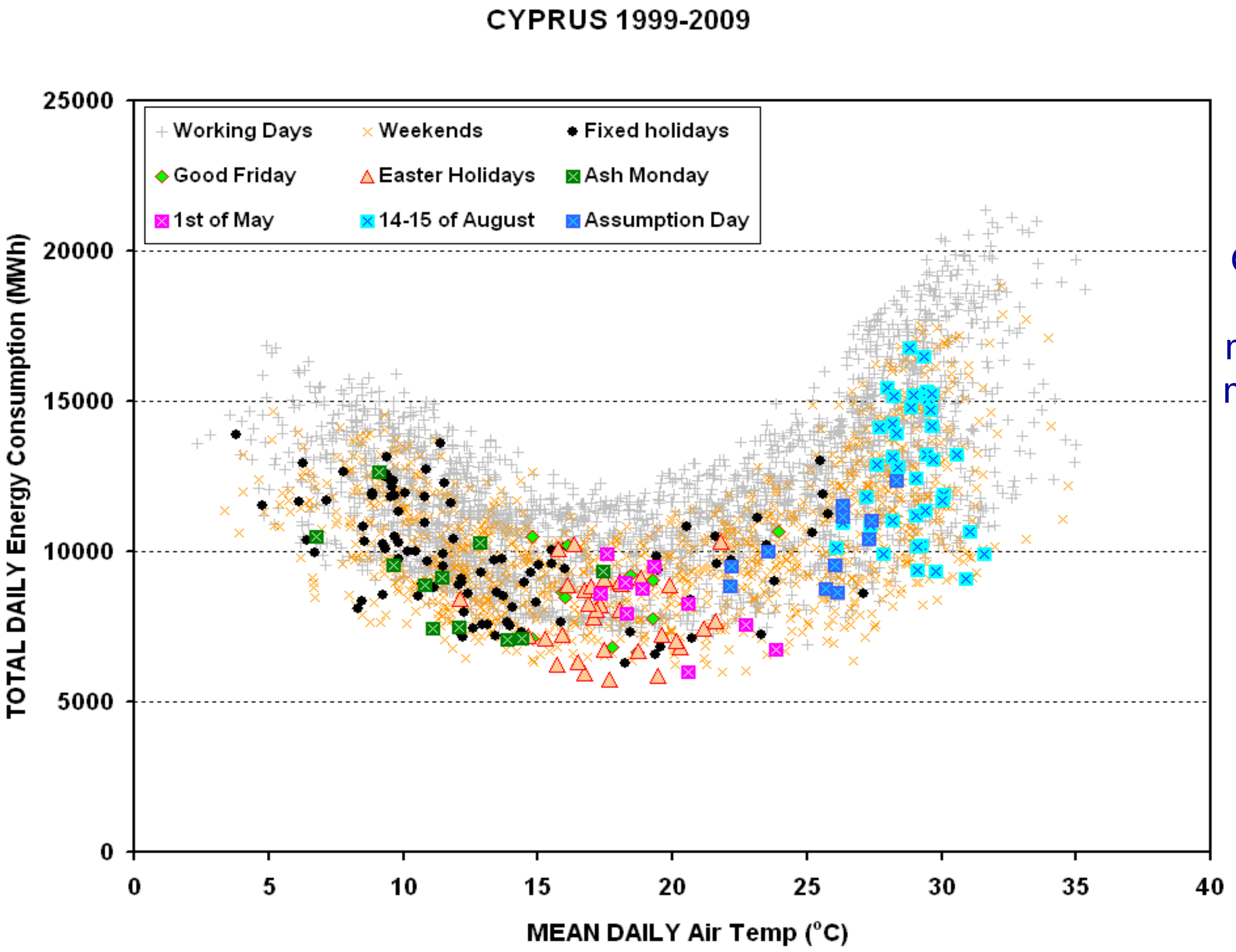
Source: → Cyprus Meteorological Service and Cyprus Transmission System Operator

Daily Mean Air Temperature (^{o}C) and electricity demand (MWh) for Cyprus for the period 1999-2009



- Electricity demand shows upward trend due to economic growth and greater air conditioning use.
- Seasonal (influenced by weather) and yearly (influenced by socioeconomic factors) variations in demand

Scatter plot of electricity demand .vs. temperature.

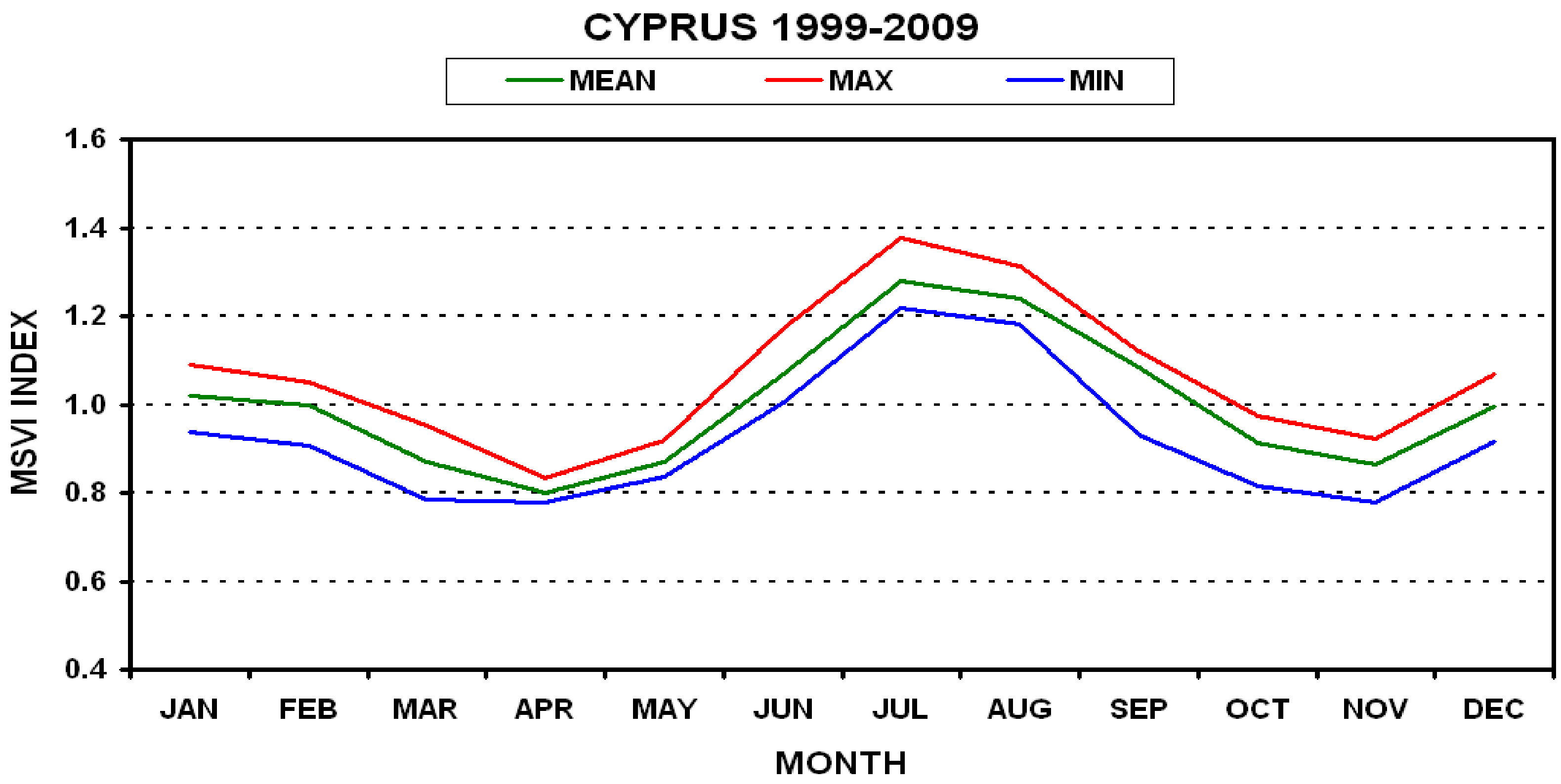


The relationship between energy consumption and air temperature is NOT linear.

On the contrary, presents two maxima and one minimum. Lower values on weekends.

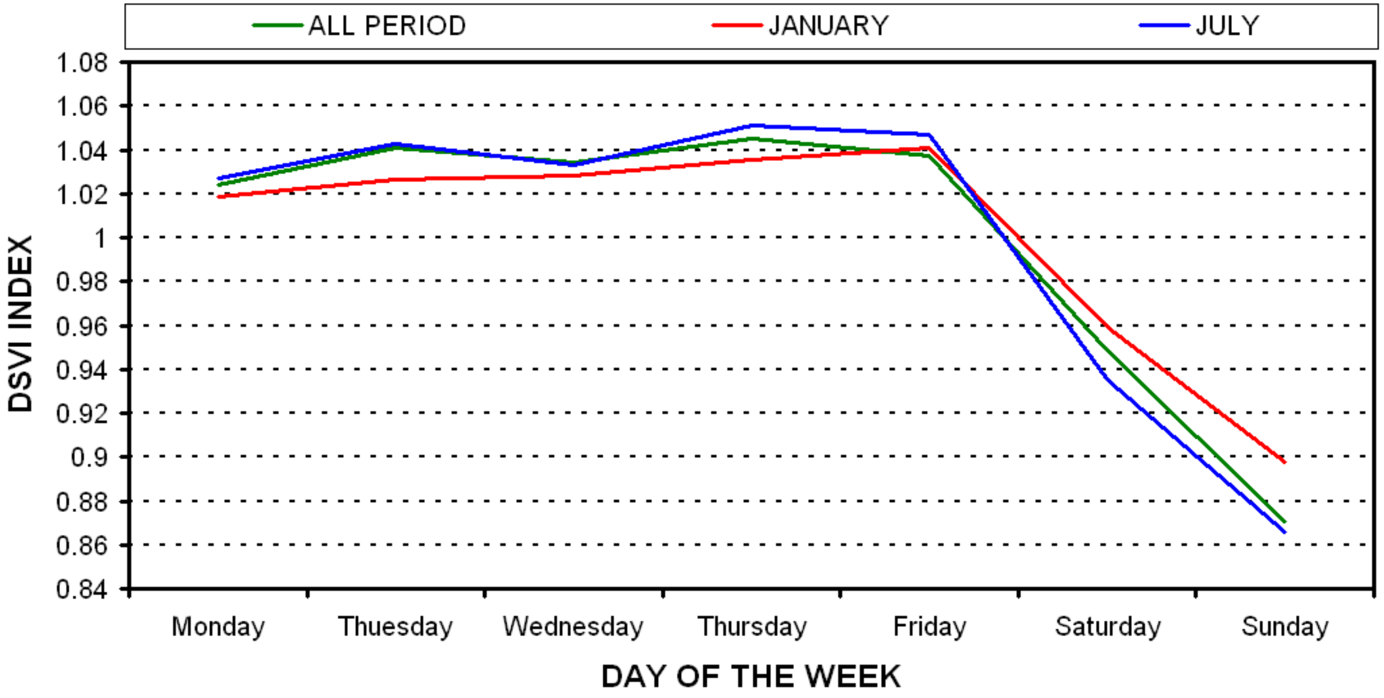
Lowest values during long Easter weekend and other bank holidays (1st May).

Monthly variation of energy consumption.



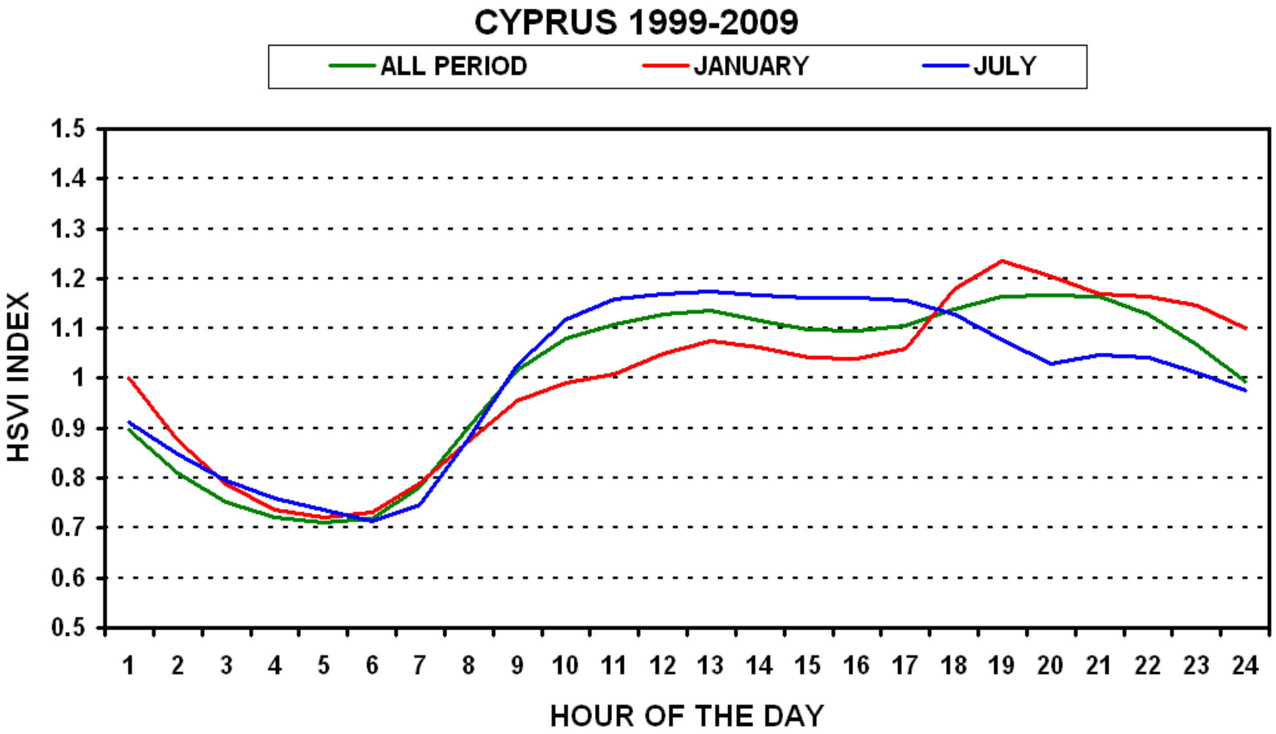
- **The maximum values of energy consumption are related to the maximum monthly temperatures, mainly in July and August, indicating the need for space cooling.**
- **Energy consumption falls as autumn approaches and increases again in December and in January related to colder temperatures. Then it decreases gradually till May.**

Daily variation of energy consumption.


CYPRUS 1999-2009

- Energy consumption is lower during the weekends (especially on Sundays) due to reduced economic activities. Small fluctuations are evident in the other days of the week.
- Winter and summer months tend to have similar behaviour with summer weekdays having higher energy levels and summer weekends having lower energy levels than the respective winter ones.

Hourly variation of energy consumption.



- Energy values rise after 9am when people have started work and remain at high levels until 9pm with a small decline soon afterwards and a larger decline from 2am-8am.
- January presents lower energy values during the day and higher during the evening/night than July.
- A small peak exists around 7-8pm in January reflecting the need for additional heating in the evening hours as people tend to stay indoors.

Future energy consumption levels

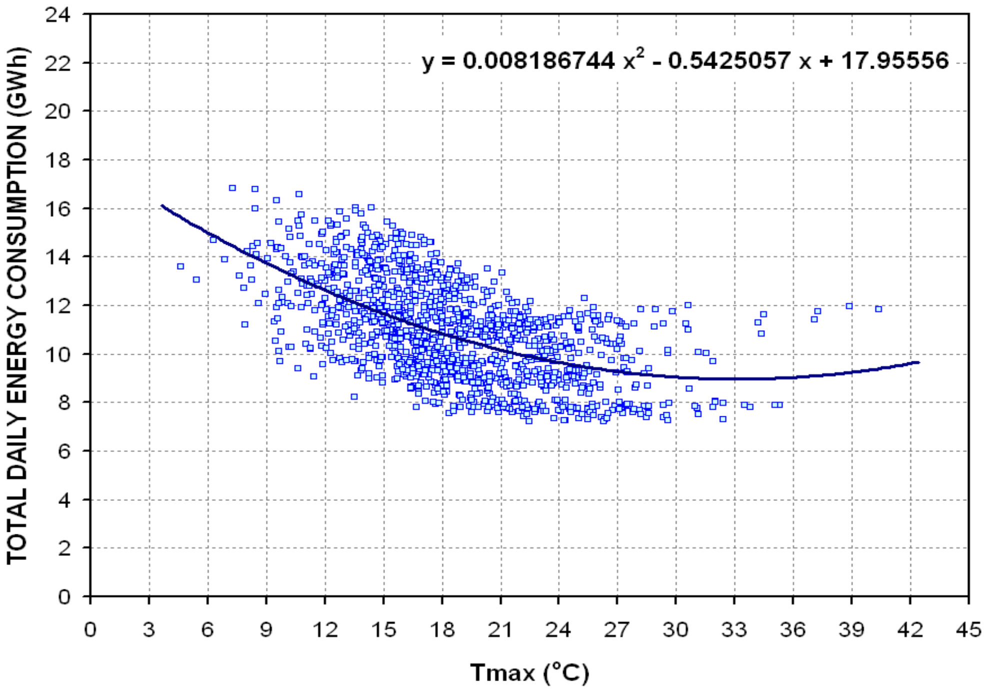
- The energy consumption is linked to climatic conditions and it is expected that with warmer weather, decreased consumption should be typical in the ‘cold’ period and increased consumption should be typical in the ‘warm’ period of the year.

- **For the investigation of future energy consumptions in relation to temperature rise, temperature data from 7 regional climate models are used for two 30 yr periods: the ‘control period’ 1961–1990 and the ‘future period’ 2021-2050, employing the A1B scenario.**

- To be able to project energy consumption under future climatic conditions, the same technology use is assumed between the control and the future period.

- **we split our examined period into ‘cold’ and ‘warm’ period. The ‘cold’ period covers the months November-April and the ‘warm’ period the months May-October.**

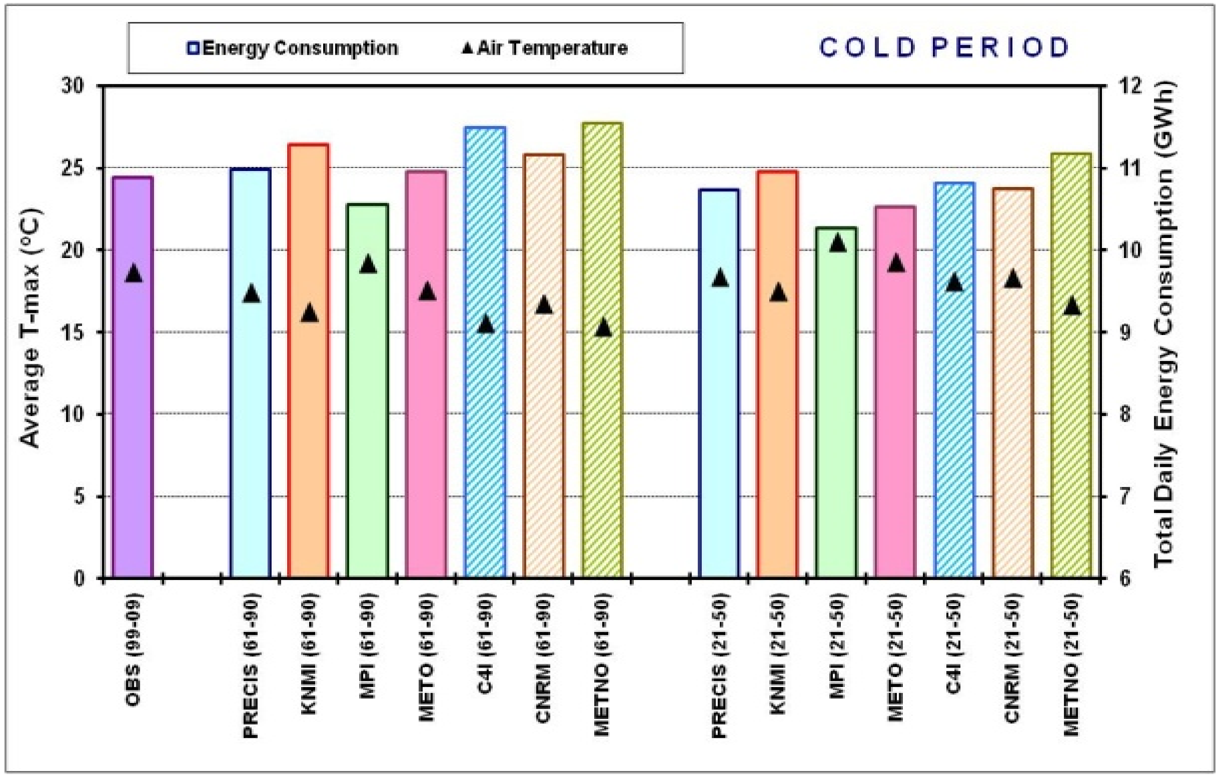
Relation of daily energy consumption with daily maximum air temperature for the 'cold' period of the year



- The variation of energy consumption in the 'cold' period follows a non-linear decreasing pattern as temperatures rise

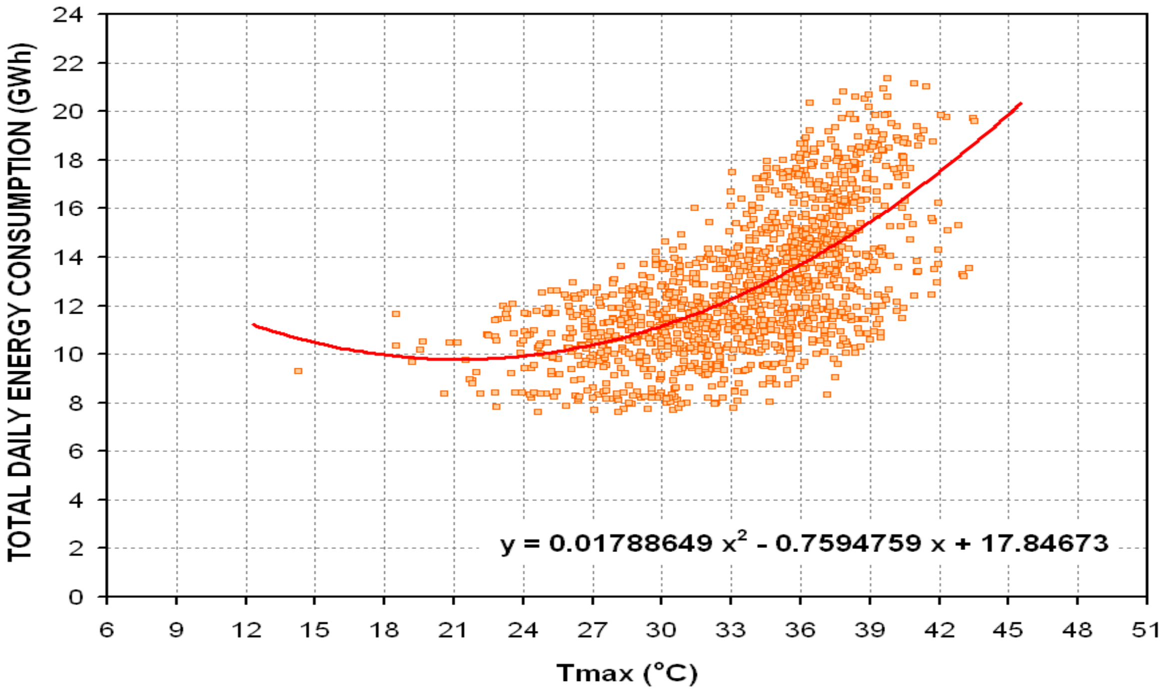
- The mathematical formula used for the extrapolation under future climatic conditions appears in Figure

Energy consumption (bars, right axis) and daily maximum air temperature (triangles, left axis) for the 'cold' period of the year for the observations period 1999-2009, the various models for the control period 1961-1990, and the future period 2021-2050.



- •For the 'cold' period of the year, a decreasing trend in energy consumption is evident as warmer conditions dominate by 2050
- •There are variations among the various examined models but all show a decrease of around 5% compared to the control period.

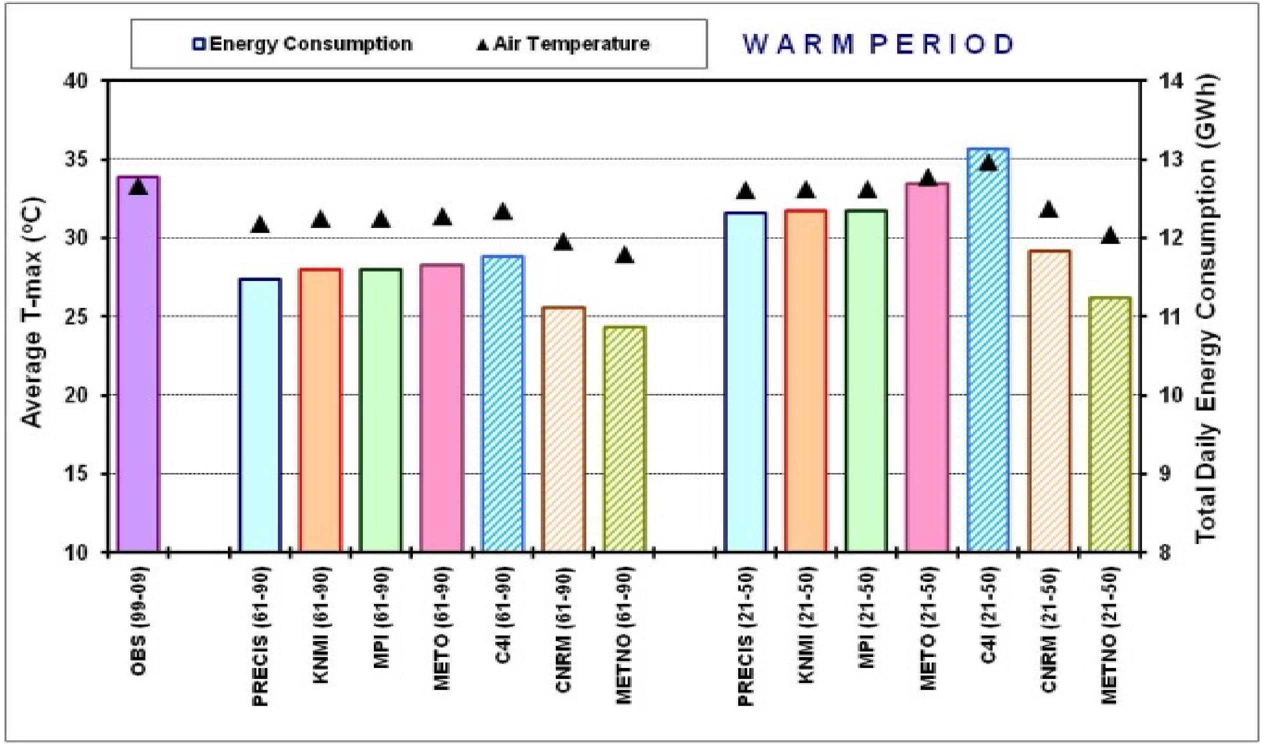
Relation of daily energy consumption with daily maximum air temperature for the ‘warm’ period of the year



- The variation of energy consumption in the ‘warm’ period follows a non-linear increasing pattern as temperatures rise

- The mathematical formula used for the extrapolation under future climatic conditions appears in Figure

Energy consumption (bars, right axis) and daily maximum air temperature (triangles, left axis) for the 'warm' period of the year for the observations period 1999-2009, the various models for the control period 1961-1990, and the future period 2021-2050.



- •For the 'warm' period of the year, an increasing trend in energy consumption is evident as warmer conditions dominate by 2050
- •There are variations among the various examined models but all show an increase of around 10% compared to the control period.
- •The increase in the 'warm' period of the year doubles the energy decrease (saving) in the 'cold' period of the year.

Degree – day Indicator

Heating Degree Days (HDD – demand for heating)

Cooling Degree Days (CDD – demand for cooling)

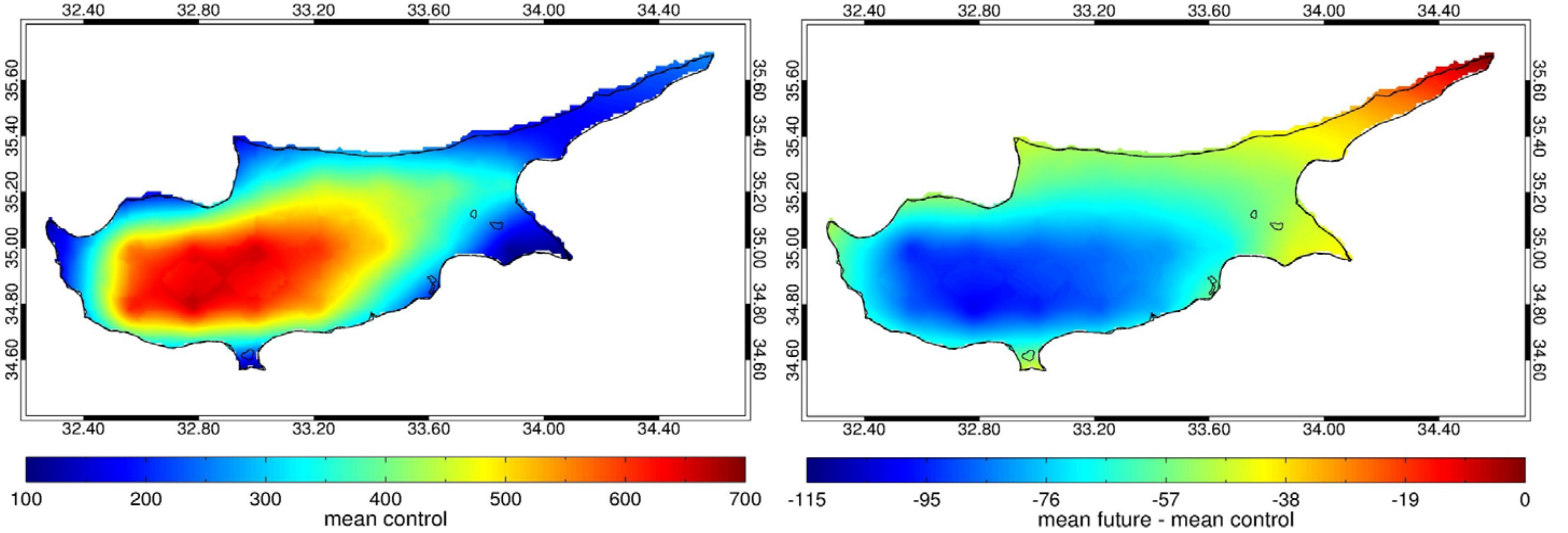
$$HDD = \max(T^* - T, 0)$$

$$CDD = \max(T - T^{**}, 0)$$

- T^* and T^{**} are the base temperatures for HDD and CDD respectively
- T is the mean daily temperature calculated from the daily data of the RCM for both the control – reference period (1961 – 1990) and the future (2021 – 2050) period
- 15°C as base temperature for the calculation of HDDs and 25°C for the calculation of CDDs
- All calculations were performed using the PRECIS Regional Climate Model (RCM), 25Km x 25 Km resolution

Heating Degree Days

Winter cumulative HDD

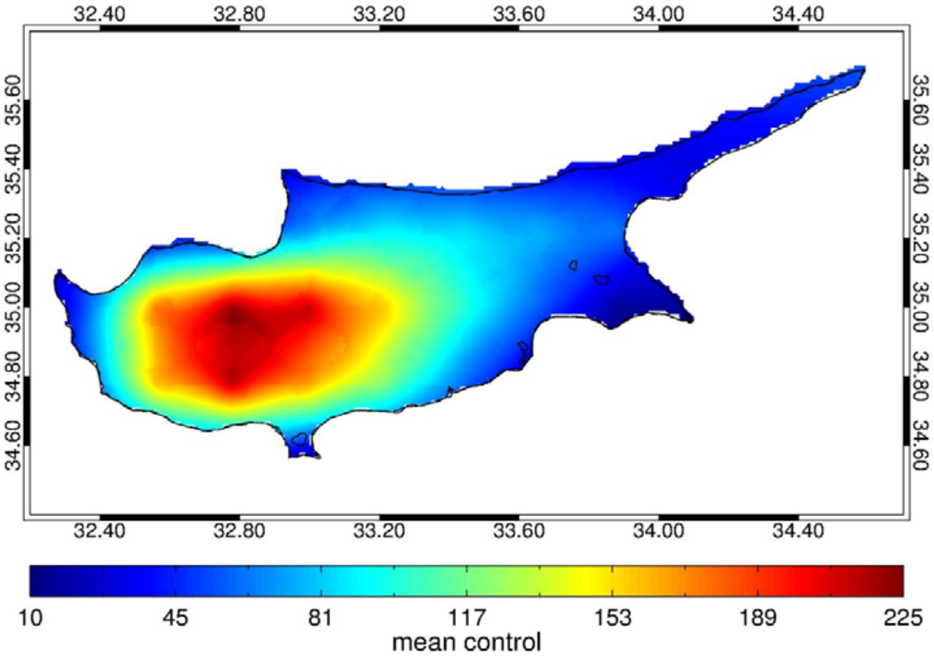


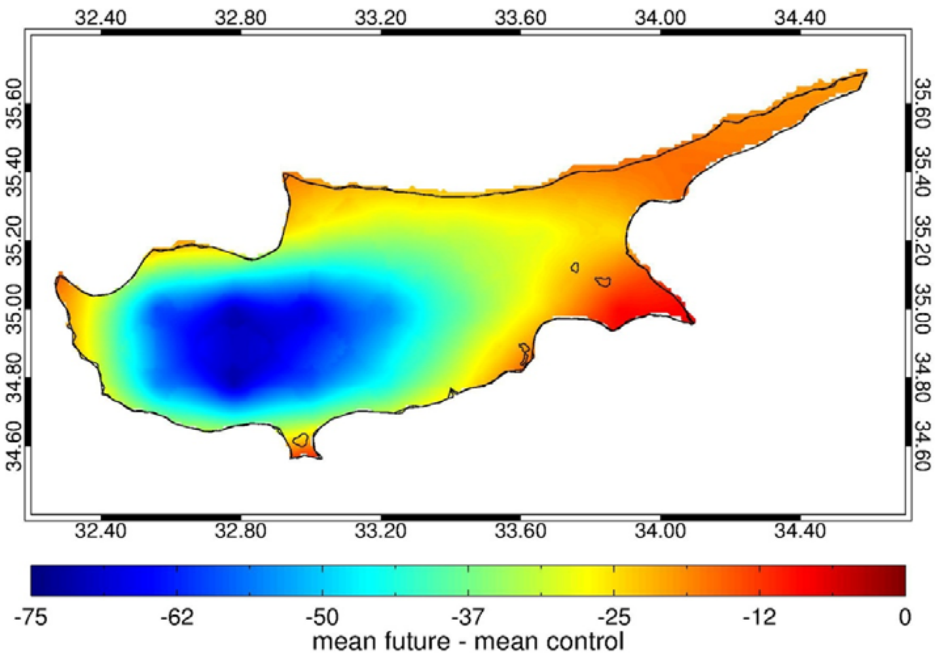
- Energy demand for heating reaches 650 degree-days mainly in the wider area of Troodos Mountain and approximately 350 degree-days in western and 450 degree-days in southern-southeastern and inland regions.

- Significant reductions in energy demand are projected.
- In Mountain regions the reduction is about 90 degree-days.
- In inland, south-southeastern and western areas the reduction is approximately 60 degree-days.

Heating Degree Days

Spring cumulative HDD



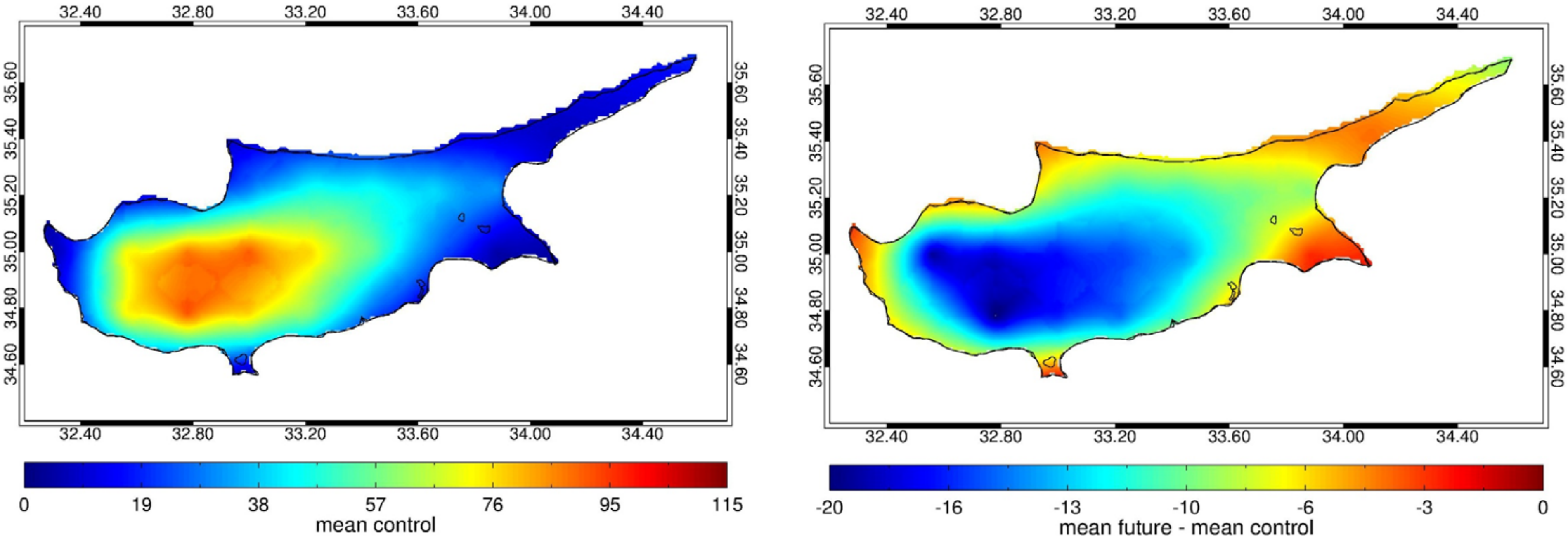


- In inland and southeastern areas energy demand for heating is about 90 and 50 degree-days respectively.
- In southern and western areas energy demand is around 100 degree-days.
- High elevation areas present 130 to 225 degree-days.

- Greater reductions are projected for mountain areas of about 75 degree-days.
- For inland and southeastern areas, the drop is about 25-30 degree-days.
- For southern and western areas the decrease is expected to reach 30 degree-days.

Heating Degree Days

Number of days with high HDD (>5 °C)



- Mountain regions of Troodos demand approximately 100 days of heavy heating while inland and southern areas require approximately 55 days.
- Southeastern and western regions require fewer days for heavy heating of the order of 35.

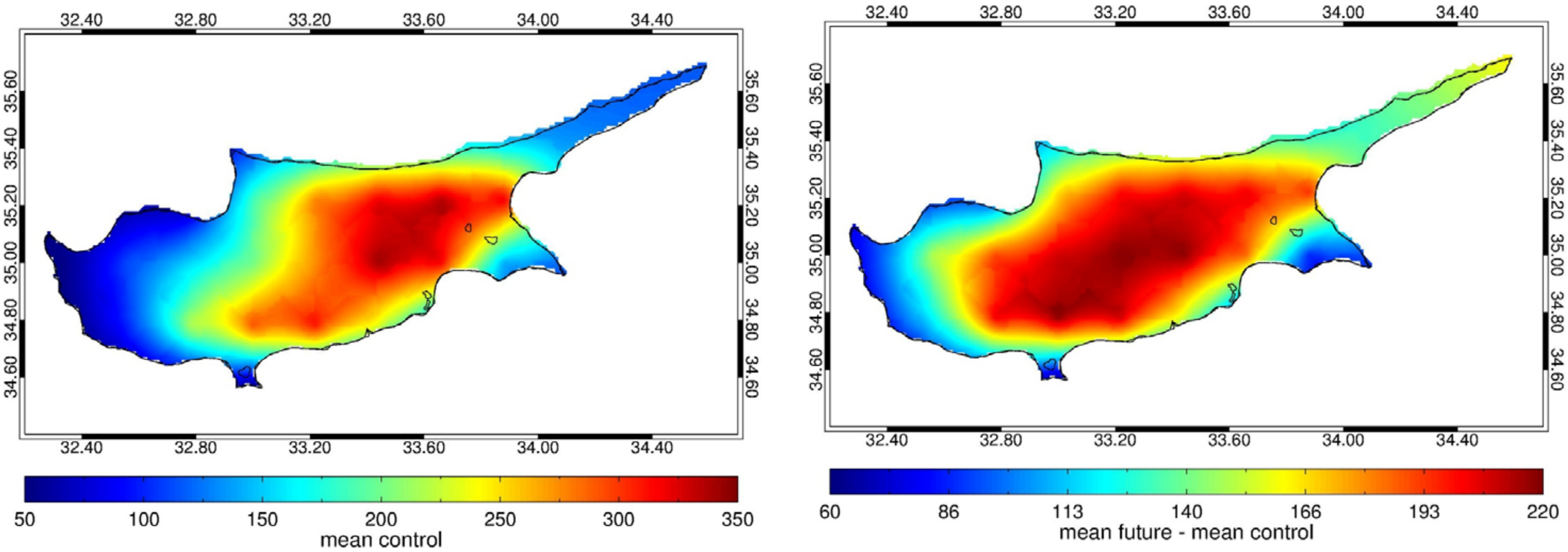
- Decrease of about 18 days is projected for mountain region while for Nicosia and Limassol Districts the decrease is about 12 days.
- Southeastern and western areas show a reduction of about 10 days.

HDD for control period as well as future changes (future – control) due to climate change in Cyprus

	Western Regions		**Southern Regions**		**Southeastern Regions**		**Inland Regions**		**Mountain Regions**	
	Control	Change	Control	Change	Control	Change	Control	Change	Control	Change
Spring Cumul. HDD	100	(-) 30	100	(-) 30	50	(-) 25	90	(-) 25	130-225	(-) 75
Winter Cumul. HDD	350	(-) 60	450	(-) 60	450	(-) 60	450	(-) 60	650	(-) 90
Nb of days with high HDD (>5)	35	(-) 10	55	(-) 12	35	(-) 10	55	(-) 12	100	(-) 18

Cooling Degree Days

Summer cumulative CDD

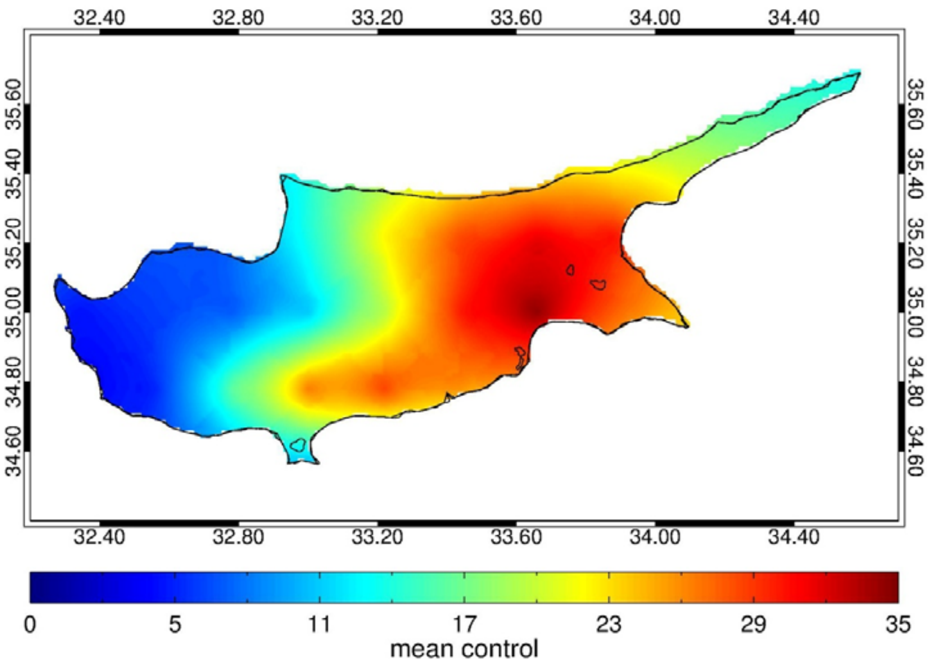


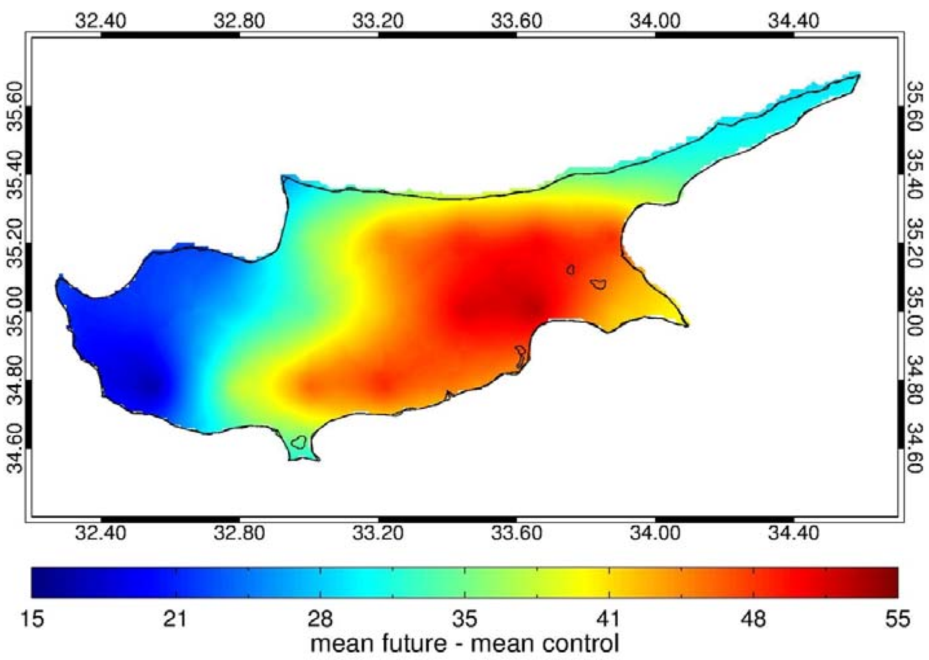
- 300 degree-days are presented in southeastern and inland regions.
- Lower energy needs are shown in mountain and much lower in western regions where energy demands reach 100-200 and 50-100 degree-days respectively.

- Increase in energy demand of about 160-200 degree-days for mountain regions and about 200 degree-days in inland and southern – southeastern areas
- Fewer energy needs are projected for western areas of about 100 degree-days.

Cooling Degree Days

Fall cumulative CDD



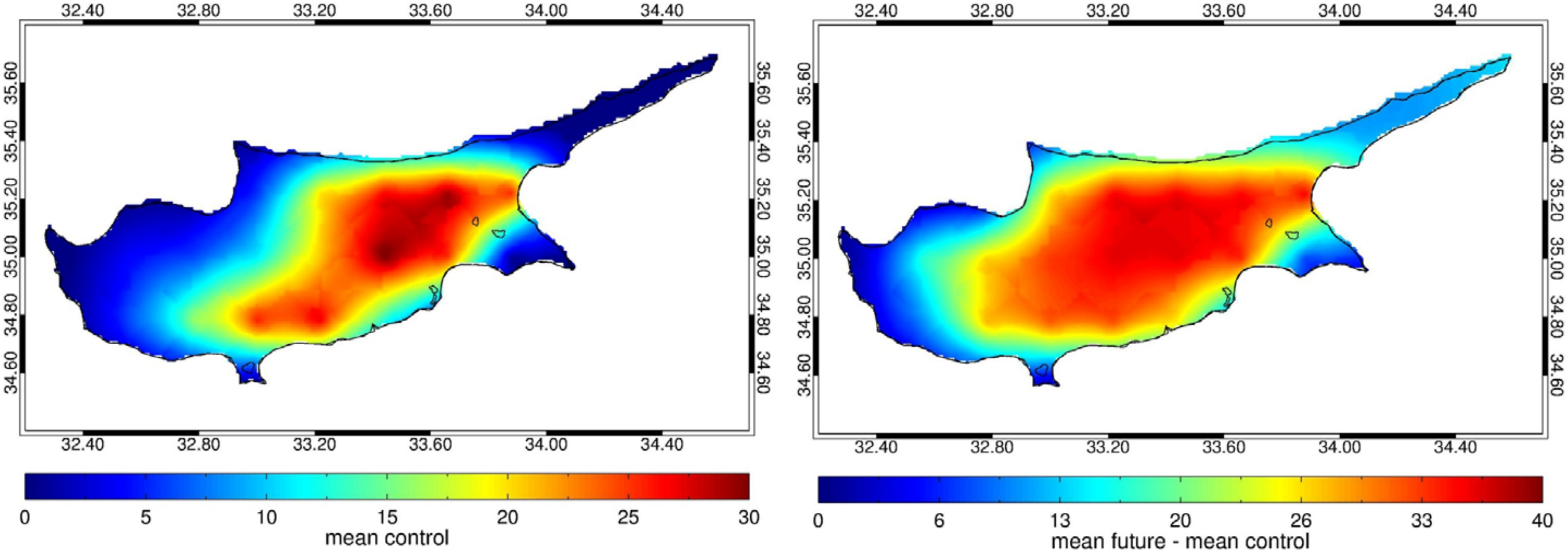


- Southeastern and inland regions present 30 degree-days
- Western regions show lower energy demands of about 10 degree-days.

- Rise in energy demand of about 50 degree-days in inland and southeastern regions and about 40 degree-days in southern regions.
- For mountain and western regions the increase is lower of around 30 and 20 degree-days respectively.

Cooling Degree Days

Number of days with high CDD (>5 °C)



- Required 25-30 days per year of heavy cooling in south-eastern, inland regions and southern regions.
- In mountain and western regions the number of days with heavy cooling is around 5-15 days and 0-5 days respectively.

- One additional month of heavy cooling for inland, southern and southeastern regions.
- In mountain regions the increase varies from 15 to 30 days depending on the height.
- For western regions a smaller increase of about 5 days is expected.

Cooling Degree Days

CDD for control period as well as future changes (future – control) due to climate change in Cyprus

	Western Regions		Southern Regions		Southeastern Regions		Inland Regions		Mountain Regions	
	Control	Change	Control	Change	Control	Change	Control	Change	Control	Change
Summer Cumul. CDD	50-100	(+) 100	150-250	(+) 200	300	(+) 200	300	(+) 200	100-200	(+) 160-200
Fall Cumul. CDD	10	(+) 20	20	(+) 40	30	(+) 50	30	(+) 50	10-20	(+) 30
Nb of days with high CDD (>5)	0-5	(+) 5	10-20	(+) 30	25-30	(+) 30	25-30	(+) 30	5-20	(+) 15-30

Conclusions

- Electricity demand shows upward trend due to economic growth and greater air conditioning use.

- The relationship between energy consumption and air temperature is NOT linear. It presents two maxima and one minimum. Lower values on weekends and especially on holidays.

- The maximum values of energy consumption are related to the maximum monthly temperatures, mainly in July and August, indicating the need for space cooling.

- Energy values rise after 9am when people have started work and remain at high levels until 9pm with a small decline soon afterwards and a larger decline from 2am-8am.

- The increase of 10% in the ‘warm’ period of the year doubles the energy decrease (5% saving) in the ‘cold’ period of the year by 2021-2050.

Conclusions

- Winter and spring energy demand for heating is anticipated to decrease. Greater reductions are anticipated in mountain areas, 90 and 75 degree-days respectively. 18 days less for heavy heating.

- For the remaining areas the reductions are expected approximately 60 (winter) and 30 (spring) degree-days. 10-12 days less for heavy heating.

- Increase in energy demand for cooling during summer, 160-200 degree-days for mountain regions, 200 degree-days in inland and southern – southeastern areas.

- Elevated energy demand for cooling during fall. 50 degree-days in inland and southeastern regions and about 40 degree-days in southern regions. 20-30 in the remaining area.

- One additional month of heavy cooling for inland, southern and southeastern regions. 15-30 in mountain areas, 5 days for western areas.

Aknowledgements :

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THANK YOU FOR YOUR ATTENTION

Contact e-mail: cgiannak@meteo.noa.gr